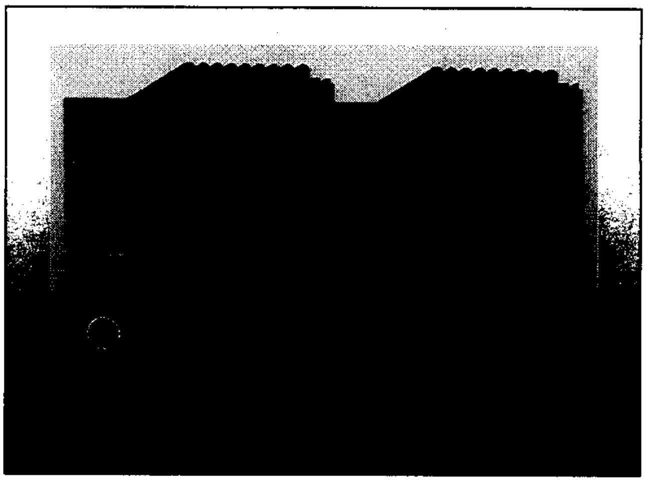
DANIELS™
ELECTRONICS LTD.



MT-4E VHF & UHF RECEIVER & TRANSMITTER INSTRUCTION MANUAL

136-174 MHz / 406-470 MHz / 470-520 MHz

Covers Models:

UR-4E420-00-000	UT-4E400-00-800
UR-4E420-A0-000	UT-4E450-00-800
UR-4E460-00-000	UT-4E500-00-800
UR-4E460-A0-000	VR-4E150-00-000
UR-4E500-00-000	VR-4E150-A0-000
UR-4E500-A0-000	VT-4E150-00-800

Document Number: IM08-MT-4E-TXRX
Revision: 1-0-2
Revision Date: Mar 2007

Daniels Electronics Ltd.
Victoria, BC
PRINTED IN CANADA

DOCUMENT CONTROL

This document has been produced, verified and controlled in accordance with Daniels Electronics' Quality Management System requirements.
Please report any errors or problems to Daniels Electronics' Customer Service Department.

DOCUMENT REVISION DEFINITION

Daniels Electronics Ltd. utilizes a three-level revision system. This system enables Daniels to identify the significance of a revision. Each element of the revision number signifies the scope of change as described in the diagram below.

1-0-0

Major Revisions: The result of a major change to product function, process or requirements.

Minor Revisions: The result of a minor change to product, process or requirements.

Editorial Revisions: The result of typing corrections or changes in formatting, grammar or wording.

Three-level revision numbers start at 1-0-0 for the first release. The appropriate element of the revision number is incremented by 1 for each subsequent revision, causing any digits to the right to be reset to 0.

For example:
If the current revision = 2-1-1 Then the next major revision = 3-0-0
If the current revision = 4-3-1 Then the next minor revision = 4-4-0
If the current revision = 3-2-2 Then the next editorial revision = 3-2-3

The complete revision history is provided at the back of the document.

NOTE

The user's authority to operate this equipment could be revoked through any changes or modifications not expressly approved by Daniels Electronics Ltd.

The AMBE+2™ voice coding Technology embodied in this product is protected by intellectual property rights including patent rights, copyrights and trade secrets of Digital Voice Systems, Inc. This voice coding Technology is licensed solely for use within this Communications Equipment. The user of this Technology is explicitly prohibited from attempting to extract, remove, decompile, reverse engineer, or disassemble the Object Code, or in any other way convert the Object Code into a human-readable form. U.S. Patent Nos. #5,870,405, #5,826,222, #5,754,974, #5,701,390, #5,715,365, #5,649,050, #5,630,011, #5,581,656, #5,517,511, #5,491,772, #5,247,579, #5,226,084 and #5,195,166.

The design of this equipment is subject to change due to continuous development. This equipment may incorporate minor changes in detail from the information contained in this manual.

RF Exposure Warning

Exposure to radio frequency (RF) energy has been identified as a potential environmental factor that must be considered before a radio transmitter can be authorized or licensed. The FCC and IC have therefore developed maximum permissible exposure (MPE) limits for field strength and power density, listed in FCC 47 CFR § 1.1310 and IC RSS-102 Issue 2 Sect 4. The FCC has furthermore determined that determination of compliance with these exposure limits, and preparation of an Environmental Assessment (EA) if the limits are exceeded, is necessary only for facilities, operations and transmitters that fall into certain risk categories, listed in FCC 47 CFR § 1.1307 (b), Table 1. All other facilities, operations and transmitters are categorically excluded from making such studies or preparing an EA, except as indicated in FCC 47 CFR §§ 1.1307 (c) and (d).

Revised FCC OET Bulletin 65 (Edition 97-01) and IC RSS-102 Issue 2 provide assistance in determining whether a proposed or existing transmitting facility, operation or device complies with RF exposure limits. In accordance with OET Bulletin 65, FCC 47 CFR § 1.1307 (b) and RSS-102 Issue Sect 2.5, this Daniels Electronics Ltd. transmitter is categorically excluded from routine evaluation or preparing an EA for RF emissions and this exclusion is sufficient basis for assuming compliance with FCC/IC MPE limits. This exclusion is subject to the limits specified in FCC 47 CFR §§ 1.1307 (b), 1.1310 and IC RSS-102 Issue 2 Sect 4. Daniels Electronics Ltd. has no reason to believe that this excluded transmitter encompasses exceptional characteristics that could cause non-compliance.

Notes:

- The FCC and IC's exposure guidelines constitute exposure limits, not emission limits. They are relevant to locations that are accessible to workers or members of the public. Such access can be restricted or controlled by appropriate means (i.e. fences, warning signs, etc.).

- The FCC and IC's limits apply cumulatively to all sources of RF emissions affecting a given site. Sites exceeding these limits are subject to an EA and must provide test reports indicating compliance.

RF Safety Guidelines and Information

Base and Repeater radio transmitters are designed to generate and radiate RF energy by means of an external antenna, typically mounted at a significant height above ground to provide adequate signal coverage. The following antenna installation guidelines are extracted from Appendix A from OET Bulletin 65 and must be adhered to in order to ensure RF exposure compliance:

Non-building-mounted Antennas:

Height above ground level to lowest point of antenna ≥ 10 m or
Power ≤ 1000 W ERP (1640 W EIRP)

Building-mounted Antennas:

Power ≤ 1000 W ERP (1640 W EIRP)

The following RF Safety Guidelines should be observed when working in or around transmitter sites:

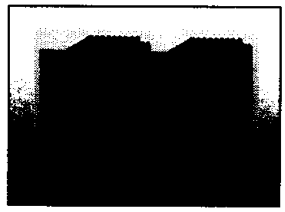
- Do not work on or around any transmitting antenna while RF power is applied.
- Before working on an antenna, disable the appropriate transmitter and ensure a "DO NOT USE" or similar sign is placed on or near the PTT or key-up control.
- Assume all antennas are active unless specifically indicated otherwise.
- Never operate a transmitter with the cover removed.
- Ensure all personnel entering a transmitter site have electromagnetic energy awareness training.

For more information on RF energy exposure and compliance, please refer to the following:

1. FCC Code of Regulations; 47 CFR §§ 1.1307 and 1.1310.
2. FCC OET Bulletin 65, Edition 97-01, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields".
3. http://www.fcc.gov/oet/rfsafety/
4. IC RSS-102 Issue 2, "Radio Frequency Exposure Compliance of Radio Communication Apparatus"

Contents

Contents continued next page



GENERAL INFORMATION

INTRODUCTION

The MT-4E Receiver and Transmitter are FM radio modules capable of analog operation in 12.5 kHz (narrow band) or 25 kHz (wide band) channels. A firmware upgrade may be purchased to allow P25 digital operation. The VHF modules operate over the band from 136 to 174 MHz and the UHF modules operate over the band from 406 to 470 MHz (transmitter) or 406 to 430 MHz, 450 to 470 MHz and 470 to 520 MHz (receiver). Modular design allows each of the Receiver and Transmitter's internal modules to be individually assembled and tested, which facilitates construction, tuning, and general maintenance.

The MT-4E Receiver and Transmitter combine state of the art performance in a compact modular enclosure for applications ranging from remote mountain top repeaters to congested urban radio environments. Each module is characterized by dependable, low maintenance performance under the most severe environmental conditions.

The MT-4E Receiver and Transmitter are primarily software controlled radio modules, allowing tuning, programming and maintenance to be done via software service with few hardware adjustments required.

The MT-4E series is compatible with all Daniels' subrack and base station enclosures. It supports a basic analog interface, and may be used in a mixed system with MT-3 and MT-4 series Receivers and Transmitters.

P25 Digital Mode

When the P25 firmware upgrade is purchased, the MT-4E family of receivers and transmitters may be configured for P25 digital operation, or mixed mode operation. In a repeater configuration, the receiver passes the complete P25 digital voice packet directly to the transmitter so no P25 digital information is lost.

All P25 specifications, operational description and information contained in this Instruction Manual require the P25 firmware upgrade to function. If the MT-4E Receiver and Transmitter are purchased without the P25 firmware upgrade, the radio will program and operate in analog mode only.

