P4-11: Pulsed Power Supply for Magnetic Field to Generate HPM from Slow Wave Structures

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Abstract:
A strong axial magnetic field is required to guide a relativistic pulsed electron beam. The magnetic field can be supplied either by a permanent magnet or an electromagnet. In a backward wave oscillator (BWO) experiment, as the required field is 0-1.2 T in a cylindrical volume having radius of a couple of centimeters and length of about 10-12 cm, an electromagnet is preferred. A large pulsed current is passed into a solenoid to generate a pulsed magnetic field. This current is provided by a capacitor bank. In the paper, development of a pulsed magnetic field system is described. The generated magnetic field is of strength 1.25T with the pulse duration of 2 ms. Inner diameter of solenoid is 5 cm and length is 12 cm. The magnetic field guides a relativistic electron beam that excites a slow wave structure to generate high power microwaves.

To generate a unidirectional magnetic field, we must have a unidirectional current pulse. This is obtained by discharging a charged capacitor into an inductor with a resistor in between them. For critical damping, we get a unidirectional pulse. Assuming inductance L and resistance R, a maximum occurs at $t_{max} = 2L/R$ where the maximum current is $I_{max} = 0.74V_0/R$. The pulse duration is

The experimental set up is as follows: Secondary of a step-up transformer gives a peak voltage of 2.5 kV. After half wave rectification, a capacitor bank having capacity of 450μF is charged through a 800 ohm hand woven resistor. Charging time of the capacitor bank is 3 sec. Charged capacitor bank is discharged into a solenoid, inductance L, through pulse forming non-inductive resistance R=1.3 Ω. A small resistance R_m=0.125Ω is in series for measurements. A spherical spark gap having 2 cm sphere diameter acts as a self breaking switch.

As soon as the instantaneous value of current overshoots a predefined strength, the corresponding voltage that drops across the resistor R_m exceeds the comparing voltage on a comparator. This causes a timer circuit to give a turn on a relay that controls switching of a Marx capacitor bank for relativistic electron beam generation[1]. The voltage across R_m, therefore give us the information of current pulse as well as controls the triggering of electron beam system.

Peak current is controlled by the pulse forming resistor R. Table 1 given below shows various values of R and corresponding value of voltage on R_m. Measured current, pulse duration and magnetic field are given in last three columns.

Table 1. Measured voltage across R_m for various values of pulse forming resistor R. Corresponding maximum current, pulse duration and magnetic field

	R(Ω)	V_m(V)	I_{max} (A)	T (ms)	B(T)
1	8	45.6	364.8	1.41	0.43
2	4	67	536	1.05	0.63
3	2	94	752	0.84	0.88
4	2	110	880	1.29	1.03
5	2	105.8	846.4	1.30	1.01
6	1.3	134	1072	1.17	1.25

The current pulse for R=1.3 Ω is shown below:

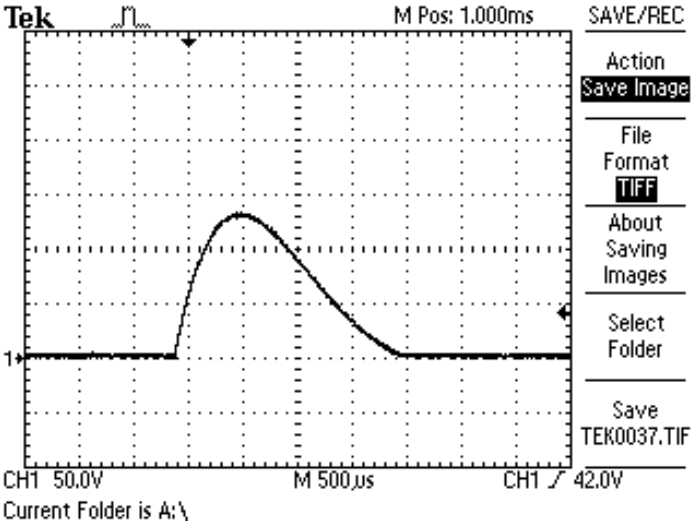

Figure 1. Voltage pulse across R_m=0.125 Ω giving the current pulse in the solenoid.

This axial magnetic field thus generated guides an electron beam that injects slow wave structures of prescribed radial

profile[2]. Experiments are done on the profiles shown below:

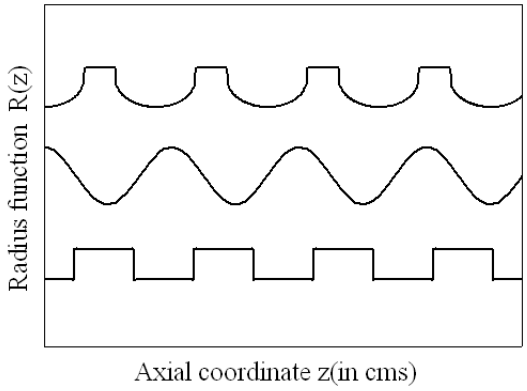

Figure 2. Three different slow wave structure profiles used in experiment.

Microwaves are detected using fast rising Schottky detector (Herotek Model No. DTL 2018H). The detected signal is given below.

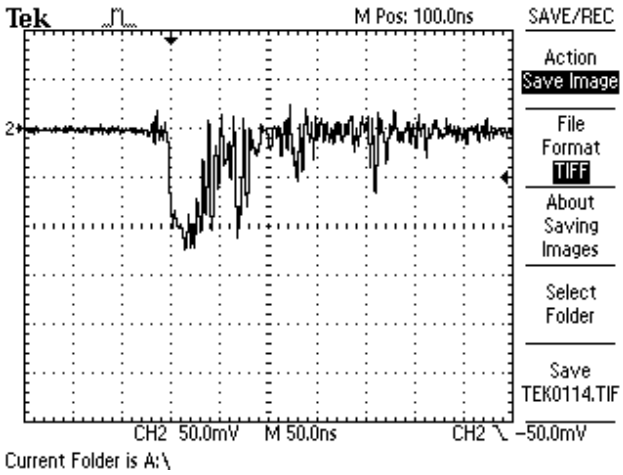

Figure 3. Voltage trace after 60 db attenuation at a distance of 2 m from the radiating horn.

The first pulse is the generated microwaves falling directly on the receiving horn. The second and subsequent smaller pulses are the reflected pulses from the exposed metallic walls of the laboratory.

In conclusion, a pulsed power supply of magnetic field generation is fabricated. We have used a spark gap as a switch. Magnetic field can be varied upto 1.25 T. The magnetic field is used to guide a pulsed electron beam of 150 ns. High power microwaves are generated using three different type of slow wave structures. Microwave pulses of ~ 50 ns are obtained[3].

References

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Keywords: Relativistic electron beam; capacitor bank; HPM generation; slow wave structures.