INSTRUCTION MANUAL

FT-221R

YAESU MUSEN CO., LTD.

TOKYO JAPAN

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This manual is revised for the units produced starting with Lot No. 011 and the lots produced subsequently.

FT-221R VHF TRANSCEIVER

GENERAL DESCRIPTION

The model FT-221R two meter transceiver is a precision built, compact, high performance transceiver of advanced design, providing all mode operation: SSB (LSB or USB selectable), AM, CW and FM with repeater offset capability. Advanced PLL (Phase-Lock Loop) circuitry offers unsurpassed stability and clean, spurious free signals. The transceiver operates at an input of 20 watts on 144 through 148 MHz, in eight 500 kHz segments permitting 1 kHz accurate dial readout. All circuits are fully transistorized and computor type plug-in modules are used for increased reliability and service ability.

Adoption of pre-set passband tuning and wide band amplifier techniques, provide the optimum selectivity and performance needed on today's active 2 meter band.

The transceiver is self contained, requiring only an antenna and power source for home, portable or mobile operation. The transceiver may be operated from 100/110/117/200/220 or 234 volt AC when the power transformer is appropriately wired. The FT-221 is normally supplied for 117 volt AC and 12 volt DC operation. Two power cords are supplied with the transceiver. Selection of AC or DC operation is automatically made when the proper line cord plug is inserted into the receptacle on the rear panel.

Deluxe features such as VOX, break-in CW with side tone, 100 kHz calibrator, noise blanker and squelch are built-in. In addition to continuous VFO coverage, 88 crystal-controlled channels (11 channels x 8 bands = 88 channels), clarifier and speaker are all integral parts of the unit. For "tone burst" actuated repeater operation, an adjustable "tone burst" generator with automatic tone actuation circuit (patent pending) is included.

The entire transceiver weighs approximately 8.5 kg, and is 280 m/m wide, 125 m/m high, and 295 m/m deep. Construction of heavy-gage steel provides an extremely rugged package, virtually immune to the effects of vibration and shock encountered in rugged mobile service.

SPECIFICATIONS

GENERAL

Frequency Range:

144.0 ~ 144.5 MHz
144.5 ~ 145.0 MHz
145.0 ~ 145.5 MHz
145.5 ~ 146.0 MHz
146.0 ~ 146.5 MHz
146.5 ~ 147.0 MHz
147.0 ~ 147.5 MHz
147.5 ~ 148.0 MHz

Frequency Readout:

Better than 1 kHz

Emission:

SSB (LSB or USB selectable), AM, FM and CW.

Power Output:

SSB	12 Watts PEP
FM, CW	14 Watts
AM	2.5 Watts

Frequency Stability:

Within 100 Hz during any 30 minute period after warm up. Not more than 20 Hz with a 10% line voltage variation.

Antenna Impedance:

50 ohms unbalanced

Repeater Burst Signal:

1500 to 2000 Hz adjustable

Repeater Split

600 kHz and any frequency up to 1 MHz

Power Requirement:

AC 100/110/117/200/220/234 volts
50/60 Hz
DC +12 ~ 14.5 Volts, negative ground

Power Consumption:

AC	Receive	30VA
	Transmit	90VA at 10 watts output
DC	Receive	0.6A
	Transmit	3A at 10 watts output

Size:

280 (W) x 125 (H) x 295 (D) m/m

Weight:

Approx. 8.5 kg

RECEIVER

Sensitivity:

SSB/CW	0.5 μV for 10 dB S/N
FM	0.75 μV for 20 dB QS
AM	1.0 μV for 10 dB S/N

Selectivity:

SSB/CW/AM	2.4 kHz at 6 dB
	4.1 kHz at 60 dB
FM	±6 kHz at 6 dB
	±12 kHz at 60 dB

Image Ratio:

Better than - 60 dB

Spurious Response:

Better than 1 μV at antenna input

Speaker Impedance:

4 ohms

Audio Output:

2 Watts at 10% distortion

TRANSMITTER

Audio Response:

300 ~ 2700 Hz ±3 dB

Carrier Suppression:

40 dB or better

Unwanted Sideband Suppression:

40 dB or better at 1 kHz

Spurious Radiation:

Down 60 dB or better

FM Deviation:

Maximum 12 kHz: Factory set at ±5 kHz

SEMICONDUCTOR COMPLEMENT

Transistors:

2SD114	1	2SC735Y	3
2SD313D	3	2SC711	1
2SC372Y	37	2SA695	1
2SC784R	5	2SD359	1
2SC373	3	2SB529	1
MPSA13	1	2SC1000GR	2
2SC741	1	2N5590	1
2SC730	1	2N5591	1

FETs:

2SK19GR	16	3SK51	1
2SK19Y	2		

Integrated Circuits:

μA703HC	2	TP4011AN	6
LD3001	2	34024PC	1
TA7061AP	1	TA7045M	1
TP4049AN	1	TP4027AN	1

Programmable Unijunction Transistor:

N13T1	1

Diodes:

DS-130YD	1	WZ-110	2
1S1555	57	1N4740	1
10D1	7	GD-1	1
M4B-5	1	RD-1	1
1S188FM	13	TLR-108	1
1S1007	12	1SV50	3
WZ-061	2	1S2209	12
WZ-090	1	FC-63	1

Thyristor:

CW-01B	1

Varistor:

MV-5W	1

The FT-221R is supplied complete with all cables, connectors, fuses and microphone as shown below.

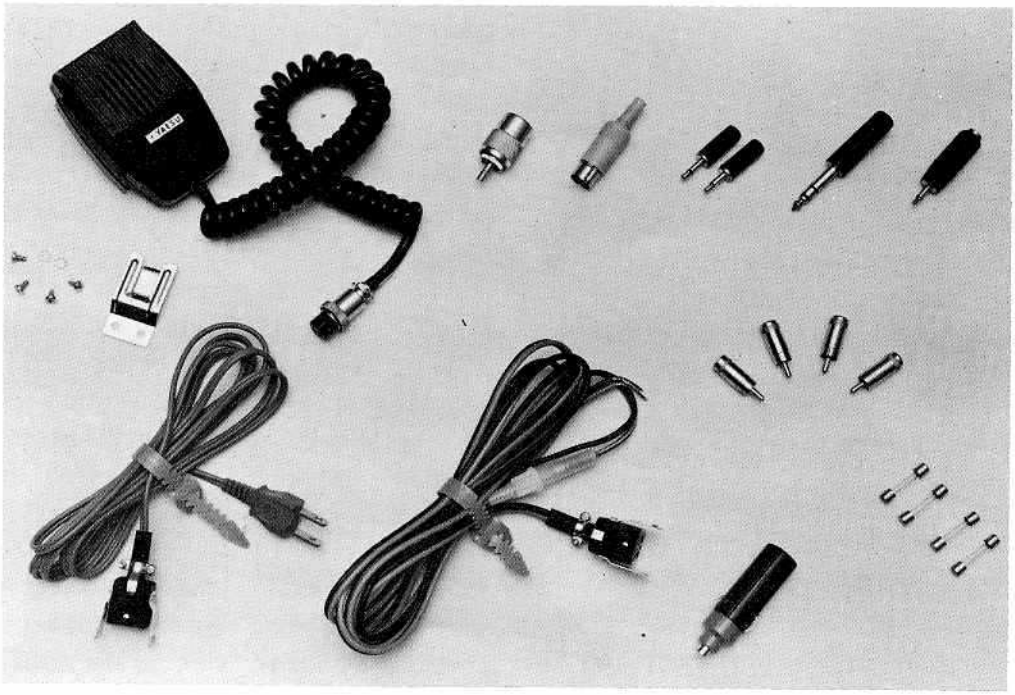


Figure 1

INSTALLATION

GENERAL

The FT-221R transceiver has been designed primarily for base service, requiring only an antenna. However, the transceiver provides for efficient mobile service. The transceiver has been factory pre-tuned and requires no adjustment for normal operation into a matched 50 ohm load.

The antenna and its location are the most important consideration in both base and mobile installations, where effective communication range is directly related to antenna height. The antenna should always be as high and in the clear as possible, and a minimum distance of 5 feet should be maintained between the VHF and other antennas. In a mobile installation, it is advisable to locate the antenna as far from the engine as practical in order to minimize any ignition noise pickup. In all installations, the most popular antenna types are either a 1/4 wave length whip with unity gain or a 5/8 wave length whip with a base matching device affording approximately 3.5 dB gain. Our mobile antenna, RSL-145, is available through your dealer.

To minimize loss in the antenna system, use the shortest length of coaxial cable that is practical, avoiding any sharp angles or kinks. Use type RG-8/U cable if the transmission line length exceeds 25 feet, while RG-58/U may be used for shorter lengths.

BASE STATION INSTALLATION

The transceiver is designed for use in many areas of the world where the supply voltage may differ from the operator's local supply voltage. Therefore, before connecting the AC cord to the power outlet, be sure that the voltage marked on the rear of the transceiver agrees with the local AC supply voltage. If not, please refer to Page 5 for rewiring of the transformer primary connections.

CAUTION

PERMANENT DAMAGE WILL RESULT IF IMPROPER AC SUPPLY VOLTAGE IS APPLIED TO THE TRANSCEIVER. OUR WARRANTY DOES NOT COVER THE DAMAGE CAUSED BY SUCH AN IMPROPER SUPPLY VOLTAGE.

