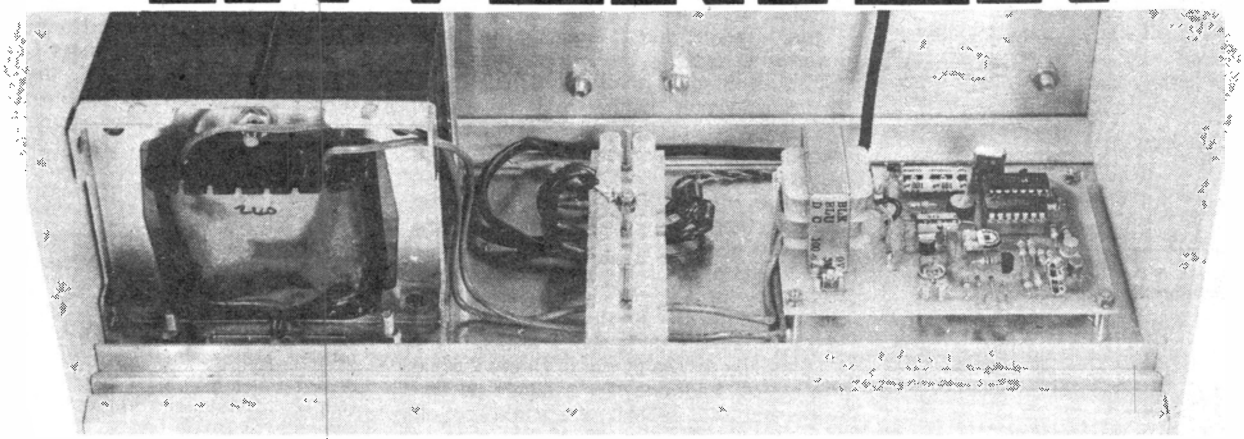
220/240V AC INVERTER



by Dave Goodman

- ★ **Runs small domestic appliances such as televisions, hi-fi and lights**
- ★ **Supplied from a standard 12V car battery**
- ★ **Ideal for camping and caravanning**

Now that winter is well on its' way, bringing the threat of power cuts, a standby power source can be extremely useful. Central heating pumps can be kept running, or the family can be entertained by connecting a television to the inverter.

The need is for a 220-240V AC (50Hz) supply at 100 Watts to be derived from a 12V car battery. The power available should be adequate for most small domestic appliances, providing that their total power requirement is less than 100W.

Circuit description

The crystal XI and IC1 produce a stable 100Hz square wave, which is further divided by IC2 to give two 50Hz waveforms, one of which is 180 degrees out-of-phase with the other.

The transistors TR1 and TR2 both drive the MOSFETs TR5-8, which alternately switch the windings of T2 to the 12V battery supply. D4 and D5 become forward biased if the battery is wrongly connected, blowing the fuse FS1. D6

