MODEL 8130

FREQUENCY STANDARD OSCILLATOR

INSTRUCTION MANUAL

PLEASE NOTE OUR NEW ADDRESS

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JUNE 1992

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LIMITED WARRANTY AND WARRANTY CLAIMS: Spectracom warrants each new product manufactured and sold by it to be free from defects in material, workmanship, and construction, except for batteries, fuses, or other material normally consumed in operation which may be contained therein, for a period of one year after shipment to the original purchaser (which period is referred to as the "warranty period"). This warranty shall not apply if the product is used contrary to the instructions in its manual or is otherwise subjected to misuse, abnormal operations, accident or repairs or modifications that have not been performed by Spectracom. Spectracom is not responsible for products which it does not manufacture.

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REPAIR AND MAINTENANCE

Instruments should be returned only upon prior authorization from Spectracom Corporation or its authorized sales and service representative. Warranty repair will be made upon request. Please provide the following information in order to enable us to serve you efficiently:

1. Model Number and type
2. Serial Number
3. Description of trouble
4. Conditions and hours of use

Upon receipt of this information our service department will send you service data or shipping instructions. Transportation to the factory is to be prepaid by the purchaser.

For assistance contact your nearest Spectracom sales representative.

WARRANTY REGISTRATION

Spectracom Corporation
95 Methodist Hill Dr. Ste 500
Rochester, NY 14623

Dear Customer,

Spectracom occasionally contacts customers regarding our products. We must know to whom we should send manual updates, change notices, and new product information. Because people sometimes change job assignments, we request department, mail station, and title information to ensure that correspondence in future years will reach either the user of our products or his/her supervisor. In filling out the registration, please use the title/mail station/department of the supervisor most interested in keeping the equipment and its documentation up-to-date. Thank you.

- -

Name _____ Title _____

Department _____ Mail Stop _____

Company _____ Model Number _____

Address _____ Serial No. _____

City _____ Date Installed _____

State _____ Zip _____

Telephone _____ Ext. _____

Remarks (problems, suggestions, etc.): _____

_____

_____

_____

_____

MODEL 8130

S/N 8130-____

CERTIFICATE OF TRACEABILITY

Spectracom Corporation hereby certifies that its Model 8130 Frequency Standard Oscillator has been calibrated at the factory using National Bureau of Standards Station WWVB as a reference.

To aid in oscillator restabilization, connect the unit to a suitable source of uninterrupted AC power immediately after unpacking.

The calibrated accuracy was determined at the time of shipment from the factory. Do not change the oscillator adjustment dial until after a proper warm-up period. Refer to the warm-up and retrace specifications published in the equipment's instruction manual.

Dial Setting:
Calibrated Accuracy:
Aging Rate:
Date:

SPECTRACOM CORPORATION

E. EUGENE DORLAND

_____

Vice-President, Manufacturing

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Spectracom's #_____

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Date_____

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OPERATING INSTRUCTIONS

SECTION 1 - OPERATING INSTRUCTIONS

1.1 INTRODUCTION

The Spectracom Model 8130 Frequency Standard Oscillator is a self-contained frequency standard source for general purpose laboratory and system applications. The frequency select push-button switches on the front panel select one of the four standard frequencies, 0.1, 1.0, 5.0 or 10 MHz for output on the front panel Standard Output connector. All four frequencies are available simultaneously from rear panel connectors. When the optional distribution amplifier is included, all rear panel outputs provide 10 MHz, and line taps are used to derive other frequencies as needed.

1.2 INSTALLATION

1.2.1 Unpacking

In the event of damage to the shipping carton or if there is hidden damage to the equipment, but the carton is not damaged, be sure to contact the carrier immediately so that his representative can witness any equipment damage that may exist inside the carton. If you fail to report shipping damage immediately you may forfeit any claim against the carrier. You should also notify SPECTRACOM CORPORATION of shipping damages so that we can assist you in obtaining a replacement or to repair the equipment.

Be sure to remove all items of equipment and accessories from the shipping carton before discarding it. This includes a three conductor line cord and an instruction manual.

1.2.2 Equipment Return

If it is necessary to return the unit to the factory, the original shipping carton may be used. If it is not available, a carton or at least 250# test corrugated paper with at least two inches of polyethylene foam surrounding the unit must be used.

NOTE: BE SURE TO SWITCH THE REAR PANEL BATTERY SWITCH TO EXT TO DISCONNECT THE OPTION 02 BATTERY, if it is installed in your unit.

The unit should be sealed in a plastic bag for moisture protection and a note must be included stating the reason for the return.

1.2.3 Input Power

The equipment may be operated from either 115 or 230 VAC ±10%, 50/60 Hz line power. A slide switch on the rear panel selects either of the two line voltages. The equipment is shipped with the switch in the 115 VAC position, unless a tag is attached stating otherwise. If the line voltage switch is moved to select 230 VAC, the fuse must be changed also, as indicated on the rear panel. Before turning on the equipment after unpacking, make sure that this switch is in the correct position.

1.2.4 Operating Environment

The equipment is designed for operation in a room temperature laboratory environment. Operation outside of a temperature range of 0 to 50°C may cause malfunction or damage to the equipment.

1.2.5 Bench Operation

The instrument is provided with four feet for standing on a bench-top surface.

1.2.6 Rack Mount Option (Option 01)

Units purchased with the rack mount kit option may be easily modified for rack mounting as shown in Figure 1-1. The four mounting feet may be removed when the unit is installed in a rack.

The rack mount panel extensions are installed by removing the vinyl-covered filler panel located just behind the handles on the sides of the enclosure. The rack mounting brackets are installed using the oval head #10-32 x 3/8 screws provided. Truss head #10-32 x 3/8 screws are furnished to mount the unit to the rack.

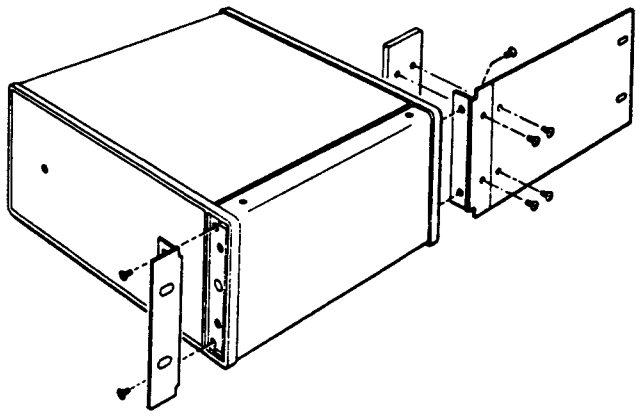

FIGURE 1-1 RACK MOUNT OPTION 01

1.3 OPERATION

1.3.1 Front Panel Functions

Power Switch: Depressing the push-button applies power to the equipment. Power is removed from all circuits except the frequency standard oscillator when the button is not depressed. Power is applied to the oscillator whenever the line cord is plugged in.

Frequency-MHz Switches (0.1, 1.0, 5.0, 10): These push-buttons select the output frequency at the front panel. These switches do not affect the rear panel outputs.

Standard Output Connector: The BNC connector provides the output of the internal frequency standard oscillator, divided down to the frequency selected by the Frequency-MHz switch.

Oscillator Adjustment Dial (parts in E^{-9}): A 10-turn dial is used to correct for aging of the internal frequency standard. It is calibrated in parts in E^{-9} for ease in making corrections. A lock lever prevents the dial from being moved accidently.

Line Interrupt Lamp: The red lamp lights to indicate that power to the unit has been interrupted. It remains lit until the reset button is pressed. The lamp indicates shut down of the frequency standard oscillator to warn that a warm-up period will be experienced.

Lamp Reset Switch: The momentary contact push-button extinguishes the Line Interrupt Lamp.

Output Fault Lamp: The red lamp lights whenever the rear panel outputs vanish due to external short-circuits or internal failure.

1.3.2 Initial Turn-On

After the frequency standard oscillator has been installed, plug the unit into the power line, making sure that the rear panel slide switch is in the correct position for the line voltage. Note that the line interrupt lamp is now lit and may be extinguished by pressing the Lamp Reset button. Turn the power switch on and the unit is now ready to use after the proper warm-up.

WARNING: DO NOT ADJUST THE OSCILLATOR ADJUSTMENT DIAL UNTIL AFTER PROPER WARM-UP AND A SUITABLE REFERENCE STANDARD AGAINST WHICH TO COMPARE THE OSCILLATOR IS OBTAINED.

If the battery pack option is installed in the unit, you may now switch the rear panel battery switch from the External position to the Internal position. This connects the battery to the power supply and provides for continuous float charging.

1.3.3 Frequency Standard Outputs

The front panel output of the frequency standard is a TTL signal at the frequency selected by pressing one of the Frequency-MHz push-buttons. Care must be taken when driving long coaxial cable. A 93-ohm terminated cable will achieve the best results in preserving the waveform.

The rear panel outputs from this standard are sine waves at frequencies of 0.1, 1.0, 5.0, and 10.0 MHz. These signals may be used to drive either a 50-ohm terminated line or a TTL load with an unterminated line. If the unit has the built-in distribution system described below, the rear panel outputs are all at 10 MHz and must be used to drive only Spectracom line taps located along a 50-ohm cable which is terminated with a DC-isolated 50-ohm load.

1.3.4 Option 03 Built-in Distribution Amplifier

Option 03 allows counters and synthesizers throughout a facility to use the 8130 as a common time base. Because equipment can share a common time base, there is no need to buy expensive, high stability time bases for each instrument or remove them from service for periodic calibration.

Units equipped with Option 03 may drive up to 25 remote stations. Multiple outputs are provided on the rear panel so that signals may be sent in several different directions. A line tap at each remote station receives DC power and the 10-MHz standard from the main coaxial trunk line cable. The signal is buffered then divided to the frequency needed at that station. After filtering, the signal is available at the line tap output. New stations are easily added to the system by inserting additional line taps.

1.3.5 System Components

A frequency distribution system may use Model 8140T or 8140TTL Line Taps, Model 8140VT VersaTap™s or an 8140TA Line Extender Amplifier. The following paragraphs describe each of these units.

1.3.5.1 Model 8140T and Model 8140TTL Line Taps

These devices, powered by DC on the coaxial feed line, are attached to the coaxial distribution network and provide an output at one of 3 specified frequencies: 1, 5, or 10 MHz. The frequencies of 500 and 100 kHz are available at somewhat higher costs.

INPUT: Buffered high input impedance causes negligible mismatch on main trunk line distribution cable. Accepts signal levels provided by the base station equipped with Option 03.

OUTPUT LEVEL: Standard unit (Model 8140T) provides 600 mV rms sine wave into 50 ohms. When used without termination, the output is TTL compatible. Optional unit (Model 8140TTL) provides TTL compatible signals into loads greater than 100 ohms.

OUTPUT FREQUENCIES - 10, 5.0, 1.0, 0.5 or 0.1 MHz: Specify frequency for each Line Tap ordered.

HARMONIC DISTORTION OF OUTPUT: -40 dB for standard unit with sine wave output.

CROSSTALK (ISOLATION): 80 dB minimum.

OUTPUT PHASE NOISE: Typically less than -130 dB/Hz 1 kHz from carrier for 10 MHz input to base station amplifier.

LINE TAP SIZE: 5.25 L x 2.63 W x 1.71 H inches. (133 L x 67 W x 43 H mm). Mounting hole pattern: 4.75 x 1.75 inches (121 x 44 mm).

Each line tap bears a label showing its output frequency. Should this label be lost, the frequency can easily be determined using a frequency counter or oscilloscope.

1.3.5.2 Model 8140VT VersaTap™ Frequency Synthesizer

The VersaTap is a single-frequency synthesizer whose output is factory-set to any frequency between 1 kHz and 16 MHz in 1-kHz increments and up to 20 MHz in 2-kHz increments. Some special frequencies can be furnished, such as the 3.5795454...MHz TV color sub-carrier. Exact frequencies must be specified at time of order.

