HOWES TX2000 Instructions

OTTAR KVINDESLAND
Belsjøvn. 5
1440 Drøbak

Caution

The TX2000 transmitter and the band filter module(s) supplied with it are separate kits. Please take care not to mix them up! The part numbering starts at C1, L1 etc. in each kit, so be sure not to start putting the parts from one kit into another kit's board by mistake!

Note: A relevant amateur radio licence is required to install or operate this transmitting equipment.

Overview of the TX2000 project

The **HOWES TX2000** is an amateur radio CW (Morse) transmitter in kit form. It can cover all the shortwave (HF) bands by means of plug-in output filter modules. The transmitter will produce up to its full output on bands from 1.8 to 14MHz, with the power reducing to about 1W at 30MHz. One band filter kit is supplied with the TX2000 (80M band as standard, others to special order). The TX2000 is compatible with many other HOWES KITS including ATUs, SWR indicator, digital frequency displays and receivers. It can be combined with a receiver for transceive operation, by adding the relevant linking module (LM2000 linking module for use with DC2000 or DXR20 receivers).

Brief Technical Details

Frequency Coverage: 1.8 to 30MHz, operating frequency is determined by the input signal frequency applied to the module. The relevant plug-in low-pass filter must be fitted to correspond with the drive frequency.

Power: Up to a nominal 5W RF (adjustable) on 160 to 20M bands (1.8 to 14MHz) reducing to about 1W at 30MHz. Maximum power for each band is set by a preset resistor on the low-pass filter module. This enables the transmitter output to be compensated for drive level and transmitter gain changes from band to band. TX2000 is rated for continuous service at full rated output at 20°C.

VFO Input: nominal 50Ω input impedance, recommended input level: 0dBm (1mW) ±6dB.

Harmonics: Typically better than –50dBc with relevant "LF" filter module fitted.

Power required: Nominal 13.8 Volts DC, supply rated at 1.5A or more. Approx. 150 mA with "key up", about 900mA with key down at 5W output (at 7MHz).

Tools Required

Small tipped soldering iron of about 25W rating, small side cutters, wire strippers, long nosed pliers, a sharp knife, a screw driver for the M3 bolt, a drill with 2 mm and 4mm bits, and trimming tool for the power level preset on the band filter.

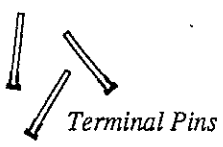
Building The Kit

Please read all the paperwork through at least once *before* starting work.

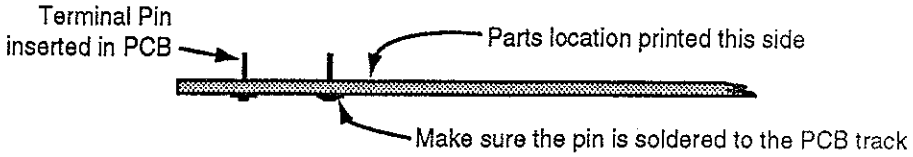
Make sure you have all the parts and tools to hand - if you don't have a small tipped iron suitable for modern electronic circuitry, then buy one, or borrow one from someone at the local radio club!

Important Note: If you intend to fit your TX2000 into the slimline HA23R hardware case, you must make a neat job of the soldering and lead trimming. There is only enough height in this case to space the PCB off the chassis by the thickness of one M3 nut. Please bear this in mind when building this kit and don't leave long lead ends, or "blobby" soldering, to short out to the case.

Fitting the Terminal Pins



Terminal Pins



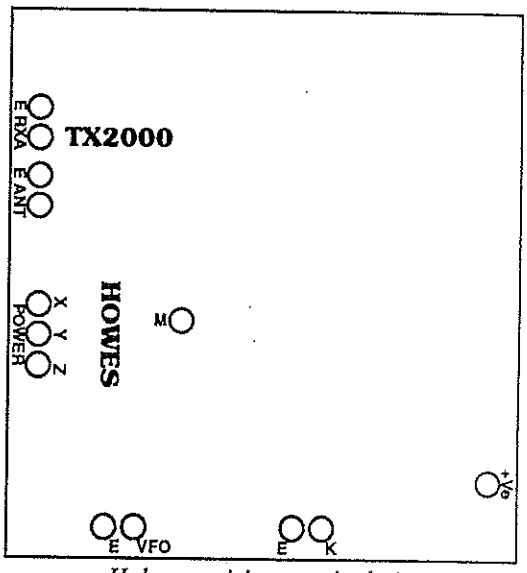
Side View: Terminal pins fitted to PCB

(continued)

TX2000 Instructions – page 2

Terminal Pins – continued

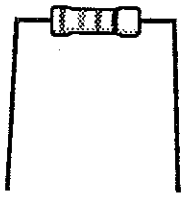
Terminal Pins need to be fitted to some of the Printed Circuit Board (PCB) holes to make it easier to wire the external connections. These are inserted into the holes shown in the diagram on the right. They have circles printed around them, so they are quite easy to find. The pins are inserted from the wiring side of the board and after fitting should project from the component/ground plane side (the green side with the printed parts locations). Push the pins into the holes by hand, and then resting the board over the edge of the bench, use a hot soldering iron and a little solder to push the pins fully home, flush into the board. ***Be careful*** not to slip with the hot iron as you do this. When all the terminal pins have been fitted, check that they are all soldered to their PCB tracks (see soldering notes for guidance)l, and that the "E" pins are also soldered to the "silver spots" around them on the ground plane side of the board. When this is done, move on to fitting the resistors.

