Interface of 120 and 270 VDC Converters

The Split Input EMI Filter

All MDI hybrid DC-DC Converters have an input EMI filter. The filter includes a common mode inductor (balun) as well as one or more differential inductors. The common mode inductor has two identical windings. One winding is placed in the positive power input leg and one winding is placed in the negative power input leg. The differential inductors have "split" windings. The term split refers to the fact that each half of the winding is placed around the core in two winding sections. One section is placed in the positive power leg and the second section is placed in the negative power leg. The reason for splitting the winding into two sections is that any electromagnetic or electrostatic coupling from nearby noise sources impinges on the inductor in approximately equal amounts. This helps in canceling the net effect. Within the hybrid microcircuit, physical proximity of components is tight and there is no room for shields or EMI plenums. Therefore, splitting the inductor windings is necessary.

Voltage Across the Input Filter

The input EMI filter is bilateral. It not only prevents noise from emanating from the DC-DC Converter, it also prevents external noise from perturbing the converter. This means that essentially any AC voltage appearing on the input to the converter appears across the input filter, since the output of the filter is a large capacitor.

AC voltage can include audio modulation on the DC input, spikes, surges and turn on transients. On an AC basis, approximately half the voltage appears across the negative leg of the input EMI filter. While this voltage can be relatively small with a 28 VDC Converter, it is proportionally larger in a 120 or 270 VDC Converter.

Pin Functions Referenced to the Input Return

A typical hybrid DC-DC Converter has several control and monitoring functions that are referenced to the input return of the DC-DC Converter. These include the inhibit pin, the sync pin, the soft start pin and the BIT pin. However, these functions are not actually referenced to the input return, they are referenced to the internal Converter circuitry, which is separated from the input return by the negative leg of the input EMI filter.

And from the preceding paragraph, approximately half of the AC component on the input power line appears across the negative leg of the filter. Because of the split input filter, extra consideration is required to a) provide proper control and monitoring function, b) prevent damage to the internal and external components and c) prevent conducted emissions from leaking around the negative leg of the input filter.

Connection Guidelines

Inhibit pin: The inhibit function on the 120 VDC and 270 VDC Converters is an "inhibit not". This means that the converter operates when the pin is open and is inhibited when the pin is connected to the return. The inhibit pin has a twelve volt zener diode and 0.1 microfarad capacitor connected from the inhibit pin to the converter common circuitry.

The inhibit pin does not pose a danger to leakage around the EMI filter, since it is in a high impedance mode when the Converter is operating. When the Converter is inhibited, no emissions are produced.

When turning on with a zero risetime, or when high voltage spikes are imposed, a 270 VDC converter can produce open circuit voltage in excess of 150 VDC on the collector of an external inhibit transistor. With negative going input voltage spikes applied, the base collector junction of an external transistor will be reverse biased.

The following recommendations should be followed when using the inhibit function on a 120 or 270 VDC hybrid DC-DC Converter. Use an external limiting resistor of 1,000 ohms, 1/4 watt, in series with the inhibit line. This will limit current flow into and out of the inhibit pin during spikes, surges and transients. Use an inhibit transistor with an adequately rated collector-emitter breakdown voltage. If driving the inhibit pin through an optocoupler, buffer the optocoupler's output with a transistor of suitable voltage rating.

BIT pin: The BIT pin is a low impedance source, however it should be connected to external circuitry through a relatively high impedance (above 47 K ohms is suggested) to prevent upset from external circuitry.

Soft start pin: The soft start pin is internally buffered and filtered. No special precautions are required for using the soft start pin.

Sync pin: The sync pin is connected internal through a 1000 pF. capacitor and limiting resistor. No special precautions are required for using the sync pin.

Piezoelectric Response of Input Capacitors

When 120 or 270 VDC hybrid DC-DC Converters are turned on from a fast rising waveform, or subjected to spike tests or audio modulation, ticks or sounds are sometimes heard emanating from the units. It is normal for the hybrid DC-DC Converter to produce sound when this type of voltage is applied.

