AN/TPQ-18 Radar Transmitter

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***Abstract*— Diversified Technologies, Inc. (DTI) has delivered a new transmitter to the U.S. Air Force (USAF) Western Range AN/TPQ-18 radar facility. This 3 MW C-Band radar transmitter energizes, controls, and protects a CPI VKC- 8313A (5.4 GHz to 5.9 GHz) Extended Interaction Klystron (EIK). This design is applicable to a number of other range instrumentation radars operated by the USAF and US Navy.**

Keywords— klystron; transmitter; radar; modulator; microwave

I. Introduction

DTI has recently installed a new transmitter for the U.S. Air Force (USAF) Western Range AN/TPQ-18 radar facility. This 3 MW C-Band radar transmitter (Fig. 1) energizes, controls, and protects a CPI VKC-8313A Extended Interaction Klystron (EIK). RF output to a space-fed Cassegrainian antenna.

At the transmitter's core is a modulator which uses a DTI advanced solid state switch to drive a pulse transformer providing 135 kV cathode pulses within the parameters detailed in Table 1. Fig. 2 shows a cathode pulse from the transmitter system. The system includes a DTI high voltage power supply (HVPS), high power RF driver amplifier, custom output waveguide, and control consoles. Fig. 3 shows a simplified transmitter system block diagram.

II. System Power Supplies

The cathode power comes from a HVPS which is a 40 kV, 100 kW switching power supply assembly. The HVPS high voltage output feeds the modulator filter capacitor. This high stability/low noise unit operates from a 480 VAC, 60 Hz three-phase input.

The HVPS uses an advanced 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. Internal filter components reduce the line disturbance to modest levels. The high voltage section is built into a small tank filled with transformer oil. A heavy-duty high voltage cable connects the power supply to the modulator. A front panel provides local controls, indicators, and voltage/current limits for the collector HVPS.

A 19" rack houses auxiliary power supplies for the klystron filament heater, pulse transformer core reset, solenoids, and ion pump.

Fig. 1. C-Band radar transmitter with modulator, klystron tube, waveguide, cooling manifold, HVPS, and control consoles.

III. Modulator

The two-section modulator tank houses an energy storage capacitor, high voltage solid-state switch, and pulse transformer. The primary section of the tank houses the solid state switch and main storage capacitor. The secondary tank section houses the pulse transformer and tube socket. The solid state switch acts both as a modulator and circuit protector; controlling pulses to the pulse transformer. If an arc fault is detected, this switch opens in less than 1 µs to disconnect high voltage from the klystron cathode.

TABLE 1. Transmitter Specifications

Specification	Parameter
Frequency	5.4-5.9 GHz
Peak Power Range	1 watt to 3 megawatts
RF Duty Factor	0.40% maximum
Pulse Width Range	0.5 to 25 µS
Pulse Repetition Frequency	1280 Hz maximum
Attenuation	65 dBm max. @ 0.5 dB increments
S/N Ratio	39 dB min
Output VSWR	≤1.40

IV. RF Rack

The RF rack houses the Microwave Control Unit (MCU), RF drive amplifier, and I/O components. The MCU handles RF faults and communicates with the Klystron Control board for pulse timing and fault interlock initiation. The RF driver is a 6 kW COTS TWTA. A remotely adjustable variable attenuator is installed between the driver and the klystron input to allow full power adjustability while keeping the TWTA saturated. There is also a switch which allows an attenuated version of the drive waveform to be routed to the radar boresight calibration tower.

V. Output Waveguide

Klystron RF output is fed to a WR187 waveguide subassembly This is sealed and pressurized with Sulfur Hexafluoride (SF6) gas to 30 psig (nominal) to prevent or minimize waveguide arcing. Components include an optical arc detector, directional couplers for signal monitoring, isolator for protection from reflected antenna power, and a switch which allows full power testing into a dummy load.

