EDITION 1

Assembly Manual

12-230V 300VA INVERTER

K-3478

DICK SMITH ELECTRONICS PTY LTD KIT

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Of compact design, this new 300VA 12/230V inverter features a toroidal transformer and automatic self starting. It is powered from a 12V car battery and boasts voltage regulation, current limiting and thermal overload protection.

Power inverters have a unique appeal to many of our readers. They provide a measure of independence from the electricity supply authorities and enable appliances to be operated away from civilisation. The applications of an inverter are many and varied and extend from supplementary mains power to supplying power at a remote site.

An inverter of this rating is particularly useful at building sites and on the farm. It is typically used to power electric drills, soldering irons and sanders in situations where mains power is not readily available. An inverter is often preferred in such cases since a long extension cord from a mains supply can be dangerous or inconvenient.

Where no mains supply is available, such as in the remote outback of Australia and at many campsites, an inverter can be used to power audio and video equipment, lights and power tools. Its 300VA output capability means that it can power a great variety of mains appliances.

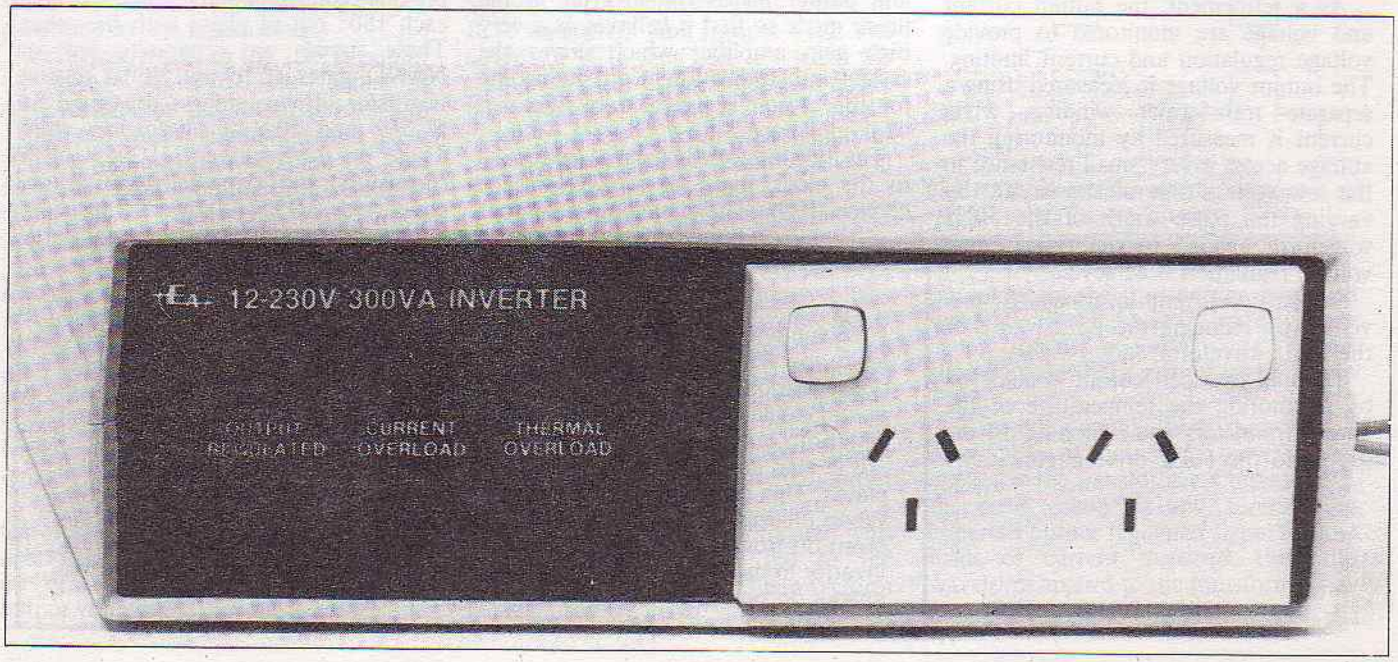
This new design has many features which provide high efficiency and user convenience. A relatively small toroidal transformer allows it to be housed in a compact plastic case that is easily carried in one hand. On the front panel are green, orange and red LED indicators and a double general-purpose mains outlet.

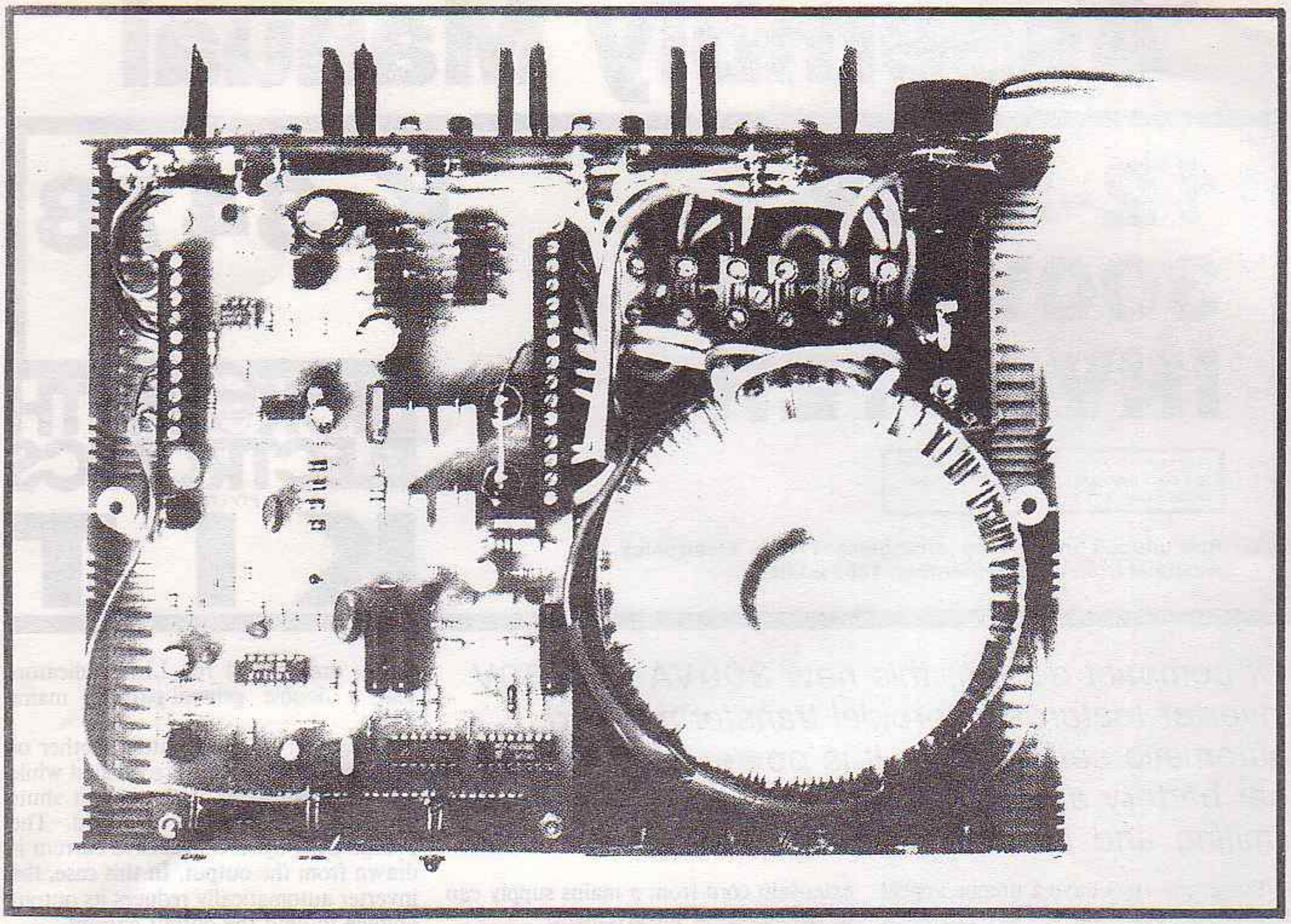
The green LED indicates whether or not the output voltage is regulated while the red LED lights if the circuit shuts down due to thermal overload. The orange LED lights if excessive current is drawn from the output. In this case, the inverter automatically reduces its output voltage to limit the output current.