INPUT: Buffered high impedance input. Accepts 10.0 MHz with signal level between 100 millivolts and 5.5 V peak-to-peak on a DC voltage of 7 to 12 VDC. The DC current requirement is 150 milliamperes at +12 VDC.

OUTPUT A: A sine wave of 600 mV rms at the specified frequency into a 50-ohm load for frequencies greater than 56 kHz. A TTL output for frequencies below 56 kHz.

OUTPUT B: A TTL output at the specified frequency. If the internal jumper, W6, is moved to location W5, Output B is HIGH when the VersaTap is phase locked to the incoming reference and LOW when it is unlocked.

LOCK LED: The LED will light when the VersaTap is locked to the incoming reference. The LED will blink if the DC input is low, which may cause the VersaTap to malfunction. The LED will be unlit when the VersaTap is not locked to the incoming reference.

VERSATAP SIZE: 8.3 L x 4.2 W x 1.7 H inches. (211 L x 107 W x 43 H mm). Mounting hole pattern 8.88 x 2.75 inches (225.4 x 69.9 mm).

1.3.5.3 Model 8140TA Line Extender Amplifier

The Line Extender Amplifier must be used to boost the output signal when the coaxial distribution network is more than 1500 feet (457 m) long. The Line Extender will drive an additional 1500 feet (457 m) of RG-58 coaxial cable with Model 8140T Line Taps installed along its length.

Two DC-isolated 50-ohm terminators must be used: one at the input tee connector of the Line Extender Amplifier and one at the far end of the cable connected to the output of the Line Extender Amplifier.

See the "Typical Interconnection Diagram" Figure 1-2, for an approved method of interconnection.

1.3.5.4 Model 8140MT MultiTap™

The Spectracom Model 8140MT MultiTap™ is a programmable frequency divider/buffer. Three outputs can be configured to the same frequency or set independently. When used with a Model 8130 the input frequency will be 10 MHz. When used as part of a Spectracom Distribution System it decreases the cost per output and allows future modifications as requirements change.

Frequency Outputs: Three square wave outputs per MultiTap. 1.5 V p-p into 50 ohms. Once group is chosen, any divisor in a group may be individually selected.

Table of output divisors:

GROUP			
A	**B**	**C**	**D**
1	1	5	5
2	2	10	10
10	20	50	100
50	100	250	500
250	500	1250	2500

For a 10-MHz input, the available outputs are:

GROUP			
A	**B**	**C**	**D**
10 MHz	10 MHz	2 MHz	2 MHz
5 MHz	5 MHz	1 MHz	1 MHz
1 MHz	500 kHz	200 kHz	100 kHz
200 kHz	100 kHz	40 kHz	20 kHz

When driven by a Distribution Amplifier, the DC load equals 3 line taps. Option 40, which is required for stand alone operation, reduces the distribution load to 1 line tap equivalent, and is required whenever output frequencies are below 100 kHz. Maximum current is less than 150 mA.

PHYSICAL/ENVIRONMENTAL SPECIFICATIONS

Size: 5.25L x 2.63W x 1.71H in. (133L x 67W x 43H mm) Mtg. hole; 4.75 x 1.75 in. (121 x 44 mm)

Connectors:Input: BNC
Outputs: BNC
Power: 2.1 mm DC Power Jack

Operating Temperature: 0 to +50°C

1.3.6 Design of Distribution Networks

This section provides guidelines for using the Option 03 distribution outputs. In planning a system installation follow the guidelines listed below:

1. A maximum of 25 line tap loads may be driven from one base station. More than 25 loads is not permitted due to power supply limitations and impedance matching. Table 1-1, Line Tap Loads, lists the equivalent number of loads and current each distribution device consumes. The receiver may provide up to 1.2 amps total to the distribution network.

DEVICE	LOADS	CURRENT (mA)
8140T All Versions	1	45
8140TA	1	45
8140MT	3	50
8140VT Standard	3	150
8140VT w/Opt 45	5	250
8140VT w/Opt 48	4	200
8140VT w/Opt 58	4	200

TABLE 1-1 LINE TAP LOADS

If more than 25 line tap loads are required you may add a Model 8140 Frequency Distribution Amplifier. The Model 8140 contains an internal power supply and will feed an additional 25 line tap loads. A line tap is required (typically 10 MHz) to provide the input frequency source to the Model 8140. This "daisy chaining" may be continued indefinitely.

2. Because of voltage drops and signal attenuation the longest trunk line using RG-58 cable is 1500 feet (457 m). Figure 1-2, Line Tap Number and Distance Chart, is used to calculate the number of line tap loads that may be used at various distances from the base station.

   For example, if 25 line taps are used, their average distance from the amplifier is limited to 750 feet (228 m), using RG-58. Up to 12 line taps may be placed at 1500 feet (457 m) on any one trunk line.

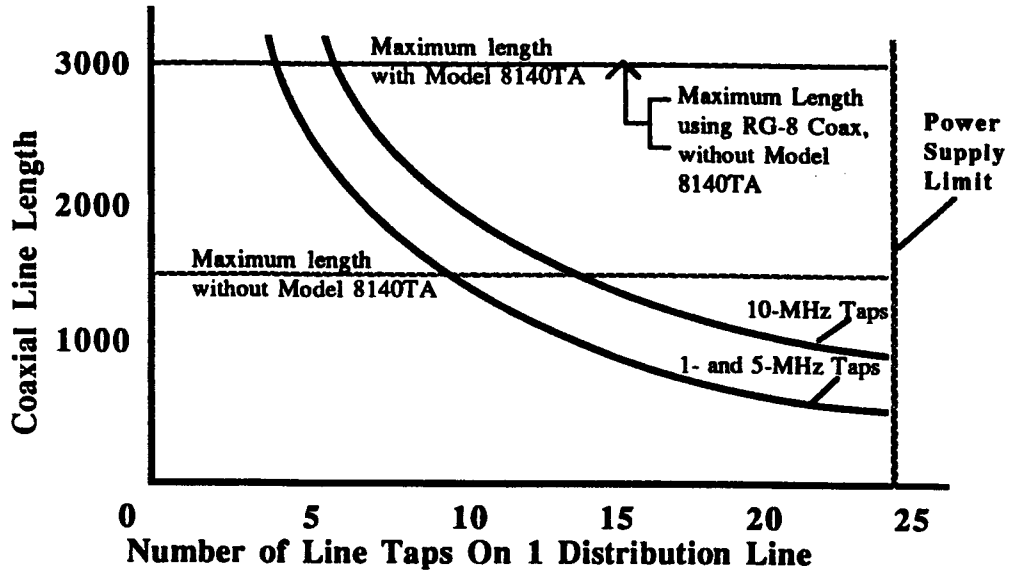

FIGURE 1-2 LINE TAP NUMBER AND DISTANCE CHART - OPTION 03

If longer runs are required, you may:

A. Locate the Model 8130 in the geographical center of the installation, running distribution lines in both directions and achieving a coverage of 3000 linear feet (914 m).

B. Use a Model 8140TA Line Extender Amplifier at 1500 feet, allowing a further 1500-foot (457 m) extension of the distribution line. The Model 8140TA counts as one line tap load towards the total number allowed. Use a 50 ohm DC isolated terminator, part number 004490, at the input tee connector and at the end of the extended line section as shown in the "Typical Interconnection Diagram", Figure 1-3.

C. Use a Model 8140 Frequency Distribution Amplifier.

3. Each distribution line must be continuous from the base station to the DC isolated 50 ohm load that must be used at the far end. Line taps are inserted along the distribution line by using the supplied input tee connector. No branching or "Y" configurations may be used as this causes impedance mismatch on the line. Anything other than a 50-ohm line impedance may cause reflections which can cancel the output waveform at the receiver triggering the OUTPUT FAULT lamp. Refer to the Typical Interconnection Diagram, Figure 1-3 for an approved method of interconnection.

4. Four DC-isolated 50-ohm loads are furnished with each unit equipped with Option 03. They may be found in the ancillary kit that is packed with each unit when it leaves the factory. If any of these loads are lost, spares may be purchased from Spectracom. The part number to order is 004490. Terminators may be placed on any unused distribution output connector to prevent loss.

5. We recommend that, wherever practical, the line taps be permanently mounted to a lab bench or wall nearby. This avoids their loss or misplacement and discourages people from occasionally disconnecting them, thus cutting off the signal to stations further down the line.

6. Never directly connect a distribution line to an instrument; always use a line tap or VersaTap. Doing so may damage the instrument or cause an impedance mismatch on the distribution line.

1.3.7 Stand-by Battery Power Supply (Option 02)

The oscillator will continue to run for up to 50 hours after power line failure with this option. This prevents the oscillator from ever being turned off and avoids settling and retrace aging problems when the power returns. The battery contained in the option is float-charged continuously as long as the power line is connected to the unit. The battery pack contains sealed lead-acid cells that require no maintenance. Note that although the oscillator and oven are kept running by the battery during power outages, the signal is not available for use because the amplifier stages are turned off to conserve battery power.

CAUTION: IF POWER IS REMOVED FROM THE UNIT FOR EXTENDED PERIODS OF TIME, THE BATTERY SWITCH ON THE REAR PANEL MUST BE MOVED TO THE EXTERNAL POSITION. THIS DISCONNECTS THE INTERNAL BATTERY FROM THE POWER SUPPLY AND WILL PREVENT IT FROM REMAINING IN A DISCHARGED CONDITION FOR EXTENDED PERIODS OF TIME. IF THE BATTERY IS LEFT IN A DISCHARGED CONDITION FOR LONG PERIODS, DAMAGE WILL RESULT.

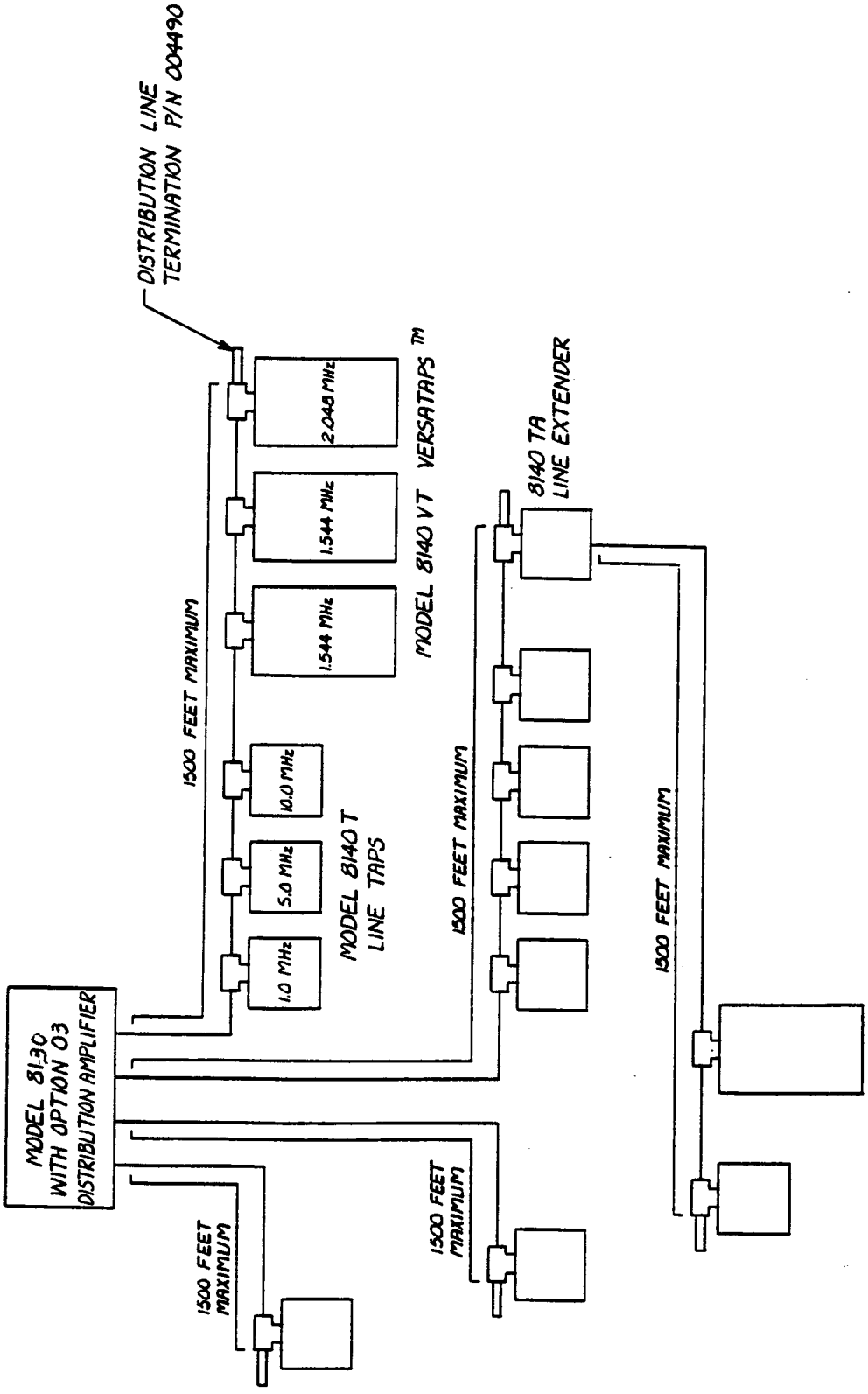

FIGURE 1-3 TYPICAL INTERCONNECTION DIAGRAM

1.3.8 Aux In/Out Connector on Rear Panel

External battery connections are available at this connector:

