HEFTI
High-Energy Frequency Tesla Inc.

EMP and MCG Simulator Studies

Specifications

- 9-stage Marx generator
- Six capacitors per module for the total of 54 capacitors
- Twelve spark gaps per stage for the total of 120 spark gaps
- Each spark gap can be adjusted to few microns
- The capacitance per stage is 15.6 nF
- Almost ideal coaxial structure achieved
- Low input impedance of 18 Ω achieved.
- The charging voltage per stage varies from 10 kV to 25 kV
- At 25 kV/stage charge, the stored energy in the system is 44J
- Excellent reproducibility of the voltage waveforms is produced

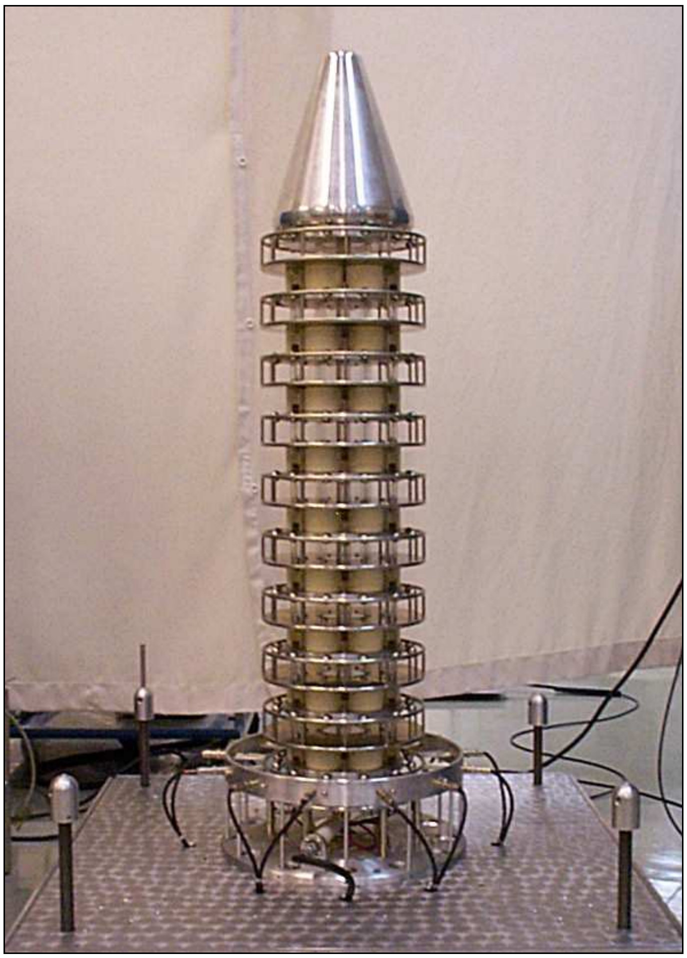

Figure 1. Photograph of interior of the Rim-Fire Marx Generator (earlier version). In the current set-up the Generator is enclosed in the metallic tube of 12 inches (≅ 30.5 cm) diameter.

EMP studies

The Generator is attached to the resistive load that symbolizes the impedance of the EMP antenna. The waveforms that the generator produces are given in Fig. 2

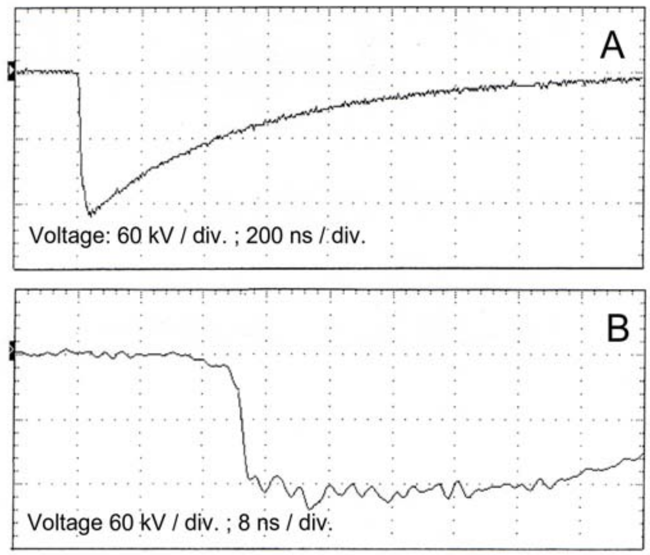

Figure 2. Output voltage across 300 Ω load. Frame A gives the width of the pulse, and frame B the rise-time. The charging voltage is 14.7 kV/stage

