Marx Generators

The Marx impulse generator basically simulates a fast lightning strike, the results of which have many applications for scientific, research, and industrial use. As an example, most lightning discharges are in the order 1 to 100 kilo-amps with 500 kilo-amps a rarity. The electric charge associated is usually 5 to 50 Coulombs. At a voltage of 50 to 500 million volts this transforms to a considerable amount of discharged energy. Even though this equates out to a destructive event, the current rise of a natural lightning bolt is not as fast as a man-made impulse generator. The rise time of a lightning bolt discharge is usually 1 to 10 microseconds with a fall time of 20 to 50 microseconds. (The reason for the relatively slow rise is due to the atmosphere not approaching an ideal spark gap switch.) The output of the Marx is under 100 kilo-amps but its current rise is faster than a natural lightning bolt, as quick as 5 nanoseconds. In other words Mother Nature got us in joules but not in rise time!

The utility of a Marx Generator can be found in materials testing, such as to verify cables, transformers, and power systems for integrity against lightning strikes. Flash x-rays and the simulating of electro magnetic pulse (EMP) from nuclear detonations are possible using a Marx Generator. The output can be coupled into a suitable load, parallel flat line antenna, etc. For flash x-rays the output must be coupled to a suitable x-ray tube.

How It Works

Marx generators are basically simple in theory: a stack of capacitors is charged in a parallel configuration to a voltage "E" and then discharged in series with a voltage of "nE" where "n" is the number of capacitors charged. Simple in theory, but in reality several problems must be addressed. Selection of the capacitors will determine the peak current and rate of current rise during the discharge cycle that are now figures of merit for the system. Not only must we select the value of capacitance and voltage, but now must consider the discharge loop inductance and peak current handling of these components. Needless to say, these are far more expensive than normal oil-filled filter capacitors. These capacitors once charged must be discharged in a series configuration through special precisely-spaced spark gap switches for each capacitor. Open air tungsten or molybdenum electrodes with Bruce or Rogowski discharge surfaces now switch the required currents with low "jitter." Switching times are fast but can be improved in a nitrogen atmosphere or by doping the electrodes with a radioactive isotope such as cesium 137 or nickel 63.

The initial charging of the capacitors is best done via a controlled current source. A good approach is the use of a current limited transformer operating at line frequency or a standard high voltage transformer with a current controlled reactor in series with the primary for higher power units. The use of semiconductors usually requires special circuit precautions and shielding from the EMP generated by most of the discharges.

The output of the transformer is rectified and voltage multiplied to the appropriate charging value and applied to the capacitors by high voltage resistors. Output is continuously variable with a variac. The system is triggered manually, or by a +5 volt level that generates a high voltage pulse to a third trigger electrode of the bottom spark switch. This now commences where all spark switches now simultaneously fire, dumping the total charge in nanoseconds.

Our basic Marx generators have charging resistors. Discharge resistors can be selected by the user dependent on the desired wave shape. Standard parallel plate transmission line with a gap of 300 mm or 500 mm is available to enable the user to couple the Marx for obtaining steep field strength of 100kV to 400kV per meter.