VX-510 Series
VHF/UHF Hand-Held Portable Land Mobile Transceiver
Operating Manual

The VX-510 is a frequency-synthesized, microprocessor-controlled FM hand portable transceiver providing up to five watts of power output on up to 32 channels in the VHF or UHF Land Mobile Bands. Designed specifically for commercial and professional applications, the VX-510 is housed in high-strength die-cast aluminum alloy, sealed to MIL-810 C, D & E intrinsically safe (I/S) and weather-tight specifications*.
User selectable features include a four-mode display with channel name or number, upright or inverted for easy viewing when on your belt; selective channel scanning, adjustable-pause priority scanning, and transmitter power output.
Other user-selectable features include push-button display illumination, 2-tone decoder enable/disable (when optional F2D-5 Unit installed) and manual squelch override. The VX-510 is easily programmed by your dealer using a Yaesu Service Kit with an IBM PC-compatible computer.
Please read this manual carefully to become familiar with the features of the VX-510.
*approval pending

Accessories & Options

F2D-5	Two-Tone Sequential Decoder
FTT-7	DTMF Keypad Tone Generator (16 keys)
FTT-7D	DTMF Keypad Tone Generator w/Decoder
FTE-17	Tone Burst Generator
MH- 30A2B	Speaker/Microphone
CD-1	Desktop Battery Rapid-Charger
PA-14 B	100 - 120 V AC Mains Adapter (used w/CD-1)
PA-14 C	200 - 234 V AC Mains Adapter (used w/CD-1)
Herical Flex Antenna (supplied option)	
FVP-22	Encryption Unit
CE-21	Channel Editor Programming Software
FRB-2	Programming Interface Connection Box
SBC-1	Swivel Belt Clip
FNB-29A	7.2 V/1700 mAh Ni-Cd Battery Pack

Controls & Connectors

Top panel

(1) **VOL** (OFF) Control
This control adjusts the volume of the receiver, and turns the radio off when rotated fully counterclockwise to the click-stop

(2) **S/DW** Button (Scan/Dual Watch)
Momentarily (< 1sec.) pressing this button turns the channel scanner on and off. Pressing and holding (> 1 sec.) button activates the Dual Watch feature (explained later).

(3) **A** Button
Pressing and holding this more than 2 seconds (but less than 4 seconds) activates functions as programmed by your dealer and determined by your system requirements (See "*Pre-Programmed Functions*"). Pressing and holding this more than 4 seconds

causes the selected channel to be assigned as the Priority Channel for use with Priority Scanning and Dual Watch functions (explained later).

(4) **B** Button
Pressing and holding this more than 2 seconds (but less than 4 seconds) also activates an assigned function (programmed by your dealer). Pressing and holding this more than 4 seconds inverts the LCD display to either frontward or backward facing readout (the backward display is convenient for viewing when wearing the transceiver on your belt).

(5) **BUSY/TX** Indicator
This lamp blinks green when a signal is being received (or the squelch is opened by pressing the **MON RES** switch) and glows red when transmitting. To avoid interference, do not transmit if this is green.

(6) **CH** Rotary Selector
This rotary switch selects the operating channel. If a channel is selected that is not available for operation, " - - - - " is displayed, accompanied by a rapid warning beeper (2 beeps/sec.).

(7) Antenna Jack
This threaded-type jack accepts the supplied flexible antenna. Any other antenna types used here must be designed for the programmed operating frequencies.

(8) Liquid Crystal Display
In addition the channel number name, the display includes some operating status symbols, indicated in the diagram below.

Side Panel Buttons

(1) **MON RES** (Monitor/Reset) button
Pressing and holding this button more than 2 seconds (but less than 4 seconds) disables the tone squelch, and permits monitoring stations transmitting on the selected channel while still keeping your receiver quiet from noise ("***MO***" will appear at the top right of the LCD). Press it again to only hear calls within your network.
Pressing and holding this button more than 4 seconds toggles the tone and noise squelch override, allowing all stations (and noise) on the channel to be heard. This may be used to hear weak stations whose signals would not normally open the squelch to be heard. Do this to pre-adjust the **VOL**ume control before receiving calls.
(With Selective Calling Option)
When the two-tone sequential decoder unit (F2D-5) is installed, and a selective call has been received ("***CALL***" indicator on), momentarily pressing this button will reset the call function on the current channel and silence the receiver, otherwise press and hold to reset the call function on ALL channels.

