"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA

"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2014
Brasov, 22-24 May 2014

HIGH POWER ELECTROMAGNETIC SYSTEMS FOR MILITARY APPLICATIONS

Vasile DOBREF, Alexandru SOTIR, Octavian TĂRĂBUȚĂ, Cătălin CLINCI

*Marine Engineering Faculty, "Mircea cel Bătrân" Naval Academy, Constanța, Romania,

Abstract:
Generation of a high energy magnetic pulse with a flux compression generator requires first of all a good mathematical approach followed by simulations of the theoretical model in laboratory and in the field. The authors above have been members of a research team that developed an electromagnetic pulse device started by a conventional explosion. This paper describes the main steps in simulating and testing the compression of the magnetic flux needed to achieve the high energy magnetic pulse.

Keywords: *electromagnetic, pulse, generator, compression*

1. INTRODUCTION

Among the military applications of the electromagnetic pulse (EMP), the most common and used method is the flux compression generation (FCG) which was the path the project followed. The first experiences involving the so called "E-bomb" of the FCG type were conducted by the U.S.A. and the U.S.S.R. in the late '50s (Bykov et al., 2001).

2. FLUX COMPRESSION SIMULATION

2.1 The simulation of the flux compression has been undertaken in a high voltage laboratory in order to check the actual flux compression development. The goal of this activity was to put into evidence the flux compression through the progressive mechanical short-circuiting of the coil's rings, according to the electrical scheme of the experimental flux compression generator (FCG) presented in Figure 1.

Two types of coils have been used. The first one was smaller and made up of off- the-shelf components (Fowler et al., 1993). The second solenoid was manufactured as a prototype in the Romanian Naval Academy's workshop according to some specific required dimensions. Eventually, the actual measurements in the experimentation facility have been done on this second variant.

2.2 The oscilloscope diagrams of the experiments using the first coil are presented in Figure 2. There have been recorded the current in the coil by using the current shunt (first two graphs) and the magnetic flux, received by the frame-type antenna.

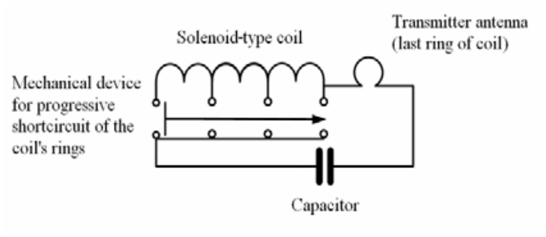
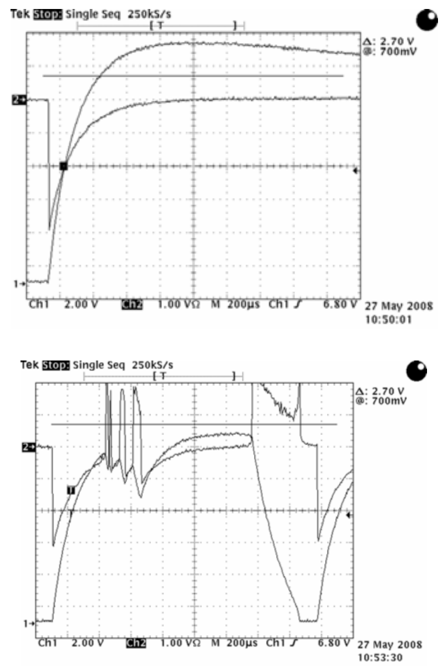


Fig. 1. The electrical principles of the experimental FCG

However, these experiments had been considered as irrelevant because, as it can be easily noticed, the vibrations of the contacts, during the mechanical short-circuiting, determine signals that have amplitudes comparable to the surge of the current and magnetic flux due to the progressive short-circuit of the coil's rings. The second experiment of the flux compression simulation used a second coil, identical to those tested in the range. This time the shunt has been removed from the circuit and only the resultant magnetic flux has been recorded by the means of the frame-type antenna (Dobref et al., 2008). We could consequently put in evidence very clearly the flux compression during the short-circuiting of the coil's rings, as presented in the oscilloscope diagrams from Figure 3.



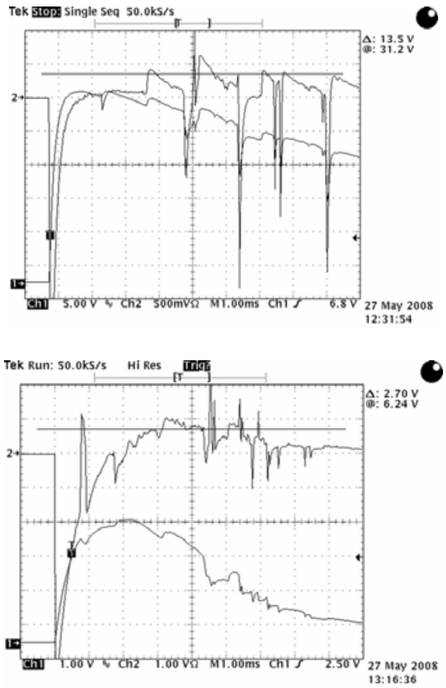
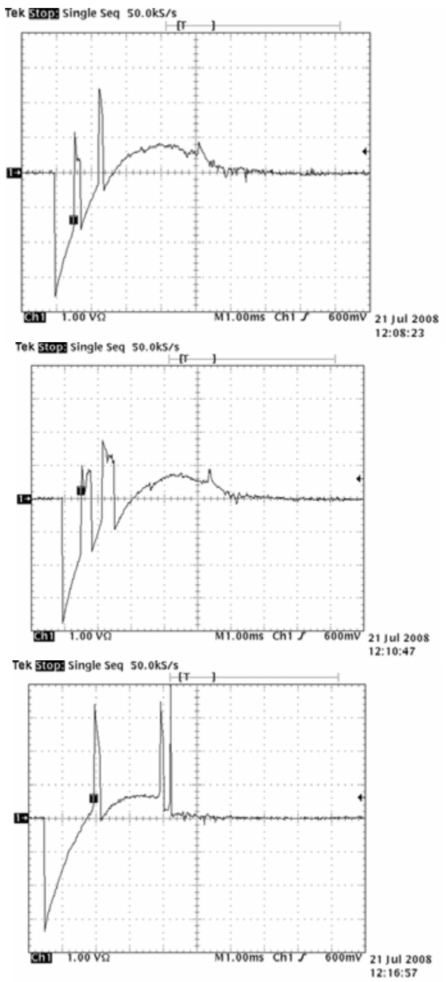


