MODEL 8161

WWVB RECEIVER/FREQUENCY STANDARD

INSTRUCTION MANUAL

PLEASE NOTE OUR NEW ADDRESS

SPECTRACOM CORPORATION
95 Methodist Hill Drive
Suite 500
Rochester, New York 14623

Main: 585.321.5800 Direct: 585.321.5801 Fax: 585.321.5218

REVISIONS, IF ANY, ARE LOCATED AT THE END OF THE MANUAL

REVISION 2.0 - 03/87
ERRATA VERSION 2.1 - 8/20/93

WARRANTY

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

Spectracom Corporation warrants to the original purchaser each new instrument to be free from defects in material and workmanship for a period of one year after shipment. Repair or replacement, at our option, will be made when our examination indicates that defects are due to workmanship or materials. Electron tubes, batteries, fuses, and lamps that have given normal service are excluded from warranty coverage. All warranty returns must first be authorized in writing by the factory.

This warranty does not apply to any of our products which have been repaired or altered by persons not authorized by Spectracom Corp. or not in accordance with instructions furnished by us. If the instrument is defective as a result of misuse, improper repair, or abnormal conditions or operations, or if any serial number or seal has been removed or altered, the warranty is void and repairs will be billed at cost.

This warranty is in lieu of all other obligations or liabilities expressed or implied and Spectracom Corp. neither assumes nor authorizes any person to assume for them, any other liability in connection with sales of its products.

REPAIR AND MAINTENANCE

Instruments should be returned only upon prior written authorization from Spectracom Corp. or its authorized sales and service representative. Warranty repair will be made upon written 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 assign ments, 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.): ______________________________

____

____

____

____

CERTIFICATE OF TRACEABILITY

SPECTRACOM CORPORATION hereby certifies that its Model 8161 Standard Frequency Receiver provides direct traceability to the National Bureau of Standards reference frequency as transmitted by station WWVB in Fort Collins, Colorado, with carrier frequency of 60 KHz.

Automatic verification is provided by the station identifying phase shift of 45° that appears on the carrier signal at 10 minutes after each hour, returning to normal five minutes later. This phase shift appears in the readout as an offset in the strip chart record and on the panel meter.

When properly installed and maintained, the Model 8161 provides time accuracy and output resolution as published in the equipment's instruction manual.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

MODEL 8161

SECTION 1

INSTALLATION

SECTION 1: INSTALLATION

1.0 INTRODUCTION

The Spectracom Model 8161 WWVB Receiver Oscillator is a complete frequency calibration system containing a receiver comparator and a high quality oven-controlled quartz frequency standard oscillator. This standard may be continuously monitored against the WWVB VLF carrier. A strip-chart recorder is built into the unit to provide a permanent record of frequency accuracy. External local oscillators and standards can be also compared against the 60 kHz WWVB signal. An optional built-in distribution amplifier sends the internal standard signal to a maximum of 25 remote stations so that each has its own time base traceable to NBS. The demodulated WWVB time code output is also available for synchronizing accurate clocks and other timekeeping equipment.

1.1 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 any 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, instruction manual, chart recorder manual, and an ancillary kit. To aid oscillator restabilization, connect the unit to a suitable source of uninterrupted AC power immediately after unpacking. DO NOT CHANGE THE OSCILLATOR ADJUSTMENT DIAL. The dial setting at the time of shipment typically yields an accuracy of better than 1×10^{-9} for the standard outputs. Consult the factory if the dial setting was accidentally changed.

1.2 RESHIPMENT

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 of at least 250# test corrugated paper with at least two inches of polyethylene foam surrounding the unit must be used. 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. Authorization for return must be obtained from Spectracom.

1.3 ANTENNA LOCATION

The antenna should be mounted a minimum of 25 feet from the receiver to prevent regeneration. The antenna MUST NOT be positioned next to the receiver or on top of it. This will make the results obtained with the equipment meaningless even though the green lock lamp on the receiver front panel may be lit.

The antenna must be at least three feet from any steel beams, roof decking, pipes, etc., as metal will detune the antenna and cause as much as 20 dB degradation of the signal-to-noise ratio. The antenna must not be mounted under a metal roof or inside a building with heavy steel structural supports, as these shield the antenna from the signal. Roof top mounts are good provided the antenna can be aimed toward Fort Collins, Colorado, without the signal being blocked by a large metal structure. Attics are ideal sites if the roof and rafters are not metallic. The signal-to-noise ratio will be optimized if the antenna is located as far as possible from local RF noise sources such as large electric motors, power lines, oscilloscopes, TV sets, or fluorescent or neon lamps that blink or sputter on and off. Any equipment containing a switching power supply is a probable cause of interference.

1.4 ANTENNA INSTALLATION

The antenna should be supported by a non-metallic pipe such as one-inch PVC water pipe and mounted where it will not be disturbed. Holding the antenna two or three feet off the ground or rooftop is adequate in most cases. The tubular housing must be positioned broadside to Fort Collins where the transmitter is located (see Figures 1-1, "Great Circle Map", and 1-2, "Antenna Mount Model 8211"), and horizontal to the ground, to allow maximum signal reception. No signal will be received if the tube points directly toward the transmitter site, as the antenna pattern nulls are located off the ends of the tube. The antenna position may be optimized using the signal strength measurement described in the Operation Section of this manual.

CAUTION: Handle the antenna with care. Dropping or rough handling may crack the ferrite core possibly detuning the antenna, rendering the antenna useless.

When the lead-in coaxial cable (RG-58/U is recommended) is connected from the BNC connector on the antenna to the BNC connector on the receiver, the system is ready for use, if the antenna has been installed and aimed properly. The antenna has a built-in preamplifier inside its housing that receives its DC operating voltage through the coaxial cable; therefore, both the center conductor and the shield of the cable must be continuous from the antenna to the receiver. A short circuit in this line will not harm the equipment as the power supply is adequately protected.

1.5 PREAMPLIFIER (MODEL 8207) INSTALLATION

The Spectracom Model 8207 Preamplifier is a low noise, tuned, 60 kHz line amplifier used in the antenna feed line wherever the WWVB signal strength is less than 50 uV/meter at the Model 8206 Loop Antenna or less than 0.3 uV at the receiver antenna terminal. Typical locations where the Preamplifier is probably required are Hawaii, Alaska, Puerto Rico, and the Canal Zone. Refer to Figure 1-3, "Measured Field Intensity Contours", for approximate signal strength of installation location. The Model 8207 Preamplifier provides approximately 40 dB of gain between the antenna and receiver increasing sensitivity to 3.0 nanovolts.

The Preamplifier is connected in the antenna feed line with INPUT connected to the antenna and OUTPUT connected to the receiver. Because of the high gain of the system, it is recommended that the preamplifier be located at least 10 feet away from the receiver, perhaps where the antenna line enters the room where the receiver is located. The antenna must be at least 25 feet beyond the Preamplifier from the Receiver. Switch A1S1 of the receiver RF Amplifier must be set at its right-hand position, marked PREAMP or P, prior to equipment turn-on, to apply DC voltage to the Model 8207 on the antenna feed line. If the preamplifier is removed from the system, the switch must be placed in the left-hand position, marked ANT or A prior to turn-on.

It is strongly recommended that no internal adjustment of the Preamplifier be made without consulting the factory.

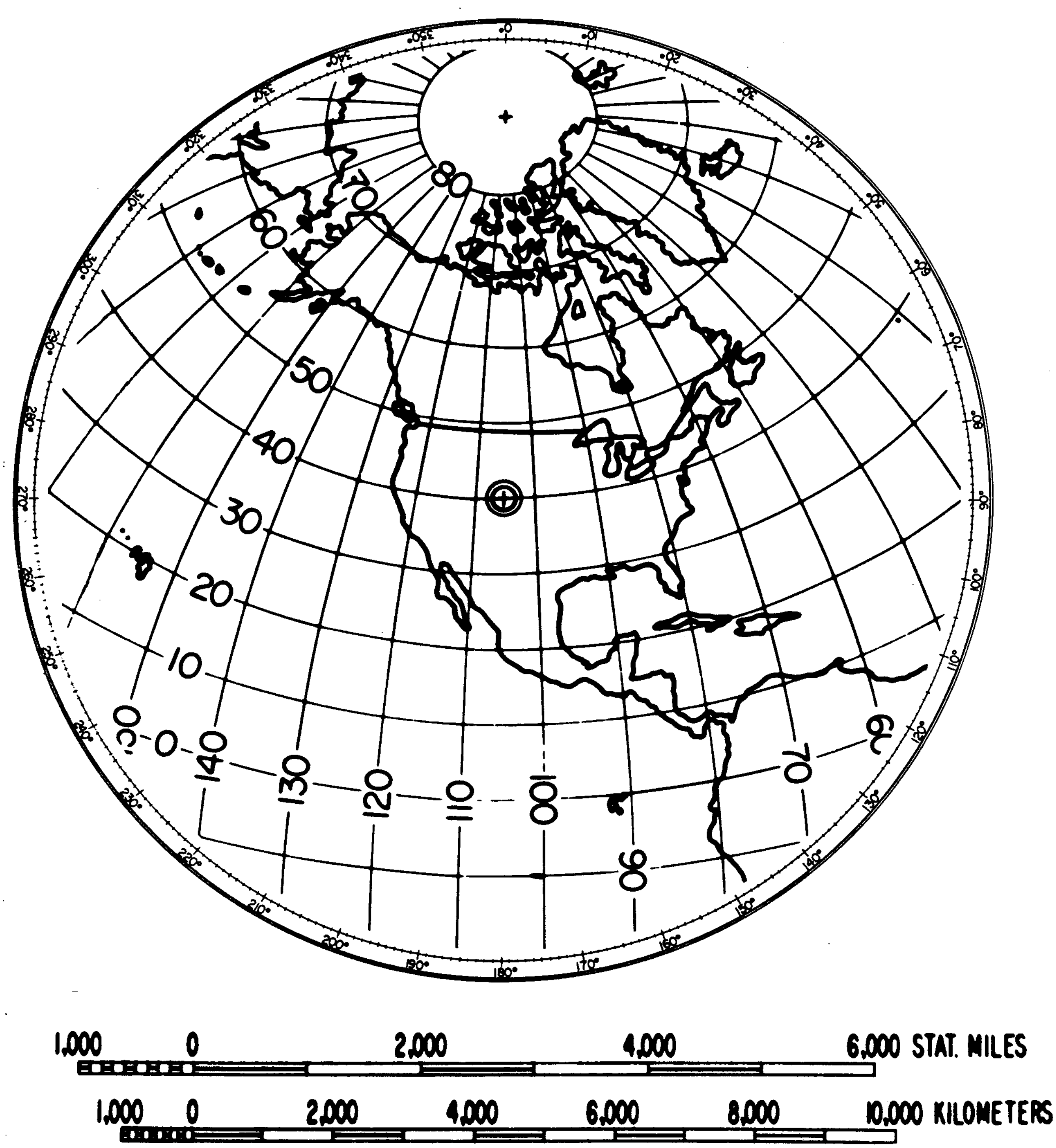
1.6 INPUT POWER

The equipment may be operated from either 115 or 230 VAC ±10%, 60 Hz line power. A slide switch on the rear panel selects either of the two line voltages. The receiver 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.

An option is available to enable operation of the receiver on 50 Hz power (Option 10).

1.7 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.



TO AIM ANTENNA AT FORT COLLINS, COLORADO, DETERMINE COMPASS HEADING FROM THIS MAP.

Draw a straight line from the receiver location through Fort Collins, CO at the center of the map. Continue until the line intersects the outer ring. The point at which the line intersects the outer ring indicates the compass heading for Fort Collins from your location.

FIGURE 1-1 GREAT CIRCLE MAP CENTERED ON FORT COLLINS, COLORADO

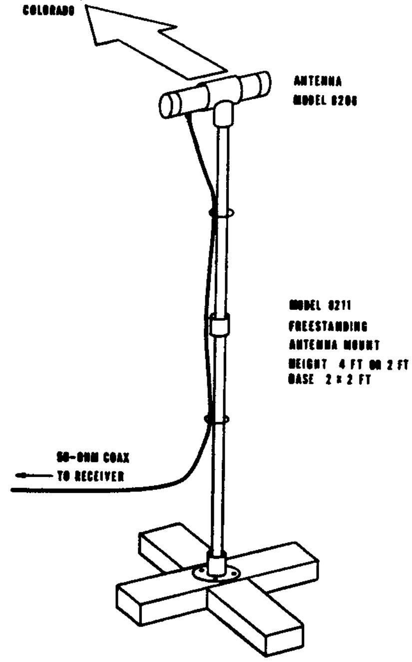


FIGURE 1-2 ANTENNA MOUNT MODEL 8211

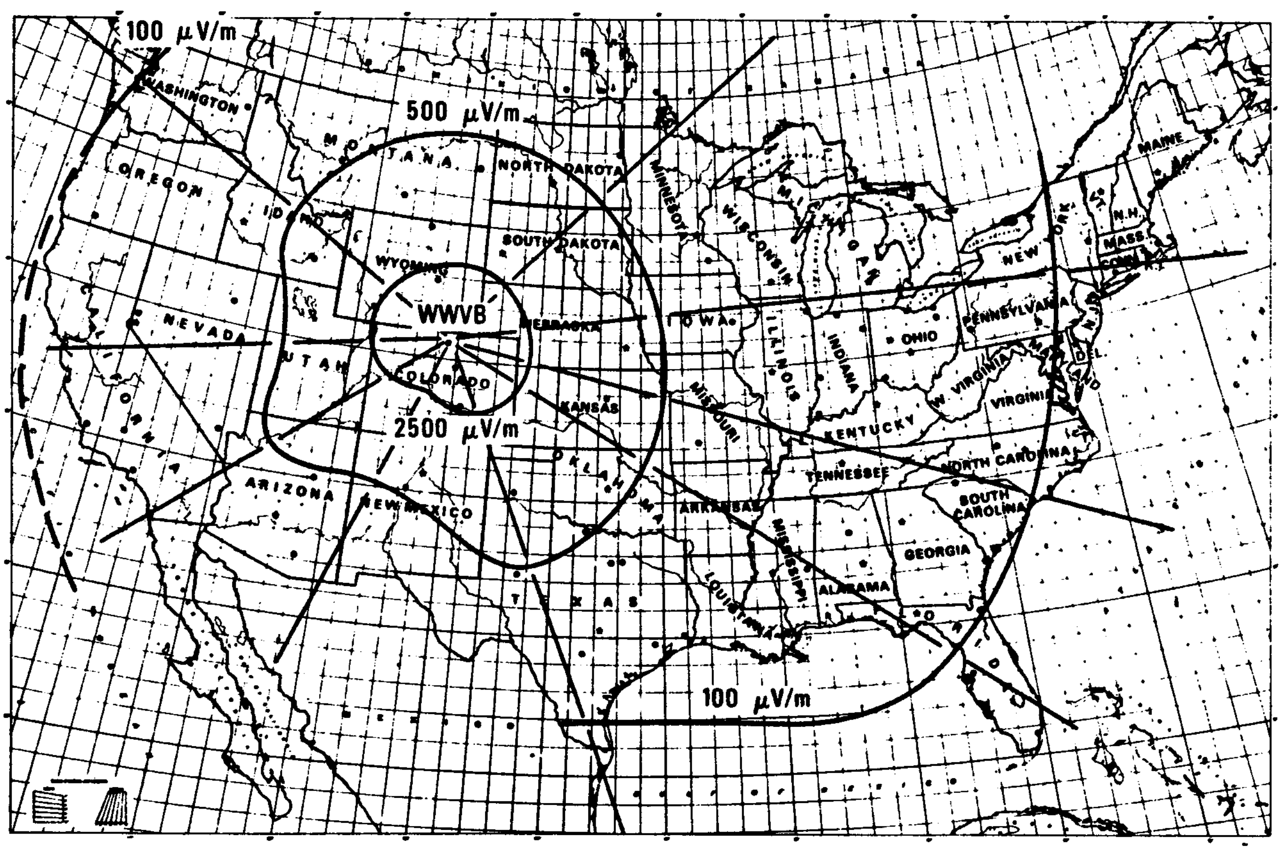


FIGURE 1-3 MEASURED FIELD INTENSITY CONTOURS WWVB @ 13 KW ERP

1.8 BENCH OPERATION

The instrument is provided with four feet for standing on a benchtop surface, along with a tilt stand which may be used to provide a convenient viewing angle.

1.9 RACK MOUNT OPERATION

For rack mount installation, refer to the Options section of this manual.

MODEL 8161

SECTION 2

OPERATION

SECTION 2: OPERATION

2.0 INTRODUCTION

This section describes how to measure standard oscillators of 0.1, 1.0, 5.0 and 10.0 MHz using the National Bureau of Standards WWVB signal. Accuracy of parts in 10^{-9} can be obtained over a measurement time of an hour. Accuracies of parts in 10^{-11} are possible if the measurement time is extended to 8 to 24 hours.

2.1 INITIAL TURN ON

After the receiver and antenna have been installed, plug the receiver into the power line, **MAKING SURE THAT THE REAR PANEL SLIDE SWITCH AND LINE FUSE ARE CORRECT.** The line interrupt light will turn on indicating the power to the ovenized oscillator has been lost. The oscillator will require a warm-up period to restabilize after each power loss. The length of the warm-up period will depend on the length of power loss. To extinguish the line interrupt light, depress the reset button. Turn on the POWER switch and note that the red UNLOCK light is on. Within one minute, the green LOCK light will turn on. If the red UNLOCK light stays lit, indicating insufficient signal is being received, recheck the antenna installation as described in Section 1.

2.2 SIGNAL STRENGTH

The Spectracom receiver may be used to measure relative field strength of the 60 kHz signal. This measurement may be used to optimize reception by indicating the best location and orientation of the antenna.

The WWVB receiver employs synchronous AGC which responds to the 60 kHz signal only and is not affected by noise. The AGC level, therefore, provides an excellent indication of the signal strength.

To measure this AGC voltage, open the cover of the receiver and locate test points TP3 and TP6 on the Receiver Board, A2. Place the positive lead of a DC voltmeter on TP6 (blue) and the negative lead on TP3 (orange). Refer to the A2 Receiver Board Assembly Drawing in Section 4.

The voltage will be approximately 2.0 VDC at a field strength of 100 microvolts/meter using a properly oriented model 8206 antenna. The AGC voltage will increase in strong signal locations, rising to a limiting value of approximately +3.6 volts as the signal input increases.

As the signal strength decreases to the receiver phase lock threshold of about 0.2 microvolts, the AGC voltage decreases to about +1.0 VDC. The red "UNLOCK" panel lamp will light below this level. The AGC voltage will decrease to a varying level around zero if the input signal is removed completely. As the signal is reapplied and increased, the receiver will again lock at an AGC level of approximately 1.0 volt.

The relative signal strength measurement may be used to aid antenna orientation by placing the antenna so as to maximize the AGC voltage measurement. The circuit that develops the AGC voltage has a very long time constant, so that a pause of 30 to 60 seconds is necessary after each move of the antenna to allow the AGC to stabilize at the new level. A few minutes of experimentation should produce good antenna orientation.

2.3 NBS OUTPUT

The frequency of the NBS output signal is selected by depressing one of the FREQUENCY-MHz switches located on the front panel. The output frequency obtained by pressing a button is phase locked to the WWVB 60-kHz carrier. This output frequency can be used as a standard for checking the accuracy of frequency counters, or used as a standard frequency signal. Note that noise will be present in the form of pulse jitter due to atmospheric noise at the receiver antenna. The counting error caused by this noise is usually not more than a few parts in 10^7 in a one-second averaging period. Longer averaging periods will decrease the effect of the jitter. The long term accuracy of this signal is as good as that of the WWVB carrier signal to which it is phase locked.

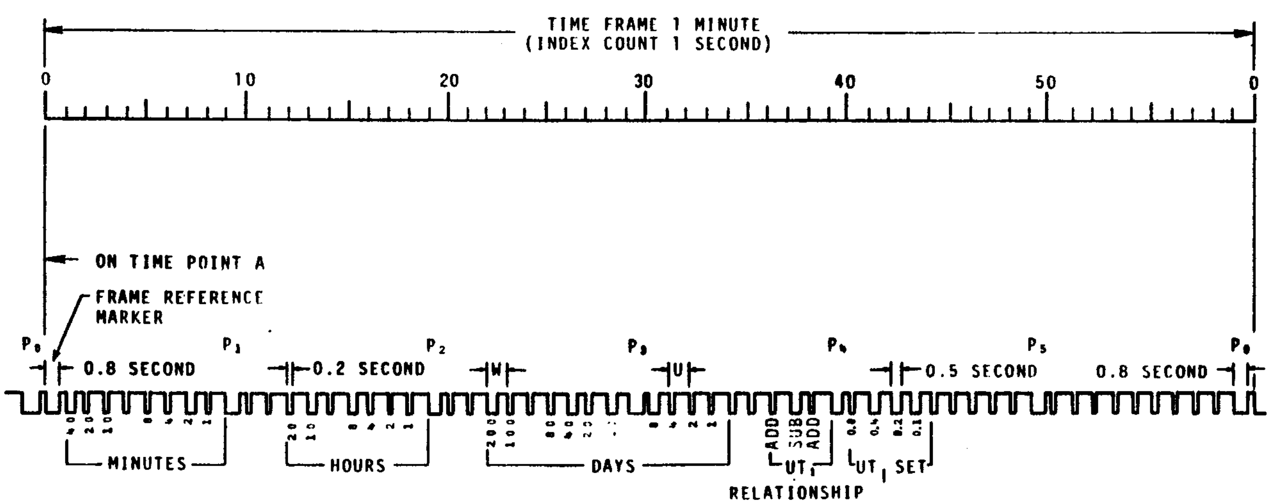
The length of coaxial cable used to feed the signal to the load is critical because the output is a TTL square wave. A 93-ohm terminated cable should be used for long runs where waveform must be preserved.

2.4 TIME CODE OUTPUTS

Time code modulation is provided on the WWVB carrier for use in synchronizing accurate clocks and other time-keeping equipment. The modulation consists of once-per-second pulsed amplitude reductions of 10 dB, lasting either 200, 500, or 800 milliseconds. Decoding a one-minute data stream yields date, time of day, and a correction factor for converting from atomic time (Coordinated Universal Time or UTC) to celestial time (UT1). (See Figure 2-1,"WWVB Time Code Format".)

Atmospheric noise levels at 60 kHz are frequently very bad, and will sometimes cause false pulses to appear on the demodulated time code output. The noise levels are extremely variable, depending on factors such as season, time of day and geographical location. Noise is lower in the northern latitudes during winter daytime hours, and higher at night during the summer in southern latitudes. In U.S. coastal areas, where the WWVB signal strength is nominally 100 micro-volts per meter, the signal-to-noise ratio may be as bad as -23 dB in a 1-kHz bandwidth. The Spectracom receiver, due to its unique synchronous detector with extremely narrow bandwidth will stay phase locked to the WWVB carrier with signal-to-noise ratios as poor as -35 dB. Time code errors will occur on bad days. Error detection techniques such as those used in Spectracom's Model 8171 Synchronized Clock are necessary if the output data is to be useful.

The 10 dB reduction of the WWVB carrier is inverted in the demodulation process and appears at the output as a positive-going TTL-compatible pulse with a fan-out of 2. The signal is available at pin 7 of the AUX IN/OUT connector (J6) on the rear panel, (see Section 2.11 REAR PANEL FUNCTIONS), and may be used to synchronize the Model 8171 Synchronized Clock.



BINARY CODED DECIMAL TIME-OF-YEAR CODE WORD (23 DIGITS)
CONTROL FUNCTIONS (15 DIGITS) USED FOR UT_1 CORRECTIONS
6 PPM POSITION IDENTIFIER MARKERS AND PULSES (P_0 THRU P_5)
(REDUCED CARRIER 0.8 SECOND DURATION PLUS 0.2 SECOND DURATION PULSE)
W - WEIGHTED CODE DIGIT (CARRIER RESTORED IN 0.5 SECOND - BINARY ONE)
U - UNWEIGHTED CODE DIGIT (CARRIER RESTORED IN 0.2 SECOND - BINARY ZERO)

UTC AT POINT A	UT1 AT POINT A
258 DAYS	258 DAYS
18 HOURS	18 HOURS
42 MINUTES	41 MINUTES
	59.3 SECONDS

NOTE: BEGINNING OF PULSE IS REPRESENTED BY NEGATIVE - GOING EDGE.

FIGURE 2-1 WWVB TIME CODE FORMAT

2.5 MEASURING FREQUENCY

Connect the local signal that you wish to calibrate to the LOCAL INPUT connector. Move the Comparator toggle switch to the left hand position. This allows the local input to be compared against the NBS reference.

Changes in the phase relationship between the local input signal and the NBS reference signal show up as meter movement. If the meter is perfectly constant, there is zero drift in the phase relationship and the local signal is exactly on frequency. The rate at which the meter moves measures the frequency error.

$$\text{FREQUENCY ERROR} = \frac{\text{PHASE SHIFT}}{\text{TIME}}$$

For example, if it takes 50 seconds for the meter to deflect full scale (50 microseconds), then the frequency error of the local signal is:

$$\text{FREQUENCY ERROR} = \frac{50 \times 10^{-6} \text{ sec}}{50 \text{ secs}}$$

$$= 1 \times 10^{-6}$$

If the meter deflects left to right, then the local input frequency is higher than the NBS reference. If the local input is lower than the reference, then the meter will deflect from right to left.

The scale may be changed from 50 microseconds full scale to 10 microseconds full scale by depressing the RECORDER EXP switch. Normally the switch is left in the 50 microsecond full scale position (not depressed).

Adjust your local oscillator so the meter is not moving. The longer the phase drift is monitored, the greater the precision of calibration. The chart recorder should be used for observations over periods of hours or days.

When the local frequency is in error by a large amount, the phase reading may change too rapidly for the meter to follow. In this case, first use a counter to adjust your local oscillator so the frequency is within 1×10^{-6} of the NBS reference.

2.6 WWVB IDENTIFICATION

WWVB identifies itself by advancing its carrier phase 45° at 10 minutes after every hour and returning the normal phase at 15 minutes after the hour. These phase changes will show up as meter deflection of 2.1 microseconds.

2.7 STRIP CHART RECORDINGS

The following examples are typical strip chart recordings showing oscillator drift, diurnal shift, noisy day, and sun flares. All strip chart recordings were made at 20 mm/hr paper speed and 50 microseconds full scale.

Figure 2-2 TRACE 1 shows a downward drifting test oscillator.

Figure 2-3 TRACE 2 shows overnight signal degradation.

Figure 2-4 TRACE 3 shows a typical 24 hour trace, diurnal shift, and some signal degradation during the night. Note the 2-microsecond phase shift that identifies the signal received from WWVB.

Figure 2-5 TRACE 4 is an example of a momentary unlock condition.

Figure 2-6 TRACE 5 is a trace made on a noisy day.

Figure 2-7 TRACE 6 was made on a day with frequent sun flares.

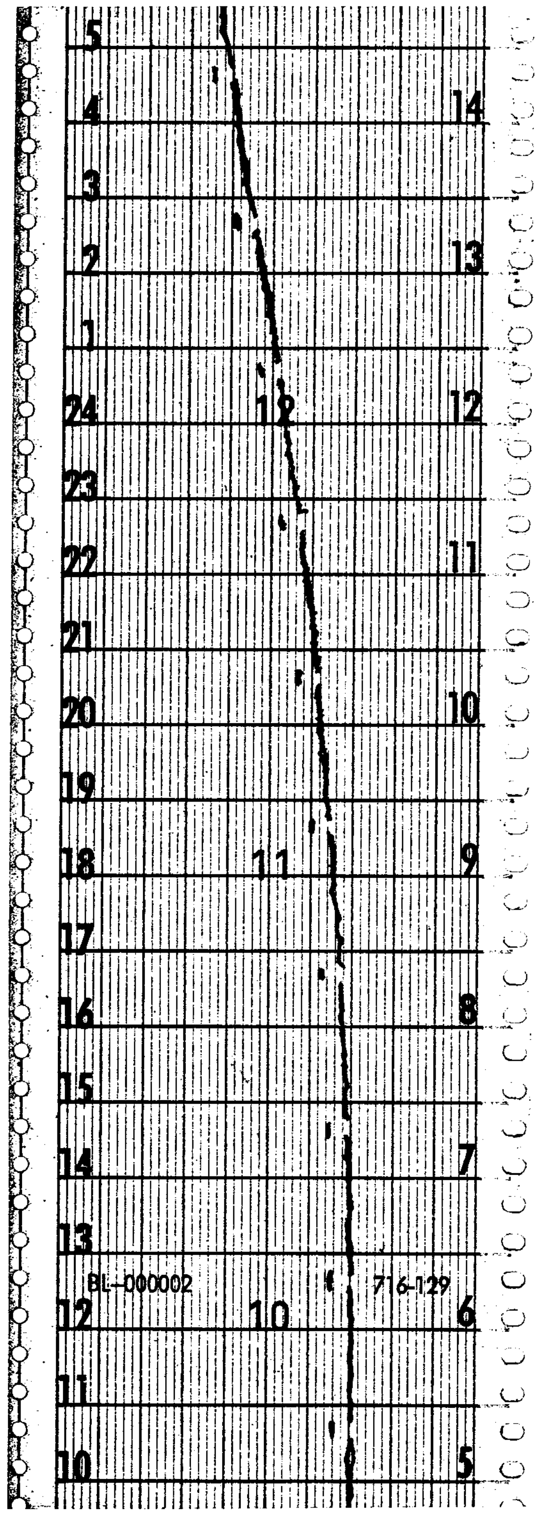


FIGURE 2-2 TRACE 1 The trace shows an oscillator which drifted low in frequency by almost 1 x 10^{-9} in a 9-hour period.

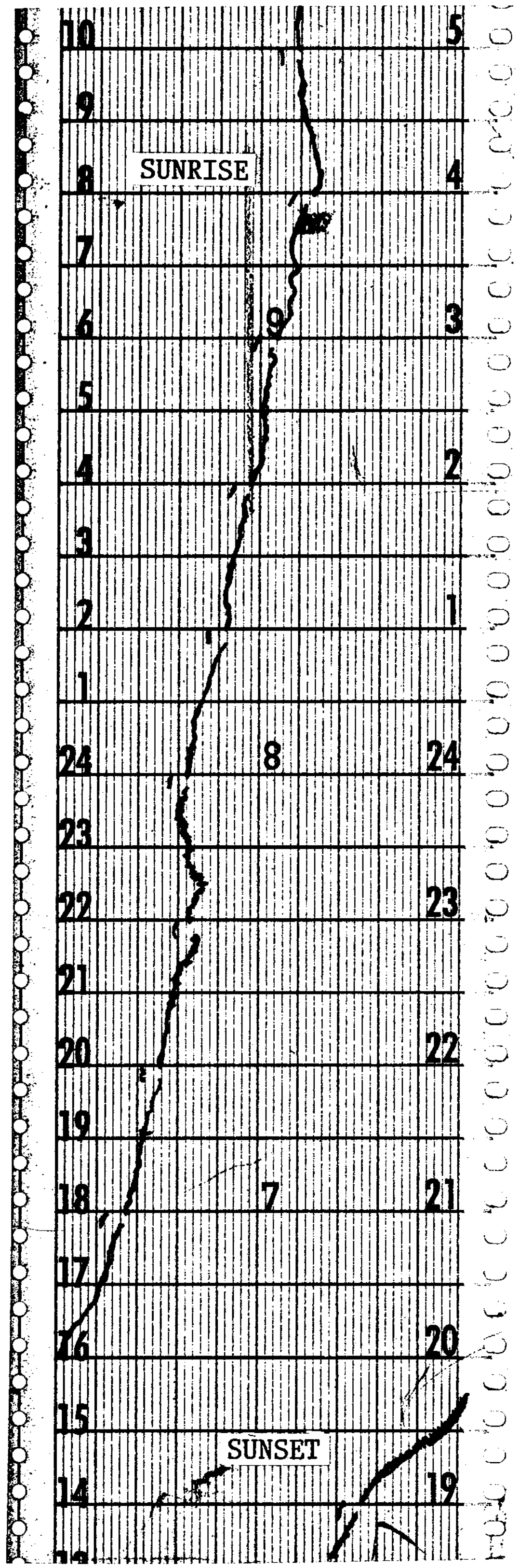


FIGURE 2-3 **TRACE 2** The trace shows overnight signal degradation between sunset and sunrise. This effect will vary considerable with geograpic location and with time of year, as well as with daily propagation variations.

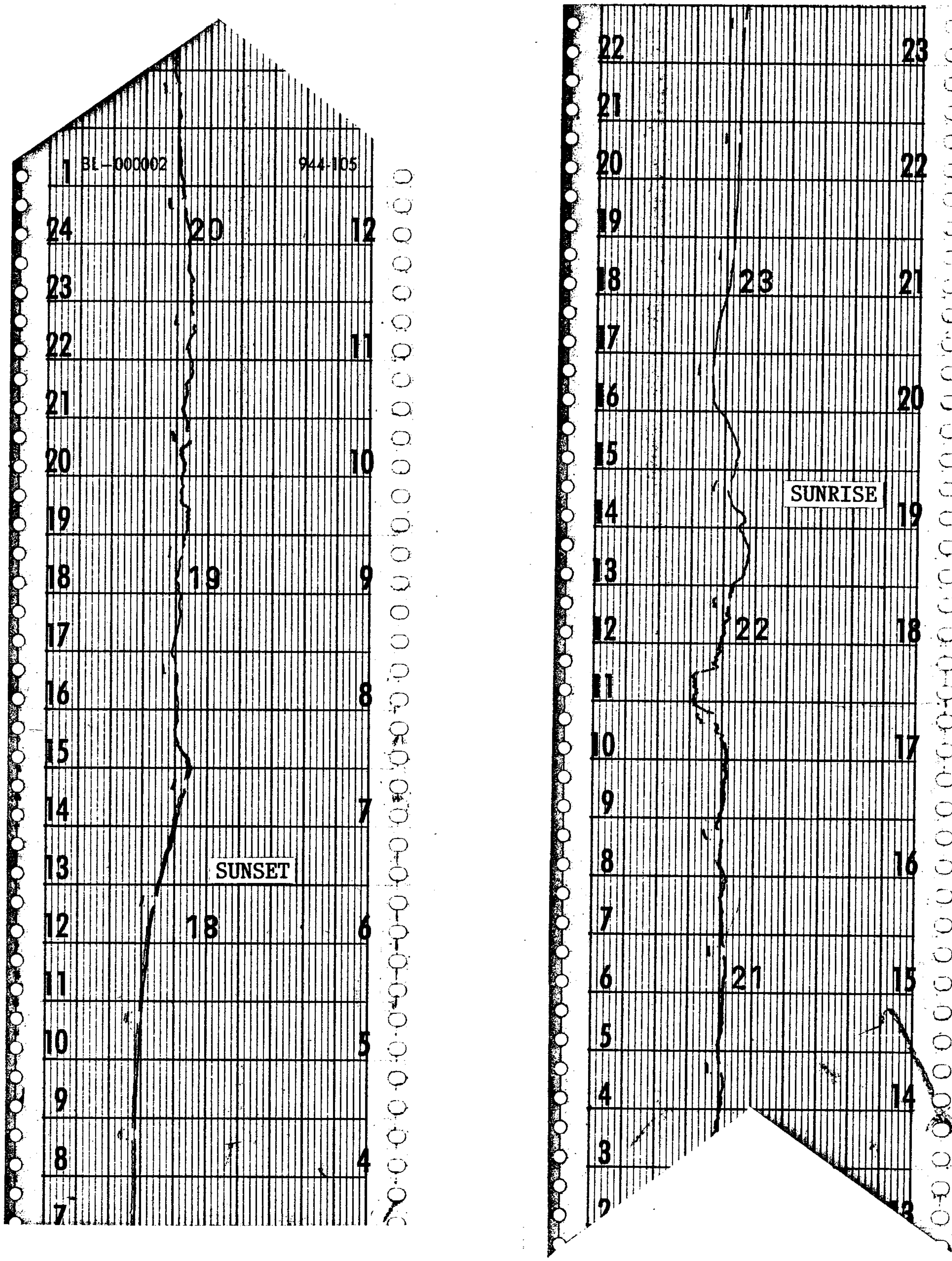


FIGURE 2-4 TRACE 3 is a typical 24-hour trace showing the diurnal shift and some signal degradation during the night. After sunrise, the trace shows oscillator error to be only a few parts in 10^{-11}.