PIN 1: External battery input (+). For continuous oven and oscillator operation in the event of power failure, an external battery may be connected here. Battery will be float-charged whenever line power is on, with maximum charge rate of 250 ma; nominal voltage at +25°C is 27.6 VDC. Recommended battery type is sealed lead-acid, 24 VDC, 1-2 ampere-hours or greater capacity.

PIN 2: External battery input (gnd).

1.4 SPECIFICATIONS

Frequency Standard Outputs

Front Panel: 0.1, 1.0, 5.0, or 10.0 MHz, front panel selectable, provides TTL compatible signals into loads greater than 100 ohms.

Rear Panel: Separate outputs at 0.1, 1.0, 5.0 and 10.0 MHz, into 50 ohms, 30 dB harmonic suppression. Output is TTL compatible when used without termination.

Frequency Standard Stability

Aging Rate: 1.5 x E^{-9} per 24 hours maximum after 120 days of continuous operation. 5 x E^{-10} per 24 hours typical after 180 days.

Short Term Stability: 2 x E^{-10} rms over 10 successive 10-second counts.

Temperature: ± 5 x E^{-10} per °C maximum, 0-50°C.

Load: ± 1.0 x E^{-11} for any load change.

Supply Voltage: ± 2.5 x E^{-10} maximum for +10% voltage change.

Warm-up at 25°C: Within 2 x E^{-7} of the final frequency in 15 minutes, 2 x E^{-8} in 20 minutes, 2 x E^{-9} in 30 minutes.

Retrace: Typically within 2 x E^{-8} one hour after 48-hour loss of oven power, 1 x E^{-8} one hour after a 12-hour loss of oven power.

Frequency Adjustments

Fine: Front panel control with +5 x E^{-7} range and 2 x E^{-10} resolution. Typically compensates for 2 years of aging.

Coarse: Internal adjustment with ± 2.5 x E^{-6} minimum range.

Mechanical & Installation

Size: 5.25 H x 13.5 W x 8.5 W (inches). Ht. is 6 in. with feet. 133 H x 343 D x 216 W (mm). Ht. is 152 mm with feet. Handles protrude 1.75 inches (45 mm) from front panel. Allow 2-3 inches cable clearance at rear.

Weight: Base station 12 lbs, (5.44 Kg), Line Tap 1 lb., (.45 Kg)

Line Power: 115/230 VAC ±10%, 50/60 Hz, 40 VA.

Operating Temperature: 0 to 50°C.

Standby Supply

External: Rear panel connector for 22-30 VDC oven and oscillator standby power during AC line interruptions. Suitable for use with lead-acid batteries. Current drain during power interruption is 40 ma typical, 200 ma maximum. The external battery is float-charged at a 200 ma rate, voltage limited and temperature compensated.

Optional Battery Pack - Option 02

Mounted internally, weight 6 lbs. Allows 50 hours typical operation at +25°C, 36 hours minimum standby operation during AC line interruption. Recharge rates, 33% in 6 hours, 66% in 12 hours, 100% in 36 hours.

Distribution Amplifier - Option 03

Number of Outputs: 25

Termination: 50 ohms DC isolated

Output Frequency: 10 MHz, Line taps are available at 1.0, 5.0, and 10.0 MHz; and at higher cost, 100 and 500 KHZ.

Options and Accessories

Option 01: Rack Mount Kit

Option 02: Battery Power Supply

Option 03: Built-in Distribution Amplifier

Option 06: High Stability Oscillator

Model 8140T Distribution Line Tap 1, 5, 10 MHz, 500 & 100 Khz.

Model 8140VT VersaTap

Model 8140MT MultiTap

Model 8140TA Distribution Line Amplifier

SECTION 2

8130

THEORY OF OPERATION

SECTION 2 - THEORY OF OPERATION

2.1. INTRODUCTION

The Model 8130 consists of an oscillator and power supply assembly and an output amplifier assembly as shown in Figure 2-1, Block Diagram. The 10-MHz output from the frequency standard oscillator is fed to the output amplifier where it is divided to the proper frequency for feeding to the outputs at front and rear panels. Option 03, Frequency Distribution Amplifier, provides the capability to distribute the standard frequency to 25 remote locations. Figure 2-2, Mainframe Schematic, shows the AC power wiring and schematic for assembly A6, Auxiliary Power Supply.

2.2. A4 OUTPUT AMPLIFIER ASS'Y, PART NO. 002400/004400

Figure 2-3 is the schematic for the Output Amplifier. Figure 2-4 is the assembly drawing. The internal frequency standard oscillator output is fed to the 10 MHz standard input of the A4 Output Amplifier Assembly at J1 pin 10 where it is buffered and amplified by Q1 and Q2. From there the signal goes through gates U1A and U1B where it is fed to the rear panel outputs, sometimes divided down to lower frequencies, and to the front panel frequency standard output jack divided down in frequency according to the front panel push button selector switches.

2.2.1 Standard Output Amplifier Assembly A4, Part No. 002400

The 10-MHz signal coming from the frequency standard is sent through gates U4C and U8A directly to the rear panel output after being filtered by L1, L2, and C17. Similarly, the divided down signals at 5.0 MHz, 1.0 MHz, and 0.1 MHz are fed to their respective output jacks at the rear panel after frequency division at U5, U6, and U7, respectively. The presence of output signal at each of these rear panel jacks is detected by a diode/capacitor combination at each output jack and used as a signal for front panel indication of output fault. If the rear panel output at any one of these four jacks is not present the red OUTPUT FAULT lamp on the front panel of the unit is lit, indicating an output fault. Detector outputs at all four jacks are gated together through diodes CR5, CR9, CR13, CR17 and fed to a transistor switch consisting of Q5, Q4, and Q3 which lights the output fault lamp in the absence of output signal. The output signals as they are divided are fed to gates U4, U3, and U2 and are selectively fed to the front panel standard output jack according to the front panel Frequency-MHz push button.

2.2.2 Output Drive Level

In the standard version of the output amplifier, drive levels from the rear panel outputs are sinusoidal at 4.0 V peak-to-peak. Diodes CR2, CR6, CR10, and CR14 allow current sinking by output drivers U8 and U9 thus enabling TTL circuitry to be driven by these outputs, if the output coaxial lines are not terminated. If the outputs are terminated with 50 ohms, the output wave shape is still sinusoidal but at a reduced voltage level, approximately 0.5 V rms.

2.2.3 Distribution Amplifier Assembly A4, Part No. 004400

The schematic for Option 03 is shown in Figure 2-3. The Component Location Diagram is Figure 2-4. The board is located on the rear panel behind the ovenized oscillator assembly. The distribution amplifier assembly is referred to as the A4 board.

The distribution output frequency source is the hi-stability ovenized oscillator. The 10 MHz output from the ovenized oscillator is fed to the A4 board on J1 Pin 10. The signal is first buffered and amplified by Q1 and Q2. The signal then passes through gates U1A and U1B where the signal is split in two directions. One direction is through the dividers U5, U6 and U7. The divided outputs are fed to gates U4, U3, and U2 and are selectively fed to the front panel standard output jack, according to the front panel Frequency-MHz pushbutton selector switches.

The other direction is through U4C and into line drivers U8 and U9. The signal is then filtered to a sine wave and a 12 volt DC offset added. The signal is then fed to each of the rear panel connectors.

The presence of output signal at each of these rear panel jacks is detected by a diode/capacitor combination at each output jack and used as a signal for front panel indication of output fault. Detector outputs at all four jacks are gated together through diodes CR5, CR9, CR13, CR17 and fed to a transistor switch consisting of Q5, Q4, and Q3 which lights the OUTPUT FAULT lamp in the absence of output signal.

