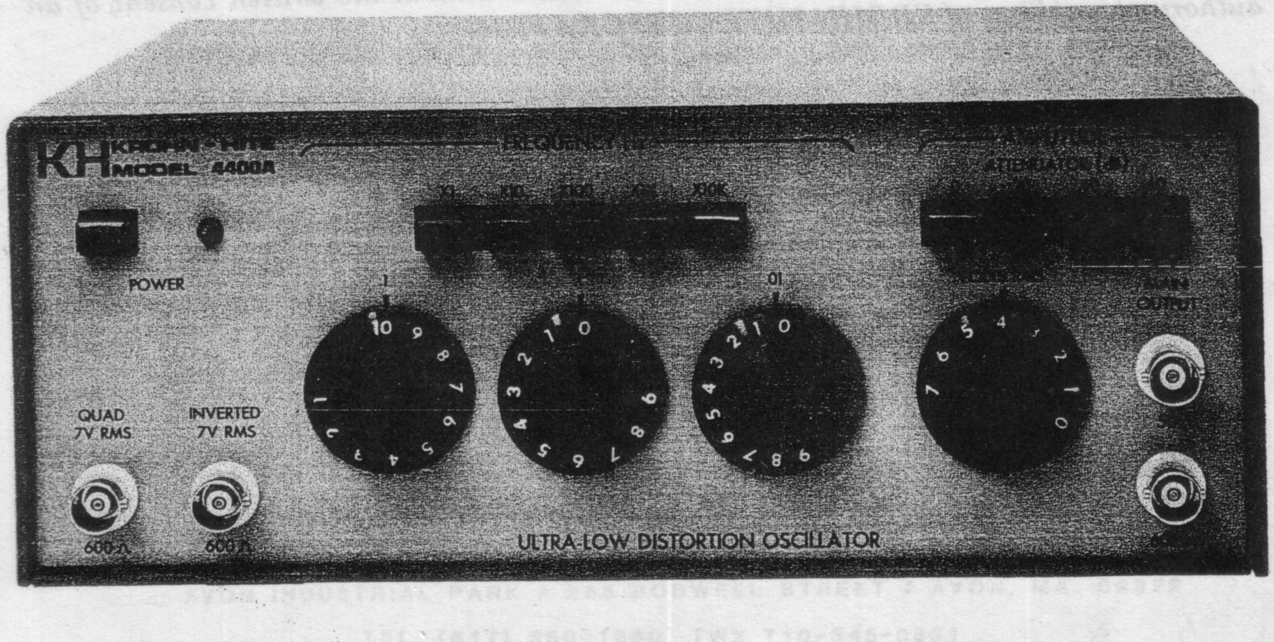
KROHN-HITE

MODEL 4400A
OPERATING and MAINTENANCE MANUAL



1Hz to 110KHz

ULTRA–LOW DISTORTION OSCILLATOR

1Hz TO 110kHz

ULTRA-LOW DISTORTION OSCILLATOR

MODEL 4400A SERIAL NO. 693

OPERATING AND MAINTENANCE MANUAL

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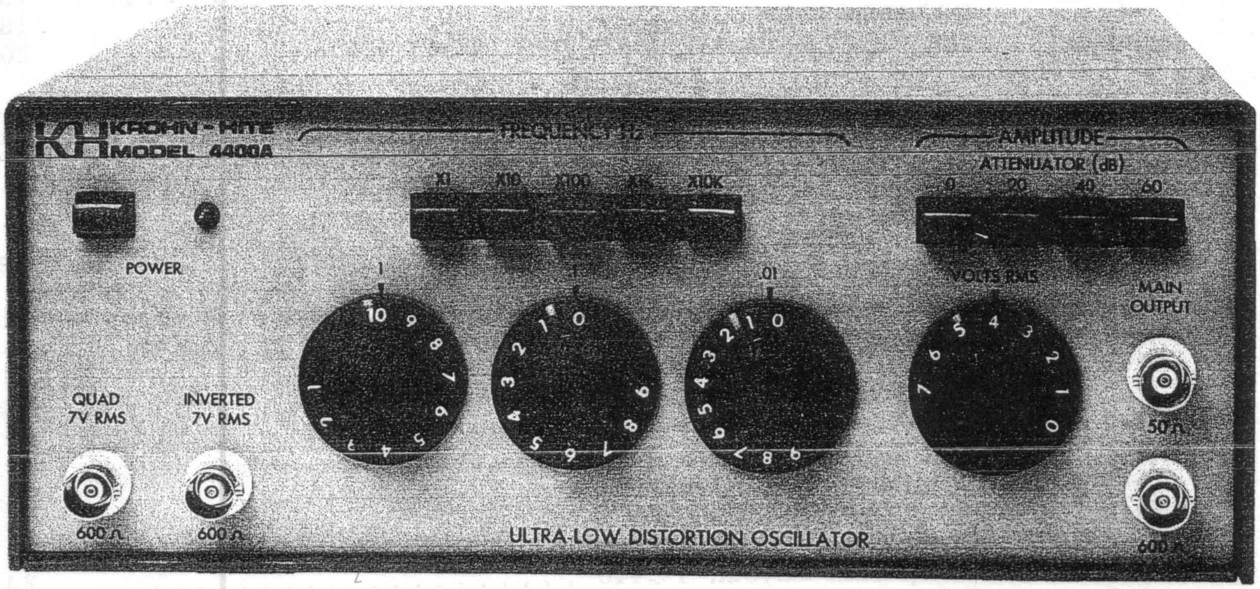


Figure 1-1. Model 4400A Oscillator

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Krohn-Hite Model 4400A, a revised Model 4400 (a 50 ohm output impedance has been added) is shown in Figure 1-1. It is an ultralow distortion, stable amplitude oscillator designed for test and measurement applications in the 1Hz to 110kHz frequency range.

The 4400 produces a virtually "distortion-free" (<0.001%) sinewave for measuring harmonic distortion in audio preamplifier and power amplifier circuits. The exceptionally flat response of the 4400 (+0.05dB) eliminates the need to constantly monitor voltage levels during amplifier response tests.

The 4400 provides a 7 volt rms sinewave. Amplitude is controlled by a 4 position pushbutton attenuator calibrated in 20dB steps from 0dB to 60dB, plus a separate vernier with an additional 30dB of coverage for a total dynamic range of 90dB. Output impedance is 50 and 600 ohms with a maximum current of 10mA rms.

Simultaneous quadrature (90°) and inverted (180°) outputs are also provided for use in multi-phase applications. Each output is fixed at 7 volts RMS from a 600 ohm source impedance.

Precise frequency tuning is provided by a 3 digit tuning selector and a 5-band decade multiplier.

The 4400 has been carefully inspected, tested and aged before shipment to insure that it is working properly. If the oscillator appears to have been damaged in shipment, inform the freight carrier of the damage and notify Krohn-Hite or its nearest sales office immediately.

1.2 SPECIFICATIONS (SPECIFICATIONS APPLY TO MAIN, QUADRATURE AND INVERTED OUTPUTS, EXCEPT WHERE NOTED)

FREQUENCY RANGE: 1 Hz to 110 kHz.

FREQUENCY CONTROL: 2 digits of frequency, calibrated in 1 Hz and 0.1 Hz steps, with a calibrated vernier providing continuous coverage between the 0.1 Hz steps, plus a 5 decade, pushbutton multiplier with overlapping ranges.

FREQUENCY ACCURACY: **0.5%** of frequency setting.

FREQUENCY STABILITY:

Vs Time:	0.01% in 1 hour or less.
Vs Temperature:	0.05%/°C.
Vs Line:	<0.001% for 10% change in line voltage.

MAXIMUM OUTPUT AMPLITUDE: 7 volts rms, open circuit, 3.5 volts rms (+13dBm) into 600 ohm load (0.5 volts into 50 ohm load).

