Measurement of the Pulses Generated by the High Power Electromagnetic Pulse Generator

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Abstract— In the article the pulses parameters generated by the high power electromagnetic pulse generator HPEM-RF are described. In the article the structure of the meter of electromagnetic field strength and the measurement methodology of the pulses parameters generated by the high power electromagnetic pulse generator HPEM DS110 is presented too. The block diagram of the meter of the pulses generated by the high power electromagnetic pulse generator is presented too. The meter of the pulses consists of: operating computer, oscilloscope with RF attenuators and sensor (AD-70D or AD-80D) with matching block. Display of data collected from sensor in the time domain occurs in the oscilloscope. 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. In order to conduct validation of the meter of the pulses equipped with electric field sensor AD-70D the measuring results acquired with the use AD-70D and AD-80D are compared.

1. INTRODUCTION

The method of measuring of the pulses parameters generated by the high power electromagnetic pulse generator HPEM DS110 is described here. The method is based on using operating computer, oscilloscope with RF attenuators and sensor (AD-70D or AD-80D) with matching block. Described in the article measuring procedure comes down to conduct of measurement of the signal level in the function of time at the input of sensor being a part of meter of the high power pulse level. Spectrum of recorded probing pulses is next calculated with the use of Fast Fourier Transform (FFT). In the article the measurement results of the high power electromagnetic pulse generated by the HPEM DS110 generator obtained with the use of the described method were presented. The measuring results acquired with the use AD-70D and AD-80D sensor are compared. The article is connected with the references [1–3, 8, 9, 11, 15].

2. THE PULSES PARAMETERS GENERATED BY HPEM GENERATOR

As the HPEM generator can be used the Marx generator. The shape of test signal generated by the above generator in the time function and its spectrum are presented in Fig. 1.

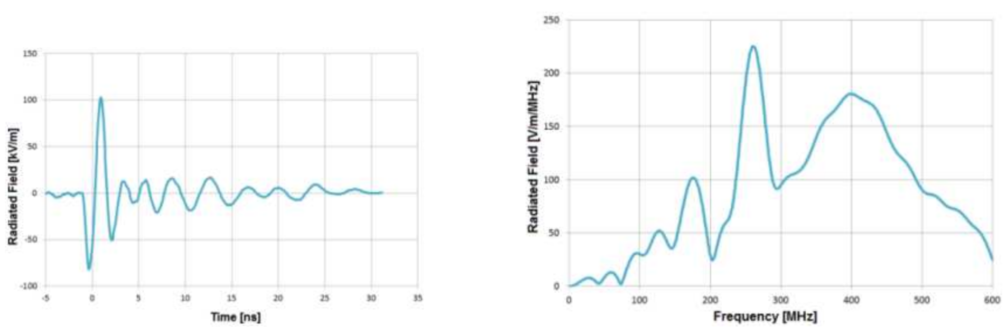


Figure 1: Representation of high power pulse generated by HPEM DS110 generator in time and frequency domain.

The shape of test signal generated by the above generator in the time function can be described by the Equation (1).

$$E(t) = E_0 \cdot \sin(\varphi + 2 \cdot \pi \cdot f \cdot t) \cdot \left(e^{\frac{-a \cdot t}{\tau}} - e^{\frac{-b \cdot t}{\tau}}\right) \quad (1)$$

where: E_0 — the initial value of electric field source function, a — the discharging coefficient, b — the charging coefficient, τ — the time constant of the charging source function.

The above equation has physical meaning in that a source of radiant energy charges the medium at the point under consideration, while the energy radiating away from the point under consideration simultaneously discharges the medium.

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 many applications [6, 7, 20] where the electromagnetic field strength distribution is needed. The transmitter of the probing signal consists of high power pulse generator HPEM DS110 along with transmitting antenna. The set is placed in a portable case of external dimensions not exceeding $550 \times 450 \times 250$ mm. The task of the generator is to supply pulses with minimum value of electric field strength 90 kV/m 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 structure of signal transmitter is shown in Fig. 2.

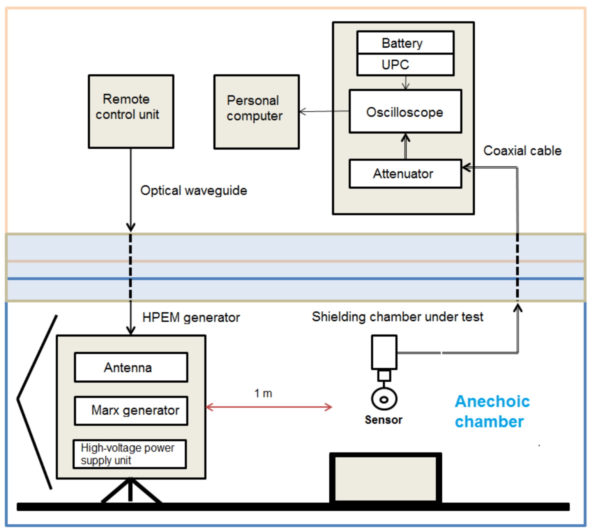


Figure 2: The structure of the meter of electromagnetic field strength.