Auto-starting

Unlike previous EA inverter designs, this circuit consumes virtually no power until an appliance is switched on. The circuit then starts automatically.

This auto-start feature is far more convenient and efficient than manually switching on the inverter, independent of the appliance. The gains in power savings are mainly realised with appliances that are used intermittently. These include power tools and sewing machines.





View inside the prototype. The transformer and PCB are mounted on a steel baseplate which prevents the case from flexing.

During the period that the appliance is not used, the inverter circuit is powered down and consumes virtually no power.

How it works

General operation of the inverter is relatively simple. A crystal locked 50Hz waveform is buffered with several transistor stages. These drive a transformer in a push pull mode to step the low voltage from the battery up to 230VAC.

As a refinement, the output current and voltage are monitored to provide voltage regulation and current limiting. The output voltage is measured using a separate transformer winding, while current is measured by monitoring the voltage across a very small resistance in the low voltage side of the circuit. By varying the pulse width of the 50Hz waveform applied to the transformer, voltage regulation is achieved.

Similarly, current overload is prevented by reducing the pulse width of the 50Hz waveform.

Thermal overload cutout is achieved by monitoring the temperature of the output transistors and switching off the supply to the 50Hz drive circuitry and diodes in series with the 230VAC output. When the load is connected, this current flows through the load and switches on a transistor. This transistor then switches on the 50Hz driver stages in the inverter circuit and the inverter becomes operational.

IC1a and its associated 4MHz crystal provide the clock signal for the circuit. Both inputs of the gate are tied together so that it functions as an inverter. A 10MΩ resistor connected between input and output places the inverter in the linear mode so that it behaves as a very high gain amplifier which drives the crystal into oscillation. Correct loading for the crystal is provided by the two 47pF capacitors.

The resulting 4MHz signal is applied to the clock input of a 4017 decade divider (IC2). The divide-by-10 output from IC2 at pin 12 is then applied to the clock input of IC3, which further divides by 10. After two further divisions in IC4 and IC5, an output frequency of 400Hz is provided at pin 12 of IC5. This is connected to the pin 15 clock input of IC6.

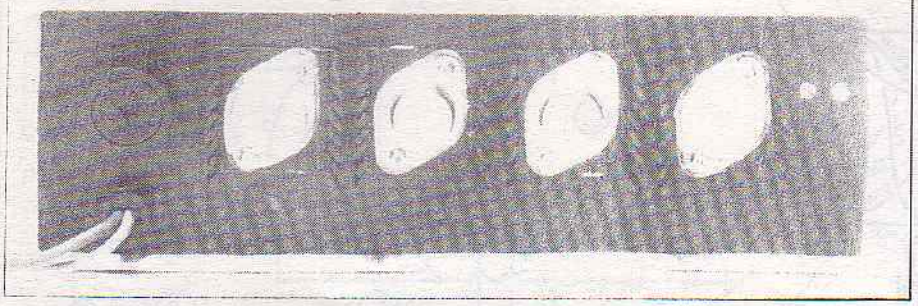
IC6 is a 4-bit binary counter. A divide-by-four signal at its Q2 output gives 100Hz and a divide-by-eight signal at its Q3 output gives 50Hz.

The 50Hz signal is inverted by IC1b to provide complementary 50Hz signals, each 180° out of phase with the other. These signals are separately fed via NAND gates IC1c and IC1d to two transistor driver stages consisting of BC559 and BD140 Darlington pairs. These in turn drive TIP3055 NPN transistors and two pairs of parallel connected 2N3771 power transistors,

WARNING!

Equipment to be operated from this inverter must be in a safe condition, since the voltages produced are at mains potential. This means that frayed cords, exposed unearthed metal parts (unless double insulated), and broken or wet insulators must be repaired before the item is used. Note that contact with both output lines could prove fatal!

It is also important to keep the electrolyte level of the battery above the plates. This prolongs battery life and reduces the risk of battery explosion. When charging the battery, do so in a well ventilated area. The hydrogen given off from a charging battery is highly explosive. When connecting the inverter to the battery, make sure that the appliance is not plugged in so that sparks do not occur near the battery.



The output transistors must be mounted using mica washers and insulating bushes.

12/230V 300VA inverter

which drive the primary windings of the transformer.

Note that the NAND gates are capacitively coupled to the bases of the BC559 transistors. This prevents one side of the transistor output stage from permanently conducting if the oscillator fails.

Another point of note is that two output transistors have been used for each phase. This arrangement ensures adequate gain, the typical gain of a 2N3771 being 20 at 15A and only 10 at 30A. The use of a transistor pair also reduces the saturation voltage since the current in each transistor is halved.