MAXIMUM OUTPUT CURRENT: 10mA rms.

MAIN OUTPUT AMPLITUDE CONTROL:

A four position pushbutton attenuator calibrated in 20 dB steps from zero to 60 dB. Accuracy, ±0.25 dB/20 dB step. Volts RMS control with greater than 30 dB of coverage calibrated in volts. Accuracy ±20% of setting. Minimum Output: Less than 0.2 millivolts.

AMPLITUDE FLATNESS:

Main and Inverted Outputs: ±0.05 dB, 1 Hz to 110 kHz.
Quadrature Output: ±2 dB, 1 Hz to 110 kHz.

AMPLITUDE STABILITY:

Vs Time:	0.01% in 1 hour or less.
Vs Temperature:	0.05%/°C.
Vs Line:	<0.001% for 10% change in line voltage.

OUTPUT DISTORTION (SEE FIGURE 1-3):

Frequency	Main and Inverted Outputs		Quadrature Output
1 Hz-10 Hz	0.0018%	(-95 dB)	0.0056% (-85 dB)
10 Hz-10 kHz	0.001%	(-100 dB)	0.0031% (-90 dB)
10 kHz-20 kHz	0.0018%	(-95 dB)	0.0056% (-85 dB)
20 kHz-50 kHz	0.0056%	(-85 dB)	0.0174% (-75 dB)
50 kHz-110 kHz	0.01%	(-80 dB)	0.031% (-70 dB)

PHASE ACCURACY:

Inverted Output (180°): 1 Hz to 10 kHz: ±0.2°
10 kHz to 110 kHz: ±1°

Quadrature Output (-90°): 1 Hz to 1 kHz: ±0.2°
1 kHz to 10 kHz: ±1°
10 kHz to 110 kHz: ±10°

HUM AND NOISE: Greater than 100 dB below signal (10 Hz to 20 kHz detector bandwidth).

AMBIENT TEMPERATURE RANGE: 0°C to 50°C.

POWER REQUIREMENTS: Switch selectable, 90-132 or 180-264 volts, single phase, 50-60 Hz, 6 watts.

FLOATING GROUND: Rear panel switch floats circuit ground from chassis ground to 100V.

DIMENSIONS AND WEIGHTS:

Cabinet Size/Weight

	H	W	D	Net	Shipping
U. S.	3. 5 in	9 in	8. 5 in	5 lbs	7 lbs
Metric	8. 9 cm	23 cm	2. 16 cm	2. 3 kgs	3. 2 kgs

OPTIONAL RACK-MOUNTING KIT: Part No. RK-39: Permits installation of the Model 4400 into a standard, 19" rack spacing.

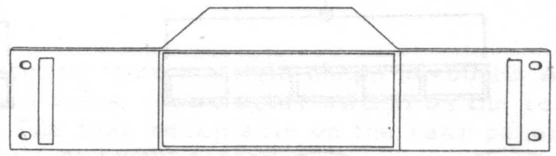


Figure 1-2. Optional Rack-Mounting Kit, RK-39

Specifications subject to change without notice.

