Output Considerations

Bandwidth Specifications of Output Ripple

Hybrid DC-DC Converters typically produce a complex output ripple spectrum that extends to 50 MHz or even to 500 MHz. The ripple voltage has two basic aspects. The first is differential voltage, and is the primary component of the lower frequency ripple. The second component is the common mode voltages generated from common mode currents. This component predominates above 2 MHz and is seen on the oscilloscope in the form of spikes.

Noise on converter output leads can also be specified and controlled by EMI specifications and techniques. However, in practice this proves cumbersome because the time domain characteristics are usually more pertinent and easier to visualize than the frequency domain characteristics.

This is why output ripple, noise and spikes are usually specified in terms of peak to peak voltage over a specified bandwidth. In actual practice, reliance on this type of specification can be misleading in several ways. One way is to limit the measurement bandwidth to 1 MHz or 2 MHz while the predominant spike content exceeds this. Virtually all manufacturers of hybrid DC-DC Converters specify output ripple with a 2 MHz bandwidth.

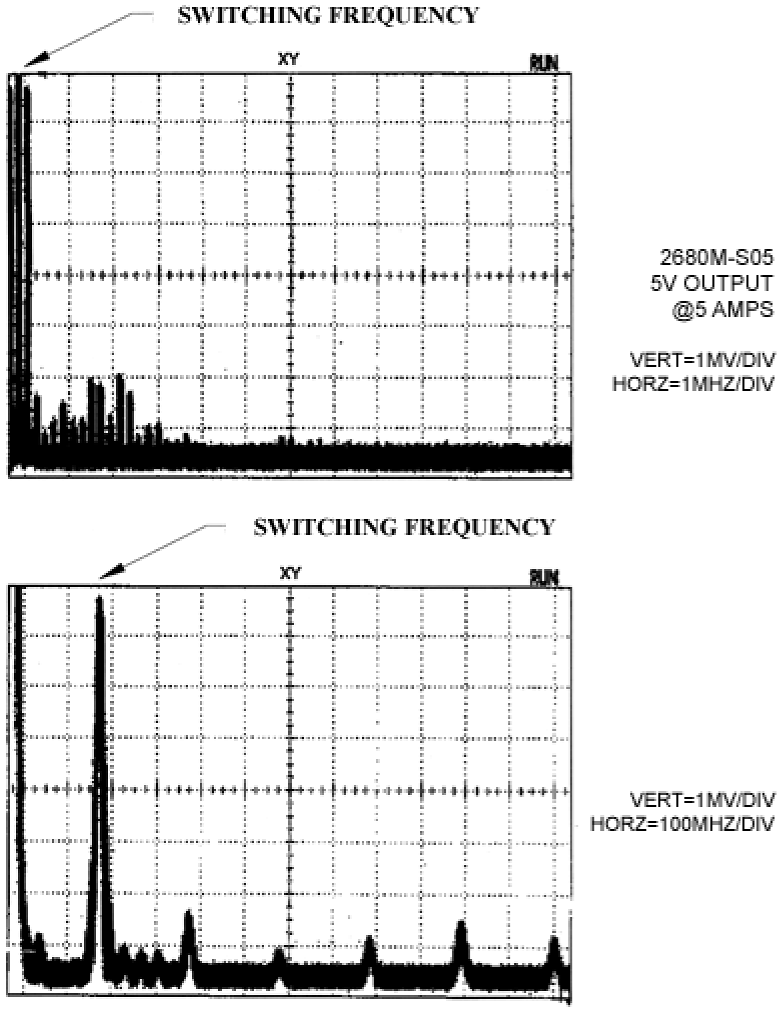
This encompasses the fundamental ripple frequency and several of its harmonics for most units sold today. This excludes the higher frequency, and often higher amplitude, noise content.

A second measurement technique is to make the measurements differentially. Since many hybrid DC-DC Converters are designed with a low ESR output chip capacitor straddling the output pins, differential measurements can produce good test results. When the units are used in a system, the noise output is inexplicably higher, but the difference is due to common mode noise.

