Contents

24.5, 28 & 50-MHz All Mode Transceiver

The FT-650 is a high performance all mode transceiver providing transmission on the 24.5, 28 and 50-MHz amateur bands, and continuous general coverage reception (where legal) from 24.5 to 56 MHz. Transmitter power output is adjustable from 10 to 100 watts in CW, SSB and FM modes, and up to 25 watts carrier in AM mode. Operating from 13.8 V DC, the FT-650 is available with or without the FP-22 switching mode AC power supply, which mounts in the rear of the transceiver using a single screw.

FT-650 design incorporates a compartmentalized steel chassis with extensive use of surface mount components on individually shielded plug-in composite epoxy boards. The diecast final amplifier module and the slide-in 100% duty cycle FP-22 power supply option each have their own independent forced-air cooling systems, for greater cooling efficiency than single flow designs.

For exceptionally clean receiver and transmitter performance, the FT-650 incorporates three Direct Digital Synthesizers (DDSs) for its local oscillators (all driven by a single ±2-ppm TCXO master oscillator), and a 2-stage low noise (1.2-dB NF) front end RF amplifier with the first stage switchable from the front panel.

Two microprocessors in the FT-650 allow a simple

MEM/CH knob is easily settable for 2.5-, 5-, 10 12.5-, 15-, 20- and 25-kHz steps (with 500-kHz step always available). In addition to standard IF bandwidths, fine tailoring of the IF passband is made possible by two of the DDSs, providing selectable I bandwidths of 1.8, 2, 2.2 and 2.4 kHz in SSB mode 300, 600, 1200 and 2400 Hz in CW mode, 2.4 and kHz in AM and 8 and 15 kHz in FM modes (the two narrowest CW modes require an optional filter). I passband shift is continuously adjustable for ±1.1 kHz, and in addition to a manual IF notch filter, a automatic IF notch filter finds and notches out interfering heterodynes without operator intervention (when enabled).

Also provided are 105 scanable memories, each of which stores its own mode and IF filter selection, in addition to one frequency on each band, scan status and CTCSS tone frequency (if the optional FTS-8 Tone Squelch Unit is installed). The FT-650 holds up to 42 independent frequency, mode, clarifier and repeater settings. Two priority channel memories are included.

External options include the DVS-2 Digital Voice Synthesizer for continuous recording and instant playback of received signals, and pushbutton pre-recorded transmissions, and the MD-1C8 Desktop Scanning

Specifications

General

Receiving frequency range: 24.5 ~ 56 MHz

Transmitting frequency ranges:
12-m band, 24.5 to 25.0 MHz
10-m band, 28.0 to 29.7 MHz
6-m band, 50.0 to 54.0 MHz

Frequency stability (0 to +50°C): < ± 2 ppm SSB/CW
< ± 10 ppm AM/FM

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

Frequency steps:
10 kHz & 500 kHz for all modes;
10 Hz for J3E, A1A and A3E;
100 Hz for F3E;
2.5, 5, 10, 15, 20, 25 kHz selectable, all modes

Antenna impedance: 50Ω nominal

Supply voltage:
13.8 VDC;
110 ~ 125 or 220 ~ 234 VAC (selectable), 50/60 Hz with optional FP-22 AC PSU.

Power consumption (approx.):
2.0/18 A DC receive/100W transmit; or
55/500 VA AC receive/100W transmit (with FP-22)

Dimensions (WHD): 285 × 110 × 262 mm without feet, knobs or FP-22.

Weight (approx.): 7 kg. for transceiver,
plus 1 kg. for FP-22 PSU

Transmitter

Power output:
10 ~ 100 watts adjustable (max 50 watts AM carrier)

Duty cycle: 100% @ 100 watts, 25 °C

Modulation types:
SSB: Balanced, filtered carrier
AM: Low-level (early stage)
FM: Variable reactance

Maximum FM deviation: ± 5kHz at normal

SSB carrier suppression:
at least 40 dB below peak output

Undesired sideband suppresion:
at least 40 dB below peak output

Audio response (SSB):
better than –6 dB from 400 to 2600 Hz

3rd-order IMD: –31 dB @ 80 watts PEP, 50.1 MHz

Microphone impedance: 200 ~ 10kΩ (600Ω nominal)

Receiver

Circuit type:
triple-conversion superheterodyne
(dual-conversion for FM)

Intermediate frequencies:
13.69 and 455 kHz, 8.215 MHz (exc. FM)

Sensitivity (RF amplifier on):
SSB/CW 0.125 µV for 10 dB S/N
AM 0.5 µV for 10 dB S/N
FM 0.16 µV for 12 dB SINAD

Squelch Sensitivity (RF amplifier on):
0.2 µV SSB/CW/AM
0.125 µV FM

Selectivity:
SSB/CW/AM-narrow 2.4/4.5 kHz (-6/-60 dB)
CW narrow 600/1200 Hz (-6/-60 dB, w/optional filte
AM normal 6/18 kHz (-6/-50 dB)
FM normal 15/30 kHz (-6/-40 dB)
FM narrow 8/30 kHz (-6/-40 dB)

IF rejection: 70 dB or better (within amateur bands)

Image rejection: 60 dB or better (within amateur bands)

IF shift range: ±1.12 kHz

IF notch depth: 40 dB or better

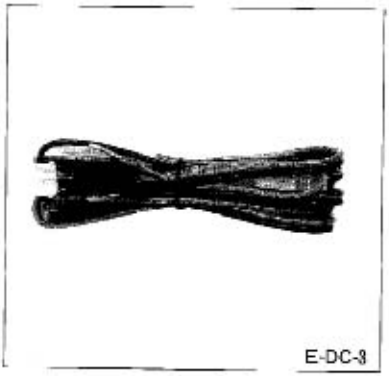
Maximum audio power output:
1.5 watts into 8Ω for <5% THD

Audio output impedance: 4 to 16Ω (8Ω nominal)

Accessories & Options

Supplied Accessories


MH-188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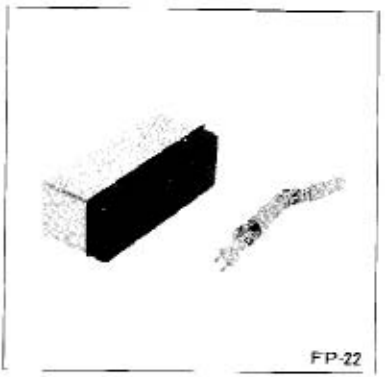

FP-22

Options

MD-1C8 Desk-Top Microphone

Designed especially to match the electrical and cosmetic features of the FT-650, the MD-1C8 has 600-Ω impedance, and includes up/down scanning buttons and a large PTT switch with latch.

SP-5 Loudspeaker with Audio Filters

Selectable audio high- and lowpass filters together with a large loudspeaker complement the superb audio characteristics of the FT-650 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 (monaural) phone jack is provided on the front panel to take advantage of the audio filters with headphones.

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 23.

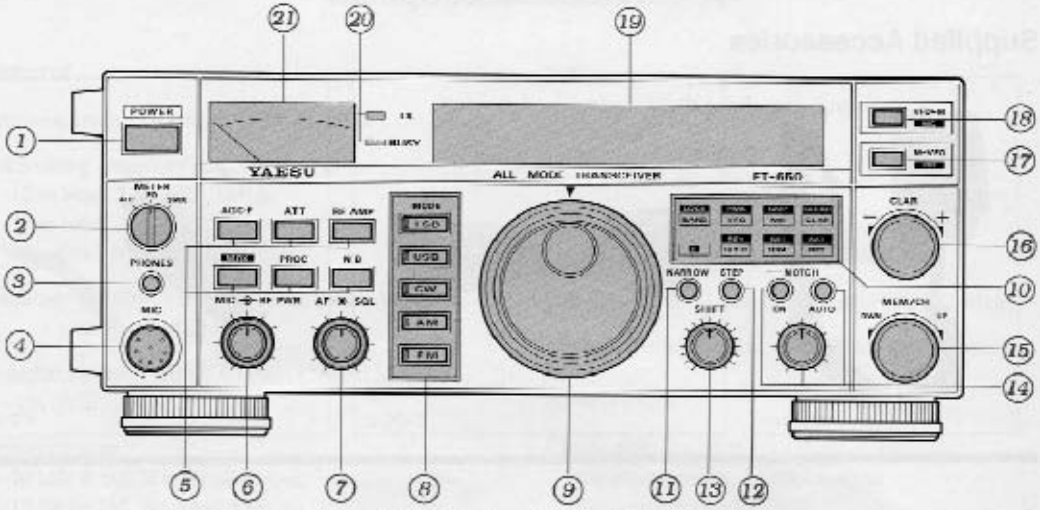
FIF-232C CAT System Interface

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.

Narrow CW IF Crystal Filter Option

The XF-455M601-01 600-Hz BW crystal filter enables both 300- and 600-Hz narrow CW bandwidths to be selected. Installation is described on page 27.

Controls & Connectors



Front Panel Controls

This chapter describes each control and connector on the FT-650. 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) METER Selector

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

ALC = relative Automatic Level Control voltage
PO = Relative RF Power Output ("8" = 100 watts)
SWR = Standing Wave Ratio (forward:reflected)

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

(3) PHONES

This 1/4-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.

(4) MIC

This 8-pin jack accepts the MD-1B8 or MD-1C8 Desktop Microphone or the MH-1B8 Handic Scanning Microphone. MIC pinout is shown on page 13. Microphone input impedance is 500 to 600 ohms.

(5) *2-Position Pushbutton Switches*

AGC-F

This button enables the fast decay rate of the receiver automatic gain control. Normally, reception will be most comfortable with fast AGC switched off, but when tuning around for weak signals on a crowded band, they may be easier to pick out from between the strong stations when this button is depressed. This button is disabled in the FM mode.

ATT

This button toggles the receiver attenuator. When activated, receiver sensitivity is reduced by about 10dB. When interference is encountered from very strong signals, and the RF AMP is already off, press this button.

RF AMP

This button toggles the receiver 1st RF amplifier on and off. When on, receiver sensitivity is increased by about 10dB. If interference is encountered from very strong signals, switch the RF

amplifier off before activating the attenuator (ATT button), if necessary.

MOX

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

NOC

This button toggles the RF speech processor on and off for SSB transmission.

This button activates the receiver noise blanker. Press to blank pulse noise such as from automobile ignitions, power lines and switching transient spikes.

⑥ MIC ◄► RF PWR

The inner MIC control adjusts the microphone input level for SSB, AM and FM 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, except in AM mode, where it is from about 5 to 50 watts.

⑦ AF ◄► SQL

The inner AF gain control adjusts the audio volume of the receiver in the speaker or headphones. The outer SQL control sets the signal level threshold at which receiver audio is muted (and the green BUSY LED turn off), in all modes. This control is normally kept fully counterclockwise, except when scanning, and during FM operation.

