Universidad de Valladolid

ESCUELA DE INGENIERÍAS INDUSTRIALES

UNIVERSIDAD DE VALLADOLID

ESCUELA DE INGENIERÍAS INDUSTRIALES

Grado en Ingeniería en Electrónica Industrial y Automática

Anexos. Diseño y construcción de una fuente de corriente AC regulable para ensayo de sondas de corriente

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Thermally Enhanced, Fully Integrated, Hall Effect-Based Linear Current Sensor IC with 100 μΩ Current Conductor

FEATURES AND BENEFITS

- Industry-leading noise performance through proprietary amplifier and filter design techniques
- Integrated shield greatly reduces capacitive coupling from current conductor to die due to high dV/dt signals, and prevents offset drift in high-side, high voltage applications
- Total output error improvement through gain and offset trim over temperature
- Small package size, with easy mounting capability
- Monolithic Hall IC for high reliability
- Ultra-low power loss: 100 μΩ internal conductor resistance
- Galvanic isolation allows use in economical, high-side current sensing in high voltage systems
- AEC Q-100 qualified

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TÜV America
Certificate Number:
U8V 14 05 54214 028
UL Certified
File No.: E316429

PACKAGE: 5-PIN CB PACAKGE

PFF Leadform **PSF Leadform** **PSS Leadform**

DESCRIPTION

The Allegro™ ACS758 family of current sensor ICs provides economical and precise solutions for AC or DC current sensing. Typical applications include motor control, load detection and management, power supply and DC-to-DC converter control, inverter control, and overcurrent fault detection.

The device consists of a precision, low-offset linear Hall circuit with a copper conduction path located near the die. Applied current flowing through this copper conduction path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional output voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy at the factory.

High level immunity to current conductor dV/dt and stray electric fields, offered by Allegro proprietary integrated shield technology, provides low output voltage ripple and low offset drift in high-side, high voltage applications.

The output of the device has a positive slope (>V_{CC}/2) when an increasing current flows through the primary copper conduction path (from terminal 4 to terminal 5), which is the path used for current sampling. The internal resistance of this conductive path is 100 μΩ typical, providing low power loss.

The thickness of the copper conductor allows survival of the device at high overcurrent conditions. The terminals of the conductive path are electrically isolated from the signal leads

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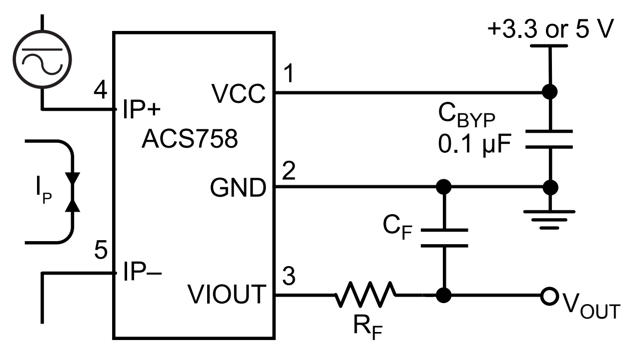


Application 1: The ACS758 outputs an analog signal, V_{OUT}, that varies linearly with the uni- or bi-directional AC or DC primary sampled current, I_P, within the range specified. C_F is for optimal noise management, with values that depend on the application.

Typical Application

FEATURES AND BENEFITS (CONTINUED)

- 3.0 to 5.5 V, single supply operation
- 120 kHz typical bandwidth
- 3 μs output rise time in response to step input current
- Output voltage proportional to AC or DC currents
- Factory-trimmed for accuracy
- Extremely stable output offset voltage
- Nearly zero magnetic hysteresis

DESCRIPTION (CONTINUED)

(pins 1 through 3). This allows the ACS758 family of sensor ICs to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques.

The device is fully calibrated prior to shipment from the factory. The ACS758 family is lead (Pb) free. All leads are plated with 100% matte tin, and there is no Pb inside the package. The heavy gauge leadframe is made of oxygen-free copper.

Selection Guide

Part Number[1]	Package		Primary Sampled Current , I_P (A)	Sensitivity Sens (Typ.) (mV/A)	Current Directionality	T_{OP} (°C)	Packing[2]
	Terminals	Signal Pins					
ACS758LCB-050B-PFF-T	Formed	Formed	±50	40	Bidirectional	–40 to 150	34 pieces per tube
ACS758LCB-050U-PFF-T	Formed	Formed	50	60	Unidirectional		
ACS758LCB-100B-PFF-T	Formed	Formed	±100	20	Bidirectional		
ACS758LCB-100B-PSF-T	Straight	Formed	±100	20	Bidirectional		
ACS758LCB-100U-PFF-T	Formed	Formed	100	40	Unidirectional		
ACS758KCB-150B-PFF-T	Formed	Formed	±150	13.3	Bidirectional	–40 to 125	
ACS758KCB-150B-PSS-T	Straight	Straight	±150	13.3	Bidirectional		
ACS758KCB-150U-PFF-T	Formed	Formed	150	26.7	Unidirectional		
ACS758ECB-200B-PFF-T	Formed	Formed	±200	10	Bidirectional	–40 to 85	
ACS758ECB-200B-PSF-T	Straight	Formed	±200	10	Bidirectional		
ACS758ECB-200B-PSS-T	Straight	Straight	±200	10	Bidirectional		
ACS758ECB-200U-PFF-T	Formed	Formed	200	20	Unidirectional		

[1]Additional leadform options available for qualified volumes.
[2]Contact Allegro for additional packing options.

SPECIFICATIONS

Absolute Maximum Ratings

Characteristic	Symbol	Notes	Rating	Units
Forward Supply Voltage	V_{CC}		8	V
Reverse Supply Voltage	V_{RCC}		–0.5	V
Forward Output Voltage	V_{IOUT}		28	V
Reverse Output Voltage	V_{RIOUT}		–0.5	V
Output Source Current	$I_{OUT(Source)}$	VIOUT to GND	3	mA
Output Sink Current	$I_{OUT(Sink)}$	VCC to VIOUT	1	mA
Nominal Operating Ambient Temperature	T_{OP}	Range E	–40 to 85	ºC
		Range K	–40 to 125	ºC
		Range L	–40 to 150	ºC
Maximum Junction	T_J(max)		165	ºC
Storage Temperature	T_{stg}		–65 to 165	ºC

Isolation Characteristics

Characteristic	Symbol	Notes	Rating	Unit
Dielectric Strength Test Voltage*	V_{ISO}	Agency type-tested for 60 seconds per UL standard 60950-1, 2nd Edition	4800	VAC
Working Voltage for Basic Isolation	V_{WFSI}	For basic (single) isolation per UL standard 60950-1, 2nd Edition	990	VDC or V_{pk}
			700	V_{rms}
Working Voltage for Reinforced Isolation	V_{WFRI}	For reinforced (double) isolation per UL standard 60950-1, 2nd Edition	636	VDC or V_{pk}
			450	V_{rms}

* Allegro does not conduct 60-second testing. It is done only during the UL certification process.

Thermal Characteristics may require derating at maximum conditions

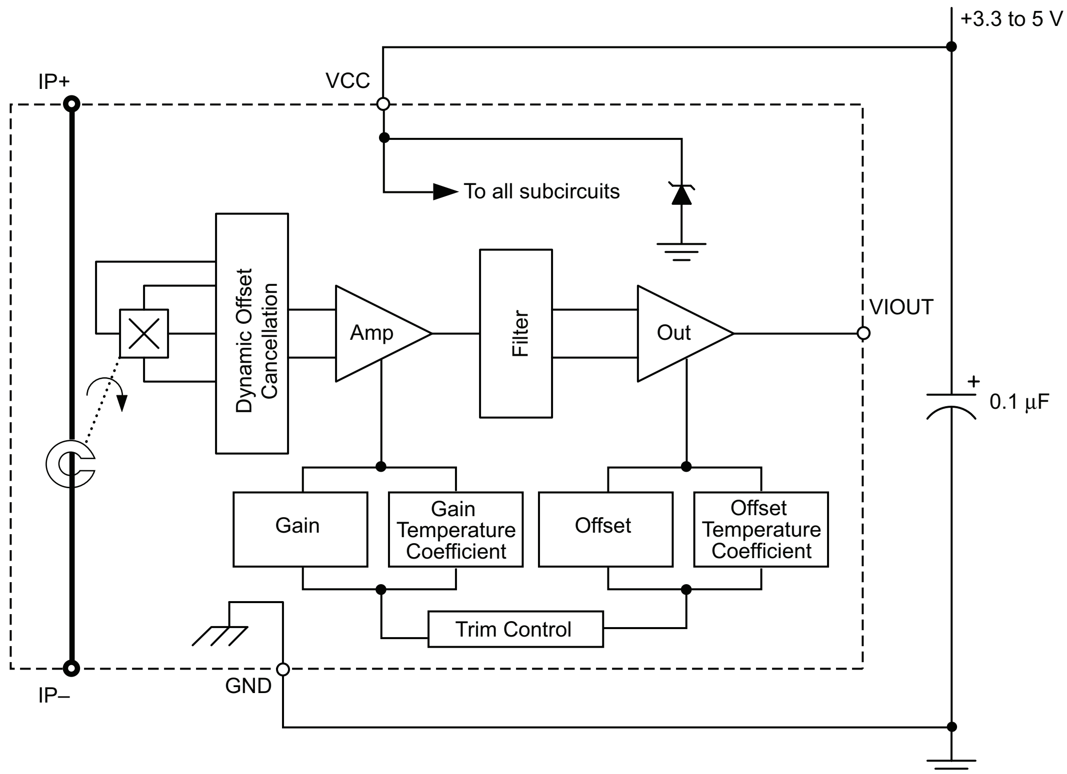
Characteristic	Symbol	Test Conditions*	Value	Unit
Package Thermal Resistance	$R_{\theta JA}$	Mounted on the Allegro evaluation board with 2800 mm^2 (1400 mm^2 on component side and 1400 mm^2 on opposite side) of 4 oz. copper connected to the primary leadframe and with thermal vias connecting the copper layers. Performance is based on current flowing through the primary leadframe and includes the power consumed by the PCB.	7	ºC/W

*Additional thermal information available on the Allegro website

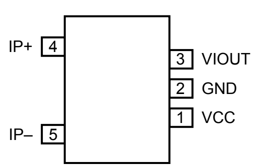
Typical Overcurrent Capabilities[1,2]

Characteristic	Symbol	Notes	Rating	Units
Overcurrent	I_{POC}	T_A = 25°C, 1s duration, 1% duty cycle	1200	A
		T_A = 85°C, 1s duration, 1% duty cycle	900	A
		T_A = 150°C, 1s duration, 1% duty cycle	600	A

[1]Test was done with Allegro evaluation board. The maximum allowed current is limited by T_J(max) only.
[2]For more overcurrent profiles, please see FAQ on the Allegro website, www.allegromicro.com.



Functional Block Diagram



Pin-out Diagram

Terminal List Table

Number	Name	Description
1	VCC	Device power supply terminal
2	GND	Signal ground terminal
3	VIOUT	Analog output signal
4	IP+	Terminal for current being sampled
5	IP–	Terminal for current being sampled

COMMON OPERATING CHARACTERISTICS[1] valid at T_{OP} = –40°C to 150°C and V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Supply Voltage[2]	V_{CC}		3	5.0	5.5	V
Supply Current	I_{CC}	Output open	–	10	13.5	mA
Power-On Delay	t_{POD}	T_A = 25°C	–	10	–	μs
Rise Time[3]	t_r	I_P step = 60% of I_P+, 10% to 90% rise time, T_A = 25°C, C_{OUT} = 0.47 nF	–	3	–	μs
Propagation Delay Time[3]	t_{PROP}	T_A = 25°C, C_{OUT} = 0.47 nF	–	1	–	μs
Response Time	$t_{RESPONSE}$	Measured as sum of t_{PROP} and t_r	–	4	–	μs
Internal Bandwidth[4]	BW_i	–3 dB; T_A = 25°C, C_{OUT} = 0.47 nF	–	120	–	kHz
Output Load Resistance	$R_{LOAD(MIN)}$	VIOUT to GND	4.7	–	–	kΩ
Output Load Capacitance	$C_{LOAD(MAX)}$	VIOUT to GND	–	–	10	nF
Primary Conductor Resistance	$R_{PRIMARY}$	T_A = 25°C	–	100	–	μΩ
Symmetry[3]	E_{SYM}	Over half-scale of Ip	99	100	101	%
Quiescent Output Voltage[5]	$V_{IOUT(QBI)}$	Bidirectional variant, I_P = 0 A, T_A = 25°C	–	$V_{CC}/2$	–	V
	$V_{IOUT(QUNI)}$	Unidirectional variant, I_P = 0 A, T_A = 25°C, $V_{IOUT(QUNI)}$ is ratiometric to V_{CC}	–	0.6	–	V
Ratiometry[3]	V_{RAT}	V_{CC} = 4.5 to 5.5 V	–	100	–	%

[1]Device is factory-trimmed at 5 V, for optimal accuracy.
[2]Devices are programmed for maximum accuracy at 5.0 V V_{CC} levels. The device contains ratiometry circuits that accurately alter the 0 A Output Voltage and Sensitivity level of the device in proportion to the applied V_{CC} level. However, as a result of minor nonlinearities in the ratiometry circuit additional output error will result when V_{CC} varies from the 5 V V_{CC} level. Customers that plan to operate the device from a 3.3 V regulated supply should contact their local Allegro sales representative regarding expected device accuracy levels under these bias conditions.
[3]See Characteristic Definitions section of this datasheet.
[4]Calculated using the formula $BW_i = 0.35 / t_r$.
[5]$V_{IOUT(Q)}$ may drift over the lifetime of the device by as much as ±25 mV.

*X*050B PERFORMANCE CHARACTERISTICS[1]: T_{OP} = –40°C to 150°C, V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Primary Sampled Current	I_P		–50	–	50	A
Sensitivity	$Sens_{TA}$	Full scale of I_P applied for 5 ms, T_A = 25°C	–	40	–	mV/A
	$Sens_{(TOP)HT}$	Full scale of I_P applied for 5 ms, T_{OP} = 25°C to 150°C	–	39.4	–	mV/A
	$Sens_{(TOP)LT}$	Full scale of I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	41	–	mV/A
Noise[2]	V_{NOISE}	T_A = 25°C, 10 nF on VIOUT pin to GND	–	10	–	mV
Nonlinearity	E_{LIN}	Up to full scale of I_P, I_P applied for 5 ms	–1	–	1	%
Electrical Offset Voltage[3]	$V_{OE(TA)}$	I_P = 0 A, T_A = 25°C	–	±5	–	mV
	$V_{OE(TOP)HT}$	I_P = 0 A, T_{OP} = 25°C to 150°C	–	±15	–	mV
	$V_{OE(TOP)LT}$	I_P = 0 A, T_{OP} = –40°C to 25°C	–	±35	–	mV
Magnetic Offset Error	I_{ERROM}	I_P = 0 A, T_A = 25°C, after excursion of 50 A	–	100	–	mA
Total Output Error[4]	$E_{TOT(HT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = 25°C to 150°C	–	–1.2	–	%
	$E_{TOT(LT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	2	–	%

[1]See Characteristic Performance Data page for parameter distributions over temperature range.
[2]±3 sigma noise voltage.
[3]$V_{OE(TOP)}$ drift is referred to ideal $V_{IOUT(Q)}$ = 2.5 V.
[4]Percentage of I_P. Output filtered.

*X*050U PERFORMANCE CHARACTERISTICS[1]: T_{OP} = –40°C to 150°C, V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Primary Sampled Current	I_P		0	–	50	A
Sensitivity	$Sens_{TA}$	Full scale of I_P applied for 5 ms, T_A = 25°C	–	60	–	mV/A
	$Sens_{(TOP)HT}$	Full scale of I_P applied for 5 ms, T_{OP} = 25°C to 150°C	–	59	–	mV/A
	$Sens_{(TOP)LT}$	Full scale of I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	61	–	mV/A
Noise[2]	V_{NOISE}	T_A = 25°C, 10 nF on VIOUT pin to GND	–	15	–	mV
Nonlinearity	E_{LIN}	Up to full scale of I_P, I_P applied for 5 ms	–1	–	1	%
Electrical Offset Voltage[3]	$V_{OE(TA)}$	I_P = 0 A, T_A = 25°C	–	±5	–	mV
	$V_{OE(TOP)HT}$	I_P = 0 A, T_{OP} = 25°C to 150°C	–	±20	–	mV
	$V_{OE(TOP)LT}$	I_P = 0 A, T_{OP} = –40°C to 25°C	–	±40	–	mV
Magnetic Offset Error	I_{ERROM}	I_P = 0 A, T_A = 25°C, after excursion of 50 A	–	100	–	mA
Total Output Error[4]	$E_{TOT(HT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = 25°C to 150°C	–	–1.2	–	%
	$E_{TOT(LT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	2	–	%

[1]See Characteristic Performance Data page for parameter distributions over temperature range.
[2]±3 sigma noise voltage.
[3]$V_{OE(TOP)}$ drift is referred to ideal $V_{IOUT(Q)}$ = 0.6 V.
[4]Percentage of I_P. Output filtered.

*X*100B PERFORMANCE CHARACTERISTICS[1]: T_{OP} = –40°C to 150°C, V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Primary Sampled Current	I_P		–100	–	100	A
Sensitivity	$Sens_{TA}$	Full scale of I_P applied for 5 ms, T_A = 25°C	–	20	–	mV/A
	$Sens_{(TOP)HT}$	Full scale of I_P applied for 5 ms, T_{OP} = 25°C to 150°C	–	19.75	–	mV/A
	$Sens_{(TOP)LT}$	Full scale of I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	20.5	–	mV/A
Noise[2]	V_{NOISE}	T_A= 25°C, 10 nF on VIOUT pin to GND	–	6	–	mV
Nonlinearity	E_{LIN}	Up to full scale of I_P, I_P applied for 5 ms	–1.25	–	1.25	%
Electrical Offset Voltage[3]	$V_{OE(TA)}$	I_P = 0 A, T_A = 25°C	–	±5	–	mV
	$V_{OE(TOP)HT}$	I_P = 0 A, T_{OP} = 25°C to 150°C	–	±20	–	mV
	$V_{OE(TOP)LT}$	I_P = 0 A, T_{OP} = –40°C to 25°C	–	±20	–	mV
Magnetic Offset Error	I_{ERROM}	I_P = 0 A, T_A = 25°C, after excursion of 100 A	–	150	–	mA
Total Output Error[4]	$E_{TOT(HT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = 25°C to 150°C	–	–1.3	–	%
	$E_{TOT(LT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	2.4	–	%

[1]See Characteristic Performance Data page for parameter distributions over temperature range.
[2]±3 sigma noise voltage.
[3]$V_{OE(TOP)}$ drift is referred to ideal $V_{IOUT(Q)}$ = 2.5 V.
[4]Percentage of I_P. Output filtered.

*X*100U PERFORMANCE CHARACTERISTICS[1]: T_{OP} = –40°C to 150°C, V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Primary Sampled Current	I_P		0	–	100	A
Sensitivity	$Sens_{TA}$	Full scale of I_P applied for 5 ms, T_A = 25°C	–	40	–	mV/A
	$Sens_{(TOP)HT}$	Full scale of I_P applied for 5 ms, T_{OP} = 25°C to 150°C	–	39.5	–	mV/A
	$Sens_{(TOP)LT}$	Full scale of I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	41	–	mV/A
Noise[2]	V_{NOISE}	T_A= 25°C, 10 nF on VIOUT pin to GND	–	12	–	mV
Nonlinearity	E_{LIN}	Up to full scale of I_P, I_P applied for 5 ms	–1.25	–	1.25	%
Electrical Offset Voltage[3]	$V_{OE(TA)}$	I_P = 0 A, T_A = 25°C	–	±5	–	mV
	$V_{OE(TOP)HT}$	I_P = 0 A, T_{OP} = 25°C to 150°C	–	±20	–	mV
	$V_{OE(TOP)LT}$	I_P = 0 A, T_{OP} = –40°C to 25°C	–	±20	–	mV
Magnetic Offset Error	I_{ERROM}	I_P = 0 A, T_A = 25°C, after excursion of 100 A	–	150	–	mA
Total Output Error[4]	$E_{TOT(HT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = 25°C to 150°C	–	–1.3	–	%
	$E_{TOT(LT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	2.4	–	%

[1]See Characteristic Performance Data page for parameter distributions over temperature range.
[2]±3 sigma noise voltage.
[3]$V_{OE(TOP)}$ drift is referred to ideal $V_{IOUT(Q)}$ = 0.6 V.
[4]Percentage of I_P. Output filtered.

X150B PERFORMANCE CHARACTERISTICS[1]: T_{OP} = –40°C to 125°C, V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Primary Sampled Current	I_P		–150	–	150	A
Sensitivity	$Sens_{TA}$	Full scale of I_P applied for 5 ms, T_A = 25°C	–	13.3	–	mV/A
	$Sens_{(TOP)HT}$	Full scale of I_P applied for 5 ms, T_{OP} = 25°C to 125°C	–	13.1	–	mV/A
	$Sens_{(TOP)LT}$	Full scale of I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	13.5	–	mV/A
Noise[2]	V_{NOISE}	T_A= 25°C, 10 nF on VIOUT pin to GND	–	4	–	mV
Nonlinearity	E_{LIN}	Up to full scale of I_P, I_P applied for 5 ms	– 1	–	1	%
Electrical Offset Voltage[3]	$V_{OE(TA)}$	I_P = 0 A, T_A = 25°C	–	±5	–	mV
	$V_{OE(TOP)HT}$	I_P = 0 A, T_{OP} = 25°C to 125°C	–	±14	–	mV
	$V_{OE(TOP)LT}$	I_P = 0 A, T_{OP} = –40°C to 25°C	–	±24	–	mV
Magnetic Offset Error	I_{ERROM}	I_P = 0 A, T_A = 25°C, after excursion of 150 A	–	205	–	mA
Total Output Error[4]	$E_{TOT(HT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = 25°C to 125°C	–	–1.8	–	%
	$E_{TOT(LT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	1.6	–	%

[1]See Characteristic Performance Data page for parameter distributions over temperature range.
[2]±3 sigma noise voltage.
[3]$V_{OE(TOP)}$ drift is referred to ideal $V_{IOUT(Q)}$ = 2.5 V.
[4]Percentage of I_P. Output filtered.

X150U PERFORMANCE CHARACTERISTICS[1]: T_{OP} = –40°C to 125°C, V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Primary Sampled Current	I_P		0	–	150	A
Sensitivity	$Sens_{TA}$	Full scale of I_P applied for 5 ms, T_A = 25°C	–	26.6	–	mV/A
	$Sens_{(TOP)HT}$	Full scale of I_P applied for 5 ms, T_{OP} = 25°C to 125°C	–	26.6	–	mV/A
	$Sens_{(TOP)LT}$	Full scale of I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	27.4	–	mV/A
Noise[2]	V_{NOISE}	T_A= 25°C, 10 nF on VIOUT pin to GND	–	8	–	mV
Nonlinearity	E_{LIN}	Up to full scale of I_P, I_P applied for 5 ms	– 1	–	1	%
Electrical Offset Voltage[3]	$V_{OE(TA)}$	I_P = 0 A, T_A = 25°C	–	±5	–	mV
	$V_{OE(TOP)HT}$	I_P = 0 A, T_{OP} = 25°C to 125°C	–	±14	–	mV
	$V_{OE(TOP)LT}$	I_P = 0 A, T_{OP} = –40°C to 25°C	–	±24	–	mV
Magnetic Offset Error	I_{ERROM}	I_P = 0 A, T_A = 25°C, after excursion of 150 A	–	205	–	mA
Total Output Error[4]	$E_{TOT(HT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = 25°C to 125°C	–	–1.8	–	%
	$E_{TOT(LT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	1.6	–	%

[1]See Characteristic Performance Data page for parameter distributions over temperature range.
[2]±3 sigma noise voltage.
[3]$V_{OE(TOP)}$ drift is referred to ideal $V_{IOUT(Q)}$ = 0.6 V.
[4]Percentage of I_P. Output filtered.

*X*200B PERFORMANCE CHARACTERISTICS[1]: T_{OP} = –40°C to 85°C, V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Primary Sampled Current	I_P		–200	–	200	A
Sensitivity	$Sens_{TA}$	Full scale of I_P applied for 5 ms, T_A = 25°C	–	10	–	mV/A
	$Sens_{(TOP)HT}$	Full scale of I_P applied for 5 ms, T_{OP} = 25°C to 85°C	–	9.88	–	mV/A
	$Sens_{(TOP)LT}$	Full scale of I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	10.13	–	mV/A
Noise[2]	V_{NOISE}	T_A= 25°C, 10 nF on VIOUT pin to GND	–	3	–	mV
Nonlinearity	E_{LIN}	Up to full scale of I_P, I_P applied for 5 ms	– 1	–	1	%
Electrical Offset Voltage[3]	$V_{OE(TA)}$	I_P = 0 A, T_A = 25°C	–	±5	–	mV
	$V_{OE(TOP)HT}$	I_P = 0 A, T_{OP} = 25°C to 85°C	–	±15	–	mV
	$V_{OE(TOP)LT}$	I_P = 0 A, T_{OP} = –40°C to 25°C	–	±25	–	mV
Magnetic Offset Error	I_{ERROM}	I_P = 0 A, T_A = 25°C, after excursion of 200 A	–	230	–	mA
Total Output Error[4]	$E_{TOT(HT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = 25°C to 85°C	–	–1.2	–	%
	$E_{TOT(LT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	1.2	–	%

[1]See Characteristic Performance Data page for parameter distributions over temperature range.
[2]±3 sigma noise voltage.
[3]$V_{OE(TOP)}$ drift is referred to ideal $V_{IOUT(Q)}$ = 2.5 V.
[4]Percentage of I_P. Output filtered.

*X*200U PERFORMANCE CHARACTERISTICS[1]: T_{OP} = –40°C to 85°C, V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Primary Sampled Current	I_P		0	–	200	A
Sensitivity	$Sens_{TA}$	Full scale of I_P applied for 5 ms, T_A = 25°C	–	20	–	mV/A
	$Sens_{(TOP)HT}$	Full scale of I_P applied for 5 ms, T_{OP} = 25°C to 85°C	–	19.7	–	mV/A
	$Sens_{(TOP)LT}$	Full scale of I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	20.3	–	mV/A
Noise[2]	V_{NOISE}	T_A= 25°C, 10 nF on VIOUT pin to GND	–	6	–	mV
Nonlinearity	E_{LIN}	Up to full scale of I_P, I_P applied for 5 ms	– 1	–	1	%
Electrical Offset Voltage[3]	$V_{OE(TA)}$	I_P = 0 A, T_A = 25°C	–	±5	–	mV
	$V_{OE(TOP)HT}$	I_P = 0 A, T_{OP} = 25°C to 85°C	–	±20	–	mV
	$V_{OE(TOP)LT}$	I_P = 0 A, T_{OP} = –40°C to 25°C	–	±35	–	mV
Magnetic Offset Error	I_{ERROM}	I_P = 0 A, T_A = 25°C, after excursion of 200 A	–	230	–	mA
Total Output Error[4]	$E_{TOT(HT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = 25°C to 85°C	–	–1.2	–	%
	$E_{TOT(LT)}$	Over full scale of I_P, I_P applied for 5 ms, T_{OP} = –40°C to 25°C	–	1.2	–	%

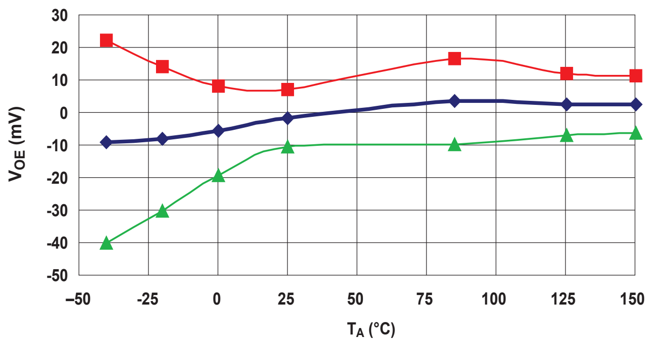
[1]See Characteristic Performance Data page for parameter distributions over temperature range.
[2]±3 sigma noise voltage.
[3]$V_{OE(TOP)}$ drift is referred to ideal $V_{IOUT(Q)}$ = 0.6 V.
[4]Percentage of I_P. Output filtered.

CHARACTERISTIC PERFORMANCE DATA

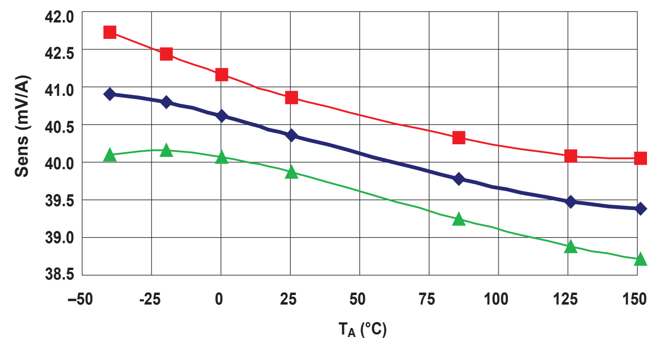
Data taken using the ACS758LCB-50B

Accuracy Data

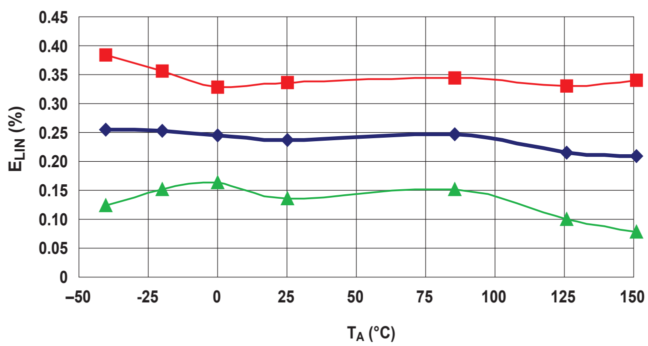
Electrical Offset Voltage versus Ambient Temperature



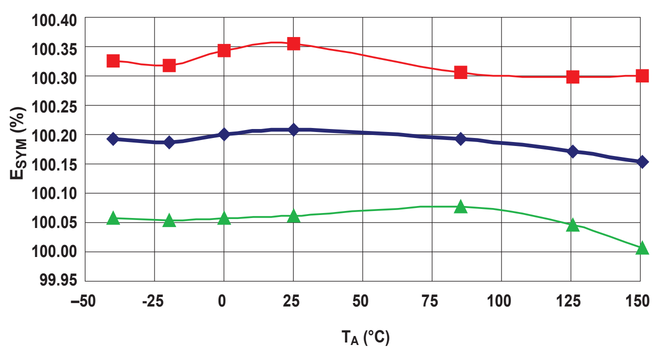
Sensitivity versus Ambient Temperature



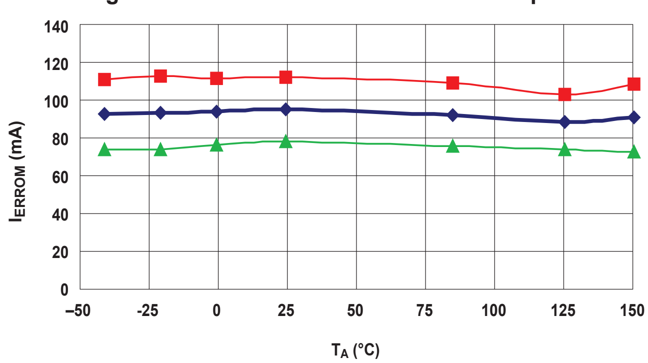
Nonlinearity versus Ambient Temperature



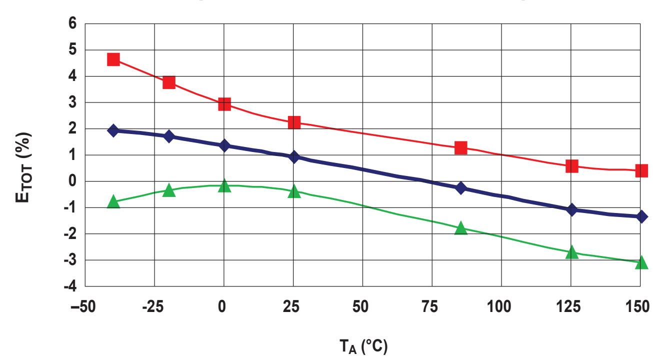
Symmetry versus Ambient Temperature



Magnetic Offset Error versus Ambient Temperature



Total Output Error versus Ambient Temperature



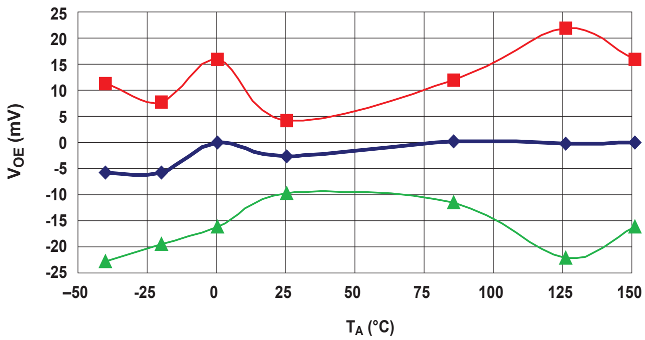
Typical Maximum Limit — Mean — Typical Minimum Limit

CHARACTERISTIC PERFORMANCE DATA

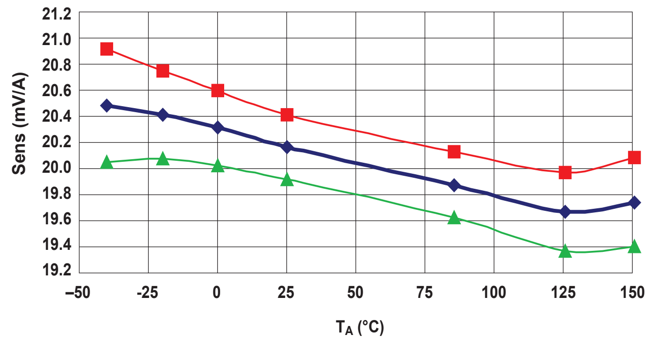
Data taken using the ACS758LCB-100B

Accuracy Data

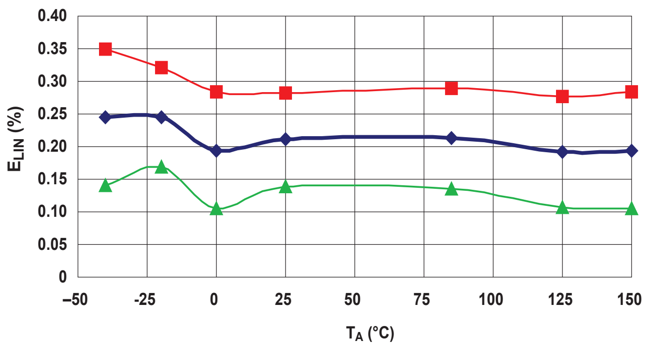
Electrical Offset Voltage versus Ambient Temperature



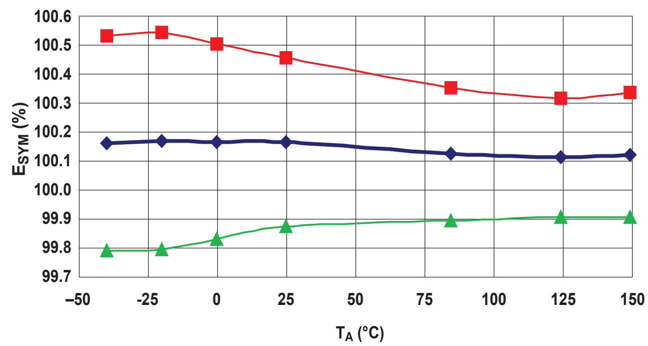
Sensitivity versus Ambient Temperature



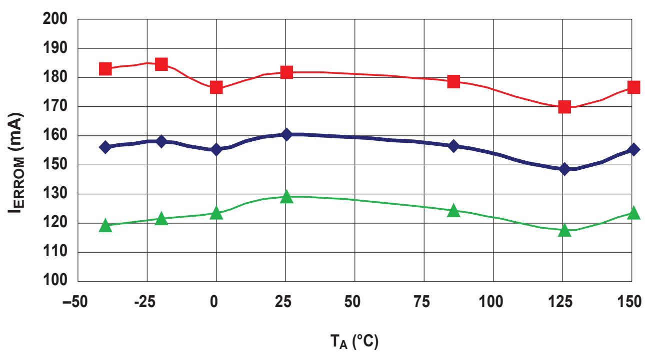
Nonlinearity versus Ambient Temperature



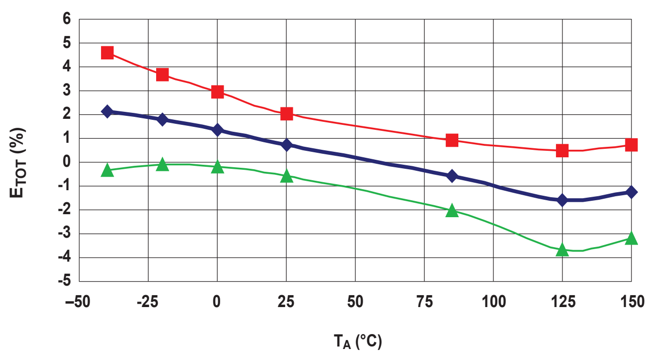
Symmetry versus Ambient Temperature



Magnetic Offset Error versus Ambient Temperature



Total Output Error versus Ambient Temperature



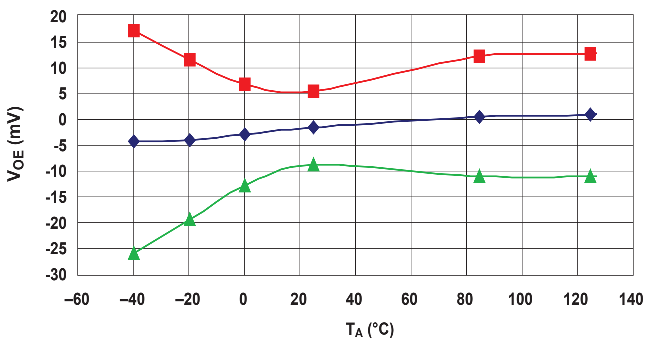
Typical Maximum Limit — Mean — Typical Minimum Limit

CHARACTERISTIC PERFORMANCE DATA

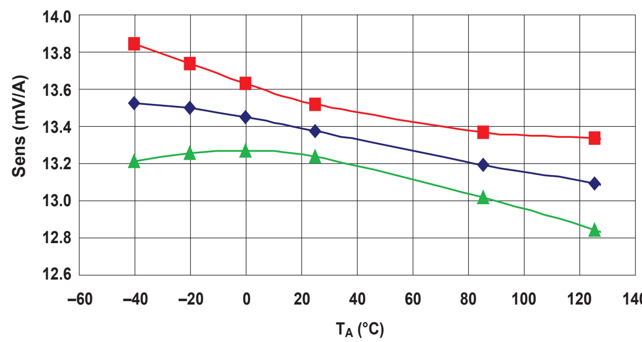
Data taken using the ACS758KCB-150B

Accuracy Data

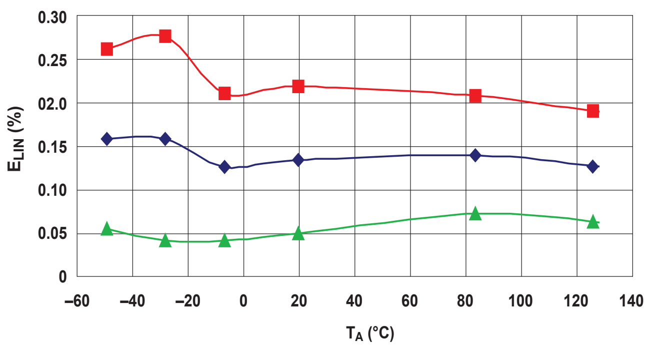
Electrical Offset Voltage versus Ambient Temperature



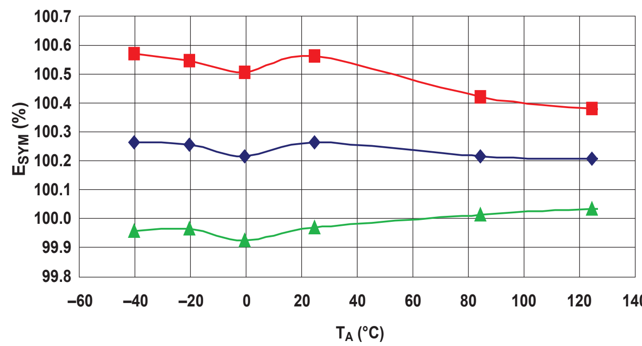
Sensitivity versus Ambient Temperature



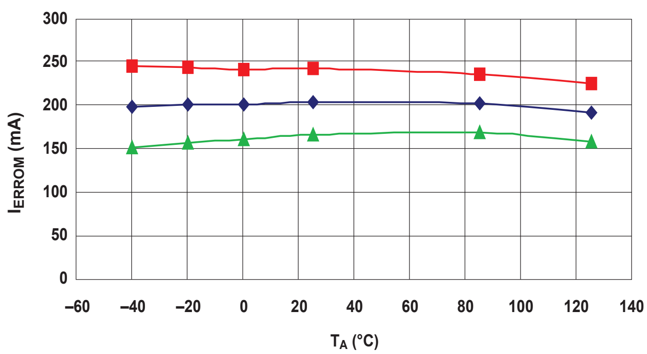
Nonlinearity versus Ambient Temperature



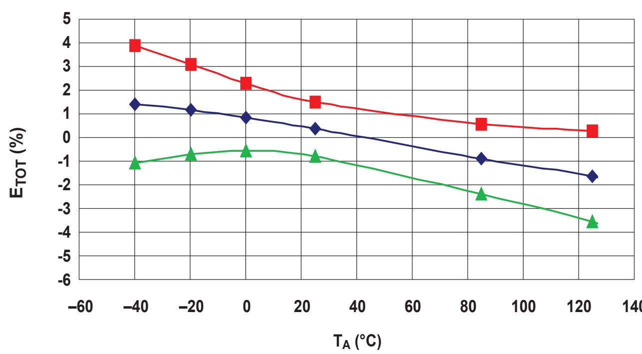
Symmetry versus Ambient Temperature



Magnetic Offset Error versus Ambient Temperature



Total Output Error versus Ambient Temperature



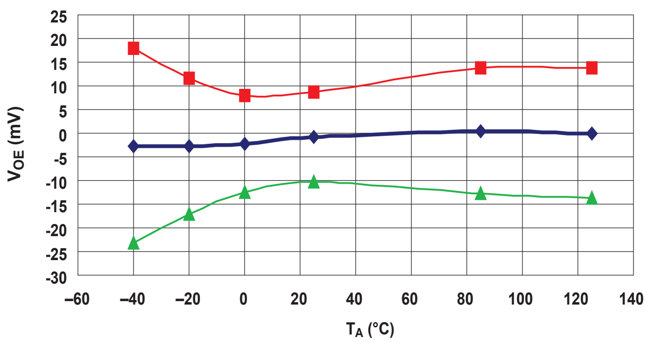
Typical Maximum Limit — Mean — Typical Minimum Limit

CHARACTERISTIC PERFORMANCE DATA

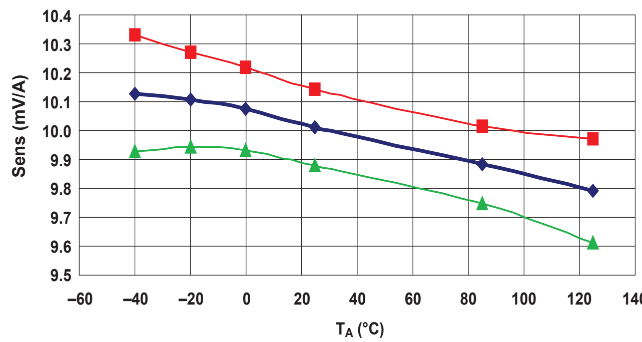
Data taken using the ACS758ECB-200B

Accuracy Data

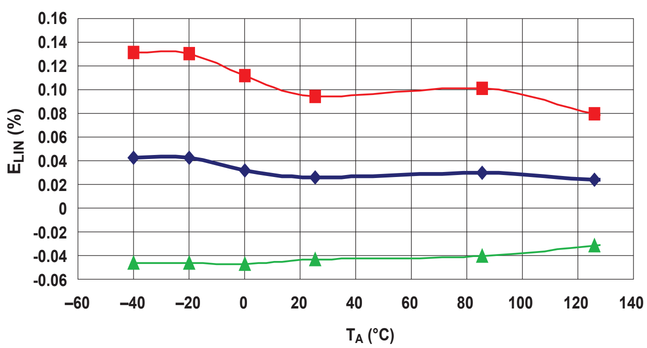
Electrical Offset Voltage versus Ambient Temperature



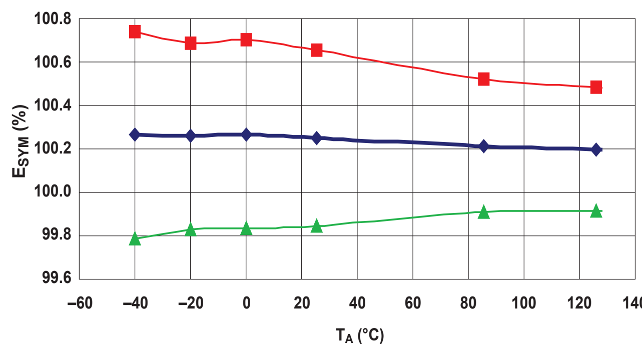
Sensitivity versus Ambient Temperature



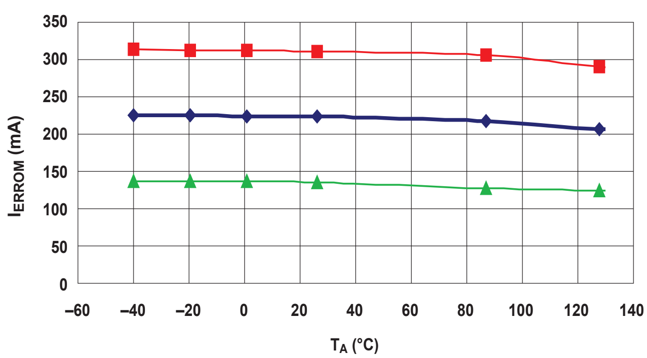
Nonlinearity versus Ambient Temperature



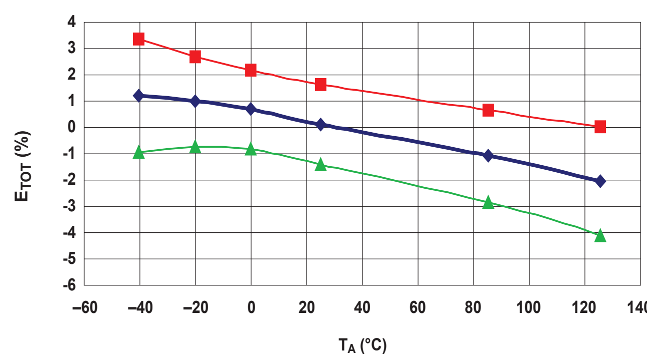
Symmetry versus Ambient Temperature



Magnetic Offset Error versus Ambient Temperature



Total Output Error versus Ambient Temperature



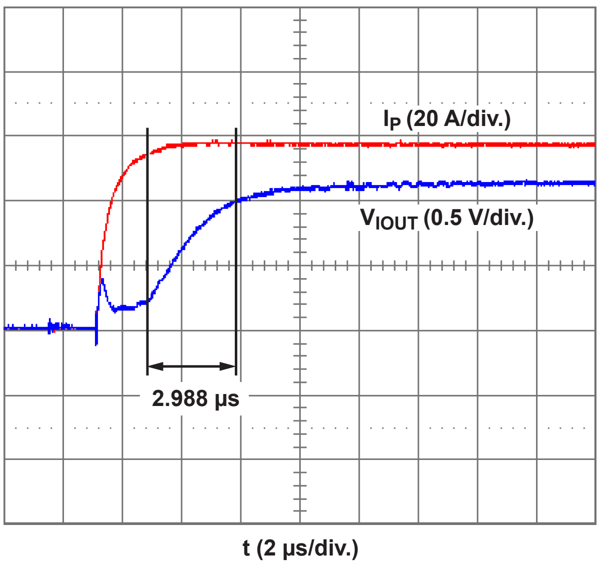
Typical Maximum Limit — Mean — Typical Minimum Limit

CHARACTERISTIC PERFORMANCE DATA

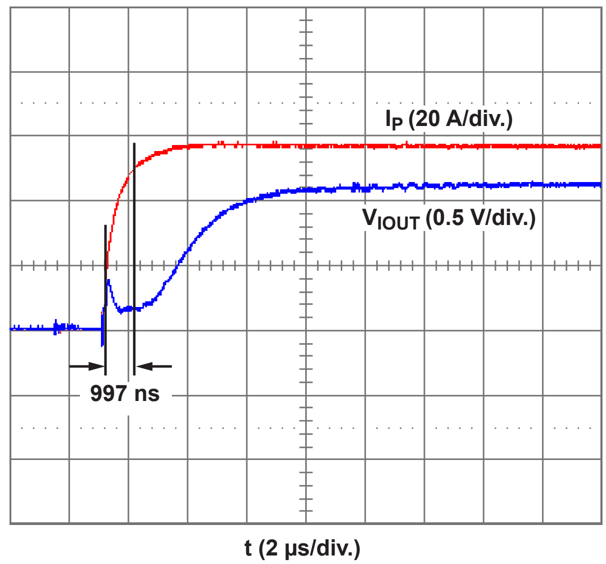
Data taken using the ACS758LCB-100B

Timing Data

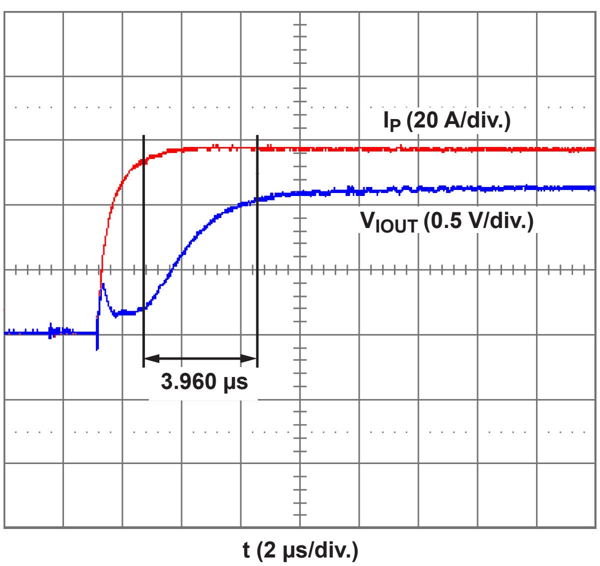
Rise Time



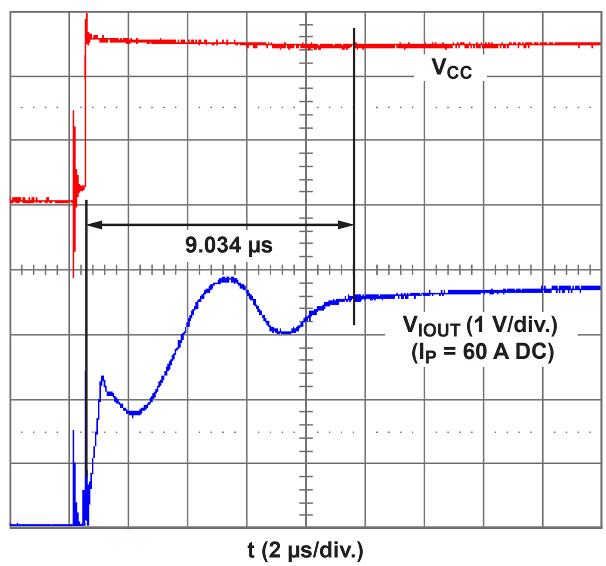
Propagation Delay Time



Response Time



Power-on Delay



CHARACTERISTIC DEFINITIONS

Definitions of Accuracy Characteristics

Sensitivity (Sens). The change in device output in response to a 1 A change through the primary conductor. The sensitivity is the product of the magnetic circuit sensitivity (G / A) and the linear IC amplifier gain (mV/G). The linear IC amplifier gain is programmed at the factory to optimize the sensitivity (mV/A) for the half-scale current of the device.

Noise (V_{NOISE}). The noise floor is derived from the thermal and shot noise observed in Hall elements. Dividing the noise (mV) by the sensitivity (mV/A) provides the smallest current that the device is able to resolve.

Nonlinearity (E_{LIN}). The degree to which the voltage output from the IC varies in direct proportion to the primary current through its half-scale amplitude. Nonlinearity in the output can be attributed to the saturation of the flux concentrator approaching the half-scale current. The following equation is used to derive the linearity:

$$100 \left\{ 1 - \left[\frac{\Delta \text{ gain} \times \% \text{ sat } (V_{\text{IOUT\_half-scale amperes}} - V_{\text{IOUT(Q)}})}{2 \, (V_{\text{IOUT\_quarter-scale amperes}} - V_{\text{IOUT(Q)}})} \right] \right\}$$

where

Δ gain = the gain variation as a function of temperature changes from 25ºC,

% sat = the percentage of saturation of the flux concentrator, which becomes significant as the current being sampled approaches half-scale $\pm I_P$, and

$V_{IOUT\_half\text{-}scale\ amperes}$ = the output voltage (V) when the sampled current approximates half-scale $\pm I_P$.

Symmetry (E_{SYM}). The degree to which the absolute voltage output from the IC varies in proportion to either a positive or negative half-scale primary current. The following equation is used to derive symmetry:

$$100 \left(\frac{V_{\text{IOUT\_+ half-scale amperes}} - V_{\text{IOUT(Q)}}}{V_{\text{IOUT(Q)}} - V_{\text{IOUT\_–half-scale amperes}}} \right)$$

Ratiometry. The device features a ratiometric output. This means that the quiescent voltage output, V_{IOUTQ}, and the magnetic sensitivity, Sens, are proportional to the supply voltage, V_{CC}.

The ratiometric change (%) in the quiescent voltage output is defined as:

$$\Delta V_{\text{IOUTQ}(\Delta V)} = \frac{V_{\text{IOUTQ(VCC)}} \,/\, V_{\text{IOUTQ(5V)}}}{V_{\text{CC}} \,/\, 5\text{ V}} \times 100\%$$

and the ratiometric change (%) in sensitivity is defined as:

$$\Delta \text{Sens}_{(\Delta V)} = \frac{\text{Sens}_{(\text{VCC})} \,/\, \text{Sens}_{(5\text{V})}}{V_{\text{CC}} \,/\, 5\text{ V}} \times 100\%$$

Quiescent output voltage ($V_{IOUT(Q)}$). Quiescent output voltage ($V_{IOUT(Q)}$). The output of the device when the primary current is zero. For bidirectional devices, it nominally remains at $V_{CC} / 2$. Thus, V_{CC} = 5 V translates into $V_{IOUT(QBI)}$ = 2.5 V. For unidirectional devices, it nominally remains at 0.12 × V_{CC}. Thus, V_{CC} = 5 V translates into $V_{IOUT(QUNI)}$ = 0.6 V. Variation in $V_{IOUT(Q)}$ can be attributed to the resolution of the Allegro linear IC quiescent voltage trim, magnetic hysteresis, and thermal drift.

Electrical offset voltage (V_{OE}). The deviation of the device output from its ideal quiescent value of $V_{CC}/2$ for bidirectional and 0.1 × V_{CC} for unidirectional devices, due to nonmagnetic causes.

Magnetic offset error (I_{ERROM}). The magnetic offset is due to the residual magnetism (remnant field) of the core material. The magnetic offset error is highest when the magnetic circuit has been saturated, usually when the device has been subjected to a full-scale or high-current overload condition. The magnetic offset is largely dependent on the material used as a flux concentrator. The larger magnetic offsets are observed at the lower operating temperatures.

Total Output Error (E_{TOT}). The maximum deviation of the actual output from its ideal value, also referred to as *accuracy*, illustrated graphically in the output voltage versus current chart on the following page.

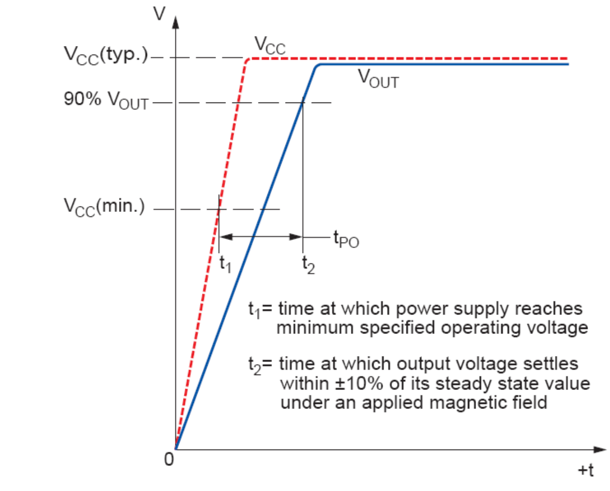
E_{TOT} is divided into four areas:

- **0 A at 25°C.** Accuracy at the zero current flow at 25°C, without the effects of temperature.
- **0 A over Δ temperature.** Accuracy at the zero current flow including temperature effects.
- **Half-scale current at 25°C.** Accuracy at the the half-scale current at 25°C, without the effects of temperature.
- **Half-scale current over Δ temperature.** Accuracy at the half-scale current flow including temperature effects.

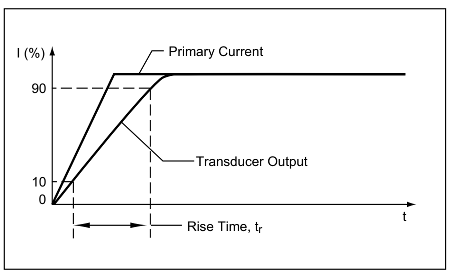
Definitions of Dynamic Response Characteristics

Power-On Time (t_{PO}). When the supply is ramped to its operating voltage, the device requires a finite time to power its internal components before responding to an input magnetic field.

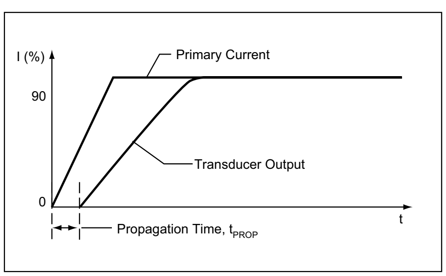
Power-On Time, t_{PO} , is defined as the time it takes for the output voltage to settle within ±10% of its steady state value under an applied magnetic field, after the power supply has reached its minimum specified operating voltage, V_{CC}(min), as shown in the chart at right.



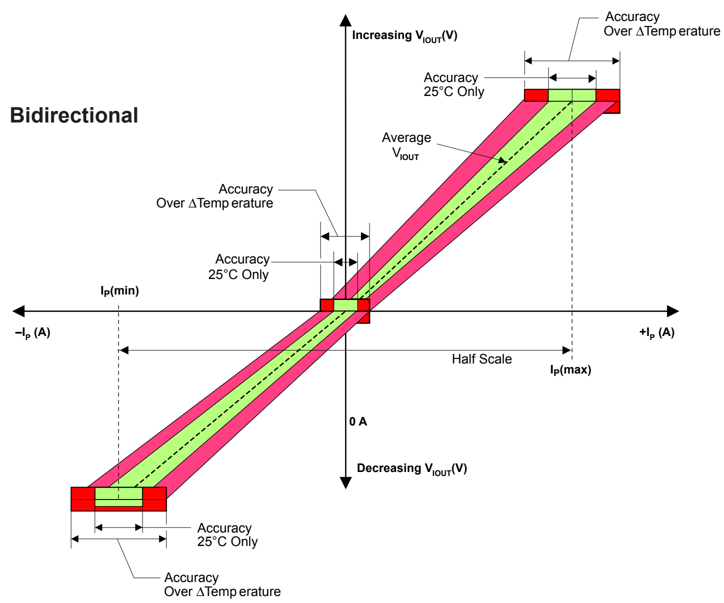
Rise time (t_r). The time interval between a) when the device reaches 10% of its full scale value, and b) when it reaches 90% of its full scale value. The rise time to a step response is used to derive the bandwidth of the device, in which $f(–3\ dB) = 0.35/t_r$. Both t_r and $t_{RESPONSE}$ are detrimentally affected by eddy current losses observed in the conductive IC ground plane.

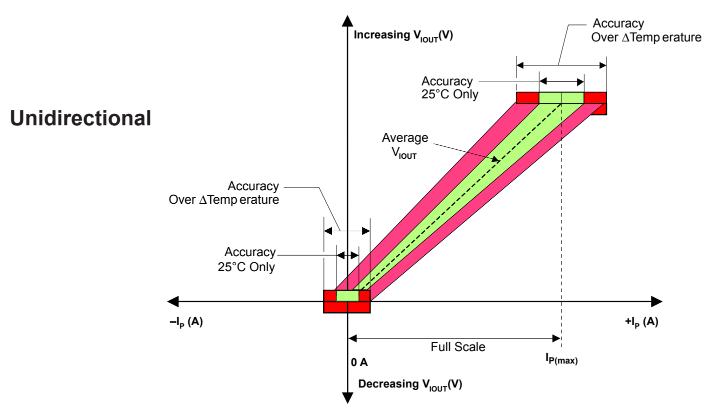


Propagation delay (t_{PROP}). The time required for the device output to reflect a change in the primary current signal. Propagation delay is attributed to inductive loading within the linear IC package, as well as in the inductive loop formed by the primary conductor geometry. Propagation delay can be considered as a fixed time offset and may be compensated.



Output Voltage versus Sampled Current
Total Output Error at 0 A and at Half-Scale Current





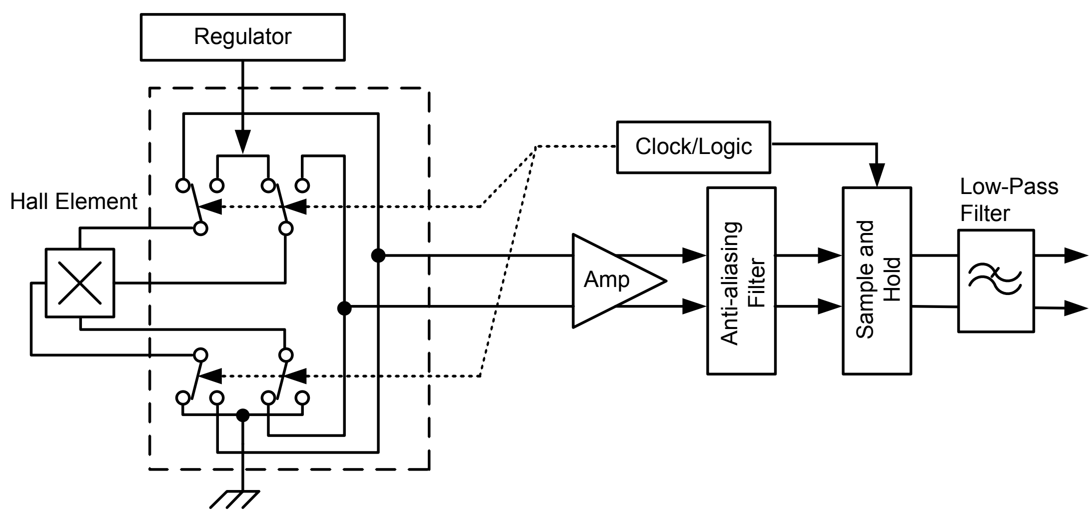
Chopper Stabilization Technique

Chopper Stabilization is an innovative circuit technique that is used to minimize the offset voltage of a Hall element and an associated on-chip amplifier. Allegro patented a Chopper Stabilization technique that nearly eliminates Hall IC output drift induced by temperature or package stress effects.

This offset reduction technique is based on a signal modulation-demodulation process. Modulation is used to separate the undesired DC offset signal from the magnetically induced signal in the frequency domain. Then, using a low-pass filter, the modulated DC offset is suppressed while the magnetically induced signal passes through the filter. The anti-aliasing filter prevents aliasing from happening in applications with high frequency signal components which are beyond the user's frequency range of interest.

As a result of this chopper stabilization approach, the output voltage from the Hall IC is desensitized to the effects of temperature and mechanical stress. This technique produces devices that have an extremely stable Electrical Offset Voltage, are immune to thermal stress, and have precise recoverability after temperature cycling.

This technique is made possible through the use of a BiCMOS process that allows the use of low-offset and low-noise amplifiers in combination with high-density logic integration and sample and hold circuits.

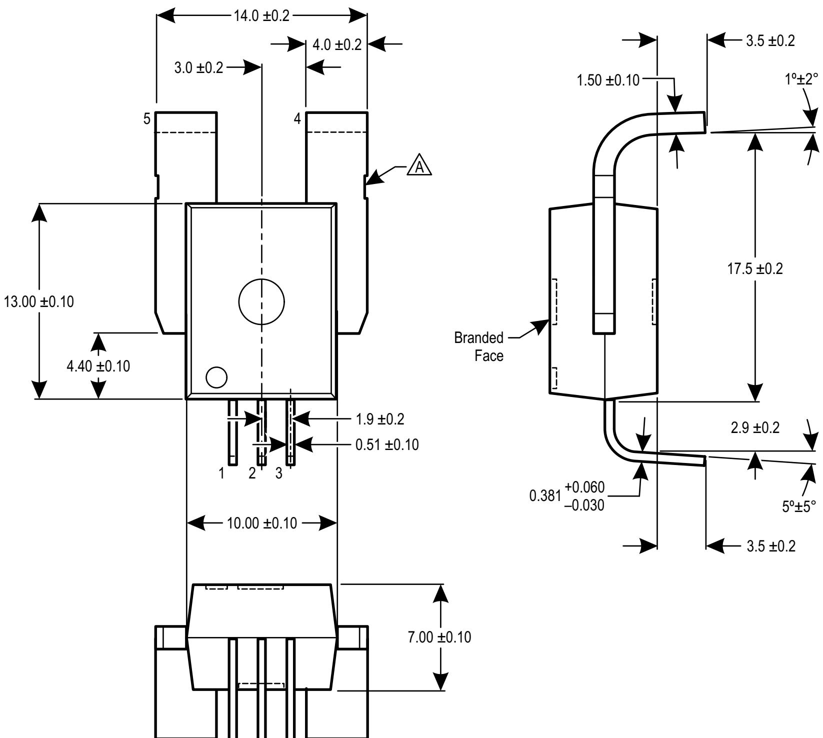


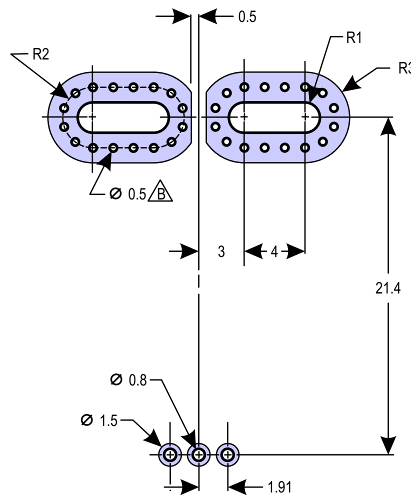
Concept of Chopper Stabilization Technique

PACKAGE OUTLINE DRAWING

For Reference Only – Not for Tooling Use

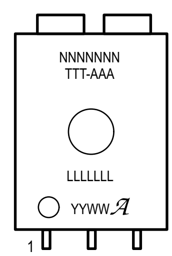
(Reference DWG-9111 & DWG-9110)
Dimensions in millimeters – NOT TO SCALE
Dimensions exclusive of mold flash, gate burs, and dambar protrusions
Exact case and lead configuration at supplier discretion within limits shown





B PCB Layout Reference View

A Dambar removal intrusion
B Perimeter through-holes recommended
C Branding scale and appearance at supplier discretion



C Standard Branding Reference View

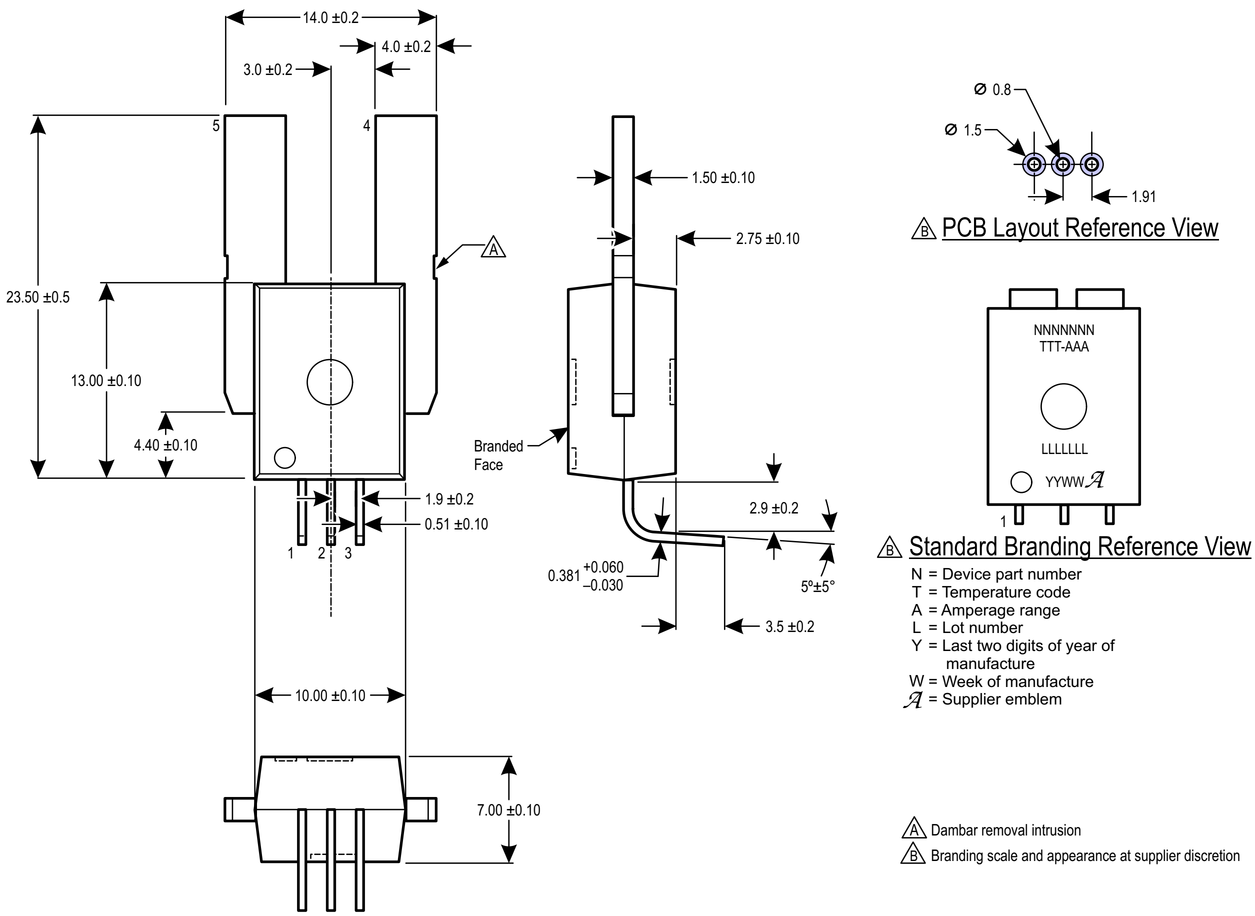
N = Device part number
T = Temperature code
A = Amperage range
L = Lot number
Y = Last two digits of year of manufacture
W = Week of manufacture
𝒜 = Supplier emblem

Creepage distance, current terminals to signal pins: 7.25 mm
Clearance distance, current terminals to signal pins: 7.25 mm
Package mass: 4.63 g typical

Package CB, 5-pin Package, Leadform PFF

For Reference Only – Not for Tooling Use

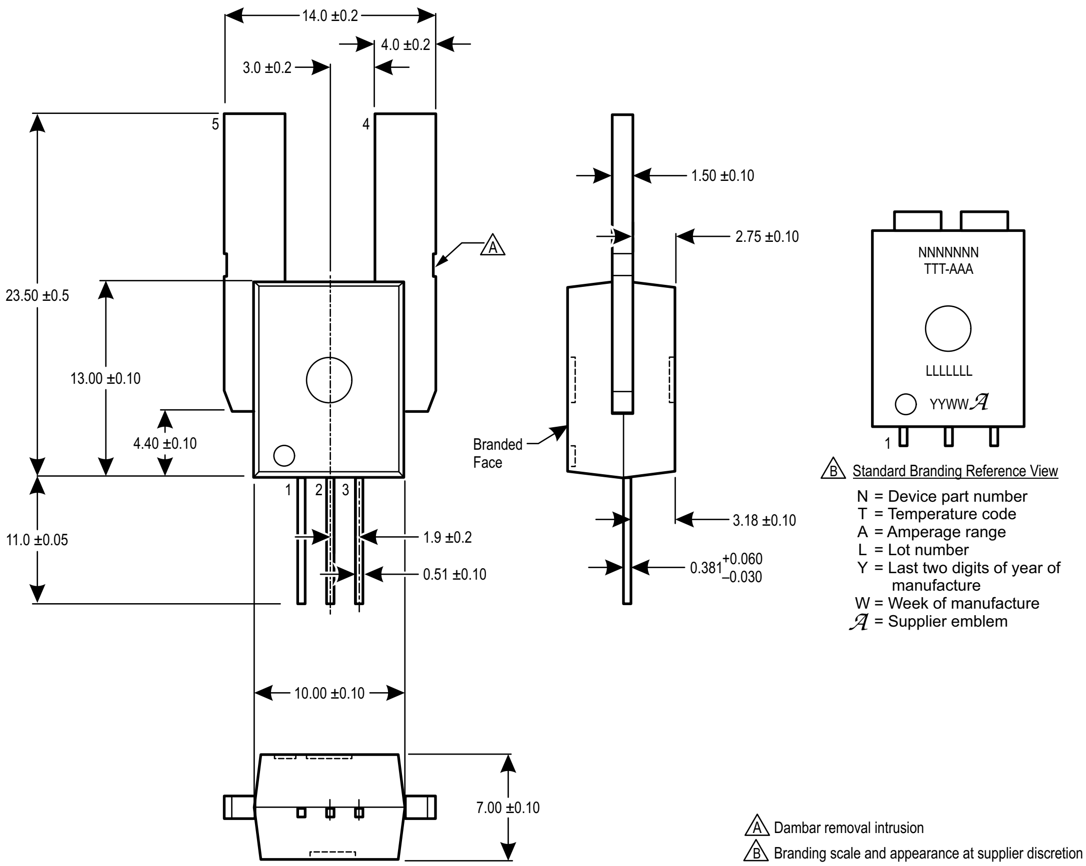
(Reference DWG-9111, DWG-9110)
Dimensions in millimeters – NOT TO SCALE
Dimensions exclusive of mold flash, gate burs, and dambar protrusions
Exact case and lead configuration at supplier discretion within limits shown



Package CB, 5-pin Package, Leadform PSF

For Reference Only – Not for Tooling Use

(Reference DWG-9111, DWG-9110)
Dimensions in millimeters – NOT TO SCALE
Dimensions exclusive of mold flash, gate burs, and dambar protrusions
Exact case and lead configuration at supplier discretion within limits shown



Creepage distance, current terminals to signal pins: 7.25 mm
Clearance distance, current terminals to signal pins: 7.25 mm
Package mass: 4.63 g typical

Package CB, 5-pin Package, Leadform PSS

Revision History

Revision	Revision Date	Description of Revision
8	January 17, 2014	Update features list and product offering
9	April 7, 2015	Updated TUV certification and refomratted document

SIEMENS

Data sheet 3NC2200-0MK

SITOR cylindrical fuse link, 22x58 mm, 100 A, gR, Un AC: 690 V, Un DC: 250 V

Model	
product brand name	SENTRON
product designation	SITOR cylindrical fuse link
General technical data	
operating class of the fuse link	gR
size of the fuse link	22x58 mm
type of voltage / of the operating voltage	AC
supply voltage / at DC	250 V
operating voltage / rated value	690 V
operational current / at AC / rated value	100 A
Main circuit	
operational current / rated value	100 A
Product details	
product component / striker	No
Mechanical Design	
mounting position	Any, preferably vertical
net weight	56 g

General Product Approval

Miscellaneous

EAC

Further information

Information- and Downloadcenter (Catalogs, Brochures,…)
http://www.siemens.com/lowvoltage/catalogs

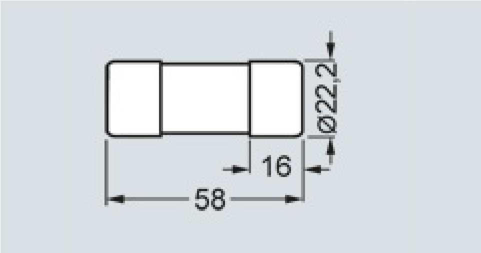
Industry Mall (Online ordering system)
https://mall.industry.siemens.com/mall/en/en/Catalog/product?mlfb=3NC2200-0MK

Service&Support (Manuals, Certificates, Characteristics, FAQs,...)
https://support.industry.siemens.com/cs/ww/en/ps/3NC2200-0MK

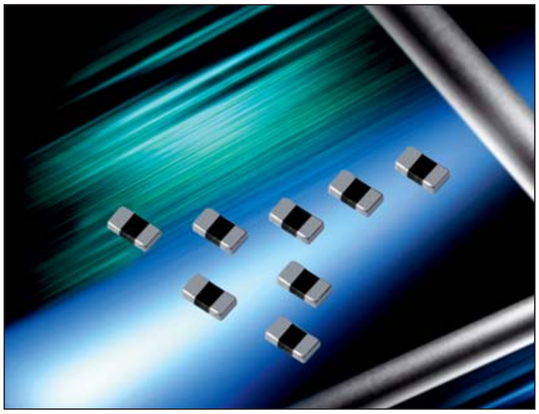
Image database (product images, 2D dimension drawings, 3D models, device circuit diagrams, ...)
http://www.automation.siemens.com/bilddb/cax_en.aspx?mlfb=3NC2200-0MK

CAx-Online-Generator
http://www.siemens.com/cax

Tender specifications
http://www.siemens.com/specifications


Ø22,2
16
58

Controlled Capacitance Multilayer Varistor



GENERAL DESCRIPTION

The Controlled Capacitance TransGuard is an application specific bi-directional transient voltage suppressor developed for use in mixed signal environments. The Controlled Cap MLV has three purposes: 1) reduce emissions from a high speed ASIC, 2) prevent induced E fields from conducting into the IC, and 3) clamp transient voltages

By controlling capacitance of the MLV, the center frequency and 20db range for filtering purposes can be targeted. A Controlled Cap MLV can greatly improve overall system EMC performance and reduce system size.

GENERAL CHARACTERISTICS

- Operating Teperature: -55°C to +125°C
- Working Voltage: 22, 26Vdc
- Case Size: 0603

FEATURES

- Single Chip Solution
- Tageted EMI/RFI Filtering
- 20dB Range for tiltering purposes
- Improves system EMC performance
- Very fast response to ESD
- 25kV ESD

APPLICATIONS

- EMI TVS Module Control
- High Speed ASICS
- Mixed Signal Environment
- Sensors
- and more

RoHS COMPLIANT

HOW TO ORDER

VCAC	0603	22	A	470	N	R	P
Varistor Chip Automotive Capacitance	**Chip Size** 0402 0603	**Working Voltage** 09 = 9V 17 = 17V 22 = 22V 26 = 26V 30 = 30V	**Energy Rating** X = 0.05J A = 0.1J B = 0.2J C = 0.3J	**Capacitance** 330 = 33pF 380 = 38pF 470 = 47pF 820 = 82pF 102 = 1000pF	**Tolerance** N = ±30% M = ±20%	**Packaging** R = 4k pcs D = 7" reel (1,000 pcs) R = 7" reel (4,000 pcs) T = 13" reel (10,000 pcs) W = 7" Reel (10,000 pcs 0402 only)	**Termination** P = Ni Barrier/ 100% Sn (matte)

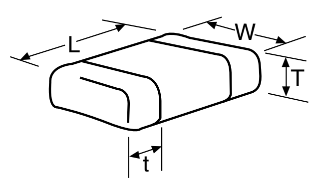
AVX Part Number	V_W (DC)	V_W (AC)	V_B	V_C	I_L	E_T	I_P	Cap	Cap Tolerance	Case Size
VCAC060309B102N	9.0	6.4	12.7±15%	22	25	0.2	120	1000	±30%	0603
VCAC060317X330M	17	12	27±20%	52	10	0.05	2	33	±20%	0603
VCAC060322A470N	22	17	32.5±25%	50	10	0.1	30	47	30%	0603
VCAC060326C820M	26	20	36.0±15%	67	10	0.3	30	82	20%	0603
VCAC040230X380N	30	21	41±10%	67	5	0.05	10	38	±30%	0402

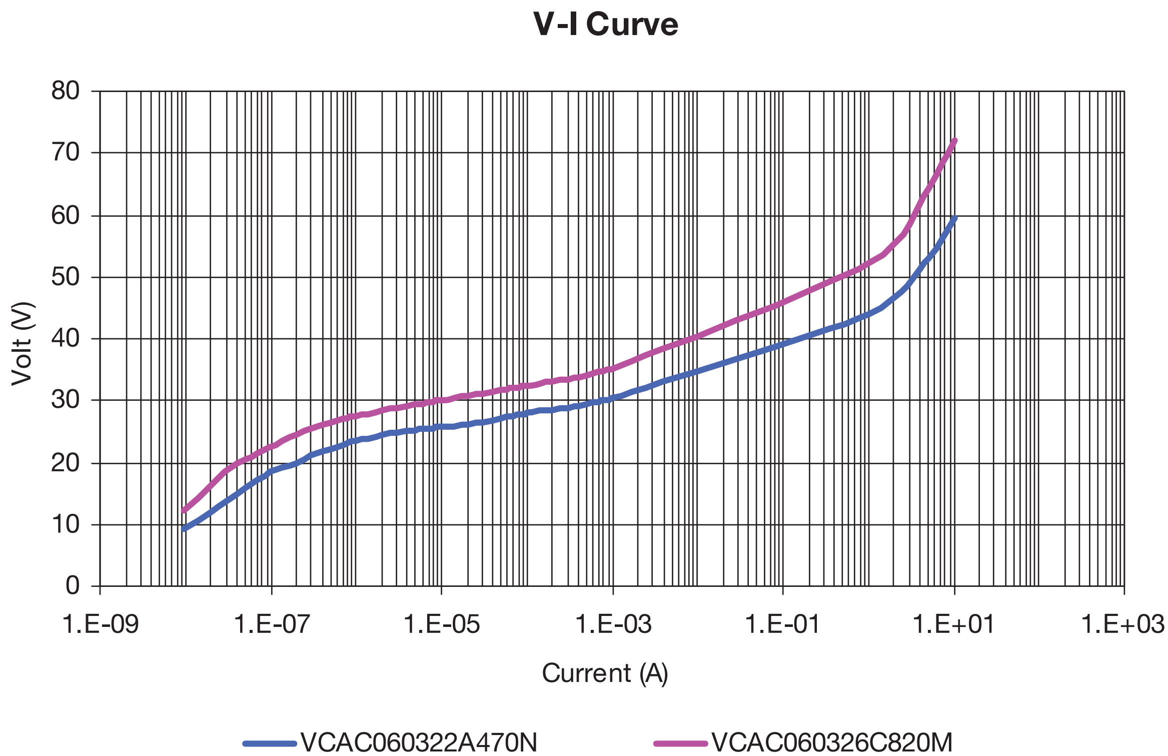
V_W(DC) DC Working Voltage [V]
V_W(AC) AC Working Voltage [V]
V_B Breakdown Votage [V @ 1mA$_{DC}$]
V_C Clamping Votage [V @ 1A]
I_L Maximum leakage current at the working voltage [µA]
E_T Transient Energy Rating [J, 10x1000µS]
I_P Peak Current Rating [A, 8x20µS]
Cap Capacitance [pF] @ 1KHz specified and 0.5V$_{RMS}$

0603 Discrete Dimensions

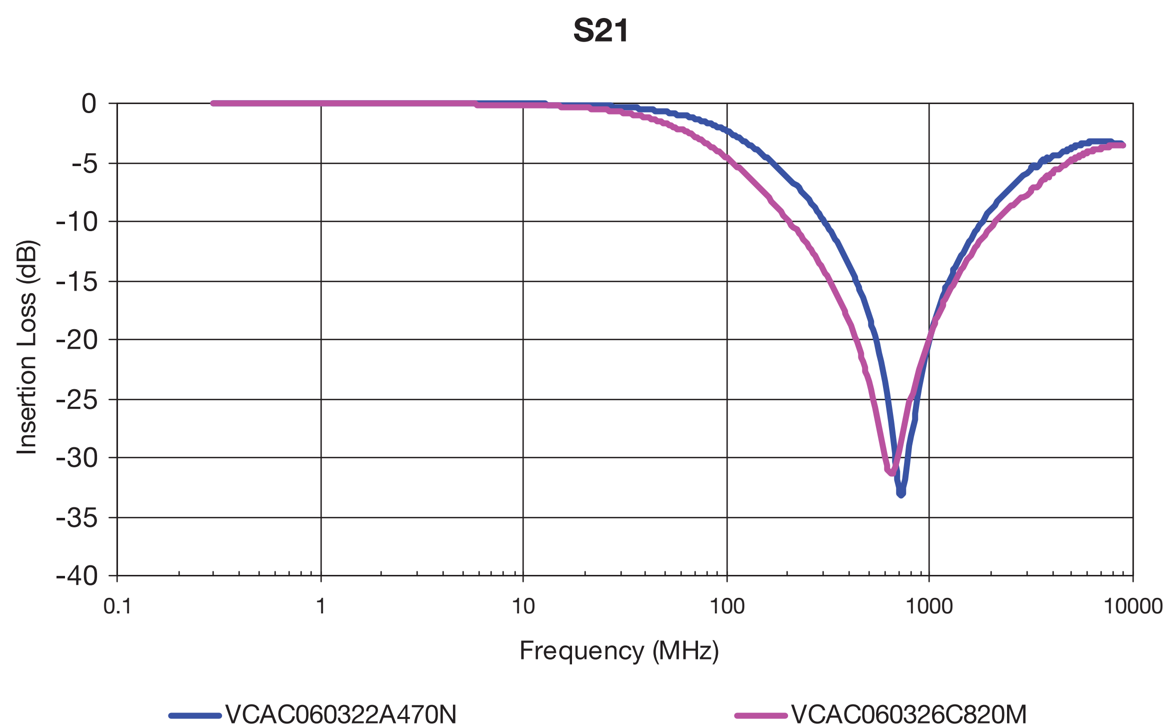
mm (inches)

Size (EIA)	Length (L)	Width (W)	Max Thickness (T)	Land Length (t)
0402	1.00±0.10 (0.040±0.004)	0.50±0.10 (0.020±0.004)	0.60 (0.024)	0.25±0.15 (0.010±0.006)
0603	1.60±0.15 (0.063±0.006)	0.80±0.15 (0.031±0.006)	0.90 (0.035)	0.35±0.15 (0.014±0.006)





V-I Curve
80
70
60
50
40
30
20
10
0
Volt (V)
1.E-09
1.E-07
1.E-05
1.E-03
1.E-01
1.E+01
1.E+03
Current (A)
VCAC060322A470N
VCAC060326C820M



S21
0
-5
-10
-15
-20
-25
-30
-35
-40
Insertion Loss (dB)
0.1
1
10
100
1000
10000
Frequency (MHz)
VCAC060322A470N
VCAC060326C820M

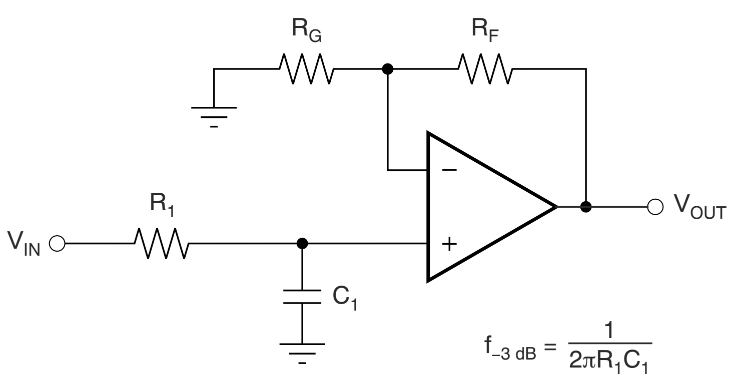
Industry-Standard Dual Operational Amplifiers

1 Features

- Wide supply range of 3 V to 36 V (B version)
- Quiescent current: 300 µA per amplifier (B version, typical)
- Unity-gain bandwidth of 1.2 MHz (B version)
- Common-mode input voltage range includes ground, enabling direct sensing near ground
- Low input offset voltage of 3 mV at 25°C (A and B versions, maximum)
- Internal RF and EMI filter (B version)
- On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

2 Applications

- Merchant network and server power supply units
- Multi-function printers
- Power supplies and mobile chargers
- Motor control: AC induction, brushed DC, brushless DC, high-voltage, low-voltage, permanent magnet, and stepper motor
- Desktop PC and motherboard
- Indoor and outdoor air conditioners
- Washers, dryers, and refrigerators
- AC inverters, string inverters, central inverters, and voltage frequency drives
- Uninterruptible power supplies
- Programmable logic controllers
- Electronic point-of-sale systems



$$f_{-3\ dB} = \frac{1}{2\pi R_1 C_1}$$

$$\frac{V_{OUT}}{V_{IN}} = \left(1 + \frac{R_F}{R_G}\right)\left(\frac{1}{1 + sR_1C_1}\right)$$

Single-Pole, Low-Pass Filter

3 Description

The LM358B and LM2904B devices are the next-generation versions of the industry-standard operational amplifiers (op amps) LM358 and LM2904, which include two high-voltage (36-V) op amps. These devices provide outstanding value for cost-sensitive applications, with features including low offset (300 µV, typical), common-mode input range to ground, and high differential input voltage capability.

The LM358B and LM2904B op amps simplify circuit design with enhanced features such as unity-gain stability, lower offset voltage of 3 mV (maximum at room temperature), and lower quiescent current of 300 µA per amplifier (typical). High ESD (2 kV, HBM) and integrated EMI and RF filters enable the LM358B and LM2904B devices to be used in the most rugged, environmentally challenging applications.

The LM358B and LM2904B amplifiers are available in micro-sized packaging, such as the SOT23-8 , as well as industry standard packages, including SOIC, TSSOP, and VSSOP.

Device Information

PART NUMBER(1)	PACKAGE	BODY SIZE (NOM)
LM358B, LM2904B, LM358, LM358A, LM2904, LM2904V, LM258, LM258A	SOIC (8)	4.90 mm × 3.90 mm
LM358B, LM2904B, LM358, LM358A, LM2904, LM2490V	TSSOP (8)	3.00 mm × 4.40 mm
LM358B, LM2904B, LM358, LM358A, LM2904, LM2904V, LM258, LM258A	VSSOP (8)	3.00 mm × 3.00 mm
LM358B(2), LM2904B(2)	SOT-23 (8)	2.90 mm × 1.60 mm
LM358, LM2904	SO (8)	5.20 mm × 5.30 mm
LM358, LM2904, LM358A, LM258, LM258A	PDIP (8)	9.81 mm × 6.35 mm
LM158, LM158A	CDIP (8)	9.60 mm × 6.67 mm
LM158, LM158A	LCCC (20)	8.89 mm × 8.89 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

(2) Package is for preview only.

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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision X (June 2020) to Revision Y (February 2021) **Page**

- Updated the numbering format for tables, figures, and cross-references throughout the document.... 1
- Added SOT23-8 (DDF) package information throughout data sheet.... 1
- Deleted preview tag from LM358B and LM2904B VSSOP (8) package in *Device Information* table.... 1
- Added SOT23-8 (DDF) package information to *Device Comparison Table* 4
- Added SOT23-8 (DDF) package information to the *Pin Configuration and Functions* section.... 5
- Added DDF (SOT-23) package to the *Thermal Information* table.... 7

Changes from Revision W (October 2019) to Revision X (June 2020) **Page**

- Added application links to *Applications* section.... 1
- Deleted preview tag from LM358B and LM2904B TSSOP (8) package in *Device Information* table 1

Changes from Revision V (September 2018) to Revision W (October 2019) **Page**

- Added specification in the *Device Comparison Table* 4
- Changed CDM ESD rating for LM358B and LM2904B in *ESD Ratings* 6
- Changed V_S to V+ in *Recommended Operating Conditions* 7
- Changed *Thermal Information* for the LM158FK and LM158JG devices.... 7
- Added *Typical Characteristics* section for the LM358B and LM2490B op amps.... 17
- Added test circuit for THD+N and small-signal step response, G = –1 in the *Parameter Measurement Information* section.... 26
- Changed the Functional Block Diagram 27

- Deleted preview designator from LM358B and LM2904B in the *Related Links* section.................................. 32

Changes from Revision U (January 2017) to Revision V (September 2018) **Page**

- Changed the data sheet title 1
- Changed first four items in the *Features* section 1
- Changed the first item in the *Applications* section and added four new items 1
- Changed voltage values in the first paragraph of the *Description* section...1
- Changed text in the second paragraph of the *Description* section.. 1
- Added devices LM358B and LM2904B to data sheet...1
- Changed the first three rows of the *Device Information* table and added a a cross-referenced note for PREVIEW-status devices.. 1
- Added *Device Comparison* table 4
- Added a table note to the *Pin Functions* table 5
- Changed "free-air temperature" to "ambient temperature" in the *Absolute Maximum Ratings* condition statement...6
- Changed all entries in the *Absolute Maximum Ratings* table except T_J and T_{stg} 6
- Deleted lead temperature and case temperature from *Absolute Maximum Ratings* 6
- Changed device listings and their voltage values in the *ESD Ratings* table 6
- Changed "free-air temperature" to "ambient temperature" in the *Recommended Operating Conditions* condition statement 7
- Changed table entries for all parameters in the *Recommended Operating Conditions* table............................7
- Added rows to the Thermal Information table, and a table note regarding device-package combinations 7
- Deleted the *Operating Conditions* table..16
- Added a condition statement to the *Typical Characteristics* section..24
- Changed specific voltages to a *Recommended Operating Conditions* reference... 27
- Changed unity-gain bandwidth from 0.7 MHz for all devices to 1.2 MHz for B-version devices.......................28
- Changed slew rate from.3 V/µs for all devices to o.5 V/µs for B-version devices... 28
- Changed the Section 9.3.3 section in multiple places throughout...28
- Changed V_{CC} to V_S in the *Section 10.1* section 29
- Subscripted the suffixes fro R_I and R_F 29
- Changed *Operational Amplifier Board Layout for Noninverting Configuration* with an image that includes a dual op amp...31
- Added Preview designation to the LM358B and LM2904B devices in Table 13-1 32

Changes from Revision T (April 2015) to Revision U () **Page**

- Changed data sheet title...1

Changes from Revision S (January 2014) to Revision T (April 2015) **Page**

- Added *Applications* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section 1

Changes from Revision R (July 2010) to Revision S (Jauary 2014) **Page**

- Converted this data sheet from the QS format to DocZone using the PDF on the web.................................... 1
- Deleted *Ordering Information* table..1
- Updated *Features* to include Military Disclaimer.. 1
- Added Typical Characteristics section..24

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5 Device Comparison Table

PART NUMBER	SUPPLY VOLTAGE	TEMPERATURE RANGE	V_{OS} (MAXIMUM AT 25°C)	I_Q / CH (TYPICAL AT 25°C)	INTEGRATED EMI FILTER	PACKAGE
LM358B	3 V–36 V	–40°C to 85°C	3 mV	300 µA	Yes	D, DDF, DGK, PW
LM2904B	3 V–36 V	–40°C to 125°C	3 mV	300 µA	Yes	D, DDF, DGK, PW
LM358	3 V–32 V	0°C to 70°C	7 mV	350 µA	No	D, PW, DGK, P, PS
LM2904	3 V–26 V	–40°C to 125°C	7 mV	350 µA	No	D, PW, DGK, P, PS
LM358A	3 V–32 V	0°C to 70°C	3 mV	350 µA	No	D, PW, DGK, P
LM2904V	3 V–32 V	–40°C to 125°C	7 mV	350 µA	No	D, PW
LM158	3 V–32 V	–55°C to 125°C	5 mV	350 µA	No	JG, FK
LM158A	3 V–32 V	–55°C to 125°C	3 mV	350 µA	No	JG, FK
LM258	3 V–32 V	–25°C to 85°C	5 mV	350 µA	No	D, DGK, P
LM258A	3 V–32 V	–25°C to 85°C	3 mV	350 µA	No	D, DGK, P

6 Pin Configuration and Functions

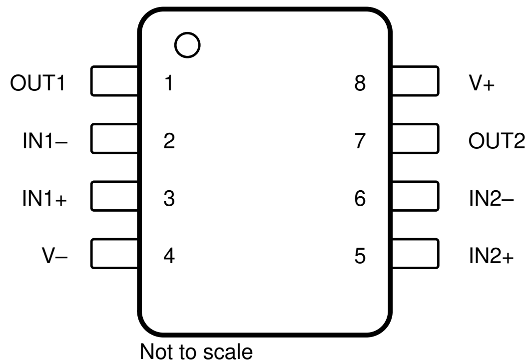
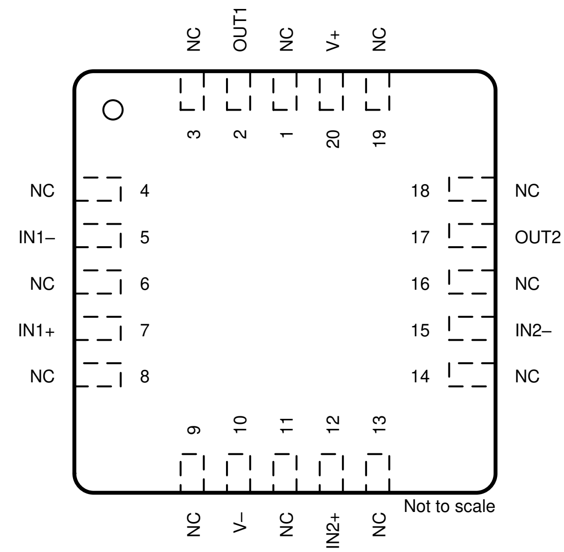


Figure 6-1. D, DDF, DGK, P, PS, PW, and JG Package
8-Pin SOIC, SOT23-8, VSSOP, PDIP, SO, TSSOP, and CDIP
Top View



NC - No internal connection

Figure 6-2. FK Package
20-Pin LCCC
Top View

Table 6-1. Pin Functions

PIN			I/O	DESCRIPTION
NAME	LCCC[1]	SOIC, SOT23-8, VSSOP, CDIP, PDIP, SO, TSSOP, CFP[1]		
IN1–	5	2	I	Negative input
IN1+	7	3	I	Positive input
IN2–	15	6	I	Negative input
IN2+	12	5	I	Positive input
OUT1	2	1	O	Output
OUT2	17	7	O	Output
V–	10	4	—	Negative (lowest) supply or ground (for single-supply operation)
NC	1, 3, 4, 6, 8, 9, 11, 13, 14, 16, 18, 19	—	—	No internal connection
V+	20	8	—	Positive (highest) supply

(1) For a listing of which devices are available in what packages, see Section 5.

7 Specifications

7.1 Absolute Maximum Ratings

over operating ambient temperature range (unless otherwise noted)[(1)]

			MIN	MAX	UNIT
Supply voltage, V_S = ([V+] – [V–])		LM358B, LM358BA, LM2904B, LM2904BA		±20 or 40	V
		LM158, LM258, LM358, LM158A, LM258A, LM358A, LM2904V		±16 or 32	
		LM2904		±13 or 26	
Differential input voltage, V_{ID} [(2)]		LM358B, LM358BA, LM2904B, LM2904BA,LM158, LM258, LM358, LM158A, LM258A, LM358A, LM2904V	–32	32	V
		LM2904	–26	26	
Input voltage, V_I	Either input	LM358B, LM358BA, LM2904B, LM2904BA	–0.3	40	V
		LM158, LM258, LM358, LM158A, LM258A, LM358A, LM2904V	–0.3	32	
		LM2904	–0.3	26	
Duration of output short circuit (one amplifier) to ground at (or below) T_A = 25°C, V_S ≤ 15 V[(3)]				Unlimited	s
Operating ambient temperature, T_A		LM158, LM158A	–55	125	°C
		LM258, LM258A	–25	85	
		LM358B, LM358BA	–40	85	
		LM358, LM358A	0	70	
		LM2904B, LM2904BA, LM2904, LM2904V	–40	125	
Operating virtual-junction temperature, T_J				150	°C
Storage temperature, T_{stg}			–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) Differential voltages are at IN+, with respect to IN−.
(3) Short circuits from outputs to V_S can cause excessive heating and eventual destruction.

7.2 ESD Ratings

			VALUE	UNIT
LM358B, LM358BA, LM2904B, AND LM2904BA				
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[(1)]	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101[(2)]	±1000	
LM158, LM258, LM358, LM158, LM258A, LM358A, LM2904, AND LM2904V				
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[(1)]	±500	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101[(2)]	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

over operating ambient temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V_S	Supply voltage, V_S= ([V+] – [V–])	LM358B, LM358BA, LM2904B, LM2904BA	3	36	V
		LM158, LM258, LM358, LM158A, LM258A, LM358A, LM2904V	3	30	
		LM2904	3	26	
V_{CM}	Common-mode voltage		V–	V+ – 2	V
T_A	Operating ambient temperature	LM358B, LM358BA	–40	85	°C
		LM2904B, LM2904BA, LM2904, LM2904V	–40	125	
		LM358, LM358A	0	70	
		LM258, LM258A	–20	85	
		LM158, LM158A	–55	125	

7.4 Thermal Information

THERMAL METRIC(1)		LM258, LM258A, LM358, LM358A, LM358B, LM358BA, LM2904, LM2904B, LM2904BA, LM2904V(2)						LM158, LM158A		UNIT
		D (SOIC)	DGK (VSSOP)	P (PDIP)	PS (SO)	PW (TSSOP)	DDF (SOT-23)	FK (LCCC)	JG (CDIP)	
		8 PINS	8 PINS	8 PINS	8 PINS	8 PINS	8PINS	20 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	124.7	181.4	80.9	116.9	171.7	TBD	84.0	112.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	66.9	69.4	70.4	62.5	68.8	TBD	56.9	63.6	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	67.9	102.9	57.4	68.6	99.2	TBD	57.5	100.3	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	19.2	11.8	40	21.9	11.5	TBD	51.7	35.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	67.2	101.2	56.9	67.6	97.9	TBD	57.1	93.3	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	—	—	—	—	—	10.6	22.3	°C/W

(1) For more information about traditional and new thermal metrics, see *Semiconductor and IC Package Thermal Metrics*.
(2) For a listing of which devices are available in what packages, see Section 5.

7.5 Electrical Characteristics: LM358B and LM358BA

V_S = (V+) – (V–) = 5 V – 36 V (±2.5 V – ±18 V), T_A = 25°C, V_{CM} = V_{OUT} = V_S / 2, R_L = 10k connected to V_S / 2 (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
OFFSET VOLTAGE								
V_{OS}	Input offset voltage	LM358B				±0.3	±3.0	mV
				T_A = –40°C to +85°C			±4	mV
		LM358BA					±2.0	mV
				T_A = –40°C to +85°C			±2.5	mV
dV_{OS}/d_T	Input offset voltage drift			T_A = -40°C to +85°C(1)		±3.5	11	µV/°C
PSRR	Power supply rejection ratio					±2	15	µV/V
	Channel separation, dc	f = 1 kHz to 20 kHz				±1		µV/V
INPUT VOLTAGE RANGE								
V_{CM}	Common-mode voltage range	V_S = 3 V to 36 V			(V–)		(V+) – 1.5	V
		V_S = 5 V to 36 V		T_A = –40°C to +85°C	(V–)		(V+) – 2	V
CMRR	Common-mode rejection ratio	(V–) ≤ V_{CM} ≤ (V+) – 1.5 V	V_S = 3 V to 36 V			20	100	µV/V
		(V–) ≤ V_{CM} ≤ (V+) – 2.0 V	V_S = 5 V to 36 V	T_A = –40°C to +85°C		25	316	µV/V
INPUT BIAS CURRENT								
I_B	Input bias current					±10	±35	nA
				T_A = –40°C to +85°C(1)			±50	nA
I_{OS}	Input offset current					0.5	4	nA
				T_A = –40°C to +85°C(1)			5	nA
dI_{OS}/d_T	Input offset current drift			T_A = –40°C to +85°C		10		pA/°C
NOISE								
E_n	Input voltage noise	f = 0.1 to 10 Hz				3		$µV_{PP}$
e_n	Input voltage noise density	f = 1 kHz				40		nV/√Hz
INPUT IMPEDANCE								
Z_{ID}	Differential					10 || 0.1		MΩ|| pF
Z_{IC}	Common-mode					4 || 1.5		GΩ|| pF
OPEN-LOOP GAIN								
A_{OL}	Open-loop voltage gain	V_S = 15 V; V_O = 1 V to 11 V; R_L ≥ 10 kΩ, connected to (V–)			70	140		V/mV
				T_A = –40°C to +85°C	35			V/mV
FREQUENCY RESPONSE								
GBW	Gain bandwidth product					1.2		MHz
SR	Slew rate	G = + 1				0.5		V/µs
Θ_m	Phase margin	G = + 1, R_L = 10kΩ, C_L = 20 pF				56		°
t_{OR}	Overload recovery time	V_{IN} × gain > V_S				10		µs
t_s	Settling time	To 0.1%, V_S = 5 V, 2-V step , G = +1, C_L = 100 pF				4		µs
THD+N	Total harmonic distortion + noise	G = + 1, f = 1 kHz, V_O = 3.53 V_{RMS}, V_S = 36 V, R_L = 100k, I_{OUT} ≤ ±50 µA, BW = 80 kHz				0.001		%
OUTPUT								
V_O	Voltage output swing from rail	Positive rail (V+)		I_{OUT} = 50 µA		1.35	1.42	V
				I_{OUT} = 1 mA		1.4	1.48	V
				I_{OUT} = 5 mA(1)		1.5	1.61	V
		Negative rail (V–)		I_{OUT} = 50 µA		100	150	mV
				I_{OUT} = 1 mA		0.75	1	V
			V_S = 5 V, RL ≤ 10 kΩ connected to (V–)	T_A = –40°C to +85°C		5	20	mV
I_O	Output current	V_S = 15 V; V_O = V–; V_{ID} = 1 V	Source(1)		-20	-30		mA
				T_A = –40°C to +85°C	-10			mA
		V_S = 15 V; V_O = V+; V_{ID} = –1 V	Sink(1)		10	20		mA
				T_A = –40°C to +85°C	5			mA
		V_{ID} = –1 V; V_O = (V–) + 200 mV			60	100		µA
I_{SC}	Short-circuit current	V_S = 20 V, (V+) = 10 V, (V–) = –10 V, V_O = 0 V				±40	±60	mA
C_{LOAD}	Capacitive load drive					100		pF
R_O	Open-loop output resistance	f = 1 MHz, I_O = 0 A				300		Ω

7.5 Electrical Characteristics: LM358B and LM358BA (continued)

V_S = (V+) – (V–) = 5 V – 36 V (±2.5 V – ±18 V), T_A = 25°C, V_{CM} = V_{OUT} = V_S / 2, R_L = 10k connected to V_S / 2 (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
POWER SUPPLY							
I_Q	Quiescent current per amplifier	V_S = 5 V; I_O = 0 A	T_A = –40°C to +85°C		300	460	µA
I_Q	Quiescent current per amplifier	V_S = 36 V; I_O = 0 A				800	µA

(1) Specified by characterization only.