The source of these sounds is the ceramic input capacitors which filter the high input voltage. The input capacitors are multilayer ceramic types with a Barium Titanate ceramic dielectric. When voltage is applied to the ceramic dielectric, the dielectric physically moves by a miniscule amount. While this effect is present at all voltages, it becomes much more pronounced at 120 or 270 VDC.

The piezoelectric effects can cause cumulative damage to the capacitor if the mounting terminations are too rigid. Therefore, MDI has developed special mounting techniques for high voltage ceramic input capacitors so that they can "sing" without damage.

The Effects of DV/DT on 120 and 270 VDC DC-DC Converters

120 VDC input hybrid DC-DC Converters have input capacitances ranging from 8 microfarads to 14.4 microfarads. 270 VDC input hybrid DC-DC Converters have input capacitances ranging from 2.3 microfarads to 5.6 microfarads. Although inrush current is limited by the input inductors, these inductors are only sized to accommodate a limited volt/second product. Therefore, on turn on, the input inductors will saturate to some extent. The saturation effect is greater for 120 and 270 VDC units than for 28 VDC parts.

As a conservative estimate of initial turn on inrush current, one may use the equation i=C(DV/DT). Typical input capacitances for hybrid DC-DC Converters is listed earlier in the application notes.

The turn on inrush current is usually more a problem during test and evaluation than in actual system applications. For example, because of contact arcing, relay contact switching is impractical at 120 VDC or 270 VDC. Most actual 120 VDC and 270 VDC systems use solid state power switching to apply bus voltage to the loads. 270 VDC buses derived from AC rectification of three phase power also have finite rise times.

Rise times of 125 microseconds or greater are preferable for 270 VDC systems; rise times of 75 microseconds or greater are preferable for 120 VDC systems. Most actual system applications have been found to meet or be lower than rise times.

Rather, it is during test and evaluation that high input voltage converters are energized from a low impedance power source by using an (over-rated) mechanical switch or a clip lead. When this happens, inrush currents can be very high and high voltages can be produced across the negative leg of the input filter. Either condition may cause damage to the Converter.

How to Lower DV/DT and Inrush Current

To lower inrush current that flows at the application of power, lower the input voltage DV/DT. If the system power source has a zero or unknown rate of rise, additional inrush limit protection should be provided.

For many high input voltage Converters, all that is required to limit inrush current is a limiting resistor in series with the input line. For example, a fully loaded 6.5 watt Converter operating from a 270 VDC source has a typical impedance of 7.8K ohms. If a 50 ohm resistor is put in series with the input line, the efficiency will drop only 0.6%. The dissipation in the resistor at this point is approximately 60 mW. However, the peak inrush current, even with a zero rise time input, will be less than 5.4 amperes. For higher power applications, use a series resistor to charge the input capacitors, as above. However, use an FET to bypass the charging resistor when the input capacitors are charged. A simple inrush limiting circuit using an N channel FET in the negative power leg is shown in Figure 17. For 120 VDC applications, it is possible to use a P channel FET in the positive power leg. For burn in and test applications, an inrush limiting thermistor is a good, simple solution to reduce turn on inrush currents. This solution does not work satis-factorily over a wide temperature range.

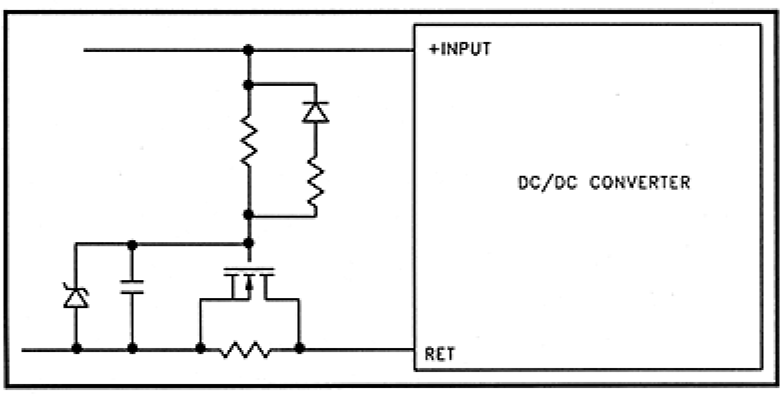

Figure 17
Inrush Limiting Circuit