Model 4402B

Ultra-Pure Sinewave Oscillator
1Hz to 110kHz
Typical Distortion of 0.0005%

Serial No. ____________

Operating Manual

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Model 4402B   Sinewave Oscillator

SECTION 1
GENERAL DESCRIPTION

1.1 INTRODUCTION

The Model 4402B is an ultra-pure sinewave, stable amplitude oscillator designed to meet the needs of today's high precision 16 to 18 bit A/D converter testing, and audio test and measurement technology.

Covering the frequency range from 1Hz to 110kHz, with precise 3 digit frequency tuning, the 4402B produces a virtually "distortion-free" (<0.0005%) sinewave for measuring A/D converter accuracy, audio preamplifier and power amplifier harmonic distortion. With its exceptionally flat response (0.02dB), the 4402B eliminates the need to constantly monitor voltage levels, during frequency response tests.

The 4402B provides a 7Vrms sinewave output, (balanced output, 14Vrms end-to-end), 3.5Vrms into 50 ohms, and has no loss in performance when loaded with a linear 50 ohm load.

A 3-position, push-button attenuator calibrated in 20dB steps, along with the a 30dB vernier, provides a total dynamic range of 90dB.

Simultaneous fixed and quadrature (90°) outputs are provided. Each output is 7Vrms with 600 ohm source impedance.

The 4402B is the perfect addition to your present test and/or precision measurement set-up.

1.2 SPECIFICATIONS

The following specifications apply to the Main, Quadrature and Fixed Outputs, except where noted.

1.2.1 FREQUENCY

Range: 1Hz to 110kHz.

Accuracy: ±0.5% of frequency setting.

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

Stability:

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

1.2.2 MAIN OUTPUTS

Maximum Amplitude: 7V rms open circuit (balanced output, 14V rms end-to-end); 3.5Vrms; +48dBm into 50 ohm load (balanced output, 7V rms end-to-end).

Impedance: Constant 50 ohms.

Maximum Current: 75mA rms.

Minimum Amplitude: <0.2mV.

Amplitude Flatness: ±0.02dB, 1Hz to 110kHz.

Amplitude Stability:

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

Amplitude Control: A 4-position push-button attenuator calibrated in 20dB steps from 0dB to –60dB, Accuracy, ±0.25dB/20dB step; Volts rms control with greater than 30dB of coverage calibrated in volts. **Accuracy:** ±20% of setting.

Main Output Distortion:

Frequency	Distortion %	Distortion (dB)
1Hz to 10kHz	<0.0005	–106
10kHz to 20kHz	<0.0018	–95
20kHz to 50kHz	<0.0056	–85
50kHz to 110kHz	<0.01	–80

Hum and Noise: Greater than 110dB below signal (10Hz to 20kHz detector bandwidth).

1.2.3 FIXED OUTPUT

Amplitude: 7V rms open circuit; 3.5V rms (+13dBm) into 600 ohm load.

Impedance: Constant 600 ohms.

Amplitude Flatness, Amplitude Stability and Distortion: Same as Main Output.

Phase Accuracy (180°, top BNC, Main Output): 1Hz to 10kHz, ±0.4°; 10kHz to 110kHz, ±5°.

1.2.4 QUADRATURE OUTPUT

Amplitude: 7V rms open circuit; 3.5V rms (+13dBm) into 600 ohm load.

Impedance: Constant 600 ohms.

Amplitude Flatness: ±2dB, 1Hz to 110kHz.

Amplitude Stability: Same as Main Output.

Phase Accuracy (–90°): 1Hz to 1kHz, ±0.2°; 1kHz to 10kHz, ±1°; 10kHz to 110kHz, ±10°.

1.2.5 GENERAL

Ambient Temperature Range: 0°C to 50°C.

Power Requirements: Switch selectable, 90-132 or 180-264 volts, single phase, 50-60Hz, 18 watts.

Floating Ground: Rear panel switch floats circuitry ground from chassis ground up to 100V.

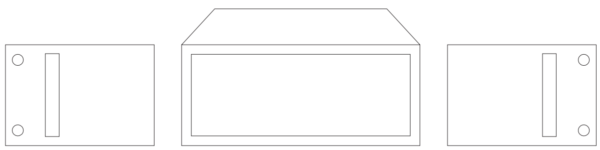
Dimensions: 3½" (8.9cm) high, 9" (23cm) wide, 8½" (21.6cm) deep.

Weights: 5 lbs (2.3kg) net; 7 lbs (3.2kg) shipping.

Accessories: 3-terminal line cord and operating manual.

1.2.6 OPTIONS

Rack Mounting Kit: Part No. RK-39 permits the installation of the Model 4402B into a standard 19"rack spacing.



Optional Rack Mount Kit RK-39

Extended 1 Year Warranty: Part No. EW4402B.

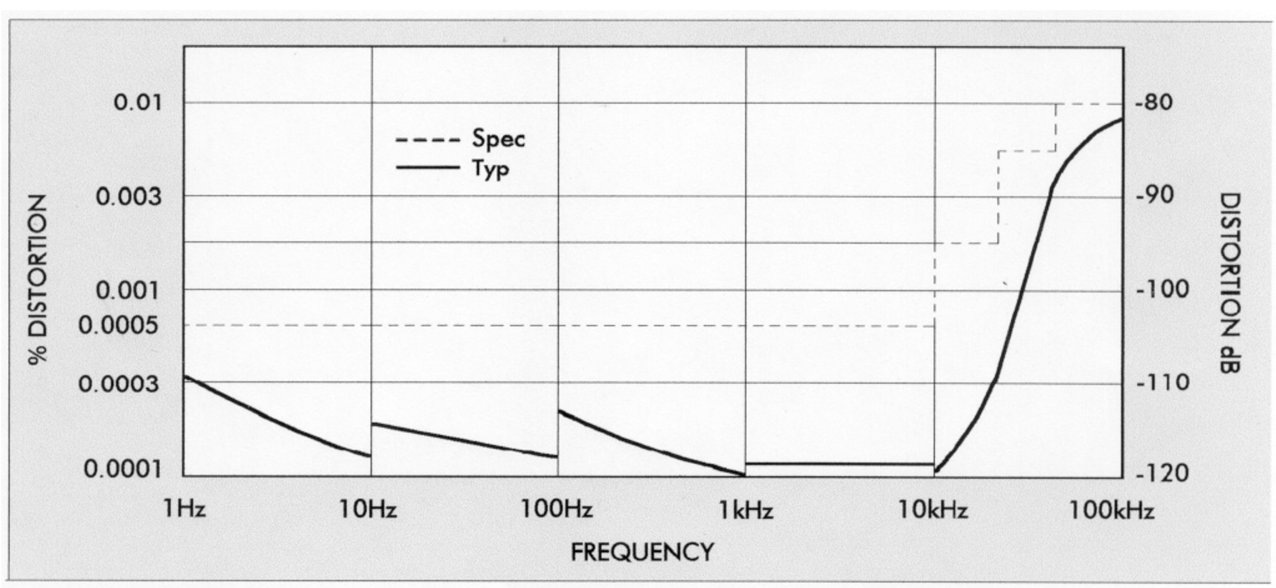


Figure 1.1 Typical Output Distortion

SECTION 2

OPERATION

2.1 POWER REQUIREMENTS

The Model 4402B is powered from a single phase, 50Hz to 60Hz ac line voltage of either 90V to 132V or 180V to 264V. A selector switch on the rear panel selects the desired voltage range.

The fuse receptacle on the rear panel contains 1/4A slow-blow fuse for 120V operation and a 1/8A fuse for 240V operation.

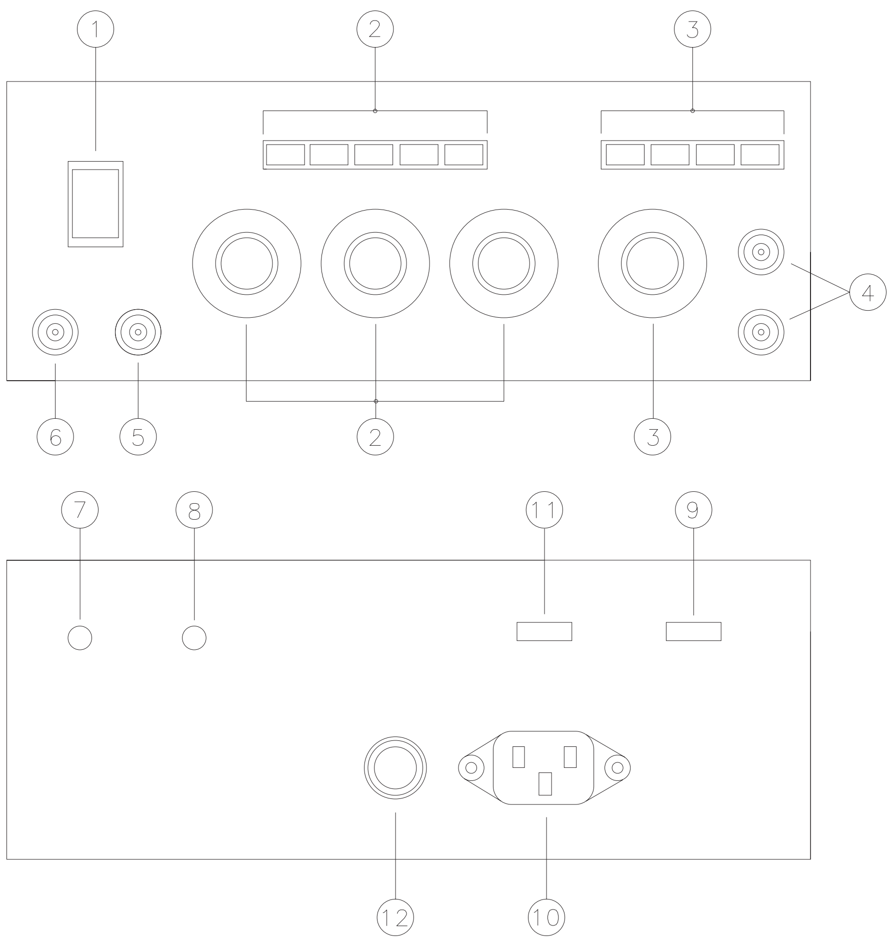


Figure 2.1 Operating Controls and Connectors

CAUTION!

