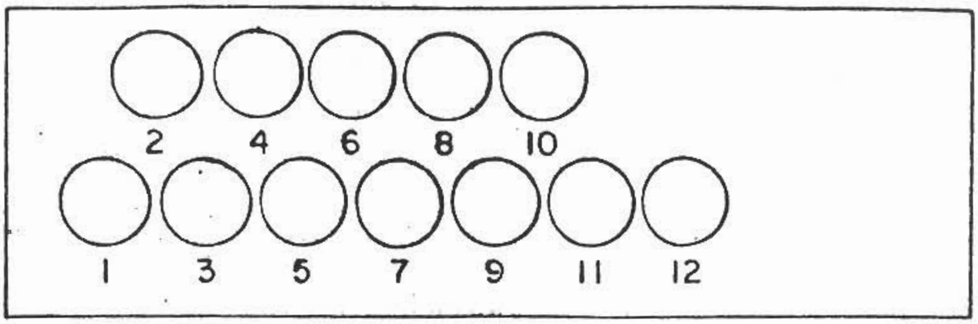
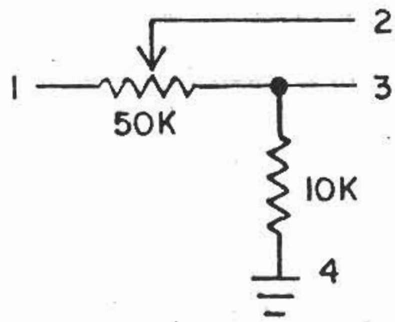
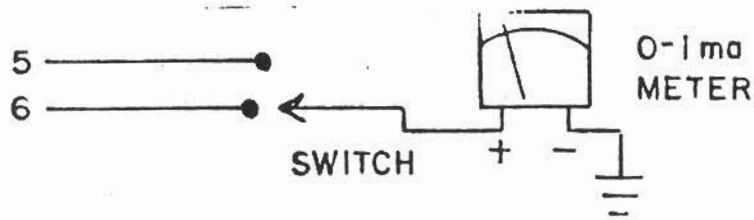
MR4 RECEIVER



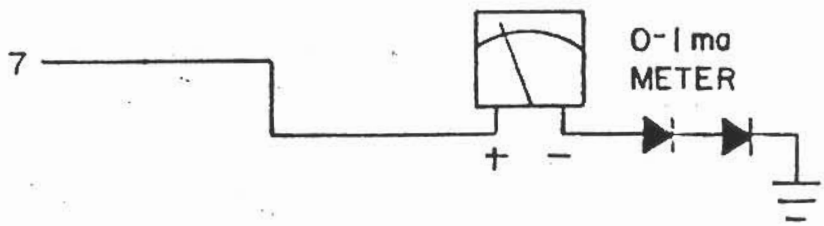
1. SQUELCH HIGH
2. SQUELCH WIPER
3. SQUELCH LOW
4. GROUND



5. 5 METER
6. PEAK DEVIATION

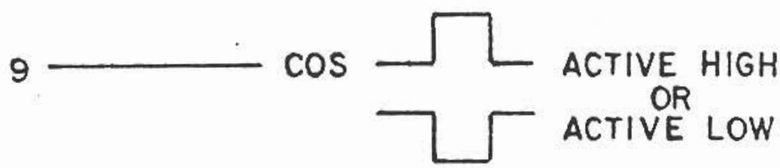


7. DISC METER

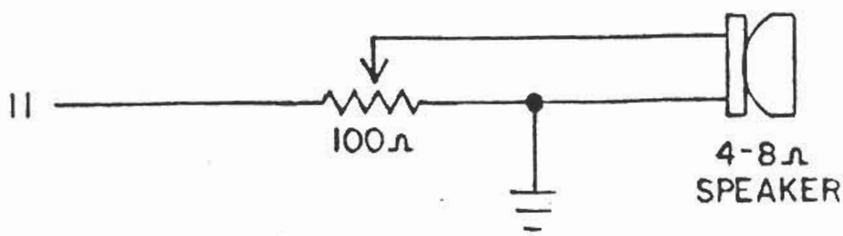


8. NO CONNECTION

9. COS LINE



10. REPEAT AUDIO
11. LOCAL AUDIO



12. +12VDC INPUT

MR4 RECEIVER

Circuit Description

The receiver RF input circuit consists of seven high-Q helical resonators (H1-H7), two amplifier transistors (Q1, Q2) and associated components. The gain of this circuitry at the RF input frequency is nominally 20 dB. Superior intermodulation performance is obtained by passing input signals through two helical resonators (H1, H2) to reject out-of-band energy before amplification. Both amplifier transistors use high bias current for maximum overload capability and minimum distortion. Feedback is used to stailize amplifier operation against temperature variations, and two sections of power supply decoupling per stage further insure stable operaion. The RF circuit output connects to the input of double balanced mixer SBL-1.

Mixer injection voltage is generated by oscillator and multiplier stages consisting of transistors Q3 through Q6 and associated components. Q3 fucntions as a fundamental frequency oscillator at a frequency determined by crystals Y1 through Y4. In single frequency receivers, diode CR2 is replaced by a strap to cause crystal Y2 to be selected as the frequency determining element. Y2 may be enclosed by an optional proportional crystal oven in applications at UHF frequencies where the receiver is subject to wide temperature variations. In multi-frequency receivers, oscillator frequency is determined by providing a ground on terminal E5, E8, E11, or E14 to select the associated crystal. The multiplication ratios of Q4 through Q6 depend upon the frequency range of the receiver as follows:

Frequency Range in MHz	Q4	Multiplier Q5	Q6
136 - 151	Doubler	Amplifier	Not used
151 - 174	Tripler	Amplifier	Not used
216 - 250	Doubler	Doubler	Not used
420 - 512	Doubler	Doubler	Doubler

High frequency crystal are used in the MR4 receiver to minimize the number of possible image frequencies by reducing the total multiplication ratio needed to obtain the required injection frequency. To further reduce image levels, double-tuned filters are used between all multiplier stages.

The double balanced mixer output is fed to the high-IF amplifier section which consists of two transistors (Q7, Q8), eight crystal filter sections, and associated components ('B' version command receivers use four filter sections.) The high-IF operates at a frequency of 21.4 MHz. Both amplifier stage outputs include broadly tuned resonant circuits (L24, C60 and L27, C66 respectively) to reject signals at frequencies beyond the skirts of the ceramic filters. Generous feedback and decoupling desensitize the amplifiers to temperature and power supply effects.

Conversion from high to low IF frequencies, amplification at the low IF frequency, limiting, and detection is done by integrated circuit U1 (squelch circuitry in U1 is not used). Frequency conversion is controlled by crystal Y5 which operates in conjuction with oscillator circuitry contained in U1. Four pole ceramic filter FL-9 operates at the low IF frequency of 455 KHz to provide additional filtering. Seven amplifier stages contained in U1 provide excellent limiting before detection. Detection is done by discriminator circuitry contained in U1 operating in conjunction with coil L28.

Wideband demodulated audio from U1 is detected by diodes CR5 and CR6 to provide the primary voltage reference for squelch operation. This detected voltage is fed to a Schmitt trigger circuit consisting of transistors Q15 and Q16. Hysteresis in the Schmitt trigger produces positive squelch action by requiring a change of about 6 dB in noise level before receiver audio is switched from off to on. The detected reference voltage is applied to the Schmitt trigger through squelch control R84 (R84 is external to the MR4.) Action of the Schmitt trigger can also be controlled by an external CTCSS decoder to disable receiver audio when no CTCSS signal is present. In applications where CTCSS operation in used, the CTCSS decoder output connects to terminal E33 to contol Schmitt trigger operation.

Squelch operation is further enhanced in the MR4 by automatically adjusting the squelch threshold in accordance with received signal level. Received signal at the low IF frequency is amplified by linear amplifier U2. detected by CR13/ CR14, level shifted by U3A, and fed to fast/slow squelch switch transistor Q14. When weak signals, less than 1 uV, are applied to the receiver transistor Q14 is turned on and applies a ground at terminal E30 to produce normal squelch action. When strong signals, greater than 1 uV, are applied to the receiver transistor Q14 is switched off. With Q14 turned off the reference voltage at the Schmitt trigger input is increased causing the squelch to be 'tightened.' 'Tightening' the squelch causes faster operation in response to signal changes and virtually eliminates squelch tail noise. Thus, the MR4 provides high squelch sensitivity to weak signals and noise-free operation for strong signals.

Output from the Schmitt trigger gates the audio output of U1. When a received signal is present audio from U1 is passed to amplifier U3C. Line audio is taken from the output of U3C at terminal E22. Audio from U3C is also routed to power amplifier U4 for driving a local speaker.

Metering circuits are provided to monitor signal strength, discriminator centering, and received signal peak deviation (Metering is not provided in version 'B' command receivers). All metering circuits are designed to drive 0-1 mA, 2200 Ohm panel meters. Signal strength metering is available at terminal E27 which is driven by DC amplifier transistor Q13. The signal strength meter indication is calibrated using potentiometer R66. DC amplifier transistor Q11 drives terminal E20 to provide discriminator metering. Potentimeter R54 allows the discriminator meter to be set to mid-scale when registering an on-frequency signal. The discriminator meter negative terminal should be returned to ground through two series connected diodes. Diodes CR7 and CR8 are provided external to the receiver module for this purpose when the MR4 is factory installed in a repeater or rack panel. Audio is amplified, rectified by CR)/ CR10, and level shifted by Q12 to drive peak deivation metering outut terminal E26. Metering calibration is done using poteniometer R64.

