Active Antenna's Array with Control and Stabilization of Regimes of Synchronizing for UWB Video-Pulses

V.M. Fedorov, I.V. Grekhov* , E.F. Lebedev , A.P. Milyaev** , V.E. Ostashev , A.V. Ul'yanov

Institute for High Energy Densities of RAS, Izhorskaya 13/19, Moscow,127412, Russia,+7(495)485-7944, vmfedorov@ihed.ras.ru
**Ioffe Physical and Technical Institute (Politehnicheskaya str. 21, St.Peterburg, Russia)*
***«Trim Ltd» (Kondrat'evskii proezd 40/6, St.Peterburg, Russia)*

Abstract – The high power ultra wide-band (UWB) radiator (Radiator) with 56×56cm aperture was built as an assembly with the eight radiating modules. Each module has the UWB radiating antenna of a TEM-horn type. One module is contented the 35MW pulsed power semiconductor generator and the auto synchronizing device. The Radiator is triggered from the multi-channel master generator (MMG10) with digital time-delay into the channels. The MMG10 is controlled by personal computer with an optical network cable of 30m length. The parameters of electromagnetic video-pulses are followings : E_{max} = 32 kV/m at 14m distance (*FOM* = 450 kV), *FWHM* ≈ 150 ps, repetition up to 250 p.p.s, and frequencies up to 2000 p.p.s in bursts 0.15 s with 1 sec time interval.

1. Introduction

The high power generators with repeated sub-nanosecond pulses are developed last years successfully using semiconductor technology [1-3]. They are applied as a power source with high repetition rate of pulses in laser technique and into the devices for a radiation of electromagnetic sub-nanosecond pulsed with ultra-wideband frequency spectrum (UWB radiation). The giga-watt-range power UWB radiators with controlled parameters can be constructed as multi-source system using the UWB radiators with semiconductor generators [4]. They have compared with the giga-watt-range power radiators using spark switches [5] an advantage as long life-time as create the Radiators with a controlled direction of the radiation pattern.

2. Problem Statement

The Radiator with a controlled direction of the radiation pattern is usually constructed by using few units of the pulsed radiators with a control system for a time-delay of output pulses. Each radiator-unit is composed by the radiating antenna-unit connected with the high power generator-unit by triggering from the multi-channel master generator (MMG) with controlled time-delay into the channels. Few problems are needed to solve then. First, to provide a stabilization of time delay with accuracy of better 50ps (between triggering pulse and an output sub-nanosecond pulse from the high power generator). Secondly, to provide electromagnetic compatibility of the giga-watt-range power UWB radiator (high voltage pulses producing) with the triggering and controlled systems (using low voltage pulses). The early Radiator with 0.12GW pulsed power was made and successfully employed at IHED RAS in the 2003 [4]. In this article we present the new radiator-2005 with better parameters.

3. Set-up of Multi Module Radiator

The high power ultra wide-band (UWB) radiator (Radiator) with total aperture of 56×56cm sizes was built as an assembly with the eight radiating modules (Fig. 1).

Fig. 1. The high power ultra wide-band radiator (the Radiator created *FOM* = E_{max}×*R* = 450kV), view on site of radiating aperture.

Each module consists of the UWB radiating antenna unit and the synchronizing pulsed power source that is placed into metallic screened box with 28×14×45cm sizes. The screened box contains the 35MW pulsed generator GIN35 (production by «FID Technology», www.fidtecnology.com) and the auto synchronizing device ASU1 (made in «TRIM Ltd»), and block to buffering the primary power supply and systems to internal ventilation (see on Fig. 2).

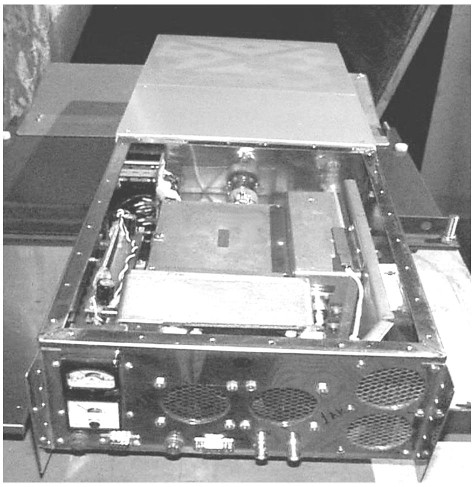

Fig.2. One radiating module

The assembly of these modules is shown on Figs. 1 and 3.

