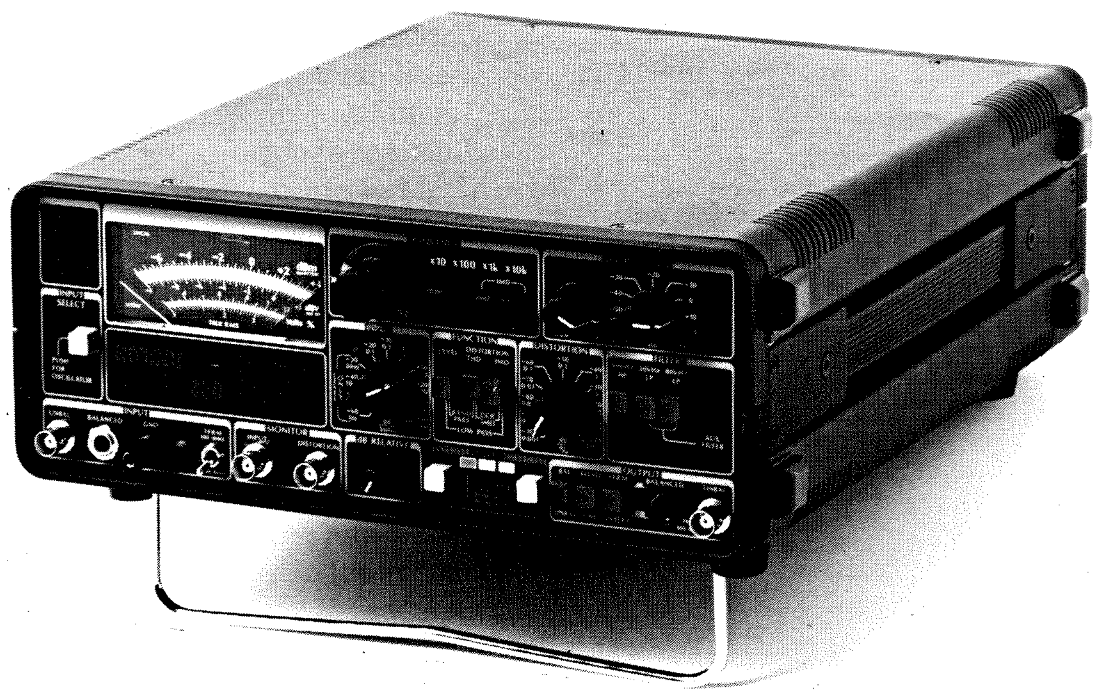
model 3501

amber

Distortion & Noise Measuring System



Operating & Service manual

Issue 09

April 1988

Amber Electro Design Inc. Montreal Canada

LIMITED WARRANTY

AMBER ELECTRO DESIGN INC. warrants its products to be free from defects in material and workmanship for a period of one year from date of original shipment. This obligation is limited to repair or replacement of defective products returned, freight prepaid, to Amber or any of its authorized service representatives. This warranty shall apply only to units which, in the sole opinion of Amber, have not been either subjected to abuse, negligence or accident, or serviced by others contrary to instructions provided by Amber. Batteries and periodic calibration are not covered by this warranty.

Notice of defect should be forwarded to Amber who will then instruct the customer where and how to ship the unit for repair. Unauthorized returns will be refused.

No other warranty is expressed or implied. Amber is not liable for consequential damages. Laws in your area may dictate rights not reflected in this warranty.

AMBER MODEL 3501 OWNER'S MANUAL

This product is protected by one or more of the following patents: 4,340,854; 3,714,462.

Other patents pending.

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AMBER model 3501

DISTORTION & NOISE MEASURING SET

OWNER'S MANUAL

Issue 09 April 1988

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DISTORTION & NOISE MEASURING SET

OWNER'S MANUAL

SECTION 1

GENERAL INFORMATION

Issue 09 April 1988

1. GENERAL INFORMATION

1.1 Instrument Description

The Amber model 3501 Distortion and Noise Measuring Set incorporates in a single compact enclosure an ultra low distortion sine wave generator, a high performance total harmonic distortion measuring system and a wide range, high sensitivity signal level and noise measuring facility.

In addition, a tunable band pass filter is included allowing the system to function as a selective voltmeter for manual spectrum analysis. This filter may also be configured as a low pass filter for band limited noise measurements.

The instrument incorporates a comprehensive set of user modifiable filters for weighted noise measurements to various standards and band limiting in the distortion mode.

As an option, the instrument may also be fitted with an additional oscillator and an Intermodulation Distortion measurement facility.

The instrument includes a balanced differential input and may also be fitted with an optional balanced output interface for measurements of professional and broadcast systems. Additionally, a high resolution digital frequency meter may be fitted.

The instrument contains a high efficiency power supply and may optionally include an internal rechargeable battery and charger. It may be powered from any international voltage from 100V to 240V AC, 50 or 60 Hz.

The model 3501 provides a high level of performance in a size significantly smaller than conventional instruments yet its performance in virtually every parameter rivals that of the best laboratory instruments. Speed of operation and speed of measurement have been optimized and automatic operation is provided for many functions.

MODEL 3501 SPECIFICATIONS

SIGNAL SOURCE (unbalanced output)

Frequency Range	: 10Hz to 100kHz in four overlapping ranges. Continuously variable vernier drive FREQUENCY control permits selection of any frequency.
Output Level Range	: maximum +18dBm (+20dBm typical) into 600 ohm load, (12.6V rms open circuit) to ≤60dBm minimum plus OFF.
Output Level Control	: 9 steps of 10dB (±0.5dB at 1kHz) and variable control of ≥10dB.
Amplitude Flatness (referred to 1kHz)	: ±0.1dB 20Hz to 20kHz ±0.2dB 10Hz to 100kHz
Output Source Impedance	: 600 ohms ±2% at all control settings (except MAX where impedance is approx. 300 ohms).
Distortion : (THD) (RL ≥600 ohms) (passive notch THD measurement method)	: 50Hz to 5kHz ≤0.0008% (-102dB) 10Hz to 10kHz ≤0.0015% (-96dB) 10kHz to 50kHz ≤0.003% (-90dB) 50kHz to 100kHz ≤0.006% (-84dB)

Additional specifications for option 006 IMD:

Signal Source (SMPTE/DIN Mode)	: Composite mix of main oscillator and additional low frequency oscillator.
Amplitude Ratio	: LF:HF 4:1 ±5% (±0.5dB)
LF Signal	: 60Hz ±5% (internally changeable from 20Hz to 500Hz)
HF Signal	: 2kHz to 100kHz total range.
Residual IM (SMPTE/DIN mode)	: ≤0.003% (-90dB)

Supplementary data for option 006:

CCIF Mode:	*Rear panel external input for second signal to mix with internal oscillator to generate twin-tone composite signal. With external oscillator level of approximate +10dBV (316mV rms) mix ratio will be 1:1.*

Additional specifications for option 005 Balanced Output:

Output Level Range	: maximum +28dBm (+30dBm typical) into 600 ohm load, (24V rms open circuit) to ≤-60dBm minimum plus OFF
Amplitude Flatness: (referred to 1kHz)	±0.2dB 20Hz to 20kHz ±0.5dB 10Hz to 100kHz
Output Source Impedance	: 600 ohms ±2% at all control settings except MAX where impedance is < 100 ohms
Distortion (THD) (+28dBm to -30dBm) terminated or open circuit. Passive notch THD measurement method.	: 50Hz to 5kHz ≤0.0015% (-96dB) 20Hz to 20kHz ≤0.003% (-90dB) 20kHz to 50kHz ≤0.006% (-84dB) 50kHz to 100kHz ≤0.01% (-80dB) 10Hz typically ≤0.03% (-70dB)

Supplementary Data for Signal Source:

Output Configuration Unbalanced	*: Output BNC connector may be referenced to chassis or floated above ground ±30V peak. (≤0.5 μf between low output terminal and chassis in float mode)*
Balanced	*: Output connector is tip-ring-sleeve telephone style jack (mates with WE-310 plug or equivalent). Output is transformer coupled to provide isolation and balance. Center tap may be referenced to chassis or floated above ground ±30V peak. (≤0.5μf between output center tap and chassis in float mode)*
Output DC Offset	*: Unbalanced : ≤0.1% of output AC rms voltage* *Balanced : ≤0.1% of output AC rms voltage*

DISTORTION MEASUREMENT (THD + N)
(specifications apply to both balanced and unbalanced input except where noted) :

Fundamental Frequency Range	: 10Hz to 100kHz in four overlapping ranges
Input Level Range	: +40dBV to -30dBV (+42dBm to -28dBm) (100V rms to 30mV rms)
Measurement Bandwidth	: 10Hz to 300kHz ±3dB
Accuracy (harmonic measurement)	: Fundamental 20Hz to 20kHz : ±1dB Fundamental 10Hz to 50kHz : ±2dB Fundamental 50kHz to 100kHz : ±3dB
Residual THD + N Input signal within top one third of meter scale in LEVEL mode and signal >0dBV (1Vrms)	: 20Hz to 10kHz, 30kHz B.W. : <0 .0018%/-95dB 50Hz to 5kHz, 30kHz B.W. typically : <0.0008%/-102dB 10Hz to10kHz, 80kHz B.W.: <0.003%/-90dB 10kHz to 100kHz, full B.W.: <0.01%/-80dB

Supplemental Data for THD + N Measurement:

Fundamental Rejection	*: Typically 10dB below specified residual THD of instrument or actual signal THD, whichever is greater.*

DISTORTION MEASUREMENT (IMD) (requires option 006)
Specifications apply to both balanced and unbalanced input except where noted.

Function :	SMPTE/DIN Mode:	Measures LF signal AM modulation of HF signal as a percentage or ratio of HF signal
	CCIF Mode:	Measures difference frequency component (F_1 - F_2) expressed as a percentage or ratio of high frequency twin-tone composite signal
Frequency Range	SMPTE/DIN:	Low frequency : 10Hz to 500Hz High frequency : 2kHz to 100kHz
	CCIF:	Mean frequency : 2kHz to 100kHz F_1 - F_2 : 10Hz to 1kHz
Input Level Range:		Same as THD
Amplitude Mix	SMPTE/DIN:	1:1 to 5:1 (LF:HF)
	CCIF :	1:1 ±10%
Residual Distortion :	SMPTE/DIN (LF 20Hz to 200Hz, HF 5kHz to 100kHz, mixed at 4:1)	: ≤0.003% (-90dB)
	CCIF (5kHz to 100kHz, F_1 - F_2 = 20Hz to 500Hz mixed at 1:1	: ≤0.003% (-90dB)

Accuracy (same conditions as residual distortion specifications above) : ±1dB (±10%)

LEVEL/NOISE MEASUREMENT FUNCTION
(specifications apply to both balanced and unbalanced input except where noted)

Maximum input level : +40dBV, (+42dBm, 100V rms)

Minimum signal reading

LEVEL mode : -70dBV (-68dBm, 0.3mV)

LOW PASS or BAND PASS mode: -130dBV, (-128dBm, 0.3μV)

Bandwidth (-3dB) : 3Hz to ≥300kHz

Residual Noise (source resistance 1k ohm):

Low Pass Mode:

$F_c \leq$ 5kHz : ≤ -120dBV (1μV)

$F_c \leq$ 100kHz: ≤ -110dBV (3μV)

Band Pass Mode (12% BW) :

$F_c \leq$ 1kHz : ≤-120dBV (1μV)
$F_c \leq$ 100kHz: ≤-100dBV (10μV)

Accuracy, LEVEL Mode
Input Signals -60dBV (1mV)
or greater : 20Hz to 20kHz : ±2% (±0.3dB)
10Hz to 100kHz : ±4% (±0.5dB)

Common Characteristics, measurement section.
(Applies to unbalanced input except where indicated.)

Input Impedance : 100k ohms ±2% shunted by ≤100pf

Balanced Input : 100k ohms ±2% each side to ground shunted by ≤200pf

Common Mode Rejection (balanced input) : ≥40dB at 50 or 60Hz

dB Relative Control range : ±12dB

Supplemental data for measurement section:

Meter Detection	*: True rms for signals with crest factor ≤3*
Meter Scales	*: dBm (ref 1mW, 600 ohms) - linear + 4dBm to -8dBm* *dBV (ref 1V rms) - linear +2dBV to -10dBV* *Volts, percent-logarithmic 4 to 1 and 1.2 to 0.3*
Indicators	*: Two input level LEDs indicate over or under range in DISTORTION mode to facilitate correct setting of INPUT level control. Low LED warns when input level is below minimum input level (i.e. -30dBV).* *Two tuning LEDs facilitate tuning of analyzer in THD mode when using an external oscillator*
Monitors	*: INPUT MONITOR provides scaled presentation of input signal. Signal level approximately -10dBV (316mV rms) for full scale signals and INPUT control settings of +40 to -20dB. Proportionately lower at lower settings. Source impedance 600 ohms ±10%* *DISTORTION MONITOR provides scaled presentation of function being measured: input signal in LEVEL mode, distortion components in DISTORTION modes and filtered signal in LOW PASS or BAND PASS modes. Signal level approximately -10dBV (316mV rms) with full scale readings in both LEVEL mode and for measured value. Proportionately lower with lower levels. Source impedance 600 ohms ±10%.*

FILTERS:

400Hz High Pass (standard)	: -3dB at 400Hz ±5%, at least 40dB rejection at 60Hz
30kHz Low Pass (standard)	: -3dB at 30kHz ±5%
80kHz Low Pass (standard)	: -3dB at 80kHz ±5%

Supplementary Data for Filters:

Filter Characteristics of three standard filters described above

	: 3 pole Butterworth response (18dB/octave)
Auxiliary Filter	*: 16 PIN socket to accept various filters available from Amber including ANSI/IEC A Weighting, CCIR and others. Details provided for user construction of custom filters.*
Band Pass Level Mode	*: Tuneable band pass filter with a bandwidth of approximately 12%. User changeable from 100% to less than 1% with single resistor change.*
Low Pass Level Mode	*: Low pass filter with tuneable cutoff point. Slope characteristics: 12dB per octave. Pass band ripple 3dB.*
Frequency Range Band Pass & Low Pass Modes	*: 10Hz to 100kHz (tracks oscillator within ±3%).*

General:

Temperature, operating	: 0°C to +50°C
Temperature, storage	: -40°C to +75°C
Humidity Range	: <95% RH, 0°C to +40°C
Power Requirements	: Instrument operates from external AC mains at 100, 120, 220 or 240V rms +5%, -10%, 48 to 62Hz.
Internal Battery (option 001)	: 12V rechargeable battery and charging system provide 1.5 hours or more of instrument operation after full charge. Two rate charger automatically switches between high charge and float mode.
(option 002)	: Same as above but provides 3 hours or more.

Dimensions (excluding bottom feet and front and rear panel projections):

H x W x D	: 114 mm x 292 mm x 356 mm (4.5 in x 11.5 in x 14 in)
Weight	: Basic instrument : 5.7 kg (12.5 lbs) As above with 001 Battery : 6.8 kg (15 lbs As above with 002 Battery : 8.2 kg (18 lbs)

Note : Values shown in SPECIFICATIONS are warranted specifications. *SUPPLEMENTARY DATA shown in italics are non-warranted and supplied for information only.*

All specifications subject to change without notice.

1.3 OPTIONS

Note : All 3501 instruments will have the same outward appearance, that is, the front panel will incorporate provision for all options. Thus although the front panel pushbutton for IMD or OUTPUT BALANCED operation may be present, it does not necessarily mean that the internal module is present to provide the function. The front panel and internal wiring are present to facilitate future instrument upgrade by the user.

To determine the instrument configuration at the time of initial factory shipment note the five digit model number suffix recorded on the serial number plate on the rear panel of the instrument. Below is a table showing the option configuration for various model numbers.

3501 -- 00000

Power Option	Output	Measurement	Auxiliary Features	Auxiliary Filter
0 AC mains only	0	0 THD only	0 None	0 None
1 001 Battery + charger	1	1 006 IMD	1 358 Frequency Counter	1 ANSI "A"
2 002 Battery + charger	2 005 Balanced Output	2	2 330 Preset Freq & Stereo	2 CCIR
3	3	3	3 331 (330+358)	3 IHF/IEEE Band Pass
4	4	4	4	4 Psophometric
5	5	5	5	5 C Message
6	6	6	6	6 C Message & Notch
7	7	7	7	7 3kHz Flat
8	8	8	8	8 15kHz Flat
9	9	9	9	9 Custom Filter

001 RECHARGEABLE BATTERY & CHARGER SYSTEM

12V 2.5AH battery and power supply provides independent instrument power and isolates grounds. Gives approximately one and one half hours or more of operation on a full charge. Automatically shuts down instrument when battery reaches end of life.

002 EXTENDED LIFE BATTERY & CHARGER

Same as 001 above but with 12V 5AH battery for approximately 3 hours or more of operation.

005 BALANCED OUTPUT

Adds a floating/balanced output capability to instrument. Also increases capability to provide up to +28dBm (+30dBm typical) output capability into a 600 ohm load. Uses a transformer for true float and a proprietary active correction technique to virtually eliminate distortion contribution.

006 INTERMODULATION DISTORTION MEASUREMENT/GENERATION FACILITY

Adds a second (low frequency) oscillator and mixing circuitry to provide twin-tone composite signal (SMPTE type) and intermodulation measurement circuits to measure SMPTE, DIN, CCIF or IHF distortion. Frequency range 2kHz to 100kHz.

107/108 RACK MOUNT KIT

Mounts the 3501 and its options in a standard 19 inch EIA rack. Option 107 occupies three rack units (nominal 5.25 inches) in height to mount a standard 3501. It can also be supplied in a four rack unit height (nominal 7 inches) to mount a 3501 and a 358 combined.

Option 108 occupies five rack units (nominal 8.75 inches) to mount a 3501 with either a 330 or 331 option.

109 SPEAKER AMPLIFIER

Adds an internal speaker and power amplifier to allow aural monitoring of the measured signal. Can be used in the narrow band mode to find interference signals in noise or in the distortion modes to identify the distortion products. A front panel volume control is included.

330 PRESET FREQUENCY and STEREO SWITCH MATRIX

This adds a stereo switch matrix on the input and output, a preset modulation percentage switch and a preset frequency switch. This facility is particularly suited to stereo broadcast transmitter measurements. Provision is included to allow the generator to feed Left channel only, Right channel only, Left and Right in phase (L + R) and Left and Right out of phase (L-R). A four-channel input switch allows independent selection of Left, Right, Aux A or Aux B input signals. A six position modulation percentage switch selects 100%, 95%, 85%, 75%, 50% or 25% and adjusts the generator output signal level accordingly. Finally, 15 common preset frequencies allow quick selection of test frequency. Frequencies are 50, 100, 200, 250, 300, 400, 1k, 2k, 2.5k, 3k, 5k, 7.5k, 10k, 12.5k and 15kHz.

331 This option combines options 330 and 358 in a single enclosure. See the separate descriptions above.

358 HIGH RESOLUTION FREQUENCY METER

Adds a six digit frequency readout of internal oscillator or external signals. Frequency multiplier provides two orders of magnitude improvement in measurement speed/resolution over conventional meters with several readings per second and up to 0.01Hz resolution. "Smart" signal detector automatically blanks display in absence of sufficient signal amplitude. Auto range circuitry (with manual override) permits measurement from below 10Hz to over 500kHz (typically 1MHz). Using the high meter sensitivity and filtering of the 3501, valid measurement of low level and noisy signals is possible. Pushbutton input selection permits measurement of 3501 oscillator, external signal input or the external signal with filtering.

Pushbuttons select either fast (approx. 3 readings/second, 0.1 Hz resolution) or high resolution (0.01Hz resolution, 1 reading/second).

The 358 is powered by the 3501 internal power supply and automatically switches off when the 3501 is turned off. It mounts on the top cover of the 3501 adding approximately 1.2 inches (3 cm) to the height and is 7.7 inches (20 cm) wide by 8.5 inches (22 cm) deep. It plugs in to existing connectors on the 3501 and may be field retrofitted.

960 CARRYING CASE

A durable, shippable case houses the 3501 and accessories. Internal foam lining protects the instrument from shock. External metal corners and reinforcing is suitable for common carrier shipping.

FILTERS

To accommodate various noise weighting standards several special and custom filters are available. Normally, if a single optional filter is ordered, it will be fitted to the AUX FILTER position of the 3501. Alternatively, any of the four filter positions may be populated with any of several available filters.

Typical choices for standard optional filters include ANSI/IEC "A" weighting and CCIR 468-2.

Custom filters include the IHF-T-200/IEEE 185 receiver band pass, the telecommunications C message weighting with and without notch, program weighting and Psophometric. One, two and three pole high pass and low pass filters are easily accommodated and may be either purchased from Amber or constructed by the user from data supplied in the 3501 owner's manual.

AMBER model 3501

DISTORTION & NOISE MEASURING SET

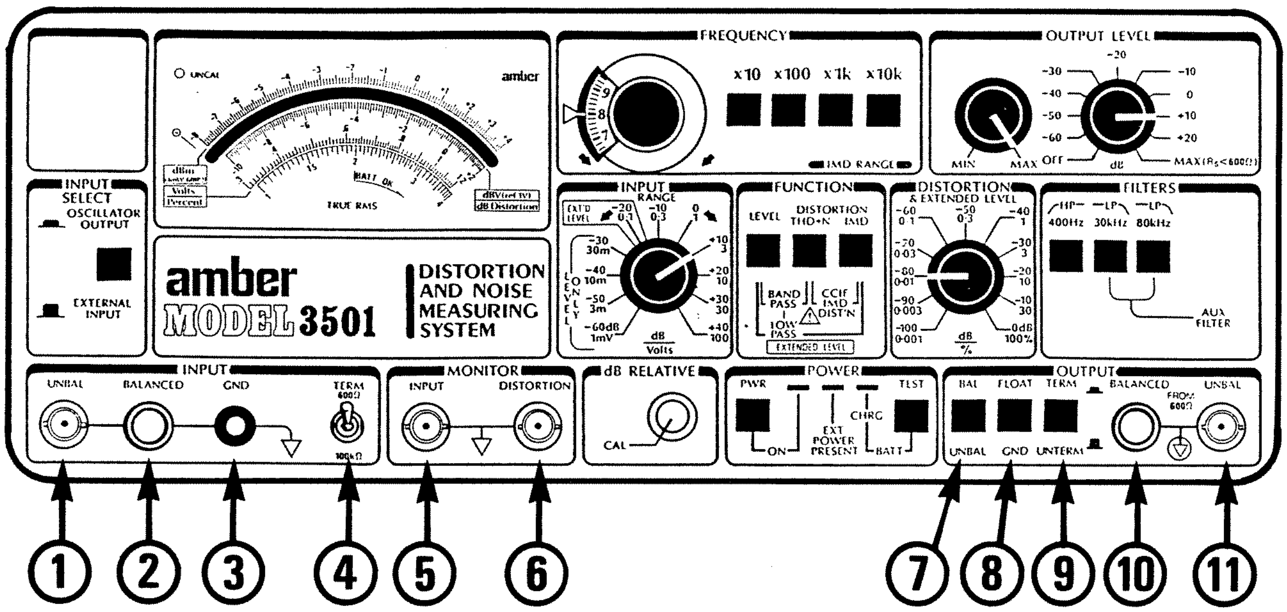
OWNER'S MANUAL

SECTION 2

OPERATING INSTRUCTIONS

Issue 09 April 1988

3501 EXTERNAL CONNECTIONS



INPUT CONNECTIONS

Connect unbalanced or single ended source to 1.

Connect balanced or non-ground referenced sources to 2. Floating or bridged power amplifiers would connect here.

This differential input can also be used to break ground loops: connect external source to tip, external ground to ring and input cable shield to sleeve. GND terminal (3) is chassis and same potential as shell of 1 or sleeve of 2.

OSCILLOSCOPE CONNECTIONS

Use dual trace oscilloscope. Connect trace A to 5 to view fundamental, trigger on this trace. Connect trace B to 6 to see distortion components.

OUTPUT CONNECTIONS

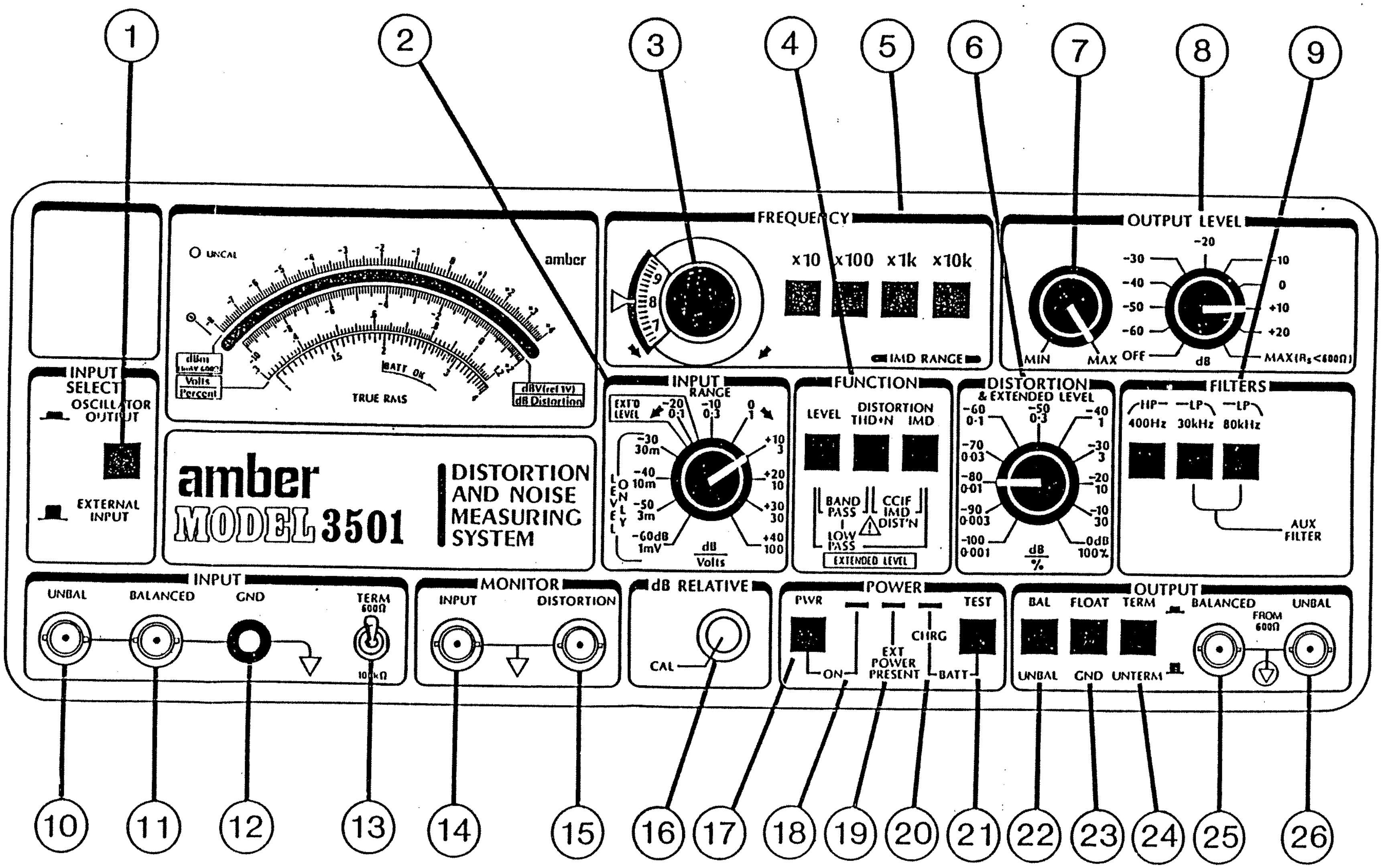
Connect inputs of unbalanced or single ended devices to be tested to 11.

If option 005, BALANCED OUTPUT, is provided, connect balanced devices to 10 (use a telephone style WE-310/PJ051 tip-ring-sleeve plug).

Select balanced or unbalanced mode at 7.

Select grounded output or floating output at 8. Use grounded mode if 3501 being used as an oscillator only. If analyzer section is also connected to device under test, use FLOAT mode as ground will be via input ground connection to 3501.

9 terminates oscillator output in 600 ohms or leaves output unterminated.


1
2
3
4
5
6
7
8
9
amber
TRUE RMS
BATT OK
dBm
Volts
Percent
dBV(ref 1V)
dB Distortion
UNCAL
INPUT SELECT
OSCILLATOR OUTPUT
EXTERNAL INPUT
amber
MODEL 3501
DISTORTION AND NOISE MEASURING SYSTEM
FREQUENCY
x10 x100 x1k x10k
IMD RANGE
OUTPUT LEVEL
MIN MAX
-30 -20 -10
-40 0
-50 +10
-60 +20
OFF dB MAX(Rs<600Ω)
INPUT RANGE
EXT'D LEVEL
-20 0·1
-10 0·3
0 1
-30 30m
+10 3
-40 10m
+20 10
-50 3m
+30 30
-60dB 1mV
+40 100
dB Volts
LEVEL ONLY
FUNCTION
LEVEL
DISTORTION THD+N IMD
BAND PASS
LOW PASS
CCIF IMD DIST'N
EXTENDED LEVEL
DISTORTION & EXTENDED LEVEL
-60 0·1
-50 0·3
-40 1
-70 0·03
-30 3
-80 0·01
-20 10
-90 0·003
-10 30
-100 0·001
0dB 100%
dB %
FILTERS
HP 400Hz
LP 30kHz
LP 80kHz
AUX FILTER
INPUT
UNBAL BALANCED GND
TERM 600Ω
100kΩ
MONITOR
INPUT DISTORTION
dB RELATIVE
CAL
POWER
PWR TEST
ON
EXT POWER PRESENT
CHRG
BATT
OUTPUT
BAL FLOAT TERM
UNBAL GND UNTERM
BALANCED
FROM 600Ω
UNBAL
10
11
12
13
14
15
16
17
18
19
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21
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26

1) INPUT SELECT PUSHBUTTON. Selects input to analyzer. Push in to read actual GENERATOR OUTPUT LEVEL for any value of external load. Release to read the INPUT signal.

2) INPUT control determines input sensitivity. Set for an on-scale meter reading in the LEVEL mode or to extinguish the HI and LO LED warning indicators in distortion modes.

3) FREQUENCY vernier control. Sets significant digit of oscillator and analyzer frequency.

4) FUNCTION pushbutton group. Basic functions of LEVEL, TOTAL HARMONIC DISTORTION and SMPTE INTERMODULATION DISTORTION are set by pushing one of the three buttons. Special functions of BAND PASS LEVEL, LOW PASS LEVEL & CCIF INTERMODULATION DISTORTION are selected by pushing two buttons together. (Note IMD functions operational only if option 006 is installed.)

5) FREQUENCY RANGE pushbutton selects multiplier of number set by rotary vernier knob.

6) DISTORTION control determines meter sensitivity. Set for an on- scale meter reading in the DISTORTION mode or the BAND PASS/LOW PASS mode.

7) Output control provides a nominal 12dB variation of output level.

8) OUTPUT attenuator sets the nominal 10dB step of output range. Source impedance is 600 ohms (in all positions except MAX). When output is loaded with 600 ohms, all steps (except MAX) will be 10dB. OFF position shuts down oscillator but retains 600 ohm source impedance.

9) FILTER pushbutton group. Chooses appropriate selection from four available filters. Three standard filters selected by pushing in one or more of the three buttons. Fourth (AUX FILTER) filter position selected by pushing in second and third button simultaneously (only functional if optional fourth filter installed).

10) UNBALANCED INPUT connector. Use for single ended sources. Shell of BNC connector is normally connected to chassis but floats when PUSH FOR OSCILLATOR is pushed. Input impedance set by (13) is 100k ohms or 600 ohms in parallel with about 100pf.

11) BALANCED INPUT connector. Tip, ring and sleeve telephone-type connector (e.g. WE310) for balanced inputs. Sleeve is chassis when INPUT is selected. Inserting a plug disconnects the UNBAL input.

12) GROUND post is normally connected to chassis but floats when PUSH FOR OSCILLATOR is pushed.

13) INPUT TERMINATION switch selects input impedance for both balanced and unbalanced inputs.

14) INPUT MONITOR connector presents a scaled replica of INPUT signal after INPUT control.

15) DISTORTION MONITOR connector presents a scaled replica of signal being measured: the input signal in LEVEL, distortion residual components in DISTORTION and the selective filter output in BAND PASS or LOW PASS.

16) dB RELATIVE control allows meter reading to be offset up to 12dB to set an arbitrary zero dB reference. (Useful for frequency response and signal-to-noise measurement.)

17) POWER ON/OFF pushbutton. Turns instrument on and off using either internal (battery) or external (transformer) power source. Will turn off automatically on low battery.

18) POWER indicator. Red LED indicates unit is ON. When optional battery reaches last 10% of life, LED starts to blink. Blinking duty cycle increases as battery nears end of discharge until instrument automatically shuts off.

19) EXTERNAL POWER PRESENT indicator. Green LED indicates the presence of adequate external power source, typically AC mains via the wall plug transformer. Will extinguish if mains voltage is too low or internal fuse opens.

20) CHARGE indicator. Orange LED indicates high-charge rate of battery charging. When battery is fully charged, indicator will extinguish and charger will switch to a float charge mode. High-charge rate may require instrument to be switched off. (Functional only if option 001 or 002 battery is installed.)

21) BATTERY TEST pushbutton. Switches measurement meter to battery to measure battery charge condition. Should be pushed with instrument turned ON. A reading of mid-scale ("BATT OK") or greater indicates satisfactory battery charge. Deflection is approx. proportional to battery life available. (Meaningful only if option 001 or 002 battery is installed.)

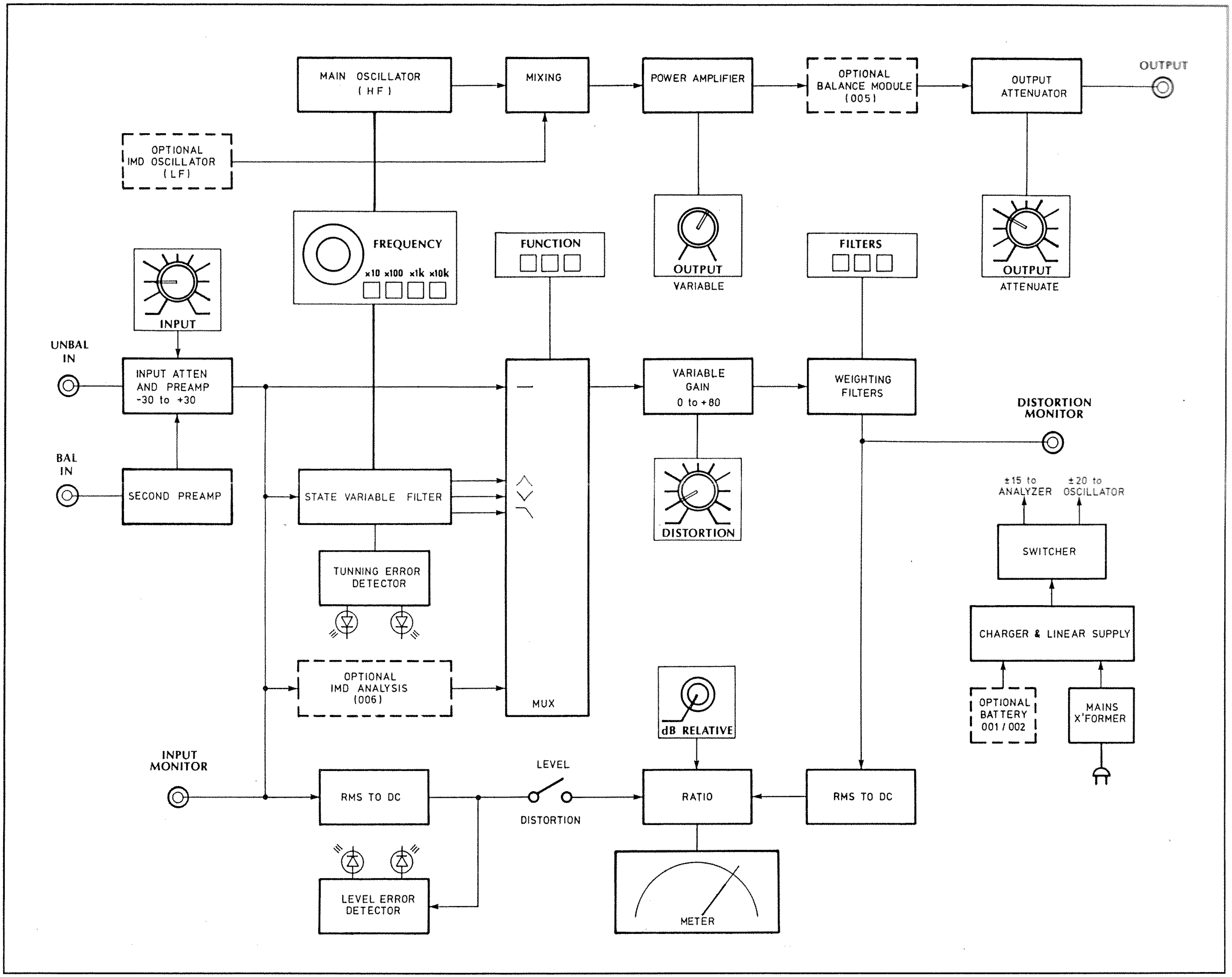
22) BALANCED/UNBALANCED pushbutton. (Valid only if option 005, Balanced Output, is provided.) With button out, generator output is present on UNBAL BNC connector and in a single ended mode on the tip- ring-sleeve BAL jack. With button in, optional balancing system is inserted and a balanced output appears at the T-R-S jack.

