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**MODEL 2702A
CITIZENS TWO-WAY RADIO**

40 channel 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**

EO-2702-A-001



First Printing, August, 1977
Original Edition, August, 1977

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CHAPTER 1 — GENERAL INFORMATION

Introduction

This service manual contains all the information needed to service and repair the Hy-Gain II transceiver (Model 2702A). It includes an explanation of the theory of operation and alignment procedures. Revisions, addendums, and errata sheets will be published as needed. Insert them as required in the manual.

The Hy-Gain II radio is a full 40 channel transceiver, type accepted and receiver certified 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. The PLL (Phase Locked Loop) synthesizer provides immediate operation on all 40 channels. Features include an automatic noise limiter (ANL), an RF gain control, public address capabilities and an output jack for an external speaker. 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 the problem. Address the 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 shipping the unit contact the National Service Manager. Often a problem is field solvable with a little extra help. This can save lost time and shipping costs. Limit factory returns to the difficult problems.

How to Ship Returns

To return a unit, get a return authorization. This is important. Handling of the unit may be delayed if shipped without it. If the unit must be shipped immediately, telephone or telex the National Service Manager for expeditious service.

When you request authorization, notification of repairs may also be requested. The notification will include a copy of the bill. Paying the bill before the return of the unit can save 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. 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 the letter directly to it so this information is not overlooked. Wrap the unit and the envelope in heavy paper or put it in a plastic bag. If the original carton is not available, place the unit in a strong carton 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 the box with gummed paper tape, tie it

with a strong cord, and ship it be 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 important that the shipment be well-packed and fully-insured. Damage claims can delay repair and return of the unit. All claims must be settled between you and the carrier.

All shipments must be sent PREPAID. We *do not* accept collect shipments. After the unit has been repaired we will send it back COD unless the bill has been prepaid. 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 40 channels in the citizens band
(26.965 MHz - 27.405 MHz)
Antenna impedance 50 ohms, nominal
Dimensions (HWD) 2¼" x 6½" x 9"
Power requirements..... 11.5 VDC - 14.5 VDC, negative or
positive ground
Compliance type accepted under FCC Rules Part 95

Receiver

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 frequency..... 1st IF - 10.695 MHz
2nd IF - 455 kHz
Audio output 3 watts maximum
Current drain receive about 300 mA (no signal)

Transmitter

RF power output..... 4 watts
Emission AM, type 6A3
Spurious response rejection all harmonic and spurious suppression
better than FCC requirements
Modulation..... AM, 90% typical
Current drain transmit less than 1.2 amps @ 13.8 VDC

CHAPTER 2 — THEORY OF OPERATION

General

The theory of operation of the Hy-Gain II transceiver is divided into three sections: the Phase Locked Loop Frequency Synthesizer, the Transmitter, and the Receiver. 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 2-2, for visual reference to the theory of operation.

Phase Locked Loop Frequency Synthesizer

The Phase Locked Loop (PLL) frequency synthesizer generates frequencies for use in both the transmitter and receiver section. Its output determines the channel on which the transceiver is operating. The PLL circuitry incorporates three crystal oscillators to perform its frequency generating function.

The 11.8066 MHz Oscillator, Q105, has its output tripled and serves as a prescaler for the output of the Voltage Controlled Oscillator (VCO), Q101. The Offset Oscillator, Q109, operates at a frequency of 10.695 MHz, which mixes with the VCO output to provide the transmit frequency. The 10.24 MHz Oscillator, Q117, provides a reference for the PLL and the injection frequency for the Second Receiver Mixer.

The PLL circuit generates the operating frequencies needed for the transceiver in accordance with the code fed to the programmable divider, IC101, from the channel selector switch. Table A shows the following for each channel: the channel frequency, VCO frequency, binary 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 37.660 MHz, and the binary code ("N" code) is 224. The channel selector switch programs the programmable divider for a division ratio of 224. The 10.24 MHz reference frequency is fed to the Integrated Circuit PLL Chip, IC101. It is divided by 1024 within the chip, producing a 10 kHz reference signal. The output of the VCO is mixed in the PLL Mixer, Q102, with the tripled output of Q105, producing a 2.24 MHz signal. This signal is fed to the programmable divider, which divides it by 224 to produce 10 kHz.

The two 10 kHz signals are phase compared in the phase detector within IC101 producing a DC voltage. This DC voltage controls the varactor diode, D101, and holds the VCO frequency at 37.660 MHz.

Assume that the channel is changed to channel 40. The channel selector switch now provides a code that will produce a division ratio of 268. At this instant the VCO frequency is at 37.660 MHz, which is mixed with the tripled output of Q105. Again, the PLL mixer, Q102, produces an output of 2.24 MHz. The 2.24 MHz signal is divided by 268 to produce a frequency of 8.3582 kHz.