We have not used emitter resistors for each of the output transistors, since they are wasteful of energy when high currents are involved. As an alternative, we have used 0.1Ω resistors on the base of each transistor. Although this is not considered the ideal manner of ensuring equal current sharing, it works well enough in practice.

The two MR110 diodes, D1 and D2, conduct the reactive current after their opposite transistor pairs have ceased conduction. This protects the output transistors from inductive kickback generated by the transformer.

Let's now return to the 100Hz output at pin 11 of IC6. This signal is differentiated by the 100kΩ resistor and 150pF capacitor combinations and fed to phase driver transistors Q1 and Q2. The idea here is to prevent both drivers from being on at the same time when switching from one driver to the other. The differentiators achieve this by slowing down the switching times of the drivers from about 10μs to 60μs.

The maximum possible pulse width of each phase is thus slightly less than 180°. However, at full power when this maximum pulse width is applied to the transformer, the loss is only about 0.6W which is negligible.

As mentioned previously, the inverter features voltage regulation and current overload protection. These features rely on error voltages derived from the output voltage and current to control the pulse width of the signal fed to the driver stages.

The output voltage is monitored via secondary winding S1, which reflects the voltage at the 230VAC output winding (S2). This monitored voltage is rectified by diodes D8 to D11, filtered and applied to the inverting input of op amp IC7b via trimpot VR1. The amplifier has a gain of 1M/220 or 4545, and the 1MΩ feedback resistor and 6.8μF capacitor give it a long response time.

The non-inverting input of IC7b is held at 5.6V with zener diode D5. Whenever the voltage at the wiper of VR1 begins to exceed the zener diode voltage, the output of IC7b begins to fall toward ground. This is the error voltage signal.

To obtain the error current signal, the supply current to the output transistors is passed through R1 to develop a small voltage proportional to current. This voltage is applied to a divider consisting of two 220Ω resistors, filtered and applied to the inverting input of IC7c.

IC7c is wired as a comparator. A voltage reference is derived by monitoring the voltage across diode D4 and this is applied to the non-inverting input of IC7c via current limit trimpot VR2. The output of IC7c thus goes low when the voltage at its inverting input goes above the reference voltage. The 6.8μF capacitor across IC7c ensures stability of the comparator when the inverter is in the current limited mode.

The outputs of IC7b and IC7c provide the DC error signals and these are fed via a diode OR gate (D6 and D7) to pin 12 of comparator IC7d. If the output voltage or current goes higher than the preset level, the error signal will go lower. An RC delay circuit (39kΩ, 4.7kΩ and 47μF) controls the rate at which the error signal changes. This is necessary because the long time constant of the voltage sensing circuit would otherwise cause the output voltage to overshoot at switch-on.

The DC error signal is compared with a 100Hz triangle wave fed to the inverting input of IC7d. This waveform is generated by IC7a which integrates the 100Hz waveform from IC6. The result of the comparison in IC7d is a pulse width modulated 100Hz square wave. This signal is applied to NAND gates IC1c and IC1d. Whenever the output of IC7d is low, there is no drive available to the transformer.

For further clarification, refer to Fig. 1. Waveform A shows the 100Hz waveform from IC6 while below it is the triangle waveform from IC7a. Whenever the error voltage and triangular waveform intersect, comparator IC7d changes state. The output from IC7d is high whenever the triangular waveform is below the error voltage and low when the triangular waveform is above the error voltage. This result is shown as waveform C.

When the 50Hz waveform (B) and waveform C are NANDed with IC1c, the result is the (B AND C)-bar waveform. A similar result occurs with IC1d, which NANDs the B-bar AND C waveform. Consequently, the transformer is only driven for the time that the (B AND C)-bar waveform is low for one phase of the transformer drive and when the (B-bar AND C)-bar waveform is low for the opposite phase. This is shown as the 230V output waveform in Fig.1.

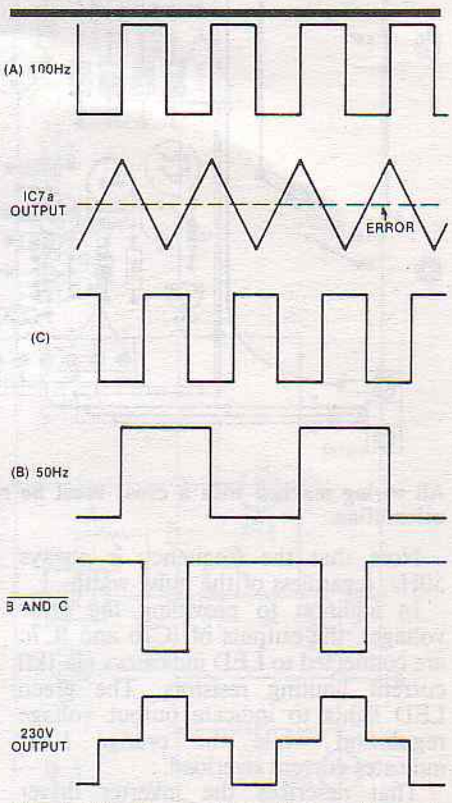
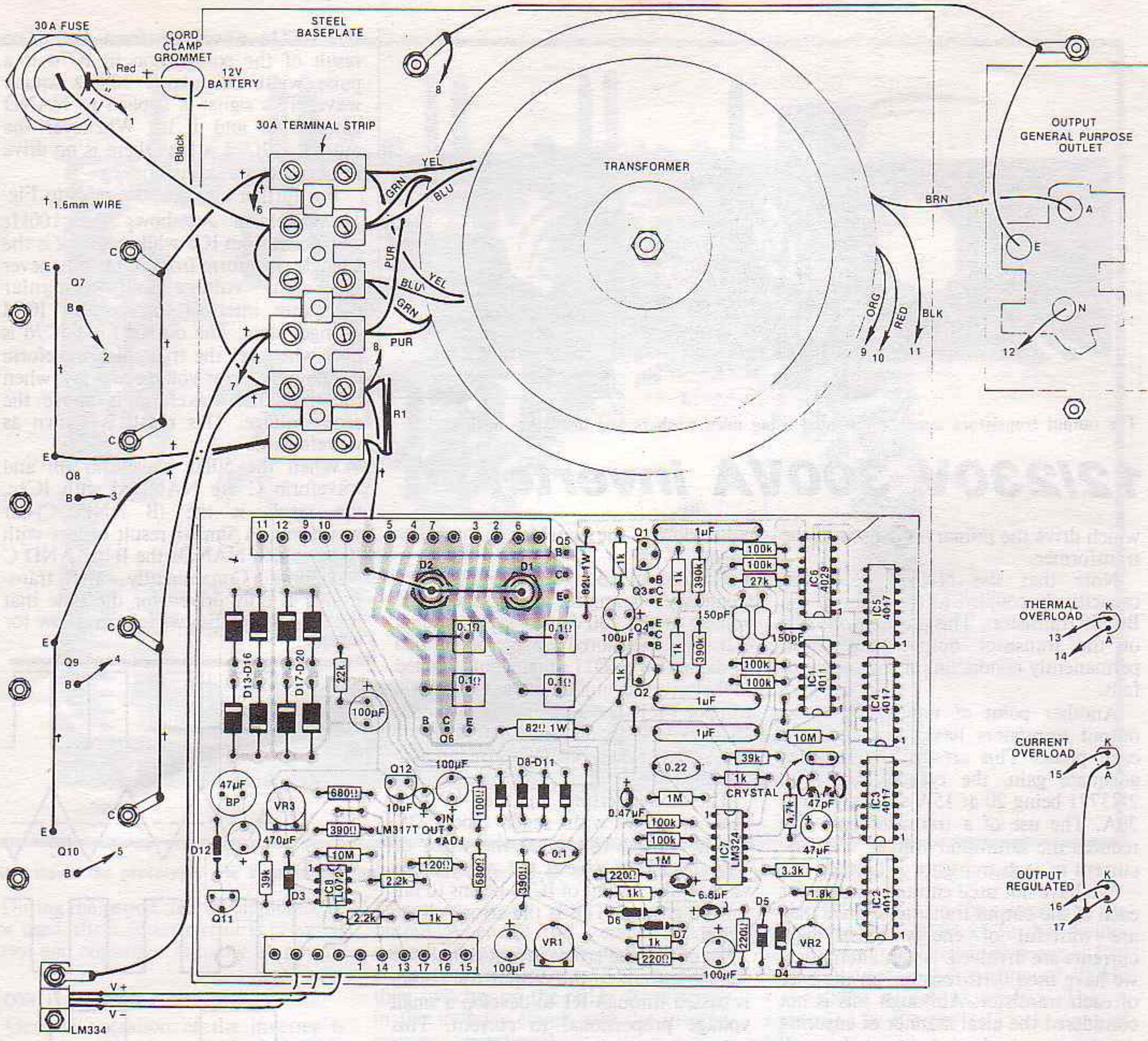