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

2.2 OPERATING CONTROLS AND CONNECTORS (see Figure 2.1 at the end of this section)

1. Power: On-off rocker switch with power-on indicator.

2. Frequency Hz: 2 rotary decade switches calibrated in 1Hz steps (1-10) and 0.1Hz steps (0-9), plus a calibrated vernier providing continuous coverage between the 0.1Hz steps. A 5-band push-button multiplier multiplies the frequency setting in decade steps from x1 to x10k.

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

4. Main Output: 2 BNC connectors. Maximum output, 7Vrms open circuit (14Vrms end-to-end, balanced) and 75mA rms loaded with a linear 50 ohm load. Output Impedance, 50 ohms, ±1%.

5. Fixed 7Vrms: BNC connector. Fixed at 7Vrms open circuit. Output is inverted by 180° on the top Main Output BNC; and is in phase with the bottom Main Output BNC (see Figure 2-1). Output impedance 600 ohms, ±1%.

6. Quad 7Vrms: BNC connector. Fixed at 7Vrms open circuit. Quadrature (90°) with respect to top Main Output BNC. Output impedance, 600 ohms, ±1%.

2.2.1 REAR PANEL

7. Main Output DC Level (bottom BNC): Screwdriver control for periodic adjustment of the Main Output DC Level.

8. Main Output DC Level (top BNC): Screwdriver control for periodic adjustment of the Main Output DC Level.

9. Circuit Ground: Slide switch. In the FLOATING mode, the signal ground becomes disconnected 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 90V to 132V; use 240V position for ac line voltages between 180V to 264 V.

12. Fuse Receptacle: Use a 1/4A, slow-blow fuse for 120V operation and 1/8A, slow-blow fuse for 240V operation.

2.3 OPERATION

2.3.1 FREQUENCY CONTROL

The frequency of the 4402B is controlled by 2 rotary decade switches, a 3rd digit vernier and a 5-decade multiplier. The decade switches are calibrated in 1Hz steps from 1 to 10 and 0.1Hz steps from 0 to 9. The 3rd digit vernier is calibrated from 0->9, and provides additional resolution between the 0.1Hz steps. The 5-band push-button multiplier is calibrated in decade steps from x1 to x10k.

Multiplier	Frequency Range
x1	1.00Hz to 11Hz
x10	10.0Hz to 110Hz
x100	100Hz to 1.1kHz
x1k	1.00kHz to 11kHz
x10k	10.0kHz to 110kHz

2.3.2 AMPLITUDE CONTROL

The Main Output control is controlled by a 4-position push-button attenuator; and a single turn variable control. The attenuator is calibrated in 20dB steps from 0dB to 60dB. The VOLTS RMS control is calibrated in volts and provides an additional 30dB coverage on each attenuator position.

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

To optimize the resolution of the adjustment, use the lower of the two attenuator settings (e.g. if the application requires a 500mV rms signal, use the 20dB setting rather than the 0dB setting).

The Quad (90°) and Fixed (180° out of phase from top Main Output BNC) outputs are fixed at 7Vrms. The output impedance of each of these outputs is 600 ohms.

2.3.3 FLOATING GROUND

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

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SECTION 3
INCOMING ACCEPTANCE

3.1 INTRODUCTION

The following procedure should be used to verify the oscillator is operating within specifications, both for incoming inspection and 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 set-up and operating procedures outlined in Section 2, Operation.

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

3.2 LIST OF EQUIPMENT REQUIRED

1. Oscilloscope: bandwidth of at least 1MHz, vertical sensitivity 10mV/cm, ac/dc coupled.

2. DC Voltmeter: 0V to ±15V.

3. AC Voltmeter: Frequency range <10Hz to >110kHz, to measure between 0V and >7Vrms, better than 3% accuracy.

4. RMS Voltmeter for Measuring Amplitude Flatness: Able to measure ac voltage variations of <0.02dB (0.23%) from 10Hz to 110kHz.

or 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 Analyzer: Able to measure harmonic components below 0.0005% (–106dB).

6. Frequency/Period Counter: Accuracy better than 0.5%, 1Hz to 110kHz.

3.3 PROCEDURE

Allow the Model 4402B to warm-up for at least 30 minutes, then set the controls on the front and rear panels to the following positions:

Frequency Hz: 1kHz (1-0-0 x1k).
Amplitude: 0dB, Volts RMS set for maximum clockwise (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" (adjusts the dc level for the top Main Output BNC connector) for a reading of 0V. Repeat the same for the bottom Main Output marked on the rear panel "MAIN OUTPUT DC LEVEL".

3.3.2 FREQUENCY ACCURACY

Connect the frequency counter to either Main Output. Verify that the frequency accuracy is within 0.05% of the FREQUENCY Hz setting between 1Hz and 110kHz.

3.3.3 MAIN OUTPUT AMPLITUDE

Set the 4402B frequency to 1kHz (1-0-0 X1k). Connect the ACVM to the Main Output; with the VOLTS RMS control set to maximum CW, the Main Output should be ≥7Vrms. Rotate the VOLTS RMS control to minimum (counter clockwise, CCW), the Main Output should be <220mV. Turn the VOLTS RMS clockwise to obtain a reading of 7Vrms. Connect a 50ohm resistor ±1% across the top BNC of the Main Output; the voltage should drop to 3.5Vrms. Repeat the same for the bottom BNC at the Main Output. Remove the 50Ω terminator.

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

Connect the ACVM to the FIXED OUTPUT. The ACVM should read ≥7Vrms. Connect a 600 ohm load (±1%) across the FIXED OUTPUT; the amplitude should drop ½ the value. Repeat the same for the QUAD OUTPUT.

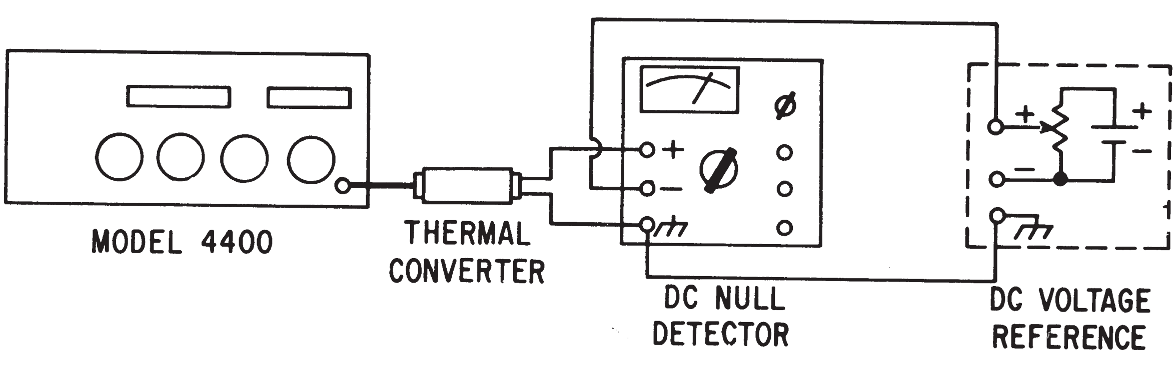

Figure 3.1 Test Set-Up for Measuring Amplitude Flatness

3.3.4 AMPLITUDE FLATNESS (see set-up on next page)

Amplitude flatness is defined as the maximum deviation from constant amplitude expressed in dB or % over a specified frequency range. Since few ac voltmeters are capable of accurately measuring voltage deviations <0.02dB (0.23%) up to 100kHz, 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 Model 4402B to a reference frequency of 1kHz and adjust the voltmeter or null meter for a 0dB/0% deviation. Tune the oscillator frequency from 10Hz to 110kHz. The Main Output should remain constant within ±0.02dB (±0.23%) over the entire frequency range.