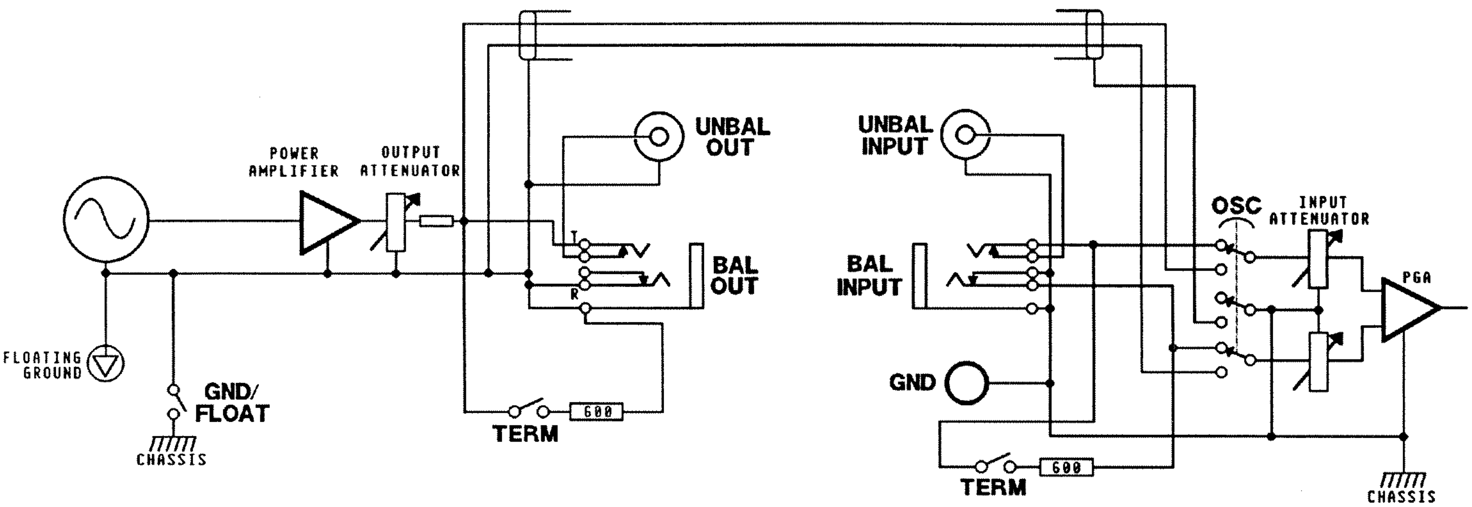
23) FLOAT/GROUND pushbutton. In unbalanced mode, button pushed in sets shell of BNC and sleeve-ring of jack to a floating condition with respect to instrument chassis and input ground. With button out, all grounds are common. In balanced mode, button in sets BAL out to float condition. Sleeve is chassis ground and center tap of output floats with respect to instrument ground. With button out, sleeve and center tap are connected to instrument common ground (chassis).

24) TERMINATE/UNTERMINATE pushbutton. With button out, output is unterminated. With button in, output is terminated (i.e. loaded with 600 ohms). Note that output source impedance is 600 ohms at all times except if OUTPUT ATTENUATOR is set to MAX when output source impedance is approximately 300 ohms unbalanced, d ohms balanced.

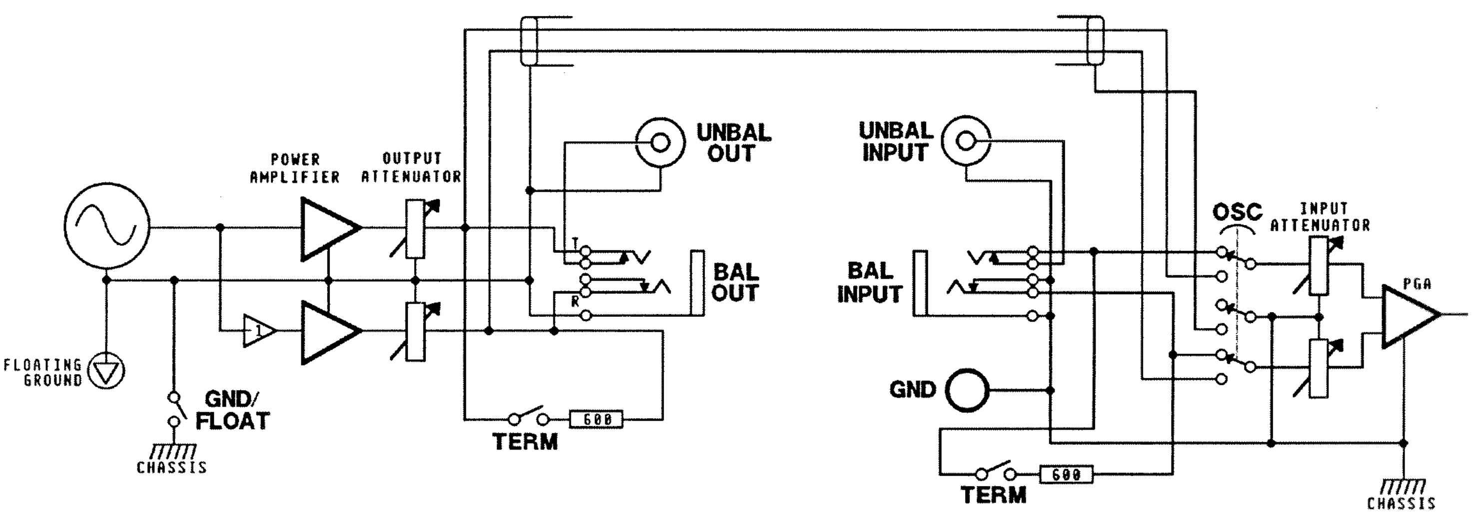
25) BALANCED output jack. Tip, ring and sleeve telephone type jack provides balanced output in balanced mode (with option 005) or single ended output (tip and sleeve) in unbalanced mode. Use only WE310 type plug.

26) UNBALANCED output connector. BNC connector provides unbalanced output. Disconnected in BALANCED mode.


MAIN OSCILLATOR (HF)
MIXING
POWER AMPLIFIER
OPTIONAL BALANCE MODULE (005)
OUTPUT ATTENUATOR
OUTPUT
OPTIONAL IMD OSCILLATOR (LF)
FREQUENCY
x10 x100 x1k x10k
FUNCTION
OUTPUT
VARIABLE
FILTERS
OUTPUT
ATTENUATE
INPUT
UNBAL IN
INPUT ATTEN AND PREAMP -30 to +30
VARIABLE GAIN 0 to +80
WEIGHTING FILTERS
DISTORTION MONITOR
BAL IN
SECOND PREAMP
STATE VARIABLE FILTER
DISTORTION
±15 to ANALYZER
±20 to OSCILLATOR
SWITCHER
TUNNING ERROR DETECTOR
CHARGER & LINEAR SUPPLY
OPTIONAL IMD ANALYSIS (006)
MUX
dB RELATIVE
OPTIONAL BATTERY 001 / 002
MAINS X'FORMER
INPUT MONITOR
LEVEL
RMS TO DC
DISTORTION
RATIO
RMS TO DC
LEVEL ERROR DETECTOR
METER



UNBALANCED MODE. This is a simplified schematic of INPUT and OUTPUT connections in the UNBALANCED MODE. INSTRUMENT GROUND is chassis.



BALANCED MODE. This is a simplified schematic of INPUT and OUTPUT connections in the BALANCED mode (provided option 005 is installed.)

2. OPERATING INSTRUCTIONS

2.0 INTRODUCTION

This section contains detailed operating instructions for use of the model 3501 instrument. It describes the general philosophy of the instrument, description and use of its operating controls, interface to the device under test and any required external equipment.

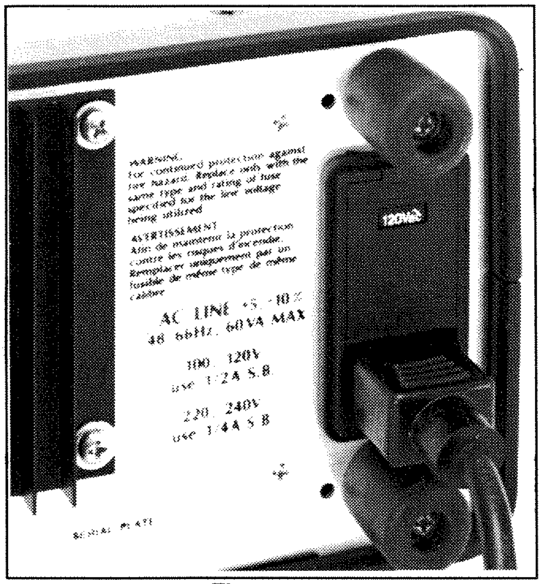


Figure 2.1

Rear panel AC mains connector with cord in place.

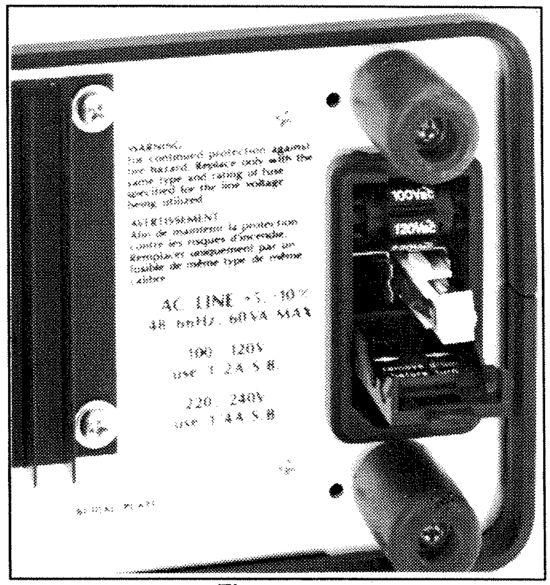


Figure 2.2

Mains connector opened to show voltage change drum and fuse carrier.

NOMINAL VOLTAGE	OPERATING RANGE (+5% -10%)	FUSE (Slow Blow) (primary)
100 Volts	90 to 105 Volts	0.5A S.B.
120 Volts	108 to 126 Volts	0.5A S.B.
220 Volts	198 to 231 Volts	0.25A S.B.
240 Volts	216 to 252 Volts	0.25A S.B.

Table 2-1

2.1 PREPARATION FOR USE

The model 3501 is able to be powered from virtually any common mains power source available worldwide. It can be set to require a nominal voltage of 100, 120, 220 or 240 V AC and will accept any frequency from 48 to 62Hz.

The AC mains is connected to a rear panel mounted standard IEC receptacle. A supplied line power cord can be used for North American operation. Users in other areas may either remove the North American plug and substitute their own or, if local code requires, provide a mains power cord with a suitable plug and cable type.

The mains power receptacle also contains a fuse holder and a voltage selection mechanism to allow the user to adapt the instrument to suit the power source available. Before connecting the instrument to the AC mains source, be sure to set these conditions properly. Severe internal damage to the 3501 can result if conditions are not properly set.

Figure 2-1 shows the AC mains receptacle/fuse holder/voltage tap selector. A small window just above the receptacle will display a nominal voltage from one of the following choices: 100, 120, 220, 240. If it is showing a number corresponding to the supply you intend to use, you need not make any further changes. Simply connect the AC mains cord and use the instrument.

If the displayed number does not correspond to the intended choice, you will have to change the selection and you may also have to change the fuse. Refer to Table 2-1 for information on the correct setting.

To change the voltage selection, remove the AC mains cord and pull down the small hinged door above the AC receptacle. This will expose a drum that has the four available voltage selections printed on its circumference. Rotate the drum to the desired selection.

If it is necessary to change the fuse, pull out the rectangular fuse carrier. The fuse may be removed and a new fuse inserted. Replace the carrier with the same orientation as before. Note that the supplied carrier is sized to accept North American 3AG type fuses (1.25 inch x 0.25 inch). Alternatively, Amber can supply a carrier to accept European type (5 x 20 mm) fuses.

With the proper fuse installed and the correct voltage selection visible on the drum, close the hinged door until it snaps. The selected nominal voltage will be visible through a small window.

Note that some countries may have an electrical safety code that requires both sides of the line to be independently fused. To conform to the majority world requirement, Amber provides a fuse for only the LINE side of the input. However, the AC mains receptacle/fuse holder/voltage tap assembly allows for two fuses to be used although some modification will be required. There is a slot for a second (identical) fuse carrier and the connector assembly can be rewired to include a fuse in the NEUTRAL side of the line. Refer to the technical information in Section 8 of this manual.

2.1.1 FUSES

The primary mains fuse is located in the AC mains receptacle on the rear panel as described in Section 2-1. A second fuse is included internally after the secondary of the mains transformer. If this fuse opens, the instrument will not receive external mains power even if the external primary fuse is functional. This will prevent the instrument from being powered from the mains supply and inhibit the operation of the optional battery charger. However, the internal battery will continue to be usable as a power source until discharged. If no battery is present, the instrument will simply not turn on. If a battery is present, the instrument may turn on as long as some charge remains in the battery. Check the "MAINS POWER PRESENT" green indicator on the front panel. If the red POWER indicator is on but the green indicator is off, the instrument is being powered by the battery only.

2.2 SYSTEM DESCRIPTION

The model 3501 Distortion and Noise Measuring set contains two electrically separate but mechanically interlocked sections: a Generator and a Measuring system. As such, it is completely able to perform measurements without the use of additional equipment although an oscilloscope is very useful.

The system will measure wide-band signal level, wide-band noise, total harmonic distortion, band limited noise and crosstalk. By extension, it can measure frequency response, noise spectrum, distortion versus frequency and distortion versus level.

The instrument contains a precision ultra low distortion sine wave oscillator followed by a power amplifier and output attenuator. This generator is able to generate the test signals for all the measurements possible in the measuring system. (An exception is CCIF IMD Section 2.13.3.)

Signal and noise levels are measured by a precision variable gain amplifier followed by a true rms detector and analog meter. It is capable of operation over a wide dynamic range of up to 160dB or 100 million-to-one.

The primary function of the instrument is to measure total harmonic distortion. In fact, the more precise description of the resulting measurement is "Total Harmonic Distortion plus Noise". It does this by sending an essentially pure single frequency to a device under test, eliminates this fundamental frequency from the received signal output of the device under test, measures everything that is left and presents this amplitude as a ratio of the total received signal.

For example, assume a test frequency of 1kHz. The 3501 will generate this signal with harmonics greater than 100dB down resulting in an essentially pure signal. For simplicity, assume the device under test is unity gain and we wish to measure THD at 0dBV, i.e. a 1V level. The generator will provide the 1kHz, 0dBV signal to the input of the device under test, the 0dBV signal output will be fed to the input of the 3501. A very deep notch filter (band reject filter) will provide over 100dB of rejection of the 1kHz fundamental. The non-linearities of the device under test will have added components at 2kHz, 3kHz, 4kHz, etc. The RMS meter of the 3501 will measure the amplitude of the root mean sum of these, compare this amplitude to that of the fundamental and display the result as a percentage or dB ratio. If the amplitude of the rms sum of the harmonics were 1 mV in this example, the meter would indicate 0.1% or -60dB.

Since the measuring circuits are measuring the total bandwidth minus only the small fundamental area, they will also measure noise along with the harmonics. In many cases, the noise will be below the harmonics and the measurement will be very close to the true harmonic distortion. In other cases, the noise will be higher and thus the measurement will actually be mostly noise and very little distortion. The use of an oscilloscope to monitor the distortion residual will assist the user in qualifying the measured result. Also see the section on Filters 2.7 following.

2.3 RMS DETECTION

Distortion and noise measurements will generally involve complex waveforms. Average-responding meters, which are usually calibrated in rms for a pure sine wave, will give significant errors when attempting to measure these complex waveforms. For this reason, the 3501 employs a precision rms detector in the measurement circuits.

Certain waveforms can yield an error of over 10% when measured with an average responding detector. The rms measuring circuits of the 3501 will provide an accurate measurement of signals with crest factors as high as 10 full scale (see Section 2.5.2 following). This assures accurate indication of distortion and noise signals.

2.4 SIGNAL GENERATION

The 3501 contains an ultra low distortion sine wave oscillator, an output power amplifier and an output attenuator. Also included are facilities to measure the output signal level using the 3501 meter.

The generator has a frequency range of 10Hz to 100kHz covered in four overlapping decade ranges. It has an amplitude range of +20dBm to - 60dBm unbalanced or up to +28dBm balanced and terminated. It provides continuous tuning and continuous level selection over its full operating range. Although ultra low distortion, it exhibits extremely fast amplitude settling time even at low frequencies. Output source impedance of the generator is 600 ohms at all but one attenuator setting including OFF. The exception is the MAX setting of the OUTPUT ATTENUATOR where the output source impedance is approximately 300 ohms unbalanced or < 100 ohms balanced. The output low terminal (BNC shell) is isolated from input low and chassis ground when in the FLOAT mode.

Frequency selection is made using the vernier drive rotary control and four-button switch bank in the FREQUENCY area of the panel. Actual frequency is the indication on the rotary dial multiplied by the number on the selected range. Some overlap is provided at each end of the rotary control to ensure that all frequencies within the instrument range are available.

Where the same frequency appears in two ranges (example 100Hz, 1kHz, 10kHz) the preferred selection is the lower range with the rotary control set to 10. (Example, 1kHz found by 10 x 100 rather than 1 x 1k; residual distortion of the instrument is slightly lower in this mode.)

Output signal level selection is made using the upper right rotary control and the rotary attenuator switch. Actual output level can be measured by pushing the PUSH FOR OSCILLATOR button at the left of the meter. This connects the input metering circuit directly across the output load for precise send-level measurements.

An OFF switch position in the OUTPUT ATTENUATOR provides a convenient means of making signal-to-noise measurements. In the OFF position the output connector is disconnected from the output power amplifier and connected to a 600 ohm resistor. For added safety, the oscillator circuit is disabled to avoid any chance of signal leak-through.

2.4.1 BALANCED OUTPUT

As an option, the instrument may be provided with a balanced output facility. Two output connectors are provided - a BNC for unbalanced output and telephone style tip-ring-sleeve jack for balanced output. This will permit convenient interface to conventional patch panels in systems applications. (The T-R-S jack mates with PJ-051 or WE-310 type plugs.)

Three pushbuttons in the OUTPUT section allow choice of output configuration:

a) BAL/UNBAL sets the output to unbalanced single ended mode or the balanced mode. In the balanced mode, an output transformer is used to provide maximum isolation and true balance. Electronic corrective circuitry (patent pending) significantly reduces the distortion contribution of the transformer.

b) FLOAT/GROUND. In the unbalanced mode this allows the oscillator to float with respect to instrument (analyzer) ground. In the balanced mode this grounds or floats the transformer secondary center tap.

c) TERM/UNTERM. In the TERM mode this terminates the output with a 600 ohm load resistor.

2.5 LEVEL MEASUREMENT (VOLTMETER OPERATION)

The 3501 will measure signal level over the frequency range of 10Hz to approximately 300kHz and from +40dBV (100 volts) to -60dBV (1mV) full scale. See Section 2.8 following for signals below -60dBV.

To measure signal level, connect the signal to the appropriate INPUT connector, select LEVEL in the FUNCTION group and turn the INPUT rotary control until the meter reading is on scale. (Note that the HIGH/LOW warning LEDs only function in the DISTORTION mode.)

The actual signal level is determined by adding the meter reading in dBV or dBm to the INPUT control selection. Or, to find the reading in volts, use the 1 or 3 scale on the meter as appropriate and the range indicated by the INPUT control. For example, if the INPUT control is pointing to 0.03, use the 3 scale. If the meter pointer shows 2.3 in this example, the actual level is 0.023 Volts or 23mV.

The input impedance is 100k ohms shunted by 100 pf or less. This presents a sufficiently high impedance load to most circuits to achieve an accurate reading. If the circuit being measured has a high source impedance (over 1k ohm), a correction factor will have to be used due to the loading of the 100k ohm input impedance.

The input preamp contains an active protection circuit which is designed to protect the sensitive input components from signal overload and will cause a fuse to open. Since the instrument must measure very low distortion, simple conventional protection circuits are not useable and a sophisticated active circuit is employed instead. This circuit achieves all the parameters required but can cause difficulties under a particular (and unusual) circumstance. If the 3501 is turned OFF and connected across a source with a finite output impedance, the 3501 will induce distortion into this source. When the 3501 is not powered, the active protection network ceases to function and the input can look like a non-linear load.

For noise measurements the FILTERS may be used in the LEVEL mode. See Section 2.7 following.

2.5.1 BALANCED INPUT

The model 3501 is equipped with an balanced or differential input. This permits measurement of non-ground referenced sources or balanced sources as found in professional and broadcast applications. Two input connectors are provided - a BNC for the Unbalanced input and a telephone style ring-tip-sleeve jack for the Balanced input. The BNC connector is wired via the normalling contacts of the RTS jack. If no plug is inserted in the jack, one of the differential inputs is connected to the BNC receptacle while the second input is grounded. An instrument input ground post is also provided. (This post is connected to chassis except it floats when the PUSH FOR OSCILLATOR button is pushed.)

An input termination switch is included to allow selection of input impedance. In the down position, the input impedance is 100k ohm to ground in parallel with less than 100 picofarad of capacitance. In the balanced configuration each input is 100k ohms to ground. With the toggle switch in the UP position, a precision 600 ohm termination resistor is added across the input (balanced) or from input to ground (unbalanced).

This precision 600 ohm termination resistor has a 2 Watt power rating. When selected for termination, the maximum input voltage must be limited to 35 Volts rms (+33dBm) as to not exceed the dissipation limit of this resistor.

2.5.2 HIGH CREST FACTOR RMS MEASUREMENTS

The model 3501 has an automatic crest factor compensation facility. This optimizes the noise floor/crest factor capability trade-off that is always present in level measuring instruments.

If the DISTORTION control is set to -80dB/0.01% or lower, the instrument presumes a low crest factor as would be the case with a clean sine wave. In this case the signal amplitude in the preamp and following circuits is maximized to provide the best signal-to-noise performance. Conversely, if the DISTORTION control is set to - 70dB/0.03% or higher, the internal signal level is lowered by 10dB giving greater crest factor handling capability.

All of the level correction required for this manipulation is transparent to the user and is handled automatically by the instrument. The only noticeable difference is the absolute level of the two MONITOR outputs which reflect this 10dB change.

If distortion is being measured, the compensation will be automatic. If only signal level is being measured, set the DISTORTION control to -70dB/0.03% or higher if the signal has a crest factor of greater than about 2. An example would be noise, narrow duty cycle pulse waveforms, signals with high value spikes superimposed, etc.

2.6 TOTAL HARMONIC DISTORTION MEASUREMENT

The model 3501 provides a complete THD measurement system by combining a low distortion signal source and an automatic distortion measurement facility. The latter may also be used with an external signal source when required.

When making THD measurements using the internal source, connect the 3501 and device under test as described on page 2.1. (It is good practice to turn the oscillator output level to minimum before connecting.) It is suggested that an oscilloscope be used to monitor the signals and verify the validity of the measurement. This will show any excessive noise, oscillation, interference or other potential source of error in the measurement.

Set the GENERATOR send level to the level required by the device under test using the procedure shown in Section 2.4 previous. Connect the 3501 OUTPUT to the input of the device under test and its output to the 3501 INPUT. (In the case of audio power amplifiers of course, an external 8 ohm load is usually used.)

If it is necessary to first measure the signal level, proceed as in Section 2.5 previous. If not, push DISTORTION in the FUNCTION group. Turn the INPUT rotary control the appropriate direction if either of the HIGH or LOW red LEDs are on. The proper setting is when both of these are extinguished. Next, turn the DISTORTION rotary control until the meter gives an on-scale reading. The instrument will automatically and rapidly null to a final value as the control is rotated counterclockwise.

Observe the distortion residual components at the front panel MONITOR DISTORTION connector using an external oscilloscope. A typical waveform is one that has a shape close to the second or third harmonic (or a mixture) of the fundamental (see page 6.6). A dual trace oscilloscope facilitates this observation. If the waveform exhibits a line synchronous component of 50 or 60Hz there is hum pickup in the test set-up. If a 100 or 120Hz component, it probably indicates an insufficiently filtered power supply in the device under test. See Section 2.7 following. Be cautious of high frequency components indicating RF pickup or device oscillation.

When using an external source, the analyzer can be easily tuned using the two LED arrows below the FREQUENCY rotary control. These indicate the direction the rotary control or the pushbutton range switches must be adjusted to properly tune the analyzer. It is only necessary to tune to within about 10% of the input signal to achieve lock and extinguish the lights. Note that the internal oscillator should be turned off (output attenuator counterclockwise) when using an external source to prevent interference due to coupling.

Note that the lowest absolute signal level for distortion measurement is -30dBV/30mV. The lowest effective INPUT control setting is - 20dB/100mV. Lower positions of this control (-30 to -60) will not give any increased sensitivity in the distortion mode. If the signal level is too low for distortion measurement (i.e. below -30dBV/30mV) the low red LED will remain on even when the input control is turned fully CCW.

2.7 USE OF FILTERS

The 3501 contains four front panel selectable filters which can enhance the accuracy of many measurements (three are standard, one is optional). For example, if the device under test is picking up mains hum this will influence the measurement and give an erroneous DISTORTION reading. Although it is necessary to be aware of these offending signals, it is useful to be able to separate the DISTORTION and NOISE readings.

400Hz HIGH PASS FILTER (standard)

This is an 18dB per octave (60dB per decade) filter useful to eliminate mains hum and other low frequency noise from the measurement. Its 3dB point or corner frequency is 400Hz and it may be used on signals whose fundamental is above 300Hz or so. It will provide approximately 50dB attenuation of 50 or 60Hz interference.

LOW PASS FILTERS (standard)

These are 18dB per octave (60dB per decade) filters useful to eliminate noise, RF interference, high frequency oscillation and, in general, to reduce the measurement bandwidth to gain a few dB improvement on the 3501 noise floor. Their 3dB down points are 30kHz and 80kHz respectively. They may be used to improve distortion measurement with fundamentals below about 10kHz with the 30kHz filter and 25kHz with the 80kHz filter.

AUXILIARY FILTER (optional)

A fourth filter position is provided for optional specialized noise weighting. It is accessed by pushing both the 30kHz and 80kHz buttons together. A typical application for this filter would be an ANSI/IEC "A" weighting filter or CCIR noise weighting curve.

All four filter positions are plug-in networks and may be easily user changeable. Each filter socket is identical and may accept any of the standard or custom filters offered by Amber or constructed by the user. (See section 4) The filters are always available in any instrument mode. They should not be used in signal level measurement modes such as frequency response measurements. They may be used for noise measurements or to enhance THD distortion measurement. They should not be used in the IMD distortion mode.

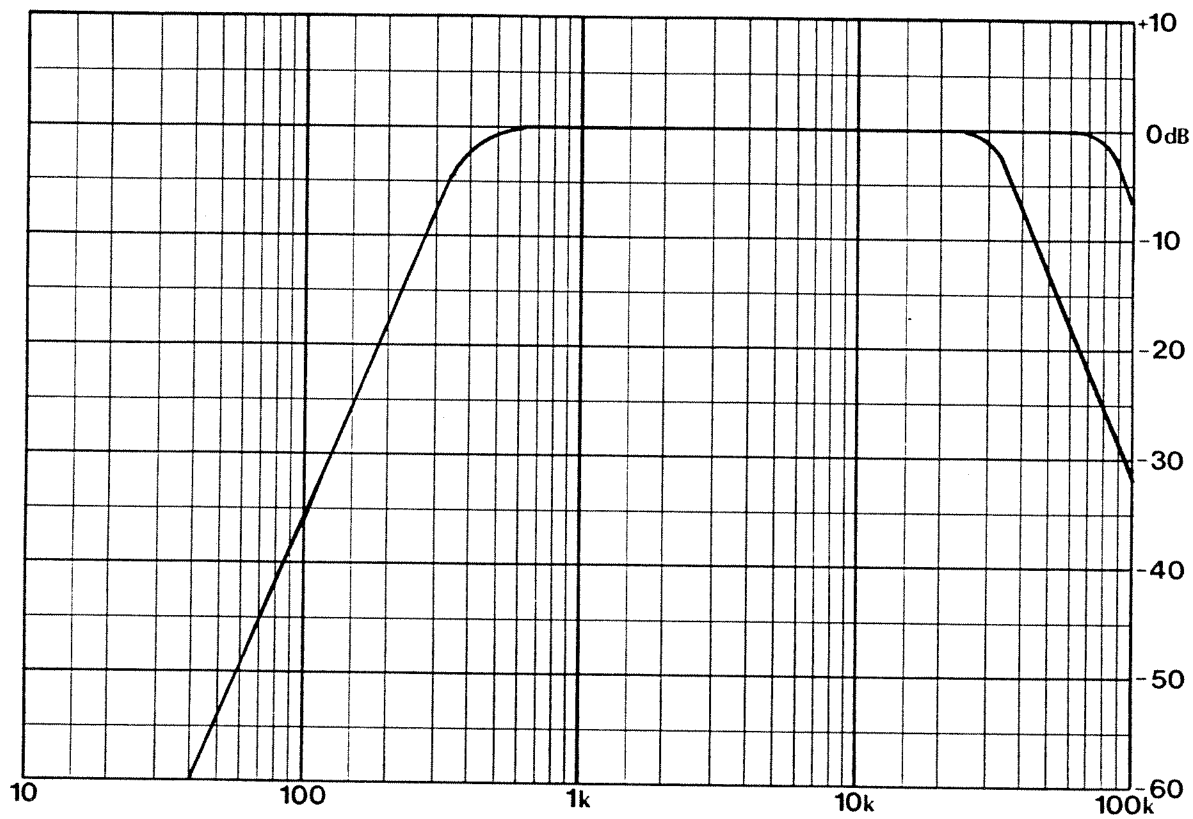


Figure 2.14 STANDARD FILTERS

Illustrated are frequency response plots of the three standard filters supplied: 400Hz High Pass, 30kHz Low Pass and 80kHz Low Pass. Each of the three filters is a 3-pole network giving 18dB per octave roll-off.

The 400Hz filter is useful to remove hum components or low frequency "flicker" noise. It can be used in THD measurements above about 500Hz. The two low pass filters can reduce high frequency bandwidth for noise measurements or for improved (and valid) THD measurements below approximately 10kHz or 25kHz respectively.

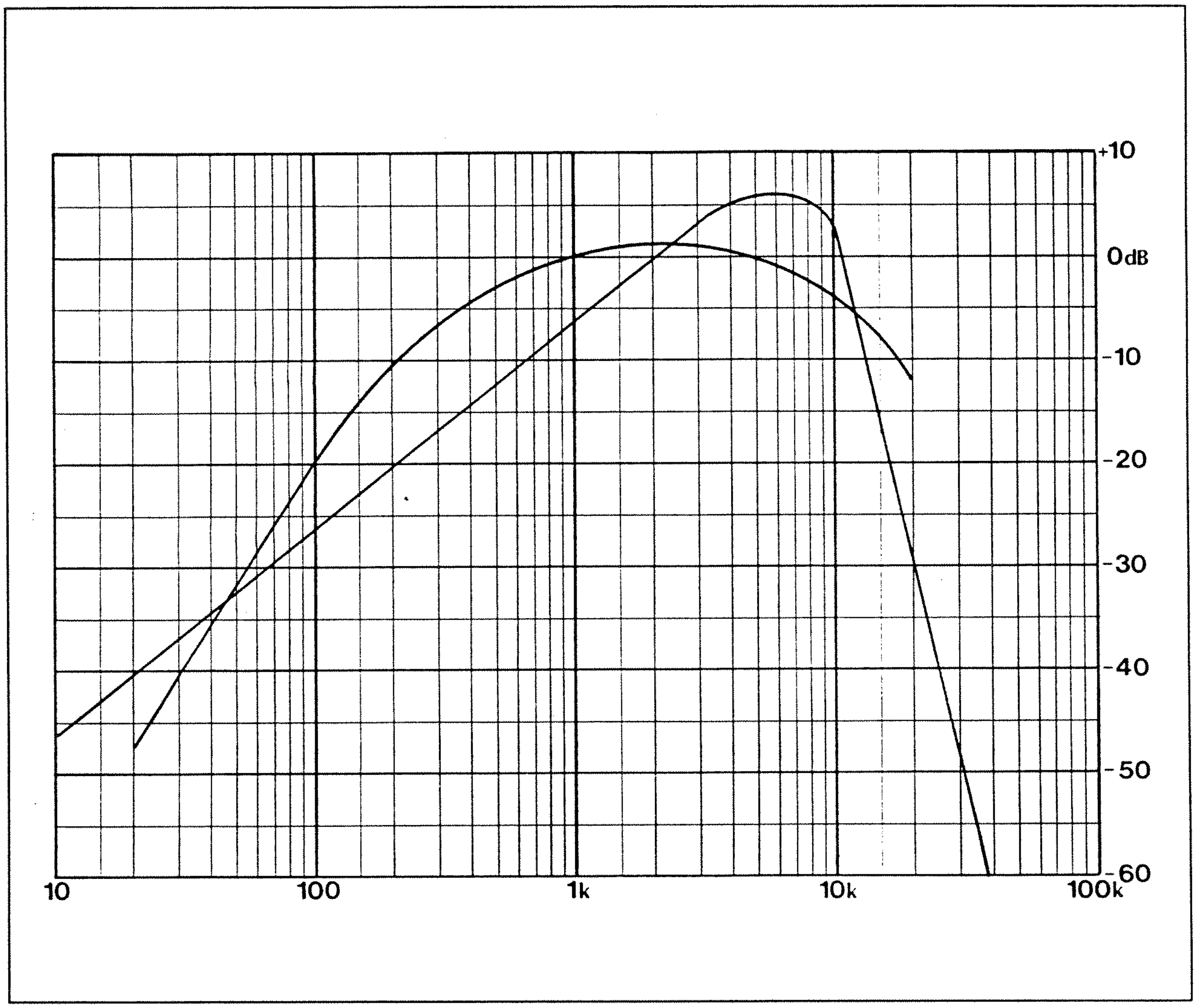


Figure 2.15 OPTIONAL FILTERS

Shown are frequency responses of some typical optional filter networks available. Usually, if one of these is provided, it would be located in the AUX FILTER position. Shown are the ANSI/IEC "A" Weighting curve and the CCIR 468-2 curve. This latter curve may be calibrated for either the 2kHz (DOLBY) reference shown or the 1kHz reference of the original specifications. (Standard factory calibration is 2kHz.)

These curves are typical of several available to meet various international noise weighting standards used in tape recorder, amplifier and system measurements.

2.8 NARROW BAND LEVEL MEASUREMENTS (Extended sensitivity voltmeter)

A unique and very useful feature of the 3501 is the narrow band level measurement capability. This enhances the signal level measurement capability for several measurement situations such as low level noise, crosstalk, signals near the noise floor and acoustic applications.

When the first two FUNCTION push buttons are pushed IN, a band pass filter is inserted in the level measurement path. This configures the instrument as a frequency selective voltmeter enabling it to read signal or noise level in a particular frequency band. The center frequency of this band-pass filter is selected by the FREQUENCY controls and tracks the generator frequency.

The shape of the filter is nominally about one-third octave (12%). It is constant percentage bandwidth and is a single pole pair configuration. The shape has skirts which asymptote to 6dB. See Fig 2.17. To change the filter bandwidths from about one octave (100%) to sharper than one tenth octave (%) see Section 4.

When using the narrow band mode, both the INPUT and DISTORTION gain controls are effective. The absolute signal level (at the filter frequency center) is the meter reading plus the INPUT control selection plus the DISTORTION control selection with the following notation. In this mode (as in the DISTORTION mode) the INPUT control has no greater sensitivity than -20dB. That is, the -30, -40, -50 and -60 positions give the same effect as -20. Therefore to measure low level signals first turn the INPUT control to -20 and then the DISTORTION control to the position that gives an on-scale meter reading. For example, if the meter reading is -4.5dBV, the INPUT control is at -20 and the DISTORTION control at -70, the actual absolute signal level is:

Signal level (dBV) = 4.5 + (-20) + (-70)
= -94.5dBV

The 3501 can also be configured to be a low pass filter. This is achieved by pushing the first and third FUNCTION buttons. In this mode the corner frequency is set by the FREQUENCY controls. The filter has a 12dB per octave roll-off. See Fig 2.18. Level measurement is the same as the BAND PASS mode.

