Icom IC-22S

PLL Synthesized 2-Meter Transceiver

Instruction Manual and Service Notes

SECTION I.
Specifications

GENERAL

Semiconductor Complement	
Transistors	34
FET	7
IC	13
Diodes	33 to 128 depending on channels
Frequency Range (for specification)	146-148 MHz
Voltage	13.8 Volts DC (negative ground)
Current Required	
TX	2.0 amps @ 10 Watts 0.9 Amps @ 1 Watt
RX	0.7 amps at maximum audio 0.4 amps squelched audio
Size	58 mm (H) x 156 mm (W) x 218 mm (D)
Weight	1.9 kilograms
Antenna Impedance	50 ohms
Number of Channels	23 channels selected from any of the 132 channels on 15 KHz spacing
Frequency Control	Stabilized master oscillator PLL programmed by diode matrix

TRANSMITTER

Power Out	10 watts or 1 watt (selectable)
Modulation Width	5 KHz
Microphone Impedance	500 ohms
Spurious Level	Lower that –60 db below carrier

RECEIVER

Modulation Acceptance	16F3
Type	Double Superhetrodyne 1^{st} IF 10.7 MHz 2^{nd} IF 455 KHz
Receiver Sensitivity	4 db below 1 uV or lower (0.4 micro)
1 uV S+N/N	30 db or better S+N/N
Spurious Response	60 db or more attenuation
Bandpass	+/-7.5 KHz: -6 db +/-15 KHz: -60 db
Squelch Sensitivity	-8 db below 1 uV
Audio Output	1.5 watts or more into 8 ohms

SECTION II.
Description

This transceiver is extremely rugged and completely solid state. State of the art devices such as integrated circuits, field effect transistors, varactor and zener diodes are engineered into a tight-knit, straightforward electronic design throughout both transmitter and receiver. Reliability, low current demand, unexcelled performance, and ease of operation are the net result.

The dual conversion receiver with its FE front end and high-Q helical cavity resonators boasts low noise and sensitivity of 0.4 volts or less. Signal gain of 90 db or more is accomplished from the second mixer back by virtue of a 6-stage IF amplifier. The need for additional front end RF amplification is thus eliminated. Zener-regulated PLL controlled first and crystal-controlled second local oscillators produce very good stability. Audio reproduction is of an unusually high order of distortion free clarity.

The transmitter section will produce a minimum of 10 watts output. Again, a phase locked loop is employed for initial frequency stability. Twenty-two (22) channels are provided for operating convenience and versatility. High-Q stages provide minimum interstage spurious response. A low pass filter is placed at the output to ensure undesirable frequency products are not being transmitted. Final PA transistor protection circuit is incorporated in the final circuitry. A new design heat radiator is employed to increase final reliability.

All circuitry is constructed on three printed circuit boards that are easily accessible for servicing. The printed circuit boards are housed in a sturdy frame that is, in turn, housed in a rigid metal case providing an extremely durable and rugged unit. Care has been taken to filter and regulate internal DC voltages. A DC input filter is provided to eliminate alternator or generator whine generated in the vehicle environment. Test points are brought up from all major circuits to facilitate maintenance checks and troubleshooting should the need arise.

Each unit comes with built-in speaker, a high quality dynamic microphone, mobile mounting bracket, microphone clip, DC cabling and plug, external speaker plug, and operating manual. A modern styled face plate, large Smeter, small size and low profile design complete the unit's styling. It is a welcome addition to a dashboard or fixed station.

SECTION III.
Installation

Unpacking
Carefully remove your transceiver from the packing carton and examine it for signs of shipping damage. Should any shipping damage be apparent, notify the delivering carrier or dealer immediately, stating the full extent of the damage. It is recommended you keep the shipping cartons. In the event of storage, moving, or reshipment becomes necessary, they come in handy. Accessory hardware, cables, etc. are packed with the transceiver. Make sure you have not overlooked anything.

Location
Where you place the transceiver in your automobile is not critical and should be governed by convenience and accessibility. Since the unit is so compact, many mobile possibilities present themselves. In general, the mobile mounting bracket will provide you with some guide as to placement. Anyplace where it can be mounted with metal screws, bolts, or pop rivets will work. For fixed station use, a power supply should be designed to produce 3 amps for the transceiver.

Power Requirements
The transceiver is supplied ready to operate from any regulated 13.5-volt DC, 2.5 amp negative ground source. An automobile 12-volt, negative ground system is usually more than adequate. Some not must be taken, however, of the condition of the vehicle's electrical system. Items such as low battery, worn generator/alternator, poor voltage regulator, etc., will impair operation of your transceiver as well as the vehicle. High noise generation or low voltage delivery can be traced to these deficiencies. If an AC power supply other than the matching supply is used with your transceiver, make certain it is adequately regulated for both voltage and current. Low voltage while under load will not produce satisfactory results from your transceiver. Receiver gain and transmitter output will be greatly impaired. Caution against catastrophic failure of the power supply should be observed.

> ***CAUTION:*** *Excessive voltage (above 15 volts DC) will cause damage to your transceiver. Be sure to check the source voltage before plugging in the power cord.*

Included with your transceiver is a DC power cable with plug attached. The red wire is positive (+) and the black wire is negative (-). If your mobile installation permits, it is best to connect these wires directly to the battery terminals. This arrangement eliminates random noise and transient spikes sometimes found springing from automotive accessory wiring. If such an arrangement is not possible, then any convenient B+ lead in the interior of the vehicle and negative frame can be utilized. Your transceiver provides an internal DC filter that will take out a large amount of the transient difficulties anyway. Remember that the unit operates on a negative ground system only – it cannot be used in a positive ground automobile.

After making your connections, simply insert the power plug into your transceiver. When your transceiver is mated with its matching power supply, the power cable from the IC-3PA is simply plugged into the same receptacle in the transceiver and the AC line cord into any convenient wall receptacle.

Antenna
The most important single item that will influence the performance of any communication system is the antenna. For that reason, a good, high quality, gain antenna of 50 ohms

impedance is recommended for fixed or mobile operation. In VHF as well as HF, every watt o ERP effective radiated power will make a difference. Therefore, 10 watts output into a 3 db gain antenna yields 20 watts effective radiated power, assuming a low VSWR, of course. Therefore the few more dollars invested in a gain type antenna is well worth it.