Fig. 1: this diagram shows the waveforms at various points on the circuit.

If the error signal is high, then the full duty cycle of the 50Hz waveform is applied to the transformer. Conversely, if the error voltage is low, representing either an output regulated signal for low loads or current overload, then the waveform applied to the transformer has a narrower pulse width applied to it.

Text and Illustrations courtesy of Electronics Australia



All wiring marked with a cross must be run using brown or blue 32 x 0.2mm strand cable. Take care with component orientation.

Note that the frequency is always 50Hz, regardless of the pulse width.

In addition to providing the error voltages, the outputs of IC7b and IC7c are connected to LED indicators via 1kΩ current limiting resistors. The green LED lights to indicate output voltage regulation while the orange LED indicates current overload.

That describes the inverter driver circuitry. Now for the auto-start and thermal overload sections.

With no mains load connected, a current flows from the 12V battery, through the 22kΩ resistor and then via D17 and D18 to the 0V line. D19 and D20 are reversed biased. Note that the positive terminal of the battery is also permanently connected to the transformer centre tap. However, with no load connected, the drive circuitry to the 2N3771 transistors will all be off. Thus the 2N3771 transistors themselves will all be off and so no current flows in this part of the circuit.

When an appliance is connected and switched on, the forward bias voltage across D17 and D18 (which is applied to the neutral AC output line) is applied via the series resistance of the appliance and the S2 winding to the anode of diode D12. This bias voltage then charges the 47μF and 470μF capacitors and turns on transistor Q11.

Q11, in turn, powers up op amp IC8 and allows current to flow through D3 and the LM334 temperature sensor. D3 sets the reference voltage on pins 3 and 6 of IC8a and IC8b respectively.

The LM334 temperature sensor is a three-terminal device which produces a current that is directly proportional to its absolute temperature. This current flows through VR3 and the series 39kΩ resistor and the resultant voltage applied to pins 2 and 5 of IC8a and IC8b.

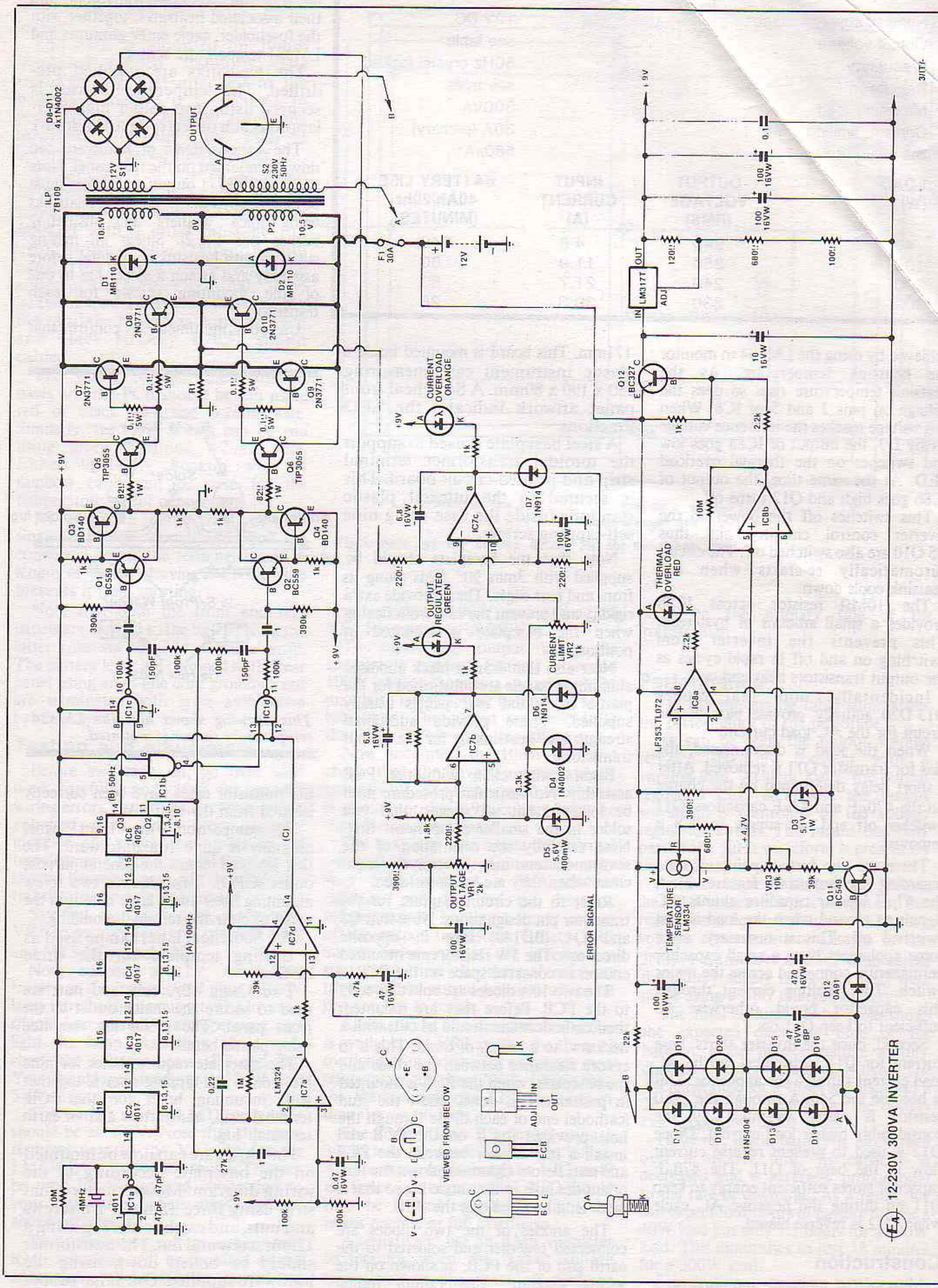
Normally, this voltage is set below the zener diode voltage. This means that comparator IC8a will have a high output and comparator IC8b will have a low output. Consequently, the thermal overload LED will be off and Q12 will be on.

