Increasing Hold-Up Time in Switch Mode Power Supplies

Hold-up time

Hold-Up time is defined as the duration of time that a power supply's output will remain within regulated limits following a loss of input power. For example, for a 5V output power supply with a ±10% (±0.5V) regulated output, the hold-up time is measured from the time the input is turned "OFF" to the time when the output voltage drops down to 4.5V. The hold-up time is measured at full load and under nominal line conditions.

In linear power supplies the time the output fails following the failure of the input is almost immediate. In switching power supplies, energy is stored in the bulk (input electrolytic) capacitor providing a useable hold up time to protect against transient power outages. Hold-up time is a function of the energy storage capability of the power supply and the specific loading of the power supply. Hold-up time values of between 15 and 50 milliseconds are often required for today's power supply systems.

Figure 1 shows graphically the relationship between the shut off of the input voltage and the fall of the output voltage.

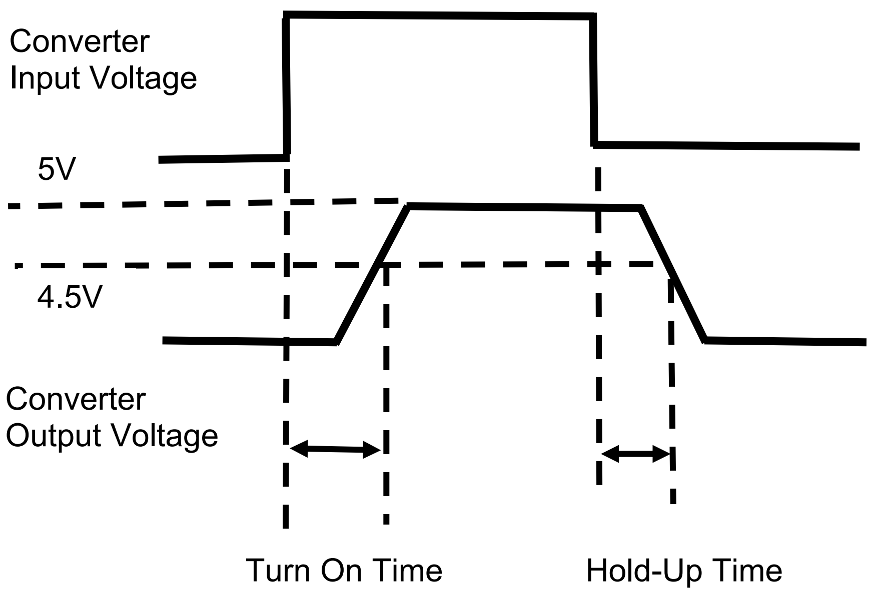

Figure 1: Turn on & Hold-Up Time DC to DC Converter

Design considerations

When a power supply requires the capability of continued operation for a short period of time following a momentary input power interruption, an external circuit providing additional capacitance can be easily designed.

Both DC to DC converters and AC to DC converters can take advantage of external hold-up capacitors, however, for AC-DC systems, the external hold-up circuitry interfaces with the internal DC bus of the power supply. Access to the internal DC bus voltage must be available and details about the power supply rectification and the DC bus is required to make these capacitance calculations

As the hold-up time of a power supply system is highly dependant on the end application and overall system parameters, hold-up capacitance is normally not designed directly into the power supply module, but designed as an external support circuit in the overall power supply system.

DC to DC converters

For DC to DC converters the calculation of hold up capacitor is straight forward.

$$Choldup \geq \left[\frac{2 \times Pload \times Tholdup}{\eta \times [(Vin\_nom)^2 - (Vin\_dropout)^2]} \right]$$

Equation 1

Where:

- Choldup is the minimum value of holdup capacitor
- Pload is the total power dissipated by the load in watts
- Tholdup is the desired hold-up time
- Vin_nom is the nominal input voltage at the time of shutdown
- Vin_dropout is the value of input voltage that defines the start of the hold-up time
- η is the efficiency of the power supply

Rearranging equation 1 to calculate the hold-up time for an existing hold-up capacitor:

$$Thold\text{-}up\_max = \left[\frac{\eta \times [(Vin\_nom)2 - (Vin\_dropout)2] \times Chold\text{-}up}{2 \times Pload} \right]$$

Equation 2

External hold up time circuit connected to input DC to DC converter

When choosing a hold-up time capacitor, it is recommended to use capacitors with low Equivalent Series Resistance (ESR) as well as high rated for high ripple current. When higher voltage is involved, it will be likely necessary to use two or more capacitors in series and/or series-parallel configurations to achieve the required total capacitance. The “cold start” temperature of the power supply must also be considered when selecting capacitor types because many capacitors will lose a large amount of their capacitance at low temperatures.