Secure Communications

The Receiver and Transmitter are capable of decoding and encoding secure communications if a DES-OFB/AES encryption module is installed. To successfully decode or encode a transmission, the encryption module must be programmed with a valid encryption key using the Motorola KVL 3000+ or KVL 3000 Keyloader in conjunction with a Daniels Keyloader Cable. The Daniels Keyloader cable plugs into the front panel RJ45 jack on the front of the Receiver or Transmitter module. For correct keyloading, the KVL must be setup to operate using ASN mode. ASN Mode is the default mode of the KVL 3000 and an optional mode of the KVL 3000+. Consult the instructions for the Keyloader for details on loading a key. A loaded key may be cleared by pulling first the CLEAR KEYS 1 then the CLEAR KEYS 2 inputs to ground 500ms apart. Alternately, the CI-BC-4E Base Controller may be used to clear the keys for all modules in a system with a single key press of the switch marked ZEROIZE KEY. The CI-BC-4E Base Controller can also be used to control whether the transmitter outputs a secure or a clear signal.

Firmware Upgrades

Receiver and Transmitter firmware upgrading is performed with the PC-based Firmware Upgrade software. A type A to 5 pin mini-type B USB cable is used to connect the USB port of an IBM compatible computer to the USB port on the front panel of the Receiver or Transmitter module.

Firmware upgrades can be found on the Daniels Electronics Ltd. website at www.danelec.com.

MT-4E Receiver Family Models

There are eight models in the MT-4E Receiver family covering the 136 to 174 MHz, 406 to 430 MHz, 450 to 470 MHz and 470 to 520 MHz bands while operating in 12.5 kHz, 15 kHz, 25 kHz, or 30 kHz occupied channel bandwidths. The receivers are classified as Class A or Class B. The eight models are as follows:

VR-4E150-A0-000	synthesized, 136-174 MHz band, 12.5/15/25/30 kHz channels; Class A
UR-4E420-A0-000	synthesized, 406 - 430 MHz band, 12.5/15/25/30 kHz channels; Class A
UR-4E460-A0-000	synthesized, 450 - 470 MHz band, 12.5/15/25/30 kHz channels; Class A
UR-4E500-A0-000	synthesized, 470 - 520 MHz band, 12.5/15/25/30 kHz channels; Class A
VR-4E150-00-000	synthesized, 136-174 MHz band, 12.5/15/25/30 kHz channels; Class B
UR-4E420-00-000	synthesized, 406 - 430 MHz band, 12.5/15/25/30 kHz channels; Class B
UR-4E460-00-000	synthesized, 450 - 470 MHz band, 12.5/15/25/30 kHz channels; Class B
UR-4E500-00-000	synthesized, 470 - 520 MHz band, 12.5/15/25/30 kHz channels; Class B

RECEIVER PERFORMANCE SPECIFICATIONS

General

Frequency Range:	136 to 174 MHz / 406 to 430 MHz / 450 to 470 MHz / 470 to 520 MHz
Channel Spacing:	12.5, 15, 25 & 30 kHz
Channel Selection:	In 2.5, 5.0 or 6.25 kHz increments selected with Radio Programming Software Package
Number of Channels:	Preset capability for 2 banks of 16 channels
Channel Switching Range:	± 2.0 MHz
Compatibility:	MT-3 and MT-4 Series Radio Systems; P25 interoperable*
System Impedance:	50 Ω (Type N connector)
Frequency Generation:	Internal Synthesizer
Reference Sensitivity:	-118 dBm (0.28uV) for 12 dB SINAD -118 dBm (0.28uV) for 5 % BER*
Local Oscillator Frequency Stability:	± 1.0 ppm (VHF) / ± 0.5 ppm (UHF)
Adjacent Channel Rejection (Selectivity):	Class A; < -45 dB; Narrowband Analog < -75 dB; Wideband Analog < -60 dB; Digital* Class B; < -40 dB; Narrowband Analog < -70 dB; Wideband Analog < -60 dB; Digital*
Intermodulation Rejection:	Class A; < -75 dB; Narrowband and Wideband Analog < -80 dB; Digital* Class B; < -70 dB; Narrowband and Wideband Analog < -70 dB; Digital*
Spurious Response Rejection:	Class A; < -75 dB; Narrowband Analog < -85 dB; Wideband Analog < -90 dB; Digital* Class B; < -70 dB; Narrowband and Wideband Analog < -70 dB; Digital*
Conducted Spurious Output Power:	< -95 dBm
Hum and Noise Ratio:	< -34 dB; Narrowband Analog < -40 dB; Wideband Analog
Audio Output:	600 Ω balanced line output (configurable for unbalanced line); De-emphasis or Flat output, +3 dBm maximum level
Audio Distortion:	Analog; ≤ 2.0 % (25 °C); ≤ 3.0 % (-30°C to +60°C) Digital as per TIA/EIA 102.CAAB*
Front Panel Controls:	Receiver Power On (Norm) / Off Squelch Disable (Push-button) Analog & Digital Receive LED indicators

** P25 Digital specifications are applicable only for modules with the P25 Digital firmware upgrade.*

COR Interface:	150 mA, 50 V open drain power MOSFET
Supply Voltage:	+13.8 VDC Nominal (range +10 to +17 VDC) +9.5 VDC Regulated
Supply Current:	Class A; < 250 mA; with no encryption module installed < 280 mA; with encryption module installed Class B; < 105 mA; with no encryption module installed < 135 mA; with encryption module installed
Operating Temperature Range:	-30°C to +60°C
Operating Humidity:	95 % RH (non-condensing) at +25°C
CTCSS Decode:	Programmable to any of 42 CTCSS tones
DCS Decode:	Programmable to any of 83 DCS sequences. Normal or inverted DCS can be selected
IC Certification No.:	n/a - Declaration of Conformity (DOC)
FCC ID:	n/a - Declaration of Conformity (DOC)

** P25 Digital specifications are applicable only for modules with the P25 Digital firmware upgrade.*

MT-4E Transmitter Family Models

There are three models in the MT-4E Transmitter family covering the 136 to 174 MHz, 406 to 470 MHz bands and 470 to 520 MHz. The three models are as follows:

VT-4E150-00-800	136-174 MHz band, 0.5-8.0 W
UT-4E450-00-800	406-470 MHz band, 0.5-8.0 W
UT-4E500-00-800	470-520 MHz band, 0.5-8.0 W

TRANSMITTER PERFORMANCE SPECIFICATIONS

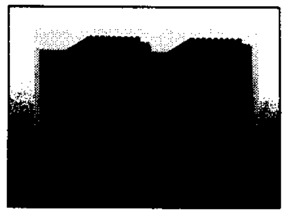
General

Frequency Range:	136 to 174 MHz / 406 to 470 MHz / 470 to 520 MHz
Carrier Frequency Stability:	± 1.0 ppm (VHF) / ± 0.5 ppm (UHF)
Channel Spacing:	12.5, 15, 25 & 30 kHz
Channel Selection:	In 2.5, 5.0 or 6.25 kHz increments selected with Radio Programming Software Package
Number of Channels:	Preset capability for 2 banks of 16 channels
Compatibility:	MT-3 and MT-4 Series Radio Systems; P25 interoperable*
RF Output Power:	0.5 to 8.0 W Continuous
Emission Designators:	Analog: 11K0F3E (Narrowband); 16K0F3E (Wideband) Digital Paging: 9K2F1D P25 Digital: 8K10F1E (Digital Voice); 8K10F1D (Digital Data)*
System Impedance:	50 Ω; Type N connector
Duty Cycle:	100 %; Continuous operation
Undesired Emissions: (Adjacent Channel Power Ratio)	< -70 dBc; Analog < -70 dBc; Digital*
Intermodulation Attenuation:	< -45 dB Analog < -45 dB Digital*
Undesired Emissions: (Conducted Spurious)	< -70 dBc @ 8 W
VSWR Protection:	< 20:1 VSWR at all phase angles
Operating Temperature Range:	-30°C to +60°C
Operating Humidity:	95 % RH (non-condensing) at +25°C
Operating Voltage:	+13.8 VDC Nominal (range +10 to +17 VDC) +9.5 VDC Regulated
Transmit Current:	< 1.7 A at 2 W RF Power Output < 2.8 A at 8 W RF Power Output
Stand By Current:	< 75 mA (no encryption modules installed) < 105 mA (with encryption modules installed)
Front Panel Controls:	Transmitter power On (Norm) / Off / Key Tx Mic Mode: Analog / Digital Analog & Digital Transmit LED indicators
PTT Time-Out-Timer:	Programmable from 15 to 465 sec. (in increments of 1 sec.) or infinity (Default 300 sec.), using Radio Service Software package
Audio Input:	Balanced, 600 Ω or optional unbalanced input (600 Ω or 15k Ω selectable input impedance)
Audio Frequency Response:	Pre-emphasis; +1, -3 dB (300 to 3000 Hz)
Audio Deviation Limiting:	± 2.5 kHz Narrowband, ± 5.0 kHz Wideband
Audio Distortion:	< 3 % THD; 1 kHz tone at 1.5 kHz or 3 kHz deviation
FM Hum and Noise Ratio:	< -34 dB (0.3 to 3.4 kHz De-Emphasis Off)
CTCSS Decode / Encode:	Programmable to any of 42 CTCSS tones.
DCS Decode / Encode:	Programmable to any of 83 DCS sequences. Normal or inverted DCS can be selected. Turnoff code optional.
IC Certification No.:	142A-VT4E150 (VHF) / 142A-UT4E450 (UHF)
FCC ID:	H4JVT-4E150 (VHF) / H4JUT-4E450 (UHF)

