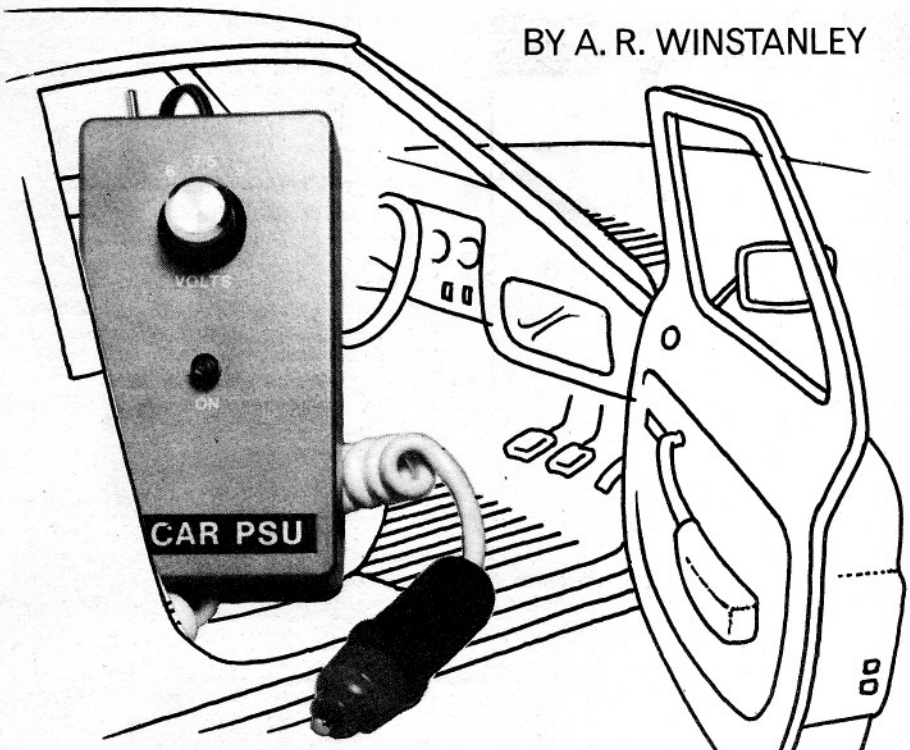


IN-CAR P.S.U.

BY A. R. WINSTANLEY

ONE of the more economical methods of providing music in the car, apart from singing to oneself, is to take along a portable cassette recorder which operates from its own dry batteries. Obviously if a long journey is envisaged then it is often a good idea to carry several spare batteries for the cassette recorder as well!

The main problem of course is that cassette recorders seem to have a voracious appetite for dry cells. It would be more desirable to operate the unit from the car battery, thereby saving the recorder's own batteries for use in and around the house. However, as the car battery is normally rated at 12V, this is not immediately possible. Some sort of adaptor is required which converts the 12V of the car's electrical system to that needed by the cassette recorder. Most cassette recorders operate from either 6V or 7·5V and draw between 400 and 500mA maximum.

The In-Car P.S.U. described here is such an adaptor. Apart from providing 6 or 7·5V, it will also give 9V d.c., the three voltages being available at the touch of a switch. With a maximum current rating of 2·2A (but see later), not only will it operate cassette recorders, but other devices as well — torches, lanterns, battery shavers and radios to mention but a few.

Virtually the only requirement is that the device to be powered from the In-Car P.S.U. must have an appropriate socket fitted to enable the d.c. supply to be connected to the apparatus. With many cassette recorders, for example, this presents no problem.

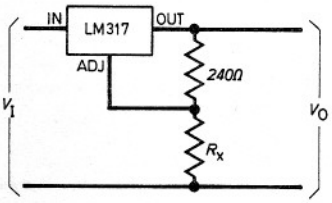


Fig. 1. The LM317T in basic voltage regulator configuration.

The circuit itself is quite simple and straightforward. This is because a modern easy-to-use integrated circuit has been used as the basis of the design. The i.c., a three-terminal variable voltage regulator type LM317T, is shown in its basic configuration in Fig. 1.

It can be seen that the three terminals are named *input, output* and *adjustment*. A 240 ohm reference resistor is normally placed between output and adjustment, and across this resistor exists a precision 1·2V reference voltage. By varying the value of R_x, a resistor placed between adjustment and ground, the output voltage may be altered. In fact, using a 240 ohm reference resistor, the value of R_x is given by the formula

$$R_x = (200 \times V_o) - 240 \text{ ohms}$$

where V_o is the output voltage in volts. To obtain 6, 7·5 and 9V output voltages therefore we require values of R_x to be 960, 1260 and 1560 ohms respectively.