When adjusting your antenna – mobile or fixed – by all means follow the manufacturer's instructions. There are some pitfalls to be aware of. For example, do not attempt to adjust the antenna for lowest VSWR when using an SWR bridge not intended for VHF use. Some instruments will give readings with as much as a 40% error. A Drake WV-4, Bird model 43, or Sierra model 164B with VHF cartridges

The RF coaxial connector on the rear chassis mates with a standard PL-259 connector. Some models may have metric thread. In any event, the RF connector will mate with almost any PL-259 connector if care is taken to seat them properly.

Microphone

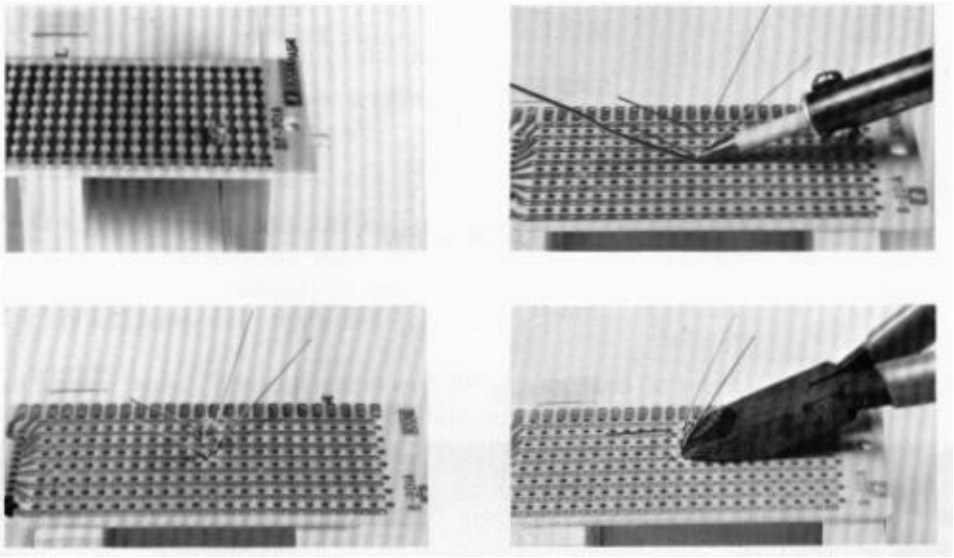
A high quality dynamic microphone is supplied with your transceiver. Merely plug it into the proper receptacle on the front panel. Should you wish to use a different microphone, make certain it is of the high impedance type; at least 500 ohms or better. Particular care should be exercised in wiring also, as the internal electronic switching system is dependent upon it. See the schematic for the proper hookup. Under no circumstances use a "gain preamp" type microphone. The audio system in your transceiver is more than adequate and additional pre-amplification is unnecessary. To use this class of microphone is to invite distortion.

Synthesizer Programming

Your transceiver does not need crystals to set the frequency. It has 22 channels selected by the channel selector switch. In addition, the channel selected has three options of how the Offset is handled: receive and transmit on the programmed frequency (SPX), receive 600 kHz higher than the programmed frequency (DPX A), and transmit 600 kHz above the programmed frequency (DPX B). The programming is done on the diode matrix board by soldering computer grade diodes into the boards in the locations indicated on the diode matrix diagram. Please refer to the chart on pages 22~24 for the locations.

The matrix board may be removed by taking out the hold-down screw at the end of the board and pulling gently straight up on the other end to disconnect the matrix from the connector. The numbers 1 through 22 indicate the channel number to be programmed and the numbers D-0 through D-7 indicate the position in which the diode is to be placed corresponding to the insert positions on the Frequency versus Matrix Chart. Insert the diode into the line for the desired channel with the cathode pointing UP. The cathode lead is bent down to go through the board to connect to the other side. After the diodes have been inserted for the channel, turn the board over carefully so as to not have the diodes fall out and solder each of the leads with a small tip, low wattage soldering iron. Clip end diode lead off as close to the board as possible. Replace the board on its connector and replace the screw in the end.

An external speaker jack and plug is supplied with your unit in the event another speaker is desirable. The external speaker impedance should be 8 ohms. The use of the external



speaker jack will disable the internal speaker. An 8 ohm headset can be utilized as well. (See Fig. 2B)

CAUTION: DO NOT USE A SOLDERING IRON OF MORE THAN 40 WATFS ON THE MATRIX

SECTION IV.
Control Functions

High-Off-Low Switch
Opens or closes the 12 VDC source voltage to the transceiver. "In High" position, output power is 10 watts. "In Low" position, output power is 1 watt.

DPXA — SPX — DPXB
This determines whether the transceiver transmits or receives on the program frequency, or +600KHz above the program frequency.

Volume Control
Controls audio output level of the receiver.

Squelch Control
Controls the squelch threshold point of the receiver.

Microphone Jack
Accepts 4 prong mike plug supplied on microphone.

S/RF Meter
Reads S signal strength in receive mode and relative RF output in transmit mode. The meter face is illuminated with a white lamp when the transceiver is switched on.

Channel Selector
Selects one of 22 channels.

C.O.S. lamp
Also shows out of lock in transmit.

Transmit Indicator

Antenna Connector
Accepts standard PL-259 coaxial connector. Note that some transceivers may come with a metric threaded connector. Most PL-259 connectors will mate satisfactorily if care is taken to seat them properly. If you have difficulty, try a different make of PL-259.

External Speaker Jack
This jack mates with the plug supplied for external 8-ohm speaker or headset use. The use of this jack mutes the internal speaker.

Power Cord
Mates with DC cord plug or power cord of IC-3P AC power supply.

Identification Plate
States model, serial number.

Accessory Socket
Center Meter, etc., can be connected with a 9 Pin plug.

SECTION V.
Operation

Initial Preparations
Connect the microphone to the microphone jack.

Connect the antenna to the antenna coax connector. Make sure the coax line is of the correct impedance (50 ohms) and is neither shorted nor open.

Make sure the function switch is in the off position, then connect the power supply cord to the power supply jack. The red lead should be connected to the positive side of the power source and the black lead to the negative side. In the event that these leads are improperly connected, the transceiver will not function. No damage will be, however, incurred since protection is provided in the P.A. for this purpose.