** P25 Digital specifications are applicable only for modules with the P25 Digital firmware upgrade.*

PHYSICAL SPECIFICATIONS

Physical Dimensions:	Width: 7.1 cm (2.8 in)	Height: 12.8 cm (5.05 in)	Depth: 19 cm (7.5 in)
Module Weight:	Receiver: 1.2 kg (2.5 lbs.) Transmitter: 1.4 kg (3.0 lbs.)		
Corrosion Prevention:	Anodized aluminum construction Stainless steel hardware Gold plated module connectors		
Module Design:	• Compact Eurostandard modular design. • Plug-in modules mate with the Daniels standard MT-3 repeater subrack. • Subracks / modules comply with IEEE 1101, DIN 41494 and IEC 297-3 (mechanical size / modular arrangement).		
External Connections:	RF Connection: type N connector located on the module front panel. Digital I/O interface is made via RJ45 modular jack located on the front panel. Programming interface is made via mini-type B USB 1.1 jack located on the front panel. Motherboard Connections (Audio, Power, and Control) are made through a 48 pin, gold plated, type F connector on the rear of the module. User connection made through mated "motherboard" assembly of the radio subrack. Type F standard connector complies with DIN 41612 Level 2 (200 mating cycles, 4 day 10 ppm SO_2 gas test with no functional impairment and no change in contact resistance).		
Handle Text Colour:	Red (VHF) / Black (UHF)		



THEORY OF OPERATION

RECEIVER THEORY

The MT-4E Receiver is constructed with the Receiver Main Board and the RF Preselector sub-assembly. The Synthesizer and the Universal Daughter Board (UDB), that contains the Digital Signal Processor Board, are mounted on the Receiver Main Board An optional Encryption Board may also be installed on the Receiver Main Board.

The MT-4E Receiver can receive both an analog FM modulated carrier and a C4FM P25 digitally modulated carrier and outputs both a baseband audio signal to the Motherboard and a Low Voltage Differential Signalling (LVDS) Serial Data signal to the front panel RJ45 jack.

Power Supply

A nominal 13.8 VDC and a regulated +9.5 VDC enters the Receiver module from the Motherboard.

Synthesizer

The synthesizer generates the LO frequency which is output through a small coax cable to the mixer in the receiver RF Preselector. There are communication inputs and outputs between the DSP and synthesizer for control functions. The synthesizer is wide band and generates LO frequencies for mixing across the entire frequency band.

RF Preselector

The RF Preselector combines a low noise bipolar amplifier with a cascaded, multiple pole, high selectivity helical resonator filter structure. RF signals at the antenna input are filtered by a 5 pole helical filter, amplified through a low noise amplifier, filtered again by a seven pole low pass or high pass filter, and then mixed, with a local oscillator supplied by the synthesizer, to produce an IF frequency of 21.4 MHz that is output to the Receiver Main Board. Interconnections are made using quick connect SMB style connectors. A high selectivity narrow bandwidth of approximately 5 MHz, combined with high ultimate out-of-band signal rejection, greatly improves Receiver spurious response and wide band intermodulation rejection. Tuning of the helical filter is provided through five capacitor adjustment points. Power for the RF Preselector is supplied from the receiver's regulated +9.5 VDC.

IF Demodulation

The Receiver Main Board processes the low level 21.4 MHz IF signal from the RF Preselector through selective crystal filtering and IF amplification. The signal is then passed through the IQ Demodulator and Digitizing Stage for demodulation to two quadrature-related baseband outputs. These outputs are represented in a digital stream which is passed to the UDB Board, where DSP techniques are used to further process the incoming sampled signal to extract P25 digital voice signals and analog voice signals.

Analog / Digital Detection

The digital detector in the UDB looks for a specific P25 bit pattern called the Frame Synch. If the Frame Synch is detected, P25 digital processing is applied, and if no Frame Synch is detected, the signal is assumed to be analog, and analog processing is applied.

Analog FM Reception

When an analog FM signal is received, the MT-4E Receiver sends the sampled audio from the demodulator to the Universal Daughter Board where it is passed to a Digital Signal Processor (DSP) for further processing. De-emphasis is applied using DSP techniques and the sampled audio is output to both the LVDS Serial Data on the front panel RJ45 jack and to the Motherboard through a D/A converter.

P25 Digital C4FM Reception

When a P25 digital C4FM signal is received, the DSP performs bit recovery and the bit stream is sent to both the LVDS Serial Data on the front panel RJ45 jack and to the Motherboard through a De-Vocoder and D/A converter.

Analog and P25 Digital Settings

The DSP controls the settings that are applied to the analog or P25 digital signal, such as CTCSS, DCS, de-emphasis, wide or narrowband selection, NAC, and TGID. These settings are all configured in the RSS software on a per channel basis.

Audio Circuitry

Baseband analog audio is output through four separate outputs to the Motherboard. An independent level adjustment is performed for the balanced audio output, the SM-3 speaker audio output, the discriminator audio output and discriminator low pass filtered output.

COR Circuitry

The MT-4E Receiver is able to distinguish between incoming analog signals and digital signals, and pulls the front panel ANALOG COR output low for an analog FM carrier, or it pulls the front panel DIGITAL COR output low for a P25 digital C4FM carrier.

The front panel DIGITAL COR and ANALOG COR outputs are typically sent to the Transmitter or Universal Interface Card.

The Receiver will also pull the COR output on the Motherboard low when either an analog FM or P25 digital C4FM carrier is detected.

When the receiver receives an analog or digital signal, the DSP will activate the front panel analog or digital LED.

MUTE Circuitry

A MUTE line from the Motherboard will override all COR outputs, balanced audio output, SM-3 speaker audio output and the LVDS Serial Data output and keep them from activating.

The Mute line is used to externally control squelching features of the receiver.

TRANSMITTER THEORY

The MT-4E Transmitter is constructed with the Transmitter Main Board and the Amplifier module sub-assembly. The Synthesizer and the Universal Daughter Board (UDB), that contains the Digital Signal Processor Board, are mounted on the Transmitter Main Board. An optional Encryption Board may also be installed on the Transmitter Main Board.

The MT-4E Transmitter can accept both a baseband audio signal from the Motherboard or microphone, or a Low Voltage Differential Signalling (LVDS) Serial Data signal from the front panel RJ45 jack for processing and transmission as an FM modulated carrier or a C4FM P25 digitally modulated carrier.

Power Supply

A nominal +13.8 VDC and a regulated +9.5 VDC enters the Transmitter module from the Motherboard.

Analog FM Transmission

When analog FM Transmision is required, the MT-4E Transmitter accepts a baseband audio signal from the microphone or balanced audio input. A level adjustment is performed and an analog to digital (A/D) convertor samples the audio. The digitized signal is applied to the Universal Daughter Board and passed to a Digital Signal Processor (DSP) for further processing.

The MT-4E Transmitter can also accept an LVDS serial data signal from the front panel RJ45 jack that is passed to the DSP for further processing.

Pre-emphasis and limiting functions are applied using DSP techniques, and the resulting signal is converted back to a baseband audio signal and applied to the VCO and TCXO on the Synthesizer, producing an analog modulated carrier.

P25 Digital C4FM Transmission

When P25 Digital transmit mode is required, the MT-4E Transmitter sends the A/D sampled microphone or balanced audio through a vocoder process in the DSP, which compresses the voice signal, and adds error protection information and other P25 Digital signalling information to produce a 9600 bps data stream.

Alternatively, the 9600 bps data stream can be obtained from the front panel RJ45 jack in the form of LVDS Serial Data.

Each pair of digital bits is used to generate one of four analog waveforms which is applied to the VCO and TCXO on the Synthesizer, thus producing a C4FM P25 digitally modulated carrier.

PTT Circuitry

For normal repeater operation, the transmitter may be keyed up in P25 Digital mode (if it is programmed for P25 Digital mode or mixed mode operation) by pulling the front panel DIGITAL PTT input low.

Similarly, it may be keyed up in analog mode (if it is programmed for analog mode or mixed mode operation) by pulling the front panel ANALOG PTT input low.

The front panel DIGITAL PTT and ANALOG PTT inputs are typically controlled by the Receiver or Universal Interface Card.

Additionally, the transmitter may be keyed by activating the microphone PTT switch; by moving the front panel power switch to the 'KEY TX' position; by grounding one of the PTT inputs on the Motherboard; or by activating the relay.