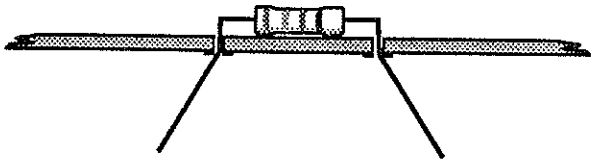


Holes requiring terminal pins

Resistors

Refer to the Parts List, and select the first resistor from the top of the list of quarter watt resistors. Bend its leads as shown in the diagram, and fit them into the holes marked for them on the circuit board. Be careful that you do not confuse the slightly larger axial inductors or the big 2 watt resistor with the quarter watt resistors. All the resistors have a light straw coloured background body colour with a gold band at one end.


Resistor with leads bent ready for insertion into PCB


Resistor inserted into PCB ready for soldering

When you have inserted the resistor's leads into their holes, push the body of the component down onto the circuit board, and then bend the ends of the leads out slightly to hold the resistor in place. Then turn the PCB over and solder the leads to the printed circuit tracks. Make sure the resistor's body is flat against the board so that its leads are kept as short as possible. If you are not an experienced hand with a soldering iron, please make yourself familiar with the "Notes on Soldering" at the bottom of page 8.

Cut the excess length of component lead off as close to the joint as possible, *after* you have soldered it. Now fit the next resistor from the parts list in a similar manner.

Note: Some resistors need to be soldered to the ground plane (component side) of the board as well as to the tracks under the board. The leads that require soldering to the ground plane are easily identified because they have a "silver spot" around them to solder to. If there is no "silver spot" around the lead's hole on the ground plane, then the component only needs to be soldered to the tracks under the board.

Carry on down the parts list until all the resistors are fitted, including the larger 2W resistor.

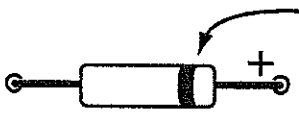
Axial Inductors

These components look just like fat resistors, but usually have a blue or green background colour to their bodies. Inside these devices is a small coil wound on ferrite material. Fit these to the PCB in the same manner as the resistors by referring to the Parts List for the inductor's colour code information.

TX2000 Instructions, continued – page 3

Diodes

Fit the diodes next, these must go the right way round. There is a band at one end of each diode's body, this indicates the lead that must go to the hole marked "+" on the board. The parts list shows the part identification information.



Band indicates the lead that goes to the hole marked "+"

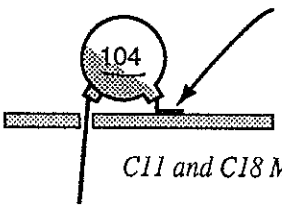
Capacitors

When the diodes are in soldered in place, move on to the capacitors. Fit all the capacitors *except C17 and C19* (the two green Mylar ones) at this point. It is best not to fit C17 and C19 until all the other components are in place (this is because C17 can get in the way of soldering TR5 to the ground plane, and as C19 is the tallest component on the board, it tends to get bent about somewhat, unless it is fitted last).

When fitting the capacitors, be sure to keep their leads as short as possible. C26's leads will need to be bent carefully before fitting to the PCB, as its holes are spaced a little wider apart than the leads coming out of the component. Be careful not to break the capacitor's body when you bend its leads.

Notes: The "electrolytic" type capacitors must be fitted the right way round – see note on the Parts List 2 page. There are two different types of .1µF capacitor in this kit (brown disc shape and a rectangular green one). Please be careful to select the correct part.

C11 and C18 have one lead soldered directly to the ground plane. There is a PCB hole for only one lead of these two components. Please *do not* drill a hole in their "silver spots" thinking we have forgotten to do this!



Lead soldered to "silver spot" on the PCB ground plane before the board is turned over to solder the other lead.

C11 and C18 Mounting Arrangement

Relay, RL1 and Filter Connector, PL1

Fit the relay, RL1 next. It will only fit in one way. The filter module plug, PL1 must be fitted the right way round. The plastic tab running alongside the pins must be closest to the centre of the PCB (see diagram on Parts List 2 page). Make sure the connector is pushed fully home into the PCB before soldering it in place.

Transistors

Select and fit the transistors, again these must be fitted the right way round, as indicated by the outline printed on the PCB. The power amplifier (PA) transistor, TR5, is mounted on the aluminium heatsink with the mica washer fitted between the transistor and the heatsink. There are also two fixing holes to drill in the heatsink. The Parts List 3 page has the assembly details. Make sure you remove any burrs around the edge of the holes when you drill these. TR5's emitter lead must be soldered to the ground plane "spot" in addition to its track connection on the "wiring" side of the board.

Coil Winding

The correct winding of the two transformers L5 and L8 is crucial to obtaining the specified performance of the transmitter, so please pay particular attention to the instruction on the Parts List 3 page. L7 also needs to be wound carefully if it is to fit neatly into its holes on the PCB.