7.6 Electrical Characteristics: LM2904B and LM2904BA

V_S = (V+) – (V–) = 5 V – 36 V (±2.5 V – ±18 V), T_A = 25°C, V_{CM} = V_{OUT} = V_S / 2, R_L = 10k connected to V_S / 2 (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
OFFSET VOLTAGE							
V_{OS}	Input offset voltage	LM2904B			±0.3	±3.0	mV
		LM2904B	T_A = –40°C to +125°C			±4	mV
		LM2904BA				±2.0	mV
		LM2904BA	T_A = –40°C to +125°C			±2.5	mV
dV_{OS}/d_T	Input offset voltage drift		T_A = –40°C to +125°C(1)		±3.5	12	µV/°C
PSRR	Power supply rejection ratio				±2	15	µV/V
	Channel separation, dc	f = 1 kHz to 20 kHz			±1		µV/V
INPUT VOLTAGE RANGE							
V_{CM}	Common-mode voltage range	V_S = 3 V to 36 V		(V–)		(V+) – 1.5	V
		V_S = 5 V to 36 V	T_A = –40°C to +125°C	(V–)		(V+) – 2	V
CMRR	Common-mode rejection ratio	(V–) ≤ V_{CM} ≤ (V+) – 1.5 V, V_S = 3 V to 36 V			20	100	µV/V
		(V–) ≤ V_{CM} ≤ (V+) – 2.0 V, V_S = 5 V to 36 V	T_A = –40°C to +125°C		25	316	µV/V
INPUT BIAS CURRENT							
I_B	Input bias current				±10	±35	nA
			T_A = –40°C to +125°C(1)			±50	nA
I_{OS}	Input offset current				0.5	4	nA
			T_A = –40°C to +125°C(1)			5	nA
dI_{OS}/d_T	Input offset current drift		T_A = –40°C to +125°C		10		pA/°C
NOISE							
E_n	Input voltage noise	f = 0.1 to 10 Hz			3		$µV_{PP}$
e_n	Input voltage noise density	f = 1 kHz			40		nV/√Hz
INPUT IMPEDANCE							
Z_{ID}	Differential				10 || 0.1		MΩ|| pF
Z_{IC}	Common-mode				4 || 1.5		GΩ|| pF
OPEN-LOOP GAIN							
A_{OL}	Open-loop voltage gain	V_S = 15 V; V_O = 1 V to 11 V; R_L ≥ 10 kΩ, connected to (V–)		70	140		V/mV
		V_S = 15 V; V_O = 1 V to 11 V; R_L ≥ 10 kΩ, connected to (V–)	T_A = –40°C to +125°C	35			V/mV
FREQUENCY RESPONSE							
GBW	Gain bandwidth product				1.2		MHz
SR	Slew rate	G = + 1			0.5		V/µs
$Θ_m$	Phase margin	G = + 1, R_L = 10kΩ, C_L = 20 pF			56		°
t_{OR}	Overload recovery time	V_{IN} × gain > V_S			10		µs
t_s	Settling time	To 0.1%, V_S = 5 V, 2-V Step , G = +1, C_L = 100 pF			4		µs
THD+N	Total harmonic distortion + noise	G = + 1, f = 1 kHz, V_O = 3.53 V_{RMS}, V_S = 36 V, R_L = 100k, I_{OUT} ≤ ±50 µA, BW = 80 kHz			0.001		%
OUTPUT							
V_O	Voltage output swing from rail	Positive rail (V+)	I_{OUT} = 50 µA		1.35	1.42	V
		Positive rail (V+)	I_{OUT} = 1 mA		1.4	1.48	V
		Positive rail (V+)	I_{OUT} = 5 mA(1)		1.5	1.61	V
		Negative rail (V–)	I_{OUT} = 50 µA		100	150	mV
		Negative rail (V–)	I_{OUT} = 1 mA		0.75	1	V
		Negative rail (V–), V_S = 5 V, RL ≤ 10 kΩ connected to (V–)	T_A = –40°C to +125°C		5	20	mV
I_O	Output current	V_S = 15 V; V_O = V–; V_{ID} = 1 V, Source(1)		–20	–30		mA
		V_S = 15 V; V_O = V–; V_{ID} = 1 V, Source(1)	T_A = –40°C to +125°C	–10			mA
		V_S = 15 V; V_O = V+; V_{ID} = –1 V, Sink(1)		10	20		mA
		V_S = 15 V; V_O = V+; V_{ID} = –1 V, Sink(1)	T_A = –40°C to +125°C	5			mA
		V_{ID} = –1 V; V_O = (V–) + 200 mV		60	100		µA
I_{SC}	Short-circuit current	V_S = 20 V, (V+) = 10 V, (V–) = –10 V, V_O = 0 V			±40	±60	mA
C_{LOAD}	Capacitive load drive				100		pF
R_O	Open-loop output resistance	f = 1 MHz, I_O = 0 A			300		Ω

7.6 Electrical Characteristics: LM2904B and LM2904BA (continued)

V_S = (V+) – (V–) = 5 V – 36 V (±2.5 V – ±18 V), T_A = 25°C, V_{CM} = V_{OUT} = V_S / 2, R_L = 10k connected to V_S / 2 (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
POWER SUPPLY							
I_Q	Quiescent current per amplifier	V_S = 5 V; I_O = 0 A	T_A = –40°C to +125°C		300	460	µA
I_Q	Quiescent current per amplifier	V_S = 36 V; I_O = 0 A	T_A = –40°C to +125°C			800	µA

(1) Specified by characterization only.

7.7 Electrical Characteristics: LM358, LM358A

For V_S = (V+) – (V–) = 5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS(1)				MIN	TYP(2)	MAX	UNIT
OFFSET VOLTAGE									
V_{OS}	Input offset voltage	V_S = 5 V to 30 V; V_{CM} = 0 V; V_O = 1.4 V	LM358				3	7	mV
				T_A = 0°C to 70°C				9	
			LM358A				2	3	
				T_A = 0°C to 70°C				5	
dV_{OS}/d_T	Input offset voltage drift		LM358	T_A = 0°C to 70°C			7		µV/°C
			LM358A	T_A = 0°C to 70°C			7	20	
PSRR	Input offset voltage vs power supply ($\Delta V_{IO}/\Delta V_S$)	V_S = 5 V to 30 V				65	100		dB
V_{O1}/V_{O2}	Channel separation	f = 1 kHz to 20 kHz					120		dB
INPUT VOLTAGE RANGE									
V_{CM}	Common-mode voltage range	V_S = 5 V to 30 V	LM358			(V–)		(V+) – 1.5	V
		V_S = 30 V	LM358A						
		V_S = 5 V to 30 V	LM358	T_A = 0°C to 70°C		(V–)		(V+) – 2	
		V_S = 30 V	LM358A						
CMRR	Common-mode rejection ratio	V_S = 5 V to 30 V; V_{CM} = 0 V				65	80		dB
INPUT BIAS CURRENT									
I_B	Input bias current	V_O = 1.4 V	LM358				–20	–250	nA
				T_A = 0°C to 70°C				–500	
			LM358A				–15	–100	
				T_A = 0°C to 70°C				–200	
I_{OS}	Input offset current	V_O = 1.4 V	LM358				2	50	nA
				T_A = 0°C to 70°C				150	
			LM358A				2	30	
				T_A = 0°C to 70°C				75	
dI_{OS}/d_T	Input offset current drift						10		pA/°C
			LM358A	T_A = 0°C to 70°C				300	
NOISE									
e_n	Input voltage noise density	f = 1 kHz					40		nV/√Hz
OPEN-LOOP GAIN									
A_{OL}	Open-loop voltage gain	V_S = 15 V; V_O = 1 V to 11 V; R_L ≥ 2 kΩ				25	100		V/mV
				T_A = 0°C to 70°C		15			
FREQUENCY RESPONSE									
GBW	Gain bandwidth product						0.7		MHz
SR	Slew rate	G = +1					0.3		V/µs
OUTPUT									
V_O	Voltage output swing from rail	Positive rail	V_S = 30 V; R_L = 2 kΩ	T_A = 0°C to 70°C				4	V
			V_S = 30 V; R_L ≥ 10 kΩ				2	3	
			V_S = 5 V; R_L ≥ 2 kΩ					1.5	
		Negative rail	V_S = 5 V; R_L ≤ 10 kΩ	T_A = 0°C to 70°C			5	20	mV
I_O	Output current	V_S = 15 V; V_O = 0 V; V_{ID} = 1 V	Source			–20	–30		mA
				LM358A				–60	
					T_A = 0°C to 70°C	–10			
		V_S = 15 V; V_O = 15 V; V_{ID} = –1 V	Sink			10	20		
					T_A = 0°C to 70°C	5			
		V_{ID} = –1 V; V_O = 200 mV				12	30		µA
I_{SC}	Short-circuit current	V_S = 10 V; V_O = V_S / 2					±40	±60	mA
POWER SUPPLY									
I_Q	Quiescent current per amplifier	V_O = 2.5 V; I_O = 0 A		T_A = 0°C to 70°C			350	600	µA
		V_S = 30 V; V_O = 15 V; I_O = 0 A					500	1000	

(1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. Maximum V_S for testing purposes is 30 V for LM358 and LM358A.
(2) All typical values are T_A = 25°C.

7.8 Electrical Characteristics: LM2904, LM2904V

For V_S = (V+) – (V–) = 5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS[1]				MIN	TYP[2]	MAX	UNIT
OFFSET VOLTAGE									
V_{OS}	Input offset voltage	V_S = 5 V to maximum; V_{CM} = 0 V; V_O = 1.4 V		Non-A suffix devices			3	7	mV
					T_A = –40°C to 125°C			10	
				A-suffix devices			1	2	
					T_A = –40°C to 125°C			4	
dV_{OS}/d_T	Input offset voltage drift				T_A = –40°C to 125°C		7		µV/°C
PSRR	Input offset voltage vs power supply ($\Delta V_{IO}/\Delta V_S$)	V_S = 5 V to 30 V				65	100		dB
V_{O1}/V_{O2}	Channel separation	f = 1 kHz to 20 kHz					120		dB
INPUT VOLTAGE RANGE									
V_{CM}	Common-mode voltage range	V_S = 5 V to maximum				(V–)		(V+) – 1.5	V
					T_A = –40°C to 125°C	(V–)		(V+) – 2	
CMRR	Common-mode rejection ratio	V_S = 5 V to maximum; V_{CM} = 0 V				65	80		dB
INPUT BIAS CURRENT									
I_B	Input bias current	V_O = 1.4 V					–20	–250	nA
					T_A = –40°C to 125°C			–500	
I_{OS}	Input offset current	V_O = 1.4 V		Non-V suffix device			2	50	nA
					T_A = –40°C to 125°C			300	
				V-suffix device			2	50	
					T_A = –40°C to 125°C			150	
dI_{OS}/d_T	Input offset current drift				T_A = –40°C to 125°C		10		pA/°C
NOISE									
e_n	Input voltage noise density	f = 1 kHz					40		nV/√Hz
OPEN-LOOP GAIN									
A_{OL}	Open-loop voltage gain	V_S = 15 V; V_O = 1 V to 11 V; R_L ≥ 2 kΩ				25	100		V/mV
					T_A = –40°C to 125°C	15			
FREQUENCY RESPONSE									
GBW	Gain bandwidth product						0.7		MHz
SR	Slew rate	G = +1					0.3		V/µs
OUTPUT									
V_O	Voltage output swing from rail	Positive rail	R_L ≥ 10 kΩ			V_S – 1.5			V
			Non-V suffix device	V_S = maximum; R_L = 2 kΩ	T_A = –40°C to 125°C			4	
				V_S = maximum; R_L ≥ 10 kΩ			2	3	
			V-suffix device	V_S = maximum; R_L = 2 kΩ				6	
				V_S = maximum; R_L ≥ 10 kΩ			4	5	
		Negative rail		V_S = 5 V; R_L ≤ 10 kΩ	T_A = –40°C to 125°C		5	20	mV
I_O	Output current	V_S = 15 V; V_O = 0 V; V_{ID} = 1 V	Source			–20	–30		mA
					T_A = –40°C to 125°C	–10			
		V_S = 15 V; V_O = 15 V; V_{ID} = –1 V	Sink			10	20		
					T_A = –40°C to 125°C	5			
		V_{ID} = -1 V; V_O = 200 mV	Non-V suffix device				30		µA
			V-suffix device			12	40		
I_{SC}	Short-circuit current	V_S = 10 V; V_O = V_S / 2					±40	±60	mA
POWER SUPPLY									
I_Q	Quiescent current per amplifier	V_O = 2.5 V; I_O = 0 A			T_A = –40°C to 125°C		350	600	µA
		V_S = maximum; V_O = maximum / 2; I_O = 0 A					500	1000	

(1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. Maximum V_S for testing purposes is 26 V for LM2904 and 32 V for LM2904V.
(2) All typical values are T_A = 25°C.

7.9 Electrical Characteristics: LM158, LM158A

For V_S = (V+) – (V–) = 5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS[1]			MIN	TYP[2]	MAX	UNIT
OFFSET VOLTAGE								
V_{OS}	Input offset voltage	V_S = 5 V to 30 V; V_{CM} = 0 V; V_O = 1.4 V	LM158			3	5	mV
				T_A = –55°C to 125°C			7	
			LM158A				2	
				T_A = –55°C to 125°C			4	
dV_{OS}/d_T	Input offset voltage drift		LM158	T_A = –55°C to 125°C		7		µV/°C
			LM158A	T_A = –55°C to 125°C		7	15[3]	
PSRR	Input offset voltage vs power supply ($\Delta V_{IO}/\Delta V_S$)	V_S = 5 V to 30 V			65	100		dB
V_{O1}/V_{O2}	Channel separation	f = 1 kHz to 20 kHz				120		dB
INPUT VOLTAGE RANGE								
V_{CM}	Common-mode voltage range	V_S = 5 V to 30 V	LM158		(V–)		(V+) – 1.5	V
		V_S = 30 V	LM158A					
		V_S = 5 V to 30 V	LM158	T_A = –55°C to 125°C	(V–)		(V+) – 2	
		V_S = 30 V	LM158A					
CMRR	Common-mode rejection ratio	V_S = 5 V to 30 V; V_{CM} = 0 V			70	80		dB
INPUT BIAS CURRENT								
I_B	Input bias current	V_O = 1.4 V	LM158			–20	–150	nA
				T_A = –55°C to 125°C			–300	
			LM158A			–15	–50	
				T_A = –55°C to 125°C			–100	
I_{OS}	Input offset current	V_O = 1.4 V	LM158			2	30	nA
				T_A = –55°C to 125°C			100	
			LM158A			2	10	
				T_A = –55°C to 125°C			30	
dI_{OS}/d_T	Input offset current drift					10		pA/°C
			LM158A	T_A = –55°C to 125°C			200	
NOISE								
e_n	Input voltage noise density	f = 1 kHz				40		nV/√Hz
OPEN-LOOP GAIN								
A_{OL}	Open-loop voltage gain	V_S = 15 V; V_O = 1 V to 11 V; R_L ≥ 2 kΩ			50	100		V/mV
				T_A = –55°C to 125°C	25			
FREQUENCY RESPONSE								
GBW	Gain bandwidth product					0.7		MHz
SR	Slew rate	G = +1				0.3		V/µs
OUTPUT								
V_O	Voltage output swing from rail	Positive rail	V_S = 30 V; R_L = 2 kΩ	T_A = –55°C to 125°C			4	V
			V_S = 30 V; R_L ≥ 10 kΩ			2	3	
			V_S = 5 V; R_L ≥ 2 kΩ				1.5	
		Negative rail	V_S = 5 V; R_L ≤ 10 kΩ	T_A = –55°C to 125°C		5	20	mV
I_O	Output current	V_S = 15 V; V_O = 0 V; V_{ID} = 1 V	Source		–20	–30		mA
				LM158A			–60	
				T_A = –55°C to 125°C	–10			
		V_S = 15 V; V_O = 15 V; V_{ID} = –1 V	Sink		10	20		
				T_A = –55°C to 125°C	5			
		V_{ID} = –1 V; V_O = 200 mV			12	30		µA
I_{SC}	Short-circuit current	V_S = 10 V; V_O = V_S / 2				±40	±60	mA

7.9 Electrical Characteristics: LM158, LM158A (continued)

For V_S = (V+) – (V–) = 5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS[1]		MIN	TYP[2]	MAX	UNIT
POWER SUPPLY							
I_Q	Quiescent current per amplifier	V_O = 2.5 V; I_O = 0 A	T_A = –55°C to 125°C		350	600	µA
		V_S = 30 V; V_O = 15 V; I_O = 0 A			500	1000	

(1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. Maximum V_S for testing purposes is 30 V for LM158 and LM158A.
(2) All typical values are T_A = 25°C.
(3) On products compliant to MIL-PRF-38535, this parameter is not production tested.

7.10 Electrical Characteristics: LM258, LM258A

For V_S = (V+) – (V–) = 5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS[1]			MIN	TYP[2]	MAX	UNIT
OFFSET VOLTAGE								
V_{OS}	Input offset voltage	V_S = 5 V to 30 V; V_{CM} = 0 V; V_O = 1.4 V	LM258			3	5	mV
			LM258	T_A = –25°C to 85°C			7	
			LM258A			2	3	
			LM258A	T_A = –25°C to 85°C			4	
dV_{OS}/d_T	Input offset voltage drift		LM258	T_A = –25°C to 85°C		7		μV/°C
			LM258A	T_A = –25°C to 85°C		7	15	
PSRR	Input offset voltage vs power supply ($\Delta V_{IO}/\Delta V_S$)	V_S = 5 V to 30 V			65	100		dB
V_{O1}/V_{O2}	Channel separation	f = 1 kHz to 20 kHz				120		dB
INPUT VOLTAGE RANGE								
V_{CM}	Common-mode voltage range	V_S = 5 V to 30 V	LM258		(V–)		(V+) – 1.5	V
		V_S = 30 V	LM258A					
		V_S = 5 V to 30 V	LM258	T_A = –25°C to 85°C	(V–)		(V+) – 2	
		V_S = 30 V	LM258A					
CMRR	Common-mode rejection ratio	V_S = 5 V to 30 V; V_{CM} = 0 V			70	80		dB
INPUT BIAS CURRENT								
I_B	Input bias current	V_O = 1.4 V	LM258			–20	–150	nA
			LM258	T_A = –25°C to 85°C			–300	
			LM258A			–15	–80	
			LM258A	T_A = –25°C to 85°C			–100	
I_{OS}	Input offset current	V_O = 1.4 V	LM258			2	30	nA
			LM258	T_A = –25°C to 85°C			100	
			LM258A			2	15	
			LM258A	T_A = –25°C to 85°C			30	
dI_{OS}/d_T	Input offset current drift					10		pA/°C
			LM258A	T_A = –25°C to 85°C			200	
NOISE								
e_n	Input voltage noise density	f = 1 kHz				40		nV/√Hz
OPEN-LOOP GAIN								
A_{OL}	Open-loop voltage gain	V_S = 15 V; V_O = 1 V to 11 V; R_L ≥ 2 kΩ			50	100		V/mV
				T_A = –25°C to 85°C	25			
FREQUENCY RESPONSE								
GBW	Gain bandwidth product					0.7		MHz
SR	Slew rate	G = +1				0.3		V/μs
OUTPUT								
V_O	Voltage output swing from rail	Positive rail	V_S = 30 V; R_L = 2 kΩ	T_A = –25°C to 85°C			4	V
			V_S = 30 V; R_L ≥ 10 kΩ			2	3	
			V_S = 5 V; R_L ≥ 2 kΩ				1.5	
		Negative rail	V_S = 5 V; R_L ≤ 10 kΩ	T_A = –25°C to 85°C		5	20	mV
I_O	Output current	V_S = 15 V; V_O = 0 V; V_{ID} = 1 V	Source		–20	–30		mA
			Source	LM258A			–60	
			Source	T_A = –25°C to 85°C	–10			
		V_S = 15 V; V_O = 15 V; V_{ID} = –1 V	Sink		10	20		
			Sink	T_A = –25°C to 85°C	5			
		V_{ID} = –1 V; V_O = 200 mV			12	30		μA
I_{SC}	Short-circuit current	V_S = 10 V; V_O = V_S / 2				±40	±60	mA
POWER SUPPLY								
I_Q	Quiescent current per amplifier	V_O = 2.5 V; I_O = 0 A		T_A = –25°C to 85°C		350	600	μA
		V_S = 30 V; V_O = 15 V; I_O = 0 A		T_A = –25°C to 85°C		500	1000	

(1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. Maximum V_S for testing purposes is 30 V for LM258 and LM258A.
(2) All typical values are T_A = 25°C.

7.11 Typical Characteristics: LM358B and LM2904B

This typical characteristics section is applicable for LM358B and LM2904B. Typical characteristics data in this section was taken with T_A = 25°C, V_S = 36 V (±18 V), V_{CM} = V_S / 2, R_{LOAD} = 10 kΩ connected to V_S / 2 (unless otherwise noted).

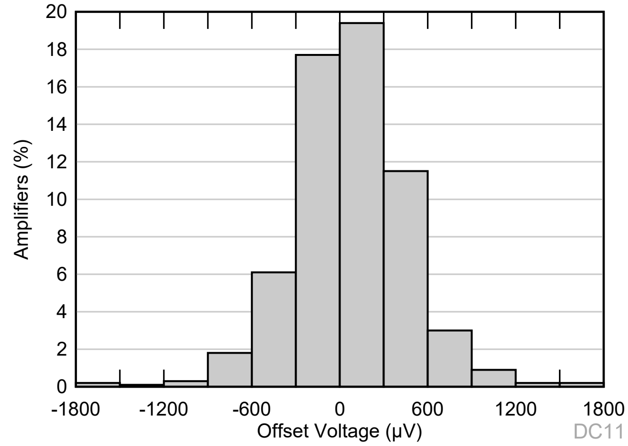


Figure 7-1. Offset Voltage Production Distribution

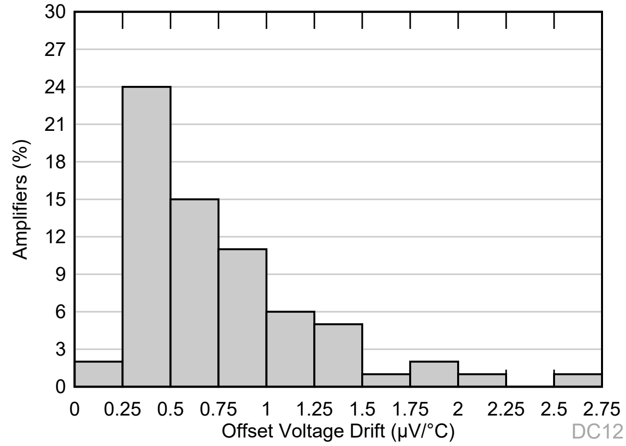


Figure 7-2. Offset Voltage Drift Distribution

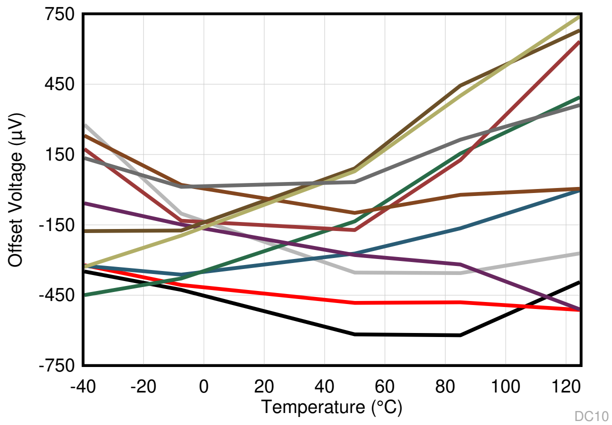


Figure 7-3. Offset Voltage vs Temperature

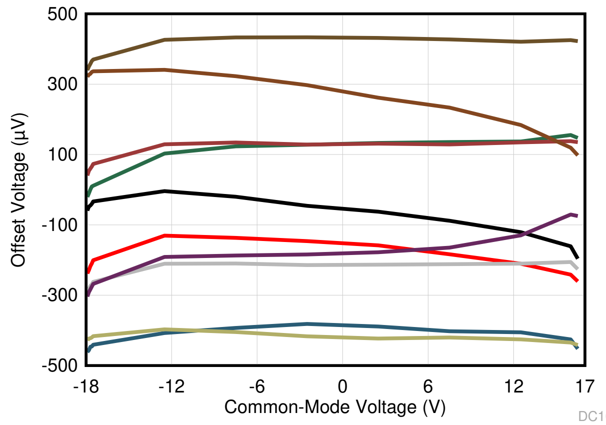


Figure 7-4. Offset Voltage vs Common-Mode Voltage

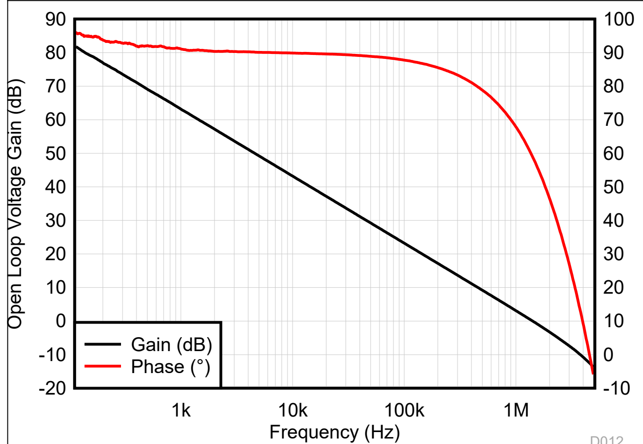


Figure 7-5. Open-Loop Gain and Phase vs Frequency

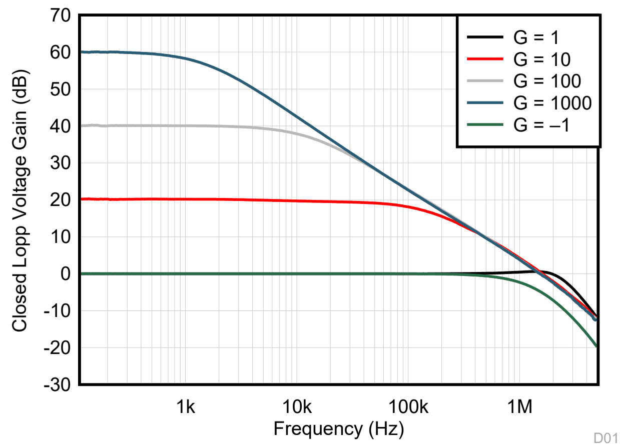


Figure 7-6. Closed-Loop Gain vs Frequency

7.11 Typical Characteristics: LM358B and LM2904B (continued)

This typical characteristics section is applicable for LM358B and LM2904B. Typical characteristics data in this section was taken with T_A = 25°C, V_S = 36 V (±18 V), V_{CM} = V_S / 2, R_{LOAD} = 10 kΩ connected to V_S / 2 (unless otherwise noted).

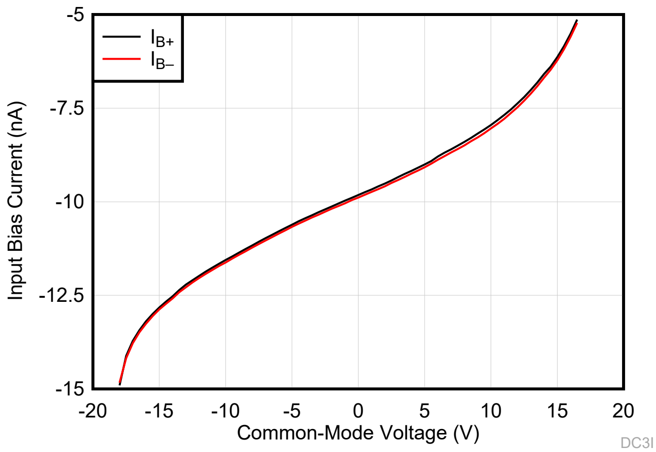


Figure 7-7. Input Bias Current vs Common-Mode Voltage

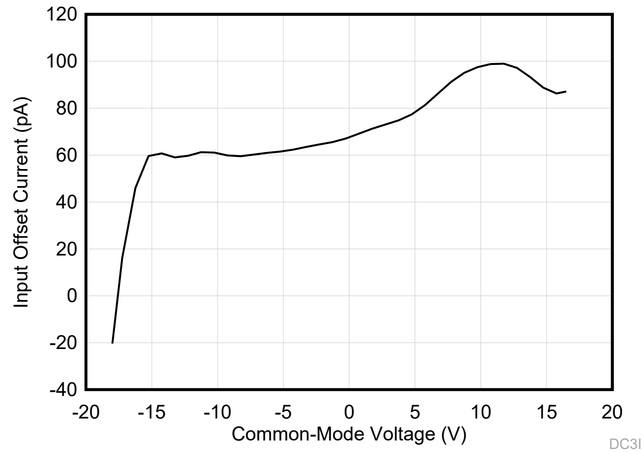


Figure 7-8. Input Offset Current vs Common-Mode Voltage

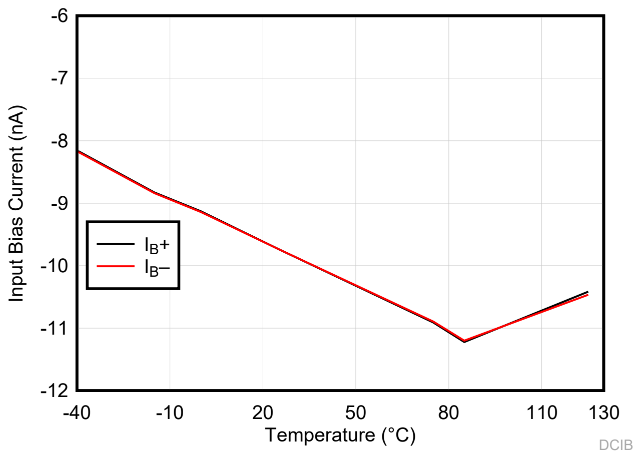


Figure 7-9. Input Bias Current vs Temperature

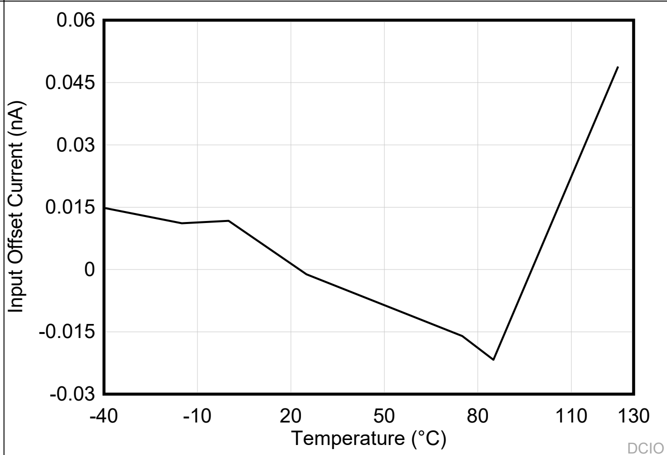


Figure 7-10. Input Offset Current vs Temperature

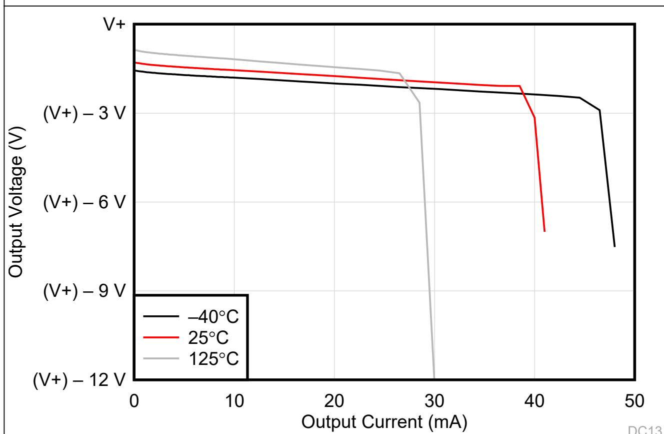


Figure 7-11. Output Voltage Swing vs Output Current (Sourcing)

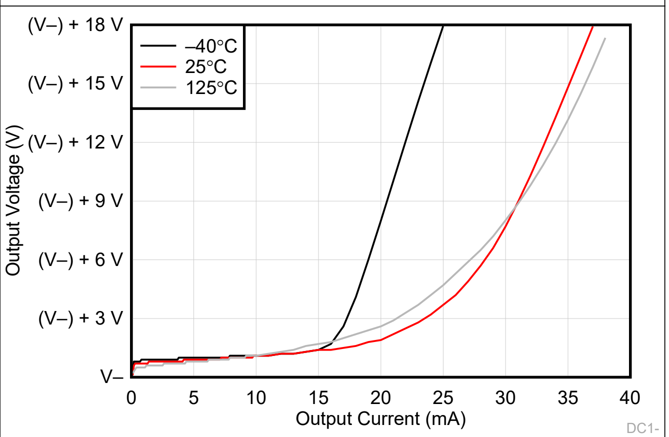


Figure 7-12. Output Voltage Swing vs Output Current (Sinking)

7.11 Typical Characteristics: LM358B and LM2904B (continued)

This typical characteristics section is applicable for LM358B and LM2904B. Typical characteristics data in this section was taken with T_A = 25°C, V_S = 36 V (±18 V), V_{CM} = V_S / 2, R_{LOAD} = 10 kΩ connected to V_S / 2 (unless otherwise noted).

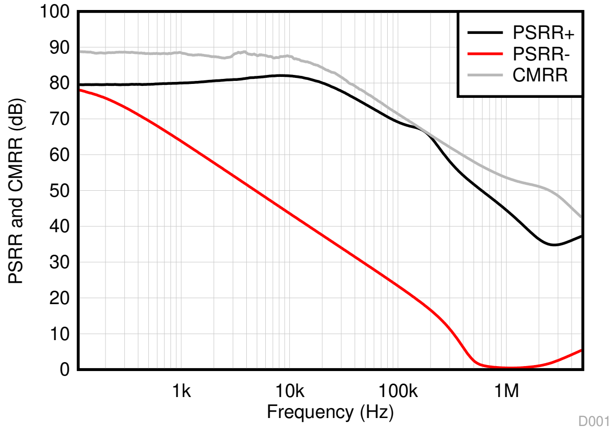


Figure 7-13. CMRR and PSRR vs Frequency

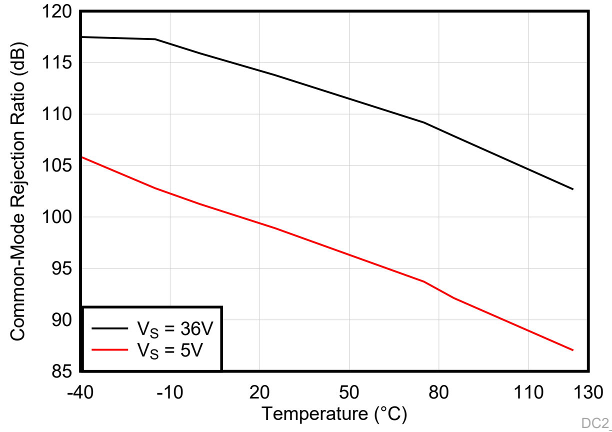
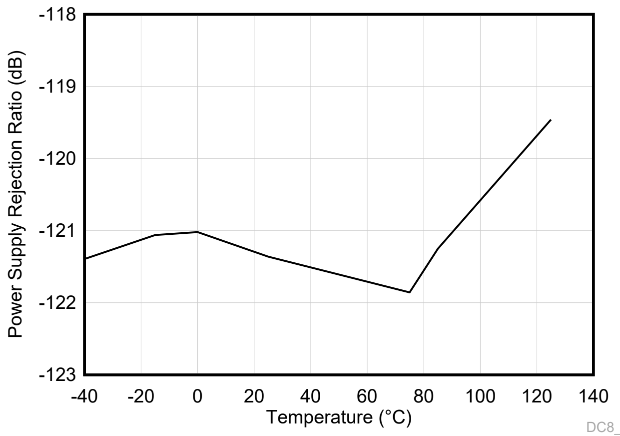


Figure 7-14. Common-Mode Rejection Ratio vs Temperature (dB)



V_S = 5 V to 36 V

Figure 7-15. Power Supply Rejection Ratio vs Temperature (dB)

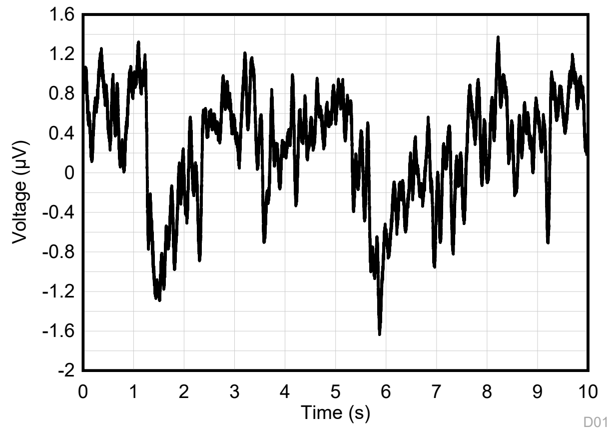


Figure 7-16. 0.1-Hz to 10-Hz Noise

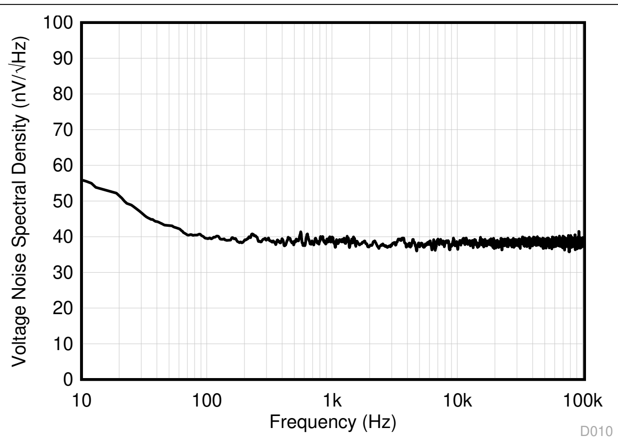
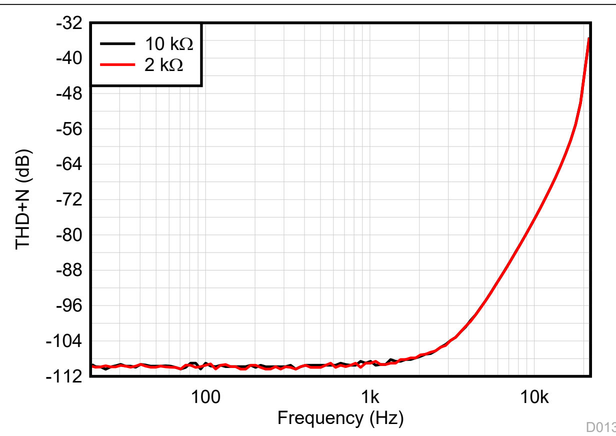


Figure 7-17. Input Voltage Noise Spectral Density vs Frequency



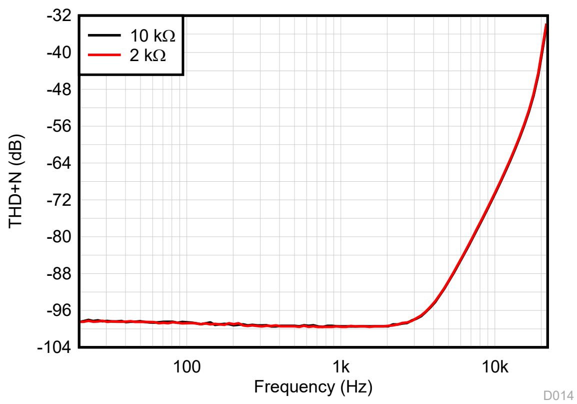
G = 1, f = 1 kHz, BW = 80 kHz,

V_{OUT} = 10 V_{PP}, R_L connected to V–

Figure 7-18. THD+N Ratio vs Frequency, G = 1

7.11 Typical Characteristics: LM358B and LM2904B (continued)

This typical characteristics section is applicable for LM358B and LM2904B. Typical characteristics data in this section was taken with T_A = 25°C, V_S = 36 V (±18 V), V_{CM} = V_S / 2, R_{LOAD} = 10 kΩ connected to V_S / 2 (unless otherwise noted).

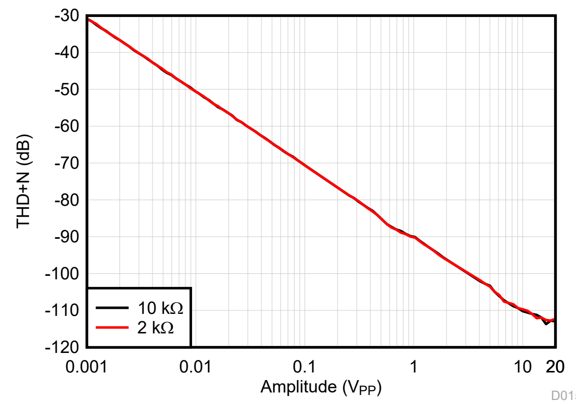


G = –1, f = 1 kHz, BW = 80 kHz,

V_{OUT} = 10 V_{PP}, R_L connected to V–

See Figure 8-3

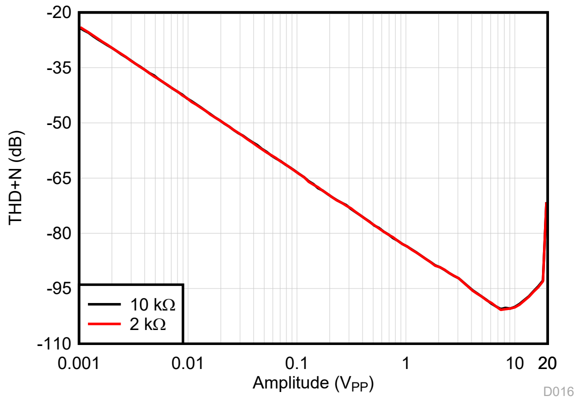
Figure 7-19. THD+N Ratio vs Frequency, G = –1



G = 1, f = 1 kHz, BW = 80 kHz,

R_L connected to V–

Figure 7-20. THD+N vs Output Amplitude, G = 1



G = –1, f = 1 kHz, BW = 80 kHz,

R_L connected to V–

See Figure 8-3

Figure 7-21. THD+N vs Output Amplitude, G = –1

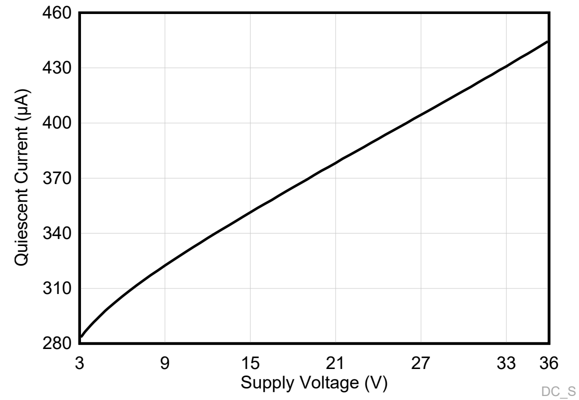


Figure 7-22. Quiescent Current vs Supply Voltage

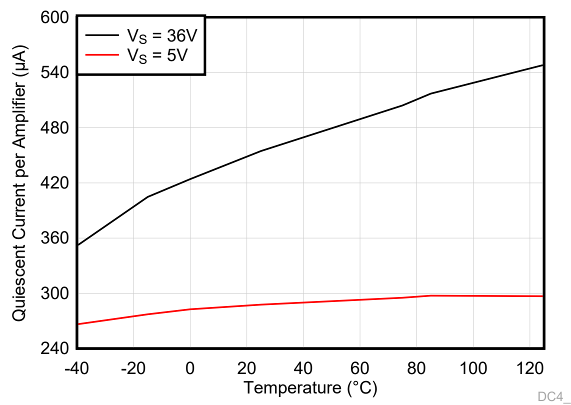


Figure 7-23. Quiescent Current vs Temperature

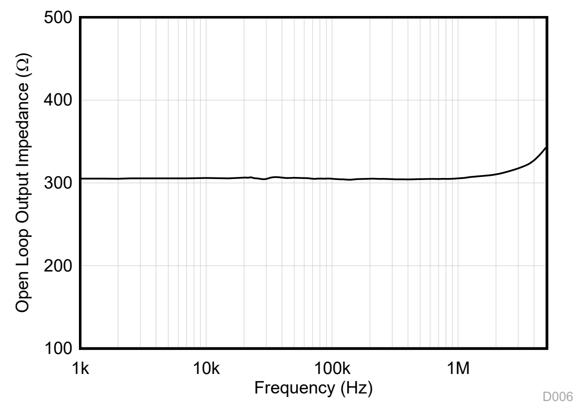
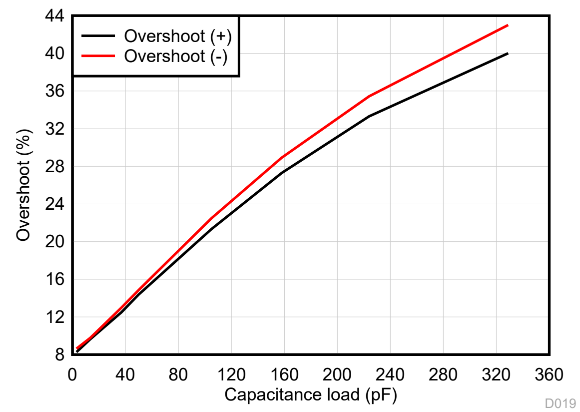


Figure 7-24. Open-Loop Output Impedance vs Frequency

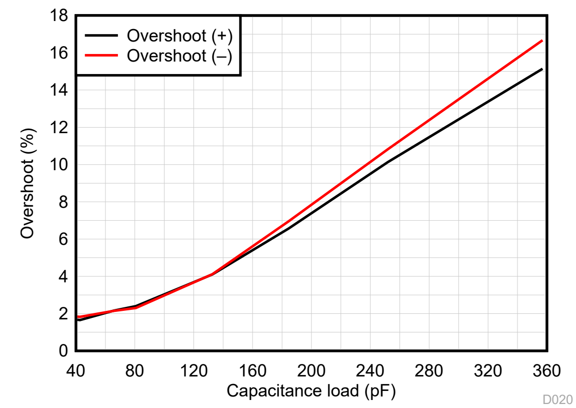
7.11 Typical Characteristics: LM358B and LM2904B (continued)

This typical characteristics section is applicable for LM358B and LM2904B. Typical characteristics data in this section was taken with T_A = 25°C, V_S = 36 V (±18 V), V_{CM} = V_S / 2, R_{LOAD} = 10 kΩ connected to V_S / 2 (unless otherwise noted).



G = 1, 100-mV output step, R_L = open

Figure 7-25. Small-Signal Overshoot vs Capacitive Load



G = –1, 100-mV output step, R_L = open

Figure 7-26. Small-Signal Overshoot vs Capacitive Load

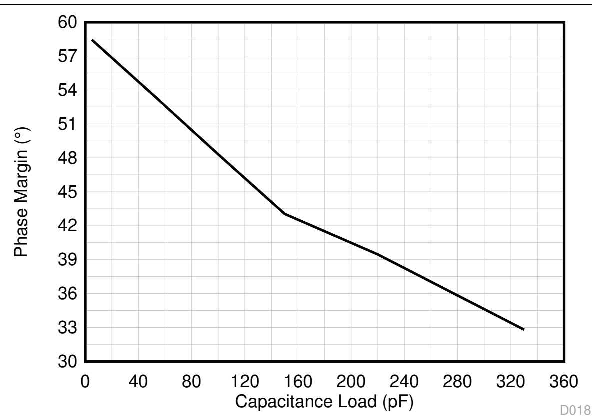
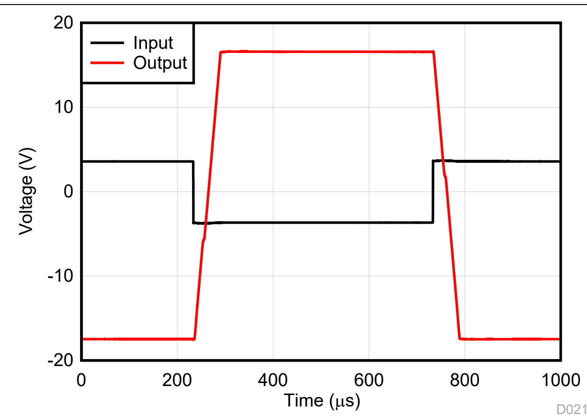
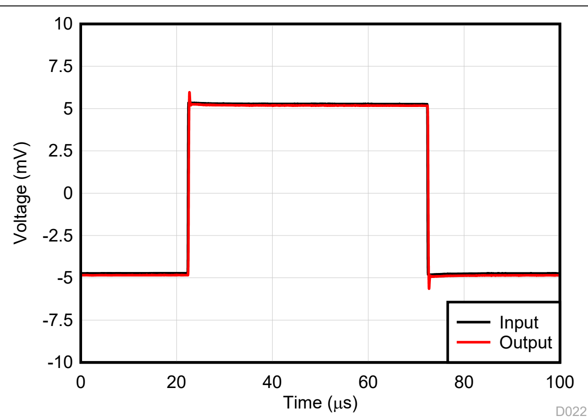


Figure 7-27. Phase Margin vs Capacitive Load



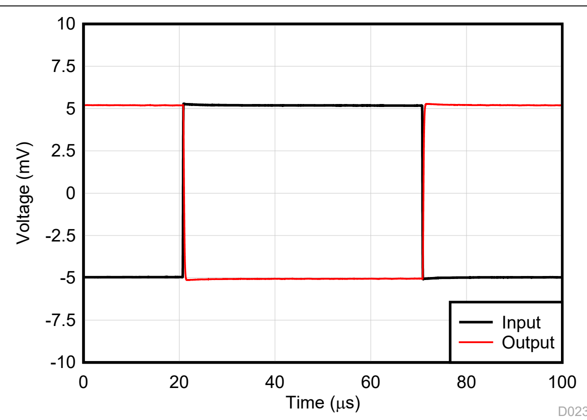
G = –10

Figure 7-28. Overload Recovery



G = 1, R_L = open

Figure 7-29. Small-Signal Step Response, G = 1



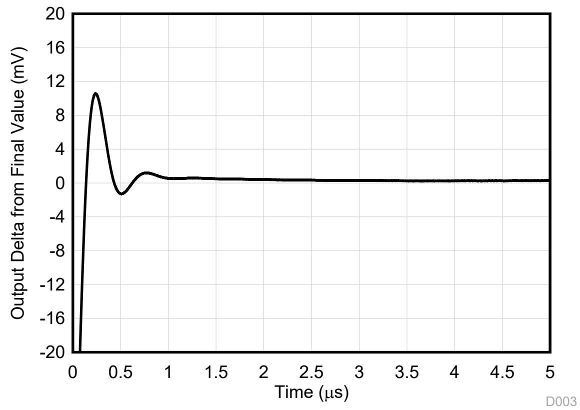
G = –1, R_L = open, R_{FB} = 10K

See Figure 8-3

Figure 7-30. Small-Signal Step Response, G = –1

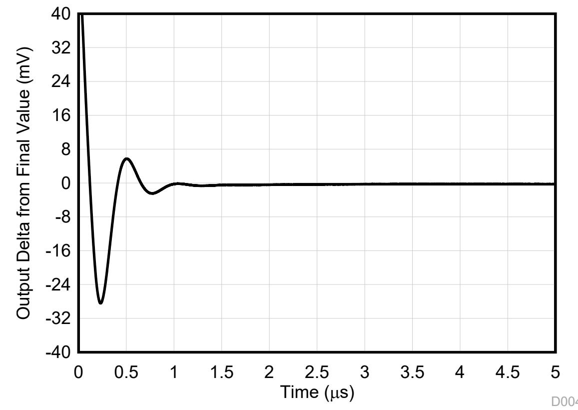
7.11 Typical Characteristics: LM358B and LM2904B (continued)

This typical characteristics section is applicable for LM358B and LM2904B. Typical characteristics data in this section was taken with T_A = 25°C, V_S = 36 V (±18 V), V_{CM} = V_S / 2, R_{LOAD} = 10 kΩ connected to V_S / 2 (unless otherwise noted).



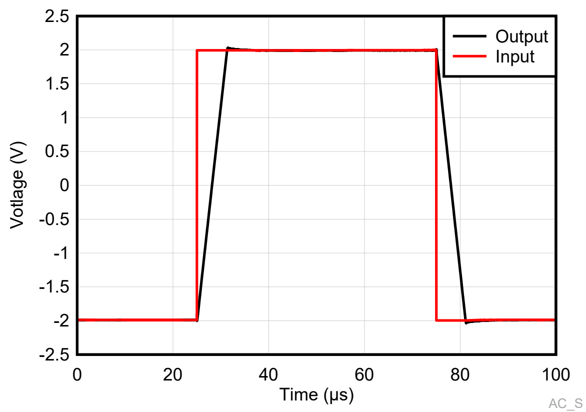
G = 1, R_L = open

Figure 7-31. Large-Signal Step Response (Rising)



G = 1, R_L = open

Figure 7-32. Large-Signal Step Response (Falling)



G = 1, R_L = open

Figure 7-33. Large-Signal Step Response

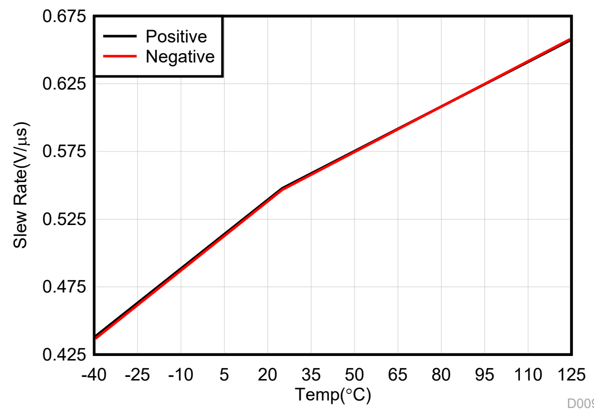


Figure 7-34. Slew Rate vs Temperature

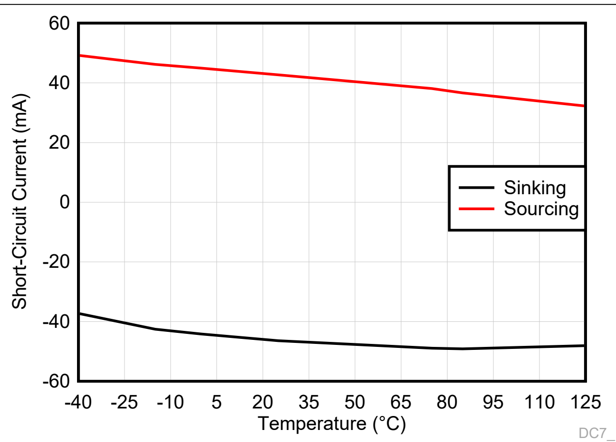
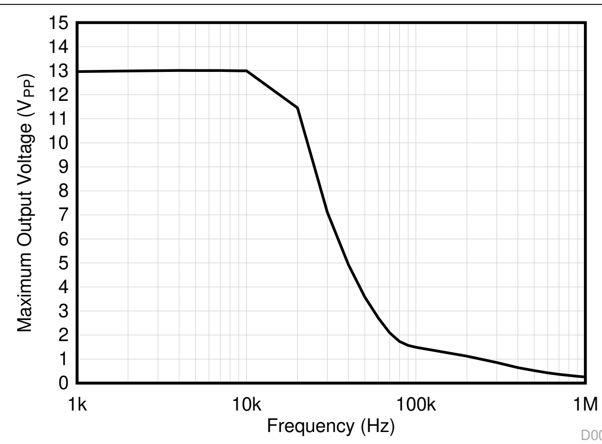


Figure 7-35. Short-Circuit Current vs Temperature



V_S = 15 V

Figure 7-36. Maximum Output Voltage vs Frequency

7.11 Typical Characteristics: LM358B and LM2904B (continued)

This typical characteristics section is applicable for LM358B and LM2904B. Typical characteristics data in this section was taken with T_A = 25°C, V_S = 36 V (±18 V), V_{CM} = V_S / 2, R_{LOAD} = 10 kΩ connected to V_S / 2 (unless otherwise noted).

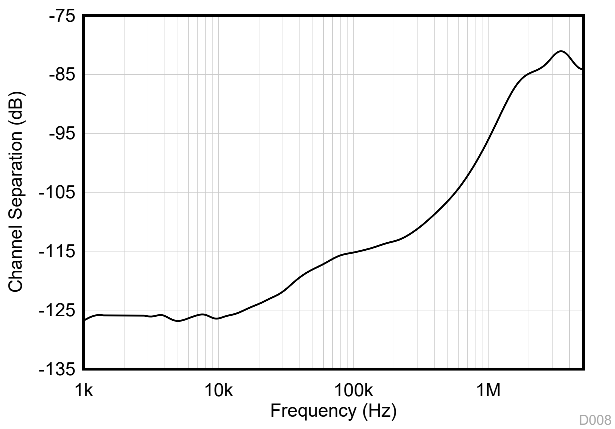


Figure 7-37. Channel Separation vs Frequency

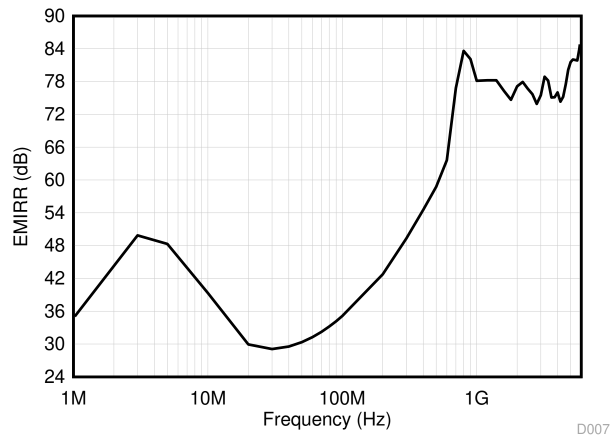


Figure 7-38. EMIRR (Electromagnetic Interference Rejection Ratio) vs Frequency

7.12 Typical Characteristics: LM158, LM158A, LM258, LM258A, LM358, LM358A, LM2904, and LM2904V

Typical characteristics section is applicable for LM158, LM158A, LM258, LM258A, LM358, LM358A, LM2904, and LM2904V.

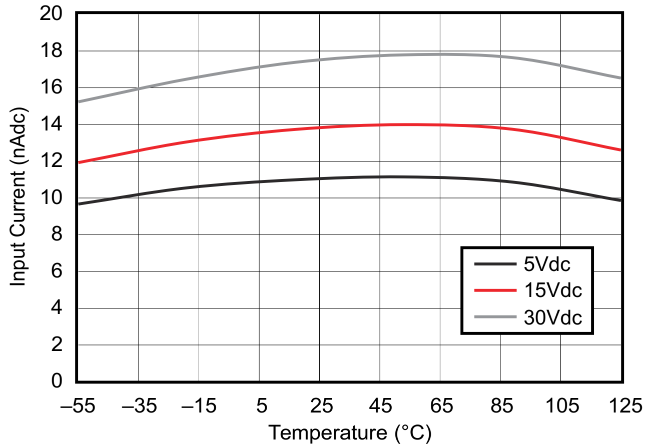


Figure 7-39. Input Current vs Temperature

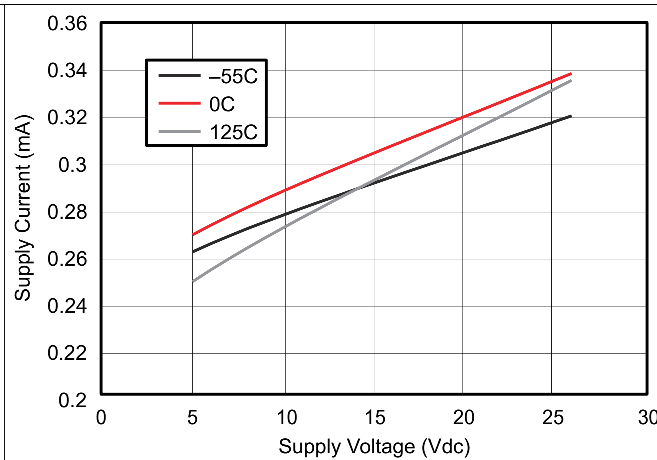


Figure 7-40. Supply Current vs Supply Voltage

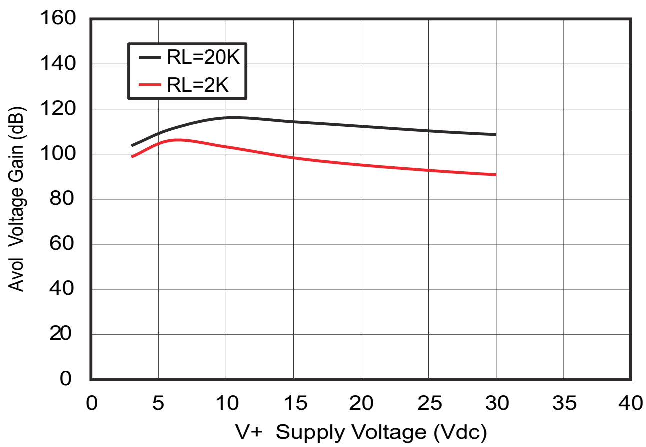


Figure 7-41. Voltage Gain vs Supply Voltage

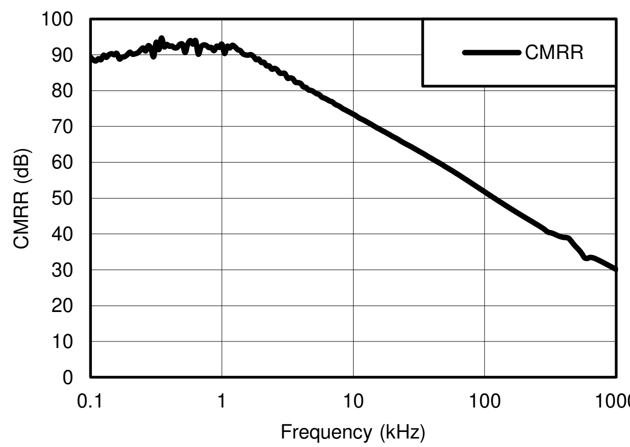


Figure 7-42. Common-Mode Rejection Ratio vs Frequency

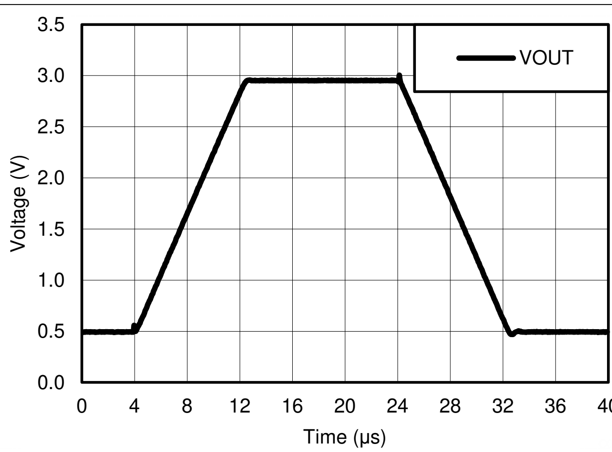


Figure 7-43. Voltage Follower Large Signal Response (50 pF)

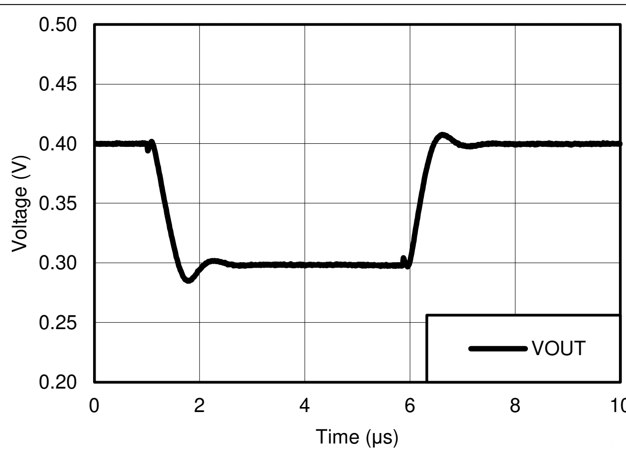


Figure 7-44. Voltage Follower Small Signal Response (50 pF)

7.12 Typical Characteristics: LM158, LM158A, LM258, LM258A, LM358, LM358A, LM2904, and LM2904V (continued)

Typical characteristics section is applicable for LM158, LM158A, LM258, LM258A, LM358, LM358A, LM2904, and LM2904V.

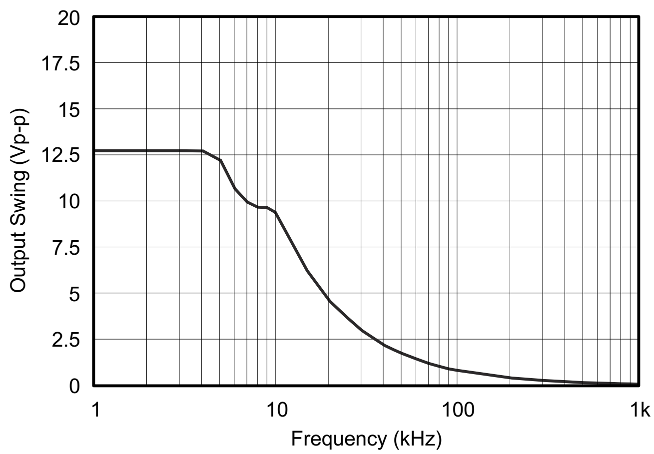


Figure 7-45. Maximum Output Swing vs Frequency (V_{CC} = 15 V)

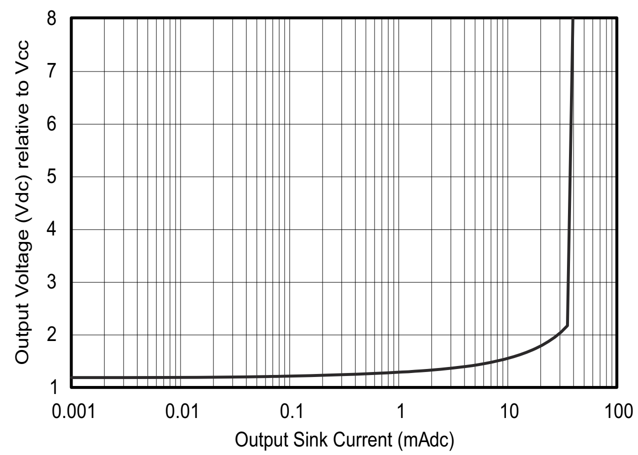


Figure 7-46. Output Sourcing Characteristics

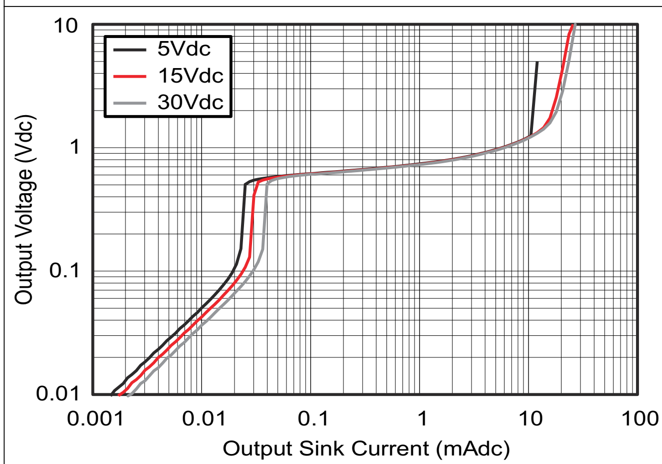


Figure 7-47. Output Sinking Characteristics

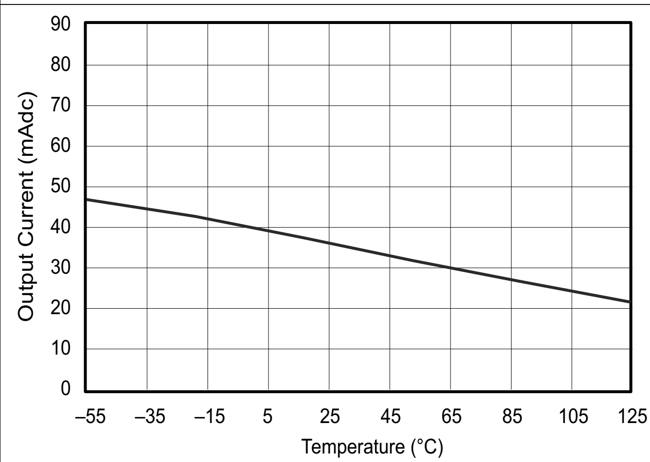


Figure 7-48. Source Current Limiting

8 Parameter Measurement Information

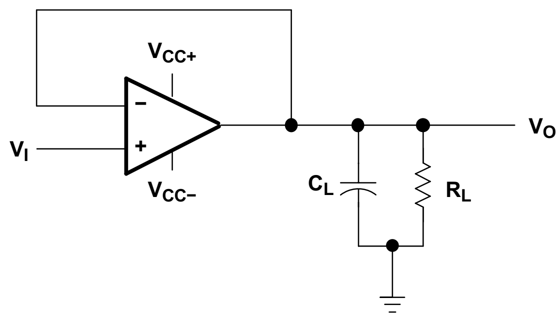


Figure 8-1. Unity-Gain Amplifier

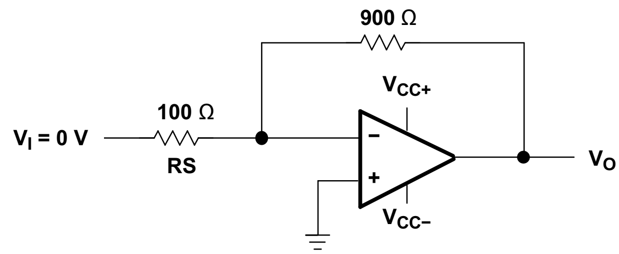


Figure 8-2. Noise-Test Circuit

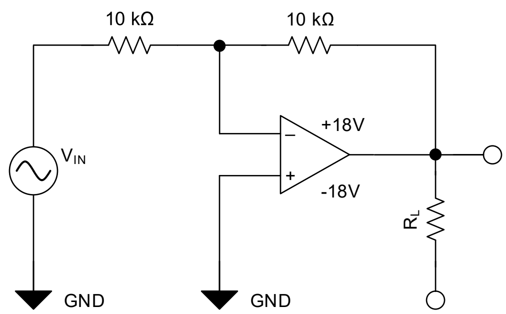


Figure 8-3. Test Circuit, G = –1, for THD+N and Small-Signal Step Response

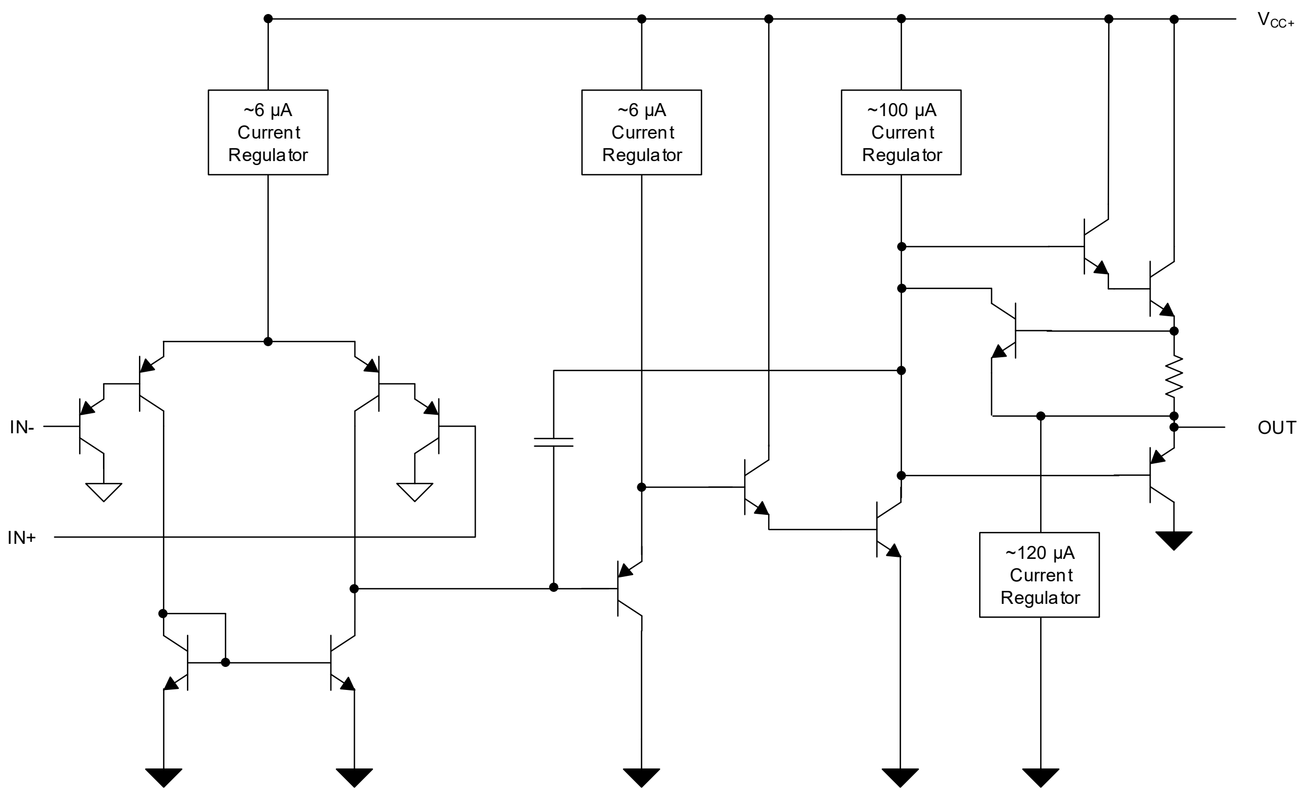
9 Detailed Description

9.1 Overview

These devices consist of two independent, high-gain frequency-compensated operational amplifiers designed to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is within the supply voltage range specified in Section 7.3 and V_S is at least 1.5 V more positive than the input common-mode voltage. The low supply-current drain is independent of the magnitude of the supply voltage.

Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational amplifier circuits that now can be implemented more easily in single-supply-voltage systems. For example, these devices can be operated directly from the standard 5-V supply used in digital systems and easily can provide the required interface electronics without additional ±5-V supplies.

9.2 Functional Block Diagram: LM358B, LM358BA, LM2904B, LM2904BA



9.3 Feature Description

9.3.1 Unity-Gain Bandwidth

The unity-gain bandwidth is the frequency up to which an amplifier with a unity gain may be operated without greatly distorting the signal. These devices have a 1.2-MHz unity-gain bandwidth (B Version).

9.3.2 Slew Rate

The slew rate is the rate at which an operational amplifier can change its output when there is a change on the input. These devices have a 0.5-V/μs slew rate (B Version).

9.3.3 Input Common Mode Range

The valid common mode range is from device ground to V_S – 1.5 V (V_S – 2 V across temperature). Inputs may exceed V_S up to the maximum V_S without device damage. At least one input must be in the valid input common-mode range for the output to be the correct phase. If both inputs exceed the valid range, then the output phase is undefined. If either input more than 0.3 V below V– then input current should be limited to 1 mA and the output phase is undefined.

9.4 Device Functional Modes

These devices are powered on when the supply is connected. This device can be operated as a single-supply operational amplifier or dual-supply amplifier, depending on the application.

10 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

10.1 Application Information

The LMx58 and LM2904 operational amplifiers are useful in a wide range of signal conditioning applications. Inputs can be powered before $V_S$for flexibility in multiple supply circuits.

10.2 Typical Application

A typical application for an operational amplifier is an inverting amplifier. This amplifier takes a positive voltage on the input, and makes it a negative voltage of the same magnitude. In the same manner, it also makes negative voltages positive.

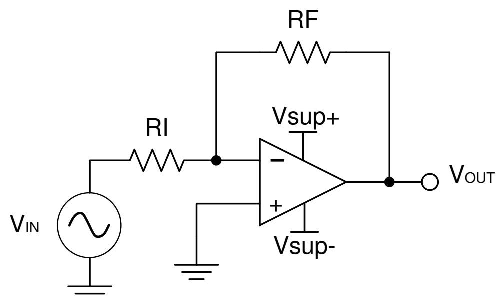


Figure 10-1. Application Schematic

10.2.1 Design Requirements

The supply voltage must be chosen such that it is larger than the input voltage range and output range. For instance, this application scales a signal of ±0.5 V to ±1.8 V. Setting the supply at ±12 V is sufficient to accommodate this application.

10.2.2 Detailed Design Procedure

Determine the gain required by the inverting amplifier using Equation 1 and Equation 2:

$$A_V = \frac{VOUT}{VIN} \tag{1}$$

$$A_V = \frac{1.8}{-0.5} = -3.6 \tag{2}$$

Once the desired gain is determined, choose a value for R_I or R_F. [Subscripts should be fixed in the accompanying figures and equations also.] Choosing a value in the kilohm range is desirable because the amplifier circuit uses currents in the milliampere range. This ensures the part does not draw too much current. This example uses 10 kΩ for R_I which means 36 kΩ is used for R_F. This was determined by Equation 3.

$$A_V = -\frac{RF}{RI} \tag{3}$$

10.2.3 Application Curve

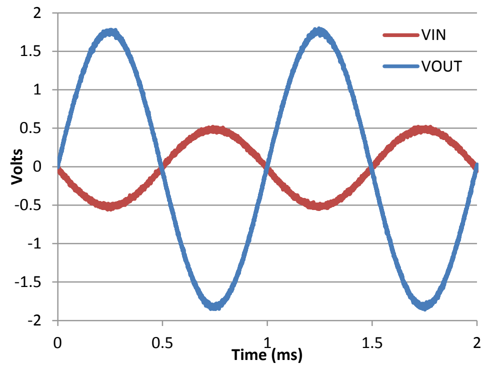


Figure 10-2. Input and Output Voltages of the Inverting Amplifier

11 Power Supply Recommendations

CAUTION

Supply voltages larger than specified in the recommended operating region can permanently damage the device (see Section 7.1).

Place 0.1-µF bypass capacitors close to the power-supply pins to reduce errors coupling in from noisy or high-impedance power supplies. For more detailed information on bypass capacitor placement, see Section 12.

12 Layout

12.1 Layout Guidelines

For best operational performance of the device, use good PCB layout practices, including:

- Noise can propagate into analog circuitry through the power pins of the circuit as a whole, as well as the operational amplifier. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
  - Connect low-ESR, 0.1-µF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single-supply applications.
- Separate grounding for analog and digital portions of circuitry is one of the simplest and most-effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds, paying attention to the flow of the ground current.
- To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If it is not possible to keep them separate, it is much better to cross the sensitive trace perpendicular as opposed to in parallel with the noisy trace.
- Place the external components as close to the device as possible. Keeping R_F and R_G close to the inverting input minimizes parasitic capacitance, as shown in Section 12.2.
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.

12.2 Layout Examples

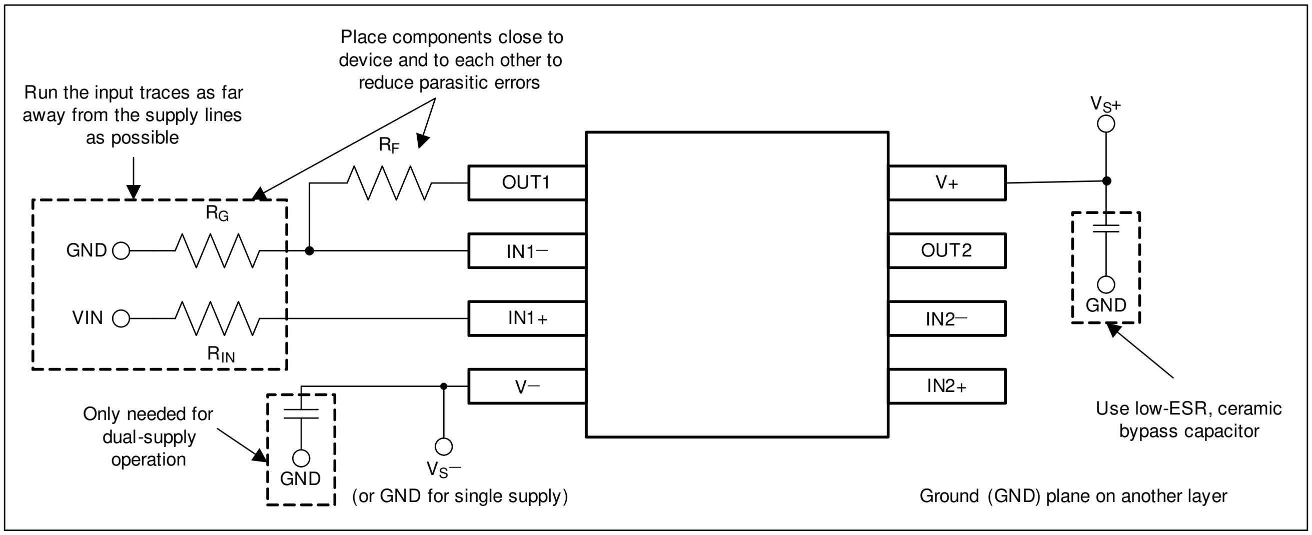


Figure 12-1. Operational Amplifier Board Layout for Noninverting Configuration

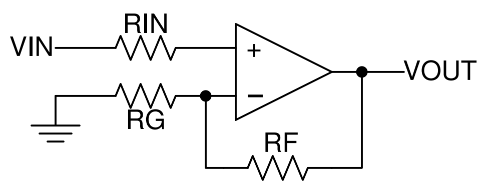


Figure 12-2. Operational Amplifier Schematic for Noninverting Configuration

13 Device and Documentation Support

13.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to order now.

Table 13-1. Related Links

PARTS	PRODUCT FOLDER	ORDER NOW	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
LM158	Click here	Click here	Click here	Click here	Click here
LM158A	Click here	Click here	Click here	Click here	Click here
LM258	Click here	Click here	Click here	Click here	Click here
LM258A	Click here	Click here	Click here	Click here	Click here
LM358	Click here	Click here	Click here	Click here	Click here
LM358A	Click here	Click here	Click here	Click here	Click here
LM358B	Click here	Click here	Click here	Click here	Click here
LM2904	Click here	Click here	Click here	Click here	Click here
LM2904B	Click here	Click here	Click here	Click here	Click here
LM2904V	Click here	Click here	Click here	Click here	Click here

13.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

13.3 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

13.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

13.5 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

13.6 Glossary

TI Glossary This glossary lists and explains terms, acronyms, and definitions.

14 Mechanical, Packaging, and Orderable Information

The following pages include mechanical packaging and orderable information. This information is the most-current data available for the designated devices. This data is subject to change without notice and without revision of this document. For browser based versions of this data sheet, see the left-hand navigation pane.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
5962-87710012A	ACTIVE	LCCC	FK	20	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962-87710012A LM158FKB	Samples
5962-8771001PA	ACTIVE	CDIP	JG	8	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	8771001PA LM158	Samples
5962-87710022A	ACTIVE	LCCC	FK	20	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962-87710022A LM158AFKB	Samples
5962-8771002PA	ACTIVE	CDIP	JG	8	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	8771002PA LM158A	Samples
LM158 MW8	ACTIVE	WAFERSALE	YS	0	1	RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125		Samples
LM158AFKB	ACTIVE	LCCC	FK	20	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962-87710022A LM158AFKB	Samples
LM158AJG	ACTIVE	CDIP	JG	8	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	LM158AJG	Samples
LM158AJGB	ACTIVE	CDIP	JG	8	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	8771002PA LM158A	Samples
LM158FKB	ACTIVE	LCCC	FK	20	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962-87710012A LM158FKB	Samples
LM158JG	ACTIVE	CDIP	JG	8	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	LM158JG	Samples
LM158JGB	ACTIVE	CDIP	JG	8	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	8771001PA LM158	Samples
LM258AD	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM258A	Samples
LM258ADGKR	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU | NIPDAUAG	Level-1-260C-UNLIM	-25 to 85	(M3L, M3P, M3S, M3 U)	Samples
LM258ADR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	-25 to 85	LM258A	Samples
LM258ADRE4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM258A	Samples
LM258ADRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM258A	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM258AP	ACTIVE	PDIP	P	8	50	RoHS & Green	NIPDAU | SN	N / A for Pkg Type	-25 to 85	LM258AP	Samples
LM258APE4	ACTIVE	PDIP	P	8	50	RoHS & Green	NIPDAU	N / A for Pkg Type	-25 to 85	LM258AP	Samples
LM258D	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM258	Samples
LM258DG4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM258	Samples
LM258DGKR	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU | NIPDAUAG	Level-1-260C-UNLIM	-25 to 85	(M2L, M2P, M2S, M2 U)	Samples
LM258DGKRG4	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-25 to 85	(M2L, M2P, M2S, M2 U)	Samples
LM258DR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	-25 to 85	LM258	Samples
LM258DRG3	ACTIVE	SOIC	D	8	2500	RoHS & Green	SN	Level-1-260C-UNLIM	-25 to 85	LM258	Samples
LM258DRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM258	Samples
LM258P	ACTIVE	PDIP	P	8	50	RoHS & Green	NIPDAU | SN	N / A for Pkg Type	-25 to 85	LM258P	Samples
LM258PE4	ACTIVE	PDIP	P	8	50	RoHS & Green	NIPDAU	N / A for Pkg Type	-25 to 85	LM258P	Samples
LM2904AVQDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904AV	Samples
LM2904AVQDRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904AV	Samples
LM2904AVQPWR	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904AV	Samples
LM2904AVQPWRG4	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904AV	Samples
LM2904BAIDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	2904BA	Samples
LM2904BIDGKR	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	28BB	Samples
LM2904BIDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	L2904B	Samples
LM2904BIPWR	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904B	Samples
LM2904D	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LM2904	Samples
LM2904DE4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LM2904	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM2904DG4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LM2904	Samples
LM2904DGKR	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU | NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	(MBL, MBP, MBS, MB U)	Samples
LM2904DGKRG4	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	(MBL, MBP, MBS, MB U)	Samples
LM2904DR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	LM2904	Samples
LM2904DRE4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LM2904	Samples
LM2904DRG3	ACTIVE	SOIC	D	8	2500	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	LM2904	Samples
LM2904DRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LM2904	Samples
LM2904P	ACTIVE	PDIP	P	8	50	RoHS & Green	NIPDAU | SN	N / A for Pkg Type	-40 to 125	LM2904P	Samples
LM2904PE4	ACTIVE	PDIP	P	8	50	RoHS & Green	NIPDAU	N / A for Pkg Type	-40 to 125	LM2904P	Samples
LM2904PSR	ACTIVE	SO	PS	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904	Samples
LM2904PW	ACTIVE	TSSOP	PW	8	150	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904	Samples
LM2904PWR	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	L2904	Samples
LM2904PWRG3	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	L2904	Samples
LM2904PWRG4	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904	Samples
LM2904PWRG4-JF	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904	Samples
LM2904QDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2904Q1	Samples
LM2904QDRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2904Q1	Samples
LM2904VQDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904V	Samples
LM2904VQDRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904V	Samples
LM2904VQPWR	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904V	Samples
LM2904VQPWRG4	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2904V	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM358AD	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM358A	Samples
LM358ADE4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM358A	Samples
LM358ADG4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM358A	Samples
LM358ADGKR	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU | NIPDAUAG	Level-1-260C-UNLIM	0 to 70	(M6L, M6P, M6S, M6 U)	Samples
LM358ADGKRG4	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	(M6L, M6P, M6S, M6 U)	Samples
LM358ADR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	0 to 70	LM358A	Samples
LM358ADRE4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM358A	Samples
LM358ADRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM358A	Samples
LM358AP	ACTIVE	PDIP	P	8	50	RoHS & Green	NIPDAU | SN	N / A for Pkg Type	0 to 70	LM358AP	Samples
LM358APE4	ACTIVE	PDIP	P	8	50	RoHS & Green	NIPDAU	N / A for Pkg Type	0 to 70	LM358AP	Samples
LM358APW	ACTIVE	TSSOP	PW	8	150	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	L358A	Samples
LM358APWR	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	0 to 70	L358A	Samples
LM358APWRG4	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	L358A	Samples
LM358BAIDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	L358BA	Samples
LM358BIDGKR	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	358B	Samples
LM358BIDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	LM358B	Samples
LM358BIPWR	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LM358B	Samples
LM358D	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM358	Samples
LM358DG4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM358	Samples
LM358DGKR	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU | NIPDAUAG	Level-1-260C-UNLIM	0 to 70	(M5L, M5P, M5S, M5 U)	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM358DGKRG4	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	(M5L, M5P, M5S, M5 U)	Samples
LM358DR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	0 to 70	LM358	Samples
LM358DRE4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM358	Samples
LM358DRG3	ACTIVE	SOIC	D	8	2500	RoHS & Green	SN	Level-1-260C-UNLIM	0 to 70	LM358	Samples
LM358DRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM358	Samples
LM358P	ACTIVE	PDIP	P	8	50	RoHS & Green	NIPDAU | SN	N / A for Pkg Type	0 to 70	LM358P	Samples
LM358PE3	ACTIVE	PDIP	P	8	50	RoHS & Non-Green	SN	N / A for Pkg Type	0 to 70	LM358P	Samples
LM358PE4	ACTIVE	PDIP	P	8	50	RoHS & Green	NIPDAU	N / A for Pkg Type	0 to 70	LM358P	Samples
LM358PSR	ACTIVE	SO	PS	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	L358	Samples
LM358PW	ACTIVE	TSSOP	PW	8	150	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	L358	Samples
LM358PWR	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	0 to 70	L358	Samples
LM358PWRG3	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	SN	Level-1-260C-UNLIM	0 to 70	L358	Samples
LM358PWRG4	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	L358	Samples
LM358PWRG4-JF	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	L358	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF LM258A, LM2904, LM2904B :

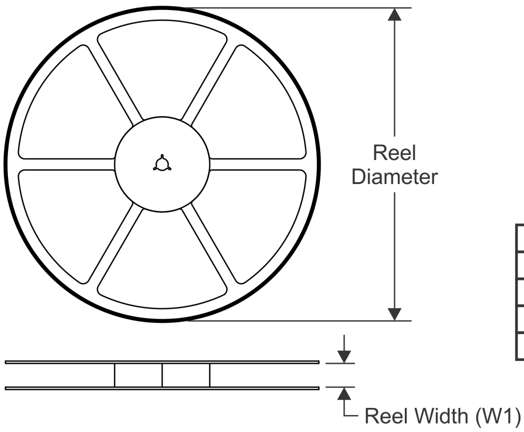
- Automotive : LM2904-Q1, LM2904B-Q1
- Enhanced Product : LM258A-EP, LM2904-EP

NOTE: Qualified Version Definitions:

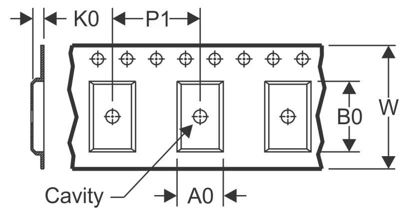
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

TAPE AND REEL INFORMATION

REEL DIMENSIONS

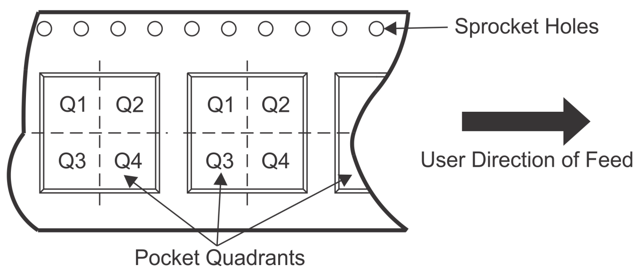


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



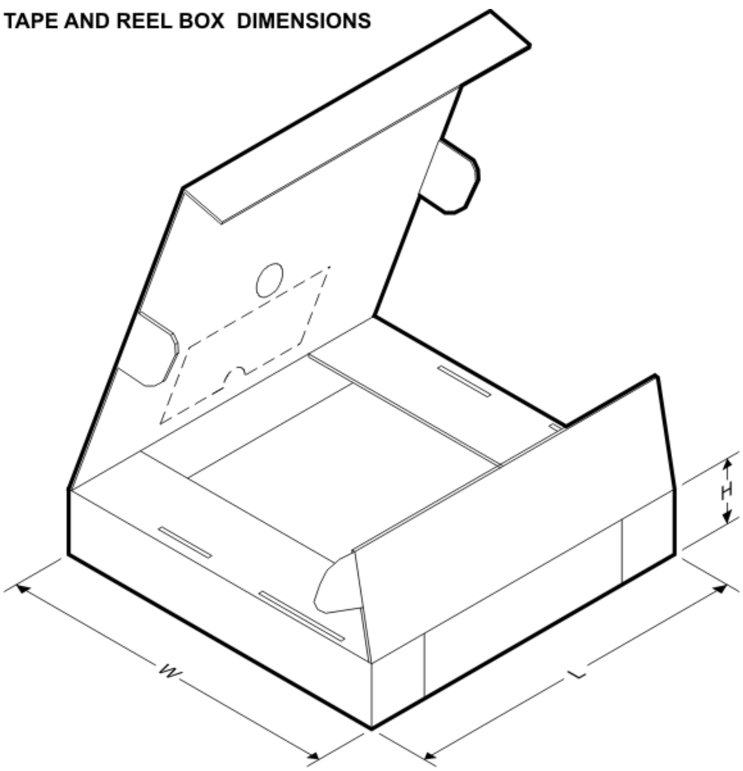
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM258ADGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM258ADR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM258ADR	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM258ADR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM258ADR	SOIC	D	8	2500	330.0	15.4	6.4	5.2	2.1	8.0	12.0	Q1
LM258ADRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM258ADRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM258DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM258DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM258DR	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM258DR	SOIC	D	8	2500	330.0	15.4	6.4	5.2	2.1	8.0	12.0	Q1
LM258DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM258DRG3	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM258DRG3	SOIC	D	8	2500	330.0	15.4	6.4	5.2	2.1	8.0	12.0	Q1
LM258DRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM258DRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2904AVQDR	SOIC	D	8	2500	330.0	12.5	6.4	5.2	2.1	8.0	12.0	Q1
LM2904AVQDRG4	SOIC	D	8	2500	330.0	12.5	6.4	5.2	2.1	8.0	12.0	Q1

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM2904AVQPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2904AVQPWRG4	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2904BAIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2904BIDGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM2904BIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2904BIPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2904DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM2904DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM2904DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2904DR	SOIC	D	8	2500	330.0	15.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2904DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2904DR	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM2904DRG3	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM2904DRG3	SOIC	D	8	2500	330.0	15.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2904DRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2904DRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2904PWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2904PWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2904PWRG3	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2904PWRG4	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2904PWRG4-JF	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2904QDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2904VQDR	SOIC	D	8	2500	330.0	12.5	6.4	5.2	2.1	8.0	12.0	Q1
LM2904VQPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2904VQPWRG4	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM358ADGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM358ADR	SOIC	D	8	2500	330.0	15.4	6.4	5.2	2.1	8.0	12.0	Q1
LM358ADR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM358ADR	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM358ADR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM358ADRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM358ADRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM358APWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM358APWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM358APWRG4	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM358BAIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM358BIDGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM358BIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM358BIPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM358DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM358DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM358DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM358DR	SOIC	D	8	2500	330.0	15.4	6.4	5.2	2.1	8.0	12.0	Q1

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM358DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM358DR	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM358DRG3	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM358DRG3	SOIC	D	8	2500	330.0	15.4	6.4	5.2	2.1	8.0	12.0	Q1
LM358DRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM358DRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM358PWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM358PWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM358PWRG3	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM358PWRG4	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM358PWRG4-JF	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



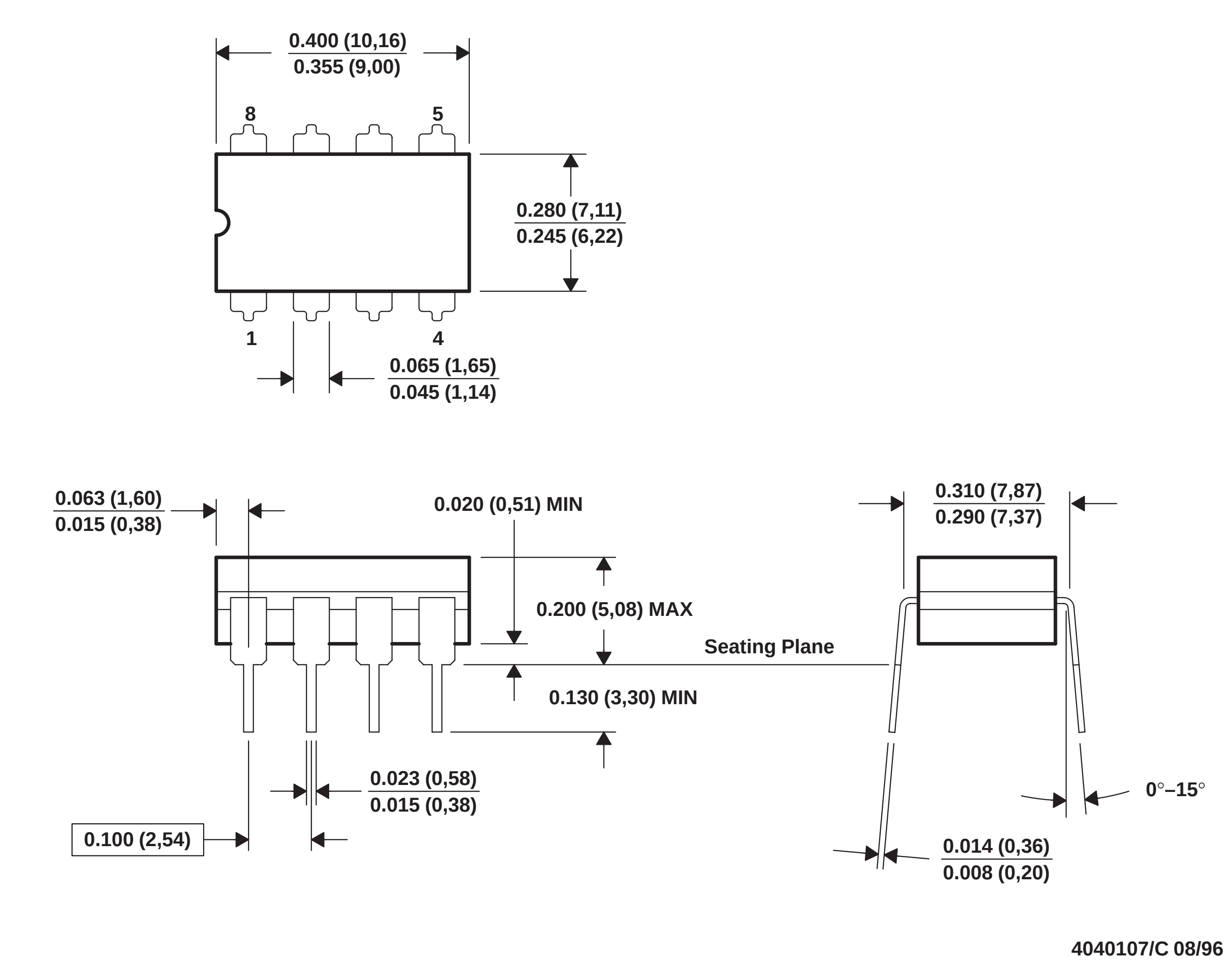
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM258ADGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0
LM258ADR	SOIC	D	8	2500	853.0	449.0	35.0
LM258ADR	SOIC	D	8	2500	364.0	364.0	27.0
LM258ADR	SOIC	D	8	2500	340.5	338.1	20.6
LM258ADR	SOIC	D	8	2500	333.2	345.9	28.6
LM258ADRG4	SOIC	D	8	2500	853.0	449.0	35.0

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM258ADRG4	SOIC	D	8	2500	340.5	338.1	20.6
LM258DGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0
LM258DR	SOIC	D	8	2500	340.5	338.1	20.6
LM258DR	SOIC	D	8	2500	364.0	364.0	27.0
LM258DR	SOIC	D	8	2500	333.2	345.9	28.6
LM258DR	SOIC	D	8	2500	853.0	449.0	35.0
LM258DRG3	SOIC	D	8	2500	364.0	364.0	27.0
LM258DRG3	SOIC	D	8	2500	333.2	345.9	28.6
LM258DRG4	SOIC	D	8	2500	340.5	338.1	20.6
LM258DRG4	SOIC	D	8	2500	853.0	449.0	35.0
LM2904AVQDR	SOIC	D	8	2500	340.5	338.1	20.6
LM2904AVQDRG4	SOIC	D	8	2500	340.5	338.1	20.6
LM2904AVQPWR	TSSOP	PW	8	2000	853.0	449.0	35.0
LM2904AVQPWRG4	TSSOP	PW	8	2000	853.0	449.0	35.0
LM2904BAIDR	SOIC	D	8	2500	340.5	338.1	20.6
LM2904BIDGKR	VSSOP	DGK	8	2500	366.0	364.0	50.0
LM2904BIDR	SOIC	D	8	2500	340.5	338.1	20.6
LM2904BIPWR	TSSOP	PW	8	2000	853.0	449.0	35.0
LM2904DGKR	VSSOP	DGK	8	2500	358.0	335.0	35.0
LM2904DGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0
LM2904DR	SOIC	D	8	2500	340.5	338.1	20.6
LM2904DR	SOIC	D	8	2500	333.2	345.9	28.6
LM2904DR	SOIC	D	8	2500	853.0	449.0	35.0
LM2904DR	SOIC	D	8	2500	364.0	364.0	27.0
LM2904DRG3	SOIC	D	8	2500	364.0	364.0	27.0
LM2904DRG3	SOIC	D	8	2500	333.2	345.9	28.6
LM2904DRG4	SOIC	D	8	2500	853.0	449.0	35.0
LM2904DRG4	SOIC	D	8	2500	340.5	338.1	20.6
LM2904PWR	TSSOP	PW	8	2000	364.0	364.0	27.0
LM2904PWR	TSSOP	PW	8	2000	853.0	449.0	35.0
LM2904PWRG3	TSSOP	PW	8	2000	364.0	364.0	27.0
LM2904PWRG4	TSSOP	PW	8	2000	853.0	449.0	35.0
LM2904PWRG4-JF	TSSOP	PW	8	2000	853.0	449.0	35.0
LM2904QDR	SOIC	D	8	2500	350.0	350.0	43.0
LM2904VQDR	SOIC	D	8	2500	340.5	338.1	20.6
LM2904VQPWR	TSSOP	PW	8	2000	853.0	449.0	35.0
LM2904VQPWRG4	TSSOP	PW	8	2000	853.0	449.0	35.0
LM358ADGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0
LM358ADR	SOIC	D	8	2500	333.2	345.9	28.6
LM358ADR	SOIC	D	8	2500	853.0	449.0	35.0
LM358ADR	SOIC	D	8	2500	364.0	364.0	27.0
LM358ADR	SOIC	D	8	2500	340.5	338.1	20.6
LM358ADRG4	SOIC	D	8	2500	853.0	449.0	35.0
LM358ADRG4	SOIC	D	8	2500	340.5	338.1	20.6

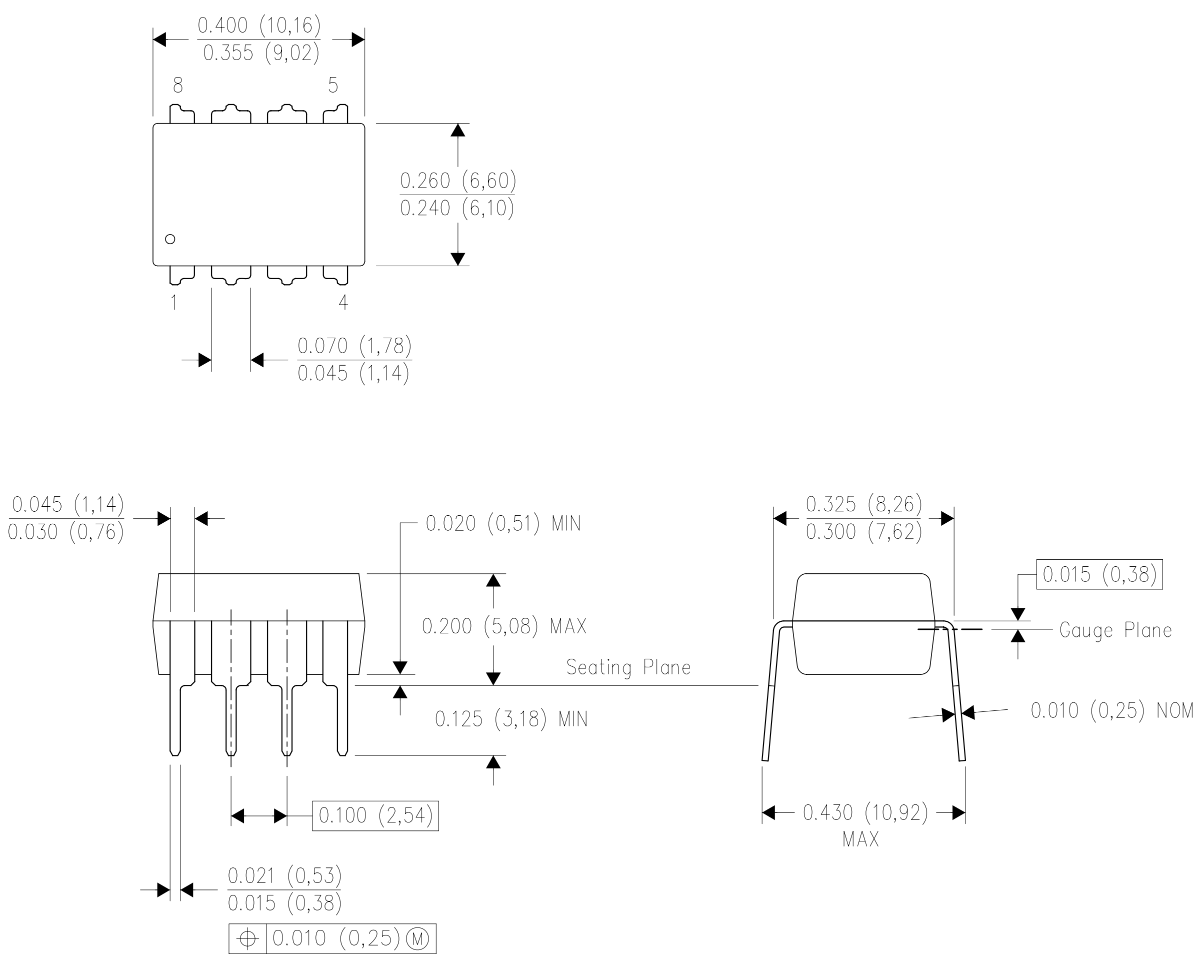
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM358APWR	TSSOP	PW	8	2000	853.0	449.0	35.0
LM358APWR	TSSOP	PW	8	2000	364.0	364.0	27.0
LM358APWRG4	TSSOP	PW	8	2000	853.0	449.0	35.0
LM358BAIDR	SOIC	D	8	2500	340.5	338.1	20.6
LM358BIDGKR	VSSOP	DGK	8	2500	366.0	364.0	50.0
LM358BIDR	SOIC	D	8	2500	340.5	338.1	20.6
LM358BIPWR	TSSOP	PW	8	2000	853.0	449.0	35.0
LM358DGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0
LM358DGKR	VSSOP	DGK	8	2500	358.0	335.0	35.0
LM358DR	SOIC	D	8	2500	853.0	449.0	35.0
LM358DR	SOIC	D	8	2500	333.2	345.9	28.6
LM358DR	SOIC	D	8	2500	340.5	338.1	20.6
LM358DR	SOIC	D	8	2500	364.0	364.0	27.0
LM358DRG3	SOIC	D	8	2500	364.0	364.0	27.0
LM358DRG3	SOIC	D	8	2500	333.2	345.9	28.6
LM358DRG4	SOIC	D	8	2500	340.5	338.1	20.6
LM358DRG4	SOIC	D	8	2500	853.0	449.0	35.0
LM358PWR	TSSOP	PW	8	2000	853.0	449.0	35.0
LM358PWR	TSSOP	PW	8	2000	364.0	364.0	27.0
LM358PWRG3	TSSOP	PW	8	2000	364.0	364.0	27.0
LM358PWRG4	TSSOP	PW	8	2000	853.0	449.0	35.0
LM358PWRG4-JF	TSSOP	PW	8	2000	853.0	449.0	35.0

JG (R-GDIP-T8) **CERAMIC DUAL-IN-LINE**



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. This package can be hermetically sealed with a ceramic lid using glass frit.
- D. Index point is provided on cap for terminal identification.
- E. Falls within MIL STD 1835 GDIP1-T8

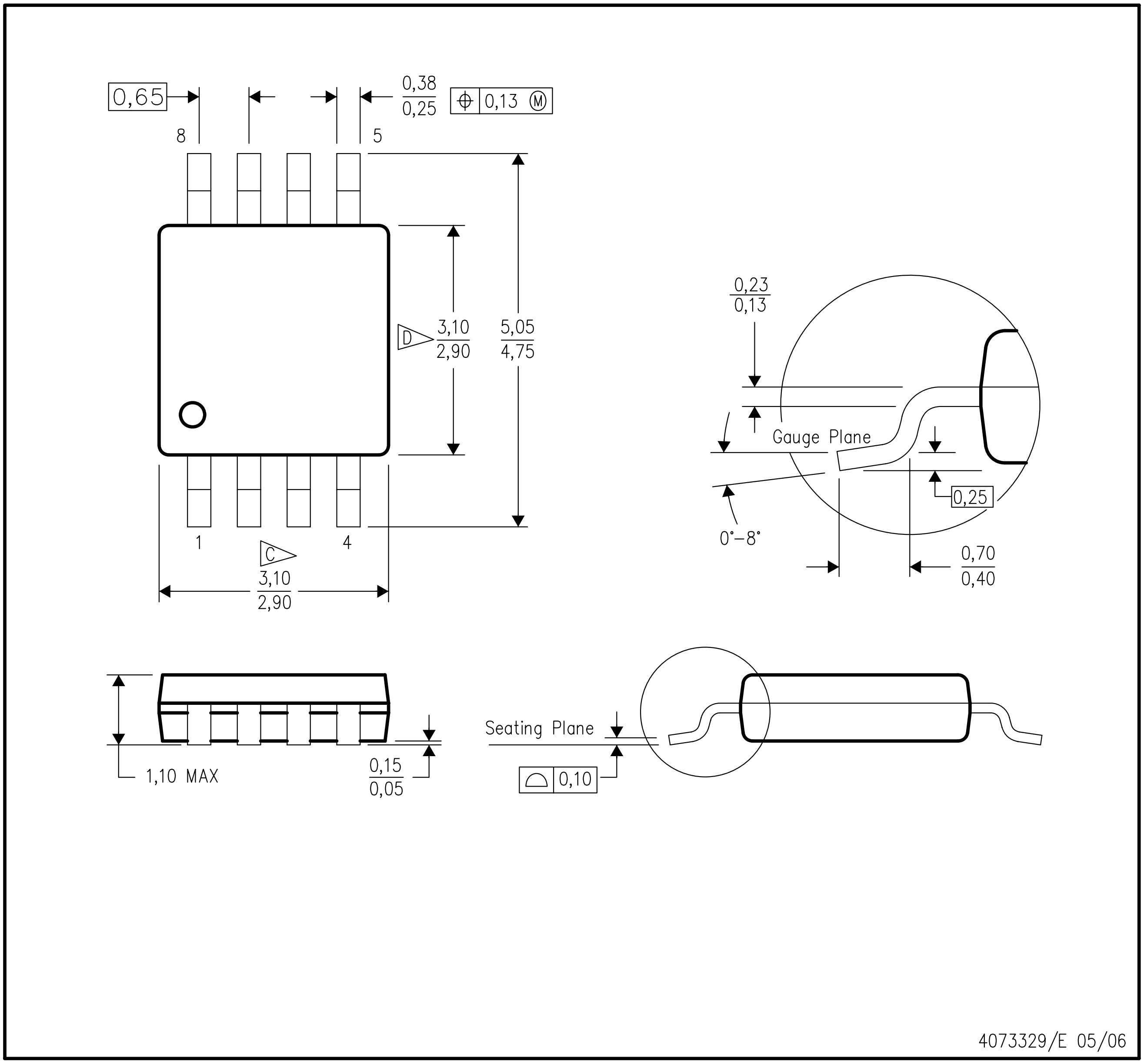
P (R-PDIP-T8) PLASTIC DUAL-IN-LINE PACKAGE



4040082/E 04/2010

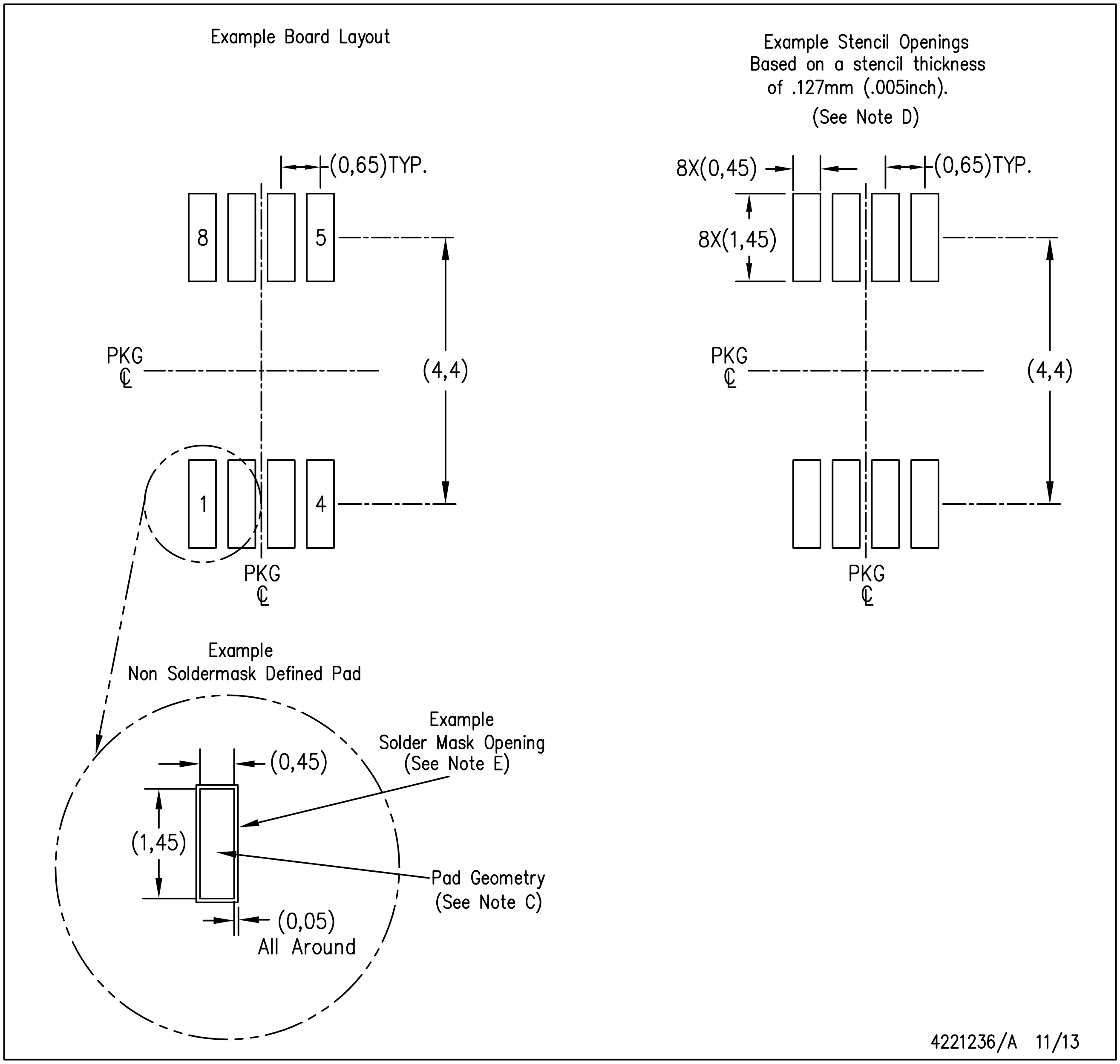
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001 variation BA.

