

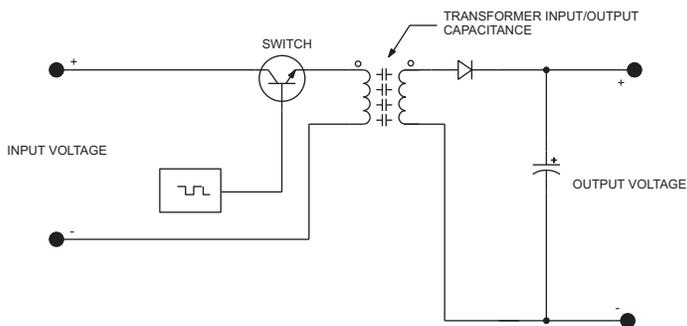


COMMON MODE NOISE CONSIDERATIONS

Common Mode Noise

DC/DC converters operate by chopping the DC input voltage into an AC signal then transferring that signal through a transformer. The AC is then rectified back into DC for the output. The output voltage can be adjusted either higher or lower than the input voltage depending on the turns ratio of the transformer.

The transformer is made from concentric windings on top of each other for the primary and secondary windings, due to their close proximity to one another, capacitance is created from input to output on the transformer.



Common Mode Current

Each time the input chopper switches, a large dV/dT is applied by the input stage across the transformer. This in turn, causes a current to want to flow from input to output through the transformer capacitance. This current flows twice each switching cycle and it must find a path back to the input "source." The current is commonly called the "Common Mode Current" since it can flow through any or all of the I/O pins individually or at the same time with no external current path from input to output, (i.e. the converter is driving isolated resistors that have very little capacitance back to the input) the common mode current is contained in the converter and flows through the stray capacitance from the input to the output, causing no further problems.

External Current Path

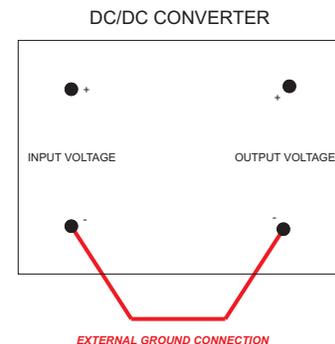
When an external current path is introduced to the converter, such as a wire from the input to output grounds, the current will tend to want to flow through this lower impedance connection. This can be OK as long as the inductance of this connection is very low. The current is a dI/dT caused by a dV/dT . If there is appreciable inductance in the external path, the dI/dT will cause a voltage ($V = L \times dI/dT$) to be developed between the grounds. This will show up as voltage noise at either the input or output terminals. So, this wire connection should have as low a value of inductance as possible. This usually dictates short length and a small total "loop area".

Reducing Common Mode Noise

There are several strategies to reduce the effect of the common mode currents when the input and output grounds must be tied together for system reasons.

Technique #1:

Tie the ground connection directly between the input and output pins with the shortest possible wiring length, that will add minimal inductance.



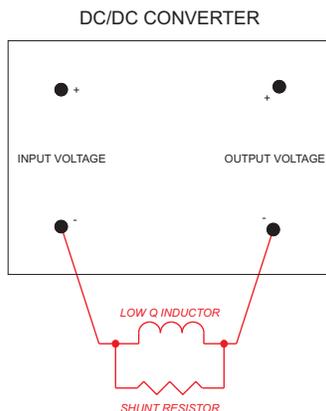


COMMON MODE NOISE CONSIDERATIONS

Technique #2

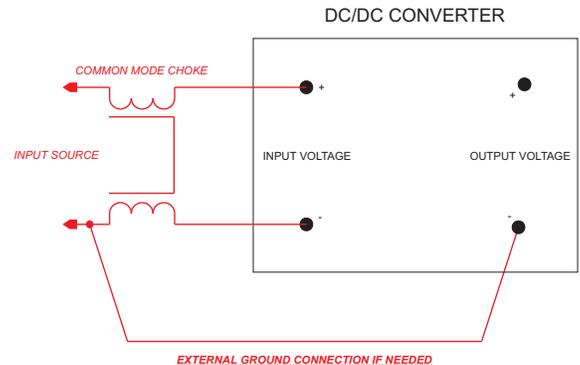
Using a DC connection to block the AC component of the common mode noise. This can be done by using a Low Q inductor between the grounds. The inductor must have sufficient impedance at the switching frequency to be at least 5 to 10 times larger in impedance than the measured stray circuit capacitance's impedance. To keep the Q low use a 100 ohm to 10K ohm shunt resistor across the inductor. The shunt resistor is necessary to prevent resonant peaking of the impedance.

This method gives a solid DC ground but blocks the common mode current from flowing in the connection.



Technique #3

Block the common mode current from flowing out of the converter by using a common mode choke on the input side. Often confused with a BALUN (meaning BALANCED to UNbalanced transmission line impedance transformer) they are typically a small high permeability, ferrite or MPP toroid that is wound with two windings. These devices present a very low impedance to any normal mode signal flowing through the lines (DC current, for example). However, they present a very large impedance to any common mode signals that try to flow through both windings in phase, such as the DC/DC converter's common mode current.



Basic Common Mode Choke Design

The basic parameters needed for common mode choke design are input current, load, and frequency. Input current determines the size of the conductor needed for the windings. Four hundred amps per square centimeter is a common design value for calculating wire size. Single stranded wire is almost always used because it is the least expensive and it helps contribute to the noise attenuation through high frequency skin effect losses.

The value of inductance required of the choke is the load in Ohms divided by the radian frequency at and above which the signal is to be attenuated. For example, attenuation at and above 1 kHz into a 50 Ohm load would require a 7.96 mH ($50/(2\pi \times 1000)$) inductor.