Finishing the Module

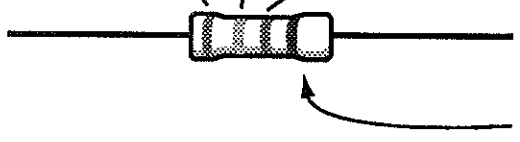
The only components left to fit now should be C17 and C19. When these are soldered in place make a very careful check that all the parts are in the right places, and the right way round. Make sure all the "silver spots" around component leads on the ground plane are soldered to the leads. It is very easy to miss one or two of these when fitting the parts, so this check is very important for even the most experienced constructor. When you have assembled a band filter module to plug in to your main transmitter board, you can start to think about testing your handiwork!

The Module Wiring page shows the normal external connections required by the TX2000. If you are using one of our hardware packs to house your project, then you should refer to the hardware pack instructions for the definitive guide to wiring the unit with that specific hardware.

TX2000 Parts List 1

.25W Resistors

Value	Colour Code			Part Numbers
10R	Brown	Black	Black	R16 R21
47R	Yellow	Violet	Black	R20 R23
56R	Green	Blue	Black	R1
100R	Brown	Black	Brown	R7 R8 R13
220R	Red	Red	Brown	R19
270R	Red	Violet	Brown	R12 R26
470R	Yellow	Violet	Brown	R14
680R	Blue	Grey	Brown	R5 R10
1k2	Brown	Red	Red	R17 R22
2k2	Red	Red	Red	R11 R18
4k7	Yellow	Violet	Red	R15 + one spare (see page 7 for usage)
10k	Brown	Black	Orange	R3 R9
18k	Brown	Grey	Orange	R25
22k	Red	Red	Orange	R4
100k	Brown	Black	Yellow	R2 R6



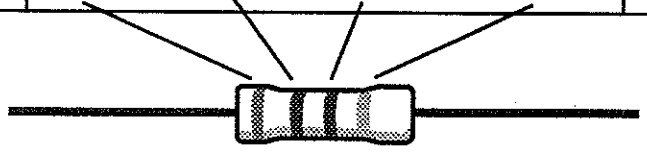
2W Resistor – R24

This is the large resistor colour coded Brown, Black, Brown, Gold and is 100R (Ω) in value.

Axial Inductors, L1 to L4 & L6

These look rather like fat resistors.

Value	Colour Code				Part Numbers
0.82µH	Grey	Red	Silver	Black	L1 L3
2.7µH	Red	Violet	Gold	Silver	L6
180µH	Brown	Grey	Brown	Silver	L4
220µH	Red	Red	Brown	Silver	L2



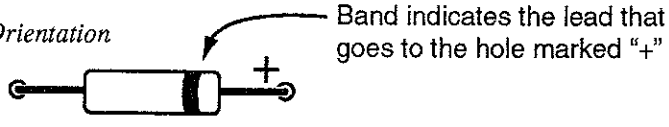
Diodes - *take care to put these in the right way round.*

The band on the diodes indicates the lead that must go to the hole marked "+" on the PCB.

D1 - This is a BZX55 Zener diode (black body with grey band) – it has BZX and its voltage (10V) marked on it.

D2 and **D3**, these are 1N4148s are orange coloured with a black band and have their type numbers marked on them.

Diode Orientation

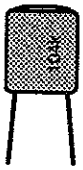


TX2000 Parts List 2

Capacitors

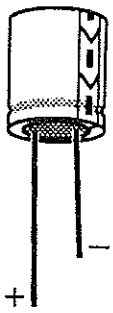
Plate Capacitor

Disc Capacitor



Mylar Capacitor

Polystyrene Capacitor mounted vertically (as used in some band modules)



Electrolytic Capacitor

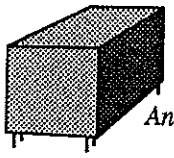
Value	Marking	Part Numbers
2p2	Plate marked 2p2	C26
1nF	Disc marked 102	C2 C4 C5
.01µF	Disc marked 103	C1 C3 C7 C9 C10 C12 C13 C14 C20 C21 C25
.1µF	Disc marked 104	C6 C11 C15 C16 C18
1µF*	Electrolytic marked 1µF	C23
22µF*	Electrolytic marked 22µF	C8
100µF*	Electrolytic marked 100µF	C22
470µF*	Electrolytic marked 470µF	C24
.1µF	Mylar, green marked 104	C19
.22µF	Mylar, green marked 224	C17

Fit C17 and C19 after all the other components are soldered in place

* Electrolytic capacitors must be fitted the right way round. The longer lead goes to the hole marked "+", the other lead goes to the "–" hole and is indicated by a band containing "–" signs on the side of the capacitor.

Relay, RL1

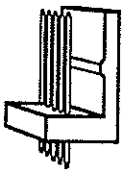
The antenna switching relay will only fit one way round.



