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hy-range Ia, IIa
by hy-gain

MODELS 681 and 682
CITIZENS TWO-WAY RADIO

mobile

Manufactured and Distributed by
Hy-Gain de Puerto Rico, Inc.
P.O. Box 68 State Hwy 31, Km. 4.0
Naguabo, Puerto Rico 00718

PN 801266

EO-0682-A-020

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CHAPTER 1 — GENERAL INFORMATION

Introduction

This service manual contains all the information needed to service and repair the Hy-Gain, Hy-Range Ia and IIa transceivers (Models 681 and 682). It includes an explanation of the theory of operation and alignment procedures. Revision, addendum, and errata sheets will be published as needed. Insert them as required in the manual.

The Hy-Range Ia and IIa are full 23-channel transceivers designed and type accepted for Class D Citizens Radio Service, as designated by the Federal Communications Commission (FCC).

It is a compact mobile unit, completely solid-state, and highly reliable with low power consumption. Its Phase Lock Loop frequency synthesizer provides immediate operation on all 23 channels. Output jacks for an optional telephone-style handset and an external speaker are also included. Use the unit with 12 VDC (nominal), either negative or positive ground.

Warranty Service Department

For help with technical problems, for parts information, and information on local and factory repair facilities, contact the National Service Manager. When you write, please include all pertinent information that may be helpful in solving your problem. Address your letter to:

Hy-Gain Warranty Service Department
4900 Superior Street
Lincoln, Nebraska 68504
ATTN: National Service Manager

The Warranty Service Department can repair any unit. Before you ship a unit to us, contact the National Service Manager. Often a problem is field solvable with just a little extra help. This can save you lost time and shipping costs. Factory returns should be limited to the difficult problems.

How to Ship Returns

To return a unit, get a return authorization first. This is important. You will only delay the handling of your unit if you ship without it. If you must ship immediately, telephone or telex the National Service Manager for expeditious service.

When you request return authorization, you may also request notification of completion of repairs. The notification will include a copy of the bill. If you pay the bill before we return your unit, you can save yourself the cost of a COD fee.

For warranty repair, prepare a letter in duplicate containing the following information (for out-of-warranty repair, delete items 2 and 3):

1. your name and address
2. purchaser's name and address
3. proof of purchase
4. serial number
5. a complete description of the problem
6. the return authorization.

Check the unit to see that all parts and screws are in place, and attach an envelope containing a copy of your letter directly to it so this information is not overlooked. Wrap the unit and envelope in heavy paper or put then in a plastic bag. If the original carton is not available, place the unit in a strong carton that is at least six inches larger in all three dimensions than the unit. Fill the carton equally around the unit with resilient packing material (shredded paper, excelsior, bubble pack, etc.). Seal it with gummed paper, tie it with a strong cord, and ship it by prepaid express, United Parcel Service, or insured parcel post to the address given previously. Mail the original of the letter in a second envelope to that same address.

It is very important that the shipment be well-packed and fully insured. Damage claims must be settled between you and the carrier and this can delay repair and return of the unit to you.

All shipments to us must be sent PREPAID. We **do not accept** collect shipments. After the unit has been repaired, we will send it back to you COD unless you have prepaid the bill. Unclaimed or refused COD shipments will not be reshipped until payment in full is received. These items become the property of Hy-Gain 60 days after refusal or return and will be sold for payment of charges due.

Units with unauthorized field modifications cannot be accepted for repair.

Purchase of Parts

Parts can be purchased from any Hy-Gain Service Center or from the factory Warranty Service Department. When ordering, please supply the following information:

1. unit model number
2. unit serial number
3. part description
4. part number

Specifications

General

Channels	all 23 channels in the Citizens Band (26.965 MHz - 27.255 MHz)
Antenna Impedance	50 ohms, nominal
Power Requirement	11.5 VDC - 14.5 VDC, negative or positive ground
Compliance	Type accepted under FCC Rules, Part 95

Receiver section

Circuitry	dual conversion superheterodyne with rf amplifier stage and 455 kHz ceramic filter
Sensitivity	0.7 uV for 10 dB (S+ N)/N ratio
Intermediate frequencies	1st IF — 5.965 MHz 2nd IF — 455 kHz
Audio output	3 watts maximum
Current drain, receive	about 300 mA (no signal)

Transmitter section

RF power output	4 watts
Emission	AM, type 8A3
Spurious response rejection	all harmonic and spurious suppression better than FCC requirements
Modulation	AM, 90% typical
Current drain, transmit	less than 1.2 amp. @ 12V DC nominal

CHAPTER 2 — THEORY OF OPERATION

General

The theory of operation of the Hy-Range Ia and IIa is divided into three sections: the Phase Lock Loop Frequency Synthesizer, the Receiver, and the Transmitter. This material covers the functioning of the transceiver with a minimum of technical involvement. We have not attempted to explain the engineering techniques and approaches that arrived at these circuit designs.

Refer to the block diagram, Figure 2-1 for visual reference to the theory of operation.

Phase Lock Loop Frequency Synthesizer

The phase lock loop (PLL) frequency synthesizer generates frequencies for use in both the transmitter and receiver sections. Its output determines the channel on which the transceiver is operating. The PLL circuitry incorporates three crystal oscillators to perform its frequency generator function.

