MPMs Meet EW Challenges with Advances in High Power Design

October 2013

By Jose Gonzales, Design Engineer, dB Control

One of the most critical elements affecting the performance of electronic warfare (EW) systems is the efficiency of the power module. The ratio of RF output power to prime power input (prime power consumption) must be low and there must be adequate thermal dissipation. Other factors in the efficiency equation are size, weight and reliability.

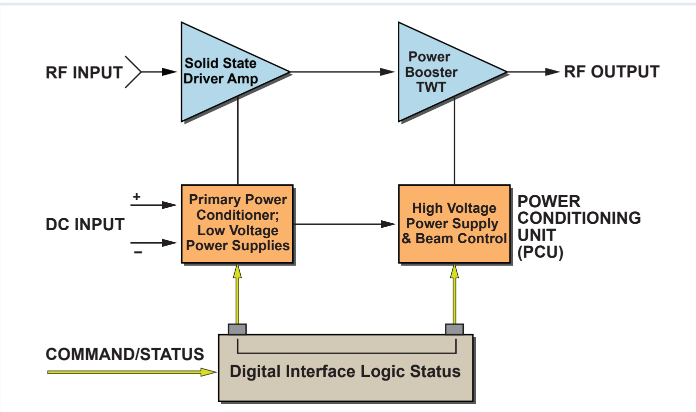

Figure 1: Block diagram of typical MPM

Although power amplifiers using solid state components can provide the bandwidth, the device's output power usually maxes out at about 40 Watts. In comparison, traveling wave tube amplifiers have no problem meeting requirements for output power of more than 100 Watts with frequencies of up to 40 GHz and broad bandwidth. The challenge for the engineer is to not only meet these specifications, but also to do so efficiently.

One solution that meets both the power and efficiency requirements is the Microwave Power Module. An MPM utilizes a synergistic combination of a microwave tube and solid state amplifier. The first MPM developed in the early 1990s used a solid state driver-amplifier based on MMICs or discrete RF power transistors to drive a mini-TWT, and combined these devices with a power supply and control circuits in a very compact enclosure. (See Figure 1)

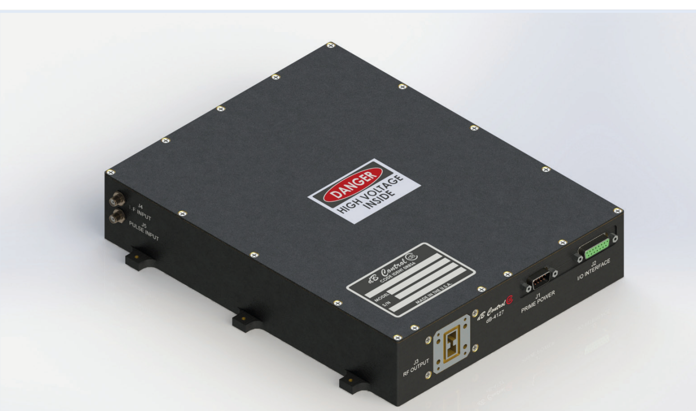

Figure 2: New dB-4127 MPM features 44% efficiency at 9.5 GHz

Today's MPMs follow the same concept. The RF signal path consists of a solid state driver amplifier and a short-length booster TWT (typically about seven inches long) specifically designed for use with a lower-voltage power supply (up to 8 kV). The gain reduction that occurs from shortening the TWT helix length is compensated by the driver amplifier, and the RF chain gain is maintained. The power handling capability, bandwidth, efficiency and heat tolerance capability of the TWT is fully utilized in this design, and the prime power consumption of the MPM is typically 450 Watts, with a dissipation of 325 Watts.

