WIDE RANGE

BAND PASS FILTER

MODEL 3103A SERIAL NO.______

OPERATING AND MAINTENANCE MANUAL

KROHN-HITE CORPORATION

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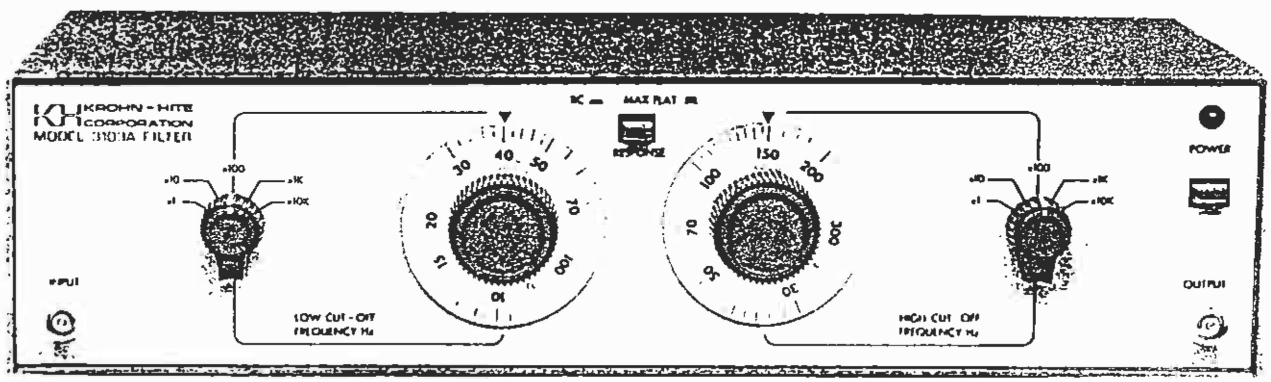


Figure 1. Model 3103A

TABLE OF CONTENTS

ILLUSTRATIONS

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Model 3103A, illustrated in Figure 1, is a variable band-pass Filter with a low cutoff frequency range adjustable from 10Hz to 1MHz and a high cutoff range adjustable from 30Hz to 3MHz. The pass-band gain is unity (0dB), with attenuation rate of 24dB per octave outside the passband, and a maximum attenuation of 80dB. Maximum input signal amplitude is 3 volts rms and output hum and noise is less than 100 microvolts.

1.2 SPECIFICATIONS

FREQUENCY RANGE: Low cutoff frequency independently adjustable from 10Hz to 1MHz in five bands.

Band	Multiplier	Frequency Hz
1	1	10-100
2	10	100-1K
3	100	1K-10K
4	1K	10K-100K
5	10K	100K-1M

High Cutoff Frequency independently adjustable from 30Hz to 3MHz in five bands.

Band	Multiplier	Frequency Hz
1	1	30-300
2	10	300-3K
3	100	3K-30K
4	1K	30K-300K
5	10K	300K-3M

FREQUENCY DIALS: Separate low cutoff and high cutoff dials are individually calibrated with logarithmic scales reading directly in Hz.

CUTOFF FREQUENCY CALIBRATION ACCURACY: ±5% (± 10% band 5) with RESPONSE switch in MAX FLAT (Butterworth) position; less accurate in RC position. Relative to mid-band level, the Filter output is down 3dB at cutoff in MAX FLAT position, and approximately 13dB in RC position.

BANDWIDTH: Continuously variable within the cutoff frequency limits of 10Hz and 3MHz.

ATTENUATION SLOPE: Nominal 24dB per octave.

MAXIMUM ATTENUATION: Greater than 80dB. See Section 5.2

PASS-BAND GAIN: 0dB ±1/2dB.

HUM AND NOISE: Less than 100 microvolts.

FREQUENCY RESPONSE: Standard response is 4th order Butterworth, maximally flat. A RESPONSE switch converts to simple RC response, optimum for transient-free performance.

INPUT CHARACTERISTICS:

Maximum Input Amplitude: 3 volts rms, decreasing to 2.5 volts at 3MHz.

Impedance: 100K ohms in parallel with 50pF.

Maximum DC Component: 200 volts.

OUTPUT CHARACTERISTICS:

Maximum Voltage: 3 volts rms, decreasing to 2.5 volts at 3MHz.

Maximum Current: 10 milliamperes rms

Internal Impedance: Approximately 50 ohms.

FLOATING (ungrounded) OPERATION: A chassis GROUND switch is provided on the rear panel to disconnect signal ground from chassis ground.

Note: For a more in depth definition of specifications, refer to Section 5.2

1.3 TERMINALS

On the front and rear panels, one BNC connector for INPUT, one for OUTPUT.

1.4 FRONT PANEL CONTROLS:

LOW CUTOFF FREQUENCY dial and multiplier switch.

HIGH CUTOFF FREQUENCY dial and multiplier switch.

RESPONSE switch for MAX FLAT (Butterworth) or RC (Transient-free) mode.

ON/OFF switch.

1.5 POWER REQUIREMENTS:

105-125 volts or 210-250 volts, single phase, 50-400 Hz, 15 watts.

1.6 DIMENSIONS AND WEIGHTS:

14"/35.6cm wide, 3.5"/9cm high, 8.5"/21.6cm deep, 8lbs./3.6Kgs.

An optional Rack Mounting Kit, (Part No. RK314), is available for installing the Filter into a standard 19" rack.

1.7 FILTER CHARACTERISTICS

BANDWIDTH ADJUSTMENT

The flexibility of adjustment of bandwidth is illustrated in Figure 2. Band-pass operation in the MAX FLAT (Butterworth) mode for two different bandwidths is illustrated by curves A and B. Curve B shows the minimum pass-band width obtained by setting the two cutoff frequencies equal. In this condition the pass-band gain is 6dB, and the -3dB cutoff frequencies occur at 0.8 and 1.25 times the mid-band frequency. The minimum pass-band for a 0dB pass-band gain is shown by curve A with the cutoffs set at 0.5 and 2 times the mid-band frequency.

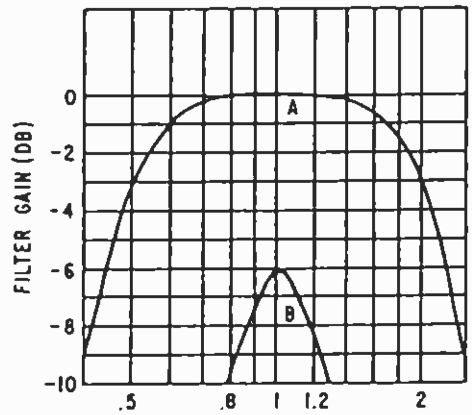
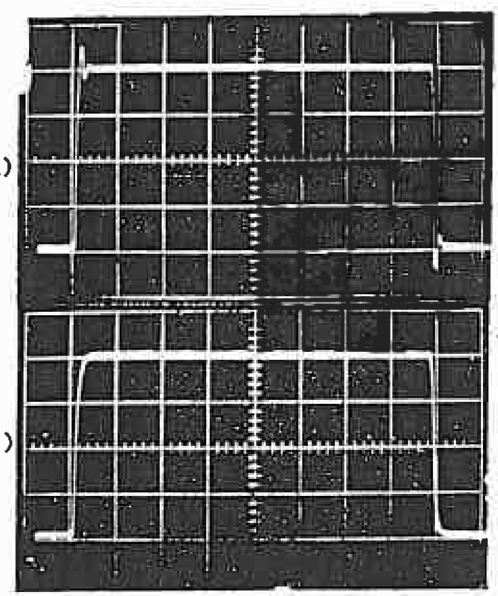


Figure 2. Normalized Filter Response

TRANSIENT RESPONSE

The frequency response characteristic of this Filter closely approximates a fourth order Butterworth with maximal flatness, ideal for filtering in the

(A)



(B)

Figure 3. Response to 10kHz Square Wave with Cutoffs at 10Hz and 1MHz. (A) Butterworth (B) RC

frequency domain. For pulse or transient signal filtering, a RESPONSE switch is provided to change the frequency response to the RC mode, optimum for transient-free filtering. Figure 3 shows a comparison of the Filter output response in these modes to a square wave input signal.

CUTOFF RESPONSE

The attenuation characteristics of the Filter are shown in Figure 4. With the RESPONSE switch in the MAX FLAT (Butterworth) mode, the gain, as shown by the solid curve, is virtually flat until the -3dB cutoff

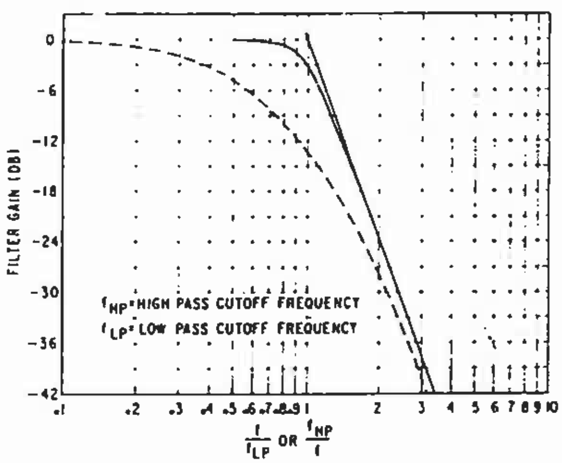


Figure 4. Normalized Attenuation Characteristics

frequency. At approximately two times the cutoff frequency, the attenuation rate coincides with the 24dB per octave straight line asymptote. In the RC mode, optimum for transient-free filtering, the dotted line shows that the gain is down approximately 13dB at cutoff and reaches 24dB per octave attenuation rate at ten times the cutoff frequency. Beyond this frequency the filter attenuation rate and maximum attenuation, in either mode, are identical.