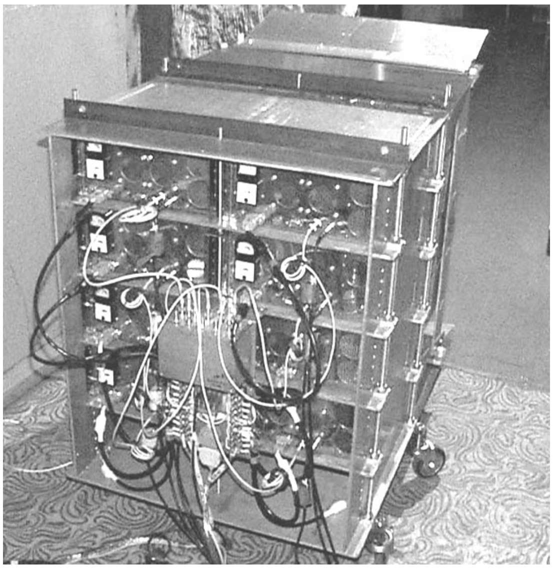

Fig.3. The Radiator, view on site to connectors for power supply and triggered cables.

For achievement of electromagnetic compatibility of the giga-watt-range power radiator (generating high voltage pulses) with the triggering and controlled systems (low voltage pulses) we applied traditional methods. For instance, they are the matching loads on cable terminals, and ferrite rings on cables, and series shielding by means of metallic screen boxes, and others. One can see some elements of the protected shielding on Figs. 2, 3 and 4. We had met hard problems on way to achieve stable operation when the Radiator was assembled with many the radiating modules of high power pulses. The Radiator is being triggered from the multi-channel master generator (MMG10) that was mounted into metallic shielded box with the noise filters (Fig. 4). Really the MMG10 device has been developed and constructed by "TRIM Ltd". The MMG10 has the digital controlled time-delay at 10ns range into all channels. It is controlled by personal computer with an optical network cable of 30m length.

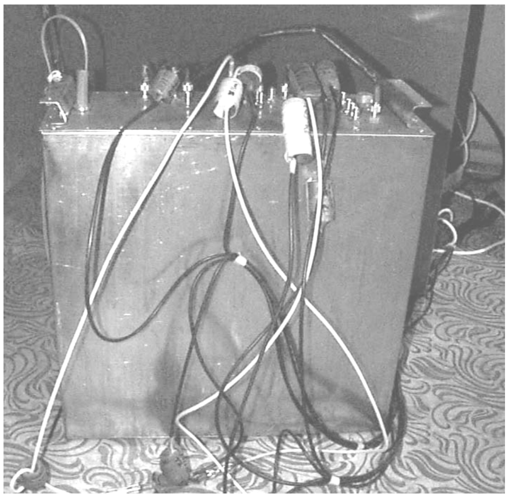

Fig.4. The multi-channel master generator (MMG10) in assembly with metallic shielded box

4. Sensors for UWB Electromagnetic Wave and System Registration

A registration of electrical pulses with sub- nanosecond duration has been produced by means of the "TRIM" digital sampling oscilloscope with 10GHz bandwidth and the TDS 6604B digital oscilloscope with 6GHz bandwidth. We used various the voltage dividers and sensors with the voltage strength up to 100kV and with high frequency bandwidth. We have tested their by using calibrated generators up to 100V amplitude with sub-nanosecond rise time. The coaxial cables are tested and measured a weakening of the voltage pulse after passed through the cable. The computer program (made by V.E.Ostashev) was used for simulations the weakening and reshaping of the pulse signal.

