

Figure 2-5 A 3-terminal regulator.

Without a heatsink the junction temperature will be:

$$T_j = P_D \cdot R_{\theta JA} + T_{A(max)} = (1.75 \text{ W})(65^\circ\text{C/W}) + 50 \\ = 163.75^\circ\text{C}.$$

A small “clip-on” style heatsink is required to bring the junction temperature down to below its maximum ratings.

Refer to Appendix A for aid in the selection of heatsinks.

Selecting the heatsink—Thermalloy P/N 6073B

Given in heatsink data: $R_{\theta SA} = 14^\circ\text{C/W}$

Using a silicon insulator $R_{\theta CS} = 65^\circ\text{C/W}$

The new worst case junction temperature is now:

$$T_{j(max)} = P_D(R_{\theta JC} + R_{\theta CS} + R_{\theta SA}) + T_A \\ = (1.75 \text{ W})(5^\circ\text{C/W} + 65^\circ\text{C/W} + 14^\circ\text{C/W}) + 50^\circ\text{C} \\ = 84.4^\circ\text{C}$$

2.3.2.2 Three-Terminal Regulator Design Variations

The following design examples illustrate how 3-terminal regulator integrated circuits can form the basis of higher-current, more complicated designs. Care must be taken, though, because all of the examples render the overtemperature protection feature of the 3-terminal regulators useless. Any overcurrent protection must now be added externally to the integrated circuit.

The current-boosted regulator

The design shown in Figure 2-6 adds just a resistor and a transistor to the 3-terminal regulator to yield a linear regulator that can provide more current to the load. The current-boosted positive regulator is shown, but the same equations hold for the boosted negative regulator. For the negative regulators, the power transistor changes from a PNP to an NPN. Beware, there is no overcurrent or overtemperature protection in this particular design.

The current-boosted 3-terminal regulator with overcurrent protection

This design adds the overcurrent protection externally to the IC. It employs the base-emitter (0.6 V) junction of a transistor to accomplish the overcurrent

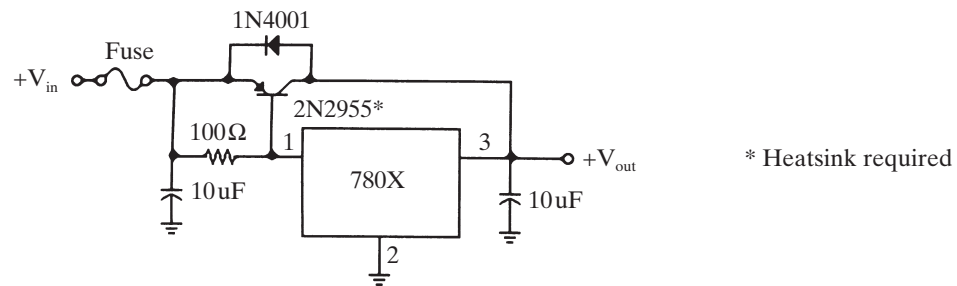


Figure 2-6 Current-boosted 3-terminal regulator without overcurrent protection.

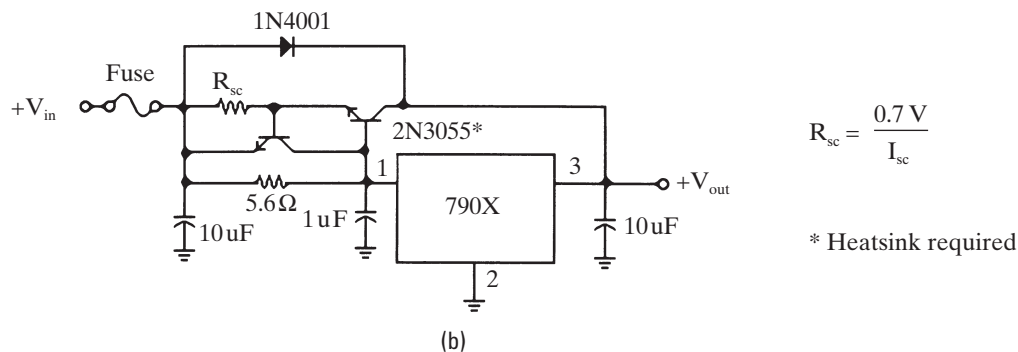
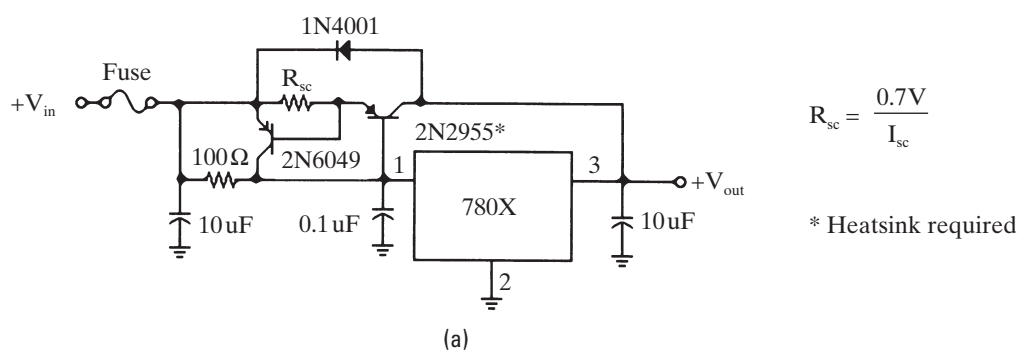


Figure 2-7 (a) Positive current-boosted 3-terminal regulator with current limiting.
(b) Negative current-boosted 3-terminal regulator with current limiting.

threshold and gain of the overcurrent stage. For the negative voltage version of this, all the external transistors change from NPN to PNP and vice versa. These can be seen in Figures 2-7a and b.

