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FEATURES

REGULARS

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ROHS2 SEEKS TO MOVE THE DIRECTIVE FORWARD AND GIVE GREATER CLARITY

What this piece states is that design engineers need to be aware of the significant developments in the ROHS Directive and its potential impact on their companies.

The potential impact of the amended RoHS proposals is one of the dominant aspects of the legislative scene at present.

The Restriction of Hazardous Substances (RoHS) Directive entered into force on 1st July 2006. It featured six restricted substances across eight broad categories of product pulled from the ten categories in the Waste Electrical and Electronic Equipment (WEEE) Directive. There were 29 exemptions to assist manufacturers and design engineers where no viable alternative was available and a whole raft of 'grey' definitions that required clarity. Subsequent proposals in December 2008 and more recently, driven by EC Presidents Sweden, in September 2009, look to move the directive forward and provide greater clarity. However, some of its provisions will potentially have cost and resource issues for industry.

The proposals recommend that the two remaining categories from the original WEEE categories, namely medical devices and monitoring and control instruments be added to the scope from 2014 (in-vitro diagnostics from 2016 and industrial test equipment in 2017). These were originally omitted from the directive due to reliability concerns over the use of lead-free solder.

While there are no substances actually restricted under either of the proposals, four were recommended for priority assessment. Three plasticisers used in a variety of applications and a flame retardant were highlighted for potential restriction. However, the Swedish proposals would withdraw these substances, which are also under the "authorisation of use process" within the REACH Regulations, from the text.

The Commission intends to adopt a methodology for the review of the restricted substances in Annex IV (the original six possible, but unlikely) and new substances deemed necessary in the future, based on the process set out in Articles 69 to 72 of the REACH Regulations. This would look to review a substance used in electrical or electronic equipment (EEE), or the waste derived from it, that poses a hazard to human health or the environment that is not adequately controlled. If, as per the Swedish proposals, RoHS is expanded to cover all EEE, then there will no longer be the "is it in or is it out of scope" issues as everything will be within scope unless specifically excluded.

Under a separate review by European Commission consultants, 29 exemptions will continue under the proposals, many with amended wording for clarity. Six will be withdrawn and one new one will be granted. These could come into force during 2010 and will be followed by a transposition period of, on average, 18 months allowing manufacturers the time to comply. In addition, a further six exemptions were added in June 2009 that had been proposed a year earlier.

RoHS proposals also clarify definitions such as equipment within out-of-scope equipment, spare parts and military where the latter clearly does not include dual-use equipment. Large Scale Industrial Tools are excluded from the text as part of the 2009 proposals.

A standard and rigid declaration of conformity appears in annex 7 and will replace the multitude of different certificates, statements and compliance documents under the original legislation. There now appears to be no scope for qualifying statements such as "so far as we are aware" and "to the best of our knowledge".

It is proposed that RoHS will become a CE mark directive placing responsibilities on manufacturers, importers and distributors. There are many requirements including building technical files and keeping them for 10 years, ensuring products comply and that they are supplied with the CE mark, as well as the manufacturer or importer is identified on the product. Sample testing should also be carried out where appropriate and corrective action is undertaken where product is found to be non-compliant.

Finally, under the Swedish proposals, the broad product categories and list of indicative products move from the RoHS directive and sit in annex 1 and 2 of the WEEE Directive, which reverses the proposals outlined in 2008.

Gary Nevison is Head of Legislation at Farnell

> **"UNDER A SEPARATE REVIEW BY EUROPEAN COMMISSION CONSULTANTS, 29 EXEMPTIONS WILL CONTINUE UNDER THE PROPOSALS, MANY WITH AMENDED WORDING FOR CLARITY"**

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Propagation Study of GSM Power in Two Dimensions in Indoor Environments – *Part 1*

This article is in two parts. Here, **José Carlos Gamazo**, **Juan Blas**, **Rubén Lorenzo** and **Jaime Gómez**, from the Department of Signal Theory, Communications and Telematic Engineering at the University of Valladolid in Spain, present the objectives, hardware and software developments of a propagation study of GSM-emitted power in two dimensions, in indoor environments

The second part will be published in the next issue and it will include the material, methods, results and conclusion of this study

THIS ARTICLE IS BASED on the application of an experimental system to measure the power of an electric field in indoor environments.