For each of these additional cases, if the transmitter is programmed for P25 Digital mode or for analog mode, it will be keyed in the appropriate mode. If it is programmed for mixed mode operation, it will use the front panel Analog/Digital switch to select the mode of operation.

When the transmitter is keyed in analog or digital mode, the DSP will activate the front panel analog or digital LED and will also activate a PTT OUT signal line that can be used to signal externally when the transmitter is keyed (eg. an Antenna Relay).

Analog and P25 Digital Settings

The DSP controls the settings that are applied to the analog or P25 digital signal, such as CTCSS, DCS, pre-emphasis, wide or narrowband selection, NAC, and TGID. These settings are all configured in the RSS software on a per channel basis.

Synthesizer

The synthesizer generates the RF frequency and modulates the analog or P25 digital signal. Modulation signals are input to the synthesizer from the DSP on the UDB via a D/A converter. There are communication inputs and outputs between the DSP and synthesizer for control functions. The modulated signal is output through a small coax cable to the transmitter amplifier. The synthesizer is capable of modulating signals from 0 to 3.4 kHz.

The synthesizer is wide band and generates RF frequencies across the entire frequency band.

RF Power Amplifier

The Transmitter RF Power Amplifier provides the final stage of RF amplification and filtering for the Transmitter. The amplifier has inputs for the RF signal from the Synthesizer, and for DC power. It has outputs for the amplified RF signal and for forward and reverse power alarms.

The amplifier is continuously adjustable from 0.5 to 8.0 W output power. The DSP will activate a power control / enable line that allows the RF power output of the amplifier to be controlled by a preselected level in the RSS software.

This Amplifier is mounted in a machined aluminum case that ensures mechanical integrity for the transmitter, provides a good ground, and also acts as a heatsink.

Amplifier Alarms and Overload Protection

The amplifier is equipped with forward output power and VSWR alarm circuitry. The forward output power alarm will activate when the forward power output drops below half of the output power setpoint. The VSWR alarm will activate at a 3:1 VSWR. The alarms are available on the Motherboard.

The VSWR overload circuit protects the Transmitter Amplifier from excessive antenna VSWR by reducing the amplifier's gain (output power) when an overload condition occurs. The VSWR overload circuit is an extension of the VSWR alarm.

CHANNEL AND BANK SELECTION

Four channel select lines CSEL0-3 are named on the Motherboard, and are brought into the receiver and transmitter modules by the 48 pin rear connector, allowing selection of 16 different channels. These signals are normally pulled low in the receiver and transmitter, but are typically set by jumpers on the Motherboard to select channel 1 by default. In addition, a bank select input is provided to switch between Bank A and B, each of which has 16 channels. The Bank select line normally floats high (+5 V), selecting Bank A, but may be pulled low or high externally.

Channel and Bank Select Line Mapping

The table below shows the relationship between the states of the bank and channel select lines. Note that the channel select lines follow a binary pattern, but that the binary "0" represents channel 1. The Bank A/B select line normally floats high (+5 V), selecting Bank A, but may be pulled low or high externally via the Bank A/B select line.

BANK A/B	CSEL3	CSEL2	CSEL1	CSEL0	Bank Selected	Channel Selected
HI	LO	LO	LO	LO	A	1
HI	LO	LO	LO	HI	A	2
HI	LO	LO	HI	LO	A	3
HI	LO	LO	HI	HI	A	4
HI	LO	HI	LO	LO	A	5
HI	LO	HI	LO	HI	A	6
HI	LO	HI	HI	LO	A	7
HI	LO	HI	HI	HI	A	8
HI	HI	LO	LO	LO	A	9
HI	HI	LO	LO	HI	A	10
HI	HI	LO	HI	LO	A	11
HI	HI	LO	HI	HI	A	12
HI	HI	HI	LO	LO	A	13
HI	HI	HI	LO	HI	A	14
HI	HI	HI	HI	LO	A	15
HI	HI	HI	HI	HI	A	16
LO	LO	LO	LO	LO	B	1
LO	LO	LO	LO	HI	B	2
LO	LO	LO	HI	LO	B	3
LO	LO	LO	HI	HI	B	4
LO	LO	HI	LO	LO	B	5
LO	LO	HI	LO	HI	B	6
LO	LO	HI	HI	LO	B	7
LO	LO	HI	HI	HI	B	8
LO	HI	LO	LO	LO	B	9
LO	HI	LO	LO	HI	B	10
LO	HI	LO	HI	LO	B	11
LO	HI	LO	HI	HI	B	12
LO	HI	HI	LO	LO	B	13
LO	HI	HI	LO	HI	B	14
LO	HI	HI	HI	LO	B	15
LO	HI	HI	HI	HI	B	16

RADIO SERVICE SOFTWARE PROGRAMMING

INTRODUCTION

Receiver and Transmitter programming is performed with the PC-based Radio Service Software (RSS). A type A to 5 pin mini-type B USB cable (included with the software) is used to connect the USB port of an IBM compatible computer to the USB port on the front panel of the Receiver or Transmitter module. The RSS allows the Receiver or Transmitter to be programmed for operating frequencies, CTCSS and DCS signaling, P25 Digital settings such as NAC and TGID, modulation type and many other parameters.

System Recommendations

- Microsoft Windows XP

Recommended Minimum Specification

- Pentium III Processor - 500 MHz
- 256 MB Memory (RAM)
- 1 GB Free Disk Space

Installation

The RSS should install automatically once the CD is inserted. If not, run SETUP.EXE, located on the CD.

Note: The Receiver and Transmitter must be programmed separately.

Once the connections are made, the Radio Service Software may be run on the computer and the radio switched on. The first time a Receiver or Transmitter is connected, the USB drivers will need to be installed from the CD using the Hardware Update Wizard. To test the connection, open the Receiver or Transmitter Configuration screen by clicking on the button in the Main screen. Click on the Receiver or Transmitter menu, then on the ID button. Click on the 'Read' button. The serial number, model number, firmware version and last programmed date should appear in the appropriate fields.

Programming settings are divided into two categories, Global options and Channel options. When the Receiver or Transmitter menu is selected from the main screen, both the Global and Channel options for the current channel are displayed. The RSS may be used to save a Receiver or Transmitter configuration to disk. This function allows the user to save a "standard" configuration, and use it as a starting configuration for all modules. An archive of configurations from each radio system in operation may also be kept so that replacement radios can be programmed easily.

If the MT-4E Receiver or Transmitter is purchased without the P25 Digital firmware upgrade, the P25 Digital options will not be available in the RSS software.

A service mode allows tuning, testing and setup of the Receiver and Transmitter modules. Analog and P25 Digital test modes may be selected by the Radio Service Software, such as Bit Error Rate testing andTest Pattern generation. Adjustments may also be performed in the Service mode, such as audio levels, RF power output and reference oscillator adjustments. The Service mode is covered in the Radio Service Software Tuning Chapter.

RECEIVER RADIO SERVICE SOFTWARE PROGRAMMING

Receiver Global Options

Several options may be set which affect the operation of the Receiver on a global basis.

Frequency Band

There are four Frequency Bands available for Receivers.

VHF	136-174 MHz
UHF	406-430 MHz
UHF	450-470 MHz
UHF	470-520 MHz

When the Frequency Band is changed, the Frequency field in every Receiver channel will be changed to the lowest frequency in the band. The Radio Service Software will allow you to change the Receiver configuration data from one Frequency Band to another, but you will need the correct Receiver Model to do so.

Note: Daniels Receivers are built differently depending upon the band. Therefore, you cannot change a receiver to a different band without a hardware change.

Base Station: Secure Hardware

This field will read if a Receiver currently has a decryption module installed.

Base Station: Monitor Type

This is selectable between OPEN and SILENT squelch types, and affects the operation of the Squelch Override push-button switch on the front panel of the Receiver. OPEN squelch means that the Receiver will unsquelch upon pushing the button, even if there is no carrier present. SILENT squelch override means that the Receiver will only unsquelch if there is a carrier present when the switch is pushed.

Holding the Squelch Disable button on the front panel for longer than 2 seconds will cause the Receiver to stay permanently unsquelched. Normal operation may be restored by pressing the Squelch Disable button again.

Squelch Settings: Threshold

This setting allows the squelch threshold to be adjusted. The value does not correspond to any specific value of squelch threshold, but is a relative indication of the RF level needed to squelch or unsquelch the radio. Increasing the value means a stronger signal will be required to unsquelch the radio.

Squelch Settings: Hysteresis

This setting allows the squelch hysteresis to be adjusted. The value does not correspond to any specific value of squelch hysteresis, but is a relative indication of the hysteresis between the squelch and unsquelch points. Increasing the value increases the hysteresis window between squelch and unsquelch.

Channel Options

The Receiver may be programmed with up to 32 channels, each with a different frequency, channel spacing and modulation type. The channels are arranged in two banks of 16 channels each, referred to as Bank A and Bank B. In this manual, a specific channel is referred to by its bank and channel i.e. B12 would refer to channel 12 in bank B. The following are all the settings that may be programmed on a per-channel basis

Channel Name

Each channel may be assigned a text name of up to 16 characters. The name is stored in the radio, but is never broadcast. It is provided as a means of identifying the channel during configuration. The channel name will default to the bank and channel number i.e. "A01" for bank A, channel 01.

