

Understanding Startup Surge Current With MSK's RH1573 Based Rad Hard LDO Regulators.

By Paul Musil, MS Kennedy Corp.; 09/2009

The MSK5800RH, 5810RH, 5820RH, 5821RH, 5822RH, 5823RH, 5824RH, 5825RH, 5826RH, 5827RH, 5950RH, and 5951RH are part of the growing line of MS Kennedy's radiation hardened regulators built around Linear Technology's RH1573 radiation hardened controller IC. Each regulator in the series utilizes the same basic power stage design. There are differences in the support circuitry and packaging to tailor the individual regulators for a wide variety of application needs.

During startup the feedback circuit senses the output is well below the programmed value and demands maximum current from the PNP pass transistor. To do this the RH1573 must sink the maximum available current through the base of the pass transistor to ground. The maximum base current is the maximum or saturated drive pin current of the RH1573 minus the current passing through the resistor between the base and emitter of the pass transistor. The saturated drive current is approximated with the following equation.

$$I_{\text{Drive}} = (V_{\text{IN}} - V_{\text{BE}} - V_{\text{DSAT}}) / R_{\text{D}}$$

Given

V_{IN}	=	The input source voltage measured at the regulator VIN pin
V_{BE}	=	The base to emitter voltage of the PNP pass transistor
V_{DSAT}	=	The RH1573 drive pin saturation voltage
R_{D}	=	The value of the resistor between the RH1573 drive pin and the base of the PNP pass transistor

NOTE : The maximum base current is the saturated drive current minus approximately 12 mA.

V_{BE} and V_{D} both change with current and temperature. R_{D} is trimmed during production to set the current limit. V_{IN} is controlled at the system level by the end user. The individual data sheets provide typical saturated drive current graphs to aid in determining the minimum current capacity required from the input source to insure proper start up. The graphs are mathematical approximations based on nominal values of V_{BE} , V_{DSAT} and R_{D} and should be used as a guide only.

Figure 1 shows the startup current waveform for the MSK5810RH and the MSK5800RH configured for $V_{\text{OUT}} = 3.3\text{V}$ and operated under the same conditions. It is clear that the MSK5800RH requires much less start up surge current than the MSK5810RH. This is expected since the MSK5800RH is designed for lower current output. The five distinct parts of the startup waveform shown in figure 1 are explained below.

1. From T_0 to T_1 the input power supply is starting to rise but the circuit is not yet active. The input current is mostly charging the input capacitors.

2. At T_1 the input voltage is greater than V_{BE} and $V_{D_{SAT}}$ and it is high enough to power up the RH1573 the pass transistor saturates and the current spikes to charge the output capacitors until the output voltage comes up to V_{IN} minus the saturation voltage of the pass transistor. This spike is the sum of the current charging the output capacitors, the current charging the input capacitors, the saturated drive current and the load current.
3. At T_2 the input current decreases because output capacitors have charged up to V_{IN} minus the saturation voltage of the pass transistor. From T_2 to T_3 the current is still supplying the same functions as it did between T_1 and T_2 but the output capacitors are charging much more slowly. This is the absolute minimum current required from the source to ensure startup.
4. At T_3 The output comes into regulation and the input continues to rise. From T_3 to T_4 the bulk of the input current is going directly to the load. Some additional current is still charging the input capacitors as the input continues to rise and a few mA are used for bias power.
5. At T_4 the input voltage levels off and the current draw is simply the load current plus a few mA for bias power.

It is important to note that the charging current requirements for the input and output capacitors will vary directly with the rise time of the input power source. If the input power source limits below the current required between T_2 and T_3 the input source voltage may sag below the minimum required to bring up the output voltage and the system will hang in a current limited state with low output voltage. If the system provides greater than this current but less than the peak of the T_1 to T_2 spike the output capacitors will charge more slowly but the system will start up. In cases where the input power source can adequately supply the load and bias requirements but can not supply the start up surge requirements it is still possible to start the system by fully charging the input capacitors with the regulators disabled then enabling the regulator. If this method is used the input capacitors must be large enough to supply the full start up charge without the voltage sagging below the programmed output voltage plus the dropout voltage.