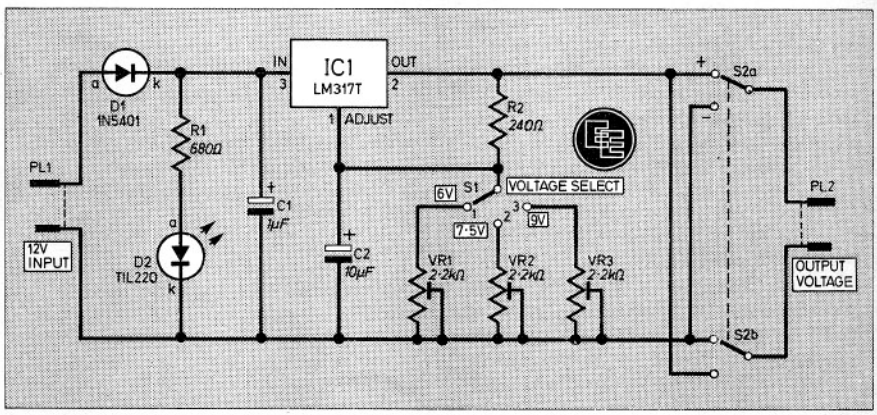
The maximum current available is 2·2A, but this will depend on the temperature and power dissipated by the i.c. The device, incorporates thermal overload shutdown and internal current limiting and is available in several packages. It is the TO-220 encapsulation (LM317T) that is employed in this design.

CIRCUIT DESCRIPTION

The complete circuit diagram is shown in Fig. 2. S1 is a one-pole three-way rotary switch which selects different values of R_x (Fig. 1) thereby enabling 6, 7·5 or 9V to be obtained. Note that three preset resistors in Fig. 2 replace R_x in Fig. 1; these are trimmed so that exact output voltages can be obtained. This does mean however that a voltmeter will be required to measure the output voltages during setting up.

D2 is a light-emitting diode which illuminates when the unit is operating. R1 is its associated series resistor which limits the forward current

Fig. 2. The complete circuit diagram of the In-Car P.S.U.



COMPONENTS

Resistors
R1 680Ω
R2 240Ω
Both ½W carbon ±5%

See Shop Talk page 233

Capacitors
C1 1μF 16V or greater tantalum bead
C2 10μF 16V tantalum bead

Semiconductors
D1 1N5401 3A rectifier
D2 TIL220 or similar red l.e.d.
IC1 LM317T adjustable voltage regulator i.c. (TO-220 case)

Miscellaneous
S1 single-pole three-way rotary
S2 miniature d.p.d.t. toggle
VR1-VR3 2·2kΩ miniature carbon preset (3 off)
PL1 two-pole plug to suit car (for example a plug to suit the car cigar/cigarette lighter socket)
PL2 two-pole plug to suit equipment (Spider or Universal—see text)
Printed circuit board, 61 × 27mm; case type BIM 5004/14, diecast aluminium, size 121 × 66 × 40 with p.c.b. guides (see text); lens clip for D2; insulating bush and mica washer for IC1 (TO-220 kit); knob; grommets (2 off); 6BA fixings for IC1.

through the l.e.d. to a reasonable level—about 15mA.

C1 is a tantalum bead capacitor placed across the input to eliminate transients and noise which often are present on the car 12V supply rail. C2 bypasses the adjustment terminal to ground to improve the ripple rejection of the i.c. D1 is a heavy-duty rectifier which protects the circuit from accidental reversed polarity.

CONNECTORS

The 12V input connection to the unit was made, on the prototype, with a twin-core curly lead terminated in a cigar-lighter plug: this enabled the unit to be connected quickly and easily into the car cigar-lighter socket.

The form of connector can be varied to suit one's need. For example, a dashboard-mounting two-pin non-reversible connector is available from motor accessory shops and this could be used if a cigar lighter is not available.

The output connector can also be altered to meet requirements. To achieve maximum versatility however, it is recommended that a 4-way "spider" or universal connector is used. This comprises a 2·5mm and 3·5mm jack plug, together with a 2·1mm and 2·5mm power plug moulded onto the end of a twin-core lead. This means that the unit can power almost every type of apparatus which has the usual forms of external power sockets fitted.

