5.14 EXTERNAL SYNCHRONIZATION

Connect a 1 kHz signal of 1/4 volt rms amplitude to the SYNC input connector located on the rear of the chassis. Set the Oscillator to approximately 1 kHz. Connect the Main output of the Oscillator to the vertical amplifier of the scope and connect the external Oscillator to the horizontal amplifier of the scope. Set the scope up for display of a circular Lissajous pattern. The Oscillator should lock to the external signal over approximately a range of ±0.5%.

5.15 SQUARE WAVE ADJUSTMENTS (Where Applicable)

5.15.1 Symmetry:

Using a wide-band oscilloscope (frequency range at least 30 mHz) connect the scope lead with a 50 ohm termination to the Square Wave output of the Oscillator. Set the Oscillator frequency to 100 kHz. Set the Oscillator Function switch to "square wave". Set the square wave amplitude control full CW. While observing the square wave symmetry, adjust Potentiometer P201, located on the Square Wave and Pulse Module, or P301, located on the Square Wave Module, for a 1% symmetrical waveform.

5.15.2 DC Level:

Adjust Potentiometer P202, located on the Square Wave and Pulse Module or P302, located on the Square Wave Module, for zero dc level on the Square Wave output. This can be observed on the scope or by using a dc voltmeter connected to the square wave output terminal.

5.15.3 Rise and Fall Time:

Using a 30 mHz bandwidth oscilloscope, with the sweep time calibrated for [illegible] nanoseconds per centimeter, measure the rise and fall time of the Square Wave at 100 kHz. The rise time is considered to be the horizontal displacement between the 10% and 90% points. The tolerance is less than 20 nanoseconds.

5.16 PULSE WIDTH (Where Applicable)

Using a calibrated sweep time on the oscilloscope, measure the Pulse width range in each position for both the negative and positive pulse. Each range should overlap so that there is continuous coverage from 0.1 microsecond to 100 microseconds.

10 HZ MULT X1 = .022 %
100 HZ " X10 = .015 %
1 KHZ " X100 = .025 %
100 H " X1 = .012
1 KHZ X10 = .015 %
10 KHZ X100 = .022 %
50 KHZ X100 .022 %

SET AT 1KHZ
ripple = +25V = 26.6V = 10mV
-20V = -21.2V = 30mV
+20V = 21.2V = 20mV

Roland

SOLID STATE

STANDARD

OSCILLATOR

SERIES 4000

MODEL NO. 4024 SERIAL NO. 104

OPERATING AND MAINTENANCE MANUAL

KROHN-HITE CORPORATION

580 Massachusetts Ave., Cambridge, Mass. 02139 U.S.A.

MODEL 4000 SERIES

PG. 1-P

The following modifications and corrections are not reflected on the Parts Lists dated October, 1966 and may be added at the discretion of the customer. This is also for changes in Published Specifications in the Manual.

		Change Order Number
On Figure 14	Change R713 from 5.1K to 3K and CB5125 to CB3025	2375
	**R840 should read .1% instead of 1%. (Resistors)	2379
On Figure 13	Change R643 from 1.8M to 820K and CB from 1851 to 8241	

** Covering Model 4020 Series Only

Note: In Instruction Manual on Harmonic Distortion Specification Model 4000 (not 4010 or 4020) change to read "Less than 0.01% from 10Hz to 20 KHz", instead of "from 1 Hz." 2378

OCUMENTATION Section 3 - Circuit Description - Page 15 2383
The last sentence of the second paragraph should read................"E_2 to discharge C717 very rapidly."

Pub. Dept. Correction Sheet No. 4000 Series - 1AB-P

CONTENTS

ILLUSTRATIONS

TABLES

Model 4004

Model 4014

Model 4024

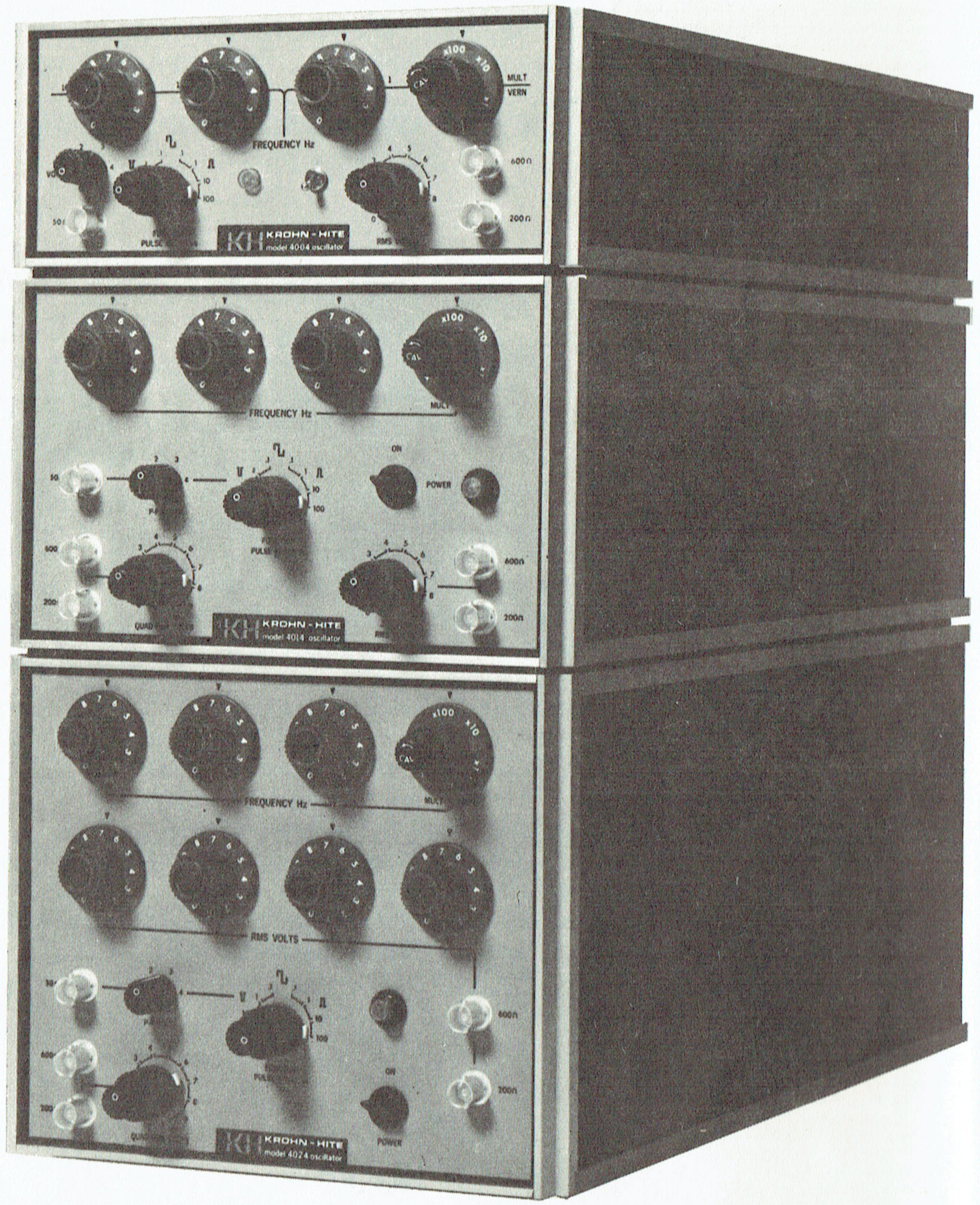


Figure 1. Series 4000 Oscillators

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

This manual provides operation and maintenance instructions, with detailed specifications, schematic diagrams and parts lists, for the Krohn-Hite Series 4000 Oscillators. Differences between Models in this Series are briefly outlined in Table 1 below, and are fully detailed in the Technical Summary (paragraph 1.3). Component differences between Models are reflected in the Parts Lists included with the Schematic Diagrams at the end of this manual.

TABLE 1 - Summary of Basic Model Differences

	Model		
	4000	4010	4020
Frequency range	0.1Hz-100kHz	0.001Hz-100kHz	0.001Hz-100kHz
Main sine wave output control	one volt steps plus vernier	one volt steps plus vernier	1.0, .1, .01, and .001 volt steps
Main sine wave amplitude accuracy	± 2%	± 2%	± 0.25%
Quadrature sine wave output control	fixed, 10v rms.	one volt steps plus vernier	one volt steps plus vernier
With Square Wave option, Model No. is	4002	4012	4022
With Square Wave & Pulse option, Model No. is	4004	4014	4024

Note: For rack mounting, add suffix "R" to Model number.

1.2 DESCRIPTION

The Series 4000 Oscillators are designed for applications in the frequency range from 0.001 Hz to 100 kHz. All models provide simultaneously Main and Quadrature sine wave output of 10 volts rms maximum at 200 or 600 ohm impedance level. Tuning is by means of decade switches with continuous vernier coverage between the smallest switched steps. Several Models provide a simultaneous Square Wave output with adjustable amplitude, while others additionally provide a synchronous Pulse output which is controlled in width and polarity as well as in amplitude. The Oscillator consists of a highly regulated power supply, a frequency-determining R-C network, two high-gain differential amplifier stages, square wave and pulse stages if required, and a unique AVC circuit that provides a high degree of cycle-to-cycle amplitude control.

1.3 TECHNICAL SUMMARY

The following specifications are stated without reference to specific Model numbers except where such reference is essential. Any specifications relating to square wave or pulse performance will be understood as applying only to those instruments that include these functions. Specifications stated as applying to a basic Model number also apply to the square wave and pulse options of that Model.

Frequency range:

Model 4000: 0.1 Hz to 100 kHz, continuously variable in three decade bands:

Band	Multiplier	Frequency (Hz)	Vernier Range (Hz)
1	1	0.1-1,000	1
2	10	1,000-10,000	10
3	100	10,000-100,000	100

Models 4010, 4020: 0.001 Hz to 100 kHz, continuously variable in five decade bands:

Band	Multiplier	Frequency (Hz)	Vernier Range (Hz)
1	.01	0.001-10	.01
2	0.1	10-100	0.1
3	1	100-1,000	1
4	10	1,000-10,000	10
5	100	10,000-100,000	100

Frequency control: Three rotary FREQUENCY switches, decade MULTIPLIER switch, and VERNIER overlapping the interval between adjacent positions of the third FREQUENCY switch. The VERNIER is also used to cover the lowest frequency decade, when all FREQUENCY switches are set at zero and the MULTIPLIER switch is in its lowest (Band 1) position.

Frequency calibration accuracy:

Model 4000: ±1% from 10 Hz to 50 kHz, rising to ±2% at 100 kHz and to ±5% at 1 Hz.

Models 4010, 4020: ±1% from 1 Hz to 50 kHz, rising to ±2% at 0.1 Hz and 100 kHz, and to ±5% at 0.01 Hz.

Frequency stability:

vs. Time: Within ±0.02% from 10 Hz to 50 kHz, and ±0.1% from 0.1 Hz to 100 kHz, in any period of one hour or less. Within ±0.1% from 10 Hz to 50 kHz, and ±0.5% from 0.1 Hz to 100 kHz, in any period of ten hours or less.

vs. Line: Within ±0.005% for a 10% change in line voltage.

vs. Load: Within ±0.005% from 1 Hz to 10 kHz, and ±0.05% from 0.1 Hz to 100 kHz, no load to full load.

vs. Temperature: Within ±0.02% per degree C from 10 Hz to 50 kHz, and ±0.1% per degree C from 0.1 Hz to 100 kHz.

External synchronization: A 0.25 volt peak-to-peak signal will lock Oscillator over a range of approximately ±0.5% and distortion will increase to approximately 0.05%. Locking range and distortion increase linearly with input amplitude. Relative phase shift is controlled by Oscillator tuning. See section 2.3.5 for additional information.

Main and quadrature sine wave outputs:

Voltage: 10 volts rms maximum open-circuit, 5 volts rms across a matched load.

Current: 30 milliamperes maximum.

Power: 125 milliwatts maximum from each output simultaneously into 200-ohm loads.

Harmonic distortion:

Model 4000: Main Output: Less than 0.01% from 1 Hz to 20 kHz, rising to 0.05% at 50 kHz, and 0.1% at 0.1 Hz and 100 kHz. Quadrature output is approximately twice these values.

Models 4010, 4020: Main Output: Less than 0.01% from 0.1 Hz to 20 kHz, rising to 0.05% at 0.01 Hz and 50 kHz, and 0.1% at 0.001 Hz and 100 kHz. Quadrature output is approximately twice these values.

Frequency response (no load or resistive load):

Model 4000: Main output: ±0.01 db from 20 Hz to 20 kHz, ±0.05 db from 1 Hz to 100 kHz, ±0.5 db at 0.1 Hz. Quadrature output: ±0.1 db from 20 Hz to 20 kHz, ±0.5 db from 0.1 Hz to 100 kHz.

Models 4010, 4020: Main Output: ±0.01 db from 20 Hz to 20 kHz, ±0.05 db from 0.01 Hz to 100 kHz, ±0.5 db at 0.001 Hz. Quadrature output: ±0.1 db from 20 Hz to 20 kHz, ±0.5 db from 0.001 Hz to 100 kHz.

Amplitude stability:

vs. Time: Within ±0.01% from 20 Hz to 20 kHz, and ±0.05% from 1 Hz to 100 kHz, in any period of one hour or less. Within ±0.02% from 20 Hz to 20 kHz, and ±0.1% from 1 Hz to 100 kHz, in any period of ten hours or less. Within ±0.1% from 20 Hz to 20 kHz, and ±0.5% from 1 Hz to 100 kHz, in any period of 100 hours or less. Quadrature amplitude is less stable by a factor of approximately 2.

vs. Line:

Model 4000: Within ±0.001% from 20 Hz to 20 kHz, and ±0.01% from 1 Hz to 100 kHz, for a 10% change in line voltage within operating limits. Quadrature amplitude change is approximately twice these values.

Models 4010, 4020: Within ±0.001% from 20 Hz to 20 kHz, and ±0.01% from 0.01 Hz to 100 kHz, for a 10% change in line voltage within operating limits. Quadrature amplitude change is approximately twice these values.

vs. Temperature:

Model 4000: Within ±0.01% per degree C from 20 Hz to 20 kHz, and ±0.1% per degree C from 1 Hz to 100 kHz. Quadrature amplitude change is approximately twice these values.

Model 4010: Within ±0.01% per degree C from 20 Hz to 20 kHz, and ±0.1% per degree C from 0.01 Hz to 100 kHz. Quadrature amplitude change is approximately twice these values.

Model 4020: Within ±0.005% per degree C from 20 Hz to 20 kHz, and ±0.05% per degree C from 0.01 Hz to 100 kHz. Quadrature amplitude change is approximately twice these values.

Tuning transients: Typical deviation 0.2 db, recovering to original amplitude within a few cycles. Maximum deviation under worst conditions is approximately 1 db, depending on actual switching point in the cycle.

Hum and noise: Less than 0.01% of output at any setting of output attenuators. Cycle-to-cycle amplitude variation less than 0.01%.

Amplitude modulation (line frequency beat): Less than 0.01% near line frequency or its harmonics.

Output circuit: Direct-coupled resistive network.

DC component: Nominal zero volts. At maximum output, drift is less than 1 millivolt per degree C, less than 1 millivolt for a 10% line voltage change, and within ±5 millivolts in any period of 10 hours or less. Drift reduced in proportion to output signal.

Floating (ungrounded) operation: A grounding switch is provided to disconnect the signal ground from the chassis ground. In this mode, performance is slightly reduced above 10 kHz. Balanced output operation is possible in the "floating" mode.

Main sine wave output:

Amplitude control:

Models 4000, 4010: Eleven position switch providing ten 1-volt increments from zero to 9 inclusive. In an additional position (0-0.1) a concentric infinite-resolution vernier provides continuous control from near zero (approximately 1 millivolt) to a nominal 100 millivolts. In the next ten positions this vernier covers a nominal 1-volt range.

Model 4020: Four-decade attenuator providing output control in increments of 1, 0.1, .01, or .001 volt, up to a maximum of 10 volts rms.

Amplitude calibration accuracy:

Models 4000, 4010: At no load with vernier amplitude control at maximum ccw position, within ±2% of indicated attenuator setting ±2 millivolts for frequencies from 1 Hz to 20 kHz, rising to ±2% ±20 millivolts at 100 kHz.

Model 4024: At no load, within ±0.25% of indicated attenuator setting ±1 millivolt for frequencies from 20 Hz to 10 kHz, and within ±0.7% ±10 millivolts from 0.01 Hz to 100 kHz, after periodic calibration.

Internal impedance:

Models 4000, 4010: Constant 200 ohms and 600 ohms, ±2%.

Model 4020: Constant 200 ohms and 600 ohms, ±0.2%.

Quadrature sine wave output:

Amplitude control:

Model 4000: Output fixed at 10 volts rms, ±2%.

Models 4010, 4020: Eleven position switch providing ten 1-volt increments from zero to 9 inclusive. In an additional position (0-0.1) a concentric infinite-resolution vernier provides continuous control from near zero (approximately 1 millivolt) to a nominal 100 millivolts. In the next ten positions this vernier covers a nominal 1-volt range.

Amplitude calibration accuracy:

Models 4010, 4020: At no load with vernier amplitude control at maximum ccw position, within ±2% of indicated attenuator setting ±2 millivolts for frequencies from 20 Hz to 20 kHz, rising to ±5% ±20 millivolts from 0.01 Hz to 100 kHz.

Internal impedance: Constant 200 ohms and 600 ohms, ±5%.

Quadrature phase accuracy: ±1 degree. Higher at ends of range.

Square wave output:

Voltage: Continuously adjustable from nominal zero to 5 volts peak-to-peak open-circuit, 2.5 volts peak-to-peak across 50 ohms.

Current: 100 milliamperes peak-to-peak maximum at very low load impedance, without waveform deterioration.

Waveform details: Rise and fall time less than 20 nanoseconds; symmetrical within 1%; flat top with no droop and less than 5% overshoot at maximum amplitude.

Pulse output:

Voltage: Continuously adjustable from nominal zero to 5 volts peak open-circuit, or 2.5 volts peak across 50 ohms.

Current: 100 milliamperes maximum peak at very low load impedance, without waveform deterioration.

Waveform details: Choice of positive or negative polarity; rise and fall time less than 20 nanoseconds; flat top with no droop and less than 5% overshoot at maximum amplitude: width continuously variable in three decade ranges from 0.1 μ sec to 100 μsec.

Ambient temperature and duty cycle: Continuous operation from zero to 50 degrees C.

Power requirements: 105-130 or 210-260 volts, single phase, 50-400 Hz, 30 watts.

Dimensions and Weights:

Bench Models 4000, 4002, 4004: 8 5/8" wide, 3 1/2" high, 17" deep, 12 lbs. net, 21 lbs. shipping
Bench Models 4010, 4012, 4014: 8 5/8" wide, 5 1/4" high, 17" deep, 13 lbs. net, 21 lbs. shipping
Bench Models 4020, 4022, 4024: 8 5/8" wide, 7" high, 17" deep, 15 lbs. net, 21 lbs. shipping
All Rack Models: 19" wide, 3 1/2" high, 16" deep, 20 lbs. net, 26 lbs. shipping

Specifications are subject to change without notice.

SECTION 2

OPERATING INSTRUCTIONS

2.1 GENERAL

On receipt of the Oscillator, carefully unpack and examine it for any damage that may have occurred in transit. If signs of damage are observed, file a claim with the transporting agency immediately, and notify Krohn-Hite Corporation. Do not attempt to use the Oscillator if damage is suspected.

Rack-mounting models (designated by a suffix "R" after the model number) mount with four machine screws in the standard 19" rack space. No special brackets or attachments are needed.

2.2 CONTROLS AND CONNECTORS

All operating and external adjustment controls, and all signal connectors, are listed in Table 2. Nomenclature is as it appears on the instrument itself.