Be sure that a proper fuse is used according to the local supply voltage: 2 amps for 117 volts and 1 amp for 220 volts. The transceiver should be connected to a good ground. The ground lead should be connected to the terminal marked GND located on the rear panel of the transceiver.

It is recommended that excessively warm locations be avoided. The transceiver should be placed in a location that has adequate space to permit free air circulation through the cabinet openings.

MOBILE INSTALLATION

The transceiver will operate satisfactorily from any 12 volt negative ground battery source by connecting the DC power cord to the rear panel receptacle. In the car, a location should be selected that is clear of heater ducts to protect it from excessive heat. No special mounting precautions need to be observed if adequate ventilation space is available. A minimum of two inches air space above the cabinet top and on all sides is recommended to allow proper air flow around the cabinet. You may put it on the seat but be sure that there is clearance between the transceiver bottom and seat. Since the transceiver requires an average of 3 amps on transmit, the fuse in the DC power cable should be rated at 5 amps.

When making connections to the car battery, be certain that the RED lead is connected to the positive (+) terminal and the BLACK lead to the negative (−) terminal of the battery. Reversed connection could permanently damage the transceiver. The BLACK lead should run directly to the negative terminal of the battery. The power cable should be kept away from ignition wires and be as short as possible to minimize voltage drop and to provide a low impedance path from the transceiver to the battery.

Prior to operating the transceiver in a mobile installation, the voltage regulator setting should be checked. In many vehicles, the voltage regulators are very poor and in some cases the regulator may be adjusted for an excessively high charging

voltage. As the battery and regulator age, the maximum voltage while charging can increase to a very high level which is not only detrimental to the battery but could cause damage to the transceiver.

The transceiver is designed to operate from a source voltage range of 11 to 14 volts. It is necessary to carefully set the regulator so that the highest charging voltage does not exceed 14 volts. The transceiver should be switched "OFF" when the vehicle is started in order to prevent voltage transients from damaging the transistors.

It is recommended that the microphone furnished with this transceiver be used, however any other microphone of 500 ~ 600 ohm impedance may be used. Refer to Figure 2 for the microphone plug connections. The microphone bracket may be put on the side of the cabinet. It may also be put at any convenient place by making two 2.5 m/m holes spaced 14 m/m.

A speaker is built into the transceiver, however the audio output is also available for an external speaker use. Any speaker having a 4 ohm impedance may be used and when the external speaker plug is plugged into the EXT SP jack on the rear panel, the built-in speaker is disabled.

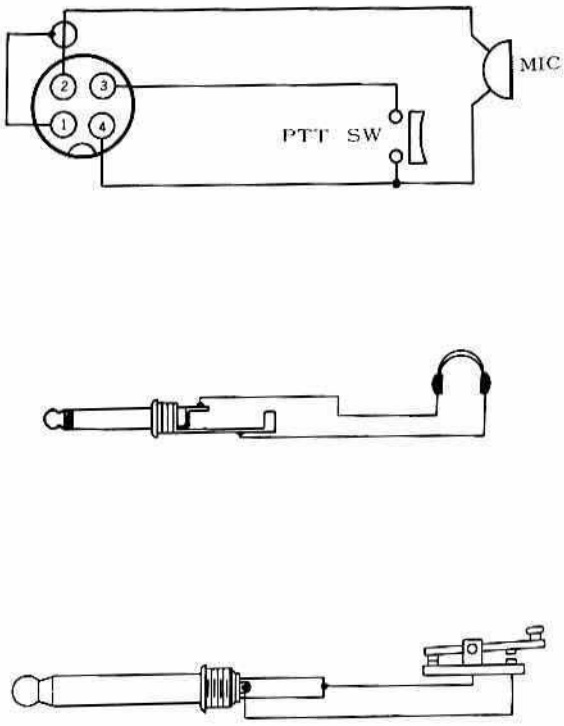


Figure 2: Connection

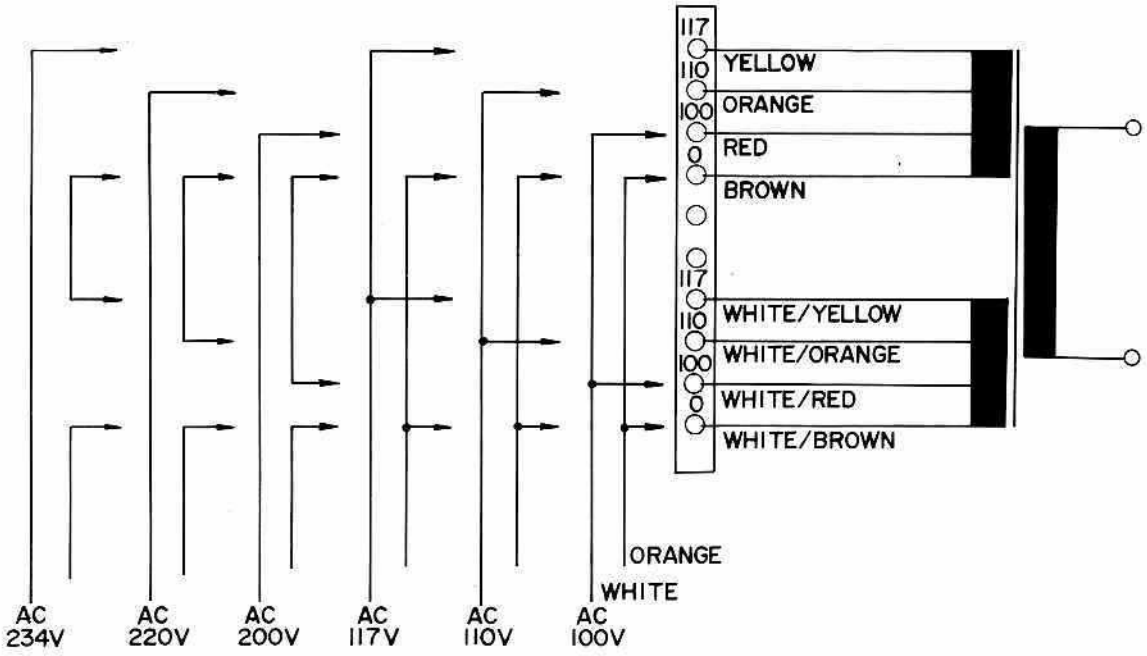


Figure 3: Transformer Primary Wiring

CONTROLS AND SWITCHES

The transceiver has been specifically designed for flexible operation and versatility. All internal controls have been preset at factory. Several of the controls are unusual in operation, and improper adjustment may result in poor quality signals. The various front panel controls and their functions are described in the following section. Be certain that you thoroughly understand the function of each control before operating the transceiver.

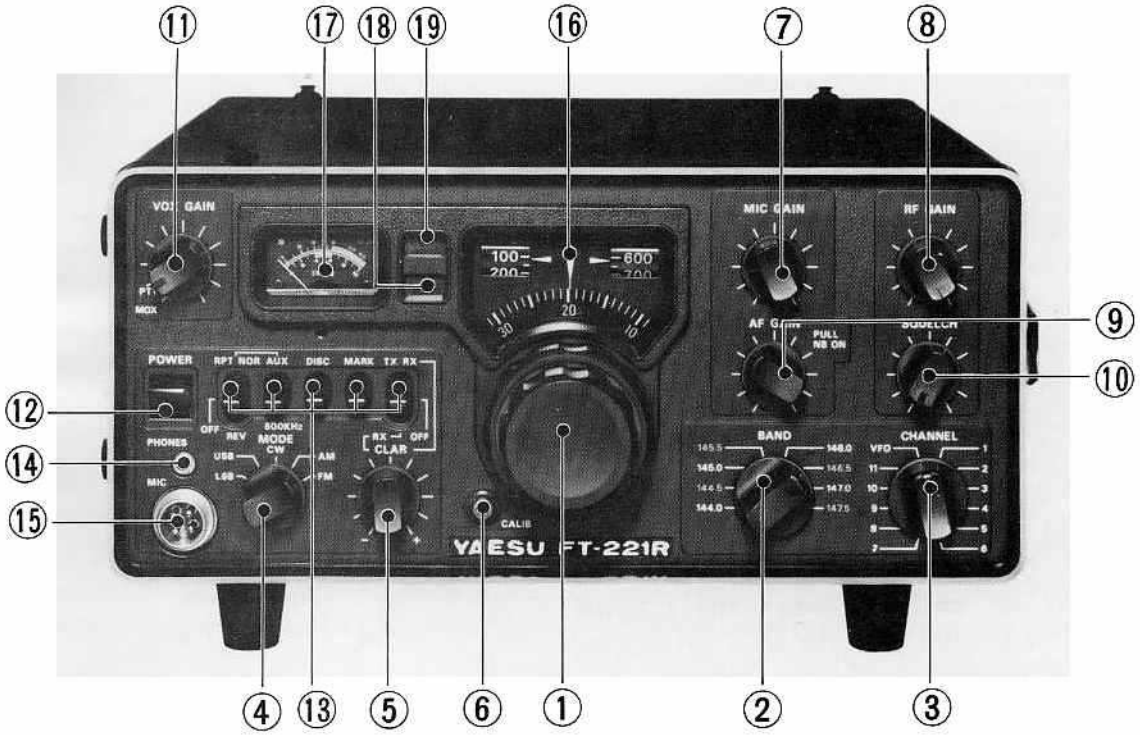


Figure 4 : **Front Panel Controls & Switches**

(1) MAIN TUNING control

The tuning knob, located below the dial window, determines the actual frequency of operation in combination with the BAND switch. A dual rate, concentric dial drive system is employed for a coarse and fine setting of the operating frequency.

