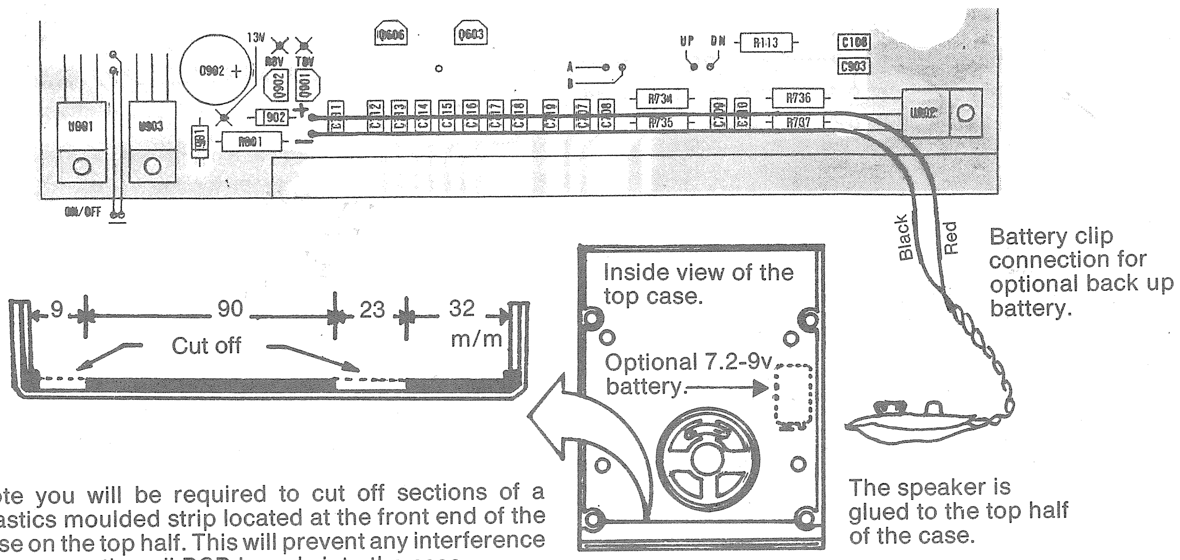
Fig.15



Note you will be required to cut off sections of a plastics moulded strip located at the front end of the case on the top half. This will prevent any interference when mounting all PCB boards into the case.

NOTES AND ERRATA

Assembly Manual

2m FM Transceiver

K-6400

DICK SMITH ELECTRONICS

ACN 000 445 956

PLEASE READ DISCLAIMER CAREFULLY AS WE CAN ONLY GUARANTEE PARTS AND NOT THE LABOUR CONTENT YOU PROVIDE

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KIT

Here's an outstanding new high performance FM transciever design for either mobile or base station use on the 144-148MHz amateur band. It features full PLL frequency synthesis, 24 memory channels with repeater shifts, selectable output of either 25W or 5W, tuning steps of either 5kHz or 25kHz, protection against excessive SWR and a microcontroller to simplify operation.

Microphone not included.

This is a brand-new multichannel FM transceiver design for the 2-metre amateur band, intended specifically for home construction.

The design is from the R&D people at Dick Smith Electronics. Judging from the prototype we've inspected, though, they've gone to a great deal of trouble to ensure that it's both easy to build and an impressive performer.

Incidentally the last multichannel 2m FM transceiver design described in EA also came from DSE. This was the very popular "Commander" design, published back in the June-July 1984 issues. A great many kits were sold for that design, and as a result DSE has been spurred to come up with a new and updated design.

The new design is by no means just a "revamp" of the 1984 Commander design. It's completely new, and designed to take advantage of the latest components and circuit techniques. This makes it significantly easier to build than the earlier design, while at the same time offering more features and higher performance.

As you can see from the specification panel, it covers the full 144-148MHz band with selectable tuning steps of either 5 or 25kHz. You can also offset the transmitter frequency for repeater operation, by either -600kHz or +600kHz. And 24 of your most common operating frequency channels can be programmed into the memories (with offset), for instant recall.

Transmitter output can be switched between 5W and a husky 25W, while built in protection circuitry shuts down the PA stage to prevent damage from high antenna SWR. The output is also very clean, with spurious components lower than -60dB.

Performance of the double conversion receiver section is also very impressive with sensitivity better than 0.25uV for 12dB SINAD, selectivity of 30kHz at the -60dB points and image rejection better than -60dB. You can also make it "scan" the memory channels, and stop when it finds one active. In short, it's a design that compares extremely well with current commercial transceivers.

INDEX

Text and illustrations courtesy of Electronics Australia

TRANSCEIVER SPECIFICATIONS

GENERAL

Frequency range:	144-148MHz
Channel steps:	5 or 25kHz
Repeater shift:	+/-600kHz
Memory channels:	24 frequencies, with repeater shifts
Mode of emission:	FM
Supply voltage:	13.8V DC, negative earth
Supply current:	0.5A (receive) 6A (transmit)
Antenna impedance:	unbalanced 50 ohms
Frequency accuracy:	+/-20ppm
Operating temperature range:	0-50°C

RECEIVER

Type:	Double conversion superhet
Intermediate frequencies:	10.7MHz and 455kHz
Sensitivity:	better than 0.25uV for 12dB SINAD
Selectivity:	12kHz (-6dB) 30kHz (-60dB)
Image rejection:	better than 60dB
Audio output:	1W/8ohms for 5% THD

TRANSMITTER

RF power output:	25W/5W
Spurious emissions:	60dB below carrier
Microphone:	low impedance dynamic
Modulation method:	FM-variable reactance
Deviation:	+/-5kHz
Duty cycle:	100% for ambient temperature up to 20°C

Dear Customer,

We are pleased that this company is the first Australian company to release a kit as sophisticated and functional as the New 2-metre FM transceiver Kit. It is bound to bring great satisfaction to you in constructing it

We would also like to give a word of warning. This kit should not be undertaken by anyone who does not have a current Amateurs Licence and has not had considerable experience in constructing RF equipment. Most "Amateurs" will have the skills necessary to complete this project without great difficulty, but for the inexperienced may we suggest you gain qualified assistance or else return the kit to us in its original packing with receipt of purchase for a full refund.

Thanking you
Dick Smith Electronics

Text and illustrations courtesy of Electronics Australia

PARTS LIST

Please check all the parts in this kit against the parts list. In the unlikely event of a part being missing or incorrectly supplied, you must use the Quality Control Card included with your kit. You can send the card directly to the Kit Department at Head Office or drop it in at your nearest Dick Smith store.

Resistor

Resistor 2.2ohm ¼w	2
Resistor 4.7ohm ¼w	2
Resistor 10ohm ¼w	3
Resistor 15ohm ¼w	1
Resistor 33ohm ¼w	9
Resistor 47ohm ¼w	1
Resistor 100ohm ¼w	18
Resistor 180ohm ¼w	1
Resistor 220ohm ¼w	4
Resistor 330ohm ¼w	3
Resistor 470ohm ¼w	1
Resistor 560ohm ¼w	1
Resistor 680ohm ¼w	2
Resistor 1Kohm ¼w	16
Resistor 1.5Kohm ¼w	2
Resistor 2.2Kohm ¼w	11
Resistor 3.3Kohm ¼w	1
Resistor 3.9Kohm ¼w	2
Resistor 4.7Kohm ¼w	11
Resistor 5.6Kohm ¼w	1
Resistor 6.8Kohm ¼w	1
Resistor 10Kohm ¼w	11
Resistor 15Kohm ¼w	3
Resistor 22Kohm ¼w	6
Resistor 33Kohm ¼w	2
Resistor 39Kohm ¼w	1
Resistor 47Kohm ¼w	6
Resistor 56Kohm ¼w	3
Resistor 68Kohm ¼w	1
Resistor 82Kohm ¼w	2
Resistor 100Kohm ¼w	18
Resistor 220Kohm ¼w	1
Resistor 270Kohm ¼w	1
Resistor 1meg ohm ¼w	1
Trimpot 100ohm	1
Trimpot 200ohm	1
Trimpot 5Kohm	1
Trimpot 10kohm	2
Trimpot 50Kohm	1
Trimpot 100Kohm	2

Capacitors

Ceramic 1pf	1
Ceramic 2.2pf	1
Ceramic 3.3pf	3
Ceramic 4.7pf	1
Ceramic 5.6pf	2
Ceramic 6.8pf	1
Ceramic 10pf	5
Ceramic 12pf	1
Ceramic 15pf	5
Ceramic 18pf	3
Ceramic 22pf	4
Ceramic 27pf	1
Ceramic 33pf	2
Ceramic 39pf	1
Ceramic 56pf	3
Ceramic68pf	1
Ceramic 82pf	1
Ceramic 150pf	1
Ceramic 270pf	1
Ceramic 1nf/.001uf	58
Ceramic 2.2nf/.0022uf	1
Ceramic 10nf/.01uf	8
Ceramic 100nf/0.1uf	18
Monolythic 1.0uf	1
Trimcap 9.8-60pf (Brown)	1
Trimcap 4.2-20pf (Red or Pink)	10
Tantalum 1uf 35v	5
Tantalum 10uf 25v	3
Tantalum 22uf 16v	2
Tantalum 33uf 10v	7
Electro 220uf 16v	1
Electro 330uf 25v	2
Electro 470uf 16v	2

Semiconductors

Diode 1N914/1N4148	15
Diode 1N4002/4	2
Diode 1N5402/4/8	1
Diode BB405	1
Diode MI407	1
Diode MC301	1
Diode MI301	4
Transistor BC548/DS548/BC108	12
Transistor BC558/DS558	6
Transistor BC328/BC327	2
Transistor BC338/BC337	4
Transistor Tip 32B	1
Transistor 2SK 125	1
Transistor 2SC 2407	1
Transistor 2SC 1923	5
Transistor BF 981	2
Regulator LM 78L05	1
Regulator LM 7805	2
Regulator 7808	1
Led Display LT 313	6
Led Red Rectangular	16
IC 4028	1
IC 4511	1
IC LM 3914	1
IC MC 3357	1
IC M 54959P PLL	1
IC M 57737 25w PA	1
IC 68705 Prog. IC	1

Components

RF Choke 10uh	1
XTAL Filter 10.7mHz	2
XTAL 10.245mHz	1
XTAL 10.240mHz	1
Coil 10.7mHz TRIOMAO 15s	2
Coil 150mHz Red Coil	1
Coil 455KHz	1
Ceramic Filter CFW 455	1

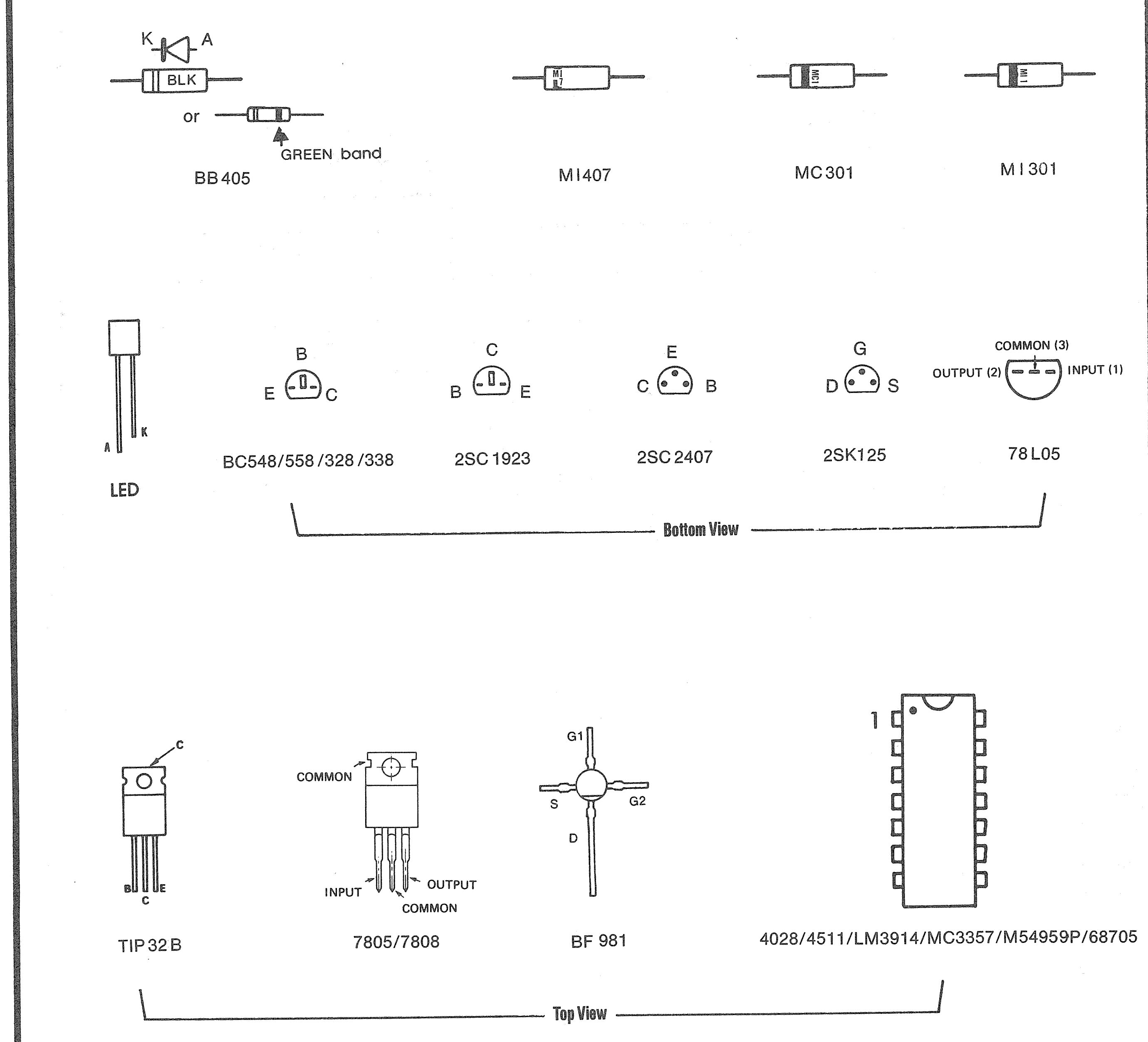
Hardware

Mic Plug 8pin	1
Mic Socket 8pin	1
Ant UHF Socket	1
Knob (small)	2
Knob (large)	1
Pot Mini 5K/10K(switched)	2
Rotary Switch Digital Encoder CB22	1
Socket 3.5mm panel	1
Socket IC 28pin Dil	1
Socket IC Strip of 32 machine pins	1
Switch Pushbutton Momentary	6
Fuse Holder inline 3AG	1
Fuse 3AG 10Amp	1
Battery Snap	1
PC Pins	25
Silicon Grease	1
Rubber Grommet	1
Spacers	4
Mounting Bracket Support	2
Wing Nuts	2
Screws,Nuts & Washers to suit	1
Red Translucent Film	1
Solder	1
Heatshrink Tubing	1
Teflon Cable	1
Shielded Cable SC1	1
Tinned Copper Wire	1
Rainbow Cable	1
En/copper Wire	1
Fig.8. H/up Wire	1
Tinplate Cover 42x127mm	1
Tinplate Bracket(R) 31x42mm	1
Tinplate Bracket(L) 31x42mm	1
Tinplate Cover 61x80mm	2
Tinplate 15x50mm	3
Tinplate 21x78mm	2
Tinplate Cover 36x78mm	2
Tinplate 15x25mm	2
Tinplate 21x47mm	2

Miscellaneous

PCB (Main board)	1
PCB (CPU board)	1
PCB (Display board)	1
PCB (Amplifier board)	1
Plastic Case	1
Speaker	1
Mounting Bracket	1
Heatsink	1
Front Panel	1
Back Panel	1
Instructions	1

Component pinouts



Design summary

In common with most of today's commercial multi-channel tranceivers, the new design features PLL (phase-locked loop) frequency synthesis, under the control of a dedicated single chip microcontroller. The microcontroller's functions include reading the front panel switches and the two-phase rotary encoded channel switch, driving the frequency and memory displays, storing memory channel information and controlling the PLL synthesizer via a three-wire serial bus.

The design employs a single PLL controlled VCO, used for both transmit and receive. In the receive mode the VCO acts as the first local oscillator, and operates 10.7MHz below the received frequency. When transmitting, it operates directly on the transmit frequency, being modulated by the audio signal from the microphone amplifier. The output signal from the VCO is fed to the RF sections of the transceiver, where it is switched to either the 1st mixer, when receiving, or the transmit driver when transmitting.

In the receiver, the narrow-band IF amplifier employs an industry standard amplifier/demodulator IC. The AF amplifier is a simple design using discrete components.

To allow you to get a good understanding of the new transceiver's operation, the first part of this Instruction manual will be devoted to a detailed look at the various sections of the circuit schematic. Then we'll start on the construction and assembly, which is organised in easy test-as-you-go stages.

Fig.1 shows the overall system design of the transceiver. Although there's a fair bit in it, understanding how everything works is not difficult as long as you take it in stages. As you can see, it consists of nine main circuit sections — most of which are operational in both receive and transmit modes. These will now be discussed in turn, starting with the power supply and regulators.

Power supply

The transceiver as a whole is designed to operate from a nominal 13.8V DC negative-ground supply, as found in most modern cars or provided by many readily available DC power supplies. It draws about 500mA on receive, and 6A when transmitting in high output (25W) mode.

The internal power supply circuitry (Fig.2) uses the +13.8V input to derive

Block Diagram

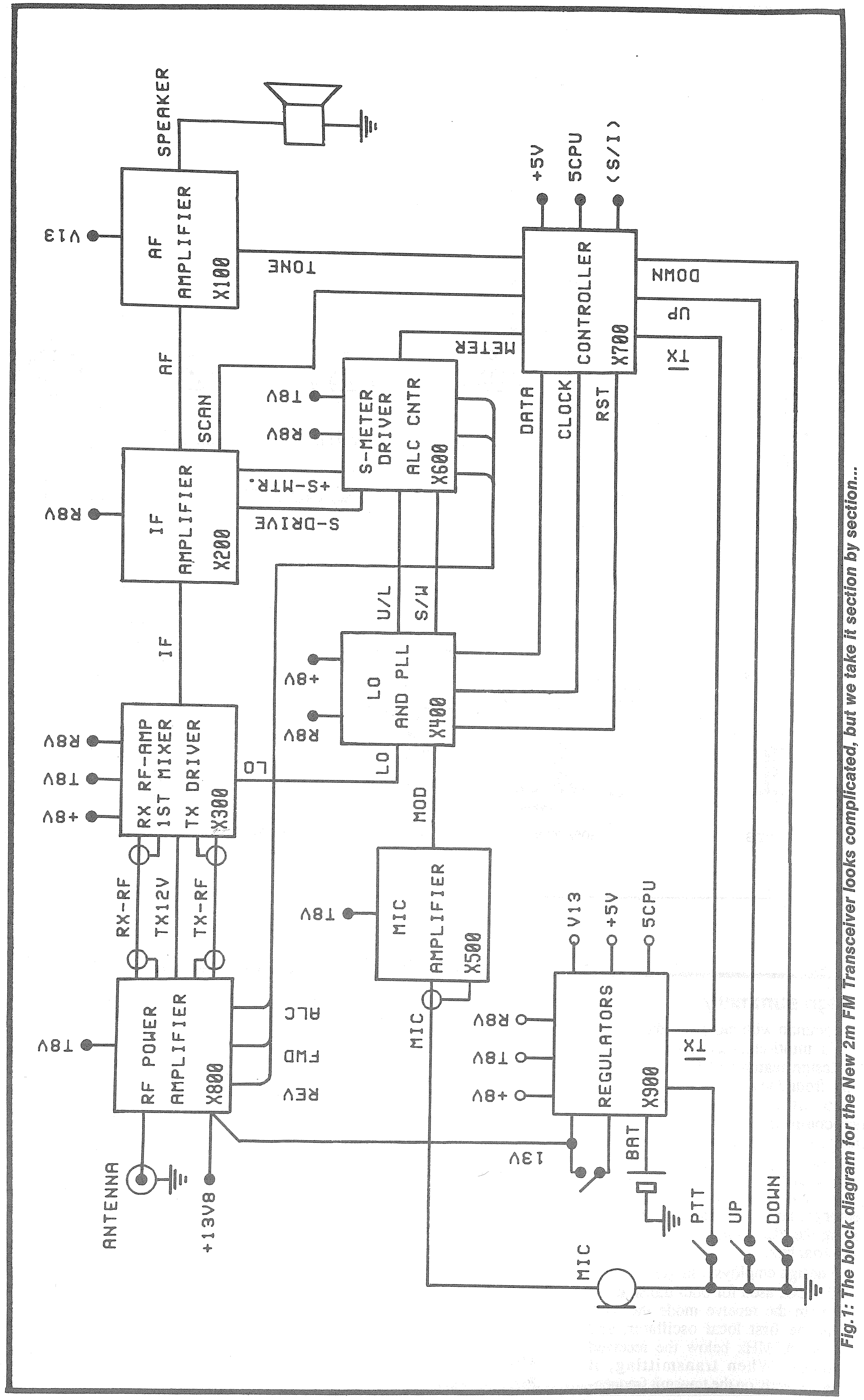


Fig.1: The block diagram for the New 2m FM Transceiver looks complicated, but we take it section by section...

the +5V and +8V supplies needed for many of the circuit sections, via standard 3-terminal IC voltage regulators.

Regulator U901 supplies a +5V rail for the microcontroller only. This supply rail is a crucial one, because if it fails the CPU will lose all data from its internal RAM. When this occurs all frequencies programmed into the memory channels of the transceiver will be lost, and on power-up the transceiver will default to a frequency of 147.000MHz.

To avoid this, the transceiver has connection for an optional 7.2-9V rechargeable backup battery.

This battery is connected to the input of U901 via D902, when no external supply is present. If the external +13.8V is connected to the transceiver, D902 will be reverse biased and the battery will be charged via R901 (the charging current is about 5mA). Series diode D901 prevents the battery from supplying other circuitry if the external +13.8V is not connected and the power switch is closed. Regulator U902 produces a separate +5V rail, for other sections of the controller circuitry.

A supply rail of +8V is produced by regulator U903. This is switched to the receive or transmit circuitry respectively by Q901 and Q902, which are switched in a complementary fashion according to the state of the microphone's press-to-talk (PTT) switch. The 'transmit' rail (T8V) will actually be a little lower than 8V, due to the saturation voltage drop of Q901 (a few hundred millivolts), while the 'receive' rail (R8V) will also be lower because of the saturation voltage and base-emitter voltage drop of Q902.

The PTT line controls the base current of these transistors via D903 and D904, to perform the supply switching, as well as controlling the level on the TX-bar line via D905. The latter is connected to the microcontroller, to switch it between transmit and receive modes.

Controller/display

Now let us look at the transceiver's 'brains' — the controller/display section, which includes the CPU and display boards and covers the controller itself, the control input sensing and the circuitry for displaying frequency, signal level and functions. This is all shown in the schematic of Fig.3.

The microcontroller employed (U701) is an 8-bit 6805 type, with 2 kilobytes of internal EPROM and 128 bytes of RAM. The CPU is preprogrammed to drive the 7 segment displays, scan the front panel switches, memorize frequently used channels and control the PLL frequency synthesizer.

A multiplexing system is used to drive the numeric displays, via seven of the CPU output pins (20-26). The segment data for the displays (in BCD format) appears on pins 20-23, while the digit-select address is fed out via pins24-26 in 3-bit binary code. The segment data is decoded by U703, a 4511 7-segment decoder, to drive the display common segment lines via current limiting resistors R717-723. Similarly the digit address is decoded by U702, a 4028 1-of-10 decoder (used here as a 1-of-6) and used to select the 7-segment displays in turn via digit driver transistors Q702-707.

This same basic multiplexing system is used to allow the CPU to control the six status LEDs D711-716, which are used to indicate repeater offset, on-air, low power mode and so on. This is done by an eighth control output, produced by the CPU on pin 27 and used to select the LEDs via Q701. The status LEDs are thus treated as if they are an 'additional segment' of the main 7- segment displays — an elegant and efficient solution.

As if that isn't enough, though, the multiplexing system is also used for sensing of the six input pushbutton switches (SW701- 706). These are used to control functions such as memory channel writing and recall, low/high power switching, tuning step selection, repeater offset and so on.

As you can see from Fig.3, the switches are connected to the decoded digit-select outputs from U702, so that one side of each switch is taken in turn to logic 'high' level during the display multiplexing cycle. The other sides of all the switches are connected together and taken to pin 19 of the CPU, which is thus able to 'scan' the switches at the same time as it's updating the displays.

The state of the rotary encoded channel switch (RE701) is sampled separately by the CPU via pins 17 and 18. Similarly if a microphone having UP and DOWN buttons is used with the transceiver, the state of these buttons is read by the CPU on pins 16 and 15. Pin 10 is also a dedicated sensing input, used to allow the CPU to monitor the state of the receiver section's squelch gate (so that it knows when to 'stop' during scanning).

If the CPU detects a change on any of the control inputs, the internal ROM firmware jumps to subroutines which perform the required functions — such as sending new serial data to the PLL, changing the display data and so on.

A separate bar-graph LED display is used for the signal strength and power output 'meter' (S&PO meter). Here the 10 LEDs (D701- 710) are driven by U704, an LM3914 linear LED driver IC. This has been used rather than a logarithmic type, because a quasi- logarithmic response is provided by the receiver circuitry.

In AM and SSB receivers, received signal strength has a direct effect on the signal/noise ratio. But in FM receivers, S/N ratio is more a function of the demodulator performance — some good FM receivers can produce the same audio quality at input signals as low as 1uV, as they can with input signals in the millivolt range. Assuming that 'S0' on the meter corresponds to 1uV, and each S-point corresponds to a 6dB increase, there may thus be little difference between 'S0' and 'S9+40dB'.

Many FM tranceivers of Japanese origin typically require only 10- 100uV for a full scale S-meter reading, and our design provides similar performance — albeit with greater resolution than much of the current commercial equipment.

The VCO and PLL

The schematic for the voltage-controlled oscillator (VCO) and PLL section of the transceiver is shown in Fig.4. The VCO uses a well-tried circuit employing a FET (Q401) in the common-gate configuration. The oscillator's frequency is determined by the parallel combination of L401 and all of the capacitance connected to the drain of the FET.

In receive mode, the VCO frequency is shifted down 10.7MHz by causing diode D402 to conduct, which adds capacitor C407 to the resonant circuit. This is done by turning on transistor Q402 via the

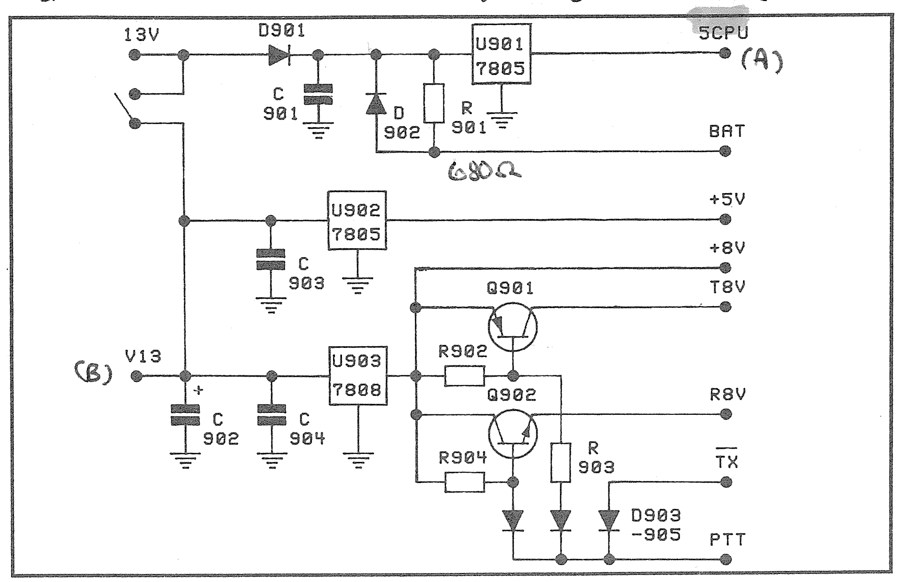


Fig.2: The power supply regulators and transmit-receive power switching.

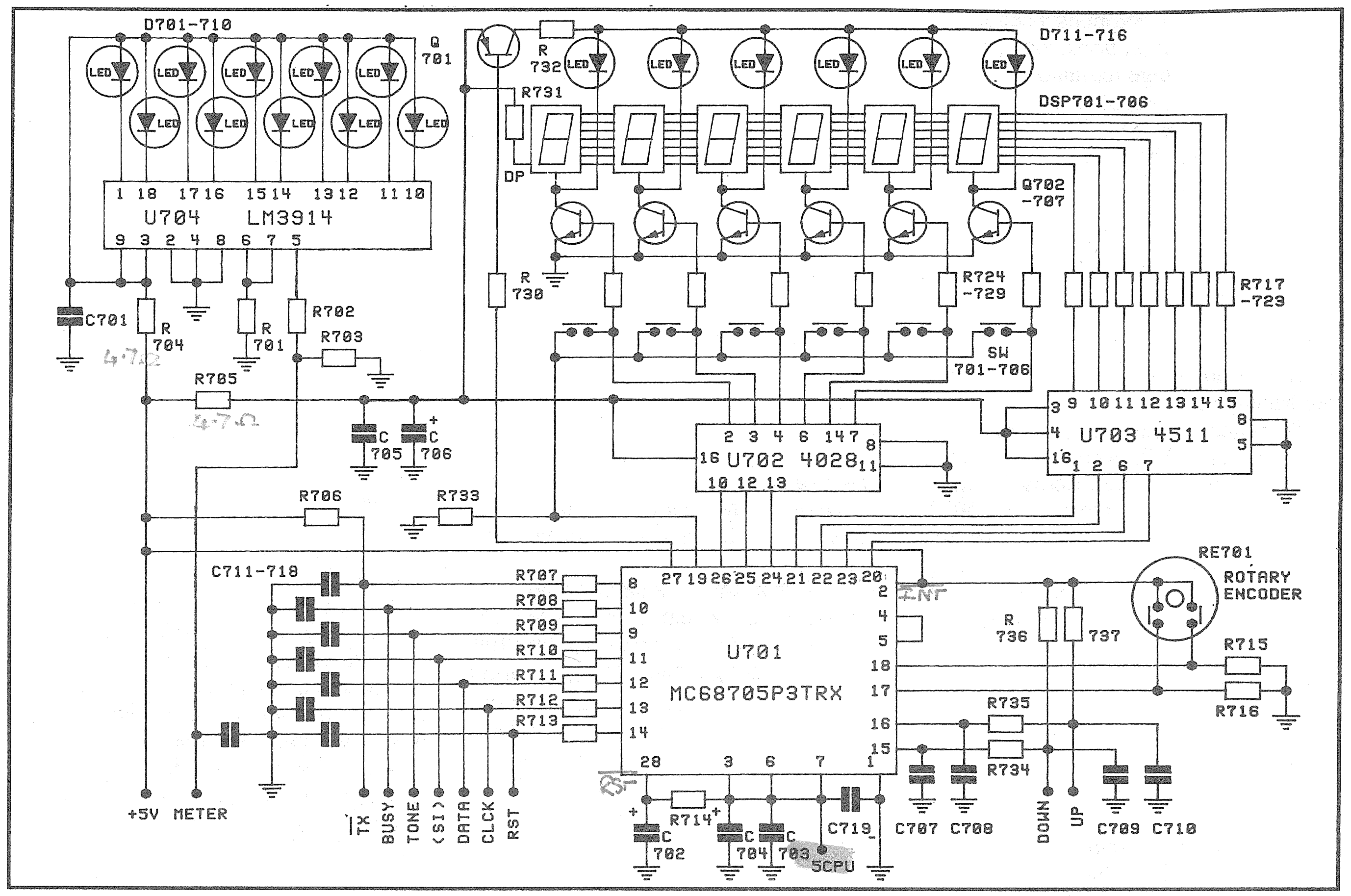


Fig.3: The circuitry for the microcontroller, front panel controls and displays.

R8V line, pulling current through D402 via R406 and R404. The diode then represents a very low RF impedance, connecting C407 and C405 in parallel with L401 and the existing drain circuit capacitance, shifting the frequency down.

In transmit mode, the R8V line is switched off and Q402 therfore turns off. As a result the cathode of D402 is pulled up to about +6V via R404 and R405. As the R8V line is now at 0V, the anode of D402 is also pulled down via R406, so D402 is now reverse biased. This effectively changes it from a low-value resistor into a high impedance — a capacitor of a few picofarads (the capacitance of its reverse-bias depletion layer).

Because the value of this depletion layer capacitance varies with the applied reverse voltage, D402 is also used to achieve the VCO's frequency modulation. The audio modulation signal (MOD) is fed in via C403 and R404, and hence varies the 6V reverse bias voltage across the diode, to vary its capacitance and hence the VCO frequency.

The best modulating performance has been found with the use of an MC301 diode for D402. This diode has a capacitance of about 2pF at 6 volts reverse voltage, and with carefully chosen additional capacitance, very linear deviation has been achieved for both negative and positive modulation.

The signal from the VCO is amplified and buffered by Q403. From the collector of this transistor the signal is divided between the PLL amplifier (Q404) and the LO output for the RF circuit sections, fed out via R414.

The PLL employs a Mitsubishi M54959 chip (U401), which is a PLL 'building block' capable of operation up to around 500MHz. The IC contains an ECL two-modulus prescaler, a 17-bit programmable divider, a crystal reference oscillator (using crystal XT-401), a 14-bit reference divider, a phase detector, an out-of-lock detector, a shift register for serial control and a 2-bit output port. The phase detector output (pin 9) is tri-state.

If the divided VCO input and reference frequencies are in phase at the inputs of the phase detector, the detector's output remains in the high impedance state. However if the phase of the divided VCO frequency is *behind* the phase of the reference frequency, the output falls to the 'low' state.

Conversely if the VCO phase moves *ahead* of the reference, the output switches to the 'high' state.

The error pulses generated by the phase detector are filtered by the PLL loop filter (C433-435, C420 and R421-424), and fed back to varicap diode D401, to act as a DC tuning voltage and hence correct the frequency of the VCO — locking it to frequency.

