

YAESU

FT-990

OPERATING MANUAL

YAESU MUSEN CO., LTD.

C.P.O. BOX 1500

TOKYO, JAPAN

General Information

The FT-990 is a high performance transceiver providing up to 100 watts transmitter power output on all HF amateur radio bands in CW, SSB, FM, RTTY and Packet (F1 and F2) modes, and up to 25 watts carrier in AM mode. The receiver tunes all frequencies between 100 kHz and 30 MHz in 10-Hz steps. An automatic antenna tuner and iambic electronic speed keyer/bug simulator are built in as standard accessories, along with five IF filters for the 2nd and 3rd receiver IFs, and a universally tunable, digital switched capacitance filter (SCF) for receiver audio. The FT-990 may be ordered with or without an efficient, heavy-duty switching regulator AC power supply.

Inside the FT-990, modular construction with plug-in composite epoxy boards provides excellent RF circuit isolation, high reliability and serviceability. Two 10-bit direct digital synthesizers (DDS) and a magnetic rotary encoder provide silent, silky-smooth tuning, pure local signals and very fast t/r changeover important in QSK CW and digital modes. Frequency accuracy and stability are assured by driving all DDSs from a single master oscillator, and the optional TCXO-2 temperature-compensated oscillator is available for exceptional 0.5-ppm stability from -10 to +50 °C. The extremely low-noise, high-performance receiver front end uses PIN-diode-controlled push-pull FETs in a constant-gain RF amplifier, feeding an active double balanced quad FET ring mixer.

Six microprocessors in the FT-990 are programmed to provide the simplest possible control interface for the operator, even for previously complex applications like HF packet. Interference rejection is facilitated by both IF shift and an IF notch filter, with pushbutton selection of IF bandwidths, and the astounding dual digital SCF audio filter with independently adjustable selectivity skirts (unique to the FT-990). An automatically mode-dependent AGC selection is provided along with manual AGC decay selection/disable.

The front panel keypad provides 1-touch band selection, with two independent (A/B) vfos for each band holding their own frequencies, modes and IF bandwidth settings, and even clarifier offsets and repeater shifts, if used. Switching bands instantly recalls all of these settings last used on each band. Ninety freely tunable and scannable memories are selectable with single (MEM) knob, each storing all of the operating data held in a vfo. Other important features include general coverage reception from 100 kHz to 30 MHz, a jack and front

panel button for a separate receive-only antenna, an effective noise blanker, all-mode squelch, independent receive and transmit clarifiers, 6-function multimeter and a unique adjustable passband-shifting RF speech processor which lets you tailor transmitter audio to your own voice for SSB.

Special features for CW include a built-in iambic memory keyer, presettable bfo offset and spotting button for precise tuning by zero-beat, and key jacks on both front and rear panels. In addition to the facility of the SCF audio filter for CW reception, a 250-Hz 3rd IF filter is available as an option to complement the 2nd IF 500-Hz bandwidth IF filter (also optional in the DC version).

Special digital mode provisions include separate interface jacks for an RTTY terminal unit and packet tnc, and RTTY and PKT mode selection buttons which disable the microphone jack automatically while providing either sideband for RTTY or LSB/FM modes for packet: switch between voice and digital modes with only the push of a button. For voice contesting, the DVS-2 digital voice recorder option introduced with the FT-1000 works with the FT-990, providing continuous-loop receiver recording and pushbutton transmission of multiple voice messages to help keep you at your peak QSO-rate throughout the contest.

With its efficient internal AC switching supply, the FT-990 weighs only 13 kg and always runs cool. An internal heatsink and quiet, thermally switched blower allow full power output without rear panel protrusions, giving easy access to connectors. The FT-990 incorporates the same high-speed antenna tuner as the FT-1000, with its own microprocessor and 39 memories which automatically store most recent antenna matching settings for nearly instant recall while changing operating frequency.

Accessories include the SP-6 Loudspeaker with audio filters and optional LL-5 Phone Patch; the YH-77ST Headset; the FP-25 AC PSU (for DC versions) or DC Cable (for AC versions) and the MD-1c8 Desktop- and MH-1b8 Hand Microphones.

Before connecting power, please read the *Installation* section carefully, heeding the warnings in that section to avoid damage to the set. After installation, please take time to work through the *Operation* chapter, referring to the *Controls & Connectors* chapter as necessary for details. These chapters are intended to be read while sitting in front of the FT-990, so you can try out each control and function as they are described.

Specifications

General

Receiving frequency range: 100 kHz — 30 MHz

Transmitting frequency ranges:

- 160-m band, 1.8 to 2.0 MHz (or 1.81/1.83 to 1.85)
- 80-m band, 3.5 to 4.0 MHz
- 40-m band, 7.0 to 7.5 MHz
- 30-m band, 10.0 to 10.5 MHz
- 20-m band, 14.0 to 14.5 MHz
- 17-m band, 18.0 to 18.5 MHz
- 15-m band, 21.0 to 21.5 MHz
- 12-m band, 24.5 to 25.0 MHz
- 10-m band, 28.0 to 29.7 MHz

Frequency stability: < 10 ppm from -10 to +50 °C (except FM, < 200 Hz),
< 0.5 ppm from -10 to +50 °C w/TCXO-2 option (FM < 150 Hz)

Emission modes: LSB/USB (J3E), CW (A1A), FSK (J1D, J2D), AM (A3E), FM (F3E)

Basic frequency steps:

- 10 Hz for J3E, A1A and J1D;
- 100 Hz for A3E, F3E and J2D

Antenna impedance: 16.5 to 150Ω (50Ω nominal)

Supply voltage:

- 100 – 117 or 200 – 234 VAC ± 10%, 50/60 Hz

Power consumption (approx.):

- 60 VA receive, 470 VA for 100 watts transmit

Dimensions (WHD): 368 × 129 × 370 mm

Weight (approx.): 13 kg. (28.6 lbs)

Transmitter

Power output:

- adjustable up to 100 watts (25 watts AM carrier)

Duty cycle: 100% @ 100 watts,

- 50% @ 100 watts (FM & RTTY, 3-minute tx)

Modulation types

- SSB: Balanced, filtered carrier
- AM: Low-level (early stage)
- FM: Variable reactance
- FSK: Audio frequency shift keying

Maximum FM deviation: ± 2.5 kHz

FSK shift frequencies: 170, 425 and 850 Hz

Packet shift frequencies: 200, 1000 Hz

Harmonic radiation: at least 50 dB below peak output

SSB carrier suppression:

- at least 40 dB below peak output

Undesired sideband suppression:

- at least 50 dB below peak output

Audio response (SSB):

- not more than -6 dB from 400 to 2600 Hz

3rd-order IMD: -36 dB typical @ 100 watts PEP on 14.2 MHz

Microphone impedance: 500 to 600 Ω

Receiver

Circuit type:

- triple-conversion superheterodyne

Intermediate frequencies:

- 47.21 and 10.94 MHz, and 455 kHz

Sensitivity:

- (for 10 dB S/N, 0 dBμ = 1 μV)

Frequency → Mode (BW) ↓	100 ~ 250 kHz	250 ~ 500 kHz	0.5 ~ 1.8 MHz	1.8 ~ 30 MHz
SSB, CW (2.4 kHz)	< 4 μV	< 1 μV	< 2 μV	< 0.25 μV
AM (6 kHz)	< 10 μV	< 2 μV	< 4 μV	< 1 μV
29-MHz FM (for 12 dB SINAD)	—	—	—	< 0.5 μV

Selectivity (-6/-60 dB):

Button	Modes	Minimum -6 dB BW	Maximum -60 dB BW
2.4 kHz	all except FM	2.2 kHz	4.0 kHz
2.0 kHz	all exc. AM, FM	1.8 kHz	3.6 kHz
500 Hz	CW, RTTY, Packet	500 Hz	1.8 kHz
250 Hz	CW, RTTY	240 Hz	700 Hz
—	AM (wide)	6 kHz	15 kHz

Squelch sensitivity:

- 1.8 ~ 30 MHz (CW, SSB, AM): < 2.0 μV
- 28 ~ 30 MHz (FM): < 0.32 μV

IF rejection (1.8 ~ 30 MHz):

- 80 dB or better

Image rejection (1.8 ~ 30 MHz):

- 80 dB or better

IF shift range: ± 1.2 kHz

Maximum audio power output:

- 2 watts into 4 Ω with < 10% THD

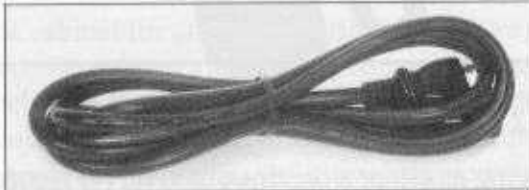
Audio output impedance: 4 to 8 Ω

Specifications are subject to change, in the interest of technical improvement, without notice or obligation.

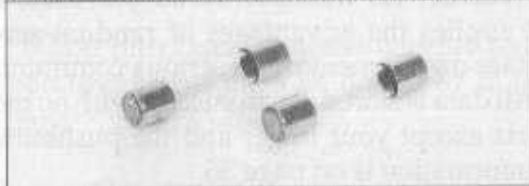
Accessories & Options

Supplied Accessories

- AC Cord (T9017780) 1



- Spare Fuses
8A (Q0000039) or 4A (Q0000006) 2



- 1/2-inch, 3-contact Plug
S-H3603 (P0090008) 1



- 1/4-inch, 2-contact Plug
C107 (P0090034) 1



- RCA Plug
T-1447 (P0090544) 2



- 4-pin DIN Plug
E4-701B-00 (P0090724) 1



- 5-pin DIN Plug
E5-701B-00 (P0090725) 1



- 8-pin DIN Plug
E8G-701B-00 (P0090816) 1



Options

TCXO-2 High Stability Master Reference Oscillator

For special applications and environments where extra frequency stability is essential, such as for long-term HF packet monitoring under wide temperature variations, the TCXO-2 provides 0.5-ppm stability from -10 to +50°C for the master reference oscillator.

MD-1C8 Desk-Top Microphone

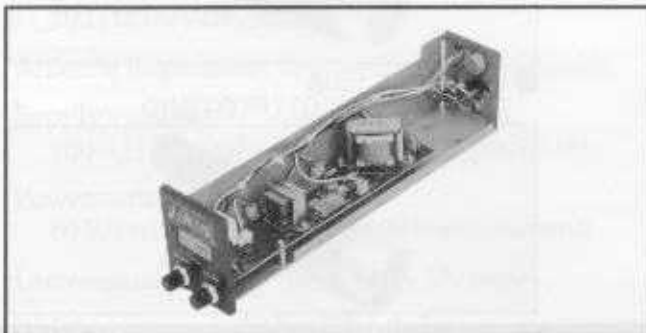
Designed especially to match the electrical and cosmetic features of the FT-990, the MD-1C8 has 600-Ω impedance, and includes up/down scanning buttons and a large PTT switch with latch.





SP-6 Loudspeaker with Audio Filters and LL-5 Phone Patch Option

Selectable audio high- and lowpass filters with a large loudspeaker complement the superb audio characteristics of the FT-990 with your choice of 12 different audio filtering combinations. Two input terminals are provided for multiple transceivers, with a front panel switch to select between them. A phone jack is provided on the front panel to take advantage of the audio filters with headphones.



With the optional LL-5 Phone Patch Unit installed in the SP-6, the FT-990 can be patched to the public telephone network. The LL-5 includes a hybrid transformer circuit to assure proper impedance matches, and gain controls and level meter to set proper audio levels on the telephone line.



YH-77ST Lightweight Headphones

Dual samarium-cobalt transducers with sensitivity of 103dB/mW (2dB, @1 kHz, 35Ω) provide the perfect match for the FT-990, taking full advantage of the spectacular audio performance.



DVS-2 Digital Voice System

Serving as either a continuous receiver recorder for instant pushbutton playback, or microphone audio recorder for multiple on air playback, the DVS-2 applies the advantages of random-access solid-state digital memory to serious communications. All data is stored electronically, with no moving parts except your finger and the pushbutton. More information is on page 36.



FIF-232C CAT System Interface

To control the FT-990 from an RS-232C serial port of an external personal computer, use the FIF-232C to convert the TTL levels required by the transceiver to the RS-232C levels required by the serial port. A cable is included for connection between the transceiver and the FIF-232C (the cable to the computer must be provided separately). The FIF-232C includes its own AC power supply.



IF Crystal Filter Options

For extra CW receiver selectivity, the XF-455K-251-01 8-pole 250-Hz crystal filter may be installed in the 455-kHz 3rd IF of the FT-990, to cascade with the 500-Hz 2nd IF filter (factory-installed in the AC version, or optional in the DC version).

Also, for SSB reception under difficult conditions, the XF-10.9M-202-01 8-pole 2-kHz crystal filter may be installed in the 10.9-kHz 2nd IF, and switched in from the front panel when needed.

Station Installation

Preliminary Inspection

Inspect the transceiver thoroughly immediately upon opening the packing carton. Check to see that all controls and switches work freely, and inspect the cabinet for any signs of damage. Make sure the accessory fuses and plugs pictured on page 3 are included. If any damage is found document it completely, and contact the shipping company (or dealer, if you purchased it over the counter) right away. Save the packing materials in case you need to return the set for service.

If you purchased optional internal accessories separately, install them as described in *Installing Internal Accessories* (page 45).

Power Connection

The FT-990 is available in an AC/DC version, which includes the FP-25 switching power supply, and a DC-only version. Page 47 describes DC installation for both versions, while the following paragraphs describes only AC power connections for the AC/DC version.

Before connecting power, check the label on the rear panel which indicates the AC mains voltage range for which your transceiver is currently set. If your AC mains voltage is outside of this range, the voltage switch on the power supply in the transceiver must be reset, and three fuses must be

CAUTION!

Permanent damage will result if improper supply voltage is applied to the transceiver. Your warranty does not cover damage caused by application of improper supply voltage, or use of improper fuses.

changed. This requires only a screwdriver and is not difficult (see below), but you should make sure the power supply is set correctly before connecting power. If you have any doubts about the procedure, ask your dealer for help.

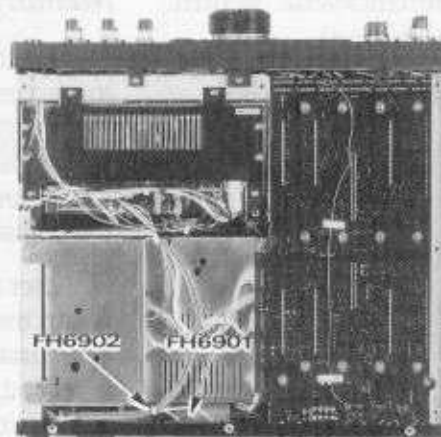
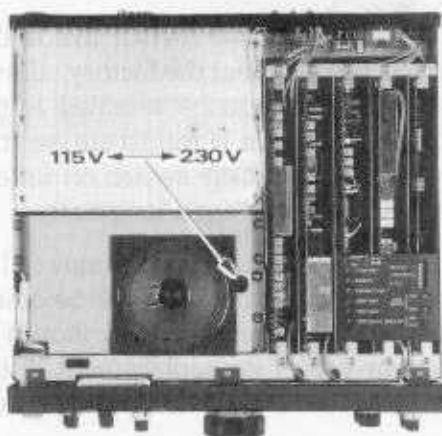
You should also make sure the fuse in the rear panel fuse holder is correct for your mains voltage:

AC Mains Voltage	Fuse Capacity
100 ~ 117	8 A
200 ~ 234	4 A

After making certain the AC voltage for which the transceiver is set matches your mains voltage, and that the correct fuse is installed in the fuse holder, connect the AC power cord to the 3-pin AC jack on the rear panel. Don't plug the cord into the wall until all other transceiver interconnections have been made.

Changing the Power Supply Setting for a Different AC Voltage Range

- Make certain that all cables are disconnected from the transceiver. Remove the top cover as shown at the top of page 10, and the bottom cover as shown at the bottom of page 12.
- Move the switch next to the speaker (see below) to the required 115 or 230 V side.
- On the bottom of the chassis (see below), replace fuses FH6901 and FH6902 with two of the supplied fuses: either the 10-A fuses (for 100 ~ 117 VAC) or 5-A (for 200 ~ 234 VAC).
- Replace the fuse in the rear panel holder, and then replace the cover and the carrying handle.



Important!

If you change the AC voltage range setting you must change the two internal fuses and the fuse in the rear panel holder. Also be sure to change the voltage marking on the label on the rear panel to match the new voltage setting. Do not use slow-blow fuses.

Transceiver Location

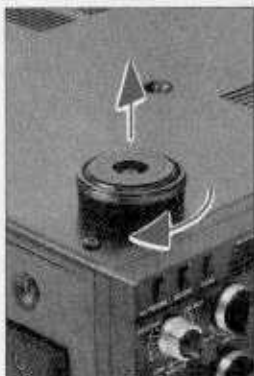
To assure long life of the components, a primary consideration in setting up the FT-990 is providing for adequate ventilation around the cabinet. The cooling system of the FT-990 must be free to draw cool air in at the bottom rear of the transceiver, and to expel warm air out of the upper rear panel. Do not place the transceiver on top of another heat-generating device such as a linear amplifier, and do not place equipment, books or papers on top of the transceiver. Place the transceiver on a hard, flat surface. Also, provide a few centimeters of space on either side of the transceiver, if possible. Avoid heating vents and window locations that could expose the transceiver to excessive direct sunlight, especially in hot climates.

Grounding

For protection from shock and proper performance, connect the **GND** terminal on the rear panel to a good earth ground, using a heavy braided cable of the shortest length possible. All other station equipment should be connected to the same grounding cable, as close together as practical. If you use a computer with or near the FT-990, you may need to experiment with grounding of both the transceiver and the computer to suppress computer noise in the receiver.

Adjusting the Front Feet

The two front feet of the FT-990 can be set in either of two positions. By turning the knurled ring around a (retracted) foot clockwise, the middle of the foot will extend about one centimeter. Turn the ring as far as it will go (about $\frac{1}{4}$ -turn) to lock the extended foot in place. To retract an extended foot, turn the knurled ring counterclockwise $\frac{1}{4}$ -turn while pressing on the center of the foot.



Adjusting the Front Feet

Antenna Considerations

Any antennas connected to the FT-990 should have coaxial feedlines with 50- Ω impedance, and include well-grounded lightning arrestors. For the antenna at the main **ANT** jack, the antenna tuner in the FT-990 is capable of matching antennas with an SWR of up to 3:1 or more on the amateur bands to the transmitter. Nevertheless, optimum performance for both reception and transmission will generally result with an antenna designed to provide a 50- Ω unbalanced resistive load at the operating frequency. An antenna that is not resonant at the operating frequency may present too high an SWR for proper matching with the built-in antenna tuner, in which case the antenna itself should be readjusted, or an outboard antenna tuner used. If the tuner is unable to bring the SWR down to an acceptable level, attempting to transmit will result in an automatic reduction in power output and increased losses in the feedline. Operation under such conditions is not recommended: it is better to install another antenna designed for that band. Also, if your antenna has a balanced feedpoint and you use a balanced feedline, install a balun between the feedline and the transceiver's **ANT** jack.

The same precautions apply to any additional (receive-only) antenna connected to the **RX ANT IN** jack, except that this antenna will not have the benefit of the built-in antenna tuner. Therefore, unless such a receive-only antenna has an impedance near 50 Ω at the operating frequency, you may need an external tuner for good performance.

Interconnection of Accessories

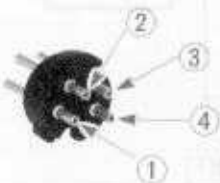
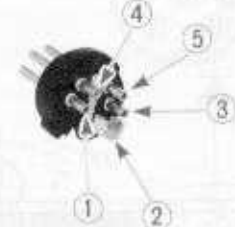
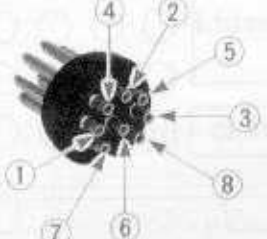
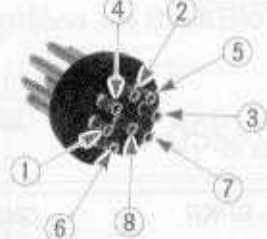
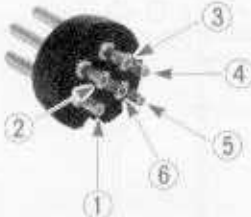
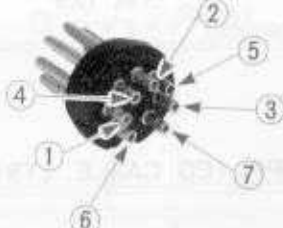
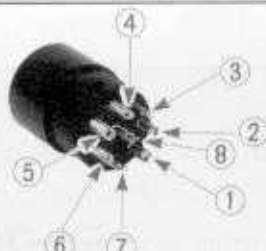
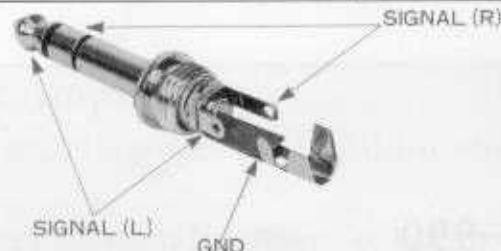


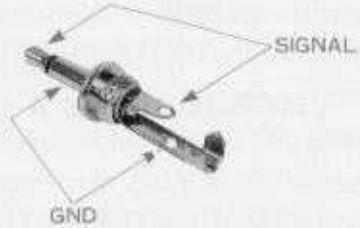
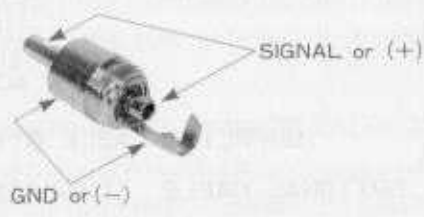
The diagrams on the following pages show interconnections of external accessories. If you have any questions on these accessories or connecting devices not shown, contact your dealer for advice.

Memory Backup

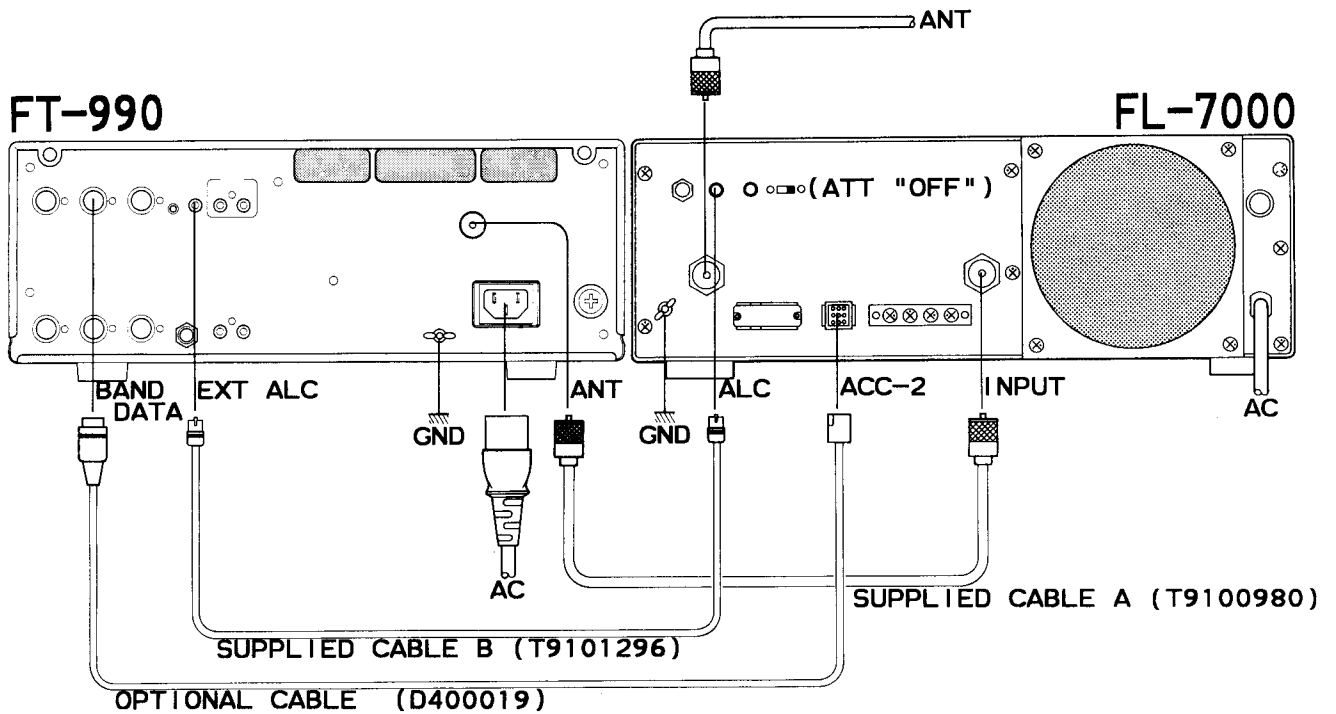
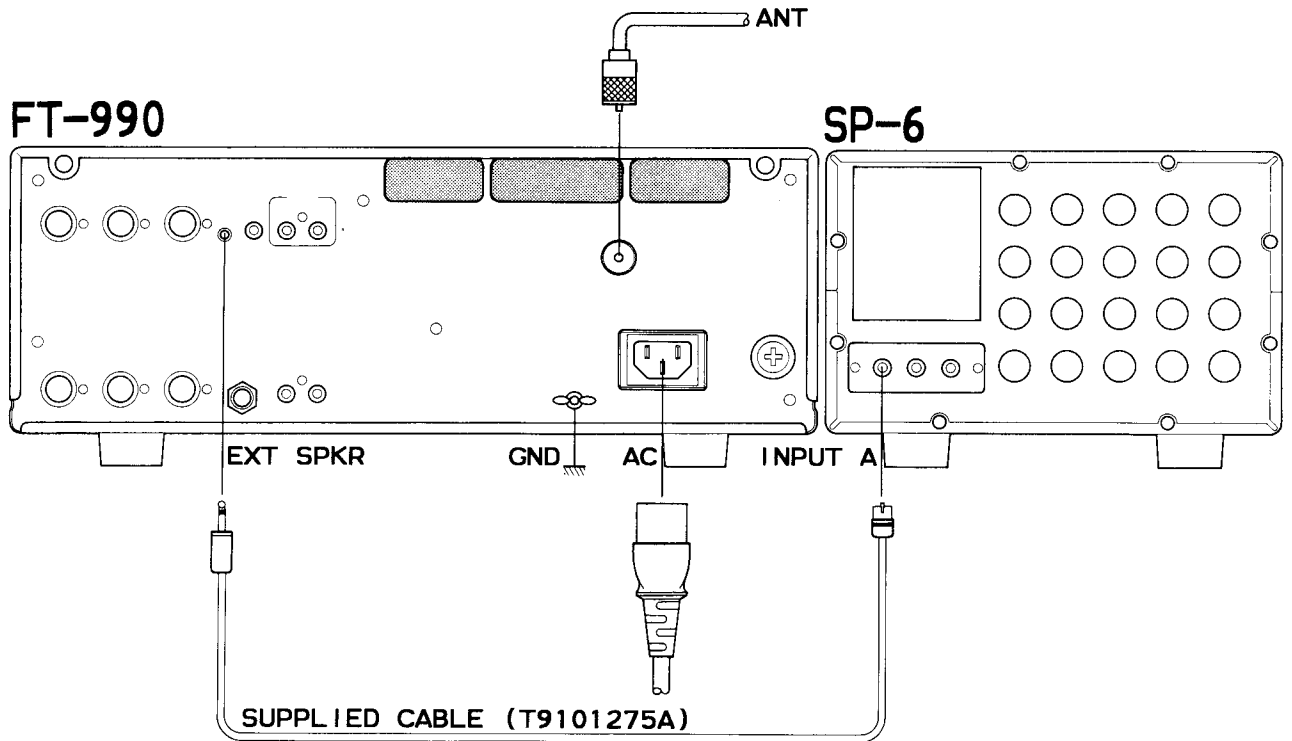
The lithium memory **BACKUP** switch inside the top access panel is turned on at the factory, allowing vfo and memory data to be retained while power is off. Backup current is miniscule, so it is not necessary to turn the **BACKUP** switch off unless the transceiver is to be stored for a long time.

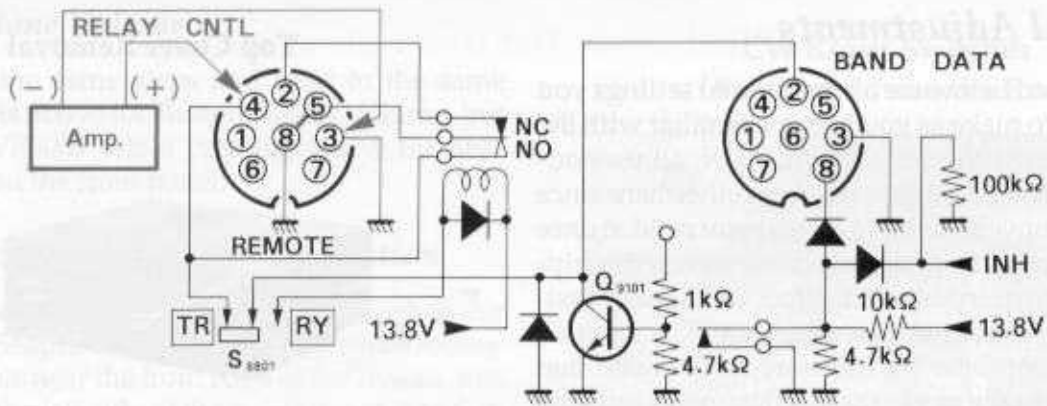
After about five years the transceiver may fail to retain memories (although operation will be otherwise unaffected), and the lithium battery should be replaced. Ask your dealer for replacement of the battery, or for instructions on how to do so yourself.

