

Supply Voltage Drop on Fast Current Demand

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ABSTRACT

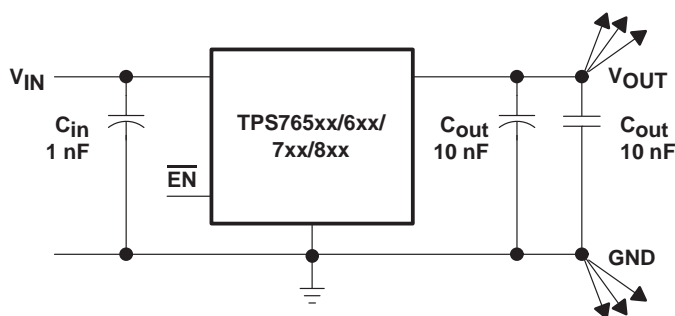
The simplest way to supply an electronic system with a continuous and stable voltage is to use a linear voltage regulator. This application brief provides recommendations to prevent additional voltage drop across a linear voltage regulator on fast current demand.

Design Problem

The linear voltage regulator should have an input voltage at least equal to the output voltage plus the drop out voltage (voltage difference between input and output). The technology used for this kind of regulator has been continuously progressing in the last twenty years. From bipolar technology with 2 V drop then 0.6 V, the use of MOS technology results in only as few as 10 mV, the latest generation of LDOs (Low Drop Out) like TPS765/6/7/8xx. This results in a lower input voltage of the voltage regulator as well as less power dissipation. Therefore the lifetime of a system is extended, especially when the system is portable or battery powered. Existing very high-speed components like DSPs that are working at more than 100 MHz demand high-speed surge current (current slope in a range of one or two nanoseconds) from a voltage regulator. To avoid output voltage variation on fast current demand, attention should be given to filtering capacitors.

Solution

To avoid output oscillation, the existing low drop out linear voltage regulators require an output capacitor with a low equivalent serial resistor (ESR). The output capacitor should be split in two parts, one in the range of above 10 μF (to prevent instability) and the other in the range of a few nanoFarads (to buffer short current spike).



The output capability to supply very fast load current is dependent on the voltage regulator as well as the output capacitors.

An output capacitor of 10 nF can buffer short current spikes. The formula: $CV = It$ gives $\Delta V = I \Delta t / C$ and allows to calculate the voltage loss for a short current pulse. For example: with 200 mA load current during 3 ns will have only 60 mV voltage loss for 10 nF.

A 10 μF capacitor is able to supply continuous current, but due to the serial parasitic inductor cannot supply spike current for a short time, so a Tantalum capacitor is recommended due to its smaller parasitic serial resistor; 200 mA load current during 3 ms will have only 60 mV voltage loss for 10 μF .

At turn on, the response time will be affected by the output capacitor value. Increasing the capacitor from 10 μF to 10,000 μF will increase the output voltage rise time by a factor of 1000. The rise time would be from around 100 μs to 100 ms.

To avoid voltage losses the layout must be done with large trace for the V_{in} , V_{out} and ground. The output capacitors must be placed as close as possible to the voltage regulator output pin. To allow the same voltage reference for all circuits, the output connection from the output capacitor to the different loads must be done in star configuration.

To prevent short input voltage switch-off, an additional large size input capacitor can be used with a serial diode between the input voltage supply and the capacitor. 1000 μF with 200 mA load current during 3 ms would maintain the input voltage with only 0.6 V voltage loss.

A thermal evaluation has to be done to be sure that the voltage regulator will be able to dissipate the power without exceeding a 150°C junction temperature. The maximum junction temperature is calculated by adding the maximum ambient temperature T_A to the package junction to ambient thermal resistor multiplied by the power dissipation $R_{\text{thja}} \times (V_{\text{in}} - V_{\text{out}}) I_{\text{out}}$.

The selection of a linear voltage regulator as well as the appropriate filtering capacitors, and the optimum printed board layout are important to get good response time with short load current demand.