VI. System Controls

The control cabinet houses the main system controls and interface, as well as most of the power distribution. The cabinet is divided into separate compartments to accommodate AC power distribution, low voltage DC utility distribution, and a controls section which includes the Klystron Control board and the Programmable Logic Controller (PLC) for system sequencing and other functions. The cabinet front panel provides an E-Stop

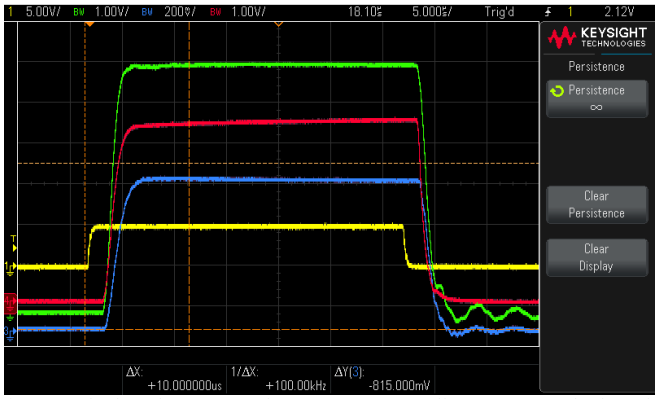

Fig. 2. Cathode Pulse. 30 µs pulse, CH1: CMD (Yellow), CH2: Cathode Voltage (Green 20KV/V), CH3: Cathode Current (Blue, 100A/V), CH4: Primary Current (Red, 100A/V).

button, touchscreen, and BNC monitor panel which allows convenient monitoring of buffered signals from the control board. The transmitter can be fully remotely controlled.

VII. Conclusion

Construction and factory acceptance testing were completed in 2020, with installation and acceptance testing at Vandenberg AFB delayed until mid-2021 due to a combination of COVID travel restrictions and to accommodate range operations. This design is applicable to a number of other range instrumentation radars operated by the USAF and US Navy.

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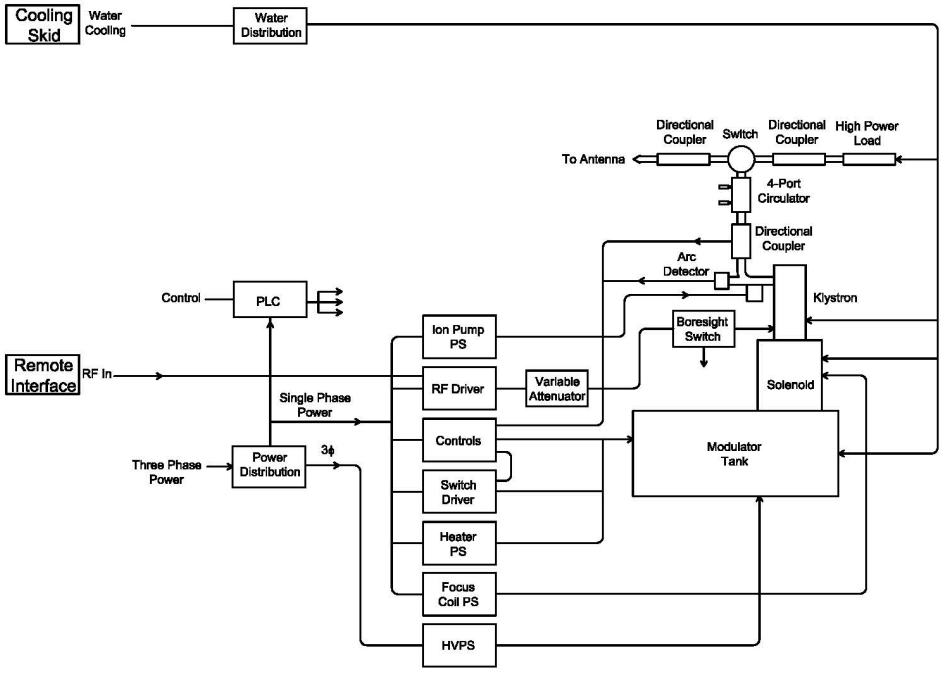

Fig. 3. Simplified Transmitter System Block Diagram.