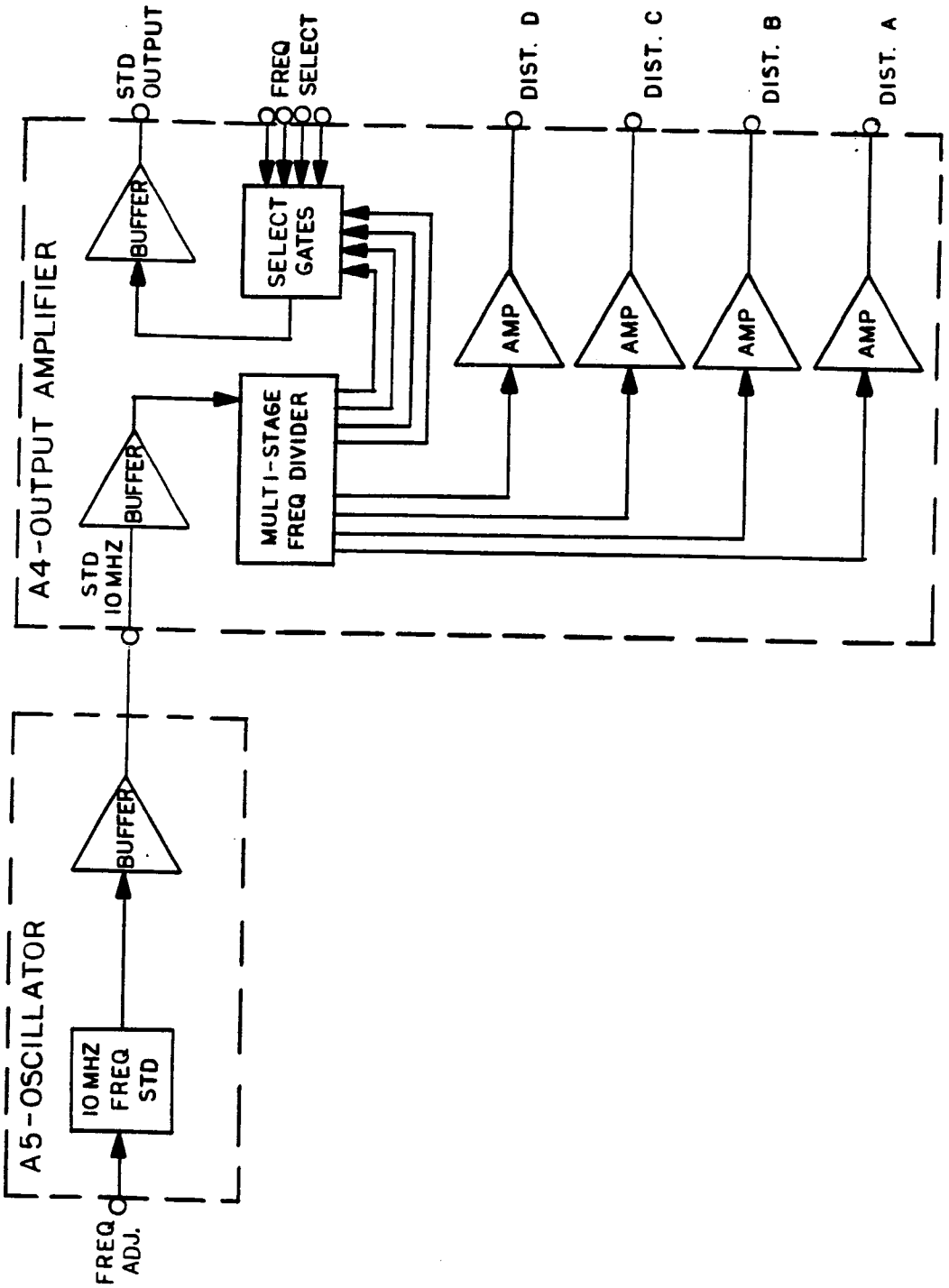

FIGURE 2-1 BLOCK DIAGRAM

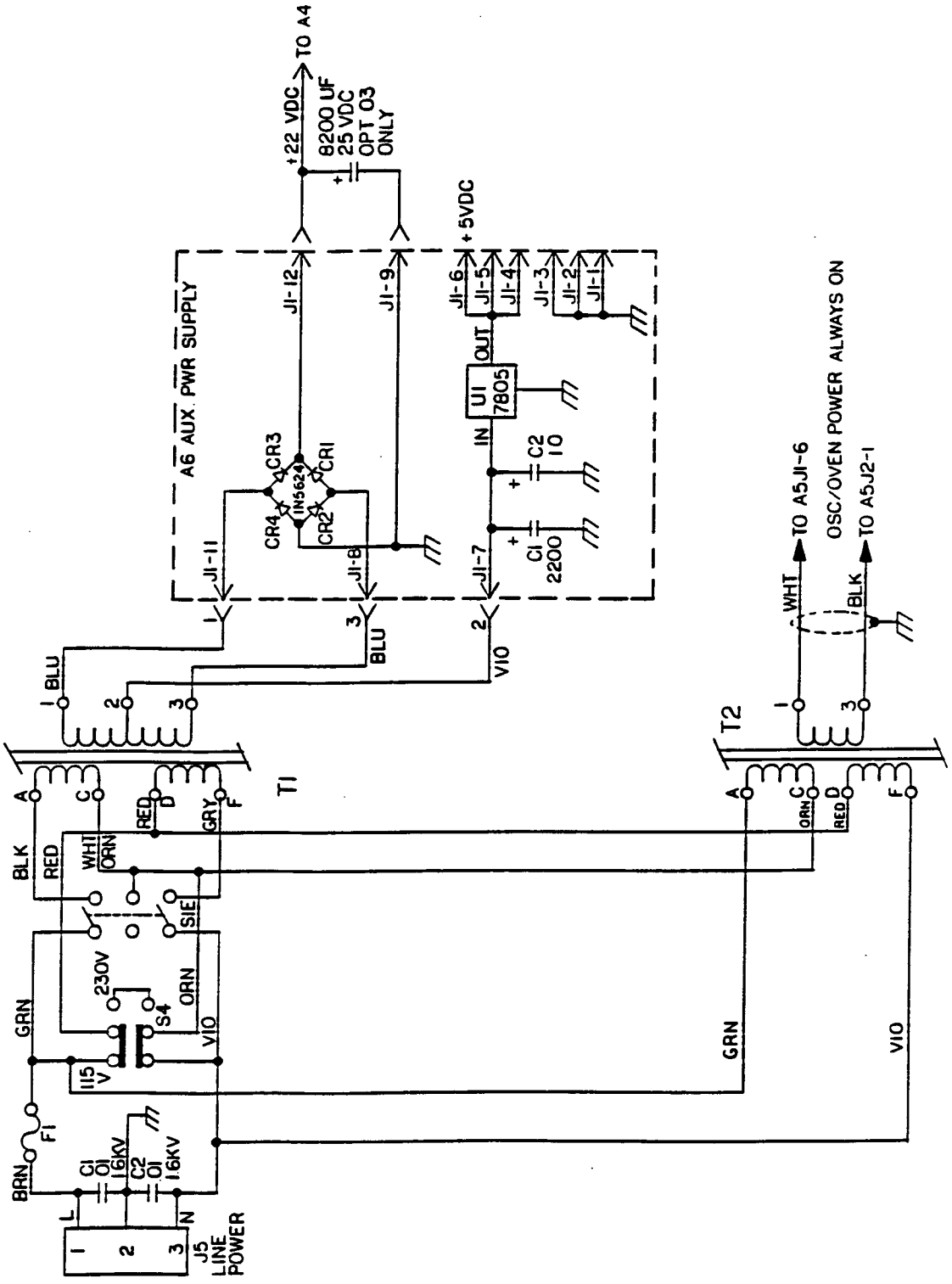

FIGURE 2-2 MAINFRAME SCHEMATIC - SHEET 1

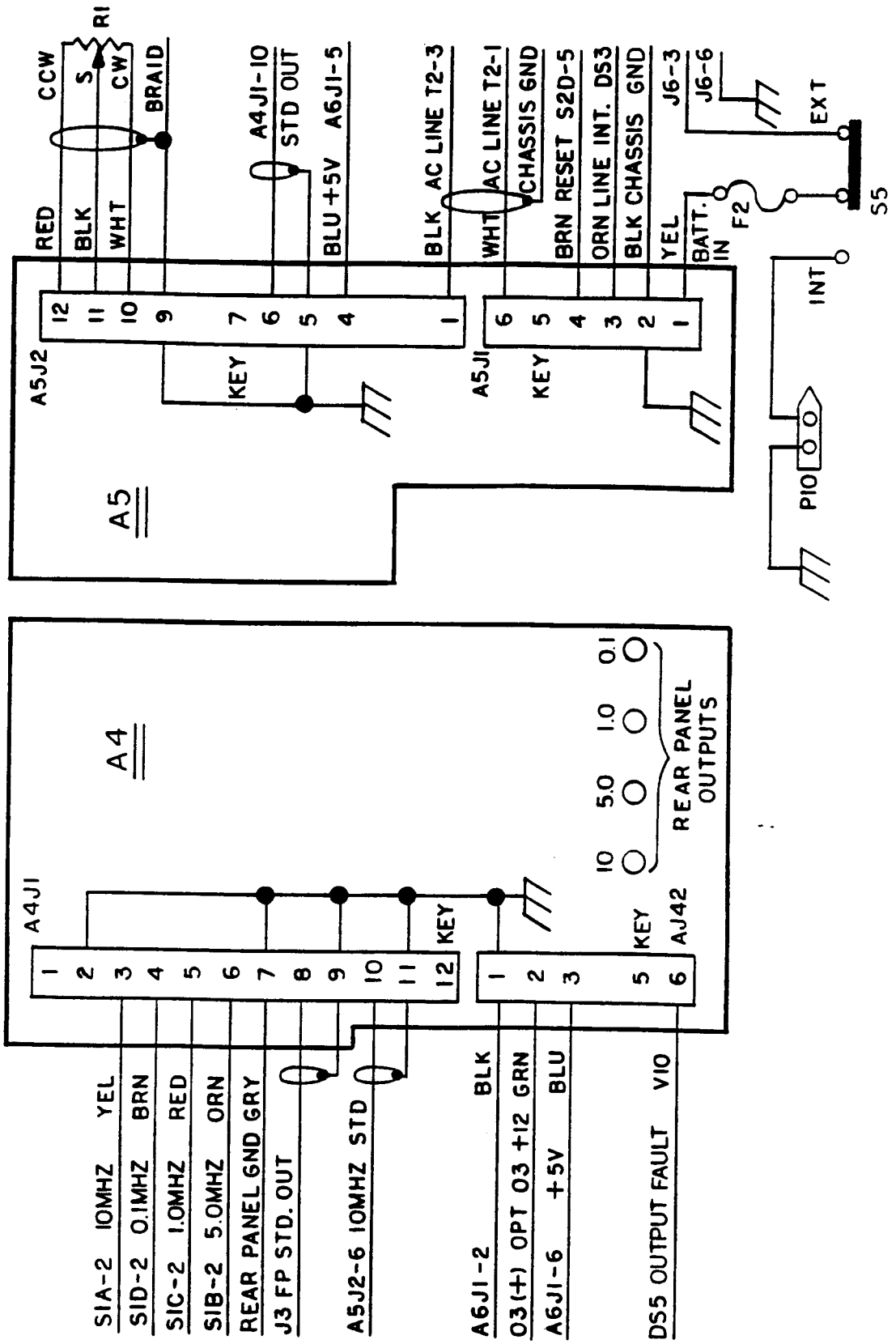

FIGURE 2-2 MAINFRAME SCHEMATIC - SHEET 2

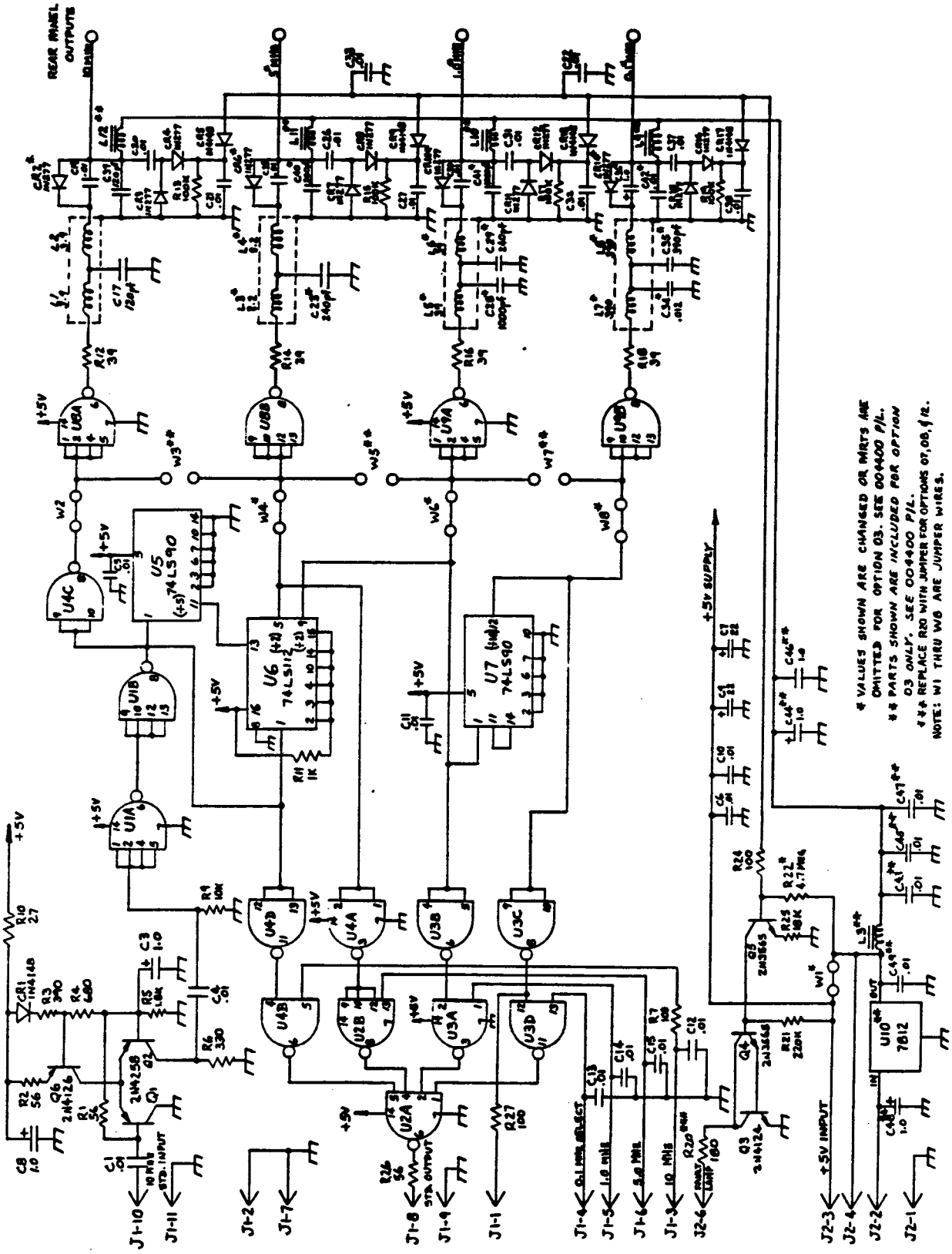

FIGURE 2-3 OUTPUT/DISTRIBUTION AMPLIFIER A4 SCHEMATIC DIAGRAM

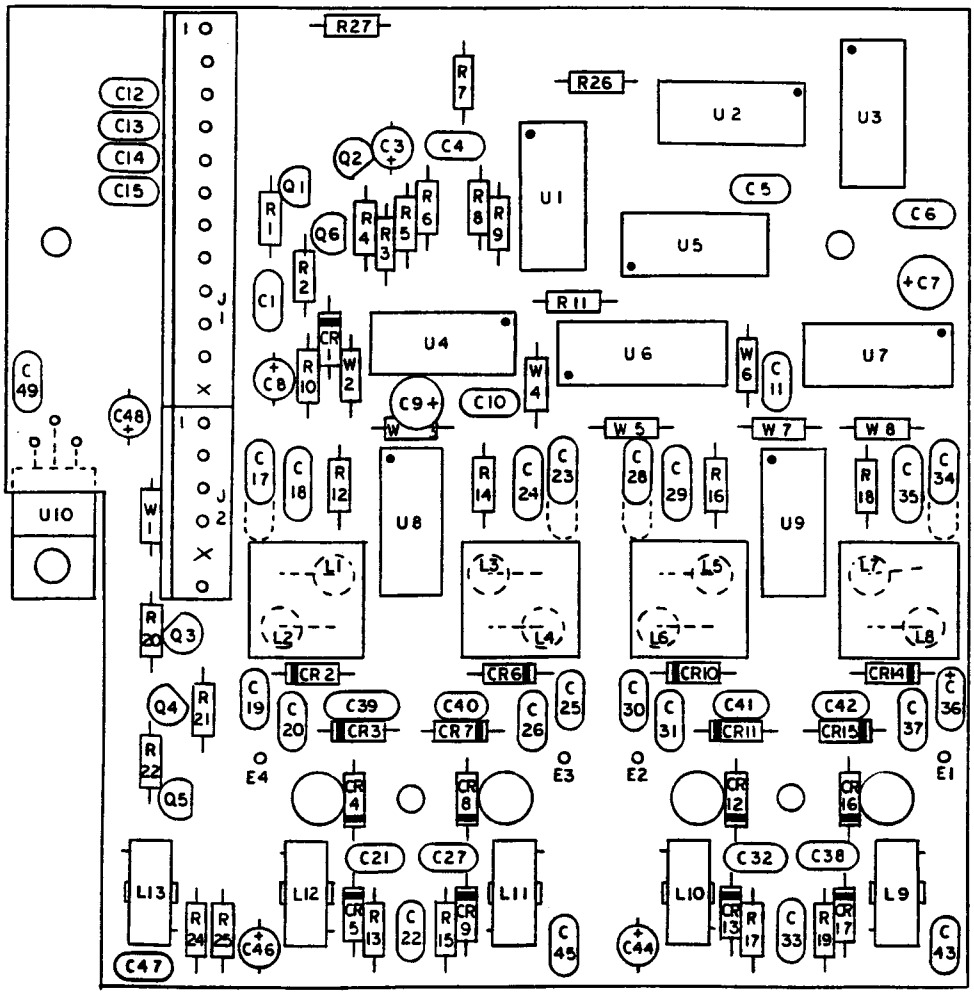

FIGURE 2-4 OUTPUT/DISTRIBUTION AMPLIFIER A4 COMPONENT LOCATION DIAGRAM

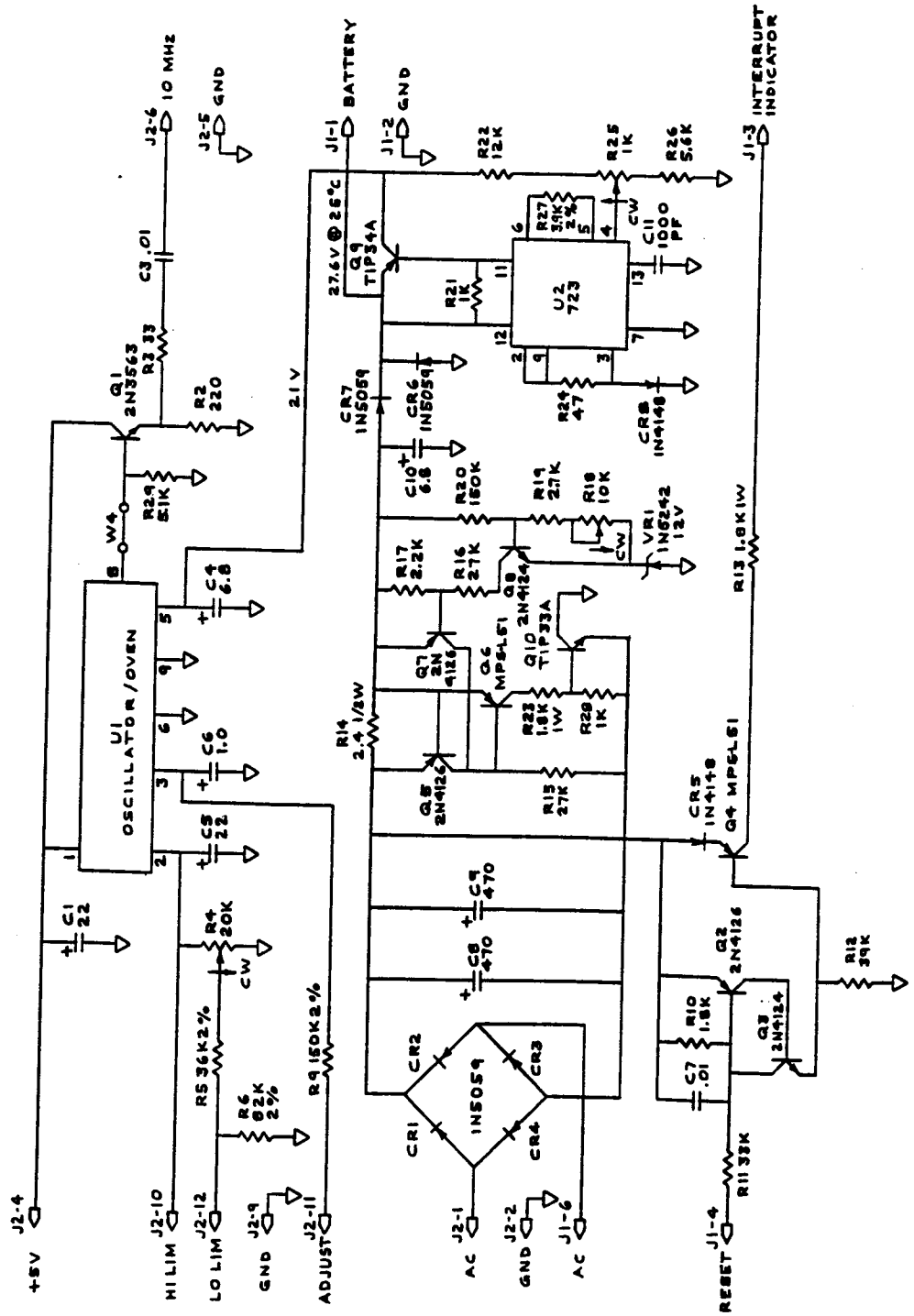