(2) **PTT** (Push-To-Talk) button
Hold this button in while transmitting (the "**BUSY/TX**" indicator glows red).

(3) **LAMP/LOCK** button
Press this button momentarily (<1 sec.) to illuminate the display for five seconds. Pressing and holding (>1 sec.) the button locks top-panel push-buttons (**S/DW**, **B**, **A**, and the DTMF keypad (optional), this can be enabled to prevent radio settings from

being disturbed.

(4) Battery Release
Slide this button in the direction of the arrow (upward) for battery removal.

(5) **EAR** Jack
This provides audio output for an earphone or the optional MH-30A2B External Speaker/Microphone here. The internal speaker is disabled when a plug is inserted into this jack.

(6) **MIC** Jack
Connect the optional MH-30A2B Speaker/Microphone here, the internal microphone is disabled when this jack is used.

Operation

Preliminaries
If the transceiver has not been used since leaving the factory, fully charge the battery using CD-1 unit (with PA-14B or C) before using it.
Mount the battery on the transceiver as described and shown in the photo below. Also, install the antenna on the jack on top of the transceiver by screwing the connector into the jack until it is finger-tight.

Battery Removal & Replacement
- Make sure that the **VOL** control is set into the off click-stop, and remove the protective soft or hard case, if used.
- Grasp the transceiver with your left hand, so your palm is over the speaker and your thumb is on the Battery Release Button.
- Move the button in the direction indicated by the arrowhead, while using your right hand to slide the battery pack toward the side with the button. The battery pack should slide smoothly out of its track.
- To replace the Ni-Cd pack, repeat the second and third steps above, simply sliding the battery case in the other direction after aligning the shorter side of the battery pack with the track below the Battery Release Button.

Preliminary Steps
Before operating the transceiver for the first time:
- Charge the battery pack and connect the supplied helical rubber flex antenna to the antenna jack on the top of the transceiver. *Never operate the transceiver without an antenna connected.*
- If you have a Speaker/Mic, we suggest you do not connect it until you are familiar with basic operation.
- Before proceeding, please review the Top & Side Panel Controls outline, if you have not already, to familiarize yourself with the functions of the controls.

Basic Operation
- Switch on the transceiver by rotating the **VOL** control clockwise out of the click-stop (a momentary beep will sound). For now, adjust the control to about mid-position (12-o'clock), later you can adjust the level to suit the operating environment.
- Rotate the CH knob to select a channel for operation, the LCD will show the currently selected channel. If " - - - - " is displayed, along with a rapid (2 beeps/sec.) beeping tone, the selected channel position is not available for operation.
- To transmit, wait until the channel is clear ("**BUSY/TX**" LED off), then press in

the **PTT** switch on the side of the transceiver while speaking across the face of the radio. A clear normal voice will provide the best quality transmission. For maximum battery life, select low power output (covered later) whenever possible. During transmission the "**BUSY/TX**" indicator glows red. Release the **PTT** switch to receive.

- To receive weak stations better, try positioning the radio as high and far away from your body as possible, or disable the squelch momentarily by holding the MON RES button on the side of the radio for > 4 sec. (until the second low/high beep sounds). With the squelch disabled, the "**BUSY/TX**" indicator will blink green and channel noise and weak stations can be heard. To quiet the radio again, press the **MON RES** button again momentarily.
- When you are done operating, be certain to turn the **VOL** control to the off position to conserve battery life.

An important note about your radio !