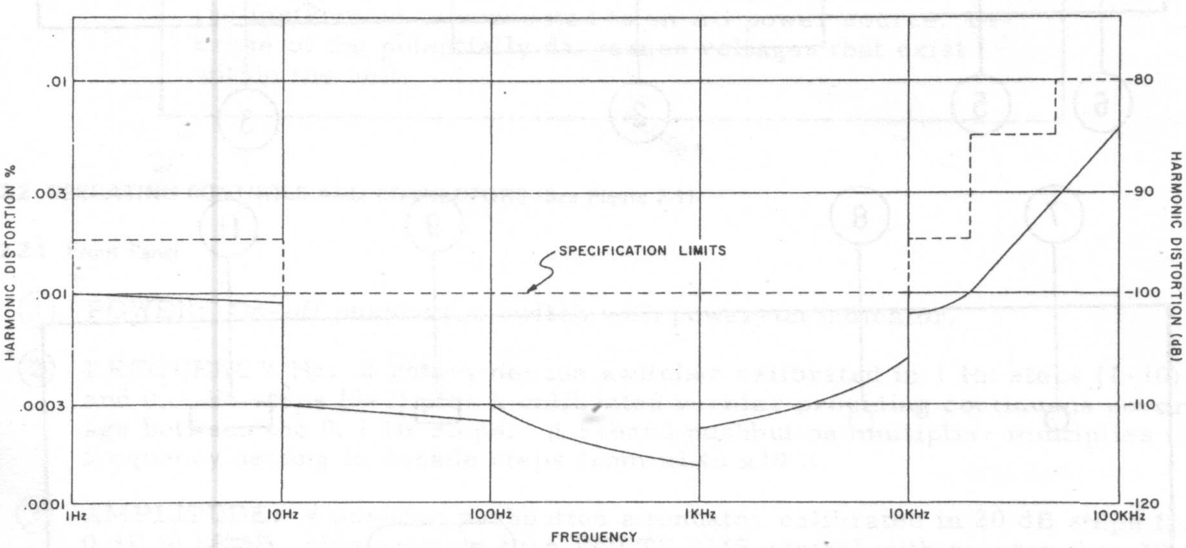


Figure 1-3. Typical Output Distortion

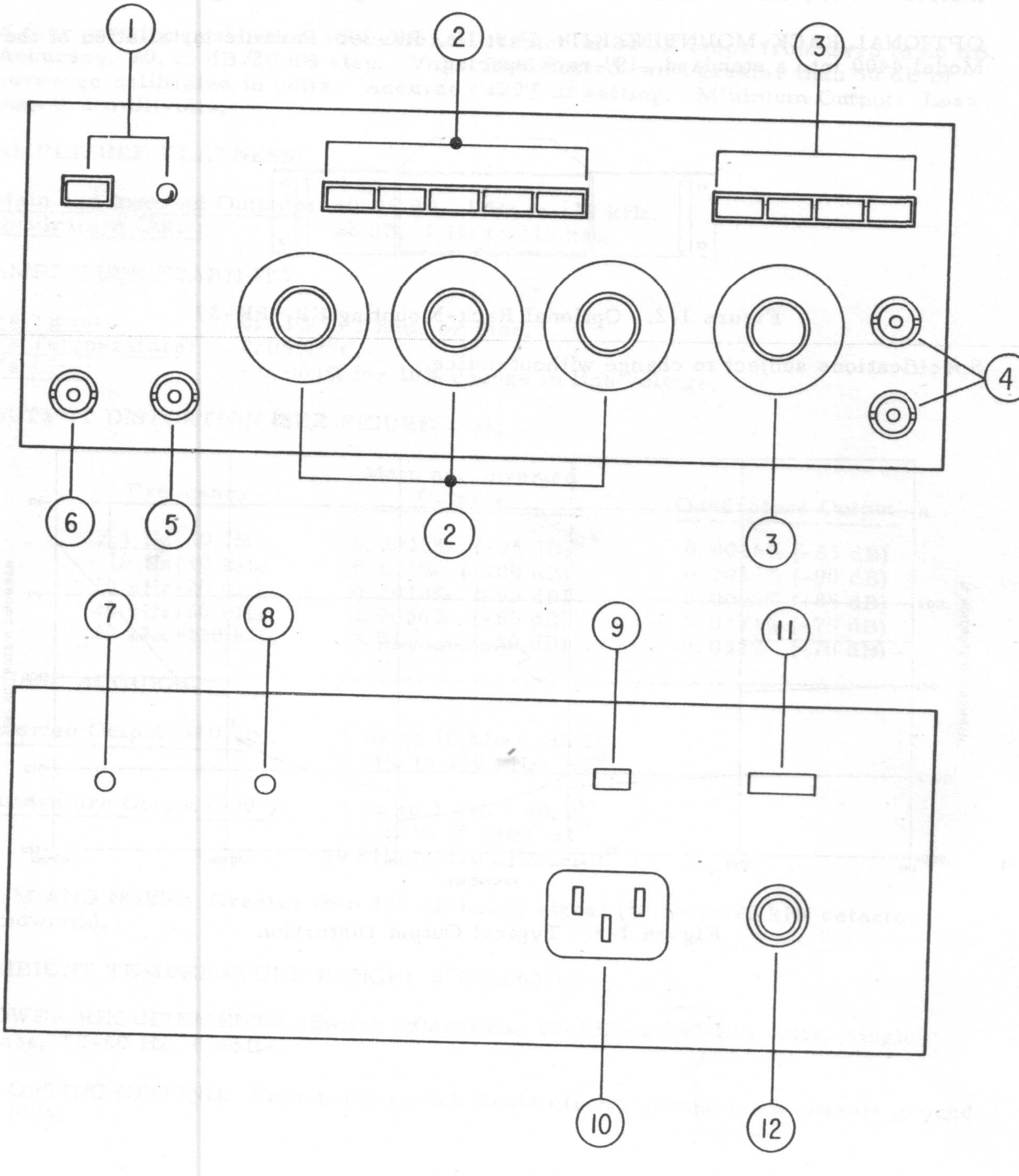


Figure 2-1. Operating Controls and Connectors

SECTION 2

OPERATION

2.1 POWER REQUIREMENTS

The Model 4400 is powered from a single phase 50-60 Hz AC line voltage of either 90-132 volts or 180-264 volts. A selector switch on the rear panel selects the desired voltage range. The fuse receptacle on the rear panel contains a **1/10** ampere slow blow fuse for 120V **and 240V operation.**

CAUTION!

The cover of this instrument should not be removed when the instrument is connected to an AC power source, because of the potentially dangerous voltages that exist within the unit.

2.2 OPERATING CONTROLS AND CONNECTORS (See Figure 2-1)

2.2.1 Front Panel

(1) POWER: On-off pushbutton switch with power-on indicator.

(2) FREQUENCY Hz: 2 rotary decade switches calibrated in 1 Hz steps (1-10) and 0.1 Hz steps (0-9) plus a calibrated vernier providing continuous coverage between the 0.1 Hz steps. A 5-band pushbutton multiplier multiplies the frequency setting in decade steps from x1 to x10 K.

(3) AMPLITUDE: 4 position pushbutton attenuator calibrated in 20 dB steps from 0 dB to 60 dB, plus a single turn VOLTS RMS control with greater than 30 dB of coverage. Dynamic output range 0 dB to -90 dB.

(4) MAIN OUTPUT: 2 BNC connectors. Maximum output, 7 volts rms open circuit and 10mA rms loaded. Output impedance, 50 and 600 ohms.

(5) INVERTED 7V RMS: BNC connector. Fixed at 7V RMS open-circuit. Inverted (180°) with respect to MAIN OUTPUT. Output impedance, 600 ohms, ±1%.

(6) QUAD 7V RMS: BNC connector. Fixed at 7V RMS open-circuit. Quadrature (90°) with respect to MAIN OUTPUT. Output impedance, 600 ohms, ±1%.

2.2.2 Rear Panel

(7) MAIN OUTPUT DC LEVEL ADJ: Screwdriver control for periodic adjustment of MAIN OUTPUT DC level.

(8) QUAD OUTPUT DC LEVEL: Screwdriver control for periodic adjustment of QUAD OUTPUT DC level.

(9) CIRCUIT GROUND: Slide switch. In FLOATING mode, disconnects signal ground (⏚) from chassis ground (⏚).

(10) AC POWER RECEPTACLE: Standard, 3-prong connector complies with European I. E. C. standard. A detachable, 3-wire line cord is included.

(11) LINE: Slide switch. Use 120V position for AC line voltages between 90-132V; use 240V position for AC line voltages between 180-264V.

(12) FUSE RECEPTACLE: Use **1/10** ampere slow blow fuse for 120V **and 240V operation.**

2.3 OPERATION

2.3.1 Frequency Control

The frequency of the 4400 is controlled by 2 rotary decade switches, a 3rd digit vernier and a 5-band decade multiplier. The decade switches are calibrated in 1 Hz steps from 1-10 and 0.1 Hz steps from 0-9. The 3rd digit vernier is calibrated from 0->9 and provides additional resolution between the 0.1 Hz steps. The 5-band, pushbutton multiplier is calibrated in decade steps from x1 to 10K.

Multiplier	Frequency Range
x1	1.00 Hz-11 Hz
x10	10.0 Hz-110 Hz
x100	100 Hz-1.1 kHz
x1K	1.00 kHz-11 kHz
x10K	10.0 kHz-110 kHz

2.3.2 Amplitude Control

The MAIN OUTPUT voltage is controlled by a 4 position, pushbutton attenuator, and a single turn variable control. The attenuator is calibrated in 20 dB steps from 0 dB to 60 dB. The VOLTS RMS control is calibrated in volts and provides an additional 30 dB coverage on each attenuator position.

Attenuator	Volts RMS Range (Main Output)
0 dB	220 mV-7V
20 dB	22 mV-700 mV
40 dB	2 mV-70 mV
60 dB	220 μV-7 mV

To optimize the resolution of adjustment, use the lower of two attenuator settings (e. g. if the application requires a 500 mV RMS signal, use the 20 dB setting rather than the 0 dB setting). The QUAD (90°) and INVERTED (180°) outputs are fixed at 7 volts RMS. The output impedance of each is 600 ohms, ±1%.

2.3.3 Floating Ground Operation

The CIRCUIT GROUND switch on the rear panel allows you to "float" or isolate the oscillator circuit or signal ground (⏚) from the chassis or earth ground (⊥). The maximum allowable DC isolation is 100V.

SECTION 3

INCOMING ACCEPTANCE AND ROUTINE PERFORMANCE TESTS

3.1 INTRODUCTION

The following procedure should be used to verify the oscillator is operating within specifications, both for incoming inspection and for routine servicing. Tests should be made with the cover in place, and the procedure given below should be followed in sequence. Familiarize yourself with the initial set-up and operating procedures outlined in Section 2, Operation.

> **CAUTION!**
>
> The cover of this instrument should not be removed when the instrument is connected to an AC power source, because of the potentially dangerous voltages that exist within the unit.

3.2 EQUIPMENT REQUIRED

Refer to The Appendix on page 20.

3.3 PROCEDURE

Allow the oscillator to warm up for at least 30 minutes, then set the controls initially to the following positions:

FREQUENCY Hz	1 kHz (1-0-0 x1K)
AMPLITUDE	0 dB, Volts RMS set for Max CW
CIRCUIT GROUND	Chassis

3.3.1 DC Level Adjustments

Connect the DVM to the MAIN OUTPUT and adjust the rear panel screwdriver control marked "MAIN OUTPUT DC LEVEL" for a reading of 0 volts.

Connect the DVM to the QUAD OUTPUT and adjust the rear panel screwdriver panel marked "QUAD OUTPUT DC LEVEL" for a reading of 0 volts.

3.3.2 Frequency Accuracy

Connect the Frequency Counter to the MAIN OUTPUT and verify that the frequency accuracy is within 0.5% of the FREQUENCY Hz setting, between 1 Hz and 110 kHz.

3.3.3 Main Output Amplitude

Set the oscillator frequency to 1 kHz (1-0-0 x1K). Connect the ACVM to the MAIN OUTPUT; with the VOLTS RMS control turned up maximum, the MAIN OUTPUT should be greater than or equal to 7 volts RMS. Rotate the VOLTS RMS control counter clockwise (minimum); the MAIN OUTPUT should drop to less than 220 mV. Turn the VOLTS RMS control clockwise to obtain a reading of 7 volts RMS. Connect a 600 ohm resistor (±1%) across the MAIN 600 ohm OUTPUT: the voltage should drop to 3.5 volts rms. Remove the 600 ohm resistor.

