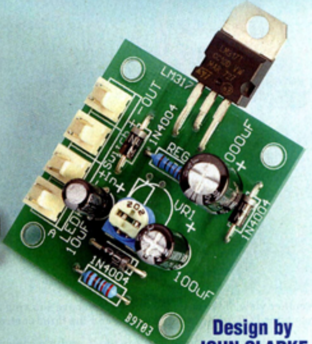
For those times when a fixed regulator is not suitable. . .

MiniReg 1.3-22V adjustable regulator



Design by JOHN CLARKE

This compact regulator PCB can be used to produce a fully regulated DC supply ranging from 1.3V to 22V at currents up to 1A. Depending on how much current you need, it can fit into tiny spaces and is easily connected with 2-pin headers for DC input, DC output, an on/off switch and a LED.

There are many fixed-voltage IC regulators available such as those with 5V, 6V 8V, 9V, 12V & 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?

The MiniReg is the answer: it can be set to provide the exact voltage you require. It's based on an LM317T 3-terminal regulator. The PCB has only a few other components: three diodes, three capacitors, two resistors and a trimpot to set the output voltage from the regulator.

Circuit details

Fig.1 shows the circuit details. The LM317T adjustable regulator 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 VR1.

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.

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.

This means that if VR1 is set to a value of 1kΩ, then the voltage across this resistor will be 1kΩ x 11.36mA or 11.36V. This voltage is then added to the 11.25V reference to derive the output voltage – in this case 12.61V.

In practice, 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.

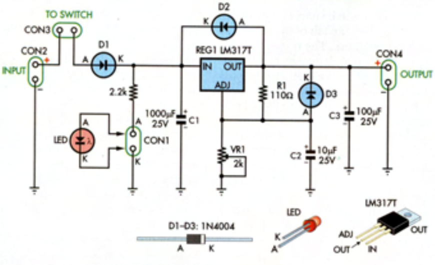
If you are interested in the output voltage equation, then it is:

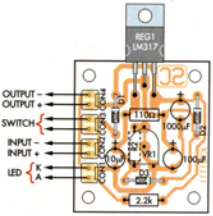
$$V_{OUT} = V_{REF}(1 + R1/R2) + I_{ADJ} \times R2$$

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 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.

Diode D1 in series with the input provides reverse polarity protection.





SC MINIREG ADJUSTABLE SUPPLY

Fig.1 (left): the circuit diagram of the MiniReg, along with Fig.2 (above) – the PCB component overlay. Note the provision for a fixed resistor (R2) instead of VR1, if required.

This means that if you connect the supply voltage around the wrong way, you cannot do any damage.

Diode D2 protects the regulator if the input becomes shorted to ground while it is powered up. Without D2, current would attempt to flow back from the output capacitor through the regulator to the shorted input and that could kill it. But D2 becomes forward biased and conducts, effectively preventing any reverse current flow through REG1.

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

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

Construction & options

All the parts for the MiniReg are mounted on a 35 x 38mm PCB, coded 18112111. Fig.2 shows the parts layout. This shows an identical component layout to the PCB in the photo but there is nothing to stop you from making a few changes. For example, do you want to use a conventional potentiometer to vary the output voltage, rather than using the on-board trimpot?

No problem: just omit the trimpot and wire up the external potentiometer in the same way.

Or do you want to use a 12V LED bezel instead of LED1? Again, no problem; especially if your DC input voltage is reasonably close to 12V. In that case, replace the 2.2kΩ resistor with a wire link and wire the 12V LED to the 2-pin header for the LED.

Similarly, you might want to omit the on/off switch. In this case, just install a 2-pin shorting link on the 2-pin header for the switch.

Assembling the PCB is not likely to take very long. You can begin by installing the 110Ω resistor (R1) and the three diodes, making sure the latter are all oriented correctly (the banded ends are the cathodes). Then capacitors C1-C3 can be installed, again taking care with their orientation since they are all electrolytics.

Next, install the four 2-pin headers. You will need to make up four matching cables with 2-way polarised header connectors. We discuss how to make these later.

