Build A High Performance Voltage Regulator From Discrete Components

By N1HFX

While integrated circuits have become a staple of all modern circuit designs, it is still possible to build circuits without IC's and still achieve a high level of performance. The circuit in Figure 1 is a high performance 5 volt voltage regulator built using discrete components that are readily available. I have used no IC's and I have even substituted a 1N4001 in lieu of a zener diode. The regulator output voltage varies by a mere .4% and has current limiting at 1.5 amps along with short circuit protection. With the exception of thermal shutdown, this circuit closely matches the performance of the 7805 5 volt regulator IC.

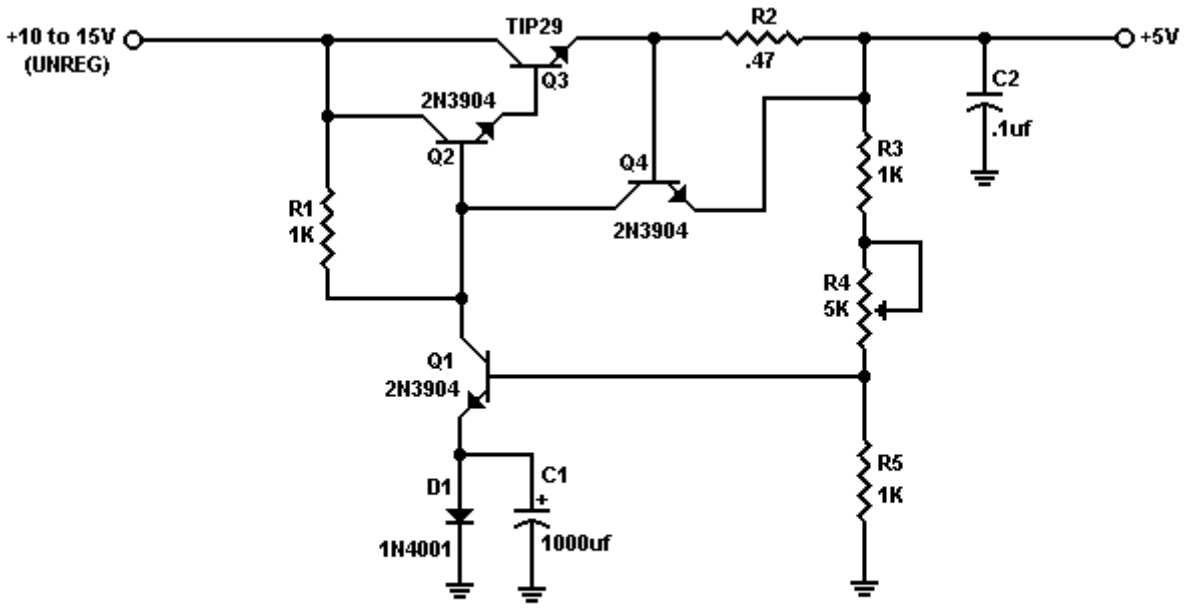

Figure 1

To understand how this circuit works, remember that the voltage across diode D1 is exactly .7 volts. Capacitor C1 prevents the voltage from changing due to sudden increases in the load current. The main reason that the voltage across D1 is so constant is because the current going through it never varies by more than 1/2 milliamps. Transistor Q1 is a negative feedback amplifier which keeps the voltage across R5 a constant 1.4 volts. These slight changes in load current seen by Q1 are amplified by transistors Q2 and Q3. The majority of the current flows through Q3, the main pass transistor, which must be heat sinked. Resistors R3, R4 and R5 form the voltage divider which determines the output voltage. Resistor R3 is not really needed but is included to prevent damage to the circuit in the event that R4 is accidentally adjusted to zero ohms. Transistor Q4 and Resistor R2 provide current limiting at about 1.5 amps. When the voltage drop across the base and emitter of Q4 reaches .7 volts, this transistor turns on and effectively shuts off pass transistors Q2 and Q3. The voltage drop across R2 has no effect on the output voltage. Capacitor C2 bypasses the output of the regulator to prevent oscillations.

This circuit can be adjusted as a 12 volt regulator by adjusting R4 to the desired output voltage. The input voltage must be at least 18 volts and should not be greater than 25 volts. If you plan to use this circuit as a 12 volt regulator, increase resistor R1 to 2.2K for best performance. The circuit will still limit at 1.5 amps regardless of the output voltage setting. All resistors used in this circuit are ¼ watt except for R2 which must be at least a 2 watt

type or larger. Almost any general purpose NPN transistor can be substituted for the 2N3904 transistors used in this circuit. Any similar TO220 type NPN switching transistor can be used for Q3. If desired, a zener diode can be substituted for D1 but the voltage should be at least 2 volts lower than the desired output voltage. Use of a zener diode may require that resistors R3 and R4 be decreased accordingly.

While it usually makes more sense to use IC's for voltage regulator applications, this circuit has great educational value for those interested in how these circuits work.

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