

Electromagnetic Weapon-Electromagnetic Bomb

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Abstract

Electromagnetic Bomb is mainly based on 2 types of HPM technologies, FCG and vircator. Its lethality is mainly due to 2 types of coupling. We'll cover how to raise them and finally maximize its lethality.

I INTRODUCTION

High Power Electromagnetic Pulse generation techniques and High Power Microwave(HPM) technology have matured to the point where practical E-bombs (Electromagnetic bombs) are becoming technically feasible, with new applications in both Strategic and Tactical Information Warfare. The development of conventional E-bomb devices allows their use in non-nuclear confrontations.

We will first review how it operates, focusing on the pulse generating in a fashion that allows the high power and the long traveling distance. We will cover 2 types of HPEM devices and their main features. Then the review on the damage and the defense will be followed. The closing of the body would be the technical issue on the design, mainly focused on performance maximized without violating the physical constraints.

II. HPEM and HPM Device – FCG & the vircator

Key technologies which are extant in the area are explosively pumped Flux Compression Generators (FCG) and the Virtual Cathode Oscillator or Vircator.

FCG is the most developed technology applicable to bomb for producing the large power in a very short time. The central idea behind the construction of FCGs is that of using a fast explosive to rapidly compress a magnetic field, transferring much energy from the explosive into the magnetic field. Among the various geometries possible, the coaxial FCG is the most commonly used arrangement, as its cylindrical form lends itself to packaging into munitions. A typical coaxial FCG are made of a cylindrical copper tubed armature surrounded by a helical coil of copper wire or stator. ([Fig.2])

The start current peaks initiates the explosive by producing a uniform plane wave detonation front. Once initiated, the front propagates through the explosive in the armature, distorting it into a conical shape. Finally, it reaches to a short circuit between the ends of the stator coil. Then, the propagating short compresses the magnetic field, whilst reducing the inductance of the stator winding. A ramping current pulse will be generated which peaks before the final disintegration of the device. Published results suggest ramp times of tens to hundreds of microseconds, specific to the characteristics of the device, for peak currents of tens of MegaAmperes and peak energies of tens of MegaJoules ([Fig.1])

On the other hand, large electrical power pulses from FCGs should be focused tightly enough to be able to couple into many target types. Moreover, considerably high frequency is required to deliver such a high power. We need an additional HPM device, Vircator to handle them.

Vircator is a one shot device capable of producing a powerful pulse, yet it is mechanically simple, small and robust, and can operate over a relatively broad band of microwave frequencies. The fundamental idea behind the Vircator is that of accelerating a high current electron beam against a foil anode. Many electrons will pass through the anode, forming a bubble of space charge behind the anode. If the space charge region is placed into a resonant cavity which is appropriately tuned, very high peak powers may be achieved. Conventional microwave engineering techniques may then be used to extract microwave power from the resonant cavity. Because the frequency of oscillation is dependent upon the electron beam parameters, Vircators may be tuned or chirped in frequency, where the microwave cavity will support appropriate modes. Power levels achieved in Vircator experiments range from 170 kilowatts to 40 Gigawatts over frequencies spanning the decimetric and centimetric bands.

The two most commonly described configurations for the Vircator are the Axial Vircator (AV), and the Transverse Vircator (TV). The Axial Vircator is typically built into a cylindrical waveguide structure. Power is most often extracted by transitioning the waveguide into a conical horn structure, which functions as an antenna. AVs typically oscillate in Transverse Magnetic (TM) modes. The Transverse Vircator injects cathode current from the side of the cavity and will typically oscillate in a Transverse Electric (TE) mode.

III. The Lethality

The issue of electromagnetic weapon lethality is not simple. It's because target types are very diverse in their electromagnetic hardness, or ability to resist damage. We often use coupling efficiency, which is a measure of how much power is transferred from the field produced by the weapon into the target. When determining lethality. Two principal coupling modes are available.

Front Door Coupling occurs when generated power is coupled into an antenna of the target. The antenna subsystem is designed to couple power in and out of the equipment, thus provides an efficient path for the power flow from the electromagnetic weapon to enter the equipment and cause damage. Communications interfaces and power supplies must typically meet electrical safety requirements imposed by regulators. Such interfaces are usually protected by isolation transformers with ratings from hundreds of Volts to about 2 to 3 kVAs. When it is breached, most of modern electronic devices, rated over the range of 5V to 50V as listed in [table 1], are so easily destroyable.