A robotic system is used to position automatically an antenna in a fixed grid within an environment. The collected data is processed, analyzed and demonstrated graphically in order to explain the 2D and 3D pattern of the electric power signal. Finally, a concrete environment is studied and the measured data evaluated in order to characterize the electric field radiated by a GSM base station and to analyze the impact on the human body. The results show that the measured signals have space and temporal variability in a concrete point of their propagation, which produces slow and fast variations with the distance.

Wireless Transfer of Information

Wireless communication is the transfer of information over a distance without the use of electric conductors or "wires". The distances involved may be short (a few meters such as television remote controls) or very long (thousands or even millions of kilometres for radio communications). When the context is clear, the term is often shortened to "wireless".

One of the most common wireless communications is GSM (Global System for Mobile Communications). GSM networks operate in four different frequency ranges. These networks operate in the 900MHz or 1800MHz bands.

The modulation used in GSM is Gaussian Minimum-Shift Keying (GMSK), a kind of continuous-phase frequency shift keying. In GMSK, GSM uses a 25MHz bandwidth, subdivided into 124 carrier frequency channels, each spaced 200kHz apart. Besides, it has eight radio timeslots (giving eight burst periods), grouped into what is called a TDMA (Time Division Multiple Access) frame. Some 82% of the global mobile market uses this standard.

GSM is used by over 2 billion people across more than 212 countries and territories. Consequently, the study of this technology and its propagation in indoor environments is a very important area to analyze. A great amount of studies have been done on this technology, including indoor propagation models or its influence on the health of users. This article shows the spatial and temporal variability of power for GSM-900 electromagnetic fields in indoor environments.

The Objectives

The main objective of this article is to analyze, investigate and apply an automatic system (robot) for measuring the power of an electric field, such as the field radiated by a mobile telephony base station.

The first stage is to develop a methodology for measuring the power of the signal in indoor environments and to optimize the performance of our system in order to automate and simplify the characterization of such environments.

Secondly, in order to determine the electric field distribution and propagation in a specific environment, the collected data is analyzed, and general conclusions and theories are obtained, which could be applied to other environments too or even to other investigation fields, such as study the influence of electromagnetic fields or just the electric field on the human body, for example.

Indoor Propagation and Signal Losses

The analysis of the state-of-the-art propagation prediction models of electromagnetic signals go from simple empirical formulas to modern models based on ray tracing. It demonstrates that the ray tracing method (or ray theory) can provide important parameters to explain the behaviour of the signal waves for their propagation in complex environments, such as arrival time, incidence angle and even statistical parameters. However, the appearance of new techniques as smart antennas or MIMO (Multiple Inputs Multiple Outputs) systems leads to the

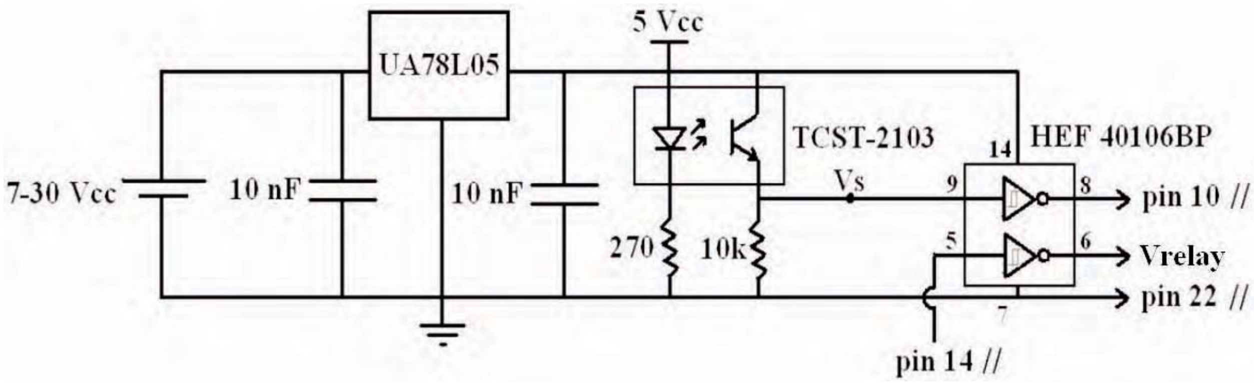


Figure 1: *Robot kernel hardware used for detecting sampling marks in the platform with rails*

development of new theories of predicting the propagation.