With Q12 on, the +12V supply from the battery is applied to an LM317 adjustable three-terminal regulator. This, in turn, supplies a regulated +9V rail to the inverter control circuitry. Thus, the inverter starts.

Operation of the regulator is as follows: the voltage between the output and adjust terminals is maintained at 1.25V which means that about 10mA flows through the 120Ω resistor. This current also flows through the 680Ω and 100Ω resistors and so the adjust terminal is jacked up to +7.8V. This means that the output is maintained at 1.25V plus 7.8V, or around +9V.

The 10μF capacitor at the input of the regulator ensures stability of the device while the 100μF and 0.1μF capacitors at the output are used for supply decoupling.

Thermal overload protection is



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SPECIFICATIONS

Nominal supply voltage	12V DC
Output voltage	see table
Frequency	50Hz crystal locked
Regulation	see table
Maximum load	300VA
Current limiting	30A (primary)
Standby current	580μA

LOAD (W)	OUTPUT VOLTAGE (RMS)	INPUT CURRENT (A)	BATTERY LIFE 40Ah/20hr (MINUTES)
40	240	4.6	240
100	250	11.9	80
200	240	21.7	50
300	230	30.3	28

achieved by using the LM334 to monitor the heatsink temperature. As the heatsink temperature rises so does the voltage on pins 2 and 5 of IC8. When this voltage reaches the reference voltage set by D3, the output of IC8a goes low and switches on the thermal overload LED. At the same time, the output of IC8b goes high and Q12 turns off.

This switches off the power to the inverter control circuitry and thus Q5-Q10 are also switched off. The circuit automatically re-starts when the heatsink cools down.

The 10MΩ resistor across IC8b provides a small amount of hysteresis. This prevents the inverter from switching on and off in rapid cycles as the output transistors heat and cool.

Incidentally, note that diodes D13-D20 actually provide part of the circuit for the AC load current.

When the load is disconnected, the bias for transistor Q11 is removed. After a short delay determined by the charge on the 470μF and 47μF capacitors, Q11 switches off and the supply to IC8 is removed.

There are two further points of note regarding the auto-start feature. First, the 47μF bipolar capacitor shunts AC signals to ground when the load is first switched off. This is necessary, since some appliances have a small capacitor permanently connected across the mains switch. The resulting current through this capacitor could otherwise be sufficient to keep Q11 on.

Second, once the inverter starts, base current for Q11 is provided by the AC load current through the appliance. This is because the 545μA through the 22kΩ resistor is easily swamped by the considerably higher load current. Diode D12 is used to prevent reverse current flow in the base of Q11. The 470μF capacitor stores sufficient energy to keep Q11 on during the negative AC cycle when D12 is reverse biased.

Construction

Most of the parts are mounted on a PCB coded 85pi9 and measuring 110 × 171mm. This board is mounted inside a plastic instrument case measuring 250 x 190 x 80mm. A Scotchcal front panel artwork indicates the LED functions.

A steel baseplate is used to support the toroidal transformer terminal strip and printed circuit board. This is secured to the integral plastic standoffs inside the case using nine self-tapping screws.

Note that the baseplate should be supplied with 3mm 90° folds along its front and rear edges. These provide extra rigidity and prevent the case from flexing when the baseplate is mounted in position.

Note also that 2.5mm black anodised aluminium panels are substituted for the plastic front and rear panels usually supplied. These provide additional strength and heatsinking for the output transistors.

Begin construction with the PCB assembly. No particular procedure need be followed but we suggest that you solder in the smaller components first. Note carefully the orientation of the semiconductors and electrolytic capacitors when they are being installed.

Refer to the circuit diagram for the transistor pin designations. Note that Q3 and Q4 (BD140) face in opposite directions. The 5W resistors are mounted end on to conserve space on the PCB.

The two 10A diodes are bolted directly to the PCB. Before they are mounted, their cathode studs should be cut, with a hacksaw, to a length of 6mm. This is to ensure clearance between the studs and the baseplate, when the PCB is mounted in position. This done, insert the stud (cathode) end of each diode through the hole provided for it on the PCB and install a star washer between the PCB and nut. Before tightening down the nut, orient the hole in the anode lug so that it faces lengthways along the PCB.

