INSTRUCTION MANUAL

UHF FM DESKTOP REPEATER

450-470 MHz

E. F. JOHNSON COMPANY, WASECA, MINNESOTA 56093
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Section 1: Specifications

1.1 GENERAL

Frequency Ranges: 450-470 MHz
Number of Channels: 1
Tx/Rx Spacing: 5 MHz
Tx/Rx to Antenna Insertion Loss: 1.5 dB max.
Rx Isolation at Tx Frequency: 60 dB min.
Operating Modes: Repeater and/or Base Station (switch selectable)
Solid State CTCSS: Tunable; separate encode and decode circuits; single tone frequency standard; second tone optional
Duplexer: Internal
Time-Out-Timer: 2-10 minutes (adjustable)
Carrier Delay: 0-6 seconds (adjustable)
Applicable Documents: The following documents form a part of these specifications to the extent specified herein: FCC parts 21, 90, 95

Temperature Range: -30°C to +60°C

Dimensions: Height Width Depth
15 11.5 13.75 in
12.7 31.75 31.75 cm

Weight: 20 lbs. (9.07 kilograms)

Modulation: 10P3, ±5 kHz deviation
FM Hum and Noise: -50 dB max. (Ref. #3 kHz Dev)
Audio Response: Linear deviation in the repeat mode up to ±5 kHz max. Pre-emphasis (+1 to -3 dB) of +6 dB/octave from 0.3 to 3 kHz
Audio Distortion: 3%

1.3 RECEIVER PERFORMANCE

EIA 12 dB SINAD: .35 uV (-116 dBm) max. at Rx input port
.42 uV (-114.6 dBm) at antenna port
20 dB QUIETING: .5 uV (-113 dBm) max. at Rx input port
.6 uV (-111.5 dBm) at antenna port

Frequency Stability: ±5 parts per million max. over the voltage and temperature range

Spurious Rejection: 70 dB min.
Image Rejection: 70 dB min.
Audio Output: 3 Watts into 3.2 ohm speaker

Audio Frequency Response: Deemphasis 6 dB per octave (+2, -8 dB) 0.4 to 3 kHz.
Audio Distortion: 55 max.

1.2 TRANSMITTER PERFORMANCE

RF Power Output at Duplexer Antenna Port: Internally adjustable to 30W
Spurious and Harmonic Output: -50 dBc
Frequency Stability: ±2.5 parts per million over the voltage and temperature range

Specifications Subject to Change Without Notice
2.1 REPEATER DESCRIPTION

The Desktop Repeater is a completely solid-state FM system capable of 20 watts RF power output and operates from 120 volts or 240 volts of AC (50 or 60 Hz). The unit is unique in that it converts to a repeater and/or a base station at the touch of a button. All controls are located prominently on the front panel for operator ease. The standard repeater is a single-tone, tone-accessed system with a second tone available as an option or as a field installable kit (022-3844-269). In addition, each repeater has a Time-Out-Timer (TOT), adjustable for 2 to 10 minutes, to prevent excessively long transmissions and promote more open and efficient use of the frequency channel. An external audio/control connector is available as an option or may be ordered as a field installable kit (022-3897-027).

The Desktop Repeater was designed to be user friendly. All of the operating controls are located on the front panel for user convenience and indicator lights, also located on the front panel, illuminate to display selected functions. The three basic modes available to the operator through the Desktop Repeater are:

- the Base Station Mode
- the Repeater Mode
- the Base Station/Repeater Mode

Refer to the Operation Section of this manual for further information on each of these modes.

2.2 REPEATER IDENTIFICATION MARKING

For repeater identification, a sticker is attached to the bottom of the repeater. This sticker identifies the repeater model, revision letter, manufacture date, plant location and warranty number.

Example:

<table>
<thead>
<tr>
<th>Model</th>
<th>Letter</th>
<th>Revision</th>
<th>Manufacture Date</th>
<th>Plant</th>
<th>Warranty Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>A</td>
<td>023</td>
<td>B</td>
<td>01301</td>
<td></td>
</tr>
</tbody>
</table>
Section 3: Operation

3.1 GENERAL
The controls of the Desktop Repeater have been designed to provide the operator with easy access to all available functions. Indicator lights show the mode of operation selected, and status lights on the upper display strip indicate the operating status of the unit at any given moment. Before operating the Desktop Repeater, it is suggested that you review the following procedure for a better understanding of all of the operational modes possible with this unit.

3.2 ACTIVATION
The unit is placed in operation by simply pressing the power on/off switch located on the right side of the control panel. The display light directly above the power switch should illuminate when the unit is on. Select the desired mode of operation by following one of the three procedures listed below.

3.3 MODES OF OPERATION

3.3.1 REPEATER OPERATION MODE
In the repeater mode, the unit allows all of the mobile and handheld units utilizing the repeater to communicate with one another. The repeater operator, however, cannot communicate with these units. Both the transmit bar on the microphone and the front panel squelch control are disabled in this mode (the squelch function is controlled by a preset internal squelch control). The operator can monitor repeater activity by pulling out the volume control knob (the volume indicator light will illuminate) and adjusting it to a comfortable listening level.

Channel Light
Tone Monitor Bar
Selector
Speaker
Microphone

3.3.2 BASE STATION OPERATION MODE
In the base station mode, the repeat function is disabled and the unit operates as a typical fixed location transceiver. The operator can communicate directly with any mobile or handheld unit within the system; however, these units cannot communicate with one another through the repeater. In this mode the operator controls both the volume and squelch functions. The operator transmits to units within the system by depressing the transmit bar on the base of the microphone and speaking into the screened portion of the microphone (the unit's receiver is disabled when the transmitter is activated). To receive a reply, release the transmit bar.

