A.13: Indigenous development of 50 kV, 2 A, 16 µs solid state Marx modulator with droop compensation technique

A 50 kV, 2 A, 16 µs, 300 Hz solid state Marx modulator has been designed and developed indigenously for electron gun test stand. The advantages of this scheme are lower ripple, lower droop, transformerless design, adjustable pulse width, fast rise time, and modular design etc. Important parameters of the modulator are illustrated in the Table A.13.1. A hybrid technique for droop compensation has been implemented. The modulator consists of twenty main Marx modules and five hybrid Marx modules. The main module consists of one capacitor, two BiMOSFETs for charging and discharging of the capacitor, bypass diodes and charging diodes. The hybrid module consists of a Marx module and a bouncer LC circuit. The schematic of the modulator is as shown in Figure A.13.1. All the modules trigger and protection unit, DC power supplies, capacitor charging power supplies and CTs are mounted in the cabinet. Corona rings have been installed on the modules for profiling of electric field.

Table A.13.1: Specifications of the Marx modulator

Parameter	**Value**
Maximum output voltage	50 kV
Maximum output current	2 A
Output peak power	100 kW
FWHM pulse width	16 µs
Rise Time	1.5 µs
Fall time	12 µs
Droop	< 0.4%
Peak to peak ripple in output voltage	< 0.4%

In this modulator, the capacitors are charged in parallel and discharged in series to produce high voltage pulse output for the desired duration. In case discharging switch of any module fails to turn on, the load current is passed through the bypass diode of the module, thus protecting the discharging switch. The output voltage droop is an important parameter and directly related with stored energy. The stored energy of capacitors is ~100 times of the pulse energy for 0.5% droop, but the drawback is higher stored energy and size. Hence, for reducing the stored energy and size of capacitors, other techniques are required to compensate the droop in output pulse. A hybrid Marx module has been developed for droop compensation.

The droop compensation is done by series resonant LC bouncer circuit using inductor and capacitor. This bouncer circuit is triggered ON to start its cycle before the start of the main pulse of the modulator. To achieve the desired < 0.4% droop, the linear part around zero crossing of the bouncer cycle is subtracted from the drooping main capacitor bank as shown in Figure A.13.2. This bouncer circuit has been incorporated with a Marx module to develop a hybrid Marx module. Figure A.13.3 shows the view of the modulator.

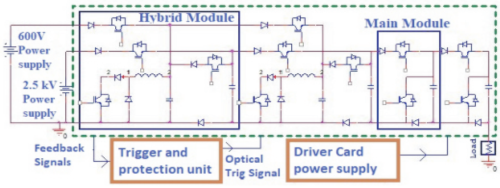

Fig. A.13.1: Schematic of the 50 kV Marx modulator.

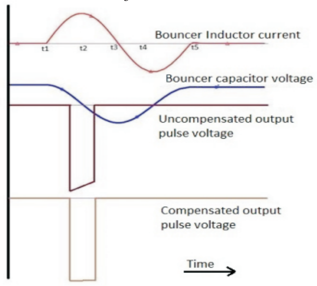

Fig. A.13.2: Bouncer droop compensation waveform.

Fig. A.13.3: Photograph showing the front and rear view of the modulator.

The modulator was tested on a 25 kΩ resistive load. It was operated from an external trigger pulse from a function generator. The 50 kV, 2 A, 16 µs output voltage pulse has 1.5 µs rise time and 12 µs fall time. The large fall time is due to parasitic capacitances. Figure A.13.4 shows the waveform of output voltage pulse.

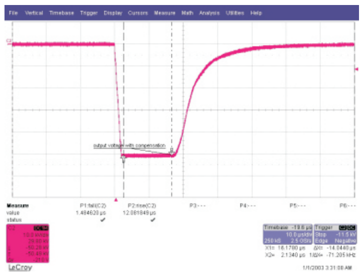

Fig. A.13.4: 50 kV output voltage pulse at 300 Hz pulse repetition rate.

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