Of course when the PLL frequency is changed by the CPU, in response to a command from the front-panel controls, the loop will temporarily become unlocked until the VCO reaches the new frequency. During this 'out of lock' condition the PLL chip delivers an 'unlocked' logic output (U/L) on pin 10, which is used for disabling transmission (so that the transceiver cannot produce spurious transmissions).

As noted above, the PLL chip has a 2-bit output port controlled by serial data from the CPU. The port's output appears on pins 6 and 7, which are of the open-collector type. In this case they are connected in parallel and used to control the transceiver's power output level on transmit, via the 'S/W' line.

Pins 3, 4 and 5 of the PLL chip are the control inputs, used to receive serial command data from the CPU. Referring back to Fig.3, this command data comes directly from pins 14, 13 and 12 of U701.

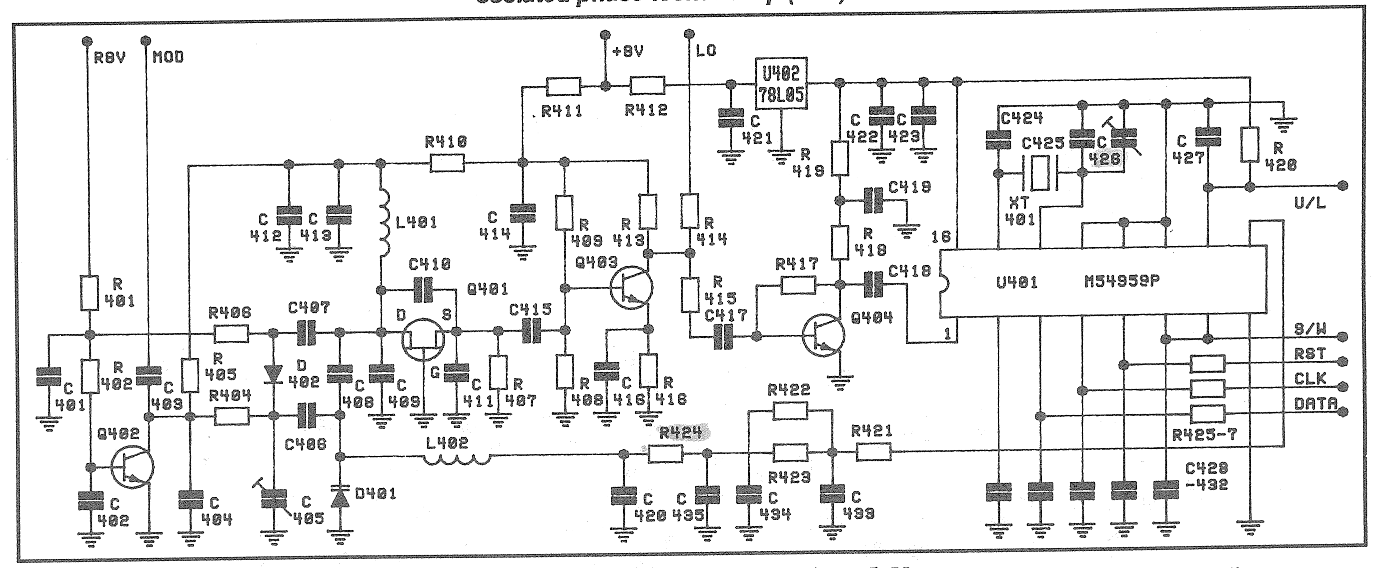
Microphone amp

The microphone preamp and transmit audio filter circuitry is shown in Fig.5. The signal from the microphone is firstly boosted by the two- transistor amplifier formed by Q501 and Q502. The resulting signal is then applied to a simple diode limiter (D501-502), to prevent over-deviation.

The limiter is followed by a second order low-pass filter stage using Q503, which limits the audio bandwidth to the voice frequency range and reduces distortion components introduced by the limiter stage.

The signal from the filter stage is bandwidth and amplitude limited, and hence ready for application to the FM modulator. Preset pot R512 is used to adjust the peak deviation. Both the mic preamp and the filter stage are operated

Fig.4: The circuitry for the voltage controlled local oscillator (LO) and its associated phase-locked loop (PLL) controller.



from the T8V supply rail, so that they function only in transmit mode.

RF section

Fig.6 shows the schematic of the main RF section of the transceiver, which includes the transmit RF driver stages together with the receiver's RF amplifier and first mixer.

The RF signal from the VCO section (LO) is amplified by Q303 and Q304, in standard common-emitter tuned amplifier stages. The RF switching diodes (D303-304) then switch the output from Q304 between the transmit driver amplifier (Q305) and 1st mixer (Q302), for transmit and receive modes respectively.

D304 is turned on for transmit b the T8V rail, via R324 and R321, while D303 is turned on for receive by the R8V rail — via R318 and R319. R320 provides the earth return for the diode cathodes.

For reception, the RX-RF signal from the antenna (via the PA board) is amplified by RF stage Q301 and filtered by the bandpass filter L303-306.

The RF stage does not have a lot of input filtering, because every dB of filter insertion loss will increase the noise figure of the receiver by the same amount. By having most of the filtering *after* the input amplifier the filter losses effectively only reduce the gain of the amplifier, resulting in a much smaller degradation of the receiver noise figure.

After filtering, the received signal is injected into a dual gate MOSFET mixer (Q302), where it is mixed with the Local oscillator signal to produce the first IF signal on 10.7MHz.

L307 provides the first stage of IF filtering, ahead of that provided in the IF amplifier section.

IF amp/demodulator

The circuitry of the IF amplifier/demodulator section is shown in Fig.7. As you can see it employs a standard Motorola MC3357 narrowband FM IF chip.

The sensitivity of this IC is about 5uV for 3dB of limiting. The 10.7MHz output from the first mixer and the first IF filter is not always this high, so the signal is amplified by transistor Q201 before being applied to the IC.

Inside the IC, the 10.7MHz signal undergoes moderate gain and is then mixed with the on-chip 10.245MHz crystal oscillator to produce the second IF signal on 455kHz. This signal is filtered by ceramic filter CF201, and then fed through the chip's high- gain 455kHz limiting amplifier.

The output of the limiting amplifier is connected to the inbuilt quadrature FM demodulator. The recovered AF signal is then filtered by an RC low-pass filter (R216/C208) and fed to the AF amplifier.

Absence of input signal is indicated by the presence of wide band AF noise at the demodulator's output (pin 9).

The high frequency part of this noise (above normal speech frequencies) is selected by a high-pass filter (pins 10 and 11), rectified and used for the receiver's squelch and scan control.

The squelch circuit controls the mute switch (pin 14), which effectively shorts the output side of coupling capacitor C207 during no-signal conditions, preventing noise from being fed to the AF amplifier. Pot R213 is the squelch control, used to adjust the muting threshold.

AF amplifier

Now let's look at the audio output section of the receiver circuit, whose schematic is shown in Fig.8. The design of this section is actually very similar to that used in previous DSE transceiver kits, but with slight changes to improve performance.

Transistor Q105 is a 'capacitance multiplier', filtering out noise on the supply rail. The base voltage of this transistor is filtered via R113, C108 and C107 and as the emitter voltage closely follows the base voltage (but about 0.7 volts lower), any noise on the incoming +V13 rail is significantly reduced.

Output transistors Q103 and Q104 are used in a fairly standard class-B configuration, providing the current gain necessary to drive a low impedance loudspeaker.

Voltage gain is provided by Q101 and Q102. Negative voltage feedback is applied to the emitter of Q101 via R106, ensuring DC stability and low distortion.

Because the amplifier operates from a single supply rail, its output at the junction of R110 and R111 sits at half the supply voltage under quiescent conditions. This DC component is blocked by coupling capacitor C106. Driver load and bias resistor R112 is connected to the speaker side of C106 to provide 'bootstrapping', boosting its effective value for AC and hence achieving greater voltage gain for driver stage Q102. This also removes the output stage bias if the speaker becomes disconnected, preventing possible damage.

Audio signals from the receiver sec-

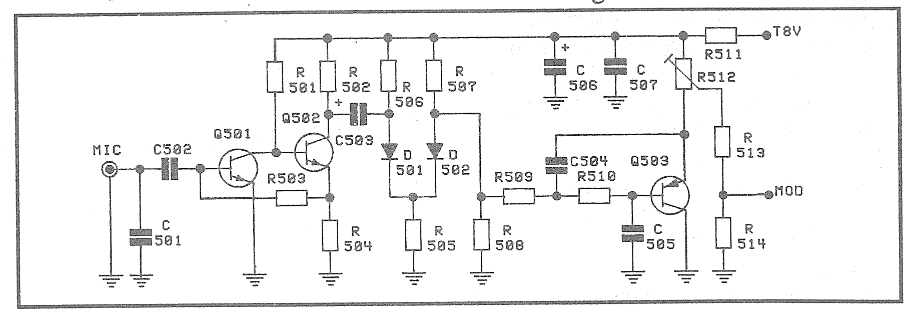


Fig.5: The mike preamplifier, limiter and audio filter stages.

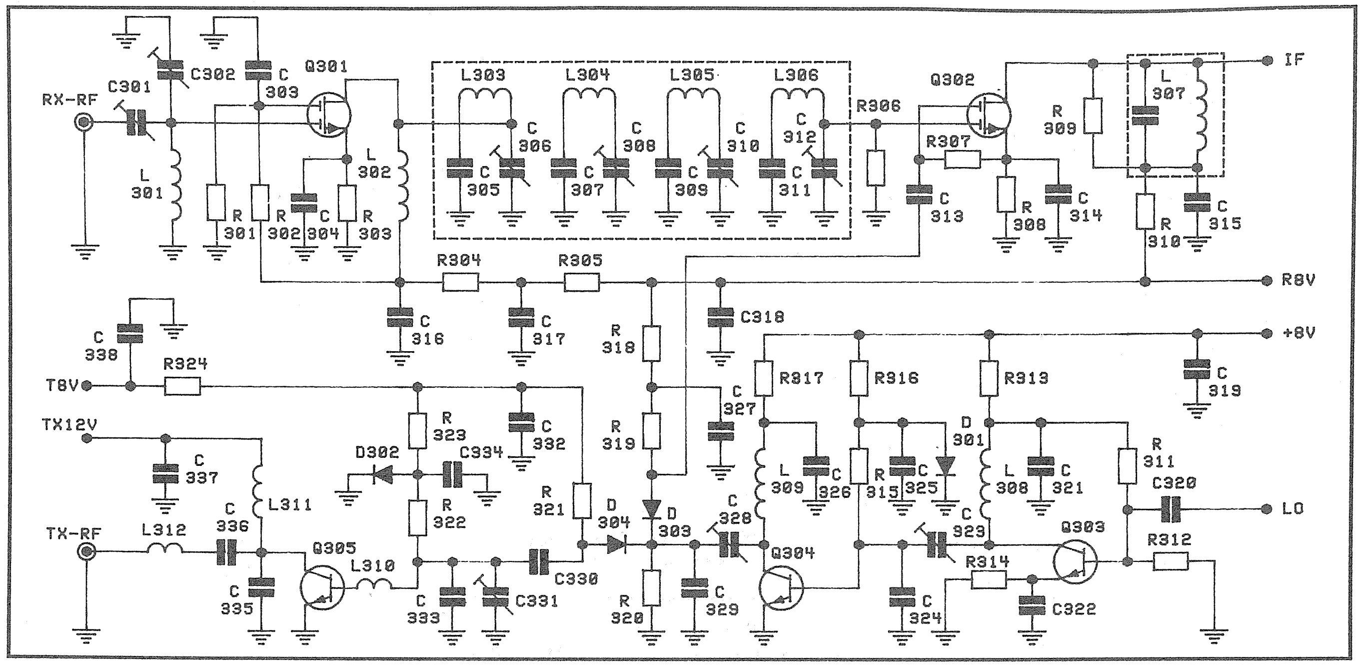


Fig.6: The receive RF amplifier and first mixer stages, together with the VCO amplifier stages and transmit driver stage.

tion are coupled to the base of Q101 after passing through the volume control. The beep tone signal from the CPU (used to provide confirmation of control button commands) is fed directly to the emitter of Q101 via C103 and R108, instead of to its base. This provides a constant beep volume, independent of the volume pot's setting.

PA circuit

The transmit RF power amplifier or 'PA' (Fig.9) is implemented using a hybrid power module (U801). These devices are now in common use in commercial equipment. In this project the hybrid device offers two significant advantages, the first being that the constructor is relieved of the burden of having to wind additional coils and construct a power amplifier from individual components. The second benefit is that using a module releases valuable PCB 'real estate', allowing a cleaner layout and again making the overall project easier to construct.

The power amplifier module used, a Mitsubishi M57737, is a two stage 144-148MHz FM amplifier module with 50-ohm input and output impedances and requiring a 100mW input signal for 25 watts output. The first stage of this amplifier as well as the RF driver transistor Q305 (Fig.6) is fed from the 'TX12V' supply rail controlled by the ALC circuitry as will shortly be described. The second stage of the PA modules amplifier is connected directly to the +13.8V supply. The output of the power amplifier is connected to the RX-TX diode switch (D806, D802-3) circuitry, which is followed by a seven pole low-pass filter.

In transmit mode, the switching diodes (D806, D802-803) all represent a low RF impedance. This is because they are forward biased by DC current from the T8V line, passing through resistor R802 and RF choke L801. As a result the lower end of inductor L802 is connected to ground by D802-803, shorting the receiver input to ground and hence protecting it from damage by the high level transmitter output signal.

Of course inductor L802 is therefore effectively connected in parallel with C809 during transmit operation. However the low- pass filter circuitry is designed to cope with this effect.

In receive mode, the T8V line is at 0V and accordingly diodes D806, D802 and D803 are all biased off, presenting a high resistance in parallel with a low capacitance. The output of the PA module is therefore isolated from the low-pass filter by D806, while the received RF from the antenna is able to pass through the low-pass filter and L802, to the receiver's RF amplifier Q301 (Fig.6). The depletion layer capacitance of D802-803 is effectively in parallel with C808, forming a further low-pass filter stage in combination with L802. In receive mode the input filter therefore becomes a 9-pole low-pass filter.

The directional coupler included in the low-pass filter stage is used to detect the power reflected back to the PA stage when there is a high SWR in the antenna circuit. It produces an output voltage which is in proportion to the phase difference between the voltage and the current in the transmit signal path. If the load is purely resistive and properly matched to the output and feeder cable impedance (i.e., 50 ohms), there will be little or no phase shift. However if there is a high SWR and hence a large phase shift, a DC voltage will be generated (REV) which is used by the ALC circuit to shut down the PA and driver stages, to prevent damage. This is described shortly.

Capacitive divider C816-C817 and

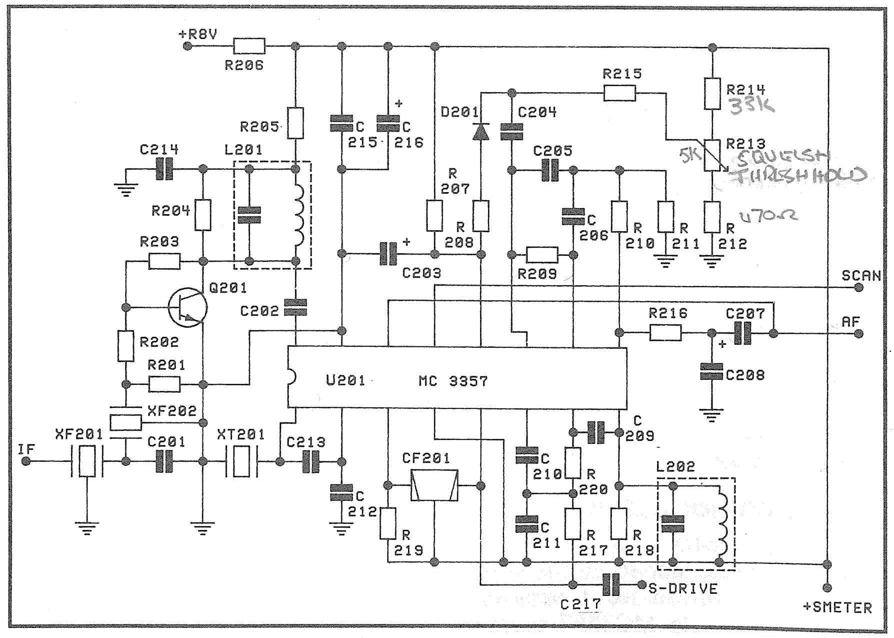


Fig.7: The receive IF amplifier and demodulator section, based on an MC3357.

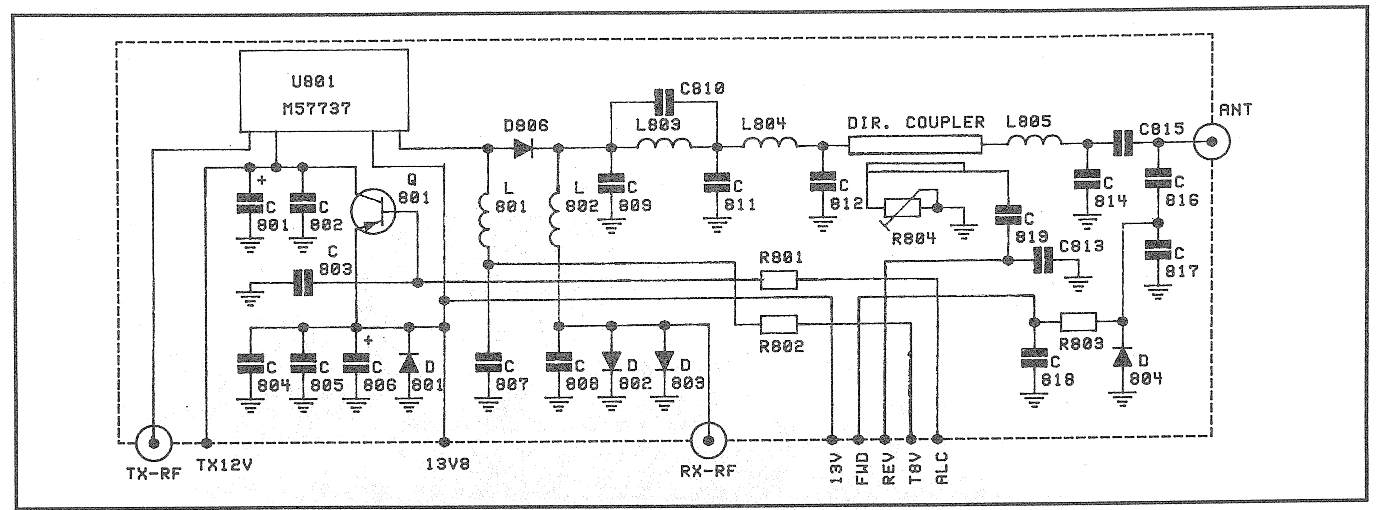


Fig.9: The RF power amplifier board circuit, based on an integrated PA module. Note the built-in directional coupler, used to detect reflected power and shut down the transmitter in the event of high antenna SWR.

diode D804 are used to produce a DC voltage (FWD) proportional to the RF output level. This is also fed back to the ALC circuitry via R803, being used to maintain the transmitter output at the desired 'high' (25W) or 'low' (5W) levels.

Diode D801 protects all of the transceiver circuitry against the application of a reversed power supply. If the supply is reversed, D801 will conduct and blow the supply line fuse. Sometimes the diode itself may also be damaged, but this is a small price to pay for protecting the much more expensive circuitry in rest of the unit. Incidentally, a shunt diode is used here in preference to a series diode because the voltage drop across a series diode can significantly reduce the maximum power output of the transmitter.

S-meter and ALC

As shown in Fig.7, the IF signal used to drive the S-meter circuit (S-DRIVE) is taken from pin 5 of IF amplifier U201, just after ceramic filter CF201 and before the main limiting amplifier. This signal is fed to the S-meter driver stage (Fig.10), where it is amplified by Q601 and Q602. Trimpot R604 controls the gain of this amplifier. The amplified signal is then rectified by diodes D601-602 and the resultant DC voltage used to feed the LED driver IC (U704, Fig.3), on

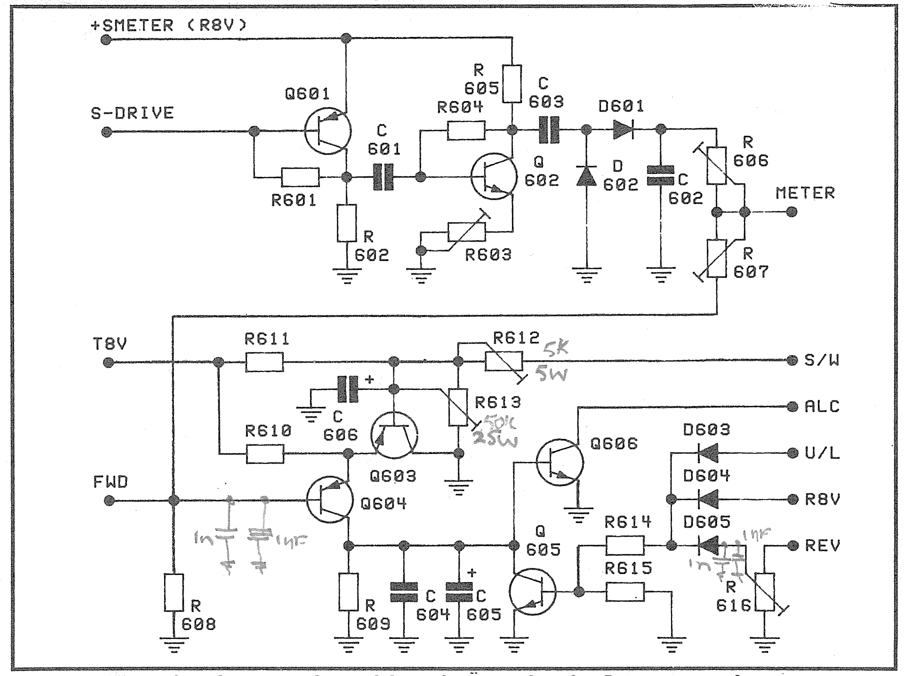


Fig.10: The circuitry used to drive the receiver's S-meter and power meter, together with that used to control the output level of the transmitter.

receive. Preset pot R606 is used to adjust meter calibration.

The ALC (automatic level control) circuit controls the RF output power of the transmitter, by adjusting the supply voltage (TX12V) fed to the PA module U801 and driver stage Q305. The actual ALC circuitry can be divided to the following parts: a differential amplifier/comparator (Q603-604), a shutdown circuit (Q605) and the DC supply control circuit (Q606 and Q801, on the PA amplifier board).

The differential amplifier (Q603-604) compares the voltage on the base of Q603, set by preset pots R613 (25W output) and/or R612 (5W), with the voltage at the base of Q604 — which is a function of transmitted power (FWD signal). Any difference between these voltages produces a current through Q604's collector resistor R609, and a forward bias at the base of Q606. The base current of Q606 in turn controls the current in Q801 on the PA board, and ultimately, the DC supply to the PA module and driver stage. Hence we have a feedback system which acts to maintain the RF output level at either the 25W or 5W level, as set by pots R613 and R612. The latter becomes effective when the S/W line is pulled low, by pins 6 and 7 of U401 (Fig.4).

Transistor Q605 is used to short out the base-emitter circuit of Q606, removing all supply voltage from the PA module and driver stage, and hence shutting

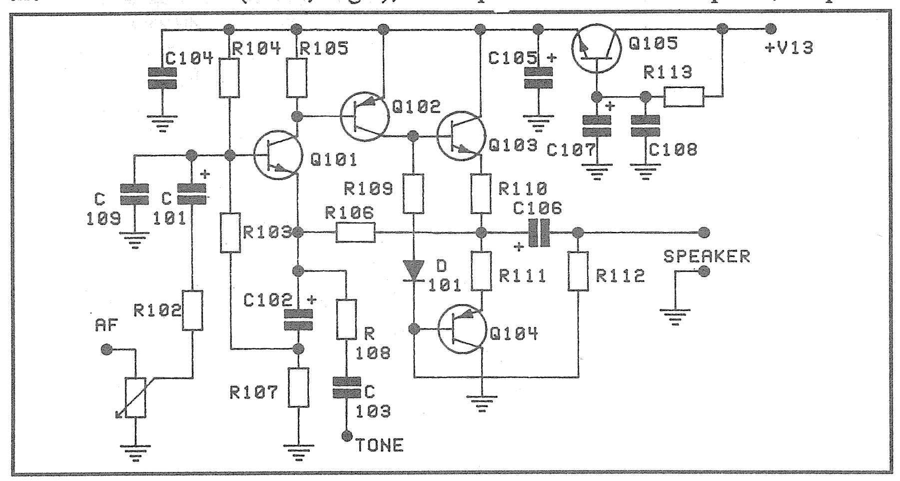
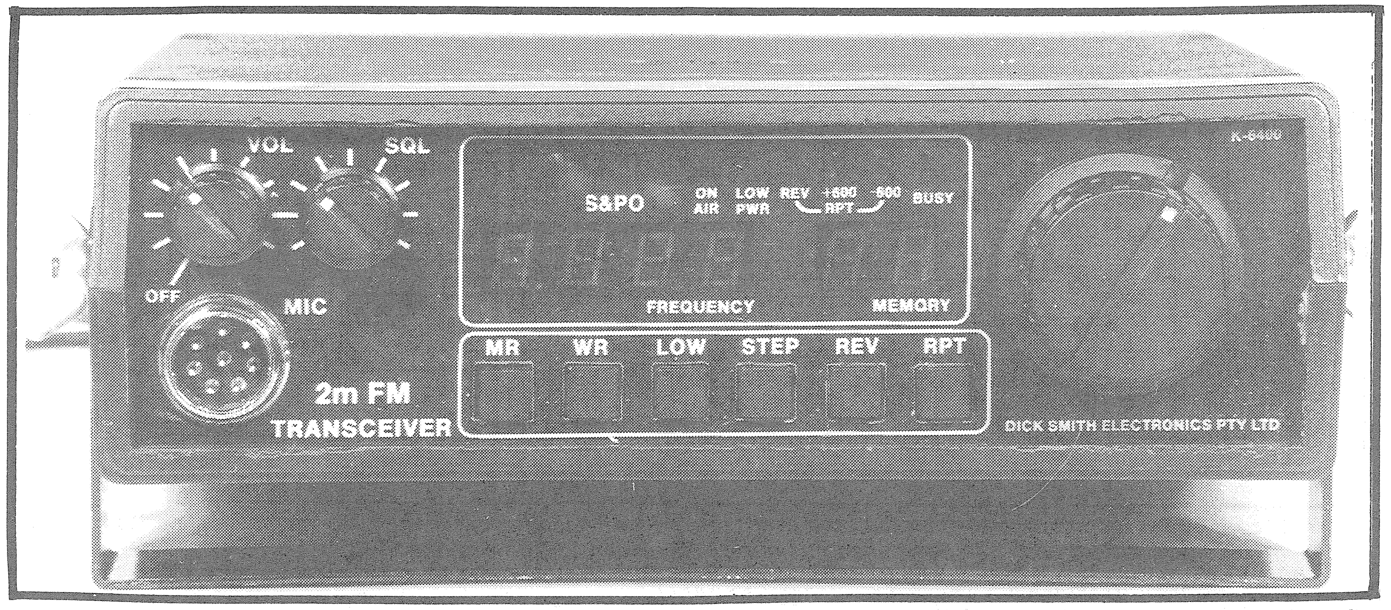


Fig.8: The receive audio amplifier. Note the 'capacitance multiplier' filter stage.

Text and illustrations courtesy of Electronics Australia



down the transmitter output altogether. This is done in receive mode, by turning on Q605 from the R8V line via D604 and R614, and also in transmit mode for various error conditions. For example D603 turns on Q605 and shuts down the transmitter when the PLL is out of lock, signified by a logic high on the U/L line from U401 pin 10 (Fig.4). Similarly if the antenna conditions are such that there is a high SWR and significant power is reflected back to the PA, this is detected by the directional coupler on the PA board and a corresponding DC voltage fed back via the 'REV' line, from where it is fed in by D605 to again turn on Q605 and to reduce the transmitter power to a safe level.

Construction Details-

First a few words of caution. You will no doubt have gathered from the circuit description that this is not really a simple beginner's project. In order to provide the kind of facilities and performance that are expected nowadays even on the amateur bands, the project has inevitably required a fairly sophisticated design.

This means that there are a number of PC boards, and many small and relatively delicate components to be fitted to them.

You won't be able to 'knock it together' in a couple of hours, and there are various aspects of the assembly that call for considerable care and not a little skill, if components are not to be damaged, and the resulting unit to perform correctly.

So if you're a relative newcomer to electronic project assembly, this probably *isn't* a project to tackle just yet — it might be wise to build up your experience with a few simple projects first.

Now for the good news. For a project of this degree of complexity, the transceiver *is* relatively easy to put together and get going.

The boys at DSE's research and development lab have gone to a lot of trouble with both the circuit and mechanical design, to ensure this.

Not only that, but they've also worked out a system of assembling and testing the various circuit sections in order, so that each one can be checked out before you proceed with the next.

So providing you follow the same order, and read carefully all construction details per stage, followed by checking and testing out the sections as you go by, there's a very good chance indeed that your transceiver will operate exactly to specifications.

Needless to say, we're going to be describing the assembly and testing in exactly the recommended order. And as yours truly has been assembling a unit as well, before writing this description, I hope to be able to pass on a little of my own experience as well.

Incidentally before we start, here's the order in which the sections will be described, so you'll know what is coming:

1. Metal shield boxes.
2. Soldering the CPU board to the main board.
3. The power supply circuitry.
4. The CPU and display circuitry.
5. The VCO and PLL circuitry.
6. The receiver AF amplifier.
7. The receiver IF amplifier.
8. The low level RF circuitry.
9. The microphone preamp.
10. The S-meter and ALC circuitry.
11. The transmitter PA circuitry.
12. Final checking and adjustment.

1. SHIELDING BOXES

There are two of these, the larger of which is to contain the VCO and PLL circuitry. The smaller one houses the receiver bandpass filter components. Both are supplied in the form of small pre-cut pieces of tinplate, which are assembled directly on the main PC board by soldering them to the PCB copper and each other.

Note that the 'long' sides of both shield boxes extend through to the underside of the board, and are fitted with a second cover so that they form a further shallow box underneath.

The first step in assembling each box is to gather together the correct pieces of tinplate. There are a total of seven pieces for the larger box: two covers, measuring 51 x 80mm and with turned-down lips along each long side; two long sides, measuring 21 x 78mm; and three short sides 15 x 50mm (one of which is the partition which divides the box into two).

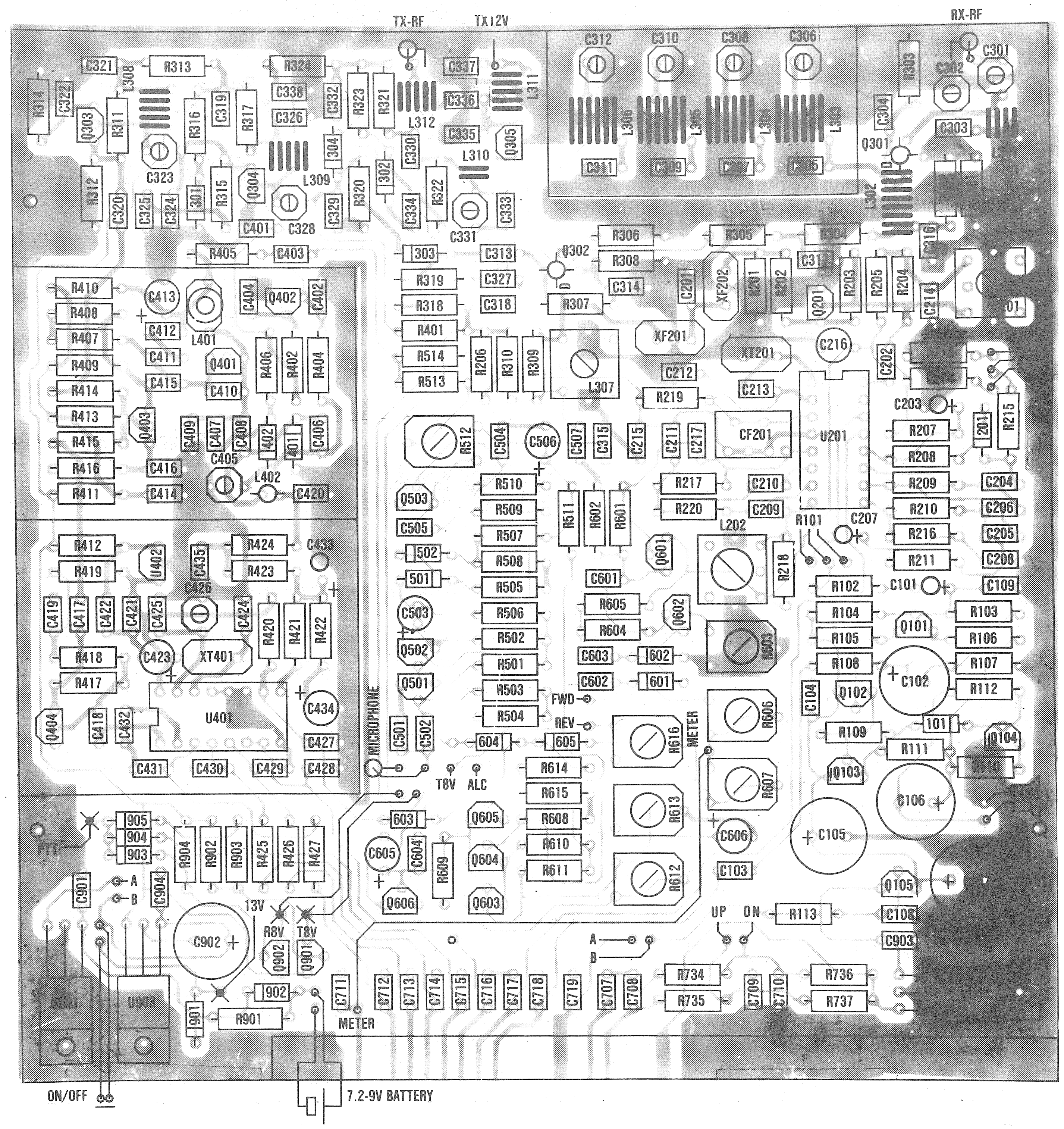
Similarly there are six pieces for the smaller box: two covers 26 x 46mm, again with turned-down lips along the long sides; two long sides 21 x 46mm; and two short sides 25 x 15mm.