NOTE: The transmit bar is mechanically inter-locked with the tone monitor bar on the microphone so that the monitor bar must be depressed before the transmit bar can be actuated. This insures that the operator disables the tone squelch and monitors the channel prior to making a transmission.
Base Station Operating Procedure

a. Depress the mode switch labeled "BASE" (the indicator light will illuminate). Check to make sure that the "RPT" switch is not activated.

b. Turn the squelch control completely counterclockwise and adjust the volume control to a comfortable listening level (if the tone squelch is to be used, depress the tone monitor bar on the microphone for this and the following step). A hissing noise should be heard if the channel is not in use.

c. Rotate the squelch control clockwise until the hissing noise is stopped.

d. To transmit, depress the microphone transmit bar and speak in a normal voice into the microphone grille.

3.3.3 Base Station/Repeater Operation Mode

The combined base station/repeater mode of operation allows the handheld and mobile units within the system to converse with one another through the repeater as well as with the base station operator. In this mode the front panel squelch control is disabled and the squelch function is controlled by a preset internal squelch control. The operator transmits to units within the system by depressing the transmit bar on the base of the microphone (the unit’s receiver is muted when the transmitter is activated). To receive a reply, release the transmit bar. With the unit set in this mode, the operator will also be able to monitor all repeater activity. The transmit bar is mechanically interlocked with the tone monitor bar on the microphone. As a result, the monitor bar must be depressed before the transmit bar can be activated. This insures that the operator disables the tone squelch and monitors the channel prior to making a transmission.

Base Station/Repeater Operation Procedure

a. Depress both the "BASE" and "RPT" mode switches on the front panel. The red indicator lights adjacent to those buttons will illuminate.

b. Verify that the red squelch indicator light is not illuminated. In this operational mode the squelch function is controlled by a preset internal squelch control.

c. To transmit, depress the microphone transmit bar and speak in a normal voice. Depressing the transmit bar disables the unit’s receiver and also interrupts the repeater function.

3.4 Transmit Indicator Light

The red transmit indicator light illuminates each time the transmitter is keyed by the operator, or when one of the mobile or handheld units in the system keys the transmitter through the repeater.

3.5 Channel Busy Indicator Light

The green channel busy light will illuminate any time the unit’s receive channel is in use. It should be noted that transmissions from nearby systems, operating on the same frequency, may also illuminate the busy light. With the tone squelch activated, the channel busy light will still illuminate for uncoded signals, even though these transmissions will not be heard in the loudspeaker. If the unit is in the base station only mode, constant illumination of the busy light may indicate improper adjustment of the squelch control knob (rotation too far counterclockwise). For proper threshold squelch adjustment see the section on squelch control.

3.6 Volume Control

The volume control is used to adjust the level of the sound heard from the loudspeaker. Counter-clockwise rotation decreases the volume level, while turning the control clockwise will cause an increase. In the Repeater mode of operation, no sound will be present at the loudspeaker if the volume control switch is pushed in. To monitor repeater activity in this mode, pull the volume control switch out and adjust the volume level normally.

3.7 Squelch Control

The unit is equipped with a front panel squelch control. However, this control is activated only in the Base Station mode. In the Base Station/Repeater and Repeater modes, the squelch function is controlled by a preset internal squelch control.

When the Base Station Mode is selected, the front panel squelch control is used to quiet the receiver in the absence of a received carrier. In the extreme counterclockwise position the receiver is unsquelched, and any channel or CTCSS is activated) there will be noise at the loudspeaker. Rotating the squelch control in the clockwise direction quiets the receiver. The position at which noise becomes undetectable is called the threshold squelch position. Occasional noise bursts at this setting may cause the receiver to chatter (continuous opening and closing of the audio output). A slight clockwise rotation should overcome the receiver chatter. The extreme clockwise position is the tight squelch position. At this control setting it will require a stronger signal to open the audio output. It should be noted that the squelch control will establish the threshold signal level at which a decoded signal will be heard and/or repeated.

3.8 Tone Squelch (CTCSS)

When the continuous tone "coded" squelch system (CTCSS) is activated, the receiver
will be unsquelched only by transmission
which are coded with the proper audible
tone. All units come equipped with one tone
(Tone A) as a standard feature. An optional
second tone (Tone B) is available and gives
the operator a choice of three possible tone
modes: Tone A only, Tone B only, and Tones A
and B.

To place the unit in either the Tone A only
or Tone B only mode, depress the button cor-
responding to the desired tone. The red in-
dicator light next to the button will illum-
inate (verify that the indicator light for
the other tone is off). In either of these
modes, the selected tone will be transmitted
when the transmitter is keyed and the re-
ciever will unsquelch only for properly coded
transmissions. The amber tone indicator
lights on the status light strip will illum-
inate the corresponding display when Tone A
or Tone B is transmitted or received.

To place the unit in the Tone A and Tone B
mode, depress both the Tone A and Tone B but-
tons and check to see that the red light ad-
jacent to each is illuminated. In this mode,
transmissions coded with either Tone A or
Tone B will unsquelch the receiver. The am-
ber status light corresponding to the re-
cieved tone will illuminate when a coded
transmission is received. Transmissions gen-
erated via the repeat function will be en-
coded with a regenerated A or B tone corres-
ponding to the received tone. Transmissions
generated through the microphone will automa-
tically be encoded with tone A when 2-tone
modes are selected.

NOTE: If the tone squelch is activated, the
channel must be monitored prior to transmis-
sion. To disable the tone squelch and moni-
tor channel activity, simply depress the moni-
tor bar located on the base of the micro-
phone. The monitor bar can be locked in the
monitor position by depressing the bar and
pulling it forward until it locks. Repeater
operation will not be affected when the moni-
tor bar is depressed.

3.9 TRANSMIT/MONITOR BARS

Located on the base of the microphone (figure
3-2), the transmit and monitor bars allow
communication with the system's handheld and
mobile radios (the bars are both disabled in
the Repeater only mode). The transmit and
monitor bars are mechanically interlocked so
that the monitor bar must be depressed before
the transmit bar can be actuated. This as-
sures that the operator will disable the cone
squelch function and monitor the channel
prior to making a transmission. Depressing
the monitor bar and then pulling it forward
will lock it in the monitor position.

