



# SERVICE MANUAL

13 — 513

VHF-FM 20 WATT 220-225 MHZ  
PLL AMATEUR TRANSCEIVER

MANUAL NO. 13-220167

DATE: NOV. 1, 1977



## SPECIFICATIONS

### GENERAL

Frequency Coverage	220.00 to 225.00 MHz
Number of Transistors	Transistors ..... 41 FET ..... 11 IC ..... 13 Diodes ..... 35
Modulation Type	F3
Power Voltage	DC 13.8V ± 15% Negative ground
Current Drain	Transmit: Hi (20W) Average ..... 6A Middle(10W) Average ..... 4A Low(2W) Average ..... 2A Receive Average ..... 0.8A
Antenna Impedance	50 ohms
Size	2-3/5" (H) x 6-4/5" (W) x 9-3/5" (D)
Weight	3.0 kg, 6.6 lbs

### TRANSMITTER

RF Power Output	Hi ..... 20W Middle ..... 10W Low ..... 2W
Frequency Control Channels	Phase Locked Loop (PLL) 1000 channels in 220 to 225 MHz (10 KHz steps +5 KHz shift up) +1.6 MHz or -1.6 MHz Transmitter shift Adjustable between 3 to 16 KHz Normal 5 KHz
Repeater Operations	600 ohms
Frequency Deviation	Direct FM (Reactance)
Audio Input	600 ohms - Dynamic microphone with push button switch
Modulation System	
Microphone	

### RECEIVER

Reception Frequencies	1000 channels in 220 to 225 MHz
Reception System	Double Superheterodyne
Intermediate Frequencies	1st I.F. 16.9 MHz 2nd I.F. 455 KHz
Sensitivity	(a) Better than 0.5µV 20 dB quieting (b) S+N/N at 0.3µV input 12dB or more
Spurious Response	-60dB
Squelch Threshold	Less than 0.3µV
Band Width	±7.5KHz at 6dB down
Selectivity	±15KHz at 70dB down
Audio output power	1.5W



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## ACCESSORIES

The following accessories for the model 13-513 are included.

- 1) Microphone (dynamic type) .....1
- 2) Microphone hanger .....1
- 3) Spare fuse (6A) .....1
- 4) Mounting bracket .....1
- 5) Instruction manual .....1
- 6) Product information card .....1
- 7) EXT Speaker plug .....1
- 8) Accessory plug .....1

## SECTION 2. GENERAL INFORMATION

The 13-513 is a sophisticated solid state amateur radio transceiver employing phase Locked Loop circuitry. Operating on full 220 MHz bands between 220 to 225 MHz, this unit offers many advanced, modern features. Its entire construction is modular with all major electronic circuits built on separated circuits boards. The 13-513 includes many features found as extras on other transceivers. Included in the equipment are 20 watts RF output power on "HI" position, no channel crystals required, 1000 channels selectable for both transmit and receive in 5 KHz steps, LED frequency display, automatic repeater split with  $\pm 1600$  KHz transmit frequency shift for repeater operations. As other special feature, it provides an accessory of bracket for desk-top use, which makes the transceiver ideal for base station operation by using an external power supply, as well as mobile operation.

## SECTION 3. INSTALLATION

### 3.1 Unpacking:

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

### 3.2 Location:

Where you place the transceiver in your automobile is not critical and should be governed by convenience and accessibility entirely. Since the unit is so compact, many mobile possibilities present themselves. In general, the mobile mounting bracket will provide you with some guide as to placement. Any place where it can be mounted with metal screws, bolts, or pop-rivets will work. For base station operation, the bracket for desk-top use is useful.

### 3.3 Power Requirements:

The transceiver is supplied ready to operate from any regulated 13.8V DC, 6.0 ampere negative ground source. An automobile, 12 volt, negative ground, system is usually more than adequate. Some note must be taken, however, to the condition of the vehicle's electrical system. Problems such as low battery, worn generator/alternator, poor voltage regulator, etc., will impair operation of your transceiver as well as the vehicle.

High noise generation or low voltage delivery can be traced to these deficiencies. If an AC power supply is used with your transceiver, make certain it is adequately regulated for both voltage and current. Low voltage while under load will not produce satisfactory results from your transceiver. Receiver gain and transmitter output will be greatly impaired.

**Caution:** Excessive Voltage (above 16VDC) will cause damage to your transceiver. Be sure to check the source voltage before connecting the power cord.

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

### 3.4 Antenna:

The most important single item that will influence the performance of any communication system is the antenna. For that reason, a good, high-quality, gain antenna of 50 ohms impedance is recommended. When adjusting your antenna, whether mobile or fixed, by all means follow the manufacturer's instructions. There are some pitfalls to be aware of. For example, do not attempt to adjust an antenna for lowest VSWR when using a diode VSWR meter not engineered for VHF applications. Such readings will invariably have an error of 40% or more. Rather, use an in line watt meter similar to the Drake WV-4 or Bird Model 23 with VHF cartridge. Further, when adjusting a mobile antenna, do so with the motor running preferably above normal idling speed. This will insure proper voltage level to the transceiver.

Do not become alarmed if your transceiver fails to transmit at times during the antenna tune up procedure. Remember, your transceiver has a built-in Automatic Protection Circuit (APC) that will disable the transmitter if excessive VSWR, a shorted coaxial line or connector, or other antenna deficiency is present. A quick check on a good 50 ohm dummy load will show the transceiver to be working. The difficulty will lie with the antenna or its transmission line.

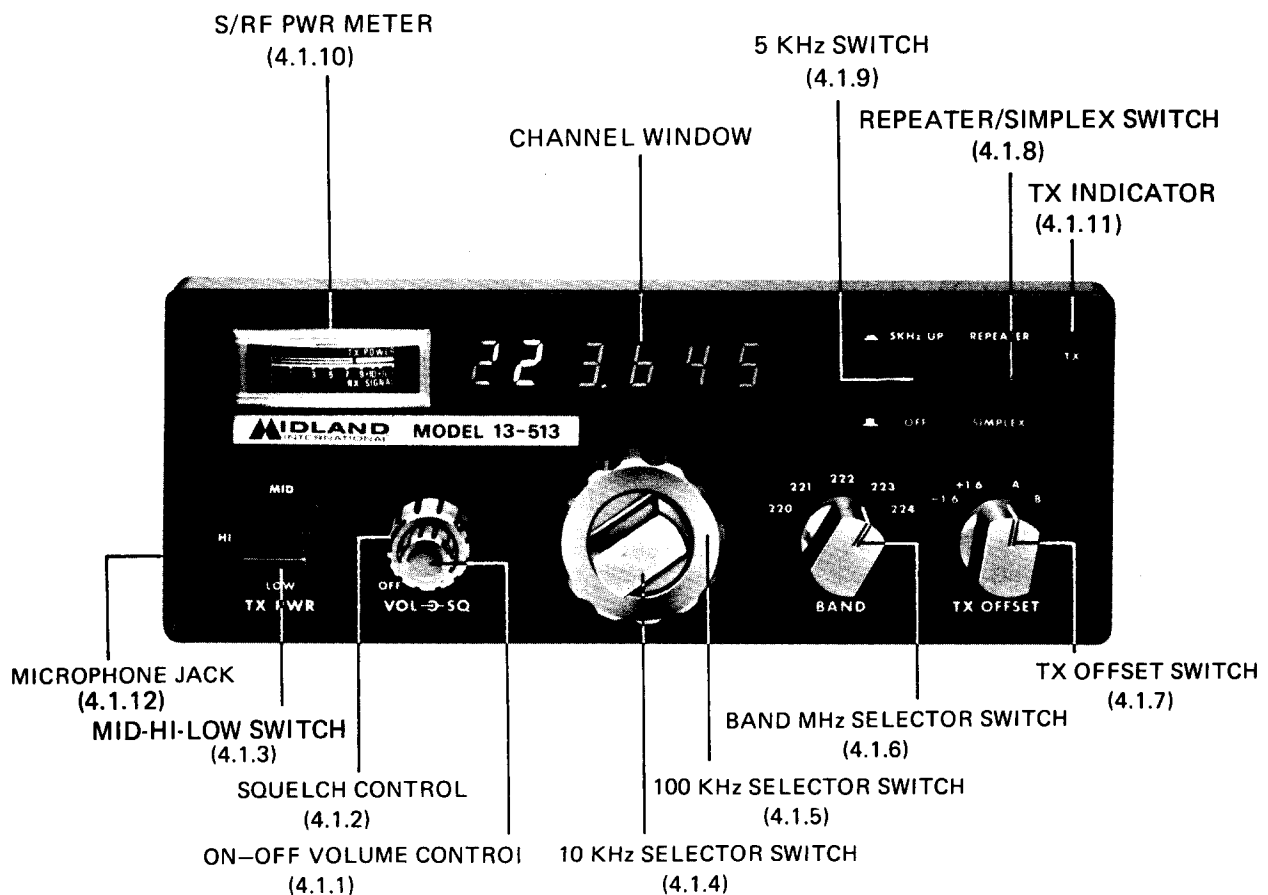
The RF coaxial connector on the rear chassis mates with a standard PL-259 connector.

### 3.5 Microphone:

A high quality dynamic microphone is supplied with your transceiver. Merely plug it into the proper receptacle on the side cabinet. Should you wish to use a different microphone, make certain it is of the low impedance type (600 ohms). Particular care should be exercised in wiring also, as the internal electronic switching system is dependant upon it. See the schematic for the proper hook up. Under no circumstances use a "gain pre-amp" type microphone. The audio system in your transceiver is more than adequate and additional pre-amplification is unnecessary. To use this class of microphone is to invite distortion and possible damage to the transceiver.

## SECTION 4. CONTROL FUNCTIONS

### 4.1 FRONT PANEL CONTROLS



**4.1.1 ON-OFF/VOLUME CONTROL:** Applies power to the unit and adjusts desired level of sound.

**4.1.2 SQUELCH CONTROL:** Silences background noise in the absence of a received signal when properly adjusted.

#### 4.1.3 MID—HI—LOW SWITCH:

"LOW" position: transmitter is powered at the 2 watts level

"MID" position: transmitter is powered at the 10 watts level

"HIGH" position: transmitter is powered at the 20 watts level

4.1.4 **10 KHz SELECTOR SWITCH:** The inner switch selects the desired frequency digit on 10 KHz from 0 to 9 and simultaneously activates LED display on the channel window.

4.1.5 **100 KHz SELECTOR SWITCH:** The outer switch selects the desired frequency digit on 100 KHz from 0 to 9 and simultaneously activates LED display on the channel window.

4.1.6 **BAND MHz SELECTOR SWITCH:** This five position rotary switch selects the desired frequency digit on MHz from 0 to 4 and simultaneously activates LED display on the channel window. Note that the digits "22" are fixed and back-lighted when the power is "ON".

4.1.7 **TX OFFSET SWITCH:** In the REPEATER position on REPEATER/SIMPLEX switch, this switch activates and is used for Repeater operation and different frequency operation. "-1.6" position shifts Transmit frequency by -1.6 MHz against Receiver frequency. Note, in this case, that the frequency on the LED display coincide Receiver frequency. Also, "+1.6" position shifts Transmit frequency by +1.6 MHz against Receiver frequency. "A" and "B" positions make it possible to set optional shifting frequencies by putting additional crystals. The following is computation of additional crystal frequency:

$16.900 \text{ MHz} \pm \text{desired shifting frequency} = \text{crystal frequency}$

Ex: In case of "-800 KHz" of shifting frequency.

$16.900 \text{ MHz} - 800 \text{ KHz} = 16.100 \text{ MHz (crystal frequency)}$

#### 4.1.8 REPEATER/SIMPLEX SWITCH:

"REPEATER" position: The unit is set to REPEATER operating which activates TX OFFSET SWITCH.

"SIMPLEX" position: The unit is set to SIMPLEX operation which communicates on the same frequency of Transmit and Receive.

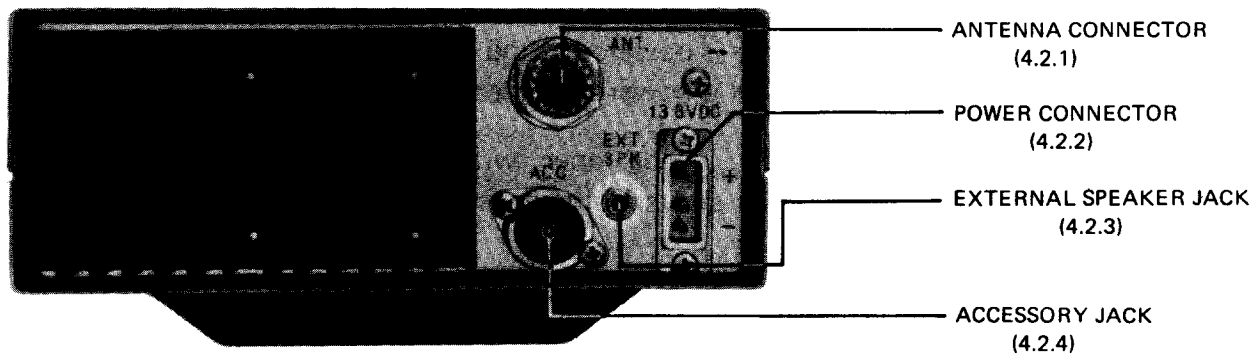
4.1.9 **5 KHz SWITCH:** This switch increases operating frequency by 5 KHz and simultaneously activates LED display on the channel window.

4.1.10 **S/RF PWR METER:** Shows field strength of the signal when receiving and relative transmitter RF output power, when transmitting.

4.1.11 **TX INDICATOR LIGHT:** Lights brightly when transmitting.

4.1.12 **MICROPHONE JACK:** Accepts 4 prong mike plug supplied on microphone.

## 4.2 REAR PANEL CONTROLS



**4.2.1 ANTENNA CONNECTOR:** Accepts standard PL-259 coaxial connector.

Note: Some transceivers may come with a metric threaded connector. If this is the case, a mating metric PL-259 is supplied also. Most PL-259 connectors will mate satisfactorily if care is taken to seat them properly. If you have difficulty, try a different make of PL-259.

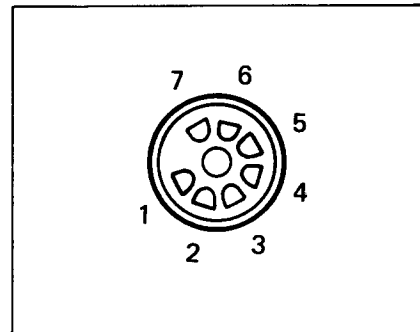
**4.2.2 POWER CONNECTOR:** For use with supplied power cord.

**4.2.3. EXTERNAL SPEAKER JACK:** This jack mates with the accessory Ext. Speaker plug supplied for external 4 ohm speaker or headset use. The use of this jack will disable the internal speaker.

**4.2.4. ACCESSORY JACK:** Accepts accessory 7 prong plug supplied for tone-burst and discriminator meter.

It would have as connections.

1. Blank
2. Transmit keyed 12 VDC positive
3. Discriminator meter connection
4. Ground
5. Tone audio input (10 mV)
6. Ground
7. Blank



## SECTION 5. OPERATING INSTRUCTIONS

### 5.1 INITIAL PREPARATIONS

**5.1.1** Connect the microphone to the microphone jack.

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

**5.1.3** Make sure the volume control is in the off position and the squelch control is in the maximum counterclockwise position. The red lead should be connected to the positive side of the power source and the black lead to the negative side. In the event that these leads are improperly connected, the 13-513 will not function.

## **5.2 OPERATION**

- 5.2.1 Rotate the volume control clockwise a few degrees until the switch snaps into the ON position, and LED frequency display on the channel window and S/RF meter will be illuminated.
- 5.2.2 Adjust BAND MHz, 100kHz and 10kHz selector switches to the desired frequency.

## **5.3 RECEIVER**

- 5.3.1 Advance the volume control to the desired audio level.
- 5.3.2 Carefully adjust the squelch control clockwise until the audio noise just disappears. This is the proper squelch threshold setting and must be done when no signal is present. Your transceiver will now remain silent until an incoming signal is received which opens the squelch. If the squelch is unstable due to the reception of weak or unstable stations, adjust the squelch control further until the proper threshold is obtained.
- 5.3.3 The S meter indicates the signal strength of the incoming stations and is calibrated in S units. An input signal of approximately  $5\mu$  V will provide an S9 reading.

## **5.4 TRANSMITTER**

The operation of the transmitter and receiver is controlled by the push-to-talk switch located on the side of the microphone. When depressed, the transmitter is placed into operation and the receiver becomes inoperative. When released, the receiver is automatically restored to operation and, at the same time, the transmitter becomes inoperative.