The low pass configuration is particularly useful for noise measurements in a specific bandwidth. For example, to measure the noise in a flat spectrum to say 20kHz just tune the FREQUENCY control to that frequency and proceed as above.

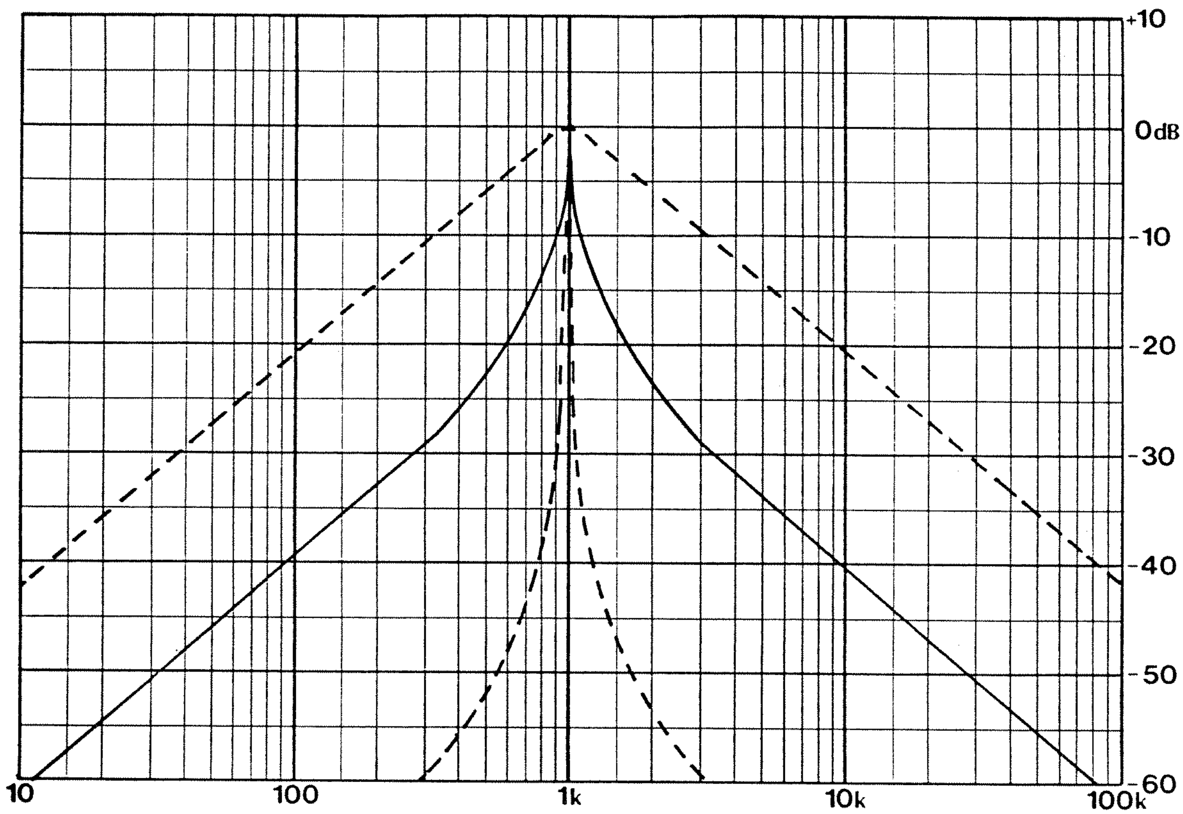


Figure 2.17 BAND PASS RESPONSE

Frequency response of the tunable filter selected by the BAND PASS mode. The filter is shown plotted with a 1kHz center frequency but may be tuned from 10Hz to 100kHz with the same percentage bandwidth or Q. The wide response shown is the lowest Q available; the narrow. response the highest Q (about 1% or a Q of 100). The middle response is approximately 12% (Q of 8.3) and is the response of the filter at factory shipment. See Section 4 for details of alternate bandwidth settings.

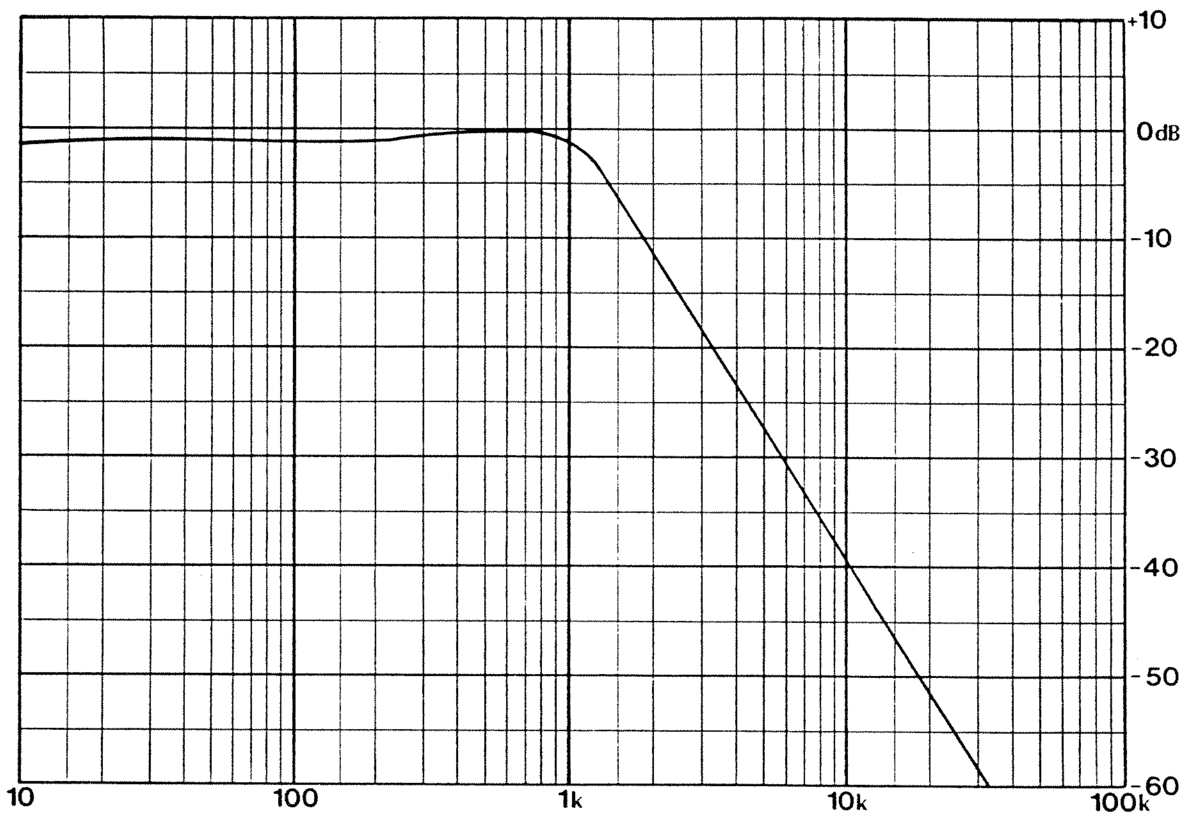


Figure 2.18 LOW PASS RESPONSE

Frequency response of the tunable filter selected by the LOW PASS mode. The filter is shown plotted with a 1kHz corner (-3dB) frequency but may be tuned from 10Hz to 100kHz and retain the same shape. The filter is a 2-pole network giving a 12dB per octave roll-off. Pass band ripple is 3dB maximum; 2dB typical.

This filter may be used for specified bandwidth signal-to-noise measurements. For example, it may be set to 20kHz for an "Audio Bandwidth" measurement.

2.9 dB RELATIVE MEASUREMENTS

This front panel rotary control can offset the meter readings by up to + or -12dB. Using this control a given level reading can be adjusted to "0dB" so subsequent readings will be in dB, relative to this first one. This control can be used in any mode although in general it will only be used in the LEVEL mode.

For example, to measure frequency response "relative to 1kHz":

a) Set the generator to 1kHz.

b) Select LEVEL and make an on-scale reading as described in 2.5 previously.

c) Adjust the meter pointer to 0dBV or 0dBm using the dB relative control.

d) Readjust the FREQUENCY control to other frequencies and note the variation in dB relative to 1kHz.

Note that an "UNCAL" red LED will be lit in the meter scale area when the dB relative feature is being used as a reminder to return it to the detented off position after use.

2.9.1 SIGNAL-TO-NOISE MEASUREMENTS

Signal to noise measurements are used to qualify the noise performance of a device under test. They are expressed as a dB figure relating noise floor to normal signal level -- the larger the number, the lower the noise floor and hence the better the performance.

Signal to Noise Measurements (S/N) can be easily made using the 3501. First, it is necessary to establish the signal reference point. This is based on tradition, manufacturers' choice, a particular standard or other source. For amplifiers it is usually the full power level or clipping point. For processing equipment it is usually the operating level or program level (possibly 10 or more dB below clipping). For tape recorders it is the level that produces a particular amount of distortion, perhaps 3% or 1%. Consult the manual for the device under test or the standard to determine the Reference Signal Level.

The second factor is the measurement bandwidth and any possible bandwidth weighting. These factors can have a very significant effect on the measured figure and it is essential to use the specified procedure. For example, tape recorders are usually measured using ANSI/IEC "A" weighting. Amplifiers and signal paths are often measured using a flat "program weighted" or "audio" bandwidth of 20Hz to 20kHz. Virtually all standard weighting characteristics can be produced by a 3501. Some may require the addition of an accessory in the form of a plug-in network. For example, "A" weighting can be provided as a simple module; "audio" bandwidth by the low pass configuration described in Section 2.8.

Having established the proper reference signal level and weighting we can now proceed to the S/N ratio measurement.

Step 1:

With the weighting (Filters) not selected establish the correct Reference Signal Level at the output of the device under test. This may require a Distortion measurement, Wattage measurement or other condition.

Step 2:

With the 3501 in the LEVEL mode, reading this Reference Signal Level, adjust the dB RELATIVE control to obtain a 0dBV (or 0dBm) meter reading.

Step 3:

Turn off the GENERATOR of the 3501 using the OUTPUT ATTENUATOR. Select the appropriate WEIGHTING filter, if required.

Step 4:

Select the LOW PASS function by pushing the first and third FUNCTION buttons. Turn the FREQUENCY control to set the upper cutoff frequency - usually 100kHz or 20kHz.

Step 5:

Turn the DISTORTION control to obtain an on-scale meter reading (without changing the previously set dB relative control).

Step 6:

Add the meter reading on the dBV (or dBm) scale to the dB value on the DISTORTION control to obtain the correct signal-to-noise value.

For example, suppose the Reference Signal Level is established to be +8dBm. The INPUT control is set to +10dB/3V, LEVEL is selected and a meter reading of -2dBm is noted. This reading is changed using the dB relative control to 0dBV, the OUTPUT LEVEL attenuator set to OFF and the required weighting selected. The FREQUENCY is set to perhaps 20kHz and the LOW PASS mode selected. The DISTORTION control is turned until an on-scale meter reading is obtained. If this happens at say -70dB and shows a meter reading of say -4.5dBV, the correct signal-to-noise ratio is -74.5dB.

2.10 MONITOR OUTPUTS

These front panel outputs provide a signal for external observation. They will normally be connected to an external oscilloscope but can also be connected to an external low frequency spectrum analyzer to improve the distortion measurement resolution.

2.10.1 INPUT MONITOR

This output is a scaled representation of the INPUT signal. It is after the input attenuator and presents a signal for an external oscilloscope for fundamental monitoring, trigger purposes, external counter, etc. The output signal level is approximately -10dBV or 300mV for full scale readings in the LEVEL mode and DISTORTION control settings of -80dB/0.01% or lower. For DISTORTION control settings of - 70dB/0.03% or higher the signal is 10dB lower (i.e. -20dBV or 100mV). Output source impedance is approximately 600 ohms.

2.10.2 DISTORTION MONITOR

This output is a scaled representation of whatever the meter is indicating. In the LEVEL mode, it is the signal being measured. In DISTORTION it is the distortion residual products. In the NARROW BAND mode (BAND PASS and LOW PASS) it is the filter output. The signal levels are the same as the INPUT monitor described above.

2.11 POWER SUPPLY

The enclosure of the 3501 contains the regulated power supply and optional battery and charger system.

This supply operates from 100, 120, 220 or 240 V AC and produces the two isolated bipolar supply rails required by the instrument. (±15V for the measurement circuits and ±20V for the generator circuits). It contains a high efficiency switching type inverter using state of the art techniques such as VMOS transistors and operates outside the measurement bandwidth (approx. 600kHz) to avoid interference.

The rear panel mounted AC mains connector also houses the mains fuse and a switch to select the appropriate power transformer primary tap to correspond to the AC mains source. See Section 2-1 for instructions on how to use this connector/switch.

2.12 OPTIONAL RECHARGEABLE BATTERY

If this option is supplied, an internal rechargeable battery is provided in addition to the above described power supply.

The supply also includes a battery charging circuit and battery voltage detector circuit. During operation from the battery (or external power source) the 3501 will automatically switch off when the battery (or external source) falls below approximately 9 Volts. This will avoid total discharge of, and consequent damage to, the battery.

A BATTERY TEST push button switch is located on the front panel. This uses the front panel meter to indicate battery voltage. Midscale corresponds to approximately 8V and is indicated by a reading of -4dBV or 2 on the Volts/% scale. A fully charged battery will indicate approximately +1dBV or 3.5 on the V/% scale under load (i.e. 3501 operating).

(With no battery installed, BATTERY TEST will indicate the internal power supply voltage.)

The red POWER ON LED will indicate when the battery life is in the last 10 percent of its range. It will flash at a rate indicating the remaining time starting at a slow rate when about 90% of the battery is consumed and increasing until automatic shut-off.

2.12.1 BATTERY CHARGING CONDITIONS

To charge the battery, connect the external mains transformer (or a user supplied source of 14V AC or 18V DC) to the 3501 power input connector. The battery will charge in 6 to 12 hours with this source and the instrument turned off. It may not charge with the instrument turned on (nor will the battery be discharged). During this charge period, the front panel CHRG LED will light. At the completion of charge, the charger will automatically revert to a float mode and the LED will be extinguished. It can remain in this mode indefinitely.

Do not allow a discharged battery to sit for an extended period (more than a few days) prior to recharging.

2.12.2 BATTERY DISCHARGE CONDITIONS

With option 001, a fully charged battery should give between one and two hours of continuous use before automatic shut off. If it is not used continuously, the total discharge time can be extended beyond this time. Option 002 gives approximately twice this discharge time.

If the instrument is allowed to run until shut off, then left to sit for several hours, it should be possible to obtain additional time before recharging. However, if possible, avoid this procedure as this deep discharge operation will shorten battery cycle life.

Under proper conditions, a single battery will give 300 to 500 or more charge/discharge cycles. Good battery care includes recharging as soon as possible after discharge and avoiding deep discharge conditions (repeated deep discharge prior to recharge).

2.13 IMD Distortion Measurement (OPTIONAL)

Option 006 adds IMD measurement and generation capability. Internal changes include the addition of a second oscillator and the IMD measurement circuits. These additional facilities share the input, output, monitors and metering functions of the basic instrument.

2.13.1 SMPTE/CCIF SELECTOR

The front panel function switch selects one of two IMD modes: SMPTE or CCIF. Select SMPTE by simply pushing the third FUNCTION button labelled IMD. Select CCIF by pushing the second and third buttons simultaneously. The SMPTE mode involves the use of two sine waves, one a low frequency of 60Hz and the second a high frequency (7kHz for the normal SMPTE specification) mixed in a 4-to-1 amplitude ratio. The CCIF mode involves the use of two high frequency signals with a small frequency separation, for example 10kHz and 10.5kHz.

2.13.2 SMPTE IMD

The 3501 generates the SMPTE type of signal by adding a 60Hz LF sine wave to the existing variable frequency oscillator with the LF amplitude being 12dB higher than the HF. The frequency of the HF signal is set by tuning the front panel FREQUENCY control. Any frequency in the range from 2kHz to 100kHz may be used including, of course, the 7kHz SMPTE standard. The amplitude of this composite signal is internally calibrated to have the same peak amplitude as the equivalent THD sine wave signal. This peak calibration will ensure no clipping at high signal levels but will show a different RMS value on the LEVEL meter.

Measurement of the distortion of the LF + HF signal is identical to the THD measurement described in Section 2.6 of this manual. The INPUT and DISTORTION controls are set as in THD and the INPUT and DISTORTION MONITOR connectors provide oscilloscope outputs. The FILTERS should not be used in the IMD mode. The Low Pass filters are redundant and will show no significant change. The 400Hz High Pass filter would incorrectly eliminate the distortion components which may appear at 60Hz, 120Hz, etc.

To repeat: use the instrument in the same way as THD but be sure the FREQUENCY is above 2kHz and don't use the filters.

2.13.3 CCIF IMD

The 3501 does not generate the complete CCIF test signal alone. This requires the use of two oscillators for a 1-to-1 amplitude mix. The test signals should each have a minimum value of 2kHz and a maximum frequency separation of 1kHz.

To generate the CCIF composite test signal, connect an external oscillator to the rear panel auxiliary input. This source should be adjustable in amplitude and have a nominal amplitude of approximately +12dBm (3V rms) when connected to the 600 ohm load presented by the auxiliary input.

It should have a frequency range of 2kHz to 100kHz. It need not have a low harmonic distortion but should have low hum content. Look at the composite waveform at the OUTPUT on an oscilloscope. Adjust the amplitude of the external oscillator to just produce a null in the waveform. (See figure 2.13.3 below.)

This sets the two oscillators (internal and external) to a 1 to 1 amplitude ratio. Note that the peak amplitude of the composite signal is 6dB higher than the single THD signal. This limits the maximum setting of the OUTPUT level control before clipping will occur in the power amplifier. Be careful not to clip the output during measurement - no damage will result but serious errors will occur.

The 3501, when switched to CCIF, will measure the difference frequency component and express this amplitude as a percentage of the RMS sum of the two HF signals. It is somewhat equivalent to a highly sensitive voltmeter with a 1kHz low pass filter at the input. As above, do not use the FILTERS in this mode.

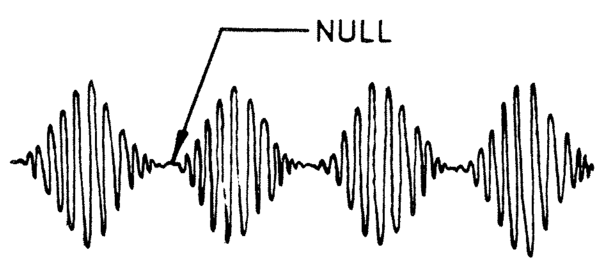


Figure 2.13.3 Setting 1:1 CCIF Composite mix

AMBER model 3501

DISTORTION & NOISE MEASURING SET

OWNER'S MANUAL

SECTION 3

FUNCTIONAL VERIFICATION & PERFORMANCE TEST

Issue 09 April 1988

3. FUNCTIONAL VERIFICATION & PERFORMANCE TEST

3.0 INTRODUCTION

This section contains an instrument functional verification procedure and a detailed performance verification. The functional verification can be used as a quick test of basic operation using a minimum of external equipment. The performance test verifies all specifications and requires specialized, precision equipment of sufficient accuracy to meet the required specifications.

3.1 FUNCTIONAL VERIFICATION

This section describes an abbreviated test sufficient to verify basic instrument function using only an external oscilloscope.

3.1.1 SET UP PROCEDURE

Equipment required:

Dual trace oscilloscope with a bandwidth of 1MHz or greater

2 cables with BNC plugs on each end

Connect trace A input on the oscilloscope to INPUT MONITOR on the 3501. Connect trace B input to DISTORTION MONITOR on the 3501. Set the oscilloscope trigger selection to internal input A.

Set the 3501 FREQUENCY controls to approximately 1kHz (vernier to 10 and range to x100). Set the OUTPUT LEVEL attenuator to +10 and the vernier to approximately three quarters open (3 o'clock).

Push the INPUT SELECT button in (PUSH FOR OSCILLATOR). Set the INPUT control to +10. Select the LEVEL FUNCTION. The DISTORTION CONTROL should be set to -100/0.001 and all three FILTER buttons released (no filter selected).

Turn the dB RELATIVE control to the CAL position (fully CCW). In the OUTPUT area have all three buttons released, that is, UNBALANCED, GROUNDED, and UNTERMINATED.

3.1.2 OSCILLATOR & LEVEL METER FUNCTIONAL VERIFICATION

With the setup described in 3.1.1 above, turn on the power of the 3501. You should observe a sine wave on the A trace of the oscilloscope of approximately 1kHz and 300mV rms (-10dBV). Trace B will have a similar signal of opposite phase.

Adjust the OUTPUT LEVEL vernier control so the meter indicates 0dB on the top scale (dBm). Turn the FREQUENCY vernier control CCW from 10 to 1 and observe that the sine wave on the oscilloscope changes from approximately 1kHz to approximately 100Hz. Select the three other FREQUENCY ranges (x10, x1k and x10k) and observe appropriate waveforms on the oscilloscope.

Return the FREQUENCY control to approximately 1kHz. Turn the OUTPUT LEVEL attenuator down 10dB to 0dB and the INPUT control also down 10dB to 0dB. The meter should remain on-scale. Progressively select each 10dB lower step on both controls until -60dB is reached and observe that the meter remains on-scale. Set both controls to +20dB and again read an on-scale meter indication. Push the TERM button in the OUTPUT section and observe a reduced meter reading.

3.1.3 FILTER VERIFICATION

This section assumes the three standard filters of 400Hz High Pass, 30kHz Low Pass, and 80kHz Low Pass are installed in the instrument.

Set up the instrument as described in Section 3.1.1 above. Adjust the OUTPUT vernier control for an indication of 0dB on the top scale. Push the 400Hz HP FILTER button and the 30kHz LP FILTER button. Turn the FREQUENCY vernier down to 400Hz and observe that the meter has begun to fall to a lower level. As the FREQUENCY control is lowered below 400Hz, the meter should continue to fall until it will be off-scale below 300Hz.

Change the FREQUENCY to 30kHz and observe a similar performance at 30 kHz and falling to off-scale above 40kHz. Release the 30kHz filter and push the 80kHz filter. Turn the FREQUENCY control to 80kHz and observe a similar roll-off. (Note that the above FILTER verification assumes the instrument is equipped with standard filters.)

3.1.4 TOTAL HARMONIC DISTORTION VERIFICATION

Set up the instrument as described in Section 3.1.1 above. Push the THD FUNCTION button and adjust the DISTORTION control for an on-scale reading. After a few seconds of automatic nulling you should observe a random noise signal on trace B of the oscilloscope. Push the 30kHz FILTER and observe that the high frequency components are removed from trace B on the oscilloscope.

Turn the 30kHz FILTER off (no filters should be selected now). Observe the automatic nulling on the oscilloscope trace B as the FREQUENCY vernier control is turned from 10 to 1. Select each of the other three FREQUENCY ranges and observe that the instrument will null anytime the FREQUENCY vernier control is stopped. It may be necessary to readjust the DISTORTION control.

3.1.5 dB RELATIVE CONTROL

Set up the instrument as described in Section 3.1.1 above. Adjust the OUTPUT LEVEL controls for a full scale meter indication (+4dBm on the top scale). Turn the dB relative control noting that any on-scale meter reading can be set (a range of approximately 12dB). Return the dB relative to CAL and adjust the OUTPUT LEVEL vernier to obtain a low scale reading (-8dBm on the top scale). Again, turn the dB relative control and observe that any on-scale indication can be set (a range of approximately 12dB). Return the dB relative control to CAL.

3.1.6 INTERMODULATION DISTORTION FUNCTIONAL VERIFICATION (assumes option 006 is installed)

Set up the instrument as described in Section 3.1.1 above. Push the IMD function and set the FREQUENCY range to x1k (for a frequency of approximately 10kHz). Observe a composite waveform on trace A of the oscilloscope consisting of an LF component of approximately 60Hz and an HF component of one quarter peak amplitude and approximately 10kHz. Trace B will be an IMD residual with dominant low frequency energy. Turn the DISTORTION control to -90dB and observe an on-scale reading (typically -2dB on the second scale, i.e. -92dB).

3.2 PERFORMANCE TEST

3.2.1 INTRODUCTION

The following procedure is intended to be used to verify the performance to specification of an Amber model 3501 Distortion and Noise Measuring Set. All tests can be performed without access to the interior of the instrument.

3.2.2 EQUIPMENT REQUIRED

FUNCTION	CHARACTERISTICS
Calibrator, AC	Frequency range: 10Hz to 100kHz Level range : 100V to 1 mV Level accuracy : ± 0.2%
Spectrum Analyzer, low frequency	Frequency range : 10Hz to 500kHz Minimum bandwidth : 3Hz
Oscilloscope, dual trace	Bandwidth : 10MHz
Level meter, AC rms	Bandwidth : 10Hz to 500kHz Dynamic range : 100 V rms to 1mV rms Readout : Volts, mV, μV and dBV or dBm Accuracy : ±0.10dB at 1kHz and 1V Resolution : ±0.01dB
Frequency Counter	Frequency range: 10Hz to 500kHz
Low Distortion Oscillator	Frequency range: 10Hz to 100kHz Residual THD: <-102dB 50Hz to 5kHz <-85dB 10Hz to 100kHz Source impedance : 600 ohm ±1%
Low Distortion Analyzer	Frequency range : 10Hz to 100kHz Residual THD: <-102dB 50Hz to 5kHz <-85dB 10Hz to 100kHz
Power Supply	0 to ±30V DC at 0.5A
Resistors	59k0 ±1% metal film

3.2.3 OSCILLATOR LEVEL VERIFICATION

Connect an AC level meter to the oscillator unbalanced output (BNC connector). Set the external level meter sensitivity to approximately 15V rms full scale or greater. Set the 3501 frequency dial to 1kHz (10 on the vernier and x100 range). Turn the output attenuator control fully clockwise (max.). Turn the variable output level control fully clockwise. Observe an output level of 11V rms or greater.

3.2.4 OSCILLATOR FLATNESS VERIFICATION

Connect the AC level meter as described in 3.2.3 bove. Adjust the output variable and step level controls to produce a reading of 1.00V or 0.0dBV on the external AC meter at 1kHz. Change the frequency of the oscillator to each of the frequencies in the table below and observe the signal level (either dB or V).

FREQUENCY	LEVEL METER READING	
	dBV	**Volts**
1kHz	0.0dB (ref)	1.00 V (ref)
10Hz	-0.2dB to +0.2dB	980mV to 1.020V
20Hz	-0.1dB to +0.1dB	990mV to 1.010V
10kHz	-0.1dB to +0.1dB	990mV to 1.010V
20kHz	-0.1dB to +0.1dB	990mV to 1.010V
100kHz	-0.2dB to +0.2dB	980mV to 1.020V

3.2.5 OSCILLATOR FREQUENCY ACCURACY

Connect a frequency counter to the oscillator unbalanced output. Set the oscillator to an output level of approximately 1 V. Set the frequency controls on the 3501 to each of the frequencies in the following table and observe the frequency indication on the external frequency counter.

FREQUENCY	DIAL	RANGE	EXTERNAL INDICATION
10Hz	1	x10	9.0 to 11.0 Hz
50Hz	5	x10	45 to 55 Hz
100Hz	10	x10	90 to 110 Hz
100Hz	1	x100	90 to 110 Hz
500Hz	5	x100	450 to 550 Hz
1kHz	10	x100	900 to 1100 Hz
1kHz	1	x1k	900 to 1100 Hz
5kHz	5	x1k	4500 to 5500 Hz
10kHz	10	x1k	9.0k to 11k Hz
10kHz	1	x10k	9.0k to 11k Hz
50kHz	5	x10k	45 k to 55k Hz
100kHz	10	x10k	90k to 110k Hz

3.2.6 OSCILLATOR TOTAL HARMONIC DISTORTION

Note: This test requires a known high performance distortion analyzer. The analyzer section of the 3501 may be used provided its residual distortion performance is within specifications.

Select OSCILLATOR as input to the analyzer section of the 3501. Set the OUTPUT attenuator to +10 and the variable control approximately three quarters clockwise. Select +10dB on the INPUT control and select LEVEL. Choose a frequency of 1kHz. The meter should show an on-scale reading. Adjust the output variable control so the meter is close to full scale (i.e. 0dB). Set the DISTORTION control to -70dB.

Connect the spectrum analyzer to the DISTORTION monitor connector. Set up the spectrum analyzer to sweep a range of approximately 0 to 10kHz. Adjust the spectrum analyzer sensitivity and bandwidth controls to produce a clear presentation of the 1kHz signal.

Push the THD button on the 3501. Do not select any filters. Turn the DISTORTION control down until an on-scale reading is obtained. (The meter may bounce as the control is turned indicating the automatic nulling activity.) The DISTORTION control will typically be at the -80 or -90dB (0.01% or 0.003%) range. Do not use the -100dB range.

Without changing the controls on the spectrum analyzer, perform a second analysis. This will now show some components at the second and third harmonics. Note the level of each of these relative to the previous analysis of the fundamental. To this relative difference add the position of the DISTORTION control. For example, if the first reading on the spectrum analyzer of the fundamental (1kHz) was -5dB and the second measurement showed a second harmonic amplitude of -25dB with the DISTORTION control at -90dB, then the second harmonic level relative to the fundamental is:

(-25dB) - (-5dB) + (-90dB) = -110dB

Calculate the amplitude of the third harmonic in the same way. The amplitude of both harmonics should be below the levels shown in the following table. Repeat the above procedure for each frequency listed, using an appropriate sweep range.

FREQUENCY	HARMONIC LEVEL
10Hz	<-96 dB
50Hz	<-102 dB
5kHz	<-102 dB
10kHz	<-96 dB
50kHz	<-90 dB
100kHz	<-84 dB

3.2.7 LEVEL METER ACCURACY

Connect the AC calibrator to the 3501 INPUT. Select the external input on the 3501 (button out). Select the LEVEL mode and turn off all filters. Set the DISTORTION control to -80dB (0.01%).

The level accuracy and frequency response (flatness) will be tested at several frequencies and signal levels. For each test, select the required signal level and frequency on the AC calibrator and set the corresponding INPUT control on the 3501. (It is not necessary to set the FREQUENCY controls on the 3501.) Each test should produce a nominal full scale meter indication. Using the dBV scale, a perfect result will show "0dB" on the scale. The table below shows the allowed deviations from this 0dB scale indication for each frequency and level.

LEVEL	TEST LIMITS				
	10Hz	20Hz	1kHz	20kHz	100kHz
+40dBV 100V	±0.5dB	±0.2dB	±0.2dB	±0.2dB	±0.5dB
+30dBV 31.6V	±0.5dB	±0.2dB	±0.2dB	±0.2dB	±0.5dB
+20dBV 10.0V	±0.5dB	±0.2dB	±0.2dB	±0.2dB	±0.5dB
+10dBV 3.16V	±0.5dB	±0.2dB	±0.2dB	±0.2dB	±0.5dB
0dBV 1.00V	±0.5dB	±0.2dB	±0.2dB	±0.2dB	±0.5dB
-10dBV 316mV	±0.5dB	±0.2dB	±0.2dB	±0.2dB	±0.5dB
-20dBV 100mV	±0.5dB	±0.2dB	±0.2dB	±0.2dB	±0.5dB
-30dBV 31.6mV	±0.5dB	±0.2dB	±0.2dB	±0.2dB	±0.5dB
-40dBV 10.0mV	±0.5dB	±0.2dB	±0.2dB	±0.2dB	±0.5dB
-50dBV 3.16mV	±0.5dB	±0.2dB	±0.2dB	±0.2dB	±0.5dB
-60dBV 1mV	±0.5dB	±0.2dB	±0.2dB	±0.2dB	±0.5dB

3.2.8 METER ACCURACY

Using the same set up as in Section 3.2.7 above, verify intermediate meter levels using the following table. Set the INPUT control to +10dBV. Set the AC calibrator to 1kHz and +10dBV (3.16V). The 3501 meter should indicate 0.0dB ±0.2dB. Repeat for each value in the table.

INPUT LEVEL	METER INDICATION
+10dBV/3.162 V	+0.2dB to -0.2dB
+ 8dBV/2.512 V	-1.8dB to -2.2dB
+ 6dBV/1.995 V	-3.8dB to -4.2dB
+ 4dBV/1.585 V	-5.8dB to -6.2dB
+ 2dBV/1.259 V	-7.8dB to -8.2dB

3.2.9 FILTER ACCURACY

Select the internal oscillator as the INPUT to the 3501. Set a frequency of approximately 5kHz, LEVEL mode, OUTPUT level and INPUT level controls set to +10dB. Connect a frequency counter to the INPUT monitor and an AC level meter to the DISTORTION monitor output. With no filters selected, adjust the output variable level control for a convenient reference level on the external meter (e.g. 0dB). Select the 400Hz high pass filter and adjust the frequency control (near 400Hz) for a new level reading exactly 3dB below the previous reading. Note the frequency. Repeat for the 30kHz and 80kHz filters referring to the following table for acceptable limits.

FILTER	FREQUENCY RANGE FOR -3dB
400HP	380Hz to 420Hz
30kHz LP	28.5kHz to 31.5kHz
80kHz LP	76kHz to 84kHz

3.2.10 FUNDAMENTAL REJECTION & RESIDUAL DISTORTION VERIFICATION

Note: This test uses the internal oscillator as a signal source. For this procedure to be valid, the internal oscillator must have a THD within its specified limits.

Select the internal oscillator as input to the 3501 analyzer. Connect the DISTORTION monitor output to the external spectrum analyzer. Set the OUTPUT and INPUT attenuator to +10dBV. Select the LEVEL mode, no filters and a frequency of approximately 1kHz. Adjust the output variable control for a near full scale meter reading (0dB). Set the DISTORTION control to -70dB range.

Set the controls on the external spectrum analyzer to obtain a CRT presentation of the fundamental. Note the amplitude of this signal.

Select THD on the 3501 and turn the DISTORTION control for an on-scale reading (typically -80 or -90dB). Do not use the -100dB range.

Make a new measurement on the spectrum analyzer noting the level of the fundamental, the second and the third harmonic. Compare these levels to the previous fundamental reference level and add the value of the DISTORTION control. For example, if the initial reference measurement produced a fundamental value of -10dB while the second measurement produced values -30, -20 and -25dB for fundamental, second and third harmonic respectively and the distortion control is set to - 90dB then the level of each component is :

Fundamental : (-30dB) - (-10dB) + (-90dB) = -110dB

Second harmonic : (-20dB) - (-10dB) + (-90dB) = -100dB

Third harmonic : (-25dB) - (-10dB) + (-90dB) = -105dB

Repeat this procedure for each of the frequencies shown in the table below and verify that the fundamental and harmonic ratios are equal or better than the values shown.

FREQUENCY	VERNIER - RANGE		FUNDAMENTAL HARMONIC	2nd HARMONIC	3rd HARMONIC
10Hz	1	x10	-100dB	-96dB	-96dB
50Hz	2	x10	-105dB	-102dB	-102dB
5kHz	5	x1k	-105dB	-102dB	-102dB
10kHz	10	x1k	-100dB	-96dB	-96dB
50kHz	5	x10k	-90dB	-84dB	-84dB
100kHz	10	x10k	-90dB	-84dB	-84dB

3.2.11 DISTORTION MEASUREMENT ACCURACY

Connect the outputs of the internal 3501 oscillator and an external oscillator with the combining network shown in Fig 3.2.11. This will produce an artificial "distorted signal" of known magnitude.

Set the 3501 to 1kHz, select external input, set the output attenuator to +10dB and the input attenuator to +10dB. Select LEVEL mode and adjust the output variable control for a +10dBV (i.e. 0dB on the meter scale) reading.

Adjust the external oscillator for a level of -10dBV as read on the external oscillator level meter and a frequency of 10kHz. With the combining resistors, this will produce a "distortion" signal 60dB (or 0.1%) below the fundamental.

With no filters selected, select THD on the 3501 and turn the DISTORTION control to -60dB (0.1%). The meter should indicate 0dB 1dB. Without changing any controls on the 3501, change the frequency of the external oscillator to those indicated in the table below and observe the meter readings.