(2) BAND switch

The BAND switch is an eight-position switch that selects one of the 500 kHz segments in two meter amateur band.

These segments are:

144.0 : 144.0 ~ 144.5 MHz
144.5 : 144.5 ~ 145.0 MHz
145.0 : 145.0 ~ 145.5 MHz
145.5 : 145.5 ~ 146.0 MHz
146.0 : 146.0 ~ 146.5 MHz
146.5 : 146.5 ~ 147.0 MHz
147.0 : 147.0 ~ 147.5 MHz
147.5 : 147.5 ~ 148.0 MHz

(3) CHANNEL switch

The CHANNEL switch selects one of 11 crystals for crystal controlled operation. This switch also selects the VFO for continuous tuning with the main tuning knob.

(4) MODE switch

The MODE switch is a five-position switch. This switch selects the mode of operation: LSB (lower side band SSB), USB, (upper side band SSB), CW (code operation), AM (amplitude modulation) and FM (frequency modulation).

(5) CLARIFIER control

The CLARIFIER control provides a means of OFF setting the receiver frequency approximately 4 kHz to either side of the transmitting frequency. Thus it is possible to set the pitch of the voice or signal you are receiving to the most readable point without affecting your transmitting frequency. Its

use is particularly valuable in "net" operation when several participants may be transmitting slightly off frequency. The CLARIFIER control may be switched off with CLARIFIER switch and the receiver locked to the transmitting frequency. Normally you will want to keep the CLARIFIER in the OFF position until the initial contact is made. The CLARIFIER switch may also be used to change both transmitting and receiving frequencies simultaneously when the CLARIFIER switch is put in the TX-RX position.

(6) CALIB.

When depressed, this button locks the 1 kHz dial for dial calibration.

(7) MIC GAIN control

The MIC GAIN control varies the audio level from the microphone amplifier stages. The control has sufficient range to permit the use of any 600 ohm dynamic microphone.

(8) RF GAIN control

The RF GAIN control varies the gain of the receiver RF and IF amplifiers. Maximum sensitivity is obtained when the control is set to the fully clockwise position.

(9) AF GAIN control & switch

The AF GAIN control adjusts the audio output level to the speaker and phone jack. Clockwise rotation increases the audio output. When the knob is pulled out, the noise blanker is activated in order to minimize pulse type noises.

(10) SQUELCH control

This control adjusts the receiver squelch threshold level.

(11) VOX GAIN control & switch

This controls the VOX gain and functions for push to talk, stand-by or manual operation.

(12) POWER switch

The POWER switch turns transceiver "ON" and "OFF" for both AC and DC operation.

(13) FUNCTION switches

RPT

This switch is used for repeater operation. In the NOR (normal) position, the transmitter frequency shifts 600 kHz down and in the REV (reverse) position, the receiver frequency shifts 600 kHz up.

AUX/600 kHz

Selects the repeater shift frequency. In the 600 kHz position, the TX or RX frequency shifts 600 kHz with the REPEATER switch ON. Any split within 1 MHz can be installed as option. Refer to Repeater Operation paragraph on Page 12.

DISC

This switch selects the meter to read discriminator center current for FM reception.

MARK

100 kHz calibrator switch.

CLAR

Clarifier switch. Turns the CLARIFIER on in upper position, and off in middle position. In the TX-RX position, the CLARIFIER works for both transmit and receive.

(14) PHONE jack

Phone jack for an external headphones or speaker. The internal speaker is disconnected when the headphone plug is inserted.

(15) MIC jack

The microphone supplied is the recommended one for use with the transceiver, however any microphone having a 500 to 600 ohm impedance may be used.

(16) DIAL

Dial window for frequency readout. The coarse scale indicates 100 kHz increments and fine scale indicates 1 kHz increments.

(17) METER

The meter indicates signal strength, FM discriminator center current in receive and relative power output in transmit.

(18) CLAR lamp

This lamp lights when the CLARIFIER is in use.

(19) RPT lamp

This lamp lights when the repeater switch is ON.

REAR PANEL CONNECTIONS

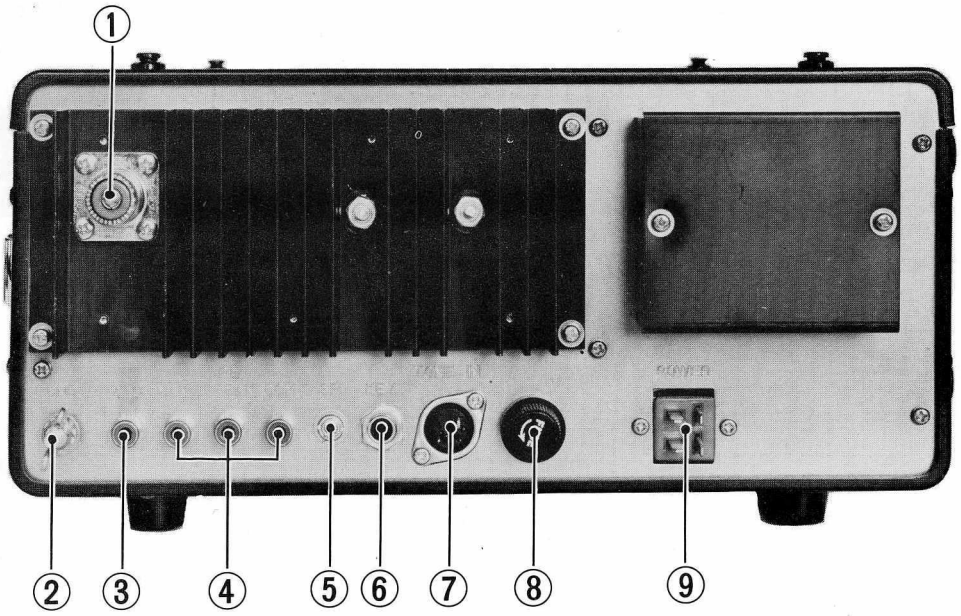


Figure 5 : **Rear Panel Connections**

(1) ANT

Coaxial connector for an antenna.

(2) GND

Ground connection.

(3) ALC

ALC (automatic level control) input.

(4) RL

Relay contacts for the control of external equipment.

(5) SP jack

External speaker audio output.

(6) KEY jack

Key jack for code operation.

(7) TONE-IN

Tone-pad input jack.

(8) FUSE

Fuse holder. For AC operation, a 2 amp fuse is used on 100/117 volts and, a 1 amp fuse on 200/234 volts.

(9) POWER receptacle

Both AC and DC cables are supplied with the transceiver.

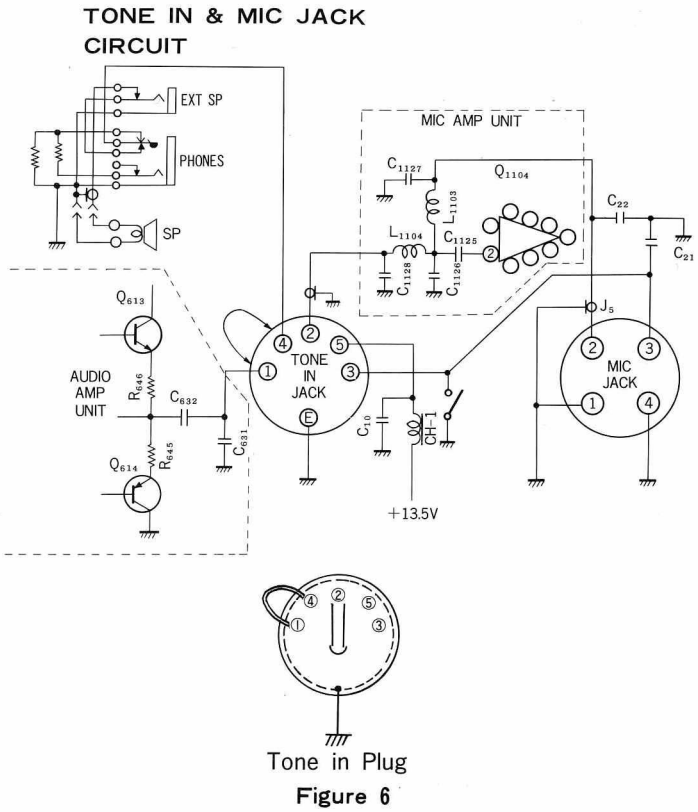


Figure 6

OPERATION

The tuning procedure of the transceiver is not complicated, however care should be exercised when tuning to insure peak performance of the equipment. The following paragraphs describe the procedure for receiver and transmitter tuning.

INITIAL CHECK

Before connecting the transceiver to a power source, carefully examine the unit for any visible damage. Check that all modules and crystals are firmly in place and that controls and switches are operating normally. Ensure that voltage specification marked on the rear panel matches the supply voltage.