The 3-terminal regulator can then be mounted. It can either be mounted on the top of the PC board (as shown in the photo) or underneath it, so that it can be fastened to a heatsink.

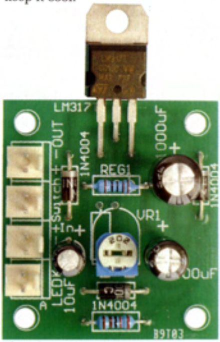
Do you need a heatsink?

Whether or not you need a heatsink for REG1 depends on how much power it is likely to dissipate.

The output current and the voltage between the IN and OUT terminals of the regulator are the critical values. 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 about 0.5W or 500 milliwatts, no heatsink will be required. For example, if the current drawn from the regulator is 100mA and the voltage between the IN and OUT terminals is 5V, then the dissipation will be 0.5W and no heatsink will be necessary.

However, if the dissipation is more than this or if it is installed in in a small, enclosed space, you will need to fasten the regulator to a heatsink to keep it cool.



This photo of the completed PCB is deliberately over-size for clarity, so you can see exactly what goes where. Note the resistor (R2) shown on the PCB under/adjacent to VR1 is in case you want to substitute a fixed resistor to give you a specific output voltage.

Parts List – MiniReg

- 1 PCB, 35 x 38mm, code 18112111
- 4 2-way polarised pin headers, 0.1in spacing (with matching leads – see below)
- 1 LM317 variable voltage regulator
- 3 1N4004 power diodes
- 1 LED (any colour)
- 1 1000µF 25V electrolytic
- 1 100µF 25V electrolytic
- 1 10µF 25V electrolytic
- 1 110Ω 0.25W resistor
- 1 2.2kΩ 0.25W resistor
- 1 2kΩ PC-mount trimpot
- (Heatsink, silicone insulator, etc if needed)

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 x 0.25) and a heatsink *will* be necessary.

The type of heatsink required depends on the wattage dissipated by the regulator and the temperature rise that can be tolerated.

Typically, a 20°C rise in heatsink temperature is OK because this means that at a typical room temperature of say 25°C, the heatsink will run at 45°C, which is quite acceptable.

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.

Usually, it will be necessary to electrically isolate the tab of the regulator from the heatsink. The reason for this is that the heatsink may be connected to ground, while the regulator 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.

Note that capacitor C1 may need to be increased in value if the input voltage has a lot of 100Hz ripple.

In addition, you should make sure that the input voltage does not go above C1's 25V rating. Increase C1's voltage rating to at least 35V if it does. In fact, you can apply up to 35V to the input if C1 is a 35V type.

Making up connecting leads

As noted above, you will need to make up four cables with polarised 2-way header connectors. We show how to do these in the panel below.

Adjusting the output

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

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 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 voltage across D1) plus 1.5V (for the dropout voltage), ie, the input voltage must be at least 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.

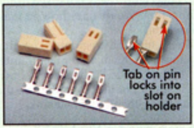
Once you've connected the supply, it's just a matter of adjusting trimpot VR1 to set the required output voltage.

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

Making up the polarised header connector leads

You can buy ready-made header leads but they are not particularly easy to find. It's usually much quicker and cheaper to buy the bits and make up your own, even if it is fiddly!

The connector terminals are usually supplied in a strip, as shown at right – these need to be separated by either individually cutting them off or bending back and forth until they break off.



These terminals, when completed, slide into the connector housing and have a small tab which prevents them coming out again (so get it right the first time!).

Before you make up the connectors, take a note of which way around your terminals need to go – most of the time, they are polarised and the connector only fits on the header pins one way.

Making up the leads is not difficult but it is a bit fiddly. It's easiest to do one pin at a time.

(1) Strip all the ribbon lead ends for the number of connectors required – it's best done with a wire stripper to get them nice and even.

(2) Crimp the bare wires into the connector using a pair of fine pliers. Make sure no loose strands of wire are left out.

(3) Solder the wires in place. It's a belt'n'braces approach but it does ensure that you don't have any wires separating later on.

(4) Using your fine pliers, push the connector into the housing, noting which way is up and which way gets the right polarity. If you do have to remove it, push the tab with a fine needle.