The 8.3582 kHz output, along with the 10 kHz obtained from the reference oscillator, is fed to the phase detector. 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 again 10 kHz. When the two frequencies are matched at 10 kHz, the error voltage output of the phase detector is zero.

Transmitter

Switching to the transmit mode is accomplished in the following manner: When the PTT switch is closed, the base of the Transmit Switch, Q107, is grounded. This establishes

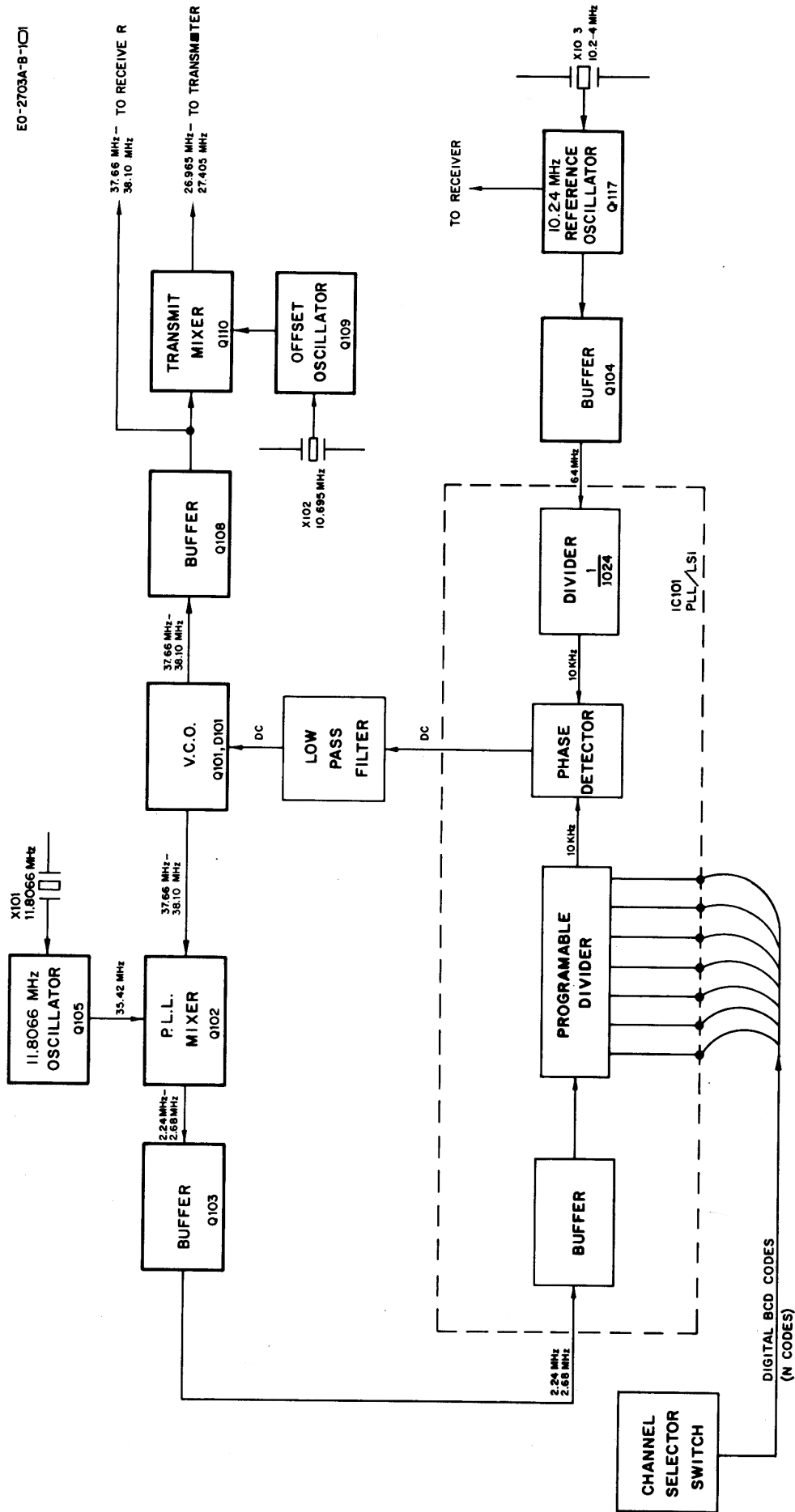


Figure 2-1. Block Diagram PLL Circuitry, Model 2702A

forward bias which causes Q107 to conduct. Regulated voltage from the Automatic Voltage Regulator (AVR), Q106, is then supplied through Q107 to Q109 and Q110.