PHASE RESPONSE

Due to the high-pass and low-pass sections of the Filter, the phase angle at any frequency is the sum of the angles. Figure 5 gives the phase characteristics for either section in degrees lead (+) or lag (-), as a function of the ratio of the operating frequency (f) to low cutoff frequency (f_L) or high cutoff frequency (f_H). The solid curve is for the MAX FLAT (Butterworth) mode and the dotted curve is for the RC mode.

Example:

Determine the phase shift through the filter, in the MAX FLAT (Butterworth) mode with the low cutoff (f_L) at 200Hz, the high cutoff (f_H) at 600Hz and an input frequency (f) at 300Hz.

Phase shift due to low cutoff (f_L)

$$\frac{f}{f_L} = \frac{300}{200} = 1.5$$

from Figure 5; 1.5 = +100°

Phase shift due to high cutoff (f_H)

$$\frac{f}{f_H} = \frac{300}{600} = .5$$

from Figure 5; .5 = -80°

Total phase shift

= +100° -80° = +20°

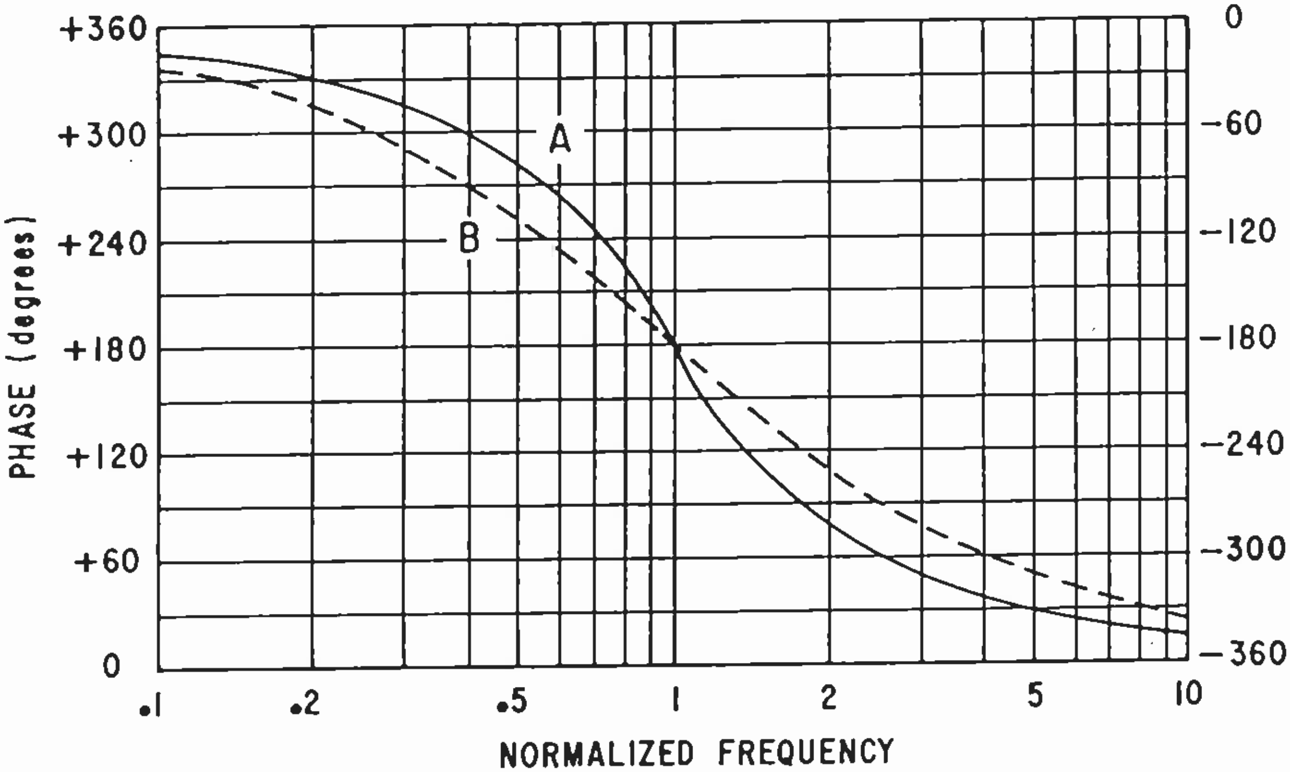


Figure 5. Normalized Phase Characteristics

SECTION 2

OPERATION

2.1 INTRODUCTION

As shown in the Simplified Schematic Diagram, Figure 6, the Filter consists of an input amplifier, a variable low-pass section (HIGH CUTOFF FREQUENCY), and a variable high-pass section (LOW CUTOFF FREQUENCY) connected in series. Both cutoff frequencies are tuned capacitively in decade steps by the band multiplier switch, and continuously within each decade by the frequency dial which varies four cascaded resistor-filter elements. A RESPONSE switch, S1, selects the desired filter characteristics.

2.2 TERMINALS

BNC coaxial connectors are provided on the front panel and on the rear panel for both INPUT and OUTPUT connections.

2.3 FRONT PANEL CONTROLS

The front panel of the Filter includes two dials and associated multiplier switches used to set cutoff frequencies; a power ON/OFF switch with indicator light; a RESPONSE switch for MAX FLAT or RC mode; two BNC coaxial connectors, one for the INPUT signal and one for the OUTPUT signal.

Each frequency dial is calibrated with a logarithmic scale reading directly in Hz. The left dial (LOW CUTOFF FREQUENCY) and the band multiplier switch select the low cutoff frequency. The right dial (HIGH CUTOFF FREQUENCY) and the multiplier switch select the high cutoff frequency.

The LOW CUTOFF FREQUENCY multiplier switch has five positions, covering the frequency ranges as follows:

Band	Multiplier	Frequency Hz
1	1	10-100
2	10	100-1K
3	100	1K-10K
4	1K	10K-100K
5	10K	100K-1M

The HIGH CUTOFF FREQUENCY multiplier switch has five positions, covering the frequency ranges as follows:

Band	Multiplier	Frequency Hz
1	1	30-300
2	10	300-3K
3	100	3K-30K
4	1K	30K-300K
5	10K	300K-3M

2.4 LINE VOLTAGE AND FUSES

The Filter is powered from an ac line voltage of either 105-125 volts, with a 1/8A slow blow fuse, or 210-250 volts, with a 1/16A slow blow fuse, single phase, 50-400Hz. Use the LINE selector switch on the rear panel to select the proper mode of operation.

CAUTION

The covers should not be removed when the filter is connected to an ac power source because of the potentially dangerous voltages that exist within the unit.

2.5 OPERATION

To operate the Filter, proceed as follows:

a. Select proper ac line as described in Section 2.4.

b. Make appropriate connections to the INPUT and OUTPUT connectors of the Filter. The input voltage should not exceed 3 volts rms.

c. Set cutoff frequencies by means of the band multiplier switches and the frequency dials. The minimum passband is obtained by setting the HIGH CUTOFF FREQUENCY equal to the LOW CUTOFF FREQUENCY. (Refer to Section 1.7)

NOTE

The left multiplier switch and frequency dial are used to select the LOW CUTOFF FREQUENCY, and the right multiplier switch and frequency dial are used to select the HIGH CUTOFF FREQUENCY.

d. Push power switch on.

e. For normal Filter operation the FLOATING/CHASSIS GROUND switch, located on the rear panel, should be in the CHASSIS position. If the Filter is used in a system where ground loops make ungrounded or floating operation essential, this switch should be in the FLOATING position.

f. When filtering consists principally of separating frequency components of a signal, (frequency domain), the RESPONSE switch, should be in the MAX FLAT position. If the Filter is used to separate pulse type signals from noise, (time domain), this switch should be in the RC position.