Turn the volume and squelch controls to the maximum counter-clockwise position.

Operation
When the function switch is set to either the high or low position the set is switched on and the channel indicator window and meter will be illuminated.

Switch the channel selector to the desired channel.

Choose the proper DPX offset setting, or SPX for simplex operation.

Reception
Adjust the volume control to a comfortable listening level of noise, if no signal is present.

Carefully adjust the squelch control clockwise until the noise just disappears. This is the proper squelch threshold setting and must be done when no signal is present. Your transceiver will now remain silent until an in-coming signal is received which opens the squelch. If the squelch is unstable due to the reception of weak or stations, adjust the squelch control further until the proper threshold is obtained.

The S meter indicates the signal strength of the incoming stations and is calibrated in S units. and db over S9. The light illuminating the meter acts also as lock indicator for the PCC.

Transmitting
Push the PTT (push to talk) button on the microphone and the transceiver will transmit. At the same time the TX indicator will be illuminated red and the meter will provide an indication of relative power output of the transmitter. The pointer will be on or near the red mark on the meter scale when on high power and just a little over 1 on low power. Hold the microphone about three inches from your mouth and speak in a normal voice. The microphone is of the dynamic type and provides good pickup for all levels of voice.

To receive again, just release the PTT button. This will also switch off the light.

SECTION VI
Theory of Operation

TRANSMITTER

Microphone, pre-amplifier circuit
The pre-amplifier circuit is composed of Q30, Q29, in an NPN, PNP direct-coupled 2-stage amplifier configuration. The low noise transistors used and application of a large amount of feedback in the 1st stage gives a high signal-to-noise ratio and high stability.

Since DC voltage is supplied through Rl39 to the microphone connector, the ICSM2 (electrolytic condenser microphone) can be used also. C 166, R140, C65 constituting a which filter suppress high frequency regeneration and C 163 provided between base and emitter of the 1st stage transistor prevents oscillation due to regeneration.

Pre-amplifier output is through R132 to the microphone circuit.

IDC circuit (Instantaneous Deviation Control)
Passing of signals through narrow band filter stage can result in distortion if the signal is over-modulated and consequent degrading of following channels. To give improved limiting characteristics Q28, Q27, Q26, are connected in a 3-stage direct-coupled configuration that results in less distortion and protects succeeding stages from the effects of excessive input.

Since feedback is supplied to the 3-stage DC circuit and the input impedance is low, the frequency characteristic of the differentiation by R130 and C159 is improved. R124 through which the feedback circuit connects to ground serves for adjusting the operating point of Q26 and insuring symmetry of clipped waveforms. Dl 8 and D19 are temperature compensating elements for the 3-stage DC. circuit.

The limiter output is close to square waves in form, and since it includes harmonics an active filter is provided to eliminate anything over 3 kHz. To prevent the frequency deviation from becoming too large as temperature increases, compensation is made by thermistor R13, after which adjustment is made by R12 to narrow the frequency deviation range.

Frequency modulation, 10.7 MHz Oscillator
Because of the quartz crystal characteristics in the frequency modulator Q24, a non-Controlled VXO configuration, the circuit is tolerant of temperature variations, and there is less drift. Output signals from the IDC circuit are supplied to the anode of varicap diode D17. To improve the temperature characteristics, temperature compensation is effected by thermistor Rl06 connected to the cathode of D17. The signal is set to 10.7 MHz by L4 connected to the cathode of D17.

Transmission Mixer
1C3 includes a constant current circuit and differential amplifier. 1C9 provides balanced output from the 10.7 MHz oscillator and drives the two inputs of the differential amplifier. Local oscillator output enters via the constant current input and differential amplifier output is filtered by L36, opposite phase components of the 10.7 MHz output and local oscillator cancel, and so signals obtained at the secondary side of L36 are LO+/ 10.7 MHz. The required LO+ 10.7 MHz signals are obtained from the Band Pass Filter following L36.

Interstage Amplifier
BPF output is amplified up to about 2 mW in the Q22 stage that is a MOSEFT with good linearity.

Low Level Amplifier
Interstage amplifier output is amplified to about 100 mW by stage Q19, which also functions as an ALC circuit.

Driver stage
Low level output is amplified to approximately 1.6 W by Q18.

ALC Circuit
Spurious signals, which might occur when voltage is reduced or when the degree of excitation is low, are prevented by a small amount of forward bias applied by bias circuit D14.

Part of this output is brought up to excitation level in the threshold type voltage-doubling rectifying circuit constituted by D19, D29. When AI..C is not applied, the self-bias of Q5 causes Q16 to conduct. When ALC is applied, both 015 and Q16 are close to cut-off, collector voltage of Q19 falls, and the excitation level is lowered.

ALC is effective for both high power and low modes. For high power, the threshold level is controlled by R73, and for low power, the threshold is set by R149.

Power Amplification
Output is amplified by Q7 to give an output of 10 watts, including low pass filter losses. Since power handled in this stage is particularly high, use is make of an aluminum die-cast radiator which is in direct contact with the rear chassis and serves to keep the transistor temperature low in order to insure reliability. A padding mica trimmer which has an excellent temperature characteristic and causes little induction loss is also employed.

Low pass filter and SWR detector
Power amplifier output includes harmonic components and in passing through 2 Chebyshev section and one standard section in order to get to the ANT terminal, harmonic components are attenuated by about 70 dB. Cut-off frequency of this low-pass filter is set to about 180MHz, and so there is very little loss in the 146-148 MHz band.

SWR
D10, D11 constitute an SWR detector. The closer it is to the ANT terminal the better the detector functions, but because of diode rectification, harmonics are produced. An excellent compromise is therefore made by inserting the detector between the low-pass filters. Standing waves that pass through the SWR detector are rectified by D11 and supplied to the RF meter. Indication of the RF meter for proper high power output is set to 4/5 of full-scale by R156.

APC circuit
Reflected waves are rectified by D10 and then amplified by Q20, 021 up to the level set by 89. By raising Q22 source voltage, excitation level is lowered, and damage to the power amplifier transistor due to mismatch is prevented.

RECEIVER

R.F. Amplifier

Antenna input or self contained antenna signals pass through switching diode D-40 located in the PA section to the RF amplifier Q2 where it is amplified and passed to the R.F. filter section. Out-of-band signals are attenuated by the band pass filters.