Specifically in indoor environments, temporary-space models can be used to evaluate the joint behaviour of all the rays, since these can arrive in groups (or clusters). Another tendency is to put more attention on the characterization of the wall structures that constitute the environment with the purpose of developing more accurate models.

In this study some parameters have been considered, for example reflection, refraction or absorption indexes of some materials that constitute the walls of buildings, such as ceramics or bricks.

In particular, due to reasons of traffic and capacity on mobile telephone systems in urban environments, the coverage areas of base stations are smaller, which have coverage radiuses of a few hundred meters, called "microcells". In addition, the situation and direction of the terminals with respect to the streets and buildings are important in the propagation, as well as the urban topography, like the width of streets for example.

Then, two modalities of propagation exist: LOS (Line of Sight) and NLOS (Non-Line of Sight). Also, there are prediction methods with models taken from COST 231 and ITU-R 8/1.

Propagation Attenuation

The propagation in indoor environments is a very complex phenomenon, so that there are sometimes LOS passages, but generally, the trace is NLOS (the direct ray is blocked by walls, grounds, screens or other objects). In this case, the signal arrives at the receiver through multipath with dispersion, diffraction and reflection. Due to the complexity that involves classic models in terms of rays, most of the indoor models have been obtained from experimental measurements, which are what have been realized in this study.

Some of the most important models studied to analyze the propagation attenuation are indicated here.

Model 1

This is the simplest model, and it is based on determining the adjustment line by means of regression to the measurements, and only taking into account the frequency and the distance. It is expressed in **Equation 1**:

$$L(dB) = L_0 + 10 \cdot n \cdot \log d(m) \quad (1)$$

where L_0 is a constant that represents the losses in a reference distance (generally equal to 1m), *d* is the distance and *n* is the power variation index with the distance.

Model 2

In this model the attenuation due to the walls and ceilings is considered explicitly. For this reason the analysis is a bit more complex, as the planes of the building and information of its materials are needed. In return, more accurate predictions are provided. This is shown in **Equation 2**:

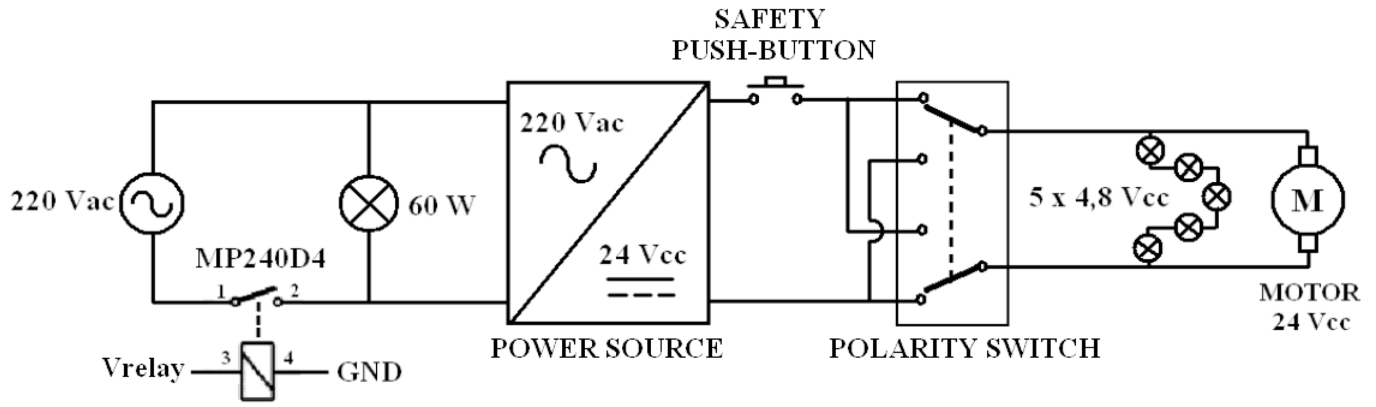
$$L(dB) = L_0 + 10 \cdot n \cdot \log d + \sum_{i=1}^{I} k_{fi} \cdot L_{fi} + \sum_{j=1}^{J} k_{wj} \cdot L_{wj} \quad (2)$$

where *d* is the distance (m), *n* is the power variation index with the distance, L_0 is the loss in a reference point (1m of distance), L_{fi} is the loss factor for a floor of type *i*, L_{wj} is the loss factor for a wall of type *j*, k_{fi} is the number of floors of type *i* crossed, k_{wj} is the number of walls of type *j* crossed, *I* is the number of types of floor and *J* is the number of types of walls.