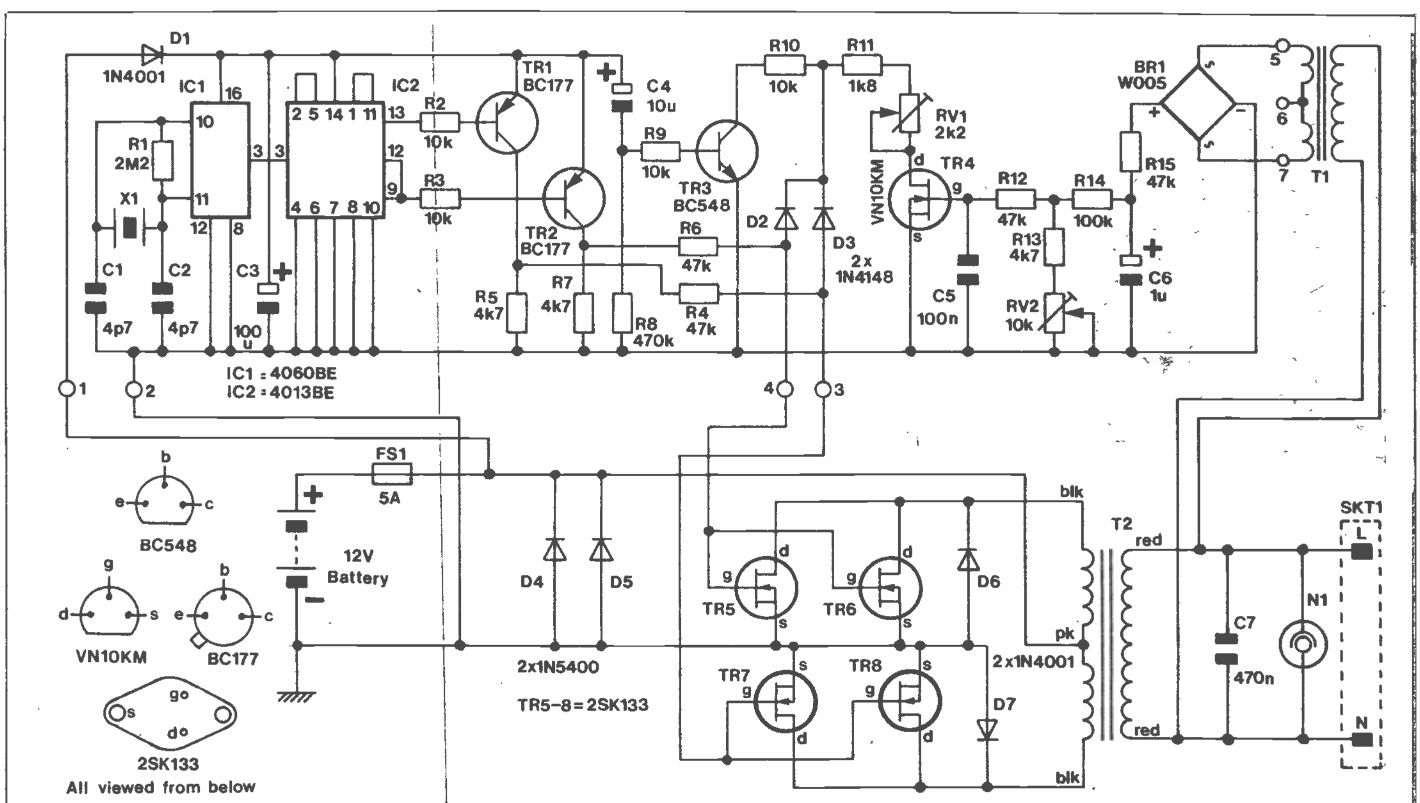


Figure 1. Inverter circuit diagram.

and D7 prevent reverse voltage spikes, developed across T2 primary windings, from damaging the MOSFETs. Transformer T2 has been specially developed for use in this system, and steps up the voltage on its primary windings from 17.5V rms to 250V rms across the secondary. Because of the fast switching action that use of the MOSFETs provides, the waveform appearing at T2 secondary under load is a good square wave, whose high harmonic content may cause problems with some equipment connected to it. C7 removes many of the upper harmonics, 'rounding off the edges' of the square wave and producing a more sine wave like waveform.

To produce a high power output, T2 turns ratio is about 20:1. With reference to the primary voltage (17.5V) this would produce 350V rms with small loads connected to T2. To control this voltage T1 monitors the supply output, producing 12V AC across pins 5 and 7 for 250V input. This voltage increases to 15V AC for 350V input, and is rectified by BR1 to produce a small DC biasing voltage at TR4 gate. TR4 acts as a voltage controlled resistor in this circuit, and the drain to source resistance decreases in proportion to a positive value voltage applied to its' gate. RV2 and associated resistors determine the bias voltage to TR4. With