EXTERNAL OSCILLATOR FREQUENCY	DISTORTION METER READING
10Hz	-58dB to -62dB
20Hz	-59dB to -61dB
500Hz	-59dB to -61dB
5kHz	-59dB to -61dB
20kHz	-59dB to -61dB
50kHz	-58dB to -62dB
100kHz	-57dB to -63dB
300kHz	-57dB to -63dB

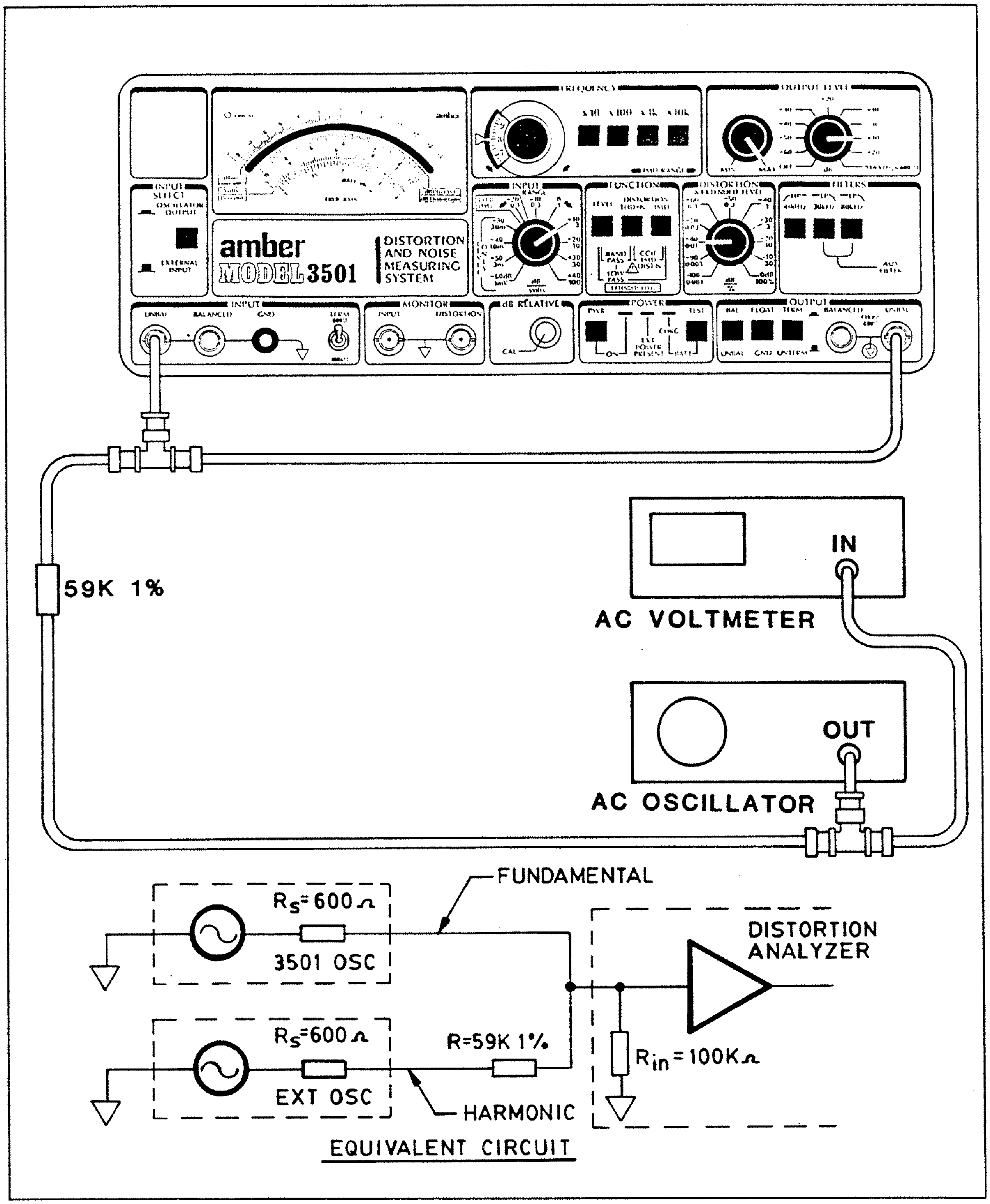


Figure 3.2.11 Harmonic Accuracy Test

3.2.12 RESIDUAL NOISE

Connect a shielded 600 ohm terminating plug to the 3501 INPUT BNC connector. Select the LEVEL mode, no filters and external input. Turn off the internal oscillator by turning the OUTPUT attenuator fully counterclockwise to OFF. Turn the INPUT control fully counterclockwise to -60dBV and observe an off-scale meter reading indicating a noise level below -70dBV.

Select BAND PASS mode, set the INPUT control to -20dBV and the FREQUENCY to 1kHz. Turn the DISTORTION control to a level that produces an on-scale meter reading. The absolute level is the meter reading plus the distortion control setting plus the INPUT control setting. For example, with a meter reading of -6dB, a distortion setting of -90dB and the input set to -20dBV, the noise level is :

$$(-20) + (-90) + (-6) = -116\text{dBV}$$

The reading at 1kHz should be -100dBV or lower. Repeat the measurement at 100kHz and obtain a reading below -90dBV.

3.2.13 DISTORTION FREQUENCY ACCURACY

The distortion analyzer has an electronic fine tuning system that automatically adjusts its internal tuning circuits over a limited range. For these automatic tuning circuits to function, the signal should be within approximately ± 10% of the frequency dial setting. This is indicated by tuning error lights below the frequency dial. When the tuning lights are on, the signal may be greater than the pull-in range of the auto-tune circuits.

To verify frequency accuracy, signals of known frequency are sent to the 3501 and the frequency dial on the 3501 is set to these frequencies. Under these conditions, the tuning error lights should not illuminate and the auto-null circuit should function.

Connect an external oscillator to the INPUT of the 3501. Set a level of 1V on the external oscillator and set the INPUT control to 0dB/1V. Monitor the frequency of the external oscillator using a frequency counter. Connect an oscilloscope to the INPUT and DISTORTION monitor outputs to observe nulling action.

Set the 3501 frequency control to 1kHz and select the THD mode. Set the frequency of the external oscillator to 1000Hz and observe that the tune error lights do not illuminate and automatic nulling occurs. Repeat for all frequencies in the following table:

EXTERNAL OSCILLATOR FREQUENCY	3501 FREQUENCY DIAL SETTING	
10Hz	1	x10
50Hz	5	x10
100Hz	10	x10
500Hz	5	x100
1kHz	10	x100
5kHz	5	x1k
10kHz	10	x1k
50kHz	5	x10k
100kHz	10	x10k

3.2.14 DISTORTION INPUT LEVEL REQUIREMENT

Set up the 3501 to measure THD of its internal oscillator at 1kHz. Observe a correct distortion measurement by connecting an oscilloscope to the two MONITOR outputs.

Select the LEVEL mode and set the oscillator to produce a level of - 30dBV (30mV). Select THD again and observe that the UNDER level error light does not illuminate and a THD reading is obtained.

3.2.15 DC ISOLATION CHECK

The 3501 has a floating oscillator and an AC coupled differential input. Both the oscillator and the inputs can have a DC float potential of ±30V above chassis.

Connect the oscillator output to the differential input of the 3501 as shown in Figure 3.2.15. Push the FLOAT button to isolate the oscillator from chassis. Select a 1V, 1kHz level on the oscillator, LEVEL mode on the analyzer. With the INPUT control at 0dBV/1V a full scale meter reading should be provided.

Connect a variable power supply between chassis and the low terminal of the oscillator. Observe as the power supply is adjusted from 0 to ±30V, no change is seen in the 3501 meter reading.

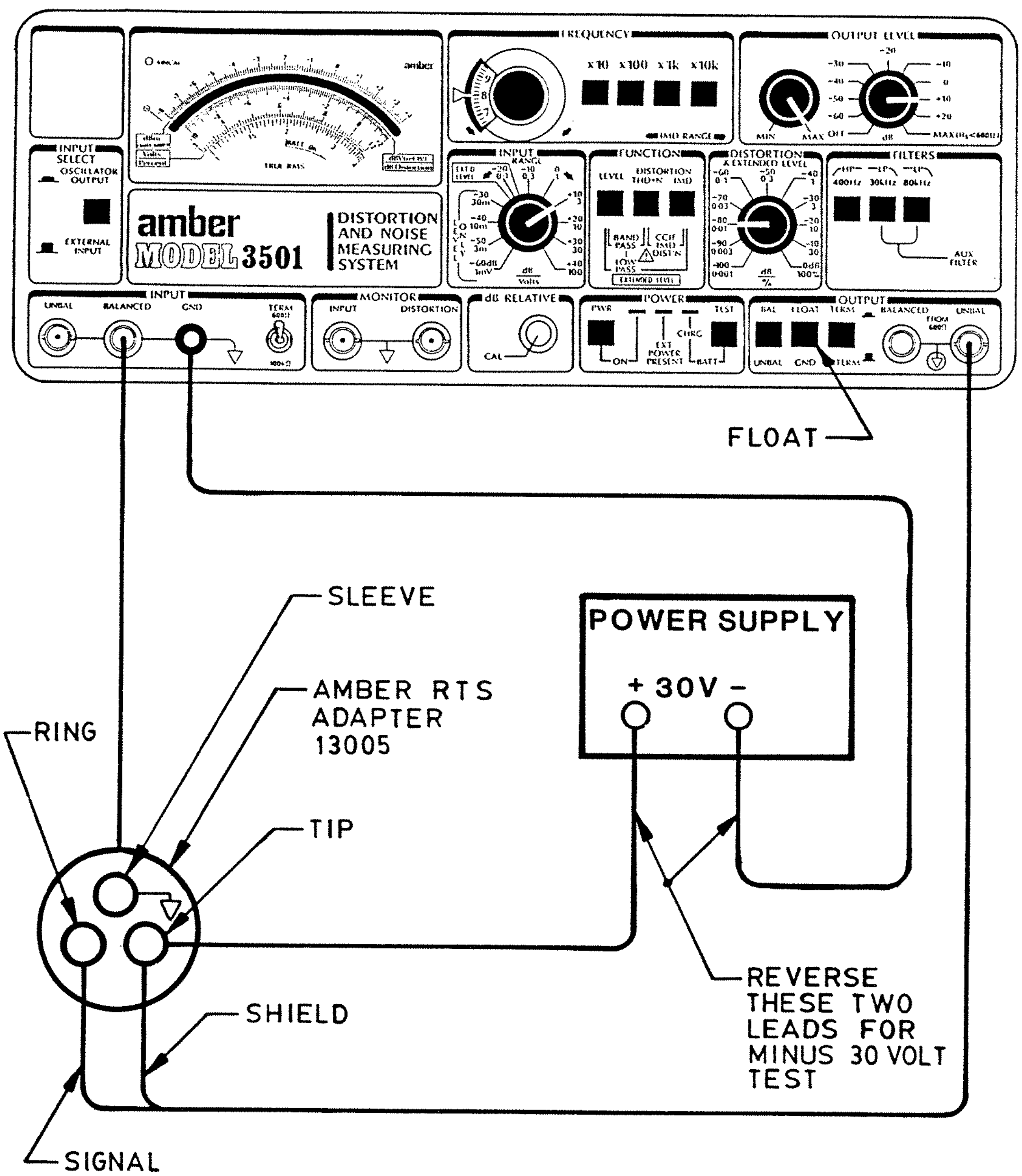


Figure 3.2.15 DC Isolation Test

AMBER model 3501

DISTORTION & NOISE MEASURING SET

OWNER'S MANUAL

SECTION 4

MODIFICATIONS & CUSTOM NETWORKS

Issue 09 April 1988

4. MODIFICATIONS & CUSTOM NETWORKS

4.0 INTRODUCTION

The 3501 has some provision for user modification for particular applications. Most of these changes must be done by a qualified technician and it is assumed care will be exercised. Before proceeding with this section, refer to Section 6 and read the cautions regarding static sensitive devices and the 3501 disassembly procedure.

4.1 BAND PASS FILTER "Q" ADJUSTMENT

The 3501 may be onfigured as a frequency selective voltmeter by selecting the BAND PASS mode. This is done by pushing the first two FUNCTION buttons.

The BAND PASS mode inserts a variable frequency active band pass filter in the level measurement circuit. The filter is a State Variable type and is constant percentage bandwidth. This means the shape of the filter plotted on a log frequency axis will remain the same at any frequency.

The instrument is normally shipped with the filter set to a bandwidth of approximately 12%. This translates to a Q of 8.3 and means the filter will have -3 dB points separated by 120Hz when the center frequency is 1kHz.

By changing the value of one resistor the bandwidth of the filter may be varied over a range of approximately 100% to less than 1%.

The filter has been configured so that as the bandwidth is changed the pass band gain (gain at the center frequency) will remain essentially constant at unity. In fact, within the filter itself lower bandwidths (higher Q) mean higher filter gain. At 1%, the effective internal filter gain exceeds 40dB although the actual instrument pass band gain is approximately -3dB. (At higher Q values, the center frequency gain suffers a slight attenuation.) This additional gain means a higher equivalent input noise when in the BAND PASS mode. It is equivalent to additional gain in the preamp as selected by the INPUT control. This noise will appear on the DISTORTION MONITOR output and may look like oscillation. It is in fact front end noise filtered by a sharp band pass filter and will therefore exhibit noise predominantly at the setting of the FREQUENCY control.

Note that the filter retains the automatic tuning capability of the notch configuration used in the THD mode. Thus, it will try to lock on to an incoming signal within its ± 10% capture range. This will simplify most measurements and relieve the difficulty of trying to manually tune an extremely sharp filter. However, it will also mean it is almost impossible to plot the frequency response of the filter since it will try to automatically track an incoming sweep. See the details on SERVO INHIBIT below if it is desired to suppress this automatic tuning.

4.1.1 FILTER Q MODIFICATION

Resistor R2045 located on the top (FILTER/OSCILLATOR) board is the one to be changed to effect modification of Q. Its effective value is that of this resistor in series with the R_{ds} ON of FET Q2077. As shipped, its value is 620 ohms resulting in a bandwidth of approximately 12%. The resistor may take values of infinity to zero ohms resulting in bandwidths of 100% to less than 1%. See Figure 4.1 for frequency response plots of various bandwidths. For sharper bandwidths (higher Q) the resistor must be decreased. The safest way to do this is to solder a resistor in parallel with the existing 620 ohm part. If the resistor must be removed, use caution to avoid damaging the circuit board.

A pot may be used to provide an adjustable bandwidth. For best results, use a 10k ohm reverse log taper. It may be mounted on the front panel to the left of the meter.

4.2 FILTER SERVO INHIBIT

The state variable filter used in the THD measurement section and the BAND PASS and LOW PASS modes has an automatic frequency tuning adjustment. This is one of the two servos used to automatically null the notch filter in THD. This frequency adjust servo will automatically tune the filter if a single input signal is within ±10% of the manual FREQUENCY setting.

There may be some applications where this automatic tuning is undesirable. For example, in the BAND PASS mode if it is desired to set the center frequency of the filter with the FREQUENCY knob and not have it drift to a nearby frequency trying to lock on to an input signal. To achieve this, the servo may be disabled to cause the filter to find its mean (panel dial) value. Of course, the servo must be enabled again in the THD mode or nulling will not take place.

To disable the frequency tuning servo, short out capacitor C2019 or short PIN 2 to Pin 6 of U2006. This may be done with a switch but the leads to the switch must be short (less than 10 inches). A switch could be mounted on the front panel to the left of the meter.

4.3 IMD LOW FREQUENCY CHANGE

If option 006 is provided, a second low frequency oscillator is contained on the option circuit board located on the bottom chassis. The frequency of this oscillator is nominally set to 60Hz but can be changed over the range of approximately 10Hz to 500Hz.

Two resistor values must be changed to set a new frequency. These resistors are R604 and R605 on assembly 3501-460-02. They follow the relationship:

$$\text{FREQUENCY} = \frac{10^6}{1.38\,R}$$

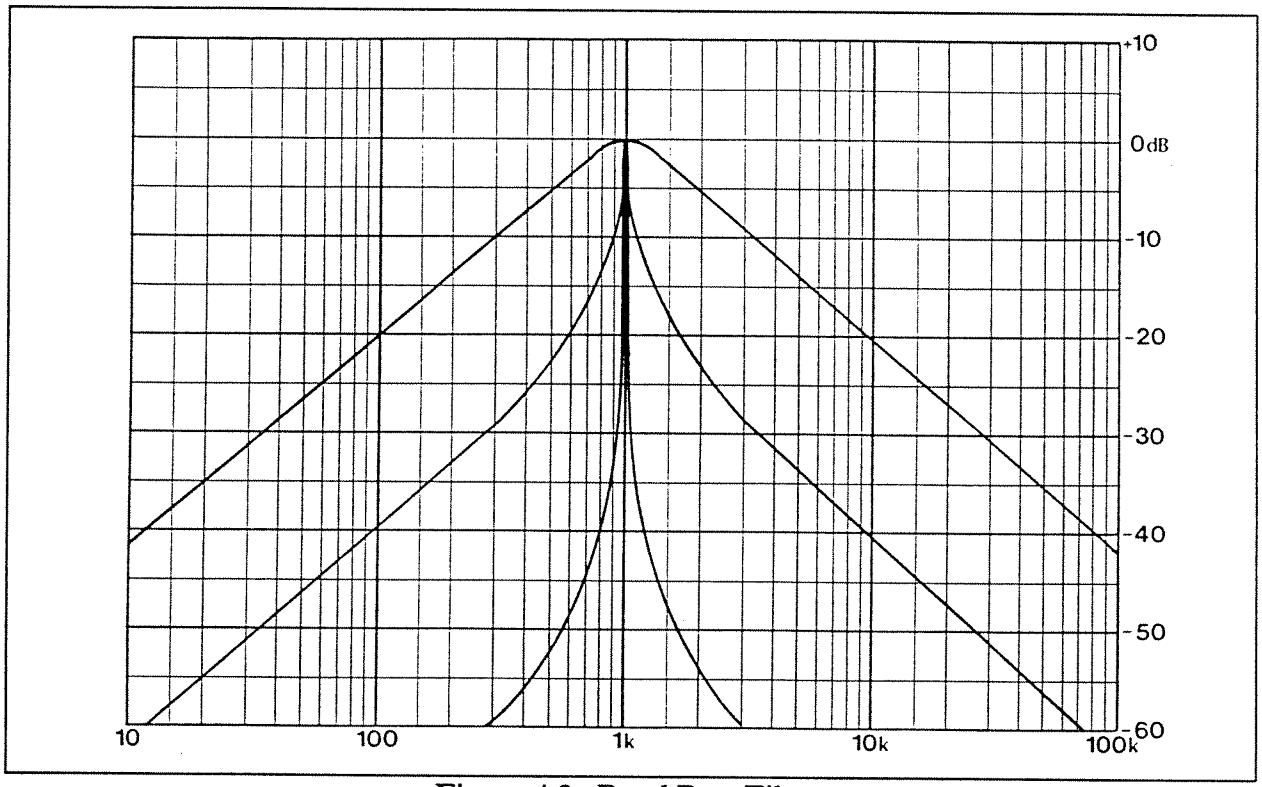


Figure 4.3 Band Pass Filter

Shown are typical frequency responses of the BAND PASS filter for various values of R2045. The widest response is a Q of 1 or percentage bandwidth of 100% with a resistor value of infinity (no resistor installed).

The center response is a Q of 8.3, bandwidth of 12% and resistor of 620 ohms. This is the standard response shipped from the factory. The narrowest response is a Q of 100 or more, bandwidth of 1% or less and is obtained with a resistor value of 0 ohms (plus inherent resistance of FET).

As shipped, they are 12.2k ohm giving a frequency of 60Hz. For 10Hz use 71.5k and for 500Hz use 1.43k ohm. A dual ganged 50k ohm pot may be used to provide a variable frequency. There is provision for a four pin connector, J601, to handle an external control.

4.4 NOISE WEIGHTING FILTERS

The 3501 has provision for up to four noise weighting filter networks. Three are provided as standard and the fourth position is available for optional filters. This section contains details on how to construct filter networks to be used for noise weighting in the 3501. Note that all four filter positions may be installed in any position. The only caution is to observe the pin number orientation during installation.

4.4.1 GENERAL

Amplitude or Level measurements are generally made with a wide-band level meter which treats all signals in the frequency band of interest with equal weighting. That is, the frequency response of the meter is essentially flat over the measurement band. There are occasions, however, where it is desirable to restrict the bandwidth of the measuring circuits. Two common reasons are to reject noise or other unwanted signals and to better tailor the measurement to the subjective response of the human ear.

Examples would be: measurement of a signal in the presence of hum, reduction of measurement bandwidth from say 1MHz to 20kHz, removal of a noise component from a distortion + noise measurement and measurement of noise performance to some noise weighting standard. This latter example results from the response of the human ear. At low sound pressure levels, the ear (or more correctly, the subjective realization of sound) is less sensitive to low and high frequencies. Noise in an electronic system is usually at a low level compared to signal. Thus, the ear would be less sensitive to a low or high frequency low level noise than a low or high frequency high level signal. Weighting curves approximating the ear's response have been developed. They are specified in standards available from ANSI, IEC and others. (See "A" Weighting following.)

Bandwidth restriction is very necessary for proper noise measurements. For "flat" noise (white noise) the noise level is proportional to the square root of bandwidth. Therefore, a preamplifier, for example, with a reasonably flat noise spectrum (not dominated by hum, crosstalk, etc.) will exhibit vastly different noise performance when measured with a wide band AC voltmeter with a 1MHz bandwidth versus a voltmeter with a 20kHz bandwidth. It is therefore imperative that measurement bandwidth be specified with noise figures. It is equally imperative that the correct bandwidth or weighting be used in the measuring instrument when readings are to be repeated with consistency. If a manufacturer specifies the noise of his amplifier in a 20kHz bandwidth the user must use this bandwidth to verify proper performance.

4.4.2 CONSTRUCTION OF CUSTOM NETWORKS

Several types of standard filters are described here along with details of how to determine component values to provide specific parameters. In addition to the networks presented here several others may be derived using classic filter design technique and implemented in a similar fashion. The configuration of the filter sockets, dedicated op amp and terminations provide near ideal filter conditions: low source impedance, extremely high op amp input impedance and wide op amp bandwidth.

For best results resistors should be 1/4 watt metal film with 1% tolerance, capacitors should be ceramic, plastic film or mica with 5% or better tolerance.

4.4.2.1 3rd Order Butterworth HIGH PASS and LOW PASS filter Networks

Three pole filters may be realized by using three resistors and three capacitors as shown in the instructions.

The component location determines the filter character while its value, the -3dB point.

Capacitor values should lie between 200 pf and 0.5 μf while resistor values should be between 1k ohm and 500k ohm. Values for several frequencies are shown. Component values for other frequencies can be found by interpolation or extrapolation or using the 1Hz values and the following procedure:

LOW PASS

Divide the capacitor values shown by the desired -3dB frequency (f_c). If the resulting capacitor values are too small multiply each by a constant and divide the 10k ohm resistor value by the same constant. If the capacitor values are too large divide each by a constant and multiply the 10k ohm resistor values by the same constant.

HIGH PASS

Divide the resistor values shown by the desired -3dB frequency (f_c). If the resulting resistor values are too small multiply each by a constant and divide the 0.01 μf capacitor value by the same constant. If the resistor values are too large divide each by a constant and multiply the resistor values by the same constant.

EXAMPLE

Suppose we want a 60Hz high pass filter:

C1 = C2 = C3 = 0.01μf

R1 = 11.43 M ohm divided by 60
= 190.5K ohm

R2 = 78.63 M ohm divided by 60
= 1.310 M ohm

R3 = 4.49 M ohm divided by 60
= 74.83 K ohm

R2 is over 1M ohm and should be scaled to about 20% of this value. Choosing a standard value capacitor of 0.047 μf or 4.7 times the previous value we divide all resistors by 4.7 to arrive at the final values:

C1 = C2 = C3 = 0.047 μf

R1 = 190.5K divided by 4.7
= 40.5K ohm

R2 = 1.310M divided by 4.7
= 279K ohm

R3 = 74.83K divided by 4.7
= 15.9K ohm

Note: when soldering to the 16-pin dual-in-line headers, use caution not to melt the plastic. Install the header in a 16-pin socket clamped in a vise to hold the pins straight during soldering.

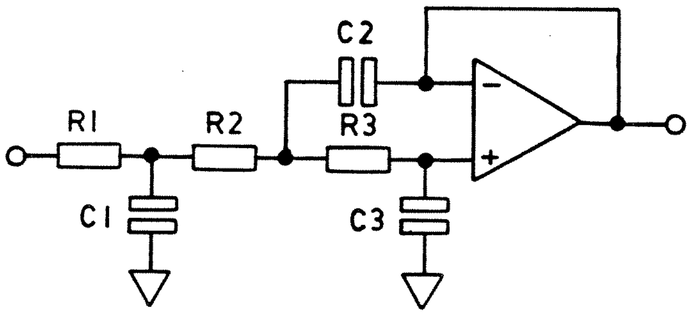
4.4.2.2 ANSI/IEC "A" WEIGHTING

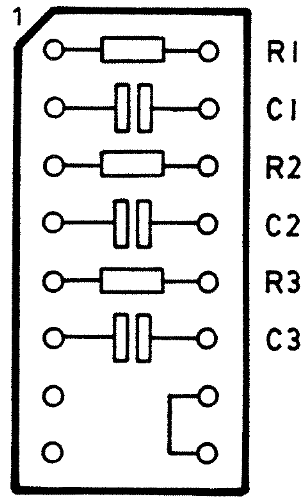
Details are also provided for construction of networks to provide curves conforming to the ANSI/IEC "A" Weighting specification.

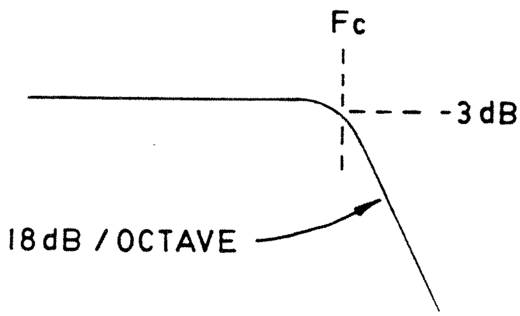
This curve conforms to ANSI specifications S1-4-1971 "Specifications for Sound Level Meters"; IEC Recommendation of Publication 123, First Edition 1961 "Recommendation for Sound Level Meters" and Publication 179 Second Edition 1973 "Precision Sound Level Meters".

"A" Weighting is typically used for tape recorder signal-to-noise measurements and acoustic noise measurements.

3 POLE LOW PASS FILTER

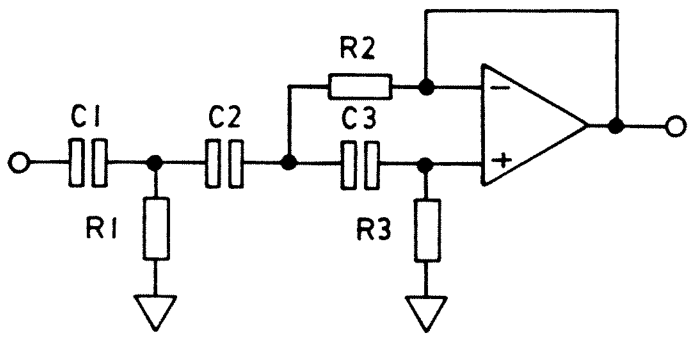


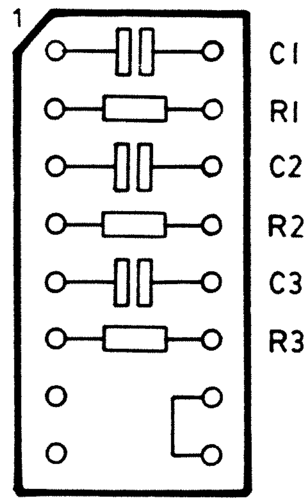


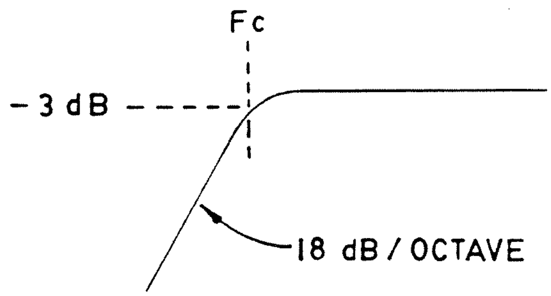


COMPONENT VALUES FOR LOW PASS FILTER				
F_c	C_1	C_2	C_3	$R_1 = R_2 = R_3$
100Hz	0.047 µf	0.12 µf	0.0068 µf	47k5 ohm
1kHz	0.022 µf	0.056 µf	3300 pf	10k0 ohm
10kHz	2200 pf	5600 pf	330 pf	10k0 ohm
20kHz	2200 pf	5600 pf	330 pf	4k99 ohm
30kHz	2200 pf	5600 pf	330 pf	3k32 ohm
50kHz	2200 pf	5600 pf	330 pf	2k00 ohm
80kHz	2200 pf	5600 pf	330 pf	1K24 ohm
100kHz	2200 pf	5600 pf	330 pf	1k00 ohm
1kHz	22.15 pf	56.44 pf	3.221 µf	10k ohm

3 POLE HIGH PASS FILTER

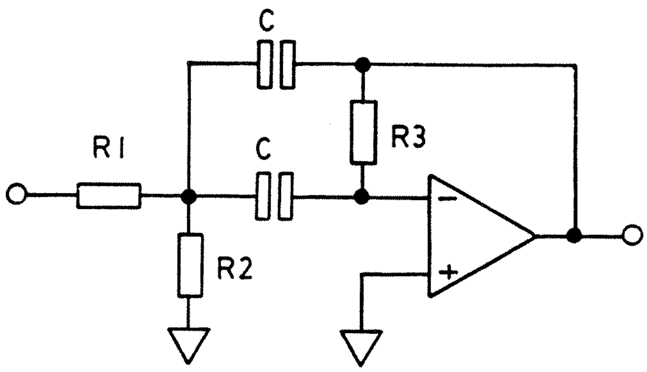


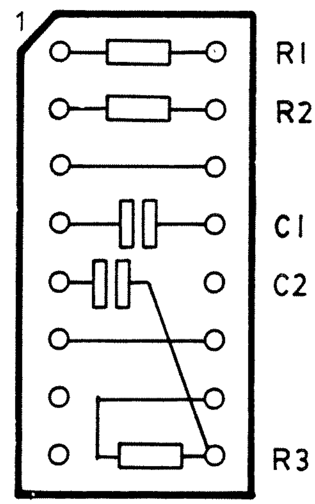


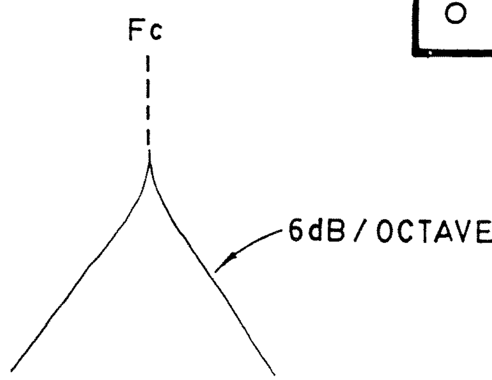


COMPONENT VALUES FOR HIGH PASS FILTER				
F_c	R_1	R_2	R_3	$C_1 = C_2 = C_3$
20Hz	26k1 ohm	10k2 ohm	178k ohm	0.22 μf
30Hz	17k4 ohm	6k81 ohm	118k ohm	0.22 μf
50Hz	48k7 ohm	19k1 ohm	332k ohm	0.047 μf
100Hz	24k3 ohm	9k53 ohm	169k ohm	0.047 μf
400Hz	28k7ohm	11k3 ohm	196k ohm	0.01 μf
1kHz	22k6 ohm	8k87 ohm	158k ohm	0.005 μf
10kHz	24k3 ohm	9k53 ohm	169k ohm	470 μf
1Hz	11M43 ohm	4M49 ohm	78M63 ohm	0.01 μf

SINGLE POLE PAIR BANDPASS FILTER







For Gain at $F_c = -1$ $\qquad R_3 = 2R_1$

$$\text{Filter } Q = F_c R$$

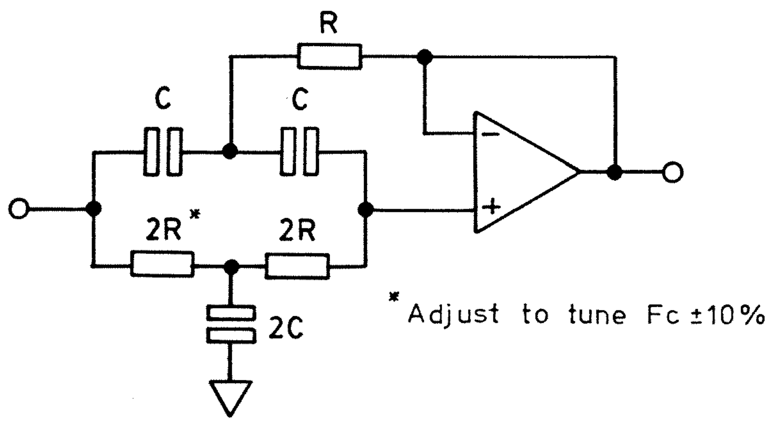
$$\text{Filter } Q = \frac{F_c R_3 C}{2}$$

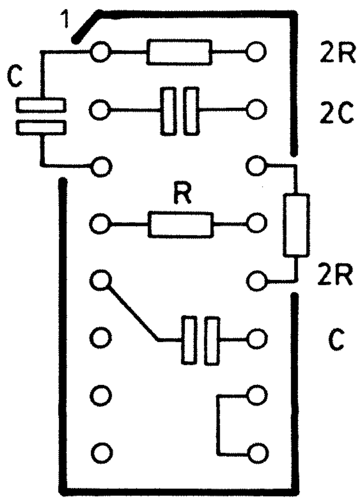
$$F_c = \frac{1}{\pi} \cdot \frac{R_1 + R_2}{2R_1^2 C^2 R}$$

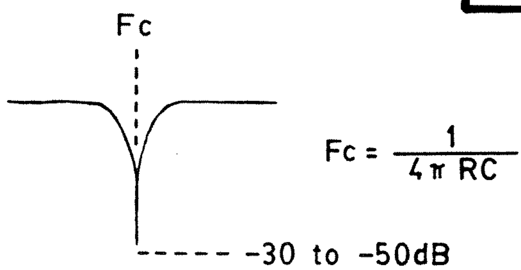
Example: For Q = 10

F_c	= 1kHz
C	= 0.1 μf
R_1	= 10k ohm
R_2	= 530 ohm
R_3	= 200k ohm

2 POLE "TWIN TEE" BAND REJECT FILTER

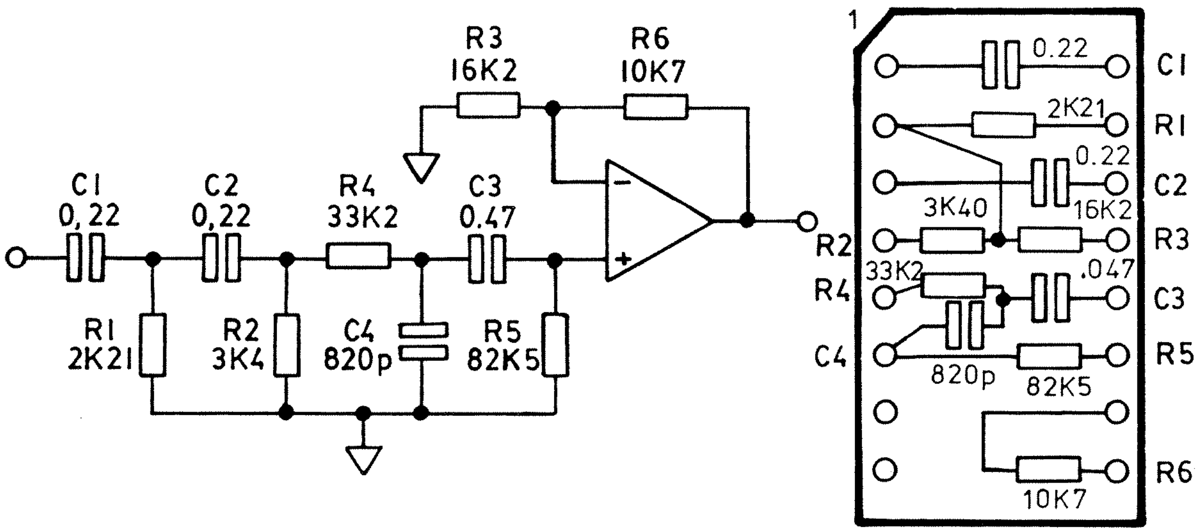


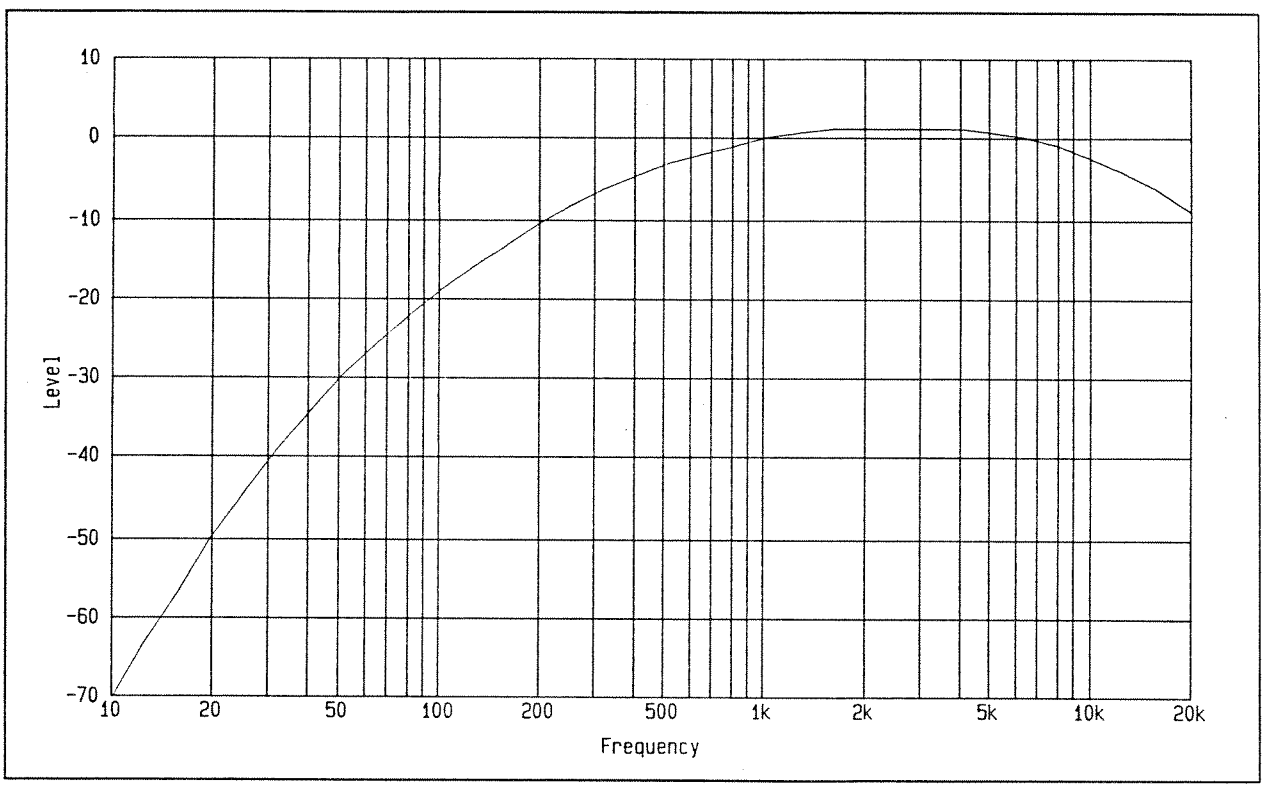




COMPONENT VALUES FOR BAND REJECT FILTER				
F_c	**R**	**2R**	**C**	**2C**
60Hz	26k7 ohm	56k6 ohm	0.05 μf	0.1 μf
120Hz	13k3 ohm	26k7 ohm	0.05 μf	0.1 μf
400Hz	20k0 ohm	39k2 ohm	0.01 μf	0.02 μf
1kHz	15k8 ohm	31k6 ohm	0.005 μf	0.01 μf
10kHz	2k43 ohm	4k87 ohm	3300 pf	6800 pf

ANSI-IEC A WEIGHTING FILTER





AMBER model 3501

DISTORTION & NOISE MEASURING SET

OWNER'S MANUAL

SECTION 5

THEORY OF OPERATION

Issue 09 April 1988

5.0 THEORY OF OPERATION

This section describes the various circuits used in the 3501 as a guide to circuit operation and to assist in troubleshooting. Reference should be made to Section 8, Schematic Diagrams. The second digit of each subsection in this Theory of Operation identifies the schematic being described. For example, subsection 5.4 Weighting Filters describes schematic 4.