⑧ MODE

These five momentary buttons select the operating mode, indicated by the LED in each button. Only one may be activated at a time.

⑨ ***Main Tuning Knob***

This knob adjusts the operating frequency. Tuning increments are normally 10 or 100 Hz, according to setting of the STEP switch (except in FM mode). Fast tuning in 10-kHz steps can be enabled by pressing the yellow [F] button on the keypad. The markings on the knob represent 50 increments each, and one full turn of the knob provides 1,000 increments (10 or 100 kHz).

⑩ ***Control Keypad***

Normally, these buttons provide the primary function marked on the keyface. However, when [F] is pressed first, these buttons perform their alternate function (marked in reverse letters above each key).

[LOCK] BAND — The normal function of this key is to change bands. The 24.5, 28 and 50 MHz bands are selected by repeated presses. The alternate function of this key locks either the tuning knob ([LOCK] displayed at the lower right), or if held for ½-second, all of the mode and tuning controls on the panel ([PANEL] displayed). In either case, [F] and this key must be pressed again to unlock the control(s).

[PMS] VFO — Normally, pressing this button switches between the two vfos (VFO-A or VFO-B displayed to the left of the operating frequency). When receiving on a memory, however, this button switches from the memory to the last-used vfo. The alternate function of this button activates Programmable Memory Scanning, described in the Operation chapter.

[SKIP] MR — This button normally switches reception from a vfo to the last-used memory. When receiving on a memory, pressing this button allows you to tune the memory. The alternate function toggles the current memory for either inclusion or exclusion from memory scanning.

[CLEAR] CLAR — Press this button to toggle the receiver clarifier on and off, to enable tuning the receive frequency without affecting the transmit frequency ([CLAR] is displayed when activated). The alternate function clears (cancels) clarifier offset, so receive and transmit frequencies are the same.

Button Beeper

The beep that sounds in the loudspeaker when pressing the front panel buttons can be toggled on and off by the following key sequence:

Key →	[F]	[Alt] TONE	[F]	[Shift] TONE
Resulting Display	[F] (at right)	88.5 (TONE frequency)	bp (toggles on/off)	Display returns to normal

[REV] [SPLIT] This button normally toggles split-frequency operation: receiving on the selected vfo, and transmitting on the other vfo ([SPLIT] is displayed when active). The alternate function exchanges transmit and receive frequencies, so you can check your transmit frequency.

[SET] [TONE] If the optional FTS-8 Tone Squelch Unit is installed, this button toggles the subaudible CTCSS tone features between encode (transmit tone) only, encode/decode (transmit, plus tone squelch on receive), and off. In the encode-only mode, [T] is displayed, and in the tone squelch mode, [T] [SQL] is displayed. The alternate function of this key allows setting the frequency of the CTCSS tone. However, this key can also be used to toggle the button beeper as described in the box on the previous page.

This button normally toggles repeater offset of the transmitting frequency between plus (above), minus (below) and simplex (equal) relative to the receiving frequency. [–] or [+] is displayed when repeater offset is active. The alternate function is used to select the desired repeater offset, when different from the default. See the Operating chapter for details.

(11) NARROW Button

This momentary button enables a narrow IF bandwidth for the current mode. The narrow bandwidths for AM and FM are fixed, while for CW and SSB modes, you can select from several choices by pressing [IF] first and then turning the MEM/CH knob. NARROW is displayed when the narrow bandwidth is active. Available bandwidths are:

Mode	Wide BW	Narrow Bandwidth(s)
LSB & USB	2.4 kHz	1.8, 2.0, 2.2, 2.4 kHz
CW	2.4 kHz	300*, 600*, 1200 Hz, 2.4 kHz
AM	6 kHz	2.4 kHz
FM	15 kHz	8 kHz

* requires XF455M601-01 optional filter

(12) STEP Button

This momentary button toggles the main tuning knob steps between 10 and 100 kHz in SSB, CW and AM modes. The 100-kHz selection allows fast tuning. The 100-kHz steps of the FM mode are unaffected by this button.

(13) SHIFT Control

In all modes except FM, this knob shifts the IF passband down (counterclockwise) or up (clockwise) from the IF center frequency. Normally this control is kept in the 12-o'clock position, except when interference is present from a signal on a nearby frequency.

(14) NOTCH Two-Position Pushbuttons & Control

The ON button turns the IF Notch on (▂) and off (▁). With the ON button depressed (▂) and the AUTO button off (▁), the NOTCH control can be used to manually tune the notch frequency within the passband. For SSB reception, when both buttons are on, the Notch circuitry will automatically suppress a heterodyne if stronger than the desired signal (in this case, the NOTCH control is disabled).

(15) MEM/CH Knob

When receiving on (or storing) a memory, turning this knob selects another memory. When receiving on a vfo, this knob tunes the receiver in operator-selectable steps, or in 500-kHz giant steps if [IF] is pressed first. This knob is also used for setting the sizes of the operator-selectable tuning steps, repeater offsets, and CTCSS tone frequency when used in conjunction with other keys and buttons, as detailed in the *Operation* chapter.

(16) CLAR Control

When the clarifier (receiver offset) function is activated by the button with the same name, this control allows tuning of the receiver independently from the transmitter.

(17) M▷ VFO Button

When receiving on a memory, holding this button for 1/2-second copies the frequency and mode data from the memory to the last-used vfo, and also shifts operation to the vfo (as opposed to the memory) mode. Previous data in the vfo is overwritten. Pressing this button while operating on a vfo does nothing.

The alternate ([PRI]) function of this key (after pressing [IF]) activates PRIority monitoring, in

Digital Display Annunciators

which the receiver checks for activity on special memories P1 and P2 while operating on a vfo or other memories. Details are on page 22.

⑱ V/M Button

The main function of this button is to store the currently displayed frequency and mode (from a vfo or memory) into a memory. Pressing it momentarily causes the memory number to the right of the frequency to blink for a few seconds, during which you can turn the MEM/CH knob to select a memory number for storage. Holding this button for $^1/_2$-second transfers (writes) the current frequency and mode data into the selected memory channel, *overwriting any previous data stored there.*

The alternate ([MC]) function of this button clears (deletes) all data in the selected memory when receiving on the memory.

⑲ ***Digital Display***

In addition to the operating frequency, the display shows the current status of practically all transceiver functions, as indicated above.

⑳ TX and BUSY LED Indicators

The TX LED glows red when the transmitter is activated. The BUSY LED glows green when the squelch is open (while receiving).

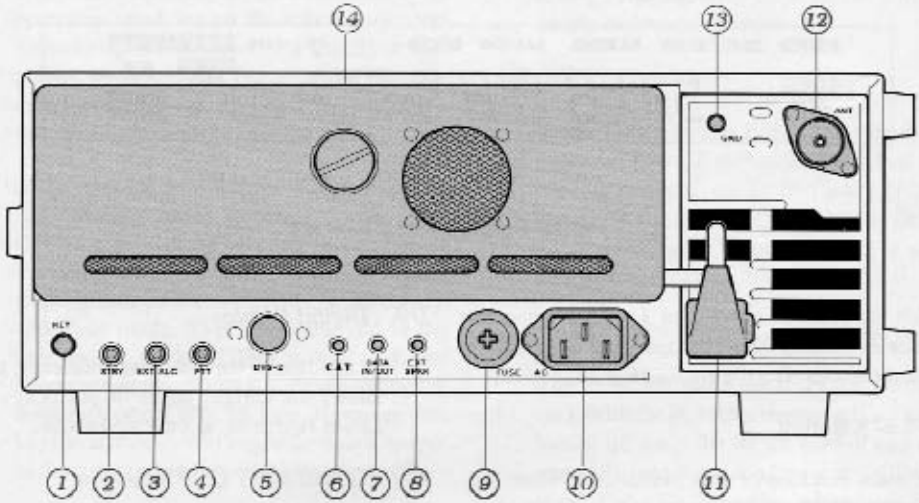
㉑ ***Meter***

The 4-function multimeter normally indicates receiver signal strength on the top scale, and one of three parameters (selected by the METER selector) during transmit on the lower scales.

M0290059

PO Meter Peak/Average Selection

The meter can be set to indicate either peak or average power when the selector is set to the PO position (the scale markings, however, are relative). See the section on Internal Settings on page 12 for the location of the Peak Hold/Normal (average power) selection switch.



Rear Panel

① KEY 3-Contact Phone Jack

This 1/4-inch phone jack accepts a CW key. *A 2-contact plug cannot be used in this jack.* Key-up voltage is +5 V, and key-down current is 0.5 mA. Pinout is shown on page 13.

② STBY Phono Jack

This output jack connects inside the transceiver to a switching transistor, which conducts to chassis ground whenever the transmitter is active, to provide transmit/receive switching of an external device such as a linear amplifier. Maximum ratings for this jack are 300 mA @ +24 V DC (the center contact must be positive). *Before connecting an external device, make sure its switching requirements will not exceed these limits.*

If your amplifier requires higher current, or has higher voltage switching requirements or different polarity, an external switching device such as the Yaesu FRB-757 Relay Box must be used, and may be connected here.

③ 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. Acceptable input voltage range is 0 to –1.5 V DC.

④ PTT Phono Jack

This input jack may be used to key the transmitter manually using a footswitch or other switching device. Its function is identical to the MOX button on the front panel. Open-circuit voltage is +5 VDC, and closed-circuit current is 5 mA.

⑤ DVS-2 DIN Jack

This 7-pin input/output jack is for the DVS-2 Digital Voice Recorder option, described on page 23.

⑥ CAT Mini Phone Jack

This 3-contact input/output jack provides output of the squelch Busy status (ring contact), and accepts serial commands to control the FT-650 from an external computer (center contact). Signal levels are TTL (0 and 5V DC). The signalling protocol and data formats are described in the CAT chapter near the end of this manual.

⑦ DATA IN/OUT Mini Phone Jack

This 3-contact input/output jack provides receiver audio (ring contact) for, and accepts AFSK transmitter audio (center contact) from a packet tnc. 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* on page 12 for how to gain access to this trimmer, if necessary).

⑧ EXT SPKR Mini Phone Jack

This 2-contact output jack provides receiver audio for an external loudspeaker, such as the SP-5. The AF control on the front panel affect the volume here. Inserting a plug into this jack disables the internal loudspeaker. Impedance is 4 to 16 Ω.

⑨ FUSE Holder

When the FP-22 AC Power Supply is installed on the transceiver, this holder requires an 8-A fuse for operation from AC voltages below 125 V, and an 4-A fuse for AC voltages of 200 V and above. Only normal fast-blow type fuses should be used.

Note! The AC Supply is also protected by two internal fuses. All three must be changed if changing the supply voltage. See page 10.

⑩ AC Line Cord Socket

When using the FP-22 AC Power Supply, connect the supplied AC line cord to this socket after ensuring that your AC mains voltage matches that on the label. See page 10 for instructions on how to change the AC supply voltage for the FP-22, if necessary.