Mixer Filter

The amplifier signal is injected into Gate-i of the mixer Q-3. The LO frequency is also applied to Q3 where a resultant 10.7 MHz IF signal is derived. This signal is passed through a crystal BP filter that greatly attenuates other in-band signals. The 10.7 MHz signal is again mixed with a second local oscillator, Q8 operating at 10.245 MHz at mixer 2, Q4. The resulting mixer output is 455 kHz.

I. F. Amplifiers

Two ceramic filters provide the low frequency selectivity and the adjacent channel rejection needed in today's crowded repeater world. I.F. amplifiers Q5 and Q7 drive IC1 limiter. The signal is detected by the ceramic discriminator.

Audio

Lower frequency audio components (300 Hz to 3 kHz) are amplified by Q1O and passed by Q11 active filter. These (desired) audio signals are adjusted to level by the volume control and amplified to I watt power by IC-2.

Squelch

At point J-5, higher frequency discriminator noise is taken at a selected level by the R1 squelch Control back via J4 and amplified by Q14 and Q13 rectified by D7 and applied to Q12's base. Under no signal conditions, when noise is high, this rectified voltage is high, and Q12 turns off Q11. The reverse is true when a signal is of sufficient strength to reduce noise and the squelch opens permitting the audio signal path to operate normally.

During transmit, positive voltage is fed to the Q9 base, silencing the audio system. After switching back to receive, a delay in Q9 base voltage change provided by C-56 allows a silent transition.

PHASE LOCKED LOOP

Voltage controlled oscillator

Use of a clap oscillator in the form of a junction FET in Q8 gives an improved signal-to-noise, and by use of other elements having excellent temperature characteristics, frequency stability of the order of +/50 ppm/C is achieved.

Varicap diode D3 serves to broaden the range of frequency permitted and by contributing to the linearity improves stability of the circuit as a whole.

Buffer amplifier

In Q5, a MOSEFT using very little feedback minimizes the effects of load variation, and the necessary LO output of 400 mV of the main unit is obtained.

Local oscillator
The overtone oscillator in Q7 is provided to reduce spurious signals resulting from multiplication of the fundamental oscillator. L6 is provided in series with the crystal to facilitate frequency adjustment. L5, which is connected to the collector, is tuned to a frequency that is three (3) times the overtone oscillator output, giving a frequency of 133.69 MHz.

Frequency converter
Balanced mixer 1C4 is a voltage regulator and a differential amplifier. A portion of the buffer amplifier output is fed to the voltage regulator portion of 1C4 and input to the differential amplifier is the local oscillator output. This is fed through U to balance the transformation of pulses. Using this frequency conversion technique employing the MHz signal insures the elimination of spurious signals in the PLL output.

Low pass ***filter***
The Heterodyning process in various frequencies being present at the output of ICC4, but the LPF passes only the frequencies of 6 MHz or lower.

Limiting amplifier
Since the level of the LPF output is small, a broad band amplifier ICS consisting of 3 differential amplifier stages is provided to amplify these signals. The interface with the divide by two circuit is transistor Q6.

Divide by two
Since maximum operating frequency of ICI is low, ½ of 1C6, whose operating frequency is high, divides the Q6 output frequency by 2, to give signals of approximately 3 MHz or less which are supplied to the programmable divider.

Programmable divider
IC! divides the 1C6 output using a frequency division ratio determined by the program set by the diode matrix.

This IC operates in binary and the maximum dividing ratio is 255. Because of this circuit's action, lock is not released when VCO free-running oscillations are at the upper frequency limit. At the low frequency limit, lock-up is terminated when the frequency of the VCO is lower than a value equal to the local oscillator frequency plus N times the reference frequencies. When power is connected, the transient voltage of the differentiating circuit defined by C24, R2 is passed through D2, and potential at the varicap diode temporarily goes to a high value. As this voltage falls, and the value set by the programmable divider N is entered, D2 is reverse-biased, and in normal conditions is off. By putting D4 in parallel to R12 the charge on C4 is discharged quickly when power is switched off, and when power is connected again the lock circuit is reset.

Diode Matrix
This is a binary code, read only memory, defining a frequency as a binary number. This matrix determines the frequency dividing ratio (N) to be employed by the programmable divider in order to obtain the frequency required in response to activation of each of the 22 switch positions.
See diode matrix charts

Reference oscillator divider
IC3 is an IC used to produce the reference frequency for the synthesizer, and includes a quartz crystal oscillator and a 12-stage high speed divider. The oscillator produces 7.68 MHz oscillations which the high-speed divider section divides by 1024 to give the 7.5 kHz reference pulses.

Phase detection loop filter
IC2 is a phase detector for the frequency synthesizer and is made up of a digital phase comparator and an amplifier for the active low-pass filter. Reference pulses from 1C3 are supplied to IC2 Pin 7 and divided pulses from ICl to 1C2 Pin 8, and the digital phase comparator produces output which is proportional to the difference in phase of these inputs, and is taken out at 1C2 Pin 3. Damping factor of this output is set at 0.6. Lock-up time is set to 50 msec, 25% overshoot by a lag-lead filter consisting of R9, R10, R8, C10 and the filter amplifier in 1C2.

If the divider output frequency becomes higher than the reference frequency, output voltage of the lag-lead filter becomes low and the VCO frequency is lowered. When the divider output frequency becomes low, circuit action is the reverse, and the VCO synchronizes the output with the reference frequency.

Lock indication circuit, transmission termination circuit
At 1C2 Pin 4 there is a pulse output which is equal to VCC of Pin 5 when reference pulses and divider output have the same frequency. When these inputs to 1C2 are not phase locked they have a width proportional to the phase difference of the inputs. Pin 4 output pulses are integrated by R7, C8, and when the integrated value obtained exceeds the junction potential of Q4, Q4 conducts and Qi of the next stage also is turned on.

Transmission is terminated when current flowing through Dl connected to the Qi collector causes base voltage of main unit Q32 to be lowered and the lock is released. As the transmit 9V supply comes down, the signal lamp lights during transmission to indicate that lock-up is no longer in effect. When Q2 base bias disappears, the meter lamp goes out both for transmit and receive and, together with the signal lamp, indicates that lock is not present.

