Technical Article

Modules or Hybrids for MIL-SPEC DC/DC Conversion?

Martin Brabham, Industry Director for Defence and Aerospace at XP Power, looks at the demand drivers for COTS DC/DC modules as replacements for hybrid MIL SPEC devices.

Technology transference between high reliability and high volume markets is bringing benefits to both sectors, in terms of speed of manufacture and unit cost.

It's difficult to overstate how significant the shift in attitudes has been towards using commercial components for defence and aerospace applications. Many years since its inception, the concept of COTS has repeatedly come up against resistance and, equally, has ably defeated arguments against its adoption.

It would be naive to suggest the use of commercial components is applicable in all scenarios and not even its most ardent supporter could realistically make a sound case against the use of specialist devices where no suitable COTS alternative exists. But in the same spirit, condemning those alternatives without trial is equally extreme. And yet there exists, it seems, some trepidation when evaluating MIL-SPEC devices, particularly where the devices in question are DC/DC converters. The reason behind this could reside more in their construction than their functionality. The fundamentals of DC/DC conversion are well understood and widely deployed, in all sectors and vertical markets. Applying those principles, therefore, represents minimal challenge to specialist suppliers in terms of delivering electrical performance.

In order to be considered for military applications, converters need to meet electrical specifications such as MIL STD 461E for EMI, MIL STD 1275 AND 704 for input surges and transients, and environmental requirements covered under MIL STD 810 such as shock, vibration, altitude and salt atmosphere. Here, there is no difference between hybrid and commercial off-the-shelf (COTS) products.

The ability to meet customers' end product specification without the need for additional components, whilst retaining all the benefits of COTS, is typically where doubt creeps into the minds of engineers. But by considering the key requirements and evaluating the supplier against them, that doubt can be removed.

The primary benefit of COTS is cost reduction. By manufacturing devices in production volumes, and utilizing commercially available components and processes, economies of scale come in to play and unit pricing is driven down. For hybrid converters, these economies simply aren't present. But the issues go deeper. Physical attributes such as size and weight play an important role in selection. Hybrid converters make good use of bare die, which offers smaller packaging and improved heat dissipation. This, in turn,

can lead to what appears as a small overall size. However, it isn't uncommon for manufacturer's datasheets to omit details of the necessary external components when quoting converter dimensions; components that are much more easily incorporated into the construction of COTS converters, thanks to the use of multiple PCBs and 3D design.

Figure 1: Typical COTS converter using stacked PCBs to make use of 3D space.

For example, inductor and capacitor networks, which aren't normally attached to the substrate, require secure bonding inside the hybrid enclosures, where space is already limited, so often need to be added externally.

COTS designs, on the other hand, will often use new technologies such as planar magnetics to achieve the same level of electrical noise protection but with everything inside the enclosure.

Anyone familiar with military manufacturing practices may expect conformal coating to be standard practice for hybrid converters. However, this is not the case, nor does the design lend itself to encapsulation. Instead, environmental protection is often provided through hermetic sealing, via a glass or ceramic seal. This can become prone to damage during manufacturing, test or preparation, and once a hermetic seal is broken, the bare dies and other exposed surfaces in a hybrid device are particularly vulnerable to corrosion. This glass or ceramic seal approach is also used to insulate pins from the metal case, incurring intricate manufacturing processes.

COTS designs which target high reliability applications are almost always fully potted, a process that coupled with good design helps pass the tough MIL STD 810 salt/fog test and provide long term integrity.

As well as providing excellent protection against shock, vibration and salt/fog exposure, the potting compound also provides good thermal conductivity to the case.

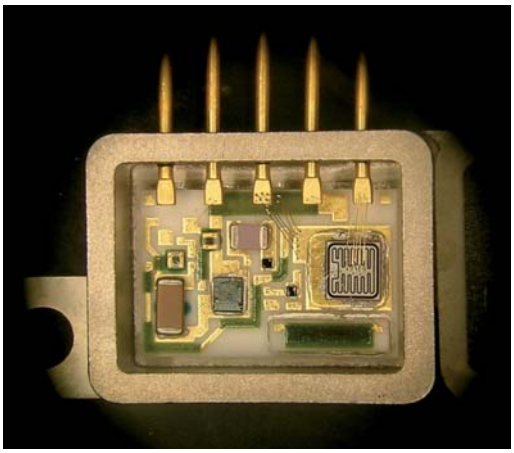

Figure 2: A hybrid before sealing, showing large numbers of conductors and wires that need securing.

Hybrid converters are generally specified to operate at the higher temperature of 125 deg C, while COTS converters are normally limited to a maximum baseplate temperature of 100 deg C. If the application calls for full power at 125 deg C, the construction style of short thermal paths typified by hybrid converters can offer an advantage over COTS devices.

The application of commercial components in MIL SPEC systems is mimicked, to an extent, by the transference of technology originally developed for high reliability environments to mass-market applications. At the same time, there is little doubt that a gap in the market exists for DC/DC converters that fall between full MIL SPEC parts and traditional commercial components.

In the final analysis, what most distinguishes COTS from hybrid converters is cost and lead-time. COTS devices exhibit savings in the order of 100% over the latter, for both metrics.

These significant savings can give rise to concerns over quality, reliability and applicability. However, as shown here, through good design, an understanding of the key requirements and a heritage in leading edge manufacturing practices, it is possible to bridge that gap with a range of products that meet these overriding requirements, whilst retaining the essence of COTS.

Parameter	15W COTS Device	15W Hybrid Device
Input Range	15 – 40 VDC	16 – 40 VDC
Transient Input Range	10 – 50 VDC	14 –50 VDC
Operating Temp.	-55 to 100 Deg C	-55 to 125 Deg C
Effective Output Power	15W	12W
Efficiency	81%	76%
Size (PCB X-Y)	40 x 26mm (inc. Mtg Holes)	37 x 28.7 (Not Included Mtg Holes)
Volume	10088 mm^3	8917 mm^3
Output Noise	60mV	80 mV
Sealing	Potting Material (Not Hermetic)	Hermetic Sealing (No Potting)
Remote Sense	Yes	No
Calculated MTBF 217F AIF 55°C	458kHrs	457kHrs
Manufacturing General Lead-time	6 Weeks	16 Weeks
Price	$ 176	$ 325

Table 1: A brief summary comparing two real-life dc-dc converters of similar power levels in COTS and hybrid formats.

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North American HQ

XP Power
990 Benecia Avenue
Sunnyvale, CA 94085
Phone : +1 (408) 732-7777
Fax : +1 (408) 732-2002
Email : nasales@xppower.com

European HQ

XP Power
Horseshoe Park
Pangbourne
Berkshire, RG8 7JW
Phone : +44 (0)118 984 5515
Fax : +44 (0)118 984 3423
Email : eusales@xppower.com

Asian HQ

XP Power
401 Commonwealth Drive
Haw Par Technocentre
Singapore 149598
Phone : +65 6411 6900
Fax : +65 6741 8730
Email : apsales@xppower.com

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