

# 2500HZ 16KV HIGH CURRENT THYRISTOR BASED SOLID STATE SWITCH

Howard D Sanders, Steven C. Glidden  
Applied Pulsed Power, Inc.  
2025 Dryden Road  
Freeville, NY 13068

**Abstract - High-current, high-frequency, high-voltage solid state switches have thus far required a large number of parallel and series connected components, such as MOSFET or IGBT. Such a large number of components increases both the complexity and the cost and failure risks associated with the switch. Applied Pulsed Power has developed a high current, high frequency, thyristor based switch capable of 5kA, 2500Hz operation with 30kA/ $\mu$ s peak di/dt. Operation of the thyristor based switch to IGBT and MCT based switches at low current, will be compared, and data from the thyristor based switch at high current, shown.**

## I. INTRODUCTION

The goal was to achieve an inexpensive robust high voltage solid state switch capable of operating at 2500 Hz pulse repetition frequency. The possibility of using thyristor based components seemed to alleviate the risks associated with manufacturing this switch using MOSFET, IGBT, or MCT based components. Instead of requiring 20 devices in series as would be needed with MOSFET, IGBT, or MCT, only 4 would be needed with thyristors. Another advantage of the thyristors is their higher current capability versus MOSFET or IGBT. However, to achieve the operational frequency, these thyristors would need to have very fast turn-on and recovery times. APP Inc. has previously demonstrated 200Hz operation using thyristors in their model S25 and model S38 switch modules [1]. Using proprietary triggering technology we were able to achieve 2500Hz operation.

## II. TURN-OFF TIME

The first test was to determine if the thyristor can turn off rapidly enough to allow a circuit to recharge in time to operate at 2500Hz. We employed an existing model S25 module using our advanced triggering technology, and could achieve turn-off times of less than 60 $\mu$ s, more than adequate time to recharge the circuit for operation at 2500Hz. This can be seen in fig. 1.

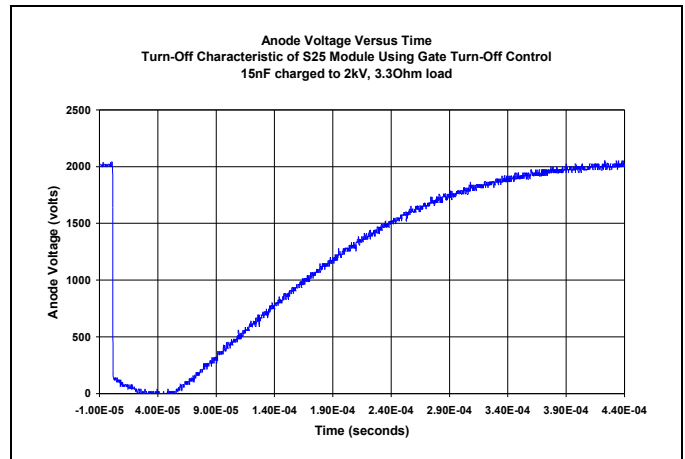


Fig. 1. Turn-Off Time of Model S25 Dual Thyristor Module

## III. COMPARISON WITH IGBT AND MCT

At low currents of only 40A, the MCT and IGBT can achieve faster turn-on than the thyristor. This is shown in Fig. 2. The S38S module uses a modified thyristor ion implanted to reduce carrier lifetimes. The data shows that the modified thyristor has a faster turn-on than the standard version of our model S38 module. While the thyristor turn-on times seem slow compared to the IGBT, it can achieve 100 times the current in the same turn-on time which equates to a 10 times higher peak di/dt than the IGBT can. This advantage allows the thyristor based switch to operate at much higher peak currents than the IGBT switch. In the low current operation, the faster turn-on does equate to higher efficiency as can be seen in table 1. However, the modified thyristor does achieve nearly equal efficiency to the IGBT, and the efficiency of the thyristor will increase with increasing peak current while the IGBT efficiency will decrease with increasing peak current.