Repeat this procedure for both Main Outputs and the Fixed Output. Repeat for the Quad Output, tolerance, ±2dB (±2.5%).

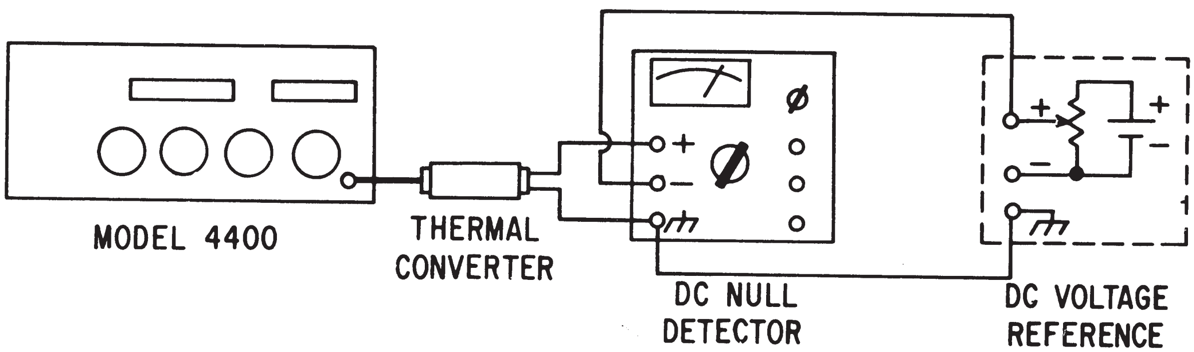

Figure 3.2 Amplitude Flatness Test Set-Up

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 frequency in order to increase the sensitivity of the spectrum or wave analyzer.

Component Values:		R = 7.96k, ±1%	
Center Frequency (Hz)	100	1k	10k
Capacitance (μF)*	0.1	0.01	0.001
* Capacitance values are ±1% tolerance			

The diagram below shows the test set-up for measuring the output distortion of the 4402B.

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	1kHz
AMPLITUDE MODE	Log dB/Div
AMPLITUDE REFERENCE LEVEL	0 (Zero)
INPUT SENSITIVITY	+20dB (10V)
RESOLUTION BANDWIDTH	100Hz
FREQUENCY SPAN/DIV	0.5Hz
SWEEP TIME/DIV	1Sec
SWEEP MODE	Repetitive

2. Set switch S1 to the “INPUT” position. Adjust the 4402B frequency to correspond to the “twin-tee” null frequency.

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

4. Switch S1 to the “OUTPUT” position. Adjust the frequency of the 4402B to null the fundamental frequency. It may be necessary to make fine adjustments to the “twin-tee” component values to obtain sufficient null of the fundamental.

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 0dB 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 +9dB to the second harmonic component and +5dB to the 3rd harmonic component.

For example, if the second harmonic is –128dB: –128dB +9dB = –119dB.

The total harmonic distortion may then be calculated as follows:

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

$$\text{Since: } \log^{-1}(x) = \frac{1}{\log(x)} = 10^{(x)}$$

$$T.H.D.(dB) = 10\log(10^{\frac{dB2nd}{10}} + 10^{\frac{dB3rd}{10}} = 10^{\frac{dB4th}{10}} + \ldots 10^{\frac{dBnth}{10}})$$

$$T.H.D.(dB) = 10\log\sum(10^{\frac{dBn}{10}})$$ dBn = sum of all harmonics

Example: 2nd harmonic = -40dB
3rd harmonic = -46dB
4th harmonic = -50dB

$$T.H.D. = 10\log(10^{\frac{-40}{10}} + 10^{\frac{-46}{10}} + 10^{\frac{-50}{10}})$$

$$= 10\log(10^{-4} + 10^{-4.6} + 10^{-5})$$

$$= 10\log(100\mu + 25\mu\_10\mu)$$

$$= 10\log(135\mu)$$

$$= 10 \times -3.87$$

$$= -38.7dB$$

$$\% = (10^{\frac{-38.7}{20}}) \times 100$$

$$\% = 1.16$$

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SECTION 4
CIRCUIT DESCRIPTION

4.1 THEORY OF OPERATION

A simplified block diagram of the oscillating loop is shown in Figure 4.1.

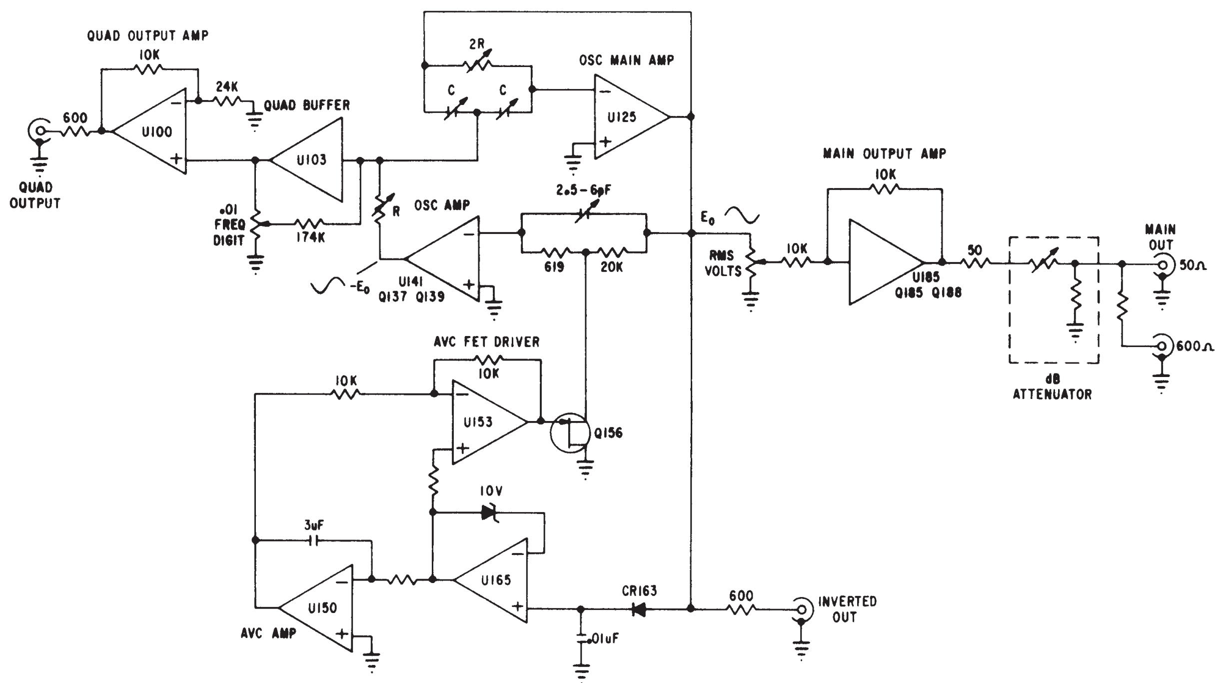

Figure 4.1 Model 4402B Simplified Block Diagram

The 4402B oscillator is a true RC oscillator designed to generate ultra-pure sinewaves and flat amplitude response.

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

It uses two resistors and two capacitors connected in a bridge T as the tuning or the 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. At that frequency, the loop will oscillate. The regenerative gain is controlled by the Automatic Voltage Control (AVC) to maintain the oscillation at its proper amplitude.

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

The Main Output is provided by U183, which is fed from the VOLTS RMS control potentiometer, R180.

The FIXED Output is derived from the oscillator loop.

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

4.2 AVC OPERATION

The AVC system is shown in Figure 4.2.

The oscillator loop output signal in Figure 4.1 is fed to the peak detector diode CR163 and inverter amplifier U138, which inverts the signal and drives CR162 for peak detection on both + and – peaks. It also feeds one input of the linear multiplier U145. The multiplier functions as a variable gain in the regenerative path of the oscillator.