To transmit, depress the monitor bar and lis-
ten for channel traffic. If the channel is
clear, depress the transmit bar and speak in-
to the microphone grille in a normal tone.
Release the transmit bar immediately after
speaking so that a reply may be heard.
Section 4: Circuit Description

4.1 Receiver Board

The transmit frequency is determined by crystal Y1 located in the base circuit of the oscillator. Q1 is a crystal controlled oscillator with its collector circuit tuned to three times the crystal frequency. A variable inductor, L1, in series with the crystal is used to adjust the transmit frequency. A varactor diode, CR1, in series with the crystal and Q1, is used for frequency modulating the oscillator, hence the transmitter. Q2 is a tripler, and Q3 a doubler, increasing the multiplication factor to 18. Two test points, R9 (TP1) and R13 (TP2) are provided in the emitter circuit of the multiplier stages, and are used for observing the peak emitter voltage while tuning. Multiple tuned circuits between the oscillator and multipliers enhance the suppression of the crystal and multiplier products. Q4 is the driver stage, and amplifies the FM signal to a level adequate for driving the final stage amplifier, Q5, to over the rated wattage. A low pass filter in the collector circuit of the final amplifier (Q5) provides matching to the RF Amplifier module, and assists in the suppression of spurious radiation.

CR2 is a zener diode supplying 8.6 volts to posistor RT1. RT1 is a 33 ohm heater for crystal Y1. Q6 and Q7, along with their associated components, provide protection for CR2 by placing a short across CR2 when RT1 first turns on.

When a TTL level voltage (+2.5V to +5.0V) is applied to the key line (J1-5) the base of Q9 goes high causing it to conduct. This in turn pulls the base of Q8 low allowing it to conduct, supplying voltage to the exciter circuits. Q1 serves as a voltage regulator to supply the crystal controlled oscillator with a regulated 8 volts. The tripler, doubler, and driver stages are powered by the switched 13.8 volts while the final stage is supplied directly from the power supply.

The audio input to the transmitter enters at J1-1 and develops across the deviation control, R21. The bias of CR1 varies at the rate of the modulated input as does the capacitance. This causes the frequency of the oscillator to vary with the modulated input rate to produce the desired frequency modulation. The small frequency shift of the oscillator is also multiplied by eighteen to produce the 40 KHz of deviation. Variable resistor R21 adjusts the level of the modulated input applied to the varactor diode and consequently the deviation of the transmitter. The standard deviation is 40 KHz and the transmitter should be adjusted so that the peaks of the modulating signal do not cause the deviation to exceed that figure (no limiting action is provided by the transmitter circuitry).
4.2 RECEIVER BOARD

Most of the active devices in the receiver are connected in a series-parallel configuration across the power source. The supply voltage (13.8 VDC) flows through switching transistor Q13 and is regulated by Q12 to 9.5 V. Variable resistor R45 is used to adjust this voltage.

The received signal from the antenna is fed to the input stage of the receiver, RF amplifier Q1, through a two pole bandpass filter comprised of helical resonators L3 and L4. C1 provides impedance matching to the antenna (input of the filter) and C5 provides matching to the RF amplifier (output of the filter). Q1 is a common emitter RF amplifier.

The amplified RF signal at the collector of Q1 is coupled to the base of mixer transistor Q2, through a two pole helical filter comprised of L6 and L7. Q4 is a crystal controlled oscillator, with its collector tuned to three times the crystal frequency. (A third overtone crystal is used with this oscillator.) The receiver frequency is determined by a crystal (Y2) located in the base circuit of the oscillator and heated by a 33 ohm thermistor (RT1). A variable inductor (L11) in series with the crystal is used to set the receive channel on frequency. The output of the oscillator (3Fx) is fed to a tripler, Q5, and the resulting output signal (9Fx) is capacitively coupled to the emitter of the mixer, Q2. The difference frequency of 21.4 MHz (the first I.F.) is selected by three series two pole crystal filters (FL1, FL2, and FL3) and amplified by the I.F. amplifier Q3. The output of Q3 is taken from its collector, and fed to a multipurpose integrated circuit U1.

U1 operates as an I.F. amplifier, oscillator, mixer, limiter, detector, amplifier, and in addition has a Schmitt trigger circuit that is used to activate the signal present indicator. The crystal Y1, in the circuit of pins 1 and 2, sets the frequency of the second oscillator to 30.485 MHz, and the second I.F. of 455 kHz is filtered by ceramic filter FL4. Inductor L10 tunes the detector to 455 kHz, and the detector output is taken from pin 9, and developed across the discriminator output level control (R55). Q9 serves as an amplifier/buffer, supplying the audio/control board (pin 5 of J9) with the final amplified discriminator output.

Depending on the operating mode, squelch adjustment is made either on the audio/control board (R55) or by the front panel squelch control (R7). The squelch control is part of a voltage divider network and controls the DC voltage to the Schmitt trigger input at pin 12 of U1. The output of pin 13 is used to activate the signal present light (D6) and front panel channel busy indicator through switching transistor Q8, Q7, and Q6. With no signal present, pin 13 supplies the base of Q8 with sufficient voltage to cause it to conduct, thus shutting off Q7 and Q6. Upon receipt of a signal, pin 13 goes to ground and Q8 stops conducting. This switches on both Q6 and Q7 by supplying voltage to their bases. Q6 causes pin 13-6 to sink to ground, thus removing the current supplied thru pull-up resistor R53. Q7 allows the signal present light (D6) to illuminate.
The audio/control board is a multifunction board containing the audio processing circuits, the switching control logic circuits, the time-out-timer, and the plug-in tone squelch modules. Adjustments for the time-out-timer (R3), the internal squelch control (R5), and the carrier delay, often referred to as hang time (R11), are easily accessible and clearly labeled. The board receives a regulated 13.8 volts DC from the unit's power supply and a fourteen pin connector (J8), on the audio/control board, can be interfaced with an optional connector on the rear panel to allow for external audio control. As standard equipment the board contains encode and decode modules, inserted into connectors J7 and J4 respectively, for tone "A", Encode and decode modules are available for tone "B", as an option, and are inserted into connectors J6 and J5 respectively.