Additional relevant details are provided in Section 6, Maintenance and Calibration and Section 7, Parts List.

5.1 INPUT ATTENUATOR & PREAMP

The signal connected to the front panel connectors appears at J1003 as one input of S1009, the input selection switch. The second input appears on J1009 and comes from the internal oscillator. S1009 selects one of these two possible signals to be the input to the distortion and level measurement circuitry.

The selected input is coupled via input coupling capacitors, C805 and C806. This signal appears on the input attenuator formed by the resistor string of R1065, R1062, R1061, R1067 and R1059 for one input and the second input on R1069, R1070, R1071, R1072 and R1073. These sets of resistors form voltage dividers to provide the input attenuator function. Their values are chosen to provide an input impedance of 100k ohm to ground and voltage division steps of exactly 10dB. The additional resistors and capacitors connected across this series string of resistors is used to provide high frequency compensation to cancel the effects of stray capacitance in the switches.

S1002A and S1002B is an eleven position rotary switch which selects the appropriate input level from the input attenuator. In the unbalanced case, the signal from the output of S1002A is coupled via resistor R1075 and bulbs F1001 and F1002 to the input preamp. The resistor provides current limiting protection and the bulbs protect the input preamp from gross overloads. Should excessive voltage be presented to the input Q1024 and Q1025, two transistors connected as diodes, conduct the excessive input current via D1010 and D1008 to the preamp supply rails and through D1013 and D1007 to ground. Excessive input voltage will cause conduction of both of these diode paths and under certain conditions will light the protection bulbs, F1001 and F1002.

The input preamp is formed by U1028 and surrounding components. Since the input characteristics of the 5534 operational amplifier, like most operational amplifiers, includes non-linear capacitance, excessive high frequency distortion would result if the attenuator were set to any of its mid positions. This would be due to the non-linear attenuation of the HF portion of the input signal. To prevent this problem a cascode circuit is used formed by dual matched FET U1029 and surrounding components.

The output of U1028 is coupled to the post amp formed by U1030. The complementary signal is connected in a similar fashion to Pin 3 of U1030. S1001A is an eleven position rotary switch labelled on the front panel as DISTORTION. In this capacity it sets the value of gain of the post-amp U1030. In high distortion settings of -70 to 0, a 10dB loss is provided. At low distortion settings of -80, -90 and -100, gain is unity. The final output from the input preamp is available on Pin 6 of U1030. This output is also DC corrected by integrator U1031 which also drives common mode rejection trims in the feedback path.

5.3 INPUT MULTIPLEXER & SWITCHED GAIN

U1016 and U1017 are CMOS switches used as the input multiplexer to select one of six possible inputs to be measured. The first input, LEVEL, is the direct output from the preamp shown on schematic 1. This input is selected in the LEVEL mode. The second plexers described in schematic 3 and certain other functions described later.

The gain logic shown on the right of schematic 5 sets the appropriate gain for the circuitry described in schematics 1 and 3. This is a complicated function of front panel knob setting and instrument function. For example S1001C, one section of the front panel DISTORTION control, sets the gain of the switched gain stages shown in schematic 3 only in the DISTORTION or NARROW BAND LEVEL mode. The various settings of S1002C and S1001C choose gain and attenuation combinations decoded by the various OR gates shown in the lower right hand corner of the schematic. Tables 6-1, 6-2, 6-3 and 6-4, in Section 6 and Schematic 18, describe all instrument gain conditions during various instrument functions.

5.6 DETECTORS & METER DRIVE

The signal to be measured ap pears as WEIGHTING OUT as shown on schematic 4. This signal is AC coupled to the main measurement RMS- to-DC converter, U1026. The linear output of this device is connected to a logarithmic amplifier formed by U1032A and U1032B in conjunction with U1033 to provide the logarithmic meter drive. Q1011 provides complementary temperature compensation for the logging diodes config ured from U1033, a LM394. U1035 is the meter driver amplifier. Q1010, a FET, is used as a switch to select a second averaging capacitor in parallel with C1033 to provide additional ripple suppression for low frequencies. This switch is enabled by a low frequency detect circuit shown in schematic 10.

In distortion applications, a ratiometric measurement is required: the measured value presented to U1026 must be compared against the fundamental signal which appears at PREAMP OUT. This latter signal is coupled to U1027, a second RMS-to-DC converter. The logarithmic output of this device is amplified by U1035B and coupled via R1104, CMOS switch U1034 and R1133 to the output meter drive amp. The logic shown in schematic 5 closes contacts 13 and 14 of CMOS switch U1034 only in the DISTORTION modes.

U1036 A and B are window voltage comparators which drive front panel level error indicative LEDs. The amplified DC output from U1027, representative of the PREAMP OUTPUT amplitude, is supplied as one set of inputs to these comparators. The second set of inputs is a reference voltage derived by the resistor string R1112, R1111, R1116 and R1114. Should the signal level at PREAMP OUT exceed its operating level, U1036B will change state thereby illuminating D1018 and showing a front panel overload condition. Should the signal at PREAMP OUT be too low in level, U1036A will change state and D1019 will illuminate on the front panel indicating an underload condition.

Since the distortion measurement system requires an equivalent meter gain of up to 100dB and the circuitry shown on schematic 3 only provides 80dB, the simulated meter gain is made up by DC offsets connected via the second and third sections of U1034. Tables 6-1 through 6-4, in Chapter 6, show the functions of the METER ADD and METER SUBTRACT circuits. The logic to drive these is shown in schematic 5 while

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schematic 18 shows a simplified configuration.

U1014 and U1015 are shunt regulators which generate the +7 and -7 Volt supply rails for the CMOS switches and the reference voltages used in the METER ADD and METER SUBTRACT functions.

5.7 OSCILLATOR & AGC

The oscillator is basically a state variable filter with controlled positive feedback. The three active elements are U2023, U2022 and U2020 forming the summing amp and two integrators of the conventional state variable circuit. The frequency decade range is set by selecting precision sets of capacitors via front panel FREQUENCY pushbuttons S2001, S2002 and S2003. Fine frequency control is achieved via the two section variable control V2015. V2014 and V2017 allow a small trim to the range of this frequency control.

The controlled positive feedback to sustain oscillation is via U2022 Pin 6, which is the phase two output of the state variable filter, via R2148 and the voltage controlled amplifier formed by U2024 and U2025 and also via R2049. The control inputs to this VCA are Pins 2 and 9 and 6 and 13 respectively. R2049 provides the majority of the feed back in order that the VCA need only provide a small contribution to maintain oscillation.

The control voltage input for the AGC VCA is provided by the circuitry shown in the lower portion of schematic 7. The output signal of the oscillator appears on U2020, Pin 6 and is coupled via C2067 to buffer U2019. U2021B and surrounding components generate a sampling pulse to drive Q2010 which charges C2064 to provide a voltage on Pin 3 of U2018A representative of the peak output signal amplitude. Q2009 is a shunt regulator used to develop an accurate reference voltage which is converted to a current via R2084 and forms the second input of U2018A. The error signal developed at Pin 1 of U2018A is further integrated in the sampling circuit composed of U2021A and U2018B. The final output from U2018B is the clean control voltage used to drive the AGC VCA.

The four trim controls, V2008, V2009, V2010 and V2011, permit the injection of controlled amounts of signal into the VCA control ports to null out the second harmonic distortion appearing at the final output of the oscillator. V2009 and V2010 are frequency independent controls while the remaining two affect only the high frequency portion. As both normal and quadrature signals are derived by using phases 1 and 2, second harmonic distortion of any phase or amplitude can be completely cancelled by appropriate settings of the trim controls.

Q2011 inhibits the AGC circuit in order to shut off the oscillator when the output attenuator S2011A is turned to the off position.

5.8 POWER AMP & OUTPUT ATTENUATOR

The final oscillator output from schematic 7 appears at one side of R2101 and via R2161 appears at U2030. The gain of this stage is set by the front panel OUTPUT LEVEL control over a range of approximately 12dB. The output of this stage is coupled via R2156 to the output power amplifier composed of U2029 and several discrete transistors as shown in the schematic.

If option 006, Intermodulation Distortion, is provided then the low frequency portion of the composite signal is injected through R2160 to form the composite signal. At the same time R2162 is grounded to attenuate the high frequency signal and provide the 4-to-1 ratio required by SMPTE specification.

The final power amp output appears at TP4 and is connected to J2004 and eventually to switches shown in schematic 15. Schematic 17 shows a simplified interconnection of the output configuration. The signal returns via Pin 1 of J2004 to appear on the output attenuator switch composed of a several-resistor ladder attenuator. S2005B is the primary output attenuator switch and if the option 005, balanced out is provided S2005C is also used. The final instrument output appears on J2003, Pins 3 and 4 which then connects via the switches on schematic 15 to the output connectors.

5.9 NOTCH FILTER

This filter is a conventional state variable filter formed by active devices U2017, U2016 and U2012. The center frequency of the filter is set in a similar matter to the filter used for the oscillator described in schematic 7. To provide the automatic tuning required, U2013 and a frequency adjust voltage controlled amplifier are injected into the path. This frequency adjust VCA is composed of U2009, U2010 and U2011. The control input to the frequency adjust VCA is via R2062 and is described in schematic 10 following. The center frequency of the filter may be varied over a narrow range by adjusting U2013 via R2071 and R2070 the gain of which controls the amount of contribution of the frequency VCA.

The band pass output of the state variable filter, phase two, appears on Pin 6 of U2016. This signal is coupled via R2048 as one input of summing amplifier U2008. The second input of this summing amplifier is the PREAMP OUTPUT or fundamental signal and is connected via R2047. The ratio of summing of these two signals is adjusted by light dependent resistor Q2021 via R2051. Servo circuits discussed in Section 10 control the amount of current fed to the LED of Q2021 and thereby the amount of band pass signal connected to U2008. At center frequency the band pass output is exactly 180 degrees out of phase with the input signal to the filter.

Thus when the summing of the two signals is adjusted to be identical the two signals will exactly cancel at the center frequency giving a band reject or notch output. This is connected via redundant CMOS switch, U2014, to the input multiplexer described in Section 3. U2016 is a second CMOS switch used as redundant switching for the LEVEL, BAND PASS and LOW PASS modes for the input multiplexer described in schematic 3. This CMOS switching is called redundant since it duplicates the function of the input multiplexer shown in schematic 3. However it is necessary in order to achieve the high levels of attenuation from unused inputs required for a distortion analyzer.

5.10 NOTCH SERVO NULL

U2003 together with U2002 form a 66dB gain amplifier to amplify the low level signal at the notch output shown in schematic 9. U2001A is an integrator used to provide DC offset correction to the 66dB gain stage. U2004A and U2004B are zero crossing detectors which produce square waves representative of the signals available at phase two and phase three respectively of the state variable filter shown in schematic 9. The output from U2004B is also sent via R2001 to the low frequency detector formed by the charge pump consisting of Q2001 and associated capacitors. The output of this frequency detect circuit is used to change the gain of integrator U2001A and the time constant of the RMS-to-DC converters described earlier in schematic 6. This frequency detect circuit is overridden when the instrument is in the DISTORTION mode.

Q2003 and Q2005 form switch-mode phase comparators used to servo tune the notch filter. U2006 and U2007 are integrators used to develop error signals from these switched comparators. The error signals are used to adjust the frequency and amplitude of the notch filter and summing circuits described in schematic 9.

U2005A and U2005B are window comparators used to drive the front panel tuning error LEDs, D2048 and D2049. A characteristic of the state variable filter is that it provides simultaneous high pass and low pass outputs (which are here called phase 1 and phase 3). When the filter is correctly tuned to the incoming frequency the signal am plitudes on phase 1 and phase 3 will be the same. When the filter is not tuned correctly one output will be a significantly lower signal amplitude than the other one. D2017, D2018, D2016 and D2015 and associated resistors and C2018 and C2017 compare the signal amplitude at these two phases and provide input to the window comparators, U2005B and U2005A. When the filter is in tune the signal levels on phase 1 and phase 3 are the same but the phase is opposite. In this condition, neither LED will illuminate. If the filter is out of tune by more than approximately 10% the diode and resistor network will generate an error voltage which will cause the comparator to change state and the appropriate LED to illuminate. The resistor ratios are set to give the appropriate overlap by making R2033 267k and R2034 200k and a similar ratio for R2032 and R2031.

5.11 LINEAR REGULATOR & BATTERY CHARGER

5.11.1 BATTERY CHARGER

The battery charger is of the dual rate stepped charge type to allow relatively fast charging of a discharged battery, yet provide a safe float voltage on prolonged overcharge. It is temperature compensated to avoid thermal runaway charging of a hot battery and provides an indication to show when the battery is being charged at the high rate.

The power control element of the battery charger consists of a 7805 5V three terminal regulator driven by U401A. Noting that the 7805 maintains 5V between its output and reference terminals, it is possible to control the output voltage relative to circuit ground by driving the reference terminal. The error signal is derived by comparing the difference between the 5V reference and the IR drop across the R408, R406 string. A temperature dependency matching that of the battery is introduced by including the diode located in the battery case in the reference circuit. Additionally, an integrating comparator circuit (U401B) measures the IR drop across current sensing resistor R402. At currents greater than approximately C/20 the output of U401B is at a high voltage level, reverse biasing D405 and effectively raising the reference voltage at the input of error amp U401A, producing a battery terminal voltage of 15.1V. At lower currents, U401B output goes low and robs current from the reference via D405 and R407, lowering the charge voltage to 13.9V. This imple ments the dual charge rate function. In the high charge rate mode, D406 is forward biased forcing the output of U401C high and illuminating the line present LED. This may also be effected by lowering the output of U401D which may be caused by reverse breakdown of D410 by a high enough voltage out of the rectifier filter circuit or more importantly by reverse biasing of the base emitter junction of Q405, indicating that the battery is not being used to power the instrument.

5.11.2 LINEAR REGULATOR

The linear regulator provides controlled drive to the switching converter. It provides automatic battery/line changeover determined by the magnitude of the incoming AC power. It regulates the drive to the switcher by sensing its auto transformer primary voltage. This reduces the output impedance of the switcher by including the switcher primary circuit in the feedback loop.

The main control element here is U402A which compares the attenuated output of the switcher with the precision reference voltage provided by Q402. The base drive for Q404, line sourced pass element, is supplied by R429. The output of U402A must be more negative than the base of Q404 to modulate its drive, thus reverse biasing the base emitter junction of Q405 and holding it in cutoff to avoid draining the battery. If the collector-base junction of Q404 is not reverse biased (indicating that there is not sufficient line voltage present), the output of U401A rises to attempt to maintain regulation. This will extract instrument operating curre
nt from the battery.

5.11.3 LOW BATTERY WARNING INDICATOR

A circuit is provided to indicate that an instrument that is being powered by the battery has almost exhausted its stored charge. If the battery voltage falls below a preset level, an oscillator is enabled which causes the front panel power-on LED to blink. This warns the operator that the battery is approximately 90% discharged.

The battery voltage is compared to a fraction of the stabilized output of the switching converter by U402C which is configured with a gain of 7 to effectively allow small changes in battery voltage to cause large changes in pulse width modulated oscillator U402D. With the battery voltage sufficiently high, U402C remains in positive saturation which causes the output of U402D to remain positive, holding the power-on LED full on. As the battery voltage drops, U402D is allowed to start oscillating but with a positive bias causing periodic dips in the intensity of the

LED which become progressively deeper as the battery voltage drops lower.

5.11.4 POWER SWITCH

An electronic power switch circuit permits low current ON/OFF switching as well as a feature which automatically shuts down the unit at the end of the battery discharge curve. This reduces battery drain to microamps to avoid damaging the battery. When the manual power switch is turned to the OFF position the battery drain is below its self-discharge characteristic.

The ON position of the ON/OFF switch sends diode or'd power from either the battery, battery charger circuit or the output of the switching regulator to the emitter of Q403. This waveform is coupled through C417 to the SET input of the RS latch comprised of U403A + U403B, setting the output of U403A low and turning on Q403. This applies V_{CC} to the linear regulator circuit which has a soft start feature provided by C416 across the voltage reference Q402. Comparator U402B will drive the reset input of the RS latch if the linear regulator falls out of regulation. This will shut off Q403 and thus remove power from the linear regulator, removing base drive from Q405 and thus terminating battery drain. Placing the ON/OFF switch in the OFF position effectively removes all drive to and grounds out of the linear regulator V_{CC}, guaranteeing that Q405 remains in cutoff.

5.12 IMD LOW FREQUENCY OSCILLATOR

Note this function available only if option 006, IMD, is included with the instrument. The schematic shows the low frequency oscillator used in conjunction with the existing oscillator of the 3501 to provide the composite intermodulation distortion test source. The oscillator shown in schematic 12 is a state variable filter with controlled positive feedback. The frequency of the oscillator is determined by R604, R605 and C601, C602. This is nominally set to 60Hz as shipped from the factory. By changing the value of R604 and R605 the frequency of the oscillator may be set anywhere from approximately 10Hz to over 500Hz.

Positive feedback is provided via R606 and a shunt resistor composed of R607 and the drain source resistance of Q601. When oscillating, the signal available at phase 1 (Pin 1 of U600A) and phase three (Pin 7 of U601B) is the same amplitude but of opposite phase. Thus D602 and D601 provide full wave rectification of this signal. Q608 is a shunt regulator used to derive a precision reference voltage of -6.2 volts. This voltage is converted to a current by R613 and is one input to U601A, Pin 2. The second input is the current representative of oscillator signal amplitude via R612. D603 provides temperature compensation for the inherent temperature variations in D601 and D602. U601A is a summing integrator used to compare the reference voltage to the DC representative of signal output amplitude and generate an error voltage to be fed via R609 to Q601 to control the amount of positive feedback. The circuit values are chosen so that this servo action just maintains oscillation and produces a signal amplitude of approximately 3 volts at T1, the oscillator output.

When the instrument is in the IMD mode, as determined by the functional logic described in schematic 5, RL602 will be operated. This causes the low frequency oscillator shown in this schematic to be coupled into the power amplifier described in schematic 8. A second set of contacts in RL602 attenuates the high frequency of the oscillator by grounding R2162 of schematic 8. If the instrument is in the CCIF/IMD mode then RL601 is energized and an external signal presented to J603 via a rear panel input connector is injected into the power amplifier shown in schematic 8. At the same time the high frequency signal is reduced in amplitude approximately 6dB by the shunting effect of R650.

5.13 IMD ANALYZER

The composite input signal to be analyzed which appears at PREAMP OUT is presented to the input of the 8-pole, 2kHz high pass filter shown at the top of schematic 13. This filter removes virtually all of the low frequency component leaving only the high frequency carrier with the IMD components. In the S5PTE type of IMD signal the high frequency portion of the composite waveform is 12dB below the low frequency waveform. Therefore the signal amplitude available at the output of the 2kHz high pass filter will be substantially lower than the composite amplitude of PREAMP OUT. U605B provides approximately 14dB of gain to make up for this low level signal and provides sufficient amplitude to the succeeding circuits.

U605A and U606A is an amplitude modulation detector formed by a precision absolute value circuit. The output at T8 will be a detected version of the HF carrier signal. This signal is then low pass filtered by the 1kHz 10-pole low pass filter shown at the bottom of schematic 13. The final output provided at J607 will thus be the AM products appearing on the HF carrier which are the intermodulation distortion products. When the instrument is switched to the CCIF IMD mode, the preamp output is connected directly to the 10-pole 1kHz low pass filter. This filter then removes the twin tone high frequency signal and leaves only the difference frequency signal for analysis at J607.

U610C is a CMOS switch used to attenuate the signal entering U605B in non-IMD modes and prevent clipping at T2. U610B is a switch to select the input to U602A which then goes to the ratiometric RMS-to-DC converter described in schematic 6. In the SMPTE IMD mode only, the input to the ratiometric RMS-to-DC converter is the amplitude of the high frequency signal. In all other modes the input to the RMS-to-DC converter is the signal at PREAMP OUTPUT.

5.14 SWITCHING POWER SUPPLY

The switching converter subsystem is used to convert 9V regulated input power to isolated ±15V and ±22V outputs which are used to power the analyzer and generator sections of the instrument respectively. A high frequency switching technique is used to reduce the size of the transformer which provides galvanic (ground) isolation. The unit is enclosed in a metallic case and all input and output lines are filtered to suppress the transmission of spurious radiated and conducted radio frequency signals.

The switching converter may be separated into several functional blocks: an oscillator and power switching stage and three output rectifier and filter circuits. Provision is made for including the primary circuit in a feedback loop by providing a sense output.

5.14.1 OSCILLATOR AND POWER SWITCHING CIRCUIT:

The switching converter is designed to operate at approximately 600kHz. Because it is difficult to guarantee an oscillator duty cycle of precisely 50% to avoid transformer saturation, a reference oscillator running at 1.2 MHz is divided by two to yield 600kHz at 50% duty cycle which is used to drive the power switching stage.

A classical two inverter CMOS oscillator is constructed around U502A and U502B with a design frequency of 1.2MHz and its output is divided by flip-flop U501A. The complementary outputs of the flip-flop are buffered by U502C and U502D and used to drive Q501 and Q502 out of phase. Note that the drains of Q501 and Q502 are used to short the gate-to-source junctions of Q503 and Q504 respectively and thus are only capable of turning them off. Positive gate bias is provided by R501 and R502 which are cross coupled to the drains of the complementary output devices. Thus when one of the output devices is on, its drain voltage approximates 0V and no drive is provided to its complement whose drain voltage rises to approximate twice the input voltage by virtue of auto transformer action in the primary. This provides a high gate drive voltage through the cross coupled resistor.

When the output of the flip-flop changes state the gate of the ON power device is shorted, turning it off and causing its drain voltage to rise and drive the gate of its complement whose gate has now been unclamped. Relatively large (60ma) currents flow in the cross coupled resistors for a short time (10 nsec) because the resistors must be kept low enough to quickly charge the parasitic gate capacitances. However the actual power dissipated is quite low because the voltages from which they are driven very quickly falls as the FET switches on.

5.14.2 OUTPUT RECTIFIER CIRCUIT

Full wave center tapped bridge rectifier circuits are provided for the ±15V and ±22V outputs. Very little energy storage is provided because of the square wave input. The rectifier matrix formed by D501 and D502 provides a reference output which includes half of the primary circuit IR losses and some of the magnetic circuit losses to permit the use of negative feedback in the drive circuit to lower output impedance and improve regulation.

5.15 FRONT SWITCH ASSEMBLY

This schematic describes the front panel switching for power on/off and monitoring and output configuration selection. It also contains the dB relative control. The functional switching of this assembly is best understood by referring to simplified schematic 17.

5.16 SYSTEM INTERCONNECT

Each subassembly interconnects with others by one of two kinds of harnesses: 16-conductor flat cable or 2-to-4 conductor, 4 pin Molex connector. Drawing number 16 gives the details of interconnection of a complete system including options.

5.17 SIGNAL PATH, OUTPUT CONFIGURATION

Drawing number 17 shows in simplified form the signal path of the output circuits. As the signal travels among several subassemblies, signal tracing can be difficult. This drawing simplifies the task.

The signal originates on schematic 8 then travels to schematic 15, optionally via the balancing module, back to schematic 8 and back to schematic 15 and the output connectors. All of the switching is identified as well as switch contact numbers and connector pin numbers on this simplified schematic.

5.18 GAIN & METER DRIVE SIGNAL PATH

Drawing 18 is a simplified func tional representation of the various gain stages and the meter drive circuits in the 3501. Reference is made to Tables 6-1 to 6-4 on pages 6-18 to 6-21 for actual gain values for every setting of front panel controls. Other schematics show the actual logic circuitry that decodes the front panel controls and drives the various switches that establish signal routing and gain.

5.19 INSTRUMENT GROUND SYSTEM

This drawing shows in simplified form the grounding configuration of the OUTPUT and INPUT connections to the 3501. Note that the BALANCED MODE illustration presumes the instrument has option 004 and 005 installed.

5.20 POWER TRANSFORMERS

This drawing shows the internal schematic of the mains transformer. This device converts the mains voltage to the nominal 14V AC, 3A required by the 3501 power supply.

Note that the assembly has provision to accommodate several mains supply voltages. Also as shipped, a single fuse is provided but instructions are shown for wiring of a second fuse to meet particular safety standards.

5.21 The remaining drawings are reproductions of board assembly component layouts similar to information screened on to the actual boards themselves.

AMBER model 3501

DISTORTION & NOISE MEASURING SET

OWNER'S MANUAL

SECTION 6

MAINTENANCE & CALIBRATION

Issue 09 April 1988

CAUTION : This instrument contains CMOS and other types of semiconductors that are sensitive to electrostatic discharge. These parts can be permanently damaged or their reliability diminished unless proper handling procedures are followed.

Before removing the cover of this instrument, study these procedures carefully and follow them rigorously to avoid damaging your instrument.

1 - USE A STATIC FREE WORK STATION

This includes an antistatic work surface grounded via a high value resistor (330k ohm, for example) to a hard ground. Avoid all plastics, vinyl and styrofoam including styrofoam cups, plastic coffee cups, plastic coffee cup holders, cigarette packages with cellophane wrappers, plastic combs, vinyl books or folders, plastic covers on work sheets, plastic bottles, plastic bags, potato chip bags, plastic purses, plastic solder suckers and plastic ashtrays.

2 - ENSURE THAT YOUR BODY IS GROUNDED BEFORE TOUCHING ANY STATIC SENSITIVE DEVICE

Develop habits to prevent discharging your body into static sensitive devices. When approaching a test bench touch a ground first. When working on equipment wear a metallic wrist strap connected via a 330k ohm resistor to hard ground. If not wearing a grounding strap, hold on to a ground while touching any semiconductor (unpowered of course).

3 - KEEP PARTS AT GROUND POTENTIAL

Store parts in antistatic containers such as special antistatic integrated circuit storage tubes or special conductive foam. Pick up parts by the body of the item, not the leads. Do not subject semiconductors to sliding movements over any surface at any time.

4 - USE GROUNDED TEST EQUIPMENT

This includes soldering iron tips, voltmeters, oscilloscopes, etc. Never probe or test unpow-ered semiconductor circuitry with an ohm meter.

COMPONENT REMOVAL & REPLACEMENT

Components that are soldered in place must be removed with great care to avoid permanently damaging the printed circuit board. Amber circuit boards are among the highest quality available but, as with all boards with high component density, small somewhat fragile traces are used. Improper component removal could pull these traces off the board necessitating major repair.

To remove a defective or suspect component first remove solder from the mounting pad. Use a good quality vacuum solder removal tool or similar technique to remove solder from around and inside the plated through hole that mounts the component. After this is done, carefully free the leads one by one which will probably be sticking to one side of the hole. Use care to avoid damaging the pad. It is suggested that where possible, the component be crushed to allow each lead to be removed individually. If this is not possible cut each lead close to the component body, remove the body then the leads one by one. Do not use excessive force to pull the leads out of the board. They should either fall out by gravity or be able to be gently removed by applying a slight heat to the lead with a soldering iron. Avoid overheating the pad as this could destroy the adhesive holding the pad and trace to the board substrate. Examine each removed lead to see if the internal hole plating has been removed by accident. If so, this pad will have to be soldered to both sides of the board when the new component is inserted to maintain continuity.

Careful practice in component removal will prevent any board damage and leave the component mounting pads and surrounding board area in the same state it was in before component removal.

6. MAINTENANCE & CALIBRATION

6.1 CALIBRATION

The model 3501 contains a number of internal calibrations and adjustments. These fall into two categories: those requiring calibration to an external standard and those requiring adjustment for best performance. The former require the use of high precision calibration equipment not usually available in the average shop. A reasonable level of calibration, though below the 3501 specifications, can be done using a high quality AC level meter as the external reference.

All trim adjustments are located on the three (or four) circuit boards: Filter/Oscillator, Input/Meter, Power Supply and IMD. The three signal boards are horizontal while the power supply is located on the rear panel. The Filter/Oscillator board is on the top of the instrument, with adjustments accessible by removing the top cover. The Input/Meter board is located on the bottom with its adjustments accessible by removing the bottom cover. The IMD board, if provided, is also on the bottom. Note that it is only necessary to remove the top and/or bottom cover to gain access to most trim adjustments. Exceptions are the adjustments for common mode rejection on the preamp. To gain access to these trims, the bottom chassis holding the optional IMD board must be tilted back. Refer to Section 6.6.1 for instrument disassembly before removing the chassis.

6.2 INPUT/METER BOARD (3501-410-03)

This circuit board contains seven trim adjustments which calibrate the 3501 meter. There are two trim adjustments for common mode rejection and one trim capacitor for input attenuator compensation.

6.2.1 LEVEL METER CALIBRATION

Equipment required: Precision AC calibrator. Alternat ive equipment: If a precision AC calibrator is not available, use an accurate AC level meter and the Generator of the 3501. The accuracy of the adjustment will then be only as good as the accuracy of the meter used and may produce some anomalous results.

Note that the mechanical "zero" of the meter is set to cause the pointer to rest on the left calibration mark with no signal on the meter (3501 turned off). This is due to the fact that the meter law is logarithmic.

All seven trim adjustments which calibrate the 3501 meter are on a small circuit board located adjacent to the filter/oscillator board accessible by removing the top cover. This circuit board is interconnected to the input/meter board via a 16-conductor flat cable. The trim adjustments are numbers V1001 to V1007 inclusive in numerical order from the front of the PCB (towards meter) to the rear (towards power supply).

Connect the AC calibrator to the 3501 INPUT and select the LEVEL FUNCTION. Set the INPUT control to +10dB/3V and set the distortion control to -70/0.03%. Adjust the AC calibrator to exactly 1.000V AC at some midband frequency, 1kHz preferred. Adjust V1005 so the meter points to -10dBV or 1 on the 3FS Volts/% scale (that is at the left end of the scale).

Turn the INPUT control to 0dB/1V and adjust V1001 so the meter points to 0dBV or 1V. Check the -10dBV reading with the INPUT control at +10dB again and if necessary iterate back and forth between the 0 and +10dB positions of the INPUT control and R1128 and R1122 to achieve the correct results.

With the INPUT control to 0dB/1V and the meter indicating 0dBV/1V, turn the distortion control to -80/0.01% and adjust V1004 for the same reading (0dBV/1V).

6.2.2 RADIOMETRIC CALIBRATION

Connect the AC calibrator as above, set the distortion control to - 80/0.01% and select the test mode by releasing all three FUNCTION buttons (i.e. LEVEL, THD, and IMD buttons all out).

Set INPUT control to 0dB (again using the 1.000V AC source). Adjust V1006 for a 0dBV meter indication.

Set INPUT control to +10dB and adjust V1007 for the same meter indication (0dBV).

Iterate the above steps if necessary to achieve a constant 0dBV meter reading as the INPUT control is switched between 0 and +10 with a constant input level of 1.000 Volt.

Set distortion control to -70/0.03%, adjust V1002 for the same meter indication as the -80/0.01% position.

Select low pass mode. Set input level control to -90 (0.003%) and connect an AC source with a level of -60dBV (1mV) at 1kHz. Adjust source level so the meter indicates -10dBV (if excessive meter bounce occurs, push in both 400 HP and 30k LP filter buttons). Switch distortion control from -90dB (0.003%) to -100 dB (0.001%) and adjust V1003 for a meter reading of 0 dBV.

6.2.3 COMMON MODE REJECTION

Connect a single ended AC source of approximately 3.000V (+10dBV) and 100Hz to both balanced inputs of the 3501. To do this it will be necessary to connect to both the tip and ring of the three conductor phone jack BALANCED input. Set the INPUT control to +10dB and the DISTORTION control to -80/0.01%. Connect the INPUT MONITOR output to an oscilloscope and adjust V1008 for the most complete null. Change the source frequency to 10kHz and adjust C1090 trim-cap for the most complete null.

6.3.0 FILTER/OSCILLATOR BOARD

This circuit board, located at the top, contains thirteen trim adjustments. Eight are located on the right half of the board - the oscillator. The five remaining are on the left half of the board - the fundamental rejection/filter circuit. Both the oscillator and the notch filter contain frequency independent second harmonic distortion trims. Casual adjustment of these trim controls can give deceptive results fooling the user into thinking the instrument has been adjusted for minimum residual distortion. Depending on the relative phase of distortions, reinforcements or cancellations may occur causing an erroneous calibration. Therefore the calibration of the oscillator requires a "perfect" analyzer and vice versa. However an alternative technique, described in the calibration steps, overcomes the cancellation/ reinforcement effects described and makes the 3501 oscillator and analyzer distortion self-calibrating with a very high degree of accuracy.

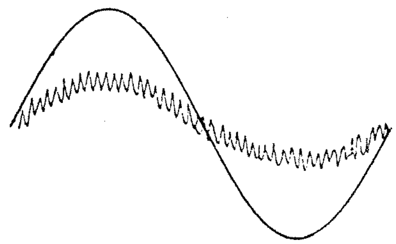
Before beginning the calibration steps, some terminology used in the description is explained which would aid in the interpretation of results.

Following is a narrative on distortion residual character with illustrative waveforms. It is important to be familiar with the nature of the residual distortion to identify the proper adjustment procedure.

Typical residual waveforms will contain noise and possibly some synchronous components. If any asynchronous components exist (example, mains hum, spurious non-related signals, etc.) they must be removed before these calibrations can proceed.