Some of the radio/button functions discussed next will only operate in your radio if so programmed by your dealer, or after the installation of certain internal optional units. In this way, the radio's operation can be simplified and customized specifically for the user according to network requirements. If pressing a button on your radio does not result in the same function described in this manual, or if you are uncertain of the functions your particular radio is configured with, contact your dealer. See "*Pre-Programmed Functions*" .

Low Battery Power Indication

When the rechargeable Ni-Cd battery pack voltage reaches a low level, the "Battery" indicator appears at the lower right corner of the LCD, and the "**BUSY/TX**" indicator will blinks red. Immediately remove the Ni-Cd pack and install a freshly charged battery pack, or insert the radio into the charging stand for a complete recharge cycle. If you plan to operate your radio for extended periods of time, you may want to keep a spare, fully-charged pack handy.

Scanning

Scanning allows you to sequentially check for calls on all or only those channels you select. To start scanning, press the **S/DW** button momentarily. A beep then sounds and the display will clear and show "***SCAN***". Scanning will pause when a signal is received, at which time the channel number(or alphanumeric tag) will be displayed. A small "***S***" will be displayed above the channel, indicating the scanner is still active, but paused. During this pause, you can press the **PTT** button and talk to the station. Otherwise, scanning will resume a few seconds after the signal is no longer present. While scanning, if you momentarily press the **PTT** button, operation automatically shifts to a default channel. This default channel can be set to the priority channel (both "***P***" and "***S/DW***" are displayed), last-busy channel, or home channel, depending on how your radio was programmed.

To stop scanning, simply press **S/DW** momentarily again. Operation will return to the channel that was last selected when scanning was activated.If enabled by dealer programming, you may select only the channels you want to scan, and have others skipped-over by performing the following routine.

Turn the radio OFF, then depress the **S/DW** button while turning the radio back ON again. "***PROG***" will momentarily appear on the display, after which it will revert to the currently selected channel (this indicates you are in the programming mode). If user-access is disabled "***INH***" will appear briefly.

Use the **CH** knob to select a channel, then press the **S/DW** button to enable the channel for scanning ("***E***" will appear in the upper left corner of the LCD). Repeat this process for each channel you want the scanner to check.
To remove a channel from those to be scanned, press **S/DW** again, so that "***E***" no longer appears in the display.
After you have enabled all the channels you want to scan, turn the radio off, then on again to return to normal operation.

Priority Scanning
Priority scanning allows you to scan and monitor channels while the receiver periodically checks for calls on a pre-selected ("priority") channel. You may want to use this feature if you want to scan different channels, but don't want to miss a call for you on a primary dispatch, emergency or tactical frequency. After a call has been received on the priority channel, operation returns to the programmed default channel scheme, as mentioned before. Only one channel at a time can be selected as the priority channel.

- To set the currently displayed channel as the priority channel, just press and hold the **A** button for 4 sec. A small "***P***" will now appear at the top left corner of the display whenever this channel is selected, along with an accompanying "beep".

When a priority channel has been selected, the scanner will check the priority channel regularly as you scan the other channels. If a signal appears on the priority channel, the scanner will pause and operation will jump to the priority channel. Otherwise, the scanner will pause on active non-priority signals as previously described.If a call comes in on a non-priority channel that you need to respond to, just press the **PTT** button while the scanner is paused on that channel. As long as no call comes in on the priority channel, you can send and receive on the other channel: scanning will resume when you finish and the channel clears.

Dual Watch
If you need to operate on a non-priority channel while still checking for calls on the priority channel, the Dual Watch feature let's you to do this without using the scanner. When enabled, operation on any selected non-priority remains normal as before, however, when a signal is received on the priority channel or when you press the **PTT** button, operation immediately shifts to the priority channel. The rate at which the Dual Watch feature samples the priority channel can be set by the user.

- To begin Dual Watch operation, first assign a priority channel as described before, then select the non-priority channel you wish to operate on.
- Press and hold the **S/DW** button until the second beep sounds, "***DW***" (but not "***S***") will appear at the top of the display.
- To manually shift to the priority channel, press the **PTT** button. At this time you make transmit, otherwise, if no signal is received within 2 seconds, operation will revert back to the other selected Dual Watch channel.
- To turn off the Dual Watch Feature, press and hold the **S/DW** button again ("***DW***" will disappear in the display).