Connector Pinouts

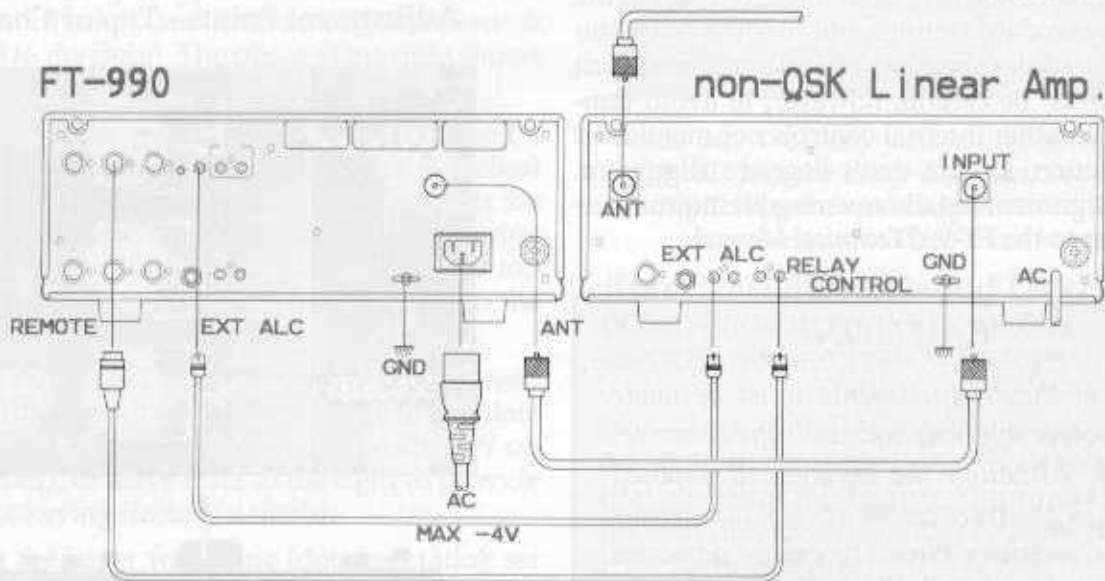
<p>RTTY</p>  <ul style="list-style-type: none"> 1 SHIFT 2 RX OUT 3 PTT 4 GND 	<p>PACKET</p>  <ul style="list-style-type: none"> 1 DATA IN 2 GND 3 PTT 4 DATA OUT 5 BUSY
<p>BAND DATA</p>  <ul style="list-style-type: none"> 1 +13V 2 TX GND 3 GND 4 BAND DATA A 5 BAND DATA B 6 BAND DATA C 7 BAND DATA D 8 LINEAR 	<p>REMOTE</p>  <ul style="list-style-type: none"> 1 EXT ALC 2 Norm. CLOSED 3 GND 4 Norm. OPEN 5 Relay Common 6 PTT 7 +13.8V 200mA 8 GND
<p>CAT</p>  <ul style="list-style-type: none"> 1 GND 2 SERIAL OUT 3 SERIAL IN 4 PTT 5 S/PO 6 NC 	<p>DVS-2</p>  <ul style="list-style-type: none"> 1 VOICE IN 2 VOICE OUT 3 PTT 4 +9V 5 CNTL1 6 CNTL 2 7 GND
<p>MIC</p>  <ul style="list-style-type: none"> 1 UP 2 GND 3 DWN 4 FAST 5 GND 6 PTT 7 GND 8 MIC 	<p>PHONES</p> 
<p>KEYER PADDLE</p> 	<p>FLAT KEY</p> 
<p>EXT SP</p> 	<p>RCA PLUG</p> 

Connecting External Accessories





Linear Amp T/R Switching Options on the REMOTE Jack



Connecting a Linear Amplifier

If using an FL-7000 with the FT-990, use optional cable D400019 to provide automatic band selection for the linear, as well as QSK t/r switching control.

For any other linear amplifier, t/r switching is provided by the **REMOTE** jack (page 23). To determine which pins to use, first determine the open circuit voltage and closed circuit current requirements of the t/r switching line for the linear. If the voltage is AC or above 50 VDC, or if the current required is more than 500 mA, switch S6801 must be set to the RY position to enable the internal relay (S6801 is set to the TR position to disable the relay at the factory, see page 11). Otherwise, if the linear's requirements are below these, connect the positive t/r control line from the linear to pin 4 of the **REMOTE** jack, and the negative side of this line to pin 3 (ground). Also, if your linear's requirements are within the above range, and if it is designed for full break-in (QSK) operation, you will need to connect its exciter-enable output to pin 8 of the **BAND DATA** jack. With a plug installed in this jack, the transmitter is normally disabled, and pin 8 floats at about 5 volts. By grounding pin 8 (to pin 3), the QSK linear enables the transmitter (this circuit prevents the FT-990 from exciting the linear before it is ready to send). Note that the FT-990 will not transmit if a plug is installed in the **BAND DATA** jack and pin 8 is not grounded.

With the relay enabled, the FT-990 can support *non-QSK* linear t/r voltage up to 125 VAC @ 200 mA, or DC voltage up to 220 V @ 300 mA, or closed-circuit current up to 2 A with DC voltage up to 30 V. Use pin 5 of the **REMOTE** jack (relay common), and pin 4 (closed-on-transmit), after setting S6801 to the RY position. *Do not attempt QSK operation with a linear if its switching requires the relay enabled.*

Internal Adjustments

Described below are a few internal settings you may wish to make as you become familiar with the FT-990. Access to, and adjustment of, all user-adjustable settings are described together here since it is most convenient to do all that you need at once while the covers are removed. However, descriptions of the purpose and effect of these adjustments are provided elsewhere in this manual, where appropriate. We therefore recommend that you do not make any of these adjustments until the purpose and effect of each is clear to you.

All adjustments have been aligned or set at the factory to standard settings, but in some cases you will want to tailor them for your particular station requirements. Be careful, however, to avoid tampering with other internal controls not mentioned in this section, so you don't degrade alignment. For full alignment details covering all internal settings, refer to the *FT-990 Technical Manual*.

CAUTION!

Some of these adjustments must be made with power applied, and with the cover removed. Although the voltages at exposed places in the transceiver are not dangerous to you, sensitive circuitry can be damaged by contact with metallic tools. Therefore we recommend using a non-metallic adjustment tool, if available. In any case, avoid touching any components not involved in the adjustment, and do not allow anything to fall in the set while the cover is removed.

Button Beeper Volume

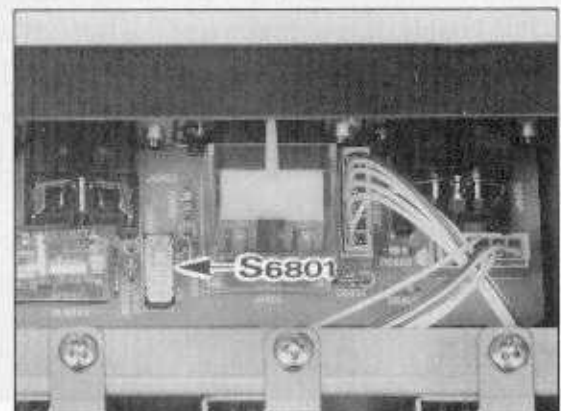
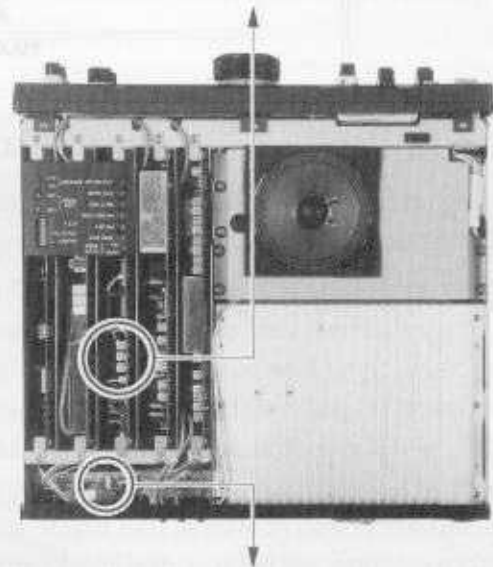
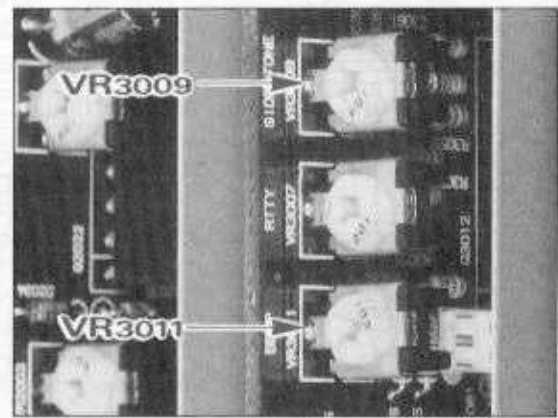
This trimmer potentiometer sets the volume of the beep that sounds when one of the front panel buttons is pressed (independently from receiver signal volume as set by the **AF** control).

- Remove the ten screws shown at the upper right, and remove the top cover.
- Turn the transceiver on, and adjust the **AF** control for normal volume on background noise on a commonly-used band.
- Referring to the photos at the right, locate VR3011 and use a small screwdriver to adjust it for the desired beep volume while repeatedly pressing a button.

Top Cover Removal



Adjustment Points - Top of Chassis



CW Sidetone Volume

- Follow the same steps and refer to the same photos as above for Button Beeper Volume, but adjust VR3009 while pressing (only) the **SPOT** button on the front panel.

CW Keyer Weighting, Bug Simulation

- With the top cover removed as described for Button Beeper Volume, notice the small rectangular hole near the front edge of the chassis, just behind the left side of the panel meter. The CW keyer setting switches are accessible through this hole (weighting DIP switch block S7204 is a little to the left, and iambic/bug slide switch S7203 to the right). The photo at the right shows a view of these switches from the rear.
- To change the switch settings you will need a thin, sharp-pointed tool about 15 cm (6 inches) long, and preferably non-metallic, to reach the switches through the hole. You can watch what you're doing through the slot between the top edge of the front panel and the chassis, to the left of the meter.
- Slide switch S7203 to the left (when viewed from the front) to change the keyer to simulate a bug (dits on one paddle, and steady CW on the other), or leave it set to the right to provide iambic keying (factory default).
- To set the keyer weighting (dot:dash ratio), set the four sections of DIP switch S7204 according to the table below (O = ON = front position).

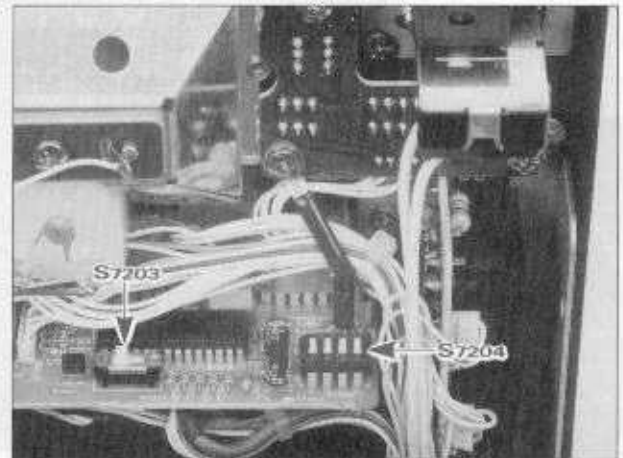
Linear Amp T/R Switch (S6801)

- The location of this switch is indicated in the photos on the previous page. Move it forward to enable the T/R relay at pins 2, 4 and 5 of the **REMOTE** Jack. The factory default (back) position

Keyer Weight Settings

Dot:Dash Ratio	DIP Switch				Dot:Dash Ratio	DIP Switch			
	1	2	3	4		1	2	3	4
1:3.0	0	0	0	0	1:4.0	0	-	0	-
1:3.1	-	0	0	0	1:4.1	-	-	0	-
1:3.2	0	-	0	0	1:4.2	0	0	-	0
1:3.3	-	-	0	0	1:4.3	-	0	-	-
1:3.4	0	0	-	0	1:4.4	0	-	-	-
1:3.5	-	0	-	0	1:4.5	-	-	-	-
1:3.6	0	-	-	0	ON (front position) = 0 OFF (rear position) = -				
1:3.7	-	-	-	0					
1:3.8	0	0	0	-					
1:3.9	-	0	0	-					

CW Keyer Switches (As viewed from the Rear)



has pin 4 of this jack switched by transistor Q9101, and the relay disabled. See the jack description in the next chapter.

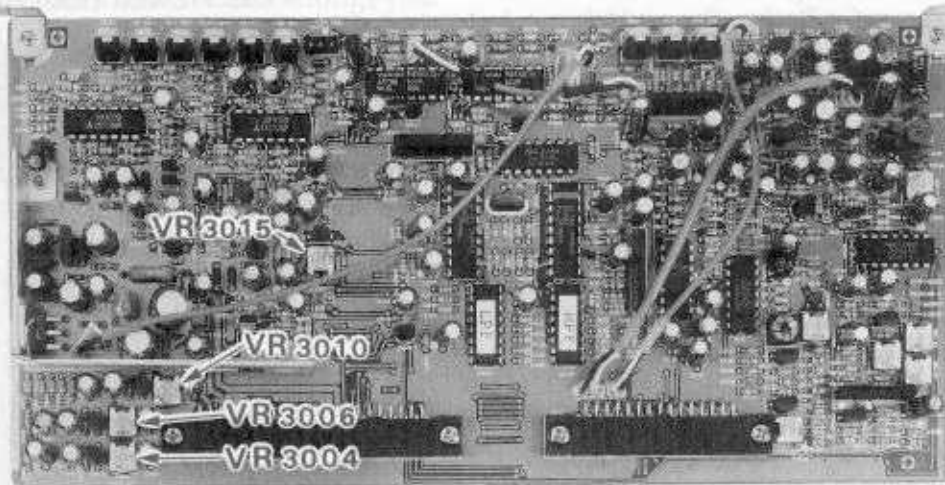
Rear Panel Audio Output Levels

(RTTY - VR3004, PACKET - VR3006, AF OUT - VR3010, DVS-2 - VR3015)

Note: these controls cannot be adjusted while the set is on, so adjustment may have to be made by trial-and-error. Make sure to turn the transceiver off each time before pulling or reinserting the circuit board.

- Make sure the transceiver is turned off.
- Remove the top cover, if necessary, as described above for Beeper Volume, and lift out the black plastic label sheet for the Top Panel Controls.
- Remove the screw at each end of the AF Unit (the board in the middle slot), and gently pull up on the brackets at each end of the board to remove it (rock them alternately).
- Refer to the AF Unit photo at the top of the next page for locations of the PKT OUT, RTTY OUT, AF OUT and DVS OUT trimmers on the board. Make a slight adjustment - clockwise to increase the output level, or counterclockwise to decrease it.
- Temporarily replace the AF Unit in its slot, using care to align the front and back edges of the card with the guide tabs in the chassis.
- Turn power on and do whatever you need to check whether the output level is satisfactory. If not, *turn the power off* and repeat the last few steps until it is.
- Replace the two screws affixing the AF Unit, and replace the plastic label sheet so that the controls are visible through the holes.

AF Unit - Audio Out Trimmer Locations



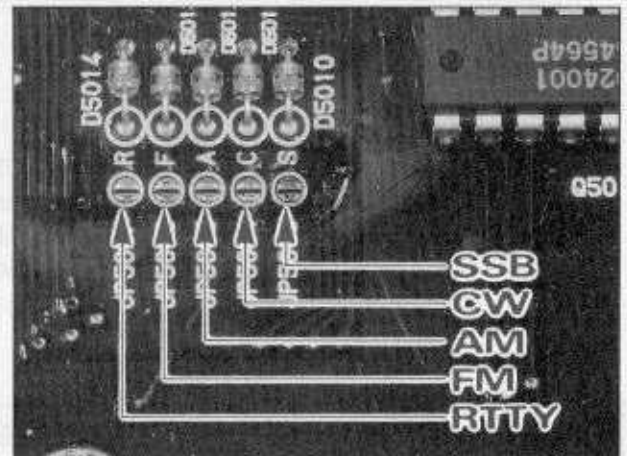
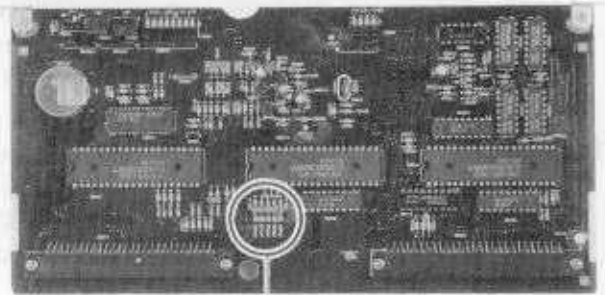
Mode-Specific Tuning Rates

- Remove the top cover, if necessary, as described above for Button Beeper Volume, and lift out the black plastic label cover for the Top Access Panel Controls.
- Remove the screw at each end of the Control Unit (the board in the rightmost slot), and gently pull up on the brackets at each end of the board to remove it (rock them alternately).
- Refer to the Control Unit photos at the right for locations of the split pads to halve tuning rates for each mode. Carefully bridge the halves of the pads corresponding to the mode(s) on which you want to reduce the tuning speed.
- Replace the Control Unit in its slot, using care to align the front and back edges of the card with the guide tabs in the chassis.
- Replace the two screws affixing the Control Unit, and replace the plastic label sheet so that the controls are visible through the holes in the sheet.

Slow AM Auto AGC

- Remove the top cover, if necessary, as described at the start of this section for Button Beeper Volume. Then carefully turn the set upside-down, and remove the ten screws shown at the right, affixing the bottom cover. Remove the bottom cover.
- Referring to the photos on the next page, locate the split pad indicated, and carefully short the halves of the pad with solder.
- Replace the bottom cover and its ten screws, and then the top cover and its ten screws.

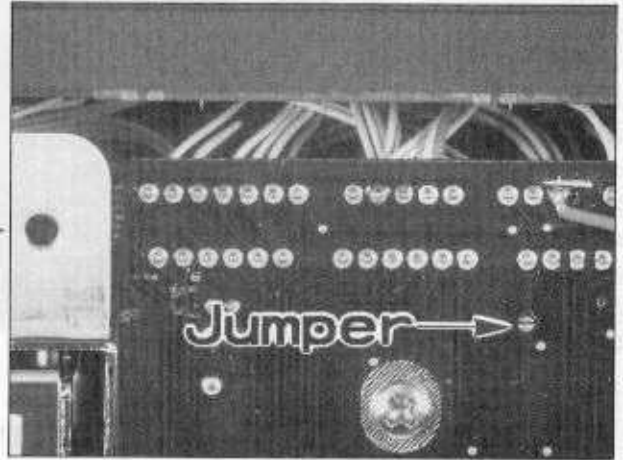
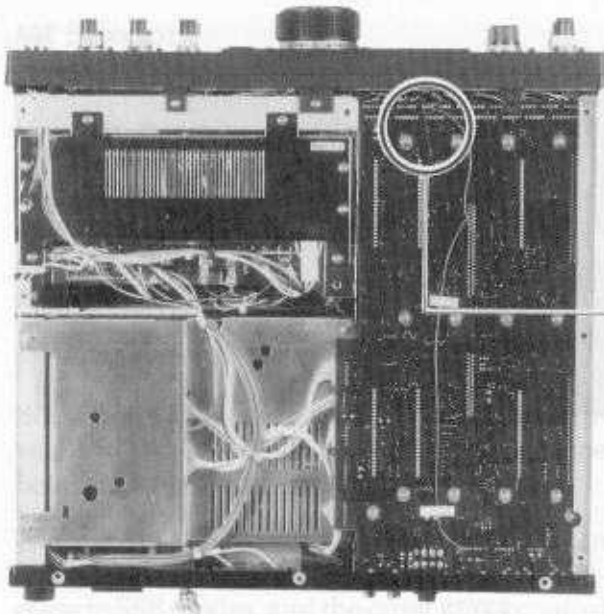
Control Unit - Split Pad Locations



Bottom Cover Removal

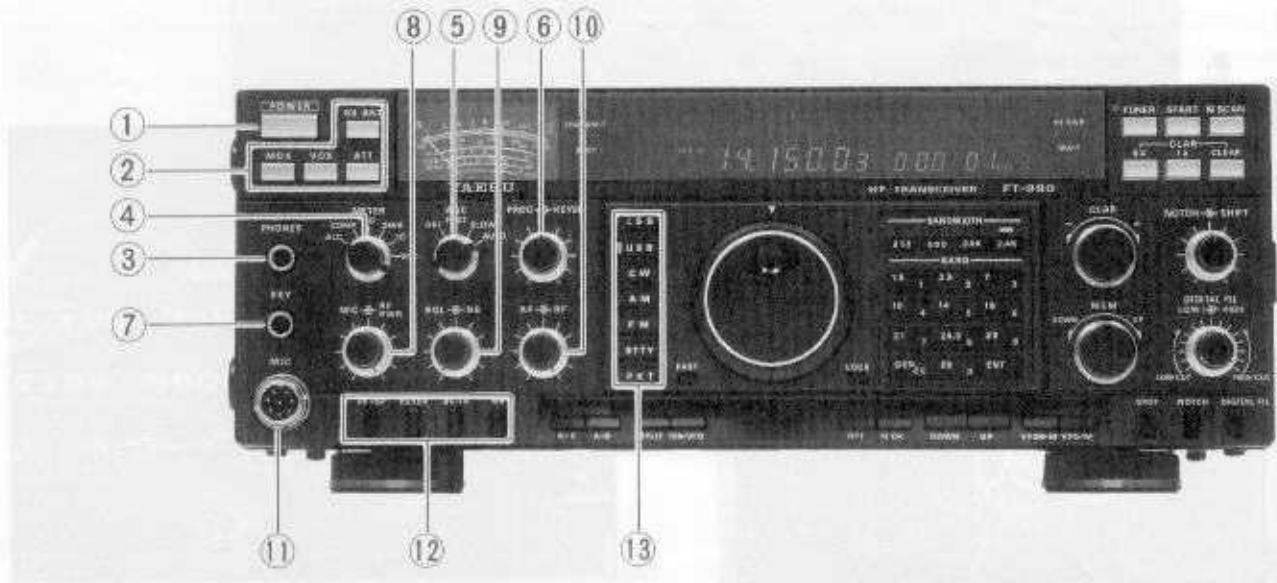


**AGC Auto Jumper for AM
(Bottom of Chassis)**



Controls & Connectors

Front Panel Controls



This chapter describes each control and connector on the FT-990. You can just read through quickly now, but some of the descriptions will be more meaningful if you first work through the *Getting Started Tutorial* at the beginning of the *Operation* chapter, and then return to this chapter with the set powered up, as questions arise during operation. Some controls and switches are disabled under certain conditions.

(1) POWER

This button turns the transceiver on and off.

(2) 2-Position Pushbutton Switches

RX ANT

When this switch is in the undepressed (■) position, the antenna connected to the main ANT socket is used for receive (it is always used for transmit). When this switch is depressed (■), the RX ANT IN & OUT jacks on the rear panel are activated, with either a receive-only antenna, external receiver or in-line receiver accessory. See the schematic on page 27 for an idea of how this works.

VOX

This button may be used in place of a microphone PTT switch or CW key to manually activate the transmitter. It must be in the undepressed (■) position for reception.

VOX

Enables automatic voice-actuated transmitter switching in voice modes; and semi break-in keying in CW mode. The controls affecting VOX operation are in the top access panel.

ATT

Press this button when receiving on a noisy band or when strong signals are present. This inserts a 20-dB attenuator in the front end to protect the receiver from overload.

(3) PHONES

This ¼-inch, 3-contact jack accepts either monaural or stereo headphones with a 2- or 3-contact plug. When a plug is inserted, the loudspeaker is disabled. Audio is supplied to both channels of a stereo headphone.

(4) METER Selector


This selector determines the function of the multimeter during transmission. The meanings of the abbreviations are as follows:

- PO** RF Power Output (watts)
- IC** Final amplifier collector current (Amps)
- SWR** Standing Wave Ratio (forward:reflected)
- COMP** RF speech compressor level (in dB, for SSB modes only)
- ALC** relative Automatic Level Control voltage
- VCC** Final amplifier collector voltage.

The meter indicates the selected parameter during transmission, and signal strength in S-units during reception (on the top scale). Each S-unit is approximately 6 dB.

(5) **AGC Selector**

Selects receiver Automatic Gain Control decay time for most comfortable reception, or disables receiver AGC (off). Normally this switch is set to the **AUTO** position, which automatically selects the AGC decay according to your operating mode. When set to **OFF**, the S-meter is disabled, and strong signals may be distorted.

(6) **PROC**  **KEYER**

Both of these controls function only when activated by the button with the same name at the bottom right side of the panel.

The inner **PROC** control sets the compression (input) level of the transmitter RF speech processor in SSB modes, and the outer **KEYER** control sets the keyer/bug simulator keying speed.


(7) **KEY Jack**

This 1/4-inch, 3-contact jack accepts a CW key or keyer paddles (for the built-in electronic keyer), or output from an external electronic keyer. *You must not use a 2-contact plug in this jack.* Pinout is shown on page 7. Key up voltage is 5 V, and key down current is 0.5 mA. There is another jack with the same name, connected in parallel with this jack, on the rear panel.

(8) **MIC**  **RF PWR**

The inner **MIC** control adjusts the microphone input level for SSB and AM transmission.

The outer **RF PWR** control adjusts the transmitter output power in all modes. The adjustment range is from less than 10 to 100 watts (or 5 to 25 watts in AM mode).

(9) **SQL**  **NB**

The inner **SQL** control sets the signal threshold at which receiver audio is muted (and the **BUSY** LED turns off), in all modes. This control is normally kept fully CCW, except when scanning, and during FM operation. Scanning stops when the squelch is open.

The outer **NB** control adjusts the blanking level when the noise blanker is activated during reception. If set very far clockwise, receiver audio can be distorted.

(10) **AF**  **RF**

The inner **AF** gain control adjusts the volume of the receiver in the speaker or headphones.

The outer **RF** gain control adjusts incoming signal level in front of the receiver RF amplifier (via PIN diodes), in tandem with the gain of the receiver IF amplifiers. This control is normally set fully clockwise for maximum sensitivity. When rotated counterclockwise from maximum, the S-meter minimum deflection point will move up the scale. The peak deflection for a particular signal will remain the same if it is greater than the level set by this control, but the main receiver will be insensitive to weaker signals. This control also affects the **SQL** setting, and should be preset fully clockwise when setting the squelch threshold.

(11) **MIC**

This 8-pin jack accepts the MD-1B8 or MD-1C8 Desktop Microphone or the MH-1B8 Handie Scanning Microphone. Pinout is shown on page 7. Proper microphone input impedance is 500 to 600 ohms.

(12) *Left Side Push Switches*

RF FSP

When operating in an SSB mode, you can press this button to toggle the RF speech processor on and off (for transmission). Processing level is set by the **PROC** control, and the filter pass-band can be adjusted. While activated, the LED above this button glows orange. This button is disabled in other modes.

KEYER & BK-IN

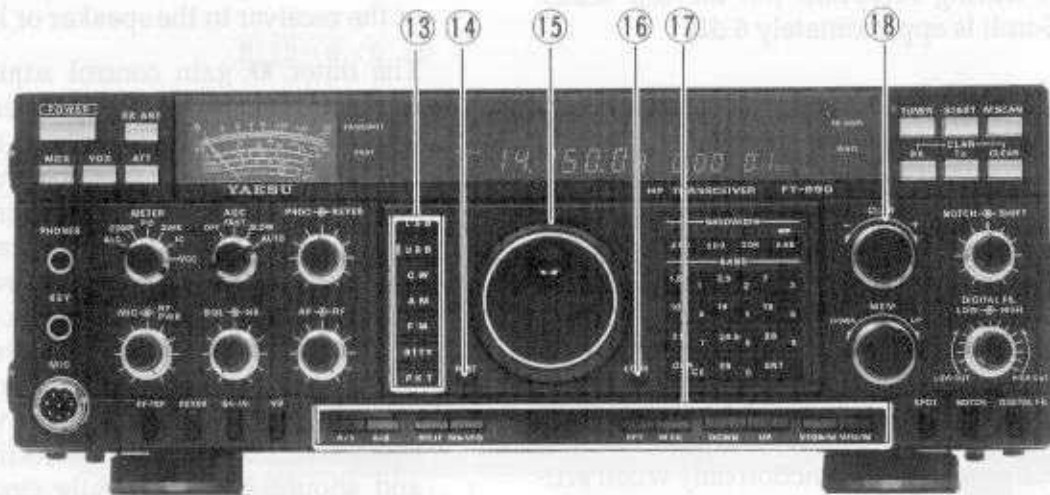
When operating in CW mode, the **KEYER** button toggles the internal keyer on and off, and **BK-IN** turns full break-in (QSK) CW operation on and off. The green LEDs above each button light when active. These buttons are disabled in other modes.

NB

This button toggles the receiver noise blanker on and off. The LED above the button glows green while activated. Blanking level is set by the control with the same name.

(13) *Mode Buttons*

These seven momentary buttons select the operating mode, indicated by the LED in each button. Note that pressing the **RTTY** and **PKT**



(packet) buttons multiple times will switch between the possible modes of emission that can be used by these digital modes (LSB and USB for RTTY, and LSB and FM for packet).

(14) FAST

For fast tuning, press this button while rotating the tuning knob or pressing the **UP** or **DOWN** button, to increase the tuning rate ten times. See the table on page 25 for all available steps. While the fast tuning rate is active, **FAST** is displayed above the MHz digits. You can set the function of this button to be either “press-and-hold”, or toggle on/off, by holding the button while switching the transceiver on.

(15) Main Tuning Knob

This knob adjusts the operating frequency of the vfo or a recalled memory. Tuning increments are normally 10 Hz (100 Hz in AM and FM modes). The markings on the knob represent 50 increments each, and one full turn of the knob provides 1,000 increments (10 kHz, or 100 kHz in AM/FM). If you prefer slower tuning rates (1/2-speed) you can install an internal jumper as described on page 12.

Display Brightness Adjustment

The brightness of the display (but not the meter pilot or LEDs) is adjustable by holding the **FAST** button while turning the **CLAR** control.

(16) LOCK

This button toggles locking of the main tuning knob to prevent accidental frequency changes. **LOCK** is displayed above the mode buttons when locked (the knob can still be turned, but it does nothing). Press again to re-enable the tuning knob. You can set the function of this button to lock most of the controls and buttons, instead of just the tuning knob, by holding the button while switching the transceiver on. In this case the **LOCK** display will blink when enabled.

(17) Horizontal Pushbuttons (lower center)

A/B

When receiving on a vfo, this button toggles operation and display between vfos A and B. The current selection is displayed to the left of the operating frequency.

A=B

When receiving on a vfo, this button copies the contents of the displayed vfo (A or B) to the other vfo. Previous contents of the non-displayed vfo are overwritten (*lost!*).

SPLIT

This button activates split transmit/receive frequency operation. The main display (either a vfo or a recalled memory channel) is used for reception, and the other vfo for transmission. The **SPLIT** indicator at the left side of the display is lit while this function is active.

M ► VFO

Pressing this button momentarily displays the contents of the currently selected memory channel for three seconds. Holding this button for for 1/2-second copies the data from the currently selected memory to the currently selected vfo, as two beeps sound. Previous data in the vfo is overwritten.

RPT

When operating in the FM mode on the 29-MHz band, this button activates standard hf FM repeater operation. Pressing this button once or twice while receiving causes the transmit frequency to be shifted 100 kHz below or above the receiving frequency, respectively. An 88.5-Hz subaudible tone is also transmitted automatically at a low level when using this feature, to allow access to repeaters that require it. Pressing this button a third time cancels repeater shift operation.

M CK (Memory Check)

This button allows display of the contents of the memory channels without disturbing operation. When pressed, **M CK** is displayed just above the channel number at the right end of the display. The contents of each memory channel can then be checked on the display and mode/filter LEDs by rotating the **MEM** selector. Empty memory channels display as decimals only, with no frequency digits. Press this button again to cancel memory checking.

DOWN & UP

Pressing either of these buttons momentarily steps the operating frequency down or up 100

kHz, respectively. Pressing the **FAST** button with one of these buttons steps down or up 1 MHz. Continue holding either button for repeated stepping.

VFO ► M

When receiving on a vfo or a retuned memory, hold this button for 1/2-second to transfer (write) the current operating data to the currently selected memory channel. Two beeps sound, and any previous data in the memory is overwritten. Also, pressing and holding this button after recalling a memory (without first retuning) causes the memory channel to be "blanked", and repeating the process restores the blanked memory.

VFO/M

This button toggles receiver operation between the memory channel and a vfo. Either **VFO-A** (or **-B**), **MEM** or **M TUNE** is displayed to the left of the frequency display to indicate the current selection. If a displayed memory has been retuned, pressing this button once returns the display to the original memory contents, and pressing it again returns operation to the (last used) vfo.