A properly adjusted and performing 3501 shows only random noise as residual distortion at mid-band frequencies. If the residual signal shows any evidence of periodicity, identify the order of the signal, that is its harmonic character, to determine the procedure for correction. Use a dual trace oscilloscope with a clean representation of the fundamental (oscillator output) on one trace and the residual on the second trace. Trigger on the fundamental.

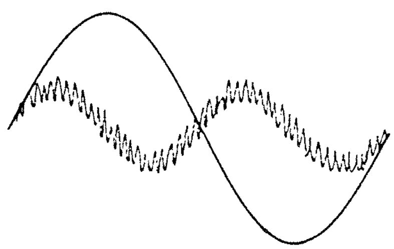
Residual waveforms will occasionally contain several components making their identification difficult. The following descriptions presume one signal dominates (above the noise). Careful examination of a composite waveform can, with experience, determine the harmonic content. Treat the elimination of each component individually.



FUNDAMENTAL

FUNDAMENTAL REJECTION -

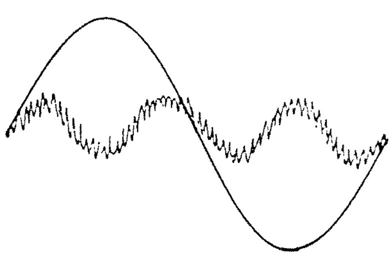
The 3501 analyzer contains a very high "Q" notch filter which rejects the fundamental test frequency and leaves the remaining harmonic content intact. This notch filter has a deep notch depth of approximately 120dB, when properly adjusted.



SECOND HARMONIC

SECOND HARMONIC DISTORTION -

Both oscillator and analyzer in the 3501 contain frequency independent second harmonic distortion trims. Second harmonic distortion may be identified by viewing the distortion products on the scope being twice (2x) the frequency of the fundamental.



THIRD HARMONIC

THIRD HARMONIC DISTORTION -

This type of distortion is produced by various device non-linearities and can not be trimmed out in the 3501. However, third order products are typically below the residual 3501 system noise and cannot be visually identified except at the highest frequency range.

Excessive levels of third order distortion indicates a faulty component which should be identified and replaced prior to calibration.

6.3.1 FILTER CIRCUIT CALIBRATION

The five trim adjustments serve the following function and must be correctly set before the oscillator calibration is performed:

V-2001, V-2002 - fundamental rejection

V-2003, V-2004 - servo second order trim

V-2005 - filter H.F. "Q" enhancement

These adjustments are critical and will compromise system residual distortion if not correctly set. The proper adjustment requires a very high purity oscillator with known distortion characteristics below 100dB/0.001% THD at 1kHz. The 3501 oscillator may be used if it is not out of calibration; if it is, see Section 6.3.2.2.

6.3.2.1 FILTER SECOND ORDER TRIM (if 3501 oscillator is properly calibrated)

Set frequency to 1kHz (10 x 100Hz) + 10dBV oscillator level and connect oscillator to analyzer by pushing PUSH FOR OSCILLATOR button. Connect a DC voltmeter to read DC voltage at U2006, Pin 6. Select THD mode on the front panel then adjust V2017 for a DC voltage reading of 0.000V ± 10mV. Adjust V2004 for minimum second order distortion.

Re-adjust V2017 for a DC voltage reading of -1.000V ± 10mV at U2006, pin 6. Adjust V2003 for minimum second order distortion.

Leave V2017 at previous setting of -1.000V ± 10mV at U2006, Pin 6. Then, while measuring distortion, change frequency with the front panel frequency vernier and go through the complete range of 100Hz to 1kHz while observing front panel frequency tuning LED's. These LED's should not light as the frequeny is changed through the above range. If they do, readjust V2017 until both LED's are always extinguished.

The filter second order trims are now properly calibrated.

6.3.2.2 FILTER SECOND ORDER TRIM (if 3501 oscillator is out of calibration)

The alternate use of tip and ring input of the balance input is necessary to overcome the filter/oscillator distortion cancellation/ reinforcement. See Section 6.3.0.

The use of this alternate inversion overcomes the false second harmonic reading which would otherwise be obtained. For example, if the oscillator had second order distortion due to improper adjustment, this distortion could be incorrectly cancelled out using the analyzer adjustments. The instrument would then appear to have no second harmonic distortion but in fact, depending on the nature of the device under test, could exhibit high levels of residual distortion thereby giving erroneous readings. Because second harmonic distortion is asymmetric in nature, the problem can be avoided by adjusting while alternately inverting and not inverting the signal in the measurement path. The interacting second harmonic null adjustments in both the oscillator and the analyzer are adjusted to give the same residual distortion magnitude in the inverting and non-inverting case. As each of the controls approaches its proper setting, the residual distortion level will gradually be reduced. Iteration between all four controls (2 on the oscillator and 2 on the analyzer) while inverting and not inverting will eventually show complete absence of second order in either mode and result in the instrument achieving its specified performance.

The inversion may be achieved by using the tip or ring inputs of the BALANCED input connector alternately while grounding the unused side of either tip or ring.

Follow the calibration procedures given in Section 6.3.2.1. The proper adjustments of V2003 and V2004 will be such that no change in the residual distortion is detected with the oscillator fed via an inversion or non-inversion. Then trim out oscillator second harmonic distortion with V2009 and V2010, if it is out of calibration. Iterate above steps until minimum system residual is achieved. (Typically -103dBV, 1kHz THD + Noise, band limited with 400Hz H.P. and 30kHz L.P. filters.)

6.3.3 FUNDAMENTAL REJECTION TRIM

With the above setup, adjust V2201 and V2202 for minimum fundamental.

6.3.4 FILTER H.F. "Q" ENHANCEMENT TRIM

Connect internal oscillator directly to analyzer. Turn distortion control to 0dB/100%. Set frequency to 100kHz at +10dBV and obtain a reading in the "LEVEL" mode. Switch to band pass mode and adjust V2005 for the same meter reading as the level mode.

6.3.5 OSCILLATOR CIRCUIT CALIBRATION

The eight trim adjustments serve the following functions:

V2006 - oscillator level

V2007 - oscillator HF "Q" enhancement

V2008 and V2011 - H.F. second harmonic cancel

V2009 and V2010 - frequency independent second harmonic cancel

V2012 - transformer linearization trim

V2013 - power amplifier bias adjust

Due to the critical nature of the adjustments and oscillator distortion desired (<104dB/ 0.0006% typical THD + noise at 1kHz), a reference analyzer with low distortion and high notch depth (>115dB) must be used. The 3501 analyzer properly calibrated will serve this function.

Set front panel oscillator level to +10dBV and connect to calibrated 3501 analyzer or external reference analyzer and setup to read THD of the oscillator. Proceed with the following adjustments in the described order.

6.3.6 FREQUENCY INDEPENDENT SECOND HARMONIC CANCEL TRIMS

Set oscillator frequency to 1kHz (10 x 100Hz) and adjust V2009 and V2010 for minimum second harmonic distortion as viewed on an oscilloscope.

6.3.7 HIGH FREQUENCY SECOND HARMONIC CANCEL TRIMS

Set oscillator frequency to approximately 70kHz (7 x 10kHz) and adjust V2008 and V2011 for minimum second harmonic distortion as viewed on an oscilloscope.

6.3.8 POWER AMPLIFIER BIAS ADJUST

Set oscillator frequency to approximately 70kHz (7 x 10kHz) and adjust V2013 until the crossover distortion spike just disappears as viewed on an oscilloscope.

6.3.9 OSCILLATOR LEVEL ADJUST

On units with option 005, Balanced Output, set oscillator to MAX position and LEVEL control fully clockwise with FREQUENCY control at 1kHz. Select balanced output, termination switch pressed in (ON) and adjust V2006 for maximum output just before clipping occurs. On units without balanced output, adjust V2006 for +10dBV (3.16V AC) at U2020, PIN 6.

6.3.10 OSCILLATOR H.F. "Q" ENHANCEMENT ADJUST

Set oscillator to 1kHz (10 x 100Hz) and monitor DC volts at U2018, PIN 7. Note reading obtained then switch to 100kHz and adjust V2007 for the same DC voltage reading as 1kHz.

6.3.11 BALANCED OUTPUT DISTORTION NULL

Set the oscillator to 20Hz (10 x 2Hz), balanced output mode, termination on level to maximum (ATTENUATOR to MAX position and LEVEL fully clockwise). Connect the OUTPUT to the INPUT by pushing the PUSH FOR OSCILLATOR button and set up the analyzer for a THD reading. Adjust V2012 for minimum distortion while observing the distortion products on an oscilloscope. This control provides compensation for the non-linear-ities in the transformer used to achieve the balanced output. With proper adjustment, a typical reading of -94/0.002% (band limited 400Hz to 30kHz) should be obtained. The adjustment is somewhat temperature dependent and so should be made with the 3501 in a typical ambient temperature environment.

6.4 IMD BOARD (3501-460-03)

This circuit board contains only one trim. It adjusts the low frequency amplitude of the IMD composite source signal to conform to the SMPTE standard of 4:1 amplitude ratio of the low and high frequency respectively. The calibration procedure is as follows:

Set front panel oscillator controls to +10dBV and 10kHz and connect OUTPUT to an oscilloscope. Note the peak--to-peak sine wave amplitude displayed in the LEVEL mode. Switch function to IMD and adjust V-601 for the same peak-to-peak amplitude.

6.5 POWER SUPPLY BOARD (3501-440-03)

This circuit board contains two trim pots and serves the following functions:

V-401 - Battery charge current adjust

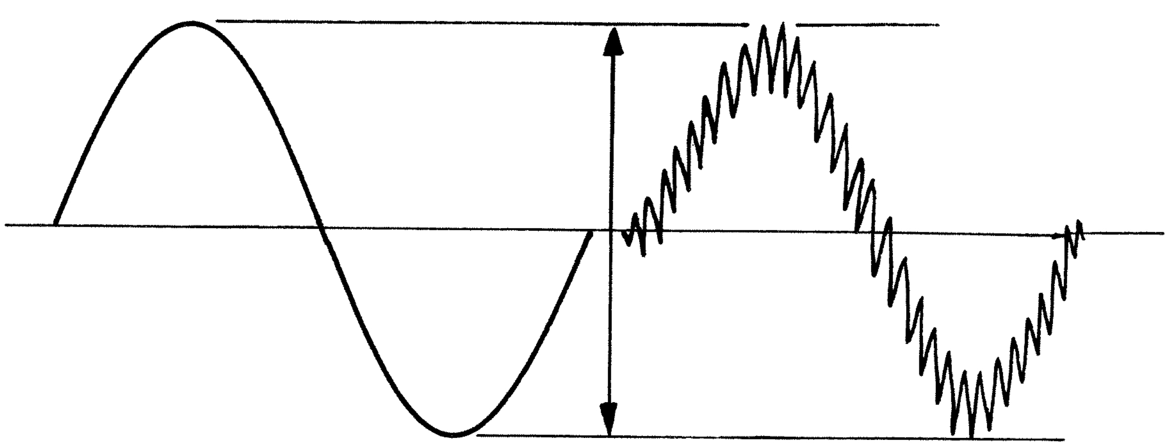
V-403 - Output DC rail voltage ±15Vand ±22V adjustment

6.5.1 OUTPUT RAIL VOLTAGE ADJUST

Monitor the ±15 Volts rail voltage on the left side of the filter/oscillator board (3501-420-02) U2016, PIN 7 for +15V and PIN 4 for -15V. Adjust V403 for ±15V DC on this section. The 22 Volt rails track the 15 Volt rails.

6.5.2 BATTERY CHARGE CURRENT ADJUST (if option 001 or 002 provided)

Replace battery with 100 ohm, 5 Watt resistor and adjust V401 to obtain 14.00 Volts DC across this resistor. This sets the proper charge current for the battery.



H.F. Level Mode   IMD Composite

FIGURE 6.4 IMD Signal Amplitude

6.6 MAINTENANCE SECTION

This section contains information for maintenance and repair of the 3501. The first section is detailed disassembly instructions for each sub-assembly.

6.6.1 3501 DISASSEMBLY INSTRUCTIONS

The disassembly of the 3501 requires only the use of a Phillips screwdriver, except where front panel knobs must be removed, which is described below:

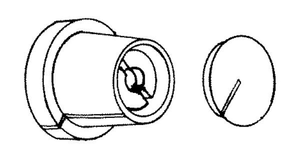


Figure 6.6.1 Knob Removal

Remove front knob caps with a to reveal a slotted nut. This must be loosened counterclockwise to decouple the knob from its shaft. This could be done by making a slotted screwdriver as shown below.

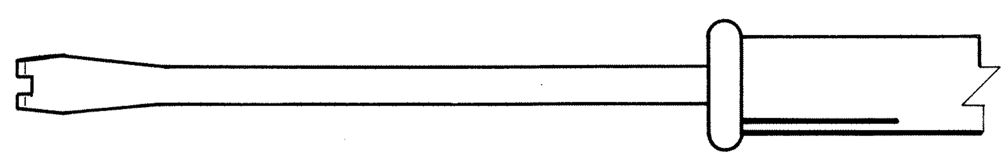


Figure 6.6.2 Special Screw Driver

CAUTION : Always unplug unit from mains supply when disassembling. Also unplug battery harness on J-404 power supply board where applicable.

6.6.2 ACCESS TO THE FRONT PANEL OUTPUT BOARD (3501-480) & IMD BOARD (3501-460)

Begin by the removal of the bottom cover which is secured by 4 black Phillips head screws; this will reveal a shield plate that contains the above boards. The right side of the IMD board contains the IMD analyzer and the left side is the low frequency oscillator. A 16 PIN flat cable loops from J-602 to the top layer board (Filter/Oscillator 3501-420). The output board (3501-480) contains switching for the oscillator output functions as well as the power functions (Power on, Battery charge, Battery test) and the dB relative control.

6.6.3 ACCESS TO THE INPUT METER BOARD (3501-410)

Follow step 1 of above then remove the dB relative knob and 2 side panel screws that secure the shield plate in place. Also remove J805 flat ribbon cable and J804, J801, J803, J812 Molex harness. By gently lifting rear of shield plate and sliding back the complete assembly it may be swung up, pivoting at the rear of the shield plate. One can then gain access to the Input/Meter board which contains the functions sketched in Figure 6.6.3.

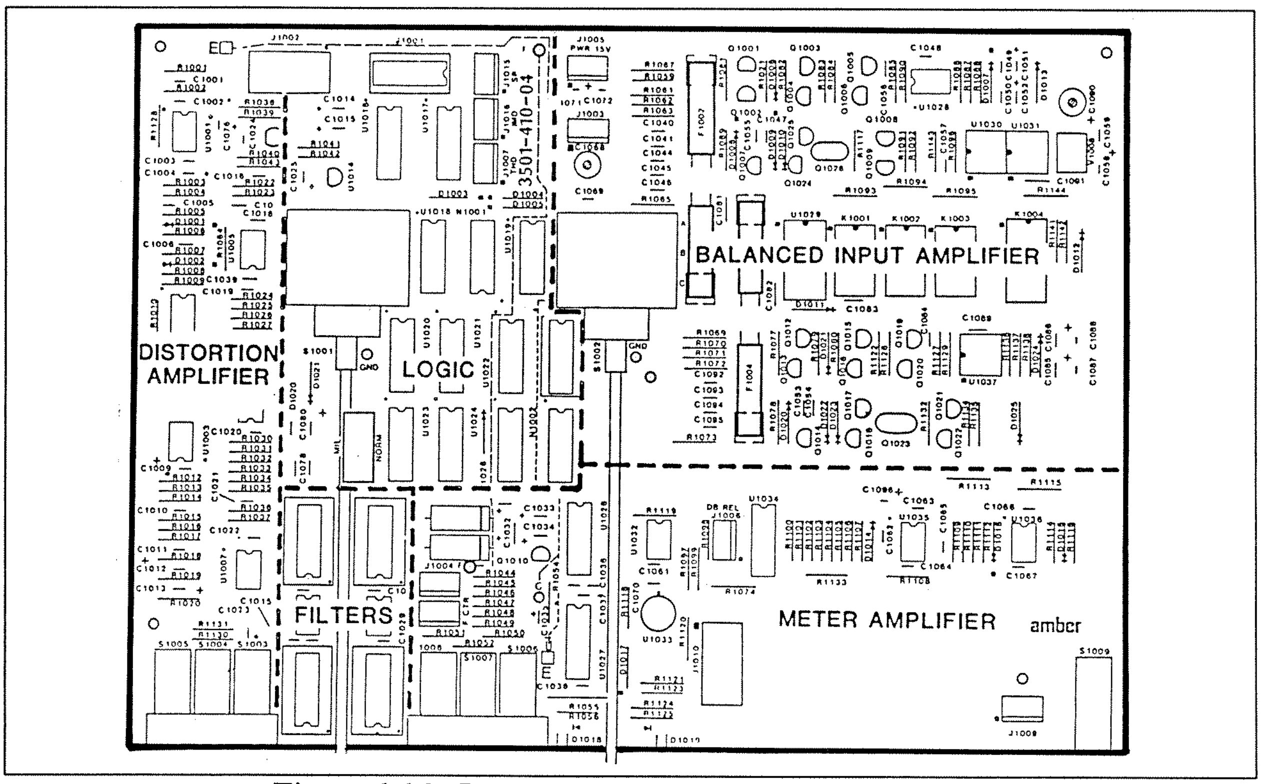


Figure 6.6.3 Input/Meter Board Functional Layout

If the removal of this board is required, the front panel is removed to allow the board to slide forward. First remove the front top and bottom dress strips and then the 4 Phillips head screws which secure the front panel to the side panels. Remove all but the FREQUENCY select knob which is part of the front panel assembly. Loosening two Allen head screws to the four section frequency pot, V2014 and V2015, will enable you to decouple it from its shaft. The front panel may be removed at this point and the Input/Meter board removed by unfastening the 5 screws securing the board to the 3501.

6.6.4 ACCESS TO THE FILTER/OSCILLATOR BOARD (3501-420)

Begin by the removal of the top cover which is secured by 4 Phillips head screws. This will reveal the Filter/Oscillator board (3501-420) which contains the main oscillator and power amp/attenuator on the right side and the state variable notch filter on the left side. To remove this board, first remove appropriate front panel knobs. The frequency select dial is part of the front panel assembly and may be decoupled from the 4 section frequency pot by loosening 2 Allen head screws. Then remove 5 Phillips screws securing the board and appropriate cables. The board may be slid out from the rear of the front panel.

6.6.5 ACCESS TO THE POWER SUPPLY BOARD (3501-440) & SWITCHER ASSEMBLY

The power supply is separated into two parts:

1) Linear section containing AC rectification, regulators and battery charge circuits

2) Switching supply containing the transformer, MOS-FETS and ±22V, ±15V regulated outputs contained in a steel enclosure.

Both of these sections are located on the rear panel and bottom plate of the 3501. The rear panel must be removed so that you can remove either of these assemblies. Proceed with the following steps:

1) Remove both top and bottom covers (8 Phillips screws)

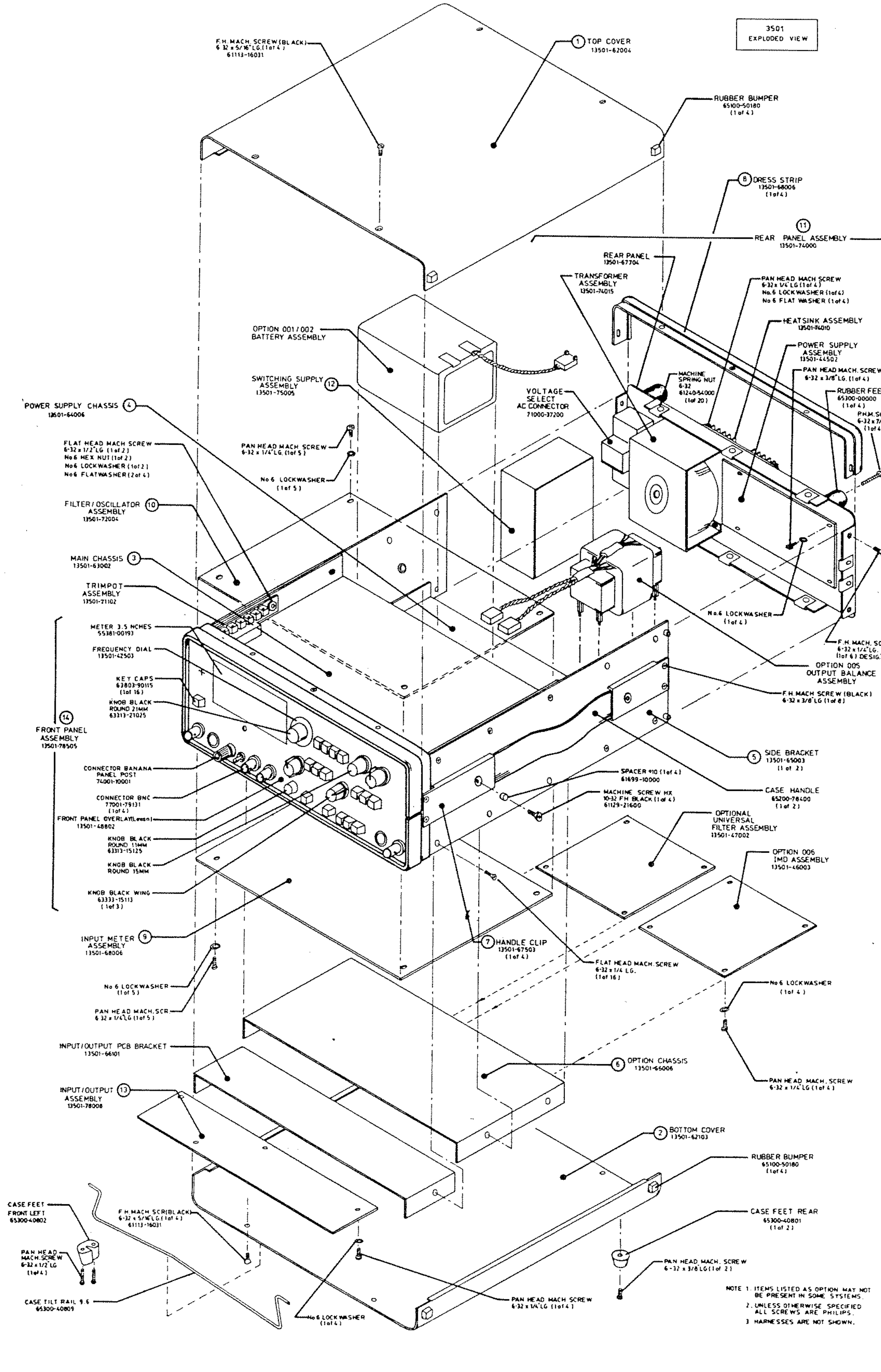
2) Remove rear top and bottom dress strips (6 screws)

3) Remove rear panel assembly, unplug appropriate harnesses (4 screws)

Note the flat cable J-401 orientation

4) Remove switching supply steel enclosure from bottom support plate (2 screws)

Reassemble in reverse order.


3501
EXPLODED VIEW
F.H. MACH. SCREW (BLACK) 6-32 x 5/16" LG. (1 of 4) 61113-16031
1 TOP COVER 13501-62004
RUBBER BUMPER 65100-50180 (1 of 4)
8 DRESS STRIP 13501-68006 (1 of 4)
11 REAR PANEL ASSEMBLY 13501-74000
REAR PANEL 13501-67704
TRANSFORMER ASSEMBLY 13501-74015
PAN HEAD MACH SCREW 6-32 x 1/4" LG (1 of 4)
No.6 LOCKWASHER (1 of 4)
No 6 FLAT WASHER (1 of 4)
HEATSINK ASSEMBLY 13501-74010
POWER SUPPLY ASSEMBLY 13501-44502
PAN HEAD MACH. SCREW 6-32 x 3/8" LG. (1 of 4)
RUBBER FEET 65300-00000 (1 of 4)
P.H.M. SCR. 6-32 x 7/8" LG (1 of 4)
MACHINE SPRING NUT 6-32 61240-54000 (1 of 20)
VOLTAGE SELECT AC CONNECTOR 71000-37200
OPTION 001/002 BATTERY ASSEMBLY
SWITCHING SUPPLY ASSEMBLY 12 13501-75005
POWER SUPPLY CHASSIS 4 13501-64006
FLAT HEAD MACH SCREW 6-32 x 1/2" LG (1 of 2)
No 6 HEX NUT (1 of 2)
No 6 LOCKWASHER (1 of 2)
No 6 FLATWASHER (2 of 4)
PAN HEAD MACH SCREW 6-32 x 1/4" LG. (1 of 5)
No 6 LOCKWASHER (1 of 5)
FILTER/OSCILLATOR 10 ASSEMBLY 13501-72004
MAIN CHASSIS 3 13501-63002
TRIMPOT ASSEMBLY 13501-21102
No.6 LOCKWASHER (1 of 4)
F.H. MACH. SCR. 6-32 x 1/4" LG. (1 of 6) DESIG."A"
OPTION 005 OUTPUT BALANCE ASSEMBLY
F.H. MACH SCREW (BLACK) 6-32 x 3/8" LG (1 of 8)
METER 3.5 NCHES 55381-00193
FREQUENCY DIAL 13501-42503
KEY CAPS 63803-90115 (1 of 16)
KNOB BLACK ROUND 21MM 63313-21025
14 FRONT PANEL ASSEMBLY 13501-78505
CONNECTOR BANANA PANEL POST 74001-10001
CONNECTOR BNC 77001-79131 (1 of 4)
FRONT PANEL OVERLAY(Lexan) 13501-48802
KNOB BLACK ROUND 11MM 63313-15125
KNOB BLACK ROUND 15MM
KNOB BLACK WING 63333-15113 (1 of 3)
5 SIDE BRACKET 13501-65003 (1 of 2)
SPACER 910 (1 of 4) 61699-10000
MACHINE SCREW HX 10-32 F.H. BLACK (1 of 4) 61129-21600
CASE HANDLE 65200-78400 (1 of 2)
OPTIONAL UNIVERSAL FILTER ASSEMBLY 13501-47002
OPTION 006 IMD ASSEMBLY 13501-46003
INPUT METER 9 ASSEMBLY 13501-68006
7 HANDLE CLIP 13501-67503 (1 of 4)
FLAT HEAD MACH. SCREW 6-32 x 1/4 LG. (1 of 16)
No 6 LOCKWASHER (1 of 5)
PAN HEAD MACH. SCR. 6-32 x 1/4" LG (1 of 5)
No 6 LOCKWASHER (1 of 4)
PAN HEAD MACH. SCREW 6-32 x 1/4" LG (1 of 4)
INPUT/OUTPUT PCB BRACKET 13501-66101
6 OPTION CHASSIS 13501-66006
INPUT/OUTPUT 13 ASSEMBLY 13501-78008
2 BOTTOM COVER 13501-62103
RUBBER BUMPER 65100-50180 (1 of 4)
CASE FEET FRONT LEFT 65300-40802
F.H. MACH SCR (BLACK) 6-32 x 5/16" LG. (1 of 4) 61113-16031
CASE FEET REAR 65300-40801 (1 of 2)
PAN HEAD MACH. SCREW 6-32 x 1/2" LG (1 of 4)
PAN HEAD MACH. SCREW 6-32 x 3/8" LG (1 of 2)
CASE TILT RAIL 9.6 65300-40809
PAN HEAD MACH SCREW 6-32 x 1/4" LG (1 of 4)
No 6 LOCKWASHER (1 of 4)
NOTE 1. ITEMS LISTED AS OPTION MAY NOT BE PRESENT IN SOME SYSTEMS.
2. UNLESS OTHERWISE SPECIFIED ALL SCREWS ARE PHILIPS.
3. HARNESSES ARE NOT SHOWN.

model 3501 Interior View

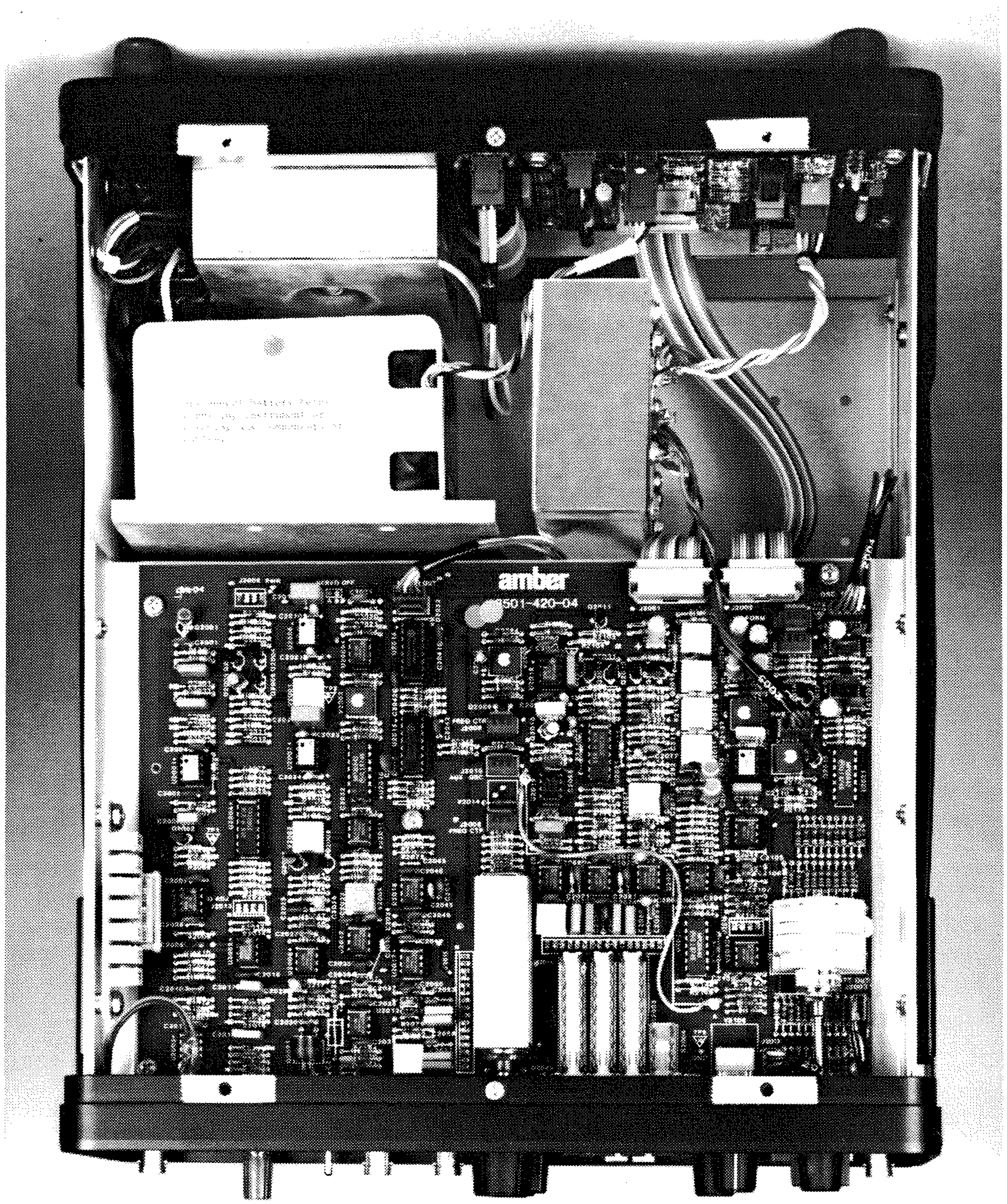


Figure 6-15 Top View

Power supply and optional battery are at the rear (top of this photo).

model 3501 Interior View

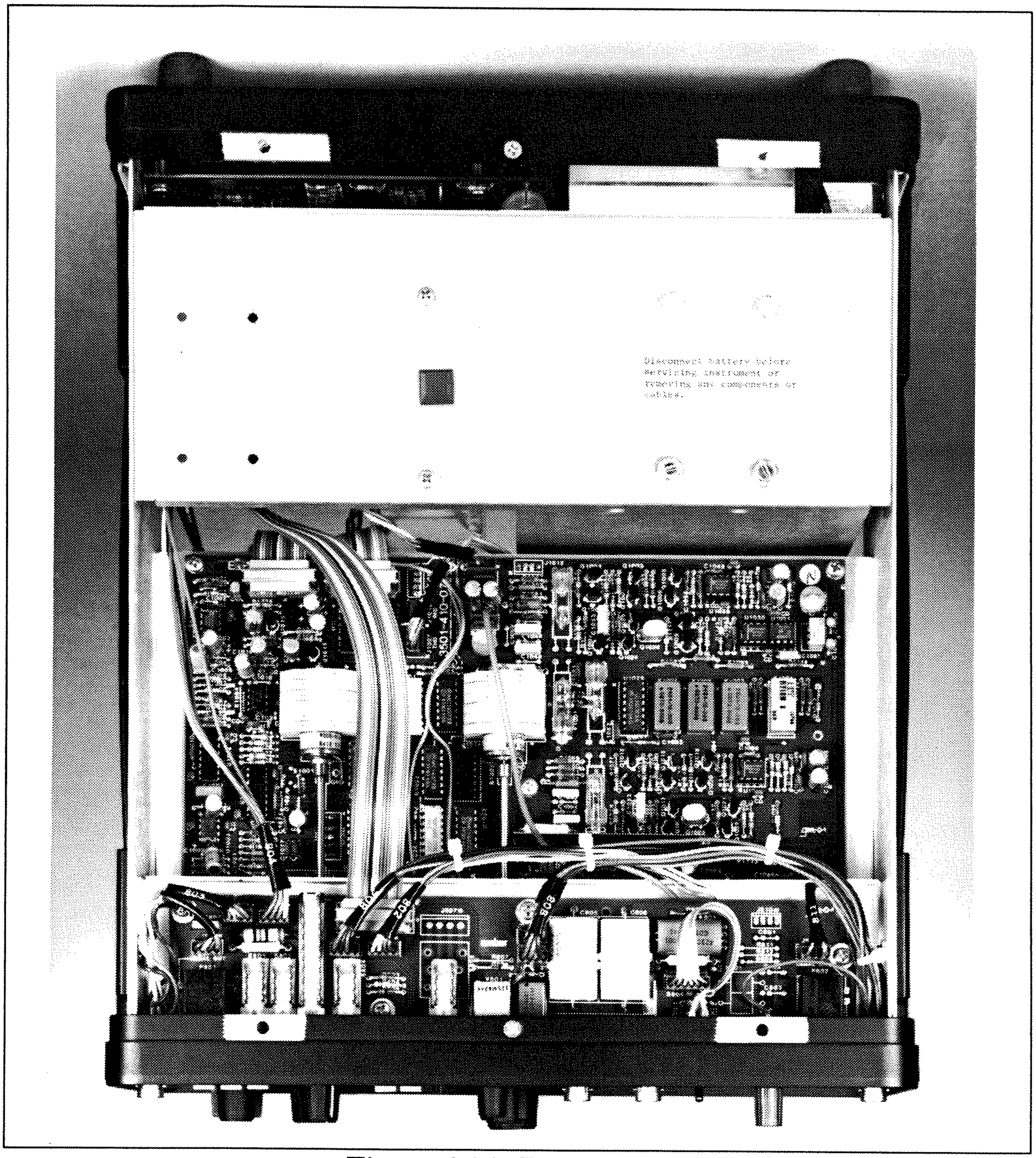


Figure 6-16 Bottom View

Large PCB is the INPUT/METER board including the Input Differential Preamp.
Small board at the bottom of this photo is INPUT/OUTPUT board.

The following tables, 6-1 to 6-4 inclusive, show in detail the actual gains or losses in each circuit subgroup for various instrument functions and front panel settings. Reference is made to Schematic 18, in Section 8, for a simplified signal path functional diagram as well as various other schematics in Section 8 that show circuit detail.

The tables should be useful for diagnostic procedures in the event of failure modes in various LEVEL or DISTORTION meter readings. Proper use of the tables and other supporting detail schematics should permit isolation of a circuit fault to a particular device.