The discriminator output from the receiver board is fed into the audio/control board at pin 5 of J2. The tone "A" decode module and U5 form a dephasis network, with the tone module acting as a high pass filter and U5 as a band pass filter. The resulting signal leaves U5, via pin 14, and enters U10-A at pin 1 (see figure 4-4). The signal then passes through a series of switches where it is routed to the transmitter in the repeat mode, and/or to the audio amplifier, (U19) for use as local audio.

U10 is a quad analog switch which uses the control logic inputs to determine the audio signal path. When the local audio is activated, the signal is routed through switches U10-A and U10-C to the front panel volume control (R8). Audio from the mike on the volume control is returned to the audio control board via pin 15 of J3 and is fed through U14 to the audio amplifier (U19) at pin 8. The output of U19 is taken from pin 12 and is directed to the 5.2 ohm speaker through C13 and pin 23 of J3. The amplified audio is sufficient to produce over 3 watts of audio for local monitoring.

With the unit in the Repeat mode or Base Station/Repeat mode, the audio from pin 14 of U3 is routed through switches U10-A and U10-B of the quad analog switch U10. The signal then enters U18, through R28, CR3 and R37, at pin 2. Quad Operational Amplifier, U18, and its associated components serve as a limiter/preemphasis network supplying audio to the exciter. U18-A and U18-B, along with their associated circuitry, comprise a high pass filter. The filtered signal is then applied to U18-C which functions in conjunction with a diode limiter made up of CR2, CR3, CR4, and CR5. When the signal level at pin 6 of U18-C exceeds 2 volts peak-to-peak, signal limiting action begins. U18-D and its associated circuitry are used as a low pass filter with the resulting signal fed to the exciter through pin 1 of J1.

Hangtime, the amount of time before the repeater unkeys after each transmission, is used only in the repeat mode. The hangtime can be set for between "0" and "5" seconds by adjusting R11 on the audio/control board and is directly proportional to the resistance of R11. When the unit is keyed in the repeat mode, pin 11 of U3 goes high and C4 is charged through CR1 (figure 4-5). As long as C4 is charged, pin 3 of U4 and pin 3 of U2 will remain high keeping the transmitter keyed. CR1 is reverse biased so, when the operator unkeys, C4 will discharge through CR9, R10 goes low, unkeying the transmitter. CR8 is a isolation diode. When C3 times out, pin 3 of U14 out, CR8 pulls down CR1 through CR7 to unkey the circuit.

The time-out-timer circuit is also located on the audio/control p.c. board. U3 is a nonstable or one-shot multivibrator and, together with its associated components, comprises the time-out-timer for the desktop repeater. When the unit is keyed in the Base and/or the Repeat mode, pin 3 of U1 goes low triggering U3 through C2. U3, when triggered with a low at pin 2, charges its state for a specified period of time and then returns to its normal state. When U3 has timed out, the Base or the Repeat mode, the audio from pin 14 of U3 is routed through switches U10-A and U10-B of the quad analog switch U10. The signal then enters U18, through R28, CR3 and R37, at pin 2. Quad Operational Amplifier, U18, and its associated components serve as a limiter/preemphasis network supplying audio to the exciter. U18-A and U18-B, along with their associated circuitry, comprise a high pass filter. The filtered signal is then applied to U18-C which functions in conjunction with a diode limiter made up of CR2, CR3, CR4, and CR5. When the signal level at pin 6 of U18-C exceeds 2 volts peak-to-peak, signal limiting action begins. U18-D and its associated circuitry are used as a low pass filter with the resulting signal fed to the exciter through pin 1 of J1.

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Hangtime, the amount of time before the repeater unkeys after each transmission, is used only in the repeat mode. The hangtime can be set for between "0" and "5" seconds by adjusting R11 on the audio/control board and is directly proportional to the resistance of R11. When the unit is keyed in the repeat mode, pin 11 of U3 goes high and C4 is charged through CR1 (figure 4-5). As long as C4 is charged, pin 3 of U4 and pin 3 of U2 will remain high keeping the transmitter keyed. CR1 is reverse biased so, when the operator unkeys, C4 will discharge through CR9, R10 goes low, unkeying the transmitter. CR8 is an isolation diode. When C3 times out, pin 3 of U14 out, CR8 pulls down CR1 through CR7 to unkey the circuit.
4.3.1 LOCAL AND REPEAT AUDIO LOGIC

In the Repeat mode, local audio can be monitored by pulling out the volume control knob (this knob is also used to adjust volume level). Repeat audio supplied to the transmitter and local audio are controlled by the carrier squelch and the tone squelch (if activated).

In the base mode, local audio is controlled by the tone and the carrier squelch but operates independent of the volume control switch position (i.e., the position of the volume control switch can be either in or out). When the push to talk (PTT) button on the microphone is pressed, both local and repeat audios are disabled. The repeat audio is not active in this mode.

In the Repeat/Base mode, local audio operates as if the unit were in the Base mode, Repeat audio operates as if the unit were in the repeat mode, and when the PTT button is pressed, both local and repeat audios are disabled.
4.3.2 KEYING LOGIC

In the Repeat mode, the keying logic is controlled by the tone and by the carrier squelch. If neither tone “A” or “B” is activated, the keying is controlled by the carrier squelch only. In this mode, the keying capability of the PTT switch on the microphone is disabled. The hangtimer and the time-out-timer are both active.

When the unit is placed in the Base mode, transmitter keying is accomplished through the push-to-talk (PTT) switch on the microphone. Tone and/or carrier squelch keying capabilities are disabled, as is the hangtimer. The time-out-timer is active. Should a remote PTT be required, it can be accessed through the back of the unit via pin 6 of J8. Remote PTT keying is independent of any mode.

With the unit in the Repeat/Base mode, keying is controlled through the PTT or through the carrier squelch and tone (if activated). The time-out-timer is active and the hangtimer is active only if the keying is done by the Repeat mode keying logic.
4.3.3 TONE CONTROL LOGIC

In the Repeat mode, the tone selected on the front panel is decoded by the unit and re-transmitted. If both tones are selected, the first tone decoded (i.e. the tone that un-squelched the unit) is transmitted. Should a second tone be decoded, while the first tone coded signal is being transmitted, the second tone coded signal will not be transmitted until the first tone user has unkeyed and hangtime has completed.