Initial MCG simulation studies

Experimental conditions

- Charging voltage is 17.5 kV/stage and the energy stored in Marx generator is 21.5 J
- Experimental set-up is similar to that presented in the paper: "HPM generation in atmospheric air" by M. M. Kekez. The main difference is that here the electric field probe is used not only to measure the field, but also to be the partial reflector. The helical antenna is of 2 inches (=5.08 cm) in diameter and is attached to the H.V. output electrode of the generator. The spark breakdown takes place between the H.V. output electrode of the generator and the ground via a short (2 mm) distance gap.
- Helical antenna directs the HPM radiation towards the electric field probe.
- Distance from the helical antenna to the probe is 50 cm.
- Experimental results are given in Figs. 3 and 4.
- In Fig. 4 minor change in the distance between the probe and the antenna has taken place in comparison to the distance used in Fig.3.

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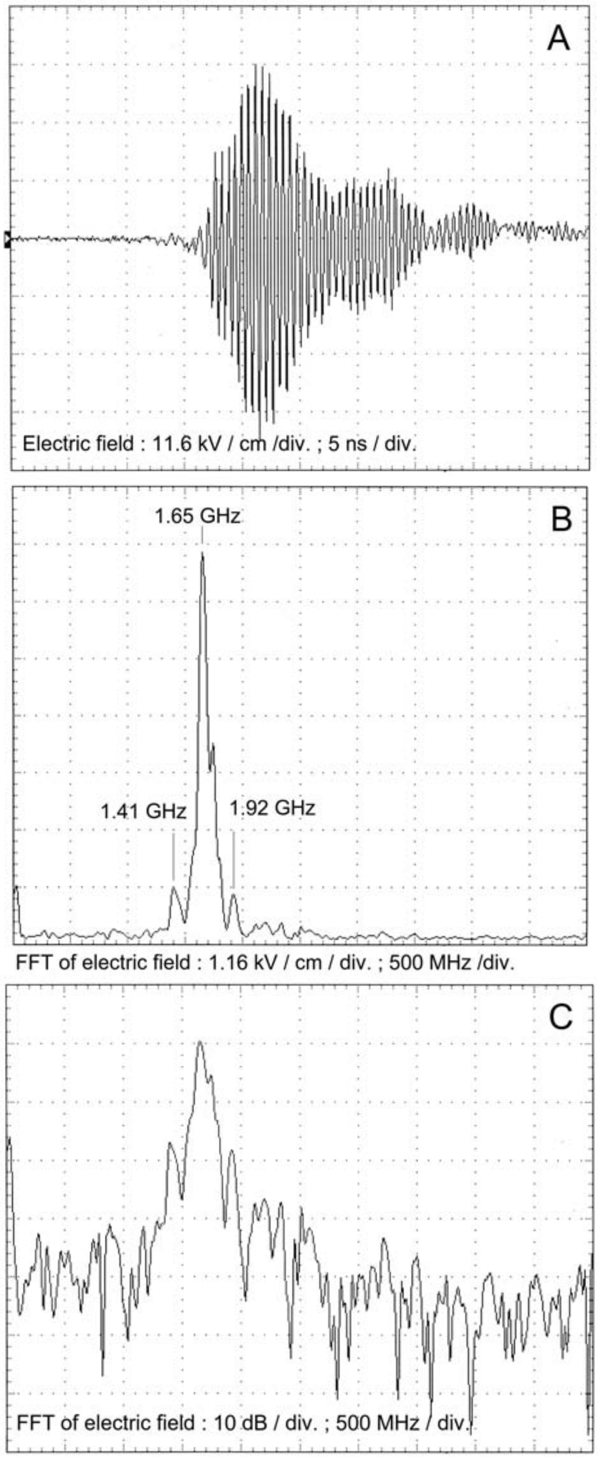

Figure 3. Frame A is the electric field. FFT is shown in frames A and B on the linear and logarithmic scale respectively.

