Ripple and Noise

Ripple is the output voltage fluctuation associated with the switching of the converter. Each switching transition pumps energy to the output, which causes it to rise a little. The typical switching frequency used in IMT converter is 250 to 350KHz. Therefore, the output noise frequency is in the 500KHz to 700KHz range. Typical value of the ripple is 1% to 2% of output. Noise on the other hand, are higher frequency components, commonly known as 'spikes'. Reduction of these 'spikes' noise can be achieved by adding a 1µF ceramic chip capacitor and a 100µF tantalum capacitor in parallel to the +OUT and -OUT near the load. See Figure 10.

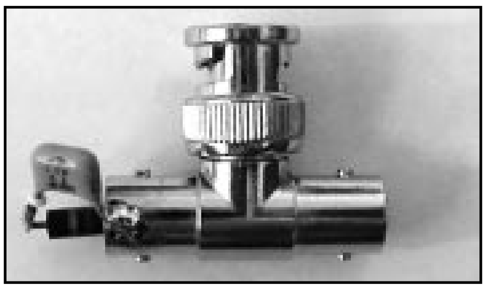

Figure 10.Capacitor in Parallel Connection

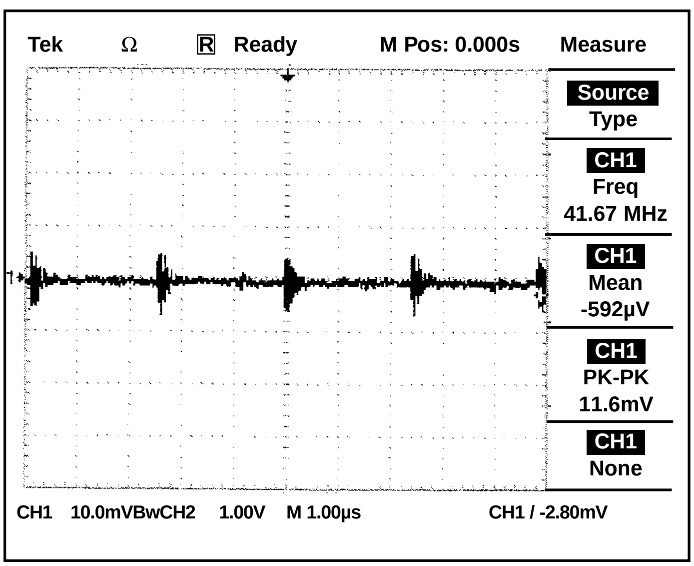

Figure 11. Ripple and Noise Chart

Measuring Output Noise and Ripple

Measuring output noise and ripple requires a basic understanding of the high frequency nature of noise. Very often, 'noise' (as commonly measured) is actually the vector sum of common and differential mode noise.

Common mode noise is common to both outputs (i.e +OUT and -OUT) with respect to chassis or earth ground. Differential mode noise is found at one output with respect to the other.

While the system load can be affected by differential mode noise, it is seldom affected by common mode noise. The common mode noise is often only created in the process of measuring the differential mode noise.

Noise can be measured as root mean square (RMS) or peak to peak. Low frequency noise with a low peak to average ratio is often measured as RMS. High frequency spike noise is measured more accurately with an oscilloscope as peak to peak noise (Figure 11).

Accurate measurement of output noise and ripple requires special attention to equipment used, measuring probes and the understanding of noises. The dc/dc converter switches large amount of output power when compared to the amplitude of the noise being measured. This means that even a few inches of open ground wire in the oscilloscope probe may pick up a fraction of a volt of noise if these probes are not properly connected to the measurement point.

The preferred test to measure noise and ripple includes a custom probe made from a length of RG58A/U coaxial cable. It is connected to the oscilloscope with a BNC 'T' connector, which is terminated with a 47 W carbon composition resistor in series with a 0.68µF Z5U capacitor. The other end of the coaxial is left bare. See Figure 12.

