Changing EW Environment Requires Even Higher RF Power

By Joe Hajduk, CEO, dB Control

The theme of AOC's 47th Annual International Symposium and Convention is "Electronic Warfare in a Changing Environment." One aspect of the EW environment that's changing rapidly is the increased sophistication and persistence of threat radars. Today's threat radar detection systems must rapidly discriminate between real targets and those created by digital RF memories (DRFMs). A DRFM captures signals, digitizes them, reconverts them to their analog origin, and then rebroadcasts them, usually after modifying the signal based on a library of known emitters. The rebroadcast signal can be altered to change the target's radar cross-section, range, speed, angle of arrival, and direction. It can also create false targets behind the target (reactive jamming) and ahead of it (predictive jamming) to trick radar detection systems into mislocating or misidentifying the target.

Ever since warfare became "electronic," most of these systems have relied on the vacuum tube, and more 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 have achieved a wide frequency range of 2 to 18 GHz, their output power maxes out at about 20 W. The ideal solution is to exploit the inherent advantages of solid-state and tube technologies to deliver the best of both worlds — which is exactly what a microwave power module (MPM) achieves.

MPMs – A Compact Alternative To The TWTA

The MPM was first developed in the early 1990s. A Tri-Service Program funded by the U.S. Army, Navy, and Air Force produced small, high-power amplifier modules in a common form factor

As seen in the September 23, 2010 edition of the RF Globalnet (www.rfglobalnet.com) newsletter.

that operated from low-voltage DC power supplies. The idea was to use a solid-state driver amplifier based on MMICs or discrete RF power transistors to drive a mini-TWT, and combine them 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. These MPMs are used extensively in ECM, radar, and communications systems. For example, dB Control's MPMs power the radar systems onboard General Atomics Aeronautical Systems' Predator B unmanned aircraft systems.

The future belongs to MPMs that can provide the highest power over the widest bandwidth. To meet this challenge, dB Control will introduce at AOC a compact, conduction-cooled MPM providing 125 W of continuous wave RF power over a frequency range of 4.5 to 18 GHz — a bandwidth wide enough to enable the use of advanced functions such as frequency hopping and other deception jamming techniques. Weighing just six pounds, the new dB-4121 MPM is designed for use onboard manned and unmanned aircraft at altitudes of up to 50,000 feet, Other MPMs and MPM-based transmitters for X- and Ku-bands featuring 300 W continuous wave (1 kW pulsed), a 20 to 40% duty cycle, a 100 to 400 microsecond pulse width, and variable PRF are also available.

dB-4121 Microwave Power Module

Selecting A Radar Transmitter

When selecting a high-power radar transmitter, both the application and the platform must be considered. For example, if the application requires multiple functions and the radar must provide time-shared roles for each function, this requires a special type of transmitter. Or, if the radar system is being used to provide countermeasures against jamming, the transmitter must provide a 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 such as extreme temperature, high altitude, dust, humidity, and vibration. Others, such as satellite communications systems, require a transmitter with an extremely long operating life. Fortunately, a TWT has a life expectancy of 100,000 hours, which means that it can reliably deliver its rated performance continuously for more than 11 years — well beyond what is required for most defense applications.

Advancing To Terahertz Requirements

Frequencies are climbing up the spectrum, and in the near 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 U.S. military groups to be able to communicate with our allies in times of war, and with the Department of Homeland Security during a national emergency, radar systems must be equipped to use additional modes of operation and new frequency bands and/or spectrums. Besides being able to communicate with our allies, we must prepare for the rapid development of EW systems by unfriendly forces. It's well known that greatly increased processing speed, miniature and nanomanufacturing, enhanced analog-to-digital and digital-to-analog conversion, field programmable gate arrays, and DRFM kernels are all being investigated by determined adversaries. Thus it's imperative that we stay at the forefront of technology.

