Friday, December 20, 2013

The advantages of using a power supply incorporating digital control to power non-linear loads

I was recently tasked with doing a presentation on the advantages of power supplies incorporating Digital Control to power non-linear loads, so I thought I would share the content with you.

A non-linear load is one that does not behave like an ideal resistor, in that the current drawn from the power supply is not proportional to voltage and/or the initial currents are often much higher than the rating of the power supply.

These loads can cause problems for power supplies, but are actually present in many applications:

Large switched capacitor banks

Point of Load DC-DC converters

Thermal printers

DC motors

The main issue from a power supply's point of view is that the load can activate the internal over-current protection. Over-current protection (OCP) is an essential feature for a power supply, but the power supply is usually expected to recover automatically with no manual intervention.

So to start with, let's look at the types of OCP. There are several basic methods used:

Constant Current

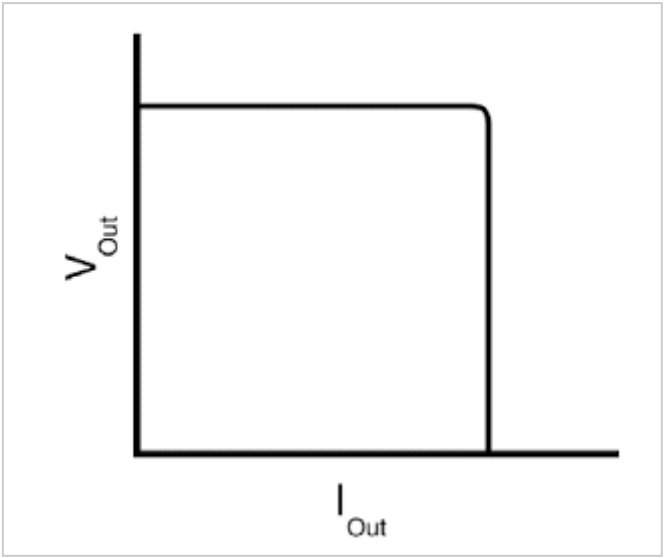
Fold Back

Fold Forward

Hiccup

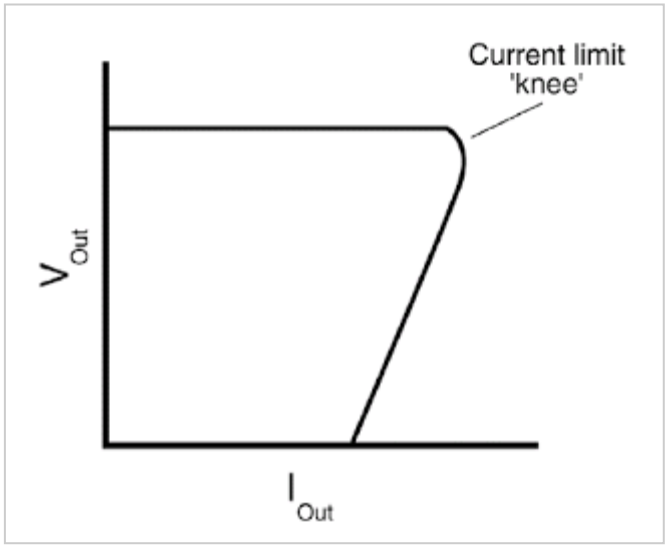
Constant Current

When an overload condition occurs, the output voltage falls but the output current remains at a fixed level. This type of protection is not well suited for delivering peak loads as it can lead to the power supply latching.



Fold back

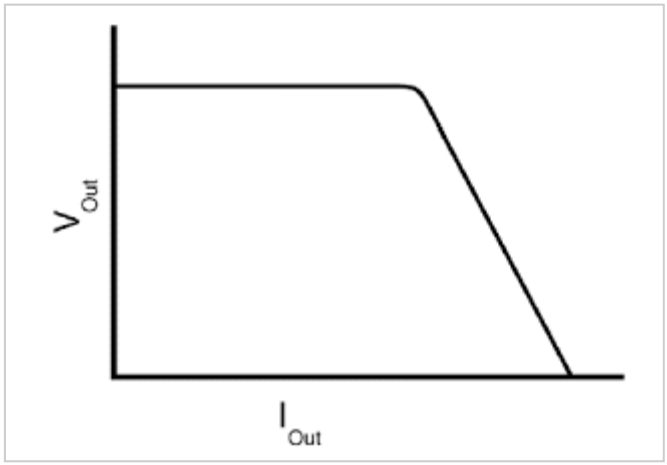
When the current drawn reaches the OCP limit, the voltage falls, but this time the current decreases as the overload gets heavier. Again this type of protection is not well suited for delivering peak loads as it can result in the power supply latching.