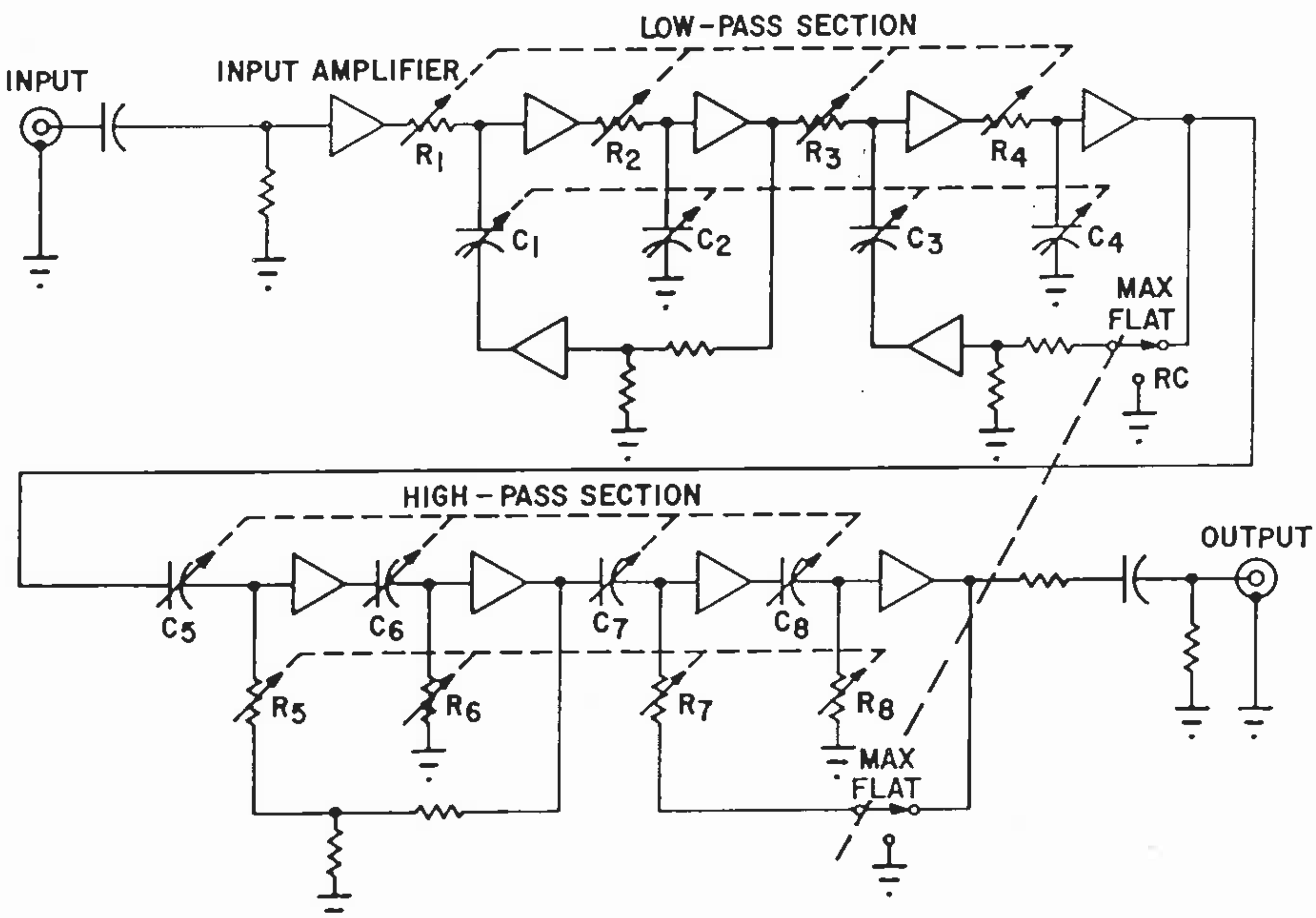


Figure 6. Simplified Schematic Diagram

SECTION 3

CIRCUIT DESCRIPTION

3.1 INTRODUCTION

As shown in the Simplified Schematic Diagram, Figure 6, the Filter consists of an input amplifier for input isolation. A four-pole low-pass filter section (HIGH CUTOFF FREQUENCY) with four RC filter networks adjustable by means of a ganged potentiometer assembly and band switch. A four-pole high-pass filter section (LOW CUTOFF FREQUENCY) with four filter networks and a similar ganged potentiometer assembly and band switch. Both cutoff frequencies are tuned capacitively in decade steps by the band switch, and continuously within each decade by the potentiometer assembly.

The Schematic of the Filter, Figure 8, is located at the rear of this manual.

3.2 CIRCUIT DESCRIPTION

INPUT AMPLIFIER

The signal input is capacitor coupled to the input amplifier, consisting of emitter followers Q201 and Q202, via current limiting resistors R201 and R202, which in conjunction with clamping diodes, CR201 and CR202 prevent damage in the event of excessive input signal. The input amplifier isolates the input and provides the low impedance source necessary to drive the first RC filter network.

LOW-PASS SECTION

The Low-Pass Section consists of a pair of two-pole filters each, containing two RC filter networks. Both two-pole filters are adjusted for the proper response to provide a Butterworth characteristic when cascaded.

All RC filter networks are isolated from each other by a buffer amplifier which consists of two emitter followers. The emitter followers, Q205 and Q206, isolate the output of the first two-pole filter from the input of the second two-pole filter. A portion of the output of the first two-pole filter is fed back via the attenuator consisting of R225 and R227 to obtain the desired response characteristic of the first two-pole filter. An emitter follower, Q207, is used to prevent loading of this attenuator.

The response of the second two-pole filter is accomplished by feeding back a portion of the output of the second two-pole filter network via the attenuator consisting of R247, R248 and P206. Q212 is an emitter follower to prevent loading of this attenuator. Q210 and Q211 isolate the low and high-pass sections and provide high frequency gain.

HIGH-PASS SECTION

The High-Pass Section also consists of a pair of two-pole filters, each adjusted for the proper response to give a Butterworth characteristic when cascaded. As in the low-pass section, emitter followers are used to isolate the RC filter networks. Q303 and Q304 act as a buffer amplifier between the first and second two-pole filters.

This amplifier also provides the gain necessary to compensate for the loss through the filter. The feedback attenuator network consisting of R317 and R318, is used to obtain the desired response characteristic for the first two-pole filter, and similarly, R327 and P305 modify the response of the second two-pole filter. Q308 and Q309 are buffer followers to provide isolation from the output.

RC/BUTTERWORTH RESPONSE

To provide minimum overshoot to fast rise pulses, S202 is used to disconnect the feedback to the second two-pole filters of both the low-pass and high-pass sections.

POWER SUPPLIES

The Power Supplies deliver a plus 10 and minus 10 volts regulated voltage. It consists of a bridge rectifier CR101, CR104, CR105 and CR106 and filter capacitors C101 and C102 to provide the necessary unregulated dc voltage. The minus 10 volts regulated supply is a typical series type regulator, using a zener reference, Z101, and amplifiers Q108 and Q105 which drive a series regulator Q106. To prevent damage when short circuits of the regulated voltage occur, a current limiting circuit consisting of Q102 and R103 turns off the minus 10 volts supply if the current in R103 exceeds a predetermined value. The plus 10 volts supply uses the minus 10 volts as a reference. A divider network consisting of R113 and R114 sets the proper voltage level for the amplifiers Q107 and Q104, which drive the series regulator Q103. Q101 and R102 limit the current in the plus 10 volts supply.

SECTION 4

MAINTENANCE

WARNING

This procedure should be performed by qualified personnel only. If the covers must be removed, it is strongly recommended that extra precautions be taken in working with exposed circuitry, and that insulated probes and tools be used.

SHUT THE POWER SWITCH OFF AND DISCONNECT THE LINE CORD FROM THE POWER SOURCE BEFORE REPAIRING OR REPLACING COMPONENTS.

4.1 INTRODUCTION

If the Filter is not functioning properly and requires service, the following procedure may help in locating the source of trouble. Access to the Filter is accomplished easily by removing the two screws on each side of the cover. (On rack units, the lower screw on the rack adapters, and the screw towards the rear on each side.)

The layout of components, test points, and adjustments is included on the Schematic, Figure 8, which is located at the rear of the manual. Various check points are shown on the Schematic and labeled on the PC board.

Many malfunctions may be found by visual inspection. Make a quick check of the unit for such things as broken wires, burnt or loose components, or similar conditions which could be a cause of malfunction. Any trouble-shooting of the Filter will be simplified if there is an understanding of the operation of the circuit. See Section 3, Circuit Description.

4.2 POWER SUPPLY

A fuse, F101, (1/8A for 115V or 1/16A for 230V operation), located on the rear panel, is provided to protect the filter from internal short circuits. The rating of this fuse was selected for proper protection of the filter, and it should be replaced with one of the same type and rating.

If the Filter is not working properly, the two power supplies should be checked first. If the plus or minus 10 volts supplies appear to be correct, within 5%, refer to the Signal Tracing Procedure Section 4.3.

If the minus 10 volts supply is out of tolerance, R118 should be adjusted.

If the minus 10 volts supply is correct, and the plus 10 volts supply is out of tolerance, R113 or R114 may be defective.

Two regulated supplies are used to provide plus 10 volts and minus 10 volts with respect to chassis ground. The minus 10 volts supply uses a zener, Z101, as its reference, while the plus 10 volts supply uses the minus supply as its reference. This should be kept in mind when doing any work on the supply, since an error in the minus will be reflected in the plus. Both supplies are provided with current limiting circuits that will shut down the supply when excessive current is being drawn from it. Because of this, an apparent power supply malfunction may be caused by an overload elsewhere in the Filter.