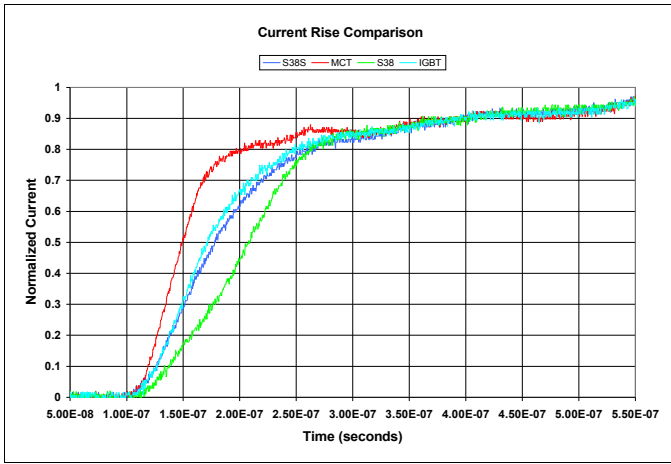


Fig. 2. IGBT, MCT, and Thyristor Turn-On Comparison

TABLE 1  
DIFFERENCE IN EFFICIENCY FOR LOW CURRENT APPLICATIONS

	S38	S38S	IGBT	MCT
Efficiency	89%	92%	93%	96%

#### IV. THYRISTOR BASED SWITCH PERFORMANCE

The performance of the thyristor based switch is shown in fig. 3 and 4. These graphs demonstrate a 16kV thyristor based switch operating at 2500Hz. Operation limited by the available power supply.

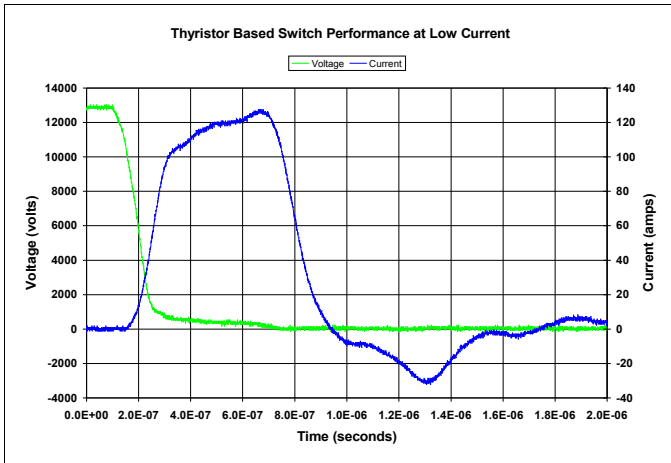


Fig. 3. Thyristor Based Switch Performance

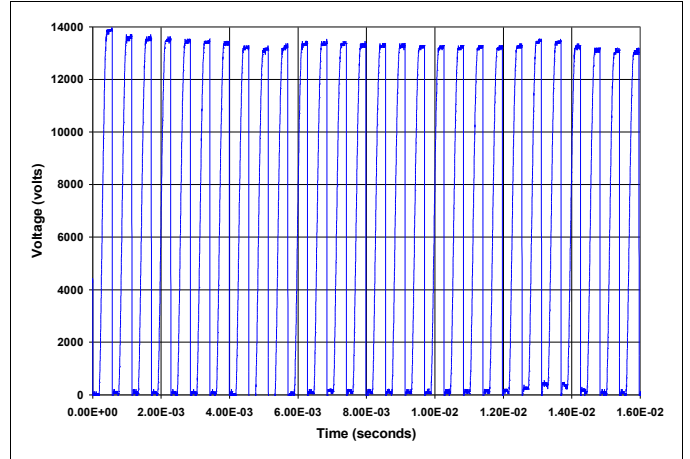


Fig. 4. Thyristor Based Switch Performance Showing 2500Hz

#### V. CONCLUSION

We have demonstrated that a 16kV thyristor based switch can achieve 2500Hz and high current operation. This switch is both robust and economical.

#### REFERENCES

[1] H. D. Sanders and S. C. Glidden, "High Power Solid State Switch Module", 2004 IEEE Power Modulator Conference, San Francisco, CA, May 2004