2.3.3 Floating Linear Regulators

A floating linear regulator is one way of achieving high-voltage linear regulation. Its philosophy is one in which the regulator controller section and the series-pass transistor “float” on the input voltage. The output voltage regulation is accomplished by sensing the ground, which appears as a negative voltage when referenced to the output voltage. The output voltage serves as the “floating ground” for the controller and the power for the controller and series-pass transistor is drawn from the headroom voltage (the input-to-output difference) or is provided by an auxiliary isolated power supply.

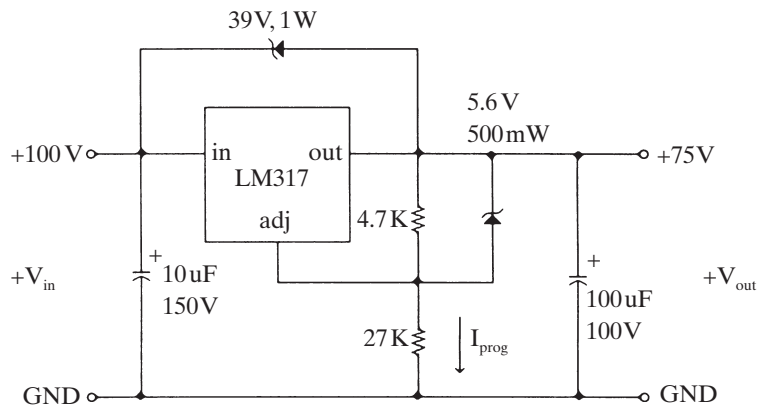


Figure 2-8 A high voltage floating linear regulator.

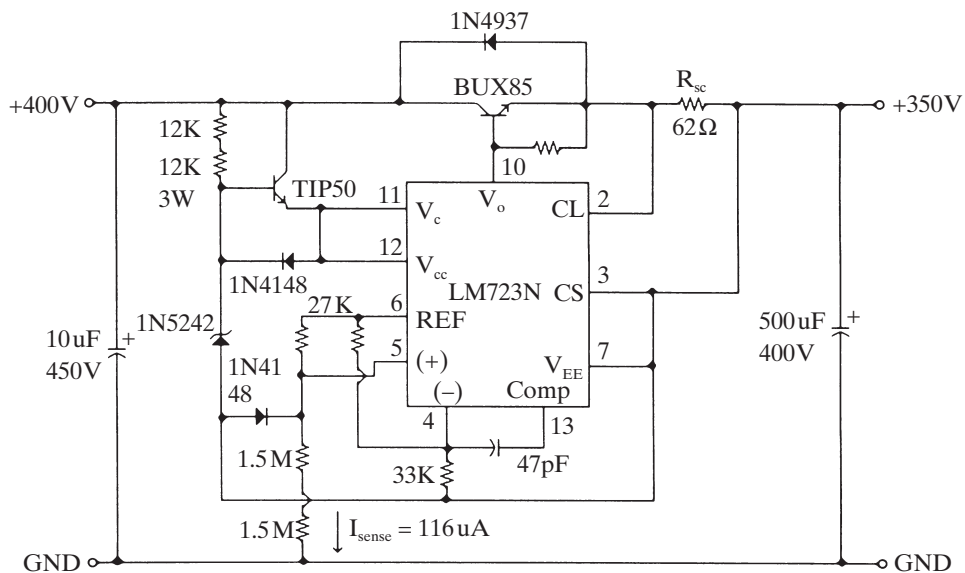


Figure 2-9 A 350 volt, 10 mA floating linear regulator.

The power transistor still needs to have a breakdown voltage rating greater than the input voltage, since at start-up, it must see the entire input voltage across it. Other methods such as a *bootstrap Zener diode* can also be used in order to shunt the voltage around the pass transistor, but only when the input voltage itself is switched on and off to activate the power supply. Also, caution must be taken to ensure that any controller input or output pin never goes negative with respect to the floating ground of the IC. Protection diodes are usually used for this purpose. One last caution is the little-known breakdown voltage of common resistors. If the output voltage exceeds 200V, more than one sensing resistor must be placed in series in order to avoid the 250V breakdown characteristic of 1/4W resistors.

A common low-voltage positive floating regulator is the LM317 (the negative regulator complementary part is the LM337). The MC1723 can also be used to create a floating linear regulator, but care must be taken to protect the IC against the high voltage.

An Introduction to the Linear Regulator

The first example shows how an LM317 can be modified to create a 70 V linear regulator from a 100 V input voltage. Several design restrictions must be strictly followed, for example, the operational headroom voltage must not exceed the voltage rating of the bootstrap Zener diode or regulation will be lost. Also the use of the protection diode on the error amplifier is mandatory. This regulator can be seen in Figure 2–8.

The second example illustrates a 350 V floating linear regulator that can provide up to 10 mA of load current from a 400 to 450 V unregulated source. The TIP50 provides the bias supply for the controller, which must withstand the full input voltage during start-up and power supply foldback. The controller is “grounded” on the output voltage and the minimum headroom voltage is 15 V. To readjust the output voltage, one changes the value of the two series resistors in the voltage sensing branch and this is set by

$$R_{\text{sense}} = (V_{\text{out}} + 4.0\text{V}) / I_{\text{sense}} \quad (2.4)$$

Floating linear regulators are particularly suited for high-output voltage regulation, but may be used anywhere. This regulator can be seen in Figure 2–9.