Gyrotron Pulse Modulator Test Stand

Dr. Marcel P.J. Gaudreau P.E., Craig Conecoff, Nigel Stuart, Luan Jashari, Tuan Nguyen, Michael Kempkes, Rebecca Simpson
Diversified Technologies, Inc. (DTI)
Bedford, MA, USA, 01730

Abstract: *Diversified Technologies, Inc. (DTI) has delivered a new 70 kV pulse modulator test stand to the Ulsan National Institute of Science and Technology (UNIST) in Ulsan, South Korea for full power testing of gyrotron tubes. The output is flat to less than 1% over 100 μs.*

Keywords: gyrotron; test stand; high voltage; modulator

Introduction

Diversified Technologies, Inc. (DTI) has delivered a new 70 kV pulse modulator test stand to the Ulsan National Institute of Science and Technology (UNIST) in Ulsan, South Korea for full power testing of experimental gyrotron tubes (Figure 1). At the system core is a high voltage power supply (HVPS), capacitor bank, filament transformer, and a solid-state switch that modulates the gyrotron cathode. Figure 4 shows a simplified high voltage circuit for the test stand.

The pulse modulator test stand is designed to operate a gyrotron tube within the parameters detailed in Table 1. Figure 2 shows a cathode pulse from the system. Figure 3 shows a waveform of a detected short fault.

Table 1. Test Stand Specifications

Specification	Parameters
Max. Peak Voltage	70 kV
Max. Peak Current	40 A
Voltage Droop	1%
Maximum Pulse Duration	1 ms
Maximum Pulse Rate	4 Hz
Maximum Duty Cycle	4%
Heater Power	900 W (30 V/30 A)

System Controls

The controls section of the system is comprised of a rectangular dishpan-like box. The controls dishpan houses the main system controls and indicators. The dishpan front door provides a Kirk Key interface, an E-Stop button, system indicators, analog meter, and BNC monitoring and system controls.

A control panel provides local controls, indicators, a metered display, and BNC monitor panel which allows convenient monitoring of buffered signals from the control board.

Figure 1. Gyrotron Pulse Modulator Test Stand with HVPS, capacitor bank, filament transformer, and solid-state switch.

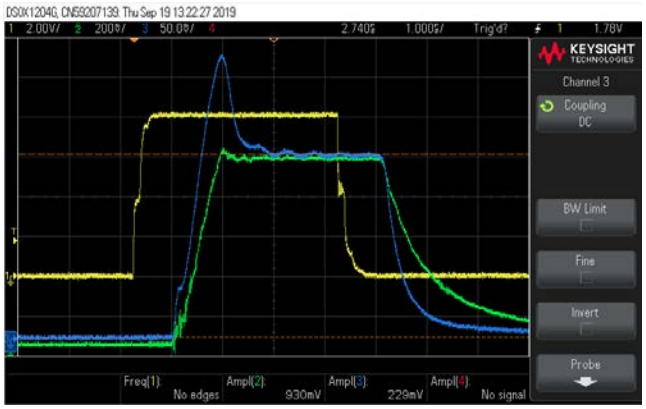

Figure 2. Gyrotron modulator voltage and current waveform. Ch 1 (yellow) CMD IN, 2.0 V/div, Ch 2 (green) Voltage, 200 mV/div, Ch 3 (blue) Current, 50 mV/div.

A controls cabinet houses a modulator sustaining switch driver, power supplies, circuit breakers, master control relay, and an interface panel. A connector panel on top of the test stand allows remote control of the unit.

Drive Switch Stack

A drive switch assembly delivers pulses to the gyrotron tube. This single stack of solid-state switch modules receives high voltage from a capacitor bank. The switch stack is driven with a single inductively coupled loop from the sustaining switch driver board located in the controls dishpan.

The switch stack is composed of six independent, epoxy encapsulated switch plates. These IGBT switch plates are connected in series for voltage standoff and redundancy. Therefore, the switch stack has voltage safety margin and is designed so that individual transistor failures do not impact operation or reliability (IGBT devices typically fail in a shorted condition).

Filament Heater

A high voltage power supply and variable transformer (Variac) panel on the front of the unit provides and controls voltage to the filament heater. An isolation transformer provides isolation between the high voltage supply and the Variac.