(18) CLAR Tuning Knob

This knob tunes the clarifier offset frequency up to 9.99 kHz, when activated by the **CLAR RX** and/or **TX** buttons above it (the 3-digit offset frequency appears in small digits just to the right of the operating frequency). Operating details are on page 33.

(19) NOTCH SHIFT

The inner **NOTCH** control adjusts the IF notch filter frequency when activated by the button with the same name at the bottom of the panel. In modes other than AM and FM, the outer **SHIFT** control offsets the IF passband center frequency from the displayed frequency when turned away from the 12-o'clock position.

(20) MEM

This detented knob selects the memory channels. When a vfo is active, turning this knob activates the memory check mode, in which the current contents of memories are displayed without otherwise affecting operation. The channel number of the selected memory is displayed at all times at the right end of the display (in front of "CH").

(21) DIGITAL FIL

These concentric controls adjust the passband skirts of the digital audio filter, when activated by the button with the same name below. The inner **LOW** control adjusts the low-frequency cutoff, and the outer **HIGH** control adjust the high-frequency cutoff. Maximum bandwidth is provided with the **LOW** control fully counter-clockwise, and the **HIGH** control fully clockwise.

(22) Lower Right Pushbuttons

SPOT turns the CW receiver spotting heterodyne oscillator on while pressed *and held*.

NOTCH turns the IF notch filter on and off (except in FM mode). The green LED above this button lights while the filter is active, and the control with the same name sets the notch frequency.

DIGITAL FIL turns the digital audio filter on and off. The green LED above this button lights while the filter is active, and the controls with the same name set the filter skirt frequencies.

(23) CLAR Pushbuttons

Pressing the **RX** button activates the **CLAR** knob (below this button), to allow offsetting the receiving frequency temporarily (see (18), above). The **TX** button provides the same function for the transmit frequency. If both buttons are pressed, the receiver and transmitter are both offset from the original frequency. Pressing the **CLEAR** button zeros any offset tuned by the **CLAR** knob. Each memory and vfo retains all clarifier settings independently.

(24) M SCAN Pushbutton

Activates scanning of the memories. Also used together with the **FAST** button to set/reset Scan Skip status of a recalled memory.

(25) TUNER Pushbutton

Pressing this button so that its LED is lit puts the antenna tuner in line between the transmitter final amplifier and the main antenna jack. Reception is not affected. The **START** button (below) also activates the antenna tuner.

(26) START Momentary Pushbutton

Pressing this button while receiving in an amateur band activates the transmitter for a few seconds while the automatic antenna tuner re-matches the antenna for minimum SWR. The resulting settings are automatically stored in one of the antenna tuner's 39 memories, for instant automatic recall later when the receiver is tuned near the same frequency.

(27) Right Side LED Indicators

The **HI SWR** LED lights when an impedance mismatch is detected at the main **ANT** jack. *Avoid transmitting until the problem has been corrected.*

The **WAIT** LED lights while the antenna tuner is tuning, and flashes briefly when changing frequency, as the main cpu sends new frequency data to the antenna tuner coprocessor: this does not affect operation.

(28) BANDWIDTH

These four momentary buttons select the 2nd and 3rd IF filters for the receiver (except in the FM mode). In AM mode, either 2.4-kHz or 6-kHz bandwidths are selected by pressing the **2.4K** button (LED off = 6 kHz). The selectivity provided by these selections can be further enhanced by installing optional filters (page 44). See the diagram on page 28 for the available filter combinations.

(29) BAND (Keypad)

The keypad provides one-touch band selection, or digital frequency entry. Normally, pressing one of the ten *white* numbered keys selects the corresponding (MHz) amateur band for operation. However, if the **ENT** key is pressed first, the *yellow* labels on the keys are activated for entering any frequency one digit at a time. See the *Operation* chapter for details.

(30) *Digital Display*

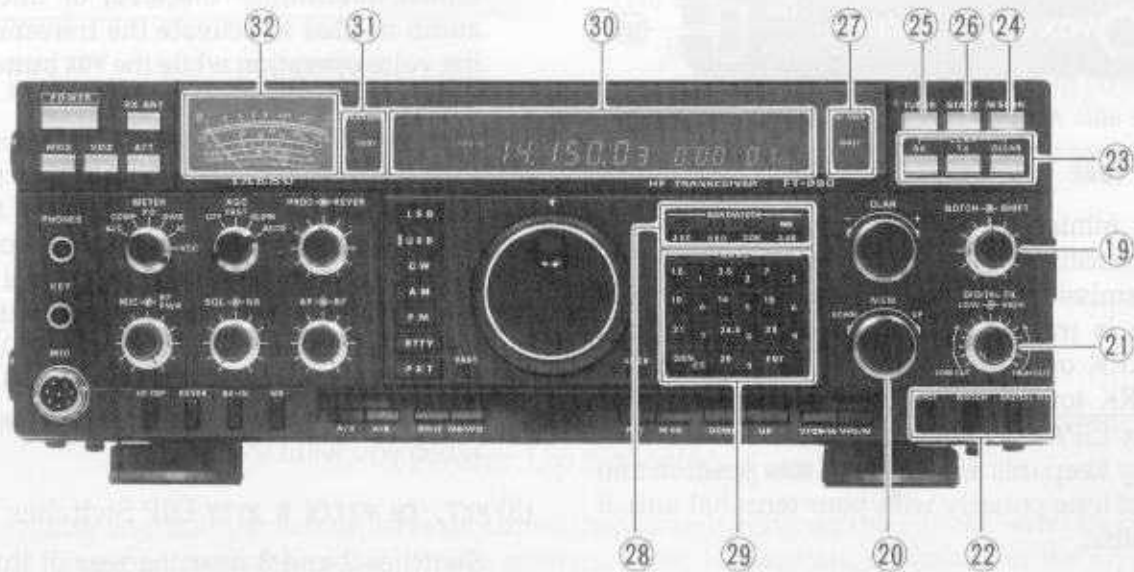
The display shows, from left to right, special operating status (**CAT SYSTEM**, **SPLIT**, **GEN**(eral coverage), or **LOCK**); and **VFO**, **MEM** or **M TUNE** mode of the receiver; **FAST** tuning, if activated; and operating frequency, clarifier offset and memory number.

(31) *Left Side LED Indicators*

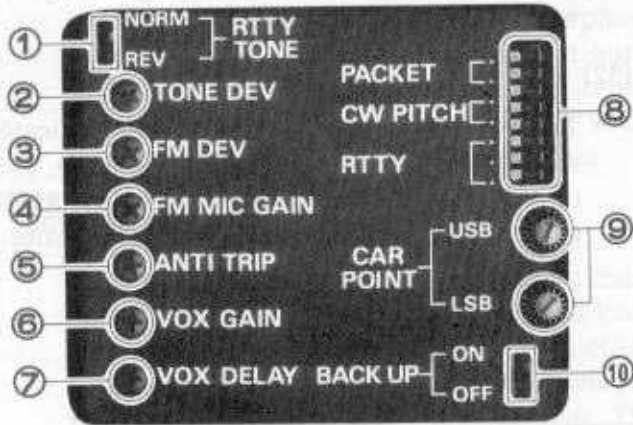
The **TRANSMIT** LED glows red when the transmitter is activated. The **BUSY** LED glows green when the squelch is open.

(32) *Meter*

The 7-function multimeter normally indicates receiver signal strength on the top scale, and one of six parameters (selected by the **METER** selector) during transmit on the lower scales.



Top Access Panel Controls



(1) RTTY TONE

This miniature slide switch selects the tone relationships of the AFSK generator for RTTY transmissions. In the **NORM** position, the SPACE tone is transmitted while the key is open (MARK on closure). In the **REV** position, the MARK tone is transmitted while the key is open (SPACE on closure). You would normally keep this switch in the **NORM** position and select tone polarity with your terminal unit, if possible.

(2) TONE DEV

This trimmer potentiometer adjusts the deviation of the 88.5-Hz subaudible tone transmitted (automatically) when operating FM on the 29-MHz band with repeater split activated (with the **RPT** button on the front panel).

Note: This and the following two controls have been preset at the factory to produce the correct deviation with standard microphone levels. A deviation meter should be connected for proper readjustment, as it is difficult to determine the proper setting by ear.

(3) FM DEV

This trimmer potentiometer adjusts the maximum deviation of transmitted FM audio. See the caution note above.

(4) FM MIC GAIN

For FM transmission, this control adjusts the microphone gain. More clockwise settings produce greater deviation, and may cause distortion if set too high. Readjustment should not be necessary unless you are using an unusual microphone.

(5) ANTI-TRIP

This control sets the level of negative feedback of receiver audio to the microphone, to prevent receiver audio from keying the transmitter (via the microphone) during VOX operation. Adjustment is described in the *Operation* chapter.

(6) VOX GAIN

This control sets the gain of the VOX (voice-actuated transmit/receive switching) circuit, which determines the level of microphone audio needed to activate the transmitter during voice operation while the **VOX** button on the front panel is depressed.

(7) VOX DELAY

This control sets the hang time of the VOX circuit, between the moment you stop speaking (or open the CW key during semi break-in operation) and the automatic switch from transmit back to receive (during VOX operation). Adjust for smooth VOX or semi break-in operation (so the receiver is activated only when you want to listen).

(8) PKT, CW PITCH & RTTY DIP Switches

Switches 2 and 3 near the rear of this switch block select the offset of the display and IF passband center from the carrier, to match most common packet tncs used for 300-baud hf packet operation. Determine which AFSK tones are used by your tnc, and then set the switches to match as shown below.

Packet FSK Tone Pairs

DIP Switches	TNC Tone Pair (Hz)			
	1070/1270	1600/1800	2025/2225	2110/2310
2	Off	On	Off	On
3	Off	Off	On	On

Switches 4 and 5 select your desired CW tone pitch, as shown below. The transmitter sidetone frequency, and receiver IF passband and display offset from the carrier frequency are all affected.

CW Pitch Switches

DIP Switches	CW Pitch (Hz)			
	700	600	500	400
4	Off	On	Off	On
5	Off	Off	On	On

The remaining switches in this switch block select the function of the internal AFSK generator for RTTY transmission. Switches 6 and 7 select the RTTY shift, and switch 8 selects either a 2125- or 1275-Hz low tone. See the table below.

RTTY DIP Settings

DIP Switches	AFSK Shift		
	170	425	850
6	Off	Off	On
7	Off	On	Off
AFSK Low Tone Frequency (Hz)			
8	Off= 2125	On=1275	

(9) **CAR POINT** Mini Rotary Selectors

These two 16-step rotary selectors adjust the carrier insertion point for USB and LSB modes

(only). Each selector step is 20 Hz. The normal carrier point setting is 1500 Hz offset from the (suppressed) carrier frequency, which centers transmit and receive audio in the IF passband. However, the IF passband can be shifted: for the receiver with the **SHIFT** control, and for SSB transmission (with FSP on) as described on page 31.

Note: before adjusting either of the SSB Carrier Point selectors, make note of the current setting so that you can return to it later if you have trouble with your adjustment.

(10) **BACKUP** Slide Switch

Keep this switch in the **ON** position to retain all memory and vfo settings during power-off periods. There is no need to turn this switch off unless you plan to store the transceiver for a long period without power.

Power Up Selections

By pressing and holding certain keys or buttons while switching on the FT-990, you can perform several functions and make some simple settings. Most of these are described in the Operation chapter, under the function to which they apply. The remaining power-up functions are described here.

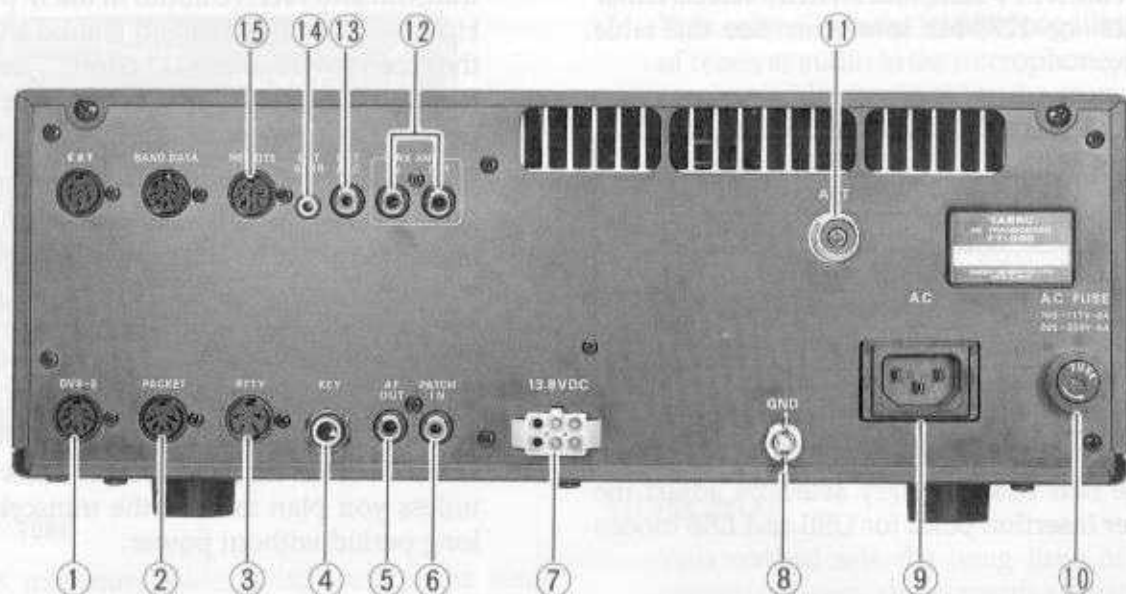
To reset the microprocessors and clear all memories, turn the transceiver off, and then press and hold the **GEN** and **ENT** keys at the lower corners of the keypad while also pressing the **POWER** switch. Normally there should be no need to do this, but it is provided for servicing purposes, to return all memories and other settings to their default states. Note that *any power-on settings are also reset to their defaults*. It is not necessary to turn off the memory backup to reset the microprocessors.

To perform the "Las Vegas" diagnostic test of the display and its microprocessor, and to check the ROM version of your transceiver, press and hold the 1.5 and 7 MHz band keys (yellow-labelled 1 and 3 keys) at the upper corners of the keypad while switching the power on. This procedure will not erase any memorized data. After testing the display segments, "YAESU" will be displayed, followed by a ROM version number. After a few seconds, the display will return to normal operation.

Pressing the 29 MHz band key (yellow-labelled 0 key) while switching on the power causes the 10-Hz digit on the main and sub vfo displays to be blanked. Repeat the same step to unblank it.

Pressing the 10, 14 and 18 MHz band keys (yellow-labelled 4, 5 and 6 keys) simultaneously while switching the power on toggles the manner in which the displayed frequency is affected when changing modes. In its default state, switching to and from CW, packet or RTTY modes causes the display to change by the amount of offset selected by the **CW PITCH** and **PKT/RTTY** DIP switches in the top access panel. After holding these keys while switching power on, the display will continue showing the same frequency when changing to and from these modes. However, the actual BFO (carrier) offsets, set by the DIP switches, relative to the display and IF bandpass are unaffected, regardless of either display state.

Rear Panel



(1) DVS-2 DIN Jack

This 7-pin input/output jack is for connection of the DVS-2 Digital Voice Recording option, described on page 36.

(2) PACKET DIN Jack

This 5-pin input/output jack provides receiver audio and squelch signals, and accepts transmit (AFSK) audio and PTT control, from an external packet tnc. Pinout is shown on page 7. The receiver audio level at this jack is at a constant 100-mV level (@600Ω), preset by VR3005 on the AF Unit (see *Internal Adjustments* page 11 for how to gain access to this trimmer, if necessary).

(3) RTTY DIN Jack

This 4-pin input/output jack provides connections for an RTTY terminal unit. Pinout is shown on page 7. The receiver audio level at this jack is at a constant 100-mV (@600 Ω) level, preset by VR3006 on the AF Unit (see *Internal Adjustments* page 11 for how to gain access to this trimmer).

(4) KEY 3-Contact Phone Jack

This 1/4-inch phone jack accepts a CW key or paddle manipulator. It is connected in parallel with the jack with the same name on the front panel (either or both may be used). A 2-contact plug cannot be used in this jack. Keyup voltage is

+5 V, and keydown current is 0.5 mA. Pinout is shown on page 7.

(5) AF OUT Phono Jack

This output jack provides low level receiver output, for recording or external amplification. Peak signal level is 100 mVrms at 600 Ω. The front panel AF control does *not* affect the signal at this jack, but the **DIGITAL FIL** controls do. Pinout is shown on page 7, and level adjustment is described on page 11.

(6) PATCH IN Phono Jack

This input jack accepts transmitter audio – either AFSK or voice, for transmission. This line is mixed with the microphone audio input line, so the microphone should be disconnected if using this jack and mixing is not desired. Impedance is 500 – 600 Ω, and optimum peak input level is 2 mVrms.

(7) 13.8 VDC Supply Jack

This 6-pin molex socket accepts DC to power the transceiver. If the FP-25 AC supply is installed, it can be used when AC is not available. See page 46 for details.

(8) GND Terminal Post

Connect this terminal to a good earth ground, for safety and optimum performance. Use a large diameter, short braided cable.

(9) AC Line Cord Socket

Connect the supplied AC line cord to this socket after ensuring that your AC mains voltage is within the range on the label. See the *Installation* section for instructions on how to change the AC power supply voltage range, if necessary.

(10) FUSE Holder

This holder requires a 8-A fuse for operation from AC voltages below 125 V, and a 4-A fuse for AC voltages of 200 V and above. Only normal fast-blow type fuses should be used here.

(11) ANT Coaxial Jack

Connect your main antenna here, using a type-M (UHF, PL-259) plug and coaxial feedline. This antenna is always used for transmission, and is also used for reception unless a separate receive antenna is connected and selected from the front panel. The internal antenna tuner affects *only* the antenna connected here, during transmission.

(12) RX ANT IN/OUT Phono Jacks

Both of these jacks have no connection unless the **RX ANT** switch on the front panel is pressed. The **OUT** jack connects through the **RX ANT** switch to the receive side of the main antenna T/R relay, which is closed while receiving. The **IN** jack connects through the **RX ANT** switch to the receiver front end. See the box on page 27. These jacks provide you with several receiver front end options. You can connect a receive-only antenna to the **IN** jack and use the main antenna jack for a transmit-only antenna, or you can connect an external receiver to the **OUT** jack to function in place of the FT-990's receiver, or you can connect a receiver preamplifier or bandpass filter between these two jacks to affect reception on the main antenna (when the **RX ANT** switch is closed).

(13) EXT ALC Phono Jack

This input jack accepts external ALC (Automatic Level Control) voltage from a linear amplifier, to prevent over-excitation by the transceiver. Usable input voltage range is 0 to -4 VDC.

(14) EXT SPKR Mini Phone Jack

This 2-contact output jack provides receiver audio for an external loudspeaker, such as the

SP-6. Inserting a plug into this jack disables the internal loudspeaker. Impedance is 4 to 16 Ω .

(15) REMOTE DIN Jack

This 8-pin input/output jack provides connections to internal relay contacts and control inputs for transmit/receive switching of an external device such as a linear amplifier (other than the FL-7000). Pin 1 is connected together with the **EXT ALC** jack, and pins 3 and 8 connect to chassis ground.

Pin 6 may be used to control manual transmitter activation using a footswitch or other switching device. Its function is identical to the **MOX** button on the front panel (short pin 6 to pin 3 or pin 8 to transmit). The same line is available at the **PACKET** and **RTTY** jacks for tnc/tu control. Open-circuit voltage is +13.5 VDC, and closed-circuit current is 1.5 mA.

Pin 7 provides +13.5 VDC at up to 200mA for powering an external device. However, this line is not fused, so *shorting this pin to ground or drawing more than 200mA can seriously damage the transceiver.*

Pins 2 and 5 are connected together through the contacts of a disabled relay inside the FT-990. Pin 4 is connected to the collector of a transistor, which is off (high impedance to ground) on receive, and on (low impedance to ground) on transmit. The relay connected to pins 2 and 5 is normally disabled to provide maximum t/r switching speed and minimum noise. However, by setting internal switch S6801 to its RY position, the functions of these three pins change so that the transistor that was switching pin 4 now controls the relay at pins 2 and 5, and pin 4 now connects to the closed-on-transmit contact of the relay (pin 5 is common, and pin 2 is closed-on-receive: see the diagram on page 9).

With switch S6801 in its factory default (TR) position, the maximum current that pin 4 can sink is 500 mA, at up to 50 V (*positive DC only!*).

If you are connecting an amplifier that requires higher current or voltage to switch, or uses AC voltage for t/r switching, you can move switch S6801 to the RY position, in which case the internal relay contacts (via pins 2, 4 and 5) will be able to handle up to 500 mA @ 125 VAC, 300 mA @ 220 VDC or 2 A @ 30 VDC. *Before connecting an external device, make sure its switching requirements will not exceed these limits.*

(16) BAND DATA DIN Jack

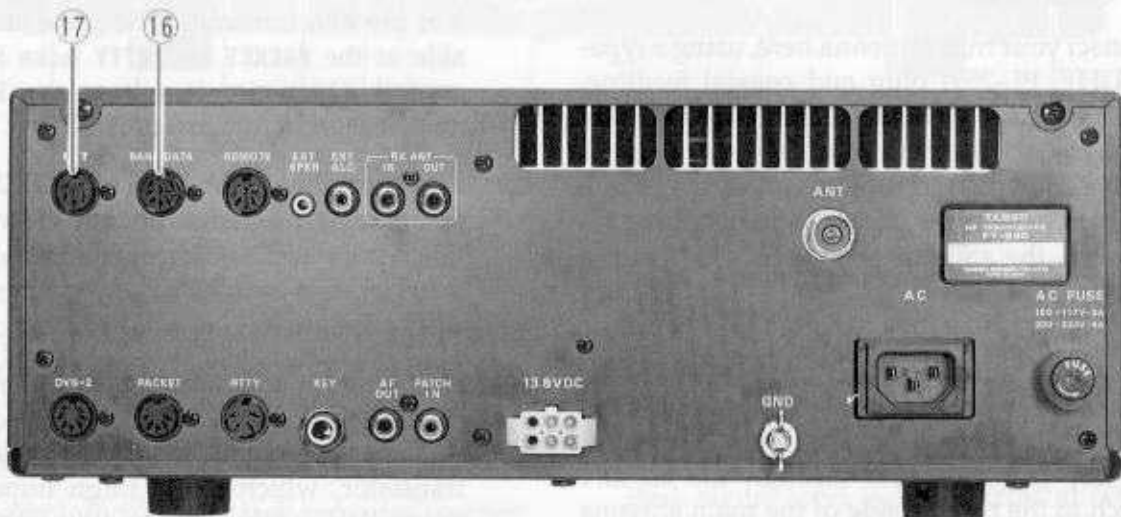
This 8-pin output jack provides control signals for the FL-7000 Solid-State Linear Amplifier or FC-1000 Remote Controlled Tower Mounting Antenna Tuner, including band selection data to automatically set the Linear or Tuner to the same band as the main display of the transceiver. Pinout is shown on page 7.

Note: this jack includes a switch which is opened by inserting a plug. When no plug is inserted, pin 8 is pulled low to enable the transmitter. Inserting a plug caused pin 8 to be biased high, disabling the transmitter

unless the plug includes connections to pull pin 8 low. This allows the FL-7000 to operate QSK safely. We do not recommend using this jack for any purpose other than connecting the FL-7000 or FC-1000.

(17) CAT DIN Jack

This 6-pin input/output jack allows external computer control of the FT-990. Signal levels are TTL (0 and 5-V DC). Pinout is shown on page 7, and the signalling protocol and data formats are described in the CAT chapter, starting on page 40.



Operation

Getting Started Tutorial

Before plugging in the transceiver the first time, double check your installation to make sure your AC voltage is correct, and that your ground and antenna are connected as described in the *Installation* chapter. Then preset the following controls as indicated:

POWER, RX ANT, MOX, VOX & ATT switches: off (■)

AGC Selector to **AUTO**

MIC, RF PWR, PROC, KEYER, SQL and **NB** all counter-clockwise

AF 10 o'clock

RF fully clockwise

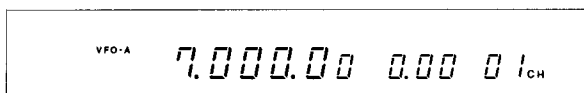
SHIFT 12 o'clock

RF FSP, KEYER, BK-IN & SPOT switches all off (■)

Connect your microphone and/or CW key or paddles, and then plug in the AC cord.

Press the **POWER** switch on. The meter and display should light up. If the display is too bright or dim for your environment, press and hold the **FAST** button below the tuning knob while turning the **CLAR** control to adjust display brightness.

Take a moment to study the display. You should see **VFO-A** or **VFO-B** at the left, with the operating frequency just above the tuning knob. To the right of that is the clarifier offset ("0.00"), followed by a memory channel number ("01CH" by default) at the far right.



Press a keypad key (to the right of the tuning knob) to select a band for which your antenna is designed. Refer to the white labels (representing MHz), and press the appropriate one.

1.5	3.5	7
10	14	18
21	24.5	28
GEN	29	ENT

Next press the mode button (to the left of the tuning knob) corresponding to the mode you wish to operate — for now, we suggest an SSB mode: **USB** if you have selected a band above 10 MHz, or **LSB** otherwise. The LED in the band button indicates the selected band, and an LED above one of the four **BANDWIDTH** buttons (above the keypad) indicates which IF bandwidth is currently selected for that mode (except in AM-

wide and FM modes). Right now, if you have selected an SSB mode, the **2.4K** LED should be lit. If not, press that button. This bandwidth provides the best fidelity for SSB reception, so should be used unless interference from stations on adjacent frequencies becomes a problem (described later).

Adjust the **AF** control for comfortable volume on signals or noise in the loudspeaker or headphones. Press the **UP** and **DOWN** buttons below the keypad to step around the band in 100-Hz steps, and then tune around the band a bit with the tuning knob. For faster (×10) tuning steps with either the tuning knob or **UP** and **DOWN** buttons, press the **FAST** button at the lower left side of the knob, to enable the "FAST" indicator above the MHz digits on the display.

Fast tuning normally requires that you hold this button down while tuning, but if you hold the button while switching the transceiver on, the button will become a toggle (press on, and press off). All available standard tuning steps in each mode

Tuning Steps

Control ↓	Mode ⇒	LSB, USB, CW, RTTY, PKT-LSB	AM, FM, PKT-FM
Tuning knob, Mic Up/Down Keys	Normal	10 Hz	100 Hz
	w/FAST button	100 Hz	1 kHz
DOWN/UP Pushbuttons	Normal	100 kHz	100 kHz
	w/FAST button	1 MHz	1 MHz
One rev of Tuning knob	Normal	10 kHz	100 kHz
	w/FAST button	100 kHz	1 MHz

Tuning rate can be doubled for any mode by installing an internal jumper (page 12) for that mode.

are shown in the table below. If your microphone has **UP** and **DWN** buttons, you can press them to tune in 10-Hz steps, and if it has a **FAST** button, you can use it to duplicate the function of the key with the same name on the front panel.

Keypad Frequency Entry

One other important tuning feature to try before going on is numeric keypad frequency entry. To do this, pick a new operating frequency, say, 14.25000 MHz, and enter it on the keypad as follows:

Press the **ENT** key at the lower right corner of the keypad (the leftmost operating frequency digit will blink). Then referring to the yellow numbers on the keypad, enter the digits of the new frequency, from left to right (1 - 4 - 2 - 5



- 0 - 0 - 0), followed by the **ENT** key again. As you enter the numbers, the next digit to be entered will blink on the display. You can use the **DOWN** and **UP** buttons below the keypad to reposition the blinking digit location as desired (but in this case, ignore the direction labels on these buttons).

The operating frequency actually changes only when you press the **ENT** key the second time, so if you decide to remain on the original frequency after starting to key in a new one, you can cancel any entered digits by pressing the **CE** key ("Clear Entry", the yellow label at the lower left corner of the keypad) instead of the **ENT** key. Note that, to enter frequencies below 10 MHz, you must key in the leading zero(s).

That's all there is to tuning. You can use the same procedures on either vfo (A or B), and on any memory, as described later. First, however, let's look at some other important receiver features.

General Coverage Reception

You may have already noticed that when you tune outside one of the amateur bands (actually, outside of the 500-kHz segment that includes each band), "**GEN**" appears in a box at the left side of the display. On such frequencies, the transmitter (and antenna tuner) are disabled. If you try to transmit, the **TRANSMIT LED** blinks.

Also, such frequencies are ignored by the normal ham band selection keys. If you select a ham band and then tune to a frequency outside of that band, the non-ham frequency will be lost when you switch to another band. When you return to the original band you will find that it has reverted to the (ham-band) frequency it was on when the band was last changed.

The **GEN** key at the lower left corner of the keypad complements the other band keys by serving as a band selection key for general coverage frequencies. This "general coverage band" key can retain only a non-ham band frequency. If you press this key and then tune to a ham band frequency, that ham frequency will be lost when you switch to

Blanking the 10's-of-Hz Digit

If you prefer to have the 10's-of-Hz digit hidden on the frequency displays, you can toggle display of this digit off and on by switching off the transceiver, and holding the 0 key (at the bottom center of the keypad) while switching the transceiver back on. Repeat this process to redisplay the digit. Tuning steps are not affected.

another band. When you later press the **GEN** key again, you will find that it has reverted to the (non-ham band) frequency it was on when the band was last changed.

Don't let the above comments about loosing frequencies worry you: any displayed frequency can always be stored in a memory (as described on page 35) so you can recall it quickly later. Once you become familiar with the memories, you will find this is convenient, as each memory can be tuned just like a vfo, and stored again without having to go through a vfo.

Aside from the above, general coverage reception provides all of the features available on ham frequencies, including interference suppression and digital modes, described on the following pages.

Button Beeper Settings

As shipped from the factory, pressing a button or key on the front panel causes a beep to sound. The volume of the beep is independent of the receiver volume, and can be set as described on page 11 (you need to remove the top cover).

You can also toggle the beeper (to be enabled or disabled) by holding the **CLEAR** button near the top right corner of the front panel while switching the transceiver on.

If you wish to change the pitch of the beeper, hold the **FAST** button (below left of the tuning knob) while pressing the **CLEAR** button. This causes the display to show the beeper frequency in Hz, while double beeps sound. Turning the **CLAR** knob adjusts the beep pitch. When done, press the **CLEAR** button again to return to normal operation.

Dealing with Interference

The FT-990 includes special features to suppress the many types of interference that may be encountered on the hf bands. However, real world conditions are constantly changing, so optimum setting of the controls is somewhat of an art, requiring familiarity with the types of interference and the subtle effects of some of the controls. Therefore the following information should be considered only as general guidelines for typical situations, and a starting point for your own experimentation.

The descriptions of the the controls are arranged in the order that you would usually make them after changing bands. The possible exception to this is if strong pulse noise is present, such as from the "Woodpecker," in which case you may need to activate the noise blanker (described on the next page) before you can make other adjustments.

Front End Attenuation

The FT-990 receiver front end uses a constant-gain, quad push-pull FET amplifier for optimum dynamic performance. However, if very strong signals cause distortion, press the **ATT** button to protect the front end from overload. This reduces the strength of all signals by 20-dB (about 3 S-units), and can make reception more comfortable, important especially in long QSOs.