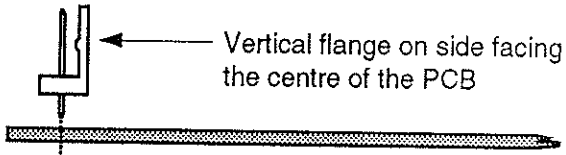
Antenna Relay

Plug-in Band Filter Connector

PL1 is a PCB mounting 6 pin plug and is the connector for the plug-in low-pass filter module. This is fitted with the plastic flange that runs along side the contacts facing towards the centre of the circuit board as indicated by the PCB part's outline.



Module Plug

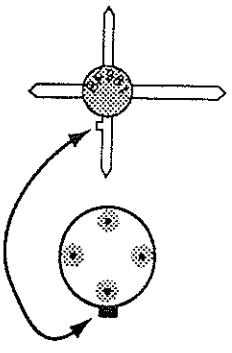


View from front of PCB showing connector orientation

BF961 Dual Gate MOSFET, TR1

Bend the leads of this transistor down at right angles to the transistor's body with its part number facing upwards. The hole for the lead with the "pip" on it is indicated on the PCB outline as shown in the diagram. Fit this carefully to the PCB and solder it in place. Trim the excess lead length off after soldering.

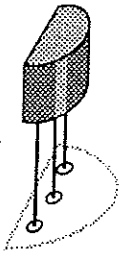
"Pip" on lead indicates the lead that goes to the hole indicated by the pip on the PCB outline. Bend the transitor's leads down at right angles to its body so that they fit into the PCB holes. The part number on the transistor should face upwards as shown. The transistor's body should sit flat on the PCB.



Transistors, TR2, TR3, TR4 & TR6

These have their type numbers marked on them. Insert them into the PCB the right way round, as the outline printed on the board indicates.

TR2 and TR3 are type MPSH10.
TR4 is the taller device marked C2500, its full title is 2SC2500.
TR6 is a BC547B.

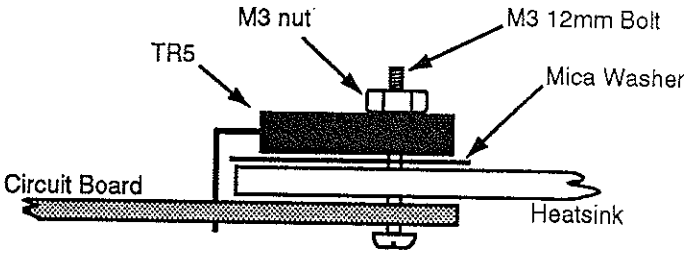


Transistor fitted to PCB

TX2000 Parts List 3

PA Transistor, TR5

TR5 is a BUP41. Bend its leads backwards at right angles, 3 to 4 mm from its plastic body, so that they will align with their PCB holes when the transistor is bolted in place on its heatsink. **Note:** the face of the transistor with its type number on it, faces upwards away from the board and heatsink.



Fitting the PA transistor to its heatsink – side view

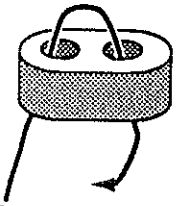
Make a temporary installation of the PA transistor without soldering it, or removing the protective plastic coating from the aluminium heatsink (see diagram for assembly order). The transistor's fixing hole is pre-drilled. You need to drill the two corner holes. Make sure the heatsink is parallel with the PCB and then mark the heatsink through the PCB fixing holes ready for drilling. Remove the heatsink, centre punch the two fixing hole positions and drill with 2 mm pilot holes. Then enlarge the holes to 4 mm and de-burr them.

Peel off the protective plastic film from the heatsink and mount TR5 on the heatsink with the mica washer between the transistor and the heatsink (you may need trim the washer to length). Make sure the heatsink and PCB corner fixing holes are aligned. Tighten TR5's fixing bolt just a little more than finger tight.

When the transistor is bolted correctly in place, solder the transistor to its PCB wiring tracks under the board, and also solder its emitter lead to its "silver spot" on the ground plane.

Matching Transformers

These are wound on the two hole balun transformer cores and provide impedance matching for the PA stage. The PA output transformer has an additional winding that provides drive for a transmitter output monitoring circuit.



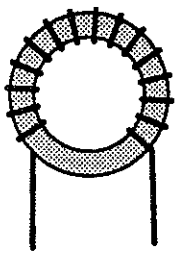
Taking the wire in one hole and out the other counts as one turn.

The finished transformer

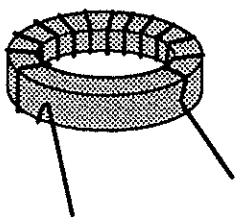
L5: Take 100 mm (4") of each of the red and yellow plastic insulated silver plated wire, and twist the wires together along their full length. Wind three turns of the twisted pair onto one of the two hole balun cores. Passing the wire in one hole and then back out of the other hole counts as one turn, as defined in these instructions. Doing this three times gives a three turn winding. The diagrams should help make this clear.

Once this transformer is wound, carefully remove the insulation from the lead ends projecting from the transformer using suitable wire strippers or a sharp knife. Please be careful not to cut or nick the wire if using a knife for this job. Then insert the leads into the PCB holes marked for L5 in the correct order. The holes are marked "y" for yellow leads and "r" for the red leads. Solder the leads and trim off the excess length.