By the way, after sorting out the pieces for the two shield boxes, you'll still have three pieces of tinplate left: two small L-shaped brackets measuring 42 x 22 x 10mm, and a cover like those for the two shield boxes, only larger: 42 x 115mm. These are the mounting brackets for the CPU/display boards, and the shield plate for the back of the CPU board — so put them aside, for the time being.

You'll no doubt have noticed that the main PCB has two narrow slots cut in it. These are to take one of the long sides, for each shield box. The other long side of each box mounts at the edge of the PCB, parallel with and in line with the side in the slot. On the other hand the shorter 'cross sides', and the internal partition of the larger box, simply mount on the top of the PCB.

With each box, you start by mounting the long side that fits through the slot. This is first pushed through from the top, and carefully positioned so that its top edge is 15mm from the top surface of the board. You can check this using one of the shorter cross-sides — the top of the long side should

Main-PCB Component Overlay



Here's the overlay/wiring diagram for the main board of the transceiver, a little larger than actual size. It may look a little daunting, but by wiring in the components for each functional subsystem stage by stage, and testing their operation before you proceed, the project can be assembled with a high degree of confidence.

be at the same height as the cross-side, at each end.

When you're happy that it's set to the right depth, carefully tack it in place at each end with small blobs of solder. Then, ensuring that it's also sitting in the slot squarely at 90° to the plane of the board, run fillets of solder along both the top, and the 'inner' side underneath (i.e., the one facing the board edge, and which becomes the inside of the shield box).

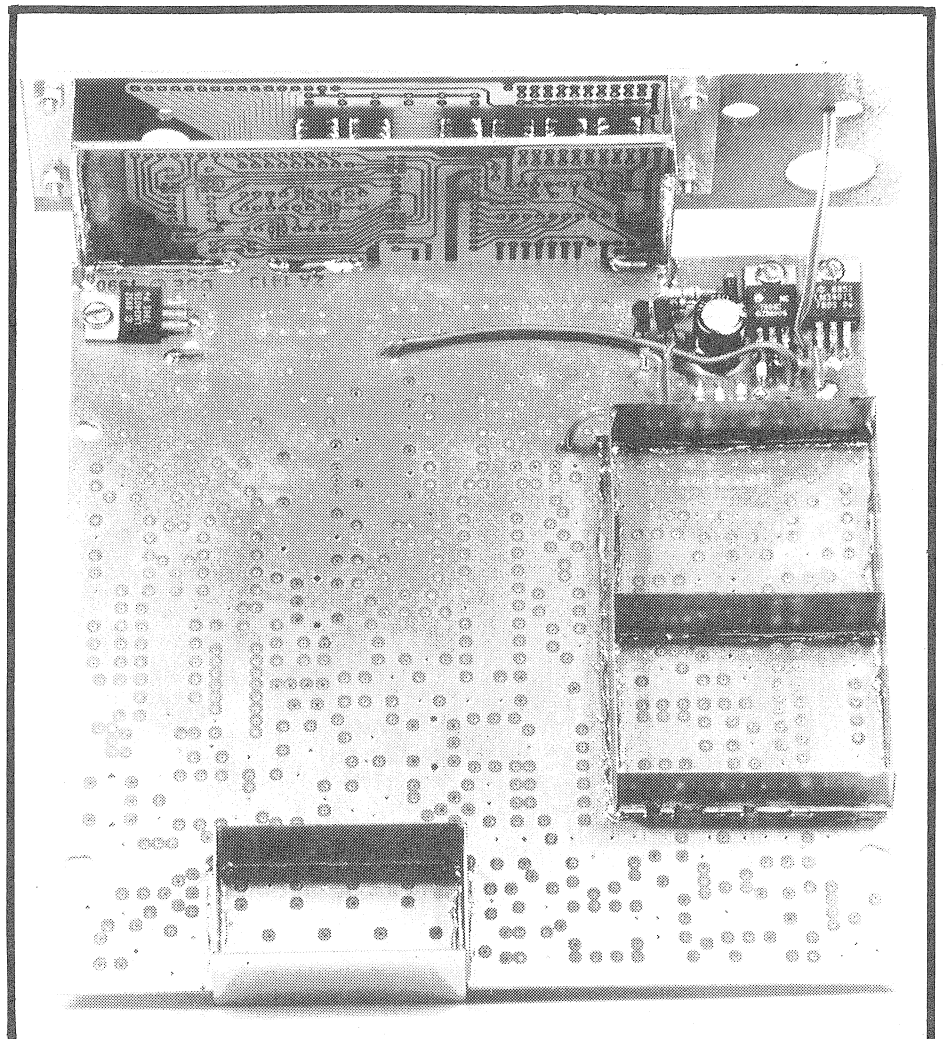
Once the long 'slot' side is in place, you can mount the short cross sides of each box — including the central partition, in the case of the larger box. Again the trick is to position them carefully (using the PCB overlay diagram as a guide to exact location, if necessary), then tack them in place using a small blob of solder at each end, and then finally run a solder fillet along the corners to complete the job. Needless to say as the box takes shape, you have more corners to fillet.

The final step for each box is to fit the second long side, which is pressed hard against the edge of the board so it lines up with the top cross sides.

Again tack it in place, and then run fillets along on the inside of both top and bottom.

If you find it difficult to hold each additional box side in place while you apply the solder tacks, try using a couple of blobs of 'Blu-tack' to hold them in position. Also you might find it necessary to set your soldering iron for a somewhat higher operating temperature than usual, to allow it to make the fillet joints properly without 'running out of heat'. As a final check of each shield box, see if the top covers fit on correctly above and below the board. You may need to bend either the covers or the box sides a little, to ensure that they fit on and are not loose.

Now you should be ready for the next stage.



Here is the prototype after the shield boxes had been assembled on the main board, the CPU board and brackets added to the front of the board, and the power supply components fitted — along with the 7-segment displays.

2. CPU/MAIN PCB MATING

This stage involves soldering the CPU board to the main board, along with the mounting brackets for the display board. The trick here is to ensure that everything is lined up correctly, and this is done in the following way.

First of all, mount a couple of the push-button switches (from the display board components pack) on the lower front of the display board — one at each end of the row is ideal. These will be used to check the PCB alignment, shortly.

Now fit the two small L-shaped brackets to the back (copper side) of the display board, using 3mm x 6mm machine screws and nuts. Both brackets have their flanges facing towards the ends of the display board, as you can see from the photos.

Then place the CPU board between the brackets (copper side away from it), about 14mm behind the display board and parallel with it (the rows of holes along the top of both boards should line up — check if necessary with a couple of guide wires). Now mount the main board into the lower half of the transceiver case, using the four small self-tapping screws provided.

Then find the front escutcheon panel of the transceiver, and holding it at the front of the display board (using the two push-button switches to line them up), try lowering the complete display/CPU board assembly down into the case, to see if it mates correctly with the main board. The escutcheon panel and the display board must be fitted into the appropriate guide channels, of course.

You may need to move the CPU board back away from the display board close to the display board, for it to butt against the front edge of the main board.

You may also need to bend the brackets slightly, so that the tracks on the CPU board line up correctly with the small etched 'cutouts' on the top front edge of the main PCB.

It's also important at this stage to check that the front push-button switches line up correctly inside the corresponding holes in the front escutcheon panel, with the rear ends of the brackets sitting against the top surface of the main board, and with the front escutcheon panel still sitting undisturbed in its slot (i.e., not kicked up).

If this doesn't happen, you may need to cut small notches in the lower edges of the brackets, until everything lines up correctly.

Once all seems well, you can apply small blobs of solder to tack the brackets and the main board together. Then remove the screws holding the main board into the case, and carefully remove the assembly for final soldering.

The CPU board is soldered first to the underside of the main PCB, with a couple of wires through the holes in the CPU and display boards so that you maintain their alignment.

Make sure that the tracks on the CPU board also align correctly with those on the underside of the main board, and that the boards are squarely lined up, and then run fillets of solder

to join both the small connection tracks, and the main earthed copper areas.

Then turn your attention to the top side, and run further fillets of solder again to link the earthed areas of the two PCB's, and also up the ends of the CPU board to bond it to the inside surfaces of the brackets.

You should now have a fairly sturdy PCB assembly, complete with the shield boxes on the main board. This means you're ready to begin the actual wiring up.

3. POWER SUPPLY

This section is that which is shown in the schematic of Fig.2 and involves all of the components identified with a "9XX" number (R901,C904,U903 and so on). These all mount along the front of the main PCB, most of them immediately in front of the large shield box.

As usual, mount the low-profile resistors and diodes first, making sure you fit the diodes with the correct polarity. Then mount the three ceramic/monolithic bypass capacitors. Note that one side of each of these is soldered not only to the copper under the board, but also to that on the top. To allow this to be done neatly if ceramic capacitors are supplied in your kit, you'll need to remove the ceramic insulation from the lead concerned, so that the lead can be soldered close to the component body, with the latter pushed down against the board.

Do this by carefully squeezing the insulation on the lead with a pair of needle-nosed pliers, so that it cracks off. Then clean the exposed lead by lightly scraping it with a small hobby knife, before re-forming the leads with the pliers so that they will pass through the PCB holes.

You may well have to carry out the same operation with many of the other bypass capacitors used in the transceiver, by the way, as many of these also have one lead soldered to the top copper as well as underneath. When soldering to the top copper, you'll also need to use an iron with a clean, fine-pointed bit — so you can make a good joint quickly, without damaging the capacitor itself.

Returning to the power supply circuitry, you can now fit the three three-terminal regulators. Note that two are 5V types, and the third is an 8V type — don't get them mixed. The 8V unit mounts in the 'U903' position, next to D901. All three regulators are mounted flat on the board, with 3mm screws and nuts clamping their tabs to the board, and also have their centre pin soldered to the top copper of the board, as well as underneath.

Next, you can solder in the four PCB pins (shown with an 'X' on the overlay drawing), and fit the two transistors (making sure of their type numbers, and their orientation). Then fit the three pairs of insulated link wires: one pair joining the 8V supply pins to the points adjacent to D603 (not fitted yet!), a second pair which join points 'A' and 'B' together, and a third pair to the two points between U901 and U903, for later connection to the ON/OFF switch.

Finally, fit electrolytic capacitor C902, making sure that its positive end is towards Q902. Now you're ready to test the power supply circuitry.

Testing:

1. Connect a 1k resistor across the input terminals of your multimeter. This is necessary because the regulators must be loaded with a few milliamps, for correct regulation.
2. Connect the positive output of a 12-13.8V DC power supply to the PCB pin marked '13V' (to the front of C902), and the negative output to the main board ground plane. Also connect together the ends of the two wires which will go to the On/Off switch.
3. Check the voltages on the output pins of the regulators U901-3. These should measure +5V, +5V and +8V respectively.
4. Measure the voltage on PCB pins R8V and T8V. At this stage they should read between 7.0-7.5V and 0V respectively.
5. Now connect the PCB pin marked 'PTT' to ground, and again measure the voltage on the pins R8V and T8V. The voltages should now have 'reversed', to read almost 0V(or close to 0V) and 7.5-8V respectively
6. Finally disconnect the power supply, and remove the 1k resistor from the terminals of the multimeter. Also disconnect the PTT line from ground.

NOTE: When you next check the voltage (steps 3, 4 and 5) after other circuitry has been soldered into place, there will be no need to connect the 1k resistor across the multimeter. Also note that if you accidently short circuit the T8V or R8V to ground during the above tests, this will probably result in damage to Q902 or Q901. So be very careful!

4. CPU/DISPLAY BOARDS

With the power supply section ok, you're now ready to fit the components for the CPU and display sections of the circuit. These components are all identified with a "7XX" number and relate to the "controller" section schematic (Fig.3). They mount on three PCBs: the display board, the CPU board and the main PCB.

You'll need to remove the four machine screws and nuts holding the display board to its mounting brackets, in order to wire up this and the CPU board.

I suggest that you tackle the display board first, as in effect you've already started it — with the earlier mounting of the two push-button switches.

3-Power Supply Parts list

Resistors (All ¼ Watt)		
R901	680 (blu-gry-brn)	☐
R902	100K (brn-blk-yel)	☐
R903	1K (brn-blk-red)	☐
R904	680 (blu-gry-brn)	☐
Capacitors		
C901	0.1uf (Ceramic)	☐
C902	470uf/16v (Electro)	☐
C903	0.1uf (Ceramic)	☐
C904	0.1uf (Ceramic)	☐
Semiconductors		
D901	1N4002/4(Diode)	☐
D902	1N4002/4(Diode)	☐
D903	1N4148 (Diode)	☐
D904	1N4148 (Diode)	☐
D905	1N4148 (Diode)	☐
Q901	BC328 (Transistor)	☐
Q902	BC338 (Transistor)	☐
U901	7805 (IC)	☐
U902	7805 (IC)	☐
U903	7808 (IC)	☐
Hardware		
3x	Bolts (⅛"x¼")	☐
3x	Nuts (⅛")	☐
4x	PCB pins	☐

Before starting, note that all eight of the resistors that mount on the display board are fitted to the 'rear', or copper side of the board.

There isn't room for them on the front. This allows them to be mounted *after* the seven-segment displays, transistors, LEDs and push-buttons. And I suggest that you fit these components in that order, for easiest access.

Make sure that the LEDs, seven-segment displays and pushbuttons are mounted as close as possible to the board, and in straight lines.

Note that the holes for the LEDs are a bit larger than necessary, to allow mounting these squarely and evenly. Of course, don't forget to watch the LED polarity — as you can see from the overlay diagram, the 10 closely-spaced LEDs (D701- 710) mount with their cathodes towards the top of the PCB, while the six others mount the other way.

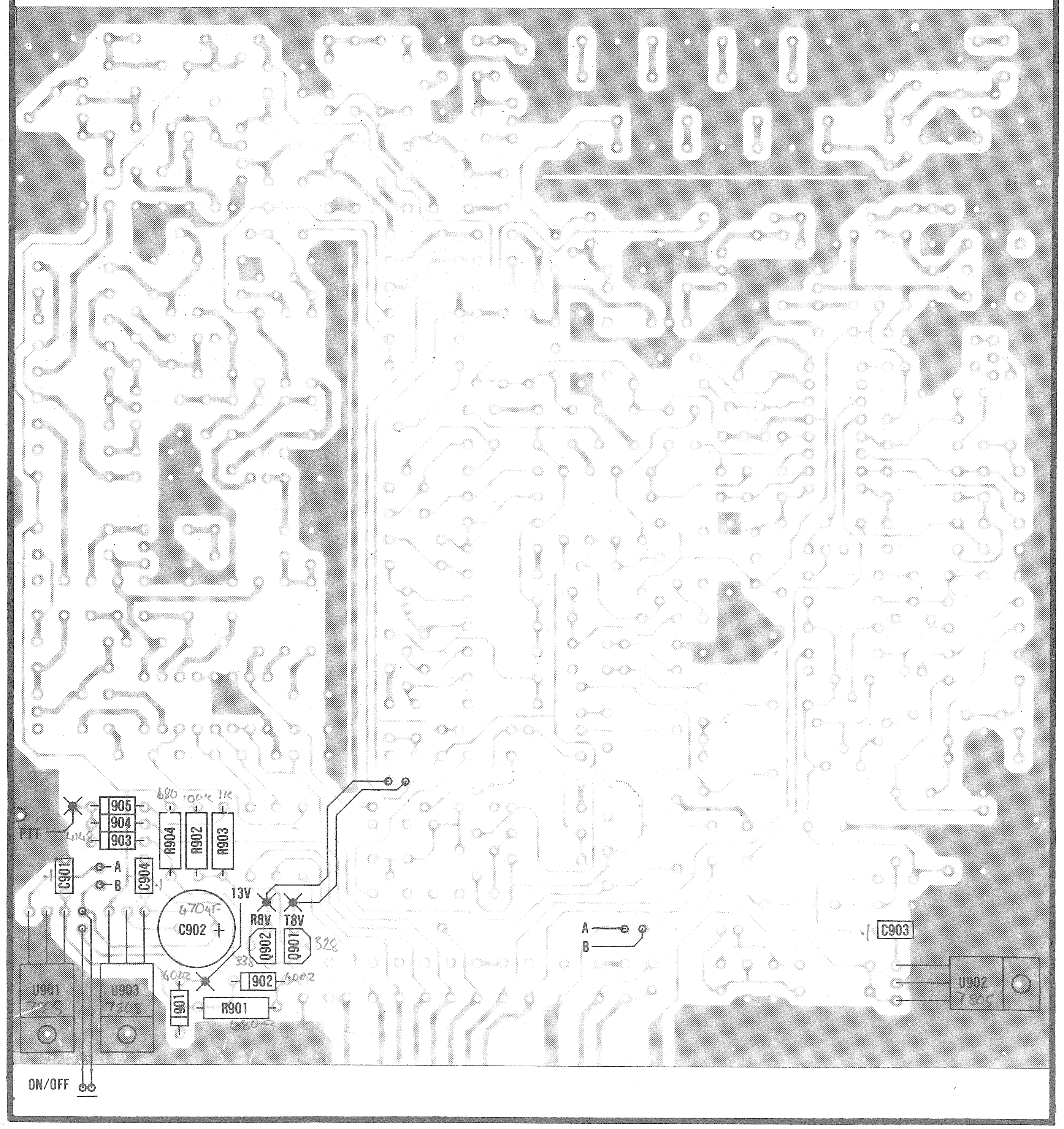
Note too that the transistors (Q702-707) should also be mounted with their bodies down fairly close to the board, so that the tops of their bodies are no higher than those of the LEDs.

The leads should be gently splayed to allow this to be done, without straining them.

Take particular care when soldering the pins for the seven-segment displays, as the display board tracks are quite fine, and closely-spaced at this point.

The final steps in assembling the display board at this stage are to mount the rotary optical encoder RE701, and

3-Power Supply



to fit the 12-pin and 16-pin SIL sockets used for the interconnections with the CPU board. Take special care with the latter — like the resistors, they mount on the copper side of the board, and making good joints isn't easy as the socket body is only about 3mm above the board.

You'll again need an iron with a clean, narrow bit, in order to make good joints without causing damage.

Note that the volume and squelch controls are not fitted to the display board at this stage.

Now for the CPU board. This is wired in the usual way, fitting the resistors and small capacitors first, and then the transistor and ICs. (Keep the cut-off ends of the resistor pigtails — you'll need them shortly.)

Watch the polarity of the tantalum electros, and also the orientation of the ICs. Note that tantalum capacitor C706 must be mounted horizontally, to ensure that it clears the rotary encoder when the boards are re-assembled.

The controller chip (U701) mounts in a socket, to reduce the risk of damaging it, but take care with the other chips — two of which are CMOS. A well-earthed iron (and operator) are advisable.

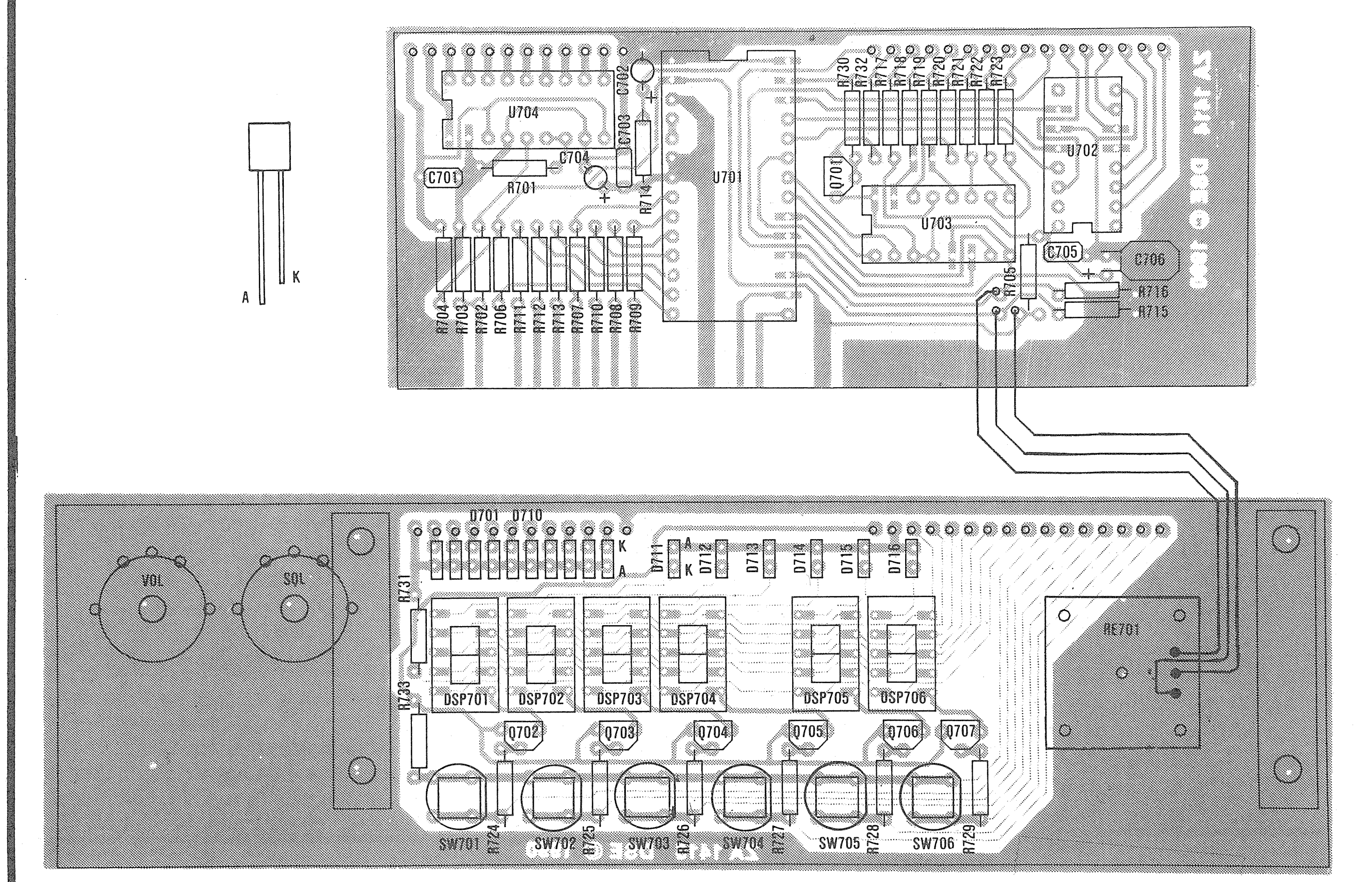
The three-lead cable from the CPU board to the rotary encoder should be fitted to the CPU board, and cut to about 80mm long. It can then be connected to the encoder lugs, with the connections as shown.

By the way, if your rotary encoder is a small round unit with two long lugs extending out of the rear, these will need to be cut off so that they clear U702, C705 and C706 on the display board.

After checking your work carefully, you should now be able to plug the CPU chip U701 into its socket, and bolt the display board back onto the front of the mounting brackets. Then you're ready to fit the rest of the interconnections.

Here's where you use 28 of those cut-off resistor pigtails. Push each one through from the rear of the CPU

4-CPU/Display Boards



* Note that resistors R724 to R729 and R731 and R733 are mounted on the rear (copper track) side at the board

4-CPU/Display Boards Parts list

Resistors (All ¼ Watt)

R701	22K (red-red-org)	☐
R702	22K (red-red-org)	☐
R703	22K (red-red-org)	☐
R704	4.7ohm (yel-vio-gold)	☐
R705	4.7ohm (yel-vio-gold)	☐
R706	100K (brn-blk-yel)	☐
R707	100K (brn-blk-yel)	☐
R708	100K (brn-blk-yel)	☐
R709	22K (red-red-org)	☐
R710	22K (red-red-org)	☐
R711	1K (brn-blk-red)	☐
R712	1K (brn-blk-red)	☐
R713	1K (brn-blk-red)	☐
R714	1M (brn-blk-grn)	☐
R715	100K (brn-blk-yel)	☐
R716	100K (brn-blk-yel)	☐
R717	33ohm (org-org-blk)	☐
R718	33ohm (org-org-blk)	☐
R719	33ohm (org-org-blk)	☐
R720	33ohm (org-org-blk)	☐
R721	33ohm (org-org-blk)	☐
R722	33ohm (org-org-blk)	☐
R723	33ohm (org-org-blk)	☐
R724	4K7 (yel-vio-red)	☐
R725	4K7 (yel-vio-red)	☐
R726	4K7 (yel-vio-red)	☐
R727	4K7 (yel-vio-red)	☐
R728	4K7 (yel-vio-red)	☐
R729	4K7 (yel-vio-red)	☐
R730	4K7 (yel-vio-red)	☐
R731	33ohm (org-org-blk)	☐
R732	33ohm (org-org-blk)	☐
R733	100K (brn-blk-yel)	☐
R734	100K (brn-blk-yel)	☐
R735	100K (brn-blk-yel)	☐
R736	100K (brn-blk-yel)	☐
R737	100K (brn-blk-yel)	☐

Capacitors

C701	0.1uf (Ceramic)	☐
C702	1uf/16v (TANT)	☐
C703	0.1uf (Ceramic)	☐
C704	33uf/10v (TANT)	☐
C705	0.1uf (Ceramic)	☐
C706	33uf/10v (TANT)	☐
C707	.001uf (Ceramic)	☐
C708	.001uf (Ceramic)	☐
C709	.001uf (Ceramic)	☐
C710	.001uf (Ceramic)	☐
C711	.001uf (Ceramic)	☐
C712	.001uf (Ceramic)	☐
C713	.001uf (Ceramic)	☐
C714	.001uf (Ceramic)	☐
C715	.001uf (Ceramic)	☐
C716	.001uf (Ceramic)	☐
C717	.001uf (Ceramic)	☐
C718	.001uf (Ceramic)	☐
C719	.001uf (Ceramic)	☐

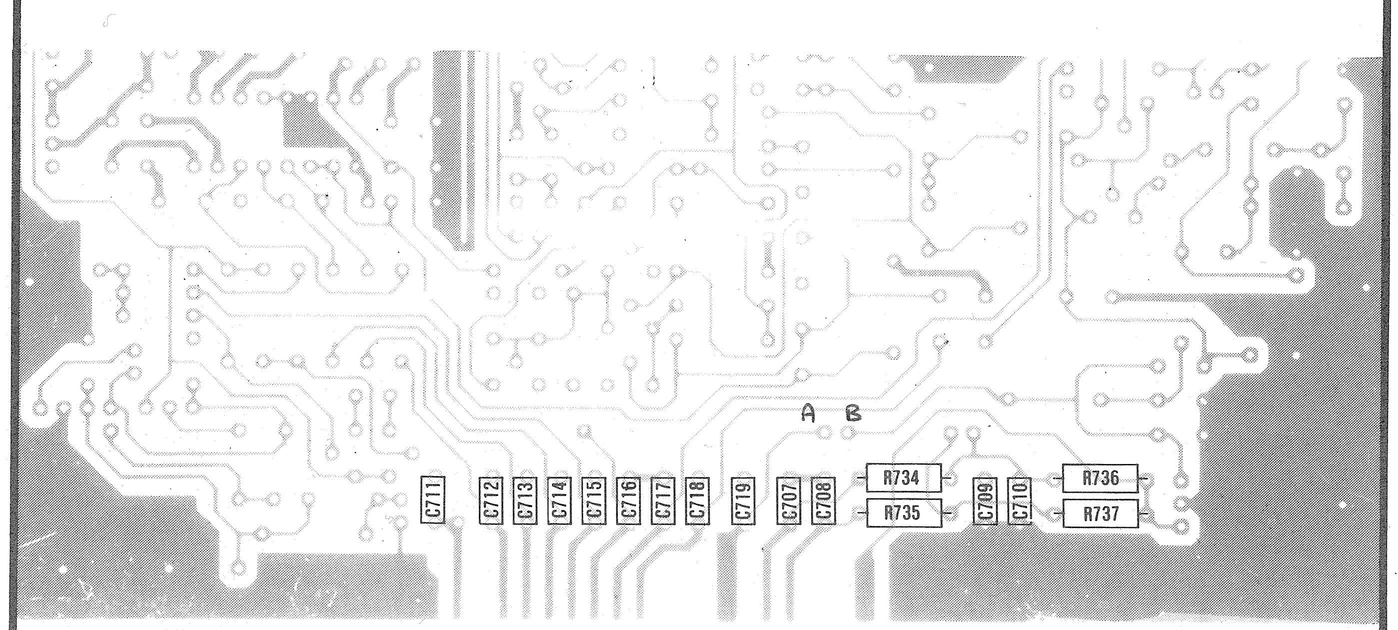
Semiconductors

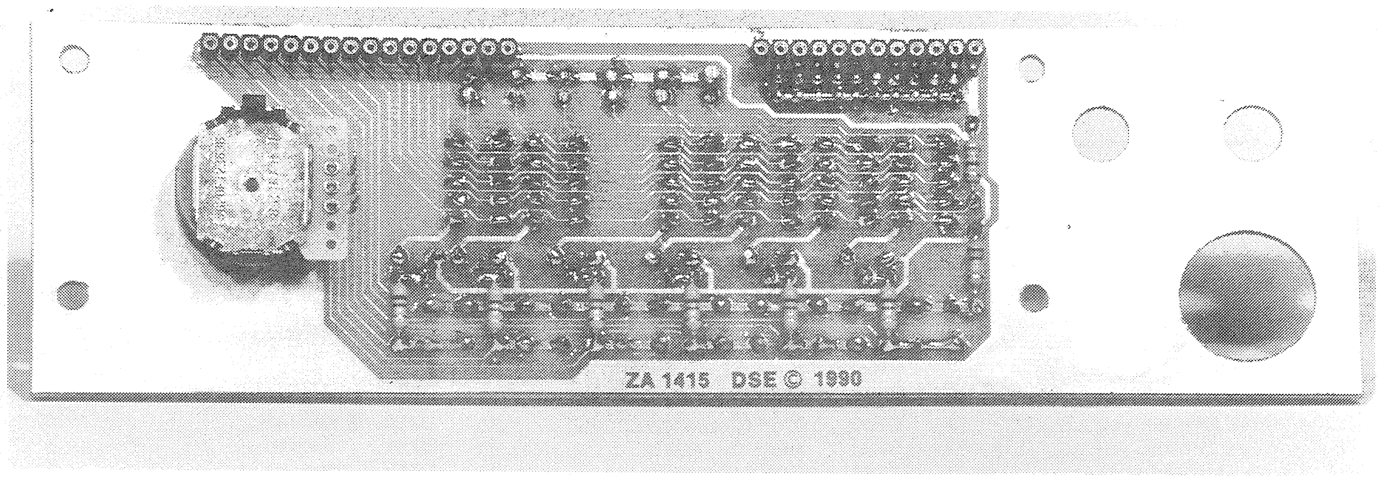
Q701	BC558 (Transistor)	☐
Q702	BC548 (Transistor)	☐
Q703	BC548 (Transistor)	☐
Q704	BC548 (Transistor)	☐
Q705	BC548 (Transistor)	☐
Q706	BC548 (Transistor)	☐
Q707	BC548 (Transistor)	☐
U701	68705 Prog. (IC)	☐
U702	CMOS 4028 (IC)	☐
U703	CMOS 4511 (IC)	☐
U704	LM3914 (IC)	☐
D701	Red led	☐
D702	Red led	☐
D703	Red led	☐
D704	Red led	☐
D705	Red led	☐
D706	Red led	☐
D707	Red led	☐
D708	Red led	☐
D709	Red led	☐
D710	Red led	☐
D711	Red led	☐
D712	Red led	☐
D713	Red led	☐
D714	Red led	☐
D715	Red led	☐
D716	Red led	☐
DSP701	Led Display LT313	☐
DSP702	Led Display LT313	☐
DSP703	Led Display LT313	☐
DSP704	Led Display LT313	☐
DSP705	Led Display LT313	☐
DSP706	Led Display LT313	☐

Hardware

SW701	Switch P/B	☐
SW702	Switch P/B	☐
SW703	Switch P/B	☐
SW704	Switch P/B	☐
SW705	Switch P/B	☐
SW706	Switch P/B	☐
RE701	Rotary Encoder	☐
28pin	Dil IC Socket	☐
16pin	Sil Socket	☐
12pin	Sil Socket	☐
Wire	Hook up	☐
4x	Screws M3x5mm	☐
4x	M3 Nuts	☐

4-CPU/Display Boards





To help you (hopefully) in wiring up your display board, here is a shot of the copper side of the author's board. Note the resistors and the two SIL connector strips (take care when soldering these in!). The optical encoder shown is an alternative type, with different connections — and rear lugs that must be cut off, to clear the CPU board components.

board, and gripping it carefully between the boards with a pair of needle-nosed pliers, push the end into the corresponding SIL socket hole as far as it will go. Then solder it to the pad on the rear of the CPU board, and cut off the excess. It's a little tedious doing this operation 28 times, but not difficult!

The final assembly step at this stage is fitting the remaining components to the front of the main PCB. There are four 100k resistors, plus 13 small bypass capacitors — each of which has one lead soldered to the top ground plane. If your kit comes with 1nF ceramics for these capacitors, you'll need to remove the ceramic from these leads as described earlier.

Testing:

1. Check that the wires that will ultimately connect to the On/Off switch are still joined together. Then apply 12-13.8V DC as before, from a power supply. The display should now indicate 7.000.
2. Test all the functions of the display and control LEDs by activating the keyboard, rotary encoder and PTT line (see Table 1).
3. Turn off the main power supply, and connect one end of a 100k resistor to the METER input of the CPU section (between C711 and C712). Connect the other end of this resistor to a positive variable voltage, with the negative of this source connected to the tranceiver's ground. Initially this voltage source should be adjusted for 0 volts.
4. Turn on the main power supply again. All of LEDs D701-710 should still be off, but as you start increasing the voltagefrom the variable supply, they should come on progressively. The input voltage for 'full scale' (all 10 LEDs on) should be about 7 volts (1.25-1.30V on pin 5 of U704).
5. Turn off the power, disconnect the variable supply and remove the 100k resistor.