⑪ DC IN Socket

This 6-pin connector requires a 13.8-volt supply capable of 20 amperes continuous duty. For base station operation, the FP-22 power supply mounted on the back of the transceiver provides the required voltage. For DC operation, use the Yaesu E-DC-3 DC Cable with two 20-A fuses.

⑫ ANT Coaxial Jack

Connect your antenna here using a type-M (UHF, PL-259) plug and coaxial cable. Antenna impedance must be close to 50Ω for proper performance.

⑬ GND Terminal Post

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

⑭ FP-22 AC Power Supply (option)

The FP-22 Switching Regulator AC Power Supply installs here on the rear panel. AC input is provided via the AC socket and fuse, and the output pigtail connects to the DC IN jack. See the Installation chapter for details on setting the correct AC voltage range when installing the FP-22.

Power Up Selections

By pressing and holding certain buttons while switching on the FT-650, you can perform several functions and make some simple settings.

To reset the microprocessors and clear all memories, turn the transceiver off, and hold the VFO►M and M►VFO buttons (at the upper right) while switching the transceiver back on. 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 it is not necessary to turn off the memory backup to reset the microprocessors, but that doing so *will erase all memory contents.*

To perform the "Las Vegas" diagnostic test of the display and its microprocessor, pressand hold [F] while switching on the transceiver. This will not erase any memorized data or other settings. All of the display segments will be turned on, and then cycled through a test pattern. After a few seconds, the display will return to normal.

To adjust the display brightness, press and hold [SET] TONE and [SET] RPT while switching the transceiver on. Several of the display segments will blink (the decimals, CH and a small bell), and the memory indicator will show a number between 01 and 08, which in this situation indicates the current display brightness level (01 is the dimmest). Just turn the MEM/CH knob while the segments are blinking to change the brightness level. After a few seconds, the display will return to normal.

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 have purchased optional internal accessories separately, install them as described in Chapter 6 (page 26).

Power Connection

The FT-650 is designed for operation from 13.8 V DC, requiring up to 20A continuous current. This may be supplied by the optional FP-22 AC Power Supply, which attaches to the rear panel, or by a DC source such as an automobile electrical system or an external AC power supply.

In any case, before connecting power, ensure that your power source is capable of providing the necessary current, and for AC operation, confirm the power supply and fuses are correct for your mains voltage.

AC Operation with the FP-22

If your transceiver is supplied with the FP-22, a label on the FP-22 indicates the AC mains voltage range for which the transceiver and FP-22 are currently set. If your AC mains voltage is outside of this range, a switch in the FP-22 must be reset, and *three* fuses in the transceiver must be changed. The procedure is described on the next page. If you have any doubts about the procedure or do not have the required fuses, contact your dealer for assistance.

Regardless of the voltage label, we recommend that you open the fuse holder on the rear panel, and make sure that the fuse is correct for your mains voltage:

AC Mains Voltage	Fuse Capacity
100 to 125 V	8 A
200 to 234 V	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. Wait until all other transceiver interconnections have been made before connecting the other end of the power cord to the wall outlet.

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. Use extreme care when making power connections.

DC Power (Mobile, or External AC Supply)

A double-fused DC power cable (model E-DC-3) is supplied with the FT-650. This cable should be used when powering the transceiver from a DC source, such as an automobile battery, or from an external AC power supply. Confirm that two 20-A fuses are installed, one in each side of the cable.

For mobile installation, before connecting the power cable the maximum battery charging voltage should be checked to ensure that it remains below 15V when the engine is run fast. If more than 15V is found, the voltage regulator of the car should be adjusted before connecting the transceiver.

The cable should be connected directly to the vehicle battery, RED wire to the "+" terminal, and BLACK wire to the "–" terminal. Route the cable as far as possible from the car's electronic ignition/control circuitry, if present, but also try to keep the cable as short as possible to avoid excessive voltage drop during transmissions. *Do not attempt to run the FT-650 from the cigarette lighter or other circuitry.* If the cable is not long enough, extend it using stranded, insulated wire of the same size or larger than the supplied cable, and make sure the splices are well soldered and carefully insulated with plastic sleeving or tape.

For operation from an external AC supply, make sure the supply is set properly for your AC mains voltage, and use the fused cable supplied with the transceiver to make the connections. Be absolutely certain that the RED wire connects to the POSITIVE supply terminal, and the BLACK wire to the NEGATIVE supply terminal, before plugging in the supply.

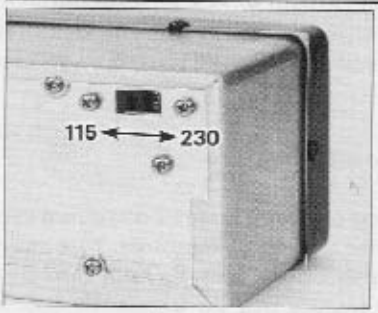
Changing the AC Voltage Range

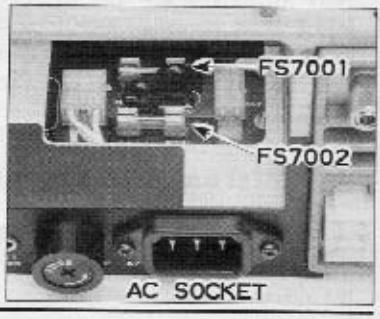
The AC voltage range for which the transceiver and FP-22 are set should be marked on the rear panel. If your AC mains voltage is not in this range, the FP-22 must be switched to its alternate range, and *three* fuses in the transceiver must be replaced.

- ☐ Remove the 6 screws affixing the top cover, and remove the cover.
- ☐ Using a large coin, loosen the large screw in the center of the FP-22 on the rear panel, and pull the FP-22 out of the transceiver chassis.
- ☐ Referring to the photo at the right, move the AC range switch to the **115** position for operation from 100 to 125 VAC, or to the **230** position for operation from 200 to 234 VAC.
- ☐ Locate fuses FS7001 and FS-7002 just inside the AC socket at the rear of the transceiver, and replace them with 10A fuses if your mains voltage is 100 to 125 VAC, or with 5A fuses if your mains voltage is 200 to 234 VAC.
- ☐ Remove the fuse from the fuse holder in the rear panel of the transceiver, and install an 8A fuse for 100 to 125 VAC operation, or a 4A fuse for 200 to 234 VAC operation.
- ☐ Replace the FP-22 in the rear panel, and tighten the large screw.
- ☐ Replace the top cover and its six screws.

Important!

If you change the AC voltage range, make sure to also change the voltage marking on the label on the rear panel to match the new voltage setting. Also, make certain that all three fuses in the transceiver have been changed if you change the setting of the FP-22, as indicated in text above. Do not use slow-blow type fuses.





Transceiver Location

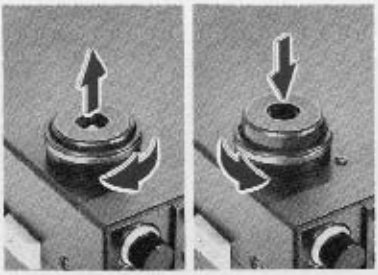
To assure long life of the components, a primary consideration in setting up the FT-650 is providing for adequate ventilation around the cabinet. The cooling system of the FT-650 must be free to draw cool air in at the left side and, if the FP-22 is installed, at the lower rear of the transceiver, and to expel warm air out of the upper rear panel. Provide a few centimeters (an inch or more) of space for cool air intake at the left side of the transceiver. 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. Also, avoid heating vents and window locations that could expose the transceiver to direct sunlight for long periods, 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-650, you may need to experiment with ground wire routing and computer grounding to suppress computer noise in the receiver.

Adjusting the Front Feet

The two front feet of the FT-650 can be set in either of two positions. By turning the knurled ring around a (retracted) foot clockwise, the middle of the foot will



Adjusting the Front Feet

extend about one centimeter. Turn the ring as far as it will go (about 1/4-turn) to lock the extended foot in place. To retract an extended foot, turn the knurled ring counterclockwise 1/4-turn while pressing on the center of the foot.

Antenna Considerations

Any antenna connected to the FT-650 should have a coaxial feedline with 50-Ω impedance. Base antenna systems should include a well-grounded lightning arrestor in the feedline near the transceiver. Optimum performance for both reception and transmission requires an antenna designed to provide a 50-Ω unbalanced resistive load at the operating frequency. An antenna that is not designed for resonance at the operating frequency may present too high an SWR, in which case power output will be reduced. Operation under such conditions is not recommended: the antenna itself should be readjusted, an antenna matching unit ("tuner") employed, or another antenna designed for that band should be used.

Interconnection of Accessories

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

Memory Backup

The FT-650 retains memory and vfo data (although no actual control programming) in CMOS RAM backed up by a lithium battery. The current drawn from the battery is miniscule, so it is kept on all the time.

After five or more years the transceiver may fail to retain memories, at which time the lithium battery should be replaced. Contact your dealer for replacement of the battery, or for instructions on how to do so yourself.

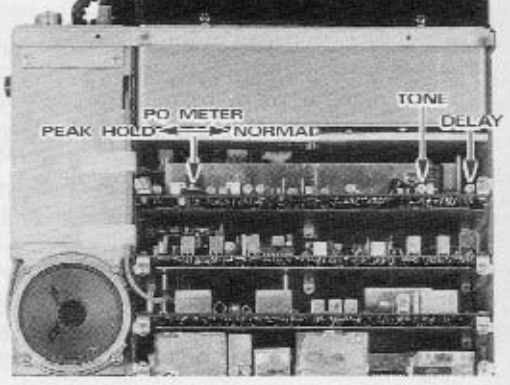
Internal Adjustments: Beeper/Sidetone Volume & CW Hang Time

To suit individual preference, the beeper/sidetone volume and CW hang time can be adjusted by removing the top cover as shown at the right.

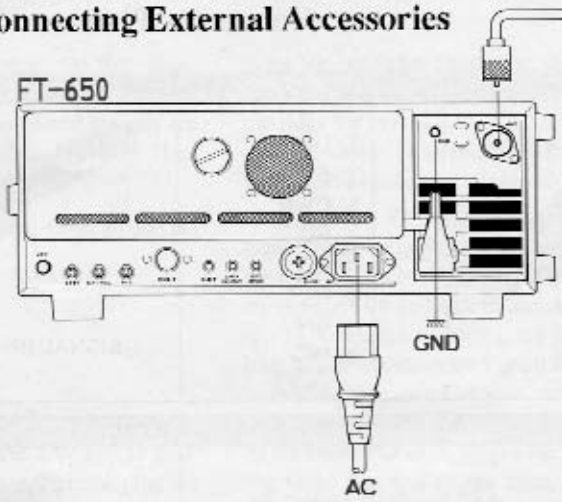
To se the key beeper/sidetone volume, adjust the **TONE** trimmer potentiometer while repeatedly pressing a key on the front panel (or your CW key, with the RF PWR control set to minimum). This adjustment is independent of the AF control.