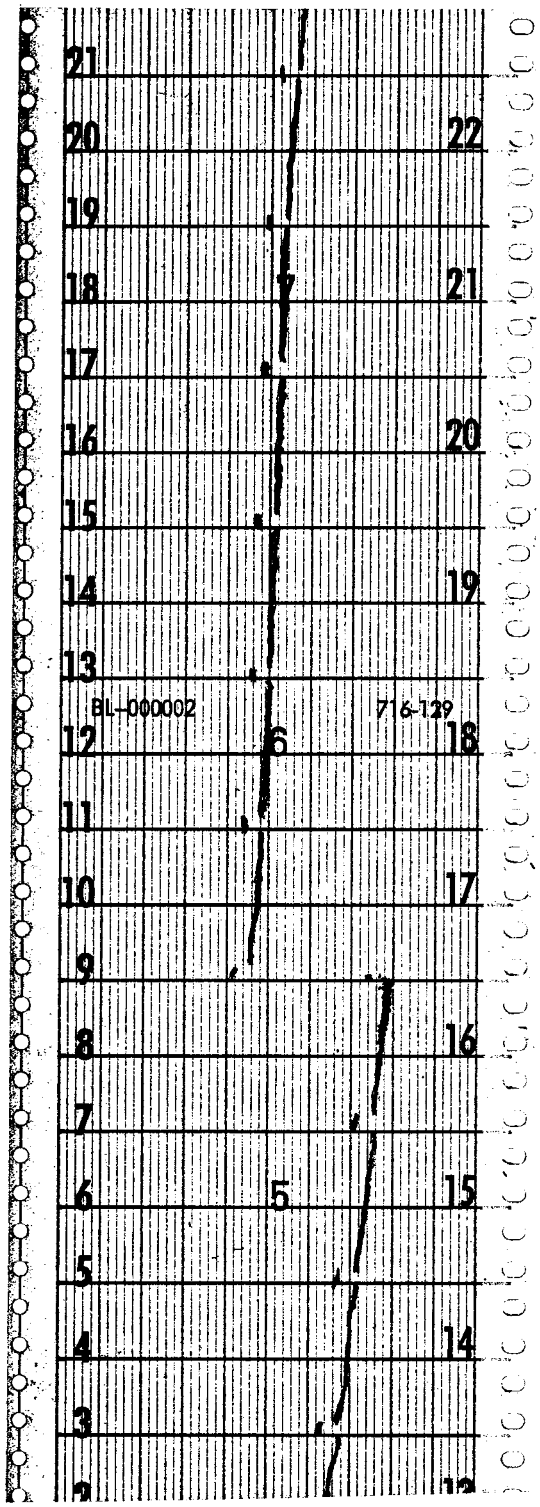


FIGURE 2-5 **TRACE 4** The trace shows a momentary unlock condition due to noise bursts or signal fading. When receiver phase lock is re-established, the trace starts at a new position on the scale.

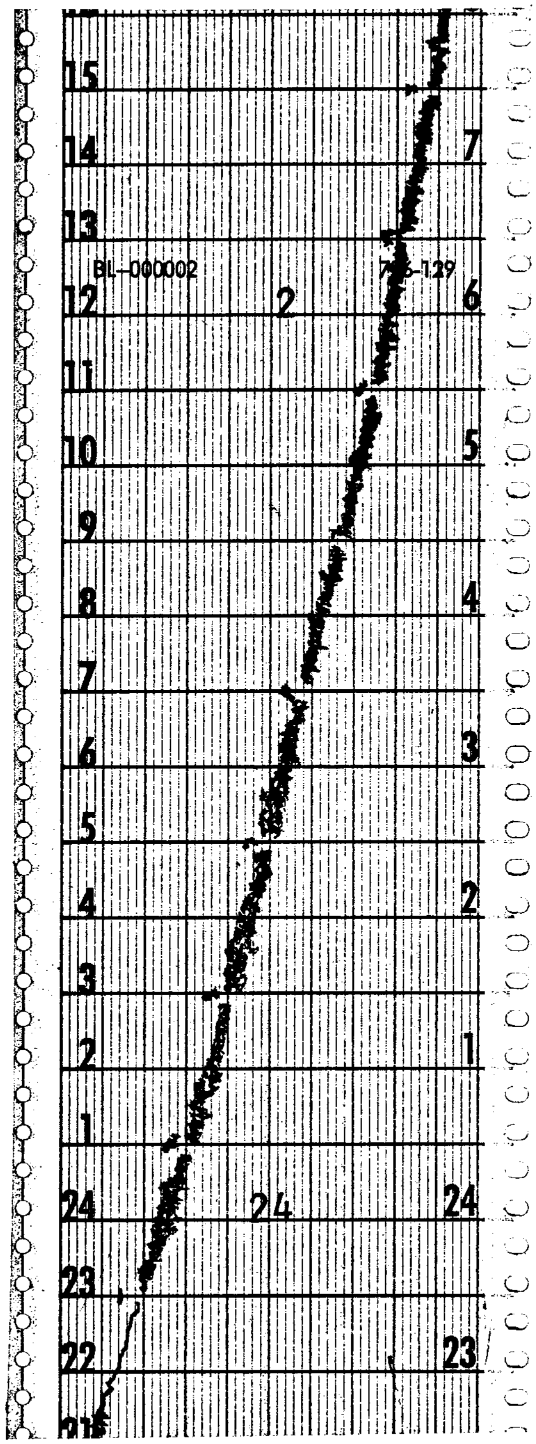


FIGURE 2-6 TRACE 5 The trace was made on a very noisy day, causing a trace width of about four microseconds. This problem is encountered less frequently with improved antenna placement.

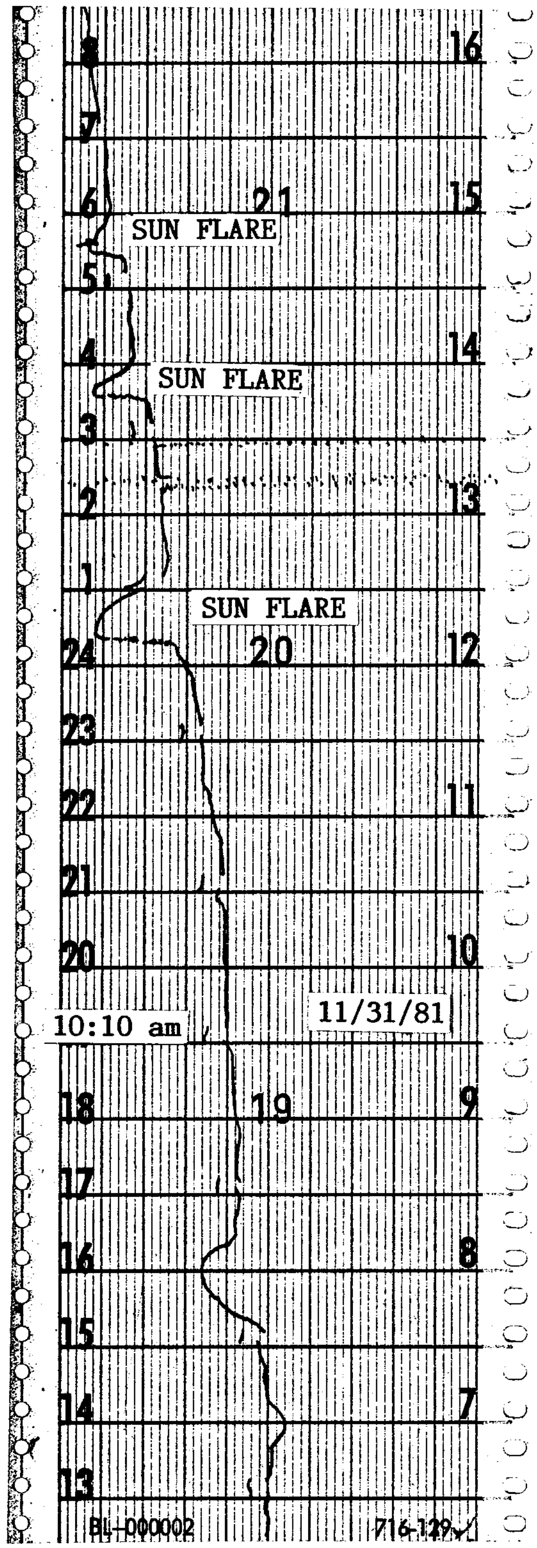


FIGURE 2-7 **TRACE 6** was made on a day with frequent sun flares.

2.8 FREQUENCY ERROR CALCULATION

Frequency error is measured by observing the speed with which the meter deflects as it slowly travels across the scale; that is, by noting the slope of the recorder trace on the paper. The following is an example (see Figure 2-8).

The recorder trace moves from left to right, a total distance of 9 microseconds during a one hour period. The scale setting is 50 microseconds and the hours are marked along the length of the chart paper. The calculation is made by dividing the phase movement, expressed in seconds, by the time during which the movement occurred, also expressed in seconds:

$$\frac{\text{Phase Movement (seconds)}}{\text{Time for Movement to Occur (seconds)}} = \frac{11 \times 10^{-6}}{3600} = +3.1 \times 10^{-9}$$

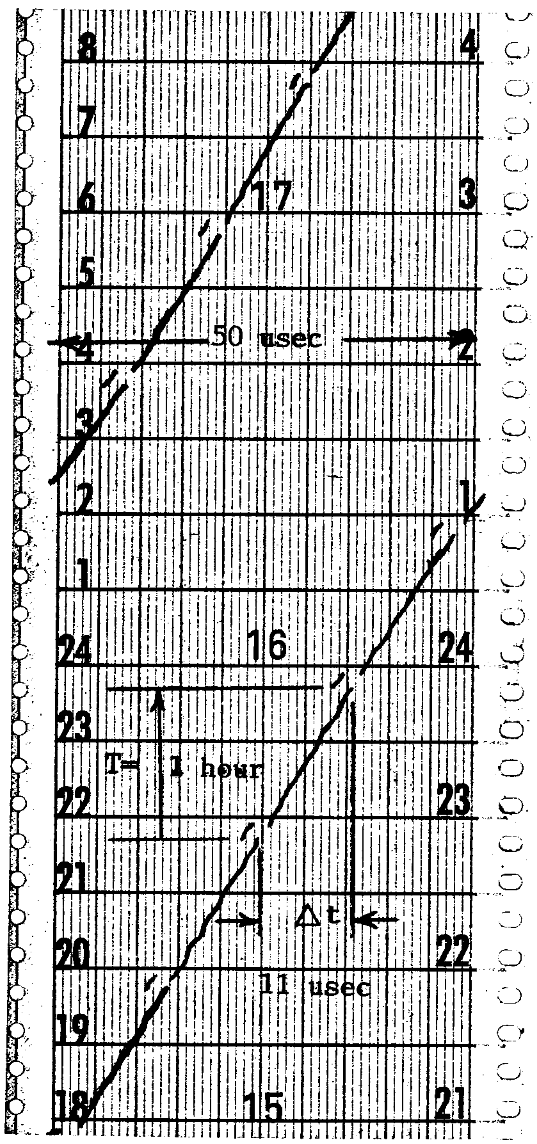


Figure 2-8 is an example of a frequency error calculation is made for the trace shown here. Oscillator error is positive (frequency is high) because the trace slopes to the right.

$$\text{Frequency Error} = \frac{\Delta t}{T} = \frac{11 \times 10^{-6}\ \text{sec}}{3600\ \text{sec}}$$

$$= +3 \times 10^{-9}$$

This calculation may be made mentally to close approximation by noting the phase drift in microseconds (Δ t) that occurs in one hour. Divide this by 3.6, yielding frequency error expressed as parts in 10^9.

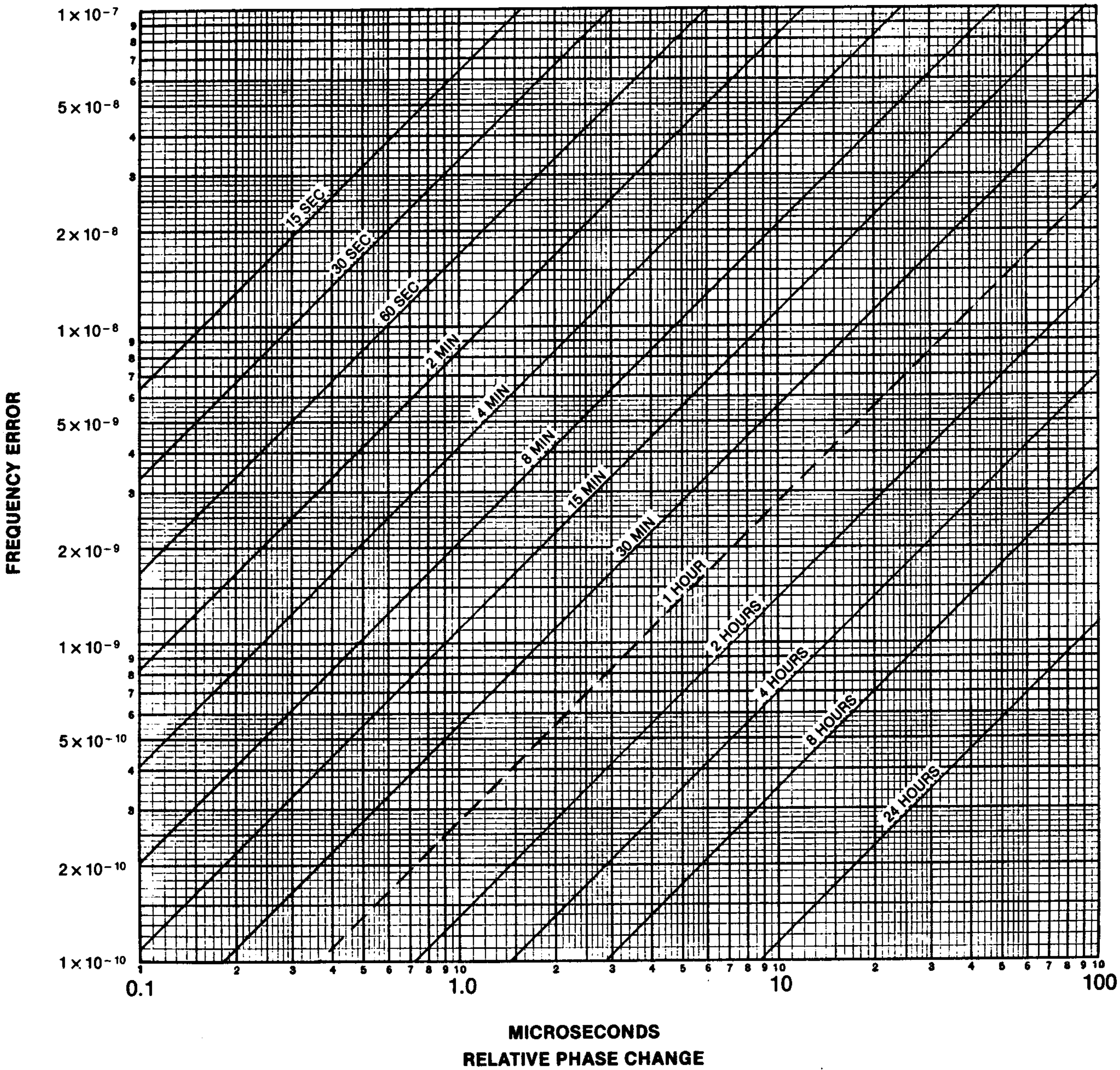


FIGURE 2-9 ERROR CALCULATION CHART

In this example, the local frequency is high by about 3.1 parts in 10^{-9} or .0031 parts per million.

As a general rule of thumb, an 8 hour working day is adequate time to resolve one part in 10^{-11}, using the expanded scale settings, and two or three full days are needed to approach one part in 10^{-12}, the accuracy limit of WWVB. However, signal-to-noise ratio must be very favorable to achieve this resolution. Figure 2-9, "Error Calculation Chart", can be used to find frequency error as a function of phase change and time.

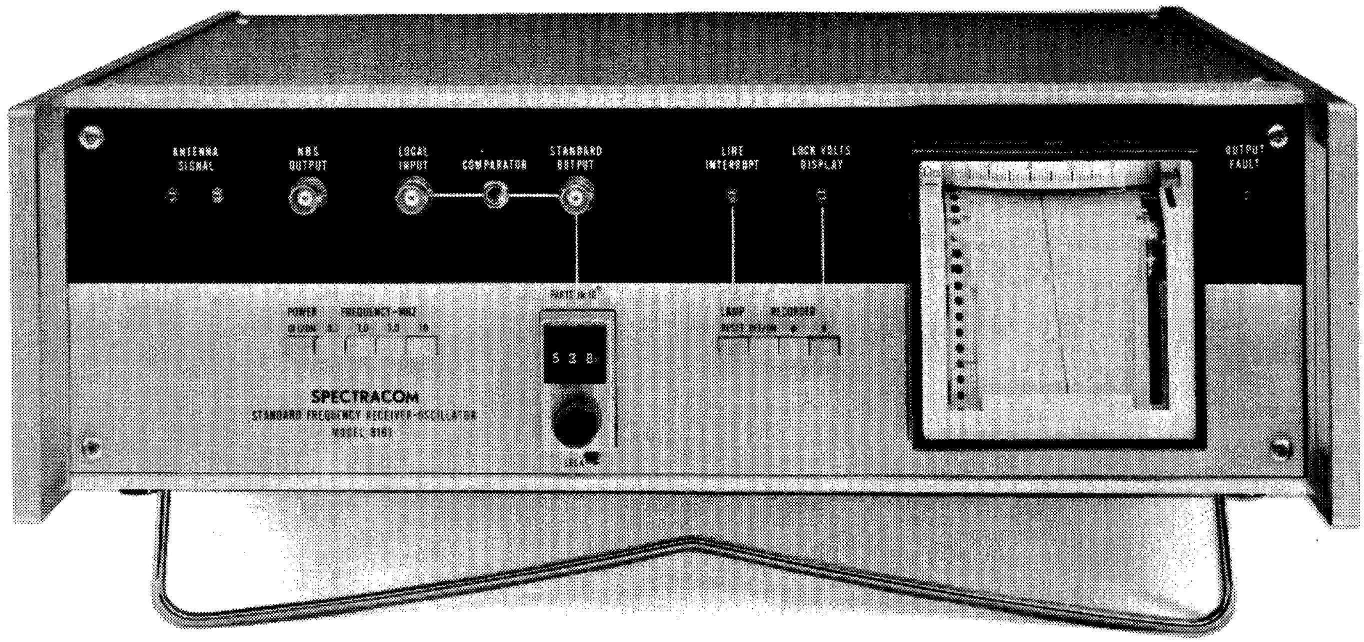


FIGURE 2-10 8161 FRONT PANEL

2.9 FRONT PANEL FUNCTIONS

Use Figure 2.10, 8161 Front Panel, to locate the following:

Power Switch:

Depressing the pushbutton applies power to the receiver. 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 four pushbuttons select the frequency of operation associated with the three BNC connectors on the front panel (the connector functions are described below). These switches do not affect the rear panel outputs.

Unlock/Lock Lamps:

The red lamp is lit when there is insufficient signal received for the receiver to lock to the WWVB carrier. This is usually due to improper placement or aiming of the antenna. The green lamp lights when the receiver acquires phase lock.

NBS Output Connector:

The BNC connector provides an output signal that is phase locked to the Bureau of Standards signal whenever the green phase lock lamp is lit. The output frequency is selected by means of the Frequency-MHz Switches described previously.

Refer to the section entitled "NBS Output" on page 2-3 for a more complete discussion of the NBS output.

Local Input Connector:

The BNC connector is the input jack for local frequency standard oscillators to be calibrated or tracked against WWVB. The input frequency must be the same as that chosen by the Frequency-MHz Switch.

Comparator Switch:

The toggle switch selects the comparator input to be monitored and read out on the strip chart recorder. In the left position, the recorder monitors the phase relationship between the local input frequency and WWVB. In the right position, the internal frequency standard phase relationship is tracked by the recorder.

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 10^9):

A 10-turn dial is used to correct for aging of the internal frequency standard. It is calibrated approximately in parts in 10^9 for ease in making corrections. A lock lever is included to prevent the dial from being accidently moved.

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 is necessary.

Lamp Reset Switch:

The momentary contact pushbutton extinguishes the Line Interrupt Lamp.

Lock Volts Display Lamp:

The red lamp warns the operator that the strip chart recorder is displaying VCO lock voltage instead of phase comparison.

Recorder Off/On Switch:

Depressing the pushbutton starts the chart recorder. The chart drive is disabled and impressions are not made on the chart paper when the button is not depressed. The meter movement in the recorder continues to function normally if the recorder is not turned off with the striker bar holding the meter needle against the paper.

Recorder Ø Switch:

Depressing the pushbutton expands the meter/recorder scale to read 10 microseconds full scale. When the button is not depressed, the full scale reading is 50 microseconds.

Recorder V Switch:

Depressing the pushbutton causes the strip chart recorder to display VCO lock voltage (see Lock Volts Display Lamp). When the button is not depressed, the recorder displays phase comparison.

Strip Chart Recorder:

The normal readout is phase comparison in microseconds of relative time. The recorder may be switched to read VCO lock voltage for diagnostic purposes. The integral meter scale at the top of the display provides a real time readout, while the strip chart records continuously with impressions every three seconds. Paper roll replacement and speed changes may be made from the front panel by removing the front cover.

Output Fault Lamp:

The red lamp lights whenever the rear panel outputs vanish due to external short-circuits, internal failure, or improperly terminated distribution lines on units with Option 03, Built-in Distribution Amplifier.

Mating Connectors:

All front panel connectors are BNC connectors.

Designation	Spectracom P/N	MFR P/N	MFR
BNC, Female	P00002	KC51-01	Kings

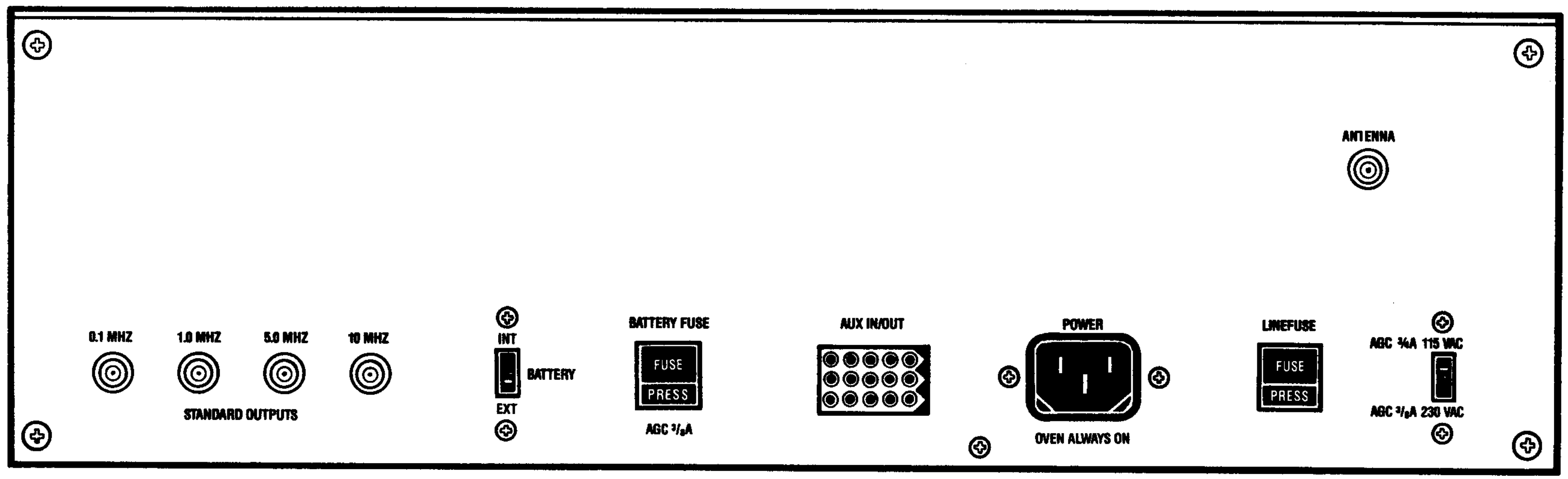


FIGURE 2-11 8161 REAR PANEL

2.10 REAR PANEL FUNCTIONS

Use Figure 2-11, 8161 Rear Panel, to locate the following:

Standard Outputs:

Separate BNC outputs at 0.1, 1.0, 5.0, and 10.0 MHz are provided. The signal is 500 mv RMS sine wave when driving a 50-ohm load. The harmonic suppression is 30 dB. When used without termination, the output is TTL-compatible.

Distribution Amplifier - Option 03:

If the four standard output connectors at the lower left of the rear panel are labeled A, B, C, D, then Option 03 is installed. The outputs are the standard 10-MHz riding on 12 VDC. They must be terminated by a 50-ohm DC isolated load (P/N 004490) and will drive a maximum of 25 Spectracom Line Taps, Model 8140T. Line Taps are available with outputs of 0.1, 0.5, 1.0, 5.0 or 10.0 MHz.

Refer to the Option section of the manual for a more complete discussion of the Distribution Amplifier, Option 03.

Battery INT/EXT Switch:

This switch, when in the EXT position, connects an external battery via the AUX connector to the 10-MHz Standard Oscillator (See Pin 3 AUX IN/OUT for battery recommendations.)

When in the INT position and Option 02 Standby Power Supply is installed, the internal battery is connected to the 10-MHz Standard Oscillator.

CAUTION: IF OPTION 02 IS INSTALLED, PLACE THE SWITCH IN THE EXT POSITION BEFORE SHIPPING AND WHEN POWER WILL BE REMOVED FOR MORE THAN 36 HOURS.

AUX IN/OUT (J6):

Auxillary and remote functions of the receiver are available at this 15-pin connector. Use Figure 2-12, AUX IN/OUT J6 a view from the rear of the unit, to locate the pins.

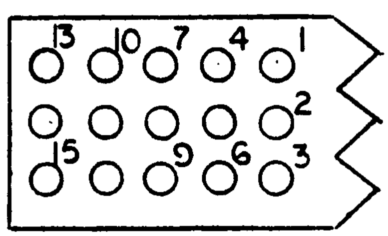


FIGURE 2-12 AUX IN/OUT J6, REAR VIEW

PIN 1 PHASE COMPARATOR OUTPUT (+). For driving any external meter or strip chart recorder with a 0-1 ma meter movement, 1500 OHM impedance maximum.

PIN 2 PHASE COMPARATOR OUTPUT (GND)

PIN 3 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 A-H or greater capacity. (Omitted with Option 16.)

PIN 4 TIME CODE OUTPUT (GND).

PIN 5 PHASE LOCK OUTPUT (+). Allows remote monitoring of receiver phase lock condition. Ground when unlocked, +5 VDC behind 3.3K ohms when locked.

PIN 6 EXTERNAL BATTERY INPUT (GND) (Omitted with Option 16)

PIN 7 TIME CODE OUTPUT (+). Logic high is +5 VDC behind 3.3K ohms, low is ground.

PIN 8 60 Hz PHASE LOCKED OUTPUT (+). Option 15 only. TTL compatible (fan out, 2 max.) 3.4V rectangular positive pulses into 93 ohms min. resistive load.

PIN 9 60 Hz PHASE LOCKED OUTPUT (GND). Option 15 only.

PIN 10 1.0 Hz PHASE LOCKED OUTPUT (+). Option 15 only. TTL compatible (fan out, 2 max) 3.4 V rectangular positive pulses into 93 ohms min. resistive load.

PIN 11 1.0 Hz PHASE LOCKED OUTPUT (GND). Option 15 only.

PIN 12 1-kHz PHASE LOCKED OUTPUT (+). Option 28 only. TTL compatible (fan out 2 max.) 3.4V. Rectangular pulse that will drive a 93 ohm minimum resistive load.

PIN 13 10 MHz PHASE LOCKED OUTPUT (+). TTL compatible (fan out, 2 max.) 3.4V rectangular positive pulses into 93 ohms min. resistive load. This signal is phase locked to WWVB and will have some short-time jitter.

PIN 14 10 MHz PHASE LOCKED OUTPUT (GND).

PIN 15 1-kHz PHASE LOCK OUTPUT (GND). Option 28 only.

Power:

This is the input connector from the power source.

Line Fuse:

This is the main power fuse for the unit. When operating this unit at 115 VAC use a 3/4 Amp fuse. If the unit is to be operated at 230 VAC use a 3/8 Amp fuse.

115 VAC/230 VAC Switch:

TO PREVENT DAMAGE TO THE UNIT, VERIFY THAT THIS SWITCH IS SET TO THE CORRECT INPUT VOLTAGE AND THAT THE CORRECT FUSE IS INSERTED IN THE FUSE HOLDER.

Antenna:

This BNC connector is the antenna input to the receiver. The antenna also receives DC power from this connector.

Mating Connectors

The mating connectors for the rear panel functions are listed below:

Reference	Description	Spectracom P/N	MFR P/N	MFR
Std. Outputs, Antenna	BNC, Female	P00002	KC51-01	Kings
Aux in/out	Plug, 15 position	P01115	03-09-2151	MOLEX
	Socket pins	P01100	02-09-2118	MOLEX

The crimping tool for the pins is MOLEX 11-01-0002. The extractor tool is MOLEX 11-03-0006. There is no insertion tool required.

MODEL 8161

SECTION 3

SPECIFICATIONS

SECTION 3: SPECIFICATIONS

3.0 INTRODUCTION

This section contains the detailed electrical and mechanical specifications for the unit.

3.1 RECEIVER/COMPARATOR

Received Standard Frequency:
60 kHz, NBS Station WWVB

Sensitivity:
0.5 uV rms into 50 ohms. Minimum field strength at antenna, 30 uv per meter when used with Model 8206 antenna.

Phase Locked Output:
0.1, 1.0, 5.0, or 10.0 MHz, front panel selectable, TTL compatible (fan out 2 max.) 3.4 v rectangular pulses into 93 ohms minimum resistive load, phase locked to the WWVB carrier.

Local Comparator Input:
0.1, 1.0, 5.0, or 10.0 MHz, front panel selectable, 100 mv rms minimum into 1000 ohms.

Time Code Output

Code:
BCD yielding date, time of day, and a correction factor for converting from atomic time to celestial time.

Signal-to-Noise Ratio:
- 35 dB worst case to remain phase locked to the carrier.

Timing Pulse Outputs - Option 15

Frequency:
60 Hz and 1.0 Hz phase locked to WWVB. Pulse Characteristics: 3.4 volt rectangular pulses which are TTL compatible.

Load:
Terminated line with 93-ohm minimum impedance. Timing Accuracy: 1×10^{-11} long term, 1×10^{-7} short term 1-second averaging time.

1 kHz Output - Option 28

Frequency:
1 kHz phase locked to WWVB.

Pulse Characteristics:
3.4 volt symmetrical rectangular pulse which is TTL compatible.

Load:
Terminated line with 93 ohm minimum impedance.

Accuracy:
The 1 KHz output is derived from the internal frequency standard oscillator. Frequency accuracy may be obtained directly from the strip chart recorder. Refer to Section 2.8, "Frequency Error Calculation", to determine the standard oscillator accuracy. For stability specifications, see below.

3.2 FREQUENCY STANDARD OUTPUTS

Front Panel:
0.1, 1.0, 5.0, or 10.0 MHz, front panel selectable, TTL compatible (fan out, 2 max.) 3.4 v rectangular positive pulses, 93 ohms minimum resistive load.

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.

If Option 03 is added, all four rear panel outputs provide 10 MHz sine wave riding on +12V DC. They must be terminated by a 50 ohm DC isolated load and will drive a maximum of 25 Line Taps. In both versions, Output Fault lamp shows absence of signal at any output connector.

Frequency Standard Stability

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

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

Temperature:
$\pm 5 \times 10^{-10}$ per °C maximum, 0-50°C.

Load:
$\pm 1.0 \times 10^{-11}$ for any load change.

Supply Voltage:
$\pm 2.5 \times 10^{-10}$ maximum for ±10% voltage change.

Warm-up at 25°C:

Within 2×10^7 of the final frequency in 15 minutes, 2×10^{-8} in 20 minutes, 2×10^{-9} in 30 minutes.

Retrace:

Typically within 2×10^{-8} one hour after 48-hour loss of oven power, 1×10^{-8} hour after a 12-hour loss of oven power.

Frequency Adjustments

Fine:

Front panel control with $\pm 5 \times 10^{-7}$ range and $\pm 2 \times 10^{-10}$ resolution. Typically compensates for 2 years of aging.

Coarse:

Internal adjustment with $\pm 2.5 \times 10^{-6}$ minimum range.

3.3 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:

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.

3.4 STRIP CHART RECORDER

Readout:

Displays comparison of local input signal or internal frequency standard with WWVB. May be switched to monitor receiver phase lock voltage. Readings are permanently recorded on chart paper. Real-time readout on edgewise meter with 2 1/2 inch scale at the top of the panel display.

Chart Speeds:

Chart recorder speed as shipped from the factory is 20 mm per hour. The speed may be changed to 10 or 60 mm per hour by substituting cams supplied with the Simpson manual. Refer to the Simpson Operators Manual for instructions on chart speed changing and paper replacement.

Phase Comparison Scale:

Selectable 0-50 or 0-10 usec full scale relative time.

Paper:

50 ft. reel, 2.3 inches wide, pressure sensitive, rectilinear scales. One roll lasts for 1 month of continuous use. The time scale and hour markers are printed on the chart paper.

Control:

Front panel off/on switch.

3.5 MECHANICAL & INSTALLATION

Size:

5.25 H x 13.5 D x 17 W (inches) Height is 6 inches including feet. 133 H x 343 D x 432 W (mm) Height is 152 mm including feet.

Handles protrude 1.75 inches (45 mm) from the front panel. Allow 2-3 inches for cable clearance at the rear.

Weight:

21 lbs. (9.53 Kg); Shipping wt. 25 lbs. (11.35 Kg)

Line Power:

115/230 VAC ±10%, 60 Hz, 60 VA, 50 Hz available as Option 10.

Operating Temperatures:

0 to 50°C

3.6 MODEL 8206 LOOP ANTENNA

Operation:

High gain directional ferrite loop in tubular housing 14 1/2 L x 1 1/4 dia. (inches), 368 L x 70 dia. (mm). Built-in preamplifier receives DC power over the coaxial center conductor from the receiver. Equivalent electrical height is 5.0 cm.