DIAL READOUT

The main tuning dial is color coded with the band selector switch for proper frequency readout. When the band selected is marked in white on the transceiver front panel, the operator reads the white scale on the main tuning drum. When the band selected is marked in amber the operator reads the amber scale. The main tuning drum is marked in 50 kHz increments. This provides a coarse frequency setting within the band. The round subdial on the dial window surrounding the tuning knob is scaled in 1 kHz increments and provides fine settings of the transceiver operating frequency. The following example will familiarize yourself with the relationship of main and subdial frequency readout.

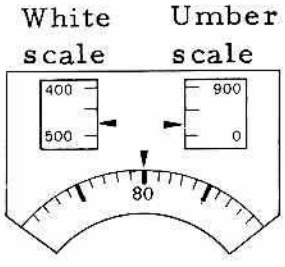


Figure 7

Read the white scale on main dial for the bands 144.0, 145.0, 146.0 and 147.0, and amber scale for 144.5, 145.5, 146.5 and 147.5.
Then the setting shown in the example would be 144.480 MHz on 144.0 BAND switch setting, and 145.480 MHz on 145.0. And also the frequency would be 144.980 MHz on 144.5 BAND switch setting, and 145.980 MHz on 145.5.

RECEIVER

After the transceiver is properly set up for operation, set the controls and switches as follows;

POWER ..... Down to "OFF" position.
MODE ..... Desired mode.
BAND ..... Desired band.
RPT ..... Lever position horizontal to OFF position.
AUX-600 kHz ..... Lever position horizontal to 600 kHz shift
DISC ..... Lever position horizontal to OFF position.
MARK ..... Lever position horizontal to OFF position.
CALR ..... Lever position horizontal to OFF position.
NOR-REV ..... "NOR" position.
MAIN TUNING DIAL .. Desired operating frequency.
VOX GAIN ..... PTT.
AF GAIN ..... Desired audio level.
RF GAIN ..... Fully clockwise position.
CHANNEL ..... VFO.
SQUELCH ..... Fully counter-clockwise position.

Connect the cord supplied to the appropriate power source, and an antenna to antenna connector on the rear panel.

CAUTION

PERMANENT DAMAGE WILL RESULT IF IMPROPER SUPPLY VOLTAGE IS APPLIED TO THE TRANSCEIVER. WARRANTY DOES NOT COVER THE DAMAGE CAUSED BY IMPROPER SUPPLY VOLTAGE.

Turn on the POWER switch. The dial and meter lamps should light up, and the transceiver is now ready to operate.

(1) SSB and AM Modes

Using the main tuning control (VFO), tune in an incoming signal. USB (upper side band) is mostly used for 2 meter SSB operation. When the received signal can not be heard clearly, then change to the opposite side band. The RF GAIN control is normally set to the fully clockwise position, but if the incoming signal is extremely strong, it is recommended to turn this control back to prevent overload of the front end. When there is noise caused by automobiles, pull the AF GAIN control out to switch on the NB (noise blanker) in order to eliminate these pulse type noises.

(2) CW Mode

With the CLARIFIER switch in the OFF position, tune in a signal until an 800 Hz beat tone is heard. Under this condition, your transmitting frequency coincides with the received signal. If you desire to hear a beat tone of your choice, then use the CLARIFIER control.

(3) FM Mode

Using the tuning control, tune in an incoming signal for a maximum and steady S-Meter reading where a natural voice is heard. For accurate tuning, set the DISC switch to the upper ON position. Carefully readjust the tuning control until the meter indicates zero (half way of the full scale).
If the S-Meter indication wabbles or if a clean audio output is not available, it is very likely that the signal is in the SSB mode. In this case, turn the MODE switch to USB or LSB position, and carefully tune the tuning control until a clear voice is heard. It is important that the CLARIFIER switch be set to the OFF position when calling the another station. After the initial contact is made, then the CLARIFIER may be used for the desired listening sound.

FREQUENCY CALIBRATION

(1) SSB Mode

Set the CLARIFIER to the OFF position, and the tuning control to the 100 kHz point on the dial nearest to the desired frequency. Set the MARK switch to the upper position. While pressing the CALIB knob to lock the dial, tune the tuning control for a zero beat. The transceiver must be recalibrated when changing the mode of operation: USB, LSB, AM or CW.

(2) FM Mode

Set the CLARIFIER to the OFF position, and the tuning control to the 100 kHz point in the round dial nearest to the desired operating frequency. Set the MARK switch and DISC switch to ON position. While pressing the CALIB knob down to lock the dial, tune the main tuning control until the meter indicates the green portion of its scale.

NOTE: WHEN THE MARKER SWITCH IS IN THE "ON" POSITION, THE ANTENNA IS DISCONNECTED FOR EASIER CALIBRATION.

TRANSMITTER

Connect a 50 ohm dummy load or a matched antenna to the coaxial fitting on the rear panel. Since the transmitter section utilizes wide band techniques no tuning control is necessary except the main tuning control to select the operating frequency. Plug the microphone into the MIC jack and select the desired mode. Push down the PTT (push-to-talk) switch on the microphone and speak into the microphone.

(1) SSB Mode

The meter indicates maximum deflection on voice peak and zero with no microphone input. Release the PTT switch for receive. Excessive setting of the MIC GAIN will result in poor quality transmitted signals.

(2) AM Mode

When the PTT switch is depressed, the proper amount of carrier is automatically inserted. Adjust the MIC GAIN control until the meter indicates a very slight movement with voice peaks while speaking into the microphone normally.

(3) CW Mode

Plug the key into the KEY jack on the rear panel. In the key down condition, the meter will show a 6 to 8 relative power output, and with the key up, the receiver will recover. The break-in delay time may be adjusted with VR_{601}, under the top cover. Keying is accomplished by closing the DC 8V line to ground. The current that flows in the KEY is around 8mA. Use caution when an Electronic Keyer is used, to be sure polarity reversals or excessive voltages do not cause damage to one or both units.

(4) FM Mode

Set the MIC GAIN control to the 12 o'clock position and push the PTT switch on the microphone while speaking normally into the microphone. The meter will show a 6 to 8 relative power output. Release the PTT switch on the microphone for receive.

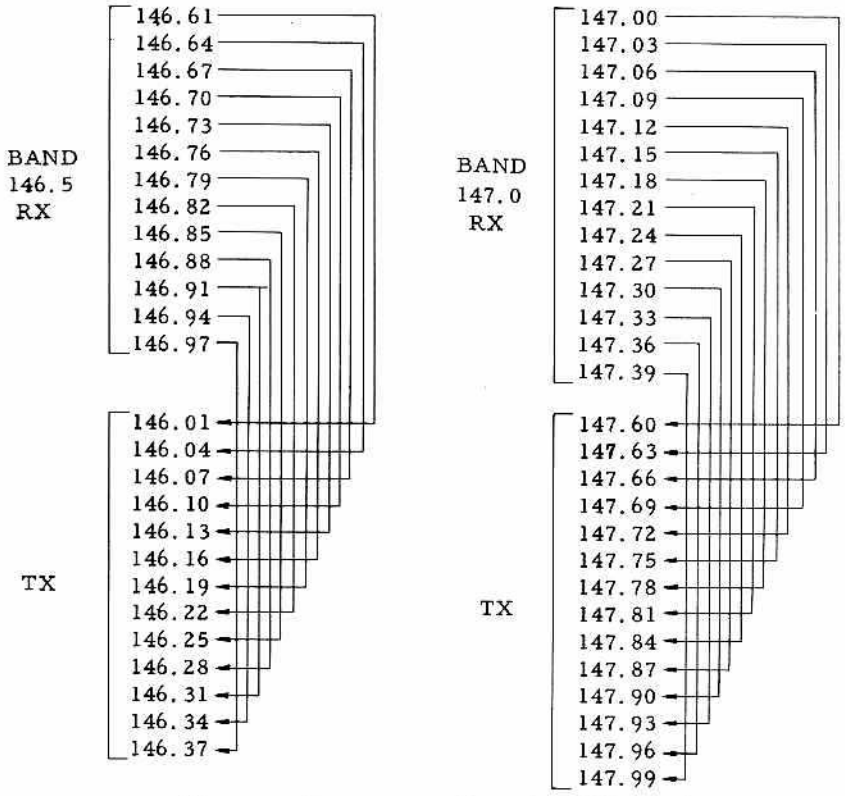
(5) VOX (Voice Controlled) Operation

Adjust the VOX GAIN control on the front panel until your voice actuates the transmitter while speaking normally into the microphone. Set the ANTITRIP control to the minimum point in order to prevent the speaker output from tripping the VOX circuit. Do not use more VOX GAIN or ANTITRIP GAIN than necessary. Adjust the DELAY control for a suitable release time. The RELAY control provides coarse adjustment for relay sensitivity and this control has been preset at factory. These controls are located on the AF AMP UNIT under the top cover.

REPEATER OPERATION

Transmitting and receiving frequencies may be shifted 600 kHz for repeater operation. When the REPEATER switch is ON (upward position) with NOR-REV switch in the NOR (normal) position, the transmitted frequency is shifted 600 kHz down from the dial readout. With the NOR-REV switch at REV position, the received frequency is shifted 600 kHz down from the dial readout. The U.S. model has an automatic cross-over system in which this shift is automatically reversed from 147.0 to 148.0 MHz.