RF Gain Setting

When tuned to a moderate strength signal, if low level background noise is present, try reducing the **RF** gain control from the fully clockwise position. This reduces the signal input to the first mixer via a PIN diode attenuator and causes the minimum S-meter reading to move up the scale, often clearing up the background noise and putting the desired signal more "in the clear." But don't forget to return this control fully clockwise when you want to receive weak signals, or read low levels on the S-meter. See also the box on AGC off.

Locking the Dial or Buttons

Normally, pressing the **LOCK** button disables only the tuning knob (it still turns, but does nothing). If you wish to have the **LOCK** button also disable the keypad and mode buttons, turn the set off and then press and hold it the **LOCK** button while switching back on.

AGC Off

The **AGC OFF** position disables the overload-protection normally provided by the AGC circuit. If the **RF** gain control is left fully clockwise in this condition, the RF and IF amplifiers can be easily overloaded (causing distortion) when a strong signal is received. Correct the overload either by setting the **AGC** selector to another position, or by turning the **RF** control counterclockwise to manually set receiver gain to a comfortable level.

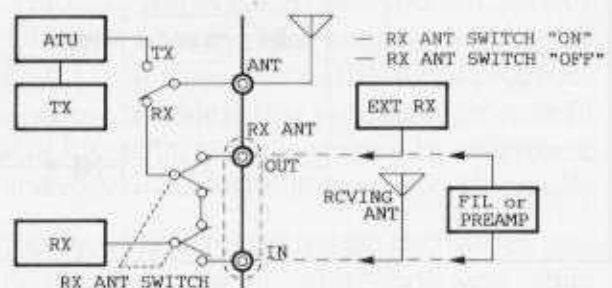
AGC (Automatic Gain Control) Selection

When tuning around the band looking for signals, the **AGC** selector is usually best kept in the **FAST** position, to allow the receiver gain to recover quickly after tuning past strong signals. However, once you have a station tuned in, you can switch to **AUTO** position, which selects a decay rate corresponding to your operating mode: slow for SSB, and fast for other modes. You can change the auto rate for AM to slow, if you prefer, by installing a jumper as shown on page 12.

For weak signal CW reception on a crowded frequency, the **OFF** position can avoid AGC "pumping" (gain fluctuations) caused by strong undesired signals. The **OFF** position also allows the quickest receiver recovery for AMTOR and 300-baud packet, which will usually give the fewest errors/retries.

Receive-Only Antennas & Separate Receivers

The **RX ANT IN** and **OUT** jacks on the rear panel allow use of a receive-only antenna, external receiver, or external preamp or filter for the FT-990 receiver. The diagram below illustrates some of the possible configurations.



Noise Blanker Setting

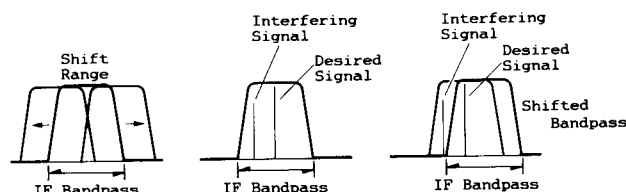
The noise blanker circuit in the FT-990 is designed to blank both wide and narrow pulse noise, and can sometimes also reduce the level of static crashes from electrical storms. The **NB** button activates the blanker. If you hear pulse noise, just press the **NB** button so that the green LED above it lights, and turn the **NB** control clockwise just until the noise is blanked. If the blanker seems to distort a signal you're listening to, reduce the setting for optimum readability.

Bandwidth and IF Shift Adjustment (not used in FM mode)

Once you have tuned in a signal you are going to listen to for a while, if you hear interference from stations on nearby frequencies, use the **BANDWIDTH** buttons, **SHIFT** control and Digital Filter to suppress the interference. Their use varies somewhat from mode to mode. In general, however, you will want to press the **LOCK** button beneath the tuning knob before adjusting the **SHIFT** and Digital Filter controls, as accidentally retuning would invalidate your settings (particularly in narrow-bandwidth modes). When ready to retune to a new frequency, press **LOCK** again to release it, and return the **SHIFT** and Digital Filter controls to their normal positions (centered, and fully CW and CCW, respectively).

In the SSB modes, the optional **2.0K** bandwidth filter can sharply cut interference from unwanted signals on either side of the desired signal (although with some necessary loss of fidelity). The

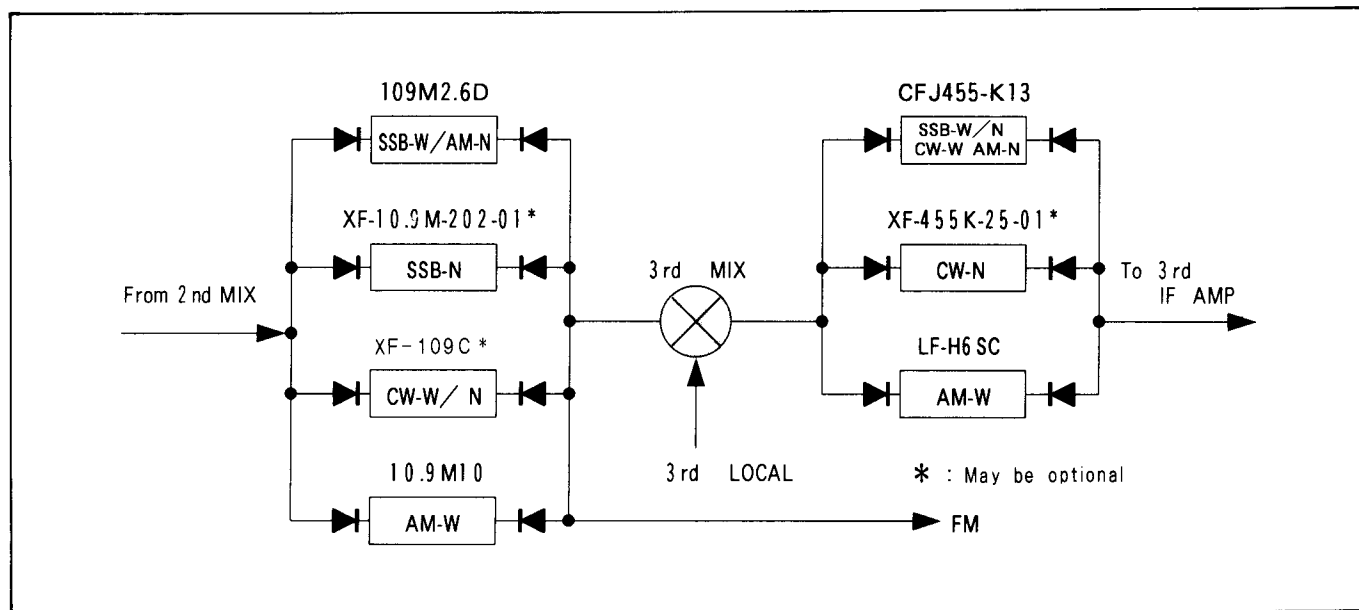
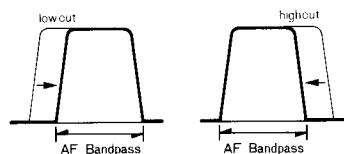
IF Shift Adjustment



SHIFT control can be turned left or right from center to shift the center frequency lower or higher, as depicted above.

In AM mode, if the **BANDWIDTH** LEDs are all off, the 6-kHz AM wide bandwidth is selected. This gives the highest fidelity, and is best on strong AM signals (and particularly music). The **SHIFT** control is disabled in the AM mode, but the Digital Filter controls can be helpful in honing audio characteristics. For weaker AM signals, or where adjacent channel interference is present, the **2.4K** bandwidth offers a compromise between interference rejection and fidelity. Again, you may be able to improve fidelity with the Digital Filter. However,

Digital Filter Adjustment



IF Bandwidth Filter Selections

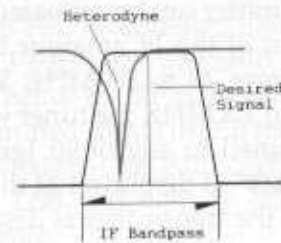
even better reception of AM signals under these conditions can usually be had by switching to an SSB mode (whichever gives the clearest reception). Along with the choice of the best sideband, this gives the potential benefits of the **SHIFT** control.

For RTTY and AMTOR, the wider bandwidth selections are fine for tuning around, but the **250** or **500** (Hz) bandwidths will generally give the best copy with narrow shifts. If you have the top panel **RTTY** DIP switches set to match your tnc/terminal unit (see page 21) you should not need to adjust the **SHIFT** control at all, and the Digital Filter controls should only be adjusted with great care (to avoid losing the contact). See the section on digital modes at the end of this chapter for more details.

For 300-baud packet, use the **500** (Hz) bandwidth, and make sure the **PKT** DIP switches in the top panel are set to match your tnc/terminal unit (or see the section on HF Packet on page 38). The Digital Filter should be off, and the **SHIFT** control may need to be fine tuned very slightly either side of center for optimum copy of weak signals. Experiment with the **SHIFT** setting while receiving on a busy packet channel, and then note the optimum setting for all future hf packet operation (it will be the same unless you replace your tnc or recalibrate the input tones).

For CW, the **2.0K** or **2.4K** bandwidth is often convenient to give "a wide view" of the band when tuning around, but once a signal of interest has

IF Notch Filter Adjustment



been found and centered in the passband, the **500** or **250** (Hz) selections are much better. Then the Digital Filter can be activated, if needed, for even narrower (audio) bandwidth. More details of CW operation are provided in the box below, and in the next section on transmission.

IF Notch Filter (not used in FM mode)

After tuning in a desired signal and adjusting the bandwidth and IF shift, if heterodyne interference is heard, activate the IF notch filter by pressing the **NOTCH** button and adjusting the control with the same name to null the heterodyne. Note that if the interfering heterodyne is more than about 1.2 kHz away from the center of the passband, the notch filter may be unable to null it. In this case, switch the notch filter off, and readjust the IF shift and Digital Filter skirts so that the heterodyne is outside of the passband.

Special Tips for CW Reception: Pitch Setting and Spotting

The FT-990 can be set for 400-, 500-, 600- or 700-Hz CW pitch, by setting the **CW PITCH** DIP switches in the top access panel. With the **CW SPOT** button pressed, set these to the tone you prefer, according to the table on page 20. This selection sets the audio frequency of the spotting heterodyne, which sounds a tone in the receiver when you press the **SPOT** button near the lower right corner of the front panel.

The volume of the CW sidetone (which is what you hear when holding the **SPOT** button and also when your key is closed while sending) is constant, regardless of receiver volume. You can adjust the volume by removing the top cover, as described on page 11. After changing the pitch, the displayed offset will be different after you retune and change modes.

The frequency of this tone is also (exactly) the frequency that the IF center frequency and display will be offset from the true carrier frequency during CW reception, which means that you can use this switch when tuning in another station to zero beat with him, so that when you transmit, your signal will be on exactly the same frequency as his. When you have a station tuned so that his signal produces the same audio note as the spotting oscillator, you will know that his signal is centered in your IF passband, which ensures that you will not lose track of his signal when switching to a narrower filter or activating the Digital Filter. Of course you should release the **SPOT** button to copy his signal.

If you prefer to have the display show your carrier frequency without regard for the pitch offset, you can change the display mode of the FT-990 by holding the 10, 14 and 18 (MHz) band keys while switching the transceiver on. Repeat the same procedure to cancel the change.

Transmitting

The transmitter can be activated within the 500-kHz segment of the hf amateur bands above 1.8 MHz, and from 28 to 30 MHz. When tuned between 1.5 and 1.8 MHz, the tuner will not function, and when tuned to any other (general coverage) frequency, "GEN" is displayed at the left side of the display, and the transmitter is disabled. However, you should restrict your transmissions to those frequencies on which you are authorized to do so, and to those frequencies for which your antenna is designed.

Attempting to transmit when "GEN" is displayed causes the red **TRANSMIT** LED to the right of the meter to blink, indicating the transmitter is inhibited. The transmitter is also temporarily inhibited when stopping memory scanning (described later), as pressing the PTT switch while scanning just causes the scanner to stop.

When the transmitter is activated on an amateur band, the FT-990 automatically detects any reflected power that might appear at the main antenna jack (as a result of an impedance mismatch), and disables the transmitter if too much reflected power is found (in which case the red **HI SWR** LED at the right side of the display will be lit). Although this protection system should prevent any damage to the transceiver, we still recommend that you never activate the transmitter without having a proper antenna connected to the **ANT** jack.

Automatic Antenna Matching

The automatic antenna tuner in the FT-990 makes even first-time transmitter setup very simple. After you have used it once on your favorite bands, it will be able to recall previous settings from memory (the tuner has 39 of its own) during reception, whenever you tune to the same part of the band again. When you use the tuner the first time on an antenna, we recommend you set the **RF PWR** control to around the 9-o'clock position (or 12-o'clock above 24.5 MHz), to minimize interference you might cause others, and also to minimize stress on the tuner, feedline and antenna (in case there is a high SWR). All you have to do beforehand is to make sure the frequency you will transmit on is clear of other signals. If you want to visually monitor the tuner's action, set the **METER** selector to the **SWR** position.

If "SPLIT" is displayed to the left of the frequency, press the **SPLIT** button below the mode buttons to disable split frequency operation for

CAUTION

*If the red **HI SWR** LED lights at any time, the tuner is unable to match your antenna to the transmitter at the displayed frequency. You will have to tune to another frequency, or repair or replace your antenna or feedline.*

now (you can press the **A/B** button to switch vfos, if desired).

After making sure you are on a valid transmitting frequency, and that the channel is clear of other signals, press the **START** button near the upper right corner of the front panel. The green **TUNER** LED will come on, indicating the automatic tuner is activated, and the orange **WAIT** LED at the right end of the display and red **TX** LED at the left end of the display will light for one to about thirty seconds while the tuner seeks the proper matching settings.

*Note: if you attempt to activate the tuner between 1.5 and 1.8 MHz, the LEDs will come on as above, but no power will be transmitted, and the LEDs will not turn off (but transmission does not occur). Press the **TUNER** button to reset the tuner.*

If monitoring SWR on the meter, you should see the tuner select the lowest possible reading. When the **WAIT** LED turns off, you are ready to transmit (assuming the **HI SWR** LED didn't light).

Once you have used the antenna tuner, the green **TUNER** LED will remain on (unless you press the **TUNER** button to switch the tuner off), and the orange **WAIT** LED will occasionally flash when you change frequency (while receiving), indicating that the main microprocessor is reporting the frequency change to the tuner coprocessor (reception is unaffected). The tuner coprocessor compares the current frequency with the frequencies in its own memories, and resets itself to the new range if it has any previously stored settings for that range. However, when you first connect a new antenna, the tuner will not have the correct settings stored in these memories, so you will need to "train" the tuner, by pressing the **START** button whenever you change to a new frequency range (for this antenna).

SSB Transmission

To transmit in LSB or USB mode:

- Make sure the appropriate mode indicator to the left of the tuning knob is lit, and set the **METER** selector to the **ALC** position. This lets you moni-

tor the automatic control voltage, which is negative feedback in the later transmitter stages that prevents overdriving the final amplifier (higher ALC indicates greater reduction of drive level).

- If this is the first time you are transmitting SSB with the FT-990, preset the **MIC** control to about the 12-o'clock position, the **RF PWR** control fully clockwise, and make sure the **VOX** is off (■).
- Confirm that the display shows the frequency you want to transmit on, and make sure the "GEN" box is not displayed to the left of the frequency.
- Listen carefully on the frequency to make sure you will not interfere with any other stations, then press **START** to match the antenna.
- Now press the PTT (push-to-talk) switch on your microphone, and give your callsign (to identify your transmission) or make your call. You should see the meter fluctuate as you speak.

To determine the optimum setting of the **MIC** control for your microphone, adjust it while the **RF PWR** control is fully clockwise. Speak into the microphone (at a normal level) so that the meter deflects no further than midrange on voice peaks (the upper end of the blue ALC range). Once found, this setting can be left as it is for all modes unless you change microphones.

You can switch the **METER** selector to the **PO** position and adjust the **RF PWR** control for more or less output, from about 10 to 100 watts (on the second meter scale from the top), as desired. However, you should always use the lowest possible power output to maintain reliable communications — not only as a courtesy to other stations, but to minimize the possibility of causing RFI and TVI, and to maximize the life of the equipment.

Note: reducing power with the **RF PWR** control causes the ALC voltage to increase, as can be seen when the meter selector is set to the **ALC** position. The meter will then deflect beyond the blue ALC zone. This is normal, and is not an indication that you should readjust the **MIC** or other controls.

RF Speech Processor (FSP)

Once the proper **MIC** control setting has been determined (with full power), you can activate the RF speech processor to increase the average power of your signal. The **RF PWR** setting does not affect speech processor adjustment or the compression meter indication.

- Set the **METER** selector to the **COMP** (speech processor compression) position, and press the **RF FSP**

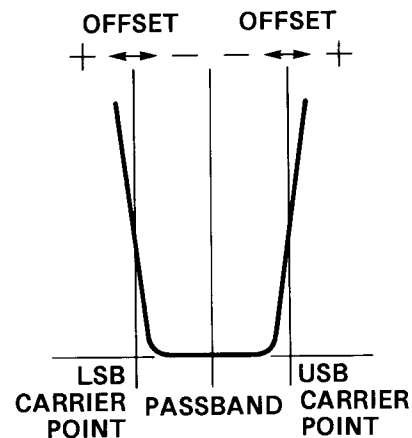
Adjusting Processor Frequency Shift

The unique FSP (Frequency-Shifted Processor) in the FT-990 lets you shift the IF passband (and hence the RF passband as well) of your transmitted signal in SSB modes, to customize your signal for your own voice characteristics. LSB and USB IF offsets are set independently.

To display the current transmitter offset for the selected SSB mode, press and hold both the **FAST** and **RF FSP** buttons. The FSP offset can be set between -0.3 (-300 Hz) and 0.5 ($+500$ Hz) by turning the tuning knob slightly while holding the two buttons. A minus sign indicates the offset is closer to the carrier (low-frequency speech audio emphasized).

Of course you can adjust the offset by trial-and-error on the air, but it is better if you have a separate receiver in which you can hear the effect yourself. Otherwise, we recommend starting with $+100$ Hz offset initially, to add some "crispness" to your processed speech.

To obtain the same result on both USB and LSB, just set them for the same offset display.



button (at the left end of the row of buttons along the bottom) so that its orange LED lights.

- Now while speaking into the microphone, adjust the **PROC** control for a compression level of 5 to 10 dB on the **COMP** scale of the meter (the second scale from the bottom). We do not recommend higher compression settings, as your signal will become less readable.
- If you want to confirm that your **MIC** control setting is correct, set the **RF PWR** control to maximum, move the **METER** selector back to the **ALC** position, and if necessary, adjust the **MIC** control again so that the meter stays in the blue **ALC** scale on voice peaks.

VOX (Voice-Actuated T/R Switching)

VOX operation allows you to activate the transmitter in any voice mode merely by speaking into the microphone, without having to press the PTT.

For the VOX circuit to operate properly, three trimmers in the top access panel must be set to match your microphone and the acoustic environment of your station. Once set, these trimmers should not require readjustment unless you change your microphone or station location.

- First make sure the receiver is set for normal volume on a clear channel, and preset the **VOX GAIN** control in the top access panel fully counterclockwise. Also preset the **ANTI-TRIP** and **DELAY** controls in the top access panel to midrange.
- Set the **RF PWR** control fully CCW (to avoid creating interference while you set up the VOX controls).
- Now press the **VOX** switch near the upper left corner of the front panel to activate VOX.
- Without pressing the PTT switch, speak continuously into the microphone while slowly advancing the **VOX GAIN** control (in the top access panel) clockwise, just until your voice activates the transmitter.
- Now speak intermittently into the microphone, and note the "hang time" between the moment you stop speaking and when the receiver is reactivated. This period should be just long enough so that the transmitter remains keyed between words, but drops back to receive during pauses. Adjust the **DELAY** trimmer, if necessary, for comfortable hang time.

The **ANTI-TRIP** trimmer probably needs no adjustment, but if you find that, with the microphone in its normal operating position, receiver audio from the loudspeaker trips the transmitter, advance the **ANTI-TRIP** control more clockwise. On the other hand, if transmitter keying with the VOX keying seems sluggish or unstable when you speak into the microphone, try a more counterclockwise setting.

Note: if VOX operation is unstable regardless of these adjustments, you may have RF feedback from the antenna or feedline getting back into the transmitter. Make sure your antenna is properly matched, and that your antenna or feedline is not radiating near the transceiver.

CW Transmission

There are several types of CW transmission available with the FT-990. All require, of course,

that you have a CW key or keyer paddles connected to either of the **KEY** jacks on the front or rear panel (with a 3-contact plug). There are no critical adjustments for the transmitter: you just use the **RF PWR** control to set your output power.

- Begin by setting the **METER** selector to the **PO** position. Of course you must select the CW mode, if you haven't already, and for now, make sure the **KEYER** and **BK-IN** switches near the lower right corner of the front panel are both off (■).
- Press the **VOX** button to turn on the VOX circuit, which in CW mode provides automatic transmitter activation when you close your key.
- Now close your key, and listen to the CW sidetone volume. This is adjustable independently of receiver volume, by an internal trimmer as described on page 11.
- Now you can adjust the **RF PWR** control for the desired power output. Note that if you select a low level and set the **METER** selector to **ALC**, the meter reading will deflect beyond the the ALC zone. This is perfectly normal, and will not degrade your signal.
- Release the key to return to receive.

Courtesy of the VOX circuitry, you are now using semi break-in CW, in which the transmitter remains activated except during pauses in your sending. You can set the "hang time" during which the transmitter remains on after you stop sending, by adjusting the **DELAY** trimmer in the top panel.

However, if you prefer full break-in (QSK) operation, in which the receiver is activated between each dot and dash, simply press the **BK-IN** switch near the lower left.

Using the Internal Electronic Keyer

You will need to connect keyer paddles to one of the **KEY** jacks to use the keyer.

- Once the transceiver has been set up for CW transmission as just described, you can activate the keyer with the **KEYER** pushbutton near the lower left corner of the front panel (its green LED should light).
- Now squeeze the paddles, and adjust the **KEYER** control for the desired speed (if you are using the bug simulator mode, described in the box on the next page, don't squeeze both paddles: just press the dit paddle).

If the dot:dash weighting is not to your preference, see page 11 to set the internal **WEIGHT** DIP switches. If you prefer a higher or lower sidetone pitch, see page 29 and the Pitch table on page 20.

Bug Simulation with the Internal Keyer

The internal CW speed keyer is set at the factory to the iambic keying mode, in which one keyer paddle produces dits, and the other dahs. Squeezing both gives alternating dits and dahs.

If you prefer bug operation, in which one paddle produces dits and the other is used to manually produce dahs (like a straight key), you can change the position of an internal switch, as described on page 11.

The keyer works for both semi and full break-in keying, as described in the previous section.

AM Transmission

Transmitter power output in the AM mode is limited to 25 watts (carrier). All you need to do is to adjust the **MIC** control to avoid overmodulating, and select the desired power level.

- With the **AM** mode selected, set the meter selector to the **PO** position, and preset the **RF PWR** control fully clockwise.
- Even if you have already set the **MIC** control as described for SSB transmission, you will need to readjust it to avoid overmodulation.
- VOX operation can be used in the AM mode, but for now, make sure the **VOX** switch is off, so as not to confuse adjustments.
- Close the PTT switch and speak into the microphone while adjusting the **MIC** control to the point where very slight movement of the (PO) meter can be seen. Don't set it too far beyond this point or your signal will become distorted.
- Adjust the **RF PWR** control for the desired output. The speech processor is disabled in AM mode.

FM Transmission

For FM transmission, the only control on the front panel you need be concerned about is **RF PWR**. Microphone gain for FM is set the separate **FM MIC GAIN** control in the top panel, and normally needs no adjustment after leaving the factory. If you receive signals reports of low audio with a strong carrier, you may want to increase the gain, or if you receive reports of distortion, you may want to decrease it. Otherwise, we suggest leaving it alone.

All you need to do is set the **METER** selector to the **PO** position, and adjust the **RF PWR** control for the desired output while transmitting. If you need full

power, keep your transmissions to three minutes or less, with the same time for reception.

You can use the VOX circuit for t/r switching, if desired. See also the *FM Repeater Operation* box.

Clarifier (Rx/Tx Offset Tuning)

The three **CLAR** buttons near the upper right corner of the panel and the **CLAR** knob are used to offset either the receive, transmit or both frequencies from their settings on the frequency display. The three small numbers on the display just to the right of the frequency show the current clarifier offset. The clarifier controls on the FT-990 are designed to allow you to preset an offset (up to 9.99 kHz) without actually retuning, and then to activate it with the clarifier's **RX** and **TX** buttons.

Perform the following steps, if you like, to familiarize yourself with the clarifier controls:

- Turn the **CLAR** knob back and forth while watching the center of the display. Notice that a minus sign appears when the offset is negative.

FM Repeater Operation

The FT-990 includes several features specifically intended for operation on FM repeaters above 29 MHz which use 100-kHz splits.

To locate these repeaters, you can ask around the calling channel (29.6 MHz), or you may want to load a block of memory channels (page 35) with 20-kHz frequency multiples from 29.62 to 29.68 MHz (and FM mode, of course). Then set the squelch so that the receiver is silent on a clear channel, and press **M SCAN** to scan the memories.

When you find a repeater, press the **RPT** button, once for "-" shift (to transmit 100 kHz below your receiving frequency). Pressing it again will select "+" shift, but this is not used above 29.6 MHz. Press it once more to return to simplex.

Try a quick ID transmission to make sure you have the shift right (the FT-990 also automatically transmits a low-level 88.5-Hz subaudible tone during FM Repeater transmissions, to access those repeater that require it).

Once you have made contact through the repeater, you can store the frequency, mode and repeater shift settings in memory (page 35) for later recall.

- Now, with a non-zero offset displayed, press the **RX** button several times while watching the display. When the clarifier is activated, "**RX CLAR**" appears near the top center of the display, and the main frequency display shifts by the amount displayed for the clarifier offset.
- Press the PTT switch and notice that the transmit frequency remains the same as the original (that is, non-offset) frequency display when the receive clarifier is on.
- With the receive clarifier active, turn the **CLAR** knob again, and notice that both the main frequency and the clarifier offset displays change together.
- Now press the clarifier **CLEAR** key and observe that the offset is cleared to zero, and the vfo frequency returns to what it was originally.

The transmit clarifier works almost the same way as the receive clarifier, by pressing the clarifier **TX** button. "**TX CLAR**" appears near the top center of the display when active. The offset is added to the displayed operating frequency, however, only when you transmit.

A typical application for the clarifier is when you are in contact with a station whose transmitter drifts (or perhaps you didn't have him quite tuned in when you called him). You don't want to change your transmitting frequency, as that would force him to retune — you just want to adjust your receiver. You could proceed as follows while listening to his signal:

- Press the clarifier **CLEAR** button if the displayed clarifier offset is not zero.
- Then press the clarifier **RX** button to activate the receiver clarifier, and carefully retune his signal with the **CLAR** knob.

After you finish your conversation with him, you must remember to press the clarifier **RX** button again to turn off the clarifier. However, if you hear another station you want to call right on the frequency he was on, instead of turning off the clarifier, you can just press the **TX** clarifier button to bring your transmitter onto the same frequency, and make your call (now both the receive and transmit frequencies are offset by the displayed amount). Keep in mind, however, that you will need to press both the **RX** and **TX** clarifier buttons again to turn off the clarifier when you finish. You might also want to clear the offset when done.

The FT-990 actually has an independent clarifier for each vfo, on every band, plus one on each of the 90 memories. This means that clarifier TX/RX and offset settings are not carried over

when you change bands or memory channels, but rather are stored until you return to that vfo, band, or memory again.

Vfo B & Split Frequency Operation

As already mentioned, vfo B works exactly like vfo A, although each is totally independent of the other. You can use vfo B as a general-purpose "instant recall" memory, although its primary purpose is to facilitate split-frequency operation: receiving on one vfo (or a memory channel), and transmitting on the other vfo. The special case of FM repeater operation uses some features of its own, and is described in the box on page 33. Also, if the difference in transmit and receive frequencies is less than 10 kHz, and transmit and receive modes are the same, using the clarifier functions, just described, is likely to be the easiest approach.

The four buttons along the bottom of the panel below the mode buttons are provided to facilitate setting up the two vfos:

- A/B** (below the volume control) lets you switch between vfo A and B, without affecting the contents of either.
- A=B** copies the contents of the currently displayed vfo (A or B) to the other (B or A, respectively), overwriting the contents of the non-displayed vfo.
- SPLIT** (below the mode buttons) activates the "hidden" vfo for transmission. Note that activating split operation with a memory recalled uses the last-used vfo for transmission.
- M→VFO** copies the contents of a memory into the displayed (or last selected) vfo (by pressing it for ½-second). This also overwrites the vfo.

Before activating split operation, you need to load the vfos with the desired transmit and receive frequencies and modes. You can set up either vfo manually (with the mode buttons, band keys and tuning controls), or you can copy the contents of previously-stored memories. If you plan to use the two vfos for split operation, you can check your transmit frequency by pressing **A/B**. Similarly, if you plan to use a memory as the receive frequency in split operation, you can press **VFO/M** to check your transmit frequency. In either case, press the same button again to return to the split setup.

To activate split receive/transmit operation, just press the **SPLIT** button. "**SPLIT**" appears in a box at the left edge of the display.

If you are using a separate receive-only antenna, also press the **RX ANT** button.

Memory Features

Memory Channel Storage

The 90 memories in the FT-990 each store frequency, mode, filter selection and clarifier settings copied from the frequency display into the current memory channel (displayed at the right). Just press and hold the **VFO**→**M** button for ½-second. The data to be copied from the display may be either in a vfo or in a memory that has been retuned.

Example: to store 14.25 MHz in memory 10.

- First tune the display to the desired frequency. To do this with the keypad (as just one of several ways), press **ENT** and then the keys with the (yellow) numbers **1 4 2 5 0 0 0**, followed by **ENT** once more. Also select the desired mode and **BANDWIDTH** filter.
- Next press the **VFO**→**M** button momentarily, and turn the **MEM** knob until "**10CH**" is displayed (to select the channel number to store). The display will be blank on memories not already stored.
- Now press and hold the **VFO**→**M** button for ½-second. Two beeps sound from the key beeper (confirming that the memory has been stored).

If you have the clarifier set for some offset, and either receive or transmit clarifier functions activated, these settings are also stored in the memory.

Checking Stored Memories

One memory channel number is displayed at all times (in front of the "**CH**" at the right end of the display). You can change the selected channel number by turning the **MEM** knob.

If you rotate this knob while receiving on a vfo or a retuned memory, "**M CK**" will appear blinking above the channel number, and the mode and frequency previously stored in the selected channel, if any, will be displayed in place of the operating data, until a few seconds after you stop turning the knob. Try that now.

You can also view memory frequencies and modes by pressing the **M CK** button beneath the tuning knob, in which case memory channel data (and "**M CK**", non-blinking) will be displayed until you press **M CK** again to return the display to the operating frequency. Of course, if nothing has been stored in a memory, you will not see any frequency or mode displayed — just the decimal points in place of the frequency and clarifier offset display.