The Variac controls the amount of voltage going to the filament. The Variac is connected to a limit switch that must be turned on to enable the Variac's contactor. Every time the system turns on, the Variac must be reset to zero so the limit switch may engage the contactor, allowing the heater to start conducting. This allows the system to have a soft start, preventing a sudden jump in voltage on the heater. A FILAMENT ON indicator illuminates whenever voltage is applied to the filament. The brightness of the indicator is proportional to the voltage applied to the filament.

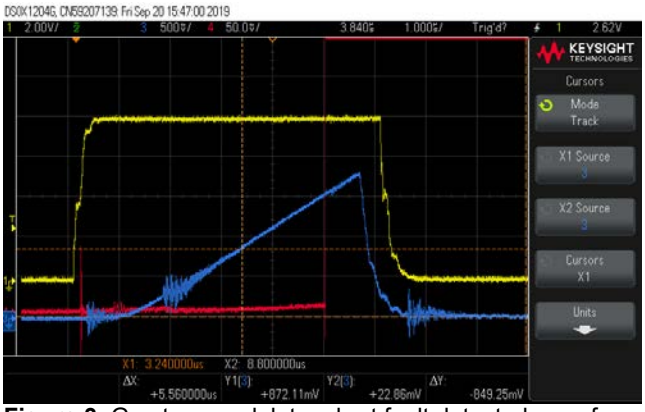

Figure 3. Gyrotron modulator short fault detected waveform. Ch 1 (yellow) CMD IN, 2.0 V/div, Ch 3 (blue) cathode current, 500 mV/div, Ch 4 (red) fault detected, 50 mV/div.

Snubber Circuit

A snubber circuit limits the rate of change in voltage and over voltage during switch stack turn-on and turn-off. This circuit protects the IGBT devices in the switch stack and improves performance.

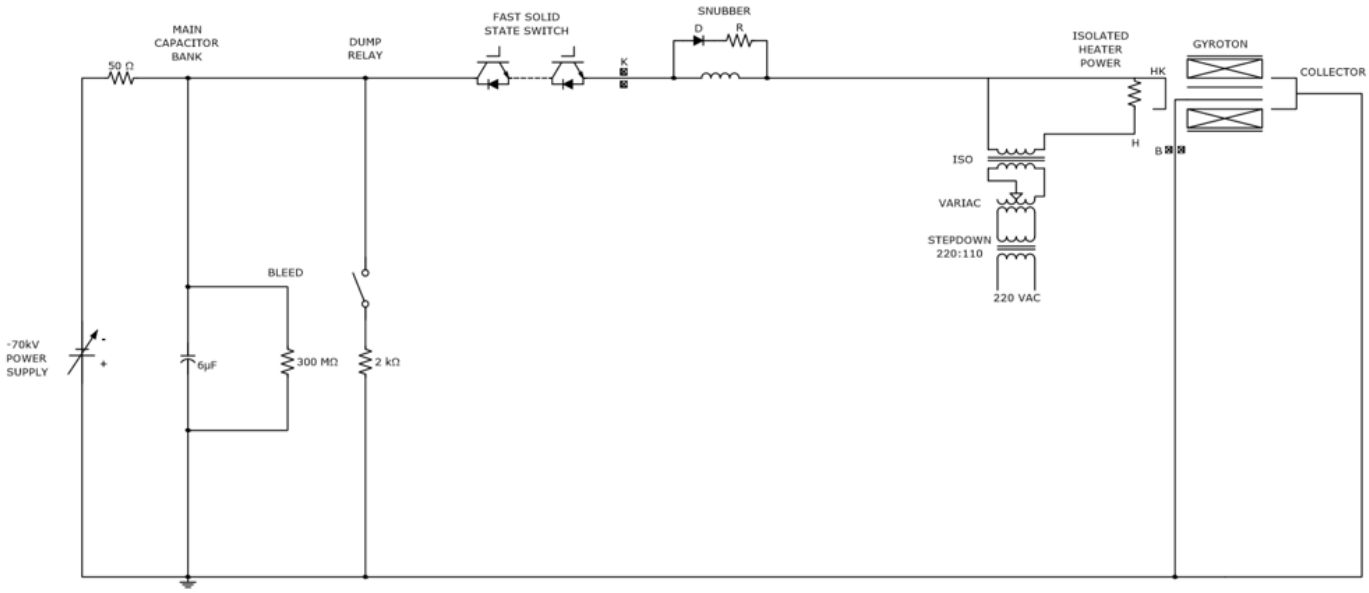

Figure 4. Simplified High Voltage Circuit