

How to Handle Non-Linear Loads on a Power Supply

Non-linear loads, in the context of a power supply, are those that do not behave like an ideal resistor, causing high current. In most cases these high current peaks are not an issue as the hiccup current limit protection circuitry operates but, under certain circumstances, they can be. This white paper looks into how to deal with a large switched capacitive load without going into hiccup.

This white paper is intended for electronics engineers and designers working with power systems that may experience highly non-linear loads.

References

www.uk.tdk-lambda.com/cfe-m

How to Handle Non-Linear Loads on a Power Supply

Non-linear loads, in the context of a power supply, are those that do not behave like an ideal resistor such as Point Of Load (POL) DC-DC converters and discharged capacitors that are switched onto the output causing high currents to flow until the capacitor is charged. In most cases these high current peaks are not an issue as the current limit protection circuitry operates but, under certain circumstances, they can be. Here Andrew Skinner, TDK-Lambda UK's Chief Technology Officer, explains.

Current-limit protection, or Over Current Protection (OCP), is an essential design feature for a power supply; the techniques used include constant-current, foldback and hiccup. Of these three types, the favoured technique is hiccup current limit even though, in some cases, the circuitry to achieve this can be quite complex in nature. Upon detection of an over current event, the whole power supply shuts down for an interval before it tries to power itself up again (auto restart). The cycle repeats, or hiccups, until the over current fault disappears.

The benefit to the equipment manufacturer using a power supply with hiccup current limit is that it can accommodate peak power conditions and the cable does not need to be rated at this higher peak current. Power supplies using simple analogue control circuitry would typically have fixed timing for the hiccup but digitally controlled power supplies can employ load dependent timing; typical values being 10s on-time for an overload condition, around 60ms for heavy overloads and approximately 5ms for a short-circuit condition. Off-times would typically be 1 to 2 seconds.

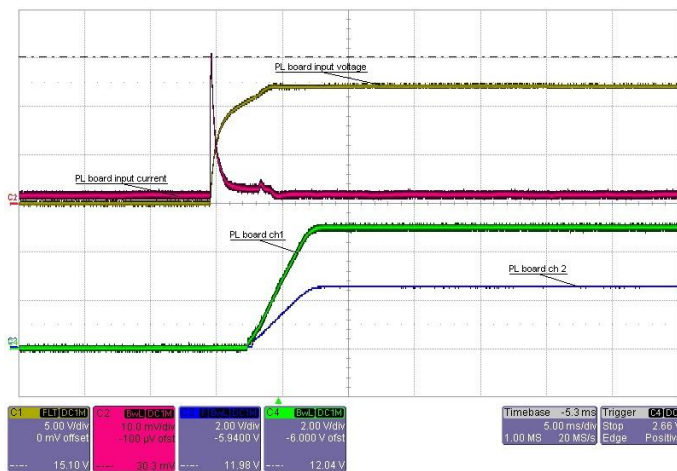


Fig. 1: Power supply start-up into a POL converter

Figure 1 shows the start-up of an AC-DC power supply with hiccup current limit starting into a POL converter load; the yellow curve shows the output voltage and the red curve shows the current. During start-up, there is a large inrush current from the capacitors of about 150A peak – although this inrush current is very high, it is occurring during the soft-start phase of the AC-DC power supply and is of short duration and so the power supply remains unaffected. The soft start-up characteristic of the power supply is optimised to handle this kind of inrush current and, provided that the peak occurs before the voltage comes into regulation, it's not a problem. It can be problem however when this occurs once the regulated voltage is established and the reason for this is the hiccup current limit.

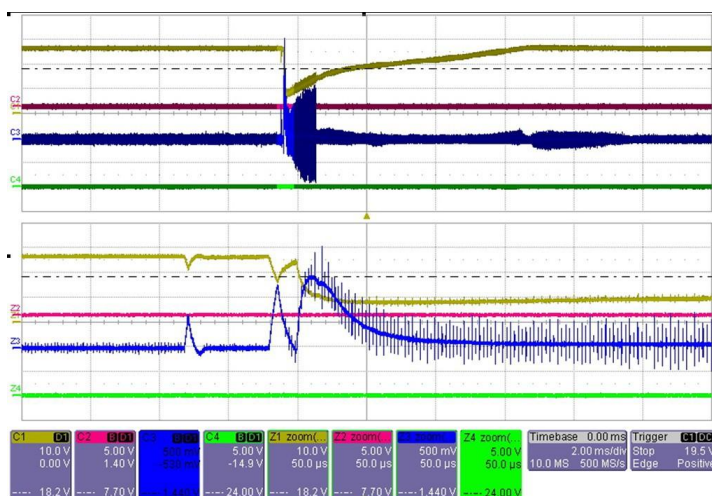


Fig. 2: A discharged capacitor being switched onto the established output of an AC-DC power supply with hiccup OCP

In the waveforms shown in figure 2, the blue trace shows the current supplied by the AC-DC power supply as a discharged, low-impedance capacitor is switched onto the established output. As you can see, the power supply has turned on three times – this happens because the relay bounces. At just under 60A, there’s about 700W being drawn from the power supply, which could cause a standard power supply to hiccup thus preventing correct start-up of the load. In this case however the output does recover as can be seen by the yellow trace.

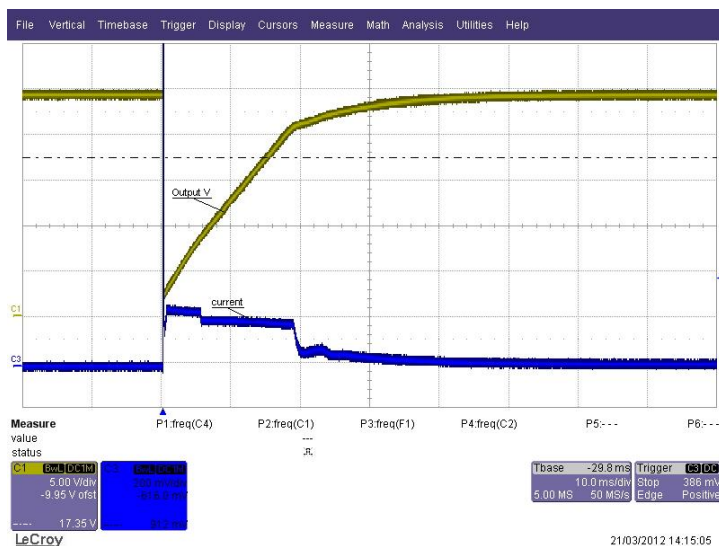


Fig. 3: The CFE400M can run at 300W and have the 3000 μ F capacitance switched in and still recover without going into hiccup.

The design team at TDK-Lambda has improved the hiccup current limit algorithms with the introduction of its next generation CFE series. The waveform above shows the CFE400M running at 24V; when a 3000 μ F capacitor is switched in, it discharges the output to almost zero (yellow trace) as it discharges the much smaller output capacitor on the product.

As you can see, the CFE is optimised to deal with this large switched capacitive load, supplying almost 50A of output current for about 1.5ms (in short-circuit mode) and then dropping down to a lower level of about 30A (over-current protection mode) for approximately 50ms, which is typically long enough for the voltage to recover. The CFE400M can run at 300W and have the 3000 μ F capacitance switched in and still recover without going into hiccup; thus offering the benefits of hiccup current limiting, such as a

150% peak-power capability with reduced cable size requirements, whilst still being able to handle highly non-linear loads normally associated with power supplies having constant current type OCP.

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

www.uk.tdk-lambda.com/cfe-m

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