The 9.51 MHz Oscillator, Q105, has its output doubled and serves as a pre-scaler for the output of the Voltage Controlled Oscillator (VCO), Q101. The Offset Oscillator, Q109, operates at a frequency of 5.945 MHz, which mixes with the VCO output to provide the transmit frequency. The Reference Oscillator, Q117, serves as a reference for the PLL and as an injection frequency for the Second Receive Mixer.

The PLL circuit generates the operating frequencies needed for the transceiver by feeding the proper code from the channel selector switch to the programmable divider. Table A shows the following for each channel: the channel frequency, VCO frequency, BCD code, and the division ratio of the programmable divider.

For example, assume that channel 1 has been selected. The channel frequency is 26.965 MHz, the VCO frequency is 21.020 MHz, the BCD code (N code) is 200. The channel selector switch programs the Programmable Divider for a division ratio of 200. The 6.4 MHz reference frequency is fed to the Integrated Circuit PLL Clip, IC101. It is divided by 640 within the chip, producing a 10 KHz reference signal. The output of the VCO is mixed in the PLL Mixer, Q102, with the doubled output of Q105. This produces a 2 MHz output. The Programmable Divider, which is set for 200, divides the 2 MHz output of Q105 down to 10 KHz.

The two KHz signals are phase compared in the phase detector within IC 101 producing a voltage that holds the VCO at 21.020 MHz. This is the DC voltage that controls the variactor diode, D102, to hold the oscillator to the output frequency of 21.020 MHz.

Assume that the channel selector is changed to channel 23. The channel selector now provides a code that will produce a division ratio of 229. At this instant the VCO frequency is at 21.020 MHz, which is mixed with the doubled output of Q105. Again, the PLL Mixer, Q102, produces an output of 2 MHz. The 2 MHz signal is divided by 229 to produce a frequency of 8.73 KHz.

The 8.73 KHz output, along with the 10 KHz reference 17, is fed to the phase de-tector. The comparison of the two frequencies in the phase detector produces an error output which is a combined AC-DC voltage. The low pass filter removes the AC component and allows only the DC voltage to be fed to the VCO. The VCO frequency changes until the output of the programmable divider is 10 KHz. When the

two frequencies are matched at 10 KHz, the error voltage output of the phase detector is zero.

When the error output voltage is zero, there is a new DC voltage set up to tune the varicap to the VCO frequency of 21.31 MHz. When this occurs the loop is considered locked. With the channel selector at 23, the following outputs of the PLL circuitry are produced: the 21.310 MHz VCO output is fed to the First Receive Mixer, Q115, and in the transmit mode it is mixed with the output of Q109 to produce a transmit frequency of 27.255 MHz.

N CODE — FREQUENCY CORRELATION CHART

Channel No.	*Channel Frequency*	*"N" Code*	*V.C.O. Frequency*	*Channel Switch Output (PLL Inputs)* 1 A	2 B	4 C	8 D	10 A	20 B
1	26.965 MHz	200	21.020 MHz	0	0	0	0	0	0
2	26.975 MHz	201	21.030 MHz	1	0	0	0	0	0
3	26.985 MHz	202	21.040 MHz	0	1	0	0	0	0
4	27.005 MHz	204	21.060 MHz	0	0	1	0	0	0
5	27.015 MHz	205	21.070 MHz	1	0	1	0	0	0
6	27.025 MHz	206	21.080 MHz	0	1	1	0	0	0
7	27.035 MHz	207	21.090 MHz	1	1	1	0	0	0
8	27.055 MHz	209	21.110 MHz	1	0	0	1	0	0
9	27.065 MHz	210	21.120 MHz	0	0	0	0	1	0
10	27.075 MHz	211	21.130 MHz	1	0	0	0	1	0
11	27.085 MHz	212	21.140 MHz	0	1	0	0	1	0
12	27.105 MHz	214	21.160 MHz	0	0	1	0	1	0
13	27.115 MHz	215	21.170 MHz	1	0	1	0	1	0
14	27.125 MHz	216	21.180 MHz	0	1	1	0	1	0
15	27.135 MHz	217	21.190 MHz	1	1	1	0	1	0
16	27.155 MHz	219	21.210 MHz	1	0	0	1	1	0
17	27.165 MHz	220	21.220 MHz	0	0	0	0	0	1
18	27.175 MHz	221	21.230 MHz	1	0	0	0	0	1
19	27.185 MHz	222	21.240 MHz	0	1	0	0	0	1
20	27.205 MHz	224	21.260 MHz	0	0	1	0	0	1
21	27.215 MHz	225	21.270 MHz	1	0	1	0	0	1
22	27.225 MHz	226	21.280 MHz	0	1	1	0	0	1
23	27.255 MHz	229	21.310 MHz	1	0	0	1	0	1

