Automatic Measurement of Small Boxes Shielding Effectiveness

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Abstract. *This paper describes a possible solution for automatic shielding effectiveness measurements for small shielding boxes for frequencies from 10 kHz to 1 MHz. The complete measuring system containing electromagnetic field generating and detection parts and control software is presented. The measurement method is generally described and the measured results are demonstrated.*

Keywords: Shielding Effectiveness, Shielding Boxes

1. Introduction

The fundamental parameter for shielding quality characteristic is a shielding effectiveness. This parameter is defined like this [1]:

$$SE[dB] = 20 \cdot \log\left|\frac{H_i}{H_t}\right| \quad , \quad SE[dB] = R[dB] + A[dB] + M[dB]. \tag{1}$$

Where

- SE shielding effectiveness
- H_i magnetic field intensity in definite point without shielding barrier
- H_t magnetic field intensity in the same point of shielded space
- R/A/M reflection/absorption/multiple reflection attenuation.

The shielding effectiveness can be defined also as a sum of three possible rise mechanisms of shielding effect. The near field radiation must be considered for small boxes. The limitation factor for shielding effectiveness in monitored frequency band is a quality of magnetic field shield. The corresponding technical equipments have to be used. These equipments have to react to magnetic part and mustn't be affected by electrical part of electromagnetic field.

2. Measurement system description

The presented measuring system consists of parts for magnetic field generating and detection and the control unit handling device operation and measured data processing.

For generating and detection of electromagnetic fields for shielding effectiveness measurements in band 9 kHz to 20MHz is recommended small loop antennas utilization with diameter of 0.3 m [2]. The recommended configuration is usually problematically applicable for small shielding boxes by reason of its dimensions. The alternative solution is Helmholtz coils utilization for magnetic field generating and the use of small shield loop antenna with decreased diameter of 0.1 m or ferrite antenna with electrically shielding coil for field detection. The possibilities and limitations of both receiving antenna types are solved in study [3]. The complete system configuration and connection is shown in figure 1.

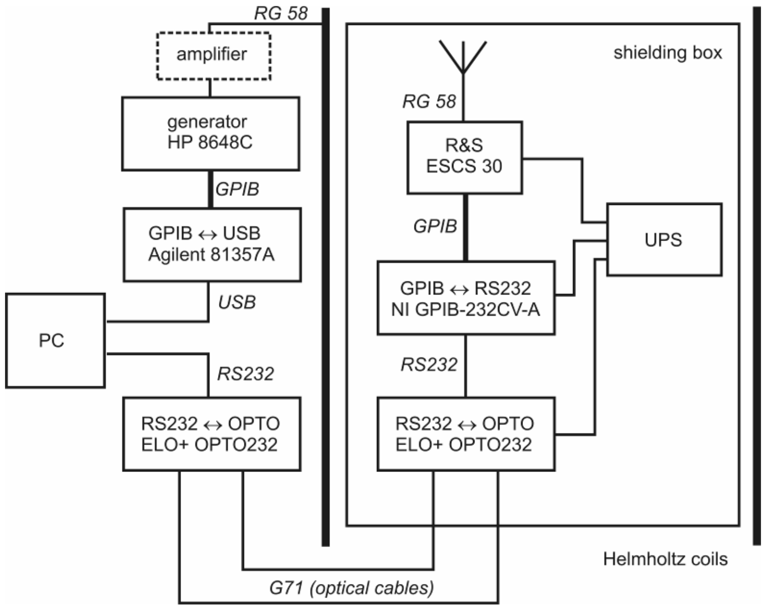

Fig. 1. Block diagram of measuring system

The uniform magnetic field is obtained by means of Helmholtz coils. The square shape of serial-connected coils with side of 2 m in mutual 1 m distance is elected. Computer simulation shows the magnetic field distribution inside coils on frequency 100 kHz (figure 2).