If the unit is in the Base mode, the tone selected will be transmitted when the PTT button is pressed; however, if both tones are selected, only tone "A" will be transmitted when the PTT is pressed.

When the unit is in the Repeat/Base mode, the tone selected will be transmitted when decoded. If both tones are selected, the tone decoded will be transmitted. Should a second tone be decoded while the first one is being transmitted, the second tone will not be transmitted until the user with the first tone has unkeyed and hangtime has completed.

Should the Base Station operator press the PTT (tone B) while tone "A" is being repeated, the tone "B" coded signal would continue to be transmitted until the user has unkeyed and the hangtime has completed. When the PTT is pressed with both tones selected, tone "A" is transmitted.
### TONE CONTROL LOGIC TABLE

<table>
<thead>
<tr>
<th>BASE</th>
<th>KEYING</th>
<th>REPEAT</th>
<th>BASE Tone</th>
<th>KEYING Tone</th>
<th>A Tone</th>
<th>A Tone</th>
<th>B Tone</th>
<th>A Tone</th>
<th>B Tone</th>
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</tr>
</tbody>
</table>

**NOTES:**
1. O = Inactive, I = Active. — The State has no Effect On The Output.
2. The Table Repeats itself in the Base/Repeat Mode.

---

**Figure 4-7**

Tone Control

![Diagram of Tone Control System]
**4.4 VOLTAGE REGULATOR BOARD**

U1 is a three-terminal, adjustable voltage regulator and is connected directly to the 15.8 Volt output of the voltage regulator p.c. board. As the load demand at the output varies, current drawn by U1 varies accordingly (typical operating current is 100 mA). U1 controls the emitter/base current of Q1. Q1 supplies current through the discrete Darlington pair consisting of Q2 and the power transistor (part number 48-01-117) located on the heatsink assembly. This Darlington pair is used as a current amplifier for Q1 to allow for large current drains while maintaining a regulated 13.8 Volt output. CR3, R10, R11 and CR4 form a voltage crowbar circuit which is used for overvoltage protection of the repeater circuitry.

**4.5 RF AMPLIFIER BOARD**

The signal enters the RF Amplifier, from the 2 Watt exciter board, via J1 and is developed across L6, C2 and C1 (a matching network). Q1 is a class "C" amplifier and is biased off when no signal is present. The output of Q1 is taken from its collector and matched to the input of Q2 through components C5, C4, C17 and L2. L2 and its respective RF bead also supply a DC return for the base of Q2. C7, C1, C9 and C10, together with p.c. board striplines L7 and L8, form a filter and matching network to minimize spurious signals. The amplified signal is coupled to J2 through DC blocking capacitor C11.

---

**PRECAUTIONS FOR HANDLING CMOS DEVICES**

The extremely low power consumption of CMOS devices makes them ideally suitable for a variety of electronic equipment. Although most CMOS devices have built in protective diode networks which protect the device against damage due to static electric discharge, special care should be exercised in handling any CMOS device. Additional precautions should be followed to assure trouble-free performance after assembly. The following recommendations should be considered and observed prior to handling CMOS devices:

1. Use conductive or static shielding envelopes for storing or transporting CMOS devices. Untreated plastic materials should not be used for this purpose.

2. All work with CMOS devices should be done on a grounded bench surface, and the technician should be kept at ground potential. This can be accomplished by having the technician reach an electrical ground prior to handling the devices and by wearing conductive wrist bands utilizing a one megohm resistor to ground.

3. Nylon clothing should not be worn while handling CMOS devices.

4. When soldering CMOS devices, a grounded soldering iron should be used and the operation should be limited to 5 seconds with 250°C maximum temperature.

5. Do not insert or remove CMOS devices or subassemblies containing CMOS devices when electrical power is applied.
Section 5: Alignment

5.1 GENERAL

All modules should be in place and secured with mounting screws before alignment of the Desktop Repeater is attempted. A test fixture used to facilitate alignment procedures may be constructed as shown in Figure 5-1.

The following test equipment is recommended to properly align and service the Desktop Repeater:

1. DC Voltmeter
2. FM Signal Generator*
3. 30 dB 50 Watts Attenuator
4. RF Wattmeter
5. Test fixture/mic interface (see Figure 5-1)
6. Speaker Test Plug (21-01-013)
7. Audio Signal Generator*
8. Modulation Monitor*
9. Frequency Counter*
10. Distortion Analyzer
11. DC Oscilloscope
12. 21.4 MHz Test Oscillator*
13. Splitter/Combiner (4:1)
14. CTCSS Tone Generator
15. Spectrum Analyzer (for duplexer tuning only)

* A communications monitor may be used for these functions where applicable.

Figure 5-2 reflects the proper connections of the test equipment to the Desktop repeater.

NOTE: The RX and TX portions of the repeater may be tested separately by disconnecting the RX and TX cables at the duplexer.

5.2 RECEIVER ALIGNMENT PROCEDURE

NOTE: The signal generator settings must reflect the attenuation through the wattmeter/feedthrough power attenuator and signal splitter, so RF levels called out will appear at the antenna port of the duplexer (reference figure 5-2). See Figure 5-3 for the location of test points and tuning adjustments.

1. Connect test equipment as shown in Figure 5-2 and preset the repeater controls as follows:
   - Power - off
   - Mode switch - in Base mode
   - Squelch control - counterclockwise
   - Volume control - counterclockwise
   - Tone controls - off
   - Hangtime control - clockwise
   - Time-out-timer control - counterclockwise

   preset the mic test fixture switches as follows:
   - Tx key - off
   - Tx audio - off
   - Squelch mode switch - to "CARRIER"

2. With the power supply voltage on, observe the DC Voltmeter at the 13.8 Volt test point (Figure 5-3) and adjust R8 of the power supply module to 12.8 volts ± 0.1 volts.
3. Set the unit for "Base" mode with both tones (A and B) off. Refer to figure 5-4 and adjust the receiver discriminator output level (R22) to midrange.