FIGURE 2-5 OSCILLATOR AND POWER SUPPLY A5 SCHEMATIC DIAGRAM

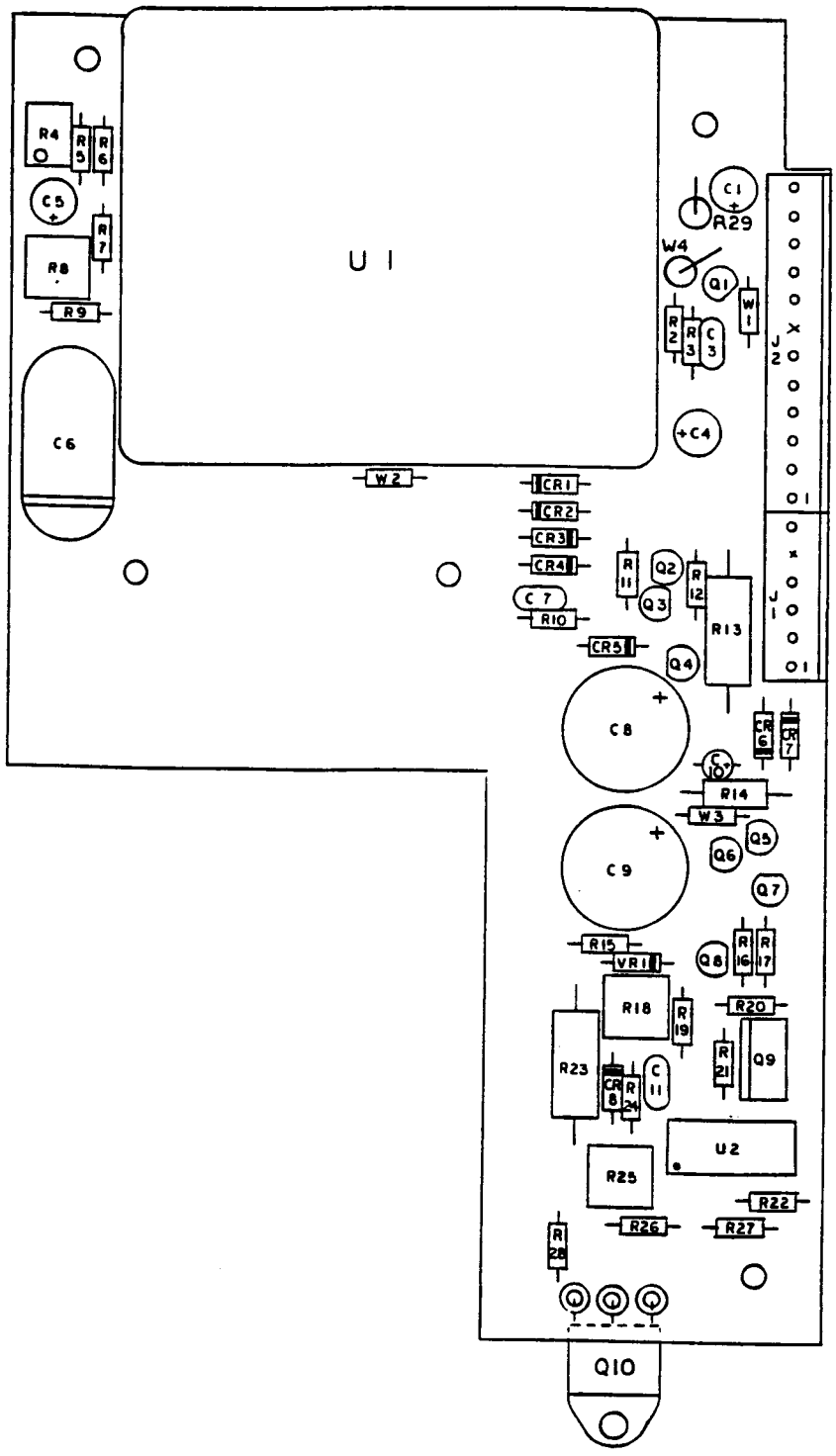

FIGURE 2-6 OSCILLATOR AND POWER SUPPLY A5 COMPONENT LOCATION DIAGRAM

2.3. A5 OSCILLATOR AND POWER SUPPLY ASS'Y, 002500

Oscillator U1 is a high-stability, oven-controlled quartz crystal oscillator. The board consists of a power supply and control circuitry. The output frequency from the board is 10 MHz. Figure 2-5 is the schematic for the Oscillator Board. Figure 2-6 is the Assembly Drawing for A5.