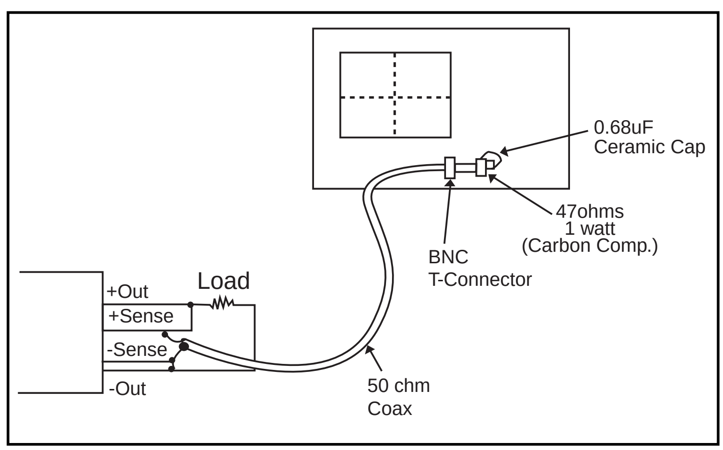

Figure12. Set up for Measuring Noise and Ripple

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Measure noise as closely as possible to the converter's output terminals to reduce noise pick up. If an oscilloscope probe must be used, it must be set up for high frequency measurements. The greatest source of error is usually the unshielded portion of the oscilloscope probe. Voltage errors induced by magnetic radiation in the loop can easily suppress the actual values. To reduce measurement errors, keep unshielded leads as short as possible.

To prepare the probe for high frequency measurement, first remove the clip-on ground wire and the probe body fishhook adapter. Then attach a special tip and ground lead assembly as shown in Figure 13.

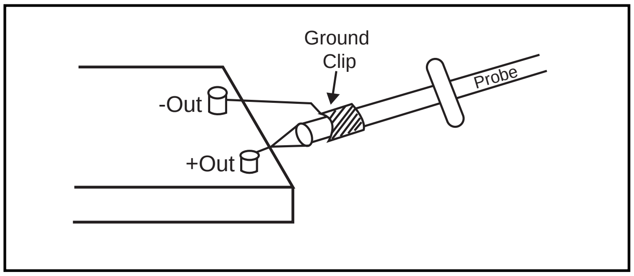

Figure 13. High Frequency Measurement Set Up.

To determine the presence of common mode noise, connect both the tip and the ground lead of the oscilloscope to the -OUT pin. The appearance of waveform on the screen suggests the presence of common mode noise. Such noise may be eliminated or reduced as suggested below:

1) Wrap the oscilloscope probe lead several times around a large diameter Nickel Zinc ferrite toroid (permeability about 1600). This will act as a balun or common mode inductor. It increases common mode impedance without significantly increasing differential mode impedance.
2) Isolate the oscilloscope power source from the line voltage with an isolation transformer.
3) Wrap the power source AC line cord several times around a large diameter nickel zinc ferrite toroid. This will also reduce the common mode current.
4) Do not use the ground lead clipped to most common oscilloscope probes. The loop of wire itself will pick up the high frequency radiated noise and will give erroneous readings.

Measuring Equipment Set up

The power supply to the converter should be mounted about 1" away from the ground shield (or ground plane) which consist of a aluminium or copper sheet. The dimension of the aluminium or copper sheet should be at least as large as the power supply itself. If the power supply is provided with a 'L' bracket, this can be served as the 'ground' plane. Chassis grounding points on the PCB where the converters is mounted, including the 'green wire' terminal for the line input ground lead, should be electrically connected to this shield with a short conductor no more than 2" long. The ground plane should be electrically connected to the conduit or the ground of a 3 prong safety plug.

The set up above is very important to ensure that the noise from the power supply itself does not interfere with the measurement.

Measuring of the noise and ripple is made with the output return connected to the ground plane. If the power supply has more than one return, all the returns should be connected to the ground plane.

Measurement Procedure

A 12" of twisted #16AWG wire with a 47µF capacitor at an appropriate voltage rating and polarity is conencted to an output terminal and return. The noise measurement is taken across the capacitor with a 50 Mhz or greater bandwidth oscilloscope. See Figure 14. The ground lead should be as short as possible, preferrably the type which clips onto the barrel of the probe at one end of the probe body.