The operating channel is determined by the PLL frequency synthesizer. The buffered VCO frequency is mixed in Q110 with the 10.695 MHz Oscillator, Q109, output to yield the transmit frequency. The transmit frequency from Q110 passes through the filter circuit of L103, L104, and T102 and is supplied 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 final stage, 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 consisting of L109, C152, L110, and C1, 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 audio output transformer, T110. Control voltages for the transmit audio, ALC, Q122, and the Range Boost, Q121, come from the detector diode, D111. The transmit audio ALC boosts or lowers the amplifier gain in response to line voltage fluctuations. This ensures full modulation of the carrier despite any changes in line voltage. The Range Boost reduces AF peaks so that a higher average AF level is supplied to the Audio Amplifier. This gives the desired high average modulation without overmodulation of peaks.

Receiver

The receiver is a dual-conversion superheterodyne, receiving AM signals from 26.965 MHz to 27.405 MHz. The operating channel is determined by the PLL frequency synthesizer, which provides the local oscillator frequency to the First Mixer. 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, keeping it open so that the transceiver circuits remain in receive.

Radio signals are received by the antenna and enter the radio at the antenna jack. The filter formed by L109, L110, C152, and C151 matches the antenna impedance to the RF Amplifier. Signals in the 26.965 - 27.405 MHz range are filtered and amplified by the RF Amplifier, Q114, and its tuned circuit C152/T104. D107 is a signal overload protector.

The output of the RF Amplifier and the buffered VCO signal (which in this case could be called the "first local oscillator frequency") are applied to the First Receiver Mixer, Q115, which produces an output of 10.695 MHz, which is the first IF.

The first IF passes through tuned circuits L112 and T106. It is then applied to the Second Receiver Mixer, Q116, along with a 10.240 MHz signal from the Reference Oscillator, Q117. The two signals are mixed in the Second Receiver Mixer and produce an output of 455 kHz, which is the second IF.

The second IF passes through the ceramic filter, CF101, and is amplified by Q118 and Q119. The amplified signal is then fed to the detector, D110. The detector establishes an automatic gain control (AGC) voltage and recovers the audio from the modulated signal. The AGC voltage maintains the output volume of the receiver constant under variations in input signal strength and also controls 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 RV101. In the absence of a

signal, the base of Q120 is positively biased and is on. This biases the squelch transistor inside IC102 such that the audio amplifier is turned on and the signal is heard.

The recovered audio from the detector passes through a series automatic noise limiter (ANL), D108. 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.

PA Amplifier and Switch

When the PA mode is selected by placing S3 in the PA position, the PA Gate Switch, Q4, is grounded. With Q4 grounded, all other functions of the unit except PA are inoperative.

The PA Audio Gate, Q3, functions as an amplifier for the microphone when it is not clamped to AC ground by Q4. The audio signal from the microphone is amplified by Q3 and is then applied to the Audio Amplifier, IC102. The audio signal is amplified by IC102 and is then applied to the PA jack, J5.

Channel Selection

Channel Selection is accomplished with the channel selector switch. The switch selects the proper binary code and feeds it to the programmable divider of the PLL, IC101. A portion of the coded channel selector switch output passes through the resistor array and controls the two 7 segment LED readouts to indicate the channel in use.