2.3.1 Oscillator Control Circuitry

The resistors connected to pins 2 and 3 of the oscillator are voltage dividers which linearize the VCO control voltage for the fine tune adjustment on the front panel dial. The +5 V DC is fed into the oscillator at pin 1 where it drives the output stages and the output buffer stage Q1. The +21 VDC is fed into pin 5 of the oscillator where it powers the oven and the oscillator itself. This voltage is double-regulated and filtered extremely well before it reaches the oscillator.

2.3.2 Voltage Regulators

A diode bridge consisting of CR1 through CR4 feeds the primary regulator Q5, Q6, Q7, Q8, and Q10. Current is limited by Q5 as sensed at R14 and voltage is limited by Q8 as sensed by the voltage divider in its base circuit and VR1. Q10 provides output limiting for both voltage and current and holds the output voltage at the cathode of CR7 at exactly 27.6 volts. If battery power supply Option 02 is provided, the battery is connected at the cathode of CR7 via the battery fuse. A 24-volt lead-acid battery will be trickle-charged at 27.6 continuously when connected at this point. Maximum battery charging current under low charge conditions is approximately 200 milliamperes, and final trickle-charge level is about 2.0 milliamperes under full charge conditions. If the primary power is disconnected from the unit, diode CR7 becomes back-biased by the battery voltage, effectively removing the primary voltage regulator from the circuit, and power is furnished to the secondary regulator U2 by the battery.

2.3.3 Secondary Regulators

Regulator U2 and series pass transistor Q9 provide regulation of the battery voltage down to +21.0 VDC to power the oscillator and oven.

2.3.4 Voltage Adjustments

Primary output regulator voltage of 27.6 volts at +25°C is adjusted at trimmer resistor R18. This voltage should be adjusted by -50 millivolts per degree C if the temperature varies from +25°C. This provides optimum battery charging performance. Secondary regulator output voltage is adjusted to exactly 21.0 VDC by trimmer resistor R25.

2.3.5 Oscillator Adjustments

The oscillator coarse frequency adjustment and trimmer resistors R4 and R8 are used for centering the oscillator frequency (only after 24 hours of warm-up) and for calibrating and linearizing the control voltage for the adjustment potentiometer at the front panel. (See oscillator alignment procedure.)

2.3.6 Line Interrupt Detector

Transistors Q2, Q3, and Q4 provide an indication of line interruption after power has been restored following a power outage. When the voltage from the diode bridge disappears and then is restored , Q4 causes the front panel line interrupt LED indicator to remain lit until the reset line is grounded by pushing the front panel momentary-contact push button. This causes Q3 and Q2 to hold transistor Q4 in the OFF position causing the front panel indicator to be extinguished. The front panel line interrupt indicator warns the operator that a power interruption has occurred and that oscillator warm-up must be accomplished before completely stable frequencies are obtained from the oscillator.

2.4. A6 AUXILIARY POWER SUPPLY ASS'Y, 003600

Figure 2-2 contains the schematic for the Auxiliary Power Supply. Figure 2-7 is the assembly drawing. The board consists of a full wave rectifier, CR1, CR2, CR3, and CR4 and a +5 volt regulator, U1. The output voltage from the full wave rectifier is 23.4 volts. If Option 03 is present, capacitor C3, 8200 μF, is added to the mainframe as a filter input capacitor for the 12 volt regulator on the A4 board.

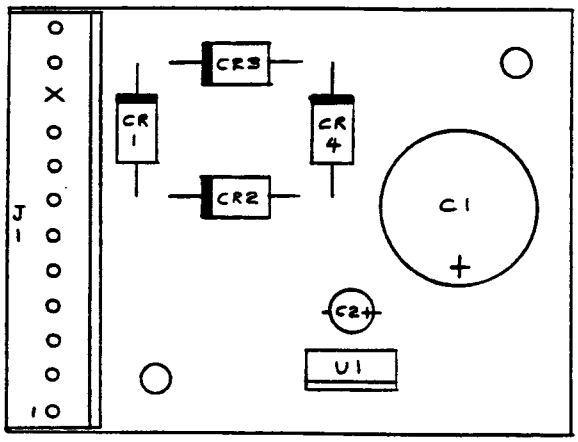

FIGURE 2-7 AUXILIARY POWER SUPPLY A6 COMPONENT LOCATION DIAGRAM

SECTION 3

8130

SERVICE INFORMATION

SECTION 3 SERVICE INFORMATION

3.1. CALIBRATION OF FREQUENCY STANDARD OSCILLATORS

Periodic calibration of a frequency standard oscillator is necessary to maintain a known accuracy. The Model 8130 must either be sent to the National Institute of Standards and Technology or calibrated against a traceable standard in a secondary standards laboratory. The most common and inexpensive way of accomplishing this is to use a WWVB receiver/comparator such as the Spectracom Model 8161, 8163, 8164, or 8165. These units allow your laboratory to be "connected" directly to the Bureau of Standards via a radio signal transmitted from station WWVB for calibration of frequency.

3.1.1 Calibration Interval and Aging Rate

To determine your necessary calibration interval, you must first know the approximate aging rate of the oscillator and the oscillator accuracy that you require in your application. Your approximate calibration interval is determined by dividing the required accuracy by the aging rate.

EXAMPLE: When you first receive your frequency standard oscillator, the exact aging rate is still unknown. Referring to the specification sheet for the equipment, you note that the typical aging rate is $5 \times E^{-9}$ per day after one day of warm-up. If your absolute accuracy requirement is $\pm 5 \times E^{-7}$, you would calculate your initial calibration interval as follows:

$$\text{Initial Calibration Interval} = \frac{\text{Accuracy Required}}{\text{Aging Rate}}$$

$$= \frac{5 \times E^{-7}}{5 \times E^{-9}/\text{Day}}$$

$$= 100 \text{ Days}$$

After a frequency standard oscillator has been running for a long period, the aging rate usually decreases asymptotically to a final aging rate. This final, or long term aging rate, can only be determined after you have owned the oscillator for several months. It is likely that after the first few calibrations you will determine that the aging rate has slowed so that a longer calibration interval is possible. To calculate the actual aging rate after the oscillator has been running for several months, divide the long term frequency change by the number of days over which the change took place:

$$\text{Aging Rate} = \frac{\text{Frequency Change}}{\text{Time for Change to Occur}}$$

The frequency change over a period of time can be easily found if you keep a log book, recording the oscillator adjustment dial settings next to the date that each correcting adjustment is made. Your log for the last few months might look like this if you have made 100-day adjustments to correct the oscillator frequency:

Date	**New Dial Setting**
Feb 28	762
Jun 10	720
Sep 20	685
Dec 30	655
Apr 10	625

The settings which kept the oscillator "on" frequency have changed in the last two hundred days by 685 minus 625 or 60 parts in E^{-9}. The aging rate is calculated for the period as:

$$\text{Aging Rate} = \frac{60 \times E^{-9}}{200 \text{ Days}}$$

$$= 3 \times E^{-10}/\text{Day}$$

The error before the June 10 adjustment was 762 minus 720 or 42 x E^{-9} or less than .5 x E^{-7}; well within your original goal of 5 x E^{-7}. At the April 10 adjustment, the error was 655 minus 625 or 30 x E^{-9}, showing that the aging has slowed.

EXAMPLE: You have determined that after owning the equipment for several months the aging rate has settled out at about 3 x E^{-10} per day. You have also determined that your required accuracy is better than before; you now need 1 x E^{-7} of absolute accuracy. Your new long-term calibration interval is calculated as follows:

$$\text{Long Term Calibration Interval} = \frac{\text{Accuracy Required}}{\text{Aging Rate}}$$

$$= \frac{1 \times E^{-7}}{3 \times E^{-10}/\text{Day}}$$

$$= 333 \text{ Days}$$

The aging rate of an oscillator is higher after the oscillator has been turned off. For this reason and for warm-up reasons, it is highly recommended that your laboratory frequency standard oscillator never be turned off. If you have a WWVB receiver/ comparator in your facility, the oscillator should be calibrated in place without removing the power from it. This avoids problems of warm-up and aging retrace which will be encountered if you turn the unit off.

If you are required to maintain even higher accuracy than the above examples, such as +3 x E^{-9}, your calibration interval must be considerably shorter and it is highly recommended that a WWVB receiver be mounted adjacent to your frequency standard oscillator.

EXAMPLE: Your required accuracy is $+3 \times E^{-9}$ and your oscillator is aging at $3 \times E^{-10}$ per day.

$$\text{Calibration Interval} = \frac{\text{Accuracy Required}}{\text{Aging Rate}}$$

$$= \frac{3 \times E^{-9}}{3 \times E^{-10}}$$

$$= 10 \text{ Days.}$$

3.1.2 Other Calibration Considerations

Besides calibrating the frequency accuracy a functional test check-up should be made when the unit is calibrated. Verification should be made of output signal levels, front panel frequency selection operation, and presence of output frequencies at the rear panel.

CALIBRATION CHECK LIST

1.	Line Interrupt Lamp Off	_____
2.	Power Lamp On	_____
3.	Output Fault Lamp Off	_____
4.	Frequency Counter Check of Output Frequencies:	
	Front Panel 4 frequencies all OK	_____
	Rear Panel Output frequencies OK	_____
5.	Oscillator Dial Setting before calibration	_____
6.	Oscillator Dial Setting after calibration	_____

3.2 ALIGNMENT PROCEDURES

First check to see that all power supply voltages are present at the correct levels.

3.2.1 Oscillator and Power Supply Assembly (A5 Board)

3.2.1.1 Regulator Alignment

1. Connect the negative lead of a DMM to the chassis. Select the +200 VDC full scale range and connect the positive lead to the pin marked + on the connector on rear panel of the unit. Place the rear panel battery selector switch in the EXT position. The DMM should read +27.6 V at 25°C ambient. This voltage will vary by -0.05 Volts per degree C for room temperatures other than 25°C. If the temperature corrected voltage is not correct, adjust potentiometer A5R18 for the correct reading, and re-seal the potentiometer.

2. Temporarily disconnect the positive lead of the DMM and set it for a full scale range of greater than +0.5 Amperes. Reconnect the meter, it should read .25 $\pm$.05 A. This measurement checks the maximum charge current limiting at the EXT battery terminal by shorting the power supply through the ammeter to ground. Afterward, the front panel LINE INTERRUPT lamp should be reset, and the DMM MUST BE SET TO READ VOLTS.

3. Disconnect the positive lead of the DMM and set for a full scale range of +200 VDC. Connect the lead to transistor A5Q9-C (metal side of the package).

4. The DMM should read +21.0 volts. If it does not, adjust potentiometer A5R25 for the correct reading and re-seal it.

5. Disconnect the DMM. If an internal battery pack is to be used, set the rear panel battery switch to the INT position.

3.2.1.2 Oscillator Alignment

NOTE: Alignment is not required until front panel dial indication is out of range, or unless oscillator is replaced.

1. Allow the oscillator to operate with uninterrupted oven and oscillator power for at least 24 hours before performing the following alignment.

