Facility to Generate Pulsed High Magnetic Fields and Pressure Using High Current Capacitor Banks

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Abstract – Two fast (high current) capacitor banks have been fabricated to produce pulsed high magnetic fields and pressure to study their effect on materials. The first bank is of 136 kJ stored energy at 40 kV charging voltage. It can deliver 3.6 MA of current. This bank is being used to produce initial (seed) magnetic field in a coil. The second bank is of 1.2 MJ stored energy at 44 kV charging voltage. It can deliver 3.6 MA of current. This is being used to electro-magnetically implode a liner to amplify (by flux compression) the seed field produced by the first bank. The paper discusses the optimization calculations and the results obtained.

1. Introduction

The pulse power laboratory has commissioned several fast (high current) capacitor banks. These can be used singly or jointly with other banks to produce very high-pulsed magnetic fields, which in turn can produce, pulsed ultra high pressures. This paper describes some of these banks, experiments and preliminary results obtained so far.

2. High Current Capacitor Banks

RUDRA BANK: It is the largest bank in our laboratory. It stores 1.2 MJ of energy and can deliver 3.6 MA in a relatively high impedance load. The specifications of this bank are tabulated in Table 1

Table 1 Capacitor Bank Rudra

Total Capacitance	1248 μF
Energy	1.2 MJ
Charging Voltage	44kV
Maximum Current	3.6MA
Voltage Reversal	10%
Expected Life	3000 Shots at full ratings
System Inductance	50nH
No. of Modules	6
Capacitors in Module	24
Connections	Parallel Plate Trans. Line
Energy transfer Switch	Railgap
Repetition Rate	1 Shot every five minutes

The Fig. 1 shows the collector plate and the (liner) load. Fig. 2 shows the complete capacitor bank. Fig. 3 shows one of the six modules of the bank. Fig. 4 shows the schematic of the capacitor bank

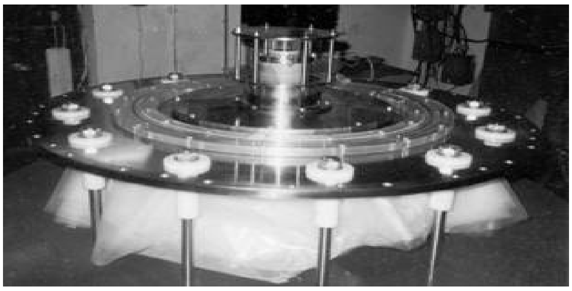

Fig. 1 Collector Plate and Load – Rudra Bank

Fig. 2 The 1.2 Mega-Joule Rudra Bank

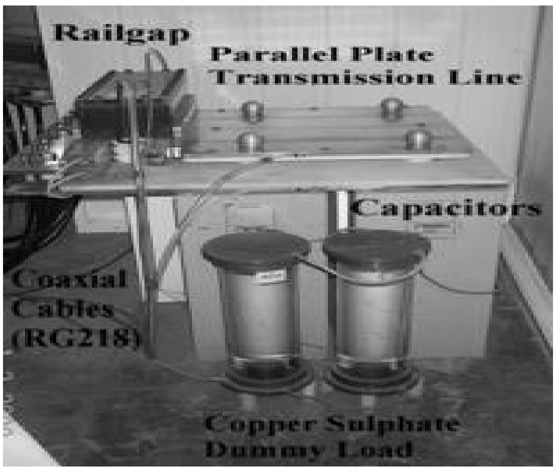

Fig .3 One of the six Modules of Rudra Bank

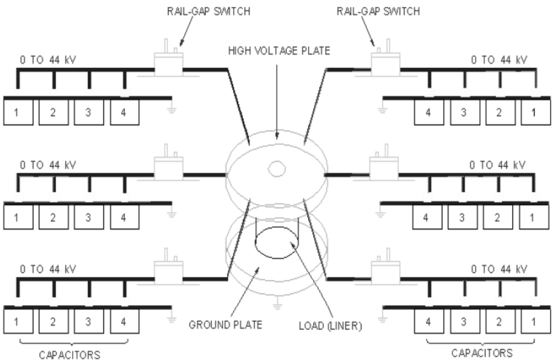

Fig. 4 Schematic of Rudra Bank

Table 2 Capacitor Bank Rudrika

ENERGY	136kJ
No. OF CAPACITORS	24
No. OF SWITCHES	24
CAPACITANCE	170μF
VOLTAGE	40 kV
SYSTEM INDUCTANCE	10nH
CURRENT (SHORT CIR.)	3.6MA
LIFE	50,000C/D CYCLES
CONNECTOR	COAXIAL CABLES
REP RATE	1 SHOT PER 5 MIN.

RUDRIKA BANK: Rudrika bank is smaller but faster than Rudra bank. It can store 136 kJ energy and can deliver short circuit current of 3.6 MA. Table 2 tabulates the main specifications of this bank.
Fig.5 shows one of the views of this Rudrika Bank. Fig. 6 shows another view of this bank.