Channel Type

Allowed values here are P25 Digital, Analog, and Mixed Mode. P25 Digital signaling is a purely digital mode compatible with other P25 radios. Analog mode is for receiving analog FM modulated signals. Mixed Mode allows either type of transmission to be received.

Frequency

The Receiver's channel frequency, in MHz, may be set here. Only frequencies within the operational band of the Receiver are allowed to be entered.

P25 Digital Settings: Unmute on

Allowed settings are:

- Unmute on any P25 signal. This setting allows the receiver to unsquelch on any P25 digital signal, regardless of the NAC or TGID value.
- Unmute on NAC.This setting requires that the received NAC matches the programmed value before the receiver will unsquelch.
- Unmute on NAC and TGID. This setting requires that both the received NAC and TGID match the programmed values before the receiver will unsquelch.

P25 Digital Settings: Network Access Code

The receiver's Network Access Code can be set here. The receiver may be set to unsquelch on a specific Network Access Code, or on any Network Access Code.

The Network Access Code (NAC) is a 12 bit field embedded within every P25 voice call.
NACs are primarily used for two purposes:

1. They allow a large system coverage area to be serviced by separate repeaters.
2. They allow multiple repeaters to service multiple systems with overlapping coverage areas. NACs achieve these functions by minimizing co-channel interference. This is done by keeping the receiver squelched unless a signal with a matching NAC arrives.

The NAC's 12 bit field ranges from 0 to 4095 (hexadecimal $0 to $FFF). The default value is $293 and two values are defined for special functions.

1. When a receiver is set for NAC $F7E, it unsquelches on any incoming NAC, but changes the NAC to the one programmed in the transmitter.
2. If a repeater receiver is set for NAC $F7F, it also unsquelches on any incoming NAC. The P25 repeater will repeat any NAC that it receives.

P25 Digital Settings: Talk Group ID

The receiver's Talk Group ID can be set here. This applies to P25 signals only. The receiver may be set to unsquelch on a specific Network Access Code, or on any Network Access Code.

The Talk Group Identifier (TGID) is a 16 bit field embedded within every P25 voice call. The purpose of a Talkgroup is to allow logical groupings of radio users into distinct organizations.

The TGID's 16 bit field ranges from 0 to 65,535 (hexadecimal $0 to $FFFF). Three of these values are set up for special functions.

1. The default value of $1 should be used in systems where no other talk groups are defined.
2. A value of $0 corresponds to "no-one" or a talk group with no users.
3. A value of $FFFF is reserved as a talk group which includes everyone.

Analog Settings: Squelch Type

This setting may be set to Carrier Squelch, CTCSS or DCS. When the receiver is set to Carrier Squelch, it will unsquelch when it sees a carrier whose level exceeds the Squelch Threshold for the channel. CTCSS Squelch Type requires that a particular Continuous Tone Coded Squelch System tone be present to unsquelch. DCS Squelch Type requires that a particular Digital Coded Squelch code be received continuously to unsquelch the Receiver. When either CTCSS or DCS Squelch Type is selected, additional combo boxes appear to allow selection of a particular tone or code.

Analog Settings: CTCSS Tone

This field allows selection of any of 42 EIA CTCSS tones.

Analog Settings: DCS Code

This field allows selection of any of 83 DCS tones.

Analog Settings: Invert DCS

This setting is in effect when the Squelch Type is set to DCS. It may be set to Normal DCS or Invert DCS. When Invert DCS is selected, the receiver will respond to a DCS code that has been inverted by an odd number of amplification stages. This should not be required unless the DCS signal has been inverted in the source transmitter.

Analog Settings: Bandwidth

This setting should be changed to match the channel spacing and bandwidth of the analog channel. This setting applies ONLY to the analog channel, and it is possible in Mixed Mode to have a 25 kHz analog channel and a P25 digital channel, which is always a 12.5 kHz channel.

Analog Settings: Audio De-emphasis

For conventional analog channels, the standard 6 dB/octave de-emphasis curve may be disabled or applied to the demodulated audio. This affects the analog signal at the Audio Output of the Receiver as well as the digital representation of the analog signal which is passed out the LVDS Serial Data on the front panel.

TRANSMITTER RADIO SERVICE SOFTWARE PROGRAMMING

Transmitter Global Settings

Several options may be set which affect the operation of the Transmitter on a global basis.

Frequency Band

There are three Frequency Bands available for Transmitters:

VHF	136 - 174 MHz
UHF	406 - 470 MHz
UHF	470 - 520 MHz

When the Frequency Band is changed, the Frequency field in every Transmitter channel will be changed to the lowest frequency in the band. The Radio Service Software will allow you to change the Transmitter configuration data from one Frequency Band to another, but you will need the correct Transmitter Model to do so.

Note: Daniels Transmitters are built differently depending upon the band. Therefore, you cannot change a transmitter to a different band without a hardware change.

Unit ID

This field contains the unique Transmitter unit ID. The default value is $1. The spin button to the right of this field allows you to incrementally change the ID.This unit ID will be transmitted in the source ID field along with every P25 voice frame if the transmitter is keyed in a non-repeater mode. Each Transmitter should have a unique unit ID.

Secure Hardware

This field will read if a Transmitter currently has an encryption module installed.

Hang Time: Duration

Hang time is a selectable time delay, which can be enabled to keep the transmitter keyed after its front panel PTTs are released. It can be used to prevent a chain of repeaters from dropping out if the user de-keys briefly.

It is also commonly used, in conjunction with the Courtesy Tone, at the end of the transmission to keep the transmitter keyed long enough to provide confirmation that the repeater has been activated by mobile radios.

Hang Time: Courtesy Tone

This Courtesy Tone can be set to Silent, Beep Tone or Burst Noise. When the transmitter is set to Burst Noise, a burst of noise is transmitted for the duration of the hang time. Beep Tone sends out a short continuous tone for the duration of the hang time.

Timeout Options

The transmitter provides a selectable timeout timer for each channel, which causes the transmitter to be de-keyed after the selected interval of continuous transmission has been completed. Two transmitter timeout values are provided, and one of the timeout values may be used in each of the 32 programmable channels. The range of values is from 15 to 465 seconds in increments of 15 seconds, or Infinite Time may be chosen.

These selected Timeouts can then be used in the Timeout Value field in each Transmitter Channel Setting. These fields are used to program the parameters for a single Transmitter channel only. There are 32 different available channels labeled A1 - A16 and B1 - B16. The parameters for each channel are independent of parameters in other channels.

Channel Settings

The transmitter may be programmed with up to 32 channels, each with a different frequency, channel spacing and modulation type. The channels are arranged in two banks of 16 channels each, referred to as Bank A and Bank B. In this manual, a specific channel is referred to by its bank and channel i.e. B12 would refer to channel 12 in bank B. The following are all the settings that may be programmed on a per-channel basis.

Channel Name

Each channel may be assigned a text name of up to 16 characters. The name is stored in the radio, but is never broadcast. It is provided as a means of identifying the channel during configuration. The channel name will default to the bank and channel number i.e. "A01" for bank A, channel 01.

Channel Type

Each MT-4E Transmitter can be programmed in analog only, P25 digital only, or mixed mode. P25 Digital signaling is a purely digital mode, compatible with other P25 radios. Analog mode is for transmitting analog FM modulated signals. Mixed Mode is both P25 Digital and Analog signals.

Frequency

The transmitter's frequency may be set here. The Radio Service Software will only allow frequencies within the operation band (set in the Transmitter Global options above) to be entered.

Timeout Value

This option allows selection of one of two preset timeout timer values. Each of the two preset values is set in the Transmitter Wide Settings panel, in the section called Timeout Options. If the transmitter is keyed continuously for longer than the selected time, it will be de-keyed. To reset the timeout timer, the applied PTT signal must be removed for a period at least as long as the hang time.

P25 Digital Settings: Network Access Code

For P25 channels, the transmitted Network Access Code can be set here. The Network Access Code (NAC) is a 12 bit field embedded within every P25 voice call.
NACs are primarily used for two purposes:

1. They allow a large system coverage area to be serviced by separate repeaters.
2. They allow multiple repeaters to service multiple systems with overlapping coverage areas. NACs achieve these functions by minimizing co-channel interference. This is done by keeping the receiver squelched unless a signal with a matching NAC arrives.

The NAC's 12 bit field ranges from 0 to 4095 (hexadecimal $0 to $FFF). The default value is $293 and two values are defined for special functions in the receiver.

1. When a receiver is set for NAC $F7E, it unsquelches on any incoming NAC, but changes the NAC to the one programmed in the transmitter.
2. If a repeater receiver is set for NAC $F7F, it also unsquelches on any incoming NAC. The P25 repeater will repeat any NAC that it receives.

P25 Digital Settings: Talk Group ID

The transmitter's Talk Group ID can be set here. This applies to P25 signals only.