2. Set the front panel fine frequency control to 1000 (the next full unit above 999, dial reading of 000). Press the 10 MHz front panel push-button and connect a frequency counter to the standard output connector. The counter must have an accuracy of at least 1 x E^{-8} and a resolution of at least 0.1 Hz.

3. For all new oscillators and older oscillators exhibiting upward frequency aging, the counter should read 10,000.0025 kHz. In the rare cases of older oscillators known to be aging downward the counter should read 10,000.0050 kHz. The oscillator coarse frequency control (accessible through the top of the oscillator can) may be adjusted to provide the required reading. The coarse adjustment has a nominal sensitivity of 10 Hz/turn at 10 MHz, with clockwise rotation decreasing the frequency.

NOTE: A metal tipped non-metallic tuning tool is to be used for the coarse adjustment. The coarse adjustment sealing screw is to be replaced as soon as possible after adjustment to avoid thermal disruption of the oscillator.

4. Set the front panel fine frequency control to 000 (at the low end of the range). The counter shall read exactly 10.0 Hz (.0100 kHz) below that obtained in step 3 above. If it is not, adjust potentiometer A5R4. Clockwise rotation of the potentiometer decreases the oscillator frequency.

5. Set the front panel fine frequency control to 500. The frequency counter shall read exactly 5.0 Hz (.0050 kHz) below that obtained in step 3 above. If it does not, adjust potentiometer A5R8 for the correct reading and re-seal it.

6. Set the front panel frequency control for a counter reading of exactly 10 MHz, then calibrate to any greater degree of precision using a WWVB receiver/comparator.

NOTE: Potentiometer A5R4 is a tracking control, and should be tuned exactly the same amount in the same direction as any future adjustment of the oscillator coarse frequency control, unless a complete oscillator realignment is performed.

OSCILLATOR ALIGNMENT CHART

Power Supplies +5V	_____	VDC
Power Supplies +12V (if present)	_____	VDC
Front Panel Outputs - 4 frequencies	_____	
Rear Panel outputs - All 4 jacks	_____	
Output Fault - 4 jacks	_____	
Line Interrupt Circuit	_____	
Oscillator Warm-up Start Date	_____	
Oscillator - Adj 27.6V - A5R18	_____	
Adj 21.0V - A5R25	_____	
Max Charge Rate	_____	mADC
24 hour warm-up	_____	
1000 Coarse 10,000,002.5	_____	
000 A5R4 9,999,992.5	_____	
500 A5R8 9,999,997.5	_____	
	Dial Setting @ 10,000,000.0	

3.3 LINE TAP TEST PROCEDURE

This section describes the test procedure for the 8140T Line Tap. Refer to Figure 3-1 for the test set-up.

1. Connect a coaxial BNC tee to the output of the line tap under test. Connect the oscilloscope to the other tee output.

2. Set the scope for DC coupling and set the sweep at 1 cycle per cm.

3. The oscilloscope presentation should be a 1.4 V peak-to-peak minimum (2.0 V peak-to-peak typical) sine wave symmetrical around the 0 volt reference.

4. Remove the 50-ohm output termination. The scope should show 3.0 V peak-to-peak minimum (4.0 V peak-to-peak typical) sine wave with a DC offset as shown.

NOTE: At frequencies of 5 or 10 MHz, a 10:1 oscilloscope probe must be used to prevent loading.

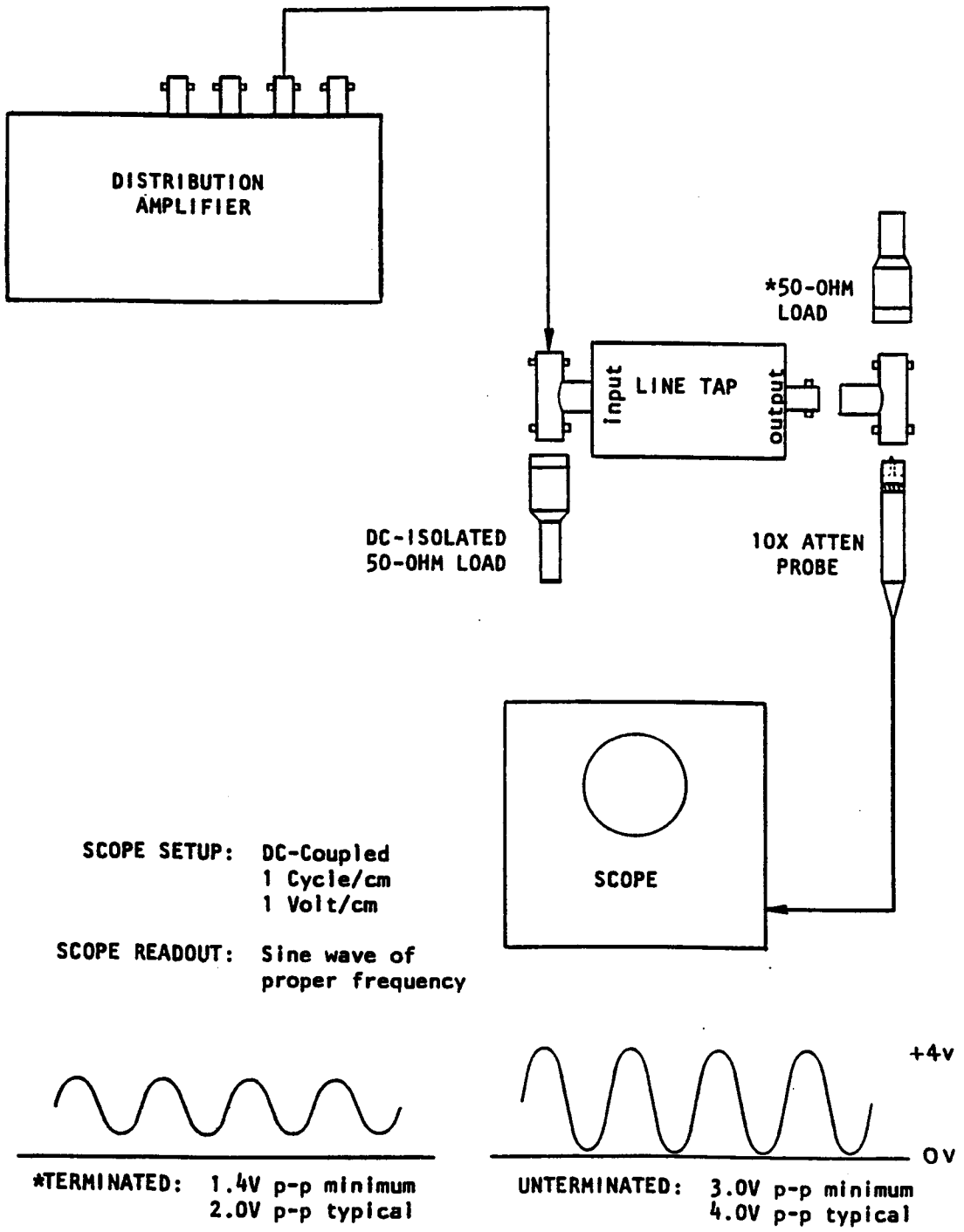

FIGURE 3-1 LINE TAP MODEL 8140T TEST SET-UP

3.4 TROUBLE SHOOTING

If a problem occurs with the frequency standard oscillator, some simple checks can isolate the problem to specific areas. Some of the more likely problems and the procedures for solving them are as follows:

1. Fault Lamp Lights: This lamp comes on whenever one of the rear panel outputs has disappeared for any reason, whether it has been shorted or open-circuited inside the unit. If the fault light is on, at least one of these outputs should be missing. Signal tracing methods may be used to find the source of the problem.

2. Frequency Output is Wildly Unstable: This type of problem can only be caused by a fault in the oscillator module itself. The oscillator module should be replaced or the unit sent back to the factory for repair.

3. No Standard Output: If the front panel output from the internal frequency standard oscillator is not present, or if the rear panel outputs from this standard oscillator are missing, the fault can lie with either assemblies A4 or A5. The A5 oscillator assembly is the source of the signals and contains both the oscillator and its power supply. If any of these are malfunctioning the frequency standard outputs will be missing. Assembly A4 is the output amplifier which feeds the appropriate frequencies from the A5 assembly to both the front and rear panels. Signal tracing from the input of this board to the outputs which feed the front and rear panels can establish whether or not this board is performing properly.

4. Fuse blows: This problem is most likely caused by power supply malfunction. The problem may be isolated to a circuit board inside the unit by disconnecting the circuit board connectors one at a time and turning the unit on again.

SECTION 4

8130

REPLACEABLE PARTS LIST

SECTION 4 REPLACEABLE PARTS LIST

Assembly	Ref. No	Part No.	Description
Final Assy		W01000	Line Cord
	F1	F00R75	Fuse, 3/4A, 3AG, 1-1/4 for Op. 03
	F2	F00R37	Fuse, 3/8A, 3AG,.6A for Op. 03
	XF1-2	X00060	Fuseholder
Mainframe	A4	002400	Output Amplifier Assy
	A5	002500	Osc/Power Supply Assy
	A6	003600	Aux. Power Supply Assy
	C1-2	C00202	Capacitor, .0l uf,1.6KV
	R3	R01151	Resistor, 150 ohms,1/4W,5%
Ancillary Kit		F00R75	Fuse, 3/4A, 3AG
		F001R2	Fuse, 1-1/4 for Op. 03
		F00R37	Fuse, 3/8A, 3AG
		F00R60	Fuse, .6A for Op. 03
		P01102	Connector, 2 pins
		P01100	Pin, male
		004490	DC-isolated 50-ohm load (Op. 03)
Battery, Op. 02	B1-4	B00000	Battery, sealed lead acid 6V
	J10	J01102	Receptacle
	J10	J01100	Pin, Female
Distribution Amplifier,			
Op. 03	C3	C00300	Capacitor, 8200 mfd, 25V DC
Harness	P3	P00112	Connector, 12 pins
	P6	P00106	Connector, 6 pins
	P7	P00112	Connector, 12 pins
	P8	P00106	Connector, 6 pins
	P9	P00112	Connector, 12 pins
	P10	P01102	Connector, 2 pins
		P00100	Pin, terminal
		P00300	Key, polarizing
Front Panel	DS1	DS00045	Display, LED
	DS2-3	DS00042	Display, LED
	J1	J00010	Receptacle, BNC
	R1	R09503	Potentiometer, 50K, 10turn
	S1	S00006	Switch, Pushbutton
	S2	S00003	Switch, Pushbutton
Chassis	T1	T10000	Transformer, Power
	T2	T10001	Transformer, Power
Rear Panel	J2	J01102	Receptacle
	J3	J01000	Receptacle, BNC
	J4-7	J00010	Receptacle, BNC
	S3-4	S00102	Switch, Slide
	XF1-2	X00050	Fuseholder, 3AG