Ripple filter
The ripple filter, Q3, acts to further smooth the 9V supply and so protect the VCO phase comparator and loop filter against voltage variations and improve stability.

Lock start circuit
When PLL lock is applied, the upper frequency limit is determined mainly by the operating frequency of the divider ½ 1C6, and the VCO filter L7 is set so that oscillation is at this upper limit when loop filter output is at maximum.

LO switching circuit
1st LO output from PLL is supplied to J1 and J2. While receiving, forward bias passes through RiO, L43, R155, and flows through Dl5. D15 is switched on so the 1st LO is directed to L43.

Similarly, during transmit, forward current passes through R96, R155, flows through in D16, which is switched on and 1st LO is supplied to 1C3.

Power supply

Reverse connection protection circuit

If power with the wrong polarity is applied, D28 is forward biased and there is, therefore, a large current flow which blows the fuse provided on the external lead, preventing damage to circuit elements.

Power supply circuit, stand-by circuit

The constant 9 V supply appears as regulated voltage at the anode of D20 due to the action of the clamp circuit of R142, D20, and zener diode D21. This voltage is sent by the emitter-follower circuit Q3i and supplied to the PLL, IDC circuit, reception AF circuit, and the low pass filter group.

Similarly, 9 V for reception is taken from the clamp circuit of R147, D27, and D21 by Q34 in an emitter-follower configuration. This voltage is supplied to the RF, IF, 2nd LO and noise amplification circuits.

The 9 V for transmit is similarly taken from emitter-follower circuit Q32 from the clamp circuit constituted by Ri43, D22, D21, and is supplied to the IDC, 10.7 MHz oscillator, transmission mixer, inter-stage amplifier, and bias circuits.

The 13.8 V supply is supplied to the ALC DC amplifier, exciting amplifier, power amplifier, and IC2.

In the stand-by mode, when the PTT switch is switched off, D24 and D26 are both non-conductive and +9 V for reception is obtained. Since D25 also is switched off, Q33 conducts due to bias established by R145. The base of Q32 is connected to ground through D3, and transmit voltage ceases.

When the PU switch is switched on, the base of Q34 is connected to ground through D26 and the 9 V receive supply dies. D24 connected to the emitter of Q34 is used for effecting rapid discharge of the electrolytic condenser connected to the 9 V receive supply line. Q33 becomes non-conductive since its base is connected to ground through D2 5, and 9 V for transmit is obtained.

SECTION VII
Charts

Diode Matrix Chart

Freq.	"N"	+Offset	-Offset	D7	D6	D5	D4	D3	D2	D1	D0
144.390	0	144.990	143.790	0	0	0	0	0	0	0	0
144.405	1	145.005	143.805	0	0	0	0	0	0	0	1
144.420	2	145.020	143.820	0	0	0	0	0	0	1	0
144.435	3	145.035	143.835	0	0	0	0	0	0	1	1
144.450	4	145.050	143.850	0	0	0	0	0	1	0	0
144.465	5	145.065	143.865	0	0	0	0	0	1	0	1
144.480	6	145.080	143.880	0	0	0	0	0	1	1	0
144.495	7	145.095	143.895	0	0	0	0	0	1	1	1
144.510	8	145.110	143.910	0	0	0	0	1	0	0	0
144.525	9	145.125	143.925	0	0	0	0	1	0	0	1
144.540	10	145.140	143.940	0	0	0	0	1	0	1	0
144.555	11	145.155	143.955	0	0	0	0	1	0	1	1
144.570	12	145.170	143.970	0	0	0	0	1	1	0	0
144.585	13	145.185	143.985	0	0	0	0	1	1	0	1
144.600	14	145.200	144.000	0	0	0	0	1	1	1	0
144.615	15	145.215	144.015	0	0	0	0	1	1	1	1
144.630	16	145.230	144.030	0	0	0	1	0	0	0	0
144.645	17	145.245	144.045	0	0	0	1	0	0	0	1
144.660	18	145.260	144.060	0	0	0	1	0	0	1	0
144.675	19	145.275	144.075	0	0	0	1	0	0	1	1
144.690	20	145.290	144.090	0	0	0	1	0	1	0	0
144.705	21	145.305	144.105	0	0	0	1	0	1	0	1
144.720	22	145.320	144.120	0	0	0	1	0	1	1	0
144.735	23	145.335	144.135	0	0	0	1	0	1	1	1
144.750	24	145.350	144.150	0	0	0	1	1	0	0	0
144.765	25	145.365	144.165	0	0	0	1	1	0	0	1
144.780	26	145.380	144.180	0	0	0	1	1	0	1	0
144.795	27	145.395	144.195	0	0	0	1	1	0	1	1
144.810	28	145.410	144.210	0	0	0	1	1	1	0	0
144.825	29	145.425	144.225	0	0	0	1	1	1	0	1
144.840	30	145.440	144.240	0	0	0	1	1	1	1	0
144.855	31	145.455	144.255	0	0	0	1	1	1	1	1
144.870	32	145.470	144.270	0	0	1	0	0	0	0	0
144.885	33	145.485	144.285	0	0	1	0	0	0	0	1
144.900	34	145.500	144.300	0	0	1	0	0	0	1	0
144.915	35	145.515	144.315	0	0	1	0	0	0	1	1
144.930	36	145.530	144.330	0	0	1	0	0	1	0	0
144.945	37	145.545	144.345	0	0	1	0	0	1	0	1
144.960	38	145.560	144.360	0	0	1	0	0	1	1	0
144.975	39	145.575	144.375	0	0	1	0	0	1	1	1
144.990	40	145.590	144.390	0	0	1	0	1	0	0	0
145.005	41	145.605	144.405	0	0	1	0	1	0	0	1