The *E(t)* fields in electromagnetic wave traveling in a free space were measured by sensors of the linear strip transducer [6]. The original strip transducer was made at All Russian NIIOFI. It has sensitivity about 0.5V/(kV/m) with a communication cable of 12m length. It has a "hard" frequency correction provided low distortions for an measurements of the field *E(t)* with a pulse duration from 0.15ns up to 5ns. In measurements of the sub-nanosecond video-pulses we use also the strip transducer of production by IHED RAS with low losses cable.

5. Pulsed source of the Radiating Module

Pulsed semiconductor generators GIN35 (Fig. 5) produce pulses of 43 ± 3 kV amplitude with 120 ± 15ps rise time and with *FWHM* =250-500ps on 50Ω load with continual repetition up to 250 p.p.s, and frequencies up to 2000 p.p.s in bursts 0.15 s with 1 sec time interval. Primary power supply uses DC 21-27V source with average power up to 60W. In bursts regime it use also energy buffers of capacity banks and accumulators. Typical waveform of output voltage of the GIN35 operated at continual repetition on the 50Ω load is shown on Fig. 6.

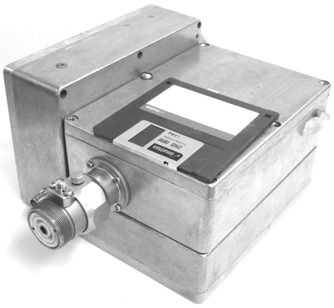

Fig.5. 35MW pulsed generator GIN35

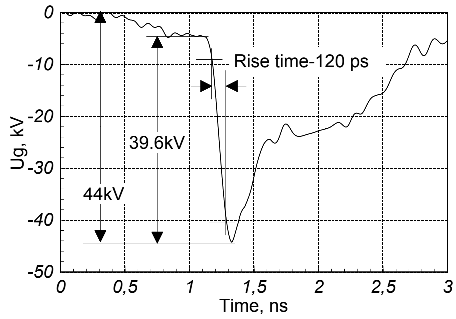

Fig 6. Voltage waveform of the GIN35 output pulse

The time-delay between trigger impulse and the GIN35 output pulse is equal about 170ns. It may change in a range of ±0.5ns for various temperatures and operated regimes. The auto synchronizing device ASU1 stabilizes time-delay of radiated pulses.

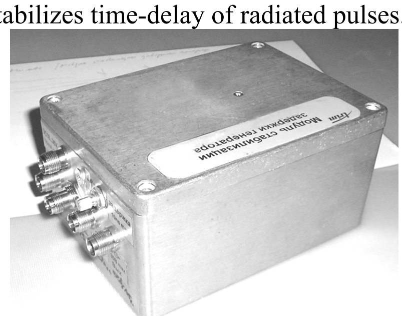

Fig.7. ASU1 stabilizer for time-delay of power pulses

The ASU1 was included into trigger line between the generator MMG10 and the GIN35 triggered input. The ASU1 stabilizes total time-delay in the GIN35 and the ASU1. Electronics of the ASU1 tunes up time-delay in the ASU1 to conserve total time-delay. This device uses caliber line and comparator with feedback.

6. Antenna Unit of the Radiating Module

The antenna unit has been developed and constructed in IHED RAS like used in [4]. Really radiating antenna is designed as the flat-plane TEM-horn with 27×13cm aperture. That horn is mounted inside the insulator box with 28×14×50cm sizes (Fig.5) and strength of pulsed voltage of more 50kV.

