Boost Converter Hold-Up

General Description

Hold-Up Time: The amount of time (in milliseconds) that a power supply can maintain output within the specified voltage range after a loss of input power. This enables a system to continue running without resetting or rebooting if a brief interruption of input power occurs. Values of 15–50 milliseconds are often required for today's power supply systems. For instance, the MIL-STD-704A specification calls for 50ms hold-up time for critical applications.

When the power system application under consideration requires the ability to continue operation for a period of time following an input power interruption, additional capacitance can be used to permit the power supply module(s) to continue operation. Since the hold-up time requirement of a power supply system can vary depending on the end-use and overall system requirements, hold-up capacitance is usually not designed into the modules. The added size and weight, which may or may not be required, is more appropriately designed into the system. DC-DC power supply modules readily accept power from external hold-up capacitance.

Calculation of Required Capacitance

Calculations for the hold-up capacitance for DC-DC converters, such as Rantec's High Density Modules (HDM product lines), are very straightforward.

The amount of capacitance required, for DC-DC converters, or at the DC bus level for AC-DC systems, is given by the following equation:

$$C_{holdup} \geq \frac{2 \times P_{LOAD} \times t_{HOLDUP}}{\eta \times \left((V_{NOM})^2 - (V_{DROPOUT})^2 \right)}$$

Where
C_{holdup} = Total hold-up capacitance
P_{load}= Output Power Requirement: The total delivered power to the load(s) (output from the DC-DC modules) in Watts
t_{holdup}= Desired holdup time in seconds
V_{nom}= The nominal boost DC output voltage
$V_{dropout}$= The low-line, or dropout voltage, of the DC Module(s) connected to the boost converter's output. Note that for multiple DC-DC modules, the highest low-line value specified must be used
η = Efficiency of the power supply
P_{rated}= Boost Module's Rated Output Power

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Calculation of Hold-Up For Capacitance

Alternatively, a computation of hold-up time based on an existing hold-up capacitance can be done, as follows:

$$t_{holdup\max} = \frac{\eta \times \left(\left(V_{NOM} \right)^2 - \left(V_{DROPOUT} \right)^2 \right) \times C_{HOLDUP}}{2 \times P_{LOAD}}$$

Implementing the Storage Capacitor

In selecting the storage capacitor or capacitors, Aluminum Electrolytics are typically used. Where relatively high voltage is involved, it may be necessary to use two or more capacitors in series or series-parallel configuration to accomplish the desired total capacitance (see Figure 1).

Note that in many applications, the Boost converter's output is low enough to omit the series combination capacitors (and the associated diodes and resistors. Capacitor selection and application-specific de-rating will dictate this.

When selecting capacitors, note the specified initial tolerance. Also pay attention to the operating temperature range of the power supply, as most capacitors, especially electrolytics, will lose a significant percentage of their capacity (rated C) at low temperatures.

Voltage bleeding resistors and reverse polarity protection diodes may also be required to prevent possible injury from stored charge, and to protect the capacitors from damage at turn-on and turn-off (see Figure 1).

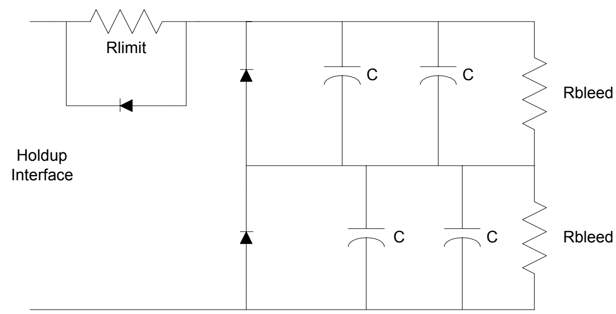

Figure 1 - Sample hold-up circuit

This sample hold-up circuit shows sets of series/parallel capacitors, to achieve the required capacitance and provide a design margin for the capacitor breakdown voltage of a DC-DC converter or DC bus system. For this example circuit using four capacitors of the same value, the resulting holdup capacitance, C_{holdup} would be equal to the value of C. In addition, consideration is given to in-rush current limiting during hold-up capacitor charging, by using resistor R_{limit}. The diode in parallel with R_{limit} provides the low impedance path required during a hold-up condition. See Figure 2 for a typical connection.