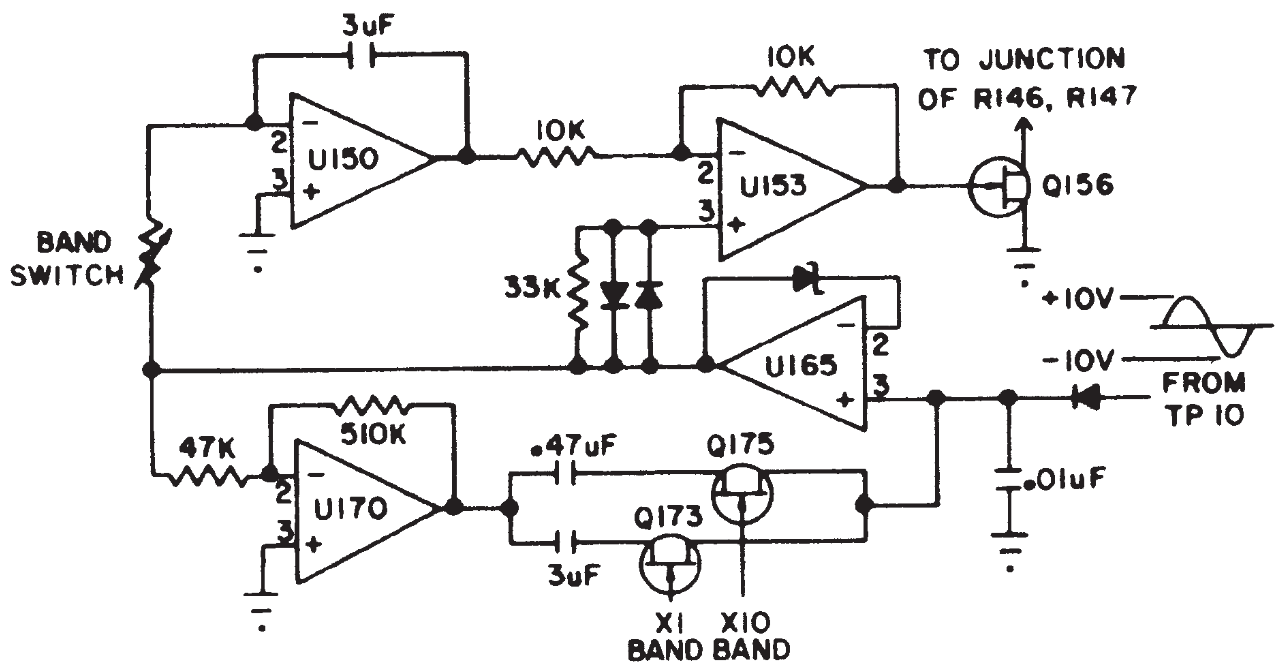

Figure 4.2 Simplified AVC Diagram

The peak detector charges its capacitor to the plus peak value of the sinewave and is fed to one input of U165A, the Detector Buffer. A difference or error voltage proportional to the difference between the reference and detected value is produced on the output of U165A. The error voltage is fed to the AVC amplifier, U150B, for additional filtering and dc gain. The AVC amplifier output feeds U150 which in turn drives the second input of the linear multiplier U145.

This control loop varies the regenerative gain thereby controlling the oscillator loop amplitude.

A small portion of the error signal on the output of U165A is fed directly to the input of U150B, 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 and x10) the peak detector the peak detector capacitor is electrically multiplied up in value by amplifier U165B. The Output of U165B is dynamically limited so that on large amplitude changes, U165B 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 U150B is provided by back-to-back diodes from the peak detector buffer.

To optimize the AVC amplifiers time constant, the input resistor feeding U150A is switched with the frequency MULTIPLIER.

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SECTION 5
MAINTENANCE

5.1 INTRODUCTION

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. 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 problem. 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 for this information.

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 screws located on both sides of the top cover.

5.2 EQUIPMENT REQUIRED

1. Oscilloscope: bandwidth of at least 1MHz, vertical sensitivity 10mV/cm, ac/dc coupled.
2. DC Voltmeter: 0V to ±15V.
3. AC Voltmeter: Frequency range <10Hz to >110kHz, to measure between 0V and >7Vrms, better than 3% accuracy.

4. RMS Voltmeter for Measuring Amplitude Flatness: Able to measure ac voltage variations of <0.02dB (0.23%) from 10Hz to 110kHz.

or 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 Analyzer: Able to measure harmonic components below 0.0005% (–106dB).

6. Frequency/Period Counter: Accuracy better than 0.5%, 1Hz to 110kHz.

5.3 PRELIMINARY SET-UP

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

FREQUENCY Hz	1-0-0 (x1k) = 1kHz
AMPLITUDE	Attenuator (dB) set for 0 (Zero); VOLTS RMS set for maximum CW.
CIRCUIT GROUND	Chassis

5.4 PROCEDURE

The following troubleshooting flowchart should help to localize the source of trouble within the 4402B.

PROCEED TO FLOW CHART ON NEXT PAGE.