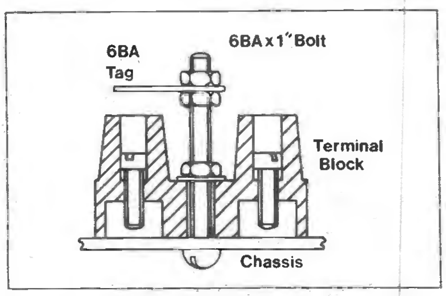


Figure 3. Chassis connection

TR4 low resistance diodes D2 and D3 both conduct, and the drive signals to the MOFSETs TR5-8 is reduced. With reduced drive T2 output voltage drops, and the monitoring voltage drops, causing TR4 to increase in resistance. D2 and D3 start to turn off, to a point where the drive to the MOSFETs is maintained and held, so the output from T2 is determined by RV2. This monitoring circuit can be likened to A.V.C. (Automatic Voltage Control). When first switched on no voltage output appears from T2 for a short period of time, this is due to the conduction period of the MOSFETs and primary windings.

When a voltage first appears C6 starts to charge, and TR4 bias is developed as before, therefore the A.V.C. being delayed allows an initial 350V AC to appear at the output. TR3 prevents this surge voltage by conducting immediately a battery is connected. D2 and D3 are forward biased by R10, and the drive signals from TR1 and TR2 are reduced. When C4 is charged, via R8, TR3 then switches off. This charge time allows the A.V.C. to be developed, and the T2 output voltage gradually rises to 240V over a one second period. The