Also, after recalling a memory to the display (described next), as long as you haven't retuned it, you can view the other memories by turning the

MEM knob. In this case reception shifts to each memory as it is displayed.

Memory Channel Operation/Recall

To recall data stored in a memory channel for operation, you can either copy it into a vfo, or you can switch operation from the vfo to the memories.

The **M**→**VFO** button below and to the left of the tuning knob can be used to copy the current memory channel data into the current (or last-used) vfo, by pressing and holding this button for ½-second. Pressing it only momentarily shows you the contents of the memory, without actually overwriting the vfo data. Otherwise, when you press and hold this button, the previous contents of the vfo are lost, and if you were receiving on the vfo, operation will shift to the memory frequency/mode.

In most situations you may find it more convenient to simply switch operation from the vfo to the memory, by pressing the **VFO/M** button below the **MEM** knob. This method allows you to leave any settings in the vfos undisturbed, so you can instantly recall them just by pressing **VFO/M** again.

When actually operating on a memory, "**MEM**" is displayed at the left (instead of "**VFO-A**" or "**VFO-B**"), and you can rotate the **MEM** knob to select any previously-stored memory for operation.

If you change frequency, mode, filter or clarifier settings while operating on a memory, "**MEM**" on the display is replaced with "**M TUNE**" (but see the box below). This makes each memory just as flexible as a vfo. If you want to save any changes you have made to a memory channel, just rotate the **MEM** knob (if you want to store the new settings into another channel), and press **VFO**→**M** for ½-second until the double beep sounds. The labelling of the **VFO**→**M** button is somewhat deceptive: the settings of the vfos, which are hidden at this point, are not actu-

Clarifying Memories, and **M TUNE**

As shipped from the factory, the FT-990 will automatically activate the "**M TUNE**" indicator if the clarifier is activated while receiving on a memory. If you prefer to have the memory stay in the normal memory mode in this situation, press and hold the 24.5 (MHz) band key while switching the set on. Repeat the same procedure to cancel the change.

ally involved in this operation at all, since those of the recalled memory have taken their place.

If you just want to cancel any changes you have made to a recalled memory, press **VFO/M** once ("MEM" will be displayed again), and press it again if you want to return to the vfo.

Split operation can be activated while operating on a memory, in which case the last-used vfo will be used for transmission. Similarly, pressing the **A/B** button while receiving on a memory switches operation between that memory and the vfo that was used last.

Note that pressing **A/B** while receiving on a memory allows you to retune the resulting vfo frequency, mode and clarifier settings only temporarily. When you later exit the memories and return to regular vfo operation, the changes are lost.

Memory Scanning

You can scan stored memories by pressing the **M SCAN** key at the upper right corner. However, for this to work, you must first adjust the **SQL** control so that the receiver is silenced (**BUSY LED** right of the meter off). During memory scanning, the scanner pauses on any channel having a signal strong enough to open the squelch, during which the two decimal points in the frequency display will blink. Scanning resumes a few seconds after the signal disappears on the channel, so you may need to readjust the **SQL** control to keep the scanner from stopping on only background noise.

To stop scanning press the **PTT** switch (no transmission will occur), or the **M SCAN** button again.

Note that the **ATT** switch and **RF** gain settings also affect the squelch threshold.

Memory Scan Skip

Once you have stored a lot of memories, you probably won't want to scan every one of them. You can mark some of them to be skipped during scanning. To do this, recall the channel to be skipped, and press and hold the **FAST** button below the left side of the tuning knob while also pressing **M SCAN** momentarily.

By default, when a memory is first stored, it is set to be included in scanning ("SCAN" is displayed above the channel number). When you set the memory to be skipped, this indicator disappears from the display. If you have set a memory to be skipped, and later want to include it, just repeat the same **FAST + M SCAN** procedure.

Memory Blanking

After storing many memories, you may want to completely hide some from normal operation, to simplify selection of the others. To blank a displayed memory, while "MEM" is displayed at the left of the frequency, press and hold the **VFO-M** button for 1/2-second until the double beep sounds (this won't work if "M TUNE" is displayed – if you have retuned the memory, either store it again, or cancel changes by pressing **VFO/M** once). Note: memory number 1 cannot be blanked.

As long as you don't overwrite a blanked memory, you can unblank it simply by repeating the same procedure you used to blank it.

Optional DVS-2 Digital Voice Recorder

The DVS-2 is a digital recorder designed especially for voice contesting and DXing. The FT-990 has a special jack for connection of the DVS-2 on the rear panel. It offers two independent functions: recording received signals for playback later in the loudspeaker/headphone, and recording signals by the microphone for playback later over the air (during transmission). Operating details are provided with the DVS-2, but here is an overview.

Receiver Recording

When used in this mode, the DVS-2 maintains a continuous recording of the last 16 seconds of audio from the main receiver. This can be particularly helpful in picking out callsigns during a pileup, as you can replay the same recording several times with the push of a button.

Transmission Recording

This mode allows the DVS-2 to record either two 8-second segments or four 4-second segments of audio from the microphone, such as contest exchanges or station IDs. Each can then be played back, either in a monitor mode (without transmission), or directly over the air. The 8- and 4-second segments share the same memory, so two 4-second segments can be combined into one 8-second segment. Note that the digital memory used in this mode is independent from that used for receiver recording. If for some reason transmission by the DVS-2 must be disabled, it can be by holding the **RF FSP** button while switching the FT-990 on.

Digital Modes: AMTOR, RTTY & Packet

The FT-990 offers some special features to meet the requirements of digital modes, such as a built-in digitally-synthesized AFSK generator for RTTY and AMTOR transmission, IF bandwidth optimization and automatic display offsets, and a very fast transmit-to-receive turnaround time.

RTTY and AMTOR with a Terminal Unit

Connect your TU to the **RTTY** jack on the rear panel, as shown below. Also, set the three **RTTY** DIP switches and the **RTTY TONE** slide switch in the top access panel for the Mark frequency, shift amount and usual direction you wish to use (see page 21 for the switch settings).

To operate, just press the **RTTY** mode button, once or twice to select the desired sideband for operation (which is normal will depend on your **RTTY TONE** slide switch setting — if you selected **NORM**, LSB will give normal shift). The display shows your actual Mark frequency, but if you prefer to display the (suppressed) carrier frequency, hold the **FAST** button while pressing the **RTTY** mode button to toggle the RTTY display mode.

For optimum signal-to-noise ratio, use the 250-Hz **BANDWIDTH** selection for 170-Hz shift, the 500-Hz selection for AMTOR or 450-Hz shift, or the 2.0-kHz selection for 850-Hz shift.

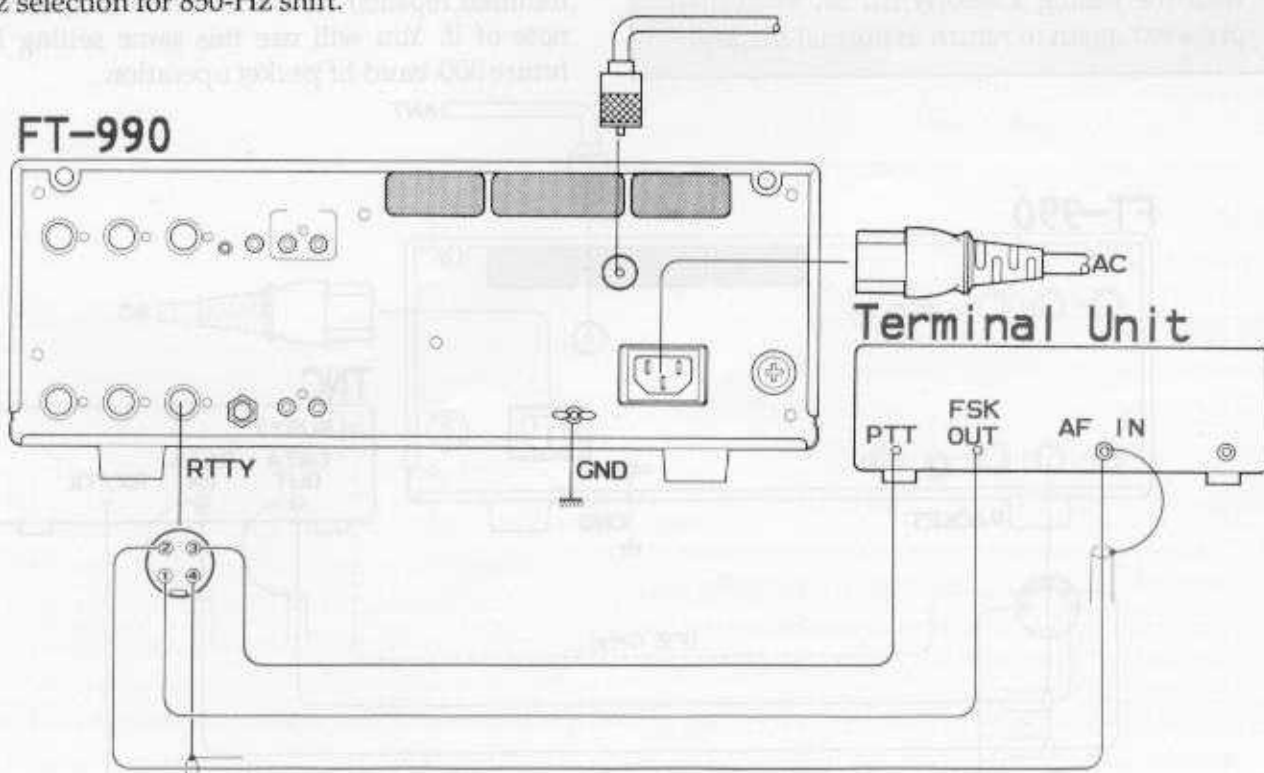
CAUTION

Although the FT-990 cooling system is designed to handle continuous duty transmission at 100 watts output, full key-down output for long periods is not recommended. Especially during hot or humid weather, we recommend reducing power to preserve the life of the components. In any case, during long transmissions, place your hand on the left rear quarter of the top panel occasionally to ensure that it's not getting too hot. The safest approach is to keep power output at 50 watts or less during long transmissions.

Before transmitting the first time, preset the **RF PWR** control to about 12 o'clock, and set the **METER** selector to **ALC**. Key the transmitter (you can use the **MOX** button) and, if necessary adjust RTTY mic gain trimmer potentiometer VR3007 (shown on page 10) for mid-scale indication.

Now you can switch the **METER** selector to **P0** and set the **RF PWR** for the desired power output.

Note that for AMTOR operation, you must have the **VOX** button off (■), and may need to use either **AGC FAST** or **OFF** (and reduced **RF** gain) for mode A (ARQ).



RTTY/AMTOR Terminal Unit Interconnections

300-Baud Packet

Connect your tnc to the **PACKET** jack on the rear panel, as shown on the next page. Do *not* connect the squelch line (pin 5) for 300-baud packet operation.

Tuning is very critical for F1 packet: you should tune the transmitter and receiver within 10 Hz of a signal to minimize repeats. The FT-990 includes a packet frequency display offset feature that allows it to display the center frequency of the two transmitted carriers, without any offset, in accordance with the latest convention. However, for this to work properly, you must set the **PACKET** DIP switches in the top access panel to match the tones generated by your tnc. See the Packet DIP Settings Table on page 20.

Select the 500-Hz **BANDWIDTH** filter for 300-baud packet, and press the **PKT** mode button on the front panel once or twice, so that the green **LSB** LED indicator lights along with the orange **PKT** LED.

Custom Packet Display Offset

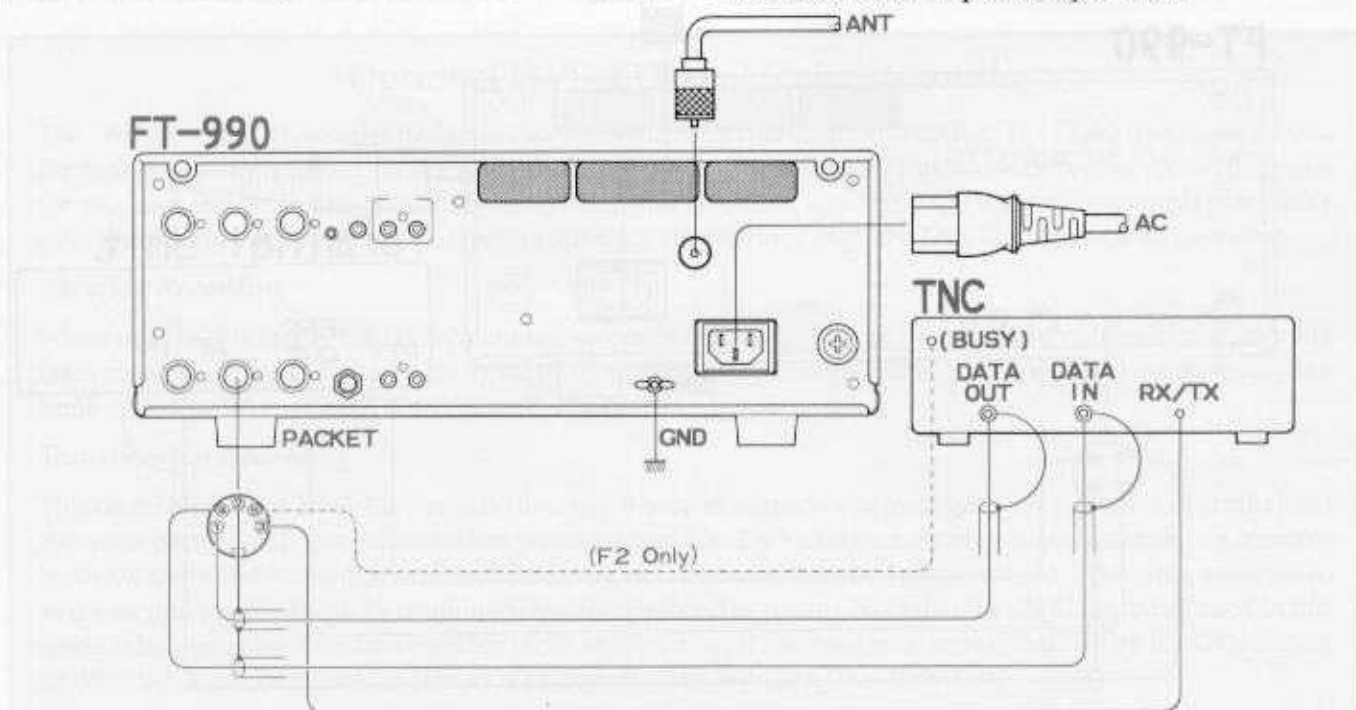
If you prefer to have the display show the suppressed carrier frequency, or some other offset (such as to match a different type of tnc), you can adjust the packet display offset by holding the **FAST** button while pressing the **PKT** mode button. The display will show the current offset (in kHz), and you can change it with the tuning knob. When set as desired, press **PKT** again to return to normal display.

Transmitter adjustment is similar to SSB:

- Preset the **RF PWR** control fully clockwise, and set the **METER** selector to **ALC**.
- Now set your tnc to its "calibrate" mode, preferably with both tones alternating, and adjust the **MIC** control so that the meter deflects to mid-scale.
- Switch the **METER** selector to **PO** and reduce the **RF PWR** control for the desired power output.

When tuning, bear in mind that some common hf packet channels, such as "14.103" MHz, were originally determined to correspond with an actual IF center frequency 1700 Hz lower sideband (in accordance with an old TAPR convention). Therefore, if you have the DIP switches set to match your tnc's actual tones, the display will show 14.101.30 when you are tuned to the above frequency — which is the actual center of your receiver passband, and the frequency mid-way between the two FSK carriers you will transmit. See the box at the left if you want to change this.

Initially, you may need to adjust the receiver IF shift slightly to the right or left to get the 500-Hz IF perfectly centered over incoming signals. Start with the **SHIFT** control centered, and try to establish a connection with a moderately strong signal on a clear channel. If the connection is poor (many repeats), move the **SHIFT** control very slightly to the right, and see if the repeats decline. Continue in this manner until you find a "sweet spot" (with minimal repeats) for the **SHIFT** control, and make note of it. You will use this same setting for all future 300-baud hf packet operation.



Packet TNC Interconnections

1200-Baud FM Packet

The equipment setup for 1200-baud FM packet (above 29 MHz) is the same as for 300-baud packet, except that you may want to connect the squelch line of the tnc to pin 5 of the **PACKET** jack if you plan to use the squelch (performance will be better, however, if your tnc has PLL-type DCD, in which case you can leave the squelch open and not connect pin 5).

Press the **PKT** mode switch until both it and the green LED on the **FM** mode button are lit. Tuning is

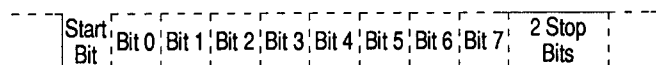
much less critical in this mode, requiring no special adjustments. Also, the **FM MIC GAIN** control in the top access panel has been preset at the factory for proper deviation with typical signal levels, so you should not need to readjust it (you should adjust the tx audio output level of your tnc, though, if you receive reports of distortion).

To transmit FM packet, just set the **METER** selector to **P0** and set the **RF PWR** control for the desired power output.

CAT System Computer Control

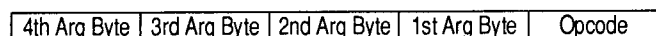
The CAT (Computer Aided Transceiver) System in the FT-990 provides control of frequency, mode, VFO, memory and other settings by the operator's external personal computer. This allows multiple control operations to be fully automated as single keystroke operations on the computer keyboard.

Serial data is passed at TTL levels (0 and +5V) via SO (serial output) and SI (serial input) pins 2 and 3 of the CAT jack on the rear panel of the transceiver at 4800 bits/s. CAT jack pinout is shown on page 7. Each byte sent consists of one start bit, 8 data bits, no parity bit and two stop bits:



One byte, sent left-to-right

All commands sent from the computer to the transceiver consist of blocks of five bytes each, with up to 200 ms between each byte. The last byte sent in each block is the instruction opcode, while the first four bytes of each block are arguments: either parameters for that instruction, or dummy values (required to pad the block out to five bytes):



5-Byte Command Block, sent left-to-right

There are twenty-five instruction opcodes for the FT-990, listed in the table on the next page. Notice that several instructions require no specific parameters. However, every Command Block sent to the transceiver *must* always consist of five bytes.

The CAT control program on the computer must construct the 5-byte block by selecting the appropriate instruction opcode, organizing the parameters, if any, and providing unused (dummy) argument bytes for padding (the dummy bytes can contain any value). The resulting five bytes are then sent, *opcode last*, to the SI serial input pin of the CAT jack on the transceiver.

Example: Set operation to 14.25000 MHz;

- First determine the opcode for the desired instruction (see the CAT Commands Table, next page). These opcodes should be stored in the program so they can be looked up when the user requests the corresponding command. In this case the instruction is "Set Op Freq.," so the opcode is 0Ah. The small "h" following each value indicate hexadecimal (base 16) values.

- Build the four argument byte values from the desired frequency by breaking it into 2-digit blocks (BCD "packed decimal" format). Note that a leading zero is always required in the hundreds-of-MHz place (and another in the ten's-of-MHz if below 10 MHz).

- The resulting 5-byte block should now look like this (again, in hexadecimal format):

Byte Value	0Ah	01h	42h	50h	00h
Content of this byte	Set Main VFO Freq. opcode	100's & 10's of MHz	1's of MHz & 100's of kHz	10's & 1's of kHz	100's & 10's of Hz

- Send these five bytes to the transceiver, in *reverse* order from that shown above — from right-to-left (see the Basic example on page 43).

Reading Transceiver Status

The *Update*, *Read Flags*, *Read Meter* and *Pacing* commands report various conditions to the computer via the SO (Serial Output) line. *Update* causes the FT-990 to return 1, 16 or 1,508 bytes of Status Update data, while *Read Flags* obtains only the first 3 bytes (the Status Flags), plus 2 Model ID bytes (09h and 90h), and *Read Meter* returns the meter deflection (0 — 0FFh) repeated in four bytes, followed by one "filler" byte (0F7h). Each returned byte may be delayed by an interval determined by the *Pacing* command (0 to 255 ms in 1-ms steps). This delay is initially zero until the *Pacing* command is sent.

The *Pacing* command allows returned data to be read and processed by even very slow computers. However, you should set it as short as your computer will allow, to minimize the inconvenience of the delay. Sending 1,508 bytes requires just over 3 seconds with zero-length delay selected, but over 6 minutes if the maximum delay is selected!

Status Update Data Organization

The 1,492 bytes of available update data are organized as shown schematically after the command table. Aside from the *Read Flags* command, different portions of this data can be returned in blocks of 1, 16 or 1,508 bytes, depending on the parameters of the *Update* command sent by the computer. The details of these commands follow the descriptions of the data.

CAT Commands

Legend:

Send all commands in REVERSE order from that shown! Commands that duplicate a front panel button are named with all caps.

Parameter variables are named to reflect their format: eg., "CH" indicates a memory channel number, from 1 to 5Ah (1 to 90 decimal).

"—" indicates a padding byte. Value is unimportant, but it must be present to pad the block out to five bytes.

Opcodes are listed in both hex and decimal format for convenience - only one byte can be actually sent.

Command	Opcode		Parameter Bytes				Notes
	hex	(dec)	1	2	3	4	
SPLIT	01	(1)	T	—	—	—	Switch Split VFO operation ON (T=1) and OFF (T=0)
Recall Memory	02	(2)	CH	—	—	—	Recalls memory number CH : 1 to 5Ah corresponding to mems 1 to 90
VFO > M	03	(3)	CH	P2	—	—	Copy display to channel CH (P2=0), Hide CH (P2=1) or Unhide CH (P2=2)
LOCK	04	(4)	P	—	—	—	Tuning knob lock/unlock (P=1/0)
Select VFO A/B	05	(5)	V	—	—	—	Select operation on VFO A (V=0) or VFO B (V=1)
M > VFO	06	(6)	CH	—	—	—	Copy memory channel CH (1 to 5Ah) to last-used VFO
UP	07	(7)	00h	S	—	—	Step current display up 100 kHz (S=0) or 1 MHz (S=1)
DOWN	08	(8)	00h	S	—	—	same as UP
Clarifier	09	(9)	C1	C2	C3	C4	Rx clarifier on/off (C1=1/0), Tx clarifier on/off (C1=81h/80h), or clear offset (C1=FFh). Tune clarifier up (C2=0) or down (C2=FFh) by C3 (kHz) + C4 (Hz)
Set Op Freq	0Ah	(10)	F1	F2	F3	F4	New operating frequency in F1 – F4, in BCD format: see text for example
Select Op Mode	0Ch	(12)	M	—	—	—	M values : LSB=0, USB=1, CW2.4K=2, CW500=3, AM6K=4, AM2.4K=5, FM=6 or 7, RTTY(LSB)=8, RTTY(USB)=9, PKT(LSB)=0Ah, PKT(FM)=0Bh.
Pacing	0Eh	(14)	N	—	—	—	Add N-millisecond (0 – 0FFh) delay between bytes of Status Update (from radio)
PTT	0Fh	(15)	T	—	—	—	Transmitter on (T=1) or off (T=0)
Update	10h	(16)	U	—	—	CH-1	Instructs the radio to return 1, 16 or 1,508 bytes of Status Update data to the PC. CH is significant only when U=4. See text.
TUNER	81h	(129)	T	—	—	—	Switch antenna tuner on (T=1) or off (T=0).
START	82h	(130)	—	—	—	—	Start antenna tuner.
RPT	84h	(132)	R	—	—	—	Select simplex (R=0), -shift (R=1) or +shift (R=2)
A = B	85h	(133)	—	—	—	—	Copy displayed VFO (A or B) data to other VFO (B or A, respectively)
BANDWIDTH	8Ch	(140)	B	—	—	—	B is filter selection for display: 2.4-kHz=0, 2.0-kHz=1, 500-Hz=2, 250-Hz=3.
Memory Scan Skip	8Dh	(141)	CH	T	—	—	For channel CH (1 – 5Ah), skip (T=1) or include in scanning (T=0)
Step Op Freq	8Eh	(142)	D	—	—	—	Step operating freq up (D=0) or down (D=1) minimal step (10- or 100-Hz)
Read Meter	0F7h	(247)	—	—	—	—	Instructs radio to return digitized meter indication (4 repeated bytes, and 0F7h)
DIM Level	0F8h	(248)	L	—	—	—	Set dim display brightness between L=1 and L=0Dh (brightest)
Rptr Offset	0F9h	(249)	00h	S2	S3	S4	Set offset for RPT shifts, valid values are 0 to 19999 Hz (BCD format, in S2 – S4). Parameter 1 must be zero
Read Flags	0FAh	(250)	—	—	—	—	Instructs radio to return the 24 1-bit Status Flags (3 bytes), plus 2 Model ID bytes (09h and 90h, see following pages)

Data Returned From FT-990

Update Data

An overview of the data returned to the PC in response to the full *Update* command (with 1st parameter 0) is shown at the right. The sequence of the data stream is from top left to bottom.

The first three bytes are subdivided into 1-bit flag fields: if a bit is set (1), the function is enabled (on); and if reset (0), the function is disabled (off). These flags (also returned by the *Read Flags* command) reflect current states of various functions, most of which are indicated on the radio display.

Flags Byte 1

- Bit 0: Split frequency operation
- Bit 1: VFO B in use for transmit or receive
- Bit 2: FAST tuning rate is activated
- Bit 3: CAT System activated (after any cmd)
- Bit 4: Antenna tuner now tuning
- Bit 5: Key Entry in progress (digit blinking)
- Bit 6: Current memory is empty
- Bit 7: Transmission in progress (PTT closed)

Flags Byte 2

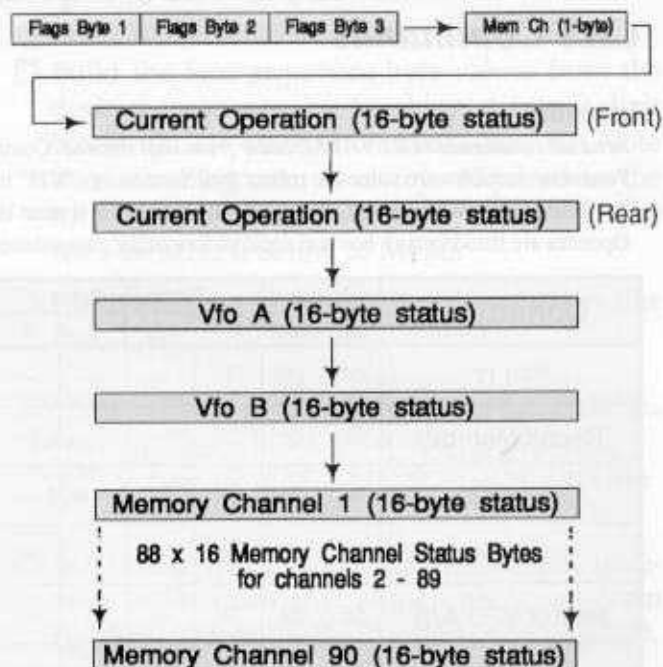
- Bit 0: Memory scanning is paused
- Bit 1: Memory checking (M CK) in progress
- Bit 2: Scanning in progress
- Bit 3: Main tuning knob locked
- Bit 4: Memory tuning (M TUNE) activated
- Bit 5: VFO operation (= left side of display)
- Bit 6: MEM operation (= left side of display)
- Bit 7: GEN operation (= left side of display)

Flags Byte 3

- Bit 0: PTT line closed by CAT command
- Bit 1: Tx inhibit (e.g., out-of-band)
- Bit 2: 0.5-sec transfer key release timer active
- Bit 3: 5-sec mem check (M CK) timer active
- Bit 4: PTT Tx inhibited during memory scan
- Bit 5: Transmit monitor
- Bit 6: Antenna TUNER on (panel LED)
- Bit 7: Sidetone is active (SPOT or CW Tx)

Memory Channel Byte 4

The fourth byte of Update data contains a binary value between 0 and 59h (89 decimal), indicating the current memory channel number on the display, *minus 1* (0 for channel 1, and 89 for channel 90). Only this byte is returned by sending the Update command with the first parameter set to 1.



16-Byte Structures

The rest of the Update data consists of 16-byte record structures indicating the VFO- and memory-specific selections. The first of these records is for the current display, followed by the two VFOs, and then the 90 memory channels, from lowest to highest. Each byte in this record is identified below by its offset from the start (base address) of the record. Note that the first record, for the current

Format of 16-byte Update Structures

Offset	Content & Format of Byte Field
0	BPF selection: 0 to 30h binary (bit 7=1 on a blanked memory)
1-3	Bytes 1-3: Base frequency in 10's of Hz (w/o clar/rpt offset). Binary value in range 10000-3000000. Byte 1 is MSB.
4	Clarifier/Rpt status (bit set=on, reset=off) Bit 0:Tx clarifier enabled. Bit 1: Rx clarifier enabled. Bit 2: +Rpt shift enabled. Bit 3: -Rpt shift enabled. Bits 4-7: not used
5-6	Clarifier offset. 2's complement (signed) value between -999d (FC19h) and +999d (03E7h)
7	Mode: binary, 0=LSB, 1=USB, 2=CW, 3=AM, 4=FM, 5=RTTY, 6=PKT
8	IF filter: binary, 0=2.4K, 1=2.0K, 2=500, 3=250, 4=6K(AM) (bit 7=1 for FM Packet or Reverse RTTY)
9	Last selected SSB filter (see Byte 8 format)
10	Last selected CW filter (see Byte 8 format)
11	Last selected RTTY filter (see Byte 8 format)
12	Last selected PKT filter (see Byte 8 format)
13	Last state of Clarifier/Rpt in FM mode (see Byte 4 format)
14	Bit 0 is set if this is a memory to be skipped during scanning. Bit 7 is set if AM mode last used (or is using) the 2.4K filter.
15	This byte is either 0, or 0FFh if the current AM or FM frequency is not an integer multiple of 100 Hz

display, is duplicated by either VFO data, or by one of the memories, unless currently operating on a retuned memory (M TUNE displayed).

Selecting Update Data to Return

The 1st and 4th parameters of the Status Update command allow selection of different portions of the Status data to be returned, as follows ("U" is the 1st parameter, "CH" is the 4th):

Parameter	Data Returned	Comment
U=0	All 1,508 bytes	see ROM note below
U=1	1-Byte: Memory Number -1	Current, or Last-Selected Memory
U=2	16-Byte structure for Current Operation (either a VFO or Mem)	See the Table on previous page
U=3	Two 16-Byte structures (32 bytes) for VFOs A & B	
U=4 and CH=0 - 59h	16-Byte structure for memory number CH	

Note that early FT-990 firmware revisions (prior to rev. 1.3) were only capable of returning all 1,508 bytes. Early sets can be upgraded by contacting your dealer. Software written for early versions is compatible with current versions if the 1st parameter of the Update command is always 0.

The 4th Update parameter (CH) is significant only when the 1st parameter is 4.

Read Flags Data

The Read Flags command retrieves only the three Flag Bytes (and two Model ID bytes). The Flag Bytes are described on the preceding page. The ID bytes can be used in a program to distinguish the FT-990 from other models, which have different, unique values returned in this situation. The constant values of 09h and 90h are returned by the FT-990, as shown here:

Flag Byte 1	Flag Byte 2	Flag Byte 3	ID Byte 1 (09h)	ID Byte 2 (90h)
-------------	-------------	-------------	-----------------	-----------------

Read Meter Data

Sending the Read Meter command causes the computer to return a digitized meter deflection indication, between 0 and 0FFh (in practice, around 0F0h maximum). Four copies of this value

are returned, along with one padding byte (0F7h), as follows:

Meter Byte	Meter Byte	Meter Byte	Meter Byte	0F7h
------------	------------	------------	------------	------

During reception, the signal strength deflection is returned. During transmission, the parameter represented by the reading returned depends on the setting of the METER switch.

