

How to Use DC Voltage Regulators

Solid state voltage regulators are inexpensive. They are available in many sizes and shapes for a wide variety of applications. Experimenters and radio amateurs are often confused about how to use voltage regulators safely and correctly. This is because little has been published about the hands-on use of these popular ICs. Furthermore, there is frequent indecision about which terminal is which among the various voltage regulator package styles (TO-92, TO-204, TO-3 and TO-220). This article provides the basic knowledge required for putting regulators to work in your electronics projects.

Why Use Regulators?

Most solid-state equipment is designed for a fairly narrow range of dc operating voltage. Excessive supply voltage can destroy transistors and ICs quickly. Too low a supply voltage can render the circuit inoperative or cause faulty performance. Therefore, it is desirable to use a power supply that delivers a fixed value of voltage that conforms to the manufacturer's specifications.

Voltage regulators are important in ac-operated power supplies as well as in dc power supplies. For example, some radio

equipment is designed for +6- or +9-volt operation. Mobile operation with this type of gear requires reducing the car's ignition voltage from 13.6 to 6 or 9 volts. A simple voltage regulator makes this possible at low cost. Furthermore, voltage regulators function as electronic filters to ensure a nearly pure dc output that would otherwise require many thousands of microfarads of capacitance to achieve. Regulators are available for positive or negative voltage control, depending upon the builder's needs.

Fixed-Voltage Regulators

Voltage regulators are available for fixed-value or variable dc output. The smaller ones (in TO-92 plastic cases) can handle up to 100 mA of current, whereas the larger ones (in TO-220 or TO-204 cases) may be rated at 1.5 amperes. Figure 1 shows the pinout (lead identification) for the various case styles. Please note that the metal cases or metal tabs are common to certain inner elements of these ICs. Keep this in mind when you mount your regulator on a metal chassis or heat sink: Prevent causing destructive short circuits! Some regulators must be separated from ground by means of mica insulators and nylon shoulder washers.

Figure 2A shows a basic fixed-voltage regulator that will deliver +5, +6, +8 or +12 volts, depending upon the regulator IC used at U1. These are standard output voltages for non-adjustable regulators. The dc input voltage to U1 must always exceed the output voltage in order to obtain the desired regulation. As a rule of thumb, the input voltage should be at least 1.33 the output voltage. Thus, you should use at least 16 dc input volts for a 12-volt regulator, and so on.

Beware of excessive input voltage because it can ruin the IC or cause destructive power dissipation and heating. The greater the input voltage the larger the heat-sink area required to keep the IC from overheating and shutting itself down. Voltage regulators have built-in shut-down circuits that protect them from excessive heat and current.

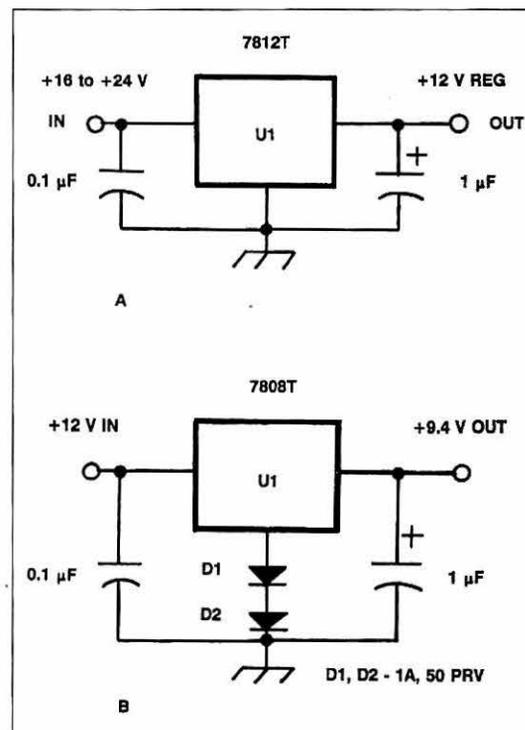


FIGURE 2: Shown at A is the circuit for a basic fixed-voltage regulator. U1 is selected for the desired output voltage and current. Drawing B shows how to use diodes to increase the IC output voltage.

Figure 2B illustrates a method for increasing the output voltage from a fixed-voltage regulator. One or more silicon rectifier diodes are inserted between the IC ground lead and circuit ground. The barrier voltage for a silicon diode is 0.7, so one diode would raise the output voltage by that amount. Two diodes would increase the output by 1.4 volts. In this manner we can, for example, cause an 8-volt regulator to provide 9.4 volts at its output port.