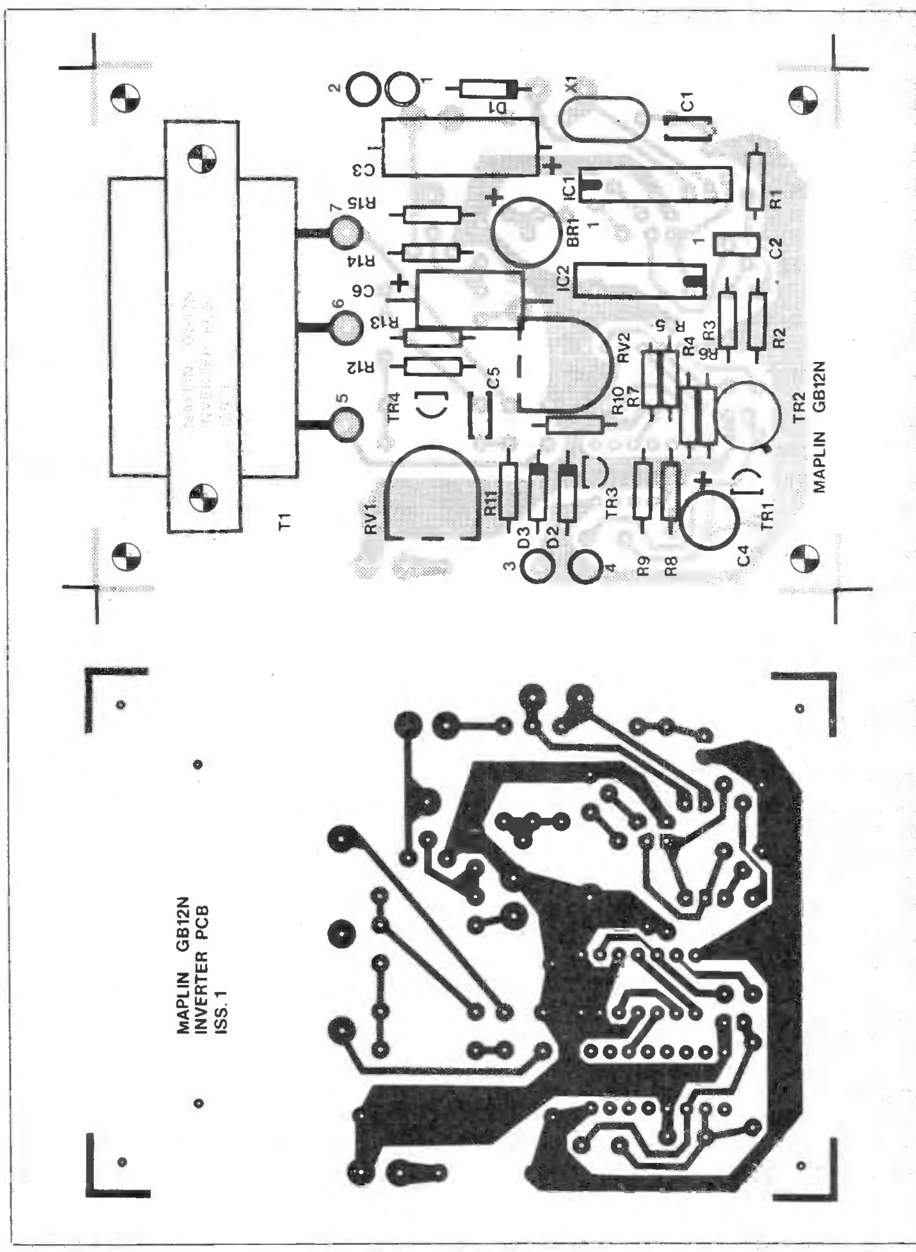


Figure 2. Legend and artwork

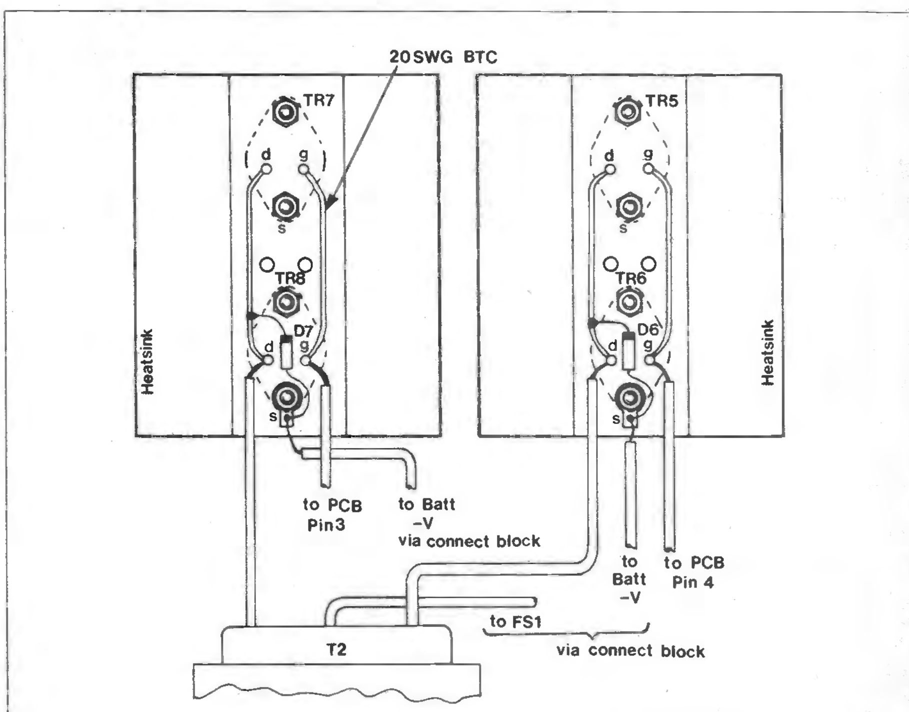


Figure 4. Heatsink and MOSFET assembly

neon lamp N1 indicates that a high voltage is present on SKT1.

PCB assembly

Refer to the parts list and figure 2. Fit R1 to R14 and diodes D1 to D3. Insert BR1. The bridge will have either a plus sign or one lead longer than the other three. In either case this must go into the hole next to the plus sign. Fit RV1 and RV2, followed by transistors TR1 to 4. TR4 has a metal plate on top, and TR1 and 2 cases have a small pip on the side which must line up with the legend. Fit C1 to 6. C3, C4, and C6 are polarised, and you must ensure correct orientation. Fit IC1 and IC2 sockets, and crystal X1. Now solder all components in, and cut all spare leads. Fit veropins P1 to 7 from the track side, then solder in. Mount T1 with two 6BA x ¼in. bolts, nuts and washers, and connect the secondary leads to pins 5 to 7. Recheck all components and look for bad joints and shorts on the track face.

