TWTS PROVIDE DRIVE FOR HIGH-POWER SYSTEMS

MEPPALLI SHANDAS, Vice President of Technology
dB Control, 1120 Auburn St., Fremont, CA 94538,
(510) 656-2325, Internet: www.dbcontrol.com.

Vacuum tubes, now commonly referred to as vacuum electron devices (VED), are still essential to high-power RF/microwave military systems. While VEDs, such as klystrons, crossed-field amplifiers (CFAs), gyrotrons, magnetrons and inductive output tubes (IOTs), and traveling wave tubes (TWTs), may represent older technology, they can achieve power levels still unmatched by transistors.

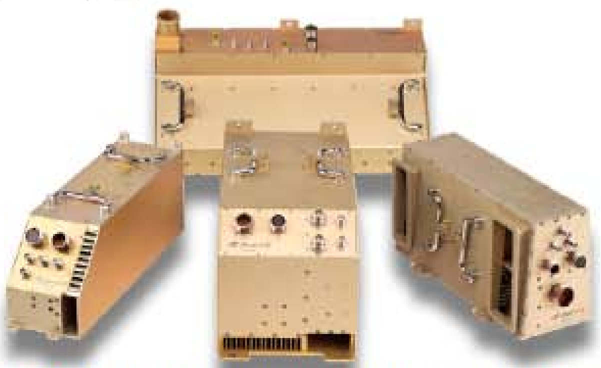
The TWT is the most widely used VED for microwave defense, instrumentation, and satellite communications. Although TWTs are mature, work continues on refining the devices themselves, the amplifiers they support, and the power supplies that energize them. A TWT uses a slow-wave structure (either a coupled-cavity circuit or for purposes of this discussion, helix) to create interaction between a high-energy electron beam and an RF wave in a vacuum envelope.

A good example of a TWT amplifier (or TWTA) application is a radar transmitter. In this system, a pulsed signal from the radar waveform generator is applied to an amplifier that employs RF power transistors to produce an output to drive the TWT. This signal is sent to the input of the TWT where isolators are used to ensure proper input matching and interstage isolation, and a PIN-diode switch shut off the driver's output when needed to protect the TWT from overload. In addition to the TWT, the RF output section includes a dual-directional coupler to determine the RF output level as well as the reflected power level to protect the TWT from damage in high VSWR conditions.

Other components include an isolator and often a harmonic suppression filter and waveguide switch that can divert the TWT's output to a dummy load for testing. An arc detector is generally included in very-high-power transmitters, which senses breakdown in the waveguide and turns off the RF drive power to the TWT to prevent damage to its output port window.

TWTs used for transponder amplifiers in satellites are typical examples for the high efficiency and reliability figures that can be achieved by careful design of TWTs. RF output power to prime power input ratio that describes real efficiency is greater than 60 percent for these devices, and recent reports show that efficiency of nearly 70 percent has been achieved.

A mini-TWT is a small version (typically about 7 in. long) of a TWT designed for use with a lower-voltage power supply (to 8 kV). Its smaller size results in less power that its larger counterparts, to about 200 W CW (1 kW peak), although retaining its broadband, high-frequency capabilities though about 50 GHz. Mini-TWTs are well suited for use in Microwave Power Module (MPM), an output architecture that resulted from development efforts supported by the US Air Force, Army, and Navy launched in 1990. A wide array of MPMs has been developed for operation from S-band to W-band in CW and pulsed configurations, with RF outputs from less than 20 W to more than 1 kW with a 20 to 40 percent duty cycle, 100 to 400 μs pulse width, and variable pulse repetition frequency.



This 2-to-18 GHz ECM transmitter suite was designed to survive extreme environmental conditions.

One example of a MPM-based transmitter suite for ECM applications consists of four MPM-based CW and pulsed transmitters covering 2 to 7 GHz and 6 to 18 GHz for full 2-to-18-GHz coverage. The transmitter suite was designed for the harsh conditions encountered in airborne environments, and can withstand gunfire vibration, operation at +100° C for short periods, and is compliant with MIL-STD461E. In addition to a solid-state driver amplifier, the RF input section includes isolators, directional couplers for sampling at various stages, bandpass filters, switches for selecting specific filters, and a TWT gain equalizer. A dual-directional coupler, forward and reflected power monitoring, and high-VSWR protection circuit follow the TWT.

The ECM suite met requirements for performance over temperature, altitude, vibration, shock acceleration, explosive atmosphere, rain, humidity, and EMC compliance. The suite delivers RF output power of 250 W C or pulse from 2 to 7 GHz and 100 W from 6 to 18 GHz, 1.5 kW peak (6-percent duty cycle) from 6 to 18 GHz, and to 300 W CW or pulse from 6.5 to 18 GHz from its dual-transmitter "high-band" section.

next page • Case Study