To check the attenuator accuracy, adjust the VOLTS RMS control for a ACVM reading of 7 volts RMS. Verify that the attenuator accuracy is within ±0.25 dB (±2.9%) per 20 dB step.

Connect the ACVM to the INVERTED (180°) OUTPUT; the ACVM should read greater than or equal to 7 volts RMS. Connect a 600Ω load (±1%) across the INVERTED OUTPUT; amplitude should drop to 1/2 the value. Repeat this for the QUAD (90°) OUTPUT.

3.3.4 Amplitude Flatness

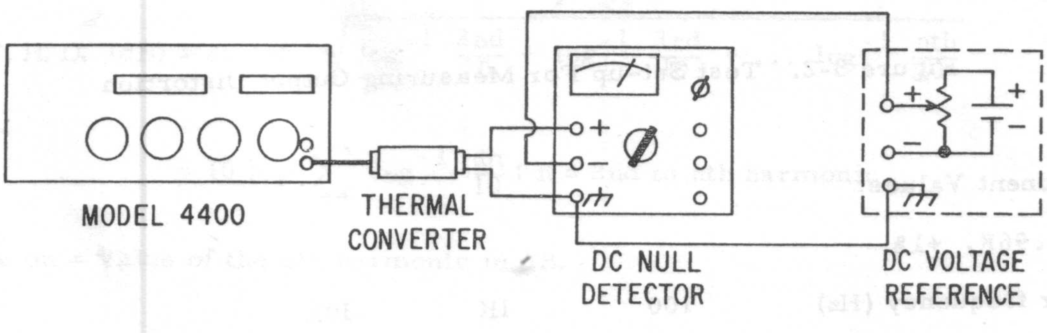


Figure 3-1. Test Set-up for Measuring Amplitude Flatness (use 600 ohm output).

Amplitude flatness is defined as the maximum deviation from constant amplitude expressed in dB or % over a specified frequency range. Since few AC voltmeters today are capable of accurately measuring voltage deviations of less than 0.05 dB (0.6%) up to 100 kHz, the use of a high frequency thermal converter, and either a differential DC voltmeter or DC null meter with a calibrated or stable DC supply, is recommended (see figure 3-1).

Minimize the capacitance in the meter leads to avoid loading effects at the higher frequencies.

Set the frequency of the 4400 to a reference frequency such as 1 kHz and adjust the voltmeter or null meter for a 0 dB/0% deviation. Tune the oscillator frequency from 1 Hz to 110 kHz. The MAIN OUTPUT should remain constant within ±0.05 dB (±0.6%) over the entire frequency range.

Repeat this for the INVERTED OUTPUT; tolerance, ±0.05 dB, 1 Hz to 110 kHz.

Repeat again for the QUAD OUTPUT; tolerance, ±2 dB (±2.5%).

3.3.5 Output Distortion

The use of a spectrum or wave analyzer (HP, B & K, Marconi, etc.) and a pre-filter is recommended for distortion measurements below 0.001%. The pre-filter consists of a passive "twin-tee" or notch filter and is used to attenuate the fundamental, to increase the sensitivity of the spectrum or wave analyzer.

The diagram below shows the test set-up for measuring the output distortion of the 4400, using a spectrum or wave analyzer.

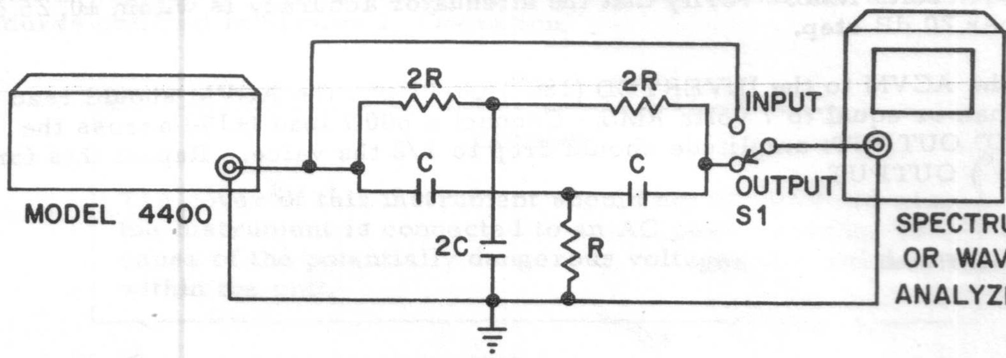


Figure 3-2. Test Set-up For Measuring Output Distortion

Component Values:

R = 7.96K, ±1%

Center frequency (Hz)	100	1K	10K
Capacitance (μ F)*	.1	.01	.001

*Capacitance values are ±1% tolerance.

To measure distortion, proceed as follows:

1) Set the controls on the analyzer to the following initial positions:

ADAPTIVE SWEEP	Off
DISPLAY	Clear Write
FREQUENCY	1 kHz
AMPLITUDE MODE	LOG dB/DIV
AMPLITUDE REF LEVEL	0 (Zero)
INPUT SENSITIVITY	+20 dB (10V)
RESOLUTION BANDWIDTH	100 Hz

FREQ SPAN/DIV	0.5 kHz
SWEEP TIME/DIV	1 Sec
SWEEP MODE	Repetitive

2) Set switch S1 (Figure 3-2) to the "INPUT" position. Adjust the 4400 frequency to correspond to the twin-tee null frequency.

3) Adjust the INPUT SENSITIVITY vernier on the Analyzer to obtain a 0 dB reference at the fundamental frequency.

4) Switch S1 to the "OUTPUT" position. Adjust the frequency of the 4400 to null the fundamental frequency.

5) Increase the INPUT SENSITIVITY in dB steps until the harmonic components are visible.

The dB level of each harmonic component is the sum of the dB below the 0 dB reference level on the display, plus the change in the INPUT SENSITIVITY level, in dB.

To compensate for loss through the twin-tee filter, add +9 dB to the second harmonic component and +5 dB to the 3rd harmonic component.

For example, if the 2nd harmonic is -118 dB,

$$-118 \text{ dB} + 9 \text{ dB} = -109 \text{ dB}.$$

Total harmonic distortion may then be calculated as follows:

(1) $$\text{T.H.D. (dB)} = 20 \log \sqrt{\log^{-1}\frac{2nd}{10} + \log^{-1}\frac{3rd}{10} + \ldots \log^{-1}\frac{nth}{10}}$$

(2) $$= 10 \log \sum \log^{-1}\frac{dn}{10}\text{ ; n = 2nd to nth harmonic}$$

Where dn = Value of the nth harmonic in dB.

OR,

(3) $$\text{T.H.D. (\%)} = 100 \times \sqrt{\sum \left[\log^{-1}\frac{dn}{10}\right]}\text{ ; n = 2nd to nth harmonic}$$

Where dn = Value of the nth harmonic in dB.

SECTION 4

CIRCUIT DESCRIPTION

4.1 THEORY OF OPERATION

A simplified diagram of the oscillating loop is shown in Figure 4-1.