The Talk Group Identifier (TGID) is a 16 bit field embedded within every P25 voice call. The purpose of a Talkgroup is to allow logical groupings of radio users into distinct organizations. The TGID's 16 bit field ranges from 0 to 65,535 (hexadecimal $0 to $FFFF). Three of these values are set up for special functions.

1. The default value of $1 should be used in systems where no other talkgroups are defined.
2. A value of $0 corresponds to "no-one" or a talk group with no users.
3. A value of $FFFF is reserved as a talk group which includes everyone.

Analog Settings: Signaling

This setting may be set to No Tone, CTCSS or DCS. When either CTCSS or DCS Squelch Type is selected, additional boxes appear to allow selection of a particular tone or code.

Analog Settings: CTCSS Tone

This field allows selection of any of 42 EIA CTCSS tones.

Analog Settings: Reverse Burst

For CTCSS channels only: When this field is set to "Enabled", each transmission is terminated with a short burst of CTCSS tone with its phase reversed. This allows suitably equipped receivers to squelch their audio circuits before the transmitted carrier is dropped, giving a silent squelch operation.

Analog Settings: Burst Phase

Various mobile manufactures use either one of the following TIA recommended Reverse burst formats.

120° deg
Reverse Burst Phase is shifted forward 120° for 180 milliseconds prior to turning off the RF carrier.

180° deg
Reverse Burst Phase is shifted forward 180° for150 milliseconds prior to turning off the RF carrier

Analog Settings: DCS Code

This field allows selection of any of 83 DCS tones.

Analog Settings: Turnoff Code

For DCS channels only: When this field is set to "Enabled", each transmission is terminated with a short burst of 138 Hz tone. This allows suitably equipped receivers to squelch their audio circuits before the transmitted carrier is dropped, giving a silent squelch operation.

Analog Settings: Invert DCS

This setting is in effect when the Squelch Type is set to DCS. It may be set to Normal DCS or Invert DCS. When Invert DCS is selected, the transmitter will broadcast a DCS signal whose polarity is reversed. This should not be required unless the distant receiver has its DCS configured with the wrong polarity, typically when DCS has been installed as an after-market option.

Analog Settings: External Input

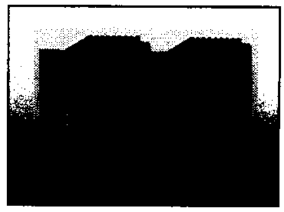
This setting allows the external input to supply the CTCSS tone or DCS code for transmission on the RF carrier.

Analog Settings: Bandwidth

This setting should be changed to match the channel spacing and bandwidth of the analog channel. This setting is visible only when the Channel Type field is set to Analog or Mixed Mode.

Analog Settings: Pre-emphasis

For analog channels, the standard 6 dB/octave pre-emphasis curve may be either disabled or applied to the transmitted audio. Pre-emphasis is applied to audio from the balanced audio input, the microphone input, and the digital representation of the analog signal which is received from the LVDS Serial Data on the front panel.



RADIO SERVICE SOFTWARE TUNING

INTRODUCTION

The RSS has the ability to put the receiver or transmitter into Service mode, where adjustments to the Audio Levels, RF Power Levels, Reference Oscillator and System Setup may be carried out. Bit Error Rate (BER) testing and transmitter test patters may also be performed in Service mode.

To put the receiver or transmitter in Service mode, the module must be connected to a PC running the Radio Service Software (RSS) through a type A to 5 pin mini-type B USB cable. From the RSS Configuration window, click on the Service button. The Service window appears, followed by a message box saying "Service mode entered". Click on the OK button to dismiss the message box.

When any required service functions have been completed, the receiver or transmitter can be taken out of Service mode by clicking on the Exit button in the Service Receiver window. There will be a delay of several seconds, then the message box will be displayed saying "Out of Service mode". The receiver or transmitter will also exit Service mode if power is removed. In this case, the RSS will display warning messages when any service functions are attempted. If this should occur, dismiss the error messages by clicking on the OK buttons in each message box until the Configuration window appears again. With the radio powered up, the Service mode may be entered again by clicking on the Service button.

RECEIVER SERVICE SOFTWARE TUNING

Reference Oscillator Adjustment

To adjust the reference oscillator frequency, disconnect the RF Preselector from the Receiver Main Board by separating the SMB connectors. The Receiver Main Board will *GENERATE* a 0 dBm RF signal from its IF *INPUT*. Connect the IF input of the Receiver Main Board to a frequency counter or communications test set. Put the receiver into test mode. Click on the Reference Oscillator button in the RSS's Service Receiver window, and the Receiver Reference Oscillator window will appear. Note the frequency stated in the Target Synthesizer RF OUT text, and adjust the communications test set to monitor this frequency. Click on the Enable button, and the communications test set will show the presence of a carrier near the stated frequency. Note the frequency error and change the Softpot Value until the measured frequency is as close as possible to the stated frequency. Click on the Program button to save the new reference oscillator Softpot value to the radio, or on the Cancel button to return to the original setting. The Service Receiver window will appear again at this point. This completes the adjustment of the reference oscillator. The receiver may be left in Service mode.

Sensitivity Verification

Two methods of sensitivity verification are used, one for analog channels and one for P25 digital channels. For either method, the radio should have a channel programmed for the desired frequency of operation, and the correct channel and bank selected. Reconnect the RF Preselector to the Receiver Main Board

Analog Channel

The Receiver's RF input is connected to a signal generator or communications monitor. Connect a 600 Ω load across the balanced audio output of the receiver. Apply power to the receiver.
Set the RF signal generator level to –70 dBm, modulated by a 1 kHz tone at 3 kHz deviation for a 25 kHz channel and at 1.5 kHz deviation for a 12.5 kHz channel. Monitor the RMS voltage across the 600 Ω load using a communications monitor or SINAD meter. Reduce the RF level of the signal generator while monitoring the SINAD. When a 12 dB SINAD ratio is reached, the RF level should be less than –118 dBm. It may be necessary to press the Squelch Disable Button on the Receiver's front panel to prevent the Receiver from squelching at these low RF signal levels.

P25 Digital Channel

The Receiver's RF input should be connected to a signal generator or communications monitor capable of P25 digital operation. If the radio is not already in Service mode from the previous step, put the receiver into Service mode. From the RSS Service Receiver window, click on the BER Test button, whereupon the Bit Error Rate window will appear. Set the signal generator to the receiver's frequency at –70 dBm, modulated with the P25 Standard 1011 Hz Pattern or Bit Error Rate test pattern. Change the frequency displayed in the Frequency text box to match the receiver's channel frequency.

For continuous error measurement, make sure the Test Type box is set to Continuous, and click on the Start Test button. The AverageFrames text box should be set to three frames, which gives an update rate of about a second. The text boxes labeled Number of Bit Errors and Bit Error Rate will be updated each second. Reduce the RF level of the signal generator while monitoring the Bit Error Rate displayed in the Bit Error Rate screen. When a 5 % Bit Error Rate is reached, the RF level should be less than –118 dBm. Note that the reading will not be exactly 5 %, but will vary slightly from second to second, similar to the SINAD reading on an analog receiver.
If long term error testing is required, the Test Type box may be set to Single, and the Number of Frames increased to give a long Integration Time. When the Start Button is pressed, a single test is begun, with errors accumulating until the test is complete. A progress bar indicates how much of the test period has passed.

Audio Level Alignment

The audio level should be set after all other alignments have been completed. The Receiver's RF input is connected to a signal generator or communications monitor and power applied. Connect a 600 Ω load across the balanced audio output. Two adjustment procedures are used depending on whether the channel is analog or P25 digital. For mixed mode channels, use the analog adjustment procedure, since there may be small variations in the audio level when switching between analog and digital modes. Put the receiver into Service mode. From the RSS Service Receiver window, click on the Audio Levels button.

Analog Channel

Set the RF signal generator level to –70 dBm, modulated by a 1 kHz tone at 3 kHz deviation for a 25 kHz channel and at 1.5 kHz deviation for a 12.5 kHz channel and monitor the RMS voltage across the 600 Ω load using a communications monitor. Adjust each Softpot Value to achieve an audio level of 308 mVRMS (-8 dBm) at each of the audio outputs. The Discriminator LPF output does not require adjustment unless it is being used. Confirm that audio distortion is less than 3 %.

P25 Digital Channel

For P25 only mode application, set the RF signal generator level to –70 dBm, modulated with the standard Project 25 1011 Hz test pattern at 2.83 kHz deviation and monitor the RMS voltage across the 600 Ω load using a communications monitor. Adjust each Softpot Value to achieve an audio level of 166 mVRMS (-13.4 dBm) at each of the audio outputs. The Discriminator LPF output does not require adjustment unless it is being used.

Received Signal Strength Indicator

The RSSI Meter will show a value of 0 to 5000 depending on the strenght of the carrier signal being received at the RF Input. This value is not calibrated and is only used for relative signal strength measurements.

System Setup: Jumper Settings

MT-4D Pin Compatibility

This setting should always be left as MT-3 / MT-4E unless the Receiver is being used with an older (2006 or earlier) Base Controller. When an older Base Controller is used, the MT-4D selection will set the Rx Mode pin to be compatible with the Base Controller.