Freq.	"N"	+Offset	-Offset	D7	D6	D5	D4	D3	D2	D1	D0
145.020	42	145.620	144.420	0	0	1	0	1	0	1	0
145.035	43	145.635	144.435	0	0	1	0	1	0	1	1
145.050	44	145.650	144.450	0	0	1	0	1	1	0	0
145.065	45	145.665	144.465	0	0	1	0	1	1	0	1
145.080	46	145.680	144.480	0	0	1	0	1	1	1	0
145.095	47	145.695	144.495	0	0	1	0	1	1	1	1
145.110	48	145.710	144.510	0	0	1	1	0	0	0	0
145.125	49	145.725	144.525	0	0	1	1	0	0	0	1
145.140	50	145.740	144.540	0	0	1	1	0	0	1	0
145.155	51	145.755	144.555	0	0	1	1	0	0	1	1
145.170	52	145.770	144.570	0	0	1	1	0	1	0	0
145.185	53	145.785	144.585	0	0	1	1	0	1	0	1
145.200	54	145.800	144.600	0	0	1	1	0	1	1	0
145.215	55	145.815	144.615	0	0	1	1	0	1	1	1
145.230	56	145.830	144.630	0	0	1	1	1	0	0	0
145.245	57	145.845	144.645	0	0	1	1	1	0	0	1
145.260	58	145.860	144.660	0	0	1	1	1	0	1	0
145.275	59	145.875	144.675	0	0	1	1	1	0	1	1
145.290	60	145.890	144.690	0	0	1	1	1	1	0	0
145.305	61	145.905	144.705	0	0	1	1	1	1	0	1
145.320	62	145.920	144.720	0	0	1	1	1	1	1	0
145.335	63	145.935	144.735	0	0	1	1	1	1	1	1
145.335	63	145.935	144.735	0	0	1	1	1	1	1	1
145.350	64	145.950	144.750	0	1	0	0	0	0	0	0
145.365	65	145.965	144.765	0	1	0	0	0	0	0	1
145.380	66	145.980	144.780	0	1	0	0	0	0	1	0
145.395	67	145.995	144.795	0	1	0	0	0	0	1	1
145.410	68	146.010	144.810	0	1	0	0	0	1	0	0
145.425	69	146.025	144.825	0	1	0	0	0	1	0	1
145.440	70	146.040	144.840	0	1	0	0	0	1	1	0
145.455	71	146.055	144.855	0	1	0	0	0	1	1	1
145.470	72	146.070	144.870	0	1	0	0	1	0	0	0
145.485	73	146.085	144.885	0	1	0	0	1	0	0	1
145.500	74	146.100	144.900	0	1	0	0	1	0	1	0
145.515	75	146.115	144.915	0	1	0	0	1	0	1	1
145.530	76	146.130	144.930	0	1	0	0	1	1	0	0
145.545	77	146.145	144.945	0	1	0	0	1	1	0	1
145.560	78	146.160	144.960	0	1	0	0	1	1	1	0
145.575	79	146.175	144.975	0	1	0	0	1	1	1	1
145.590	80	146.190	144.990	0	1	0	1	0	0	0	0
145.605	81	146.205	145.005	0	1	0	1	0	0	0	1
145.620	82	146.220	145.020	0	1	0	1	0	0	1	0
145.635	83	146.235	145.035	0	1	0	1	0	0	1	1
145.650	84	146.250	145.050	0	1	0	1	0	1	0	0
145.665	85	146.265	145.065	0	1	0	1	0	1	0	1
145.680	86	146.280	145.080	0	1	0	1	0	1	1	0
145.695	87	146.295	145.095	0	1	0	1	0	1	1	1

Freq.	"N"	+Offset	-Offset	D7	D6	D5	D4	D3	D2	D1	D0
145.710	88	146.310	145.110	0	1	0	1	1	0	0	0
145.725	89	146.325	145.125	0	1	0	1	1	0	0	1
145.740	90	146.340	145.140	0	1	0	1	1	0	1	0
145.755	91	146.355	145.155	0	1	0	1	1	0	1	1
145.770	92	146.370	145.170	0	1	0	1	1	1	0	0
145.785	93	146.385	145.185	0	1	0	1	1	1	0	1
145.800	94	146.400	145.200	0	1	0	1	1	1	1	0
145.815	95	146.415	145.215	0	1	0	1	1	1	1	1
145.815	95	146.415	145.215	0	1	0	1	1	1	1	1
145.830	96	146.430	145.230	0	1	1	0	0	0	0	0
145.845	97	146.445	145.245	0	1	1	0	0	0	0	1
145.860	98	146.460	145.260	0	1	1	0	0	0	1	0
145.875	99	146.475	145.275	0	1	1	0	0	0	1	1
145.890	100	146.490	145.290	0	1	1	0	0	1	0	0
145.905	101	146.505	145.305	0	1	1	0	0	1	0	1
145.920	102	146.520	145.320	0	1	1	0	0	1	1	0
145.935	103	146.535	145.335	0	1	1	0	0	1	1	1
145.950	104	146.550	145.350	0	1	1	0	1	0	0	0
145.965	105	146.565	145.365	0	1	1	0	1	0	0	1
145.980	106	146.580	145.380	0	1	1	0	1	0	1	0
145.995	107	146.595	145.395	0	1	1	0	1	0	1	1
146.010	108	146.610	145.410	0	1	1	0	1	1	0	0
146.025	109	146.625	145.425	0	1	1	0	1	1	0	1
146.040	110	146.640	145.440	0	1	1	0	1	1	1	0
146.055	111	146.655	145.455	0	1	1	0	1	1	1	1
146.070	112	146.670	145.470	0	1	1	1	0	0	0	0
146.085	113	146.685	145.485	0	1	1	1	0	0	0	1
146.100	114	146.700	145.500	0	1	1	1	0	0	1	0
146.115	115	146.715	145.515	0	1	1	1	0	0	1	1
146.130	116	146.730	145.530	0	1	1	1	0	1	0	0
146.145	117	146.745	145.545	0	1	1	1	0	1	0	1
146.160	118	146.760	145.560	0	1	1	1	0	1	1	0
146.175	119	146.775	145.575	0	1	1	1	0	1	1	1
146.190	120	146.790	145.590	0	1	1	1	1	0	0	0
146.205	121	146.805	145.605	0	1	1	1	1	0	0	1
146.220	122	146.820	145.620	0	1	1	1	1	0	1	0
146.235	123	146.835	145.635	0	1	1	1	1	0	1	1
146.250	124	146.850	145.650	0	1	1	1	1	1	0	0
146.265	125	146.865	145.665	0	1	1	1	1	1	0	1
146.280	126	146.880	145.680	0	1	1	1	1	1	1	0
146.295	127	146.895	145.695	0	1	1	1	1	1	1	1
146.310	128	146.910	145.710	1	0	0	0	0	0	0	0
146.325	129	146.925	145.725	1	0	0	0	0	0	0	1
146.340	130	146.940	145.740	1	0	0	0	0	0	1	0
146.355	131	146.955	145.755	1	0	0	0	0	0	1	1
146.370	132	146.970	145.770	1	0	0	0	0	1	0	0
146.385	133	146.985	145.785	1	0	0	0	0	1	0	1