5. VCO-PLL CIRCUIT

Now you can turn your attention to the VCO-PLL circuitry, which was shown in the schematic of Fig.4

The components for this section are

Transceiver Control Functions

MR: Toggles between memory and 'dial' modes: In memory mode, the rotary tuning control and microphone Up/Down buttons select memory channels; in 'dial' mode, these controls select operating frequency directly in steps of either 5 or 25kHz.

WR Writes a frequency setting to either the dial or the current memory channel. In 'dial' mode, it writes the displayed frequency to the memory channel; in memory mode, it writes the memory channel contents to the display.

LOW Toggles between low (5W) and high (25W) output modes for transmit. The 'Low Pwr' LED lights in low power mode.

STEP Toggles between 5 and 25kHz tuning steps, in 'dial' mode (as selected by MR switch).

REV Toggles between 'normal' and 'reversed' repeater offset. Reverse offset mode is indicated by illumination of the 'Rev' LED. In reverse offset mode, the receiver frequency is offset from the displayed frequency, rather than the transmitter.

RPT Selects repeater frequency offset mode on-off, and polarity. Repeated presses cycle through -600kHz, +600kHz and 0kHz (no offset) modes. Current offset is indicated by the '-600' and '+600' LEDs.

ON AIR This LED illuminates during transmission.

BUSY This LED illuminates when the CPU is busy servicing a control command.

Scanning operation

1. Before scanning, the Squelch must be closed (i.e., the 'BUSY' LED must be off, and the speaker quiet).
2. Use the MR button to select either the 'dial' mode, for frequency scanning, or the memory mode for memory scanning. In dial mode, the STEP button can be used to select either 5kHz or 25kHz scanning steps.
3. To begin scanning, press the microphone Up or Down button as desired, for about two seconds.
4. Scanning will stop automatically when an input signal opens the squelch. To stop scanning manually, turn down the Squelch control to open it or press the microphone Up, Down or PTT buttons.

all identified with '4XX' numbers, as listed in the parts list.Most of them mount inside the larger of the two shield boxes, with only five resistors and two capacitors 'outside'.

Many of the capacitors, and some of the transistors and diodes of this section have one lead connected to the ground plane copper on the top of the board.

As the space inside the shield box is rather confined, I suggest that you fit these components before the rest. This allows you to make the ground-plane joints a little easier than otherwise, and with less risk of damaging either the components concerned, or others nearby.

Then you can follow the usual order, with low profile components such as resistors, capacitors, diodes and ICs.

As the box walls underneath can make it hard to bend over some of the component leads to hold them in place for soldering, you might wish to use a small blob of 'Blu-tack' as a holding aid.

Pay particular attention to the orientation of polarised components such as electrolytic capacitors and diodes — removing and replacing them later would be very awkward.

When you're soldering in the plastic components such as the trimmer capacitors and the adjustable coil, be careful not to melt the plastic bodies.

Also take considerable care with the PLL controller chip U401, as it is an expensive part. I suggest that you fit this component second last, followed only by the crystal XT401.

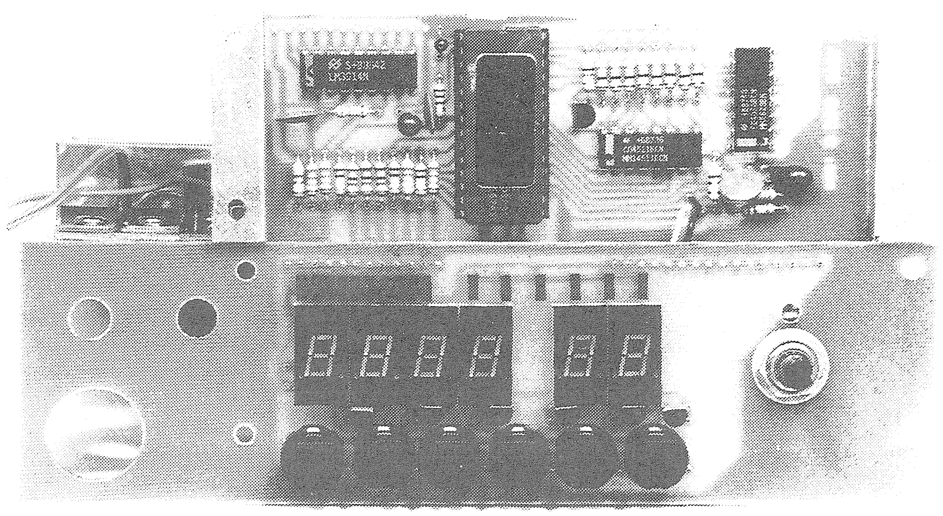
Testing:

1. Adjust the core of L401 so that it is at the same level as the top of the plastic coil former.
2. After checking that the ends of the two On/Off switch wires are still joined together, apply a 13.8V supply.
3. Measure the voltage between either end of resistor R424 and ground. This should be 0.5V or less. If it is not, adjust C426.
4. Now connect the PCB pin marked 'PTT' to ground, and turn the core of L401 clockwise into the former, with an alignment tool. After about 1-1/2 turns, the voltage on R424 should increase to 2-4 volts. At this stage, the voltage at pin 10 of U401 should be low. This means that the PLL is in lock.
5. With the PTT pin connected to ground, Adjust the voltage on R424 to 3.0V by tuning L401.
6. Remove the ground from the PTT pin, and this time adjust trimcap C405 to bring the voltage at R424 back to 3.0V. Make sure that the front display shows 7.000 (corresponding to 147.000MHz), and that the RPRT offset function is switched off.
7. Repeat steps 5 and 6 until the PLL voltage remains at 3.0V in both the receiving and transmitting modes.
8. Try tuning to the bottom of the band (display reads 4.000), and then to the top end (7.999). Confirm that the voltage at R424 is higher than 1.0 volts at the low end, and no higher than 4.0 volts at the high end. Also check that the PLL stays in lock, over the full range by checking for a low voltage at pin 10 of U401.
9. Connect a frequency counter to the LO output (the end of R414 nearer to the edge of the board), then connect the PTT line to ground. Now adjust trimcap C426 to get the same reading on the transceiver's display as measured on the frequency counter.

Troubleshooting

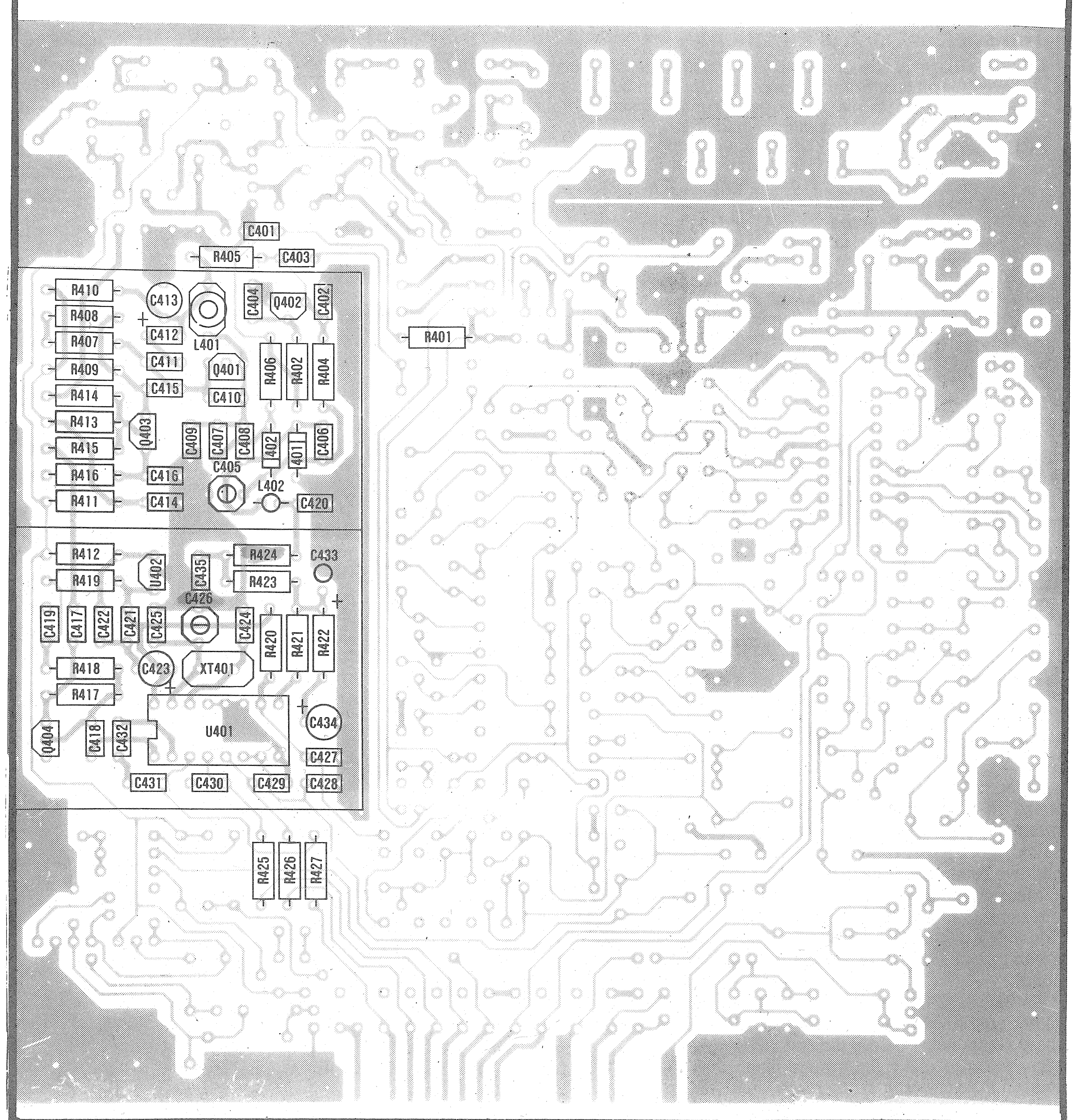
In the event of trouble with any of the above steps, check the following DC voltages with a high-impedance multimeter:

U402	input	7.0V
	output	5.0V
U401	pin 16	5.0V
Q404	collector	3.0V
	base	0.7V
Q403	collector	5.6V
	emitter	2.1V



Here's a shot showing the CPU and display boards after all of the components were fitted - but before the two were bolted together, and the SIL connectors and resistor pigtail "pins" used to make the interconnectors.

5-VCO-PLLCircuit



5-VCO-PLLCircuit parts list

Resistors (All ¼watt)

R401	4K7 (yel-vio-red)	□
R402	10K (brn-blk-org)	□
R403	No Location	
R404	4K7 (yel-vio-red)	□
R405	10K (brn-blk-org)	□
R406	4K7 (yel-vio-red)	□
R407	330 (org-org-brn)	□
R408	10K (brn-blk-org)	□
R409	10K (brn-blk-org)	□
R410	220 (red-red-brn)	□
R411	100 (brn-blk-brn)	□
R412	10 (brn-blk-blk)	□
R413	100 (brn-blk-brn)	□
R414	10 (brn-blk-blk)	□
R415	10 (brn-blk-blk)	□
R416	220 (red-red-brn)	□
R417	47K (yel-vio-org)	□
R418	330 (org-org-brn)	□
R419	100 (brn-blk-brn)	□
R420	10K (brn-blk-org)	□
R421	100 (brn-blk-brn)	□
R422	1K (brn-blk-red)	□
R423	2K2 (red-red-red)	□
R424	100 (brn-blk-brn)	□
R425	1K (brn-blk-red)	□
R426	1K (brn-blk-red)	□
R427	1K (brn-blk-red)	□

Capacitors

C401	.001uF (ceramic)	□
C402	.001uF (ceramic)	□
C403	.1uF (ceramic)	□
C404	.001uF (ceramic)	□
C405	20pF (Trimcap) (Red or Pink)	□
C406	3.3pF Ceramic NPO	□
C407	15pF Ceramic NPO	□
C408	18pF Ceramic NPO	□
C409	3.3pF Ceramic NPO	□
C410	4.7pF Ceramic NPO	□
C411	5.6pF Ceramic NPO	□
C412	.001uF (ceramic)	□
C413	33uF/10V (TANT)	□
C414	.001uF (ceramic)	□
C415	2.2pF (ceramic NPO)	□
C416	.001uF (ceramic)	□
C417	10pF (ceramic NPO)	□
C418	.001uF (ceramic)	□
C419	.001uF (ceramic)	□
C420	.001uF (ceramic)	□
C421	.1uF (ceramic)	□
C422	.1uF (ceramic)	□
C423	33uF/10V (TANT)	□
C424	56pF (ceramic NPO)	□
C425	27pF ceramic NPO	□
C426	20pF (trimcap) (red or pink)	□
C427	.001uF (ceramic)	□
C428	.001uF (ceramic)	□
C429	.001uF (ceramic)	□
C430	.001uF (ceramic)	□
C431	.001uF (ceramic)	□
C432	.001uF (ceramic)	□
C433	1uF/16V (TANT)	□
C434	10uF/25V (TANT)	□
C435	.1uF (ceramic)	□

Semiconductors

L401	150MHz red coil 2.5T	□
L402	Choke 10uH	□
D401	BB405 (diode)	□
D402	MC301 (diode)	□
Q401	2SK125 (transistor)	□
Q402	BC548 (transistor)	□
Q403	2SC1923 (transistor)	□
Q404	2SC1923 (transistor)	□
U401	M54959P (IC)	□
U402	78 L05 (IC)	□
XT401	10.240MHz (X-tal)	□

base 2.8V
Q401 drain 5.0V
source 5.1V
Q402 collector 0.1V (RX), 5.0V (TX)
base 0.7V (RX), 0.4V (TX)

(Note: The collector voltage might vary slightly, due to transistor gain tolerance, etc.)

By connecting a frequency counter, capable of measuring up to 200MHz, to the LO output you can check the output frequency.

This frequency (whether the PLL is in or out of lock) must be able to be adjusted by tuning coil L401 over the range 144-148MHz in transmit mode (PTT pin grounded), and over the range 133.3- 137.3MHz in receive mode.

The reference oscillator within the PLL synthesiser chip U401 can be checked with an oscilloscope. Connect the CRO input to pin 14 of U401, using a 10:1 probe to minimise loading effects.

This level should be an AC signal of about 1V p-p, with a period of about 100ns (corresponding to 10.24MHz). This test point is at a very high impedance, and therefore will not drive many standard frequency counters as these often have high input capacitance or low input impedance.

If you try connecting one of these the oscillator will either change frequency or stop oscillating altogether.

As the test pin of U401 (pin 13) is connected to ground, the DC output level on pins 6 and 7 of this IC are controlled by serial data from the CPU.

The DC output from these pins is used for high and low RF power switching.

With pin 13 connected to logic 1 (+5V at pin 16), pin 6 of U401 becomes the output of the reference oscillator divided by the reference divider, and the pin 7 output is the input frequency divided by the programmable divider. So if it becomes necessary to check the operation of the built-in dividers of the PLL chip, you will have to de-solder pins 6, 7 and 13 from the PCB, or cut the tracks leading to them.

Next, connect pin 13 to pin 16, and check the signal on pin 6. It should be 5.00kHz. Also check the signal on pin 7 — this should again be close to 5kHz, as defined by the formulas:

f(pin7)=f(input)/(f(display)/5kHz), in transmit
=f(input)/((f(display) 10700kHz)/5kHz), in receive

After you have checked these, you'll have to disconnect pin 13 from +5V and reconnect pins 6, 7 and 13 as they were before.

The serial data, clock and reset signals from the CPU should look like Fig.11, with a clock period of about 100us. Check with a CRO that the inputs on pins 3, 4, and 5 of U401 are less than 0.6 volts for a logic low, and more than 2 volts for a logic high.

Transmission of data from the CPU is only activated by changing a frequency control, such as turning the rotary encoder, grounding or ungrounding the PTT pin and so on.

When the PLL is locked, the signal on pin 9 of U401 should look like Fig.12.

If the PLL is unlocked, and the divided input frequency is higher than the reference frequency in the phase detector of U401, then the voltage on pin 9 of this chip should be close to 0 volts.

If the input frequency is lower, this voltage should be close to 5 volts. By slowly tuning the core of L401 and monitoring the voltage on pin 9 with a CRO or multimeter, you should be able to see the PLL trying to lock.

This indicates a problem around the lowpass filter R421-424 and C433-436, or tuning varicap D401 (perhaps

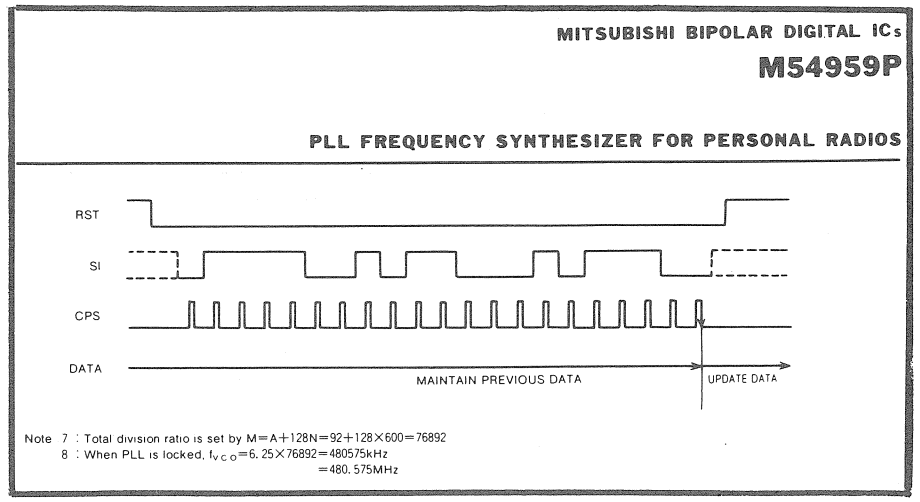
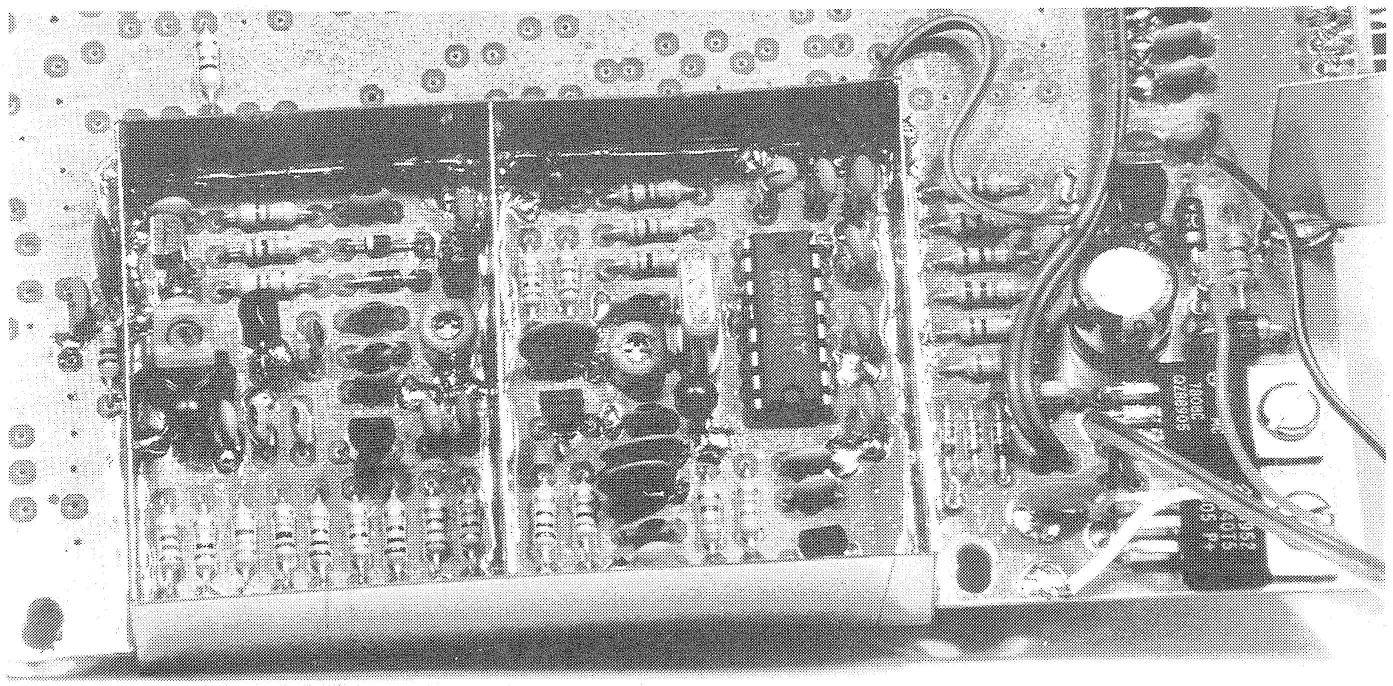


Fig.11: The serial data (SI), clock (CPS-bar) and reset (RST) signals fed from the CPU to the PLL chip (U401) should look like this, should you need to check them. But signals are only sent when a 'frequency change' control is operated.



Here is a close-up of the VCO/PLL circuitry inside its shield box. Many of the power supply parts are also visible, on the right. Note that many capacitors in the project have one lead soldered to the top 'ground plane' copper.

the diode is connected in back to front).

If the PLL locks only in transmit mode, or only in receive mode, check the voltage on the collector of Q402.

In receive mode this should be less then 1 volt, while it should rise to about 6V in transmit mode.

Tune the VCO so that the PLL is out of lock, by adjusting the core of L401 deep into the coil, and then verify if the frequency of the local oscillator can be adjusted by trimcap C405 for about 8% frequency change between receive and transmit.

If the PLL doesn't remain in lock across the whole band, due to component spread, then the value of C407 should be slightly increased for receive, and C408 slightly increased for transmit.

Finally, the so-called PLL noise can be checked using a VHF communications receiver. By listening to the LO frequency with the receiver set to SSB, you will be able to check the noise output and PLL locking time.

With the receiver set to FM you may be able to check the level of FM noise. A high frequency 5kHz tone means there is insufficient filtering in the PLL low pass filter (R421-424, C433-435). All noise components should correspond to less than 0.1kHz deviation (more than 50dB below the signal).

With the receiver set to AM, you can listen for any AM noise. If present this will be most likely caused by lack of bypassing and filtering of the supply and inputs to the PLL and LO. If you have a modulation meter, the level of modulation should be less than 1%.

6. AF AMPLIFIER

The audio amplifier circuitry is located near the front of the right-hand side of the main board,as you will have gathered. The only exception is the "receive" volume control pot R101,which mounts on the display board at the top of the left-hand end. More about the pot later - for the moment it can be put aside,while we concentrate on the other components. These are all identified by a "1XX" number.

Incidentally the schematic for the audio amplifier section is shown in Fig.8 if you need to refer to it during the assembly or testing.

There are a relatively small number of components involved in this section, so it won't take long. As usual it's a good idea to start with the low-profile resistors and diode first, then fit the smaller capacitors, followed by the larger electrolytics and finally the transistors. Take care with the orientation of these last-named groups, of course.

Note that while it probably isn't essential to solder the pigtails of the 'earthed ends' of C104, C108, C109 and R107 to the top ground plane copper as well as the underside copper tracks, there's no harm in doing so. It might even help ensure that the AF amp operates a little more reliably, with greater immunity to stray RF. The same applies to the collector lead of Q104. Just make sure, if you do decide to solder these leads to the top copper, that you don't overheat the components in the process.

A couple of PCB terminal pins should be used for the speaker connections, to allow the lead from the speaker to be connected and disconnected easily. Again the 'earthed' pin should be soldered on the top side of the board as well as the bottom.

At this stage, your audio amplifier section should almost be ready for testing. The one remaining step is to mount the volume control pot R101 on the display board, at the top of the left-hand end. At this stage it isn't wired up, however. R213 the squelch control

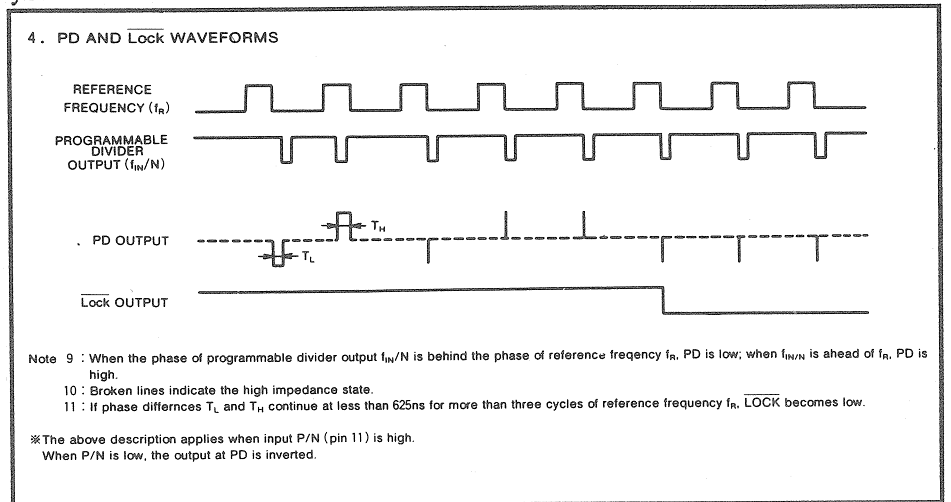
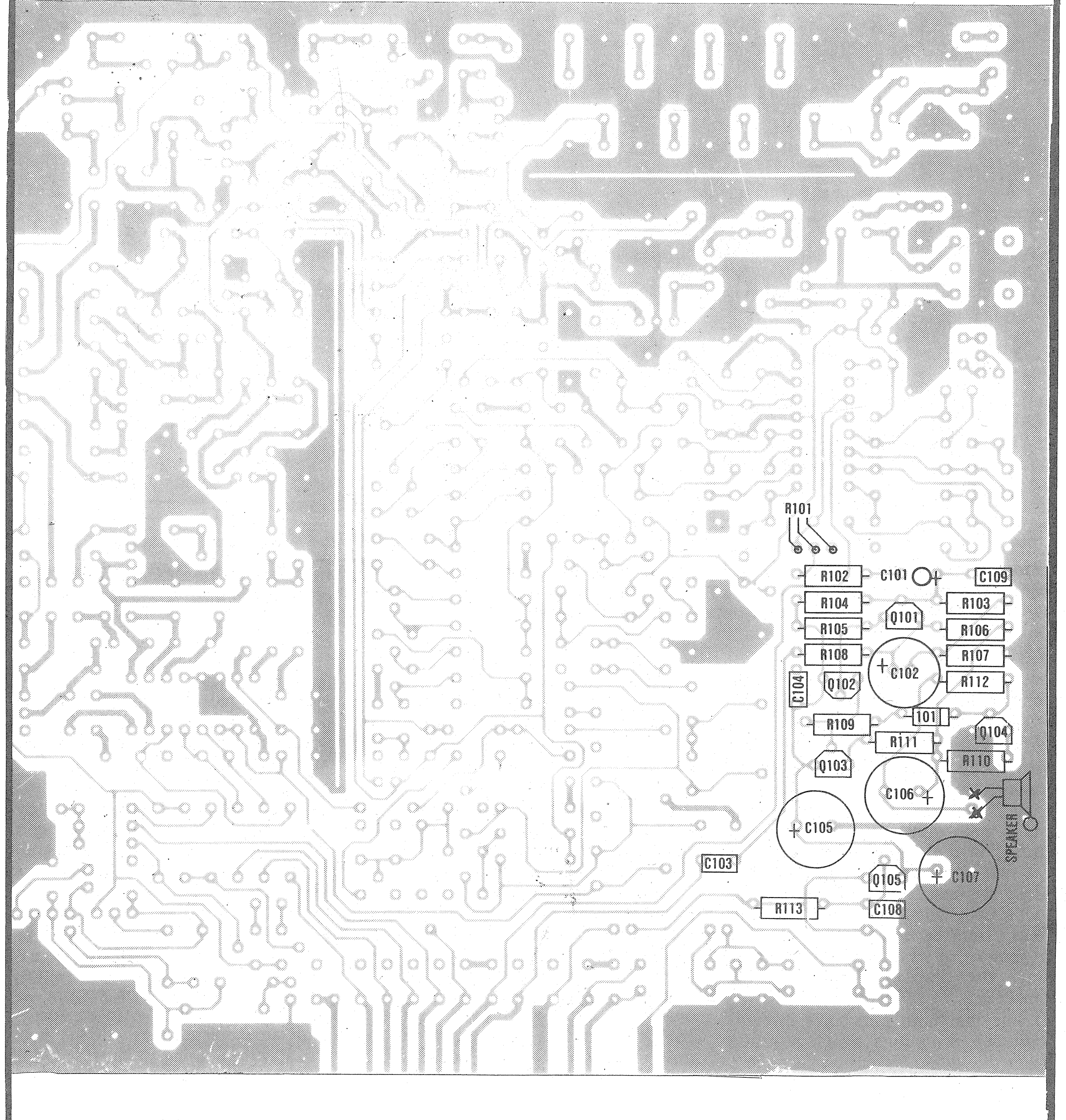


Fig.12: Waveforms associated with PLL chip U401, for both locked and unlocked conditions. Pin 9 is the PD output; pin 10 is the Lock-bar output (L=locked).

6-AF Amplifier



6-AF Amplifier Parts list

Resistors (All ¼watt)

R101	5K/LOG (POT)	☐
R102	2K2 (red-red-red)	☐
R103	56K (grn-blu-org)	☐
R104	33K (org-org-org)	☐
R105	2K2 (red-red-red)	☐
R106	3K3 (org-org-red)	☐
R107	220 (red-red-brn)	☐
R108	10K (brn-blk-org)	☐
R109	15 (brn-grn-blk)	☐
R110	2R2 (red-red-gold)	☐
R111	2R2 (red-red-gold)	☐
R112	1K (brn-blk-red)	☐
R113	220 (red-red-brn)	☐

Capacitors

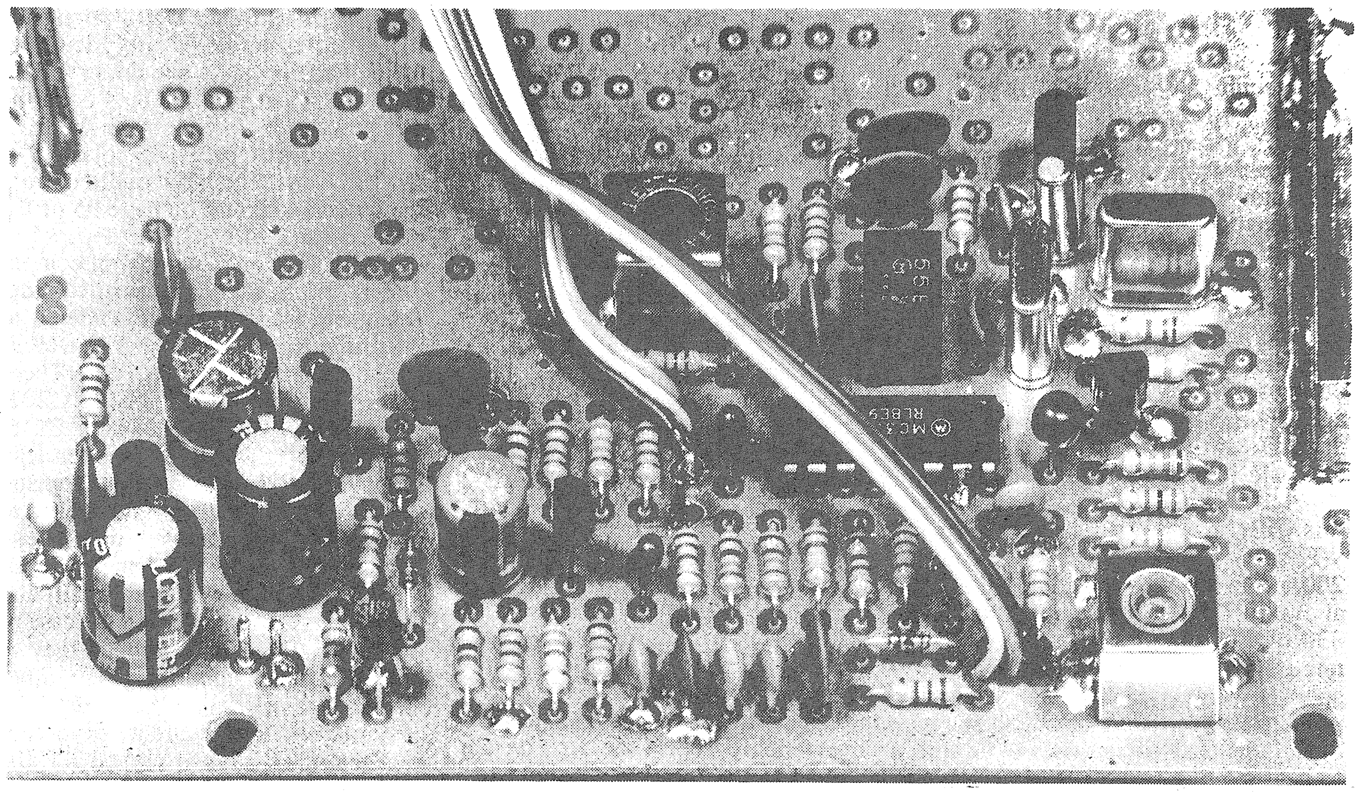
C101	1uF/16V (TANT)	☐
C102	220uF/16V (electro)	☐
C103	.1uF (ceramic)	☐
C104	.1uF (ceramic)	☐
C105	470uF/16V (electro)	☐
C106	330uF/16V (electro)	☐
C107	330uF/16V (electro)	☐
C108	.1uF (ceramic)	☐
C109	1nF (ceramic)	☐

Semiconductors

D101	1N4148/1N914 (diode)	☐
Q101	BC548 (Transistor)	☐
Q102	BC558 (transistor)	☐
Q103	BC338 (transistor)	☐
Q104	BC328 (transistor)	☐
Q105	BC338 (transistor)	☐

Hardware

2 x	pcb pins	☐
20cm x	audio coax cable	☐



Here's a shot of the next two sections — the audio amp and IF amp/demodulator, which are both positioned along the right-hand side of the main PC board. The audio amp is on the left, here, with the IF section to the right. Use this picture and the overlay diagram as a guide, when you're wiring these sections.

pot can also be mounted at the same time, in the adjacent hole.