If the supply does not appear to be working properly, the resulting error signal should be traced through the regulator loop to find the faulty component. Correct voltages for various points in the supply are shown on the Schematic, Figure 8. As an example of the method of trouble-shooting, let us assume that the minus 10 volts supply is low. This should make the base of Q108 more positive than normal, while making its collector more negative. The base of Q106 should then be more positive than normal and the collector more negative, thus correcting the output of the supply. If a faulty component is present in the regulating loop this corrective action would be blocked. That component would then be found at the point in the loop where the action was blocked. The plus supply uses approximately the same type of circuit, therefore, the same basic method of trouble-shooting may be used there as well.

4.3 SIGNAL TRACING PROCEDURE

If the power supplies appear to be correct, but the Filter is not working, the following procedure should locate the area of malfunction:

Set both the low and high cutoff frequencies to 300Hz. Connect a 300Hz, 1 volt rms sine wave signal to the input terminals. If the test signal does not appear correctly at the output, the area of the malfunction may be localized by determining where in the Filter the single first deviates from normal.

Figure 7 shows various test points with their correct signal levels. If a test point is found whose signal level differs appreciably from the correct value, the circuitry immediately preceding that test point should be checked. Trace the signal through the entire Filter, and they should be checked in the order given. The range determining capacitors associated with the band multiplier switches S201 and S301 are specially selected for close capacitance tolerance. All capacitor values fall within ±5% of the specified value, but in order to maintain accurate frequency calibration over the entire dial range and also between decade ranges, the capacitors are matched within ±2% of each other and generally within ±2% in decade ratios.

The values of capacitance used on the two higher bands are selected to compensate for stray capacitance and are therefore not completely in decade ratios of those used on the lower bands.

For replacement purposes, a capacitor within ±1% of the specified value can be used with negligible effect on the overall calibration accuracy. If more than one capacitor on a particular range is to be changed, it is recommended that several other capacitors on the switch be carefully measured on a capacitance bridge to de-

LOW CUTOFF FREQUENCY: 300Hz
HIGH CUTOFF FREQUENCY: 300Hz
RESPONSE Switch: MAX FLAT
INPUT: 1 Volt rms, 300Hz Sine Wave

Test Point	Correct Signal Level, RMS Volts
INPUT	1.0
1	0.9
3	0.7
5	0.5
7	0.7
9	0.6
11	0.5
13	0.5
15	0.6
OUTPUT	0.5

Figure 7. Test Point Voltages

termine the average percentage deviation from the nominal value. Any capacitors, except those used on the two highest frequency ranges, may be measured to determine this tolerance.

Replacement can then be made with capacitors of the exact value, and calibration will not be impaired.

Each of the variable resistance elements consists of four potentiometers ganged together with a gear assembly. Each potentiometer has series and shunt trims to insure proper tracking. The trims and the angular orientation of the potentiometers are adjusted at the factory. If it becomes necessary to change one of these potentiometers in the field, it should be replaced only with a unit supplied by the factory. The angular orientation should then be adjusted following the procedure supplied with the parts.

4.4 TUNING CIRCUITS

If signal tracing shows one of the tuning circuits to be faulty, it should be determined if the trouble is in the resistive or capacitive element. If there is trouble in a capacitive element, it will show up only on a particular multiplier band. If there is a problem in a resistive element, the trouble will be of a general nature and will show up on all multiplier bands. For replacement purposes, a capacitor within ±1% of the specified value can be used with negligible effect on the overall calibration accuracy. The values of capacitors used on the two higher bands are selected to compensate for stray capacitance and, therefore, are not completely in decade ratios of those used on the lower bands.

Each of the variable resistance elements consists of four potentiometers ganged together with a gear assembly. Each potentiometer has series and shunt trims to insure proper tracking. The trims and the angular orientation of the potentiometers are adjusted at the factory. If it becomes necessary to change one of these potentiometers, do not attempt to replace the defective potentiometer, instead notify our Factory Service Department and they will provide you with the necessary information regarding repair or recalibration.

SECTION 5

CALIBRATION

WARNING

This procedure should be performed by qualified personnel only. If the covers must be removed, it is strongly recommended that extra precautions be taken in working with exposed circuitry, and that insulated probes and tools be used.

5.1 INTRODUCTION

The following procedure is provided for the calibration of the Filter. The steps outlined, follow closely the operations which are performed on the Filter by our Final Test Department. Strict adherence to this procedure should restore the Filter to its original specifications. If any difficulties are encountered, refer to Section 4, Maintenance. Please consult our Factory Service Department for any question which are not covered in this procedure.

5.2 SPECIFICATIONS

CUTOFF FREQUENCY CALIBRATION

The high and low cutoff frequencies, as defined below, should be within ±5%, (±10% band 5), of the corresponding dial reading, KROHN-HITE Filters are calibrated to conform to passive Filter terminology. The cutoff frequency in the MAX FLAT (Butterworth) mode is the frequency at which the gain of the Filter is 3dB down from the gain at the middle of the pass-band. This pass-band varies with separation of the cutoff frequencies as shown in Figure 2. In the RC transient-free mode, this cutoff frequency gain is approximately 13dB down.

PASS-BAND GAIN

The Filter output voltage, under open circuit conditions, will be within ±1/2dB of the input voltage for all frequencies within the pass-band.

To determine the pass-band gain accurately, the high and low cutoff frequencies must be separated by a factor of at least four, and the measuring frequency must be the geometric mean of these frequencies.

ATTENUATION SLOPE

A typical attenuation curve is shown in Figure 4. At the cutoff frequency, in the MAX FLAT (Butterworth) mode, the slope is approximately 12dB per octave, and at the 12dB point the slope has essentially reached its nominal value of 24dB per octave. The slope of the straight portion of the curve may vary slightly from 24dB per octave at certain frequencies because of cross-coupling effects.

MAXIMUM ATTENUATION

This Filter has a maximum attenuation specification of 80dB which applies over most of the frequency range. At the high frequency end, this attenuation is reduced due to unavoidable cross-coupling between input and output.

OUTPUT IMPEDANCE

The Filter will operate into any load impedance providing the maximum output voltage and current specification is not exceeded. For a matched load impedance of 50 ohms, the pass-band gain will be approximately 6dB. Lower values of load resistance will not damage the filter but will increase the distortion.

Higher values of external load may be used with no sacrifice in performance and correspondingly, lower pass-band gain. In KROHN-HITE Filters, there is no requirement for the load impedance to match the output impedance.

INTERNALLY GENERATED HUM AND NOISE

The internally generated hum and noise measurement is based on the use of a Ballantine Model 310 Voltmeter or equivalent. The measurement is made with the input connector shorted, and with no other external signal connections to the Filter, and with the voltmeter leads shielded.

DISTORTION

Filter distortion is a function of several variables and is difficult to specify exactly. In general, if the Filter is operated within its ratings, distortion products introduced by the Filter and not present in the input signal will not exceed 0.5%. In most cases distortion will be considerably less than 0.5%.

5.3 TEST EQUIPMENT REQUIRED

a. Oscillator - capable of supplying at least 3 volts rms from 10Hz to 10MHz with frequency calibration better than $\pm$1%, distortion less than 0.1% and frequency response within $\pm$0.2dB.

b. AC Meter - frequency response, 10Hz to 10MHz; full scale sensitivity from 10mV to 10 volts rms; dB scale; input capacitance should be less than 20pF.

c. Oscilloscope - having direct coupled horizontal and vertical amplifiers with equal phase characteristics to at least 20kHz and vertical sensitivity of 10mV per division.

d. DC Voltmeter - 15 volts dc full scale.

e. Variable Auto-Transformer - to adjust line voltage.

f. AC Voltmeter - to measure line voltage.

5.4 POWER SUPPLIES

With the Filter operating at 115 or 230 volts line, whichever is applicable, check the plus and minus 10 volts supplies with respect to chassis ground. The FLOATING/CHASSIS grounding switch, located on the rear panel, should be in the CHASSIS position.

If the minus 10 volts supply is out of tolerance R118 should be adjusted.

If the minus 10 volts supply is correct and the plus 10 volts supply is out of tolerance, R113 or R114 may be defective.

5.5 CALIBRATION PROCEDURE

The following procedure must be used in the sequence given in order to have the controls in the proper positions. Throughout the procedure, low cutoff is abbreviated LCO and high cutoff is abbreviated HCO. Note that LOW CUTOFF dial and multiplier refers to the left frequency dial and band multiplier switch, and the HIGH CUTOFF and multiplier refers to the right frequency dial and band multiplier switch. For all steps, the ac input line voltage should be at 115 or 230 volts, whichever is applicable.

The layout of components, test points, and adjustments is shown on the schematic, Figure 8.

In the event the Filter does not meet

the correct tolerance as specified in each step of the calibration procedure, refer to Section 4, Maintenance.

1. LCO dial slope calibration at 30.

Set: LCO dial: 30
LCO Multiplier: X10
HCO dial: 300
HCO Multiplier: X10K
Input signal: 0.5 volts rms at 300Hz.
Connect scope's vertical input to Filter's output.
Connect scope's horizontal input and oscillator to Filter input.
Set RESPONSE switch to MAX FLAT position.

Adjust LCO dial to close the ellipse at about a 135 degree angle. If necessary, loosen LCO dial screws and set dial to 30.