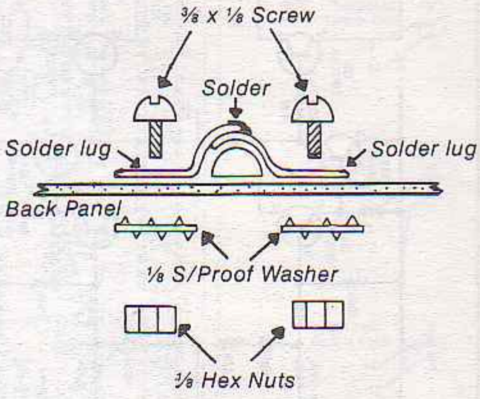
The anodes of the two diodes are connected together and soldered to the earth pad of the PCB, as shown on the wiring diagram. Use 1.6mm tinned copper wire for this job.

Work can now begin on the aluminium rear panel. This accommodates the 2N3771 transistors and their associated heatsinks, together with the fuseholder, cable entry grommet and LM334 temperature sensor.

The heatsinks are supplied pre-drilled. The temperature sensor is secured using two solder lugs overlapping each other (refer to diagram).

The various items of hardware can now be mounted on the rear panel. Note that the 2N3771 output transistors must be electrically isolated from the heatsinks using mica washers and insulating bushes (see Fig.2). Smear all mating surfaces with heatsink compound before assembly and attach a solder lug to one of the mounting screws for each transistor.

Use your multimeter to confirm that



This drawing shows how the LM334 temperature sensor is mounted.

the transistor cases have been correctly isolated from the heatsinks.

By comparison, the front panel assembly is quite straightforward. The first job is to mount the general purpose outlet (GPO). This requires two screw mounting holes and a large cutout in the panel to clear the terminal moulding.

The Scotchcal label can be used as a drilling template for the three LED's.

Two 12mm 4BA bolts and nuts are used to secure the mains outlet to the front panel. The LEDs are mounted using plastic bezels.

The baseplate requires holes for nine No.4 6mm self-tapping screws, together with mounting holes for the PCB, terminal strip, transformer and an earth terminal lug.

The hardware can now be mounted on the baseplate according to the wiring diagram. Mount the terminal strip using three 15mm x 1/8 screws and nuts, and earth solder lug using a 12mm screw and nut. The transformer should be bolted down using the hardware supplied. One large rubber washer is sandwiched between the transformer and the base, while the other goes between the top of the transformer and the large metal washer.

The PCB is mounted on 10mm insulated tapped standoffs. The standoffs are first attached to the baseplate (before it is secured in position) using screws from the underside and then the PCB is secured, also using short screws.

Construction can now be completed by wiring up the unit according to the wiring diagram. Note that all wiring marked with a cross must be run using brown or blue 32 strand 0.2mm cable. This includes the wiring to the collector and emitter terminals of the heatsink transistors. The wiring to the fuse and the battery is done with red and black H/Duty 41/0.32 strand cable.

The wiring between the transistor bases and the PCB should be run using red or black 24-strand 0.2mm wire. Similarly, the earth wiring can be run using green 24-strand 0.2mm wire. Either light-duty hookup wire or rainbow cable can be used for the temperature sensor connections.

R1 is simply a 200mm length of 1mm single-strand wire wound into a coil and connected across the terminal block. A length of plastic sleeving over the wire prevents it from shorting.

Note that both the front and rear panels are earthed to the baseplate, in the latter case via the 30A terminal strip. The battery leads are clamped to the rear panel using an in-line cord grommet and are terminated with large automotive battery clips.

Testing and adjustment

Before switching on, go over your work carefully and check for possible wiring errors. In particular, check that all polarised parts have been correctly installed and check the wiring to the transformer. Check also that there are no shorts between any of the heatsink transistor terminals and ground.

Satisfied that all is well, set trimpot VR1 to mid-position and trimpots VR2 and VR3 fully clockwise.

Now connect a 12V automotive battery to the inverter and plug a 100W lamp into the mains output. The inverter should immediately start operating and light the lamp. Assuming all is well, check the voltages across D3 and D5. You should get readings of 5.1V and 5.6V respectively.

The output of the LM317 regulator should be at +9V. Note that the spare terminal next to the V- input for the LM334 is connected to ground. This can be used for the ground connection to your multimeter when measuring the above voltages.

To set the output voltage, either a true RMS voltmeter will be required or the adjustment will have to be carried out using a comparison method. If an RMS meter is available, lightly load the inverter using a 100W lamp and adjust VR1 for a reading of 250VAC.

To adjust the output using the comparison method, connect a second 100W lamp to the mains and adjust VR1 until both lamps appear to have the same brightness. The output regulated LED should be lit following this adjustment.

Now disconnect the 100W load and check that the inverter automatically switches off. The best way to check this is to monitor the +9V output from the three-terminal regulator.

The next step is to adjust the thermal overload protection. Connect a very large load, such as a 1kW electric radiator, and monitor the heatsink temperature by keeping a finger on one of the output transistors. Rotate VR3 anticlockwise so that the inverter restarts each time the thermal overload trips, until the output transistors become just too hot to touch.

Alternatively, if a temperature probe is available, set VR3 so that the thermal overload trips when the transistor case temperature reaches 70°C. Check that the thermal overload LED lights each time the circuit trips.

The current limit is adjusted using a 300W load (eg, three 100W light bulbs). All you have to do is adjust VR2 until the lamps just begin to dim. VR2 should then be backed off slightly until the lamps operate at full brightness.

Alternatively, use an RMS voltmeter to monitor when the output voltage begins to drop, then back off until the output voltage is restored to normal. This sets an approximate 30A current limit on the primary side of the transformer.