Main assembly

If using the box recommended for this project figure 6 shows the holes to be drilled to enable all components to be mounted. Note that the two sides finished in black will be the top and front, and the plastic covered panel will be the rear (with the plastic facing inwards and the metal facing outwards).

The plain aluminium sheet is the base, and once it is drilled the PCB can be mounted using four 6BA x ½in. nuts, bolts, washers, and four 6BA x ¼in spacers. T1 end of the board should be innermost. Next, fit the eight way connecting strip using three 6BA x 1in bolts, nuts and washers (figures 3 and 5). This lies across the base from front to back. Use two 6BA nuts and a 6BA solder tag fitted to the centre bolt for the chassis connection to the battery negative.

Mount T2 to the left side of the base panel. Use four 2BA x ½in bolts, nuts and washers. This completes the base panel assembly.

Drill the black top panel (figure 6). Mount the 13A socket pattress using two 2BA x ½in CSK bolts, nuts and washers. Neon N1 fits into hole D, and the 1¼in fuseholder fits into hole E. This completes the top panel assembly.

Next, mount TR5 and 6 to a predrilled heatsink. Use a suitable silicon grease for good heatsink conduction. No mounting kit is required here. The FETs will only fit one way round (figure 4). Use four 4BA x ½in bolts and nuts with 4BA washers fitted under the heads of three bolts and a 4BA solder tag under the fourth. The fourth bolt is at the bottom of the drawing and the tag fits on the heatsink side. Use 20 swg copper wire to join Drain pin to Drain pin and Gate pin to Gate pin. Diode D6 mounts under the heat sink, with the cathode (bar end) connected to Drain and the anode connected to the solder tag. Repeat this assembly for TR7 and 8. These two heatsinks will eventually

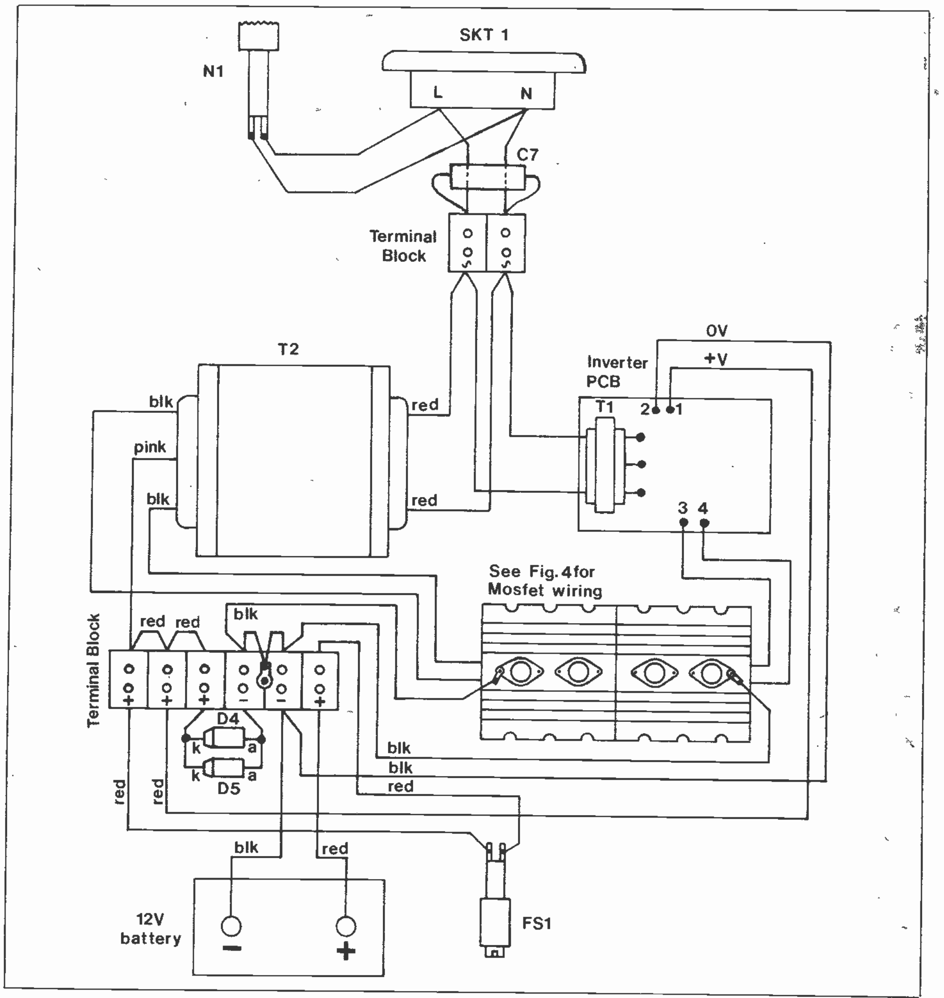
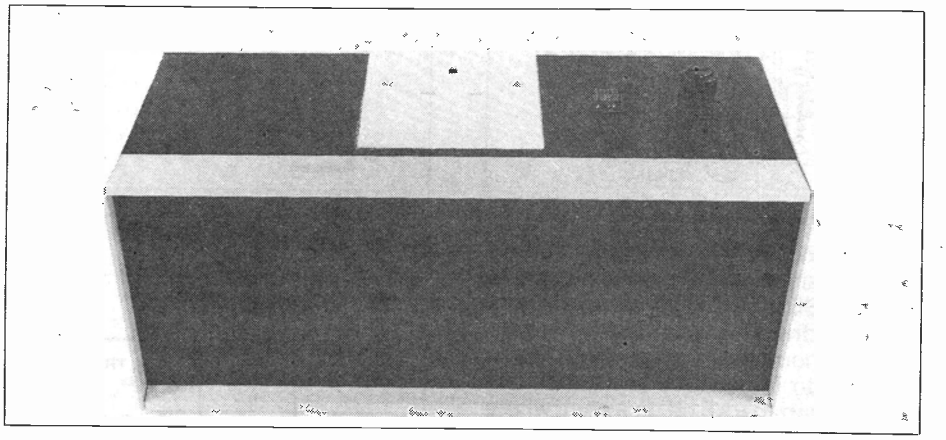