Other Considerations

For implementations using Rantec's boost modules, Figure 1 attaches in parallel to the output of the boost module, and the input of the DC-DC converter(s). R_{limit} provides the in-rush current limiting of charging hold-up

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capacitor(s) during initial turn-on and recovery from an input drop out condition. The minimum value of R_{limit} should be sized to not exceed the boost module's output current rating while powering the DC-DC modules and charging the hold-up capacitor(s). As a guideline, $R_{limit} \geq V_{nom}^2/(P_{rated} - (P_{load}/\eta))$. Additionally, the resistor's peak power rating should be at least $(V_{nom})^2/R_{limit}$, and it's voltage rating should be at least V_{nom}. Values of R_{limit}, which are too small with respect to C_{holdup} and with the load applied, will affect how quickly the boost module's output rises on power up, and recovers from a loss of input power. Approximately 120 ohms is sufficient for 50V boost module applications. The diode in parallel with R_{limit} provides the low impedance path needed during hold-up. This diode must be rated to at least V_{nom}, and have the forward current capability needed to power the load during the hold-up condition. Since this is typically a constant power application, the diode current rating must be $\geq (P_{load}/\eta)/V_{dropout}$. See Figure 2 for a typical connection. Figure 3 shows an alternate implementation, where one DC-DC module requires hold-up and the other DC-DC module does not require the hold-up.

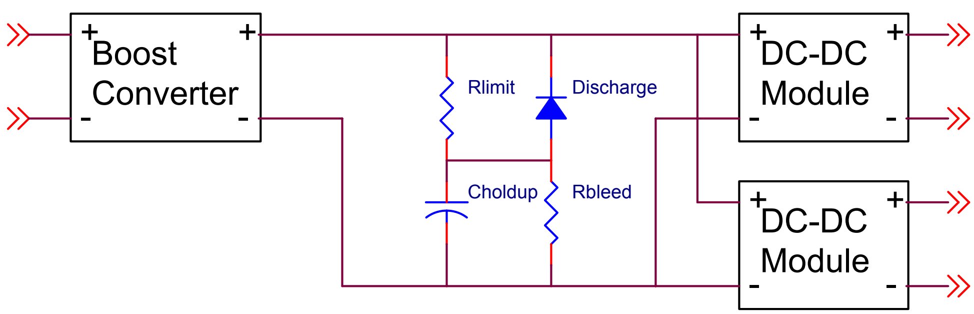

Figure 2 – Typical System Connection (both DC-DC modules have hold-up)

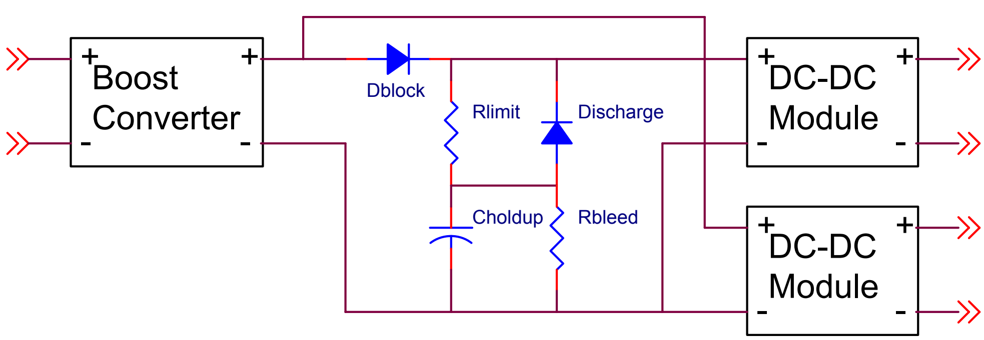

Figure 3 – Alternate System Connection (only the top DC-DC module has hold-up)

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Table 1 – Typical Component Values

Model	V_{nom} (VDC)	P_{rated} (W)	P_{load} (W)	η (%)	$V_{dropout}$ (VDC)	t_{holdup} (msec)	C_{holdup}[1] (µF)	R_{limit} (Ω)	I $D_{discharge}$ (A)	$D_{discharge}$
HDM-BT-01	50	185	138	84	36	50	13645 use 16400	120 use 120	4.56	100V 6A
HDM-BT-02	65	185	138	84	36	50	5609 use 6800	204 use 220	4.56	100V 6A

[1] Upper C_{holdup} values shown are calculated. This is the minimum capacitance value required. Initial tolerance and temperature effects need to be considered next to determine the nominal value of the capacitor required. Example is given to ensure continuous running through a 50ms dropout of input voltage.

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