OTTAR KVINDESLAND
Belsjøvn. 5
1440 Drøbak

HOWES LM2000 Instructions

The **HOWES LM2000** is a linking module for connecting a direct conversion receiver to a transmitter for transceive operation. In particular, it is designed for use with the HOWES DC2000 and TX2000. Facilities include additional audio filtering for the receiver and a side-tone oscillator for Morse operation, in addition to the buffering and muting facilities that transceive operation requires.

Brief Technical Details

VFO Buffer: Dual gate MOSFET input buffer with adjustable amplifier gain of nominally –4dB to +10dB. Output signal level nominally 0dBm (1mW). Test figures at 7MHz.

Side-tone oscillator: Side tone injection into receiver audio amplifier stage from key operated oscillator (earth/ground for oscillation) with adjustable pitch, volume and attack.

Audio Filter: A special low pass filter gives a nominal 6dB peak at 800Hz (standard CW pitch), –6dB points nominally 450 and 1100Hz (650Hz bandwidth). This filter is also quite effective for narrow bandwidth SSB reception.

Receiver Muting: Relay operated muting, switches the receiver audio output stage over to side-tone input on transmit, and switches the receiver antenna input connection to earth (ground).

Incremental Receiver Tuning: The variable resistor ("pot") controlled IRT function, allows the receiver's VFO to be frequency shifted from the transmit frequency by a small amount, to give a "beat note" for CW reception. A "dead spot" circuit ensures the control has no effect over a few degrees of rotation either side of the transmit frequency, to make accurate netting easy, and avoid the need for a receiver IRT on/off switch.

Power Required: 12 to 14V DC at about 95 mA maximum (transmit), 38 mA in receive mode. Onboard voltage stabiliser for VFO buffer and side-tone oscillator stages.

Tools Required

Small tipped soldering iron of 25W rating (or greater if thermostatic type), small side cutters, long nosed pliers and a trimming tool for the preset resistors.

Building The Kit

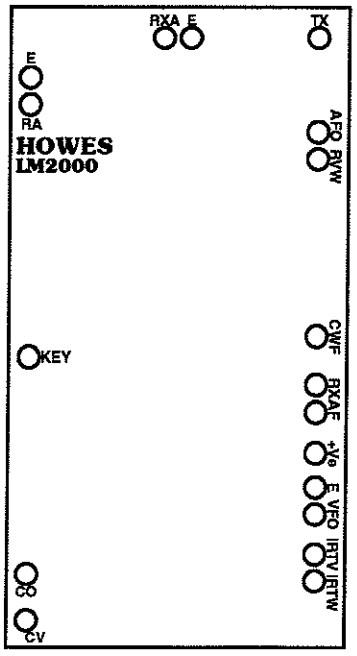
Please read all the paper work through at least once *before* starting work.

Make sure you have all the correct tools and parts to hand. A decent soldering iron appropriate to this type of work is essential for good soldered joints. Please do not use an underpowered iron (not less than 25W). The large copper area on the ground plane (the top, green side of board) will soak up almost all the heat output from a 10 or 15W iron, and the ground plane solder joints will tend to be "dry" as a result.

Terminal Pins

Terminal Pins need to be fitted to some of the Printed Circuit Board (PCB) holes for wiring to 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 "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, and also to the ground plane, if there is a "silver spot" around the pin to solder to. The next job is to fit the resistors.

Terminal Pins

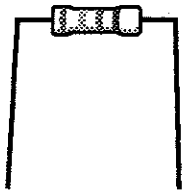


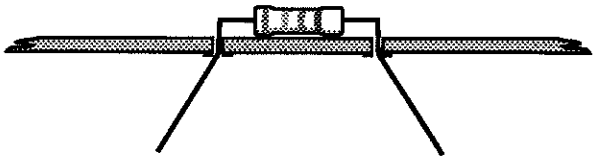
Holes Requiring Terminal Pins

HOWES

LM2000 Instructions – Page 2

Resistor with leads bent ready for insertion into PCB





Cutaway Side View: Resistor inserted into PCB with leads bent out slightly, to hold it in place for soldering

Fixed Resistors

Select the first resistor from the list on the Parts List 1 page, by using the colour code shown. Bend its leads as shown in the diagram above, and fit it to the holes marked for it on the PCB. Push the resistor fully home, so that its body is resting on the board. Then, holding the resistor in place, turn the board over and bend its leads outwards a little, so that the component is held firmly in position. Now solder the resistor to its PCB tracks. Some resistor's leads also have "silver spots" around them on the ground plane side of the board, and these need to be soldered to the leads, in addition to the track connections under the board. Please refer to the soldering notes on page 8 for soldering advice.