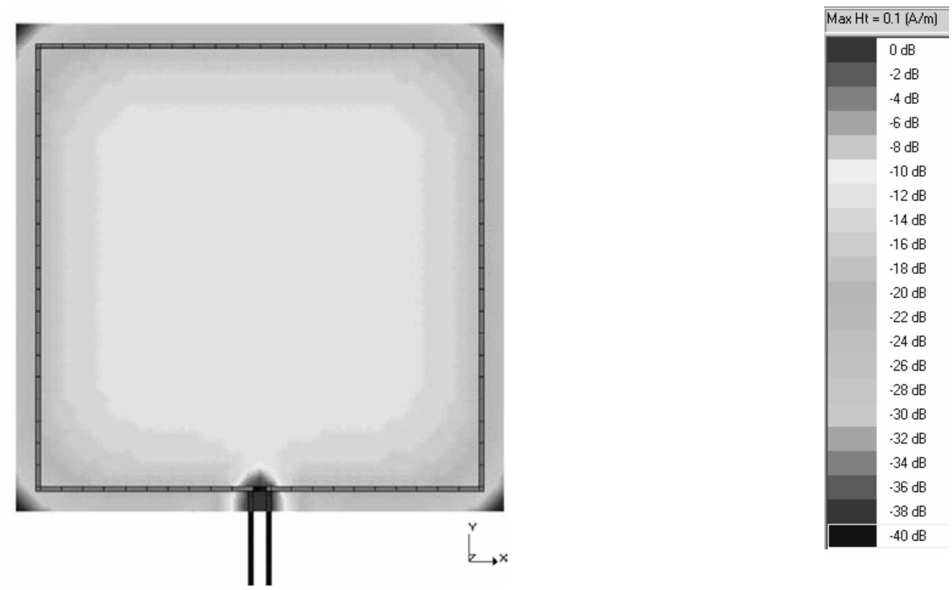

Fig. 2. Magnetic field distribution inside Helmholtz coils

The simulation results demonstrate that the magnetic field is uniform in inner space of coils without sections of 10 cm distance from the coils. This condition limits maximal possible dimensions of tested boxes. The Helmholtz coils generate testing field in whole box neighborhood and the field leaks in the box steady from all directions. The simulation details are described in study [3].

For leaking field measurement all possibilities for background level suppression have to be utilized. The smallest possible receiver bandwidth is used and the low noise preamplifier is suitable to use. The further improvement is achieved by means of measured values processing e.g. averaging. The obvious condition is prevention the disturbed signal leaking via feeding cables and data communication circuits.

The selective voltmeter R&S ESCS 30 is chosen for signal level measurement inside the shielding box. The best results for frequencies from 10 kHz to 1 MHz are achieved with the use of internal preamplifier, average detector with measuring time 1 s and 200 Hz bandwidth. The measured receiver internal noise is less than – 34 dBμV in whole band except the frequencies 64 kHz and 1 MHz (figure 3). The level is measured with 50 Ω input load.

The GPIB interface is necessary to use for external control and data transmission inside shielding box. The multimode optic fiber is used for communication inward and outward the box. The direct conversion GPIB to optic is relatively expensive, therefore the dual conversion is used. The GPIB interface is converted to the RS 232 serial interface via NI GPIB-232CV-A and then the serial data are converted by ELO+OPTO modem to optical signals and sent via optic cable. The reverse conversion from optics to RS-232 is performed outside the Helmholtz coils and the serial cable is connected to computer.

The Helmholtz coils are fed from generator HP 8648C with output impedance 50 Ω and output level 1 V (13 dBm). This generator also uses GPIB interface for remote control and the converter between GPIB and USB is used for connection to computer. The backup UPS device is used for device power supply inside shielding box. All devices can be also supplied from accumulator.

The whole system is controlled by software that enables changing the device settings and measurement conditions. The control software automatically sets the same frequency for devices from required frequency range with adjustable step. The software starts measurement and reads the measured data. The control software is developed in VEE environment.

3. Shield effectiveness measurement

The reference level measurements are provided for various receiving antennas and the results are shown in figure 3. The untuned ferrite antenna brings better results in comparison to shield loop antenna on the frequencies up to 3 MHz. The further improvement for concrete frequencies is achieved by tuning the ferrite antenna into the resonance (e.g. 44 kHz tuned antenna on figure 3).

