Measurement of Shielding Effectiveness with the Method Using High Power Electromagnetic Pulse Generator

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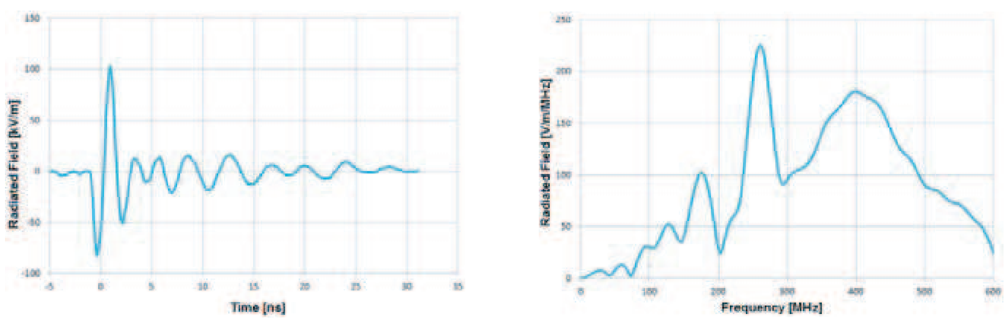
Abstract— The new shielding effectiveness (SE) measurement methodology basing on HPEM-RF DS110 pulse generator is described. In order to conduct validation of research methodology the shielding effectiveness measurement results for selected enclosure are presented. During the measurement the worked out methodology was used. The obtained measurement results are compared to shielding efficiency measurement results which are obtained using standard measurement methodology basing on the selective measurement receiver and RF signal generator which is used as source of testing signal.

1. DESCRIPTION OF THE SHIELDING EFFECTIVENESS METHOD WITH THE USE OF HIGH POWER ELECTROMAGNETIC PULSE GENERATOR

One of the most innovative solutions of the problem of increasing measuring dynamics range of shielding effectiveness of small shielding chambers is using, as probing signal, high power pulses generated by Marx generator. As the source of test signal in the designed laboratory stand for measuring shielding effectiveness the high power pulse generator HPEM-RF DS110 was used. The shape of test signal generated by the above generator in the time function and its frequency spectrum were presented in Fig. 1. Due to significant levels of spectrum components of test pulse and its coverage in the frequency range it can be used as probing signal in the procedure of measuring shielding effectiveness of small shielding chambers within the frequency range from 10 MHz to 600 MHz.



(a) (b)

Figure 1: Representation of high power pulse generated by HPEMRF DS110 generator in time and frequency domain.

In order to measure shielding effectiveness values of small shielding chambers with the method using high power pulse generator a measuring set is required which includes transmitter of measuring signal and meter of electric field strength. The transmitter of measuring signal consists of high power pulse generator HPEM-RF DS110 along with transmitting antenna. The task of the generator is to supply pulses with minimum value of electric field strength of several hundred thousand volts per meter with maximum duration of a single pulse not exceeding 5 ns. The effect of its action is obtaining high power pulse at the input of transmitting antenna of the order of several hundred thousand volts for a very short period of time.

The meter of electric field strength consists of: operating computer, oscilloscope with RF attenuators and sensor with matching block. Sensor with matching unit connected through RF attenuators to oscilloscope with the use of coaxial cable is used for monitoring generated electric field strength. Display of data collected from sensor in the time domain occurs in the oscilloscope. In order to guarantee correct measurement the oscilloscope must be placed in a special shielding casing protecting it from the high generated electric field strength level. Installed software of the operating computer allows, on the basis of high power pulse recorded in the time domain, to determine the frequency spectrum with the use of FFT.

Measuring SE by the method using high power generator amounts to performance of two measurements of signal level at the input of sensor included in the meter of the high power pulse level. The first measurement is conducted as so called standardization measurement. Block diagram of the position for standardization measurement is presented in Fig. 2(a). Standardization measurement takes place for a particular value of signal level generated by high power pulse generator. The electric field strength level is measured in the place of installation of sensor along with matching block. Measured values of electric field strength matching particular measuring frequencies are remembered by a computer operating the measuring process.

After conducting standardization measurement basic measurement should be carried out during which sensor with matching block is placed in the examined small shielding chamber. Block diagram of the position for basic measurement is shown in Fig. 2(b). Basic measurement takes place for a particular value of signal level generated by high power pulse generator. The electric field strength level is measured in the place of installation of sensor along with matching unit. Measurements should be performed in the same way as during standardization measurement. Measured values of electric field strength corresponding with particular measuring frequencies ought to be remembered. After subtracting recorded field strength levels corresponding with particular measuring frequencies, during standardization ($E(f)_{stand}$) and basic ($E(f)_{basic}$) measurement, we will receive the difference of levels of received signals in [dB], which is the value of shielding effectiveness of the small shielding chamber casing defined in the fallowing way:

$$\mathrm{SE} = 20\log_{10} = (E(f)_{stand}/E(f)_{basic})\,[\mathrm{dB}]. \tag{1}$$

Measurements of shielding effectiveness should be conducted for each of the four sides of the tested casing. As the final result of shielding effectiveness results of shielding effectiveness measurements with the lowest value should be chosen from the set of four values corresponding with each side of the tested casing, for each frequency of test signal. The shielding effectiveness depend on the parameters of the material used for tested enclosure. The parameters of materials can be obtained by using measurement methodology described in literature items [1, 7, 8].