When the resistor is soldered in place, use side-cutters to trim off the excess lead length, as close to the joint as possible. Move on to fit the next resistor from the parts list, and carry on down the list, until they are all soldered in place. The preset resistors are the next parts to fit.

Preset Resistors

There are four preset resistors in this kit, all having different resistance values! Please be careful to select the correct parts. Refer to the Parts List for the details. If you bend the leads outwards just a little, before pushing then into the board, they should stay in place as you solder them. The diodes are the next parts to fit.

Diodes

These must be fitted the right way round. There is a band at one end of each diode's body - this indicates the lead that goes to the hole marked "+" on the board. D1 is the largest of the six diodes. One of its leads should be soldered to the ground plane, in the same way that some of the resistors' leads were. When the diodes are all soldered in position, move on to fitting the relays.

Relays

The two relays are simple to install, they will only fit one way round. But, be careful that all their pins go through their PCB holes, and that one doesn't get bent over as you push it in.

Capacitors

When the relays are in soldered in place, move on to the capacitors. When fitting these, be sure to keep their leads as short as possible.

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 .01µF (10nF) and .1µF (100nF) capacitor in this kit (brown disc shape and rectangular green ones). Please be careful to select the correct part. We have described the capacitance of the disc capacitors in µF (micro Farads) and the Mylar ones in nF (nano Farads) to help distinguish them (1000nF = 1µF).

Transistors

The last parts to select and fit are the transistors. TR1 must have its leads bent for insertion into the PCB. The details are on the Parts List 2 page. The outlines printed on the PCB should show the orientation of the other transistors quite clearly. Keep these transistors' leads quite short by sliding them down into the board, so that the body of the device is about 3 or 4 mm above the PCB. Once these are all soldered in place and their leads are trimmed, make a thorough inspection of the module to make sure that everything is correctly assembled.

LM2000 Checking and Alignment

Checking the Assembly

Make especially sure that all the ground plane "silver spots" have been soldered to the terminal pins or leads passing through them. It is very easy to miss one of these. There is one spot without any connection (near "CO"). This is for soldering a lead to when you instal the module, and will have no connection at the moment.

Hold the board up to a bright light and check that there is no light coming through any of the holes where a solder joint should be. Resolder any connections that are in any way suspect with a little fresh solder, but do not build the joints up into a "blob"! Good soldering is bright and shiny.

When you are happy everything is correct, you can move on to installing and testing the module. Information about this is on the Module Wiring pages.

Alignment

Alignment is very straightforward. The initial mechanical positions of the preset resistors are as follows:

VR1 & VR4: Set to one third clockwise rotation.

VR2 & VR3: Set to half rotation.

Testing the Module

With the LM2000 wired to the receiver as per the Module Wiring information, you can test the basic functions of the unit. You do not need to connect up the transmitter to carry out these basic tests.

Connecting the "TX" terminal to chassis (earth/ground) will mute the receiver and bring the side-tone oscillator into use. Connect the "KEY" terminal to chassis to cause the side-tone oscillator to sound (with "TX" still earthed). Adjust the side-tone preset controls as set out below to suit your preferences.

Remove the "TX" chassis connection and the receiver should return to normal operation, with just a short delay between removing the "TX" earth and the receiver audio returning. This short delay is to ensure the transmission is completely finished before the receiver unmutes.

You can now connect up the transmitter and see how the units work together. Do not forget to fit the same frequency band modules in both the transmitter and the receiver!

Final Preset Adjustments

VR1 adjusts the VFO buffer gain. Turning the control clockwise increases the VFO output level. The nominal output level is 0dBm (1mW), but this is not critical, and the mechanical adjustment above will be quite adequate in most instances. The TX2000 transmitter also has gain adjustment, and output power can be set for the desired level by the transmitter's band filter preset power control.

