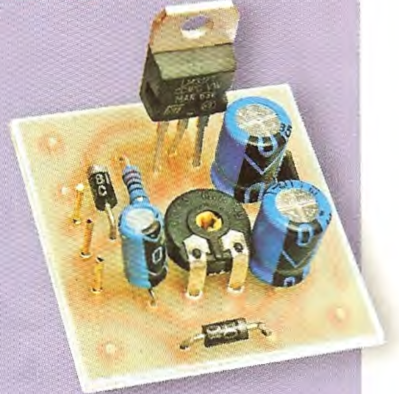
Adjustable 1.3V to 22V Regulated Power Supply

Want a regulated voltage that can be adjusted to suit your application? This Adjustable Power Supply is small, easy-to-build and can be adapted to produce a fully regulated voltage ranging from 1.3V to 22V, at currents up to 1A.



By JOHN CLARKE

THERE are many fixed-voltage IC regulators available, and these can be had with 5V, 6V 8V, 9V, 12V and 15V outputs. But what if you want a voltage output that does not fit into one of the standard ranges, or if you want to be able to easily adjust this output voltage? An adjustable regulator is the answer – one that can be set to provide the exact voltage you require.

This Adjustable Power Supply comprises a small PC board that utilises a 3-terminal voltage regulator. It does not have too many other components – in fact, there are just three diodes, three capacitors, a resistor and a trimpot to set the output voltage from the regulator.

Circuit details

The full circuit diagram for the Adjustable Regulated Power Supply is shown in Fig.1. REG1 is an LM317T 1.5A adjustable voltage regulator that provides a nominal 1.25V between its OUT and ADJ (adjust) terminals.

We say it is a 'nominal 1.25V' because, depending on the device, it can be anywhere between 1.2V and 1.3V. This doesn't really matter though, because we can adjust the output voltage to the required level using the trimpot.

Note: if you do want a regulator that provides a better tolerance for the 1.25V reference, then you could use an LD1117V instead. This has a 1.238-1.262V range. However, do not apply more than 15V to the input of this regulator.

Output voltage

The output voltage from REG1 is set by the 110Ω resistor (R1) between the OUT and ADJ terminals and by the resistance between the ADJ terminal and ground (0V). This works as follows.

By using a 110Ω resistor and assuming an exact 1.25V reference, the current flow is set at 11.36mA. This is calculated by dividing the voltage between the OUT and ADJ terminals (1.25V) by the 110Ω resistor. This current also flows through trimpot VR1.

Parts List

- 1 PC board, code 698, available from the *EPE PCB Service*, size 35 × 38mm
- 1 LM317T adjustable 3-terminal voltage regulator (REG1)
- 3 1N4004 1A diodes (D1-D3)
- 2 100mF 25V PC electrolytic capacitors (C1,C3)
- 1 10mF 25V PC electrolytic capacitor (C2)
- 1 110W 0.25W 1% resistor (R1)
- 1 2kW horizontal trimpot (VR1)
- 4 PC stakes
- 1 T0-220 semiconductor insulating kit

This means that if VR1 is set at say 1kΩ, then the voltage across this resistor will be 1kΩ x 11.36mA, or 11.36V. This voltage is then added to the 1.25V reference to derive the output voltage – in this case 12.61V.

In practice, however, the current flow out of the ADJ terminal also contributes slightly to the final output voltage. This current is of the order of 100µA. So, if VR1 is set to 1kΩ, this can add 0.1V to the output – ie, we get 12.71V.

If you are interested in the output voltage equation, then it is:

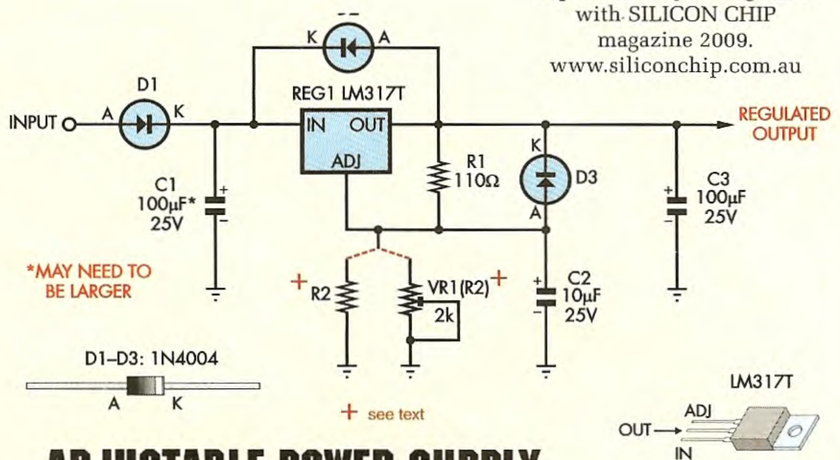
$$V_{OUT} = V_{REF}(1 + R1/R2) + (I_{ADJ} \times R2)$$

