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Comparing Commercial and Military Components

High-frequency components may be designed and fabricated in similar ways, but typically it's screening and special features that determine how they will be used.

Components for RF/microwave systems differ in many ways, including functionality, package styles, performance levels, and even in the way that they screened or qualified for commercial applications compared to aerospace and military applications.

System designers may develop a high-frequency electronic system through the old-fashioned practice of drawing a block diagram on a piece of paper. In the case of a receiver, they may start with antennas and filters, then work through low-noise amplifiers (LNAs), mixers, intermediate-frequency (IF) amplifiers, and analog-to-digital converters (Adcs). Or they may reach for a trusted system simulation computer-aided-engineering (CAE) software tool to put the components together, then predict what level of system performance is possible with them.

The industry provides a healthy choice of different active and passive components for many different application areas, including commercial, industrial, military, and aerospace systems. But how is it possible to differentiate components suited for commercial use versus those developed for military applications?

Often, very little in a component's specifications will immediately declare that it is a better fit for a commercial or a military application (other than price). Some components may simply be designed for particular performance characteristics, such as for high power levels at L-band and S-band frequencies, which suggest that they are suited for military (radar) applications.

Other components may also be designed for high power levels, but for frequency ranges of 85 to 110 MHz that are more in line with commercial frequency-modulated (FM) broadcast systems. Often, there simply may not be any design or manufacturing differences between components earmarked for commercial use and those developed for military applications.

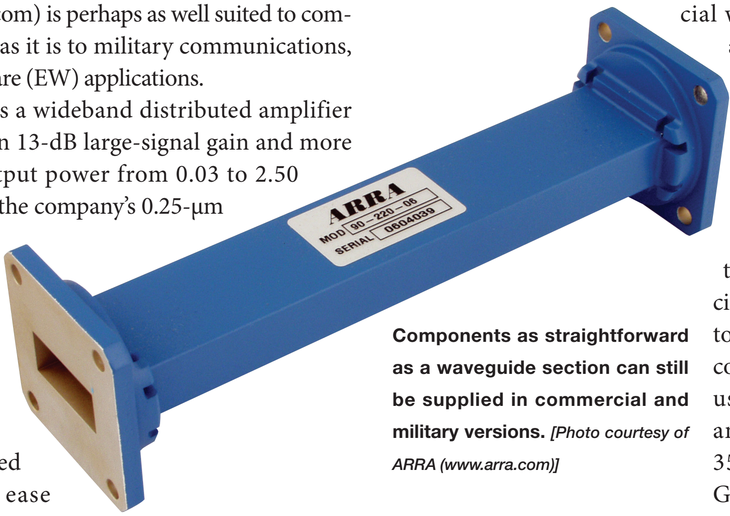
For an active component such as an amplifier, for example, typical performance specifications such as gain, gain flatness versus frequency, output power at 1-dB compression, noise figure, and VSWR may appear quite good and within limits that satisfy both commercial and military requirements. Mechanically, the packaging may be rugged and reliable, whether in chip, drop-in, surface-mount, or coaxial format.

But a key difference between components for commercial applications versus components for military applications is their behavior under somewhat different sets of environmental conditions. Commercial component applications are generally assumed to be environmentally stable and predictable, with components for a commercial application projected to be used within fairly reasonable operating temperatures, and with performance specifications often referred to room temperature (+25°C).

Even in the case of a component as straightforward as a rectangular waveguide section *(see figure)*, there may be no discernable differences between models offered for commercial versus military use. In the case of an older technology such as rectangular waveguide, however, these components tend to be used more readily in military systems than in commercial systems. This is typically because of price.

It is also due to the fact that this older technology and component configuration often exceeds the performance levels of more-recent component alternatives (such as flexible or semi-rigid coaxial cable assemblies) in certain critical areas (like insertion loss and power-handling capabilities). Although physically larger than more-recent component alternatives, such a waveguide section is often referred to as a "legacy component"; the physical format has been an accepted part of the mechanical design of a military system for some time.