Model ITU-R

With the purpose of simplifying calculations, the Group 8/1 of ITU-R has proposed a model synthesis of the previous two, as the **Equation 3** demonstrates:

Figure 2: Robot platform hardware used for moving the mobile component (antenna) of the measurement robot



$$L(dB) = 38 + 30 \cdot \log d + L_f(n) \quad (3)$$

where $L_f(n)$ is the factor that represents the penetration loss through walls and floors, as it is illustrated in **Equation 4**:

$$L_f(n) = 15 + 4 \cdot (n - 1) \quad (4)$$

where n is the number of floors existing between the base station and the mobile station.

Statistical and Frequency Variations

Statistical variation

In indoor NLOS paths, the variability of the signal can be modelled with a Rayleigh distribution. In LOS paths, the most suitable model is the Rice distribution. In reality, it is not always possible to carry out the distinction between LOS and NLOS conditions, for this reason the Rayleigh distribution is usually adopted for being more 'pessimistic'.

The slow variations (Long-Term Fading) caused by the shade of walls and obstacles are modelled with a Gaussian distribution with a standard deviation between 8 and 11dB.

Frequency variation

A remarkable characteristic of the variation of the indoor propagation losses with the frequency (see Equation 2) is that the theoretical variation of the L_0 term with the frequency is 6dB/octave. Also, the n factor usually decreases with frequency. Nevertheless, when other loss elements are included, the value of n is 2 in order to include the frequency dependency in those terms.

Losses L_f for 900MHz are considered between 2.8 and 6dB. For L_W these differences are approximately 1dB in walls or thin elements (walls made of wood, doors and so on) and 1.5dB in heavy walls (walls made of bricks, cement, etc).

Building-penetration losses

These models are applied to paths between an exterior transmitter, such as the telephone base-station of this study, and a receiver within a building, such as the isotropic antenna of the robot. With this analysis, the service of mobile telephone can be emulated, so that the propagation attenuation is given by **Equation 5**:

$$L = L_0 + 10 \cdot n \cdot \log d + k \cdot F + p \cdot W_i + W_e \quad (5)$$

where L_0 is the reference loss (a typical value for 900MHz is 31.6dB), n is the attenuation variation law with the distance (n = 2, generally), k is the number of ceilings or grounds crossed by the signal (k = 0, if the signal emitted by the transmitter does not cross any ceiling or ground, but only the building's facade and walls), F is the unitary loss due to ceiling or ground (F = 8 for 900MHz), p is the number of inner walls in the building between the transmitter and the receiver, W_i is the unitary loss due to an inner wall ($0.4 < W_i < 8$) and We is the penetration loss through the building facade ($3.8 < W_e < 10.5$).

Designs and Developments

The robot is a rail-guided vehicle and the rails have narrow slots at centimeter intervals. The function of this hardware is detecting sampling points (slots) and conditioning the signals that are transmitted to the control computer (using the parallel port) and the DC motor (by means of a solid state relay). **Figure 1** shows the schematic of the designed circuit.

When a slot is detected, a high voltage level ('1' or 5V) is obtained (using a Texas Instruments UA78L05 voltage regulator powered by a 9V battery) at the output of the optical sensor (Vishay Telefunken TCST 2103), but this signal is inverted by a Schmitt trigger (Philips HEF 40106BP) before it is received by the pin 10 of the parallel port (PP) of the computer, with the purpose of stabilizing it and eliminating noise.

When a change of value in pin 10 takes place, an interruption of PP is generated (IRQ7), which is used by the control program to detect in a more efficient way (against polling) that the robot has crossed a slot (two consecutive slots are separated 1cm).

For example, if the sensor detects that it is on a slot (pin 10 of the PP is '0'), it sends a low voltage level through pin 14 of the PP (bit *C1* of the control registry). This signal is inverted to '1' by a Schmitt trigger, obtaining V_{relay}, which acts on a solid state relay (Crydom MP240D4) with the purpose of switching this device and stopping the motor (the relay switches off the 24Vcc power source). If the computer transmits '1' (pin 14), the motor will start and the robot will advance until the next sampling position.