3.7 MODEL 8207 PREAMPLIFIER

Sensitivity:

3.0 nanovolts

Gain:

40 dB

Power:

DC power derived over the coaxial center conductor from the receiver.

MODEL 8161

SECTION 4

THEORY OF OPERATION

SECTION 4: THEORY OF OPERATION

4.0 INTRODUCTION

The receiver consists of an RF Amplifier Assembly (A1), a Receiver Assembly (A2), an Oscillator and Power Supply Assembly (A5), and an Output Amplifier Assembly (A4) as shown in the block diagram, Figure 4-1.

The 60 kHz output of the RF Amplifier Assembly is fed to the Receiver Assembly where the carrier is detected and translated to a phase locked 10 MHz. The AGC voltage is generated in the Receiver Assembly for use in controlling the gain of the RF Amplifier during phase lock conditions.

The output of the 10 MHz frequency standard, located in the Oscillator and Power Supply Assembly, is fed to the Output Amplifier Assembly for distribution and is also divided down to 100 kHz for phase comparison with the WWVB-derived signal found in the Receiver Assembly.

Refer to Figures 4-2 and 4-3, "Mainframe Schematic", for wiring diagrams. Figure 4-5, "Assembly Drawing Mainframe", shows board and major component locations.

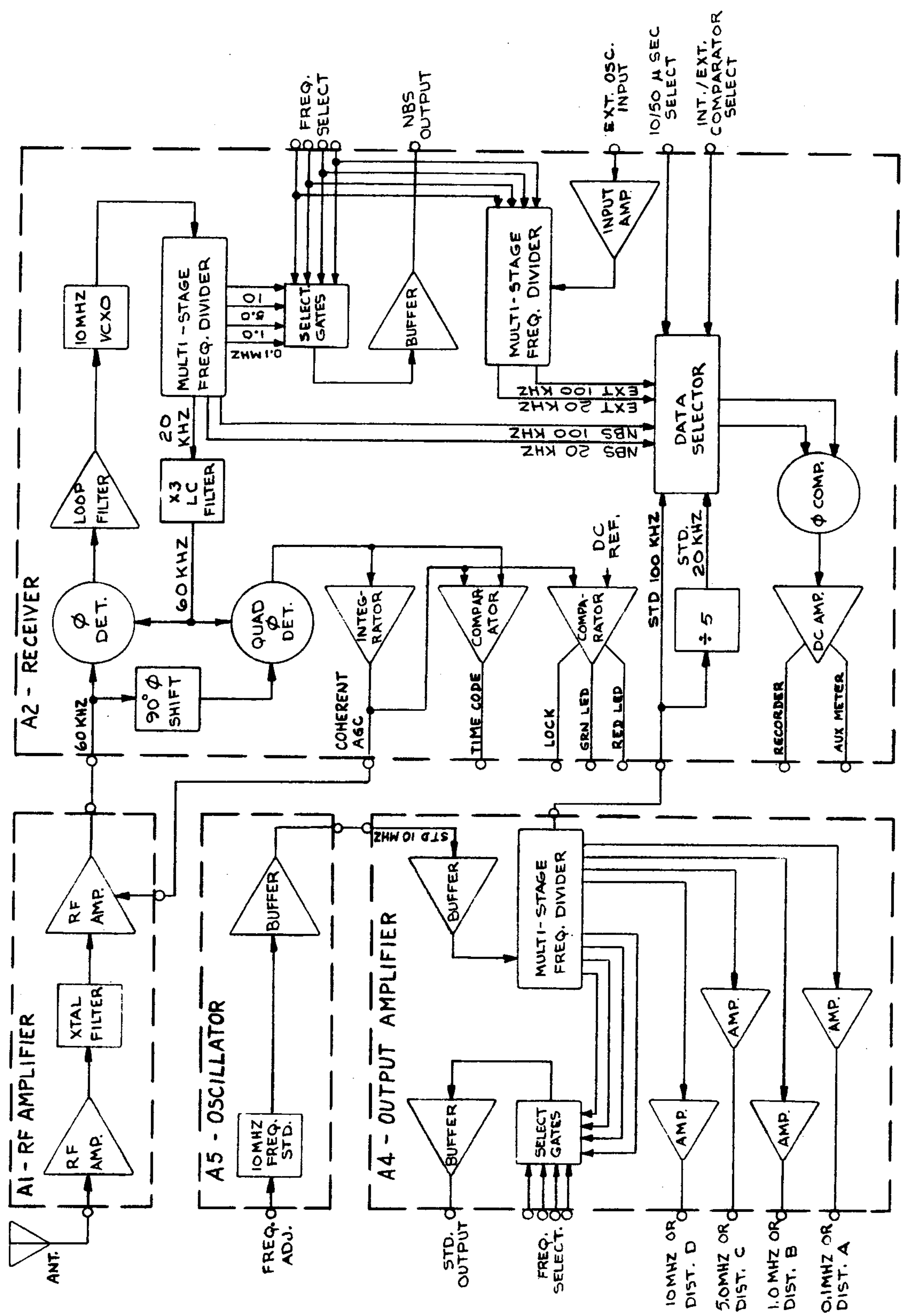


FIGURE 4-1 BLOCK DIAGRAM

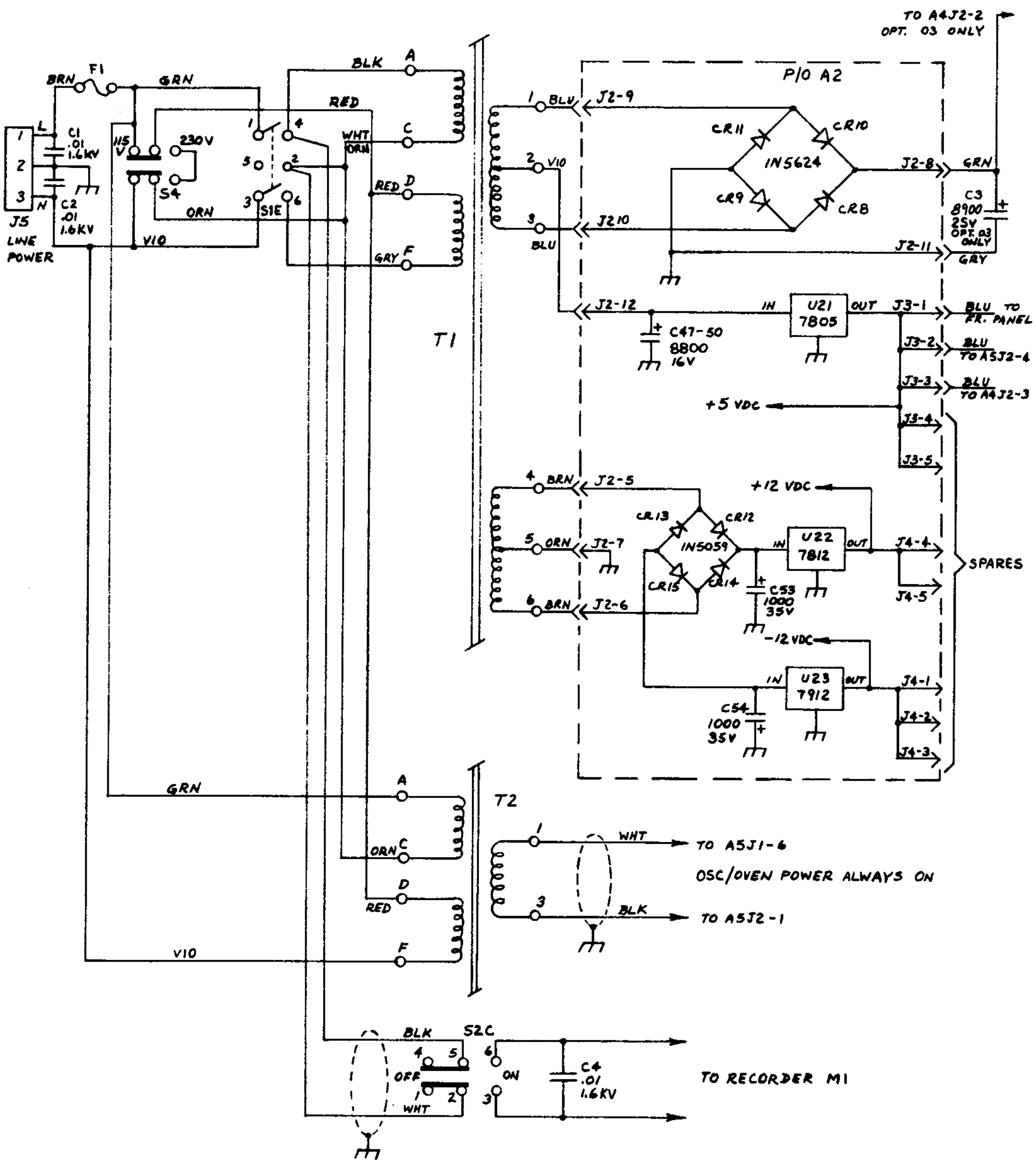


FIGURE 4-2 MAINFRAME SCHEMATIC

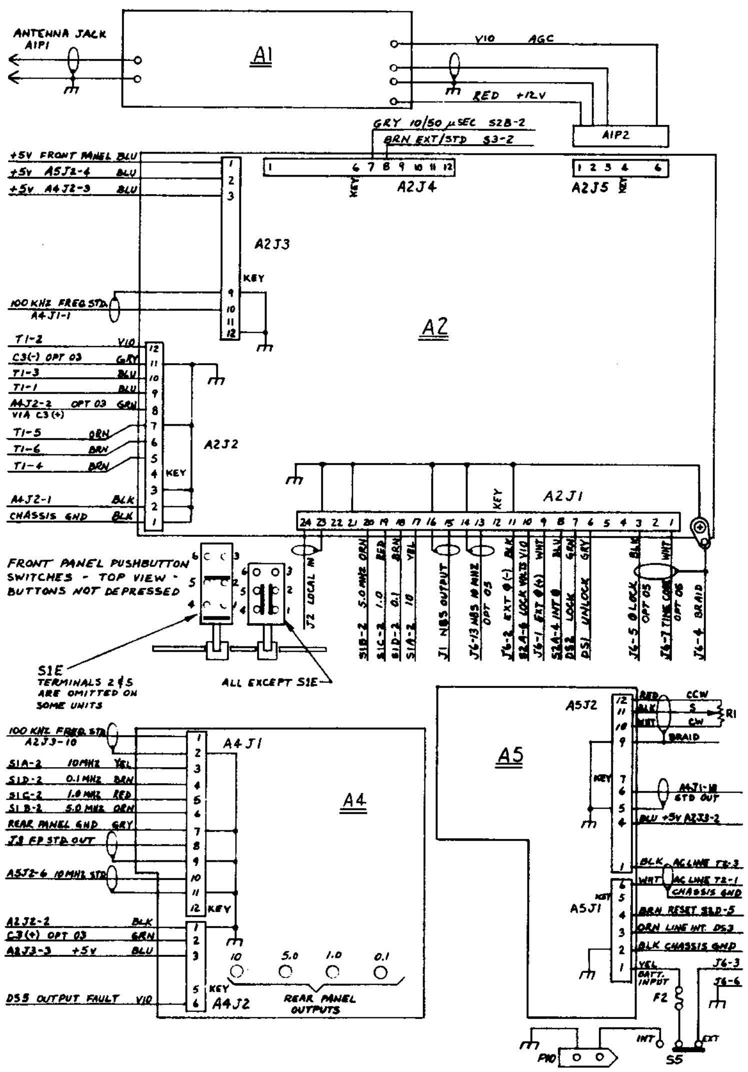


FIGURE 4-3 MAINFRAME SCHEMATIC

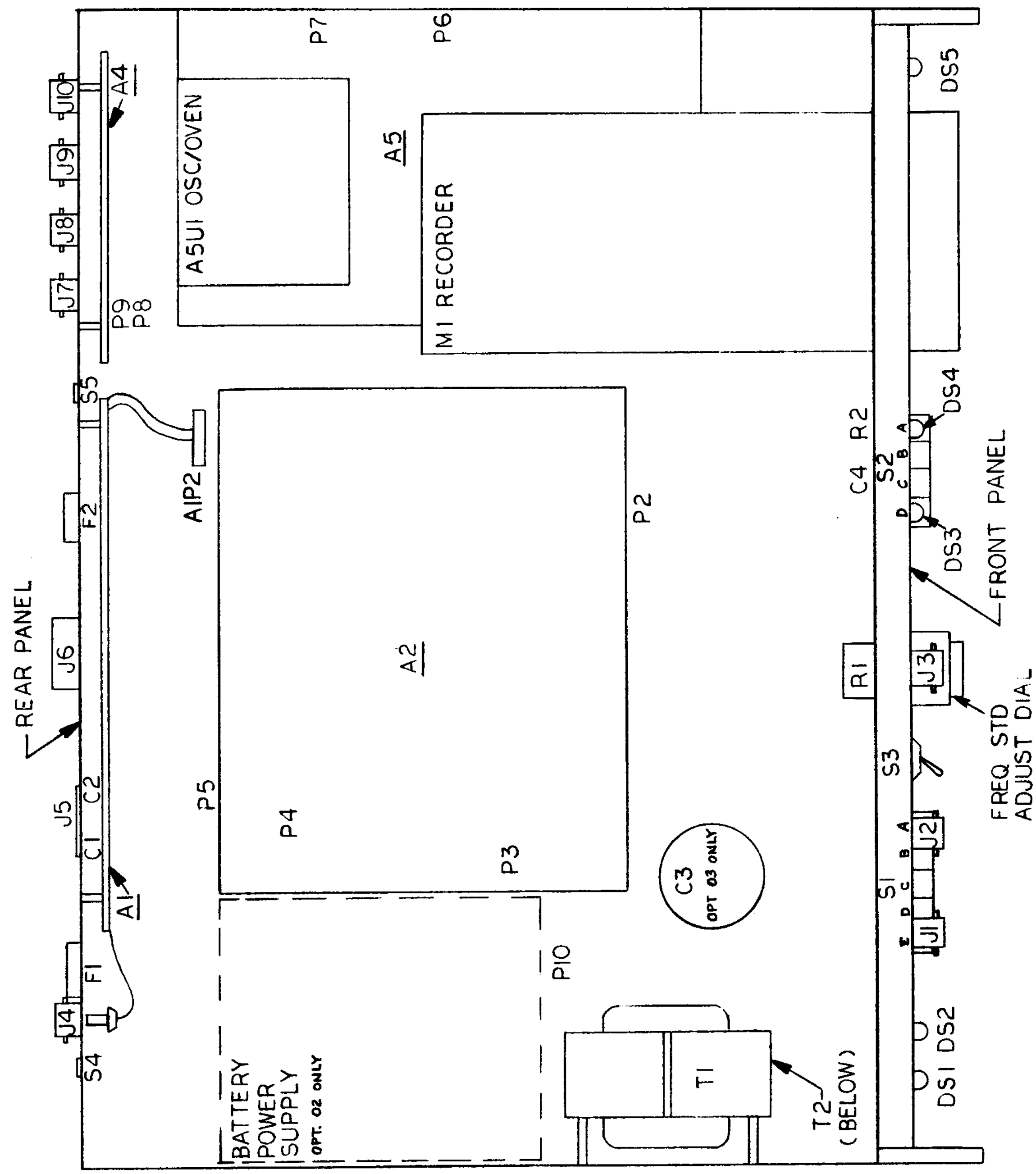


FIGURE 4-4 ASSEMBLY DRAWING MAINFRAME

4.1 A1, RF AMPLIFIER, Part Number 001100

The RF Amplifier Assembly filters and amplifies the antenna signal to a level suitable for use by the A2 Receiver Assembly. (See Figure 4-5 for the schematic, and 4-6 for the Assembly Drawing.)

The signal from the antenna is applied to input transformer T1 which matches the 50-ohm input impedance to the input of the first stage of amplification, Q1. The impedance looking into transformer T1 is approximately 50-ohms, with the secondary of T1 and capacitor C2 forming a 60 kHz tuned circuit with approximately a 200 Hz bandwidth. The output of amplifier Q1 is applied to transistor Q2 which, together with crystal Y1 and capacitors C7, C8, C9, and C10, form a narrow bandpass crystal filter centered at 60 kHz. The filter bandwidth is approximately 30 Hz, with capacitor C8 trimming the bandpass center frequency at 60 kHz. Capacitors C9 and C10 feed to the output side of the crystal a signal that is 180° out of phase and is tuned so that a passband null occurs at 100 kHz. This combination provides a sharp bandpass response at 60 kHz with very steep high frequency rejection.

The output from the crystal filter is fed to amplifier U1, whose output is tuned with inductor L3 and capacitors C14, C15, and C23. Amplifier U1 is the stage that provides AGC for the receiver, with its gain control input port at pin 5. Trimmer resistor R19 provides AGC level adjustment.

The output of amplifier stage U1 is fed to the input of the second amplifier stage U2, the output of which goes to emitter follower Q3, providing the output signal to the A2 receiver assembly.

The supply voltage for the RF amplifier is +12 volts fed in at P2-1 and through R18, L2, and L1, to provide power for the amplifier stages. This power supply is also fed through switch S1 and resistor R2 to the input transformer where it goes out onto the antenna line to provide DC voltage to the preamplifier in the antenna. If switch S1 is moved to the P (preamplifier) from the A (antenna) position the power supply is fed through R1 providing a smaller voltage drop so that both a series line preamplifier Model 8207, and the antenna may be powered from the receiver.

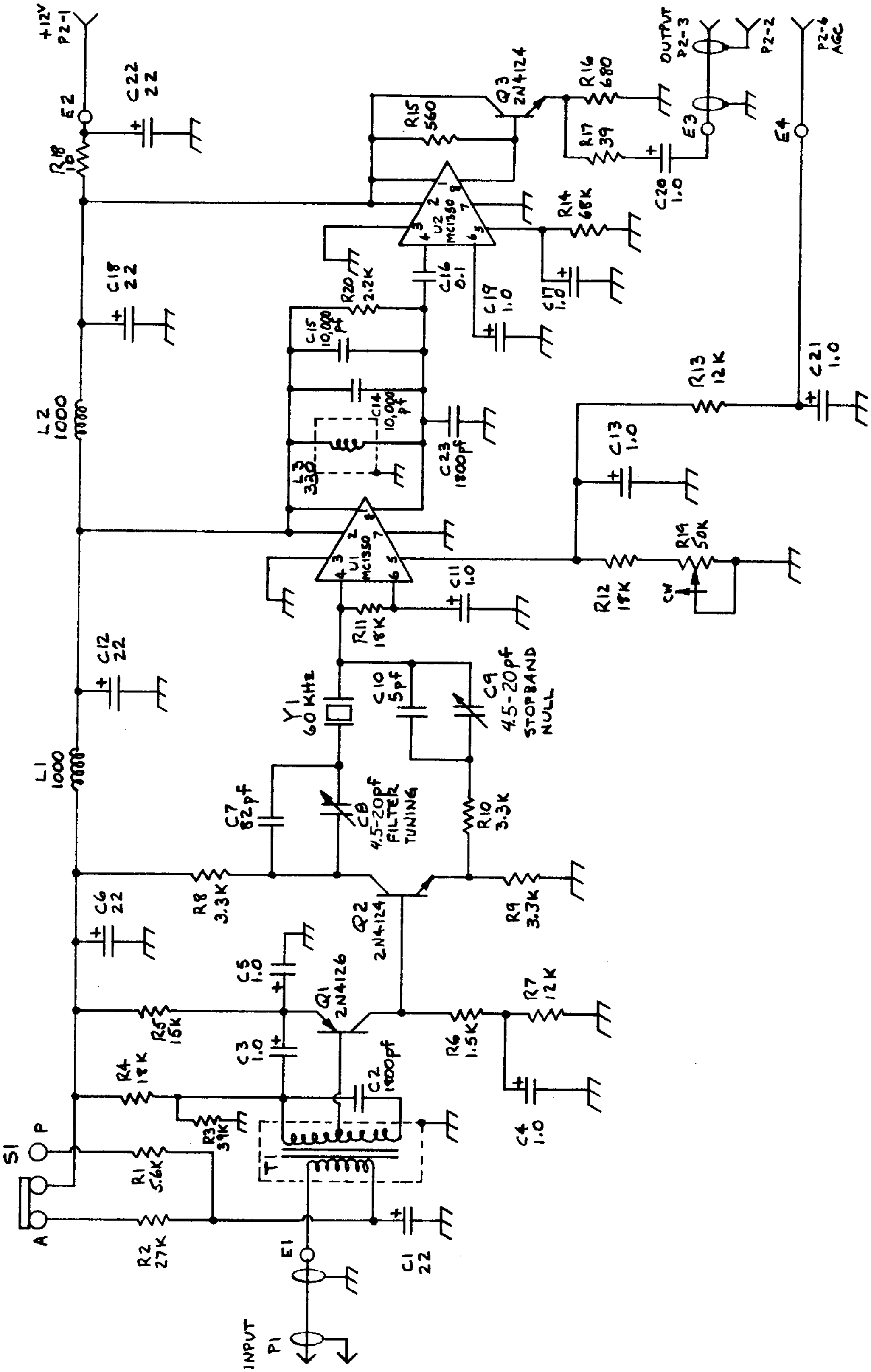


FIGURE 4-5 SCHEMATIC - A1 RF AMPLIFIER

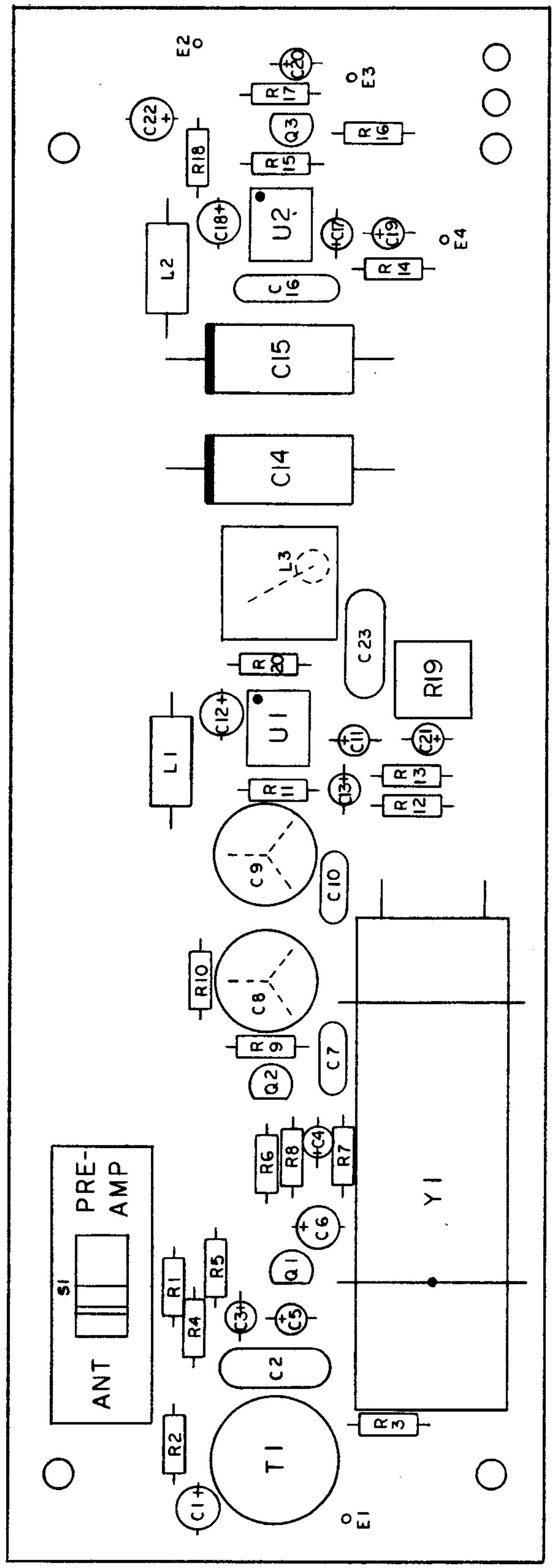


FIGURE 4-6 ASSEMBLY DRAWING - A1 RF AMPLIFIER

4.2 A2, RECEIVER ASSEMBLY, Part Number 001200

When the signal from the RF amplifier assembly is fed into connector J5-3, it splits and goes in two directions. The first, through U1 and U2A, is the phase locked loop which provides synchronous detection of the carrier frequency and translates it to 10 MHz at the detector output. The second is through U3 and U2B to provide AGC voltage, time code detection, and phase lock/unlock indication.

Other functions of the A2 receiver assembly board include:

1. Derivation of front panel NBS Output signal from the 10 MHz phase locked oscillator.

2. Buffering, amplifying and dividing the external local oscillator input to the front panel and feeding it to the phase comparator.

3. The phase comparator which compares the local input frequency with the phase locked oscillator output to determine frequency error and drift.

4. Power supplies.

Refer to Figures 4-7, 4-8, 4-9 for the Schematic, and Figure 4-10 for the Assembly Drawing.

4.2.1 PHASE LOCKED LOOP

The reference input to phase detector U1 pin 1 comes from the RF amplifier output (A1 assembly). The comparison frequency input to phase detector U1 pin 8 is derived from the phase locked oscillator, Q4 output. The output from U1 is a DC voltage which is a function of the phase difference of these 60-kHz signals. The output is amplified by U2A, the loop filter/amplifier. This amplified DC voltage is then fed through amplifiers Q2 and Q3 where it becomes the VCO control voltage which pulls the oscillator (Q4 and Y1) into phase lock relationship with the incoming carrier frequency from WWVB. This oscillator pulling is performed by the DC voltage which appears on the upper end of voltage variable capacitor CR2 controlling the "pulling" of crystal Y1. The oscillator output frequency is thus held exactly 10 MHz by the DC voltage applied to the VCO control line. The collector output from Q4 at BB is buffered by gate U5A and fed to a divider chain consisting of U8, U9, U10, and U16. At various points within this divider chain, frequencies are picked off and fed to the NBS output connector at the front panel through gate U6B. NBS output frequency is chosen by the front panel pushbutton selector switches through gates U7A, U7B, U7C and U7D. This phase locked signal is divided down to 100 kHz and to 20 kHz, and both of these frequencies are fed into data selector U17 pins 4 and 6 and U17 pins 3 and 5 (see phase comparator).

The 20 kHz output from U16 is fed to U18D and to the tripler stage Q9 where the output at 60 kHz is filtered and fed back at point AA into the comparison input of phase detector U1, pin 8. Thus, the phase locked loop translates the incoming 60 kHz carrier frequency from WWVB to 10 MHz at the crystal oscillator output, and divides it down to 60 kHz for comparison in the phase detector.