"N" Code-Frequency Correlation Chart

Table A

Channel No.	Channel Frequency	"N" Code	V.C.O. Frequency	PLL INPUT CODE									
				(256) B8	(128) B7	(64) B6	(32) B5	(16) B4	(8) B3	(4) B2	(2) B1	(1) B0	
1	26.965 MHz	224	37.660 MHz	0	1	1	1	0	0	0	0	0	0
2	26.975 MHz	225	37.670 MHz	0	1	1	1	0	0	0	0	0	1
3	26.985 MHz	226	37.680 MHz	0	1	1	1	0	0	0	0	1	0
4	27.005 MHz	228	37.700 MHz	0	1	1	1	0	0	0	1	0	0
5	27.015 MHz	229	37.710 MHz	0	1	1	1	0	0	0	1	0	1
6	27.025 MHz	230	37.720 MHz	0	1	1	1	0	0	0	1	1	0
7	27.035 MHz	231	37.730 MHz	0	1	1	1	0	0	0	1	1	1
8	27.055 MHz	233	37.750 MHz	0	1	1	1	0	1	0	0	0	1
9	27.065 MHz	234	37.760 MHz	0	1	1	1	0	1	0	0	1	0
10	27.075 MHz	235	37.770 MHz	0	1	1	1	0	1	0	0	1	1
11	27.085 MHz	236	37.780 MHz	0	1	1	1	0	1	1	0	0	0
12	27.105 MHz	238	37.800 MHz	0	1	1	1	0	1	1	1	1	0
13	27.115 MHz	239	37.810 MHz	0	1	1	1	0	1	1	1	1	1
14	27.125 MHz	240	37.820 MHz	0	1	1	1	1	0	0	0	0	0
15	27.135 MHz	241	37.830 MHz	0	1	1	1	1	0	0	0	0	1
16	27.155 MHz	243	37.850 MHz	0	1	1	1	1	0	0	0	1	1
17	27.165 MHz	244	37.860 MHz	0	1	1	1	1	0	1	0	0	0
18	27.175 MHz	245	37.870 MHz	0	1	1	1	1	0	1	0	0	1
19	27.185 MHz	246	37.880 MHz	0	1	1	1	1	0	1	1	1	0
20	27.205 MHz	248	37.900 MHz	0	1	1	1	1	1	0	0	0	0
21	27.215 MHz	249	37.910 MHz	0	1	1	1	1	1	0	0	0	1
22	27.225 MHz	250	37.920 MHz	0	1	1	1	1	1	0	0	1	0
23	27.255 MHz	253	37.950 MHz	0	1	1	1	1	1	1	0	0	1
24	27.235 MHz	251	37.930 MHz	0	1	1	1	1	1	0	1	1	1
25	27.245 MHz	252	37.940 MHz	0	1	1	1	1	1	1	0	0	0
26	27.265 MHz	254	37.960 MHz	0	1	1	1	1	1	1	1	1	0
27	27.275 MHz	255	37.970 MHz	0	1	1	1	1	1	1	1	1	1
28	27.285 MHz	256	37.980 MHz	1	0	0	0	0	0	0	0	0	0
29	27.295 MHz	257	37.990 MHz	1	0	0	0	0	0	0	0	0	1
30	27.305 MHz	258	38.000 MHz	1	0	0	0	0	0	0	0	1	0
31	27.315 MHz	259	38.010 MHz	1	0	0	0	0	0	0	0	1	1
32	27.325 MHz	260	38.020 MHz	1	0	0	0	0	0	0	1	0	0
33	27.335 MHz	261	38.030 MHz	1	0	0	0	0	0	0	1	0	1
34	27.345 MHz	262	38.040 MHz	1	0	0	0	0	0	0	1	1	0
35	27.355 MHz	263	38.050 MHz	1	0	0	0	0	0	0	1	1	1
36	27.365 MHz	264	38.060 MHz	1	0	0	0	0	1	0	0	0	0
37	27.375 MHz	265	38.070 MHz	1	0	0	0	0	1	0	0	0	1
38	27.385 MHz	266	38.080 MHz	1	0	0	0	0	1	0	0	1	0
39	27.395 MHz	267	38.090 MHz	1	0	0	0	0	1	0	0	1	1
40	27.405 MHz	268	38.100 MHz	1	0	0	0	0	1	1	0	0	0

CHAPTER 3 — ALIGNMENT

General

These procedures must be followed to align the Hy-Gain II transceiver (Model 2702A).

Alignment should not be undertaken unless the technician has adequate test equipment and 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 radio operator license", as stipulated in Part 95.97(b) of the FCC Rules and Regulations.

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

NOTE: The ferrite cores in the tuned coils are easily chipped or broken. Always use care when inserting an alignment tool in the coil; insert it straight into the core.

Recommended Tools and Equipment

The following equipment is recommended for use in aligning the Hy-Gain II transceiver:

1. Audio Signal Generator, 1 kHz
2. AC VTVM, 1 mV measurable
3. DC Ampere Meter, 2A
4. Variable Regulated Power Supply, DC 8-15, 2A
5. Frequency Counter, 0 to 40 MHz, high input impedance type
6. VTVM with RF probe
7. Oscillator, 30 MHz, high input impedance
8. RF wattmeter and 50 ohm, 5W dummy load
9. Standard RF signal generator, 27 MHz CB band
10. Speaker dummy resistor, 8 ohm 5W
11. VOM 20k ohm/V

NOTE: Test voltage is 13.8 VDC unless otherwise specified.

Transmitter Alignment

Equipment Set-up

Refer to Figure 3-4 for the location of components to be adjusted for transmitter alignment.

Connect test equipment as shown in Figure 3-1.