- 5.4.1 Place the REPEATER/SIMPLEX switch in either the REPEATER or SIMPLEX position at your desire. In the REPEATER position, TX OFFSET switch activates. In the -1.6 position on TX OFFSET switch, the transceiver transmits at the frequency of -1.6 MHz than Receiver frequency and in the +1.6 position, the transceiver transmits at the frequency of +1.6 MHz.
- 5.4.2 Place the MID-HI-LOW power switch at your desired power position. In the HI position, the transceiver operates at 20 watts power output level. In the MID position, the transceiver operates at 10 watts of power level. And in the LOW position, it operates at 2 watts of power level. When using the transceiver as a driver or exciter for a linear amplifier the MID-HI-LOW power switch can be set to the LOW power position and the power output adjusted as described in the Transmitter Alignment Procedure SECTION 7.4.3.(m). This will provide the required amount of drive for the linear amplifier without wasting power in swamping resistors, etc.
- 5.4.3 When pushing the PTT (push-to-talk) button on the microphone, The TX INDICATOR LIGHT is illuminated and the METER provides an indication of relative power output of the transmitter. The pointer will be on or near the red mark on the meter scale when on high power and just a little over one on low power.

**NOTE:** Do not attempt to transmit unless your antenna is properly connected.

## SECTION 6. CIRCUIT DESCRIPTION

### 6.1 RECEIVER CIRCUIT

- 6.1.1 RF Unit:** Signal from the antenna connector passes through the dual-tuned band pass filter, and is amplified by Q101, and fed into FT101 a 3-section helical resonator. The signal is then mixed with signal from the VCO unit by Q102 first mixer, and produces first IF 16.9MHz.
- 6.1.2 IF Unit:** Signal from the RF unit passes through FT151 3-section monolithic crystal filter, and is amplified by Q151 first IF AMP, and is mixed with signal from Q153, 16.445 MHz. Second IF passes through FT152 ceramic filter, and is limited in amplification by IC151 and 152. The AF signal is detected by FT153 ceramic discriminator, and fed into the AF unit.
- 6.1.3 AF Unit:** AF signal from the IF unit is amplified by Q203 and IC202, and drives the speaker, while noise signal from the IF unit is amplified by IC201 and Q201, and detected by D201 and D202, and drives switching transistor. Q202 and Q204 controls Q203 AF amplifier and activates squelch.

### 6.2 TRANSMITTER CIRCUIT

- Tx Younger Unit:** Signal from the VCO and Signal which is selected from X701 to X705 and oscillated by Q706 in IF unit are mixed with balanced mixer Q401 and Q402, and produce mixer output in the 220 MHz band. That signal is then amplified by Q403, Q404 and Q405, and drives the final unit.
- 6.2.2 Final Unit and APC Unit:** Output from the transmit Younger unit is amplified by Q451. Q452 and Q453 into a 20 watt output which is supplied into the APC unit. Signal from the final unit passes through the SWR bridge, diode switch D503 and D504, and also passes through 3-section low pass filter, and produces 20 watts output which is supplied into the APC unit.

### 6.3 PHASE LOCKED LOOP CIRCUIT

- 6.3.1 Local Unit:** Crystals X251 and X252 are selected by switching transistors Q251 and Q252, and are oscillated by Q253. Oscillation output is multiplied Five times by Q254, and again multiplied three time by Q255, and then it is fed into PLL mixer Q256. Simultaneously fed into Q256 is the output of VCO unit, and PLL IF (4.000 – 6.995 MHz) is produced.
- 6.3.2 Counter Unit:** The PLL IF is amplified by Q304 and then generated by Q303 and fed into IC304. This signal is divided in half by IC304. It is then program-divided by IC301 to produce an output of 25 KHz. On the other hand, X301(10.24 MHz) is oscillated by Q306, and fed into IC304 through driver Q305. Here again, the signal frequency is divided in half by IC304, and fed into IC301, where the output of 1/1024 (5 KHz) is produced.



**6.3.3 VCO Unit:** The difference output from the counter unit passes through the active low pass filter (Q351 through Q353), and goes into the VCO D351 and Q354, and controls the VCO frequency. The output of the VCO is amplified by Q356, and fed into the local unit PLL mixer Q256. On the other hand, the output of the VCO is also amplified by Q355, which produces the local frequency for both transmit and receive.

**6.3.4 Display Unit:** The desired BCD code is selected by the channel selector, and decoded by IC651 through IC653, and it drives the LED display.

## **6.4 POWER SUPPLY CIRCUIT**

13.8V DC input from the power connector is selected for transmit and receive by switching transistor Q551 through Q553. Q557 and Q558 are worked as protector circuit. When the excessive power happens to be supplied in transmit or receive, Q558 is automatically cut off and protects the circuits from the damage. IC801 is used for a 5V regulator for the TTL and C-MOS. Q554, Q555 and Q801 regulate the final unit as high-low power controller. D553, D554 and Q556 are activated by APC unit, and unlock signal of the counter unit, and regulate Q555 to shut down the transmit power.

# **SECTION 7. ALIGNMENT PROCEDURE**

## **7.1 GENERAL**

THE 13-513 HAS BEEN FACTORY ALIGNED USING TECHNIQUES AND TEST EQUIPMENTS NOT NORMALLY AVAILABLE TO THE SERVICE TECHNICIAN. IT SHOULD NOT BE NECESSARY TO PERFORM ANY ALIGNMENT ON THE UNIT AS RECEIVED FROM THE FACTORY. IN THE EVENT OF COMPONENT FAILURE, ANY REALIGNMENT WILL BE MINIMAL. IF IT APPEARS THAT ANY LARGE DEGREE OF REALIGNMENT IS REQUIRED, THOROUGHLY CHECK THE REPLACEMENT COMPONENT BEFORE PROCEEDING.

## **7.2 PHASE LOCKED LOOP CIRCUIT**

### **7.2.1 Equipment Required:**

- a) 13.8V DC Power Source (3A).
- b) Synchroscope (DC to more than 250 MHz)
- c) Frequency Counter (More than 250 MHz)

## 7.2.2 Set-up:

a) Initial front panel controls should be set in the following manner:

- \* POWER SWITCH (OFF—Volume) : Off
- \* 10KHz & 100KHz SELECTOR SWITCH : Any position
- \* BAND MHz SELECTOR SWITCH : Any position
- \* 5 KHz SWITCH : Either position
- \* REPEATER-SIMPLEX SWITCH : Simplex
- \* TX OFFSET SWITCH : Any position
- \* MID-HI-LOW SWITCH : Either position

b) Connect the power cable to the 13.8VDC power source.

c) In the VCO unit.

- c-1) Remove the wire of either J353 or J303
- c-2) Remove the connector plug of J352 and connect to Synchroscope using coaxial cable with 2 -P connector to be fitted to the terminals, 6 (HOT) and 7 (GROUND).
- c-3) Connect VTVM and 200K ohm variable resistor to TP351 as described below:

## 7.2.3 Procedure:

- a) Apply power to the unit.
- b) Adjust 200K ohm variable resistor connected to TP351 for 6.0 Volt VTVM reading and L352 for 208.1MHz  $\pm$  0.2MHz frequency counter reading.
- c) Adjust 200Kohm variable resistor for 205.6 MHz  $\pm$  0.2 MHz frequency counter reading and L354 for maximum synchroscope amplitude.
- d) Remove the connector for J352 6 and 7 and reconnect it to J352 4 and 5. Then, adjust L353 for maximum.
- e) Connect TP251 to 10 : 1 probe of synchroscope and adjust L253 and 254 for maximum synchroscope amplitude, and also adjust them so as to be within 20% of amplitude difference in case 221 and 222MHz bands are switched over each other.
- f) As for TP-252, adjust L255 and 256, the same to above.
- g) Conduct frequency adjustment in the following manner:
  - 1) Connect frequency counter to the plug (PIN1) of J401.
  - 2) Measure and adjust frequency on following channels.
    - \* 220.005 MHz : f=203.105 MHz..... CT254
    - \* 220.000 MHz : f=203.100 MHz..... CT251
    - \* 224.005 MHz : f=207.105 MHz..... CT253
    - \* 224.000 MHz : f=207.100 MHz..... CT252

**Note:** Repeat the procedures 220.005 MHz, 220.000 MHz and 224.005 MHz, 224.000 MHz respectively.

- h) Adjust L352 for  $6.0 \pm 0.2$  Volts on TP351 by VTVM at the frequency of 224.990 MHz.

### **7.3 RECEIVER**

#### **7.3.1 Equipment Required:**

- a) 13.8VDC Power Source (3A)
- b) VHF Sweep generator and all accessories
- c) Signal generator (220 – 225 MHz)
- d) AF measurement equipments –4 ohm dummy load  
V.T.V.M.  
Oscilloscope  
Distortion Meter
- e) DC Volt Meter

#### **7.3.2 Set-up:**

- a) Initial front panel controls should be set in the following manner :
  - \* POWER SWITCH (Off-volume) : Off
  - \* SQUELCH CONTROL : Fully counterclockwise
  - \* OTHER SWITCHES : Any position

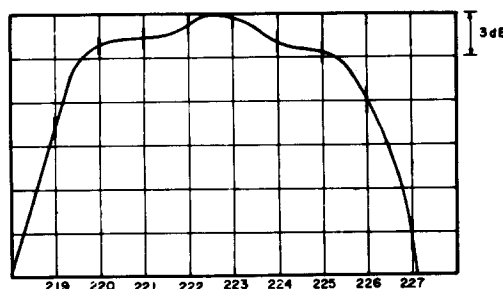
Connect the power cable to the 13.8VDC power source.

- c) Connect all of AF measurement equipments (See 7.3.1 – d) to external speaker jack.
- d) Connect the top of Q102 in RF unit to the RF input of sweep generator.
- e) Adjust the Helical Resonator FT101, but be sure to detach J351 in VCO unit.

#### **7.3.3 Procedure:**

- a) Apply power to the unit and turn on power switch.

- b) Adjust L101, L102 and FT101 to obtain a wave form as illustrated below on the following measurement conditions.



- \* Input level ..... 5.6mV rms
- \* Marker ..... Increment by 1 MHz
- \* Center frequency ..... 222.500 MHz
- \* Oscilloscope ..... x 1 range (max.)

- c) Then, detach the sweep generator and remove the cable from the top of Q102 in RF unit, and connect the signal generator (222.500 MHz, 3.3 KHz deviation at AF 1 KHz) with the antenna terminal and also connect again J351 in VCO unit.
- d) Increase the power of the signal generator for one third reading of indicator on the S-Meter scale and adjust L103, L104, L151 and L152 several times respectively for the peak power.
- e) Adjust the signal generator for the 60dB input and adjust RT152 to make the meter indicator stay at the center position between the full-scale point and the maximum point.
- f) Keep the squelch control at the tight position and obtain the 4 dB output of the signal generator, and adjust RT151 for no AF output power.

## 7.4 TRANSMITTER

### 7.4.1 Equipment Required:

- a) 13.8VDC power source (8A)
- b) RF power meter (Bird Watt Meter 50W 230MHz)
- c) Frequency Counter (More than 250MHz)
- d) FM Linear detector
- e) AF distortion meter
- f) VTVM
- g) AF oscillator
- h) Spectrum analyzer (1.2G Hz)
- i) Microphone or TX Switch
- j) DC volt meter
- k) Feed through dummy load (more than 30 watts)
- l) RF attenuator

### 7.4.2 Set-up:

- a) Initial front panel controls should be set in the following manner:

- |                             |   |              |
|-----------------------------|---|--------------|
| * POWER SWITCH (Off-volume) | : | Off          |
| * MID-HI-LOW SWITCH         | : | HI Position  |
| * REPEATER-SIMPLEX SWITCH   | : | Simplex      |
| * OTHER SWITCHES            | : | Any position |

- b) Connect the power cable to the 13.8V DC power source.
- c) Connect the power meter to the antenna terminal.
- d) Connect the FM linear detector and the frequency counter.
- e) Connect the TX switch, the AF oscillator and the VTVM to the microphone connector (Mike connector pin No. 1 – Audio, 2 & 3 – Ground, 4 – PTT.).

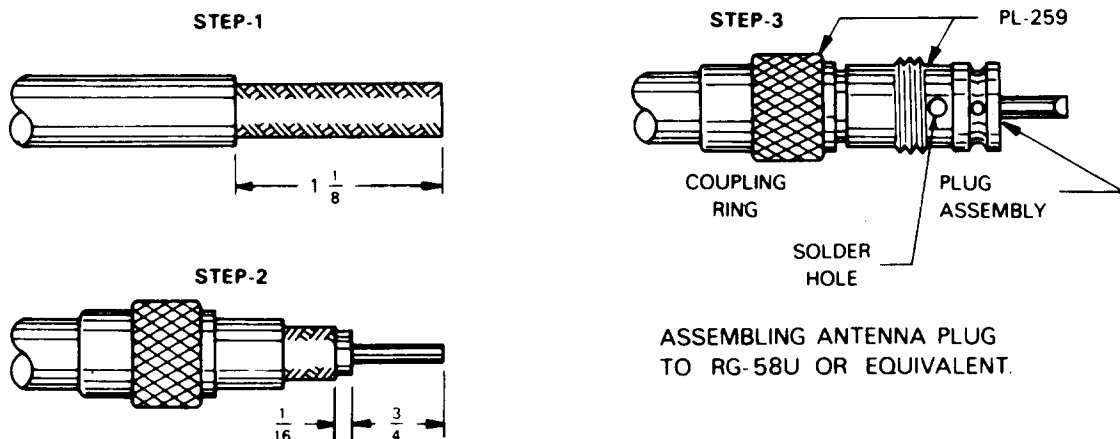
### 7.4.3 Procedure:

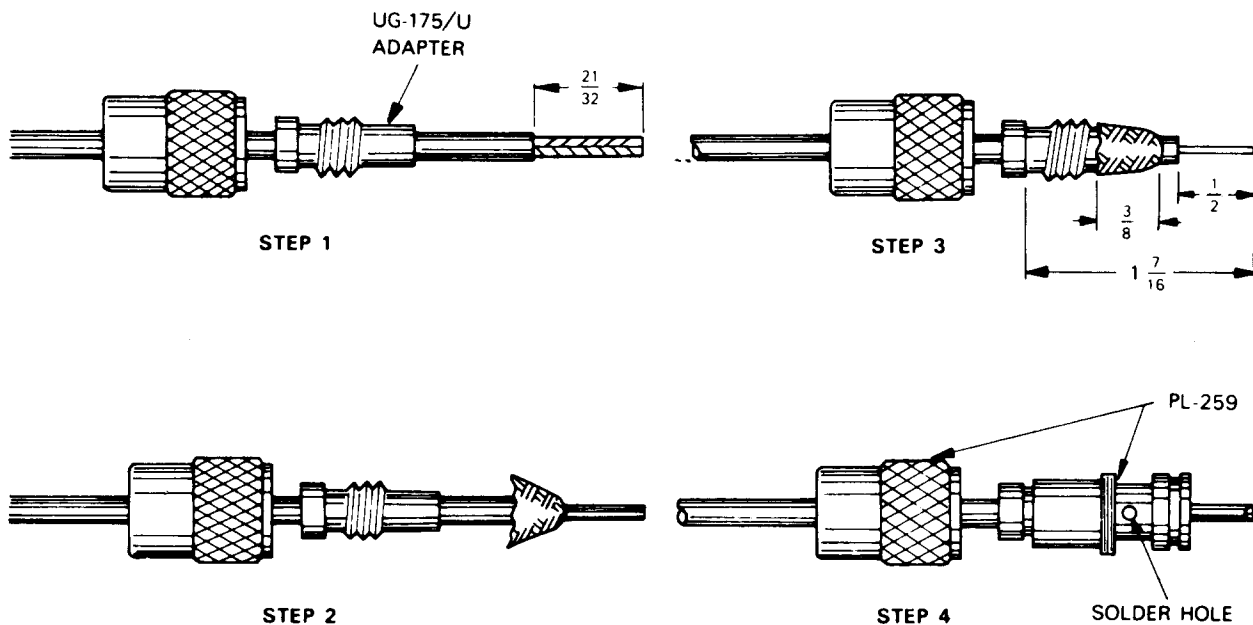
- a) Before the power switch is on, make the preliminary adjustment as follows:
  - a-1) Adjust L401 through L407 so that the core enters about 1.2mm below the can.
  - a-2) Turn the semi-fixed resistors as follows:
 

RT552 and RT553	:	Fully clockwise
RT351, RT551 and RT502	:	Fully counterclockwise
RT401 and RT501	:	Middle position
  - a-3) Set the trimmer CT401, CT402, CT451, CT452, CT453, CT454 and CT501 at the position of half capacitance.
- b) Turn on the power switch and set the channel to the 222.500MHz.
- c) Keep the unit in TX with the microphone or the TX switch and adjust L401 through L406 for the maximum voltage at the TP401.
- d) Adjust L407, CT401 and CT402 for the maximum reading on the RF power meter.
- e) Adjust CT451, CT452 and CT453 for the maximum reading on the RF power meter.
- f) Repeat the above step c) through e) adjustments repeatedly.
- g) Feed the output power of feed through dummy load to the spectrum analyzer through the RF attenuator.
- h) Connect J502 (APC output in APC unit) to the DC volt meter.
- i) Repeat the following adjustments several times respectively.  
(Set the channel to the SIMPLEX of 222.500 MHz)
  - i-1) Adjust RT551 for 20 watts on RF power meter.
  - i-2) Adjust CT501 and RT501 for the minimum swing on DC volt meter.