VR2 is side-tone bias adjustment. This alters the attack and purity of the note and will also have some interaction with the pitch control. If you are using a transistorised keyer with this equipment, the bias control will need to be turned more clockwise than if you are using a "straight" key. If the bias is set too low, the side-tone oscillator will not oscillate. Turn it up (clockwise) to "kick" the oscillator harder.

VR3 adjusts the side tone pitch. The normal 800Hz frequency occurs with it set about half way, but simply adjust this to your taste (in conjunction with VR2).

VR4 is the side-tone volume control. Set the level to suit your monitoring requirements. It operates independently of the receiver's volume control setting.

Receiver Alignment

The "CO" and "CV" connections from the LM2000 to the receiver's oscillator circuit have a small capacitance effect, and will lower the frequency of the oscillator. The oscillator coil (L5 on the BM band module) will need to be adjusted to compensate for this.

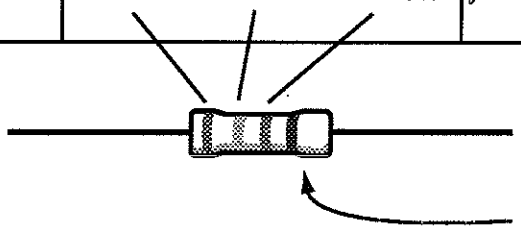
IRT Knob Alignment

There is a "dead spot" at about the centre of the IRT pot's rotation, where it has no effect on the frequency for a few degrees of rotation. This corresponds to the transmit frequency, and is provided to make "netting" easier. Ensure that the IRT pot's knob pointer is vertical in the centre of this "dead spot".

LM2000 Parts List 1

Resistors

Value	Colour Code			Part Numbers
10R	Brown	Black	Black	R9 R29
100R	Brown	Black	Brown	R2 R3
330R	Orange	Orange	Brown	R7 R11
680R	Blue	Grey	Brown	R6
1k0	Brown	Black	Red	R24 (+ one extra for IRT pot wiring)
2k2	Red	Red	Red	R15 R19 R21
4k7	Yellow	Violet	Red	R27
5k6	Green	Blue	Red	R16
6k8	Blue	Grey	Red	R17
8k2	Grey	Red	Red	R25
10k	Brown	Black	Orange	R26 R30 R32
22k	Red	Red	Orange	R8 R10 R12 R18 R22
47k	Yellow	Violet	Orange	R13 R14 R20
100k	Brown	Black	Yellow	R1 R4 R5 R23 R28 R31



Note: There should be two fixed resistors left over after the PCB mounted ones are in place. These are for wiring to the IRT pot (also supplied in this kit), when you come to install it later. The 1k0 resistor's colour code is shown above, the 3k3 one is Orange, Orange, Red.

Preset Resistors

These all look similar, but are of different values. The resistance is printed on them.

VR1 is 4k7, **VR2** is 100k, **VR3** is 22k and **VR4** is 470R.

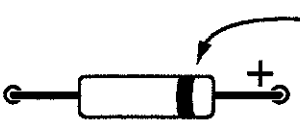
Preset Resistor

Diodes – *make sure these are fitted the right way round.*

D1 is a 1N4004 and has its type number marked on it. It is black with a silver/grey band.

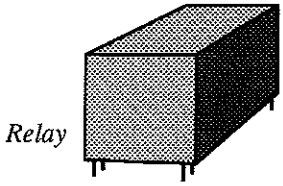
D4 is a BZX55C 9V1 zener diode it is marked with its type number. It is orange with a white band.

D2, D3, D5, D6 & D7 are all 1N4148. These are small orange coloured diodes with a black band.



Relays, RL1 & RL2

These are easy to identify and fit. Solder just one "leg" first and check that the relay is flat against the PCB before soldering the rest of the pins.