DGK (S-PDSO-G8) PLASTIC SMALL-OUTLINE PACKAGE

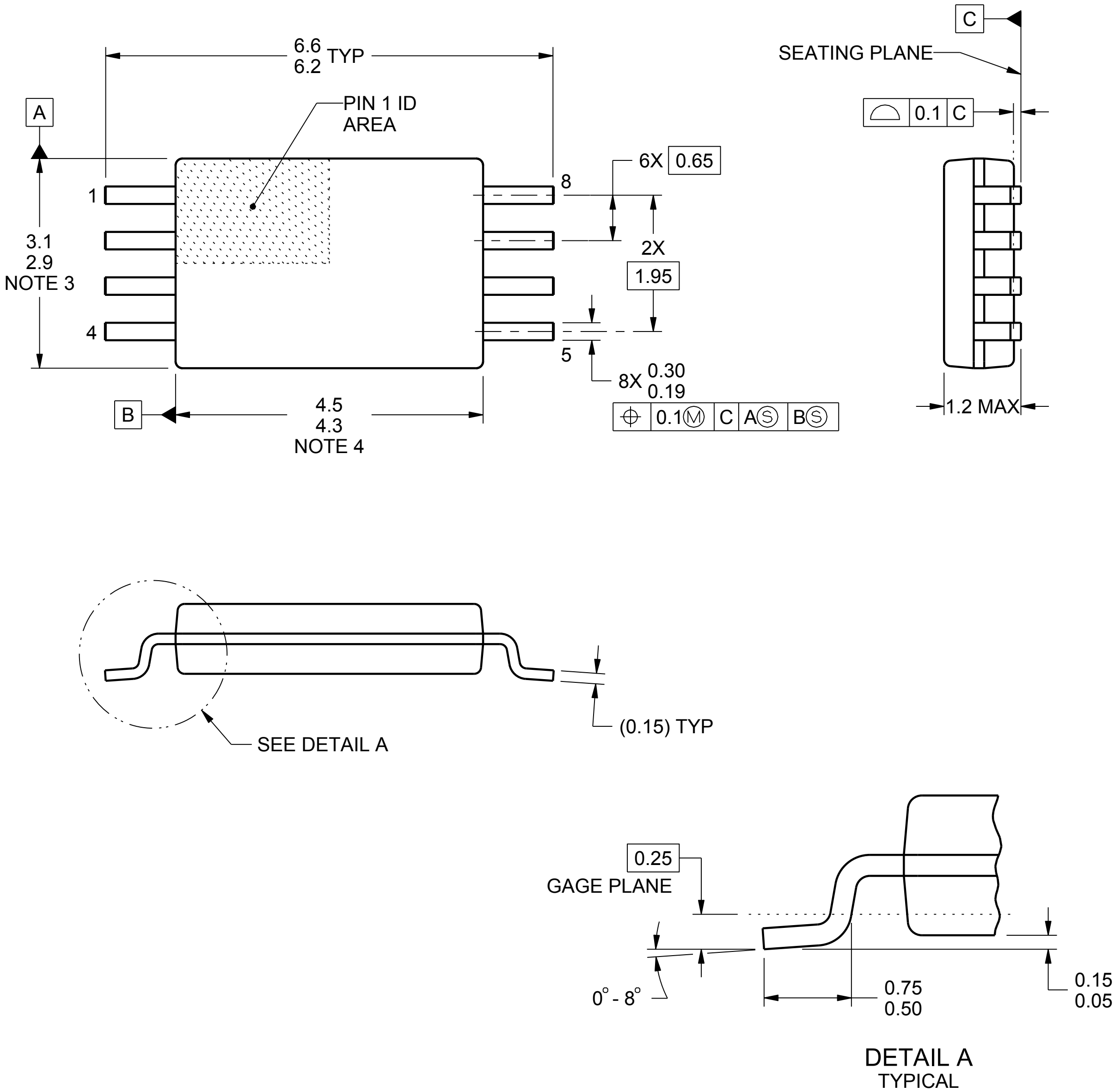


NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
E. Falls within JEDEC MO-187 variation AA, except interlead flash.

DGK (S-PDSO-G8) PLASTIC SMALL OUTLINE PACKAGE



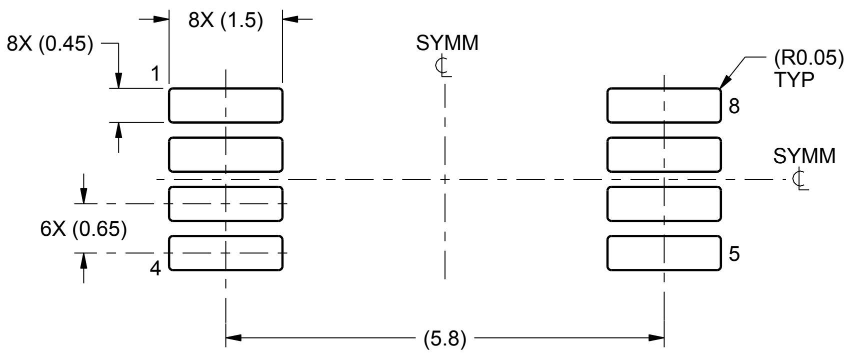
NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
- E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.



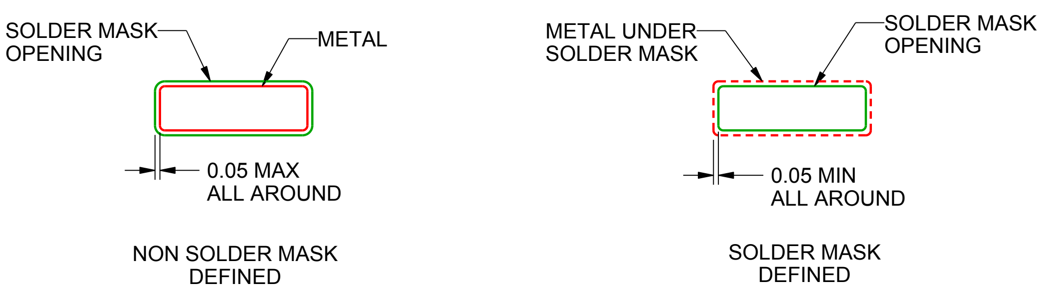
4221848/A 02/2015

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153, variation AA.



LAND PATTERN EXAMPLE
SCALE:10X

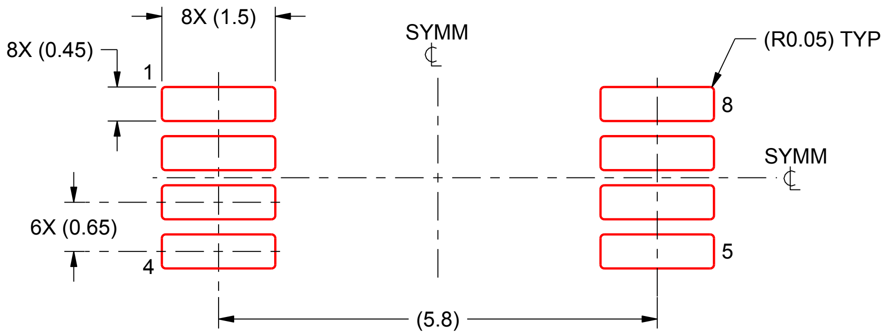


SOLDER MASK DETAILS
NOT TO SCALE

4221848/A 02/2015

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:10X

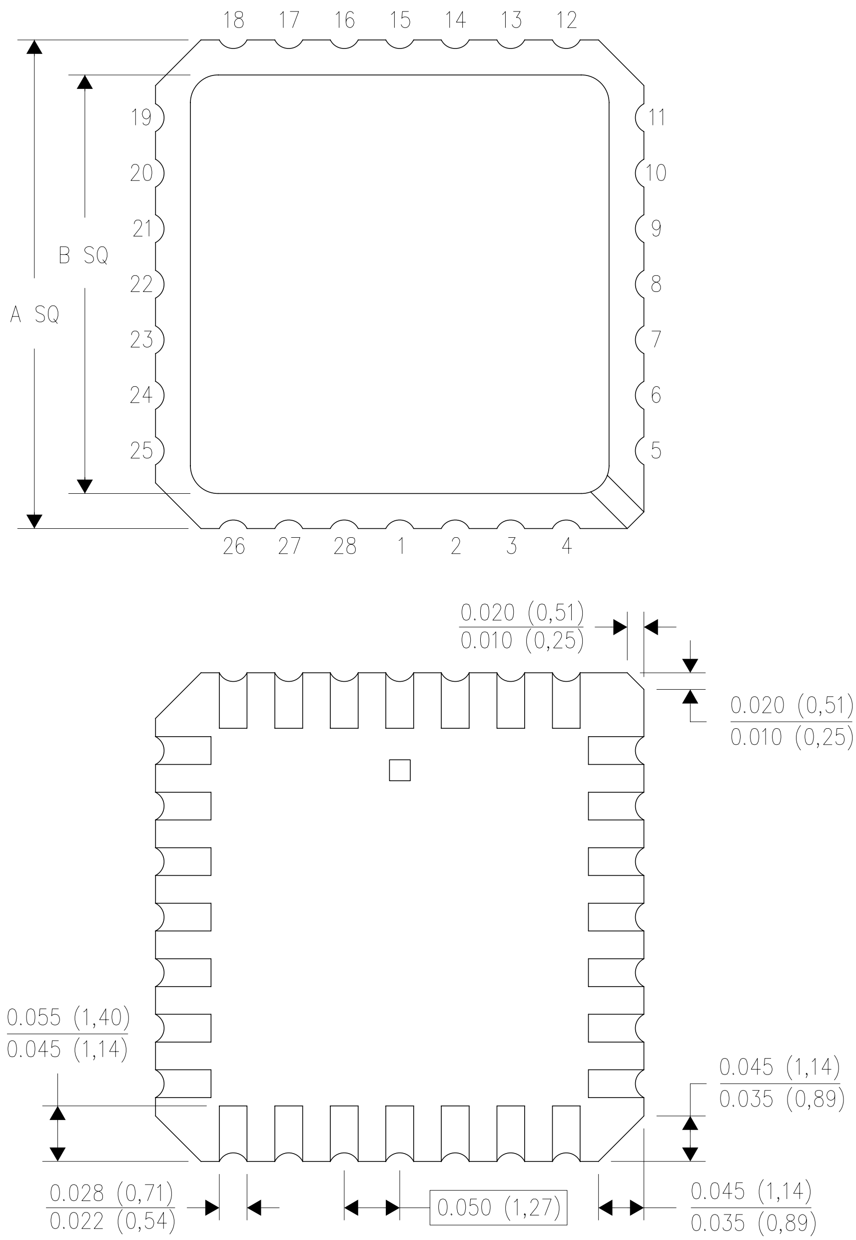
4221848/A 02/2015

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

FK (S-CQCC-N**) LEADLESS CERAMIC CHIP CARRIER

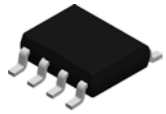
28 TERMINAL SHOWN



NO. OF TERMINALS **	A		B	
	MIN	MAX	MIN	MAX
20	0.342 (8,69)	0.358 (9,09)	0.307 (7,80)	0.358 (9,09)
28	0.442 (11,23)	0.458 (11,63)	0.406 (10,31)	0.458 (11,63)
44	0.640 (16,26)	0.660 (16,76)	0.495 (12,58)	0.560 (14,22)
52	0.740 (18,78)	0.761 (19,32)	0.495 (12,58)	0.560 (14,22)
68	0.938 (23,83)	0.962 (24,43)	0.850 (21,6)	0.858 (21,8)
84	1.141 (28,99)	1.165 (29,59)	1.047 (26,6)	1.063 (27,0)

4040140/D 01/11

NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. This package can be hermetically sealed with a metal lid.
- D. Falls within JEDEC MS-004

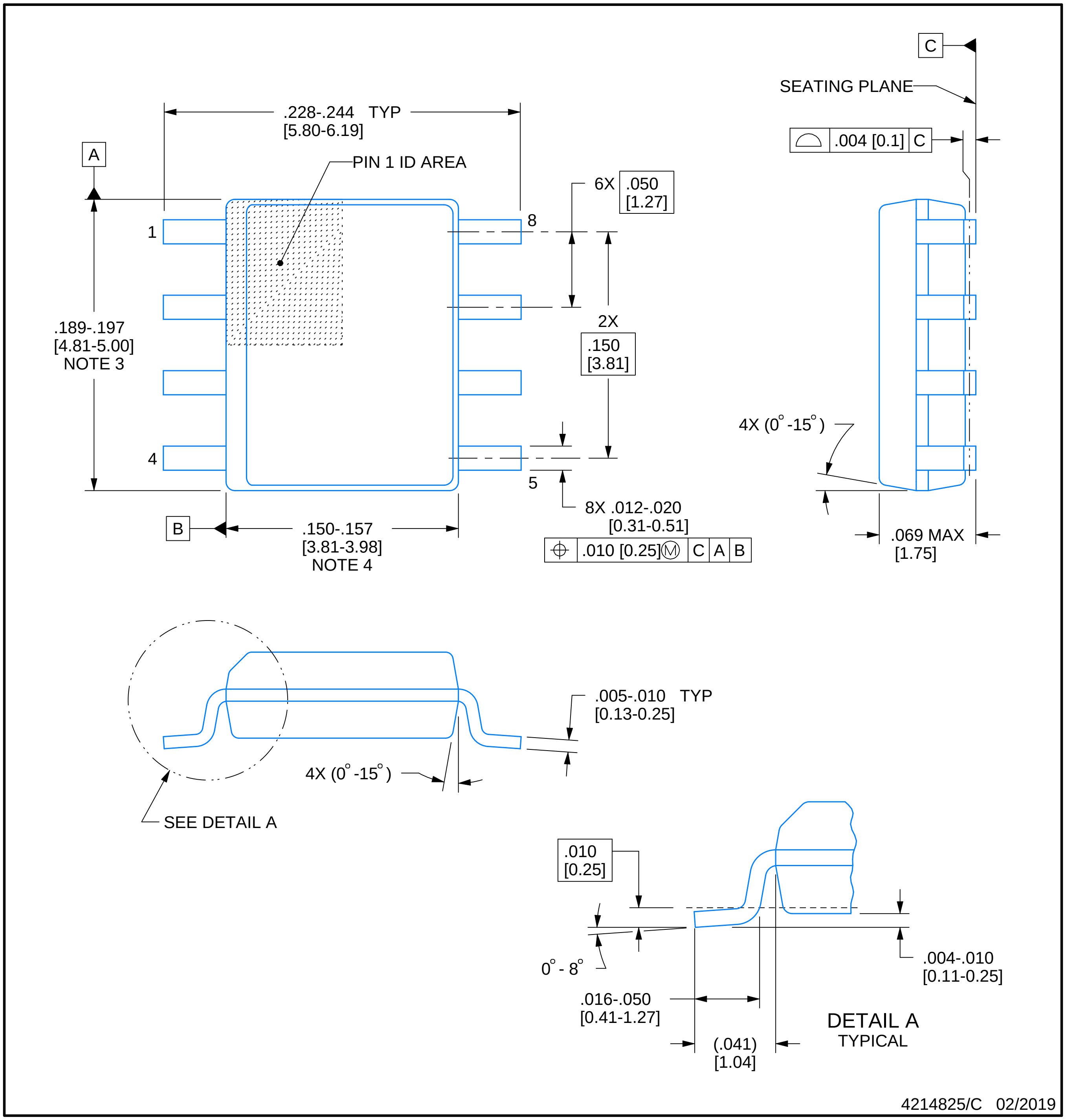


PACKAGE OUTLINE

D0008A

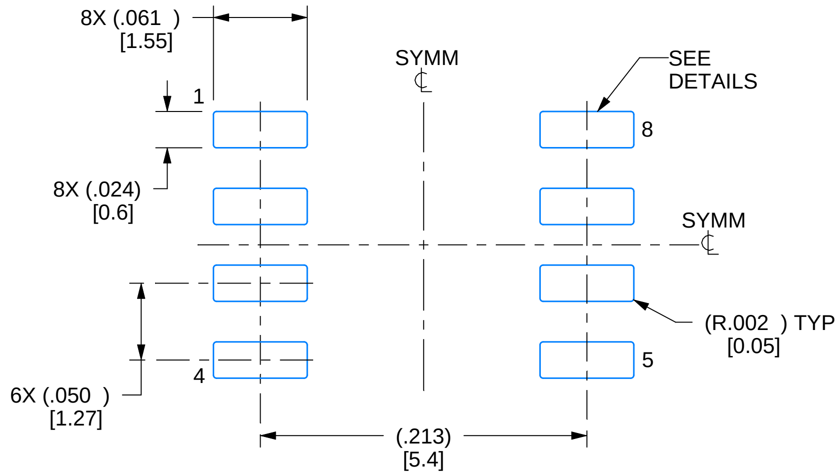
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

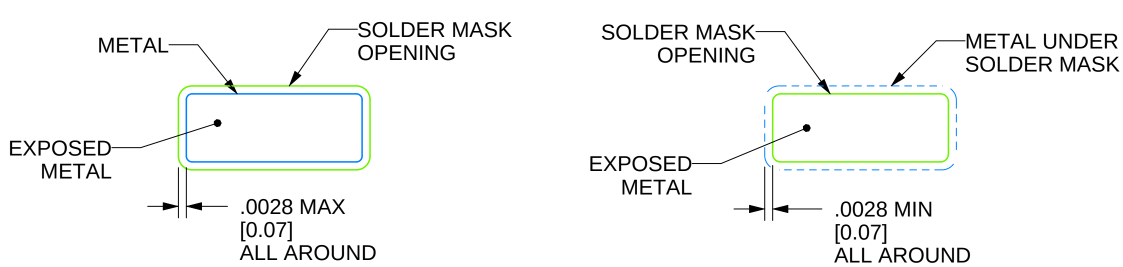


NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



NON SOLDER MASK DEFINED

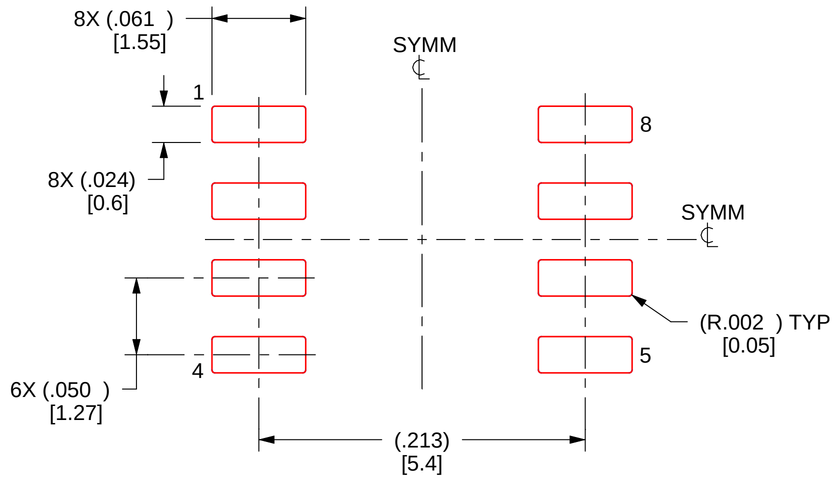
SOLDER MASK DEFINED

SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



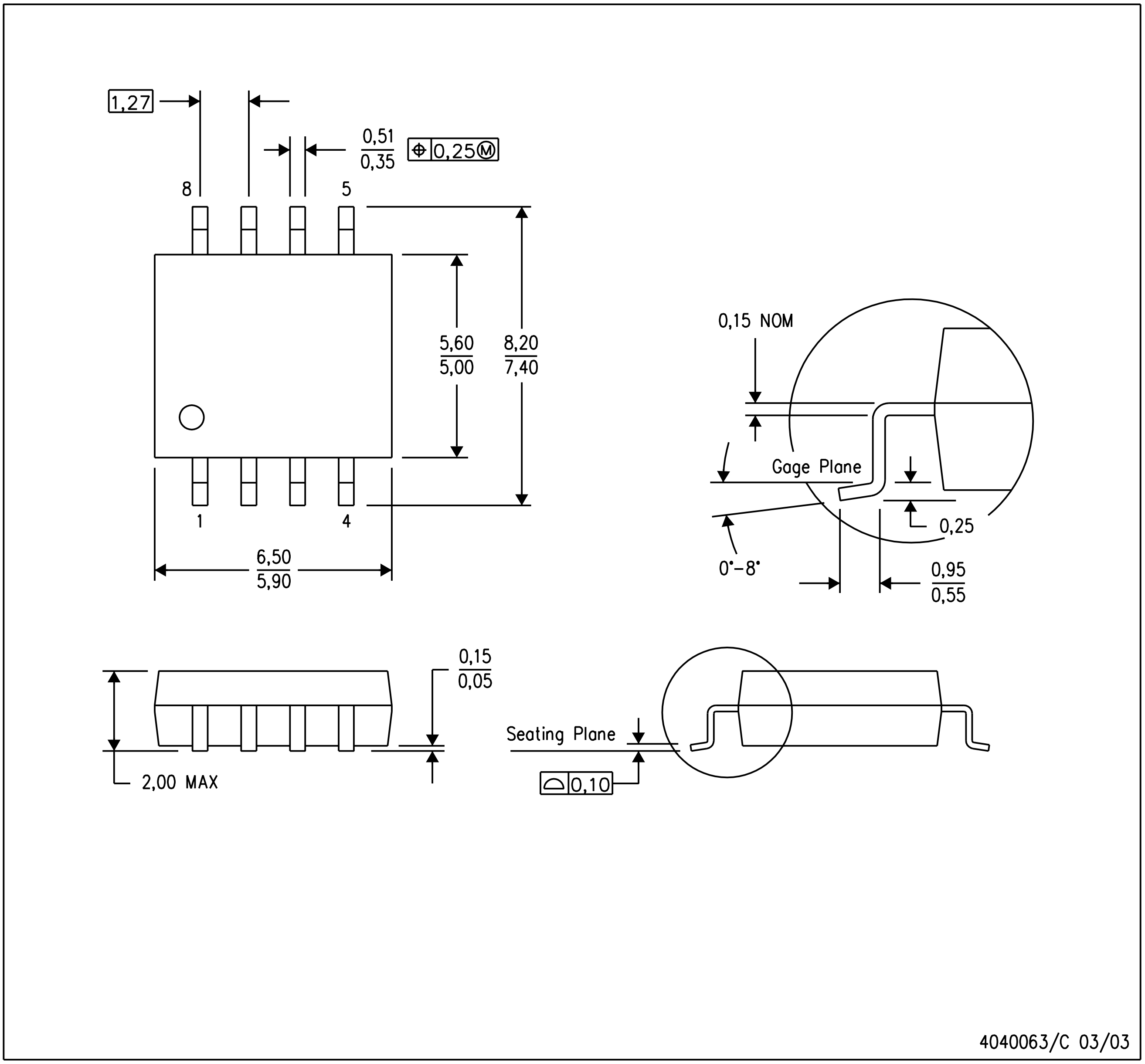
SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

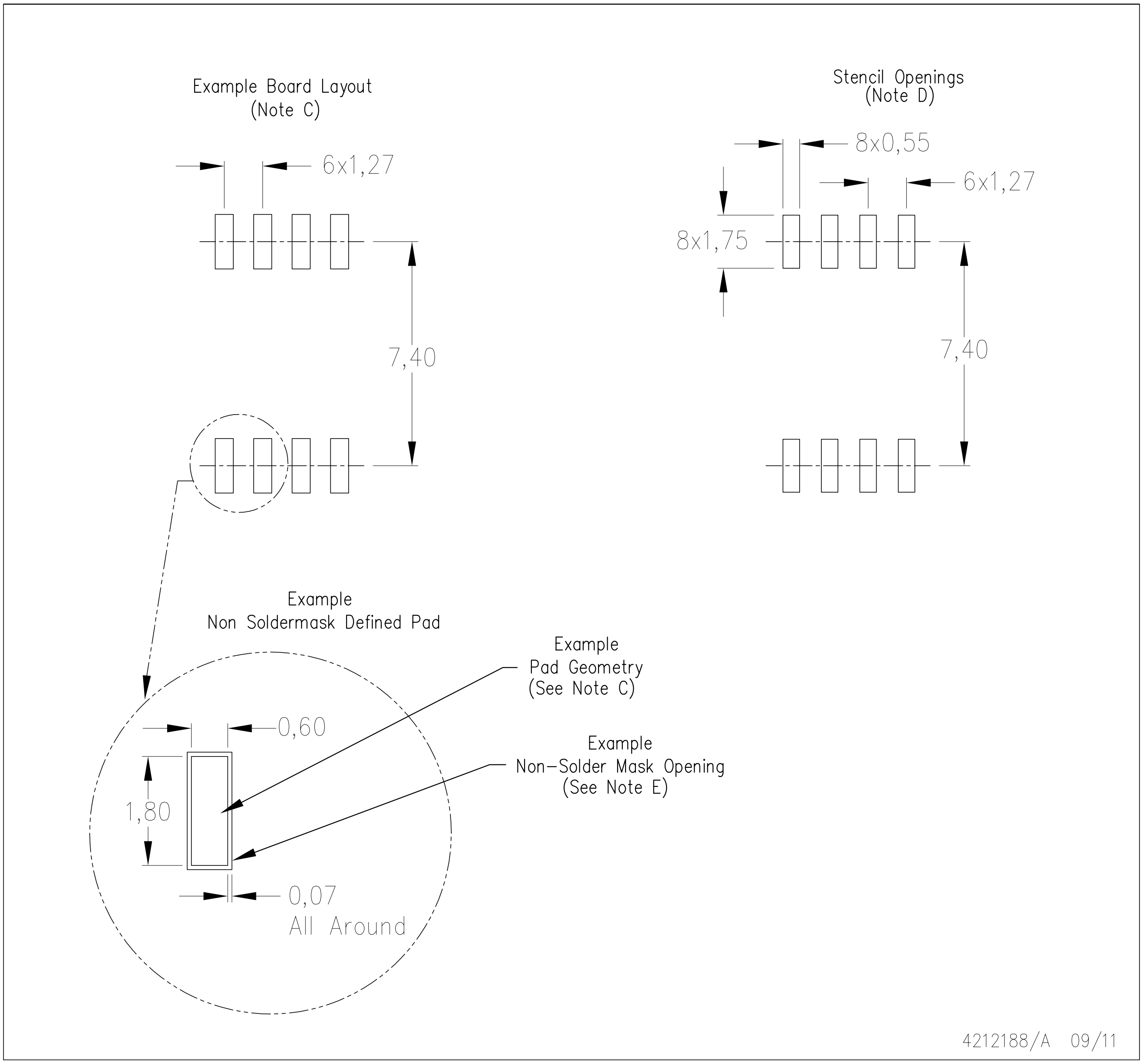
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

PS (R-PDSO-G8) **PLASTIC SMALL-OUTLINE PACKAGE**



NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

PS (R-PDSO-G8) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC-7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

IMPORTANT NOTICE AND DISCLAIMER

ESP32 Series

Datasheet

Including:

- ESP32-D0WD-V3
- ESP32-D0WDQ6-V3
- ESP32-D0WD
- ESP32-D0WDQ6
- ESP32-D2WD
- ESP32-S0WD
- ESP32-U4WDH

Version 3.6
Espressif Systems

About This Guide

This document provides the specifications of ESP32 family of chips.

Document Updates

Please always refer to the latest version on https://www.espressif.com/en/support/download/documents.

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1 Overview

ESP32 is a single 2.4 GHz Wi-Fi-and-Bluetooth combo chip designed with the TSMC ultra-low-power 40 nm technology. It is designed to achieve the best power and RF performance, showing robustness, versatility and reliability in a wide variety of applications and power scenarios.

The ESP32 series of chips includes ESP32-D0WD-V3, ESP32-D0WDQ6-V3, ESP32-D0WD, ESP32-D0WDQ6, ESP32-D2WD, ESP32-S0WD, and ESP32-U4WDH, among which, ESP32-D0WD-V3, ESP32-D0WDQ6-V3, and ESP32-U4WDH are based on ECO V3 wafer.

For details on part numbers and ordering information, please refer to Section 7.

For details on ECO V3 instructions, please refer to *ESP32 ECO V3 User Guide*.

1.1 Featured Solutions

1.1.1 Ultra-Low-Power Solution

ESP32 is designed for mobile, wearable electronics, and Internet-of-Things (IoT) applications. It features all the state-of-the-art characteristics of low-power chips, including fine-grained clock gating, multiple power modes, and dynamic power scaling. For instance, in a low-power IoT sensor hub application scenario, ESP32 is woken up periodically and only when a specified condition is detected. Low-duty cycle is used to minimize the amount of energy that the chip expends. The output of the power amplifier is also adjustable, thus contributing to an optimal trade-off between communication range, data rate and power consumption.

Note:
For more information, refer to Section 3.7 *RTC and Low-Power Management*.

1.1.2 Complete Integration Solution

ESP32 is a highly-integrated solution for Wi-Fi-and-Bluetooth IoT applications, with around 20 external components. ESP32 integrates an antenna switch, RF balun, power amplifier, low-noise receive amplifier, filters, and power management modules. As such, the entire solution occupies minimal Printed Circuit Board (PCB) area.

ESP32 uses CMOS for single-chip fully-integrated radio and baseband, while also integrating advanced calibration circuitries that allow the solution to remove external circuit imperfections or adjust to changes in external conditions. As such, the mass production of ESP32 solutions does not require expensive and specialized Wi-Fi testing equipment.

1.2 Wi-Fi Key Features

- 802.11 b/g/n
- 802.11 n (2.4 GHz), up to 150 Mbps
- WMM
- TX/RX A-MPDU, RX A-MSDU
- Immediate Block ACK

- Defragmentation
- Automatic Beacon monitoring (hardware TSF)
- 4 × virtual Wi-Fi interfaces
- Simultaneous support for Infrastructure Station, SoftAP, and Promiscuous modes
  Note that when ESP32 is in Station mode, performing a scan, the SoftAP channel will be changed.
- Antenna diversity

Note:
For more information, please refer to Section 3.5 *Wi-Fi*.

1.3 BT Key Features

- Compliant with Bluetooth v4.2 BR/EDR and BLE specifications
- Class-1, class-2 and class-3 transmitter without external power amplifier
- Enhanced Power Control
- +12 dBm transmitting power
- NZIF receiver with –94 dBm BLE sensitivity
- Adaptive Frequency Hopping (AFH)
- Standard HCI based on SDIO/SPI/UART
- High-speed UART HCI, up to 4 Mbps
- Bluetooth 4.2 BR/EDR BLE dual mode controller
- Synchronous Connection-Oriented/Extended (SCO/eSCO)
- CVSD and SBC for audio codec
- Bluetooth Piconet and Scatternet
- Multi-connections in Classic BT and BLE
- Simultaneous advertising and scanning

1.4 MCU and Advanced Features

1.4.1 CPU and Memory

- Xtensa® single-/dual-core 32-bit LX6 microprocessor(s), up to 600 MIPS (200 MIPS for ESP32-S0WD/ESP32-U4WDH, 400 MIPS for ESP32-D2WD)
- 448 KB ROM
- 520 KB SRAM
- 16 KB SRAM in RTC
- QSPI supports multiple flash/SRAM chips

1.4.2 Clocks and Timers

- Internal 8 MHz oscillator with calibration
- Internal RC oscillator with calibration
- External 2 MHz ~ 60 MHz crystal oscillator (40 MHz only for Wi-Fi/BT functionality)
- External 32 kHz crystal oscillator for RTC with calibration
- Two timer groups, including 2 × 64-bit timers and 1 × main watchdog in each group
- One RTC timer
- RTC watchdog

1.4.3 Advanced Peripheral Interfaces

- 34 × programmable GPIOs
- 12-bit SAR ADC up to 18 channels
- 2 × 8-bit DAC
- 10 × touch sensors
- 4 × SPI
- 2 × I^2S
- 2 × I^2C
- 3 × UART
- 1 host (SD/eMMC/SDIO)
- 1 slave (SDIO/SPI)
- Ethernet MAC interface with dedicated DMA and IEEE 1588 support
- Two-Wire Automotive Interface (TWAI®, compatible with ISO11898-1)
- IR (TX/RX)
- Motor PWM
- LED PWM up to 16 channels
- Hall sensor

1.4.4 Security

- Secure boot
- Flash encryption
- 1024-bit OTP, up to 768-bit for customers
- Cryptographic hardware acceleration:
  - AES
  - Hash (SHA-2)

- RSA
- ECC
- Random Number Generator (RNG)

1.5 Applications (A Non-exhaustive List)

- Generic Low-power IoT Sensor Hub
- Generic Low-power IoT Data Loggers
- Cameras for Video Streaming
- Over-the-top (OTT) Devices
- Speech Recognition
- Image Recognition
- Mesh Network
- Home Automation
  - Light control
  - Smart plugs
  - Smart door locks
- Smart Building
  - Smart lighting
  - Energy monitoring
- Industrial Automation
  - Industrial wireless control
  - Industrial robotics
- Smart Agriculture
  - Smart greenhouses
  - Smart irrigation
  - Agriculture robotics
- Audio Applications
  - Internet music players
  - Live streaming devices
  - Internet radio players
  - Audio headsets
- Health Care Applications
  - Health monitoring
  - Baby monitors
- Wi-Fi-enabled Toys
  - Remote control toys
  - Proximity sensing toys
  - Educational toys
- Wearable Electronics
  - Smart watches
  - Smart bracelets
- Retail & Catering Applications
  - POS machines
  - Service robots

1.6 Block Diagram

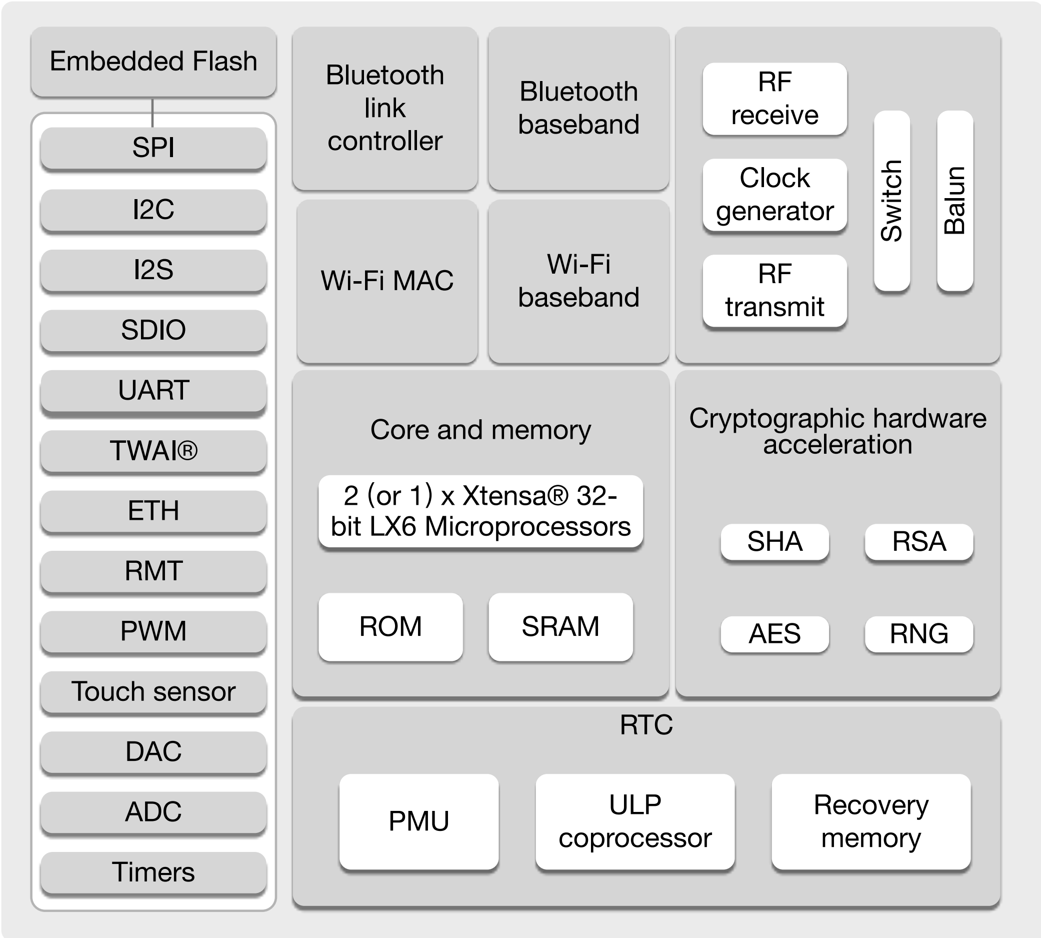


Figure 1: Functional Block Diagram

> **Note:**
> Products in the ESP32 series differ from each other in terms of their support for embedded flash and the number of CPUs they have. For details, please refer to Section *7 Part Number and Ordering Information*.

2 Pin Definitions

2.1 Pin Layout

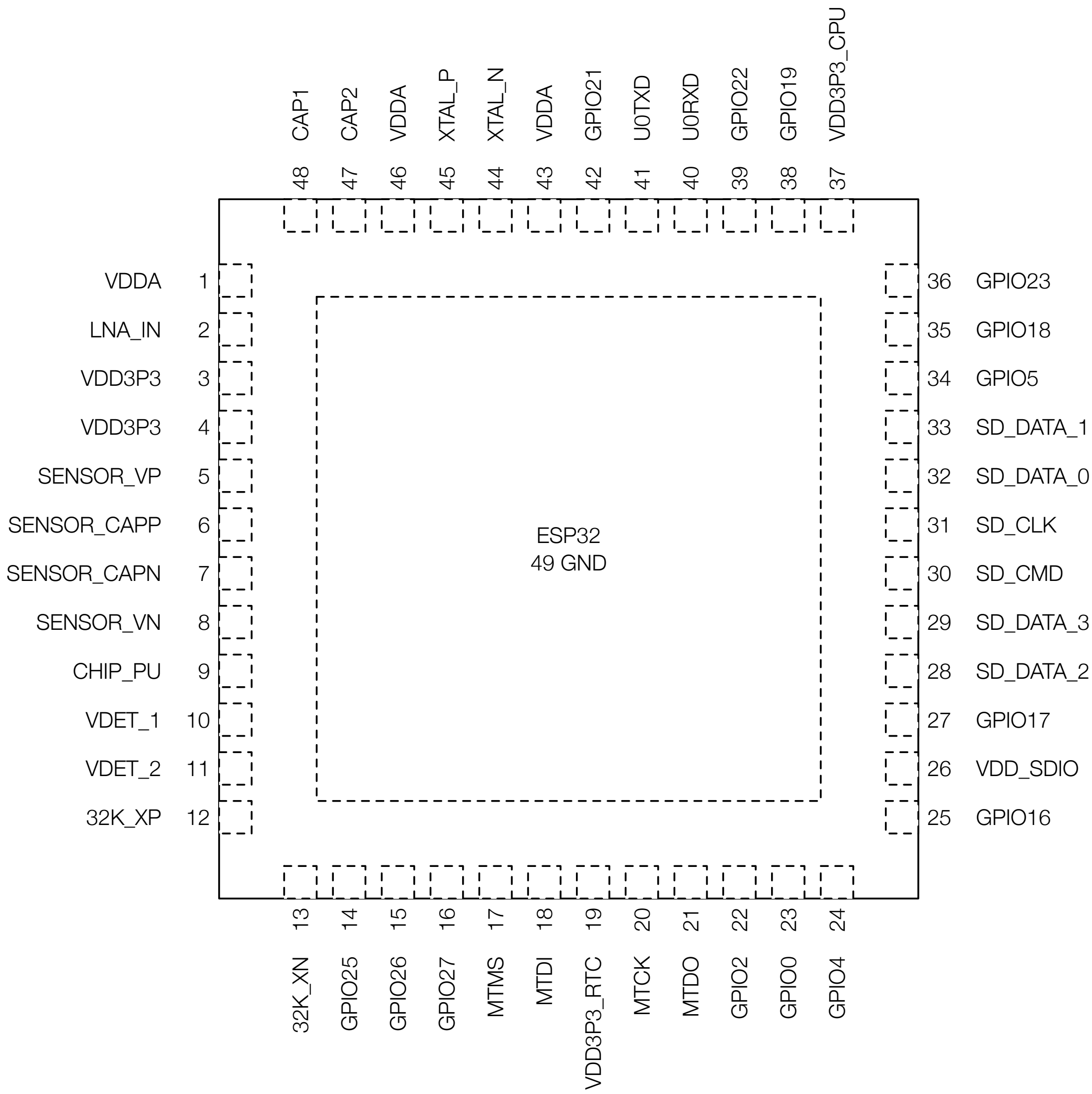


Figure 2: ESP32 Pin Layout (QFN 6*6, Top View)

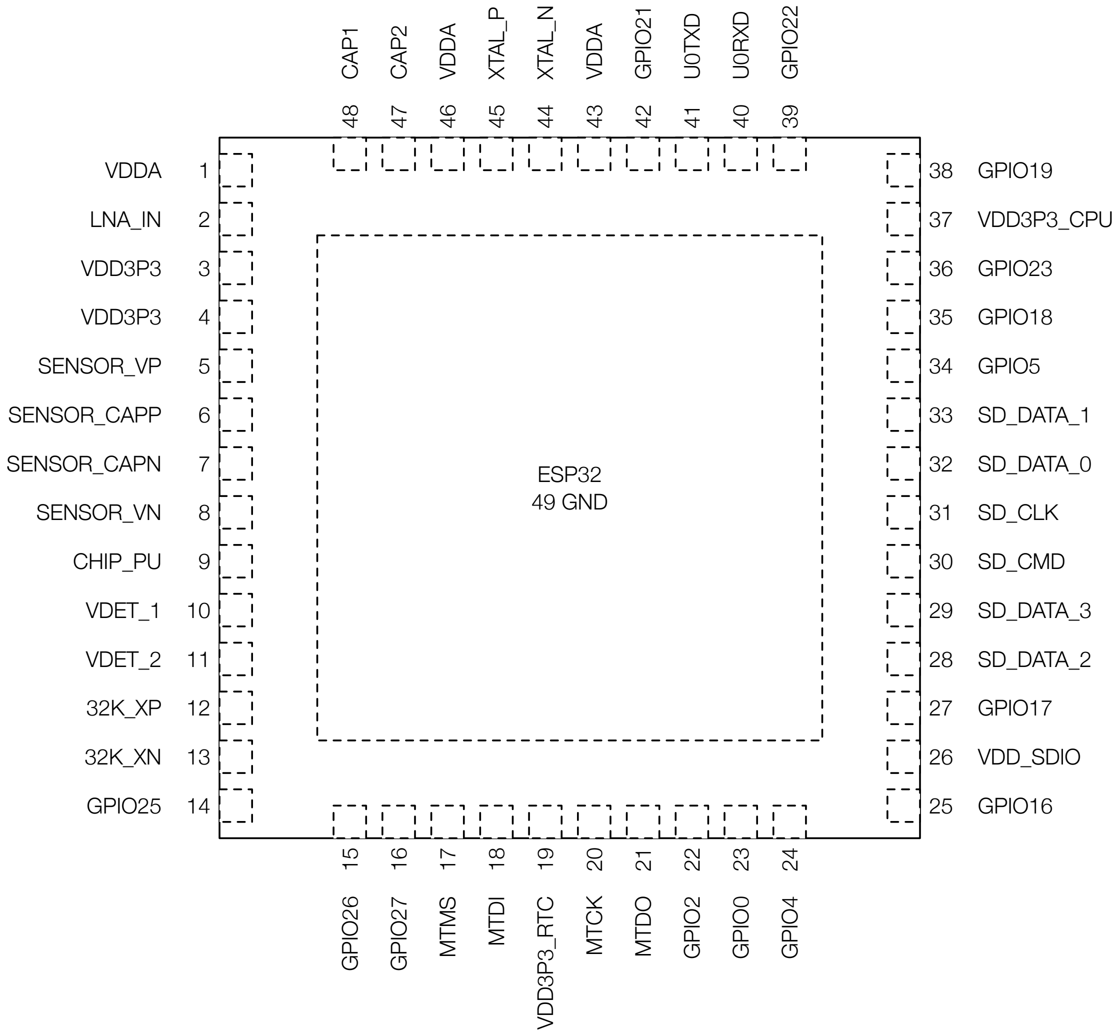


Figure 3: ESP32 Pin Layout (QFN 5*5, Top View)

Note:

For details on ESP32's part numbers and the corresponding packaging, please refer to Section 7 *Part Number and Ordering Information*.

2.2 Pin Description

Table 1: Pin Description

Name	No.	Type	Function
Analog			
VDDA	1	P	Analog power supply (2.3 V ~ 3.6 V)
LNA_IN	2	I/O	RF input and output
VDD3P3	3	P	Analog power supply (2.3 V ~ 3.6 V)
VDD3P3	4	P	Analog power supply (2.3 V ~ 3.6 V)
VDD3P3_RTC			
SENSOR_VP	5	I	GPIO36, ADC1_CH0, RTC_GPIO0
SENSOR_CAPP	6	I	GPIO37, ADC1_CH1, RTC_GPIO1
SENSOR_CAPN	7	I	GPIO38, ADC1_CH2, RTC_GPIO2
SENSOR_VN	8	I	GPIO39, ADC1_CH3, RTC_GPIO3
CHIP_PU	9	I	High: On; enables the chip Low: Off; the chip powers off Note: Do not leave the CHIP_PU pin floating.
VDET_1	10	I	GPIO34, ADC1_CH6, RTC_GPIO4
VDET_2	11	I	GPIO35, ADC1_CH7, RTC_GPIO5
32K_XP	12	I/O	GPIO32, ADC1_CH4, RTC_GPIO9, TOUCH9, 32K_XP (32.768 kHz crystal oscillator input)
32K_XN	13	I/O	GPIO33, ADC1_CH5, RTC_GPIO8, TOUCH8, 32K_XN (32.768 kHz crystal oscillator output)
GPIO25	14	I/O	GPIO25, ADC2_CH8, RTC_GPIO6, DAC_1, EMAC_RXD0
GPIO26	15	I/O	GPIO26, ADC2_CH9, RTC_GPIO7, DAC_2, EMAC_RXD1
GPIO27	16	I/O	GPIO27, ADC2_CH7, RTC_GPIO17, TOUCH7, EMAC_RX_DV
MTMS	17	I/O	GPIO14, ADC2_CH6, RTC_GPIO16, TOUCH6, EMAC_TXD2, HSPICLK, HS2_CLK, SD_CLK, MTMS
MTDI	18	I/O	GPIO12, ADC2_CH5, RTC_GPIO15, TOUCH5, EMAC_TXD3, HSPIQ, HS2_DATA2, SD_DATA2, MTDI
VDD3P3_RTC	19	P	Input power supply for RTC IO (2.3 V ~ 3.6 V)
MTCK	20	I/O	GPIO13, ADC2_CH4, RTC_GPIO14, TOUCH4, EMAC_RX_ER, HSPID, HS2_DATA3, SD_DATA3, MTCK
MTDO	21	I/O	GPIO15, ADC2_CH3, RTC_GPIO13, TOUCH3, EMAC_RXD3, HSPICS0, HS2_CMD, SD_CMD, MTDO

Name	No.	Type	Function
GPIO2	22	I/O	GPIO2, ADC2_CH2, RTC_GPIO12, TOUCH2, HSPIWP, HS2_DATA0, SD_DATA0
GPIO0	23	I/O	GPIO0, ADC2_CH1, RTC_GPIO11, TOUCH1, EMAC_TX_CLK, CLK_OUT1,
GPIO4	24	I/O	GPIO4, ADC2_CH0, RTC_GPIO10, TOUCH0, EMAC_TX_ER, HSPIHD, HS2_DATA1, SD_DATA1
VDD_SDIO			
GPIO16	25	I/O	GPIO16, HS1_DATA4, U2RXD, EMAC_CLK_OUT
VDD_SDIO	26	P	Output power supply: 1.8 V or the same voltage as VDD3P3_RTC
GPIO17	27	I/O	GPIO17, HS1_DATA5, U2TXD, EMAC_CLK_OUT_180
SD_DATA_2	28	I/O	GPIO9, HS1_DATA2, U1RXD, SD_DATA2, SPIHD
SD_DATA_3	29	I/O	GPIO10, HS1_DATA3, U1TXD, SD_DATA3, SPIWP
SD_CMD	30	I/O	GPIO11, HS1_CMD, U1RTS, SD_CMD, SPICS0
SD_CLK	31	I/O	GPIO6, HS1_CLK, U1CTS, SD_CLK, SPICLK
SD_DATA_0	32	I/O	GPIO7, HS1_DATA0, U2RTS, SD_DATA0, SPIQ
SD_DATA_1	33	I/O	GPIO8, HS1_DATA1, U2CTS, SD_DATA1, SPID
VDD3P3_CPU			
GPIO5	34	I/O	GPIO5, HS1_DATA6, VSPICS0, EMAC_RX_CLK
GPIO18	35	I/O	GPIO18, HS1_DATA7, VSPICLK
GPIO23	36	I/O	GPIO23, HS1_STROBE, VSPID
VDD3P3_CPU	37	P	Input power supply for CPU IO (1.8 V $\sim$ 3.6 V)
GPIO19	38	I/O	GPIO19, U0CTS, VSPIQ, EMAC_TXD0
GPIO22	39	I/O	GPIO22, U0RTS, VSPIWP, EMAC_TXD1
U0RXD	40	I/O	GPIO3, U0RXD, CLK_OUT2
U0TXD	41	I/O	GPIO1, U0TXD, CLK_OUT3, EMAC_RXD2
GPIO21	42	I/O	GPIO21, VSPIHD, EMAC_TX_EN
Analog			
VDDA	43	P	Analog power supply (2.3 V $\sim$ 3.6 V)
XTAL_N	44	O	External crystal output
XTAL_P	45	I	External crystal input
VDDA	46	P	Analog power supply (2.3 V $\sim$ 3.6 V)
CAP2	47	I	Connects to a 3.3 nF (10%) capacitor and 20 kΩ resistor in parallel to CAP1

Name	No.	Type	Function
CAP1	48	I	Connects to a 10 nF series capacitor to ground
GND	49	P	Ground

Note:

- The pin-pin mapping between ESP32-D2WD/ESP32-U4WDH and the embedded flash is as follows: GPIO16 = CS#, GPIO17 = IO1/DO, SD_CMD = IO3/HOLD#, SD_CLK = CLK, SD_DATA_0 = IO2/WP#, SD_DATA_1 = IO0/DI. The pins used for embedded flash are not recommended for other uses.
- In most cases, the data port connection between ESP32 series of chips other than ESP32-D2WD/ESP32-U4WDH and external flash is as follows: SD_DATA0/SPIQ = IO1/DO, SD_DATA1/SPID = IO0/DI, SD_DATA2/SPIHD = IO3/HOLD#, SD_DATA3/SPIWP = IO2/WP#.
- For a quick reference guide to using the IO_MUX, Ethernet MAC, and GIPO Matrix pins of ESP32, please refer to Appendix *ESP32 Pin Lists*.

2.3 Power Scheme

ESP32's digital pins are divided into three different power domains:

- VDD3P3_RTC
- VDD3P3_CPU
- VDD_SDIO

VDD3P3_RTC is also the input power supply for RTC and CPU.

VDD3P3_CPU is also the input power supply for CPU.

VDD_SDIO connects to the output of an internal LDO whose input is VDD3P3_RTC. When VDD_SDIO is connected to the same PCB net together with VDD3P3_RTC, the internal LDO is disabled automatically. The power scheme diagram is shown below:

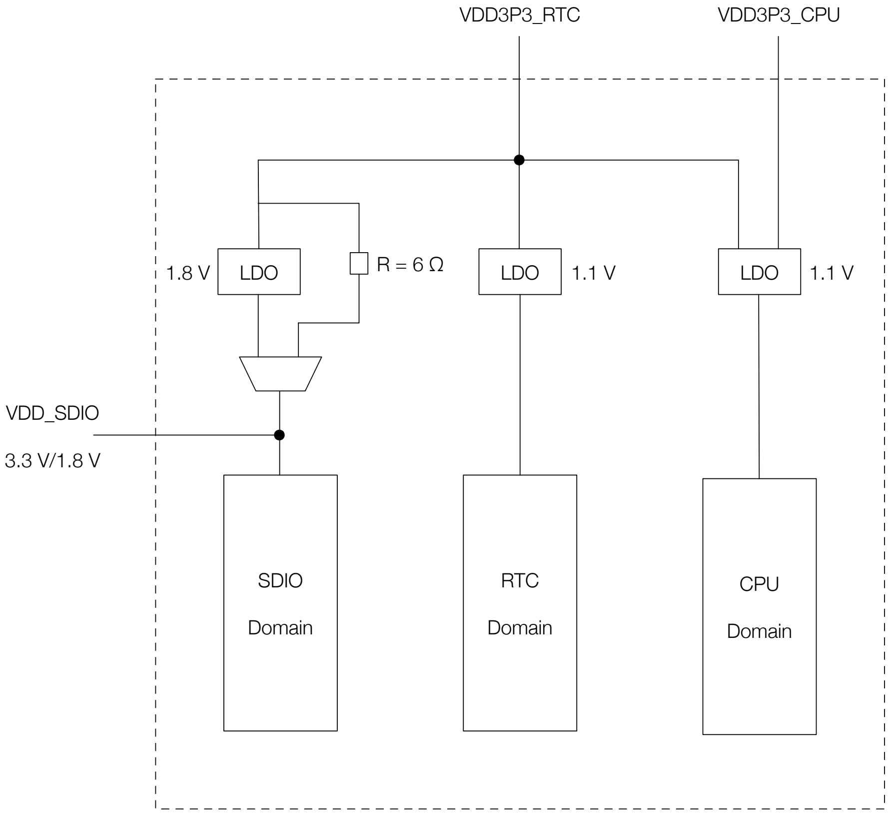


Figure 4: ESP32 Power Scheme

The internal LDO can be configured as having 1.8 V, or the same voltage as VDD3P3_RTC. It can be powered off via software to minimize the current of flash/SRAM during the Deep-sleep mode.

Notes on CHIP_PU:

- The illustration below shows the ESP32 power-up and reset timing. Details about the parameters are listed in Table 2.

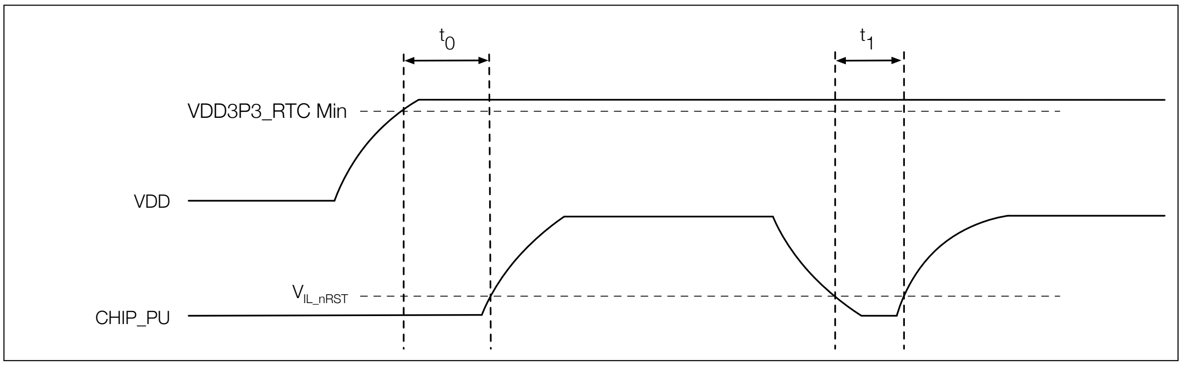


Figure 5: ESP32 Power-up and Reset Timing

Table 2: Description of ESP32 Power-up and Reset Timing Parameters

Parameters	Description	Min.	Unit
t_0	Time between the 3.3 V rails being brought up and CHIP_PU being activated	50	μs
t_1	Duration of CHIP_PU signal level < V_{IL_nRST} (refer to its value in Table 13 DC Characteristics) to reset the chip	50	μs

- In scenarios where ESP32 is powered on and off repeatedly by switching the power rails, while there is a large capacitor on the VDD33 rail and CHIP_PU and VDD33 are connected, simply switching off the CHIP_PU power rail and immediately switching it back on may cause an incomplete power discharge cycle and failure to reset the chip adequately.
  An additional discharge circuit may be required to accelerate the discharge of the large capacitor on rail VDD33, which will ensure proper power-on-reset when the ESP32 is powered up again.
- When a battery is used as the power supply for the ESP32 series of chips and modules, a supply voltage supervisor is recommended, so that a boot failure due to low voltage is avoided. Users are recommended to pull CHIP_PU low if the power supply for ESP32 is below 2.3 V.

Notes on power supply:

- The operating voltage of ESP32 ranges from 2.3 V to 3.6 V. When using a single-power supply, the recommended voltage of the power supply is 3.3 V, and its recommended output current is 500 mA or more.
- When VDD_SDIO 1.8 V is used as the power supply for external flash/PSRAM, a 2 kΩ grounding resistor should be added to VDD_SDIO. For the circuit design, please refer to Figure **ESP32-WROVER Schematics**, in *ESP32-WROVER Datasheet*.
- When the three digital power supplies are used to drive peripherals, e.g., 3.3 V flash, they should comply with the peripherals' specifications.

2.4 Strapping Pins

There are five strapping pins:

- MTDI
- GPIO0
- GPIO2

- MTDO
- GPIO5

Software can read the values of these five bits from register ”GPIO_STRAPPING”.

During the chip’s system reset release (power-on-reset, RTC watchdog reset and brownout reset), the latches of the strapping pins sample the voltage level as strapping bits of ”0” or ”1”, and hold these bits until the chip is powered down or shut down. The strapping bits configure the device’s boot mode, the operating voltage of VDD_SDIO and other initial system settings.

Each strapping pin is connected to its internal pull-up/pull-down during the chip reset. Consequently, if a strapping pin is unconnected or the connected external circuit is high-impedance, the internal weak pull-up/pull-down will determine the default input level of the strapping pins.

To change the strapping bit values, users can apply the external pull-down/pull-up resistances, or use the host MCU’s GPIOs to control the voltage level of these pins when powering on the chip.

After reset release, the strapping pins work as normal-function pins.

Refer to Table 3 for a detailed boot-mode configuration by strapping pins.

Table 3: Strapping Pins

Voltage of Internal LDO (VDD_SDIO)					
Pin	Default	3.3 V		1.8 V	
MTDI	Pull-down	0		1	
Booting Mode					
Pin	Default	SPI Boot		Download Boot	
GPIO0	Pull-up	1		0	
GPIO2	Pull-down	Don’t-care		0	
Enabling/Disabling Debugging Log Print over U0TXD During Booting					
Pin	Default	U0TXD Active		U0TXD Silent	
MTDO	Pull-up	1		0	
Timing of SDIO Slave					
Pin	Default	FE Sampling FE Output	FE Sampling RE Output	RE Sampling FE Output	RE Sampling RE Output
MTDO	Pull-up	0	0	1	1
GPIO5	Pull-up	0	1	0	1

Note:

- FE: falling-edge, RE: rising-edge.
- Firmware can configure register bits to change the settings of “Voltage of Internal LDO (VDD_SDIO)” and “Timing of SDIO Slave”, after booting.
- For ESP32 chips that contain an embedded flash, users need to note the logic level of MTDI. For example, ESP32-D2WD contains an embedded flash that operates at 1.8 V, therefore, the MTDI should be pulled high. ESP32-U4WDH contains an embedded flash that operates at 3.3 V, therefore, the MTDI should be low.

The illustration below shows the setup and hold times for the strapping pin before and after the CHIP_PU signal goes high. Details about the parameters are listed in Table 4.

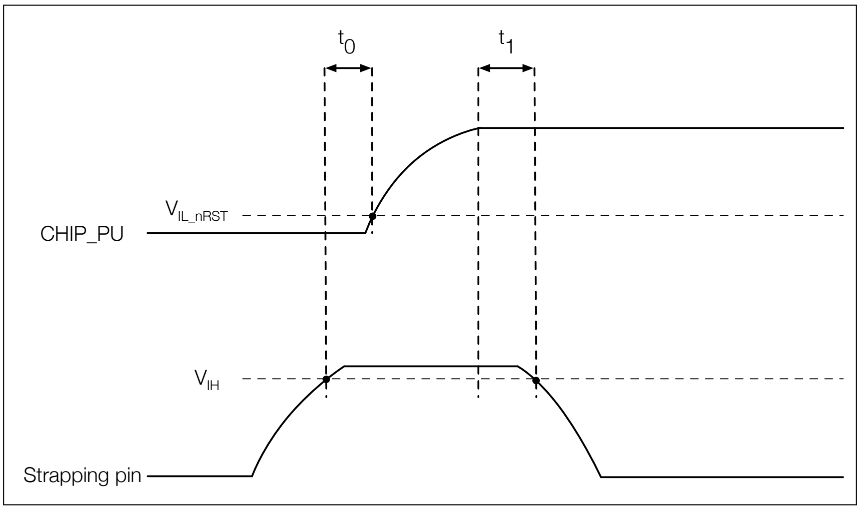


Figure 6: Setup and Hold Times for the Strapping Pin

Table 4: Parameter Descriptions of Setup and Hold Times for the Strapping Pin

Parameters	Description	Min.	Unit
t_0	Setup time before CHIP_PU goes from low to high	0	ms
t_1	Hold time after CHIP_PU goes high	1	ms

3 Functional Description

This chapter describes the functions integrated in ESP32.

3.1 CPU and Memory

3.1.1 CPU

ESP32 contains one or two low-power Xtensa® 32-bit LX6 microprocessor(s) with the following features:

- 7-stage pipeline to support the clock frequency of up to 240 MHz (160 MHz for ESP32-S0WD, ESP32-D2WD, and ESP32-U4WDH)
- 16/24-bit Instruction Set provides high code-density
- Support for Floating Point Unit
- Support for DSP instructions, such as a 32-bit multiplier, a 32-bit divider, and a 40-bit MAC
- Support for 32 interrupt vectors from about 70 interrupt sources

The single-/dual-CPU interfaces include:

- Xtensa RAM/ROM Interface for instructions and data
- Xtensa Local Memory Interface for fast peripheral register access
- External and internal interrupt sources
- JTAG for debugging

3.1.2 Internal Memory

ESP32's internal memory includes:

- 448 KB of ROM for booting and core functions
- 520 KB of on-chip SRAM for data and instructions
- 8 KB of SRAM in RTC, which is called RTC FAST Memory and can be used for data storage; it is accessed by the main CPU during RTC Boot from the Deep-sleep mode.
- 8 KB of SRAM in RTC, which is called RTC SLOW Memory and can be accessed by the co-processor during the Deep-sleep mode.
- 1 Kbit of eFuse: 256 bits are used for the system (MAC address and chip configuration) and the remaining 768 bits are reserved for customer applications, including flash-encryption and chip-ID.
- Embedded flash

Note:
Products in the ESP32 series differ from each other, in terms of their support for embedded flash and the size of it. For details, please refer to Section 7 *Part Number and Ordering Information*.

3.1.3 External Flash and SRAM

ESP32 supports multiple external QSPI flash and SRAM chips. More details can be found in Chapter SPI in the *ESP32 Technical Reference Manual*. ESP32 also supports hardware encryption/decryption based on AES to protect developers' programs and data in flash.

ESP32 can access the external QSPI flash and SRAM through high-speed caches.

- Up to 16 MB of external flash can be mapped into CPU instruction memory space and read-only memory space simultaneously.
  - When external flash is mapped into CPU instruction memory space, up to 11 MB + 248 KB can be mapped at a time. Note that if more than 3 MB + 248 KB are mapped, cache performance will be reduced due to speculative reads by the CPU.
  - When external flash is mapped into read-only data memory space, up to 4 MB can be mapped at a time. 8-bit, 16-bit and 32-bit reads are supported.
- External SRAM can be mapped into CPU data memory space. SRAM up to 8 MB is supported and up to 4 MB can be mapped at a time. 8-bit, 16-bit and 32-bit reads and writes are supported.

Note:
After ESP32 is initialized, firmware can customize the mapping of external SRAM or flash into the CPU address space.

3.1.4 Memory Map

The structure of address mapping is shown in Figure 7. The memory and peripheral mapping of ESP32 is shown in Table 5.

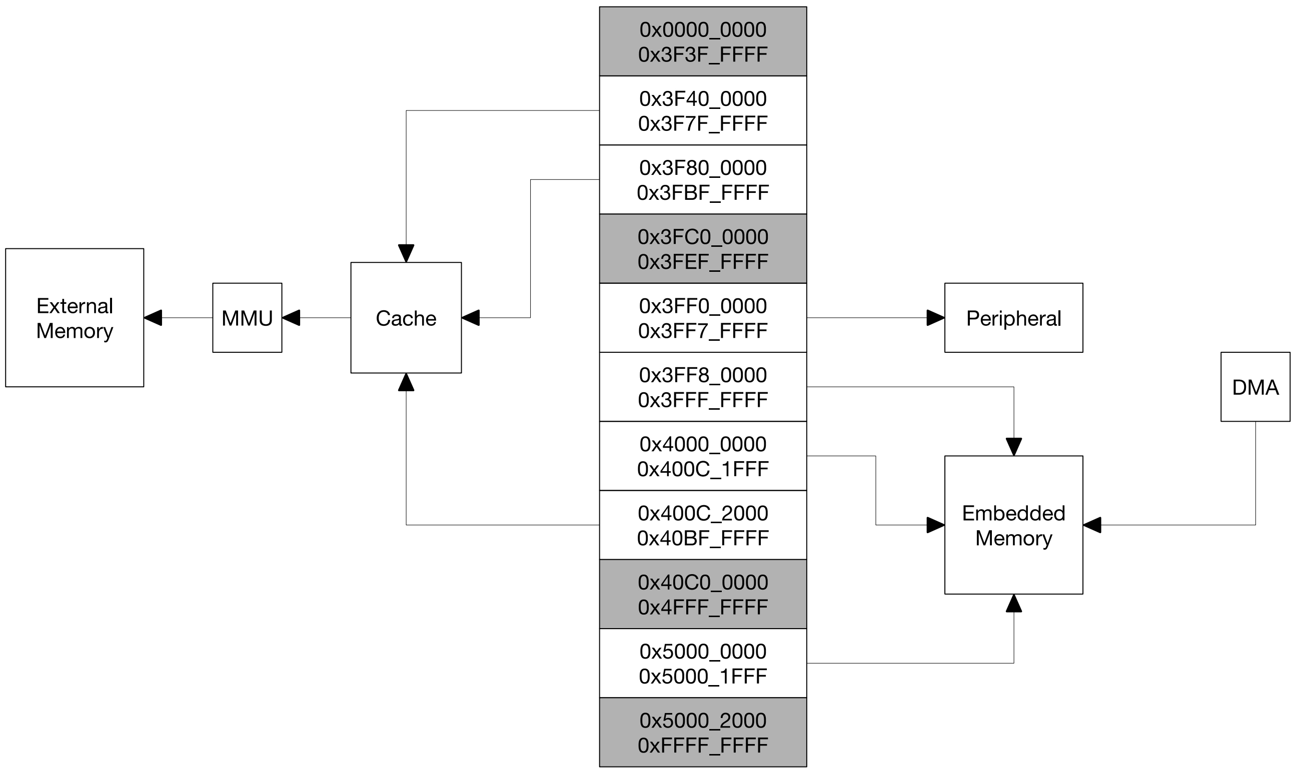


Figure 7: Address Mapping Structure

Table 5: Memory and Peripheral Mapping

Category	Target	Start Address	End Address	Size
Embedded Memory	Internal ROM 0	0x4000_0000	0x4005_FFFF	384 KB
	Internal ROM 1	0x3FF9_0000	0x3FF9_FFFF	64 KB
	Internal SRAM 0	0x4007_0000	0x4009_FFFF	192 KB
	Internal SRAM 1	0x3FFE_0000	0x3FFF_FFFF	128 KB
		0x400A_0000	0x400B_FFFF	
	Internal SRAM 2	0x3FFA_E000	0x3FFD_FFFF	200 KB
	RTC FAST Memory	0x3FF8_0000	0x3FF8_1FFF	8 KB
		0x400C_0000	0x400C_1FFF	
	RTC SLOW Memory	0x5000_0000	0x5000_1FFF	8 KB
External Memory	External Flash	0x3F40_0000	0x3F7F_FFFF	4 MB
		0x400C_2000	0x40BF_FFFF	11 MB+248 KB
	External RAM	0x3F80_0000	0x3FBF_FFFF	4 MB
Peripheral	DPort Register	0x3FF0_0000	0x3FF0_0FFF	4 KB
	AES Accelerator	0x3FF0_1000	0x3FF0_1FFF	4 KB
	RSA Accelerator	0x3FF0_2000	0x3FF0_2FFF	4 KB
	SHA Accelerator	0x3FF0_3000	0x3FF0_3FFF	4 KB
	Secure Boot	0x3FF0_4000	0x3FF0_4FFF	4 KB
	Cache MMU Table	0x3FF1_0000	0x3FF1_3FFF	16 KB
	PID Controller	0x3FF1_F000	0x3FF1_FFFF	4 KB
	UART0	0x3FF4_0000	0x3FF4_0FFF	4 KB
	SPI1	0x3FF4_2000	0x3FF4_2FFF	4 KB
	SPI0	0x3FF4_3000	0x3FF4_3FFF	4 KB
	GPIO	0x3FF4_4000	0x3FF4_4FFF	4 KB
	RTC	0x3FF4_8000	0x3FF4_8FFF	4 KB
	IO MUX	0x3FF4_9000	0x3FF4_9FFF	4 KB
	SDIO Slave	0x3FF4_B000	0x3FF4_BFFF	4 KB
	UDMA1	0x3FF4_C000	0x3FF4_CFFF	4 KB
	I2S0	0x3FF4_F000	0x3FF4_FFFF	4 KB
	UART1	0x3FF5_0000	0x3FF5_0FFF	4 KB
	I2C0	0x3FF5_3000	0x3FF5_3FFF	4 KB
	UDMA0	0x3FF5_4000	0x3FF5_4FFF	4 KB
	SDIO Slave	0x3FF5_5000	0x3FF5_5FFF	4 KB
	RMT	0x3FF5_6000	0x3FF5_6FFF	4 KB
	PCNT	0x3FF5_7000	0x3FF5_7FFF	4 KB
	SDIO Slave	0x3FF5_8000	0x3FF5_8FFF	4 KB
	LED PWM	0x3FF5_9000	0x3FF5_9FFF	4 KB
	eFuse Controller	0x3FF5_A000	0x3FF5_AFFF	4 KB
	Flash Encryption	0x3FF5_B000	0x3FF5_BFFF	4 KB
	PWM0	0x3FF5_E000	0x3FF5_EFFF	4 KB
	TIMG0	0x3FF5_F000	0x3FF5_FFFF	4 KB
	TIMG1	0x3FF6_0000	0x3FF6_0FFF	4 KB
	SPI2	0x3FF6_4000	0x3FF6_4FFF	4 KB
	SPI3	0x3FF6_5000	0x3FF6_5FFF	4 KB

Category	Target	Start Address	End Address	Size
Peripheral	SYSCON	0x3FF6_6000	0x3FF6_6FFF	4 KB
	I2C1	0x3FF6_7000	0x3FF6_7FFF	4 KB
	SDMMC	0x3FF6_8000	0x3FF6_8FFF	4 KB
	EMAC	0x3FF6_9000	0x3FF6_AFFF	8 KB
	TWAI	0x3FF6_B000	0x3FF6_BFFF	4 KB
	PWM1	0x3FF6_C000	0x3FF6_CFFF	4 KB
	I2S1	0x3FF6_D000	0x3FF6_DFFF	4 KB
	UART2	0x3FF6_E000	0x3FF6_EFFF	4 KB
	PWM2	0x3FF6_F000	0x3FF6_FFFF	4 KB
	PWM3	0x3FF7_0000	0x3FF7_0FFF	4 KB
	RNG	0x3FF7_5000	0x3FF7_5FFF	4 KB

3.2 Timers and Watchdogs

3.2.1 64-bit Timers

There are four general-purpose timers embedded in the chip. They are all 64-bit generic timers which are based on 16-bit prescalers and 64-bit auto-reload-capable up/down-timers.

The timers feature:

- A 16-bit clock prescaler, from 2 to 65536
- A 64-bit timer
- Configurable up/down timer: incrementing or decrementing
- Halt and resume of time-base counter
- Auto-reload at alarming
- Software-controlled instant reload
- Level and edge interrupt generation

3.2.2 Watchdog Timers

The chip has three watchdog timers: one in each of the two timer modules (called the Main Watchdog Timer, or MWDT) and one in the RTC module (called the RTC Watchdog Timer, or RWDT). These watchdog timers are intended to recover from an unforeseen fault causing the application program to abandon its normal sequence. A watchdog timer has four stages. Each stage may trigger one of three or four possible actions upon the expiry of its programmed time period, unless the watchdog is fed or disabled. The actions are: interrupt, CPU reset, core reset, and system reset. Only the RWDT can trigger the system reset, and is able to reset the entire chip, including the RTC itself. A timeout value can be set for each stage individually.

During flash boot the RWDT and the first MWDT start automatically in order to detect, and recover from, booting problems.

The watchdogs have the following features:

- Four stages, each of which can be configured or disabled separately
- A programmable time period for each stage

- One of three or four possible actions (interrupt, CPU reset, core reset, and system reset) upon the expiry of each stage
- 32-bit expiry counter
- Write protection that prevents the RWDT and MWDT configuration from being inadvertently altered
- SPI flash boot protection
  If the boot process from an SPI flash does not complete within a predetermined time period, the watchdog will reboot the entire system.

3.3 System Clocks

3.3.1 CPU Clock

Upon reset, an external crystal clock source is selected as the default CPU clock. The external crystal clock source also connects to a PLL to generate a high-frequency clock (typically 160 MHz).

In addition, ESP32 has an internal 8 MHz oscillator. The application can select the clock source from the external crystal clock source, the PLL clock or the internal 8 MHz oscillator. The selected clock source drives the CPU clock directly, or after division, depending on the application.

3.3.2 RTC Clock

The RTC clock has five possible sources:

- external low-speed (32 kHz) crystal clock
- external crystal clock divided by 4
- internal RC oscillator (typically about 150 kHz, and adjustable)
- internal 8 MHz oscillator
- internal 31.25 kHz clock (derived from the internal 8 MHz oscillator divided by 256)

When the chip is in the normal power mode and needs faster CPU accessing, the application can choose the external high-speed crystal clock divided by 4 or the internal 8 MHz oscillator. When the chip operates in the low-power mode, the application chooses the external low-speed (32 kHz) crystal clock, the internal RC clock or the internal 31.25 kHz clock.

3.3.3 Audio PLL Clock

The audio clock is generated by the ultra-low-noise fractional-N PLL. More details can be found in Chapter Reset and Clock in the *ESP32 Technical Reference Manual*.

3.4 Radio

The radio module consists of the following blocks:

- 2.4 GHz receiver
- 2.4 GHz transmitter
- bias and regulators

- balun and transmit-receive switch
- clock generator

3.4.1 2.4 GHz Receiver

The 2.4 GHz receiver demodulates the 2.4 GHz RF signal to quadrature baseband signals and converts them to the digital domain with two high-resolution, high-speed ADCs. To adapt to varying signal channel conditions, RF filters, Automatic Gain Control (AGC), DC offset cancelation circuits and baseband filters are integrated in the chip.

3.4.2 2.4 GHz Transmitter

The 2.4 GHz transmitter modulates the quadrature baseband signals to the 2.4 GHz RF signal, and drives the antenna with a high-powered Complementary Metal Oxide Semiconductor (CMOS) power amplifier. The use of digital calibration further improves the linearity of the power amplifier, enabling state-of-the-art performance in delivering up to +20.5 dBm of power for an 802.11b transmission and +18 dBm for an 802.11n transmission.

Additional calibrations are integrated to cancel any radio imperfections, such as:

- Carrier leakage
- I/Q phase matching
- Baseband nonlinearities
- RF nonlinearities
- Antenna matching

These built-in calibration routines reduce the amount of time required for product testing, and render the testing equipment unnecessary.

3.4.3 Clock Generator

The clock generator produces quadrature clock signals of 2.4 GHz for both the receiver and the transmitter. All components of the clock generator are integrated into the chip, including all inductors, varactors, filters, regulators and dividers.

The clock generator has built-in calibration and self-test circuits. Quadrature clock phases and phase noise are optimized on-chip with patented calibration algorithms which ensure the best performance of the receiver and the transmitter.

3.5 Wi-Fi

ESP32 implements a TCP/IP and full 802.11 b/g/n Wi-Fi MAC protocol. It supports the Basic Service Set (BSS) STA and SoftAP operations under the Distributed Control Function (DCF). Power management is handled with minimal host interaction to minimize the active-duty period.

3.5.1 Wi-Fi Radio and Baseband

The ESP32 Wi-Fi Radio and Baseband support the following features:

- 802.11b/g/n
- 802.11n MCS0-7 in both 20 MHz and 40 MHz bandwidth
- 802.11n MCS32 (RX)
- 802.11n 0.4 μs guard-interval
- up to 150 Mbps of data rate
- Receiving STBC 2×1
- Up to 20.5 dBm of transmitting power
- Adjustable transmitting power
- Antenna diversity
  ESP32 supports antenna diversity with an external RF switch. One or more GPIOs control the RF switch and selects the best antenna to minimize the effects of channel fading.

3.5.2 Wi-Fi MAC

The ESP32 Wi-Fi MAC applies low-level protocol functions automatically. They are as follows:

- 4 × virtual Wi-Fi interfaces
- Simultaneous Infrastructure BSS Station mode/SoftAP mode/Promiscuous mode
- RTS protection, CTS protection, Immediate Block ACK
- Defragmentation
- TX/RX A-MPDU, RX A-MSDU
- TXOP
- WMM
- CCMP (CBC-MAC, counter mode), TKIP (MIC, RC4), WAPI (SMS4), WEP (RC4) and CRC
- Automatic beacon monitoring (hardware TSF)

3.6 Bluetooth

The chip integrates a Bluetooth link controller and Bluetooth baseband, which carry out the baseband protocols and other low-level link routines, such as modulation/demodulation, packet processing, bit stream processing, frequency hopping, etc.

3.6.1 Bluetooth Radio and Baseband

The Bluetooth Radio and Baseband support the following features:

- Class-1, class-2 and class-3 transmit output powers, and a dynamic control range of up to 24 dB
- $\pi/4$ DQPSK and 8 DPSK modulation
- High performance in NZIF receiver sensitivity with over 94 dBm of dynamic range
- Class-1 operation without external PA
- Internal SRAM allows full-speed data-transfer, mixed voice and data, and full piconet operation

- Logic for forward error correction, header error control, access code correlation, CRC, demodulation, encryption bit stream generation, whitening and transmit pulse shaping
- ACL, SCO, eSCO and AFH
- A-law, μ-law and CVSD digital audio CODEC in PCM interface
- SBC audio CODEC
- Power management for low-power applications
- SMP with 128-bit AES

3.6.2 Bluetooth Interface

- Provides UART HCI interface, up to 4 Mbps
- Provides SDIO / SPI HCI interface
- Provides PCM / I^{2}S audio interface

3.6.3 Bluetooth Stack

The Bluetooth stack of the chip is compliant with the Bluetooth v4.2 BR/EDR and Bluetooth LE specifications.

3.6.4 Bluetooth Link Controller

The link controller operates in three major states: standby, connection and sniff. It enables multiple connections, and other operations, such as inquiry, page, and secure simple-pairing, and therefore enables Piconet and Scatternet. Below are the features:

- Classic Bluetooth
  - Device Discovery (inquiry, and inquiry scan)
  - Connection establishment (page, and page scan)
  - Multi-connections
  - Asynchronous data reception and transmission
  - Synchronous links (SCO/eSCO)
  - Master/Slave Switch
  - Adaptive Frequency Hopping and Channel assessment
  - Broadcast encryption
  - Authentication and encryption
  - Secure Simple-Pairing
  - Multi-point and scatternet management
  - Sniff mode
  - Connectionless Slave Broadcast (transmitter and receiver)
  - Enhanced power control

  - Ping
- Bluetooth Low Energy
  - Advertising
  - Scanning
  - Simultaneous advertising and scanning
  - Multiple connections
  - Asynchronous data reception and transmission
  - Adaptive Frequency Hopping and Channel assessment
  - Connection parameter update
  - Data Length Extension
  - Link Layer Encryption
  - LE Ping

3.7 RTC and Low-Power Management

With the use of advanced power-management technologies, ESP32 can switch between different power modes.

- Power modes
  - **Active mode**: The chip radio is powered on. The chip can receive, transmit, or listen.
  - **Modem-sleep mode**: The CPU is operational and the clock is configurable. The Wi-Fi/Bluetooth baseband and radio are disabled.
  - **Light-sleep mode**: The CPU is paused. The RTC memory and RTC peripherals, as well as the ULP co-processor are running. Any wake-up events (MAC, host, RTC timer, or external interrupts) will wake up the chip.
  - **Deep-sleep mode**: Only the RTC memory and RTC peripherals are powered on. Wi-Fi and Bluetooth connection data are stored in the RTC memory. The ULP co-processor is functional.
  - **Hibernation mode**: The internal 8-MHz oscillator and ULP co-processor are disabled. The RTC recovery memory is powered down. Only one RTC timer on the slow clock and certain RTC GPIOs are active. The RTC timer or the RTC GPIOs can wake up the chip from the Hibernation mode.

Table 6: Power Consumption by Power Modes

Power mode	Description			Power consumption
Active (RF working)	Wi-Fi Tx packet			Please refer to Table 15 for details.
	Wi-Fi/BT Tx packet			
	Wi-Fi/BT Rx and listening			
Modem-sleep	The CPU is powered on.	240 MHz *	Dual-core chip(s)	30 mA ~ 68 mA
			Single-core chip(s)	N/A
		160 MHz *	Dual-core chip(s)	27 mA ~ 44 mA
			Single-core chip(s)	27 mA ~ 34 mA

<table>
<tr><th>Power mode</th><th colspan="3">Description</th><th>Power consumption</th></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">Normal speed: 80 MHz</td><td>Dual-core chip(s)</td><td>20 mA ~ 31 mA</td></tr>
<tr><td>Single-core chip(s)</td><td>20 mA ~ 25 mA</td></tr>
<tr><td>Light-sleep</td><td colspan="3">-</td><td>0.8 mA</td></tr>
<tr><td rowspan="3">Deep-sleep</td><td colspan="3">The ULP co-processor is powered on.</td><td>150 µA</td></tr>
<tr><td colspan="3">ULP sensor-monitored pattern</td><td>100 µA @1% duty</td></tr>
<tr><td colspan="3">RTC timer + RTC memory</td><td>10 µA</td></tr>
<tr><td>Hibernation</td><td colspan="3">RTC timer only</td><td>5 µA</td></tr>
<tr><td>Power off</td><td colspan="3">CHIP_PU is set to low level, the chip is powered off.</td><td>1 µA</td></tr>
</table>

Note:

- * Among the ESP32 series of SoCs, ESP32-D0WD-V3, ESP32-D0WDQ6-V3, ESP32-D0WD, and ESP32-D0WDQ6 have a maximum CPU frequency of 240 MHz, ESP32-D2WD, ESP32-S0WD, and ESP32-U4WDH have a maximum CPU frequency of 160 MHz.
- When Wi-Fi is enabled, the chip switches between Active and Modem-sleep modes. Therefore, power consumption changes accordingly.
- In Modem-sleep mode, the CPU frequency changes automatically. The frequency depends on the CPU load and the peripherals used.
- During Deep-sleep, when the ULP co-processor is powered on, peripherals such as GPIO and I^2C are able to operate.
- When the system works in the ULP sensor-monitored pattern, the ULP co-processor works with the ULP sensor periodically and the ADC works with a duty cycle of 1%, so the power consumption is 100 µA.

4 Peripherals and Sensors

4.1 Descriptions of Peripherals and Sensors

4.1.1 General Purpose Input / Output Interface (GPIO)

ESP32 has 34 GPIO pins which can be assigned various functions by programming the appropriate registers. There are several kinds of GPIOs: digital-only, analog-enabled, capacitive-touch-enabled, etc. Analog-enabled GPIOs and Capacitive-touch-enabled GPIOs can be configured as digital GPIOs.

Most of the digital GPIOs can be configured as internal pull-up or pull-down, or set to high impedance. When configured as an input, the input value can be read through the register. The input can also be set to edge-trigger or level-trigger to generate CPU interrupts. Most of the digital IO pins are bi-directional, non-inverting and tristate, including input and output buffers with tristate control. These pins can be multiplexed with other functions, such as the SDIO, UART, SPI, etc. (More details can be found in the Appendix, Table IO_MUX.) For low-power operations, the GPIOs can be set to hold their states.

4.1.2 Analog-to-Digital Converter (ADC)

ESP32 integrates 12-bit SAR ADCs and supports measurements on 18 channels (analog-enabled pins). The ULP-coprocessor in ESP32 is also designed to measure voltage, while operating in the sleep mode, which enables low-power consumption. The CPU can be woken up by a threshold setting and/or via other triggers.

With appropriate settings, the ADCs can be configured to measure voltage on 18 pins maximum.

Table 7 describes the ADC characteristics.

Table 7: ADC Characteristics

Parameter	Description	Min	Max	Unit
DNL (Differential nonlinearity)	RTC controller; ADC connected to an external 100 nF capacitor; DC signal input; ambient temperature at 25 °C; Wi-Fi&BT off	–7	7	LSB
INL (Integral nonlinearity)		–12	12	LSB
Sampling rate	RTC controller	–	200	ksps
	DIG controller	–	2	Msps

Notes:

- When atten=3 and the measurement result is above 3000 (voltage at approx. 2450 mV), the ADC accuracy will be worse than described in the table above.
- To get better DNL results, users can take multiple sampling tests with a filter, or calculate the average value.
- The input voltage range of GPIO pins within VDD3P3_RTC domain should strictly follow the DC characteristics provided in Table 13. Otherwise, measurement errors may be introduced, and chip performance may be affected.

By default, there are ±6% differences in measured results between chips. ESP-IDF provides couple of calibration methods for ADC1. Results after calibration using eFuse Vref value are shown in Table 8. For higher accuracy, users may apply other calibration methods provided in ESP-IDF, or implement their own.

Table 8: ADC Calibration Results

Parameter	Description	Min	Max	Unit
Total error	Atten=0, effective measurement range of 100 ~ 950 mV	–23	23	mV
	Atten=1, effective measurement range of 100 ~ 1250 mV	–30	30	mV
	Atten=2, effective measurement range of 150 ~ 1750 mV	–40	40	mV
	Atten=3, effective measurement range of 150 ~ 2450 mV	–60	60	mV

4.1.3 Hall Sensor

ESP32 integrates a Hall sensor based on an N-carrier resistor. When the chip is in the magnetic field, the Hall sensor develops a small voltage laterally on the resistor, which can be directly measured by the ADC.

4.1.4 Digital-to-Analog Converter (DAC)

Two 8-bit DAC channels can be used to convert two digital signals into two analog voltage signal outputs. The design structure is composed of integrated resistor strings and a buffer. This dual DAC supports power supply as input voltage reference. The two DAC channels can also support independent conversions.

4.1.5 Touch Sensor

ESP32 has 10 capacitive-sensing GPIOs, which detect variations induced by touching or approaching the GPIOs with a finger or other objects. The low-noise nature of the design and the high sensitivity of the circuit allow relatively small pads to be used. Arrays of pads can also be used, so that a larger area or more points can be detected. The 10 capacitive-sensing GPIOs are listed in Table 9.

Table 9: Capacitive-Sensing GPIOs Available on ESP32

Capacitive-sensing signal name	Pin name
T0	GPIO4
T1	GPIO0
T2	GPIO2
T3	MTDO
T4	MTCK
T5	MTDI
T6	MTMS
T7	GPIO27
T8	32K_XN
T9	32K_XP

4.1.6 Ultra-Low-Power Co-processor

The ULP processor and RTC memory remain powered on during the Deep-sleep mode. Hence, the developer can store a program for the ULP processor in the RTC slow memory to access the peripheral devices, internal timers and internal sensors during the Deep-sleep mode. This is useful for designing applications where the CPU needs to be woken up by an external event, or a timer, or a combination of the two, while maintaining minimal power consumption.

4.1.7 Ethernet MAC Interface

An IEEE-802.3-2008-compliant Media Access Controller (MAC) is provided for Ethernet LAN communications. ESP32 requires an external physical interface device (PHY) to connect to the physical LAN bus (twisted-pair, fiber, etc.). The PHY is connected to ESP32 through 17 signals of MII or nine signals of RMII. The following features are supported on the Ethernet MAC (EMAC) interface:

- 10 Mbps and 100 Mbps rates
- Dedicated DMA controller allowing high-speed transfer between the dedicated SRAM and Ethernet MAC
- Tagged MAC frame (VLAN support)
- Half-duplex (CSMA/CD) and full-duplex operation
- MAC control sublayer (control frames)
- 32-bit CRC generation and removal
- Several address-filtering modes for physical and multicast address (multicast and group addresses)
- 32-bit status code for each transmitted or received frame
- Internal FIFOs to buffer transmit and receive frames. The transmit FIFO and the receive FIFO are both 512 words (32-bit)
- Hardware PTP (Precision Time Protocol) in accordance with IEEE 1588 2008 (PTP V2)
- 25 MHz/50 MHz clock output

4.1.8 SD/SDIO/MMC Host Controller

An SD/SDIO/MMC host controller is available on ESP32, which supports the following features:

- Secure Digital memory (SD mem Version 3.0 and Version 3.01)
- Secure Digital I/O (SDIO Version 3.0)
- Consumer Electronics Advanced Transport Architecture (CE-ATA Version 1.1)
- Multimedia Cards (MMC Version 4.41, eMMC Version 4.5 and Version 4.51)

The controller allows up to 80 MHz clock output in three different data-bus modes: 1-bit, 4-bit and 8-bit. It supports two SD/SDIO/MMC4.41 cards in a 4-bit data-bus mode. It also supports one SD card operating at 1.8 V.

4.1.9 SDIO/SPI Slave Controller

ESP32 integrates an SD device interface that conforms to the industry-standard SDIO Card Specification Version 2.0, and allows a host controller to access the SoC, using the SDIO bus interface and protocol. ESP32 acts as the slave on the SDIO bus. The host can access the SDIO-interface registers directly and can access shared memory via a DMA engine, thus maximizing performance without engaging the processor cores.

The SDIO/SPI slave controller supports the following features:

- SPI, 1-bit SDIO, and 4-bit SDIO transfer modes over the full clock range from 0 to 50 MHz
- Configurable sampling and driving clock edge
- Special registers for direct access by host

- Interrupts to host for initiating data transfer
- Automatic loading of SDIO bus data and automatic discarding of padding data
- Block size of up to 512 bytes
- Interrupt vectors between the host and the slave, allowing both to interrupt each other
- Supports DMA for data transfer

4.1.10 Universal Asynchronous Receiver Transmitter (UART)

ESP32 has three UART interfaces, i.e., UART0, UART1 and UART2, which provide asynchronous communication (RS232 and RS485) and IrDA support, communicating at a speed of up to 5 Mbps. UART provides hardware management of the CTS and RTS signals and software flow control (XON and XOFF). All of the interfaces can be accessed by the DMA controller or directly by the CPU.

4.1.11 I²C Interface

ESP32 has two I²C bus interfaces which can serve as I²C master or slave, depending on the user's configuration. The I²C interfaces support:

- Standard mode (100 Kbit/s)
- Fast mode (400 Kbit/s)
- Up to 5 MHz, yet constrained by SDA pull-up strength
- 7-bit/10-bit addressing mode
- Dual addressing mode

Users can program command registers to control I²C interfaces, so that they have more flexibility.

4.1.12 I²S Interface

Two standard I²S interfaces are available in ESP32. They can be operated in master or slave mode, in full duplex and half-duplex communication modes, and can be configured to operate with an 8-/16-/32-/48-/64-bit resolution as input or output channels. BCK clock frequency, from 10 kHz up to 40 MHz, is supported. When one or both of the I²S interfaces are configured in the master mode, the master clock can be output to the external DAC/CODEC.

Both of the I²S interfaces have dedicated DMA controllers. PDM and BT PCM interfaces are supported.

4.1.13 Infrared Remote Controller

The infrared remote controller supports eight channels of infrared remote transmission and receiving. By programming the pulse waveform, it supports various infrared protocols. Eight channels share a 512 x 32-bit block of memory to store the transmitting or receiving waveform.

4.1.14 Pulse Counter

The pulse counter captures pulse and counts pulse edges through seven modes. It has eight channels, each of which captures four signals at a time. The four input signals include two pulse signals and two control signals. When the counter reaches a defined threshold, an interrupt is generated.

4.1.15 Pulse Width Modulation (PWM)

The Pulse Width Modulation (PWM) controller can be used for driving digital motors and smart lights. The controller consists of PWM timers, the PWM operator and a dedicated capture sub-module. Each timer provides timing in synchronous or independent form, and each PWM operator generates a waveform for one PWM channel. The dedicated capture sub-module can accurately capture events with external timing.

4.1.16 LED PWM

The LED PWM controller can generate 16 independent channels of digital waveforms with configurable periods and duties.

The 16 channels of digital waveforms operate with an APB clock of 80 MHz. Eight of these channels have the option of using the 8 MHz oscillator clock. Each channel can select a 20-bit timer with configurable counting range, while its accuracy of duty can be up to 16 bits within a 1 ms period.

The software can change the duty immediately. Moreover, each channel automatically supports step-by-step duty increase or decrease, which is useful for the LED RGB color-gradient generator.

4.1.17 Serial Peripheral Interface (SPI)

ESP32 features three SPIs (SPI, HSPI and VSPI) in slave and master modes in 1-line full-duplex and 1/2/4-line half-duplex communication modes. These SPIs also support the following general-purpose SPI features:

- Four modes of SPI transfer format, which depend on the polarity (CPOL) and the phase (CPHA) of the SPI clock
- Up to 80 MHz (The actual speed it can reach depends on the selected pads, PCB tracing, peripheral characteristics, etc.)
- up to 64-byte FIFO

All SPIs can also be connected to the external flash/SRAM and LCD. Each SPI can be served by DMA controllers.