Assembly	Ref. No	Part No.	Description
A4, Output	C1	C02103	Capacitor, Disc, .01 uf, 50V
Amp Assy	C2	Not used	
	C3	C15105	Capacitor, Tant, 1.0 uf, 35V
	C4-6	C02103	Capacitor, Disc, .01 uf, 50V
	C7	C12226	Capacitor, Tant, 22 uf, 15V
	C8	C15105	Capacitor, Tant, 1.0 uf, 35V
	C9	C12226	Capacitor, Tant, 22 uf, 15V
	C10-15	C02103	Capacitor, Disc, .0l uf, 50V
	C16		Not used
	C17	C05121	Capacitor, Mica, 120 pf
	C18		Not Used
	C19-22	C02103	Capacitor, Disc, .0l uf, 50V
	C23	C05241	Capacitor, Mica, 240 pf
	C24		Not Used
	C25-27	C02103	Capacitor, Disc, .0l uf, 50V
	C28	C05102	Capacitor, Mica, 1000 pf
	C29	C05241	Capacitor, Mica, 240 pf
	C30-33	C02103	Capacitor, Disc, .0l uf, 50V
	C34	C21123	Capacitor, Polycarb,12000 pf,250V
	C35	C05391	Capacitor, Mica, 390 pf
	C36	C15105	Capacitor, Tant, 1.0 uf, 35V
	C37-38	C02103	Capacitor, Disc, .0l uf, 50V
	C39	C05101	Capacitor, Mica, 100 pf
	C40	C05201	Capacitor, Mica, 200 pf
	C41	C05102	Capacitor, Mica, 1000 pf
	C42	C02103	Capacitor, Disc, .0l uf, 50V
	C43-49		Not Used
	CR1	CR04148	Diode, 1N4148
	CR2-4	CR00277	Diode, 1N277
	CR5	CR04148	Diode, 1N4148
	CR6-8	CR00277	Diode, 1N277
	CR9	CR04148	Diode, 1N4148
	CR10-12	CR00277	Diode, 1N277
	CR13	CR04148	Diode, 1N4148
	CR14-16	CR00277	Diode, 1N277
	CR1	CR04148	Diode, 1N4148
	J1-2	J00106	Receptacle, 6 pins
	L1-2	L023R9	Choke, 3.9 uH
	L3-4	L028R2	Choke, 8.2 uH
	L5-6	L02390	Choke, 39 uH
	L7-8	L03391	Choke, 390 uH
	L9-13		Not Used
	Q1-2	Q04258	Transistor, 2N4258
	Q3	Q04124	Transistor, 2N4124
	Q4-5	Q03565	Transistor, 2N3565
	Q6	Q04126	Transistor, 2N4126

Assembly	Ref. No	Part No.	Description
A4	R1-2	R01560	Resistor, 1/4w, 5%, 56 ohms
	R3	R01391	Resistor, 390 ohms
	R4	R01681	Resistor, 680 ohms
	R5	R01182	Resistor, 1.8K
	R6	R01331	Resistor, 330 ohms
	R7	R01101	Resistor, 100 ohms
	R8		Not used
	R9	R01472	Resistor, 1/4w, 5%, 4.7K
	R10	R01270	Resistor, 27 ohms
	R11	R01102	Resistor, 1K
	R12	R01390	Resistor, 39 ohms
	R13	R01104	Resistor, 100 K
	R14	R01390	Resistor, 39 ohms
	R15	R01104	Resistor, 1/4w, 5%, 100 K
	R16	R01390	Resistor, 39 ohms
	R17	R01104	Resistor, 100 K
	R18	R01390	Resistor, 39 ohms
	R19	R01104	Resistor, 100 K
	R20	R01181	Resistor, 180 ohms
	R21	R01224	Resistor, 220 K
	R22	R01475	Resistor, 4.7 Megohm
	R23		Not used
	R24	R01101	Resistor, 100 ohms
	R25	R01183	Resistor, 18 K
	R26	R01560	Resistor, 56 ohms
	R27	R01101	Resistor, 100 ohms
	U1	U4LS20	Integrated Circuit, SN74LS20
	U2	U4S140	Integrated Circuit, SN74S140N
	U3-4	U4LS37	Integrated Circuit, SN74LS37
	U5	U4LS90	Integrated Circuit, SN74LS90
	U6	ULS112	Integrated Circuit, SN74LS112N
	U7	U4LS90	Integrated Circuit, SN74LS90
	U8-9	U4S140	Integrated Circuit, SN74S140N
	U10		Not used
	W1-2	R01000	Jumper
	W3		Not used
	W4	R01000	Jumper
	W5		Not used
	W6	R01000	Jumper
	W7		Not used
	W8	R01000	Jumper

Assembly	Ref. No	Part No.	Description
A5, OSC/PS Assy	C1	C12226	Capacitor, Tant, 22 uf, 15V
	C2	R01512	Resistor, 1/4W, 5%, 5.1K
	C3	C02103	Capacitor, Disc, .0l uf, 50V
	C4	C15685	Capacitor, Tant, 6.8 uf, 35V
	C5	C12226	Capacitor, Tant, 22 uf, 15V
	C6	C22105	Capacitor, Polyester, 1 uf
	C7	C02103	Capacitor, Disc, .0l uf, 50V
	C8-9	C09471	Capacitor, Electrolytic, 470uf, 50V
	C10	C15685	Capacitor, Tant, 6.8 uf, 35V
	C11	C05102	Capacitor, Mica, 1000 pf
	CR1-4	CR05059	Diode, 1N5059
	CR5	CR04148	Diode, 1N4148
	CR6-7	CR05059	Diode, 1N5059
	CR8	CR04148	Diode, 1N4148
	J1-2	J00106	Receptacle, 6 pins
	L1	R01000	Jumper
	Q1	Q03563	Transistor, 2N3563
	Q2	Q04126	Transistor, 2N4126
	Q3	Q04124	Transistor, 2N4124
	Q4	Q00L51	Transistor, MPS-L51
	Q5	Q04126	Transistor, 2N4126
	Q6	Q00L51	Transistor, MPS-L51
	Q7	Q04126	Transistor, 2N4126
	Q8	Q04124	Transistor, 2N4124
	Q9	Q00034	Transistor, TIP34A
	Q10	Q00033	Transistor, TIP33A
	R1		Not used
	R2	R01221	Resistor, 1/4w,5%,220 ohms
	R3	R01330	Resistor, 33 ohms
	R4	R07203	Potentiometer,Cermet,20K
	R5	R11363	Resistor, Metal Glaze,1/4w,5%, 36K
	R6	R11823	Resistor, 82K
	R7	R11153	Resistor, 15K
	R8	R05503	Potentiometer, Cermet, 50K
	R9	R01154	Resistor, 1/4w, 5%, 150K
	R10	R01182	Resistor, 1.8K
	R11	R01333	Resistor, 33 K
	R12	R01393	Resistor, 39 K
	R13	R03182	Resistor, Carbon, 1w, 1.8K
	R14	R022R4	Resistor, 1/2w, 2.4ohms
	R15-16	R01273	Resistor, 1/4w, 5%, 27 K
	R17	R01222	Resistor, 2.2 K
	R18	R05103	Potentiometer, Cermet, 10K
	R19	R01272	Resistor, 1/4w, 5%, 2.7 K
	R20	R01154	Resistor, 150 K
	R21	R01102	Resistor, 1 K
	R22	R11123	Res, Metal Glaze, 1/4w,5%,12 K
	R23	R03182	Resistor, Carbon, 1w, 1.8 K
	R24	R01470	Resistor, 1/4w, 5%, 47 ohms
	R25	R05102	Potentiometer, Cermet, 1 K
	R26	R11562	Res, Metal Glaze, 1/4w,5%, 5.6 K
	R27	R11392	Resistor, 3.9 K
	R28	R01102	Resistor, 1/4w, 5%, 1 K

Assembly	Ref. No	Part No.	Description
A5	U1	002590	Oscillator Assembly
	U2	U00723	Voltage Regulator, uA723C
	VR1	VR05242	Zener Diode, 1N5242B
	W1-3	R01000	Jumper
A6	C1	C07222	Capacitor, Electrolytic, 2200 pf, 16V
	C2	C15105	Capacitor, Tant, 1.0 uf, 35V
	CR1-4	CR05624	Diode, 1N5624
	J1	J00106	Jumper
	U1	U78M05	
A4, Output Amp Assy (Op. 03)	C1	C02103	Capacitor, Disc, .0l uf, 50 V
	C2		Not used
	C3	C15105	Capacitor, Tant, 1.0 uf, 35 V
	C4-6	C02103	Capacitor, Disc, .01 uf, 50 V
	C7	C12226	Capacitor, Tant, 22 uf, 15 V
	C8	C15105	Capacitor, Tant, 1.0 uf, 35 V
	C9	C12226	Capacitor, Tant, 22 uf, 15 V
	C10-15	C02103	Capacitor, Disc, .01 uf, 50 V
	C16		Not used
	C17	C05121	Capacitor, Mica, 120 pf
	C18		Not used
	C19-22	C02103	Capacitor, Disc, .01 uf, 50 V
	C23	C05121	Capacitor, Mica, 120 pf
	C24		Not used
	C25-27	C02103	Capacitor, Disc, .01 uf, 50 V
	C28	C05121	Capacitor, Mica, 120 pf
	C29		Not used
	C30-33	C02103	Capacitor, Disc, .01 uf, 50 V
	C34		Not used
	C35	C05121	Capacitor, Mica, 120 pf
	C36-39	C02103	Capacitor, Disc, .01 uf, 50 V
	C39-42	C05101	Capacitor, Mica, 100 pf
	C43	C02103	Capacitor, Disc, .01 uf, 50 V
	C44	C15105	Capacitor, Tant, 1.0 uf, 35 V
	C45	C02103	Capacitor, Disc, .01 uf, 50 V
	C46	C15105	Capacitor, Tant, 1.0 uf, 35 V
	C47	C02103	Capacitor, Disc, .01 uf, 50 V
	C48	C15105	Capacitor, Tant, 1.0 uf, 35 V
	C49	C02103	Capacitor, Disc, .01 uf, 50 V
	CR1	CR04148	Diode, 1N4148
	CR2-4	CR00277	Diode, 1N277
	CR5	CR04148	Diode, 1N4148
	CR6-8	CR00277	Diode, 1N277
	CR9	CR04148	Diode, 1N4148
	CR10-12	CR00277	Diode, 1N277
	CR13	CR04148	Diode, 1N4148
	CR14-16	CR00277	Diode, 1N277
	CR17	CR04148	Diode, 1N4148
	J1-2	J00106	Receptacle, 6 pins
	L1-8	L023R9	Choke, 3.9 uH
	L9-13	L04000	Inductor, Toroidal

Assembly	Ref. No	Part No.	Description
A4 (Op 03)	Q1-2	Q04258	Transistor, 2N4258
	Q3	Q04124	Transistor, 2N4124
	Q4-5	Q03565	Transistor, 2N3565
	Q6	Q04126	Transistor, 2N4126
	R1-2	R01560	Resistor, 1/4w, 5%, 56 ohms
	R3	R01391	Resistor, 390 ohms
	R4	R01681	Resistor, 680 ohms
	R5	R01182	Resistor, 1.8 K
	R6	R01331	Resistor, 330 ohms
	R7	R01101	Resistor, 100 ohms
	R8		Not used
	R9	R01103	Resistor, 10 K
	R10	R01270	Resistor, 27 ohms
	R11	R01102	Resistor, 1/4w, 5%, 1K
	R12	R01390	Resistor, 39 ohms
	R13	R01104	Resistor, 100 K
	R14	R01390	Resistor, 39 ohms
	R15	R01104	Resistor, 100 K
	R16	R01390	Resistor, 39 ohms
	R17	R01104	Resistor, 100 K
	R18	R01390	Resistor, 39 ohms
	R19	R01104	Resistor, 100 K
	R20	R01181	Resistor, 180 ohms
	R21	R01224	Resistor, 220 K
	R22	R01126	Resistor, 12 megohm
	R23		Not used
	R24	R01101	Resistor, 100 ohms
	R25	R01183	Resistor, 18 K
	R26	R01560	Resistor, 56 ohms
	R27	R01101	Resistor, 100 ohms
	U1	U4LS20	Integrated Circuit, SN74LS20
	U2	U4S140	Integrated Circuit, SN74S140N
	U3-4	U4LS37	Integrated Circuit, SN74LS37
	U5	U4LS90	Integrated Circuit, SN74LS90
	U6	ULS112	Integrated Circuit, SN74LS112N
	U7	U4LS90	Integrated Circuit, SN74LS90
	U8-9	U4S140	Integrated Circuit, SN74S140N
	U10	U78T12	Voltage Regulator, 78T12ACT
	W1		Not used
	W2-3	R01000	Jumper
	W4		Not used
	W5	R01000	Jumper
	W6		Not used
	W7	R01000	Jumper
	W8		Not used