In order to conduct validation of research methodology based on the high power pulse generator described above, tests of a sample shielding chamber designed in the form of cube being closed by adding one wall were carried out (Fig. 3).

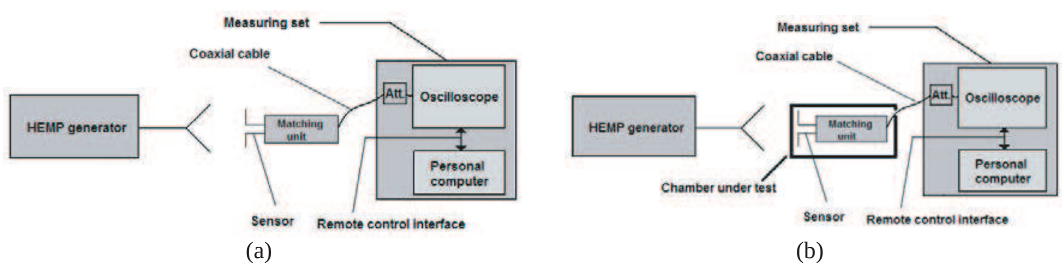


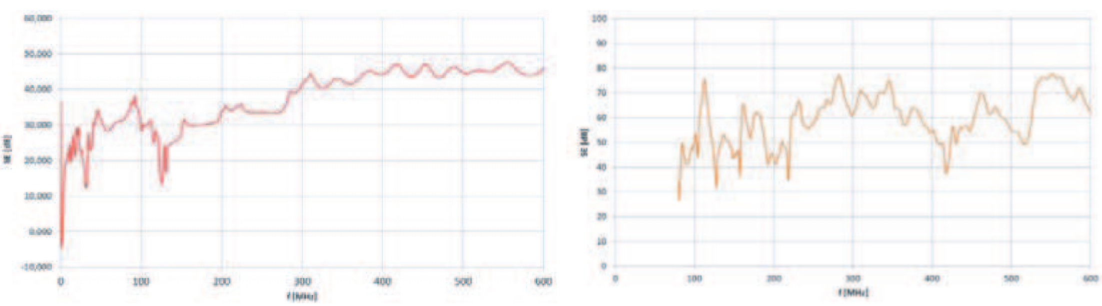
Figure 2: Block diagram of measuring position for (a) standardization and (b) basic measurement.

Figure 3: Measuring position for measuring shielding effectiveness with the use of high power generator: (a) standardization measurement, (b) basic measurement.

2. MEASUREMENT RESULTS

In order to conduct validation of the designed measuring methodology levels of shielding effectiveness obtained as a result of measurements carried out with the method using high power pulses with measurement results obtained with the use of a different measuring methodology were compared. For comparison a classic measuring methodology was used which uses selective measuring receiver and signal generator as the source of test signal. In Fig. 4(a) the final result of shielding effectiveness measurement corresponding with results of shielding effectiveness measurements of the lowest value was presented, from the set of four values matching each side of the tested casing and for each frequency of test signal.

Unfortunately due to physical limitations of measuring potentials used for validation of measuring methods, it is impossible to compare — in the full frequency range — results obtained with the method using high power pulse generator and the method using selective measuring receiver and RF signal generator as the source of test signal. The results of shielding effectiveness measurements shown in Fig. 4(a) obtained with the method using high power pulse generator and values of shielding effectiveness obtained with the method using the selective measuring receiver and RF signal generator presented in Fig. 4(b) can be compared only within the range of frequency from 100 MHz to 600 MHz. Limitation of measuring range of suggested method only up to 600 MHz results from the fact that the used for measurements high power pulse generator generates test signal with large enough spectral concentration up to 600 MHz (Fig. 1). Whereas limitation of measuring range of the method using the selective measuring receiver from 100 MHz results from the fact that small shielding chambers (dimensions smaller than 1 m × 1 m × 1 m) do not allow to place in their interior test antennas with dimensions large enough to effectively radiate test signal with frequency smaller than 100 MHz. As measurement antenna can be used optional antenna [2–6] tuned to the frequency of the test signal.



(a) (b)

Figure 4: The final result of shielding effectiveness for the examined shielding casing: (a) the method basing on HPEMRF DS110 pulse generator, (b) the method basing on selective measuring receiver and signal generator as the source of test signal.

3. CONCLUSIONS

The shielding effectiveness values obtained with the use of the method basing on high power pulse generator differ from the values measured with the use of the method using selective measuring receiver and signal generator in about 10 dB. The above difference results from a big influence of the difference of measuring probe location during standardization and basic measurement in both measuring methods. Difficulties with location of measuring probes in the same place inside and outside the tested shielding casing result from differences of dimensions of used measuring probes in both measuring procedures. The foregoing has the influence on uncertainty of measurement with both methods, which oscillates around the value 10 dB.

The described measuring method basing on high power pulse generator has many advantages such as:

- large dynamics range of shielding effectiveness measurement,
- large measurement rate in comparison with traditional methods of measuring casing shielding effectiveness,
- measuring probe dimensions allow to conduct measurements of shielding casings of small overall dimensions (smaller than 1 m × 1 m × 1 m).

The measured shielding effectiveness can be used in many applications where the electromagnetic field distribution is needed [9–22].

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