4.1.18 TWAI Controller

ESP32 family has a TWAI® controller with the following features:

- compatible with ISO11898-1 protocol
- standard frame format (11-bit ID) and extended frame format (29-bit ID)
- bit rates from 1 Kbit/s to 1 Mbit/s
- multiple modes of operation: Normal, Listen Only, and Self-Test
- 64-byte receive FIFO
- special transmissions: single-shot transmissions and self reception
- acceptance filter (single and dual filter modes)
- error detection and handling: error counters, configurable error interrupt threshold, error code capture, arbitration lost capture

4.1.19 Accelerator

ESP32 is equipped with hardware accelerators of general algorithms, such as AES (FIPS PUB 197), SHA (FIPS PUB 180-4), RSA, and ECC, which support independent arithmetic, such as Big Integer Multiplication and Big Integer Modular Multiplication. The maximum operation length for RSA, ECC, Big Integer Multiply and Big Integer Modular Multiplication is 4096 bits.

The hardware accelerators greatly improve operation speed and reduce software complexity. They also support code encryption and dynamic decryption, which ensures that code in the flash will not be hacked.

4.2 Peripheral Pin Configurations

Table 10: Peripheral Pin Configurations

Interface	Signal	Pin	Function
ADC	ADC1_CH0	SENSOR_VP	Two 12-bit SAR ADCs
	ADC1_CH1	SENSOR_CAPP	
	ADC1_CH2	SENSOR_CAPN	
	ADC1_CH3	SENSOR_VN	
	ADC1_CH4	32K_XP	
	ADC1_CH5	32K_XN	
	ADC1_CH6	VDET_1	
	ADC1_CH7	VDET_2	
	ADC2_CH0	GPIO4	
	ADC2_CH1	GPIO0	
	ADC2_CH2	GPIO2	
	ADC2_CH3	MTDO	
	ADC2_CH4	MTCK	
	ADC2_CH5	MTDI	
	ADC2_CH6	MTMS	
	ADC2_CH7	GPIO27	
	ADC2_CH8	GPIO25	
	ADC2_CH9	GPIO26	
DAC	DAC_1	GPIO25	Two 8-bit DACs
	DAC_2	GPIO26	
Touch Sensor	TOUCH0	GPIO4	Capacitive touch sensors
	TOUCH1	GPIO0	
	TOUCH2	GPIO2	
	TOUCH3	MTDO	
	TOUCH4	MTCK	
	TOUCH5	MTDI	
	TOUCH6	MTMS	
	TOUCH7	GPIO27	
	TOUCH8	32K_XN	
	TOUCH9	32K_XP	

Interface	Signal	Pin	Function
JTAG	MTDI	MTDI	JTAG for software debugging
	MTCK	MTCK	
	MTMS	MTMS	
	MTDO	MTDO	
SD/SDIO/MMC Host Controller	HS2_CLK	MTMS	Supports SD memory card V3.01 standard
	HS2_CMD	MTDO	
	HS2_DATA0	GPIO2	
	HS2_DATA1	GPIO4	
	HS2_DATA2	MTDI	
	HS2_DATA3	MTCK	
Motor PWM	PWM0_OUT0~2	Any GPIO Pins	Three channels of 16-bit timers generate PWM waveforms. Each channel has a pair of output signals, three fault detection signals, three event-capture signals, and three sync signals.
	PWM1_OUT_IN0~2		
	PWM0_FLT_IN0~2		
	PWM1_FLT_IN0~2		
	PWM0_CAP_IN0~2		
	PWM1_CAP_IN0~2		
	PWM0_SYNC_IN0~2		
	PWM1_SYNC_IN0~2		
SDIO/SPI Slave Controller	SD_CLK	MTMS	SDIO interface that conforms to the industry standard SDIO 2.0 card specification
	SD_CMD	MTDO	
	SD_DATA0	GPIO2	
	SD_DATA1	GPIO4	
	SD_DATA2	MTDI	
	SD_DATA3	MTCK	
UART	U0RXD_in	Any GPIO Pins	Three UART devices with hardware flow-control and DMA
	U0CTS_in		
	U0DSR_in		
	U0TXD_out		
	U0RTS_out		
	U0DTR_out		
	U1RXD_in		
	U1CTS_in		
	U1TXD_out		
	U1RTS_out		
	U2RXD_in		
	U2CTS_in		
	U2TXD_out		
	U2RTS_out		
I2C	I2CEXT0_SCL_in	Any GPIO Pins	Two I2C devices in slave or master mode
	I2CEXT0_SDA_in		
	I2CEXT1_SCL_in		
	I2CEXT1_SDA_in		
	I2CEXT0_SCL_out		
	I2CEXT0_SDA_out		
	I2CEXT1_SCL_out		

Interface	Signal	Pin	Function
	I2CEXT1_SDA_out		
LED PWM	ledc_hs_sig_out0~7	Any GPIO Pins	16 independent channels @80 MHz clock/RTC CLK. Duty accuracy: 16 bits.
	ledc_ls_sig_out0~7		
I2S	I2S0I_DATA_in0~15	Any GPIO Pins	Stereo input and output from/to the audio codec; parallel LCD data output; parallel camera data input
	I2S0O_BCK_in		
	I2S0O_WS_in		
	I2S0I_BCK_in		
	I2S0I_WS_in		
	I2S0I_H_SYNC		
	I2S0I_V_SYNC		
	I2S0I_H_ENABLE		
	I2S0O_BCK_out		
	I2S0O_WS_out		
	I2S0I_BCK_out		
	I2S0I_WS_out		
	I2S0O_DATA_out0~23		
	I2S1I_DATA_in0~15		
	I2S1O_BCK_in		
	I2S1O_WS_in		
	I2S1I_BCK_in		
	I2S1I_WS_in		
	I2S1I_H_SYNC		
	I2S1I_V_SYNC		
	I2S1I_H_ENABLE		
	I2S1O_BCK_out		
	I2S1O_WS_out		
	I2S1I_BCK_out		
	I2S1I_WS_out		
	I2S1O_DATA_out0~23		
Infrared Remote Controller	RMT_SIG_IN0~7	Any GPIO Pins	Eight channels for an IR transmitter and receiver of various waveforms
	RMT_SIG_OUT0~7		
General Purpose SPI	HSPIQ_in/_out	Any GPIO Pins	Standard SPI consists of clock, chip-select, MOSI and MISO. These SPIs can be connected to LCD and other external devices. They support the following features: • Both master and slave modes; • Four sub-modes of the SPI transfer format; • Configurable SPI frequency; • Up to 64 bytes of FIFO and DMA.
	HSPID_in/_out		
	HSPICLK_in/_out		
	HSPI_CS0_in/_out		
	HSPI_CS1_out		
	HSPI_CS2_out		
	VSPIQ_in/_out		
	VSPID_in/_out		
	VSPICLK_in/_out		
	VSPI_CS0_in/_out		
	VSPI_CS1_out		
	VSPI_CS2_out		

Interface	Signal	Pin	Function
Parallel QSPI	SPIHD	SD_DATA_2	Supports Standard SPI, Dual SPI, and Quad SPI that can be connected to the external flash and SRAM
	SPIWP	SD_DATA_3	
	SPICS0	SD_CMD	
	SPICLK	SD_CLK	
	SPIQ	SD_DATA_0	
	SPID	SD_DATA_1	
	HSPICLK	MTMS	
	HSPICS0	MTDO	
	HSPIQ	MTDI	
	HSPID	MTCK	
	HSPIHD	GPIO4	
	HSPIWP	GPIO2	
	VSPICLK	GPIO18	
	VSPICS0	GPIO5	
	VSPIQ	GPIO19	
	VSPID	GPIO23	
	VSPIHD	GPIO21	
	VSPIWP	GPIO22	
EMAC	EMAC_TX_CLK	GPIO0	Ethernet MAC with MII/RMII interface
	EMAC_RX_CLK	GPIO5	
	EMAC_TX_EN	GPIO21	
	EMAC_TXD0	GPIO19	
	EMAC_TXD1	GPIO22	
	EMAC_TXD2	MTMS	
	EMAC_TXD3	MTDI	
	EMAC_RX_ER	MTCK	
	EMAC_RX_DV	GPIO27	
	EMAC_RXD0	GPIO25	
	EMAC_RXD1	GPIO26	
	EMAC_RXD2	U0TXD	
	EMAC_RXD3	MTDO	
	EMAC_CLK_OUT	GPIO16	
	EMAC_CLK_OUT_180	GPIO17	
	EMAC_TX_ER	GPIO4	
	EMAC_MDC_out	Any GPIO Pins	
	EMAC_MDI_in	Any GPIO Pins	
	EMAC_MDO_out	Any GPIO Pins	
	EMAC_CRS_out	Any GPIO Pins	
	EMAC_COL_out	Any GPIO Pins	

Interface	Signal	Pin	Function
Pulse Counter	pcnt_sig_ch0_in0	Any GPIO Pins	Operating in seven different modes, the pulse counter captures pulse and counts pulse edges.
	pcnt_sig_ch1_in0		
	pcnt_ctrl_ch0_in0		
	pcnt_ctrl_ch1_in0		
	pcnt_sig_ch0_in1		
	pcnt_sig_ch1_in1		
	pcnt_ctrl_ch0_in1		
	pcnt_ctrl_ch1_in1		
	pcnt_sig_ch0_in2		
	pcnt_sig_ch1_in2		
	pcnt_ctrl_ch0_in2		
	pcnt_ctrl_ch1_in2		
	pcnt_sig_ch0_in3		
	pcnt_sig_ch1_in3		
	pcnt_ctrl_ch0_in3		
	pcnt_ctrl_ch1_in3		
	pcnt_sig_ch0_in4		
	pcnt_sig_ch1_in4		
	pcnt_ctrl_ch0_in4		
	pcnt_ctrl_ch1_in4		
	pcnt_sig_ch0_in5		
	pcnt_sig_ch1_in5		
	pcnt_ctrl_ch0_in5		
	pcnt_ctrl_ch1_in5		
	pcnt_sig_ch0_in6		
	pcnt_sig_ch1_in6		
	pcnt_ctrl_ch0_in6		
	pcnt_ctrl_ch1_in6		
	pcnt_sig_ch0_in7		
	pcnt_sig_ch1_in7		
	pcnt_ctrl_ch0_in7		
	pcnt_ctrl_ch1_in7		
TWAI	twai_rx	Any GPIO Pins	Compatible with ISO11898-1 protocol
	twai_tx		
	twai_bus_off_on		
	twai_clkout		

5 Electrical Characteristics

5.1 Absolute Maximum Ratings

Stresses beyond the absolute maximum ratings listed in the table below may cause permanent damage to the device. These are stress ratings only, and do not refer to the functional operation of the device that should follow the recommended operating conditions.

Table 11: Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit
VDDA, VDD3P3, VDD3P3_RTC, VDD3P3_CPU, VDD_SDIO	Voltage applied to power supply pins per power domain	–0.3	3.6	V
I_{output} *	Cumulative IO output current	-	1200	mA
T_{store}	Storage temperature	–40	150	°C

* The chip worked properly after a 24-hour test in ambient temperature at 25 °C, and the IOs in three domains (VDD3P3_RTC, VDD3P3_CPU, VDD_SDIO) output high logic level to ground.

5.2 Recommended Operating Conditions

Table 12: Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit
VDDA, VDD3P3_RTC,[note 1] VDD3P3, VDD_SDIO (3.3 V mode)[note 2]	Voltage applied to power supply pins per power domain	2.3/3.0[note 3]	3.3	3.6	V
VDD3P3_CPU	Voltage applied to power supply pin	1.8	3.3	3.6	V
I_{VDD}	Current delivered by external power supply	0.5	-	-	A
T [note 4]	Operating temperature	–40	-	125	°C

1. When writing eFuse, VDD3P3_RTC should be at least 3.3 V.
2.
   - VDD_SDIO works as the power supply for the related IO, and also for an external device. Please refer to the Appendix IO_MUX of this datasheet for more details.
   - VDD_SDIO can be sourced internally by the ESP32 from the VDD3P3_RTC power domain:
     - When VDD_SDIO operates at 3.3 V, it is driven directly by VDD3P3_RTC through a 6 Ω resistor, therefore, there will be some voltage drop from VDD3P3_RTC.
     - When VDD_SDIO operates at 1.8 V, it can be generated from ESP32's internal LDO. The maximum current this LDO can offer is 40 mA, and the output voltage range is 1.65 V ~ 2.0 V.
   - VDD_SDIO can also be driven by an external power supply.
   - Please refer to Power Scheme, section 2.3, for more information.
3.
   - ESP32-U4WDH (with a 3.3 V flash embedded): this minimum voltage is 3.0 V;
   - ESP32-D2WD (with a 1.8 V flash embedded) and other chips (no flash): this minimum voltage is 2.3 V;
   - For more information, see Table 23 *Part Number and Ordering Information*.
4. The operating temperature of ESP32-D2WD and ESP32-U4WDH ranges from –40 °C to 105 °C, due to the flash embedded in them. The other chips in this series have no embedded flash, so their range of operating temperatures is –40 °C ~ 125 °C.

5.3 DC Characteristics (3.3 V, 25 °C)

Table 13: DC Characteristics (3.3 V, 25 °C)

Symbol	Parameter		Min	Typ	Max	Unit
C_{IN}	Pin capacitance		-	2	-	pF
V_{IH}	High-level input voltage		0.75×VDD[1]	-	VDD[1]+0.3	V
V_{IL}	Low-level input voltage		–0.3	-	0.25×VDD[1]	V
I_{IH}	High-level input current		-	-	50	nA
I_{IL}	Low-level input current		-	-	50	nA
V_{OH}	High-level output voltage		0.8×VDD[1]	-	-	V
V_{OL}	Low-level output voltage		-	-	0.1×VDD[1]	V
I_{OH}	High-level source current (VDD[1] = 3.3 V, V_{OH} >= 2.64 V, output drive strength set to the maximum)	VDD3P3_CPU power domain [1, 2]	-	40	-	mA
		VDD3P3_RTC power domain [1, 2]	-	40	-	mA
		VDD_SDIO power domain [1, 3]	-	20	-	mA
I_{OL}	Low-level sink current (VDD[1] = 3.3 V, V_{OL} = 0.495 V, output drive strength set to the maximum)		-	28	-	mA
R_{PU}	Resistance of internal pull-up resistor		-	45	-	kΩ
R_{PD}	Resistance of internal pull-down resistor		-	45	-	kΩ
V_{IL_nRST}	Low-level input voltage of CHIP_PU to power off the chip		-	-	0.6	V

Notes:

1. Please see Table IO_MUX for IO's power domain. VDD is the I/O voltage for a particular power domain of pins.
2. For VDD3P3_CPU and VDD3P3_RTC power domain, per-pin current sourced in the same domain is gradually reduced from around 40 mA to around 29 mA, V_{OH}>=2.64 V, as the number of current-source pins increases.
3. For VDD_SDIO power domain, per-pin current sourced in the same domain is gradually reduced from around 30 mA to around 10 mA, V_{OH}>=2.64 V, as the number of current-source pins increases.

5.4 Reliability Qualifications

ESP32 chip series passed all reliability qualifications listed in Table 14.

Table 14: Reliability Qualifications

Test Item	Test Condition	Test Standard
HTOL (High Temperature Operating Life)	125 °C, 1000 hours	JESD22-A108
ESD (Electro-Static Discharge Sensitivity)	HBM (Human Body Mode) [1] ± 2000 V	JESD22-A114
	CDM (Charge Device Mode) [2] ± 500 V	JESD22-C101F
Latch up	Current trigger ± 200 mA	JESD78
	Voltage trigger 1.5 × VDD_{max}	
Preconditioning	Bake 24 hours @125 °C Moisture soak (level 3: 192 hours @30 °C, 60% RH) IR reflow solder: 260 + 0 °C, 20 seconds, three times	J-STD-020, JESD47, JESD22-A113

Test Item	Test Condition	Test Standard
TCT (Temperature Cycling Test)	–65 °C / 150 °C, 500 cycles	JESD22-A104
Autoclave Test	121 °C, 100% RH, 96 hours	JESD22-A102
uHAST (Highly Accelerated Stress Test, unbiased)	130 °C, 85% RH, 96 hours	JESD22-A118
HTSL (High Temperature Storage Life)	150 °C, 1000 hours	JESD22-A103

1. JEDEC document JEP155 states that 500 V HBM allows safe manufacturing with a standard ESD control process.
2. JEDEC document JEP157 states that 250 V CDM allows safe manufacturing with a standard ESD control process.

5.5 RF Power-Consumption Specifications

The power consumption measurements are taken with a 3.3 V supply at 25 °C of ambient temperature at the RF port. All transmitters' measurements are based on a 50% duty cycle.

Table 15: RF Power-Consumption Specifications

Mode	Min	Typ	Max	Unit
Transmit 802.11b, DSSS 1 Mbps, POUT = +19.5 dBm	-	240	-	mA
Transmit 802.11g, OFDM 54 Mbps, POUT = +16 dBm	-	190	-	mA
Transmit 802.11n, OFDM MCS7, POUT = +14 dBm	-	180	-	mA
Receive 802.11b/g/n	-	95 ~ 100	-	mA
Transmit BT/BLE, POUT = 0 dBm	-	130	-	mA
Receive BT/BLE	-	95 ~ 100	-	mA

5.6 Wi-Fi Radio

Table 16: Wi-Fi Radio Characteristics

Parameter	Condition	Min	Typ	Max	Unit
Operating frequency range *note1*	-	2412	-	2484	MHz
Output impedance *note2*	-	-	*note 2*	-	Ω
TX power *note3*	11n, MCS7	12	13	14	dBm
	11b mode	18.5	19.5	20.5	dBm
Sensitivity	11b, 1 Mbps	-	–98	-	dBm
	11b, 11 Mbps	-	–88	-	dBm
	11g, 6 Mbps	-	–93	-	dBm
	11g, 54 Mbps	-	–75	-	dBm
	11n, HT20, MCS0	-	–93	-	dBm
	11n, HT20, MCS7	-	–73	-	dBm
	11n, HT40, MCS0	-	–90	-	dBm
	11n, HT40, MCS7	-	–70	-	dBm

Parameter	Condition	Min	Typ	Max	Unit
Adjacent channel rejection	11g, 6 Mbps	-	27	-	dB
	11g, 54 Mbps	-	13	-	dB
	11n, HT20, MCS0	-	27	-	dB
	11n, HT20, MCS7	-	12	-	dB

1. Device should operate in the frequency range allocated by regional regulatory authorities. Target operating frequency range is configurable by software.
2. The typical value of ESP32's Wi-Fi radio output impedance is different between chips in different QFN packages. For ESP32 chips with a QFN 6×6 package, the value is 30+j10 Ω. For ESP32 chips with a QFN 5×5 package, the value is 35+j10 Ω.
3. Target TX power is configurable based on device or certification requirements.

5.7 Bluetooth Radio

5.7.1 Receiver – Basic Data Rate

Table 17: Receiver Characteristics – Basic Data Rate

Parameter	Conditions	Min	Typ	Max	Unit
Sensitivity @0.1% BER	-	–90	–89	–88	dBm
Maximum received signal @0.1% BER	-	0	-	-	dBm
Co-channel C/I	-	-	+7	-	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	-	-	–6	dB
	F = F0 – 1 MHz	-	-	–6	dB
	F = F0 + 2 MHz	-	-	–25	dB
	F = F0 – 2 MHz	-	-	–33	dB
	F = F0 + 3 MHz	-	-	–25	dB
	F = F0 – 3 MHz	-	-	–45	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	–10	-	-	dBm
	2000 MHz ~ 2400 MHz	–27	-	-	dBm
	2500 MHz ~ 3000 MHz	–27	-	-	dBm
	3000 MHz ~ 12.5 GHz	–10	-	-	dBm
Intermodulation	-	–36	-	-	dBm

5.7.2 Transmitter – Basic Data Rate

Table 18: Transmitter Characteristics – Basic Data Rate

Parameter	Conditions	Min	Typ	Max	Unit
RF transmit power (see note under Table 18)	-	-	0	-	dBm
Gain control step	-	-	3	-	dB
RF power control range	-	–12	-	+9	dBm
+20 dB bandwidth	-	-	0.9	-	MHz
Adjacent channel transmit power	F = F0 ± 2 MHz	-	–47	-	dBm
	F = F0 ± 3 MHz	-	–55	-	dBm

Parameter	Conditions	Min	Typ	Max	Unit
	F = F0 ± > 3 MHz	-	–60	-	dBm
$\Delta\ f1_{avg}$	-	-	-	155	kHz
$\Delta\ f2_{max}$	-	133.7	-	-	kHz
$\Delta\ f2_{avg}/\Delta\ f1_{avg}$	-	-	0.92	-	-
ICFT	-	-	–7	-	kHz
Drift rate	-	-	0.7	-	kHz/50 μs
Drift (DH1)	-	-	6	-	kHz
Drift (DH5)	-	-	6	-	kHz

Note:
There are a total of eight power levels from 0 to 7, and the transmit power ranges from –12 dBm to 9 dBm. When the power level rises by 1, the transmit power increases by 3 dB. Power level 4 is used by default and the corresponding transmit power is 0 dBm.

5.7.3 Receiver – Enhanced Data Rate

Table 19: Receiver Characteristics – Enhanced Data Rate

Parameter	Conditions	Min	Typ	Max	Unit
$\pi/4$ DQPSK					
Sensitivity @0.01% BER	-	–90	–89	–88	dBm
Maximum received signal @0.01% BER	-	-	0	-	dBm
Co-channel C/I	-	-	11	-	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	-	–7	-	dB
	F = F0 – 1 MHz	-	–7	-	dB
	F = F0 + 2 MHz	-	–25	-	dB
	F = F0 – 2 MHz	-	–35	-	dB
	F = F0 + 3 MHz	-	–25	-	dB
	F = F0 – 3 MHz	-	–45	-	dB
8DPSK					
Sensitivity @0.01% BER	-	–84	–83	–82	dBm
Maximum received signal @0.01% BER	-	-	–5	-	dBm
C/I c-channel	-	-	18	-	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	-	2	-	dB
	F = F0 – 1 MHz	-	2	-	dB
	F = F0 + 2 MHz	-	–25	-	dB
	F = F0 – 2 MHz	-	–25	-	dB
	F = F0 + 3 MHz	-	–25	-	dB
	F = F0 – 3 MHz	-	–38	-	dB

5.7.4 Transmitter – Enhanced Data Rate

Table 20: Transmitter Characteristics – Enhanced Data Rate

Parameter	Conditions	Min	Typ	Max	Unit
RF transmit power (see note under Table 18)	-	-	0	-	dBm
Gain control step	-	-	3	-	dB
RF power control range	-	–12	-	+9	dBm
$\pi/4$ DQPSK max w0	-	-	–0.72	-	kHz
$\pi/4$ DQPSK max wi	-	-	–6	-	kHz
$\pi/4$ DQPSK max |wi + w0|	-	-	–7.42	-	kHz
8DPSK max w0	-	-	0.7	-	kHz
8DPSK max wi	-	-	–9.6	-	kHz
8DPSK max |wi + w0|	-	-	–10	-	kHz
$\pi/4$ DQPSK modulation accuracy	RMS DEVM	-	4.28	-	%
	99% DEVM	-	100	-	%
	Peak DEVM	-	13.3	-	%
8 DPSK modulation accuracy	RMS DEVM	-	5.8	-	%
	99% DEVM	-	100	-	%
	Peak DEVM	-	14	-	%
In-band spurious emissions	F = F0 ± 1 MHz	-	–46	-	dBm
	F = F0 ± 2 MHz	-	–40	-	dBm
	F = F0 ± 3 MHz	-	–46	-	dBm
	F = F0 +/– > 3 MHz	-	-	–53	dBm
EDR differential phase coding	-	-	100	-	%

5.8 Bluetooth LE Radio

5.8.1 Receiver

Table 21: Receiver Characteristics – BLE

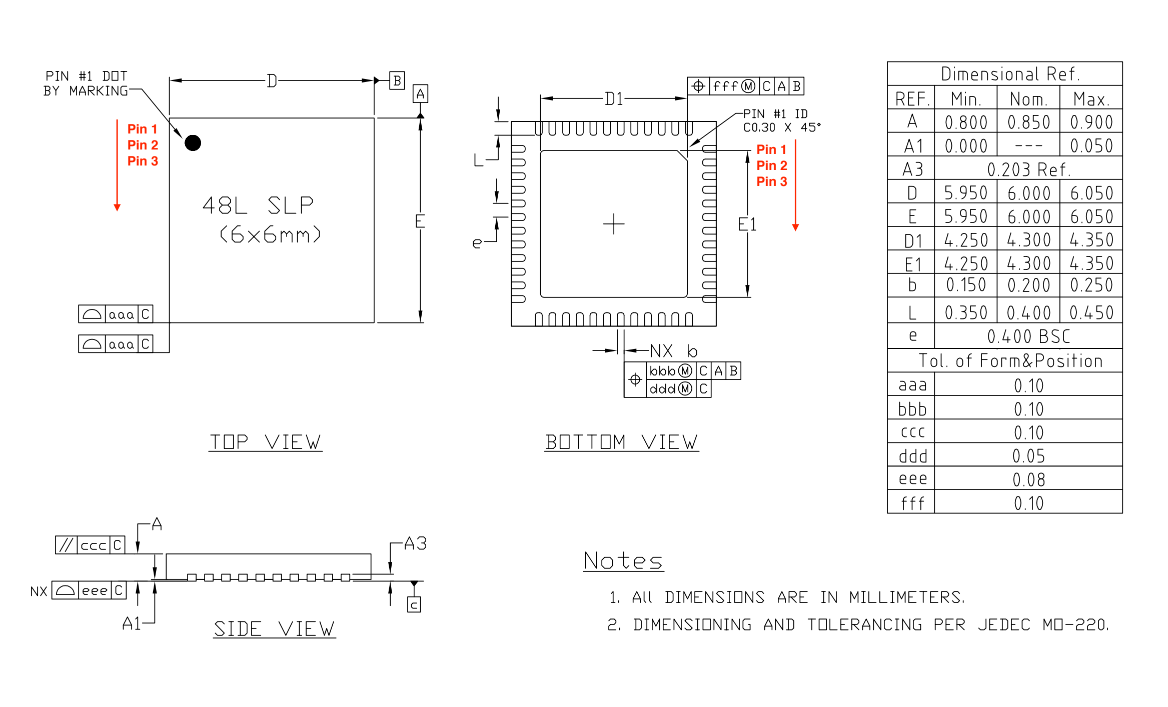
Parameter	Conditions	Min	Typ	Max	Unit
Sensitivity @30.8% PER	-	–94	–93	–92	dBm
Maximum received signal @30.8% PER	-	0	-	-	dBm
Co-channel C/I	-	-	+10	-	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	-	–5	-	dB
	F = F0 – 1 MHz	-	–5	-	dB
	F = F0 + 2 MHz	-	–25	-	dB
	F = F0 – 2 MHz	-	–35	-	dB
	F = F0 + 3 MHz	-	–25	-	dB
	F = F0 – 3 MHz	-	–45	-	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	–10	-	-	dBm
	2000 MHz ~ 2400 MHz	–27	-	-	dBm
	2500 MHz ~ 3000 MHz	–27	-	-	dBm
	3000 MHz ~ 12.5 GHz	–10	-	-	dBm
Intermodulation	-	–36	-	-	dBm

5.8.2 Transmitter

Table 22: Transmitter Characteristics – BLE

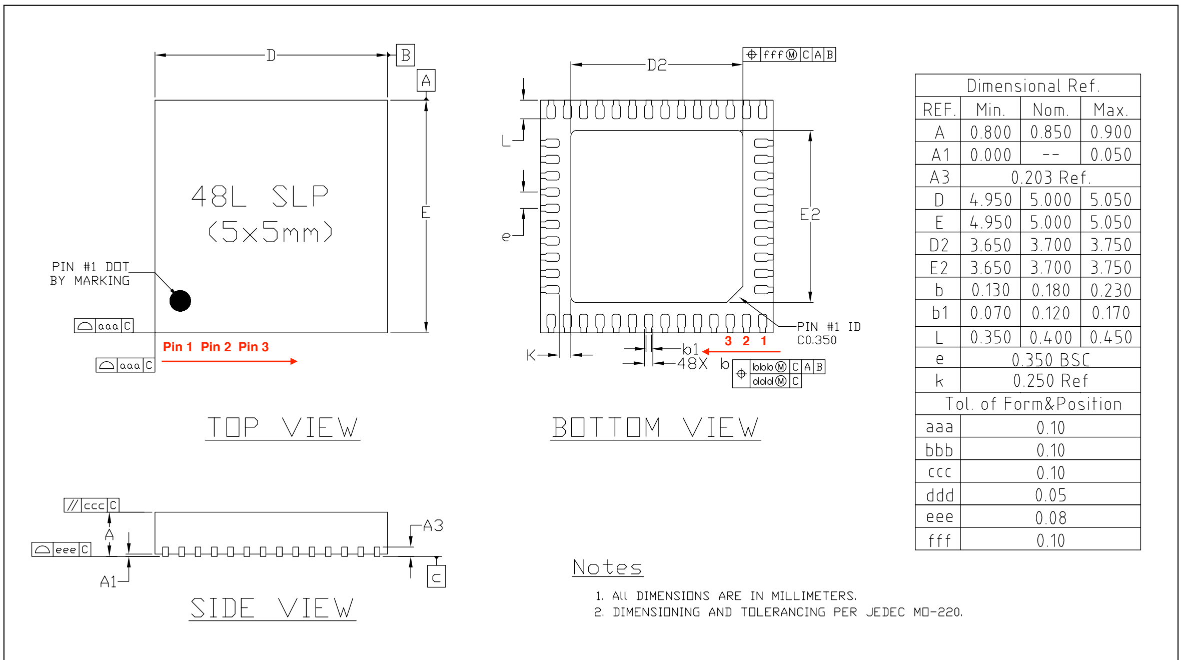
Parameter	Conditions	Min	Typ	Max	Unit
RF transmit power (see note under Table 18)	-	-	0	-	dBm
Gain control step	-	-	3	-	dB
RF power control range	-	–12	-	+9	dBm
Adjacent channel transmit power	F = F0 ± 2 MHz	-	–52	-	dBm
	F = F0 ± 3 MHz	-	–58	-	dBm
	F = F0 ± > 3 MHz	-	–60	-	dBm
$\Delta\ f1_{\text{avg}}$	-	-	-	265	kHz
$\Delta\ f2_{\text{max}}$	-	247	-	-	kHz
$\Delta\ f2_{\text{avg}}/\Delta\ f1_{\text{avg}}$	-	-	0.92	-	-
ICFT	-	-	–10	-	kHz
Drift rate	-	-	0.7	-	kHz/50 μs
Drift	-	-	2	-	kHz

6 Package Information



Dimensional Ref.			
REF.	Min.	Nom.	Max.
A	0.800	0.850	0.900
A1	0.000	---	0.050
A3	0.203 Ref.		
D	5.950	6.000	6.050
E	5.950	6.000	6.050
D1	4.250	4.300	4.350
E1	4.250	4.300	4.350
b	0.150	0.200	0.250
L	0.350	0.400	0.450
e	0.400 BSC		
Tol. of Form&Position			
aaa	0.10		
bbb	0.10		
ccc	0.10		
ddd	0.05		
eee	0.08		
fff	0.10		

Figure 8: QFN48 (6x6 mm) Package



Dimensional Ref.			
REF.	Min.	Nom.	Max.
A	0.800	0.850	0.900
A1	0.000	--	0.050
A3	0.203 Ref.		
D	4.950	5.000	5.050
E	4.950	5.000	5.050
D2	3.650	3.700	3.750
E2	3.650	3.700	3.750
b	0.130	0.180	0.230
b1	0.070	0.120	0.170
L	0.350	0.400	0.450
e	0.350 BSC		
k	0.250 Ref		
Tol. of Form&Position			
aaa	0.10		
bbb	0.10		
ccc	0.10		
ddd	0.05		
eee	0.08		
fff	0.10		

Figure 9: QFN48 (5x5 mm) Package

Note:

The pins of the chip are numbered in an anti-clockwise direction from Pin 1 in the top view.

7 Part Number and Ordering Information

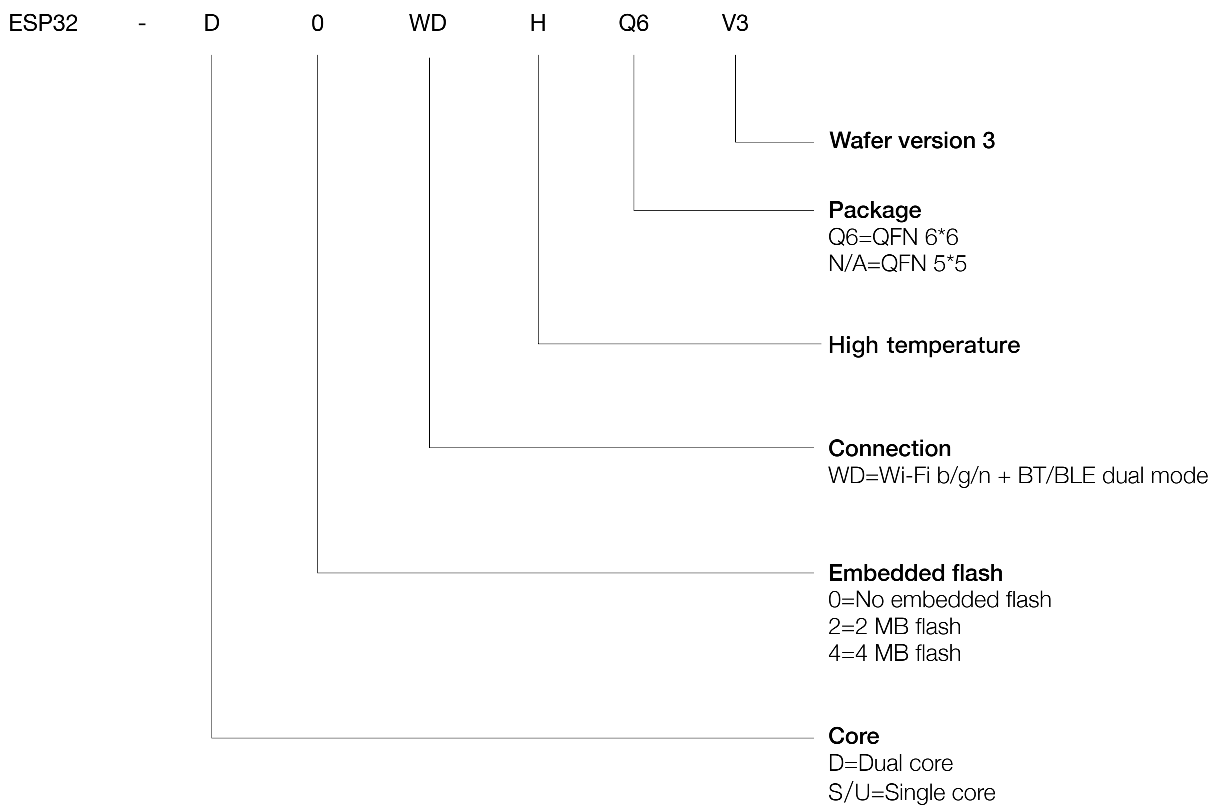


Figure 10: ESP32 Part Number

The table below provides the ordering information of the ESP32 series of chips.

Table 23: ESP32 Ordering Information

Ordering code	Core	Embedded flash	Package
ESP32-D0WD-V3	Dual core	No embedded flash	QFN 5*5
ESP32-D0WDQ6-V3	Dual core	No embedded flash	QFN 6*6
ESP32-D0WD	Dual core	No embedded flash	QFN 5*5
ESP32-D0WDQ6	Dual core	No embedded flash	QFN 6*6
ESP32-D2WD	Dual core	2 MB embedded flash (40 MHz)	QFN 5*5
ESP32-S0WD	Single core	No embedded flash	QFN 5*5
ESP32-U4WDH	Single core	4 MB embedded flash (80 MHz)	QFN 5*5
Note: All above chips support Wi-Fi b/g/n + BT/BLE Dual Mode connection.			

8 Learning Resources

8.1 Must-Read Documents

Click on the following links to access documents related to ESP32.

- *ESP32 ECO V3 User Guide*
  This document describes differences between V3 and previous ESP32 silicon wafer revisions.
- *ECO and Workarounds for Bugs in ESP32*
  This document details hardware errata and workarounds in the ESP32.
- *ESP-IDF Programming Guide*
  It hosts extensive documentation for ESP-IDF, ranging from hardware guides to API reference.
- *ESP32 Technical Reference Manual*
  The manual provides detailed information on how to use the ESP32 memory and peripherals.
- ESP32 Hardware Resources
  The zip files include schematics, PCB layout, Gerber and BOM list.
- *ESP32 Hardware Design Guidelines*
  The guidelines provide recommended design practices when developing standalone or add-on systems based on the ESP32 series of products, including the ESP32 chip, the ESP32 modules and development boards.
- *ESP32 AT Instruction Set and Examples*
  This document introduces the ESP32 AT commands, explains how to use them, and provides examples of several common AT commands.
- *Espressif Products Ordering Information*

8.2 Must-Have Resources

Here are the ESP32-related must-have resources.

- ESP32 BBS
  This is an Engineer-to-Engineer (E2E) Community for ESP32, where you can post questions, share knowledge, explore ideas, and solve problems together with fellow engineers.
- ESP32 GitHub
  ESP32 development projects are freely distributed under Espressif's MIT license on GitHub. This channel of communication has been established to help developers get started with ESP32 and encourage them to share their knowledge of ESP32-related hardware and software.
- ESP32 Tools
  This is a webpage where users can download ESP32 Flash Download Tools and the zip file "ESP32 Certification and Test".
- ESP-IDF
  This webpage links users to the official IoT development framework for ESP32.
- ESP32 Resources
  This webpage provides the links to all available ESP32 documents, SDK and tools.

Appendix A – ESP32 Pin Lists

A.1. Notes on ESP32 Pin Lists

Table 24: Notes on ESP32 Pin Lists

No.	Description
1	In Table IO_MUX, the boxes highlighted in yellow indicate the GPIO pins that are input-only. Please see the following note for further details.
2	GPIO pins 34-39 are input-only. These pins do not feature an output driver or internal pull-up/pull-down circuitry. The pin names are: SENSOR_VP (GPIO36), SENSOR_CAPP (GPIO37), SENSOR_CAPN (GPIO38), SENSOR_VN (GPIO39), VDET_1 (GPIO34), VDET_2 (GPIO35).
3	The pins are grouped into four power domains: VDDA (analog power supply), VDD3P3_RTC (RTC power supply), VDD3P3_CPU (power supply of digital IOs and CPU cores), VDD_SDIO (power supply of SDIO IOs). VDD_SDIO is the output of the internal SDIO-LDO. The voltage of SDIO-LDO can be configured at 1.8 V or be the same as that of VDD3P3_RTC. The strapping pin and eFuse bits determine the default voltage of the SDIO-LDO. Software can change the voltage of the SDIO-LDO by configuring register bits. For details, please see the column "Power Domain" in Table IO_MUX.
4	The functional pins in the VDD3P3_RTC domain are those with analog functions, including the 32 kHz crystal oscillator, ADC, DAC, and the capacitive touch sensor. Please see columns "Analog Function 1~3" in Table IO_MUX.
5	These VDD3P3_RTC pins support the RTC function, and can work during Deep-sleep. For example, an RTC-GPIO can be used for waking up the chip from Deep-sleep.
6	The GPIO pins support up to six digital functions, as shown in columns "Function 1~6" In Table IO_MUX. The function selection registers will be set as "*N*-1", where *N* is the function number. Below are some definitions: • SD_* is for signals of the SDIO slave. • HS1_* is for Port 1 signals of the SDIO host. • HS2_* is for Port 2 signals of the SDIO host. • MT* is for signals of the JTAG. • U0* is for signals of the UART0 module. • U1* is for signals of the UART1 module. • U2* is for signals of the UART2 module. • SPI* is for signals of the SPI01 module. • HSPI* is for signals of the SPI2 module. • VSPI* is for signals of the SPI3 module.

No.	Description
7	Each column about digital "Function" is accompanied by a column about "Type". Please see the following explanations for the meanings of "type" with respect to each "function" they are associated with. For each "Function-*N*", "type" signifies: • I: input only. If a function other than "Function-*N*" is assigned, the input signal of "Function-*N*" is still from this pin. • I1: input only. If a function other than "Function-*N*" is assigned, the input signal of "Function-*N*" is always "1". • I0: input only. If a function other than "Function-*N*" is assigned, the input signal of "Function-*N*" is always "0". • O: output only. • T: high-impedance. • I/O/T: combinations of input, output, and high-impedance according to the function signal. • I1/O/T: combinations of input, output, and high-impedance, according to the function signal. If a function is not selected, the input signal of the function is "1". For example, pin 30 can function as HS1_CMD or SD_CMD, where HS1_CMD is of an "I1/O/T" type. If pin 30 is selected as HS1_CMD, this pin's input and output are controlled by the SDIO host. If pin 30 is not selected as HS1_CMD, the input signal of the SDIO host is always "1".
8	Each digital output pin is associated with its configurable drive strength. Column "Drive Strength" in Table IO_MUX lists the default values. The drive strength of the digital output pins can be configured into one of the following four options: • 0: ~5 mA • 1: ~10 mA • 2: ~20 mA • 3: ~40 mA The default value is 2. The drive strength of the internal pull-up (wpu) and pull-down (wpd) is ~75 μA.
9	Column "At Reset" in Table IO_MUX lists the status of each pin during reset, including input-enable (ie=1), internal pull-up (wpu) and internal pull-down (wpd). During reset, all pins are output-disabled.
10	Column "After Reset" in Table IO_MUX lists the status of each pin immediately after reset, including input-enable (ie=1), internal pull-up (wpu) and internal pull-down (wpd). After reset, each pin is set to "Function 1". The output-enable is controlled by digital Function 1.
11	Table Ethernet_MAC is about the signal mapping inside Ethernet MAC. The Ethernet MAC supports MII and RMII interfaces, and supports both the internal PLL clock and the external clock source. For the MII interface, the Ethernet MAC is with/without the TX_ERR signal. MDC, MDIO, CRS and COL are slow signals, and can be mapped onto any GPIO pin through the GPIO-Matrix.
12	Table GPIO Matrix is for the GPIO-Matrix. The signals of the on-chip functional modules can be mapped onto any GPIO pin. Some signals can be mapped onto a pin by both IO-MUX and GPIO-Matrix, as shown in the column tagged as "Same input signal from IO_MUX core" in Table GPIO Matrix.

No.	Description
13	*In Table GPIO_Matrix the column "Default Value if unassigned" records the default value of the an input signal if no GPIO is assigned to it. The actual value is determined by register GPIO_FUNC*m*_IN_INV_SEL and GPIO_FUNC*m*_IN_SEL. (The value of *m* ranges from 1 to 255.)

A.2. GPIO_Matrix

Table 25: GPIO_Matrix

Signal No.	Input signals	Default value if unassigned*	Same input signal from IO_MUX core	Output signals	Output enable of output signals
0	SPICLK_in	0	yes	SPICLK_out	SPICLK_oe
1	SPIQ_in	0	yes	SPIQ_out	SPIQ_oe
2	SPID_in	0	yes	SPID_out	SPID_oe
3	SPIHD_in	0	yes	SPIHD_out	SPIHD_oe
4	SPIWP_in	0	yes	SPIWP_out	SPIWP_oe
5	SPICS0_in	0	yes	SPICS0_out	SPICS0_oe
6	SPICS1_in	0	no	SPICS1_out	SPICS1_oe
7	SPICS2_in	0	no	SPICS2_out	SPICS2_oe
8	HSPICLK_in	0	yes	HSPICLK_out	HSPICLK_oe
9	HSPIQ_in	0	yes	HSPIQ_out	HSPIQ_oe
10	HSPID_in	0	yes	HSPID_out	HSPID_oe
11	HSPICS0_in	0	yes	HSPICS0_out	HSPICS0_oe
12	HSPIHD_in	0	yes	HSPIHD_out	HSPIHD_oe
13	HSPIWP_in	0	yes	HSPIWP_out	HSPIWP_oe
14	U0RXD_in	0	yes	U0TXD_out	1'd1
15	U0CTS_in	0	yes	U0RTS_out	1'd1
16	U0DSR_in	0	no	U0DTR_out	1'd1
17	U1RXD_in	0	yes	U1TXD_out	1'd1
18	U1CTS_in	0	yes	U1RTS_out	1'd1
23	I2S0O_BCK_in	0	no	I2S0O_BCK_out	1'd1
24	I2S1O_BCK_in	0	no	I2S1O_BCK_out	1'd1
25	I2S0O_WS_in	0	no	I2S0O_WS_out	1'd1
26	I2S1O_WS_in	0	no	I2S1O_WS_out	1'd1
27	I2S0I_BCK_in	0	no	I2S0I_BCK_out	1'd1
28	I2S0I_WS_in	0	no	I2S0I_WS_out	1'd1
29	I2CEXT0_SCL_in	1	no	I2CEXT0_SCL_out	1'd1
30	I2CEXT0_SDA_in	1	no	I2CEXT0_SDA_out	1'd1
31	pwm0_sync0_in	0	no	sdio_tohost_int_out	1'd1
32	pwm0_sync1_in	0	no	pwm0_out0a	1'd1
33	pwm0_sync2_in	0	no	pwm0_out0b	1'd1
34	pwm0_f0_in	0	no	pwm0_out1a	1'd1

Signal No.	Input signals	Default value if unassigned*	Same input signal from IO_MUX core	Output signals	Output enable of output signals
35	pwm0_f1_in	0	no	pwm0_out1b	1’d1
36	pwm0_f2_in	0	no	pwm0_out2a	1’d1
37	-	0	no	pwm0_out2b	1’d1
39	pcnt_sig_ch0_in0	0	no	-	1’d1
40	pcnt_sig_ch1_in0	0	no	-	1’d1
41	pcnt_ctrl_ch0_in0	0	no	-	1’d1
42	pcnt_ctrl_ch1_in0	0	no	-	1’d1
43	pcnt_sig_ch0_in1	0	no	-	1’d1
44	pcnt_sig_ch1_in1	0	no	-	1’d1
45	pcnt_ctrl_ch0_in1	0	no	-	1’d1
46	pcnt_ctrl_ch1_in1	0	no	-	1’d1
47	pcnt_sig_ch0_in2	0	no	-	1’d1
48	pcnt_sig_ch1_in2	0	no	-	1’d1
49	pcnt_ctrl_ch0_in2	0	no	-	1’d1
50	pcnt_ctrl_ch1_in2	0	no	-	1’d1
51	pcnt_sig_ch0_in3	0	no	-	1’d1
52	pcnt_sig_ch1_in3	0	no	-	1’d1
53	pcnt_ctrl_ch0_in3	0	no	-	1’d1
54	pcnt_ctrl_ch1_in3	0	no	-	1’d1
55	pcnt_sig_ch0_in4	0	no	-	1’d1
56	pcnt_sig_ch1_in4	0	no	-	1’d1
57	pcnt_ctrl_ch0_in4	0	no	-	1’d1
58	pcnt_ctrl_ch1_in4	0	no	-	1’d1
61	HSPICS1_in	0	no	HSPICS1_out	HSPICS1_oe
62	HSPICS2_in	0	no	HSPICS2_out	HSPICS2_oe
63	VSPICLK_in	0	yes	VSPICLK_out_mux	VSPICLK_oe
64	VSPIQ_in	0	yes	VSPIQ_out	VSPIQ_oe
65	VSPID_in	0	yes	VSPID_out	VSPID_oe
66	VSPIHD_in	0	yes	VSPIHD_out	VSPIHD_oe
67	VSPIWP_in	0	yes	VSPIWP_out	VSPIWP_oe
68	VSPICS0_in	0	yes	VSPICS0_out	VSPICS0_oe
69	VSPICS1_in	0	no	VSPICS1_out	VSPICS1_oe
70	VSPICS2_in	0	no	VSPICS2_out	VSPICS2_oe
71	pcnt_sig_ch0_in5	0	no	ledc_hs_sig_out0	1’d1
72	pcnt_sig_ch1_in5	0	no	ledc_hs_sig_out1	1’d1
73	pcnt_ctrl_ch0_in5	0	no	ledc_hs_sig_out2	1’d1
74	pcnt_ctrl_ch1_in5	0	no	ledc_hs_sig_out3	1’d1
75	pcnt_sig_ch0_in6	0	no	ledc_hs_sig_out4	1’d1
76	pcnt_sig_ch1_in6	0	no	ledc_hs_sig_out5	1’d1
77	pcnt_ctrl_ch0_in6	0	no	ledc_hs_sig_out6	1’d1
78	pcnt_ctrl_ch1_in6	0	no	ledc_hs_sig_out7	1’d1

Signal No.	Input signals	Default value if unassigned*	Same input signal from IO_MUX core	Output signals	Output enable of output signals
79	pcnt_sig_ch0_in7	0	no	ledc_ls_sig_out0	1'd1
80	pcnt_sig_ch1_in7	0	no	ledc_ls_sig_out1	1'd1
81	pcnt_ctrl_ch0_in7	0	no	ledc_ls_sig_out2	1'd1
82	pcnt_ctrl_ch1_in7	0	no	ledc_ls_sig_out3	1'd1
83	rmt_sig_in0	0	no	ledc_ls_sig_out4	1'd1
84	rmt_sig_in1	0	no	ledc_ls_sig_out5	1'd1
85	rmt_sig_in2	0	no	ledc_ls_sig_out6	1'd1
86	rmt_sig_in3	0	no	ledc_ls_sig_out7	1'd1
87	rmt_sig_in4	0	no	rmt_sig_out0	1'd1
88	rmt_sig_in5	0	no	rmt_sig_out1	1'd1
89	rmt_sig_in6	0	no	rmt_sig_out2	1'd1
90	rmt_sig_in7	0	no	rmt_sig_out3	1'd1
91	-	-	-	rmt_sig_out4	1'd1
92	-	-	-	rmt_sig_out6	1'd1
94	twai_rx	1	no	rmt_sig_out7	1'd1
95	I2CEXT1_SCL_in	1	no	I2CEXT1_SCL_out	1'd1
96	I2CEXT1_SDA_in	1	no	I2CEXT1_SDA_out	1'd1
97	host_card_detect_n_1	0	no	host_ccmd_od_pullup_en_n	1'd1
98	host_card_detect_n_2	0	no	host_rst_n_1	1'd1
99	host_card_write_prt_1	0	no	host_rst_n_2	1'd1
100	host_card_write_prt_2	0	no	gpio_sd0_out	1'd1
101	host_card_int_n_1	0	no	gpio_sd1_out	1'd1
102	host_card_int_n_2	0	no	gpio_sd2_out	1'd1
103	pwm1_sync0_in	0	no	gpio_sd3_out	1'd1
104	pwm1_sync1_in	0	no	gpio_sd4_out	1'd1
105	pwm1_sync2_in	0	no	gpio_sd5_out	1'd1
106	pwm1_f0_in	0	no	gpio_sd6_out	1'd1
107	pwm1_f1_in	0	no	gpio_sd7_out	1'd1
108	pwm1_f2_in	0	no	pwm1_out0a	1'd1
109	pwm0_cap0_in	0	no	pwm1_out0b	1'd1
110	pwm0_cap1_in	0	no	pwm1_out1a	1'd1
111	pwm0_cap2_in	0	no	pwm1_out1b	1'd1
112	pwm1_cap0_in	0	no	pwm1_out2a	1'd1
113	pwm1_cap1_in	0	no	pwm1_out2b	1'd1
114	pwm1_cap2_in	0	no	pwm2_out1h	1'd1
115	pwm2_flta	1	no	pwm2_out1l	1'd1
116	pwm2_fltb	1	no	pwm2_out2h	1'd1
117	pwm2_cap1_in	0	no	pwm2_out2l	1'd1
118	pwm2_cap2_in	0	no	pwm2_out3h	1'd1
119	pwm2_cap3_in	0	no	pwm2_out3l	1'd1
120	pwm3_flta	1	no	pwm2_out4h	1'd1

Signal No.	Input signals	Default value if unassigned*	Same input signal from IO_MUX core	Output signals	Output enable of output signals
121	pwm3_fltb	1	no	pwm2_out4l	1'd1
122	pwm3_cap1_in	0	no	-	1'd1
123	pwm3_cap2_in	0	no	twai_tx	1'd1
124	pwm3_cap3_in	0	no	twai_bus_off_on	1'd1
125	-	-	-	twai_clkout	1'd1
140	I2S0I_DATA_in0	0	no	I2S0O_DATA_out0	1'd1
141	I2S0I_DATA_in1	0	no	I2S0O_DATA_out1	1'd1
142	I2S0I_DATA_in2	0	no	I2S0O_DATA_out2	1'd1
143	I2S0I_DATA_in3	0	no	I2S0O_DATA_out3	1'd1
144	I2S0I_DATA_in4	0	no	I2S0O_DATA_out4	1'd1
145	I2S0I_DATA_in5	0	no	I2S0O_DATA_out5	1'd1
146	I2S0I_DATA_in6	0	no	I2S0O_DATA_out6	1'd1
147	I2S0I_DATA_in7	0	no	I2S0O_DATA_out7	1'd1
148	I2S0I_DATA_in8	0	no	I2S0O_DATA_out8	1'd1
149	I2S0I_DATA_in9	0	no	I2S0O_DATA_out9	1'd1
150	I2S0I_DATA_in10	0	no	I2S0O_DATA_out10	1'd1
151	I2S0I_DATA_in11	0	no	I2S0O_DATA_out11	1'd1
152	I2S0I_DATA_in12	0	no	I2S0O_DATA_out12	1'd1
153	I2S0I_DATA_in13	0	no	I2S0O_DATA_out13	1'd1
154	I2S0I_DATA_in14	0	no	I2S0O_DATA_out14	1'd1
155	I2S0I_DATA_in15	0	no	I2S0O_DATA_out15	1'd1
156	-	-	-	I2S0O_DATA_out16	1'd1
157	-	-	-	I2S0O_DATA_out17	1'd1
158	-	-	-	I2S0O_DATA_out18	1'd1
159	-	-	-	I2S0O_DATA_out19	1'd1
160	-	-	-	I2S0O_DATA_out20	1'd1
161	-	-	-	I2S0O_DATA_out21	1'd1
162	-	-	-	I2S0O_DATA_out22	1'd1
163	-	-	-	I2S0O_DATA_out23	1'd1
164	I2S1I_BCK_in	0	no	I2S1I_BCK_out	1'd1
165	I2S1I_WS_in	0	no	I2S1I_WS_out	1'd1
166	I2S1I_DATA_in0	0	no	I2S1O_DATA_out0	1'd1
167	I2S1I_DATA_in1	0	no	I2S1O_DATA_out1	1'd1
168	I2S1I_DATA_in2	0	no	I2S1O_DATA_out2	1'd1
169	I2S1I_DATA_in3	0	no	I2S1O_DATA_out3	1'd1
170	I2S1I_DATA_in4	0	no	I2S1O_DATA_out4	1'd1
171	I2S1I_DATA_in5	0	no	I2S1O_DATA_out5	1'd1
172	I2S1I_DATA_in6	0	no	I2S1O_DATA_out6	1'd1
173	I2S1I_DATA_in7	0	no	I2S1O_DATA_out7	1'd1
174	I2S1I_DATA_in8	0	no	I2S1O_DATA_out8	1'd1
175	I2S1I_DATA_in9	0	no	I2S1O_DATA_out9	1'd1

Signal No.	Input signals	Default value if unassigned*	Same input signal from IO_MUX core	Output signals	Output enable of output signals
176	I2S1I_DATA_in10	0	no	I2S1O_DATA_out10	1'd1
177	I2S1I_DATA_in11	0	no	I2S1O_DATA_out11	1'd1
178	I2S1I_DATA_in12	0	no	I2S1O_DATA_out12	1'd1
179	I2S1I_DATA_in13	0	no	I2S1O_DATA_out13	1'd1
180	I2S1I_DATA_in14	0	no	I2S1O_DATA_out14	1'd1
181	I2S1I_DATA_in15	0	no	I2S1O_DATA_out15	1'd1
182	-	-	-	I2S1O_DATA_out16	1'd1
183	-	-	-	I2S1O_DATA_out17	1'd1
184	-	-	-	I2S1O_DATA_out18	1'd1
185	-	-	-	I2S1O_DATA_out19	1'd1
186	-	-	-	I2S1O_DATA_out20	1'd1
187	-	-	-	I2S1O_DATA_out21	1'd1
188	-	-	-	I2S1O_DATA_out22	1'd1
189	-	-	-	I2S1O_DATA_out23	1'd1
190	I2S0I_H_SYNC	0	no	pwm3_out1h	1'd1
191	I2S0I_V_SYNC	0	no	pwm3_out1l	1'd1
192	I2S0I_H_ENABLE	0	no	pwm3_out2h	1'd1
193	I2S1I_H_SYNC	0	no	pwm3_out2l	1'd1
194	I2S1I_V_SYNC	0	no	pwm3_out3h	1'd1
195	I2S1I_H_ENABLE	0	no	pwm3_out3l	1'd1
196	-	-	-	pwm3_out4h	1'd1
197	-	-	-	pwm3_out4l	1'd1
198	U2RXD_in	0	yes	U2TXD_out	1'd1
199	U2CTS_in	0	yes	U2RTS_out	1'd1
200	emac_mdc_i	0	no	emac_mdc_o	emac_mdc_oe
201	emac_mdi_i	0	no	emac_mdo_o	emac_mdo_o_e
202	emac_crs_i	0	no	emac_crs_o	emac_crs_oe
203	emac_col_i	0	no	emac_col_o	emac_col_oe
204	pcmfsync_in	0	no	bt_audio0_irq	1'd1
205	pcmclk_in	0	no	bt_audio1_irq	1'd1
206	pcmdin	0	no	bt_audio2_irq	1'd1
207	-	-	-	ble_audio0_irq	1'd1
208	-	-	-	ble_audio1_irq	1'd1
209	-	-	-	ble_audio2_irq	1'd1
210	-	-	-	pcmfsync_out	pcmfsync_en
211	-	-	-	pcmclk_out	pcmclk_en
212	-	-	-	pcmdout	pcmdout_en
213	-	-	-	ble_audio_sync0_p	1'd1
214	-	-	-	ble_audio_sync1_p	1'd1
215	-	-	-	ble_audio_sync2_p	1'd1
224	-	-	-	sig_in_func224	1'd1

Signal No.	Input signals	Default value if unassigned*	Same input signal from IO_MUX core	Output signals	Output enable of output signals
225	-	-	-	sig_in_func225	1'd1
226	-	-	-	sig_in_func226	1'd1
227	-	-	-	sig_in_func227	1'd1
228	-	-	-	sig_in_func228	1'd1

A.3. Ethernet_MAC

Table 26: Ethernet_MAC

PIN Name	Function6	MII (int_osc)	MII (ext_osc)	RMII (int_osc)	RMII (ext_osc)
GPIO0	EMAC_TX_CLK	TX_CLK (I)	TX_CLK (I)	CLK_OUT(O)	EXT_OSC_CLK(I)
GPIO5	EMAC_RX_CLK	RX_CLK (I)	RX_CLK (I)	-	-
GPIO21	EMAC_TX_EN	TX_EN(O)	TX_EN(O)	TX_EN(O)	TX_EN(O)
GPIO19	EMAC_TXD0	TXD[0](O)	TXD[0](O)	TXD[0](O)	TXD[0](O)
GPIO22	EMAC_TXD1	TXD[1](O)	TXD[1](O)	TXD[1](O)	TXD[1](O)
MTMS	EMAC_TXD2	TXD[2](O)	TXD[2](O)	-	-
MTDI	EMAC_TXD3	TXD[3](O)	TXD[3](O)	-	-
MTCK	EMAC_RX_ER	RX_ER(I)	RX_ER(I)	-	-
GPIO27	EMAC_RX_DV	RX_DV(I)	RX_DV(I)	CRS_DV(I)	CRS_DV(I)
GPIO25	EMAC_RXD0	RXD[0](I)	RXD[0](I)	RXD[0](I)	RXD[0](I)
GPIO26	EMAC_RXD1	RXD[1](I)	RXD[1](I)	RXD[1](I)	RXD[1](I)
U0TXD	EMAC_RXD2	RXD[2](I)	RXD[2](I)	-	-
MTDO	EMAC_RXD3	RXD[3](I)	RXD[3](I)	-	-
GPIO16	EMAC_CLK_OUT	CLK_OUT(O)	-	CLK_OUT(O)	-
GPIO17	EMAC_CLK_OUT_180	CLK_OUT_180(O)	-	CLK_OUT_180(O)	-
GPIO4	EMAC_TX_ER	TX_ERR(O)*	TX_ERR(O)*	-	-
In GPIO Matrix*	-	MDC(O)	MDC(O)	MDC(O)	MDC(O)
In GPIO Matrix*	-	MDIO(IO)	MDIO(IO)	MDIO(IO)	MDIO(IO)
In GPIO Matrix*	-	CRS(I)	CRS(I)	-	-
In GPIO Matrix*	-	COL(I)	COL(I)	-	-
*Notes: 1. The GPIO Matrix can be any GPIO. 2. The TX_ERR (O) is optional.					

A.4. IO_MUX

For the list of IO_MUX pins, please see the next page.

IO_MUX

Pin No.	Power Supply Pin	Analog Pin	Digital Pin	Power Domain	Analog Function1	Analog Function2	Analog Function3	RTC Function1	RTC Function2	Function1	Type	Function2	Type	Function3	Type	Function4	Type	Function5	Type	Function6	Type	Drive Strength (2'd2: 20 mA)	At Reset	After Reset
1	VDDA			VDDA supply in																				
2		LNA_IN		VDD3P3																				
3	VDD3P3			VDD3P3 supply in																				
4	VDD3P3			VDD3P3 supply in																				
5		SENSOR_VP		VDD3P3_RTC	ADC_H	ADC1_CH0		RTC_GPIO0		GPIO36	I			GPIO36	I								oe=0, ie=0	oe=0, ie=0
6		SENSOR_CAPP		VDD3P3_RTC	ADC_H	ADC1_CH1		RTC_GPIO1		GPIO37	I			GPIO37	I								oe=0, ie=0	oe=0, ie=0
7		SENSOR_CAPN		VDD3P3_RTC	ADC_H	ADC1_CH2		RTC_GPIO2		GPIO38	I			GPIO38	I								oe=0, ie=0	oe=0, ie=0
8		SENSOR_VN		VDD3P3_RTC	ADC_H	ADC1_CH3		RTC_GPIO3		GPIO39	I			GPIO39	I								oe=0, ie=0	oe=0, ie=0
9		CHIP_PU		VDD3P3_RTC																				
10		VDET_1		VDD3P3_RTC		ADC1_CH6		RTC_GPIO4		GPIO34	I			GPIO34	I								oe=0, ie=0	oe=0, ie=0
11		VDET_2		VDD3P3_RTC		ADC1_CH7		RTC_GPIO5		GPIO35	I			GPIO35	I								oe=0, ie=0	oe=0, ie=0
12		32K_XP		VDD3P3_RTC	XTAL_32K_P	ADC1_CH4	TOUCH9	RTC_GPIO9		GPIO32	I/O/T			GPIO32	I/O/T							2'd2	oe=0, ie=0	oe=0, ie=0
13		32K_XN		VDD3P3_RTC	XTAL_32K_N	ADC1_CH5	TOUCH8	RTC_GPIO8		GPIO33	I/O/T			GPIO33	I/O/T							2'd2	oe=0, ie=0	oe=0, ie=0
14			GPIO25	VDD3P3_RTC	DAC_1	ADC2_CH8		RTC_GPIO6		GPIO25	I/O/T			GPIO25	I/O/T					EMAC_RXD0	I	2'd2	oe=0, ie=0	oe=0, ie=0
15			GPIO26	VDD3P3_RTC	DAC_2	ADC2_CH9		RTC_GPIO7		GPIO26	I/O/T			GPIO26	I/O/T					EMAC_RXD1	I	2'd2	oe=0, ie=0	oe=0, ie=0
16			GPIO27	VDD3P3_RTC		ADC2_CH7	TOUCH7	RTC_GPIO17		GPIO27	I/O/T			GPIO27	I/O/T					EMAC_RX_DV	I	2'd2	oe=0, ie=0	oe=0, ie=0
17			MTMS	VDD3P3_RTC		ADC2_CH6	TOUCH6	RTC_GPIO16		MTMS	I0	HSPICLK	I/O/T	GPIO14	I/O/T	HS2_CLK	O	SD_CLK	I0	EMAC_TXD2	O	2'd2	oe=0, ie=0	oe=0, ie=1, wpu
18			MTDI	VDD3P3_RTC		ADC2_CH5	TOUCH5	RTC_GPIO15		MTDI	I1	HSPIQ	I/O/T	GPIO12	I/O/T	HS2_DATA2	I1/O/T	SD_DATA2	I1/O/T	EMAC_TXD3	O	2'd2	oe=0, ie=1, wpd	oe=0, ie=1, wpd
19	VDD3P3_RTC			VDD3P3_RTC supply in																				
20			MTCK	VDD3P3_RTC		ADC2_CH4	TOUCH4	RTC_GPIO14		MTCK	I1	HSPID	I/O/T	GPIO13	I/O/T	HS2_DATA3	I1/O/T	SD_DATA3	I1/O/T	EMAC_RX_ER	I	2'd2	oe=0, ie=0	oe=0, ie=1, wpd
21			MTDO	VDD3P3_RTC		ADC2_CH3	TOUCH3	RTC_GPIO13	I2C_SDA	MTDO	O/T	HSPICS0	I/O/T	GPIO15	I/O/T	HS2_CMD	I1/O/T	SD_CMD	I1/O/T	EMAC_RXD3	I	2'd2	oe=0, ie=1, wpu	oe=0, ie=1, wpu
22			GPIO2	VDD3P3_RTC		ADC2_CH2	TOUCH2	RTC_GPIO12	I2C_SCL	GPIO2	I/O/T	HSPIWP	I/O/T	GPIO2	I/O/T	HS2_DATA0	I1/O/T	SD_DATA0	I1/O/T			2'd2	oe=0, ie=1, wpd	oe=0, ie=1, wpd
23			GPIO0	VDD3P3_RTC		ADC2_CH1	TOUCH1	RTC_GPIO11	I2C_SDA	GPIO0	I/O/T	CLK_OUT1	O	GPIO0	I/O/T					EMAC_TX_CLK	I	2'd2	oe=0, ie=1, wpu	oe=0, ie=1, wpu
24			GPIO4	VDD3P3_RTC		ADC2_CH0	TOUCH0	RTC_GPIO10	I2C_SCL	GPIO4	I/O/T	HSPIHD	I/O/T	GPIO4	I/O/T	HS2_DATA1	I1/O/T	SD_DATA1	I1/O/T	EMAC_TX_ER	O	2'd2	oe=0, ie=1, wpd	oe=0, ie=1, wpd
25			GPIO16	VDD_SDIO						GPIO16	I/O/T			GPIO16	I/O/T	HS1_DATA4	I1/O/T	U2RXD	I1	EMAC_CLK_OUT	O	2'd2	oe=0, ie=0	oe=0, ie=1
26	VDD_SDIO			VDD_SDIO supply out/in																				
27			GPIO17	VDD_SDIO						GPIO17	I/O/T			GPIO17	I/O/T	HS1_DATA5	I1/O/T	U2TXD	O	EMAC_CLK_OUT_180	O	2'd2	oe=0, ie=0	oe=0, ie=1
28			SD_DATA_2	VDD_SDIO						SD_DATA2	I1/O/T	SPIHD	I/O/T	GPIO9	I/O/T	HS1_DATA2	I1/O/T	U1RXD	I1			2'd2	oe=0, ie=1, wpu	oe=0, ie=1, wpu
29			SD_DATA_3	VDD_SDIO						SD_DATA3	I0/O/T	SPIWP	I/O/T	GPIO10	I/O/T	HS1_DATA3	I1/O/T	U1TXD	O			2'd2	oe=0, ie=1, wpu	oe=0, ie=1, wpu
30			SD_CMD	VDD_SDIO						SD_CMD	I1/O/T	SPICS0	I/O/T	GPIO11	I/O/T	HS1_CMD	I1/O/T	U1RTS	O			2'd2	oe=0, ie=1, wpu	oe=0, ie=1, wpu
31			SD_CLK	VDD_SDIO						SD_CLK	I0	SPICLK	I/O/T	GPIO6	I/O/T	HS1_CLK	O	U1CTS	I1			2'd2	oe=0, ie=1, wpu	oe=0, ie=1, wpu
32			SD_DATA_0	VDD_SDIO						SD_DATA0	I1/O/T	SPIQ	I/O/T	GPIO7	I/O/T	HS1_DATA0	I1/O/T	U2RTS	O			2'd2	oe=0, ie=1, wpu	oe=0, ie=1, wpu
33			SD_DATA_1	VDD_SDIO						SD_DATA1	I1/O/T	SPID	I/O/T	GPIO8	I/O/T	HS1_DATA1	I1/O/T	U2CTS	I1			2'd2	oe=0, ie=1, wpu	oe=0, ie=1, wpu
34			GPIO5	VDD3P3_CPU						GPIO5	I/O/T	VSPICS0	I/O/T	GPIO5	I/O/T	HS1_DATA6	I1/O/T			EMAC_RX_CLK	I	2'd2	oe=0, ie=1, wpu	oe=0, ie=1, wpu
35			GPIO18	VDD3P3_CPU						GPIO18	I/O/T	VSPICLK	I/O/T	GPIO18	I/O/T	HS1_DATA7	I1/O/T					2'd2	oe=0, ie=0	oe=0, ie=1
36			GPIO23	VDD3P3_CPU						GPIO23	I/O/T	VSPID	I/O/T	GPIO23	I/O/T	HS1_STROBE	I0					2'd2	oe=0, ie=0	oe=0, ie=1
37	VDD3P3_CPU			VDD3P3_CPU supply in																				
38			GPIO19	VDD3P3_CPU						GPIO19	I/O/T	VSPIQ	I/O/T	GPIO19	I/O/T	U0CTS	I1			EMAC_TXD0	O	2'd2	oe=0, ie=0	oe=0, ie=1
39			GPIO22	VDD3P3_CPU						GPIO22	I/O/T	VSPIWP	I/O/T	GPIO22	I/O/T	U0RTS	O			EMAC_TXD1	O	2'd2	oe=0, ie=0	oe=0, ie=1
40			U0RXD	VDD3P3_CPU						U0RXD	I1	CLK_OUT2	O	GPIO3	I/O/T							2'd2	oe=0, ie=1, wpu	oe=0, ie=1, wpu
41			U0TXD	VDD3P3_CPU						U0TXD	O	CLK_OUT3	O	GPIO1	I/O/T					EMAC_RXD2	I	2'd2	oe=0, ie=1, wpu	oe=0, ie=1, wpu
42			GPIO21	VDD3P3_CPU						GPIO21	I/O/T	VSPIHD	I/O/T	GPIO21	I/O/T					EMAC_TX_EN	O	2'd2	oe=0, ie=0	oe=0, ie=1
43	VDDA			VDDA supply in																				
44		XTAL_N		VDDA																				
45		XTAL_P		VDDA																				
46	VDDA			VDDA supply in																				
47		CAP2		VDDA																				
48		CAP1		VDDA																				
Total Number	8	14	26																					

Notes:

- wpu: weak pull-up;
- wpd: weak pull-down;
- ie: input enable;
- oe: output enable;
- Please see *Table: Notes on ESP32 Pin Lists* for more information.（请参考表：管脚清单说明。）

Revision History

Date	Version	Release notes
2021-03-19	V3.6	Updated Figure 1: *Functional Block Diagram* Updated Table 14: *Reliability Qualifications* Updated Figure 4: *ESP32 Power Scheme* Updated Table 12: *Recommended Operating Conditions* Updated the notes below Table 2: *Power Scheme* Provided more information about TWAI® in Table 5, Table 10, Table 8.2, and Section 4.1
2021-01-22	V3.5	Updated the description for CAP2 from 3 nF to 3.3 nF Added TWAI® in Section 1.4.3: *Advanced Peripheral Interfaces* Updated Figure 1: *Functional Block Diagram* Updated the reset values for MTCK, MTMS, GPIO27 in Appendix IO_MUX
2020-04-27	V3.4	Added one chip variant: ESP32-U4WDH Updated some figures in Table 6, 16, 17, 19, 21, 22 Added a note under Table 18
2020.01	V3.3	Added two chip variants: ESP32-D0WD-V3 and ESP32-D0WDQ6-V3. Added a note under Table 7.
2019.10	V3.2	Updated Figure 5: *ESP32 Power-up and Reset Timing*.
2019.07	V3.1	Added pin-pin mapping between ESP32-D2WD and the embedded flash under Table 1 *Pin Description*; Updated Figure 10 *ESP32 Part Number*.
2019.04	V3.0	Added information about the setup and hold times for the strapping pins in Section 2.4: Strapping Pins.
2019.02	V2.9	Applied new formatting to Table 1: Pin Description; Fixed typos with respect to the ADC1 channel mappings in Table 10: Peripheral Pin Configurations.
2019.01	V2.8	Changed the RF power control range in Table 18, Table 20 and Table 22 from –12 ~ +12 to –12 ~ +9 dBm; Small text changes.
2018.11	V2.7	Updated Section 1.5; Updated pin statuses at reset and after reset in Table IO_MUX.
2018.10	V2.6	Updated QFN package drawings in Chapter 6: Package Information.
2018.08	V2.5	• Added "Cumulative IO output current" entry to Table 11: Absolute Maximum Ratings; • Added more parameters to Table 13: DC Characteristics; • Changed the power domain names in Table IO_MUX to be consistent with the pin names.

Date	Version	Release notes
2018.07	V2.4	• Deleted information on Packet Traffic Arbitration (PTA); • Added Figure 5: ESP32 Power-up and Reset Timing in Section 2.3: Power Scheme; • Added the power consumption of dual-core SoCs in Table 6: Power Consumption by Power Modes; • Updated section 4.1.2: Analog-to-Digital Converter (ADC).
2018.06	V2.3	Added the power consumption at CPU frequency of 160 MHz in Table 6: Power Consumption by Power Modes.
2018.05	V2.2	• Changed the voltage range of VDD3P3_RTC from 1.8-3.6V to 2.3-3.6V in Table 1: Pin Description; • Updated Section 2.3: Power Scheme; • Updated Section 3.1.3: External Flash and SRAM; • Updated Table 6: Power Consumption by Power Modes; • Deleted content about temperature sensor; Changes to electrical characteristics: • Updated Table 11: Absolute Maximum Ratings; • Added Table 12: Recommended Operating Conditions; • Added Table 13: DC Characteristics; • Added Table 14: Reliability Qualifications; • Updated the values of "Gain control step" and "Adjacent channel transmit power" in Table 18: Transmitter Characteristics - Basic Data Rate; • Updated the values of "Gain control step", "π/4 DQPSK modulation accuracy", "8 DPSK modulation accuracy" and "In-band spurious emissions" in Table 20: Transmitter Characteristics – Enhanced Data Rate; • Updated the values of "Gain control step", "Adjacent channel transmit power" in Table 22: Transmitter Characteristics - BLE.
2018.01	V2.1	• Deleted software-specific features; • Deleted information on LNA pre-amplifier; • Specified the CPU speed and flash speed of ESP32-D2WD; • Added notes to Section 2.3: Power Scheme.
2017.12	V2.0	Added a note on the sequence of pin number in Chapter 6.
2017.10	V1.9	• Updated the description of the pin CHIP_PU in Table 1; • Added a note to Section 2.3: Power Scheme; • Updated the description of the chip's system reset in Section 2.4: Strapping Pins; • Added a description of antenna diversity and selection to Section 3.5.1; • Deleted "Association sleep pattern" in Table 6 and added notes to Active sleep and Modem-sleep.
2017.08	V1.8	• Added Table 4.2 in Section 4; • Corrected a typo in Figure 1.

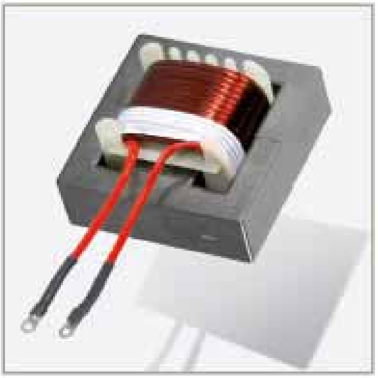
Date	Version	Release notes
2017.08	V1.7	• Changed the transmitting power to +12 dBm; the sensitivity of NZIF receiver to -97 dBm in Section 1.3; • Added a note to Table 1 Pin Description; • Added 160 MHz clock frequency in section 3.1.1; • Changed the transmitting power from 21 dBm to 20.5 dBm in Section 3.5.1; • Changed the dynamic control range of class-1, class-2 and class-3 transmit output powers to "up to 24 dBm"; and changed the dynamic range of NZIF receiver sensitivity to "over 97 dB" in Section 3.6.1; • Updated Table 6: Power Consumption by Power Modes, and added two notes to it; • Updated sections 4.1.1, 4.1.9; • Updated Table 11: Absolute Maximum Ratings; • Updated Table 15: RF Power Consumption Specifications, and changed the duty cycle on which the transmitters' measurements are based by 50%. • Updated Table 16: Wi-Fi Radio Characteristics and added a note on "Output impedance" to it; • Updated parameter "Sensitivity" in Table 17, 19, 21; • Updated parameters "RF transmit power" and "RF power control range", and added parameter "Gain control step" in Table 18, 20, 22; • Deleted Chapters: "Touch Sensor" and "Code Examples"; • Added a link to certification download.
2017.06	V1.6	Corrected two typos: • Changed the number of external components to 20 in Section 1.1.2; • Changed the number of GPIO pins to 34 in Section 4.1.1.
2017.06	V1.5	• Changed the power supply range in Section: 1.4.1 CPU and Memory; • Updated the note in Section 2.3: Power Scheme; • Updated Table 11: Absolute Maximum Ratings; • Changed the drive strength values of the digital output pins in Note 8, in Table 24: Notes on ESP32 Pin Lists; • Added the option to subscribe for notifications of documentation changes.
2017.05	V1.4	• Added a note to the frequency of the external crystal oscillator in Section 1.4.2: Clocks and Timers; • Added a note to Section 2.4: Strapping Pins; • Updated Section 3.7: RTC and Low-Power Management; • Changed the maximum driving capability from 12 mA to 80 mA, in Table 11: Absolulte Maximum Ratings; • Changed the input impedance value of 50Ω, in Table 16: Wi-Fi Radio Characteristics, to output impedance value of 30+j10 Ω; • Added a note to No.8 in Table 24: Notes on ESP32 Pin Lists; • Deleted GPIO20 in Table IO_MUX.
2017.04	V1.3	• Added Appendix: ESP32 Pin Lists; • Updated Table: Wi-Fi Radio Characteristics; • Updated Figure: ESP32 Pin Layout (for QFN 5*5).

Date	Version	Release notes
2017.03	V1.2	• Added a note to Table: Pin Description; • Updated the note in Section: Internal Memory.
2017.02	V1.1	• Added Chapter: Part Number and Ordering Information; • Updated Section: MCU and Advanced Features; • Updated Section: Block Diagram; • Updated Chapter: Pin Definitions; • Updated Section: CPU and Memory; • Updated Section: Audio PLL Clock; • Updated Section: Absolute Maximum Ratings; • Updated Chapter: Package Information; • Updated Chapter: Learning Resources.
2016.08	V1.0	First release.













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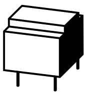
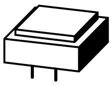
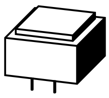
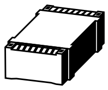
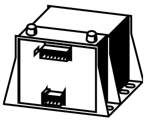
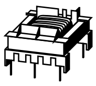
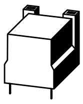
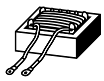
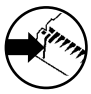
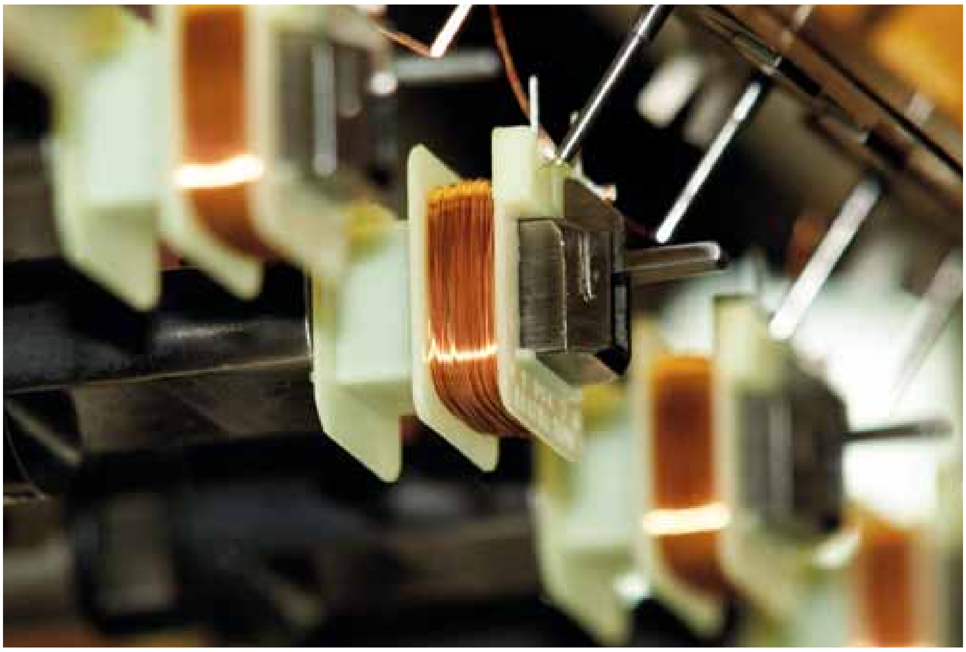
BV 20 Series		• Printed-Circuit-Board transformers frame size EE 20 (0.35 VA – 0.5 VA)	Pages 19 - 22
EI 30 Series		• Printed-Circuit-Board transformers frame size EI 30 (0.5 VA – 3.6 VA) • Flat-type Printed-Circuit-Board transformers with small base areas frame size EI 30/40 (1.6 VA – 8.0 VA)	Pages 23 - 36
EI Series		• Printed-Circuit-Board transformers frame size EI 38 – EI 96 (4.5 VA – 200 VA)	Pages 37 - 74
UI Series		• Printed-Circuit-Board Flat-type transformers frame size UI 21 – UI 48 (1.0 VA – 60 VA)	Pages 75 - 84
RAST 5 Series		• Transformers with RAST 5 connecting technology frame size EI 48 – EI 84 (10.0 VA – 120 VA)	Pages 85 - 90
Flyback converter/ SMPS-Converter		• Flyback converters frame size EF 16/5 – 8 mm creeping distance • Individual version 8 mm creeping distance • Flyback converters frame size EF 20/5 – 4 mm creeping distance • Individual version 4 mm creeping distance	Pages 91 - 100
Ignition transformers		• Ignition transformers • Electronic ignition devices	Pages 101 - 104
Choke program		• Extended mains choke series • Extensive range of customer-specific chokes	Pages 105 - 120
Special solutions		• Electrical Power Supply Facilities / Supply units • Transformers Top-Hat-Rail Fixtures EI 48 – EI 78 • Transformers in open version, vacuum impregnated version • Customer-specific winding goods / Fine-wire-coils	Pages 121 - 128
HAHN worldwide		• Your partner in charge in Germany • HAHN's Distributors • Your partner in charge abroad	Pages 129 - 138

Content

Interesting news about HAHN



HAHN Quality – Performance that builds trust.

HAHN-History

This has been the corporate philosophy of the HAHN company since its foundation in 1949. Right from the start, it was the maxim of HAHN to supply products of high quality and to base all efforts on customer-requirements and satisfaction. Corporate growth has been achieved to a dynamic and reliable extent. The ongoing expansion of the manufacturing facilities furthered the improvement in quality and HAHN was able to invest in new products. Today, HAHN employs a workforce of approaching 500, which serve an international clientele in various industrial sectors. HAHN's principal aim is to continue to supply quality products and to provide reliable customer service and thus contribute to the success of its customers.

1949
- Founded on April 21st, the company was registered as an armature winding works, repair shop for electric motors, generators, electrical installations and the sale of domestic electrical appliances

1969
- September – commencement of small size transformer production in the storage space of the newly renovated electrical installation shop

1971
- Construction of the first new hall building of 700 square meters floor space

1981
- Opening of new production and warehouse hall of 1,600 total square meters floor space

1985
- Extension of the production floor space by some 600 square meters

1990
- Extension of the storage space by some 500 square meters

1994
- Removal of the final inspection and quality control facility and the standard transformer inventory into a new hall building of some 1,000 square meter floor space

1995
- A new raw materials' and semi-finished products' warehouse was constructed with a floor area of some 600 square meters

1996
- Award of the DIN EN ISO 9001:1994 certification
- New warehouse and goods' consignment facility was constructed with a floor space of some 600 square meters

1998
- Commissioning of the new manufacturing facility in Güsten
- Extension of the trading floor space by some 20,000 square meters
- Production capacity was extended by 20%
- A new reception area was opened

2002
- Award of the DIN EN ISO 9001:2000 certification for the locations at Hungen and Güsten in Germany

2003
- Approval/Authorization of an UL-Electro-Isolation-System class F (HAHN 155-1)
- Disposable and reusable packagings are given the designation 'Blue Angel'

2004
- A third manufacturing facility has been set up in the Ukraine

2005
- Starting production in our new manufacturing facility in Ukraine

2008
- Award of the DIN EN ISO 9001:2008 certification for the location at Hungen, Güsten and Ukraine
- Approval/Authorization of an UL-Electro-Isolation-System class B (HAHN 130-1)

2009/2010
- Hungen works – Site expansion with warehouse building transformed into high-bay warehouse, extended staff car park
- Güsten works – Further investments in automation
- Ukraine works – Continuous increase in production capacity

2011/2012
- Structure and beginning of production for ignition transformers at plant Güsten
- Approval/Authorization of 2nd UL-Electro-Isolation-System class F (HAHN 155-2)
- Update of the approvals according to DIN EN 61558-1/2005 and DIN EN 61558-2-6/2009 for all HAHN-Series-Products
- Continuous increase in production capacity

HAHN Locations

The parent company in Hungen, Germany
All the business decisions of HAHN are taken here, just only half an hour away by car from Frankfurt's International Airport; in terms of a qualitative and consumer-oriented corporate cultural philosophy. New, user-friendly products are developed here. Progressive production technology for highest process quality and economically high volume is located here. All employees are trained to satisfy customer requirements all over the world.

Production in Güsten, Saxony-Anhalt, Germany
The rising demand for HAHN products in Eastern European countries made it necessary to transfer partial production into a region near the border in order to reduce logistical costs.

3rd Production Plant in Novovolynsk (Ukraine)
With foundation of the 3rd plant in Eastern Europe, HAHN removed the manual production from plant Hungen and Güsten to Novovolynsk. Custom-made and wage-intensive products made this step necessary to be as one of the leading transformer producer further more competitive on the constantly growing market.


Hungen/Hesse


Güsten/Saxony-Anhalt


Novovolynsk (Ukraine)

HAHN Electronic Component Parts


CERTIFICATE

VDE

Quality awareness, product liability legislation and the growing demands of worldwide markets today make it necessary for equipment and appliance manufacturers to pass on these stringent requirements to their subcontractors and suppliers to ensure, that no component or assembly can become a critical weak spot. HAHN successfully meets these requirements. All products leaving the HAHN works have been manufactured of high grade, quality-controlled raw materials or semi-manufactures on the most modern production equipment. A quality management system meeting **DIN EN ISO 9001:2008** German and European standards provides the means for ensuring such high quality.

HAHN permanently maintains a large stock inventory of all items and sizes. Customers can take advantage of this service as required, by means of placing call orders – no matter what item of size is required – the comprehensive range from capacities 0.35 VA to 200.0 VA is always available. A detailed overview can be found on the following pages of this catalog.

HAHN has its own laboratory with TDAP the qualification for all the prerequisites, to carry out tests for VDE-marks, an expert's report or for certificates in an international procedure together with VDE-experts to carry out.

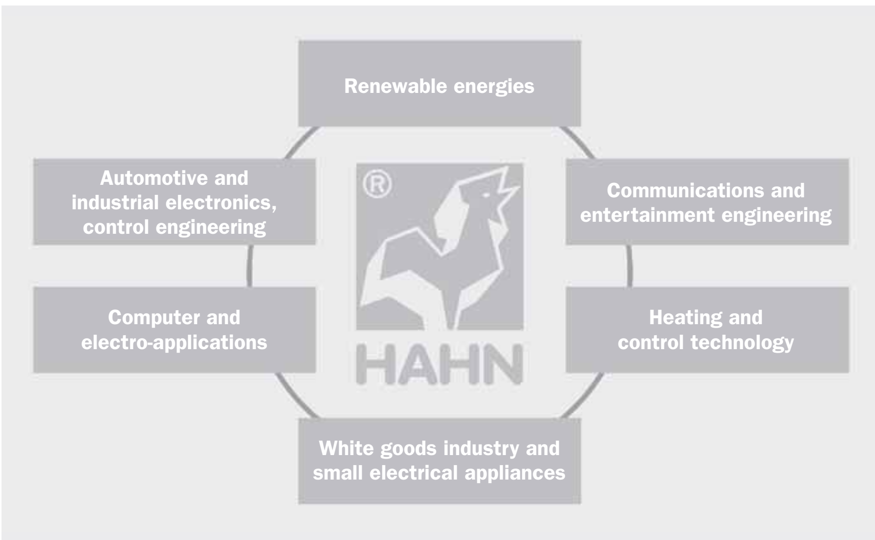

VDE

More electrical safety and long service life for consumers’ appliances

- Chokes
- Coils, custom-made coils
- Control transformers
- Current- and voltage converters
- Flat-type transformers
- Inductive assembly components
- Isolating transformers
- Mains transformers
- Printed circuit-board transformers
- Safety transformers
- Single-phase transformers
- Small size transformers
- SMPS-transformers
- Special transformers
- Three-phase transformers
- Ignition transformers and electronic ignition devices

All HAHN transformers carry a test certificate, so that customers obtain an assurance of maximum electrical safety and long service-life for their equipment and appliances. HAHN invites new customers and other interested parties to place their reliance on its quality products and services.

Highest quality and customer-orientated services in all industries



Quality and economy in the production process

HAHN products are characterized by their performance and reliability. Ongoing in-house quality control management ensures uncompromising raw material selection and the highest standards of production with the corporate aim of achieving reliability and an optimum of economy and efficiency for customers.

To ensure the competitiveness of its products, HAHN attaches great importance to automation in production. Modern technology with automatic assembly lines, integrated quality control devices, transfer systems and ‘intelligent’ production equipment are the prerequisites for highly rationalised and flexible manufacturing facilities. This minimizes costs and positively influences the marketability of its products. All the corporate-related decisions of HAHN are thus taken from an economic and ecological viewpoint. HAHN already exceeds such requirements by implementing numerous appropriate measures of such a nature. For example, all works-internal movements are carried out with electric vehicles and in the areas of production and distribution, HAHN employs reusable packaging.

All according to customer requirements

Packed and consigned

In order to meet the requirements of any specific trade and industry, HAHN can provide practically any desired problem solution in the areas of packing and distribution. No matter whether customers require cases, cartons, polystyrene or plastic packagings – whether ‘just-in-time’ delivery, special forwarding services or self collection – HAHN can always provide customers with the right problem solution. The examples mentioned above meet current standards, whereby the new designed plastic tubes is worthy of special mention. The transformers can thus be extracted from a ‘magazine’ and inserted directly into customers’ production. ESD-conform packaging is contemporary and has come to stay on the European market. HAHN will, of course re-accept packagings returned in a usable condition. These can be cleaned and used again for further consignments to customers.

Content

ErP Series

ErP ready!

ErP-Eco Design solutions
- Frame size EI 30
- Switch-Mode-Power-Supply of HS series

Printed-Circuit-Board transformers

Output Power: 1.3 VA – 2.8 VA

EI 30
ErP

10, VDE	**DINEN 61558-2-6**	**VDE**	115801/124257
VDE-Mark for Glow-Wire-Test	**DINEN 60 335-1**	**VDE**	102961/84814
UR	**UL 5085-3**	**UL**	E177280
UR	**UL 5085-1**	**UL**	E98173
SP	**C22.2**	**CSA**	99204

- according to REACH regulation
- according to RoHs regulation
- according to ErP regulation

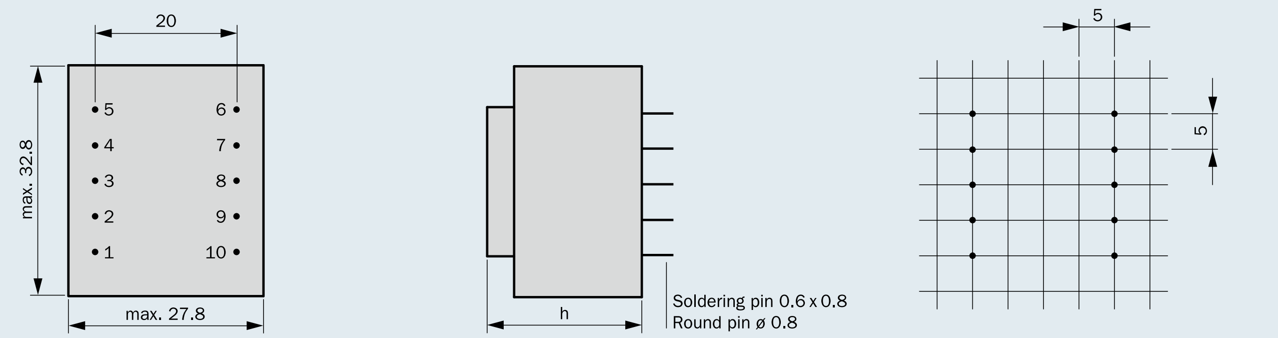
EBPG
ErP

- Primary voltages up to 250 V
- Secondary voltages 2 V to max. 38 V or 2 x 2 V to max. 2 x 19 V
- Output Power up to 2.8 VA
- Short-circuit-proof
- Temperature class ta 70 °C/F
- Vacuum-encapsulated, bobbin with dual chamber windings
- Per item tested quality with certificate
- Excellent temperature fluctuation resistance properties
- Self-extinguishing cast housing and sealing material
- Minimal size available

We have expanded our program for you in the course of ErP (Energy related Products).

The **ErP Serie 2013** of **HAHN** is perfect for applications of the electric power supply in electrical and electronic household and office equipment with "stand by" and "off" conditions. Already today where a reduced **power consumption** of **P_0 < 0,4 W** is required, the **ErP Serie 2013** of **HAHN** will be a solution.

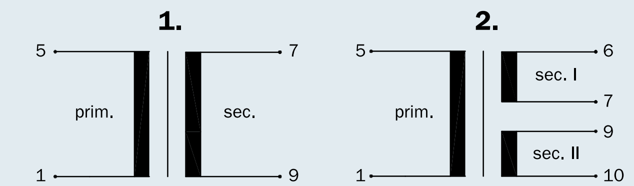
Connecting pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme (only connected pins are present)



2.) double voltage – bridge: 7 + 9, double current – bridge: 6 + 9/7 + 10

Frame size/Core height	Output Power ta 70 °C/F	Size (h)	Weight	Packaging unit
BV EI 307 8... /11.5 mm	1.3 VA	22.1 mm	0.076 kg	50 pieces
BV EI 303 8... /12.5 mm	1.5 VA	23.8 mm	0.081 kg	50 pieces
BV EI 304 8... /15.5 mm	2.1 VA	26.8 mm	0.099 kg	50 pieces
BV EI 305 8... /18.0 mm	2.3 VA	29.5 mm	0.111 kg	50 pieces
BV EI 306 8... /23.0 mm	2.8 VA	34.0 mm	0.135 kg	50 pieces

Printed-Circuit-Board transformers

Output Power: up to 2.8 VA

EI 30 ErP

ErP ready!

1.3 VA ta 70 °C/F

Frame size/Core height **BV EI 307 .... / 11.5 mm**

inherently short-circuit-proof

no load power loss **< 0.4 W**

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 307 8009	230	1 - 5	1 x 6	217	7 - 9	1 x 10.7	1
BV EI 307 8011	230	1 - 5	1 x 9	144	7 - 9	1 x 15.7	1
BV EI 307 8001	230	1 - 5	1 x 12	108	7 - 9	1 x 19.8	1
BV EI 307 8002	230	1 - 5	2 x 12	54	6 - 7/9 - 10	2 x 19.8	2
BV EI 307 8012	230	1 - 5	1 x 15	87	7 - 9	1 x 25.0	1

1.5 VA ta 70 °C/F

Frame size/Core height **BV EI 303 .... / 12.5 mm**

inherently short-circuit-proof

no load power loss **< 0.4 W**

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 303 8008	230	1 - 5	1 x 9	167	7 - 9	1 x 14.0	1
BV EI 303 8021	230	1 - 5	2 x 9	83	6 - 7/9 - 10	2 x 14.0	2
BV EI 303 8023	230	1 - 5	1 x 12	125	7 - 9	1 x 18.8	1

2.1 VA ta 70 °C/F

Frame size/Core height **BV EI 304 .... / 15.5 mm**

inherently short-circuit-proof

no load power loss **< 0.4 W**

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 304 8013	230	1 - 5	1 x 6	350	7 - 9	1 x 11.0	1
BV EI 304 8024	230	1 - 5	1 x 7.5	280	7 - 9	1 x 13.9	1
BV EI 304 8014	230	1 - 5	1 x 9	233	7 - 9	1 x 16.2	1
BV EI 304 8005	230	1 - 5	1 x 12	175	7 - 9	1 x 20.5	1
BV EI 304 8006	230	1 - 5	2 x 12	88	6 - 7/9 - 10	2 x 20.5	2
BV EI 304 8015	230	1 - 5	1 x 15	140	7 - 9	1 x 27.0	1

2.3 VA ta 70 °C/F

Frame size/Core height **BV EI 305 .... / 18.0 mm**

inherently short-circuit-proof

no load power loss **< 0.4 W**

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 305 8022	230	1 - 5	1 x 7.5	307	7 - 9	1 x 13.2	1
BV EI 305 8019	230	1 - 5	1 x 9	255	7 - 9	1 x 16.0	1
BV EI 305 8020	230	1 - 5	2 x 9	127	6 - 7/9 - 10	2 x 15.7	2

2.8 VA ta 70 °C/F

Frame size/Core height **BV EI 306 .... / 23.0 mm**

inherently short-circuit-proof

no load power loss **< 0.4 W**

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 306 8016	230	1 - 5	1 x 6	467	7 - 9	1 x 10.5	1
BV EI 306 8017	230	1 - 5	1 x 9	311	7 - 9	1 x 16.1	1
BV EI 306 8003	230	1 - 5	1 x 12	233	7 - 9	1 x 21.4	1
BV EI 306 8007	230	1 - 5	2 x 12	117	6 - 7/9 - 10	2 x 21.4	2
BV EI 306 8018	230	1 - 5	1 x 15	187	7 - 9	1 x 26.1	1
BV EI 306 8034	230	1 - 5	2 x 9	155	6 - 7/9 - 10	2 x 16.2	2

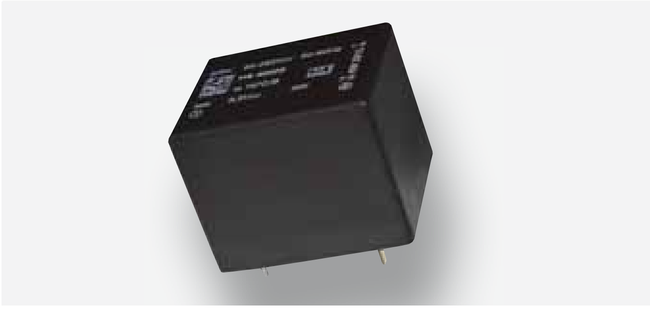
Switch-Mode-Power-Supply

HS series

HS ErP

VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	on request
UL	UL 5085-3	UL	on request
UL	UL 5085-1	UL	on request
CSA	C22.2	CSA	on request

- according to REACH regulation
- according to RoHs regulation
- according to ErP regulation



ErP ready

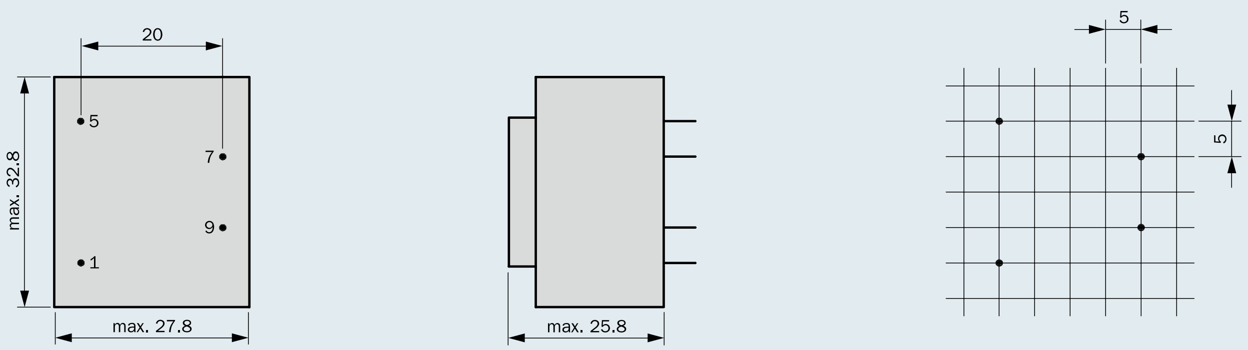
EBPG ErP

Ecological in design – and solutions based on switch mode technology developed by **HAHN**. Within the scope of the Eco-Design Directive for energy-related products, we have expanded our product portfolio for you.

The new **HS series** by **HAHN** incorporating switch mode technology has a no load power loss of **< 0.15 W** and an efficiency of > 70 %! It is ideal for applications within the broad input voltage range of 85 –265 V for power supplies.

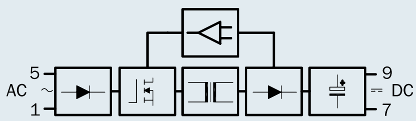
Design is short-circuit-proof and wiring is strictly isolated according to DIN EN 61558-2-16 and DIN EN 60950. All components are UL- and DIN EN 60335-compliant. The power of the safety extra-low output voltage is up to 3 W.

Connecting pins



Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

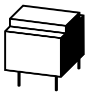
Connection scheme



3.0 W ta 70 °C/F	Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V (DC)	Current sec. mA (DC)	Connecting pins sec.	Connection scheme
	HS 40003	85 –265 V	1 –5	1 x 3.3	900	7 –9	1
	HS 40005	85 –265 V	1 –5	1 x 5	600	7 –9	1
inherently short-circuit-proof	HS 40009	85 –265 V	1 –5	1 x 9	333	7 –9	1
	HS 40012	85 –265 V	1 –5	1 x 12	250	7 –9	1
	HS 40015	85 –265 V	1 –5	1 x 15	200	7 –9	1
no load power loss	HS 40018	85 –265 V	1 –5	1 x 18	167	7 –9	1
< 0.15 W	HS 40024	85 –265 V	1 –5	1 x 24	125	7 –9	1

Content

BV 20 Series



- Printed-Circuit-Board transformers
  frame size EE 20 (0.35 VA – 0.5 VA)

Printed-Circuit-Board transformers BV 20

Output Power: 0.35 VA – 0.5 VA

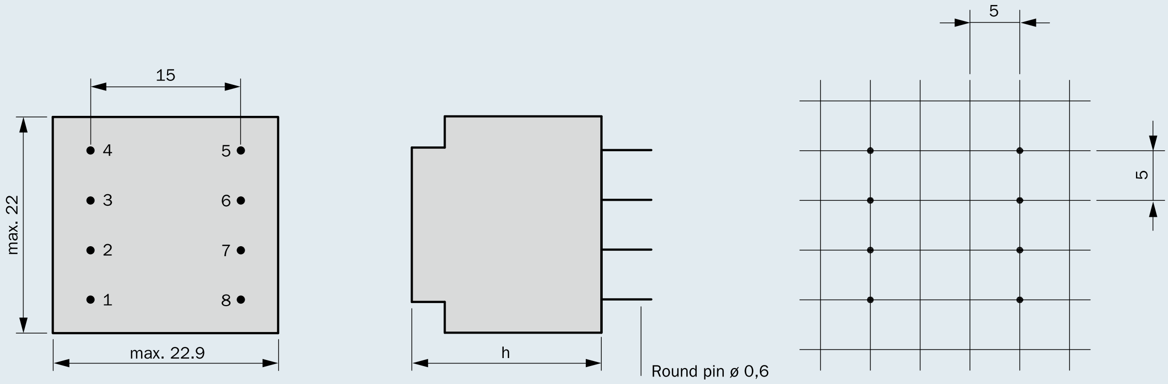
10	DIN EN 61558-2-6	VDE	115642
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	102961/84814
UR	UL 5085-3	UL	on request
UR	UL 5085-1	UL	E98173
SP	C22.2	CSA	99204

- according to REACH regulation
- according to RoHs regulation

- Minimal size available
- Primary voltages from 12 V to 250 V
- Secondary voltages from 4 V to 24 V or 2 x 3 V to 2 x 12 V
- Output Power up to 0.5 VA
- Further voltages on demand
- Inherently short-circuit-proof
- Vacuum-encapsulated, bobbin type with dual chamber windings
- Temperature class ta 70 °C/B
- High electrical safety and long service-life features
- Per item tested quality with certificate
- Excellent temperature fluctuation resistance properties
- Self-extinguishing cast housing and sealing material

Thanks to its minimal size the BV 20 is the ideal problem solution for appliance manufacturers requiring small components and who are not prepared to enter into any comprises as regards quality and performance demands. Processing with double-coated windings, special extreme heat-resistant epoxy insulating resins and self-extinguishing encapsulation housing materials give HAHN transformers extra electrical safety reserves enabling applications of extreme limits to be addressed.
The BV 20 with insulation class B properties is especially suitable for printed circuit boards, computer processors, other electronic applications, domestic appliances, telecommunications', lighting and photo technologies. Particularly in regard to competitiveness on international markets and the product liability of manufacturers, the BV 20 offers users the greatest functional electrical safety and long-life service by reason of its superior quality for their products.