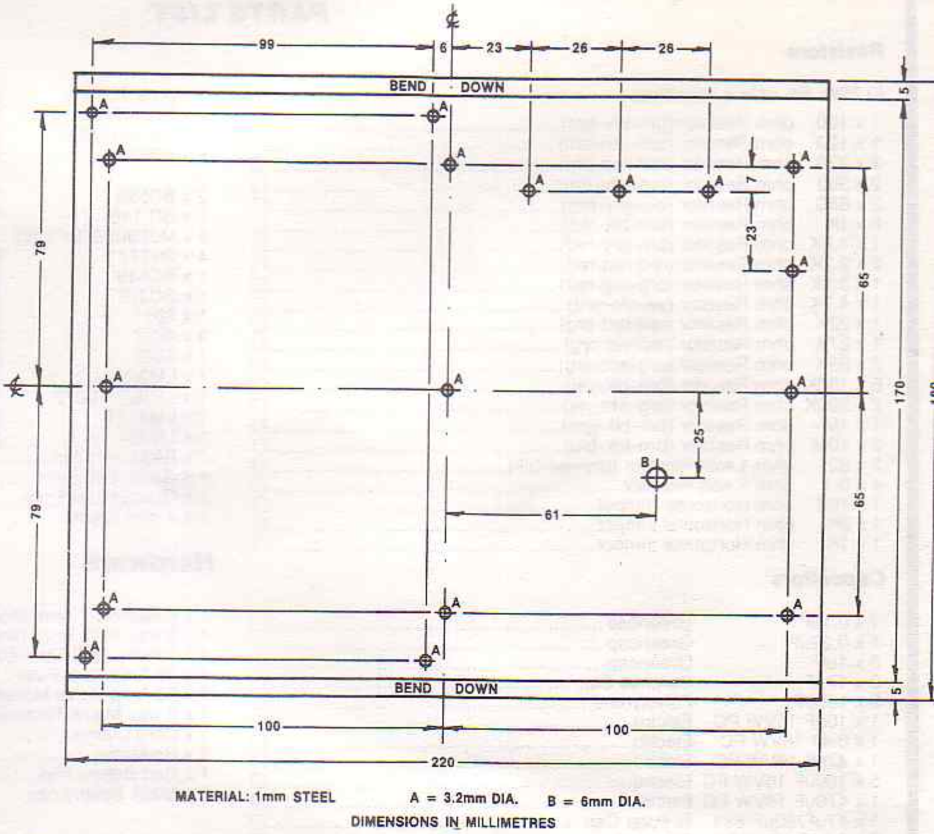


Fig.3: here are the drilling details for the metal baseplate.

Performance

The accompanying table summarises the performance of the prototype.

As can be seen the output voltage remains relatively constant with a varying load. At light loads, the output regulated LED is lit and the output waveform is controlled by the voltage regulation circuit. This means that only part of the 50Hz waveform is present on the output.

At much higher loads (around 300W), the full 50Hz waveform is present and the regulation is dependent upon the battery voltage, the saturation voltages of the 2N3771 transistors and the drop across the battery supply leads. Our tests were made using a fully charged battery.

The final column of the table shows the expected discharge time of the battery. These figures assume a fully-charged battery rated at 40Ah. The discharge time for a 40Ah specification is 20 hours which means that the battery can supply 2A for 20 hours.

However, if the battery is discharged over a shorter time, its capacity is decreased and is inversely proportional to the rate of discharge. As a result, we can expect four hours of battery life for a 40W load but only 1.5 hours for a 100W load. This diminishes to just 28 minutes for a 300W load.

Substituting a traction battery or a battery with a higher capacity will provide longer discharge times.

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PARTS LIST

Resistors

(0.25W, 5% unless specified)

- 1 x 100 ohm Resistor (brn-blk-brn) ☐
- 1 x 120 ohm Resistor (brn-red-brn) ☐
- 3 x 220 ohm Resistor (red-red-brn) ☐
- 2 x 390 ohm Resistor (org-wht-brn) ☐
- 2 x 680 ohm Resistor (blu-gry-brn) ☐
- 8 x 1K ohm Resistor (brn-blk-red) ☐
- 1 x 1.8K ohm Resistor (brn-gry-red) ☐
- 2 x 2.2K ohm Resistor (red-red-red) ☐
- 1 x 3.3K ohm Resistor (org-org-red) ☐
- 1 x 4.7K ohm Resistor (yel-vio-red) ☐
- 1 x 22K ohm Resistor (red-red-org) ☐
- 1 x 27K ohm Resistor (red-vio-org) ☐
- 2 x 39K ohm Resistor (org-wht-org) ☐
- 6 x 100K ohm Resistor (brn-blk-yel) ☐
- 2 x 390K ohm Resistor (org-wht-yel) ☐
- 1 x 1M ohm Resistor (brn-blk-grn) ☐
- 2 x 10M ohm Resistor (brn-blk-blu) ☐
- 2 x 82 ohm 1 watt Resistor (gry-red-blk) ☐
- 4 x 0.1 ohm 5 watt Resistor ☐
- 1 x 10K ohm Horizontal trimpot ☐
- 1 x 2K ohm Horizontal trimpot ☐
- 1 x 1K ohm Horizontal trimpot ☐

Capacitors

- 1 x 0.1uF Greencap ☐
- 1 x 0.22uF Greencap ☐
- 3 x 1uF Greencap ☐
- 2 x 47pF Ceramic Cap ☐
- 2 x 150pF Polystyrene ☐
- 1 x 10uF 16VW PC Electro ☐
- 1 x 0.47 16VW PC Electro ☐
- 1 x 47uF 16VW PC Electro ☐
- 5 x 100uF 16VW PC Electro ☐
- 1 x 470uF 16VW PC Electro ☐
- 1 x 47uF/50uF 63V Bi Polar Cap ☐
- 2 x 6.8uF 16V/35V Tantalum ☐

Semi-Conductors

- 2 x MR110 10A 100piv Stud Diode (D1,D2) ☐
- 1 x 5.1V 1 watt zener (IN4733) (D3) ☐
- 5 x IN4002 Diode (D4,D8,D9,D10, D11) ☐
- 1 x 5.6V 400MW Zener (IN752) (D5) ☐
- 2 x IN4148/IN914 Diode (D6,D7) ☐
- 1 x OA91/OA95 Germ Diode (D12) ☐
- 8 x IN5404 Diode (D13,D14,D15,D16, D17,D18,D19,D20) ☐
- 2 x BC559 Transistor (Q1,Q2) ☐
- 2 x BD 140 Transistor (Q3,Q4) ☐
- 2 x MJE3055/TIP3055 Transistor (Q5,Q6) ☐
- 4 x 2N3771 Pwr Transistor (Q7,Q8,Q9,Q10) ☐
- 1 x BC549 Transistor (Q11) ☐
- 1 x BC327 Transistor (Q12) ☐
- 1 x 4011 IC (IC1) ☐
- 4 x 4017 IC (IC2,IC3,IC4,IC5) ☐
- 1 x 4029 IC (IC6) ☐
- 1 x LM324 IC (IC7) ☐
- 1 x LF353, TL072 IC (IC8) ☐
- 1 x LM317T Regulator ☐
- 1 x LM334 Temp. Sensor ☐
- 1 x Red Led 5mm ☐
- 1 x Green Led 5mm ☐
- 1 x Orange Led 5mm ☐
- 1 x 4 mhz Crystal ☐