- i-3) Adjust CT452, CT453 and CT454 for the maximum power on the RF power meter.
- i-4) Adjust RT502 for the middle reading of Red mark on S/RF PWR meter of the unit.
- j) Adjust CT701 and set the frequency to the 222.500 MHz.
- k) Press the REPEATER-SIMPLEX switch and set the TX OFFSET switch to the -1.6 position, and adjust CT702 for the 220.900 MHz.
- l) Set the TX OFFSET switch to the +1.6 position and adjust CT703 for the 224.100 MHz.
- m) Set in the MID-HI-LOW switch to the LOW position and adjust RT552 for 2.0W on RF power meter.
- n) Feed AF 1KHz 100mV from the microphone connector and adjust RT 351 for 5 KHz on FM linear detector.
- o) Feed the AF signal to the pin No. 5 and 6 (Ground) in the accessory jack and check if the modulation is activated.
- p) Remove the RF power meter from the antenna connector and adjust RT553 for 2.0 amperes on the 13.8V power source meter.
- q) Again, connect the RF power meter to the antenna connector and just adjust CT454 to minimize the power difference during 220 to 224.900 MHz.

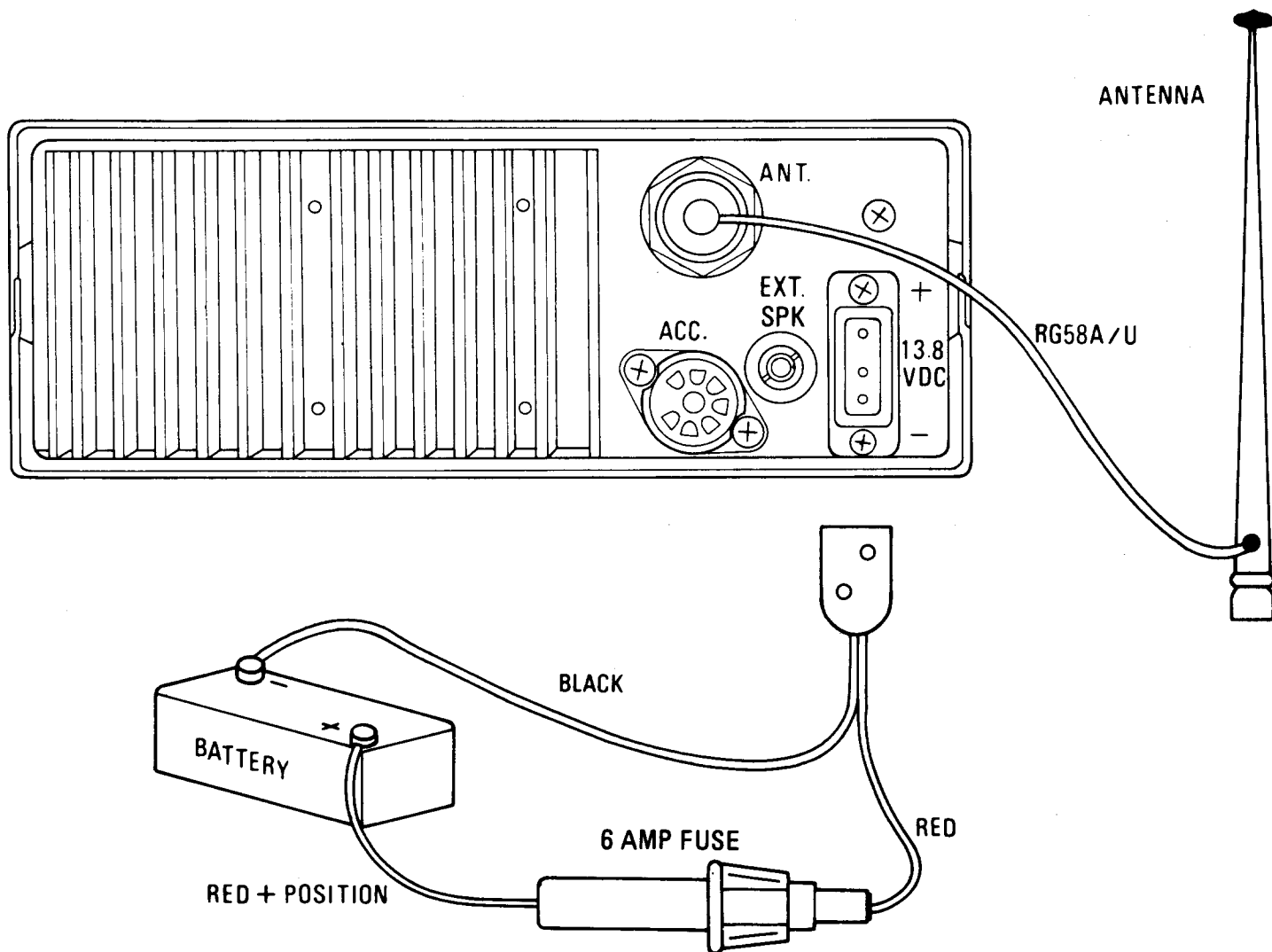
## COAXIAL CONNECTOR ASSEMBLY DETAIL





ASSEMBLING ANTENNA PLUG TO RG-58U  
OR OTHER 1/4" COAXIAL CABLE

## INSTALLATION DIAGRAM



# FREQUENCY CHART

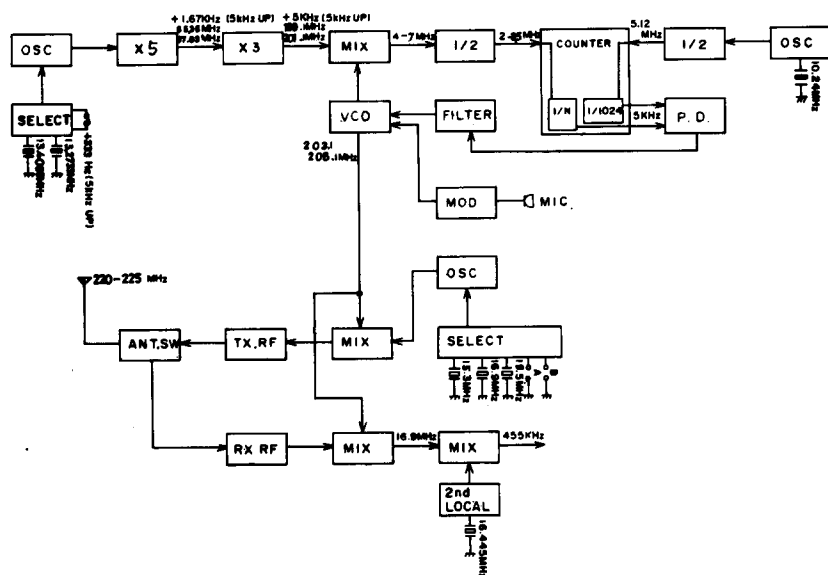
Channel Designator	Local Crystal Frequency	PLL IF Frequency	Divide Ratio [N]	Out put Frequency
<b>22[A] . [B] [C]</b>				
A=0 or 1	13.2733	[A+4] [B] [C] MHz	[A+4] [B] [C]	22[A] . [B] [C] MHz -16.9 MHz
A-2 or 3 or 4 <b>[A] . [B] [C] 5</b>	13.4066	[A+2] . [B] [C]	[A+2] [B] [C]	do.
A-0 or 1	13.2736	[A+4] . [B] [C]	[A+4] [B]	do.
A-2 or 3 or 4	13.4069	[A+2] . [B] [C]	[A+2] [B] [C]	do.

Channel Designator	+5 K	Local Crystal Frequency	+5 K	PLL IF Frequency	Divide Ratio [N]	Out put Frequency	+5 K	
220.00 ? 220.99	5	13.273	+333 Hz	4.000	400	203.100	+5 KHz	
?				?	?	?		
221.00				4.990	499	204.090		
?				5.000	500	204.100		
221.99				?	?	?		
?				5.990	599	205.090		
222.00		13.4066		+333 Hz	4.000	400		205.100
?					?	?		?
222.99					4.990	499		206.090
?					5.000	500		206.100
223.00					?	?		?
?					5.990	599		207.090
224.00	13.4066	+333 Hz	6.000	600	207.100			
?			?	?	?			
224.99			6.990	699	208.090			

\* Frequencies are in MHz.

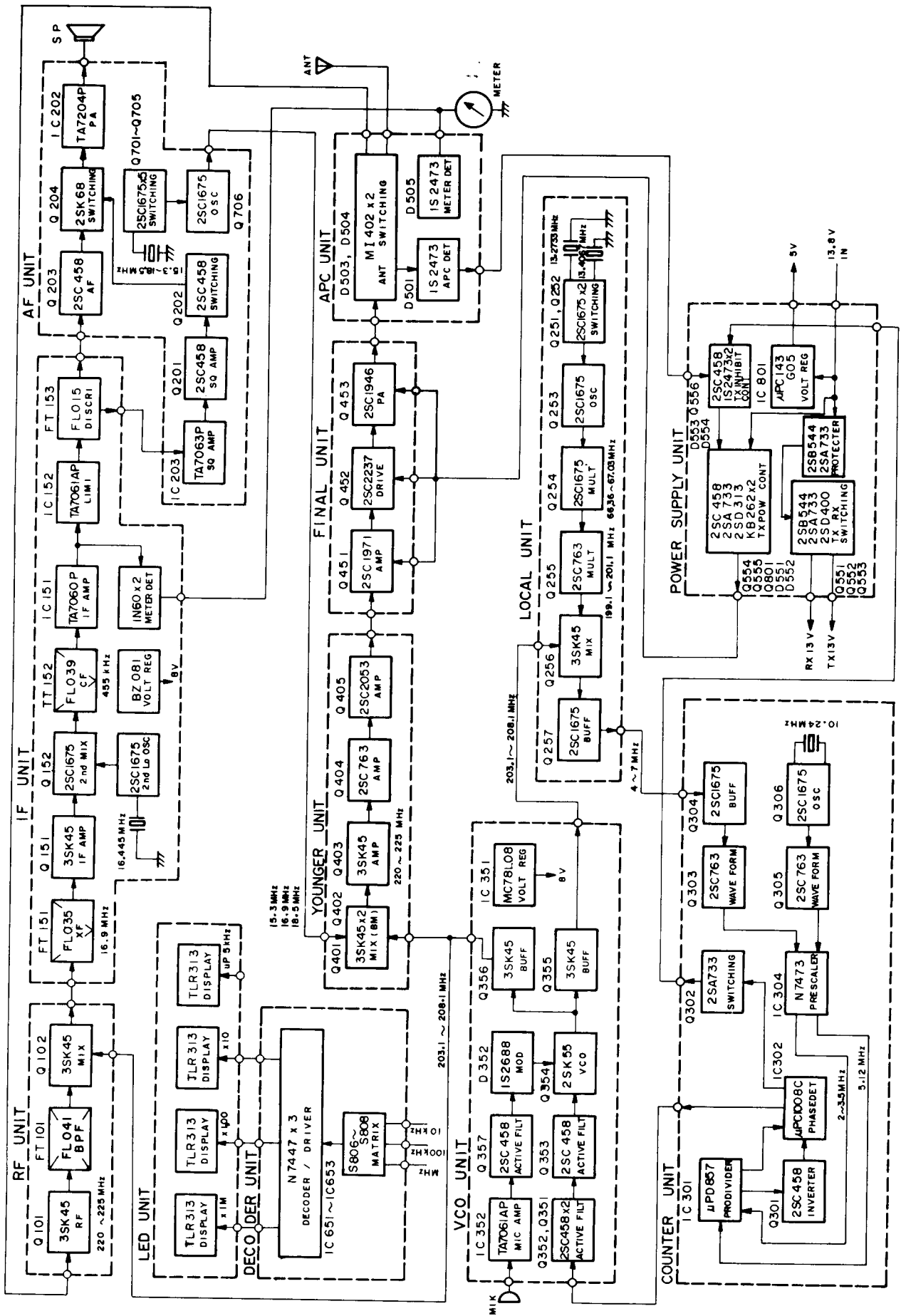
### BCD CODE

	A	B	C	D
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1





# BLOCK DIAGRAM



# VOLTAGE CHART

## Dual Gate MOS-FET

#	Name	G1	G2	S	D	Remarks
Q101	3SK45-B	0	3.9	0.3	12.8	
102	do.	0	0	0.2	12.3	
151	do.	0.7	1.8	0.8	6.0	
256	do.	0	0	0.3	5.5	
355	do.	0	3.1	0	6.2	
356	do.	0	3.1	0.7	6.7	
401	do.	0	0	0.3	12.0	
402	do.	0	0	0.3	12.0	
403	do.	0	4.3	0	11.8	

## Bipolar Transistor & J-FET

#	Name	B/G	E/S	C/D	Remarks
Q152	2SC1675-L	1.9	1.3	11.5	
153	do.	3.0	2.7	6.6	
201	2SC458-C	1.0	0.5	5.5	
202	do.	0 (0.6)	0 (0)	1.3 (0)	( ) ; SQ Max.
203	do.	1.3	0.7	4.4	
204	2SK68	0 (3.2)	4.4 (0.5)	4.5 (4.3)	( ) : SQ Max.
253	2SC1675-L	3.5	3.3	7.3	
254	do.	2.2	2.6	7.1	
255	2SC763-C	1.3	1.3	7.2	
257	2SC1675-L	1.5	0.9	5.7	
301	2SC458-C	0.4	0	2.3	
302	2SA733-P	4.7	4.8	0	
303	2SC763-C	0.1	0	2.3	
304	2SC1675-L	1.4	0.9	1.8	
305	2SC763-C	0.1	0	2.4	
306	2SC1675-L	2.0	1.9	4.5	
351	2SC458-LGC	1.2	0.6	7.4	
352	do.	0.6	0	4.1	
353	do.	4.0	3.4	7.4	
354	2SK55-D	0	0.5	7.0	
357	2SC458-C	7.3	6.9	13.5	
404	2SC763-C	0.7	1.0	9.6	
405	2SC2053	-0.5	0	9.1	
451	2SC1971	-0.6	0	13.2	HI POWER TX
452	2SC2237	0	0	11.2	do.
453	2SC1946	0	0	13.2	do.
551	2SB544-E	13.5 (12.9)	13.5 (13.5)	0 (13.5)	( ) ; TX
552	2SA733-P	12.9 (13.5)	13.5 (13.5)	13.5 (0)	do.
553	2SD400-E	13.5 (0)	13.5 (0)	13.5 (13.5)	do.
557	2SA733-P	13.2	13.8	13.2	
558	2SB544-E	13.2	13.8	13.8	
706	2SC1675-L	6.0	5.6	13.5	

### Note.

1. Data were measured at 223.00 MHz.
2. Data were measured by DC voltmeter 50K ohm/V, ±3%. (Unit=Volt)

### Bipolar Transistor

#	Name	B	E	C	Remarks
Q554	2SA733-P	12.9	13.8	13.8	Normal operating at Hi-power.
		13.8	13.8	3.3	Normal operating at Low-power.
		13.8	13.8	0	Controlled by APC or unlooked signal.
Q555	2SC458-C	5.8	5.3	13.2	Normal operating at Hi-power.
		1.0	0.6	13.8	Normal operating at Low-power.
		0	0	13.8	Controlled by APC or unlooked signal.
Q556	2SC458-C	0	0	5.8	Normal operating at Hi-power.
		0	0	1.0	Normal operating at Low-power.
		0.6	0	0	Controlled by APC or unlooked signal.
Q801	2SD313-E	13.8	11.2	13.8	Normal operating at Hi-power.
		3.3	2.5	13.8	Normal operating at Low-power.
		0	0	13.8	Controlled by APC or unlooked signal.