VX-510L Alignment

The VX-510 has been carefully aligned at the factory for the specified performance across the frequency range specified for each version. Re-alignment should therefore not be necessary except in the event of component failure, or altering version type. All component replacement and service should only be performed by an authorized Yaesu representative, or the warranty policy may be void.

Required Test Equipment

- IBM PC / compatible computer
- Yaesu VPL-1 Cable, or FRB-2 Service Kit, with CE-21 Channel Programming Diskette
- Yaesu CN-1 BNC Adapter plug
- RF Signal Generator with calibrated output level at 60 MHz
- Deviation Meter (Linear Detector)
- Oscilloscope
- AC Voltmeter
- SINAD Meter
- In-Line wattmeter with 5% accuracy at 60 MHz
- Regulated DC Supply adjustable from 4 to 10 V, 3 A
- 50-Ω Non-reactive Dummy Load: 10 W at 60 MHz
- Frequency Counter: ±0.2 ppm accuracy at 60 MHz
- AF Signal Generator
- DC Voltmeter: high impedance

Before beginning alignment, connect the transceiver and PC using the VPL-1 Cable or FRB-2 Set as described in the EEPROM Programming chapter, and download the EEPROM data from the transceiver to the computer.

Then store this data in a disk file so that it can be up-loaded when alignment is finished.

You should find the corresponding data file on the computer disk for the transceiver version you are aligning, containing channel settings for the high edge, middle and low edge of the transceiver's frequency range in channels 1, 2 and 3, respectively. Up-load this file to the transceiver.

PLL & Transmitter

Set up the test equipment as shown for transmitter alignment. Adjust the supply voltage to 7.2 V for all steps where not specified otherwise.

	LOW BAND EDGE CH. (1)	BAND CENTER CH. (2)	HIGH BAND EDGE CH. (3)
ver. A	29.7 MHz	33.9 MHz	38.0 MHz
ver. B	38.0 MHz	44.0 MHz	50.0 MHz

PLL VCV (Varactor Control Voltage)

- Connect the DC voltmeter between C2105 on the PLL Unit and chassis ground.
- Set the transceiver to CH 3 (high band edge), and adjust T2402 on the VCO Unit for 3.4 V ± 0.1 V (ver. A), or 4.0 V ± 0.1 V (ver. B) on the voltmeter.
- Transmit on the high band edge, and adjust T2401 for 3.0 V ± 0.1 V (ver. A), or 3.2 V ± 0.1 V (ver. B).
- Set the transceiver to HC 1 (low band edge), and confirm the low-end VCV is more than 1.0 V while transmitting, and also while receiving.

PLL Reference Frequency

- With CH 2 (band center) selected, key the transmitter and adjust TC2101 on the PLL Unit, if necessary, so the frequency counter displays the band center frequency ± 150 Hz (for the version being aligned) when transmitting.

Transmitter Output Power

- Set the transceiver to band center CH 2, and select high power output.

VX-510L Circuit Description

Refer to the block diagram when reading this description. For finer details, refer to the schematic diagrams.

Receiver

In coming signals at the antenna are passed through a low pass filter and T/R switching diode on the ANT-SW Unit before delivery to the front-end circuitry on the mother board. Here, RF amplifier FET Q3201 (2SK302Y) boosts the signal prior to filtering by a 3-stage varactor-tuned resonator, and application to the first mixer FET Q3202 (SGM2016AM) along with the first local signal from Local Amplifier Q2402 (2SC4226) on the VCO Unit.