Freq.	"N"	+Offset	-Offset	D7	D6	D5	D4	D3	D2	D1	D0
146.400	134	147.000	145.800	1	0	0	0	0	1	1	0
146.415	135	147.015	145.815	1	0	0	0	0	1	1	1
146.430	136	147.030	145.830	1	0	0	0	1	0	0	0
146.445	137	147.045	145.845	1	0	0	0	1	0	0	1
146.460	138	147.060	145.860	1	0	0	0	1	0	1	0
146.475	139	147.075	145.875	1	0	0	0	1	0	1	1
146.490	140	147.090	145.890	1	0	0	0	1	1	0	0
146.505	141	147.105	145.905	1	0	0	0	1	1	0	1
146.520	142	147.120	145.920	1	0	0	0	1	1	1	0
146.535	143	147.135	145.935	1	0	0	0	1	1	1	1
146.550	144	147.150	145.950	1	0	0	1	0	0	0	0
146.565	145	147.165	145.965	1	0	0	1	0	0	0	1
146.580	146	147.180	145.980	1	0	0	1	0	0	1	0
146.595	147	147.195	145.995	1	0	0	1	0	0	1	1
146.610	148	147.210	146.010	1	0	0	1	0	1	0	0
146.625	149	147.225	146.025	1	0	0	1	0	1	0	1
146.640	150	147.240	146.040	1	0	0	1	0	1	1	0
146.655	151	147.255	146.055	1	0	0	1	0	1	1	1
146.670	152	147.270	146.070	1	0	0	1	1	0	0	0
146.685	153	147.285	146.085	1	0	0	1	1	0	0	1
146.700	154	147.300	146.100	1	0	0	1	1	0	1	0
146.715	155	147.315	146.115	1	0	0	1	1	0	1	1
146.730	156	147.330	146.130	1	0	0	1	1	1	0	0
146.745	157	147.345	146.145	1	0	0	1	1	1	0	1
146.760	158	147.360	146.160	1	0	0	1	1	1	1	0
146.775	159	147.375	146.175	1	0	0	1	1	1	1	1
146.775	159	147.375	146.175	1	0	0	1	1	1	1	1
146.790	160	147.390	146.190	1	0	1	0	0	0	0	0
146.805	161	147.405	146.205	1	0	1	0	0	0	0	1
146.820	162	147.420	146.220	1	0	1	0	0	0	1	0
146.835	163	147.435	146.235	1	0	1	0	0	0	1	1
146.850	164	147.450	146.250	1	0	1	0	0	1	0	0
146.865	165	147.465	146.265	1	0	1	0	0	1	0	1
146.880	166	147.480	146.280	1	0	1	0	0	1	1	0
146.895	167	147.495	146.295	1	0	1	0	0	1	1	1
146.910	168	147.510	146.310	1	0	1	0	1	0	0	0
146.925	169	147.525	146.325	1	0	1	0	1	0	0	1
146.940	170	147.540	146.340	1	0	1	0	1	0	1	0
146.955	171	147.555	146.355	1	0	1	0	1	0	1	1
146.970	172	147.570	146.370	1	0	1	0	1	1	0	0
146.985	173	147.585	146.385	1	0	1	0	1	1	0	1
147.000	174	147.600	146.400	1	0	1	0	1	1	1	0
147.015	175	147.615	146.415	1	0	1	0	1	1	1	1
147.030	176	147.630	146.430	1	0	1	1	0	0	0	0
147.045	177	147.645	146.445	1	0	1	1	0	0	0	1
147.060	178	147.660	146.460	1	0	1	1	0	0	1	0
147.075	179	147.675	146.475	1	0	1	1	0	0	1	1

Freq.	"N"	+Offset	-Offset	D7	D6	D5	D4	D3	D2	D1	D0
147.090	180	147.690	146.490	1	0	1	1	0	1	0	0
147.105	181	147.705	146.505	1	0	1	1	0	1	0	1
147.120	182	147.720	146.520	1	0	1	1	0	1	1	0
147.135	183	147.735	146.535	1	0	1	1	0	1	1	1
147.150	184	147.750	146.550	1	0	1	1	1	0	0	0
147.165	185	147.765	146.565	1	0	1	1	1	0	0	1
147.180	186	147.780	146.580	1	0	1	1	1	0	1	0
147.195	187	147.795	146.595	1	0	1	1	1	0	1	1
147.210	188	147.810	146.610	1	0	1	1	1	1	0	0
147.225	189	147.825	146.625	1	0	1	1	1	1	0	1
147.240	190	147.840	146.640	1	0	1	1	1	1	1	0
147.255	191	147.855	146.655	1	0	1	1	1	1	1	1
147.255	191	147.855	146.655	1	0	1	1	1	1	1	1
147.270	192	147.870	146.670	1	1	0	0	0	0	0	0
147.285	193	147.885	146.685	1	1	0	0	0	0	0	1
147.300	194	147.900	146.700	1	1	0	0	0	0	1	0
147.315	195	147.915	146.715	1	1	0	0	0	0	1	1
147.330	196	147.930	146.730	1	1	0	0	0	1	0	0
147.345	197	147.945	146.745	1	1	0	0	0	1	0	1
147.360	198	147.960	146.760	1	1	0	0	0	1	1	0
147.375	199	147.975	146.775	1	1	0	0	0	1	1	1
147.390	200	147.990	146.790	1	1	0	0	1	0	0	0
147.405	201	148.005	146.805	1	1	0	0	1	0	0	1
147.420	202	148.020	146.820	1	1	0	0	1	0	1	0
147.435	203	148.035	146.835	1	1	0	0	1	0	1	1
147.450	204	148.050	146.850	1	1	0	0	1	1	0	0
147.465	205	148.065	146.865	1	1	0	0	1	1	0	1
147.480	206	148.080	146.880	1	1	0	0	1	1	1	0
147.495	207	148.095	146.895	1	1	0	0	1	1	1	1
147.510	208	148.110	146.910	1	1	0	1	0	0	0	0
147.525	209	148.125	146.925	1	1	0	1	0	0	0	1
147.540	210	148.140	146.940	1	1	0	1	0	0	1	0
147.555	211	148.155	146.955	1	1	0	1	0	0	1	1
147.570	212	148.170	146.970	1	1	0	1	0	1	0	0
147.585	213	148.185	146.985	1	1	0	1	0	1	0	1
147.600	214	148.200	147.000	1	1	0	1	0	1	1	0
147.615	215	148.215	147.015	1	1	0	1	0	1	1	1
147.630	216	148.230	147.030	1	1	0	1	1	0	0	0
147.645	217	148.245	147.045	1	1	0	1	1	0	0	1
147.660	218	148.260	147.060	1	1	0	1	1	0	1	0
147.675	219	148.275	147.075	1	1	0	1	1	0	1	1
147.690	220	148.290	147.090	1	1	0	1	1	1	0	0
147.705	221	148.305	147.105	1	1	0	1	1	1	0	1
147.720	222	148.320	147.120	1	1	0	1	1	1	1	0
147.735	223	148.335	147.135	1	1	0	1	1	1	1	1
147.735	223	148.335	147.135	1	1	0	1	1	1	1	1
147.750	224	148.350	147.150	1	1	1	0	0	0	0	0