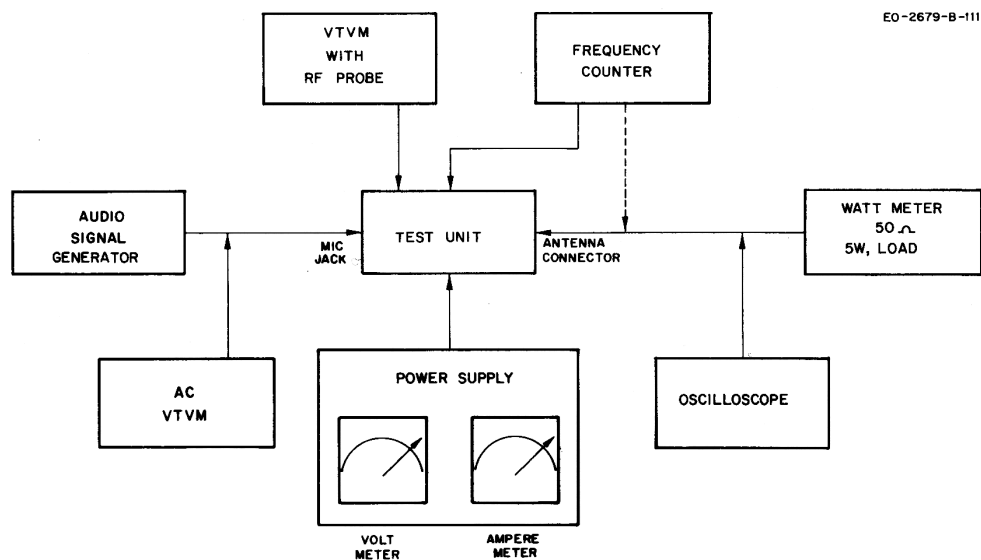


Figure 3-1. Equipment Set-up, Transmitter Alignment

Pre-Alignment Frequency Check

Before alignment, use the frequency counter through a 1000pF coupling capacitor connected in series with a counter input probe to check the operating frequencies at the following points:

1. Pin 3 of IC101, reference input, check to read 10.24 MHz accurate to four significant digits. If not, proceed to VCO Alignment.
2. Q108 base, transceiver on Ch. 1, check to read 37.66 MHz accurate to four significant digits. If not, proceed to VCO alignment.

VCO Alignment

1. Connect VOM (DC 10V ranged) across C135 and check to read 5.0V - 5.5V.
2. Place the channel selector in the channel 1 position.
3. Connect the VOM between ground and R114 (TP-8 side).
4. Adjust T101 to obtain 1.5 + .1V.
5. Place the channel selector in the channel 40 position and read the value on the meter. It should be 4.0 + 0.6V.

RF Output Adjustment

1. Adjust the power supply voltage to 8.0V.
2. Connect the VTVM RF probe between the base of Q111 and ground.
3. Set the transceiver channel selector to channel 19. Perform the following procedure on channel 19.
4. Key the transmitter.
5. Adjust the slugs of L103, L104, and T102 for a maximum reading on 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 on the VTVM.
8. Adjust L106, L109, and L110 for a maximum RF power output as indicated on the wattmeter.
9. Raise the power supply voltage to 13.8V.
10. Repeat steps 2 through 8 without VTVM.
11. Repeat step 8 until no further improvement is noted.
12. Back off L110 (clockwise) for a reading of 4.0 watts RF power output.
13. Readjust L109 for a maximum power out.
14. Repeat steps 12 and 13 until the maximum power output is 4.0 watts with L110 peaked for maximum output. Total transceiver current at this setting should not exceed 1.35A.
15. Check power output on channels 1 and 40. Power should not be less than 3.6 watts. If less, repeat alignment procedure.

NOTE: See Figure 3-2 for connection of frequency counter and dummy load.

Transmitter Frequency Check

1. Turn the transceiver off.
2. Connect the dummy load and frequency counter to the antenna jack as shown in Figure 3-2.

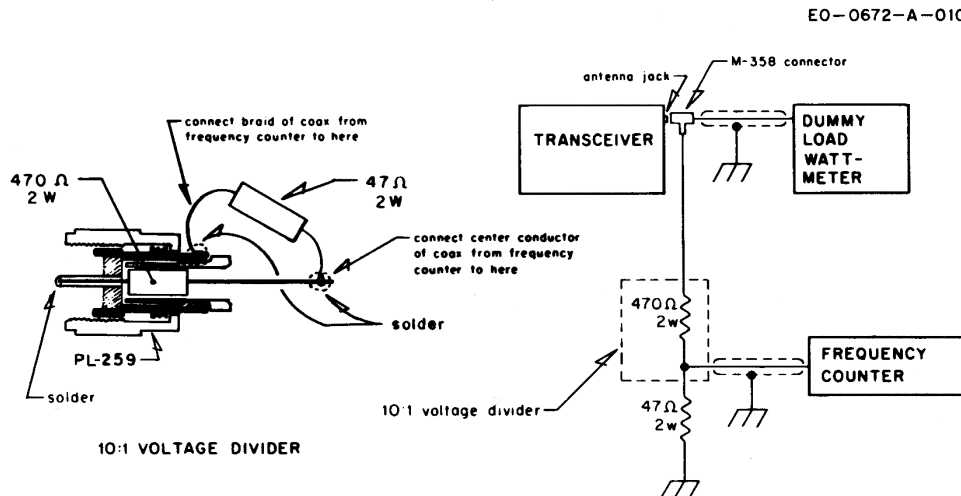


Figure 3-2. Connection of Frequency Counter and Dummy Load

3. Turn the transceiver on.
4. Key the transmitter with the microphone PTT button.
5. Check the frequency of each channel with the following chart. Frequencies should be within 800Hz at 25°C (room temperature).