2. LCO dial gain calibration at 30.

Set: HCO dial: 300
HCO Multiplier: X10K

Switch LCO frequency multiplier to X1.
Connect AC Meter to Filter output.
Adjust oscillator output until AC Meter indicates exactly 14dB. Return LCO frequency multiplier to X10 position. Adjust P305 until AC Meter indicates 11dB. If P305 requires adjustment, recheck 14dB reference level.

3. LCO dial gain calibration at 10.

Set: LCO dial: 10
HCO dial: 300
HCO Multiplier: X10K
Input signal: 0.5 volts rms at 100Hz

Switch LCO frequency multiplier to X1. Adjust oscillator output until AC Meter indicates exactly 14dB. Return LCO frequency multiplier to X10. Adjust LCO dial until AC Meter indicates 11dB. Tolerance is a dial setting from 9.5 to 10.5.

4. LCO dial gain calibration at 100.

Set: LCO dial: 100
HCO dial: 300
HCO Multiplier: X10K
Input signal: 0.5 volts rms at 1kHz

Switch LCO frequency multiplier to X1. Adjust oscillator output until AC Meter indicates exactly 14dB. Return LCO frequency multiplier to X10. Adjust LCO dial until AC Meter indicates 11dB. Tolerance is a dial setting from 95 to 105.

5. Unity gain adjustment at 5kHz.

Set: LCO dial: 70
LCO multiplier: X1
HCO dial: 45
HCO Multiplier: X10K
Input signal: 1 volt rms at 5kHz

With AC Meter, compare ac signal on input Filter with ac signal on output. If necessary, adjust P302 for unity gain.

6. X10K band calibration.

Set: LCO dial: 10
LCO multiplier: X100
HCO dial: 300
HCO Multiplier: X10K
Input signal: 0.5 volts rms at 1MHz

a. Switch LCO multiplier to X10K. Adjust P205 for minimum change, less than 0.3dB, in output amplitude when switching LCO multiplier from X100 to X10K.

b. Change input frequency to 50kHz. Switch LCO multiplier to X100. Adjust oscillator amplitude until AC Meter indicates exactly 0.1 volts, 20dB on output of Filter. Switch LCO multiplier to X10K. If necessary, adjust C317 and C319 until AC Meter indicates output of Filter is down 24dB and repeat part a.

c. Change input frequency to 100kHz. Switch LCO multiplier to X1K. Adjust oscillator amplitude until AC Meter indicates exactly 0.1 volts, 20dB on output of Filter. Switch LCO multiplier to X10K. Adjust LCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 9.5 to 10.5. If off, dial reading high, increase C319 and decrease C317. If dial reading is low, decrease C319 and increase C317. Repeat parts a and b respectively.

d. Set LCO dial to 100. Set output frequency to 1MHz. Switch LCO multiplier to X1K. Adjust oscillator amplitude until AC Meter indicates exactly 0.1 volts, 20dB on output of Filter. Switch LCO multiplier to X10K. Adjust C325 until AC Meter indicates 17dB.

e. Set LCO dial to 30. Set input frequency to 300kHz. Switch LCO multiplier to X1K. Adjust oscillator amplitude until AC Meter indicates exactly 20dB on output on Filter. Set LCO multiplier to X10K. Adjust LCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 28.5 to 31.5. If out of tolerance, divide the error between 10 and 100 on the dial.

7. LCO dial gain calibration at 30 on all bands.

Set: LCO dial: 30
LCO multiplier: X1
HCO dial: 300
HCO multiplier: X10K
Input signal: 0.1 volts rms with the frequency as noted.

a. X1 calibration:

Connect AC Meter to Filter output. Set oscillator frequency to 300Hz. Adjust oscillator output until AC Meter indicates exactly 20dB. Change frequency to 30Hz. Adjust LCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 28.5 to 31.5.

b. X100 calibration:

Set: LCO dial: 30
LCO multiplier: X10
Input signal: 1 volt rms at 3kHz

Adjust oscillator output until AC Meter indicates exactly 20dB. Set LCO frequency multiplier to X100. Adjust LCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 28.5 to 31.5.

c. X1K calibration:

Set: LCO dial: 30
HCO dial: 100
Input signal: 1 volt rms at 30kHz

Adjust oscillator output until AC Meter indicates exactly

20dB. Set LCO frequency multiplier to X1K. Adjust LCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 28.5 to 31.5.

8. HCO dial calibration at 90.

Set: LCO dial: 90
LCO multiplier: X10
HCO dial: 90
HCO multiplier: X10K
Input signal: 0.5 volts rms at 900Hz

Connect oscillator output to scope's horizontal input. Adjust the scope for horizontal deflection of 20 divisions. Remove oscillator output from scope horizontal input and connect to scope vertical input. Adjust scope for vertical deflection of 20 divisions. Remove oscillator output from scope and connect to Filter input. Connect scope horizontal input to input of Filter and scope vertical input to Filter output. Adjust LCO dial to close ellipse at about a 45 degree angle. Switch HCO multiplier to X10. Adjust HCO dial to close ellipse at about a 135 degree angle. If necessary, loosen HCO dial screws and set dial to 90.

9. HCO dial gain calibration at 90.

Set: LCO dial: 10
LCO multiplier: X1
HCO dial: 90
HCO multiplier: X10

Switch HCO frequency multiplier to X100 and adjust oscillator output until AC Meter indicates exactly 14dB. Return HCO frequency multiplier to X10. Adjust P206 until AC Meter indicates 11dB.

10. HCO dial gain calibration at 30.

Set: LCO dial: 10
LCO multiplier: X1
HCO dial: 30
HCO multiplier: X10
Input signal: 0.5 volts rms at 300Hz

Switch HCO frequency multiplier to X100 and adjust oscillat or output until AC Meter indicates exactly 14dB. Return HCO frequency multiplier to X10. Adjust HCO dial until AC Meter indicates 11dB. Tolerance is a dial setting from 28.5 to 31.5.

11. HCO dial calibration at 300.

Set: LCO dial: 10
LCO multiplier: X1
HCO dial: 300
Input signal: 0.5 volts rms at 3kHz

Switch HCO frequency multiplier to X100 and adjust oscillator until AC Meter indicates exactly 14dB. Return HCO frequency multiplier to X10. Adjust HCO dial until AC Meter indicates 11dB. Tolerance is a dial setting from 285 to 315.

12. X10K band calibration:

Set: LCO dial: 10
LCO multiplier: X1
HCO dial: 300
Input signal: 0.1 volts rms at 30kHz

Adjust oscillator output until AC Meter indicates exactly 20dB. Change oscillator frequency to 300kHz. Adjust C223 until AC Meter indicates 17dB. Set filter dial to 300 and oscillator to 3MHz. Adjust C228 until AC Meter indicates 17dB. Check 90 on the dial with the oscillator set at 90kHz. It may be necessary to divide the error by re-adjusting C223 and C228.

13. HCO dial gain calibration at 100 on all bands.

Set: LCO dial: 10
LCO multiplier: X1
HCO dial: 100
Input signal: 0.1 volts rms at 100kHz.

a. X1K band calibration:

Adjust oscillator output until AC Meter indicates exactly 20dB. Switch HCO multiplier to X1K. Adjust HCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 95 to 105.

b. X100 band calibration:

Set: Input signal: 0.1 volts rms at 10kHz

Adjust oscillator output until AC Meter indicates exactly 20 dB. Switch HCO multiplier to X100. Adjust HCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 95 to 105.

c. X1 band calibration:

Set: HCO multiplier: X10
Input signal: 0.1 volt rms at 100Hz

Adjust oscillator output until AC Meter indicates exactly 20dB. Switch HCO multiplier to X1. Adjust HCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 95 to 105.

14. Maximum attenuation at 90kHz.

Set: LCO dial: 100
LCO multiplier: X10K
HCO dial: 30
HCO multiplier: X10K
Input signal: 3 volts rms at 90kHz

Output signal should be below 330 microvolts.

15. Maximum attenuation at 3MHz.

Set: LCO dial: 100
LCO multiplier: X10K
HCO dial: 30
HCO multiplier: X10K
Input signal: 3 volts rms at 3MHz

Output signal should be below 3.3 millivolts.

16. Maximum input voltage.

Set: LCO dial: 100
LCO multiplier: X1
HCO dial: 300
HCO multiplier: X10K
Input signal: 3 volts at 300kHz

Check that output signal is not distorted.

17. Output impedance.

Set: LCO dial: 100
LCO multiplier: X1
HCO dial: 300
HCO multiplier: X10K
Input signal: 1 volt rms at 1kHz

Connect 50 ohm resistor to Filter output. Output signal should decrease to approximately 0.5 volts. Remove 50 ohm resistor.

18. Hum and noise.

Set: LCO dial: 10
LCO multiplier: X1
HCO dial: 300

HCO multiplier: X10K
Input signal: 0

Remove oscillator. Connect AC Meter only to Filter output and a shorting jumper across the input connector. Replace all covers. Output signal level should be below 150 microvolts. Caution! If output level is greater than 150 microvolts, monitor output to be sure excessive output is not due to radio or television station interference.

