MICROWAVE engineering europe

Future EW environment calls for high RF power

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Since the dawn of electronic warfare, RF engineers have relied on the vacuum tube – specifically the traveling wave tube amplifier (TWTA) – to produce high microwave frequencies of up to 100 GHz and very high power levels over a broad bandwidth. While solid-state amplifiers are smaller and lighter than TWT amplifiers, even the most impressive gallium nitride (GaN), silicon LDMOS, or GaAs RF power transistors produce at most just over 1 kW of RF power, and then only at comparatively low frequencies.

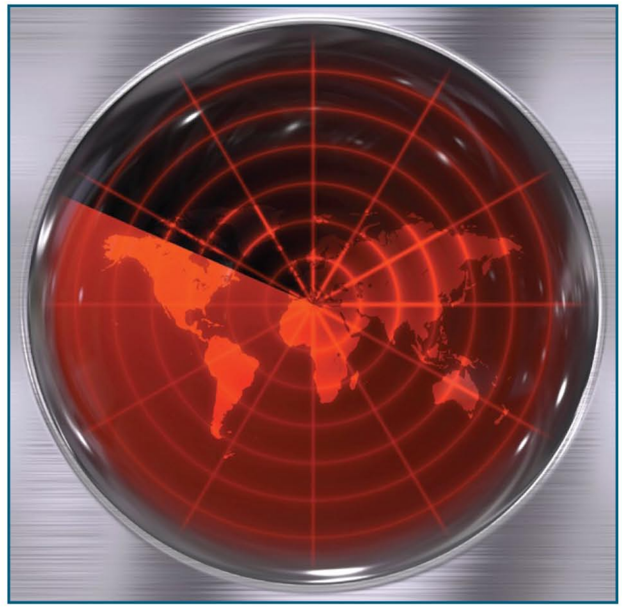
While some solid-state devices can achieve a wide frequency range of 2 to 18 GHz, their output power remains at a maximum of about 20 W. The ideal solution is to exploit the integral advantages of solid-state and TWT technologies to deliver the best of both worlds — which is exactly what a microwave power module (MPM) accomplishes.

MPMs – a compact alternative to the TWTA

About 20 years ago, a joint project of the U.S. Armed Forces produced small, high-power amplifier modules in a common form factor that operated from low-voltage DC power supplies. The design used a solid-state driver amplifier based on MMICs or discrete RF power transistors to drive a mini-TWT. This was combined with a power supply and control circuits in a very compact enclosure. Today, MPMs from dB Control and other manufacturers are available with RF outputs up to about 300 W continuous wave (1 kW pulsed), and at frequencies as high as 50 GHz.

A reliable, efficient source for high power that is both compact and lightweight, MPMs are now extensively used in ECM, radar, and satellite communications systems. For example, dB Control's MPMs are used to power Synthetic Aperture Radar (SAR) systems like the Lynx SAR/GMTI onboard General Atomics Aeronautical Systems' MQ-9 Reaper Unmanned Aerial Vehicles. These long-range UAVs can remain in the air for up to 35 hours at altitudes of more than 65,000 feet while being controlled from a secure base.

In addition to military applications, UAVs are being employed worldwide for disaster management, wildfire detection, law enforcement and pollution monitoring. In fact, the U.S. Air Force's Global Hawk UAV was used to acquire images of damaged nuclear reactors in the aftermath of Japan's recent earthquake and tsunami.



Selecting a radar transmitter

Both the application and the platform must be considered when selecting a high-power radar transmitter. For example, the radar applications with multiple functions require time-shared roles for each function – which in turn requires a special type of transmitter. In addition, if the radar system is used to deliver countermeasures against jamming, the transmitter must provide wide bandwidth to enable frequency agility.

The installation platform is also important because it can impose size, weight, and thermal limitations on the transmitter. Some platforms test the transmitter's reliability by exposing it to harsh environmental conditions (i.e., extreme temperature, high altitude, dust, humidity, and vibration). Others, such as satellite communications systems, require a transmitter with an extremely long operating life. Fortunately, TWTAs have a life expectancy of 100,000 hours, enabling them to reliably deliver its rated performance continuously for more than 11 years — well beyond what is required for most defense applications.

TWTAs advancing to meet new requirements

As frequencies ascend, future radar transmitters may be required to provide up to 3 GHz of reliable bandwidth and handle a multitude of secure modulation formats. Also, for military groups to be able to communicate with allies in times of war and during emergencies, radar systems must be equipped to use additional modes of operation and new frequency bands and/or spectrums.

Fortunately, TWTAs continue to be top of mind for research and development engineers worldwide. DARPA, the U.S. Department of Defense's Advanced Research Projects Agency responsible for the development of new military technology, has a High Frequency Integrated Vacuum Electronics (HiFIVE) Program that is developing a 50- to 100-W TWTA at 220 GHz that can operate for 100+ hours in a high-bandwidth tactical communications link. The goal is to achieve throughput comparable to optical fiber – with no degradation.

Internationally, TWTA research is being conducted to develop products that will meet the needs of systems operating in the upper echelons of the millimeter-wave region. At the 2011 International Vacuum Electronics Conference in Bangalore, India for example, novel technologies for new components and materials, including high-density graphite, were explored.

While TWT technology may not be familiar to every microwave or RF engineer, it is ubiquitous throughout terrestrial, airborne, and space-based defense systems worldwide, and in commercial and scientific applications as well. Solid-state amplifiers may be chipping away at the lower echelons, but they're chasing a target that is moving upwards in both frequency and RF output power – a situation that is likely to remain for decades to come.