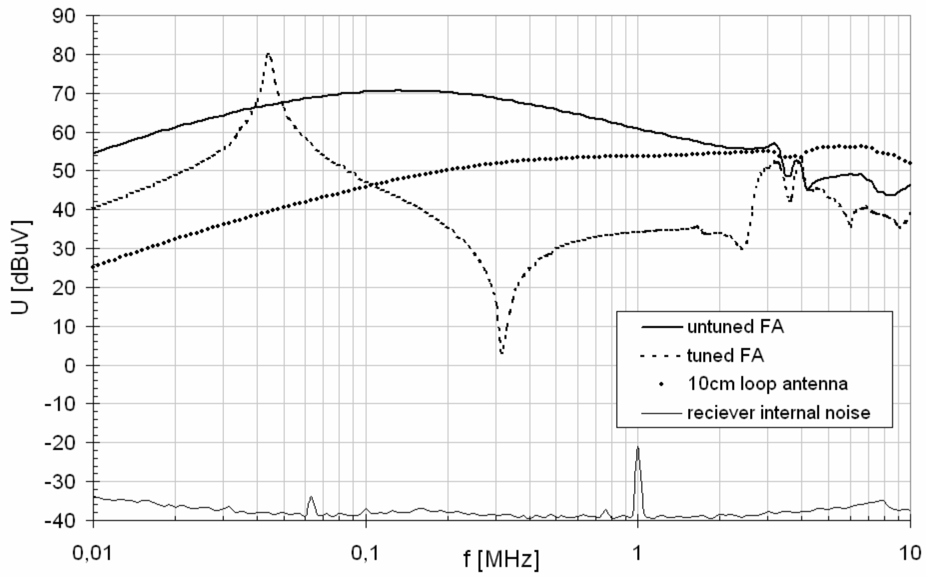

Fig. 3. Reference levels for various receiving antennas

The difference between receiving antenna output level and receiver internal noise gives maximum measurable value of shield attenuation for given frequency. The shielding box MICOS with dimensions 0.65x0.85x0.8 m was used for test measurements and the shield attenuation was measured in several positions. The results for the worst case are shown on figure 4. On the frequencies above 3 MHz the Helmholtz coils reactance makes itself felt.

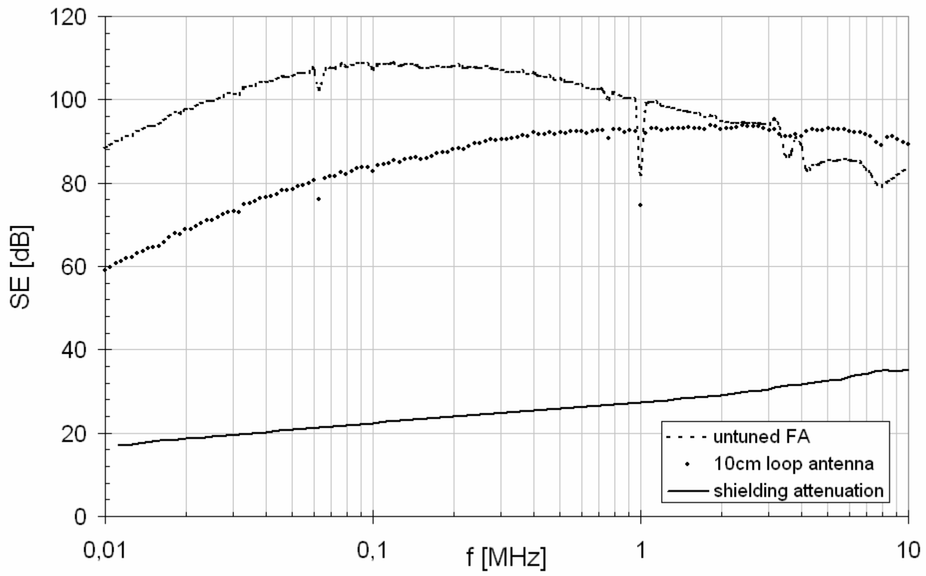

Fig. 4. Measurable shielding attenuation values and tested box shielding attenuation

4. Conclusions

The solution for automatic shielding effectiveness measurements of small shielding boxes in the band 10 kHz to 1 MHz is presented. All measurements were made in the band 10 kHz to 10 MHz, but the results on frequencies above 3 MHz are affected by the big reactance of Helmholtz coil. The measurement results demonstrate suitability of using Helmholtz coils in combination with untuned ferrite antenna for frequencies up to singles of MHz. The shield loop antenna is preferable for higher frequencies. The further increase of measurable shielding attenuation is achieved by utilization of amplifier on the generator side.

Acknowledgements

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