SECTION 6

PARTS LISTS, SCHEMATICS AND BOARD LAYOUTS

6.1 ORDERING INFORMATION

When ordering parts from Krohn-Hite, specify the instrument model number (Model 3103A), instrument serial number, schematic reference designation (ie; R, C, CR etc..) and the manufacturer's part number (see the list below for the Manufacturer's abbreviation and FSCM number).

Address all inquiries to your local Krohn-Hite Sales Representative or directly to Krohn-Hite.

Any engineering modifications will be found on a Modification Sheet inside the rear cover of this manual.

The part numbers listed are either the actual parts used or direct replacements.

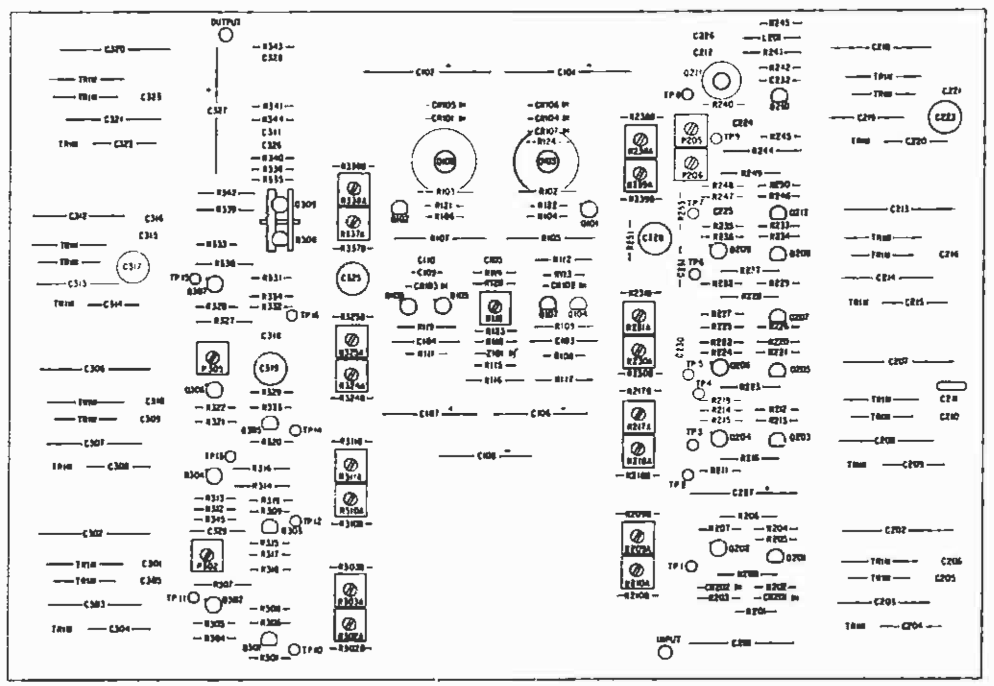
6.2 ORDERING UNLISTED PARTS

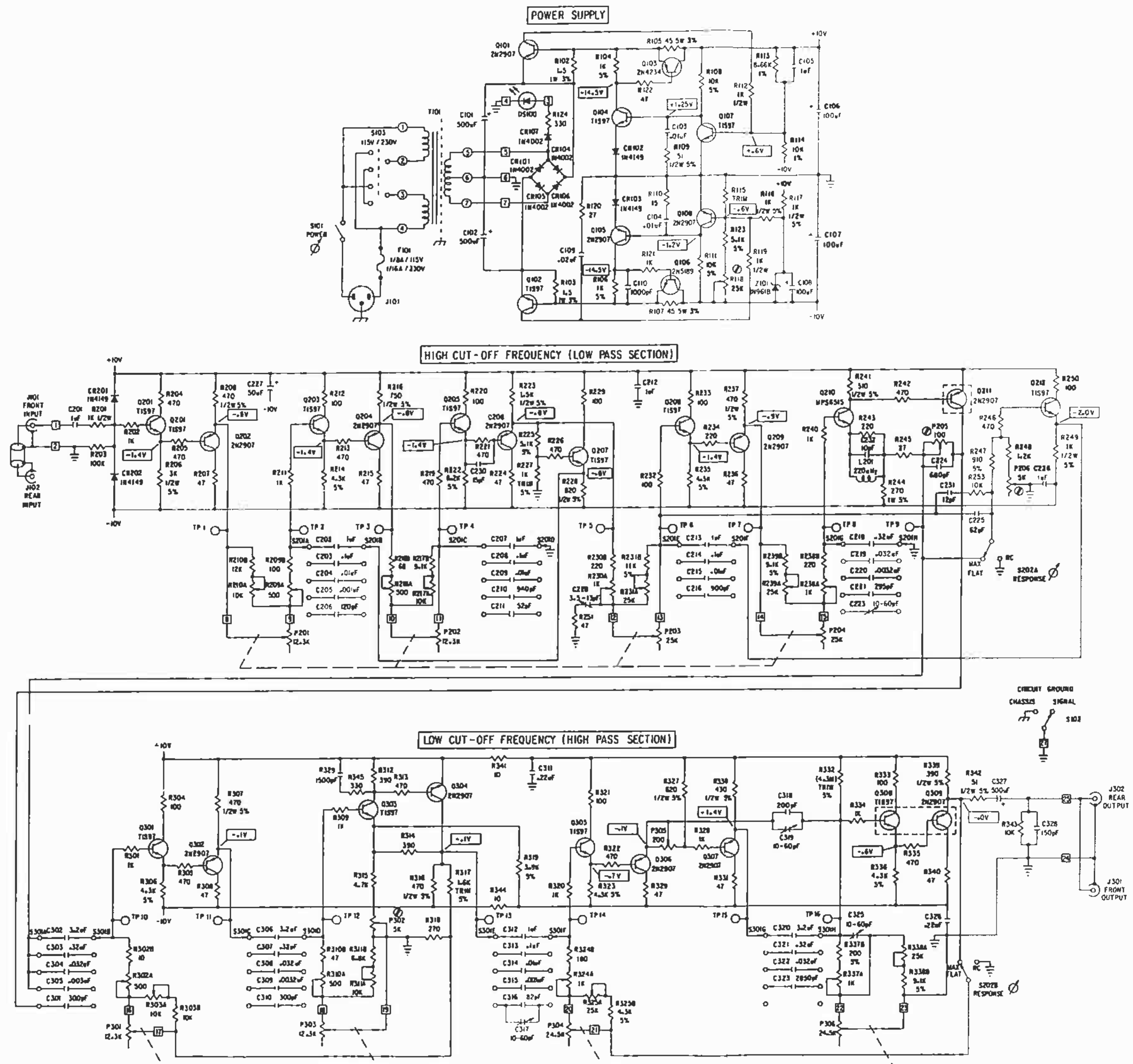
When ordering parts from Krohn-Hite that are not listed, include the instrument model number (Model 3103A), instrument serial number, a description and location of the part.

MFR	NAME	FSCM
AV	Aavid Engineering, Laconia, NH	30161
AB	Allen Bradley Co., Milwaukee, WI	01121
AD	Analog Devices Inc., Norwood, MA	24355
ALC	Alco Electronic Products Inc., Div. of Augat Inc., North Andover, MA	95146
AMP	Amphenol North America, Div. of Buker-Ramo, Oak Brook, IL	29587
AMZ	American Zettler, Irvine, CA.	-----
APD	American Power Devices, Andover, MA	50273
AS	Atlantic Semiconductor, Northridge, CA	17545
ATM	Amatom Electronics Hardware, Windsor Locks, CT	06540
AVX	Aerovox Inc., New Bedford, MA	00656
BKM	Beckman Helipot Div., Fullerton, CA	73138
BUS	Bussman, Div. of McGraw-Edison Co., St. Louis, MO	71400
CA	Circuit Assembly, Costa Mesa, CA.	-----
CC	Coto-Coil Co., Providence, RI	71707
CD	Cornell-Dubilier Electronics, Newark, N.J.	14655
CDI	Compensated Devices Inc., Melrose, MA	-----
CGW	Corning Glass Works, Wilmington, NC	27167
CK	C&K Components Inc., Newton, MA	09353
CLX	Clairex Corp., Mt. Vernon, NY	-----
CPC	Components Corp., Denville, NJ	26364
CW	CW Industries, Warminster, PA	79727
DE	Dale Electronics Inc., Columbus, NE	91637
DLV	Delevan Corp., East Aurora, NY	99800
DL	Dialight Corp., Brooklyn, NY	72619
ECI	Electronic Concepts Inc., Eatontown, NJ	50558
FCD	Fairchild, Semiconductor Group, Mountain View, CA	07263 -----
FXC	Ferroxcube Corp., Div. of N.A. Phillips, Saugerties, NY	02114
GI	General Instrument Corp., Semiconductor Div., Hicksville, NY	11711
HG	Hi-G Co., Windsor Locks, CT	02289
HP	Hewlett-Packard component supplied by Schweber, Bedford, MA	-----

