



**Radar Transmitters**



**Advanced RF Systems**



**Power Converters**

# PowerMod™

## Solid-State DC Circuit Breakers

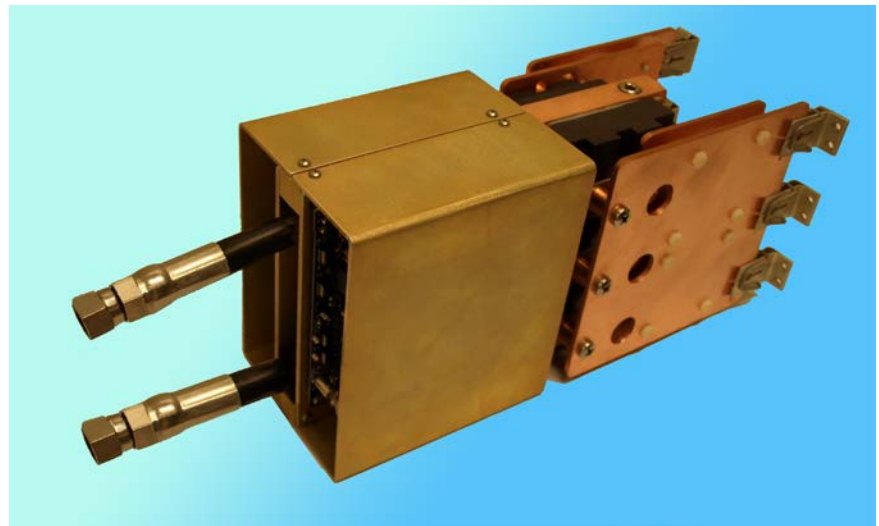
### System at a Glance



**1 MW Solid-State DC Circuit Breaker.** This molded-case circuit breaker operates at 1 kA and 1 kVDC. It maintains the look, functionality, and feel of a conventional 2.5 kA, 480 VAC three-phase circuit breaker.

The adoption of medium voltage AC and DC distribution has been hindered by the lack of fast circuit breakers and high voltage switches. Limited MVAC circuit breakers are available at high voltages and power levels, but rely on mechanical switches operating in SF6 or vacuum, typically requiring several milliseconds to open – existing DC circuit breakers are even slower. Consequently, the current into a short circuit fault will build to very large values, orders of magnitude greater than the nominal current, before the switch opens.

Solid-state opening and closing switches built by Diversified Technologies, Inc., capable of multi-kA switching at voltages up to 100 kV, have been demonstrated and qualified for military applications. The ability of these high voltage solid-state switches to interrupt full load currents within microseconds limits the fault current to less than twice the normal load current – enabling dramatic improvements in system reliability and safety. In addition to sub-microsecond opening and closing times, DTI switches typically exhibit multi-kHz switching, continuous operation, high-reliability, and long life.



**4.5 kV, 600 A Solid-State DC Circuit Breaker.** Breaker is based on technology developed to protect radar and particle accelerators. This DC solid-state circuit breaker is comprised of two 4.5 kV IGBTs in series (for voltage margin). and has dimensions of 16”w x 8”d x 6”h.

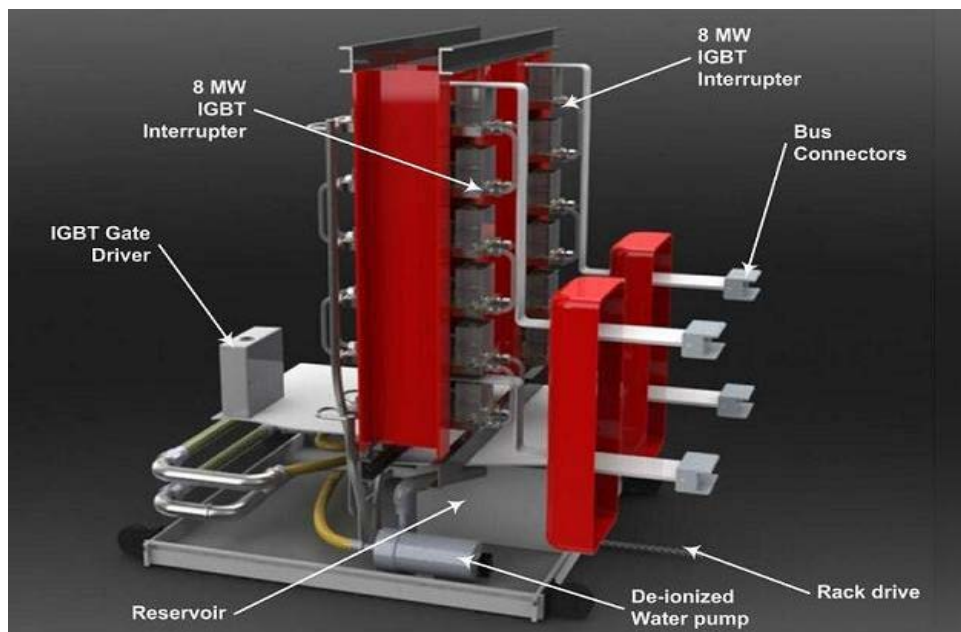
| DTI Solid-State DC Circuit Breaker | Product Specification |
|------------------------------------|-----------------------|
| Voltage                            | 1 - 50 kV             |
| Current                            | to 5 kA               |
| Opening Time                       | 0.8 - 15 us           |
| Openings                           | > 10,000              |
| MTBF                               | ~30 years             |



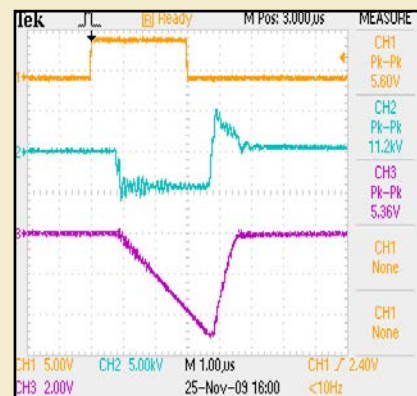
The small fault current and fast opening time of DTI's solid-state switches means that there is minimal impact to the load from a fault – it never reaches damaging energy levels. Solid-state switches can also be programmed to open at arbitrary currents, up to their maximum rating, allowing for simple breaker coordination.



**Fault Testing.** #40 AWG arc test wire shown next to a ball point pen for scale. Shorting a 100 kV capacitor bank to ground through a 500  $\mu$ H inductor and a length of #40 AWG wire leaves the wire intact, due to DTI's rapid fault detection and current interruption circuitry.



**8 MW Solid-State DC Circuit Breaker.** Conceptual drawing of a solid-state circuit breaker comprised of two 10 kV, 8 MW interrupters. Dimensions of 32" w x 32" d x 42" h.



**Waveforms with a DTI Circuit Breaker at 10 kV and 1 kA.** Traces: orange, command signal; blue, voltage (10 kV/div); purple, current (400 A/div); time, 1  $\mu$ s/division. The breaker opens into a typical 23  $\mu$ H short-circuit load; the delay between the command and switch opening is 800 ns.