Table A

Fundamental Block Diagram of PLL Circuitry

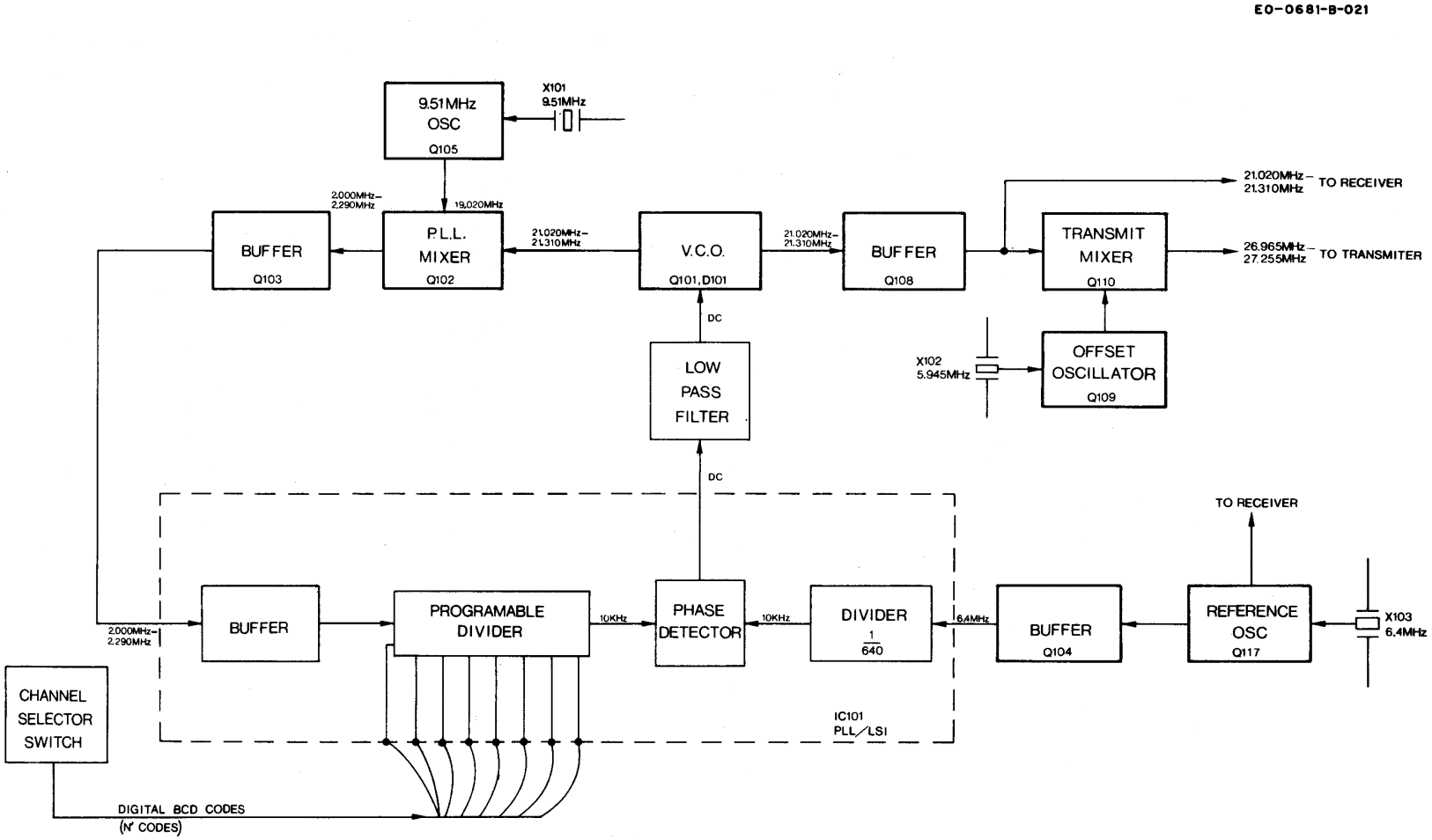


Figure 2-1

Receiver

The receiver is a dual-conversion superheterodyne, receiving AM signals from 26.965 MHz to 27.255 MHz. The operating channel is determined by the P.L.L. frequency synthesizer, which provides the first local oscillator frequency. A variable squelch circuit is included to quiet the receiver between transmissions.

In the receive mode, 13.8 VDC is supplied to IC102, Q114, Q115, Q118, Q119 and to Q106 (the AVR). The AVR supplies regulated voltage to the synthesizer stages and to the Reference Oscillator, Q117. A bias voltage is also applied to the base of the Transmit Switch, Q107. This bias holds the Transmit Switch open, so that the transceiver circuits remain in receive.

AM signals are received by the antenna and enter the radio at the antenna jack. The filter formed by L109, L110, C152 and C1 of the rear panel matches the antenna impedance to the RF Amplifier, Q114. Signals in the 26.965 MHz - 27.255 MHz range are filtered out and amplified by the RF Amplifier and a tank circuit, C154/T104, that precedes it. (D107 is a signal overload protector.)

The output of the RF Amplifier and the synthesizer frequency, (which in this case could be called the "first local oscillator frequency,") are applied to the First Receive Mixer, Q115. These two signals are mixed in the First Receive Mixer for an output of 5.945 MHz, which is the first i-f.

The first i-f passes through the i-f tuned circuit, L112 and T106. It is then applied to the Second Receive Mixer, Q116, along with the output of the Reference Oscillator, Q117. The Reference Oscillator frequency is 6.400 MHz. The two signals are mixed in the Second Receive Mixer for an output of 455 kHz, which is the second i-f.

The second i-f is fed to the Crystal Filter, CF 101. It is then amplified by Q118 and Q119. They are the Second IF, First Stage and Second Stage Amplifiers, respectively. The amplified signal is then fed to the Detector, D110. The Detector recovers the audio from the modulated signal to yield an af output. The output is applied to the Automatic Noise Limiter (ANL), D108, and the Squelch Switch, Q120.