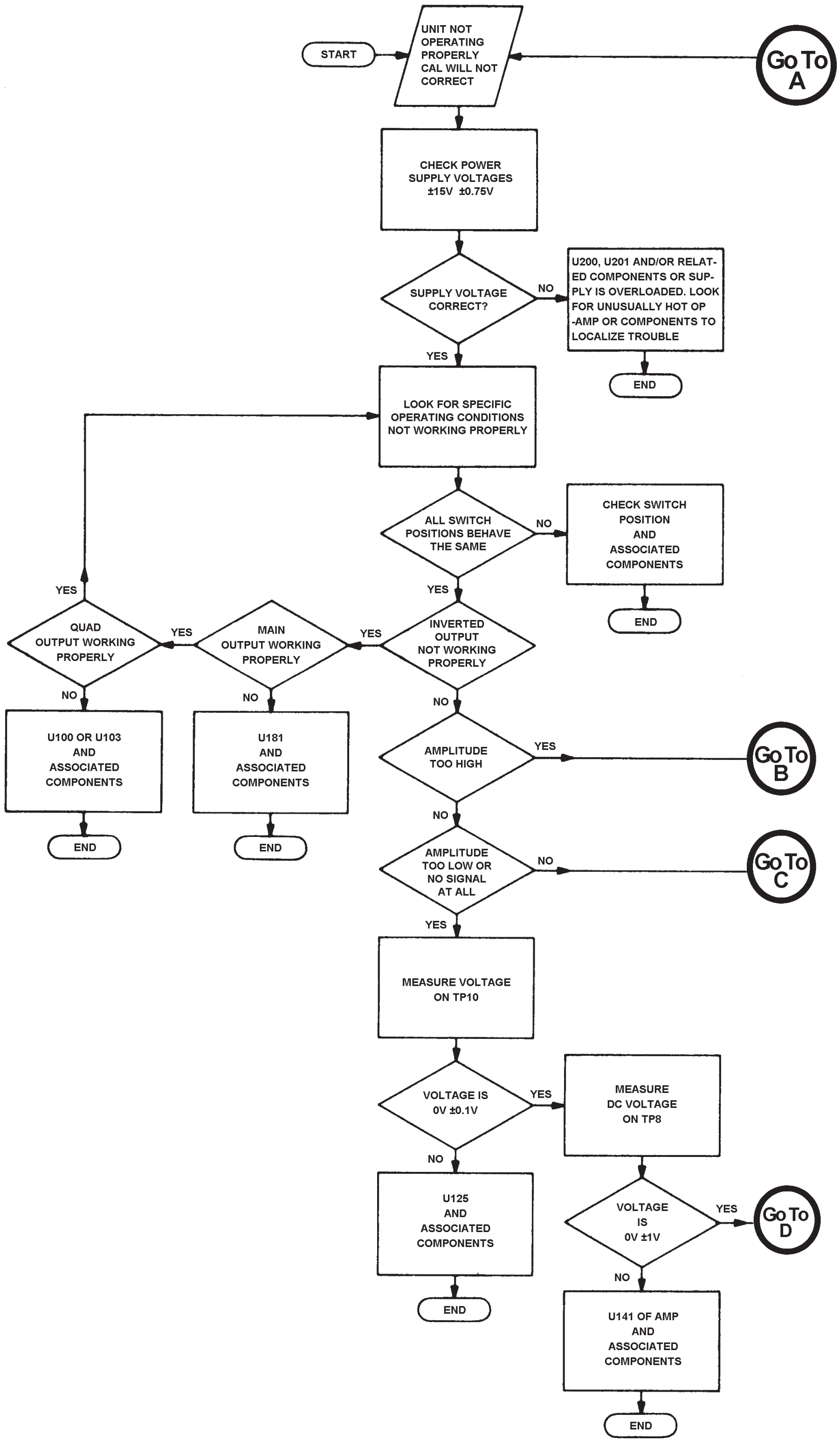

Figure 5.1A Troubleshooting Flow-Chart

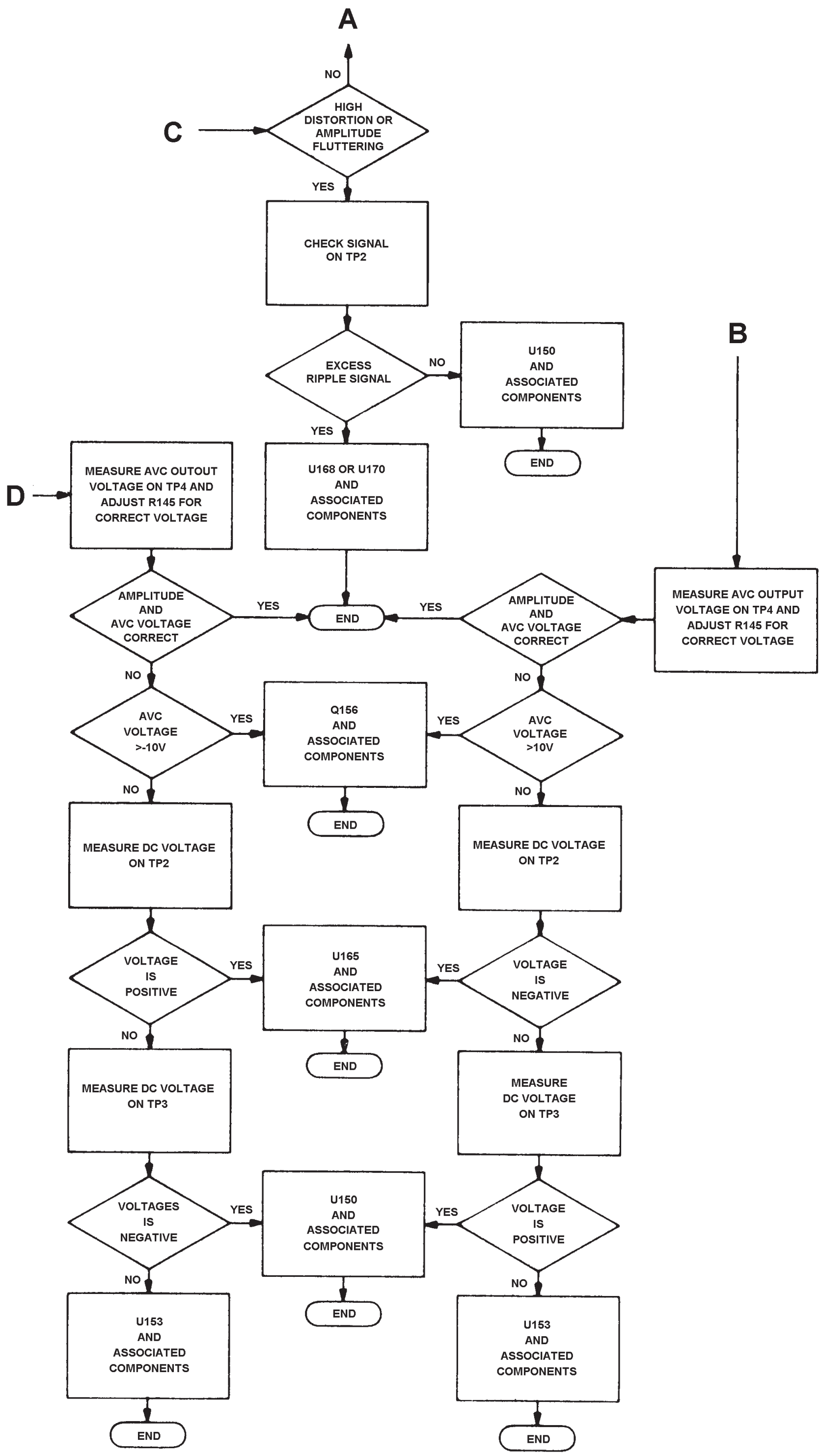

Figure 5.1B Troubleshooting Flow-Chart

SECTION 6

CALIBRATION

6.1 INTRODUCTION

The following procedure is provided for the calibration and adjustment of the 4402B in the field, and adherence to this procedure should restore the oscillator to its original performance specifications. If the 4402B can not be calibrated by this procedure, refer to Section 5, Maintenance, or consult the Krohn-Hite Service Department. The location of all test points and adjustments may be found in the Circuit Layout 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

1. Oscilloscope: bandwidth of at least 1MHz, vertical sensitivity 10mV/cm, ac/dc coupled.

2. DC Voltmeter: 0V to ±15V.

3. AC Voltmeter: Frequency range <10Hz to >110kHz, to measure between 0V and >7Vrms, better than 3% accuracy.

4. RMS Voltmeter for Measuring Amplitude Flatness: Able to measure ac voltage variations of <0.02dB (0.23%) from 10Hz to 110kHz.

or 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 Analyzer: Able to measure harmonic components below 0.0005% (–106dB).

6. Frequency/Period Counter: Accuracy better than 0.5%, 1Hz to 110kHz.

6.3 TEST PROCEDURE

Turn on the 4402B and allow it to warm-up for at least 30 minutes. Set the controls initially to the following positions.

FREQUENCY Hz	1-0-0 (x1k) 1kHz
AMPLITUDE	Attenuator (dB) set for 0; VOLTS RMS set to maximum CW.
CIRCUIT GROUND	Chassis

6.3.1 POWER SUPPLY CHECK

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

Connect DVM to −15V test point. Tolerance: −14.25Vdc to −15.75Vdc.

6.3.2 AVC ADJUSTMENT

Connect DVM to TP4. Adjust R145 for AVC voltage of 0V ±0.1V at TP4.

6.3.3 OUTPUT DC LEVEL ADJUSTMENT

Set VOLTS RMS control maximum counter-clockwise (CCW), minimum output.

Connect DVM to the Main Output.

Adjust R181 for 0V ±1mVdc.

Repeat the same for the bottom (inverted) Main Output BNC and adjust R481.

Connect DVM to the Quad Output.

Adjust R143 for 0V ±1mVdc.

Connect DVM to the Fixed Output. Tolerance: 0V ±50mVdc.

6.3.4 FREQUENCY CALIBRATION (Bands x1 - x1k)

Connect the frequency counter to the Fixed Output and the DVM to TP4.

Set the FREQUENCY decades for 10.00.

Adjust the frequency of the oscillator as indicated below.

Band	Adjustment	Counter Reading (Period)
x1	R110	9995 to 10005
x10	R111	9995 to 10005
x100	R112	9995 to 10005
x1k	R113	9995 to 10005

On each band, AVC voltage at TP4 should be within ±2.0V.

Set frequency decades to 1.00 and check frequency accuracy on band x1 to x1k. Tolerance: 995 to 1005.

If the AVC voltage change is too great, it will effect distortion performance. The problem indicates an imbalance in the tuning network. Measure each network resistor for accuracy. See parts list for tolerance. Be sure when making the measurement, that the switch is **NOT** set to the resistor under test. If they are within tolerance, measure the matching between each capacitor on a band. They should be within 1% of each other on the x1, x10, x100 and x1k bands.

6.3.5 FREQUENCY CALIBRATION (x10k Band)

Set the 4402B frequency to 1.00 x10k (10kHz).

Adjust R122 for a counter reading of 9995 to 10005 (frequency).

Adjust C115 for an AVC voltage at TP4 of 0V ±0.1V.

Set the 4402B frequency to 10.00 x10k (100kHz).

Adjust C143 for a counter reading of 9995 to 10005.

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

6.3.6 DISTORTION CHECK

Refer to Section 3 and Figure 3.2, for the correct test set-up and procedure. Perform steps 1 through 5.

The total harmonic distortion as defined in Section 3 equations. Measurements should be greater than or equal to −106dB or less than or equal to 0.0005%.

END OF CALIBRATION

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SECTION 7

PARTS LIST, SCHEMATIC DIAGRAMS & PC BOARD LAYOUT

7.1 INTRODUCTION

The following are the parts contained on the Main PC Card. It does not contain any parts such as covers, side rails, etc.

When ordering parts from Krohn-Hite, please specify the instrument model number, its serial number, the schematic reference number and either the Krohn-Hite Part number or the manufacturer's part number.

Any engineering change orders and/or modifications will be found on a Krohn-Hite Modification Sheet or Addendum Sheet at the rear of this manual.

Address all inquiries to Krohn-Hite Corporation, 15 Jonathan Drive, Unit 4, Brockton, MA 02301-5566 or call directly at (508) 580-1660. Also, you can fax inquiries to Krohn-Hite at (508) 583-8989.

Parts Listing

Schem	Description	Mfr	Mfr Part Number	KH Part No.
+15V	Terminal Red	CCP	TP-104-01-00	039100
-15V	Terminal Red	CCP	TP-104-01-00	039100
C100	6.8uF 20% 35V	SP	T350F685M035AS	471568
C101	10pF 10% 500V	MUR	9213-10110	411010
C102	6.8uF 20% 35V	SP	T350F685M035AS	471568
C103	0.1uF 20% 100V	MUR	RPE122Z5U104M100V	413410
C104	0.1uF 20% 100V	MUR	RPE122Z5U104M100V	413410
C106	6.8pF 5% 500V	KGN	C320689D2G5CA	400968
C109	3.2uF 1% 50V	ASZ	X363UW T3	451532
C110	0.32uF 1% 50V	ASZ	X1263UW	461432
C111	0.032uF 1% 100V	ASZ	X1263UW	461333
C112	0.0033uF 1% 50V	ASZ	TC=0;+-30PP	461233