Figure 5. Wiring assembly



bolt onto the outside of the back panel (metal face).

Wiring assembly

Figure 5 shows the wiring arrangements. The centre (pink) wire of T2 primary fits directly into the tag strip, whilst the other two (black) primary wires go through the back panel holes and solder onto the Drain common bus bars (one wire to each bus bar), as shown in figure 5. Use 5A rated cable to join TR5 and 6 Gate bus bar to PCB pin 4, and repeat for TR7 and 8 to PCB pin 3.

Keep these last two cable runs as short as possible. Use two lengths (300mm each) of black 20A rated cable, and pass through each of the two holes in the back panel beneath each heatsink. Place the heatsinks onto the back panel and fit with six 2BA x ½in bolts, nuts and washers. Solder one end of each cable onto the solder tag fitted on each heatsink. The other ends of the cable go into the two centre connecting strips. Fit two short lengths of 20A cable into the same strips and solder their other ends to the 6BA solder tag chassis connection (figure 5).

Assemble the back panel and base panel along with the two side plates and three extrusions. Leave the top and front open for now. Complete the rest of the wiring as shown. Use red 20A cable to and from the fuse FS1 and 20A black and 20A red cables with crocodile clips to the battery.

Capacitor C7 may be fitted directly into the connector strip providing that systoflex sleeving is placed over both bare leads. The same applies to diodes D4 and 5. The cathodes (bar ends) go to positive and the anodes go to negative.

Testing

Set RV1 fully clockwise and RV2 to halfway. Insert a 5A fuse into the holder. Remember you are dealing with 250V AC and that you should treat this with the same respect you would have for normal mains supply. Connect the battery. If you have an ammeter capable of reading up to 15A DC connect this in series with the battery positive and red connecting lead. Neon N1 should come on and the transformer may quietly buzz. The supply current should be approximately 500mA with no load connected.