The squelch functions in the following manner: in the receive mode, a bias voltage from Q106 is applied to the base of Q120, as determined by VR2. In the absence of a signal, the base of Q120 is positive biased and it activates. This biases the squelch transistor inside IC102, which turns off the Audio Amplifier and squelches the receiver.

The output of the ANL goes through the volume control, VR1 and is RC-coupled to the Audio Amplifier, IC102. The amplified af output from IC102 passes through the audio transformer, T110, to be applied to the speaker jacks and the speaker.

Transmitter

The operating channel is determined by the P.L.L. frequency synthesizer. The synthesizer frequency is mixed with the offset oscillator output to yield the transmit signal. This frequency is then amplified by a three-stage power amplifier. T/R switching to the transmit mode is done in the following manner: when the PTT switch is closed, the base of the Transmit Switch, Q107, is grounded. This prevents biasing of Q107, which closes it. Regulated voltage from the Automatic Voltage Regulator (AVR), Q106, can then be supplied through Q107 to Q109, Q110, and Q111. With the PTT switch closed and rf applied to Q112 and Q113, the transceiver is in the transmit mode.

The synthesizer frequency is applied to the Transmit Mixer, Q110, along with the 5.945 MHz output of the Offset Oscillator, Q109. The synthesizer frequency is determined by the channel selector switch, S2, (as explained in the synthesizer section of this chapter). These two frequencies are mixed to yield the transmit frequency.

The transmit frequency from Q110 passes through the filter circuit of L103, L104 and T102 and is applied to the Pre-driver, Q111. The filter circuit partially removes spurious signals from the transmit frequency.

The Pre-driver, Q111, and the Driver, Q112, form two stages of amplification leading to the final stage. The filter circuit of T103 follows Q111, and L106 follows Q112. These two circuits filter out the remaining spurious signals from the transmit frequency.

From the Driver the signal is applied to the third stage of amplification, the RF Power Amplifier, Q113. This is a current amplifier that raises the transmit signal to an output of four watts. Its output is applied to a filter, L109, L110, and C1 of the rear panel, and C152, and then to the antenna jack.

The transmit signal is modulated in the following manner: microphone output is applied to the Audio Amplifier, IC102. The output is applied to the collectors of Q112 and Q113 through the secondary coil of the audio output transformer, T110.

Control voltages for the Transmit Audio ALC, Q122, and the Range Boost, 121 come from detector diode D111. The Transmit Audio ALC boosts, or lowers, the amplifier gain in response to line voltage fluctuations. This insures full modulation of the carrier despite any changes in line voltage. The Range Boost rolls off af peaks so that a higher average af level is supplied to the Audio Amplifier. This gives the high average modulation desired at the output of Q113 without an overmodulation of the peaks.

CHAPTER 3 — ALIGNMENT

General

These procedures must be followed to properly align the Hy-Range Ia and IIa transceivers (Models 681 and 682). Alignment should not be undertaken unless the technician has adequate test equipment and a full understanding of the circuitry of the transceiver.

IMPORTANT: Tuning adjustment of this transceiver "shall be made by or under the immediate supervision and responsibility of a person holding a first- or second-class commercial radiotelephone operator license," as stipulated in Part 95.97 (b) of the FCC Rules and Regulations.

The procedures are divided into two main sections: Receiver Alignment, and Transmitter Alignment. See *Tools and Equipment* below for a complete list of recommended equipment.

These procedures assume that voltages are present at all points of the unit. If not, troubleshoot before continuing.

NOTE: The ferrite cores in the tuning coils are rather easily chipped or broken. Therefore, always use care when inserting an alignment tool in the tuning coil: insert it straight into the core.

Tools and Equipment

The following tools and equipment are recommended for use in aligning the Hy-Range Ia and IIa transceivers.

1. Audio signal generator, 10 Hz - 20 KHz
2. VTVM, 1 mV measurable
3. DC Ampere Meter, 2A
4. Regulated power supply, DC 0 to 20 V, 2A or higher
5. Frequency Counter, 0 to 40 MHz, high input impedance type
6. RF VTVM, Probe Type
7. Oscilloscope, 39 MHz, high input impedance
8. RF wattmeter, 50 ohm, 5W
9. Standard signal generator, 100 KHz - 50 MHz
10. Speaker dummy resistor, 8 ohm, 5W
11. VOM 20 K ohm/V

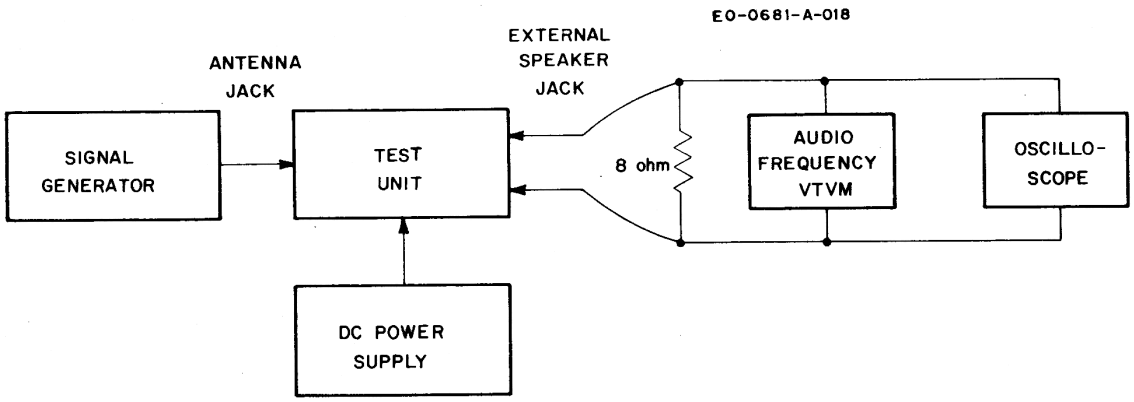
All test equipment should be properly calibrated.

