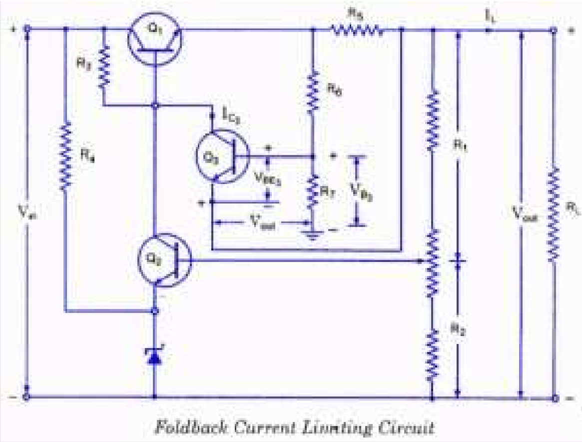
Foldback Current Limiting

A problem with the simple current limiting circuit is that there is a large amount of power dissipation in the series pass transistor Q_1 when the regulator remains short-circuited. This foldback current-limiting circuit is the solution of the above problem.



Foldback Current Limiting Circuit

The circuit of a transistor series voltage regulator with foldback current limiting is illustrated in the figure. In this circuit, the base of transistor Q_3 is biased by a voltage divider network consisting of resistors R_6 and R_7. The load current I_L flows through resistor R_5, causing a voltage drop of $I_L R_5$ across it. Thus a voltage of $(I_L R_5 + V_{out})$ acts across the voltage divider ($R_6 – R_7$) network. The voltage applied to the base of transistor Q_3 is equal to the voltage drop across resistor R_7 and is given as

$$V_{B3} = [R_7 / (R_6 + R_7]) (I_L R_5 + V_{out}) = K(I_L R_5 + V_{out}) \qquad [1]$$

where $K = R_7 / (R_6 + R_7)$ **[2]**

The emitter of transistor Q_3 is connected to the positive terminal of V_{out}. Applying Kirchhoff's voltage law to closed mesh of Q_3 shown in the figure we have

$$V_{out} + V_{BE3} = V_{B3} \qquad [3]$$

or $V_{BE3} = V_{B3} – V_{out} = K (I_L R_5 + V_{out}) – V_{out} = K I_L R_5 - (1-K) V_{out}$ **[4]**

The magnitude of base drive of transistor Q_1 is controlled by V_{be3} of transistor Q_3 . If the load resistance R_L decreases, the load current I_L will increase, causing voltage drop $I_L R_5$ to increase. This causes V_{B3} to increase and therefore V_{be3} to increase. This makes transistor Q_3 begin to conduct. The increased collector current I_{C3} of transistor Q_3 flows through the resistor R_3 thereby decreasing the base voltage of transistor Q_1. This results in reduction of the conduction level of transistor Q_1, limiting further increase in load current I_L. Using the base-emitter saturation voltage V_{BE3} = 0.7 volts, the maximum current is

$$I \; \boldsymbol{I_{Lmax} = [\, 0.7 + (1\text{-}K)\, V_{out} \,] \,/\, KR_5} \qquad [5]$$

<u>Example for non-foldback current limiting</u>

For R_5 = 1 ohm and K = 1, I_{Lmax} = 0.7 amps (independent of V_{out})

<u>Example for foldback current limiting</u>

For R_5 = 1 ohm, V_{out} = 5 volts, and K = 0.7, I_{Lmax} = 3.1 amps.

For R_5 = 1 ohm, V_{out} = short circuit, and K = 0.7, I_{Lshort} = 1.0 amps.

Check the actual I_{Lmax} and I_{Lshort} by varying R_5 and bench test it.

One final note. In Eq [4], for I_L=0, $\boldsymbol{V_{BE3} = -\,(1\text{-}K)\, V_{out}}$. Thus the base emitter junction is reverse biased when the load current is zero. The V_{EBO} rating of most transistors is very low, sometimes about 5 volts. A properly placed diode can protect this junction.

==================

Adapted from http://www.circuitstoday.com/category/power-supplies/page/2

By Bob S 12/26/2010