At the semiconductor or chip level, there is very little to differentiate a component that is designed for military circuits and systems from one that has been developed for commercial use. As an example, a recent product introduced by TriQuint Semiconductor (www.triquint.com) is perhaps as well suited to commercial communications as it is to military communications, radar, and electronic-warfare (EW) applications.



Components as straightforward as a waveguide section can still be supplied in commercial and military versions. *[Photo courtesy of ARRA (www.arra.com)]*

Model TGA2237-SM is a wideband distributed amplifier which provides more than 13-dB large-signal gain and more than 10 W saturated output power from 0.03 to 2.50 GHz. It is fabricated with the company's 0.25-μm gallium-nitride (GaN) on silicon-carbide (SiC) semiconductor process and supplied in a low-cost, surface-mount 32-lead, 5 × 5 lead AIN QFN package.

The amplifier is matched to 50 Ω impedance for ease of integration in 50-Ω circuits and systems. It is an RoHS-compliant, lead-free design that achieves better than 50% power-added efficiency (PAE). At this component level, however, the same chip amplifier is as well suited (and priced) for commercial as well as for military applications.

In some cases, it may be clear from the ruggedized design and construction of a component that it is specifically intended for the severe conditions of a military or aerospace application. The ZHL-100W-352+ and ZHL-100W-43+ amplifiers from Mini-Circuits (www.minicircuits.com) are clearly housed in large, heavy-duty packages that are designed for rough handling and severe environmental conditions.

These are Class-AB (very linear) amplifiers that are designed to provide unconditionally stable performance, even with changing temperatures and poor load conditions. Model ZHL-100W-352+ provides 100 W saturated output power from 3.0 to 3.5 GHz, while model ZHL-100W-43+ delivers 100 W saturated output power from 3.5 to 4.0 GHz. Both amplifiers are designed to deliver typical gain of 50 dB across their frequency ranges, with gain flatness of ±1.5 dB across the full operating bandwidths.

Although these are components that target both commercial and military applications, they have been designed and equipped with numerous additional safety features to improve reliability under harsh operating conditions. These features include protection against excessive signal drive levels, high case temperatures, reverse polarity connections, and the ability to operate under short-circuit conditions.

For instance, the amplifiers are built to survive without damage accidentally being put into short- or open-circuit operation even when delivering output signals as high as 100 W. Both amplifiers are supplied in rugged aluminum alloy cases with metal coaxial connectors and optional heat sinks. By their construction, they are clearly designed and fabricated for military applications, although they may also be suitable for commercial wireless communications applications.

MITEQ (www.miteq.com) recently introduced its model AMFW-6F-18004000-29-8P low-noise amplifier (LNA). It boasts a compact design that employed advanced circuit and packaging design to make it as well suited for commercial and for military use. The RoHS-compliant amplifier, which achieves 35-dB gain from 18 to 40 GHz, employs an aluminum housing that is only 1.32 × 0.88 in. with field-replaceable 2.92-mm coaxial connectors. The housing contributes to excellent thermal management to enable maintaining the noise figure below 3 dB across a wide operating-temperature range (–40 to +75°C). For this amplifier, the single design fits both commercial and military needs.

Military system designers operate with the assumption that a specified component will meet its own performance specifications, maintaining those specifications over time and over a variety of other conditions spelled out in numerous military standards. Perhaps one of the better known of these standards is MIL-STD-883, which defines a series of mechanical, environmental, and electrical tests for microelectronic devices intended for aerospace and military use.

MIL-STD-883 covers mechanical and electrical tests; the tests are essentially meant to measure a component's resistance to the natural elements and conditions that may be found in military and space operations. They ensure that a component will continue to provide its specified performance levels even when subjected to harsh operating conditions.

The tests can even be used for services and training programs in relation to the components. The comprehensive standard uses the term "device" to refer to a wide range of electronic components, including monolithic components, multiple-chip components, hybrid components, and the materials from which the components are formed [such as printed-circuit-board (PCB) materials].