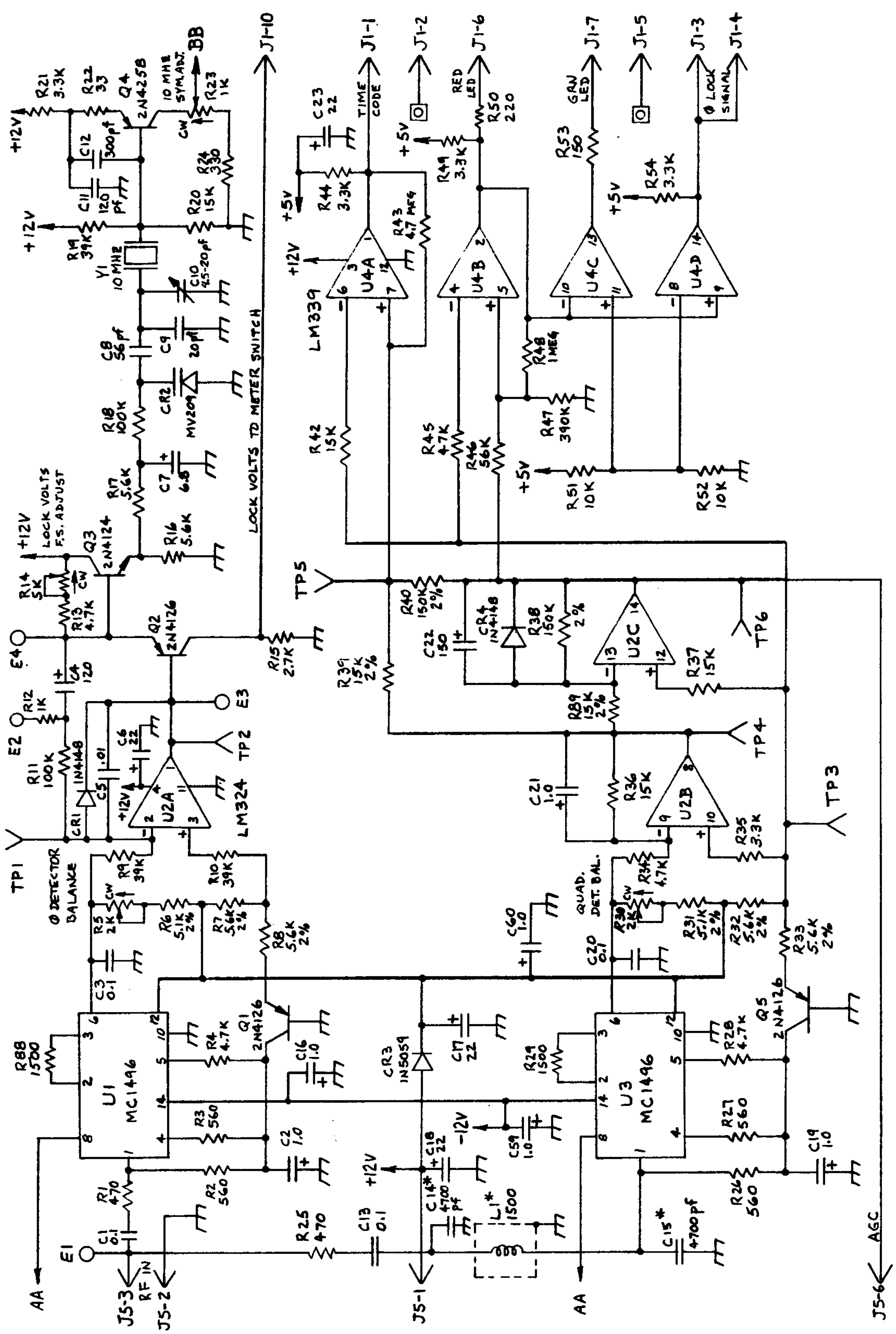


FIGURE 4-7 SCHEMATIC - A2 RECEIVER

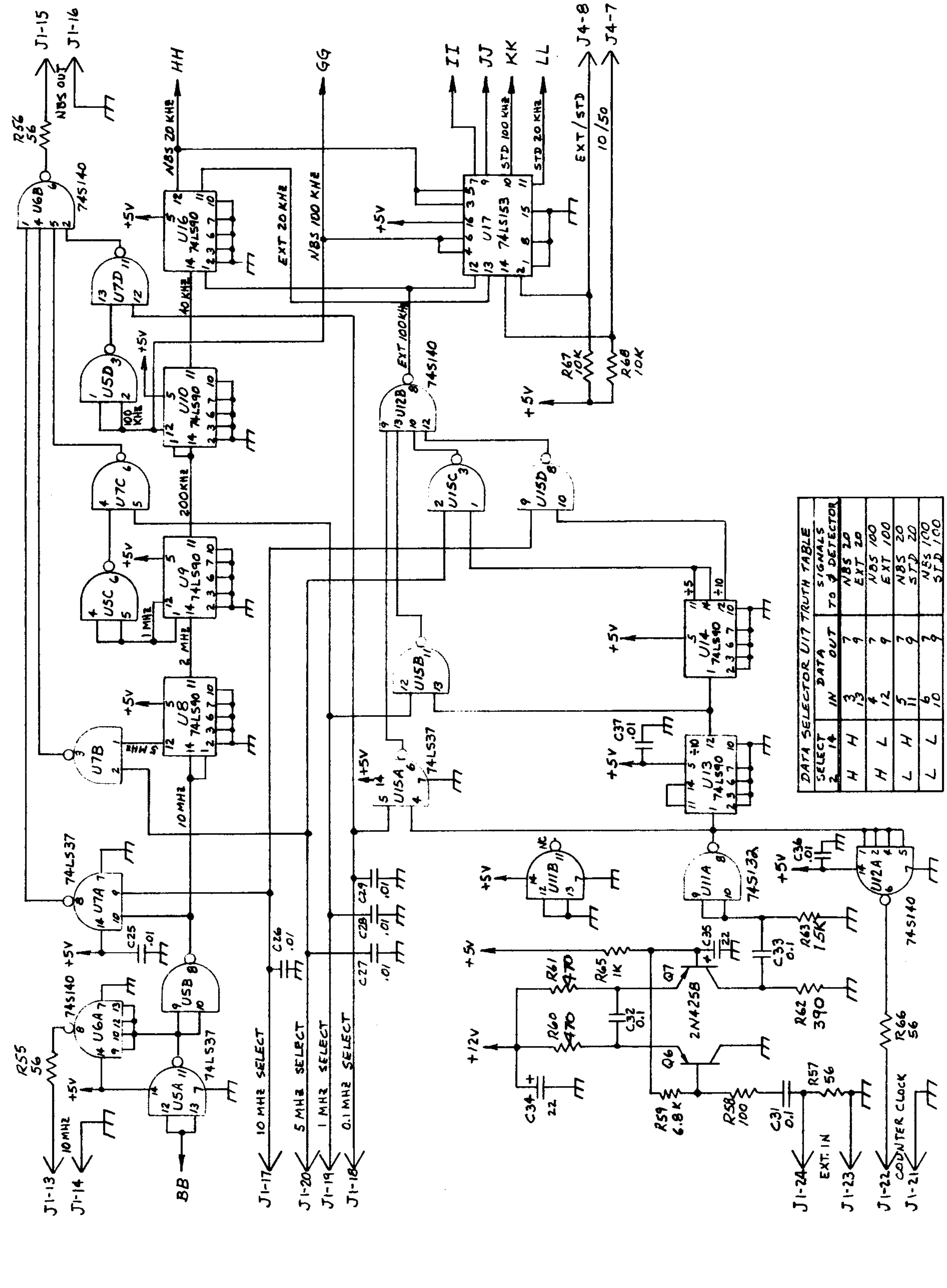


FIGURE 4-8 SCHEMATIC - A2 RECEIVER

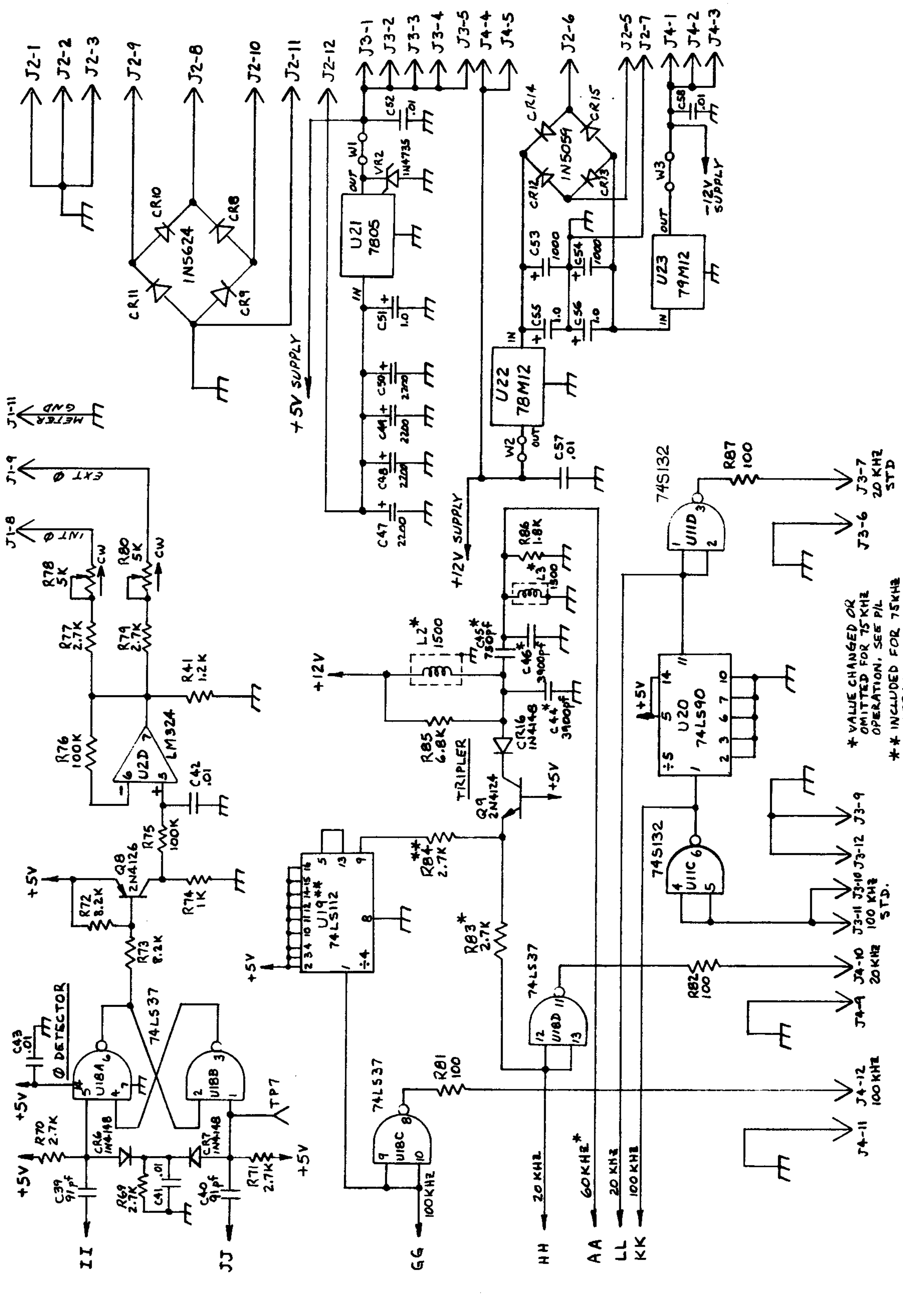


FIGURE 4-9 SCHEMATIC - A2 RECEIVER

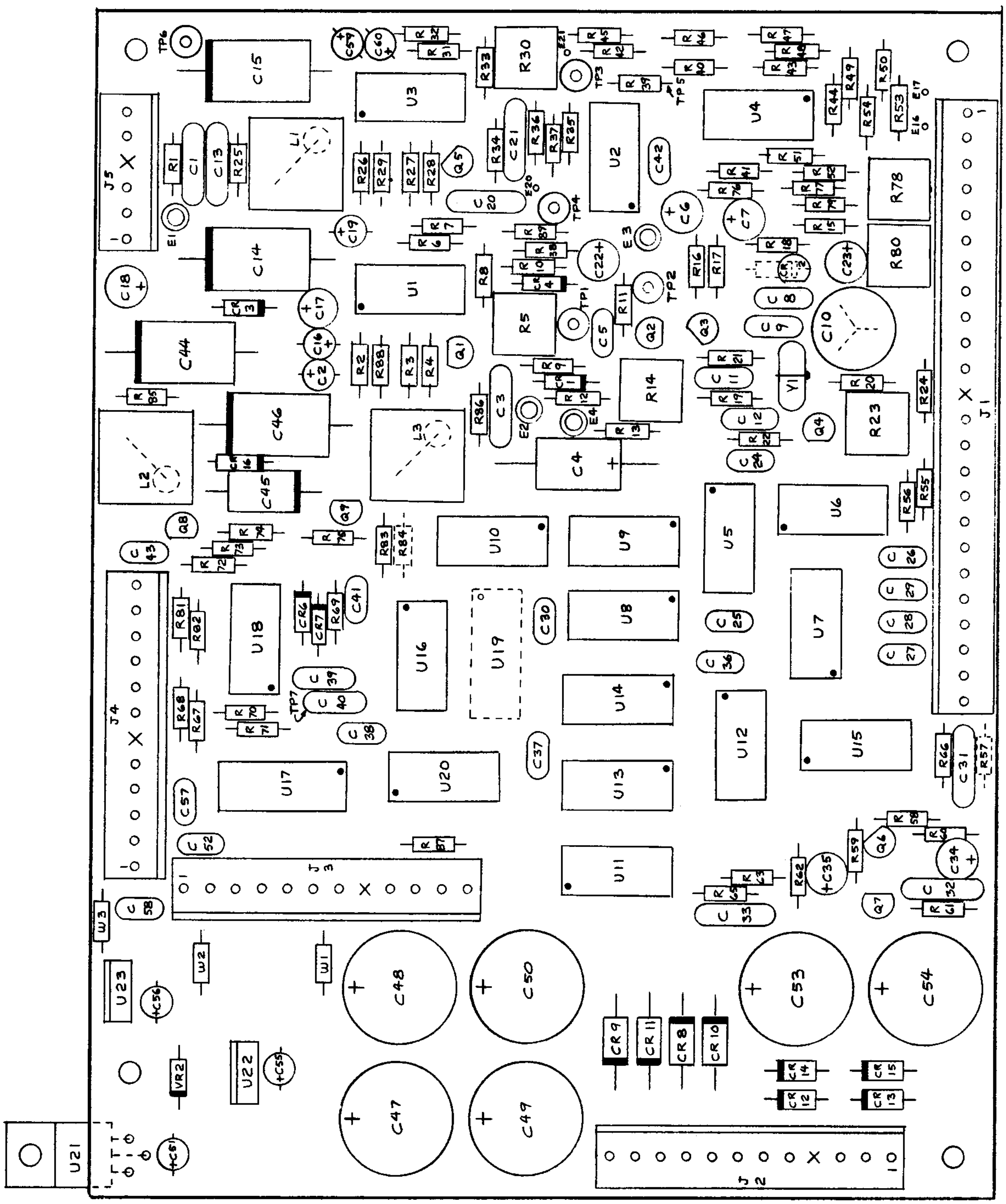


FIGURE 4-10 ASSEMBLY DRAWING - A2 RECEIVER

4.2.2 AGC LOOP

The input from the RF amplifier also goes to pin 1 of phase detector U3 after being shifted in phase by 90° by C14, C15, and L1. Thus, U3 becomes a quadrature phase detector whose output at pin 6 goes high only when the inputs at pin 1 and pin 8 are in quadrature with each other at 60 kHz. The output level from this phase detector is proportional to the level of the incoming carrier, and thus provides the basis for time code amplitude detection, and for AGC voltage generation.

The phase detector output is amplified by U2B, whose time constant is approximately 15 milliseconds. The output of U2B is split and is fed in two directions: first through R39 to voltage comparator U4A where small amplitude variations in the signal are detected and provide the time code output.

The output of U2B also is fed through R89 to amplifier U2C which has an integrating time constant of approximately 25 seconds. The slowly varying output of U2C is used as the AGC voltage and is fed back to the RF amplifier to control the gain of the input stage.

Because the AGC voltage is derived from the output of a quadrature detector, it is present only after phase lock is achieved, and thus becomes the basis for a synchronous AGC. The gain of the amplifier in the front end of the receiver is running wide open until phase lock occurs. After phase lock is acquired, the input amplifier gain is reduced to a level just sufficient to provide a reference for the phase locked loop and other stages in the A2 receiver assembly. Thus, no stages in the A2 receiver assembly are allowed to saturate or be overdriven in strong signal conditions.

Test point 3 is located at the reference voltage against which AGC amplifier U2C operates. Thus, the voltage measured from TP3 to TP6 is proportional to the input signal level, and can be used as a synchronous detector, or "lock-in voltmeter", as an indication of signal strength. If the antenna is adjusted and aimed to maximize this AGC voltage, optimum receiver operation is obtained.

The AGC voltage is also sent to voltage comparators U4B, U4C, and U4D as a means of indicating phase lock. When the AGC voltage measured between test points 3 and 6 rises to approximately 1.0 volt DC, the output of comparator U4B goes high turning off the red unlock panel indicator on the front panel. When lock is acquired and the green light goes on, the output of U4D goes high and provides a rear panel output at the auxilliary connector showing that phase lock has been acquired.

4.2.3 PHASE DETECTOR BALANCE ADJUSTMENTS

The output of phase detector U1 for the phase locked loop control is balanced by adjustment of trimmer potentiometer R5. (See alignment procedure for A2 receiver assembly.) The output of the quadrature phase detector U3 is balanced by adjustment of trimmer potentiometer R30. (See alignment procedure for A2 receiver assembly.)

4.2.4 PHASE COMPARATOR

When local oscillators to be calibrated are fed into the local input jack on the front panel, they appear at the "external input" terminals of the A2 receiver assembly at J1 pin 24. The buffer amplifier Q6-Q7 feeds this signal to gate U11A where it is then divided in frequency by U13 and U14. Gates U15A, U15B, U15C and U15D are used to select the appropriate divider output to provide a 100 kHz signal to data selector U17.

The operation of data selector U17 is shown in the truth table on page 2 of the A2 receiver assembly schematic. The function of data selector U17 is to select the appropriate signal to be fed into each port of the phase detector U18A/B. The two outputs from U17 are chosen by selecting the appropriate combination of highs and lows on inputs 2 and 14. Referring to the truth table for data selector U17, we can see that if both pins 2 and 14 are high, then output pins 7 and 9 will provide NBS 20 kHz and External 20 kHz to the phase detector inputs. Under this condition, the phase detector output will cause the meter to read 50 microseconds full scale (the reciprocal of 20 kHz is 50 microseconds, or one full cycle of a 20 kHz signal). If the front panel phase comparator selector switch is put into the Standard Output position, then a low appears at pin 2 of the data selector and 20 kHz derived from the internal frequency standard will be fed to the phase comparator for comparison with the NBS 20 kHz signal. (The function of comparing the internal standard with the WWVB carrier is provided only in those receivers containing an internal frequency standard oscillator.) If the data selector is set up to provide 100 kHz signals to the phase comparator, then the full scale reading of the output meter will be 10 microseconds (one full cycle at 100 kHz).

U18A and U18B are connected as a flip-flop phase detector whose output pulse width is proportional to the relative phase relationship between the two input signal pulses. Buffering of this output pulse is provided by Q8, and integration of the output pulse by R75 and C42. Buffer amplifier U2D then drives the front panel meter and the rear panel auxiliary output for an external meter or chart recorder. Full scale adjustments of both are made by adjusting the current to ground through a milliammeter at each output to exactly 1.00 ma with no local signal input and with TP7 grounded, causing the phase detector to indicate full scale. Trimmer resistor R80 adjusts full scale setting of rear panel output and R78 is used to adjust the front panel full scale meter reading.

4.2.5 POWER SUPPLIES

Three terminal regulators U21, U22, and U23 provide output voltages of +5.0 volts, +12.0 volts, and -12.0 volts. Because U21 which provides the +5.0 volts is the most heavily loaded of the voltage regulators, it is heat sunk to the chassis at the rear left corner of the circuit board. Regulators U22 and U23 are loaded more lightly and do not require heat sinking.

When Option 03, Built-in Frequency Distribution Amplifier, is provided in the unit, an additional +12.0 volts supply is provided as a part of the A4 output amplifier assembly. This additional +12 volt supply also is given much more filtering.

4.3 STANDARD OUTPUT AMPLIFIER ASSEMBLY A4, Part Number 002400

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 pushbutton selector switches. (See Figure 4-11 for the schematic and Figure 4-12 for the Assembly Drawing.)

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 lamp on the front panel of the unit is it 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 output frequency selector pushbutton.

4.3.1 OUTPUT DRIVE LEVEL

In the standard version of the output amplifier, drive levels from the rear panel outputs are sinusoidal at 4.0 volts 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 volts rms.

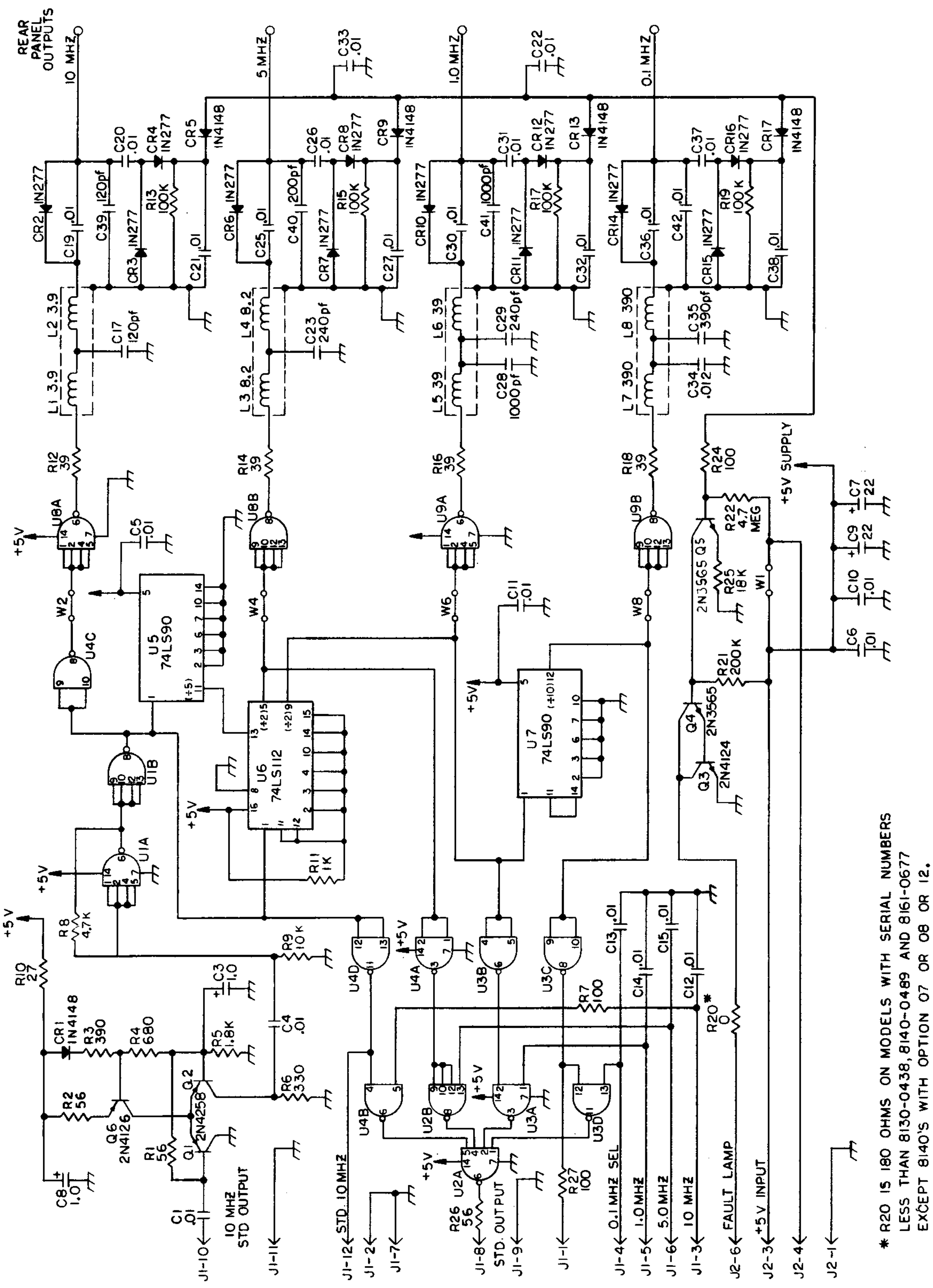


FIGURE 4-11 SCHEMATIC - A4 OUTPUT AMPLIFIER

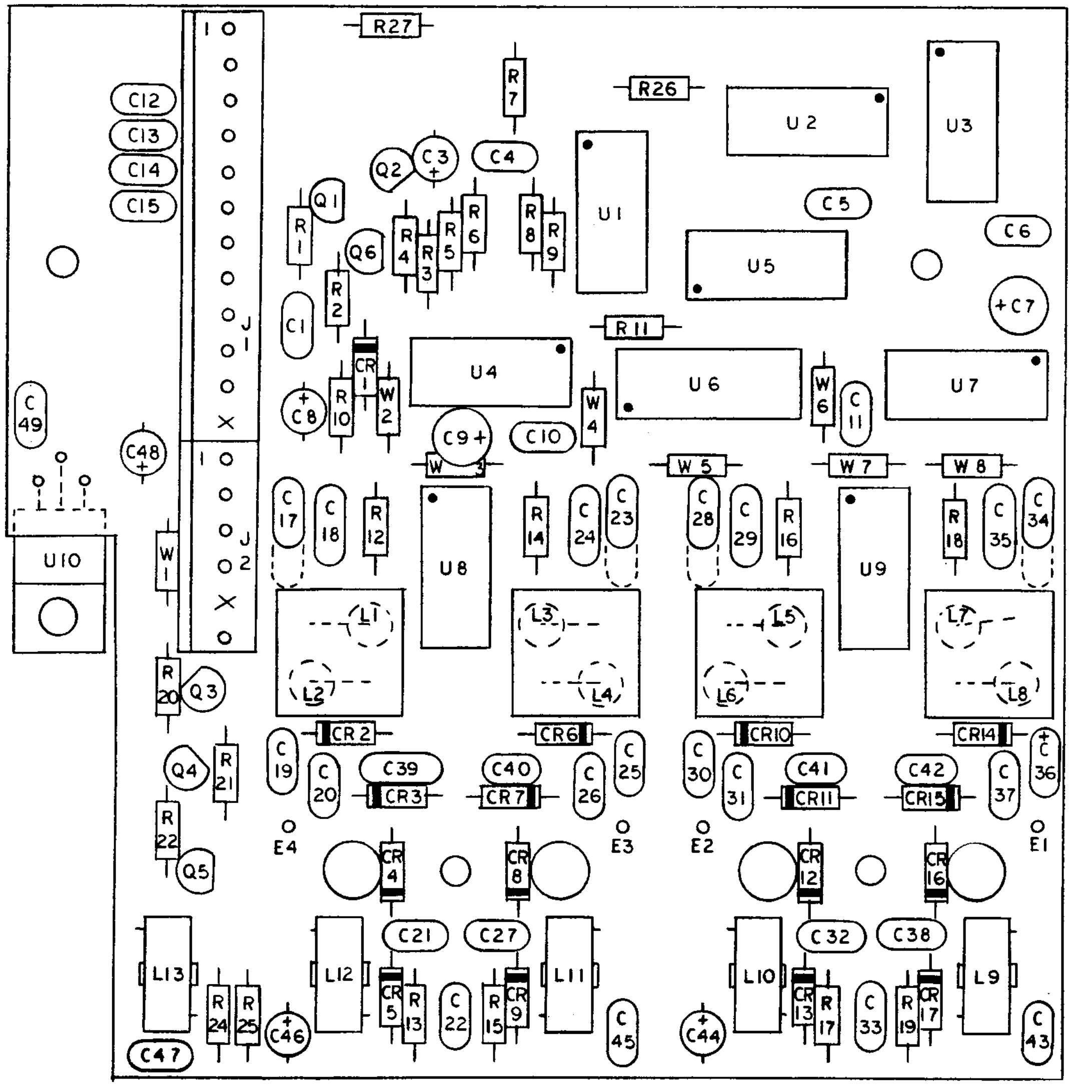


FIGURE 4-12 ASSEMBLY DRAWING A4 OUTPUT AMPLIFIER

4.4 A5 OSCILLATOR AND POWER SUPPLY ASSEMBLY 002500

Oscillator U1 is a high-stability, oven-controlled quartz crystal oscillator. The board consists of power supply and control circuitry for this oscillator only. The output frequency from the board is 10.0 MHz. (See Figure 4-13 for the schematic and Figure 4-14 for the Assembly Drawing.)

4.4.1 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. (See oscillator alignment procedure.)

+5 volts DC is fed into the oscillator at pin 1 where it drives the output stages and the output buffer stage Q1. +21 volts DC 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.

4.4.2 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 2.0 milliamps 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.

4.4.3 SECONDARY REGULATORS

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

4.4.4 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 volts DC by trimmer resistor R25.

4.4.5 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.)

4.4.6 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 pushbutton. 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 warmup must be accomplished before completely stable frequencies are obtained from the oscillator.

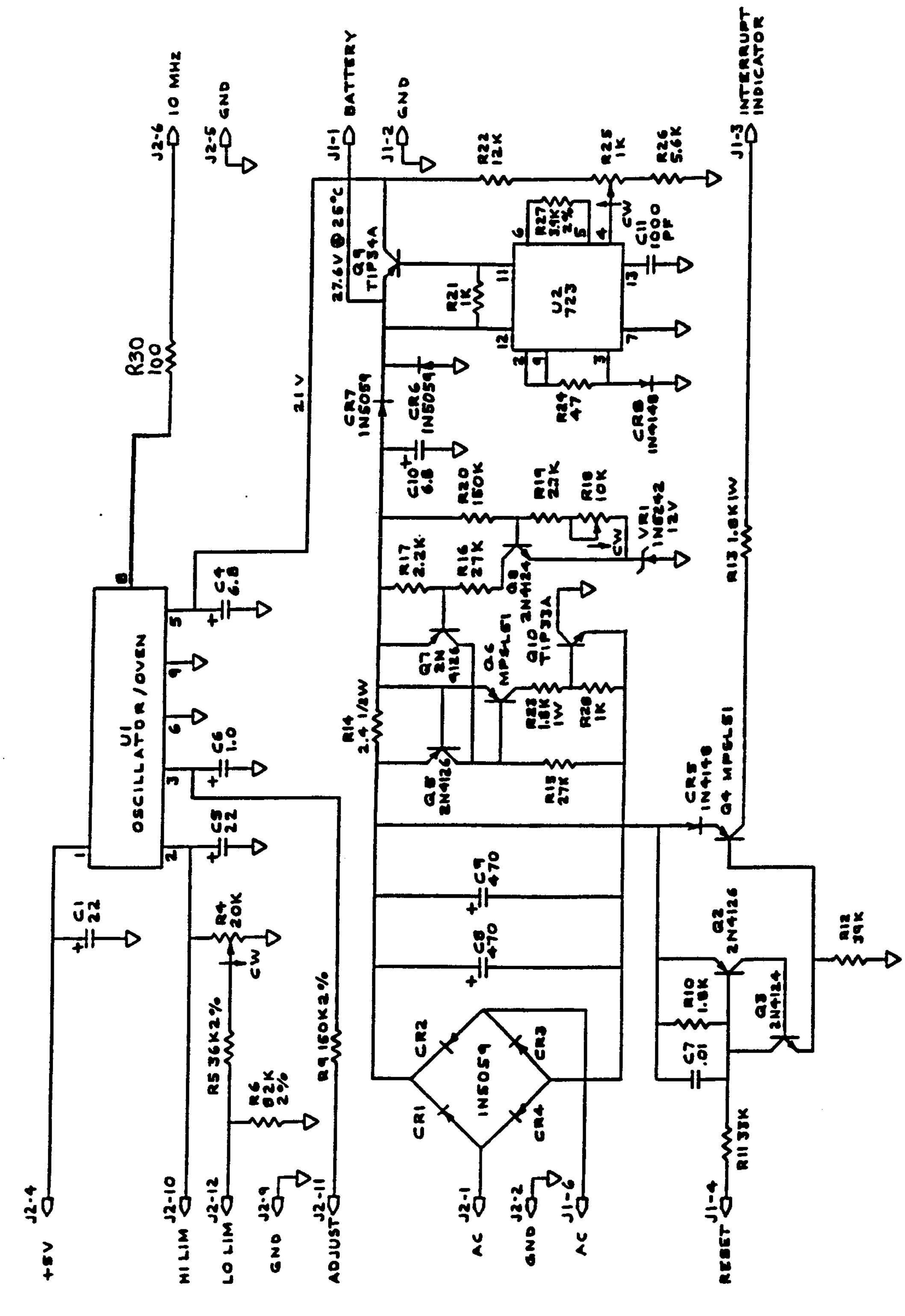


FIGURE 4-13 SCHEMATIC - A5 OSCILLATOR AND POWER SUPPLY

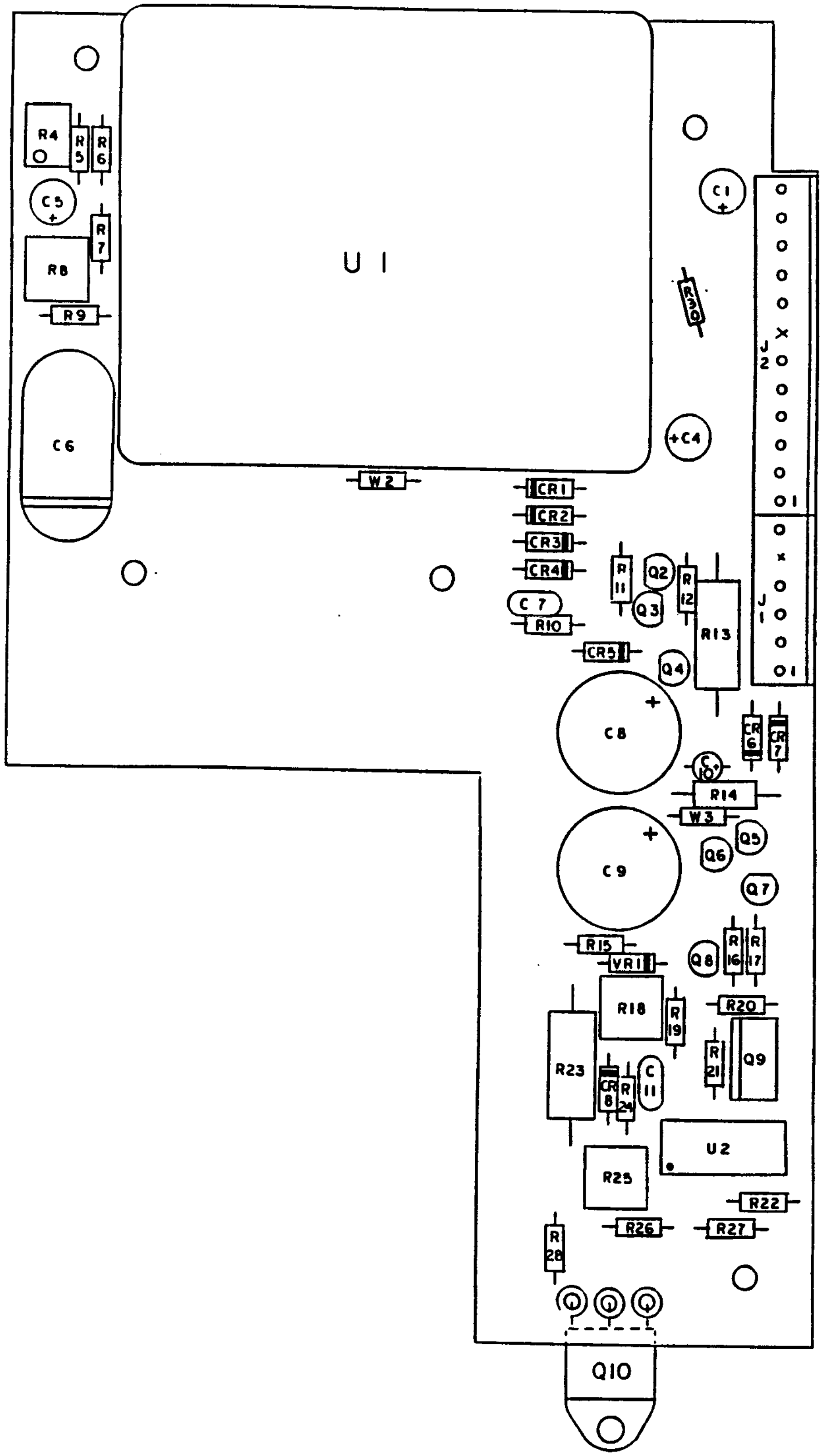


FIGURE 4-14 ASSEMBLY DRAWING - A5 OSCILLATOR AND POWER SUPPLY

MODEL 8161

SECTION 5

OPTIONS AND ACCESSORIES

5.0 INTRODUCTION

This section describes the options and accessories which are available for the Model 8161.

5.1 OPTION 01 RACK MOUNT OPTION

Units purchased with the rack mount kit are not provided with the tilt stand. The four mounting feet are included but these may be removed when the receiver is installed in a rack.

The rack mount panel extensions are installed by removing the vinyl-covered filler panels 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. (See Figure 5-1, "Rack Mount Option 01".)

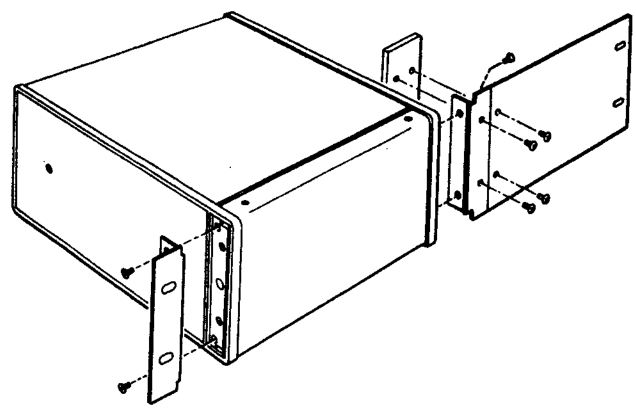


FIGURE 5-1 RACK MOUNT OPTION 01

5.2 OPTION 02 BATTERY POWER SUPPLY

With this option the oscillator will continue to run for up to 36 hours after power line failure. 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 oft to conserve battery power.

The battery power supply has capacity for 36 hours of minimum standby operation. Recharge rates, 33% in 6 hours, 66% in 12 hours, 100% in 36 hours.

> NOTE: THE INTERNAL BATTERY HAS BEEN DISCONNECTED FOR SHIPMENT BY PLACING THE REAR PANEL BATTERY SELECTOR SWITCH IN THE "EXT" POSITION. TO RECONNECT THE BATTERY, RETURN THE SWITCH TO THE "INT" POSITION.
>
> THE INTERNAL BATTERY WILL MAINTAIN POWER TO THE OSCILLATOR FOR 36 HOURS. IF THE UNIT WILL BE DISCONNECTED FROM AC POWER FOR MORE THAN 36 HOURS, PLACE THE REAR PANEL SELECTOR SWITCH IN THE "EXT" POSITION.
>
> IF THE UNIT IS RETURNED TO THE FACTORY FOR REPAIR, PLACE THE REAR PANEL BATTERY SELECT SWITCH IN THE "EXT" POSITION.

5.2.1 PRINCIPLES OF OPERATION

The battery charging circuitry is located on the oscillator assembly (A5). The schematic for the oscillator assembly is shown on page 4-23, Figure 4-13. The assembly drawing is on page 4-24, Figure 4-14.

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 milliamps, and final trickle charge level is about 2.0 milliamps 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.

5.3 OPTION 03 BUILT-IN DISTRIBUTION AMPLIFIER

5.3.0 INTRODUCTION

Option 03 allows counters and synthesizers throughout your facility to use the standard output frequency as a common time base oscillator. Because the same external time base can be used for all these instruments, there is no need to buy high stability time bases for each of them, and they need not be taken out of 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 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.

The outputs are provided on four BNC connectors. Each provides a 10-MHz sinewave signal to terminated and dc-isolated cable via separate buffer amplifiers. Level is 0.5 V rms, 50 ohms, with superimposed +12 VDC to power the line tap modules.

TRUNK LINE LOADING LIMITATIONS

NUMBER OF REMOTE STATIONS: A total of 25 line tap loads on all 4 outputs. One VersaTap™ = 3 line tap loads.

DISTANCE TO REMOTE STATIONS: Up to 25 line tap loads on one output at an average distance of 750 feet (228m). 1500 feet (457m) maximum using RG-58 cable.

CAUTION: The 10 mHz signal is riding on 12VDC and should be used to drive only Spectracom Line Taps or VersaTap™. After the last line tap on each trunk line, a dc-isolated 50-ohm load (part number 004490) must be connected to correctly terminate the line.

5.3.1 PRINCIPLES OF OPERATION

The schematic for Option 03 is shown in Figure 5-2, "Distribution Amplifier Schematic - Option 03". The Assembly Drawing is Figure 5-3. 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 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 pushbutton selector switches.

The other direction is through U4C and into line drivers U8 and U9. The signal is then filtered to a sinewave 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. If the rear panel output at any one of these four jacks is not present, the red 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.