Switched outputs indicating the presence of received signal are available from Q9 or Q10. Q10 provides a ground at terminal E16 when received signal is present and an open when no signal is present. An inverted output can be obtained by connecting a strap from terminal E16 to terminal E17 and taking the output from terminal E15.

Installation

The following describes connections which may be made to MR4 receivers furnished in modular form. Receivers furnished in repeaters are completely connected and require no field installation.

1. Connect to receiver terminals E34 (positive) and E35 (ground) from a DC power source having the following characteristics:

Nominal voltage	12 VDC
Regulation	+/- 5%
Ripple	< 100 mV
Current	250 mA

CAUTION: The MR4 uses negative ground and must be powered from a negative ground or floating power supply. DO NOT connect a positive ground power source to the receiver.

2. To obtain a fixed-level audio output (line audio) connect to terminals E22 (signal) and E23 (ground). This output provides a level of approximately 0.4 vrms and a source impedance of 1000 Ohms. Shielded wire should be used for making this connection.

3. To obtain power amplifier audio output for driving a loudspeaker connect to terminals E24 (signal) and E25 (ground). This output provides a fixed level of approximately 3 vrms. An external 100 Ohm potentiometer may be connected between this output and the loudspeaker, as shown in the receiver schematic drawing, to adjust loudspeaker volume.

4. Connect a strap from terminal E28 to terminal E29. (Input terminal E28 is used for remote squelch control in repeater

applications and is not normally used in other applications.)

5. Connect a 50 KOhm potentiometer to terminals E30, E31, and E32 as shown in the receiver schematic diagram. This potentiometer is used for setting the receiver squelch threshold. Shielded wire should be used for making these connections.

6. To obtain a logic output signal indicating the presence of received signal connect to terminal E16. Output E16 provided a ground when received signal is present and an open when no received signal is present.

If an inverted logic signal is desired, connect a strap from terminal E16 to terminal E17 and take the output from terminal E15. Terminal E15 provides a open when received signal is present and a ground when no received signal is present.

7. If CTCSS operation is to be used, connect from tèrminals E18 (signal) and E19 (ground) to the CTCSS decoder input. Connect from the CTCSS decoder output to terminal E33. The logic signal connected to terminal E33 should provide a ground when a CTCSS signal is detected by the decoder and an open when no CTCSS signal is detected.

8. If metering is to be used, connect 0-1 mA meters having internal resistances of 2200 Ohms to the following terminals:

	Meter + Terminal	Meter - Terminal
Signal Strength	E27	Ground
Peak Deviation	E26	Ground
Discriminator	E20	Ground through series connected diodes

Adjust the signal strength meter by applying a strong (10,000 uV) signal to the receiver input and setting potentiometer R66 until compression begins (further rotation of the potentiometer causes no further change in the meter indication).

Set the discriminator meter by applying an on freqency signal to the receiver and adjusting potentiometer R54 for a center scale meter reading.

Set the peak deviation meter by applying a signal having 5KHz deviation to the receiver and adjusting potentiometer R64 for a center scale reading. Meter indication is directly proportional to deviation, i.e. 0.5 mA meter indication corresponds to 5 KHz deivation.

Alignment

All MR4 receivers are factory aligned prior to shipment and require no initial alignment. The information given below is intended to aid readjustment following component replacement; it is not a step-by-step alignment procedure. Perform only the adjustments pertaining to the receiver section having the replaced component.

1. The RF section may be aligned by applying a signal to the receiver input and connecting a selective RF monitor to terminal E1. Adjust helical resonator capacitors and coupling capacitors C4 and C15 to obtain a maximum indication on the monitor. Some interaction will be found between resonator H2 and capacitor C4 and between resonator H6 and capactior C15 so these adjustments should be repeated as necessary until no further increase in gain is obtained.

As adjustments are made, reduce the applied signal level to avoid saturating the amplifier transistors or the RF meter. When properly aligned the RF section will exhibit a gain of approximately 20 dB.

2. IF amplifier resonant circuits have a low Q so inductors L24 and L27 should not require adjustment in the field. The IF frequency can be set by loosely coupling a frequency counter to U1 terminal 1 and adjusting C107 to obtain a reading of 21.855 MHz.

3. The discriminator may be adjusted by applying an on-frequency, deviated signal to the receiver input and adjusting L28 for maximum output audio. The adjustment of L28 is not critical and will be found to have a broad maximum.

4. Receiver frequency may be set by applying an on-frequency signal to the receiver and adjusting capacitor C24 to obtain a center scale reading on the discriminator meter. In multi-frequency receivers, apply a ground to terminals E14, E11, E5, and E8 in turn to select the appropriate crystal and sdjust capacitors C28, C26, C22, and C24 respectively.

5. Multiplier stages may be adjusted by connecting a selective RF monitor to test point TP4 and adjusting the tuning components (inductors and capactiors) for a maximum indication on the monitor. When the multipliers are operating properly, the injection voltage at TP4 should be greater than 300 mv.

MR4 Receiver Parts List-1
Rev A

CAPACITORS

C 1	Part of Helical Resonator
C 2	Part of Helical Resonator
C 3	Part of Helical Resonator
C 4	5-25 pf Trim Cap
C 5	.001 Disc
C 6	.001 Disc
C 7	.001 Disc
C 8	.001 Disc
C 9	Part of Helical Resonator
C 10	Part of Helical Resonator
C 11	Part of Helical Resonator
C 12	Part of Helical Resonator
C 13	Part of Helical Resonator
C 14	Part of Helical Resonator
C 15	5-25 pf Trim Cap
C 16	.001 Disc
C 17	.001 Disc
C 18	.001 Disc
C 19	.001 Disc
C 20	Part of Helical Resonator
C 21	.001 Disc
C 22	5-25 pf Trim Cap
C 23	.001 Disc
C 24	5-25 pf Trim Cap
C 25	.001 Disc
C 26	5-25 pf Trim Cap
C 27	.001 Disc
C 28	5-25 pf Trim Cap
C 29	.001 Disc
C 30	100 pf Siver Mica
C 31	4.7Mfd 16v.
C 32	.01 Disc
C 33	F.S. 8 pf SM (135-174 Mhz) 8 pf SM (420-512 Mhz) 12 pf SM (216-250 MHZ)
C 34	F.S. 56 pf NPO (135-151 MHz) 47 pf NPO (151-158 MHz) 36 pf NPO (158-174 MHz) 39 pf NPO (215-250 MHz) 20 pf NPO (420-512 MHz)
C 35	.001 Disc
C 36	.001 Disc
C 37	F.S. 1 pf tubular
C 38	F.S 10 pf NPO (135-151 MHz) 12 pf NPO (151-158 MHz)

RESISTORS

R 1	1K
R 2	1.8K
R 3	220 Ohm with F.Bead
R 4	100 Ohm
R 5	1K
R 6	1.8K
R 7	220 ohm with F.Bead
R 8	100 Ohm
R 9	10K *
R 10	10K *
R 11	10K *
R 12	10K *
R 13	15K
R 14	3.3K
R 15	220 Ohm
R 16	39 Ohm with F.Bead
R 17	1.5K
R 18	6.8K
R 19	1.8K
R 20	220 Ohm
R 21	47 Ohm with F.Bead
R 22	6.8K
R 23	1.8K
R 24	220 Ohm
R 25	47 Ohm with F Bead
R 26	6.8K
R 27	1.8K
R 28	220 Ohm
R 29	47 Ohm with F. Bead
R 30	1K
R 31	2.7K
R 32	1K
R 33	47 Ohm with F. Bead
R 34	75 Ohm
R 35	2K
R 36	2K
R 37	47 Ohm With F. Bead
R 38	1K
R 39	2.7K
R 40	1 K
R 41	75 Ohm
R 42	2.2K
R 43	100K
R 44	4.7K
R 45	1K
R 46	47K
R 47	4.7K
R 48	390K

MR4 Receiver Parts List-2
Rev A3

CAPACITORS

	10 pf NPO (158-250 MHz)
	15 pf NPO (420-512 MHz)
C 39	F.S.
	10pf NPO (135-151 MHz)
	10 pf NPO (151-158 MHz)
	8 pf NPO (158-174 MHz)
	12 pf NPO (215-512 MHz)
C 40	1 pf (5 pf 220 Mhz only)
C 41	.001 Disc
C 42	.01 Disc
C 43	F.S. 1 pf tubular
C 44	F.S.
	22 pf (135-151Mhz)
	(151-158Mhz)
	(158-174Mhz)
	(215-250Mhz
	(420-512Mhz)
C 45	6.8 NPO Disc
C 46	F.S. 1 pf
C 47	.001 Disc
C 48	.01 Disc **
C 49	3-15 pf Trim Cap **
C 50	1 pf tubular
C 51	3-15 pf Trim Cap **
C 52	3-15 pf Trim Cap **
C 53	3-15 pf Trim Cap **
C 54	1 pf tubular **
C 55	33 pf NPO
C 56	10 pf NPO
C 57	27 pf NPO
C 58	.01 Disc
C 59	.01 Disc
C 60	33 pf NPO
C 61	.01 Disc
C 62	10 pf NPO
C 63	.01 Disc
C 64	.01 Disc
C 65	.001 Disc
C 66	33 pf NPO
C 67	.01 Disc
C 68	100 pf S.M.
C 69	17 pf S.M.
C 70	.01 Disc
C 71	100 pf NPO
C 72	.1 Disc
C 73	.1 Disc
C 74	100 pf S.M.
C 75	100 pf NPO