Modern Mechanical Design Features New Layout, Increased Efficiency

This month dB Control, a designer and manufacturer of mission-critical products for defense contractors and commercial manufacturers, is introducing a new MPM providing 200 Watts of continuous wave RF power over a frequency range of 6 - 18 GHz. With double the power of the company's previous MPMs such as the dB-4118, the dB-4127 (see Figure 2) not only meets the power requirements of today's ECM systems and EW threat simulators, but is on average 30 percent more efficient than the dB-4118, thanks to its highly efficient high-voltage-power-supply topology and critical component placement for an optimal thermal design. Figure 3 shows a plot of typical output power versus frequency. Thanks to a highly efficient TWT and HVPS, this new MPM puts out 300 Watts of power at 9.5 GHz and only consumes about 675 Watts of prime power. With a 44 percent efficiency (at 9.5 GHz), the dB-4127 is one of the most efficient MPMs on the market.

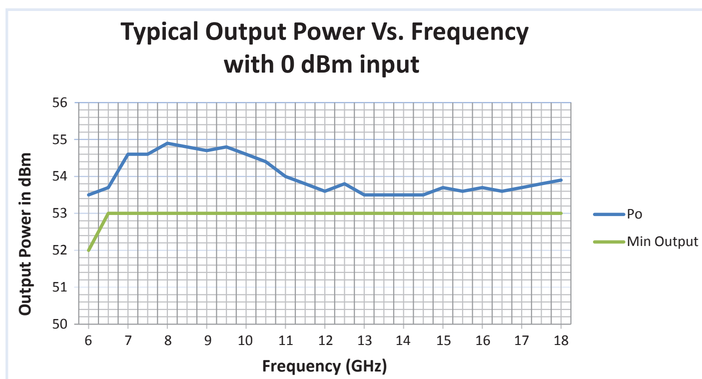

Figure 3: Typical Output Power vs. Frequency

Efficient Thermal Design Handles the Heat

Whenever there is a request for the design and development of a new product with more output power, a challenge arises for HVPS engineers. More output power typically means more power dissipation, which ultimately increases heat. Heat-sensitive devices are strategically placed during the design phase to produce a more efficient thermal design that spreads out the heat more evenly. Even with twice as much power, the new dB-4127 MPM has nearly the same heat dissipation as the previous dB-4118 at 9.5 GHz, and averages only about a 10 percent increase in heat at other frequencies. This was achieved by increasing the volume 29 percent compared to the dB-4118. No change to the mounting pattern was required. Figure 4 shows the thermal footprint during saturation at 9.5 GHz. Note that the dB-4127 is a conduction-cooled MPM, and the thermal analysis was performed with an attached extruded aluminum heat sink at 50° C air and natural convection. In addition, with new demanding platforms comes a need for custom configurations and mounting. This MPM's modular architecture allows for full customization to meet customer requirements.

Potting, Encapsulation Contribute to Efficiency and Compact Packaging

Potting, encapsulation and conformal coating are critical processes which enable high-voltage components to be located in close proximity to each other. These processes increase efficiency by significantly reducing the size of a power supply. For example, every 10kV requires approximately an inch of air space between components to prevent arcing. Without this space, unprotected components can cause system failures. Potting reduces this isolation space down to approximately one-tenth of an inch, enabling a 20 kV power supply with approximately 30 isolated components to fit in a shoe box instead of a 10-foot by 10-foot by 10-foot packing crate. Potting and conformal coating also helps protect components from exposure to elements such as dust, moisture and extreme temperatures. Another benefit is defense against shock, vibration and corrosive substances.