TABLE 1

3501 SIGNAL GAIN CONDITIONS
LEVEL MODE

(Distortion Control Set to -80, -90 or -100)

FUNCTION	UNITS	CONDITION										
Front Panel INPUT Control		+40	+30	+20	+10	0	-10	-20	-30	-40	-50	-60
Front Panel DIST Control		Set to -80, -90 or -100										
Input Attenuator Loss	dB	-30	-20	-10	0	0	0	0	0	0	0	0
Preamp Gain	dB	0	0	0	0	+10	+20	+30	+30	+30	+30	+30
Post Amp Gain	dB	0	0	0	0	0	0	0	0	0	0	0
Level at PREOUT	dBV	+10	+10	+10	+10	+10	+10	+10	+10	+10	+10	+10
State Variable Gain	dB	NOT USED										
Level at Notch Out	dBV	NOT USED										
Meter Amp A Gain	dB	0	0	0	0	0	0	0	0	0	+20	+20
Meter Atten A Loss	dB	0	0	0	0	0	0	0	-10	0	-10	0
Meter Amp B Gain	dB	0	0	0	0	0	0	0	+20	+20	+20	+20
Meter Atten B Loss	dB	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
Meter Amp C Gain	dB	+40	+40	+40	+40	+40	+40	+40	+40	+40	+40	+40
Total Meter Gain	dB	0	0	0	0	0	0	0	+10	+20	+30	+40
Total System Gain	dB	-30	-20	-10	0	+10	+20	+30	+40	+50	+60	+70
Level at Filter Input	dBV	+10	+10	+10	+10	+10	+10	+10	+10	+10	+10	+10
Level at Filter Output	dBV	+10	+10	+10	+10	+10	+10	+10	+10	+10	+10	+10
Meter DC Add Gain	dB	0	0	0	0	0	0	0	0	0	0	0
Meter DC Sub Gain	dB	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
Meter Ratio Sub Gain	dB	NOT USED										

TABLE 2

3501 SIGNAL GAIN CONDITIONS
LEVEL MODE

(Distortion Control Set to 0 to -70)

FUNCTION	UNITS		CONDITION									
Front Panel INPUT Control		+40	+30	+20	+10	0	-10	-20	-30	-40	-50	-60
Front Panel DIST Control			Set from 0 to -70									
Input Attenuator Loss	dB	-30	-20	-10	0	0	0	0	0	0	0	0
Preamp Gain	dB	0	0	0	0	+10	+20	+30	+30	+30	+30	+30
Post Amp Gain	dB	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
Level at PREOUT	dBV	0	0	0	0	0	0	0	0	0	0	0
State Variable Gain	dB		NOT USED									
Level at Notch Out	dBV		NOT USED									
Meter Amp A Gain	dB	0	0	0	0	0	0	0	0	0	+20	+20
Meter Atten A Loss	dB	0	0	0	0	0	0	0	-10	0	-10	0
Meter Amp B Gain	dB	0	0	0	0	0	0	0	+20	+20	+20	+20
Meter Atten B Loss	dB	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
Meter Amp C Gain	dB	+40	+40	+40	+40	+40	+40	+40	+40	+40	+40	+40
Total Meter Gain	dB	0	0	0	0	0	0	0	+10	+20	+30	+40
Total System Gain	dB	-30	-20	-10	0	+10	+20	+30	+40	+50	+60	+70
Level at Filter Input	dBV	0	0	0	0	0	0	0	0	0	0	0
Level at Filter Output	dBV	0	0	0	0	0	0	0	0	0	0	0
Meter DC Add Gain	dB	0	0	0	0	0	0	0	0	0	0	0
Meter DC Sub Gain	dB	0	0	0	0	0	0	0	0	0	0	0
Meter Ratio Sub Gain	dB		NOT USED									

TABLE 3

3501 SIGNAL GAIN CONDITIONS

DISTORTION MODE (THD or IMD)

FUNCTION	UNITS	CONDITION										
Front Panel INPUT Control		-40 to -20 to extinguish LEDs										
Front Panel DIST Control		0	-10	-20	-30	-40	-50	-60	-70	-80	-90	-100
Input Attenuator Loss	dB	-30 to 0 depending on input level										
Preamp Gain	dB	0 to +30 depending on input level										
Post Amp Gain	dB	-10	-10	-10	-10	-10	-10	-10	-10	0	0	0
Level at PREOUT	dBV	0	0	0	0	0	0	0	0	+10	+10	+10
State Variable Gain	dB	0	0	0	0	0	0	0	0	0	0	0
Level at Notch Out	dBV	0	-10	-20	-30	-40	-50	-60	-70	-70	-80	-90
Meter Amp A Gain	dB	0	0	0	+20	+20	0	0	+20	+20	+20	+20
Meter Atten A Loss	dB	0	-10	0	-10	0	-10	0	-10	-10	0	0
Meter Amp B Gain	dB	0	+20	+20	+20	+20	+20	+20	+20	+20	+20	+20
Meter Atten B Loss	dB	-40	-40	-40	-40	-40	0	0	0	0	0	0
Meter Amp C Gain	dB	+40	+40	+40	+40	+40	+40	+40	+40	+40	+40	+40
Total Meter Gain	dB	0	+10	+20	+30	+40	+50	+60	+70	+70	+80	+80
Total System Gain	dB	NOT APPLICABLE										
Level at Filter Input	dBV	0	0	0	0	0	0	0	0	0	0	-10
Level at Filter Output	dBV	0	0	0	0	0	0	0	0	0	0	-10
Meter DC Add Gain	dB	0	0	0	0	0	0	0	0	0	0	+10
Meter DC Sub Gain	dB	0	0	0	0	0	0	0	0	0	0	0
Meter Ratio Sub Gain	dB	-10	-10	-10	-10	-10	-10	-10	-10	0	0	0

TABLE 4

3501 SIGNAL GAIN CONDITIONS

LOW PASS or BAND PASS MODE

FUNCTION	UNITS	CONDITION										
Front Panel INPUT Control		-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20
Front Panel DIST Control		0	-10	-20	-30	-40	-50	-60	-70	-80	-90	-100
Input Attenuator Loss	dB	0	0	0	0	0	0	0	0	0	0	0
Preamp Gain	dB	+30	+30	+30	+30	+30	+30	+30	+30	+30	+30	+30
Post Amp Gain	dB	-10	-10	-10	-10	-10	-10	-10	-10	0	0	0
Level at PREOUT	dBV	30dB more than input signal										
State Variable Gain	dB	0	0	0	0	0	0	0	0	0	0	0
Level at Notch Out	dBV	NOT USED										
Meter Amp A Gain	dB	0	0	0	+20	+20	0	0	+20	+20	+20	+20
Meter Atten A Loss	dB	0	-10	0	-10	0	-10	0	-10	-10	0	0
Meter Amp B Gain	dB	0	+20	+20	+20	+20	+20	+20	+20	+20	+20	+20
Meter Atten B Loss	dB	-40	-40	-40	-40	-40	0	0	0	0	0	0
Meter Amp C Gain	dB	+40	+40	+40	+40	+40	+40	+40	+40	+40	+40	+40
Total Meter Gain	dB	0	+10	+20	+30	+40	+50	+60	+70	+70	+80	+80
Total System Gain	dB	+20	+30	+40	+50	+60	+70	+80	+90	+100	+110	+110
Level at Filter Input	dBV	0	0	0	0	0	0	0	0	0	0	-10
Level at Filter Output	dBV	0	0	0	0	0	0	0	0	0	0	-10
Meter DC Add Gain	dB	0	0	0	0	0	0	0	0	0	0	+10
Meter DC Sub Gain	dB	0	0	0	0	0	0	0	0	0	0	0
Meter Ratio Sub Gain	dB	NOT USED										

AMBER model 3501

DISTORTION & NOISE MEASURING SET

OWNER'S MANUAL

SECTION 7

PARTS LISTS

Issue 09 April 1988

3501 PARTS LISTS

TABLE OF CONTENTS

List of Manufacturers & their Federal Supply Codes

FSC	Company	Address	CITY	STATE PROV	Postal Code	COUNTRY	Phone
09581	3M CANADA Inc.	1840 Oxford Street East	London	Ont	N6A 4T1	Canada	(519) 451-2500
01121	Allen Bradley Co.	1201 South 2nd Street	Milwaukee	WI	53204	USA	(414) 671-2000
92194	Alpha Wire Corporation	711 Lidgerwood Avenue	Elizabeth	NJ	07207	USA	(201) 925-8000
38047	Amber Electro Design Inc.	3391 Griffith Street	St Laurent	PQ	H4T 1W5	Canada	(514) 735-4105
00779	AMP Incorporated	2800 Fulling Mill	Harrisburg	PA	17105	USA	(717) 564-0100
24355	Analog Devices	Two Technology Way	Norwood	MA	02062-9106	USA	(617) 329-4700
26394	Ansley Electronics	4371 Vly Blvd	Los Angeles	CA	90032-3632	USA	
91506	Augat Inc.	33 Perry Avenue	Attleboro	MA	02703-2417	USA	(617) 222-2202
04222	AVX Corporation	19th Avenue South	Myrtle Beach	SC	29577	USA	(803) 448-9411
32997	Bourns Inc.	1200 Columbia Avenue	Riverside	CA	92507-2114	USA	
21604	Buckeye Stamping Co.	555 Marion Road	Columbus	OH	43207-2550	USA	(614) 445-8433
09353	C & K Components Inc.	15 Riverdale Avenue	Newton	MA	02158-1057	USA	(617) 964-6400
03911	Clairex Electronics	560 South Third Avenue	Mount Vernon	NY	10550	USA	(914) 664-6602
12697	Clarostat Mfg Co. Inc.	Lower Washington Street	Dover	NH	03820	USA	(603) 742-1120
18310	Concord Electronics Corp.	30 Great Jones Street	New York	NY	10012-1115	USA	(212) 777-6571
24546	Corning Glass Works	550 High Street	Bradford	PA	16701-3737	USA	(814) 362-5700
71707	COTO Corporation	65 Pavilion Avenue	Providence	RI	02905-1523	USA	(401) 467-4777
91637	Dale Electronics Inc.	2064 12th Avenue	Columbus	NE	68601-3632	USA	(402) 564-3131
78553	Eaton Corporation	8700 Brookpark Drive	Cleveland	OH	44101	USA	(800) 221-2304
31781	EDAC Inc.	20 Railside Road	Don Mills	Ont	M3A 1A4	Canada	(416) 445-2292
89597	Fredericks Company, The	Pillmont Avenue & Anne St.	Huntingdon Valley	PA	19006	USA	(215) 947-2500
71744	General Instrument	4433 N. Ravenswood Ave.	Chicago	IL	60640-5802	USA	(312) 784-1020
58361	General Instrument	3400 Hillview Avenue	Palo Alto	CA	94303-1319	USA	(415) 493-0400
73831	Hammond Manufacturing	394 Edinburgh Road	Guelph	Ont	N1H 1ES	Canada	(519) 822-2960
9J979	Hitachi America Ltd.	950 Benicia Avenue	Sunnyvale	CA	94086-2804	USA	(408) 773-8833
62786	Hitachi America Ltd.	1810 Bering Drive	San Jose	CA	95122	USA	(408) 292-6404
59993	International Rectifier	233 Kansas Street	El Segundo	CA	90245-4316	USA	
32293	Intersil Inc.	10600 Ridgeview Court	Cupertino	CA	95014-0704	USA	
68919	Intertechnical Group	1 Bridge Street	Irvington	NY	10533	USA	(914) 591-8822
31918	ITT Schadow Inc.	8081 Wallace Road	Eden Prairie	MN	55344-2224	USA	(612) 934-4400
04426	ITW Switches	6615 West Irving Park Rd	Chicago	IL	60634-2410	USA	(312) 282-4040
99813	Jan Hardware	47 - 27 36th Street	Long Island City	NY	11101-1823	USA	(212) 361-0800
91833	Keystone Electronics Co.	49 Bleecker Street	New York	NY	10012-2408	USA	(212) 475-4600
91836	Kings Electronics Co.	40 Marbledale Road	Tuckahoe	NY	10707-3420	USA	(914) 793-5000
83330	Kulka Smith	1913 Atlantic Avenue	Manasquan	NJ	08736-1005	USA	(201) 223-9400
75915	Littlefuse/Tracor	800 E. Northwest Highway	Des Plaines	IL	60016-3049	USA	(312) 824-1188
9C599	Mallory Distributor Prod	PO Box 1558	Indianapolis	IN	46206	USA	
52942	Minnesota Mining & Mfg/3M	2111 West Braker Lane	Austin	TX	78769-2963	USA	
27264	Molex	2222 Wellington Court	Lisle	IL	60532-1613	USA	(312) 969-4550
04713	Motorola Inc.	5005 E McDowell Road	Phoenix	AZ	85008-4229	USA	
51406	Murata Erie North America	2200 Lake Park Drive	Smyrna	GA	30080	USA	(404) 436-1300
27014	National Semiconductor	2900 Semiconductor Drive	Santa Clara	CA	95051-0606	USA	(408) 721-5000
12136	PHC Industries Inc.	1643 Haddon Avenue	Camden 3	NJ	08103-3109	USA	
02735	RCA Corporation	Route 202	Somerville	NJ	08876	USA	
06915	Richco	5825 N. Tripp Avenue	Chicago	IL	60646-6013	USA	(312) 539-4060
65032	Rogers Corporation	Box 700	Chandler	AZ	85224	USA	(602) 963-4584
1N137	Schaffner Inc.	220 Little Falls Road	Cedar Grove	NJ	07009-1231	USA	(201) 239-4321
86928	Seastrom Mfg Co.	701 Sonora Avenue	Glendale	CA	91201-2431	USA	(213) 245-9121
59270	Selco Products Co.	7580 State Road	Buena Park	CA	90621-1224	USA	(714) 521-8673
25088	Siemens Company	186 Wood Avenue South	Iselin	NJ	08830-2704	USA	(201) 3400
ICH66	Signetics Corporation	811 E. Arques Avenue	Sunnyvale	CA	94088-3409	USA	(408) 991-2000
17856	Siliconix Incorp.	2201 Laurelwood Road	Santa Clara	CA	95054-1516	USA	(408) 988-8000
94223	Spae Naur Inc.	815 Victoria Street N.	Kitchener	Ont	N2G 4B1	Canada	(519) 744-3521
53848	Standard Microsystems Co	35 Marcus Boulevard	Hauppauge	NY	11788	USA	
94322	Tel Labs Inc.	154 Harvey Road	Londonderry	NH	03053	USA	(603) 625-8994
01295	Texas Instruments	PO Box 225012	Dallas	TX	75265	USA	
13103	Thermalloy Inc.	2021 West Valley View Lane	Dallas	TX	75381-0839	USA	(214) 243-4321
7M235	Toshiba America Inc.	2692 Dow Avenue	Tustin	CA	92680	USA	(714) 832-6300
12969	Unitrode Corporation	5 Forbes Road	Lexington	MA	02173-7305	USA	(617) 861-6540
95275	Vitramon North America	Box 544	Bridgeport	CT	06601-0544	USA	(203) 268-6261

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	SERIAL NO. PLATE	11000-40011			38047	AMBER	11000-40011	1
	CALIBRATION STICKER	11000-40021			38047	AMBER	11000-40021	1
	HARNESS 805-401	13501-30805	14"		38047	AMBER	13501-30805	1
	HARNESS 1006-802	13501-31006	9"		38047	AMBER	13501-31006	1
	HARNESS 1007-2007	13501-31007	6"		38047	AMBER	13501-31007	1
	HARNESS 1009-808	13501-31009	10"		38047	AMBER	13501-31009	1
	HARNESS 2001-1001	13501-32001	3"		38047	AMBER	13501-32001	2
	HARNESS 2003-803	13501-32003	8"		38047	AMBER	13501-32003	
	HARNESS 2004-804	13501-32004	12"		38047	AMBER	13501-32006	1
1	TOP COVER	13501-62004			38047	AMBER	13501-62004	1
2	BOTTOM COVER	13501-62103			38047	AMBER	13501-62103	1
3	MAIN CHASSIS	13501-63002			38047	AMBER	13501-63002	1
4	POWER SUPPLY CHASSIS	13501-64006			38047	AMBER	13501-64006	1
5	SIDE BRACKET	13501-65003			38047	AMBER	13501-65003	2
6	OPTION CHASSIS	13501-66006			38047	AMBER	13501-66006	1
7	HANDLE CLIPS	13501-67503			38047	AMBER	13501-67503	4
8	DRESS STRIPS	13501-68006			38047	AMBER	13501-68006	4
9	INPUT METER ASSEMBLY	13501-71006			38047	AMBER	13501-71006	1
10	FILTER/OSC ASSEMBLY	13501-72004			38047	AMBER	13501-72004	1
11	REAR PANEL ASSEMBLY	13501-74000			38047	AMBER	13501-74000	1
12	SWITCHING SUPPLY ASSEMBLY	13501-75005			38047	AMBER	13501-75005	1
13	INPUT/OUTPUT PCB ASSEMBLY	13501-78008			38047	AMBER	13501-78008	1
14	FRONT PANEL ASSEMBLY	13501-79000			38047	AMBER	13501-79000	1
	MACHINE SCREW PHIL 6-32 FH	61113-16025	1/4			VARIOUS	AN507-632-R4	27
	MACHINE SCREW PHIL 6-32 FH BLK	61113-16031	5/16			VARIOUS	AN507-632-R5	16
	MACHINE SCREW PHIL FH 6-32	61113-16050	1/2			VARIOUS	AN507-632-R8	2
	MACHINE HEX SCREW 10-32 FH BLK	61129-21600	1/2		94223	SPAE NAUR	HX-216	4
	MACHINE HEX NUT	61220-63200	#6			VARIOUS	MS35649-262	2
	MACHINE SPRING NUTS	61240-54000	6-32		78553	EATON	TN-226	20
	WASHER FLAT	61510-16400	#6			VARIOUS	AN-960-6	4
	SPACER #10	61699-10000			94223	SPAE NAUR	SPA-22	4
	KNOB BLACK ROUND	63312-11103	11M		59270	SIFAM	S111 003	1
	KNOB BLACK ROUND	63313-15125	15MM		59270	SIFAM	S151-125	1
	KNOB BLACK WING	63333-15113	15MM		59270	SIFAM	SB151 125	3
	KNOB CAP BLACK	63803-11100	11MM		59270	SIFAM	C111	1
	NUT COVER BLACK	63803-11101	11MM		59270	SIFAM	N111	1
	KNOB CAP BLACK	63803-15100	15MM		59270	SIFAM	C151	4
	NUT COVER BLACK	63803-15101	15MM		59270	SIFAM	N151	4
	RUBBER BUMPER BUTTON	65100-50180			09581	3M	SJ5018/6227	4
	CASE HANDLE	65200-78400	10"		12136	PHC	7840	2
	CASE FEET REAR	65300-40801			21604	BUCKEYE	MP40008-01B	2
	CASE FEET LEFT FRONT	65300-40802			21604	BUCKEYE	MP40008-01B	1
	CASE FEET RIGHT FRONT	65300-40803			21604	BUCKEYE	MP40008-01B	1
	CASE TILT BAIL 9.6	65300-40809			21604	BUCKEYE	MP40008-9.6	1
	POWER CORD	85400-00000			92194	ALPHA	ALPHA 533	1

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DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	PRINTED CIRCUIT BOARD	13501-41007			38047	AMBER	13501-41007	1
	PCB SHIELD	13501-61201			38047	AMBER	13501-61201	1
	TRIMPOT PCB ASSEMBLY	13501-71102			38047	AMBER	13501-71102	1
	WIRE COAXIAL CABLE	58350-02381	21"			MOGAMI	2381	1
	KEY CAPS BEIGE	63803-90115			04426	ITW/LICON	80-3901150000	7
	SCREW LUG #10	67100-27000			94223	SPAE NAUR	WT-27	2
	CONNECTOR SOCKET PCB DIL	71008-20839	8 PIN		91506	AUGAT	208-AG39D	13
	CONNECTOR SOCKET PCB DIL	71014-21439	14PIN		91506	AUGAT	214-AG39D	9
	CONNECTOR SOCKET PCB DIL	71016-21639	16PIN		91506	AUGAT	216-AG39D	6
	CONNECTOR MACHINE SOCKET	71615-51610	16PIN		91506	AUGAT	516-AG10D	5
	FUSE CLIPS	85314-10206			7E222	LITTLE FUSE	102068	4
C1001	CAPACITOR CERAMIC DISC	41033-04700	47P	5%	51406	MURATA/ERIE	DD06B10N750470J500V	1
C1002	NOT USED							
C1003	NOT USED							
C1004	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1005	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1006	CAPACITOR CERAMIC DISC	41033-01500	15P	5%	51406	MURATA/ERIE	DD05B10N750150J500V	1
C1007	CAPACITOR FILM	45042-44701	0.47	20%	68919	WIMA	MKS3 0.47/63/20W	1
C1008	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1009	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1010	NOT USED							
C1011	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	9
C1012	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1013	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1014	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1015	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1016	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1017	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1018	NOT USED							
C1019	CAPACITOR CERAMIC DISC	41033-00330	3P3		51406	MURATA/ERIE	DD05BN7503R3D500V	1
C1020	CAPACITOR CERAMIC DISC	41033-11500	150P	20%	51406	MURATA/ERIE	DD09B10N750151J500V	1
C1021	NOT USED							
C1022	NOT USED							
C1023	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1024	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1025	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1026	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C1027	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C1028	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C1029	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C1030	CAPACITOR ELECT 22/40	48050-02200	22	20%	25088	SIEMENS	85200/22/40	
C1031	CAPACITOR ELECT 22/40	48050-02200	22	20%	25088	SIEMENS	85200/22/40	2
C1032	CAPACITOR FILM	45042-31002	0.01	20%	68919	WIMA	MKS3 0.01/100/20W	1
C1033	CAPACITOR TANTALUM 1/25	47031-01090	1	20%	31918	ITT	TAG 1.5M25	
C1034	CAPACITOR TANTALUM 10/25V	47031-10000	10	20%	31918	ITT	TAG 10M25	
C1035	CAPACITOR TANTALUM 1/25	47031-01090	1	20%	31918	ITT	TAG 1.5M25	2
C1036	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1037	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1038	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1039	NOT USED							
C1040	CAPACITOR CERAMIC DISC	41033-03300	33P	5%	51406	MURATA/ERIE	DD05B10N750330J500V	1
C1041	CAPACITOR FILM	45042-11500	150P	5%	68919	WIMA	FKC3 150/160/5W	

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
C1044	NOT USED							
C1045	CAPACITOR FILM	45042-11000	100P	5%	68919	WIMA	FKC3 100/160/5W	
C1046	NOT USED							
C1047	CAPACITOR FILM	45042-13300	330P	5%	68919	WIMA	FKC3 330/160/5	
C1048	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C1049	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1050	CAPACITOR CERAMIC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1051	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	21
C1052	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1053	NOT USED							
C1054	CAPACITOR FILM	45042-13300	330P	5%	68919	WIMA	FKC3 330/160/5	2
C1055	NOT USED							
C1056	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C1057	CAPACITOR CERAMIC DISC	41033-02200	22P	20%	51406	MURATA/ERIE	DD05B10N750220J500V	1
C1058	CAPACITOR TANTALUM 10/25V	47031-10000	10	20%	31918	ITT	TAG 10M25	3
C1059	CAPACITOR TANTALUM 10/25V	47031-10000	10	20%	31918	ITT	TAG 10M25	
C1060	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1061	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1062	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1063	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1064	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1065	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1066	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	21
C1067	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1068	CAPACITOR TRIM CONTROL TA	49000-53801	7-25P		51406	MURATA/ERIE	DV11PS25B	2
C1069	NOT USED							
C1070	CAPACITOR FILM	45042-21000	1000P	5%	68919	WIMA	FKC3 1000/160/5W	1
C1071	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1072	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1073	CAPACITOR CERAMIC DISC	41033-05600	56P	20%	51406	MURATA/ERIE	DD06B10N750560J500V	1
C1076	CAPACITOR ELECT 4.7/16	48020-04790	4.7	20%	25088	SIEMENS	85200/4.7/16	1
C1077	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1078	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1079	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1080	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1081	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1082	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1083	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1084	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C1085	CAPACITOR CERAMIC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1086	CAPACITOR CERAMIC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD16F10Y5P103K1KV	
C1087	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1088	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C1089	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C1090	CAPACITOR TRIM CONTROL TA	49000-53800	7-25P		51406	MURATA/ERIE	DV11PR25A	
C1091	CAPACITOR FILM	45042-42000	0.22	20%	68919	WIMA	MKS3 0.22/63/20W	1
C1092	CAPACITOR FILM	45042-11500	150P	5%	68919	WIMA	FKC3 150/160/5W	2
C1093	NOT USED							
C1094	NOT USED							0
C1095	CAPACITOR FILM	45042-11000	100P	5%	68919	WIMA	FKC3 100/160/5W	2
C1096	CAPACITOR ELECT 47/16	48020-04700	47	20%	25088	SIEMENS	85200/47/16	1
C1097	CAPACITOR CERAMIC DISC	41033-68000	680P	5%	51406	MURATA/ERIE	DD06B10Y5P681K1KV	1

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
CD	CAPACITOR MONOLYTHIC	43031-41000	0.1	20%	04222	AVX	SR205C104MAA	19
D1001	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	20
D1002	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1003	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1004	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1005	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1006	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1007	SEMICON DIODE ZENER 22V	21207-47480	22V		1A223	MOTOROLA	1N4748A	
D1008	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1009	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1010	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1011	SEMICON DIODE ZENER 22V	21207-47480	22V		1A223	MOTOROLA	1N4748A	5
D1012	SEMICON DIODE ZENER 3.3V	21207-07461	3.3V		1A223	MOTOROLA	1N746A	1
D1013	SEMICON DIODE ZENER 22V	21207-47480	22V		1A223	MOTOROLA	1N4748A	
D1014	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1015	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1016	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1017	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1018	SEMICON LED RECT RED	21531-57124			58361	GI	MV57124	
D1019	SEMICON LED RECT RED	21531-57124			58361	GI	MV57124	2
D1020	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1021	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1022	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1023	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1024	SEMICON DIODE ZENER 22V	21207-47480	22V		1A223	MOTOROLA	1N4748A	
D1025	SEMICON DIODE ZENER 22V	21207-47480	22V		1A223	MOTOROLA	1N4748A	
D1026	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1027	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1028	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D1029	NOT USED				1A223			
F1001	LAMP MINIATURE SLIDE BASE	91000-12000	120		71744	GI/CHICAGO	120PSB	4
F1002	LAMP MINIATURE SLIDE BASE	91000-12000	120		71744	GI/CHICAGO	120PSB	
F1003	LAMP MINIATURE SLIDE BASE	91000-12000	120		71744	GI/CHICAGO	120PSB	
F1004	LAMP MINIATURE SLIDE BASE	91000-12000	120		71744	GI/CHICAGO	120PSB	
J1001	CONNECTOR FLAT CABLE BLUE	72016-16780	16 PIN		26394	ANSLEY	609-1678	4
J1002	CONNECTOR FLAT CABLE BLUE	72016-16780	16 PIN		26394	ANSLEY	609-1678	
J1003	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J1004	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J1005	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J1006	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J1007	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	7
J1008	NOT USED							
J1009	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J1010	CONNECTOR FLAT CABLE BLUE	72016-16780	16 PIN		26394	ANSLEY	609-1678	
J1011	NOT USED							
J1012	NOT USED							
J1015	NOT USED							
J1016	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
K1001	RELAY REED 1 FORM A	84801-26041	12V		71707	COTO	2604-12-300	3
K1002	RELAY REED 1 FORM A	84801-26041	12V		71707	COTO	2604-12-300	
K1003	RELAY REED 1 FORM A	84801-26041	12V		71707	COTO	2604-12-300	
K1004	RELAY 2 FORM C	84801-18000	18V		31918	ITT	RY-18WK	1

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
N1001	RESISTOR NET 16PIN 15 RES	38167-10030	100K	5%	23997	BOURNS	4116R-002-104	1
N1002	RESISTOR NET 16PIN 8 RES	38165-22020	22K	5%	23997	BOURNS	4116R-001-223	1
Q1001	SEMICON TRANSISTOR PNP	22622-44030			1A223	MOTOROLA	2N4403	10
Q1002	SEMICON TRANSISTOR PNP	22622-44030			1A223	MOTOROLA	2N4403	
Q1003	SEMICON TRANSISTOR NPN	22522-44010			1A223	MOTOROLA	2N4401	12
Q1004	SEMICON TRANSISTOR PNP	22622-44030			1A223	MOTOROLA	2N4403	
Q1005	SEMICON TRANSISTOR NPN	22522-44010			1A223	MOTOROLA	2N4401	
Q1006	SEMICON TRANSISTOR PNP	22622-44030			1A223	MOTOROLA	2N4403	
Q1007	SEMICON TRANSISTOR PNP	22622-44030			1A223	MOTOROLA	2N4403	
Q1008	SEMICON TRANSISTOR NPN	22522-44010			1A223	MOTOROLA	2N4401	
Q1009	SEMICON TRANSISTOR NPN	22522-44010			1A223	MOTOROLA	2N4401	
Q1010	SEMICON FET N CHANNEL	22392-09200			17856	SILICONIX	J-111	2
Q1011	SEMICON FET N CHANNEL	22392-09200			17856	SILICONIX	J-111	
Q1012	SEMICON TRANSISTOR PNP	22622-44030			1A223	MOTOROLA	2N4403	
Q1013	SEMICON TRANSISTOR PNP	22622-44030			1A223	MOTOROLA	2N4403	
Q1014	SEMICON TRANSISTOR PNP	22622-44030			1A223	MOTOROLA	2N4403	
Q1015	SEMICON TRANSISTOR NPN	22522-44010			1A223	MOTOROLA	2N4401	
Q1016	SEMICON TRANSISTOR PNP	22622-44030			1A223	MOTOROLA	2N4403	
Q1017	SEMICON TRANSISTOR NPN	22522-44010			1A223	MOTOROLA	2N4401	
Q1018	SEMICON TRANSISTOR NPN	22522-44010			1A223	MOTOROLA	2N4401	
Q1019	SEMICON TRANSISTOR NPN	22522-44010			1A223	MOTOROLA	2N4401	
Q1020	SEMICON TRANSISTOR PNP	22622-44030			1A223	MOTOROLA	2N4403	
Q1021	SEMICON TRANSISTOR NPN	22522-44010			1A223	MOTOROLA	2N4401	
Q1022	SEMICON TRANSISTOR NPN	22522-44010			1A223	MOTOROLA	2N4401	
Q1023	SEMICON DUAL N CH FET	22318-25146			7M235	TOSHIBA	2SK146GR	2
Q1024	SEMICON TRANSISTOR NPN	22522-44010			1A223	MOTOROLA	2N4401	
Q1025	SEMICON TRANSISTOR NPN	22522-44010			1A223	MOTOROLA	2N4401	
Q1026	SEMICON DUAL N CH FET	22318-25146			7M235	TOSHIBA	2SK146GR	
R1001	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	11
R1002	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	
R1003	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R1004	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R1005	RESISTOR CF 1/4W	32033-22000	220	5%	01121	ALLEN BRADLEY	CB2215	2
R1006	RESISTOR CF 1/4W	32033-33000	330	5%	01121	ALLEN BRADLEY	CB3315	
R1007	RESISTOR CF 1/4W	32033-10010	1K	5%	01121	ALLEN BRADLEY	CB1025	6
R1008	RESISTOR MF 1/4W	32040-10020	10K00	0.1%	91637	DALE	CMF55-T2-10.00K-.1	
R1009	RESISTOR MF 1/4W	32040-31610	3K162	0.1%	91637	DALE	CMF55-T2-3.162K-.1	1
R1010	RESISTOR MF 1/4W	32040-14610	1K463	0.1%	91637	DALE	CMF55-T2-1.463K-.1	1
R1011	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R1012	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R1013	RESISTOR MF 1/4W	32040-20010	2K000	0.1%	91637	DALE	CMF55-T2-2.000K-.1	1
R1014	RESISTOR MF 1/4W	32040-43300	432R6	0.1%	91637	DALE	CMF55-T2-432.6R-.1	1
R1015	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R1016	RESISTOR MF 1/4W	32040-56200	562R3	0.1%	91637	DALE	CMF55-T2-562.3R-.1	1
R1017	RESISTOR CF 1/4W	32033-10050	10M	5%	01121	ALLEN BRADLEY	CB1055	1
R1018	RESISTOR CF 1/4W	32033-10010	1K	5%	01121	ALLEN BRADLEY	CB1025	
R1019	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R1020	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R1021	RESISTOR CF 1/4W	32033-47000	470	5%	01121	ALLEN BRADLEY	CB4715	
R1022	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R1023	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R1024	RESISTOR CF 1/4W	32033-22000	220	5%	01121	ALLEN BRADLEY	CB2215	

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
R1025	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R1026	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R1027	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	13
R1028	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R1029	RESISTOR MF 1/4W	32040-11110	1K111	0.1%	91637	DALE	CMF55-T2-1.111K-.1	1
R1030	RESISTOR MF 1/4W	32040-10020	10K00	0.1%	91637	DALE	CMF55-T2-10.00K-.1	3
R1031	RESISTOR CF 1/4W	32033-10010	1K	5%	01121	ALLEN BRADLEY	CB1025	
R1032	RESISTOR CF 1/4W	32033-20010	2K	5%	01121	ALLEN BRADLEY	CB2025	1
R1033	RESISTOR MF 1/4W	32040-99010	9K900	0.1%	91637	DALE	CMF55-T2-9.900K-.1	1
R1034	RESISTOR MF 1/4W	32040-10000	100R0	0.1%	91637	DALE	CMF55-T2-100.0R-.1	1
R1035	RESISTOR CF 1/4W	32033-22020	22K	5%	01121	ALLEN BRADLEY	CB2235	2
R1036	RESISTOR MF 1/4W	32040-10020	10K00	0.1%	91637	DALE	CMF55-T2-10.00K-.1	
R1037	NOT USED							0
R1038	RESISTOR CF 1/4W	32033-20020	20K	5%	01121	ALLEN BRADLEY	CB2035	
R1039	RESISTOR CF 1/4W	32033-12020	12K	5%	01121	ALLEN BRADLEY	CB1235	
R1040	RESISTOR CF 1/4W	32033-68000	680	5%	01121	ALLEN BRADLEY	CB6815	1
R1041	RESISTOR CF 1/4W	32033-12020	12K	5%	01121	ALLEN BRADLEY	CB1235	2
R1042	RESISTOR CF 1/4W	32033-20020	20K	5%	01121	ALLEN BRADLEY	CB2035	2
R1043	RESISTOR CF 1/4W	32033-33000	330	5%	01121	ALLEN BRADLEY	CB3315	
R1044	RESISTOR MF 1/4W	32035-60410	6K04	1%	24546	CORNING	SMA4-6.04K-1	2
R1045	RESISTOR MF 1/4W	32035-66500	665	1%	24546	CORNING	SMA4-665R-1	2
R1046	RESISTOR MF 1/4W	32035-66500	665	1%	24546	CORNING	SMA4-665R-1	
R1047	RESISTOR MF 1/4W	32035-60410	6K04	1%	24546	CORNING	SMA4-6.04K-1	
R1048	NOT USED							0
R1049	RESISTOR CF 1/4W	32033-10010	1K	5%	01121	ALLEN BRADLEY	CB1025	
R1050	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R1051	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R1052	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R1054	RESISTOR CF 1/4W	32033-22020	22K	5%	01121	ALLEN BRADLEY	CB2235	
R1055	THERMISTER 3500 PPM/DEG. C	34066-10010	1K0	1%	94322	TEL LABS	Q-81-1K0	1
R1056	RESISTOR MF 1/4W	32035-24920	24K9	1%	24546	CORNING	SMA4-24.9K-1	1
R1059	RESISTOR MF 1/4W	32040-21610	2K162	0.1%	91637	DALE	CMF55-T2-2.162K-.1	
R1061	RESISTOR MF 1/4W	32040-68410	6K838	0.1%	91637	DALE	CMF55-T2-6.838K-.1	2
R1062	RESISTOR 1/2W	32050-21620	21K62	0.1%	91637	DALE	CMF55-T2-21.62K-.1	
R1063	RESISTOR CF 1/4W	32033-18030	180K	5%	01121	ALLEN BRADLEY	CB1815	1
R1064	NOT USED							0
R1065	RESISTOR MF 1.5 WATT	34063-68420	68K38	0.1%	91637	DALE	CMF55-T2-68.38K-.1	
R1067	RESISTOR MF 1/4W	32040-10010	1K000	0.1%	91637	DALE	CMF55-T2-1.000K-.1	
R1069	RESISTOR MF 1/4W	32040-10010	1K000	0.1%	91637	DALE	CMF55-T2-1.000K-.1	2
R1070	RESISTOR MF 1/4W	32040-21610	2K162	0.1%	91637	DALE	CMF55-T2-2.162K-.1	2
R1071	RESISTOR MF 1/4W	32040-68410	6K838	0.1%	91637	DALE	CMF55-T2-6.838K-.1	
R1072	RESISTOR MF 1/2W	32050-21620	21K62	0.1%	91637	DALE	CMF55-T2-21.62K-.	2
R1073	RESISTOR MF 1.5 WATT	34063-68420	68K38	0.1%	91637	DALE	CMF55-T2-68.38K-.1	2
R1074	RESISTOR MF 1/4W	32035-14000	140	1%	24546	CORNING	SMA4-140R-1	1
R1075	RESISTOR MF 1/4W	32035-49900	499	1%	24546	CORNING	SMA4-499R-1	3
R1076	RESISTOR MF 1/4W	32035-49900	499	1%	24546	CORNING	SMA4-499R-1	
R1077	RESISTOR CF 1/4W	32033-36000	360	5%	01121	ALLEN BRADLEY	CB3615	2
R1078	RESISTOR CF 1/4W	32033-04700	47	5%	01121	ALLEN BRADLEY	CB4705	
R1079	RESISTOR CF 1/4W	32033-47000	470	5%	01121	ALLEN BRADLEY	CB4715	
R1080	RESISTOR CF 1/4W	32033-33000	330	5%	01121	ALLEN BRADLEY	CB3315	7
R1081	RESISTOR CF 1/4W	32033-36000	360	5%	01121	ALLEN BRADLEY	CB3615	
R1082	RESISTOR CF 1/4W	32033-33000	330	5%	01121	ALLEN BRADLEY	CB3315	