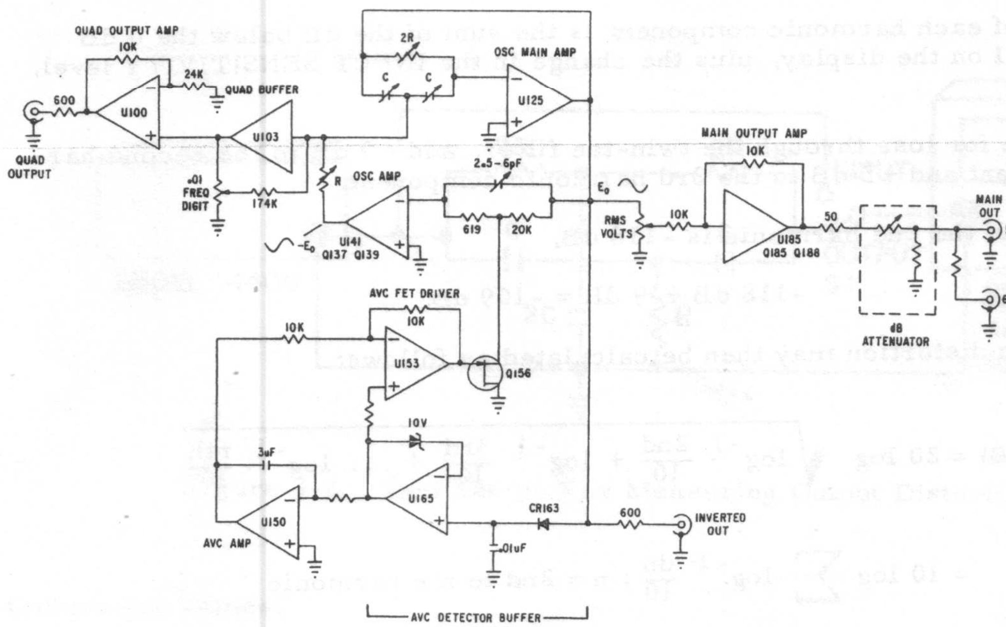


Figure 4-1. Model 4400 Simplified Block Diagram

The 4400 oscillator is a true RC sinusoidal oscillator designed for ultra low wave-form distortion and flat amplitude response.

It consists of two feedback loop systems, one to produce the sine waves and one to maintain stable amplitude.

It uses two resistors and two capacitors connected in a bridge T as the tuning or resonating part of the circuit.

The transfer function of the bridge T network is that of a notch filter. Degenerative feedback around U125 is through the notch filter. Regenerative feedback is provided by U141 to the bottom of the network. At all frequencies except the notch frequency the degenerative feedback is greater than the regenerative. At the notch frequency the degenerative feedback is balanced out by the regenerative feedback and is slightly in favor of the regenerative feedback. At that frequency the loop will oscillate. The regenerative gain is controlled by the Automatic Voltage Control or A. V. C. to maintain the oscillation at its proper amplitude.

The two R values are selected by the FREQUENCY Hz switches (S104, S105) and the two C values by the frequency MULTIPLIER switches (S103).

The MAIN OUTPUT is provided by U181 which is fed from the VOLTS RMS control potentiometer, R180.

The INVERTED OUTPUT is derived from the oscillator loop.

The signal on the common point of the bridge T capacitors is lagging the oscillator loop output signal by 90°. This signal is buffered by amplifier U103 and fed to the frequency vernier (R104), the band calibration potentiometers (R110-R113, R122), and the QUAD OUTPUT amplifier U100.

4.2 AVC OPERATION

The AVC system is shown in Figure 4-2.

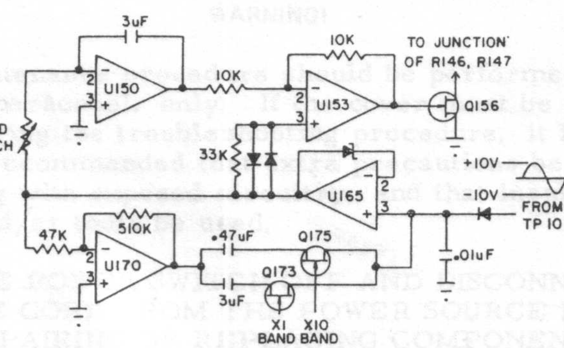


Figure 4-2. Simplified AVC Diagram

The oscillator loop output signal in Figure 4-1 is fed to peak detector diode CR163 and the voltage divider formed by R147 and Q156. Q156 is an FET operated as a voltage controlled resistor. The peak detector charges its capacitor to the plus peak value of the sine wave and is fed to one input of U165 the Detector Buffer. A difference or error voltage proportional to the difference between the reference and detected value is produced on the output of U165. This error voltage is fed to the AVC amplifier for additional filtering and DC gain. The AVC amplifier output feeds the AVC FET Driver amp U153 which in turn drives the gate of Q156.

This control loop varies the voltage dividers loss there by controlling the gain of U141 in the oscillator loop.

A small portion of the error signal on the output of U165 is fed directly to the input of U153, bypassing the AVC amplifier's time delay and stabilizing the control loop from oscillating.

To minimize amplitude transients when changing frequency and to speed up the recovery of the amplitude control loop, certain circuit refinements are added.

On the lower two bands (X1, X10) the peak detector capacitor is electronically multiplied up in value by amplifier U170. The output of U170 is dynamically limited so that on large amplitude changes U170 no longer multiplies the capacitor values and the peak detector can respond more quickly.

To further enhance the AVC response to a large amplitude transient, additional feed forward to the FET drive is provided by back to back diodes from the peak detector buffer.

To optimize the AVC amplifiers time constant, the input resistor feeding U150 is switched with the frequency MULTIPLIER.

SECTION 5

MAINTENANCE

5.1 INTRODUCTION

If the oscillator is not functioning properly and requires service, the following procedure may facilitate locating the source of trouble. Access to the interior of the oscillator is accomplished by removing the two screws on both sides of the cover.

> **WARNING!**
>
> This maintenance procedure should be performed by qualified personnel, only. If the cover must be removed during the troubleshooting procedure, it is strongly recommended that extra precautions be taken in working with exposed circuitry, and that insulated probes and/or tools be used.
>
> SHUT THE POWER SWITCH OFF AND DISCONNECT THE LINE CORD FROM THE POWER SOURCE BEFORE REPAIRING OR REPLACING COMPONENTS.

When a malfunction is detected, first check the line voltage and fuses, and then make an inspection for broken wires, burnt or loose components, poor solder joints, or similar conditions which could cause trouble. Before troubleshooting, it should be determined if the normal adjustments mentioned in Section 6, Calibration, will correct the trouble. The troubleshooting of the oscillator will be greatly simplified if there is an understanding of the operation of the circuit. Reference should be made to Section 4, Circuit Description.

5.2 EQUIPMENT REQUIRED

Refer to the Appendix on page 20.

5.3 PRELIMINARY SET-UP

Before troubleshooting, set the controls to the following initial positions:

FREQUENCY Hz	1-0-0 x 1K (1 kHz)
AMPLITUDE	Attenuator (dB) set for 0 (Zero); Volts RMS set for max CW.
FLOATING	Chassis

5.4 PROCEDURE

The troubleshooting flow chart on page 17 should help to localize the source of trouble.