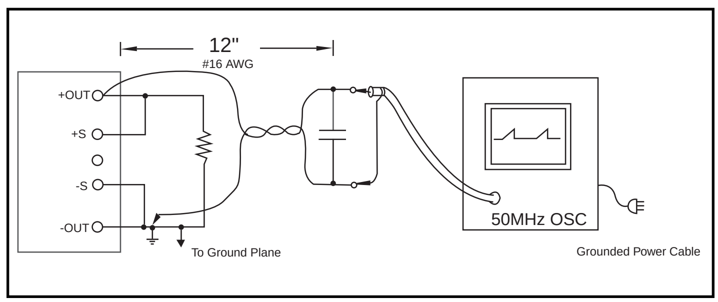

Figure14. Noise Measurement Procedure

Connecting the dc/dc converter

Set up the dc/dc converter as shown in Figure 15.

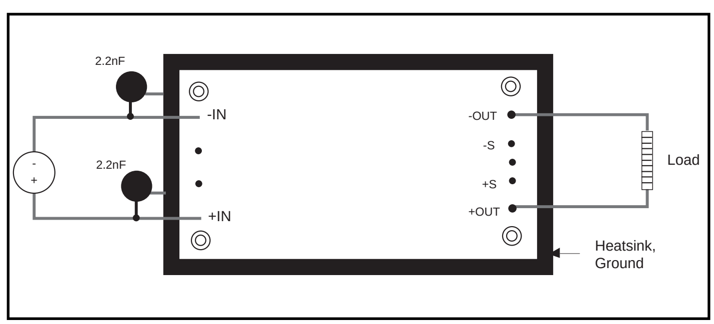

Figure15. Converter Set Up

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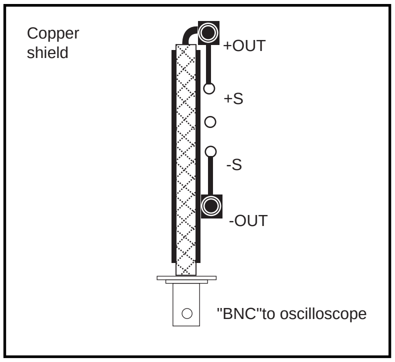
Jan. 2000
Rev. 1.0

Two 2.2nF / 250 Vac 'Y' capacitor are connected between each of the inputs (-IN and +IN) to the base plate. The base plate as well as the attached heat sink should have a solid connection to the ground plane. The purpose of the Y-caps is to provide a balanced low impedence path to ground for the common mode noise.

BTCPower has a specially designed fixture for measuring these noise and ripple. This is shown in Figure 16.

Picture16. Special Fixture for Measuring Noise Ripple



This fixture consist of a coaxial like cable with a #16AWG wire inside a cylindrical copper shield. The #16 wire is connected to the +OUT and the copper shield is connected to the -OUT. A 'BNC' connector is used to connect the coaxial cable to the oscilloscope. With this arrangement, minimum loop is obtained and accurate measurements can be achieved. Note that a 47µF capacitor still needs to be connected across the -OUT and +OUT pins.

BTCPower's evaluation boards have the above fixture installed to facilitate easy measurements of the output noise and ripple. Please call the factory to obtain these boards. These board can also be used to evaluate the performance of IMT converters. See Figure17 for Evaluation Boards.

Figure 17. BTC Evaluation Boards

Measuring Noise and Ripple using BTCPower's Evaluation Board.

Obtain a 1:1 coaxial cable with a female BNC connector at each end. A ceramic capacitor of 0.68uF connected in series with the 50 Ohms resister is installed at the BNC located at the oscilloscope end of the coaxial cable. Please see Figure18.

Figure 18. Special Coaxial Cable

The purpose of the capacitor is to block the DC power from dissipating in the resistor. If the DC voltage being measured is less than 5 volts and a 1 Watt carbon composition resistor is used, the capacitor may not be needed. In this case, just a 50 ohm resistor is connected to reduce power dissipation caused by the DC component.

In addition, there is potential for a ground loop to be formed from AC power ground connecting to Oscilloscope probe ground. To check this problem, connect the probe tip and its ground to the -OUT of the dc/dc converter. If there are signals generated on the scope, then the common mode noise due to this ground loop exists. In such a case, an isolation transformer is needed for the oscilloscope. A good isolation transformer must have the primary and secondary on separate bobbin, with ground shield between them.

Alternatively, use a differential probe such as the Tektronix 5200 for accurate measurements.