Coding Examples

Although Yaesu Musen Company cannot offer to provide complete CAT control programs (owing to the large variety of incompatible computers used by our customers), following are a few examples of critical CAT i/o functions, in Basic. Note that all variations of Basic may not support some of the commands, in which case alternate algorithms may have to be developed to duplicate the functions of those shown.

Sending a Command

After "opening" the computer's serial port for 4800-baud, 8 data bits and 2 stop bits with no parity, as i/o device #2, any CAT command may be sent. However, if you determine that your computer may need extra time to process data returned from the transceiver, you should send the Pacing command first. Here is an example of the Pacing command setting a 2-ms delay:

```
PRINT #2, CHR$(0);CHR$(0);CHR$(0);CHR$(2);CHR$(&HE);
```

Notice that the instruction opcode is sent last, with the first (MSB) parameter sent just before it, and the LSB parameter (or dummies) sent first. This means that the parameters are sent in the reverse order from that in which they appear in the CAT Commands table. Also note that in this and the following examples, we are sending zeros as dummy bytes: this is not necessary, however. If you decide to send commands through a 5-byte array, the values of the dummy parameters need not be cleared.

Using the same example as on page 31, the following command could be used to set the frequency of the display to 14.25000 MHz:

```
PRINT #2, CHR$(&H00); CHR$(&H50);  
CHR$(&H42); CHR$(&H01); CHR$(&HA);
```

Notice here that the BCD values can be sent just by preceding the decimal digits with "&H" in this example. However, in an actual program you may prefer to convert the decimal frequency variable in

the program to an ASCII string, and then to convert the string to characters through a lookup table.

If you send a parameter that is out of range for the intended function, or not among the specified legal values for that function, the FT-990 should do nothing. Therefore, you may wish to alternate your sending regular commands or command groups with *Read Flags* and short-form *Update* commands, allowing the transceiver to let the computer know if everything sent so far has been accepted and acted upon as expected.

Bear in mind that some commands specify "binary", as opposed to BCD-formatted parameters. You can send binary parameters without going through the character/hex string conversion process. For example, the CH parameter in the Command table is binary. You could have the FT-990 recall memory 50 (decimal) by the following:

```
PRINT #2, CHR$(0);CHR$(0);CHR$(0);CHR$(49);CHR$(2);
```

Reading Returned Data

The reading process is easily done through a loop, storing incoming data into an array, which can then be processed after the entire array has been read. To read the meter:

```
FOR I=1 TO 5
  MDATA(I) = ASC(INPUT$(1,#2))
NEXT I
```

Recall from above that the meter data consists of four identical bytes, followed by a filler byte, so we really only need to see one byte to get all of the information this command offers. Nevertheless, we must read all five bytes (or 1, 16 or 1,508, in the case of the Update data). After reading all of the data, we can select the bytes of interest to us from the array (MDATA, in the above example).

Installing Internal Accessories

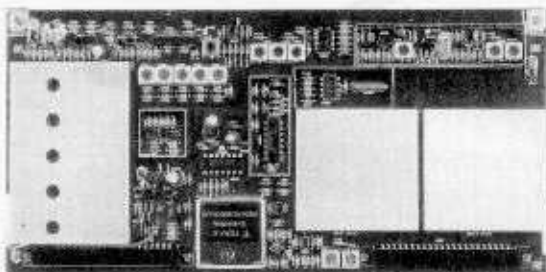
This chapter describes installation of the internal options available for the FT-990.

TCXO-2 High-Stability Master Oscillator

The ± 0.5 -ppm TCXO-2 option can be installed as a replacement for the standard ± 10 -ppm crystal oscillator. However, doing so requires removing existing components from a double-sided circuit board, which is difficult unless you have the proper tools and experience. We therefore recommend that this job be done by your Yaesu dealer, as damage that might result from improper installation may not be covered by your warranty (if in doubt, check with your dealer before starting).

- Remove the power cord from the rear panel.
- Remove the ten screws affixing the top cover, as shown at the upper right. Then lift off the top cover, and the small black plastic label cover for the top access panel controls.
- Locate the PLL Unit, which is the second plug-in card from the right side of the chassis (see photo at right), and carefully pull off the TMP coaxial plug near the front of the board.
- Remove the two screws in the bracket ears at the front and rear edges of the board, and lift the board slightly out of the chassis so that you can remove the second TMP coaxial plug near the rear. Remove the board from the chassis.
- Referring to the photos at the lower right, carefully unsolder crystal X4001, capacitors C4047 and C4048, and trimmer TC4001.
- Position the new TCXO-2 board so that the trimmer hole is nearest the bottom edge of the board (see below). Then push the module leads through the board and solder in place on the other side. The label should be upside-down.
- Replace the board in the chassis, using care to align the board edges with the tracks at the front and back of the slot. Reconnect the rear TMP plug before replacing the screws in the brackets.
- Replace the top cover and screws removed above (unless also installing crystal filters now).

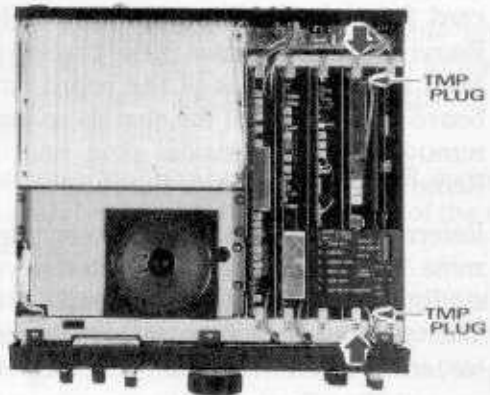
TCXO-2 Orientation



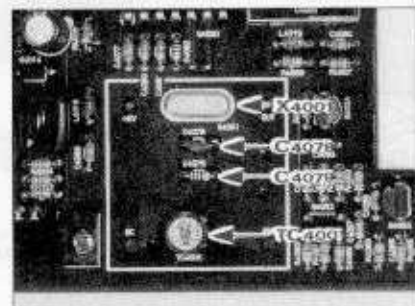
Top Cover Removal



PLL Unit Location



Oscillator Parts Removal



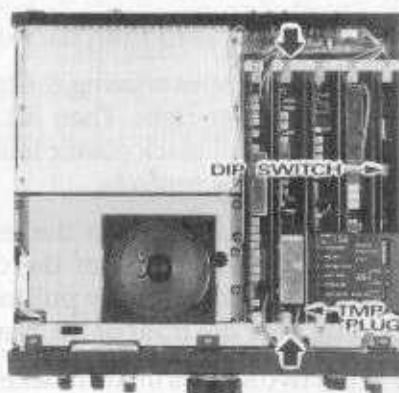
Narrow CW & SSB IF Filters

The XF-10.9M-202-1 IF filter can be installed in the 2nd IF to provide a 2.0-kHz bandwidth in SSB and CW modes, and the XF-109C and XF-455K-251-01 IF filters can be installed in the 3rd IF to provide 500- and 250-Hz bandwidth in CW mode, respectively (the XF-109C is factory-installed in AC-operated versions). Proper performance with these filters depends on proper installation. If you are unsure of the procedure after reading the following, feel free to ask your Yaesu dealer for help.

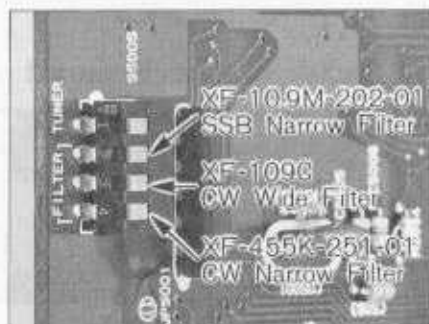
- Remove the power cord from the rear panel.
- Remove the ten screws affixing the top cover, as shown at the top of the previous page. Then lift off the top cover.
- Locate the IF Unit, which is the second plug-in card from the loudspeaker (see right photo). Remove the two screws in the bracket ears at the front and rear edges of the board, and lift the board slightly out of the chassis so that you can remove the TMP coaxial plug near the front. Remove the board from the chassis.
- Referring to the photo at the lower right, determine the location(s) of the filter(s) you are installing. Straighten the filter leads, if necessary. Then position each filter as indicated in the photos, and push the filter leads through the board.
- Solder each wire on the solder side of the board, and then clip off any excess leads. Check your solder joints carefully.

- Replace the board in the chassis, using care to align the board edges with the tracks at the front and back of the slot. Reconnect the TMP plug before replacing the screws in the brackets.
- Referring to the Filter Switch photo below left, locate the DIP switch block near the top center of the Control Unit (in the rightmost slot). Set switch "ON" for each filter you have just installed: Switch 2 for the 2.0-kHz SSB filter, Switch 3 for the 500-Hz filter, and Switch 4 for the 250-Hz CW filter.
- Replace the top cover and ten screws removed above.

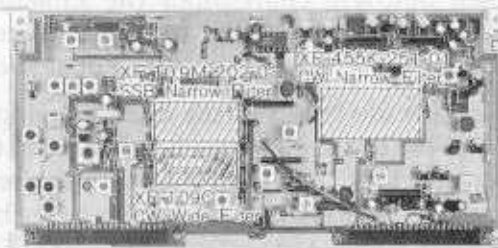
IF Unit Location



Filter Switch (on Control Unit)



Optional Filter Locations



Installation for DC Operation

The DC version of the FT-990 is supplied without the FP-25 internal AC power supply. A dual-fused 3-meter-long DC cable, part number T9018320, is supplied instead, for operating the transceiver from an external source of 13.1- to 15.2-V DC (13.8 V nominal) at up to 20 amperes. The FP-25 internal AC supply is available as an option for the DC version of the FT-990, and the DC cable is available as an option for the AC/DC version.

Installation

Use the fused DC cable to connect the transceiver to the DC power source. If the cable is not long enough, it may be extended with #12 AWG or larger stranded, insulated copper wire. However, this is not recommended, as the resulting voltage

Caution!

Our warranty does not cover damage that may result from improper supply voltage or use of an improper fuse.

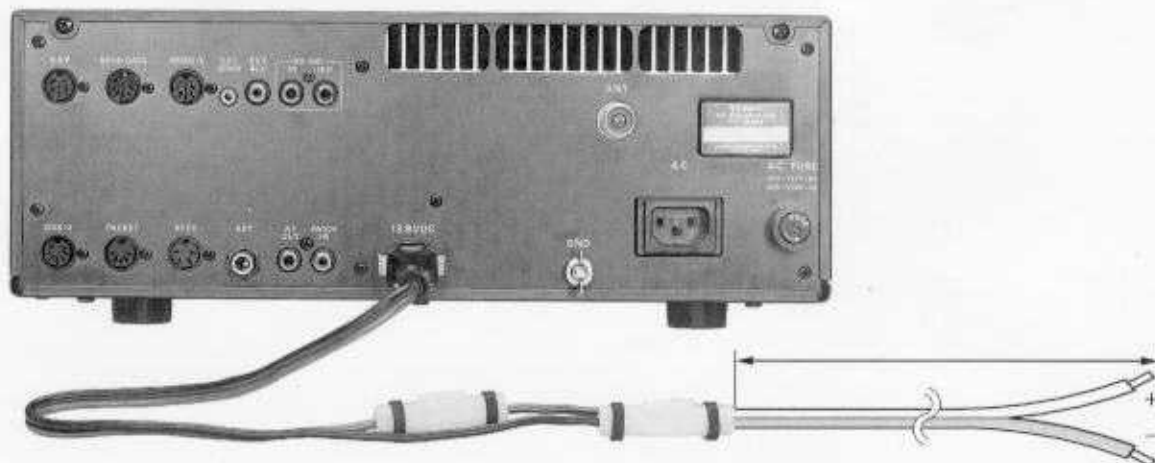
To avoid damage to the FT-990 from switching spikes, always make sure it is switched off before turning your DC power source on or off, or before starting or stopping the engine (in mobile installations).

drop may restrict transmitter power output. In any installation, the DC cable should be cut as short as possible to avoid voltage drop while still keeping the fuses in line. The supplied fuses are 20-A, fast-blow type, and should only be replaced with the same type.

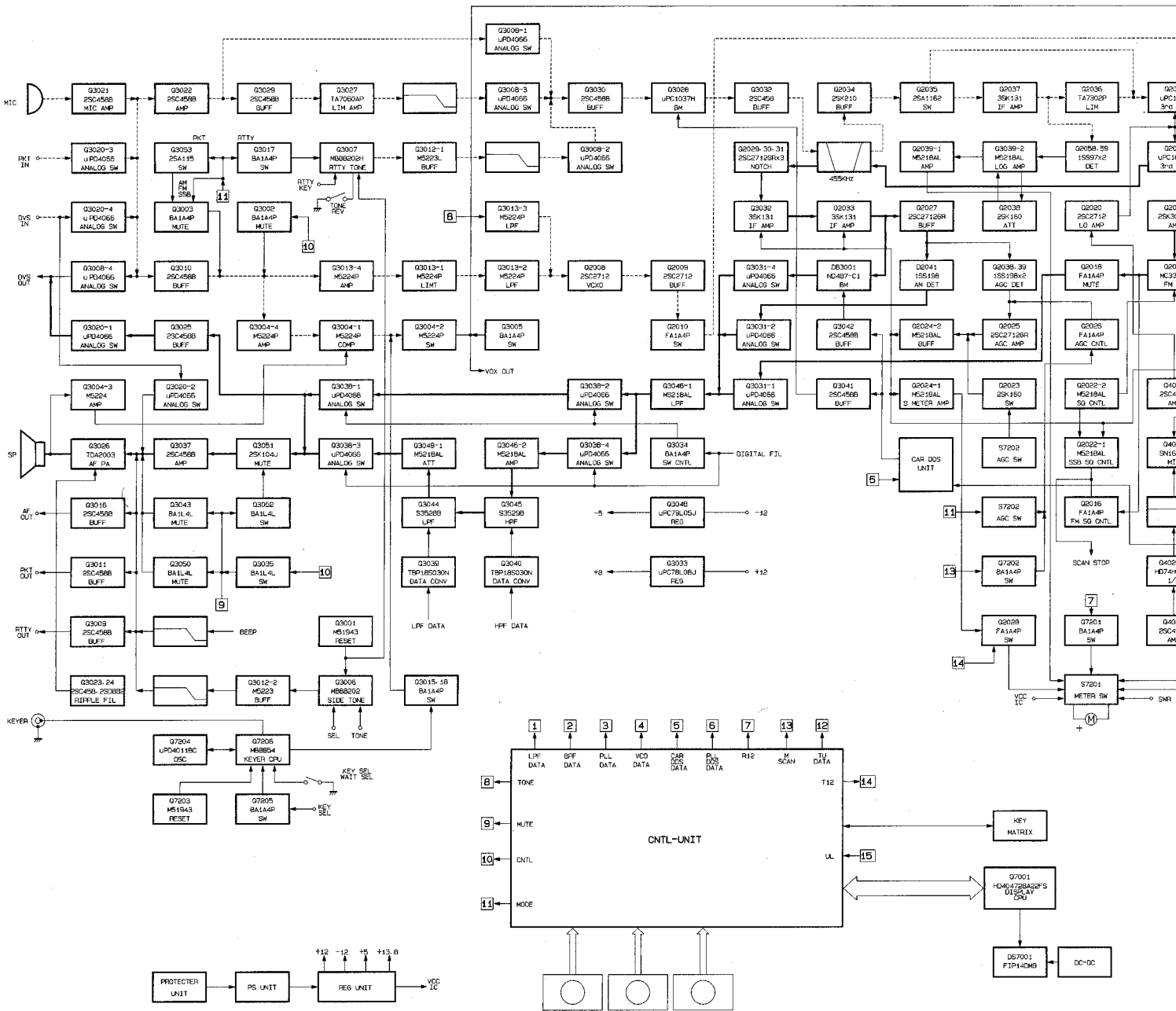
Mobile Installation

- Before connecting the cable, measure the DC voltage at the battery terminals while revving the engine. If the voltage exceeds 15 volts, have the vehicle's voltage regulator adjusted before proceeding.
- Determine just where the transceiver will be located, then route the DC cable to the battery and cut off any excess.
- With the transceiver end of the cable unconnected, connect the DC cable directly to the battery terminals: RED lead to positive, and BLACK to negative.
- Make sure the transceiver **POWER** switch is OFF, and then connect the other end of the cable to the transceiver.

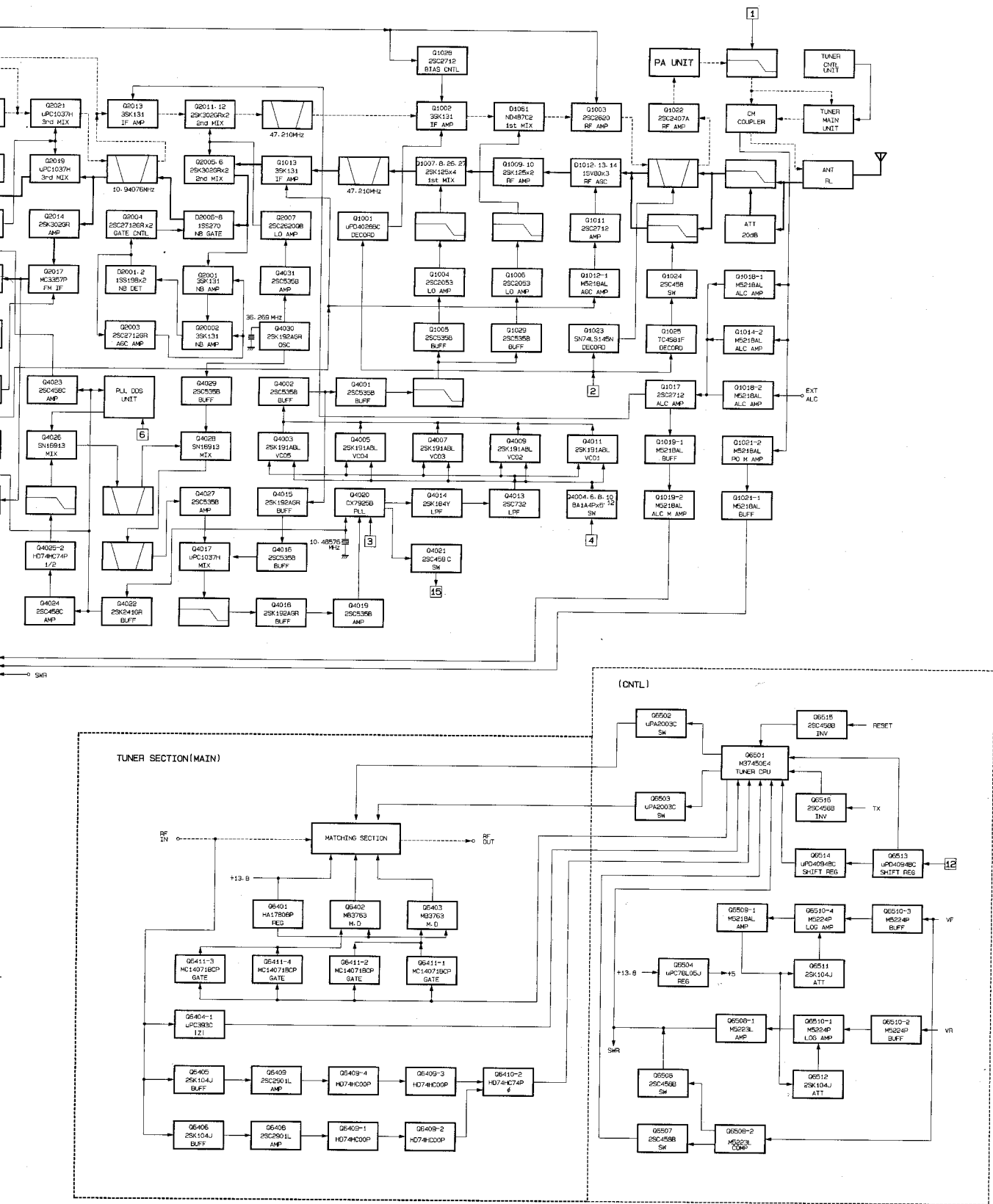
When transmitting using an external DC source, voltage drop in the DC cable or connections, or poor regulation of the external supply, may cause the pilot lamps to dim. This can cause distortion of your signal, so you should reduce the **RF PWR** setting until the lamps no longer dim.



Keep lead length as short as possible!

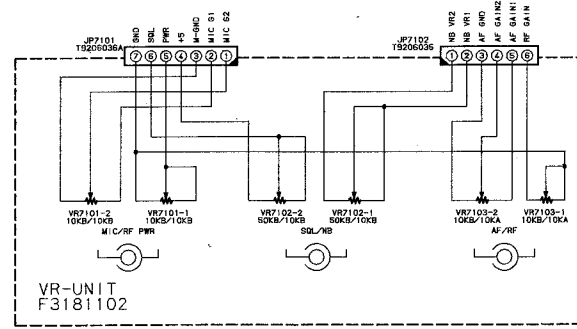
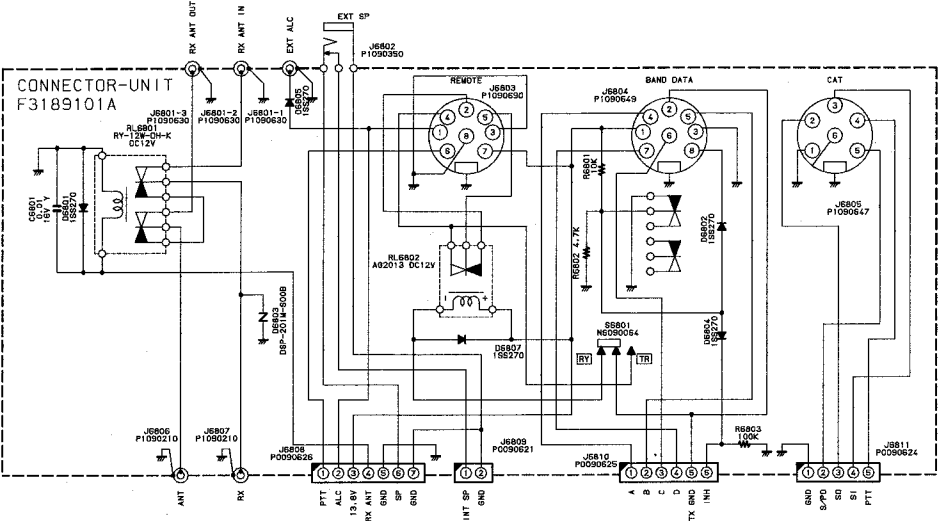
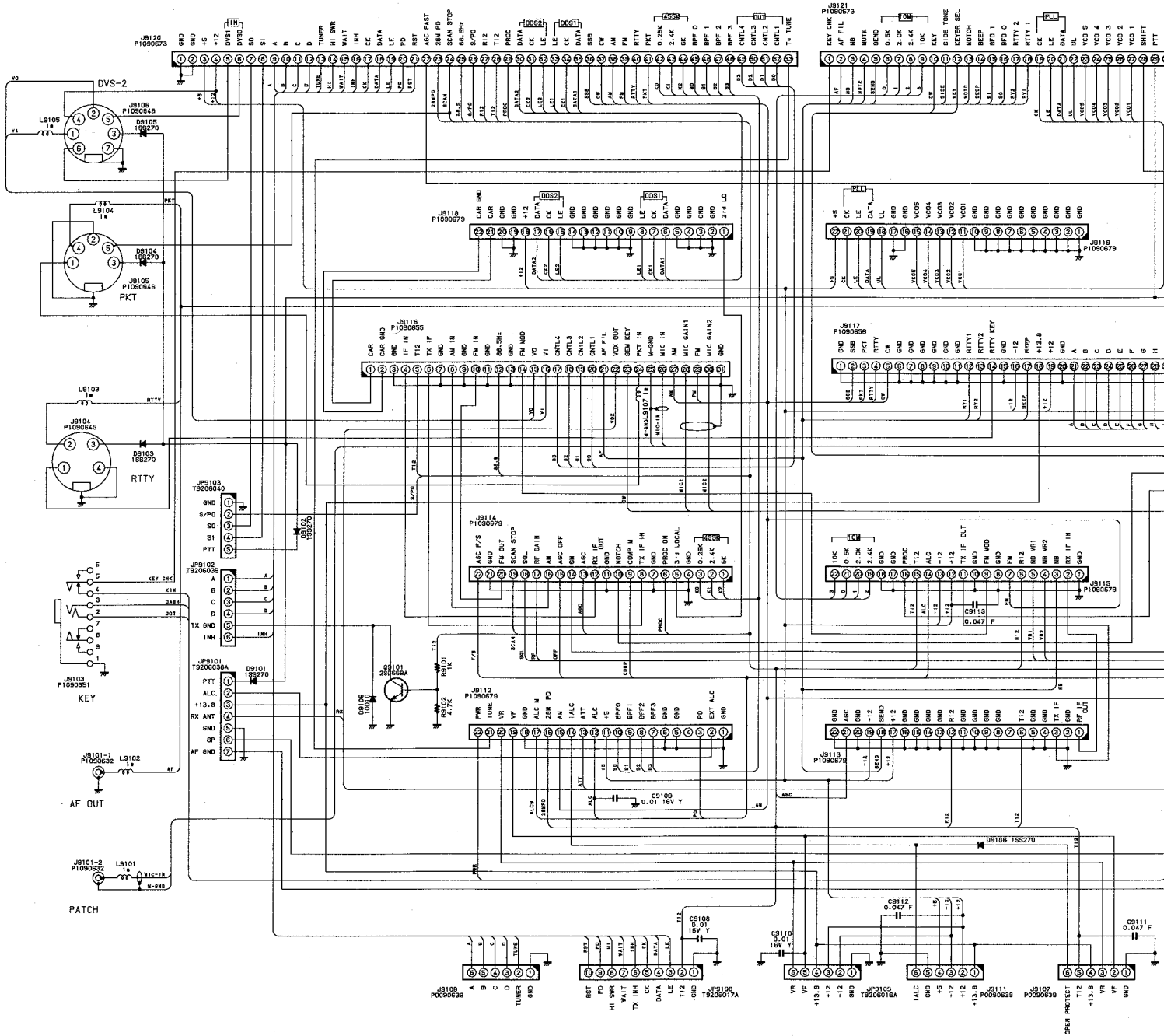


- - - - - TRANSMIT
 ———— RECEIVE
 ———— CONTROL

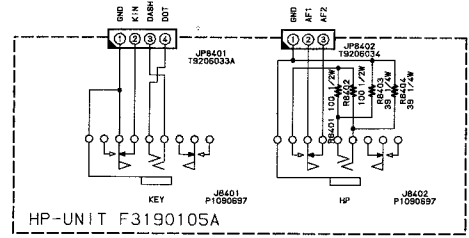
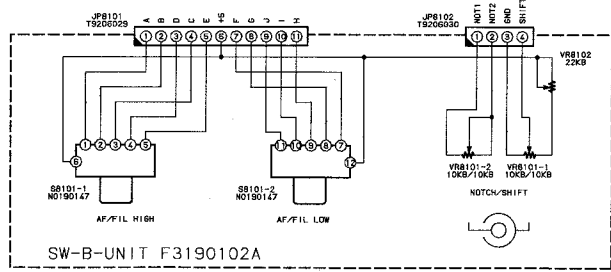
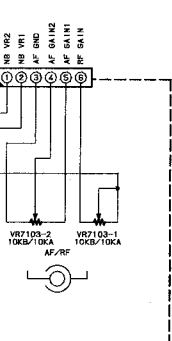
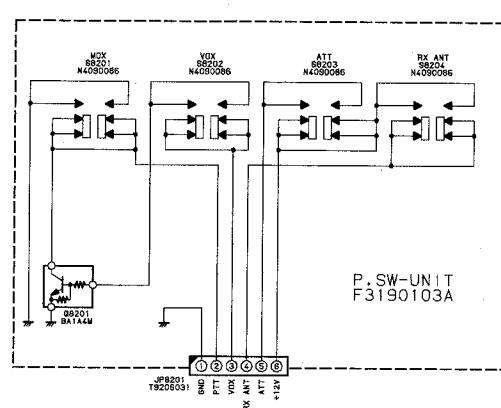
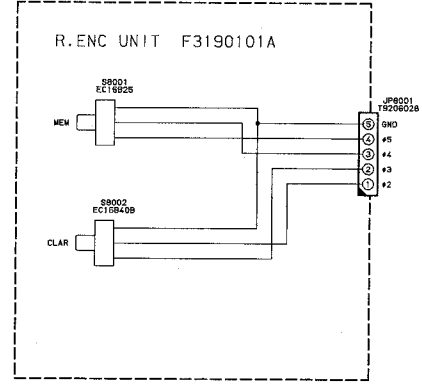
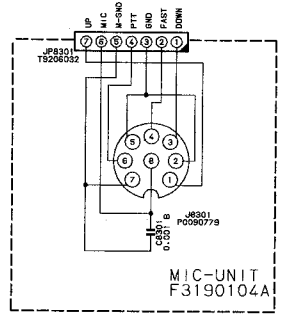
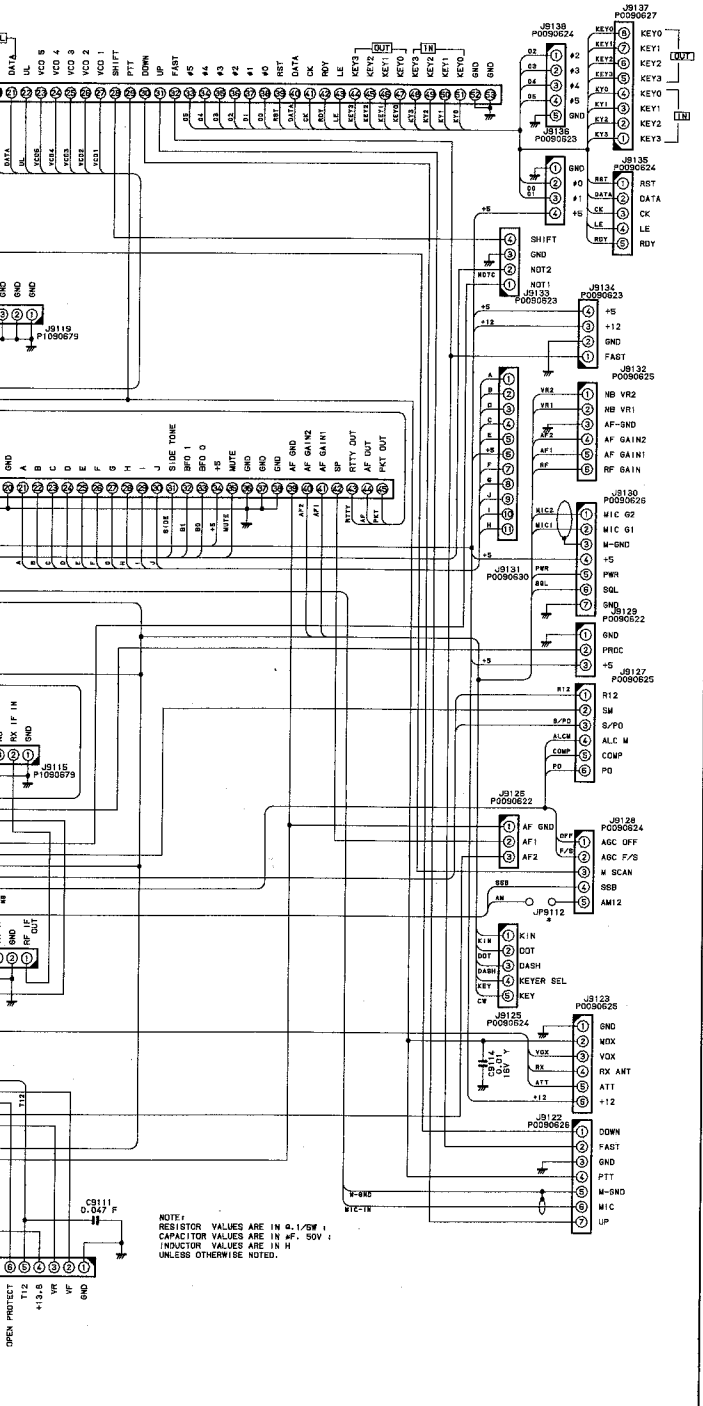