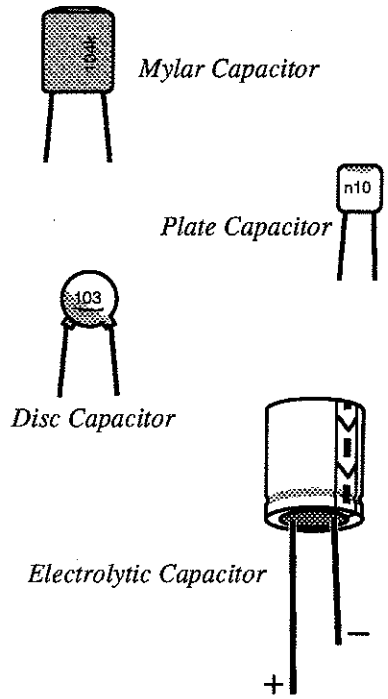


Relay

LM2000 Parts List 2

Capacitors

Value	Identification Details	Part Numbers
5p6F	Plate marked 5p6	C1, C2
1nF	Disc marked 102	C4, C11
.01µF	Disc marked 103	C5, C6, C7, C21
.1µF	Disc marked 104	C3, C8, C9
4n7F	Green Mylar marked 472	C12, C18
10nF	Green Mylar marked 103	C16, C17, C19
100nF	Green Mylar marked 104	C10, C14
220nF	Green Mylar marked 224	C13
1µF*	Electrolytic marked 1µF	C15
4µ7F*	Electrolytic marked 4.7µF	C22
470µF*	Electrolytic marked 470µF	C20



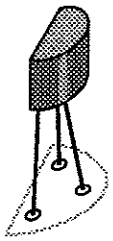
* **Electrolytic capacitors** are polarised devices and must be fitted the right way round. The longer lead goes to the hole marked "+", and the other lead, which is indicated by "–" signs on the side of the capacitor, goes to the hole marked "–" on the board.

Transistors

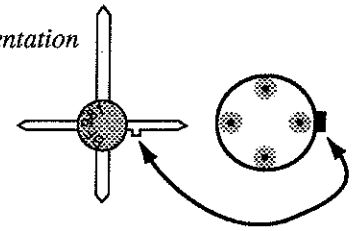
TR1: This is a BF961 dual gate MOSFET. The part number can be quite hard to read on these. The shape is distinctive though. Refer to the diagram below for fitting details. Make sure the body of the transistor is flat against the PCB after installation, and trim off the excess lead lengths after soldering.

TR2 to TR7. These are all similar shaped "bipolar" transistors (and a couple of similar numbers), but there are several different types with some very different electrical characteristics, so please be careful not to mix them up. They have their type numbers marked on them. The BC547A is marked "C547A".

TR2: MPSH10.
TR3: BC547*B*
TR4 & TR5: BC550C
TR6: BC547*A*
TR7: BC307B


Bipolar Transistor mounted in PCB

TR1 Orientation



"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.

PCB Pillars

Two plated brass PCB mounting pillars are included in this kit. They enable the LM2000 to be mounted 20mm above the DC2000 receiver. The right hand side fixing nuts of the DC2000 module are removed and replaced with the pillars, the LM2000 is placed on top of the pillars, and the removed nuts used to fix it in place. If you are using the LM2000 with a different receiver, the fixing holes of the two boards are unlikely to align. In this case, fit a small aluminium plate on top of the pillars and mount the module on this.

LM2000 Module Wiring 1

Outline of Connections

The diagram on this page shows the connections to the LM2000 module in general terms. The diagram on the next page shows the actual practical wiring layout when the module is used with the DC2000 receiver in the HA22R hardware pack. Refer to whichever diagram you find more appropriate for your project. The notes about the modules connections are intended as additional guidance.