Fig .5 Rudrika- Fast 132 kJ Capacitor Bank

Other Capacitor Banks: Two more capacitors bank (Chandi-1 and Chandi-2) have also been fabricated. These banks are relatively slower. Each bank is of 160 kJ -8 capacitors of 20 kJ each, charged to 15 kV. First bank has rail-gap switch and can deliver 1.2 MA current. The second bank has ignitron switch and can deliver 400 kA current. Figs. 7 and 8 show the capacitor banks Chandi-1 and Chandi-2 respectively.

Fig. 6 Rudrika Bank- Another View

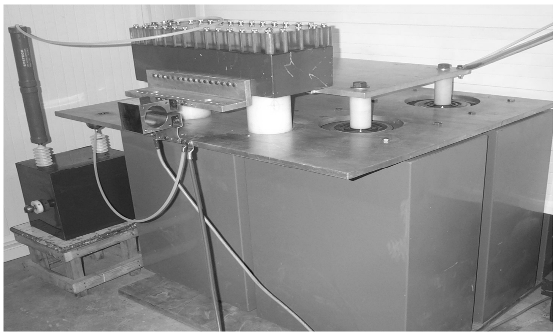

Fig. 7 One Segment of Chandi-1 Capacitor Bank

Fig. 8 Chandi-2 Capacitor Bank

3. Magnetic Field Generating Experiments

Two types of magnetic field generating configurations have been used. In first configuration a single (or few) turn coil has been used. Fig. 9 shows the schematic of the experiment.
In the second configuration, the principle of flux compression (conservation) is employed using two capacitor banks. One capacitor bank is used to establish the initial (seed) magnetic field using a few turn coil(s). This field diffuses through a stainless steel liner. The second bank is than used to compress the liner, rapidly, so that the flux is approximately conserved. As the liner area reduces, the magnetic field trapped inside the liner is amplified. Fig. 10 shows the configuration of these experiments.

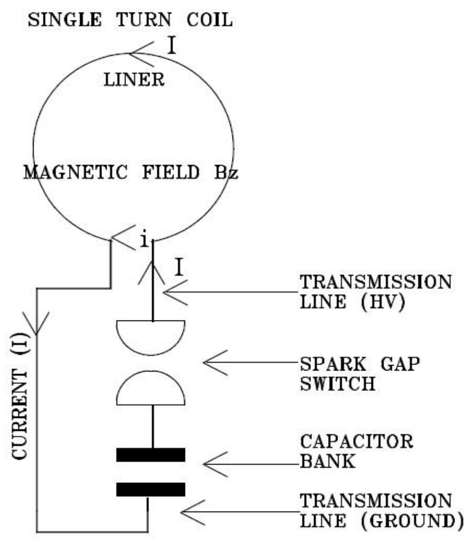

Fig. 9 Schematic of Single Turn Experiments

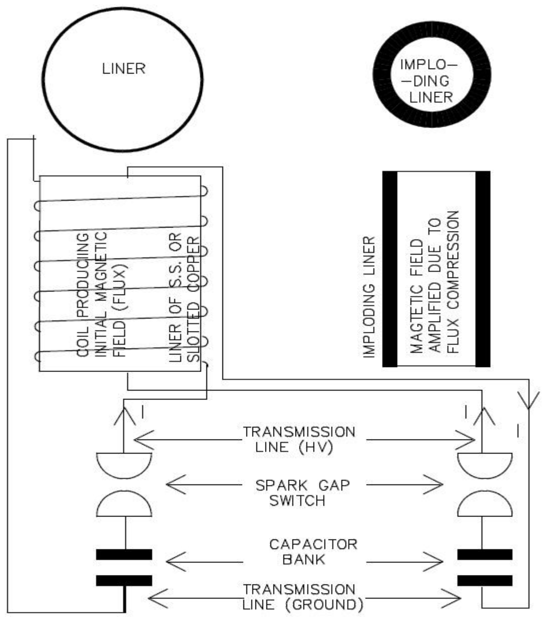

Fig. 10 Schematic of Flux Compression Experiment using Two Capacitor Banks

3. Analysis and Preliminary Results

Preliminary computer analysis indicated that ~ 300 T field with single turn coil and 500 T field with flux compression configuration. could be obtained. But experimentally we have been able to achieve only 10% of the anticipated fields, so far. One of the reasons is non-uniform collapse of coil/liner. Fig. 9 shows this effect on one of the test liners.

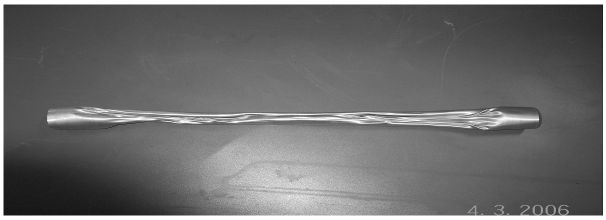

Fig. 9 Uneven collapse of the test liner

Further investigations are in progress to understand the cause of this limitation and to minimize it, so that higher fields may be obtained.

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