CHANNEL FREQUENCY

Channel	MHz	Channel	MHz
1	26.965	21	27.215
2	26.975	22	27.225
3	26.985	23	27.255
4	27.005	24	27.235
5	27.015	25	27.245
6	27.025	26	27.265
7	27.035	27	27.275
8	27.055	28	27.285
9	27.065	29	27.295
10	27.075	30	27.305
11	27.085	31	27.315
12	27.105	32	27.325
13	27.115	33	27.335
14	27.125	34	27.345
15	27.135	35	27.355
16	27.155	36	27.365
17	27.165	37	27.375
18	27.175	38	27.385
19	27.185	39	27.395
20	27.205	40	27.405

Modulation Sensitivity Alignment

1. Place the unit in the transmit mode and apply a 20 mV, 1 kHz signal to wire wrap pin 22 on the radio P.C. board.
2. Adjust RV102 to obtain 90% modulation as observed on the oscilloscope.
3. Decrease the signal input to 6 mV. Modulation should not fall below 80%.

Receiver Alignment Procedure

Equipment Set-up

Refer to Figure 3-5 for the location of components to be adjusted for receiver alignment.

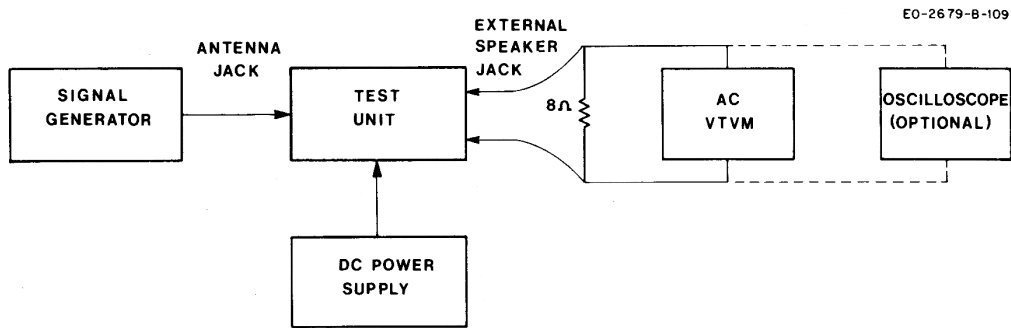


Figure 3-3. Equipment Set-up, Receiver Alignment

Receiver Alignment

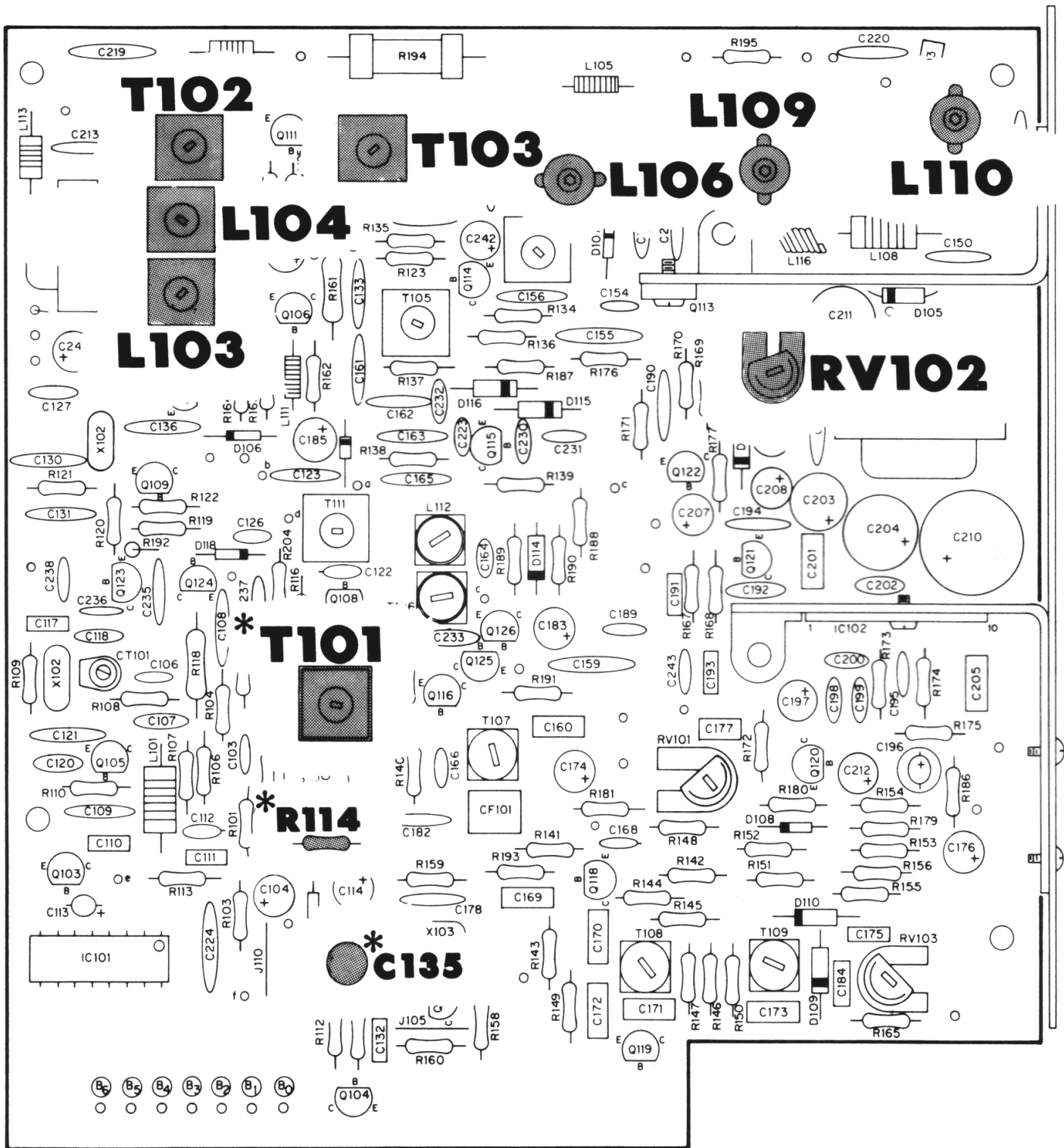
1. Set the Signal Generator to 27.185 MHz, + 1 kHz, 30% modulation and set the transceiver on channel 19.