RESISTORS

R 49	10K
R 50	20K
R 51	7.5K
R 52	4.7K
R 53	390 Ohm
R 54	10K Pot
R 55	20K
R 56	47K
R 57	20K
R 58	1K
R 59	200K
R 60	39 K F.S.
R 61	470K
R 62	1 Meg
R 63	470K
R 64	10K Pot
R 65	1 Meg
R 66	5k Pot
R 67	22 Meg
R 68	150 Ohm with F. Bead
R 69	22 Meg
R 70	3.9K
R 71	2.2K
R 72	470K
R 73	10K
R 74	1 Meg
R 75	10K
R 76	20K
R 77	4.7K
R 78	100K
R 79	10K
R 80	10K
R 81	10K
R 82	150 Ohm
R 83	3.9K
R 84	50K pot (Squelch)

SEMI-CONDUCTOR DEVICES

Q 1	MRF 901

MR4 Receiver Parts list -3
Rev A3

C 76 100 pf NPO
C 77 4.7 Mfd 16 v.
C 78 4.7 MFD 16v.
C 79 .047 Mylar
C 80 .01 Mylar
C 81 2.2 MFD
C 82 2.2 MFD 16v.
C 83 4.7 MFD 16v.
C 84 220 MFD 35v.
C 85 .1
C 86 33 MFD 35v.
C 87 .1 MFD Disc

C 88 220 MFD 35v.
C 89 .1 MFD Disc
C 90 .1 MFD Disc
C 91 .1 MFD Disc.
C 92 100 pf NPO
C 93 100 pf NPO
C 94 4.7 MFD 16v.
C 95 100 pf NPO
C 96 100 pf NPO
C 97 2.2 MFD 16v.
C 98 .1 MFD Disc
C 99 .1 MFD Disc

C 100 .1 MFD Disc
C 101 .1 MFD Disc
C 102 2.2 MFD 16v.
C 103 33 MFD 35v.
C 104 .1 MFD Disc
C 105 .01 Mylar
C 106
C 107 5-25 pf Trim Cap

CRYSTALS and FILTERS

Y1-Y4
136-151 Fx=(F0-21.4Mhz)/2
151-174 Fx=(Fo-21.4Mhz)/3
216-250 Fx=(Fo-21.4Mhz)/4
420-512 Fx=(
Parallel resonant,third overtone,resistance 30 Ohm max 12 pf load capacity,HC-25/U case

Q 2 MRF 901
Q 3 2N4123
Q 4 2N3563
Q 5 2N3563
Q 6 2N5179
Q 7 2N3563
Q 8 2N3563
Q 9 2N4123
Q 10 2N4123
Q 11 2N4123
Q 12 2N4123
Q 13 2N4123

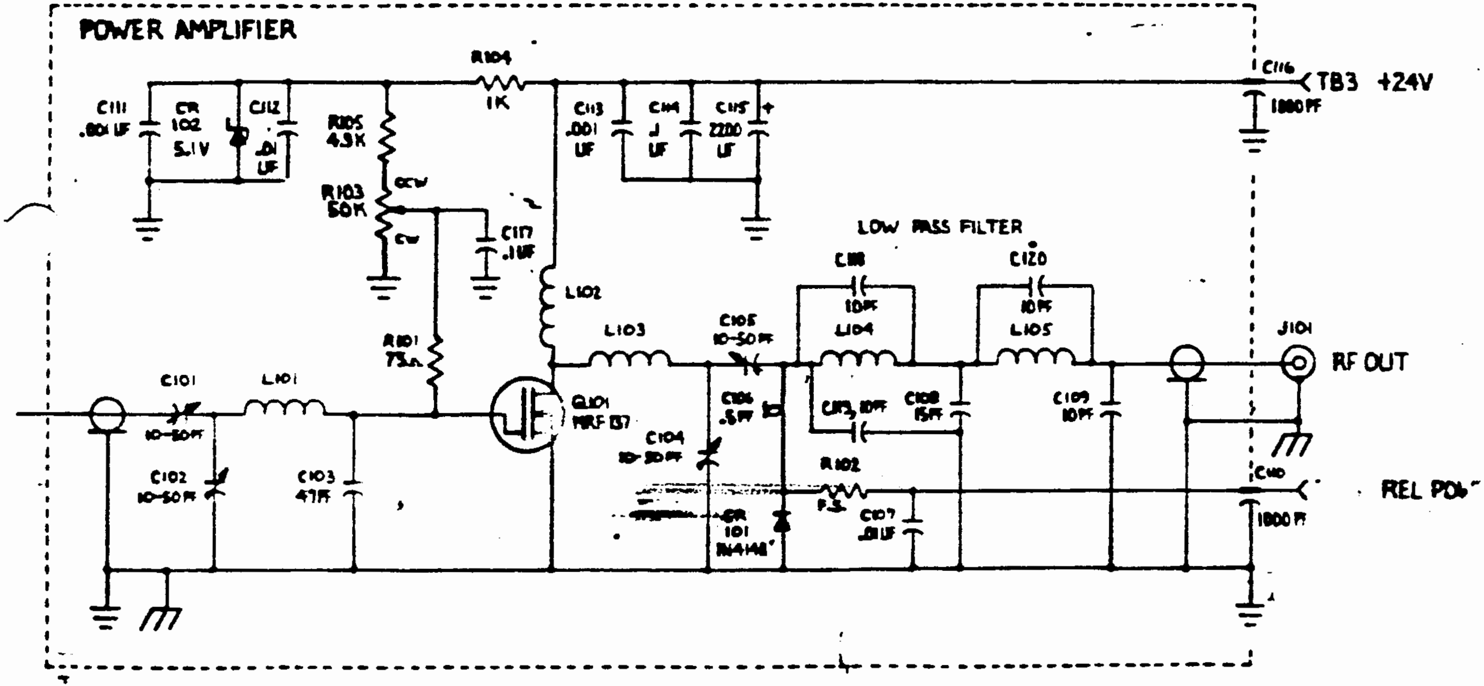
Q 14 2N4123
Q 15 2N4123
Q 16 2N4123

U 1 MC 3359
U 2 CD4007
U 3 LM3900
U 4 LM380
U 5 7808
CR 1 1N1448 *
CR 2 1N1448 *
CR 3 1N1448 *

CR 4 1N1448 *
CR 5-14 1N1448

COILS and INDUCTORS

L1 Part of Hel.Resonator
L2 Part of Hel.Resonator
L3 Part of Hel.Resonator
L4 6T2518 (135-174 Mhz)
L5 Part of Hel.Resonator
L6 Part of Hel.Resonator
L7 Part of Hel.Resonator
L8 Part of Hel.Rersonator
L9 Part of Hel.Resonator
L10 6T2528 (135-174 Mhz)
5T2518 (216-250 Mhz)
L11 5T2518
L12 Part of Hel.Resonator
L13 Part Hel.Resonator


POWER AMPLIFIER
R104
1K
C116
TB3 +24V
1000PF
C111
.001 UF
CR 102
5.1V
C112
.01 UF
R105
4.3K
R103
50K
CCW
CW
C117
.1UF
C113
.001 UF
C114
.1 UF
C115
2200 UF
L102
LOW PASS FILTER
C118
10PF
C120
10PF
L103
C105
10-50PF
L104
L105
J101
RF OUT
R101
75Ω
C101
10-50PF
L101
Q101
MRF 137
C106
.5PF
C119 10PF
C108
15PF
C109
10PF
C104
10-50PF
C102
10-50PF
C103
47PF
R102
F.S.
CR 101
1N4148
C107
.01UF
C110
1000PF
REL PO

PA 30

GENERAL DESCRIPTION

The MT4-V1 transmitter is a single-frequency, crystal-controlled FM transmitter designed for operation in the 132-174 and 215-250 megahertz band. All transmitter circuitry is contained in a single 6-inch (15.2 mm.) X 6-inch (15.2 mm.) X 2-inch (5 mm.) aluminum enclosure. All input leads, and non-RF output leads, enter the transmitter enclosure via individual feed-through bypass capacitors. RF output energy is delivered through an enclosure-mounted SO-239 type coaxial connector.

The MT4-V1 is a completely solid-state transmitter and features a TMOS FET output power amplifier for low noise and fail-free operation in the event of antenna faults. Transmitter power output is adjustable from 15 to aprox 35 watts, slightly less in the 220 MHz band. The transmitter is engineered for continuous duty operation and can be expected to provide reliable, long-life operation in repeater and base station applications.