Variable-Voltage Regulator

Various regulator ICs are available for use in variable-voltage dc power supplies. This type of supply is especially handy in the experimenter's workshop. A practical power supply might have an adjustment range of 1.2 to 45 volts at 1.5 ampere. However, most experimenters prefer a voltage range of 1.2 to 24 or 28. An LM317T regulator makes this

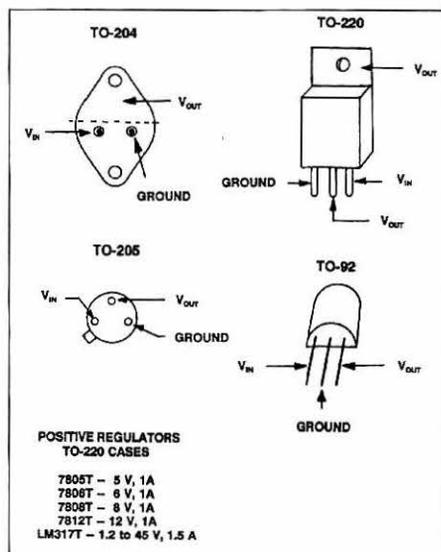


FIGURE 1: Terminal connections and case styles for voltage common regulators.

possible. A practical circuit is presented in Figure 3.

It is important to understand that the lower the power supply output voltage the lower the available current from the IC. This is because the regulator must dissipate greater power within itself, owing to the higher input-output voltage ratio. Therefore, a 1.5-ampere regulator will not deliver its maximum current as the output voltage is lowered. For example, the available current is roughly 600 mA at 3 volts output, 1 A at 9 volts output and 1.2 A at 12 volts output when using an LM317T.

R1 in Figure 3 should be rated at no less than 1/4 watt, and preferably at 1/2 watt or greater in order to ensure R1 longevity. This potentiometer may be replaced by a single-pole multiposition wafer switch and fixed-value resistors of the appropriate ohmage for obtaining specific output voltages, such as 1.5, 5, 6, 9 and 12. A potentiometer would be used first to determine how much resistance is required for each voltage level, as indicated by an ohmmeter.

Regulator Protection

Two rectifier diodes and a 10- μ F capacitor may be added to a typical three-terminal voltage regulator to protect it from potentially damaging voltage spikes that can occur when high values of capacitance are used before and/or after the regulator. D1 and D2 in Figure 3 (optional) will prevent damage to the IC when installed as shown. Since the diodes are inexpensive and readily available it is wise to include them when you build your regulator circuit.

Capacitors C1 and C2 in Figure 3 prevent the regulator IC from self-oscillating at low frequencies. Oscillation prevents proper operation of the IC and can transmit unwanted spurious energy into the equipment that is powered by the regulator.

Heat Sinks

Although a heat sink (large metal surface that draws heat away from the IC) may not be necessary at low values of current flow, it is prudent to include one. The greater the current taken from the regulator, the more intense the internal heating and the larger the required heat-sink area or mass. Silicone heat-sink grease (thin layer) should be used between the IC body or metal tab and the heat sink in order to ensure maximum heat transfer. The surface

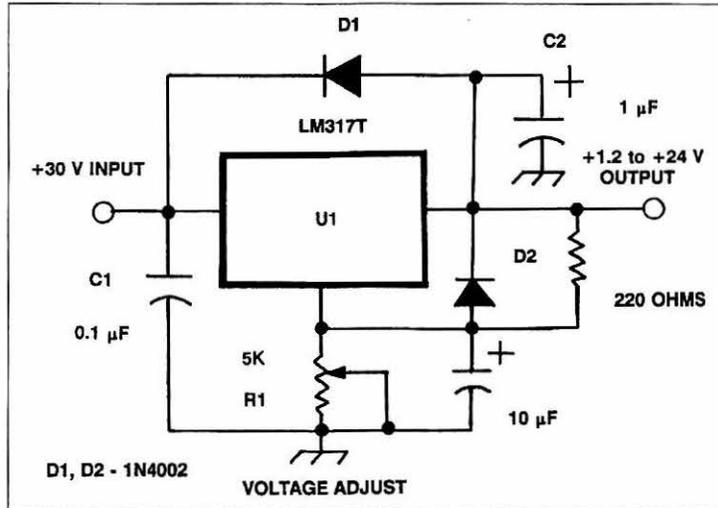


FIGURE 3: Circuit for a standard variable-voltage regulator that provides +1.2 to +24 volts at up to 1.5 A. The unregulated dc input voltage is +30. Lower values of input voltage may be used if less than 24 volts of output is desired. Fixed-value resistors and a multiposition switch can be used in place of R1 to obtain preset output voltages (see text). Optional diodes D1 and D2, along with the 10- μ F capacitor, are optional. The diodes protect U1 against voltage spikes (see text).

of the heat sink should be smooth where it contacts the IC.

Closing Remarks

Voltage regulators, diodes and the other components for voltage regulator circuits are widely available at modest cost from the vendors of surplus electronics parts. Most surplus fixed-voltage, 1-A regulators sell for

\$1 or less. The voltage-variable, 1.5-A regulators are in the \$3.50 price class.

Any regulated or unregulated dc power supply can be used to supply voltage to the regulators discussed here. The requirement is only that the power supply have higher output voltage than will be delivered by the regulator. A regulator is recommended when you use a dc-output wall transformer.

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