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

2. Adjust T104, T105, L112, T106, T107, T108 and T109 for maximum audio output as indicated on the AC VTVM (or oscilloscope if used).

Tight Squelch Adjustment

1. Set the signal generator to provide an RF input signal of 50 μ V (1 kHz, 30% modulation).
2. Rotate the squelch control fully clockwise.
3. Adjust RV101 so that the squelch just breaks with the 50 μ V signal input.

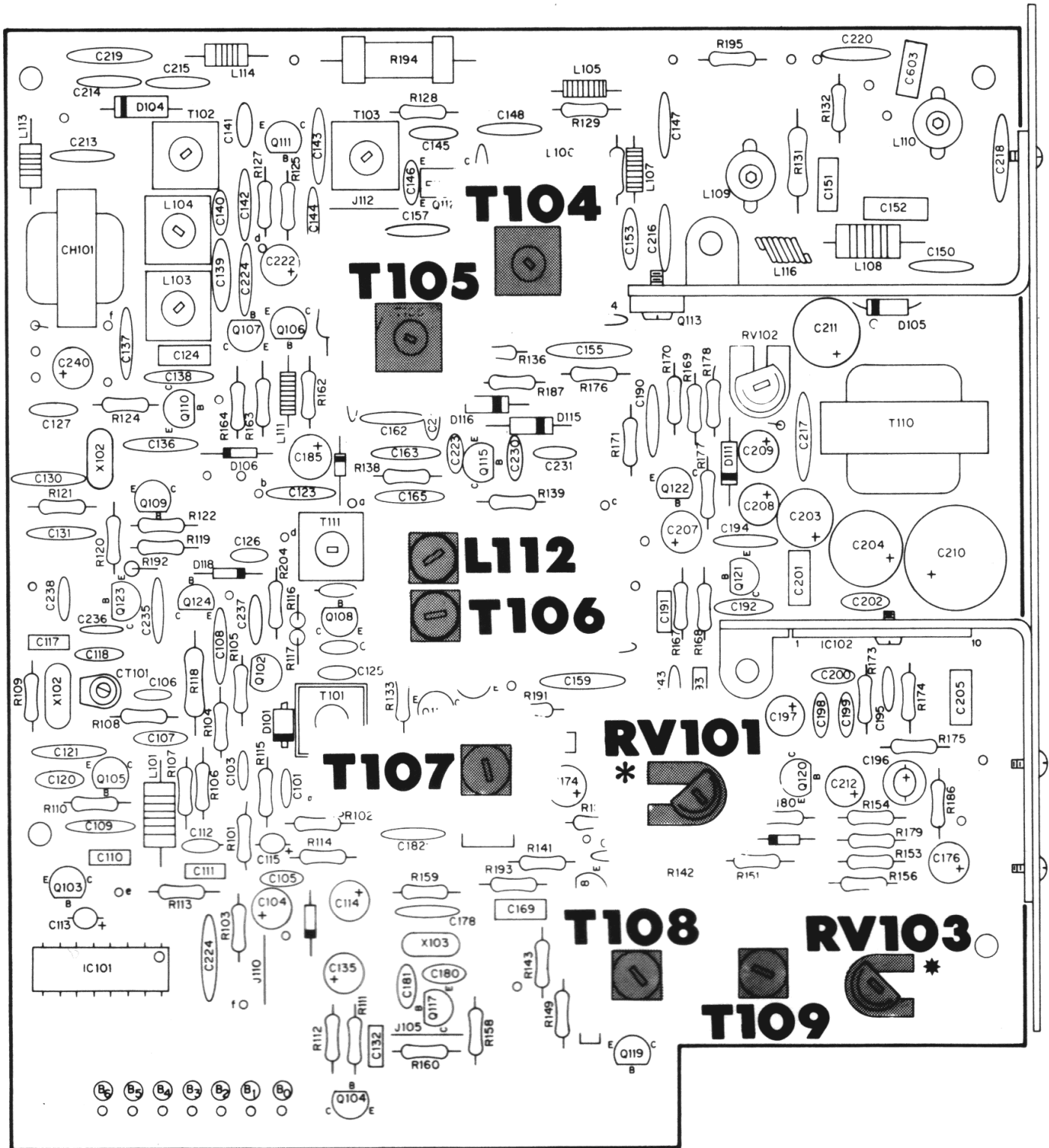


NOTES:

T101 - adjusted for VCO Alignment.

R114 and C135 - test connections for VCO Alignment.

Figure 3-4. Components Adjusted for Transmitter Alignment



NOTES:

RV103 - not adjusted in this radio.

RV101 - adjusted for Tight Squelch Adjustment.

Figure 3-5. Components Adjusted for Receiver Alignment

CHAPTER 4 — CHARTS AND DRAWINGS



Voltage Charts

VOLTAGE MEASUREMENT CHART

Reference Designator	E		B		C	
	RX	TX	RX	TX	RX	TX
Q101	0	0	.5	.5	5.8	5.8
Q102	0	0	.28	.28	2.3	2.3
Q103	0	0	.76	.76	2.6	2.6
Q104	0	0	.56	.56	3.0	3.0
Q105	2.2	2.2	2.6	2.6	3.75	3.75
Q106	8.1	8.1	8.8	8.8	13.3	12.3