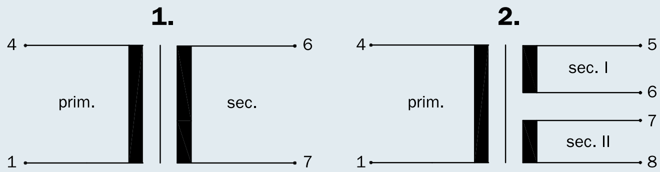
Connecting pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme (only connected pins are present)



2.) double voltage – bridge: 6 + 7, double current – bridge: 5 + 7/ 6 + 8

Frame size/Core height	Output Power ta 70 °C/B	Size (h)	Weight	Packaging unit
BV 201 .... / 6 mm	0.35 VA	15 mm	0.025 kg	176 pieces
BV 202 .... /10 mm	0.50 VA	19 mm	0.035 kg	88 pieces

Printed-Circuit-Board transformers

Output Power: up to 0.5 VA

BV20

0.35 VA
ta 70 °C/B

Frame size/Core height
BV 201 …. /
6 mm

inherently short-circuit-proof

no load power loss
type 1.2 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV 201 0128	230	1 – 4	1 x 6	58	6 – 7	1 x 10.0	1
BV 201 0142	230	1 – 4	2 x 6	29	5 – 6/7 – 8	2 x 10.6	2
BV 201 0143	230	1 – 4	1 x 7.5	47	6 – 7	1 x 12.6	1
BV 201 0136	230	1 – 4	1 x 9	39	6 – 7	1 x 14.4	1
BV 201 0144	230	1 – 4	2 x 9	19	5 – 6/7 – 8	2 x 16.2	2
BV 201 0145	230	1 – 4	1 x 12	29	6 – 7	1 x 20.8	1
BV 201 0146	230	1 – 4	2 x 12	15	5 – 6/7 – 8	2 x 19.7	2
BV 201 0147	230	1 – 4	1 x 15	23	6 – 7	1 x 26.1	1
BV 201 0149	230	1 – 4	1 x 18	19	6 – 7	1 x 30.4	1
BV 201 0150	230	1 – 4	1 x 21	17	6 – 7	1 x 36.0	1
BV 201 0135	230	1 – 4	1 x 24	15	6 – 7	1 x 36.8	1

0.5 VA
ta 70 °C/B

Frame size/Core height
BV 202 …. /
10 mm

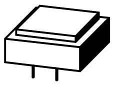
inherently short-circuit-proof

no load power loss
type 1.5 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV 202 0154	230	1 – 4	1 x 6	83	6 – 7	1 x 10.2	1
BV 202 0155	230	1 – 4	2 x 6	42	5 – 6/7 – 8	2 x 9.7	2
BV 202 0156	230	1 – 4	1 x 7.5	67	6 – 7	1 x 12.8	1
BV 202 0157	230	1 – 4	1 x 9	55	6 – 7	1 x 15.4	1
BV 202 0158	230	1 – 4	2 x 9	28	5 – 6/7 – 8	2 x 15.4	2
BV 202 0159	230	1 – 4	1 x 12	42	6 – 7	1 x 21.2	1
BV 202 0160	230	1 – 4	2 x 12	21	5 – 6/7 – 8	2 x 21.2	2
BV 202 0161	230	1 – 4	1 x 15	33	6 – 7	1 x 25.9	1
BV 202 0162	230	1 – 4	1 x 18	28	6 – 7	1 x 30.9	1
BV 202 0163	230	1 – 4	1 x 21	24	6 – 7	1 x 36.2	1
BV 202 0164	230	1 – 4	1 x 24	21	6 – 7	1 x 41.2	1

Content

EI 30 Series



- Printed-Circuit-Board transformers
  frame size EI 30 (0.5 VA – 3.6 VA)
- Flat-type Printed-Circuit-Board transformers with small base areas
  frame size EI 30/40 (1.6 VA – 8.0 VA)

Printed-Circuit-Board transformers

Output Power: 0.5 VA – 3.6 VA

	DIN EN 61558-2-6	VDE	115801/124257
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	102961/84814
	UL 5085-3	UL	E177280
	UL 5085-1	UL	E98173
	C22.2	CSA	99204

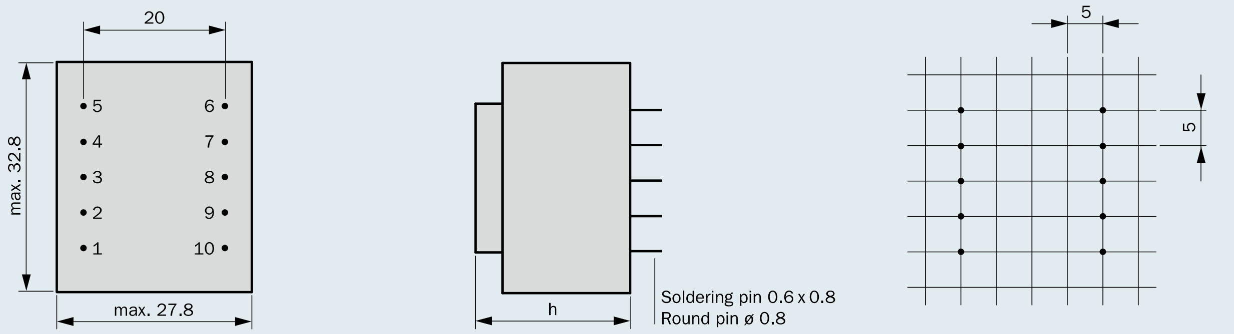
- according to REACH regulation
- according to RoHs regulation

- Primary voltages from 12 V to 250 V or 2 x 12 V to 2 x 125 V
- Secondary voltages from 2 V to max. 38 V or 2 x 2 V to max. 2 x 19 V
- Output Power up to 3.6 VA
- Short-circuit-proof
- Vacuum-encapsulated, bobbin with dual chamber windings
- Temperature class ta 40 °C/F and ta 70 °C/F
- Per item tested quality with certificate
- Excellent temperature fluctuation resistance properties
- Self-extinguishing cast housing and sealing material
- Minimal size available

Several hundreds of types provide safety and long service-life for printed circuit boards, household appliances, leisure electronics, heating and control technol ogy as well as in assembly techniques. Transformers for special requirements with lower open-circuit (no-load) loss capacity are also available in the range.

Enhanced customer benefit due to ongoing high quality standards throughout 40 years experience in transformer technology.

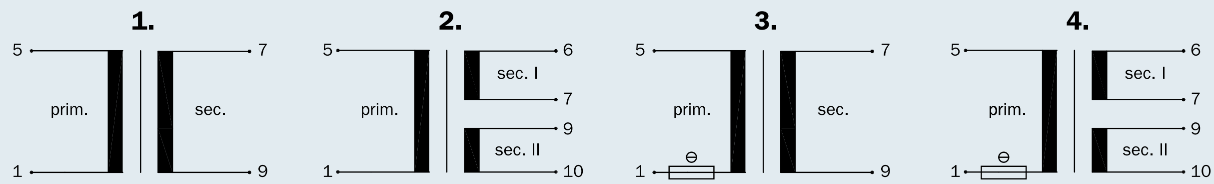
Connecting pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme (only connected pins are present)



2.+4.) double voltage – bridge: 7 + 9, double current – bridge: 6 + 9/7 + 10

Frame size/ Core height	Output Power ta 40 °C/F	Output Power ta 70 °C/F	Output Power ta 70 °C/F with thermo-fuse	Height (h)	Weight	Packaging unit
BV EI 301 .... / 5.5 mm	0.6 VA	0.5/0.7 VA	0.65 VA	15.2 mm	0.044 kg	50 pieces
BV EI 302 .... /10.5 mm	1.8 VA	1.5 VA	1.8 VA	21.8 mm	0.070 kg	50 pieces
BV EI 307 .... /11.5 mm	2.2 VA	1.8 VA	1.8 VA	22.1 mm	0.076 kg	50 pieces
BV EI 303 .... /12.5 mm	2.3 VA	1.9 VA	2.3 VA	23.8 mm	0.081 kg	50 pieces
BV EI 304 .... /15.5 mm	2.6 VA	2.1 VA	2.4 VA	26.8 mm	0.099 kg	50 pieces
BV EI 305 .... /18.0 mm	3.0 VA	2.3 VA	2.7 VA	29.5 mm	0.111 kg	50 pieces
BV EI 306 .... /23.0 mm	3.6 VA	3.0 VA	3.4 VA	34.0 mm	0.135 kg	50 pieces

Printed-Circuit-Board transformers

Output Power: up to 0.7 VA

EI 30

0.5 VA ta 70 °C/F

Frame size/Core height
BV EI 301 …. / 5.5 mm

inherently short-circuit-proof

no load power loss
type. 1.0 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 301 3005	230	1–5	1 x 6	83	7–9	1 x 10.2	1
BV EI 301 3538	230	1–5	2 x 6	41	6–7/9–10	2 x 10.1	2
BV EI 301 3017	230	1–5	1 x 7.5	67	7–9	1 x 12.2	1
BV EI 301 3970	230	1–5	2 x 7.5	33	6–7/9–10	2 x 11.7	2
BV EI 301 2911	230	1–5	1 x 9	56	7–9	1 x 14.7	1
BV EI 301 3172	230	1–5	2 x 9	28	6–7/9–10	2 x 13.3	2
BV EI 301 2824	230	1–5	1 x 12	42	7–9	1 x 18.0	1
BV EI 301 3971	230	1–5	2 x 12	21	6–7/9–10	2 x 18.7	2
BV EI 301 2845	230	1–5	1 x 15	33	7–9	1 x 22.8	1
BV EI 301 2741	230	1–5	2 x 15	17	6–7/9–10	2 x 23.3	2
BV EI 301 2967	230	1–5	1 x 18	28	7–9	1 x 26.0	1
BV EI 301 3020	230	1–5	1 x 21	24	7–9	1 x 30.6	1
BV EI 301 2807	230	1–5	1 x 24	21	7–9	1 x 35.5	1

0.7 VA ta 70 °C/F

Frame size/Core height
BV EI 301 …. / 5.5 mm

inherently short-circuit-proof

no load power loss
type. 2.3 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 301 3582	230	1–5	1 x 6	117	7–9	1 x 10.3	1
BV EI 301 3583	230	1–5	2 x 6	58	6–7/9–10	2 x 10.5	2
BV EI 301 3584	230	1–5	1 x 7.5	94	7–9	1 x 12.7	1
BV EI 301 3585	230	1–5	2 x 7.5	47	6–7/9–10	2 x 12.7	2
BV EI 301 3586	230	1–5	1 x 9	78	7–9	1 x 14.6	1
BV EI 301 3587	230	1–5	2 x 9	39	6–7/9–10	2 x 14.6	2
BV EI 301 3588	230	1–5	1 x 12	58	7–9	1 x 19.5	1
BV EI 301 3589	230	1–5	2 x 12	29	6–7/9–10	2 x 19.5	2
BV EI 301 3590	230	1–5	1 x 15	47	7–9	1 x 24.5	1
BV EI 301 3591	230	1–5	2 x 15	23	6–7/9–10	2 x 24.5	2
BV EI 301 3592	230	1–5	1 x 18	39	7–9	1 x 28.3	1
BV EI 301 3593	230	1–5	1 x 21	33	7–9	1 x 32.9	1
BV EI 301 3594	230	1–5	1 x 24	29	7–9	1 x 37.8	1

0.65 VA ta 70 °C/F

Frame size/Core height
BV EI 301 …. / 5.5 mm

non inherently short-circuit-proof with thermo-fuse

no load power loss
type. 2.3 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 301 7002	230	1–5	1 x 6	108	7–9	1 x 10.5	3
BV EI 301 7003	230	1–5	2 x 6	54	6–7/9–10	2 x 10.5	4
BV EI 301 7004	230	1–5	1 x 7.5	87	7–9	1 x 13.0	3
BV EI 301 7005	230	1–5	2 x 7.5	43	6–7/9–10	2 x 13.0	4
BV EI 301 7006	230	1–5	1 x 9	72	7–9	1 x 15.4	3
BV EI 301 7007	230	1–5	2 x 9	36	6–7/9–10	2 x 15.4	4
BV EI 301 7008	230	1–5	1 x 12	54	7–9	1 x 20.4	3
BV EI 301 7009	230	1–5	2 x 12	27	6–7/9–10	2 x 20.4	4
BV EI 301 7010	230	1–5	1 x 15	43	7–9	1 x 24.9	3
BV EI 301 7011	230	1–5	2 x 15	21	6–7/9–10	2 x 24.9	4
BV EI 301 7012	230	1–5	1 x 18	36	7–9	1 x 30.1	3
BV EI 301 7013	230	1–5	1 x 21	31	7–9	1 x 35.1	3
BV EI 301 7014	230	1–5	1 x 24	27	7–9	1 x 40.0	3

Printed-Circuit-Board transformers

Output Power: up to 1.8 VA

1.8 VA ta 40 °C/F

Frame size/Core height
BV EI 302 .... / 10.5 mm

inherently short-circuit-proof

no load power loss
type. 2.2 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 302 2000	230	1–5	1 x 6	300	7–9	1 x 8.8	1
BV EI 302 2005	230	1–5	2 x 6	150	6–7/9–10	2 x 8.8	2
BV EI 302 3021	230	1–5	1 x 7.5	240	7–9	1 x 10.7	1
BV EI 302 3562	230	1–5	2 x 7.5	120	6–7/9–10	2 x 11.0	2
BV EI 302 2001	230	1–5	1 x 9	200	7–9	1 x 12.6	1
BV EI 302 2006	230	1–5	2 x 9	100	6–7/9–10	2 x 13.0	2
BV EI 302 2002	230	1–5	1 x 12	150	7–9	1 x 16.9	1
BV EI 302 2007	230	1–5	2 x 12	75	6–7/9–10	2 x 18.3	2
BV EI 302 2003	230	1–5	1 x 15	120	7–9	1 x 21.2	1
BV EI 302 2008	230	1–5	2 x 15	60	6–7/9–10	2 x 21.8	2
BV EI 302 2004	230	1–5	1 x 18	100	7–9	1 x 25.4	1
BV EI 302 3022	230	1–5	1 x 21	86	7–9	1 x 30.4	1
BV EI 302 2990	230	1–5	1 x 24	75	7–9	1 x 34.5	1

1.5 VA ta 70 °C/F

Frame size/Core height
BV EI 302 .... / 10.5 mm

inherently short-circuit-proof

no load power loss
type. 1.4 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 302 2020	230	1–5	1 x 6	250	7–9	1 x 8.2	1
BV EI 302 2025	230	1–5	2 x 6	125	6–7/9–10	2 x 8.4	2
BV EI 302 3058	230	1–5	1 x 7.5	200	7–9	1 x 10.5	1
BV EI 302 3561	230	1–5	2 x 7.5	100	6–7/9–10	2 x 10.5	2
BV EI 302 2021	230	1–5	1 x 9	166	7–9	1 x 12.1	1
BV EI 302 2026	230	1–5	2 x 9	83	6–7/9–10	2 x 12.4	2
BV EI 302 2022	230	1–5	1 x 12	125	7–9	1 x 16.6	1
BV EI 302 2027	230	1–5	2 x 12	62	6–7/9–10	2 x 16.6	2
BV EI 302 2023	230	1–5	1 x 15	100	7–9	1 x 20.7	1
BV EI 302 2028	230	1–5	2 x 15	50	6–7/9–10	2 x 20.7	2
BV EI 302 2024	230	1–5	1 x 18	83	7–9	1 x 24.5	1
BV EI 302 2029	230	1–5	2 x 18	41	6–7/9–10	2 x 24.8	2
BV EI 302 3059	230	1–5	1 x 21	71	7–9	1 x 28.6	1
BV EI 302 2989	230	1–5	1 x 24	62	7–9	1 x 33.5	1

1.8 VA ta 70 °C/F

Frame size/Core height
BV EI 302 .... / 10.5 mm

non inherently short-circuit-proof
with thermo-fuse

no load power loss
type. 2.1 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 302 7015	230	1–5	1 x 6	300	7–9	1 x 9.8	3
BV EI 302 7016	230	1–5	2 x 6	150	6–7/9–10	2 x 10.6	4
BV EI 302 7017	230	1–5	1 x 7.5	240	7–9	1 x 12.2	3
BV EI 302 7018	230	1–5	2 x 7.5	120	6–7/9–10	2 x 13.4	4
BV EI 302 7019	230	1–5	1 x 9	200	7–9	1 x 14.6	3
BV EI 302 7020	230	1–5	2 x 9	100	6–7/9–10	2 x 15.9	4
BV EI 302 7021	230	1–5	1 x 12	150	7–9	1 x 19.4	3
BV EI 302 7022	230	1–5	2 x 12	75	6–7/9–10	2 x 20.9	4
BV EI 302 7023	230	1–5	1 x 15	120	7–9	1 x 24.3	3
BV EI 302 7024	230	1–5	2 x 15	60	6–7/9–10	2 x 24.8	4
BV EI 302 7025	230	1–5	1 x 18	100	7–9	1 x 29.2	3
BV EI 302 7026	230	1–5	1 x 21	86	7–9	1 x 34.1	3
BV EI 302 7027	230	1–5	1 x 24	75	7–9	1 x 38.8	3

Printed-Circuit-Board transformers

Output Power: up to 1.8 VA

EI 30

1.8 VA ta 70 °C/F

Frame size/Core height
BV EI 307 …. / 11.5 mm

inherently short-circuit-proof

no load power loss
type. 1.0 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 307 3842	230	1–5	1 x 6	300	7–9	1 x 9.7	1
BV EI 307 3843	230	1–5	2 x 6	150	6–7/9–10	2 x 9.4	2
BV EI 307 3844	230	1–5	1 x 7.5	240	7–9	1 x 12.7	1
BV EI 307 3845	230	1–5	2 x 7.5	120	6–7/9–10	2 x 12.4	2
BV EI 307 3846	230	1–5	1 x 9	200	7–9	1 x 14.5	1
BV EI 307 3847	230	1–5	2 x 9	100	6–7/9–10	2 x 14.3	2
BV EI 307 3801	230	1–5	1 x 12	150	7–9	1 x 18.7	1
BV EI 307 3848	230	1–5	2 x 12	75	6–7/9–10	2 x 18.9	2
BV EI 307 3849	230	1–5	1 x 15	120	7–9	1 x 24.5	1
BV EI 307 3850	230	1–5	2 x 15	60	6–7/9–10	2 x 24.5	2
BV EI 307 3851	230	1–5	1 x 18	100	7–9	1 x 28.4	1
BV EI 307 3852	230	1–5	1 x 21	86	7–9	1 x 33.4	1
BV EI 307 3853	230	1–5	1 x 24	75	7–9	1 x 37.9	1

1.8 VA ta 70 °C/F

Frame size/Core height
BV EI 307 …. / 11.5 mm

non inherently short-circuit-proof
with thermo-fuse

no load power loss
type. 1.1 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 307 7079	230	1–5	1 x 6	300	7–9	1 x 9.8	3
BV EI 307 7080	230	1–5	2 x 6	150	6–7/9–10	2 x 9.8	4
BV EI 307 7081	230	1–5	1 x 7.5	240	7–9	1 x 12.9	3
BV EI 307 7082	230	1–5	2 x 7.5	120	6–7/9–10	2 x 13.2	4
BV EI 307 7083	230	1–5	1 x 9	200	7–9	1 x 14.7	3
BV EI 307 7084	230	1–5	2 x 9	100	6–7/9–10	2 x 15.2	4
BV EI 307 7085	230	1–5	1 x 12	150	7–9	1 x 19.4	3
BV EI 307 7086	230	1–5	2 x 12	75	6–7/9–10	2 x 20.1	4
BV EI 307 7087	230	1–5	1 x 15	120	7–9	1 x 24.1	3
BV EI 307 7088	230	1–5	2 x 15	60	6–7/9–10	2 x 24.1	4
BV EI 307 7089	230	1–5	1 x 18	100	7–9	1 x 28.9	3
BV EI 307 7090	230	1–5	1 x 21	86	7–9	1 x 34.8	3
BV EI 307 7091	230	1–5	1 x 24	75	7–9	1 x 38.5	3

Printed-Circuit-Board transformers

Output Power: up to 2.3 VA

2.3 VA ta 40 °C/F

Frame size/Core height
BV EI 303 …. / 12.5 mm

inherently short-circuit-proof

no load power loss
type. 2.0 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 303 2010	230	1–5	1 x 6	383	7–9	1 x 8.5	1
BV EI 303 2015	230	1–5	2 x 6	191	6–7/9–10	2 x 9.4	2
BV EI 303 3611	230	1–5	1 x 7.5	307	7–9	1 x 11.4	1
BV EI 303 3612	230	1–5	2 x 7.5	153	6–7/9–10	2 x 12.4	2
BV EI 303 2011	230	1–5	1 x 9	255	7–9	1 x 12.9	1
BV EI 303 2016	230	1–5	2 x 9	127	6–7/9–10	2 x 14.6	2
BV EI 303 2012	230	1–5	1 x 12	191	7–9	1 x 17.4	1
BV EI 303 2017	230	1–5	2 x 12	95	6–7/9–10	2 x 18.7	2
BV EI 303 2013	230	1–5	1 x 15	153	7–9	1 x 21.6	1
BV EI 303 2018	230	1–5	2 x 15	76	6–7/9–10	2 x 23.5	2
BV EI 303 2014	230	1–5	1 x 18	127	7–9	1 x 25.8	1
BV EI 303 3563	230	1–5	1 x 21	110	7–9	1 x 30.2	1
BV EI 303 2991	230	1–5	1 x 24	96	7–9	1 x 34.3	1

1.9 VA ta 70 °C/F

Frame size/Core height
BV EI 303 …. / 12.5 mm

inherently short-circuit-proof

no load power loss
type. 1.2 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 303 2030	230	1–5	1 x 6	316	7–9	1 x 8.6	1
BV EI 303 2035	230	1–5	2 x 6	158	6–7/9–10	2 x 9.3	2
BV EI 303 3060	230	1–5	1 x 7.5	253	7–9	1 x 11.0	1
BV EI 303 2095	230	1–5	2 x 7.5	126	6–7/9–10	2 x 12.3	2
BV EI 303 2031	230	1–5	1 x 9	211	7–9	1 x 12.9	1
BV EI 303 2036	230	1–5	2 x 9	105	6–7/9–10	2 x 13.9	2
BV EI 303 2032	230	1–5	1 x 12	158	7–9	1 x 17.2	1
BV EI 303 2037	230	1–5	2 x 12	79	6–7/9–10	2 x 18.5	2
BV EI 303 2033	230	1–5	1 x 15	126	7–9	1 x 21.5	1
BV EI 303 2038	230	1–5	2 x 15	63	6–7/9–10	2 x 22.0	2
BV EI 303 2034	230	1–5	1 x 18	105	7–9	1 x 25.8	1
BV EI 303 3013	230	1–5	1 x 21	90	7–9	1 x 30.0	1
BV EI 303 2100	230	1–5	1 x 24	79	7–9	1 x 35.5	1

2.3 VA ta 70 °C/F

Frame size/Core height
BV EI 303 …. / 12.5 mm

non inherently short-circuit-proof with thermo-fuse

no load power loss
type. 2.0 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 303 7028	230	1–5	1 x 6	383	7–9	1 x 9.4	3
BV EI 303 7029	230	1–5	2 x 6	191	6–7/9–10	2 x 9.7	4
BV EI 303 7030	230	1–5	1 x 7.5	306	7–9	1 x 11.3	3
BV EI 303 7031	230	1–5	2 x 7.5	153	6–7/9–10	2 x 12.2	4
BV EI 303 7032	230	1–5	1 x 9	256	7–9	1 x 13.8	3
BV EI 303 7033	230	1–5	2 x 9	128	6–7/9–10	2 x 14.3	4
BV EI 303 7034	230	1–5	1 x 12	191	7–9	1 x 17.4	3
BV EI 303 7035	230	1–5	2 x 12	96	6–7/9–10	2 x 19.1	4
BV EI 303 7036	230	1–5	1 x 15	153	7–9	1 x 22.3	3
BV EI 303 7037	230	1–5	2 x 15	76	6–7/9–10	2 x 23.7	4
BV EI 303 7038	230	1–5	1 x 18	128	7–9	1 x 26.4	3
BV EI 303 7039	230	1–5	1 x 21	110	7–9	1 x 30.5	3
BV EI 303 7040	230	1–5	1 x 24	96	7–9	1 x 34.0	3

Printed-Circuit-Board transformers

Output Power: up to 2.6 VA

EI 30

2.6 VA ta 40 °C/F

Frame size/Core height
BV EI 304…./ 15.5 mm

inherently short-circuit-proof

no load power loss
type. 1.0 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 304 2040	230	1–5	1 x 6	434	7–9	1 x 10.4	1
BV EI 304 2045	230	1–5	2 x 6	217	6–7/9–10	2 x 10.8	2
BV EI 304 3564	230	1–5	1 x 7.5	346	7–9	1 x 12.5	1
BV EI 304 2840	230	1–5	2 x 7.5	173	6–7/9–10	2 x 12.5	2
BV EI 304 2041	230	1–5	1 x 9	289	7–9	1 x 15.9	1
BV EI 304 2046	230	1–5	2 x 9	145	6–7/9–10	2 x 16.2	2
BV EI 304 2042	230	1–5	1 x 12	217	7–9	1 x 21.7	1
BV EI 304 2047	230	1–5	2 x 12	108	6–7/9–10	2 x 22.4	2
BV EI 304 2043	230	1–5	1 x 15	174	7–9	1 x 27.4	1
BV EI 304 2044	230	1–5	1 x 18	145	7–9	1 x 30.9	1
BV EI 304 2995	230	1–5	1 x 21	123	7–9	1 x 32.1	1
BV EI 304 2992	230	1–5	1 x 24	108	7–9	1 x 41.7	1

2.1 VA ta 70 °C/F

Frame size/Core height
BV EI 304…./ 15.5 mm

inherently short-circuit-proof

no load power loss
type. 0.7 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 304 2080	230	1–5	1 x 6	350	7–9	1 x 10.5	1
BV EI 304 2085	230	1–5	2 x 6	175	6–7/9–10	2 x 11.2	2
BV EI 304 2889	230	1–5	1 x 7.5	280	7–9	1 x 13.7	1
BV EI 304 2773	230	1–5	2 x 7.5	140	6–7/9–10	2 x 14.2	2
BV EI 304 2081	230	1–5	1 x 9	234	7–9	1 x 16.0	1
BV EI 304 2086	230	1–5	2 x 9	117	6–7/9–10	2 x 16.2	2
BV EI 304 2082	230	1–5	1 x 12	175	7–9	1 x 21.5	1
BV EI 304 2087	230	1–5	2 x 12	88	6–7/9–10	2 x 22.0	2
BV EI 304 2083	230	1–5	1 x 15	140	7–9	1 x 26.5	1
BV EI 304 2084	230	1–5	1 x 18	117	7–9	1 x 30.0	1
BV EI 304 2843	230	1–5	1 x 21	100	7–9	1 x 33.4	1
BV EI 304 2868	230	1–5	1 x 24	88	7–9	1 x 37.3	1

2.4 VA ta 70 °C/F

Frame size/Core height
BV EI 304…./ 15.5 mm

non inherently short-circuit-proof
with thermo-fuse

no load power loss
type. 1.0 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 304 7041	230	1–5	1 x 6	400	7–9	1 x 10.6	3
BV EI 304 7042	230	1–5	2 x 6	200	6–7/9–10	2 x 10.1	4
BV EI 304 7043	230	1–5	1 x 7.5	320	7–9	1 x 13.2	3
BV EI 304 7044	230	1–5	2 x 7.5	160	6–7/9–10	2 x 13.2	4
BV EI 304 7045	230	1–5	1 x 9	266	7–9	1 x 16.3	3
BV EI 304 7046	230	1–5	2 x 9	133	6–7/9–10	2 x 16.9	4
BV EI 304 7047	230	1–5	1 x 12	200	7–9	1 x 21.8	3
BV EI 304 7048	230	1–5	2 x 12	100	6–7/9–10	2 x 21.8	4
BV EI 304 7049	230	1–5	1 x 15	160	7–9	1 x 26.7	3
BV EI 304 7095	230	1–5	2 x 15	80	6–7/9–10	2 x 24.7	4
BV EI 304 7050	230	1–5	1 x 18	133	7–9	1 x 32.6	3
BV EI 304 7051	230	1–5	1 x 21	114	7–9	1 x 37.2	3
BV EI 304 7052	230	1–5	1 x 24	100	7–9	1 x 42.3	3

Printed-Circuit-Board transformers

Output Power: up to 3.0 VA

EI 30

3.0 VA ta 40 °C/F

Frame size/Core height
BV EI 305…. / 18.0 mm

inherently short-circuit-proof

no load power loss
type. 1.0 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 305 2050	230	1–5	1 x 6	500	7–9	1 x 10.7	1
BV EI 305 2055	230	1–5	2 x 6	250	6–7/9–10	2 x 10.7	2
BV EI 305 3565	230	1–5	1 x 7.5	400	7–9	1 x 13.7	1
BV EI 305 2922	230	1–5	2 x 7.5	200	6–7/9–10	2 x 13.7	2
BV EI 305 2051	230	1–5	1 x 9	334	7–9	1 x 17.3	1
BV EI 305 2056	230	1–5	2 x 9	167	6–7/9–10	2 x 15.7	2
BV EI 305 2052	230	1–5	1 x 12	250	7–9	1 x 20.3	1
BV EI 305 2057	230	1–5	2 x 12	125	6–7/9–10	2 x 20.3	2
BV EI 305 2053	230	1–5	1 x 15	200	7–9	1 x 26.7	1
BV EI 305 2054	230	1–5	1 x 18	167	7–9	1 x 32.5	1
BV EI 305 2188	230	1–5	1 x 21	143	7–9	1 x 35.7	1
BV EI 305 2993	230	1–5	1 x 24	125	7–9	1 x 42.0	1

2.3 VA ta 70 °C/F

Frame size/Core height
BV EI 305…. / 18.0 mm

inherently short-circuit-proof

no load power loss
type. 0.8 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 305 2878	230	1–5	1 x 6	383	7–9	1 x 11.6	1
BV EI 305 2882	230	1–5	2 x 6	192	6–7/9–10	2 x 10.9	2
BV EI 305 2893	230	1–5	1 x 7.5	307	7–9	1 x 15.2	1
BV EI 305 2894	230	1–5	2 x 7.5	153	6–7/9–10	2 x 13.0	2
BV EI 305 2879	230	1–5	1 x 9	255	7–9	1 x 17.6	1
BV EI 305 2866	230	1–5	2 x 9	127	6–7/9–10	2 x 16.1	2
BV EI 305 2800	230	1–5	1 x 12	192	7–9	1 x 21.4	1
BV EI 305 2847	230	1–5	2 x 12	96	6–7/9–10	2 x 21.5	2
BV EI 305 2805	230	1–5	1 x 15	153	7–9	1 x 28.2	1
BV EI 305 2844	230	1–5	2 x 15	76	6–7/9–10	2 x 24.5	2
BV EI 305 2851	230	1–5	1 x 18	128	7–9	1 x 32.4	1
BV EI 305 2772	230	1–5	1 x 21	110	7–9	1 x 38.4	1
BV EI 305 2874	230	1–5	1 x 24	96	7–9	1 x 45.4	1

2.7 VA ta 70 °C/F

Frame size/Core height
BV EI 305…. / 18.0 mm

non inherently short-circuit-proof with thermo-fuse

no load power loss
type. 1.0 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 305 7053	230	1–5	1 x 6	450	7–9	1 x 10.9	3
BV EI 305 7054	230	1–5	2 x 6	225	6–7/9–10	2 x 10.3	4
BV EI 305 7055	230	1–5	1 x 7.5	360	7–9	1 x 13.7	3
BV EI 305 7056	230	1–5	2 x 7.5	180	6–7/9–10	2 x 13.4	4
BV EI 305 7057	230	1–5	1 x 9	300	7–9	1 x 16.2	3
BV EI 305 7058	230	1–5	2 x 9	150	6–7/9–10	2 x 16.8	4
BV EI 305 7059	230	1–5	1 x 12	225	7–9	1 x 20.7	3
BV EI 305 7060	230	1–5	2 x 12	112	6–7/9–10	2 x 22.1	4
BV EI 305 7061	230	1–5	1 x 15	180	7–9	1 x 26.6	3
BV EI 305 7062	230	1–5	2 x 15	90	6–7/9–10	2 x 24.6	4
BV EI 305 7063	230	1–5	1 x 18	150	7–9	1 x 33.0	3
BV EI 305 7064	230	1–5	1 x 21	128	7–9	1 x 37.6	3
BV EI 305 7065	230	1–5	1 x 24	112	7–9	1 x 42.9	3

Printed-Circuit-Board transformers

Output Power: up to 3.6 VA

EI 30

3.6 VA ta 40 °C/F

Frame size/Core height
BV EI 306 …. / 23.0 mm

inherently short-circuit-proof

no load power loss
type. 1.3 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 306 3595	230	1–5	1 x 6	600	7–9	1 x 10.8	1
BV EI 306 3596	230	1–5	2 x 6	300	6–7/9–10	2 x 10.8	2
BV EI 306 3597	230	1–5	1 x 7.5	480	7–9	1 x 13.3	1
BV EI 306 3598	230	1–5	2 x 7.5	240	6–7/9–10	2 x 13.3	2
BV EI 306 3599	230	1–5	1 x 9	400	7–9	1 x 15.7	1
BV EI 306 3600	230	1–5	2 x 9	200	6–7/9–10	2 x 15.7	2
BV EI 306 3601	230	1–5	1 x 12	300	7–9	1 x 21.0	1
BV EI 306 3602	230	1–5	2 x 12	150	6–7/9–10	2 x 21.0	2
BV EI 306 3603	230	1–5	1 x 15	240	7–9	1 x 24.5	1
BV EI 306 3604	230	1–5	2 x 15	120	6–7/9–10	2 x 24.5	2
BV EI 306 3605	230	1–5	1 x 18	200	7–9	1 x 31.4	1
BV EI 306 3606	230	1–5	1 x 21	171	7–9	1 x 35.5	1
BV EI 306 3607	230	1–5	1 x 24	150	7–9	1 x 42.0	1

3.0 VA ta 70 °C/F

Frame size/Core height
BV EI 306 …. / 23.0 mm

inherently short-circuit-proof

no load power loss
type. 0.8 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 306 3359	230	1–5	1 x 6	500	7–9	1 x 10.5	1
BV EI 306 3360	230	1–5	2 x 6	250	6–7/9–10	2 x 10.5	2
BV EI 306 3361	230	1–5	1 x 7.5	400	7–9	1 x 12.7	1
BV EI 306 3362	230	1–5	2 x 7.5	200	6–7/9–10	2 x 12.7	2
BV EI 306 3363	230	1–5	1 x 9	333	7–9	1 x 15.9	1
BV EI 306 3364	230	1–5	2 x 9	167	6–7/9–10	2 x 15.9	2
BV EI 306 3365	230	1–5	1 x 12	250	7–9	1 x 20.3	1
BV EI 306 3366	230	1–5	2 x 12	125	6–7/9–10	2 x 20.3	2
BV EI 306 3367	230	1–5	1 x 15	200	7–9	1 x 23.8	1
BV EI 306 3368	230	1–5	2 x 15	100	6–7/9–10	2 x 24.0	2
BV EI 306 3369	230	1–5	1 x 18	167	7–9	1 x 29.2	1
BV EI 306 3371	230	1–5	1 x 21	143	7–9	1 x 34.3	1
BV EI 306 3372	230	1–5	1 x 24	125	7–9	1 x 38.4	1

3.4 VA ta 70 °C/F

Frame size/Core height
BV EI 306 …. / 23.0 mm

non inherently short-circuit-proof with thermo-fuse

no load power loss
type. 1.3 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 306 7066	230	1–5	1 x 6	566	7–9	1 x 11.0	3
BV EI 306 7067	230	1–5	2 x 6	283	6–7/9–10	2 x 10.7	4
BV EI 306 7068	230	1–5	1 x 7.5	453	7–9	1 x 13.6	3
BV EI 306 7069	230	1–5	2 x 7.5	226	6–7/9–10	2 x 12.4	4
BV EI 306 7070	230	1–5	1 x 9	378	7–9	1 x 16.0	3
BV EI 306 7071	230	1–5	2 x 9	189	6–7/9–10	2 x 16.8	4
BV EI 306 7072	230	1–5	1 x 12	283	7–9	1 x 21.0	3
BV EI 306 7073	230	1–5	2 x 12	141	6–7/9–10	2 x 22.1	4
BV EI 306 7074	230	1–5	1 x 15	226	7–9	1 x 26.0	3
BV EI 306 7075	230	1–5	2 x 15	113	6–7/9–10	2 x 24.6	4
BV EI 306 7076	230	1–5	1 x 18	189	7–9	1 x 32.2	3
BV EI 306 7077	230	1–5	1 x 21	162	7–9	1 x 37.5	3
BV EI 306 7078	230	1–5	1 x 24	141	7–9	1 x 43.1	3

Flat-type Printed-Circuit-Board transformers with small base areas

EI 34

Output Power: 1.6 VA – 8.0 VA

10	**DIN EN 61558**	**VDE**	on request
VDE-Mark for Glow-Wire-Test	**DIN EN 60 335-1**	**VDE**	102961/84814
	UL 5085-3	**UL**	on request
	UL 5085-1	**UL**	on request
	C22.2	**CSA**	on request

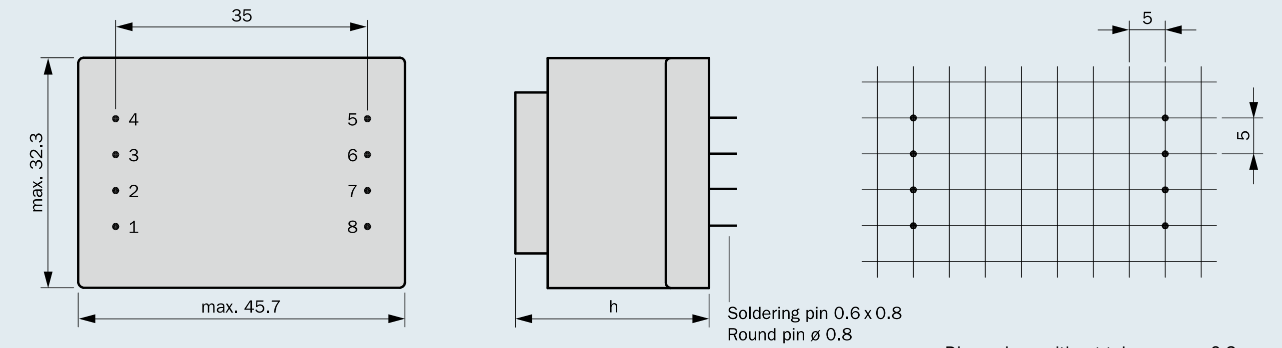
- according to REACH regulation
- according to RoHs regulation

- Primary voltages up to 230 V
- Secondary voltages from 2 V to max. 38 V
- Output Power up to 8.0 VA
- Temperature class ta 70 °C/B
- Short-circuit-proof
- Vacuum-encapsulated, bobbin with dual chamber windings
- Per item tested quality with certificate
- Excellent temperature fluctuation resistance properties
- Self-extinguishing cast housing and sealing material
- Minimal size available

The EI 34 Series provides solutions for applications requiring low heights and a small base areas. HAHN offers rapid and economic problem solutions for customer applications especially developed by our experienced R&D development engineers. The EI 34 Transformers meet the stringent requirements of the DIN EN 61558 and DIN VDE 0570 standards. Short-circuit-proof and non short-circuit-proof transformers are available in five different stacking heights. Outputs from 1.6 VA to 8.0 VA, at an ambient temperature of 70 °C, are supplyable to meet customer requirements in encapsulated versions.

HAHN has established itself on the market as a reliable and innovative supplier with its application-oriented solutions.

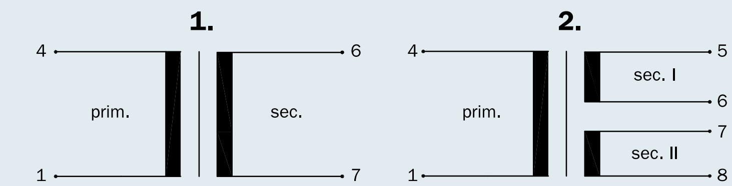
Connecting pins



Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

View looking onto pins

Connection scheme (only connected pins are present)



2.) double voltage – bridge: 6 + 7, double current – bridge: 5 + 7/ 6 + 8

Frame size/Core height	Output Power ta 70 °C/B inherently short-circuit-proof	Output Power ta 70 °C/B non short-circuit-proof	Height (h)	Weight	Packaging unit
BV EI 341 .... / 5.5 mm	1.6 VA	–	16.2 mm	75 g	36 pieces
BV EI 342 .... / 7.5 mm	2.0 VA	–	18.1 mm	90 g	36 pieces
BV EI 343 .... /10.5 mm	2.4 VA	3.0 VA	21.0 mm	120 g	36 pieces
BV EI 344 .... /16.5 mm	–	5.0 VA	26.9 mm	165 g	36 pieces
BV EI 345 .... /26.0 mm	–	8.0 VA	36.7 mm	245 g	36 pieces

Flat-type Printed-Circuit-Board transformers with small base areas

Output Power: up to 2.4 VA

EI 34

1.6 VA ta 70 °C/B

Frame size/Core height
BV EI 341 .... / 5.5 mm

inherently short-circuit-proof

no load power loss
type. 1.7 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 341 0001	230	1–4	1 x 6	266	6–7	1 x 10.0	1
BV EI 341 0002	230	1–4	2 x 6	133	5–6/7–8	2 x 9.7	2
BV EI 341 0003	230	1–4	1 x 7.5	213	6–7	1 x 12.8	1
BV EI 341 0004	230	1–4	2 x 7.5	107	5–6/7–8	2 x 13.5	2
BV EI 341 0005	230	1–4	1 x 9	178	6–7	1 x 15.1	1
BV EI 341 0006	230	1–4	2 x 9	89	5–6/7–8	2 x 15.1	2
BV EI 341 0007	230	1–4	1 x 12	133	6–7	1 x 19.6	1
BV EI 341 0008	230	1–4	2 x 12	67	5–6/7–8	2 x 20.3	2
BV EI 341 0009	230	1–4	1 x 15	107	6–7	1 x 25.5	1
BV EI 341 0010	230	1–4	2 x 15	53	5–6/7–8	2 x 24.7	2
BV EI 341 0011	230	1–4	1 x 18	89	6–7	1 x 30.1	1
BV EI 341 0012	230	1–4	1 x 21	76	6–7	1 x 35.6	1
BV EI 341 0013	230	1–4	1 x 24	67	6–7	1 x 39.6	1

2.0 VA ta 70 °C/B

Frame size/Core height
BV EI 342 .... / 7.5 mm

inherently short-circuit-proof

no load power loss
type. 1.0 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 342 0014	230	1–4	1 x 6	333	6–7	1 x 10.7	1
BV EI 342 0015	230	1–4	2 x 6	167	5–6/7–8	2 x 10.7	2
BV EI 342 0016	230	1–4	1 x 7.5	266	6–7	1 x 13.5	1
BV EI 342 0017	230	1–4	2 x 7.5	133	5–6/7–8	2 x 13.5	2
BV EI 342 0018	230	1–4	1 x 9	222	6–7	1 x 15.6	1
BV EI 342 0019	230	1–4	2 x 9	111	5–6/7–8	2 x 16.1	2
BV EI 342 0020	230	1–4	1 x 12	167	6–7	1 x 21.4	1
BV EI 342 0021	230	1–4	2 x 12	83	5–6/7–8	2 x 21.4	2
BV EI 342 0022	230	1–4	1 x 15	133	6–7	1 x 27.0	1
BV EI 342 0024	230	1–4	1 x 18	111	6–7	1 x 31.4	1
BV EI 342 0025	230	1–4	1 x 21	95	6–7	1 x 37.6	1
BV EI 342 0026	230	1–4	1 x 24	84	6–7	1 x 43.2	1

2.4 VA ta 70 °C/B

Frame size/Core height
BV EI 343 .... / 10.5 mm

inherently short-circuit-proof

no load power loss
type. 0.7 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 343 0027	230	1–4	1 x 6	400	6–7	1 x 10.4	1
BV EI 343 0028	230	1–4	2 x 6	200	5–6/7–8	2 x 10.4	2
BV EI 343 0029	230	1–4	1 x 7.5	320	6–7	1 x 13.3	1
BV EI 343 0030	230	1–4	2 x 7.5	160	5–6/7–8	2 x 13.3	2
BV EI 343 0031	230	1–4	1 x 9	267	6–7	1 x 16.1	1
BV EI 343 0032	230	1–4	2 x 9	134	5–6/7–8	2 x 15.4	2
BV EI 343 0033	230	1–4	1 x 12	200	6–7	1 x 20.8	1
BV EI 343 0034	230	1–4	2 x 12	100	5–6/7–8	2 x 20.2	2
BV EI 343 0035	230	1–4	1 x 15	160	6–7	1 x 26.8	1
BV EI 343 0037	230	1–4	1 x 18	134	6–7	1 x 31.2	1
BV EI 343 0038	230	1–4	1 x 21	114	6–7	1 x 35.9	1
BV EI 343 0039	230	1–4	1 x 24	100	6–7	1 x 41.2	1

Flat-type Printed-Circuit-Board transformers with small base areas

Output Power: up to 8.0 VA

EI 34

3.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 343 …. / 10.5 mm

non short-circuit-proof

no load power loss
type. 1.2 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 343 0040	230	1–4	1 x 6	500	6–7	1 x 10.1	1
BV EI 343 0041	230	1–4	2 x 6	250	5–6/7–8	2 x 10.1	2
BV EI 343 0042	230	1–4	1 x 7.5	400	6–7	1 x 12.3	1
BV EI 343 0043	230	1–4	2 x 7.5	200	5–6/7–8	2 x 12.8	2
BV EI 343 0044	230	1–4	1 x 9	333	6–7	1 x 14.6	1
BV EI 343 0045	230	1–4	2 x 9	167	5–6/7–8	2 x 14.6	2
BV EI 343 0046	230	1–4	1 x 12	250	6–7	1 x 19.1	1
BV EI 343 0047	230	1–4	2 x 12	125	5–6/7–8	2 x 19.1	2
BV EI 343 0048	230	1–4	1 x 15	200	6–7	1 x 23.5	1
BV EI 343 0049	230	1–4	2 x 15	100	5–6/7–8	2 x 24.5	2
BV EI 343 0050	230	1–4	1 x 18	167	6–7	1 x 27.7	1
BV EI 343 0051	230	1–4	1 x 21	143	6–7	1 x 31.9	1
BV EI 343 0052	230	1–4	1 x 24	125	6–7	1 x 36.5	1

5.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 344 …. / 16.5 mm

non short-circuit-proof

no load power loss
type. 1.3 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 344 0053	230	1–4	1 x 6	834	6–7	1 x 8.7	1
BV EI 344 0054	230	1–4	2 x 6	417	5–6/7–8	2 x 8.7	2
BV EI 344 0055	230	1–4	1 x 7.5	667	6–7	1 x 11.0	1
BV EI 344 0056	230	1–4	2 x 7.5	334	5–6/7–8	2 x 11.0	2
BV EI 344 0057	230	1–4	1 x 9	555	6–7	1 x 12.6	1
BV EI 344 0058	230	1–4	2 x 9	278	5–6/7–8	2 x 12.6	2
BV EI 344 0059	230	1–4	1 x 12	417	6–7	1 x 17.3	1
BV EI 344 0060	230	1–4	2 x 12	208	5–6/7–8	2 x 16.5	2
BV EI 344 0061	230	1–4	1 x 15	334	6–7	1 x 21.6	1
BV EI 344 0062	230	1–4	2 x 15	167	5–6/7–8	2 x 21.6	2
BV EI 344 0063	230	1–4	1 x 18	278	6–7	1 x 25.4	1
BV EI 344 0064	230	1–4	1 x 21	238	6–7	1 x 29.6	1
BV EI 344 0065	230	1–4	1 x 24	208	6–7	1 x 31.8	1

8.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 345 …. / 26.0 mm

non short-circuit-proof

no load power loss
type. 1.7 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 345 0066	230	1–4	1 x 6	1332	6–7	1 x 8.2	1
BV EI 345 0067	230	1–4	2 x 6	667	5–6/7–8	2 x 8.2	2
BV EI 345 0068	230	1–4	1 x 7.5	1067	6–7	1 x 10.3	1
BV EI 345 0069	230	1–4	2 x 7.5	533	5–6/7–8	2 x 10.3	2
BV EI 345 0070	230	1–4	1 x 9	888	6–7	1 x 11.6	1
BV EI 345 0071	230	1–4	2 x 9	444	5–6/7–8	2 x 11.6	2
BV EI 345 0072	230	1–4	1 x 12	667	6–7	1 x 15.7	1
BV EI 345 0073	230	1–4	2 x 12	333	5–6/7–8	2 x 15.7	2
BV EI 345 0074	230	1–4	1 x 15	533	6–7	1 x 20.6	1
BV EI 345 0075	230	1–4	2 x 15	267	5–6/7–8	2 x 20.6	2
BV EI 345 0076	230	1–4	1 x 18	444	6–7	1 x 23.1	1
BV EI 345 0077	230	1–4	1 x 21	380	6–7	1 x 26.8	1
BV EI 345 0078	230	1–4	1 x 24	334	6–7	1 x 30.4	1

Content

EI Series

- Printed-Circuit-Board transformers
  frame size EI 38 – EI 96 (4.5 VA – 200 VA)

Printed-Circuit-Board transformers

Output Power: 4.5 VA

EI 38

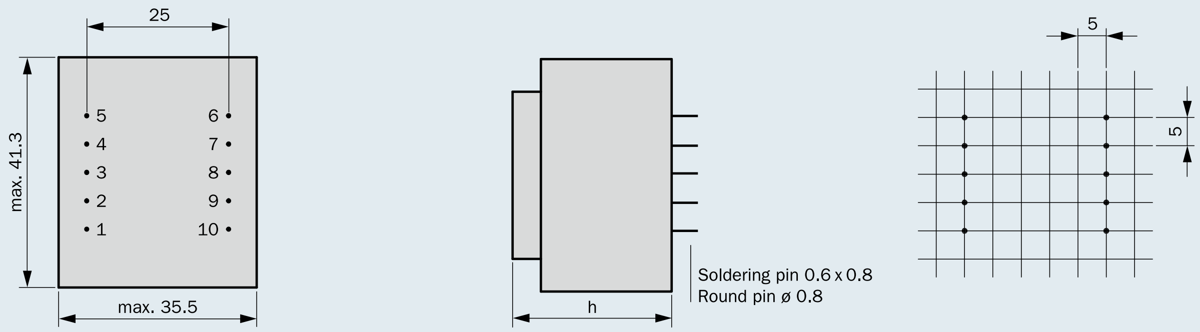
10 VDE	DIN EN 61558-2-6	VDE	119359
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	102961/84814
UL	UL 5085-3	UL	on request
UL	UL 5085-1	UL	E98173
CSA	C22.2	CSA	1290235

- according to REACH regulation
- according to RoHs regulation

- Output Power up to 4.5 VA
- Non short-circuit-proof at temperature class ta 70 °C/B
- Standard type cast housing "0"
- Excellent temperature fluctuation resistance properties
- High electrical safety and long service-life features
- High voltage resistance
- Self-extinguishing cast housing and sealing material
- Per item tested quality with certificate

Protection extern secondary by:
- Micro fuse according to IEC 127 or
- PTC resistance

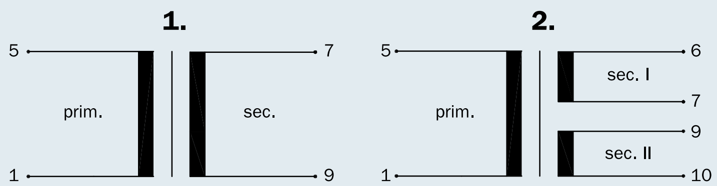
Connecting pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme (only connected pins are present)



2.) double voltage – bridge: 7 + 9, double current – bridge: 6 + 9/ 7 + 10

Frame size/Core height	Output Power ta 70 °C/B	Height (h)	Weight	Packaging unit
BV EI 382 .... /13.6 mm	4.5 VA	28.1 mm	0.150 kg	30 pieces

Printed-Circuit-Board transformers

Output Power: 4.5 VA

EI 38

4.5 VA
ta 70 °C/B

Frame size/Core height
BV EI 382 …. / 13.6 mm

non short-circuit-proof

no load power loss
type. 1.5 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 382 1185	230	1–5	1 x 6	750	7–9	1 x 9.7	1
BV EI 382 1186	230	1–5	2 x 6	375	6–7/9–10	2 x 9.2	2
BV EI 382 1187	230	1–5	1 x 7.5	600	7–9	1 x 10.6	1
BV EI 382 1188	230	1–5	2 x 7.5	300	6–7/9–10	2 x 11.0	2
BV EI 382 1189	230	1–5	1 x 9	500	7–9	1 x 13.0	1
BV EI 382 1190	230	1–5	2 x 9	250	6–7/9–10	2 x 13.0	2
BV EI 382 1191	230	1–5	1 x 12	375	7–9	1 x 17.0	1
BV EI 382 1192	230	1–5	2 x 12	187	6–7/9–10	2 x 18.4	2
BV EI 382 1193	230	1–5	1 x 15	300	7–9	1 x 20.8	1
BV EI 382 1194	230	1–5	2 x 15	150	6–7/9–10	2 x 21.2	2
BV EI 382 1195	230	1–5	1 x 18	250	7–9	1 x 24.4	1
BV EI 382 1196	230	1–5	2 x 18	125	6–7/9–10	2 x 24.9	2
BV EI 382 1267	230	1–5	1 x 21	215	7–9	1 x 29.0	1
BV EI 382 1197	230	1–5	1 x 24	187	7–9	1 x 33.5	1

Printed-Circuit-Board transformers

Output Power: 2.5 VA – 9.0 VA

EI 38

10	DIN EN 61558-2-6	VDE	on request
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	on request
	UL 5085-3	UL	on request
	UL 5085-1	UL	on request
	C22.2	CSA	on request

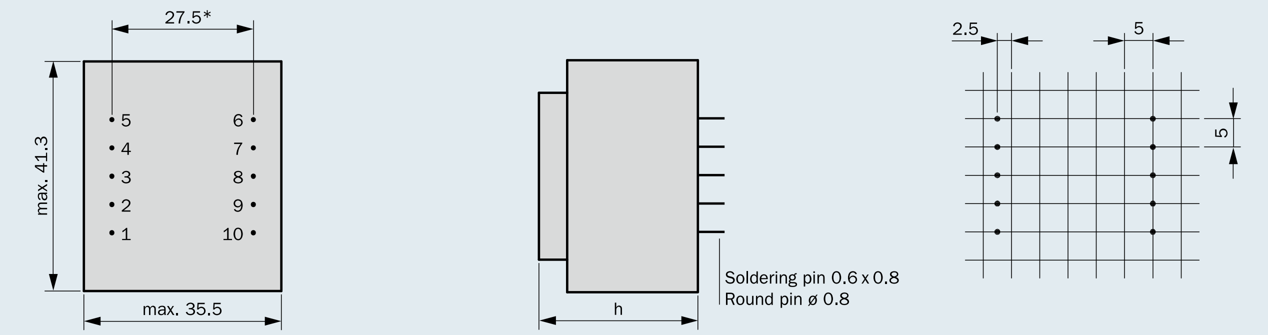
- according to REACH regulation
- according to RoHs regulation

Individual version!

Parallel to the cataloged EI 38 series transformers. HAHN also produces other variants. e.g. with integrated thermo fuse or thermo switch. other housing-. fixing- and connective options as well as non-encapsulated transformers.

Frame size/Core height	Output Power ta 70 °C/B	Height (h)	Weight
BV EI 381 .... / 7.5 mm	2.5 VA	22.1 mm	0.100 kg
BV EI 382 .... /13.6 mm	4.5 VA	28.1 mm	0.150 kg
BV EI 383 .... /16.5 mm	6.0 VA	30.8 mm	0.190 kg
BV EI 384 .... /28.0 mm	9.0 VA	42.8 mm	0.280 kg

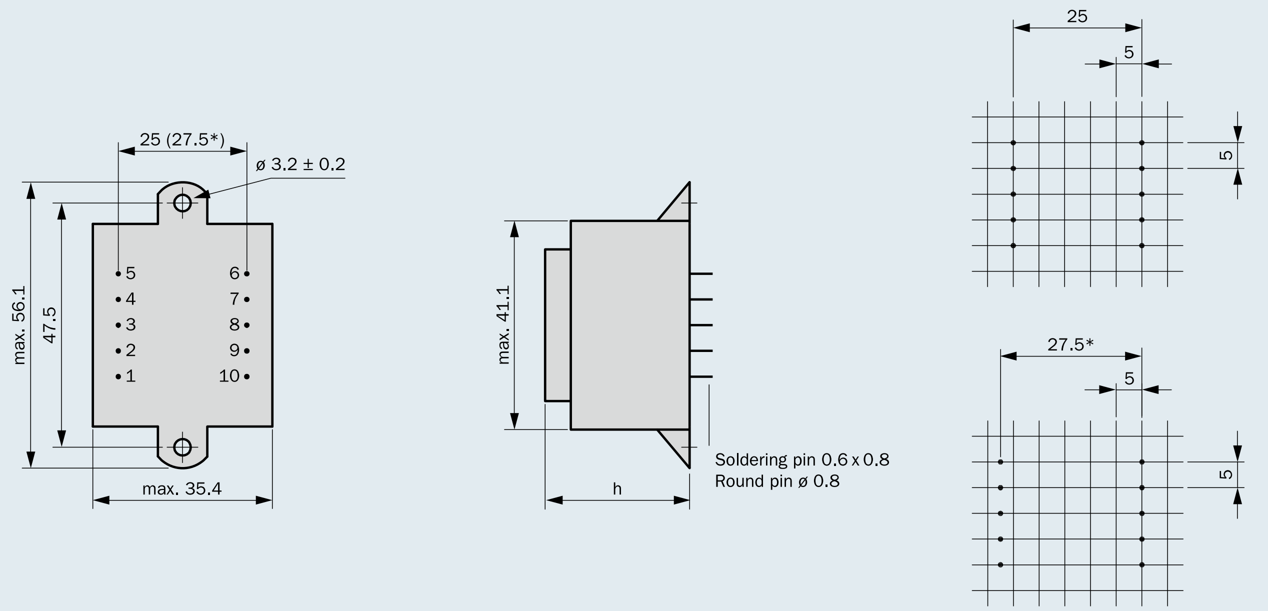
Type cast housing “0”



View looking onto pins
* alternative version with connecting grid 27.5 mm

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

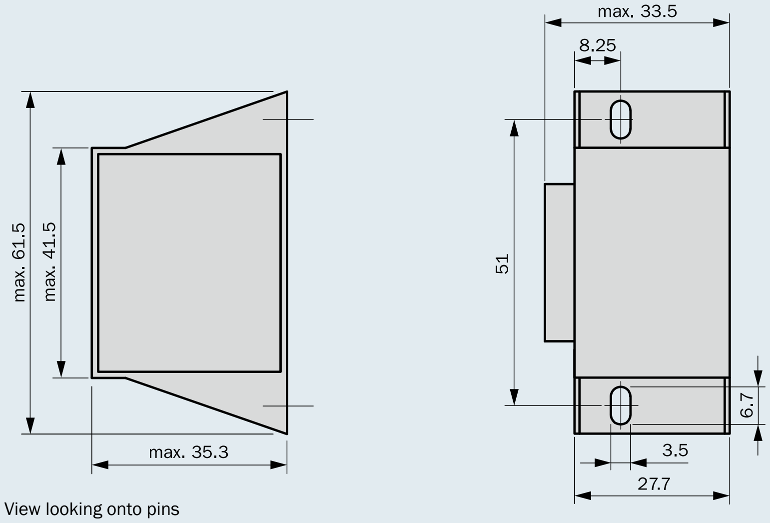
Type cast housing “K” with 2 fixing straps



View looking onto pins
* alternative version with connecting grid 27.5 mm

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Type cast housing "SV" for upright mounting



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

Printed-Circuit-Board transformers

Output Power: 6.0 VA

EI 42

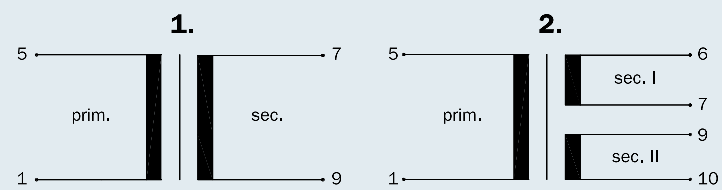
10	**DIN EN 61558-2-6**	**VDE**	119359
VDE-Mark for Glow-Wire-Test	**DIN EN 60 335-1**	**VDE**	102961/84814
	UL 5085-3	**UL**	on request
	UL 5085-1	**UL**	E98173
	C22.2	**CSA**	on request

- according to REACH regulation
- according to RoHs regulation

- Output Power up to 6.0 VA
- Non short-circuit-proof at temperature class ta 70 °C/B
- Standard type cast housing “K” and “O”
- Excellent temperature fluctuation resistance properties
- High electrical safety and long service life features
- High voltage resistance
- Self-extinguishing cast housing and sealing material
- Per item tested quality with certificate

Protection extern secondary by:
- Micro fuse according to IEC 127 or
- PTC resistance

Connection scheme (only connected pins are present)

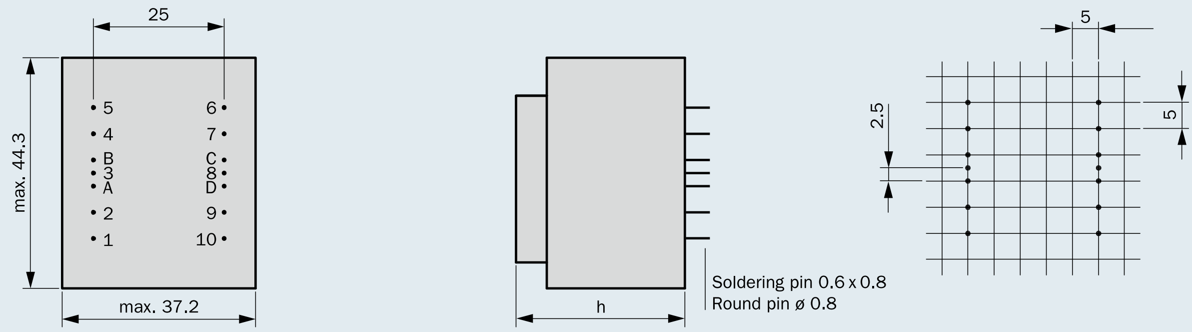


2.) double voltage – bridge: 7 + 9, double current – bridge: 6 + 9/ 7 + 10

Frame size/Core height	Output Power ta 70 °C/B	Height (h)	Weight	Packaging unit
BV EI 422 .... /14.8 mm	6.0 VA	32.3 mm	0.200 kg	30/21 pieces*

* it depends on kind of cast housing

Connecting pins type cast housing “0”



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

Type cast housing “0”

6.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 422 .... /
14.8 mm

non short-circuit-proof

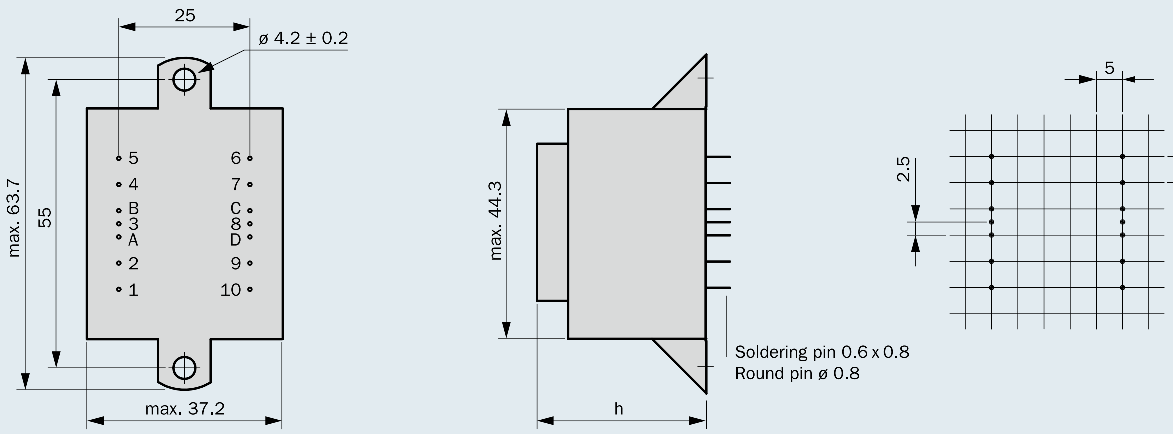
no load power loss
type. 1.3 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 422 1320	230	1 – 5	1 x 6	1000	7–9	1 x 8.7	1
BV EI 422 1298	230	1 – 5	2 x 6	500	6–7/9–10	2 x 8.7	2
BV EI 422 1303	230	1 – 5	1 x 7.5	800	7–9	1 x 10.9	1
BV EI 422 1304	230	1 – 5	2 x 7.5	400	6–7/9–10	2 x 10.9	2
BV EI 422 1285	230	1 – 5	1 x 9	667	7–9	1 x 13.0	1
BV EI 422 1281	230	1 – 5	2 x 9	334	6–7/9–10	2 x 13.0	2
BV EI 422 1275	230	1 – 5	1 x 12	500	7–9	1 x 16.7	1
BV EI 422 1260	230	1 – 5	2 x 12	250	6–7/9–10	2 x 16.7	2
BV EI 422 1276	230	1 – 5	1 x 15	400	7–9	1 x 20.2	1
BV EI 422 1305	230	1 – 5	2 x 15	200	6–7/9–10	2 x 20.6	2
BV EI 422 1289	230	1 – 5	1 x 18	334	7–9	1 x 24.6	1
BV EI 422 1306	230	1 – 5	2 x 18	167	6–7/9–10	2 x 24.6	2
BV EI 422 1355	230	1 – 5	1 x 21	285	7–9	1 x 27.1	1
BV EI 422 1307	230	1 – 5	1 x 24	250	7–9	1 x 30.8	1

Printed-Circuit-Board transformers

Output Power: 6.0 VA

Connecting pins type cast housing “K” with 2 fixing straps



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Type cast housing “K”

6.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 422 …. / 14.8 mm

non short-circuit-proof

no load power loss
type. 1.3 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 422 1218	230	1 – 5	1 x 6	1000	7–9	1 x 8.7	1
BV EI 422 1219	230	1 – 5	2 x 6	500	6–7/9–10	2 x 8.7	2
BV EI 422 1220	230	1 – 5	1 x 7.5	800	7–9	1 x 10.9	1
BV EI 422 1221	230	1 – 5	2 x 7.5	400	6–7/9–10	2 x 10.9	2
BV EI 422 1222	230	1 – 5	1 x 9	667	7–9	1 x 13.0	1
BV EI 422 1223	230	1 – 5	2 x 9	334	6–7/9–10	2 x 13.0	2
BV EI 422 1224	230	1 – 5	1 x 12	500	7–9	1 x 16.7	1
BV EI 422 1225	230	1 – 5	2 x 12	250	6–7/9–10	2 x 16.7	2
BV EI 422 1226	230	1 – 5	1 x 15	400	7–9	1 x 20.2	1
BV EI 422 1227	230	1 – 5	2 x 15	200	6–7/9–10	2 x 20.6	2
BV EI 422 1228	230	1 – 5	1 x 18	334	7–9	1 x 24.6	1
BV EI 422 1229	230	1 – 5	2 x 18	167	6–7/9–10	2 x 24.6	2
BV EI 422 1354	230	1 – 5	1 x 21	285	7–9	1 x 27.1	1
BV EI 422 1230	230	1 – 5	1 x 24	250	7–9	1 x 30.8	1

Printed-Circuit-Board transformers

Output Power: 3.0 VA – 10.0 VA

EI 42

10	**DIN EN 61558-2-6**	**VDE**	on request
VDE-Mark for Glow-Wire-Test	**DIN EN 60 335-1**	**VDE**	on request
	UL 5085-3	**UL**	on request
	UL 5085-1	**UL**	on request
	C22.2	**CSA**	on request

- according to REACH regulation
- according to RoHs regulation

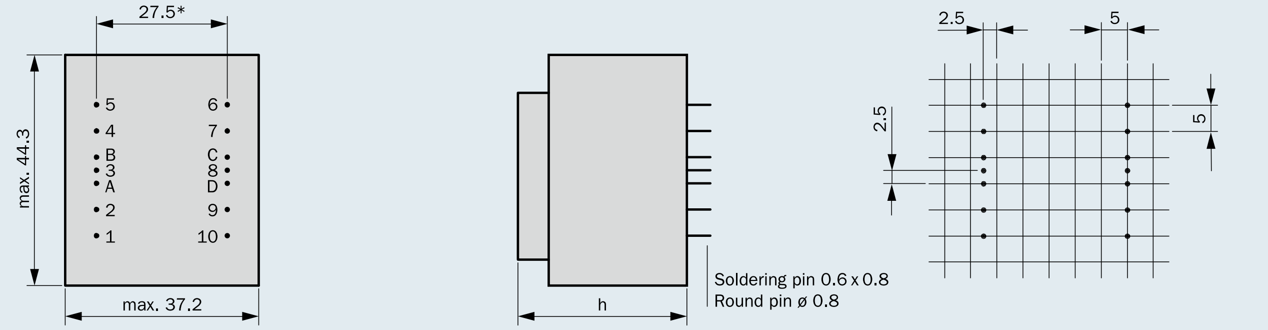
Individual version!

Parallel to the cataloged EI 42 series transformers, HAHN also produces other variants, e.g. with integrated thermo fuse or thermo switch, other housing-, fixing- and connective options as well as non-encapsulated transformers.

Frame size/Core height	Output Power ta 70 °C/B	Height (h)	Weight
BV EI 421 .... / 8.5 mm	3.0 VA	26.2 mm	0.120 kg
BV EI 422 .... /14.8 mm	6.0 VA	32.3 mm	0.200 kg
BV EI 423 .... /20.0 mm*	10.0 VA	38.0 mm	0.250 kg

* only type cast housing "O"

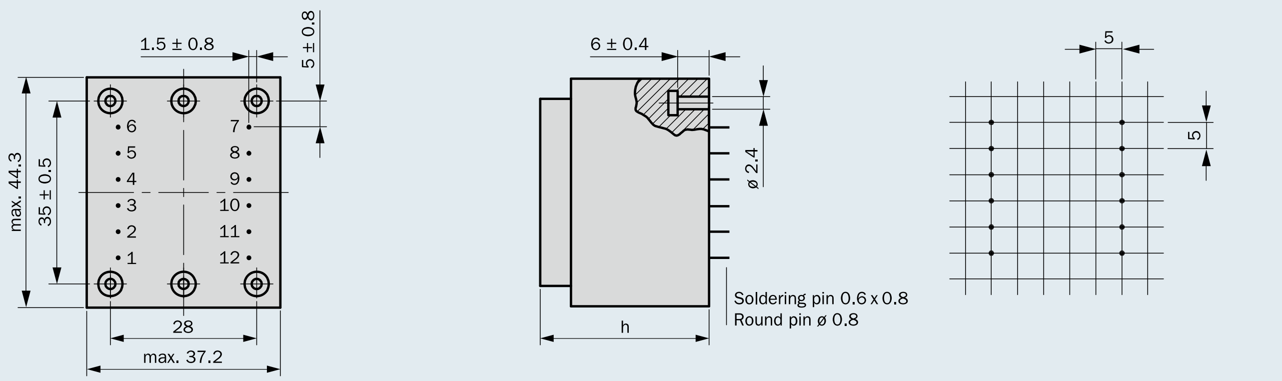
Connecting pins type cast housing "O"



View looking onto pins
* alternative version with connecting grid 27.5 mm

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

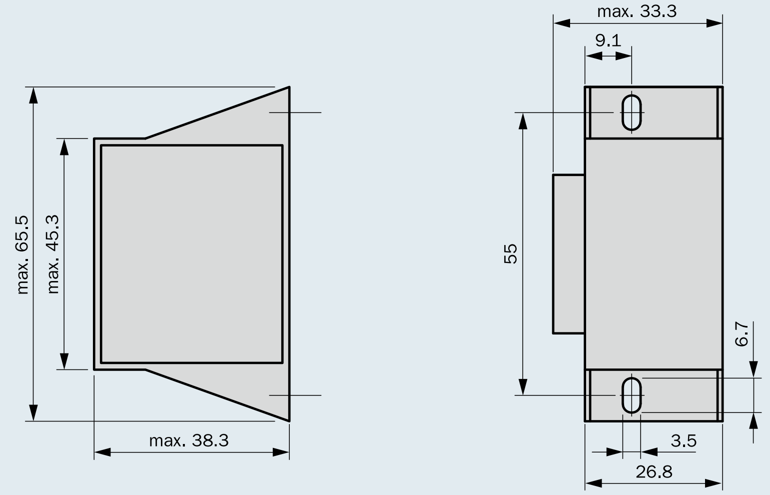
Connecting pins type cast housing "O" with fixing band



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connecting pins type cast housing “SV” for upright mounting



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

Printed-Circuit-Board transformers

Output Power: 7.0 VA – 15.0 VA

EI 48

10	DIN EN 61558-2-6	VDE	108266
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	102961/84814
	UL 5085-3	UL	on request
	UL 5085-1	UL	E98173
	C22.2	CSA	on request

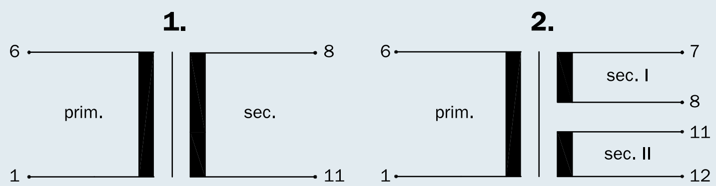
- according to REACH regulation
- according to RoHs regulation

- Output Power up to 15.0 VA
- Non short-circuit-proof at temperature class ta 70 °C/B
- Standard type cast hou sing “K” and “O”
- Excellent temperature fluctuation resistance properties
- High electrical safety and long service-life features
- High voltage resistance
- Self-extinguishing cast housing and sealing material
- Per item tested quality with certificate

Protection extern secondary by:

- Micro fuse according to IEC 127 or
- PTC resistance

Connection scheme (only connected pins are present)



2.) double voltage – bridge: 8 + 11, double current – bridge: 7 + 11/ 8 + 12

Frame size/Core height	Output power ta 70 °C/B	Height (h)	Weight	Packaging unit
BV EI 480 .... /12.5 mm*	7.0 VA	30.2 ± 0.5 mm	0.250 kg	20/16 pieces**
BV EI 481 .... /16.8 mm	10.0 VA	34.6 ± 0.5 mm	0.300 kg	20/16 pieces**
BV EI 482 .... /20.5 mm	12.0 VA	38.5 ± 0.5 mm	0.350 kg	20/16 pieces**
BV EI 483 .... /25.5 mm	15.0 VA	43.5 ± 0.5 mm	0.450 kg	20/16 pieces**

* only type cast housing ‘O‘

** it depends on kind of cast housing

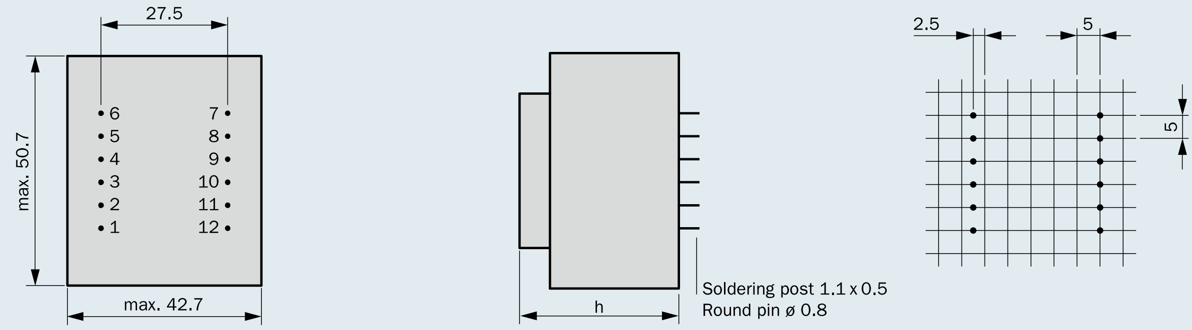
HAHN

Printed-Circuit-Board transformers

Output Power: up to 10.0 VA

EI 48

Connecting pins type cast housing "0"



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

Type cast housing "0"

7.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 480 …. / 12.5 mm

non short-circuit-proof

no load power loss
type. 2.3 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 480 1385	230	1–6	1 x 6	1167	8–11	1 x 7.9	1
BV EI 480 1386	230	1–6	2 x 6	583	7–8/11–12	2 x 7.9	2
BV EI 480 1387	230	1–6	1 x 7.5	933	8–11	1 x 9.8	1
BV EI 480 1388	230	1–6	2 x 7.5	467	7–8/11–12	2 x 9.8	2
BV EI 480 1389	230	1–6	1 x 9	788	8–11	1 x 11.8	1
BV EI 480 1390	230	1–6	2 x 9	388	7–8/11–12	2 x 11.8	2
BV EI 480 1391	230	1–6	1 x 12	583	8–11	1 x 15.8	1
BV EI 480 1392	230	1–6	2 x 12	292	7–8/11–12	2 x 15.8	2
BV EI 480 1393	230	1–6	1 x 15	467	8–11	1 x 19.5	1
BV EI 480 1394	230	1–6	2 x 15	233	7–8/11–12	2 x 19.5	2
BV EI 480 1395	230	1–6	1 x 18	389	8–11	1 x 23.3	1
BV EI 480 1396	230	1–6	2 x 18	195	7–8/11–12	2 x 23.3	2
BV EI 480 1397	230	1–6	1 x 21	333	8–11	1 x 27.5	1
BV EI 480 1398	230	1–6	1 x 24	292	8–11	1 x 31.3	1

Type cast housing "0"

10.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 481 …. / 16.8 mm

non short-circuit-proof

no load power loss
type. 2.0 W

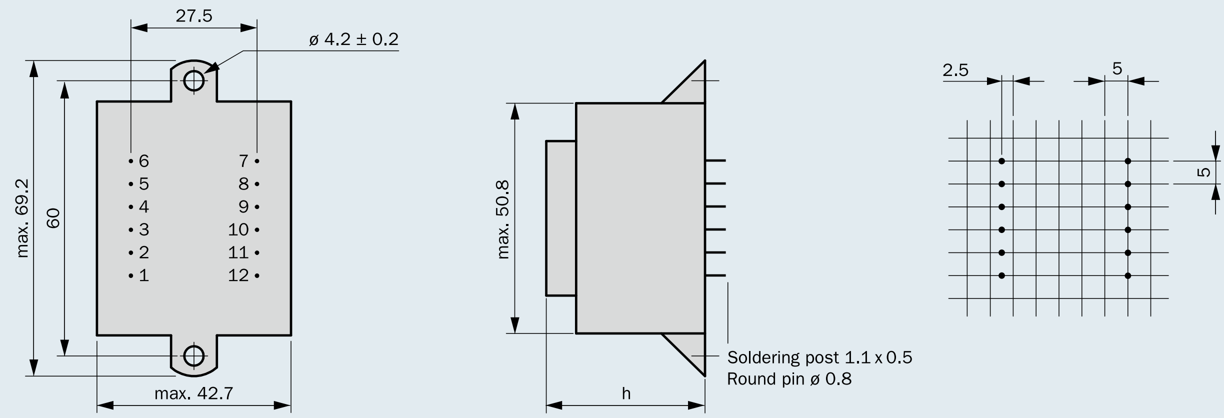
Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 481 1325	230	1–6	1 x 6	1667	8–11	1 x 7.6	1
BV EI 481 1305	230	1–6	2 x 6	833	7–8/11–12	2 x 7.6	2
BV EI 481 1312	230	1–6	1 x 7.5	1333	8–11	1 x 9.8	1
BV EI 481 1326	230	1–6	2 x 7.5	667	7–8/11–12	2 x 9.8	2
BV EI 481 1291	230	1–6	1 x 9	1111	8–11	1 x 11.5	1
BV EI 481 1271	230	1–6	2 x 9	556	7–8/11–12	2 x 11.5	2
BV EI 481 1295	230	1–6	1 x 12	834	8–11	1 x 15.5	1
BV EI 481 1327	230	1–6	2 x 12	417	7–8/11–12	2 x 15.3	2
BV EI 481 1323	230	1–6	1 x 15	667	8–11	1 x 18.6	1
BV EI 481 1324	230	1–6	2 x 15	333	7–8/11–12	2 x 18.6	2
BV EI 481 1307	230	1–6	1 x 18	556	8–11	1 x 22.3	1
BV EI 481 1328	230	1–6	2 x 18	278	7–8/11–12	2 x 22.3	2
BV EI 481 1381	230	1–6	1 x 21	477	8–11	1 x 25.1	1
BV EI 481 1329	230	1–6	1 x 24	417	8–11	1 x 28.7	1

Printed-Circuit-Board transformers

Output Power: up to 12.0 VA

EI 48

Connecting pins type cast housing “K” with 2 fixing straps



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Type cast housing “K”

10.0 VA ta 70 °C/B

Frame size/Core height **BV EI 481 …. / 16.8 mm**

non short-circuit-proof

no load power loss **type. 2.0 W**

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 481 1142	230	1–6	1 x 6	1667	8–11	1 x 7.6	1
BV EI 481 1134	230	1–6	2 x 6	833	7–8/11–12	2 x 7.6	2
BV EI 481 1182	230	1–6	1 x 7.5	1333	8–11	1 x 9.8	1
BV EI 481 1188	230	1–6	2 x 7.5	667	7–8/11–12	2 x 9.8	2
BV EI 481 1167	230	1–6	1 x 9	1111	8–11	1 x 11.5	1
BV EI 481 1118	230	1–6	2 x 9	556	7–8/11–12	2 x 11.5	2
BV EI 481 1172	230	1–6	1 x 12	834	8–11	1 x 15.5	1
BV EI 481 1119	230	1–6	2 x 12	417	7–8/11–12	2 x 15.3	2
BV EI 481 1184	230	1–6	1 x 15	667	8–11	1 x 18.6	1
BV EI 481 1120	230	1–6	2 x 15	333	7–8/11–12	2 x 18.6	2
BV EI 481 1185	230	1–6	1 x 18	556	8–11	1 x 22.3	1
BV EI 481 1192	230	1–6	2 x 18	278	7–8/11–12	2 x 22.3	2
BV EI 481 1273	230	1–6	1 x 21	477	8–11	1 x 25.1	1
BV EI 481 1186	230	1–6	1 x 24	417	8–11	1 x 28.7	1

Type cast housing “K”

12.0 VA ta 70 °C/B

Frame size/Core height **BV EI 482 …. / 20.5 mm**

non short-circuit-proof

no load power loss **type. 1.8 W**

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 482 1231	230	1–6	1 x 6	2000	8–11	1 x 8.3	1
BV EI 482 1232	230	1–6	2 x 6	1000	7–8/11–12	2 x 8.3	2
BV EI 482 1233	230	1–6	1 x 7.5	1600	8–11	1 x 10.6	1
BV EI 482 1236	230	1–6	2 x 7.5	800	7–8/11–12	2 x 10.6	2
BV EI 482 1237	230	1–6	1 x 9	1333	8–11	1 x 12.4	1
BV EI 482 1238	230	1–6	2 x 9	667	7–8/11–12	2 x 12.4	2
BV EI 482 1239	230	1–6	1 x 12	1000	8–11	1 x 16.3	1
BV EI 482 1240	230	1–6	2 x 12	500	7–8/11–12	2 x 16.3	2
BV EI 482 1241	230	1–6	1 x 15	800	8–11	1 x 19.9	1
BV EI 482 1242	230	1–6	2 x 15	400	7–8/11–12	2 x 19.9	2
BV EI 482 1243	230	1–6	1 x 18	667	8–11	1 x 23.5	1
BV EI 482 1234	230	1–6	2 x 18	333	7–8/11–12	2 x 23.5	2
BV EI 482 1382	230	1–6	1 x 21	572	8–11	1 x 26.1	1
BV EI 482 1244	230	1–6	1 x 24	500	8–11	1 x 30.3	1

Printed-Circuit-Board transformers

Output Power: up to 15.0 VA

Type cast housing "K"

15.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 483..../
25.5 mm

non short-circuit-proof

no load power loss
type. 2.5 W

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 483 1260	230	1–6	1 x 6	2500	8–11	1 x 7.8	1
BV EI 483 1257	230	1–6	2 x 6	1250	7–8/11–12	2 x 7.8	2
BV EI 483 1258	230	1–6	1 x 7.5	2000	8–11	1 x 9.5	1
BV EI 483 1245	230	1–6	2 x 7.5	1000	7–8/11–12	2 x 9.5	2
BV EI 483 1246	230	1–6	1 x 9	1667	8–11	1 x 12.0	1
BV EI 483 1247	230	1–6	2 x 9	833	7–8/11–12	2 x 12.0	2
BV EI 483 1248	230	1–6	1 x 12	1250	8–11	1 x 15.9	1
BV EI 483 1249	230	1–6	2 x 12	625	7–8/11–12	2 x 15.9	2
BV EI 483 1250	230	1–6	1 x 15	1000	8–11	1 x 19.1	1
BV EI 483 1251	230	1–6	2 x 15	500	7–8/11–12	2 x 19.1	2
BV EI 483 1252	230	1–6	1 x 18	833	8–11	1 x 22.8	1
BV EI 483 1259	230	1–6	2 x 18	417	7–8/11–12	2 x 22.8	2
BV EI 483 1302	230	1–6	1 x 21	714	8–11	1 x 26.0	1
BV EI 483 1253	230	1–6	1 x 24	625	8–11	1 x 30.6	1

Printed-Circuit-Board transformers

Output Power: 7.0 VA – 15.0 VA

EI 48

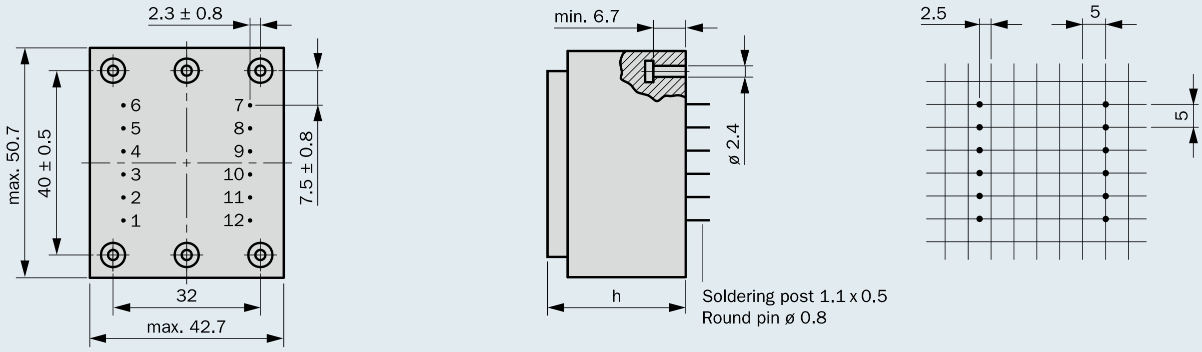
ENEC 10, VDE	**DIN EN 61558-2-6**	**VDE**	on request
VDE-Mark for Glow-Wire-Test	**DIN EN 60 335-1**	**VDE**	102961/84814
UR	**UL 5085-3**	**UL**	on request
UR	**UL 5085-1**	**UL**	on request
CSA	**C22.2**	**CSA**	on request

- according to REACH regulation
- according to RoHs regulation

Individual version!

Parallel to the cataloged EI 48 series transformers, HAHN also produces other variants, e.g. with integrated thermo fuse or thermo switch, other housing-, fixing- and connective options as well as non-encapsulated transformers.

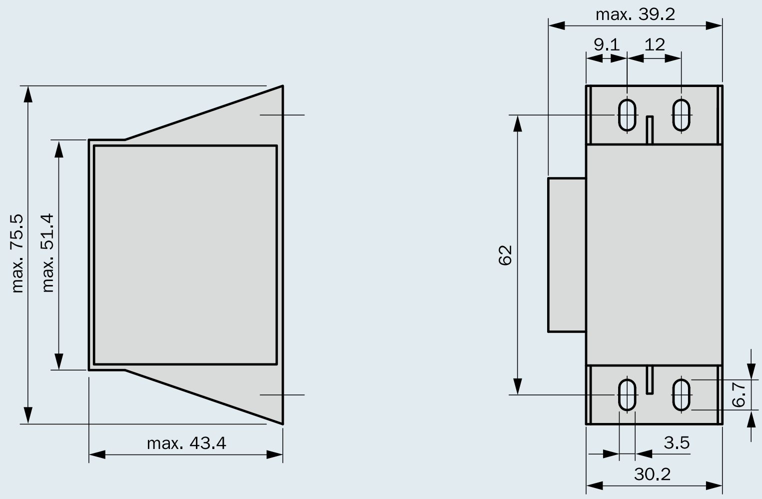
Type cast housing "0" with fixing band



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Type cast housing "SV" for upright mounting



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Printed-Circuit-Board transformers

Output Power: 12.0 VA – 22.0 VA

EI 54

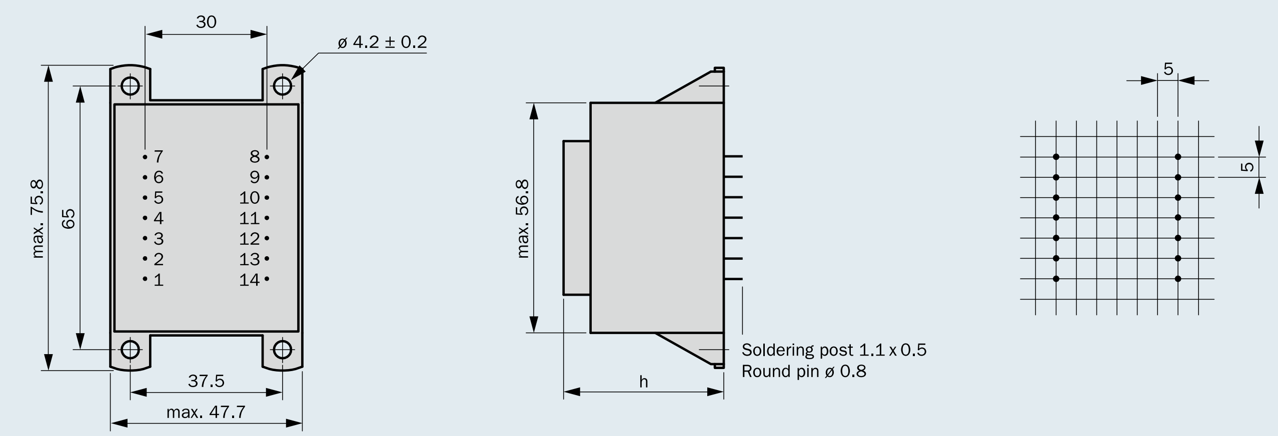
	DIN EN 61558-2-6	**VDE**	108267
VDE-Mark for Glow-Wire-Test	**DIN EN 60 335-1**	**VDE**	102961/84814
	UL 5085-3	**UL**	on request
	UL 5085-1	**UL**	E98173
	C22.2	**CSA**	on request

- according to REACH regulation
- according to RoHs regulation

- Output Power up to 22.0 VA
- Non short-circuit-proof at temperature class ta 70 °C/B
- Standard type cast housing "KK"
- Excellent temperature fluctuation resistance properties
- High electrical safety and long service-life features
- High voltage resistance
- Self-extinguishing cast housing and sealing material
- Per item tested quality with certificate

Protection extern secondary by:
- Micro fuse according to IEC 127 or
- PTC resistance

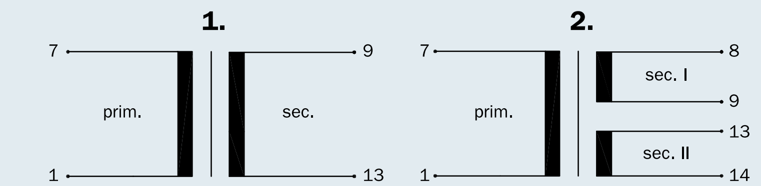
Type cast housing "KK" with 4 fixing straps



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme (only connected pins are present)



2.) double voltage – bridge: 9 + 13, double current – bridge: 8 + 13/ 9 + 14

Frame size/Core height	Output Power ta 70 °C/B	Height (h)	Weight	Packaging unit
BV EI 540 .... /14.0 mm*	12.0 VA	35.0 ± 0.5 mm	0.350 kg	14 pieces
BV EI 541 .... /18.8 mm	16.0 VA	38.8 ± 0.5 mm	0.400 kg	14 pieces
BV EI 542 .... /23.0 mm	20.0 VA	43.2 ± 0.5 mm	0.500 kg	14 pieces
BV EI 543 .... /25.5 mm	22.0 VA	47.4 ± 0.5 mm	0.550 kg	14 pieces

* only type cast housing '0'

HAHN

Printed-Circuit-Board transformers

Output Power: up to 20.0 VA

EI 54

12.0 VA ta 70 °C/B

Frame size/Core height
BV EI 540 .... / 14.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 540 1137	230	1–7	1 x 6	2000	9–13	1 x 8.1	1
BV EI 540 1138	230	1–7	2 x 6	1000	8–9/13–14	2 x 8.1	2
BV EI 540 1139	230	1–7	1 x 7.5	1600	9–13	1 x 9.9	1
BV EI 540 1140	230	1–7	2 x 7.5	800	8–9/13–14	2 x 9.9	2
BV EI 540 1141	230	1–7	1 x 9	1333	9–13	1 x 12.2	1
BV EI 540 1142	230	1–7	2 x 9	667	8–9/13–14	2 x 12.2	2
BV EI 540 1143	230	1–7	1 x 12	1000	9–13	1 x 15.8	1
BV EI 540 1144	230	1–7	2 x 12	500	8–9/13–14	2 x 15.8	2
BV EI 540 1145	230	1–7	1 x 15	800	9–13	1 x 19.4	1
BV EI 540 1146	230	1–7	2 x 15	400	8–9/13–14	2 x 19.4	2
BV EI 540 1147	230	1–7	1 x 18	667	9–13	1 x 23.5	1
BV EI 540 1148	230	1–7	2 x 18	334	8–9/13–14	2 x 23.5	2
BV EI 540 1149	230	1–7	1 x 24	500	9–13	1 x 30.6	1

16.0 VA ta 70 °C/B

Frame size/Core height
BV EI 541 .... / 18.8 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 541 1121	230	1–7	1 x 6	2667	9–13	1 x 7.9	1
BV EI 541 1128	230	1–7	2 x 6	1334	8–9/13–14	2 x 7.9	2
BV EI 541 1122	230	1–7	1 x 7.5	2134	9–13	1 x 9.7	1
BV EI 541 1129	230	1–7	2 x 7.5	1067	8–9/13–14	2 x 9.7	2
BV EI 541 1123	230	1–7	1 x 9	1778	9–13	1 x 11.7	1
BV EI 541 1130	230	1–7	2 x 9	889	8–9/13–14	2 x 11.7	2
BV EI 541 1124	230	1–7	1 x 12	1333	9–13	1 x 15.2	1
BV EI 541 1131	230	1–7	2 x 12	667	8–9/13–14	2 x 15.2	2
BV EI 541 1125	230	1–7	1 x 15	1067	9–13	1 x 19.1	1
BV EI 541 1132	230	1–7	2 x 15	534	8–9/13–14	2 x 19.1	2
BV EI 541 1126	230	1–7	1 x 18	889	9–13	1 x 22.3	1
BV EI 541 1150	230	1–7	2 x 18	445	8–9/13–14	2 x 22.3	2
BV EI 541 1110	230	1–7	1 x 24	667	9–13	1 x 29.1	1

20.0 VA ta 70 °C/B

Frame size/Core height
BV EI 542 .... / 23.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 542 1151	230	1–7	1 x 6	3334	9–13	1 x 7.7	1
BV EI 542 1152	230	1–7	2 x 6	1667	8 – 9/13 – 14	2 x 7.7	2
BV EI 542 1153	230	1–7	1 x 7.5	2667	9–13	1 x 9.5	1
BV EI 542 1154	230	1–7	2 x 7.5	1334	8 – 9/13 – 14	2 x 9.5	2
BV EI 542 1155	230	1–7	1 x 9	2223	9–13	1 x 11.4	1
BV EI 542 1156	230	1–7	2 x 9	1112	8–9/13–14	2 x 11.4	2
BV EI 542 1157	230	1–7	1 x 12	1667	9–13	1 x 15.0	1
BV EI 542 1158	230	1–7	2 x 12	834	8–9/13–14	2 x 15.0	2
BV EI 542 1159	230	1–7	1 x 15	1334	9–13	1 x 18.6	1
BV EI 542 1160	230	1–7	2 x 15	667	8–9/13–14	2 x 18.6	2
BV EI 542 1161	230	1–7	1 x 18	1112	9–13	1 x 21.8	1
BV EI 542 1162	230	1–7	2 x 18	556	8–9/13–14	2 x 21.8	2
BV EI 542 1163	230	1–7	1 x 24	834	9–13	1 x 29.5	1

Printed-Circuit-Board transformers

Output Power: up to 22.0 VA

EI 54

22.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 543 …. /
25.5 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 543 1166	230	1–7	1 x 6	3667	9–13	1 x 7.4	1
BV EI 543 1167	230	1–7	2 x 6	1834	8–9/13–14	2 x 7.4	2
BV EI 543 1168	230	1–7	1 x 7.5	2934	9–13	1 x 8.9	1
BV EI 543 1169	230	1–7	2 x 7.5	1467	8–9/13–14	2 x 8.9	2
BV EI 543 1170	230	1–7	1 x 9	2445	9–13	1 x 10.7	1
BV EI 543 1171	230	1–7	2 x 9	1223	8–9/13–14	2 x 10.7	2
BV EI 543 1172	230	1–7	1 x 12	1834	9–13	1 x 14.5	1
BV EI 543 1173	230	1–7	2 x 12	917	8–9/13–14	2 x 14.5	2
BV EI 543 1174	230	1–7	1 x 15	1467	9–13	1 x 17.9	1
BV EI 543 1175	230	1–7	2 x 15	734	8–9/13–14	2 x 17.9	2
BV EI 543 1176	230	1–7	1 x 18	1223	9–13	1 x 21.0	1
BV EI 543 1177	230	1–7	2 x 18	612	8–9/13–14	2 x 21.0	2
BV EI 543 1178	230	1–7	1 x 24	917	9–13	1 x 28.0	1

Printed-Circuit-Board transformers

Output Power: 12.0 VA – 22.0 VA

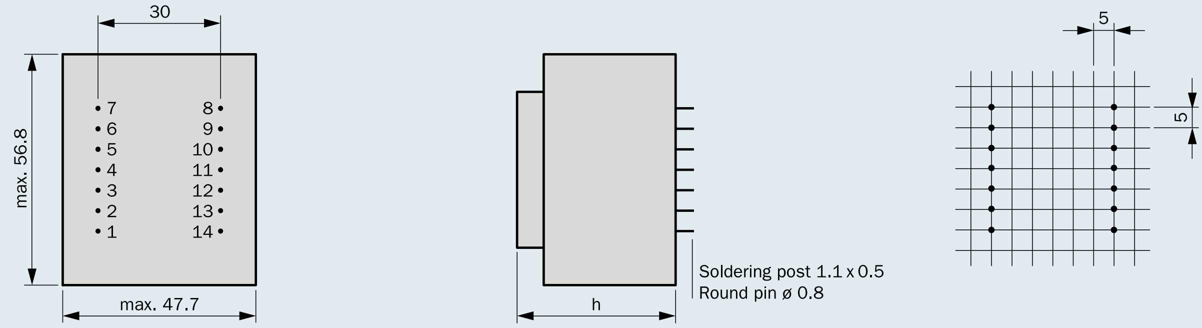
10	DIN EN 61558-2-6	VDE	on request
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	on request
	UL 5085-3	UL	on request
	UL 5085-1	UL	on request
	C22.2	CSA	on request

- according to REACH regulation
- according to RoHs regulation

Individual version!

Parallel to the cataloged EI 54 series transformers, HAHN also produces other variants, e.g. with integrated thermo fuse or thermo switch, other housing-, fixing- and connective options as well as non-encapsulated transformers.

