

DTI Application Brief

HIGH ENERGY PHYSICS

PowerMod™

DTI's PowerMod™ modulators and power supplies are employed in many areas of high energy physics. Their modularity permits the design of a wide range of topologies and configurations that match a customer's requirements precisely.

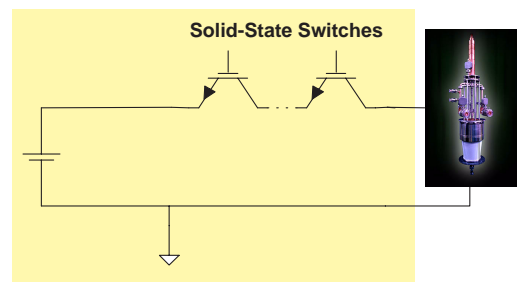
Accelerator Modulators

Solid state modulators can be used as cathode modulators or mod-anode modulators in typical accelerator systems. They can be configured at very high voltage and moderate current to switch microwave devices directly; or combined with pulse transformers at lower switch voltage and high current. In both cases, pulses achieve very fast risetimes and falltimes, resulting in improved operational and cost efficiencies.

DTI is developing two modulator designs, a "hybrid modulator" that uses a pulse transformer, and a transformerless, direct-switched modulator based on a solid-state Marx bank, for the Next Linear Collider project.

The hybrid modulator uses a storage capacitor, a solid-state switch and a pulse transformer. It provides high current pulses into the pulse transformer at 80 kV using IGBTs in series. Designed to drive two NLC klystrons, it achieves an efficiency of about 80%, and offers easy maintenance. Careful attention was paid to inductance in the primary circuit because of the very high primary currents and fast risetimes required. The system was delivered to the Stanford Linear Accelerator Center (SLAC) in Oct 2002.

Marx generators are widely known for high power pulses accompanied by inefficiencies and frequencies of a few pulses per second. As a result, they have not been employed where moderate pulse frequencies are required. In conventional Marx



Solid-state cathode modulator.



DTI's hybrid modulator. The capacitors, 80 kV solid-state switch, and a 6.33:1 pulse transformer are insulated by transformer oil and reside in two isolated sections of a single large tank. System controls are in the small enclosure on top of the tank.

HIGH ENERGY PHYSICS

generators, closing switches (i.e. spark gaps or SCRs) are used to fire the pulse, which discharges essentially all of the energy stored in the capacitors.

In DTI's Marx design, the switches connect the capacitors in series only for the duration of the pulse. At the end of the pulse, when the switches open, the capacitors have only fractionally discharged, resulting in significantly improved efficiency. The need for pulse-forming networks is eliminated, allowing wide flexibility in pulse width.

DTI's on/off switched Marx Bank concept uses inductive decoupling and provides directly switched voltages approaching 1 MV. It yields faster risetime, higher efficiency, a flat top pulse, and low life-cycle cost. The improved modulator efficiency translates directly into lower operating costs.

Crowbar Replacement

A related application is an "opening" switch, a system in which a single PowerMod series switch provides both pulse modulation and arc protection. DTI's switches can open in less than a microsecond, so are effective as "fast fuses" that can intercept arcs on a pulse by pulse basis. They can be closed again almost immediately, greatly minimizing system downtime due to arcs.

Solid-state opening switches have significant advantages compared to other approaches to tube protection. They use no hazardous mercury, offer high circuit efficiency and far lower fault currents (by orders of magnitude in many cases), and impose significantly lower stresses on upstream power components such as transformers, circuit breakers, and capacitors. Any high voltage system using a crowbar for load protection can be upgraded to a fast opening series switch.



DTI's opening switch built for the Advanced Photon Source at Argonne National Laboratory

High Power Tube Testing and Conditioning

Communications and Power Industries (CPI) in Palo Alto, California uses a PowerMod modulator for testing and conditioning high power klystrons destined for use in large scale Department of Energy projects. The modulator is rated at 140 kV and 500 A peak, and designed to pulse at up to 10 kHz. A companion 160 kV DC-DC power delivery system based upon a unique DTI buck regulator design is also in use. The complete solid-state system enables a testing capability not achievable using conventional vacuum tube technology.