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Modern Defense Electronics Manufacturing: Mastering the Balancing Act

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Unmanned aerial vehicles (UAVs) like the MQ-9 Reaper (originally the Predator B), have changed the military theater forever. Utilizing UAVs, the modern battlefield resembles more of a video game than Apocalypse Now. However, even though a UAV can remove soldiers, or at least a good majority of them, from the battlefield and out of harm's way, today's war is often won in the design of the underlying technologies that go into these complex and sophisticated game changers.

The MQ-9 can fly autonomously, operated by a pilot and a support airman in charge of sensors and weapons. These personnel operate the UAV from a ground control station thousands of miles away from the actual combat. They rely on a high-resolution, all-weather synthetic aperture radar (SAR)/ground moving target indicator (GMTI) airborne radar system to be their "eyes." The Lynx SAR/GMTI radar system onboard General Atomics Aeronautical Systems' MQ-9, as well as onboard various other unmanned and sometimes even manned platforms, provides the images. The accuracy of these images depends on the performance, reliability and operational capability of one of the most critical underlying technologies: the traveling wave tube amplifier (TWTA).

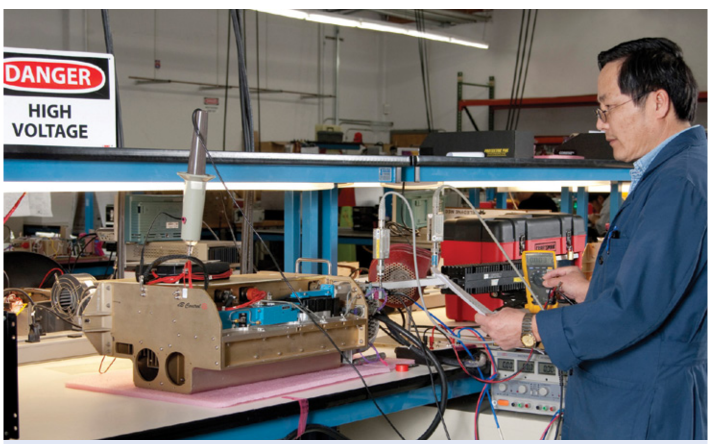

Figure 1: Technician trained to work with high voltage tests a dB Control TWTA

High-power TWTAs used onboard the MQ-9 are designed and manufactured by dB Control. One of the primary reasons these amplifiers can perform under the harshest of conditions is the manufacturer's strictly controlled processes and procedures. Due to the required higher operating voltages for TWTAs and microwave power modules (MPMs), all factory personnel, including assemblers, must be extensively trained on how to work with high-voltage assemblies and products. (See Figure 1.) Equipment and personal safety are of paramount importance.

In the defense electronics industry, reliability cannot be an afterthought. It must be incorporated from the onset in the initial design. Parts selections, manufacturing processes/controls and environmental stress screening/testing of the critical assemblies and the final product are essential for high reliability. Defense manufacturers must adhere to stringent military specifications, focus on the training of assemblers and technicians, ensure repeatability of the quality of the products they produce, and do so while keeping the cost of the products affordable. When this balancing act is mastered, the supplier will not only be successful, but could also mean the difference between life and death in the modern military theater.

Selecting High-Quality Parts and Materials

As the demand for lighter, faster, more rugged military vehicles grows, many manufacturers are employing newer, more advanced materials. However, before implementing new components into a proven assembly, it is imperative that the evaluation process require a thorough design and analytical review. In fact, manufacturers must focus on verifying the design before the hardware ever gets out to the field where lives are at stake.

It is also crucial to partner with suppliers that hold their parts to the highest stringent requirements, such as AS9100, the quality management standard specifically written for the aerospace industry. While AS9100 aligns with the globally recognized quality management system ISO 9001:2008 standards, there are additional requirements, including acquisition traceability, configuration management, product documentation and control of work performed outside the supplier's facilities, that must be taken into account.

Manufacturing Process Controls Ensure Reliability

Another component of an effective defense manufacturer is internal process control, a method used to collect information during production so that productivity trends and quality issues can be identified and the process continuously improved. While the commercial market thrives on original applications and consumer demand, military applications require specialized innovation backed by mature technologies. Defense manufacturers must adhere to proven, repeatable methods supported by stringent certifications and military standards.

Figure 2: Encapsulated high-voltage components being prepard for curing in dB Control's potting laboratory

For instance, dB Control assemblers are trained and certified to IPC-A-610 (Class 3) Acceptability of Electronics Assemblies and IPC/

EIA J-STD-001 (Class 3) Certified for Soldered Electrical and Electronic Assemblies. Both standards are recognized worldwide. The processes and standard operating procedures the assemblers use are consistent across product lines, no matter whether an amplifier is designed for use in a rugged environment with an extreme vibration requirement, such as in a military helicopter, or in a rack-mounted system similar to those commonly seen in commercial manufacturing facilities. (See Figure 2.) In both cases, each assembly has the ruggedized design built into the product.

Pushing Assemblies to the Limit

Once a design is established, proven on paper and preproduction runs are assembled, a full environmental testing regimen is required to simulate a long mission life. Reliable internal screening processes must be incorporated into all aspects of the assembly manufacturing process and should be constant across the operation. In addition, using established, mature techniques facilitates repeatability.

Pushing subassemblies to extremes, regardless of the specific application, ensures that potential reliability issues are solved before the units are shipped to customers. While this often requires defense contractors to invest more up front (training, documentation, etc.), doing so extends the life cycle of the assembly, and thus reduces its total cost. (See Figure 3.) In addition, using proven assembly designs minimizes replacement costs and downtime in the field resulting from failed units. Reliability is also a critical issue for many defense contractors, as anticipated dwindling defense budgets will not support a buildup of excess spare components.