To adjust the CW hang time, set the RF PWR control to minumum, and adjust the **DELAY** control while sending some CW phrases at your normal speed, so that the transmitter remains keyed between letters and phrases.

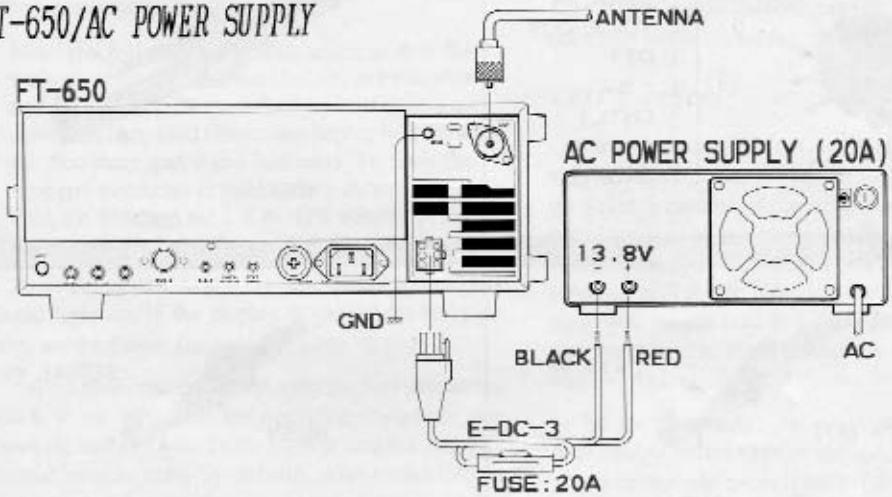
> ### *CAUTION*
>
> *These adjustments must be made with power applied, and with the cover removed. Although the voltages at exposed places in the transceiver are not dangerous to you, sensitive circuitry can be damaged by contact with metallic tools. Therefore we recommend using a non-metallic adjustment 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.*



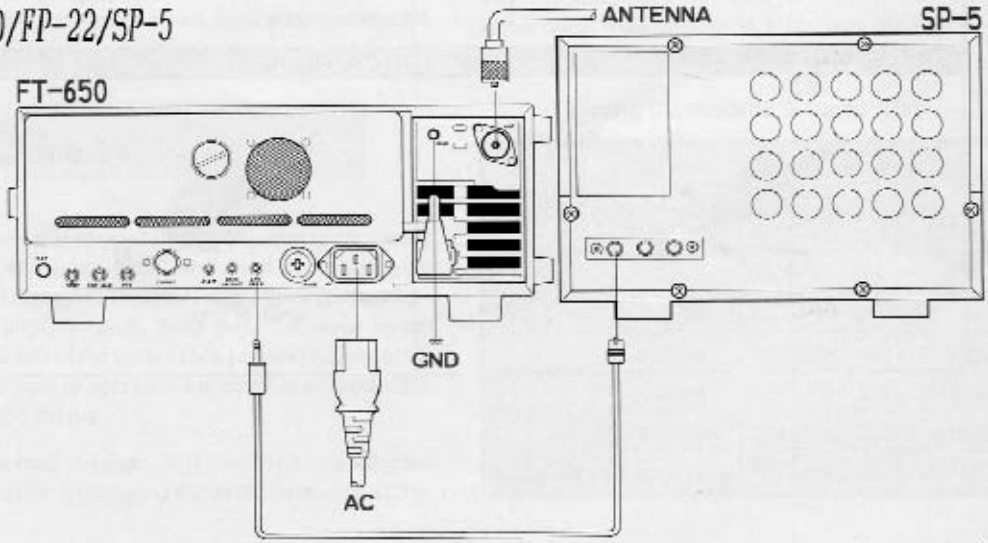
FT-650/FP-22



FT-650/AC POWER SUPPLY

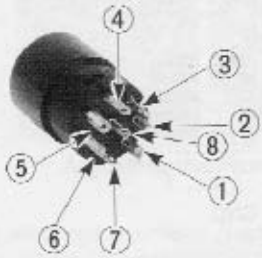


FT-650/FP-22/SP-5



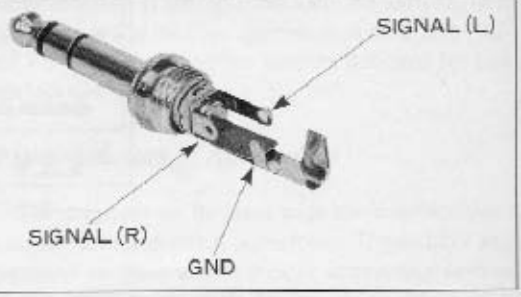
Connector Pinouts

MIC

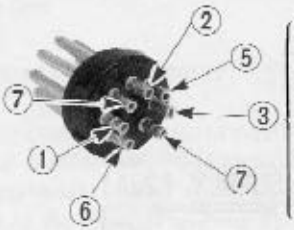


① UP
② 5V
③ DWN
④ NC
⑤ NC
⑥ PTT
⑦ GND
⑧ MIC

PHONES

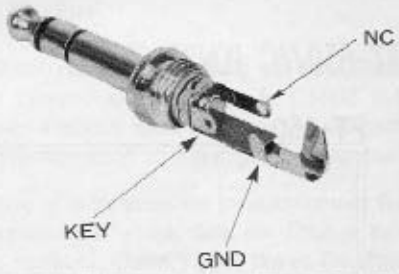


DVS-2

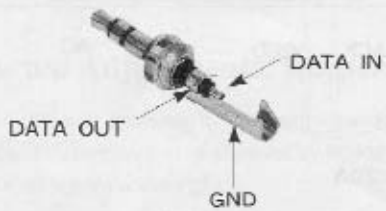


① VOICE IN
② VOICE OUT
③ PTT
④ +9V
⑤ CNTL1
⑥ CNTL 2
⑦ GND

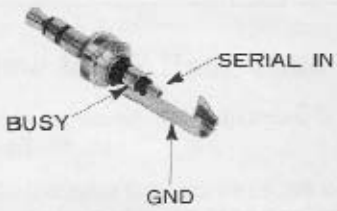
KEY



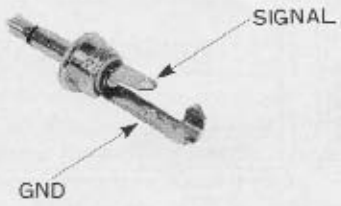
DATA IN/OUT



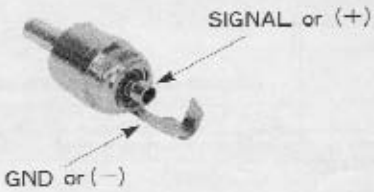
CAT



EXT SPKR



RCA PLUG



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:

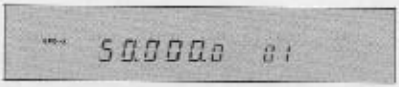
- ☐ POWER, and the six buttons under the meter all off (▬)
- ☐ MIC, RF PWR, and SQL all counterclockwise
- ☐ AF 10 o'clock
- ☐ SHIFT 12 o'clock (centered)
- ☐ NOTCH ON and AUTO switches off (▬)

Connect your microphone and/or CW key or paddles, and then, if operating from the AC mains, plug the AC cord into the wall outlet.

Note: the following procedure assumes that the transceiver has not been used before, and that vfos and memories are in the default state. If the transceiver has been used before, the display will show the frequency and status last used. To reset the vfos and memories to their factory default states, hold the V/M ▷ Band M ▷ V/M buttons at the upper right when switching the transceiver on.

Press the POWER switch on. The meter and display should light up. If the display is too bright for your taste, see the *Power Up Selections* box on page 9.

Take a moment to study the display. You should see VFO-A at the left, with the operating frequency just above the tuning knob. To the right of that is a memory channel number (01 by default). Also notice that an LED in one of the MODE keys is lit (default USB), and that the green BUSY indicator glows, indicating that squelch is open.



Press the [100K] keypad key (to the right of the tuning knob), if necessary, to select a band for which your antenna is designed. This key rotates through the 24.5-, 28- and 50-MHz bands. Next press the mode button (just to the left of the tuning knob) corresponding to the mode you wish to operate – for now, we suggest USB, which is the default.

The normal 2.4-kHz SSB bandwidth is selected, unless NARROW is displayed above the frequency. If it is, press the NARROW button (to the right of the tuning knob) to turn it off for now. The (wide) bandwidth provides the best fidelity for SSB reception, so should be used unless interference from stations on adjacent frequencies becomes a problem (as described later).

Adjust the AF control for comfortable volume on signals or noise in the loudspeaker or headphones. Now try the tuning controls: the main tuning knob and the microphone UP and DWN buttons normally provide fine tuning, while the M-CH knob provides channel stepping at convenient rates. For coarser (×10 steps) tuning in modes other than FM with either the tuning knob or microphone buttons, press the STEP button to the right of the knob. For even bigger steps, such as when moving from one end of the band to another, press the yellow [F] button before tuning. The table below shows all available tuning rates.

VFO Scanning

Two scanning methods are available: endless, and stop-on-signal. You select the scanning method with the squelch control: if the squelch is open (green BUSY indicator next to the meter on), endless scanning will result; if the squelch is closed (BUSY off), stop-on-signal scanning will result. Note that for stop-on-signal scanning, you should tune to a clear frequency before setting the squelch, if you want the scanner to stop on weak signals.

To start scanning, just press and hold one of the microphone buttons for ½-second. Release the microphone button and press it again (or the PTT switch) to stop. If scanning is left running, it will loop through the entire range from 24.5 to 56 MHz. You can select the scanning speed with the STEP button.

Tuning Increments & Steps (Hz)

Control ⇓	Mode ⇒	LSB, USB, CW, AM			FM	
	STEP button or [F] ⇒	Normal	STEP on	F on	Nor or STEP	F on
Tuning knob	min. step size	10	100	10k	100	10k
	per knob mark	500	5k	500k	5k	500k
	per rotation	10k	100k	10M	100k	10M
M-CH knob	per click	2.5k	2.5k	500k	5k	500k
	per rotation	62.5k	62.5k	12.5M	125k	12.5M
Microphone UP/DWN buttons		10	100	10k	5k	500k

Tuning Knob & Panel Locking

For mobile operation, you may want to lock the tuning knob (by pressing [F] and [LOCK BAND]) once a stations is tuned in, to avoid loosing him by accidentally bumping the tuning knob. Remember to press the same keys again to unlock the knob when you want to retune.

You can also lock most of the controls on the panel by holding [LOCK BAND] for a half second after [F]. Remember to press the same keys again to unlock the knob when you want to retune.

Note: pressing [F] starts a 5-second timer, which displays [F] while the timer is running. This timer resets each time another key is pressed or the frequency is changed, causing the special "alternate" functions to be active until 5 seconds after the last key (or tuning) action. The timer can be stopped before the end of the 5-second period by pressing [F] again, the PTT switch or any MODE button, returning the keys and tuning knob to their regular functions.

