Solid-State Thyratron Replacement

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Abstract: *Diversified Technologies, Inc. (DTI) has developed and built a solid-state switch as a form-fit-function interface upgrade kit to replace legacy thyratron equipment. Under a US DOE SBIR for the SLAC National Accelerator Laboratory, this switch was designed using arrays of series- and parallel-connected commercial insulated-gate bipolar transistors (IGBTs). The solid-state switch's extremely long life and reliability presents an attractive replacement opportunity for many thyratron-based systems.*

Keywords: thyratron; solid-state; switch; IGBT

Introduction

The thyratron has been used as a switch in pulsed-power applications for almost a century. In the last 20 years, as a result of developments pioneered at Diversified Technologies, Inc. (DTI), most new applications have transitioned away from thyratrons as solid-state switching technology has become available. As the cost and capabilities of solid-state modulators has improved, their adoption has grown rapidly. With the continued evolution and reliability of solid-state pulsed-power systems, virtually all new pulsed-power systems are designed around solid-state capabilities.

Switch Description

Figure 1 shows the solid-state switch that was built. The IGBTs are in the large tank. In front is the shallow control box. There is an oil-water heat exchanger in the box at the upper left. The HV output is at the upper right.

Solid-State Switch Benefits

Thyratrons, typically used as the switch in modulators with pulse-forming networks, have a lifetime of only ten to twenty thousand hours and require periodic adjustment of their reservoir heater voltage. In contrast, solid-state switches have a much longer lifetime and need no regular maintenance. However, solid-state switches have not historically been capable of handling the voltage, current, and risetime required to replace thyratrons.

DTI's unique solid-state switch removes this problem and has successfully demonstrated full operating capability required by SLAC to completely replace (form-fit-function-interface) the L-4888 thyratron: 48 kV, 6.3 kA, and 1 μs risetime. In addition, the switch improves performance by reducing peak-to-peak pulse jitter to a level five times shorter than is typical for thyratrons. This demonstrated lower jitter of 1.5 ns (Figure 2) improves the performance of the Linac Coherent Light Source (LCLS) beam and increases the HV stability in the accelerator. In addition, a solid-state switch better protects the klystron tube from arc faults.

Replacing thyratrons with solid-state switches that last 20 years or more without maintenance would provide significant savings. The solid-switch's extremely long life and reliability offers an attractive replacement opportunity for many thyratron-based systems.

Figure 1. Solid-State Switch to Replace Thyratron.

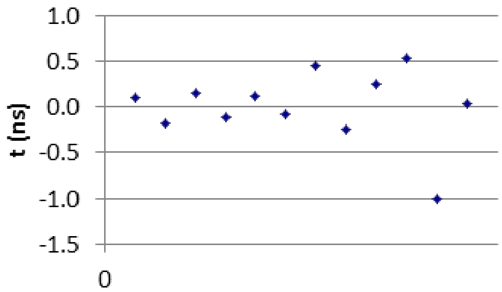

Figure 2. Times between turn-on of the switch and trigger-generator pulse. Most of the times are within 1 ns of each other; the maximum variation is 1.5 ns.

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