Technical Article

Modules or Hybrids?

High reliability DC/DC converter applications: should you choose modules or hybrids?

When considering Commercial Off-The-Shelf (COTS) DC/DC converters, it is important to compare the traditional hybrid approach with the use of COTS modules to establish whether the benefits of COTS have any disadvantages and whether the claimed advantages of hybrid circuits are real.

From design flexibility, cost and lead-time perspectives, COTS components have clear advantages so demand for COTS converters in aerospace and other high reliability (hi-rel) sectors is growing. By contrast, the hybrid market is shrinking. Let's consider why.

What are the basic differences between COTS and hybrid construction?

One of the main advantages of using COTS converters in a standard package is their ready availability compared with hybrid sealed devices, or compared with purchasing custom silicon wafers and dies. Furthermore, when taking the COTS approach, module makers will often be able to find "Form Fit and Function" (FFF) compatible components that allow for dual sourcing on all but a very few items. Also, the cost and lead-time advantages of purchasing components that are already in mass production are significant.

Nearly all DC/DC modules are now built using a high percentage of surface mount devices, which means the final assembly can be automated. Modules are normally then encapsulated, to secure all of the internal parts.

A hybrid power converter is built using a substrate that has surface mount components, inductors and bare semiconductor dies attached to it. Using bare dies instead of packaged semiconductors occupies less space on the substrate and improves the thermal performance, reducing the size of the converter. However, the manufacturing process is much more complex and difficult to automate than a COTS approach. Furthermore, hybrid devices are usually not encapsulated. This presents a thermal design challenge and leaves hybrids more susceptible to shock and vibration than their potted-module counterparts. Hybrid housings are typically welded and hermetically sealed.

Parameter	15 W COTS Device	15 W Hybrid Device
Input Range	15 - 40 VDC	16 - 40 VDC
Transient Input Range	10 - 50 VDC	14 - 50 VDC
Operating Temperature	-55 to 100ºC	-55 to 125ºC
Effective Output Power	15 W	12 W
Efficiency	81%	76 %
Size (PCB X-Y)	40 x 26mm (inc. Mtg Holes)	37 x 287 (not included Mtg Holes)
Volume	10088 mm^3	8917 mm^3
Output Noise	60 mV	80 mV
Sealing	Potting Material (Not Hermetic)	Hermetic Sealing (No Potting)
Switching Frequency	450 kHz	550 kHz
Frequency Synch	400 - 500 kHz	
Remote Sense	Yes	No
Inhibit	Yes	Yes
Calculated MTBF 217F AIF 55ºC	458 kHrs	457 kHrs
Manufacturing General Lead-time	6 Weeks	16 Weeks
Price	$ 176	$ 325

Table 1: COTS and hybrid DC/DC converter compared

Table 1 shows a brief summary comparing two real-life DC/DC converters of similar power levels in COTS and hybrid formats. COTS DC/DC power has significant advantages over hybrid construction in most cases. XP Power has released a range of COTS DC-DC converters designed with the special requirements of aerospace and other hi-rel applications.

A comparison of the most important DC-DC converter requirements

Size: COTS devices lend themselves well to 3D packaging techniques that can minimize the board area occupied. For example, building control or signals functions onto daughter boards and knitting them together in 3D can reduce the overall volume of a DC-DC converter, compared with using a single-board approach. Many of the apparent space-saving advantages of using bare dies in the X-Y dimension are lost by the inherent inability of this construction technique to work in 3D.

Figure 1 – Example of 3D design technique to conserve PCB area on COTS converter.

Weight: A 15W COTS device can weigh as little as 20 grams, whereas a metal packaged hybrid will typically weigh 30% more.

Reliability: COTS converters use automated production, which means higher reliability. Hybrids substrates layer can be used to create resistive components and interconnects, which results in fewer soldered connections. However, many of the other components have to be placed by hand, which is less reliable than automated assembly. COTS products can be designed with all of the power components attached to a cooling baseplate, which in turn is easily mounted to an enclosure sidewall or heatsink for effective heat removal. This can be hard to achieve using hybrid construction and the majority of off-the-shelf hybrid power converters have a baseplate on the same side as the pins, which is less effective for heat removal.

Temperature: Many hybrid designers will specify their devices to work at full power at 125 degrees C. If the waste heat can be removed then this offers an advantage over COTS devices, which will normally be limited to a maximum ambient temperature around 85 degrees C.

Environmental: In many systems the entire equipment package is hermetically sealed, removing the need for sealing of individual components. However, many OEMs still require individual components to pass salt/fog or other corrosion tests as a measure of both long-term reliability, or to ensure continued operation should the system seal ever be damaged. COTS designs intended for high reliability environments can be fully potted. By adding the potting material using a vacuum process, these parts pass the required tests. The potting materials remain soft at low temperatures, providing mechanical elasticity. Hybrid engineers use a glass or ceramic seal to insulate each pin from the case. This is expensive and the glass can crack during lead preparation, insertion into test sockets, during manufacturing, or in installation, causing reliability problems. Hybrid designs do not lend themselves to full encapsulation, and specialist tests required in production increase costs and lead-time.

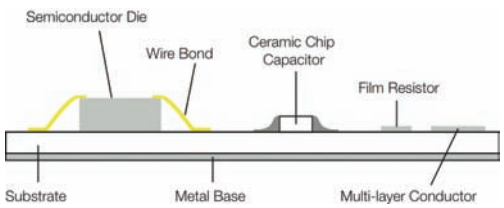

Figure 2 Picture of a hybrid device before sealing. Large numbers of conductors and wires require securing.

EMI/RFI: Metal cases used for DC-DC converters prevent radiated noise and both input and output filtering is added to the PCB. The space within hybrids is often too restrictive to allow filtering components to mounted in the most reliable way.

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