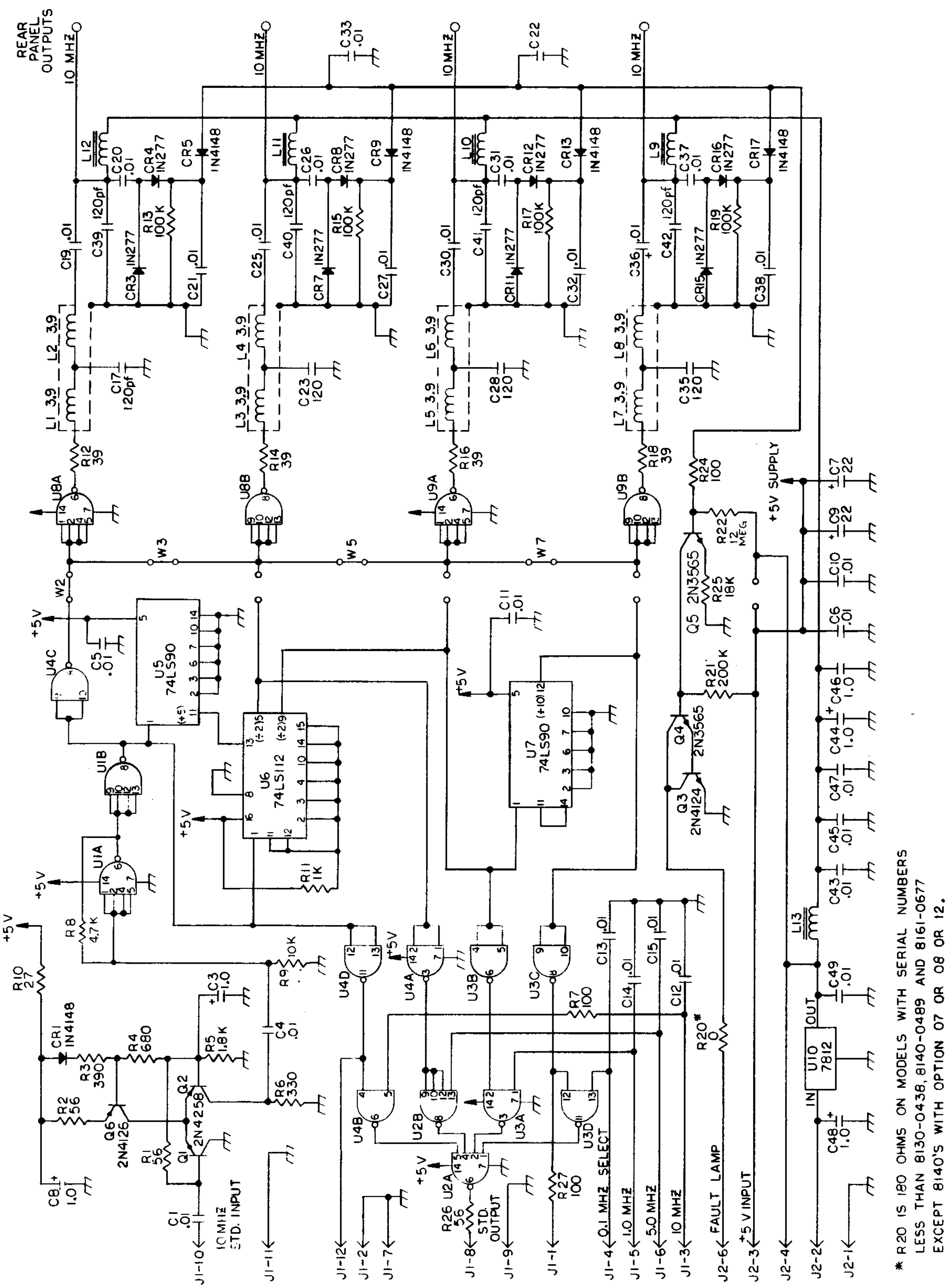


FIGURE 5-2 A4 DISTRIBUTION AMPLIFIER SCHEMATIC

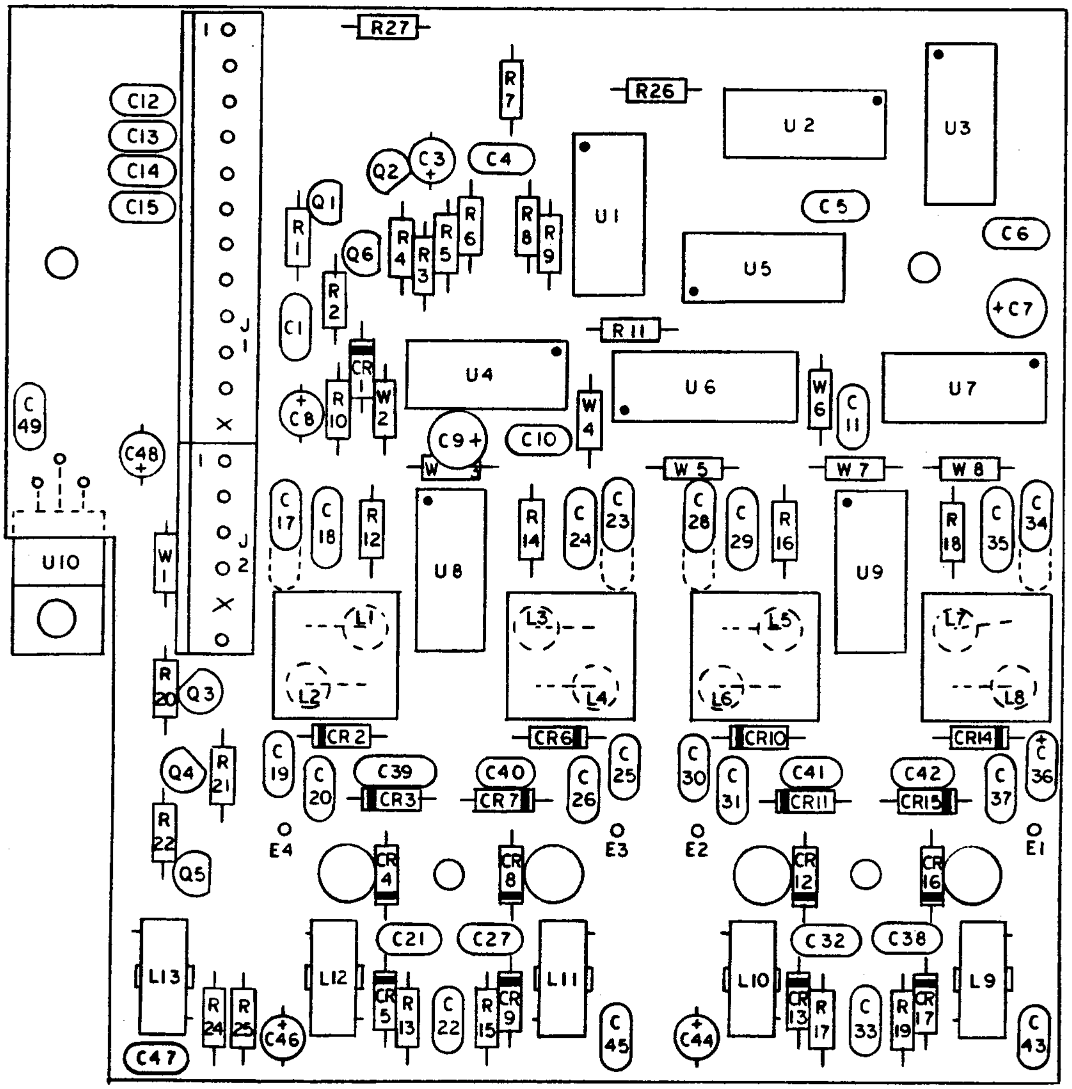


FIGURE 5-3 A4 COMPONENT LOCATION ASSEMBLY DRAWING

5.3.2 SYSTEM COMPONENTS

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

5.3.2.1 Model 8140 T and Model 8140 TTL Line Taps. These devices, powered by DC on the coaxial feedline, 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 ohm. When used without termination, the output is TTL compatible. Optional unit (Model 8140TTL) provides TTL 3.4 V rectangular positive pulses from a 50-ohm source.

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:
In inches - 5.25 L x 2.63 W x 1.71 H. (In mm: 133 L x 67 W x 43 H).
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.

5.3.2.2 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 volts peak-to-peak on a DC voltage of 7 to 12 VDC. The DC current requirement is 110 milliamps at +12 VDC.

Output A:
: A sine wave of 1.7 volts peak-to-peak at the specified frequency into a 50-ohm load for frequencies greater than 100 kHz. A TTL output for frequencies below 100 kHz with a source impedance of 50 ohms (SN74S140 driver).

Output B:
: A TTL output at the specified frequency with a source impedance of 50 ohms (SN75S140 driver). 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:
: In inches 8.3 L x 4.2 W x 1.7 H. (In mm: 211 L x 107 W x 43 H). Mounting hole pattern 8.88 x 2.75 inches (225.4 x 69.9 mm).

5.3.2.3 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 RG58 coaxial cable with Model 8140 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" at the end of this section for an approved method of interconnection.

5.3.3 Design of Distribution Networks

Four buffered outputs, labeled "A", "B", "C", and "D", are provided on the rear panel of the base station so that trunk lines may be run in each of four directions from the base station. This minimizes the total length of coaxial cable in the system. In planning the system installation, follow these basic rules:

1. No more than 25 Line Taps may be driven from one base station. The power supply capacity will be exceeded if additional Line Taps are added.

   If more than 25 line tap loads are required, a Model 8140 Frequency Distribution Amplifier is required. The Model 8140 will feed an additional 25 line taps by using the output of one of the first 25 line taps. This "daisy-chaining" may be continued indefinitely.

2. Using RG-58 cable, 1500 feet (457 m) is the longest trunk line that may be used. Using RG-8 cable, 3000 feet (914 m) is the longest trunk line permitted. Figure 5-4, " Line Tap Number & Distance Chart", may be used to calculate the number of line taps 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.

   If longer runs are required, you may:

   a. Locate the Model 8161 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 towards the total number allowed. Use a Distribution Line Termination, 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 5-5.

   c. Use a Model 8140 Frequency Distribution Amplifier.

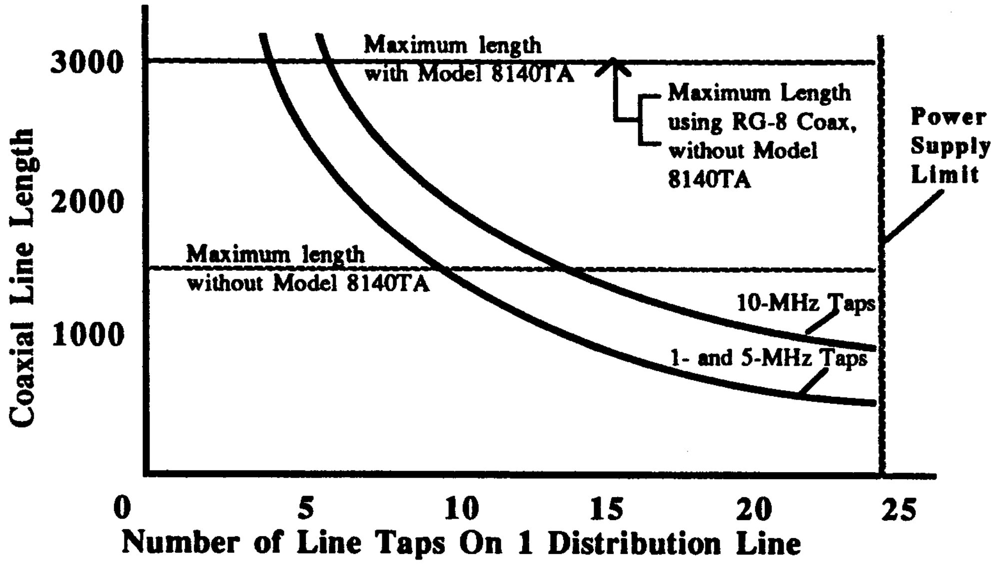


FIGURE 5-4 LINE TAP NUMBER AND DISTANCE CHART - OPTION 03

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 5-5 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.

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. Special considerations when using the Model 8140VT VersaTap™

The Model 8140VT VersaTap™ is used in lieu of a standard line tap when a special frequency output, such as 1.544 or 2.048 MHz, is required by the remote station equipment.

See the VersaTap™ Instruction Manual for details of installation and operation.

Each VersaTap™ consumes the DC power of 3 line taps; the total number of line taps allowed is correspondingly reduced.

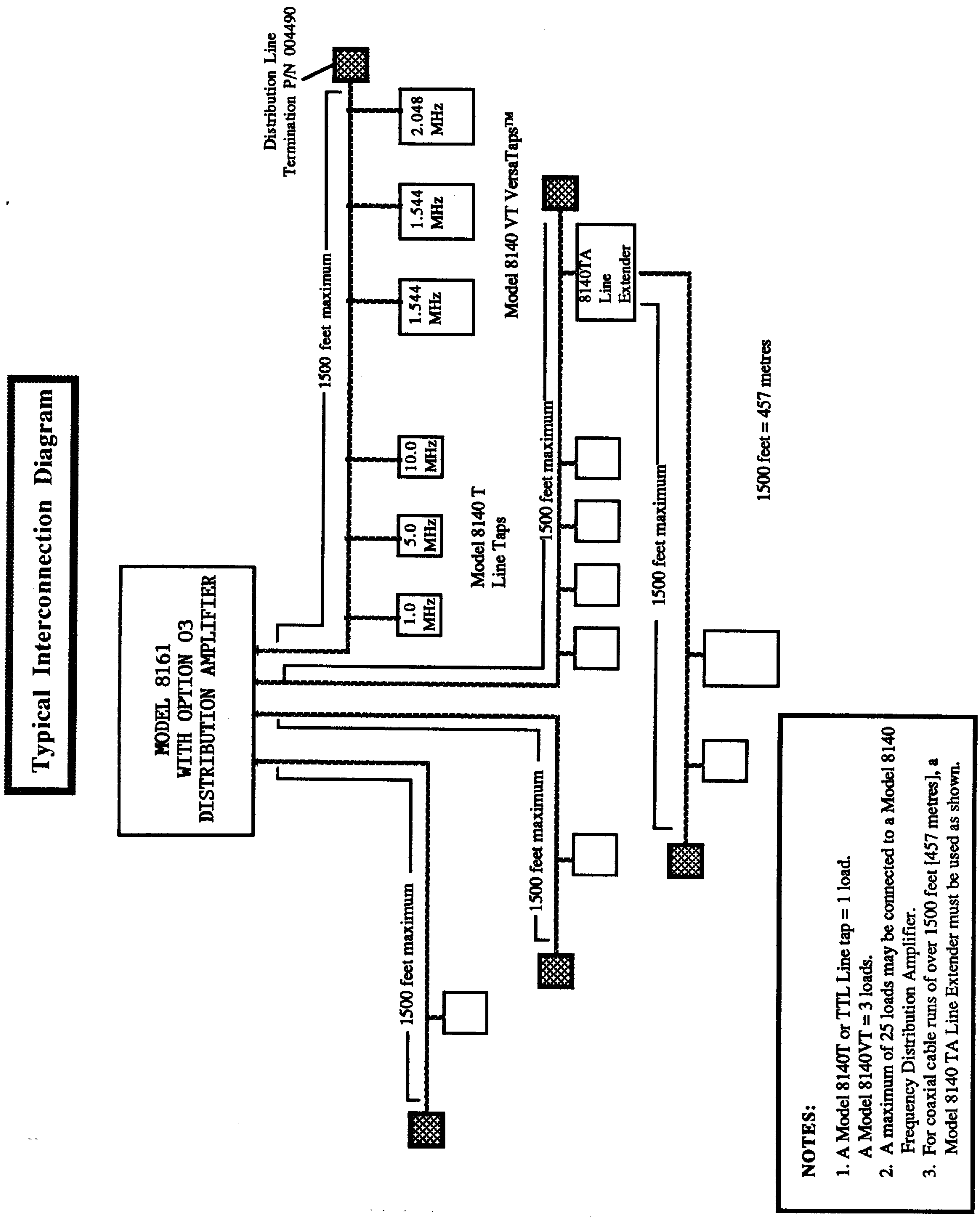


FIGURE 5-5 TYPICAL INTERCONNECTING DIAGRAM

5.4 OPTION 10 50 HZ POWER LINE

This option provides a 50-Hz drive motor in the Model 8161 Strip Chart Recorder.

5.5 OPTION 11 RACK MOUNT WITH SLIDES

The chassis section of the slides are attached to the sides of the receiver using the #10-32 x 3/4 screws provided. The filler plates are located between the slides and the receiver sides.

The stationary section of each rack slide must be assembled to the proper length for the rack being used, using the brackets, screws, and nuts provided. The slides are bolted to the front and rear channels of the rack using the 10-32 x 1/2 screws and nut plates as shown in Figure 5-6, "Slide Assembly Option 11". Additional panel mounting angles (such as Emcor No. PMA) may be added to the rack cabinet for securing the front ends of the stationary slide sections if needed. They should be located immediately behind the panel mounting angles to which the equipment panel extensions will be fastened.

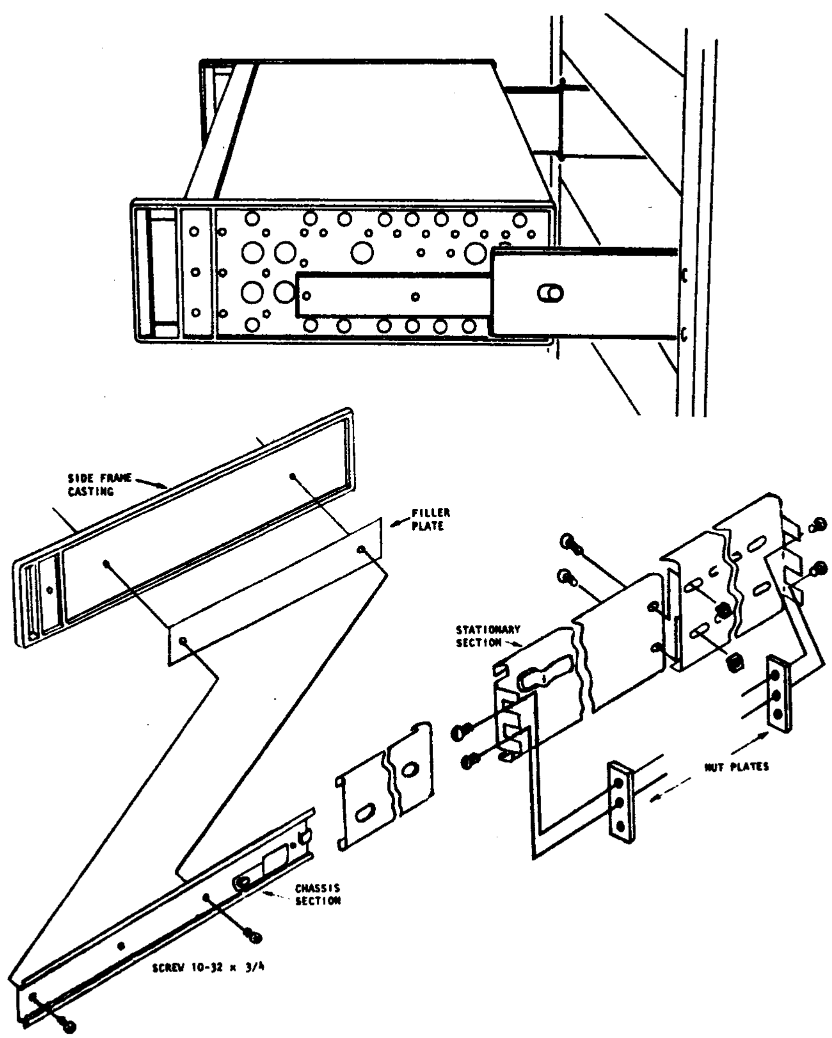


FIGURE 5-6 SLIDE ASSEMBLY OPTION 11

5.6 OPTION 15 TIMING PULSE OUTPUT

This option provides both 60 Hz and 1.0 Hz at the rear panel AUX/OUTPUT J6 which are phase locked to the WWVB carrier. The 60 Hz signal can be monitored at J6-8. J6-9 is the ground return. The 1.0 Hz output is on J6-10. J6-11 is the ground return. The pulses use symmetrical 3.4 V rectangular positive pulses that are TTL compatible. These outputs will also drive terminated lines with impedance as low as 93 ohms resistive.

Typical long-term accuracy with normal signal reception is $1x10^{-11}$ and short-term accuracy for a one-second averaging time is $1x10^{-7}$. During loss of signal accuracy gradually decreases to typically worst case of $1x10^{-5}$.

5.6.1 PRINCIPLES OF OPERATION

The schematic for Option 15 is shown in Figure 5-7. The Assembly Drawing is shown in Figure 5-8.

The Option 15 board (A7) is physically located between the front panel and the receiver assembly (A2). The NBS 100 kHz input signal at A7J1-1 originates at A2J2-12. Input signal at A7J1-1 originates at A2J2-12. It is divided by 5 by U1 and multiplied by 3 by the tripler. This 60 kHz signal is divided by 1000 by U2, U3, and U4. The resulting 60-Hz signal is fed to the rear panel AUX IN/OUT connector, (A5J6-8), through line driver U7. The 60 Hz signal is also divided down to 1-Hz by dividers U5 and U6. The 1 Hz signal is also fed to the rear panel (A5J6-10) through line driver U7.

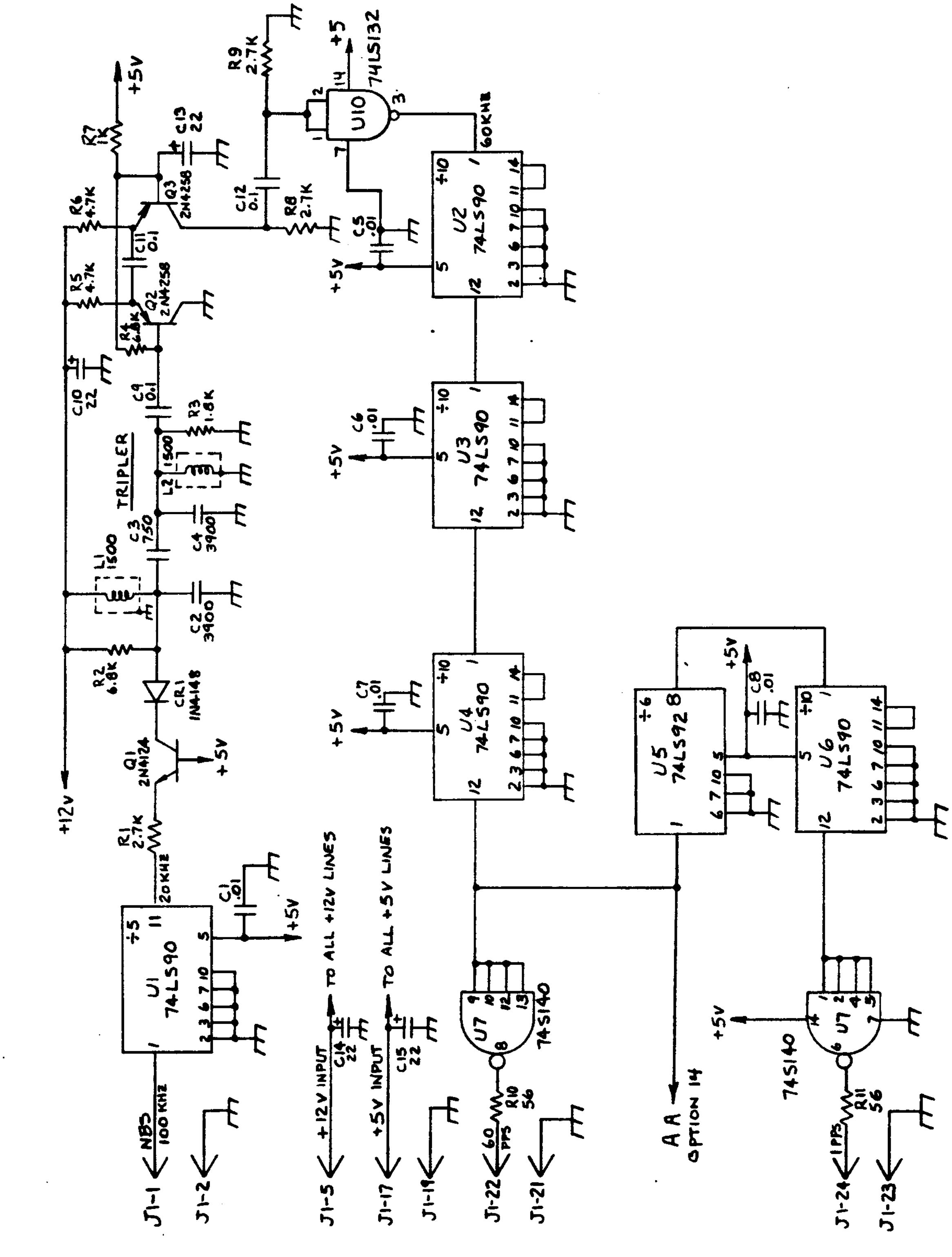


FIGURE 5-7 OPTION 15 - SCHEMATIC

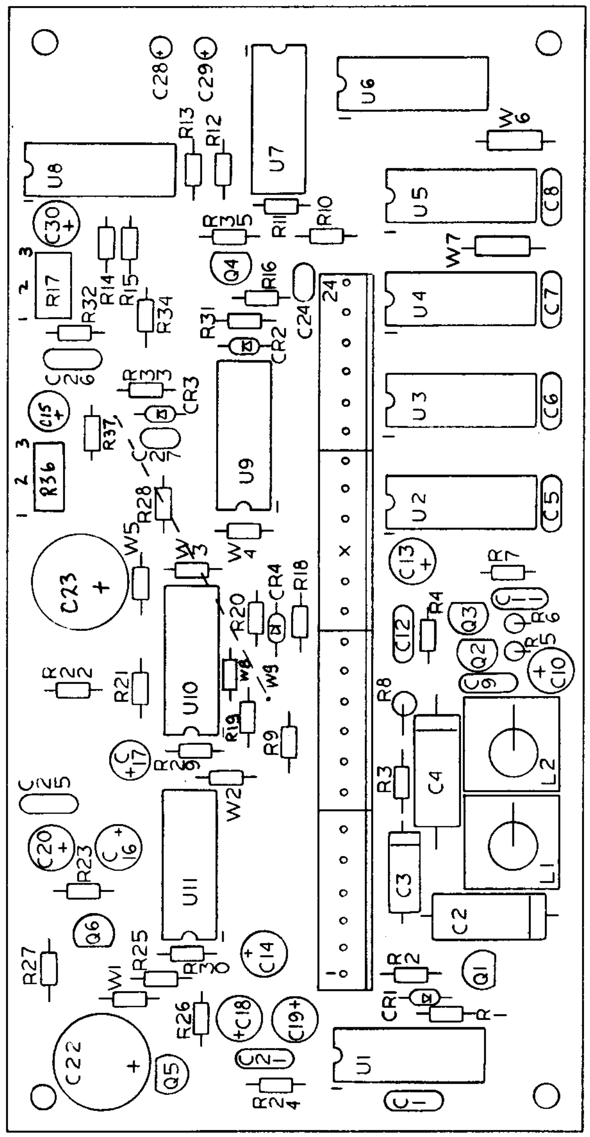


FIGURE 5-8 OPTION 15 - COMPONENT LOCATION DIAGRAM

5.7 OPTION 16 WITHOUT FREQUENCY STANDARD OSCILLATOR

Option 16 removes the hi-stability oscillator and distribution assemblies from the Model 8161. This provides users who have a house standard the ability to compare that standard against WWVB. The results from the comparison are permanently recorded by the strip chart recorder. Accuracy of parts in 10^{-9} can be obtained over a measurement time of an hour. Accuracies of parts in 10^{-11} are possible if the measurement time is extended to 8 to 24 hours.

5.7.1 OPTION 16 FRONT PANEL FUNCTIONS

Power Switch:
Depressing the pushbutton applies power to the receiver.

Frequency-MHz Switches (0.1, 1.0, 5.0, 10):
These four pushbuttons select the frequency of operation associated with the two BNC connectors on the front panel (the connector functions are described below).

Unlock/Lock Lamps:
The red lamp is lit when there is insufficient signal received for the receiver to lock to the WWVB carrier. This is usually due to improper placement or aiming of the antenna. The green lamp lights when the receiver acquires phase lock.

REF Output Connector:
The BNC connector provides an output signal that is phase locked to the Bureau of Standards signal whenever the green phase lock lamp is lit. The output frequency is selected by means of the Frequency-MHz Switches described previously. The output is TTL compatible (fan out 2 max) 3.4 V rectangular pulses into 93 ohm minimum resistive load. Refer to the section entitled "Using the REF Output" for special considerations when using this output.

Local Input Connector:
The BNC connector is the input jack for local frequency standard oscillators to be calibrated or tracked against WWVB. The input frequency must be the same as that chosen by the Frequency-MHz Switch. The minimum signal level input is 100 mV rms into 1000 ohms. See "Using the Phase Comparator" for phase comparison operating instructions.

Lock Volts Display Lamp:
The red lamp warns the operator that the strip chart recorder is displaying VCO lock voltage instead of phase comparison.

Recorder Off/On Switch:

Depressing the pushbutton starts the chart recorder. The chart drive is disabled and impressions are not made on the chart paper when the button is not depressed. The meter movement in the recorder continues to function normally if the recorder is not turned off with the striker bar holding the meter needle against the paper.

Recorder EXP Switch:

Depressing the pushbutton expands the meter/recorder scale to read 10 microseconds full scale. When the button is not depressed, the full scale reading is 50 microseconds.

Recorder V Switch:

Depressing the pushbutton causes the strip chart recorder to display VCO lock voltage (see Lock Volts Display Lamp). When the button is not depressed, the recorder displays phase comparison.

Strip Chart Recorder:

The normal readout is phase comparsion in microseconds of relative time. The recorder may be switched to read VCO lock voltage for diagnostic purposes. The integral meter scale at the top of the display provides a real time readout, while the strip chart records continuously with impressions every three seconds. Paper roll replacement and speed changes may be made from the front panel by removing the front cover.

5.7.2 OPTION 16 REAR PANEL FUNCTIONS

Antenna:

This BNC connector is the antenna input to the receiver.

115 VAC/230 VAC Switch:

To prevent damage to the unit, verify that this switch is set to the correct input voltage and that the correct fuse is inserted in the fuse holder.

Line Fuse:

This is the main power fuse for the unit. When operating this unit at 115 VAC use a 3/4 amp fuse. If the unit is to be operated at 230 VAC use a 3/8 amp fuse.

Power:

This is the input jack from the power source.

AUX IN/OUT:

Auxillary and remote functions of the receiver are available at this 15-pin connector. Use Figure 5-9, AUX IN/OUT J6 a view from the rear of the unit, to locate the pins.

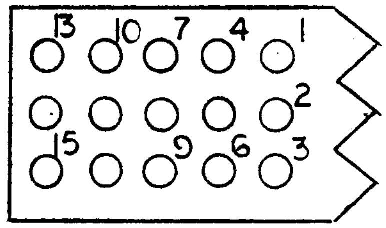


FIGURE 5-9 AUX IN/OUT J6, REAR VIEW

PIN 1 Phase Comparator Output (+). For driving any external meter or strip chart recorder with a 0-1 ma meter movement. (1500 ohms max.)

PIN 2 Phase Comparator Output (GND)

PIN 4 Time Code Output (GND)

PIN 5 Phase Lock Output (+). Allows remote monitoring of receiver phase lock condition. Ground when unlocked, +5 VDC behind 3.3K ohms when locked.

PIN 7 Time Code Output (+). Logic high is +5 VDC behind 3.3K ohms, low is ground.

PIN 13 10 MHz Phase Locked Output (+). TTL compatible (fan out, 2 max.) 3.4 rectangular positive pulses into 93 ohms min. resistive load.

PIN 14 10 MHz Phase Locked Output (GND).

5.7.3 INITIAL TURN-ON

After the receiver and antenna have been installed as described in Section 1 of this manual, plug the receiver into the power line, making sure that the rear panel slide switch is in the correct position for the line voltage. Turn the power switch on and note that the green lock lamp lights within one minute. If the red unlock lamp stays lit, insufficient signal is being received, probably due to improper antenna placing or alignment. Recheck the antenna installation and refer to "Signal Strength" found in Section 2 to optimize antenna orientation.

5.7.4 USING THE REF OUTPUT

The output signal at the REF output connector on the receiver front panel is phase locked to the WWVB 60 kHz carrier. The frequency of the output signal is selected by pressing the Frequency-MHz pushbutton on the front panel which corresponds to the desired frequency (0.1, 1.0, 5.0, or 10.0 MHz). The output signal may be used as a standard for checking the accuracy of frequency counters, or it may be used in a variety of ways as a standard frequency signal. Some pulse jitter will appear on the signal due to atmospheric noise at the receiver antenna. The counting jitter caused by this is usually not worse than a few parts in 10^{-8} in a one-second averaging period if the antenna is well-installed. The long term accuracy of this signal can be considered as good as that of the WWVB carrier signal since it is phase locked to it.

Caution should be observed when coaxial cable is used to feed the output signal to the load. The signal is a TTL square wave, and 93-ohm terminated cable should be used for long runs where the waveform must be preserved.

5.7.5 USING THE PHASE COMPARATOR

Connect the local signal that you wish to calibrate to the LOCAL INPUT connector. Depress the FREQUENCY button corresponding to the input frequency being compared. Turn the chart recorder ON by depressing the RECORDER ON switch. Do not depress the RECORDER EXP switch. The frequencies that may be calibrated are 0.1 MHz, 1.0 MHz, 5.0 MHz, and 10.0 MHz.

Changes in the phase relationship between the local input signal and the NBS reference signal show up as meter movement. If the meter is perfectly constant, there is zero drift in the phase relationship and the local signal is exactly on frequency. The rate at which the meter moves measures the frequency error.

$$\text{FREQUENCY ERROR} = \frac{\text{PHASE SHIFT}}{\text{TIME}}$$

For example, if it takes 50 seconds for the meter to deflect full scale (50 microseconds), then the frequency error of the local signal is:

$$\text{FREQUENCY ERROR} = \frac{50 \text{ X } 10^{-6} \text{ sec}}{50 \text{ sec}}$$

$$\text{FREQUENCY ERROR} = 1 \times 10^{-6}$$

If the meter deflects left to right, then the local input frequency is higher than the NBS reference. If the local input is lower than the reference, then the meter will deflect from right to left.

The scale may be changed from 50 microsecond full scale to 10 microsecond full scale by depressing the RECORDER EXP switch. Normally, the switch is left in the 50 microsecond full scale position (not depressed).

Adjust your local oscillator so the meter is not moving. The longer the phase drift is monitored, the greater the precision of the calibration. The chart recorder should be used for observations over periods of hours or days.

When the local frequency is in error by a large amount, the phase reading may change too rapidly for the meter to follow. In this case, first use a counter to adjust your local oscillator so the frequency is within 1×10^{-6} of the NBS reference.

WWVB identifies itself by advancing its carrier phase 45° at 10 minutes after every hour and returning the phase at 15 minutes after the hour. These phase changes will show up as meter deflection of 2.1 microseconds. Sample frequency error calculation and sample traces are found in Section 2 of this manual.

5.7.6 THEORY OF OPERATION

The Model 8164 with Option 16 Receiver consists of an RF Amplifier (A1) and a Receiver Assembly (A2). The theory of operation of these two assemblies is discussed in Section 4 of this manual.

5.7.7 SERVICE INFORMATION

Calibration and troubleshooting information is covered in Section 6 of this manual. Perform only the alignment procedures for the A1 and A2 board assemblies.

5.8 OPTION 28 1 KHZ OUTPUT

This option provides a 1 kHz output derived from the internal standard oscillator to the rear panel AUX connector. Refer to Section 2.10, "Rear Panel Functions", on page 2-20 for the physical pin locations. The 1 KHz output is found on pin 12. The pulse is a symmetrical TTL-compatible (fan out 2 maximum) 3.4V rectangular positive pulse that will drive a 93 ohm minimum resistive load. Pin 15 is ground.

Accuracy: Frequency accuracy may be obtained directly from the strip chart recorder. Refer to Section 2.8, "Frequency Error Calculation" on Page 2-13, to determine the standard oscillator accuracy.

5.8.1 PRINCIPLES OF OPERATION

The schematic for Option 28 is shown in Figure 5-10. The assembly drawing is Figure 5-11. The board is physically located between the front panel and the A2 board.

The STD 100 kHz from A2J3-11 is fed into U5-1, where it is divided by 10. This 10-kHz signal is fed into U4-1 and divided down to 1 kHz. Buffer amplifier U3 feeds the signal to the rear panel AUX IN/OUT connector.