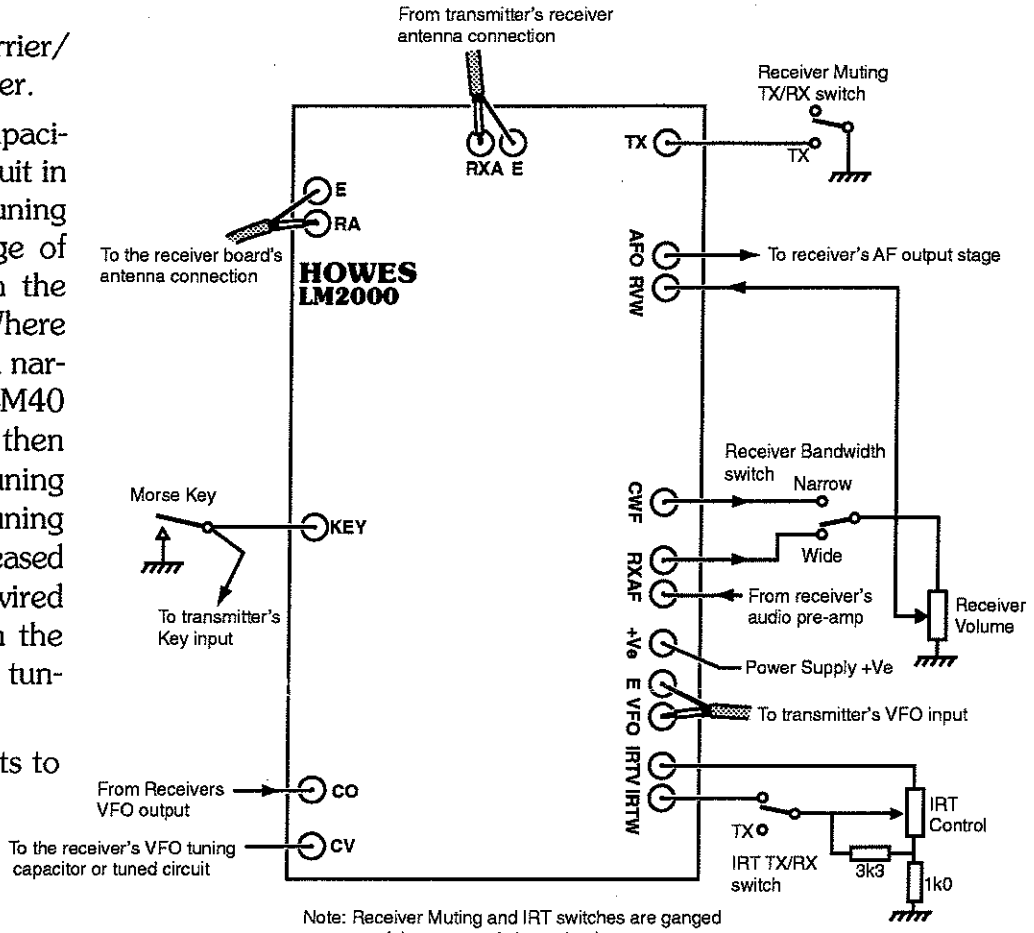
Module Terminals

CO: Connects to "CO" (**C**arrier/ counter **O**utput) of the receiver.

CV: Connects to the tuning capacitor ("CV") or VFO tuned circuit in the receiver. This is the IRT tuning connection. The tuning range of the IRT diode will vary with the receiver band module used. Where the band module only tunes a narrow frequency range (e.g. the BM40 with bandspread link option), then the IRT will give only a small tuning range when wired to the tuning capacitor. Its range can be increased if the LM2000 CV terminal is wired to the L5/C7 connection on the band module instead of to the tuning capacitor.

KEY: The Morse key connects to this terminal.

RA & E: The coax output to the receiver board's antenna connection. This connection is shorted to ground on transmit by relay RL1.



RXA & E: The coax connection for the antenna input to the module. Usually taken from the receiver antenna connection of the transmitter ("RXA" on TX2000).

TX: This terminal is connected to earth (ground) to switch the LM2000 to transmit mode.

AFO: **A**udio **F**requency **O**utput, the audio signal leaving the LM2000 to go to the receivers audio output stage.

RVW: ***R***eceiver's ***V***olume control ***W***iper. Takes in the audio signal from the receiver's volume control.

CWF: ***CW F***ilter terminal, the output of the LM2000's audio filter stage.

RXAF: ***Receiver A***udio ***F***requency terminals, the connection points for the output of the receiver's audio pre-amp stages and the "wide" connection to the optional audio bandwidth switch.

+Ve: The terminal for the positive power supply input. This needs 12 to 14V DC. The power supply 0V (earth/ground) connection should be made via the module's mounting arrangement, and does not need to be wired separately.

VFO & E: Terminals for the coax cable taking the buffered VFO signal to the transmitter. A parallel high impedance frequency counter feed can also be taken from here.

IRTV: The stabilised ***V***oltage feed to the ***IRT*** pot.

IRTW: The ***IRT*** pot's ***W***iper connection.

LM2000 Module Wiring 2

HA22R Installation

The diagram on the right shows the basic connections needed to install the LM2000 above the DC2000 receiver module in the HA22R hardware pack.