Schem	Description	Mfr	Mfr Part Number	KH Part No.
C113	270pF 5% 500V	KGN	NPO	400127
C115	4.5-20pF Trimmer	STT	7S-TRIK0-02-N075	482012
C116	3.2uF 1% 50V	ASZ	X363UW T3	451532
C117	0.32uF 1% 50V	ASZ	X1263UW	461432
C118	0.032uF 1% 100V	ASZ	X1263UW	461333
C119	0.0033uF 1% 50V	ASZ	TC=0;+-30PP	461233
C120	27pF 5% 500V	KGN	NPO	400027
C121	330pF 5% 500V	KGN	NPO	400133
C122	47pF 10% 500V	KGN	DM15C470K	422047
C124	0.1uF 20% 100V	MUR	RPE122Z5U104M100V	413410
C125	33pF 5% 500V	KGN	NPO	400033
C126	0.1uF 20% 100V	MUR	RPE122Z5U104M100V	413410
C127	470pF 5% 500V	KGN	NPO	400147
C128	6.8uF 20% 35V	SP	T350F685M035AS	471568
C129	6.8uF 20% 35V	SP	T350F685M035AS	471568
C135	2pF 10% 500V	MUR	9208-20910	411002
C141	3pF 10% 500V	MUR	9208-309-10	411003
C143	2-12pF Trimmer	STT	7S-TRIKO-O2-NO75	482003
C145	0.1uF 20% 100V	MUR	RPE122Z5U104M100V	413410
C146	0.1uF 20% 100V	MUR	RPE122Z5U104M100V	413410
C150	0.47uF 20% 100V	MUR	RPE113Z5U474M100V	413447
C151	1uF 20% 100V	MUR	RPE11425U105M100V	412AB
C152	1uF 20% 100V	MUR	RPE11425U105M100V	412AB
C153	1uF 20% 100V	MUR	RPE11425U105M100V	412AB
C166	220uF 10% 16V	SP	513D227M016CC4	471722
C167	0.1uF 20% 100V	MUR	RPE122Z5U104M100V	413410
C171	22pF 5% 500V	KGN	NPO	400022
C172	0.47uF 20% 100V	MUR	RPE113Z5U474M100V	413447
C173	1uF 20% 100V	MUR	RPE11425U105M100V	412AB
C174	1uF 20% 100V	MUR	RPE11425U105M100V	412AB
C175	1uF 20% 100V	MUR	RPE11425U105M100V	412AB

Schem	Description	Mfr	Mfr Part Number	KH Part No.
C176	0.47uF 20% 100V	MUR	RPE113Z5U474M100V	413447
C179	3.3pF 10% 500V	MUR	9210-33910	411933
C183	0.1uF 20% 100V	MUR	RPE122Z5U104M100V	413410
C184	0.1uF 20% 100V	MUR	RPE122Z5U104M100V	413410
C185	10pF 10% 500V	MUR	9213-10110	411010
C186	6.8uF 20% 35V	SP	T350F685M035AS	471568
C187	0.47uF 20% 100V	MUR	RPE113Z5U474M100V	413447
C188	0.47uF 20% 100V	MUR	RPE113Z5U474M100V	413447
C189	6.8uF 20% 35V	SP	T350F685M035AS	471568
C200	2200uF 35V	SP	513D228M035FR4	471822
C201	2200uF 35V	SP	513D228M035FR4	471822
C202	2200uF 35V	SP	513D228M035FR4	471822
C203	2200uF 35V	SP	513D228M035FR4	471822
C210	0.1uF 20% 500V	SP	5HK-P10	412410
C479	3.3pF 10% 500V	MUR	9210-33910	411933
C482	2000pF 20% 1000V	KGN	5GA-D20	412220
C483	0.1uF 20% 100V	MUR	RPE122Z5U104M100V	413410
C484	0.1uF 20% 100V	MUR	RPE122Z5U104M100V	413410
C485	10pF 10% 500V	MUR	9213-10110	411010
C486	6.8uF 20% 35V	SP	T350F685M035AS	471568
C487	0.47uF 20% 100V	MUR	RPE113Z5U474M100V	413447
C488	0.47uF 20% 100V	MUR	RPE113Z5U474M100V	413447
C489	6.8uF 20% 35V	SP	T350F685M035AS	471568
CR132	Diode Switching	NS	1N4149	234149
CR162	Diode Switching	NS	1N4149	234149
CR163	Diode Switching	NS	1N4149	234149
CR164	Diode Hot Carrier	TOM	1N6263	286263
CR165	Diode Hot Carrier	TOM	1N6263	286263
CR167	Diode Low Leakage	NS	FD300	280300
F200	Fuse Slow Blow	BUS	MDL 1/4A	021005
HS200	Heat Sink	KH	A4626	318291

Schem	Description	Mfr	Mfr Part Number	KH Part No.
L188	Ferrite Bead	KH	57-0181	019001
L488	Ferrite Bead	KH	57-0181	019001
Q127	Transistor NPN	AMC	2N3904	203904
Q128	Transistor NPN	AMC	2N3904	203904
Q137	Transistor FET	AMC	MPF4392	204392
Q139	Transistor NPN	AMC	2N3904	203904
Q173	Transistor FET	AMC	MPF4392	204392
Q175	Transistor FET	AMC	MPF4392	204392
Q176	Transistor FET	AMC	MPF4391	204391
Q186	Transistor NPN	AMC	2N2219A	202219
Q187	Transistor PNP	AMC	2N5771	204258
Q188	Transistor PNP	AMC	2N2905A	202905
Q189	Transistor FET	AMC	MPF4393	204393
Q486	Transistor NPN	AMC	2N2219A	202219
Q487	Transistor PNP	AMC	2N5771	204258
Q488	Transistor PNP	AMC	2N2905A	202905
Q489	Transistor FET	AMC	MPF4393	204393
R091	220K 1% 1/4W	AB	5043	927422
R092	33.2K 1% 1/4W	AB	5043	927333
R093	10K 1% 1/4W	AB	5043	927310
R094	1K 1% 1/4W	AB	5043	927210
R098	100 1% 1/4W	AB	5043	927110
R099	2.43K 1% 1/4W	AB	5043	927224
R100	600 1% 1/4W	AB	5043	825AMC
R101	10K 1% 1/4W	AB	5043	927310
R102	22.1K 1% 1/4W	AB	5043	927322
R103	3.01K 1% 1/4W	AB	5043	927230
R104	10K Pot	AB	JAIH056P103MA	619307
R105	16.2K 1% 1/4W	AB	5043	927316
R106	121K 1% 1/4W	AB	5043	850412
R107	130K 1% 1/4W	AB	5043	927413
R108	5.11K 1% 1/4W	AB	5043	927251

Schem	Description	Mfr	Mfr Part Number	KH Part No.
R109	332 1% 1/4W	AB	5043	927133
R110	100K 10% Pot	BIT	72PMR100K	658410
R111	100K 10% Pot	BIT	72PMR100K	658410
R112	100K 10% Pot	BIT	72PMR100K	658410
R113	100K 10% Pot	BIT	72PMR100K	658410
R115	750 1% 1/4W	AB	5043	927175
R116	47.5K 1% 1/4W	AB	5043	927347
R118	511K 1% 1/4W	AB	5043	927451
R119	100K 1% 1/4W	AB	5043	927410
R120	51.1K 1% 1/4W	AB	5043	927351
R121	51.1K 1% 1/4W	AB	5043	927351
R122	10K 10% Pot	BIT	72PMR10K	658310
R123	22.1 1% 1/4W	AB	5043	928022
R124	22.1 1% 1/4W	AB	5043	928022
R125	221 1% 1/4W	AB	5043	928122
R126	150 1% 1/4W	AB	5043	928115
R127	26.7 1% 1/4W	AB	5043	928027
R128	61.9 1% 1/4W	AB	5043	850061
R130	600 1% 1/4W	AB	5043	825AMC
R131	100M 10% 1/4W	AB	EB1071	928710
R132	2K 1% 1/4W	AB	5043	927220
R133	24.3K 1% 1/4W	AB	5043	927324
R135	10K 1% 1/4W	AB	5043	927310
R136	33.2K 1% 1/4W	AB	5043	927333
R137	47.5 1% 1/4W	AB	5043	927047
R138	5.0K 0.1% 1/4W	PRP	GP1/4W-T100	812250
R139	5.0K 0.1% 1/4W	PRP	GP1/4W-T100	812250
R141	221 1% 1/4W	AB	5043	928122
R142	3.3M 10% 1/4W	PRP	GP1/4W-T100	928533
R143	100K 10% Pot	BIT	72PMR100K	658410

Schem	Description	Mfr	Mfr Part Number	KH Part No.
R144	9.76K 1% 1/4W	AB	5043	850297
R145	1K Pot	BIT	68WR1K	658512
R146	220K 1% 1/4W	AB	5043	927422
R147	20K 1% 1/4W	AB	5043	927320
R151	3.3M 10% 1/4W	PRP	GP1/4W-T100	928533
R152	5.1M 5% 1/4W	AB	CB5G165	927551
R153	10K 1% 1/4W	AB	5043	927310
R154	10K 1% 1/4W	AB	5043	927310
R155	1.78M 1% 1/4W	AB	5043	835517
R161	2K 1% 1/4W	AB	5043	927220
R162	301 1% 1/4W	AB	5043	927130
R164	4.75K 1% 1/4W	AB	5043	927247
R165	33.2K 1% 1/4W	AB	5043	927333
R166	2K 1% 1/4W	AB	5043	927220
R167	5.11M 1% 1/4W	AB	5043	850551
R168	100 1% 1/4W	AB	5043	927110
R170	47.5K 1% 1/4W	AB	5043	927347
R171	511K 1% 1/4W	AB	5043	927451
R172	100K 1% 1/4W	AB	5043	927410
R173	100K 1% 1/4W	AB	5043	927410
R174	100K 1% 1/4W	AB	5043	927410
R175	100K 1% 1/4W	AB	5043	927410
R176	100K 1% 1/4W	AB	5043	927410
R177	100K 1% 1/4W	AB	5043	927410
R179	47.5 1% 1/4W	AB	5043	927047
R180	2K 10% Pot	CSC	BA-402-226	639220
R181	100K 10% Pot	BIT	72XWR100K	658411
R182	2.21K 1% 1/4W	AB	5043	850222
R183	10K 1% 1/4W	AB	5043	927310
R184	6.8M 5% 1/4W	AB	CB6G865	927568
R185	3.01K 1% 1/4W	AB	5043	927230