### Linear IC

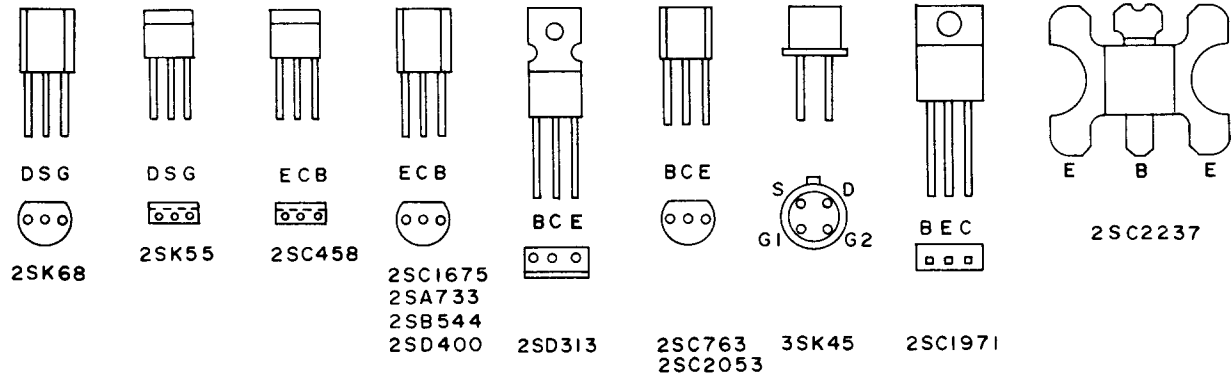
#	Name	Pin number									
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
IC151	TA7060P	1.4	1.4	0	7.6	7.4	—	—	—	—	—
152	TA7061AP	1.8	1.8	5.7	0	7.1	1.6	1.7	—	—	—
201	TA7063P	1.3	0.6	0.1	0	0.7	5.2	8.0	—	—	—
202	TA7204P	0	6.3	13.8	7.7	1.3	11.3	13.1	6.3	6.2	4.6
351	MC78L08CP	13.8	7.4	0	—	—	—	—	—	—	—
352	TA7061AP	1.9	1.9	11.4	0	11.2	1.9	1.9	—	—	—
801	μPC143G05	13.8	4.9	0	—	—	—	—	—	—	—

### Digital IC

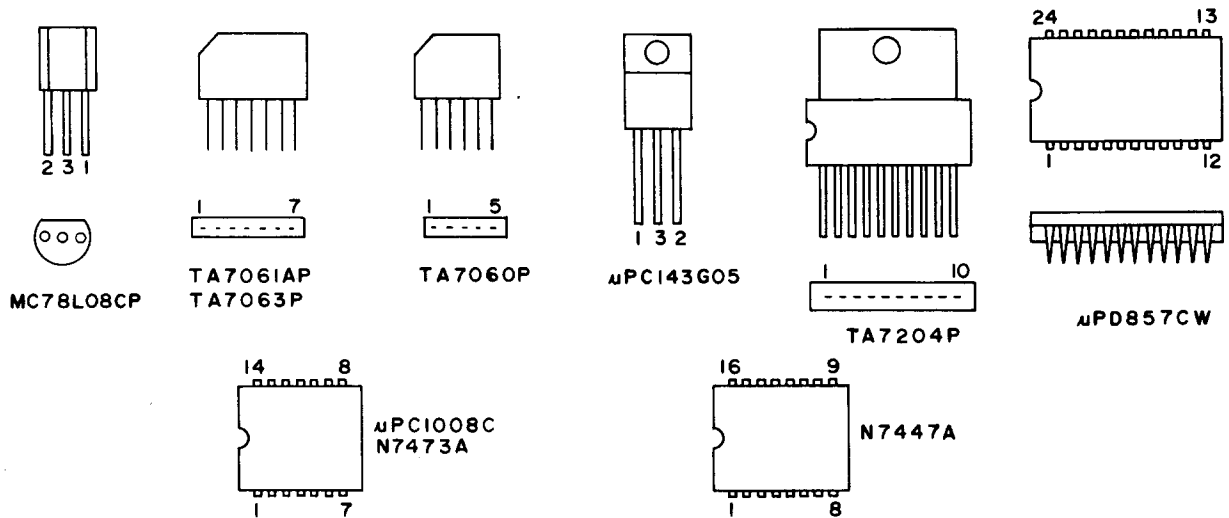
IC302 μPC1008C		IC303 N7473A		IC651 N7447A		IC652 N7447A		IC653 N7447A		IC301 μPD857CW	
Pin		Pin		Pin		Pin		Pin		Pin	
1	0.1	1	2.3	1	4.9	1	0.4	1	0.4	1	0.4
2	4.0	2	—	2	4.9	2	0.4	2	0.4	2	0.4
3	2.3	3	—	3	—	3	—	3	—	3	0.4
4	4.0	4	4.8	4	—	4	—	4	—	4	0.4
5	4.6	5	2.4	5	—	5	—	5	—	5	0.4
6	—	6	—	6	0	6	0.4	6	0.4	6	0.4
7	0	7	—	7	0.5	7	0.4	7	0.4	7	0.4
8	—	8	—	8	0	8	0	8	0	8	0.4
9	—	9	1.8	9	0.1	9	0.1	9	0.1	9	0
10	1.3	10	4.8	10	0.1	10	0.1	10	0.1	10	0
11	4.0	11	0	11	0.1	11	0.1	11	0.1	11	4.8
12	—	12	—	12	0.3	12	0.1	12	0.1	12	4.8
13	4.0	13	1.8	13	0.3	13	0.1	13	0.1	13	0.1
14	4.8	14	—	14	0.1	14	0.3	14	0.3	14	0
				15	0.1	15	0.1	15	0.1	15	0
				16	4.9	16	4.9	16	4.9	16	—
										17	—
										18	1.8
										19	2.1
										20	0
										21	—
										22	—
										23	—
										24	—

# FET, TRANSISTOR & IC TERMINAL GUIDE

## FET & TRANSISTOR CONNECTIONS

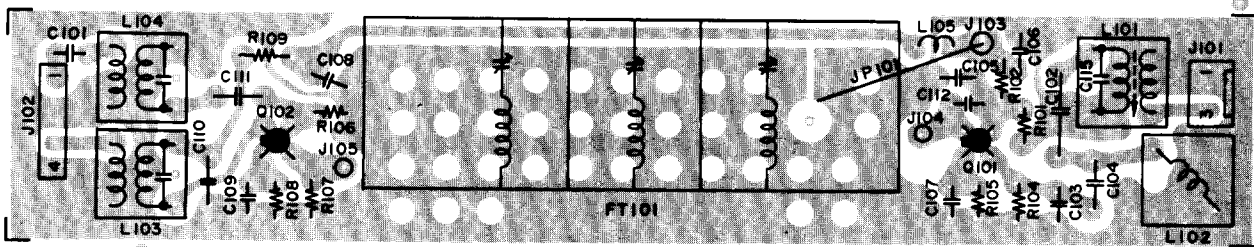
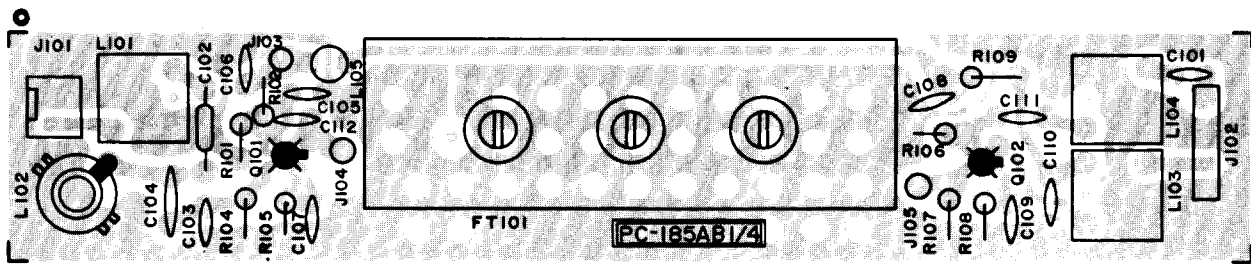


## INTEGRATED CIRCUIT CONNECTIONS

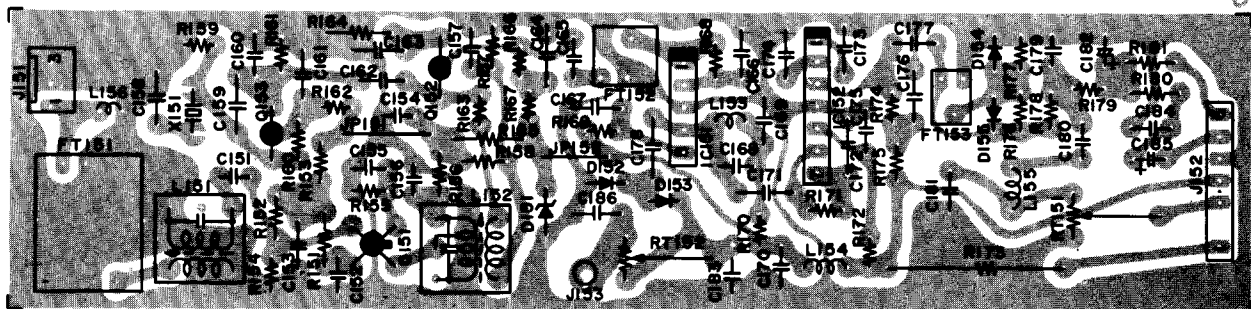
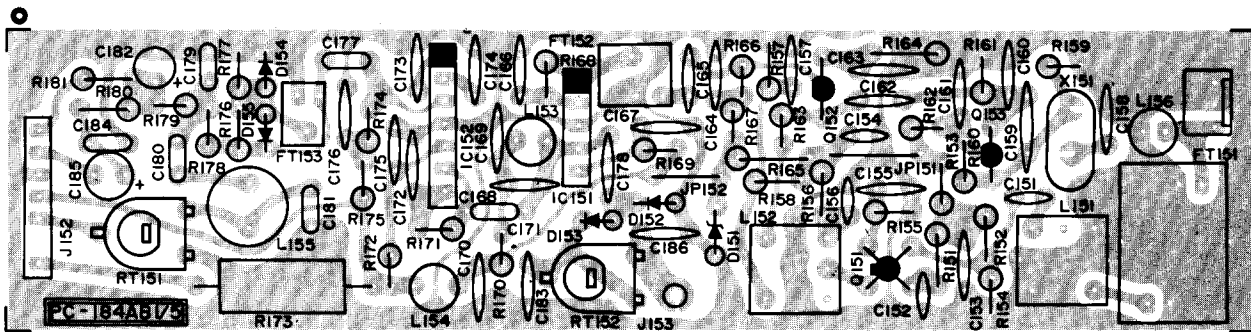


# PRINTED CIRCUIT BOARD DETAIL

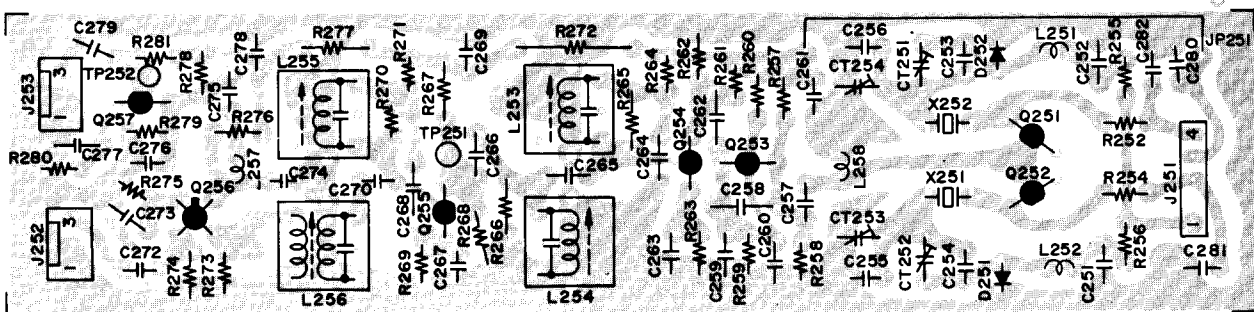
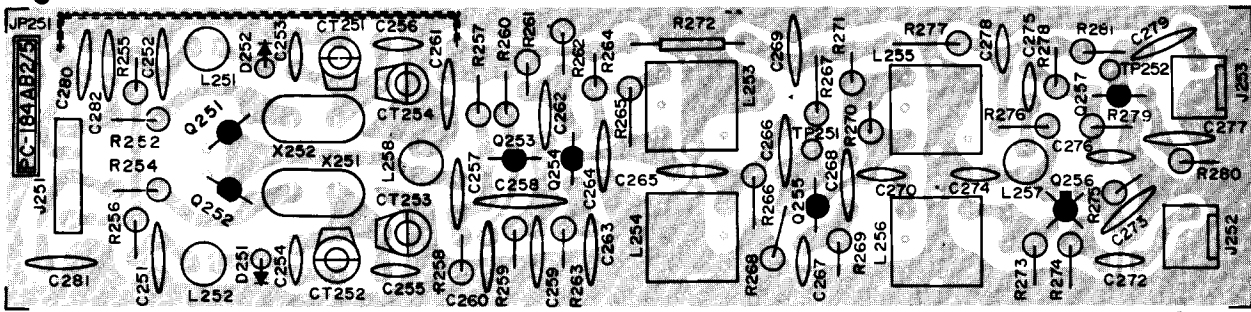
## RF Unit PC - 185 1/4



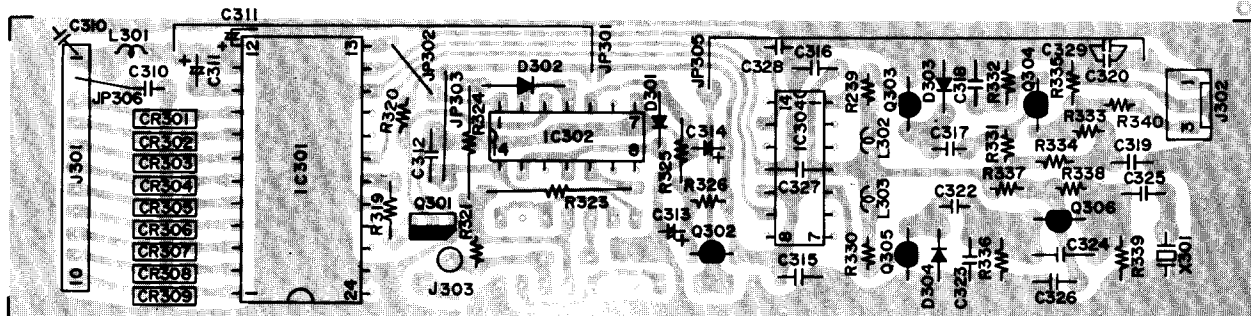
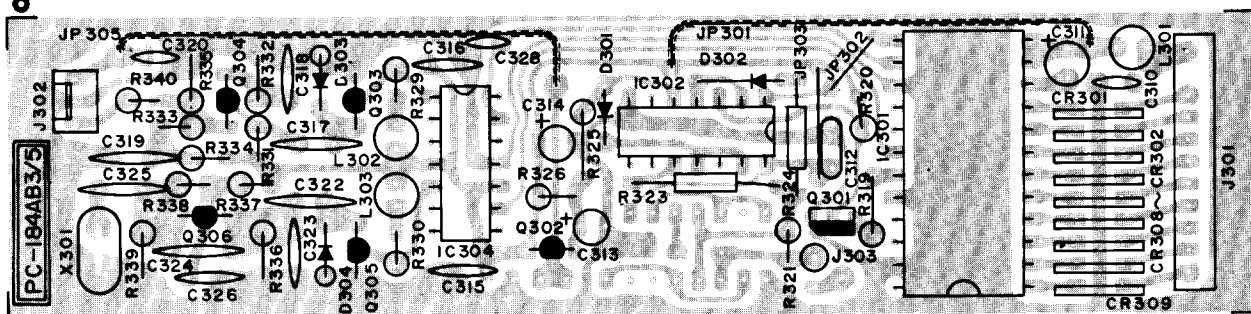
## IF Unit PC - 184 1/5