TABLE 2 - Controls and Connectors

Controls	Applicable Models	Description and Function
FREQUENCY Hz	All	Three rotary decade switches, each with ten positions (0-9) to establish significant figures of the operating frequency.
MULTIPLIER/ VERNIER	All	Concentric decade multiplier switch and vernier. Multiplier selects frequency band (see FREQUENCY RANGE, paragraph 1.3). Vernier provides continuous tuning over the interval between adjacent positions of the third FREQUENCY Hz switch, and is also used to cover the lowest frequency decade when all FREQUENCY Hz switches are set at zero and the MULTIPLIER switch is in its lowest (Band 1) position.
RMS VOLTS	4000 4002 4004 4010 4012 4014	Control for Main sine wave amplitude. Eleven position switch providing successive 1-volt ranges from 0 to 10, plus a separate range from 0 to 100 mv, with a concentric vernier for continuous coverage of each range.

Table 2 (cont.)

Controls	Applicable Models	Description and Function
RMS VOLTS (cont).	4020 4022 4024	Four rotary decade switches, controlling the Main sine wave output amplitude in increments of 1, 0.1, 0.01, and 0.001 volt, from nominal zero to 10 volts rms.
QUADRATURE RMS VOLTS	4010 4012 4014 4020 4022 4024	Control for Quadrature (cosine) output amplitude. Eleven position switch providing successive 1-volt ranges from 0 to 10, plus a separate range from 0 to 100 mv, each range being continuously covered by a concentric vernier. In Models 4000, 4002 and 4004, the Quadrature output is fixed at 10 volts rms.
FUNCTION/ PULSE WIDTH μs	4004 4014 4024	Seven position rotary switch with concentric vernier. Switch selects either the Square Wave output, or the Pulse output with a choice of positive or negative polarity and any of three pulse-width decade ranges. The vernier provides continuous control of pulse width within each switched range.
P-P VOLTS	4002 4004 4012 4014 4022 4024	Potentiometer control for peak-to-peak amplitude of Square Wave and Pulse outputs.
FLOATING/ CHASSIS	All	Slide switch (rear of chassis) operating on all outputs simultaneously, to permit choice of either isolated (floating) or chassis-ground connection.
POWER - ON	All	Toggle switch with indicator light.
Adjustments		
MAIN OUTPUT DC LEVEL ADJUST	All	Screw-driver adjustment (rear of chassis) for setting dc level of Main sine wave output.
QUAD OUTPUT DC LEVEL ADJUST	All	Screw-driver adjustment (rear of chassis) for setting dc level of Quadrature output.

All connectors are coaxial, Type BNC. Main sine wave and Quadrature (cosine) outputs are provided at 600-ohm and 200-ohm impedance levels. Square Wave and Pulse outputs, in Models where these are available, are at a 50-ohm impedance level. The EXTERNAL SYNC Type BNC connector on the rear of the chassis in all Models is the input for an external synchronizing signal. Also on the rear of the chassis is a multi-purpose binding post providing a separate chassis tie point independent of the signal ground connection of the input or output cables.

2.3 OPERATING PROCEDURE

To turn on the Oscillator, plug the power line cord into an ac outlet providing 105-125 volts (or 210-250 volts if the instrument is so wired), single phase, 50-400 Hz power. Turn the POWER switch to the ON position, noting that the indicator lamp lights. Allow the Oscillator to warm up for at least 15 minutes, and preferably for one-half hour if maximum stability of frequency and output amplitude are desired.

2.3.1 Selecting A Frequency

To select a frequency, proceed as follows:

a. Determine the band which contains the desired frequency, and set the FREQUENCY Hz - MULTIPLIER switch for that band.

b. Turn the three FREQUENCY Hz decade switches to the first three significant figures of the desired frequency.

   NOTE: For maximum frequency accuracy, the first decade switch should not be set to zero. Thus, the frequency 15 Hz could be selected by placing the MULTIPLIER switch in the x1 position, turning the first decade switch to 0, the second to 1, and the third to 5. It is preferable, however, to select this frequency by placing the MULTIPLIER switch in the x0.1 position, and turning the first decade switch to 1, the second to 5, and the third to 0.

c. Check the position of the VERNIER knob. With full counterclockwise rotation, the frequency is as set by the three decade switches, and it is this position (as indicated by an arrow and the letters CAL) which is assumed in the frequency accuracy calibration specifications. As the vernier is rotated clockwise, the operating frequency increases continuously from the value corresponding to the set position of the third decade switch, to a value corresponding to the next higher position of that switch.

   The VERNIER is also used to cover the lowest frequency decade when all FREQUENCY switches are set at zero and the MULTIPLIER switch is in its lowest (Band 1) position. Although this control is not calibrated, the frequency can be set quite accurately by the following procedure: Set all three FREQUENCY switches to zero and the MULTIPLIER switch to x100. The VERNIER now covers a range from 10 Hz to 100 Hz. Setting the VERNIER now to any frequency in this range and switching the MULTIPLIER back to x1 will produce 1/100 of that frequency, and switching the MULTIPLIER to x.01 (Models 4010 and 4020) results in a frequency division of 10,000. For example, setting 60 Hz on x100 will give 0.6 Hz in the x1 position and 0.006 Hz in the x.01 position. When the VERNIER is used to cover the lowest frequency decade, optimum performance of the Oscillator is obtained when the dc level of the Main and Quadrature sine wave output is adjusted to zero as closely as possible. This can be obtained by setting the VERNIER to a frequency of approximately 50 Hz and adjusting the two screwdriver controls in the rear of the chassis to zero using a VTVM with a minimum full scale sensitivity of approximately 1 volt. Before doing this it is advisable to check and adjust, if necessary, the output dc level of the AVC amplifier as described in Calibration and Adjustment, Section 5.4.

2.3.2 Adjusting Sine Wave Output Amplitude

To adjust the amplitude of the Main sine wave output, proceed as follows:

a. In all except Models 4020, 4022, and 4024, turn the 11-position RMS VOLTS switch so that its indicator lies in the desired voltage range, then adjust for the required value by using the concentric vernier.

b. In Models 4020, 4022 and 4024, set the four RMS VOLTS decade switches to provide the required value. The minimum increment of 1 millivolt is provided by the fourth switch.

To adjust the amplitude of the Quadrature (cosine) output, proceed as follows:

a. In all except Models 4000, 4002 and 4004, turn the 11-position QUADRATURE RMS VOLTS switch so that its indicator lies in the desired voltage range, then adjust for the required value by using the concentric vernier.

b. In Models 4000, 4002 and 4004, the Quadrature output is fixed at 10 volts rms.

2.3.3 Square Wave And Pulse Operation

In Models 4002, 4012 and 4022, a simultaneous Square Wave at the operating frequency is available. In Models 4004, 4014 and 4024, a choice of either a Square Wave or Pulse is available by placing the FUNCTION/PULSE WIDTH μs switch in the appropriate position. In its center (12 o' clock) position, the switch selects the Square Wave alternative. The three positions to the left of center provide a negative pulse, while the three to the right provide a positive pulse, whose width can be varied by means of the concentric vernier over the three ranges of 0.1 to 1 μsec, 1 to 10 μsec, and 10 to 100 μsec.

2.3.4 Adjusting Square Wave And Pulse Amplitude

The P-P VOLTS control is calibrated in peak-to-peak volts and adjusts the amplitude of the Square Wave, and of the Pulse if one is available, to a maximum of plus 2.5 volts and minus 2.5 volts with reference to signal ground. As this control is varied, the positive and negative excursions of the wave form increase or decrease simultaneously, by equal amounts.

2.3.5 External Synchronization

All Models carry an EXTERNAL SYNC connector on the rear of the chassis. To synchronize the output of the Oscillator with an external signal, connect the external signal to the EXTERNAL SYNC input and tune the Oscillator to an internal operating frequency approximately at the mid-point of the range of variation expected of the external signal. With an external sine or square wave input of 1/4 volt peak-to-peak, the Oscillator output will be locked in frequency to the sync signal over a range of approximately ±1/2% of the Oscillator frequency setting, and distortion will be approximately 0.05%. Locking range and distortion increase linearly with input amplitude up to a maximum range of approximately ± 15%. With a sine wave input, the distortion is nearly constant within the locking range. However, with a square wave input, the distortion remains low in the center of the range, but is higher at the ends of the range than with a sine wave. With a sine wave clipped by back-to-back diodes, the distortion is lower over most of the range than with a sine or square wave for the same locking range.

2.3.6 Floating Or Chassis-Ground

On the rear of the chassis, a slide switched marked ALL OUTPUTS-FLOATING/CHASSIS permits operation with either isolated (floating) or chassis-ground connection. All outputs are simultaneously controlled by the position of this switch. If the Oscillator is isolated from its chassis ground its signal ground must be tied to a suitable external (remote) chassis ground point.

2.4 POWER LINE CONNECTION

As originally shipped, the Oscillator is connected for operation from 105-125 volts ac, except when specifically ordered otherwise. To change the connections for operation at 210-250 volts, remove the jumpers between terminals 1 and 3 and terminals 2 and 4 of the power transformer, and jumper terminals 2 and 3.

SECTION 3

CIRCUIT DESCRIPTION

3.1 INTRODUCTION

A regenerative circuit will oscillate if two conditions are fulfilled. The net phase shift around the entire regenerative loop must be zero degrees and the voltage gain around the loop must be exactly unity at the oscillating frequency. In the 4000 Series Oscillator, two amplifiers, in conjunction with their associated networks R_1C_1 and $R_2R_3C_2$, produce a net phase shift of zero degrees at the oscillating frequency. Refer to Figure 2 Simplified Block Diagram. The phase shift introduced by R_1C_1 is 45 degrees leading,

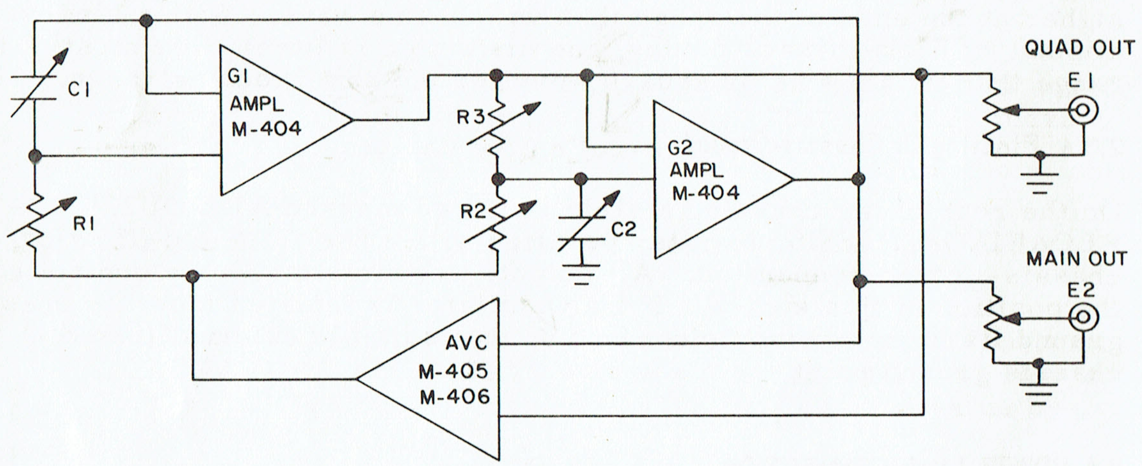


Figure 2. Oscillator Simplified Block Diagram

and that produced by $R_2R_3C_2$ is 45 degrees lagging, for a net shift of zero degrees around the entire loop. The phase relationship established in this manner leads to two useable output signals E_1 and E_2 which bear a fixed 90 degree relationship to each other at any oscillating frequency.

A net loop gain of unity is obtained by the AVC[automatic volume (gain) control] circuit which samples the output voltage E_2, comparing it to a stable dc reference voltage and generates a control signal. This control signal maintains the overall loop gain at exactly unity by reducing or increasing the gain when the output voltage, E_2, changes for any reason. Since the output voltage E_2 is the one which is sampled and controlled, it is called the Main sine wave output, where E_1 is called the Quadrature (cosine) sine wave output.

3.2 FREQUENCY DETERMINING CIRCUITS

The tuning controls for this Oscillator consist first of a decade band switch which selects a pair of capacitors, C_1 and C_2, of the same value to establish each decade or band of frequency. Resistors R_1, R_2 and R_3 establish the frequency within decades, and a vernier adjustment in the form of a dual potentiometer shunting both resistor networks is provided for setting frequency between the smallest digit increments, thus giving continuous frequency coverage. The vernier is also the sole frequency control for the lowest decade of the frequency range.

3.3 AMPLIFIERS

Both amplifiers are identical using Amplifier Module M404 shown in Figure 11. The Amplifier consists of three gain stages and an emitter follower output stage. The differential input stage uses two field effect transistors, Q403A and Q403B, plus three transistors Q401, Q402 and Q409. Input 1, a very high impedance input, is connected to the gate of Q403B, and input 2, a low impedance input, is connected to the gate of Q403A after being added to the output signal in feedback summing resistors R403 and R404. Q409 acts like a high-value load resistor while at the same time passing the required bias current with a relatively low supply voltage. A high effective load resistance at this point approximates a constant-current source and maintains the sum of the input stage drain currents constant. The common-mode signal, appearing at the junction of R412 and R413 at practically full amplitude, is added to a positive dc level and then fed to the input stage drain load resistors through the unity-gain amplifier loop, Q401 and Q402. R412 and R413 are trimmed to set the output dc level to its nominal value, zero volts. The differential output signal of the first stage, developed across R415 and R416, is connected to the bases of Q404 and Q405, the second differential gain stage. Q410 functions in exactly the same manner as Q409 and provides high-common-mode signal rejection in the second stage. A single-ended output signal is taken from R410 and fed to the base of Q406. This is a grounded-emitter stage which is used to drive the output follower. The complementary push-pull emitter follower output stage, Q407 and Q408 is fed directly from the collector of Q406. CR401 and CR402 provide thermal compensation and also establish a bias for proper quiescent current in Q407 and Q408.

3.4 AVC

The AVC circuit consists of two modules, the Main AVC module M405, as shown in Figure 12 and the Reference AVC module M406, shown in Figure 13. The AVC output is a square wave whose amplitude is dependent on the deviation of the Main sine wave output, E_2, from its correct amplitude, and whose phase with respect to the Quadrature sine wave output, E_1, is zero or 180 degrees, depending on the direction of E_2 deviation. The AVC can best be understood by utilizing the Simplified Block Diagram shown below in Figure 3 in conjunction with the schematics Figure 12 and 13.

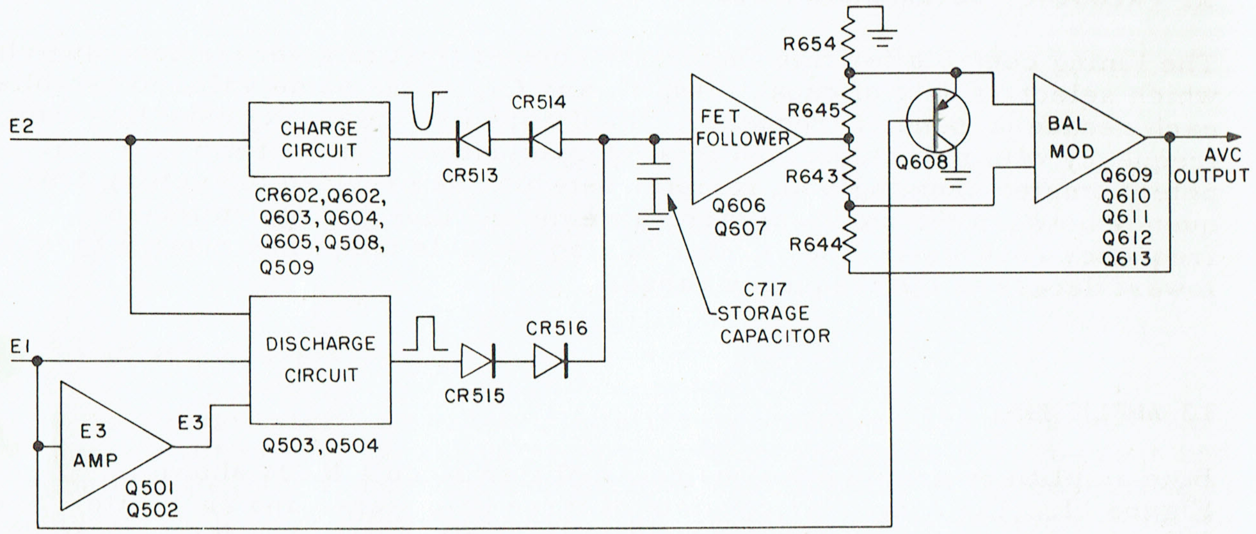


Figure 3. AVC Simplified Block Diagram

The basic principle of operation of the AVC circuit is that of depositing a charge on a storage capacitor C717 proportional to the Main sine wave amplitude, E_2, and using the resulting dc potential to control the balanced modulator which provides the AVC output signal. The potential across C717 is determined by the relative amplitude of both the Charge pulse and Discharge pulse. The Charge pulse, appearing at the collector of Q509, is negative and its width and amplitude vary with E_2 amplitude. This is accomplished by back biasing diode CR602 and permitting only the extreme negative peak of E_2 to be amplified by Q602. The Discharge pulse, appearing at the collector of Q504, is positive and of constant amplitude and width. It is generated by rectifying E_1, E_2 and E_3 via diodes CR502, 503 and 504. The composite rectified signal drives Q504 to conduction at the negative peak of E_2. If the E_2 level is correct, the net potential of capacitor C717 after both pulses have occurred is zero. If the amplitude of E_2 increases, the amplitude of the Charge pulse increases and a net negative potential is left on C717, since the amplitude of the Discharge pulse remains constant. Conversely, if the amplitude of E_2 decreases, the potential of C717 becomes positive.

The dc potential of C717 is transferred to the balanced modulator by FET follower Q606 and emitter follower Q607. The modulator Q608 is supplied with the dc error signal from Q607, and Quadrature output signal, E_1. The action of Q608 is such that when the dc error signal is zero, no ac signal whatever is generated at the base of Q609. If the dc level goes positive, Q608 conducts when E_1 goes negative and the dc level at the base of Q609 is pulled back down to ground level during the time E_1 is negative. The phasing is such that the resulting AVC correction signal is a square wave in phase with the E_1 signal. When the dc level goes negative, conduction in Q608 again takes place when E_1 is negative, but in this case the base of Q609 is pulled up to ground level during the time E_1 is negative. The AVC correction signal again is a square wave, but in this case the phasing is such that the square wave is 180 degrees out of phase with E_1.

3.5 TRANSIENT CONDITIONS

The preceding discussion covers the steady-state condition when the output amplitude is normal or very close to normal. When the output amplitude deviates widely from normal, fast recovery circuits restore normal amplitude more rapidly. When the level of E_2 drops below normal, Q605 becomes non-conducting, and the Discharge pulse path to C717 is paralleled by the low impedance path consisting of R537, C510 and CR519.

When the E_2 amplitude is above normal, the Charge pulse path is paralleled by the low impedance path consisting of R534, C511 and CR521. The Charge pulse is normally narrower than the Discharge pulse and CR509 clamps any Charge signal at the junction of R534 and C511. However, when E_2 exceeds its normal level, the Charge pulse becomes wider and two large charge pulses are fed to C717 through C511, lowering the potential of C717 and restoring the correct E_2 amplitude. When the amplitude of E_2 is extremely high, a direct path is provided by diodes CR521 and 522 for the negative half-cycle of E_2 to discharge C730 very rapidly.

