

USB Power Injector

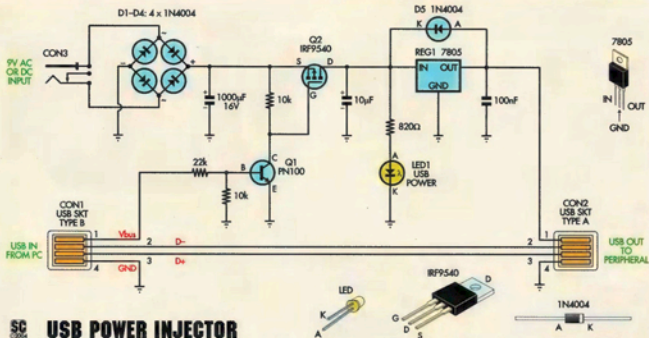
By JIM ROWE

Do you have a new USB-powered peripheral like a scanner that needs more power than can be drawn from the socket on your PC or USB hub? Here's a little gadget that will solve your problem. It allows you to feed extra power into the USB line, controlled automatically by the PC – so your new peripheral will be turned on and off just as if it were being powered directly by the PC.

EACH USB SOCKET of a PC or self-powered USB (Universal Serial Bus) hub can supply up to 500mA at 5VDC, which can be used to power many USB peripherals directly. That's one of the advantages of USB and many of the newer peripherals are designed to be powered in this way.

Many low-cost USB hubs are also designed to take their own power from the PC, via their "upstream" USB cable. That's fine in most cases, as the hub's internal circuitry only needs a few tens of milliamps to operate.

However, things start to get a little more complicated if you try to connect a number of bus-powered USB peripherals to your PC via such a hub, because the hub's "downstream" output sockets can each only supply a maximum of 100mA. That's because



SC 2004 USB POWER INJECTOR

Fig.1: the USB Power Injector is essentially a switch and a 5V regulator. The V_{bus} supply from USB socket CON1 turns on transistor Q1 which then turns on Mosfet Q2. This then feeds unregulated DC to REG1 which in turn supplies 5V to the downstream USB socket CON2.

all of their power must ultimately come from the PC itself, of course.

What happens if you have one of these hubs already powering say, three USB powered peripherals and then you buy a USB-powered scanner or label printer that needs to draw more than 100mA? Ah, that is a problem. Luckily it's easily solved; all you need is the USB Power Injector described here. It's designed to be connected in series with the USB cable to your new peripheral and also to a 9V AC or DC plugpack.

When it detects 5V DC coming from the PC and/or hub, it switches power from the plugpack through to a built-in 5V regulator, to provide your new peripheral with its own 5V power at up to 500mA.

All of the components used in the USB Power Injector are mounted directly on a very small PC board, which fits snugly inside a small jiffy box.

How it works

Looking at the circuit diagram of Fig.1, power from the external plugpack comes in via socket CON3 and then passes through diodes D1-D4. These provide rectification for an AC plugpack or automatic polarity

correction for a DC plugpack. Either way, a DC voltage of between 8V and 14V (or thereabouts) appears across the 1000µF reservoir capacitor.

CON1 is a USB "Type B" socket, used as the Injector's "upstream" or input port. It connects back to one of the USB output/downstream ports of your PC or hub, via a standard USB cable. Both of the data lines of CON1 are connected directly to the corresponding pins of CON2, a USB "Type A" socket which is the Injector's output/downstream port. This connects to your new USB peripheral via another standard USB connecting cable, so the Injector is fully transparent in terms of USB data communication. USB data can pass straight through the Injector in either direction, between PC and peripheral and vice-versa.

When the PC is powered down though, power from the plugpack is not able to flow through to the peripheral because P-channel power MOSFET Q2 is connected in series and it is normally turned off. When the PC is turned on, +5V appears at pin 1 of CON1 and this switches on transistor Q1 via a 22kΩ base resistor. Q1 then switches on Q2, which becomes a very low resistance, about 0.1Ω.

This feeds the unregulated DC voltage across the 1000µF capacitor through to REG1, a 7805 +5V regulator which now provides +5V to pin 1 of CON2 and your peripheral devices.

LED1 is used to provide "power on" indication. LED1 is fed via the 820Ω series resistor from the switched DC at the input to REG1, so it's only illuminated when the Injector's power is switched on by Q2.

The 10µF and 100nF capacitors are included to ensure stable operation of REG1, while diode D5 is to protect it from reverse-voltage damage when the power is turned off.

Although REG1 has very little heat-sinking, it should be able to power virtually any USB-powered peripheral which draws no more than the maximum drain of 500mA.

Construction

All the components used in the USB Power Injector (apart from the plugpack) are mounted directly on a small PC board. This measures 76 x 46mm and is coded 07110041.

The artwork (Fig.3) for the PC board has rounded cutouts in each corner, allowing it to fit snugly in one of the smallest UB-5 jiffy boxes (83 x 54 x

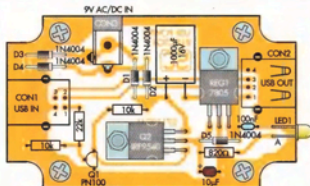


Fig.2: follow this component overlay to assemble the PC board. Don't get Q2 and REG1 mixed up - they look the same!

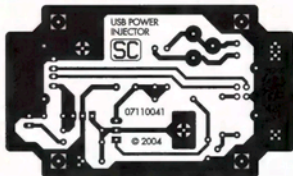


Fig.3: check your PC board carefully against this full-size etching pattern before installing any of the parts.

31mm). It's supported inside the box by four 9mm long M3 tapped spacers, using four countersink 6mm x M3 screws through the bottom of the box and another four round-head 6mm

x M3 screws through the PC board itself.