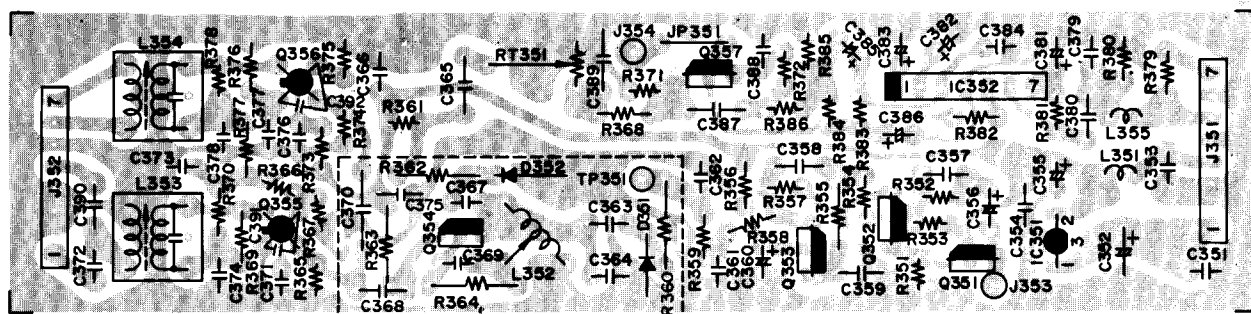
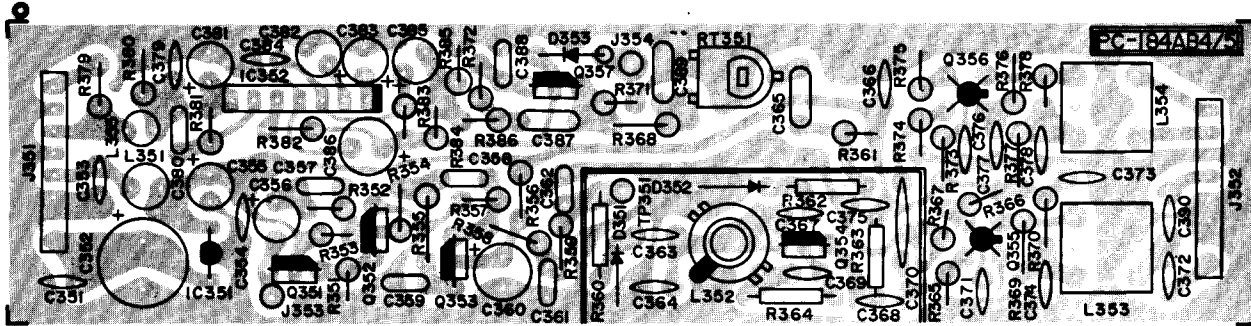
# LOCAL Unit PC - 184 2/5



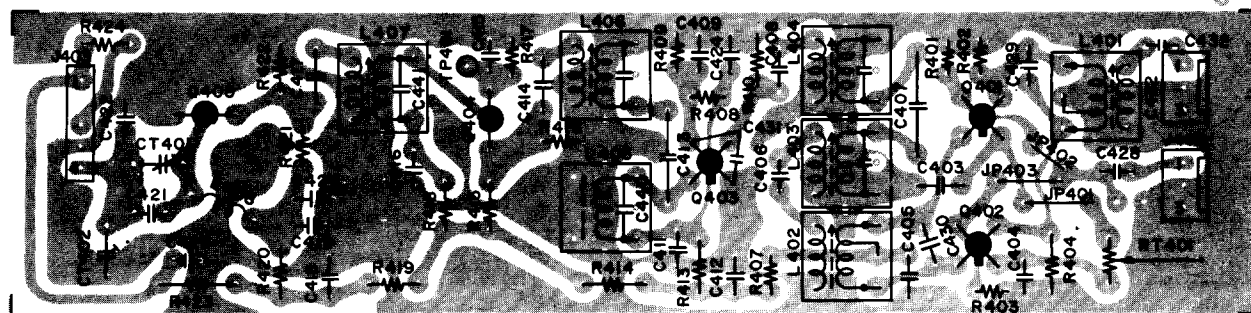
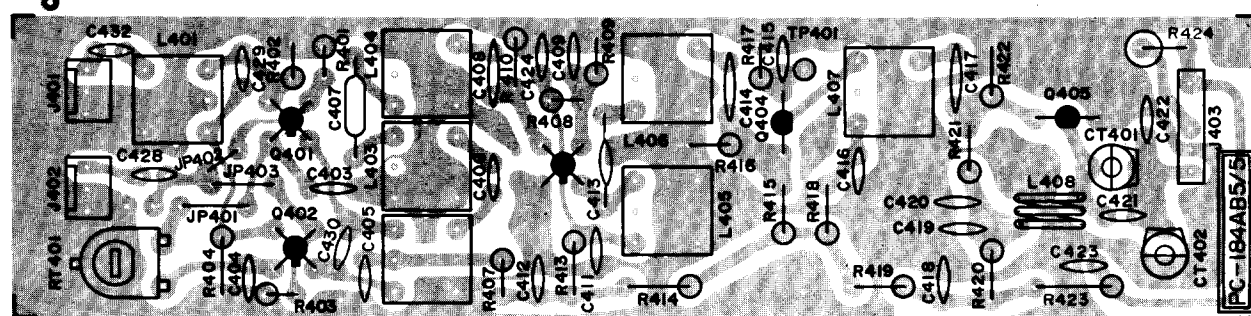
# Counter Unit PC - 184 3/5



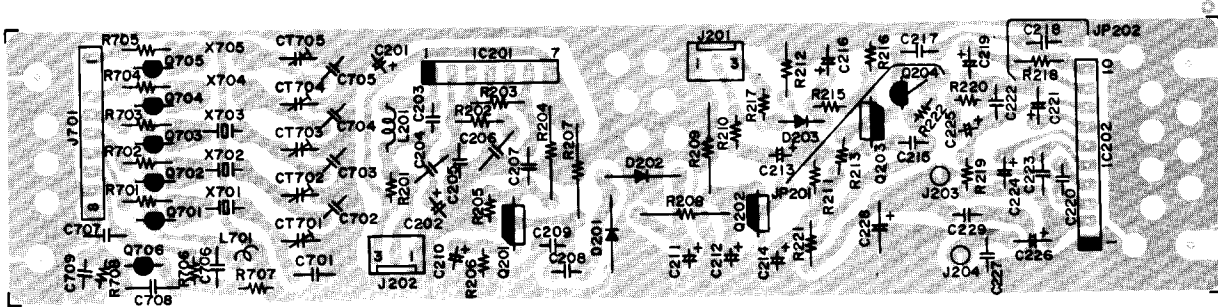
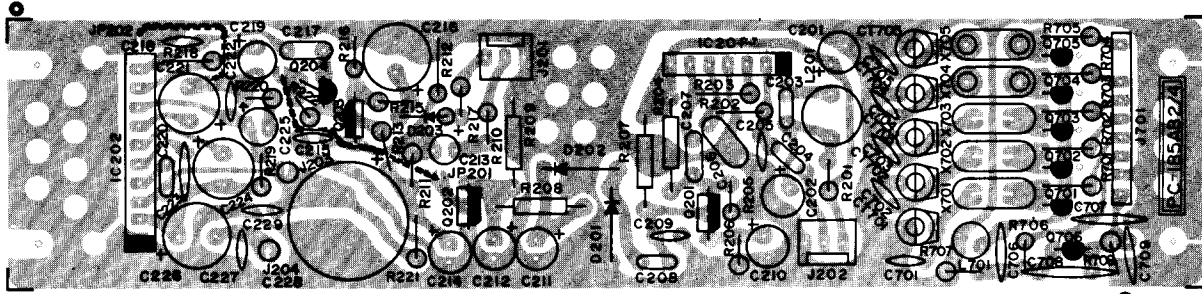
VCO Unit PC - 184 4/5



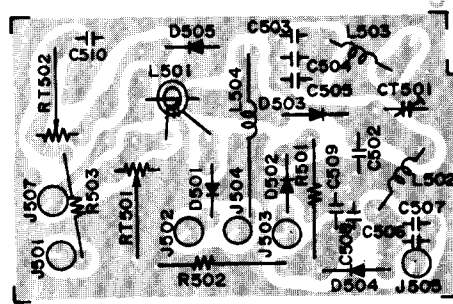
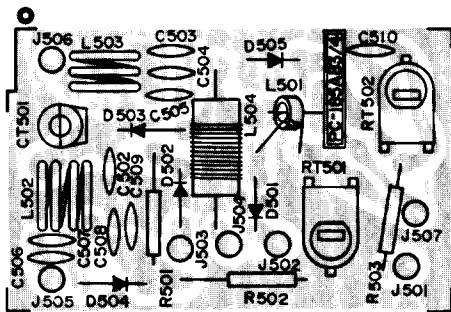
TX Younger Unit PC - 184X5/5



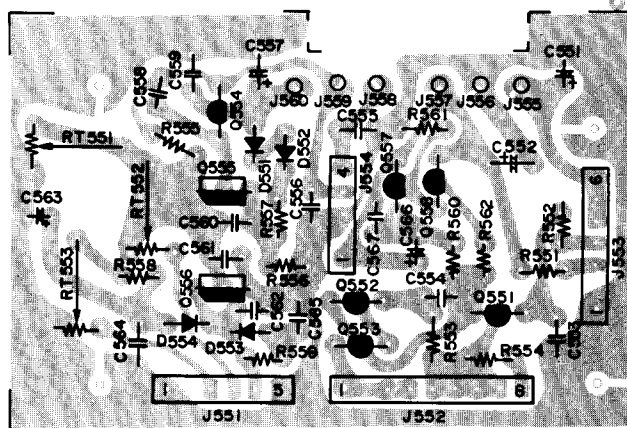
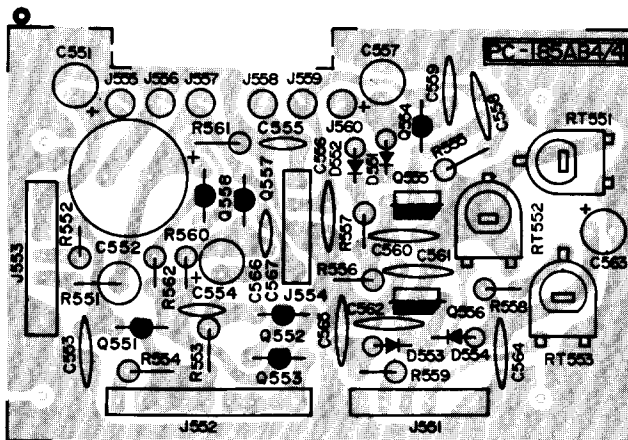
AF Unit PC – 185 2/4