NOTE: Test voltage is DC 13.8 V unless otherwise specified.

Receiver Alignment Procedure

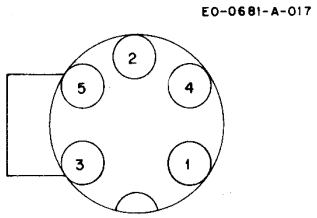
Refer to Figure 3-1 for the location of components to be adjusted for receiver alignment.

Equipment Set-up



NOTE: Place the ANL switch in the on position (682 only).

To put the transceiver in the receive mode, insert a 5-pin plug wired as shown below into the microphone jack on the front panel.



Receiver Alignment

1. Set the Signal Generator to 27.115 MHz, 1 KHz 30% modulation and set the transceiver to the channel 13 position.

NOTE: This alignment should be performed with an extremely small signal input from the signal generator to avoid inaccurate alignment due to agc action.

2. Adjust L115, T104, T105, L112, T106, T107, T108 and T109 for maximum audio output on the oscilloscope, or use the S-meter on the unit.

Tight Squelch Adjustment

1. Set the signal generator to provide an rf input signal of 50uV, (1KHz, 30%, Mod.)

2. Rotate the squelch control fully clockwise.

3. Adjust RV101 so that tight squelch just breaks with the 50uV input.

S-Meter Adjustment

1. Set the signal generator to provide a 10 uV signal input.

2. Adjust RV-103 so the S-meter pointer reads 7 on the meter on the front panel.

Transmitter Alignment Procedures

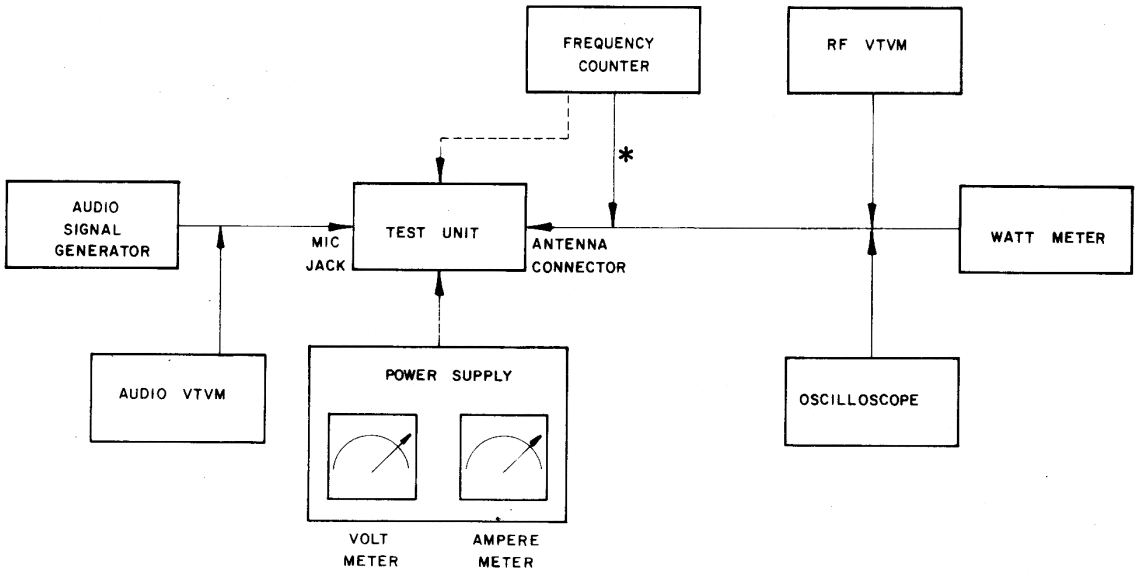
Equipment Set-up

Refer to Figure 3-2 for the location of components to be adjusted for transmitter alignment.

Connect all test equipment as shown below.

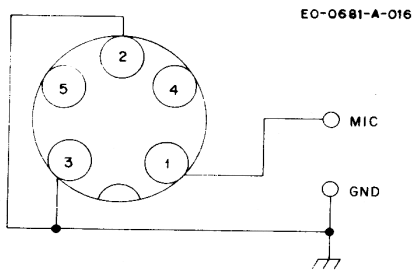
***NOTE:** Refer to the figure on page 13 for connection of the dummy load.

EO-0681-B-020



To set the transceiver to the transmit mode without the microphone, insert a 5-pin plug wired as shown below into the MIC jack on the transceiver. When applying an audio modulation signal to the microphone input circuit, use the same plug.