Subtones on audio path

This setting will allow the analog subtones (CTCSS or DCS) to pass through the Balanced and Speaker Audio output for testing or custom configurations. When set to Don't Pass, the subaudible tones are filtered out of these audio lines (but the subtones are still available on the Discrimintaor Audio output).

Squelch Relay

This setting will enable or disable a small COR relay that can be used for custom configurations. This setting should be set to Disable, unless used.

TRANSMITTER SERVICE SOFTWARE TUNING

Reference Oscillator Adjustment

The reference oscillator provides an accurate frequency standard to which the transmitter's carrier signal is phase locked. For this test, the Transmitter will generate an RF signal from its RF output. Connect the RF output to a frequency counter or communications test set. To adjust the reference oscillator frequency, put the transmitter into Service Mode. Click on the Reference Oscillator button in the RSS's Service Transmitter window, and the Transmitter Reference Oscillator window will appear. Note the frequency stated in the Target Frequency text, and adjust the communications test set to monitor this frequency. Click on the Key Tx button, and the communications test set will show the presence of a carrier near the stated frequency. Note the frequency error and change the Softpot Value until the measured frequency is as close as possible to the stated frequency. Click on the Program button to save the new reference oscillator Softpot Value to the radio, or on the Cancel button to return to the original setting. The Service Transmitter window will appear again at this point. This completes the adjustment of the reference oscillator. The transmitter may be taken out of Service Mode and the amplifier module reconnected.

Audio Level Alignment

The audio level should be set after all other alignments have been completed. The transmitter should be programmed to an analog channel for the purposes of the test, since the vocoder in the transmitter encodes pure sine signals with a large amount of distortion. The transmitter's balanced audio input should be connected to an audio signal generator set up to deliver a 1 kHz tone at a level of 308 mVRMS (-8 dBm). The RF output of the transmitter should be connected to a service monitor set to monitor the deviation of the carrier signal generated by the transmitter. Click on the Key Tx button and adjust the Balanced Input Softpot Value to achieve a deviation of 3 kHz (for a 25 kHz wide channel) or 1.5 kHz (for a 12.5 kHz wide channel).

Next, de-key the transmitter and connect the signal generator with a 1 kHz tone at a level of 245 mVRMS (-10 dBm) to the microphone connector Pin 2. Click on the Key Tx button and adjust the Microphone Input Softpot Value to achieve a deviation of 3 kHz (for a 25 kHz wide channel) or 1.5 kHz (for a 12.5 kHz wide channel).

Subtone Level Alignment

The subtone level should be set after the audio level alignment has been completed. The subtone levels are set in the System Setup: Subtone Deviation Levels tab. Subtone levels can be set for both narrowband or wideband, internally or externally generated. The transmitter should be programmed to an analog channel for the purposes of the test. The RF output of the transmitter should be connected to a service monitor set to monitor the deviation of the carrier signal generated by the transmitter.

Internal Subtone Deviation Levels

The subtone is generated internally by the CTCSS tone programmed in the Channel Settings.

External Subtone Deviation Levels

The transmitter's subtone input should be connected to an audio signal generator set up to deliver the subtone at a level of 98 mVRMS (-18 dBm). Remove any inputs from the balanced or microphone audio input.

Click on the Key Tx button and adjust the appropriate Softpot Value to achieve a deviation of 500 Hz (for a 25 kHz wide channel) or 350 Hz (for a 12.5 kHz wide channel).

Amplifier Alignment

The RF power output of the amplifier is set to its rated value of 0.5 to 8.0 W at the factory. This should not require adjustment under normal circumstances.

The RF output of the transmitter should be connected to a service monitor set to monitor the power output of the carrier signal generated by the transmitter. A short section of 50 Ω low loss coaxial cable should be used. Click on the Key Tx button and adjust the Transmitter Output Power Softpot Value to achieve the desired RF power of 0.5 to 8.0 W.

Note: Do not exceed the power input rating of the external Power Amplifer when this Transmitter is used as an exciter.

Test Patterns

The Test Patterns allow the transmitter to generate a number of P25 Test Patterns for testing purposes.

C4FM Modulation Fidelity Pattern

The standard Transmitter C4FM modulation fidelity pattern is a continuously repeating bit stream defined by the following 24 bit sequence (01 01 11 00 00 01 10 01 11 10 11 11 ...).

(Refer to TIA/EIA 102.CAAB for performance recommendations).

P25 Test Tone

This pattern produces a standard P25 1011 test tone. Test set should be set to P25 demodulation to observe a 1 kHz tone

P25 Test Silence

This pattern produces a standard P25 silence. Test set should be set to P25 demodulation to verify silence.

Symbol Rate Pattern

The standard Transmitter symbol rate pattern is a continuously repeating bit stream (10 10 00 00 10 10 00 00 ...) that produces a 1200 Hz tone with deviation between 2543 Hz and 3110 Hz.

Low Deviation Pattern

The standard Transmitter low deviation pattern is a continuously repeating bit stream (10 10 00 00 10 10 00 00 ...) that produces a 1200 Hz tone with deviation between 841 Hz and 1037 Hz.

V.52 Pattern

This standard Transmitter test pattern is a continuously repeating 511 bit binary pseudo random bit sequence based on ITU-T O.153 (formerly CCITTV.52).

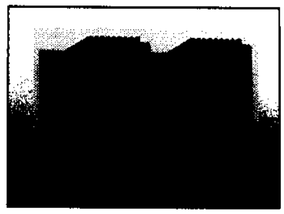
System Setup: Jumper Settings

MT-4D Pin Compatibility

This setting should always be left as MT-3 / MT-4E unless the Receiver is being used with an older (2006 or earlier) Base Controller. When an older Base Controller is used, the MT-4D selection will set the Clear / Secure pin to be compatible with the Base Controller.

Synthesizer Reference

This setting allows an external reference to lock the synthesizer for high stability in applications such as Simulcast. The Internal reference must be used for all P25 transmissions.



HARDWARE TUNING AND TROUBLESHOOTING

REPAIR NOTE

The MT-4E Receiver and Transmitter family employ a high percentage of surface mount components which should not be removed or replaced using an ordinary soldering iron. Removal and replacement of surface mount components should be performed only with specifically designed surface mount rework and repair stations complete with Electrostatic Discharge (ESD) protection.

When removing Surface Mount Solder Jumpers, it is recommended to use solder wick braid in place of vacuum type de-soldering tools. This will help prevent damage to the circuit boards.

RECOMMENDED TEST EQUIPMENT

Alignment of the Receiver and/or Transmitter requires the following test equipment or its equivalent.

Power supply - Regulated +9.5 VDC at 2 A	Phillips PM 2811
Power Supply - Regulated +13.8 VDC at 2 A	Topward TPS-4000
Oscilloscope / Multimeter	Fluke 97 Scopemeter
Current Meter:	Fluke 75 multimeter
Communications Service Monitor (Analog)	Marconi Instruments 2965A or equivalent
Communications Service Monitor (P25 Digital and Analog)	IFR 2975
Alignment Tools	Daniels A-TK-04

It is recommended that the radio communications test set be frequency locked to an external reference (WWVH, GPS, Loran C) so that the high stability local oscillator may be accurately set to within its ± 1 ppm frequency tolerance.

Complete Receiver and Transmitter Alignment

A complete Receiver and Transmitter Alignment is performed at the factory and should not be required under normal circumstances. A large change in Receiver or Transmitter operating frequency, as discussed in the next section, or a replacement of major Receiver or Transmitter sub-assembly modules, may require a complete realignment operation.

RECEIVER ASSEMBLY

The UDB, Synthesizer and optional Encryption Board are mounted on the Receiver Main Board. The RF Preselector is attached with two front panel screws and one screw through the rear F connector. An extruded aluminum shell that slides over the receiver assembly forms an enclosure. The enclosure is completed by the installation of side and front panel screws.

Receiver hardware alignment is performed solely on the RF Preselector. Alignment is simplified by using a SR-3 Subrack, SM-3 System Regulator, and extender card or cable to provide Receiver power and signal interconnection.

RECEIVER FREQUENCY CHANGE

The Receiver is initially aligned at the factory for the frequency stamped on the 'Factory Set Operating Frequency' label. This label should list the frequency at which the last complete Receiver alignment was performed.

A small frequency change of less than ± 2.0 MHz from the frequency stamped on the frequency label will generally not require any adjustment.

Changes greater than ± 2.0 MHz from a previously tuned working receive frequency will require RF Preselector alignment using the tuning procedure outlined below. Failure to perform a realignment after a large frequency change could result in unreliable Receiver operation or operation that does not conform to the published specifications.

Change the frequency using the Radio Programming Software package. Verify that the Receiver sensitivity is ≈ -118 dBm for 12 dB SINAD. Slight adjustment of the RF Preselector tuning capacitors (5) may be performed to maximize sensitivity at the new frequency. Be aware that the preferred RF Preselector tuning procedure requires swept frequency response measurement of the RF Preselector filter in order to provide a maximally flat response over a range of input frequencies, with the primary channel frequency centered in the filter passband. This alignment approach is not mandatory for single channel operation.