MIL-STD-883 is hundreds of pages long and is quite comprehensive in its definitions of requirements needed for designing and testing components and circuits appropriate for military and government use. The standard is so comprehensive that it includes numerous other standards and reference documents within it. Among these are several specifications from the U.S. Department of Defense: MIL-PRF-19500 for semiconductor devices, MIL-PRF-38534 for hybrid microcircuits, and MIL-PRF-38535 for integrated circuits. These define requirements for various component circuit formats.

MIL-STD-883 in its different forms is just one standard developed to ensure that RF/microwave components are designed and constructed with long-term reliability in mind. This even holds true for apparently simple RF/microwave components such as a waveguide bend or section. ARRA (www.arra.com), to cite one example, offers components with the firm's distinctive blue coating applied according to the guidelines of the MIL-C-22750 standard.

MIL-C-22750 defines the type of coating needed to provide the environmental protection required by different military and industrial applications. The standard even denotes what types of primer materials can be used with the topcoat material, such as primers meeting the requirements of MIL-PRF-23377 or MIL-PRF-53022 primer standards.

The many military standards represent the major difference between components designed and built for commercial applications versus those for military and aerospace applications. Depending upon the application and the system, the requirements set forth by the applicable standards can be quite challenging. Certainly, the testing employed to determine a component's adherence to these requirements can certainly drive up the component's cost.

ENVIRONMENTAL EXTREMES

Some military standards, such as MIL-STD-810, have proven so effective in evaluating a component's operation under severe environmental conditions that they are often applied to commercial and industrial components, as well. MIL-STD-810 checks a component at different temperature extremes; with such environmental conditions as rain and humidity; with shock and acceleration; and with random (and even gunfire) vibration.

Components that survive the minimal requirements of the standard are well equipped for almost any application, and it has been used when components are anticipated to be subjected to harsh environments and operating conditions, regardless of the application area.

Some military standards are very focused and will only apply to a limited group of components. For example, MIL-STD-704 refers to aircraft electrical power characteristics and defines a standard power interface between a military aircraft and its systems and components. It covers power-supply issues, including voltage, frequency, phase, power factor, power-supply ripple, maximum current, and electrical noise for both ac and dc systems.

COMMON GROUND

Other standards are more universal in their relevance, such as MIL-STD-461F. This standard sets conducted and radiated electromagnetic-compatibility (EMC) requirements, such as for power amplifiers, and has as much relevance for commercial components as for military and aerospace components.

Military electrical standards have become so diverse that individual components and groups of components are now defined by individual standards. For example, MIL-PRF-55365 is a standard that defines the performance of tantalum dielectric chip capacitors in terms of voltage, capactance, and various other parameters. MIL-DTL-38999 standards (which were formerly MIL-C class standards) relate to electrical connectors in terms of requirements for construction, dimensions, and contact types and expected performance under different environmental conditions. From the sheer number of these military standards, the appearance of a commercial-grade component and a military-grade component may be similar, but it is clear that considerable testing must be performed to qualify a component for military and aerospace use.

Military electronic systems may often have special requirements for components, above and beyond the requirements outlined in a particular standard. Multichannel communications systems and phased-array radar systems, for example, may rely on the close matching of amplitude and phase among the channels in the system; and the components within the signal-processing path for each channel must often provide fairly tight tolerances in amplitude and phase matching (e.g., amplitude matching).

One of the challenges in achieving amplitude and phase matching between and among components of a particular type—such as filters and amplifiers—is maintaining that tight amplitude and phase matching tolerance across a wide frequency bandwidth and under severe environmental conditions. The latter includes the wide temperature ranges specified by military applications.

Even in terms of military standards, measuring amplitude and phase across a wide bandwidth and for a wide temperature range can be time consuming and difficult, the presence of modern test software and automated test equipment notwithstanding. Such components may appear similar to standard commercial units, but are usually offered as custom models—whether for military or commercial use. mw