

Integrated Klystron Test Stand

Dr. Marcel P.J. Gaudreau P.E., Luan Jashari, Michael Kempkes, Rebecca Simpson

Diversified Technologies, Inc. (DTI)
Bedford, MA, USA, 01730

Abstract— Diversified Technologies, Inc. (DTI) recently delivered an Integrated Klystron Test Stand for klystrons under development at the Naval Research Laboratory (NRL) and Communication and Power Industries, Inc. (CPI). The test stand provides an HV beam and depressed collector power supplies, mod-anode modulator, controls, and circuit /klystron protection. The Integrated Klystron Test Stand simplifies and speeds the ability of the user to safely and efficiently test and exercise the klystron over the full range of its capabilities.

Keywords—klystron, test stand, high voltage, modulator

I. INTRODUCTION

Diversified Technologies, Inc. (DTI) recently developed an Integrated Klystron Test Stand for the Naval Research Laboratory (NRL) (Fig. 1). The system includes a high voltage beam supply, mod anode modulator, depressed collector voltage control, overall operating controls, and circuit protection for both the transmitter and the klystron itself. Table 1 details the an Integrated Klystron Test Stand specifications.

The design of the equipment draws directly on previous DTI solid-state systems in operation today, and shares common design elements based on DTI's patented solid-state switching technology—which has a history of reliable operational performance across more than 600 high voltage systems around the world. A single capacitor and solid-state cathode switch provide the peak beam power while providing protection for the klystron in the event of an arc, with the ability to remove cathode voltage within $\sim 1 \mu\text{s}$ after an arc is detected. The overall Test Stand design is shown in Fig. 2 and the specifications are shown in TABLE I.

II. CONTROLS

The control panel houses the main system controls and interface, as well as most of the power distribution. The control panel is divided into separate compartments to accommodate AC power distribution, low voltage DC utility distribution, and the controls section which includes the control boards and the Programmable Logic Controller (PLC) for system sequencing, parameter and fault monitoring, and other functions. The PLC sequences are based on DTI's klystron transmitter systems, with the addition of the flexibility and programmable sequencing in voltage, pulsewidth, and frequency required for klystron conditioning and test across a range of parameters, rather than just the full power operation.

A co-located 19" rack contains the 480V/208V step-down transformer, HV body supply, solenoid power supplies, and the Vac-Ion power supply.



Fig. 1. Complete Klystron Test Stand, showing controls and auxiliary supplies in the left cabinet (Cabirack), the high voltage power supply (center-left), the high voltage modulator cabinets (center-right), and stand (right).

TABLE I. KEY SPECIFICATIONS OF THE KLYSTRON TEST STAND.

Parameter	Requirement
Cathode Voltage	-10 kV to -32 kV, regulation better than 1%
Peak/Average Current	30 A / 1.5 A
Collector Depression Voltage	0 - 10 kV
Duty Factor	5%
Repetition Rate	Single Shot to 1 kHz, or Duty Limit
Pulse Width	10 - 1000 μs , or Duty Limit
Pulse Regulation	+/- 0.2 % RMS

III. HIGH VOLTAGE POWER SUPPLY

The 10 to 32 kV DC high voltage input is supplied to the modulator by a standard DTI switching power supply. This high stability/low noise unit has variable output and operates from 480 VAC, 60 Hz three-phase input. The supply uses an advanced PWM inverter which gives excellent voltage and current regulation over the full output range. Nominal output behavior is 0.1% ripple and +/- 0.2% voltage regulation, with fast response to transients. Internal filter components reduce