L8 is wound in a similar manner to L5, except that this needs 100 mm lengths of red, yellow and blue wires to be twisted together. Three turns of the twisted wires should be wound on the remaining two hole balun core. Remove the insulation from the wires ends as before, and then insert the leads into their correct holes for soldering. The colours of the leads are indicated by "y" = yellow, "r" = red, and "b" = blue.



L7 Side View



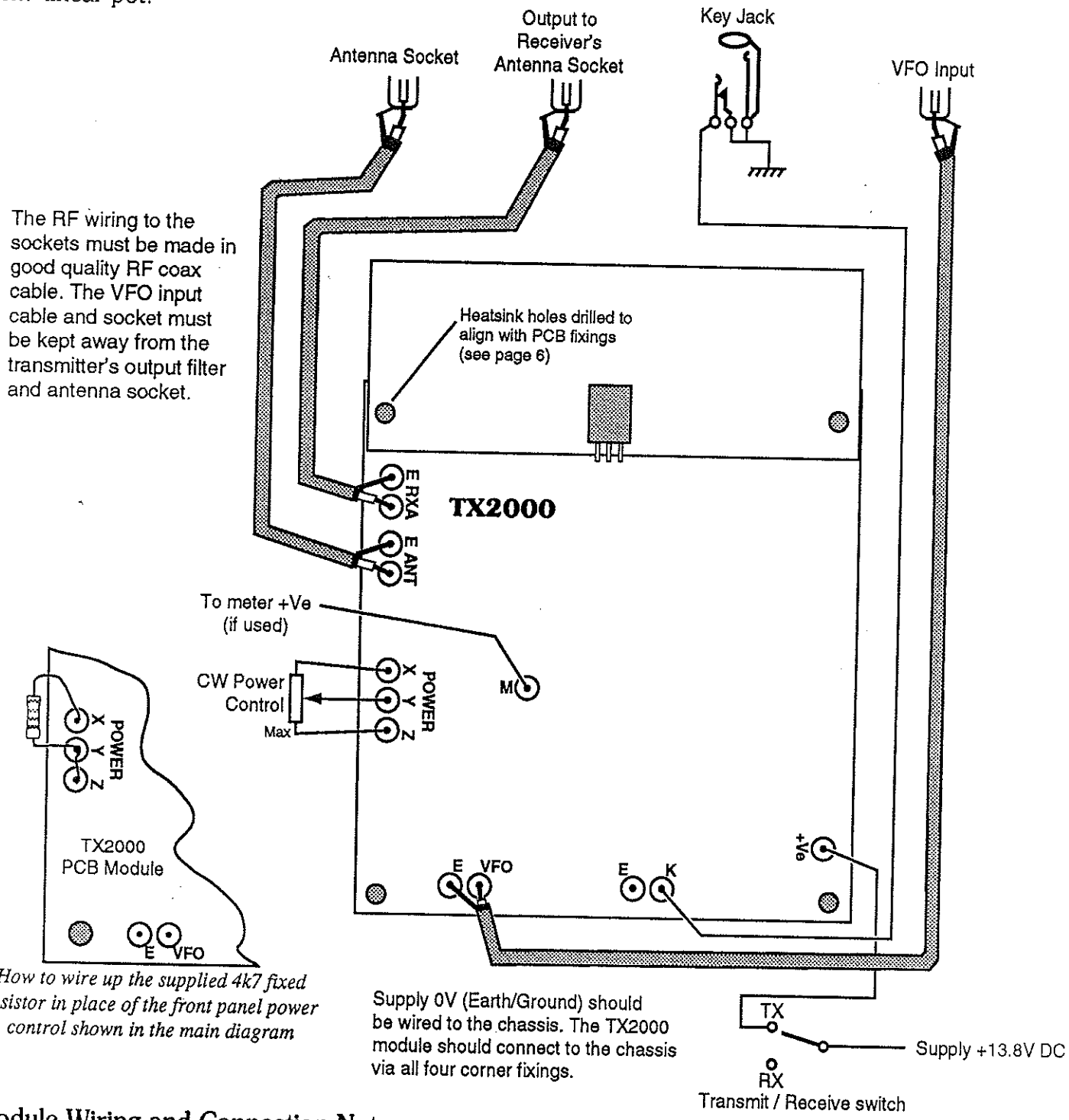
L7 showing how the leads should be bent

RF Choke – L7

Take 300 mm (12") of the enamelled copper wire, and wind 15 turns on the grey toroid core. Space the turns evenly around the core, and wind the wire tightly so that it follows the contours of the core, without any air gaps between the wire and the toroid. Bend the leads at the end of the winding as shown in the diagram, so that the coil will sit neatly in its PCB holes between the other components (the end leads need to be bent out at right angles from a point half way across the outside of the core). Use a sharp knife to scrape the insulation off the coil's end leads before inserting them into their PCB holes and soldering them to their tracks.

TX2000 Module Wiring

When your TX2000 module is fully assembled, you can install it in a metal case and wire it up, as shown in the diagram. If you are using one of our hardware packs to house your project, then refer to the hardware instructions for details of how to wire up the actual parts supplied. The optional power control shown is a 4k7 linear pot.