Alignment for the RF Preselector consists of tuning the five section preselector filter only. No tuning is required for frequency changes within the 3 dB bandwidth of its originally tuned frequency (5 MHz for VHF and 7 MHz for UHF); although, without tuning at the 3 dB band edges, the Receivers sensitivity will be degraded. For frequency changes outside of the RF Preselector's 3 dB bandwidth, use the tuning procedure outlined below.

RECEIVER RF PRESELECTOR TUNING PROCEDURE

The best way to tune the RF Preselector is to use a Spectrum Analyzer with a tracking generator. The frequency response of the Preselector Filter can be seen at the IF output. Use the following procedure for swept frequency tuning:

1. Check that the +9.5 VDC red wire is connected to the RF Preselector from the Receiver Main Board.
2. Connect the Tracking Generator output to the RF Preselector's RF input (the RF IN, N type connector on the Receiver front panel).
3. The tracking generator should have an output level of -10 dBm (Class A) or -20 dBm (Class B) and a frequency span of at least 10 MHz. If the preselector filter is grossly misaligned, a larger frequency span may be required.
4. Disconnect the RF Preselector's IF output from the Receiver Main Board, and connect it to the Tracking Generator input. The IF output is an SMB connector and will likely require an adapter to connect to the Tracking Generator. The Tracking Generator frequency will be the Receiver's RF frequency.
5. Adjust the helical filter trimmer capacitors for a flat response centered at the desired RF frequency. The measured input level should be approximately -25 or -30 dBm and the 3 dB bandwidth should be 5 MHz and 7 MHz in the VHF and UHF range respectively.
6. Once the RF Preselector is tuned, reconnect the RF Preselector's IF output back to the Receiver Main Board.

ALTERNATE TUNING PROCEDURE

The alternate method of tuning the RF Preselector is to monitor Receiver SINAD. This tuning procedure is typically used when the Receiver only has a single RF frequency. Use the following procedure for SINAD frequency tuning:

1. Check that the +9.5 VDC red wire is connected to the RF Preselector from the Receiver Main Board.
2. Inject the desired RF frequency into the RF IN connector on the Receiver front panel at a level of -118 dBm.
3. Ensure the synthesizer is connected to the LO input of the RF Preselector.
4. Adjust the helical filter trimmer capacitors for best receiver SINAD (> -118 dBm).

TRANSMITTER ASSEMBLY

The UDB, Synthesizer and optional Encryption Board are mounted on the Transmitter Main Board. The RF Amplifier module is secured on the Transmitter Main Board by screws, and an enclosure is formed by an extruded aluminum shell that slides over the Transmitter Main Board . This shell also serves as a heat sink to remove heat from the Amplifier module and for this reason, it is important that the four screws that bond the shell to the amplifier module be installed before prolonged operation of the transmitter. Moreover, the surface of the Amplifier module that contacts the shell should be clean and free of foreign material.

Transmitter hardware alignment is performed solely on the Amplifier. Alignment is simplified by using a SR-3 Subrack, SM-3 System Regulator, and extender card or cable to provide Transmitter power and signal interconnection.

TRANSMITTER FREQUENCY CHANGE

The Transmitter is initially aligned at the factory for the frequency stamped on the 'Factory Set Operating Frequency' label. This label should list the frequency at which the last complete Transmitter alignment was performed.

A small frequency change of less than ± 0.5 MHz from the frequency stamped on the frequency label will generally not require any adjustment.

Changes greater than ± 0.5 MHz from a previously tuned working transmit frequency will require VSWR alarm / overload alignment using the tuning procedure outlined below. Failure to perform a realignment after a large frequency change could result in unreliable Transmitter VSWR alarm / overload operation.

When the VSWR alarm / overload circuit is properly set, the Amplifier is protected from excessive antenna VSWR by reducing the amplifier's gain when an overload condition occurs. If the VSWR alarm is not set, the amplifier is still protected by a current limiter circuit. The circuit limits Amplifier current draw to 2.0 A and protects the Amplifier from damage.

TRANSMITTER AMPLIFIER TUNING PROCEDURE

The Transmitter Amplifier requires 0 dBm of input power and is continuously adjustable over its power range of 0.5 to 8.0 W. The amplifier provides Output Power and Antenna VSWR Alarm outputs (open drain; active low) through the transmitter to the Motherboard. The amplifier's output power level and alarm level can be set without detaching the amplifier from the transmitter board.

Transmitter Amplifier Adjustment

The RF output and VSWR alarm threshold level adjustments are easily accessible so that fine adjustments can be made in the field. The forward power alarm does not require alignment. Depending on user requirements, the VSWR alarm threshold level should be checked whenever a significant change in operating frequency (± 0.5 MHz) is made. As the antenna VSWR alarm is dependent on the output power, the output power should always be set first. The order of adjustment should be:

1. Set the output power.
2. Set the desired Transmitter VSWR alarm level.
3. Test the Transmitter Overload.
4. Verify Transmitter Current Draw.

Initial Set-Up

Step	Reference	Action	Desired Results	Notes
1	Transmitter RF output connector	Connect to radio communications test set		Use short section of low loss 50 Ω coaxial cable
2	Potentiometers RV1 & RV3	Turn fully CCW		Initial starting point
3	MT-4E RSS Software	Click "Key Tx", and adjust slider	Desired Transmitter RF Output Power	Transmitter RSS software - Service - Power Levels

Transmitter VSWR Alarm (Reverse Power)

Step	Reference	Action	Desired Results	Notes
1	Transmitter	Disconnect the test set and terminate the Transmitter with a 3:1 mismatch load		
2	Connector J1	Connect a voltmeter to Pin 5 of connector J1		
3	RV3	Adjust CW	Until Pin 5 reads +2.5 VDC, or a noticeable drop (10 % of total curent or more) in current on the +13.8 VDC line occurs	
4	Transmitter RF output connector	Connect to radio communications test set	Pin 5 should read approximately 0 VDC	Use short section of low loss 50 Ω coaxial cable

Transmitter Overload Test

Step	Reference	Action	Desired Results	Notes
1	Amplifier	Disconnect radio communications test set	Amplifier terminated with an open circuit	
2	+13.8 VDC supply	Monitor current	Noticeable drop (10 % of total current or more) in +13.8 VDC current	
3	Amplifier	Reconnect radio communications test set	+13.8 VDC current should return to previous level	

Transmitter Current Draw Verification

Step	Reference	Action	Desired Results	Notes
1	+13.8 VDC supply		Current < 2.0 A	When transmitting
2	+9.5 VDC supply		Current < 0.2 A	When transmitting

RECEIVER JUMPERS

Receiver Main Board

Jumper	Default Position	Function / Description
JU1	OUT	When installed enables Clear Keys 1 Input
JU2	OUT	When installed enables Clear Keys 2 Input
JU3	IN	When installed enables power to Discriminator Output amplifier
JU5	OUT	When installed bypasses capacitance coupling on the Discriminator output
JU7	OUT	When installed enables power to Discriminator Output LPF amplifier
JU9	X	X: 600 Ω Audio Transformer Y: Bypass Transformer
JU10	X	X: 600 Ω Audio Transformer Y: Bypass Transformer
JU11	IN	When installed enables power to Balanced Audio Output amplifier
JU12	OUT	When installed increases the gain of Balanced Audio Output amplifier
JU13	OUT	When installed selects 600 Ω resistance to ground
JU14	X	X: 600 Ω Audio Transformer Y: Bypass Transformer

Jumpers are shown on the MT-4E Receiver Jumper and Test Point Locator Illustrations.

TRANSMITTER JUMPERS

Transmitter Main Board

Jumper	Default Position	Function / Description
JU1	X	X: A/D Front Panel Switch selects transmitter A/D mode Y: A/D External Input selects transmitter A/D mode
JU2	Y	X: MIC OUT connects to Microphone Audio Input Y: MIC IN connects to Microphone Audio input
JU3	X	X: 600 Ω Audio Transformer Y: Bypass Transformer
JU4	IN	When installed selects 600 Ω resistance to ground
JU5	IN	When installed enables Clear Keys 1 Input
JU6	IN	When installed enables Clear Keys 2 Input
JU7	X	X: 600 Ω Audio Transformer Y: Bypass Transformer
JU8	X	X: 600 Ω Audio Transformer Y: Bypass Transformer
JU9	OUT	When installed bypasses capacitance coupling on the Subtone / Direct Modulation Input

Jumpers are shown on the MT-4E Transmitter Jumper and Test Point Locator Illustrations.

FRONT PANEL RJ45 JACK PINOUTS

A single, 8 position RJ45 jack is mounted on the front panel of the receiver and transmitter. The following are the connections on the RJ45 jack.

Pin	Signal
1	CRYPTO MODULE KF
2	UNUSED SPARE
3	ANALOG COR / PTT
4	LVDS DATA A
5	LVDS DATA B
6	DIGITAL COR / PTT
7	NO CONNECTION
8	NO CONNECTION