The 16.9 MHz product from the first mixer is delivered through 4-pole monolithic crystal filter XF3201 (± 7.5 kHz BW) to strip away all but the desired signal which is amplified by Q3203 (2SC2714Y) on the mother board. FM receiver sub-system IC Q2302 (MC3372D) on the IF Unit includes local oscillator, mixer, IF limiter amplifier and FM detector circuits. The amplified first IF signal is applied to mixer section, along with the second local signal generated via 17.355 MHz crystal X2301 which produces the 455 kHz 2nd IF when mixed with the 1st IF signal within Q2302. The 2nd IF passes through ceramic filter CF2301 (±7.5 kHz BW) to strip away unwanted mixer products, and is then applied to the limiter amp in Q2302, which remove amplitude variations in the 455 kHz IF before detection of the speech by Q2302 via quadrature resonator CD2301.

Detected audio is delivered to the CTCSS IC Q1001 (FX365CLS) and then passes through the de-emphasis circuitry consisting of R1033 & C1015, via muting gate Q1011 (2SK160-K6) and volume control to audio power amplifier Q2206 (TDA2822D) on the regulator unit, providing up to 0.5 W to the external speaker jack or 16-Ω loudspeaker.

Squelch Control

The squelch control circuit consists of noise amplifier Q2301 (2SC4116GR) and band-pass filter and squelch trigger within Q2302 on the IF Unit, and control circuitry within microprocessor Q1017 (M38063M6) on the control unit.

When no carrier is received, noise at the output of the detector in Q2302 is amplified by Q2301, and band-pass filtered by the noise amplifier section of Q2302 and then rectified by D2302 to provide a DC control voltage for the squelch switching transistor Q2303 (2SA1586Y). With no carrier, the emitter of Q2303 is high. The signal is buffered by Q1013. This SCAN STOP signal is delivered to the microprocessor on the Control Unit, and microprocessor controlled through Q1003 (FMG5) to the **BUSY** indicator on the top panel, which remains off until a carrier is received. The microprocessor causes audio mute gate Q2207 (DTC144EU) & Q2202 (2SB1122S) to open the audio power amplifier power source, thus disabling the audio amplifier and silencing the receiver when no signal is being received, and during transmission. When a carrier appears at the discriminator, noise is removed from the output, causing the emitter of Q2303 to go low, then Q1017 controls the signal high, which in turn causes Q1003 to turn on the **BUSY** indicator. The microprocessor then checks for CTCSS tone information from Q1001, plus Digital Code Squelch information form Q1006 (TA75S393F). If not transmitting and no tone squelch is programmed for the channel, or if the received tone matches that programmed for the channel, the microprocessor switches Q2207 to allow operation of the audio power amplifier.

Transmitter

When the PTT switch is depressed, audio from the microphone is delivered to the Control Unit, where it is high-pass filtered by Q1018 (2SC4116GR), and by one section of microphone audio processing dual op-amp IC Q1008 (NJM2904V). After pre-emphasis by C1074 and R1030, another section of Q1008 serves as an IDC (Instantaneous Deviation Control) amplifier to prevent over-deviation from excessive microphone levels, and the two remaining states provide low-pass filtering to suppress out-of-band modulation, and buffering.

Processed audio from the IDC Unit is delivered to VCO Amplifier Unit where it is applied,

along with carefully filtered DC from Q2403 (2SC4116), to varactor diode D2402 (1T362) to modulate (via the SAVE 5V line) VCO Q2401 (2SC4226), on the VCO Unit, which oscillates at the transmit frequency. VCO output is buffered and amplified by Q2402 on the VCO Amplifier Unit before returning to the Main Unit. Buffered, modulated VCO output is applied via T/R switch D3208 to driver Q3206 (2SC3356), and transmit signal is delivered to the PA Unit for amplification by Q6001 (2SC4240).

Transmitter output is controlled by Q2001 (2SB1182F5-Q) and Q2002 (FMW1) on the ANT SW Unit. When the TX +B line (from the regulator Unit) is active, bias voltage and driver collector voltage is applied to the PA Unit Q2003 and Q2004, turning it on. A sample of the final transistor collector current in the PA Unit is detected by D2001 (1SS319), passed through RF Power potentiometer VR3201 on the Main Unit back to APC switch Q2001 (2SB1182F5-Q) via one half of Q2002 (FMW1) on the ANT SW Unit. Q2002 passes the Automatic Power Control voltage when enabled by the other (transmit sequencer) half of Q2002. This circuit is also used by the PLL to disable the transmitter when the PLL is unlocked, and by the microprocessor to select low power output.