How to wire up the supplied 4k7 fixed resistor in place of the front panel power control shown in the main diagram

Module Wiring and Connection Notes

Important – you must have some means of limiting the current to the transmitter in case of a fault condition. Either a current limited power supply should be used (set to between 1 and 2A), or fit a 2A fuse in the positive supply lead going to the transmitter. This fusing is of the utmost importance if you are using a car battery or other source of potentially high currents. For correct protection, the fuse should be fitted at the battery connection end of the wire, not at the transmitter end.

"M" Terminal

The "M" (meter output) terminal is for connecting to a moving coil meter (use 250µA or a slightly higher rating) to indicate transmitter output. The HOWES DCS2 "S meter" kit has a suitable connection point (marked "M") so that it can indicate transmitter output, as well as receiver signal strength.

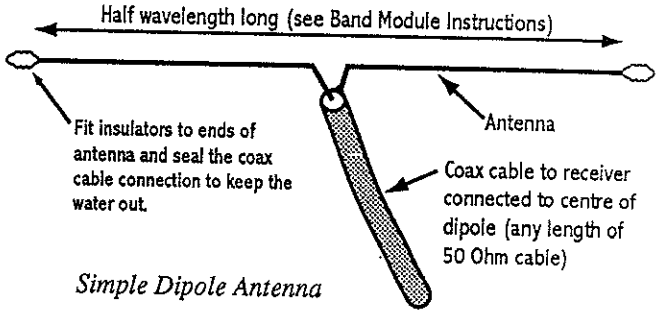
TX2000 User Information – 1

Power Supply

The TX2000 requires a power source providing a nominal 13.8V DC. It should be capable of providing at least 1.5 Amps, and should be of the regulated type, or a vehicle type battery.

Antenna Requirements

The TX2000 is designed to work with a nominal 50Ω antenna impedance. It is recommended that an SWR indicator is used to check that the antenna provides a good impedance "match". If the antenna provides an SWR of greater than 1.5 : 1, then an antenna tuning unit (ATU) should be used to improve the match. A half-wave dipole antenna should provide a reasonable match (usually about 1.5:1) without an ATU.



Simple Dipole Antenna

Always keep antennas away from other wiring, especially high voltage power lines, and always disconnect them from the equipment when they are not in use, or in weather conditions that may cause high static voltage discharges (thunder storms etc.).

Testing the Module and Alignment.

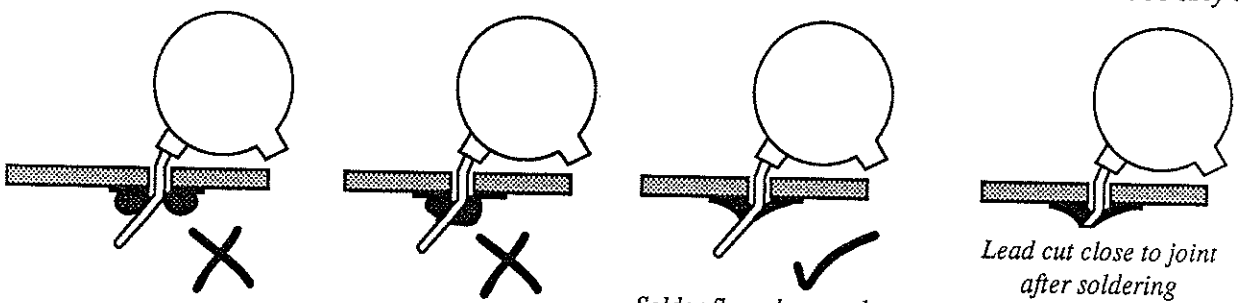
Wire the output of the TX2000 to a suitable RF power indicator with a 50Ω dummy load on its output. Connect the TX2000 VFO input to a suitable VFO/signal generator/LM2000 Linking Module, to drive the TX. Make sure the frequency is correct for the plug-in low pass band filter you are using. Set the preset power control on the filter module to half travel. If you have a front panel power control, turn this to maximum. Plug in a Morse key and connect up the power supply, being very careful to get the polarity correct.

Switch the TX/RX switch to transmit and press the key. You should obtain a reading on the power indicator. Adjust the power level preset resistor on the plug-in filter module for the desired output power, but keep the power to 5W or less. If the unit appears to be non functional, try turning the power control the other way! If there is still no output, recheck all your connections. Refer to the fault finding list on page 10 for additional help.

When all is well, fit the lid onto the transmitter's case and use your station receiver and test gear to check that the signal is "clean". You should now be able to connect up the receiver, antenna, SWR bridge etc. and set about making your first contact with your new rig! Good DX!