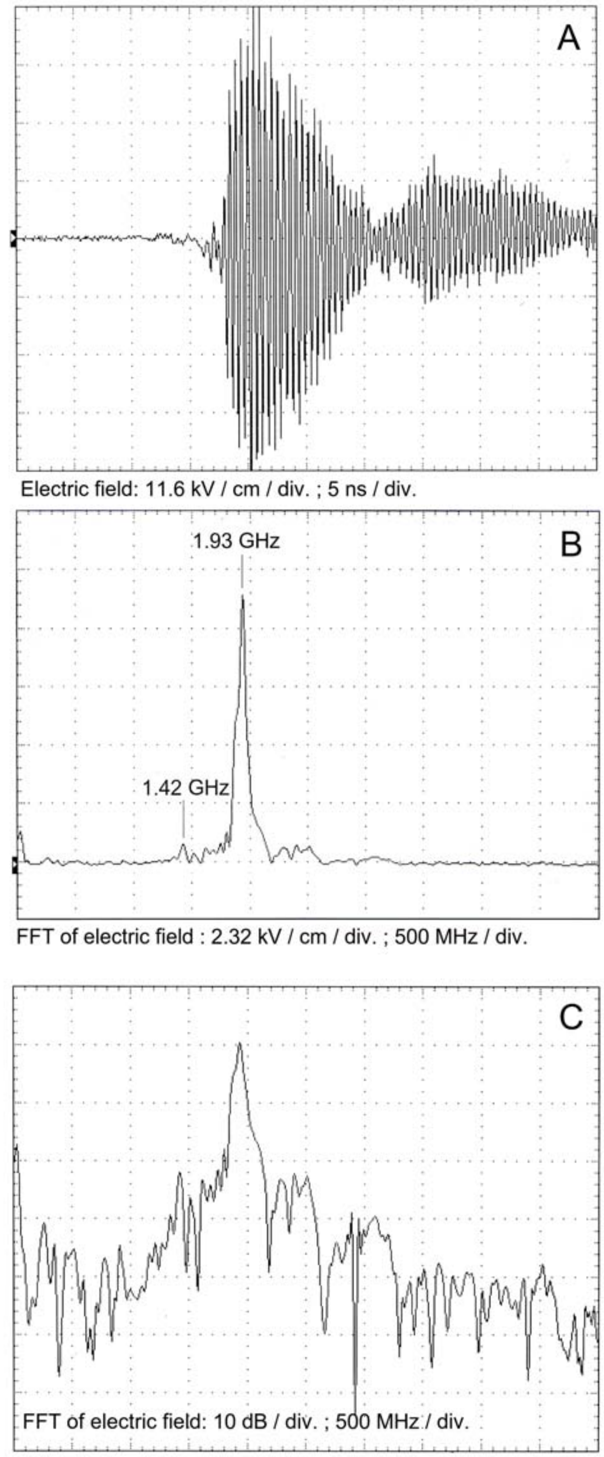

Figure 4. Description of the frames is as in Fig. 2.

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Current HPM studies

Experimental conditions

- Charging voltage is 19 kV/stage.
- Energy stored in Marx generator is 25 J
- 3 GHz bandwidth oscilloscope is used to record the data.

- Single loop B-dot probe is used. It is made by Advanced Engineering Manufacturing Solutions, Albuquerque, NM, USA. Effective diameter of the loop is about 1.2 mm.

- B-dot probe is calibrated in the TEM-cell. For frequency of 1.69 GHz, the amplitude of the signal of 1 Volt corresponds to the electric field of 1.8854 kV/cm.

- As in Figs. 3 and 4, the experimental set-up used is similar to that given in the paper: "HPM generation in atmospheric air" by M. M. Kekez. The main difference now is that a smaller size metallic cylinder is placed at the output of the generator,

- To understand better the evolution of the HPM emission, the helix is replaced by a solid brass electrode of 5 cm diameter and 6 cm height.

- The partial reflector is placed on top of the cylinder of 4½ inches (=11.43 cm) in diameter.

- The resonant cavity is tuned to 1.69 GHz. The cavity occupies the space of the following boundaries: the output metallic flange of the generator at the bottom, the metallic cylinder at the side and the partial reflector at the top

Discussion

When the resonant cavity appears to be well tuned, the data of Fig. 5 are obtained. The typical results are given in Fig. 6.