EO-0681-A-016



Pre-Alignment Frequency Check

Before alignment, using the frequency counter through a 1000 PF coupling capacitor connected in series with the counter input probe, check the operating frequencies at the following points.

Buffer, Q104, collector frequency should be 6400.5 MHz.

Buffer, Q108, base frequency should be 21.0195 MHz in the channel 2 position.

Offset Oscillator, Q109, emitter frequency should be 5945.300 MHz.

VCO Alignment

1. Place the channel selector in the channel 1 position.

2. Connect the VOM (DC 3V range) between ground and R114 (TP-8 side).

3. Adjust the T101 core clockwise to obtain *1.5V ± 0.1V* on the meter.

4. Place the channel selector in the open channel position. A voltage reading of 5.1 to 5.4 V is obtained.

5. Place the channel selector in the channel 23 position and read the value on the meter. It should be 2.7 ± 0.6 V.

RF Output Adjustment

1. Adjust the power supply voltage to 8.0 volts.

2. Connect the VTVM rf probe between the base of Q111 and ground.

3. Set the transceiver channel selector at channel 13. Perform the following procedure at channel 13.

4. Key the transmitter.

5. Adjust the slugs of L103, L104, and T102 for a maximum reading of the VTVM.

6. Connect the VTVM rf probe between the base of Q112 and ground.

7. Adjust the slug of T103 for a maximum reading of the VTVM.

8. Adjust L109 and L110 for maximum rf power output as indicated by the wattmeter.

9. Raise the power supply voltage to 13.8V.

10. Repeat steps 2 thru 8.

11. Repeat step 8 until no further improvement is noted.

12. Back off L110 (counterclockwise) for a reading of 4.0 watts maximum rf power output.

13. Readjust L109 for maximum power out.

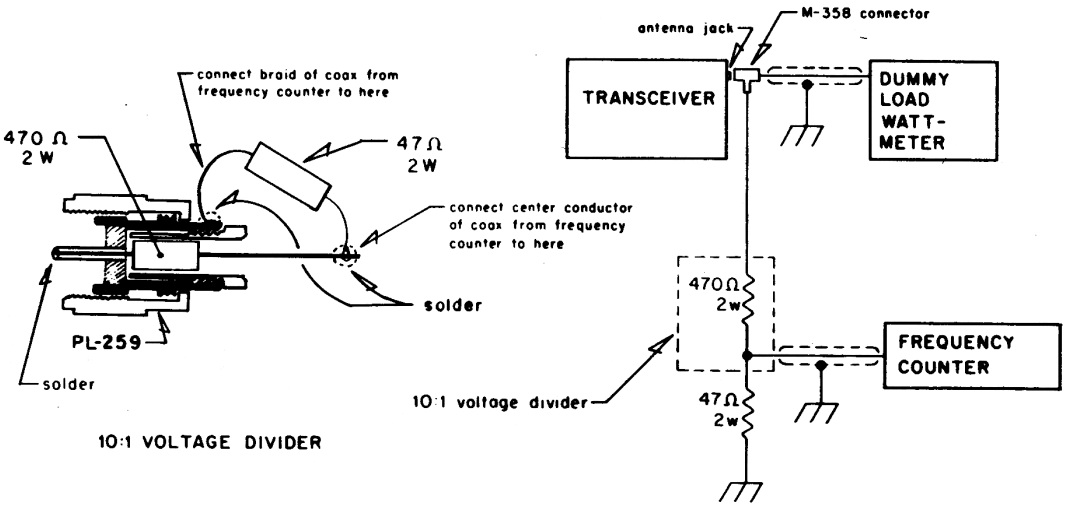
14. Repeat steps 12 and 13 until the maximum power output is 4.0 watts with L109 peaked for maximum output. Total transceiver current at this setting must not exceed 1.3A.

Transmitter Frequency Check

1. Turn the transceiver off.

2. Connect the dummy load and frequency counter of the antenna jack as shown below.

EO-0672-A-010



10:1 VOLTAGE DIVIDER

3. Key the transmitter with the microphone PTT button.

4. Check the frequency of each channel with the chart below:

CHANNEL FREQUENCY

Channel	MHz	Channel	MHz
1	26.965	13	27.115
2	26.975	14	27.125
3	26.985	15	27.135
4	27.005	16	27.155
5	27.015	17	27.165
6	27.025	18	27.175
7	27.035	19	27.185
8	27.055	20	27.205
9	27.065	21	27.215
10	27.075	22	27.225
11	27.085	23	27.255
12	27.105		

Modulation Sensitivity Alignment

1. Set the unit in the transmit mode and apply a 20mV, 1 KHz signal to the microphone input circuit.

2. RV-102 should be adjusted to obtain 90% modulation in this condition.

3. Decrease the signal input to 6 mV and ensure that the modulation ratio is keeping a value higher than 80%.

RF Meter Alignment

Adjust RV-104 so that the meter pointer indicates the same wattage as the reading obtained on the wattmeter; or so that the meter pointer coincides with the center of the red zone on the meter scale.

NOTE: (Refer to step 3 of the RF power alignment procedure to set the reference power level (3.8 W on the wattmeter).