Schem	Description	Mfr	Mfr Part Number	KH Part No.
R186	10K 1% 1/4W	AB	5043	927310
R187	200 1% 1/4W	AB	5043	927120
R188	15 1% 1/4W	AB	5043	928015
R189	10 1% 1/4W	AB	5043	928010
R190	15 1% 1/4W	AB	5043	928015
R191	10 1% 1/4W	AB	5043	928010
R192	49.9 1% 1W	PRP	TYPE RN65E	895049
R193	61.9 1% 1/4W	AB	5043	850061
R194	61.1 1% 1/4W	AB	5043	850060
R195	54.9 1% 1/4W	AB	5043	850054
R196	453 1% 1/4W	AB	5043	850145
R197	495 1% 1/4W	AB	5043	825149
R198	495 1% 1/4W	AB	5043	825149
R199	500 10% Pot	BIT	72PMR500	658150
R210	100 1% 1/4W	AB	5043	927110
R300	75.31K 0.25% 1/4W	PRP	GP1/4W-T100	821375
R301	37.66K 0.25% 1/4W	PRP	GP1/4W-T100	821337
R302	25.1K 0.25% 1/4W	PRP	GP1/4W-T100	821325
R303	18.83K 0.25% 1/4W	PRP	GP1/4W-T100	821318
R304	15.06K 0.25% 1/4W	PRP	GP1/4W-T100	821315
R305	15.06K 0.25% 1/4W	PRP	GP1/4W-T100	821315
R306	7.531K 0.25% 1/4W	PRP	GP1/4W-T100	821275
R307	7.531K 0.25% 1/4W	PRP	GP1/4W-T100	821275
R308	9.414K 0.25% 1/4W	PRP	GP1/4W-T100	821294
R309	12.55K 0.25% 1/4W	PRP	GP1/4W-T100	821312
R310	18.83K 0.25% 1/4W	PRP	GP1/4W-T100	821318
R311	37.66K 0.25% 1/4W	PRP	GP1/4W-T100	821337
R312	753.1K 1% 1/4W	AB	5043	825475
R313	376.6K 1% 1/4W	AB	5043	825437
R314	251K 1% 1/4W	AB	5043	850425

Schem	Description	Mfr	Mfr Part Number	KH Part No.
R315	188.3K 1% 1/4W	AB	5043	825418
R317	75.31K 0.25% 1/4W	PRP	GP1/4W-T100	821375
R318	94.14K 1% 1/4W	AB	5043	825394
R319	125.5K 1% 1/4W	AB	5043	825412A
R321	376.6K 1% 1/4W	AB	5043	825437
R479	47.5 1% 1/4W	AB	5043	927047
R481	100K 10% Pot	BIT	72XWR100K	658411
R482	2.21K 1% 1/4W	AB	5043	850222
R483	10K 1% 1/4W	AB	5043	927310
R484	6.8M 5% 1/4W	AB	CB6G865	927568
R485	3.01K 1% 1/4W	AB	5043	927230
R486	10K 1% 1/4W	AB	5043	927310
R487	200 1% 1/4W	AB	5043	927120
R488	15 1% 1/4W	AB	5043	928015
R489	10 1% 1/4W	AB	5043	928010
R490	15 1% 1/4W	AB	5043	928015
R491	10 1% 1/4W	AB	5043	928010
R492	49.9 1% 1W	PRP	TYPE RN65E	895049
R493	61.9 1% 1/4W	AB	5043	850061
R494	61.1 1% 1/4W	AB	5043	850060
R495	54.9 1% 1/4W	AB	5043	850054
R496	453 1% 1/4W	AB	5043	850145
R497	495 1% 1/4W	AB	5043	825149
R498	495 1% 1/4W	AB	5043	825149
R499	500 10% Pot	BIT	72PMR500	658150
S100	Switch Illuminated	SES	SW300-ND	346407
S101	Switch Slide	UID	SW422-SOPC	346615
S104	Switch Rotary	CI	B3940	340461
S105	Switch Rotary	CI	B3940	340461
S106	Switch Pushbutton	KH	B3933	343273
S204	Switch Slide	UID	SW422-SOPC	346615

Schem	Description	Mfr	Mfr Part Number	KH Part No.
T200	Transformer, Toroidal	KH	A4630	361046
TPG1	Terminal Black	CCP	TP-104-01-00	039100B
TPG2	Terminal Black	CCP	TP-104-01-00	039100B
TP2	Terminal Red	CCP	TP-104-01-00	039100
TP4	Terminal Red	CCP	TP-104-01-00	039100
TP5	Terminal Red	CCP	TP-104-01-00	039100
TP6	Terminal Red	CCP	TP-104-01-00	039100
TP7	Terminal Red	CCP	TP-104-01-00	039100
TP8	Terminal Red	CCP	TP-104-01-00	039100
TP10	Terminal Red	CCP	TP-104-01-00	039100
TP12	Terminal Red	CCP	TP-104-01-00	039100
TP14	Terminal Red	CCP	TP-104-01-00	039100
TP15	Terminal Red	CCP	TP-104-01-00	039100
TP42	Terminal Red	CCP	TP-104-01-00	039100
TP145	Terminal Red	CCP	TP-104-01-00	039100
TP165	Terminal Red	CCP	TP-104-01-00	039100
TP415	Terminal Red	CCP	TP-104-01-00	039100
U100	Opamp	AMC	LM318N	200318
U103	Buffer	NS	LM310N	200310
U125	Opamp	AMC	LM318N	200318
U138	Opamp	AMC	LM318N	200318
U141	Opamp	AMC	LM318N	200318
U145	Analog Multiplier	AD	AD633JD	280633
U150	IC	AMC	TL072BCP	200072
U165	IC	AMC	TL072BCP	200072
U183	Opamp	NS	NE5534AN	265534
U200	IC Regulator	NS	LM2940CT-15	202940
U201	IC Regulator	NS	LM2990T-15	202990
U483	Opamp	NS	NE5534AN	265534
VR166	Diode Zener 10V	AMC	1N961B	230961

Schem	Description	Mfr	Mfr Part Number	KH Part No.
VR168	Diode Zener 10V	AMC	1N961B	230961
VR170	Diode Zener 4.3V	AMC	1N749A	280749
VR171	Diode Zener 4.3V	AMC	1N749A	280749

MFR	NAME	FSCM
AVV	AAVID Engineering Laconia, NH 03247	——-
AB	Allen Bradley Milwaukee, WI 53204	01121
APH	Amphenol Lisle, IL 60532	29587
AD	Analog Devices Norwood, MA 02062	24355
APX	Apex Microtechnology Corp., Tucson, AZ 85741	——-
BKM	Beckman, Fullerton, CA 92635	73138
BIV	Bivar, Inc., Irvine, CA 92718	32559
BUC	Buckeye Stamping Co.,Columbus, OH 43207	21604
BUS	Bussman Mfg. Co.,St. Louis, MO 63107	——-
CLS	Clarostat Sensors, El Paso, TX 79936	12697
DAT	Datel Systems, Inc., Canton, MA 02021	——-
DEL	Delta Products Corp., Freemont, CA 94538	——-
DIA	Dialight Corporation, Manasquan, NJ 08736	1EG71
DI	Diodes, Inc., Chatsworth, CA 91311	12060
KH	Krohn-Hite, Brockton, MA 02301	88865
KEM	Kemet, Greenville, NC 29606	31433
LF	Littlefuse, Des Plaines, IL	75915
LNX	Lionex, Burlington, MA	——-
MAL	P. R. Mallory Components, Indianapolis, IN 46206	37942
MEP	Mepco Electra, Mineral Wells, TX 76067	80031
MOT	Motorola, Pheonix, AZ 85072	04713
PRP	Precision Resistive Products, Mediapolis, IA	——-
NS	National Semiconductor, Santa Clara, CA 95052	27014
RPC	Richco Plastic Co., Chicago, IL 60646	06915
SCH	Schaal Associates,Burlington, MA 01803	——-
SES	Sager Electric Supply, Higham, MA 02043	——-
SE	Sterling Electronics, Woburn, MA 01889	——-
SP	Sprague Electric Co., Lexington, MA 02173	56289
TOW	Tower Manufacturing, Providence, RI 02907	87930