General Coverage Reception (24.5 – 56 MHz)

You may have already noticed that you can tune outside one of the amateur bands (above 25 MHz or below 50 MHz), to receive any frequency between these bands. However, the transmitter is disabled outside of the amateur band ranges, and if you try to transmit, the display shows Error.

Also, such frequencies are ignored by the band selection key: if you tune a vfo to a frequency outside of a ham band, you will have to switch vfos or store it in a memory (as described on page 20) if you want to be able to recall it quickly later. Otherwise, as soon as you press the band key, the general coverage frequency will be lost as the vfo reverts to the (ham-band) frequency it was on when the band was last changed.

Once you become familiar with the memories, you will find this really doesn't present a problem, as each memory can be tuned just like the vfo, and stored into another channel without having to go through the vfo.

Dealing with Interference

The FT-650 includes several special features to suppress interference that may be encountered on the low VHF bands. Real world interference 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.

Attenuation & RF Amplifiers

Once you have selected a band for operation, you may want to set the receiver front end and IF stages for optimum performance, using the AGC-F, ATT, RF AMP and NB buttons below the meter. The best selection will depend on the type and level of noise, how busy the band is, and whether or not you want to hear very weak signals.

Of course, if you hear pulse noise such as from automobile ignition systems, press the NB button (▂). Otherwise, reception is likely to be better with this button off (▁). If you're going to tune around for (non-FM) weak signals, press AGC-F. This allows receiver gain to recover quickly after a noise pulse or tuning through a strong signal. However, once you've tuned in a voice station, return this button to the off (▁) position for most comfortable copy (in CW, you may want to leave it on all the time). Neither the AGC nor noise blanker are used in FM mode, since the FM circuitry limits all signals and noise to the same amplitude.

The ATT and RF AMP buttons allow you to tailor receiver gain in all modes for optimum sensitivity. The effects of these buttons are similar, but not identical. Three levels of gain are available: the middle level is selected when both buttons are off (▁). Pressing only ATT reduces sensitivity by about 10 dB (with a resistive network in the receiver front end), pressing RF AMP increases gain by about 10 dB (by switching in a second RF amplifier stage). Note that having both buttons depressed at the same time (not recommended) results in about the same gain as leaving both out, but with a lot of extra circuitry in the signal path.

If the front end is set for too much gain, background noise and very strong signals on other frequencies may make listening difficult, especially for weaker signals. On the other hand, if the front end is set for too little gain (or too much attenuation), very weak signals will not be heard either.

If background noise or intermodulation products from strong signals causes the meter to deflect on clear channels, press ATT. Otherwise, if you're looking for weak signals and the band is quiet, press RF AMP. Once you have tuned in a station you want to work, you may want to switch off the RF AMP or activate the ATT, as this

make reception of the desired station more comtable, important especially in long QSOs.

Bandwidth and Shift Adjustment

Once you have tuned in a signal you are going to en to for a while, if you hear interference from tions on nearby frequencies, press the NARROW button select a narrower IF bandwidth, and turn the SHIFT ntrol, if necessary, to suppress the interference. The ect of these controls varies somewhat from mode to de, and in SSB and CW, according to which narrow dwidth you have selected (see the box below).

Notch Filter (not used in FM mode)

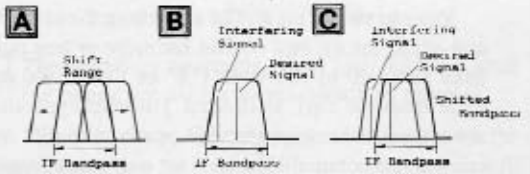
After tuning in a desired signal, selecting the IF dwidth and adjusting the shift, if heterodyne interence is heard, activate the IF notch filter by pressing NOTCH button. Unless the heterodyne is very weak too far from the center of the passband, you can also ss the AUTO button, which will automatically seek t and null the heterodyne. Otherwise, leave the AUTO tton off (▬), and adjust the manual control just be- the buttons to null the heterodyne. Note that if the erfering heterodyne is more than about 1.2 kHz away m the center of the passband, the notch filter may be able to null it. In this case, switch the notch filter off, d readjust the IF shift so that the heterodyne is out-

Choosing Narrow SSB & CW IF Bandwidths

While the narrow AM and FM IF bandwidths are preset to 2.4- and 8-kHz, respectively, you can choose the narrow IF bandwidth you want to have activated in the other modes by the NARROW button. Possible selections are shown in the table on page 6. To check or change the current selection, press [F] before the NARROW button. The frequency display will be replaced with the current narrow IF bandwidth for the current mode (whether or not the narrow bandwidth is actually in use at that time), and you can turn the NEW/CW knob to select another bandwidth. To return the display to normal, press the NARROW button again, by itself.

Note that you can do this after activating the narrow bandwidth ("NARROW" displayed) so that any new selection will take effect immediately, and you can hear the result.

IF Shift Adjustment



side of the passband. While the auto-notch function is active, the notch control provides fine tuning of the (automatic) notch frequency.

Transmitting

The transmitter can be activated in the amateur band ranges of 24.5 ~ 25 MHz, 28 ~ 29.7 MHz, and 50 ~ 54 MHz. If the transmitter is keyed on any other frequency, Error is displayed in place of the operating frequency, and the transmitter is disabled. However, you should also restrict transmissions to the frequencies for which your antenna is designed.

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.

Whenever the transmitter is activated, the FT-650 automatically detects any reflected power that might appear at the antenna jack (as a result of an impedance mismatch), and reduces power output if too much reflected power is found. Although this protection system should prevent any damage to the transceiver, we still recommend that you avoid transmitting without having a proper antenna connected to the ANT jack.

SSB Transmission

To transmit in LSB or USB mode:

- ❒ Make sure the appropriate mode indicator is lit, and set the METER selector to the ALC position.
- ❒ If this is the first time you are transmitting SSB with the FT-650, preset the MIC and RF PWR controls to about the 12-o'clock position.
- ❒ Press the PTT (push-to-talk) switch on your microphone, and talk.

To determine the optimum setting of the MIC control for your microphone, adjust it while speaking into the microphone (at a normal level) so that the meter deflects to about midrange on voice peaks (the upper end

of the blue ALC range). Once found, this setting can be left as it is 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 ("8" 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.

Once the proper MIC control setting has been determined, you can activate the speech processor by pressing the PROC button to increase the average power of your signal.

CW Transmission

With your CW key or external keyer connected to the KEY jack on the rear panel, just set the METER selector to the PO position and use the RF PWR control to set your output power while the key is closed.

The FT-650 provides semi break-in CW with a sidetone oscillator, 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 open the key, and the volume of the CW sidetone in the loudspeaker, by adjusting the internal DELAY and TONE trimmer potentiometers (see page 12).

AM Transmission

Power output in the AM mode must be limited to 50 watts, since both sidebands plus a carrier must be transmitted.

- ❒ Set the METER selector to the PO position, and preset the MIC and RF PWR controls to their 12-o'clock positions.
- ❒ Press the PTT switch on the microphone to transmit, and use the RF PWR control to set your output power up to 50 watts: the maximum safe meter indication in the AM mode is mid-scale ("4" on the PO scale).
- ❒ To optimize your modulation, speak into the microphone while advancing the MIC control just to the point where slight movement of the meter can be seen. Don't set it beyond this point or your signal will become distorted from overmodulation.

Note that the speech processor is disabled in the AM mode.

FM Transmission

The MIC control sets your deviation in the FM mode, so it will need to be set carefully.

- ❒ Select the FM mode, preset the MIC control to 12 o'clock, RF PWR to maximum, and set the METER selector to the PO position.

FM Repeater Operation

The FT-650 includes several features specifically intended for operation on FM repeaters in the 29.6 – 29.7 MHz and 52 – 54 MHz subbands.

To locate these repeaters, you can ask around the calling channel (29.6 or 52.0 MHz), or you may want to load a block of memory channels (page 20) with the standard repeater channels on these bands. Then set the squelch so that the receiver is silent on a clear channel, and hold one of the microphone keys to start scanning the memories (see the example on page 21).

When you find a repeater, press the key, once for " " shift (to transmit below your receiving frequency). Pressing it again will select "+" shift (not commonly used on these bands). Press it once more to return to simplex. Default shifts are 100 kHz for the 10-meter band, and 1 MHz for the 6-meter band. You can change these as needed by pressing [F] and [SHIFT], tuning a new shift, and pressing [SHIFT] again.

Try a quick identification transmission to make sure you have the shift set correctly.

Once you have made contact through the repeater, you can store the frequency, mode and repeater shift settings in memory (page 20) for later recall.

If repeaters you wish to use require a subaudible CTCSS tone, you can install the FTS-8 Tone Squelch Unit, as described on page 26. Operation of the FTS-8 is described on page 24.

- ❒ Close the PTT switch and, while speaking into the microphone, adjust the MIC control so that the BUSY LED just blinks on voice peaks. This sets your deviation to 5 kHz.
- ❒ Don't forget to reduce your power with the RF PWR control (if you need full power, you should keep your transmissions to three minutes or less, with the same time for reception).

Clarifier (Receiver Offset Tuning)

The CLEAR CLAR key and the CLAR control are used to adjust the receive frequency independently from the transmit frequency, typically to fine tune a station after establishing contact. On the FT-650, these controls allow you to store a particular offset (up to 9.99 kHz) and then to reactivate it later.

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

- ❒ Press the CLEAR CLAR key and turn the CLAR control back and forth while watching the display frequency. The tuning rate and 10-Hz steps of the CLAR knob are the same in all modes, but if you turn the main knob or the MEM/CH selector while the clarifier is active, their steps will be the same as if the clarifier was off.
- ❒ With the clarifier offset to some frequency other than that on which you started, close the PTT switch and notice the displayed frequency shifts back to its original spot while transmitting.
- ❒ Press CLEAR CLAR again to turn the clarifier off. Notice that the offset disappears.
- ❒ Now retune with the main knob or MEM/CH selector, and press CLEAR CLAR once more to reactivate the clarifier. Notice that the same offset that you had set previously returns, but is applied to the new frequency.
- ❒ To clear the offset from the clarifier it is not necessary to readjust the CLAR control. Just press F followed by CLEAR CLAR (the clarifier does not even have to be active at the time).

Now let's look at a typical application for the clarifier. Say 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 and watching your display:

- ❒ Press CLEAR CLAR to activate the clarifier, and if you notice the frequency change, press F followed by CLEAR CLAR to cancel the previous offset.
- ❒ Then carefully retune his signal with the CLAR knob (be careful not to turn the main knob by mistake!).

That's it. Your transmissions will remain on the frequency where he originally found you, but you will hear him clearly. But there's one more thing: after you finish your conversation with him, you must remember to press CLEAR CLAR again to turn off the clarifier. Otherwise, the next station you call will find you off frequency. Alternatively, you can leave the clarifier on and just clear it with F and CLEAR CLAR (if you expect to need it again soon.