where V_{OUT} is the output voltage, V_{REF} is the voltage between the OUT and ADJ terminals, and I_{ADJ} is the current out of the ADJ terminal (typically 50µA, but can be as high as 100µA). R1 is the resistance between the OUT and ADJ terminals, while R2 is the resistance between the ADJ terminal and ground (0V).

Protection

Diode D1, in series with the input, provides reverse polarity protection. This means that if you connect the supply voltage around the wrong way, you cannot do any damage.

Diode D2 protects the regulator should the input become shorted to ground. If that happens, D2 becomes forward biased and conducts, effectively preventing any reverse current



ADJUSTABLE POWER SUPPLY

Fig.1: the circuit is based on an LM317T adjustable voltage regulator. D1 provides reverse polarity protection, while VR1 sets the output voltage.

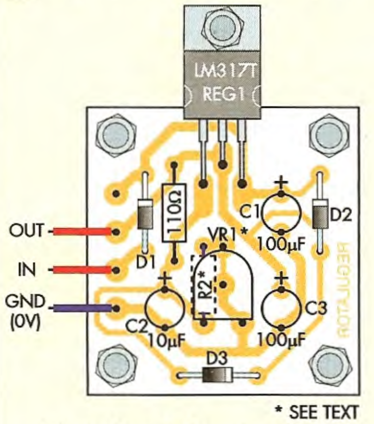


Fig.2: here's how to install the parts on the PC board.

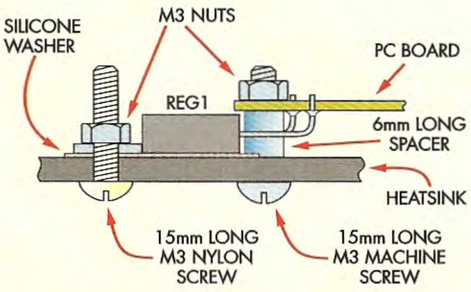


Fig.3: regulator REG1 can be mounted underneath the PC board and attached to a heatsink, as shown here. Note that its metal tab must be isolated from the heatsink using a TO-220 silicone washer and a nylon screw.

flow through REG1, which could cause damage.

Diode D3 is also included to protect REG1. It does this by clamping the voltage between the ADJ terminal and the OUT and IN terminals in the event that one of the latter is shorted to ground (0V).

Finally, capacitors C1 and C2 reduce ripple by bypassing the IN (input) and ADJ terminals respectively. Capacitor C3 prevents regulator oscillation by swamping any low-value capacitance that may be connected to this output.

Construction

All parts for the Adjustable Power Supply are mounted on a PC board, code 698, measuring just 35×38mm. This board is available from the *EPE PCB Service*. The circuit board component layout is shown in Fig.2 and the PCB copper foil master in Fig.4. As usual, begin construction by checking the PC board for any shorts between copper tracks or open circuits and make any necessary repairs.

You can now begin the assembly by installing the 110Ω resistor (R1) and the three diodes, making sure the latter are all oriented correctly (the banded ends are the cathodes (K)). That done, capacitors C1 to C3 can be installed, again taking care with their orientation since they are all electrolytic types.

Next, install PC stakes for the IN, OUT and GND terminals, then install trimpot VR1. Regulator REG1 can also be mounted. It can either be mounted on the top of the PC board (as shown in the photo) or underneath, as shown in Fig.3, so that it can be fastened to a heatsink.

Heatsinking

Whether or not you need a heatsink for REG1 depends on the output current and the voltage between the IN and OUT terminals of the regulator. That's because these two values together determine the power dissipation within the regulator. It's determined simply by multiplying the two values together to get the power dissipation in watts – ie, $P = VI$.