In NOR operation, the transmitting frequency is shifted 600 kHz down for the frequency range of 146.61 through 146.97 MHz and shifted 600 kHz up for the frequency range of 147.00 through 147.39. This is shown on the chart on Figure 8. These relations are reversed with the NOR-REV switch in the REV position. Extreme caution should be observed so as not to transmit outside



Repeater Frequency Chart for U.S. Model

Figure 8

the amateur bands with repeater switch ON. The most repeaters use 600 kHz split between transmitter and receiver frequencies, however, other split than 600 kHz has been adopted in some areas.

When the AUX/600 kHz switch is in the AUX position, the frequency is shifted to any frequency within 1 MHz determined by the optional crystal installed in the local unit. The RPT lamp lights up when the repeater switch is ON.

Tone actuated repeaters can be operated with the built-in tone burst signal which is automatically inserted by the push-to-talk switch at the start of a transmission. When the microphone PTT switch is depressed for 0.2 – 0.5 seconds before the voice transmission, the burst tone signal is inserted at the beginning of the transmission. Normal operation of the PTT switch does not generate the burst signal. The frequency of the burst signal may be adjusted from 1500 to 2000 Hz with VR_{1002} under the top cover.

AUX crystal specification is calculated as follows:

BAND 146.5 ; X MHz =
(127.8 – shift frequency) ÷ 9

BAND 147.0 ; X MHz =
(128.3 + shift frequency) ÷ 9

Example 1
Calculate crystal frequency for –800 kHz shift in 146.5 MHz segment.
(TX frequency 800 kHz lower)
X MHz = (127.8 – 0.8) ÷ 9 = 14.111 MHz

Example 2
Calculate crystal frequency for +800 kHz shift in 147.0 MHz segment.
(TX frequency 800 kHz higher)
X MHz = (128.3 + 0.8) ÷ 9 = 14.344 MHz

CRYSTAL CONTROLLED OPERATION

In addition to the normal VFO controlled operation, eleven crystals may be selected by the channel switch on the front panel for crystal controlled operation. This crystal controlled operation is of great advantage when the transceiver is operated on the preset frequencies. Since the entire 2 meter band has been split into eight bands, eleven crystals can be used as 88 crystal controlled channels.

The crystal holders accept standard, HC-25/U type crystals. All crystal frequencies must fall between 8,000 kHz and 8,500 kHz. A trimmer capacitor has been connected in series with each crystal to permit proper frequency adjustment. Adjustment of this trimmer will change the crystal frequency approximately 1 kHz. The correct crystal frequency for any desired operating frequency may be determined by using the following formula:

$$fx = fo - f_1$$

where fx : **crystal frequency**
fo : **operating frequency**
f_1 : **given from Table 1**

BAND (MHz)	LSB (kHz)	USB (kHz)	FM (MHz)
144.0–144.5	136001.5	135998.5	136.0
144.5–145.0	136501.5	136498.5	136.5
145.0–145.5	137001.5	136998.5	137.0
145.5–146.0	137501.5	137498.5	137.5
146.0–146.5	138001.5	137998.5	138.0
146.5–147.0	138501.5	138498.5	138.5
147.0–147.5	139001.5	138998.5	139.0
147.5–148.0	139501.5	139498.5	139.5

Table 1

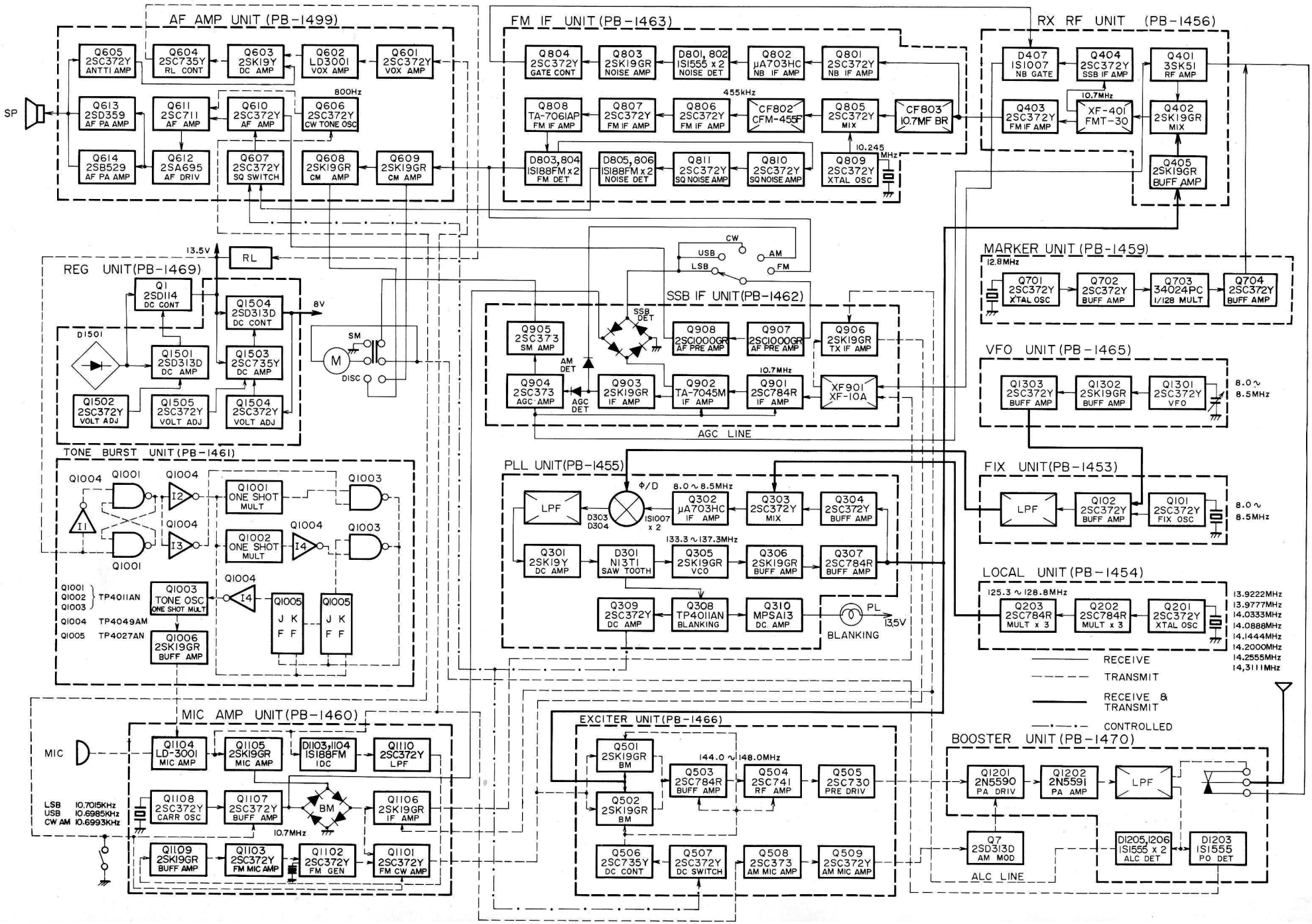
Example (1)– Find the proper crystal frequency for 144.15 MHz USB operation

From the Table 1, f_1 for USB is 135998.5.
Therefore, fx = 144.15 – 135.9985 = 8151.5 kHz

Example (2)– 144.72 MHz FM operation

fx = 144.72 – 136.5 = 8220 kHz

FT-221R BLOCK DIAGRAM



CIRCUIT DESCRIPTION

GENERAL

The block diagram and the circuit description that follows with provide you will a better understanding of this transceiver. Computor type plug-in modules have been adoped throughout the transceiver.

The transceiver consists of a single conversion receiver with a 10.7 MHz IF for SSB, CW and AM, a double conversion receiver with a 10.7 MHz first IF and 455 kHz second IF for FM. A single conversion transmitter, utilizing a 10.7 MHz high frequency crystal filter for SSB generation and varactor diode frequency modulation on 10.7 MHz crystal oscillator is incorporated.

NOTE:
The parts number starts with the number shown below the printed board designation. For example, the field effect transistor 3SK51 in RX RF unit PB-1456 is Q_{401}.

RECEIVER

RX RF UNIT (PB-1456)

The 144 MHz input signal from the antenna is fed through the antenna relay, RL_{1201}, to pin 5 of the RX RF unit. The signal is amplified by the RF amplifier Q_{401}, **3SK51** field effect transistor, and then fed to the gate of the first mixer Q_{402}, **2SK19GR**, where the input signal is heterodyned with a 133.3 MHz to 137.3 MHz signal, delivered from phase-lock-loop unit, and thus produces an IF signal of 10.7 MHz at the drain circuit of Q_{402}.

The input and output circuits of the RF amplifier utilize a double tuned circuit, which is sharply tuned to the center of the band with the varactor diodes, D_{401} through D_{404}, thus eliminating cross modulation and intermodulation effects.

The IF signal passes through crystal filter XF401, FMT-30, and the SSB, AM and CW signal is then fed to the first IF amplifier Q_{404}, **2SC372Y**, while the FM signal is fed to Q_{403}, **2SC372Y**.

The SSB, AM and CW signal amplified by Q_{404} is fed through a noise blanker gate diode D_{407}, **1S1007**, to pin 14, and the FM signal amplified by Q_{403} is fed to pin 9.