Remember that the clarifier stores its offset until you clear it. The FT-650 actually has an independent clarifier for each vfo (A and B) and each of the 105 memories, on each of the three bands! This means that clarifier offset settings are not carried over when you change bands, vfos or memories, but rather are stored until you return to that vfo or memory and band.

Using Vfo B

As you might imagine, vfo B works identically to vfo A. The major purpose of this second vfo is to provide simple, unlimited-range split (transmit/receive) frequency operation, described in the following section, and to allow you to keep all settings in one vfo while using another (for quick return later). To activate vfo B, press A/B VFO while receiving on vfo A (the current vfo selection is indicated to the left of the frequency display). Band, frequency, mode, IF filter, clarifier and repeater shift data can be selected entirely independently of vfo A, and you can switch between the two at any time just by pressing A/B VFO (go ahead and try it). You can also copy the contents of the displayed vfo to the other, by pressing and holding the A=VFO button for ½-second.

Split Frequency Operation

Split operation is performed by receiving on one vfo (A or B) and transmitting on the other. The special case of FM repeater operation uses some features of its own, and is described in the box on page 18.

- ❒ Before activating split operation, you need to tune one vfo to the frequency you are going to transmit on, and then press F-INP V/M to switch to the other vfo.

❒ Then to activate split operation, press SPLIT. SPLIT appears in a box at the top left corner of the display, and when the transmitter is keyed, operation shifts to the other vfo.

You can now tune the (receiving) vfo around as desired, and you can press V/M and SPLIT (A/B reverse) to check activity on the other vfo (normally your transmitting frequency). However, you cannot tune while the vfos are reversed – if you try to, reverse operation is cancelled.

Note that A/B reverse exchanges the transmit and receive frequencies for transmission, as well as reception, so you will probably want to press V/M and SPLIT again to return things to normal before you transmit (although you don't have to).

Memory Storage

The 105 memory channels in the FT-650 each store frequency, mode, normal/narrow IF filter selection and clarifier settings copied from the display into the displayed memory channel number when the VFO►M button is pressed and held for ½-second. The data to be copied from the main display may be either in the vfo, or in another memory. General-purpose memories are numbered from 01 to 99, and special-purpose memories (described in detail later) are labelled L1, U1, L2, U2, P1 and P2.

Example: to store 14.25 MHz USB in memory 10:

❒ First tune to the desired band, frequency and mode, and activate the repeater shift, if desired.

Note: Just like the vfos, each memory stores three groups of settings, one for each band. If you like, you can set up frequencies on any or all three bands, and all of them will be stored together in one memory. In addition, after setting up any or all bands, you can tune the vfo to a frequency outside of the ham bands – if you do this last, it will also be stored in the memory along with the setting for the three ham bands!

❒ Once you have the vfo set up as desired for memorization (up to four frequencies, plus settings), press the VFO►M button (at the upper right) momentarily – the channel number on the display will begin to blink, and rotate the MEM/CH knob until 10 is displayed (to select the channel number to store).

Note: when selecting the memory number in which to store new data, the small "CH" will appear to the right of the channel number if it is already holding data. Therefore, if you do not want to overwrite data that has been stored previously, select a memory number that does not have CH displayed after it.

❒ Now just press and hold the VFO►M button for ½-second, until a second beep sounds from the key beeper (confirming that the memory has been stored).

If you have the clarifier set for some offset or the repeater shift activated, these are also stored in the memory.

Note that storing a memory does not shift operation to that memory. A memory must be recalled as described next before it is used for operation. However, before proceeding, we suggest you store a few memories as described above so that the next section will not be confusing (you only need to store one frequency in each – they can be modified later).

Memory Recall & Operation

To recall data stored in a memory channel for operation, just press M▶VFO. The vfo indication at the left edge of the display will be replaced with MEM as the mode indicator LEDs and display change, if appropriate, to reflect the contents of the memory channel. Turning the MEM/CH knob now selects from among all stored memories, while empty memories remain hidden.

You can put this to advantage by grouping your memories according to their use when you store them. For example, put 10-meter repeater channels in memories 20 – 23, 6-meter repeater channels in 30 – 79, utility stations (like the Red Cross channels around 45 MHz) in memories 80 – 99, etc. Then when you are recalling old or storing new memories you will be able to better keep track of which memories are in use.

Once you have recalled a memory for operation, you can treat it just like a vfo: retuning, changing bands and modes, etc. As soon as you make any changes to the memory, the MEM displayed at the left will change to M TUNE.

If you want to make any changes permanent, you must press and hold the VFO►M button for ½-second to restore the new data is the same channel; or you can press the button briefly, select another channel for the new data, and then press and hold it for ½-second.

If you recall a non-ham band memory and then press the LOCK BAND key, you will be forced onto the ham bands. To get back to the non-ham band frequency, just press the

key (to cancel changes to the memory). If you don't want to loose your changes, first store them to an new memory channel.

While a memory is recalled (and retuned or not), you can copy all of its data to the last-selected vfo, by holding the M▸VFO button for ½-second. *The previous contents of the vfo are lost!*

To get out of the memories and back to the vfos, press the key.

Memory Scanning

You can scan any stored memories by pressing and holding either of the UP or DWN buttons on the microphone for ½-second while a memory is recalled (and *not* retuned). If MEM is displayed to the left of the frequency, only the memory channels will be scanned. If M TUNE is displayed, scanning will be the same as vfo scanning (that is, scanning of the entire range of the transceiver), beginning with the displayed frequency.

As with vfo scanning, both endless and stop-on-signal scanning modes are available for the memories, depending on whether the squelch is initially open or closed, respectively. As with vfo scanning, you may first want to adjust the SQL control on a clear channel.

During stop-on-signal memory scanning, the scanner will pause on any channel having a signal (or noise) strong enough to open the squelch, during which the two decimal points in the main frequency display will blink, so you may need to readjust the SQL control to keep the scanner from stopping on channels with high background noise. After pausing, scanning will resume either after five seconds, or after the signal disappears, depending on your scan resume selection (see box below).

Scan Resume Selections

The FT-650 provides a choice of two conditions for which scanning will resume after pausing on a signal: 5-second timer or carrier drop. To check or change the selection, press and the STEP button. The frequency display will be replaced with the current tuning step for the current mode, and either a "5" (for 5-second timer mode) or a "P" (for carrier drop mode). Pressing with this display will toggle the scan resume mode between the two, and pressing STEP again will return the display to normal.

To stop the scanner, press the PTT switch (no transmission will occur), or one of the microphone buttons again. Note that the ATT and RF AMP selections 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 then . SKIP will appear to the right of the channel number (this setting is automatically stored in memory, so you do not need to store it manually). Repeat the same keystrokes to re-include the memory in scanning.

Even with some memories marked to be skipped, you can still all memories just by holding the microphone button down while scanning.

Clearing/Hiding Memories

You can clear the contents of a memory when no longer needed (or to hide it temporarily), by pressing and then the VFO▸M button. Now, when this memory is selected during memory storage, **CLEAR** will be displayed next to the memory number. This helps in keeping track of which memories are in use during the memory storage process: cleared memories will display **CLEAR**, and unused memories will display their channel number without "EMP", as described on the previous page. You can also unhide a cleared memory simply by repeating the same keystrokes used to hide it.

Mode-Specific Scanning

As described so far, memory scanning includes channels in the scan regardless of mode – that is, if the memories were stored with different modes (AM, USB, FM, etc.), the correct mode will be recalled whenever a channel is scanned. You can limit the scanner to only memories of a specific mode, by pressing the corresponding mode button (to the left of the tuning knob) *after* you activate the scanner. It will then skip any memories that were not stored in that mode. This is particularly handy for scanning FM repeaters, as described in the following example:

To scan the standard FM repeater channels on the 29-MHz band:

- ❒ Select the FM mode, and store the 10-meter FM repeater output channels, 29.62, 29.64, 29.66 and 29.68 MHz, in any four memories. Then recall one of these memories.

- ☐ With the squelch closed, press a microphone button to start scanning, and then press the FM mode button.
- ☐ Scanning will cover the four repeater channels, plus any other memories stored with the FM mode.

Programmable Scanning Limits (PMS)

The four memories labelled L1, L2, U1 and U2 can be used just like the other memories, but they also provide a special function: as frequency subband limit pairs (L1/U1 and L2/U2). Store the lower subband edge in memory L1 or L2, and the corresponding upper edge (or actually, one step past it) in U1 or U2.

Example — Scan 28.05 to 28.992 MHz and 50.003 to 50.399 MHz (as you might to watch for DX beacons on these bands):

- ☐ Press the [PMS] [V/M] key, if necessary, to select a vfo, and tune it to the lower edge of the first range (28.05 MHz). You do not need to select the mode now, as this must be selected later when you activate PMS.
- ☐ Now press [V/M] briefly, turn the [MEM/CH] knob to select channel L1, and then press and hold it again for 1/2-second to store the displayed frequency in the memory.
- ☐ Retune to 28.9921 MHz, one step above the upper edge of the first range, and store this in memory U1 in the same manner as above.
- ☐ Retune to 50.003 MHz, the lower edge of the second range, and store this in memory L2.
- ☐ Now retune to 50.3991 MHz, the upper edge of the second range, and store this in memory U2. The memories are now all set for PMS operation.
- ☐ Before activating PMS, select the mode (FM, in this example), and press [SHIFT] [REV] to activate minus repeater shift – standard for repeaters on these bands.
- ☐ Finally, press [F] and then [SHIFT] [PMS] to activate the PMS subband limits (you can do this from a vfo or memory – it doesn't matter). The display frequency will change to that of memory L1, although the displayed channel number will likely be different (you can ignore it), and PMS will appear above the memory number. If you turn the tuning knob you will see that the tuning range is limited to the L1 ~ U1 and L2 ~ U2 subbands.
- ☐ To scan both subbands, make sure the squelch is closed, and just hold one of the microphone keys for 1/2-second. The scanner will traverse 29.62 to 29.68 MHz, then 53.01 to 53.99 MHz, and then jump back to 29.62 MHz.

While PMS operation is active, you can change scanning steps, modes, repeater and clarifier settings. Pressing [PMS] [V/M] or [REV] [A/B] will deactivate PMS operation.

After setting up your PMS memories, if you wish to use the PMS feature to tune or scan only one of the ranges, just hide one of the band limit memories of the band you do not want to scan, as described on the previous page.

Priority Monitoring

You have probably already noticed the two other special purpose memories, labelled P1 and P2. You can store frequencies (and modes and repeater shifts) in these memories that you wish to monitor for activity while receiving on a vfo or other memories, by activating priority monitoring.

PMS & Repeaters

When PMS operation is activated, the repeater shift effective at the time remains active, even though operation may shift to a different band (such as in the 28-/50-MHz example above). Thus if repeater shift is active and the transmitter is keyed on the other band, the shift will most likely be incorrect.

