



PowerMod Technology Breakthrough Brings High Availability to High Power Electronics

# PowerMod™

## PowerMod Technology

DTI's PowerMod™ technology delivers the revolutionary advantages of solid-state high power switching to demanding pulsed power and power conversion applications. Selected twice by R&D Magazine as one of the 100 Most Significant New Products of the year, DTI's solid-state switches are built from a series stack of IGBTs, or Pulsed Power Transistors (PPTs) configured for very high voltage standoff, and operated as a single, nearly ideal switch. Highly synchronized gate drives ensure the load on the switch is shared equally between devices. The entire switch can be closed or opened in less than a microsecond, safely disconnecting the load when it arcs. Each switch operates fully isolated from ground, and can open without damage under fault currents up to 10 kA.



**Switch Plates** are used in high-current applications, such as particle accelerators. This switch plate is rated at 4.5 kV, 3.5 kA.

Switch modules and plates are controlled at ground with a simple magnetically coupled loop, and are easy to operate in floating high voltage circuits. The entire switch can float at up to 200 kV where required. They require no ancillary high-voltage isolated power and operate fully on or fully off, greatly easing high-voltage management when compared to conventional floating decks.



**Switch Modules** handle lower current applications, such as some radar transmitters. These modules are rated at 5-10 kV, 10-50 A.

PowerMod solid-state switches offer nearly ideal switching behavior. Less than 1 mA of leakage current is present when the switch is open. When closed, the voltage drop across the switch is less than 3 V/ kV. Switching can occur in as little as 50 ns, and pulse repetition frequencies up to 100 kHz can be achieved. Pulsewidths are variable on a pulse-to-pulse basis from 1 μs to DC. Switches require only 110 V AC power for operation, and accept pulse commands via fiber optic link. Switches can utilize existing voltage and current monitoring and control circuits, or circuits can be provided by DTI as part of complete modulator.



**The Pulsed Power Transistor (PPT)**, developed in association with a leading electronics manufacturer, is a key building block for DTI's solid-state switches. PPTs are optimized for pulsed power applications.

Technology Comparison		
	PowerMod™ Solid-State Switches	Vacuum Tubes (Triodes, Tetrodes)
Reliability	<b>Tens of thousands of hours</b>	Thousands of hours
Voltage Range	<b>Up to 200 kV with multiple modules in series</b>	< 100 kV, typically tens of kV
Current Range	<b>Up to 5 kA</b>	1 - 200 A opening & closing
PRF	<b>DC - 100 kHz</b>	DC - 5 kHz
Efficiency	<b>&gt; 95% (load dependent)</b>	80 - 90% peak
Switching Speed	<b>&gt; 50 ns</b>	10 ns - 500 ns
Infrastructure Requirements	<b>None</b>	<ul style="list-style-type: none"> <li>• Filament/grid supplies</li> <li>• Tube sockets</li> <li>• Active cooling</li> <li>• Protection circuits</li> </ul>



## Enhanced Reliability and Efficiency

Solid-state devices can be orders of magnitude more reliable than vacuum tubes. In a large radar system, for example, a tube-based modulator may fault several more times in a single day than the solid-state system faults in a year. Better reliability means increased availability and reduced maintenance costs. In addition, the lower power dissipation of a solid-state switch translates directly into lower operating costs and infrastructure requirements, because cooling requirements are greatly reduced.

## Increased Pulse Flexibility

DTI's solid-state switches provide broad flexibility in controlling pulsewidth, PRF, peak current, voltage, and duty cycle. Dissipated heat is significantly lower, and because the heat is distributed across multiple air, water, or oil-cooled switch modules, the modulator can generate pulses from 1  $\mu$ s to DC.

## Increased Current Handling

Tube-based modulators are inherently current limiting, and high voltage, high current switch tubes are inherently expensive. DTI's solid-state modulators are designed to handle high maximum current for fast risetime. DTI has built modulators capable of handling 2000 A, and higher currents can be accommodated by paralleling switch modules.

## No Crowbars

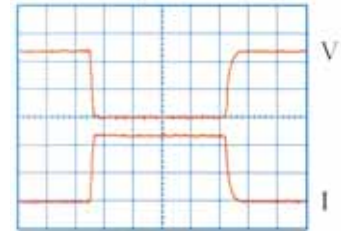
DTI's solid-state switches employed as fast opening switches, remove the need for crowbars and eliminate their drawbacks. An opening switch opens in less than a microsecond when an arc is sensed, yet can be closed immediately. Because the circuit's energy-storage capacitor does not discharge during an arc, high voltage (and RF) can be turned on again immediately after the arc clears.

## No Arcing - No X-ray Emissions - No Hazardous Materials

DTI's PowerMod™ systems do not create X-rays or parasitic oscillations at any voltage or current level. No special shielding of the tube is required for safe operation. DTI's solid-state opening switch uses no hazardous elements such as those found in mercury-containing ignitrons.

## Predictable and Consistent Performance

Performance over time, and from one unit to the next, is highly repeatable and consistent because DTI's solid-state modulators need only to contend with a small variance in the individual performance between switch modules. This variation is further reduced by combining a number of independent switch modules in one modulator.



**Very Fast Pulse Rise And Fall Times** and low ripple, produce a nearly ideal flat-top pulse. 20 kV, 100 A, 1  $\mu$ s/cm. Upper trace voltage, lower trace current.



**High Current Switch Plate Assemblies** such as this 20 kV, 1500 A unit replace thyratrons, PFNs, and crowbars in particle accelerators, x-ray systems, and e-beams.



**Switch Module Assemblies**, such as this 45 kV, 30 A unit are used in radar systems, light sources, and other low current applications.