The most useful method is to retain the voltage measurement over a meaningful bandwidth but measure it so as to include the output common mode noise since most higher frequency output ripple, noise and spikes are originated as common mode signals.

What is the significance of the distinction between the differential and common mode outputs? The differential ripple and noise can be relatively easy to filter either internally or externally. Common mode noise is relatively more difficult to filter and thus tends to proliferate throughout a system.

Figure 3
Typical Spectral Ripple Components to 10MHz



Common mode noise is caused by internal EMI currents that flow out through output lines seeking a return path back to the noise source. The best way of suppressing common mode noise is by using common mode filtering at the point closest to the noise source. The ideal location for this common mode filtering is within the hybrid converter itself.

Older generation hybrid DC-DC Converters have very simple filtering systems, often consisting of no more than output capacitors. These types of converters are usually very noisy at frequencies above 2 MHz, particularly in terms of common mode noise.

The latest generation of hybrid DC-DC Converter parts incorporate two advances that dramatically lower output ripple and spikes when compared to earlier generation DC-DC Converters. The first advance is the incorporation of output common mode filter chokes directly within the DC-DC Converter package. The second advance is the incorporation of high capacitance, low ESR ceramic multilayer capacitors in the output stage. These capacitors, which replace solid tantalum types common to older generation DC-DC

Converters, provide 1 to 2 decades of improved filtering at high frequency when compared to solid tantalum filters.

Although these noise reduction techniques are not in themselves novel, they represent a radical improvement in performance when they are contained within the shielded enclosure of the hybrid DC-DC Converter.

The result of these two significant technology advances is dramatically reduced output ripple and noise.

Figure 4 shows the functional block diagram of a typical DC-DC Converter hybrid, with integral input and output noise filtering. As this diagram shows, it requires a substantial number of LC elements to control hybrid DC-DC Converter noise. However, by tailoring the elements precisely to the noise spectrum, the small sizes needed to fit within the hybrid converter package may be realized.

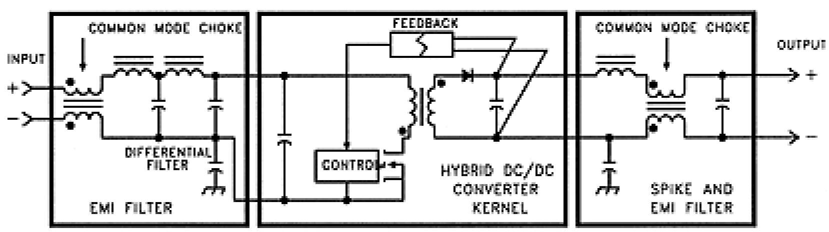


Figure 4
Hybrid DC/DC Converter Architecture

On the power input side, the common mode currents are interrupted by a high inductance common mode choke or balun. A shunt capacitor connected to the hybrid case allows the common mode input currents to be localized, instead of flowing out to the input leads. Two stages of LC differential filtering are used to reduce ripple current levels. By using two cascaded higher frequency stages, each stage is physically smaller than a larger, lower frequency single stage.

On the output side, it can be seen again that there is no substitute for filter elements. A common mode choke and shunt capacitor to case completely tame the common mode spikes. A small differential filter adds the final bit of filtering to the output leads. At above approximately 10 MHz, the output filters within the hybrid can become capacitive. To have these high frequency spikes, external ferrite leads and small capacitors may be used to tame the residual spikes.

In some applications (such as cameras, low noise amplifiers, etc.) it is desirable to attain additional differential filtering. Surface mount ceramic capacitors make the best filters when wired as shown in the figure (as a four terminal capacitor).

While other filter circuit topologies are possible, this type of filter arrangement has proved to be highly useful in production applications requiring good suppression of converter noise.

It is important to note that although the outputs of the hybrid DC-DC Converter are highly filtered, the outputs will normally exceed MIL-STD-461 levels. Also, connecting the case to the output leads bypasses the internal common mode filter and may result in the input exceeding EMI levels or the output spikes increasing. If the case must be connected to output ground for any reason, it is helpful to use a high value resistor (a value of 10K to 100K should be considered).

However, the case may be connected to RF or chassis ground to enhance EMI filtering.