3.6 AMPLITUDE CONTROLS

Two types of amplitude controls are provided in the 4000 Series Oscillators. For the Main sine wave output E_2 a single decade switch and concentric vernier, as shown in the Main Assembly Schematic Diagram Figure 14, is used for amplitude control in the 4000 and 4010 series. In the 4020 series, also shown in the Main Assembly Schematic Diagram Figure 14, four switched decade attenuators are provided. The quadrature output amplitude control in both the 4010 and 4020 series consists of a single decade control and concentric vernier. In the 4000 series there is no Quadrature amplitude control.

3.7 POWER SUPPLY

The Power Supply Module, M401, as shown in Figure 10 furnishes three regulated voltages of +25, +20, and -20 volts. The plus 25 volt output is obtained from the first regulating circuit. Z101 supplies the reference voltage, Q101 and Q103 are the regulating amplifiers, and Q701 is the series transistor. Using plus 25 volts as a reference, the minus 20 volt output is obtained from the second regulating circuit. Q107, Q108 and Q110 are amplification stages, and Q702 is the series transistor. Current limiting is provided within the amplifier by voltage developed across R125 and amplified by Q109. The plus 20 volt supply uses the minus 20 volt regulated output as a voltage reference. Q104 is the regulating amplifier and Q105 is the series transistor. Current limiting for the plus 25 volt output is provided by voltage developed across R101 and amplified by Q102. In a similar manner, current limiting for the plus 20 volt output is provided by voltage developed across R119, amplified by Q106, and fed in to the plus 25 volt regulating amplifier via Q102.

3.8 SQUARE WAVE AND PULSE GENERATOR

The optional Square Wave and Pulse generator module M402 is triggered by the sine wave output. As shown in the Schematic Diagram Figure 15, the sine wave is first shaped by the input Schmidt trigger circuit consisting of Q207, Q208 and Q209 to produce a square wave suitable for triggering the multivibrator, Q203 and Q204. Q210 and P201 adjust the triggering level of the input Schmidt trigger and thus control the symmetry of the square wave trigger pulses. The multivibrator output, which is in phase with the input trigger signal, is fed to switch circuit Q201 and Q202, and the other output is fed to switch Q205 and Q206. Q214 is a constant-current source which supplies 50 milliamperes to the output P-P Volts potentiometer, developing a level of plus 2.5 volts dc at the output under conditions of no signal, no load, and maximum setting of the output control. Q215 is normally non-conducting. When the Function switch is in the square wave position, Q215 passes 100 milliamperes and sets the output dc level at minus 2.5 volts for no signal, no load, and maximum setting conditions. Switch circuit Q205 and Q206 selects the negative-going multivibrator output which turns Q215 off and produces a square wave at the output which is in phase with the sine wave output. The pulse width Schmidt trigger is disabled and does not operate in the square wave position. In the pulse positions of the Function switch, when the multivibrator is triggered by the positive-going sine wave crossing of the zero axis, current flows into the pulse width capacitors, allowing the potential at the input of the pulse width Schmidt trigger Q211, Q212 and Q213 to rise at a rate determined by the capacitor value and the setting of the Pulse-Width control. When this potential reaches the triggering level of the width trigger, a signal is sent to the multivibrator to reverse its state, thus forming a pulse rather than a square wave. When the Function switch is in the plus pulse position, the operation is the same as for a square wave output except that the duration of the positive excursion is reduced. In the minus pulse position, switch Q201 and Q202 selects the positive-going pulse from the multi-vibrator to turn Q215 on for the duration of the pulse, thus forming a negative-going output pulse.

3.9 SQUARE WAVE

The Square Wave Module, M403, as shown in the Schematic Diagram Figure 16, is similar to module M402 but provides only a Square Wave output. The pulse width Schmidt trigger, the Function and Pulse-Width controls, and the switch circuits are not included. Only the internal symmetry control and the external P-P Volts control remain. The input Schmidt trigger, multivibrator and output circuits function as described above.

SECTION 4

MAINTENANCE

4.1 INTRODUCTION

If the Oscillator is not functioning properly and requires service, the following procedure may facilitate locating the source of trouble. The general layout of major components of the Oscillator is shown in Figure 4. The Oscillator consists basically of a main chassis and five or six plug-in modules. These modules include a Power Supply Module M401, a Square Wave and Pulse Module M402 or Square Wave Module M403 (both optional), two Amplifier Modules M404, a Main AVC Module M405, and a Reference AVC Module M406. Component layouts and parts lists for these Modules are included with their schematics at the end of this manual.

Access to the Oscillator is accomplished easily without any hand tools by removing the top and bottom covers. It is first necessary to loosen (not remove) the two thumb screws centered on each side at the rear of the chassis and then pulling out the two side covers. This unlocks the top and bottom covers which then may be pulled out.

The most frequently used check points have been provided with test jacks. These jacks are color coded and are identified as shown in Figure 4. When servicing the various plug-in modules, a plug-in extension card fastened internally to the side of the chassis is provided to allow access to the components of the module while the unit is in operation.

Many troubles may easily be found by visual inspection. When a malfunction is detected, make a quick check of the unit for such things as broken wires, burnt or loose components, or similar conditions which could cause trouble. When a malfunction is encountered, before beginning troubleshooting it should be determined if the normal adjustments mentioned in Calibration and Adjustment procedure, Section 5, will correct the trouble. Any troubleshooting of the Oscillator will be greatly simplified if there is an understanding of the operation of the circuit. Before any detailed troubleshooting is attempted, reference should be made to Circuit Description, Section 3. When a problem is encountered, it should first be determined if the malfunction is present under all conditions, or is only present under certain conditions such as certain frequency selector switch positions or on certain frequency multiplier bands. If the problem seems to be of a general nature, the troubleshooting procedure outlined here should be followed. If the trouble is only present under specific conditions, however, the procedure must be adapted to fit the circumstances. Because of the floating ground provision, measurements to chassis should not be done until the Floating/Chassis grounding switch, located at the rear of the chassis, is in the Chassis position.

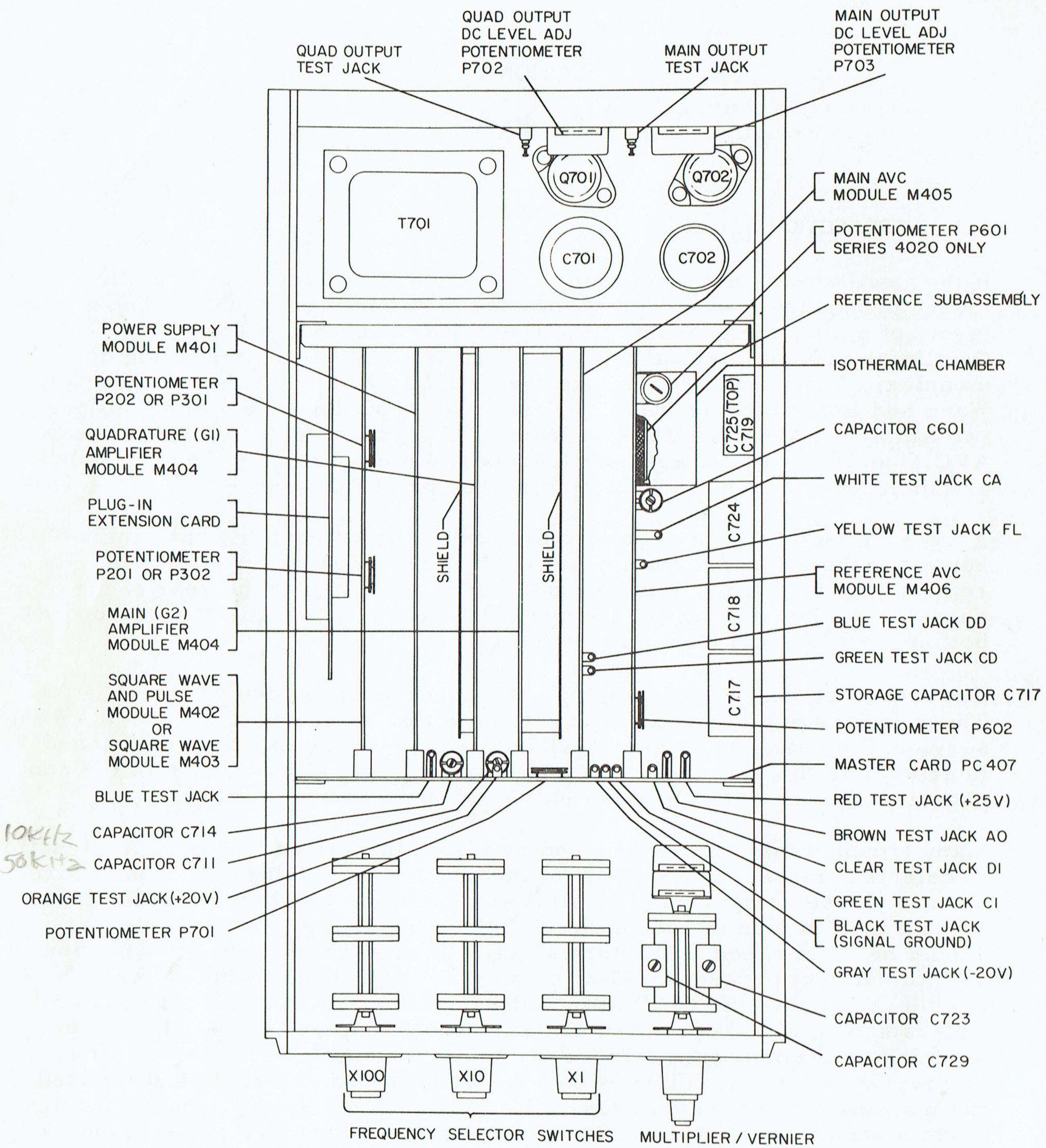


Figure 4. Top View of Main Assembly Chassis

4.2 PRELIMINARY CHECKS

The Oscillator should be set up as follows:

1. Frequency selector switches at 100
2. Frequency Multiplier switch at 10
3. Main output amplitude controls at maximum cw
4. Quadrature output amplitude controls at maximum cw (if applicable)
5. Floating/Chassis grounding switch in chassis position

If the sine wave outputs appear to be correct, but the Pulse and/or Square Wave (where applicable) is not, refer to Section 4.9. First check the three dc Power Supply voltages, +25 vdc (red test jack), +20 vdc (orange test jack), -20 vdc (grey test jack). If these levels are off by more than ±5%, refer to Section 4.4. If these supplies are correct, the Main and Quadrature output dc levels should be checked. To eliminate any ac signals when making these measurements connect a 0.02 uf capacitor in series with a 1200 ohm resistor from the blue test jack on the Master card (caution: there is also a blue test jack DD on the main AVC Module, M405) to chassis ground. Also remove the Reference AVC Module, M406, and ground the brown test jack (AO). These dc levels should both be within less than ±0.1 volt. Screwdriver controls and associated test jacks are provided at the rear of the chassis for monitoring and adjusting these levels. If the correct levels can not be obtained, the trouble is probably in either the G1 or G2 Amplifier Modules, M404. If the levels are both off in the same direction (either plus or minus), the trouble is probably in the G1 Amplifier Module. If the dc levels are off in different directions (one plus and one minus), the trouble is probably in the G2 Amplifier Module. When the trouble has been isolated to a particular module, reference should be made to section 4.5. If the Main and Quadrature output dc levels are correct, a signal tracing analysis should be used to find the source of trouble.

4.3 SIGNAL TRACING

Connect an external signal source as shown below in Figure 5. This source should be capable of providing a 10 volt rms sine wave into a 1000 ohm load

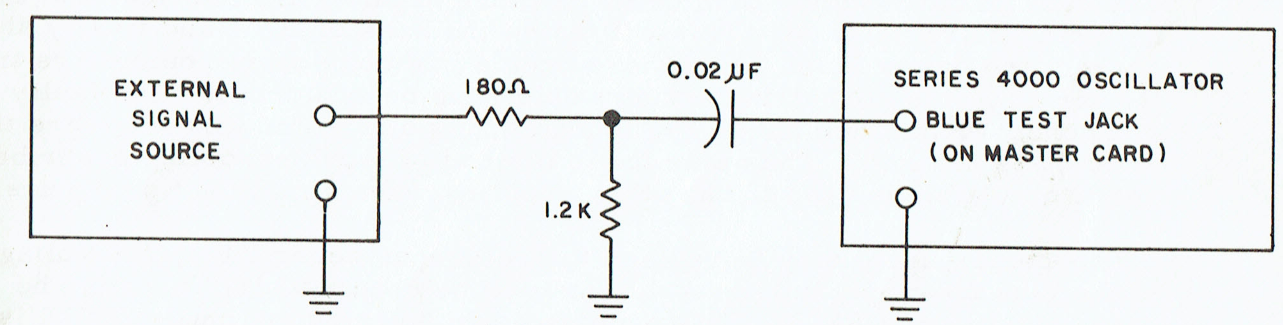


Figure 5. Circuit for External Signal Application

at 1000 Hz. The Reference AVC Module, M406 should remain out of the unit and the brown test jack (AO) should remain grounded for this check. Adjust the external source to provide 8.1 volts rms, and check the Quadrature output voltage. This should be a sine wave with an amplitude of approximately 10 volts rms. If this signal is incorrect, the trouble is probably in the G1 Amplifier Module. If the Quadrature signal is correct, check the Main Output voltage. This should also be a sine wave of approximately 10 volts rms amplitude. If this signal is incorrect, the trouble is probably in the G2 Amplifier Module. When the trouble has been isolated to a particular module, reference should be made to Section 4.5.

The Main and Quadrature output should be approximately 90 degrees out of phase. If this phase relationship is not correct there may be a problem in the tuning network (see Section 4.7).

If both the Main and Quadrature output signals appear to be correct, the trouble is probably in the AVC section of the Oscillator. In this case, reference should be made to Section 4.6.

4.4 POWER SUPPLY

The Power Supply consists of three separate supplies of plus 25, plus 20, and minus 20 volts. The plus 25 is used as a reference supply for the minus 20, and the minus 20 is used as a reference supply for the plus 20. This fact should be kept in mind when doing any work on the supply, as a malfunction in the plus 25 will be reflected in the other two, and a malfunction in the minus 20 will be reflected in the plus 20. If the other supplies do not seem to be working properly, the plus 25 should be checked before beginning work on them; if the plus 20 is not working, the minus 20 should be checked first. The three supplies have current limiting circuits which will shut down the supply if excessive current is being drawn from it. For this reason an apparent malfunction in the supply could be caused by an overload in one of the other circuits.

Nominal voltages for various points in the supply are given on the schematic, Figure 10. If a malfunction occurs the error signal thus developed should be traced through the circuit to find the faulty component. Let us suppose for example that the plus 25 was lower than normal. This would produce an error signal which would make both the base and emitter of Q103 more negative than normal. Because the base moves less than the emitter the total result is a lowering of the collector of Q103 from its normal value. The base of Q101 should then be made more negative than normal and the collector more positive. This will raise the base of Q701 and finally should correct the output level. Had there been a bad component somewhere in the circuit, this correcting action would have been blocked. The faulty component would then have been found at the point in the circuit where the action was blocked. The same basic method of troubleshooting described above may also be used in the other supplies when a malfunction occurs.

If it becomes necessary to replace the reference zener Z101, the voltage of the plus 25 supply will probably have to be readjusted. This may be done by trimming R115. This supply should be trimmed until plus 25 is within ±5%.

4.5 AMPLIFIER MODULE

When a problem has been isolated to one of the Amplifier Modules, the other Amplifier Module should be removed from the unit so that there will be no interaction between the two during troubleshooting. If the G1 Module has been removed, the Quadrature output should then be tied to chassis ground. If the G2 Module has been removed, the Main output should be tied to chassis ground. In addition, the Reference AVC Module, M406 should be removed from the unit and the brown test jack (AO) should be tied to ground.

Under the above conditions, measure the dc output level of the Amplifier under test. This will be the Quadrature output for the G1 Amplifier Module and the Main output for the G2 Amplifier Module. If the level is greater than ±0.5 volt there is probably trouble in the Amplifier, and the dc error signal thus developed should be traced through the circuit. For example, if the output level is plus, the feedback should raise the gate of Q403A from its normal value of zero. Through the differential stage this will then cause the drain of Q403B to become more positive than the drain of Q403A. The collector of Q404 will then go more positive while the collector of Q406 will go more negative than their normal values. This should then lower the emitters of Q407 and Q408 and correct the output level. If a faulty component is present in the circuit, it will usually prevent this corrective action from taking place. The faulty component will be found at the point in the circuit where the correcting action is blocked.

Most problems in the Amplifier will show up in a level check and the troubleshooting method described above may be used to find the problem. If all the levels seem to be right and the unit seems to be working but will not take a load, Q407 and Q408 should be checked.

If it becomes necessary to replace the dual field effect transistor, Q403A and Q403B, the output dc level may have to be retrimmed for the new unit. With the same initial set up as given at the beginning of this section, check the dc level at the output of the Amplifier in question (Quadrature output for G1, Main output for G2). If this level is other than zero, and the level control will not correct it, R412 and R413 should be adjusted. One of these resistors should be zero ohms at all times. The other is then adjusted to provide zero output level. If the output is plus, an increase in R413 will correct it. If the level is negative, an increase in R412 will correct it. The adjustment should be made with the dc level control in the center of its range to give an optimum range of adjustment.

4.6 AVC CIRCUIT

If there appears to be trouble in the AVC circuit, remove the ground lead from the brown test jack (AO), insert the Reference AVC Module, M406 in the unit, and check various waveforms as follows:

The unit should remain set up for an external input signal as shown in Figure 5. The signal from the external source should be varied in amplitude so that the voltage of the Main output varies from 9 to 11 volts rms. It should be noted that the signal on the Main output will be somewhat distorted when at the extremes of this range. While making this variation the signal at the brown test jack (AO) should be observed. When the Main output is at 9 volts rms, the AO signal should be a square wave in phase with the Quadrature output with an amplitude of at least 3 volts peak-to-peak. When the output is at 11 volts rms, the AO signal should be a square wave out of phase with the Quadrature output with an amplitude of at least 3 volts peak-to-peak. As the output is varied through 10 volts, the AO signal should go through a null. If this action takes place, the AVC circuit is probably functioning properly.

If the AO signal is not correct, check the Follower output level (FO) located at the emitter of Q607. This should be a dc voltage of at least plus 4 volts when the Main output is at 9 volts rms, and at least minus 4 volts when the Main output is at 11 volts rms. As the output swings through 10 volts rms, the FO voltage should swing through zero. If the FO signal is correct but AO is not, the trouble probably lies in the balanced modulator or the AO output loop.

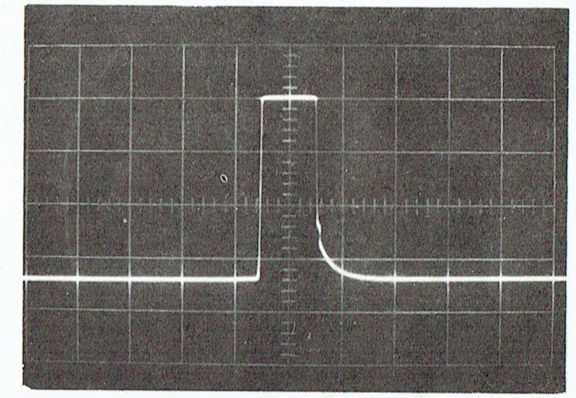
To determine if the modulator is operating properly, look at the signal on the base of Q609. When the Main output is made 9 volts rms the signal here should be a square wave in phase with the Quadrature output with an amplitude of at least 2 volts peak-to-peak. When the Main Output is made 11 volts rms the square wave should change phase and have an amplitude of at least 2 volts peak-to-peak. As the output is varied through 10 volts rms, the signal should go through a null. It should be noted that the dc level of this signal will normally change as its amplitude and phase changes. If the proper signal does not appear, check that a drive signal is reaching the base of Q608. If a drive signal is present but the modulator does not seem to be working, check Q608 and its associated components. If one of these components is changed, the symmetry of the AO signal should be checked. If necessary it may be adjusted by trimming R652. The flatness of the AO signal should also be checked. If necessary an adjustment may be made by trimming R645. If the proper modulator signal is present but the correct AO signal is not, the trouble is probably in the AO output loop.