Transmitter circuitry is contained on two printed circuit boards mounted within the enclosure. One circuit board contains audio, modulator, oscillator, multiplier, and driver stages. The second circuit board contains the TMOS FET power transistor amplifier stage and harmonic filter.

SPECIFICATIONS

Frequency range:	132-174 220-250MHz
Power Output:	15-35 watts
Stability:	.0005% (-30 to +50 C) (with optional oven)
Harmonic and spurious output:	Minimum 70 dB below rated output
Modulation:	Frequency Modulation, Deviation adjustable 0-5 kHz with instantaneous peak limiting
Audio Response:	Within +2 to -3 dB of EIA standard 6dB/octave pre-emphasis response from 300Hz to 2800Hz
Audio Input:	Limiting occurs with 180 millivolt peak-to-peak input from a 600-Ohm, 1 KHz audio source
Audio Distortion:	Less than 5%
Duty Cycle:	Continuous
Emission designator:	15F3

CIRCUIT DESCRIPTION

AUDIO AND LIMITER CIRCUITS

Audio from a low-impedance (600-Ohm) external source is applied to the transmitter at terminal TB4. RF decoupling is provided by C2, as well as by enclosure mounted feed-through capacitor C1. Capacitor C3 and resistor R1 provide 6 dB/ octave pre-emphasis shaping when the transmitter is driven from a 600 Ohm audio source.

Amplifier U1A provides audio preamplification of 20 dB. Amplifier U1B provides an additional 20 dB of amplification and also performs the audio limiting function. Both sections of amplifier U1 are DC coupled and both sections are from a common reference voltage established by R3 and R4. The reference voltage is established at one-half of the supply voltage applied to the amplifier. This circuit arrangement enables U1B to limit the audio in a highly symmetric manner which minimizes intermodulation distortion.,

POST-LIMITER FILTER AND AMPLIFIER

The limited audio signal is fed through deviation adjustment potentiometer R8 to the post-limiter filter. The filter consists of capacitors C6, C7, C8, and C11, and resistors R9, R10, and R11. The filter attenuates all audio frequency components greater than 3 KHz. Output of the audio filter is applied to class A voltage amplifier transistor Q1. The output of Q1 is fed to modulating varactor diode VC1 through capacitor C13 and resistor R11. Bias voltage for the varactor diode is derived from the regulated +8 volt supply through resistors R17 and R18. The bias voltage maintains VC1 in a reverse biased condition at all times and prevents distortion on audio signal peaks.

OSCILLATOR / MODULATOR

The transmitter oscillator consists of transistor Q2 and its associated components which are connected in a Colpitts arrangement with feedback provided by capacitors C18 and C19. Transmitter frequency is determined principally by crystal Y1 and may be adjusted to precise cystal resonance with trimmer capacitor C16. Modulation of the oscillator frequency occurs by the application of an audio frequency signal from voltage amplifier Q1 to varactor diode VC1. The audio voltage adds to the bias voltage of the varactor diode and thus alters the capacitance afforded by the diode. This change in diode capacitance causes a resulting change in transmitter frequency.

Crystal Y1 is enclosed in a proportionally controlled temperature envelope (option) to maintain exceedingly high frequency stability. The crystal heater is a solid-state unit which maintains crystal temperature typically within 1 degree C over the operating temperature range of the transmitter. Unlike older thermostatic ovens, the proportional heater used in the MT4 does not cycle on and off; therefore, crystal units are not subjected to thermal shocks. This results both in higher freqency stability and longer crystal unit life.

Frequency stability is controlled further through the use of silver mica capacitors in locations C17, C18, and C20. Capacitor C19 is a mica capacitor having a temperature coefficient which is especially selected to compensate for thermal characteristics of varactor diode VC1.

Oscillator output is taken from the emitter of Q2 through capacitor C20 and fed to the first multiplier stage. Because the oscillator output is taken from a low impedance point, oscillator frequency stability is not affecte by tuning of the subsequent multiplier stages.

Voltage regulator VR1 provides a constant 8-volt supply voltage for the oscillator and crystal heater unit. The use of an internal voltage regulator minimizes the effects of supply voltage variations on transmitter frequency stability.

MULTIPLIERS

Three multiplier stages are used to obtain the final transmitter output frequency: Q3 is used as a frequency tripler, Q4 is used as a frequency doubler, and Q5 is used as a frequency doubler (tripler in 220 units)Thus, the tranmsitter output frequency is 12-times (18-times 220 units) the crystal frequency. Double-tuned interstage networks are used at the output of all multiplier stages to give excellent rejection of unwanted mulitples. The interstage network at the output of Q3, consisting of L1/C23 and L2/C25, is tuned to 3-times the crystal frequency.. The interstage network at the output of doubler Q4, consisting of L3/C28 and L4/C30 is tuned to 6-times the crystal frequency. The tuned circuit, consisting of L5/C35 and L6/C37, at the output of doubler stage Q5 is tuned to 12-times the crystal frequency. All double-tuned interstage networks operate as high-Q circuits with low value coupling capacitors (C24, C29, and C34). Values of certain capacitors in the multiplier circuits depend upon the sub-band frequency of the transmitter and are factory selected. These capacitrs are designated F.S. on te schematic drawing. Test points TP1 and TP2 are provided at the emitters of the doubler stages to aid in alignment.

DRIVER STAGES

Three power amplifying driver stages consisting of transistors to the operating frequency by a T-matching network consisting of L103, C104, and C105. The output signal is then passed through a two-section harmonic reduction filter consisting of L104/C118, C108, L15/C120 and C109. RF power output is taken from J101.

Output power is sampled by capacitor C106 and rectified to provide an indication of relative power output at TB6.

The power amplifier operates from a supply voltage of 24 VDC. This supply is applied to the FET drain through decoupling inductor L101. Gate bias for the FET is also developed from the 24 volt supply through a regulated divider network. Potentiometer R103 sets the quiescent drain current of transistor Q101 and is used to compensate for manufacturing variations among devices.

INSTALLATION

MOUNTING

The MT4-V1 transmitter may be mounted in any position. The unit should be installed in a location where it will not be subjected moisture or a corrosive atmosphere. Although the transmitter is designed for operation over a temperature range from -30 to +50 degrees C, the reliability of components will be extended by selecting a location where the unit will not be subjected to temperature extremes or rapid temperature changes. The transmitter may be held in position with the four mounting screws on the bottom side of the enclosure. Mounting should be done in a manner which allows access to internal adjustments by removal of the top cover.

CONNECTIONS

All non-RF connections to the transmitter should be made by soldering to the feedthrough capacitor terminals extending from the side panel of the enclosure. In making these connections care should be taken to not exert excessive bending stress on the capacitor terminals as this may result in cracking the capacitor insulators. Audio connections to terminals TB4 and TB5 should be made using shielded wire.

RF output is taken from enclosure mounted coaxial connector J101. Connection should be made using coaxial cable terminated in a PL-259, or compatible, coaxial plug.

POWER SUPPLIES

Three power supplies are required. Connections for these power supplies, and their current capacities are as follows:

Connection to	Voltage	Current
TB1	+18 to +24 VDC	500 mA
TB2	+12VDC	500 mA
TB3	+24VDC	2 A

The power supply connected to TB1 powers the transmitter oscillator and proportional crystal heater. The nominal current drain from this power supply is approximately 50 mA; however, the current drain approaches 500 mA for a period of about one-minute following the initial application of power until the crystal heater temperature stabilizes. The supply connected to TB2 powers the excitier multipliers and drivers. This source is typically switched to cause transmitter keying.

ALIGNMENT

The MT4-V1 transmitter is factory aligned and tuned prior to shipment; however, the following procedure should be used to verify proper alignment upon initial installation and as required to compensate for normal component ageing. Following the alignment, transmitter frequency and deviation should be set as described in following sections. If the transmitter frequency is to be changed then the procedure given below for changing crystals should be followed prior to alignment.

Test equipment needed for alignment is as follows:

1- DC current meter, 0-1 Ampere
1- DC current meter, 0-5 Amperes
1- DC voltmeter, 0-5 volts, 20000 Ohms/volt
1- RF wattmeter, Bird model 43, or equivalent, arranged to measure 25 watts in the frequency range 134-174 MHz
1- Spectrum analyzer capable of measuring in the frequency range 110-550 MHz and having a dynamic range of 60dB
1- 50 Ohm resistive dummy load having a power rating of at least 25 watts

1. Remove the four mounting screws holding the enclosure top cover and remove the cover to gain access to the two transmitter

circuit boards.

2. Connect the transmitter through an RF wattmeter to a dummy load.

3. Connect a +18 volt power source to terminal TB1 and a +24 volt power source through a 0-5 Ampere current meter to terminal TB3.

4. Connect the DC voltmeter to the junction of resistor R101 and capacitor C117 on the power amplifier circuit board and adjust potentiometer R103 to obtain a voltage of 3.0 volts.

5. Allow a period of two-minutes for the crystal heater temperature to stabilize.

6. Connect a +12 volt source through a 0-1 Ampere current meter to terminal TB2.

7. Connect a 0-5 VDC meter to test point TP1 and adjust inductors L1 and L2 to obtain a maximum indication on the meter.

8. Move the 0-5 VDC meter to test point TP2 and adjust inductors L3 and L4 to obtain a maximum indication on the meter. Disconnect the meter from TP2.