PLL

PLL circuitry on the PLL Unit consists of PLL subsystem IC Q2105 (MB1505PF), which contains a divider, serial-to-parallel data latch, programmable divider and a phase comparator. Stability is obtained by a regulated 5-V supply via Q2105 and temperature compensating capacitors associated with 12.8 MHz frequency reference crystal X2101.

Receiver VCO Q2404 (2SC4226) on the VCO Unit oscillates between 54.9 and 66.9 MHz according to the programmed receiving frequency. The VCO output is buffered by Q2402 (2SC2759) on the VCO Unit, and then returned to the PLL Unit. There the VCO signal is divided by 64 or 65, according to a control signal from the data latch section of Q2105, before being applied to the programmable divider section of the PLL chip.

The data latch section of Q2105 also receives serial dividing data from microprocessor Q1017 on the Control Unit, which causes the pre divided VCO signal to be further divided by 10,980 ~ 13,380 in the programmable divider section, depending upon the desired receive frequency, so as to produce a 5-kHz derivative of the VCO frequency. Meanwhile, the reference divider section of Q2105 divides the 12.8-MHz crystal reference by 2560 to produce the 5-kHz loop reference (respectively).

The 5-kHz signal from the programmable divider (derived from the VCO) and that derived from the crystal are applied to the phase detector section of Q2105, which produces a dual 5-V pulsed output with pulse duration depending on the phase difference between the input signals. This pulse train is converted to DC by charge pump Q2102 (IMD3), low-pass filtered, then fed back to varactors D2403 and D2404 (HVU306Ax2) on the VCO Unit.

Changes in the level of the DC voltage applied to D2403/D2404 affect the reactance in the tank circuit of VCO Q2404, changing the oscillating frequency according to the phase difference between the signals derived from the VCO and the crystal reference oscillator. The VCO is thus phase-locked to the crystal reference oscillator.

The output of receiver VCO Q2404, after buffering by Q2402 is delivered to the Main Unit before application to the 1st mixer, as described previously.

Transmitter VCO Q2401 (2SC4226) oscillates between 38 and 50 MHz according to the programmed transmit frequency. The remainder of the PLL circuitry is shared with the receiver. However, the dividing data from the microprocessor is such that the VCO frequency is at the actual transmit frequency (rather than offset for IFs, as in the receiving case). Also, the transmitter VCO is modulated by the filtered speech audio applied to modulating varactor D2402, as described previously. If the Digital Coded Squelch option is installed, DCS modulation is applied both to the VCO and to the PLL frequency reference, via varactor D2102/D2103 (HVU300Ax2).

Control Unit & Supply Bus

Microprocessor Q1017 (M38063M6GP) on the Control Unit contains programming in masked ROM to generate serial data to control the Liquid Crystal Display driver IC Q5001 (LC75821E) on

the LCD Unit and the programmable divider in the PLL according to channel frequency data stored in externally programmable EEPROM. Q1017 also includes programming for channel frequency scanning. DCS encode/decode, CTCSS IC Control, option unit control, selectable channel steps and frequency range. The microprocessor receives an indication of the condition of the noise squelch from the FM subsystem IC on the IF Unit, by which scanning is activated or deactivated. Q1017 also controls the power saver function and transmit/receive switching by selecting the supply buses on the Regulator Unit Q2209 (DTB123EK), Q2205 (DTA143XK) and Q2210 (DTC144EU) disables the RX 5V bus when the power saver is active.

When the PTT switch is pressed, the impedance change on the microphone line is detected by Q1015 (2SA1586Y) on the Control Unit, which signals the microprocessor that the transmitter is active. The microprocessor then activates LED indicator D5001 to glow red (TX). Voltage comparator Q1012 (RN5VL45AA) controls power-up resetting of the microprocessor.