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Verification of background noise in the short wave frequency range according to recommendation ITU-R P.372

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Abstract

The so-called background noise level is a very critical figure in many EMC problems, especially when sensitive radio services are involved. In order to provide a sufficient signal-to-noise ratio (SNR) the minimum signal strength is most commonly calculated on the basis of existing noise levels. On the other hand, if the impact of unwanted emissions on radio services is studied, background noise takes on the function of a reference level. An extensive database of noise levels to be expected is available in the recommendation ITU-R P.372. However, most data concerning man-made noise were already measured in the 1970s. Thus, the significant increase of use of electrical devices with fast digital circuits and various communication systems gives reason to question the validity of the ITU recommendation for today's EMC purposes. This paper deals with different measurement techniques with respect to their suitability for measuring extremely low field strengths in the short wave range and presents measurement results for selected environments. Although the measurements are performed with the constraint of using a mobile measuring setup a considerable sensitivity is reached, leading to the conclusion that the ITU-R P.372 still seems to be valid for estimating noise levels.

Keywords: Background noise; ITU-R recommendation; Man-made noise; Powerline communications; Short wave radio spectrum

1. Introduction

In the past years the deployment of electrical devices and communication systems has steadily increased. In every household various electrical devices with switching power supplies or fast digital circuits can be found. Besides, the density of communication systems operating in different frequency bands is also growing. Often the “unwanted” radiation of such devices and installations in certain frequency bands – e.g. emissions from personal computers or from Ethernet components using UTP (unshielded twisted pair) – is nearly inevitable but can be mitigated by EMC measures like shielding, for example. To decide if interference with radio services is likely to occur, emissions are compared with the received signal strengths and the existing background noise. Thus, field strength limits aim at conserving a certain minimum signal-to-noise ratio (SNR) specified as acceptable for the considered radio services.

An interesting example in this context is the so-called powerline communication (PLC) [1], which uses, e.g. the low-voltage mains network for transmitting high frequency signals to provide data rates in the Mbits/s range. Obviously, the potential of this technique, regarding, e.g. Internet access or Indoor-LANs, appears highly competitive with usual telecommunication networks. However, due to the use of unshielded cables, portions of the injected PLC signals

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are emitted as radiation. Such unwanted "spectral pollution" is currently the reason for various conflicts between manufacturers of PLC equipment and the power supply industry on the one side and short wave radio spectrum users on the other. Especially radio amateurs and wireless security services are able to work with extremely low field strengths, limited only by the background noise, which can reach values as low as $-15\,\mathrm{dB\mu V/m}$ at locations far away from populated areas (cities, towns or villages) [2]. To estimate the impact of PLC on sensitive short wave radio services [3], the cumulative radiation in the far field has to be studied [4–6]. Taking sensitive radio services into account, an increase of the existing background noise must be avoided by appropriate regulations. Such restrictions also apply for other wire-bound communication systems, such as xDSL systems, cable TV, or computer networks.

For estimating the noise level, a common approach is to use the recommendation ITU-R P.372 [7], which provides data for calculating noise levels in different environments. However, in discussions concerning the EMC of PLC sometimes background noise levels well above ITU-R P.372 are mentioned as a reason for difficulties in measuring emitted field strengths in the HF band. Therefore, a verification of the "old" noise database is desirable, which can only be done by the use of very sensitive measurement equipment. In the following sections, after a short review of ITU-R P.372, different measurement approaches are discussed. Note that the reported work has to be regarded in the context of EMC of PLC, which is the reason for putting emphasis on the use of standard EMC equipment and the constraint of a mobile measuring setup and limited duration. Thus, an adequate evaluation of the measured field strengths has to be developed, leading to the fact that the results are not directly comparable to ITU-R P.372. However, a perceptible rise of background noise should also be observable with the measuring setup described in this paper. Finally, an overview of the measurement results in comparison with "old" data is presented.

2. Recommendation ITU-R P.372-8

As mentioned above, the recommendation ITU-R P.372 is the basis for most estimations of the unavoidable background noise level. The current release is P.372-8, dating from the year 2003, but referring to data which were measured in the 1970s. However, during the last decade, a tremendous increase of the number of electrical devices with fast digital circuits or switching power supplies could be observed. Thus, due to cumulating emissions from these devices, an overall increase of noise seems conceivable.

Generally, electromagnetic noise is classified according to its origin, i.e. atmospheric noise or man-made noise. The latter is the noise level that can be measured, e.g. within or in the vicinity of cities, whereas far away from urban areas a constant "natural" noise level is expected. This so-called atmospheric or ambient noise originates primarily from sun activity or atmospheric activity like thunder storms. In recommendation ITU-R P.372 different environment classes like business, residential, rural, and quiet rural are defined. To calculate the expected noise-related electric field strength level the formula

$$\frac{E_n}{\mathrm{dB\mu V/m}} = F_a + 20\,\log\frac{f}{\mathrm{MHz}} + \frac{B}{\mathrm{dBHz}} - 95.5 \qquad (1)$$

is given, which applies to a short vertical monopole. F_a is the external noise factor in logarithmic notation, f is the frequency, and $B/\mathrm{dBHz} = 10\,\log(b/\mathrm{Hz})$ the logarithmic notation of the measuring bandwidth b. The external noise factor is also given in the ITU recommendation. Basically, the logarithmic relationship

$$\frac{F_a}{\mathrm{dB}} = c - d\,\log\frac{f}{\mathrm{MHz}} \qquad (2)$$

applies. The parameters c and d characterize the environmental category in which the measurement takes place. An overview of the values given in recommendation ITU-R P.372-8 is presented in Table 1. Finally, to calculate an expected noise level, the corresponding measuring bandwidth needs to be specified. In the frequency band relevant for fast PLC applications [8], i.e. from 1.5 to 30 MHz, the standard measuring bandwidth is 9 kHz, which is the typical AM broadcasting bandwidth. Thus, this bandwidth appears also reasonable for noise levels in the short wave frequency range. Inserting (2) and the data from Table 1 into Eq. (1), the expected noise level for each of the environmental categories can be calculated depending on frequency.

Table 1. Parameters of recommendation ITU-R P.372-8 for calculating the external noise factor

Environmental category	c	d
Business	76.8	27.7
Residential	72.5	27.7
Rural	67.2	27.7
Quiet rural	53.6	28.6
Galactic noise ($f > 4$ MHz)	52.0	23.0

The resulting curves are plotted in Fig. 1 (man-made noise, e.g. in urban environments) and Fig. 2 (quiet location, i.e. far away from cities). The figures show noise levels in the range of 0–20 $\mathrm{dB\mu V/m}$ in densely populated areas and between -10 and $-5\,\mathrm{dB\mu V/m}$ in quiet areas. Note that strictly speaking in quiet areas the superposition of both