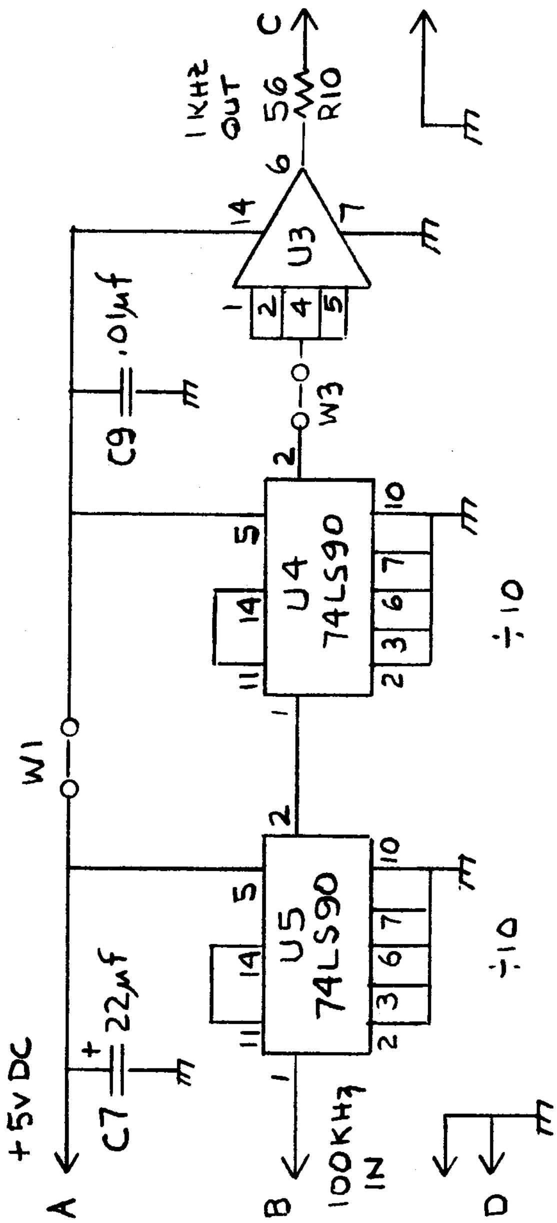


FIGURE 5-10 OPTION 28 SCHEMATIC

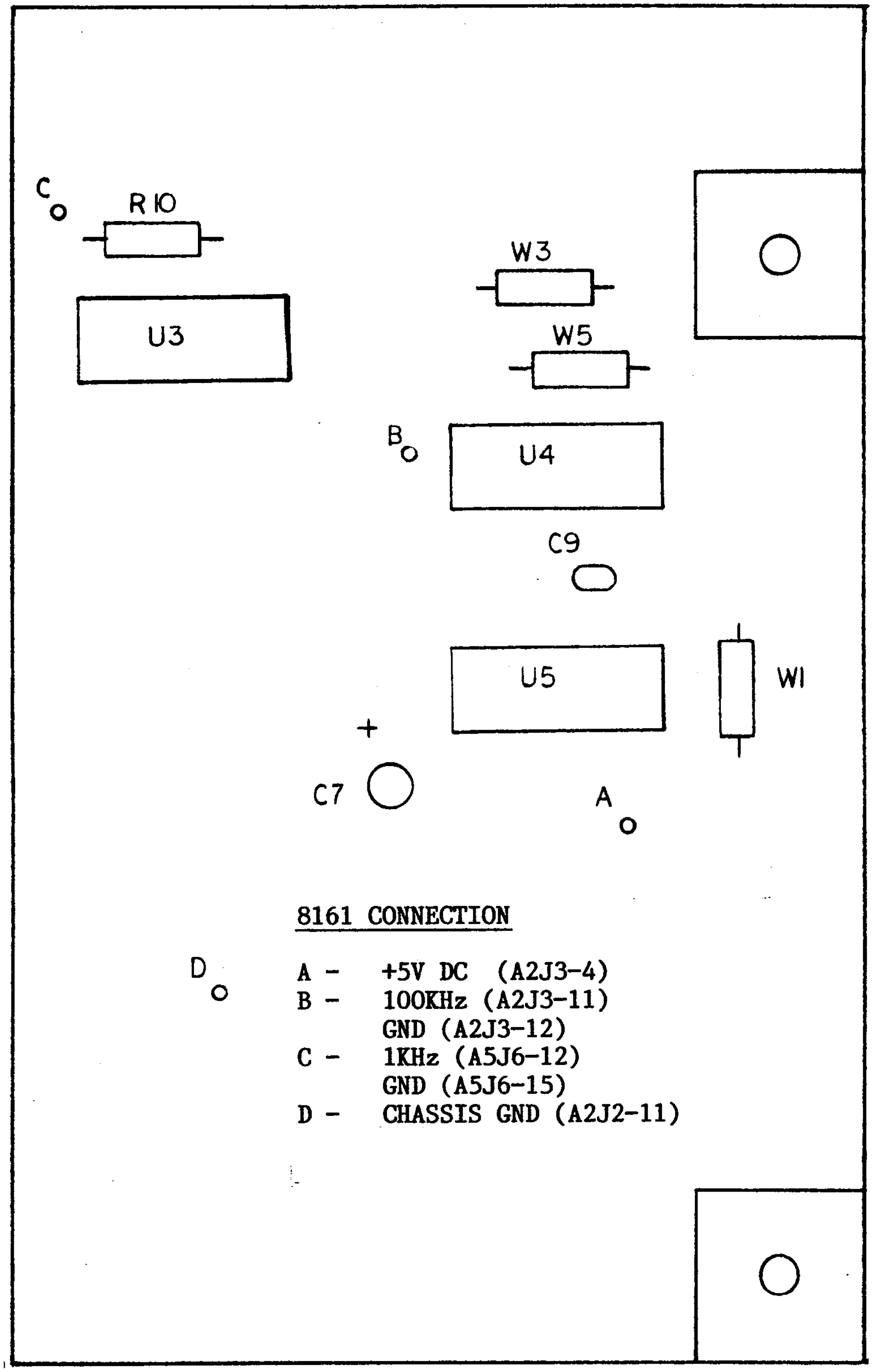


FIGURE 5-11 OPTION 28 ASSEMBLY DRAWING

5.9 ACCESSORIES

Model 8140T Line Tap: Furnishes sinewave output at remote test station. Specify output frequency for each when ordering. For use with Option 03.

Model 8140TTL Line Tap: Same but with TTL output. For use with Option 03.

Model 8140TA Distribution Line Amplifier: Boosts output signal to drive beyond 1500 ft. of RG-58. For use with Option 03.

Model 8140VT VersaTap™: Single frequency synthesizer.

Model 8206 Loop Antenna: Weather sealed high-gain directional ferrite loop. Built-in preamp gets DC power over coaxial cable (RG-58 is recommended) from the receiver. Equivalent electrical height is 5.0 cm, size 14.5 L x 2.75 dia. inches (368 L x 70 dia. mm). Required for all Spectracom WWVB receiver.

Model 8207 Line Preamplifier: 60-kHz line amplifier used in antenna feed line for fringe area reception, provides 40 dB gain. Gets DC power over cable from receiver. Size 5 L x 3 W x 1.7H inches (12.7 c 7.6 x 4.3 mm). Not recommended in 48 states or southern Canada.

Model 8211 Antenna Mount: Freestanding base and non-metallic mast with two 2-foot sections for mounting 8206 Antenna. Use of a single 2-foot section recommended for most installation. Base should be weighted or fastened to roof for wind stability.

Chart Paper: Part No. MP00025, ten rolls for front panel recorder in Model 8161. One roll lasts one month.

Model 8171A Synchronized Clock: Uses the WWVB time code and translated carrier frequency from the 8161 receiver to provide precise time. A microprocessor performs digital filtering, decoding, phase locking, and time-keeping functions, and provides a front panel time display and rear panel data outputs. Computer interfaces are RS-232, RS-422 and optionally parallel BCD.

Additional Instruction Manual: One manual is furnished with each instrument. Additional manuals may be purchased as needed.

Antenna Cable: RG-58 coaxial cable with BNC connectors. Specify length in feet.

SECTION 6

8161

SERVICE INFORMATION

6.0 SERVICE INFORMATION

This section contains calibration, alignment and test procedures for the Model 8161 WWVB Receiver/Comparator and accessory items.

6.1 CALIBRATION OF WWVB RECEIVERS

Periodic calibration of a WWVB receiver, in the usual sense that an instrument must be sent to the Bureau of Standards or calibrated against a traceable standard, is unnecessary. Time and frequency are the only two measurable quantities that can be transmitted via a radio signal. Because of this, it is possible to be "connected" directly to the Bureau of Standards via a radio signal for calibration of both time and frequency.

We can draw a simple analogy by considering a secondary voltage standard, or standard cell, which is used for voltage calibration. Standard cells are usually returned to the Bureau of Standards or a secondary standards laboratory where they are calibrated and certified traceable to the Bureau of Standards. If it were possible to have a pair of wires connected from your laboratory directly to the "standard volt" at the Bureau of Standards, it would be unnecessary to return your voltage cell periodically to the Bureau of Standards for calibration. This is exactly the situation that we find with time and frequency being received by a radio signal directly from the Bureau of Standards. Periodic "calibration" of the instrument is unnecessary because its output is being derived directly from the Bureau of Standards. The only periodic checks that are necessary are one to determine that the receiver is operating properly and that the correct signal is being received.

Spectracom recommends an abbreviated procedure for verifying proper equipment operation. For those users concerned about formal establishment of calibration traceability, the following monthly checks will be sufficient, especially if formally recorded in a log book.

1. Check to see that the green lock light is lit on the front panel of the receiver. This establishes that the receiver is phase locked to a 60 kHz signal being received via the antenna.

2. Check to see that the hourly offset of approximately 2.1 microseconds is occurring at 10 minutes after each hour, returning to normal at 15 minutes after the hour. These offsets occur due to the 45° phase shift that is applied to the signal at the transmitter at 10 minutes after the hour, returning to normal 15 minutes after the hour. The presence of those offsets both identifies the station and gives hourly "time ticks" on a chart recorder trace of the phase comparator output. Their presence indicates that the chart recorder line can be coming only from the National Bureau of Standards.

3. Move the front panel meter switch to the "lock voltage" position, and observe that the reading is at or near center scale. If this reading is reaching the outer boundaries of the middle one-third of the scale when the green lock light is on, a trimmer adjustment should be made on the A2 circuit board in the receiver to recenter the meter reading. To obtain a center scale reading, first verify that the green lock light is lit due to an antenna signal, then adjust A2C10 to obtain a center scale reading. This is a very sensitive adjustment, and must be made very slowly in extremely small increments. The long time constant in the phase locked loop will prevent the meter reading from changing rapidly, and at least 30 seconds must be allowed between adjustments for the phase locked loop to settle down. This adjustment compensates for the long-term aging of 10 MHz crystal A2Y1 which is phase locked to the WWVB carrier frequency. In a properly functioning receiver, this adjustment should not need to be made more often than every 6 months.

If the answers to the three items on the checklist are yes, assurance is established that the receiver is operating properly, and that calibration made with it are traceable directly to the Bureau of Standards.

CHECKLIST

	YES	NO
1. Lock Lamp Lit	_____	_____
2. Offset (phase shift) of 2.1 usec at 10 and 15 minutes after each hour.	_____	_____
3. Lock Voltage near center scale.	_____	_____

6.2 RF AMPLIFIER ASSEMBLY (A1 BOARD) ALIGNMENT PROCEDURES

1. Disconnect the AGC wire (violet) from Connector A1P2, Pin 6, but leave the remaining wires in place and the connector mated.

2. Connect an oscilloscope probe to A1E3. Set the scope for AC coupling. The ground lead is connected to the chassis.

3. Connect a signal generator to the antenna input of the receiver. Set the generator to provide a 1.0 uv rms signal at exactly 60,000 Hz, unmodulated.

   CAUTION: There is 12 VDC at the antenna input connector. This is used to power the Model 8206 Loop Antenna or the Model 8207 Line Preamplifier. It may be necessary to connect a decoupling capacitor between the signal generator and receiver if the generator is not reverse power protected. If needed, choose a capacitor value around 10 uf and install with the plus side (+) to the receiver.

4. Apply power to the receiver and adjust the signal generator level as necessary to provide a 1 volt p-p output signal on the oscilloscope.

5. Adjust the slug in transformer A1T1 for a peak on the oscilloscope, while reducing the signal generator level to maintain the 1 V p-p output.

6. Adjust capacitor A1C8 for maximum output on the scope.

7. Readjust the signal generator frequency to 100,000 Hz and increase the output for a reading of 1 V p-p on the oscilloscope. (Do not exceed 0.1 volt rms at the antenna input.)

8. Adjust capacitor A1C9 for minimum output on the oscilloscope, while increasing the signal generator level to maintain 1 V p-p output. (Do not exceed 0.1 volt at the antenna input.)

9. Readjust the signal generator output frequency to 60.000 kHz at a 1 mv rms level.

10. Synchronize the oscilloscope, and observe the output waveform and level. The output should be a square wave with a 50% ±10% duty cycle and 3V p-p ±20% amplitude.

11. Set the signal generator output level at 5 uv. The oscilloscope amplitude should equal or exceed 1.5V p-p (the rms output will be a sine wave until the clipping point is reached at approximately 3V p-p).

12. The AGC Alignment is performed as described in step 1/ of the Receiver Assembly (A2 board) procedure described below.

    NOTE: The AGC wire (violet) remains disconnected until step 1/ of the Receiver Alignment.

13. Disconnect the oscilloscope and signal generator.

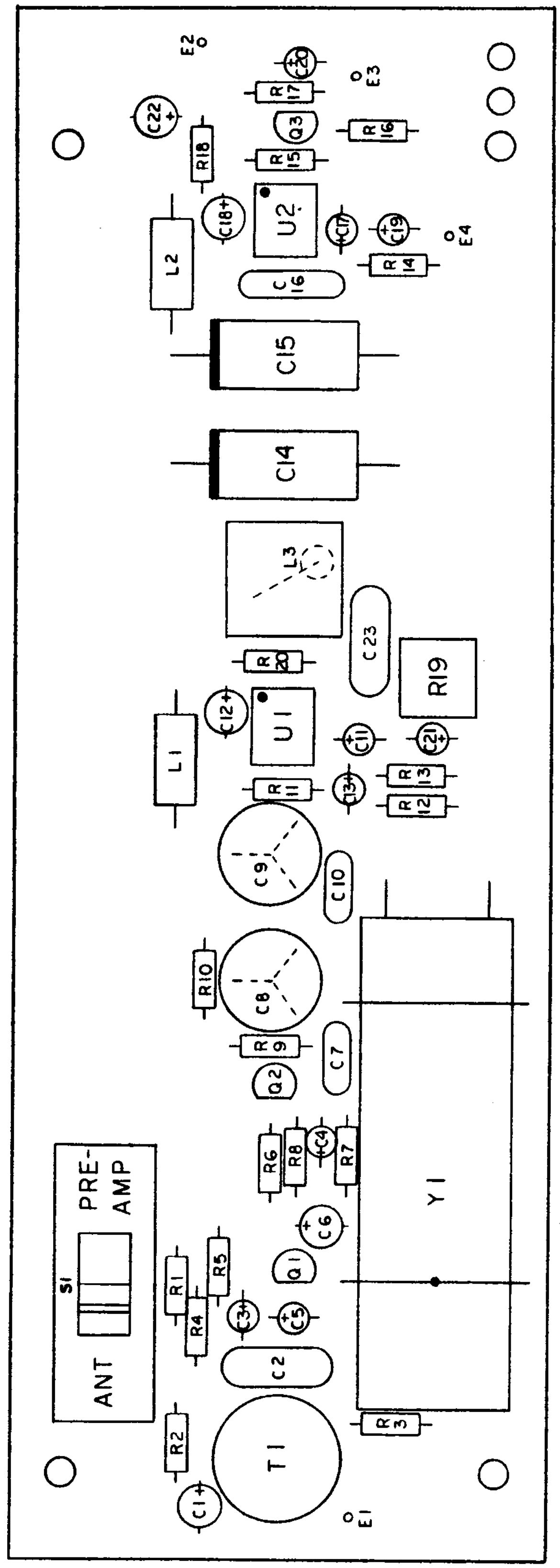


FIGURE 6-1 ASSEMBLY DRAWING - A1 RF AMPLIFIER

6.3 RECEIVER ASSEMBLY (A2 BOARD) ALIGNMENT PROCEDURES

1. Connect a clip lead from A2E2 to A2E3. Connect the negative lead of a DVM to test point A2TP3 and the positive lead to test point A2TP4. Set the DVM for a full scale range of ±2V. There should be no connection to the antenna input at this time.

2. Apply power to the receiver. The DVM should read zero ±5 mV. If the voltage variation is greater than ±5 mV, adjust potentiometer A2R30. Some variation will be noted, but it should be less than ±5 mV.

3. Move the positive DVM lead from test point A2TP4 to A2TP6. The reading should be less than 500 mV. Glyptol A2R30 if it has been adjusted.

4. Move the positive DVM lead to test point A2TP2 and the negative DVM lead to A2TP1.

5. The DVM reading should be zero ±5 mV as observed in step 2 above. If the voltage variation is greater than +5 mV, adjust potentiometer A2R5.

6. Remove both DVM leads from the test points and turn off the receiver.

7. Move the clip lead from A2E3 to A2E4 (A2E2 jumpered to A2E4). Set the meter switch on the receiver front panel to read "Lock Voltage."

8. Apply power to the receiver. The meter should read 80% of full scale. If it does not, adjust potentiometer A2R14. Glyptol A2R14 if it has been adjusted.

9. Connect a frequency counter to the NBS Output Connector on the receiver front panel. Select the 10 MHz output frequency by pressing the 10 MHz frequency pushbutton. The counter should read 9,999.900 kHz (9.999900 MHz). If necessary, adjust capacitor A2C10 to obtain this reading. Disconnect the frequency counter and the clip lead from A2E2 to A2E4.

10. Connect the NBS Output Connector on the receiver front panel to a spectrum analyzer or selective voltmeter through a suitable attenuator. The 10 MHz output frequency should be selected as described in step 9 above.

11. Adjust potentiometer A2R23 for minimum 2nd harmonic (20 MHz) on the spectrum analyzer. It should be adjustable to at least -20 dB relative to the 10 MHz output. Glyptol A2R23.

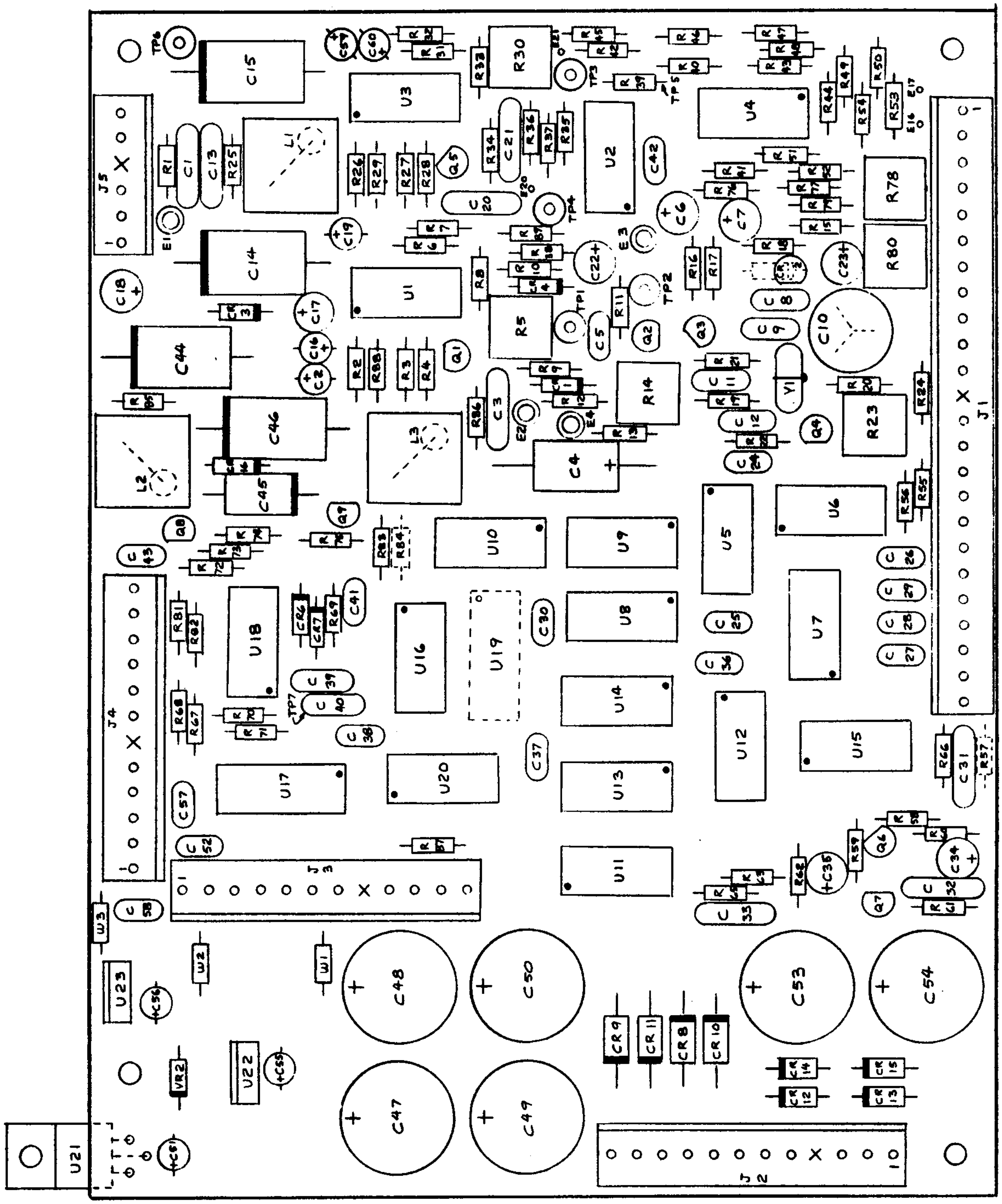


FIGURE 6-2 ASSEMBLY DRAWING A2 RECEIVER

12. Connect a signal generator to the receiver antenna input, set the level at 1 mV output at 60.000 kHz unmodulated. The receiver should lock to this signal as indicated by the green lock lamp being lit. The meter should indicate a lock voltage exactly at center scale. If necessary, adjust capacitor A2C10 very slowly until the lock voltage is exactly at center scale.

13. Disconnect the signal generator from the receiver antenna input and note the Lock Voltage meter reading on the receiver front panel drift (disregard any sudden small jump at the moment of disconnection). If a downward drift is observed, adjust A2R5 clockwise by very small amounts until the drift is stopped (small jumps may occur as the potentiometer is adjusted, disregard these and note only the slow drift). Conversely, if an upward drift is observed, adjust potentiometer A2R5 CCW by very small amounts until the drift is stopped. This is a very fine adjustment, and is completed when no perceptible drift is evident after one minute of observation. Glyptol the potentiometer if it has been adjusted.

14. Connect the signal generator to the receiver antenna input and set it for a 1.0 microvolt signal at 60.000 kHz, unmodulated.

15. Connect the negative lead of a DVM to test point A2TP3. Select a scale in the +5 to +20 VDC range and connect the positive lead to test point A2TP6. The reading should increase to greater than 2.38 V after the receiver has locked (green light on). Lock-up may take several minutes at the 1.0 uV input, and the voltage at test point A2TP6 may continue to rise after the green lock light has lit.

16. After the voltage at the above test point has exceeded +2.38V, decrease the signal generator output level by small amounts (less than 1 dB) until the voltage has decreased to +2.38V. When approaching the correct voltage, it will be necessary to wait one minute or more between a signal generator level changes, as the voltage read on the DVM is delayed by 90-second time constant from the initiation of change. A +2.38V reading at test point A2TP6 is normally reached with an antenna input level between 0.25 and 1.0 uV.

17. Without changing the signal generator level from that obtained in step 16 above, reconnect the violet AGC wire to pin 6 of connector A1P2 (see step 1, RF Amplitier Assembly). The DVM reading will slowly decrease and stabilize at +1.38 volts. If the DVM stabilizes at a different reading, adjust the AGC control potentiometer, A1R19, on the RF Amplifier Assembly (A1) in very small amounts until the meter reading stabilizes at 1.38 volts. A wait of one minute or more between pot settings may be necessary due to the long time constant described above. If potentiometer A1R19 has been adjusted, it must be glyptolled.

18. Increase the signal generator level to 10 uV and wait a minute for the receiver to stabilize. Decrease the signal generator level to 1.0 uV and allow one minute for the receiver to stabilize. The green lock lamp should be lit. Slowly decrease the signal generator level (do not exceed 1 dB per 10 seconds) until the red unlock lamp comes on (do not decrease the level further than necessary). A level between 0.1 and 0.5 uV should be required.

19. Slowly increase the signal generator level (do not exceed 1 dB per 10 seconds) until the green lock lamp comes on. The level will typically be 6 dB above that determined in step 18, and should be between 0.25 and 1.0 uV Disconnect the DVM from test points TP3 and TP6.

20. Turn off the receiver and recheck the mechanical zero adjustment of the chart recorder.

21. Turn the receiver on. The recorder EXP switch and the recorder V switch should not be depressed, for phase comparator operation at 50 usec full scale. The 10 MHz frequency pushbutton should be pressed. There should be no connection to the phase comparator input on the receiver. The comparator switch should be in the left (local input) position. Ground test point A2TP7 to the chassis with a clip lead. The recorder should indicate full-scale deflection. If it does not, adjust potentiometer A2R78. Reglyptol the potentiometer if necessary.

22. If an external meter or recorder is to be used, full scale calibration can be performed by adjusting potentiometer A2R80. Test point A2TP7 must be grounded as described above. Only devices with a range of 0 to 1 ma and a DC resistance which does not exceed 1500 ohms may be calibrated. Reglyptol the potentiometer if it has been adjusted.

23. Disconnect the clip lead from test point A2TP7 to the chassis, and connect a stable and accurate 10 MHz source to the phase comparator input on the receiver. (One of the other input frequencies may be used if 10 MHz is not available. The appropriate Frequency MHz pushbutton must be pressed.) Set the frequency source for an output of at least 100 mV (50 mV indicated on a 50-ohm output impedance signal generator).

24. Normal phase comparator operation should be observed when the receiver antenna input is connected to either a 60.000 kHz, 100 uV signal generator output or to a normally installed antenna system (allow time for lock-up).

25. Decrease the frequency comparator external source input level until phase comparator operation becomes erratic, then increase the level until stable operation is attained. This shall be at an input level of no more than 100 mV.

26. Disconnect the signal generator.

6.4 OSCILLATOR AND POWER SUPPLY ASSEMBLY (A5 BOARD)

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 pin 3 of the auxiliary connector on the rear panel of the receiver. Place the rear panel battery selector switch in the EXT position. The DMM should read +27.6 V at 25° 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 reglyptol 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 ± .05 A. This measurement checks the minimum 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 reglyptol it.

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

Oscillator Alignment

NOTE: Alignment is not required until front panel dial indicator is out of range.

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 pushbutton and connect a frequency counter to the standard output connector. The counter must have an accuracy of at least 1×10^{-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 (accessable through the top of the oscillator) 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.

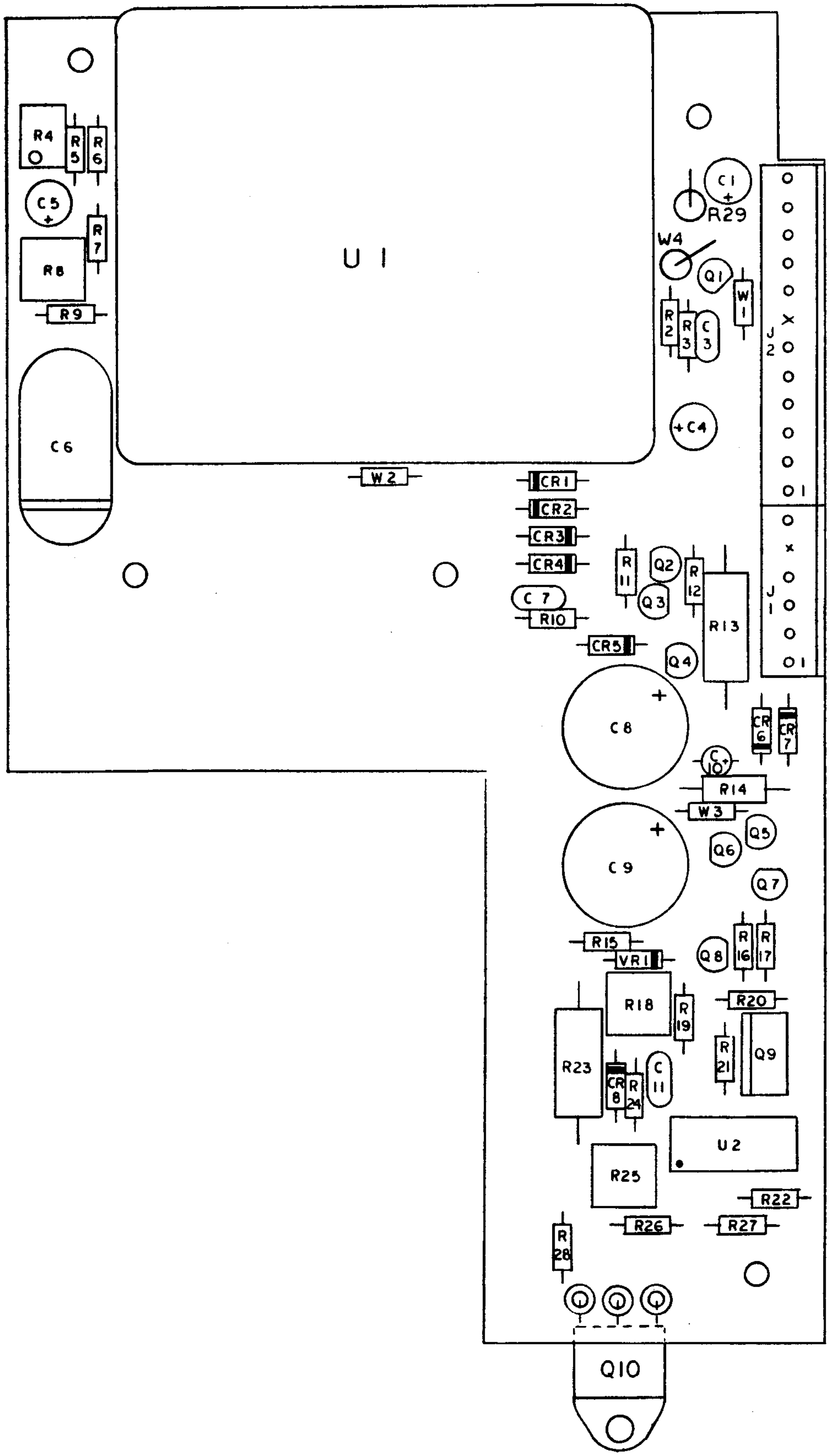


FIGURE 6-3 ASSEMBLY DRAWING - A5 OSCILLATOR & POWER SUPPLY

NOTE: Use a metal tipped non-metallic tuning tool for the coarse adjustment. Replace the coarse adjustment sealing screw 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 <u>exactly</u> 5.0 Hz (.0050 kHz) below that obtained in step 3 above. If it does not, adjust potentiometer A5R8 for the correct reading and reglyptol it.

6. Set the front panel frequency control for a counter reading of <u>exactly</u> 10 MHz, then calibrate to any greater degree of precision desired using the WWVB signal or other suitable means.

   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 <u>coarse</u> frequency control, unless a complete oscillator realignment is performed.

RECEIVER ALIGNMENT CHART

Power Supplies +5V	________	VDC
+12V	________	VDC
-12V	________	VDC
RF Amp - T1 Tuning	________	
- Input @ 1v p-p Output	________	uV
- Xtal Fltr Tune A1C9	________	
- Stopbank Null A1C9	________	
- Output/5uV In	________	Vp-p
Quad Detector Balance A2R30	________	
0 Detector Balance A2R5	________	
Lock Volts Set @ 80% A2R14	________	
Oscillator - Preset A2C10	________	
- Symmetry A2R23	________	
Lock Volts with Signal A2C10	________	%FS
0 Detector Drift A2R5	________	
AGC Volts Disconnected	________	VDC
AGC Connected - Set A2R19	________	VDC
Sensitivity - Unlock	________	uV
- Lock	________	uV
AGC Volts @ Unlock	________	VDC
@ 1.0 uv	________	VDC
@ 100 uv	________	VDC
Antenna Volts DC	________	VDC
FP Outputs - NBS 4 Freq	________	
- Std 4 Freq	________	
RF Outputs - All 4 jacks	________	
Output Fault - 4 jacks	________	
0 Comparator - Mech Zero	________	
- F.S. A2R78	________	
- Sensitivity	________	
All 4 Freqs	________	
- 50 usec	________	
- 10 usec	________	
Line Interrupt Ckt	________	
Osc Warmup Start Date	________	
Oscillator - Adj 27.6V-A5R18	________	
- Adj 21.0V-A5R25	________	
- Max Chg Rate	________	mADC
- 24 Hr Warmup	________	
1000 Coarse 10,000,002.5	________	
000 A5R4 9,999,992.5	________	
500 A5R8 9,999,997.5	________	
Dial Setng@ 10,000,000.0	________	

6.5 MODEL 8207 PREAMP ALIGNMENT

The Model 8207 Antenna Preamplifier is a low noise, tuned, 60 kHz line amplifier used in the antenna feed line if the WWVB signal strength is less than 0.3 uV at the receiver antenna terminator.

Set the receiver A1S1 switch to the preamp (P) position.

Use the RG-58 coax to connect the preamp between the signal generator and the WWVB receiver as shown in Figure 6-4, "Model 8207 Preamplifier Alignment".

Physically separate the preamp from the receiver by at least 10 feet. Keep the cable from the signal generator to the preamp away from the vicinity of the receiver to prevent signal regeneration.

In the receiver, disconnect the AGC wire (violet) from connector A1P2, Pin 6, but leave the remaining wires in place and the connector mated.

Connect an oscilloscope probe to A1E3. Set the scope for AC coupling. The ground lead is connected to the chassis.

Set the generator to provide a 1.0 uV signal at exactly 60.000 kHz, unmodulated.

Apply power to the receiver and adjust the signal generator level as necessary to provide a 1 volt peak-to-peak output signal on the oscilloscope.

Adjust the slug in transformer A1T1 in the Model 820/ for a peak on the oscilloscope, while reducing the signal generator level to maintain the 1 V p-p output.

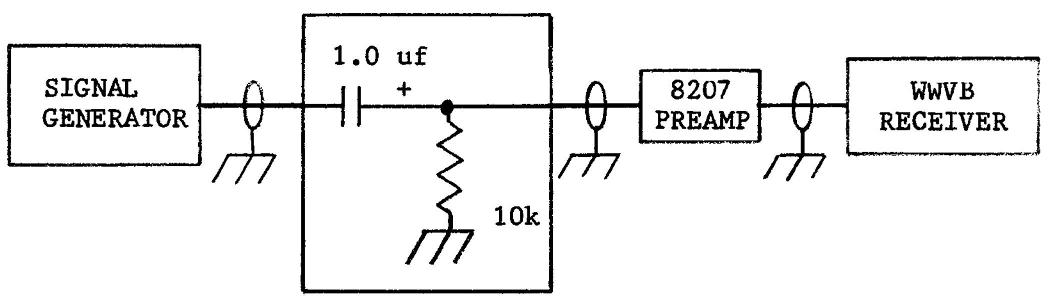


FIGURE 6-4 MODEL 8207 PREAMPLIFIER ALIGNMENT

6.6 LINE TAP (Model 8140T) TEST PROCEDURES

1. Connect a coaxial BNC tee to the output of the line tap under test. Connect the 50-ohm load to one output of the tee and connect the oscilloscope to the other tee output. Refer to Figure 6-5 for test set up.

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

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

4. Remove the 50-ohm output termination. The scope should show 3.0 V p-p minimum (4.0 V p-p 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.