The optional audio filter bandwidth switching is omitted for clarity. The feed to the volume control is shown coming from the CW Filter ("CWF") terminal on the linking module (filter in circuit). If you prefer to have a wider bandwidth, then the wire to the volume control should come from the spare receiver audio terminal ("RXAF") instead. You can of course add a switch, to switch between the two bandwidths, as shown on the previous page.

Wire the "CO" and "CV" terminals, plus the VFO signal return (see below), in 20 or 22 SWG tinned copper wire. The other, non coax, connections are best wired in flexible insulated wire.

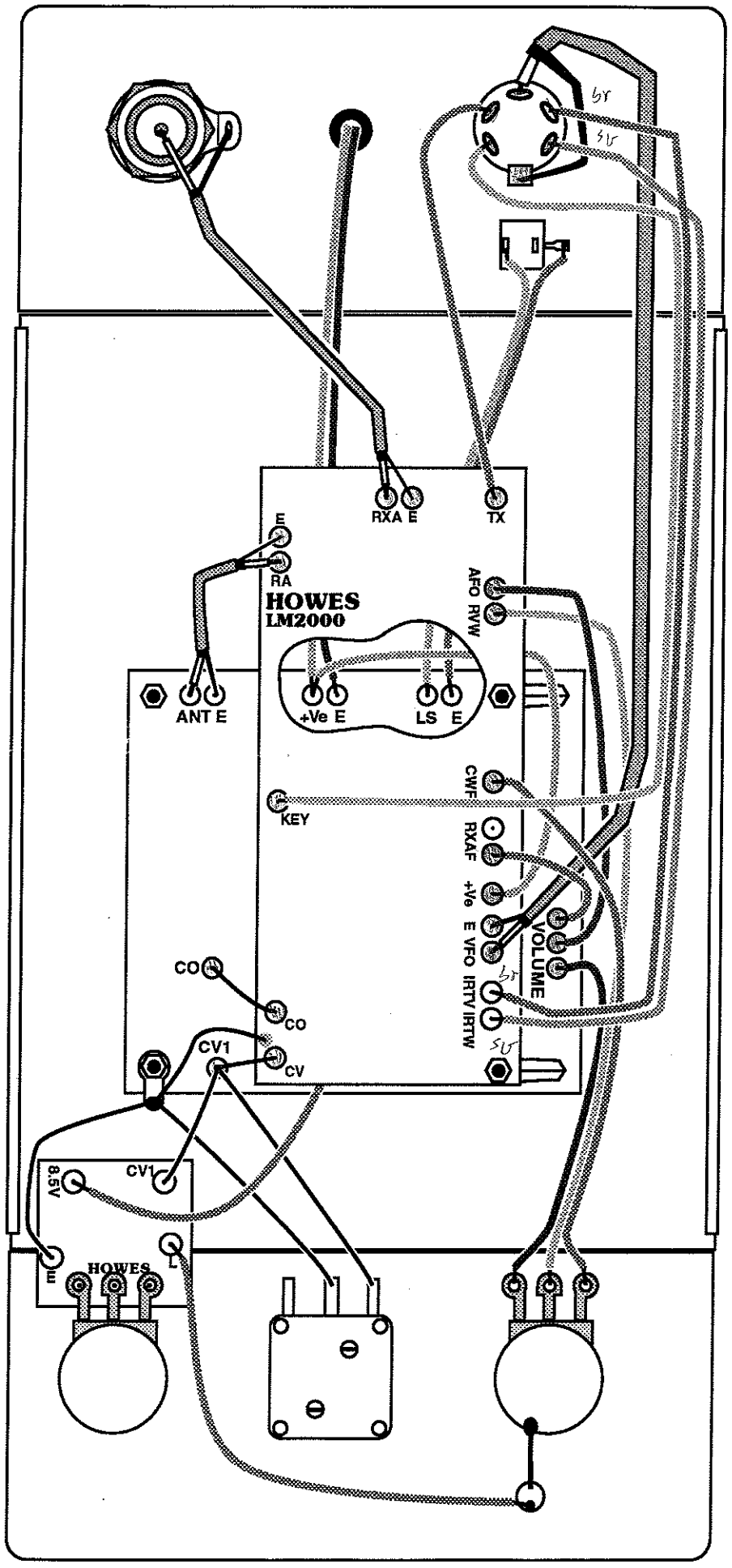
Notes

The diagram is not to scale. Some items shown have been moved slightly from their real relative positions for clarity. The front and rear panels of the hardware are shown as if they have been hinged outwards, this is to allow a view of the back of their components, so that the wiring can be seen.