SSB IF UNIT (PB-1462)

The SSB, AM and CW signal from pin 14 of the RX RF unit is fed through pin 3 to the SSB IF unit. The signal is fed through the diode switch and a crystal filter, XF-9, to the IF amplifier Q_{901}, **2SC784R**. The signal is amplified by Q_{901} and Q_{902}, **TA7045M**, and then fed to the ring demodulator consisting of D_{904} through D_{907}, **1S1007**, where a carrier signal is applied through pin 32 from the carrier oscillator in the MIC AMP unit.

The audio output is fed through pin 33 and the MODE switch, S3D, to pin 28 of the same unit. The IF signal is further amplified by Q_{903}, **2SK19GR**, and detected by the AM detector D_{910}, **1S188FM**, for AM mode. Then the audio signal is fed through pin 25 to the MODE switch S3D.

A part of the IF signal output from Q_{903} is rectified by D_{908}, **1S1007**, and D_{913}, **1S1555**, for AGC (automatic gain control). The AGC voltage is amplified by Q_{904} and Q_{905}, **2SC373** and controls the gain of IF amplifier Q_{901} and Q_{902}. A part of

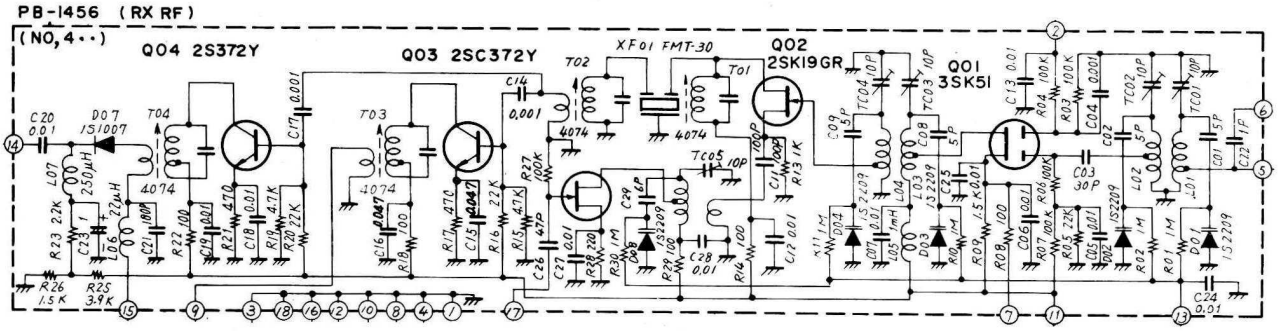


Figure 10

it is fed through pin 17 to the RX RF unit to control the gain of the RF amplifier Q_{401}. The AGC voltage is amplified by the S-meter amplifier Q_{905}, **2SC373**, and fed to the S-meter through the DISC/SM switch on the front panel.

The audio signal from the MODE switch is pre-amplified by Q_{907} and Q_{908}, **2SC1000GR** and fed through pin 29 to the AF AMP unit.

FM IF UNIT (PB-1463)

The FM IF signal from pin 17 of this unit is fed through a ceramic filter CF_{803}, 10.7 MFBR to the second mixer Q_{805}, **2SC372Y**, where the 10.7 MHz signal is mixed with the 10.245 MHz signal generated by the second heterodyne oscillator Q_{809}, **2SC372Y**, producing a 455 kHz second IF signal. The 455 kHz IF signal is fed through the ceramic filter, CF_{802}, to the second IF amplifier Q_{806} and Q_{807}, **2SC372Y**, and the amplifier limitter Q_{808}, **TA7061AP**, which removes any amplitude modulation component on the signal. The output from Q_{808} is applied to the dsicriminator D_{304} and D_{305}, **1S188FM**. The discriminator produces an audio output in response to a corresponding frequency (or phase) shift in the 455 kHz IF signal. The discriminator output is then fed to the common audio amplifier stage in SSB IF unit through the MODE switch.

For FM reception, when no carrier is present in the 455 kHz IF, the noise at the discriminator output is fed through the squelch threshold potentiometer, VR_6, to the noise amplifier Q_{810} and Q_{811}, **2SC372Y**, and detected by D_{805} and D_{806}, **1S188FM**. The DC voltage is applied from pin 8 to the squelch controller Q_{607}, **2SC372Y**, in the AF AMP unit.

The 10.7 MHz signal is also applied to the noise blanker amplifier Q_{801}, **2SC372Y**. The signal is amplified by Q_{801}, **2SC372Y**, and Q_{802}, **μA703HC**.

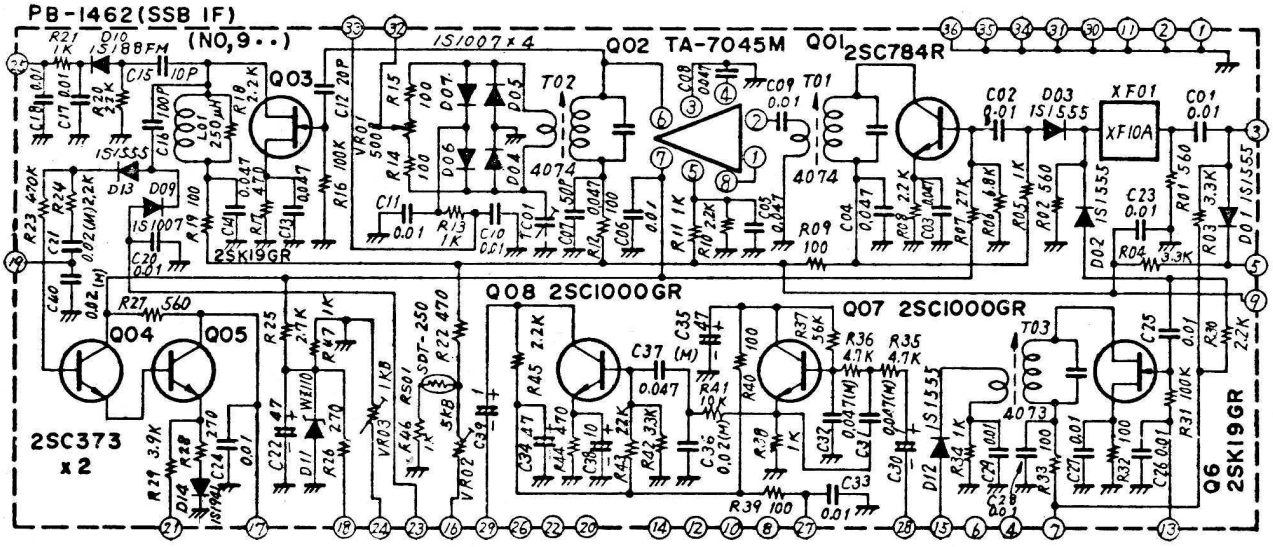


Figure 11

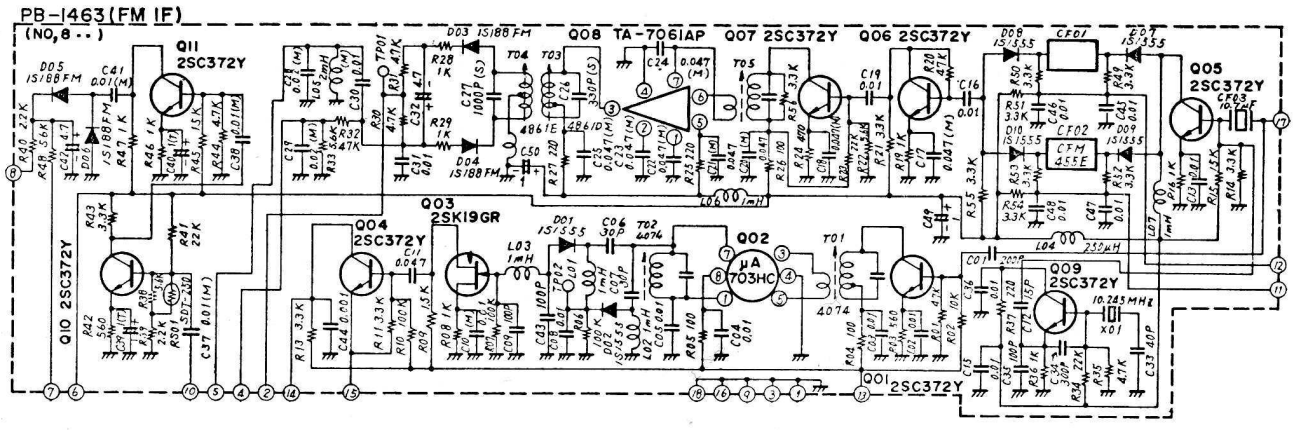


Figure 12

The noise rectifier diodes D_{801} and D_{802}, **1S1555**, produce a DC voltage which is amplified by following noise pulse amplifier Q_{803}, **2SK19GR**.

Under normal conditions, Q_{803} conducts producing the cut-off voltage to the base of the gate controller Q_{804}, **2SC372Y**, in turn the high collector voltage of Q_{804} is supplied from pin 15 to the gate diode D_{407}, **1S1007**, in the RX RF unit which conducts to pass the signal freely. With pulse noise, Q_{804} conducts and its collector voltage drops causing the gate diode D_{407} to disconnect the IF signal during the noise pulse exists.

AF AMP UNIT (PB-1499)

The audio signal pre-amplified in the SSB IF unit is fed through pin 13 to the audio amplifier stage consisting of Q_{610}, **2SC372Y**, Q_{611}, **2SC711**, Q_{612}, **2SA695**, Q_{613}, **2SD359** and Q_{614}, **2SB529**. The audio power amplifier circuit utilizes the OTL (output transformer less) circuitry and delivers 2 watts output to the speaker from pin 8.

