

## How to Accurately Measure Power Supply Efficiency

Manufacturers of Industrial and Medical end systems and equipment are asking power supply manufacturers, not only for the headline efficiency of products but also for high efficiency levels over the typical operating load range of their equipment. With efficiency levels approaching the mid-90's, it is also becoming increasingly more important for design engineers to verify a power supply's performance before specifying it into a design.

This white paper outlines the critical factors that must be considered to help minimise measurement error and is intended for electronics engineers and designers working with high-performance power systems.

### References

[www.uk.tdk-lambda.com/cfe-m](http://www.uk.tdk-lambda.com/cfe-m)

## How to Accurately Measure Power Supply Efficiency

*Andrew Skinner, Chief Technology Officer, TDK-Lambda UK outlines the critical factors to help minimise measurement error.*

In the Industrial and Medical equipment markets more and more manufacturers of end systems are starting to ask power supply manufacturers, not only for the headline efficiency of products but also for high efficiency levels over the typical operating load range of their equipment. Even when their own equipment does not fall within the scope of any standards or Directives today, there is a real desire to produce environmentally responsible products on a voluntary basis.

Efficiency	Input Power	Input power range for a 1% change in efficiency
80%	125W	123.5 – 126.6W
90%	111W	119.9 – 114W
95%	105W	104.2 – 106.4W

*Fig. 1: Efficiency of a 100W power supply from the point of view of input power*

It is common to benchmark the efficiency of products against existing standards such as 80 Plus, even if they are not required for the end application. The 80 PLUS specification requires that the input and output power is measured to within 0.5% accuracy, which means results in a  $\pm 1\%$  accuracy on the efficiency measurement. So looking at the effects of that on the 80% efficient power supply  $\pm 1.5W$  it is not a significant error. As the efficiency goes up to 90 or 95 percent, the error is at around  $\pm 1W$  – a level of accuracy that seems quite acceptable when considering input power. But if you look at the losses in the power supply instead, then the story is rather different.

Efficiency	Loss in PSU	Loss changes by X for a 2% ( $\pm 1\%$ ) change in efficiency
80%	25W	13%
90%	11W	25%
95%	5W	52%

Fig. 2: Efficiency of a 100W power supply from the point of view of PSU losses

Taking the 80% efficient power supply, a loss of 25W is seen, and in a typical power supply temperature rises of around 50 degrees C at full load would be expected. So a  $\pm 1\%$  measurement accuracy, could actually equate to a 13% error ( $\pm 6.5$  degrees C), which is a perfectly acceptable level of accuracy.

However, with an efficiency of 90% the error can be as high as  $\pm 25\%$ , giving a variation in temperature rise of greater than 10 degrees C, which can half the life of the electrolytic capacitors and have a significant impact on the end application.

Above 90% efficiency, the impact of this  $\pm 1\%$  measurement accuracy becomes more critical. If an engineer were to design in a power supply that was at 96% efficiency and then tries to use a unit that is at 94% then there could be a problem with temperatures varying by over 20 degrees C. At these high efficiency levels, it is becoming increasingly more important for design engineers to verify a power supply's performance before specifying it into a design.

Looking at how the efficiency of an AC-DC power supply is measured, the input power is typically measured using an AC power analyser – measure the input voltage, the input current, the power factor and the power. The specification for a typical AC power analyser looks quite good with a headline specification that can be 0.1% but other factors such as the size of the measured signals versus the measurement range, and the frequency of the signals can reduce the final measurement accuracy.

Equipment	Voltage	Current	Power
AC Power analyser	0.1% +0.1% of range +0.1%/kHz	0.1% + 0.1% of range +0.2%/kHz	0.2% + 0.2% of range
Digital Multimeter	0.02%	0.02%-3%	n/a

Fig. 3: Accuracy of Test Equipment

Perhaps even more interesting is how the output power is measured. When using a digital multimeter, voltages can be measured very accurately. Typically current is often not so accurate, as it depends on the range, often a higher accuracy can be achieved by measuring the voltage across a calibrated shunt resistor to measure current.

Another important factor to consider is that digital multimeters use a sampling technique for measurements and unfortunately the sampling frequency and algorithms used are rarely explained in the product literature – you could take two or three multimeters from different manufacturers and get fairly significant differences in the measurement results.