Fortunately, there has been considerable progress on the design of systems that can operate at the upper end of the millimeter-wave spectrum. At the 2010 International Vacuum Electronics Conference (IVEC), the development of several new TWT amplifiers was announced, including a compact, lightweight 220 GHz, 50 W sheet electron beam amplifier that uses nanoparticle cathodes, and a compact, three-beam 220 GHz, 73 W serpentine TWT amplifier with a saturated gain of 42 dB over an instantaneous bandwidth of 50 GHz (23%), when powered by three 100 mA, 20 kV, well-focused electron beams. The developers predict that this performance can be achieved in a very compact circuit length of only 1.5 cm. This is a significant advantage for electron beam devices, where issues of fabrication tolerances, beam alignment, and electron interception are critical.

DARPA, the Defense Advanced Research Projects Agency of the U.S. Department of Defense responsible for the development of new military technology, has a high-frequency integrated vacuum electronics (hiFIVE) program focused on the development of a 5 to 220 GHz, 50 W MPM with greater than 5% efficiency. A first-stage MMIC driver circuit will be integrated into the overall amplifier, along with cathode, electron-beam, interaction, and collection structures. Since these structures are incredibly tiny, the MPM will be produced using microfabrication technologies such as reactive ion etching, along with advances in material, device, and circuit technologies. The device is predicted to be able to operate without degradation for more than

100 hours in a high-bandwidth tactical communications link and provide throughput comparable to optical fiber — a very appealing feature for tomorrow's extremely small unmanned aircraft.

Government, Commercial Applications Abound

Although MPMs and TWT amplifiers may not be familiar to some engineers, these devices are ubiquitous throughout terrestrial, airborne, and space-based defense systems worldwide, and are used in commercial and scientific applications as well. For example, the Department of Homeland Security uses General Atomics' Predator B drones to patrol the U.S./Mexican and U.S./Canadian borders to help stem the flow of drugs, migrants, and terrorists. Although this unarmed, unmanned aircraft is capable of flying at an altitude of 65,000 feet, for this mission it cruises at about 20,000 feet, gathering information and transmitting it to operators who in turn contact border agents.

Every Predator B is equipped with Lynx SAR/GMTI radar systems powered by dB Control's MPMs to transmit near real-time, full-motion images of objects on the ground, with resolutions as fine as four inches. Amazingly, these images can be captured from 16 miles above, in total darkness, through clouds and rain. Equipped with advanced sensors and cameras, the drone can remain in the air for 20 hours and detect a moving person from 32,000 feet above ground.

In addition to surveillance, unmanned aeronautical vehicles (UAVs) are being adapted for other aerial monitoring applications. The Department of Energy, for instance, is testing UAVs for the detection of potential nuclear reactor accidents, and the Massachusetts Institute of Technology (MIT) is developing GPS and video camera guidance systems to enable UAVs to locate and identify toxic substances. NASA uses UAVs to monitor pollution and measure ozone levels, and two ex-USAF Global Hawk UAVs are stationed at NASA's Dryden Research Center on Edwards Air Force Base in California to be used as airborne science research platforms.

The essential element in each of these applications is a radar system powered by an MPM. Considering the intense research and development being invested to extend the power levels and frequency range, while reducing the size weight of these devices, it's safe to assume that even as the electronic warfare and commercial environments change, TWT amplifiers and MPMs will adapt.

About The Author

Joe Hajduk, CEO of dB Control, provides the leadership, strategy, and vision that have enabled the company to grow from the start-up he co-founded in 1990, to the successful, multimillion dollar international organization it is today. Now as part HEICO's Electronics Technologies Group, dB Control continues to develop and deliver innovative, high-quality power products for a wide variety of applications, including radar, ECM, EW threat simulation, airborne data links, communications, RFI/EMI/EMC test and measurement, and commercial applications. Hajduk began his career as a production engineer at Teledyne, after which he joined Aydin and then Varian (now CPI). At Varian he worked on military and SATCOM projects, including the development and production of amplifiers for the U.S. Air Force's AN/ALQ-172 Pave Mint Countermeasures System, which eventually became the largest military amplifier program in the company's history. Hajduk holds a B.S. in engineering with honors from Cogswell College in San Francisco, and is being honored this year with AOC's Business Management Award.