Periodically during the experimental run, the amplitude of the signal may rise suddenly by factor of 10 and the power density by 100. These results are given in Fig. 7 and the evolution of this sudden increase is recorded with different sensitivity of the oscilloscope in Fig. 8.

The tentative explanation for Figs 7 and 8 is that inside the generator, RF and microwave radiation are also produced. These radiations have numerous frequencies. They are penetrating inside the resonant cavity that tuned to the frequency of 1.69 GHz. When occurs that the generator produces large amount of radiation at 1.69 GHz, the resonant cavity under study will also act as the amplifier of these radiation. The situation is analogous to the experiments done by Price *et al.*, J. Appl. Phys. **65**, pp 5185-5189, 1989

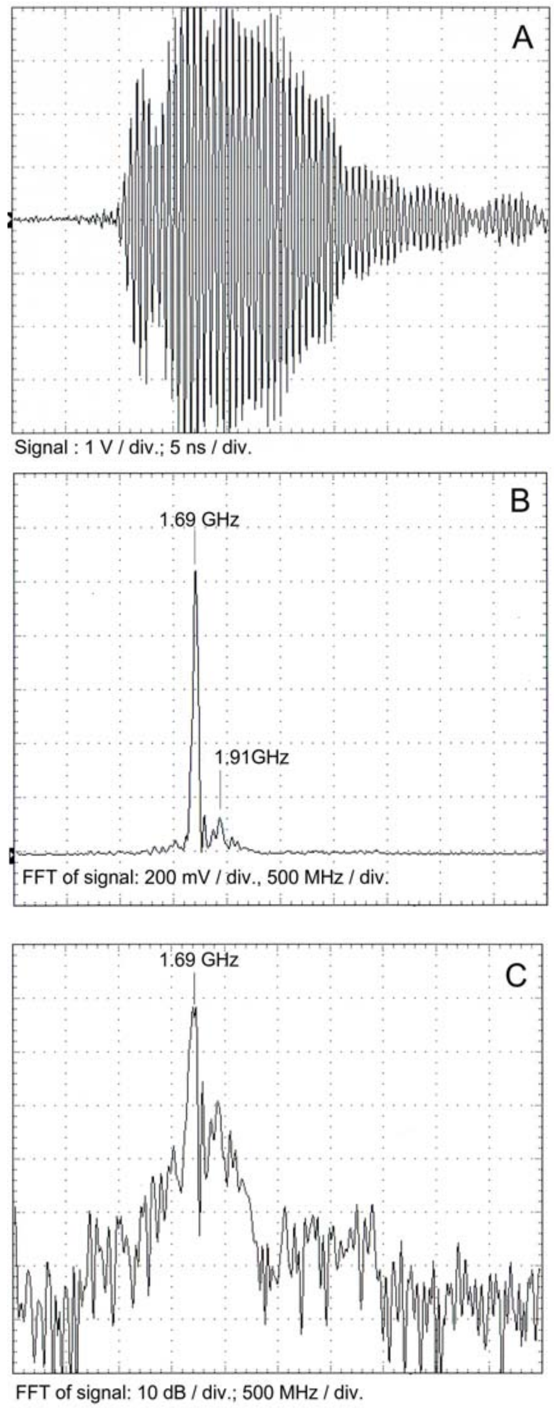

Figure 5. Description of the frames is as in Fig. 2.

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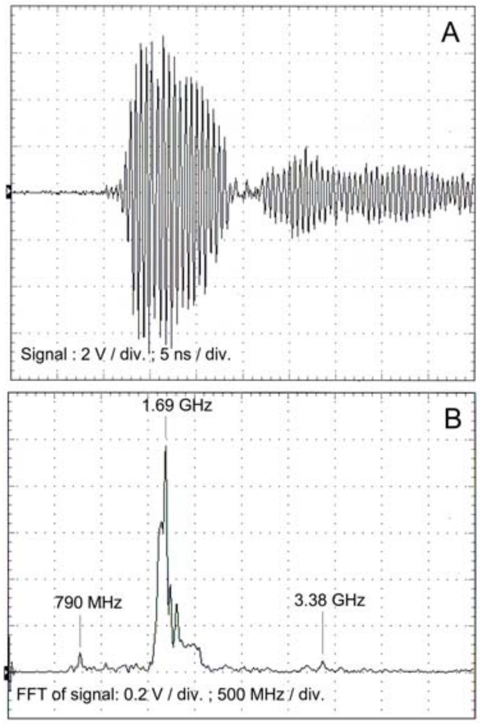

Figure 6. Description of frames is as in Fig. 2.