9. Rotate potentiometer R34 to maximum its maximum clockwise position.

10. Adjust inductors L5, L6, and L7 to obtain a maximum indication on the current meter connected to TB2.

11. Adjust capacitors C45, C48, and C49 to obtain a maximum indication on the current meter connected to terminal TB2. The current indicated on the meter should not exceed 400 mA. If the current exceeds 400 mA rotate potentiometer R34 to reduce the current to 400 mA.

12. Adjust capacitors C101 and C102 to obtain an indication of approximately 500 mA on the current meter connected to terminal TB3.

13. Adjust capacitors C104 and C105 to obtain maximum power output as indicated on the wattmeter.

14. Re-adjust capacitors C101 and C102 to obtain maximum power output as indicated on the wattmeter.

15. Retune capacitors C104 and C105 to obtain maximum amplifier efficiency. This adjustment is made by simultaneously observing the wattmeter and the current meter connected to terminal TB3 and adjusting for maximum power output with minimum current input.

16. Loosely couple a link from the spectrum analyzer to the

transmitter amplifier and verify that the second and third harmonic signals are at least 60dB below the fundamental output signal.

17. Rotate potentiometer R31 as necessary to obtain a power output of 15, 20, or 25 watts in accordance with the licensed authorization.

18. This completes the transmitter alignment. Proceed to set the transmitter deviation and frequency as described below.

TYPICAL OPERATING CHARACTERISTICS

When adjusted in accordance with the alignment procedure given above, the transmitter operating parameters should be approximately as follows:

Power Output (watts)	Exciter Current (mA)	Amplifier Current (A)	Efficiency (%)
15	225	1.0	62
20	310	1.4	60
25	400	1.7	61

MODULATION LEVEL ADJUSTMENT

The deviation level is adjusted prior to shipment; however it is suggested that the level be checked upon initial installation of the unit and periodically thereafter as necessary to compensate for normal component ageing.

Test equipment required:

1- Audio oscillator capable of providing a 1 Khz output at a level of 70 mv rms.
1- Modulation meter, Wavetek model 4200, or equivalent
1- 50 Ohm resistive dummy load having a 25 watt, or greater, power rating

1. Remove the four screws holding the transmitter top cover and remove the top cover.

2. Connect the transmitter output the dummy load and apply power to transmitter input terminals TB1 (+18V), TB2 (+12V), TB3 (+24V). Allow about 2-minutes for component temperature

stabilization.

3. Connect the audio oscillator to transmitter input terminals TB4 (high) and TB5 (low). Adjust the oscillator to provide 70 mv rms at a frequency of 1 KHz.

4. Adjust DEVIATION ADJ (potentiometer R8 on the exciter board) to obtain a 4.5 KHz peak deviation with the polarity which gives the highest reading as indicated on the modulation meter.

5. Verify that the peak deviation level of the opposite polarity is greater than 4.0 KHz.

6. This completes the modulation level adjustment. If no other adjustments are required then replace the unit top cover and secure the cover with screws.

FREQUENCY ADJUSTMENT

Tranmsitter frequency is adjusted prior to shipment; however, it is suggested that the frequency accuracy be checked upon initial adjustment and periodically thereafter to compensate for normal component ageing.

Equipment needed:

1- 50 Ohm resistive dummy load having a power rating of at least 25 watts
1- Frequency counter having an accuracy better than 2 ppm and capable of measuring to 200 MHz

1. Remove the four screws holding the unit top cover and remove the top cover.

2. Connect the transmitter output to the dummy load and apply power to terminals TB1 (+18V), TB2 (+12V), and TB3 (+24V).

3. Wait at least 2-minutes for the crystal heater and other circuit components to temperature stabilize.

4. Loosely couple a link from the frequency counter to the transmitter output circuit. Adjust capacitor C16 on the exciter circuit board to set the transmitter frequency.

5. This completes the frequency adjustment. If no other adjustments are to be made replace the unit top cover and secure with screws.

CRYSTAL REPLACEMENT

The MT4-V1 is shipped from the factory with the frequency controlling crystal unit installed and with the unit tuned to frequency. If the ooperating frequency of the transmitter is to be changed or if the crystal unit must be replaced the procedure given below should be followed. Replacement crystal units should conform to the following specification:

Crystal Frequency = (Operating frequency)/12

Crystal Mode: Series resonant, 22 pf load capacity

Grade: High Accuracy, 60 degree C turnover

Holder: HC/25-u

CRYSTAL REPLACEMENT

Caution: Soldering and unsoldering should be done using a fine pointed, temperature controlled soldering iron. DO NOT use a soldering gun or iron greater than 50 watts as this may cause damage to the circuit board. De-soldering should be done with the aid of a wick or desoldering tool. Apply the minimum heat necessary and do not exert excessive pressure on the components being removed.

1. Disconnect all power from the unit.

2. Remove the four screws holding the unit top cover and remove the cover.

3. Remove the four screws holding the exciter circuit board and carefully lift the circuit board to gain access to the foil side of the board.

4. Locate the crystal heater unit and observe the orientation of the unit. Unsolder the two wire leads holding the heater unit to the circuit board and remove the heater.

5. Unsolder the two wire leads holding the crystal unit to the circuit board and remove the crystal unit.

6. Solder the new crystal unit in place, and then solder the crystal heater in place. Be sure to position the crystal heater in its original orientation.

7. If crystal replacement is being done to change the transmitter frequency it may be necessary to change certain

capacitors in the exciter multiplier stages to allow proper tuning. Appropriate values for these frequency sensitive components is given in the table below.

8. Replace the exciter circuit board into the enclosure and secure it in place with screws.

9. This completes the crystal unit replacement. Follow the procedure given above for setting the transmitter frequency.

FREQUENCY DEPENDENT COMPONENTS

Certain capacitors in the exciter multiplier stages have values which are selected to provide proper tuning of the stages in different frequency sub-bands. If the transmitter frequency is to be changed to a different sub-band the capacitors should be changed to correspond to the following capacitance values (in pf):

Capacitor	Frequency sub-band in MHz	
	132-150	150-174
C23	62	47
C25	62	47
C28	20	15
C30	20	
15		
C34	1	1
C37	22	22
C39	12	12
C40	22	22

TROUBLE SHOOTING

Voltage readings given in the following table are intended as an aid for troubleshooting. Actual voltage reading may vary 15% from values given in the table. Meaurements should be taken with the transmitter operating (key down) into a dummy load and with a 90 mv rms, 1 KHz signal applied to the audio input.

Test equipment needed for trouble shooting:

DC voltmeter 0-25 volts, 20000 Ohms/volt
AC voltmeter or oscilloscope
RF voltmeter
50 Ohm resistive dummy load having a power rating of at least 25 watts

Circuit Location	DC Voltage
Q2 Emitter	0.9 V
Q3 Emitter	2.0 V
TP 1	1.0 V
TP 2	1.6 V

KENDECOM MT450-B UHF TRANSMITTER

OPERATING MANUAL

Issue November 1987

Kendecom Incorporated

23 Elm Park   Groveland, Massachusetts 01834

CONTENTS

DESCRIPTION

The MT450-B is a solid-state FM transmitter capable of operating on any crystal-controlled single-frequency in the 406-512 Mhz range. The MT450-B is engineered for high reliability to provide maintenance free operation in continuous-duty repeater and base station applications. The transmitter may be configured to operate output power levels of 2 watts or 15 watts.

Transmitter circuitry is contained on two printed wiring boards mounted in a 6-inch (15.2 mm) X 6-inch (15.2 mm) X 2-inch (5 mm) aluminum enclosure. One circuit board contains audio, modulator, oscillator, multiplier, and driver stages plus the low power (2-watt) amplifier. The second board contains the high power (15-watt) TMOS FET amplifier. All input leads and non-RF output leads entering the transmitter enclosure are bypass-filtered with individual feed-through capacitors. RF output energy is delivered through an enclosure-mounted type N coaxial connector.

Notices

The MT450-B transmitter is type accepted for operation under FCC Regulations parts 90 and 95. The transmitter may be operated only in accordance with an authorized station license issued under those regulations. Installation and adjustment of the transmitter must be done by a licensed technician.

Kendecom Incorporated limits its liability with respect to the ownership and operation of this equipment as described in the warranty section of this manual. By installing and/or operating this equipment the owner signifies acceptance of these limitations.