The volume pot should be mounted with its three main lugs uppermost, while the squelch pot should be mounted with its main lugs at the bottom. This allows the two locating spigots to mate with a pair of 3mm holes, drilled in the display board between the two main pot mounting holes and along the line between them, so that neither pot will tend to rotate in use. (R213 can't be mounted with its lugs uppermost, as its spigot would conflict with the display board support bracket).

Note that both pots have integral switches, with lugs which protrude from the sides. To ensure that these lugs don't touch either each other or the display board mounting bracket, it's necessary to bend them inwards by about 90°. This can be seen in one of the photographs.

Testing the amp

1. Join the ON-OFF switch wires together, if they aren't already joined; also connect the speaker to the speaker connection pins, via a length of two-wire rainbow cable about 250mm long. Then connect 13.8V DC power to the unit.
2. By pressing any of the display board keys you should be able to hear a 2kHz 'beep' from the speaker, with a duration of a few hundred milliseconds.
3. Apply an audio signal from an audio generator to the input of the amplifier. The 'hot' input is the centre of the three PCB pads which will ultimately connect to R101, while the pad to its right (nearer to C101) is the earthy input. About 200mV RMS input should result in the rated output of 1W into 8 ohms. But if you do not have an audio generator, simply touch one end of R102 with your finger. You should hear the typical (not very loud) amplifier hum from the speaker when you do this.

Troubleshooting

In the (unlikely) event that your amplifier doesn't seem to be working correctly, here is the relevant information to assist in troubleshooting.

1. Check the following DC voltages:

Q105	collector	13.8V
	base	13.8V
	emitter	13.1V
Q101	collector	12.5V
	base	8.2V
	emitter	7.6V
Q102	collector	6.8V
	base	12.5V
Q103	base	6.8V
	emitter	6.3V
Q104	base	6.0V
	emitter	6.5V

2. Assuming all of the DC voltages are correct, you will need to trace the progress of a test signal through the amplifier, ideally using an oscilloscope (although this is not essential). If you don't have an audio generator to provide the test signal, you can use almost any audio equipment, such as a radio or tape recorder, with an external output capable of providing a signal of around 200mV.

If such a source only has a speaker output, you may need to make a voltage divider with two resistors, to reduce the signal to around 200mV. For example if you have a cassette player capable of delivering 1W into 8 ohms, this will provide about 2.8V RMS (E = √(P x R)). To reduce this to around 200mV, you'll need to divide this by about 13:1. We would suggest using a 330-ohm and a 27-ohm resistor, connected in series across the player's speaker — or preferably across an 8-ohm resistor used to substitute for it, during the tests (if you want to be able to hear the transceiver's speaker!).

The 200mV test signal will be produced across the 27-ohm resistor — but it will be advisable to connect a 0.1uF capacitor in series with the 'hot' side, if you're going to be injecting it into the various stages of the amplifier. This will prevent the 27-ohm resistor from disturbing the amplifier's DC circuit conditions.

If you have a 'scope, you can connect the audio test signal to the transceiver amplifier's input and trace its progress through Q101, Q102, Q103/4 and so on, using the 'scope. Obviously if there's a problem, its location will soon become apparent.

Alternatively if you don't have a 'scope, you can work in reverse by listening to the transceiver's speaker and applying the test signal first to the base of Q104, then that of Q103, Q102 and finally Q101. Not only should you be able to hear the signal in each case, but the volume should increase as you inject it earlier in the chain.

The most likely cause of any trouble with the amplifier is a wiring error, such as fitting a component in the wrong position or with the wrong orientation. So if you take care with these aspects and check everything carefully before applying the power, it's unlikely that you'll have any problems.

7. IF AMPLIFIER

Now you should be ready to wire up the IF amplifier and demodulator section, which occupies the area on the main PC board just behind the audio amplifier at the centre of the right-hand end. The circuit schematic for this section was shown in Fig.7, while its components are identified with a "2XX" number.

As before, it's best to start with the low-profile resistors and capacitors, work up to the larger and taller components and finally fit transistor Q201 and IC U201.

Take care again with the polarised parts, such as diode D201 (alongside R215) and tantalum electrolytic C216. Note that the latter should be orientated so that its positive lead is on the right-hand side, looking from the front — i.e., nearer C202.

Again, there are a number of components which have an 'earthy' side, where the lead should be soldered to the top ground-plane copper as well as to the copper under the PCB. These include R201, R211, R212, C201, C203, C208, C212, C214 and C216. When you fit Q201, its emitter lead should also be soldered to both top and bottom copper, and the same applies to pin 15 of IC U201. All of these ground-plane joints are virtually essential for this section of the circuit, and not optional as they were in the case of the audio amplifier. Here, if they're not done the IF amplifier may either have low gain, or could 'take off'.

Similarly it's also important to connect the metal case of crystal XT201, crystal filters XF201/202 and coils L201/202 to the ground plane, with a small solder joint at one end (or both ends for L201/202). As before take care to achieve good electrical bond to the ground-plane copper, with proper solder 'wetting', but without overheating the components concerned.

The wiring to connect pots R101 and R213 to the indicated board points should now be fitted, using a section of rainbow cable initially about 300mm long and with six wires. Three are used to connect R101 to the pads between C207 and R102, while the other three connect R213 to the pads just in front of L201.

Keep all six wires together for the main length of their run, separating them into the two separate groups at either end and chopping them to the correct length as shown in the photo. This makes for a neater job. Note again that the wire from the 'earthy' (fully-anticlockwise) end of R101 connects to the pad nearest R211, and is soldered to the top ground plane copper as well as to the underside.

Incidentally at this stage, the transceiver ON/OFF wires can also be connected to the switch contacts at the rear of R101, so that the switch can become operational.

Testing the IF

Here are the steps for checking the operation of the completed IF amplifier and demodulator section:

1. Connect the speaker and 13.8V DC power supply, and switch on.
2. Adjust the volume to midway and then turn up the squelch pot R213. At a particular point this pot should act like a noise switch, turning the IF amplifier's noise on and off as heard in the speaker. This shows that the squelch gating circuitry is working.
3. Open the squelch (noise audible) and adjust L202 for a null in the noise level, with minimum high-frequency content. Either side of this null the noise should increase, and become more harsh.
4. If you have an FM signal generator, adjust it for an output at 10.700MHz but with no modulation. Then connect its output to the input of the IF amplifier, at the pad of crystal filter XF201 nearest the VCO/PLL shield box. Adjusting L201 and L202 should allow you to achieve about 12dB of quieting for around 3uV of input, if everything is operating as it should be. That is, the audio noise output should drop by 12dB when the generator output is switched on and set for about 3uV, compared with the noise level when it is switched off.

Note that if the squelch gate closes during your adjustments, R213 should be turned to open it again.

Switching on the generator's modulation, with the deviation set for 3.5kHz, should produce a sinewave audio output. L202 should be adjusted for the largest undistorted output, judged either by ear or by observation with the 'scope.

Note that the tuning of L201 will appear to be very broad, due to the way the limiter operates. The best way to adjust this coil is to gauge its effect on the squelch 'switching' threshold, as set by R213.

That's about all you can do at this stage. Final adjustments can be done when assembly of the transceiver is nearer completion.

Troubleshooting

If you weren't able to carry out the foregoing tests satisfactorily, here is the information to assist in troubleshooting.

1. Measure the following DC voltages:

IC 201	pin 1	7.0V
	2	6.5V
	3	7.0V
	4	7.2V
	5	1.2V
	6	1.2V
	7	1.5V
	8	7.0V
	10	2.2V
	13	6.5V
	15	0V
	16	2.2V
Q201	base	0.6V
	collector	7.0V

2. If there is an absence of noise output, for any position of R213, this might be caused by three main things. There may be a problem with the squelch or the discriminator, or a faulty or low gain IF preamp (Q201). Alternatively there could be a problem with the 10.7/455 mixer inside U201.
3. If the squelch doesn't seem to be operating, try varying R213 and measure the DC voltage on pin 12 of IC201. This should change from about 300mV to 1.1V. The squelch threshold is at about 0.8 volts. If the voltage on this pin is higher, the mute switch (U201 pin 14) will be open and the signal or noise should be going to the audio amplifier.

If there is a problem where the noise is present and cannot be gated off using the squelch control, then this is probably related to a fault with one of the components connected to U201 pins 10, 11, 12 and 14.

4. The FM discriminator and limiting amplifier can be tested by connecting a signal generator to the input or output of the ceramic filter (pins 3 or 5 of U201). By adjusting coil L202, the DC level on pin 9 should change between 800mV and 6V volts. If the generator is being modulated, you might be able to see with a 'scope the audio signal on this pin superimposed on the IF (455kHz) signal. This is filtered out by the R216 and C208 low pass filter. Any malfunction in this area could be caused by the circuitry around U201 pins 6, 7 and 8.
5. If the sensitivity is poor, this could be due to a problem with the IF preamp stage around Q201, or the IF second mixer (10.7MHz/455kHz) section within U201. A problem with the latter is usually caused by an incorrect level injected from the crystal oscillator.

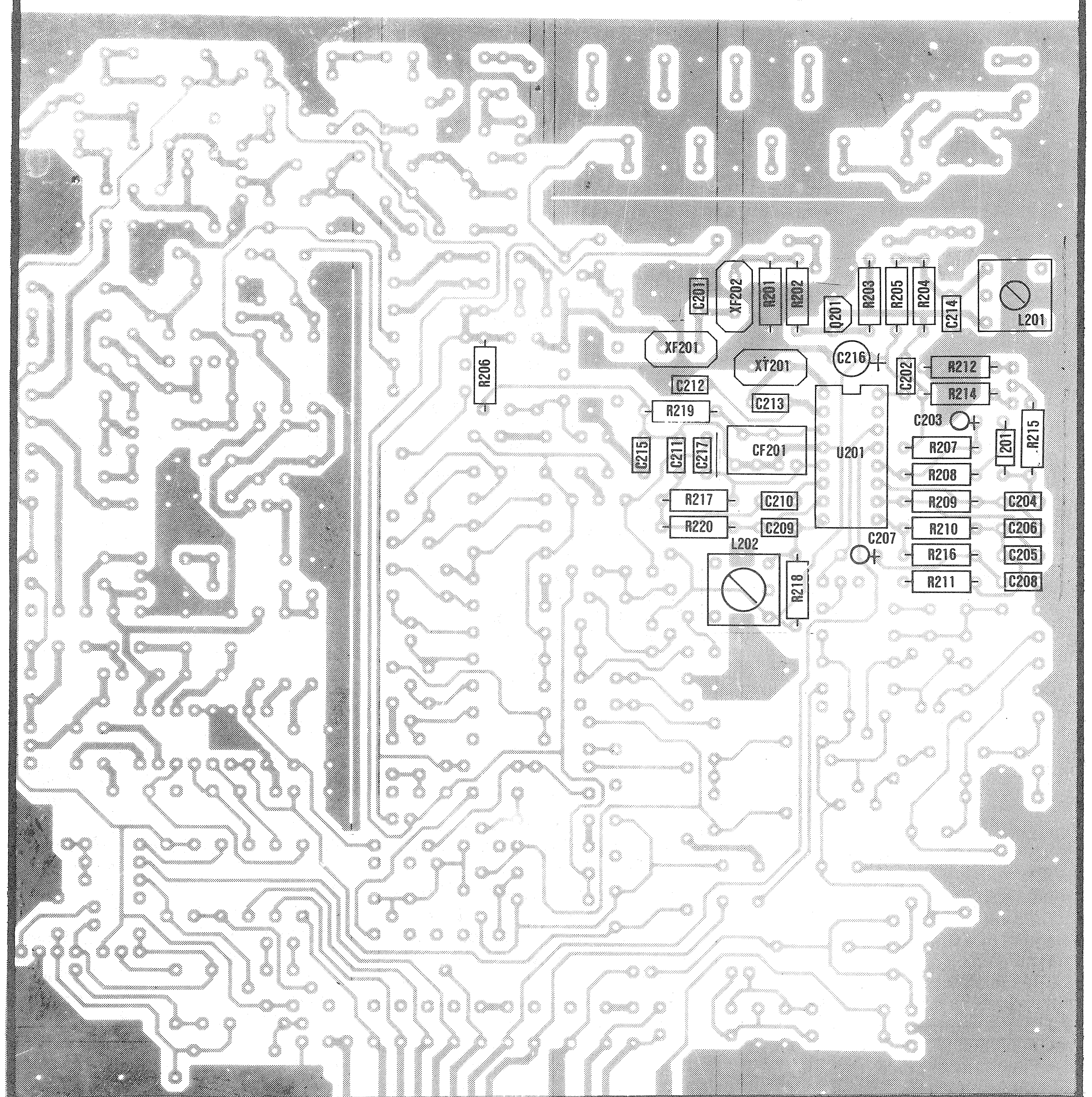
Within-tolerance variations in the internal impedance of the crystal XT201 might require that the value of C213 be changed slightly. To try this, temporarily fit a trimcap of about 60pF instead of C213 and adjust this for best IF sensitivity. Then switch off, remove the trimcap and fit a fixed capacitor that is closest to the measured value.

The level of signal injected into pin 2 of U201 should be about 50-100mV peak to peak (measured using a 'scope fitted with a 10:1 probe).

8. RF SECTION

The final section required to complete the basic 'receive' side of the transceiver (and the 'transmit' RF driver circuitry) is the low-level RF

7-IF Amplifier



7-IF Amplifier Parts List

Resistors (All ¼Watt)

R201	6K8 (blu-gry-red)	□
R202	3K9 (org-wht-red)	□
R203	68K (blu-gry-org)	□
R204	47K (yel-vio-org)	□
R205	100 (brn-blk-brn)	□
R206	100 (brn-blk-brn)	□
R207	82K (gry-red-org)	□
R208	1K (brn-blk-red)	□
R209	270K (red-vio-yel)	□
R210	15K (brn-grn-org)	□
R211	1K5 (brn-grn-red)	□
R212	470 (yel-vio-brn)	□
R213	5K/LOG (POT)	□
R214	33K (org-org-org)	□
R215	2K2 (red-red-red)	□
R216	10K (brn-blk-org)	□
R217	2K2 (red-red-red)	□
R218	82K (gry-red-org)	□
R219	2K2 (red-red-red)	□
R220	47K (yel-vio-org)	□

Capacitors

C201	6.8pF (ceramic)	□
C202	.001uF (ceramic)	□
C203	1uF/16V (tant)	□
C204	.1uF (ceramic)	□
C205	.001uF (ceramic)	□
C206	.001uF (ceramic)	□
C207	1uF/16V (tant)	□
C208	.01uF (ceramic)	□
C209	10pF (ceramic)	□
C210	.1uF (ceramic)	□
C211	.1uF (ceramic)	□
C212	150pF (ceramic)	□
C213	33pF (ceramic)	□
C214	.01uF (ceramic)	□
C215	.1uF (ceramic)	□
C216	33uF/10V (tant)	□
C217	33pF (ceramic)	□

Semiconductors

D201	1N4148/1N914 (diode)	□
Q201	2SC1923 (transistor)	□
U201	MC3357 (IC)	□
XT201	10.245MHz (X-tal)	□
XF201	10.7MHz (crstl.fltr)	□
XF202	10.7MHz (crstl.fltr)	□
CF201	455 (ceramic.fltr)	□
L201	10MA (coil)	□
L202	455KHz (coil)	□

Hardware

30cm x 6 way rainbow cable	□

section, and this is the next to assemble and test.

The schematic for this section was shown in Fig.6, while its components are all identified with "3XX" numbers. Basically it occupies the rearmost 50mm or so of the main board, and across the full width.

As before it's best to start with the low profile components such as the resistors and diodes — making sure that the latter are placed in the correct positions and with the right orientation. Note that biasing diodes D301/302 are type 1N4148 (or 1N914), while the RF switching diodes D303/304 are type MI301. The latter are usually marked 'MI1', while the 1N4148/1N914 sometimes have no marking except a black band to indicate the cathode. (The MC301 diode used for D402 in the VCO section is generally marked 'MC1', by the way.)

The capacitors should be added next. As before many of the ceramics need to have their 'earthy' pigtail soldered to the copper ground-plane on the top of the PCB, as well as to the underside. You'll need to carefully remove the ceramic on the chosen pigtail, by gently crushing it with pliers and then scraping back to the body with a hobby knife. This allows the component to be mounted close to the board, with minimal length leads, but still permits you to make a soldered joint to the groundplane. The capacitors involved are C303, C304, C305, C307, C309, C311, C312, C314, C315, C316, C317, C318, C319, C321, C322, C324, C325, C326, C327, C329, C332, C333, C334, C335, C337 and C338.

Many of the trimmer capacitors also have one side grounded, and those in this category also need to have this side soldered to the top ground plane copper as well as underneath. This applies to C302, C306, C308, C310, C312 and C331. Note that with each of these trimmers (all 20pF max), it is the exposed lead at the *rounded* end that should be earthed. This is really the only practical way to do it (the other lead is inaccessible), and it also ensures that the trimmer can be adjusted with a metal- bladed alignment tool without disturbing its operation.

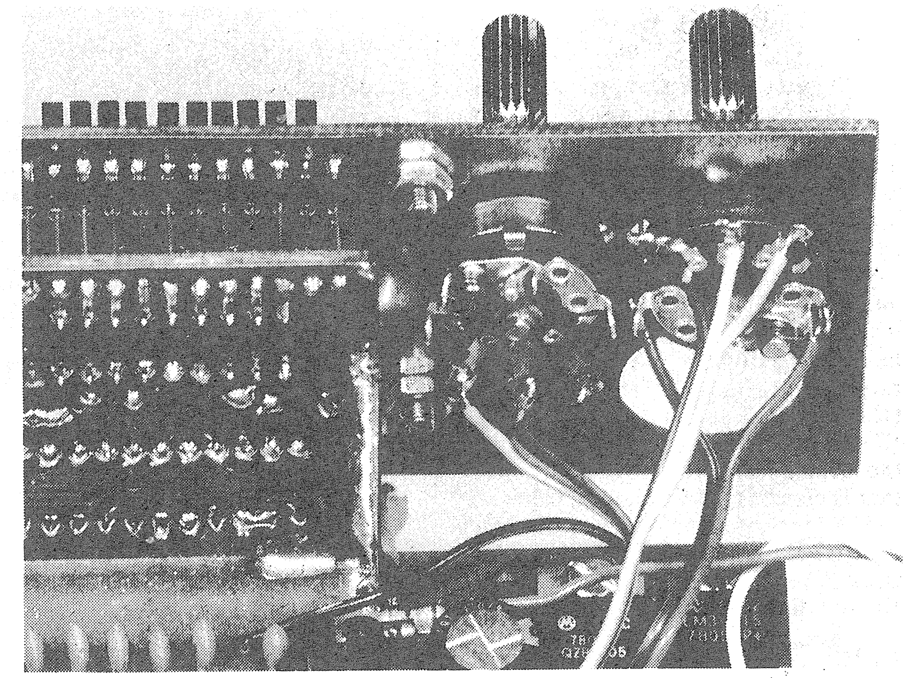
Note that four each of the affected ceramics and trimmers are inside the rear 'filter' shield box. This makes the job of soldering their earthy sides to the ground plane rather awkward, but it can be done. You just have to be especially careful not to damage the components in the process.

The remaining trimmers have neither side earthed, and so can be fitted either way around. Note that C301 is the odd one out — a 60pF maximum type, with a brown body instead of the red body used for the 20pF trimmers.

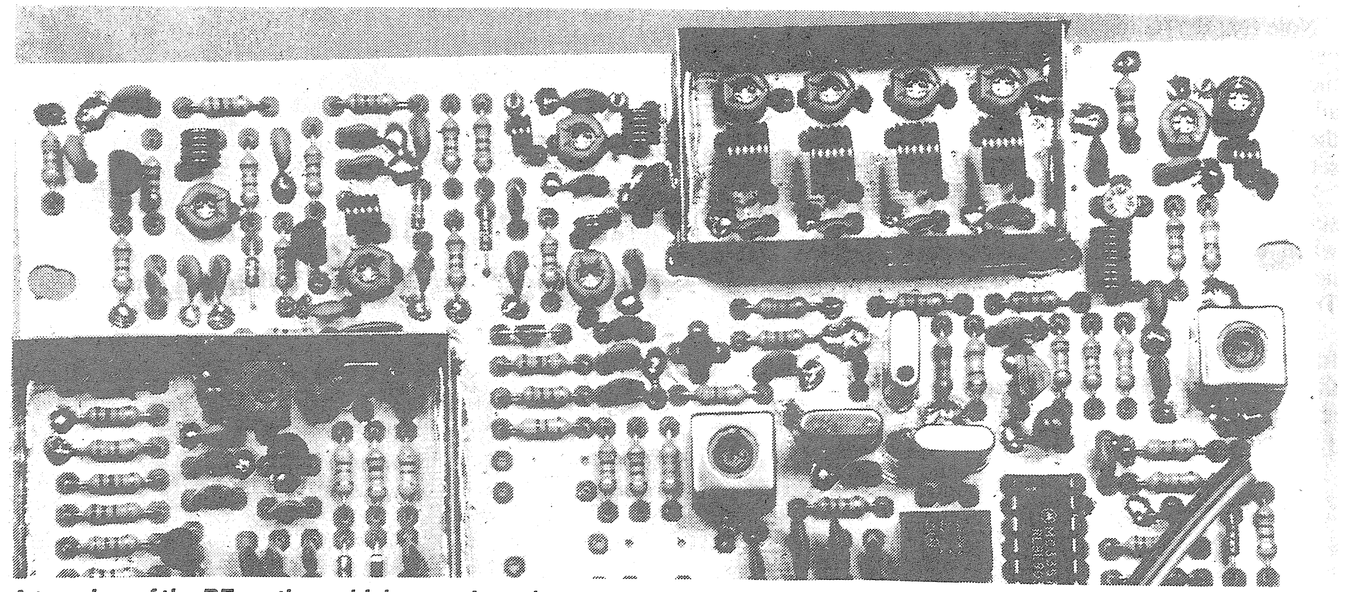
The transistors can now be fitted, again taking care to fit the right one in each position and that they're the correct way around. Note that Q304 and Q305 both have their emitter leads soldered to the top ground plane — with Q304 this is the lead nearest C401, while with Q305 it's the centre lead. Again, take care not to overheat the components when making these ground- plane connections.

Note that Q304-306 are mounted with their bodies about 4mm from the board.

Take special care when you're fitting the two MOSFETs, Q301 and Q302. These are both the BF981 device, which is in a mini 'pill' package with four leads coming out of the sides. These need to be bent carefully at right

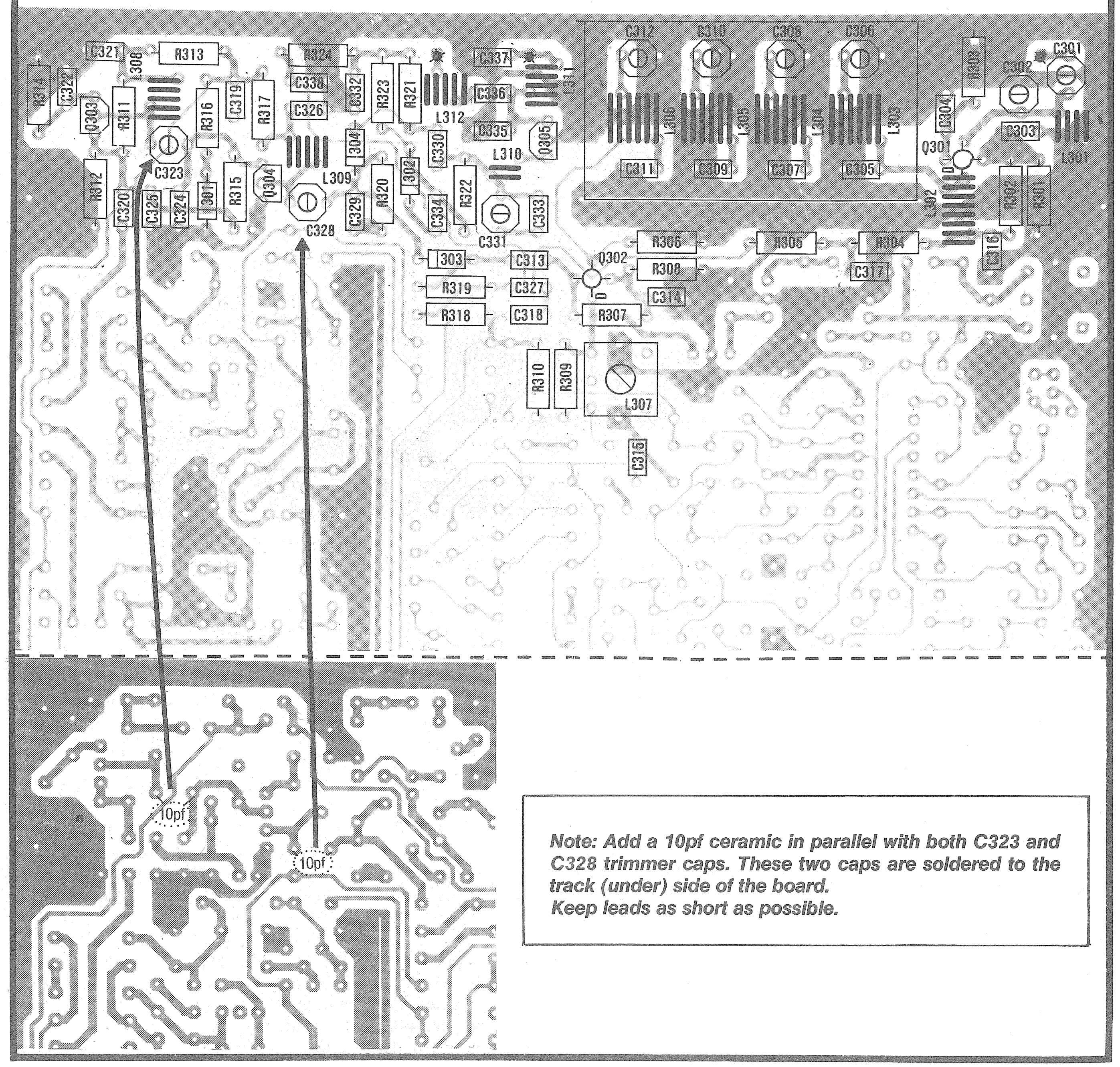


Here is a close-up of the volume control and squelch pots, mounted on the end of the display board. Note the switch lugs are bent, to prevent them touching.



A top view of the RF section, which runs along the rear of the main board. The receive input RF stage is here at upper right, with the bandpass filter box to its left and the transmit RF driver stages further left again. The VCO shield box is visible at lower left, and the IF stage at lower right. Note the orientation of the trimmer caps and coils.

8-RF Section

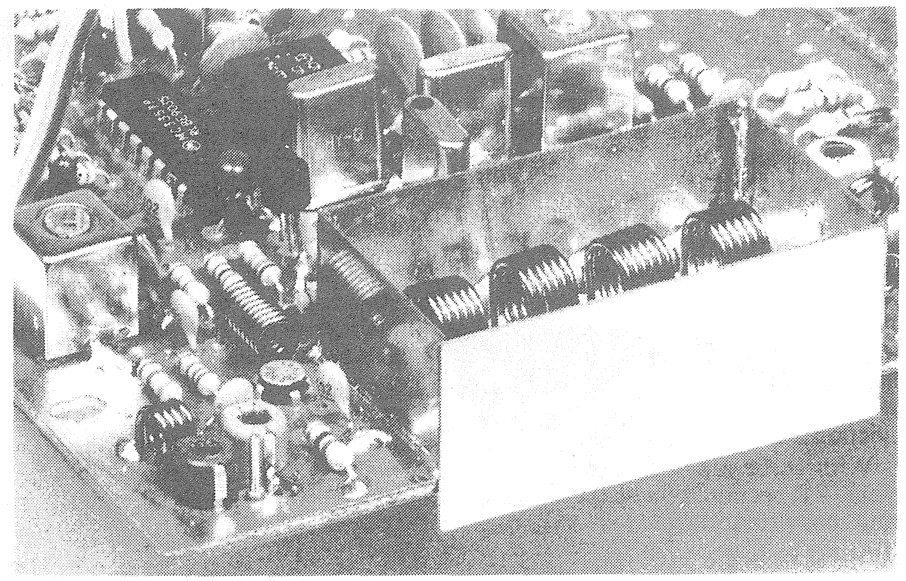


Note: Add a 10pf ceramic in parallel with both C323 and C328 trimmer caps. These two caps are soldered to the track (under) side of the board.
Keep leads as short as possible.

angles, close to the body, so that they can mate with the PCB holes. But note that in the case of Q301, the leads are bent *down* with the 'label' side facing you, while with Q302 they must be bent *up*. This is because Q301 mounts on the board with its label side uppermost, while Q302 mounts with its label side down towards the board. Both of these transistors mount right down against the board.

How can you tell the correct orientation for Q301/302? Easy — the drain lead is the longest of the four, and both drains go towards the front of the main board. So the drain of Q301 is the one nearest L302, while that for Q302 is the one nearest R307.

Now you should be ready to wind and fit the coils. These are all wound using 0.8mm enamelled wire (#20 B&S, or #21 SWG). The number of turns, direction of winding and former diameter used for each coil are shown in the table.



A close-up of the receive input RF stage, to guide you further during assembly.

8-RF Section Parts List

Resistors (All ¼ Watt)

R301	3K9 (org-wht-red)	□
R302	2K2 (red-red-red)	□
R303	47 (yel-vio-blk)	□
R304	100 (brn-blk-brn)	□
R305	100 (brn-blk-brn)	□
R306	47K (yel-vio-org)	□
R307	47K (yel-vio-org)	□
R308	100 (brn-blk-brn)	□
R309	47K (yel-vio-org)	□
R310	100 (brn-blk-brn)	□
R311	10K (brn-blk-org)	□
R312	2K2 (red-red-red)	□
R313	100 (brn-blk-brn)	□
R314	100 (brn-blk-brn)	□
R315	100 (brn-blk-brn)	□
R316	2K2 (red-red-red)	□
R317	100 (brn-blk-brn)	□
R318	100 (brn-blk-brn)	□
R319	1K (brn-blk-red)	□
R320	1K (brn-blk-red)	□
R321	1K (brn-blk-red)	□
R322	100 (brn-blk-brn)	□
R323	2K2 (red-red-red)	□
R324	100 (brn-blk-brn)	□

Capacitors

C301	60pF (trimcap) (Brown)	□
C302	20pF (trimcap) (Red or Pink)	□
C303	.001uF (ceramic)	□
C304	.001uF (ceramic)	□
C305	15pF (ceramic)	□
C306	20pF (trimcap) (Red or Pink)	□
C307	15pF (ceramic)	□
C308	20pF (trimcap) (Red or Pink)	□
C309	15pF (ceramic)	□
C310	20pF (trimcap) (Red or Pink)	□
C311	15pF (ceramic)	□
C312	20pF (trimcap) (Red or Pink)	□
C313	22pF (ceramic)	□
C314	.001uF (ceramic)	□
C315	.01uF (ceramic)	□
C316	.001uF (ceramic)	□
C317	.001uF (ceramic)	□
C318	.01uF (ceramic)	□
C319	.001uF (ceramic)	□
C320	10pF (ceramic)	□
C321	.001uF (ceramic)	□
C322	.001uF (ceramic)	□
C323	20pF (trimcap) (Red or Pink)	□
C324	82pF (ceramic)	□
C325	.001uF (ceramic)	□
C326	.001uF (ceramic)	□
C327	.001uF (ceramic)	□
C328	20pF (trimcap) (Red or Pink)	□
C329	68pF (ceramic)	□
C330	22pF (ceramic)	□
C331	20pF (trimcap) (Red or Pink)	□
C332	.001uF (ceramic)	□
C333	22pF (ceramic)	□
C334	.001uF (ceramic)	□
C335	18pF (ceramic)	□
C336	22pF (ceramic)	□
C337	.001uF (ceramic)	□
C338	.001uF (ceramic)	□

Semiconductors

D301	1N914 (diode)	□
D302	1N914 (diode)	□
D303	MI301 (diode)	□
D304	MI301 (diode)	□
Q301	BF981 (transistor)	□
Q302	BF981 (transistor)	□
Q303	2SC1923 (transistor)	□
Q304	2SC1923 (trasnsistor)	□
Q305	2SC2407 (transistor)	□
L307	10MA (coil)	□

Hardware

3 x Pcb pins .... □
1m x 0.8mm En/copper wire .... □
2 x 10pF ceramic caps .... □
(see RF Section PCB overlay)

Take special care when winding the coils, as the single most common cause of trouble with previous transceivers and similar RF projects has been mistakes in coil winding. Use the shank of a 1/4" drillbit as a former for L303-306, and that of a 1/8" drill for the rest. It is very important to use the *exact* diameter (i.e., a 1/8" drill, not 3mm or 3.5mm).

Similarly all coils should be *close wound* — i.e., the turns must be wound tight against each other. You'll find it a lot easier to do this if the wire has been 'stretched' slightly, before winding. I do this by cutting off a length about a metre long at a time, clamping one end in a vyce and gripping the other with a pair of stout pliers. I then pull until the wire stretches a bit — making it both straight and stiff for convenient close winding.

To clarify the winding terminology, the description '3-1/2 turns' means that the coil has three whole turns, from the start point to the end, and then a further half turn, so that the legs of the coil both face in the same direction. So if you count the number of turns of such a coil from the top, there should be four, but from the bottom there will appear to be three.

Don't forget to follow the specification for the direction of winding — note that L302 is wound in a clockwise direction, while the rest are wound anticlockwise. This is important if the coil legs are to mate with the corresponding PCB holes, with each coil aligned in the correct direction as shown on the overlay diagram (and visible in the photos).

It's a good idea to scrape the enamel insulation from the legs of each coil with a hobby knife, after it is wound and while it is still on the shank of the drillbit former. This avoids distorting the shape, but makes the coil ready for soldering into the PC board.