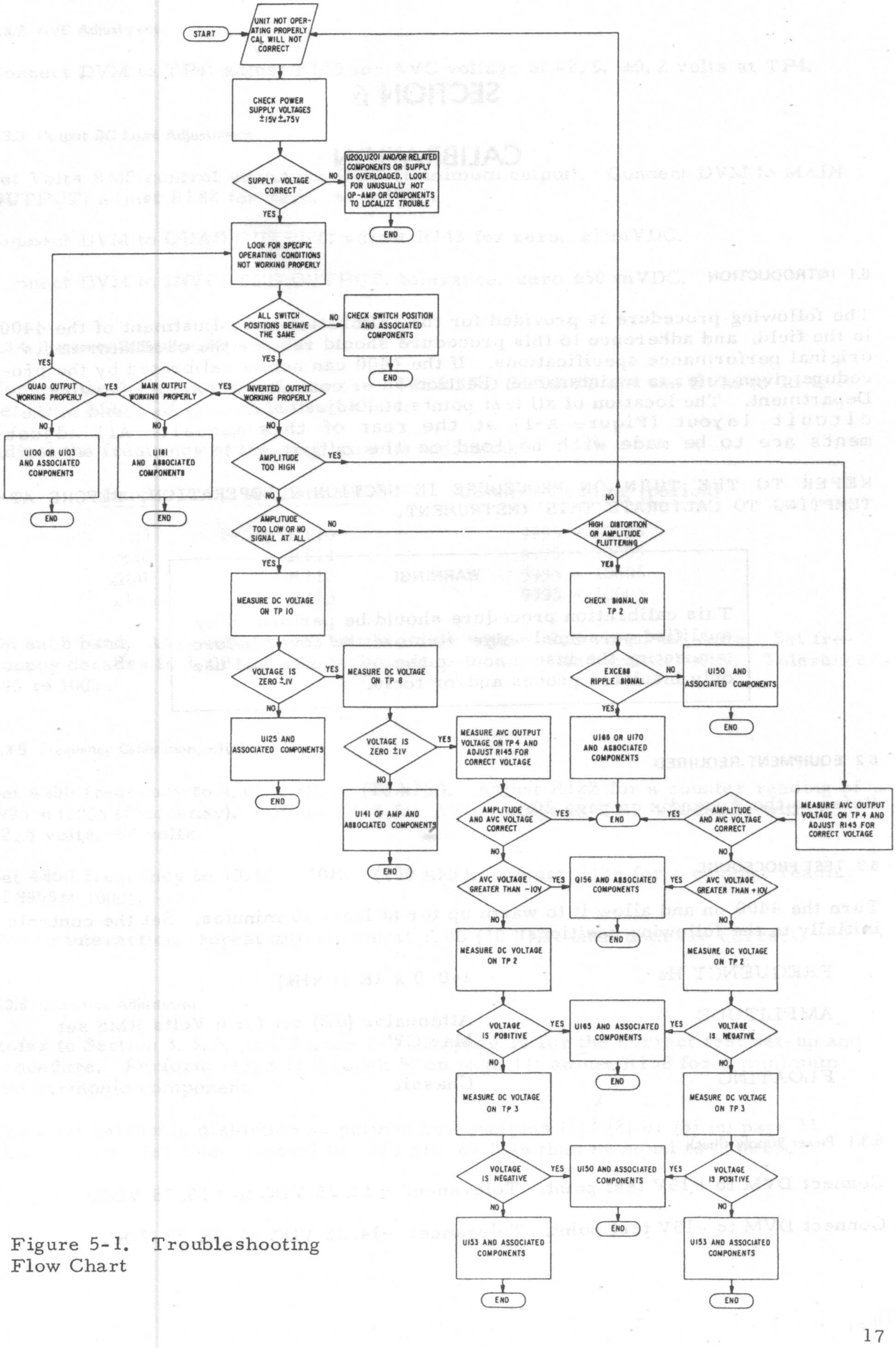


Figure 5-1. Troubleshooting Flow Chart

SECTION 6

CALIBRATION

6.1 INTRODUCTION

The following procedure is provided for the calibration and adjustment of the 4400 in the field, and adherence to this procedure should restore the oscillator to its original performance specifications. If the 4400 can not be calibrated by the procedure given refer to maintenance, Section 5, or consult our Factory Service Department. The location of all test points and adjustments may be found in the circuit layout (Figure A-1) at the rear of this manual. All adjustments are to be made with no load on the output.

REFER TO THE TURN ON PROCEDURE IN SECTION 2, OPERATION, BEFORE ATTEMPTING TO CALIBRATE THIS INSTRUMENT.

> **WARNING!**
>
> This calibration procedure should be performed by qualified personnel only. Remove the cover before connecting the instrument to the AC source and use only insulated probes and/or tools.

6.2 EQUIPMENT REQUIRED

Refer to the Appendix on page 20.

6.3 TEST PROCEDURE

Turn the 4400 on and allow it to warm up for at least 30 minutes. Set the controls initially to the following positions:

FREQUENCY Hz	1-0-0 x 1K (1 kHz)
AMPLITUDE	Attenuator (dB) set for 0 Volts RMS set Max CW
FLOATING	Chassis

6.3.1 Power Supply Check

Connect DVM to + 15V test point. Tolerance: + 14.25 VDC to + 15.75 VDC.

Connect DVM to - 15V test point. Tolerance: - 14.25 VDC to - 15.75 VDC.

6.3.2 AVC Adjustment

Connect DVM to TP4; adjust R145 for AVC voltage of -2.5, ±0.2 volts at TP4.

6.3.3 Output DC Level Adjustments

Set Volts RMS control maximum CCW (minimum output). Connect DVM to MAIN OUTPUT; adjust R182 for zero, ±1 mVDC.

Connect DVM to QUAD OUTPUT; adjust R143 for zero, ±1 mVDC.

Connect DVM to INVERTED OUTPUT; tolerance, zero ±50 mVDC.

6.3.4 Frequency Calibration, Bands x1-x1K

Connect the frequency counter to the INVERTED OUTPUT and the DVM to TP4. Set the FREQUENCY decades for 10.00.

Adjust the frequency of the oscillator as indicated.

Band	Adjustment	Counter Reading (period)
x1	R110	9995 - 10005
x10	R111	9995 - 10005
x100	R112	9995 - 10005
x1K	R113	9995 - 10005

On each band, AVC voltage at TP4 should be within -2.5 volts, ±2 volts. Set frequency decades to 1.00 and check frequency accuracy on bands x1-x1K. Tolerance: 995 to 1005.

6.3.5 Frequency Calibration, x10K Band

Set 4400 frequency to 1.00 x 10K. (10 kHz). Adjust R122 for a counter reading of 9995 to 10005 (frequency). Adjust C115 for AVC voltage at TP4; should be within -2.5 volts, ±2 volts.

Set 4400 frequency to 10.00 x 10K. (100 kHz). Adjust C134 for a counter reading of 9995 to 10005.

Due to interaction, repeat adjustment at 1.00 (10 kHz) until both are correct.

6.3.6 Distortion Adjustment

Refer to Section 3.3.5, and Figure 3-2, on page 10 for the correct test set-up and procedure. Perform steps 1) through 5) on page 11; adjust R158 for a minimum 2nd harmonic component.

The total harmonic distortion as defined by equations (1), (2) or (3) on page 11 should be greater than or equal to -100 dB, or less than or equal to 0.001%.

APPENDIX

List of Recommended Test Equipment

1) Oscilloscope, bandwidth of at least 1 MHz, Vertical Sensitivity 10 mV/cm, AC/DC coupled.

2) DC Voltmeter, zero to ±15 volts.

3) AC Voltmeter, Frequency Range less than 1 Hz to greater than 110 kHz, to measure between zero and greater than 7 volts RMS, better than 3% accuracy.

4) Amplitude Flatness Measuring Equipment:

