Pre-Test Checklist

1. If a line fuse is fitted, ensure that it is correctly rated.
2. For mains operated units check that the input voltage selector is set for the correct voltage.
3. The following safety precautions are advised before switching on mains operated units.
   - Connect the power supply protective earth terminal to an external safety earth conductor
   - If testing is to be carried out on a bench, cover the bench top with insulating material of 2mm minimum thickness
   - Where mains inputs terminals or live uninsulated high voltage conductors, such as PCB tracks are exposed, a safety screen should be used between the unit under test and the test operative

Basic Tests

Basic tests which most users carry out on power converters are the measurement of line and load regulation and output ripple and noise.

Comprehensive testing is beyond the scope of this guide, so only basic tests are covered with a mention of some additional tests that can be carried out once the test equipment is in place.

A useful test set up for regulation testing is shown in Fig. 12. This can be used for linear and switched mode power supplies and for DC/DC converters if the auto transformer is replaced by a well regulated adjustable laboratory power supply.

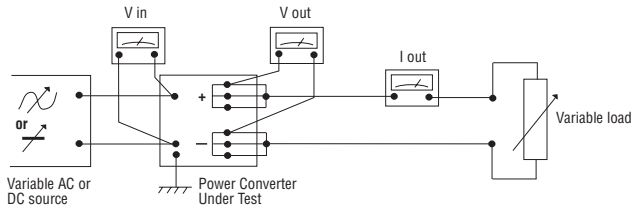

Fig 12 Schematic of test set up for line and load regualtion measurements

Minimising Measurement Errors

1. Use adequately rated AC and/or DC variable power sources so that high current peaks drawn by switched mode converters do not drive the source into saturation or current limit. The current rating of the source should be equal to at lease 3 times the maximum VA rating of the converter under test divided by the minimum test input voltage.
2. Voltmeters must be connected to the terminals of the converter under test to prevent measurement errors caused by voltage drops in the connecting leads.
3. If the converter has multiple pins for output and return connections it is advisable to use all the pins in parallel to connect the load. This avoids voltage drops due to high connector resistance.
4. Ensure that the area where testing is carried out is at a reasonably constant temperature. Incoming goods areas which are subject to cold draughts of outside air are not suitable environments for carrying out accurate measurements.
5. For switched mode power converters, the output current should be set at the minimum rated load before any testing commences. The majority of such converters require at least 10% loading to regulate, therefore checks carried out with zero load are meaningless.

Line Regulation

At full rated load the output voltage is recorded with the line input voltage at nominal, then at high line and low line. Line regulation is the maximum of the two voltage deviations recorded expressed as a percentage of the output voltage at nominal input.

Load Regulation

With the input voltage set to nominal, the output voltage is recorded at minimum and maximum rated loads. Load regulation is the difference between the two recorded voltages expressed as a percentage of the output voltage at maximum rated load. Many switched mode power supplies have load regulation expressed as a ± percent deviation at 60% ± 40% of rated load, and the measurement procedure can be modified appropriately.

Other Measurements

Other simple measurements that can be carried out with the test set up illustrated are output current limit, short circuit output current and output setting accuracy.

Electronic Loads

Where testing is expected to be carried out frequently, the acquisition of a set of wide range electronic loads such as the Powerload 50 and 500 is recommended. These combine adjustable load, load current and voltage measurement in one compact unit, greatly reducing set up time especially for multiple output power converter testing. If regulation measurements give worse values than expected, an external voltmeter can be used to check the difference between the voltage at the output terminals and the voltage registered by the electronic load internal voltmeter.

When large numbers of power converters are to be tested, computer controlled testing is a great time saver. With a digital to analogue interface unit like the PC 4400B Powercontroller, programmable electronic load(s) such as the Powerload 50 and 500, and a PC fitted with a GPIB card a very effective high speed test station can be assembled. Complete testing of a power converter, similar to the manufacturers production tests can be carried out in less than one minute.

Temperature Coefficient

With the test set up illustrated in Fig. 12, but with the power converter under test in an enclosed temperature chamber, output voltage temperature coefficient can be determined. The input voltage is set to nominal and the output current to maximum rating and the temperature chamber to 25°C. After allowing time to stabilise the output voltage Vo is recorded. The chamber is then set to 0°C, or the converters minimum specified operating temperature if this is higher, and the temperature allowed to stabilise. This could take as long as 30 minutes, dependent on the size of the chamber and the VA rating of the unit under test. If the air in the chamber is stirred by a low speed paddle bladed fan, the time to reach temperature stability is shortened. When stability is reached the output voltage is again recorded. The chamber is reset to +50°C or the converter maximum operating temperature if this is lower, and the measuring procedure repeated. The two output voltage deviations from Vo are expressed as a percentage, then divided by 25 to obtain the temperature coefficient in %/°C.

