125kV, 100kA, 150ns, 5pps Test Facility with Solid State Switched Distributed Pulse Compression Marx

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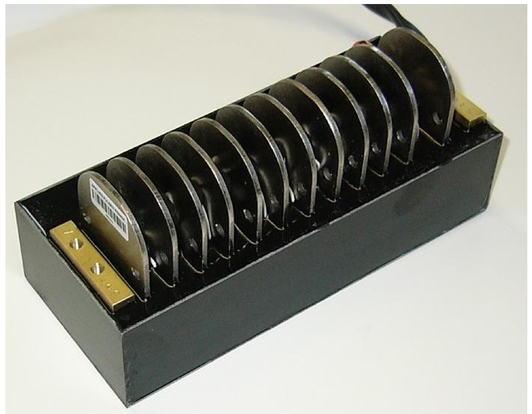
Abstract

Electra is a repetitively pulsed, electron beam pumped Krypton Fluoride (KrF) laser at the Naval Research Laboratory. This program is developing technologies to meet the Inertial Fusion Energy (IFE) requirements for durability, efficiency, and cost. The Electra laser main amplifier requires a 500kV, 100kA, 150ns, 5Hz pulsed power source. At present, the main amplifier uses gas insulated spark gap switches with lifetimes of 10^5 pulses. Solid state switched pulsed power sources are being developed to achieve lifetimes of 10^8 pulses. Applied Pulsed Power has developed a 48kV compact solid state switch for this application that operates at 8kA and can withstand fault currents of 14kA and 80% current reversal. Individual modules used in the switch have been tested for >200 million pulses without failure, and lifetime testing of the complete switch is in progress. Using these switches, we are manufacturing and testing a quarter scale version of the Electra pulsed power source. Scaling was done by reducing the number of Marx stages and the impedance of the downstream pulse forming components and load by a factor of four, resulting in a 125kV, 100kA, 150ns, 5pps test facility. This approach ensures that each Marx stage operates at the design voltage and current, and the pulse forming components and magnetic switches operate at the same design current and timing as for the full scale system. The electric fields in the pulse forming components for the quarter scale version exceed the design values for the full scale system.

This system uses a six stage, solid state switched, distributed pulse compression Marx (DC Marx). The DC Marx provides one level of magnetically switched pulse compression with a gain of 3 in each stage of the Marx. By distributing the pulse compression among the stages of the Marx, the initial pulse compression is performed at the stage voltage rather than the full output voltage. This design also removes the solid state switches from the Marx output current path. Two solid state switches are used for each stage resulting in a 48kA peak Marx current.

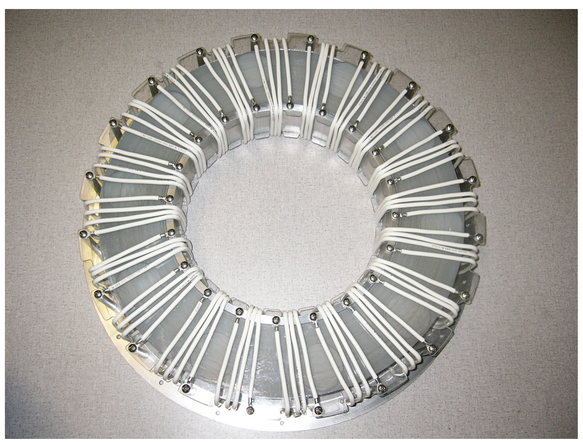
The DC Marx is followed by two-stages of pulse compression using water insulted coaxial lines and magnetic switches. The 1.25 ohm PFL is switched into two parallel connected 2.5 ohm output lines terminated with 2.5 ohm water resistors.

48kV, 12kA Solid State Switch



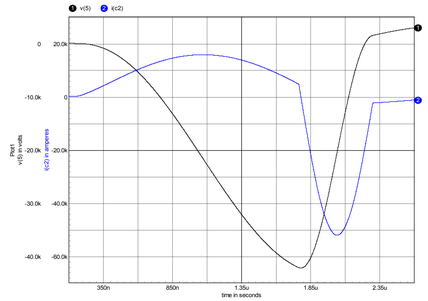
The 48 kV switch uses the voltage across the switch to power the gate drives and optical trigger. No external power supply is required and the switch is triggered via a fiber optic cable. The switch is capable of conducting large reverse currents.

Two switches will be used in each stage of the DC Marx, operating at peak current of 8 kA . In the event of a fault in the Marx, the switches could see as much as 12 kA, which will not damage them.

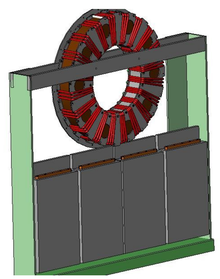


Distributed Compression Marx

The DC Marx uses a magnetic switch at each stage to increase the output current by a factor of 3 over the solid state switch current, resulting in a 48 kA Marx current. Two sets of capacitors are used at each stage, with the second set of capacitors pulse charged from the first set via the solid state switches. The magnetic switch then switches the second set of capacitors to erect the Marx. As a result, the solid state switches are not in the main current path.



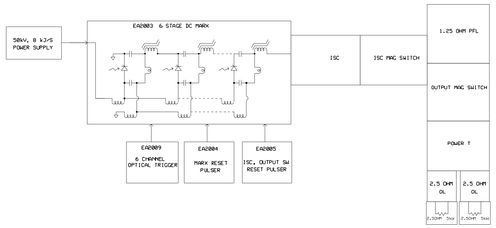
Circuit Simulation of DC Marx Current



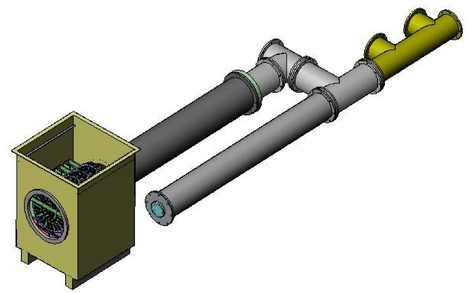
Layout of DC Marx Capacitors and Magnetic Switch

Assembly of the DC Marx is in progress. Testing of the Marx into a resistive load will be carried out while the ISC is being fabricated. Ultimately the full system will be operated at 5pps and tested for 10^7 pulses. Testing will also be performed to determine the effects of various system faults.

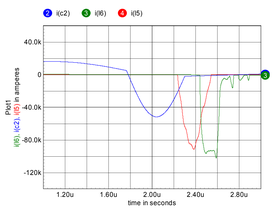
125kV Testbed



125kV Testbed



Layout of 125kV Testbed



Marx ISC and PFL Switch Currents from Circuit Simulation

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