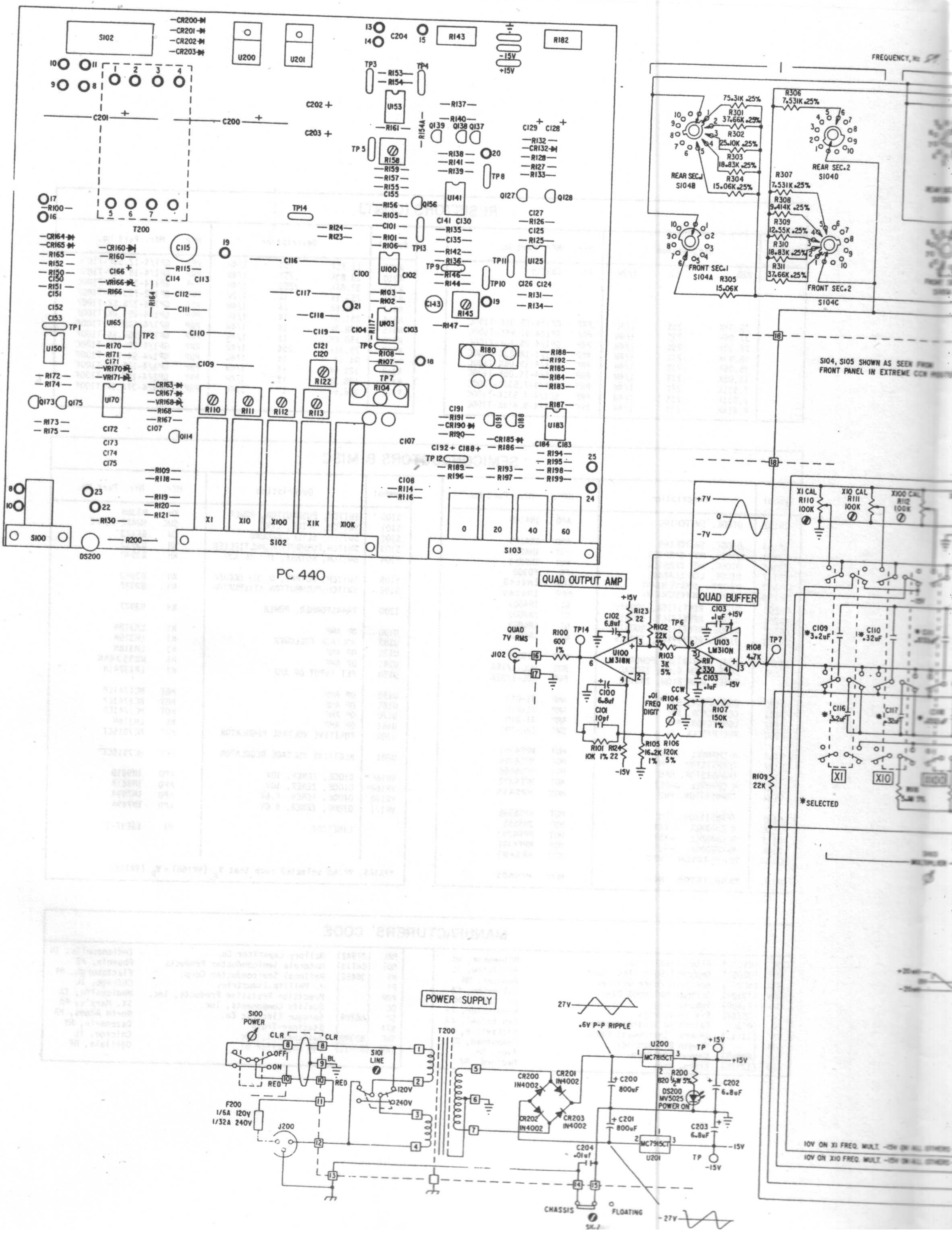
   a) RMS Voltmeter that will measure AC voltage variations of less than 0.05 dB (0.6%) from 1 Hz to 110 kHz,

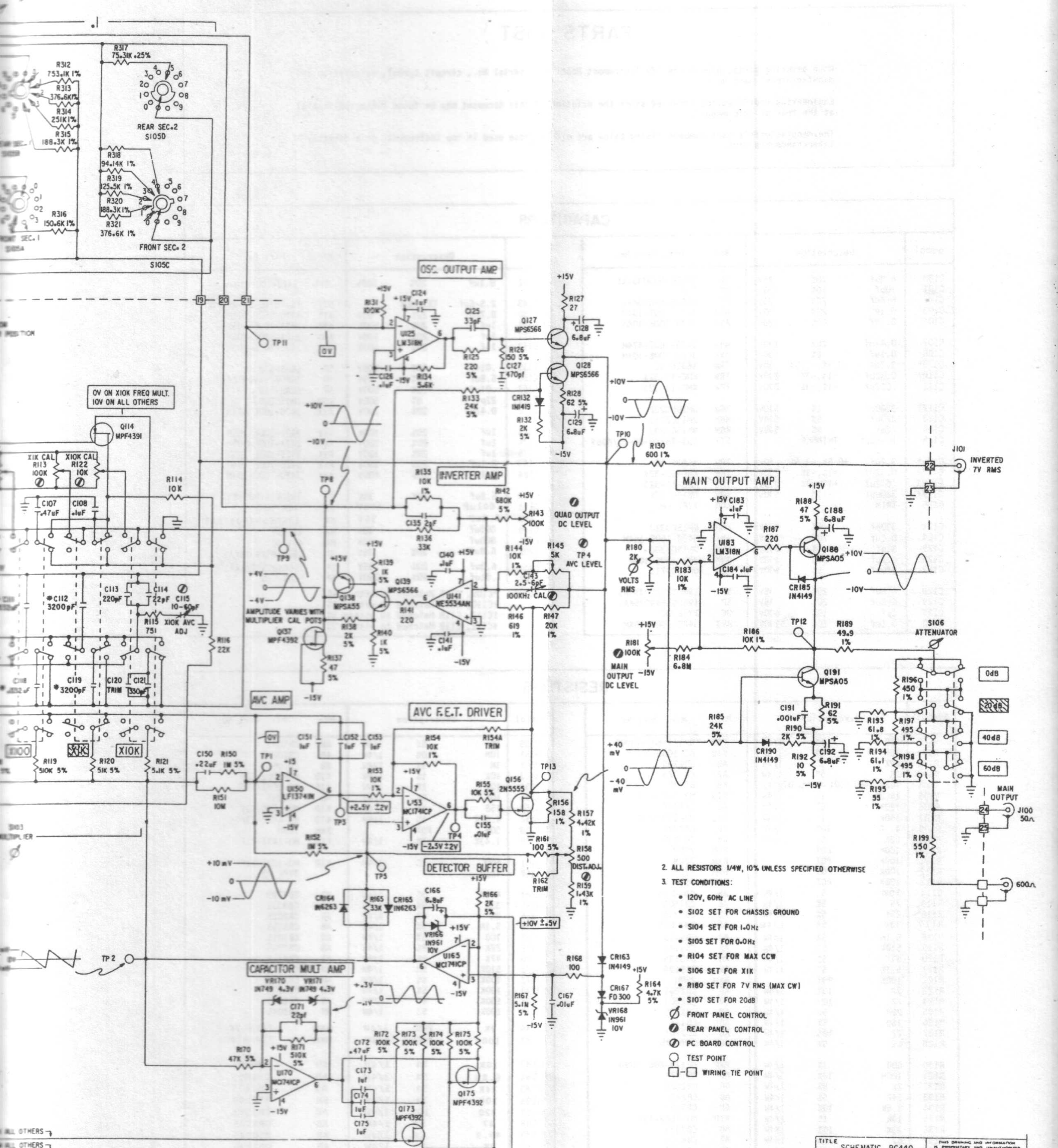
   OR

   b) High Frequency Thermal Converter (Fluke Model A55) and either a DC Differential Voltmeter (Fluke Model 895A), or a DC Null Detector (Fluke Model 845A) with a stable, DC reference supply.

5) Spectrum or Wave Analyzer, to measure harmonic components down to 0.001% (-100 dB).

6) Frequency/Period counter, accuracy better than.5%, 1 Hz to 110 kHz.


PC 440
QUAD OUTPUT AMP
QUAD BUFFER
POWER SUPPLY
REAR SEC.1 S104B
REAR SEC.2 S104D
FRONT SEC.1 S104A
FRONT SEC.2 S104C
S104, S105 SHOWN AS SEEN FROM FRONT PANEL IN EXTREME CCW POSITION
*SELECTED
.6V P-P RIPPLE
CHASSIS
FLOATING
10V ON X1 FREQ. MULT.
10V ON X10 FREQ. MULT.