Fold forward

When the current drawn reaches the OCP limit, the voltage falls. This time the output current increases to a set maximum at short circuit.

Fold forward is well suited for powering up motors, but requires heavier system load cabling to handle the additional overload current.



Hiccup

At the OCP limit, the power supply turns off for a short interval and then automatically tries to restart. Hiccup mode reduces the need for heavy cabling or pcb traces, and this type of protection can be modified to deliver a peak load.

With traditional Analog Control though, the OCP points and recovery timing are fixed.

With Digital Control we can use software settings to adjust the limits and timing; for example we can set:

10s for an initial overload condition

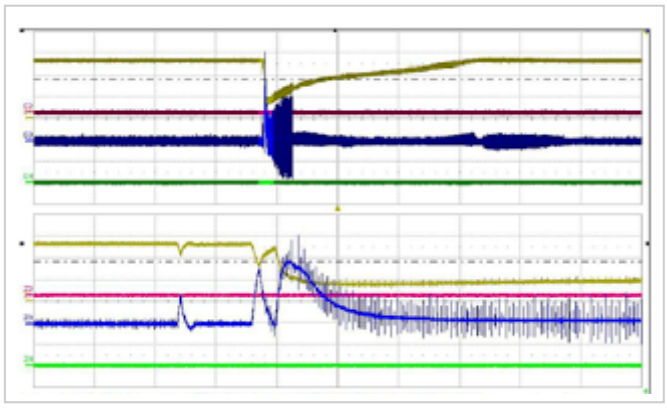
60ms for heavy overloads

5ms for a short circuit condition with recovery times or 1 to 2 seconds

Let's take an application example of a discharged capacitor bank being switched onto an operating power supply with Analog control.

The lower (blue) trace is the power supply current; restarting twice with the power supply current limit set at around 60A.

The top (gold) trace shows the output eventually recovering, but tolerances with the hiccup mode timing could have prevented a full recovery.



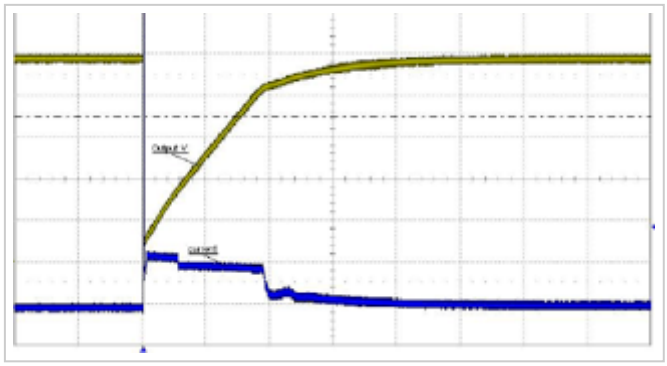
This time the same discharged capacitor bank is switched into a TDK-Lambda CFE400M supply incorporating digital control.

The blue trace is the current, gold trace is the output voltage

Using Digital Control, we can set the thresholds and timing accurately.

50A for 1.5ms (The short circuit condition)

30A for 50ms (The over current condition)



Notice that there are no multiple attempts to recover after the capacitor bank is applied to the power supply.

To summarize:

Digital control can allow for precise and repeatable current limiting using load dependant timing. We are not restricted to the value of a timing capacitor which can change due to:

a) Batch tolerances

b) Aging of the capacitor

c) Capacitor values changing with temperature

Digital control allows for easy tailoring for different applications with no physical modification of the power supply is needed. All changes are handled with software programming!

Power Guy