Fig. 2. Currents and magnetic fluxes in coil no.1.



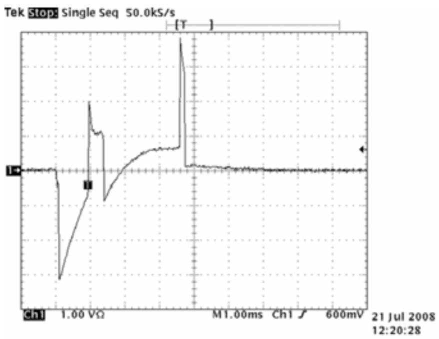


Fig. 3. Currents and magnetic fluxes in coil no.2.

2.3 EXPERIMENTAL RESULTS

During the final stage of this project – the experiments conducted in the range – the coil rings have been continuously shorcircuited at a very high speed (approximately 7200 m/s) by the means of the explosive charge. The explosive charge consisted of a mix of RDX (hexogen) and TNT. The building principles of the FCG are shown in Figure 4 (Johns, 2004).

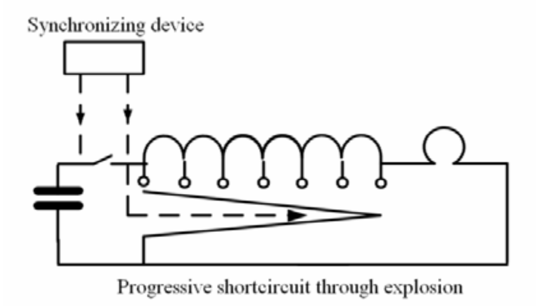


Fig. 4. FCG building principles

The actual arrangement of the experimental device was the following: the coil with the explosive charge inside was put in the first bunker. The two identical receiving antennas were mounted on the walls, simetrically with respect to the coil, on the same axis of the emitter antenna (the last ring of the coil). The coaxial cables needed to transport the signal from the antennas have been connected to two Tektronix (TDS 724 D and TDS 5052) oscilloscopes, placed in the second bunker. The recordings were done in the same time. The two coils used for the experiments were identical.

Figure 5 presents the pulse recordings corresponding to the first and second blast, respectively

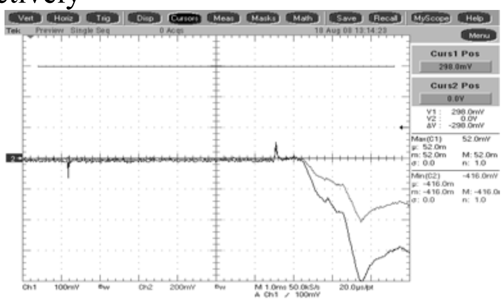


Fig. 5. The experimental recordings of the magnetic pulse

3. CONCLUSIONS

The authors take full responsibility for the contents and scientific correctness of the paper. The main conclusion rests in the compression of the flux generated by the two coils. We noticed that the signal in the receiving antenna is much greater for the second detonation, which is possible thanks to a greater starting coil current (different timing) but also to a different evolution of the explosion (Dobref et al., 2008). For establishing the maximum value of the magnetic pulse we took in account the second diagram in Figure 5. Then, the magnetic pulse size has been calculated in laboratory, after calibration. The tests in the own facilities confirmed the simulation results

REFERENCES

1. Abrams, M. (2003). The dawn of the e-bomb, IEEE Spectrum

2. Bykov, A.I.; Dolotenko, M.I. & Kolokol'chikov, N.P. (2001). Achievements on Ultra-High Magnetic Fields Generation, Physica B, 294-295, p.574-578
3. Dobref, V. et al., (2008). Research report: Modeling and design of a conventional payload for an electromagnetic pulse generation destined to block C4I systems, "Mircea cel Batran" Naval Academy, Constanta, Romania
4. Fowler, C.M.; Caird, R.S. & Garn, B. (1993). An introduction to explosive magnetic flux compression generators. Abstract, Los Alamos
5. Johns, D. (2004). Analysis of EMI/E3 Problems in Defense Applications, Flomerics
6. Knoepfel, H. (1970), Pulsed High Magnetic Fields, Nord-Holland