If there appears to be trouble in the AO output loop, measure the dc level of the brown test jack (AO). This should be at zero volts ±0.5 volt. If this level is not right and the control will not correct it, the error voltage thus developed should be traced through the feedback loop. Nominal voltages for various points in the loop are shown on the Reference AVC Schematic, Figure 13.

As an example of this method of tracing, let us assume that AO is plus. Through the feedback this will make the base of Q610 more plus than normal. This should make the collector of Q610 more negative than normal, the collector of Q612 more negative than normal, and finally the output level should be corrected. When trouble is encountered, the faulty component will usually be found at the point in the loop where this corrective action is blocked. If, for example, in the previous case Q612 had been defective, its collector would not have gone more negative than normal when the base of Q611 went more negative than normal. This would then have been the point in the loop where the corrective action was blocked.

If the voltage at FO does not vary properly as the output is changed, check the voltage across the Storage Capacitor (SC), C730, located as shown in Figure 4. This is a high impedance point and care should be taken not to load it while making measurements. The measuring equipment should have an input impedance of at least 10 megohms. SC should vary from at least plus 4 volts through zero volts to at least minus 4 volts as the main output is varied from 9 to 11 volts rms. If SC varies properly but the FO does not, check Q606 and Q607 and their associated components.

If SC is not varying properly, check the waveform of the Discharge Drive pulse (DD) at the blue test jack located on the Main AVC Module, M405. This should be as pictured in Figure 6. If the DD pulse is not correct, check the three signals used by the DD circuit to develop the DD pulse. The three signals used are E_1, E_2, and E_3. E_1 is the Quadrature output before the attenuator, E_2 is the Main output before the attenuator, and E_3 a sine wave 180 degrees out of phase with the Quadrature output having an amplitude of approximately 7 volts rms. E_3 is developed from E_1 using an amplifier consisting of Q501, Q502, and their associated components. If these signals are being fed to the DD circuit but there is no DD pulse, the trouble is probably in Q503 or Q504 or their associated components.

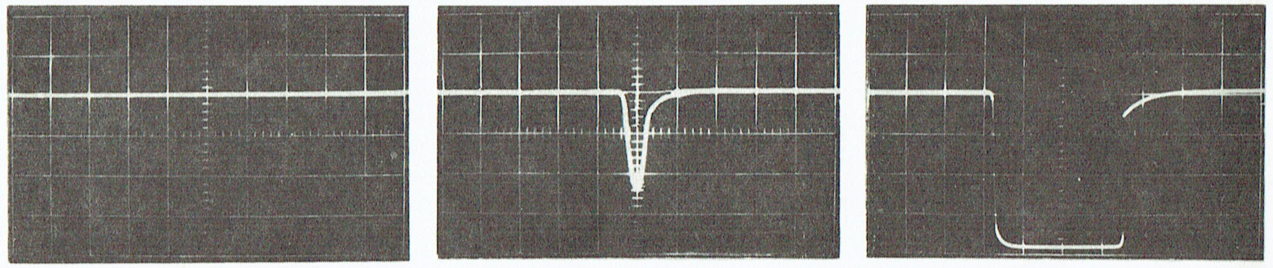


Vert-5v/cm Hor-50μs/cm

Figure 6. Discharge Drive Pulse

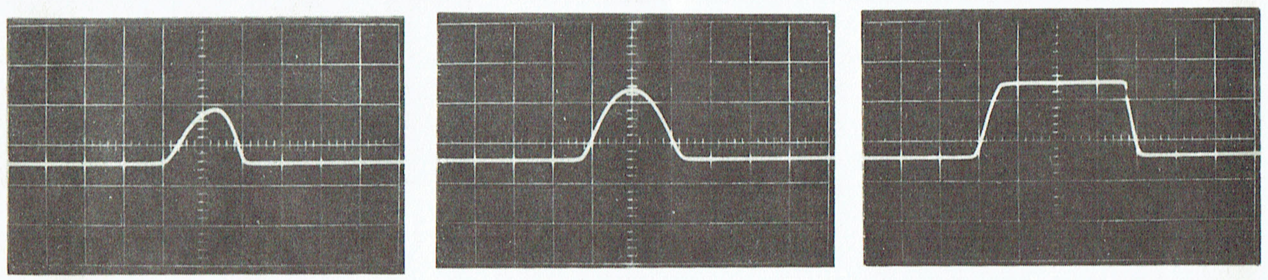
If any components are changed in the DD circuit or the E_3 amplifier, the position and width of the DD pulse should be checked. The DD pulse should then be approximately 18 degrees wide and should be centered about the Charge Drive pulse (CD) which is approximately 10 degrees wide when the Oscillator is functioning normally. R511 controls the start position of the DD pulse, R513 controls the stop position, and R514 controls the width.

If the DD pulse appears to be correct, check the waveform of the Charge Drive pulse (CD) at the green test jack located on the Main AVC Module, M405. While looking at this point, vary the Main output from 9 volts rms to 10 volts rms and then to 11 volts rms. The proper waveform of the CD pulse for these three conditions are shown in Figure 7. If these signals are not correct, check the waveform of the Charge Amplifier (CA) at the white test jack. The waveforms should be as shown in Figure 8 when the Main output is varied from 9 to 10 to 11 volts rms. If the CA is correct but CD is not, the trouble is probably in Q508, Q509, Q603 or Q604 or their associated components. If it becomes necessary to replace one of these components, R627 may have to be readjusted. To do this look at the FL signal at the yellow test jack. This should be as shown in Figure 9. R627 should then be adjusted so that the width of the lower portion of the signal is approximately 1.5 times the width of the upper portion. This adjustment should be made with the Oscillator in its normal operating condition (without the external signal).



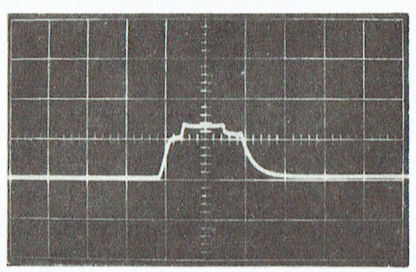
9 Volts 10 Volts 11 Volts

Figure 7. Charge Drive Pulse (CD) Shown when Main Output is at 9, 10 and 11 Volts rms. Vertical Sensitivity 5v/cm. Horizontal 50μs/cm.



9 Volts 10 Volts 11 Volts

Figure 8. Charge Amplifier Pulse (CA) Shown when Main Output is at 9, 10 and 11 Volts rms. Vertical Sensitivity 2v/cm. Horizontal Sensitivity 50 μs/cm.



Vert-0.5v/cm Hor-50μs/cm

Figure 9. FL Signal

If CA is not correct, check the various components associated with the reference subassembly, located on the Reference AVC Module, by removing the black plastic cover of the isothermal chamber. The problem may be in the reference zener Z601, diodes CR604, CR603, Q601, (used as collector base diode) CR602, and amplifier Q602 or their associated components.

4.7 TUNING NETWORK

Problems on certain multiplier bands or on certain positions of the frequency selector switches will usually be caused by something in the tuning network. If the trouble is on one particular multiplier band, the faulty component is probably one of the tuning capacitors associated with that band. If the trouble appears only at a particular setting of the frequency selector switches, the problem is most likely in the resistor(s) associated with that setting. The Main Assembly Schematic Diagram, Figure 14, shows which resistors come into play for each setting of the frequency selector switches. After determining which switch position is bad, reference to this figure should point out the faulty resistor.

4.8 OUPTUT ATTENUATORS (Main and Quadrature)

The Main Assembly Schematic Diagram, Figure 14, also shows the two types of attenuators used on the 4000 Series. If trouble is encountered with one of the attenuators, it should first be determined which position of the switch is bad. After determining this, reference to the appropriate attenuator should point out the faulty component.

4.9 SQUARE WAVE AND PULSE

The Square Wave and Pulse Module, M402 and Square Wave Module, M403 depend on the Main sine wave output for their operation. If the Square Wave or Pulse does not seem to be working, check to see if the Oscillator is operating properly before attempting to troubleshoot the Square Wave or Pulse. The 4000 Series also offers a Square Wave only option in addition to the Square Wave and Pulse option. They both use basically the same circuit for the square wave. This procedure will deal mainly with the Square Wave and Pulse whose Schematic Diagram is shown in Figure 15. Part numbers in parenthesis will apply only to the Square Wave circuit, shown in Figure 16, so the same procedure may be used for that portion of the circuit.

The Oscillator should be set up as follows before beginning troubleshooting of the square wave or pulse.

1. Oscillator frequency at 1000 Hz
2. Square Wave amplitude control at maximum cw
3. Function switch to square wave (if applicable)

If no Square Wave appears at the output, various waveforms should be checked as outlined below:

Reference should be made to Schematic Diagrams Figures 15 and 16. Check the waveform at point A. The signal here should be a square wave of approximately 9 volts peak-to-peak amplitude. If this signal is incorrect, the trouble is probably in Q207 (Q303) or Q208 (Q304) or their associated components. If point A appears to be correct, check the signal at point B. This also should be a square wave of approximately 9 volts peak-to-peak amplitude. If B is incorrect, the trouble is probably in Q209 (Q305) or Q210 (Q306) or their associated components.

With the correct signal at B, the waveform at C should be a square wave of approximately 4-5 volts peak-to-peak amplitude. Any discrepancy here would probably be caused by trouble in the multivibrator consisting of Q203 (Q301) and Q204 (Q302) and their associated components.

The waveform of point D should be a square wave of approximately 10 volts peak-to-peak amplitude when the correct signal is present at point C. If point D is not correct, the trouble is probably in the switching transistors Q201, Q202, Q205 or Q206 or their associated components. Since these switching transistors are omitted in the Square Wave Module, the output of the multivibrator (point C) is coupled directly to the output transistors. If the correct signal is present at point D but not at the output, check the output transistors Q214 (Q307) and Q215 (Q308) and their associated components.

The Pulse generator uses basically the same circuits as the Square Wave, therefore, before attempting to correct any problems with the Pulse, it should first be determined if the Square Wave is operating properly. If the Square Wave appears to be working, but the Pulse is not, the Oscillator should be set up as follows and various waveforms checked.

1. Oscillator frequency at 1000 Hz
2. Square Wave/Pulse amplitude control at maximum cw
3. Function switch to plus 10 - 100 μs
4. Pulse width control maximum cw

Check the waveforms at point F. It should be a sawtooth with a peak amplitude of 3 volts. If the proper signal is not present at point F, check C801, C802, C803, S801, R801, P801, R204 and CR201.

Check the waveform at point G. It should be a negative pulse of approximately 5-10 volts peak coinciding with the trailing edge of the sawtooth. If the signal at point G is not correct, check the Schmidt Trigger consisting of Q211, Q212, and Q213 and their associated components. If the proper signal is present at point G and the output pulse is still not correct, check C207, R211 and CR205 to determine if triggering signals are being fed to the multivibrator.

SECTION 5

CALIBRATION AND ADJUSTMENT

5.1 INTRODUCTION

The following procedure is provided for the purposes of facilitating the calibration and adjustments of the Series 4000 Oscillators in the field. The steps outlined follow very closely the operations which are performed on the instrument by our Final Test Department, and strict adherence to this procedure should restore the Oscillator to its original specifications. It should be noted that some of the tolerances given in this procedure are much tighter than our general specifications. This is to ensure, in test, that all general specifications are met with adequate safety factor. These nominal tolerances, therefore, should not be used for purpose of accepting or rejecting the instrument. If any difficulties are encountered, please refer to Maintenance, Section 4. If any questions arise which are not covered by this procedure, please consult our Factory Service Department. The location of all major components, modular sub-assemblies, test jacks, screwdriver controls and adjustments are shown in Figure 4.

Access to the Oscillator is accomplished easily without any hand tools by removing the top and bottom covers. It is first necessary to loosen (not remove) the two thumb screws centered on each side at the rear of the chassis and then pulling out the two side covers. This unlocks the top and bottom covers which then may be pulled out.

5.2 TEST EQUIPMENT REQUIRED

The following test equipment is required to perform these tests:

a. Oscilloscope - having direct coupled horizontal and vertical amplifier with at least 10mv/cm sensitivity and a band width of 30 MHz, Tektronix type 545 or equivalent.

b. Differential Comparator Plug-In Unit, Tektronix Type W or equivalent.

c. Wide Band Plug-In Unit, Tektronix Type 1A1 or equivalent.

d. Precision Frequency and Period Counter - capable of measuring frequency from 100 Hz to 100 kHz and period from 1000 seconds to 1.0 millisecond.

e. Vacuum Tube Voltohmmeter - reading to 500 volts dc. Do not use this instrument for ac signal measurements.

f. Precision AC Differential Voltmeter, capable of measuring voltages from 10 mv to 10 volts rms from 30 Hz to 50 kHz with ±0.1% accuracy. Fluke Model 931P or equivalent.

g. Variable auto-transformer - to adjust the line voltage from 105 to 125 volts.

h. Distortion Meter and/or Wave Analyzer - capable of measuring distortion below 0.01% from 20 Hz to 20 kHz, B&K Models 1607 and 2107 or equivalents.

i. AC Voltage Monitor - Krohn-Hite Model AC-601R or equivalent.

j. Phase meter capable of measuring phase angle to within 1 degree.

k. Strip Chart Recorder having 10 mv full scale sensitivity.

l. Thermal Transfer Voltmeter, Holt Model 6 or equivalent.

5.3 POWER SUPPLY OPERATION

With the Oscillator operating at 115 volts line, check the following dc voltages with respect to chassis. The Floating/Chassis grounding switch located on the rear of the chassis should be in the Chassis position. All test jacks are color coded and their locations are shown in Figure 4.

Test Point	Voltage and Tolerance	
Red test jack on Master Card	+25 vdc ±5%	26.25 to 23.75
Orange test jack on Master Card	+20 vdc ±5%	19 to 21
Gray test jack on Master Card	-20 vdc ±5%	-19 to -21

5.4 DC LEVEL ADJUSTMENTS

Adjust all dc level controls to zero ±10 mv, in the following order:

Test Point	Control
1. Brown test jack (AO) on Master Card	P602 located on Reference AVC Module, M406
2. Main output test jack on rear of chassis	P703 located on rear of chassis
3. Quadrature output test jack on rear of chassis	P702 located on rear of chassis

5.5 DISTORTION ADJUSTMENT

Set the Oscillator frequency to 10 Hz. Connect a high sensitivity oscilloscope (at least 10mv/cm) to the brown test jack (AO) on the Master card. Adjust P701 located on Master card for minimum signal. This signal

should be less than 10 mv peak-to-peak. Check other bands; the signal should be less than 10 mv at all frequencies up to 20 kHz. If it is not, readjust P701 for optimum setting.

Change the Oscillator frequency to 10 kHz and set the Multiplier switch to the x10 position. Adjust C714, located on the Master card for minimum signal. This signal should be less than 10 mv peak-to-peak.

Change the Oscillator frequency to 50 kHz. Adjust C711, located on the Master card, for minimum signal. This signal should be less than 30 mv peak-to-peak.

5.6 100 kHz FREQUENCY AND PHASE ADJUSTMENT

Set the Oscillator frequency to 99.9 kHz with the frequency vernier in the CAL position (maximum ccw). Check the frequency calibration using a frequency counter, at the same time monitoring the phase relationship between the Main output and the Quadrature output. If the frequency is off calibration by more than ±1%, and the phase relationship is 90 degrees ±1 degree, adjust both trimmer capacitors C729 and C723, located on the Multiplier band switch as shown in Figure 4, in the same direction by approximately equal increments to correct the frequency without affecting the phase angle. If the frequency calibration is within ±1%, and the phase angle is off by more than 1 degree, adjust C729 and C723 in opposite directions by equal increments. With a frequency counter and phase meter, check the frequency calibration and phase relationship of the Main output and the Quadrature output at other frequencies. If any frequency is out of tolerance, refer to Maintenance, Section 4.

5.7 DISTORTION

We recommend that the total harmonic distortion be checked at the following frequencies on both the Main and Quadrature outputs:

Frequency	Tolerance: Main Output	Tolerance: Quadrature Output
20 kHz	0.01%	0.03%
10 kHz	0.01%	0.03%
1 kHz	0.01%	0.03%
100 Hz	0.01%	0.03%
20 Hz	0.01%	0.03%

Equipment that will measure distortion of this order of magnitude below 20 Hz is not known to be commercially available, therefore, this procedure does not cover the measurements beyond this range.

From 20 Hz up, this can be done fairly successfully by using a wave analyzer (GR, HP, B&K or Marconi) and a pre-filter (B&K and Marconi). Most manufacturers of wave analyzers have the same specification - 1% full scale on the most sensitive range with a 10 volt input signal and internal distortion of about 0.03%. If the pre-filter is set to attenuate the fundamental amplitude, say 60 db, to almost the level of the harmonics, then the analyzer sensitivity can be increased until the largest harmonic is full scale at the new sensitivity. Assume 0.01% second harmonic distortion only. The analyzer is calibrated for an input level (fundamental + harmonic) of 10 volts rms. When the analyzer is set to the second harmonic frequency, the meter sensitivity only can be increased to 1% full scale (0.1 volts) from 100% full scale or 10 volts. Since the residual analyzer distortion is 0.3%, the example value of 0.01% will not be measurable. Now, if we add a pre-filter and attenuate the fundamental, say 40 db, the analyzer input sensitivity can be increased 40 db for a full scale meter sensitivity of 0.01% and we can now read our theoretical second harmonic value of 0.01% with good accuracy.

Below 20 Hz, Krohn-Hite uses a noise meter type of instrument which has practically no residual distortion in the internal amplifiers - much less than the 0.03% specification of commercial analyzers and distortion meters, and which has an extremely sharp null. Because of the difficulty of achieving a very sharp null at low frequencies, the instrument is not continuously tunable but is fixed tuned at certain selected frequencies.

5.8 ATTENUATOR CALIBRATION

The Main output of the Series 4000 and 4010 and Quadrature output of the Series 4010 and 4020 use a single decade switch attenuator plus concentric vernier. Set the Oscillator frequency to 1 kHz. Using an ac voltmeter with better than 0.25% accuracy, check the calibration of the attenuator with the Vernier off (maximum ccw). The calibration accuracy should be within ±2% of indicated attenuator setting ± 2 millivolts.

The Main output attenuator of the Series 4020 uses four decade switches. Set the attenuator to 10[9.99 (10)] volts. Connect a high accuracy differential voltmeter (Fluke Model 931P or equivalent) to the Main output of the Oscillator. Set the Oscillator frequency to 1 kHz. Adjust potentiometer P601, located on the Reference AVC Module for a voltage reading of exactly 10.00 volts. Set the Oscillator frequency to 100 kHz and adjust C601 trim capacitor, located on the Reference AVC Module, for a voltage reading of exactly 10.00 volts.

Set the Oscillator frequency to 1 kHz. Check the calibration of the attenuator at other voltage settings. The accuracy should be within ±0.25% of indicated attenuator setting ± 1 millivolt.

5.9 FREQUENCY RESPONSE

Using a thermocouple voltmeter, such as the Holt Thermal Transfer Voltmeter, Model 6, compare the output voltage versus frequency from 20 Hz

to 20 kHz, it should be within ± 0.1%. The absolute voltage accuracy is not important because only changes in voltage are observed.

Below 20 Hz it is necessary to check the frequency response, using an ac-dc voltage comparator such as the Rotek Model 212H.

