COBRA DANE Radar Transmitter Group Replacement

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***Abstract*—In 2019, Diversified Technologies, Inc. (DTI) delivered a transmitter group replacement (TGR) for the COBRA DANE ground-based radar facility at Eareckson Air Station, Shemya Island, Alaska. This individual L-Band transmitter subsystem is part of the twelve transmitter groups housed at the facility. Each transmitter group energizes, controls, and protects eight high-power, ring-bar type traveling wave tubes (TWTs). Individual RF outputs from each tube are input to a space-fed phased array antenna. As a result of this successful installation, the USAF awarded DTI a contract to build and deliver the remaining 11 transmitter groups in 2020.**

Keywords—solid state; modulator; traveling wave tube; transmitter; radar.

I. INTRODUCTION

In 2019, Diversified Technologies, Inc. (DTI) delivered a transmitter group replacement (TGR) for the COBRA DANE ground-based radar facility at Eareckson Air Station, Shemya Island, Alaska. This L-Band transmitter group (Fig. 1) is one of twelve transmitter groups housed at the facility. Each transmitter group energizes, controls, and protects eight high-power, ring-bar type traveling wave tubes (TWTs). Individual RF outputs from each tube drive the elements of the phased array antenna.

The transmitter group is designed to energize eight TWTs. Fig. 2 shows a cathode pulse from one modulator / TWT in the transmitter group.

At the transmitter's core is the modulator which manages the operation of high-speed solid state opening switches, tube filament/grid supplies, and grid switch for each of the eight TWTs in the group. A Power Distribution Unit feeds the group's two high voltage power supplies (HVPSs) which power the Capacitor Bank. The Capacitor Bank feeds the modulator opening switches to provide the full beam current for the group of 8 TWTs at 42 kilovolts. A simplified system block diagram for the transmitter is shown in Fig. 3.

II. SYSTEM CONTROLS

The Group Controls Cabinet houses the Programmable Logic Controller (PLC), Human Machine Interface (HMI) touchscreen, Group Fault Control (GFC) board, control/monitor panel, Kirk Key interlock switches, and Group Off button. This cabinet also handles local 208 VAC distribution which includes six circuit breakers. The PLC controls transmitter status transitions and sequencing (e.g., from standby to radiate). The GFC board manages all group faults by interfacing with the TWT Control boards in the Modulator.

Fig. 1. L-Band radar transmitter group with (left to right) Controls Cabinet, Auxiliary Rack, HVPS 1 & 2, Capacitor Bank Cabinets (two) and Modulator Cabinet.

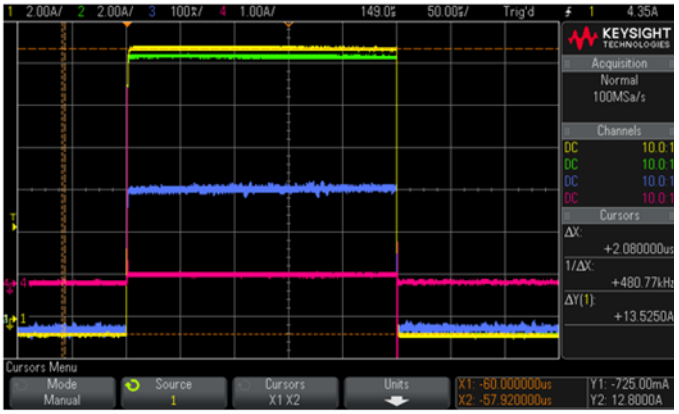

Fig. 2. Typical Traveling Wave Tube Cathode, Collector, and Body Currents. Vk = 42 kilovolts (kV).

III. SYSTEM POWER

A 19" Auxiliary Electronics rack houses power supplies for the regulator, second collector, and solenoids. The HVPS group consists of two 50 kilovolts, 250 kilowatt switching power supplies. These supplies provide the average power for eight TWTs at approximately 42 kilovolts. This high stability/low noise unit operates from a 480 VAC, 60 hertz three-phase input.

Each HVPS uses a pulse width modulation (PWM) inverter to provide voltage and current regulation over the full output range. Nominal output behavior is 0.1% ripple and voltage regulation, with fast response to transients. If one power supply faults, the transmitter group controls deselect two modulators and a single HVPS continues to operate, providing power to six TWTs.