The one remaining problem relates to the polarity of the P.S.U. output. The author's radio/cassette recorder requires a 2·1mm power plug with the tip at 0V and the "body" of the plug at +6V. It is likely however that other loads may require a reversed polarity to this, with the tip of the plug positive and the "body" negative.

S2 has been included in the output to switch over the polarity of the spider plug as necessary. This switch needs to have a heavy action on the operating lever to prevent the switch being accidentally knocked over whilst the unit is in operation. A reversed voltage polarity with some devices could have dire results!

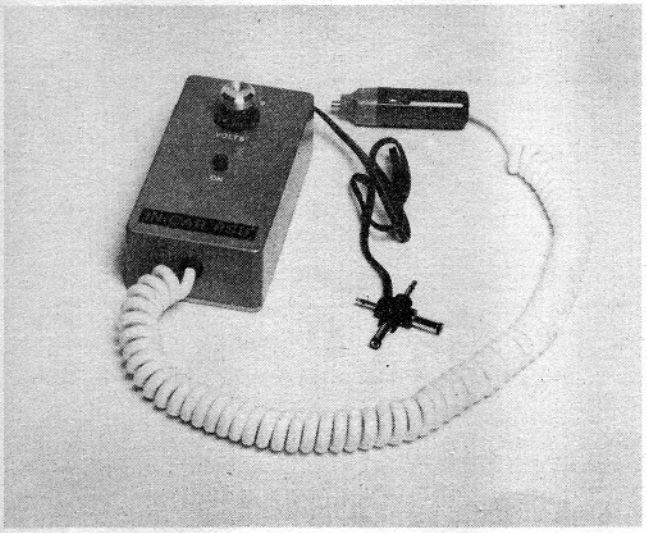
CONSTRUCTION starts here

PRINTED CIRCUIT BOARD

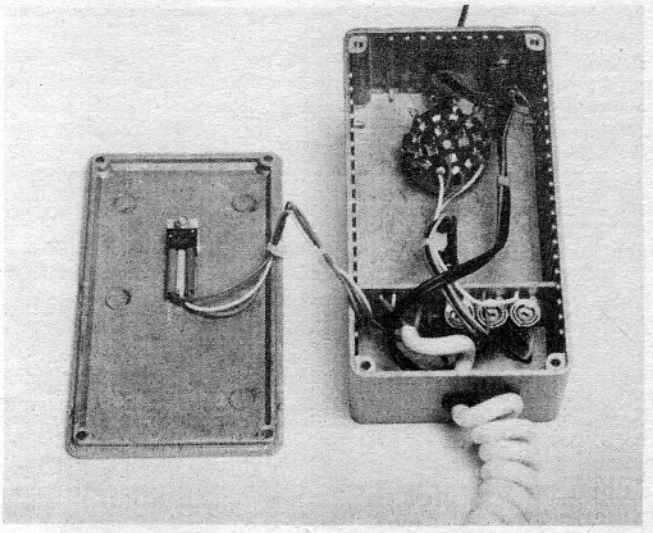
The circuit, with the exception of IC1, is constructed on a glass-fibre printed circuit board measuring 61×27mm. The unit is built into a diecast Bimbox type 5004/14 measuring 121×40×66mm. The dimensions of the p.c.b. are such that it can slide directly into the p.c.b. guides formed on the inside of the specified case, thus eliminating any requirements for p.c.b. mounting pillars.

If another metal case is used then it is necessary that the p.c.b. is mounted in a different manner. Probably 8BA mounting hardware can be used here. A full size master pattern

The finished unit ready for use in the car. You can see the "universal" or "spider" connector.



In the final stages of assembly, the prototype with lid removed showing in particular the p.c.b. inserted in a slot and the i.c mounted to the lid.



IN-CAR P.S.U.