6.7 ANTENNA (Model 8206) TEST PROCEDURES

1. Connect a length of coaxial cable to the output connector of a signal generator.

2. Wrap 2 turns of wire around the antenna. Connect one end of the wire to the coaxial cable shield. Connect the other side to a 1K ohm resistor. The other side of the resistor is connected to the center conductor of the cable as shown in Figure 6-6.

3. Adjust the signal generator for an output of 60.000 kHz at .007 V RMS (.014 volts behind 50-ohms).

4. Connect the output connector of the antenna to the oscilloscope as shown in the above figure, i.e., connect a .1 uf capacitor in series with the scope input.

5. Connect a 12 VDC power supply to the antenna output through a 27K ohm series resistor.

6. The oscilloscope shall display a 60.0 $\pm$.3 kHz resonant frequency at an amplitude of approximately 0.010 v p-p and a bandwidth at the 3 dB points of approximately 1 kHz.

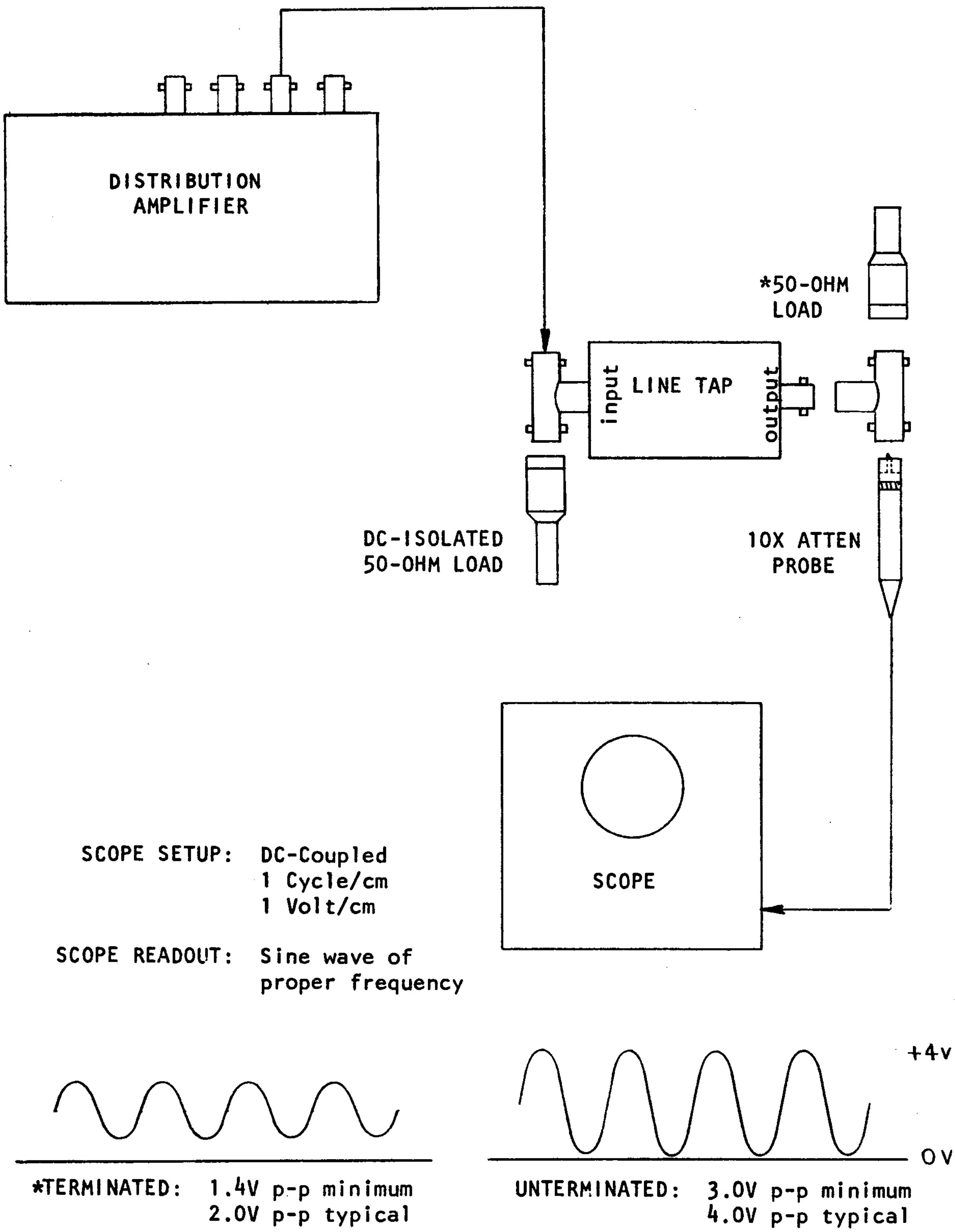

DISTRIBUTION
AMPLIFIER
*50-OHM
LOAD
input
LINE TAP
output
DC-ISOLATED
50-OHM LOAD
10X ATTEN
PROBE
SCOPE
SCOPE SETUP: DC-Coupled
1 Cycle/cm
1 Volt/cm
SCOPE READOUT: Sine wave of
proper frequency
+4v
0V
*TERMINATED: 1.4V p-p minimum
2.0V p-p typical
UNTERMINATED: 3.0V p-p minimum
4.0V p-p typical

FIGURE 6-5

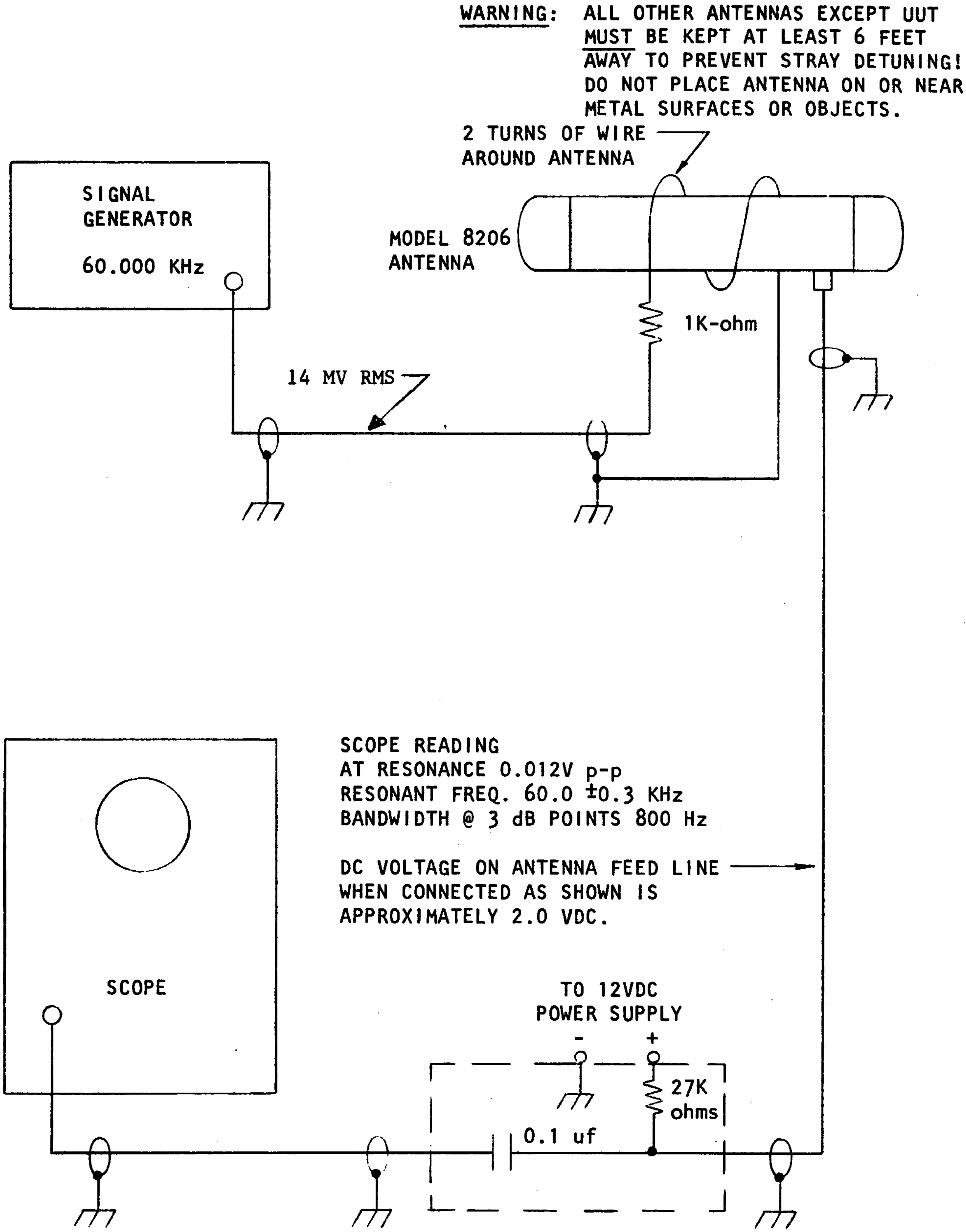

WARNING: ALL OTHER ANTENNAS EXCEPT UUT MUST BE KEPT AT LEAST 6 FEET AWAY TO PREVENT STRAY DETUNING! DO NOT PLACE ANTENNA ON OR NEAR METAL SURFACES OR OBJECTS.
2 TURNS OF WIRE AROUND ANTENNA
SIGNAL GENERATOR
60.000 KHz
MODEL 8206 ANTENNA
1K-ohm
14 MV RMS
SCOPE READING
AT RESONANCE 0.012V p-p
RESONANT FREQ. 60.0 ±0.3 KHz
BANDWIDTH @ 3 dB POINTS 800 Hz
DC VOLTAGE ON ANTENNA FEED LINE WHEN CONNECTED AS SHOWN IS APPROXIMATELY 2.0 VDC.
SCOPE
TO 12VDC POWER SUPPLY
-
+
27K ohms
0.1 uf

FIGURE 6-6

6.8 TROUBLE SHOOTING

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

1. Receiver does not lock. Improper reception. The most efficient way of solving this type of problem is to isolate the problem to one of the three major receiver system components. These are antenna, A2 RF amplifier assembly, and A2 receiver board assembly.

   A. Antenna DC check. Measure the DC voltage on the antenna line with a DVM. With the antenna connected to the receiver and the receiver turned on, the DC voltage on the coaxial line should be approximately 2.0 volts ± 10%. This can be measured by inserting a coaxial tee in the line at the rear of the receiver and measuring the antenna voltage with the antenna connected. With the antenna disconnected, the DC voltage at the antenna terminal of the receiver should be approximately 11.5 volts DC ± 10%. If both these measurements are satisfactory, proper DC conditions are verified in both the antenna and its power supply in the receiver.

   If the 11.5 volt level is not present with the antenna disconnected, the fault is in either the A1 RF amplifier assembly or in the A2 Receiver assembly. Disconnect the A1 board and check for +12 VDC at pin 1 of the connector A1P2. If the voltage is not present, the problem is in the power supply on the A2 board assembly (diodes CR12 through CR14, capacitors C53 through C57, or regulator U22). If the 12 volt level is present, the problem is in the A1 board assembly.

   B. Check the receiver without the antenna connected. Using a signal generator set at 60.000 kHz with an accuracy of $\pm 1 \times 10^{-6}$ feed a 1.0 microvolt signal from the generator to the antenna input of the receiver. Apply power to the receiver and see if the receiver locks. If it does lock under this condition, the problem is most likely with the RF performance of the antenna or with the antenna placement or installation. If the receiver does not lock with 1.0 microvolts applied, the fault is in the receiver.

   Check the 60 kHz signal at E3 of RF amplifier board A1. If the signal is present, the RF amplifier is operating satisfactorily and the problem is in Receiver assembly board A2. If the 60 kHz signal is not present at E3, the fault is in the A1 board assembly.

2. No NBS output at front panel jack. Check pin 11 of U5A on the A2 board to see that the oscillator stage containing A2Y1 is operating properly, and oscillating at 10.0 MHz. If this oscillator, which gets phase locked to WWVB, is not oscillating then the most likely problem is with the crystal Y1, which may need to be replaced. If this oscillator stage is not performing properly, the NBS output will not be present, and the receiver will not phase lock, or alternatively, the phase lock lamp may remain on continuously even though the receiver is not operating properly. This condition can be checked by removing the antenna signal and checking to see that the phase lock lamp is extinguished after approximately 30 seconds.

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 in the A2 board or in the chassis power supply components such as power transformers, filter capacitors, etc. The problem may be isolated to on or off-board causes by disconnecting all of the connectors from the A2 board and turning the unit on again. If the fuse still blows, the cause is not on the A2 board. If the fuse does not blow with the connectors removed from the A2 board, reconnect them in the following order, turning power on after each connector is reattached:

   A. Reattach the connector from the cable harness to A2J2. This connects the power transformers to the power supply rectifier circuits. If this causes the fuse to blow, the problem is most likely a power supply short on the A2 board itself. Check the voltage regulators U21, U22, and U23 for proper operation. Check to see that Zener diode VR2 is not shorted to ground. This diode provides over-voltage protection on the +5 VDC line and will fuse, shorting to ground causing a fuse to blow if U21 fails and lets the +5 volts go high. Before replacing VR2, disconnect it and check U21 for proper operation. If connecting the cable at A2J2 does not cause the fuse to blow after power is reapplied, proceed to the next step.

B. Connect the A1 assembly to A2J5. Reapply power.

C. Connect the cable harness connector to A2J1. Reapply power. If this causes the fuse to blow, the problem is most likely in the A4 or A5 assemblies, perhaps a power supply short circuit on one of these boards.

D. Reconnect the cables at A2J3 and A2J4. A2J3 provides +5 volts DC to the other parts of the receiver, including the front panel and a short on one of these lines will cause a fuse to blow.

5. Output fault light is on. The presence of a fault light indicates that a rear panel output from the instrument has disappeared. First check to see that the fault indicator circuitry is operating properly. If so, the problem lies somewhere in the frequency standard output signal path.

SECTION 7

8161

PARTS LIST

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
Main Frame	A1	001100	RF Amplifier Assembly
	A2	001200	Receiver Assembly
	A4	002400	Output Amplifier Assembly
	A4	004400	Output Amplifier Assembly (Op. 03, Distr. Ampl. Only)
	A5	002500	Oscillator/Power Supply Assy.
Front Panel Assem.	-	MP09000	Dial, Turns-counting
	C4	C00202	Capacitor, 01 uf, 1.6 KV
	DS1	DS00042	Display, LED
	DS2	DS00045	Display, LED
	DS3	DS00042	Display, LED
	DS4	DS00042	Display, LED
	DS5	DS00042	Display, LED
	J1	J00010	Receptacle, BNC
	J2	J00010	Receptacle, BNC
	J3	J00010	Receptacle, BNC
	R1	R09503	Potentiometer, 50K, 10-turn
	R2	R01221	Res. 1/4 w, 5%
	S1	S00001	Switch, Pushbutton
	S2	S00002	Switch, Pushbutton
	S3	S00201	Switch, Toggle

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
Chassis Assembly	C3	C00300	Capacitor, 8200MFD 25V (Option 03, Distr. Ampl. only)
	T1	T10000	Transformer, Power
	T2	T10001	Transformer, Power
Rear Panel Assem.	C1		Capacitor, 0.1 uf, 1.6 KV
	C2		Capacitor, 0.1 uf, 1.6 KV
	F1	F00R75	Fuse, 3/4 A, 3AG (1 1/4A Op. 03)
	F2	F00R37	Fuse, 3/8 A, 3AG
	J4	J00002	Receptacle, BNC
	J5	J01000	Receptacle, Power
	J6	J01115	Connector, 15 pins
	J7	J00010	Receptacle, BNC
	J8	J00010	Receptacle, BNC
	J9	J00010	Receptacle, BNC
	J10	J00010	Receptacle, BNC
	S4	S00102	Switch, Slide
	S5	S00102	Switch, Slide
	XF1	X00050	Fuseholder Body, 3AG
	XF1	X00060	Fuseholder Cap
	XF2	X00050	Fuseholder Body, 3AG
	XF2	X00060	Fuseholder Cap
A1, RF Amplifier	C1	C07220	Capacitor, Elect, 22 uf, 25V
	C2	C06182	Capacitor, Mica, 1800 pf
	C3	C09010	Capacitor, Elect, 1 uf, 50V
	C4	C09010	Capacitor, Elect, 1 uf, 50V
	C5	C09010	Capacitor, Elect, 1 uf, 50V
	C6	C07220	Capacitor, Elect, 22 uf, 25V
	C7	C05820	Capacitor, Mica, 82 pf
	C8	C00040	Capacitor, Trimmer, 4.5-20 pf
	C9	C00040	Capacitor, Trimmer, 4.5-20 pf
	C10	C05050	Capacitor, Mica, 5 pf
	C11	C09010	Capacitor, Elect, 1 uf, 50V
	C12	C07220	Capacitor, Elect, 22 uf, 25V
	C13	C09010	Capacitor, Elect, 1 uf, 50V
	C14	C18103	Capacitor, Polystyrene, .01 uf
	C15	C18103	Capacitor, Polystyrene, .01 uf
	C16	C01104	Capacitor, Disc, 0.1 uf
	C17	C09010	Capacitor, Elect, 1 uf, 50V
	C18	C07220	Capacitor, Elect, 22 uf, 25V
	C19	C09010	Capacitor, Elect, 1 uf, 50V
	C20	C09010	Capacitor, Elect, 1 uf, 50V
	C21	C09010	Capacitor, Elect, 1 uf, 50V
	C22	C07220	Capacitor, Elect, 22 uf, 25V
	C23	C06182	Capacitor, Mica, 1800 pf
	L1	L03102	Choke, 1000 uH
	L2	L03102	Choke, 1000 uH
	L3	L03331	Choke, 330 uH

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A1, RF Amplifier	P1	J00002	Receptacle, BNC for RG-316
	P2	P00106	Plug Body, 6 pins
	P2	P00100	Contacts
	P2	P00300	Key Polarizing
	Q1	Q04126	Transistor, 2N4126
	Q2	Q04124	Transistor, 2N4124
	Q3	Q04124	Transistor, 2N4124
	R1	R01562	Resistor, 1/4 w, 5%, 5.6 K
	R2	R01273	Resistor, 1/4 w, 5%, 27 K
	R3	R01393	Resistor, 1/4 w, 5%, 39 K
	R4	R01183	Resistor, 1/4 w, 5%, 18 K
	R5	R01153	Resistor, 1/4 w, 5%, 15K
	R6	R01152	Resistor, 1/4 w, 5%, 1.5 K
	R7	R01123	Resistor, 1/4 w, 5%, 12 K
	R8	R01332	Resistor, 1/4 w, 5%, 3.3 K
	R9	R01332	Resistor, 1/4 w, 5%, 3.3 K
	R10	R01332	Resistor, 1/4 w, 5%, 3.3 K
	R11	R01183	Resistor, 1/4 w, 5%, 18 K
	R12	R01183	Resistor, 1/4 w, 5%, 18 K
	R13	R01123	Resistor, 1/4 w, 5%, 12 K
	R14	R01683	Resistor, 1/4 w, 5%, 68 K
	R15	R01561	Resistor, 1/4 w, 5%, 560 ohm
	R16	R01681	Resistor, 1/4 w, 5%, 680 ohm
	R17	R01390	Resistor, 1/4 w, 5%, 39 ohm
	R18	R01100	Resistor, 1/4 w, 5%, 10 ohm
	R19	R05503	Potentiometer, 50 K
	R20	R01222	Resistor, 1/4 w, 5%, 2.2 K
	S1	S00420	Switch, Slide, 2 pole
	T1	T00020	Transformer
	U1	U01350	Integrated Circuit MC1350P
	U2	U01350	Integrated Circuit MC1350P
	Y1	Y00000	Crystal, Quartz, 60 kHz
A2, Receiver Assy	C1	C01104	Capacitor, Disc, 0.1 uf, 25V
	C2	C09010	Capacitor, Elect, 1 uf, 50V
	C3	C01104	Capacitor, Disc, 0.1 uf, 25V
	C4	C00100	Capacitor, Tant, 120 uf, 15V
	C5	C02103	Capacitor, Disc, .01 uf, 50V
	C6	C07220	Capacitor, Elect, 22 uf, 25V
	C7	C15685	Capacitor, Tant, 6.8 uf, 35V
	C8	C05560	Capacitor, Mica, 56 pf
	C9	C05200	Capacitor, Mica, 20 pf
	C10	C00040	Capacitor, Trimmer, 4.5-20 pf
	C11	C05121	Capacitor, Mica, 120 pf, 500V
	C12	C05301	Capacitor, Mica, 300 pf, 500V
	C13	C01104	Capacitor, Disc, 0.1 uf, 25V
	C14	C18472	Capacitor, Polystyrene, 4700 pf, 160V
	C15	C18472	Capacitor, Polystyrene, 4700 pf, 160V
	C16	C09010	Capacitor, Elect, 1.0 uf, 50V

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A2, Receiver Assy	C17	C07220	Capacitor, Elect, 22 uf, 25V
	C18	C07220	Capacitor, Elect, 22 uf, 25V
	C19	C09010	Capacitor, Elect, 1.0 uf, 50V
	C20	C01104	Capacitor, Disc, 0.1 uf, 25V
	C21	C15105	Capacitor, Tant, 1.0 uf, 35V
	C22	C10157	Capacitor, Tant, 150 uf, 6V
	C23	C07220	Capacitor, Elect, 22 uf, 25V
	C24	C02103	Capacitor, Disc, .01 uf, 50V
	C25	C02103	Capacitor, Disc, .01 uf, 50V
	C26	C02103	Capacitor, Disc, .01 uf, 50V
	C27	C02103	Capacitor, Disc, .01 uf, 50V
	C28	C02103	Capacitor, Disc, .01 uf, 50V
	C29	C02103	Capacitor, Disc, .01 uf, 50V
	C30	C02103	Capacitor, Disc, .01 uf, 50V
	C31	C01104	Capacitor, Disc, 0.1 uf, 25V
	C32	C01104	Capacitor, Disc, 0.1 uf, 25V
	C33	C01104	Capacitor, Disc, 0.1 uf, 25V
	C34	C07220	Capacitor, Elect, 22 uf, 25V
	C35	C07220	Capacitor, Elect, 22 uf, 25V
	C36	C02103	Capacitor, Disc, .01 uf, 50V
	C37	C02103	Capacitor, Disc, .01 uf, 50V
	C38	C02103	Capacitor, Disc, .01 uf, 50V
	C39	C05910	Capacitor, Mica, 91 pf
	C40	C05910	Capacitor, Mica, 91 pf
	C41	C02103	Capacitor, Disc, .01 uf, 50V
	C42	C02103	Capacitor, Disc, .01 uf, 50V
	C43	C02103	Capacitor, Disc, .01 uf, 50V
	C44	C18392	Capacitor, Polystyrene, 3900 pf, 160V
	C45	C18751	Capacitor, Polystyrene, 750 pf, 160V
	C46	C18392	Capacitor, Polystyrene, 3900 pf, 160V
	C47	C07222	Capacitor, Electrolytic, 2200 pf, 16V
	C48	C07222	Capacitor, Electrolytic, 2200 pf, 16V
	C49	C07222	Capacitor, Electrolytic, 2200 pf, 16V
	C50	C07222	Capacitor, Electrolytic, 2200 pf, 16V
	C51	C09010	Capacitor, Elect, 1.0 uf, 50V
	C52	C01104	Capacitor, Disc, 0.1 uf, 50V
	C53	C08102	Capacitor, Electrolytic, 1000 uf, 35V
	C54	C08102	Capacitor, Electrolytic, 1000 uf, 35V
	C55	C09010	Capacitor, Elect, 1.0 uf, 50V
	C56	C09010	Capacitor, Elect, 1.0 uf, 50V
	C57	C01104	Capacitor, Disc, 0.1 uf, 50V
	C58	C01104	Capacitor, Disc, 0.1 uf, 50V
	C59	C09010	Capacitor, Elect, 1.0 uf, 50V
	C60	C09010	Capacitor, Elect, 1.0 uf, 50V

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A2, Receiver Assy	CR1	CR04148	Diode, 1N4148
	CR2	CR00209	Voltage Variable Capacitor, MV-209
	CR3	CR05059	Diode, 1N5059
	CR4	CR04148	Diode, 1N4148
	CR5	Not Used	
	CR6	CR04148	Diode, 1N4148
	CR7	CR04148	Diode, 1N4148
	CR8	CR05624	Diode, 1N5624
	CR9	CR05624	Diode, 1N5624
	CR10	CR05624	Diode, 1N5624
	CR11	CR05624	Diode, 1N5624
	CR12	CR05059	Diode, 1N5059
	CR13	CR05059	Diode, 1N5059
	CR14	CR05059	Diode, 1N5059
	CR15	CR05059	Diode, 1N5059
	CR16	CR04148	Diode, 1N4148
	E1	E02320	Terminal, turret
	E2	E02320	Terminal, turret
	E3	E02320	Terminal, turret
	E4	E02320	Terminal, turret
	J1	J10014	Receptacle - 6 pin
	J2	J10014	Receptacle - 6 pin
	J3	J10014	Receptacle - 6 pin
	J4	J10014	Receptacle - 6 pin
	J5	J10014	Receptacle - 6 pin
	L1	L03152	Choke, 1500 uH
	L2	L03152	Choke, 1500 uH
	L3	L03152	Choke, 1500 uH
	Q1	Q04126	Transistor, 2N4126
	Q2	Q04126	Transistor, 2N4126
	Q3	Q04124	Transistor, 2N4124
	Q4	Q04258	Transistor, 2N4258
	Q5	Q04126	Transistor, 2N4126
	Q6	Q04258	Transistor, 2N4258
	Q7	Q04258	Transistor, 2N4258
	Q8	Q04126	Transistor, 2N4126
	Q9	Q04124	Transistor, 2N4124
	R1	R01471	Resistor, 1/4 w, 5%, 470 ohms
	R2	R01561	Resistor, 1/4 w, 5%, 560 ohms
	R3	R01561	Resistor, 1/4 w, 5%, 560 ohms
	R4	R01472	Resistor, 1/4 w, 5%, 4.7 K
	R5	R05202	Potentiometer, Trimming, Cermet 2 K
	R6	R21512	Resistor, Metal Glaze, 1/4w, 2%, 5.1K
	R7	R21562	Resistor, Metal Glaze, 1/4w, 2%, 5.6K
	R8	R21562	Resistor, Metal Glaze, 1/4w, 2%, 5.6K

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A2, Receiver Assy	R9	R01393	Resistor, 1/4 w, 5%, 39 K
	R10	R01393	Resistor, 1/4 w, 5%, 39 K
	R11	R01104	Resistor, 1/4 w, 5%, 100 K
	R12	R01102	Resistor, 1/4 w, 5%, 1 K
	R13	R01472	Resistor, 1/4 w, 5%, 4.7 K
	R14	R05502	Potentiometer, Trimming, Cermet, 5K
	R15	R01272	Resistor, 1/4 w, 5%, 2.7 K
	R16	R01562	Resistor, 1/4 w, 5%, 5.6 K
	R17	R01562	Resistor, 1/4 w, 5%, 5.6 K
	R18	R01104	Resistor, 1/4 w, 5%, 100 K
	R19	R01393	Resistor, 1/4 w, 5%, 39 K
	R20	R01153	Resistor, 1/4 w, 5%, 15 K
	R21	R01332	Resistor, 1/4 w, 5%, 3.3 K
	R22	R01330	Resistor, 1/4 w, 5%, 33 ohms
	R23	R05102	Potentiometer, Trimming, Cermet, 1K
	R24	R01331	Resistor, 1/4 w, 5%, 330 ohms
	R25	R01471	Resistor, 1/4 w, 5%, 470 ohms
	R26	R01561	Resistor, 1/4 w, 5%, 560 ohms
	R27	R01561	Resistor, 1/4 w, 5%, 560 ohms
	R28	R01472	Resistor, 1/4 w, 5%, 4.7 K
	R29	R01152	Resistor, 1/4 w, 5%, 1.5 K
	R30	R05202	Potentiometer, Trimming, Cermet, 2K
	R31	R21512	Resistor, Metal Glaze, 1/4w, 2%, 5.1K
	R32	R21562	Resistor, Metal Glaze, 1/4w, 2%, 5.6K
	R33	R21562	Resistor, Metal Glaze, 1/4w, 2%, 5.6K
	R34	R01472	Resistor, 1/4 w, 5%, 4.7 K
	R35	R01332	Resistor, 1/4 w, 5%, 3.3 K
	R36	R01153	Resistor, 1/4 w, 5%, 15 K
	R37	R01153	Resistor, 1/4 w, 5%, 15 K
	R38	R21154	Resistor, Metal Glaze, 1/4w, 2%, 150K
	R39	R21153	Resistor, Metal Glaze, 1/4w, 2%, 15K
	R40	R21154	Resistor, Metal Glaze, 1/4w, 2%, 150K
	R41	R01122	Resistor, 1/4 w, 5%, 1.2 K
	R42	R01153	Resistor, 1/4 w, 5%, 15 K
	R43	R01475	Resistor, 1/4 w, 5%, 4.7 megaohms
	R44	R01332	Resistor, 1/4 w, 5%, 3.3 K
	R45	R01473	Resistor, 1/4 w, 5%, 47 K
	R46	R01563	Resistor, 1/4 w, 5%, 56 K
	R47	R01394	Resistor, 1/4 w, 5%, 390 K
	R48	R01105	Resistor, 1/4 w, 5%, 1 megaohm
	R49	R01332	Resistor, 1/4 w, 5%, 3.3 K
	R50	R01221	Resistor, 1/4 w, 5%, 220 ohms
	R51	R01103	Resistor, 1/4 w, 5%, 10 K
	R52	R01103	Resistor, 1/4 w, 5%, 10 K
	R53	R01151	Resistor, 1/4 w, 5%, 150 ohms

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A2, Receiver Assy	R54	R01332	Resistor, 1/4 w, 5%, 3.3 K
	R55	R01560	Resistor, 1/4 w, 5%, 56 ohms
	R56	R01560	Resistor, 1/4 w, 5%, 56 ohms
	R57	Not Used	
	R58	R01101	Resistor, 1/4 w, 5%, 100 ohms
	R59	R01682	Resistor, 1/4 w, 5%, 6.8 K
	R60	R01471	Resistor, 1/4 w, 5%, 470 ohms
	R61	R01471	Resistor, 1/4 w, 5%, 470 ohms
	R62	R01391	Resistor, 1/4 w, 5%, 390 ohms
	R63	R01152	Resistor, 1/4 w, 5%, 1.5 K
	R64	Not Used	
	R65	R01102	Resistor, 1/4 w, 5%, 1 K
	R66	R01560	Resistor, 1/4 w, 5%, 56 ohms
	R67	R01103	Resistor, 1/4 w, 5%, 10 K
	R68	R01103	Resistor, 1/4 w, 5%, 10 K
	R69	R01272	Resistor, 1/4 w, 5%, 2.7 K
	R70	R01272	Resistor, 1/4 w, 5%, 2.7 K
	R71	R01272	Resistor, 1/4 w, 5%, 2.7 K
	R72	R01822	Resistor, 1/4 w, 5%, 8.2 K
	R73	R01822	Resistor, 1/4 w, 5%, 8.2 K
	R74	R01102	Resistor, 1/4 w, 5%, 1 K
	R75	R01104	Resistor, 1/4 w, 5%, 100 K
	R76	R01104	Resistor, 1/4 w, 5%, 100 K
	R77	R01272	Resistor, 1/4 w, 5%, 2.7 K
	R78	R05502	Potentiometer, Trimming, Cermet, 5K
	R79	R01272	Resistor, 1/4 w, 5%, 2.7 K
	R80	R05502	Potentiometer, Trimming, Cermet, 5K
	R81	R01101	Resistor, 1/4 w, 5%, 100 ohms
	R82	R01101	Resistor, 1/4 w, 5%, 100 ohms
	R83	R01272	Resistor, 1/4 w, 5%, 2.7 K
	R84	Not Used	
	R85	R01682	Resistor, 1/4 w, 5%, 6.8 K
	R86	R01182	Resistor, 1/4 w, 5%, 1.8 K
	R87	R01101	Resistor, 1/4 w, 5%, 100 ohms
	R88	R01152	Resistor, 1/4 w, 5%, 1.5 K
	R89	R21153	Resistor, Metal Glaze, 1/4w, 5%, 15K
	TP1	TP00001	Test Point, Brown
	TP2	TP00002	Test Point, Red
	TP3	TP00003	Test Point, Orange
	TP4	TP00004	Test Point, Yellow
	TP6	TP00006	Test Point, Blue

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A2, Receiver Assy	U1	U01496	Integrated Circuit, LM1496N
	U2	U00324	Integrated Circuit, LM324N
	U3	U01496	Integrated Circuit, LM1496N
	U4	U00339	Integrated Circuit, LM339N
	U5	U4LS37	Integrated Circuit, SN74LS37
	U6	U4S140	Integrated Circuit, SN74S140N
	U7	U4LS37	Integrated Circuit, SN74LS37
	U8	U4LS90	Integrated Circuit, SN74LS90
	U9	U4LS90	Integrated Circuit, SN74LS90
	U10	U4LS90	Integrated Circuit, SN74LS90
	U11	U4S132	Integrated Circuit, SN74132
	U12	U4S140	Integrated Circuit, SN74S140N
	U13	U4LS90	Integrated Circuit, SN74LS90
	U14	U4LS90	Integrated Circuit, SN74LS90
	U15	U4LS37	Integrated Circuit, SN74LS37
	U16	U4LS90	Integrated Circuit, SN74LS90
	U17	ULS153	Integrated Circuit, SN74LS153N
	U18	U4LS37	Integrated Circuit, SN74LS37
	U19	Used	
	U20	U4LS90	Integrated Circuit, SN74LS90
	U21	U07805	Voltage Regulator, 7805UC
	U22	U78M12	Voltage Regulator, 78M12UC
	U23	U79M12	Voltage Regulator, 79M12AUC
	VR1	Not Used	
	VR2	VR04735	Zener Diode, 1N4735A
	W1	R01000	Jumper
	W2	R01000	Jumper
	W3	R01000	Jumper
	Y1	Y00011	Crystal, Quartz
A4, Output Amp Assy	C1	C02103	Capacitor, Disc, .01 uf, 50V
	C2	Not Used	
	C3	C09010	Capacitor, Elect, 1.0 uf, 50V
	C4	C02103	Capacitor, Disc, 0.1 uf, 50V
	C5	C02103	Capacitor, Disc, 0.1 uf, 50V
	C6	C02103	Capacitor, Disc, 0.1 uf, 50V
	C7	C07220	Capacitor, Elect, 22 uf, 25V
	C8	C09010	Capacitor, Elect, 1.0 uf, 50V
	C9	C07220	Capacitor, Elect, 22 uf, 25V
	C10	C02103	Capacitor, Disc, .01 uf, 50V
	C11	C02103	Capacitor, Disc, .01 uf, 50V
	C12	C02103	Capacitor, Disc, .01 uf, 50V
	C13	C02103	Capacitor, Disc, .01 uf, 50V
	C14	C02103	Capacitor, Disc, .01 uf, 50V
	C15	C02103	Capacitor, Disc, .01 uf, 50V
	C16	Not Used	