1.0 SPECIFICATIONS

Frequency range:	406 - 512 MHz
Power output:	2 watts in low-power mode 15 watts in high-power mode
Output amplifier:	TMOS FET in high-power mode. Capable of withstanding infinite VSWR
Frequency control:	Parallel resonant crystal (32pf load capacitance, HC-25/U holder) mounted in a proportionally controlled oven
Multiplication ratio:	24 X
Frequency stability:	+/- 0.00025% (-30° to +60°C)
Harmonic output:	Greater than 65 dB below rated output
Spurious output:	Greater than 70 dB below rated output
Noise output:	Greater than 90 dB below rated output in high-power mode at +/- 5MHz from output carrier frequency
Modulation:	Frequency modulation. Deviation adjustable to +/- 5 KHz
Audio Response:	Within +2 dB, -3 dB of EIA standard 6dB/octave pre-emphasis from 300 Hz to 2700 Hz.
Audio Distortion:	Less than 2%
Power Requirements:	+12 VDC and +28VDC (in high power mode)
Duty Cycle:	Continuous
FCC Identifier:	D4D6NA-MT450B
Emission designator:	16F3

2. INSTALLATION

2.1 Operating Location

As with any electronic equipment, the reliability of the MT450-B transmitter will be enhanced by selecting a location which will not subject the unit to extreme environmental conditions. The location should be chosen such that the transmitter will not be exposed to moisture or corrosive atmospheres.

2.2 Mounting

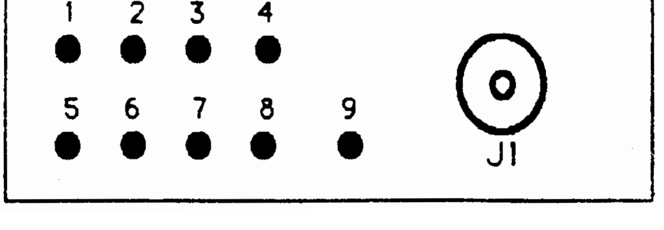
The MT450-B may be mounted in any position. The mounting arrangement should allow sufficient clearance so that internal adjustments can be accessed by removing the top cover of the unit. The transmitter enclosure provides sufficient heat sinking in most cases. In those cases where ventilation is inadequate, the transmitter enclosure should be mounted firmly to an equipment rack panel or other supplemental heat sink to insure that the transmitter internal ambient temperature does not exceed 60° C.

Four mounting studs are provided on the bottom of the transmitter enclosure for holding the unit in place. The mounting studs accept standard 8-32 machine screws.

2.3 Connections - General

Non-RF connections should be made to the feed-thru capacitor terminals and ground terminal on the side of the transmitter enclosure. Connections may be made by soldering directly to the terminals. RF output is taken from a type-N coaxial connector which is also located on the side of the transmitter enclosure. Relative positions of the terminals and the coaxial connector are shown in figure 2.1.

Figure 2.1
Transmitter side view showing locations of terminals TB1 - TB9 and coaxial connector J1



2.4 Power Connections

Power for the MT450-B should be supplied from an external, well-filtered DC power source. Three separate power input terminals are provided on the transmitter, and connections to these terminals should be made as shown in Table 2.1.

> **Note: The power source input should be disconnected so that power is not applied to the transmitter at this time.**

Connect the power supply positive voltage inputs to the transmitter terminals shown in the table, and the negative input from the power supply to the transmitter ground terminal.
Connections must be made with the correct polarity otherwise the transmitter or power supply may be damaged. Power connections should be fused to limit the maximum current to the values the shown in the table.

The power source should be arranged so that voltage is applied to terminals **TB4** and **TB2** continuously. The voltage applied to terminal **TB5** should be keyed (switched) so that voltage is applied when the transmitter is active, and voltage is removed when the transmitter is in a standby or idle state.

TABLE 2.1

Terminal	Input Voltage	Current limit
TB4	+12 to +14	250 mA.
TB5	+12 to +14	500 mA.
TB2	+28 to +30	1.5 A.

2.5 RF Output

RF output from the transmitter is taken from a type N coaxial connector **J1**. Connection should be made from **J1** to a 50Ω antenna system using a 50Ω coaxial cable terminated in a type N coaxial connector. For proper operation, the antenna system VSWR should not exceed 1.5:1

2.6 Audio Input

Audio input should be applied at an amplitude of approximately 500 millivolts peak-to-peak from a nominal 600Ω audio source. Connect the audio input to transmitter terminal **TB6**. Shielded wire should be used for making this connection.

Grounding arrangements in some installations may cause hum and noise pickup on the wiring between the audio source and the MT450-B transmitter. In these cases hum pickup can often be eliminated by grounding the shield only at the audio source (and by making no connection from the shield to the transmitter.) In cases where the audio source is separated from the transmitter by a long distance, noise pickup can often be minimized by connecting the shield to the transmitter ground through a small capacitor (approximately 0.001 uF.)

2.7 CTCSS (optional)

In applications where Continuous Tone Coded Squelch (CTCSS) is used, audio from an external CTCSS encoder should be applied to transmitter terminal **TB7**. The signal applied to this input must be a single-frequency tone with a sinusoidal waveform having less than 10% distortion. The encoder should have an output amplitude of approximately 0.7 volts rms.

2.8 Initial Adjustments

The MT450-B transmitter is completely aligned and tested prior to shipment from the factory, so field adjustments are not normally needed before placing the transmitter in service. However, as a precaution the transmitter deviation and frequency should be checked to verify that these adjustments were not affected during shipment. Procedures for checking deviation and frequency are given in sections 3.1 and 3.3 respectively.

The transmitter is tuned at the factory to operate into a 50Ω resistive load. For proper operation, the antenna and/or duplexers connected to the transmitter should be adjusted to present a 50Ω termination to the transmitter. If the antenna system cannot be tuned to obtain an ideal 1:1 VSWR, a slight adjustment of the transmitter output amplifier stage may be necessary as described in section 3.5.

3. ADJUSTMENTS

3.1 Deviation Adjustment

The modulation level was adjusted prior to shipment from the factory to provide 5 kHz. deviation. The transmitter limiter will allow this full deviation level to be reached on voice peaks over a wide range of audio input levels. Transmitter deviation may be adjusted as follows:

Test equipment required:

- 600Ω sinewave audio oscillator
- Communications test set or modulation meter
- RF dummy load

Procedure:

1. Connect the audio oscillator to transmitter terminals TB6 (audio) and TB1 (ground). Adjust the audio oscillator to provide a 200 millivolt rms, 1000 Hz output signal.

2. Connect the transmitter RF output (J1) to the dummy load.

3. Apply operating DC voltages to the transmitter.

4. Measure the transmitter deviation using the modulation meter.

5. Use a fine bladed screwdriver to set the DEVIATION ADJUST (**R20**) to obtain 5 kHz deviation with the polarity which gives the highest reading on the modulation meter.

3.2 Audio Level Adjustment

Input audio level should be adjusted so that occassional voice peaks produce a full 5 kHz. deviation. The transmitter limiter will prevent excessive transmitter for any audio input level setting; however, improper settings may degrade performance by emphasizing background noises. Transmitter deviation must be set (per section 3.1 above) prior to adjusting the audio level

Test equipment required:

- Communications test set or modulation meter
- RF dummy load

Procedure:

1. Connect an amplified microphone or equivalent audio source to transmitter terminals **TB6** (audio) and **TB1** (ground).

2. Connect the transmitter RF output (**J1**) to a dummy load.

3. Apply operating DC voltages to the transmitter

4. Speak into the microphone in a normal voice.

4. Measure the transmitter deviation using the modulation meter.

5. Adjust the input audio level control so that audio peaks indicate 5 kHz deviation on the modulation meter. DO NOT adjust the transmitter deviation setting

3.3 Frequency Adjustment

Test equipment required:

- Frequency counter of 2 ppm accuracy
- RF dummy load

Procedure:

1. Remove the four screws holding the transmitter top cover and remove the top cover.

2. Connect the transmitter RF output (**J1**) to a dummy load.

3. Apply +12 volts DC to transmitter terminal **TB4**. Wait at least 2-minutes for transmitter component temperatures to stabilize.

4. Loosely couple an insulated wire loop from the frequency counter to the transmitter harmonic filter wire line.

5. Apply +12 volts to transmitter terminal **TB5**.

6. Rotate **C27** using an insulated tuning tool to set the transmitter to the correct frequency as indicated on the frequency meter.

7. Remove the wire loop and replace the transmitter top cover.

3.4 CTCSS Level Adjustment (optional)

In applications where Continuous Tone Coded Squelch is used, tone encoder amplitude should be adjusted to properly modulate the transmitter. Transmitter deviation must be adjusted (per section 5.1 above) prior to setting the CTCSS level.

Test equipment required:

- Communications test set or modulation meter
- RF dummy load

Procedure:

1. Connect the CTCSS encoder to transmitter terminals **TB7** (tone) and **TB1** (ground).

2. Connect the transmitter RF output (**J1**) to a dummy load.

3. Apply operating DC voltages to the transmitter.

4. Insure that no audio is being applied to transmitter terminal **TB6**.

4. Measure the transmitter deviation using the modulation meter.

5. Adjust the CTCSS encoder level to obtain an indication of 0.5 kHz deviation on the modulation meter. DO NOT adjust the transmitter deviation setting.

3.5 Alignment

The MT450-B transmitter is completely aligned prior to shipment from the factory. Re-alignment should not be necessary unless a component is replaced. Transmitter frequency (see 3.3) and modulation level (see 3.1) should be checked following alignment.