HPM weapons operating in the centimetric and millimetric bands however offer an additional coupling mechanism to Back Door Coupling. This is the ability to directly couple into equipment through

ventilation holes or gaps which may behave like a slot in a microwave cavity, allowing microwave radiation to directly excite or enter the cavity. The microwave radiation will form a spatial standing wave pattern within the equipment. Components situated within the anti-nodes within the standing wave pattern will be exposed to potentially high electromagnetic fields.

IV. Lethality Maximized Design

To maximize the lethality of an electromagnetic bomb it is necessary to maximize the power coupled into the target set. The first step is to raise the peak power and duration of the radiation of the weapon. Increasing the coupling efficiency by exploiting every coupling opportunity available within the bandwidth will give a far advanced performance. It could be acquired by sweeping the frequency or chirping the Vircator. This would lead to far improved coupling efficiency in comparison with a single frequency weapon, by enabling the radiation to couple into apertures and resonances over a range of frequencies. Alternative scheme is to make use of polarization of the weapon's emission. If we assume that the orientations of possible coupling apertures and resonances in the target set are random in relation to the weapon's antenna orientation, a linearly polarized emission will only exploit half of the opportunities available. A circularly polarized emission will exploit all coupling opportunities. The practical constraint is that it may be difficult to produce an efficient high power circularly polarized antenna design which is compact and performs over a wide band. A suitable interface to a Vircator with multiple extraction ports must be devised. A possible implementation is depicted in Fig.4.

V. Conclusion

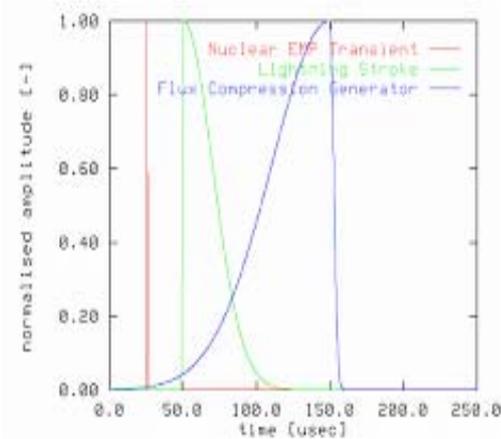
In this work, we investigated core technologies of Electromagnetic Bomb. The most mature technology is FCG and more advanced one is a vircator. To improve its performance, we covered the specific view of the damaging process- front and back-door coupling and methods to maximize them.

REFERENCES

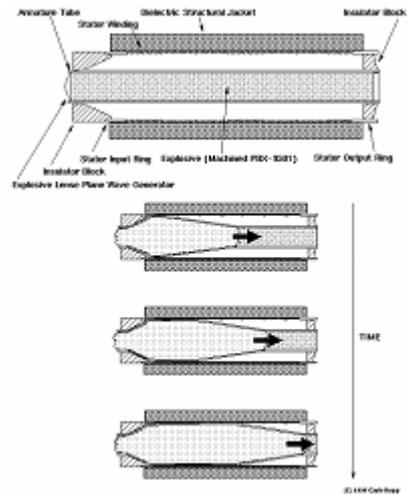
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| types of semiconductor devices | voltage range |
|--|---------------|
| Silicon high frequency bipolar transistors | 15V~65V |
| Gallium Arsenide Field Effect Transistors | 10V |
| High density Dynamic Random Access Gallium Arsenide Field Effect Transistors | 10V |
| High density Dynamic Random Access Memories (DRAM) | 7V |
| Generic CMOS logic | 7V~15V |
| Microprocessors running off 3.3 V or 5 V power supplies | 3.3V~5V |

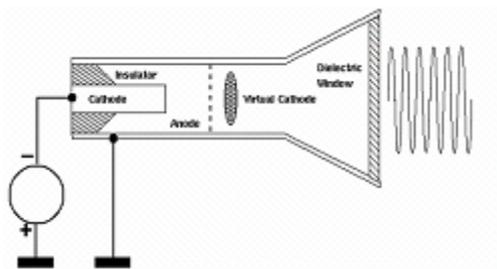
table 1 Rated Voltage of Device



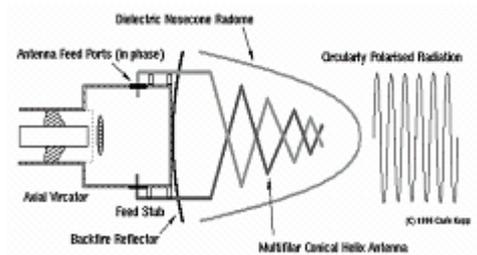
[Figure. 1 Typical Electromagnetic Pulse Shape]



[Figure. 2 Flux Compression Generator]



[Figure. 3 Axial Virtual Cathode Oscillator]



[Figure. 4 Vircator / Antenna Assembly]