5.10 AMPLITUDE STABILITY

The long term amplitude stability may be monitored by using a suitable ac voltage monitor such as the Krohn-Hite Model AC-601R and a sensitive strip chart recorder. Connect the output of the Oscillator prior to the output attenuator to the input of the AC Monitor. Set the Oscillator frequency to 1 kHz. Set the input voltage controls on the AC Monitor to 10 volts. Connect the output of the AC Monitor to the input of a strip chart recorder. Adjust the input voltage controls on the AC Monitor for a null on the recorder at maximum sensitivity. When using the Krohn-Hite Model AC 601R in the maximum sensitivity (0.01%) position, a 0.01% change in input voltage will produce a 0.5 millivolt dc change in the output of the monitor. With a recorder having a full scale sensitivity of 10 millivolts, changes in ac voltages of 0.001% can be observed.

5.11 HUM AND NOISE (Cycle to Cycle Stability)

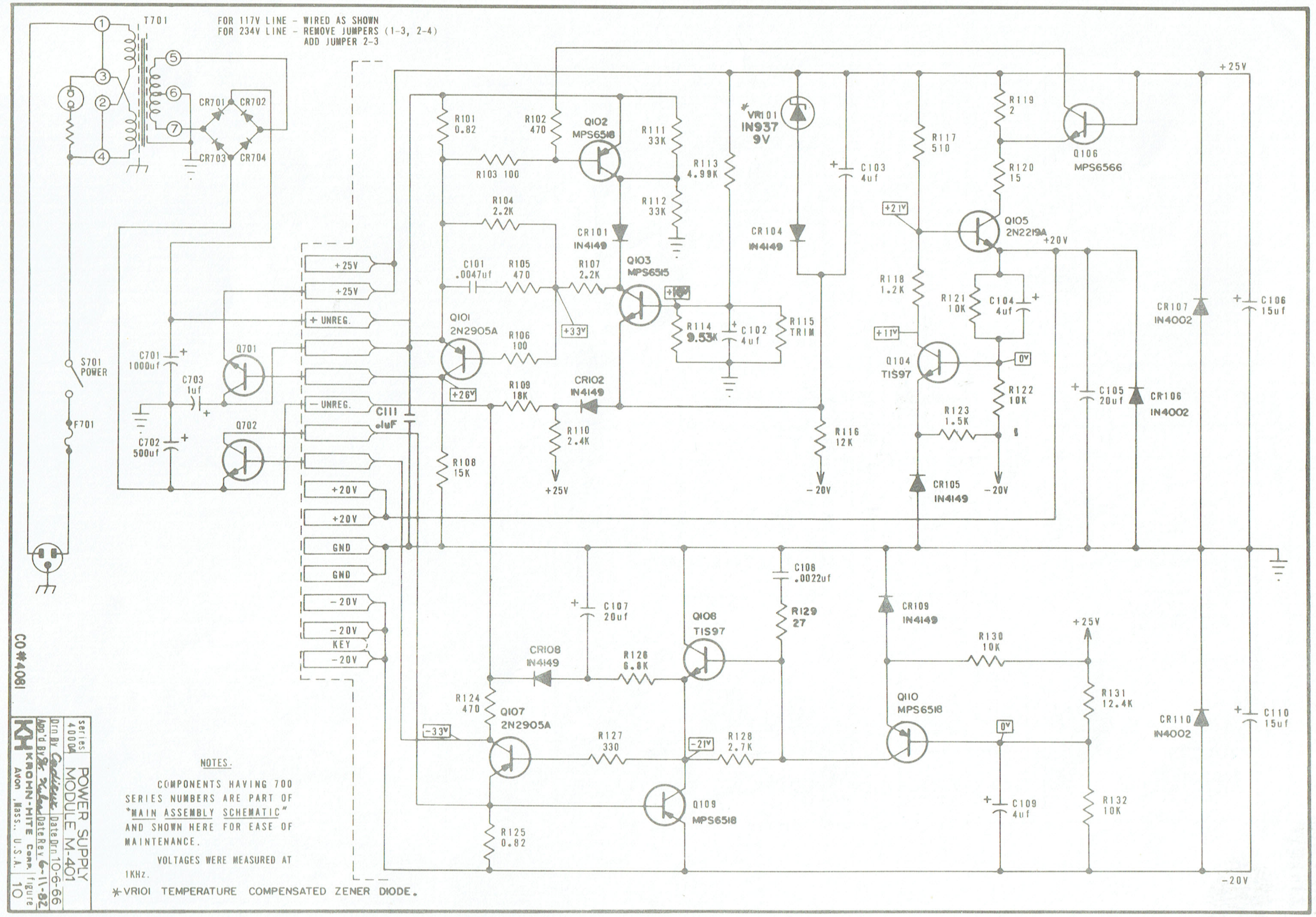
This specification can be checked by using a Tektronix scope with a type W differential comparator type plug-in unit or equivalent. Using 1 millivolt per centimeter sensitivity, check the cycle-to-cycle peak amplitude variations with the Oscillator output at 7 volt rms. The peak variations should be less than 1 cm (1 mv). The total hum and noise can also be observed on the peak of the waveform.

5.12 HUM MODULATION

Using the same method as above in step 5.11, check the line frequency modulation or beat at approximately 63 Hz and 123 Hz. The maximum peak excursion should be less than 1 cm (1 mv).

5.13 OUTPUT IMPEDANCE

Connect the 600 ohm output to an ac voltmeter. Adjust the output attenuator for a reading of 10 volts. Load the output with 600 ohms. The output voltage should drop to 5 volts. Repeat this check on the 200 ohm output using a 200 ohm load. This check can be performed at various attenuator settings. In each case the output voltage should drop 6 db when shunted with the matched load.



MODEL 4000 SERIES

RESISTORS

Symbol	Description	Mfr.	Part No.	Symbol	Description	Mfr.	Part No.
R101	0.82 5% 1W	TL	TYPE ELIA	R117	510 5% 1/2W	AB	EB5115
R102	470 10% 1/4W	AB	CB4711	R118	1/2K 10% 1/2W	AB	EB1221
R103	100 10% 1/4W	AB	CB1011	R119	2 5% 1W	TL	TYPE ELIA
R104	2.2K 10% 1/2W	AB	EB2221	R120	15 5% 2W	AB	HB1505
R105	470 10% 1/4W	AB	CB4711	R121	10K 1% 1/4W	AB	CC1002F
R106	100 10% 1/4W	AB	CB1011	R122	10K 1% 1/4W	AB	CC1002F
R107	2.2K 10% 1/2W	AB	EB2221	R123	1.5K 5% 1/2W	AB	EB1525
R108	15K 10% 1/4W	AB	CB1531	R124	470 10% 1/4W	AB	CB4711
R109	18K 10% 1/2W	AB	EB1831	R125	0.82 5% 1W	TL	TYPE ELIA
R110	2.4K 5% 1/4W	AB	CB2425	R126	6.8K 10% 1/2W	AB	EB6821
R111	33K 10% 1/4W	AB	CB3331	R127	330 10% 1/4W	AB	CB3311
R112	33K 10% 1/4W	AB	CB3331	R128	2.7K 10% 1/2W	AB	EB2721
R113	4.99K 1% 1/4W	AB	CC4991F	R129	27 10% 1/4W	AB	CB2701
R114	9.53K 1% 1/4W	AB	CC9531F	R130	10K 10% 1/4W	AB	CB1031
R115	TRIM	AB	TYPE CB	R131	12.4K 1% 1/4W	AB	CC1242F
R116	12K 10% 1/4W	AB	CB1231	R132	10K 1% 1/4W	AB	CC1002F

CAPACITORS

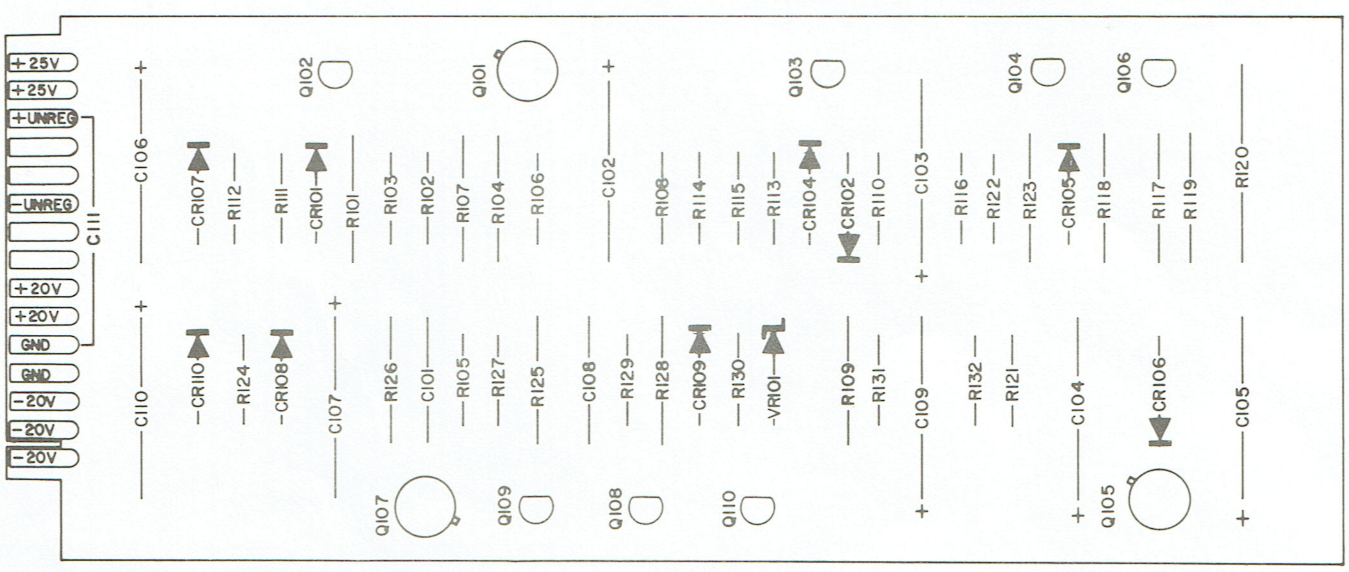
Symbol	Description	Mfr.	Part No.	Symbol	Description	Mfr.	Part No.
C101	0.0047uf 10% 100V	CD	WMF1D47	C106	15uf 50V	SP	150D156X0050R2
C102	4uf 50V	SP	30D405G050BA2	C107	20uf 50V	SP	30D206G050CC4
C103	4uf 50V	SP	30D405G050BA2	C108	0.0022uf 10% 100V	CD	WMF1D22
C104	4uf 50V	SP	30D405G050BA2	C109	4uf 50V	SP	30D405G050BA2
C105	20uf 50V	SP	30D206G050CC4	C110	15uf 50V	SP	150D156X0050R2
				C111	.1µF 20% 100V	KH	413410

TRANSISTORS, DIODES & MISC.

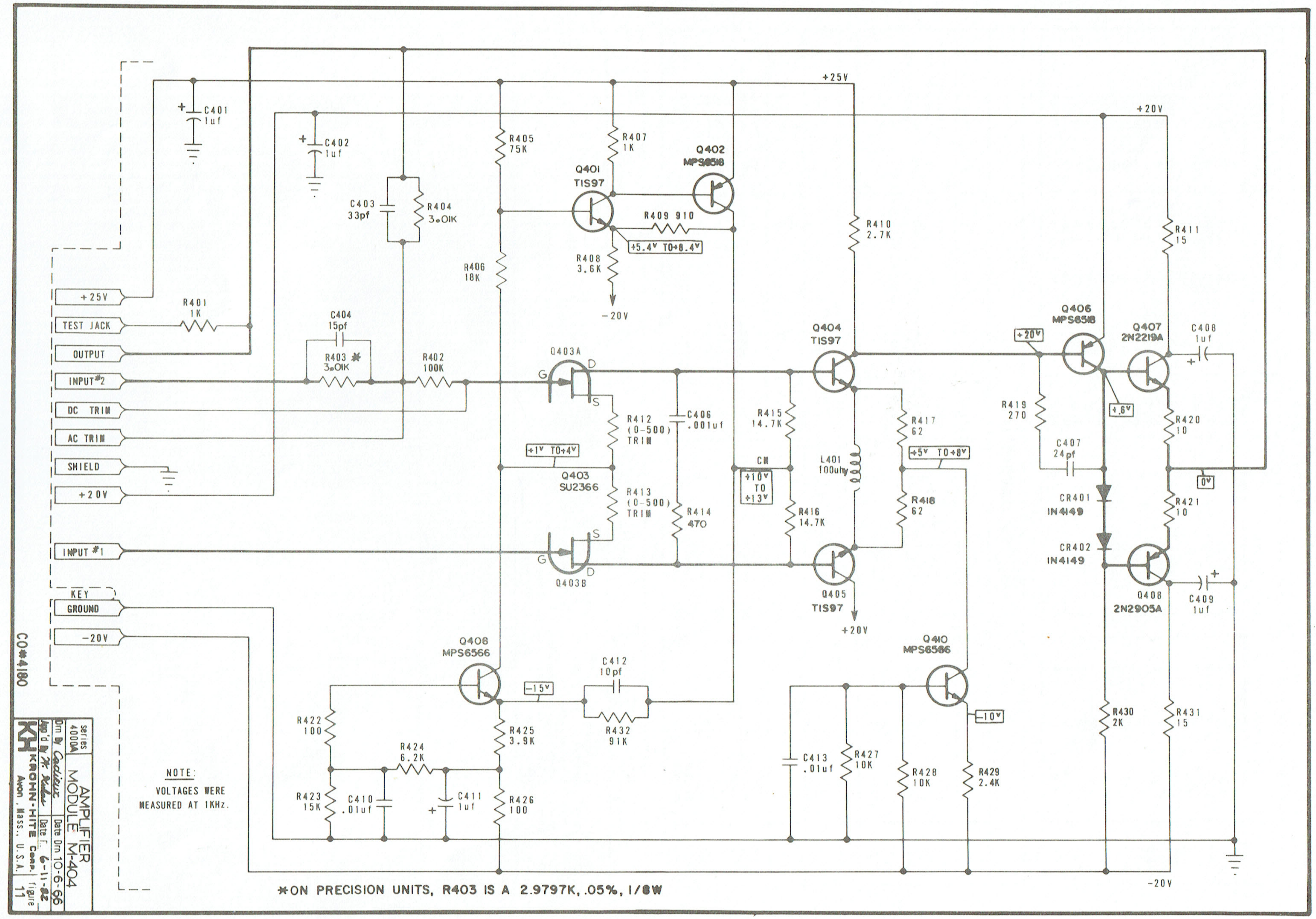
Symbol	Description	Mfr.	Part No.	Symbol	Description	Mfr.	Part No.
Q101	2N2905A	MOT	2N2905A	CR101	IN4149	APD	IN4149
Q102	MPS6518	MOT	MPS6518	CR102	IN4149	APD	IN4149
Q103	MPS6515	MOT	MPS6515				
Q104	TIS97	TI	TIS97	CR104	IN4149	APD	IN4149
Q105	2N2219A	MOT	2N2219A	CR105	IN4149	APD	IN4149
Q106	MPS6566	MOT	MPS6566	CR106	IN4002	TR	IN4002
Q107	2N2905A	MOT	2N2905A	CR107	IN4002	TR	IN4002
Q108	TIS97	TI	TIS97	CR108	IN4149	APD	IN4149
Q109	MPS6518	MOT	MPS6518	CR109	IN4149	APD	IN4149
Q110	MPS6518	MOT	MPS6518	CR110	IN4002	TR	IN4002
				VR101	1N937, 9V	TR	1N937

MANUFACTURERS CODE

AB	(01121)	Allen Bradley Co.	Milwaukee, Wisc.
APD	(50273)	American Power Devices	Andover, Mass.
CD	(88419)	Cornell-Dubilier, Inc.	
CODI	(16352)	Computer Diode Corp.	Fairlawn, N.J.
MOT	(04713)	Motorola Semiconductor	Phoenix, Az.
SP	(56289)	Sprague Electric Co.	North Adams, Mass.
TI	(01295)	Texas Instruments, Inc.	Dallas, Tex.
TL	(94322)	Tel-Labs Inc.	Needham, Mass.
TR	(03877)	Transitron Electric Co.	Wakefield, Mass.



M401


+25V
TEST JACK
OUTPUT
INPUT #2
DC TRIM
AC TRIM
SHIELD
+20V
INPUT #1
KEY
GROUND
-20V
C401 1uf
C402 1uf
C403 33pf
R404 3.01K
R401 1K
C404 15pf
R403 * 3.01K
R402 100K
R405 75K
R406 18K
R407 1K
Q401 TIS97
Q402 MPS6518
R409 910
R408 3.6K
+5.4V TO +8.4V
-20V
Q403A
Q403 SU2366
Q403B
+1V TO +4V
R412 (0-500) TRIM
R413 (0-500) TRIM
C406 .001uf
R414 470
CW
+10V TO +13V
R415 14.7K
R416 14.7K
Q404 TIS97
Q405 TIS97
+20V
L401 100uh
R417 62
R418 62
+5V TO +8V
R410 2.7K
+25V
+20V
R411 15
Q406 MPS6518
Q407 2N2219A
C408 1uf
+20V
R419 270
+.6V
C407 24pf
R420 10
0V
R421 10
CR401 IN4149
CR402 IN4149
Q408 2N2905A
C409 1uf
Q409 MPS6566
-15V
C412 10pf
R432 91K
R422 100
R425 3.9K
R424 6.2K
R423 15K
C410 .01uf
C411 1uf
R426 100
Q410 MPS6566
-10V
C413 .01uf
R427 10K
R428 10K
R429 2.4K
R430 2K
R431 15
-20V
NOTE:
VOLTAGES WERE MEASURED AT 1KHz.
*ON PRECISION UNITS, R403 IS A 2.9797K, .05%, 1/8W
CO#4180
AMPLIFIER MODULE M-404
series 4000A
KROHN-HITE CORP. Avon, Mass., U.S.A.
Date Dm 10-6-66
figure 11

RESISTORS

Symbol	Description	Mfr.	Part No.
R401	1K 10% 1/2W	AB	EB1021
R402	100K 5% 1/4W	AB	CB1045
R403	3.01K 0.1% 1/8W	KID	M3-TI-3.01K
R404	3.01K 0.1% 1/8W	KID	M3-TI-3.01K
R405	75K 5% 1/4W	AB	CB7535
R406	18K 10% 1/4W	AB	CB1831
R407	1K 10% 1/2W	AB	EB1021
R408	3.6K 5% 1/2W	AB	EB3625
R409	910 5% 1/4W	AB	CB9115
R410	2.7K 10% 1/2W	AB	EB2721
R411	15 10% 1/4W	AB	CB1501
R412	TRIM (0-500)	AB	TYPE CC
R413	TRIM (0-500)	AB	TYPE CC
R414	470 10% 1/4W	AB	CB4711
R415	14.7K 1% 1/4W	AB	CC1472F
R416	14.7K 1% 1/4W	AB	CC1472F
R417	62 5% 1/2W	AB	EB6205
R418	62 5% 1/2W	AB	EB6205
R419	270 10% 1/4W	AB	CB2711
R420	10 10% 1/4W	AB	CB1001
R421	10 10% 1/4W	AB	CB1001
R422	100 10% 1/4W	AB	CB1011
R423	15K 5% 1/4W	AB	CB1535
R424	6.2K 5% 1/4W	AB	CB6225
R425	3.9K 5% 1/4W	AB	CB3925
R426	100 10% 1/4W	AB	CB1011
R427	10K 5% 1/4W	AB	CB1035
R428	10K 5% 1/4W	AB	CB1035
R429	2.4K 5% 1/4W	AB	CB2425
R430	2K 5% 1/2W	AB	EB2025
R431	15 10% 1/4W	AB	CB1501
R432	91K 5% 1/2W	AB	EB9135