The wire coming from the receiver's "+Ve" terminal to the linking module's "+Ve" terminal (seen through the diagrammatic cutaway in the top board) must be soldered to the receiver terminal, before the linking module is installed.

Signal Earth Return

The return path for the receiver's VFO signal should be provided by a piece of tinned copper wire linking the "silver spot" near the "CO" terminal on the LM2000, to the solder tag on the front left hand fixing screw of the DC2000 module. This is the only connection shown in the diagram on the right, that does not wire to a terminal pin.



LM2000 User Information

Netting

This is the term used to describe the action of tuning a transmitter to operate on the same frequency as another transmission. A number of stations in communication with each other on the same frequency, are described as being in a "net". The term can also be used to describe the action of tuning a receiver to match the transmitter frequency when using a separate transmitter and receiver.

With the LM2000 linking a transmitter and receiver together for transceive operation, the receiver main tuning (and the fine tune control, if fitted) also tunes the transmitter's frequency. The IRT control tunes the receiver *only*, by just a small amount, either side of the transmitting frequency.

To net your transmitter frequency to a received signal, you need to turn the IRT control to its centre position (knob pointer at the "dead spot" – see alignment information), and then tune the receiver's main tune (and fine tune if fitted) for "zero beat" with the incoming CW signal. "Zero beat" means the receiver is tuned so that the pitch (the "beat" note) of the received signal, reduces to zero frequency (hence "zero beat"). Once the receiver's tuning controls (main and fine) have been used to obtain zero beat, the receive and transmit frequencies are the same. To listen to the incoming signal, you need to restore a beat note by using the IRT control. This can be tuned to either side of the incoming signal frequency by the IRT pot. Adjust this for best reception. Do not touch the receiver's main or fine tune controls again, until you wish to repeat the netting procedure.

When searching for signals, it is a good idea to keep the IRT control in its centre position, so that netting is speeded up, if you decide to give the station a call.

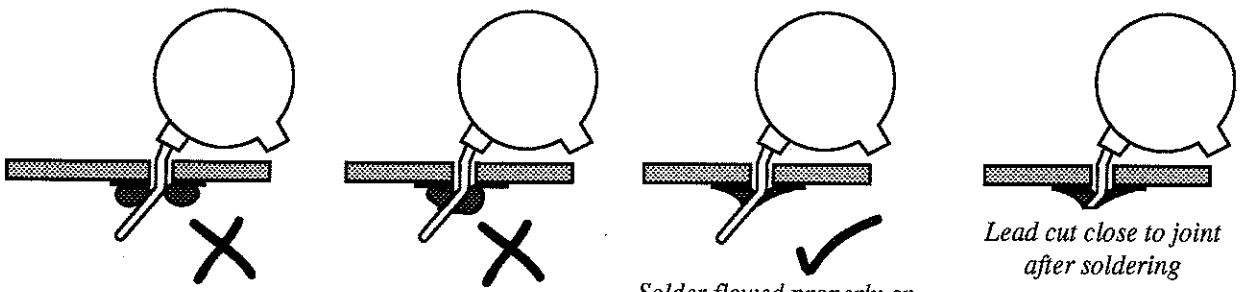
If you wish to call CQ, remember to tune the IRT either side of the frequency, to check that you won't be about to interfere with a QSO already in progress. Remember, some QRP operators may not be very skilled at netting, and you may need to use your IRT control to tune around the frequency for replies to your CQ call. Do not touch the main or fine tune controls when listening for replies, as this will shift your transmitting frequency, and you will probably lose any station trying to call you.

Using a Frequency Counter

If you have a DFD5 or other counter connected to the VFO output of the LM2000, remember that it displays the actual VFO frequency of the receiver. This is only the same as the transmit frequency, when the IRT control is centred. On receive, the exact frequency of an incoming signal is displayed at zero beat.

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.

LM2000 Circuit Diagram