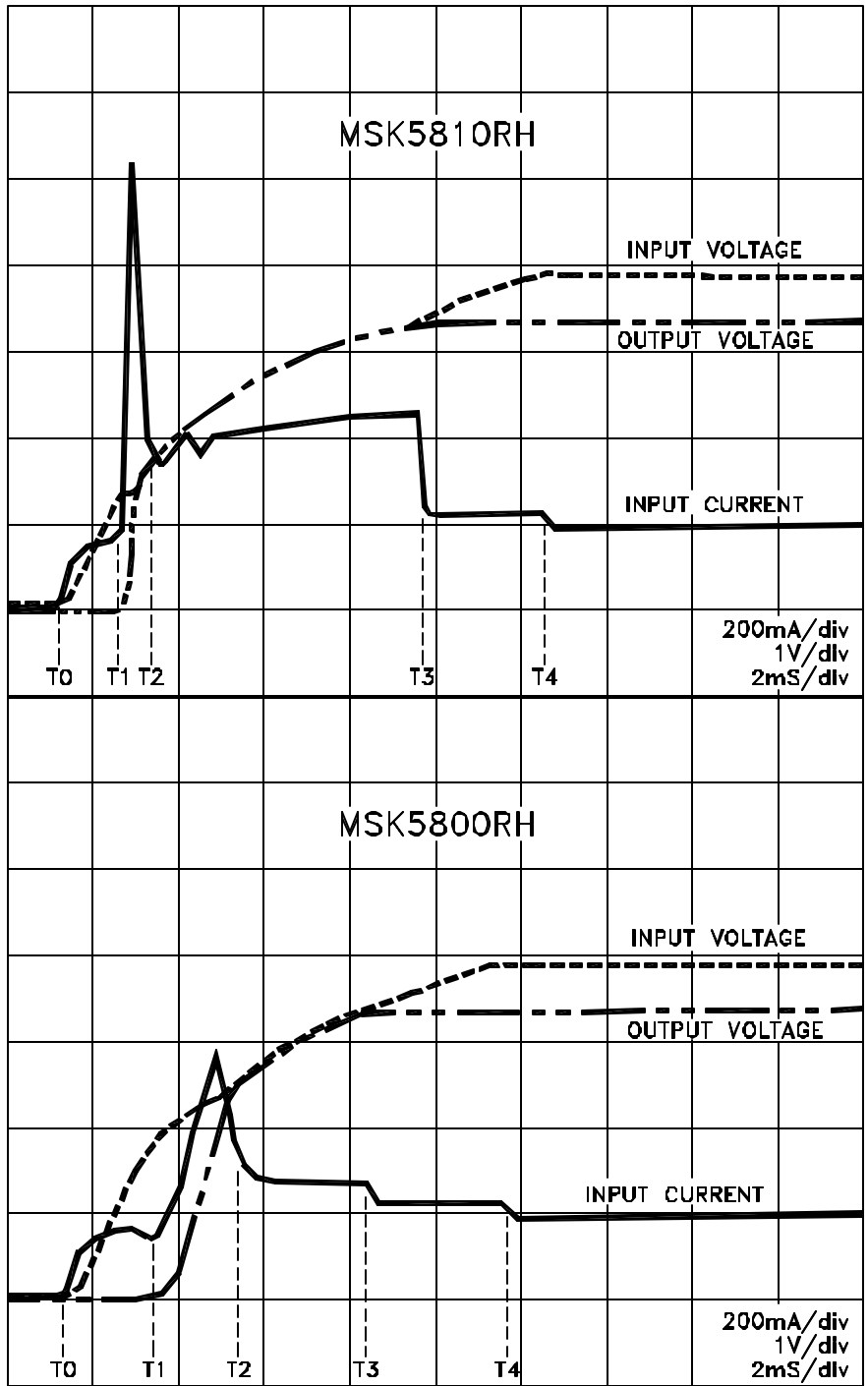


Figure 1