CAPACITORS

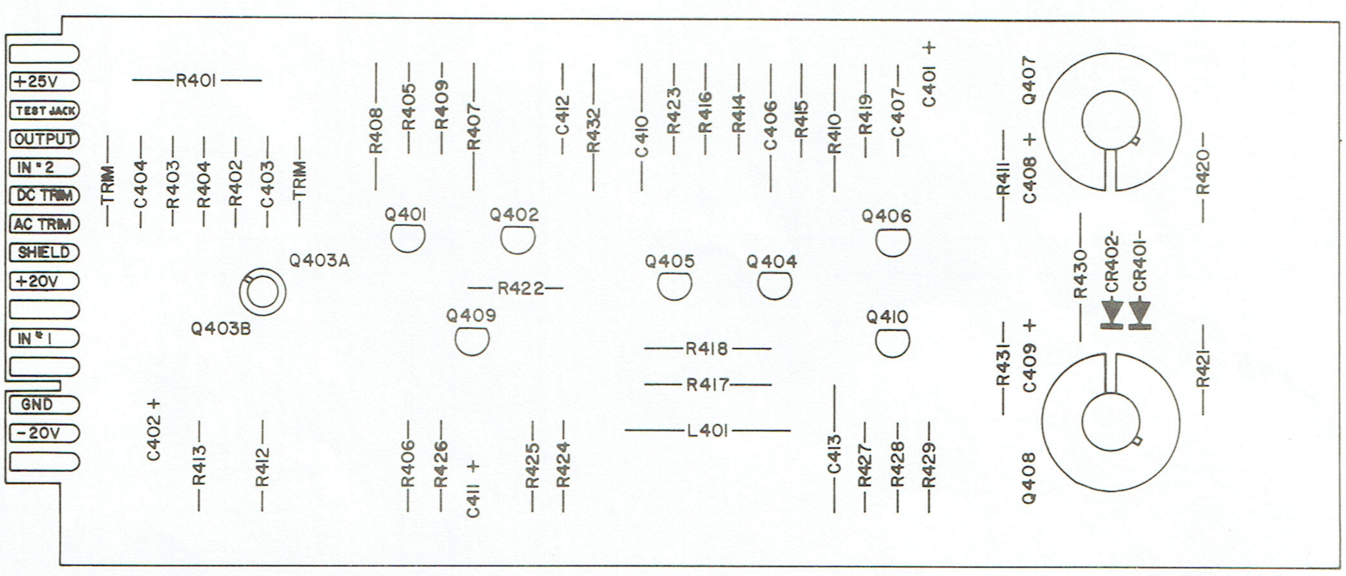
Symbol	Description	Mfr.	Part No.
C401	1uf 35V	SP	196D105X0035HA1
C402	1uf 35V	SP	196D105X0034HA1
C403	33pf 5% 500V	ELM	DM15C330J
C404	15pf 5% 500V	ELM	DM15C150J
C406	0.001uf 10% 100V	CD	WMF1D1
C407	24pf 10% 500V	ELM	DM15C240K
C408	1uf 35V	SP	196D105X0035HA1
C409	1uf 35V	SP	196D105X0035HA1
C410	0.01uf 10% 100V	CD	WMF1S1
C411	1uf 35V	SP	196D105X0035HA1
C412	10pf 10% 500V	ASP	9213-10110
C413	0.01uf 10% 100V	CD	WMF1S1

TRANSISTORS, DIODES & MISC.

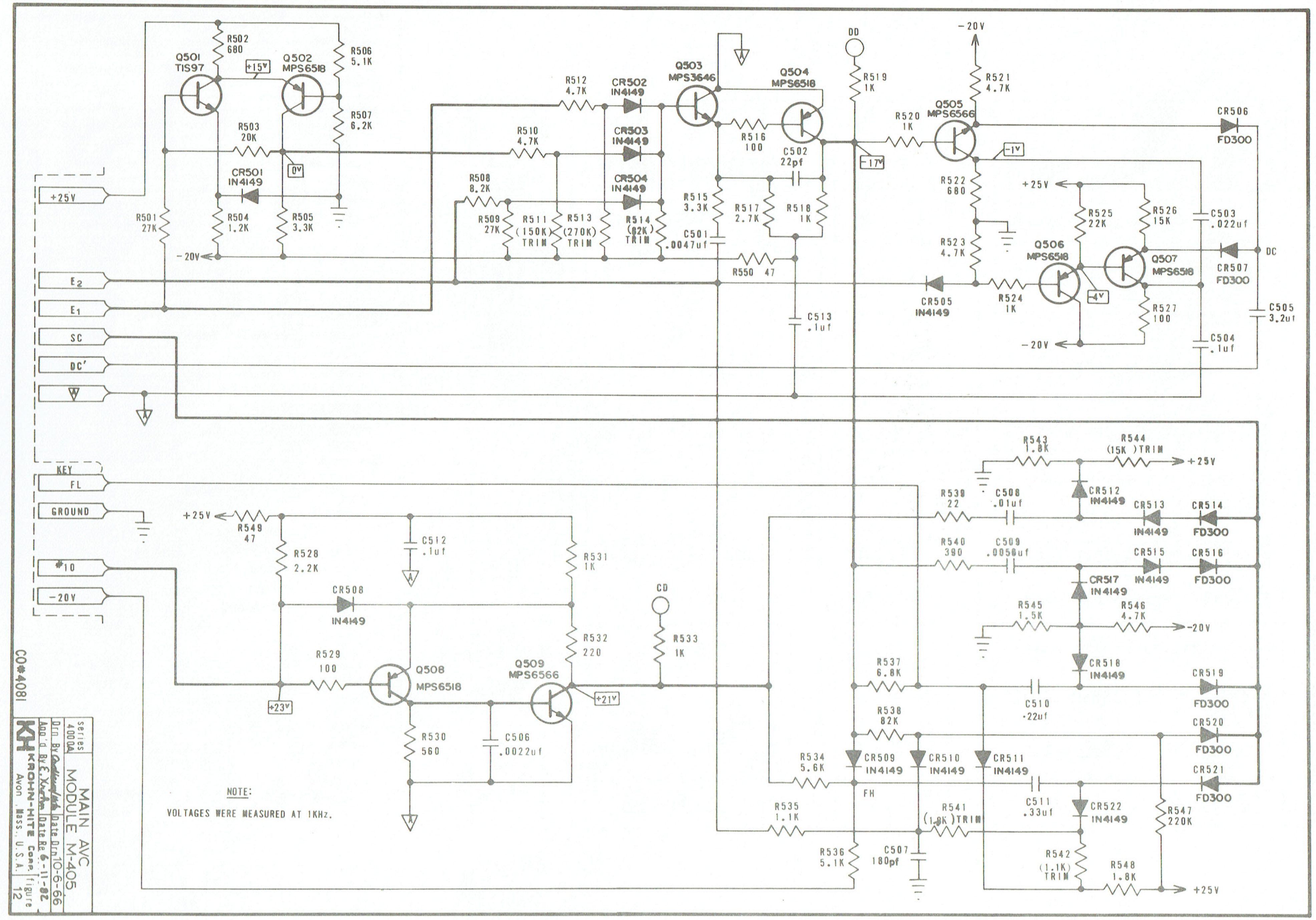
Symbol	Description	Mfr.	Part No.
Q401	TIS97	TI	TIS97
Q402	MPS6518	MOT	MPS6518
Q403	SU2366	SIL	SU2366
Q404	TIS97	TI	TIS97
Q405	TIS97	TI	TIS97
Q406	MPS6518	MOT	MPS6518
Q407	2N2219A	MOT	2N2219A
Q408	2N2905A	MOT	2N2905A
Q409	MPS6566	MOT	MPS6566
Q410	MPS6566	MOT	MPS6566
CR401	IN4149	APD	IN4149
CR402	IN4149	APD	IN4149
L401	100uHy	DLV	3500-08

MANUFACTURERS CODE

AB	(01121)	Allen Bradley Co.	Milwaukee, Wisc.
APD	(50273)	American Power Devices	Andover, Mass.
ASP	(82142)	Airco Speer	Dubois, Pa.
CD	(88419)	Cornell-Dubilier, Inc.	
DLV	(99800)	Delevan Electronics	East Aurora, N.Y.
ELM	(72136)	Electromotive Mfg.	Willimantic, Conn.
KID	(12126)	Kidco Inc.	Medford, N.J.
MOT	(04713)	Motorola Semiconductor	Phoenix, Az.
SIL	(17856)	Siliconix	Sunnyvale, CA.
SP	(56289)	Sprague Electric Co.	North Adams, Mass.
TI	(01295)	Texas Instruments Inc.	Dallas, Tex.



M404



MAIN AVC MODULE M-405
KROHN-HITE Corp. Avon, Mass., U.S.A.
series 4000A
figure 12
CO#4081
NOTE:
VOLTAGES WERE MEASURED AT 1KHz.
+25V
E2
E1
SC
DC'
KEY
FL
GROUND
#10
-20V
Q501 TIS97
Q502 MPS6518
Q503 MPS3646
Q504 MPS6518
Q505 MPS6566
Q506 MPS6518
Q507 MPS6518
Q508 MPS6518
Q509 MPS6566

RESISTORS

Symbol	Description			Mfr.	Part No.
R501	27K	10%	1/4W	AB	CB2731
R502	680	10%	1/4W	AB	CB6811
R503	20K	5%	1/4W	AB	CB2035
R504	1.2K	10%	1W	AB	GB1221
R505	3.3K	10%	1/4W	AB	CB3321
R506	5.1K	5%	1/4W	AB	CB5125
R507	6.2K	5%	1/4W	AB	CB6225
R508	8.2K	10%	1/4W	AB	CB8221
R509	27K	10%	1/4W	AB	CB2731
R510	4.7K	10%	1/4W	AB	CB4721
R511	150K	10%	1/2W	AB	EB1541
R512	4.7K	10%	1/4W	AB	CB4721
R513	270K	10%	1/2W	AB	EB2741
R514	82K	10%	1/4W	AB	CB8231
R515	3.3K	10%	1/4W	AB	CB3321
R516	100	20%	1/4W	AB	CB1012
R517	2.7K	10%	1/4W	AB	CB2721
R518	1K	10%	1/2W	AB	EB1021
R519	1K	10%	1/4W	AB	CB1021
R520	1K	10%	1/4W	AB	CB1021
R521	4.7K	10%	1/4W	AB	CB4721
R522	680	10%	1/4W	AB	CB6811
R523	4.7K	10%	1/4W	AB	CB4721
R524	1K	10%	1/4W	AB	CB1021
R525	22K	10%	1/4W	AB	CB2231

Symbol	Description			Mfr.	Part No.
R526	15K	10%	1/4W	AB	CB1531
R527	100	20%	1/4W	AB	CB1012
R528	2.2K	10%	1/2W	AB	EB2221
R529	100	20%	1/4W	AB	CB1012
R530	560	10%	1/4W	AB	CB5611
R531	1K	10%	1W	AB	GB1121
R532	220	10%	1/4W	AB	CB2211
R533	1K	10%	1/4W	AB	CB1021
R534	5.6K	5%	1/4W	AB	CB5625
R535	1.1K	5%	1/4W	AB	CB1125
R536	5.1K	5%	1/4W	AB	CB5125
R537	6.8K	5%	1/4W	AB	CB6825
R538	82K	10%	1/4W	AB	CB8231
R539	22	10%	1/4W	AB	CB2201
R540	390	5%	1/4W	AB	CB3915
R541	1.8K	5%	1/2W	AB	EB1825
R542	1.1K	5%	1/4W	AB	CB1125
R543	1.8K	10%	1/4W	AB	CB1821
R544	15K	10%	1/4W	AB	CB1531
R545	1.5K	10%	1/4W	AB	CB1531
R546	4.7K	10%	1/4W	AB	CB4721
R547	220K	5%	1/4W	AB	CB2245
R548	1.8K	5%	1/2W	AB	EB1825
R549	47	10%	1/4W	AB	CB4701
R550	47	10%	1/4W	AB	CB4701

CAPACITORS

Symbol	Description			Mfr.	Part No.
C501	0.0047uf	10%	100V	CD	WMF1D47
C502	22pf	10%	500V	ELM	DM15C220K
C503	0.022uf	10%	100V	CD	WMF1S22
C504	0.1uf	10%	100V	CD	WMF1P1
C505	3.2uf	+0.5%-3.5%	50V	TRW	X663F-12
C506	0.0022uf	10%	100V	CD	WMF1D22
C507	180pf	10%	500V	ELM	DM15C181K

Symbol	Description			Mfr.	Part No.
C508	0.01uf	10%	100V	CD	WMF1S1
C509	0.0056uf	10%	100V	CD	WMF1D56
C510	0.22uf	10%	100V	CD	WMF1P22
C511	0.33uf	10%	100V	CD	WMF1P33
C512	0.1uf	20%	100V	ERT	8131-100-651-104M
C513	0.1uf	20%	100V	ERT	8131-100-651-104M

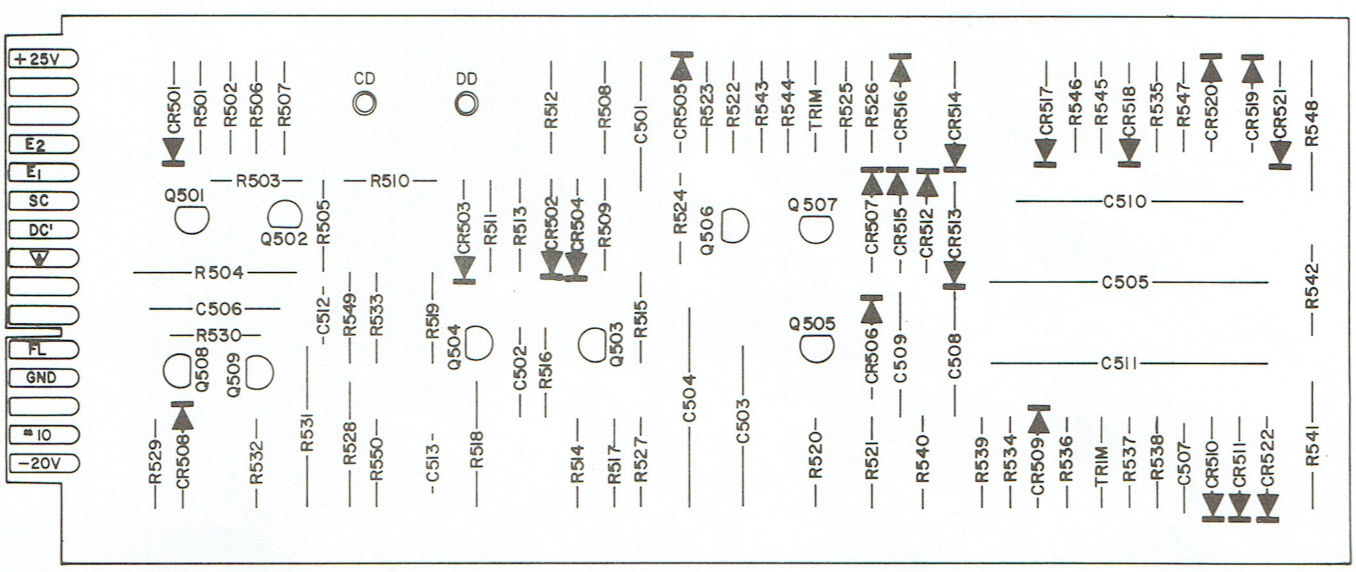
TRANSISTORS, DIODES & MISC.

Symbol	Description	Mfr.	Part No.
Q501	TIS97	TI	TIS97
Q502	MPS6518	MOT	MPS6518
Q503	MPS3646	MOT	MPS3646
Q504	MPS6518	MOT	MPS6518
Q505	MPS6566	MOT	MPS6566
Q506	MPS6518	MOT	MPS6518
Q507	MPS6518	MOT	MPS6518
Q508	MPS6518	MOT	MPS6518
Q509	MPS6566	MOT	MPS6566
CR501	IN4149	APD	IN4149
CR502	IN4149	APD	IN4149
CR503	IN4149	APD	IN4149
CR504	IN4149	APD	IN4149
CR505	IN4149	APD	IN4149
CR506	FD-300	FR	FD-300

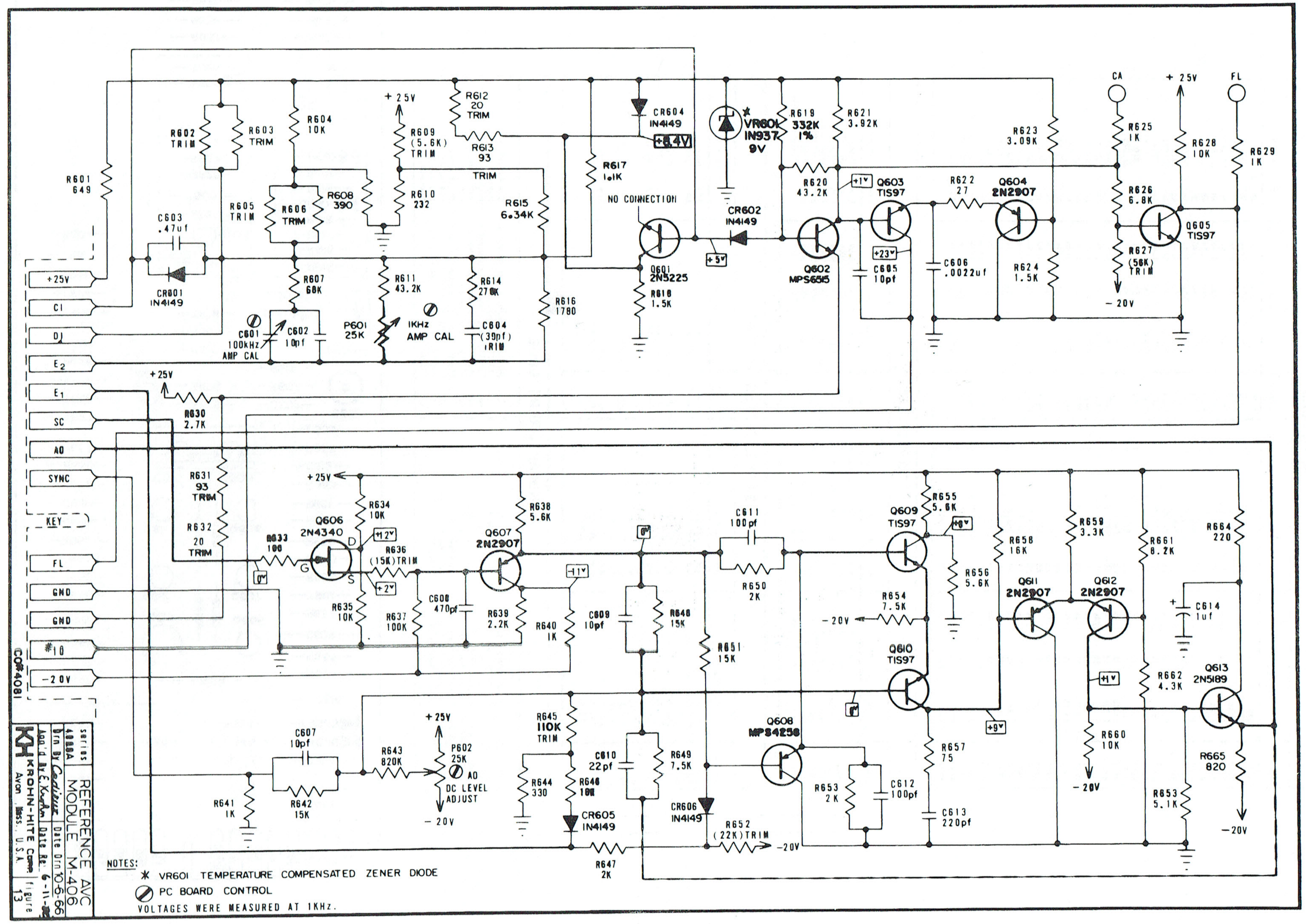
Symbol	Description	Mfr.	Part No.
CR507	FD-300	FR	FD-300
CR508	IN4149	APD	IN4149
CR509	IN4149	APD	IN4149
CR510	IN4149	APD	IN4149
CR511	IN4149	APD	IN4149
CR512	IN4149	APD	IN4149
CR513	IN4149	APD	IN4149
CR514	FD-300	FR	FD-300
CR515	IN4149	APD	IN4149
CR516	FD-300	FR	FD-300
CR517	IN4149	APD	IN4149
CR518	IN4149	APD	IN4149
CR519	FD-300	FR	FD-300
CR520	FD-300	FR	FD-300
CR521	FD-300	FR	FD-300
CR522	IN4149	APD	IN4149

MANUFACTURERS CODE

AB	(01121)	Allen Bradley Co.	Milwaukee, Wisc.
APD	(50273)	American Power Devices	Andover, Mass.
CD	(88419)	Cornell-Dubilier, Inc.	
ELM	(72136)	Electromotive Mfg.	Willimantic, Conn.
ERT	(72982)	Erie Technological	Erie, Pa.
FR	(07263)	Fairchild Semiconductor	San Rafael, Cal.
MOT	(04713)	Motorola Semiconductor	Phoenix, Az.
TI	(01295)	Texas Instruments, Inc.	Dallas, Tex.
TRW	(84411)	TRW Capacitor Div.	Ogallala, Neb.