Test equipment required:

- 20,000 Ω/V multimeter having a 0-10 volt scale
- 0-2 A current meter
- RF dummy load
- RF power meter

Procedure:

1. Remove the four screws holding the transmitter top cover and remove the top cover.

2. Connect the transmitter RF output (**J1**) through the RF power meter to the dummy load.

3. Apply +12 volts to transmitter terminals **TB4** and **TB5**.

4. Connect the multimeter between ground and each test point (**TP**) shown in table 3.4. Adjust the circuit components shown in the table to obtain maximum reading on the multimeter. Some interaction may occur, so repeat the adjustments as necessary until no further increase can be obtained in the multimeter reading.

If the transmitter is wired for high-power operation (15 watt output) follow steps 5 through 9. If the transmitter is wired for low-power operation (2 watt output) skip to step 10 to continue the alignment procedure.

The following step (step 5) sets the bias voltage of the final amplifier transistor (**Q101**). This adjustment is needed only if the transistor is replaced.

5. Remove the voltage from terminal **TB5** and apply +28 volts through the current meter to terminal **TB2**. Connect the multimeter to the input (gate) of amplifier **Q101**. Adjust potentiometer **R102** to obtain a voltage of 3.0 volts.

6. Connect +28 volts to terminal **TB2** and +12 volts to terminal **TB5.**

7. Connect the multimeter to terminal **TB3**. Adjust capacitors **C107, C108**, and **C109** to obtain maximum indication on the multimeter. Some interaction may occur, so repeat the adjustments until no further increase can be obtained in the multimeter reading.

8. Rotate the Power Adjust potentiometer (**R58**) to obtain the desired power output as indicated on the RF power meter. Observe the current meter to verify that the final amplifier current does not exceed 1.3 A. Adjust **R58** if necessary to prevent the current from exceeding 1.3 A

9. Replace the transmitter top cover. This completes the alignment of the transmitter for high-power (15 watt) operation.

The following steps should be done to complete the alignment when the transmitter is wired for low-power (2 watt) operation.

10. Rotate the Power Adjust potentiometer (R58) to obtain a power output of 2 watts as indicated on the RF power meter.

11. Replace the transmitter top cover. This completes the transmitter alignment.

Table 3.4

Test Point	Nominal voltage	Adjust Components
TP3	4 VDC	L2, C43, L3, C46
TP4	4	L4, C52, L5, C54
TP5	6	L6, C58, L8, C61
TP6	2.2	L10, C67, L11, C69

4. CRYSTAL

4.1 Crystal Specifications

The MT450-B transmitter is shipped from the factory with the frequency controlling crystal installed and with the transmitter tuned to frequency. If the transmitter frequency is to be changed the replacement crystal unit should conform to the following specifications:

Crystal frequency = (Transmitter operating frequency) / 24

Mode: Parallel resonant, 32 pf load capacitance

Type: High-accuracy, 60°C turnover, HC-25/U holder

4.2 Crystal Replacement

1. Remove all power from the transmitter.

2. Remove the four screws holding the transmitter top cover and remove the cover.

3. Remove the four screws holding the exciter circuit board and carefully lift the circuit board to gain access to the foil side of the board.

4. Locate the crystal heater unit and observe the orientation of the heater

unit. Unsolder the two wire leads holding the heater unit to the circuit board and remove the heater unit.

> **Caution:** Use a fine-pointed, temperature controlled soldering iron and a solder wick or desoldering tool. Apply the minimum heat necessary. Do not exert excessive stress on component leads

5. Unsolder the two wire leads holding the crystal unit and remove the crystal.

6. Solder the new crystal unit in place, and then solder the heater unit in place. Be sure to position the heater unit in its original orientation.

7. Replace the exciter circuit board and secure it in place with the mounting screws.

This completes the crystal replacement procedure. Follow the procedure in section 3.3 to set the transmitter frequency.

5. LOW POWER OPERATION

The MT450-B transmitter can be arranged to operate in a low power mode for use in applications where the maximum permitted output power is 2 watts. The wiring changes needed to operate in the low power mode are given below. These wiring changes are made at the factory when the low power option is ordered. The power amplifier board is not functional in the low power mode, therefore, this board is not furnished in units which are factory wired with the low power option.

> **Caution:** Remove power from the transmitter before making wiring changes.

1. Remove the coaxial cable connecting from the power amplifier board to RF output coaxial connector **J1**.

2. Locate the coaxial cable connecting from terminal **E6** on the exciter board to terminal **E101** on the power amplifier board, and disconnect the end of the cable which is connect to terminal **E101**.

3. Connect the free end of the coaxial cable to the RF output coaxial connector **J1**.

Power amplifier stage **Q101** is not used in the low power mode, therefore, no power connection should be made to terminal **TB2**. After the wiring changes are made, the transmitter should be aligned in accordance with the procedure given in section 3.5 for low opower operation. Power Adjust potentiometer **R58** should be used to set the transmitter output power to 2 watts.

6. CIRCUIT DESCRIPTION

6.1 Audio Amplifiers

Input audio is applied to the transmitter through feedthru capacitor **TB6** which removes any RF energy present on the input audio wiring. Additional RF bypassing is provided by capacitor **C1**. Audio input impedance is established as 1KΩ by resistor **R1**. Audio signals are amplified in two operational amplifiers, **U1A** and **U1B**. Each amplifier section provides a gain of 20 dB. The two amplifier stages are AC coupled, and the output of each amplifier stage is biased at level of +6 VDC. Feedback is provided by capacitors **C3** and **C6** to control the frequency response of the amplifiers. Supply voltages to the amplifiers are decoupled to prevent noise pickup with ferrite bead **FB2** providing high-frequency decoupling and **R7/C7** providing low-frequency decoupling. Amplifier bias is established by resistive divider **R2** and **R3** with bead **FB1** and capacitor **C4** providing decoupling for the bias divider. Audio output from the second stage amplifier is applied to the limiter stage through resistor **R9**.

6.2 Limiter, post limiter filter

Integrated circuit **U2A** contains an audio amplifier and a variable gain cell which serves as both a compressor and peak limiter. Input audio is applied to pin 5 of **U2A** and output audio is taken from pin 7. DC feedback is provided by **R11** and AC feedback is provided by **C10** in combination with the internal circuitry of **U2A**. The gain of **U2A** is determined by the voltage present on capacitor **C13**. At low audio levels the voltage present on **C13** is small so **U2A** operates as a linear amplifier. The output of **U2A** is sampled and further amplified by **U3**. The output of **U3** is fed to **Q1**. At high audio levels, **Q1** causes the voltage across capacitor **C1** to increase which, in turn, reduces the gain of **U2A**. The adjustable gain cell in U2A operates in a logarithmic manner to accommodate a wide dynamic range of audio levels. In typical operation where the transmitter deviation is set to a maximum of 5 kHz deviation, U2A will function as a linear amplifier for audio levels which produce less than 4.8 kHz deviation. Compression will begin at levels which produce 4.8 kHz deviation and hard limiting will occur at levels which produce 5 kHz. deviation. In the hard limiting region, the output is held constant for input overdrive levels greater than 30 dB.

The output of **U2A** is fed to Deviation Adjust potentiometer **R20** and then to the post limiter audio filter consisting of **R21**, **R22**, **R23**, **C15**, **C16**,

C17, and **C19**. The post limiter filter provides a minimum of 18 dB per octave rejection of signals above 3kHz. The output of the post limiter filter is fed to voltage amplifier **Q2** which drives varactor diode **CR1** to deviate the transmitter frequency.

6.3 Oscillator, buffer

Transistor **Q3** and associated components form a Colpitts oscillator. Feedback to sustain oscillation is provided by capacitors **C33** and **C34**. Stable silver mica capacitors are used to maintain a precise feedback ratio. The voltage applied to **Q3** is maintained precisely by voltage regulator **VR1** to enhance oscillator stability. The frequency of the oscillator is determined primarily by crystal **Y1**. Capacitors **C28A**, **C28B**, and variable capacitor **C27** are placed in series with the crystal and permit the transmitter frequency to be adjusted in a small range about the resonant frequency of the crystal.

Direct frequency modulation is obtained by applying an audio voltage to varactor diode **CR1** which is also placed in series with the crystal. Audio signals are applied to the varactor diode from voltage amplifier **Q2** through resistor **R30**. The applied audio voltage causes a corresponding change in diode capacitance which, in turn, causes deviation of the oscillator frequency.

Crystal **Y1** and varactor diode **CR1** are mounted in a proportional oven which maintains both components at a constant temperature to prevent variations in ambient temperature from changing transmitter frequency.

Output from the oscillator is fed through capacitor **C35** to buffer amplifier **Q4**. The buffer amplifier acts as a constant load to isolate the oscillator from variations in loading as the multiplier stages are tuned. A test point, **TP1**, is provided at the emitter of buffer amplifier **Q4**. A nominal voltage of 1.7 VDC at this test point signifies that the oscillator and buffer stages are operating properly.

6.4 Multipliers

Four stages are used to multiply the oscillator fundamental frequency to the final output frequency. The four stages comprise a total multiplication ratio of 24. Each stage consists of a transistor followed by a double-tuned interstage filter. Double-tuned interstage networks provide increased rejection of unwanted harmonics compared with single tuned networks. In addition, the double-tuned stages give reduced sensitivity to temperature variations and component ageing. The four multiplier stages are as follows.