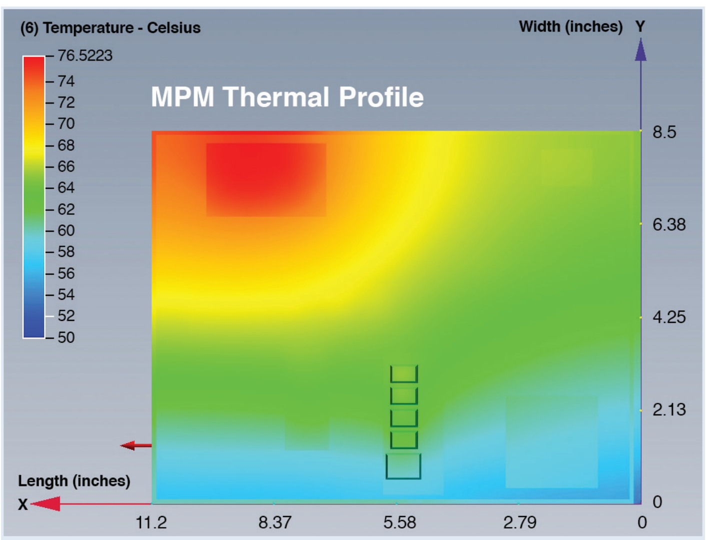

Figure 4: MPM thermal footprint at saturated power output (Note: Contact resistance omitted in analysis)

To ensure superior reliability, dB Control designs and manufactures all high-voltage transformers, magnetics and dielectrics in-house. The company utilizes proprietary transformer fabrication, encapsulation and high-voltage component potting techniques specifically designed for demanding military applications. For example, dB Control's proprietary conformal coating process uses silicone instead of polyurethane because higher glass transition temperature (Tg) potting compounds can fracture solder bonds as they harden and shrink at decreased temperatures. As a result, hundreds of high-voltage components are produced to the exact same specifications and integrated into amplifiers every month.

Testing Key to Reliability

When systems are used for applications where lives are at stake, reliability is non-negotiable. As assured reliability requires extensive testing, dB Control invested in modern testing facilities to gain complete control over the processes. In-house testing with services such as automated 24-hour test cycling also reduces processing time and cost for the company's customers. Customized test services for specific temperature and altitude requirements are performed in environmental test chambers with enclosures that can accommodate small airborne to large rack-mount assemblies. HALT/HASS reliability testing is also available for custom application profiles, in addition to ESS, temperature cycle testing, vibration testing, altitude testing and temperature-altitude testing.

Applications

MPMs are available for S- to W-band applications in both continuous wave and pulsed configurations. With RF outputs from 20 Watts to more than 2 kW, MPMs are widely used as transmitters for radar, ECM, and any application where the platform resources (prime power, size and weight) are limited, and long, failure-free operation is essential. For instance, on board every Predator drone is a LYNX I or II Synthetic Aperture Radar (SAR) powered by a dB Control MPM. Designed for the harsh conditions encountered in airborne environments, these MPMs can withstand high altitudes, gunfire vibration, shock acceleration, explosive atmospheres, rain and humidity. The modules will operate at temperatures up to +100° C for short periods and are compliant with MIL-STD461E standards.

Rigorous MPM Testing Services

- Environmental Stress Screening (ESS)
- Temperature/altitude chambers
- Vibration at high G-force levels
- Highly Accelerated Life Cycle Testing (HALT)
- Highly Accelerated Stress Screening (HASS)

With at least 70 military organizations around the world using unmanned aerial vehicles (UAVs), the IHS Industry Research & Analysis forecasts $81.3 billion will be spent worldwide on UAV business from 2012 to 2021. Here in the U.S., the Department of Defense is set to spend at least $5.78 billion on UAV technologies in fiscal year 2013. In terms of revenues, a Market Research Media report indicates that the military UAV market alone will reach $86.5 billion by 2018.

As applications continue to increase in sophistication, there will continue to be a need for even more bandwidth, especially because wider channel bandwidth translates into higher data throughput — a feature always in demand for defense applications. The satellite communication systems market will also continue to grow as the demand for data, video and internet over satellite increases.

MPMs now serve as transmitters for these advanced radar, ECM and communication systems. As waveforms become more exotic, threats continue to increase in volume, and cross sections of targets decrease due to the use of stealth technologies, these radar systems will require high stability of the transmitted waveform, spectral purity and higher power over a wider bandwidth. Plus, new applications will spur the development of MPMs that operate at higher frequencies, such as K-band (18-26.5 GHz), Ka-band (26.5-40 GHz), Q-band (33-50 GHz) and V-band (50-75 GHz). All of these developments bode well for the continuing need for high-power MPMs, and for engineers who can design these modules to meet increased efficiency specifications.

For more information, please visit our website.
www.dbcontrol.com