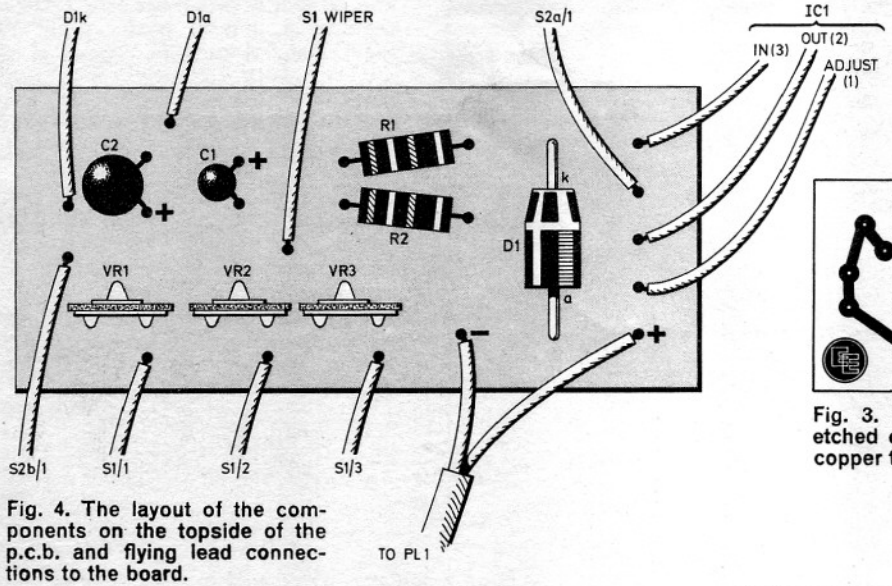


Fig. 4. The layout of the components on the topside of the p.c.b. and flying lead connections to the board.

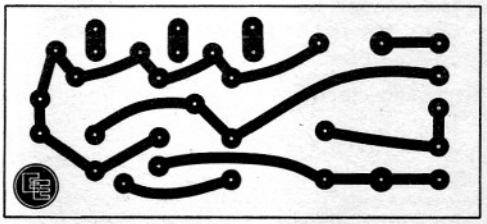


Fig. 3. Full-size master of the pattern to be etched on the board. Black regions denote the copper to remain after etching.

COMPONENTS
approximate cost £10·50

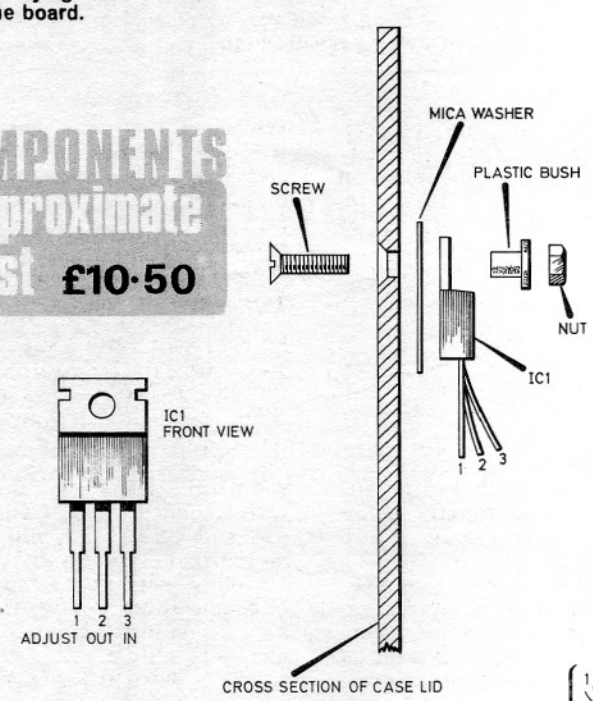
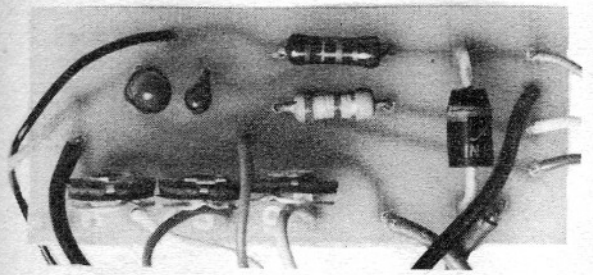
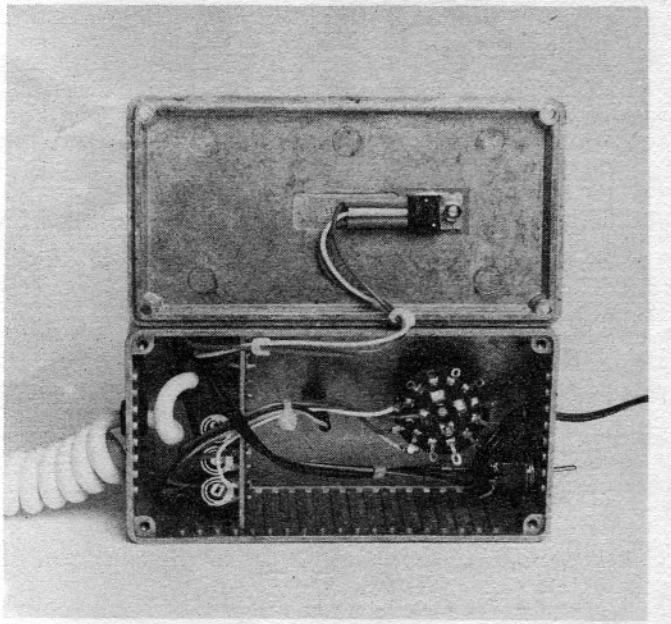


