Compact Flash X-ray Systems for Radiographic Applications

M.G. Mayes and J. R. Mayes
Applied Physical Electronics, L.C.
P.O. Box 341149, Austin, Texas 78734
mgmayes@apelc.com

APELC Marx Generators – Designed for Flash X-ray Systems

Model MG40-3C-2700PF – Specifically designed for sourcing flash x-ray diodes, with open circuit voltages in excess of 1.6 MV, and diode conduction voltages of more than 600 kV. This generator two man-portable and can be operated from battery power. With larger power sources, this generator can be operated with repetition rates of more than 50 Hz.

Wave erection – comes with proper design of the stray components. The switches sequentially close, leading to ultra-fast voltage risetimes, increased efficiency, and ultra-compact geometries

System Characteristics

The developed compact MV Marx generator system offers many improvements over typical compact systems, including:

- a rugged and modular stage design for easy maintenance and high mechanical strength for field use
- Inductive charging elements for low charging losses and high repetition rate operation
- Modular output interfaces allowing for a multitude of load devices to be interchangeable (i.e. flash x-ray, cable, RF)
- Integrated ancillary components including power supply, voltage controlled air regulator and trigger source
- Embedded controller leading the way to smart autonomous operation
- A variety of controller interfaces including RS-232 (optical link), manual control box (fiber link), or manual front panel

Abstract

Recent developments in Marx generator technology has led to ultra compact geometries and enhanced performances, which has forge new applications for this type of generator. Applied Physical Electronics, L.C. has been a leader in the new developments of the Marx generator, making devices that are man-portable, battery operated for low average power applications and extremely fast. APELC has recently begun making strides in developing ultra compact flash x-ray loads to directly mate to their generators. This paper discusses the generators and the diode development

Background

The wave-erection Marx generator

General operation – charge capacitors in parallel. Simultaneous closure of the switches momentarily adds voltages for short duration voltage multiplication.

Wave erection – comes with proper design of the stray components. The switches sequentially close, leading to ultra-fast voltage risetimes, increased efficiency, and ultra-compact geometries

System Characteristics

The developed compact MV Marx generator system offers many improvements over typical compact systems, including:

- A 200 Hz repetition rate observed
- Demonstration at Vcharge = 24 kV
- External thyratron trigger
- Load = 50 Ohm (close match to generator)
- Un-calibrated CVR probes, mounted on coaxial cable (looking for waveshape and temporal information)

Discussion

This paper has presented two Marx generators well suited for ultra-compact, man-portable flash x-ray applications. APELC’s MG15-3C-940PF generator offers advantages in portability, weighing less than 30 lbs, this generator can easily be placed in an infinite orientations. And with its capabilities in high repetition rates, higher doses are achievable. APELC’s MG40-3C-2700PF generator is unmatched in other commercially available generator, with erected voltages in excess of 3.2 MV, battery-powered and two-man portable, this generator is ideal for flash x-ray applications.

More recently, APELC has developed a dual polarity MV system, employing two MG-3C-2700PF generators charged with opposite polarity voltages. With a common trigger source, the generators deliver nearly simultaneous pulses, with less than 10 ns temporal jitter. APELC now reports development of flash x-ray diodes based on the rod pinch concept. These diodes are being developed with compactness and interchangeability, to meet the design guidelines used in the successful development of the Marx generators. These topologies are presented and include the direct connection diode, the cable fed geometry and the dual polarity geometry. These geometries are currently in the design process and experimental results are expected in the next year.

Integrated X-ray Load

- Rod-pinch geometry
- Modular/Interchangeable load
- Same “quick-change” interface for both HPML, x-ray, and cable load
- X-ray load testing underway

Development of a Dual Polarity X-ray Source

High Repetition Rate Operation

- Load = 50 Ohm (close match to high power source)
- External thyratron trigger
- External 4 kJh/s power supply
- Demonstration at Vcharge = 24 kV
- Published repetition rate of 100 Hz (continuous)
- A 200 Hz repetition rate observed

Sample voltage waveform with a 50 Ohm cable load

- Un-calibrated CVR probes, mounted on coaxial cable (looking for waveshape and temporal information)
- Temporal jitter < 10 ns with +/- 30 kV charge (or greater)
- Load highly inductive (and produces BIG arc, hearing protection desirable)