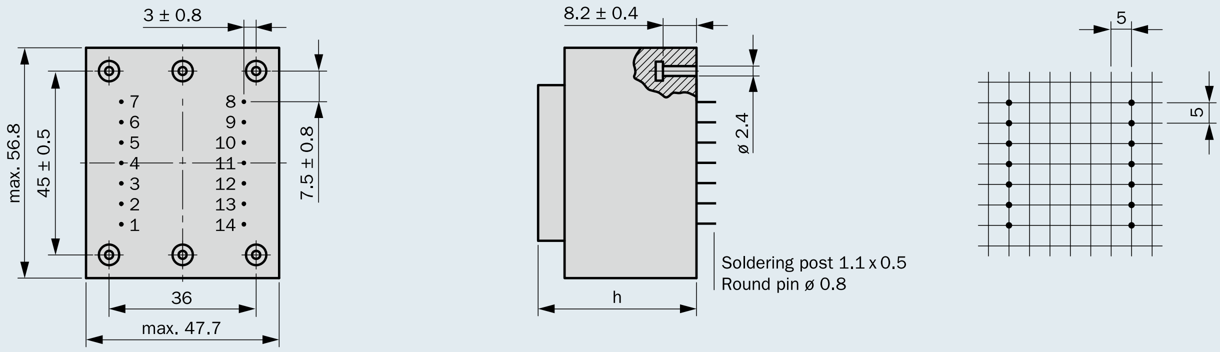
Type cast housing "0"



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

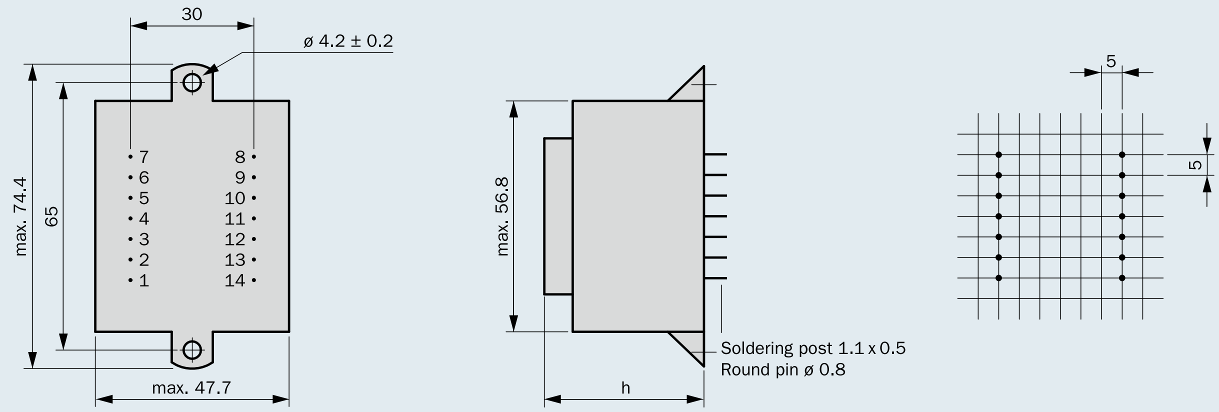
Type cast housing "0" with fixing band



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

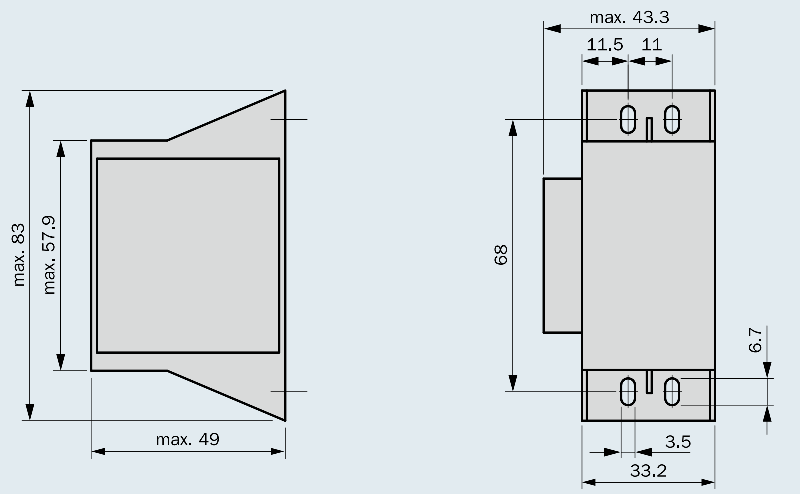
Type cast housing "K" with 2 fixing straps



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

Type cast housing "SV" for upright mounting



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

Printed-Circuit-Board transformers

Output Power: 17.0 VA – 35.0 VA

EI 60

10	**DIN EN 61558-2-6**	**VDE**	110044
VDE-Mark for Glow-Wire-Test	**DIN EN 60 335-1**	**VDE**	102961/84814
	UL 5085-3	**UL**	on request
	UL 5085-1	**UL**	E98173
	C22.2	**CSA**	on request

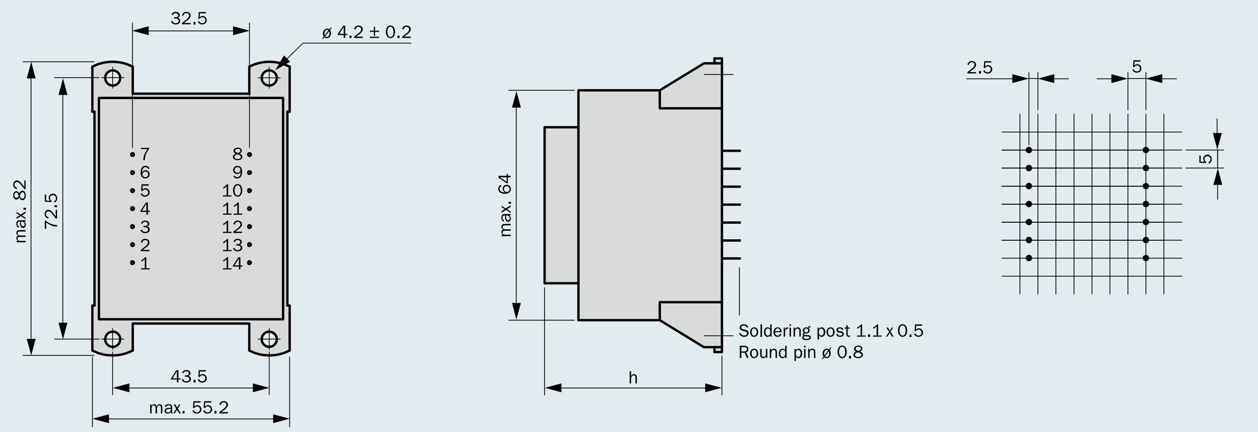
- according to REACH regulation
- according to RoHs regulation

- Output Power up to 35.0 VA
- Non short-circuit-proof at temperature class ta 70 °C/B
- Standard type cast housing “KK”
- Excellent temperature fluctuation resistance properties
- High electrical safety and long service-life features
- High voltage resistance
- Self-extinguishing cast housing and sealing material
- Per item tested quality with certificate

Protection extern secondary by:

- Micro fuse according to IEC 127 or
- PTC resistance

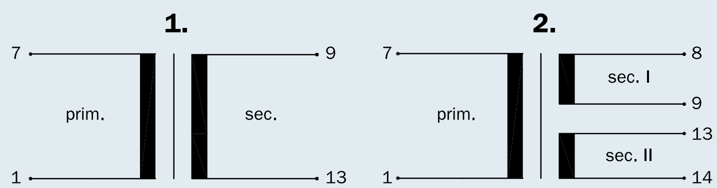
Connecting pins type cast housing “KK” with 4 fixing straps



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

Connection scheme (only connected pins are present)



2.) double voltage – bridge: 9 + 13, double current – bridge: 8 + 13/ 9 + 14

Frame size/Core height	Output Power ta 70 °C/B	Height (h)	Weight	Packaging unit
BV EI 600 .... /16.0 mm*	17.0 VA	40.5 ± 0.5 mm	0.450 kg	10 pieces
BV EI 601 .... /21.0 mm	20.0 VA	44.7 ± 0.5 mm	0.600 kg	10 pieces
BV EI 602 .... /25.5 mm	28.0 VA	49.2 ± 0.5 mm	0.700 kg	10 pieces
BV EI 603 .... /30.5 mm	30.0 VA	54.2 ± 0.5 mm	0.800 kg	10 pieces
BV EI 604 .... /35.0 mm	35.0 VA	57.3 ± 0.5 mm	0.900 kg	10 pieces

* only type cast housing ‘0‘

Printed-Circuit-Board transformers

Output Power: up to 28.0 VA

17.0 VA ta 70 °C/B

Frame size/Core height
BV EI 600 …. / 16.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 600 1050	230	1–7	1 x 6	2834	9–13	1 x 7.4	1
BV EI 600 1051	230	1–7	2 x 6	1417	8–9/13–14	2 x 7.4	2
BV EI 600 1052	230	1–7	1 x 7.5	2267	9–13	1 x 9.3	1
BV EI 600 1053	230	1–7	2 x 7.5	1134	8–9/13–14	2 x 9.3	2
BV EI 600 1054	230	1–7	1 x 9	1889	9–13	1 x 11.1	1
BV EI 600 1055	230	1–7	2 x 9	945	8–9/13–14	2 x 11.1	2
BV EI 600 1056	230	1–7	1 x 12	1417	9–13	1 x 15.2	1
BV EI 600 1057	230	1–7	2 x 12	708	8–9/13–14	2 x 15.2	2
BV EI 600 1058	230	1–7	1 x 15	1134	9–13	1 x 18.2	1
BV EI 600 1065	230	1–7	2 x 15	567	8–9/13–14	2 x 18.7	2
BV EI 600 1072	230	1–7	1 x 18	944	9–13	1 x 21.9	1
BV EI 600 1061	230	1–7	2 x 18	472	8–9/13–14	2 x 21.9	2
BV EI 600 1062	230	1–7	1 x 24	708	9–13	1 x 28.9	1

20.0 VA ta 70 °C/B

Frame size/Core height
BV EI 601 …. / 21.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 601 1069	230	1–7	1 x 6	3334	9–13	1 x 7.0	1
BV EI 601 1070	230	1–7	2 x 6	1667	8–9/13–14	2 x 7.0	2
BV EI 601 1071	230	1–7	1 x 7.5	2667	9–13	1 x 8.8	1
BV EI 601 1059	230	1–7	2 x 7.5	1334	8–9/13–14	2 x 8.8	2
BV EI 601 1060	230	1–7	1 x 9	2223	9–13	1 x 10.5	1
BV EI 601 1042	230	1–7	2 x 9	1111	8–9/13–14	2 x 10.5	2
BV EI 601 1046	230	1–7	1 x 12	1667	9–13	1 x 14.2	1
BV EI 601 1043	230	1–7	2 x 12	834	8–9/13–14	2 x 14.2	2
BV EI 601 1064	230	1–7	1 x 15	1334	9–13	1 x 17.0	1
BV EI 601 1044	230	1–7	2 x 15	667	8–9/13–14	2 x 17.0	2
BV EI 601 1066	230	1–7	1 x 18	1111	9–13	1 x 20.5	1
BV EI 601 1068	230	1–7	2 x 18	556	8–9/13–14	2 x 20.5	2
BV EI 601 1067	230	1–7	1 x 24	834	9–13	1 x 27.6	1

28.0 VA ta 70 °C/B

Frame size/Core height
BV EI 602 …. / 25.5 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 602 1011	230	1–7	1 x 6	4667	9–13	1 x 7.1	1
BV EI 602 1018	230	1–7	2 x 6	2334	8–9/13–14	2 x 7.1	2
BV EI 602 1012	230	1–7	1 x 7.5	3734	9–13	1 x 8.8	1
BV EI 602 1019	230	1–7	2 x 7.5	1867	8–9/13–14	2 x 8.8	2
BV EI 602 1013	230	1–7	1 x 9	3111	9–13	1 x 10.6	1
BV EI 602 1020	230	1–7	2 x 9	1556	8–9/13–14	2 x 10.6	2
BV EI 602 1014	230	1–7	1 x 12	2334	9–13	1 x 14.4	1
BV EI 602 1021	230	1–7	2 x 12	1167	8–9/13–14	2 x 14.4	2
BV EI 602 1015	230	1–7	1 x 15	1867	9–13	1 x 17.8	1
BV EI 602 1022	230	1–7	2 x 15	934	8–9/13–14	2 x 17.8	2
BV EI 602 1016	230	1–7	1 x 18	1556	9–13	1 x 20.5	1
BV EI 602 1076	230	1–7	2 x 18	778	8–9/13–14	2 x 20.5	2
BV EI 602 1017	230	1–7	1 x 24	1167	9–13	1 x 27.4	1

Printed-Circuit-Board transformers

Output Power: up to 35.0 VA

EI 60

30.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 603 .... / 30.5 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 603 1023	230	1–7	1 x 6	5000	9–13	1 x 7.0	1
BV EI 603 1030	230	1–7	2 x 6	2500	8–9/13–14	2 x 7.0	2
BV EI 603 1024	230	1–7	1 x 7.5	4000	9–13	1 x 8.7	1
BV EI 603 1031	230	1–7	2 x 7.5	2000	8–9/13–14	2 x 8.7	2
BV EI 603 1025	230	1–7	1 x 9	3334	9–13	1 x 10.2	1
BV EI 603 1032	230	1–7	2 x 9	1667	8–9/13–14	2 x 10.2	2
BV EI 603 1026	230	1–7	1 x 12	2500	9–13	1 x 13.7	1
BV EI 603 1034	230	1–7	2 x 12	1250	8–9/13–14	2 x 13.7	2
BV EI 603 1027	230	1–7	1 x 15	2000	9–13	1 x 16.8	1
BV EI 603 1035	230	1–7	2 x 15	1000	8–9/13–14	2 x 16.8	2
BV EI 603 1028	230	1–7	1 x 18	1667	9–13	1 x 20.3	1
BV EI 603 1080	230	1–7	2 x 18	834	8–9/13–14	2 x 20.3	2
BV EI 603 1029	230	1–7	1 x 24	1250	9–13	1 x 27.0	1

35.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 604 .... / 35.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 604 1082	230	1–7	1 x 6	5834	9–13	1 x 7.0	1
BV EI 604 1083	230	1–7	2 x 6	2917	8–9/13–14	2 x 7.0	2
BV EI 604 1084	230	1–7	1 x 7.5	4667	9–13	1 x 8.7	1
BV EI 604 1085	230	1–7	2 x 7.5	2334	8–9/13–14	2 x 8.7	2
BV EI 604 1086	230	1–7	1 x 9	3889	9–13	1 x 10.3	1
BV EI 604 1087	230	1–7	2 x 9	1994	8–9/13–14	2 x 10.3	2
BV EI 604 1088	230	1–7	1 x 12	2917	9–13	1 x 13.9	1
BV EI 604 1089	230	1–7	2 x 12	1458	8–9/13–14	2 x 13.9	2
BV EI 604 1090	230	1–7	1 x 15	2334	9–13	1 x 17.1	1
BV EI 604 1091	230	1–7	2 x 15	1167	8–9/13–14	2 x 17.1	2
BV EI 604 1092	230	1–7	1 x 18	1994	9–13	1 x 20.3	1
BV EI 604 1093	230	1–7	2 x 18	972	8–9/13–14	2 x 20.3	2
BV EI 604 1094	230	1–7	1 x 24	1458	9–13	1 x 26.9	1

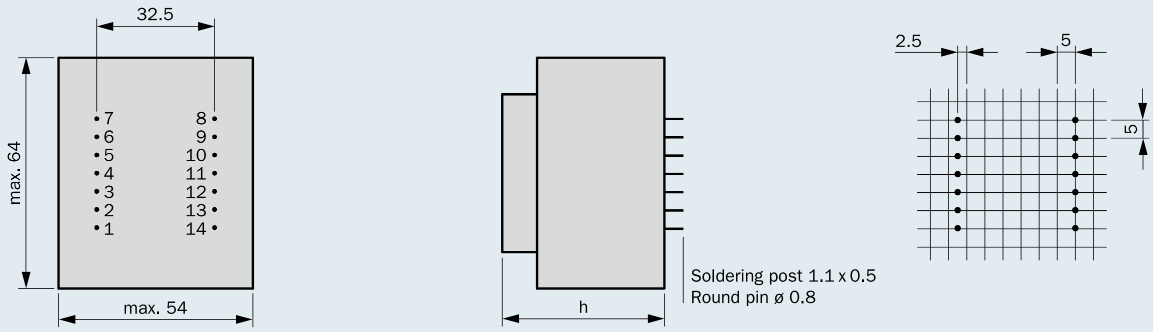
VDE 10	DIN EN 61558-2-6	VDE	on request
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	on request
UR	UL 5085-3	UL	on request
UR	UL 5085-1	UL	on request
SP	C22.2	CSA	on request

- according to REACH regulation
- according to RoHs regulation

Individual version!

Parallel to the cataloged EI 60 series transformers, HAHN also produces other variants, e.g. with integrated thermo fuse or thermo switch, other housing-, fixing- and connective options as well as non-encapsulated transformers.

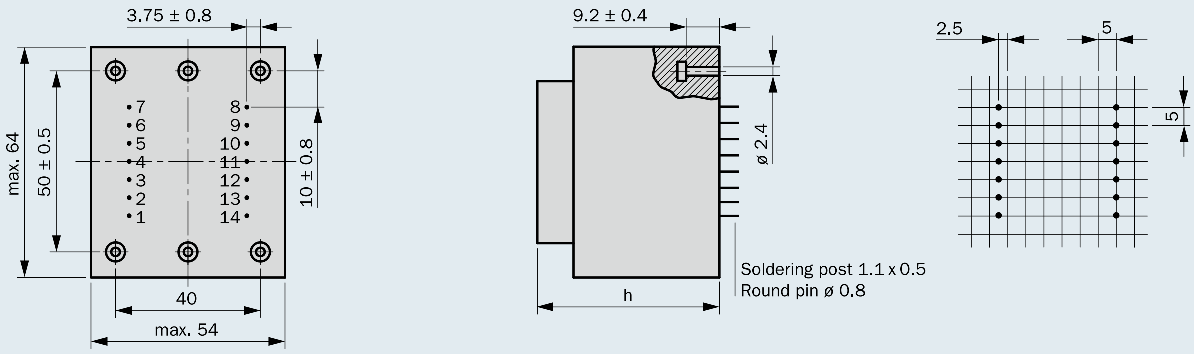
Type cast housing "0"



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

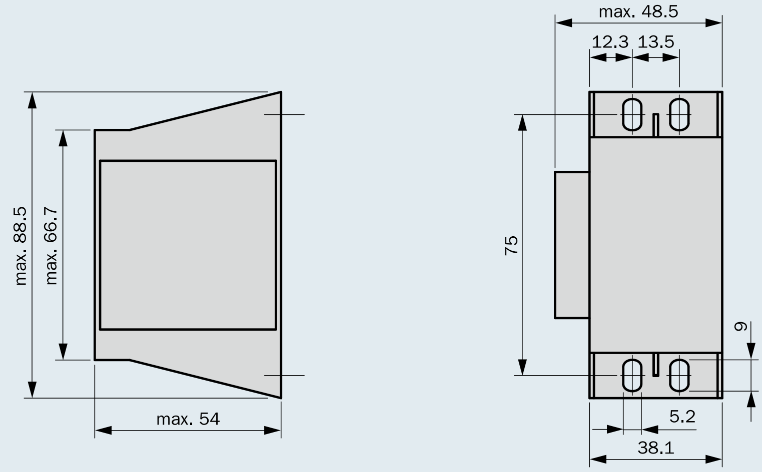
Type cast housing "0" with fixing band



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Type cast housing "SV" with fixing band



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

Printed-Circuit-Board transformers

Output Power: 17.0 VA – 50.0 VA

EI 66

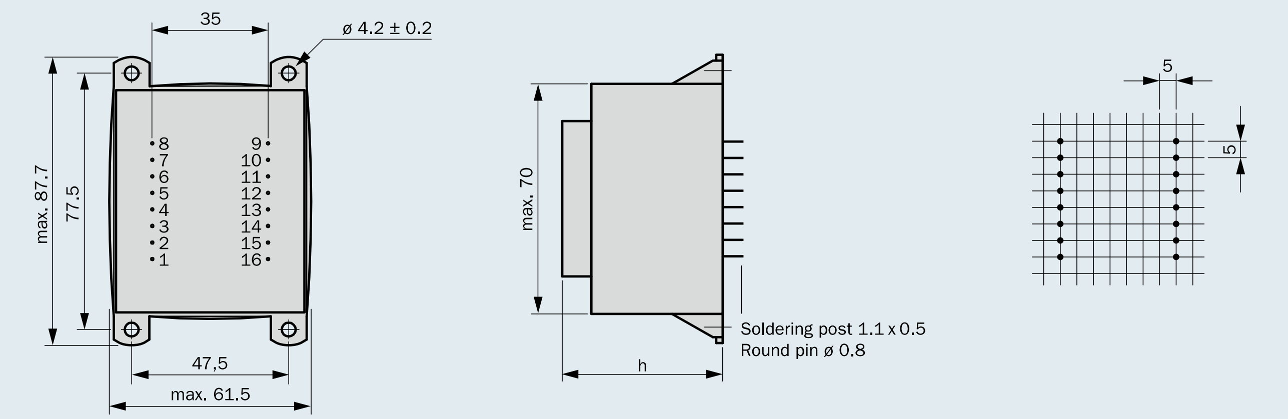
10	DIN EN 61558-2-6	VDE	108268
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	102961/84814
	UL 5085-3	UL	on request
	UL 5085-1	UL	on request
	C22.2	CSA	1486889

- according to REACH regulation
- according to RoHs regulation

- Output Power up to 50.0 VA
- Non short-circuit-proof at temperature class ta 70 °C/B
- Standard type cast housing “KK”
- Excellent temperature fluctuation resistance properties
- High electrical safety and long service-life features
- High voltage resistance
- Self-extinguishing cast housing and sealing material
- Per item tested quality with certificate

Protection extern secondary by:
- Micro fuse according to IEC 127 or
- PTC resistance

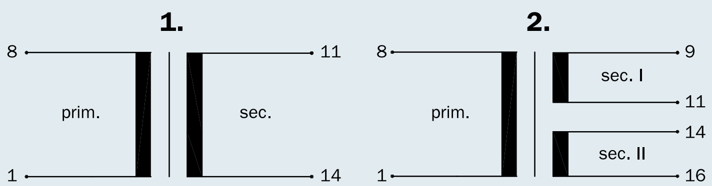
Connecting pins type cast housing “KK” with 4 fixing straps



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme (present only connected pins)



2.) double voltage – bridge: 11 + 14, double current – bridge: 9 + 14/ 11 + 16

Frame size/Core height	Output Power ta 70 °C/B	Height (h)	Weight	Packaging unit
BV EI 660 .... /12.0 mm	17.0 VA	38.5 ± 0.5 mm	0.500 kg	9 pieces
BV EI 661 .... /18.0 mm	25.0 VA	44.5 ± 0.5 mm	0.700 kg	9 pieces
BV EI 662 .... /23.0 mm	33.0 VA	48.5 ± 0.5 mm	0.800 kg	9 pieces
BV EI 663 .... /30.0 mm	44.0 VA	55.8 ± 0.5 mm	0.950 kg	9 pieces
BV EI 664 .... /34.8 mm	47.0 VA	60.2 ± 0.5 mm	1.000 kg	9 pieces
BV EI 665 .... /40.0 mm	50.0 VA	66.5 ± 0.5 mm	1.200 kg	9 pieces

Printed-Circuit-Board transformers

Output Power: up to 33.0 VA

EI 66

17.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 660 …. /
12.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 660 1060	230	1–8	1 x 6	2833	11–14	1 x 7.4	1
BV EI 660 1061	230	1–8	2 x 6	1417	9–11/14–16	2 x 7.7	2
BV EI 660 1062	230	1–8	1 x 7.5	2267	11–14	1 x 9.1	1
BV EI 660 1063	230	1–8	2 x 7.5	1133	9–11/14–16	2 x 9.1	2
BV EI 660 1064	230	1–8	1 x 9	1889	11–14	1 x 10.8	1
BV EI 660 1065	230	1–8	2 x 9	944	9–11/14–16	2 x 10.8	2
BV EI 660 1066	230	1–8	1 x 12	1417	11–14	1 x 14.4	1
BV EI 660 1067	230	1–8	2 x 12	708	9–11/14–16	2 x 14.2	2
BV EI 660 1068	230	1–8	1 x 15	1133	11–14	1 x 18.0	1
BV EI 660 1069	230	1–8	2 x 15	567	9–11/14–16	2 x 17.8	2
BV EI 660 1070	230	1–8	1 x 18	944	11–14	1 x 21.0	1
BV EI 660 1071	230	1–8	2 x 18	472	9–11/14–16	2 x 21.7	2
BV EI 660 1072	230	1–8	1 x 24	708	11–14	1 x 28.0	1

25.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 661 …. /
18.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 661 1073	230	1–8	1 x 6	4167	11–14	1 x 7.3	1
BV EI 661 1074	230	1–8	2 x 6	2083	9–11/14–16	2 x 7.3	2
BV EI 661 1075	230	1–8	1 x 7.5	3333	11–14	1 x 9.0	1
BV EI 661 1076	230	1–8	2 x 7.5	1667	9–11/14–16	2 x 9.0	2
BV EI 661 1077	230	1–8	1 x 9	2778	11–14	1 x 10.9	1
BV EI 661 1078	230	1–8	2 x 9	1389	9–11/14–16	2 x 10.6	2
BV EI 661 1079	230	1–8	1 x 12	2083	11–14	1 x 13.9	1
BV EI 661 1080	230	1–8	2 x 12	1042	9–11/14–16	2 x 13.9	2
BV EI 661 1081	230	1–8	1 x 15	1667	11–14	1 x 17.4	1
BV EI 661 1082	230	1–8	2 x 15	833	9–11/14–16	2 x 17.4	2
BV EI 661 1083	230	1–8	1 x 18	1389	11–14	1 x 20.9	1
BV EI 661 1084	230	1–8	2 x 18	694	9–11/14–16	2 x 20.5	2
BV EI 661 1085	230	1–8	1 x 24	1042	11–14	1 x 27.9	1

33.0 VA
ta 70 °C/B

Frame size/Core height
BV EI 662 …. /
23.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 662 1086	230	1–8	1 x 6	5500	11–14	1 x 7.0	1
BV EI 662 1087	230	1–8	2 x 6	2750	9–11/14–16	2 x 7.0	2
BV EI 662 1088	230	1–8	1 x 7.5	4400	11–14	1 x 8.5	1
BV EI 662 1089	230	1–8	2 x 7.5	2200	9–11/14–16	2 x 8.5	2
BV EI 662 1090	230	1–8	1 x 9	3667	11–14	1 x 10.3	1
BV EI 662 1091	230	1–8	2 x 9	1833	9–11/14–16	2 x 10.3	2
BV EI 662 1092	230	1–8	1 x 12	2750	11–14	1 x 14.0	1
BV EI 662 1093	230	1–8	2 x 12	1375	9–11/14–16	2 x 14.0	2
BV EI 662 1094	230	1–8	1 x 15	2200	11–14	1 x 16.9	1
BV EI 662 1095	230	1–8	2 x 15	1100	9–11/14–16	2 x 16.9	2
BV EI 662 1096	230	1–8	1 x 18	1833	11–14	1 x 20.1	1
BV EI 662 1097	230	1–8	2 x 18	917	9–11/14–16	2 x 20.1	2
BV EI 662 1098	230	1–8	1 x 24	1375	11–14	1 x 26.8	1

Printed-Circuit-Board transformers

Output Power: up to 50.0 VA

EI 66

44.0 VA ta 70 °C/B

Frame size/Core height
BV EI 663 …. / 30.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 663 1099	230	1–8	1 x 6	7333	11–14	1 x 6.8	1
BV EI 663 1100	230	1–8	2 x 6	3667	9–11/14–16	2 x 6.8	2
BV EI 663 1101	230	1–8	1 x 7.5	5867	11–14	1 x 8.8	1
BV EI 663 1102	230	1–8	2 x 7.5	2933	9–11/14–16	2 x 8.6	2
BV EI 663 1103	230	1–8	1 x 9	4889	11–14	1 x 10.5	1
BV EI 663 1104	230	1–8	2 x 9	2444	9–11/14–16	2 x 10.3	2
BV EI 663 1105	230	1–8	1 x 12	3667	11–14	1 x 13.7	1
BV EI 663 1106	230	1–8	2 x 12	1833	9–11/14–16	2 x 13.7	2
BV EI 663 1107	230	1–8	1 x 15	2933	11–14	1 x 17.2	1
BV EI 663 1108	230	1–8	2 x 15	1467	9–11/14–16	2 x 17.2	2
BV EI 663 1109	230	1–8	1 x 18	2444	11–14	1 x 20.2	1
BV EI 663 1110	230	1–8	2 x 18	1222	9–11/14–16	2 x 20.2	2
BV EI 663 1111	230	1–8	1 x 24	1833	11–14	1 x 26.9	1

47.0 VA ta 70 °C/B

Frame size/Core height
BV EI 664 …. / 34.8 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 664 1112	230	1–8	1 x 6	7833	11–14	1 x 7.3	1
BV EI 664 1113	230	1–8	2 x 6	3917	9–11/14–16	2 x 7.1	2
BV EI 664 1114	230	1–8	1 x 7.5	6267	11–14	1 x 8.6	1
BV EI 664 1115	230	1–8	2 x 7.5	3133	9–11/14–16	2 x 8.6	2
BV EI 664 1116	230	1–8	1 x 9	5222	11–14	1 x 10.1	1
BV EI 664 1117	230	1–8	2 x 9	2611	9–11/14–16	2 x 10.1	2
BV EI 664 1118	230	1–8	1 x 12	3917	11–14	1 x 13.4	1
BV EI 664 1119	230	1–8	2 x 12	1960	9–11/14–16	2 x 13.4	2
BV EI 664 1120	230	1–8	1 x 15	3133	11–14	1 x 16.4	1
BV EI 664 1121	230	1–8	2 x 15	1570	9–11/14–16	2 x 16.4	2
BV EI 664 1122	230	1–8	1 x 18	2610	11–14	1 x 19.7	1
BV EI 664 1123	230	1–8	2 x 18	1306	9–11/14–16	2 x 19.7	2
BV EI 664 1124	230	1–8	1 x 24	1958	11–14	1 x 26.3	1

50.0 VA ta 70 °C/B

Frame size/Core height
BV EI 665 …. / 40.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV EI 665 1125	230	1–8	1 x 6	8333	11–14	1 x 6.9	1
BV EI 665 1126	230	1–8	2 x 6	4167	9–11/14–16	2 x 6.7	2
BV EI 665 1127	230	1–8	1 x 7.5	6667	11–14	1 x 8.5	1
BV EI 665 1128	230	1–8	2 x 7.5	3333	9–11/14–16	2 x 8.5	2
BV EI 665 1129	230	1–8	1 x 9	5556	11–14	1 x 10.0	1
BV EI 665 1130	230	1–8	2 x 9	2778	9–11/14–16	2 x 10.0	2
BV EI 665 1131	230	1–8	1 x 12	4167	11–14	1 x 13.0	1
BV EI 665 1132	230	1–8	2 x 12	2083	9–11/14–16	2 x 13.0	2
BV EI 665 1133	230	1–8	1 x 15	3333	11–14	1 x 16.4	1
BV EI 665 1134	230	1–8	2 x 15	1667	9–11/14–16	2 x 16.4	2
BV EI 665 1135	230	1–8	1 x 18	2778	11–14	1 x 19.7	1
BV EI 665 1136	230	1–8	2 x 18	1388	9–11/14–16	2 x 19.7	2
BV EI 665 1137	230	1–8	1 x 24	2083	11–14	1 x 26.1	1

Printed-Circuit-Board transformers

Output Power: 17.0 VA – 50.0 VA

EI 66

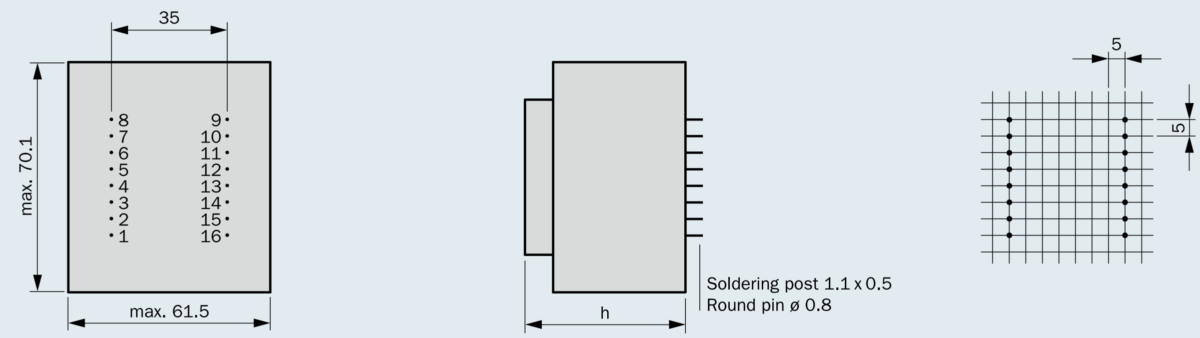
10	DIN EN 61558-2-6	VDE	on request
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	on request
	UL 5085-3	UL	on request
	UL 5085-1	UL	on request
	C22.2	CSA	on request

- according to REACH regulation
- according to RoHs regulation

Individual version!

Parallel to the cataloged EI 66 series transformers, HAHN also produces other variants, e.g. with integrated thermo fuse or thermo switch, other housing-, fixing- and connective options as well as non-encapsulated transformers.

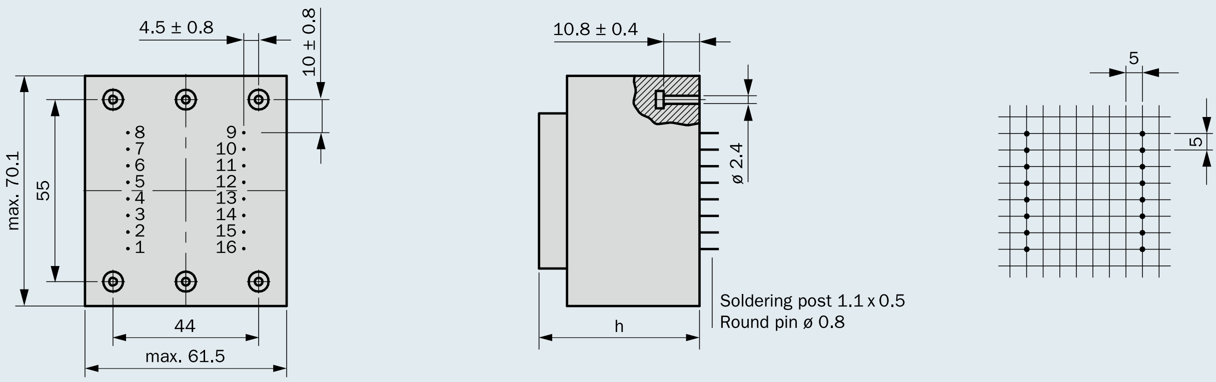
Type cast housing "0"



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Type cast housing "0" with fixing band



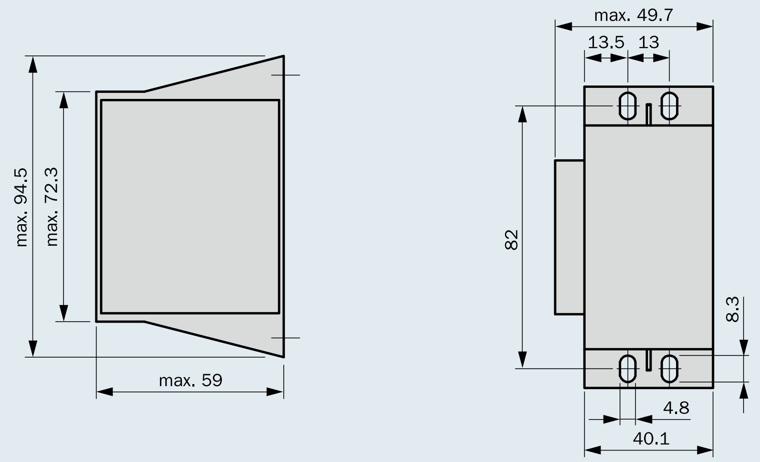
View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Printed-Circuit-Board transformers

Output Power: 17.0 VA – 50.0 VA

Type cast housing "SV" for upright mounting



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

Printed-Circuit-Board transformers

Output Power: 50.0 VA – 70.0 VA

EI 78

	DIN EN 61558-2-6	VDE	on request
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	on request
	UL 5085-3	UL	on request
	UL 5085-1	UL	on request
	C22.2	CSA	on request

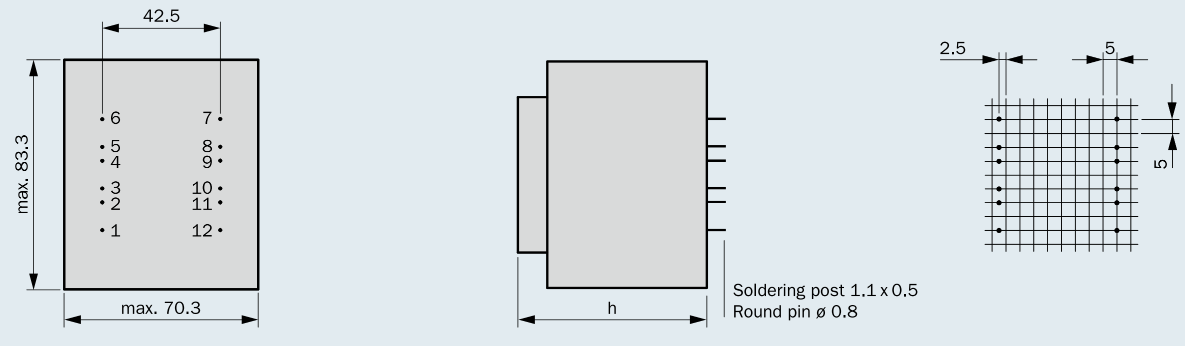
- according to REACH regulation
- according to RoHs regulation

Individual version!

Custom-made models are available on request, e.g. with or without mounting brackets, other heights, pin configurations or connections.

Frame size/Core height	Output Power ta 70 °C/B	Height (h)	Weight
BV EI 781 .... /27.5 mm	50.0 VA	59.0 ± 0.5 mm	1.250 kg
BV EI 782 .... /36.5 mm	60.0 VA	68.0 ± 0.5 mm	1.500 kg
BV EI 783 .... /40.5 mm	70.0 VA	72.0 ± 0.5 mm	1.700 kg

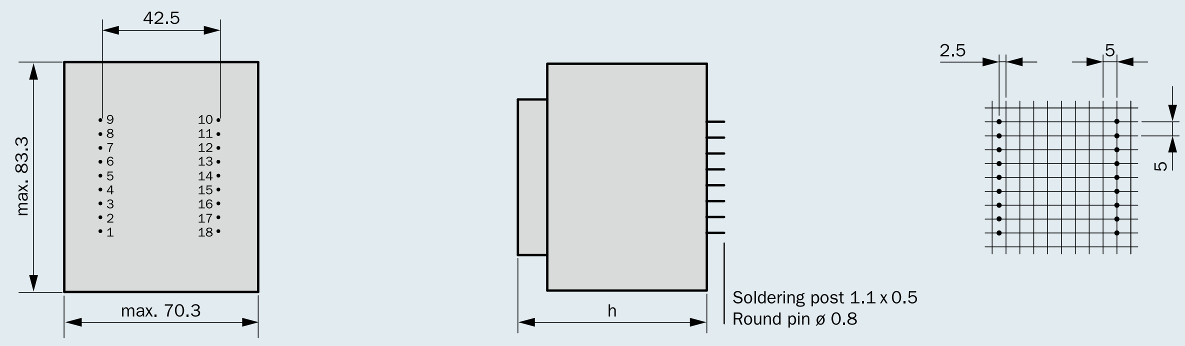
Type cast housing “0” with 12 connection pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

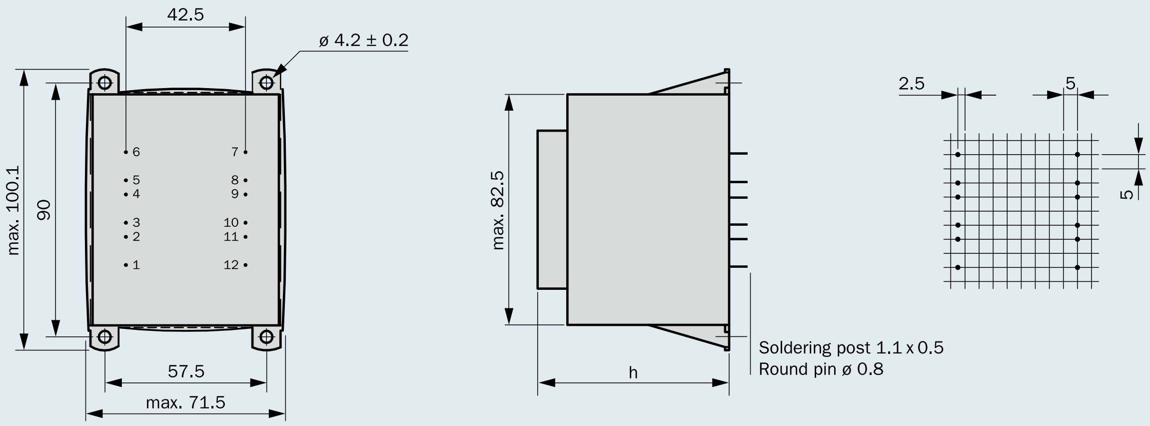
Type cast housing “0” with 18 connection pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

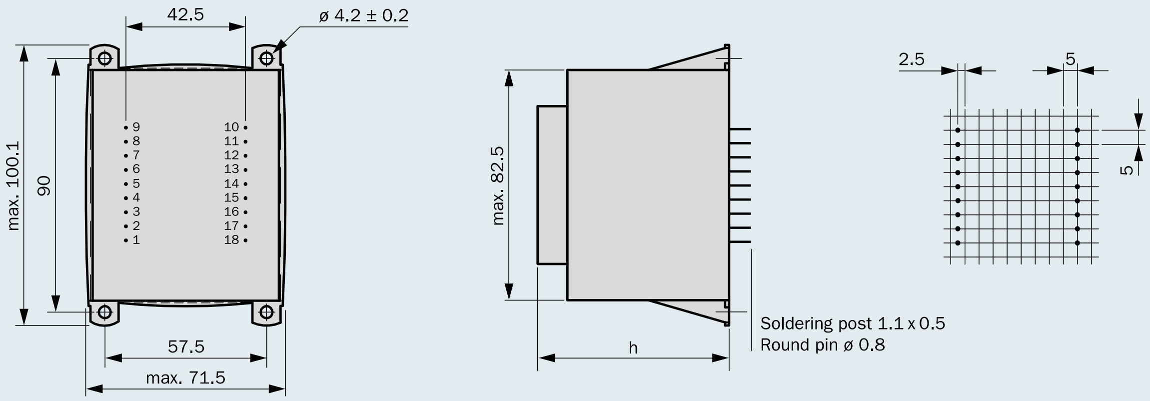
Type cast housing "KK" with 12 connection pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

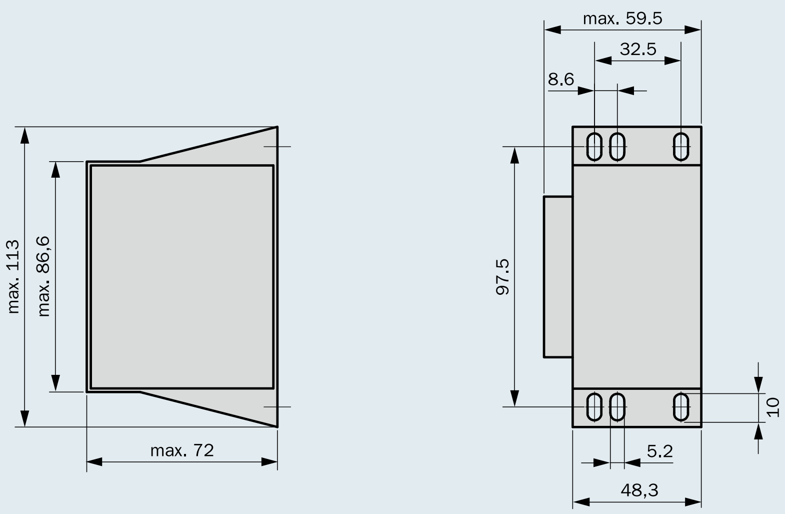
Type cast housing "KK" with 18 connection pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

Type cast housing "SV" for upright mounting



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

HAHN

Printed-Circuit-Board transformers

Output Power: 75.0 VA – 100.0 VA

EI 84

10 VDE	DIN EN 61558-2-6	VDE	on request
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	on request
UR	UL 5085-3	UL	on request
UR	UL 5085-1	UL	on request
SP	C22.2	CSA	on request

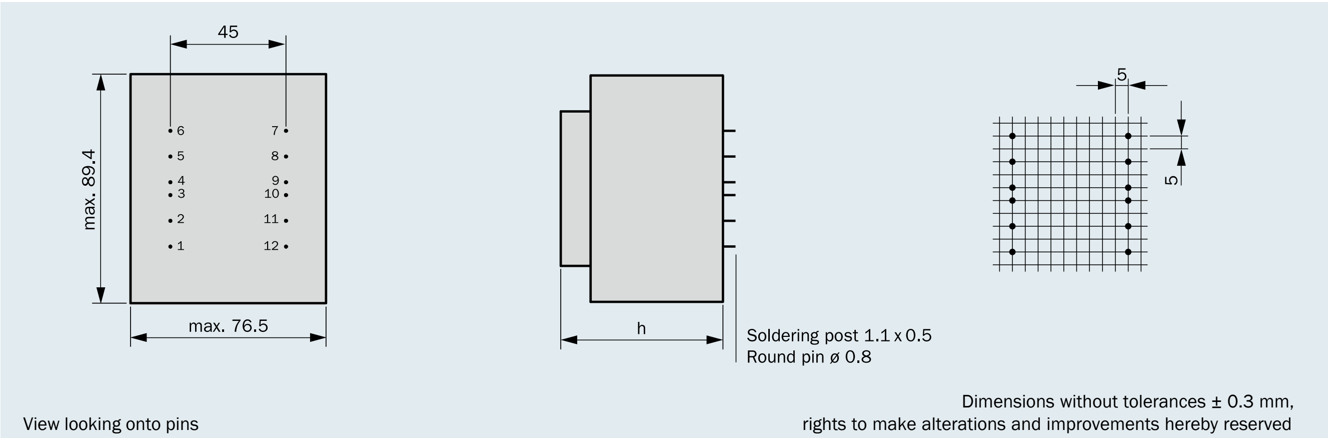
- according to REACH regulation
- according to RoHs regulation

Individual version!

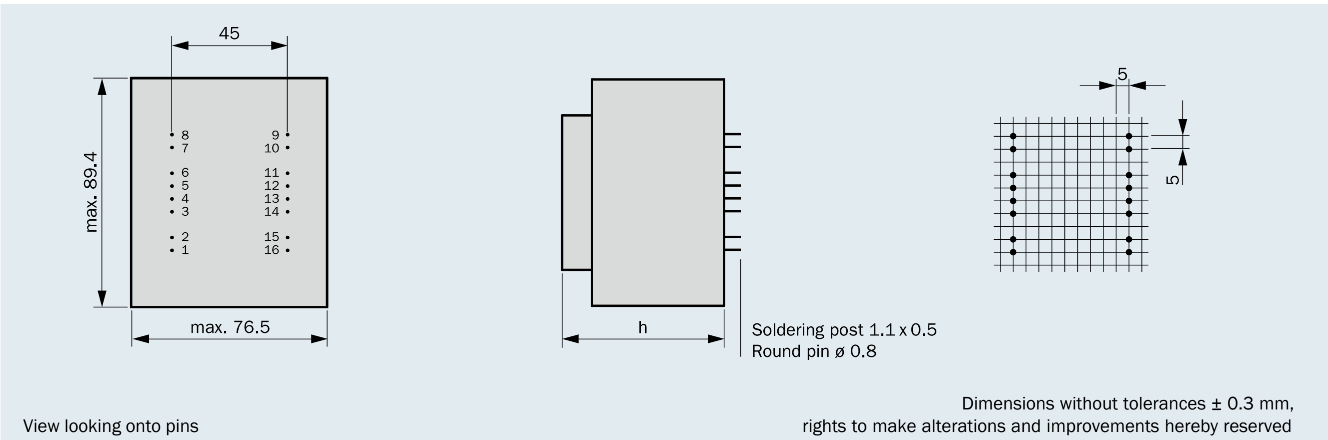
Custom-made models are available on request, e.g. with or without mounting brackets, other heights, pin configurations or connections.

Frame size/Core height	Output Power ta 70 °C/B	Height (h)	Weight
BV EI 841 .... /29.5 mm	75.0 VA	63.0 ± 0.5 mm	1.600 kg
BV EI 842 .... /43.5 mm	100.0 VA	76.5 ± 0.5 mm	2.100 kg

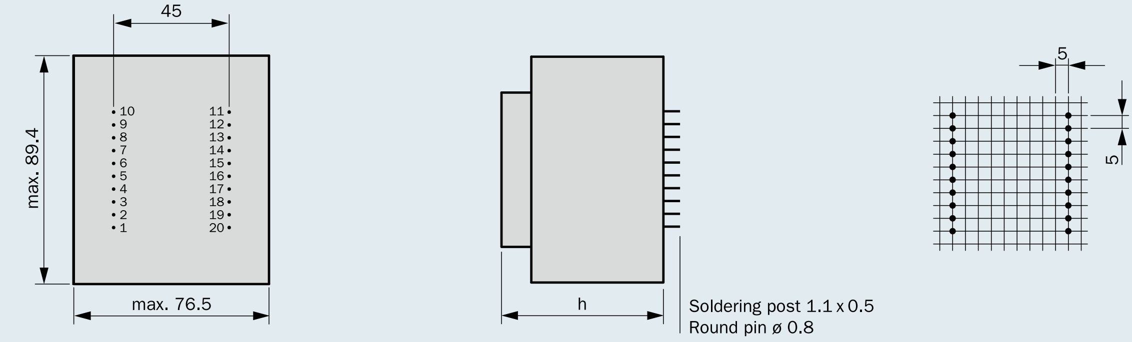
Type cast housing "0" with 12 connection pins



Type cast housing "0" with 16 connection pins



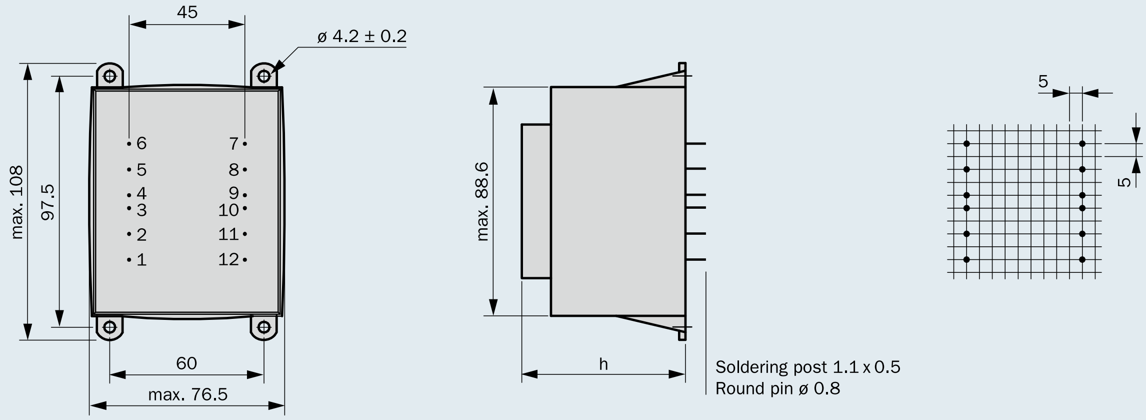
Type cast housing “0” with 20 connection pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

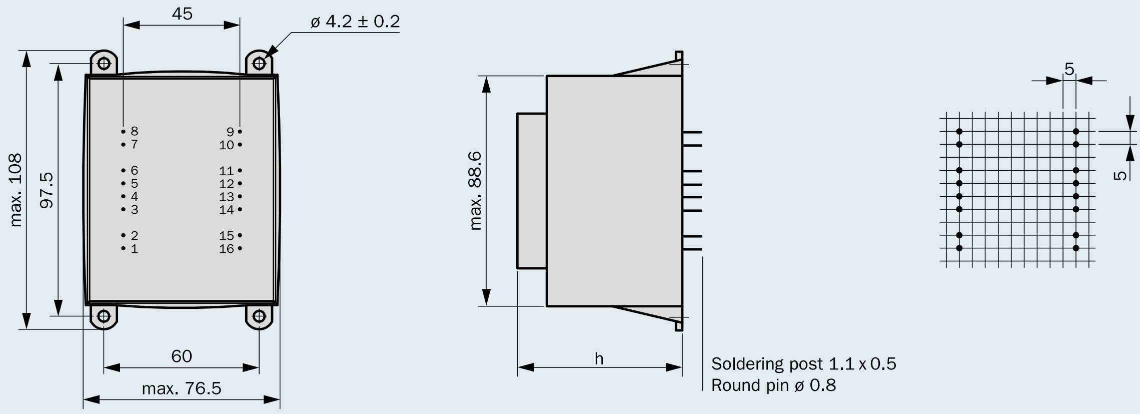
Type cast housing “KK” with 12 connection pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

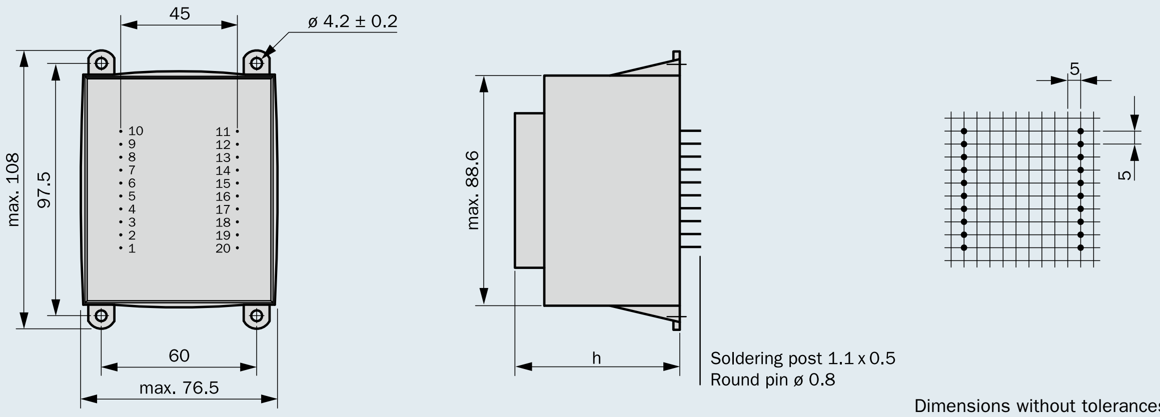
Type cast housing “KK” with 16 connection pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

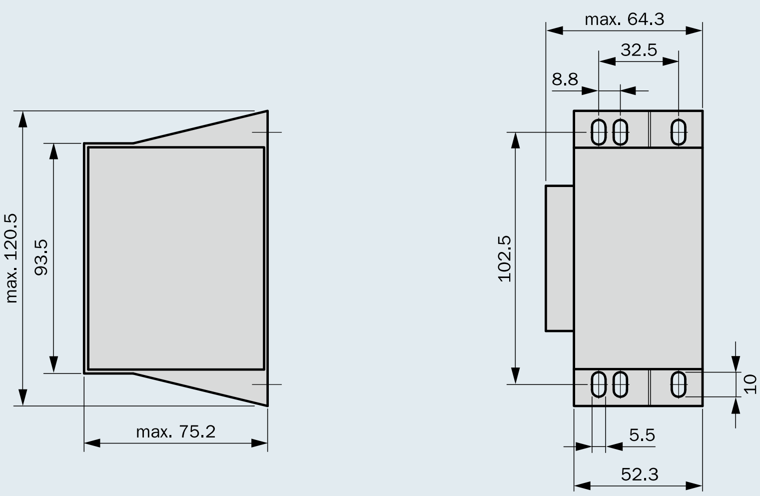
Type cast housing “KK” with 20 connection pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Type cast housing “SV” for upright mounting



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Printed-Circuit-Board transformers EI 96

Output Power: 130.0 VA – 200.0 VA

10	DIN EN 61558-2-6	VDE	on request
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	on request
	UL 5085-3	UL	on request
	UL 5085-1	UL	on request
	C22.2	CSA	on request

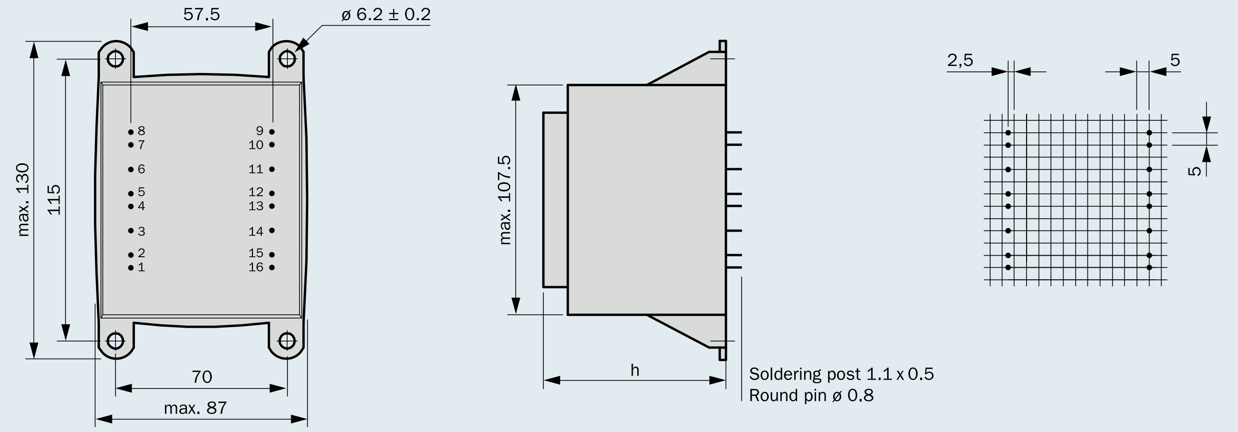
- according to REACH regulation
- according to RoHs regulation

Individual version!

Custom-made models are available on request, e.g. with or without mounting brackets, other heights, pin configurations or connections.

Frame size/Core height	Output Power ta 70 °C/B	Height (h)	Weight
BV EI 961 .... /35.7 mm	130.0 VA	74.6 ± 0.5 mm	2.600 kg
BV EI 962 .... /45.5 mm	160.0 VA	84.4 ± 0.5 mm	3.800 kg
BV EI 963 .... /59.7 mm	200.0 VA	98.4 ± 0.5 mm	4.600 kg

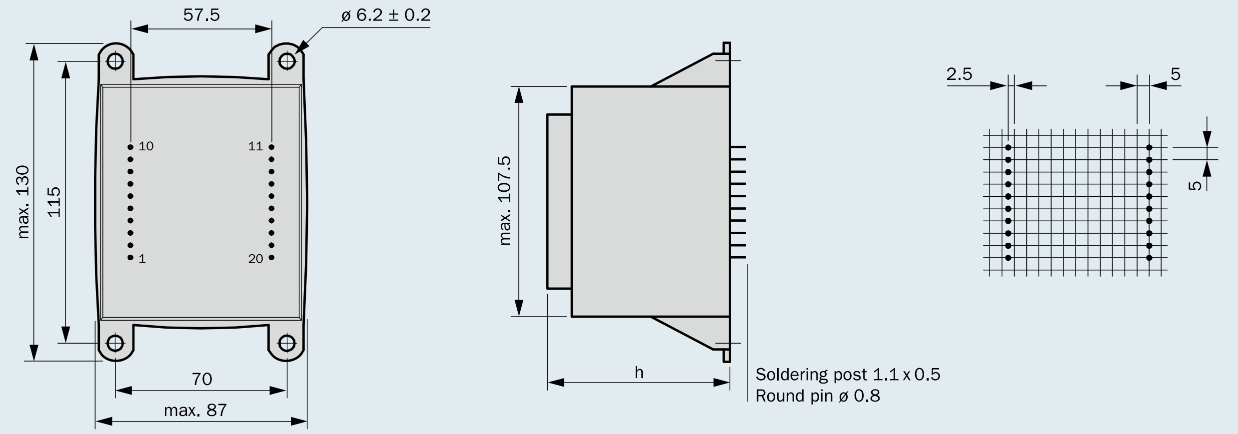
Type cast housing “KK” with 16 connection pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Type cast housing “KK” with 20 connection pins



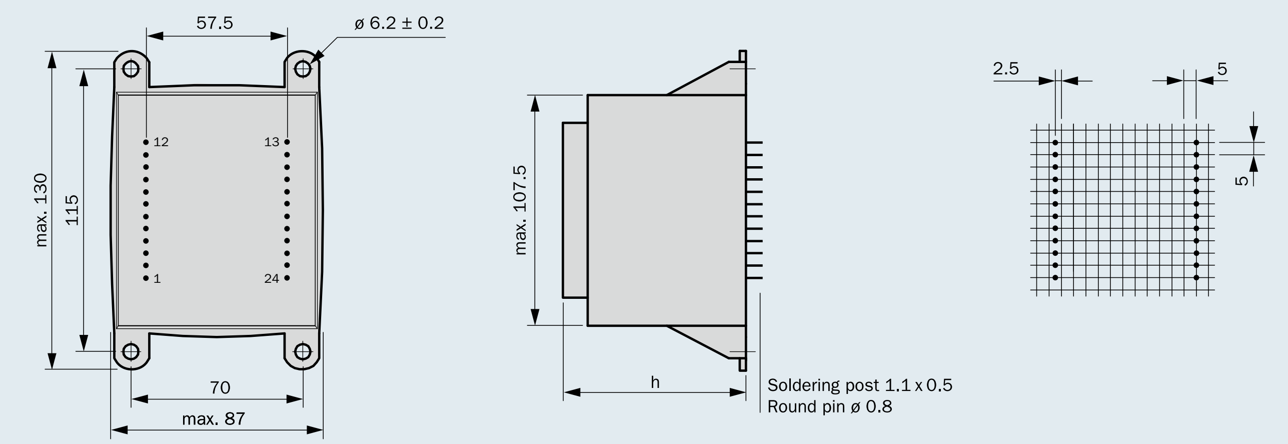
View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Printed-Circuit-Board transformers

Output Power: 130.0 VA – 200.0 VA

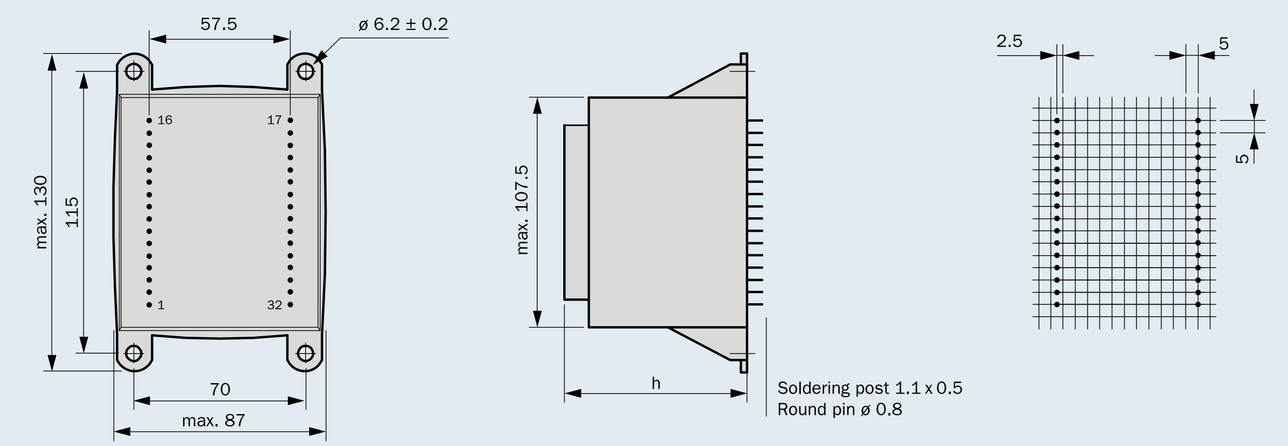
Type cast housing "KK" with 24 connection pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

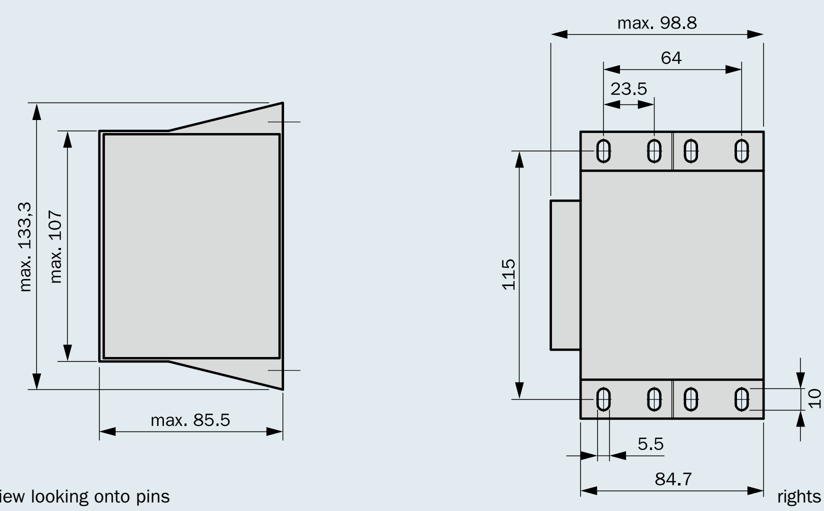
Type cast housing "KK" with 32 connection pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Type cast housing "SV" for upright mounting

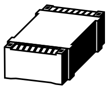


View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Content

UI Series



- Printed-Circuit-Board Flat-type transformers
  frame size UI 21 – UI 48 (1.0 VA – 60 VA)

Printed-Circuit-Board Flat-type transformers

UI 21

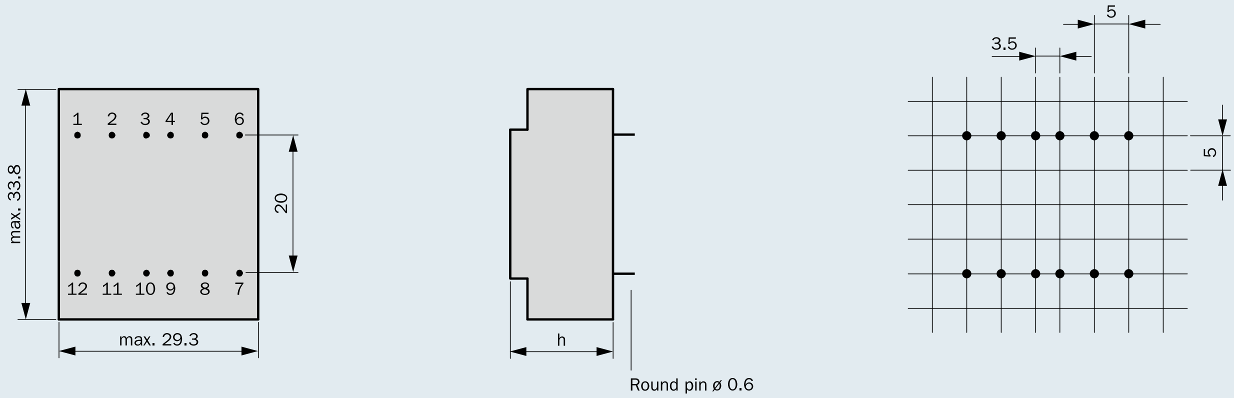
Output Power: 1.0 VA

	DIN EN 61558	**DEKRA**	2147944.01
VDE-Mark for Glow-Wire-Test	**DIN EN 60 335-1**	**VDE**	102961/84814
	UL 5085-3	**UL**	on request
	UL 5085-1	**UL**	E98173
	C22.2	**CSA**	1077600

- according to REACH regulation
- according to RoHs regulation

- Output Power up to 1.0 VA
- Temperature class ta 70 °C/B
- Inherently short-circuit-proof
- Excellent temperature fluctuation resistance properties
- Vacuum-encapsulated, bobbin type with dual chamber windings
- High electrical safety and long service-life features
- High voltage resistance
- Self-extinguishing cast housing and sealing material
- Per item tested quality with certificate

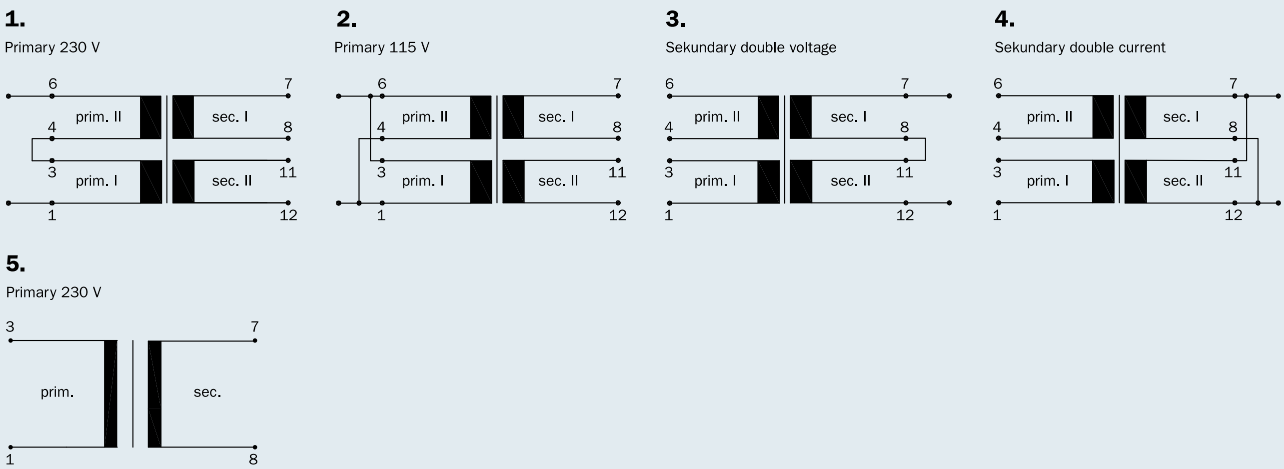
Connecting pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme (only connected pins are present)



Test voltage: up to 6000 V

Frame size/Core height	Output Power ta 70 °C/B	Size (h)	Weight	Packaging unit
BV UI 21 .... / 7.3 mm	1.0 VA	14.9 mm	0.050 kg	40 pieces

Printed-Circuit-Board Flat-type transformers

UI 21

Output Power: 1.0 VA

1.0 VA
ta 70 °C/B

Frame size/Core height
BV UI 21 .... /
7.3 mm

inherently short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. m A	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 21 0011	230	1 – 3	1 x 3	333	7 – 8	1 x 4.7	5
BV UI 21 0012	230	1 – 3	1 x 6	166	7 – 8	1 x 10.4	5
BV UI 21 0013	230	1 – 3	1 x 7.5	133	7 – 8	1 x 12.9	5
BV UI 21 0014	230	1 – 3	1 x 9	111	7 – 8	1 x 14.4	5
BV UI 21 0015	230	1 – 3	1 x 10	100	7 – 8	1 x 15.4	5
BV UI 21 0016	230	1 – 3	1 x 12	83	7 – 8	1 x 20.4	5
BV UI 21 0017	230	1 – 3	1 x 15	67	7 – 8	1 x 24.6	5
BV UI 21 0018	230	1 – 3	1 x 18	56	7 – 8	1 x 29.1	5
BV UI 21 0019	230	1 – 3	1 x 21	47	7 – 8	1 x 34.0	5
BV UI 21 0021	230	1 – 3	1 x 24	41	7 – 8	1 x 39.7	5
BV UI 21 0001	2 x 115	1 – 3/4 – 6	2 x 3	166	7 – 8/11 – 12	2 x 5.8	1 – 4
BV UI 21 0002	2 x 115	1 – 3/4 – 6	2 x 6	83	7 – 8/11 – 12	2 x 11.4	1 – 4
BV UI 21 0008	2 x 115	1 – 3/4 – 6	2 x 7.5	67	7 – 8/11 – 12	2 x 13.1	1 – 4
BV UI 21 0003	2 x 115	1 – 3/4 – 6	2 x 9	56	7 – 8/11 – 12	2 x 17.1	1 – 4
BV UI 21 0009	2 x 115	1 – 3/4 – 6	2 x 10	50	7 – 8/11 – 12	2 x 17.4	1 – 4
BV UI 21 0004	2 x 115	1 – 3/4 – 6	2 x 12	41	7 – 8/11 – 12	2 x 21.8	1 – 4

Printed-Circuit-Board Flat-type transformers

Output Power: 3.0 VA – 16.0 VA

UI 30

	DIN EN 61558	DEKRA	2147944.01
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	102961/84814
	UL 5085-3	UL	on request
	UL 5085-1	UL	E98173
	C22.2	CSA	1077600

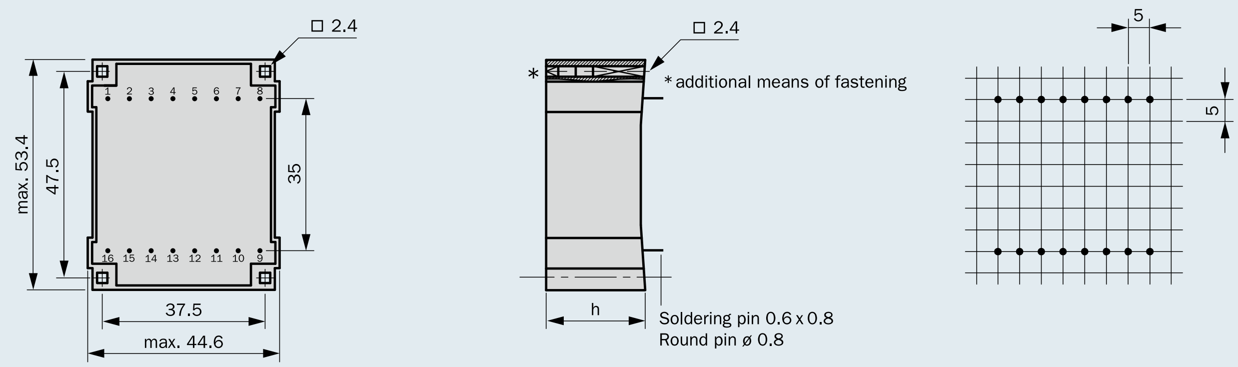
- according to REACH regulation
- according to RoHs regulation

- Output Power up to 16.0 VA
- Temperature class ta 70 °C/B, butnon short-circuit-proof
- Vacuum-encapsulated, bobbin type with dual chamber windings
- Excellent temperature fluctuation resistance properties
- High electrical safety and long service-life features
- High voltage resistance up to 6000 V
- Self-extinguishing cast housing and sealing material
- Per item tested quality with certificate

Protection extern secondary by:
- Micro fuse according to IEC 127 or
- PTC resistance

Parallel to the cataloged UI 30 series transformers, HAHN also produces other variants, e. g. with integrated thermo fuse or thermo switch.

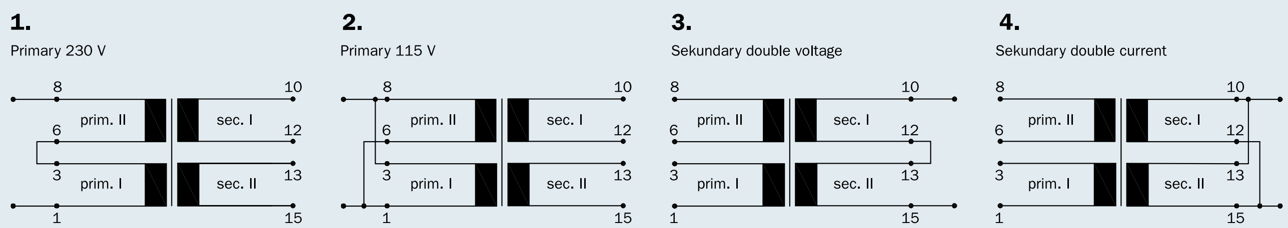
Connecting pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme (only connected pins are present)



Test voltage: up to 6000 V

Frame size/Core height	Output Power ta 70 °C/B	Size (h)	Weight	Packaging unit
BV UI 301 .... / 5.5 mm	3.0 VA	17.8 mm	0.130 kg	20 pieces
BV UI 302 .... / 7.5 mm	4.0 VA	19.8 mm	0.150 kg	20 pieces
BV UI 303 .... / 10.5 mm	6.0 VA	22.8 mm	0.180 kg	20 pieces
BV UI 304 .... / 16.5 mm	10.0 VA	28.8 mm	0.260 kg	20 pieces
BV UI 305 .... / 26.0 mm	16.0 VA	37.6 mm	0.370 kg	20 pieces

Printed-Circuit-Board Flat-type transformers

Output Power: up to 16.0 VA

UI 30

3.0 VA ta 70 °C/B

Frame size/Core height **BV UI 301…./ 5.5 mm**

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 301 0167	2 x 115	1–3/6–8	2 x 6	250	10–12/13–15	2 x 7.9	1–4
BV UI 301 0168	2 x 115	1–3/6–8	2 x 9	167	10–12/13–15	2 x 14.0	1–4
BV UI 301 0133	2 x 115	1–3/6–8	2 x 12	126	10–12/13–15	2 x 18.4	1–4
BV UI 301 0166	2 x 115	1–3/6–8	2 x 15	100	10–12/13–15	2 x 22.8	1–4

4.0 VA ta 70 °C/B

Frame size/Core height **BV UI 302…./ 7.5 mm**

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 302 0164	2 x 115	1–3/6–8	2 x 6	333	10–12/13–15	2 x 10.1	1–4
BV UI 302 0161	2 x 115	1–3/6–8	2 x 9	222	10–12/13–15	2 x 13.5	1–4
BV UI 302 0144	2 x 115	1–3/6–8	2 x 12	166	10–12/13–15	2 x 20.2	1–4
BV UI 302 0165	2 x 115	1–3/6–8	2 x 15	133	10–12/13–15	2 x 24.9	1–4

6.0 VA ta 70 °C/B

Frame size/Core height **BV UI 303…./ 10.5 mm**

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 303 0162	2 x 115	1–3/6–8	2 x 6	500	10–12/13–15	2 x 9.0	1–4
BV UI 303 0179	2 x 115	1–3/6–8	2 x 7.5	400	10–12/13–15	2 x 11.4	1–4
BV UI 303 0158	2 x 115	1–3/6–8	2 x 9	334	10–12/13–15	2 x 12.8	1–4
BV UI 303 0145	2 x 115	1–3/6–8	2 x 12	250	10–12/13–15	2 x 17.2	1–4
BV UI 303 0163	2 x 115	1–3/6–8	2 x 15	200	10–12/13–15	2 x 21.8	1–4

10.0 VA ta 70 °C/B

Frame size/Core height **BV UI 304…./ 16.5 mm**

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 304 0155	2 x 115	1–3/6–8	2 x 6	833	10–12/13–15	2 x 8.7	1–4
BV UI 304 0129	2 x 115	1–3/6–8	2 x 7.5	667	10–12/13–15	2 x 10.0	1–4
BV UI 304 0153	2 x 115	1–3/6–8	2 x 9	555	10–12/13–15	2 x 12.4	1–4
BV UI 304 0154	2 x 115	1–3/6–8	2 x 12	416	10–12/13–15	2 x 16.0	1–4
BV UI 304 0136	2 x 115	1–3/6–8	2 x 15	333	10–12/13–15	2 x 19.7	1–4
BV UI 304 0159	2 x 115	1–3/6–8	2 x 18	277	10–12/13–15	2 x 23.4	1–4

16.0 VA ta 70 °C/B

Frame size/Core height **BV UI 305…./ 26.0 mm**

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 305 0147	2 x 115	1–3/6–8	2 x 6	1330	10–12/13–15	2 x 7.5	1–4
BV UI 305 0148	2 x 115	1–3/6–8	2 x 9	888	10–12/13–15	2 x 10.9	1–4
BV UI 305 0149	2 x 115	1–3/6–8	2 x 12	666	10–12/13–15	2 x 14.6	1–4
BV UI 305 0150	2 x 115	1–3/6–8	2 x 15	533	10–12/13–15	2 x 18.0	1–4
BV UI 305 0151	2 x 115	1–3/6–8	2 x 18	444	10–12/13–15	2 x 21,5	1–4
BV UI 305 0152	2 x 115	1–3/6–8	2 x 21	380	10–12/13–15	2 x 25,0	1–4

Printed-Circuit-Board Flat-type transformers

Output Power: 10.0 VA – 30.0 VA

UI 39

ENEC 05 / KEMA KEUR	DIN EN 61558	DEKRA	2147944.01
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	102961/84814
UR	UL 5085-3	UL	on request
UR	UL 5085-1	UL	E98173
CSA	C22.2	CSA	1077600

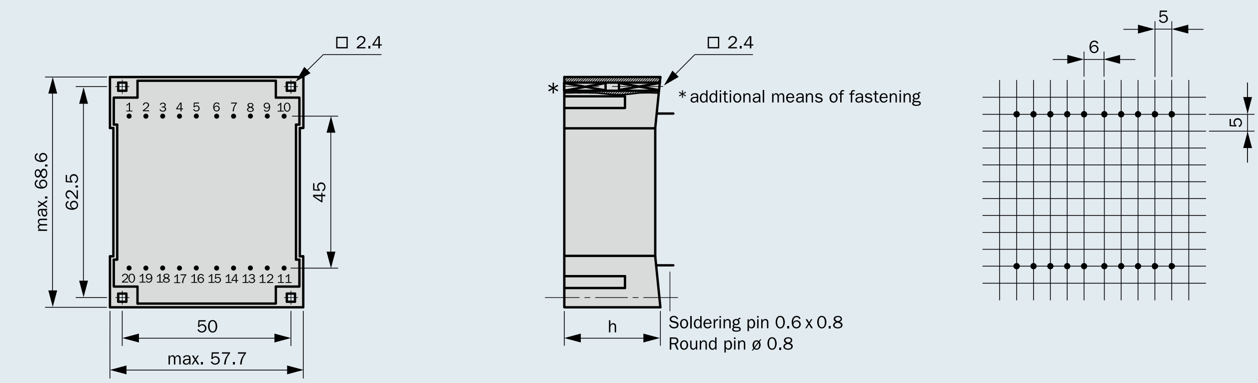
- according to REACH regulation
- according to RoHs regulation

- Output Power up to 30.0 VA
- Temperature class ta 70 °C/B, non short-circuit-proof
- Vacuum encapsulated, bobbin type with dual chamber windings
- Excellent temperature fluctuation resistance properties
- High electrical safety and long service-life features
- High voltage resistance up to 6000 V
- Self-extinguishing cast housing and sealing material
- Per item tested quality with certificate

Protection extern secondary by:
- Micro fuse according to IEC 127 or
- PTC resistance

Parallel to the cataloged UI 39 series transformers, HAHN also produces other variants, e.g. with integrated thermo fuse or thermo switch.

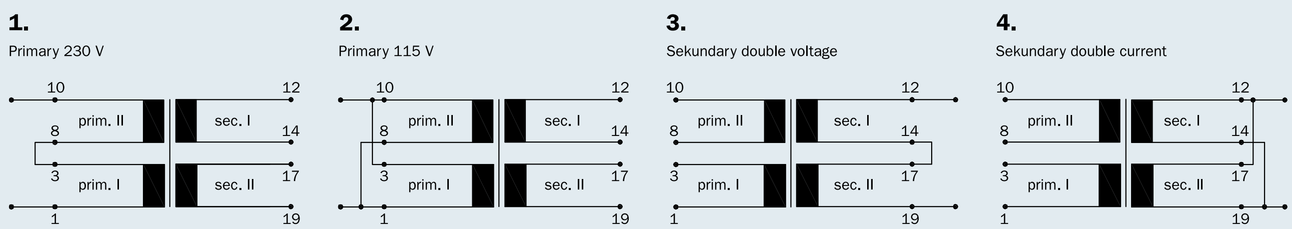
Connecting pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme (only connected pins are present)



Test voltage: up to 6000 V

Frame size/Core height	Output Power ta 70 °C/B	Size (h)	Weight	Packaging unit
BV UI 392 .... / 8.0 mm	10.0 VA	23.0 mm	0.290 kg	12 pieces
BV UI 393 .... / 10.2 mm	14.0 VA	25.2 mm	0.330 kg	12 pieces
BV UI 394 .... / 13.5 mm	18.0 VA	28.5 mm	0.390 kg	12 pieces
BV UI 395 .... / 17.0 mm	24.0 VA	32.0 mm	0.460 kg	12 pieces
BV UI 396 .... / 21.0 mm	30.0 VA	36.0 mm	0.550 kg	12 pieces

HAHN

Printed-Circuit-Board Flat-type transformers

UI 39

Output Power: up to 30.0 VA

10.0 VA ta 70 °C/B

Frame size/Core height
BV UI 392…. / 8.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 392 0092	2 x 115	1–3/8–10	2 x 6	833	12–14/17–19	2 x 8.2	1–4
BV UI 392 0076	2 x 115	1–3/8–10	2 x 9	556	12–14/17–19	2 x 11.9	1–4
BV UI 392 0093	2 x 115	1–3/8–10	2 x 12	416	12–14/17–19	2 x 16.4	1–4
BV UI 392 0077	2 x 115	1–3/8–10	2 x 15	333	12–14/17–19	2 x 19.3	1–4
BV UI 392 0094	2 x 115	1–3/8–10	2 x 18	277	12–14/17–19	2 x 23.8	1–4

14.0 VA ta 70 °C/B

Frame size/Core height
BV UI 393…. / 10.2 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 393 0085	2 x 115	1–3/8–10	2 x 6	1166	12–14/17–19	2 x 8.0	1–4
BV UI 393 0074	2 x 115	1–3/8–10	2 x 9	778	12–14/17–19	2 x 12.0	1–4
BV UI 393 0081	2 x 115	1–3/8–10	2 x 12	583	12–14/17–19	2 x 15.6	1–4
BV UI 393 0078	2 x 115	1–3/8–10	2 x 15	467	12–14/17–19	2 x 19.9	1–4
BV UI 393 0062	2 x 115	1–3/8–10	2 x 18	389	12–14/17–19	2 x 23.7	1–4

18.0 VA ta 70 °C/B

Frame size/Core height
BV UI 394…. / 13.5 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 394 0086	2 x 115	1–3/8–10	2 x 6	1500	12–14/17–19	2 x 8.0	1–4
BV UI 394 0110	2 x 115	1–3/8–10	2 x 7.5	1200	12–14/17–19	2 x 9.8	1–4
BV UI 394 0063	2 x 115	1–3/8–10	2 x 9	1000	12–14/17–19	2 x 12.0	1–4
BV UI 394 0087	2 x 115	1–3/8–10	2 x 12	750	12–14/17–19	2 x 15.5	1–4
BV UI 394 0088	2 x 115	1–3/8–10	2 x 15	600	12–14/17–19	2 x 19.6	1–4
BV UI 394 0075	2 x 115	1–3/8–10	2 x 18	500	12–14/17–19	2 x 23.2	1–4

24.0 VA ta 70 °C/B

Frame size/Core height
BV UI 395…. / 17.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 395 0089	2 x 115	1–3/8–10	2 x 6	2000	12–14/17–19	2 x 7.4	1–4
BV UI 395 0190	2 x 115	1–3/8–10	2 x 7.5	1600	12–14/17–19	2 x 9.3	1–4
BV UI 395 0098	2 x 115	1–3/8–10	2 x 9	1333	12–14/17–19	2 x 11.0	1–4
BV UI 395 0091	2 x 115	1–3/8–10	2 x 12	1000	12–14/17–19	2 x 14.7	1–4
BV UI 395 0083	2 x 115	1–3/8–10	2 x 15	800	12–14/17–19	2 x 18.2	1–4
BV UI 395 0099	2 x 115	1–3/8–10	2 x 18	666	12–14/17–19	2 x 22.0	1–4
BV UI 395 0100	2 x 115	1–3/8–10	2 x 21	571	12–14/17–19	2 x 25.0	1–4

30.0 VA ta 70 °C/B

Frame size/Core height
BV UI 396…. / 21.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 396 0101	2 x 115	1–3/8–10	2 x 6	2500	12–14/17–19	2 x 7.3	1–4
BV UI 396 0187	2 x 115	1–3/8–10	2 x 7.5	2000	12–14/17–19	2 x 9.0	1–4
BV UI 396 0102	2 x 115	1–3/8–10	2 x 9	1666	12–14/17–19	2 x 10.7	1–4
BV UI 396 0079	2 x 115	1–3/8–10	2 x 12	1250	12–14/17–19	2 x 14.1	1–4
BV UI 396 0103	2 x 115	1–3/8–10	2 x 15	1000	12–14/17–19	2 x 17.6	1–4
BV UI 396 0080	2 x 115	1–3/8–10	2 x 18	833	12–14/17–19	2 x 21.2	1–4

Printed-Circuit-Board Flat-type transformers

UI 48

Output Power: 40.0 VA – 60.0 VA

	DIN EN 61558	DEKRA	2147944.01
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	102961/84814
	UL 5085-3	UL	on request
	UL 5085-1	UL	E98173
	C22.2	CSA	1077600

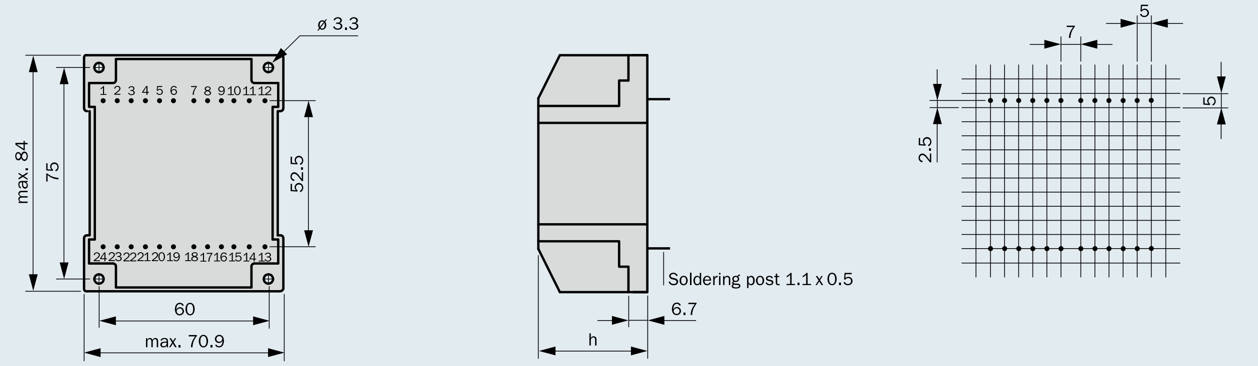
- according to REACH regulation
- according to RoHs regulation

- Output Power up to 60.0 VA
- Temperature class ta 70 °C/B, non short-circuit-proof
- Excellent temperature fluctuation resistance properties
- Vacuum-encapsulated, bobbin type with dual chamber windings
- High electrical safety and long service-life features
- High voltage resistance up to 6000 V
- Self-extinguishing cast housing and sealing material
- Per item tested quality with certificate

Protection extern secondary by:
- Micro fuse according to IEC 127 or
- PTC resistance

Parallel to the cataloged UI 48 series transformers, HAHN also produces other variants, e.g. with integrated thermo fuse or thermo switch.

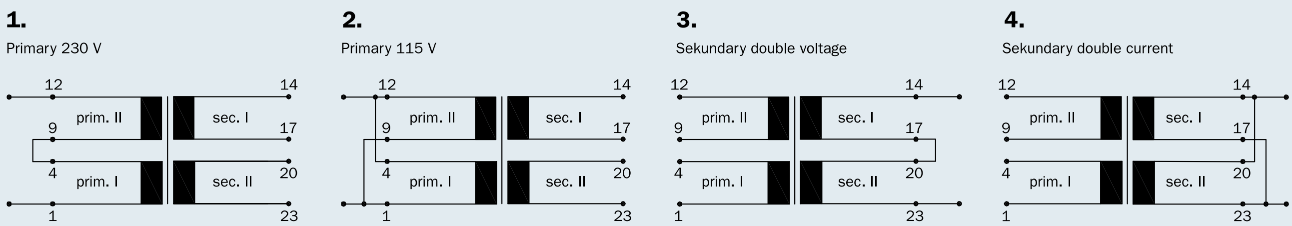
Connecting pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme (only connected pins are present)



Test voltage: up to 6000 V

Frame size/Core height	Output Power ta 70 °C/B	Size (h)	Weight	Packaging unit
BV UI 481 .... /17.0 mm	40.0 VA	38.7 mm	0.780 kg	6 pieces
BV UI 482 .... /26.0 mm	60.0 VA	47.9 mm	1.100 kg	6 pieces

Printed-Circuit-Board Flat-type transformers

Output Power: up to 60.0 VA

40.0 VA
ta 70 °C/B

Frame size/Core height
BV UI 481…. / 17.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 481 0001	2 x 115	1–4/9–12	2 x 6	3333	14–17/20–23	2 x 7.3	1–4
BV UI 481 0002	2 x 115	1–4/9–12	2 x 9	2222	14–17/20–23	2 x 10.8	1–4
BV UI 481 0003	2 x 115	1–4/9–12	2 x 12	1666	14–17/20–23	2 x 14.3	1–4
BV UI 481 0004	2 x 115	1–4/9–12	2 x 15	1333	14–17/20–23	2 x 17.7	1–4
BV UI 481 0005	2 x 115	1–4/9–12	2 x 18	1111	14–17/20–23	2 x 21.7	1–4

60.0 VA
ta 70 °C/B

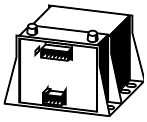
Frame size/Core height
BV UI 482…. / 26.0 mm

non short-circuit-proof

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage V	Current sec. mA	Connecting pins sec.	No-load voltage V	Connection scheme
BV UI 482 0007	2 x 115	1–4/9–12	2 x 6	5000	14–17/20–23	2 x 7.3	1–4
BV UI 482 0008	2 x 115	1–4/9–12	2 x 9	3333	14–17/20–23	2 x 10.5	1–4
BV UI 482 0009	2 x 115	1–4/9–12	2 x 12	2500	14–17/20–23	2 x 14.0	1–4
BV UI 482 0010	2 x 115	1–4/9–12	2 x 15	2000	14–17/20–23	2 x 17.5	1–4
BV UI 482 0011	2 x 115	1–4/9–12	2 x 18	1666	14–17/20–23	2 x 21.1	1–4
BV UI 482 0012	2 x 115	1–4/9–12	2 x 21	1428	14–17/20–23	2 x 24.5	1–4

Content

RAST 5 Series



- Transformers with RAST 5 connecting technology
  frame size EI 48 – EI 84 (10.0 VA – 120 VA)

Transformers

Output Power:

10.0 VA – 120.0 VA

RAST 5

10	**DIN EN 61558-2-6**	**VDE**	on request
VDE-Mark for Glow-Wire-Test	**DIN EN 60 335-1**	**VDE**	102961/84814
	UL 5085-3	**UL**	on request
	UL 5085-1	**UL**	on request
	C22.2	**CSA**	on request

- according to REACH regulation
- according to RoHs regulation

- High Output Power up to 120.0 VA
- Primary voltages from 12 V to 400 V
- Secondary voltages from 6 V to 24 V or 2 x 6 V to 2 x 24 V
- Minimal size available
- Vacuum-encapsulated, bobbin with dual chamber windings
- Per item tested quality with certificate
- Temperature class ta 70 °C/B
  meeting VDE 0570/DIN EN 61558 regulations
- High electrical safety and long service-life features
- Excellent temperature fluctuation resistance properties
- Self-extinguishing cast housing and sealing material

RAST 5 Transformers frame size EI 48 to EI 84.
All transformers of the RAST 5 series are equipped with a variable user-friendly parallel-wired connector to VDE 0627/PM 906 (Regulations of the Association of German Electrical Engineers). This greatly facilitates the assembly of the components by as much as a third. It only remains to attach the lead connectors to the primary and secondary sides. The tedious and time-consuming routines of soldering, screw-attachment or individual plug-ins is no longer required. Especially coded connectors with form guides ensure proper assembly. Confusion in connecting up routines is impossible, even for a layman. Lead connectors are prefabricated, thus also reducing costs.

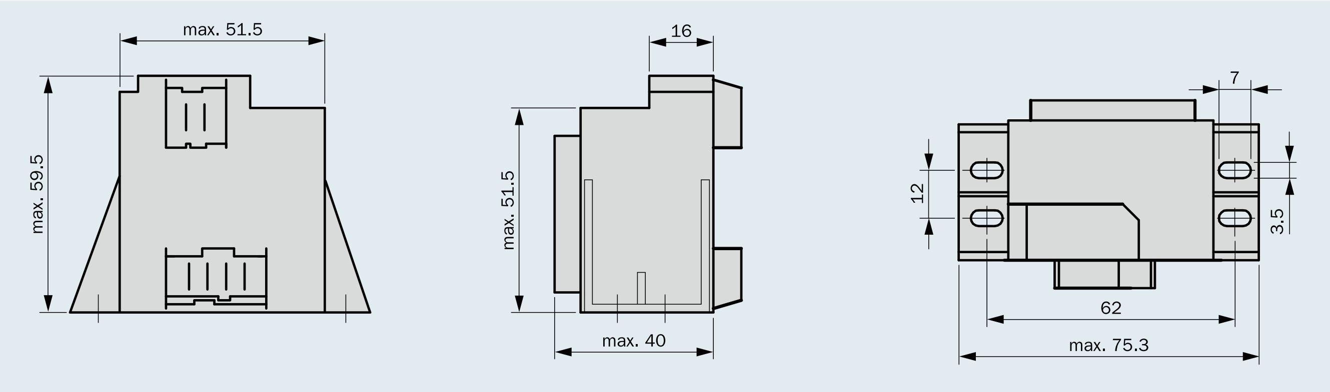
The RAST 5 interconnective techniques developed by HAHN for transformers provide makers of electrical and white goods with assured economical- and electrical safety aspects in the manufacture of appliances.

Transformers

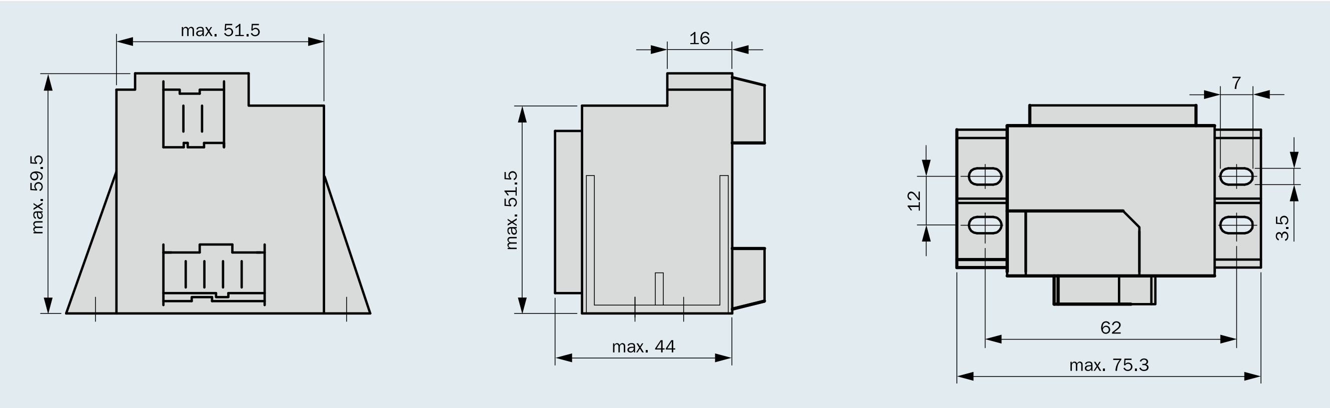
Output Power:
10.0 VA – 16.0 VA

Frame size	Output Power ta 70 °C/B	Packaging unit
EI 48 / 16.8	10.0 VA	12 pieces
EI 48 / 20.5	12.0 VA	12 pieces
EI 54/ 18.8	16.0 VA	10 pieces

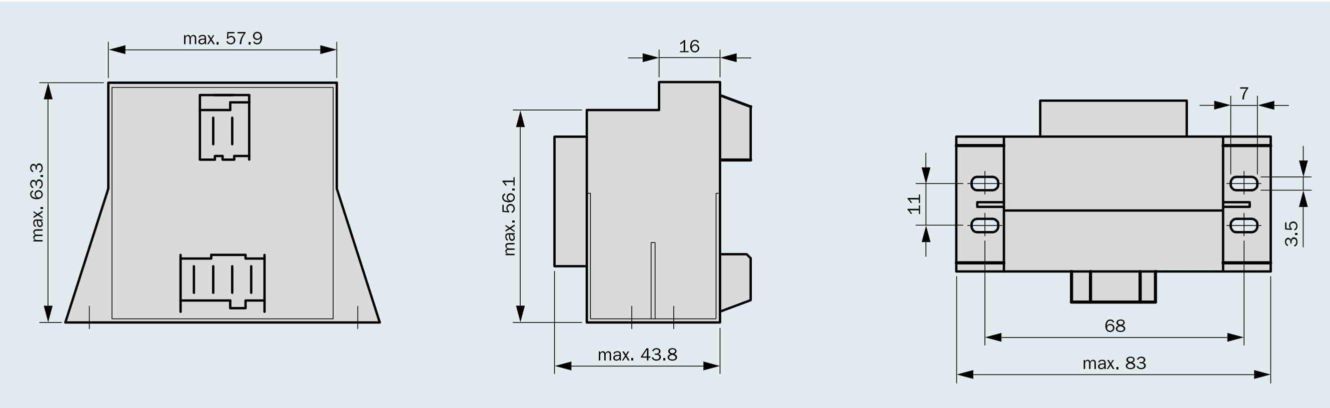
Connecting pins Version EI 48 / 16.8



Connecting pins Version EI 48 / 20.5



Connecting pins Version EI 54 / 18.8



HAHN

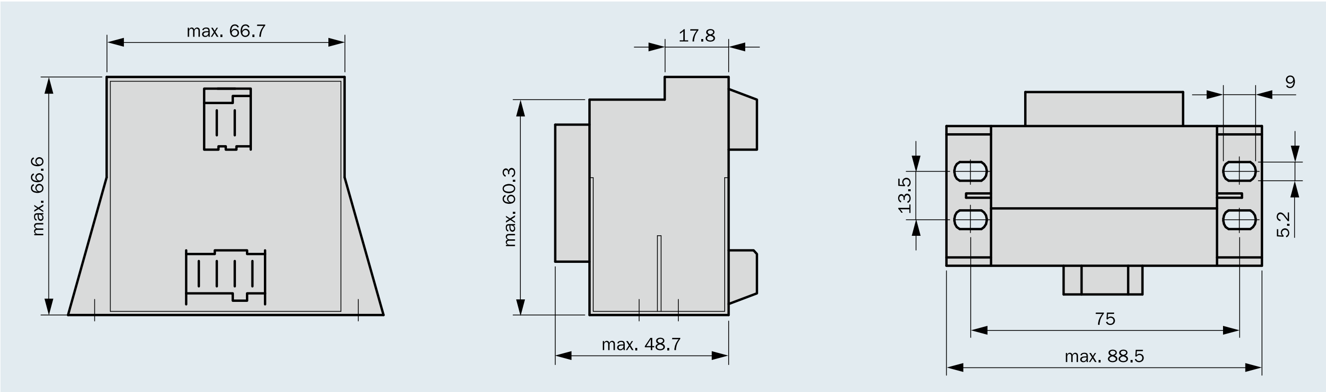
Transformers
Output Power:
20.0 VA – 40.0 VA

RAST 5

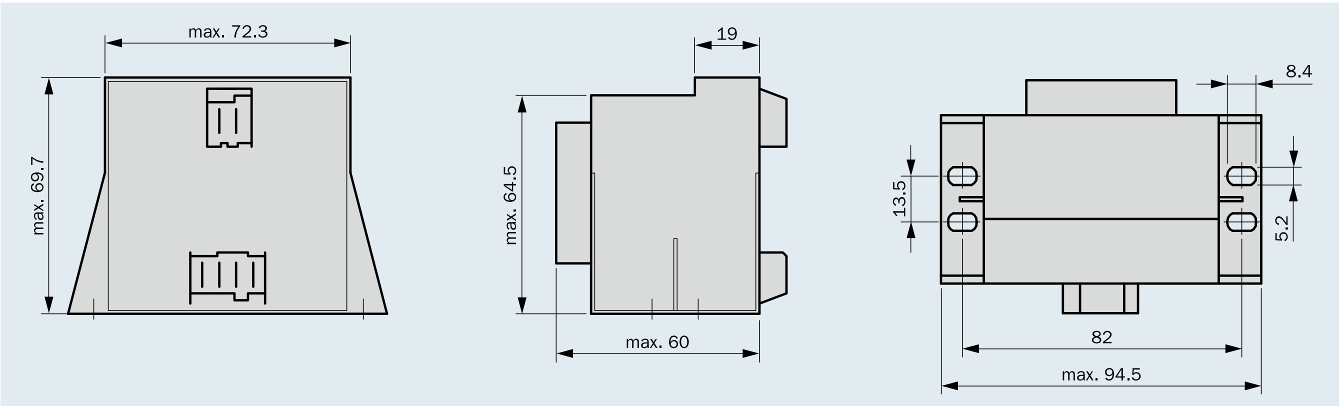
Frame size	Output Power ta 70 °C/B	Packaging unit
EI 60 / 21.0	20.0 VA	8 pieces
EI 66 / 30.0	40.0 VA	8 pieces

Maximum Convenience combined with cogent Quality. Equipped with service- and user-friendly connective techniques plus the usual quality benefits of the EI transformer series. Designed to customer requirements – capacities from 10.0 VA to 120.0 VA. Temperature class ta 70 °C/B. Vacuum encapsu lated items are, subjected of course to 100 % quality control.

Connecting pins Version EI 60 / 21.0



Connecting pins Version EI 66 / 30.0



Transformers

Output Power:

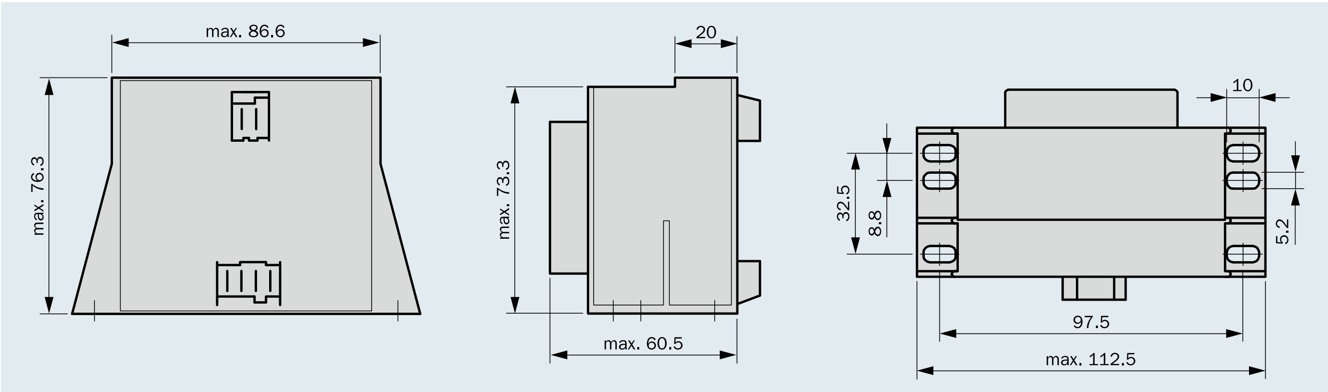
50.0 VA – 120.0 VA

RAST 5

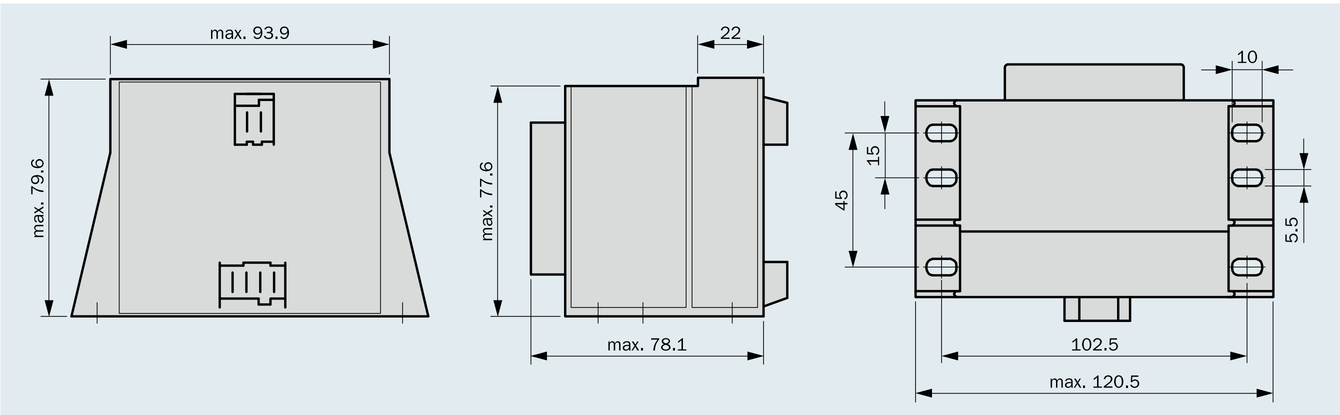
Frame size	Output Power ta 70 °C/B	Packaging unit
EI 78 / 27.5	50.0 VA	4 pieces
EI 84 / 43.5	120.0 VA	4 pieces

Maximum Convenience combined with cogent Quality. Equipped with service- and user-friendly connective techniques plus the usual quality benefits of the EI transformer series. Designed to customer requirements – capacities from 10.0 VA to 120.0 VA. Temperature class ta 70 °C/B. Vacuum encapsu lated items are, subjected of course to 100 % quality control.

Connecting pins Version EI 78 / 27.5



Connecting pins Version EI 84 / 43.5



Content

Flyback converter / SMPS-Converter

- Flyback converters frame size EF 16/5 – 8 mm creeping distance
- Individual version 8 mm creeping distance
- Flyback converters frame size EF 20/5 – 4 mm creeping distance
- Individual version 4 mm creeping distance

Flyback converters for Switch Mode Power Supplies

EF

HAHN flyback converters with the following characteristics:
- Construction to DIN EN 61 558, DIN EN 60 950
- Operational frequency 10 – 500 kHz
- Increased creeping distance 12 mm possible

Insulating material classification
- E / 120 °C
- B / 130 °C (optional)
- F / 155 °C (optional)
- UL 9 – V0 (optional)
- 100 % unleaded

100 % piece inspections
- Inductivity
- Turns ratio
- Winding direction
- Voltage resistance (50 Hz / 1 s)

Switch Mode Power Supplies with HAHN flyback converters – can be employed for lower and middle range capacities with the structural size quantities EF 12.6 to EF 30.0. Through the use of high-quality of core materials it is possible to reach working frequencies up to the MHZ-area.