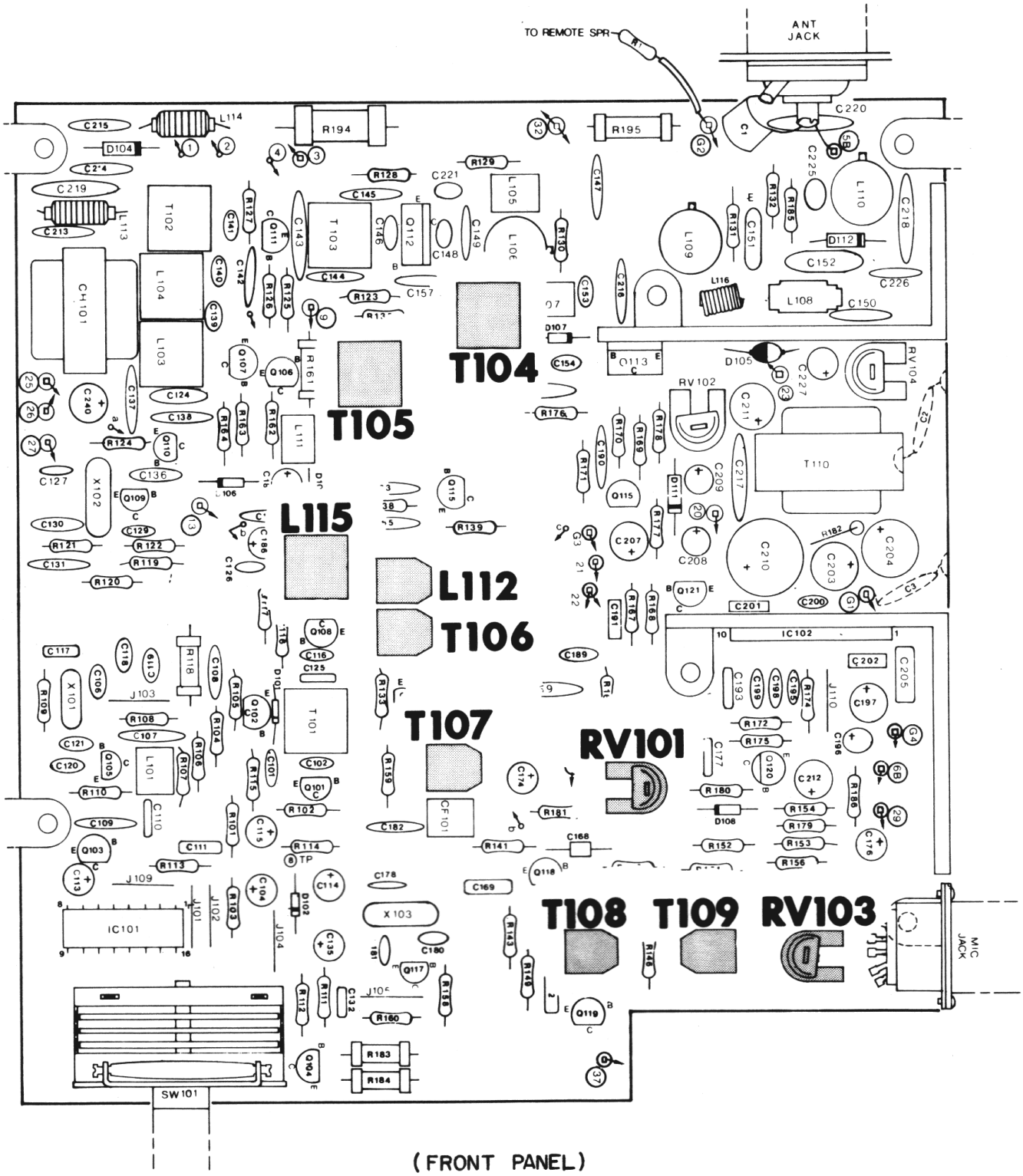
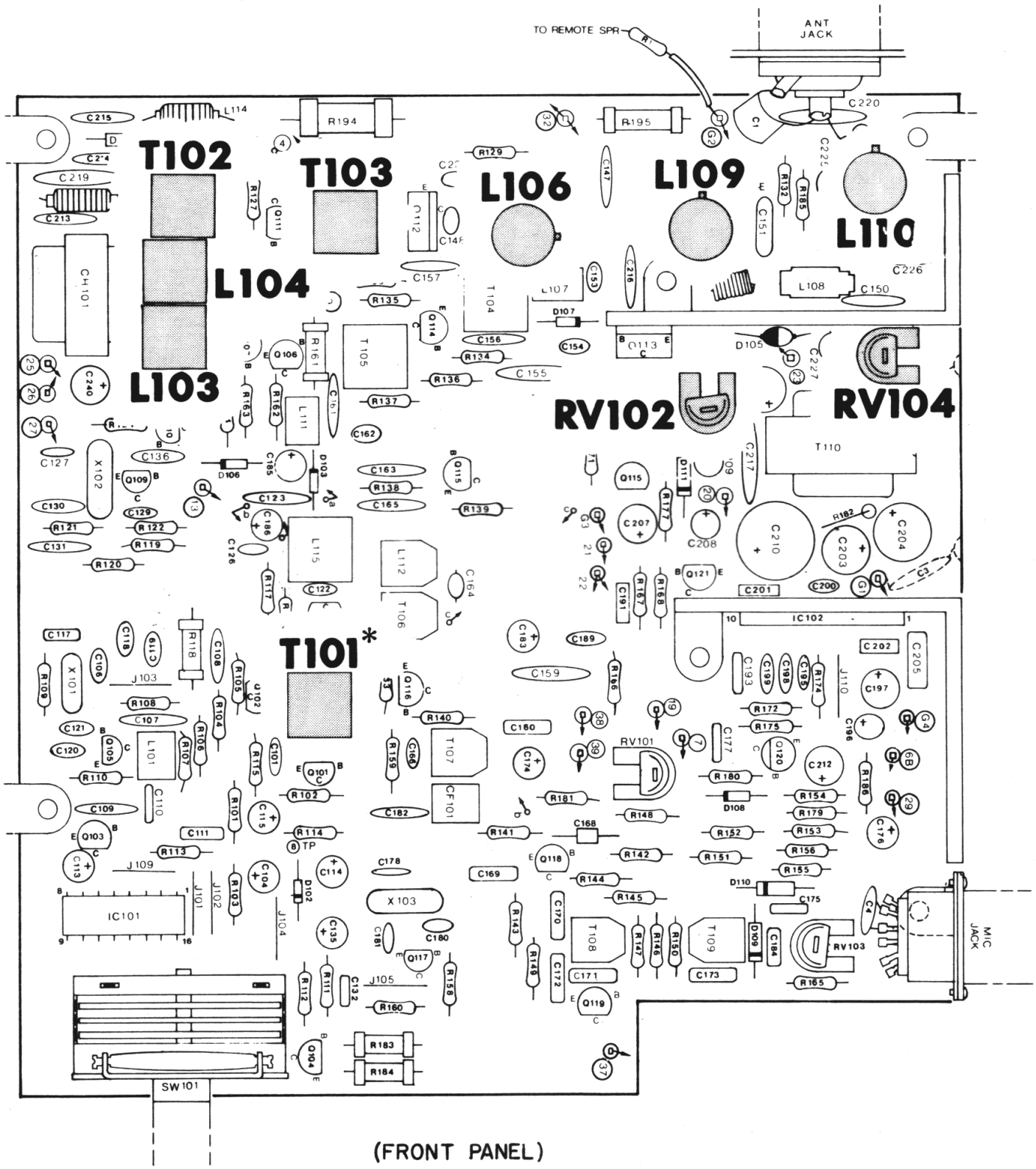