M 405


+25V
CI
DJ
E2
E1
SC
AO
SYNC
KEY
FL
GND
GND
#10
-20V
CA
FL
R601 649
R602 TRIM
R603 TRIM
R604 10K
R605 TRIM
R606 TRIM
R607 68K
R608 390
R609 (5.6K) TRIM
R610 232
R611 43.2K
R612 20 TRIM
R613 93 TRIM
R614 270K
R615 6.34K
R616 1780
R617 1.1K
R618 1.5K
R619 332K 1%
R620 43.2K
R621 3.92K
R622 27
R623 3.09K
R624 1.5K
R625 1K
R626 6.8K
R627 (56K) TRIM
R628 10K
R629 1K
R630 2.7K
R631 93 TRIM
R632 20 TRIM
R633 100
R634 10K
R635 10K
R636 (15K) TRIM
R637 100K
R638 5.6K
R639 2.2K
R640 1K
R641 1K
R642 15K
R643 820K
R644 330
R645 110K TRIM
R647 2K
R648 15K
R649 7.5K
R650 2K
R651 15K
R652 (22K) TRIM
R653 2K
R654 7.5K
R655 5.6K
R656 5.6K
R657 75
R658 16K
R659 3.3K
R660 10K
R661 8.2K
R662 4.3K
R664 220
R665 820
C601 100kHz AMP CAL
C602 10pf
C603 .47uf
C604 (39pf) TRIM
C605 10pf
C606 .0022uf
C607 10pf
C608 470pf
C609 10pf
C610 22pf
C611 100pf
C612 100pf
C613 220pf
C614 1uf
P601 25K
1kHz AMP CAL
P602 25K
AO DC LEVEL ADJUST
CR601 IN4149
CR602 IN4149
CR604 IN4149
CR605 IN4149
CR606 IN4149
VR601 IN937 9V
+8.4V
NO CONNECTION
Q601 2N5225
Q602 MPS6515
Q603 TIS97
Q604 2N2907
Q605 TIS97
Q606 2N4340
Q607 2N2907
Q608 MPS4258
Q609 TIS97
Q610 TIS97
Q611 2N2907
Q612 2N2907
Q613 2N5189
+1V
+5V
+23V
+12V
+2V
-11V
+9V
0V
D
G
S
CO#4081
NOTES:
* VR601 TEMPERATURE COMPENSATED ZENER DIODE
PC BOARD CONTROL
VOLTAGES WERE MEASURED AT 1KHz.
KH
series 4000A
REFERENCE AVC MODULE M-406
KROHN-HITE Corp. Avon, Mass. U.S.A.
figure 13

RESISTORS

Symbol	Description			Mfr.	Part No.
R601	649	1%	1W	TL	TYPE ELIA
R602	TRIM			AB	TYPE CC
R603	TRIM			AB	TYPE CB
R604	10K	5%	1/4W	AB	CB1035
R605	TRIM			AB	TYPE CC
R606	TRIM			AB	TYPE CB
R607	68K	10%	1/4W	AB	CB6831
R608	390	10%	1/4W	AB	CB3911
R609	5.6K	10%	1/4W	AB	CB5621
R610	232	1%	1/4W	AB	CC2320F
R611	43.2K	1%	1/4W	AB	CC4322F
R612	20	1%	1W	TL	TYPE ELIA
R613	93	1%	1W	TL	TYPE ELIA
R614	270K	10%	1/4W	AB	CB2741
R615	6.34K	1%	1/4W	AB	CC6341F
R616	1.78K	1%	1W	TL	TYPE ELIA
R617	1.1K	1%	1/4W	AB	CC1101F
R618	1.5K	1%	1W	TL	TYPE ELIA
R619	332K	1%	1/4W	KH	850433
R620	43.2K	1%	1/4W	AB	CC4322F
R621	3.92K	1%	1/4W	AB	CC3921F
R622	27	10%	1/4W	AB	CB2701
R623	3.09K	1%	1/4W	AB	CC3091F
R624	1.5K	1%	1/4W	AB	CC1501F
R625	1K	10%	1/4W	AB	CB1021
R626	6.8K	5%	1/4W	AB	CB6825
R627	56K	10%	1/4W	AB	CB5631
R628	10K	5%	1/4W	AB	CB1035
R629	1K	10%	1/4W	AB	CB1021
R630	2.7K	1%	1W	TL	TYPE ELIA
R631	93	1%	1W	TL	TYPE ELIA
R632	20	1%	1W	TL	TYPE ELIA
R633	100	10%	1/4W	AB	CB1021

Symbol	Description			Mfr.	Part No.
R634	10K	10%	1/4W	AB	CB1031
R635	10K	10%	1/4W	AB	CB1031
R636	15K	5%	1/4W	AB	CB1535
R637	100K	5%	1/4W	AB	CB1045
R638	5.6K	10%	1/4W	AB	CB5621
R639	2.2K	10%	1/4W	AB	CB2221
R640	1K	10%	1/4W	AB	CB1021
R641	1K	10%	1/4W	AB	CB1021
R642	15K	5%	1/4W	AB	CB1535
R643	820K	10%	1/4W	AB	CB8241
R644	330	5%	1/4W	AB	CB3315
R645	110K	5%	1/4W	AB	CB1145
R646	10K	5%	1/4W	AB	CB1035
R647	2K	5%	1/4W	AB	CB2025
R648	15K	5%	1/4W	AB	CB1535
R649	7.5K	5%	1/4W	AB	CB7525
R650	2K	5%	1/4W	AB	CB2025
R651	15K	10%	1/4W	AB	CB1531
R652	22K	10%	1/4W	AB	CB2231
R653	2K	5%	1/4W	AB	CB2025
R654	7.5K	5%	1/4W	AB	CB7525
R655	5.6K	10%	1/4W	AB	CB5621
R656	5.6K	10%	1/4W	AB	CB5621
R657	75	5%	1/4W	AB	CB7505
R658	76K	5%	1/4W	AB	CB1635
R659	3.3K	10%	1/4W	AB	CB3321
R660	10K	5%	1/4W	AB	CB1035
R661	8.2K	5%	1/4W	AB	CB8225
R662	4.3K	5%	1/4W	AB	CB4325
R663	5.1K	5%	1/4W	AB	CB5125
R664	220	10%	1W	AB	GB2211
R665	820	10%	1W	AB	GB8211

CAPACITORS

Symbol	Description			Mfr.	Part No.
C601	7-35pf	TRIMMER		STT	7S-TRIKO-02-7/35pf
C602	10pf	10%	500V	ASP	9213-10110
C603	0.47uf	20%	100V	ERT	8131-100-651-474M
C604	39pf	10%	500V	ELM	DM15C390K
C605	10pf	10%	500V	ASP	9213-10110
C606	2200pf	10%	100V	CD	WMF1D22
C607	10pf	10%	500V	ASP	9213-10110

Symbol	Description			Mfr.	Part No.
C608	470pf	10%	500V	ELM	DM15C471K
C609	10pf	10%	500V	ASP	9213-10110
C610	22pf	10%	500V	ELM	DM15C220K
C611	100pf	10%	500V	ELM	DM15C101K
C612	100pf	10%	500V	ELM	DM15C101K
C613	220pf	10%	500V	ELM	DM15C221K
C614	1uf	10%	35V	SP	196D105X0034HA1

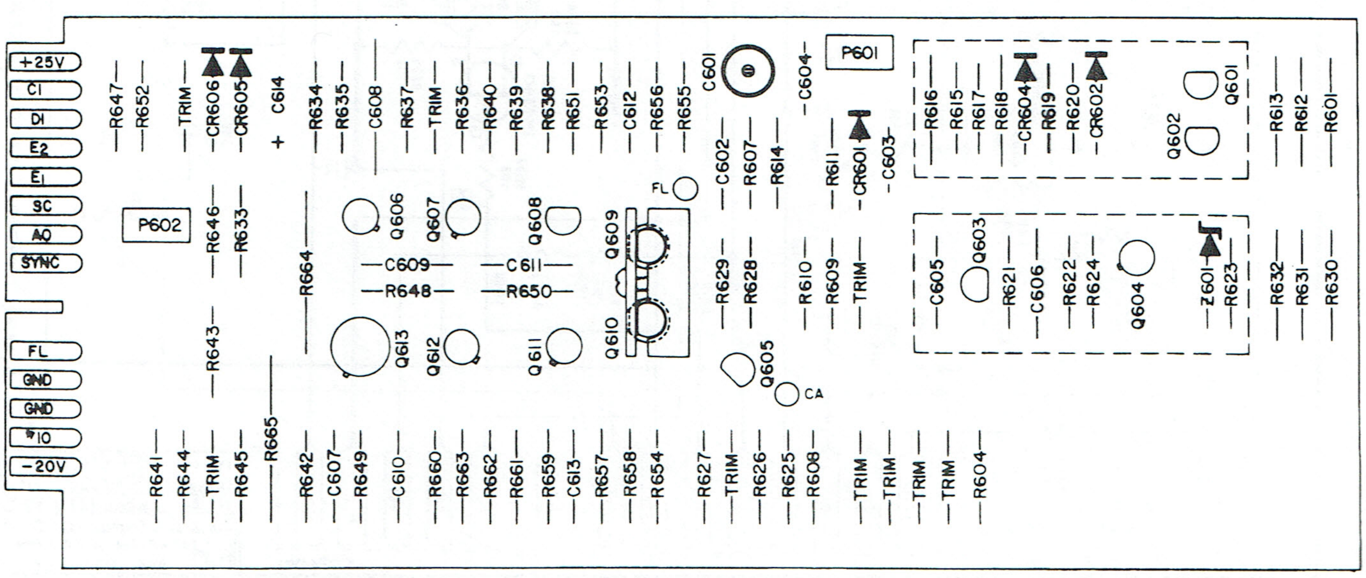
TRANSISTORS, DIODES & MISC.

Symbol	Description	Mfr.	Part No.
Q601	2N5225	MOT	2N5225
Q602	MPS6515	MOT	MPS6515
Q603	TIS97	TI	TIS97
Q604	2N2907	MOT	2N2907
Q605	TIS97	TI	TIS97
Q606	2N4340	SIL	2N4340
Q607	2N2907	MOT	2N2907
Q608	MPS4258	MOT	MPS4258
Q609	TIS97	TI	TIS97
Q610	TIS97	TI	TIS97
Q611	2N2907	MOT	2N2907
Q612	2N2907	MOT	2N2907
Q613	2N5189	RCA	2N5189

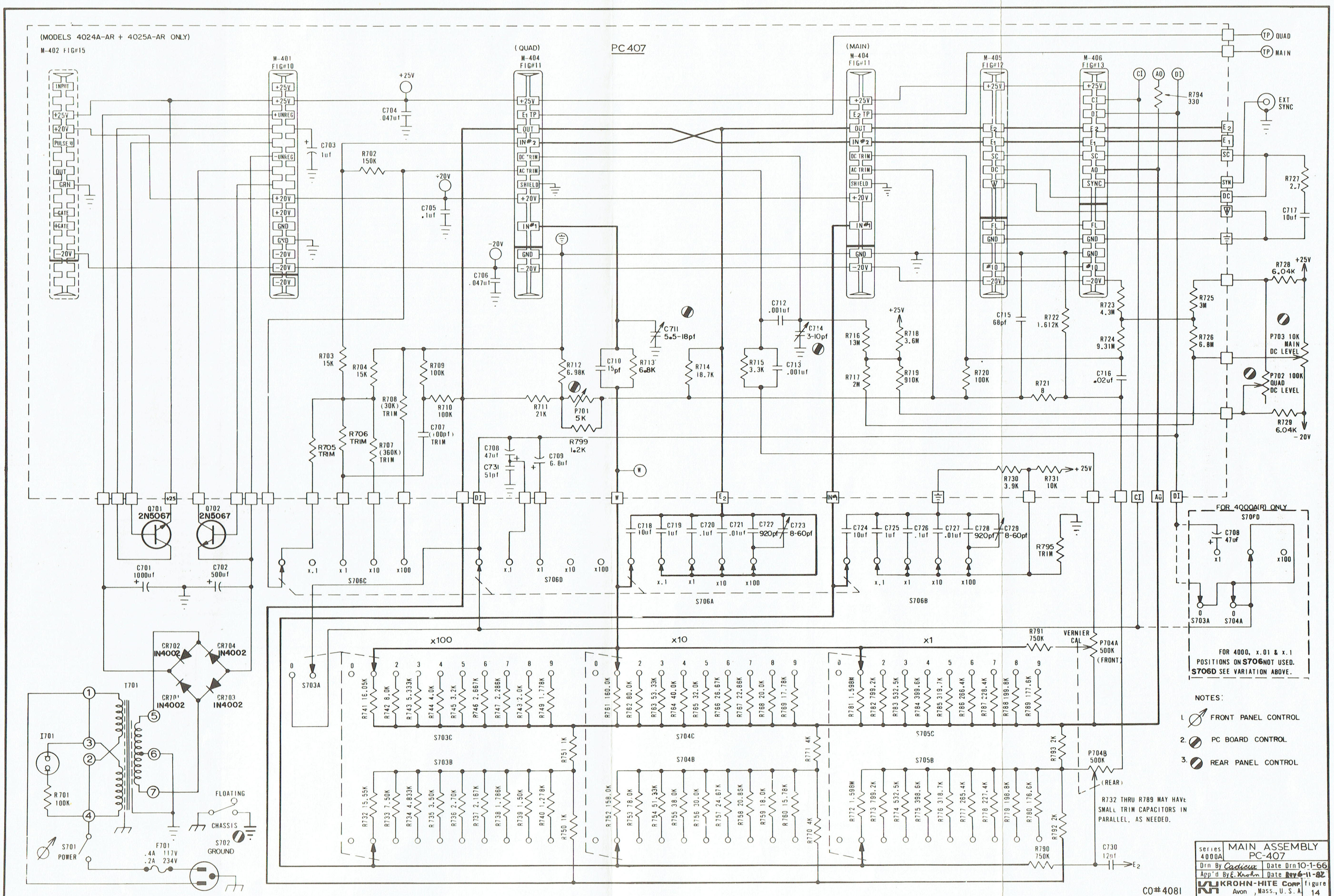
Symbol	Description	Mfr.	Part No.
CR601	IN4149	APD	IN4149
CR602	IN4149	APD	IN4149
CR604	IN4149	APD	IN4149
CR605	IN4149	APD	IN4149
CR606	IN4149	APD	IN4149
VR601	1N937, 9V	TR	1N937
P601	25K POT	BKM	72XW
P602	25K POT	BKM	72XW

MANUFACTURERS CODE

AB	(01121)	Allen Bradley Co.	Milwaukee, Wisc.
APD	(50273)	American Power Devices	Andover, Mass.
ASP	(82142)	Airco Speer	Dubois, Pa.
BKM	(30646)	Beckman Instr. Co.	Milwaukee, Wisc.
CD	(88419)	Cornell-Dubilier, Inc.	
CODI	(16352)	Computer Diode Corp.	Fairlawn, N.J.
ELM	(72136)	Electromotive Mfg.	Willimantic, Conn.
ERT	(72982)	Erie Technological	Erie, Pa.
FR	(07263)	Fairchild Semiconductor	San Rafael, Cal.
KID	(12126)	Kidco Inc.	Medford, N.J.
MOT	(04713)	Motorola Semiconductor	Phoenix, Az.
RCA	(49671)	Radio Corp. of America	Harrison, N.J.
SIL	(17856)	Siliconix	Sunnyvale, Cal.
SP	(56289)	Sprague Electric Co.	North Adams, Mass.
STT	( )	Stettner-Trush	Cazenovia, N.Y.
TI	(01295)	Texas Instruments, Inc.	Dallas, Tex.
TL	(94322)	Tel-Labs, Inc.	Needham, Mass.