2. ALL RESISTORS 1/4W, 10% UNLESS SPECIFIED OTHERWISE

3. TEST CONDITIONS:

- 120V, 60Hz AC LINE
- S102 SET FOR CHASSIS GROUND
- S104 SET FOR 1.0Hz
- S105 SET FOR 0.0Hz
- R104 SET FOR MAX CCW
- S106 SET FOR X1K
- R180 SET FOR 7V RMS (MAX CW)
- S107 SET FOR 20dB

FRONT PANEL CONTROL

REAR PANEL CONTROL

PC BOARD CONTROL

TEST POINT

WIRING TIE POINT

TITLE	SCHEMATIC PC440
MODEL	4400A
DRAWN BY	P.Crossman
DATE	3-3-80
	R31
	4-16-85
DWG NO.	S-3997

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RESISTORS (CONT.)

Symbol	Description			Mfr.	Mfr. Part No.
	820	5%	1/2W	AB	EB8215
	75.31K	.25%	1/4W	PRP	GP1/4-75.31K-T100C
	37.66K	.25%	1/4W	PRP	GP1/4-37.66K-T100C
	25.10K	.25%	1/4W	PRP	GP1/4-25.10K-T100C
	18.83K	.25%	1/4W	PRP	GP1/4-18.83K-T100C
	15.06K	.25%	1/4W	PRP	GP1/4-15.06K-T100C
	15.06K	.25%	1/4W	PRP	GP1/4-15.06K-T100C
	7.531K	.25%	1/4W	PRP	GP1/4-7.531K-T100C
	7.531K	.25%	1/4W	PRP	GP1/4-7.531K-T100C
	9.414K	.25%	1/4W	PRP	GP1/4-9.414K-T100C

Symbol	Description			Mfr.	Mfr. Part No.
R309	12.55K	.25%	1/4W	PRP	GP1/4-12.55K-T100C
R310	18.83K	.25%	1/4W	PRP	GP1/4-18.83K-T100C
R311	37.66K	.25%	1/4W	PRP	GP1/4-37.66K-T100C
R312	753.1K	1%	1/2W	PRP	GP1/2-753.1K-T100F
R313	376.6K	1%	1/4W	PRP	GP1/4-376.6K-T100F
R314	251.0K	1%	1/4W	PRP	GP1/4-251.0K-T100F
R315	188.3K	1%	1/4W	PRP	GP1/4-188.3K-T100F
R316	150.6K	1%	1/4W	PRP	GP1/4-150.6K-T100F
R317	75.31K	.25%	1/4W	PRP	GP1/4-75.31K-T100C
R318	94.14	1%	1/4W	PRP	GP1/4-94.14K-T100F
R319	125.5K	1%	1/4W	PRP	GP1/4-125.5K-T100F
R320	188.3K	1%	1/4W	PRP	GP1/4-188.3K-T100F
R321	376.6K	1%	1/4W	PRP	GP1/4-376.6K-T100F

SEMICONDUCTORS & MISC

Symbol	Description	Mfr.	Mfr. Part No.
CR132	DIODE, SWITCHING	APD	1N4149
CR163	DIODE, SWITCHING	APD	1N4149
CR164	DIODE, HOT CARRIER	MOT	1N6263
CR165	DIODE, HOT CARRIER	MOT	1N6263
CR167	DIODE, LOW LEAKAGE	FR	FD300
CR185	DIODE, SWITCHING	APD	1N4149
CR190	DIODE, SWITCHING	APD	1N4149
CR200	DIODE, RECTIFIER, 100piv	GI	1N4002
CR201	DIODE, RECTIFIER, 100piv	GI	1N4002
CR202	DIODE, RECTIFIER, 100piv	GI	1N4002
CR203	DIODE, RECTIFIER, 100piv	GI	1N4002
DS200	LED, INDICATOR, POWER	MOT	MV5025
F200	FUSE, SLOW BLOW, 120VAC	BUS	MDL-1/16A
	FUSE, SLOW BLOW, 240VAC	BUS	MDL-1/32A
J100	CONNECTOR, BNC	AMP	31-010
J101	CONNECTOR, BNC	AMP	31-010
J102	CONNECTOR, BNC	AMP	31-010
J200	RECEPTACLE, AC	SWC	EAC-301
Q114	N-CHANNEL J-FET	MOT	MPF4391
Q127	TRANSISTOR, NPN	MOT	MPS6566
Q128	TRANSISTOR, NPN	MOT	MPS6566
Q137	N-CHANNEL J-FET	MOT	MPF4392
Q138	TRANSISTOR, PNP	MOT	MPSA55
Q139	TRANSISTOR, NPN	MOT	MPS6566
Q156	N-CHANNEL J-FET	MOT	2N5555
Q173	N-CHANNEL J-FET	MOT	MPF4392
Q175	N-CHANNEL J-FET	MOT	MPF4392
Q188	TRANSISTOR, NPN	MOT	MPSA05
Q191	TRANSISTOR, NPN	MOT	MPSA05

Symbol	Description	Mfr.	Mfr. Part No.
S100	SWITCH, PUSHBUTTON, POWER	KH	B3386
S101	SWITCH, SLIDE, LINE	SWC	SW422-SO-PC
S102	SWITCH, SLIDE, GROUND	CW	GF123
S103	SWITCH,PUSHBUTTON,MULTIPLIER	KH	B3933
S104	SWITCH, ROTARY, 1Hz DECADE	KH	B3940
S105	SWITCH, ROTARY, 0.1Hz DECADE	KH	B3940
S106	SWITCH,PUSHBUTTON,ATTENUATOR	KH	B3932
T200	TRANSFORMER, POWER	KH	B3927
U100	OP AMP	NS	LM318N
U103	VOLTAGE FOLLOWER	NS	LM310N
U125	OP AMP	NS	LM318N
U141	OP AMP	NS	NE5534AN
U150	FET INPUT OP AMP	NS	LF1374IN
U153	OP AMP	MOT	MC1741CP
U165	OP AMP	MOT	MC1741CP
U170	OP AMP	MOT	MC1741CP
U181	OP AMP	NS	LM318N
U200	POSITIVE VOLTAGE REGULATOR	MOT	MC7815CT
U201	NEGATIVE VOLTAGE REGULATOR	MOT	MC7915CT
VR166*	DIODE, ZENER, 10V	APD	1N961B
VR168*	DIODE, ZENER, 10V	APD	1N961B
VR170	DIODE, ZENER, 4.6V	APD	1N749A
VR171	DIODE, ZENER, 4.6V	APD	1N749A
	LINECORD	PI	13E37-1

*VR166, VR168 selected such that V_R (VR168) = V_R (VR166)

MANUFACTURERS' CODE

AB	(01121)	Allen Bradley Co.	Milwaukee, WI
AMP	(02660)	Amphenol-Borg Elec. Corp.	Broadview, IL
APD	(50273)	American Power Devices	Andover, MA
BKM	(73138)	Bechman Helicpot Div.	Fullerton, CA
BUS	(71400)	Bussman Mfg.	St. Louis, MO
CW	(79727)	C-W Industries	Warminster, PA
FR	(07263	Fairchild Semiconductor	San Rafael, CA
GI	(11711)	General Instrument Corp.	Hicksville, NY
KGN	( )	Kahgan Electronics	Hempstead, NY
KH	(88865)	Krohn-Hite Corp.	Avon, MA
KID	(12126)	Kidco, Inc.	Medford, NJ

MAL	(37942)	Mallory Capacitor Co.	Indianapolis, IN
MOT	(04713)	Motorola Semiconductor Products	Phoenix, AZ
NS	(36462)	National Semiconductor Corp.	Plattsburgh, NY
PI	( )	J. Phillip Industries	Chicago, IL
PRP	( )	Precision Resistive Products, Inc.	Mediapolis, IA
QC	( )	Quality Components, Inc.	St. Mary's, PA
SP	(56289)	Sprague Electric Co.	North Adams, MA
STT	( )	Stettner-Trush	Cazenovia, NY
SWC	(82389)	Switchcraft, Inc.	Chicago, IL
TRW	(84411)	TRW Capacitor Di.	Ogallala, NE

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