The coils for the bandpass filter (L303-306) should sit about 4- 5mm above the board, so that their axes will be roughly midway between the PCB and the lid of the shield box when it is fitted. All of the other coils should sit closer to the board — roughly 1mm or so above it.

Only one coil has an earthed end, which needs to be soldered to the PCB ground plane. This is L301, and you'll need to scrape back one of its legs further than for the other coils, to allow the joint to be made.

The final step in assembling the RF section is to fit the three PCB terminal pins, along the rear of the board. These are for the 'TX12V' connection alongside L311, the 'TX-RF' connection alongside L312 and the 'RX-RF' connection alongside C301/302.

With these fitted and soldered in, your RF section should be complete and ready for testing.

Testing, testing...

Here is the testing procedure for this section of the circuit:

1. Reconnect the speaker and the 13.8V DC supply, and if possible connect a signal generator tuned to 147.000MHz to the RX-RF input (earthy side to the ground plane). If you don't have access to a signal generator, connect a 2-metre antenna instead. Then check that the 'PTT' pin near the front of the main PCB is disconnected from ground (so that the transceiver will be in 'receive' mode), and turn on the power.

2. If you're using a generator, check that the transceiver display indicates '7000', showing that it is tuned to 147MHz. Otherwise tune the transceiver onto a strong local signal (e.g., a local repeater, or a second transmitter that is transmitting

COIL WINDING DATA

No. of turns:	Former diameter:	Winding direction:	Locations on PCB:
5-1/2	1/4"	ccw	L303, L304, L305, L306
1-1/2	1/8"	ccw	L310
5-1/2	1/8"	ccw	L312
3-1/2	1/8"	ccw	L301
4-1/2	1/8"	ccw	L308, L309, L311
8-1/2	1/8"	cw	L302

All coils are wound with 0.8mm diameter enamelled wire (#20 B&S, #21 SWG).

into a dummy load. The leakage from such a load is usually enough to produce a suitable signal level).

3. Now proceed to adjust all the trimcaps (except C331), as well L307 for maximum 'receive' sensitivity (best signal to noise ratio). Note that at this stage, the maximum sensitivity for 12dB of quieting will only be around 1uV (about 0.3-0.4uV for 12dB SINAD), due to the incorrect matching of the direct input to the RX-RF pin.

4. If all seems well, turn off the power and disconnect the generator or antenna from the RX-RF transmitter input.

5. Now connect a sensitive wattmeter, or SWR meter that is able to indicate RF power level in 100's of milliwatts, with a 50-ohm load, between the TX-RF output pin and ground. If you don't have either of these instruments, connect a small 2-6 volt (0.1-0.3W) lamp.

6. Temporarily connect the TX12V pin to the +13.8V supply rail at the transceiver side of the on-off switch (on R101), and connect the PTT pin to the ground plane. Then re-apply the power.

7. Adjust trimmer C331 for maximum deflection on the watts/SWR meter, or the brightest glow from the lamp.

8. Adjust trimmers C323 and C328 for maximum power and then adjust C331 again until all three trimmers are peaked. The power output should be more than 150mW.

Once C323 and C328 have been adjusted for maximum power, do not try to re-adjust them for maximum receive sensitivity. This is important as maximum power coincides with minimum harmonic content of the driver stage.

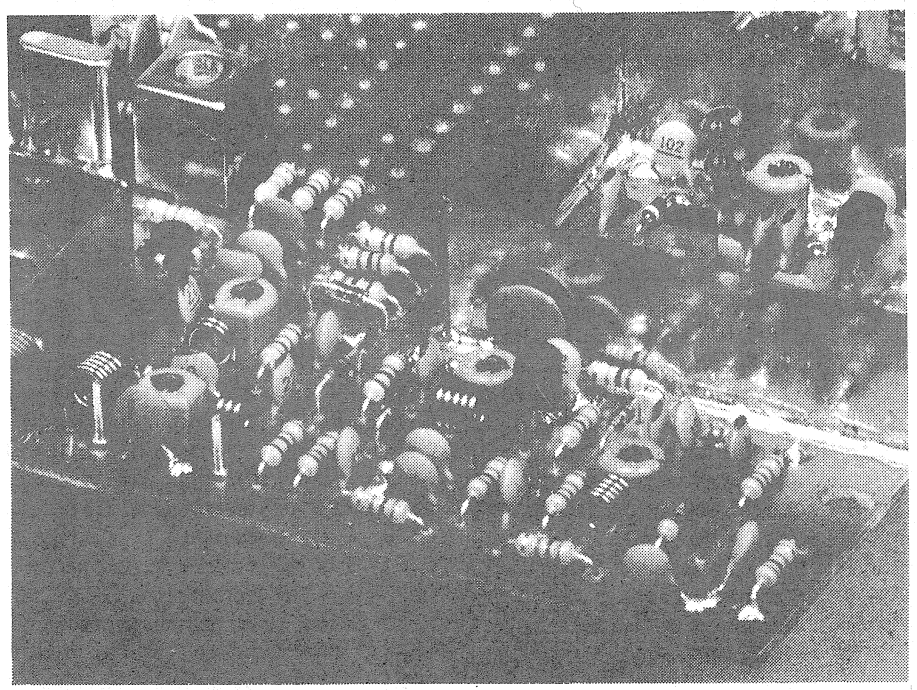
Troubleshooting

If for some reason your unit doesn't check out according to the above tests, check the following DC voltages:

		RX	TX
Q301	drain	6.0V	0V
	source	0.3V	0V
	gate1	0V	0V
	gate2	3.8V	0V
Q302	drain	7.2V	0V
	source	0.3V	0V
	gate1	0V	0V
	gate2	0.3V	0V
Q303	base	1.2V	1.2V
	collector	6.8V	6.8V
	emitter	0.6V	0.6V
Q304	base	0.6V	0.6V
	collector	6.5V	6.5V
Q305	base	0V	0.6V
	collector	0V	13.0V

9. MIC PREAMP

This section of the circuit is that covered by the schematic shown in Fig.5. it comprises the mic preamp proper, plus a simple dual-diode limiter and low pass filter. The relatively small number of components involved are all identified



Another view of the RF amplifier and transmit driver stages, to help in assembly.

with a "5XX" number; they are fitted to the main board very near its centre, and just to the right of the VCO/PLL shield box.

As before begin assembly with the low profile resistors and diodes, and work through the capacitors to the deviation trimpot R512 and the transistors. Take the usual care with the polarised components — here C503, D501-502 and the three transistors. Also make sure you don't confuse the PNP transistor Q503 with the other two, which are both NPN types.

Be careful when fitting trimpot R512, as a number of different brands may need to be supplied by DSE, according to availability, and the leg shape and configuration may change between different manufacturers. Make sure that none of the trimpot legs touches the ground plane on the component side of the PCB. If it looks as if this could happen, then either trim the leg(s) with sidecutters, or use a 4-8mm drill bit to increase the ground plane clearance around the PCB hole(s).

Note too that some of the components have one lead soldered to the PCB's top ground-plane copper as well as underneath, just as in previous sections of the circuit. Don't forget to make these top joints, but at the same time take the usual care not to overheat the components when you're doing so.

There are two PCB pins to be fitted for this circuit section: those for the 'mic input', just to the front of C501-502. The earthy pin is that nearest the VCO/PLL shield box, and this must be soldered to the top ground-plane copper.

That's really all there is to assembling this section. But before you can fire it up for testing, you'll need to make a temporary connection between the microphone socket and the 'mic input' PCB pins on the board, just fitted. Do this with a shielded cable about 200mm long. Use audio cable and not true RF coaxial cable, which has a tendency to be microphonic at audio frequencies. In addition, audio cable tends to attenuate RF more than true coax, and this is desirable for a transmitter's microphone lead.

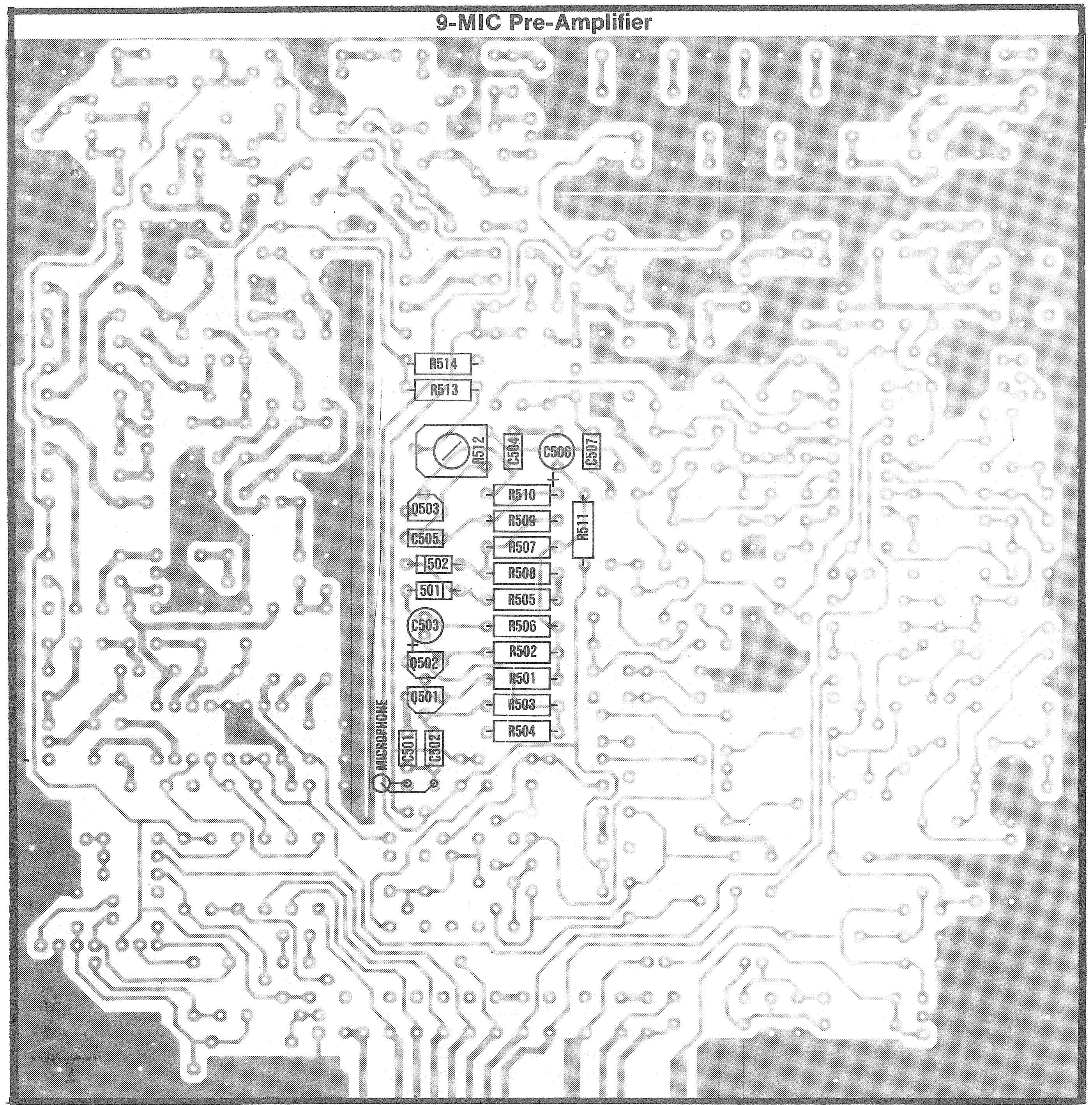
Testing the preamp

1. Connect a modulation meter or 2m FM receiver to the TX-RF output at the back of the main board. **Do not connect the 'TX 12V' positive supply for Q305 at this stage, though. If it is still connected from testing the RF driver stages, disconnect it before turning on the power. Otherwise, your meter or receiver front-end could easily be damaged by the driver's output. We're going to perform this section's tests without Q305 powered up, for safety. Enough signal leaks through the unpowered stage to allow this to be done.**

   If you're using a receiver, it might be a good idea to make sure you don't overload its front end by using an adjustable RF attenuator (say 20-100dB) in series with the input connected to TX-RF. Otherwise use a small series capacitor — say less than 5pF.

2. Connect a microphone, apply the +13.8V power and ground the PTT line — either via the microphone switch, or via the wire link used previously.

3. Using a normal level of speech, adjust R512 for a deviation of about 3.5kHz as read on the deviation meter. If you're using a receiver, adjust R512 until the modulation level is comparable with other FM signals on the 2m band.



9-MIC Pre-Amplifier Parts List

Resistor (All ¼ Watt)

R501	100K (brn-blk-yel)	☐
R502	5K6 (grn-blu-red)	☐
R503	100K (brn-blk-yel)	☐
R504	560 (grn-blu-brn)	☐
R505	15K (brn-grn-org)	☐
R506	22K (red-red-org)	☐
R507	39K (org-wht-org)	☐
R508	100K (brn-blk-yel)	☐
R509	56K (grn-blu-org)	☐
R510	56K (grn-blu-org)	☐
R511	330 (org-org-brn)	☐
R512	10K (Trimpot)	☐
R513	15K (brn-grn-org)	☐
R514	1K5 (brn-grn-red)	☐

Capacitors

C501	.001uF (ceramic)	☐
C502	1.0uF (monolythic)	☐
C503	33uF/10V (TANT)	☐
C504	270pF (ceramic)	☐
C505	.0022uF (ceramic)	☐
C506	33uF/10V (TANT)	☐
C507	.1uF (ceramic)	☐

Semiconductors

D501	1N4148/1N914 (Diode)	☐
D502	1N4148/1N914 (Diode)	☐
Q501	BC548 (Transistor)	☐
Q502	BC548 (Transistor)	☐
Q503	BC558 (Transistor)	☐

Hardware

20cm x	shielded audio cable	☐

Troubleshooting

In the fairly unlikely event that you weren't able to carry out the above test, because there isn't any modulation, here are the suggested troubleshooting steps:

1. Check for the following DC voltages:

Q501	collector	1.2V
	base	0.6V
Q502	collector	2.2V
	emitter	0.6V
	base	1.2V
Q503	emitter	4.2V
	base	3.6V
D501	anode	3.6V
	cathode	3.0V
D502	anode	3.6V

2. If the above voltages seem OK,

connect an audio generator to the MIC input, set to about 1kHz and with an output of 1mV RMS. Then check the voltage gain of the overall preamp circuit with a CRO or audio millivoltmeter, by comparing the signal at the emitter of Q503 with that from the generator. THe gain should be about 50dB (i.e., around 300 times).

If you increase the input signal to around 2mV RMS, the limiting action should start to become evident. The maximum signal level at the emitter of Q503 should be about 2.5V peak to peak.

3. If the foregoing tests suggest that the preamp itself is working correctly, check that the modulating signal is present at the collector of Q402 (in the VCO/PLL shield box). The level here should be around 30mV for an input signal of 2mV. No signal here would suggest a problem associated with trimpot R512, resistors R513-514 or coupling capacitor C403.

10. S-METER & ALC

All going well, you should now be ready to tackle the next section, which includes the S-meter and ALC drive circuitry.

The schematic for this section was shown in Fig.10. Its components are all coded "6XX" and they again mount on the main PCB near the centre - between the mic preamp just completed, and the receiver audio amp section.

As before it's a good idea to start with the low profile resistors and diodes, then the capacitors and trimpots and finally the transistors.

This time there are six trimpots, and as before it's important to make sure that their legs don't contact the ground plane of the PCB — unless they are meant to be soldered to it, as is the case with R603, R613 and R616.

Take the usual care with orientating the polarised components, of course. Here they are the six transistors, the five diodes D601- 605, and the two tantalum electro's C605-606.

Needless to say it's also important not to confuse the PNP and NPN transistors. The BC558 (PNP) devices go into locations Q601, Q603 and Q604, with the BC338 NPN device in location Q606 and BC548 or similar NPN devices in locations Q602 and Q605.

As before some of the devices have earthed leads which need to be soldered to the PCB groundplane copper as well as underneath. These include diode D602 and transistors Q603, Q605 and Q606; I suggest that you use a small clamp-on heatsink to prevent them from damage during the soldering to the ground-plane.

There are four PCB pins to be fitted to the board for this section, in the holes marked FWD, REV (both near D605), ALC and T8V (both near Q605). If you still have a short length of insulated wire connected to the 'METER' input on the front edge of the main PCB (near C711), from your previous testing of the display board, cut this to an appropriate length and use it as the link to the other METER connection point, between trimpots R606 and R607. It's rather easier to do this *before* you fit the two trimpots, by the way...

Your S-meter and ALC section should now be complete, and ready for the only test we can easily do at this stage:

Testing the S-meter

1. Adjust R603 to its minimum value (fully anticlockwise) and R607 to its maximum value (fully clockwise).
2. Connect an RF signal generator to the RX-RF input, set for a few microvolts. Otherwise connect to an antenna, and tune for a strong signal.
3. Adjust R606 until the LED level meter (display board) reads half scale.

Note that final adjustment of the S-meter really needs to be done together with the ALC control circuit, and the latter can't be easily tested or adjusted until the PA module is assembled and connected — so more about this shortly.

11. PA MODULE

At this stage your transceiver's main PCB assembly should be effectively complete and operational, so that you're ready to tackle the final section: the PA module. This mounts on a separate small PCB, which mounts vertically at (and on) the rear of the case.

The schematic for the PA module was shown in Fig.9. The components for the module are all coded "8XX"

A difference between the PA module and the rest of the transceiver is that here virtually all of the components are mounted on the 'track' side of the PCB, except for the PCB pins used for the connections to the main board and antenna socket. These are mounted from the ground-plane side.

The key component of the PA module is the M57737 hybrid power amp (U801), which actually mounts on the PCB 'upside down', with its metal heatsink flange/mounting plate uppermost — so that it can make good thermal contact with the metal rear panel of the transceiver case, and the finned radiator.

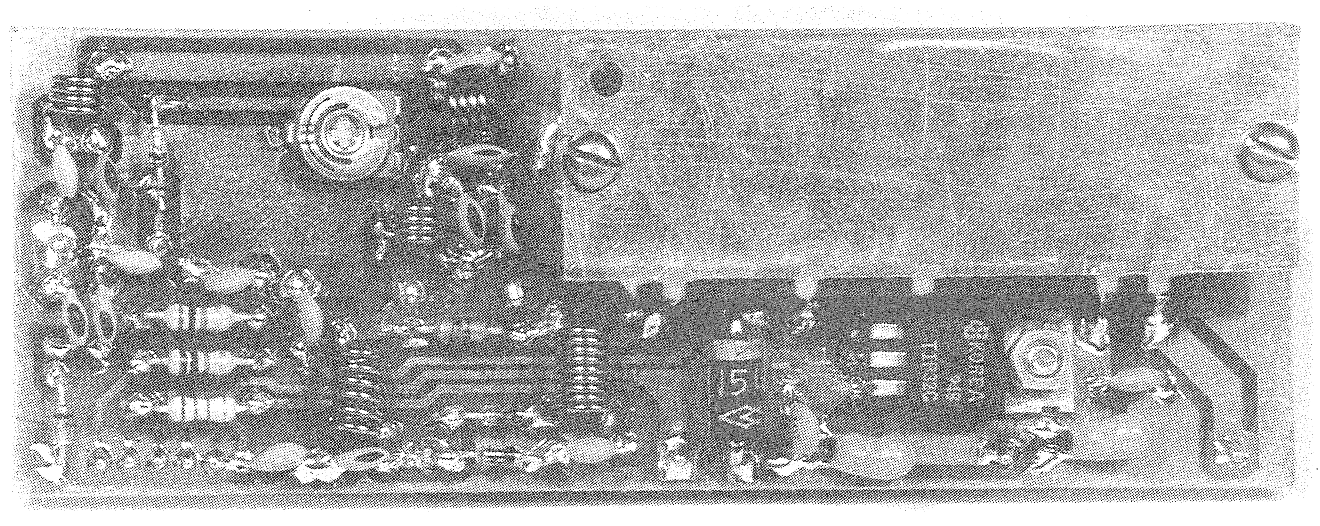
Two long machine screws are used to clamp the PA module PCB and U801 to the rear panel/radiator, so that ultimately it is the rear panel which supports the overall assembly inside the case. To facilitate this mounting arrangement, two 8mm-long brass spacers (4x4mm spacers are supplied, need to solder 2x4mm spacers together), are used to provide a solid mechanical link between the flange of the M57737 and the PA module PCB. These spacers are soldered to the copper on the track side of the PCB, so that they are concentric with the holes for the power amp's mounting screws.

As soldering these spacers to the board involves a fair bit of heating, it's important to do this before mounting any of the other components, so that they aren't damaged during the process.

With this soldering operation completed, the assembly of the rest of the PA module's components can proceed in the usual way. As usual, it's probably easiest to start with the low-profile components first — the resistors and diodes. At this stage it's also easy to fit the 10 PCB pins, which are pushed through from the ground-plane side, but soldered on the track side.

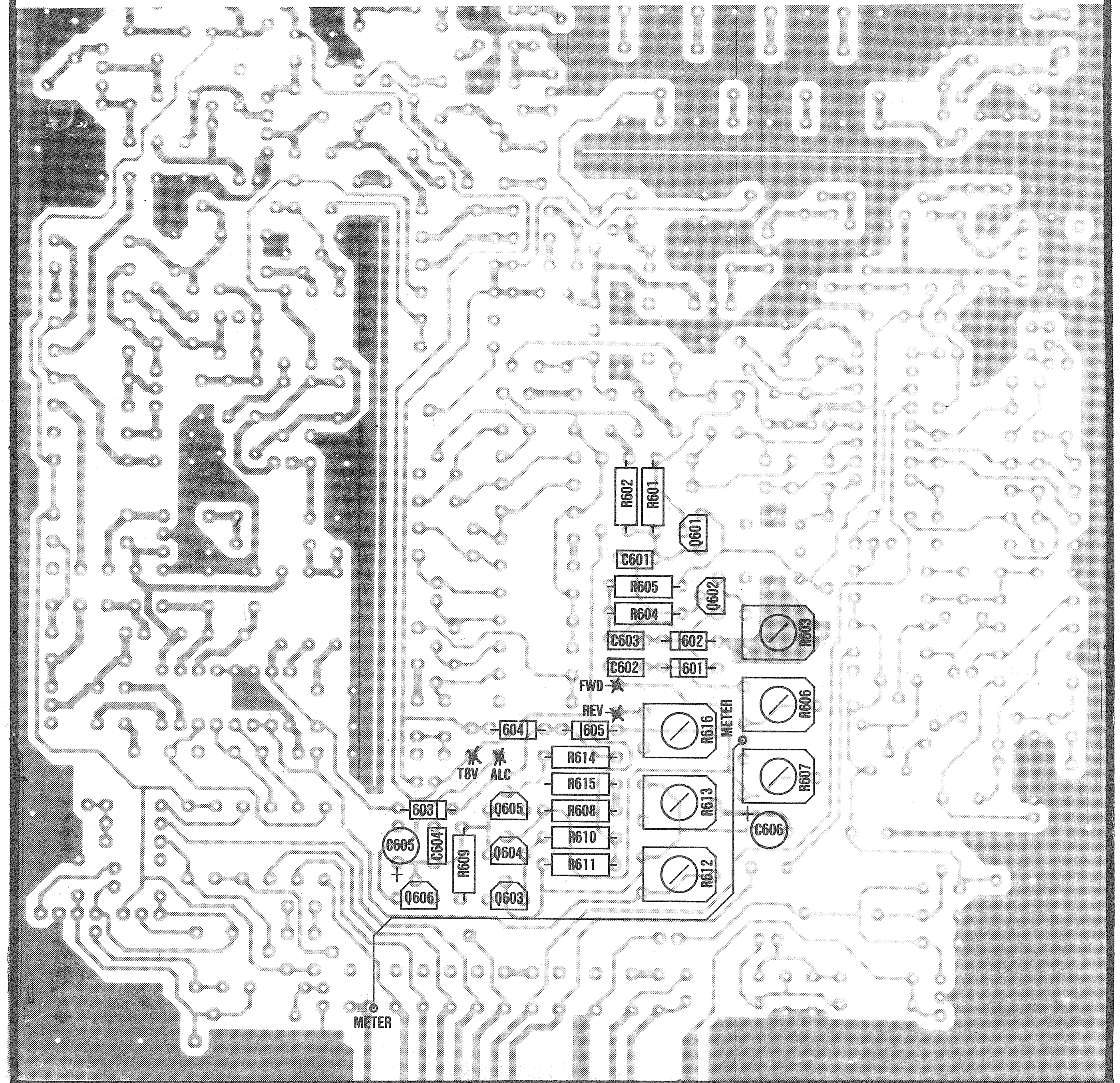
By the way, the fact that all of the components mount on the track side of the PCB calls for special care in preparing their leads, and soldering them in place.

In many cases they need to be bent fairly sharply close to the body, without causing strain, and then also soldered close to the body to minimise



A close up of the track side of the PA module board. Virtually all of the components are mounted on this side, as you can see. Note too that the amplifier module U801 (top right) effectively mounts 'upside down', with its heatsink uppermost.

10-S-Meter & ALC Circuit



10-S-meter & ALC Circuit Parts list

Resistors (All ¼ Watt)

R601	220K (red-red-yel)	□
R602	2K2 (red-red-red)	□
R603	200 (trimpot)	□
R604	100K (brn-blk-yel)	□
R605	1K (brn-blk-red)	□
R606	100K (trimpot)	□
R607	100K (trimpot)	□
R608	10K (brn-blk-org)	□
R609	100K (brn-blk-yel)	□
R610	10K (brn-blk-org)	□
R611	10K (brn-blk-org)	□
R612	5K (trimpot)	□
R613	50K (trimpot)	□
R614	4.7K (yel-vio-red)	□
R615	100K (brn-blk-yel)	□
R616	10K (trimpot)	□

Capacitors

C601	.01uF (ceramic)	□
C602	.01uF (ceramic)	□
C603	.01uF (ceramic)	□
C604	.01uF (ceramic)	□
C605	10uF/16V (tant)	□
C606	10uF/16V (tant)	□

Semiconductors

D601	1N4148/1N914 (Diode)	□
D602	1N4148/1N914 (Diode)	□
D603	1N4148/1N914 (Diode)	□
D604	1N4148/1N914 (Diode)	□
D605	1N4148/1N914 (Diode)	□
Q601	BC558 (transistor)	□
Q602	BC548 (transistor)	□
Q603	BC558 (transistor)	□
Q604	BC558 (transistor)	□
Q605	BC548 (transistor)	□
Q606	BC338 (transistor)	□

Hardware

4 x	pcb pins	□
1 x	9cm H/up wire	□

lead length — again without damaging the component.

Before mounting the capacitors, trimpot and transistor, you should wind and fit the coils. As before, the coil winding details are shown in a separate box, to guide you in getting them right.

Take particular care when winding the coils. There are only five, but they're all fairly critical for correct transceiver operation; so a little patience at this stage could save a lot of trouble later on.

Note that coils L801 and L803-805 are wound with the turns close together, but L802 is wound with a spacing of about 1mm between each turn. The total length of this coil is therefore very close to that for L801. All coils for the PA module are mounted between 1 and 2mm above the board.

With the coils wound and soldered to the board, you can fit the capacitors, trimpot R804 and transistor Q801.

As before, some of these components have earthed pins which must be soldered to both sides of the board. Note that this applies to two of the pins of R804, while the third pin connects only to the track copper on the side line of the directional coupler. You may need to shorten this pin a little, so that the pot can be mounted squarely.

The hole in the PCB beneath R804 is to allow its adjustment using a small screwdriver or alignment tool, from the ground-plane side, when the transceiver is assembled.

Before mounting the pot, check that this hole is of about 3mm in diameter — it will be very difficult to drill it out to this size once the pot is soldered in place!

You'll need to be especially careful in mounting the ceramic capacitors, as in many cases these have one lead soldered only to the solder side, but the other passing through a hole and soldered to both sides.

And as both joints need to be made as close to each capacitor body as possible, to minimise lead inductance, you'll need to break away the ceramic flash from the leads very carefully by squeezing with needle-nosed pliers. Then scrape the exposed leads clean with a small scalpel, to ensure that the joint can be made quickly and with no more heating than is necessary for good 'wetting'.

The final step is to fit the M57737 module, U801. This is done in the following way. First, bolt the device to the board (upside down, of course) using a pair of 3mm or 1/8" machine screws and nuts, with the screws passing through the spacers.

Then form each of the wire leads of the module into a tight 'U' shape, so it is thicker than a single wire, and then solder them to the board as directly as possible.

This done, carefully remove the screws, put heatsink compound between U801's mounting flange and the rear panel — and also between the rear panel and the heatsink — and then screw them all together with the screws designed to mate with the tapped holes in the radiator.

Needless to say, as you tighten up the screws, it's important to make sure that the PCB, body of U801, rear panel and radiator are all squared up correctly.

Mount the antenna socket to the rear panel and connect its centre spigot to the adjacent 'antenna' pin on the PCB with a short but stout wire link — or a short length of brass shim, 2-3mm wide.

The earthy side of the socket should also be bonded to the PCB ground-plane copper, near the same pin. Then strip two 60mm long PTFE coaxial cables as in the small diagram — removing 10mm of the outside insulation, compressing the braid back to about 2-3mm in length and stripping 5mm of the inner insulation — and solder them to the TX-RF and RX-RF connections of the PA module PCB, on the ground-plane side.

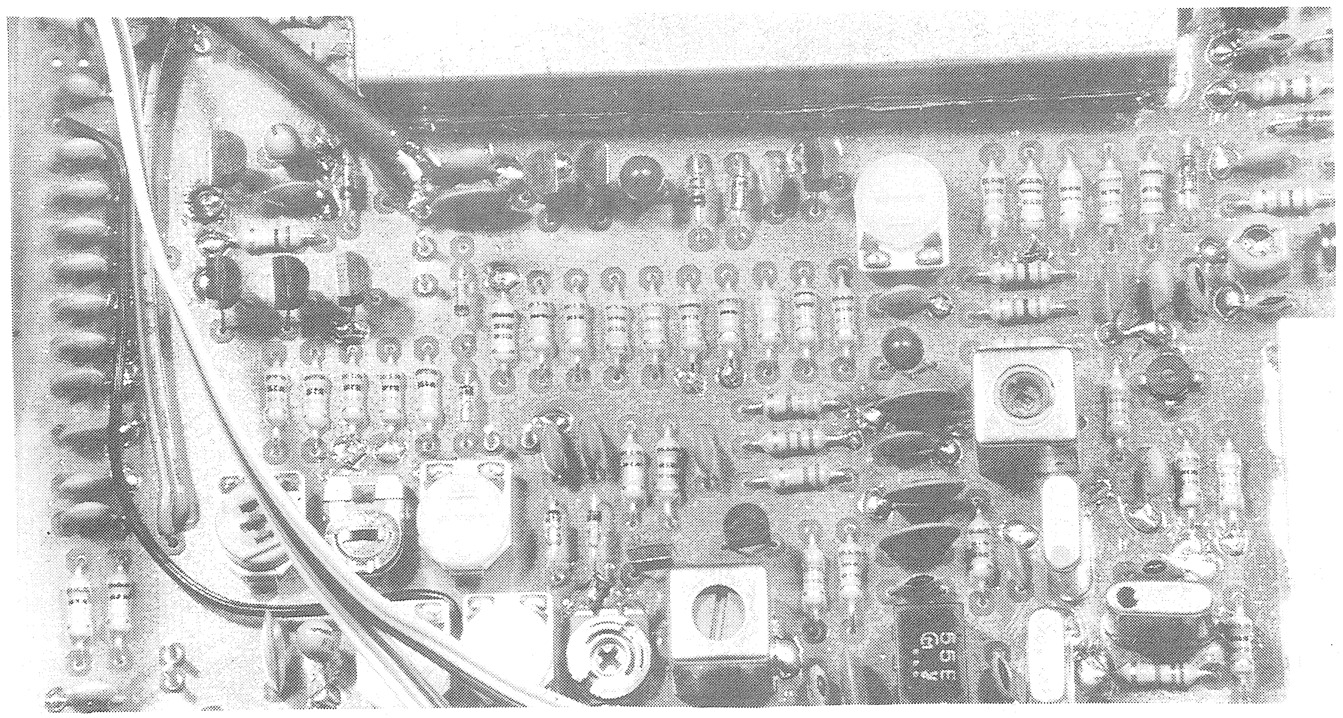
The shield braid goes to the ground-plane copper, while the centre conductor connects to the pins. Solder one 60mm long wire to the TX12V point and a five-wire ribbon cable about 250mm long to the 13V, FWD, REV, T8V and ALC connection pins — again on the ground-plane side.

Now you can fit the PA module board assembly and the main board into the case and solder the 'other ends' of these cables to the main board. The ribbon can be cut to length for a neat appearance, but note that the shield braid of both coax cables must be connected to the ground-plane copper of the main PC board.

Finally, you can introduce the transceiver's main 13.8V supply input cable to the PA module board. The red positive lead goes to the '13V8' pin, again on the ground-plane side, while the black negative lead goes to the ground-plane copper just near it.