APC Unit PC – 185 3/4

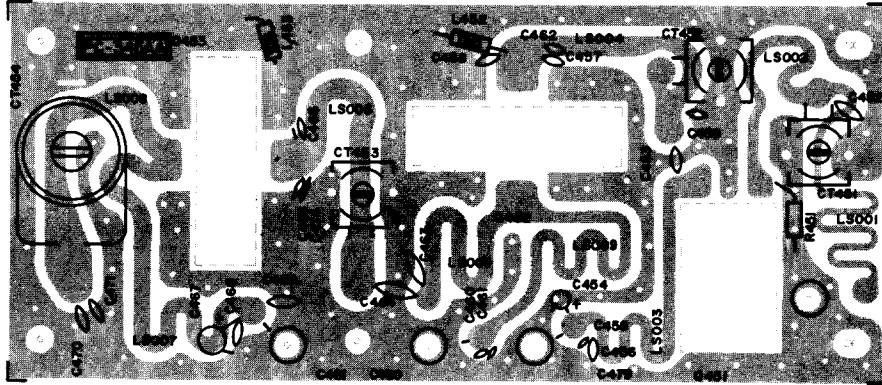


Power Supply Unit PC – 185 4/4

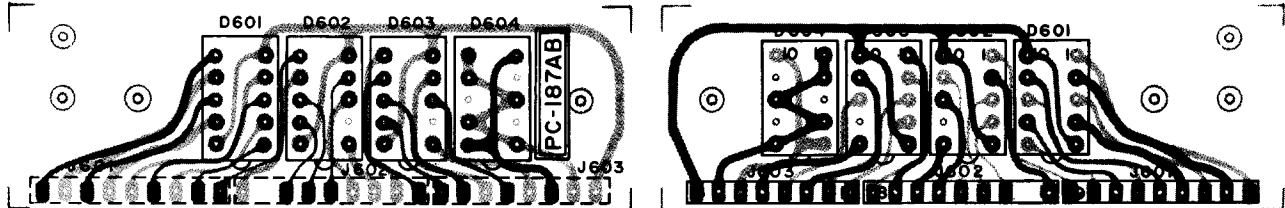




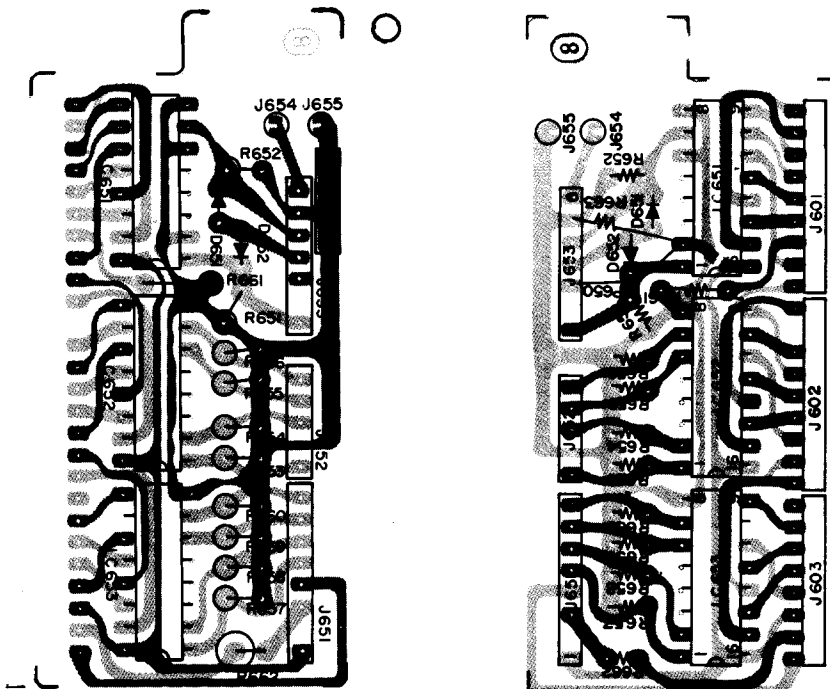
Final Unit PC - 345



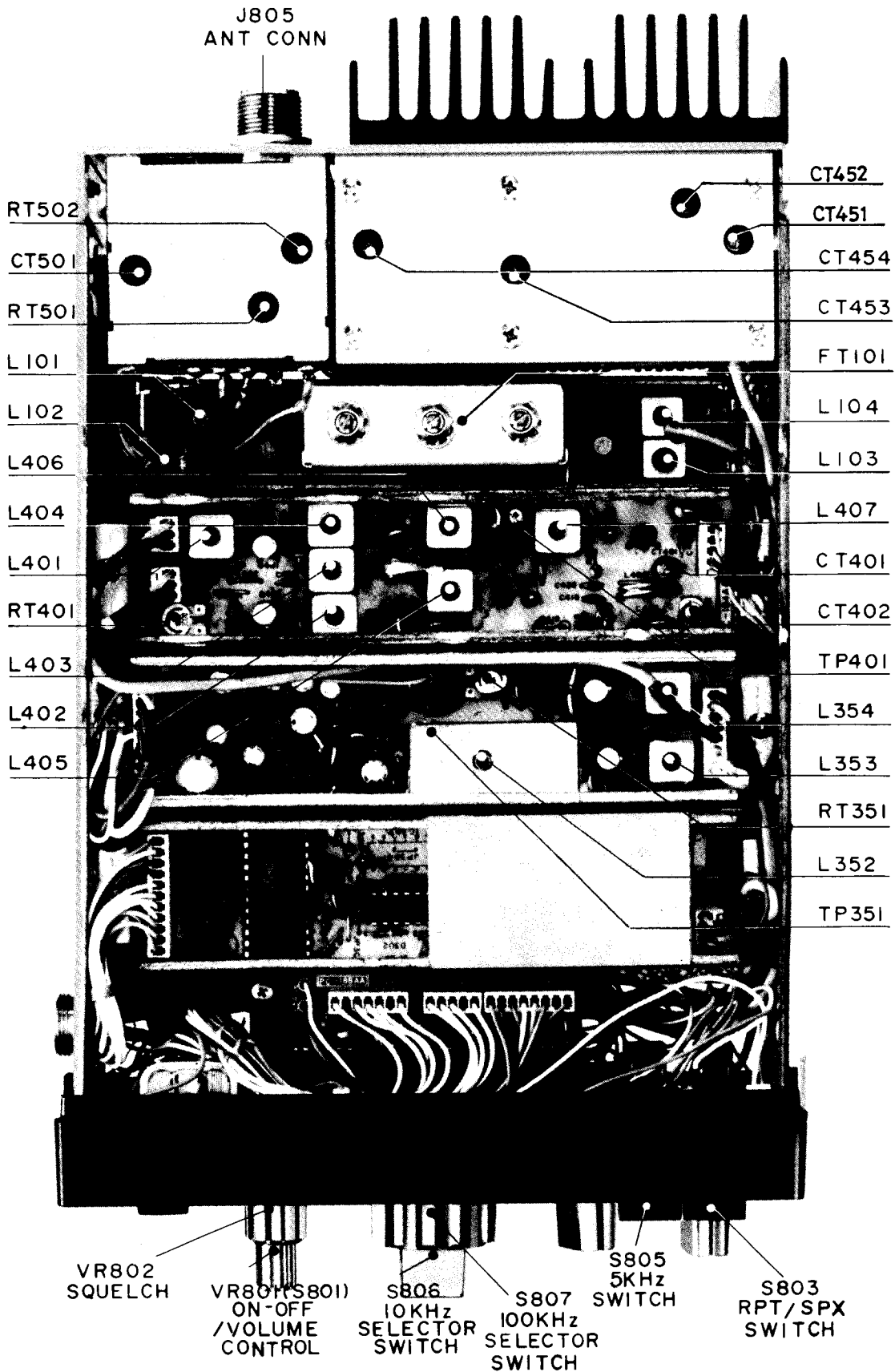
LED Unit PC - 187



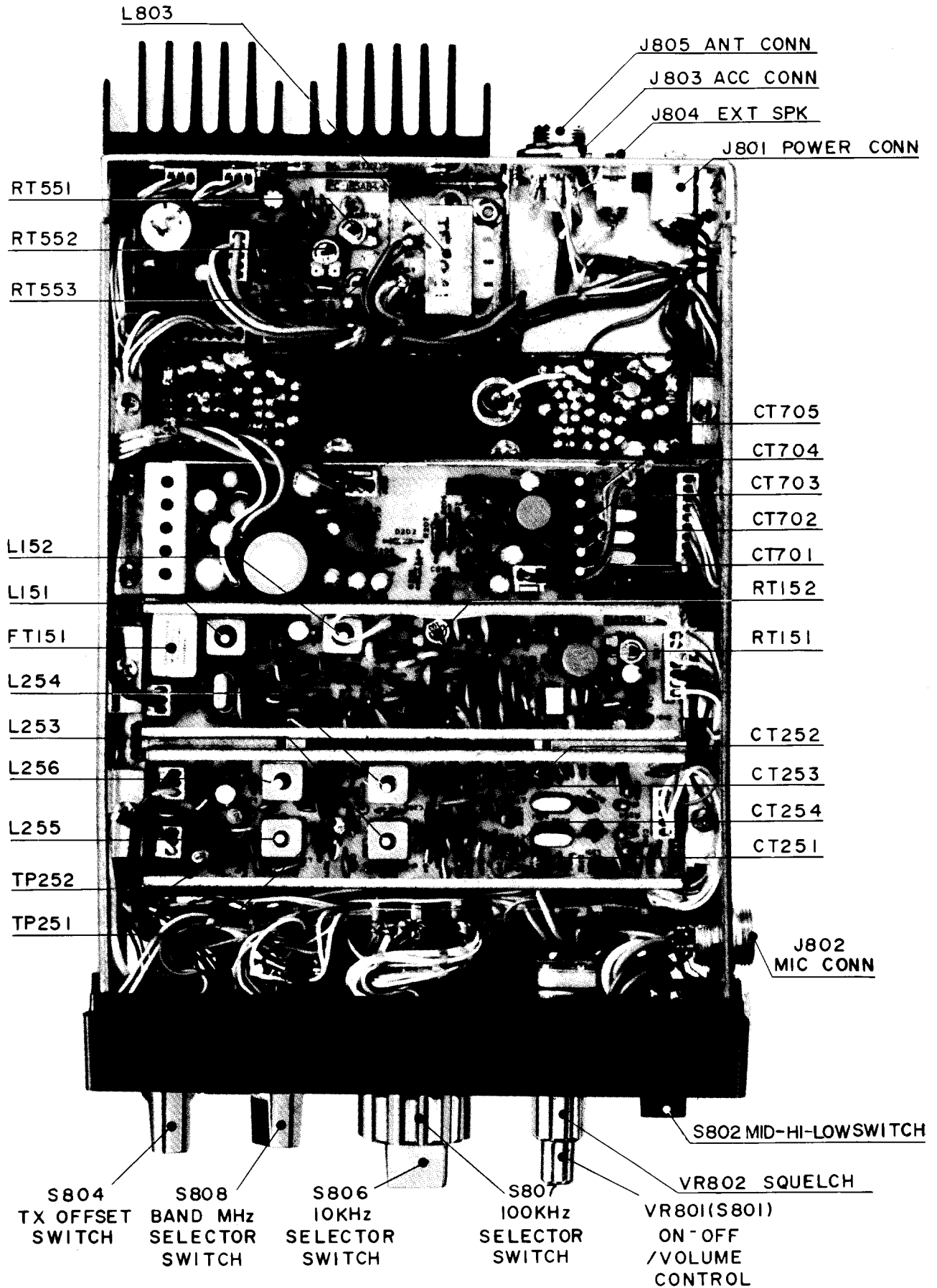
Decoder Unit PC - 188



# TOP VIEW OF CHASSIS DETAIL

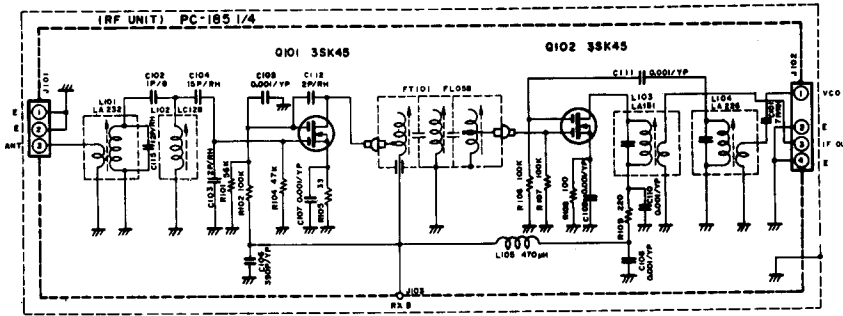


# BOTTOM VIEW OF CHASSIS DETAIL

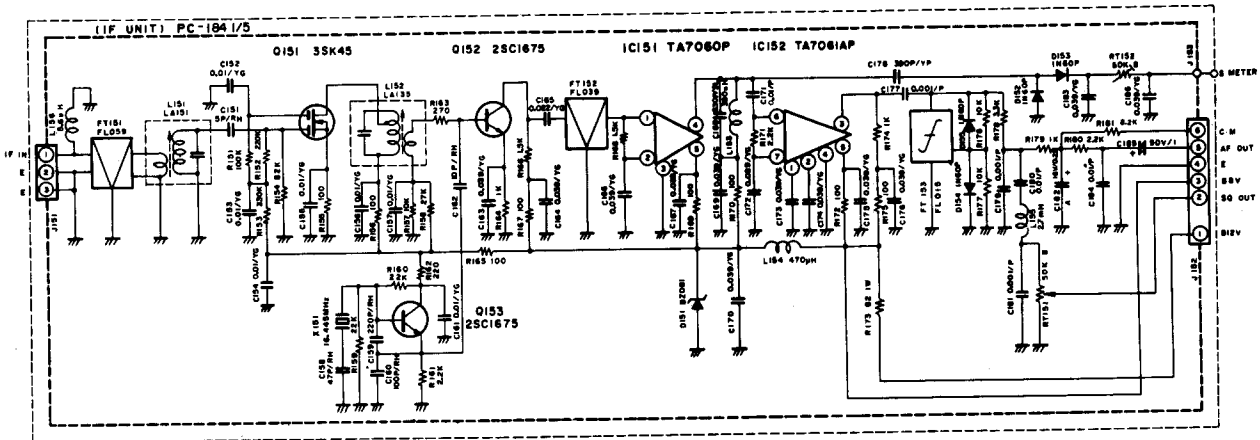


# SCHEMATIC DIAGRAM (SEGMENT)

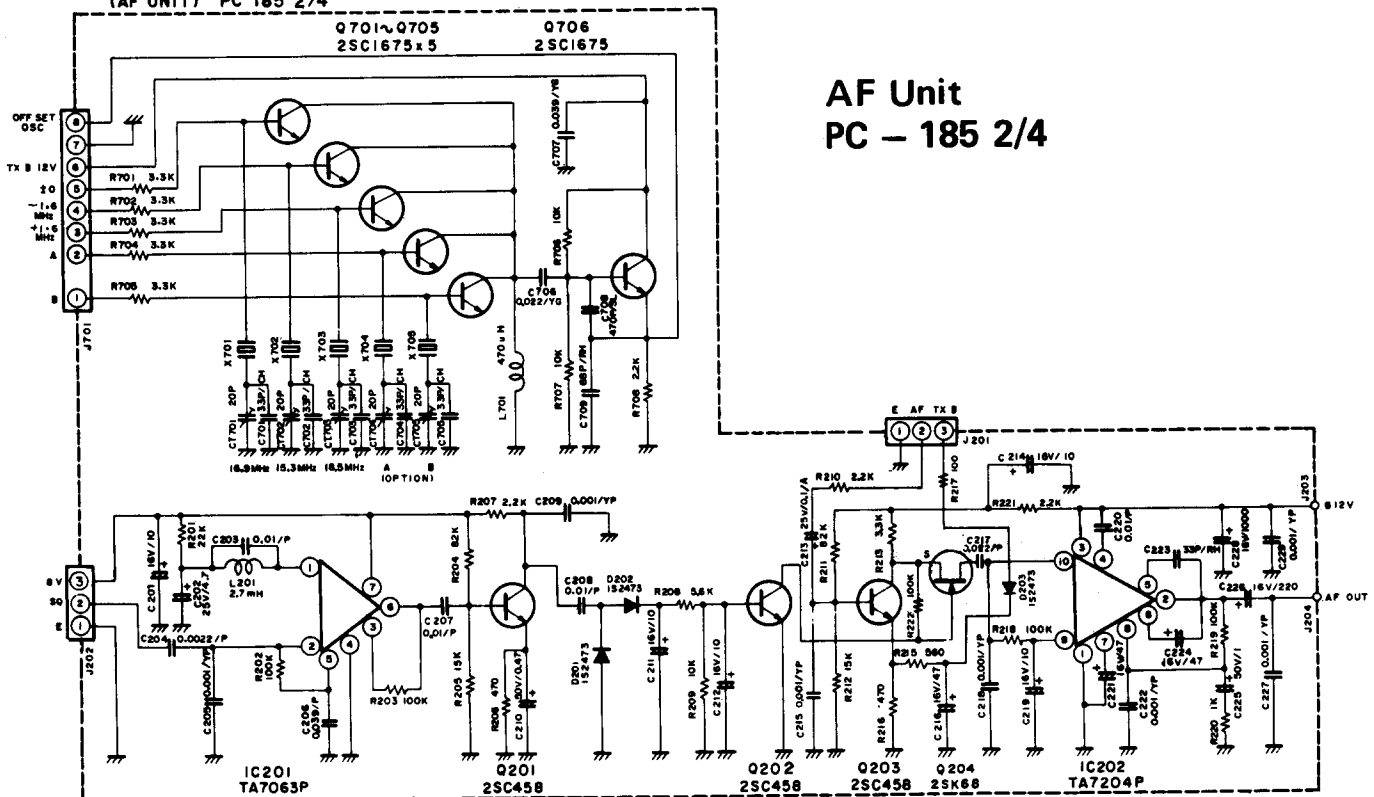
## RF Unit PC – 185 1/4



## IF Unit PC – 184 1/5

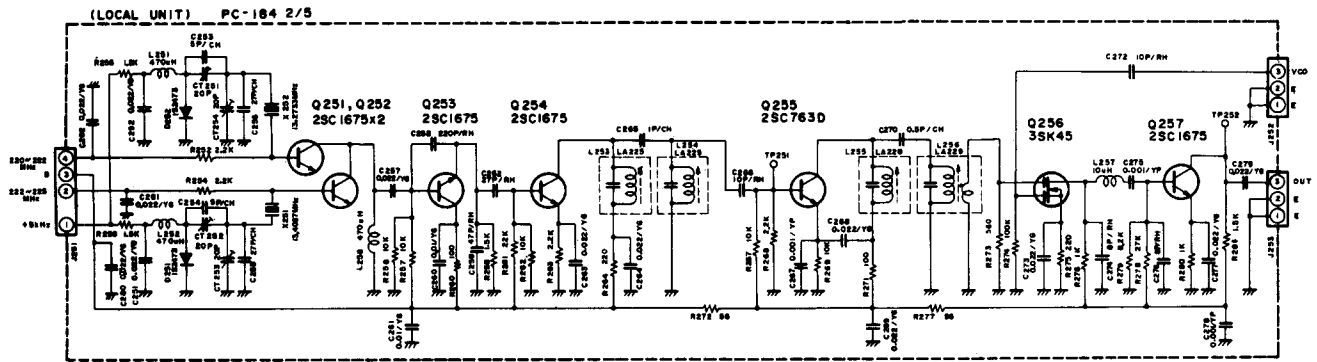