MFR	NAME	FSCM
ITT	ITT Components-Capacitors, Santa Ana, CA	-----
KGN	Kahgan Electronics Corp., Hempstead, NY	57582
KH	Krohn-Hite Corp., Avon, MA	88865
KLN	Kelvin Industries, Fajardo, PR	-----
KNG	Kings Electronics, Tuckahoe, NY	91836
KRL	KRL Electronics Inc., Manchester, NH	18235
LFI	Littlefuse Inc., Des Plaines, IL	75915
LNX	Lionex, Burlington, MA	-----
MAL	Mallory Capacitor Co., Indianapolis, IN	90201
MON	Monsanto, Electronics Div., Palo Alto, CA	26483
MOT	Motorola Inc., Semiconductor Group, Phoenix, AZ	04713
MT	M-Tron Industries Mfg. Inc., Van Nuys, CA	31649
NS	National Semiconductor Corp., Semiconductor Div., Santa Clara, CA	27014 -----
PRP	Precision Resistive Products Inc., Mediapolis, IA	-----
QC	Quality Components Inc., St. Mary's, PA	-----
RCA	RCA Solid State Div., Somerville, NJ	02735
RCL	RCL Electronics, Div. of AMF, Electro-Components Group, Pompano Beach, FL	-----
RI	Resistors Inc., Chicago, IL	83827
SCH	ITT Schadow Inc., Eden Prarie, MN	-----
SIG	Signetics, Sunnyvale, CA	-----
SLX	Siliconix Inc., Sunnyvale, CA	100010
STL	Stackpole Components Co., Raliegh, NC	-----
SP	Sprague Electric Co., N. Adams, MA	56289
STT	Stettner-Trush Inc., Cazenovia, NY	52763
SUP	Superior Electric Company, Bristol, CT.	-----
SWC	Switchcraft Inc., Chicago, IL	82389
TD	Teledyne Semiconductor, Mountain View, CA	15818
TI	Texas Instruments, Dallas, TX	01295
THY	Thermalloy, Dallas, TX	13103
TOR	Torin Corp., Torrington, CT	60399
TRW	TRW Capacitors, Ogallala, NE	84411
YSA	Yuasa Battery, Santa Fe, CA	-----

Manufacturer's Abbreviation and FSCM Number.





TITLE FILTER SCHEMATIC

3103A

KH KROHN-HITE CORPORATION

11/19/82

NOTES

1. When ordering parts, please specify the following:
   a. Instrument model number and serial number.
   b. Schematic reference.
   c. Manufacturer's part number.
2. Any engineering modifications will be found at the rear of this manual.
3. The part numbers listed are either the actual parts used or direct replacements.

CAPACITORS

SCHEM. REF.	DESCRIPTION			MFR.	PART NUMBER
C101	500uF		25V	SP	TT501N025
C102	500uF		25V	SP	TT501N025
C103	.01uF	10%	100V	CD	WMD1S1
C104	.01uF	10%	100V	CD	WMD1S1
C105	1uF	+80-20%	100V	AVX	5C023105D8250B3
C106	100uF		25V	SP	30D107G025DD4
C107	100uF		25V	SP	30D107G025DD4
C108	100uF		25V	SP	30D107G025DD4
C109	.02uF	20%	500V	SP	C023A501J203M
C110	1000pF	20%	500V	SP	C023B501E102M
C201	1uF	10%	200V	TRW	X663F-11
C202	1uF	10%	200V	TRW	X663F-11
C203	.1uF	+1-3%	200V	TRW	X663F-5
C204	.01uF	+1-3%	200V	TRW	X663F-1
C205	.001uF	1%	500V	KGN	DM19C102F
C206	120pF	5%	500V	KGN	DM15C121J
C207	1uF	+1-3%	200V	TRW	X663F-9
C208	.1uF	+1-3%	200V	TRW	X663F-5
C209	.01uF	+1-3%	200V	TRW	X663F-1
C210	940pF	1%	500V	KGN	DM19C941F
C211	52pF	10%	500V	KGN	DM15C520K
C212	1uF	+80-20%	100V	AVX	5C023105D8250B3
C213	1uF	+1-3%	200V	TRW	X663F-9
C214	.1uF	+1-3%	200V	TRW	X663F-5
C215	.01uF	+1-3%	200V	TRW	X663F-1
C216	900pF	1%	500V	KGN	DM19C901F
C218	.32uF	+1-3%	200V	TRW	X663F-7
C219	.032uF	+1-3%	200V	TRW	X663F-3
C220	.0032uF	1%	300V	KGN	DM19C322F
C221	295pF	1%	500V	KGN	DM19C295F
C223	10-60pF	TRIMMER		STT	10STRIKO06N1500
C224	680pF	10%	500V	KGN	DM19C681K
C225	62pF	5%	500V	KGN	DM15C620J
C226	1uF	+80-20%	100V	AVX	5C023105D8250B3
C227	50uF		25V	SP	30D506G025CC4
C228	3.5-13pF	TRIMMER		STT	75-TRIKO-02-N033
C230	15pF	5%	500V	KGN	DM15C150J
C231	12pF	10%	500V	QC	TYPE QC
C232	10pF	10%	500V	QC	TYPE QC
C301	300pF	1%	500V	KGN	DM19C301F
C302	3.2uF	+1-3%	50V	TRW	X663F-12
C303	.32uF	+1-3%	200V	TRW	X663F-7
C304	.032uF	+1-3%	200V	TRW	X663F-3
C305	.003uF	1%	300V	KGN	DM19C302F
C306	3.2uF	+1-3%	50V	TRW	X663F-12
C307	.32uF	+1-3%	200V	TRW	X663F-7
C308	.032uF	+1-3%	200V	TRW	X663F-3
C309	.0032uF	1%	300V	KGN	DM19C322F
C310	300pF	1%	500V	KGN	DM19C301F
C311	.22uF	20%	100V	AVX	8131-100-651-224M
C312	1uF	+1-3%	200V	TRW	X663F-9
C313	.1uF	+1-3%	200V	TRW	X663F-5
C314	.01uF	+1-3%	200V	TRW	X663F-1
C315	.001uF	1%	500V	KGN	DM19C102F
C316	82pF	5%	500V	KGN	DM15C820J
C317	10-60pF	TRIMMER		STT	10STRIKO06N1500
C318	200pF	10%	500V	KGN	DM15C201K
C319	10-60pF	TRIMMER		STT	10STRIKO06N1500
C320	3.2uF	+1-3%	50V	TRW	X663F-12
C321	.32uF	+1-3%	200V	TRW	X663F-7
C322	.032uF	+1-3%	200V	TRW	X663F-3
C323	2850pF	1%	300V	KGN	DM19C2850F
C325	10-60pF	TRIMMER		STT	10STRIKO06N1500
C326	.22uF	20%	100V	AVX	8131-100-651-224M
C327	500uF		25V	SP	TT501N025
C328	150pF	10%	500V	KGN	DM15C151K
C329	1500pF	10%	100V	CD	WMF1D15

RESISTORS

SCHEM. REF.	DESCRIPTION			MFR.	PART NUMBER
R102	1.5	3%	1W	KRL	P-1AW1-1R5H
R103	1.5	3%	1W	KRL	P-1AW1-1R5H
R104	1K	5%	1/4W	AB	CB1025
R105	45	3%	5W	KRL	P-5W1-45RH
R106	1K	5%	1/4W	AB	CB1025
R107	45	3%	5W	KRL	P-5W1-45RH
R108	10K	5%	1/4W	AB	CB1035
R109	51	5%	1/2W	AB	EB5105
R110	15	10%	1/4W	AB	CB1501
R111	10K	5%	1/4W	AB	CB1035
R112	1K	10%	1/2W	AB	EB1021
R113	8.66K	1%	1/4W	PRP	8.66KGP1/4-T100
R114	10K	1%	1/4W	PRP	10KGP1/4-T100
R115	TRIM		1/4W		
R116	1K	5%	1/2W	AB	EB1025
R117	1K	10%	1/2W	AB	EB1021
R118	25K	POT	1/2W	BKM	72PMR25K
R119	1K	10%	1/2W	AB	EB1021
R120	27	10%	1/4W	AB	CB2701
R121	1K	10%	1/4W	AB	CB1021
R122	47	10%	1/4W	AB	CB4701
R123	5.1K	5%	1/4W	AB	CB5125
R124	330	10%	1/4W	AB	CB3311
R201	1K	10%	1/2W	AB	EB1021
R202	1K	10%	1/4W	AB	CB1021
R203	100K	10%	1/4W	AB	CB1041
R204	470	10%	1/4W	AB	CB4711
P205	100	POT	1/2W	BKM	72PMR100
R205	470	10%	1/4W	AB	CB4711
P206	5K	POT	1/2W	BKM	72PMR5K
R206	3K	5%	1/2W	AB	EB3025
R207	47	10%	1/4W	AB	CB4701
R208	470	5%	1/2W	AB	EB4715
R209A	500	POT	1/2W	BKM	72PMR500
R209B	100	10%	1/4W	AB	CB1011
R210A	10K	POT	1/2W	BKM	72PMR10K
R210B	12K	10%	1/4W	AB	CB1231
R211	1K	10%	1/4W	AB	CB1021
R212	100	10%	1/4W	AB	CB1011
R213	470	10%	1/4W	AB	CB4711
R214	4.3K	5%	1/4W	AB	CB4325
R215	47	10%	1/4W	AB	CB4701
R216	750	5%	1/2W	AB	EB7515
R217A	10K	POT	1/2W	BKM	72PMR10K
R217B	9.1K	10%	1/4W	AB	CB9121
R218A	500	POT	1/2W	BKM	72PMR500
R218B	68	5%	1/4W	AB	CB6805
R219	470	10%	1/4W	AB	CB4711
R220	100	10%	1/4W	AB	CB1011
R221	470	10%	1/4W	AB	CB4711
R222	8.2K	5%	1/4W	AB	CB8225
R223	1.5K	5%	1/2W	AB	EB1525
R224	47	10%	1/4W	AB	CB4701
R225	5.1K	5%	1/4W	AB	CB5125
R226	470	10%	1/4W	AB	CB4711
R227	1K	5%	1/4W	AB	CB1025
R228	820	5%	1/2W	AB	EB8215
R229	100	10%	1/4W	AB	CB1011
R230A	1K	POT	1/2W	BKM	72PMR1K
R230B	220	10%	1/4W	AB	CB2211
R231A	25K	POT	1/2W	BKM	72PMR25K
R231B	11K	5%	1/4W	AB	CB1135
R232	100	10%	1/4W	AB	CB1011
R233	100	10%	1/4W	AB	CB1011
R234	220	10%	1/4W	AB	CB2211
R235	4.3K	5%	1/4W	AB	CB4325
R236	47	10%	1/4W	AB	CB4701

