Calculation of Maximum Capacitive Load for DC/DC Converters

When implementing a modular switch mode converter solution many designers chose to add an external capacitor to the output of the DC/DC converter to reduce ripple and noise.

A single capacitor is a low cost alternative to designing an LC filter; however excessive capacitance can cause problems at the converter's start-up.

The "filter" capacitance value is generally part of the system capacitance, which includes decoupling capacitors, and other load capacitances.

At start-up the output capacitor has no charge, the DC/DC converters sees a large sudden demand for load current, both from the steady-state current and the capacitor charge current.

With large load capacitances the current demand may trigger the converters over current protection circuit and the converter will momentarily shut down and then attempt to restart itself. If the cycle of shut down and restart continues the converters will experience permanent damage.

Frequently the charge current may not be significant if it is small compared to the steady-state current when the converter's steady-state current is below its maximum rated current. In higher power converters max capacitive load is less of an issue, but in low power applications it becomes more of a concern.

The following is a guideline for calculating the maximum load capacitance so that start-up issues and converter damage may be prevented:

The basic relationship is for calculating total current is: **I(total) = I(cap) + I(steady-state)**

As long as I(total) does not exceed the rated current of the converter there is no cause for concern.
The charging current of the capacitor is given as:

$$I(cap) = C\left[\frac{\Delta V}{\Delta T}\right]$$

Where:
C is the total capacitor value in Farads
ΔV is the change in output voltage in Volts
ΔT is the rise time on the input pins in seconds

The input rise time is used as it is the worst case scenario because this is the time the converter is trying to charge the output capacitor.

An example follows showing the effect on output current with longer rise times on the input.

If C = 10uF, ΔV=5V, ΔT=10uS, the I(cap) = 5A

However if ΔT = 10mS, I(cap) =5mA

If a start-up problem exists one solution is to add a capacitor at the input of the converter to slow the rise time as shown in the above example

Another option is to use a higher power converter and derate it to a level where the charge current does not cause the converter to go into over current protection.