4. Check TP3 for 9.5V to 10V volts. Adjust R45 if necessary.

5. Connect the scope to TP1 and adjust L12 and L13 for maximum (5.7V typical).

6. Connect the scope to TP2 and adjust L15 and L16 for maximum (0.6V typical).

7. Adjust the volume control for 1 V RMS and adjust L10 for maximum noise on the distortion analyzer.

8. Adjust the volume control fully counterclockwise. Remove the audio test jack from the external speaker socket. Adjust the volume control for a comfortable listening level.

9. Set the RF signal generator (unmodulated) to the channel frequency and adjust to quiet the receiver. Then reduce the signal by 10 dB.

10. Using the 21.4 kHz test oscillator coupled near the I.F. amplifier (U1), adjust L11 for zero beat.

11. Plug the audio test jack back into the external speaker socket.

12. Set the RF signal generator to 3 kHz deviation (with 1 kHz audio) and 1 mV output at the antenna port.

13. Adjust the volume control for 3.1 V RMS.

14. Tune L3, L4, L5, L7, L8 and L9 for best 12 dB SINAD. Adjust the signal generator level as required to maintain 12 dB SINAD.

15. Set the generator to 1 mV. Adjust the volume control for 1 V RMS and tune L10 for maximum audio on the distortion analyzer. Adjust R22 for 0.7 VPP (0.1V) at pin 10 of the tone modules (A or B).

16. Set audio to 3 kHz and deviation to 5 kHz. Set volume control for approximately 1.0 V rms.

17. Tune L6, and L9 for minimum audio distortion. Repeat as required. Distortion should be less than 5%. Reset audio to 1 kHz, deviation to 3 kHz. Recheck distortion for less than 5%.

18. The 12 dB SINAD should be no greater than 0.42 uV (-115 dBm). Note the RF level for use in step 4 of Section 5.8.

19. The 20 dB quieting should be no greater than 0.60 uV (-111 dBm).

20. To set the squelch operating point, adjust the signal generator for 0.1 mV.
Set the unit for "Base" mode with both tones (A and B) off. Refer to Figure 5-6 for the location of test points and tuning adjustments.

Connect the scope to TP1 (R8). Key the transmitter and adjust L2 and L3 for maximum (nominal voltage 1.0 VDC).

Connect the scope to TP2 (R13). Key the transmitter and adjust L4 and L5 for maximum (nominal voltage 1.75 VDC).

Adjust C26, L6, C30 and C34 for maximum power output. Set transmitter power (R87) to 2W 40.1%. Readjust L6, C26,
C30 and C34 for maximum power output. Set C30 and C34 for maximum power output.

8. Adjust Li to set transmit frequency. A nonmetallic tuning tool is recommended.

5.4 RF AMPLIFIER ALIGNMENT

1. Reconnect the exciter to the RF Amplifier. Refer to figure 5-7 for the location of tuning adjustments.

2. Connect the 50 ohm wattmeter to the antenna port on the duplexer.

3. Key the transmitter and adjust C1 and C9 on the RF amplifier for maximum power. Adjust C34 on exciter for maximum power.

4. Adjust the transmitter power (R27) on the exciter (figure 5-6) for 20W.

5.5 DECODE TONE ALIGNMENT

NOTE: If "B" Tone is not used, a jumper must be installed between pins 2 and 7 of J6, the tone "B" decoder connector.

1. Preset front panel controls and microphone test fixture controls as follows:
   - Base mode-on
   - RF? mode-off
   - Tone "A"-off
   - Tone "B"-off
   - Squelch control as set in RX alignment, step 50
   - Tx key-off
   - Tx Audio-off
   - Squelch mode switch to "CTCSS"

2. Connect a high impedance frequency counter to the left leg (nearest speaker) of the single turn potentiometer on the decoder being adjusted. Make sure both tone switches are in the off position and adjust the multturn potentiometer for the proper decode frequency.

3. To test the CTCS8 squelch opening, modulate the signal generator with the required tone frequency at 500 Hz deviation. Depress the front panel tone switch corresponding to the decoder being tested. Set the RF level of the signal generator to zero, and increase the level until the squelch and TONE (A or B) lights come on. Verify that audio is present at the speaker or at the external speaker jack. The unit should decode and open the squelch with an RF level of less than .25 nV (−119 dBm) at the antenna port.

4. Return the microphone test fixture squelch mode switch to "carrier."

5.6 DEVIATION ADJUSTMENT

1. Place the unit in "Base" mode with "A" and "B" tones off.

2. Set the audio frequency to 1,000 Hz and the output to 2V P-P (700 mV RMS) as measured on the oscilloscope.

3. Turn on the "Tx Audio" switch located on the microphone test fixture.

4. Key the transmitter and set the transmitter deviation, R21 (figure 5-6), for 45 kHz deviation.

5. Turn the "Tx Audio" switch to the off position.

5.7 ENCODE TONE ALIGNMENT

1. With the unit in Base mode, depress the tone switch corresponding to the encoder to be tuned (A or B). Set the front panel squelch control fully clockwise.

2. Connect the frequency counter to the output of the modulation monitor.

3. Preset the encoder single turn potentiometer, by turning the level adjustment (figure 5-5) for one "A" or "B", to mid range.

4. Key the transmitter via the microphone test fixture and adjust the multturn potentiometer on the appropriate encoder (figure 5-6) for the required frequency 40.1 Hz on the frequency counter.

5. Adjust the appropriate encoder level adjustment for 750 Hz deviation.

6. Repeat procedure for deviation check as outlined in step 5.6. With tone A on, the deviation should be between 4.7 and 5.0 kHz. If the deviation exceeds 5.0 kHz, adjust R31.

7. Return both front panel tone switches to the off position.

5.8 REPEAT AUDIO ALIGNMENT

1. Adjust the signal generator, at the 14-
3. Place the unit in the "Repeat" mode with both tones (A and B) off.

4. Adjust the receiver discriminator output level (282) for 3 kHz deviation on the modulation monitor (figure 5-4).

5. Place unit in base mode and recheck audio distortion at rated audio (5% max).

5. To test for desense, place the unit in the repeat mode. The 12 dB SINAD level should be no greater than 3dB above the level noted in step 18 of Section 5.2. If necessary, L3 and L4 can be adjusted to achieve best SINAD. Both base and repeat modes should be checked.