Rectangular holes are cut in the narrow ends of the box to provide access to the two USB connectors (CON1 and CON2), while a 3mm round hole is drilled in the end next to CON2, to allow LED1 to protrude. Similarly, a 9mm hole is drilled in one of the longer sides of the box, to allow access to power input connector CON3. The locations of all box holes are shown in Fig.4.

The component overlay diagram for the PC is shown in Fig.2 and you can cross-check this with the internal photo.

Fit the low-profile resistors and diodes first, taking care with the diode

polarity as usual. Then fit the capacitors, taking care with the polarity of the 10µF and 1000µF capacitors. Note that the larger capacitor mounts over on its side, to make sure there is clearance between it and the box lid - see photograph below.

Next, fit the three connectors. The two USB connectors are different in terms of their pin layout, so make sure you fit them in their correct positions. You may need to elongate the holes for their attachment lugs slightly with a jeweller's file, before the connectors will fit down against the board.

The last components to fit are the TO-92 transistor Q1, LED1 and the two TO-220 devices Q2 and REG1. Make sure you don't swap the latter

Parts List

- 1 PC board, code 07110041, 76 x 46mm
- 1 plastic utility box, UB-5 size (83 x 54 x 31mm)
- 1 USB socket type B, PC-mount (CON1)
- 1 USB socket type A, PC-mount (CON2)
- 1 2.5mm concentric LV power socket (CON3)
- 4 M3 tapped spacers, 9mm long
- 6 M3 x 6mm machine screws, round head
- 4 M3 x 6mm machine screws, countersink head

Semiconductors

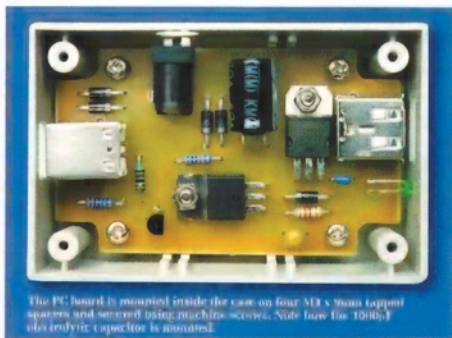
- 1 7805 5V regulator (REG1)
- 1 PN100 NPN transistor (Q1)
- 1 IRF9540 P-channel MOSFET (Q2)
- 1 3mm green LED (LED1)
- 5 1N4004 diodes (D1-D5)

Capacitors

- 1 1000µF 16V PC electrolytic
- 1 10µF 25V tantalum
- 1 100nF (0.1µF) multilayer monolithic (code 104 or 100n)

Resistors (0.25W 1%)

- 1 22kΩ
- 2 10kΩ
- 1 820Ω



The PC board is mounted inside the case on four M3 x 9mm tapped spacers and secured using machine screws. Note how the 1000µF electrolytic capacitor is mounted.



The power indicator LED protrudes through a hole in the end of the case, adjacent to the USB output socket (CON2).

devices, as this may cause one or both of them to be damaged. Both devices mount flat down against the top of the board, with a 6mm x M3 machine screw and nut used to hold them down and also provide a small amount of heatsinking.

Make sure also that you fit LED1 with its "flat" side towards connector CON2 and its longer anode lead further away. The LED leads are soldered in place with the body about 11mm above the board and they are then bent down at right angles about 4mm above the board, so the body can protrude through the matching hole in the end of the box.

Once you have made the necessary holes in the UB-5 box (including the countersunk holes in the bottom, for the PC board mounting screws), the completed board assembly can be mounted in the box using the 9mm M3 tapped spacers.

Checkout time

There are no adjustments or setup needed on the completed USB Power Injector and very little in the way of testing. All you need do is connect the output of a 9V DC or AC plugpack to CON3 and confirm that indicator LED1 doesn't light until you also connect CON1 to a downstream USB port on your PC or USB hub.

If the LED then turns on and off when the PC is itself turned on and off, this confirms that it's working cor-

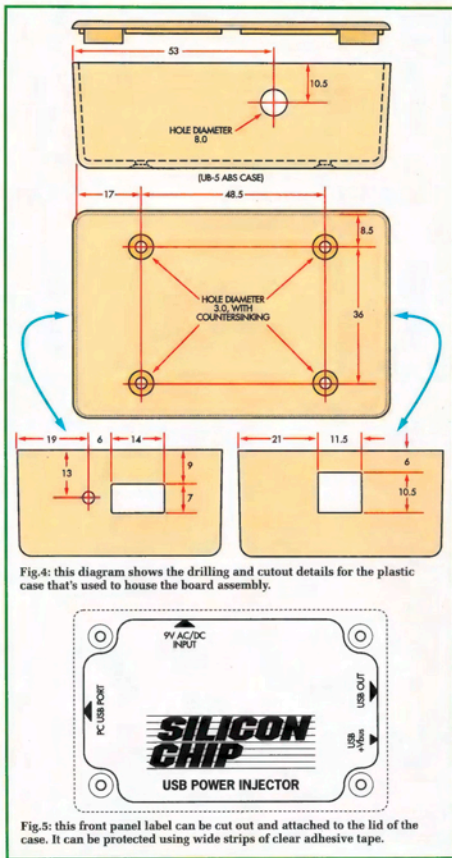


Fig.4: this diagram shows the drilling and cutout details for the plastic case that's used to house the board assembly.

Fig.5: this front panel label can be cut out and attached to the lid of the case. It can be protected using wide strips of clear adhesive tape.

rectly. All that remains is to screw on the lid of the UB-5 box and fit the cover plugs – although you might also want

to stick on a dress label as well, to finish the job. The artwork for a suitable label is shown in Fig.5. **SC**