Considerable know-how and specialist experience in transformer technology for open, encapsulated, impregnated or vacuum encapsulated converters are guarantees for HAHN quality and optimum customer benefit.

Current developments in electronic components involve ever shorter research and development time periods and every greater manufacturing reliability.

HAHN has the opportunity of optimally developing flyback converters for well known manufacturers of regulator controllers, e. g. Power Integration, Infinion, Philips or ON Semiconductor as customer-specific components. These were all rapid-, economic- and high quality problem solutions from HAHN.

Frame size	Output Power*	Packaging unit
EF 12.6/4	up to 5 W	300 pieces
EF 16/5	up to 9 W	176 pieces
EF 20/6	up to 20 W	176 pieces
EF 25/7	up to 45 W	60 pieces
EF 30/7	up to 70 W	48 pieces

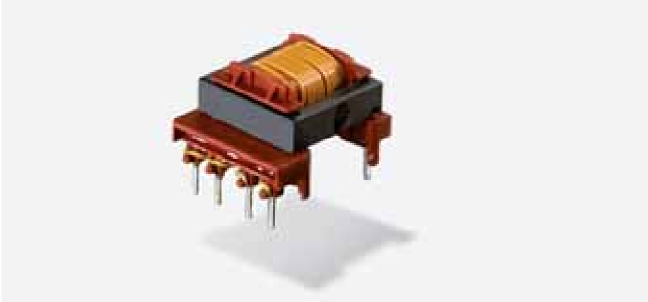
* dependent on input voltage range and switch governor type

Flyback converters for Switch Mode Power Supplies

EF16/5

Output Power: 5 – 7 W

ENEC 10, VDE	**DIN EN 61 558**	**VDE**	on request
VDE-Mark for Glow-Wire-Test	**DIN EN 60 335-1**	**VDE**	on request
UR	**UL 5085-3**	**UL**	on request
UR	**UL 5085-1**	**UL**	on request
CSA	**C22.2**	**CSA**	on request

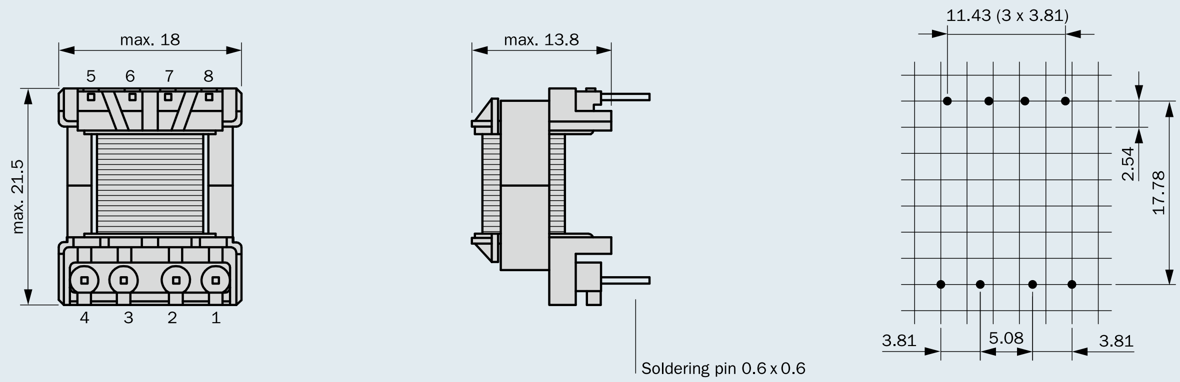


- according to REACH regulation
- according to RoHs regulation

Technical Specifications
- Construction to DIN EN 61 558, DIN EN 60 950
- Creeping distance 8 mm min.
- 100 % unleaded
- UL listed materials
- Insulating material classification B (130 °C)
- Two outputs for connection in parallel or in series (*)

100 % piece inspection
- Inductance
- Turns ratio
- Winding direction
- Voltage resistance (50 Hz / 1 s)

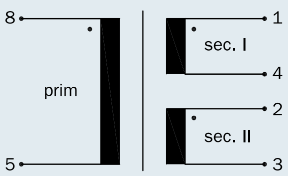
Connecting pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

Connection scheme (only connected pins are present)



double voltage – bridge: 4 + 2, double current – bridge: 1 + 2/4 + 3

Flyback converters for Switch Mode Power Supplies

EF16/5

Output Power: 5 – 7 W

5 W

TinySwitch-II® Product family TNY 264

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage I V	Current sec. I mA	Connecting pins sec. I	Secondary voltage II V	Current sec. II mA	Connecting pins sec. II
V 50100*	85 – 265	5 – 8	3	830	1 – 4	3	830	2 – 3
V 50101*	85 – 265	5 – 8	9	280	1 – 4	9	280	2 – 3
V 50102*	85 – 265	5 – 8	12	210	1 – 4	12	210	2 – 3
V 50103*	85 – 265	5 – 8	15	170	1 – 4	15	170	2 – 3

* Two outputs for connection in parallel or in series

5 W

TinySwitch-II® Product family TNY 266

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage I V	Current sec. I mA	Connecting pins sec. I	Secondary voltage II V	Current sec. II mA	Connecting pins sec. II
V 50104	85 – 265	5 – 8	12	390	1 – 2	3.3	100	3 – 4
V 50105	85 – 265	5 – 8	24	195	1 – 2	3.3	100	3 – 4
V 50106	85 – 265	5 – 8	12	375	1 – 2	5	100	3 – 4
V 50107	85 – 265	5 – 8	24	187	1 – 2	5	100	3 – 4

7 W

TinySwitch-III® Product family TNY 276

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage I V	Current sec. I mA	Connecting pins sec. I	Secondary voltage II V	Current sec. II mA	Connecting pins sec. II
V 50110*	85 – 265	5 – 8	3	1170	1 – 4	3	1170	2 – 3
V 50111*	85 – 265	5 – 8	9	390	1 – 4	9	390	2 – 3
V 50112*	85 – 265	5 – 8	12	290	1 – 4	12	290	2 – 3
V 50113*	85 – 265	5 – 8	15	230	1 – 4	15	230	2 – 3

* Two outputs for connection in parallel or in series

7 W

TinySwitch-III® Product family TNY 276

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage I V	Current sec. I mA	Connecting pins sec. I	Secondary voltage II V	Current sec. II mA	Connecting pins sec. II
V 50114	85 – 265	5 – 8	12	555	1 – 2	3.3	100	3 – 4
V 50115	85 – 265	5 – 8	24	277	1 – 2	3.3	100	3 – 4
V 50116	85 – 265	5 – 8	12	540	1 – 2	5	100	3 – 4
V 50117	85 – 265	5 – 8	24	270	1 – 2	5	100	3 – 4

Flyback converters for Switch Mode Power Supplies

EF 20/6

Output Power: 8 – 16 W

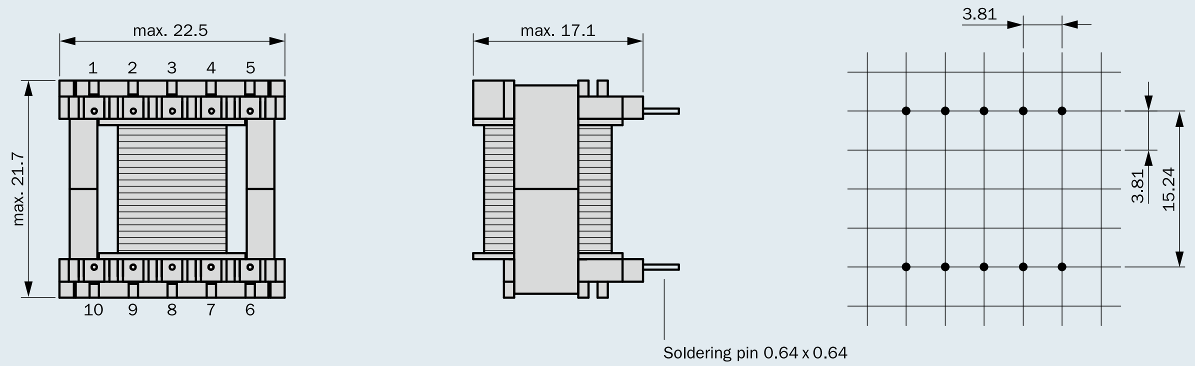
10	**DIN EN 61 558**	**VDE**	on request
VDE-Mark for Glow-Wire-Test	**DIN EN 60 335-1**	**VDE**	on request
	UL 5085-3	**UL**	on request
	UL 5085-1	**UL**	on request
	C22.2	**CSA**	on request

- according to REACH regulation
- according to RoHs regulation

Technical Specifications
- Construction to DIN EN 61 558, DIN EN 60 950
- Creeping distance 4 mm min.
- 100 % unleaded
- UL listed materials
- Insulating material classification E (120 °C)
- Two outputs for connection in parallel or in series(*)

100 % piece inspection
- Inductance
- Turns ratio
- Winding direction
- Voltage resistance (50 Hz/1 s)

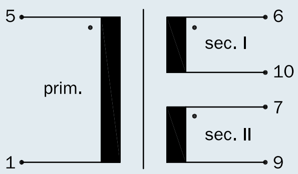
Connecting pins



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme (only connected pins are present)



double voltage – bridge: 10 + 7, double current – bridge: 6 + 7/10 + 9

Flyback converters for Switch Mode Power Supplies

Output Power: 8 – 16 W

EF 20/6

8 W

TinySwitch-II® Product Family TNY 267

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage I V	Current sec. I mA	Connecting pins sec. I	Secondary voltage II V	Current sec. II mA	Connecting pins sec. II
V 50200*	85 – 265	1 – 5	3	1330	6 – 10	3	1330	7 – 9
V 50201*	85 – 265	1 – 5	9	440	6 – 10	9	440	7 – 9
V 50202*	85 – 265	1 – 5	12	330	6 – 10	12	330	7 – 9
V 50203*	85 – 265	1 – 5	15	270	6 – 10	15	270	7 – 9

* Two outputs for connection in parallel or in series

8 W

TinySwitch-II® Product Family TNY 267

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage I V	Current sec. I mA	Connecting pins sec. I	Secondary voltage II V	Current sec. II mA	Connecting pins sec. II
V 50204	85 – 265	1 – 5	12	640	6 – 7	3.3	100	9 – 10
V 50205	85 – 265	1 – 5	24	320	6 – 7	3.3	100	9 – 10
V 50206	85 – 265	1 – 5	12	625	6 – 7	5	100	9 – 10
V 50207	85 – 265	1 – 5	24	312	6 – 7	5	100	9 – 10

16 W

TinySwitch-III® Product Family TNY 279

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage I V	Current sec. I mA	Connecting pins sec. I	Secondary voltage II V	Current sec. II mA	Connecting pins sec. II
V 50210*	85 – 265	1 – 5	3	2670	6 – 10	3	2670	7 – 9
V 50211*	85 – 265	1 – 5	9	890	6 – 10	9	890	7 – 9
V 50212*	85 – 265	1 – 5	12	670	6 – 10	12	670	7 – 9
V 50213*	85 – 265	1 – 5	15	530	6 – 10	15	530	7 – 9

* Two outputs for connection in parallel or in series

16 W

TinySwitch-III® Product Family TNY 278

Order No.	Primary voltage V	Connecting pins prim.	Secondary voltage I V	Current sec. I mA	Connecting pins sec. I	Secondary voltage II V	Current sec. II mA	Connecting pins sec. II
V 50214	85 – 265	1 – 5	12	1300	6 – 7	3.3	100	9 – 10
V 50215	85 – 265	1 – 5	24	650	6 – 7	3.3	100	9 – 10
V 50216	85 – 265	1 – 5	12	1290	6 – 7	5	100	9 – 10
V 50217	85 – 265	1 – 5	24	645	6 – 7	5	100	9 – 10

Flyback converters for Switch Mode Power Supplies

8 mm creeping distance

EF

	DIN EN 61 558	**VDE**	on request
VDE-Mark for Glow-Wire-Test	**DIN EN 60 335-1**	**VDE**	on request
	UL 5085-3	**UL**	on request
	UL 5085-1	**UL**	on request
	C22.2	**CSA**	on request

- according to REACH regulation
- according to RoHs regulation

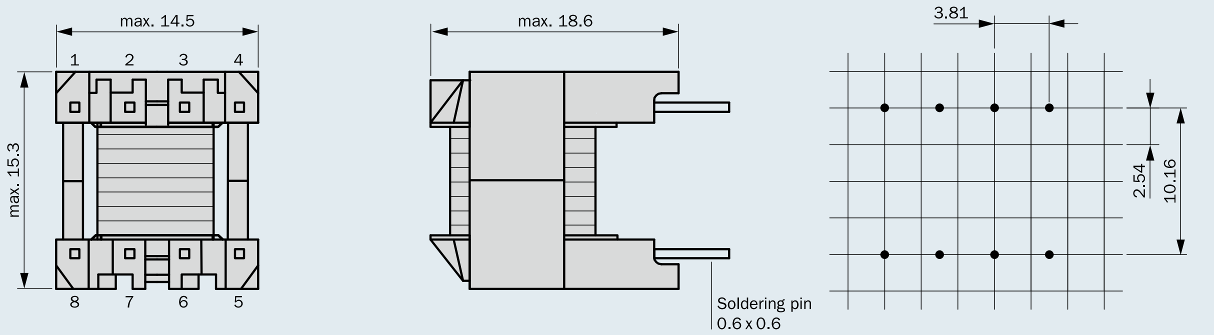
Individual version!

All Flyback converters are produced according to customer specifications.

Current developments in electronic components involve ever shorter research and development time periods and every greater manufacturing reliability.

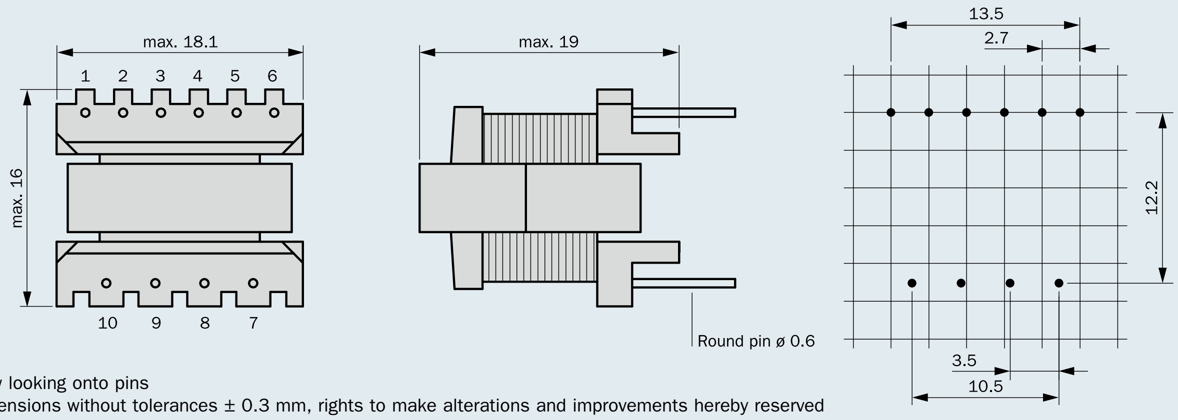
HAHN has the opportunity of optimally developing flyback converters for well known manufacturers of regulator controllers, e.g. Power Integration, Infinion, Philips or ON Semiconductor as customer-specific components. These were all rapid-, economic- and high quality problem solutions from HAHN.

Connecting pins version EF 13/6



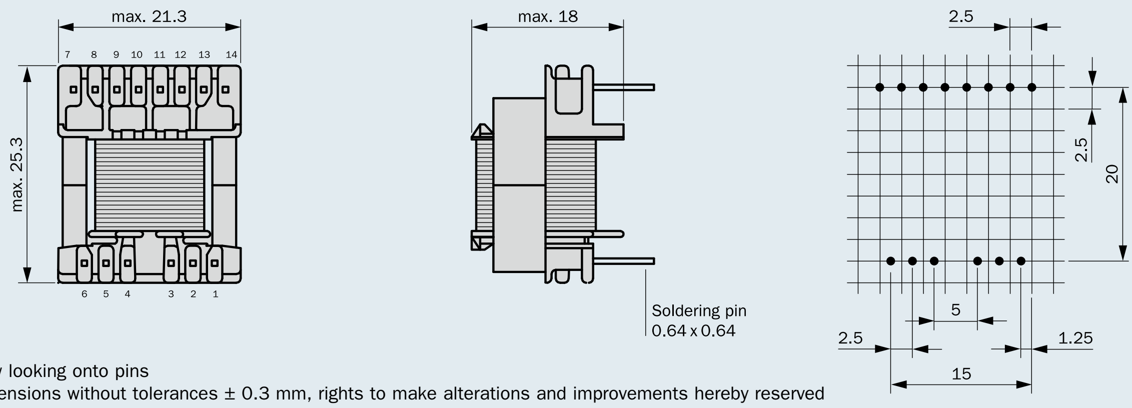
View looking onto pins
Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connecting pins version EF 16/5



View looking onto pins
Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connecting pins version EF 20/6



View looking onto pins
Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Flyback converters for Switch Mode Power Supplies

4 mm creeping distance

EF

	DIN EN 61 558	VDE	on request
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	on request
	UL 5085-3	UL	on request
	UL 5085-1	UL	on request
	C22.2	CSA	on request

- according to REACH regulation
- according to RoHs regulation

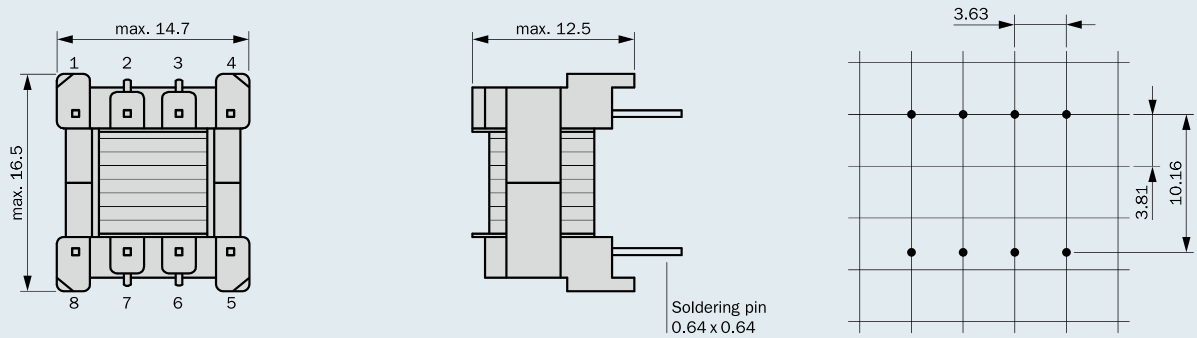
Individual version!

All Flyback converters are produced according to customer specifications.

Current developments in electronic components involve ever shorter research and development time periods and every greater manufacturing reliability.

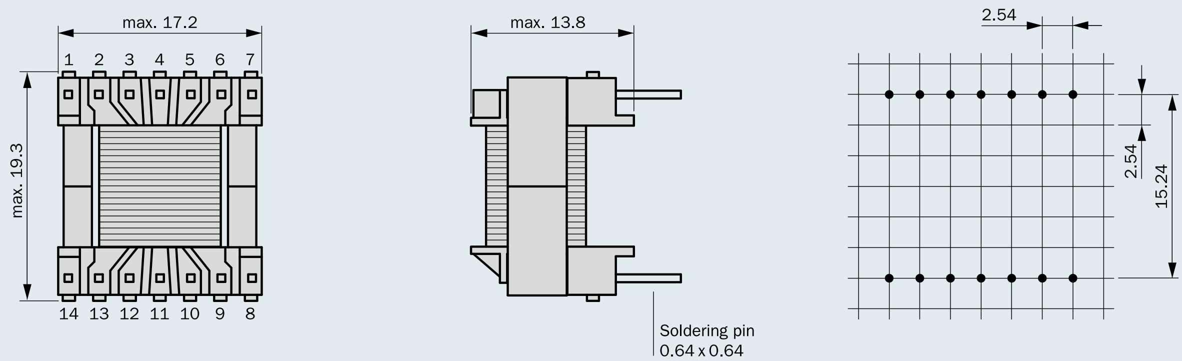
HAHN has the opportunity of optimally developing flyback converters for well known manufacturers of regulator controllers, e.g. Power Integration, Infinion, Philips or ON Semiconductor as customer-specific components. These were all rapid-, economic- and high quality problem solutions from HAHN.

Connecting pins version EF 12/4



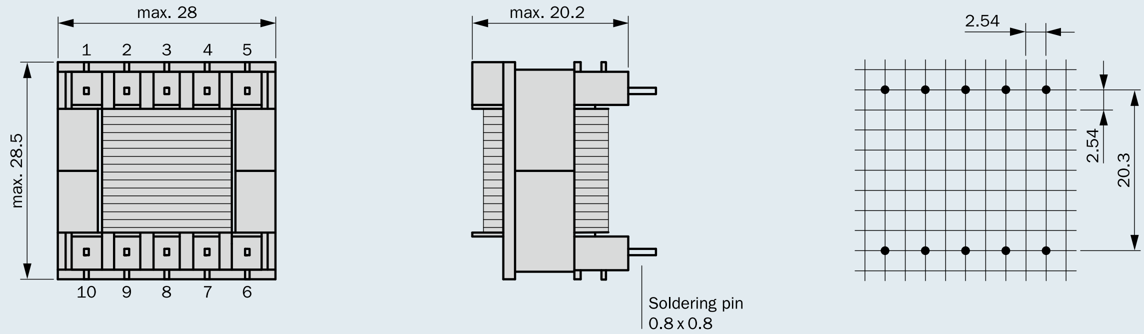
View looking onto pins
Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connecting pins version EF 16/5



View looking onto pins
Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

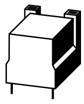
Connecting pins version EF 25/7



View looking onto pins
Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Content

Ignition transformers



- Ignition transformers
- Electronic ignition devices

Ignition transformers

For safe and stable ignition of gas heating systems!
- Circuit board assembly
- Compact design
- For unipolar or bipolar ignition
- For one or two ignition points
- Stringent individual quality-testing
- Self-extinguishing potting and housing material

Ignition transformers from HAHN guarantee safe and stable ignition of your gas-powered heating systems. Compact in design, they are ideal for use with printed circuit boards.

Within our comprehensive Quality Management System which includes several interim checks, each component is subjected to a final 100 % test. In this test, not only the characteristic data are checked but a high-voltage insulation test is carried out.

The specially selected components are all subjected to a glow wire test according to DIN EN 60 335-1:2005, section 30.2.3.

Electronic ignition devices

For safe and stable ignition of boiler systems in the heating industry.

Electronic stroke-spark ignition for use in gas-condensing boiler systems. High-performance ignition for oil-burning systems.

- Voltages 230 V~ and 120 V~
- Single- or dual-pole ignition
- One or two ignition points
- Quality is based on individual testing
- EMV according to DIN EN 55014-1 and DIN EN 55014-2
- Construction according to DIN EN 60335-1 and DIN EN 60335-2-102

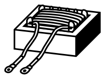
Electronic ignition devices from HAHN are designed according to the highest requirements in heating and industrial plants.

Continuous monitoring of all process steps and the use of top-quality components guarantee safety, reliability and durability. All components are subjected to a 100% individual final check. Here, not only characteristic data are checked; integrated high-voltage tests are carried out that guarantee voltage stability. All ignition devices are compliant with current national and international standards.

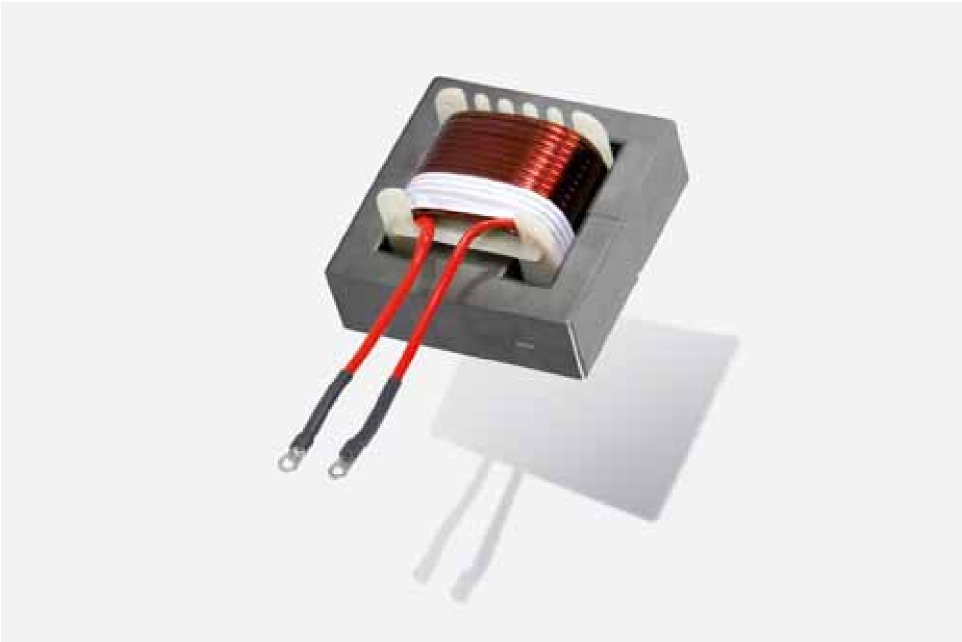
For the user, national regulations are binding. Protection from electrical contact is the responsibility of the user.

Content

Choke program



- Extended mains choke series
- Extensive range of customer-specific chokes



Choke program

We supply green power!
The increasing requirements regarding the electromagnetic compatibility of network harmonics according to DIN EN 61000 -3 has motivated HAHN to provide economical solutions for optimizing your products – whether by supplying alternative energy to networks or by reducing harmonics caused by conversion.

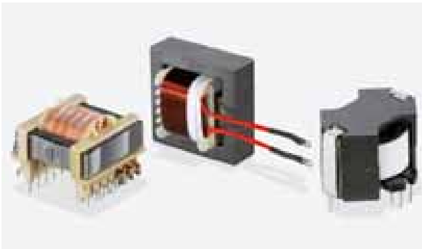
HAHN, with its vast experience and technical know-how, is now able to provide solutions in the form of a wide range of customized coils. The application areas comprise smoothing chokes, commutation chokes, power chokes, PFC chokes and storage chokes in various core materials such as laminated sheet metal, tape-wound core, iron powder and ferrite.

Whether it's a matter of designing a choke, optimizing connections and wiring, assembly via foot angle or top-hat rail G 35, our vastly experienced team of highly qualified development engineers will be able to help.

Choke program

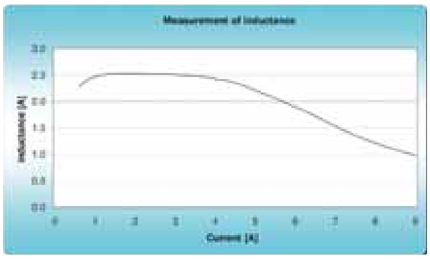
Laminated Iron Core Chokes/Tape-wound Core Choke
- Frequency range 0–400 Hz
- Current range 0–200 A
- Types EI 30 to EI 120, UI 30 to UI 120, tape-wound core SUI
- Open, impregnated or vacuum-encapsulated
- Economically priced and customized to your own specific requirements with respect to design, fitting and contacting

Iron Powder Core Chokes
- Frequency range 0–100 kHz
- Current range 0–30 A
- Types: toroidal or pot core
- Open, impregnated or vacuum-encapsulated
- Economically priced and customized to your own specific requirements with respect to design, fitting and contacting

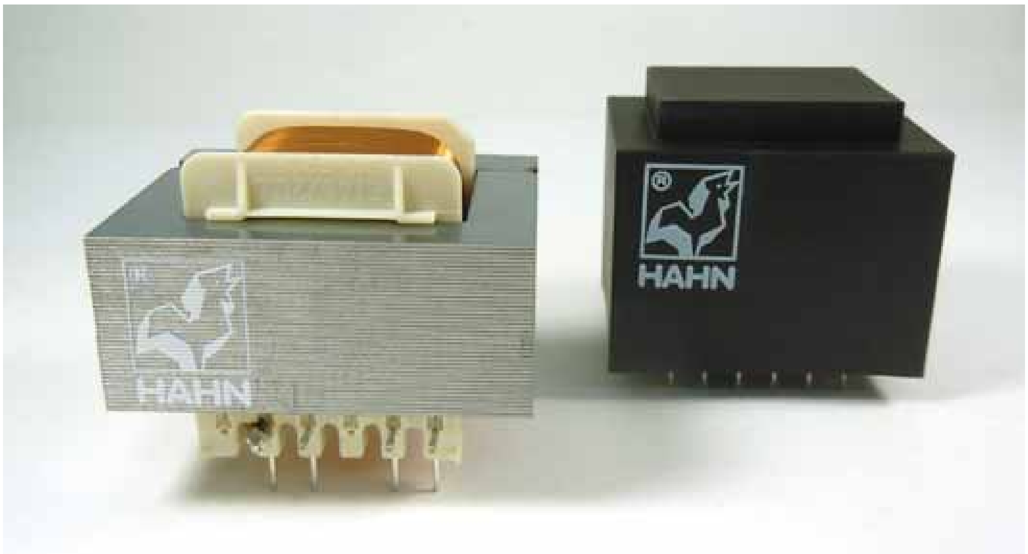


Ferrite Chokes
- Frequency range 10 kHz–1 MHz
- Current range 0–200 A
- Types EE 13–EE 120, RM, PQ, UI to 126, toroidal
- Open, impregnated or vacuum-encapsulated
- Economically priced and customized to your own specific requirements with respect to design, fitting and contacting

Lead by Know-how!
By using state-of-the-art measurement technology and through cooperation with a technical university in the area of EMC, HAHN is able to provide you with comprehensive support right from the beginning of your development work. This will save you time and money.



Extended mains choke Series



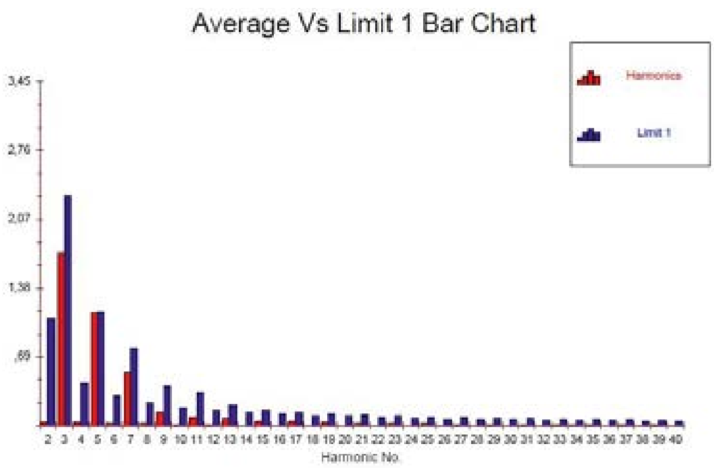
One of the most important environmental conditions for the smooth operation of electrical equipment is a reliable quality of supply networks. Disturbances and influences caused by power-ups, switching power supplies, frequency controllers, etc., endanger equipment and systems in their operational safety.
A significant area of the disturbances and influences on the mains voltage set phase effects; they do arise when resources are operated with a nonlinear current - voltage characteristic or with non-stationary operating behavior of a power grid. This problem of network perturbations gains through the increased use of power electronics with increased emission increasingly important.

In view of the increasing network pollution and the necessary reduction to comply with the power network stability, the requirements are to be adapted to device manufacturers to comply with the electromagnetic compatibility. With the harmonization of EU Directive 2004/108/EC towards the new version 2014/30/EG with effect from 20th April 2016, new guidelines have been applied for the marketing of new devices in Europe.

In order to meet these future requirements on the grid-connected emissions, HAHN provides you already an extended mains choke series, which allows you within very short time to optimize the EMC-features of your device, compliant to the new standard location.

With a power range up to 10 A as well as a wide range of inductance values, this series covers completely the range of common household appliances using their typical plug connected load. Through compliance with the standards in relation to the relevant standards EN 61558-2-20 for chokes , EN 62041, as well as the compliance with the glow wire tests of all materials used in accordance with EN 60335-1 and the use of insulation to the insulation class B and F UL 1446 , the integration of these components is quick and easy.

Investments in new measurement techniques also allow customized solutions.
Our HAHN development team and our technical support team will be happy to answer your questions.



Mains chokes (PFC)

Inductivity: 1.0 – 20.0 mH

Nominal current: max. 5.2 A

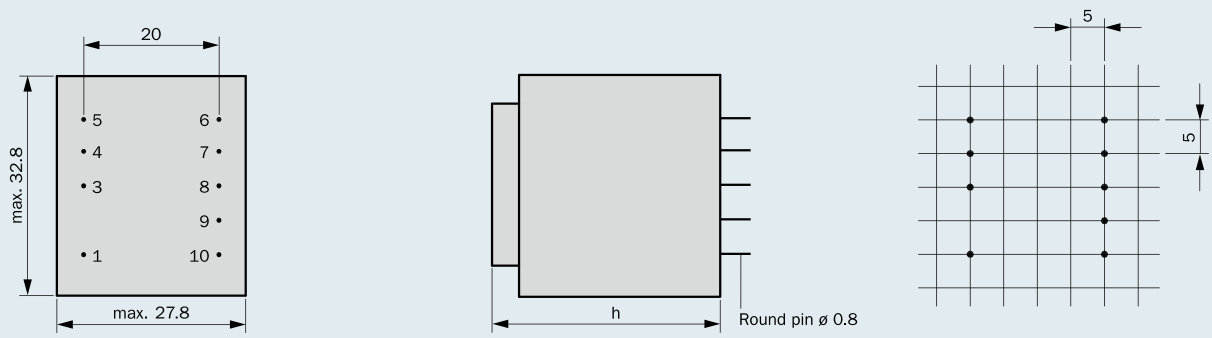
EI 30

	DIN EN 61558-2-20 DIN EN 62041	VDE	on request
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	102961/84814
	UL 1446	UL	E237745

- according to REACH regulation
- according to RoHs regulation

- Excellent temperature fluctuation resistance properties
- High electrical safety and long service-life features
- High voltage resistance to core
- Per item tested quality with certificate
- For the standard version with cast housing “0”: Self-extinguishing cast housing and sealing material

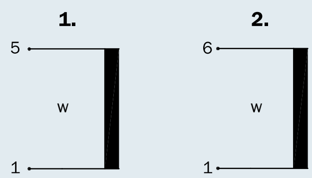
Connecting pins Type cast housing “0”



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme



Frame size/Core height	Nominal current ta 70 °C	Height (h)	Weight	Packaging unit
BVD EI 306 1... /23.0 mm	max. 5.2 A	max. 34.3 mm	0.145 kg	50 pieces

Mains chokes (PFC)

Inductivity: 1.0–20.0 mH

Nominal current: max. 5.2 A

EI 30

Type in cast housing "O"

ta 70 °C/F

Frame size/Core height
BVD EI 306 1…/ 23.0 mm

vacuum-encapsulated

Order No.	Nominal current	Nominal inductivity	Connecting pins	Not connected pins	Connection scheme
BVD EI 306 1001	5.2 A	1.0 mH	1–6	3+4+5+7+8+9+10	2
BVD EI 306 1002	4.2 A	1.5 mH	1–6	3+4+5+7+8+9+10	2
BVD EI 306 1003	3.6 A	2.0 mH	1–6	3+4+5+7+8+9+10	2
BVD EI 306 1004	3.5 A	2.5 mH	1–5	3+4+6+7+8+9+10	1
BVD EI 306 1005	3.2 A	3.0 mH	1–5	3+4+6+7+8+9+10	1
BVD EI 306 1006	3.0 A	3.5 mH	1–5	3+4+6+7+8+9+10	1
BVD EI 306 1007	2.9 A	4.0 mH	1–5	3+4+6+7+8+9+10	1
BVD EI 306 1008	2.5 A	4.5 mH	1–5	3+4+6+7+8+9+10	1
BVD EI 306 1009	2.3 A	5.0 mH	1–5	3+4+6+7+8+9+10	1
BVD EI 306 1010	1.9 A	10.0 mH	1–6	3+4+5+7+8+9+10	2
BVD EI 306 1011	1.5 A	15.0 mH	1–5	3+4+6+7+8+9+10	1
BVD EI 306 1012	1.3 A	20.0 mH	1–5	3+4+6+7+8+9+10	1

HAHN

Mains chokes (PFC)

Inductivity: 1.0–15.0 mH
Nominal current: max. 4.7 A

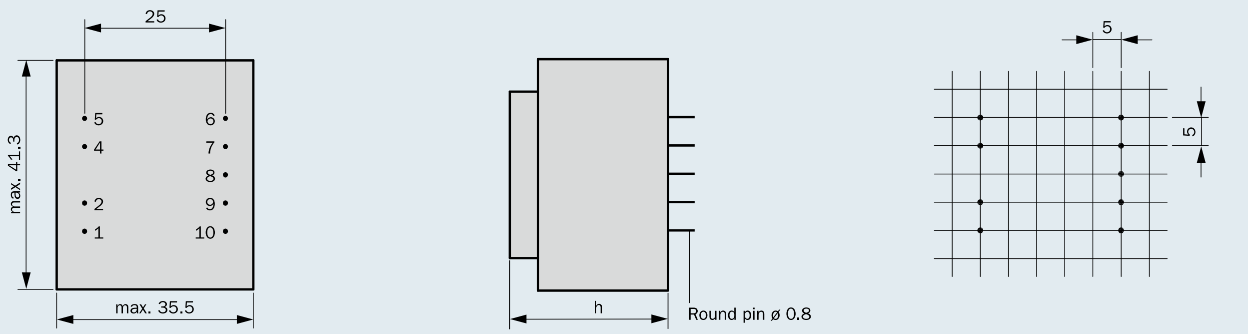
EI 38

10	DIN EN 61558-2-20 DIN EN 62041	VDE	on request
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	102961/84814
UL	UL 1446	UL	E237745

- according to REACH regulation
- according to RoHs regulation

- Excellent temperature fluctuation resistance properties
- High electrical safety and long service-life features
- High voltage resistance to core
- Per item tested quality with certificate
- For the standard version with cast housing "0": Self-extinguishing cast housing and sealing material

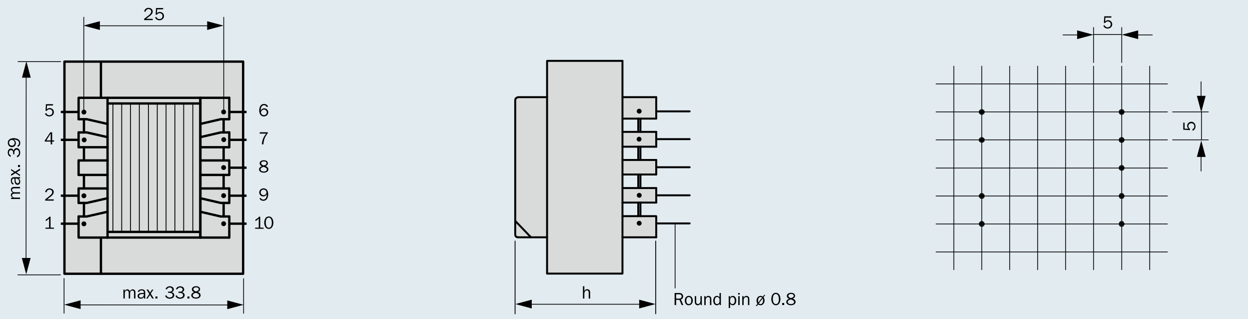
Connecting pins Type cast housing "0"



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

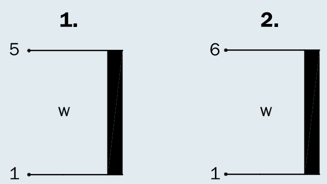
Connecting pins Type open



View looking onto pins

Dimensions without tolerances ± 0.3 mm,
rights to make alterations and improvements hereby reserved

Connection scheme



Frame size/Core height	Nominal current ta 70 °C	Height (h)	Weight	Packaging unit
BVD EI 382 1... /13.6 mm	max. 4.7 A	max. 28.6 mm	0.165 kg	30 pieces
BVD EI 382 0... /13.6 mm	max. 4.4 A	max. 26.9 mm	0.140 kg	30 pieces

Mains chokes (PFC)

Inductivity: 1.0–15.0 mH

Nominal current: max. 4.7 A

EI 38

Type cast housing "O"

ta 70 °C/B

Frame size/Core height **BVD EI 382 1.../ 13.6 mm**

vacuum-encapsulated

Order No.	Nominal current	Nominal inductivity	Connecting pins	Not connected pins	Connection scheme
BVD EI 382 1001	4.7 A	1.0 mH	1–6	2+4+5+7+8+9+10	1
BVD EI 382 1002	4.7 A	1.5 mH	1–5	2+4+6+7+8+9+10	2
BVD EI 382 1003	4.0 A	2.0 mH	1–5	2+4+6+7+8+9+10	2
BVD EI 382 1004	2.2 A	2.5 mH	1–6	2+4+5+7+8+9+10	1
BVD EI 382 1005	2.2 A	3.0 mH	1–6	2+4+5+7+8+9+10	1
BVD EI 382 1006	2.2 A	3.5 mH	1–5	2+4+6+7+8+9+10	2
BVD EI 382 1007	3.2 A	4.0 mH	1–6	2+4+5+7+8+9+10	1
BVD EI 382 1008	2.8 A	4.5 mH	1–6	2+4+5+7+8+9+10	1
BVD EI 382 1009	2.7 A	5.0 mH	1–6	2+4+5+7+8+9+10	1
BVD EI 382 1010	2.0 A	10.0 mH	1–5	2+4+6+7+8+9+10	2
BVD EI 382 1011	1.5 A	15.0 mH	1–6	2+4+5+7+8+9+10	1

Type open

ta 70 °C/F

Frame size/Core height **BVD EI 382 0.../ 13.6 mm**

open, vacuum-impregnated

Order No.	Nominal current	Nominal inductivity	Connecting pins	Not connected pins	Connection scheme
BVD EI 382 0001	4.4 A	1.0 mH	1–6	2+4+5+7+8+9+10	1
BVD EI 382 0002	4.4 A	1.5 mH	1–5	2+4+6+7+8+9+10	2
BVD EI 382 0003	3.5 A	2.0 mH	1–5	2+4+6+7+8+9+10	2
BVD EI 382 0004	2.1 A	2.5 mH	1–6	2+4+5+7+8+9+10	1
BVD EI 382 0005	2.0 A	3.0 mH	1–6	2+4+5+7+8+9+10	1
BVD EI 382 0006	2.0 A	3.5 mH	1–5	2+4+6+7+8+9+10	2
BVD EI 382 0007	2.8 A	4.0 mH	1–6	2+4+5+7+8+9+10	1
BVD EI 382 0008	2.4 A	4.5 mH	1–6	2+4+5+7+8+9+10	1
BVD EI 382 0009	2.3 A	5.0 mH	1–6	2+4+5+7+8+9+10	1
BVD EI 382 0010	1.7 A	10.0 mH	1–5	2+4+6+7+8+9+10	2
BVD EI 382 0011	1.4 A	15.0 mH	1–6	2+4+5+7+8+9+10	1

Mains chokes (PFC)

Inductivity: 1.0–20.0 mH
Nominal current: max. 5.9 A

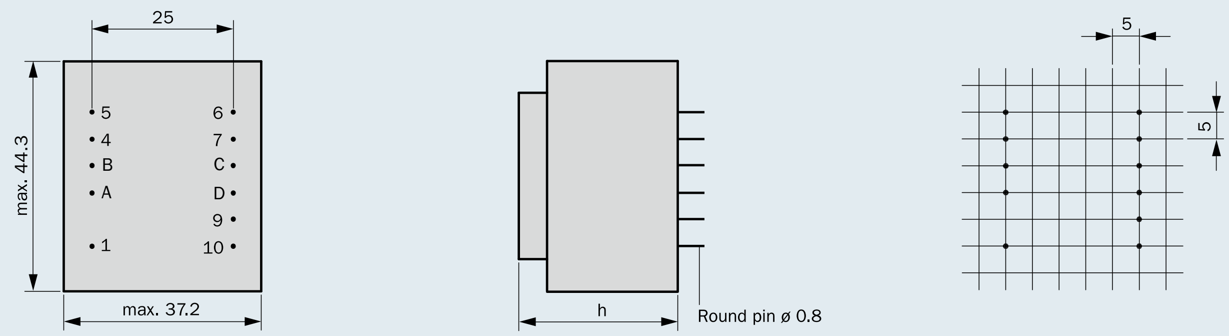
EI 42

ENEC 10, VDE	DIN EN 61558-2-20 DIN EN 62041	VDE	on request
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	102961/84814
UL	UL 1446	UL	E237745

- according to REACH regulation
- according to RoHs regulation

- Excellent temperature fluctuation resistance properties
- High electrical safety and long service-life features
- High voltage resistance to core
- Per item tested quality with certificate
- For the standard version with cast housing “0”: Self-extinguishing cast housing and sealing material

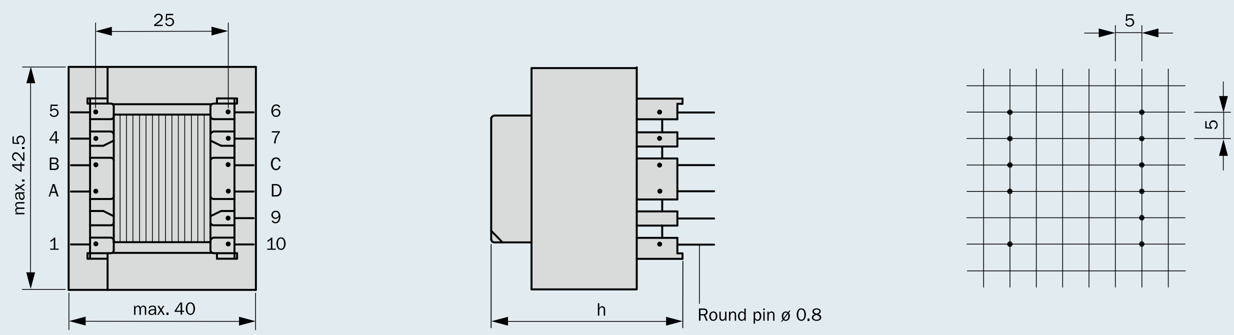
Connecting pins Type cast housing “0”



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

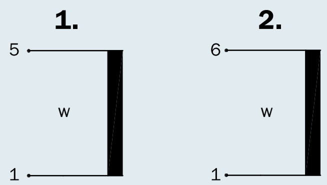
Connecting pins Type open



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme



Frame size/Core height	Nominal current ta 70 °C	Height (h)	Weight	Packaging unit
BVD EI 423 1... /20.0 mm	max. 5.9 A	max. 38.3 mm	0.270 kg	30 pieces
BVD EI 423 0... /20.0 mm	max. 5.0 A	max. 36.3 mm	0.235 kg	28 pieces

HAHN

Mains chokes (PFC)

Inductivity: 1.0–20.0 mH

Nominal current: max. 5.9 A

EI 42

Type cast housing “O”

ta 70 °C/B

Frame size/Core height
**BVD EI 423 1.../
20.0 mm**

vacuum-encapsulated

Order No.	Nominal current	Nominal inductivity	Connecting pins	Not connected pins	Connection scheme
BVD EI 423 1001	5.9 A	1.0 mH	1–6	A+B+4+5+7+C+D+9+10	2
BVD EI 423 1002	5.9 A	1.5 mH	1–6	A+B+4+5+7+C+D+9+10	2
BVD EI 423 1003	5.2 A	2.0 mH	1–6	A+B+4+5+7+C+D+9+10	2
BVD EI 423 1004	4.5 A	2.5 mH	1–6	A+B+4+5+7+C+D+9+10	2
BVD EI 423 1005	4.5 A	3.0 mH	1–5	A+B+4+6+7+C+D+9+10	1
BVD EI 423 1006	4.4 A	3.5 mH	1–5	A+B+4+6+7+C+D+9+10	1
BVD EI 423 1007	4.4 A	4.0 mH	1–5	A+B+4+6+7+C+D+9+10	1
BVD EI 423 1008	4.0 A	4.5 mH	1–5	A+B+4+6+7+C+D+9+10	1
BVD EI 423 1009	4.0 A	5.0 mH	1–5	A+B+4+6+7+C+D+9+10	1
BVD EI 423 1010	2.9 A	10.0 mH	1–6	A+B+4+5+7+C+D+9+10	2
BVD EI 423 1011	2.4 A	15.0 mH	1–5	A+B+4+6+7+C+D+9+10	1
BVD EI 423 1012	2.0 A	20.0 mH	1–5	A+B+4+6+7+C+D+9+10	1

Type open

ta 70 °C/F

Frame size/Core height
**BVD EI 423 0.../
20.0 mm**

open,
vacuum-impregnated

Order No.	Nominal current	Nominal inductivity	Connecting pins	Not connected pins	Connection scheme
BVD EI 423 0001	5.0 A	1.0 mH	1–6	A+B+4+5+7+C+D+9+10	2
BVD EI 423 0002	5.0 A	1.5 mH	1–6	A+B+4+5+7+C+D+9+10	2
BVD EI 423 0003	4.6 A	2.0 mH	1–6	A+B+4+5+7+C+D+9+10	2
BVD EI 423 0004	3.9 A	2.5 mH	1–6	A+B+4+5+7+C+D+9+10	2
BVD EI 423 0005	3.9 A	3.0 mH	1–5	A+B+4+6+7+C+D+9+10	1
BVD EI 423 0006	3.7 A	3.5 mH	1–5	A+B+4+6+7+C+D+9+10	1
BVD EI 423 0007	3.7 A	4.0 mH	1–5	A+B+4+6+7+C+D+9+10	1
BVD EI 423 0008	3.3 A	4.5 mH	1–5	A+B+4+6+7+C+D+9+10	1
BVD EI 423 0009	3.3 A	5.0 mH	1–5	A+B+4+6+7+C+D+9+10	1
BVD EI 423 0010	2.5 A	10.0 mH	1–6	A+B+4+5+7+C+D+9+10	2
BVD EI 423 0011	2.1 A	15.0 mH	1–5	A+B+4+6+7+C+D+9+10	1
BVD EI 423 0012	2.0 A	20.0 mH	1–5	A+B+4+6+7+C+D+9+10	1

Mains chokes (PFC)

Inductivity: 1.0–20.0 mH
Nominal current: max. 8.7 A

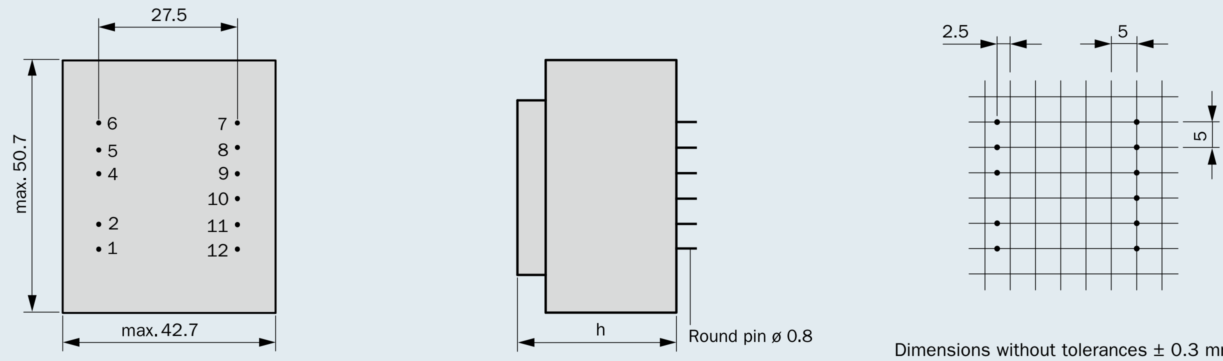
EI 48

	DIN EN 61558-2-20 DIN EN 62041	VDE	on request
VDE-Mark for Glow-Wire-Test	DIN EN 60 335-1	VDE	102961/84814
	UL 1446	UL	E237745

- according to REACH regulation
- according to RoHs regulation

- Excellent temperature fluctuation resistance properties
- High electrical safety and long service-life features
- High voltage resistance to core
- Per item tested quality with certificate
- For the standard version with cast housing "0": Self-extinguishing cast housing and sealing material

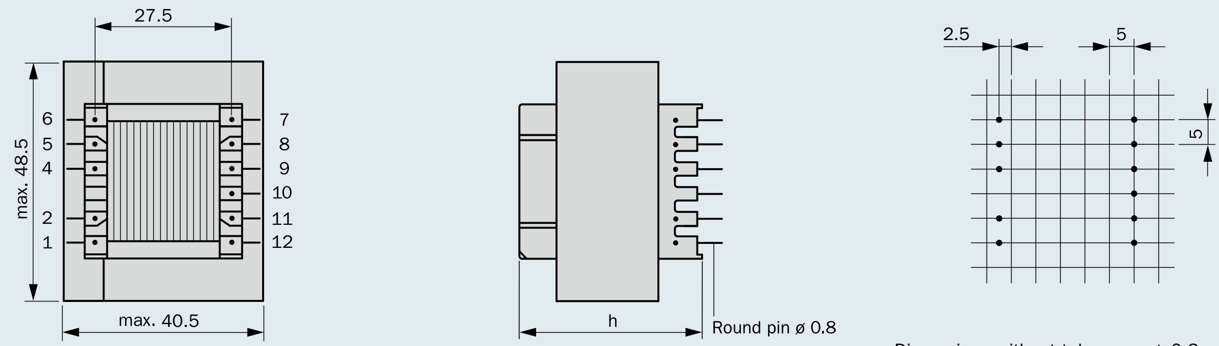
Connecting pins Type cast housing "0"



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

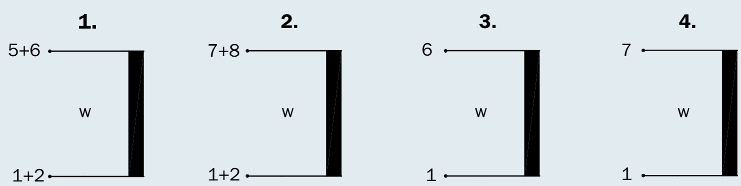
Connecting pins Type open



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme



Frame size/Core height	Nominal current ta 70 °C	Height (h)	Weight	Packaging unit
BVD EI 482 1... /20.5 mm	max. 8.7 A	max. 39.0 mm	0.360 kg	20 pieces
BVD EI 482 0... /20.5 mm	max. 7.9 A	max. 37.3 mm	0.315 kg	20 pieces

HAHN

Mains chokes (PFC)

Inductivity: 1.0–20.0 mH
Nominal current: max. 8.7 A

Type cast housing "O"

ta 70 °C/B

Frame size/Core height
BVD EI 482 1.../ 20.5 mm

vacuum-encapsulated

Order No.	Nominal current	Nominal inductivity	Connecting pins	Not connected pins	Connection scheme
BVD EI 482 1001	8.7 A	1.0 mH	1/2–5/6	4+7+8+9+10+11+12	1
BVD EI 482 1002	7.8 A	1.5 mH	1/2–7/8	4+5+6+9+10+11+12	2
BVD EI 482 1003	6.8 A	2.0 mH	1–7	2+4+5+6+8+9+10+11+12	4
BVD EI 482 1004	5.6 A	2.5 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 1005	5.5 A	3.0 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 1006	4.7 A	3.5 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 1007	4.4 A	4.0 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 1008	4.4 A	4.5 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 1009	4.2 A	5.0 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 1010	3.0 A	10.0 mH	1–7	2+4+5+6+8+9+10+11+12	4
BVD EI 482 1011	2.5 A	15.0 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 1012	2.2 A	20.0 mH	1–6	2+4+5+7+8+9+10+11+12	3

Type open

ta 70 °C/F

Frame size/Core height
BVD EI 482 0.../ 20.5 mm

open,
vacuum-impregnated

Order No.	Nominal current	Nominal inductivity	Connecting pins	Not connected pins	Connection scheme
BVD EI 482 0001	7.9 A	1.0 mH	1/2–5/6	4+7+8+9+10+11+12	1
BVD EI 482 0002	7.3 A	1.5 mH	1/2–7/8	4+5+6+9+10+11+12	2
BVD EI 482 0003	6.0 A	2.0 mH	1–7	2+4+5+6+8+9+10+11+12	4
BVD EI 482 0004	5.0 A	2.5 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 0005	5.0 A	3.0 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 0006	4.2 A	3.5 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 0007	3.9 A	4.0 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 0008	3.9 A	4.5 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 0009	3.9 A	5.0 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 0010	2.7 A	10.0 mH	1–7	2+4+5+6+8+9+10+11+12	4
BVD EI 482 0011	2.3 A	15.0 mH	1–6	2+4+5+7+8+9+10+11+12	3
BVD EI 482 0012	2.0 A	20.0 mH	1–6	2+4+5+7+8+9+10+11+12	3

Mains chokes (PFC)

Inductivity: 1.0 – 20.0 mH

Nominal current: max. 7.7 A

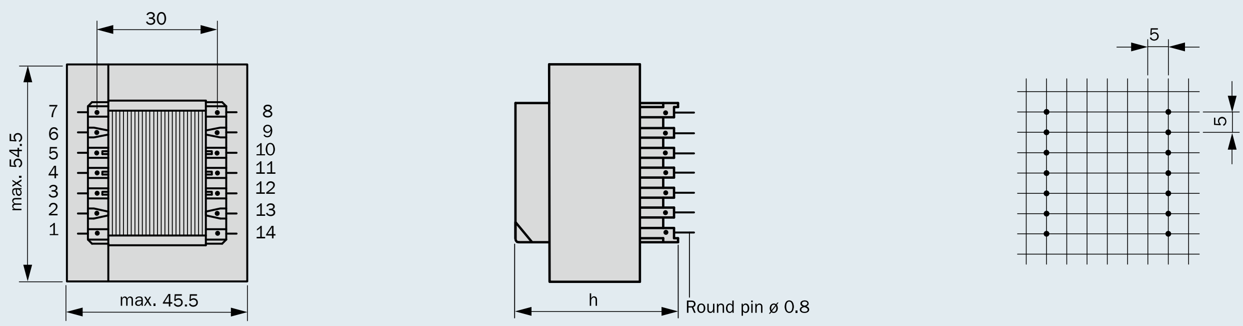
EI 54

10	**DIN EN 61558-2-20** **DIN EN 62041**	**VDE**	on request
VDE-Mark for Glow-Wire-Test	**DIN EN 60 335-1**	**VDE**	102961/84814
	UL 1446	**UL**	E237745

- according to REACH regulation
- according to RoHs regulation

- Excellent temperature fluctuation resistance properties
- High electrical safety and long service-life features
- High voltage resistance to core
- Per item tested quality with certificate

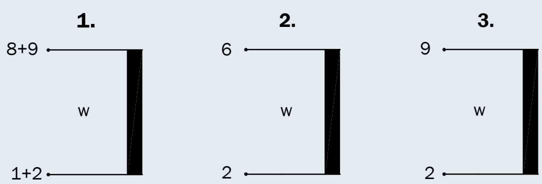
Connecting pins Type open



View looking onto pins

Dimensions without tolerances ± 0.3 mm, rights to make alterations and improvements hereby reserved

Connection scheme



Frame size/Core height	Nominal current ta 70 °C	Height (h)	Weight	Packaging unit
BVD EI 542 0... /23.0 mm	max. 7.7 A	max. 42.3 mm	0.440 kg	15 pieces

Mains chokes (PFC)

Inductivity: 1.0–20.0 mH

Nominal current: max. 7.7 A

EI 54

Type open

ta 70 °C/F

Frame size/Core height
BVD EI 542 0…/ 23.0 mm

open, vacuum-impregnated

Order No.	Nominal current	Nominal inductivity	Connecting pins	Not connected pins	Connection scheme
BVD EI 542 0001	7.7 A	1.0 mH	1/2–8/9	3+4+5+6+7+10+11+12+13+14	1
BVD EI 542 0002	6.3 A	1.5 mH	1/2–8/9	3+4+5+6+7+10+11+12+13+14	1
BVD EI 542 0003	5.5 A	2.0 mH	2–6	1+3+4+5+7+8+9+10+11+12+13+14	2
BVD EI 542 0004	5.5 A	2.5 mH	2–6	1+3+4+5+7+8+9+10+11+12+13+14	2
BVD EI 542 0005	5.1 A	3.0 mH	2–6	1+3+4+5+7+8+9+10+11+12+13+14	2
BVD EI 542 0006	4.5 A	3.5 mH	2–6	1+3+4+5+7+8+9+10+11+12+13+14	2
BVD EI 542 0007	4.1 A	4.0 mH	2–6	1+3+4+5+7+8+9+10+11+12+13+14	2
BVD EI 542 0008	3.9 A	4.5 mH	2–9	1+3+4+5+6+7+8+10+11+12+13+14	3
BVD EI 542 0009	3.9 A	5.0 mH	2–9	1+3+4+5+6+7+8+10+11+12+13+14	3
BVD EI 542 0010	3.0 A	10.0 mH	2–6	1+3+4+5+7+8+9+10+11+12+13+14	3
BVD EI 542 0011	2.5 A	15.0 mH	2–6	1+3+4+5+7+8+9+10+11+12+13+14	2
BVD EI 542 0012	2.0 A	20.0 mH	2–9	1+3+4+5+6+7+8+10+11+12+13+14	3

Content

Special solutions

- Electrical Power Supply Facilities / Supply units
- Transformers Top-Hat-Rail Fixtures EI 48 – EI 78
- Transformers in open version, vacuum impregnated version
- Customer-specific winding goods / Fine-wire-coils

Electrical Power Supply Facilities / Supply units

Safety coupled with HAHN quality for your applications!
Should you need an AC or DC power supply?
These are available from HAHN with integrated components (residual ripple < = 5 %).

Today, our flexible production allows us to make transformers both with and without rectification. Special safeguards protect your products in line with the stringent requirements of VDE/ENEC and UL. Our highly qualified and experienced HAHN developers coupled with our own tooling facility guarantee rapid and economic solutions for you.

Our technical superiority, comprehensive Quality Management and interim testing programs for each individual component guarantee reliable functionality.

Our highly flexible production concept, proven technology and product experience makes it possible to fulfill and technically implement practically any individual requirements you may have along with the amounts you require.

Transformers both with and without secure insulation, automatic transformers and unregulated power supplies round off the HAHN product range. Our own development and production within Europe guarantee solutions with optimal customer benefits.

Electrical Power Supply Facilities / Supply units

Custom-made bunch of cables

- Vacuum-encapsulated, dual chamber windings
- Excellent temperature fluctuation reactivity
- Highest degrees of safety and durability
- High degree of voltage-leak resistance
- Self-extinguishing cast housing and sealing material
- Per item tested quality with certificate
- Transformers conform to European Standard DIN EN 61558 and UL 1310

Fuse elements

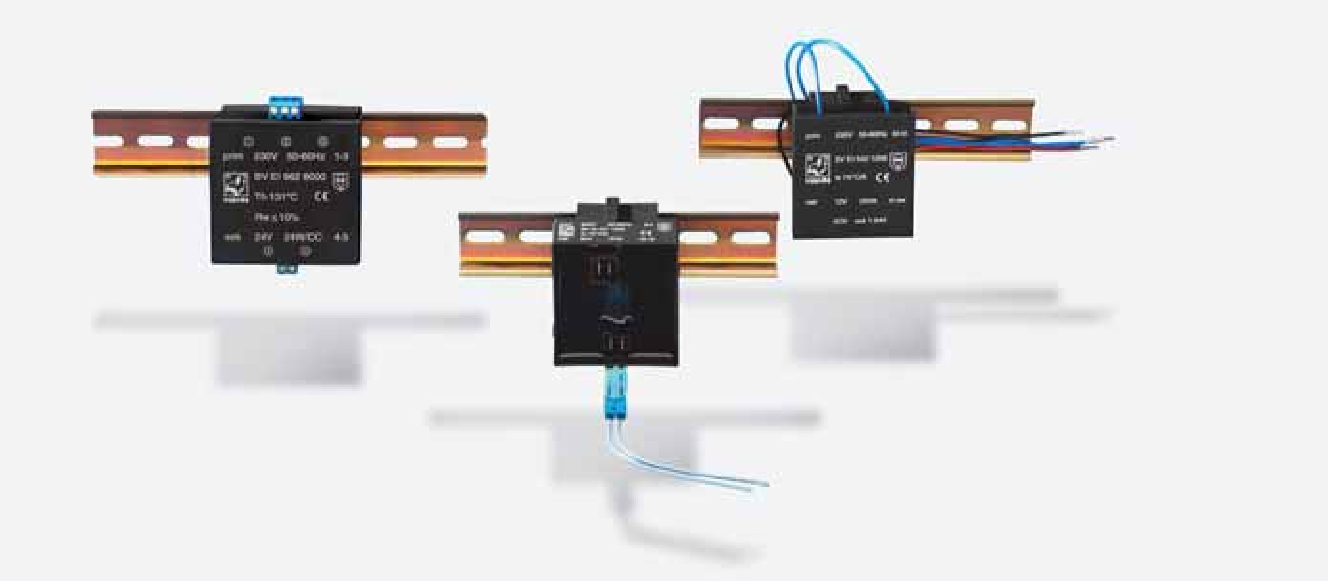
Following supply connector variants are possible
- Flat plugs
- Rast 5
- Terminal blocks
- Custom-made connectors

Rectifier units

	Frame size	Output Power (max.)	Dimensions (axbxh)
AC	EI 48	12.0 W* / ta 70 °C/B	
DC	EI 48	6.0 VA* / ta 40 °C/B	
AC	EI 54	20.0 VA* / ta 70 °C/B	60x64x52
DC	EI 54	10.0 W* / ta 40 °C/B	60x64x52
AC	EI 60	30.0 VA* / ta 70 °C/B	66x67x60
DC	EI 60	16.0 W* / ta 40 °C/B	66x67x60
AC	EI 66	47.0 VA* / ta 70 °C/B	72x70x66
DC	EI 66	24.0 W* / ta 40 °C/B	72x70x66
AC	EI 78	60.0 VA* / ta 70 °C/B	84x76x74
DC	EI 78	40.0 W* / ta 40 °C/B	84x76x74
AC	EI 84	100.0 VA* / ta 70 °C/B	91x80x79
DC	EI 84	50.0 W* / ta 40 °C/B	91x80x79

* dependent on types of supply connection and circuit breaking facilities

Transformers for Top-Hat-Rail Fixtures



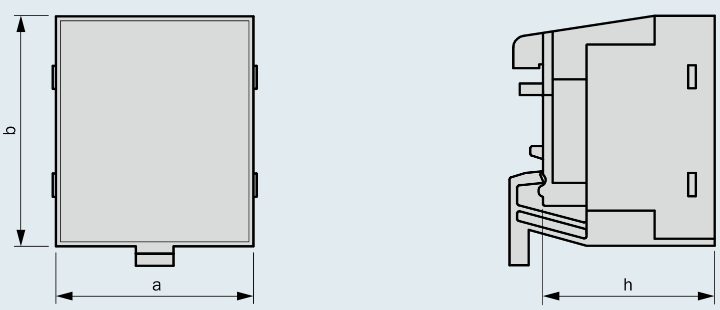
- Vacuum-encapsulated, dual chamber windings
- Excellent temperature fluctuation reactivity
- Highest degrees of safety and durability
- High degree of voltage-leak resistance
- self-extinguishing sealing material
- Per item tested quality with certificate
- Transformers conform to European Standard DIN EN 61558

Following supply connector variants are possible
- Flat plugs
- Rast 5
- Terminal blocks
- Custom-made connectors

HAHN quality now available for switchgear cabinets and domestic supply services
HAHN transformers are suitable for mounting in switchgear cabinets with the application of special encapsulation bonnets complying with German Industrial and European Standard: DIN EN 50 022 and equipped with snap-on fixtures. These encapsulated transformers stand for optimal durability and a rapid simplified mounting for such facilities.

Ongoing quality control – even at the level of components – as well as 100 % piece verification ensures the highest degree of quality from the HAHN works.

Connecting pins version RAST 5

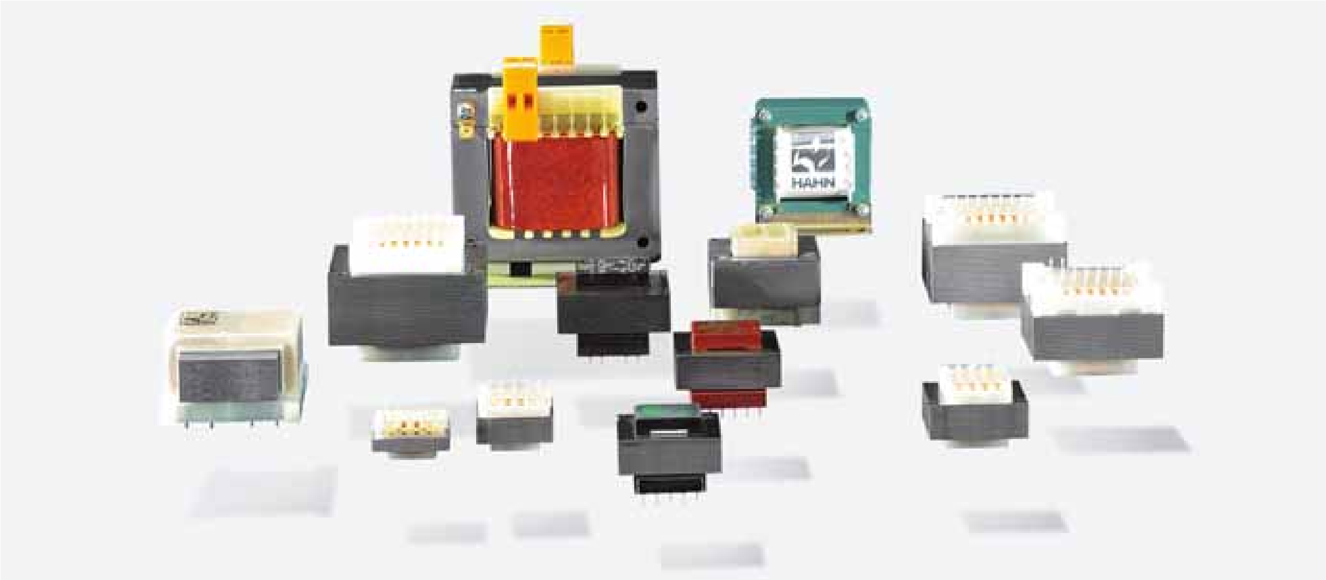


Dimensions without tolerance indications ± 1 mm

Frame Size	Output Power ta 70 °C/B	Dimensions (a x b x h)
EI 48	12.0 VA*	max. 53.8 x 61.1 x 45
EI 54	20.0 VA*	max. 59.7 x 64.2 x 52
EI 60	30.0 VA*	max. 66.2 x 67.1 x 60
EI 66	47.0 VA*	max. 72.2 x 70.1 x 66
EI 78	60.0 VA*	max. 84.7 x 78.6 x 74

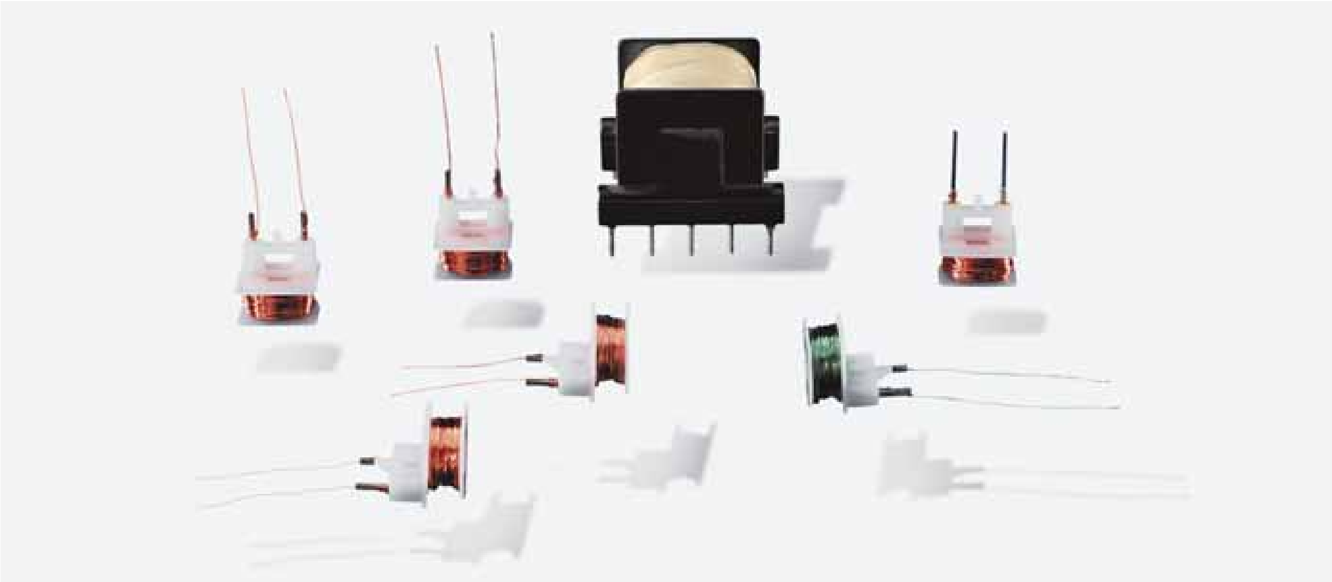
* dependent on types of supply connection and circuit breaking facilities

Transformers in open version, vacuum impregnated version



Open single-phase transformers for the power supply of appliances and assemblies. For applications with restricted spacing, HAHN's unsealed transformers are a real alternative. New versions have been introduced by reducing the casing volume. Reduced weights lead to reduced costs and can be realized in the form of printed circuit transformers, size EI 30 – EI 96 as well as UI 30 – UI 48. Applications for switch cabinets can be fitted with the sizes EI 60 – EI 150. Attachment facilities with angle pieces for top-hat rails are available. Impregnation with resin protects the unit against environmental impingements. The use of dual chamber bobbin windings guarantees an electrically safe galvanic separation to VDE 0570/DIN EN 61 558 regulations. The materials employed meet insulation class B (130 °C) minimum. Class F (155 °C) is also available on request.

Customer-specific winding goods / Fine-wire-coils



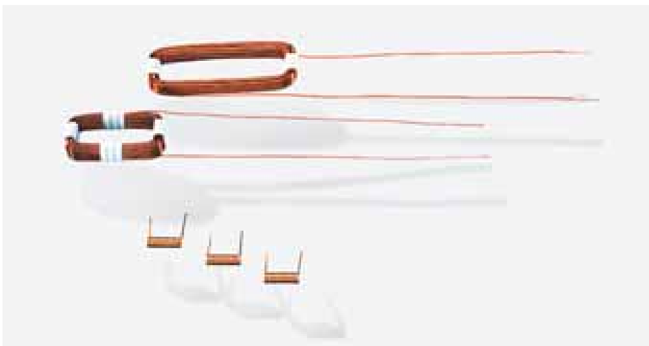
HAHN has gained a niche in the market as a reliable supplier of application-oriented special transformer coils. Our customer contact staff are exceedingly well motivated and contribute extensively to the success of the business.

HAHN is already able to produce special transformer coils in all the various constructions types to consumer specifications.

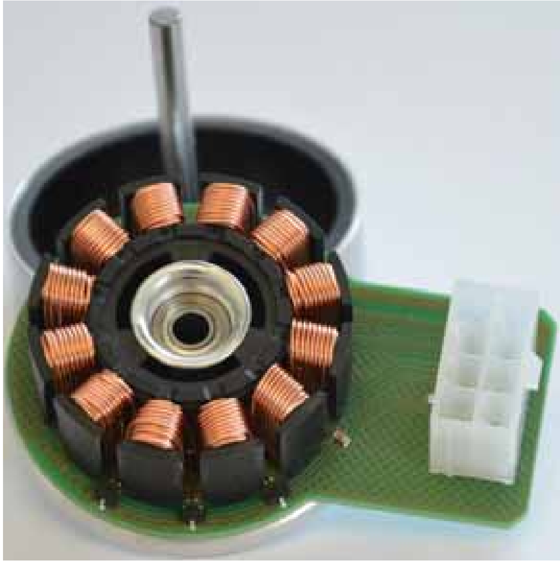
HAHN will work together with the customer to develop all manner of applications to obtain an appropriate and viable problem solution. The high grade quality of HAHN products and the readiness of the HAHN organisation to provide an appropriate customer service are also contributions to the success of the business.

HAHN's secret lies in the employment of optimised components and the consequent exploitation inherent in the possibilities of hi-tech manufacturing. This enables specialty components in high grade quality to be produced in conjunction with many years of close collaboration with its subcontractors and suppliers as well as the benefit of flexible manufacturing facilities. HAHN's experienced research and development department and its special in-house tooling facility are guarantees for rapid and economic problem solutions straight from the HAHN works.

No matter whether small amounts or large volumes – the highly flexible manufacturing concept with extensively automated production equipment – makes it possible to meet practically any consumer requirement and to implement this materially and technically; and, this not only in a highly economic manner but also on a short-term basis.



Pole coil winding goods for BLDC motor



The BLDC motor (brushless DC motor) is constructed as a three-phase synchronous machine whose efficiency exceeds 85%. It is characterized by its long life and smooth running.

Applications of BLDC are e.g. drives for fans and household appliances and compressors, model airplanes, electric actuator in the form of servo motors to drive systems for machine tools.

In addition, the BLDC motor meets the ErP guidelines. It is used for establishing requirements for the eco-design of energy related products (ERP).
This is what brings the efficiency of energy of motors, with regard to the environment and soaring energy costs, more and more into focus.

The energy efficiency of engines can be improved by:

- The use of dynamo sheet with improved magnetic properties
- Improving the cooling in the engine
- Reduction of production tolerances
- **Reduction of losses in the pole windings by Optimization of winding structure / winding execution**

With regard to the last point, the winding task, HAHN can rely on over 45 years of experience in production of coiled products.
From the beginning, HAHN relies on high product quality, innovation and progressive, solid expansion of production.

HAHN is distributing more than 100,000 pieces per day worldwide.

Due to our supportive development activity, we have experience in the coil construction, which is of significant importance for new developments. Together with our customers we bring this experience into their new projects in the field of coil design for BLDC motors.

In order to improve and realize the projects of our customers professionally, our R & D department and our technical support team of HAHN are available at any time.

Content

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- Your partner in charge abroad

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LM340, LM340A and LM7805 Family Wide V_{IN} 1.5-A Fixed Voltage Regulators

1 Features

- Output Current up to 1.5 A
- Available in Fixed 5-V, 12-V, and 15-V Options
- Output Voltage Tolerances of ±2% at T_J = 25°C (LM340A)
- Line Regulation of 0.01% / V of at 1-A Load (LM340A)
- Load Regulation of 0.3% / A (LM340A)
- Internal Thermal Overload, Short-Circuit and SOA Protection
- Available in Space-Saving SOT-223 Package
- Output Capacitance Not Required for Stability

2 Applications

- Industrial Power Supplies
- SMPS Post Regulation
- HVAC Systems
- AC Inventors
- Test and Measurement Equipment
- Brushed and Brushless DC Motor Drivers
- Solar Energy String Invertors

3 Description

The LM340 and LM7805 Family monolithic 3-terminal positive voltage regulators employ internal current-limiting, thermal shutdown and safe-area compensation, making them essentially indestructible. If adequate heat sinking is provided, they can deliver over 1.5-A output current. They are intended as fixed voltage regulators in a wide range of applications including local (on-card) regulation for elimination of noise and distribution problems associated with single-point regulation. In addition to use as fixed voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents.

Considerable effort was expended to make the entire series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

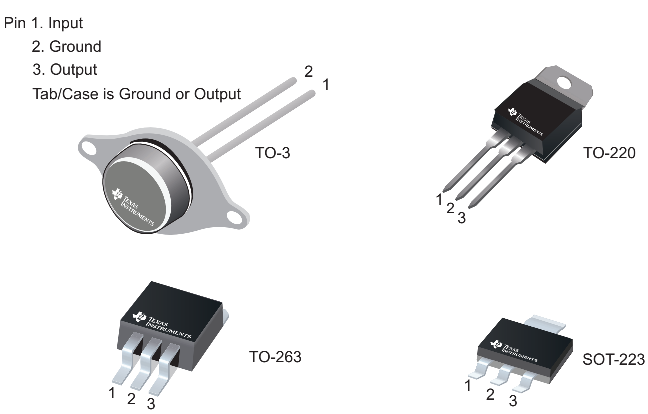
LM7805 is also available in a higher accuracy and better performance version (LM340A). Refer to LM340A specifications in the *LM340A Electrical Characterisitcs* table.

Device Information(1)

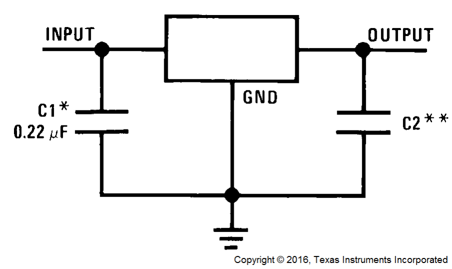
PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM340x LM7805 Family	DDPAK/TO-263 (3)	10.18 mm × 8.41 mm
	SOT-223 (4)	6.50 mm × 3.50 mm
	TO-220 (3)	14.986 mm × 10.16 mm
	TO-3 (2)	38.94 mm x 25.40 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Available Packages



Fixed Output Voltage Regulator



*Required if the regulator is located far from the power supply filter.
**Although no output capacitor is needed for stability, it does help transient response. (If needed, use 0.1-μF, ceramic disc).

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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

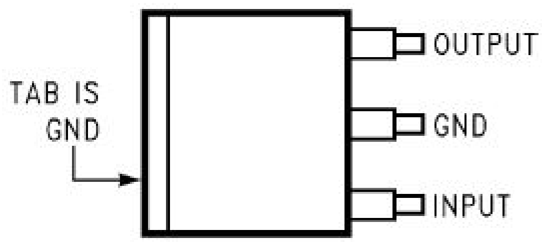
Changes from Revision K (November 2015) to Revision L	Page
• Changed pinout number order for the TO-220 and SOT-223 packages from: 2, 3, 1 to: 1, 2, 3	1

Changes from Revision J (December 2013) to Revision K	Page
• Added *ESD Ratings* table, *Thermal Information* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section	1
• Deleted obsolete LM140 and LM7808C devices from the data sheet	1
• Changed Figure 13 caption from *Line Regulation 140AK-5.0* to *Line Regulation LM340,*	11
• Changed Figure 14 caption from *Line Regulation 140AK-5.0* to *Line Regulation LM340,*	11

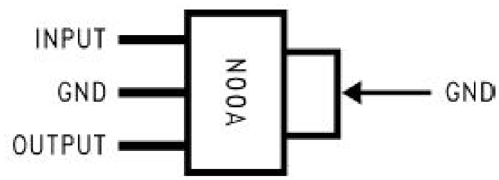
Changes from Revision I (March 2013) to Revision J	Page
• Changed 0.5 from typ to max	5

5 Pin Configuration and Functions

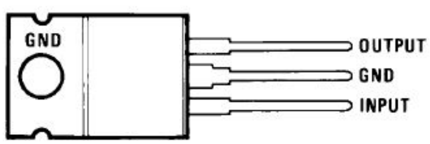
LM7805 and LM7812 KTT Package
3-Pin DDPAK/TO-263
Top View



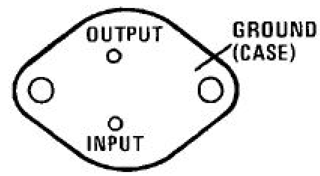
LM7805 DCY Package
4-Pin SOT-223
Side View



LM7805, LM7812, and LM7815 NDE Package
3-Pin TO-220
Top View



LM340K-5.0 NDS Package
2-Pin TO-3
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
INPUT	1	I	Input voltage pin
GND	2	I/O	Ground pin
OUTPUT	3	O	Output voltage pin

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1) (2)

		MIN	MAX	UNIT
DC input voltage			35	V
Internal power dissipation(3)		Internally Limited		
Maximum junction temperature			150	°C
Lead temperature (soldering, 10 sec.)	TO-3 package (NDS)		300	°C
	Lead temperature 1,6 mm (1/16 in) from case for 10 s		230	°C
Storage temperature		−65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.

(3) The maximum allowable power dissipation at any ambient temperature is a function of the maximum junction temperature for operation (T_{JMAX} = 125°C or 150°C), the junction-to-ambient thermal resistance (θ_{JA}), and the ambient temperature (T_A). $P_{DMAX} = (T_{JMAX} − T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature rises above T_{JMAX} and the electrical specifications do not apply. If the die temperature rises above 150°C, the device goes into thermal shutdown. For the TO-3 package (NDS), the junction-to-ambient thermal resistance (θ_{JA}) is 39°C/W. When using a heat sink, θ_{JA} is the sum of the 4°C/W junction-to-case thermal resistance (θ_{JC}) of the TO-3 package and the case-to-ambient thermal resistance of the heat sink. For the TO-220 package (NDE), θ_{JA} is 54°C/W and θ_{JC} is 4°C/W. If SOT-223 is used, the junction-to-ambient thermal resistance is 174°C/W and can be reduced by a heat sink (see Applications Hints on heat sinking).If the DDPAK\TO-263 package is used, the thermal resistance can be reduced by increasing the PCB copper area thermally connected to the package: Using 0.5 square inches of copper area, θ_{JA} is 50°C/W; with 1 square inch of copper area, θ_{JA} is 37°C/W; and with 1.6 or more inches of copper area, θ_{JA} is 32°C/W.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM)(1)	±2000	V

(1) ESD rating is based on the human-body model, 100 pF discharged through 1.5 kΩ.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
Temperature (T_A)	LM340A, LM340	0	125	°C

6.4 Thermal Information

THERMAL METRIC(1)		LM340, LM7805 Family				UNIT
		NDE (TO-220)	KTT (DDPAK/TO-263)	DCY (SOT-223)	NDS (TO-3)	
		3 PINS	3 PINS	4 PINS	2 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	23.9	44.8	62.1	39	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	16.7	45.6	44	2	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	5.3	24.4	10.7	—	°C/W
ψ_{JT}	Junction-to-top characterization parameter	3.2	11.2	2.7	—	°C/W
ψ_{JB}	Junction-to-board characterization parameter	5.3	23.4	10.6	—	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	1.7	1.5	—	—	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.

6.5 LM340A Electrical Characteristics, V_O = 5 V, V_I = 10 V

I_{OUT} = 1 A, 0°C ≤ T_J ≤ 125°C (LM340A) unless otherwise specified(1)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_O	Output voltage	T_J = 25°C		4.9	5	5.1	V
		P_D ≤ 15 W, 5 mA ≤ I_O ≤ 1 A 7.5 V ≤ V_{IN} ≤ 20 V		4.8		5.2	V
ΔV_O	Line regulation	7.5 V ≤ V_{IN} ≤ 20 V	T_J = 25°C		3	10	mV
			Over temperature, I_O = 500 mA			10	mV
		8 V ≤ V_{IN} ≤ 12 V	T_J = 25°C			4	mV
			Over temperature			12	mV
ΔV_O	Load regulation	T_J = 25°C	5 mA ≤ I_O ≤ 1.5 A		10	25	mV
			250 mA ≤ I_O ≤ 750 mA			15	mV
		Over temperature, 5 mA ≤ I_O ≤ 1 A				25	mV
I_Q	Quiescent current	T_J = 25°C				6	mA
		Over temperature				6.5	mA
ΔI_Q	Quiescent current change	T_J = 25°C, I_O = 1 A 7.5 V ≤ V_{IN} ≤ 20 V				0.8	mA
		Over temperature, 5 mA ≤ I_O ≤ 1 A				0.5	mA
		Over temperature, I_O = 500 mA 8 V ≤ V_{IN} ≤ 25 V				0.8	mA
V_N	Output noise voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz			40		µV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple rejection	f = 120 Hz 8 V ≤ V_{IN} ≤ 18 V	T_J = 25°C, , I_O = 1 A	68	80		dB
			Over temperature, I_O = 500 mA	68			dB
R_O	Dropout voltage	T_J = 25°C, I_O = 1 A			2		V
	Output resistance	f = 1 kHz			8		mΩ
	Short-circuit current	T_J = 25°C			2.1		A
	Peak output current	T_J = 25°C			2.4		A
	Average TC of V_O	Min, T_J = 0°C, I_O = 5 mA			−0.6		mV/°C
V_{IN}	Input voltage required to maintain line regulation	T_J = 25°C		7.5			V

(1) All characteristics are measured with a 0.22-µF capacitor from input to ground and a 0.1-µF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

6.6 LM340 / LM7805 Electrical Characteristics, V_O = 5 V, V_I = 10 V

0°C ≤ T_J ≤ 125°C unless otherwise specified[(1)]

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_O	Output voltage	T_J = 25°C, 5 mA ≤ I_O ≤ 1 A		4.8	5	5.2	V
		P_D ≤ 15 W, 5 mA ≤ I_O ≤ 1 A 7.5 V ≤ V_{IN} ≤ 20 V		4.75		5.25	V
ΔV_O	Line regulation	I_O = 500 mA	T_J = 25°C 7V ≤ V_{IN} ≤ 25V		3	50	mV
			Over temperature 8V ≤ V_{IN} ≤ 20V			50	mV
		I_O ≤ 1 A	T_J = 25°C 7.5V ≤ V_{IN} ≤ 20V			50	mV
			Over temperature 8V ≤ V_{IN} ≤ 12V			25	mV
ΔV_O	Load regulation	T_J = 25°C	5 mA ≤ I_O ≤ 1.5 A		10	50	mV
			250 mA ≤ I_O ≤ 750 mA			25	mV
		Over temperature, 5 mA ≤ I_O ≤ 1 A				50	mV
I_Q	Quiescent current	I_O ≤ 1 A	T_J = 25°C			8	mA
			Over temperature			8.5	mA
ΔI_Q	Quiescent current change	0°C ≤ T_J ≤ 125°C, 5 mA ≤ I_O ≤ 1 A			0.5		mA
		7 V ≤ V_{IN} ≤ 20 V	T_J = 25°C, I_O ≤ 1 A			1	mA
			Over temperature, I_O ≤ 500 mA			1	mA
V_N	Output noise voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz			40		µV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple rejection	f = 120 Hz 8 V ≤ V_{IN} ≤ 18 V	T_J = 25°C, I_O ≤ 1 A	62	80		dB
			Over temperature, I_O ≤ 500 mA	62			dB
R_O	Dropout voltage	T_J = 25°C, I_O = 1 A			2		V
	Output resistance	f = 1 kHz			8		mΩ
	Short-circuit current	T_J = 25°C			2.1		A
	Peak output current	T_J = 25°C			2.4		A
	Average TC of V_{OUT}	Over temperature, I_O = 5 mA			−0.6		mV/°C
V_{IN}	Input voltage required to maintain line regulation	T_J = 25°C, I_O ≤ 1 A		7.5			V

(1) All characteristics are measured with a 0.22-µF capacitor from input to ground and a 0.1-µF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

6.7 LM340 / LM7812 Electrical Characteristics, V_O = 12 V, V_I = 19 V

0°C ≤ T_J ≤ 125°C unless otherwise specified(1)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_O	Output voltage	T_J = 25°C, 5 mA ≤ I_O ≤ 1 A		11.5	12	12.5	V
		P_D ≤ 15 W, 5 mA ≤ I_O ≤ 1 A 14.5 V ≤ V_{IN} ≤ 27 V		11.4		12.6	V
ΔV_O	Line regulation	I_O = 500 mA	T_J = 25°C 14.5V ≤ V_{IN} ≤ 30V		4	120	mV
			Over temperature 15V ≤ V_{IN} ≤ 27V			120	mV
		I_O ≤ 1 A	T_J = 25°C 14.6V ≤ V_{IN} ≤ 27V			120	mV
			Over temperature 16V ≤ V_{IN} ≤ 22V			60	mV
ΔV_O	Load regulation	T_J = 25°C	5 mA ≤ I_O ≤ 1.5 A		12	120	mV
			250 mA ≤ I_O ≤ 750 mA			60	mV
		Over temperature, 5 mA ≤ I_O ≤ 1 A				120	mV
I_Q	Quiescent current	I_O ≤ 1 A	T_J = 25°C			8	mA
			Over temperature			8.5	mA
ΔI_Q	Quiescent current change	5 mA ≤ I_O ≤ 1 A			0.5		mA
		T_J = 25°C, I_O ≤ 1 A 14.8 V ≤ V_{IN} ≤ 27 V				1	mA
		Over temperature, I_O ≤ 500 mA 14.5 V ≤ V_{IN} ≤ 30 V				1	mA
V_N	Output noise voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz			75		μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple rejection	f = 120 Hz 15 V ≤ V_{IN} ≤ 25 V	T_J = 25°C, I_O ≤ 1 A	55	72		dB
			Over temperature, I_O ≤ 500 mA,	55			dB
R_O	Dropout voltage	T_J = 25°C, I_O = 1 A			2		V
	Output resistance	f = 1 kHz			18		mΩ
	Short-circuit current	T_J = 25°C			1.5		A
	Peak output current	T_J = 25°C			2.4		A
	Average TC of V_{OUT}	Over temperature, I_O = 5 mA			−1.5		mV/°C
V_{IN}	Input voltage required to maintain line regulation	T_J = 25°C, I_O ≤ 1 A		14.6			V

(1) All characteristics are measured with a 0.22-μF capacitor from input to ground and a 0.1-μF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

6.8 LM340 / LM7815 Electrical Characteristics, V_O = 15 V, V_I = 23 V

0°C ≤ T_J ≤ 125°C unless otherwise specified (1)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_O	Output voltage	T_J = 25°C, 5 mA ≤ I_O ≤ 1 A		14.4	15	15.6	V
		P_D ≤ 15 W, 5 mA ≤ I_O ≤ 1 A 17.5 V ≤ V_{IN} ≤ 30 V		14.25		15.75	V
ΔV_O	Line regulation	I_O = 500 mA	T_J = 25°C 17.5 V ≤ V_{IN} ≤ 30 V		4	150	mV
			Over temperature 18.5 V ≤ V_{IN} ≤ 30 V			150	mV
		I_O ≤ 1 A	T_J = 25°C 17.7 V ≤ V_{IN} ≤ 30 V			150	mV
			Over temperature 20 V ≤ V_{IN} ≤ 26 V			75	mV
ΔV_O	Load regulation	T_J = 25°C	5 mA ≤ I_O ≤ 1.5 A		12	150	mV
			250 mA ≤ I_O ≤ 750 mA			75	mV
		Over temperature, 5 mA ≤ I_O ≤ 1 A,				150	mV
I_Q	Quiescent current	I_O ≤ 1 A	T_J = 25°C			8	mA
			Over temperature			8.5	mA
ΔI_Q	Quiescent current change	5 mA ≤ I_O ≤ 1 A				0.5	mA
		T_J = 25°C, I_O ≤ 1 A 17.9 V ≤ V_{IN} ≤ 30 V				1	mA
		Over temperature, I_O ≤ 500 mA 17.5 V ≤ V_{IN} ≤ 30 V				1	mA
V_N	Output noise voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz			90		μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple rejection	f = 120 Hz 18.5 V ≤ V_{IN} ≤ 28.5 V	T_J = 25°C, I_O ≤ 1 A	54	70		dB
			Over temperature, I_O ≤ 500 mA,	54			dB
R_O	Dropout voltage	T_J = 25°C, I_O = 1 A			2		V
	Output resistance	f = 1 kHz			19		mΩ
	Short-circuit current	T_J = 25°C			1.2		A
	Peak output current	T_J = 25°C			2.4		A
	Average TC of V_{OUT}	Over temperature, I_O = 5 mA			−1.8		mV/°C
V_{IN}	Input voltage required to maintain line regulation	T_J = 25°C, I_O ≤ 1 A		17.7			V

(1) All characteristics are measured with a 0.22-μF capacitor from input to ground and a 0.1-μF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

6.9 Typical Characteristics

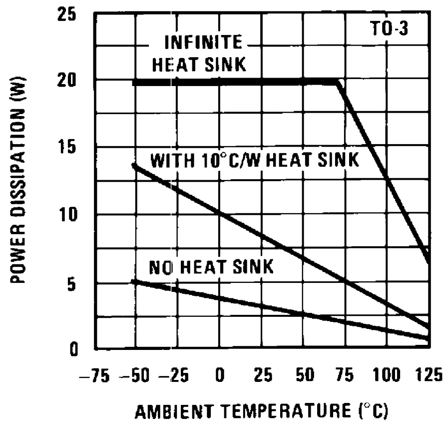


Figure 1. Maximum Average Power Dissipation

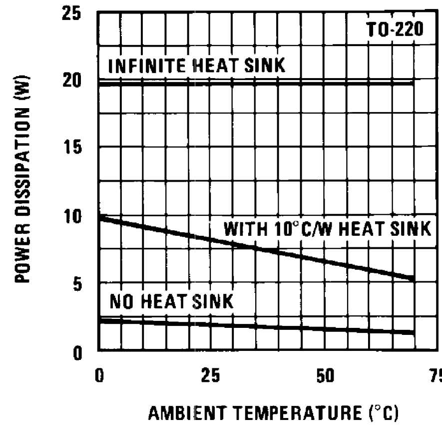


Figure 2. Maximum Average Power Dissipation

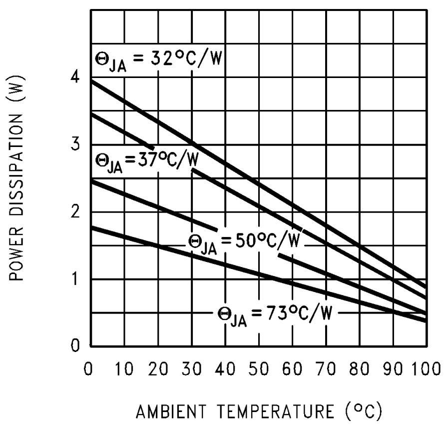
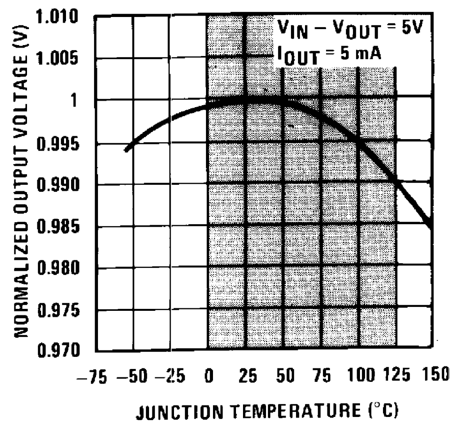


Figure 3. Maximum Power Dissipation (DDPAK/TO-263)



Shaded area refers to LM340A/LM340, LM7805, LM7812 and LM7815.

Figure 4. Output Voltage (Normalized to 1 V at T_J = 25°C)

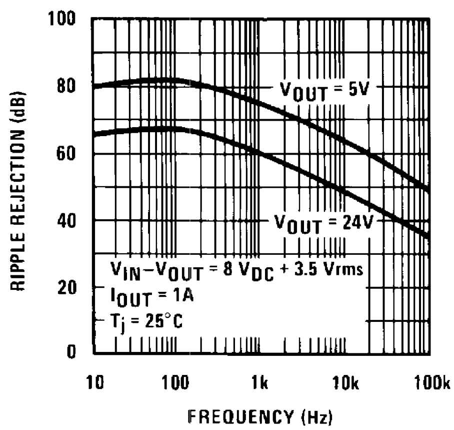


Figure 5. Ripple Rejection

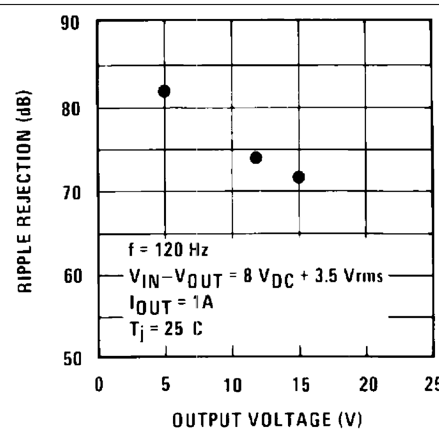


Figure 6. Ripple Rejection

Typical Characteristics (continued)

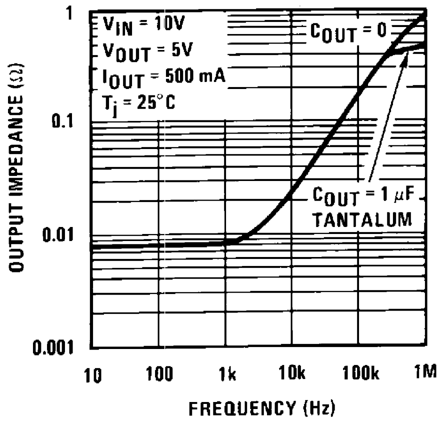


Figure 7. Output Impedance

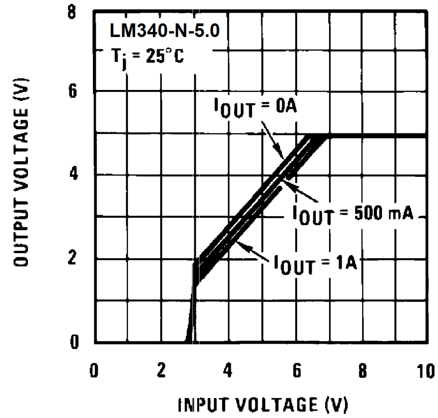
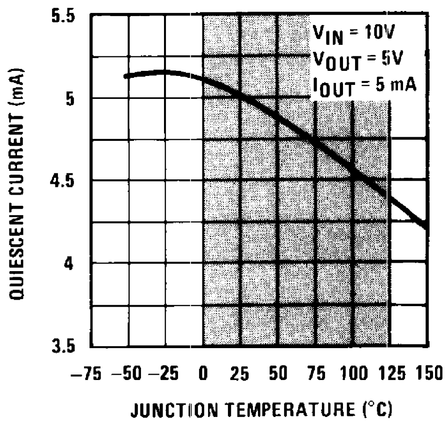


Figure 8. Dropout Characteristics



Shaded area refers to LM340A/LM340, LM7805, LM7812, and LM7815.

Figure 9. Quiescent Current

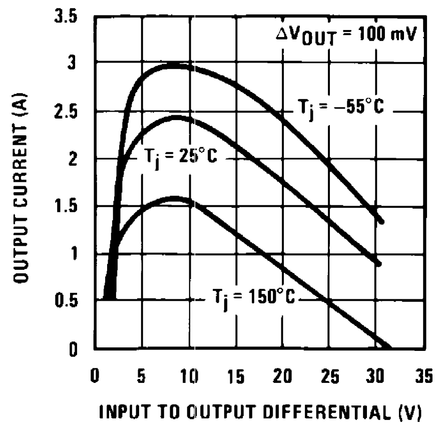
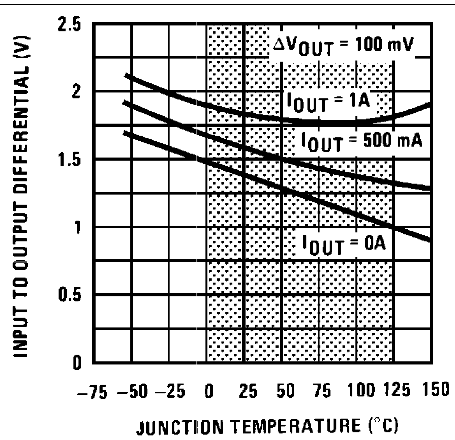


Figure 10. Peak Output Current



Shaded area refers to LM340A/LM340, LM7805, LM7812, and LM7815.