Connect a voltmeter set to read 250V AC across the 13A mains socket. There should be about 250V AC present. Turn RV2 fully clockwise. The reading should drop to 190V AC, and neon N1 may flash. Turn RV1 fully anticlockwise and the voltage reading should increase to 280/300V AC. This proves the A.V.C. is working correctly. Note that these voltage readings may vary from unit to unit. Next you will need a 15W pygmy lamp and a 60/100W lamp.

Remove the battery supply and plug a 15W lamp into SK1. Turn RV1 fully clockwise again and reconnect the battery. Both neon and lamp will flicker. Turn RV2 anti-clockwise until there is a reading of 250V AC on the meter. Now remove the 15W lamp. The reading should stay at 250V AC. If it does not, turn RV1 anti clockwise until it does. This sets up the required voltage of 250V (RV2) and the A.V.C. (RV1). Connect a 60/100W lamp to SK1. The reading will drop down to 230/240V, but all is well. If you check the battery supply current now a reading of between 7 and 10A DC can be expected! The inverter is now working.

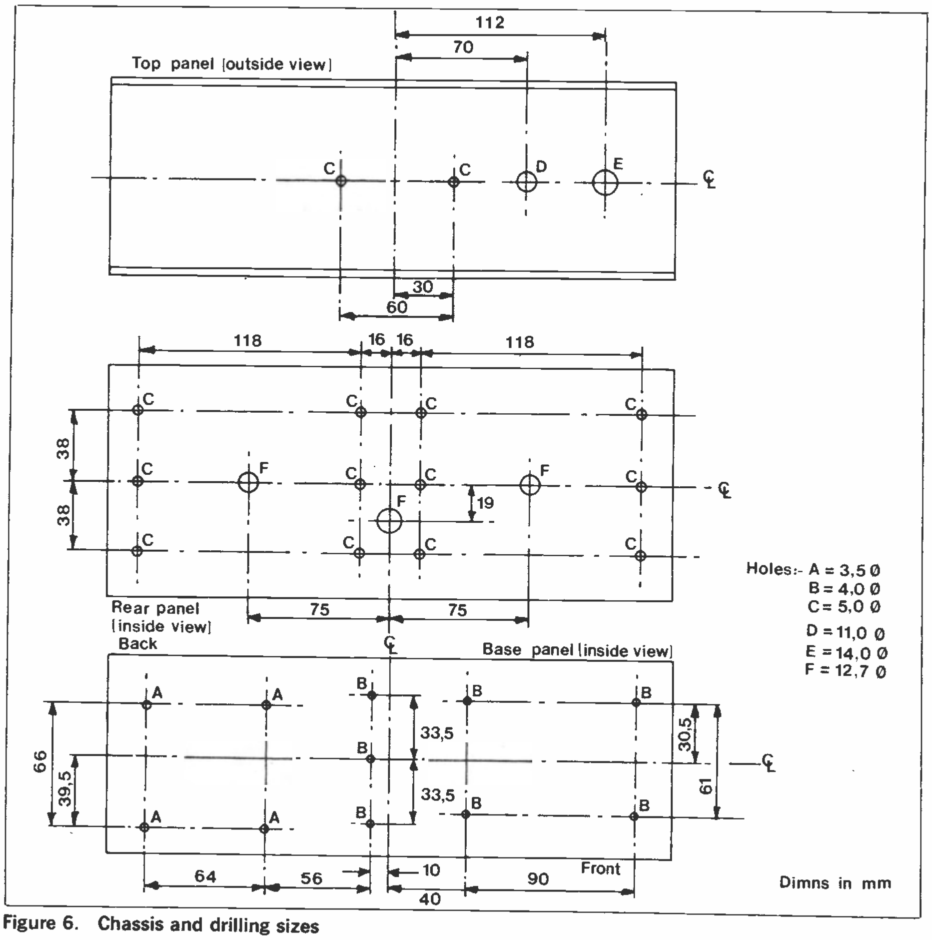


Figure 6. Chassis and drilling sizes

Finally, slot the top panel in place, followed by the blank black front panel. Fit the metal extrusion into both panels and screw to the side plates. The assembly is now complete.