Notes On Soldering

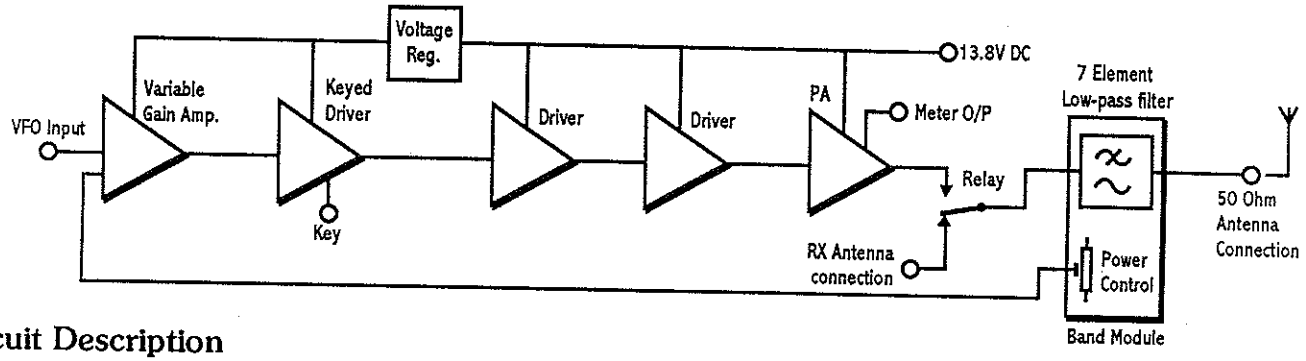
To solder properly, you must use the correct type of iron and the right quality of solder. Use a small tipped soldering iron which has a bit that is short and almost pointed at the end. The iron should be about 25 Watts (if it is not thermostatically controlled). Only use electronic type multicored solder. NEVER use any extra flux.



Lead not heated enough *Track not heated enough* *Solder flowed properly on lead and track* *Lead cut close to joint after soldering*

You should hold the hot iron in contact with both the board and component lead for about a second or so to heat them up. Then, keeping the iron in place, touch the solder onto the junction of lead and track and wait a further second or so for the solder to flow along the lead and track to form a good joint. Now remove the iron. The iron should have been in contact with the work piece for a total time of about 4 seconds in all. It is a good idea to drag the tip of the iron up the component lead as you remove it from the joint, this helps to pull any excess solder up with it and encourages good flow along the component lead.

TX2000 User Information - 2



Circuit Description

The TX2000 circuit is quite simple in concept, and the block diagram above shows the basic circuit functions in outline. The circuit diagram on the next page gives the more detailed picture. The signal from the external VFO or receiver linking module is fed into the TX2000, where a series of amplifier stages boost the signal up to a suitable level for transmission (nominally about 5W). This is in essence the main function of the TX2000. Morse "keying" is achieved by TR2 being turned on and off by the action of the Morse key. The power amplifier stage (PA), TR5, produces the transmitter's output power, and operates in a slightly different way from the other driver stages, due to its higher power operation. The transmitter output is then filtered by a plug-in low-pass filter, to reduce the harmonics of the transmitter frequency to a low level.

Variable Gain Input Stage

TR1 is a dual gate MOSFET transistor whose gain is controlled by the DC voltage applied to its second gate. The signal input is applied to gate 1 of the transistor. The gate 2 voltage is adjusted on the band filter module by the preset resistor, and also by a front panel control pot, if you chose to connect one to the terminals marked "POWER" on the PCB. A fixed resistor must be fitted to these terminals, if a front panel power control is not being used. As each band filter module has its own power control, the power output can be equalised across the bands, or set to different levels, as desired.

Driver Stages

TR2 is an "emitter follower" stage to convert the highish impedance of TR1's output to the lower impedance input of TR3. It also doubles as the keyed stage, with the current flowing through it via the Morse key, connected to the "K" and "E" terminal pins. Current only flows through TR2 when the key is pressed.

TR3 and TR4 operate in "class A" linear mode with negative feedback (some of the output signal returned to the input in opposition to the input signal) to give less distortion, and a more even frequency response, than more basic amplifier circuits can achieve. The negative feedback is reduced at the higher frequency end of the range by the action of the RF chokes, L1 and L3. This helps to keep the frequency response from tailing off as the frequency rises.