RESISTORS

SCHEM. REF.	DESCRIPTION			MFR.	PART NUMBER
R237	470	5%	1/2W	AB	EB4715
R238A	1K	POT	1/2W	BKM	72PMR1K
R238B	220	10%	1/4W	AB	CB2211
R239A	25K	POT	1/2W	BKM	72PMR25K
R239B	9.1K	5%	1/4W	AB	CB9125
R240	1K	10%	1/4W	AB	CB1021
R241	510	5%	1/2W	AB	EB5115
R242	470	10%	1/4W	AB	CB4711
R243	220	10%	1/4W	AB	CB2211
R244	270	5%	1W	AB	GB2715
R245	27	10%	1/4W	AB	CB2701
R246	470	10%	1/4W	AB	CB4711
R247	910	5%	1/4W	AB	CB9115
R248	1.2K	10%	1/4W	AB	CB1221
R249	1K	5%	1/2W	AB	EB1025
R250	100	10%	1/4W	AB	CB1011
R251	47	10%	1/4W	AB	CB4701
R253	10K	10%	1/4W	AB	CB1031
R301	1K	10%	1/4W	AB	CB1021
P302	5K	POT	1/2W	BKM	72PMR5K
R302	500	POT	1/2W	BKM	72PMR500
R302B	10	10%	1/4W	AB	CB1001
P303A	10K	POT	1/2W	BKM	72PMR10K
R303B	10K	10%	1/4W	AB	CB1031
R304	100	10%	1/4W	AB	CB1011
P305	200	POT	1/2W	BKM	72PMR200
R305	470	10%	1/4W	AB	CB4711
R306	4.3K	5%	1/4W	AB	CB4325
R307	470	5%	1/2W	AB	EB4715
R308	47	10%	1/4W	AB	CB4701
R309	1K	10%	1/4W	AB	CB1021
R310A	47	10%	1/4W	AB	CB4701
R310B	500	POT	1/2W	BKM	72PMR500
R311A	10K	POT	1/2W	BKM	72PMR10K
R311B	6.8K	10%	1/4W	AB	CB6821
R312	390	5%	1/4W	AB	CB3911
R313	470	10%	1/4W	AB	CB4711
R314	390	10%	1/4W	AB	CB3911
R315	4.7K	10%	1/4W	AB	CB4721
R316	470	5%	1/2W	AB	EB4715
R317	1.6K	5%	1/4W	AB	CB1625
R318	270	10%	1/4W	AB	CB2711
R319	3.9K	5%	1/4W	AB	CB3925
R320	1K	10%	1/4W	AB	CB1021
R321	100	10%	1/4W	AB	CB1011
R322	470	10%	1/4W	AB	CB4711
R323	4.3K	5%	1/4W	AB	CB4325
R324A	1K	POT	1/2W	BKM	72PMR1K
R324B	180	10%	1/4W	AB	CB1811
R325A	25K	POT	1/2W	BKM	72PMR25K
R325B	4.3K	5%	1/4W	AB	CB4325
R327	620	5%	1/2W	AB	EB6215
R328	1K	10%	1/4W	AB	CB1021
R329	47	10%	1/4W	AB	CB4701
R330	430	5%	1/2W	AB	EB4315
R331	47	10%	1/4W	AB	CB4701
R332	4.3M	5%	1/4W	AB	CB4355
R333	100	10%	1/4W	AB	CB1011
R334	1K	10%	1/4W	AB	CB1021
R335	470	10%	1/4W	AB	CB4711
R336	4.3K	5%	1/4W	AB	CB4325
R337A	1K	POT	1/2W	BKM	72PMR1K
R337B	200	5%	1/4W	AB	CB2015
R338A	25K	POT	1/2W	BKM	72PMR25K
R338B	9.1K	5%	1/4W	AB	CB9125
R339	390	5%	1/2W	AB	EB3915
R340	47	10%	1/4W	AB	CB4701
R341	10	10%	1/4W	AB	CB1001
R342	51	5%	1/2W	AB	EB5105
R343	10K	10%	1/4W	AB	CB1031
R344	10	10%	1/4W	AB	CB1001
R345	330	10%	1/4W	AB	CB3311

DIODES

SCHEM. REF.	DESCRIPTION	MFR.	PART NUMBER
CR101	DIODE, RECTIFIER	AS	1N4002
CR102	DIODE, SWITCHING	APD	1N4149
CR103	DIODE, SWITCHING	APD	1N4149
CR104	DIODE, RECTIFIER	AS	1N4002
CR105	DIODE, RECTIFIER	AS	1N4002
CR106	DIODE, RECTIFIER	AS	1N4002
CR107	DIODE, RECTIFIER	AS	1N4002
CR201	DIODE, SWITCHING	APD	1N4149
CR202	DIODE, SWITCHING	APD	1N4149
Z101	DIODE, ZENER, 10V	APD	1N961B

INDUCTORS

SCHEM. REF.	DESCRIPTION	MFR.	PART NUMBER
L201	220uHY 10% 2W	DEL	3500-16

SEMICONDUCTORS

SCHEM. REF.	DESCRIPTION	MFR.	PART NUMBER
Q101	TRANSISTOR, PNP	MOT	2N2907
Q102	TRANSISTOR, NPN	TI	TIS97
Q103	TRANSISTOR, PNP	MOT	2N4234
Q104	TRANSISTOR, NPN	TI	TIS97
Q105	TRANSISTOR, PNP	MOT	2N2907
Q106	TRANSISTOR, NPN	NS	2N5189
Q107	TRANSISTOR, NPN	TI	TIS97
Q108	TRANSISTOR, PNP	MOT	2N2907
Q201	TRANSISTOR, NPN	TI	TIS97
Q202	TRANSISTOR, PNP	MOT	2N2907
Q203	TRANSISTOR, NPN	TI	TIS97
Q204	TRANSISTOR, PNP	MOT	2N2907
Q205	TRANSISTOR, NPN	TI	TIS97
Q206	TRANSISTOR, PNP	MOT	2N2907
Q207	TRANSISTOR, NPN	TI	TIS97
Q208	TRANSISTOR, NPN	TI	TIS97
Q209	TRANSISTOR, PNP	MOT	2N2907
Q210	TRANSISTOR, NPN	MOT	MPS6515
Q211	TRANSISTOR, PNP	MOT	2N2907
Q212	TRANSISTOR, NPN	TI	TIS97
Q301	TRANSISTOR, NPN	TI	TIS97
Q302	TRANSISTOR, PNP	MOT	2N2907
Q303	TRANSISTOR, NPN	TI	TIS97
Q304	TRANSISTOR, PNP	MOT	2N2907
Q305	TRANSISTOR, NPN	TI	TIS97
Q306	TRANSISTOR, PNP	MOT	2N2907
Q307	TRANSISTOR, PNP	MOT	2N2907
Q308	TRANSISTOR, NPN	TI	TIS97
Q309	TRANSISTOR, PNP	MOT	2N2907

MISC.

SCHEM. REF.	DESCRIPTION	MFR.	PART NUMBER
S101	PUSHBUTTON SWITCH, POWER	KH	B3386
S102	SLIDE SWITCH, GROUND	CW	GF123
S103	SLIDE SWITCH, 115V - 230U	SWC	46256LFR
S201	ROTARY SWITCH, MULT, HCO	KH	B4038
S202	PUSHBUTTON SWITCH, RES.	KH	B3386
S301	ROTARY SWITCH, MULT, LCO	KH	B4038
F101	FUSE 1/8A - 115V	BUS	MDL-1/8A
	1/16A - 230V	BUS	MDL-1/16A
J101	RECEPTACLE	SWC	EAC-301
T101	TRANSFORMER	KH	B2290
DS100	INDICATOR LED	DL	559-0101-003