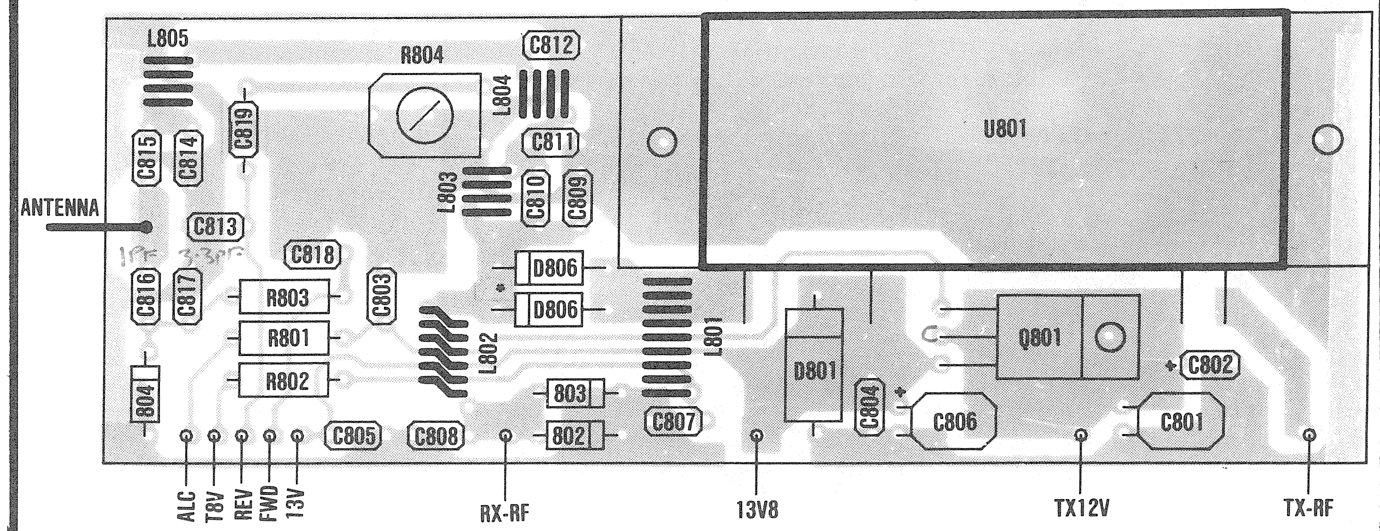
Testing the PA

1. Connect a 50-ohm dummy load and wattmeter to the antenna socket.
2. Adjust R804 to the centre of its rotation, R612 and 613 on the main PCB to their maximum value (fully clockwise) and the rotor of R616 to its ground end — again, fully clock wise.
3. Connect the 13.8V supply, in series with a DC ammeter set to a range of at least 10 amps FSD.
4. Connect the PTT pin to ground, either via the mic PTT button or a wire link. The wattmeter should indicate between 30-35 watts, while the current drawn from the power supply should be about 6-7 amps.
5. Adjust trimpot R612 until the ALC circuit reduces the wattmeter reading to 25 watts. The ammeter reading should also fall, to around 5 amps.
6. Now release the PTT button or remove the link, and select low power by pressing the 'LOW' keyboard button.
7. Close PTT line again, and this time adjust trimpot R613 for an output of 5 watts as read on the wattmeter.
8. Switch off, select high power again and connect a DC voltmeter between the 'REV' line, at its PA module PCB pin, and ground. The meter positive should go to the PCB pin, and negative to ground.
9. Now close the PTT again and adjust R804 on the PA module (using a small tool via the access hole) for *minimum* reading. If you are getting a reading of zero over a fairly wide range of adjustment from one end of the trimpot to a certain point, adjust the trimpot to that point.
10. Adjust trimpot R616 so that the current from the power supply is approximately 3 amps when the antenna output is either disconnected or shorted to the ground, with the PTT activated. Note that this adjustment should be carried out in periods of no more than five seconds, with longer stand-by periods, to prevent overheating and damage to U801 (they're quite expensive!).
11. Adjust trimpot R607 for a 'full scale' reading of the front-panel LEDs (i.e., all on) when the PTT is activated with the transceiver in high power mode.
12. Select low power and verify that in this case only about four LEDs come on when the PTT is activated (a power ratio of 1:5 corresponds to a voltage ratio of around 1:2.3).



Here's a shot of the central section of the main board, showing the mic preamp components at upper centre with the S-meter/ALC section components below and to the left.

11-PA Module



The PCB overlay/wiring diagram for the P.A module. Note that apart from the PCB pins, all other components are mounted on the track side of the board. Coil details are shown seperately in a table.

11-PA module Parts list

Resistors (All ¼ Watt)		Semiconductors	
R801	1K (brn-blk-red) ☐	D801	1N5402 (diode) ☐
R802	180 (brn-blk-brn) ☐	D802	MI301 (diode) ☐
R803	1K (brn-blk-red) ☐	D803	MI301 (diode) ☐
R804	100 (trimpot) ☐	D804	1N4148/1N914 (diode) ☐
		D806	MI407 (diode) (see Note 1) ☐
Capacitors		Q801	TIP32 (transistor) ☐
C801	.001uF (ceramic) ☐	U801	M57737 (IC) ☐
C802	22uF/16V (tant) ☐		
C803	.001uF (ceramic) ☐		
C804	.001uF (ceramic) ☐	**Hardwares**	
C805	.001uF (ceramic) ☐	10 x	pcb pins ☐
C806	22uF/16V (tant) ☐	4 x	4mm brass spacers ☐
C807	.001uF (ceramci) ☐	1 x	M3x5mm screw ☐
C808	18pF (ceramic) ☐	1 x	M3 Nut Hex ☐
C809	39pF (ceramic) ☐	1 x	Heatsink ☐
C810	5.6pf (ceramic) ☐	2 x	(⅛" x ¾") screws ☐
C811	56pf (ceramic) ☐	UHF PNL socket ☐	
C812	56pf (ceramic) ☐	Pre-punched Aluminium Rear Panel ☐	
C813	.001uF (ceramic) ☐	Supply Input Cable (red & black) ☐	
C814	12pf (ceramic) ☐	EN/CU wire 20G ½m ☐	
C815	.001uF (ceramic) ☐	2 x	6cm teflon coax cables ☐
C816	1pF (ceramic) ☐	H/up wire ☐	
C817	3.3pf (ceramic) ☐	PCB board ☐	
C818	.001uF (ceramic) ☐	Silicon Grease ☐	
C819	.001uF (ceramic) ☐		

In-line fuse holder ☐

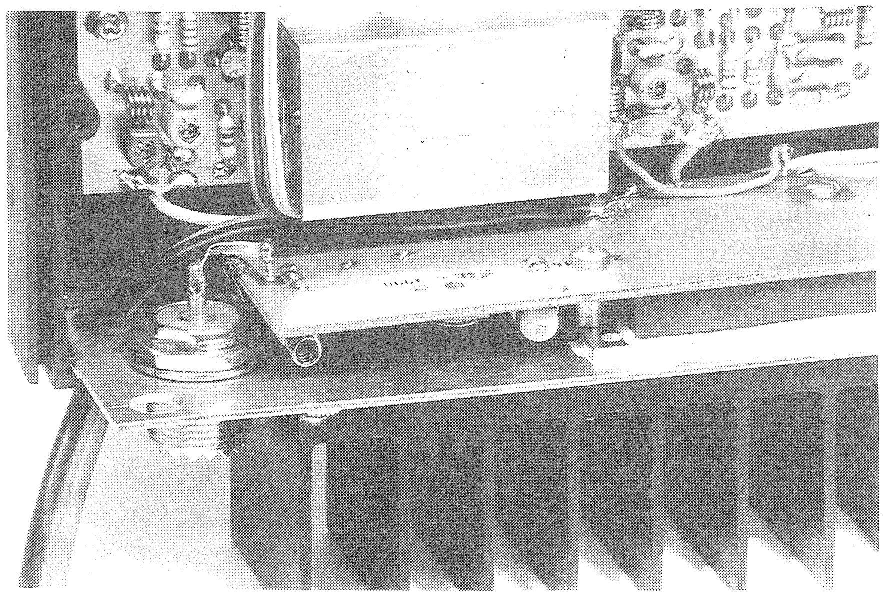
10 Amp 3AG Fuse ☐

*NOTE 1. Two MI402 or MI308 Diodes in parallel or one MI407 diode.

Troubleshooting the PA

All troubleshooting of the PA module should be carried out with the transceiver connected to the dummy load and wattmeter, and with an ammeter connected in series with supply.

Note that the supply current should not exceed 10 amps and the temperature of the heatsink radiator should not exceed about 80°C for any significant



A close up of the antenna connector end of the PA module, when the latter is mounted inside the case. Also visible are the coax connections to the main PCB.

time. If necessary, turn off and allow everything to cool before continuing.

If while troubleshooting, it is necessary to work on the track side of the power amplifier PC board, attach the power amplifier module to a large heatsink, using two bolts through the module's mounting flange.

By attaching the module to one corner of the heatsink, the rest of the components on the PCB will be easily accessible.

If the current exceeds 6A, all testing should be carried out in short periods of five seconds, or less, with longer (more than 20 seconds) stand-by periods with the transceiver in receive mode (PTT released).

By observing these precautions you should avoid damaging the expensive power amplifier module.

Basically, there are two main kinds of problems that are likely to arise:

a. Low or zero power output, and low supply current.

b. High supply current, but little or no output.

For the first kind of problem, and assuming that the supply current is roughly proportional to the output power, the PA stage itself is probably OK, and the fault is likely to be due to low drive or a fault in the ALC circuitry.

As a guide, the efficiency of the PA should be about 50%. The rest of the low-power circuitry draws about 1A, so that if you subtract this figure from the total supply current, and multiply this by 13.8V, you'll have a close estimate of the DC power input to the PA stage.

So if for example the total supply current is 4.7A, this means that the PA is drawing about 3.7A; 3.7 multiplied by 13.8 gives around 50 watts input. So if the RF wattmeter reads 25W, this would mean a PA stage efficiency of 50% amps.

These are the kind of figures you should expect, and if the power output is low, a PA efficiency of around 50% would tend to confirm that the trouble is elsewhere — either in the driver stages around Q304-305, or the ALC circuitry around Q603-606.

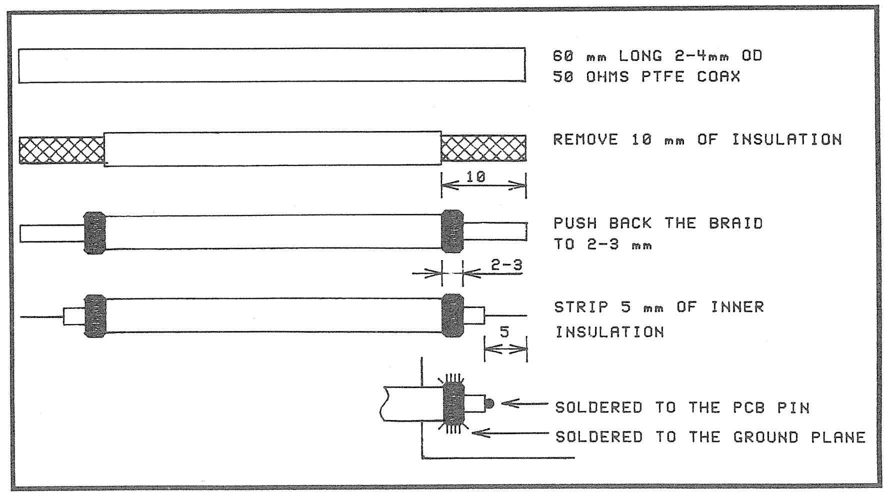
Here are some suggested further tests, to assist in tracking down the cause of low drive:

1. Check the RF drive power available at the TX-RF output from the main board, as described in section 8 of last month's article (March). If the drive was previously OK but is now low, and the 'TX12V' supply to Q305's collector is also low, there is probably a fault in the ALC circuitry (which includes Q801 on the PA module PCB).
2. Measure the voltage on the collector of Q801. This voltage should be close to 13 volts. On the other hand the voltage on the collector of ALC driver transistor Q606 (near the front of the main PCB) should be close to zero — or at least well below 12V.
3. Check that the voltages on the anodes of D603-605 are low. If any of these are high, this will cause the ALC circuitry to disable transmission. The cause of an inhibiting signal on one of the diodes should be traced back through the relevant circuits.
4. If the voltage on the base of Q605 is low and the voltage on the collector of this transistor is low also, the problem will probably be around transistors Q603-604. The base of Q603 should be at about 6V, set by the voltage divider formed by R611 (10k) and trimpot R613 (50k) connected to the T8V line. The common emitter voltage of Q603-604 should be around 0.6V higher than this figure.
Q603-604 basically compare the 'FWD' voltage at the base of Q604, fed back from output voltage detector D804, with the voltage at Q603's base. If the FWD voltage is lower than that on the base of Q603, even by a very small amount, more current will flow through Q604 which, in turn, will supply more base current to Q606 and cause it to produce more conduction in Q801 — increasing the RF drive and output.
5. If the foregoing tests still haven't revealed a fault, but it has become clear that the ALC is throttling back the drive and RF output, this may be because you have inadvertently swapped C816 and C817. This would make the 'FWD' detector output higher than it should be, for a given output, and hence the ALC circuit would attempt to reduce this 'excessive' output.

PA MODULE COIL WINDING DATA

Number of turns:	Winding direction:	Locations on PCB:
8-1/2	cw	L801
5-1/2	cw	L802
3-1/2	ccw	L803, L804, L805

All coils are wound on a 1/8" diameter former (e.g., the shank of a twist drill) with 0.8mm enamelled wire (#20 B&S, #21 SWG).



This diagram shows how to prepare the ends of the short PTFE coax cables used to carry RF between the main board and PA module.

Now let's look at the other kind of possibility, where your problem seems to be excessive current drawn from the DC power supply, with little or no RF output.

Here the fault is probably in the output circuitry between PA module U801 and the antenna socket. Things to help track down the cause of this kind of problem are:

1. If the T8V line is active (transmit mode) and has the correct +8V, the DC voltage on the anode(s) of D806 should be about 1V, while there should be about 0.5V on the anodes of D802- 803. Any lack of these voltages, if +8V is present on the T8V line, indicates a short circuit (e.g., a solder bridge) to ground in the low pass filter circuitry around L803-804 and L805.
2. The RF signal in the PA output circuit can be followed with an RF diode probe, providing it uses RF diode(s) having a reverse breakdown voltage rating of at least 150V. But note that the RF voltage will not register the same at all points along the low pass filter, due to the changing impedance levels along the filter.

12. FINAL ADJUSTMENT

If you have been able to align each of the transceiver's circuit modules according to the foregoing description, your transceiver should now be very close to its final adjustment.

However there are a few last 'fine tuning' steps needed to make sure that it's giving optimum performance.

Firstly, check the PLL voltage at R424 to see that it is varying smoothly as the channel selector is varied from one end of the band to the other (refer to testing step 8, in section 5.

It should not drop below 1.0V, nor fly above 4.0V, at any frequency within the band. Also, check to see that it does not vary significantly when the PTT is switched between receive and transmit.

In addition, check that the PLL stays 'locked' over the full range, on receive and transmit, by monitoring pin 10 of U401. A logic low (close to 0 volts) indicates that tha PLL is in lock while a logic high (close to 5 volts) indicates a problem.

If there appears to be any fault with the PLL, this must be resolved before attempting to complete the final alignment. For more information on PLL troubleshooting, refer back to section 5.

Assuming that all appears well with the PLL, tune the tranceiver to a weak signal or use a signal generator to proceed with the final receiver alignment.

Peak the trimcaps in the front- end RX amplifier (C301, C302), and the bandpass filter (C306, C308, C310 and C312). Also check the peaking of the two IF coils L307 and L201. If necessary adjust the discriminator coil, L202, in the IF amplifier for centre frequency (minimum receiver distortion).

This completes the final alignment. The transmitter stages should require no further adjustment.

Your transceiver should now be complete, although you may need to add the final touches if you haven't done these already: fitting the microphone socket to the front panel (see connection diagram), hooking up the CPU backup battery leads to the pins on the main PCB just to the front of Q901 (the + lead to the pin nearest Q901), mounting the speaker into the top of the case and then screwing everything together.

POSSIBLE MODS

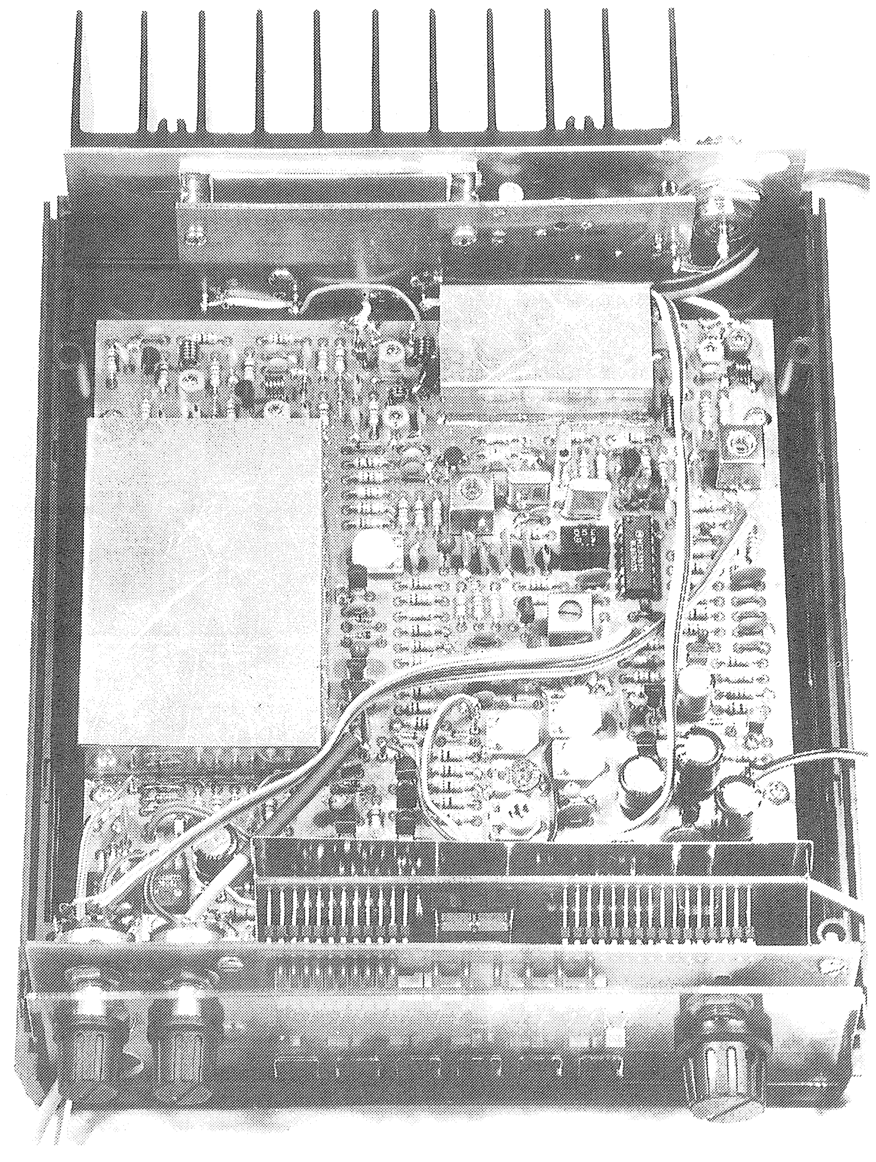
On one of the prototypes, it was noted that the transceiver's ALC circuit was disturbed by radiation from a nearby antenna.

The antenna was a dipole about half a metre away from tranceiver. With full power output the power suddenly dropped down.

If this occurs, solder a 1uF tantalum capacitor, in parallel with a 1nF ceramic, between the base of Q604 and ground. The same filtering should be added between the anode of D605 and ground.

Further protection against possible disturbances due to stray RF should be gained by painting/spraying the interior of the transceiver case with conductive paint, and connecting it to the main PCB ground-plane.

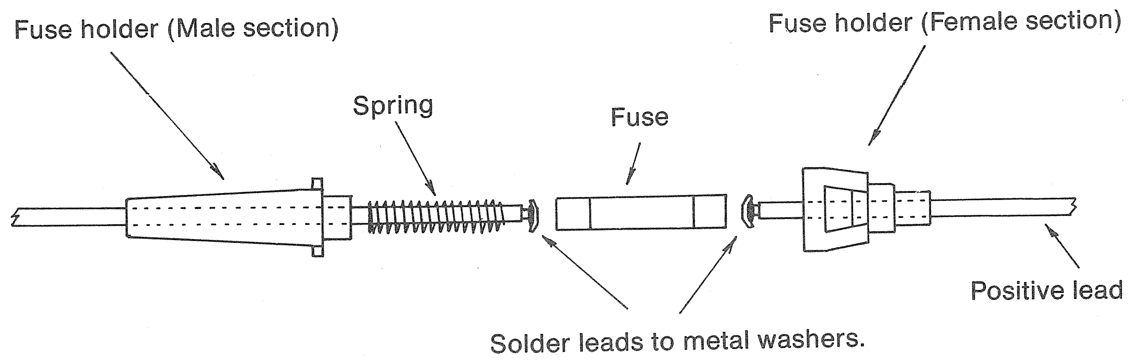
If the VCO-PLL seems to exhibit any microphonic effects, these should be eliminated if the VCO components are sealed in wax.



A general view inside the completed transceiver. Note that the PA module board mounts vertically at the rear of the main board with two 3mm machine screws clamping it and U801 to the rear panel and heatsink radiator.

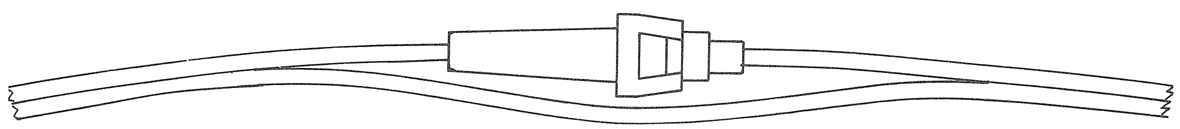
Text and illustrations courtesy of Electronics Australia

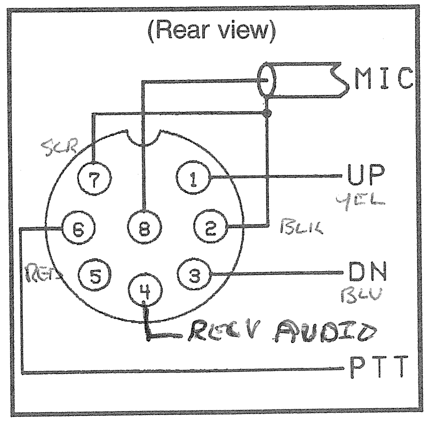
Fuse holder assembly



Note: The inline fuse holder is placed in series with the positive lead of the input power cable.

The above diagram shows correct assembly details and placement of each item. Below is a diagram showing the completed fuse holder and how it sits on the power cable. (Do not cut the negative lead).





Connection details for the microphone socket. These connections should suit most standard microphones.

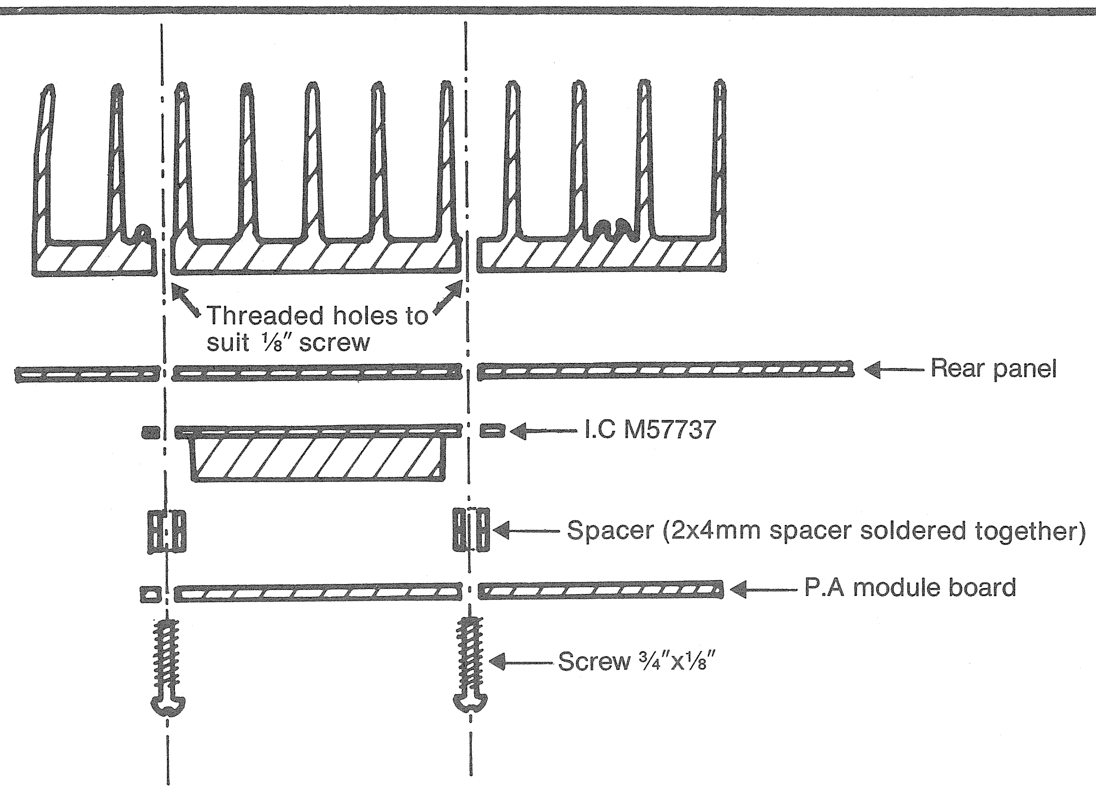


Fig.11 Mounting of the heatsink, rear panel, IC, spacers and PA module board.

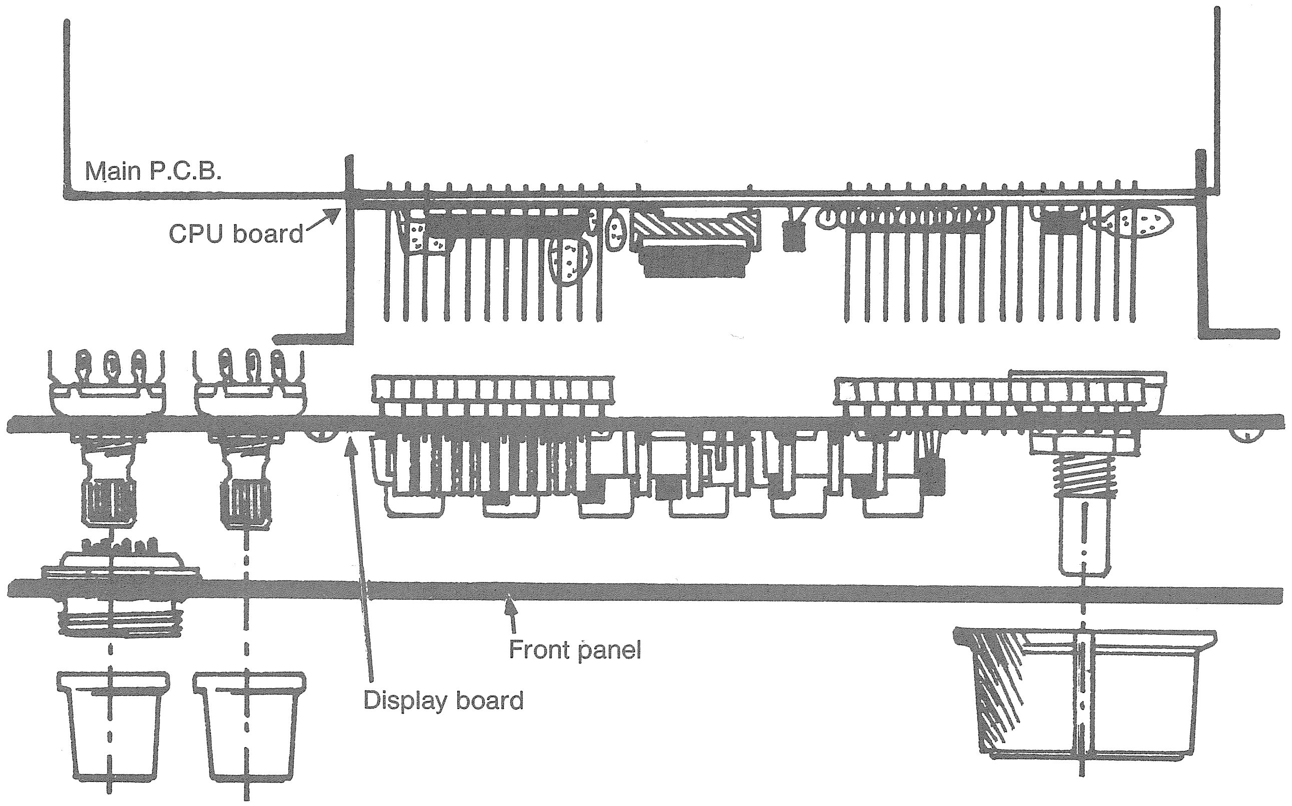


Fig.12 Top view of the front panel, CPU and display boards.

Fig.13 Wiring layout for front panel, display board, CPU board and the main board.

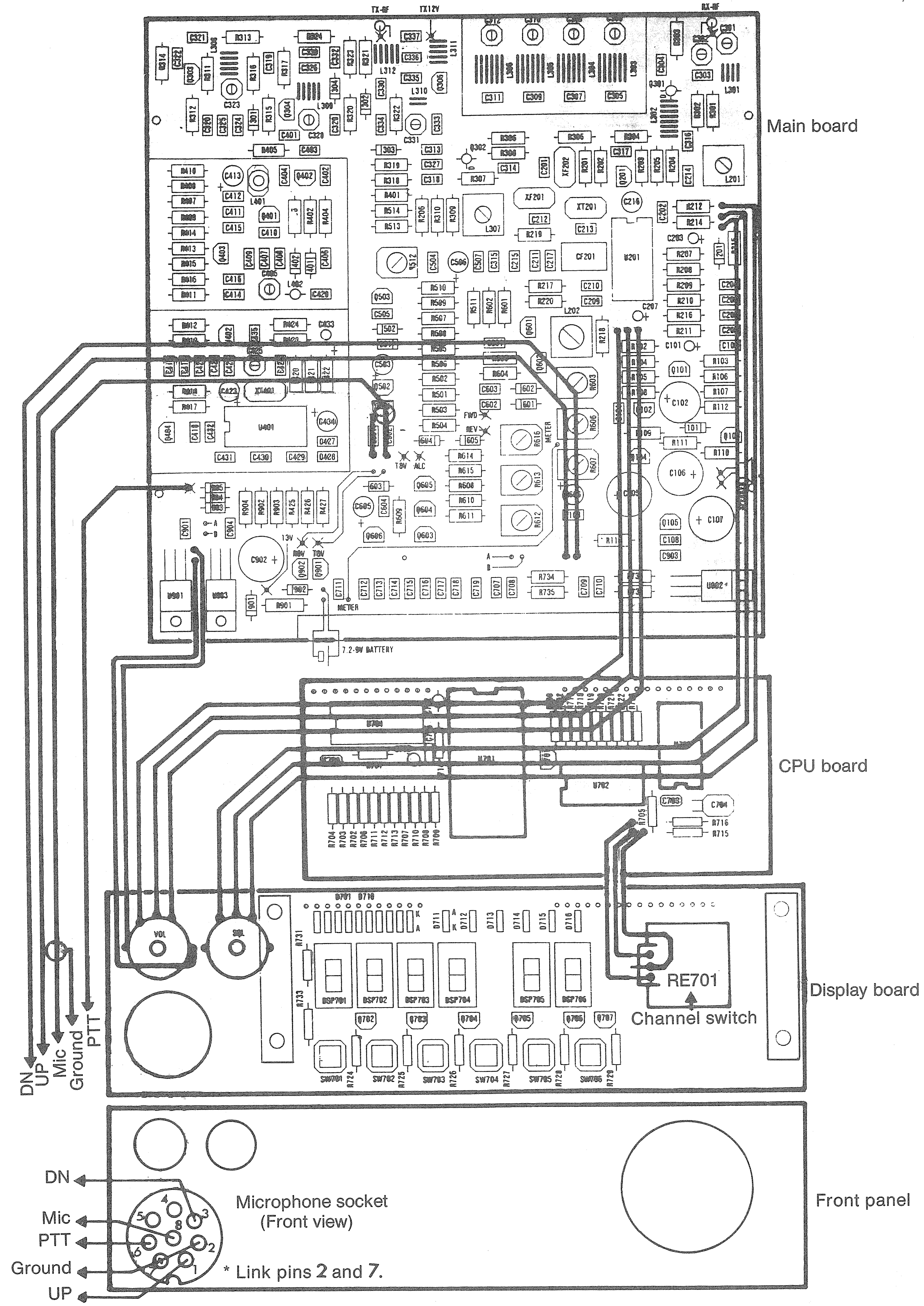
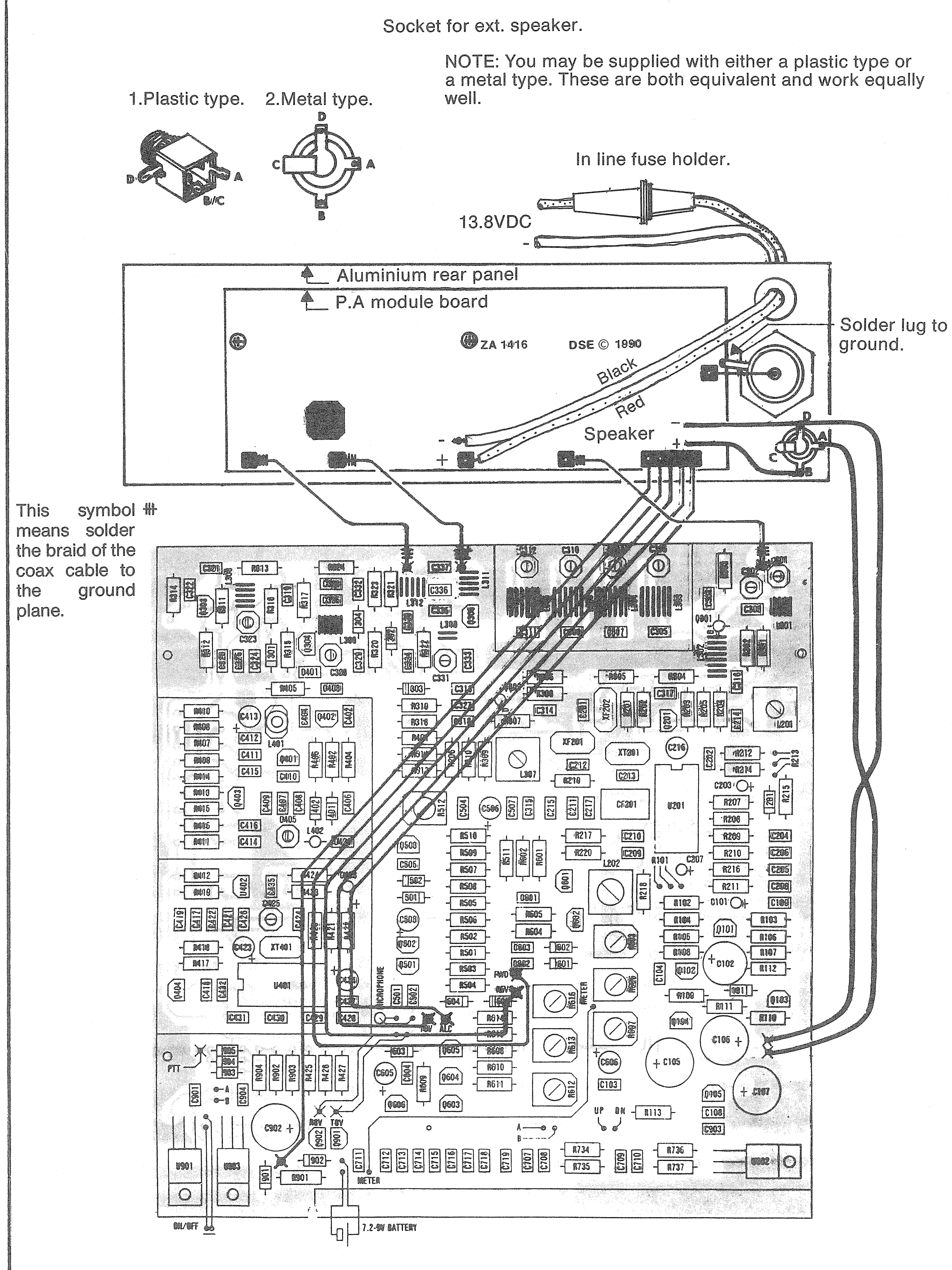


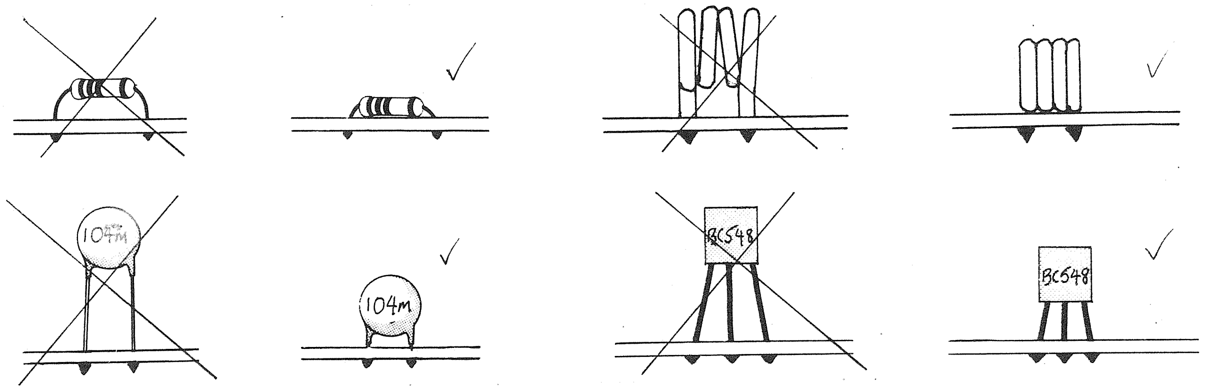
Fig 14. Wiring layout of rear panel, P.A module board, main board and speaker.