So, the PP of the computer has three functions: to control a relay to switch on and to switch off the motor (pin 14 of the PP and bit *C1* of the control register), to receive the information of the slot detector circuit (pin 10 of the PP and bit *E6* of the state register) and to switch the three-probes antenna to measure in each one of the three space directions (a sequence of bits is written in the data register, being used for such effect from pin 2/bit *D0* to pin 9/bit *D7*).

Robot Platform Hardware

The robot's objective is to power and to control the motor which moves it, obtaining a speed of approximately 1cm/s. **Figure 2** shows the circuit that realizes this function.

The first element in the schematic is a solid state relay (Crydom MP240D4), which is activated from the PP with V_{relay} (pin 14) with the purpose of controlling the ignition of the motor, switching the power source 220Vac/24Vcc.

The relay is connected before the power source for controlling its ignition/shutdown, but this is a problem for the operation of the relay (the source introduces an inductive load in its output). This makes it to remain oscillating when the control voltage cuts out the current, if the residual energy at the output of the relay is not consumed.

In order to solve this problem, a 60W lamp was introduced as a resistive load in parallel to the input of the power source. When the relay is driven the lamp switches on, warming itself up and increasing its resistance (the resistance of the lamp increases proportionally to the increase of temperature), whereas the quantity of current consumption is reduced. Thanks to this solution, when the relay is switched on, the residual energy is consumed almost instantaneously, so that the power source is turned off rapidly enough, in the process not influencing the measurement of the electric field power.

On the other hand, a series of five 4.8Vcc/300mA lamps in parallel to the input of the motor are connected (4.8Vcc x 5 = 24Vcc), which is its supply voltage (150mA of maximum consumption). Altogether, a load of 450mA is obtained, which is sufficient to consume all the current that provides the power source (with a nominal current of 420mA and a peak current of 650mA). These lamps have the function of shutting down the motor fast when a sampling slot is crossed (the residual energy stored in the output capacitors of the power supply is consumed when it is switched off). Also, they have the objective of compensating the dynamo effect of the motor when the voltage source turns off (they absorb the electromotive force generated by the motor due to the mechanical inertia of the movement that it had before disconnecting the power supply).

Other elements of this circuit include a switch to change the rotation direction of the motor (inverting the polarity of the power source) and an end of stroke switch (security device if the control program fails).

The Control Software

Software is used to manage the operations of the measurement hardware. Its primary objective is the speed; however it has other important characteristics such as scalability, reliability and robustness among others.

Two programming languages for the accomplishment of the control program have been analyzed: LabVIEW 7.1 and Visual Basic 6.0. Owing to the fact that run-time is one of the most important parameters in this application, the measurement of this time has been realized using both languages, acquiring samples from a GSM signal in the three space directions. The results were very similar for both programs (run-times between 400ms and 500ms). This is due to the main loss being the sweeping time of the spectrum analyzer (between 300ms and 400ms). Due to the fact that a reduced quantity of commands, between consecutive measures, are transmitted (for example, commutation orders for the three-dimensional probes), they have a very low influence in the total execution time.

In addition, two solutions were considered to manage the detection of slots, to stop the motor and to start a new measurement. Firstly, a bit far from the concept of real-time, the technique of sampling the PP during a time interval (in milliseconds), so that when a slot is detected, it is necessary to shut down the motor (pin 14 of the PP to '0'). Secondly, nearer to the idea of real-time, another option is to use the interruptions generated by the operating system when a change of logical level in pin 10 is detected. In order to manage this interruption, the "Interrupt.sys" driver has been used, using the functions of the Win32 application interface.

Finally, Visual Basic was chosen as the programming language due to several factors. One of them is the greater simplicity for handling interruptions, that is, detection of sampling slots to switch off the motor that moves the robot.

Data Processing Software

In order to realize the processing of the measured data by the robot, programs (.m) and data files (.mat) have been developed in Matlab 7.0. These programs are able to read the measured data from text files, to make their processing (separation in data matrixes, computing mathematical operations with the data and so on) and finally obtain the graphical representation in 2D contours or 3D. In addition, thanks to the creation of Matlab data files, the variables can be stored with their respective values and the process of graphical visualization can be automated (it is only necessary to load a data file in the Matlab program for starting an analysis). ■