

# MPD

## MICROWAVE PRODUCT DIGEST

### Editorial Statement of Purpose

Microwave Product Digest serves RF and microwave design engineers, research and development engineers, applications engineers and engineering managers. These professionals, working in facilities that serve both the commercial and government markets, are involved with the design, development, application, and use of systems and subsystems, devices, and techniques involving frequencies from RF to light.

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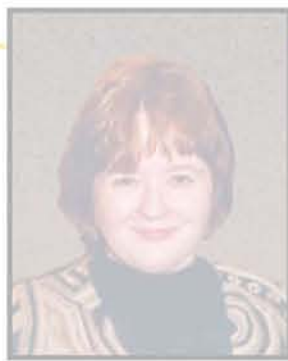
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### FROM THE EDITOR



**Karen Hoppe**  
Editor, MPD

Something that many take for granted - and without which some of my friends and relatives would be wandering the countryside - is in danger, the GPS satellite network. I'd

heard a short news item about this on the radio, so when I got home, I Googled it and found a great article in *The Pueblo Chieftain* (Southern Colorado), "Backlog in GPS satellites may someday crimp use of navigational devices."

According to this piece, "GPS satellites originally scheduled to head skyward in 2006 in a \$7 billion-plus program aimed at keeping the system going are awaiting launch in 2010. The delay means pieces of the high-altitude network could start fall-

ing out of service as early as next year. Such decay in the system could ultimately foul everything from the accuracy of U.S. bombs to the reliability of your neighborhood cash machine."

I understand that you need a minimum of 24 satellites in the network. Currently, the U.S. Air Force has 30, some of which are 20 years old. Replacements are needed.

Those of you in the satellite business know what you have to do!

## Satellites Needed for GPS, STAT!

## Long Live the Tube!

If you're like most RF and microwave engineers, it's been a long time since anyone brought up the word "tube," except for maybe tube socks. For those of us old enough to remember, tubes ushered in "the dawn of radio" and were the guts of the first TVs.

Actually, there are still quite a few engineers designing amplifiers and transmitters based on traveling wave tubes (TWTs) and other vacuum electronic devices (VEDs) such as klystrons and crossed-field amplifiers. These allegedly archaic devices remain the sole purveyors of "real" RF power. By that I mean kilowatts or megawatts - enough to power the brawniest broadcast transmitters, radar systems, and a wide assortment of defense systems such as electronic warfare or electronic countermeasures suites. In fact, it's safe to say that every EW or ECM system now in service, and most of those on the drawing board, use or are being designed around amplifiers based on tubes. And tubes are also used to power the transponders in communication satellites.

So why in this day of solid-state supremacy are TWTs still so extensively employed? The answer is simple: There is no other type of device that can match the ability of a TWT to deliver high levels of RF power over broad bandwidths at frequencies up to 95 GHz or higher. 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 solid-state devices are used for a broad range of amplifier and transmitter applications because they have a long life, can be inexpensively mass produced, and oper-

ate from low-voltage DC supplies, nearly all of these applications require comparatively low RF output power over narrow bandwidths.

Even though solid-state devices have taken center stage, the development of TWT technology has steadily progressed. VED - or what I like to call "tube" - manufacturers continuously enhance the performance of their products. For example, the operating life of many TWTs now reaches 100,000 hours, which means that they can reliably deliver their rated performance continuously for more than 11 years. This makes them well suited to the typical lifetime of a satellite communications system, and well beyond that required in most defense applications. Plus, when their day is done, a TWT can be easily replaced with another TWT in systems designed with this capability.

One of the greatest perceived disadvantages of tube-based amplifiers is their need for kilovolt power supplies, which increase size, weight, and system overhead. While this is indeed the case for very-high-power systems, in most instances, it has rarely limited the TWT amplifier's usefulness. Besides, the power supplies used to accommodate solid-state amplifiers for these applications would be just as formidable, considering that they would need to power-combine hundreds of transistors to produce the

## IN MY OPINION



**Joseph Hajduk**  
CEO, dB Control

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*“Looking over the development horizon, there is interesting tube research taking place to meet the needs of systems operating in the upper reaches of the millimeter-wave region.”*

*In My Opinion,  
Con't from pg 3*

required RF output power.

### MPMs – a Compact Alternative to the TWTA

The “mini-TWT” (essentially a shorter version of its conventional sibling), was first developed in the late 1970s. A decade and a half later, a program funded by the U.S. Army, Navy, and Air Force produced small, high-power amplifier modules in a common form factor 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 power and control circuits in a very compact enclosure. The resulting Microwave Power Module (MPM) exploits the inherent advantages of both solid-state and tube technologies to deliver the best of both worlds.

Today, MPMs from dB Control and other manufacturers are available with RF outputs up to about 300 W CW (1 kW pulsed), and at frequencies as high as 50 GHz. These MPMs are extensively used in ECM, radar, and satellite communications systems. For example, dB Control’s MPMs power the radar systems onboard the Predator UAVs that have proven so indispensable in Iraq and Afghanistan.

### Advanced Tubes for Terahertz Requirements

Looking over the development horizon, there is interesting tube research taking place to meet the needs of systems operating in the upper reaches of the millimeter-wave region. For example, DARPA’s High Frequency Integrated Vacuum Electronics (HiFIVE) program is focused on an integrated, microfabricated tube power amplifier circuit that can deliver more than 50 W of RF power at greater than five percent efficiency over a bandwidth greater than 5 GHz to 220 GHz. The subsystem will incorporate a first-stage MMIC driver circuit integrated

into the overall amplifier, along with the cathode, electron-beam and the interaction and collection structures. Since its structures are incredibly tiny, this device will be produced using microfabrication technologies such as reactive ion etching, along with advances in material, device, and circuit technologies. The program’s grand finale will be an MPM that can operate without degradation for more than 100 hours in a high-bandwidth tactical communications link, with throughput comparable to optical fiber. This is obviously an appealing piece of hardware for tomorrow’s extremely small UAVs.

The U.S. is not alone in pursuing advanced tube development, as is evident in the technical program of the recent International Vacuum Electronics Conference in Rome sponsored by the European Space Agency. R&D programs described there include development of tubes for use in the terahertz region, as well as novel topologies and many other advances. Their authors hailed from Russia, China, Korea, Germany, Israel, Switzerland, France, Italy, Ukraine, Norway, India, Brazil, the Netherlands, Belgium, Canada, Taiwan, and even Belarus. The U.S. was well represented as well.

So while TWTs and other tubes may not be familiar to every microwave or RF engineer, they are not only viable, but ubiquitous, throughout terrestrial, airborne, and space-based defense systems worldwide, and in commercial and scientific applications as well. Solid-state devices may be chipping away at the lower echelons of the tube domain, 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.

### dB CONTROL

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