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A4, Output Amp Assy	C17	C05121	Capacitor, Mica, 120 pf
	C18	Not Used	
	C19	C02103	Capacitor, Disc, .01 uf 50V
	C20	C02103	Capacitor, Disc, .01 uf 50V
	C21	C02103	Capacitor, Disc, .01 uf 50V
	C22	C02103	Capacitor, Disc, .01 uf 50V
	C23	C05241	Capacitor, Mica, 240 pf
	C24	Not Used	
	C25	C02103	Capacitor, Disc, .01 uf, 50V
	C26	C02103	Capacitor, Disc, .01 uf, 50V
	C27	C02103	Capacitor, Disc, .01 uf, 50V
	C28	C05102	Capacitor, Mica, 1000 pf
	C29	C05241	Capacitor, Mica, 240 pf
	C30	C02103	Capacitor, Disc, .01 uf, 50V
	C31	C02103	Capacitor, Disc, .01 uf, 50V
	C32	C02103	Capacitor, Disc, .01 uf, 50V
	C33	C02103	Capacitor, Disc, .01 uf, 50V
	C34	C21123	Capacitor, Polycarb, 12000 pf, 250V
	C35	C05391	Capacitor, Mica, 390 pf
	C36	C09010	Capacitor, Elect, 1.0 uf, 50V
	C37	C02103	Capacitor, Disc, .01 uf, 50V
	C38	C02103	Capacitor, Disc, .01 uf, 50V
	C39	C05121	Capacitor, Mica, 120 pf
	C40	C05201	Capacitor, Mica, 200 pf
	C41	C05102	Capacitor, Mica, 1000 pf
	C42	C02103	Capacitor, Disc, .01 uf, 50V
	C43	Not Used	
	C44	Not Used	
	C45	Not Used	
	C46	Not Used	
	C47	Not Used	
	C48	Not Used	
	C49	Not Used	
	CR1	CR04148	Diode, 1N4148
	CR2	CR00277	Diode, 1N277
	CR3	CR00277	Diode, 1N277
	CR4	CR00277	Diode, 1N277
	CR5	CR04148	Diode, 1N4148
	CR6	CR00277	Diode, 1N277
	CR7	CR00277	Diode, 1N277
	CR8	CR00277	Diode, 1N277
	CR9	CR04148	Diode, 1N4148

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A4, Output Amp Assy	CR10	CR00277	Diode, 1N277
	CR11	CR00277	Diode, 1N277
	CR12	CR00277	Diode, 1N277
	CR13	CR04148	Diode, 1N4148
	CR14	CR00277	Diode, 1N277
	CR15	CR00277	Diode, 1N277
	CR16	CR00277	Diode, 1N277
	CR17	CR04148	Diode, 1N4148
	J1	J10014	Receptacle, 6 pins
	J2	J10014	Receptacle, 6 pins
	L1	L023R9	Choke, 3.9 uH
	L2	L023R9	Choke, 3.9 uH
	L3	L028R2	Choke, 8.2 uH
	L4	L028R2	Choke, 8.2 uH
	L5	L02390	Choke, 39 uH
	L6	L02390	Choke, 39 uH
	L7	L03391	Choke, 390 uH
	L8	L03391	Choke, 390 uH
	L9	Not Used	
	L10	Not Used	
	L11	Not Used	
	L12	Not Used	
	L13	Not Used	
	Q1	Q04258	Transistor, 2N4258
	Q2	Q04258	Transistor, 2N4258
	Q3	Q04124	Transistor, 2N4124
	Q4	Q03565	Transistor, 2N3565
	Q5	Q03565	Transistor, 2N3565
	Q6	Q04126	Transistor, 2N4126
	R1	R01560	Resistor, 1/4 w, 5%, 56 ohms
	R2	R01560	Resistor, 1/4 w, 5%, 56 ohms
	R3	R01391	Resistor, 1/4 w, 5%, 390 ohms
	R4	R01681	Resistor, 1/4 w, 5%, 680 ohms
	R5	R01182	Resistor, 1/4 w, 5%, 1.8 K
	R6	R01331	Resistor, 1/4 w, 5%, 330 ohms
	R7	R01101	Resistor, 1/4 w, 5%, 100 ohms
	R8	R01472	Resistor, 1/4 w, 5%, 4.7 K
	R9	R01103	Resistor, 1/4 w, 5%, 10 K
	R10	R01270	Resistor, 1/4 w, 5%, 27 ohms
	R11	R01102	Resistor, 1/4 w, 5%, 1 K
	R12	R01390	Resistor, 1/4 w, 5%, 39 ohms
	R13	R01104	Resistor, 1/4 w, 5%, 100 K
	R14	R01390	Resistor, 1/4 w, 5%, 39 ohms
	R15	R01104	Resistor, 1/4 w, 5%, 100 K

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A4, Output Amp Assy	R16	R01390	Resistor, 1/4 w, 5%, 39 ohms
	R17	R01104	Resistor, 1/4 w, 5%, 100 K
	R18	R01390	Resistor, 1/4 w, 5%, 39 ohms
	R19	R01104	Resistor, 1/4 w, 5%, 100 K
	R20	R01000	Resistor, 1/4 w, 5%, 0 ohms
	R21	R01224	Resistor, 1/4 w, 5%, 220 K
	R22	R01475	Resistor, 1/4 w, 5%, 4.7 megaohms
	R23	Not Used	
	R24	R01101	Resistor, 1/2 w, 5%, 100 ohms
	R25	R01183	Resistor, 1/2 w, 5%, 18 K
	R26	R01560	Resistor, 1/2 w, 5%, 56 ohms
	R27	R01101	Resistor, 1/2 w, 5%, 100 ohms
	U1	U4LS20	Integrated Circuit, SN74LS20
	U2	U4S140	Integrated Circuit, SN74S140N
	U3	U4LS37	Integrated Circuit, SN74LS37
	U4	U4LS37	Integrated Circuit, SN74LS37
	U5	U4LS90	Integrated Circuit, SN74LS90
	U6	ULS112	Integrated Circuit, SN74LS112N
	U7	U4LS90	Integrated Circuit, SN74LS90
	U8	U4S140	Integrated Circuit, SN74S140N
	U9	U4S140	Integrated Circuit, SN74S140N
	U10	Not Used	
	W1	R01000	Jumper
	W2	R01000	Jumper
	W3	Not Used	
	W4	R01000	Jumper
	W5	Not Used	
	W6	R01000	Jumper
	W7	Not Used	
	W8	R01000	Jumper
A5, OSC/PS Assy	C1	C12226	Capacitor, Tant, 22 uf, 15V
	C3	C02103	Resistor, Disc, .01 uf, 50V
	C4	C15685	Resistor, Tant, 6.8 uf, 35V
	C5	C12226	Resistor, Tant, 22 uf, 15V
	C6	C22105	Resistor, Polyester, 1 uf
	C7	C02103	Resistor, Disc, 0.1 uf, 50V
	C8	C09471	Resistor, Electrolytic, 470 uf, 50V
	C9	C09471	Resistor, Electrolytic, 470 uf, 50V
	C10	C15685	Resistor, Tant, 6.8 uf, 35V
	C11	C05102	Resistor, Mica, 1000 pf

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A5, OSC/PS Assy	CR1	CR05059	Diode, 1N5059
	CR2	CR05059	Diode, 1N5059
	CR3	CR05059	Diode, 1N5059
	CR4	CR05059	Diode, 1N5059
	CR5	CR04148	Diode, 1N4148
	CR6	CR05059	Diode, 1N5059
	CR7	CR05059	Diode, 1N5059
	CR8	CR04148	Diode, 1N4148
	J1	J10014	Receptacle, 6 pins
	J2	J10014	Receptacle, 6 pins
	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, 1/4 w, 5%, 220 ohms
	R3	R01330	Resistor, 1/4 w, 5%, 33 ohms
	R4	R07203	Potentiometer, Cermet, 20 K
	R5	R11363	Resistor, Metal Glaze, 1/4w, 5%, 36K
	R6	R11823	Resistor, Metal Glaze, 1/4w, 5%, 82K
	R7	R11153	Resistor, Metal Glaze, 1/4w, 5%, 15K
	R8	R05503	Potentiometer, Cermet, 50 K
	R9	R01154	Resistor, 1/4 w, 5%, 150 K
	R10	R01182	Resistor, 1/4 w, 5%, 1.8 K
	R11	R01333	Resistor, 1/4 w, 5%, 33 K
	R12	R01393	Resistor, 1/4 w, 5%, 39 K
	R13	R03182	Resistor, Carbon, 1 w, 1.8 K
	R14	R022R4	Resistor, Carbon, 1/2 w, 2.4 ohms
	R15	R01273	Resistor, 1/4 w, 5%, 27 K
	R16	R01273	Resistor, 1/4 w, 5%, 27 K
	R17	R01222	Resistor, 1/4 w, 5%, 2.2 K
	R18	R05103	Potentiometer, Cermet, 10 K
	R19	R01272	Resistor, 1/4 w, 5%, 2.7 K
	R20	R01154	Resistor, 1/4 w, 5%, 150 K
	R21	R01102	Resistor, 1/4 w, 5%, 1 K
	R22	R11123	Resistor, Metal Glaze, 1/4w, 5%, 12K
	R23	R03182	Resistor, Carbon, 1 w, 1.8 K

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A5, OSC/PS Assy	R24	R01470	Resistor, 1/4 w, 5%, 47 ohms
	R25	R05102	Potentiometer, Cermet, 1 K
	R26	R11562	Resistor, Metal Glaze, 1/4w, 5%, 5.6K
	R27	R11392	Resistor, Metal Glaze, 1/4w, 5%, 3.9K
	R28	R01102	Resistor, 1/4 w, 5%, 1 K
	R29	R01512	Resistor, 1/4 w, 5%, 5.1 K
	U1	002590	Oscillator Ovenized
	U2	U00723	Voltage Regulator, uA723C
	VR1	VR05242	Zener Diode, In5242B
	W1	R01000	Jumper
	W2	R01000	Jumper
	W3	R01000	Jumper
	W4	R01000	Jumper
Battery (Op. 02)	B1	B00000	Battery-sealed lead acid 6V
	B2	B00000	Battery-sealed lead acid 6V
	B3	B00000	Battery-sealed lead acid 6V
	B4	B00000	Battery-sealed lead acid 6V
	J10	J01102	Receptacle
	J10	J01100	Pin, Female
A4, Output Amp. Assembly (Op 03)	C1	C02103	Capacitor, Disc, .01 uf, 50V
	C2	Not Used	
	C3	C09010	Capacitor, Elect, 1.0 uf, 50V
	C4	C02103	Capacitor, Disc, .01 uf, 50V
	C5	C02103	Capacitor, Disc, .01 uf, 50V
	C6	C02103	Capacitor, Disc, .01 uf, 50V
	C7	C07220	Capacitor, Elect, 22 uf, 25V
	C8	C09010	Capacitor, Elect, 1.0 uf, 50V
	C9	C07220	Capacitor, Elect, 22 uf, 25V
	C10	C02103	Capacitor, Disc, .01 uf, 50V
	C11	C02103	Capacitor, Disc, .01 uf, 50V
	C12	C02103	Capacitor, Disc, .01 uf, 50V
	C13	C02103	Capacitor, Disc, .01 uf, 50V
	C14	C02103	Capacitor, Disc, .01 uf, 50V
	C15	C02103	Capacitor, Disc, .01 uf, 50V
	C16	Not Used	
	C17	C05121	Capacitor, Mica, 120 pf
	C18	Not Used	
	C19	C02103	Capacitor, Disc, .01 uf, 50V
	C20	C02103	Capacitor, Disc, .01 uf, 50V
	C21	C02103	Capacitor, Disc, .01 uf, 50V
	C22	C02103	Capacitor, Disc, .01 uf, 50V
	C23	C05121	Capacitor, Mica, 120 pf
	C24	Not Used	
	C25	C02103	Capacitor, Disc, .01 uf, 50V
	C26	C02103	Capacitor, Disc, .01 uf, 50V
	C27	C02103	Capacitor, Disc, .01 uf, 50V
	C28	C05121	Capacitor, Mica, 120 pf
	C29	Not Used	

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A4, Output Amp. Assembly (Op 03)	C30	C02103	Capacitor, Disc, .01 uf, 50V
	C31	C02103	Capacitor, Disc, .01 uf, 50V
	C32	C02103	Capacitor, Disc, .01 uf, 50V
	C33	C02103	Capacitor, Disc, .01 uf, 50V
	C34	Not Used	
	C35	C05121	Capacitor, Mica, 120 pf
	C36	C02103	Capacitor, Disc, .01 uf, 50V
	C37	C02103	Capacitor, Disc, .01 uf, 50V
	C38	C02103	Capacitor, Disc, .01 uf, 50V
	C39	C05121	Capacitor, Mica, 120 pf
	C40	C05121	Capacitor, Mica, 120 pf
	C41	C05121	Capacitor, Mica, 120 pf
	C42	C05121	Capacitor, Mica, 120 pf
	C43	C02103	Capacitor, Disc, .01 uf, 50V
	C44	C09010	Capacitor, Elect, 1.0 uf, 50V
	C45	C02103	Capacitor, Disc, 0.1 uf, 50V
	C46	C09010	Capacitor, Elect, 0.1 uf, 50V
	C47	C02103	Capacitor, Disc, .01 uf, 50V
	C48	C09010	Capacitor, Elect, 1.0 uf, 50V
	C49	C02103	Capacitor, Disc, 0.1 uf, 50V
	CR1	CR04148	Diode, 1N4148
	CR3	CR00277	Diode, 1N277
	CR4	CR00277	Diode, 1N277
	CR5	CR04148	Diode, 1N4148
	CR7	CR00277	Diode, 1N277
	CR8	CR00277	Diode, 1N277
	CR9	CR04148	Diode, 1N4148
	CR11	CR00277	Diode, 1N277
	CR12	CR00277	Diode, 1N277
	CR13	CR04148	Diode, 1N4148
	CR15	CR00277	Diode, 1N277
	CR16	CR00277	Diode, 1N277
	CR17	CR04148	Diode, 1N4148
	J1	J10014	Receptacle, 6 pins
	J2	J10014	Receptacle, 6 pins
	L1	L023R9	Choke, 3.9 uH
	L2	L023R9	Choke, 3.9 uH
	L3	L023R9	Choke, 3.9 uH
	L4	L023R9	Choke, 3.9 uH
	L5	L023R9	Choke, 3.9 uH
	L6	L023R9	Choke, 3.9 uH
	L7	L023R9	Choke, 3.9 uH
	L8	L023R9	Choke, 3.9 uH

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A4, Output Amp. Assembly (Op 03)	L9	L04000	Inductor, Toroidal
	L10	L04000	Inductor, Toroidal
	L11	L04000	Inductor, Toroidal
	L12	L04000	Inductor, Toroidal
	L13	L04000	Inductor, Toroidal
	Q1	Q04258	Transistor, 2N4258
	Q2	Q04258	Transistor, 2N4258
	Q3	Q04124	Transistor, 2N4124
	Q4	Q03565	Transistor, 2N3565
	Q5	Q03565	Transistor, 2N3565
	Q6	Q04126	Transistor, 2N4126
	R1	R01560	Resistor, 1/4 w, 5%, 56 ohms
	R2	R01560	Resistor, 1/4 w, 5%, 56 ohms
	R3	R01391	Resistor, 1/4 w, 5%, 390 ohms
	R4	R01681	Resistor, 1/4 w, 5%, 680 ohms
	R5	R01182	Resistor, 1/4 w, 5%, 1.8 K
	R6	R01331	Resistor, 1/4 w, 5%, 330 ohms
	R7	R01101	Resistor, 1/4 w, 5%, 100 ohms
	R8	R01472	Resistor, 1/4 w, 5%, 4.7 K
	R9	R01103	Resistor, 1/4 w, 5%, 10 K
	R10	R01270	Resistor, 1/4 w, 5%, 27 ohms
	R11	R01102	Resistor, 1/4 w, 5%, 1 K
	R12	R01390	Resistor, 1/4 w, 5%, 39 ohms
	R13	R01104	Resistor, 1/4 w, 5%, 100 K
	R14	R01390	Resistor, 1/4 w, 5%, 39 ohms
	R15	R01104	Resistor, 1/4 w, 5%, 100 K
	R16	R01390	Resistor, 1/4 w, 5%, 39 ohms
	R17	R01104	Resistor, 1/4 w, 5%, 100 K
	R18	R01390	Resistor, 1/4 w, 5%, 39 ohms
	R19	R01104	Resistor, 1/4 w, 5%, 100 K
	R20	R01000	Resistor, 1/4 w, 5%, 0 ohms
	R21	R01224	Resistor, 1/4 w, 5%, 220 K
	R22	R01126	Resistor, 1/4 w, 5%, 12 megaohms
	R23	Not Used	
	R24	R01101	Resistor, 1/4 w, 5%, 100 ohms
	R25	R01183	Resistor, 1/4 w, 5%, 18 K
	R26	R01560	Resistor, 1/4 w, 5%, 56 ohms
	R27	R01101	Resistor, 1/4 w, 5%, 100 ohms
	U1	U4LS20	Integrated Circuit, SN74LS20
	U2	U4S140	Integrated Circuit, SN74S140N
	U3	U4LS37	Integrated Circuit, SN74LS37
	U4	U4LS37	Integrated Circuit, SN74LS37
	U5	U4LS90	Integrated Circuit, SN74LS90
	U6	ULS112	Integrated Circuit, SN74LS112N
	U7	U4LS90	Integrated Circuit, SN74LS90

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
A4, Output Amp. Assembly (Op 03)	U8	U4S140	Integrated Circuit, SN74S140N
	U9	U4S140	Integrated Circuit, SN74S140N
	U10	U78T12	Voltage Regulator, 78T12ACT
	W1	Not Used	
	W2	R01000	Jumper
	W3	R01000	Jumper
	W4	Not Used	
	W5	R01000	Jumper
	W6	Not Used	
	W7	R01000	Jumper
	W8	Not Used	
001900 Option 15	C1	C02103	Capacitor, Disc, .01 uf, 25V
	C2	C18392	Capacitor, Elect, 3900 pf, Polystyrene
	C3	C18751	Capacitor, Elect, 750 pf, Polystyrene
	C4	C18392	Capacitor, Elect, 3900 pf, Polystyrene
	C5	C02103	Capacitor, Disc, .01 uf, 25V
	C6	C02103	Capacitor, Disc, .01 uf, 25V
	C7	C02103	Capacitor, Disc, .01 uf, 25V
	C8	C02103	Capacitor, Disc, .01 uf, 25V
	C9	C01104	Capacitor, Disc, 0.1 uf, 25V
	C10	C07220	Capacitor, Elect, 22 uf, 25V
	C11	C01104	Capacitor, Disc, .1 uf, 25V
	C12	C01104	Capacitor, Disc, .1 uf, 25V
	C13	C07220	Capacitor, Elect, 22 uf, 25V
	C14	C07220	Capacitor, Elect, 22 uf, 25V
	C15	C07220	Capacitor, Elect, 22 uf, 25V
	CR1	CR04148	Diode, 1N4148
	L1	L03152	Choke, 1500 uH
	L2	L03152	Choke, 1500 uH
	Q1	Q04124	Transistor, 2N4124
	Q2	Q04258	Transistor, 2N4258
	Q3	Q04258	Transistor, 2N4258
	R1	R01272	Resistor, 1/4 w, 5%, 2.7 K
	R2	R01682	Resistor, 1/4 w, 5%, 6.8 K
	R3	R01182	Resistor, 1/4 w, 5%, 1.8 K
	R4	R01682	Resistor, 1/4 w, 5%, 6.8 K
	R5	R01472	Resistor, 1/4 w, 5%, 4.7 K
	R6	R01472	Resistor, 1/4 w, 5%, 4.7 K
	R7	R01102	Resistor, 1/4 w, 5%, 1 K
	R8	R01272	Resistor, 1/4 w, 5%, 2.7 K
	R9	R01272	Resistor, 1/4 w, 5%, 2.7 K
	R10	R01560	Resistor, 1/4 w, 5%, 56 ohms
	R11	R01560	Resistor, 1/4 w, 5%, 56 ohms

PARTS LIST

ASSEMBLY	REFER. DESIG.	PART NUMBER	DESCRIPTION
001900 Option 15	U1	U4LS90	Integrated Circuit, SN74LS90
	U2	U4LS90	Integrated Circuit, SN74LS90
	U3	U4LS90	Integrated Circuit, SN74LS90
	U4	U4LS90	Integrated Circuit, SN74LS90
	U5	U4LS92	Integrated Circuit, SN74LS92
	U6	U4LS90	Integrated Circuit, SN74LS90
	U7	U4S140	Integrated Circuit, SN74S140
	U10	ULS132	Integrated Circuit, SN74LS132
	W4	R01000	Jumper
	W5	R01000	Jumper
	W6	R01000	Jumper
	W7	R01000	Jumper
	W8	R01000	Jumper
Option 28	C7	C07220	Capacitor, Elect, 22 uf, 25V
	C9	C02103	Capacitor, Disc, 0.1 uf, 50V
	R10	R01560	Resistor, 1/4 w, 5%, 56 ohm
	U3	U4S140	Integrated Circuit SN74S140
	U4	U4LS90	Integrated Circuit SN74LS90
	U5	U4LS90	Integrated Circuit SN74LS90
	W1	R01000	Jumper
	W3	R01000	Jumper
	W5	R01000	Jumper

MODEL 8161

MANUAL ERRATA

THIS SECTION CONTAINS MANUAL CORRECTIONS OR CHANGES MADE TO THE INSTRUMENT AFTER THE PRINTING OF THIS MANUAL.

ERRATA VERSION 2.1 - 08/93

The Model 8206 Loop Antenna and the Model 8211 Antenna Mount are discontinued. Spectracom now offers two antennas, the Model 8206A Loop Antenna and the Model 8208 Whip Antenna. The antenna mount is now available as Model 8213.

Please replace Sections 1.3 through 1.5 of the installation section of the manual with the following paragraphs.

The Model 8206A is a direct replacement for the Model 8206 Loop Antenna. Any reference to the Model 8206 other than the following errata sections may be substituted with the Model 8206A.

1.3 SPECTRACOM WWVB ANTENNAS

1.3.1 Model 8206A Loop Antenna

The Model 8206A Loop Antenna reliably receives the 60 kHz WWVB transmission in field strengths of 50 μV/meter or greater. The majority of the United States exceeds 50 μV/meter as shown in Figure 1-1 Measured Field Intensity Contours. In locations having less than 50 μV/meter field strength, the Model 8207 Preamplifier is required. Refer to Section 1.5 for additional information. The equivalent electrical height of the Model 8206A is 5.0 cm.

The Model 8206A consists of a wound ferrite core surrounded by a Faraday shield which aids in noise rejection. The received signal is amplified by an internal preamplifier and output to the receiver. The preamp is powered by the receiver over the antenna coax. The antenna is packaged in a PVC housing measuring 10 inches long and 2.8 inches in diameter. The assembled antenna weight is 2.5 pounds.

The Model 8206A is a directional antenna. The tubular housing must be positioned broadside to Fort Collins, Colorado, (See Figure 1-3) and horizontal to the ground to allow maximum signal reception. No signal will be received if the tube points directly toward the transmitter site, as the antenna pattern nulls are located off the ends of the tube. The great circle map shown in Figure 1-2 is used to determine the correct antenna orientation per receiver location. The antenna position may be optimized using the AGC measurement described in Section 2.2, Signal Strength Measurement.

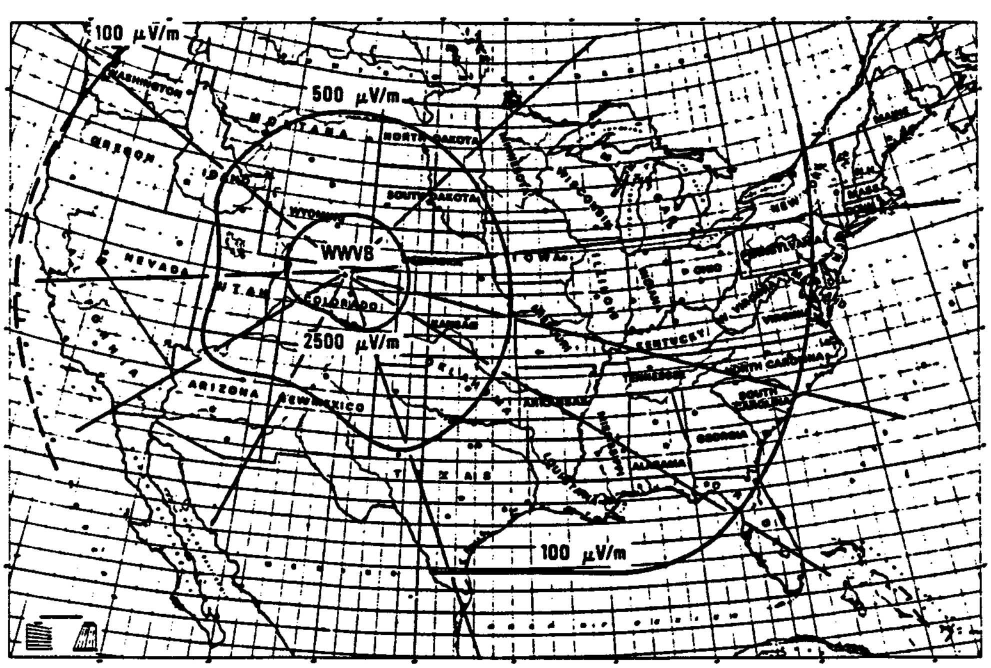
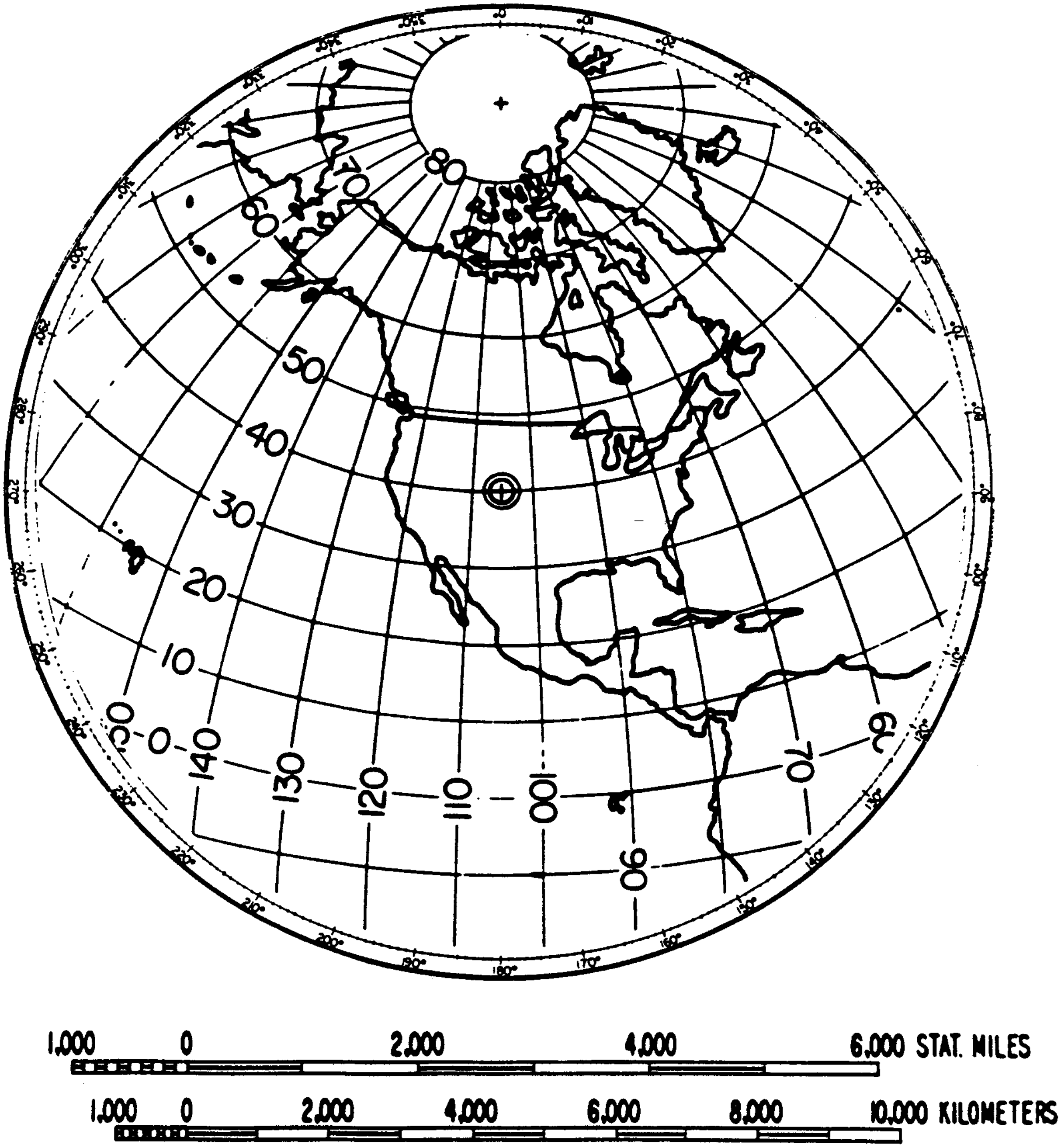


FIGURE 1-1 MEASURED FIELD INTENSITY CONTOUR WWVB @ 13 KW ERP



TO AIM ANTENNA AT FORT COLLINS, COLORADO, DETERMINE COMPASS HEADING FROM THIS MAP.

Draw a straight line from the receiver location through Fort Collins, Colo. at the center of the map. Continue until the line intersects the outer ring. The point at which the line intersects the outer ring indicates the compass heading for Fort Collins from your location.

FIGURE 1-2 GREAT CIRCLE MAP CENTERED ON FORT COLLINS, COLORADO

1.3.1 Model 8208 Whip Antenna

The Model 8208 Whip Antenna provides performance equal to the Model 8206A Loop Antenna at a reduced cost. The Model 8208 may be used in field strengths of 50 μV/meter or greater. The Model 8208 contains a preamplifier housed in a weather-proof enclosure. The preamplifier is powered by the receiver over the antenna coax cable. The Model 8208 is 58.5 inches long and weighs 1.3 pounds.

1.4 ANTENNA INSTALLATION INSTRUCTIONS

The antenna should be mounted a minimum of 25 feet from the receiver to prevent regeneration. The antenna MUST NOT be positioned next to the receiver or on top of it. Doing so will make the results obtained with the equipment meaningless even though the green lock lamp on the receiver front panel may be lit.

In system installations where more than one Spectracom antenna is used, a minimum separation of 10 feet between antennas is recommended.

The antenna must be at least three feet from any steel beams, roof decking, pipes, etc., as metal will detune the antenna and can cause as much as 20 dB degradation of the signal-to-noise ratio. The antenna must not be mounted under a metal roof or inside a building with heavy steel structural supports, as these shield the antenna from the signal. Roof tops are generally good if a clear shot toward Fort Collins is available without being blocked by a large steel structure. Attics are ideal sites if the roof and rafters are not metallic. The signal-to-noise ratio will be optimized if the antenna is located as far as possible from local RF noise sources such as TV sets, or fluorescent or neon lamps that blink or sputter on and off. Any equipment containing a switching power supply is a probable cause of interference.

Mount the antenna where it will not be disturbed. Antenna height is not critical as the 60 kHz signal is primarily a ground wave. Holding the antenna two to three feet off the ground or rooftop is adequate. Each antenna includes a two-foot mast assembly and two hose clamps to simplify installation. A typical roof-top installation is illustrated in Figure 1-3. Spectracom offers an aluminum base, Model 8213, for installations where vent pipe mounting is not practical or desired.

NOTE: THE MODEL 8206A IS A DIRECTIONAL ANTENNA. FOLLOW THE INSTRUCTIONS FOUND ON FIGURE 1-2 TO AIM THE ANTENNA CORRECTLY.

HANDLE THE ANTENNA WITH CARE. DROPPING OR ROUGH HANDLING MAY CRACK THE FERRITE CORE, POSSIBLY DETUNING THE ANTENNA, RENDERING IT USELESS.

Spectracom recommends RG-58C/U coax for the antenna cable, though any 50-ohm coax with superior specifications may be used. The antenna coax is used to provide the antenna with its DC operating voltage and the receiver with the amplified WWVB signal. Because of low attenuation characteristics at 60 kHz and the very low power requirement of the antenna (10 mW), cable lengths up to 1,500 feet are possible if care is taken to avoid routing the cable near noise sources.

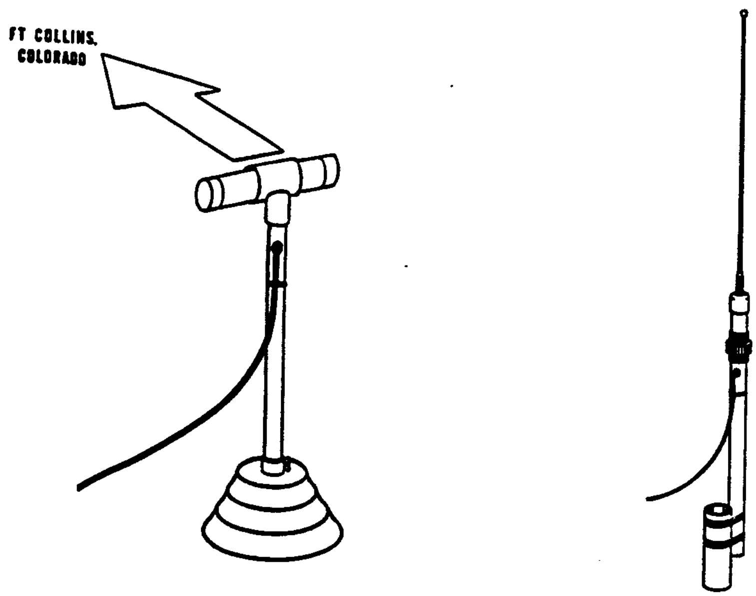


FIGURE 1-3 ANTENNA MOUNTING

1.5 MODEL 8207 PREAMPLIFIER INSTALLATION

The Spectracom Model 8207 Preamplifier is a low noise, tuned, 60-kHz line amplifier used in the antenna feed line wherever the WWVB signal strength is less than 50 μV/meter at the Antenna or less than 0.4 μV at the receiver antenna terminal. Typical locations where the preamplifier is probably required are Hawaii, Alaska, Puerto Rico, and the Canal Zone. Figure 1-1 shows the measured average signal strength for the contiguous 48 states. Atmospheric conditions may cause short term degradation of field intensity. The Model 8207 Preamplifier provides approximately 40 dB of gain between the antenna and receiver increasing sensitivity to 4.0 nanovolts.

The preamplifier is connected in the antenna feed line with **INPUT** connected to the antenna and **OUTPUT** connected to the receiver. Because of the high gain of the system, it is recommended that the preamplifier be located at least 10 feet away from the receiver. The antenna must be least 25 feet beyond the preamplifier. Switch A1S1 of the receiver RF Amplifier must be set at its right-hand position, marked PREAMP or P, prior to equipment turn-on, to apply DC voltage to the Model 8207 on the antenna feed line. If the preamplifier is removed from the system, the switch must be placed in the left-hand position, marked ANT or A prior to turn-on.

PAGE 3-2: 01/16/89, ECN 122: Change the Local Comparator Input specifications to:

> 0.1, 1.0, 5.0, 10.0 MHz, front panel selectable, 100 mV rms minimum into 50 ohms.