Generally, if the dissipation is less than 0.25W, no heatsink will be required. For example, if the current drawn from the regulator is 50mA and the voltage between the IN and OUT terminals is 5V, then the dissipation will be 0.25W and no heatsink will be necessary.

However, if the dissipation is more than this, you will need to fasten the regulator to a heatsink to keep it cool. For example, let's say that the current drawn from regulator REG1 is 250mA and that the voltage across it is 5V. In this case, the dissipation will be 1.25W (ie, 5 × 0.25) and a heatsink will be necessary.

Heatsink temperature

The type of heatsink required depends on the amount of power dissipated by the regulator and the temperature rise that can be tolerated. Typically, a 20°C rise in heatsink temperature is acceptable because this means that at a typical room temperature of say 25°C, the heatsink will run at 45°C which is quite tolerable.

Most heatsinks are specified by their temperature rise in °C per watt (°C/W). This means that a 10°C/W heatsink will rise 20°C above ambient when dissipating 2W. Note that the LM317T TO-220 package is rated at 15W maximum power dissipation.

Isolation

Usually, it will be necessary to electrically isolate the tab of the regulator from the heatsink – see Fig.3. The reason for this is that the heatsink may be connected to ground (0V), while the regulator metal tab sits at the output voltage.

To isolate the tab, use a TO-220 silicone insulating washer and secure the assembly to the heatsink using an M3 *nylon* screw and nut. Alternatively, you can use a metal screw provided you fit an insulating bush into the regulator tab fixing hole.

Note that capacitor C1 may need to be increased in value if the input voltage has a lot of ripple. In addition, you should make sure that the input

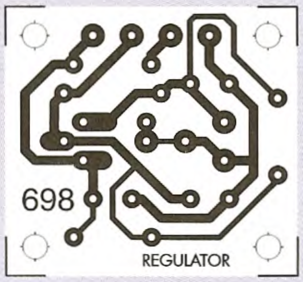


Fig.4: this is the full-size etching pattern for the PC board. Check your board for defects before mounting any of the parts.

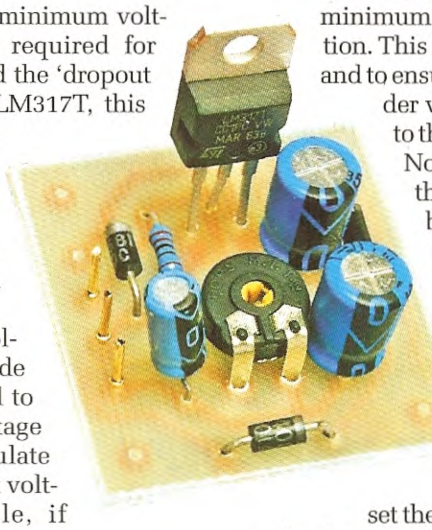
voltage does not go above C1's 25V rating. Increase C1's 'working' voltage rating to 35V if it does.

In fact, you can apply up to 35V to the input if C1 is a 35V type.

Adjusting the output

Note that the voltage applied to the supply must be several volts higher than the required output voltage. This is necessary in order for the regulator to provide regulation.

In practice, the minimum voltage across REG1 required for regulation is called the 'dropout voltage'. For the LM317T, this voltage varies with the current and is typically 1.5V for currents below 200mA, rising to 1.7V at 500mA and 2V at 1A.



Note that the voltage drop across diode D1 must be added to the dropout voltage in order to calculate the required input voltage. For example, if our power supply draws 200mA and the required output voltage is 6V, then the input voltage must be 6V plus 0.7V (to compensate for the voltage across D1) plus 1.5V (for the dropout voltage) – ie, the input voltage must be 2.2V higher than the output voltage.

Therefore, we need to apply 8.2V minimum to the input for regulation. This is the absolute minimum and to ensure correct regulation under varying loads, a 9V input to the supply would be ideal.

Note also that any ripple on the input supply that drops below the required voltage will cause problems, since the supply will not be regulated during these low-going excursions. Once you've connected the supply, it's just a matter of adjusting trimpot VR1 to set the required output volt

Finally, note that in some applications, you might want to replace VR1 with a fixed resistor (eg, if VR1's setting is close to a standard fixed value). This has been catered for on the PC board – just replace VR1 with resistor R2 (shown dotted).