In the FM mode, the squelch voltage is applied from pin 12 to the squelch controller Q_{607}, **2SC372Y**, which conducts with noise when the signal is not present, in turn the audio input is grounded to quiet the audio amplifier. When the signal is present, the Q_{607} is cut-off and permits normal operation of the audio amplifier.

The DC voltage is also applied from pin 12 to quiet the audio amplifier when the phase lock loop circuit is unlocked.

The speech output from the first microphone amplifier is fed through the VOX GAIN control potentiometer, VR_7, to the VOX amplifier Q_{601}, **2SC372Y**, and Q_{602}, **LD-3001**, from pin 2.

The amplified signal is fed to the VOX rectifier, D_{601} and D_{602}, **1S1555**. The rectified DC voltage is applied to the gate of the VOX relay controllers Q_{603}, **2SK19Y**, and Q_{604}, **2SC735Y**, causing them to conduct and actuate the VOX relay, RL_1, on the main chassis.

The ANTITRIP circuit provides a threshold voltage to prevent the speaker output from tripping the transceiver into the transmit mode. The receiver audio output voltage is connected through the ANTITRIP potentiometer, VR_{603}, to the antitrip amplifier Q_{605}, **2SC372Y**, and fed to rectifiers, D_{603} and D_{604}, **1S1555**. The negative DC output voltage from the rectifier is connected to the gate of Q_{603}, and reduces the gain of the VOX control transistor, thus providing the necessary antitrip threshold. The ANTITRIP control, VR_{603}, adjusts the value of the antitrip voltage threshold so that the speaker output will not produce an excessive positive voltage from the VOX rectifier that exceeds the negative voltage from the antitrip rectifier causing the controller transistor to actuate the relay. When speaking into the microphone, the

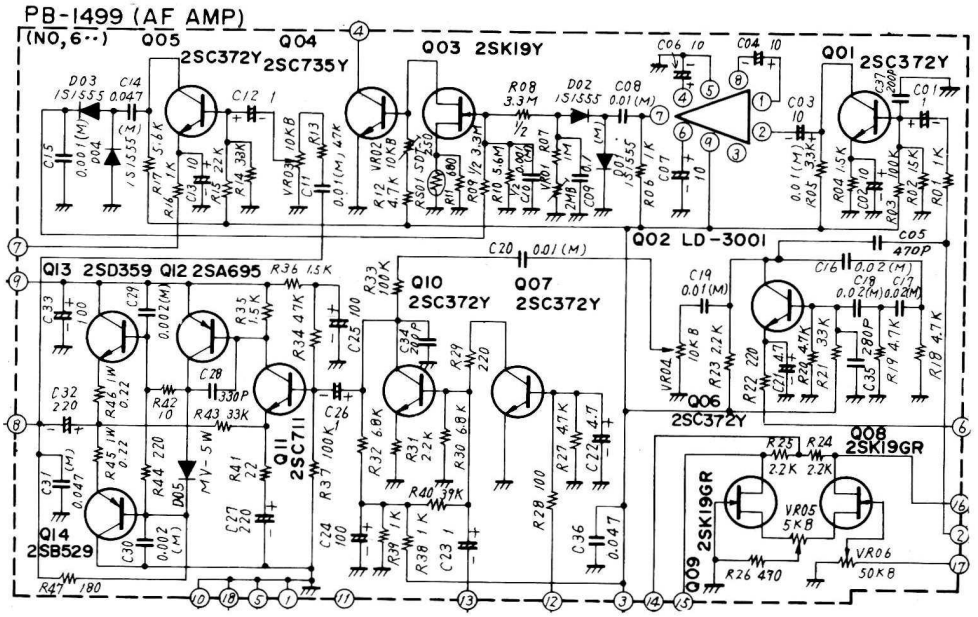


Figure 13

positive voltage will exceed the negative antitrip voltage and actuate the relay. VR_{602} provides coarse adjustment for relay sensitivity.

Relay hold tone will be determined by the DELAY control potentiometer, VR_{601}.

The tone oscillator Q_{606}, **2SC372Y**, operates when the MODE switch is in the CW position. It is a phase shift oscillator operating at approximately 800 Hz.

The tone output is activated by the keying circuit through the emitter circuit of Q_{606} and coupled through sidetone level control, VR_{604}, to the receiver audio amplifier, Q_{601}, for sidetone monitoring in CW operation. The output from Q_{606} is also coupled to the VOX amplifier, Q_{602}, for break-in CW operation. In the FM mode, a DC voltage at the discrimination output is applied from pin 17, to the differential amplifier Q_{608} and Q_{609}, **2SK19GR.**

When the frequency of received signal is shifted from the discriminator center, the resulting DC voltage causes either Q_{608} or Q_{609} to conduct indicating the amount of shift on the meter with the DISC switch in the ON position. VR_{605} balances the differential amplifier and VR_{606} calibrates the sensitivity of the meter.

TRANSMITTER

MIC AMP UNIT (PB-1460)

The speech signal from the microphone is fed from pin 31 to the first microphone amplifier, half of Q_{1104}, **LD-3001**. The input impedance of the microphone amplifier is 600 ohms. This signal is controlled in amplitude by the MIC GAIN control between pins 29 and 31, and is amplified by the second microphone amplifier, the other half of Q_{1104}, and applied to the source follower Q_{1105}, **2SK19GR**, to be delivered to the ring modulator D_{1108} through D_{1111}, **1S1007.**

The carrier oscillator Q_{1108}, **2SC372Y**, oscillates at 10.7015 MHz for LSB, 10.6985 MHz for USB and 10.6993 MHz for AM/CW depending upon the MODE switch position. In the CW mode, the carrier oscillator oscillates at 10.6993 MHz for transmit and 10.6985 MHz for receive producing an 800 Hz beat note in the receive mode. In the AM mode, the carrier oscillator does not function while receiving. The MODE switch selects the crystal by means of a diode switch. The output from the oscillator is fed through the buffer amplifier Q_{1107}, **2SC372Y** to the balanced ring modulator D_{1108} through D_{1111}, **1S1007.** The

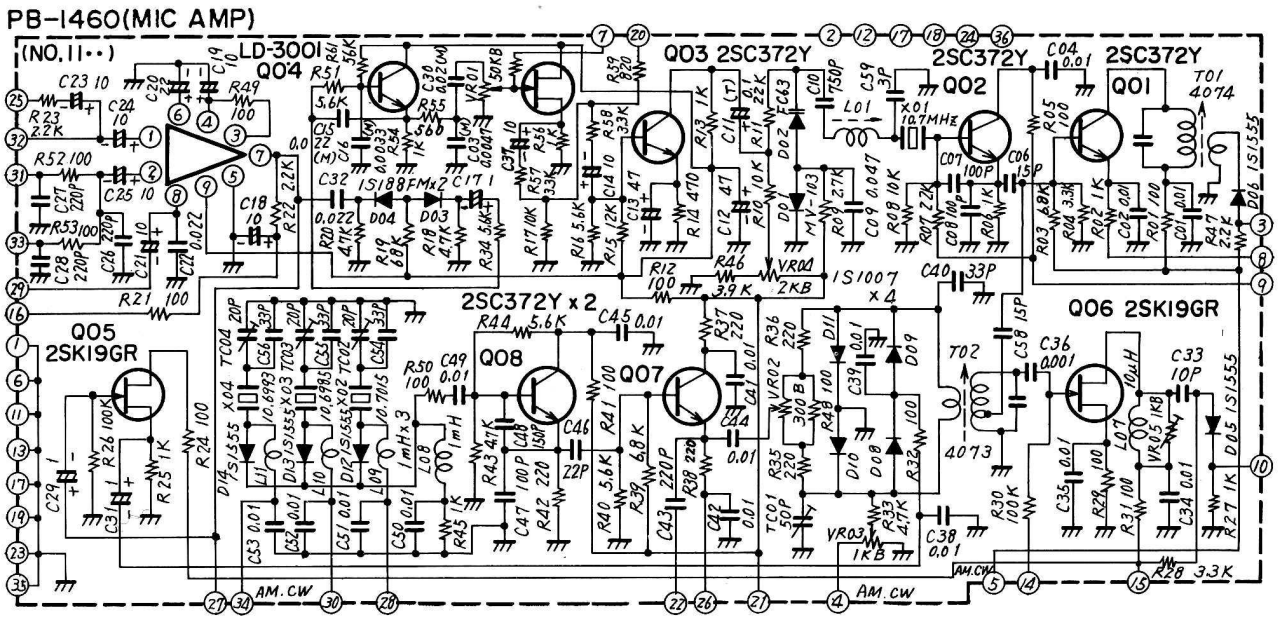


Figure 14

carrier signal output from the buffer amplifier, Q_{1107}, is fed from pin 22 to the SSB IF unit for SSB and CW reception. Carrier balance is obtained with potentiometer, VR_{1002}, and the trimmer capacitor, TC_{1101}. The double side band, suppressed carrier signal is amplified by Q_{1106}, **2SK19GR**, and fed from pin 10 to pin 5 of the SSB IF unit. In the AM and CW modes, the balanced modulator is unbalanced by the DC voltage applied from pin 4 and the carrier signal is fed through T_{1102} to carrier amplifier Q_{1101}, **2SC372Y**. The amplified carrier is fed from pin 3 to the EXCITER unit.