5.9 HANGTIME AND TIME-OUT-TIMER ADJUSTMENTS

1. Set hangtime and time-out-timer controls to approximately 75° clockwise from midpoint (2:30 o'clock). These adjustments set hangtime to approximately 2 seconds and time-out-timer to approximately 3 minutes. No test required.

5.10 DUPLEXER TUNING

NOTE: Remove duplexer from the repeater before tuning.

1. Prior to making any adjustments, connect the output of the RF signal generator to the input of the spectrum analyzer for calibration purposes. Set the signal generator to the transmit frequency and increase the output to a reference at the top line of the screen. The noise base should be at least 70dB below the carrier reference.

2. Upon completion of the calibration step, configure the equipment as shown in Figure 5-8.

3. With the appropriate connection made, inject the transmit frequency into the duplexer and adjust the two slugs on the transmit side of the duplexer for a notch of -60dB maximum (-65dB typical). Repeat as necessary.

4. Tighten the locking nuts on the slug adjustment screws for the transmit side, and check the spectrum analyzer to ascertain that the settings have not been disturbed.

5. Set the output of the signal generator to the receive frequency and, while injecting this frequency, adjust the two slugs on the receive side of the duplexer for a notch of -60dB maximum (-65dB typical). Repeat as necessary.

6. Connect the spectrum analyzer to the antenna port of the duplexer and connect the 50 ohm load to the transmitter port.

7. With the signal generator connected to the receiver port, inject the receive frequency, and confirm an insertion loss of 1.5dB or less. It may be necessary to increase the sensitivity of the spectrum analyzer.

8. With the signal generator connected to the transmitter port, the dummy load to the receive port, and the spectrum analyzer to the antenna port, inject the transmit frequency, and confirm an insertion loss of 1.5dB or less.
EXCITER TEST VOLTAGES

Q9
0V
0.7V
0V

Q8
13.8V
13.0V
13.8V

Q6
13.8V
13.0V
8.6V

Q7
12.0V
0.2V
0V

NOTE: Components shown are one Farnside
RECEIVER TEST VOLTAGES

NOTE: Components shown are Frontside
CRYSTAL SPECIFICATIONS

The equipment specifications involving frequency stability are assured only if crystals are supplied by the manufacturer or furnished by manufacturer’s approved suppliers.

RECEIVER CRYSTAL 450-470 MHz

Part Number: 23-10-016
Case Type: HC-18/U except pin length of .238" and case height of .53"
Type: Third overtone, series resonant
Series resistance: 30 ohms
Freq. Range: 47.622222 to 49.844444 MHz
Crystal Freq = Operating Frequency * 21.4

TRANSMITTER CRYSTAL 450-470 MHz

Part Number: 23-10-015
Case Type: HC-18/U except pin length of .238" and case height of .53"
Type: Fundamental, parallel resonant
Series resistance: 18 ohms
Load capacitance: 43 pF
Freq. Range: 25.000000 to 26.111111 MHz
(Calculated as follows)
Crystal Frequency = Operating Frequency * 18
*(to six decimal places)

NOTE: To access the transmit crystal, two screws holding the crystal oven must be removed from the bottom of the exciter board (see p. 36).

The crystals specified are preferred but can be replaced with receive crystal 23-09-016 or transmit crystal 22-06-015 if necessary. Alternate crystals have a case height of .42" and a pin length of .125".

Equipment Operating Frequency in MHz to Three Decimal Places
With Decimal Point Replaced
By 'T' for Transmit or 'R' for Receive.

Crystal Frequency in MHz

Lost 5 Digits of the Crystal Part Number

XXX.XXX

630

XXX.XXX

92

187

435
RF AMPLIFIER ASSEMBLY 721-064-01

Note: numbers reflect termination points referenced on the wiring harness diagram.

REF: CAPACITORS

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Description</th>
<th>Part #</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Capacitor, 5-25 pF Variable</td>
<td>15-08-001</td>
</tr>
<tr>
<td>C2</td>
<td>Capacitor, 18 pF</td>
<td>15-10-016</td>
</tr>
<tr>
<td>C3</td>
<td>Capacitor, 270 pF</td>
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<td>C4</td>
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<td>Capacitor, 36 pF</td>
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<td>C8</td>
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<td>C13</td>
<td>Capacitor, Alum., 10 uF 16 V</td>
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REF: TRANSISTORS

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<tr>
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<td>Q2</td>
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<td>L8</td>
<td>Strip Line RF</td>
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<td>RF Bead</td>
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CONNECTORS

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<td>J2</td>
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30
Note: Numbers reflect termination points referenced on the wiring harness diagram.
240 VOLT WIRING HARNESS DIAGRAM AND SCHEMATIC

NOTE: All harness wire connections are the same for 120 volt and 240 volt units except:

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<tr>
<td>WIRE</td>
<td>RED</td>
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<td>BROWN</td>
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### AUDIO/CONTROL CONNECTOR OPTION 022-3897-027

- PTT TX TONE
- SIG PRES +13.8V
- J1 mates with J8 on Audio/Control Board

### POWER SUPPLY SCHEMATIC

- PART OF CHASSIS ASSY
- PART OF FRONT PANEL ASSY
VOLTAGE MEASUREMENT CONDITIONS

1. R21 adjusted to minimum (0kHz)
2. R27 adjusted to 2W rated output
3. Voltage level at J1-8 2.5V min.
4. High impedance voltmeter

NOTES:

1. Unless otherwise noted all capacitor values are in picofarads.
2. Unless otherwise noted all resistor values are in ohms.

