HOT-PLUGGABILITY AND TURN ON DELAY IN DC/DC CONVERTERS

HOT PLUGGABLE DC/DC CONVERTERS

When a power supply or DC/DC converter fails in a redundant power system, the system continues to operate from one of the redundant power sources. To replace or repair the failed power source, the system must remain operational during this time. When a DC/DC converter has been replaced in an operating (hot) system, the converter must be able to withstand at its input the instantaneous input voltage without disturbing the operation of the system. The input capacitance of the DC/DC converter must be charged instantaneously to (hot) V_{IN}.

In non-hot pluggable DC/DC converters, the input current required to charge the input capacitance is limited only by either the resistance of the PCB trace, the pin of the converter, or the ESR of the input capacitors. The unlimited input current can destroy the input stage of a given DC/DC converter or load down the input voltage bus. Even if the converter can withstand the (hot) input voltage, it may generate unwanted noise at its output during plug-in.

The solution to this problem is a so-called "hot-pluggable" converter. Hot-pluggable converters have at least one of their input terminals disconnected during plug in and after a predetermined delay slowly connect their inputs to the input power source. Any DC/DC converter can be made to operate as a hot pluggable converter with few external parts.

Referring to Figure 1, a standard converter with four additional components operates as a hot-pluggable converter. Without the converter, R1 holds Q1 OFF. When the DC/DC converter is inserted in the circuit Q1 is OFF, no current can flow out of $-V_{IN}$. At this instance, $+V_{IN}$ and $-V_{IN}$ are at the same voltage $+V_{IN}$.

A small current of 10µA to 100µA out of the ON/OFF pin starts to charge the gate capacitance of Q1 and slowly turns Q1 ON. If more delay is needed, a small capacitor of 0.01µF to 0.10µF can be used. The voltage at the ON/OFF pin of most of Beta Dyne's converters is between 10Vdc and 12Vdc and the maximum current is the OFF-state current specified in the respective model's datasheet.

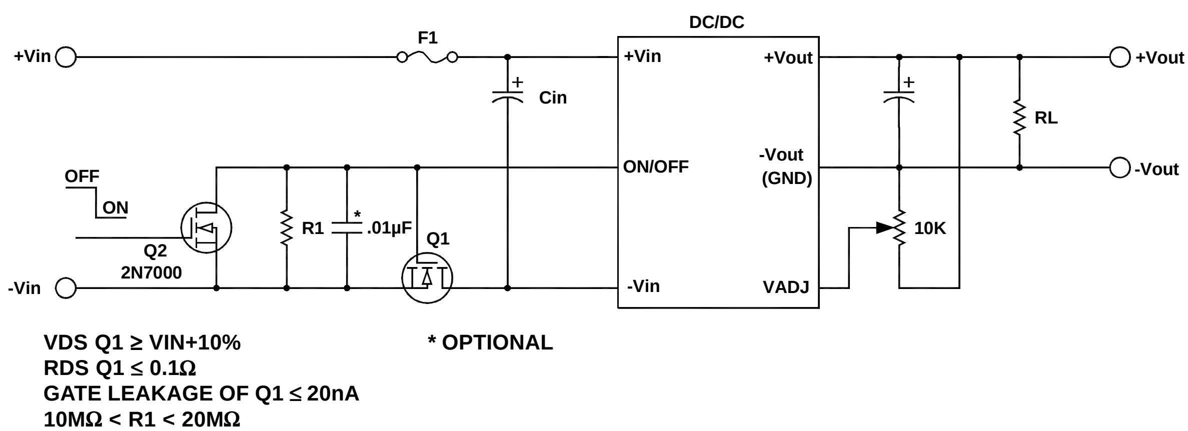


FIGURE 1. Connection diagram for hot-pluggable DC/DC converter

NOTE: The power dissipated by Q1 is given as:

$$P_{Q1} = I_{IN}^2 * RDS_{ON}$$

RDS_{ON} increases along with the temperature. To figure RDS_{ON}, double the value for RDS_{ON} given at 25°C. To figure I_{IN}, use I_{IN} at low-line, which is given by (in the worst case): $I_{IN\ LL} = I_{IN\ NOMINAL}$*1.6.

TURN ON DELAY

If the turn on delay and the soft start time of a DC/DC converter is faster than that of the AC/DC converter in applications where DC/DC converters are supplied from a current-limited or short circuit-protected AC/DC converter, such as wall-mounted AC/DC, inverters, etc., the system may not start or work intermittently. The reason is that the AC/DC at turn ON detects an overload condition, which is the DC/DC converter and its output load. This problem of not starting is due to the different delays of the AC/DC and DC/DC, which becomes worse when the DC/DC converter's output has a large capacitive load, such as step-down converters, VRM, etc.

In Figure 2, the emitter of Q1 2N3906 at turn ON holds the S/D (ON/OFF) pin low allowing the input voltage to change any input capacitance before the converter turns ON. The delay time is set by C1, R1, and R2.

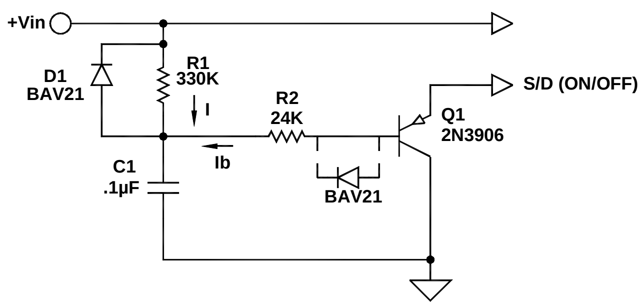
For $12V_{IN}$, the circuit in Figure 2 provides a 2.5mS/0.1µF capacitor. The S/D voltage under normal operating conditions is 5V. For higher input voltage converters (e.g. 24, 48, and 120Vdc inputs), a small signal diode is required to protect the base-to-emitter junction of the bipolar transistor from high reverse voltage. An BAV21 diode is placed between the base of Q1 and R2 as shown in Figure 2.

For higher than $12V_{IN}$, an R2 resistor must be adjusted accordingly. Keep in mind that two currents charge the capacitor: the emitter-to-base current and the current that runs through R1.

D1 provides a fast discharge of C1 when the input power is turned OFF. The circuit in Figure 2 disconnects only the output stage of the converter at turn ON, while the circuit in Figure 1 disconnects the converter completely at turn ON.

There are 3 solutions to this problem:

1) Replace the AC/DC with one that features soft start;
2) Replace the DC/DC converter with one that has a longer soft start time;
3) Use the circuit in Figure 2 to increase the turn on delay of the DC/DC converter.



DELAY ≈ 2.5mS/0.1µF for V_{IN} = 12V

FIGURE 2. Turn on delay circuit