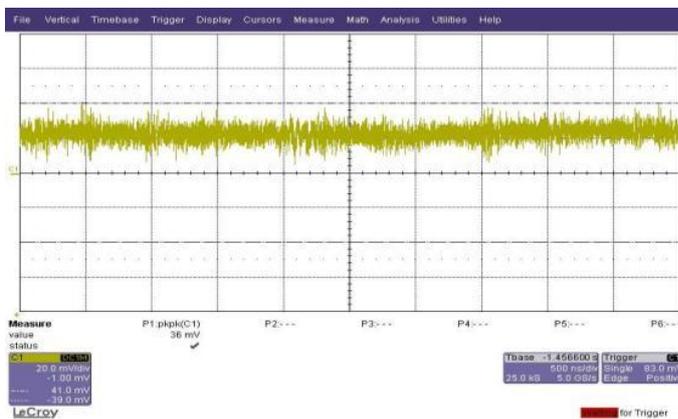


Fig. 4: Measuring output current – Spike noise with frequency content over 10MHz

As an example, of the noise that can be present in the output of a power supply, Fig4 shows the output current (voltage across a calibrated shunt) for a 10W power supply. It is clear that the signal is not DC, there is a low frequency characteristic to it and spike noise that has frequency content in excess of 10MHz.

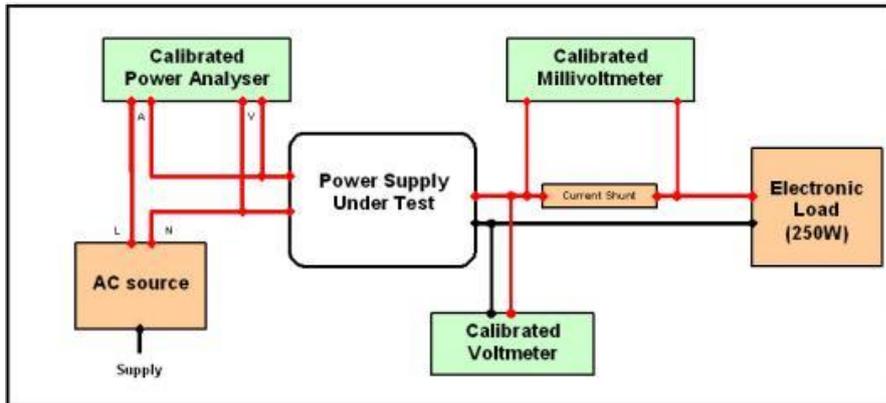


Fig. 5: Block diagram illustrates the set-up used to measure the efficiency of the CFE400M digital power supply.

In order to accurately measure the efficiency of our CFE400M digital power supply, a number of techniques were used to improve the measurement accuracy. Firstly external calibrated current shunts were used for both input and output current measurements with RC filtering added to minimise the noise – so not to rely on the unspecified filtering characteristics of the measurement equipment. This enabled the input power to be measured with accuracy in the region of  $\pm 0.4\%$ , output current to just over  $\pm 0.1\%$  and the output voltage to  $\pm 0.02\%$ . This resulted in an efficiency measurement that is accurate to within  $\pm 0.5\%$ .

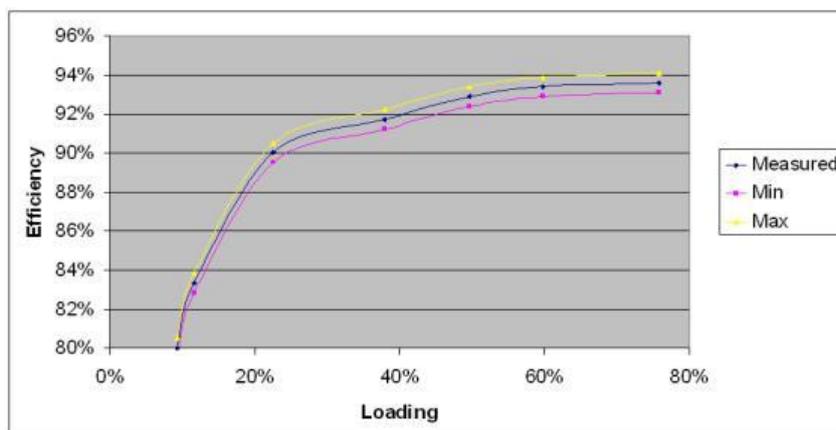


Fig. 6: CFE400M 24V Achievable accuracy with filtered signals.

Fig 6 shows the measured efficiency, the blue line shows the measured results but actually the efficiency lies between the max and min lines i.e. between 93 and 94%. Statistical techniques based on multiple measurements on multiple power supply samples could of course be used to further improve the accuracy.

The efficiency of the CFE400M is at a level where direct comparison of unit efficiencies is difficult due to the sensitivity to measurement error. An engineer therefore may well find that the measured efficiency of this or similarly specified products may not appear to be the same as that claimed on the manufacturer's datasheet, depending upon the measurement method used. Similarly, when comparing products, the measurement inaccuracies can create considerable uncertainties; if in doubt, consult your local TDK-Lambda representative who will be more than happy to offer advice and technical support.

For more information about the CFE400M range of digital power supplies, please visit:

[www.uk.tdk-lambda.com/cfe-m](http://www.uk.tdk-lambda.com/cfe-m)

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