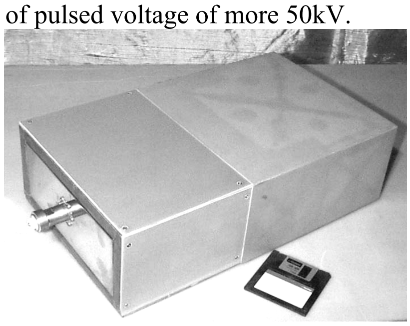

Fig.8. Unit of the high power UWB radiating antenna

The coaxial input feeder with 50Ω impedance is mounted in wall opposite radiating aperture of the antenna (see on Fig. 8). Pulsed power from the feeder is transmitted by means of two-wire lines to the horn electrodes at few places for good matching factor and a time-coherence. The radiation pulse of the module is shown on Fig.9. At distance of the R = 15m on axis antenna in free space was registered electromagnetic video-pulse with electric field amplitude of the E_{max}= 3.6kV/m. It creates "radiated voltages" of the $FOM = E_{max} \times R$ = 55kV. An attitude of this *FOM* to value of the GIN35 voltage with rapid jump ($U_{gR} \approx$ 40kV – see on Fig.6) equals $FOM/U_{gR} \approx 1.5$. It points to high efficiency of the transformation of electric energy to electromagnetic waving energy of the UWB video-pulse (calculations give to $\eta > 50\%$).

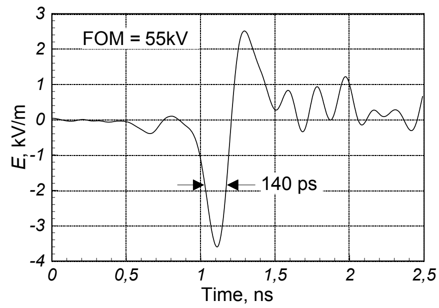

Fig.9. Electrical field waveform producing alone module

Note, one module that is placed in assemble with other modules (as on Fig.1) it produces *FOM* more value compared with the *FOM* for alone module. In first case an effective size of the radiating aperture is increased compared with the aperture for alone module.

7. Experimental Data for the Radiator

The Radiator (assemble as on Figs.1 and 3) has placed on heights up to 4m above earth surface. He produces vertical polarization of the electrical field. The *E(t)* electric fields were measured by the strip transducer that placed at heights up to 2m above earth surface. Experimental results are given in Figs.10 and 11.

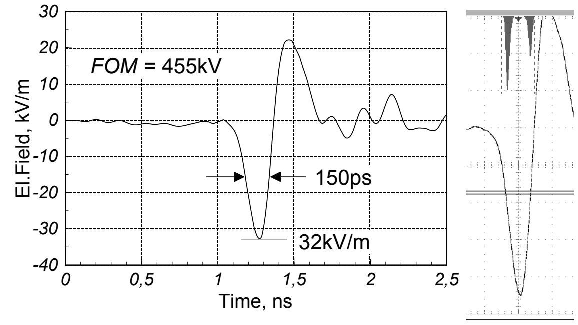

Fig.10. Electric field strength of electromagnetic video pulse was measured at 14m distance from the Radiator. On right-hand, traces of the 40ps - jitter of time-delay between the video-pulses (3×10^3) and triggered pulses were registered on TDS 6604B digital oscilloscope.

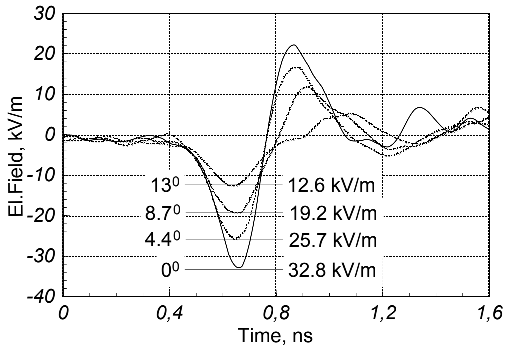

Fig.11. Electrical field waveforms were registered in following conditions of: 1) the sensor placed at 0.5m height above earth surface and on 13m distance across surface, 2) the sensor has taken aim at the Radiator with various angles in horizontal surface, 3) the Radiator placed at 3.5m height above earth surface, 4) axis of the Radiator has taken aim at earth surface on 20m distance.

Angle divergence of radiation pattern for the Radiator is estimated at the ± 8 degree (see on Fig.11) in horizontal surface for criterion of half amplitude of electrical field. We have produced an electronic scanning direction of the radiation pattern (same in work [4]) by means of changes of the time-delay for one row of the modules compared with the time-delay for other row.

8. Conclusion

The Radiator for high power video-pulses with a controlled direction of the radiation pattern was constructed and successfully employed with the *FOM* value of 450kV.

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