Fig. 5. Position of components and board within the specified case with complete interwiring information. Also shows mounting details for IC1 using mica washer and plastic bush.



Close-up view (above) of the prototype p.c.b. with all components in position.



Plan view of the completed prototype. Note the use of cable ties for the three groups of wiring.

to be etched on the board is given in Fig. 3.

Assembly details of the components on the top side of the p.c.b. are shown in Fig. 4. The polarities of the tantalum capacitors are nearly always marked on the bodies, and it is very important that these components are soldered in the right way round, as is the case with D1 and D2. The latter has a flat alongside its cathode.

The p.c.b. should be completed in accordance with Fig. 4 and then the diecast box can be prepared.

CASE

The lower section should be drilled to suit the rotary switch, the toggle switch S2, and the l.e.d. Two holes are also needed to enable the 12V input and output leads to pass through and these holes should be fitted with a grommet. It is advisable to fit cable retaining clips to both of these cables.

IC1 is mounted on the removable lid of the box, which acts as a heatsink—hence the necessity for a metal box to be used. A diecast box has the added advantage that it is very tough and will withstand quite severe knocks.

It was decided that the galvanised finish of the diecast box was somewhat less than aesthetic and so it was resprayed in an attractive shade of gold. If constructors wish to do the same it should be noted that an initial coat of primer may be required. The paint should of course be applied once all the metalworking has been completed.

After the box has been drilled and painted, the lettering can be applied to the case as required. Proprietary rub-down lettering can be used here. Note that clear protective lacquer should *not* be used over a cellulose paint finish. Experience has shown that the two tend to react unfavourably!

INTERWIRING

Once the p.c.b. and case have been completed, all interwiring can be carried out, as detailed in Fig. 5. The l.e.d. is mounted using either the usual black plastic bush/clip or alternatively a more attractive, though more costly, lens-clip may be employed, as in the prototype. The integrated circuit should be mounted on the lid of the box using a TO-220 insulating kit, so that the metal tab of the device is isolated from the case.

With regard to the rotary switch, a one-pole, three-way switch is required. This is best realised using a four-pole three-way switch. Only one pole is wired up. The remainder of the switch is ignored, as Fig. 5 illustrates.

General-purpose flexible wire, preferably having a minimum rating of 1·5A can be used throughout. All flying leads, plus the input and output leads, can be soldered directly to the p.c.b.; constructors may wish to use Veropins if required.

Check all of the interwiring and set the three presets to midway before proceeding to the setting up stage. This comprises applying 12V to the input, either from the car electrics or a bench power supply unit and then adjusting the appropriate preset until 6V, 7·5V and 9V are measured at the output connected to a 10V d.c. voltmeter for the three settings of S1.

The unit once calibrated in the manner described is then complete and ready for use.

OUTPUT CURRENT

It was mentioned earlier that the i.c. has built-in current limiting which operates at 2·2A, reducing the current level as necessary if the i.c. temperature increases.

The **peak** current available from the i.c. therefore is 2·2A. To operate the unit at such current levels for a prolonged period is impracticable. Whilst short-circuits and very heavy loads will not damage the i.c., as the device is not well heatsinked (the diecast box is not terribly efficient at this), the i.c. temperature can be expected to build up with a consequent reduction of the maximum current available.

Under worst case conditions the i.c. may shut down altogether. In such cases the device will be very hot indeed—probably too hot to touch. When powering cassette units and other devices with a current consumption of about 500mA or less, the i.c. wil barely get warm. The maximum recommended current for prolonged use is about 1A. This will ensure that no thermal problems are experienced.

Finally, note that temporary short-circuits will not damage the p.s.u. unit but ensure that the circuit in the car's electrical system will carry the 2A or so which flows under such conditions.

The cigar-lighter plug and power supply connector used by the author.