To avoid this problem, we recommend that you restrict PMS operation to only one band when using it to scan repeater channels. Alternatively, you can store the repeater channels in separate memories, and use memory scanning, as described for the 10-meter repeater channels in the previous section on *Mode-Specific Scanning*.

To activate priority monitoring, press [F] and then the [V/M] button. PRI will appear above the memory number. Every five seconds, the receiver will briefly check for activity on the priority channels, and if a signal is found strong enough to open the squelch, operation will jump to that channel for five seconds (regardless of the setting of the scan resume mode).

While paused, the decimals in the frequency display will blink, and if you press the PTT switch on the microphone, operation will shift permanently to that priority channel as priority monitoring is deactivated.

During priority monitoring you will probably want to keep the squelch closed, so that the receiver does not pause for five seconds each time it checks the priority channels.

You can tune the vfo or memory while priority monitoring, but switching vfos or between vfos or a tuned memory and other memories will cancel priority monitoring.

If you want to monitor only one priority channel after storing both, simply hide the one you don't want to monitor. If both are unhidden, P1 will always be checked before P2 (so if signals appear on both, P1 will have priority.

Optional DVS-2 Digital Voice Recorder

The DVS-2 is a digital recorder which can be connected to the special jack with the same name on the rear panel of the FT-650. 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 a summary is provided here.

Receiver Recording

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

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.

Tone Squelch

When the FTS-8 Tone Squelch option is installed, you can access CTCSS-activated stations and repeaters, and silently monitor for calls on busy channels. The transmit function of the FTS-8 superimposes a subaudible tone (at a frequency too low to be heard) on the transmitted carrier, while the receive function monitors receiver audio through a narrow filter at the same subaudible frequency, keeping the squelch closed until a matching tone is received. Installation instructions can be found on page 26.

The FTS-8 offers a choice of 37 different subaudible tone frequencies (listed below), from which you must select the one that matches the station(s) with whom you want to communicate. To check or set the CTCSS tone frequency:

- ❒ Press [F] and then [SCT TONE]. The display will show the current tone frequency, in Hertz.
- ❒ To change the tone frequency, just turn the MEM/CH knob.
- ❒ Press [SCT TONE] by itself to return the display to normal when finished.

After selecting the desired tone frequency, you can activate it for transmission by pressing [SCT TONE] once so that a "**T**" is displayed above the operating frequency. For tone-squelched reception (as well as transmission), press [SCT TONE] once more, so that "**SQL**" is displayed too.

To deactivate CTCSS operation, press [SCT TONE] until the display is cleared of the "**T**" and "**SQL**".

FTS-8 Tone Frequencies (in Hz)

067.0*	67.0	118.8	173.8
071.9	71.9	123.0	179.9
074.4	77.0	127.3	186.2
077.0	82.5	131.8	192.8
079.7	88.5	136.5	203.5
082.5	94.8	141.3	210.7
085.4	100.0	146.2	218.1
088.5	103.5	151.4	225.7
091.5	107.2	156.7	233.6
	110.9	162.2	241.8
	114.8	167.9	250.3

*Tone selections with leading 0's use high-Q decoder filters

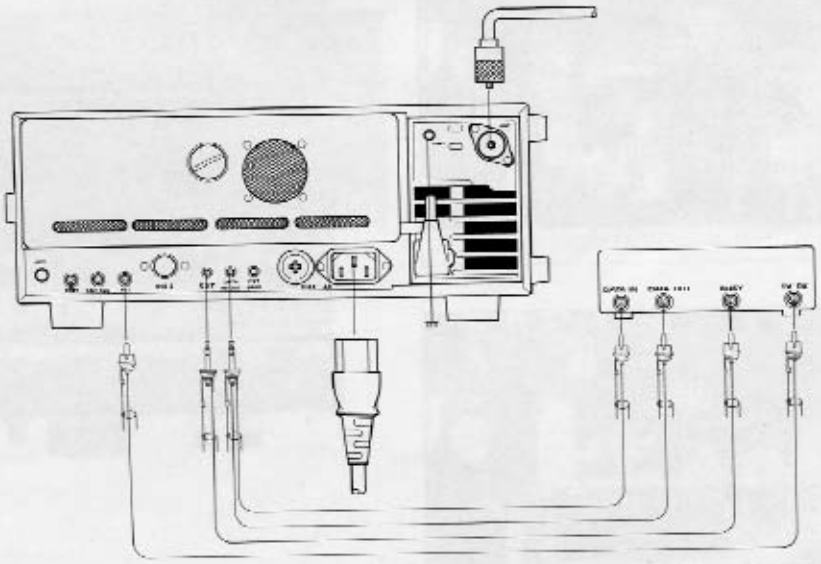
1200-Baud (FM) Packet

The **DATA IN/OUT** jack on the rear panel provides ransmit and receive audio interconnections for a pack- t tnc. Connections are shown below. Note that the quelch control line for the tnc connects to the BUSY ring contact) of the CAT jack on the transceiver.

For reception, select the FM mode. Either wide or arrow IF filters may be used, with the narrow selection ikely to give better performance if the other station lso has a narrow IF capability.

To set up the transmitter for FM packet:

- ❒ Start with the RF PWR control at about midrange, and set the METER selector to ALC.
- ❒ Set your tnc to its "calibrate" mode, preferably with both tones alternating, and adjust the transmit audio output level control of your tnc so that the meter deflects to mid-scale (this control may be an internal trimmer, but the adjustment should only need to be done once).
- ❒ Switch the METER selector to PO and set the RF PWR control for the desired power output (keep the power level as low as possible to maintain communications while avoiding unnecessary heating).



Packet TNC Interconnections

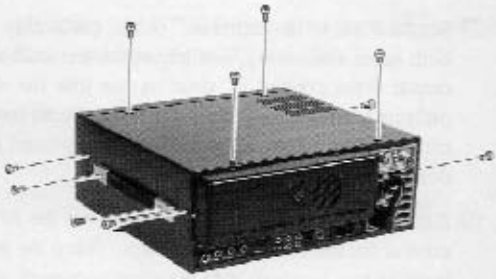
Installing Internal Accessories

This section contains the installation procedures for installable options available for the FT-650.

FTS-8 CTCSS Tone Squelch Unit

The FTS-8 provides tone squelch operation of the FT-650, allowing silent monitoring of busy channels, and access to repeaters that require a subaudible tone. It consists of a programmable subaudible tone generator (for transmission) and matching decoder (for reception), with EIA-standard tones selectable from the front panel.

- ❒ Disconnect the transceiver from the power source. Loosen the two carrying handle screws, and remove the two screws on each side of the upper half of the transceiver, and the four screws from the top, as shown at the upper right. Then lift off the top cover.
- ❒ At the top left side of the rear-most circuit board (the AF Unit — see right, and below left), locate the two white plastic connectors, one of which is empty, and the other having only a 47-k (yellow-purple-orange) resistor installed between pins 4 and 5. Remove the resistor, and save it if you expect to remove the FTS-8 later.
- ❒ Press the FTS-8 onto the two connectors, so that all pins find their mating holes (see photo, below left).
- ❒ Unless you are also installing the CW filter, replace the top cover and eight screws removed above, and retighten the carrying handle screws.



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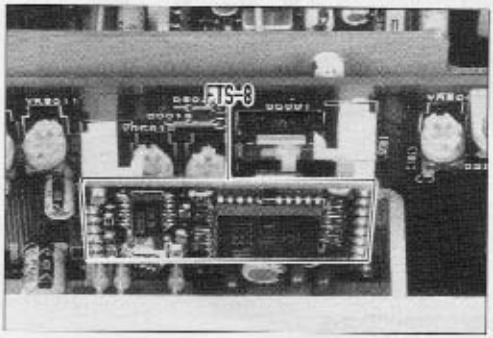
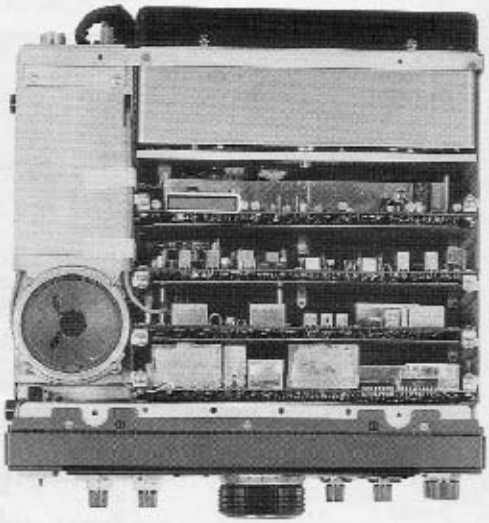




F-455M601-01 600-Hz Narrow CW Filter

his procedure requires a soldering iron.

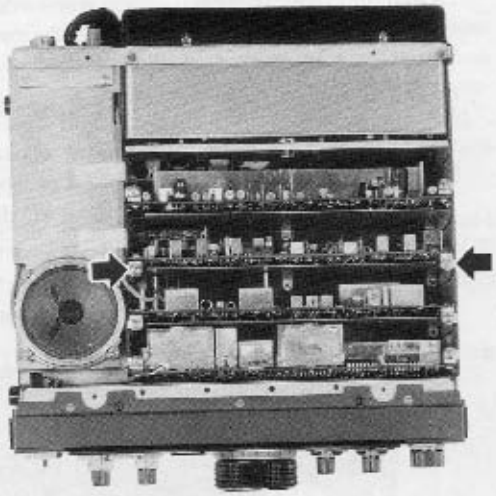
Disconnect the transceiver from the power source. Loosen the two carrying handle screws, and remove the two screws on each side of the upper half of the transceiver, and the four screws from the top, as shown at the upper right on the previous page. Then lift off the top cover.

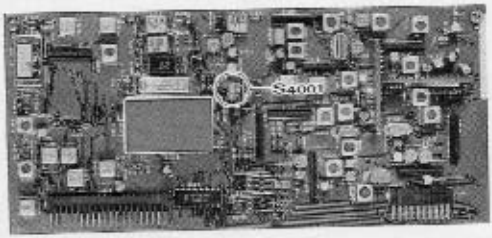
Referring to the photographs at the right, remove the screw at each side of the third board from the front (the IF Unit), and carefully pry up each side of the board about 5mm (¼"). Then lift the board out of the chassis.

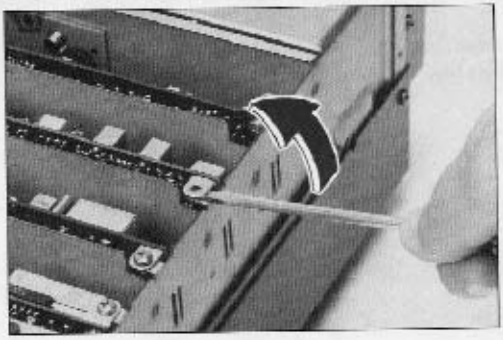
Straighten the four wires on the new filter, if necessary, and then feed them into the holes at location CF4004, just below the existing ceramic filter. Make sure the new filter is pressed all the way in, then solder each of the four leads, and trim away any excess.