The temperature coefficient is the higher of the two numbers, although it is sometimes taken as the average of the above two measurements and quoted as “typical” in the specification.

Output Ripple and Noise

This is a relatively simple measurement for linear AC/DC power supplies and readily available general purpose laboratory test equipment can be used, a low bandwidth oscilloscope for peak to peak measurements and a true RMS voltmeter being ideal. The ripple waveform is 100Hz (or 120Hz for 60Hz operation) with very little high frequency content.

Switched Mode Converters

Because of the high frequency content in the output noise waveform, and the proximity of radiated emissions from the converter it is impossible to make valid measurements without special test equipment. One of the methods used to avoid the measurement being swamped by pick up is shown in Fig. 13.
This is a specially adapted oscilloscope probe with an external ground band and a very short unshielded tip. To make the measurement the ground band is held against the output common terminal whilst the tip is in contact with the adjacent output terminal. There is still a small antenna loop created by the probe tip and output terminals. Residual pick up can be reduced by connecting a 0.1µF ceramic capacitor across the output terminals if necessary. A probe with a conventional ground clip connection would be useless for this measurement. Recommended minimum bandwidth for the oscilloscope is 20MHz.

TESTING POWER CONVERTERS

The output ripple waveform of most switched mode converters is triangular pulses at switching frequency with HF noise and spikes superimposed.

The RMS value which is usually less than 10% of the peak to peak amplitude is therefore not often quoted. AC/DC switched mode converters also have mains related ripple content in the output.

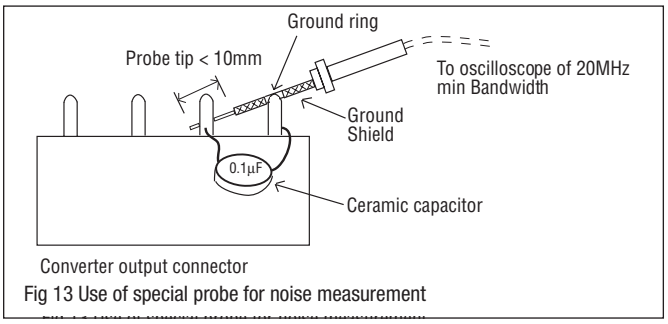

Fig 13 Use of special probe for noise measurement

Another method which can be used to obtain accurate measurements is to use a 50W terminated coaxial cable between the converter and the oscilloscope. Fig. 14 shows this technique used to measured DC/DC converter output noise.

With a high quality conductive ground plane (a sheet of copper or aluminium is acceptable) in place between the converter and the oscilloscope, the shielded low impedance interconnecting wires will pick up very little extraneous noise. To minimise the effects of common mode noise an input balun is connected to the converter input. With this method of measurement the actual noise is double the peak to peak value displayed on the oscilloscope, since the terminated coax divides the signal by 2. To obtain accurate measurements the load must have a very low reactance at the switching frequency, preferably below 2%. The coupling capacitor C can be a low ESR electrolytic type, not less than 10µF.

Reflected Ripple Current

This is an important parameter for DC/DC converters because they are sometimes supplied from relatively high impedance sources, or they are at the end of long supply wires. It occurs in all switched mode converters because during switching action very short duration high current pulses are demanded.

Suppression is by internal Pi configured LC filters. A typical measurement technique is shown in Fig. 15 using a wideband current probe and oscilloscope.

Because of the HF content it is usually quoted as a peak to peak current into a specified source impedance.

Common Mode Noise

This is current noise which is common to each output terminal. It flows to the input via the external ground. Again a suitable measuring technique uses a wideband current probe and oscilloscope to obtain peak to peak values. Fig. 16a illustrates the test set up. An alternative method using a low impedance 50W terminated coaxial transmission line is also illustrated (Fig. 16b).