Freq.	"N"	+Offset	-Offset	D7	D6	D5	D4	D3	D2	D1	D0
147.765	225	148.365	147.165	1	1	1	0	0	0	0	1
147.780	226	148.380	147.180	1	1	1	0	0	0	1	0
147.795	227	148.395	147.195	1	1	1	0	0	0	1	1
147.810	228	148.410	147.210	1	1	1	0	0	1	0	0
147.825	229	148.425	147.225	1	1	1	0	0	1	0	1
147.840	230	148.440	147.240	1	1	1	0	0	1	1	0
147.855	231	148.455	147.255	1	1	1	0	0	1	1	1
147.870	232	148.470	147.270	1	1	1	0	1	0	0	0
147.885	233	148.485	147.285	1	1	1	0	1	0	0	1
147.900	234	148.500	147.300	1	1	1	0	1	0	1	0
147.915	235	148.515	147.315	1	1	1	0	1	0	1	1
147.930	236	148.530	147.330	1	1	1	0	1	1	0	0
147.945	237	148.545	147.345	1	1	1	0	1	1	0	1
147.960	238	148.560	147.360	1	1	1	0	1	1	1	0
147.975	239	148.575	147.375	1	1	1	0	1	1	1	1
147.990	240	148.590	147.390	1	1	1	1	0	0	0	0
148.005	241	148.605	147.405	1	1	1	1	0	0	0	1
148.020	242	148.620	147.420	1	1	1	1	0	0	1	0
148.035	243	148.635	147.435	1	1	1	1	0	0	1	1
148.050	244	148.650	147.450	1	1	1	1	0	1	0	0
148.065	245	148.665	147.465	1	1	1	1	0	1	0	1
148.080	246	148.680	147.480	1	1	1	1	0	1	1	0
148.095	247	148.695	147.495	1	1	1	1	0	1	1	1
148.110	248	148.710	147.510	1	1	1	1	1	0	0	0
148.125	249	148.725	147.525	1	1	1	1	1	0	0	1
148.140	250	148.740	147.540	1	1	1	1	1	0	1	0
148.155	251	148.755	147.555	1	1	1	1	1	0	1	1
148.170	252	148.770	147.570	1	1	1	1	1	1	0	0
148.185	253	148.785	147.585	1	1	1	1	1	1	0	1
148.200	254	148.800	147.600	1	1	1	1	1	1	1	0
148.215	255	148.815	147.615	1	1	1	1	1	1	1	1

Voltage Chart

Part	Transmit				Receive				Comments
	Base Gate 1	Gate 2	Collector Drain	Emitter Source	Base Gate 1	Gate 2	Collector Or Drain	Emitter Source	
Q1	0.20V		-25.0V	0.26V	8.2V		6.8V	8.2V	
Q2					0	4.3V	8.1V	0.24V	
Q3					0	0	9.1V	E	
Q4					0		8.0V	1.3V	
Q5					1.85V		9.6V	1.7V	
Q6					0.67V		2.45V	E	
Q7					5.0V		6.6V	4.7V	
Q8	0.00V		9.60V	0.00V	1.35V		5.1V	1.0V	Squelch Open
Q9					2.4V		9.3V	3.2V	
Q10	5.90V		9.60V	5.50V	6.1V		9.7V	5.7V	
Q11	0.05V		13.80V	E	0.75V		0.35V	E	Squelch Closed
Q12	0.65V		0.75V	E	0		8.0V	E	
Q13					1.35V		5.8V	0.8V	
Q14					1.35V		9.4V	0.75V	
Q15	0.26V		12.9V	0.90V	0		13.5V	0.7V	
Q16	12.9V		6.60V	13.70V	13.5V		13.8V	13.8V	
Q17	-0.125V		13.70V	E	0		13.8V	E	
Q18	-0.4V		13.70V	E			13.8V	E	
Q19	0.85V		7.20V	0.18V			13.8V	0	
Q20	0.02V		0.95V	E					
Q21	0.60V		0.26V	9.70V					
Q22	0.00V	4.60V	8.40V	0.26V					
Q24	4.70V		9.70V	4.20V					
Q25	5.70V		9.60V	5.40V			9.6V	5.4V	
Q26	0.70V		1.65V	"E"			1.65V	E	
Q27	0.65V		0.70V	"E"			0.70V	E	
Q28	0.55V		0.65V	"E"			0.65V	E	
Q29	0.83V		7.70V	8.80V			7.7V	8.8V	
Q30	0.84V		8.10V	7.9V			8.1V	7.9V	
Q31	10.30V		12.60V	9.7V			12.7V	9.7V	
Q32	10.30V		12.90V	9.7V			13.8V	0.35V	
Q33	0.75V		10.30V	0.26V			0.85V	0.85V	
Q34	0.85V		13.70V	0.26V			12.9V	9.7V	