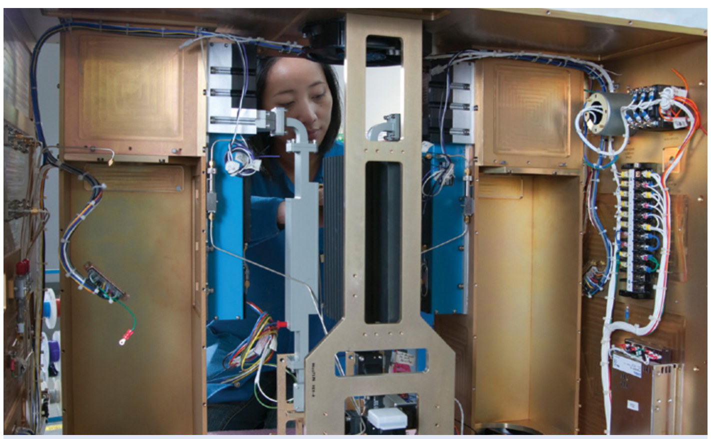

Figure 3: Highly trained dB Control assembler prepares TWTA for test and integration

Protecting High-Voltage Defense Electronics

With far more output power than solid-state based products, TWT amplifiers (TWTAs) and microwave power modules (MPMs) can be used for numerous applications, such as radar, electronic counter measure (ECM) systems, electronic warfare (EW) simulation, test and measurement and data links. TWTAs and MPMs pack a lot of power into a small package. This can only be accomplished through a high-density packaging design. Proprietary potting and encapsulation manufacturing technology enable decreased size and weight so that the components within the final product are held closely together.

Regardless of size, military equipment must perform reliably for extended periods of time in rugged environments. Components are susceptible to dust, moisture and extreme temperatures. Conformal coating solves this problem by protecting assemblies from the elements. (See Figure 4.) Because of the nonconductive properties of conformal coatings, they cannot be used where electrical contact is required or on mechanical interface locations (i.e., connector pins or mounting holes). Finally, manufacturers must ensure that electrostatic discharge (ESD) safety guidelines are followed throughout the manufacturing process to ensure that components are protected.

Figure 4: Encapsulating and conformal coating components ensure dB Control assemblies operate in stringent environments

Manufacturers must make a significant investment in capital equipment, engineering development and proprietary procedures held under disciplined documentation control to ensure mission-critical components are achieved. For example, dB Control's 40,000 square-foot facility in Fremont, California contains a modern encapsulation and potting laboratory and a dedicated environmental test area, which includes shock and vibration equipment, temperature cycling and altitude chambers. (See Figure 5.) Besides investing in equipment, manufacturers who deal with high voltages must provide extensive and costly training for personnel to ensure they thoroughly understand and practice proper safety precautions. While large-scale contract manufacturers may not choose to invest the time and money to train employees in these procedures, manufacturers who specialize in high-voltage environments must ensure that technicians are accurately building and testing product.

Figure 5: Liquid nitrogen is used to simulate extreme cold temperatures

Manufacturing to Withstand the Heat

Emerging military applications often require that more power is housed in a more compact package. While minimizing thermal dissipation starts with the design, heat removal has a critical role on the manufacturing floor. Manufacturers need to look for high-temperature materials that will improve performance while still lowering the material and manufacturing costs.

Specifically, thermal management in TWT amplifiers can be accomplished by including large-area heat sinks and forced-air cooling fans. Historically, TWTA manufacturers have used solid copper heat sinks under the collector blocks to reduce thermal stress and increase the life of the amplifier. Unfortunately, this solution is not ideal for modern applications, as copper weighs more than aluminum.

dB Control has found that specialized aluminum injected with carbon composites provides a better thermal management approach for rugged defense applications.

Balancing It All

The modern battlefield has forever changed. New threats to national security arise daily – sometimes even hourly. A successful defense electronics manufacturer must evolve to support this dynamic landscape. Technological strengths, experience of personnel, manufacturing capabilities and facility capacity must all be utilized to produce reliable, technically-superior products on time and within budget. At times it can be a difficult challenge – one that can even seem impossible to achieve. However, that is what is expected to support the underlying technologies of the complex and sophisticated game changers, like the MQ-9.

In addition to the expected challenges faced to achieve these goals, manufacturers must plan to survive expected DoD budget cuts. One option is to augment the defense portfolio with commercial projects. In addition to being employed by the military in Iraq and Afghanistan, UAVs are also being used for many non-military applications. The U.S. Customs and Border Protection Agency (CBP), as an example, flies a fleet of MQ-9s along the United States borders for homeland defense, customs and immigration enforcement and monitoring drug trafficking. There are ample other uses, such as commercial monitoring, search and rescue (S&R), and natural disaster relief, that may make UAVs immune to potential budget cuts.

By balancing its military business with complementary custom high-voltage assembly contract manufacturing, dB Control can apply the same stringent quality standards to both product lines. This keeps specialized talent in-house and allows assemblers to sharpen skill sets across a variety of tasks. This practice, along with an established heritage of mature technologies and flexible designs based on modular configuration, provides a solid foundation of excellence. It enables the synergistic combination of high-voltage power supply technology, microwave power technology and high-density packaging design in a disciplined manufacturing environment under strict quality control.

If a defense electronics supplier can master the balancing act, they have a good shot at becoming a supplier of mission-critical hardware. The one constant must always be reliability, guaranteed through quality manufacturing practices and continuous improvement. Performance, reliability and operational capability, after all, are nonnegotiable.

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www.dbcontrol.com

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