Figure 3-1

Components Adjusted for Receiver Alignment, Models 681 and 682



*T101 is adjusted for VCO alignment only.

Figure 3-2

Components Adjusted for Transmitter Alignment, Models 681 and 682

CHAPTER 4 — CHARTS AND DRAWINGS

Voltage Readings Chart Models 681 and 682

VOLTAGE READING CHART

Ref. Desig.		E	B	C
Q101	Rx	0	0	2.1
	Tx	0	0	2.1
Q102	Rx	0	0	2.3
	Tx	0	0	2.3
Q103	Rx	0	0	2.9
	Tx	0	0	2.9
Q104	Rx	0	0.6	2.7
	Tx	0	0.6	2.7
Q105	Rx	2.1	2.3	3.8
	Tx	2.1	2.3	3.8
Q106	Rx	8.0	8.2	13
	Tx	8.0	8.2	13
Q107	Rx	8.0	7.5	8
	Tx	8.0	7.5	7.8
Q108	Rx	0	0.6	6.0
	Tx	0	0.6	6.0
Q109	Rx	0	0.3	0.8
	Tx	2.2	2.5	5.0
Q110	Rx	0	0	0.4
	Tx	1.7	2.2	8.8
Q111	Rx	0	0.2	13.8
	Tx	1.1	1.75	13.8
Q112	Tx	0	-	11.5
Q113	Tx	0	-	12.5
Q114	Rx	1.8	2.2	13.0
Q115	Rx	1.8	2.2	12.7
Q116	Rx	0	0	0
Q117	Rx	1.7	2.0	3.5
	Tx	1.7	2.0	3.5
Q118	Rx	1.7	2.2	12.7
Q119	Rx	0.6	1.2	13.0
Q120				
squelched		0	0.5	0
unsquelched		0	0	6.5
Q121		0	0	0
Q122	Rx	0	0.6	0
	Tx	0	0.6	0

IC 102 (BA 521)

Pin No.	1	2	3	4	5	6	7	8	9	10
Voltage	6.8	0	1.1	6.6	6.2	6.3	1.0	8.0	8.0	13.8

IC 101 (P.L.L. 01A)

Pin No.	Voltage	Channels Selected
1	5.4	N/A
2	2.2	N/A
3	2.2	N/A
4	(not used)	N/A
5	1.8	N/A
6	2.3	N/A
7	2.3	N/A
8	0	N/A
9	4.9	All channels
10	0	All channels
11	4.9	17, 18, 19, 20, 21, 22, 23
12	4.9	9, 10, 11, 12, 13, 14, 15, 16
13	4.9	8, 16, 23
14	4.9	4, 5, 6, 7, 12, 13, 14, 15, 20, 21, 22
15	4.9	3, 6, 7, 11, 14, 15, 19, 22
16	4.9	2, 5, 7, 8, 10, 13, 15, 16, 18, 21, 23

NOTE: All voltage readings are taken with the power source set at exactly 13.8V.D.C.