Voltage bleeding resistors and reverse polarity protection diodes should be included to provide a discharge path for the capacitors, avoiding injury from stored charge, and protecting the capacitors from damage at turn-on and turn-off.

Figure 2 illustrates a sample hold-up circuit with sets of series - parallel capacitors, using four capacitors of the same value. The total holdup capacitance, C_Holdup is equal to the total value of Capacitance in the circuit. Using four capacitors also provides margin for the capacitor breakdown voltage when used with high value of Vin.

In addition, for this circuit a resistor (R_limit) is used to limit in-rush current during hold-up capacitor charging. A typical value for R_limit is around 50 ohms.

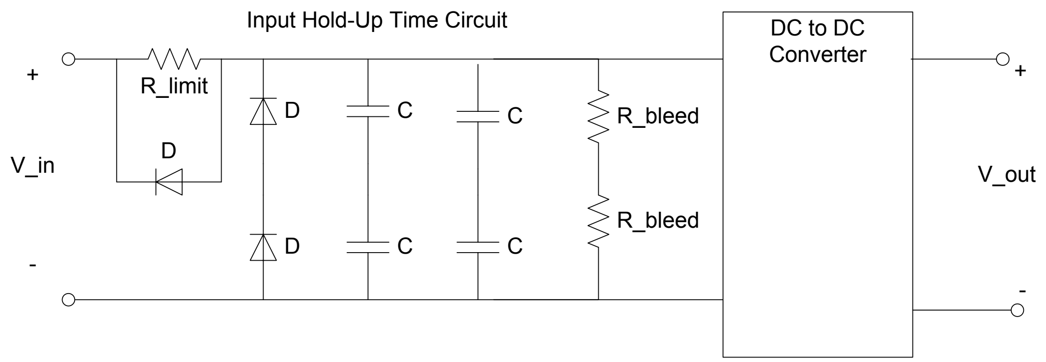

Figure 2: External Hold Up Time on Input

External hold up time circuit connected to output DC to DC converter

When the input of the converter is not accessible, the circuit in Figure 3 can be used to increase the hold-up time. At turn-on, Q1 is off and C2 is not connected to the output. When the voltage at C1 reaches the threshold of Q1, C2 starts to charge slowly towards VO. Q1 is a low RON N channel MOSFET and R1 D1 is optional for discharging C1. If R1 D1 is used, the R1 C1 time constant must be much greater than R2 C1. Also the discharge R1 C1 time constant must be much greater than the required hold-up time.

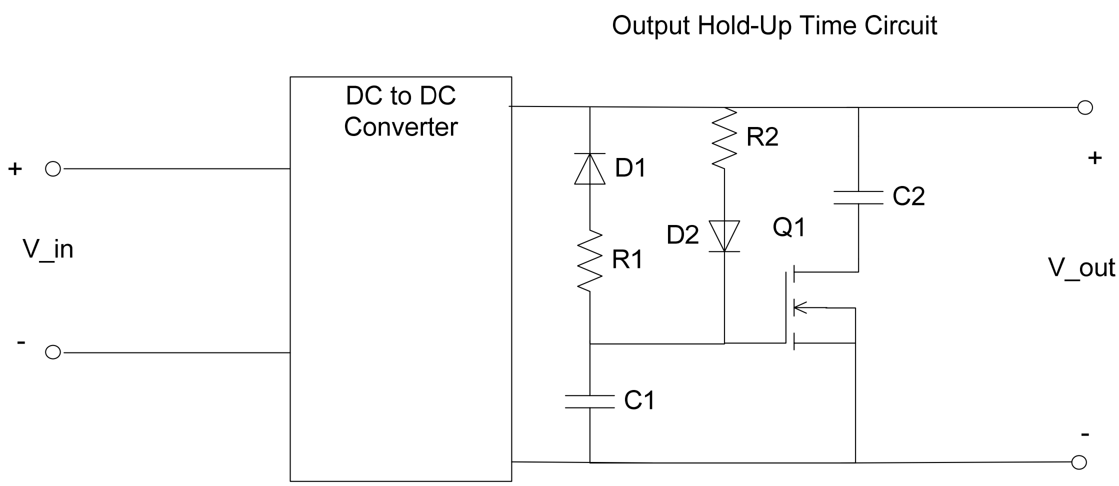

Figure 3: External Hold Up Time on Output