M406


(MODELS 4024A-AR + 4025A-AR ONLY)
M-402 FIG#15
M-401 FIG#10
(QUAD) M-404 FIG#11
PC407
(MAIN) M-404 FIG#11
M-405 FIG#12
M-406 FIG#13
TP QUAD
TP MAIN
EXT SYNC
Q701 2N5067
Q702 2N5067
C701 1000uf
C702 500uf
CR702 IN4002
CR704 IN4002
CR701 IN4002
CR703 IN4002
T701
I701
R701 100K
S701 POWER
F701 .4A 117V .2A 234V
FLOATING
CHASSIS
S702 GROUND
S706C
S706D
S706A
S706B
S703A
x100
x10
x1
S703C
S703B
S704C
S704B
S705C
S705B
R791 750K
VERNIER CAL
P704A 500K (FRONT)
P704B 500K (REAR)
R790 750K
C730 12nf
P703 10K MAIN DC LEVEL
P702 100K QUAD DC LEVEL
FOR 4000A(R) ONLY
S70FD
FOR 4000, x.01 & x.1 POSITIONS ON S706 NOT USED. S706D SEE VARIATION ABOVE.
NOTES:
1. FRONT PANEL CONTROL
2. PC BOARD CONTROL
3. REAR PANEL CONTROL
R732 THRU R789 MAY HAVE SMALL TRIM CAPACITORS IN PARALLEL, AS NEEDED.
series 4000A
MAIN ASSEMBLY PC-407
Drn By Cadieux
Date Drn 10-1-66
App'd By E. Krohn
Date Rev 6-11-82
KROHN-HITE CORP Avon, Mass., U.S.A.
figure 14
CO#4081

RESISTORS

Symbol	Description			Mfr.	Part No.
R701	100K	10%	1/4W	AB	CB1041
R702	150K	5%	1/4W	AB	CB1545
R703	15K	5%	1/4W	AB	CB1535
R704	15K	5%	1/4W	AB	CB1535
R705	TRIM			AB	TYPE CB
R706	TRIM			AB	TYPE CB
R707	TRIM(30K)			AB	TYPE CB
R708	TRIM(360K)			AB	TYPE CB
R709	100K	5%	1/4W	AB	CB1045
R710	100K	5%	1/4W	AB	CB1045
R711*	21K	1%	1/4W	AB	CC2102F
R711**	21K	.05%	1/4W	IRC	MAR6-TI3-21K
R712*	6.98K	1%	1/4W	AB	CC6981F
R712**	6.980K	.05%	1/4W	IRC	MAR6-TI3-20.4K
R713	6.8K	10%	1/4W	AB	CB6821
R714*	18.7K	1%	1/4W	AB	CC1872F
R714**	20.4K	.05%	1/4W	IRC	MAR6-TI3-20.4K
R715	3.3K	5%	1/4W	AB	CB3325
R716	13M	5%	1/4W	AB	CB1365
R717	2M	5%	1/4W	AB	CB2055
R718	3.6M	5%	1/4W	AB	CB3655
R719	910K	5%	1/4W	AB	CB9145
R720	100K	5%	1/4W	AB	CB1045
R721	8	1%	1W	TL	TYPE ELIA
R722*	1.62K	1%	1/4W	AB	CC1621F
R722**	1.6236K	.05%	1/4W	IRC	MAR6-TI3-1.6236K
R723	4.3M	5%	1/4W	AB	CB4355
R724	9.31M	1%	1/4W	AB	CC9314F
R725	3M	5%	1/4W	AB	CB3055
R726	6.8M	5%	1/4W	AB	CB6855
R727	2.7	10%	1/4W	AB	CB27G1
R728	6.04K	1%	1/4W	AB	CC6041F
R729	6.04K	1%	1/4W	AB	CC6041F
R730	3.9K	5%	1/4W	AB	CB3925
R731	10K	5%	1/4W	AB	CB1035

MODELS 4000A, - AR AND 4024A, - AR ONLY

Symbol	Description			Mfr.	Part No.
R732	15.52K	0.1%	1/4W	KID	TYPE M4-T1
R733	7.5K	0.1%	1/4W	KID	TYPE M4-T1
R734	4.833K	0.1%	1/4W	KID	TYPE M4-T1
R735	3.5K	0.1%	1/4W	KID	TYPE M4-T1
R736	2.7K	0.1%	1/4W	KID	TYPE M4-T1
R737	2.167K	0.1%	1/4W	KID	TYPE M4-T1
R738	1.786K	0.1%	1/4W	KID	TYPE M4-T1
R739	1.5K	0.1%	1/4W	KID	TYPE M4-T1
R740	1.278K	0.1%	1/4W	KID	TYPE M4-T1
R741	16.02K	0.1%	1/4W	KID	TYPE M4-T1
R742	8K	0.1%	1/4W	KID	TYPE M4-T1
R743	5.333K	0.1%	1/4W	KID	TYPE M4-T1
R744	4K	0.1%	1/4W	KID	TYPE M4-T1
R745	3.2K	0.1%	1/4W	KID	TYPE M4-T1
R746	2.667K	0.1%	1/4W	KID	TYPE M4-T1
R747	2.286K	0.1%	1/4W	KID	TYPE M4-T1
R748	2K	0.1%	1/4W	KID	TYPE M4-T1
R749	1.778K	0.1%	1/4W	KID	TYPE M4-T1
R750	1K	0.1%	1/4W	KID	TYPE M4-T1
R751	1K	0.1%	1/4W	KID	TYPE M4-T1
R752	158K	0.1%	1/4W	KID	TYPE M4-T1
R753	78K	0.1%	1/4W	KID	TYPE M4-T1
R754	51.33K	0.1%	1/4W	KID	TYPE M4-T1
R755	38K	0.1%	1/4W	KID	TYPE M4-T1
R756	30K	0.1%	1/4W	KID	TYPE M4-T1
R757	24.67K	0.1%	1/4W	KID	TYPE M4-T1
R758	20.86K	0.1%	1/4W	KID	TYPE M4-T1
R759	18K	0.1%	1/4W	KID	TYPE M4-T1
R760	15.78K	0.1%	1/4W	KID	TYPE M4-T1
R761	160K	0.1%	1/4W	KID	TYPE M4-T1
R762	80K	0.1%	1/4W	KID	TYPE M4-T1
R763	53.33K	0.1%	1/4W	KID	TYPE M4-T1
R764	40K	0.1%	1/4W	KID	TYPE M4-T1
R765	32K	0.1%	1/4W	KID	TYPE M4-T1
R766	26.67K	0.1%	1/4W	AB	TYPE M4-T1
R767	22.86K	0.1%	1/4W	AB	TYPE M4-T1
R768	20K	0.1%	1/4W	KID	TYPE M4-T1
R769	17.78K	0.1%	1/4W	KID	TYPE M4-T1
R770	4K	0.1%	1/4W	KID	TYPE M4-T1
R771	4K	0.1%	1/4W	KID	TYPE M4-T1
R772	1.598M	0.5%	1/4W	KID	TYPE M4-T1
R773	799.2K	0.5%	1/4W	KID	TYPE M4-T1
R774	532-5K	0.5%	1/4W	KID	TYPE M4-T1
R775	398.6K	0.5%	1/4W	KID	TYPE M4-T1
R776	318.7K	0.5%	1/4W	KID	TYPE M4-T1
R777	265.4K	0.5%	1/4W	KID	TYPE M4-T1
R778	227.4K	0.5%	1/4W	KID	TYPE M4-T1
R779	198.8K	0.5%	1/4W	KID	TYPE M4-T1
R780	176.6K	0.5%	1/4W	KID	TYPE M4-T1
R781	1.598M	0.5%	1/4W	KID	TYPE M4-T1
R782	799.2K	0.5%	1/4W	KID	TYPE M4-T1
R783	532.5K	0.5%	1/4W	KID	TYPE M4-T1
R784	399.6K	0.5%	1/4W	KID	TYPE M4-T1
R785	319.7K	0.5%	1/4W	KID	TYPE M4-T1
R786	266.4K	0.5%	1/4W	KID	TYPE M4-T1
R787	228.4K	0.5%	1/4W	KID	TYPE M4-T1
R788	199.8K	0.5%	1/4W	KID	TYPE M4-T1
R789	177.6K	0.5%	1/4W	KID	TYPE M4-T1
R790	750K	1%	1/4W	AB	CC7503F
R791	750K	1%	1/4W	AB	CC7503F
R792	2K	0.1%	1/4W	KID	TYPE M4-T1
R793	2K	0.1%	1/4W	KID	TYPE M4-T1

MODELS 4001A, - AR AND 4025A, - AR ONLY

Symbol	Description			Mfr.	Part No.
R732	15.66684K	.05%	1/4W	IRC	TYPE MAR6-T13
R733	7.70908K	.05%	1/4W	IRC	TYPE MAR6-T13
R734	5.05649K	.05%	1/4W	IRC	TYPE MAR6-T13
R735	3.73020K	.05%	1/4W	IRC	TYPE MAR6-T13
R736	2.93442K	.05%	1/4W	IRC	TYPE MAR6-T13
R737	2.40391K	.05%	1/4W	IRC	TYPE MAR6-T13
R738	2.02496K	.05%	1/4W	IRC	TYPE MAR6-T13
R740	1.51971K	.05%	1/4W	IRC	TYPE MAR6-T13
R741	15.91552K	.05%	1/4W	IRC	TYPE MAR6-T13
R742	7.95976K	.05%	1/4W	IRC	TYPE MAR6-T13
R743	5.30517K	.05%	1/4W	IRC	TYPE MAR6-T13
R744	3.97888K	.05%	1/4W	IRC	TYPE MAR6-T13
R745	3.18310K	.05%	1/4W	IRC	TYPE MAR6-T13
R746	2.65259K	.05%	1/4W	IRC	TYPE MAR6-T13
R747	2.27364K	.05%	1/4W	IRC	TYPE MAR6-T13
R748	1.98944K	.05%	1/4W	IRC	TYPE MAR6-T13
R749	1.76839K	.05%	1/4W	IRC	TYPE MAR6-T13
R750	497.36	.05%	1/4W	IRC	TYPE MAR6-T13
R751	497.36K	.05%	1/4W	IRC	TYPE MAR6-T13
R752	158.1605K	.05%	1/4W	IRC	TYPE MAR6-T13
R753	78.5829K	.05%	1/4W	IRC	TYPE MAR6-T13
R754	52.057K	.05%	1/4W	IRC	TYPE MAR6-T13
R755	38.7941K	.05%	1/4W	IRC	TYPE MAR6-T13
R756	30.8363K	.05%	1/4W	IRC	TYPE MAR6-T13
R757	25.5352K	.05%	1/4W	IRC	TYPE MAR6-T13
R758	21.7414K	.05%	1/4W	IRC	TYPE MAR6-T13
R759	18.8997K	.05%	1/4W	IRC	TYPE MAR6-T13
R760	16.6892K	.05%	1/4W	IRC	TYPE MAR6-T13
R761	159.1552K	.05%	1/4W	IRC	TYPE MAR6-T13
R762	79.5776K	.05%	1/4W	IRC	TYPE MAR6-T13
R763	53.0517K	.05%	1/4W	IRC	TYPE MAR6-T13
R764	39.7888K	.05%	1/4W	IRC	TYPE MAR6-T13
R765	31.8310K	.05%	1/4W	IRC	TYPE MAR6-T13
R766	26.5259K	.05%	1/4W	IRC	TYPE MAR6-T13
R767	22.7364K	.05%	1/4W	IRC	TYPE MAR6-T13
R768	19.8944K	.05%	1/4W	IRC	TYPE MAR6-T13
R769	17.6839K	.05%	1/4W	IRC	TYPE MAR6-T13
R770	1.98944K	.05%	1/4W	IRC	TYPE MAR6-T13
R771	1.98944K	.05%	1/4W	IRC	TYPE MAR6-T13
R772	1.5867M	0.1%	1/2W	KID	TYPE M5-T1
R773	790.803K	0.1%	1/4W	KID	TYPE M4-T1
R774	525.544L	0.1%	1/4W	KID	TYPE M4-T1
R775	392.915K	0.1%	1/4W	KID	TYPE M4-T1
R776	313.337K	0.1%	1/4W	KID	TYPE M4-T1
R777	260.286K	0.1%	1/4W	KID	TYPE M4-T1
R778	222.391K	0.1%	1/4W	KID	TYPE M4-T1
R779	193.971K	0.1%	1/4W	KID	TYPE M4-T1
R780	171.866K	0.1%	1/4W	KID	TYPE M4-T1
R781	1.5916M	0.1%	1/2W	KID	TYPE M5-T1
R782	795.776K	0.1%	1/4W	KID	TYPE M4-T1
R783	530.517K	0.1%	1/4W	KID	TYPE M4-T1
R784	397.888K	0.1%	1/4W	KID	TYPE M4-T1
R785	318.310K	0.1%	1/4W	KID	TYPE M4-T1
R786	265.259K	0.1%	1/4W	KID	TYPE M4-T1
R787	227.364K	0.1%	1/4W	KID	TYPE M4-T1
R788	198.944K	0.1%	1/4W	KID	TYPE M4-T1
R789	176.839K	0.1%	1/4W	KID	TYPE M4-T1
R790	750K	1%	1/4W	AB	CC7503F
R791	750K	1%	1/4W	AB	CC7503F
R792	9.9472K	0.1%	1/4W	KID	TYPE M4-T1
R793	9.9472K	0.1%	1/4W	KID	TYPE M4-T1
R794	330	10%	1/4W	AB	CB3311
R795	TRIM			AB	TYPE CB

Symbol	Description			Mfr.	Part No.
R799	1.2K	10%	1/4W	AB	CB1221
R810	1.78K	1%	1W	KH	745217
R811A	20	1%	1W	KH	745020
R811B	180	5%	1/4W	AB	CB1815
R813	2K	1%	1W	TL	TYPE ELIA
R814	1K	1%	1W	TL	TYPE ELIA
R815	1K	1%	1W	TL	TYPE ELIA
R816	500	1%	1W	TL	TYPE ELIA

MODELS 4024A, - AR AND 4025A, - AR ONLY

Symbol	Description			Mfr.	Part No.
R820	2K	.05%	.3W	KEL	TYPE RTA
R821	1K	.05%	.3W	KEL	TYPE RTA
R822	1K	.05%	.3W	KEL	TYPE RTA
R823	500	.05	.3W	KEL	TYPE RTA
R824	16K	.05%	.3W	KEL	TYPE RTA
R825	8K	.05%	.3W	KEL	TYPE RTA
R826	8K	.05%	.3W	KEL	TYPE RTA
R827	4K	.05%	.3W	KEL	TYPE RTA
R828	444	.05%	.3W	KEL	TYPE RTA
R829	16K	.05%	.3W	KEL	TYPE RTA
R830	8K	.05%	.3W	KEL	TYPE RTA
R831	8K	.05%	.3W	KEL	TYPE RTA
R832	4K	.05%	.3W	KEL	TYPE RTA
R833	20.44K	.05%	.3W	KEL	TYPE RTA
R834	16K	.05%	.3W	KEL	TYPE RTA
R835	16K	.05%	.3W	KEL	TYPE RTA
R836	8K	.05%	.3W	KEL	TYPE RTA
R837	8K	.05%	.3W	KEL	TYPE RTA
R838	4K	.05%	.3W	KEL	TYPE RTA
R839	198.4K	.05%	.3W	KEL	TYPE RTA
R840	400	1%	1W	TL	TYPE ELIA
R841	1K	10%	1/4W	AB	CB1021
R842	22K	10%	1/4W	AB	CB2231
R843	10	10%	1/4W	AB	CB1001

Symbol	Description			Mfr.	Part No.
R844	1K	10%	1/4W	AB	CB1021
R845	22K	10%	1/4W	AB	CB2231
R846	400	1%	1W	TL	TYPE ELIA

MODELS 4000A, - AR AND 4001A, - AR ONLY

Symbol	Description			Mfr.	Part No.
R847	200	1%	1W	TL	TYPE ELIA
R848	12K	10%	1/4W	AB	CB1231
R849	400	1%	1W	TL	TYPE ELIA
R850	1K	10%	1/4W	AB	CB1021

*Models 4000A, -AR and 4024A, -AR Only
**Models 4001A, -AR and 4025A, - AR Only

CAPACITORS

Symbol	Description			Mfr.	Part No.
C701	1000uf		50V	SP	62D10151
C702	500uf		50V	SP	62D45063
C703	1uf		50V	SP	30D105G050BA4
C704	0.047uf	20%	50V	ERT	8121-050-651-473M
C705	0.1uf	20%	100V	ERT	8131-100-651-104M
C706	0.047uf	20%	50V	ERT	8121-050-651-473M
C707	100pf	10%	500V	ELM	DM15C101K
C708	47uf		6V	SP	TDC476M006BL
C709	6.8uf		35V	SP	196D685X0035FB
C710	15pf	10%	500V	ASP	9300-15110
C711	5.5-18pf	TRIMMER		STT	10S-TRIKO-24-5.5/18pf
C712	0.001uf	10%	100V	CD	WMF1D1
C713	0.001uf	10%	100V	CD	WMF1D1
C714	3-10pf	TRIMMER		STT	10S-TRIKO-24-3/10pf
C715	68pf	5%	500V	ELM	DM15C680J
C716	0.02uf	20%	500V	SP	C023A501J230M
C717	10uf	+0.5%-2.5%	100V	KH	B2266-D
C718	9.94uf	±0.15%	100V	KH	B2266-D
C719*	0.9935uf	±0.15%	200V	TRW	X463UW-8
C719**	0.996uf	±0.1%	100V	KH	110-0171
C720*	0.0993uf	±0.15%	200V	TRW	X463UW-10
C720**	0.0995uf	±0.1%	100V	KH	100-0121
C721*	9950pf	±0.15%	100V	ELM	DM20C992F
C721**	9970pf	±0.1%	100V	KH	160-0970
C722	920pf	±1%	500V	ELM	DM19C921F
C723	8-60pf	TRIMMER		ELM	T50410
C724	9.94uf	±0.15%	100V	KH	B2266-D
C725*	0.9935uf	±0.15%	200V	TRW	X463UW-8
C725**	0.996uf	±0.1%	100V	KH	110-0171
C726*	0.0993uf	±0.15%	200V	TRW	X463UW-10
C726**	0.0995uf	±0.1%	100V	KH	110-0121
C727*	9950pf	±0.15%	100V	ELM	DM20C992F
C727**	9970pf	±0.1%	100V	KH	160-0970
C728	920pf	±1%	500V	ELM	DM19C921F
C729	8-60pf	TRIMMER		ELM	T50410
C730	12pf	10%	500V	ASP	9213-12110
C731	51pf	10%	500V	ELM	DM15C510K
C810	0.001uf	10%	100V	CD	WMF1D1
C811†	0.001uf	10%	100V	CD	WMF1D1
C814†	.001uf	20%	500V	SP	C023B501E102M
C815††	.001uf	10%	100V	CD	WMF1D1

*Models 4000A, -AR and 4024A, -AR Only
**Models 4001A, -AR and 4025A, -AR Only
†Models 4024A, -AR and 4025A, -AR Only
††Models 4000A, -AR and 4001A, -AR Only

TRANSISTORS, DIODES & MISC.

Symbol	Description	Mfr.	Part No.
Q701	2N5067	MOT	2N5067
Q702	2N5067	MOT	2N5067
CR701	IN4002	TR	IN4002
CR702	IN4002	TR	IN4002
CR703	IN4002	TR	IN4002
CR704	IN4002	TR	IN4002
F701	FUSE,SLOW BLOW,115V	BUS	MDL-.4A
	FUSE,SLOW BLOW,230V	BUS	MDL-.2A
I701	LAMP,INDICATOR,POWER	ELD	EG03-CCB-N110
L801†	15uHy	DLV	1537-40
L802	15uHy	DLV	1537-40
L803††	15uHy	DLV	1537-40
P701	5K POT	BKM	72XWR5K
P702	100K POT	AB	JAIL040S104RC
P703	10K POT	AB	JAIL040S103MC
P704A,-B	500K DUAL POT	AB	JJ92990A
S701	SWITCH,TOGGLE,POWER	CK	U11
S702	SWITCH,SLIDE,GROUND	CW	G123
S703	SWITCH,ROTARY,X100 FREQUENCY	KH	B2398-C
S704	SWITCH,ROTARY,X10 FREQUENCY	KH	B2398-C
S705	SWITCH,ROTARY,X1 FREQUENCY	KH	B2398-C
S706	SWITCH,ROTARY MULTIPLIER	KH	B2255-M
S810	SWITCH,ROTARY,SIMPLE ATTENUATOR	KH	B2269-G
S811†	SWITCH,ROTARY X1 AMPLITUDE	KH	B2327-D
S812†	SWITCH,ROTARY,X.1 AMPLITUDE	KH	B2327-D
S813†	SWITCH,ROTARY,X.01 AMPLITUDE	KH	B2327-D
S814†	SWITCH,ROTARY,.001 AMPLITUDE	KH	B2327-D
T701	TRANSFORMER,POWER	KH	B2329-E

†Models 4024A, -AR and 4025A, -AR only
††Models 4000A, -AR and 4001A, -AR only

MANUFACTURERS CODE

Code		Name	Location
AB	(01121)	Allen Bradley Co.	Milwaukee, Wisc.
ASP	(82142)	Airco Speer	Dubois, Pa.
BKM	(30646)	Beckman Instr. Co.	Milwaukee, Wisc.
BUS	(71400)	Bussman Mfg. Div.	St. Louis, Mo.
CD	(88419)	Cornell-Dubilier, Inc.	
CK	(09353)	C&K Components	Watertown, Mass.
CW	(79727)	C-W Industries	Warminster, Pa.
DLV	(99800)	Delevan Electronics	East Aurora, N.Y.
ELD	(03797)	Eldema Corp.	Compton, Ca.
ELM	(72136)	Electromotive Mfg.	Willimantic, Conn.
ERT	(72982)	Erie Technological	Erie, Pa.
IRC	(75042)	International Resistance Corp.	Philadelphia, Pa.
KEL	(07088)	Kilvin Resistors	Van Nuys, Ca.
KH	(83865)	Krohn-Hite Corp.	Avon, Mass.
KID	(12126)	Kidco Inc.	Medford, N.J.
RCA	(49671)	Radio Corp. of America	Harrison, N.J.
SP	(56289)	Sprague Electric Co.	North Adams, Mass.
STT	( )	Stettner-Trush	Cazenovia, N.Y.
TL	(94322)	Tel-Labs, Inc.	Needham, Mass.
TR	(03877)	Transitron Electric Co.	Wakefield, Mass.
TRW	(84411)	TRW Capacitor Div.	Ogallala, Neb.