## (AF UNIT) PC-185 2/4

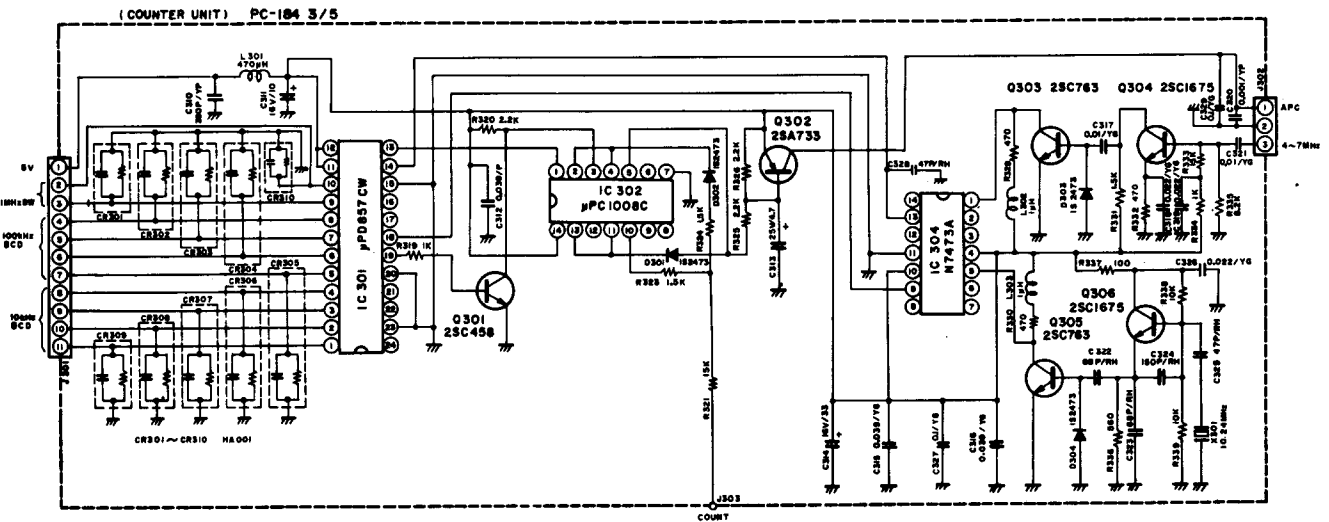


## AF Unit PC – 185 2/4

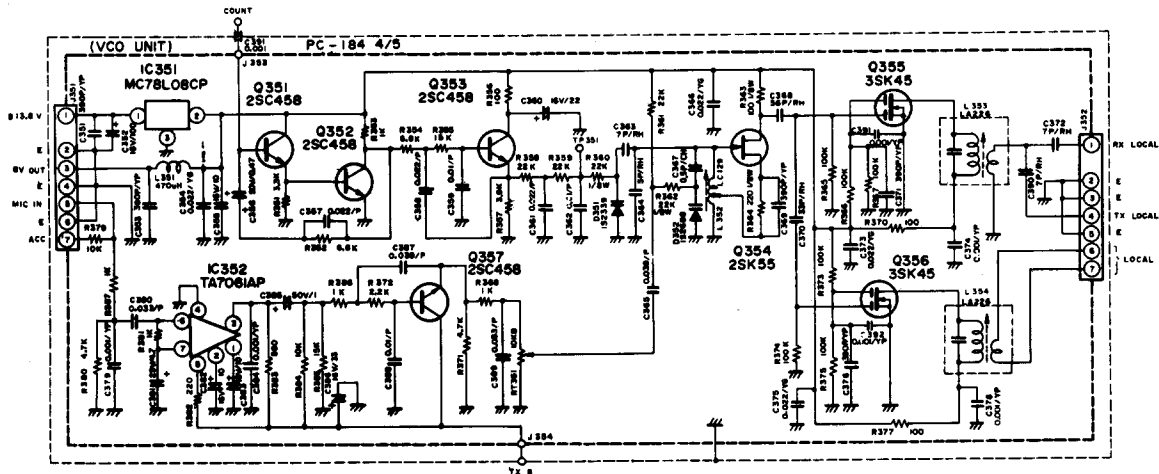
# LOCAL Unit PC – 184 2/5



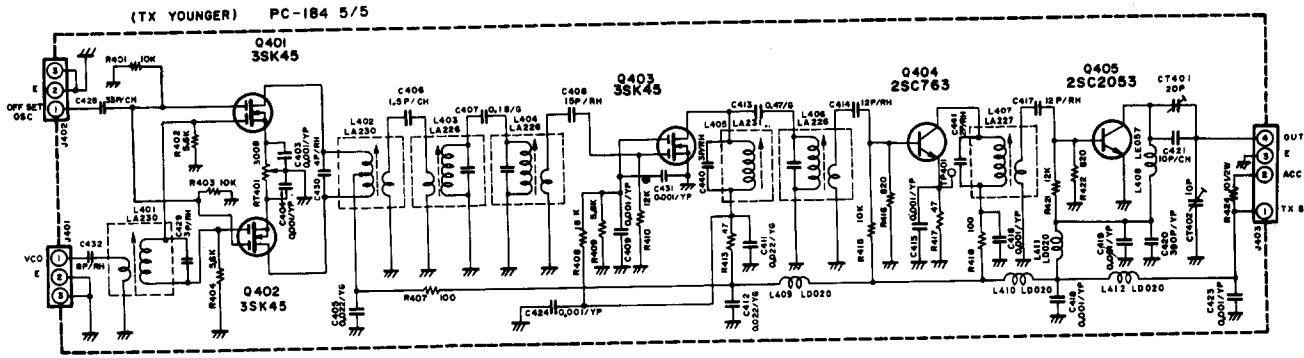
# Counter Unit PC – 184 3/5



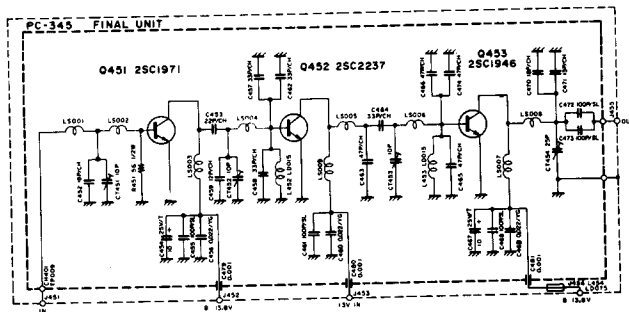
# VCO Unit PC – 184 4/5



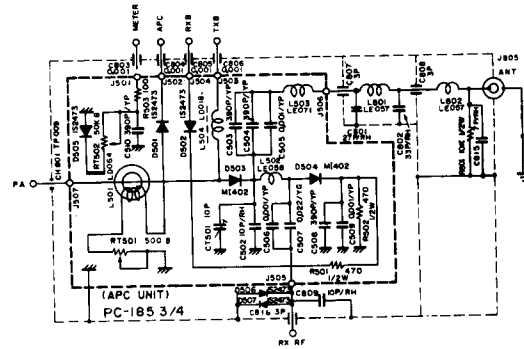
# TX Younger Unit PC-184X5/5



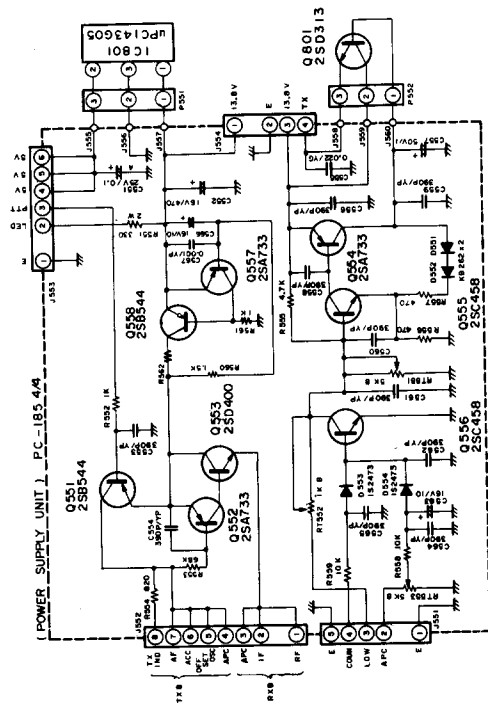
# Final Unit PC - 345



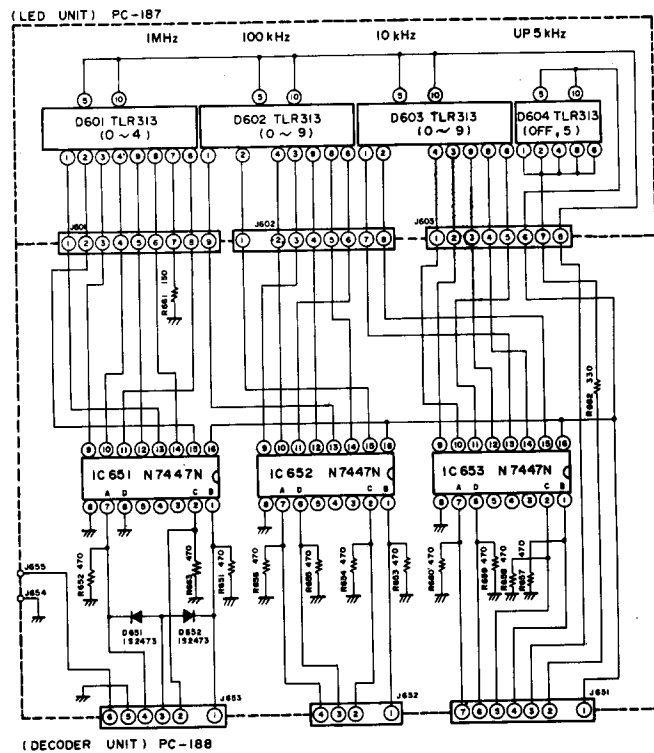
# APC Unit PC - 185 3/4



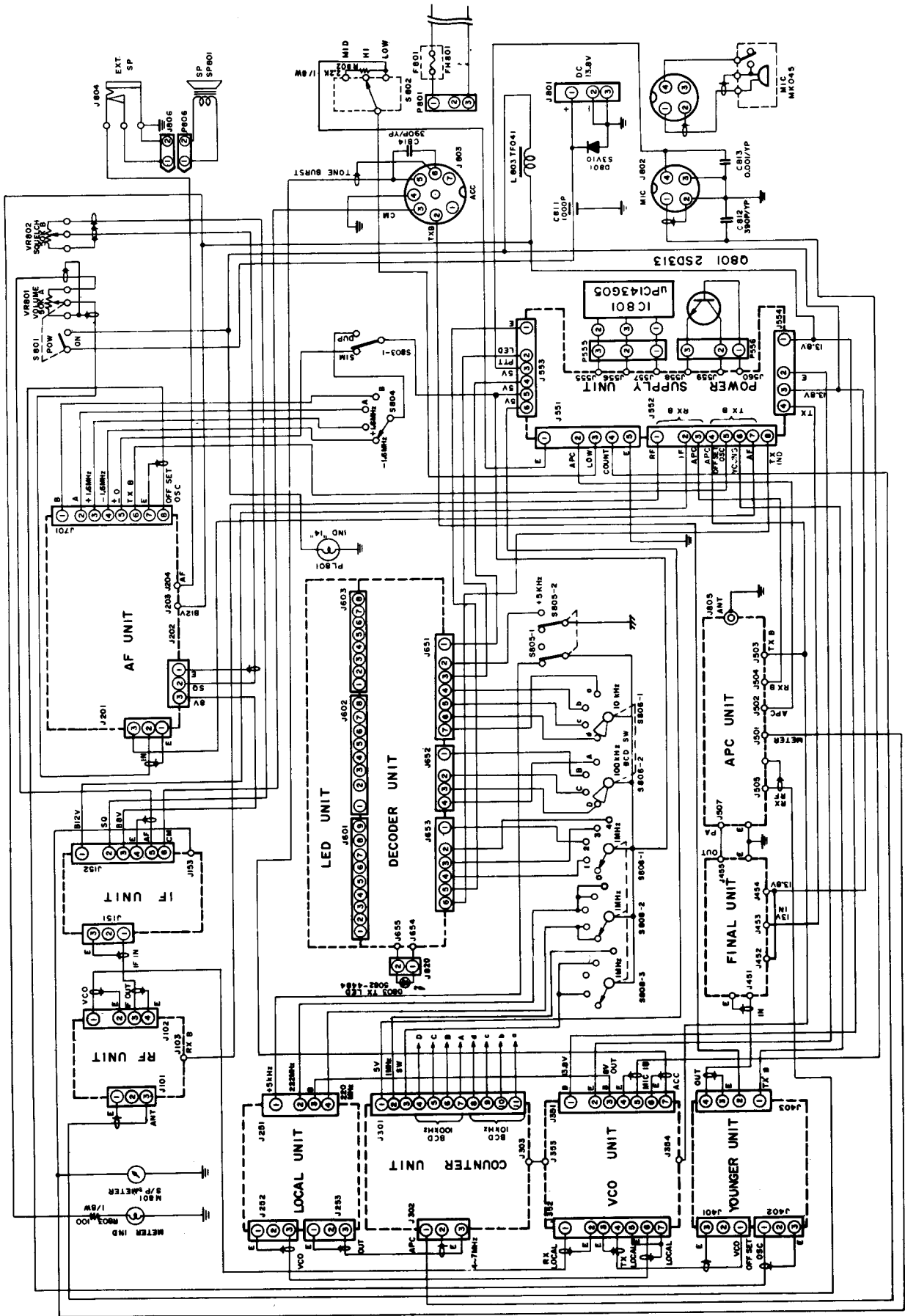
# Power Supply Unit PC - 185 4/4



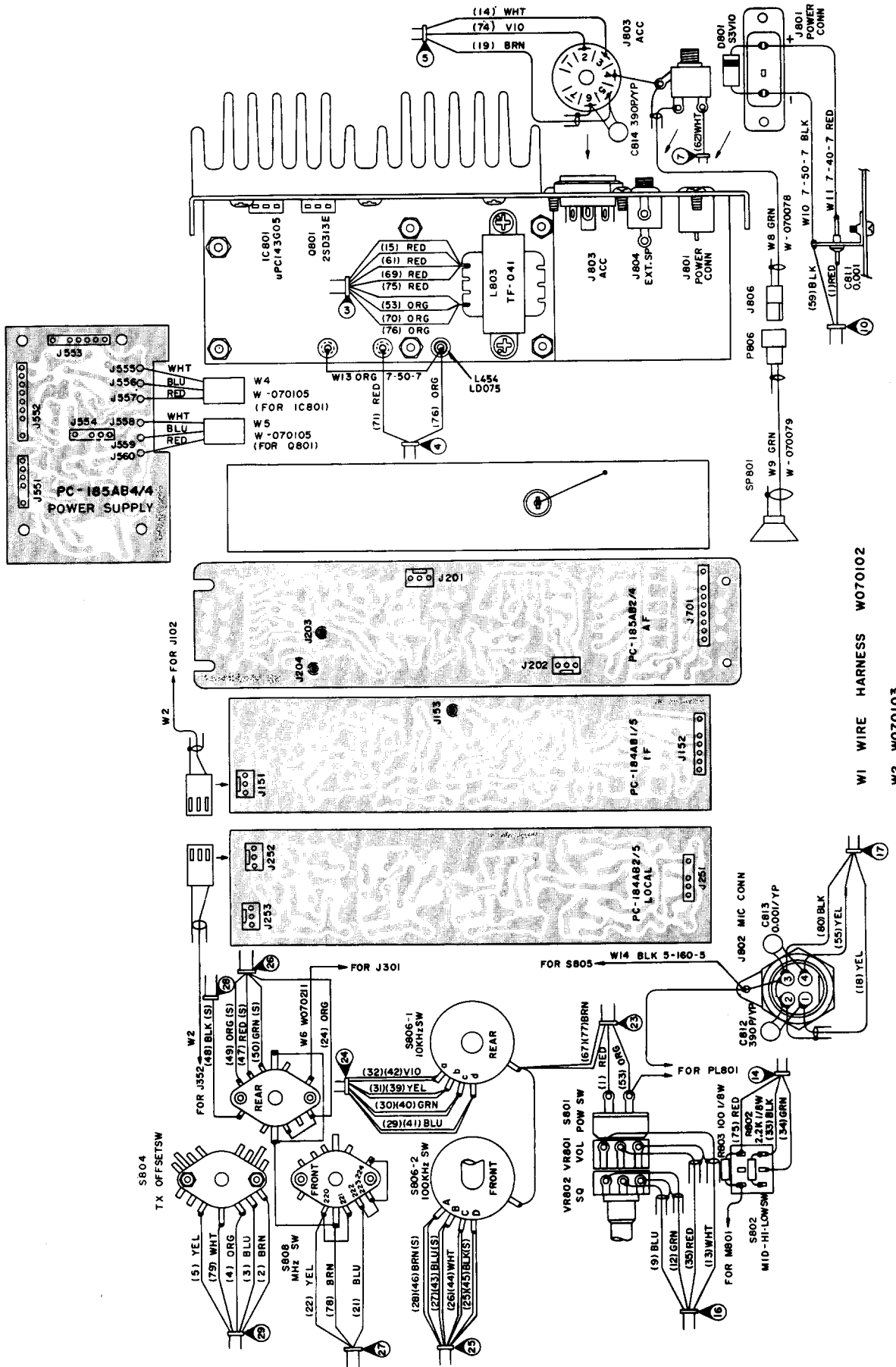
# LED Unit PC - 187 Decoder Unit PC - 188