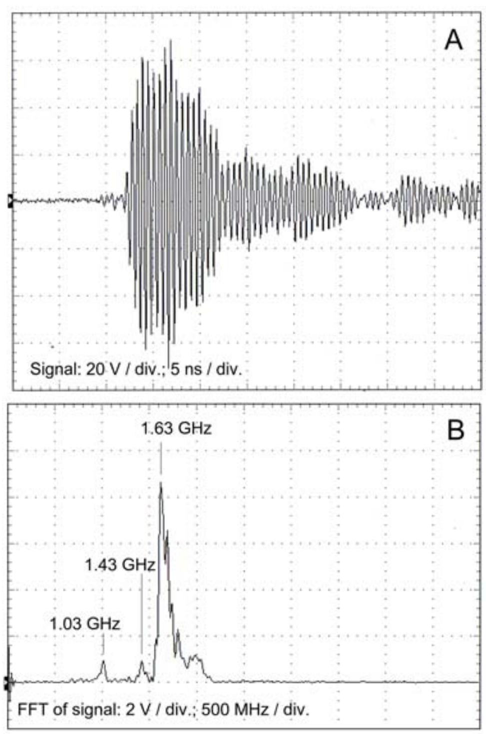

Figure 7. Description of frames is as in Fig. 2.

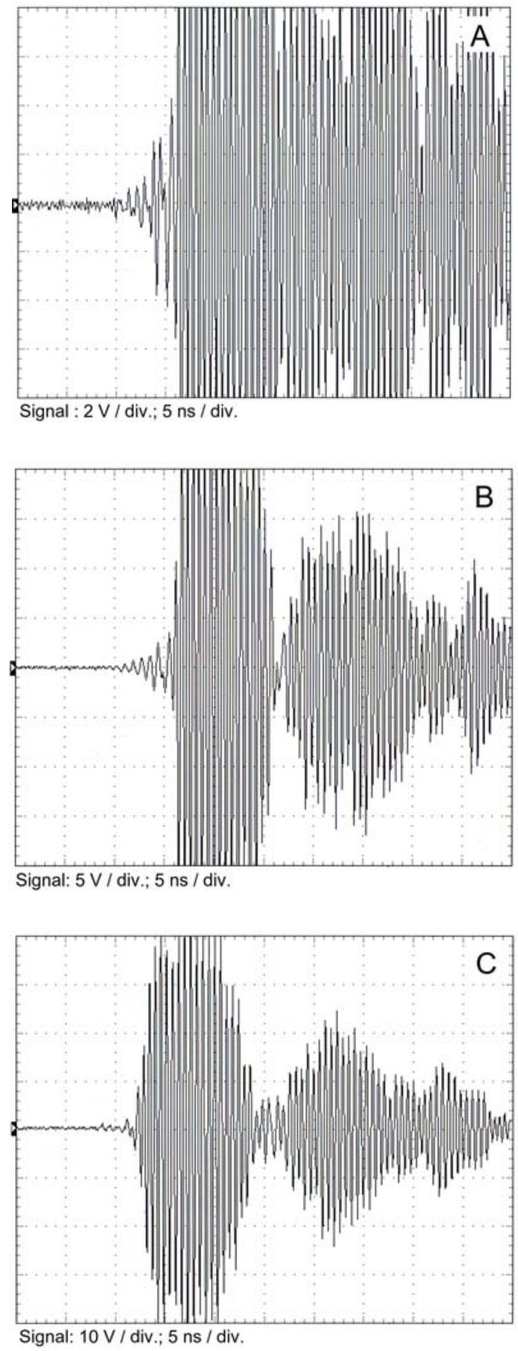

Figure 8. Description of frames is as in Fig.2.
Three different sensitivity of the oscilloscope are used.

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