The prototype has been used successfully on televisions, spot lamps, hi-fi, tuner, cassette recorders, soldering irons and AC induction motors, although the latter requires high battery current. Some time switches or synchronous motors may not run correctly on this system, and a high current choke may need to be connected in series with T2 primary centre-tap to produce a waveform suitable for operating such appliances. This will be a matter for experimentation, and outside the scope of this article.

INVERTER PCB PARTS LIST

Resistors: All 0.4W 1% Metal Film			
R1	2M2		(M2M2)
R2,3,9,10	10k	4 off	(M10K)
R4,6,12,15	47k	4 off	(M47K)
R5,7,13	4k7	3 off	(M4K7)
R8	470k		(M470K)
R11	1k8		(M1K8)
R14	100k		(M100K)
RV1	2k2 Hor-sub min Preset		(WR56L)
RV2	10k Hor-sub min Preset		(WR58N)
Capacitors			
C1,2	4p7F Ceramic	2 off	(WX40T)
C3	100uF 25V Axial Electrolytic		(FB49D)
C4	10uF 35V P.C. Electrolytic		(FF04E)
C5	100nF Minidisc		(YR75S)
C6	1uF 63V Axial Electrolytic		(FB12N)
C7	470nF IS Cap		(FF58N)
Semiconductors			
D1	1N4001		(QL73Q)
D2,3	1N4148	2 off	(QL80B)
TR1,2	BC177	2 off	(QB52G)
TR3	BC548		(QB73Q)
TR4	VN10KM		(QQ27E)
IC1	4060BE		(QW40T)
IC2	4013BE		(QX07H)
Miscellaneous			
BR1	W005		(QL37S)
X1	Crystal 3.2768 MHz		(FY86T)
T1	6-0-6 Sub-min Transformer		(WB00A)
	14 Pin Dil Skt		(BL18U)
	16 Pin Dil Skt		(BL19V)
	Veropin 2141	1 pkt	(FL21X)
	Inverter PCB		(GB12N)

ADDITIONAL PARTS LIST

Semiconductors			
D4,5	1N5400	2 off	(QL81C)
D6,7	1N4001	2 off	(QL73Q)
TR5-8 inc.	2SK133	4 off	(QQ36P)
Miscellaneous			
T2	Inverter transformer		(XG29G)
FS1	5 amp fuse x 1¼"		(WR15R)
	Safe fuseholder 1¼"		(RX97F)
SKT1	Single skt unswitched		(HL68Y)
N1	Square neon red		(RX81C)
	Terminal block 15A		(HL54J)
	Heatsink 10 DNDR	2 off	(FL55K)
	Surface Pattress 29mm single		(YB15R)
	Charger clip	2 off	(HF26D)

4BA solder tag	2 off	(BF28F)	Bolt 6BA x 1"	3 off	(BF07H)
6BA solder tag		(BF29G)	Nut 6BA	9 off	(BF18U)
Bolt 2BA x ½"	12 off	(BF00A)	Washer 6BA	7 off	(BF22Y)
Nut 2BA	14 off	(BF16S)	Spacer 6BA x ¼"	4 off	(FW34M)
Washer 2BA	14 off	(BF20W)	Systoflex 2mm Ø	150mm	(BH06J)
Bolt 4BA x ½"	12 off	(BF03D)	20A cable blk	1M	(XR57M)
Nut 4BA	12 off	(BF17T)	20A cable red	1M	(XR59P)
Washer 4BA	10 off	(BF21X)	Large grommet	3 off	(FW60Q)
Csk bolt 2BA x ½"	2 off	(LR54J)	20 SWG B.T.C.	500mm	(BL13P)
Bolt 6BA x ½"	4 off	(BF06G)	BOX NM3		(YK43W)

A complete kit of all parts excluding the case is available for this project. Order As LW95D (Inverter Kit). Price £49.95. The case suggested for this project is the NM3, shown on page 71 of our 1983 catalogue. Order As YK43W.