FT-990 BLOCK DIAGRAM

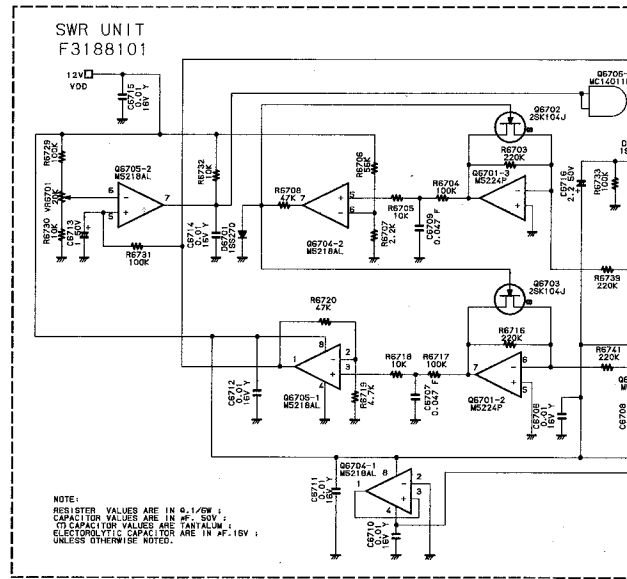
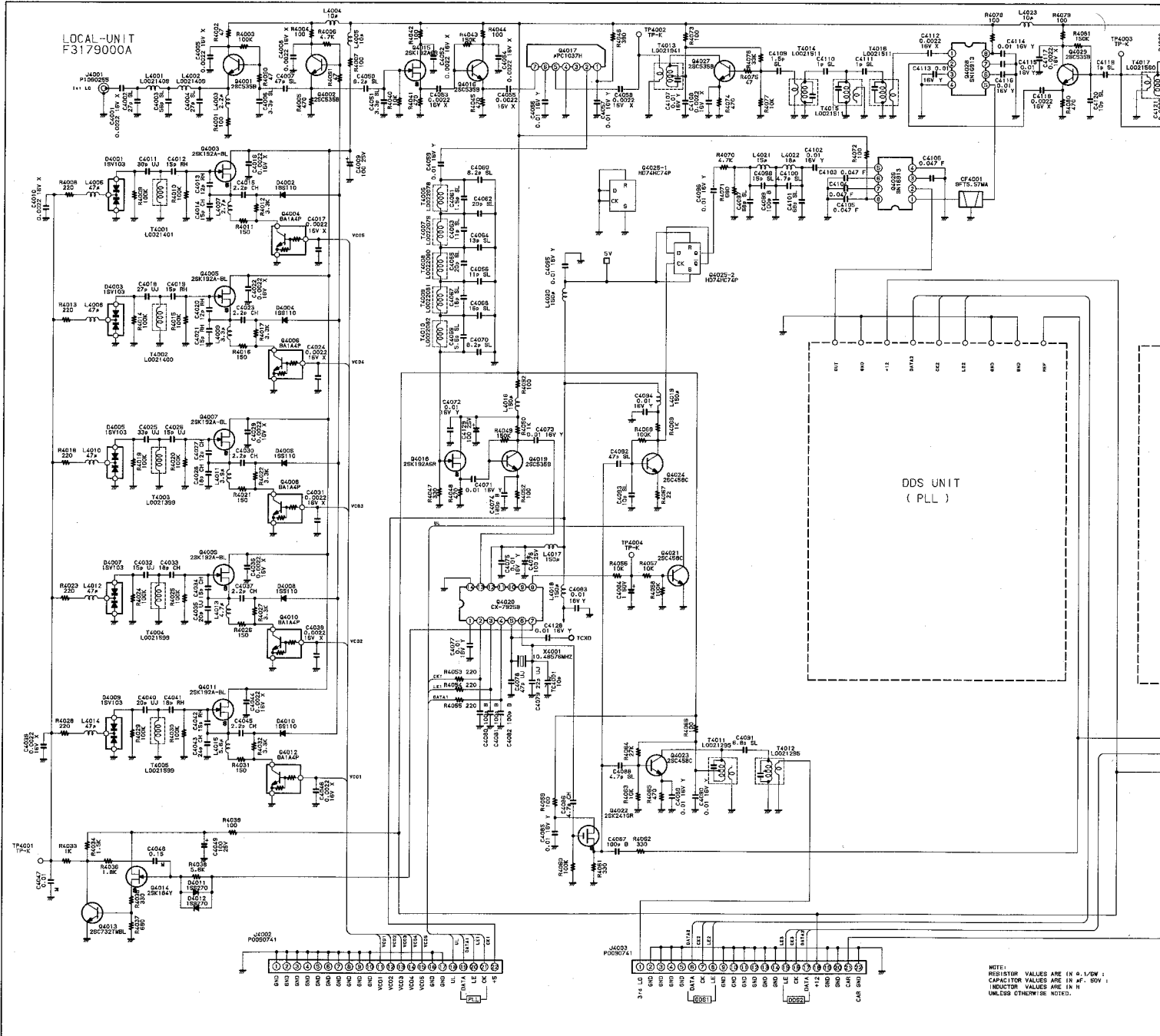
MOTHER-BOARD F3175000A

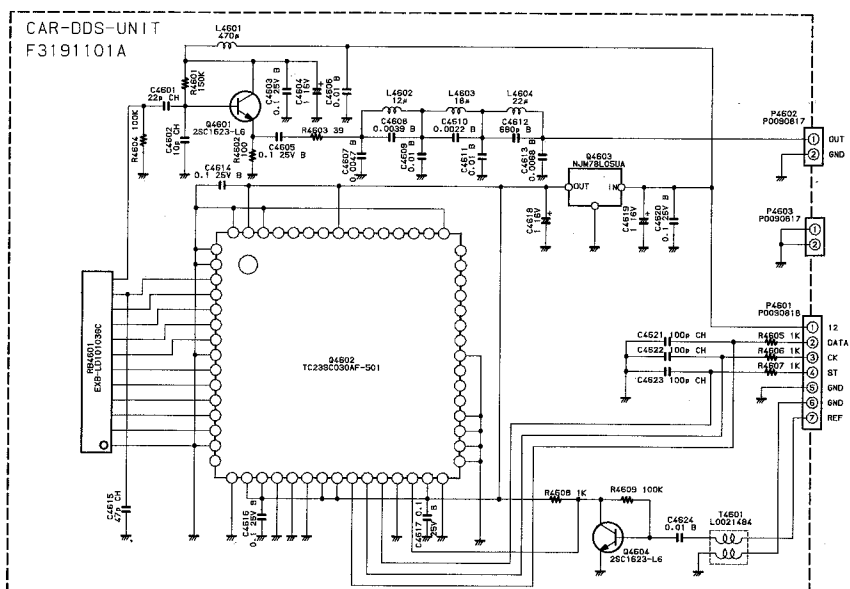
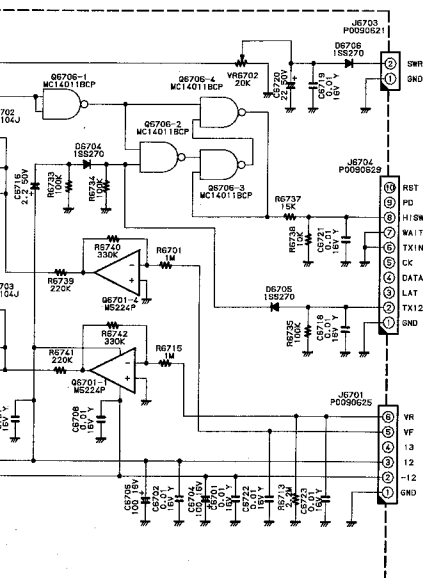
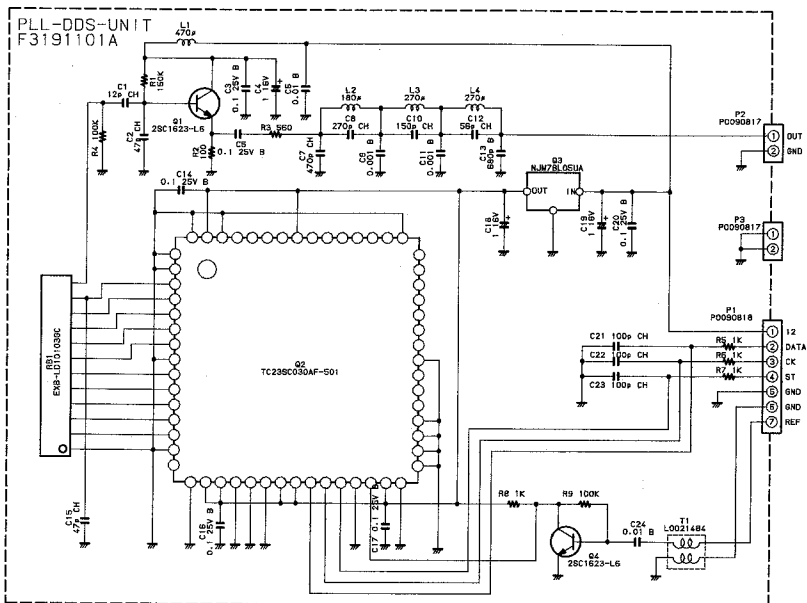
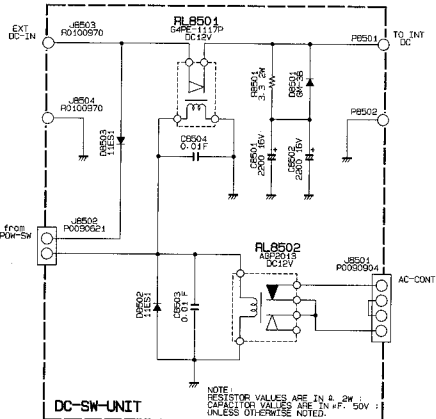
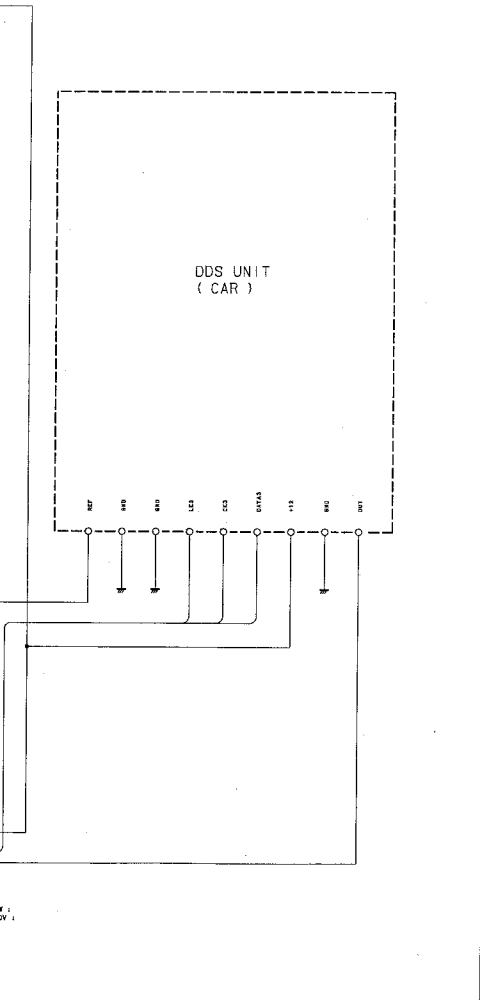
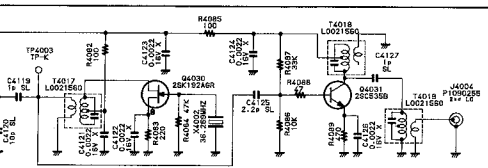


NOTE: RESISTOR VALUES ARE IN Ω, 1/4W UNLESS OTHERWISE NOTED.

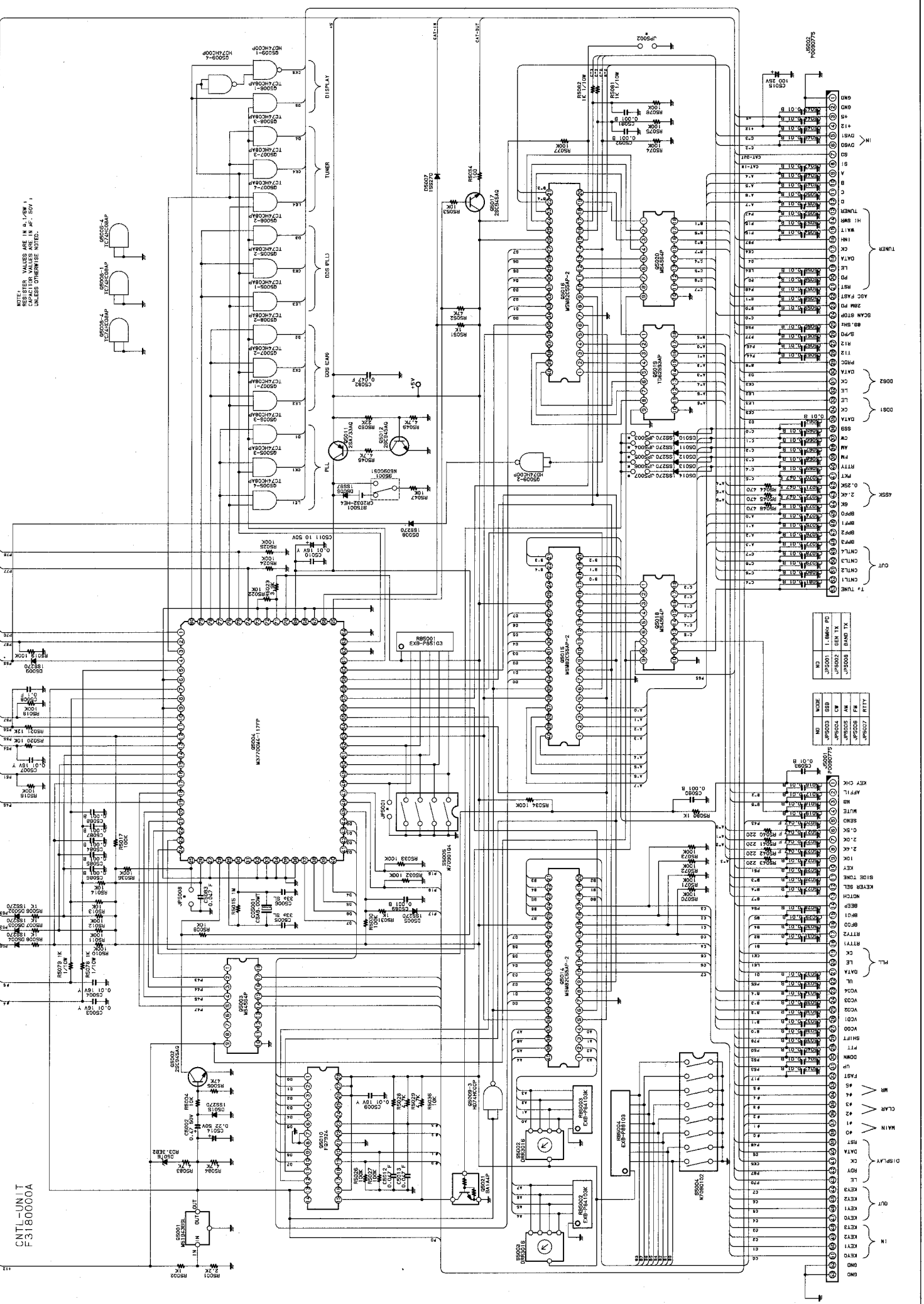


NOTE:
 RESISTOR VALUES ARE IN Ω , $\frac{1}{2}$ W
 CAPACITOR VALUES ARE IN AF, SOV
 INDUCTOR VALUES ARE IN H
 UNLESS OTHERWISE NOTED.





NOTES:
RESISTOR VALUES ARE IN Ω, 1/10 Ω,
1/2 Ω, 1 Ω, 2 Ω, 5 Ω, 10 Ω, 20 Ω,
50 Ω, 100 Ω, 200 Ω, 500 Ω, 1 Ω, 2 Ω,
5 Ω, 10 Ω, 20 Ω, 50 Ω, 100 Ω,
UNLESS OTHERWISE NOTED.



CNTL-UNIT
F318000A

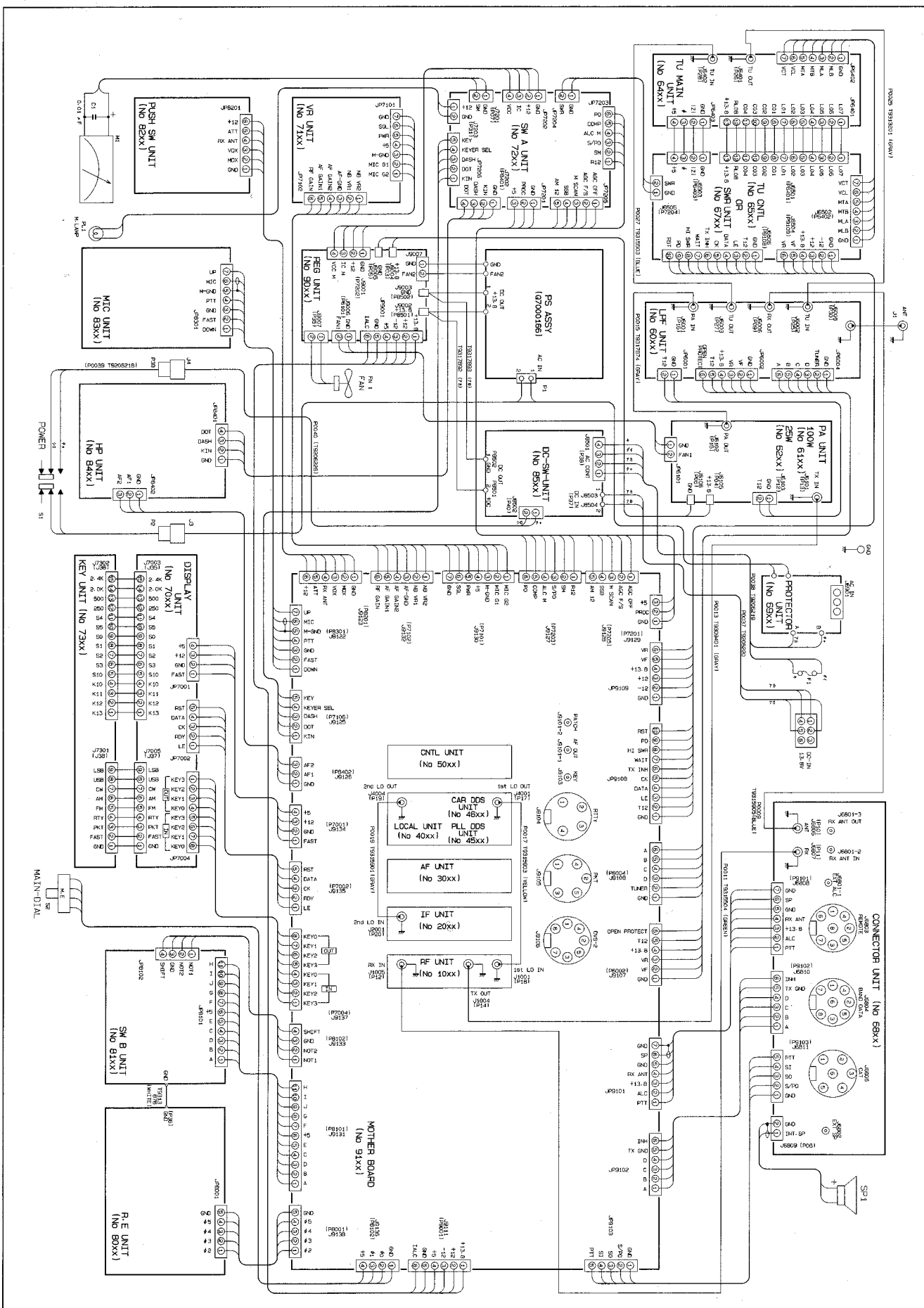
NO.	NAME	UNIT	PC	PT
1	JPS001	1.5MM	GEN	TX
2	JPS002	1.5MM	GEN	TX
3	JPS003	1.5MM	BAND	TX
4	JPS004	1.5MM	BAND	TX
5	JPS005	1.5MM	BAND	TX
6	JPS006	1.5MM	BAND	TX
7	JPS007	1.5MM	BAND	TX
8	JPS008	1.5MM	BAND	TX
9	JPS009	1.5MM	BAND	TX
10	JPS010	1.5MM	BAND	TX

NO.	NAME	UNIT	PC	PT
1	JPS011	1.5MM	GEN	TX
2	JPS012	1.5MM	GEN	TX
3	JPS013	1.5MM	GEN	TX
4	JPS014	1.5MM	GEN	TX
5	JPS015	1.5MM	GEN	TX
6	JPS016	1.5MM	GEN	TX
7	JPS017	1.5MM	GEN	TX
8	JPS018	1.5MM	GEN	TX
9	JPS019	1.5MM	GEN	TX
10	JPS020	1.5MM	GEN	TX

NO.	NAME	UNIT	PC	PT
1	JPS021	1.5MM	GEN	TX
2	JPS022	1.5MM	GEN	TX
3	JPS023	1.5MM	GEN	TX
4	JPS024	1.5MM	GEN	TX
5	JPS025	1.5MM	GEN	TX
6	JPS026	1.5MM	GEN	TX
7	JPS027	1.5MM	GEN	TX
8	JPS028	1.5MM	GEN	TX
9	JPS029	1.5MM	GEN	TX
10	JPS030	1.5MM	GEN	TX

NO.	NAME	UNIT	PC	PT
1	JPS031	1.5MM	GEN	TX
2	JPS032	1.5MM	GEN	TX
3	JPS033	1.5MM	GEN	TX
4	JPS034	1.5MM	GEN	TX
5	JPS035	1.5MM	GEN	TX
6	JPS036	1.5MM	GEN	TX
7	JPS037	1.5MM	GEN	TX
8	JPS038	1.5MM	GEN	TX
9	JPS039	1.5MM	GEN	TX
10	JPS040	1.5MM	GEN	TX

NO.	NAME	UNIT	PC	PT
1	JPS041	1.5MM	GEN	TX
2	JPS042	1.5MM	GEN	TX
3	JPS043	1.5MM	GEN	TX
4	JPS044	1.5MM	GEN	TX
5	JPS045	1.5MM	GEN	TX
6	JPS046	1.5MM	GEN	TX
7	JPS047	1.5MM	GEN	TX
8	JPS048	1.5MM	GEN	TX
9	JPS049	1.5MM	GEN	TX
10	JPS050	1.5MM	GEN	TX



POWER

MAIN-DIAL

PUSH SW UNIT
(NO 82XX)

MIC UNIT
(NO 83XX)

HP UNIT
(NO 84XX)

DISPLAY UNIT
(NO 70XX)

SM B UNIT
(NO 81XX)

R E UNIT
(NO 80XX)

VR UNIT
(NO 71XX)

REG UNIT
(NO 90XX)

PS ASSY
(0700166)

DC-9H UNIT
(NO 85XX)

CNTL UNIT
(No 50xx)

CAR DDS UNIT
(No 49xx)

LOCAL UNIT
PLL DDS UNIT
(No 40xx)
(No 45xx)

AF UNIT
(No 30xx)

IF UNIT
(No 20xx)

RF UNIT
(No 10xx)

SM A UNIT
(NO 72XX)

PS ASSY
(0700166)

DC-9H UNIT
(NO 85XX)

CNTL UNIT
(No 50xx)

CAR DDS UNIT
(No 49xx)

LOCAL UNIT
PLL DDS UNIT
(No 40xx)
(No 45xx)

AF UNIT
(No 30xx)

IF UNIT
(No 20xx)

RF UNIT
(No 10xx)

SM B UNIT
(NO 73XX)

PS ASSY
(0700166)

DC-9H UNIT
(NO 85XX)

CNTL UNIT
(No 50xx)

CAR DDS UNIT
(No 49xx)

LOCAL UNIT
PLL DDS UNIT
(No 40xx)
(No 45xx)

AF UNIT
(No 30xx)

IF UNIT
(No 20xx)

RF UNIT
(No 10xx)

TU MAIN
(NO 84XX)

LPT UNIT
(NO 80XX)

PA UNIT
(100W)
(NO 81XX)

PROTECTOR
(NO 85XX)

CONNECTOR UNIT
(NO 86XX)

MOTHER BOARD
(NO 91XX)

SM A UNIT
(NO 72XX)

SM B UNIT
(NO 73XX)

VR UNIT
(NO 71XX)

REG UNIT
(NO 90XX)

PS ASSY
(0700166)

TU ONT
(NO 83XX)

TU SPR UNIT
(NO 87XX)

PA UNIT
(100W)
(NO 81XX)

PROTECTOR
(NO 85XX)

CONNECTOR UNIT
(NO 86XX)

MOTHER BOARD
(NO 91XX)

SM A UNIT
(NO 72XX)

SM B UNIT
(NO 73XX)

VR UNIT
(NO 71XX)

REG UNIT
(NO 90XX)

PS ASSY
(0700166)

TU ONT
(NO 83XX)

TU SPR UNIT
(NO 87XX)

PA UNIT
(100W)
(NO 81XX)

PROTECTOR
(NO 85XX)

CONNECTOR UNIT
(NO 86XX)

MOTHER BOARD
(NO 91XX)

SM A UNIT
(NO 72XX)

SM B UNIT
(NO 73XX)

VR UNIT
(NO 71XX)

REG UNIT
(NO 90XX)

PS ASSY
(0700166)

TU ONT
(NO 83XX)

TU SPR UNIT
(NO 87XX)

PA UNIT
(100W)
(NO 81XX)

PROTECTOR
(NO 85XX)

CONNECTOR UNIT
(NO 86XX)

MOTHER BOARD
(NO 91XX)

SM A UNIT
(NO 72XX)

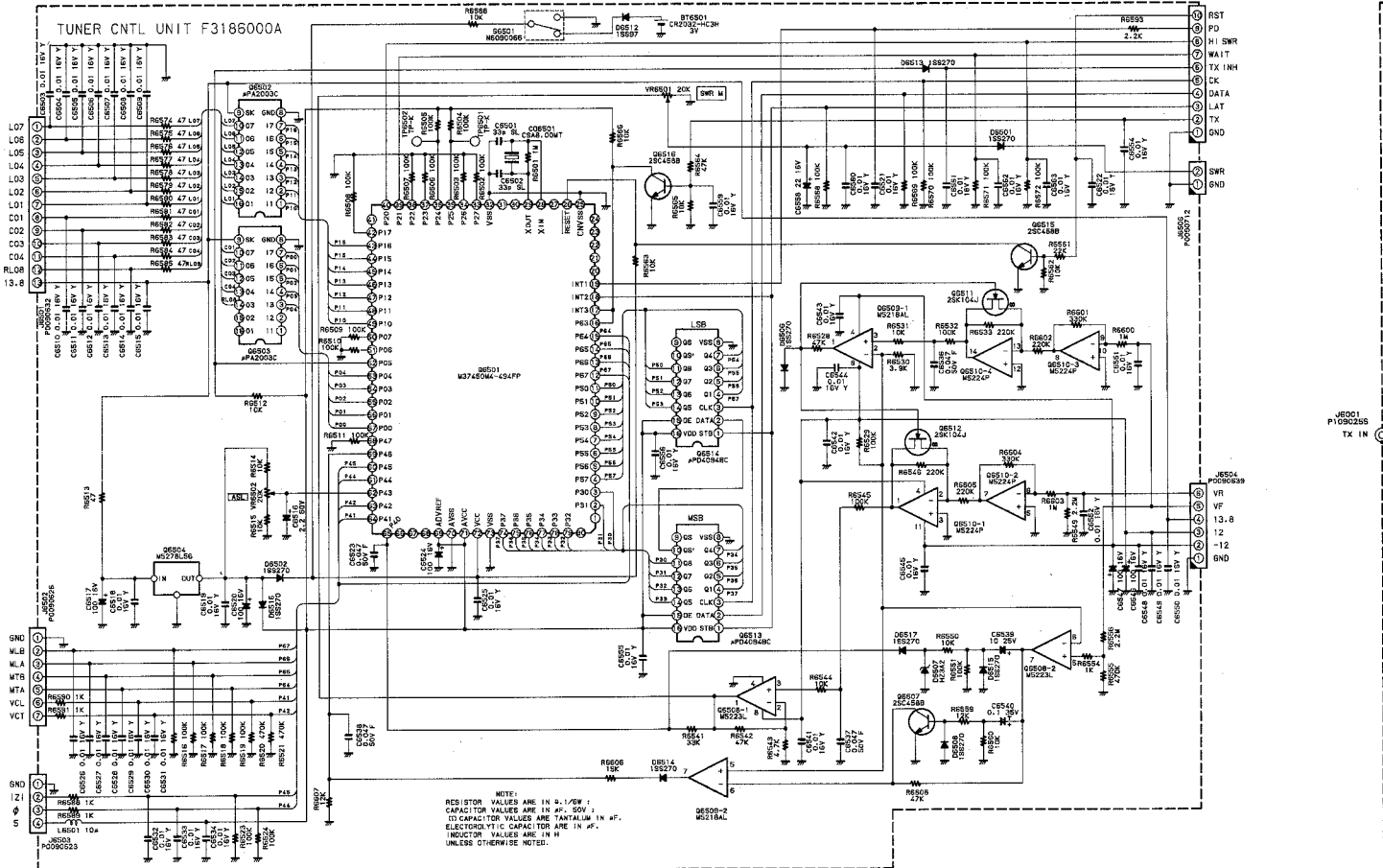
SM B UNIT
(NO 73XX)

VR UNIT
(NO 71XX)

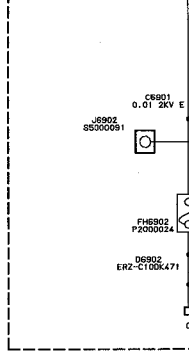
REG UNIT
(NO 90XX)

PS ASSY
(0700166)