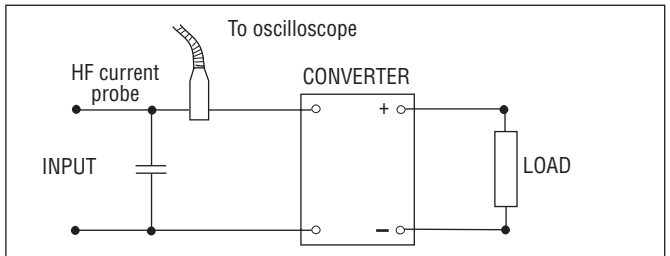

Fig 15 Input reflected ripple current measurement using HF current probe

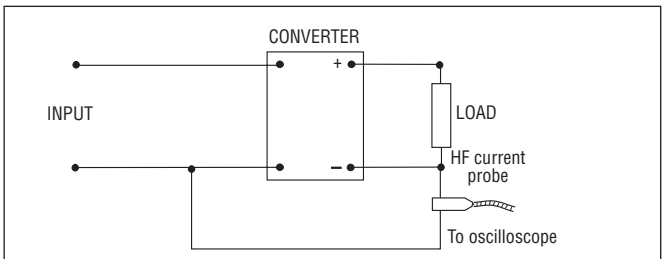

Fig 16a Common mode noise current measurement using HF current probe

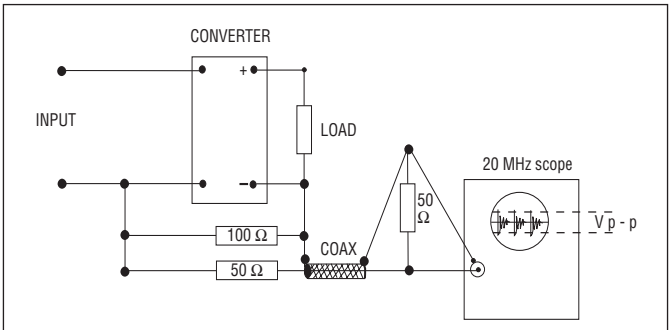

Fig 16b Common mode noise current measurement using terminated coaxial transmission line technique.
Common mode current I_C (p - p) = V p - p/50

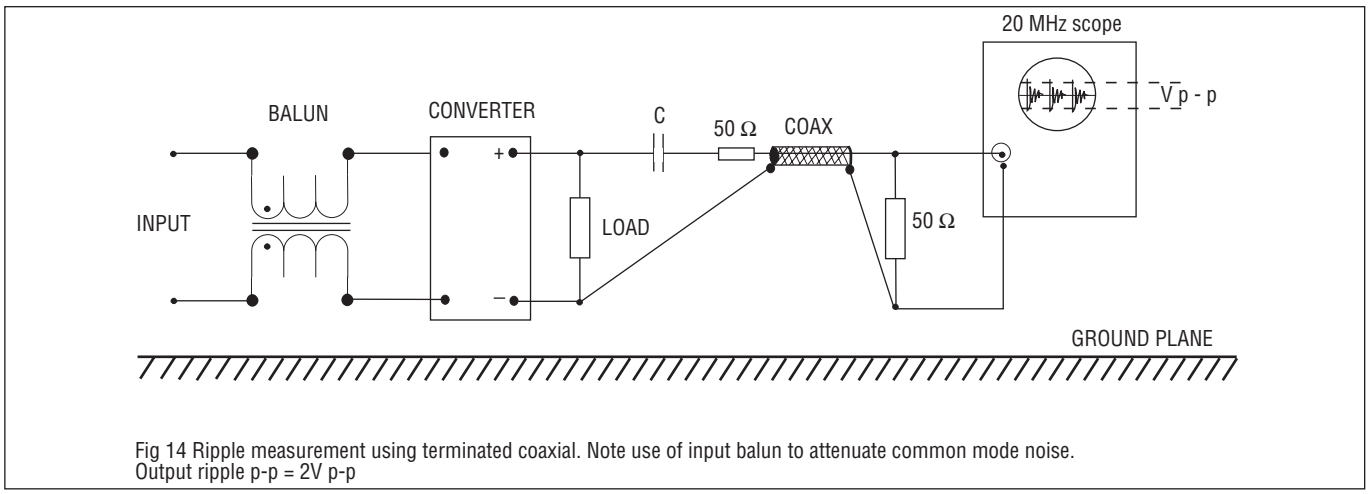

Fig 14 Ripple measurement using terminated coaxial. Note use of input balun to attenuate common mode noise.
Output ripple p-p = 2V p-p