Multiplication Ratio	Transistor	Output Frequency Range in MHz	Interstage Filter
3	Q5	50.5 - 64	L2,C43,L3,C46
2	Q6	101.5 - 128	L4,C52,L5,C54
2	Q7	203 - 256	L6,C58,L8,C61
2	Q8	406 - 512	L10,C67,L11,C69

Test points are provided at the emitter of each multiplier stage to aid in alignment and troubleshooting. DC voltage measurements made at any test point are used to align the double-tuned networks of the preceding multiplier stage as described in section 5.4.

6.5 RF Amplifiers

Amplifiers **Q9**, **Q10**, and **Q11** operate at the transmitter output frequency. **Q9** is a pre-driver amplifier with a single-tuned output network consisting of **L12**, and **C74**. Series capacitor **C75** and shunt inductor **FB19** provide impedance matching from the output of **Q9** to the input of driver stage **Q10**. Test point **TP6** is provided at the emitter of **Q9** to aid in the alignment of the preceding doubler stage. Transmitter power output can be set by using **R58** to adjust the collector voltage of **Q9**.

Amplifier transistor **Q10** provides drive to the final low-power output stage. **Q10** is tuned by **L16** and **C78** to operate at the transmitter output frequency. Series capacitor **C79** and shunt inductor **FB20** provide impedance matching from the output of **Q10** to the input of amplifer **Q11**.

Amplifier transistor **Q11** increase the transmitter power level to the 2-3 watt range. When the transmitter is wired for low-power operation, the output power may be set precisely to 2 watts by adjusting the drive level to **Q11**. When the transmitter is wired for high-power operation, **Q11** operates at an output level of about 3 watts. The tuned output network of **Q11** consists of inductors **L20** and **L11**, and capacitors **C86**, **C87**, and **C88**. This output network provides both low-pass filtering and impedance matching to a 50Ω load. A shunt feedback network consisting of **L18**, **C83**, and **R63** reduces low-frequency gain to prevent spurious oscillations.

6.6 Power Amplifier

For high-power operation TMOS FET power amplifier transistor **Q101** raises the transmitter output power to 15 watts. **Q101** operates at a nominal drain supply voltage of +28 volts and a gate bias of 3 volts. The gate bias is provided by using voltage regulator **CR101** to develop a stabilized supply voltage and potentiometer **R102** to compensate for variations in transistor characteristics. The input of **Q101** consists of a stripline filter tuned by capacitor **C107**. The mechanical arrangement of the stripline causes it to function as a distributed tuned filter. The output of **Q101** is tuned by a similar stripline arrangement operating in conjunction with capacitor **C108**. Capacitor **C109** provides impedance matching to the output harmonic filter. The harmonic filter is a four-section network which provides excellent harmonic rejection. Output power is sampled by capacitor **C114** and rectified by diode **CR102** to provide an indication of relative output power level at terminal **TB3**.

6.7 Power Distribution

The MT450-B has three separate power supply inputs: a continuous +12 volt input, a switched (keyed) +12 volt input, and a continuous +28 volt input. The continuous +12 volt input powers buffer **Q4** directly, and is regulated down to +8 volts by **VR1** to power oscillator **Q3** and the crystal heater. Multiplier, driver, and amplifier stages **Q5** through **Q11** are powered from the switched +12 volt supply. The +28 volt supply powers output amplifier transistor **Q101**. Transistor **Q101** and, consequently, the +28 volt supply are used only when the transmitter is wired for high power operation. Substantial power supply decoupling, in the form of RLC filter networks, are used on all active stages.

7. MAINTENANCE

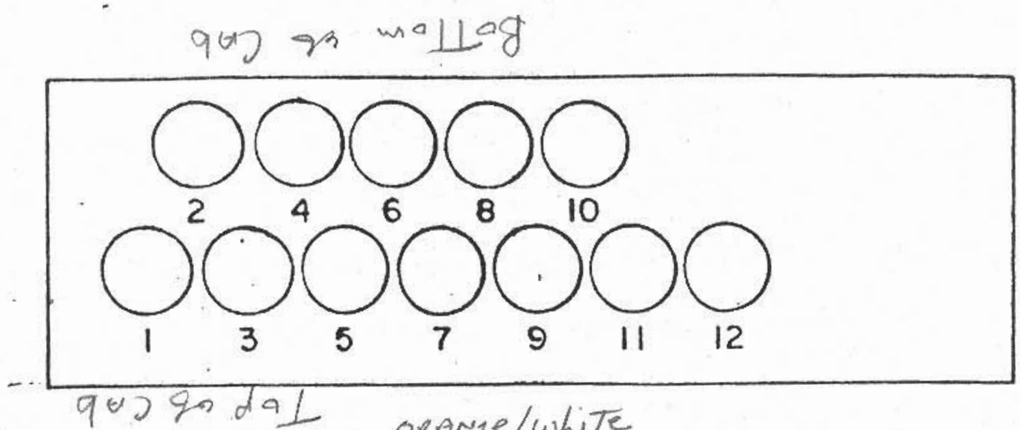
The MT450-B transmitter is designed and constructed for reliable operation and long-life. Periodic maintenance is not required.

- If the transmitter fails to operate, verify that the three power supply voltage sources are connected to the transmitter and that the correct voltages are being supplied. Also verify that the transmitter is properly grounded.

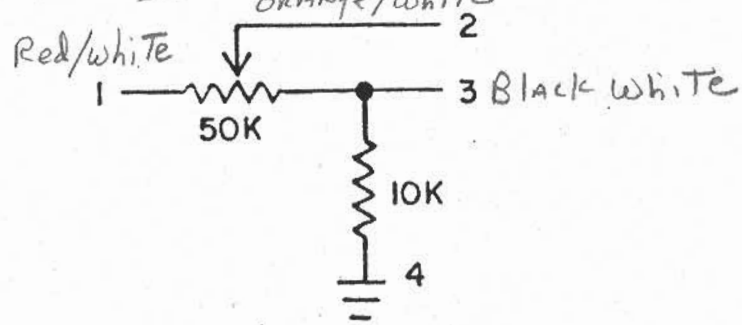
- The transmitter can be damaged by lightning induced surges. Failure of the transmitter to draw current from the +28 volt supply is an indication that amplifier **Q101** may have been damaged by a lightning surge.

- If no RF power is obtained from the transmitter, use a DC voltmeter to verify that proper voltages are present at the test points. An improper voltage indicates a fault in the stage being measured or the preceding stage. Measurements should be made sequentially beginning with **TP1**.

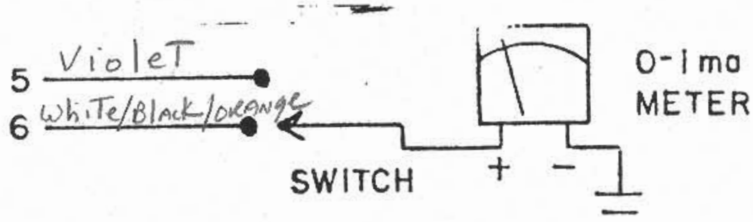
MR4 RECEIVER



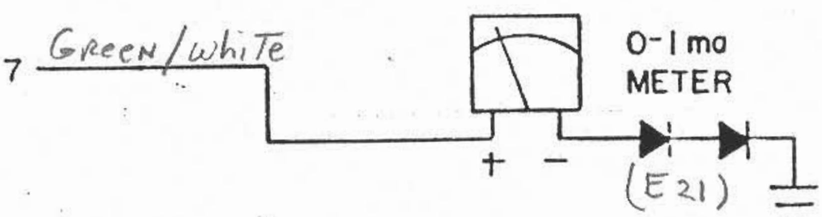
1. SQUELCH HIGH
2. SQUELCH WIPER
3. SQUELCH LOW
4. GROUND - Black



5. S METER
6. PEAK DEVIATION

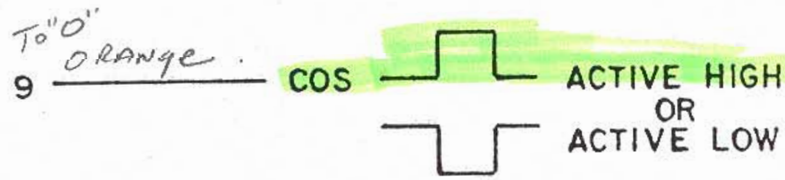


7. DISC METER

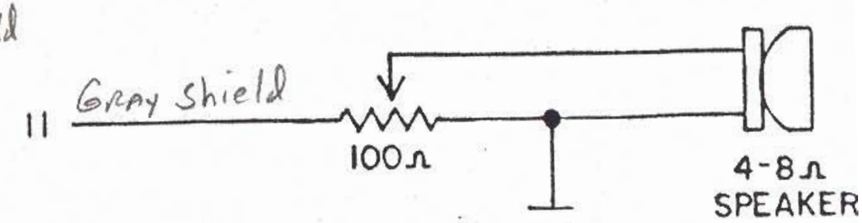


8. NO CONNECTION

9. COS LINE Go's Low 2.7 To "0" ON RCV.



10. REPEAT AUDIO - Gray Shield
11. LOCAL AUDIO



12. +12VDC INPUT - Blue