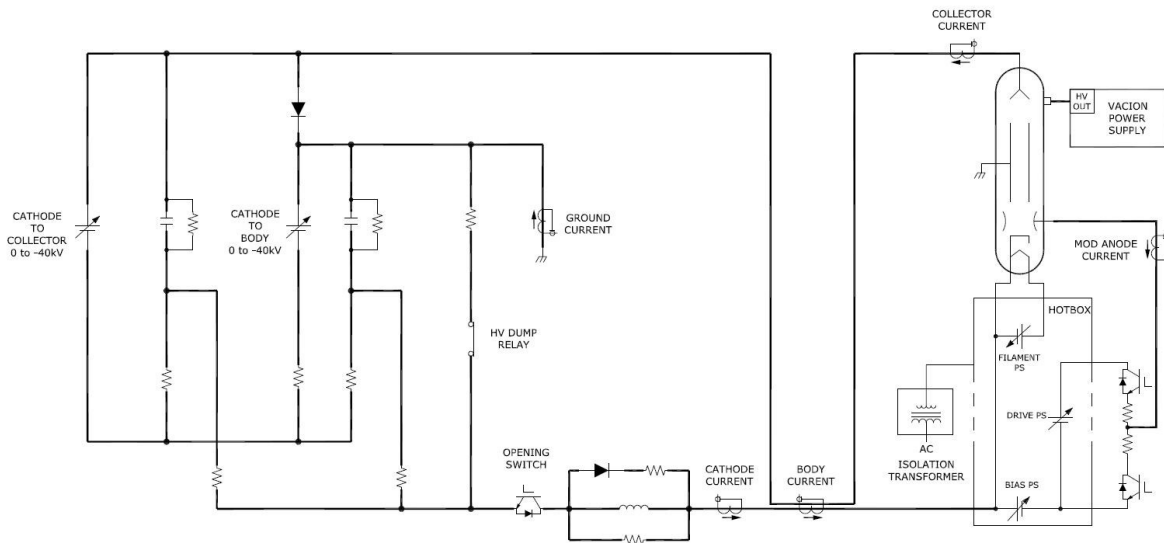


Fig. 2. High Voltage Circuitry.

the line disturbance to modest levels. The high voltage section is built into a small tank filled with transformer oil. A second, low power supply regulates the cathode-body voltage, and determines the collector depression voltage.

IV. MODULATOR

The mod-anode modulator is a push-pull design utilizing two solid-state switches, with independent control of the cathode to mod-anode and mod-anode to body voltages. The capacitor, cathode switch, and modulator are built into a single cabinet that also houses all HV components required for biasing the klystron. In addition to the major components, the modulator cabinet houses voltage dividers, current monitors, front door analog meters, grounding sticks, and other components.

V. HIGH VOLTAGE CIRCUITRY

The Klystron Test Stand is designed to operate with a maximum beam-current of 30 A (peak), -32 kV. In one configuration the test stand is outfitted with two mod-anode modulators, allowing operation of two klystrons. In this configuration, both klystrons operate from a single capacitor bank and opening switch tied to both cathodes.

VI. SUMMARY

Fig. 3 shows a typical waveform at 20 kV Cathode voltage, 100 Hz PRF, and 25 μ s pulse width. The two Klystron Test Stands were installed and accepted at CPI and NRL in December 2017 and June 2018, respectively. They have been operating without incident since their commissioning.

ACKNOWLEDGMENTS

This effort was funded under Contract N00173-15-C-2024. The support of Dr. David Abe and John Rodgers at NRL, and Cal Stanger and Adam Balkcum at CPI, Palo Alto were critical to this effort.

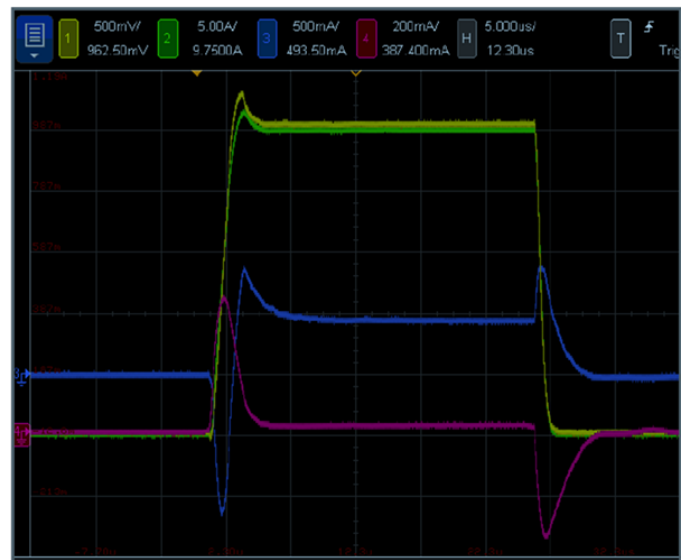


Fig. 3. Typical Waveform at 20 kV Cathode voltage, 100 Hz PRF, and 25 μ s pulse width (CH1: Cathode Current 10 A/V, CH2: Collector Current 10 A/V, CH3: Body Current 1 A/V, CH4: Mod Anode Current 1 A/V).