EXCITER ASSEMBLY
721-063-01
### Capacitors

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Description</th>
<th>Part #</th>
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<tbody>
<tr>
<td>C1</td>
<td>Capacitor, Cer., 47pF</td>
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<td>C2</td>
<td>Capacitor, 270pF</td>
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<td>C3</td>
<td>Capacitor, .01uF</td>
<td>15-01-102</td>
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<td>C4</td>
<td>Capacitor, 6.8pF</td>
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<td>C5</td>
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<td>Capacitor, 2.7pF</td>
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<td>Capacitor, 100pF</td>
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<td>Capacitor, 200pF</td>
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### Resistors

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<td>R4</td>
<td>Resistor, 220 ohm</td>
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<td>Resistor, 5.6K</td>
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<td>R23</td>
<td>Resistor, 1K</td>
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<tr>
<td>R24</td>
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### Diodes

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<td>Diode, Silicon</td>
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<tr>
<td>D2</td>
<td>Diode, Silicon</td>
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NOTES:

1. Unless otherwise noted all capacitor values are in picofarads.
**I.C. Quad Analog Switch**
- **31-31-041**
- **31-31-041**
- **31-31-041**
- **31-31-051**
- **31-31-055**
- **31-30-018**

**I.C. Triple 2 Input And Gate**
- **31-31-053**
- **31-31-054**

**I.C. Quad 2 Input Or Gate**
- **31-31-055**

**I.C. Hex Inverter**
- **31-31-043**

**I.C. Dual D Flip Flop**
- **31-31-041**

**I.C. Quad 2 Input And Gate**
- **31-31-065**

**I.C. Quad 2 Input Or Gate**
- **31-31-053**

**I.C. Quad 2 Inpout**
- **31-30-021**

**I.C. Audio Amplifier**
- **31-30-021**

**RESISTORS**
- **R1** Resistor, 100K
- **R2** Resistor, 100K
- **R3** Resistor, Variable 500K
- **R4** Resistor, 82K
- **R5** Resistor, 10K
- **R6** Resistor, 10K
- **R7** Resistor, 10K
- **R8** Resistor, 10K
- **R9** Resistor, 10K
- **R10** Resistor, 10K
- **R11** Resistor, 10K
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- **R13** Resistor, 10K
- **R14** Resistor, 10K
- **R15** Resistor, 10K
- **R16** Resistor, 10K
- **R17** Resistor, 10K
- **R18** Resistor, 10K
- **R19** Resistor, 10K
- **R20** Resistor, 10K
- **R21** Resistor, 10K
- **R22** Resistor, 10K
- **R23** Resistor, 10K
- **R24** Resistor, 10K
- **R25** Resistor, 10K
- **R26** Resistor, 10K
- **R27** Resistor, 10K
- **R28** Resistor, 10K
- **R29** Resistor, 10K
- **R30** Resistor, 10K
- **R31** Resistor, 10K
- **R32** Resistor, 10K
- **R33** Resistor, 10K
- **R34** Resistor, 2.7 ohms
- **R35** Resistor, 10K
- **R36** Resistor, 10K
- **R37** Resistor, 10K
- **R38** Resistor, 10K
- **R39** Resistor, 10K
- **R40** Resistor, 10K
- **R41** Resistor, 10K
- **R42** Resistor, 10K
- **R43** Resistor, 10K
- **R44** Resistor, 10K
- **R45** Resistor, 10K
- **R46** Resistor, 10K
- **R47** Resistor, 10K
- **R48** Resistor, 10K
- **R49** Resistor, 10K
- **R50** Resistor, 10K
- **R51** Resistor, 10K

**CAPACITORS**
- **C1** Capacitor, Cer., 0.1uF
- **C2** Capacitor, Cer., 0.1uF
- **C3** Capacitor, 10uF 20V
- **C4** Capacitor, 220pF
- **C5** Capacitor, 10uF
- **C6** Capacitor, 100pF 20V
- **C7** Capacitor, Cer., 0.01uF
- **C8** Capacitor, 0.01uF
- **C9** Capacitor, 0.01uF
- **C10** Capacitor, 0.01uF
- **C11** Capacitor, 100uF 20V
- **C12** Capacitor, 470uF 10V
- **C13** Capacitor, Cer., 0.01uF
- **C14** Capacitor, Cer., 0.01uF
- **C15** Capacitor, 0.1uF
- **C16** Capacitor, 0.1uF
- **C17** Capacitor, 0.1uF
- **C18** Capacitor, 0.1uF
- **C19** Capacitor, 0.1uF
- **C20** Capacitor, 0.1uF
- **C21** Capacitor, 0.1uF
- **C22** Capacitor, 0.1uF
- **C23** Capacitor, 0.1uF
- **C24** Capacitor, 0.1uF
- **C25** Capacitor, 0.1uF
- **C26** Capacitor, 0.1uF
- **C27** Capacitor, 0.1uF
- **C28** Capacitor, 0.1uF
- **C29** Capacitor, 0.1uF
- **C30** Capacitor, 0.1uF
- **C31** Capacitor, 0.1uF

**DIODES**
- **D1** Diode, Signal
- **D2** Diode, Signal
- **D3** Diode, Signal
- **D4** Diode, Signal
- **D5** Diode, Signal
- **D6** Diode, Signal
- **D7** Diode, Signal
- **D8** Diode, Signal
- **D9** Diode, Signal
- **D10** Diode, Signal

**CONNECTORS**
- **J1** Connector, 10 Pin
- **J2** Connector, 10 Pin
- **J3** Connector, 24 Pin
- **J4** Socket, 16 Pin
- **J5** Socket, 16 Pin
- **J6** Socket, 3 Pin
- **J7** Socket, 3 Pin
- **J8** Socket, 14 Pin
- **J9** Connector, 10 Pin
- **J10** Connector, 10 Pin
- **J11** Connector, 24 Pin

**INTEGRATED CIRCUITS**
- **I.C. Quad 2 Input An Gate**
- **I.C. Quad 2 Input Or Gate**
- **I.C. Single Timer**
- **I.C. Hex Inverter**
- **I.C. Quad 2 Input**
- **I.C. Quad Op-Amp**
- **I.C. Quad 2 Input Or Gate**
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<td>R32</td>
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**MISCELLANEOUS**

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<td>54</td>
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