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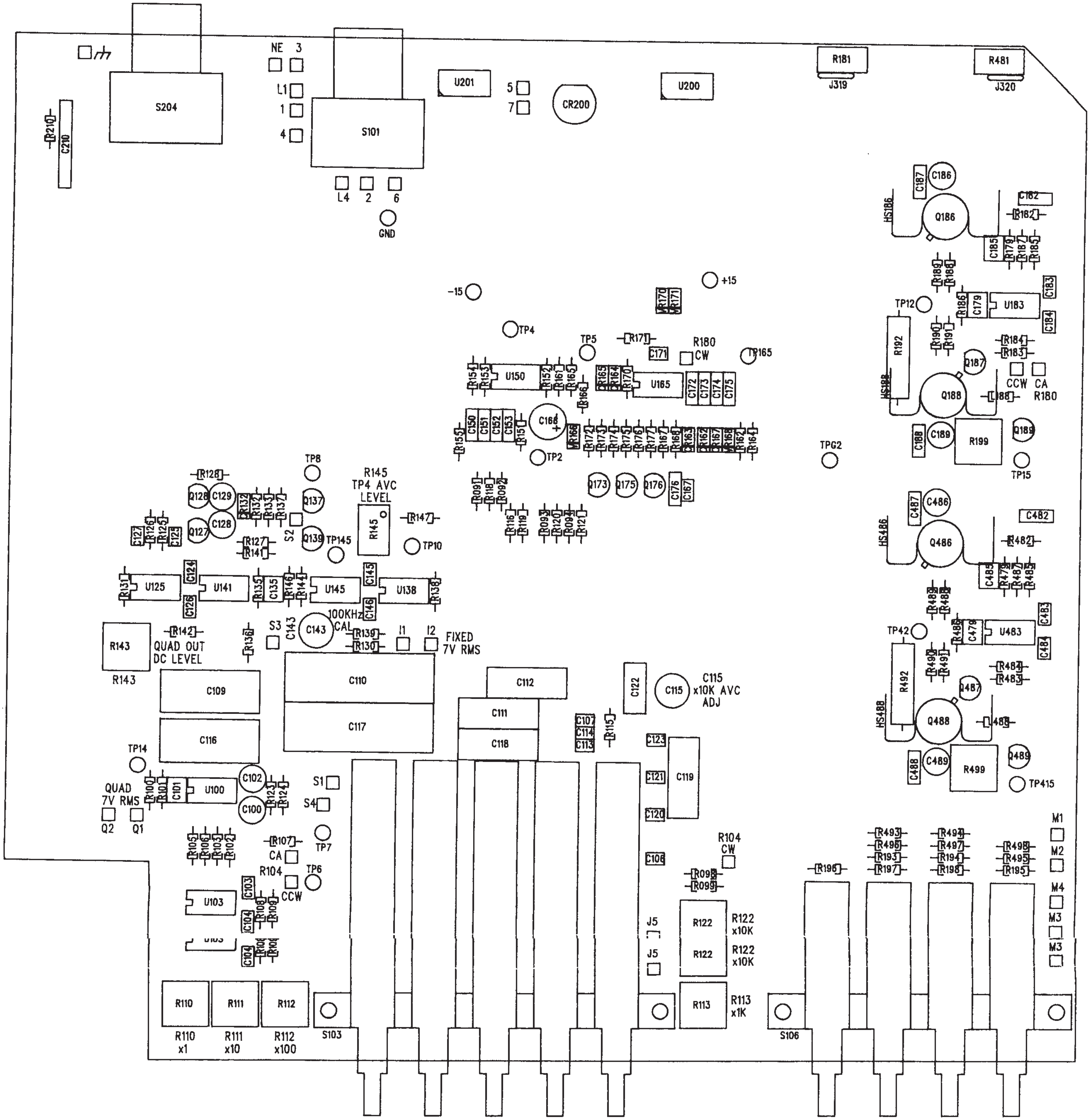
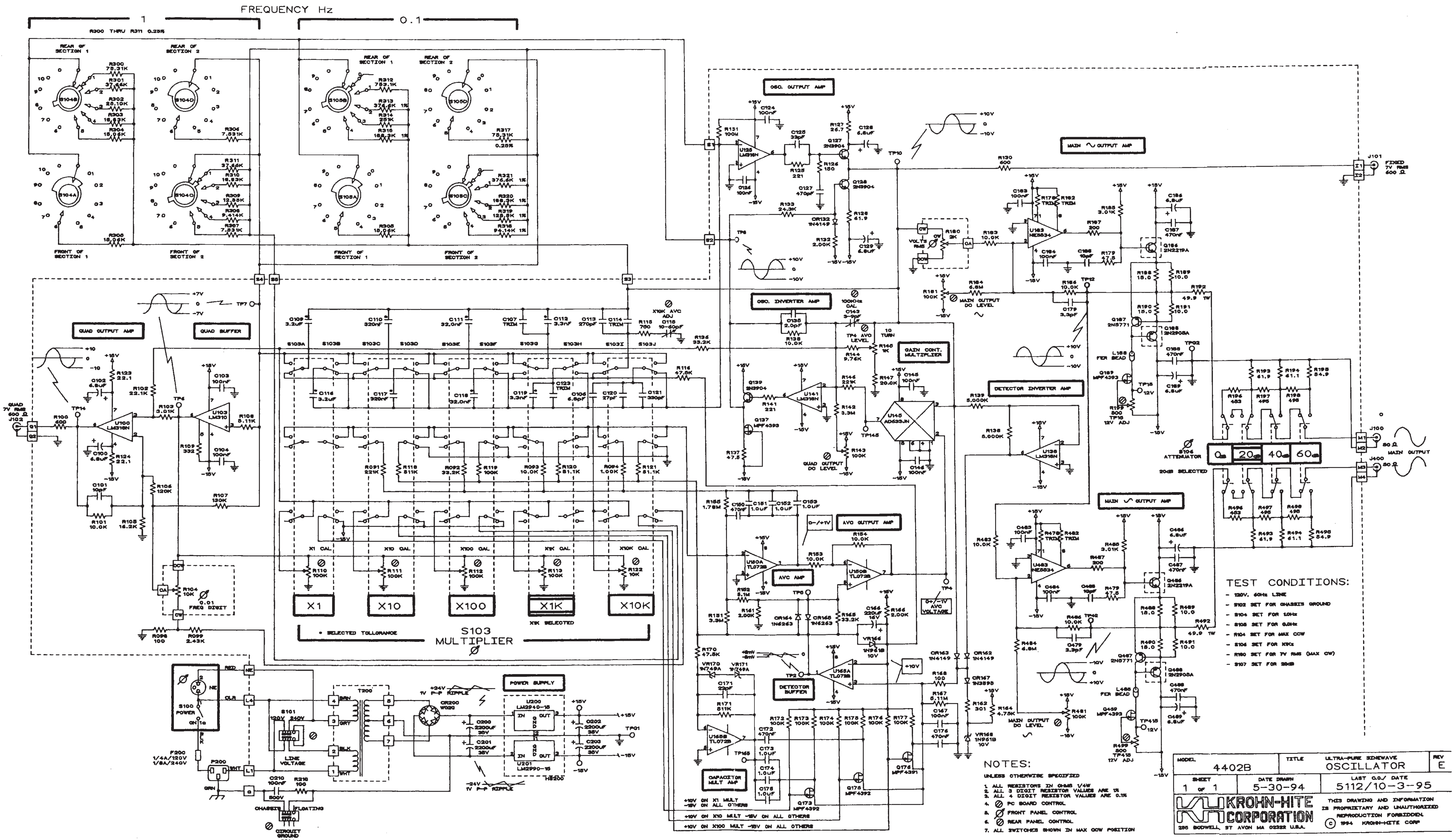


MODEL 4402B REV F COMPONENT LAYOUT



NOTES:

UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS IN OHMS 1/4W
2. ALL 3 DIGIT RESISTOR VALUES ARE 1%
3. ALL 4 DIGIT RESISTOR VALUES ARE 0.1%
4. ⊘ PC BOARD CONTROL
5. ⌀ FRONT PANEL CONTROL
6. ⊘ REAR PANEL CONTROL
7. ALL SWITCHES SHOWN IN MAX CCW POSITION

TEST CONDITIONS:

- 120V, 60Hz LINE
- S102 SET FOR CHASSIS GROUND
- S104 SET FOR 1.0Hz
- S105 SET FOR 0.0Hz
- R104 SET FOR MAX CCW
- S106 SET FOR X1Kz
- R180 SET FOR 7V RMS (MAX CW)
- S107 SET FOR 20dB

MODEL	TITLE	REV
4402B	ULTRA-PURE SINEWAVE OSCILLATOR	E

SHEET	DATE DRAWN	LAST C.O./ DATE
1 OF 1	5-30-94	5112/10-3-95

KROHN-HITE CORPORATION
255 BODWELL ST AVON MA 02322 U.S.A.