The audio signal output from Q_{1104} is fed from pin 27 to pin 12 of the EXCITER unit to be amplified to a sufficient level for low level AM modulation.

In the FM mode, a crystal oscillator Q_{1102}, **2SC372Y**, generates a 10.7 MHz signal which is shifted by the varactor diode D_{1102}, **FC-63**, in accordance with the speech voltage. The audio signal from the microphone amplifier, Q_{1104}, is applied to the IDA (instantaneous deviation adjustment) circuit. The IDA circuit, composed of diodes D_{1103} and D_{1104}, **1S188FM**, clips both positive and negative peaks when they exceed a predetermined level in order to limit the maximum deviation of the transmitter.

The limited audio signal is applied through an active low pass filter circuit, Q_{1110}, **2SC372Y**, where frequency components higher than 2.7 kHz are greatly attenuated and deviation potentiometer VR_{1101} to the audio amplifiers, Q_{1109}, **2SK19GR** and Q_{1103}, **2SC372Y**, where it is amplified and applied to the modulator, varactor diode D_{1102}.

The low pass filter limits the transmitter modulation spectrum by attenuating the frequencies above the speech range.

The frequency modulated signal is then amplified by Q_{1101}, **2SC372Y**, and fed through the output transformer T_{1101} to pin 5 of the EXCITER unit.

When the MODE switch is in the CW position, a flip-flop circuit Q_{1601}, **TP4011AN** keys Q_{1602}, **2SC372Y**. A collector circuit of Q_{1602} is connected to the emitter circuits of Q_{1101} and Q_{1107}. Sharp, click-free, wave shape is obtained by CR network consisting of R_{1602} and C_{1602}.

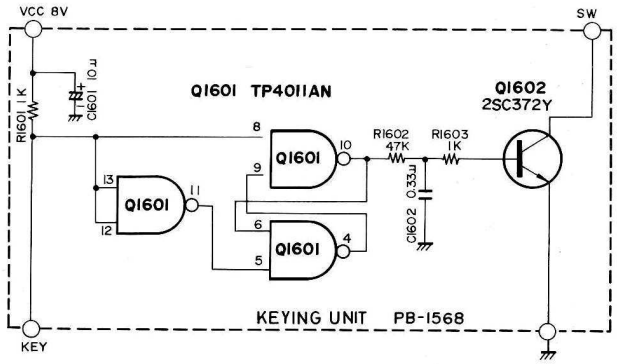


Figure 15

EXCITER UNIT (PB-1466)

The SSB, AM, CW and FM output signal (10.7 MHz) from the MIC AMP unit is fed to the EXCITER unit from pin 3 and pin 5.

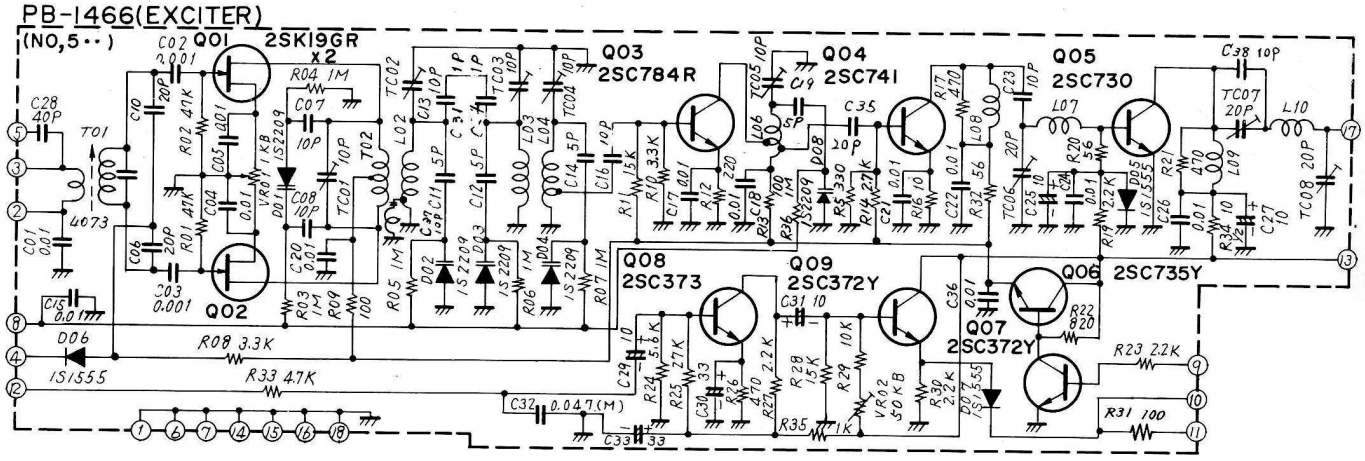


Figure 16

The 10.7 MHz signal is fed to the balanced mixer, consisting of Q_{501} and Q_{502}, **2SK19GR**, where the signal is mixed with the 133.3 to 137.3 MHz heterodyne signal delivered from pin 4, producing a 144 to 148 MHz signal. The output signal from the balanced mixer passes through the tuned circuits consisting of L_{501} through L_{504}, which are tuned by the varactor diodes D_{501} through D_{504}, **1S2209**, in which voltages are preset in accordance with the band switch position. Thus the circuit is tuned exactly to the operating frequency completely reducing any spurious radiation. The signal is then amplified by the amplifier chain Q_{503}, **2SC784R**, Q_{504}, **2SC741**, and Q_{505}, **2SC730**, and delivered from pin 17 to the BOOSTER unit.

The DC voltage for Q_{501} through Q_{504} is supplied through Q_{506}, **2SC735Y**. When the phase lock loop circuit is unlocked, the controller transistor Q_{507}, **2SC372Y**, stops conducting and in turn Q_{506} stops supplying the DC voltage for Q_{501} through Q_{504}.

The speech signal from pin 27 of the MIC AMP unit is fed through the AM amplifier Q_{508}, **2SC373**, and emitter follower Q_{509}, **2SC372Y**, to the AM modulator Q_7, **2SD313D**, which controls the supply voltage for Q_{1201}, **2N5590**, in the BOOSTER unit.

BOOSTER UNIT (PB-1470)

The signal from EXCITER unit is fed to the BOOSTER unit and amplified by the driver amplifier Q_{1201}, **2N5590**, and the final amplifier Q_{1202}, **2N5591**, which delivers 10 watts of RF power to the antenna through a two stage, low-pass filter. The DC voltage to Q_{1201} is supplied through the AM modulator Q_7, **2SD313D**.

The bias voltage is stabilized at 9 volts by a zener diode D_{1209}, **1N4740**. Two diodes D_{1201} and D_{1202}, **10D1**, are used to protect the power transistor from damage due to heating by reducing the bias voltage when the temperature rises. A small portion of the RF output is rectified by a diode D_{1203}, **1S188FM**, which delivers a resulting DC voltage to the meter where it provides an indication of relative power output from the transceiver.

The DC voltage obtained from rectifying a small portion of the RF output by the ALC diodes D_{1205} and D_{1206}, **1S1555**, which are biased by the ALC threshold control VR_{1201}, is applied to the gate of Q_{906} in the SSB IF unit and Q_{1106} in the MIC AMP unit. This controls their gain in order to automatically control the driving level to the PA transistors in order to prevent any distortion caused by overdrive.

Block diodes D_{1207} and D_{1208} disconnect the supply voltage to Q_{1202} while the antenna is disconnected for marker calibration.

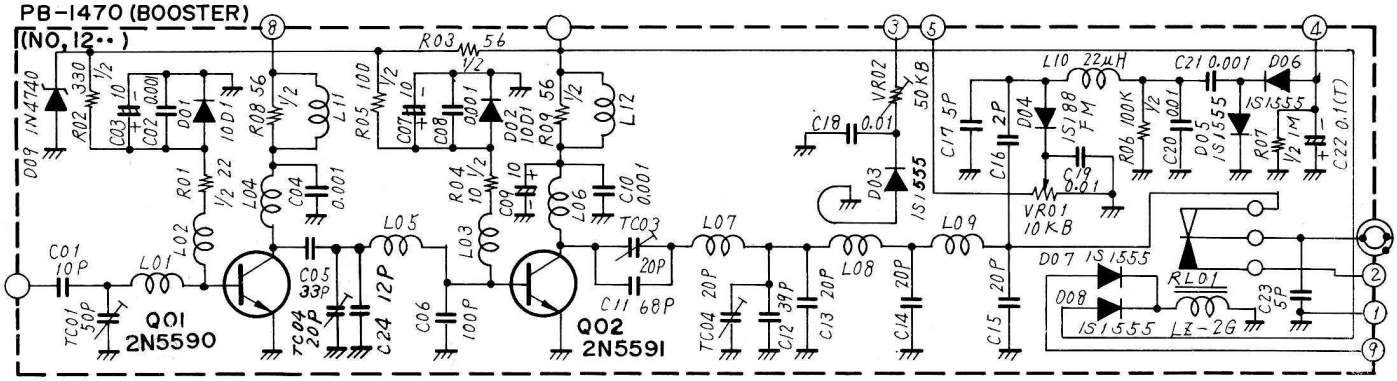


Figure 17