



PowerMod Technology Breakthrough Brings High Availability to High Power Electronics

## **PowerMod™** Cobra Judy X-Band/GrayStar Radar Upgrades

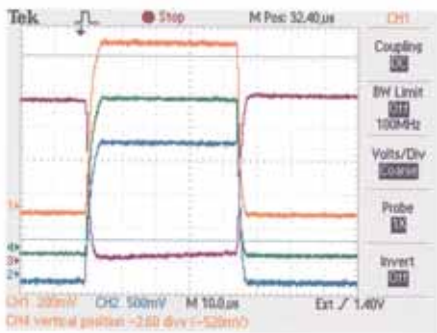


**USNS Observation Island (top) and USNS Invincible.** The Cobra Judy X-band radar is in the Observation Island. DTI also replaced a vacuum tube crowbar system in the Invincible's X-band radar with a solid-state opening switch.

The Cobra Judy X-Band radar is a dual TWT-based, precision data collection radar operated by the U.S. Air Force on board the USNS Observation Island. Installed in 1983 with a projected operating life of ten years, it has been in service since then without major modifications. Frequent problems with transmitter operation and reliability culminated in a decision to replace the transmitter from line power to tube. In the summer of 2003 DTI installed a new, modern, solid-state transmitter system.

The old transmitter included a large, 60 Hz transformer/rectifier that supplied 200 kW of average power at 45 kV, a vacuum tube post-regulator, and a vacuum spark-gap crowbar that provided arc protection for the TWTs. Mod-anode modulation was provided by two vacuum switch tubes located 30 meters above the transmitter room in the RF head. Hard-wired logic and timers significantly complicated the diagnosis of transmitter faults and ease of resuming system operation after a fault.

In DTI's new design, three 100 kW, 45 kV switching high voltage power supplies completely replaced the inductrol, the transformer/rectifier, and the vacuum tube post regulator. The power supplies provide low ripple cathode voltage to the TWTs and highly regulated power to charge the storage capacitors between pulses. Their outputs are diode-combined, and balanced using an external control loop. Only two of the three power supplies are needed for full-power operation of the radar. The third is a backup, ensuring that the radar operates at full power in the event of a power supply failure.



**These pulses** from the new Cobra Judy X-band transmitter show the fast rise and fall times and nearly ideal flat tops resulting from precise voltage control.



**New Cobra Judy X-band transmitter electronics.** Power distribution unit and transmitter interface unit (foreground), and three, 50 kV, 2 A power supplies and combiner (right).



The TWTs are protected by a new solid-state opening switch placed electrically between the capacitor bank and the TWT cathodes. The new switch, which replaces the spark gap crowbar, removes power from the TWT cathodes in less than one microsecond after the onset of an arc. Unlike the original crowbar, opening the switch does not discharge the capacitor bank or take the power supplies out of regulation, so the switch can close again almost immediately after the fault. The operation of the radar resumes within several milliseconds after the arc, missing no more than one or two pulses.

In the RF head, the original vacuum switch tubes were replaced by two solid-state switches to modulate the TWTs' mod-anodes. The design allows for future cathode pulsing where each TWT is driven by one of the solid state switches. A cathode pulsed design reduces the cumulative voltage stress on the TWTs significantly because their cathodes are at high voltage only during pulse transmission, a small fraction of their operating time.

A new PLC control system, which provides local control of each transmitter element, also enables control to be handled remotely from anywhere on the ship. A fault control unit displays all reported faults and first fault indication, and identifies test points for rapid diagnosis and repair.

DTI also designed and installed transmitter electronics on the Observation Island's companion ship, the USNS Invincible. A 45 kV, 50 A solid state opening switch and fault sensing electronics replaced the vacuum tube crowbar that protected the X-band radar's TWT. Its sub-microsecond response means that fewer pulses are missed in case of an arc. The new system offers faster fault isolation, reduces fault energy delivered to the TWT, and reduces the size of fault currents and mechanical forces by orders of magnitude. In addition, two new DTI 150 kW switching power supplies replaced the original DC power supplies. These provide higher regulation and full redundancy for the transmitter system.



A graphical PLC control system provides state control and fault reporting for the entire transmitter.



This 45 kV, 50 A solid-state opening switch replaced the vacuum tube crowbar on the Invincible's GrayStar X-band radar.