K 6400 VHF 2M TRANSCEIVER

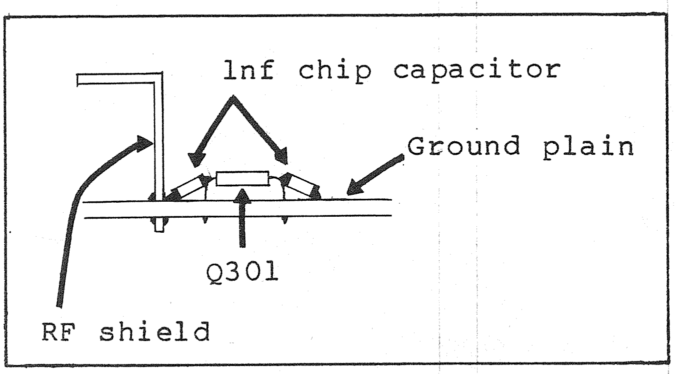
Constructors Please Note

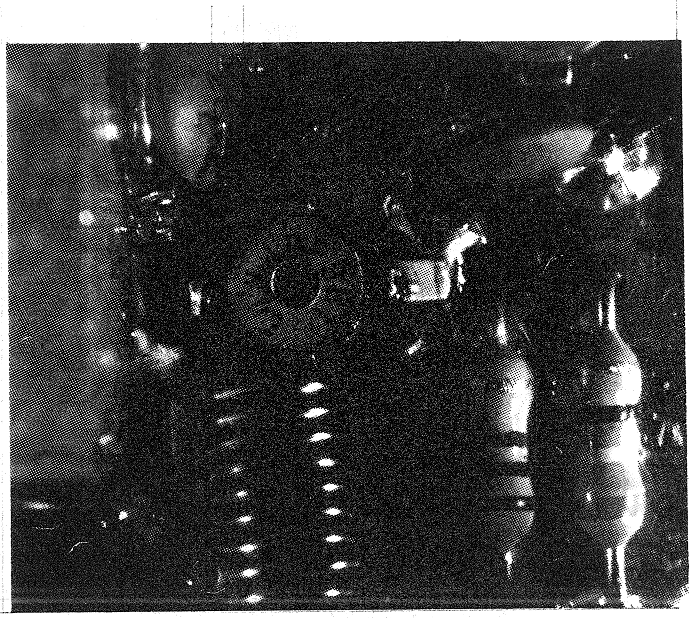
1) General: When constructing this kit, it is important that all components (unless specified otherwise in the instructions) are mounted as close as possible to the board, refer below for some examples.



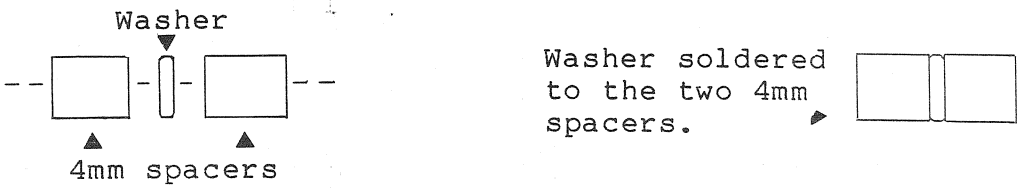
2) General: After mating both main and CPU PC boards, it will be required that the four pcb mounting holes on the main board are to be re-drilled so that they will line up with the cases mounting moulds.

3) RF Section: Add a 1nf (0.001uf) chip capacitor between the source of Q301 and ground plain and add another 1nf(0.001uf) chip capacitor between the gate of Q301 and the ground plain. Both of these addition are done on the component side of the board. As the chip capacitors are very small, special care will be required when trying to solder these components. A fine point tweezer will be required to help insert these two chip capacitors. Lightly tin the ends of the chip capacitor with some solder (a fine point soldering iron tip would be useful at this point).
Also lightly tin the four mounting points on the main board (e.g. source of Q301 and ground plain, and the gate of Q301 and ground plain). Then carefully pick up the chip capacitor with the tweezer and place it on its mounting point. While you are still holding down the capacitor with the tweezers, gently solder down each end . Be very careful here as too much solder can provide a short circuit. Because the chip capacitors are very small and may be a little difficult to insert, you have been supplied with two extras, just in case something has gone wrong.



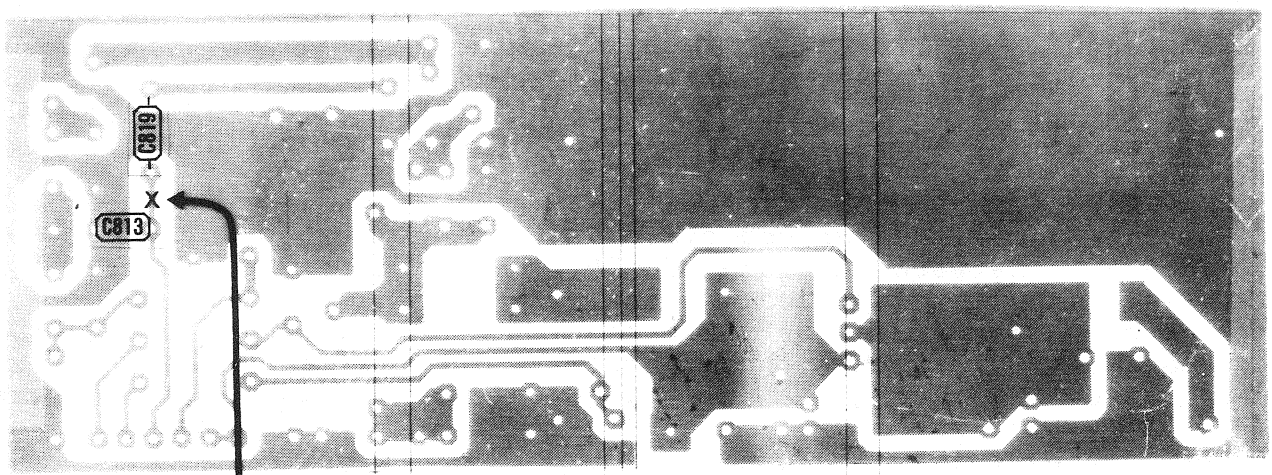


4) PA Module: It is suggested that extra spacing is needed between the mounting arrangement of U801 and the rear panel.



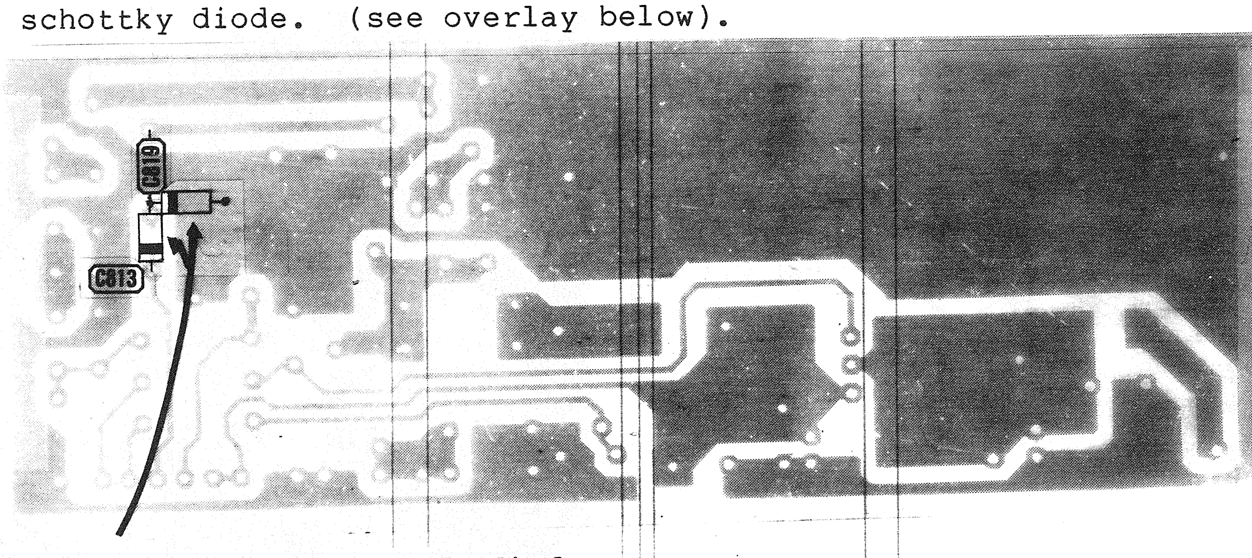
When soldering together the two 4mm spacers (to make the required spacing length) an extra washer will need to be added in between them.

5) PA Module: Before you commence construction of the PA module PCB you will first need to cut and remove the short track running between the pads for C819 and C813 (see below).



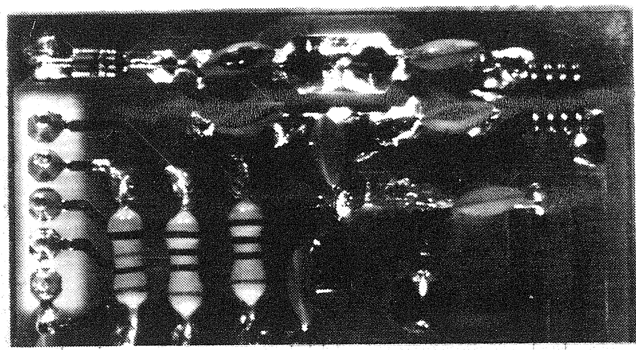
Cut and remove this track.

Then you will need to solder a schottky 5082-2800 diode between the pads now separated by the removed track, so that the cathode of the schottky diode is soldered to the pad which connects to the REV pcb pin. Also another schottky 5082-2800 diode will need to be soldered between the pad holding the anode of the first schottky diode, and the ground plain, such that the cathode of this diode is soldered to the pad of -the anode of the first schottky diode. (see overlay below).



2 x schottky 5082-2800 diodes

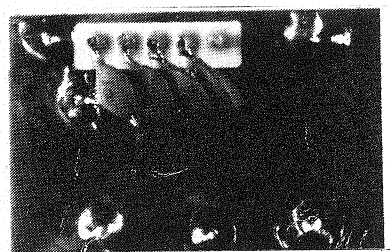
5 cont.



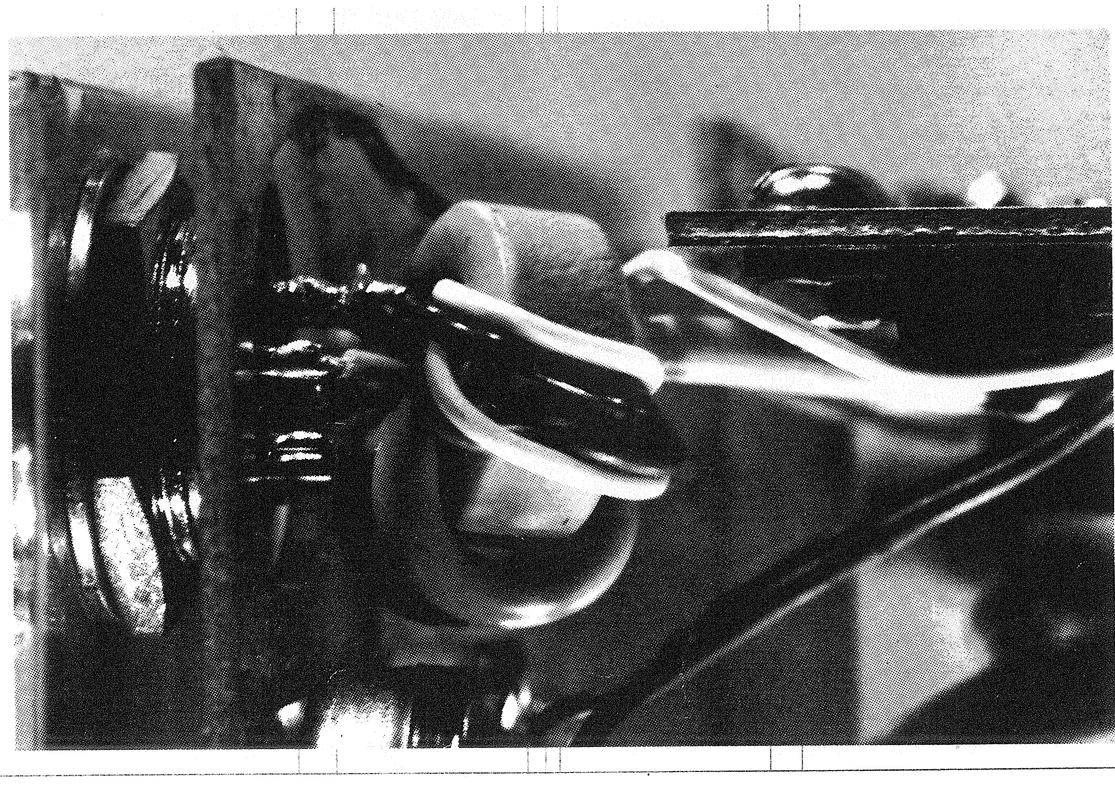
6) PA Module: Precaution must be exercised when handling the M57737 PA module (U801): a) Do not drop the module onto a hard surface as it will be damaged by the mechanical shock. b) Ensure that no foreign objects are between the module fin and the back panel and heatsink when the mounting screws are tightened. Excessive stress created by screwing the module to an uneven surface may crack the substrate and damage the module and c) Do not over tighten the mounting screws. The module should be held firmly against the back panel but overtightening will create excessive stress.

7) PA Module: Add 1nf/0.001uf ceramics capacitors between each of the following PCB pins and ground plain.

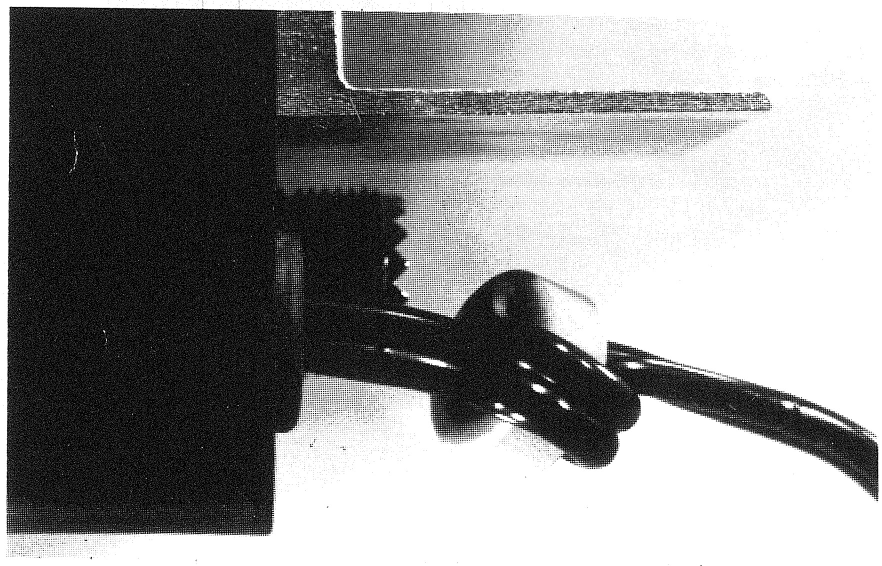
1. ALC
2. T8V
3. REV
4. FWD



8) General: Wrap all the leads connecting to the Mic socket through an iron powder toroid (grey) as many times as possible (about two turns) see picture below.

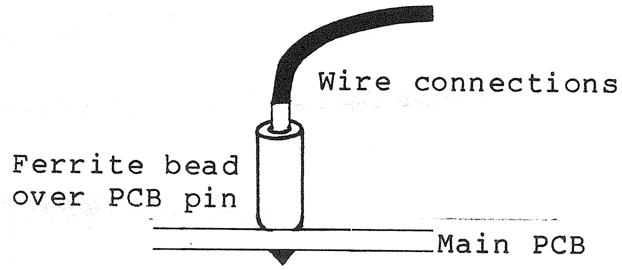


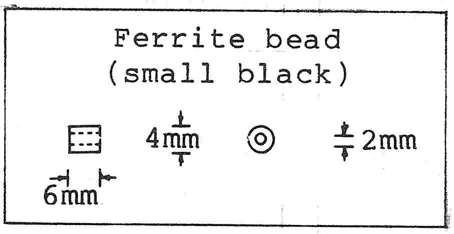
9) General: Wrap the power cable leads, also through an iron powder toroid (one turn) on the outside of the case, close to the back panel. Sleeve with heatshrink.



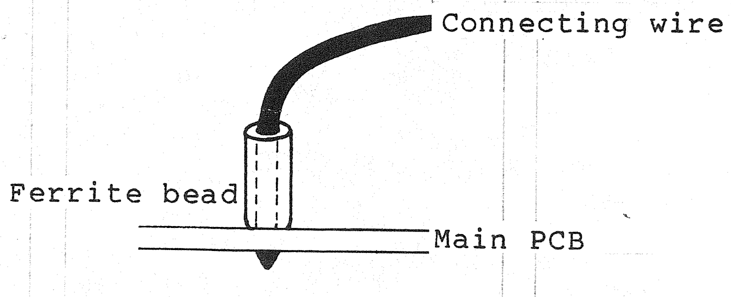
10) General: Fit small ferrite beads over the 5 PCB pins on the main board which have wires connecting to the PA module at the following points:

1. 13V
2. FWD
3. REV
4. T8V
5. ALC

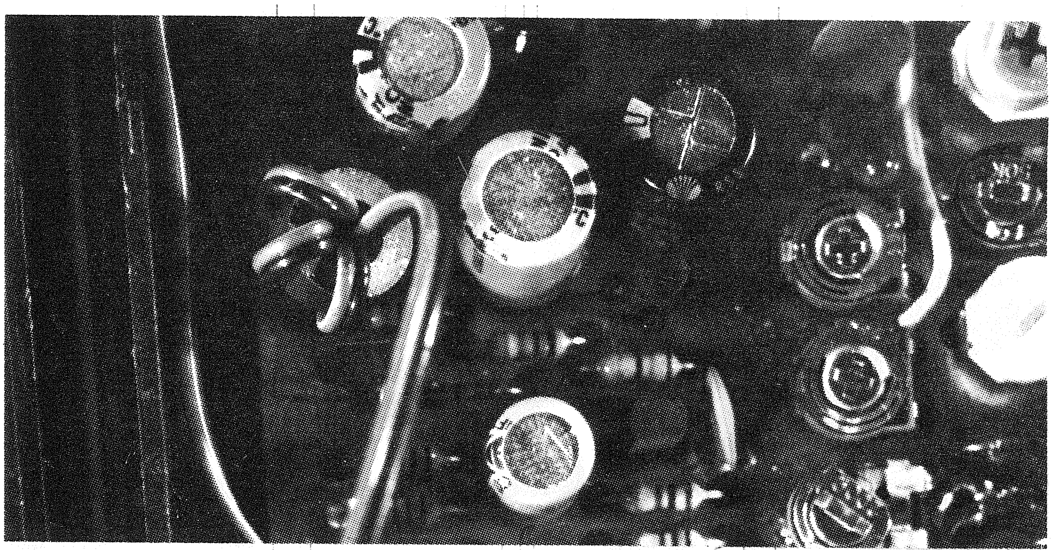


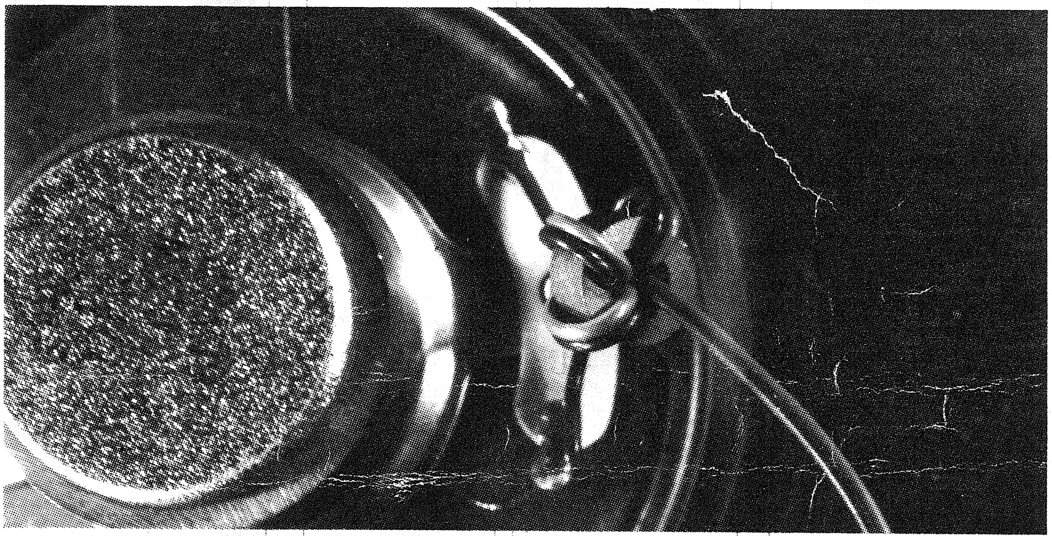


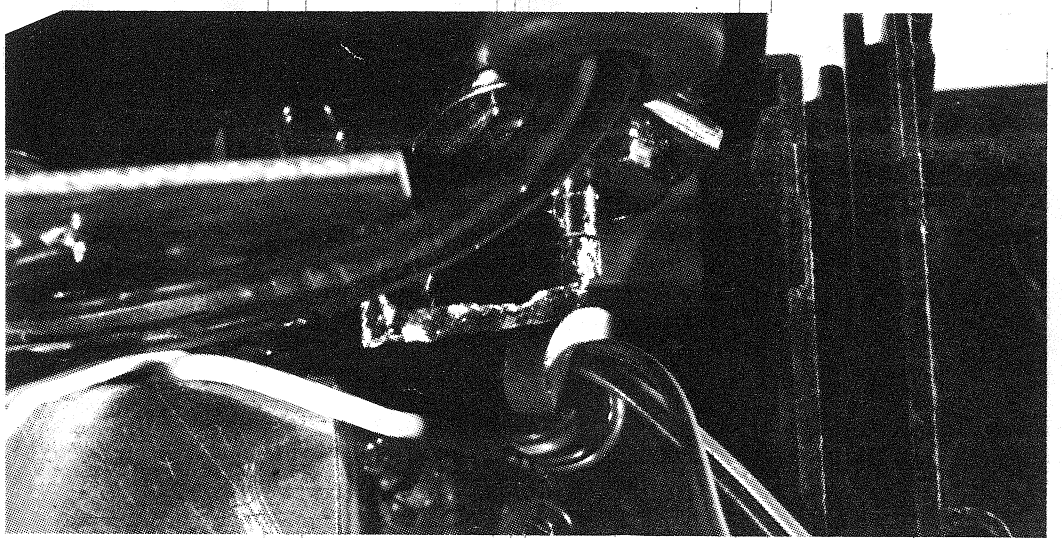
11) General: Fit small ferrite beads at the main board where the five wires from the microphone socket are connected. (refer to the wiring diagram in the instruction manual). In the case of the shielded mic cable and the PTT line, the beads can be fitted over the PCB pins. For the UP and DN lines the beads must be fitted to the wires that solder directly to the main board.

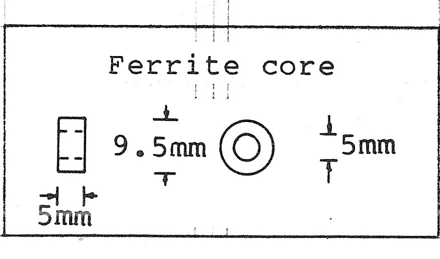


12) General: Wrap the speaker leads through a ferrite core as many times as possible at the main board, the speaker socket on the back panel and at the speaker itself.

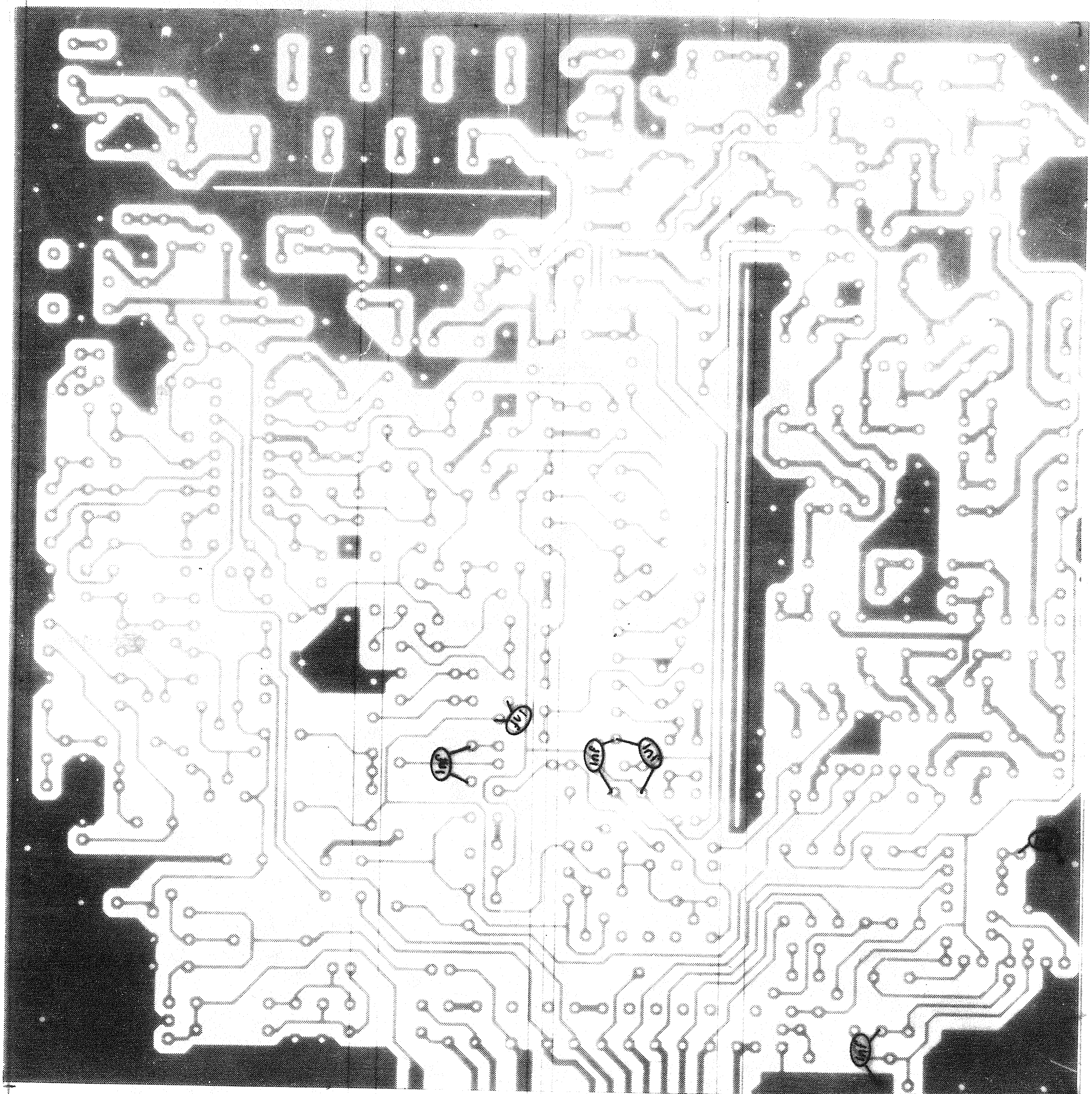








13) General: Fit 1nf/0.001uf ceramic caps underneath the main board (track side) at each of the following points to ground: a) PTT PCB pin, b) 13v PCB pin, c) ALC PCB pin, d) T8v PCB pin next to ALC PCB pin, e) Fwd PCB pin, and f) Rev PCB pin. Please refer to the overlay of the main board track side below.

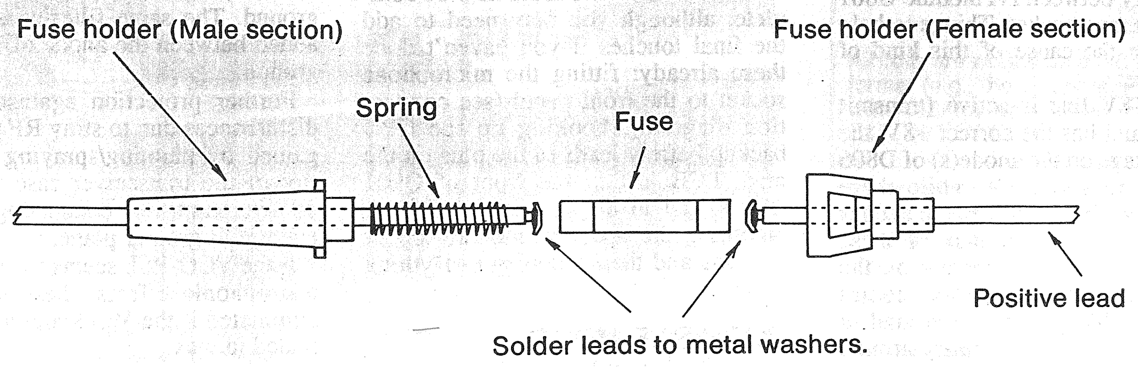


14) General: Listed below are additional parts supplied which are not listed in the main partslist of the instruction manual on page 4.

1nf/0.001uf chip capacitors -----------	4
1nf/0.001uf ceramic caps --------------	11
Schottky diode 5082-2800 --------------	2
Iron powder toroid --------------------	2
Ferrite beads -------------------------	10
Ferrite core --------------------------	3

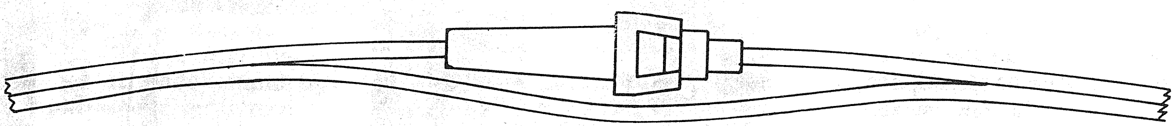
Thank you
Dick Smith Electronics

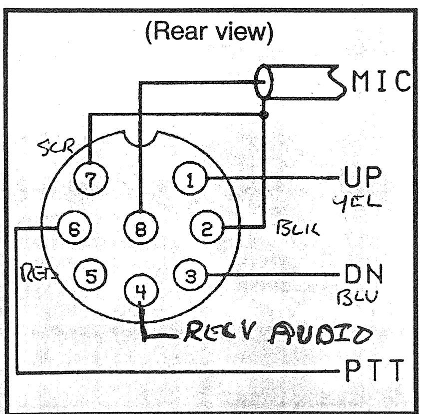
Fuse holder assembly



Note: The inline fuse holder is placed in series with the positive lead of the input power cable.

The above diagram shows correct assembly details and placement of each item. Below is a diagram showing the completed fuse holder and how it sits on the power cable. (Do not cut the negative lead).





Connection details for the microphone socket. These connections should suit most standard microphones.