Q107	8.1	8.1	7.8	7.8	1.3	8.0
Q108	0	0	.58	.72	.72	2.7
Q109	.23	2.5	.84	3.1	.96	4.1
Q110	0	1.8	.23	2.4	1.3	8.0
Q111	2.5	2.2	3.2	2.8	14.1	13.9
Q112	0	0	0	-.6	13.9	11.1
Q113	0	0	0	-.05	14.0	12.2
Q114	1.7	3.2	2.4	.35	13.2	13.4
Q115	1.7	0	2.35	.35	12.5	13.8
Q116	0	0	-.04	-.04	0	0
Q117	1.6	1.6	2.1	2.1	3.6	3.6
Q118	1.6	0	2.3	.34	12.6	13.8
Q119	1.7	0	1.28	.13	13.2	13.8
Q121	0	0	.05	.17	0	0
Q122	0	0	.59	.59	.05	.17

Q120	E		B		C	
	RX	TX	RX	TX	RX	TX
Squelch Minimum	0	0	.01	.01	3.5	3.4
Squelch Maximum	0	0	.65	.17	.01	3.4

Audio IC

	1	2	3	4	5	6	7	8	9	10
RX	14.1	13.2	4.1	12.5	.48	3.5	1.6	0	0	11.3
TX	13.8	13.7	4.1	8.2	1.34	3.5	3.4	1.34	0	6.9

PLL

Pin	Voltage	Channel Selected
1	5.2	N/A
2	2.5 - 2.6	N/A
3	3	N/A
4	5.2	N/A
5	1.4 - 4.2	1-40
6	5.2	N/A
7	5.2	28-40
8	5.2	1-27
9	5.2	1-27
10	5.2	1-27
11	5.2	14-27
12	5.2	8-13 20-27 36-40
13	5.2	4, 5, 6, 7, 11, 12, 13, 17, 18, 19, 23, 25, 26, 27, 32, 24, 35, 40.
14	5.2	3, 6, 7, 9, 10, 12, 13, 16, 19, 22, 24, 26, 27, 30, 31, 34, 35, 38, 39.
15	5.2	2, 5, 7, 8, 10, 13, 15, 16, 18, 21, 23, 24, 26, 27, 29, 31, 33, 35, 37, 39.
16	0	N/A