Hardware

- 1 x 6 way PCB Term block ☐
- 1 x 8 way PCB Term block ☐
- 1 x 10 way PCB Term block ☐
- 1 x 30 Amp 5AG Fuse ☐
- 1 x 30 Amp Panel Mount Fuse Holder ☐
- 1 x 6 way Mains Term block ☐
- 1 x Cord Clamp ☐
- 4 x Heatsinks ☐
- 1 x Red Battery clip ☐
- 1 x Black Battery clip ☐

Miscellaneous

P.C.B., Plastic case 250 x 190 x 80mm, Front Panel, Back Panel, T/Former Toroidal, Scotchcal Label, Mains Double Outlet, Steal Base Plate, Led Rings, Led Bezels, TO-3 Insulating Kit, Screws, Nuts, Washers, Wire, Silicon Grease, Spaghetti tubing, Solder lugs and Solder

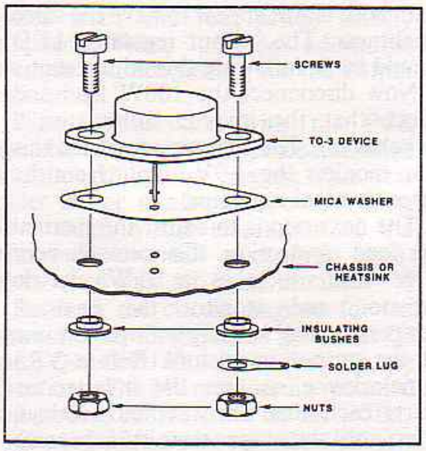

Fig.2: this diagram shows the mounting details for the output transistors.

STORE LOCATIONS

HEAD OFFICE AND DSXPRESS ORDER SERVICE
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Australia

NSW			
Swift & Young Sts	Albury	(060)	21 8399
T55 Terrace Level	Bankstown Sq	(02)	707 4888
Shop 1, 65-75 Main St	Blacktown	(02)	671 7722
613 Princess Hwy	Blakehurst	(02)	546 7744
Oxford & Adelaide Sts	Bondi Junction	(02)	387 1444
531 Pittwater Rd	Brookvale	(02)	93 0441
Campbelltown Mall Queen St	Campbelltown	(046)	27 2199
Shop 235, Archer St Entrance	Chatswood Chase	(02)	411 1955
147 Hume Hwy	Chullora	(02)	642 8922
164 Pacific Hwy	Gore Hill	(02)	439 5311
315 Mann St	Gosford	(043)	25 0235
4 Florence St	Hornsby	(02)	477 6633
Elizabeth Dr & Bathurst St	Liverpool	(02)	600 9888
450 High Street	Maitland	(049)	33 7866
621-627 The Kingsway	Miranda	(02)	525 2722
173 Maitland Rd, Tighes Hill	Newcastle	(049)	61 1896
Lane Cove & Waterloo Rds	North Ryde	(02)	88 3855
George & Smith Sts	Parramatta	(02)	689 2188
The Gateway High & Henry Sts	Penrith	(047)	32 3400
818 George St	Railway Square	(02)	211 3777
125 York St	Sydney City	(02)	267 9111
Treloar's Bldg, Brisbane St	Tamworth	(067)	66 1711
263 Keira St	Wollongong	(042)	28 3800
ACT			
96 Gladstone St	Fyshwick	(062)	80 4944
VIC			
Creswick Rd & Webster St	Ballarat	(053)	31 5433
145 McCrae St	Bendigo	(054)	43 0388
Shop 46 Box Hill Central Main St	Box Hill	(03)	890 0699
Hawthorn Rd & Nepean Hwy	East Brighton	(03)	592 2366
260 Sydney Rd	Coburg	(03)	383 4455
1150 Mt Alexander Rd	Essendon	(03)	379 7444
Nepean Hwy & Ross Smith Ave	Frankston	(03)	783 9144
Shop 9 110, High St	Geelong	(052)	43 8522
291-293 Elizabeth St	Melbourne City	(03)	67 9834
Bridge Rd & The Boulevarde	Richmond	(03)	428 1614
Springvale & Dandenong Rds	Springvale	(03)	547 0522
QLD			
157-159 Elizabeth St	Brisbane City	(07)	229 9377
166 Logan Rd	Buranda	(07)	391 6233
Gympie & Hamilton Rds	Chermside	(07)	359 6255
2nd Level Western Entrance Redbank Shopping Plaza	Redbank	(07)	288 5599
Queen Elizabeth Dr & Bernard St	Rockhampton	(079)	27 9644
Gold Coast Hwy & Welch St	Southport	(075)	32 9863
Bowen & Ruthven Sts	Toowoomba	(076)	38 4300
Kings Rd & Woolcock St	Townsville	(077)	72 5722
Cnr Pacific Hwy & Kingston Rd	Underwood	(07)	341 0844
SA			
77 Grenfell St	Adelaide	(08)	232 1200
Main South & Flagstaff Rds	Darlington	(08)	298 8977
Main North Rd & Darlington St	Enfield	(08)	260 6088
24 Park Terrace	Salisbury	(08)	281 1593
WA			
Wharf St & Albany Hwy	Cannington	(09)	451 8666
66 Adelaide St	Fremantle	(09)	335 9733
William St & Robinson Ave	North Perth	(09)	328 6944
Raine Square, 125 William St	Perth City	(09)	481 3261
TAS			
Shop 40A, Lower Level Cat & Fiddle Arcade	Hobart	(002)	31 0800
NT			
17 Stuart Hwy	Stuart Park	(089)	81 1977

New Zealand

Fort & Commerce Streets	Auckland City	(07)	38 9975
1795 Great North Road	Avondale	(09)	88 6696
Victoria Road & Bealey Avenue	Christchurch	(03)	50 405
Manse & Stafford Streets	Dunedin	(024)	74 1096
450 Anglesea Street	Hamilton	(071)	39 4490
440 Cuba Street, Alicetown	Lower Hutt	(04)	66 2022
Cnr Khyber Pass & Park Rds	Newmarket	(09)	396 495
26 East Tamaki Road	Papatoetoe	(09)	278 2355
16 Lydney Place	Porirua	(09)	37 6654
259 Cameron Road	Tauranga	(075)	87 071
154 Featherston Street	Wellington	(04)	73 9858

USA

Berkeley, Calif	(415) 486 0755	2474 Shattuck Avenue
Los Angeles, Calif	(213) 474 0626	1830 Westwood Boulevard
Redwood City, Calif	(415) 368 8844	390 Convention Way
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