# SCHEMATIC DIAGRAM (GENERAL)



# WIRING DIAGRAM

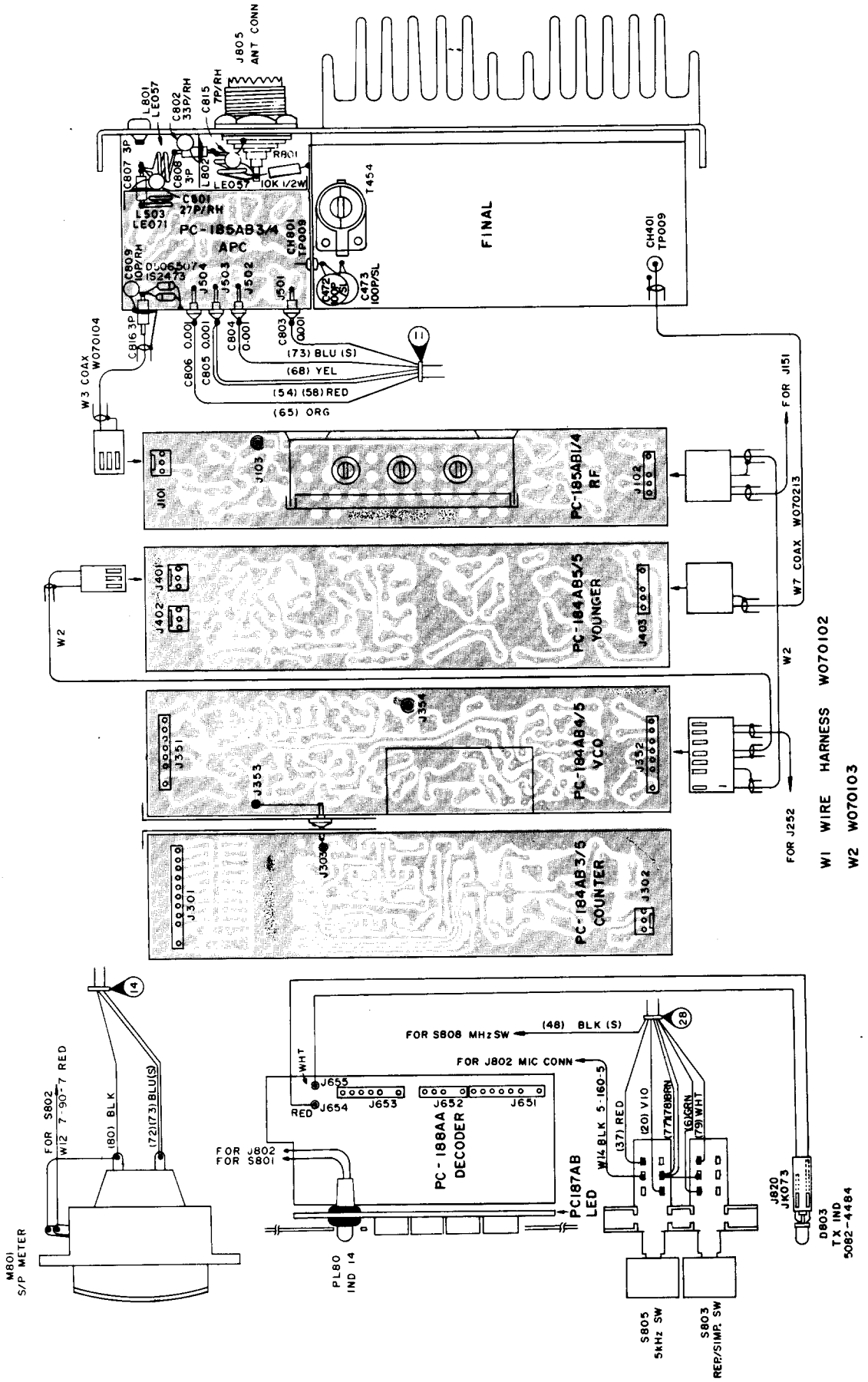


W1 WIRE HARNESS W070102

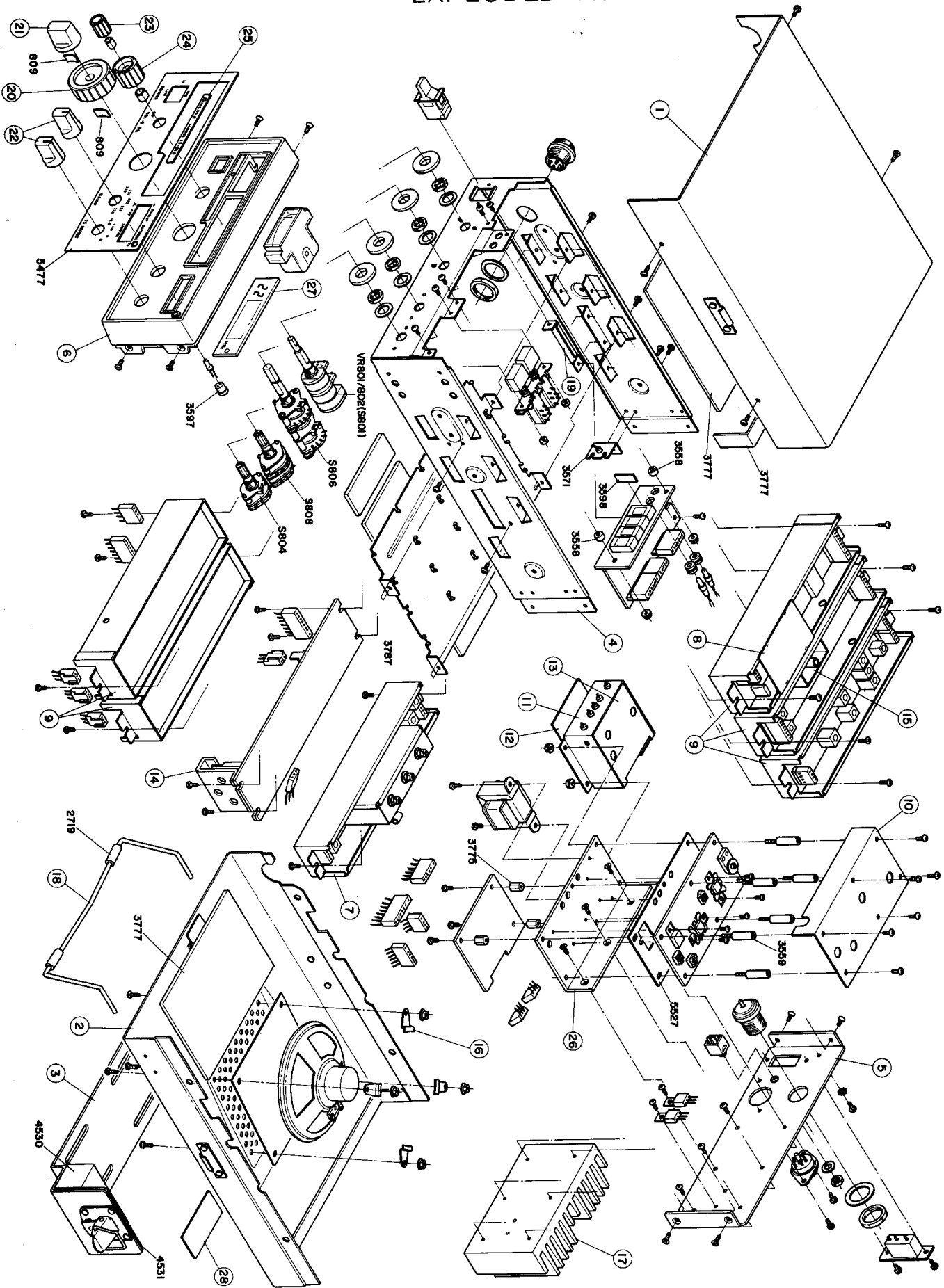
W2 W070103



# WIRING DIAGRAM



# EXPLODED VIEW



MODEL NO. 13-513

REF. NO.	DESCRIPTION	PART NO.	REF. NO.	DESCRIPTION	PART NO.
<u>CASE PARTS</u>					
1	Case, Top	13-010341			
2	Case, Bottom	13-013156			
3	Bracket, Mount	13-158550			
5	Chassis, Rear	13-013168			
6	Panel, Front	13-020748			
7	Shield, Case	13-089164			
8	Shield, Plate	13-089165			
9	Shield, Case	13-089166			
10	Cover, Final	13-020747			
11	Shield, Case, APC	13-089194			
12	Lid, Shield, A, APC	13-089168			
13	Lid, Shield, B, APC	13-089169			
14	Heatsink	13-089170			
15	Plate, Shield, VCO	13-089171			
16	Clamp, Speaker	13-158457			
17	Heatsink, Final Transistor	13-089173			
18	Stand	13-154184			
19	Mount, PCB	13-158605			
20	Knob, 100 Khz Selector	13-115155			
21	Knob, 10 Khz Selector	13-115156			
22	Knob, Band Selector + TX Offset	13-115157			
23	Knob, Volume	13-110215			
24	Knob, Squelch	13-110216			
25	Plate, Name	13-020775			
26	Heatsink, Chassis	13-089195			
27	Window, Channel Readout	13-020776			
28	Plate, FCC	13-023238			
	Plate, MIC	13-020750			
<u>MISCELLANEOUS</u>					
	Microphone MK-045	13-038077			
SP801	Speaker SP-045	13-060125			
M801	Meter MT-066	13-200083			
X704,705	Socket, Crystal SK-010	13-159262			
P804	Plug, Ext. Speaker PG-003	13-159263			
PL801	Lamp, Pilot PL-053	13-201089			
P801	Plug, DC Power PG-029	13-159264			
F801	Fuse 6A FS-006	13-204020			
	Hanger, Mic. YY-016	13-158551			
P803	Plug, Accessory PG-033	13-159265			
	Connector, LED JK-073	13-159299			
CR301-310	C R Components HA-001	13-130023			
<u>JACKS</u>					
J801	DC Power JK-059	13-153172			
J802	Microphone JK-028	13-153156			
J803	Accessory SK-019	13-153173			
J804	Ext. Speaker JK-010	13-153158			
J805	Antenna JK-035	13-159261			
<u>SWITCHES &amp; CONTROLS</u>					
VR801/802 (S801)	Control, Volume/Squelch	13-160155			
S802	Switch, Power Mid-Hi-Low	13-183261			
S803	Switch, Push & Repeater	13-183251			
S804	Switch, Offset	13-180127			
S806	Switch, Rotary	13-180128			
S808	Switch, Band	13-180137			
<u>SENSITIVITY CONTROLS</u>					
RT151,152,502	Control, Sensitivity RV-182 50K Ohm	13-164184			
RT351	Control, Sensitivity RV-182 10K Ohm	13-164183			
RT401	Control, Sensitivity RV-189 300 Ohm	13-164185			
RT501	Control, Sensitivity RV-182 500 Ohm	13-164181			
RT551,553	Control, Sensitivity RV-182 5K Ohm	13-164182			
RT552	Control, Sensitivity RV-182 1K Ohm	13-164186			
<u>COILS &amp; TRANSFORMERS</u>					
L101	Coil LA-232				13-176704
L102	Coil LC-128				13-176705
L103,151	Coil LA-151				13-090426
L104,353,354,403,404,406	Coil LA-226				13-176706
L105,154,251,252,258,301,351,701	Micro Inductor LZ-013 1 uH				13-178255
L152	Coil LA-135				13-090376
L153	Micro Inductor LZ-012 390 uH				13-178253
L155,201	Micro Inductor LZ-014 2.7 uH				13-178257
L156	Micro Inductor LZ-011 5.6 uH				13-178256
L253,254	Coil LA-225				13-176707
L255	Coil LA-228				13-176708
L256	Coil LA-229				13-176709
L257	Micro Inductor LZ-011 10 uH				13-178251
L352	Coil LC-129				13-176710
L401,402	Coil LA-230				13-176711
L405	Coil LA-231				13-176712
L407	Coil LA-227				13-176713
L408,801,802	Coil LE-057				13-090436
L409-412	Coil LD-020				13-176714
L452,453	Coil LD-015				13-176715
L454	Coil LD-075				13-176716
L501	Coil LD-064				13-090443
L502	Coil LE-058				13-090437
L503	Coil LE-071				13-176717
L504	Coil LD-018				13-090442
L803	Choke TF-041				13-178214
<u>FILTERS</u>					
FT101	Helical Resonator FL-058				13-123089
FT151	Filter, Crystal FL-059				13-123090
FT-152	Filter, Ceramic FL-039				13-179074
FT153	Discriminator, Ceramic FL-015				13-123078
<u>CRYSTALS</u>					
X151	16.445 MHz QX-076				13-129183
X251	13.406 MHz QX-085				13-129184
X252	13.273 MHz QX-085				13-129185
X301	10.240 MHz QX-076				13-129186
X701	16.900 MHz QX-076				13-129120
X702	15.300 MHz QX-085				13-129187
X703	18.500 MHz QX-085				13-129188
<u>INTEGRATED CIRCUITS</u>					
IC151	TA7060P				02-257060
IC152,352	TA7061AP				02-257061
IC201	TA7063P				02-257063
IC202	TA7204P				02-257204
IC301	uPD-057CW				02-390857
IC302	uPC-1008C				02-301008
IC304	N-7473N				02-197473
IC351	MC-78L08CP				02-187808
IC651-653	N-7447N				02-197447
IC801	uPC-143G05				02-301435
<u>TRANSISTORS</u>					
Q101,102,151,256,355,356,401-403	3SK45-B FET				01-080045
Q152,153,251,254,257,304,306,701-706	2SC1675L				01-031675
Q201-203,301,357,555,556	2SC458C				01-030458
Q204	2SK68A-M FET				01-070068
Q255,404	2SC763D				01-030763
Q302,552,554,557	2SA733P				01-010733
Q303,305	2SC763C				01-030763
Q351,353	2SC458LGC				01-030458
Q354	2SK55-D				01-070055
Q405	2SC2053				01-032053
Q451	2SC1971				01-031971
Q452	2SC2237				01-032237
Q453	2SC1946				01-031946
Q551,558	2SB544E				01-020544
Q553	2SD400E				01-040400
Q801	2SD313E				01-040313

REF. NO.	DESCRIPTION	PART NO.	REF. NO.	DESCRIPTION
	<u>DIODES</u>			<u>MYLAR, 50V</u>
D151	BZ-081 Zener	05-060081	C171,180,184,	0.01 uF
D152-155	1N-60P	05-170060	203,207,208,	
D203,251,252,	1S2473	05-182473	220,359,362,	
303,304,553,			388	
554,651,652			C177,179,181	0.001 uF
D351	1S2339G Varicap	05-182339	C204	0.0022 uF
D352	1S2688F Varicap	05-182688	C206,312,365,	0.039 uF
D503,504	MI-402	05-380402	387	
D551,552	KB-262 Varistor	05-240262	C217,357,358,	0.022 uF
D601-604	TLR-313 LED	13-202008	361	
D801	S3V-10	05-570310	C380,389	0.033 uF
D803	S082-4484 LED	13-202009		
	<u>RESISTORS</u>			<u>TANTALUM</u>
ALL RESISTORS NOT SHOWN ON THIS PARTS LIST ARE CARBON, 1/4 W. SEE SCHEMATIC FOR SPECIFIC VALUES.			C454,467	10 uF 25V
	<u>CARBON</u>			
R304	220 Ohm 1/8 W			
R360,362	22K 1/8 W			
R424	10 Ohm 1/2 W			
R451	56 Ohm 1/2 W			
R501,502	470 Ohm 1/2 W			<u>ALUMINUM</u>
R663	470 Ohm 1/8 W			
R801	10K 1/2 W		C182	0.22 uF 16V
R802	2.2K 1/8 W		C213,551	0.1 uF 25V
R803,363	100 Ohm 1/8 W			<u>ELECTROLYTIC</u>
	<u>OTHER TYPES</u>			
R173	Solid 82 Ohm 1 W		C185,225,385,	1 uF 50V
R551	Metalized 330 Ohm 2 W		557	
			C201,211,212,	10 uF 16V
			214,219,311,	
			355,382,383,	
			563,566	
			C202,313,381	4.7 uF 25V
			C210,356	0.47 uF 50V
			C216,221,224	47 uF 16V
			C226	220 uF 16V
			C228	1000 uF 16V
			C314,386	33 uF 16V
			C352	100 uF 16V
			C360	22 uF 16V
			C552	470 uF 16V
	<u>CAPACITORS</u>			
ALL CAPACITORS NOT SHOWN ON THIS PARTS LIST ARE CERAMIC, 50V. SEE SCHEMATIC FOR SPECIFIC VALUES.				
	<u>TRIMMERS</u>			
CT251-254,401,	20 PF CV-028	13-123075		
701-705				
CT402,501	10 PF CV-028	13-123075		
CT451-453	10 PF CV-024	13-123091		
CT454	25 PF CV-037	13-123076		
	<u>FEED THROUGH</u>			
C479-481,393,	0.001 PF CZ-024	13-130028		
811,803-806				
C807,808,816	3 PF CZ-023	13-130029		
	<u>MINIC, 500V</u>			
C102	1 PF			
C407	0.18 PF			
C413	0.47 PF			
	<u>CERAMIC, 25V</u>			
C152-157,161,	0.01 uF			
260,261,317,				
321				
C165,251,252,	0.022 uF			
257,263,264,				
268,269,273,				
272,279,280-				
282,318,319,				
326,359,366,				
373,375,411,				
412,405,456,				
460,469				
C183,164,167,	0.039 uF			
169,315,316,				
707,170,172-				
176,183,186				
C327,329	0.1 uF			

## HOW AND WHERE TO ORDER REPLACEMENT PARTS

NOTE: To eliminate error and speed delivery of replacement parts, always include the following information on your order:

- Complete identification of merchandise for which the part is wanted.
  - Model Number
  - Serial Number
- Best possible identification of the part itself.
  - Part Number
  - Schematic Reference Number
  - Part Description
  - Quantity Requested
  - If necessary, return old part as sample.
- Customer should use address listed below when ordering replacement parts.

MIDLAND INTERNATIONAL  
 CUSTOMER SERVICE (PARTS DEPT.)  
 1690 NORTH TOPPING AVENUE  
 KANSAS CITY, MISSOURI 64120

END OF DOCUMENT