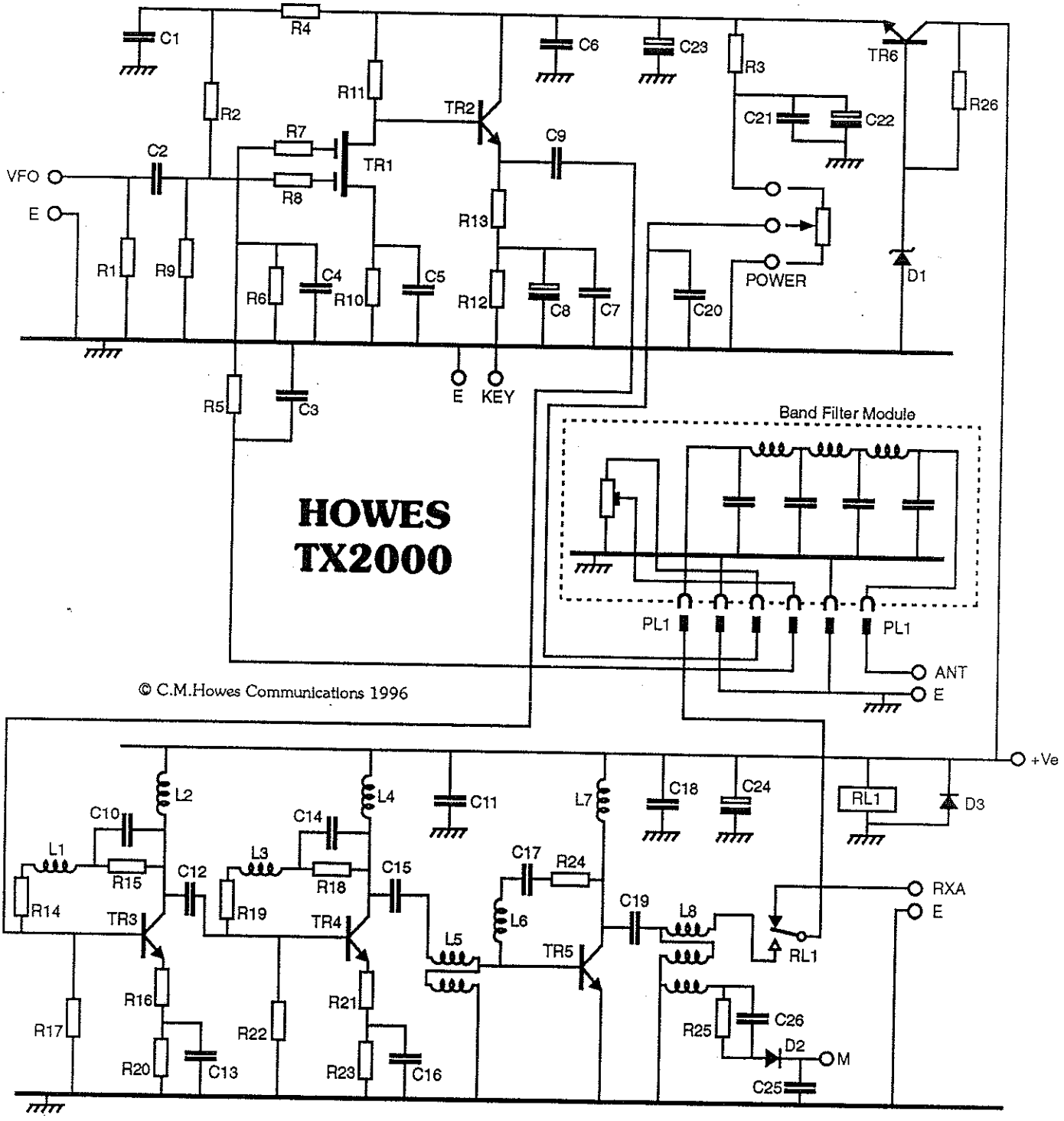
TR5 is the transmitter's Power Amplifier stage. Again some RF negative feedback is employed by means of R24, C17 and L6 to smooth the performance of the amplifier. As the power levels are higher in this stage, the currents flowing are greater, and this means that the input and output impedances of the amplifier are lower. To provide matching to the required 50Ω impedance, transformers L5 and L6 are used on the input and output of the stage. The output transformer, L8, also has an additional winding to drive a simple RF detector circuit, that can be used to drive a meter for output indication.

The output of the PA stage (which operates in class C for good power efficiency), is rich in harmonic energy, and needs to be filtered before it can be fed to an antenna. The plug-in low-pass filter module provides a good degree of harmonic suppression, and gives the TX2000 a level of harmonic performance rarely seen in simple QRP equipment. In fact, many expensive QRO linear amplifiers do not have their harmonics nearly as well suppressed!

Design

The design of good kit equipment is not just about the electronic circuitry, but also about ease of construction, minimising alignment problems and test equipment requirements, clarity of instructions, tidy board layout etc. We hope you will find your TX2000 pleasing in all these respects, as well as being a great little transmitter capable of providing you with many contacts!

TX2000 Circuit Diagram



Fault finding checklist – try these suggestions if your kit doesn't work.

1 Is the battery or power supply you are using OK? Do not try reversing the polarity under any circumstances – the unit will be damaged if you do.

2 Are your external connections correct? Pay particular attention to the key jack and antenna socket wiring. Is the SWR/Power meter you are using suitable for the power level and frequency you are using? Note: CB power meters will often under read on all frequencies below the CB band, and not register any reading at all on the 160 or 80M bands with a 5W input. Have you remembered to wire up a resistor to the "power" control terminals?

3 Are all the parts in the right places, are all the diodes etc. the right way round? Is the band filter the correct one for the frequency, is it plugged in properly?

4 Is anything loose that should not be? Try wiggling everything very gently. If a wire comes away, or a component moves on the PCB, then you have found a poor connection. There may be others, so check all parts.

5 When you have done the above and the problem persists or you have found a loose or incorrect part on the PCB, disconnect the power supply and then the wires from the terminal pins on the PCB, take the board out of the case. Recheck all the soldering. All the joints should look bright and shiny, and no light should be visible through any holes when you hold the board up to a bright light. Don't heap extra solder onto everything out of desperation! Only add solder if a joint really needs it. Too much solder will tend to "bridge" across to other tracks, so don't overdo it.

6 Reinstall the module with just the essential connections made (power, VFO input, output load) link the key terminal pin, "K" to "E" with a short wire and retest the unit. If it now works, the fault may be in the external wiring rather than on the PCB itself.

7 We can give telephone advice during office hours, and usually on Saturday too. Please carry out the above checks before 'phoning, because these are the most effective "first aid" suggestions and they should get you up and running in most cases.