Referring to the photo below left, locate miniature slide switch S4001 near the filter, and move it to the lower position (toward the new filter).

Replace the board and its two screws, and the top cover and eight screws removed above. Don't forget to retighten the carrying handle screws.

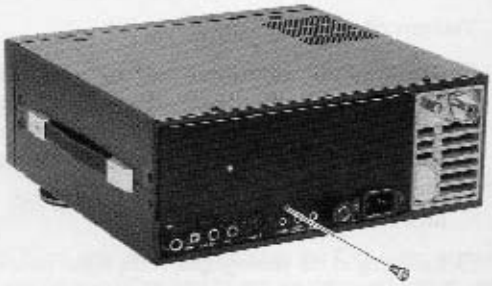


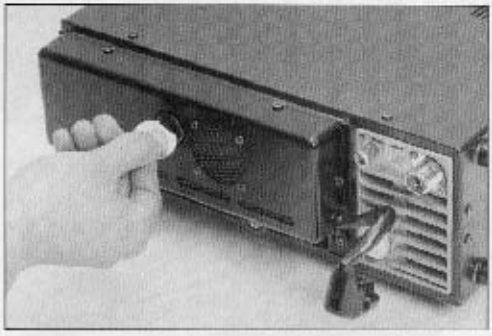


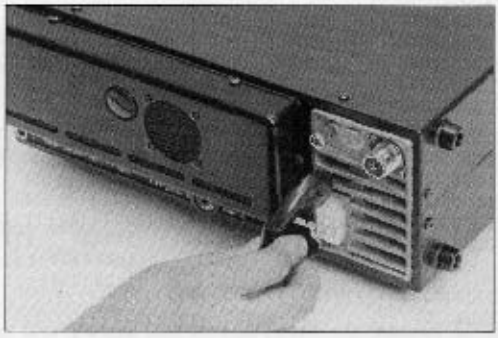


FP-22 AC Power Supply

- ❒ Referring to the photo at the right, remove the screw near the bottom of the dummy plate on the rear panel, and remove the plate.
- ❒ Slide the FP-22 into the opening, and tighten the large mounting screw using a coin.
- ❒ Press the output plug from the FP-22 on to the DC supply plug on the transceiver's rear panel. Installation is now complete.



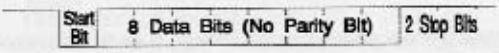




Cat System Computer Control

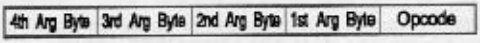
The CAT (Computer Aided Transceiver) System in the FT-650 provides control of operating frequency, mode, bandwidth, transmit/receive and memory settings by the operator's external personal computer. This allows multiple control operations, such as crossband splits, to be fully automated as single keystroke operations on the computer keyboard. While the CAT system is enabled, the front panel tuning knob, mode buttons and keypad are disabled.

Serial data from the computer is passed at TTL levels (0 and +5V) via the center (serial input) pin of the CAT jack on the rear panel of the transceiver at 4800 bits/s. The ring contact of this jack provides a TTL-level indication of the squelch status for external processing (such as for scanning). Pinout is shown on page 13. Each byte sent consists of one start bit, 8 data bits, no parity bit and two stop bits:



1 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 Block (sent left-to-right)

There are ten instruction opcodes for the FT-650, 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 in 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 serial input pin of the CAT jack on the transceiver.

EXAMPLE: Set operating frequency to the International 6m SSB DX calling frequency, 50.110 MHz;

- ❒ First determine the opcode for the desired instruction (see the CAT Commands Table). 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 01h. Small "h"s following each byte 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.
- ❒ The resulting 5-byte block should now look like this (again, in hexadecimal format):

Byte Value	05h	01h	10h	00h	01h
Content of this byte	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	Set Op. Freq. Opcode

- ❒ Send these five bytes to the transceiver, in the same order as that shown above — from left-to-right (see the Basic example on the page after next).

CAT Commands

"—" indicates a padding byte. Value is unimportant, but it must be present to pad the block out to five bytes.
Opcodes are shown in both hex and decimal format (where different) for convenience - only one byte can be actually sent.

Command	Parameter Bytes				Opcode		Notes
	1	2	3	4	hex	(dec)	
CAT On	—	—	—	—	00h		Switch CAT operation ON (if off) - Operation shifts to the VFO if on a memory
CAT Off	—	—	—	—	80h	(128)	Switch CAT operation OFF (if on)
Set Op. Freq.	F1	F2	F3	F4	01h		New frequency in F1 – F4, in BCD format: see text for example
Recall Memory	C	—	—	—	81h	(129)	Recalls memory channel number C: 01 to 63h corresponding to memories 1 to 99, or 64h (L1), 65h (L2), 66h (U1), 67h (U2), 68h (P1) or 69h (P2)
VFO ► M	C	—	—	—	C1h	(193)	Copy display to channel C
Set Bandwidth and Mode	WM	—	—	—	07h		Upper nybble W sets bandwidth: 0xh = wide FM/AM, or 2.4kHz ssb/CW 4xh = 2.2kHz ssb or 1.2k CW 8xh = narrow FM/AM, 2.0 kHz ssb or 600 Hz CW Cxh = 1.8 kHz ssb or 300 Hz CW Lower nybble M sets mode: LSB=x0h USB=x1h CW=x2h AM=x4h FM=x8h Bitwise OR the W and M nybbles before sending, or see the Table below left
Transmit	—	—	—	—	08h		Close PTT (activate transmitter)
Retn to Receive	—	—	—	—	88h	(136)	Open PTT (deactivate transmitter)
CTCSS Squelch On	—	—	—	—	0Ah	(10)	Activate CTCSS for both transmit and receive (requires FTS-8 option)
CTCSS Tx Only	—	—	—	—	4Ah	(74)	Activate CTCSS for transmit (only) (requires FTS-8 option)
CTCSS Off	—	—	—	—	8Ah	(138)	Deactivate CTCSS operation
Set CTCSS Freq.	T	—	—	—	FAh	(250)	Select a CTCSS Tone Frequency. See Tone Code Table below for the values of T that correspond with the available tones (requires FTS-8 option)

Bandwidth & Mode Codes (WM)

	Wide AM/FM	Narrow AM/FM	2.4 kHz	2.2 kHz	2.0 KHz	1.8 kHz	1.2 kHz	600 Hz	300 Hz
LSB			00h	40h	80h	C0h			
USB			01h	41h	81h	C1h			
CW			02h				42h	82h	C2h
AM	04h	84h							
FM	08h	88h							

CTCSS Tone Code Table

Tone	Code	Tone	Code	Tone	Code	Tone	Code
*067.0	1Dh	67.0	3Eh	118.8	33h	173.8	28h
071.9	1Eh	71.9	3Dh	123.0	32h	179.9	27h
074.4	1Bh	77.0	3Ch	127.3	31h	186.2	26h
077.0	1Ah	82.5	3Bh	131.8	30h	192.8	25h
079.7	19h	88.5	3Ah	136.5	2Fh	203.5	24h
082.5	18h	94.8	39h	141.3	2Eh	210.7	23h
085.4	17h	100.0	38h	146.2	2Dh	218.1	22h
088.5	16h	103.5	37h	151.4	2Ch	225.7	21h
091.5	15h	107.2	36h	156.7	2Bh	233.6	20h
		110.9	35h	162.2	2Ah	241.8	1Fh
		114.8	34h	167.9	29h	250.3	1Eh

* The tone selections with leading 0's provide low-Q decoder filters

Coding Examples

Although Yaesu Musen Company cannot offer to rovide complete CAT control programs (owing to the rge variety of incompatible computers used by our ustomers), following are a few examples of critical AT output functions, in Basic. Note that all variations f Basic may not support some of the commands, in hich case alternate algorithms may need to be devel-ped to duplicate the functions of those shown.

Sending Commands

After "opening" the computer's serial port for 4800-aud, 8 data bits and 2 stop bits with no parity, as i/o evice #2, any CAT command may be sent. Here is an xample of a typical statement (in this case, in Microsoft GW Basic) to open serial port 1, and then to ctivate the CAT system in the FT-650:

```
OPEN "COM1:4800,N,8,2,RS,CS,DS,CD" AS #2;
PRINT #2, CHR$(0);CHR$(0);CHR$(0);CHR$(0);CHR$(0);
```

The instruction opcode is sent last, with the param-ters sent in the same order as shown in the CAT Commands table. Also note that in this and the follow-ng examples, we are sending zeros as dummy bytes: his is not necessary, however. If you decide to send commands through a 5-byte array, they values of the lummy parameters need not be cleared.

Using the same example as before, the following command could be used to set the frequency of the display to 50.110 MHz:

```
PRINT #2, CHR$(&H05); CHR$(&H01);
          CHR$(&H10); CHR$(&H00); CHR$(&H01);
```

Notice here that the BCD values can be sent just by preceding the decimal digits with "&H" in this exam-ple. However, in an actual program, it may be pref-erable 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-650 should do nothing. However, if you send a wrong command accidentally, your program could loose track of the transceiver set-tings. Therefore it is very important to include plenty of error checking to test any data for validity before send-ing it to the transceiver.

Bear in mind that all commands except frequency setting specify "binary", as opposed to BCD formatted parameters. You can send binary parameters without going through the character/hex string conversion pro-cess. For example, the C parameter in the Command table is a binary value. You could have the FT-650 recall memory channel 50 (decimal) by the following:

```
PRINT #2,CHR$(50);CHR$(0);CHR$(0);CHR$(0);CHR$(129);
```

Note that only decimal values are used in this state-ment: the binary value of **CHR$(50)**, which is 32h (hex) will be sent to the transceiver without need for the program to explicitly make the conversion.

As you can see from the Command Table, the band-width and mode setting parameter byte, WM, has a unique structure. The upper four bits set the bandwidth, while the lower four bits set the mode. There are several ways you can choose to handle this, one of which is to handle the two 4-bit nybbles separately, and OR them together to get the required parameter to send. For example, if you define the valid nybble values as:

```
LSB = 0; USB = 1; CW = 2; AM = 4; FM = 8
WIDE = 0; MWIDE = &H40; MNAR = &H80; NAR = &HC0
```

Then you can set a new mode and bandwidth (USB, 2.2-kHz medium wide here) like this:

```
MODE = USB: BWIDTH = MWIDE
WM = MODE OR BWIDTH
PRINT #2,CHR$(WM);CHR$(0);CHR$(0);CHR$(0);CHR$(7);
```

However, you'll need to keep in mind that some combinations are not valid (such as medium AM or FM bandwidths), and so may want to add some checks to warn the user and prevent these from being sent.

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