IV. MODULATOR

The modulator cabinet houses a high voltage (HV) solid state opening switch, hot box, voltage divider, and isolation transformer for each of the eight TWTs in the group. Each opening switch protects its corresponding TWT by opening in less than 1 µs to a load fault, such as a TWT gun arc, to remove HV from the cathode. Each hot box modulates the grid of its dedicated TWT and provides filament power, voltages for grid bias and drive, generates grid pulse, and senses cathode current for wide-pulse fault detection.

Each TWT has a designated door-mounted front panel which provides digital readouts of the tube's Filament Voltage, Filament Current, Grid Bias Voltage, and Grid Drive Voltage.

V. CAPACITOR BANK

The Capacitor Bank Cabinet houses 7 individual 9 µF HV capacitors, regulator system, and HV dump relay assembly. Collectively, the HV capacitors provide the full beam current for the group of 8 TWTs (14A x 8 = 112A), at 42 kilovolts delivered from the HV side of the Capacitor Bank. The Capacitor Bank is split into three groups: prime collector, secondary collector, and cathode-to-regulator. The regulator system is a switching power supply (output range of -50 to -550 Volts) which maintains the cathode voltage at its setpoint, compensating for droop created by body current.

Front panel BNC connectors and analog meters are provided to monitor cathode, prime collector, and second collector voltages.

VI. CONCLUSION

After a successful Factory Acceptance Test at DTI in May, 2019, the transmitter group was flown to Shemya, Alaska by the USAF. DTI and Raytheon installed the group during the summer, and the system completed Site Acceptance Testing in October, 2019. Current plans call for the upgrade of the remaining 11 transmitter groups over the next five years.

VII. ACKNOWLEDGMENTS

The first COBRA DANE Transmitter Group Replacement was built and delivered under subcontract to Raytheon Intelligence and Information Systems. The remaining 11 Groups are being built under contract to AFLCMC/HBQK (FA8723-20-F- 0001).

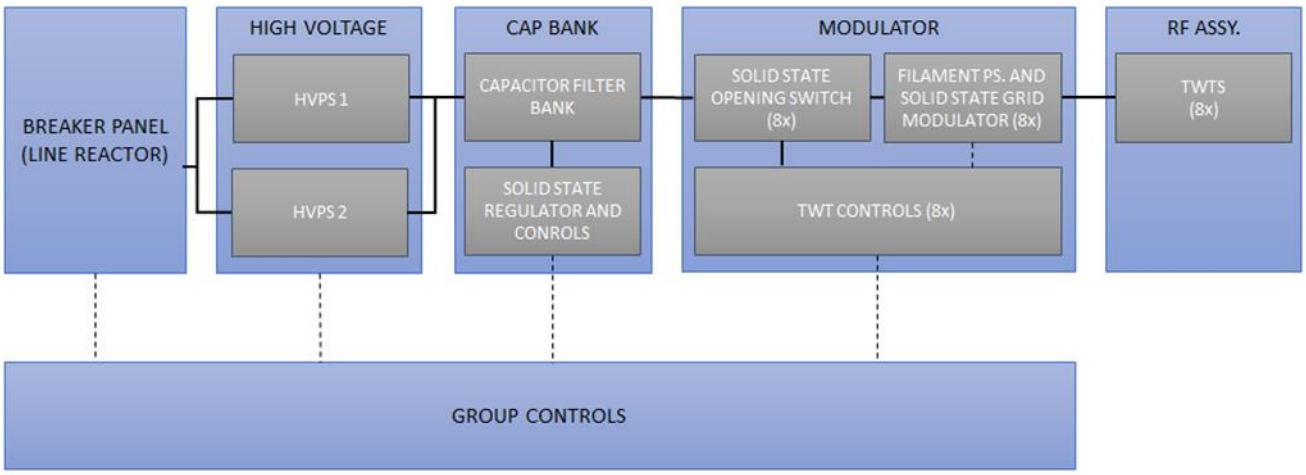

Fig. 3. Transmitter Group Block Diagram