Figure 11. Dropout Voltage

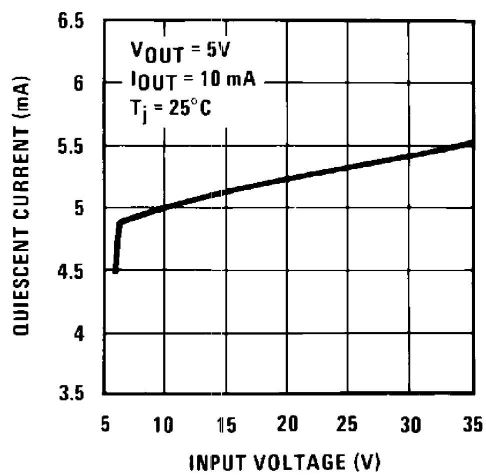
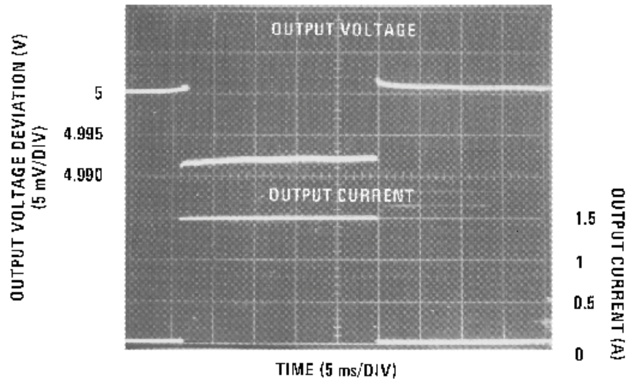


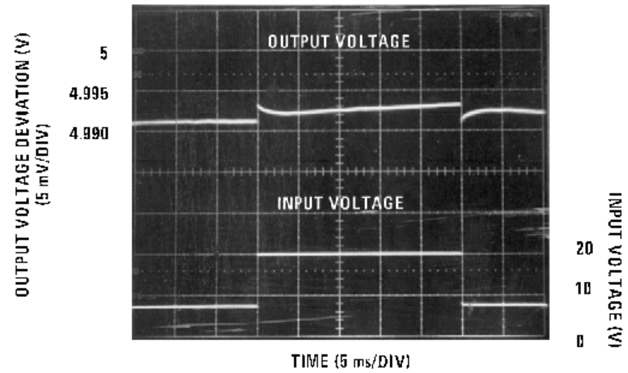
Figure 12. Quiescent Current

Typical Characteristics (continued)



I_{OUT} = 1 A, T_A = 25°C

Figure 13. Line Regulation LM340



V_{IN} = 10 V, T_A = 25°C

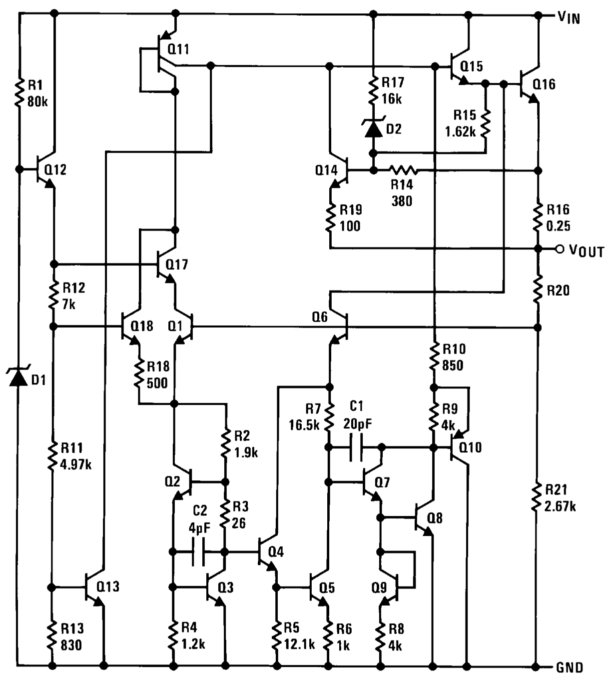
Figure 14. Line Regulation LM340

7 Detailed Description

7.1 Overview

The LM340 and LM7805 devices are a family of fixed output positive voltage regulators with outputs ranging from 3 V to 15 V. They accept up to 35 V of input voltage and with proper heat dissipation can provide over 1.5 A of current. With a combination of current limiting, thermal shutdown, and safe area protection, these regulators eliminate any concern of damage. These features paired with excellent line and load regulation make the LM340 and LM7805 Family versatile solutions to a wide range of power management designs. Although the LM340 and LM7805 Family were designed primarily as fixed-voltage regulators, these devices can be used with external component for adjustable voltage and current.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Output Current

With proper considerations, the LM340 and LM7805 Family can exceed 1.5-A output current. Depending on the desired package option, the effective junction-to-ambient thermal resistance can be reduced through heat sinking, allowing more power to be dissipated in the device.

7.3.2 Current Limiting Feature

In the event of a short circuit at the output of the regulator, each device has an internal current limit to protect it from damage. The typical current limits for the LM340 and LM7805 Family is 2.4 A.

7.3.3 Thermal Shutdown

Each package type employs internal current limiting and thermal shutdown to provide safe operation area protection. If the junction temperature is allowed to rise to 150°C, the device will go into thermal shutdown.

7.4 Device Functional Modes

There are no functional modes for this device.

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The LM340x and LM7805 series is designed with thermal protection, output short-circuit protection, and output transistor safe area protection. However, as with any IC regulator, it becomes necessary to take precautions to assure that the regulator is not inadvertently damaged. The following describes possible misapplications and methods to prevent damage to the regulator.

8.1.1 Shorting the Regulator Input

When using large capacitors at the output of these regulators, a protection diode connected input to output (Figure 15) may be required if the input is shorted to ground. Without the protection diode, an input short causes the input to rapidly approach ground potential, while the output remains near the initial V_{OUT} because of the stored charge in the large output capacitor. The capacitor will then discharge through a large internal input to output diode and parasitic transistors. If the energy released by the capacitor is large enough, this diode, low current metal, and the regulator are destroyed. The fast diode in Figure 15 shunts most of the capacitors discharge current around the regulator. Generally no protection diode is required for values of output capacitance ≤ 10 μF.

8.1.2 Raising the Output Voltage Above the Input Voltage

Because the output of the device does not sink current, forcing the output high can cause damage to internal low current paths in a manner similar to that just described in *Shorting the Regulator Input*.

8.1.3 Regulator Floating Ground

When the ground pin alone becomes disconnected, the output approaches the unregulated input, causing possible damage to other circuits connected to V_{OUT}. If ground is reconnected with power ON, damage may also occur to the regulator. This fault is most likely to occur when plugging in regulators or modules with on card regulators into powered up sockets. The power must be turned off first, the thermal limit ceases operating, or the ground must be connected first if power must be left on. See Figure 16.

8.1.4 Transient Voltages

If transients exceed the maximum rated input voltage of the device, or reach more than 0.8 V below ground and have sufficient energy, they will damage the regulator. The solution is to use a large input capacitor, a series input breakdown diode, a choke, a transient suppressor or a combination of these.

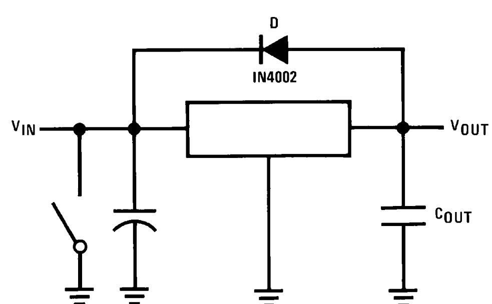


Figure 15. Input Short

Application Information (continued)

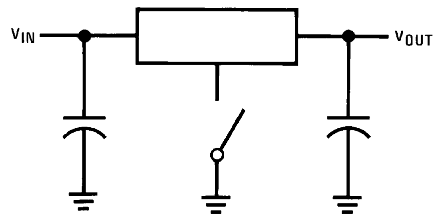


Figure 16. Regulator Floating Ground

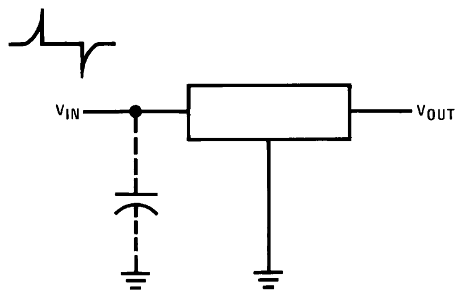


Figure 17. Transients

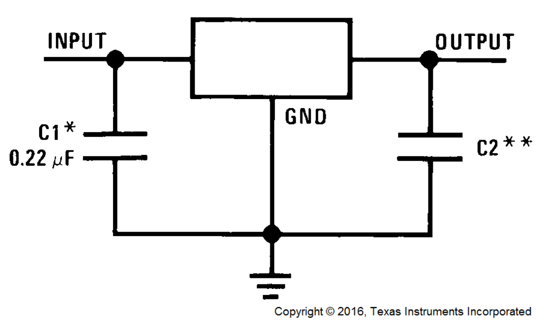
When a value for $\theta_{(H–A)}$ is found, a heat sink must be selected that has *a value that is less than or equal to this number.*

$\theta_{(H–A)}$ is specified numerically by the heat sink manufacturer in this catalog or shown in a curve that plots temperature rise vs power dissipation for the heat sink.

8.2 Typical Applications

8.2.1 Fixed Output Voltage Regulator

The LM340x and LM7805 Family devices are primarily designed to provide fixed output voltage regulation. The simplest implementation of LM340x and LM7805 Family is shown in Figure 18.



*Required if the regulator is located far from the power supply filter.
**Although no output capacitor is needed for stability, it does help transient response. (If needed, use 0.1-µF, ceramic disc).

Figure 18. Fixed Output Voltage Regulator

8.2.1.1 Design Requirements

The device component count is very minimal. Although not required, TI recommends employing bypass capacitors at the output for optimum stability and transient response. These capacitors must be placed as close as possible to the regulator. If the device is located more than 6 inches from the power supply filter, it is required to employ input capacitor.

Typical Applications (continued)

8.2.1.2 Detailed Design Procedure

The output voltage is set based on the device variant. LM340x and LM7805 Family are available in 5-V, 12-V and 15-V regulator options.

8.2.1.3 Application Curve

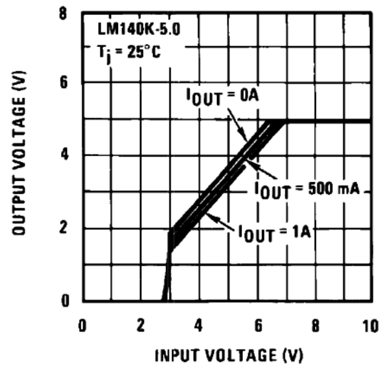
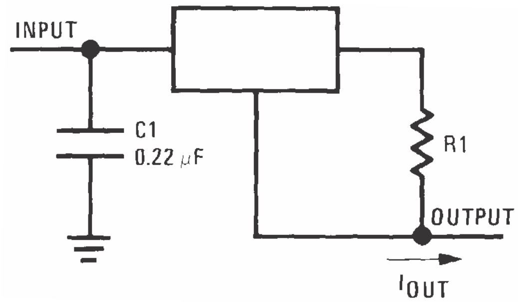


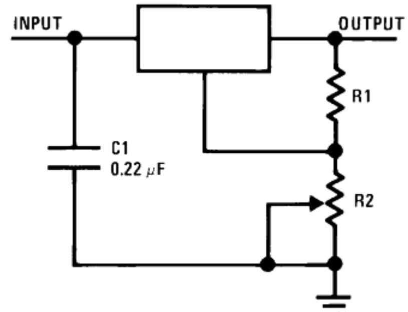
Figure 19. V_{OUT} vs V_{IN}, V_{OUT} = 5 V

8.3 System Examples



I_{OUT} = V2–3 / R1 + I_Q
ΔI_Q = 1.3 mA over line and load changes.

Figure 20. Current Regulator



V_{OUT} = 5 V + (5 V/R1 + I_Q) R2 5 V/R1 > 3 I_Q,
load regulation (L_r) ≈ [(R1 + R2)/R1] (L_r of LM340-5).

Figure 21. Adjustable Output Regulator

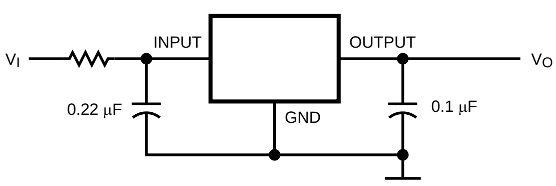


Figure 22. High Input Voltage Circuit With Series Resistor

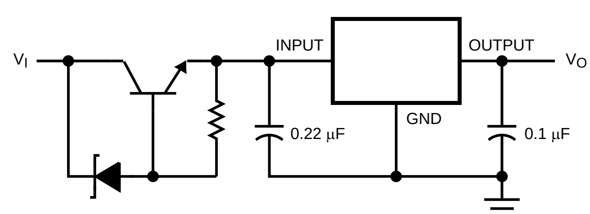
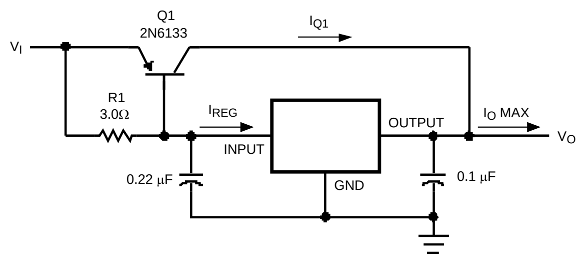


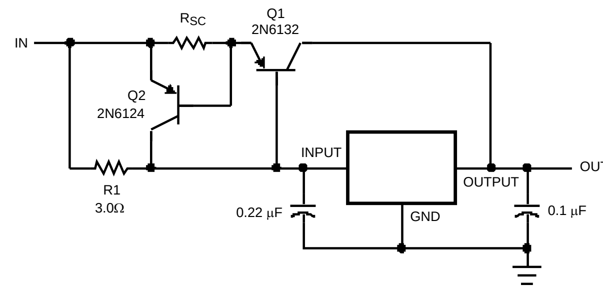
Figure 23. High Input Voltage Circuit implementation With Transistor

System Examples (continued)



$\beta(Q1) \geq I_{O\ Max} / I_{REG\ Max}$
$R1 = 0.9 / I_{REG} = \beta_{(Q1)}\ V_{BE(Q1)} / I_{REG\ Max\ (\beta\ +1)} - I_{O\ Max}$

Figure 24. High Current Voltage Regulator



$R_{SC} = 0.8 / I_{SC}$
$R1 = \beta V_{BE(Q1)} / I_{REG\ Max}\ (\beta + 1) - I_{O\ Max}$

Figure 25. High Output Current With Short-Circuit Protection

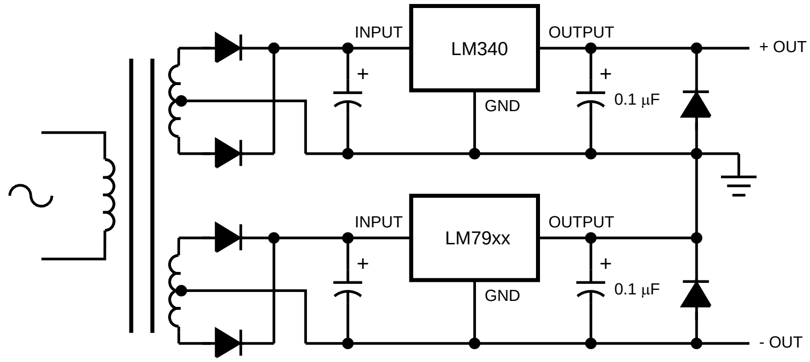


Figure 26. LM340 Used With Negative Regulator LM79xx

9 Power Supply Recommendations

The LM340 is designed to operate from a wide input voltage up to 35 V. Please refer to electrical characteristics tables for the minimum input voltage required for line/load regulation. If the device is more than six inches from the input filter capacitors, an input bypass capacitor, 0.1 µF or greater, of any type is needed for stability.

10 Layout

10.1 Layout Guidelines

Some layout guidelines must be followed to ensure proper regulation of the output voltage with minimum noise. Traces carrying the load current must be wide to reduce the amount of parasitic trace inductance. To improve PSRR, a bypass capacitor can be placed at the OUTPUT pin and must be placed as close as possible to the IC. All that is required for the typical fixed output regulator application circuit is the LM340x/LM7805 Family IC and a 0.22-µF input capacitor if the regulator is placed far from the power supply filter. A 0.1-µF output capacitor is recommended to help with transient response. In cases when VIN shorts to ground, an external diode must be placed from VOUT to VIN to divert the surge current from the output capacitor and protect the IC.

10.2 Layout Example

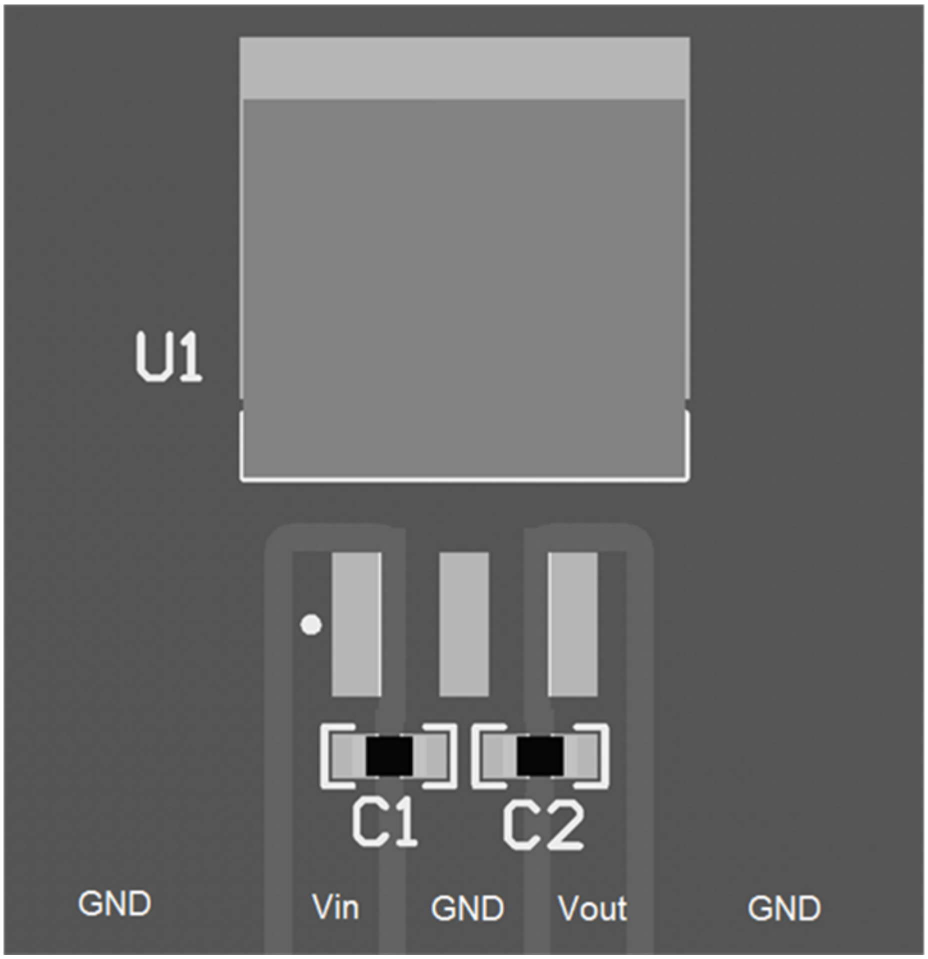


Figure 27. Layout Example DDPAK

Layout Example (continued)

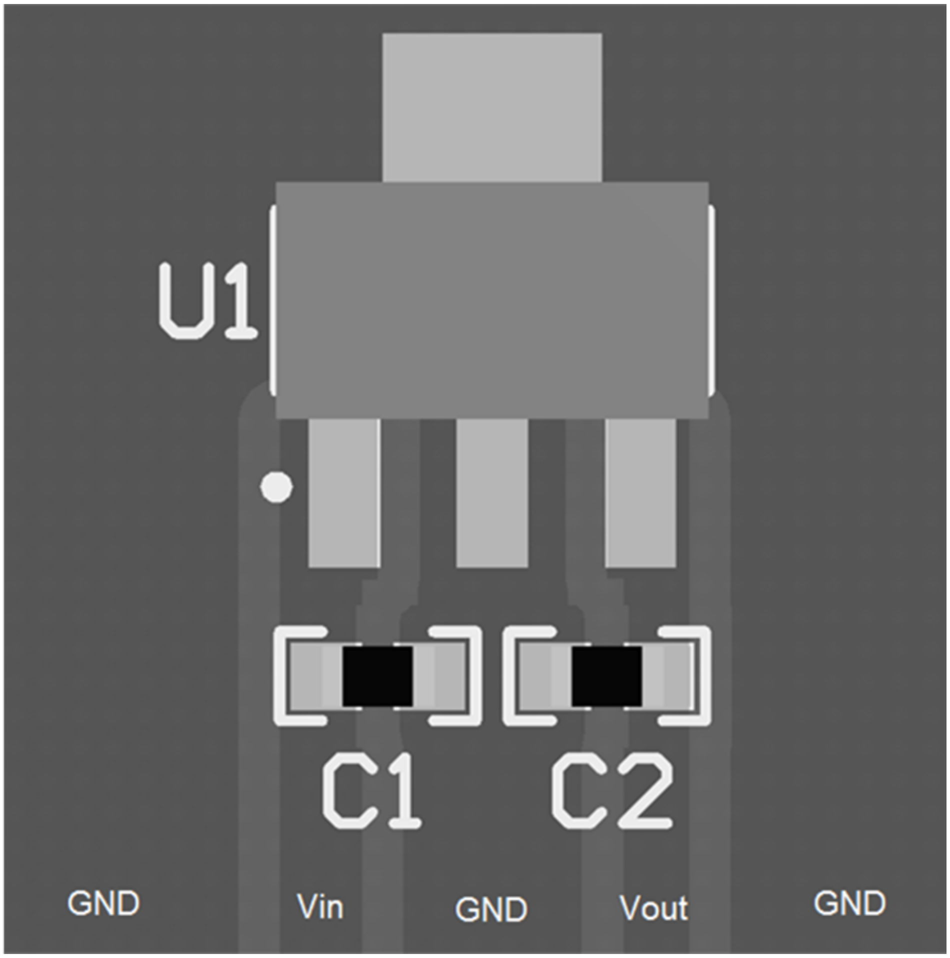


Figure 28. Layout Example SOT-223

10.3 Heat Sinking DDPAK/TO-263 and SOT-223 Package Parts

Both the DDPAK/TO-263 (KTT) and SOT-223 (DCY) packages use a copper plane on the PCB and the PCB itself as a heat sink. To optimize the heat sinking ability of the plane and PCB, solder the tab of the plane.

Figure 29 shows for the DDPAK/TO-263 the measured values of $\theta_{(J-A)}$ for different copper area sizes using a typical PCB with 1-oz copper *and no solder mask over the copper area used for heat sinking*.

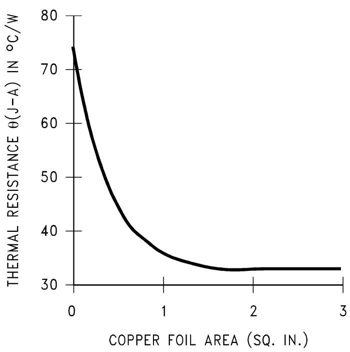


Figure 29. $\theta_{(J-A)}$ vs Copper (1 Ounce) Area for the DDPAK/TO-263 Package

Heat Sinking DDPAK/TO-263 and SOT-223 Package Parts (continued)

As shown in Figure 29, increasing the copper area beyond 1 square inch produces very little improvement. It should also be observed that the minimum value of $\theta_{(J-A)}$ for the DDPAK/TO-263 package mounted to a PCB is 32°C/W.

As a design aid, Figure 30 shows the maximum allowable power dissipation compared to ambient temperature for the DDPAK/TO-263 device (assuming $\theta_{(J-A)}$ is 35°C/W and the maximum junction temperature is 125°C).

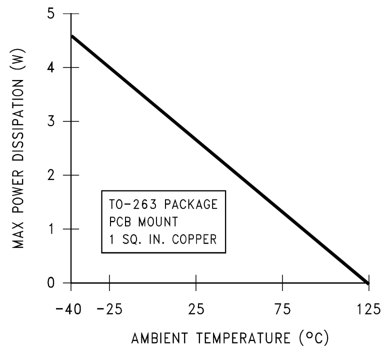


Figure 30. Maximum Power Dissipation vs T_{AMB} for the DDPAK/TO-263 Package

Figure 31 and Figure 32 show the information for the SOT-223 package. Figure 31 assumes a $\theta_{(J-A)}$ of 74°C/W for 1-oz. copper and 51°C/W for 2-oz. copper and a maximum junction temperature of 125°C.

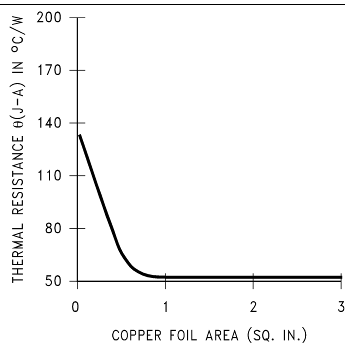


Figure 31. $\theta_{(J-A)}$ vs Copper (2 Ounce) Area for the SOT-223 Package

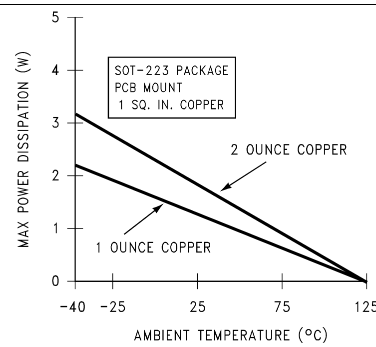


Figure 32. Maximum Power Dissipation vs T_{AMB} for the SOT-223 Package

See *AN-1028 LMX2370 PLLatinum Dual Freq Synth for RF Pers Comm LMX2370 2.5GHz/1.2GHz* (SNVA036) for power enhancement techniques to be used with the SOT-223 package.

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation, see the following:

- *AN-1028 LMX2370 PLLatinum Dual Freq Synth for RF Pers Comm LMX2370 2.5GHz/1.2GHz* (SNVA036)
- *LM140K Series 3-Terminal Positive Regulators* (SNVS994)

11.2 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 1. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
LM340	Click here	Click here	Click here	Click here	Click here
LM340A	Click here	Click here	Click here	Click here	Click here
LM7805	Click here	Click here	Click here	Click here	Click here
LM7812	Click here	Click here	Click here	Click here	Click here
LM7815	Click here	Click here	Click here	Click here	Click here

11.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

11.4 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.5 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.6 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.7 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM340AT-5.0	NRND	TO-220	NDE	3	45	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 70	LM340AT 5.0 P+	
LM340AT-5.0/NOPB	ACTIVE	TO-220	NDE	3	45	RoHS-Exempt & Green	SN	Level-1-NA-UNLIM	0 to 125	LM340AT 5.0 P+	Samples
LM340K-5.0	ACTIVE	TO-3	NDS	2	50	Non-RoHS & Non-Green	Call TI	Call TI	0 to 125	LM340K -5.0 7805P+	Samples
LM340K-5.0/NOPB	ACTIVE	TO-3	NDS	2	50	RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 125	LM340K -5.0 7805P+	Samples
LM340MP-5.0	NRND	SOT-223	DCY	4	1000	Non-RoHS & Green	Call TI	Level-1-260C-UNLIM	0 to 70	N00A	
LM340MP-5.0/NOPB	ACTIVE	SOT-223	DCY	4	1000	RoHS & Green	SN	Level-1-260C-UNLIM	0 to 125	N00A	Samples
LM340MPX-5.0/NOPB	ACTIVE	SOT-223	DCY	4	2000	RoHS & Green	SN	Level-1-260C-UNLIM	0 to 125	N00A	Samples
LM340S-12/NOPB	ACTIVE	DDPAK/ TO-263	KTT	3	45	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	0 to 125	LM340S -12 P+	Samples
LM340S-5.0	NRND	DDPAK/ TO-263	KTT	3	45	Non-RoHS & Green	Call TI	Level-3-235C-168 HR	0 to 70	LM340S -5.0 P+	
LM340S-5.0/NOPB	ACTIVE	DDPAK/ TO-263	KTT	3	45	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	0 to 125	LM340S -5.0 P+	Samples
LM340SX-12/NOPB	ACTIVE	DDPAK/ TO-263	KTT	3	500	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	0 to 125	LM340S -12 P+	Samples
LM340SX-5.0	NRND	DDPAK/ TO-263	KTT	3	500	Non-RoHS & Green	Call TI	Level-3-235C-168 HR	0 to 70	LM340S -5.0 P+	
LM340SX-5.0/NOPB	ACTIVE	DDPAK/ TO-263	KTT	3	500	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	0 to 125	LM340S -5.0 P+	Samples
LM340T-12	NRND	TO-220	NDE	3	45	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 70	LM340T12 7812 P+	
LM340T-12/NOPB	ACTIVE	TO-220	NDE	3	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM340T12 7812 P+	Samples
LM340T-15	NRND	TO-220	NDE	3	45	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 70	LM340T15 7815 P+	
LM340T-15/NOPB	ACTIVE	TO-220	NDE	3	45	RoHS & Green	SN	Level-1-NA-UNLIM	0 to 125	LM340T15 7815 P+	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM340T-5.0	NRND	TO-220	NDE	3	45	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 70	LM340T5 7805 P+	
LM340T-5.0/LF01	ACTIVE	TO-220	NDG	3	45	RoHS-Exempt & Green	SN	Level-4-260C-72 HR	0 to 125	LM340T5 7805 P+	Samples
LM340T-5.0/NOPB	ACTIVE	TO-220	NDE	3	45	RoHS-Exempt & Green	SN	Level-1-NA-UNLIM	0 to 125	LM340T5 7805 P+	Samples
LM7805CT	NRND	TO-220	NDE	3	45	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 125	LM340T5 7805 P+	
LM7805CT/NOPB	ACTIVE	TO-220	NDE	3	45	RoHS-Exempt & Green	SN	Level-1-NA-UNLIM	0 to 125	LM340T5 7805 P+	Samples
LM7805MP/NOPB	ACTIVE	SOT-223	DCY	4	1000	RoHS & Green	SN	Level-1-260C-UNLIM	0 to 125	N00A	Samples
LM7805MPX/NOPB	ACTIVE	SOT-223	DCY	4	2000	RoHS & Green	SN	Level-1-260C-UNLIM	0 to 125	N00A	Samples
LM7805S/NOPB	ACTIVE	DDPAK/ TO-263	KTT	3	45	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	0 to 125	LM340S -5.0 P+	Samples
LM7805SX/NOPB	ACTIVE	DDPAK/ TO-263	KTT	3	500	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	0 to 125	LM340S -5.0 P+	Samples
LM7812CT/NOPB	ACTIVE	TO-220	NDE	3	45	RoHS & Green	SN	Level-1-NA-UNLIM	-40 to 125	LM340T12 7812 P+	Samples
LM7812S/NOPB	ACTIVE	DDPAK/ TO-263	KTT	3	45	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	0 to 125	LM340S -12 P+	Samples
LM7812SX/NOPB	ACTIVE	DDPAK/ TO-263	KTT	3	500	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	0 to 125	LM340S -12 P+	Samples
LM7815CT/NOPB	ACTIVE	TO-220	NDE	3	45	RoHS & Green	SN	Level-1-NA-UNLIM	0 to 125	LM340T15 7815 P+	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

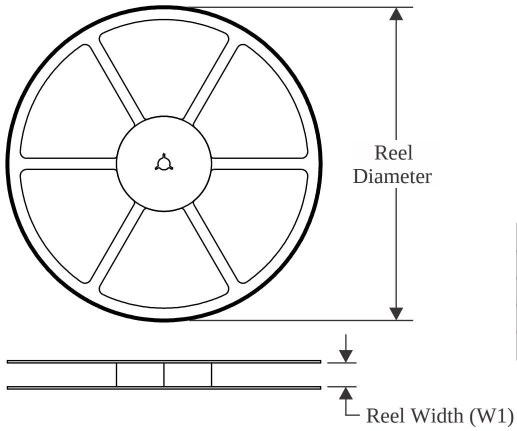
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

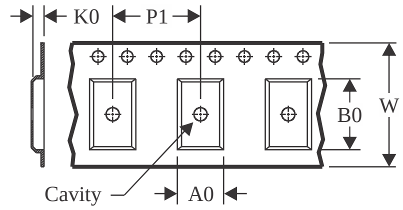
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

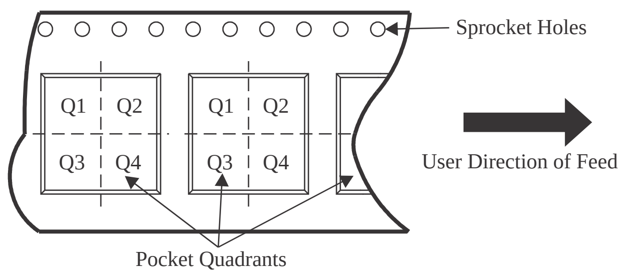


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

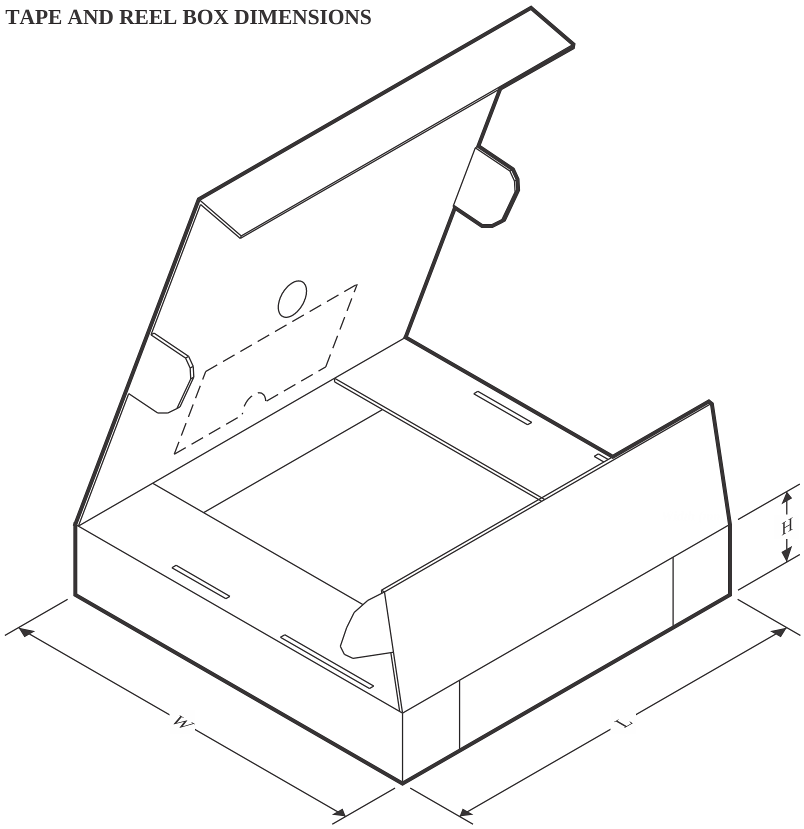
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM340MP-5.0	SOT-223	DCY	4	1000	330.0	16.4	7.0	7.5	2.2	12.0	16.0	Q3
LM340MP-5.0/NOPB	SOT-223	DCY	4	1000	330.0	16.4	7.0	7.5	2.2	12.0	16.0	Q3
LM340MPX-5.0/NOPB	SOT-223	DCY	4	2000	330.0	16.4	7.0	7.5	2.2	12.0	16.0	Q3
LM340SX-12/NOPB	DDPAK/ TO-263	KTT	3	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM340SX-5.0	DDPAK/ TO-263	KTT	3	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM340SX-5.0/NOPB	DDPAK/ TO-263	KTT	3	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM7805MP/NOPB	SOT-223	DCY	4	1000	330.0	16.4	7.0	7.5	2.2	12.0	16.0	Q3
LM7805MPX/NOPB	SOT-223	DCY	4	2000	330.0	16.4	7.0	7.5	2.2	12.0	16.0	Q3
LM7805SX/NOPB	DDPAK/ TO-263	KTT	3	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM7812SX/NOPB	DDPAK/ TO-263	KTT	3	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2

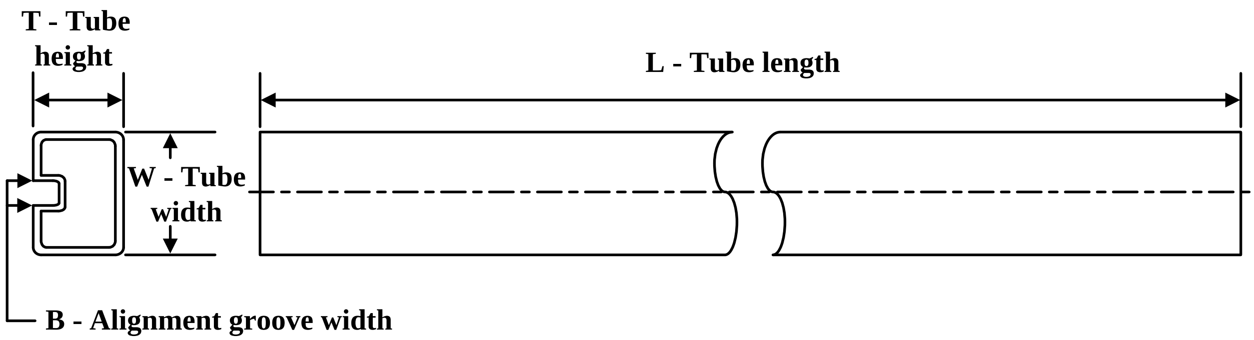
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM340MP-5.0	SOT-223	DCY	4	1000	367.0	367.0	35.0
LM340MP-5.0/NOPB	SOT-223	DCY	4	1000	367.0	367.0	35.0
LM340MPX-5.0/NOPB	SOT-223	DCY	4	2000	367.0	367.0	35.0
LM340SX-12/NOPB	DDPAK/TO-263	KTT	3	500	367.0	367.0	45.0
LM340SX-5.0	DDPAK/TO-263	KTT	3	500	367.0	367.0	45.0
LM340SX-5.0/NOPB	DDPAK/TO-263	KTT	3	500	367.0	367.0	45.0
LM7805MP/NOPB	SOT-223	DCY	4	1000	367.0	367.0	35.0
LM7805MPX/NOPB	SOT-223	DCY	4	2000	367.0	367.0	35.0
LM7805SX/NOPB	DDPAK/TO-263	KTT	3	500	367.0	367.0	45.0
LM7812SX/NOPB	DDPAK/TO-263	KTT	3	500	367.0	367.0	45.0

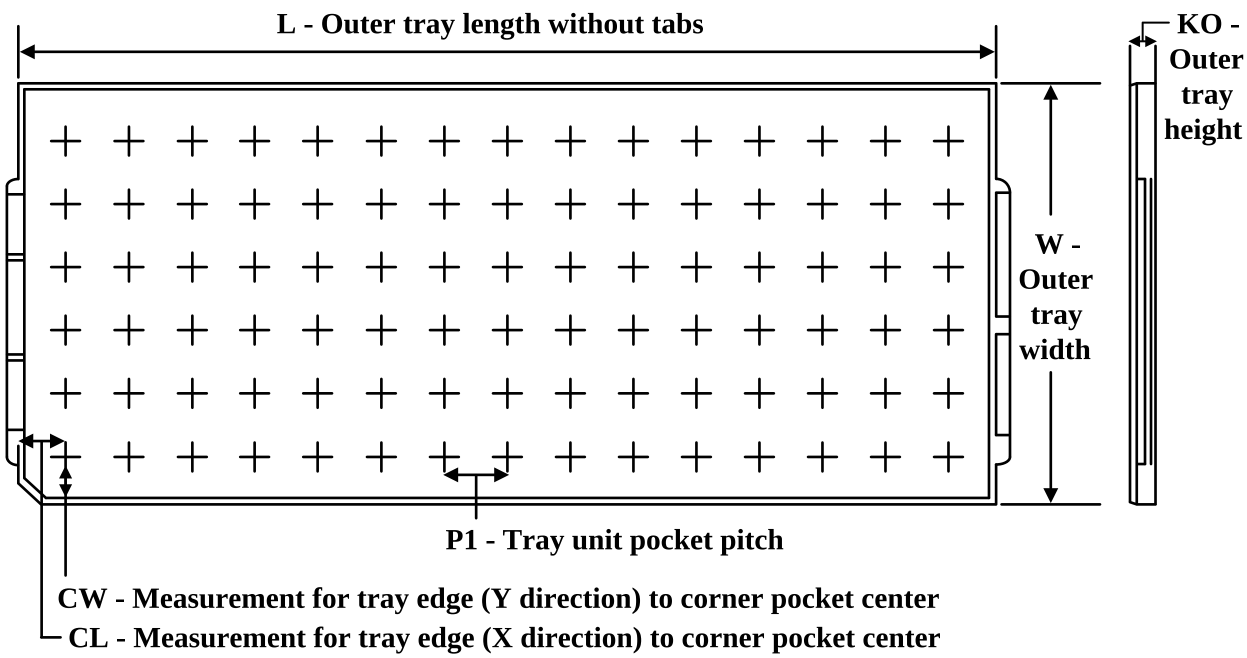
TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
LM340AT-5.0	NDE	TO-220	3	45	502	33	6985	4.06
LM340AT-5.0	NDE	TO-220	3	45	502	33	6985	4.06
LM340AT-5.0/NOPB	NDE	TO-220	3	45	502	33	6985	4.06
LM340S-12/NOPB	KTT	TO-263	3	45	502	25	8204.2	9.19
LM340S-5.0	KTT	TO-263	3	45	502	25	8204.2	9.19
LM340S-5.0	KTT	TO-263	3	45	502	25	8204.2	9.19
LM340S-5.0/NOPB	KTT	TO-263	3	45	502	25	8204.2	9.19
LM340T-12	NDE	TO-220	3	45	502	33	6985	4.06
LM340T-12	NDE	TO-220	3	45	502	33	6985	4.06
LM340T-12/NOPB	NDE	TO-220	3	45	502	33	6985	4.06
LM340T-15	NDE	TO-220	3	45	502	33	6985	4.06
LM340T-15	NDE	TO-220	3	45	502	33	6985	4.06
LM340T-15/NOPB	NDE	TO-220	3	45	502	33	6985	4.06
LM340T-5.0	NDE	TO-220	3	45	502	33	6985	4.06
LM340T-5.0	NDE	TO-220	3	45	502	33	6985	4.06
LM340T-5.0/LF01	NDG	TO-220	3	45	502	25	8204.2	9.19
LM340T-5.0/NOPB	NDE	TO-220	3	45	502	33	6985	4.06
LM7805CT	NDE	TO-220	3	45	502	33	6985	4.06
LM7805CT	NDE	TO-220	3	45	502	33	6985	4.06
LM7805CT/NOPB	NDE	TO-220	3	45	502	33	6985	4.06
LM7805S/NOPB	KTT	TO-263	3	45	502	25	8204.2	9.19
LM7812CT/NOPB	NDE	TO-220	3	45	502	33	6985	4.06
LM7812S/NOPB	KTT	TO-263	3	45	502	25	8204.2	9.19
LM7815CT/NOPB	NDE	TO-220	3	45	502	33	6985	4.06

TRAY

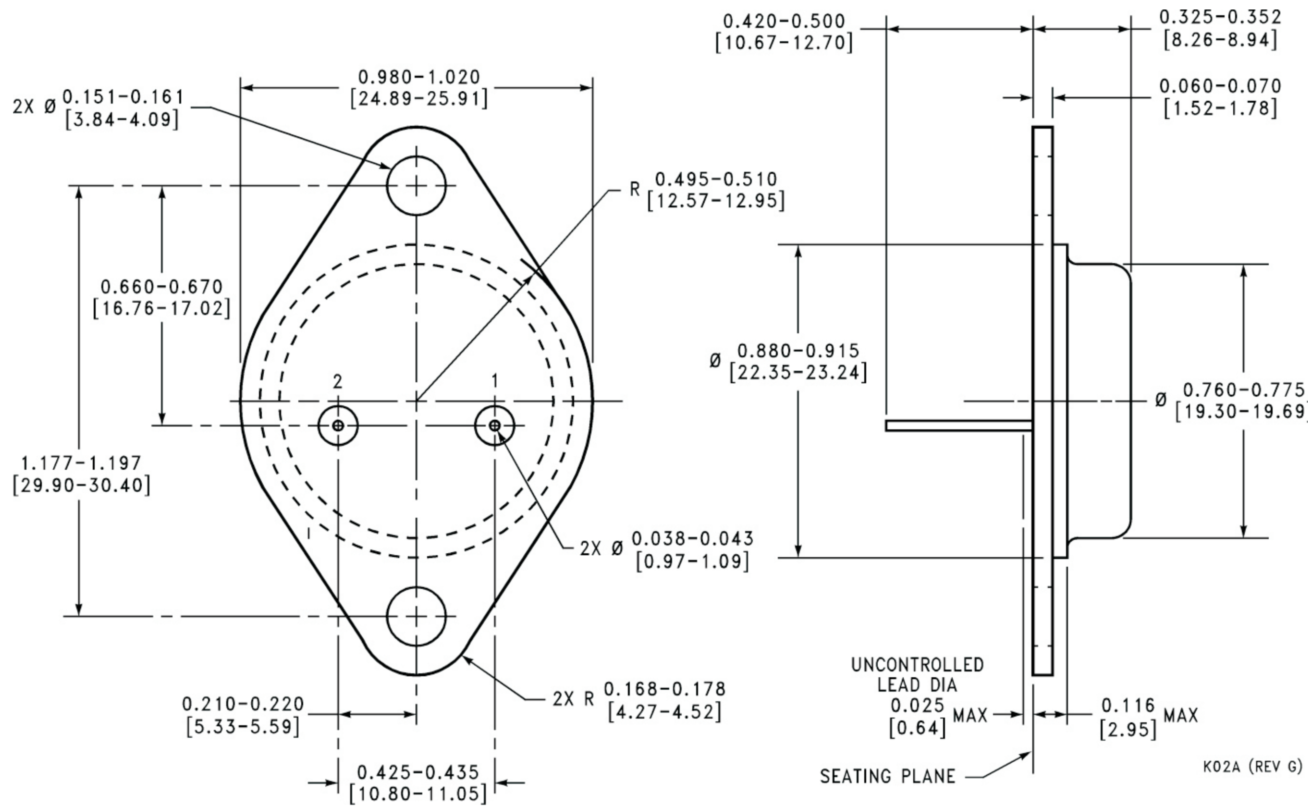


Chamfer on Tray corner indicates Pin 1 orientation of packed units.

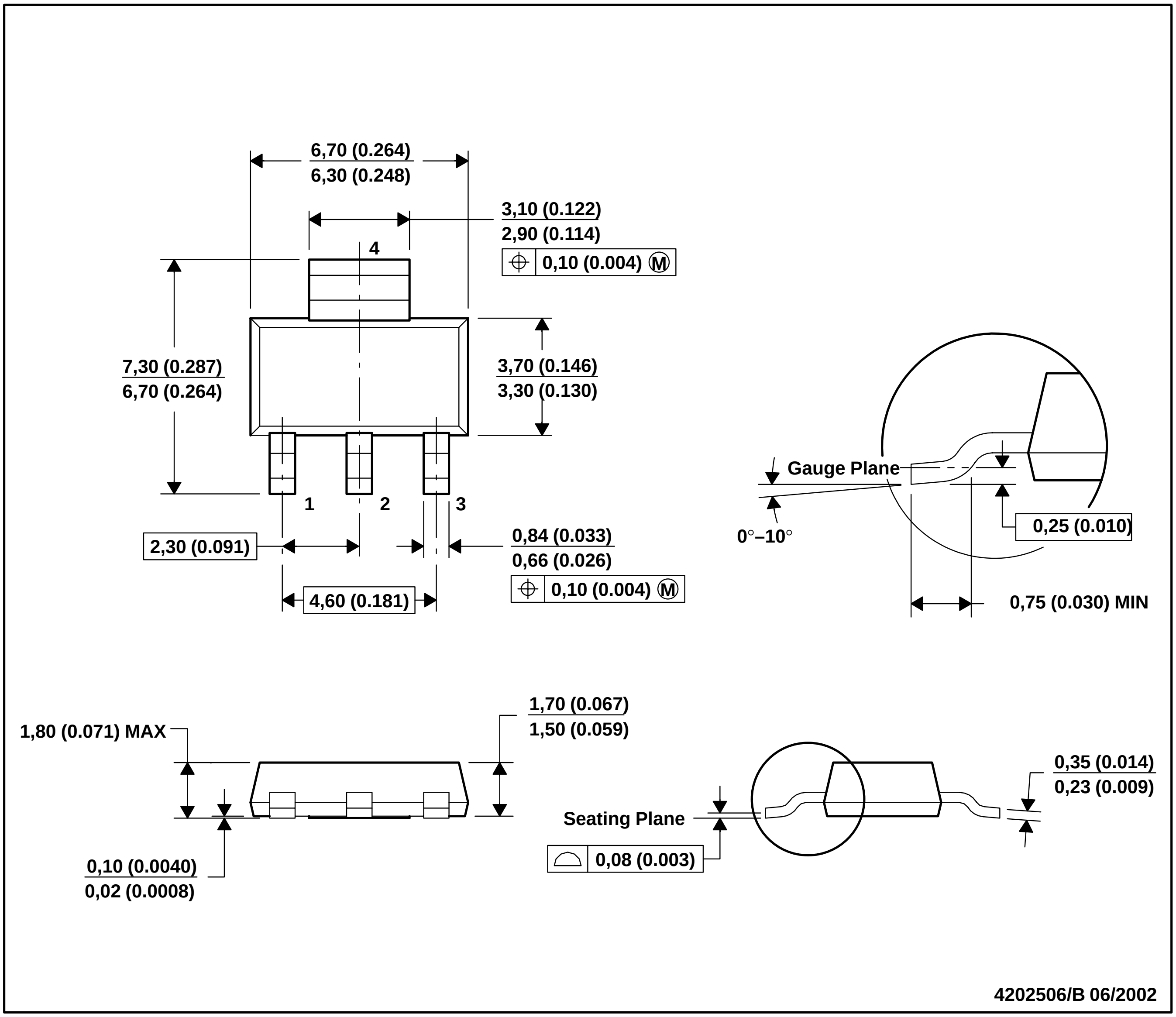
*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	Unit array matrix	Max temperature (°C)	L (mm)	W (mm)	K0 (µm)	P1 (mm)	CL (mm)	CW (mm)
LM340K-5.0	NDS	TO-CAN	2	50	9 X 6	NA	292.1	215.9	25654	3.87	22.3	25.4
LM340K-5.0/NOPB	NDS	TO-CAN	2	50	9 X 6	NA	292.1	215.9	25654	3.87	22.3	25.4

NDS0002A

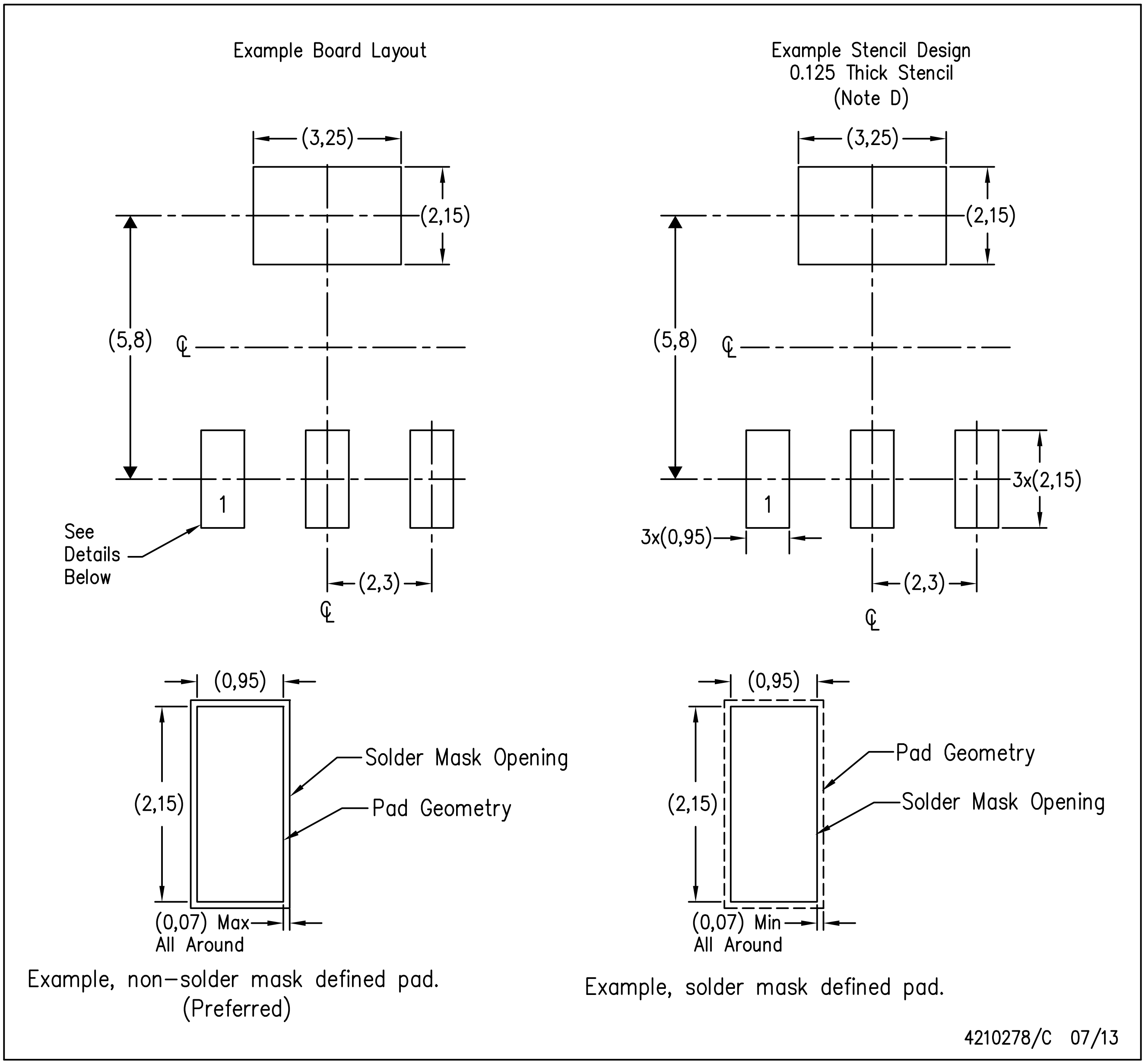

2X Ø 0.151–0.161 [3.84–4.09]
0.980–1.020 [24.89–25.91]
R 0.495–0.510 [12.57–12.95]
0.660–0.670 [16.76–17.02]
1.177–1.197 [29.90–30.40]
2
1
2X Ø 0.038–0.043 [0.97–1.09]
2X R 0.168–0.178 [4.27–4.52]
0.210–0.220 [5.33–5.59]
0.425–0.435 [10.80–11.05]
0.420–0.500 [10.67–12.70]
0.325–0.352 [8.26–8.94]
0.060–0.070 [1.52–1.78]
Ø 0.880–0.915 [22.35–23.24]
Ø 0.760–0.775 [19.30–19.69]
UNCONTROLLED LEAD DIA
0.025 [0.64] MAX
0.116 [2.95] MAX
SEATING PLANE
K02A (REV G)

DCY (R-PDSO-G4) **PLASTIC SMALL-OUTLINE**



NOTES: A. All linear dimensions are in millimeters (inches).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.
D. Falls within JEDEC TO-261 Variation AA.

DCY (R-PDSO-G4) PLASTIC SMALL OUTLINE

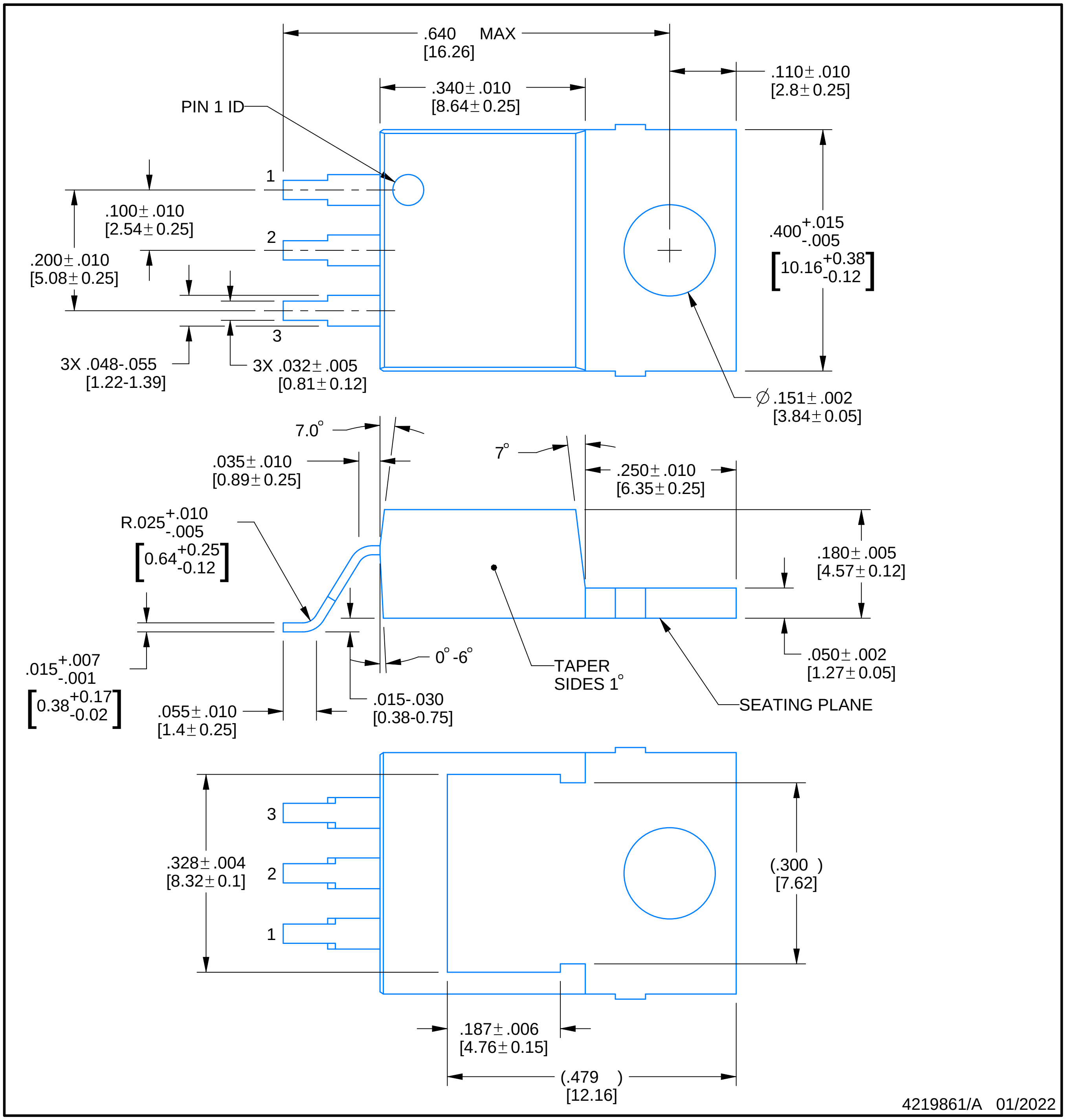


NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil recommendations. Refer to IPC 7525 for stencil design considerations.

PACKAGE OUTLINE

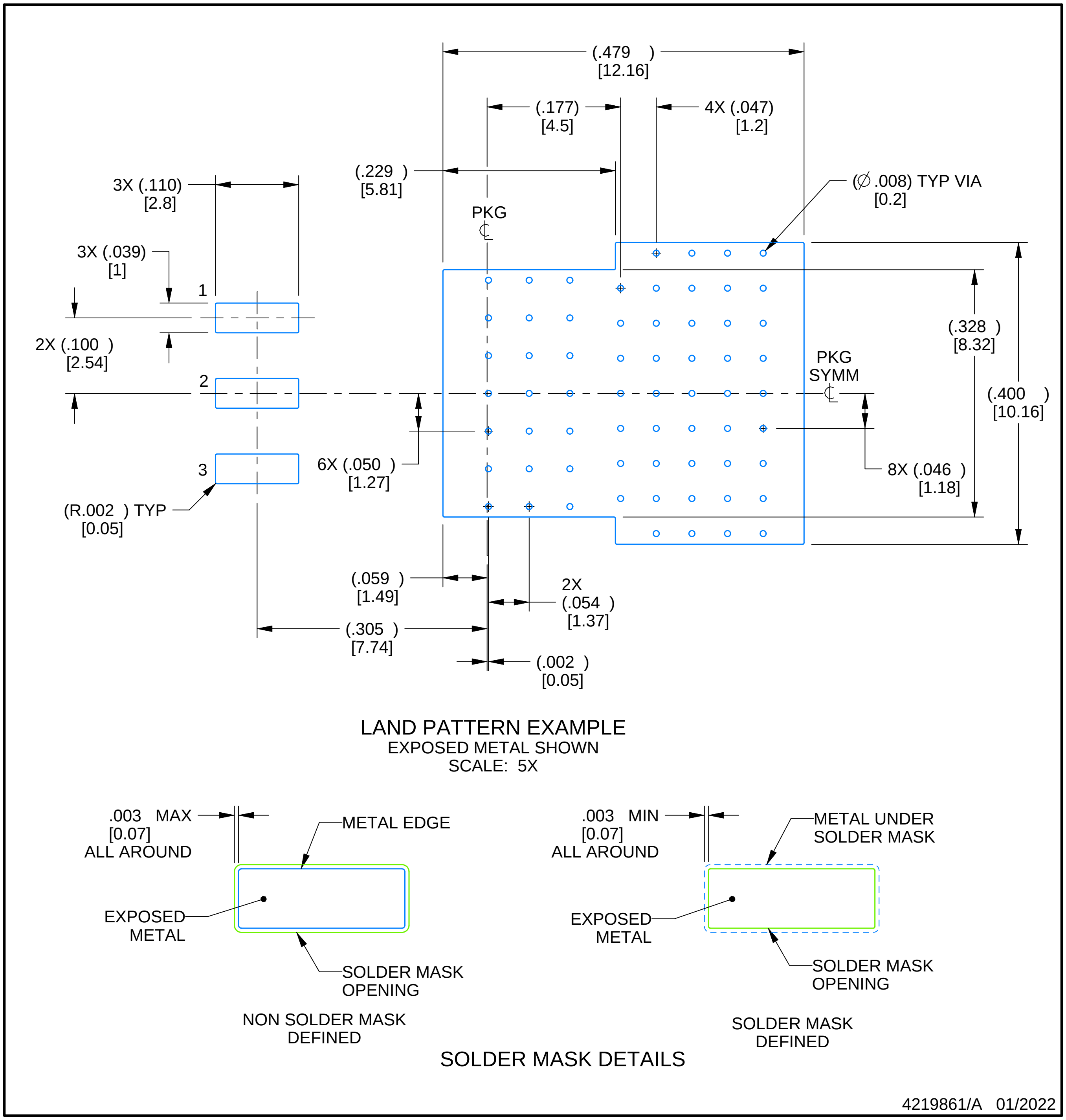
TO-220 - 4.69 mm max height

TRANSISTOR OUTLINE



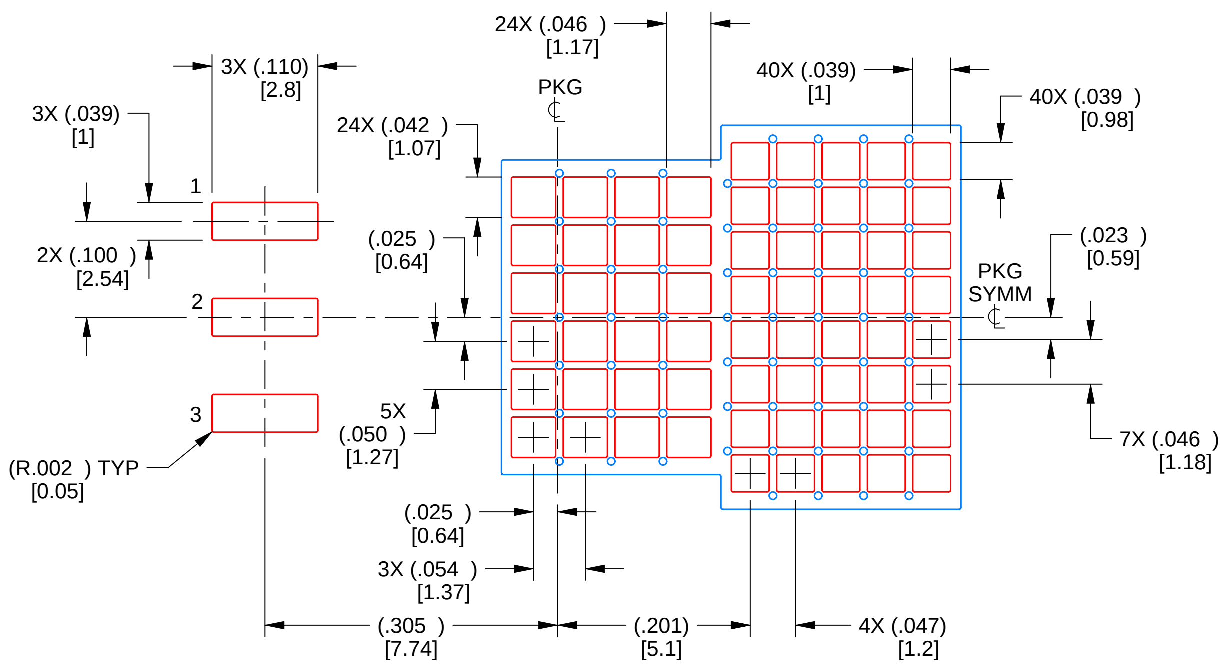
NOTES:

1. All controlling linear dimensions are in inches. Dimensions in brackets are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.



NOTES: (continued)

3. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002(www.ti.com/lit/slm002) and SLMA004 (www.ti.com/lit/slma004).
4. Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

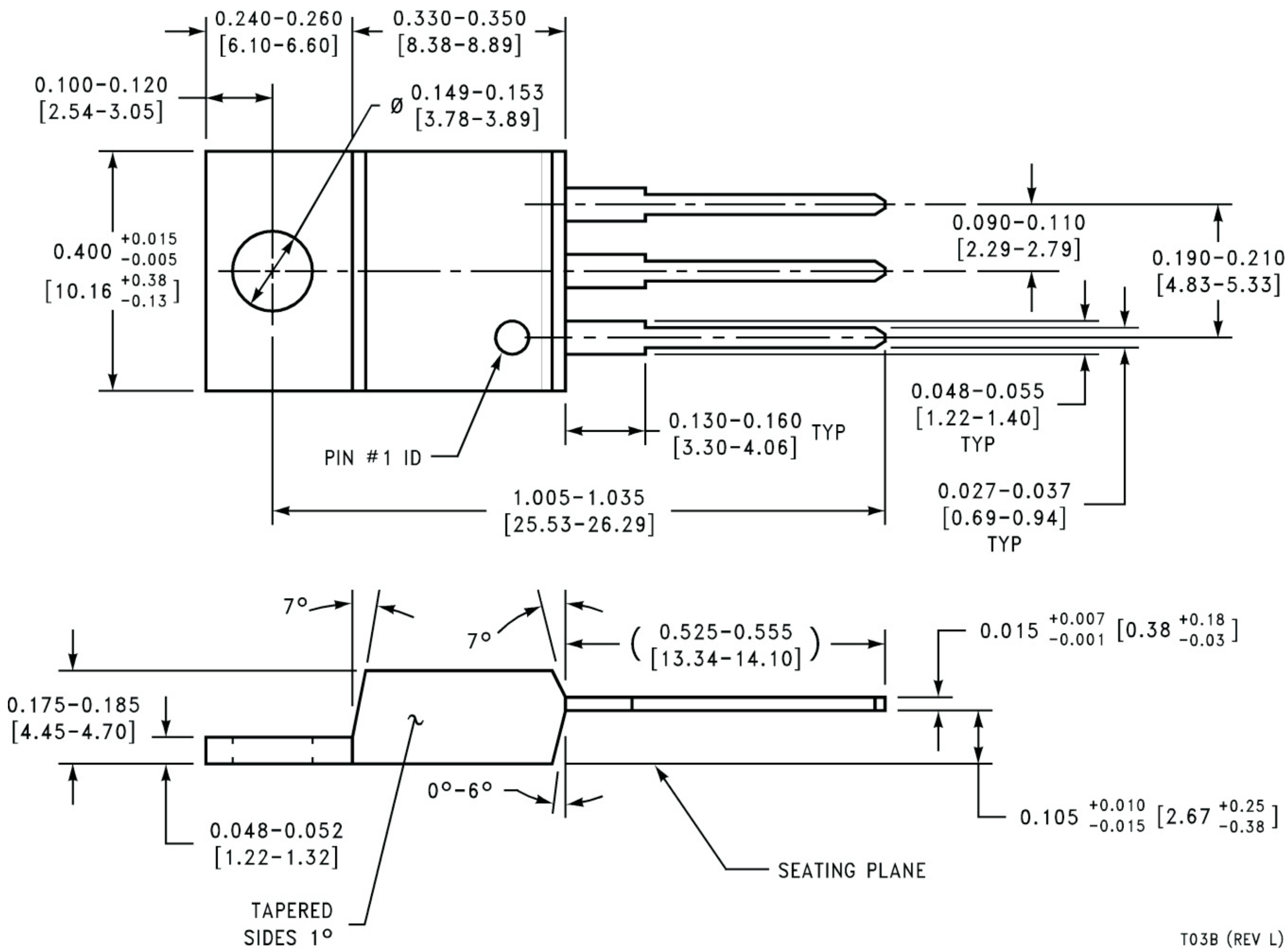
EXPOSED PAD
61% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE: 5X

4219861/A 01/2022

NOTES: (continued)

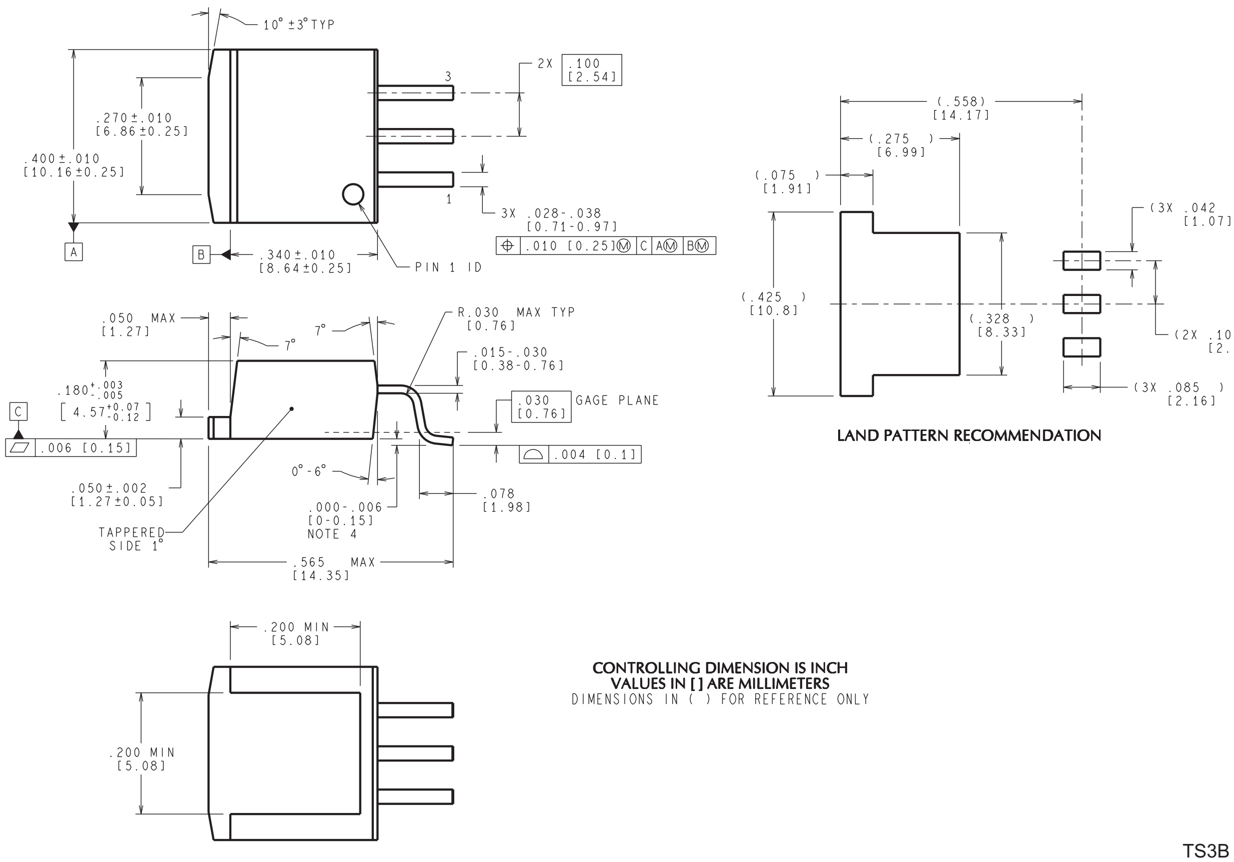
5. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
6. Board assembly site may have different recommendations for stencil design.

NDE0003B



0.240–0.260
[6.10–6.60]
0.330–0.350
[8.38–8.89]
0.100–0.120
[2.54–3.05]
Ø 0.149–0.153
[3.78–3.89]
0.400 +0.015 −0.005
[10.16 +0.38 −0.13]
0.090–0.110
[2.29–2.79]
0.190–0.210
[4.83–5.33]
0.048–0.055
[1.22–1.40]
TYP
0.130–0.160 TYP
[3.30–4.06]
PIN #1 ID
1.005–1.035
[25.53–26.29]
0.027–0.037
[0.69–0.94]
TYP
7°
7°
(0.525–0.555)
[13.34–14.10]
0.015 +0.007 −0.001 [0.38 +0.18 −0.03]
0.175–0.185
[4.45–4.70]
0°–6°
0.105 +0.010 −0.015 [2.67 +0.25 −0.38]
0.048–0.052
[1.22–1.32]
SEATING PLANE
TAPERED
SIDES 1°
T03B (REV L)

KTT0003B



LAND PATTERN RECOMMENDATION

BOTTOM SIDE OF PACKAGE

CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS
DIMENSIONS IN ( ) FOR REFERENCE ONLY

TS3B (Rev F)

LM79XX Series 3-Terminal Negative Regulators

Check for Samples: LM7905, LM7912, LM7915

FEATURES

- **Thermal, Short Circuit and Safe Area Protection**
- **High Ripple Rejection**
- **1.5A Output Current**
- **4% Tolerance on Preset Output Voltage**

DESCRIPTION

The LM79XX series of 3-terminal regulators is available with fixed output voltages of −5V, −12V, and −15V. These devices need only one external component—a compensation capacitor at the output. The LM79XX series is packaged in the TO-220 power package and is capable of supplying 1.5A of output current.

These regulators employ internal current limiting safe area protection and thermal shutdown for protection against virtually all overload conditions.

Low ground pin current of the LM79XX series allows output voltage to be easily boosted above the preset value with a resistor divider. The low quiescent current drain of these devices with a specified maximum change with line and load ensures good regulation in the voltage boosted mode.

For applications requiring other voltages, see LM137 datasheet.

Connection Diagram

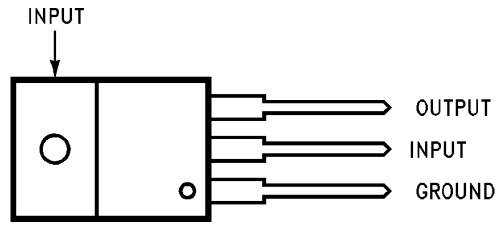
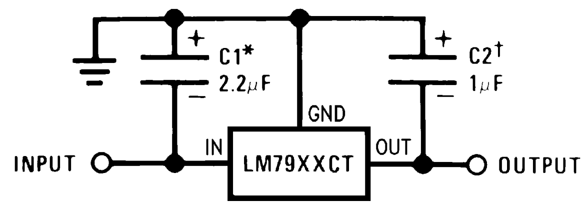


Figure 1. TO-220 Package
Front View
See Package Number NDE0003B

Typical Applications



*Required if regulator is separated from filter capacitor by more than 3″. For value given, capacitor must be solid tantalum. 25μF aluminum electrolytic may be substituted.

†Required for stability. For value given, capacitor must be solid tantalum. 25μF aluminum electrolytic may be substituted. Values given may be increased without limit.

For output capacitance in excess of 100μF, a high current diode from input to output (1N4001, etc.) will protect the regulator from momentary input shorts.

Figure 2. Fixed Regulator

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS[(1)]

Input Voltage	
(V_o = −5V)	−25V
(V_o = −12V and −15V)	−35V
Input-Output Differential	
(V_o = −5V)	25V
(V_o = −12V and −15V)	30V
Power Dissipation [(2)]	Internally Limited
Operating Junction Temperature Range	0°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	230°C

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not ensure Specific Performance limits. For ensured specifications and test conditions, see the Electrical Characteristics.
(2) Refer to DESIGN CONSIDERATIONS for details.

ELECTRICAL CHARACTERISTICS

Conditions unless otherwise noted: I_{OUT} = 500mA, C_{IN} = 2.2μF, C_{OUT} = 1μF, 0°C ≤ T_J ≤ +125°C, Power Dissipation ≤ 1.5W.

Part Number			LM7905C			Units
Output Voltage			−5V			
Input Voltage (unless otherwise specified)			−10V			
Symbol	Parameter	Conditions	Min	Typ	Max	
V_O	Output Voltage	T_J = 25°C	−4.8	−5.0	−5.2	V
		5mA ≤ I_{OUT} ≤ 1A,	−4.75		−5.25	V
		P ≤ 15W		(−20 ≤ V_{IN} ≤ −7)		V
ΔV_O	Line Regulation	T_J = 25°C, [(1)]		8	50	mV
				(−25 ≤ V_{IN} ≤ −7)		V
				2	15	mV
				(−12 ≤ V_{IN} ≤ −8)		V
ΔV_O	Load Regulation	T_J = 25°C, [(1)]				
		5mA ≤ I_{OUT} ≤ 1.5A		15	100	mV
		250mA ≤ I_{OUT} ≤ 750mA		5	50	mV
I_Q	Quiescent Current	T_J = 25°C		1	2	mA
ΔI_Q	Quiescent Current	With Line			0.5	mA
	Change			(−25 ≤ V_{IN} ≤ −7)		V
		With Load, 5mA ≤ I_{OUT} ≤ 1A			0.5	mA
V_n	Output Noise Voltage	T_A = 25°C, 10Hz ≤ f ≤ 100Hz		125		μV
	Ripple Rejection	f = 120Hz	54	66		dB
				(−18 ≤ V_{IN} ≤ −8)		V
	Dropout Voltage	T_J = 25°C, I_{OUT} = 1A		1.1		V
I_{OMAX}	Peak Output Current	T_J = 25°C		2.2		A
	Average Temperature Coefficient of Output Voltage	I_{OUT} = 5mA, 0 C ≤ T_J ≤ 100°C		0.4		mV/°C

(1) Regulation is measured at a constant junction temperature by pulse testing with a low duty cycle. Changes in output voltage due to heating effects must be taken into account.

ELECTRICAL CHARACTERISTICS

Conditions unless otherwise noted: I_{OUT} = 500mA, C_{IN} = 2.2μF, C_{OUT} = 1μF, 0°C ≤ T_J ≤ +125°C, Power Dissipation ≤ 1.5W.

Part Number			LM7912C			LM7915C			Units
Output Voltage				−12V			−15V		
Input Voltage (unless otherwise specified)				−19V			−23V		
Symbol	**Parameter**	**Conditions**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	
V_O	Output Voltage	T_J = 25°C	−11.5	−12.0	−12.5	−14.4	−15.0	−15.6	V
		5mA ≤ I_{OUT} ≤ 1A,	−11.4		−12.6	−14.25		−15.75	V
		P ≤ 15W		(−27 ≤ V_{IN} ≤ −14.5)			(−30 ≤ V_{IN} ≤ −17.5)		V
ΔV_O	Line Regulation	T_J = 25°C, (1)		5	80		5	100	mV
				(−30 ≤ V_{IN} ≤ −14.5)			(−30 ≤ V_{IN} ≤ −17.5)		V
				3	30		3	50	mV
				(−22 ≤ V_{IN} ≤ −16)			(−26 ≤ V_{IN} ≤ −20)		V
ΔV_O	Load Regulation	T_J = 25°C, (1)							
		5mA ≤ I_{OUT} ≤ 1.5A		15	200		15	200	mV
		250mA ≤ I_{OUT} ≤ 750mA		5	75		5	75	mV
I_Q	Quiescent Current	T_J = 25°C		1.5	3		1.5	3	mA
ΔI_Q	Quiescent Current	With Line			0.5			0.5	mA
	Change			(−30 ≤ V_{IN} ≤ −14.5)			(−30 ≤ V_{IN} ≤ −17.5)		V
		With Load, 5mA ≤ I_{OUT} ≤ 1A			0.5			0.5	mA
V_n	Output Noise Voltage	T_A = 25°C, 10Hz ≤ f ≤ 100Hz		300			375		μV
	Ripple Rejection	f = 120 Hz	54	70		54	70		dB
				(−25 ≤ V_{IN} ≤ −15)			(−30 ≤ V_{IN} ≤ −17.5)		V
	Dropout Voltage	T_J = 25°C, I_{OUT} = 1A		1.1			1.1		V
I_{OMAX}	Peak Output Current	T_J = 25°C		2.2			2.2		A
	Average Temperature Coefficient of Output Voltage	I_{OUT} = 5mA, 0 C ≤ T_J ≤ 100°C		−0.8			−1.0		mV/°C

(1) Regulation is measured at a constant junction temperature by pulse testing with a low duty cycle. Changes in output voltage due to heating effects must be taken into account.

DESIGN CONSIDERATIONS

The LM79XX fixed voltage regulator series has thermal overload protection from excessive power dissipation, internal short circuit protection which limits the circuit's maximum current, and output transistor safe-area compensation for reducing the output current as the voltage across the pass transistor is increased.

Although the internal power dissipation is limited, the junction temperature must be kept below the maximum specified temperature (125°C) in order to meet data sheet specifications. To calculate the maximum junction temperature or heat sink required, the following thermal resistance values should be used:

Package	Typ θ_{JC} °C/W	Max θ_{JC} °C/W	Typ θ_{JA} °C/W	Max θ_{JA} °C/W
TO-220	3.0	5.0	60	40

$$P_{D\,MAX} = \frac{T_{J\,Max} - T_A}{\theta_{JC} + \theta_{CA}} \text{ or } \frac{T_{J\,Max}\ T_A}{\theta_{JA}}$$

$$\theta_{CA} = \theta_{CS} + \theta_{SA} \text{ (without heat sink)} \quad (1)$$

Solving for T_J:

$T_J = T_A + P_D\,(\theta_{JC} + \theta_{CA})$

or

$= T_A + P_D\theta_{JA}$ (without heat sink)

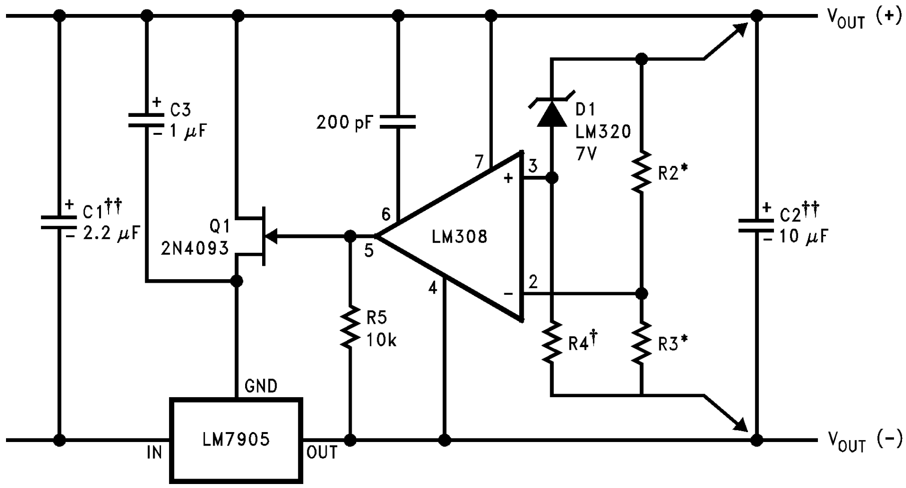
where

- T_J = Junction Temperature
- T_A = Ambient Temperature
- P_D = Power Dissipation
- θ_{JA} = Junction-to-Ambient Thermal Resistance
- θ_{JC} = Junction-to-Case Thermal Resistance
- θ_{CA} = Case-to-Ambient Thermal Resistance
- θ_{CS} = Case-to-Heat Sink Thermal Resistance
- θ_{SA} = Heat Sink-to-Ambient Thermal Resistance

Typical Applications

Bypass capacitors are necessary for stable operation of the LM79XX series of regulators over the input voltage and output current ranges. Output bypass capacitors will improve the transient response by the regulator.

The bypass capacitors, (2.2μF on the input, 1.0μF on the output) should be ceramic or solid tantalum which have good high frequency characteristics. If aluminum electrolytics are used, their values should be 10μF or larger. The bypass capacitors should be mounted with the shortest leads, and if possible, directly across the regulator terminals.



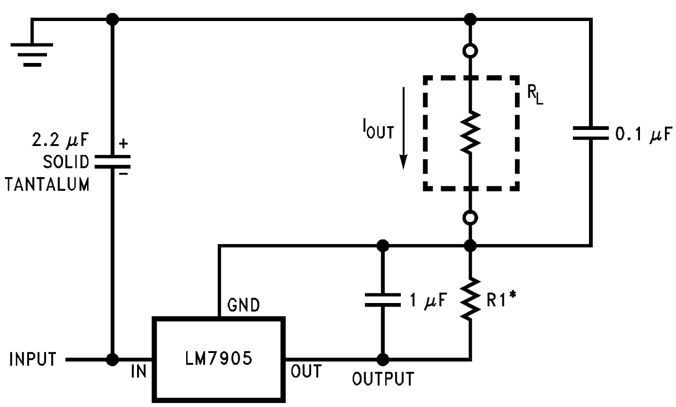
Load and line regulation < 0.01% temperature stability ≤ 0.2%

†Determine Zener current

††Solid tantalum

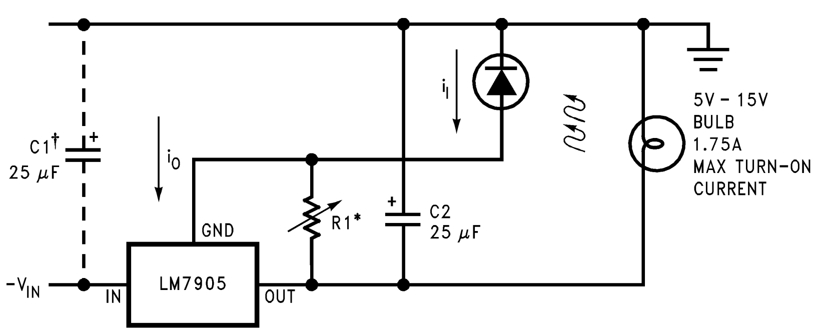
*Select resistors to set output voltage. 2 ppm/°C tracking suggested

Figure 3. High Stability 1 Amp Regulator



$^*I_{OUT} = 1\text{ mA} + \frac{5V}{R1}$

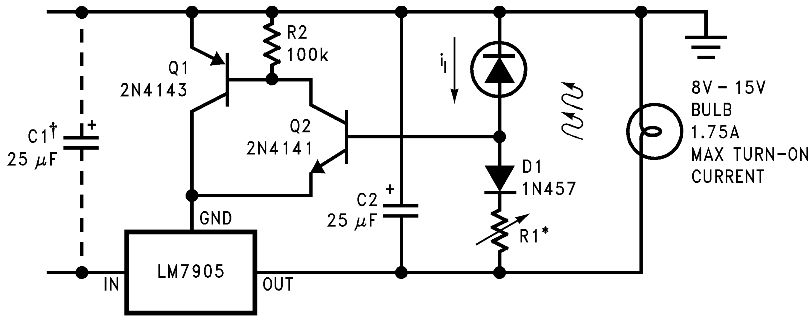
Figure 4. Current Source



*Lamp brightness increase until $i_I = i_Q$ (≈ 1 mA) + 5V/R1.

†Necessary only if raw supply filter capacitor is more that 2″ from LM7905CT

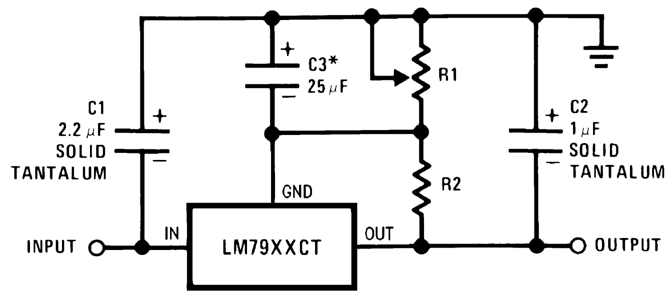
Figure 5. Light Controller Using Silicon Photo Cell



*Lamp brightness increases until i_i = 5V/R1 (I_i can be set as low as 1 μA)

†Necessary only if raw supply filter capacitor is more that 2″ from LM7905

Figure 6. High-Sensitivity Light Controller



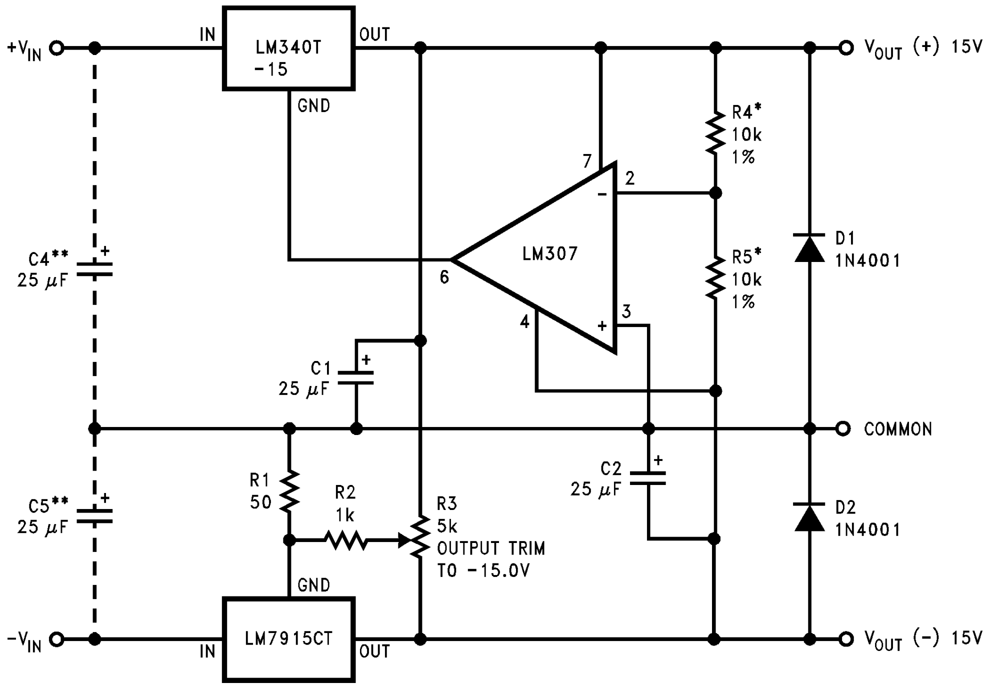
*Improves transient response and ripple rejection. Do not increase beyond 50 μF.

$$V_{OUT} = V_{SET}\left(\frac{R1 + R2}{R2}\right)$$

Select R2 as follows:

LM7905CT	300Ω
LM7912CT	750Ω
LM7915CT	1k

Figure 7. Variable Output



	(-15)	(+15)
Load Regulation at ΔI_L = 1A	40mV	2mV
Output Ripple, C_{IN} = 3000µF, I_L = 1A	100 µVms	100 µVms
Temperature Stability	50mV	50mV
Output Noise 10Hz ≤ f ≤ 10kHz	150 µVms	150 µVms

*Resistor tolerance of R4 and R5 determine matching of (+) and (−) outputs.

**Necessary only if raw supply filter capacitors are more than 3″ from regulators.

Figure 8. ±15V, 1 Amp Tracking Regulators

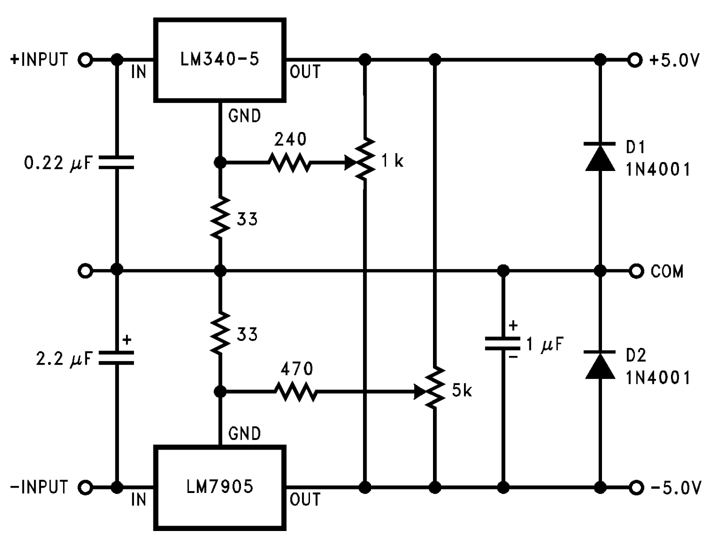


Figure 9. Dual Trimmed Supply

Schematic Diagrams

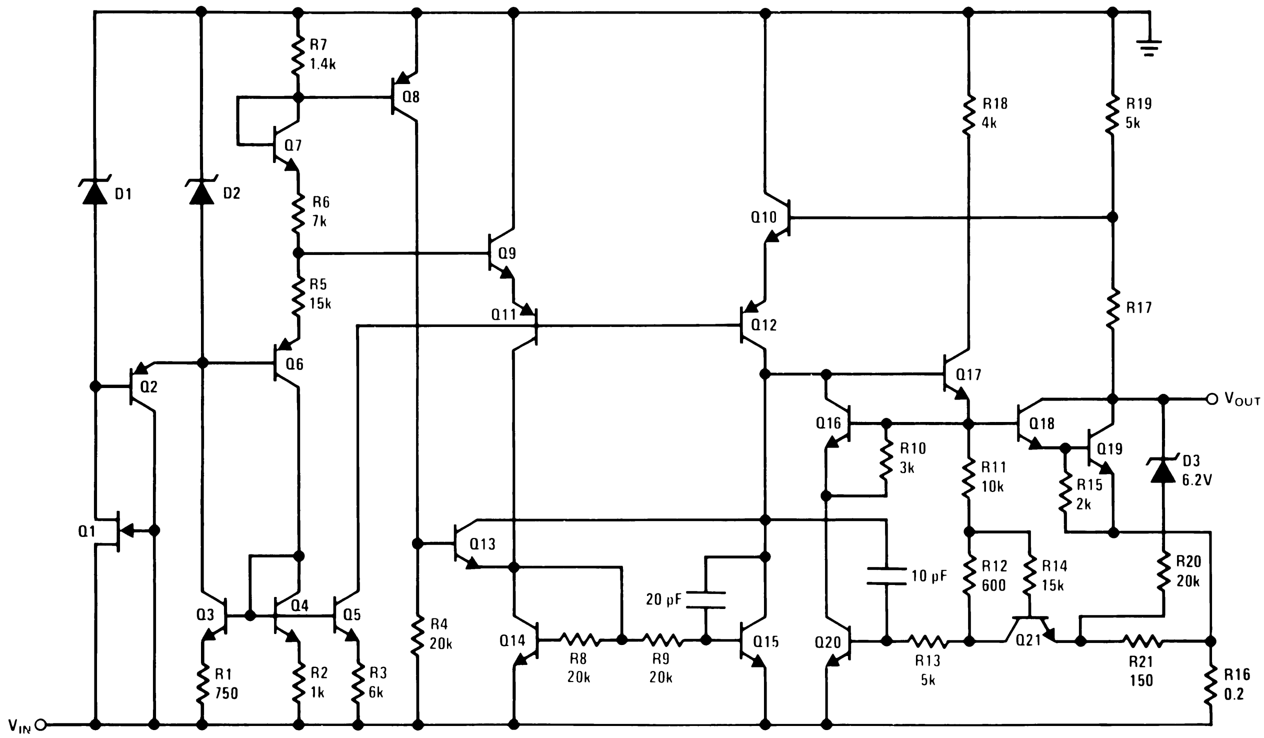


Figure 10. −5V

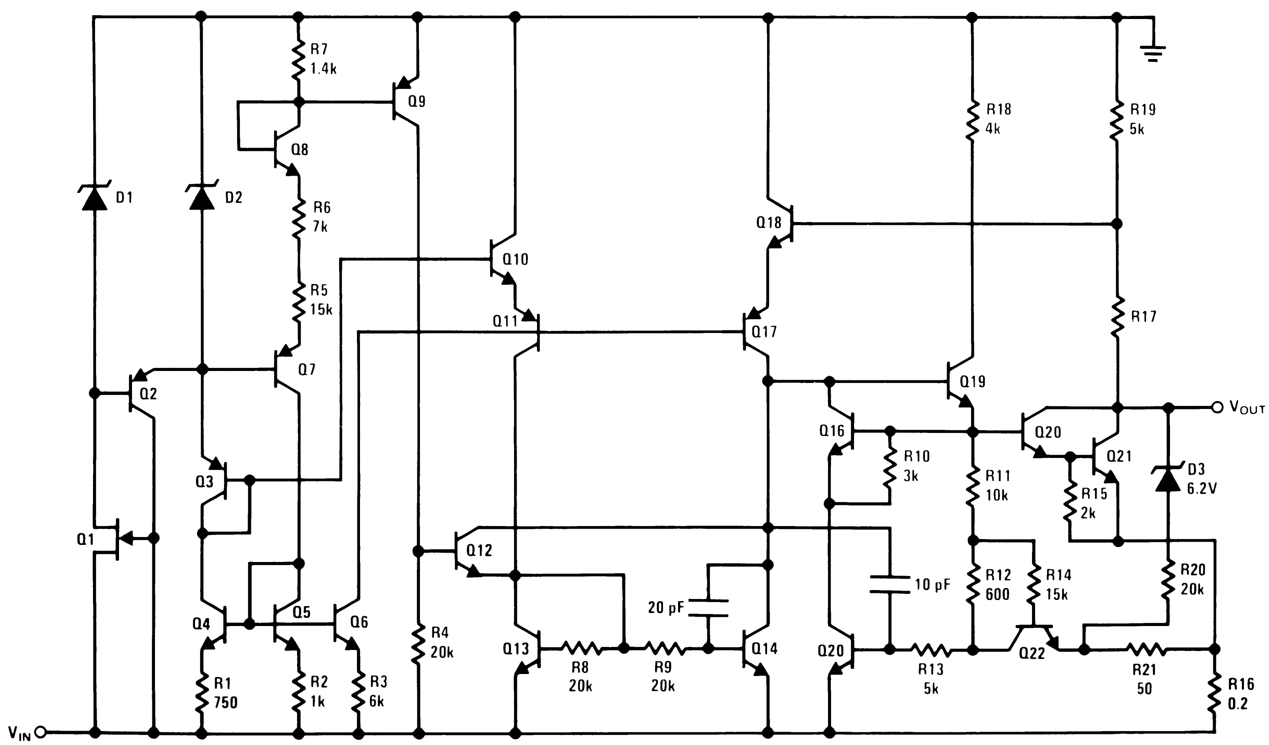


Figure 11. −12V and −15V

REVISION HISTORY

Changes from Revision B (May 2013) to Revision C	Page
• Changed layout of National Data Sheet to TI format.	8

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM7905CT	NRND	TO-220	NDE	3	45	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 125	LM7905CT	
LM7905CT/NOPB	ACTIVE	TO-220	NDE	3	45	RoHS & Green	SN	Level-1-NA-UNLIM	0 to 125	LM7905CT	Samples
LM7912CT	NRND	TO-220	NDE	3	45	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 125	LM7912CT	
LM7912CT/NOPB	ACTIVE	TO-220	NDE	3	45	RoHS & Green	SN	Level-1-NA-UNLIM	0 to 125	LM7912CT	Samples
LM7915CT	NRND	TO-220	NDE	3	45	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 125	LM7915CT	
LM7915CT/NOPB	ACTIVE	TO-220	NDE	3	45	RoHS & Green	SN	Level-1-NA-UNLIM	0 to 125	LM7915CT	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

[6] Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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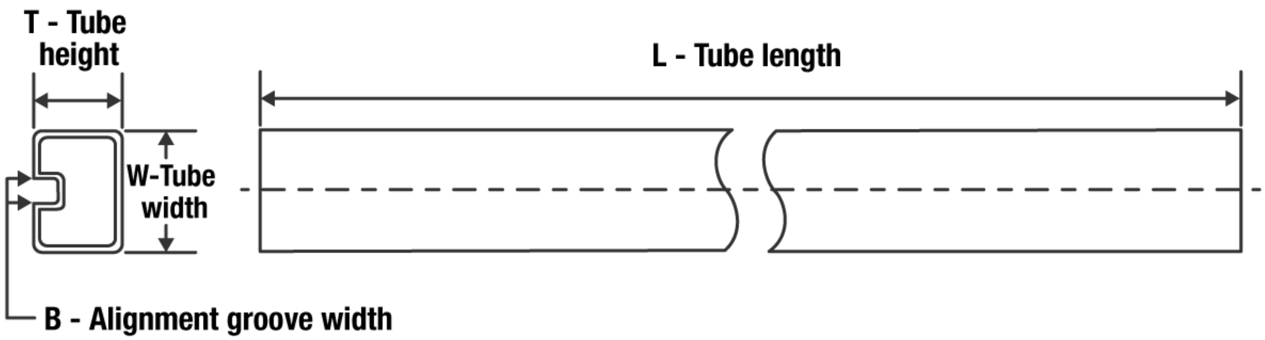
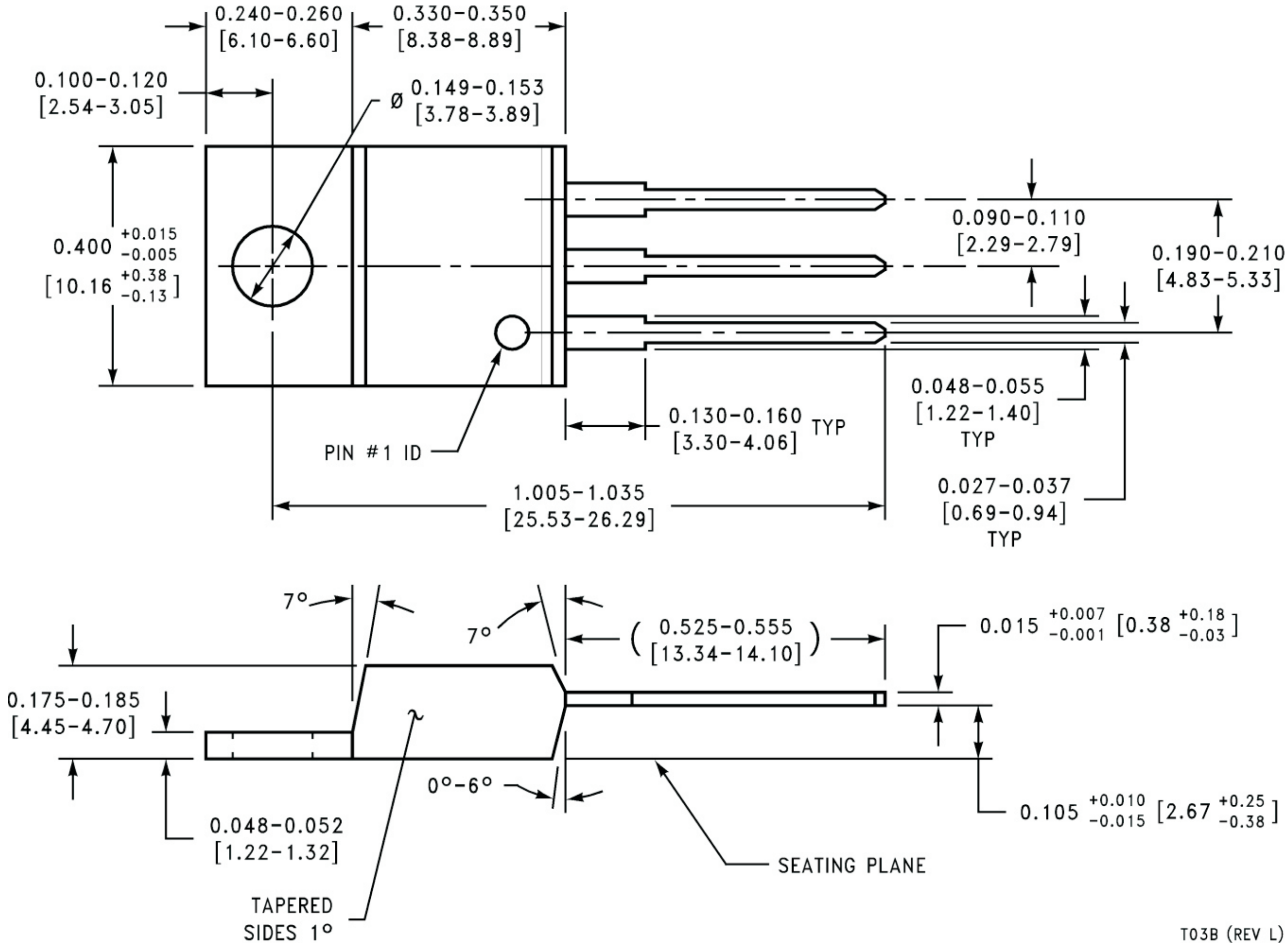
TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
LM7905CT	NDE	TO-220	3	45	502	33	6985	4.06
LM7905CT	NDE	TO-220	3	45	502	33	6985	4.06
LM7905CT/NOPB	NDE	TO-220	3	45	502	33	6985	4.06
LM7912CT	NDE	TO-220	3	45	502	33	6985	4.06
LM7912CT	NDE	TO-220	3	45	502	33	6985	4.06
LM7912CT/NOPB	NDE	TO-220	3	45	502	33	6985	4.06
LM7915CT	NDE	TO-220	3	45	502	33	6985	4.06
LM7915CT	NDE	TO-220	3	45	502	33	6985	4.06
LM7915CT/NOPB	NDE	TO-220	3	45	502	33	6985	4.06

NDE0003B


0.240–0.260
[6.10–6.60]
0.330–0.350
[8.38–8.89]
0.100–0.120
[2.54–3.05]
Ø 0.149–0.153
[3.78–3.89]
0.400 +0.015 −0.005
[10.16 +0.38 −0.13]
0.090–0.110
[2.29–2.79]
0.190–0.210
[4.83–5.33]
0.048–0.055
[1.22–1.40]
TYP
0.130–0.160 TYP
[3.30–4.06]
PIN #1 ID
1.005–1.035
[25.53–26.29]
0.027–0.037
[0.69–0.94]
TYP
7°
7°
(0.525–0.555
[13.34–14.10])
0.015 +0.007 −0.001 [0.38 +0.18 −0.03]
0.175–0.185
[4.45–4.70]
0°–6°
0.105 +0.010 −0.015 [2.67 +0.25 −0.38]
0.048–0.052
[1.22–1.32]
SEATING PLANE
TAPERED
SIDES 1°
T03B (REV L)

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