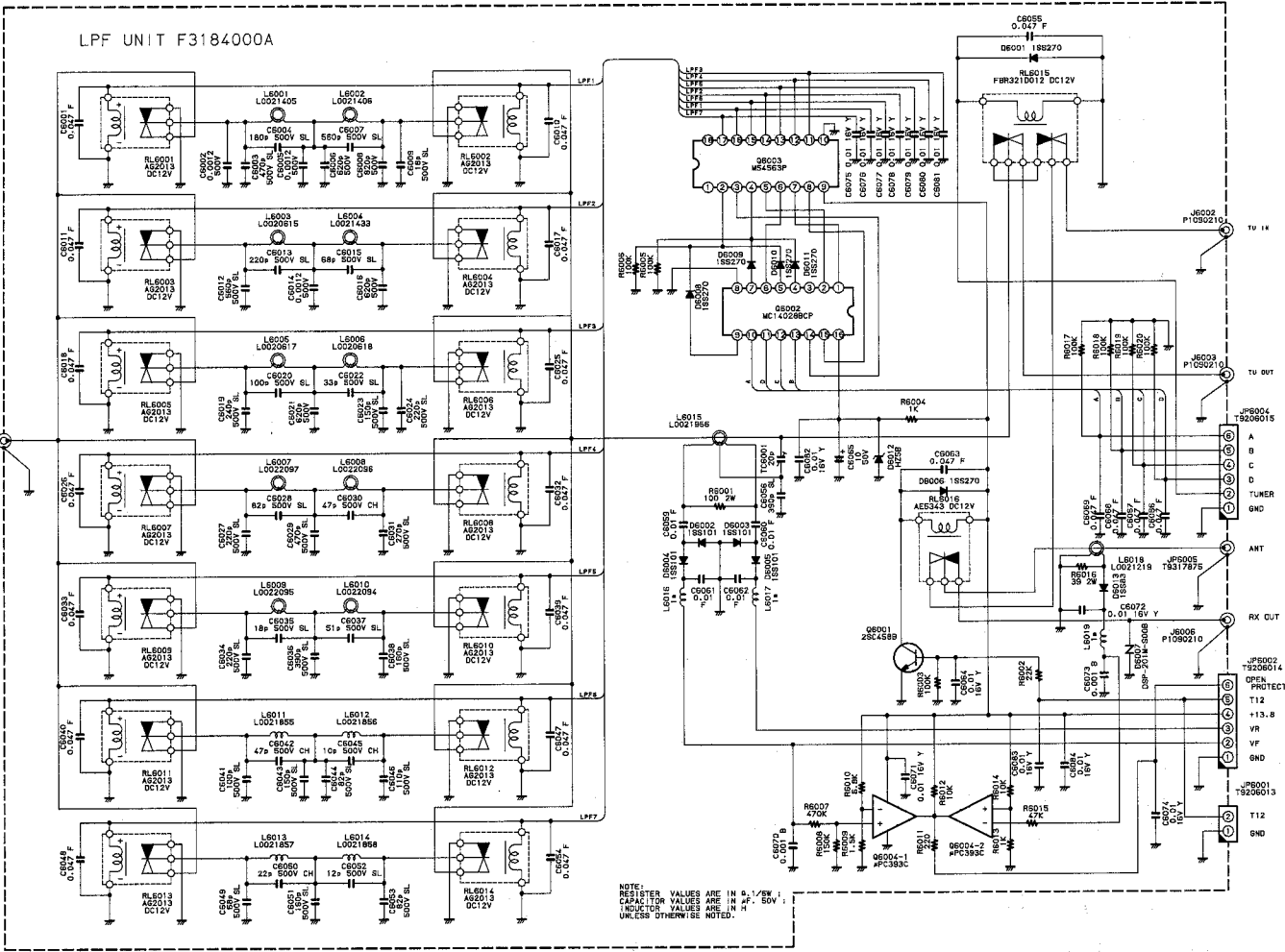
DISP
MAIN
CLR
MR
PL
TU
455
DB1
DB2
TUN



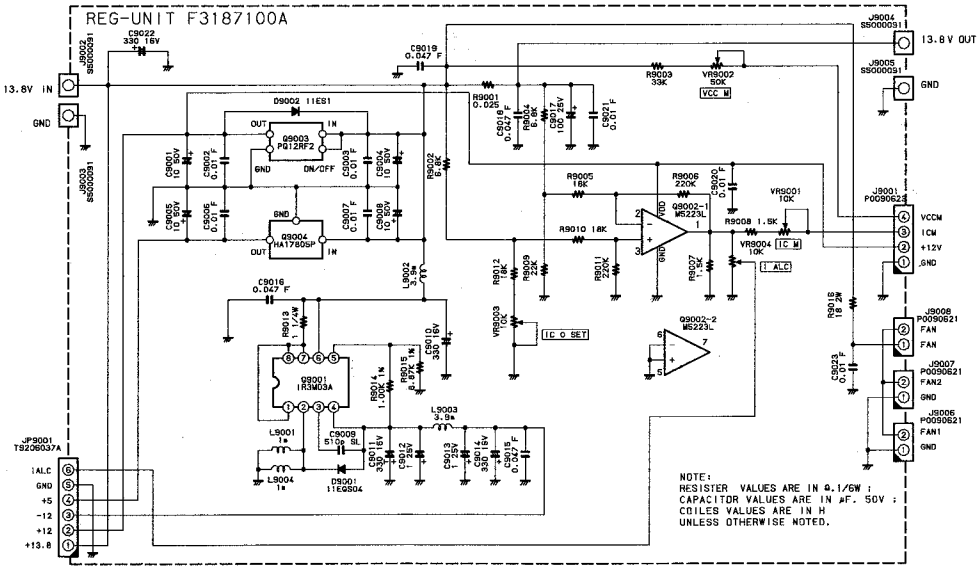
PROTECTOR-UNIT F3189102A



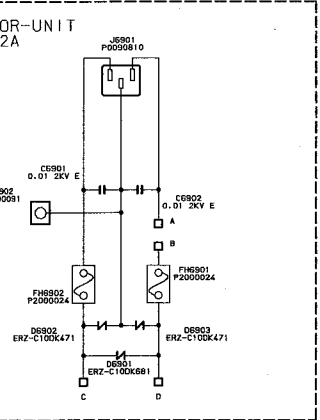
LPF UNIT F3184000A

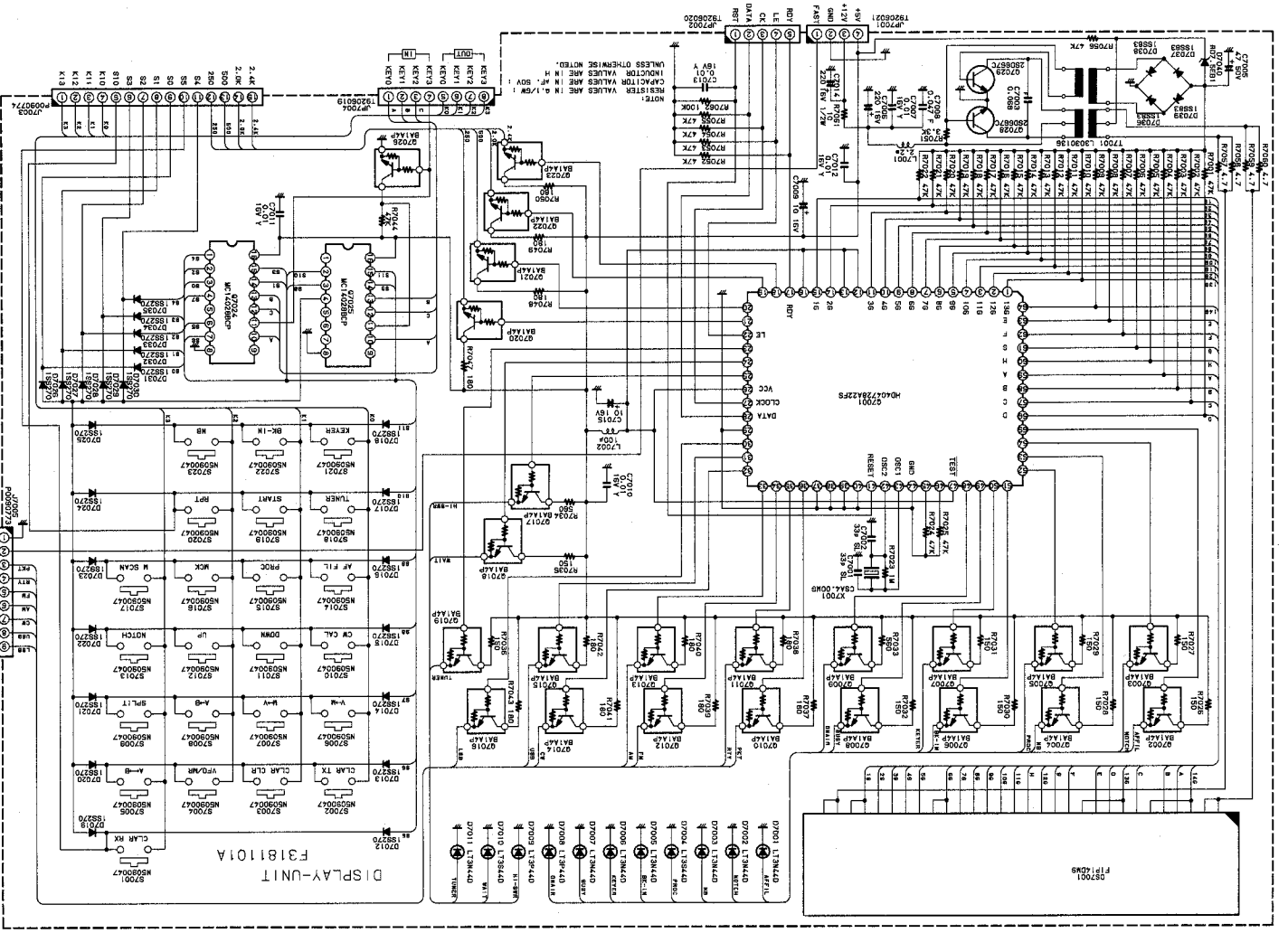
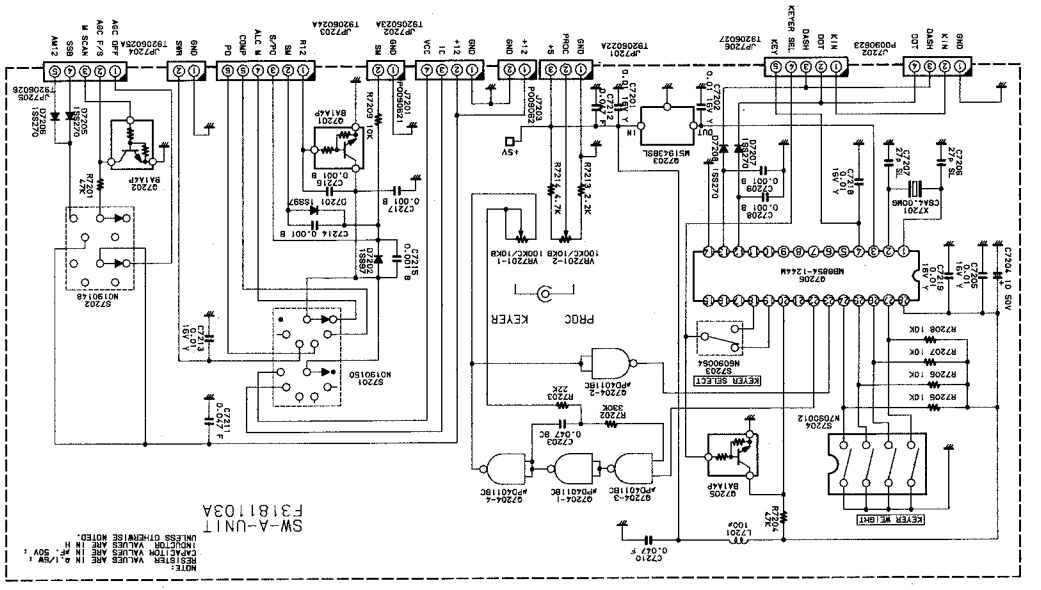


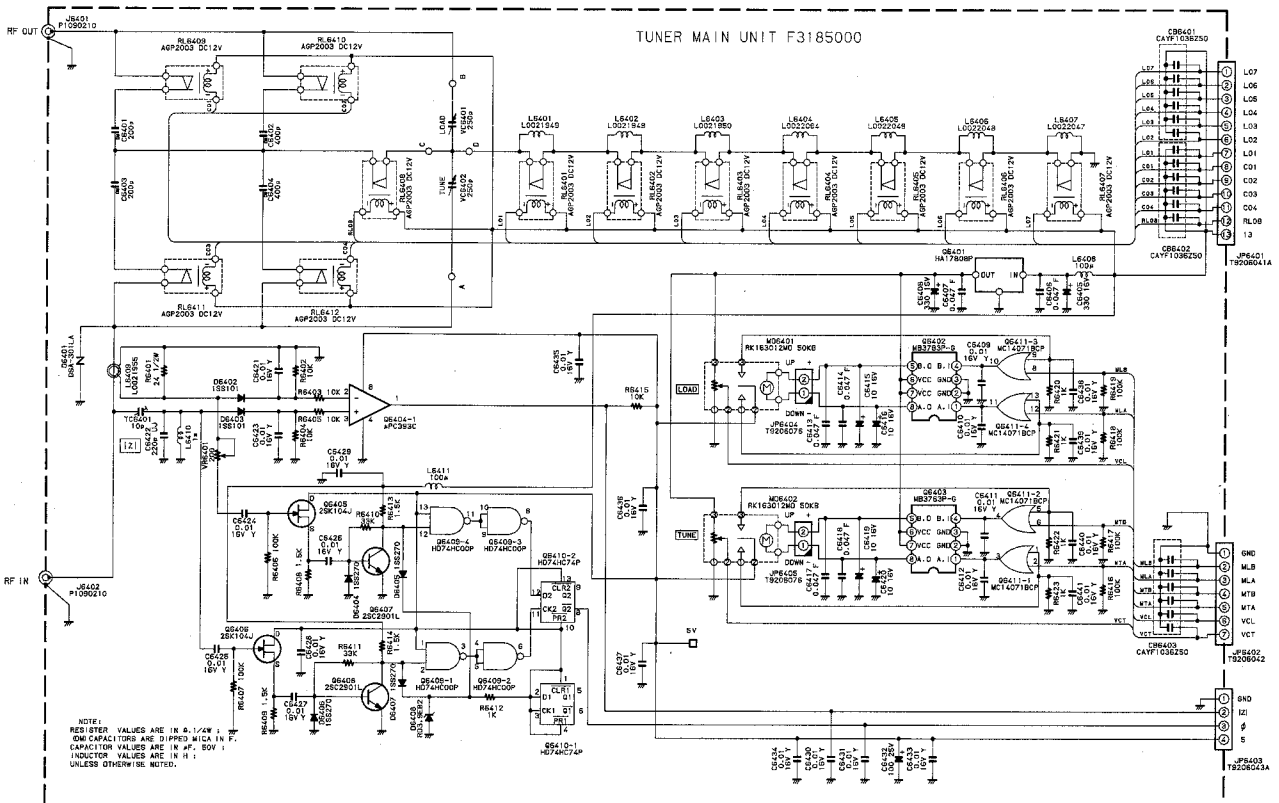
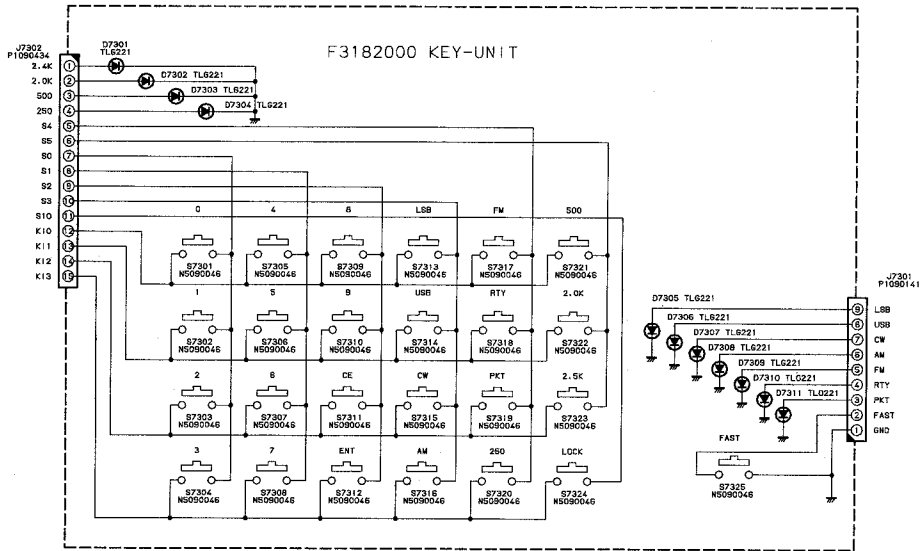
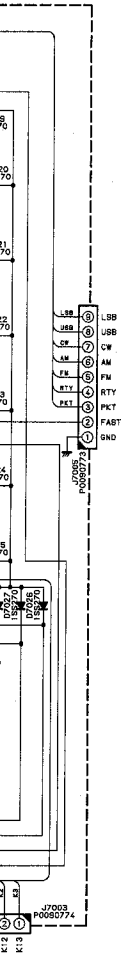
REG-UNIT F3187100A



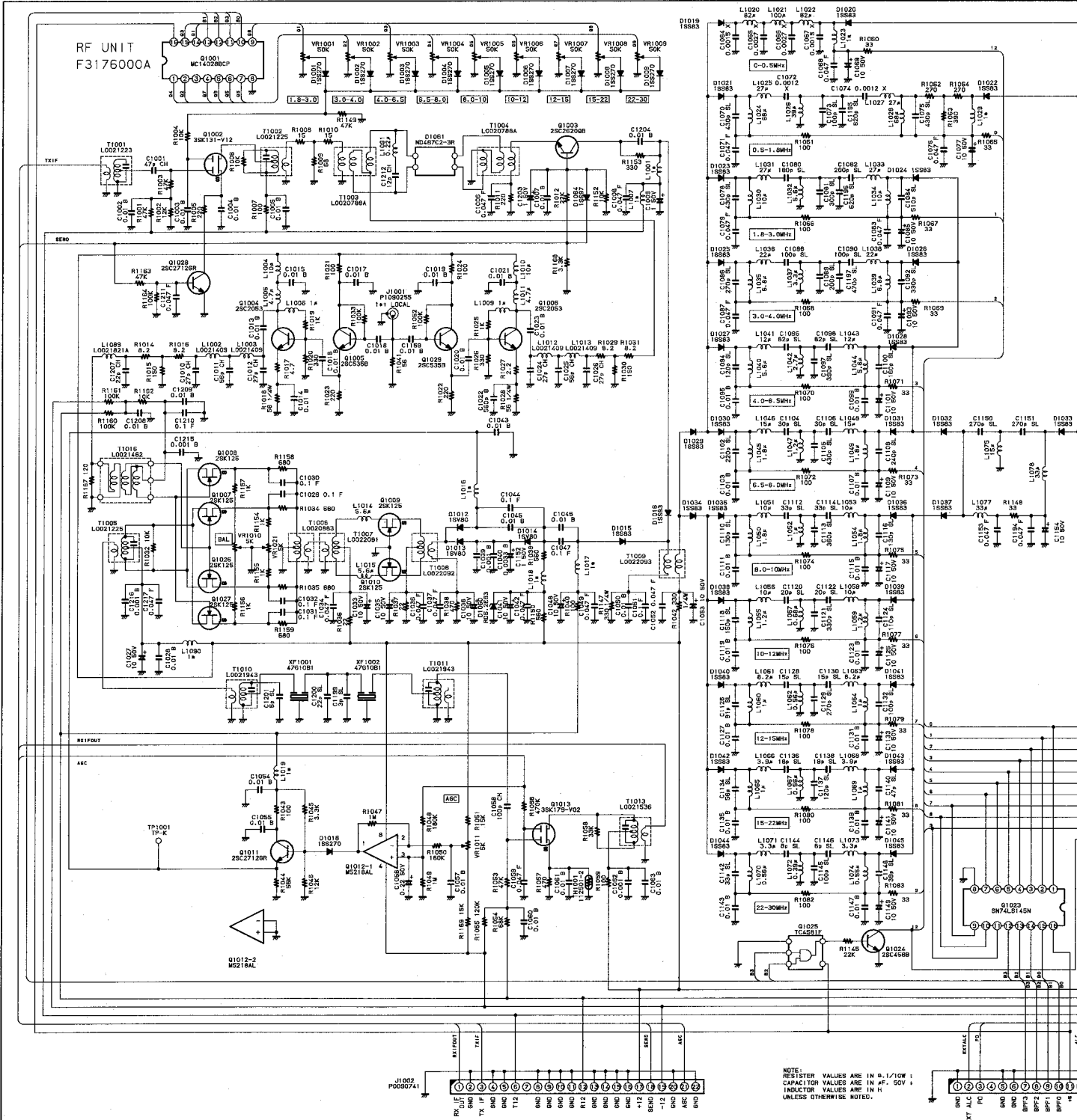
OR-UNIT 2A



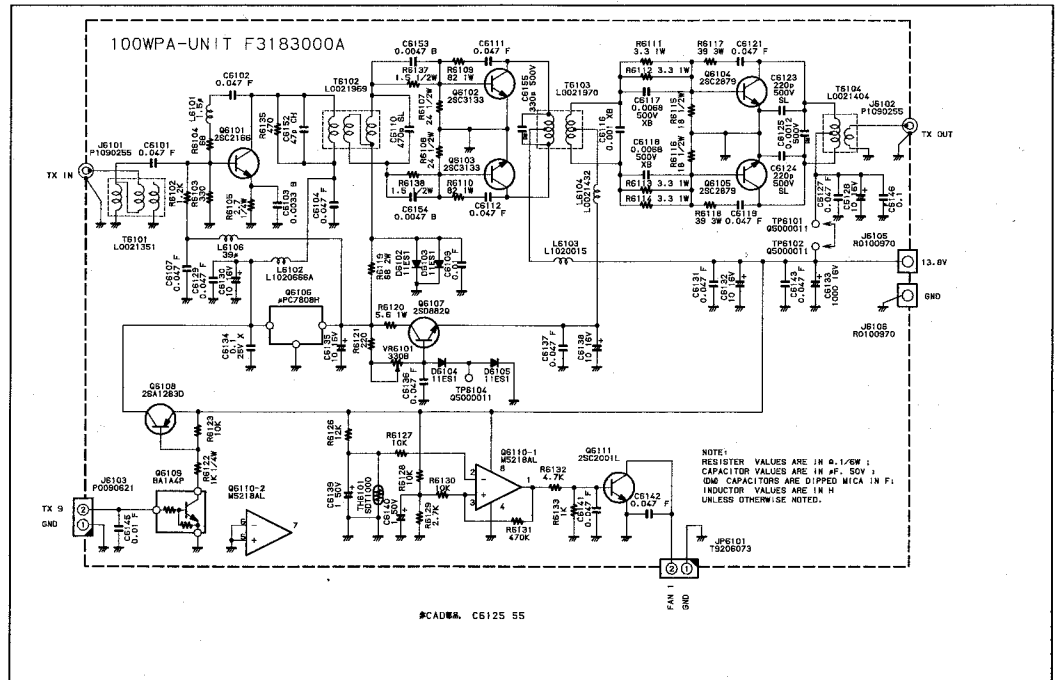
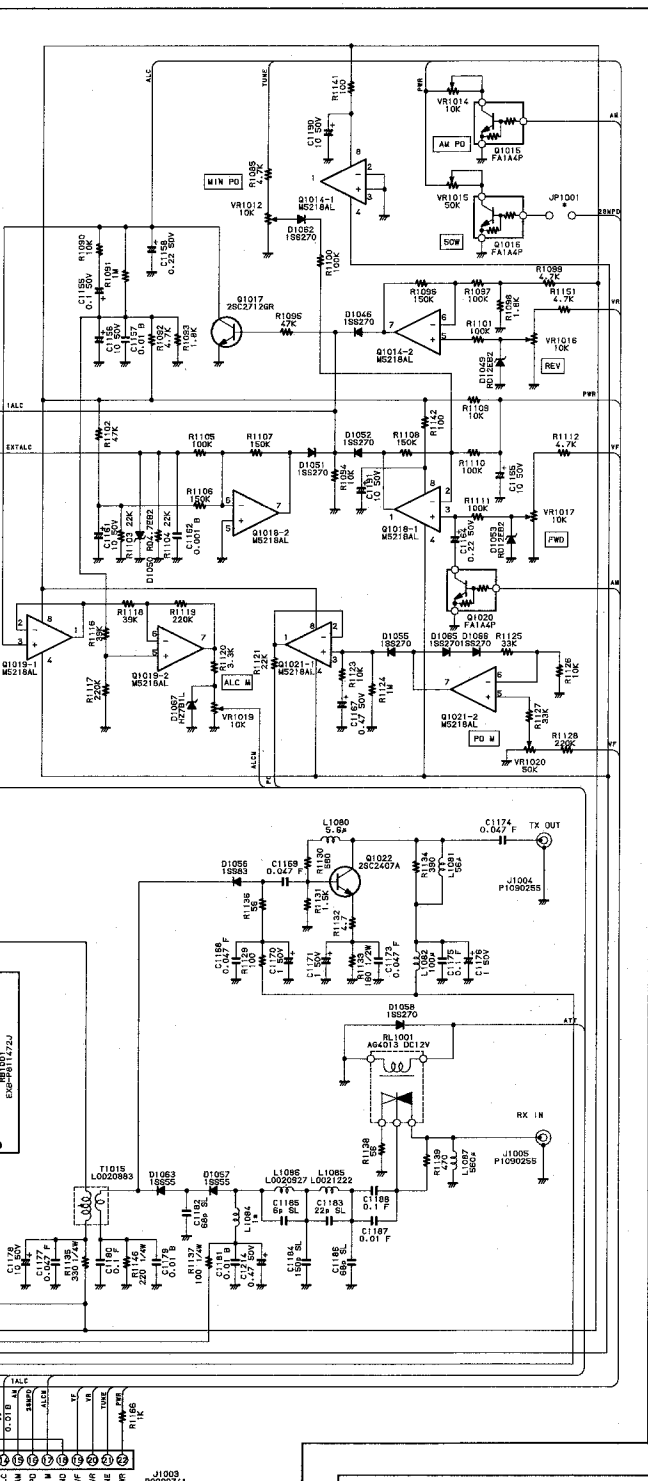


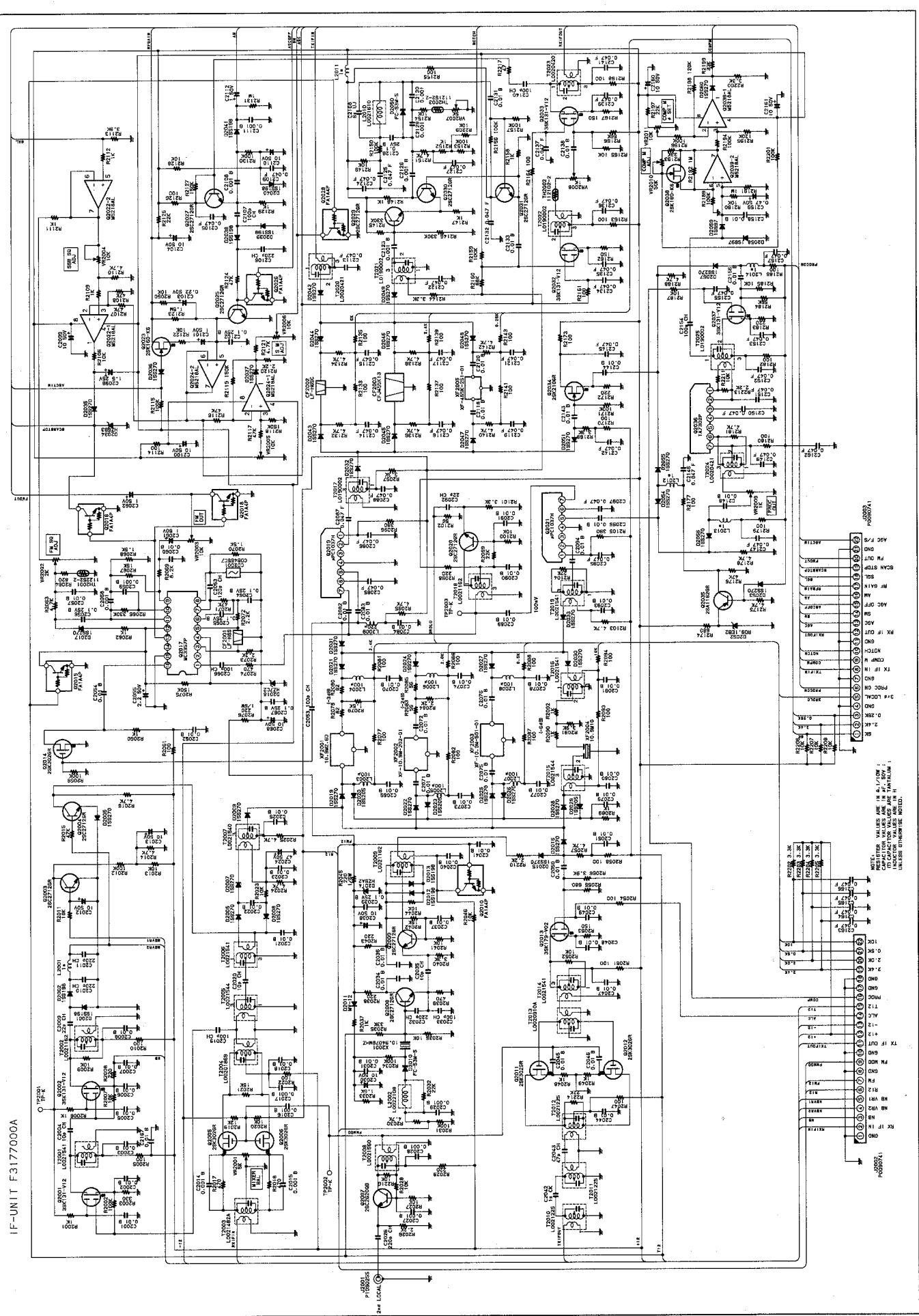


RF UNIT
F3176000A

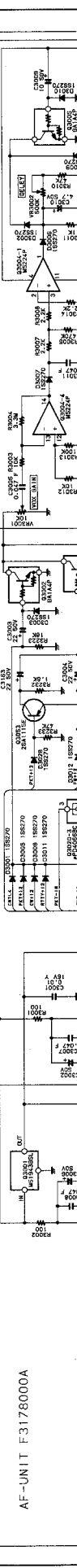
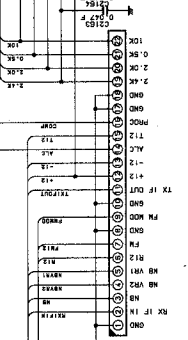


NOTE:
RESISTOR VALUES ARE IN Ω, K, M;
CAPACITOR VALUES ARE IN P, N, μF;
INDUCTOR VALUES ARE IN μH,
UNLESS OTHERWISE NOTED.

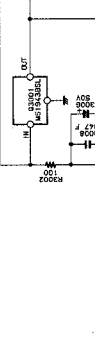




RESISTOR VALUES ARE IN Ω, K, OR M.
 CAPACITOR VALUES ARE IN P, N, OR U.
 UNLESS OTHERWISE NOTED.



RESISTOR VALUES ARE IN Ω, K, OR M.
 CAPACITOR VALUES ARE IN P, N, OR U.
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