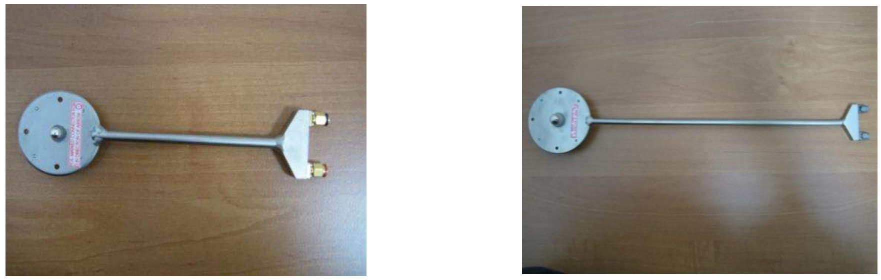
3. THE MEASUREMENT METHODOLOGY

The structure of the meter of electric field strength is presented in Fig. 2. The meter of electric field strength consists of: operating PC computer, oscilloscope with RF attenuator and sensor with matching block. Sensor with matching unit connected through RF attenuator 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.

The sensors which can be used during signal level measurements are presented in Fig. 3. The parameters of the sensors are presented in Table 1. The references describing different sensors (antennas) are [4, 5, 10, 12–14, 16–19, 21–24].

Table 1: The parameters of the sensors AD 70 and AD-80.

No	Parameter	Sensor AD-70	Sensor AD-80
1.	Equivalent area	$1 \times 10^{-3}\,\mathrm{m}^2$	$1 \times 10^{-4}\,\mathrm{m}^2$
2.	Freq. resp.	> 3.5 GHz	> 5.5 GHz
3.	Rise time	< 0.11 ns	< 0.064 ns
4.	Maximum output	± 1.5 kV	± 1 kV
5.	Output connector	SMA (Female)	SMA (Female)



(a) (b)

Figure 3: The sensors (a) AD-80 and (b) AD-70.

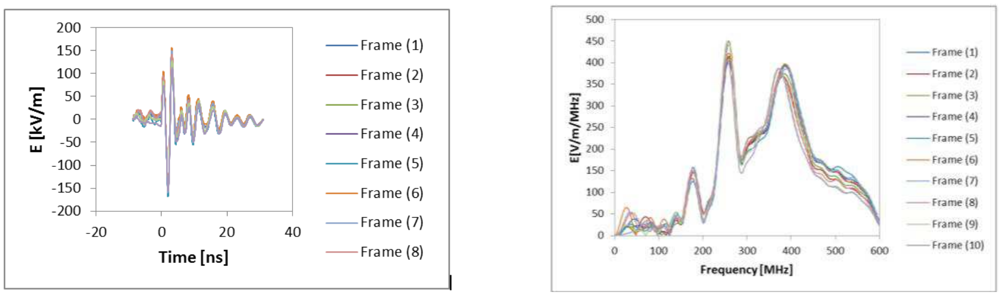


Figure 4: The representation of high power pulse measured with the use AD-70D sensor.

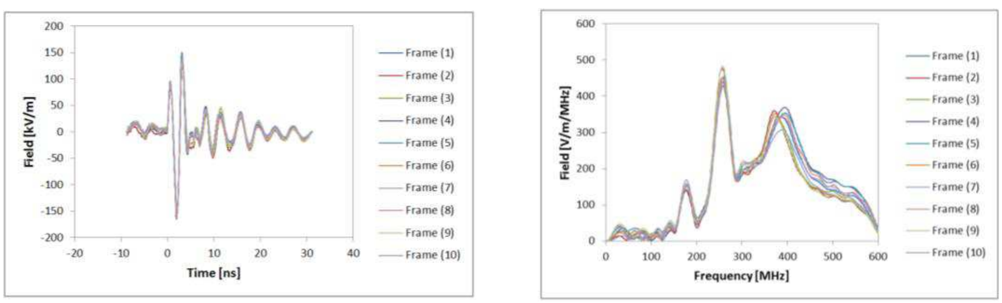


Figure 5: The representation of high power pulse measured with the use AD-80D sensor.

4. THE MEASUREMENT RESULTS

In order to conduct validation of the designed measuring methodology levels of HPEM pulses obtained as a result of measurements carried out with the method described above with the use electric field sensor AD-70D and AD-80D are compared.

In Fig. 4 the measured signal level in time and frequency domain of probing signal with the use of electric field sensor AD-70D are presented. In Fig. 5 the measured signal level in time and frequency domain of probing signal with the use of electric field sensor AD-80D are presented. The signal levels measured with the use of electric field strength sensors AD-70D and AD-80D in time domain and in frequency domain are comparable.

5. CONCLUSIONS

The signal levels measured with the use of electric field strength sensors AD-70D and AD-80D in time domain and in frequency domain are comparable. The described measuring method has many advantages and disadvantages such as:

1. Advantages: large dynamics range of signal level, large measurement rate.
2. Disadvantages: 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, in order to protect the input circuit of the oscilloscope the RF attenuators have to be used.

The measuring methodology can be used in many applications where the electromagnetic field strength distribution is needed.

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