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
R1083	RESISTOR CF 1/4W	32033-06200	62	5%	01121	ALLEN BRADLEY	CB6205	
R1084	RESISTOR CF 1/4W	32033-06200	62	5%	01121	ALLEN BRADLEY	CB6205	4
R1085	RESISTOR CF 1/4W	32033-33000	330	5%	01121	ALLEN BRADLEY	CB3315	
R1086	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	6
R1087	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R1088	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R1089	RESISTOR CF 1/4W	32033-04700	47	5%	01121	ALLEN BRADLEY	CB4705	2
R1090	RESISTOR MF 1/4W	32040-24910	2K490	0.1%	91637	DALE	CMF55-T2-2.490K-.1	
R1091	RESISTOR CF 1/4W	32033-82010	8K2	5%	01121	ALLEN BRADLEY	CB8225	2
R1092	RESISTOR CF 1/4W	32033-13000	130	5%	01121	ALLEN BRADLEY	CB1315	2
R1093	RESISTOR MF 1/4W	32040-23010	2K303	0.1%	91637	DALE	CMF55-T2-2.303K-.1	1
R1094	RESISTOR MF 1/4W	32040-55300	553R3	0.1%	91637	DALE	CMF55-T2-553.3R-.1	1
R1095	RESISTOR MF 1/4W	32040-16300	162R6	0.1%	91637	DALE	CMF55-T2-162.6R-.1	1
R1096	RESISTOR MF 1/4W	32040-24910	2K490	0.1%	91637	DALE	CMF55-T2-2.490K-.1	
R1097	RESISTOR CF 1/4W	32033-33000	330	5%	01121	ALLEN BRADLEY	CB3315	
R1098	RESISTOR MF 1/4W	32035-20020	20K0	1%	24546	CORNING	SMA4-20K-1	1
R1099	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	
R1100	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R1101	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R1102	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R1103	RESISTOR MF 1/4W	32035-12130	121K	1%	24546	CORNING	SMA4-121K-1	2
R1104	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	
R1105	RESISTOR MF 1/4W	32035-12130	121K	1%	24546	CORNING	SMA4-121K-1	
R1106	RESISTOR MF 1/4W	32035-24910	2K49	1%	24546	CORNING	SMA4-2.49K-1	1
R1107	RESISTOR MF 1/4W	32035-88710	8K87	1%	24546	CORNING	SMA4-8.87K-1	1
R1108	RESISTOR MF 1/4W	32035-49900	499	1%	24546	CORNING	SMA4-499R-1	
R1109	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	
R1110	RESISTOR MF 1/4W	32035-39220	39K2	1%	24546	CORNING	SMA4-39.2K-1	1
R1111	RESISTOR MF 1/4W	32035-33200	332	1%	24546	CORNING	SMA4-332R-1	1
R1112	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	
R1113	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R1114	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	
R1115	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R1116	RESISTOR MF 1/4W	32035-06650	66R5	1%	24546	CORNING	SMA4-66.5R-1	1
R1117	RESISTOR CF 1/4W	32033-47000	470	5%	01121	ALLEN BRADLEY	CB4715	4
R1118	RESISTOR MF 1/4W	32035-47500	475	1%	24546	CORNING	SMA4-475R-1	1
R1119	RESISTOR SELECTED MATCH Q1011							1
R1120	RESISTOR CF 1/4W	32035-33230	332K	1%	24546	CORNING	SMA4-332K-1	1
R1121	RESISTOR MF 1/4W	32033-49920	49K9	1%	24546	CORNING	SMA4-49.9K-1	1
R1122	RESISTOR CF 1/4W	32033-06200	62	5%	01121	ALLEN BRADLEY	CB6205	
R1123	RESISTOR MF 1/4W	32035-41210	4K12	1%	24546	CORNING	SMA4-4.12K-1	
R1124	RESISTOR CF 1/4W	32033-10010	1K	5%	01121	ALLEN BRADLEY	CB1025	
R1125	RESISTOR CF 1/4W	32033-10010	1K	5%	01121	ALLEN BRADLEY	CB1025	
R1126	RESISTOR CF 1/4W	32033-06200	62	5%	01121	ALLEN BRADLEY	CB6205	
R1127	RESISTOR CF 1/4W	32033-33000	330	5%	01121	ALLEN BRADLEY	CB3315	
R1128	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	3
R1129	RESISTOR MF 1/4W	32040-24910	2K490	0.1%	91637	DALE	CMF55-T2-2.490K-.1	
R1130	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R1131	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R1132	RESISTOR CF 1/4W	32033-47000	470	5%	01121	ALLEN BRADLEY	CB4715	
R1133	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	5
R1134	RESISTOR CF 1/4W	32033-13000	130	5%	01121	ALLEN BRADLEY	CB1315	

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
R1135	RESISTOR CF 1/4W	32033-82010	8K2	5%	01121	ALLEN BRADLEY	CB8225	
R1136	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R1137	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R1138	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R1139	RESISTOR MF 1/4W	32040-78710	7K874	0.1%	91637	DALE	CMF55-T2-7.874K-.1	
R1140	RESISTOR MF 1/4W	32040-24910	2K490	0.1%	91637	DALE	CMF55-T2-2.490K-.1	5
R1141	RESISTOR MF 1/4W	32040-24910	2K490	0.1%	91637	DALE	CMF55-T2-2.490K-.1	
R1142	RESISTOR MF 1/4W	32040-78710	7K874	0.1%	91637	DALE	CMF55-T2-7.874K-.1	2
R1143	RESISTOR CF 1/4W	32033-10040	1M	5%	01121	ALLEN BRADLEY	CB1055	1
R1144	RESISTOR MF 1/4W	32035-24310	2K43	1%	24546	CORNING	SMA4-2.43K-1	1
S1001	SWITCH ROTARY 3 POLE 11 POS	81113-31311			04426	ITW/RCL	0301XC30B11UPF-ARZZ0	1
S1002	SWITCH ROTARY 3 POLE 12 POS	81113-31312			04426	ITW/RCL	0301XC30B12UPF-ARZZ0	1
S1003	SWITCH PUSHBUTTON 2U	83116-20000			31918	ITT/SCHADOW	F2UEE	4
S1004	SWITCH PUSHBUTTON 2U	83116-20000			31918	ITT/SCHADOW	F2UEE	
S1005	SWITCH PUSHBUTTON 2U	83116-20000			31918	ITT/SCHADOW	F2UEE	
S1006	SWITCH PUSHBUTTON ASSEMBLY	83116-10320			31918	ITT/SCHADOW	F103X2UGR	1
S1007	SWITCH PUSHBUTTON	83116-10320			31918	ITT/SCHADOW	PART/S1006	
S1008	SWITCH PUSHBUTTON	83116-10320			31918	ITT/SCHADOW	PART/S1006	
S1009	SWITCH PUSHBUTTON 2U	83116-20000			31918	ITT/SCHADOW	F2UEE	
U1001	SEMICON OP AMP LO NOISE	25311-55340			01295	SIGNETICS	NE5534AN	5
U1002	SEMICON CMOS SWITCH	24021-40530			3L585	RCA	CD4053BPC	
U1003	SEMICON OP AMP J FET	25311-35700			27014	NATIONAL	LF357N	1
U1005	SEMICON OP AMP PRECISION	25311-31800			27014	NATIONAL	LM318N	1
U1006	SEMICON CMOS SWITCH	24021-40530			3L585	RCA	CD4053BPC	
U1007	SEMICON OP AMP LO NOISE	25311-55340			ICH66	SIGNETICS	NE5534AN	
U1008	NOT USED							
U1009	SEMICON OP AMP BI-FET DUAL	25111-07200			01295	TI	TL072CP	
U1010	FILTER NETWORK	13501-01228	80kHz		38047	AMBER	1228	1
U1011	FILTER NETWORK	13501-01223	30kHz		38047	AMBER	1223	1
U1012	SEMICON OP AMP BI-FET DUAL	25111-07200			01295	TI	TL072CP	
U1013	FILTER NETWORK	13501-01214	400Hz		38047	AMBER	1214	1
U1014	SEMICON SHUNT REGULATOR	25992-43100			01295	TI	TL431CLP	
U1015	SEMICON REGULATOR	25992-43100			01295	TI	TL431CLP	2
U1016	SEMICON CMOS SWITCH	24021-40530			3L585	RCA	CD4053BPC	
U1017	SEMICON CMOS SWITCH	24021-40530			3L585	RCA	CD4053BPC	5
U1018	SEMICON CMOS OR GATE	24021-40720			3L585	RCA	CD4072BPC	
U1019	SEMICON CMOS OR GATE	24021-40720			3L585	RCA	CD4072BPC	
U1020	SEMICON CMOS QUAD IN OR GATE	24021-40710			3L585	RCA	CD4071BPC	1
U1021	SEMICON CMOS OR GATE	24021-40750			3L585	RCA	CD4075BPC	1
U1022	SEMICON CMOS OR GATE	24021-40720			3L585	RCA	CD4072BPC	
U1023	SEMICON CMOS OR GATE	24021-40720			3L585	RCA	CD4072BPC	5
U1024	SEMICON CMOS DECODER 1 TO 10	24021-40280			3L585	RCA	CD4028BPC	1
U1025	SEMICON CMOS OR GATE	24021-40720			3L585	RCA	CD4072BPC	
U1026	SEMICON RMS TO DC CONVERTER	25000-53600			24355	ANALOG DEVICES	AD536AJD	2
U1027	SEMICON RMS TO DC CONVERTER	25000-53600			24355	ANALOG DEVICES	AD536AJD	
U1028	SEMICON OP AMP LO NOISE	25311-55340			ICH66	SIGNETICS	NE5534AN	
U1029	SEMICON TRANSISTOR ARRAY	23316-20030			1A223	MOTOROLA	ULN2003N	1
U1030	SEMICON OP AMP LO NOISE	25311-55340			ICH66	SIGNETICS	NE5534AN	
U1031	SEMICON BI-FET OP AMP	25111-07100			01295	TI	TL071CP	2
U1032	SEMICON OP AMP LO-OFFSET FET	25312-41200			27014	NATIONAL	LF412CN	1
U1033	SEMICON MATCHED TRANS ARRAY	22622-39400			27014	NATIONAL	LM394CH	1
U1034	SEMICON CMOS SWITCH	24021-40530			3L585	RCA	CD4053BPC	

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
U1035	SEMICON OP AMP BI-FET DUAL	25111-07200			01295	TI	TL072CP	
U1036	SEMICON OP AMP BI-FET DUAL	25111-07200			01295	TI	TL072CP	4
U1037	SEMICON OP AMP LO NOISE	25311-55340			ICH66	SIGNETICS	NE5534AN	

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	PRINTED CIRCUIT BOARD FIL/OSC	13501-42004			38047	AMBER	13501-42004	1
	RCL SWITCH SECTION SHIELD	13501-69402			38047	AMBER	13501-69402	1
	WIRE COAXIAL CABLE	58350-02381	6"			MOGAMI	2381	1
	KEY CAPS DARK BROWN	63803-90114			04426	ITW/LICON	80-3901140000	4
	SCREW LUG #10	67100-27000			94223	SPAE NAUR	WT-27	1
	CONNECTOR SOCKET PCB DIL	71008-20839	8 PIN		91506	AUGAT	208-AG39D	22
	CONNECTOR SOCKET PCB DIL	71014-21439	14PIN		91506	AUGAT	214-AG39D	2
	CONNECTOR SOCKET PCB DIL	71016-21639	16PIN		91506	AUGAT	216-AG39D	4
C2001	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	35
C2002	CAPACITOR FILM	45042-31002	0.01	20%	68919	WIMA	MKS3 0.1/100/20W	1
C2003	CAPACITOR FILM	45042-41002	0.1	20%	68919	WIMA	MKS3 0.1/100/20W	2
C2004	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2005	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2006	CAPACITOR FILM	45042-42202	0.22	20%	68919	WIMA	MKS3 0.22/63/20W	3
C2007	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2008	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2009	CAPACITOR CERAMIC DISC	41033-00330	3P3	20%	51406	MURATA/ERIE	DD05B10N7503R3D1KV	4
C2010	CAPACITOR CERAMIC DISC	41033-00330	3P3	20%	51406	MURATA/ERIE	DD05B10N7503R3D1KV	
C2011	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2012	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2013	NOT USED							
C2014	NOT USED							
C2015	NOT USED							
C2016	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2017	CAPACITOR FILM	45042-42202	0.22	20%	68919	WIMA	MKS3 0.22/63/20W	
C2018	CAPACITOR FILM	45042-22030	0.22	20%	68919	WIMA	MKS2 0.22/63/20W	
C2019	CAPACITOR FILM	45042-51002	1.0	20%	68919	WIMA	MKS3 1.0/63/20W	2
C2020	CAPACITOR TANTALUM 1.5/25V	47031-01590	1.5	20%	31918	ITT	TAP 1.5M25	7
C2021	CAPACITOR TANTALUM 1.5/25V	47031-01590	1.5	20%	31918	ITT	TAP 1.5M25	
C2022	CAPACITOR FILM	45042-51002	1.0	20%	68919	WIMA	MKS3 1.0/63/20W	
C2023	CAPACITOR TANTALUM 1.5/25V	47031-01590	1.5	20%	31918	ITT	TAP 1.5M25	
C2024	CAPACITOR TANTALUM 1.5/25V	47031-01590	1.5	20%	31918	ITT	TAP 1.5M25	
C2025	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2026	CAPACITOR TANTALUM 10/25V	47031-10000	10	20%	31918	ITT	TAP 10M25	
C2027	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	8
C2028	CAPACITOR TANTALUM 10/25V	47031-10000	10	20%	31918	ITT	TAP 10M25	
C2029	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2030	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C2031	CAPACITOR CERAMIC DISC	41033-13300	330P	20%	51406	MURATA/ERIE	DD12F10N750331J500V	3
C2032	CAPACITOR CERAMIC DISC	41033-02200	22P	20%	51406	MURATA/ERIE	DD05B10NPO220J500V	5
C2033	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2034	CAPACITOR CERAMIC DISC	41033-10000	100P	20%	51406	MURATA/ERIE	DD08B10N750101J500V	4
C2035	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2036	CAPACITOR CERAMIC NPO	41033-12000	220P	1%	95275	VITRAMON	VP12BA221F	4
C2037	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C2038	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2039	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2040	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C2041	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2042	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2043	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2044	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
C2045	CAPACITOR CERAMIC NPO	41033-12200	220P	1%	95275	VITRAMON	VP12BA221F	
C2046	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2047	CAPACITOR CERAMIC DISC	41033-10000	100P	20%	51406	MURATA/ERIE	DD08B10N750101J500V	
C2048	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2049	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2050	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2051	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C2052	CAPACITOR CERAMIC DISC	41033-02200	22P	20%	51406	MURATA/ERIE	DD05B10NPO220J500V	
C2053	CAPACITOR CERAMIC NPO	41033-20010	2000P	1%	95275	VITRAMON	VP12BA202F	4
C2054	CAPACITOR FILM SELECTED	45042-32203	0.022	SEL	68919	WIMA	MKS2 0.022/63/5W	4
C2055	CAPACITOR FILM SELECTED	45042-42203	0.22	SEL	68919	WIMA	MKS2 0.22/63/5W	4
C2056	CAPACITOR FILM SELECTED	45042-42203	0.22	SEL	68919	WIMA	MKS2 0.22/63/5W	
C2057	CAPACITOR FILM SELECTED	45042-32203	0.022	SEL	68919	WIMA	MKS2 0.022/63/5W	
C2058	CAPACITOR CERAMIC NPO	41033-20010	2000P	1%	95275	VITRAMON	VP12BA202F	
C2059	CAPACITOR ELECT 4.7/25V	48050-04790	4.7	20%	31918	SIEMENS	85200/4.7/25	1
C2060	CAPACITOR CERAMIC DISC	41033-13300	330P	20%	51406	MURATA/ERIE	DD12F10N750331J500V	
C2061	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2062	CAPACITOR FILM	45042-41002	0.1	20%	68919	WIMA	MKS3 0.1/100/20W	
C2063	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2064	CAPACITOR FILM	45042-24700	4700P	5%	68919	WIMA	FKC3 4700/160/5W	1
C2065	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2066	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2067	CAPACITOR FILM	45042-44701	0.47	20%	68919	WIMA	MKS3 0.47/63/20W	1
C2068	CAPACITOR CERAMIC NPO	41033-12200	220P	1%	95275	VITRAMON	VP12BA221F	
C2069	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2070	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2071	CAPACITOR CERAMIC DISC	41033-10000	100P	20%	51406	MURATA/ERIE	DD08B10N750101J500V	0
C2072	CAPACITOR CERAMIC NPO	41033-12200	220P	1%	95275	VITRAMON	VP12BA221F	
C2073	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2074	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2075	CAPACITOR ALUM ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	9
C2076	CAPACITOR CERAMIC DISC	41033-03000	30P	5%	51406	MURATA/ERIE	GG300K	1
C2077	CAPACITOR TANTALUM 1.5/25V	47031-01590	1.5	20%	31918	ITT	TAP 1.5M25	
C2078	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2079	CAPACITOR CERAMIC DISC	41033-02200	22P	20%	51406	MURATA/ERIE	DD05B10NPO220J500V	
C2080	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C2081	CAPACITOR TANTALUM 10/25V	47031-10000	10	20%	31918	ITT	TAP 10M25	4
C2082	CAPACITOR CERAMIC DISC	41033-10000	100P	20%	51406	MURATA/ERIE	DD08B10N750101J500V	
C2083	CAPACITOR TANTALUM 10/25V	47031-10000	10	20%	31918	ITT	TAP 10M25	
C2084	CAPACITOR FILM SELECTED	45042-42203	0.22	SEL	68919	WIMA	MKS2 0.22/63/5W	
C2085	CAPACITOR FILM SELECTED	45042-32203	0.022	SEL	68919	WIMA	MKS2 0.022/63/5W	
C2086	CAPACITOR CERAMIC NPO	41033-20010	2000P	1%	95275	VITRAMON	VP12BA202F	
C2087	CAPACITOR FILM SELECTED	45042-42203	0.22	SEL	68919	WIMA	MKS2 0.22/63/5W	
C2088	CAPACITOR FILM SELECTED	45042-32203	0.022	SEL	68919	WIMA	MKS2 0.022/63/5W	
C2089	CAPACITOR CERAMIC NPO	41033-20010	2000P	1%	95275	VITRAMON	VP12BA202F	
C2090	CAPACITOR CERAMIC DISC	41033-00330	3P3	20%	51406	MURATA/ERIE	DD05B10N7503R3D1KV	
C2091	CAPACITOR CERAMIC DISC	41033-00330	3P3	20%	51406	MURATA/ERIE	DD05B10N7503R3D1KV	
C2092	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2093	CAPACITOR ALUM ELE RAD 10/40	48050/01000	10	20%	25088	SIEMENS	85200/10/40V	
C2094	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2095	CAPACITOR ALUM ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C2096	CAPACITOR CERAMIC DISC	41033-13300	330P	20%	51406	MURATA/ERIE	DD12F10N750331J500V	

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
C2097	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C2098	CAPACITOR ALUM ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C2099	CAPACITOR ALUM ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C2100	CAPACITOR ALUM ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C2101	CAPACITOR ALUM ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C2102	CAPACITOR FILM	45042-13302	330P	20%	51406	MURATA/ERIE	DD12F10N750331J500V	1
C2103	CAPACITOR FILM	45042-42200	0.22	5%	68919	WIMA	MKS2 0.22/63/5W	1
C2104	CAPACITOR CERAMIC DISC	41033-02200	22P	20%	51406	MURATA/ERIE	DD05B10NPO220J500V	
C2105	CAPACITOR MONOLYTHIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	3
C2106	CAPACITOR MONOLYTHIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C2107	CAPACITOR CERAMIC DISC	41033-02200	22P	20%	51406	MURATA/ERIE	DD05B10NPO220J500V	
C2108	CAPACITOR CERAMIC DISC	41033-01000	10P	20%	51406	MURATA/ERIE	DD05B10N750100J500V	
C2109	CAPACITOR MONOLYTHIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C2110	CAPACITOR CERAMIC DISC	41033-15000	150P	20%	51406	MURATA/ERIE	DD09B10N750151J500V	1
C2111	CAPACITOR ALUM ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C2112	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2113	CAPACITOR ALUM ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	
C2114	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%	51406	MURATA/ERIE	DD12B10Z5U103M1KV	
C2115	CAPACITOR TANTALUM 1.5/25V	47031-01590	1.5	20%	31918	ITT	TAP 1.5M25	
C2116	CAPACITOR CERAMIC DISC	41033-22000	220P	20%	51406	MURATA/ERIE	DD10F10N750221J500V	1
C2117	CAPACITOR TANTALUM 1.5/25V	47031-01590	1.5	20%	31918	ITT	TAP 1.5M25	
C2118	JUMPER							
D2001	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	40
D2002	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2003	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2004	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2005	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2006	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2007	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2008	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2009	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2010	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2011	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2012	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2013	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2014	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2015	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2016	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2017	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2018	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2019	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2020	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2021	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2022	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2023	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2024	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2025	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2026	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2027	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2028	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2029	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2030	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
D2031	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2032	SEMICON DIODE ZENER	21207-07531	6.2V		1A223	MOTOROLA	1N753A	2
D2033	SEMICON DIODE ZENER	21207-07531	6.2V		1A223	MOTOROLA	1N753A	
D2034	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2035	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2036	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2037	SEMICON DIODE GEN PURPOSE	21107-41500			1A223	MOTOROLA	1N4150	
D2038	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2039	SEMICON DIODE SHOTTKY	21107-62630			1A223	MOTOROLA	1N6263	1
D2040	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2041	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D2042	SEMICON RECTIFIER	21135-40040	200V		1A223	MOTOROLA	1N4004	4
D2043	SEMICON RECTIFIER	21135-40040	200V		1A223	MOTOROLA	1N4004	
D2044	SEMICON DIODE ZENER	21207-07511	5.1V		1A223	MOTOROLA	1N751A	2
D2045	SEMICON DIODE ZENER	21207-07511	5.1V		1A223	MOTOROLA	1N751A	
D2046	SEMICON RECTIFIER	21135-40040	200V		1A223	MOTOROLA	1N4004	
D2047	SEMICON RECTIFIER	21135-40040	200V		1A223	MOTOROLA	1N4004	
D2048	SEMICO LED RECT RED	21531-57124			58361	GI	MV57124	2
D2049	SEMICO LED RECT RED	21531-57124			58361	GI	MV57124	
J2001	CONNECTOR FLAT CABLE HEADER	72016-16780	16PIN		26394	ANSLEY	609-1678	2
J2002	CONNECTOR FLAT CABLE HEADER	72016-16780	16PIN		26394	ANSLEY	609-1678	
J2003	CONNECTOR HEADER LATCH	78007-20410	4 PIN	10	27264	MOLEX	22-29-2041	
J2004	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J2005	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J2006	NOT USED							
J2007	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J2008	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J2009	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J2010	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J2011	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J2012	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J2013	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J2014	NOT USED							
J2015	NOT USED							
J2016	NOT USED							
Q2001	SEMICON FET N CHANNEL	22392-48610			17856	SILICONIX	2N4861A	3
Q2002	SEMICON FET P CHANNEL	22492-38200			1A223	MOTOROLA	2N3820	3
Q2003	SEMICON FET N CHANNEL	22392-09200			17856	SILICONIX	J-111	2
Q2004	SEMICON FET P CHANNEL	22492-38200			1A223	MOTOROLA	2N3820	
Q2005	SEMICON FET N CHANNEL	22392-48610			17856	SILICONIX	2N4861A	
Q2006	SEMICON FET P CHANNEL	22492-38200			1A223	MOTOROLA	2N3820	
Q2007	SEMICON FET N CHANNEL	22392-09200			17856	SILICONIX	J-111	
Q2008	SEMICON TRANSISTOR PNP GP	22622-44030			1A223	MOTOROLA	2N4403	3
Q2009	SEMICON SHUNT REGULATOR	25992-43100			01295	TI	TL431CLP	1
Q2010	SEMICON FET N CHANNEL	22392-48610			17856	SILICONIX	2N4861A	
Q2011	SEMICON TRANSISTOR NPN GP	22522-44010			1A223	MOTOROLA	2N4401	6
Q2012	SEMICON TRANSISTOR NPN GP	22522-44010			1A223	MOTOROLA	2N4401	
Q2013	SEMICON TRANSISTOR NPN GP	22522-44010			1A223	MOTOROLA	2N4401	
Q2014	SEMICON TRANSISTOR NPN GP	22522-44010			1A223	MOTOROLA	2N4401	
Q2015	SEMICON TRANSISTOR PNP GP	22622-44030			1A223	MOTOROLA	2N4403	

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Q2016	SEMICON TRANSISTOR PNP GP	22622-44030			1A223	MOTOROLA	2N4403	
Q2017	SEMICON TRANSISTOR NPN GP	22522-44010			1A223	MOTOROLA	2N4401	
Q2018	SEMICON TRANSISTOR NPN GP	22522-44010			1A223	MOTOROLA	2N4401	
Q2019	SEMICON TRANSISTOR NPN POWER	22522-00700			1A223	MOTOROLA	MPSU07	1
Q2020	SEMICON TRANSISTOR NPN POWER	22622-05000			1A223	MOTOROLA	MPSU57	1
Q2021	SEMICON LED/LDR	21511-65000			03911	CLAIREX	CLM8500	1
R2001	RESISTOR CF 1/4W	32033-20030	200K	5%	01121	ALLEN BRADLEY	CB2045	1
R2002	RESISTOR CF 1/4W	32033-12040	1M2	5%	01121	ALLEN BRADLEY	CB1255	1
R2003	RESISTOR CF 1/4W	32033-10050	10M	5%	01121	ALLEN BRADLEY	CB1065	4
R2004	RESISTOR CF 1/4W	32033-22020	22K	5%	01121	ALLEN BRADLEY	CB2235	
R2005	RESISTOR CF 1/4W	32033-33020	33K	5%	01121	ALLEN BRADLEY	CB3335	1
R2006	RESISTOR CF 1/4W	32033-10040	1M0	5%	01121	ALLEN BRADLEY	CB1055	2
R2007	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	10
R2008	RESISTOR CF 1/4W	32033-47030	470K	5%	01121	ALLEN BRADLEY	CB4745	1
R2009	RESISTOR CF 1/4W	32033-10010	1K0	5%	01121	ALLEN BRADLEY	CB1025	5
R2010	RESISTOR CF 1/4W	32033-20020	20K	5%	01121	ALLEN BRADLEY	CB2035	1
R2011	RESISTOR CF 1/4W	32033-10010	1K0	5%	01121	ALLEN BRADLEY	CB1025	
R2012	RESISTOR CF 1/4W	32033-10010	1K0	5%	01121	ALLEN BRADLEY	CB1025	
R2013	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	
R2014	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	
R2015	RESISTOR CF 1/4W	32033-10050	10M	5%	01121	ALLEN BRADLEY	CB1065	
R2016	RESISTOR CF 1/4W	32033-39010	3K9	5%	01121	ALLEN BRADLEY	CB3925	2
R2017	RESISTOR CF 1/4W	32033-22040	2M2	5%	01121	ALLEN BRADLEY	CB2255	2
R2018	RESISTOR CF 1/4W	32033-10050	10M	5%	01121	ALLEN BRADLEY	CB1065	
R2019	RESISTOR CF 1/4W	32033-10040	1M0	5%	01121	ALLEN BRADLEY	CB1055	
R2020	RESISTOR CF 1/4W	32033-39010	3K9	5%	01121	ALLEN BRADLEY	CB3925	
R2021	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	
R2022	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	12
R2023	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R2024	RESISTOR CF 1/4W	32033-22020	22K	5%	01121	ALLEN BRADLEY	CB2235	8
R2025	RESISTOR CF 1/4W	32033-22020	22K	5%	01121	ALLEN BRADLEY	CB2235	
R2026	RESISTOR CF 1/4W	32033-22020	22K	5%	01121	ALLEN BRADLEY	CB2235	
R2027	RESISTOR CF 1/4W	32033-22020	22K	5%	01121	ALLEN BRADLEY	CB2235	
R2028	RESISTOR CF 1/4W	32033-56020	56K	5%	01121	ALLEN BRADLEY	CB5635	4
R2029	RESISTOR CF 1/4W	32033-56020	56K	5%	01121	ALLEN BRADLEY	CB5635	
R2030	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	
R2031	RESISTOR MF 1/4W	32035-26730	267K	1%	24546	CORNING	SMA4-267K-1	2
R2032	RESISTOR MF 1/4W	32035-20030	200K	1%	24546	CORNING	SMA4-200K-1	2
R2033	RESISTOR MF 1/4W	32035-26730	267K	1%	24546	CORNING	SMA4-267K-1	
R2034	RESISTOR MF 1/4W	32035-20030	200K	1%	24546	CORNING	SMA4-200K-1	
R2035	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R2036	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	
R2037	RESISTOR CF 1/4W	32033-56020	56K	5%	01121	ALLEN BRADLEY	CB5635	
R2038	RESISTOR CF 1/4W	32033-22020	22K	5%	01121	ALLEN BRADLEY	CB2235	
R2039	RESISTOR CF 1/4W	32033-33010	3K3	5%	01121	ALLEN BRADLEY	CB3325	1
R2040	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R2041	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	
R2043	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	
R2044	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	
R2045	RESISTOR CF 1/4W	32033-62000	620	5%	01121	ALLEN BRADLEY	CB6215	
R2046	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R2047	RESISTOR MF 1/4W	32035-49910	4K99	1%	24546	CORNING	SMA4-4.99K-1	8

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R2048	RESISTOR MF 1/4W	32035-43210	4K32	1%	24546	CORNING	SMA4-4.32K-1	
R2049	RESISTOR MF 1/4W	32035-49910	4K99	1%	24546	CORNING	SMA4-4.99K-1	
R2050	RESISTOR MF 1/4W	32035-75010	7K5	1%	24546	CORNING	SMA4-7.5K-1	3
R2051	RESISTOR MF 1/4W	32035-68120	68K1	1%	24546	CORNING	SMA4-68.1K-1	1
R2052	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R2053	RESISTOR CF 1/4W	32033-22010	2K2	5%	01121	ALLEN BRADLEY	CB2225	5
R2054	RESISTOR MF 1/4W	32035-24920	24K9	1%	24546	CORNING	SMA4-24.9K-1	1
R2055	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	9
R2056	RESISTOR MF 1/4W	32035-35710	3K57	1%	24546	CORNING	SMA4-3.57K-1	1
R2058	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	
R2059	RESISTOR MF 1/4W	32035-47510	4K75	1%	24546	CORNING	SMA4-4.75K-1	1
R2060	RESISTOR MF 1/4W	32035-14320	14K3	1%	24546	CORNING	SMA4-14.3K-1	1
R2061	RESISTOR MF 1/4W	32035-33210	3K32	1%	24546	CORNING	SMA4-3.32K-1	1
R2062	RESISTOR CF 1/4W	32033-27010	2K7	5%	01121	ALLEN BRADLEY	CB2725	2
R2063	RESISTOR CF 1/4W	32033-03300	33	5%	01121	ALLEN BRADLEY	CB3305	1
R2064	RESISTOR MF 1/4W	32035-04909	49R9	1%	24546	CORNING	SMA4-49.9R-1	2
R2065	RESISTOR MF 1/4W	32035-04909	49R9	1%	24546	CORNING	SMA4-49.9R-1	
R2067	RESISTOR MF 1/4W	32035-68110	6K81	1%	24546	CORNING	SMA4-6.81K-1	3
R2068	RESISTOR MF 1/4W	32035-49910	4K99	1%	24546	CORNING	SMA4-4.99K-1	
R2069	RESISTOR MF 1/4W	32035-49910	4K99	1%	24546	CORNING	SMA4-4.99K-1	
R2070	RESISTOR MF 1/4W	32035-49910	4K99	1%	24546	CORNING	SMA4-4.99K-1	
R2071	RESISTOR MF 1/4W	32035-49910	4K99	1%	24546	CORNING	SMA4-4.99K-1	
R2072	RESISTOR CF 1/4W	32033-22000	220	5%	01121	ALLEN BRADLEY	CB2215	7
R2073	RESISTOR CF 1/4W	32033-22000	220	5%	01121	ALLEN BRADLEY	CB2215	
R2074	RESISTOR CF 1/4W	32033-22000	220	5%	01121	ALLEN BRADLEY	CB2215	
R2075	RESISTOR MF 1/4W	32035-68110	6K81	1%	24546	CORNING	SMA4-6.81K-1	
R2076	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	
R2077	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	
R2078	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	
R2079	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	
R2080	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	9
R2081	RESISTOR MF 1/4W	32035-38310	3K83	1%	24546	CORNING	SMA4-3.83K-1	3
R2082	RESISTOR MF 1/4W	32035-38310	3K83	1%	24546	CORNING	SMA4-3.83K-1	
R2083	RESISTOR CF 1/4W	32033-20010	2K0	5%	01121	ALLEN BRADLEY	CB2025	4
R2084	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	
R2085	RESISTOR MF 1/4W	32035-27420	27K4	1%	24546	CORNING	SMA4-27.4K-1	1
R2087	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R2088	RESISTOR MF 1/4W	32035-40220	40K2	1%	24546	CORNING	SMA4-40.2K-1	1
R2089	RESISTOR MF 1/4W	32035-20020	20K0	1%	24546	CORNING	SMA4-20K-1	1
R2090	RESISTOR CF 1/4W	32033-10010	1K0	5%	01121	ALLEN BRADLEY	CB1025	
R2091	RESISTOR CF 1/4W	32033-22010	2K2	5%	01121	ALLEN BRADLEY	CB2225	
R2092	RESISTOR CF 1/4W	32033-22010	2K2	5%	01121	ALLEN BRADLEY	CB2225	
R2093	RESISTOR MF 1/4W	32035-26110	2K61	1%	24546	CORNING	SMA4-2.61K-1	1
R2094	RESISTOR MF 1/4W	32035-38310	3K83	1%	24546	CORNING	SMA4-3.83K-1	
R2095	RESISTOR MF 1/4W	32035-68110	6K81	1%	24546	CORNING	SMA4-6.81K-1	
R2096	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	7
R2097	RESISTOR MF 1/4W	32035-39220	39K2	1%	24546	CORNING	SMA4-39.2K-1	1
R2098	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R2099	RESISTOR CF 1/4W	32033-06200	62	5%	01121	ALLEN BRADLEY	CB6205	1
R2100	RESISTOR CF 1/4W	32033-56030	560K	5%	01121	ALLEN BRADLEY	CB5645	2
R2101	RESISTOR MF 1/4W	32035-31610	3K16	1%	24546	CORNING	SMA4-3.16K-1	1
R2102	RESISTOR MF 1/4W	32035-57620	5K76	1%	24546	CORNING	SMA4-5.76K-1	1

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R2103	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R2104	RESISTOR CF 1/4W	32033-24010	2K4	5%	01121	ALLEN BRADLEY	CB2425	1
R2105	RESISTOR CF 1/4W	32033-68010	6K8	5%	01121	ALLEN BRADLEY	CB6825	1
R2106	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R2107	RESISTOR CF 1/4W	32033-15020	15K	5%	01121	ALLEN BRADLEY	CB1535	1
R2108	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	
R2109	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R2110	RESISTOR CF 1/4W	32033-56010	5K6	5%	01121	ALLEN BRADLEY	CB5625	4
R2111	RESISTOR CF 1/4W	32033-56030	560K	5%	01121	ALLEN BRADLEY	CB5645	
R2112	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R2113	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R2114	RESISTOR CF 1/4W	32033-56010	5K6	5%	01121	ALLEN BRADLEY	CB5625	
R2115	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R2116	RESISTOR CF 1/4W	32033-22010	2K2	5%	01121	ALLEN BRADLEY	CB2225	
R2117	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	
R2118	RESISTOR CF 1/4W	32033-27010	2K7	5%	01121	ALLEN BRADLEY	CB2725	
R2119	RESISTOR CF 1/4W	32033-22010	2K2	5%	01121	ALLEN BRADLEY	CB2225	
R2120	RESISTOR CF 1/4W	32033-56010	5K6	5%	01121	ALLEN BRADLEY	CB5625	
R2121	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R2122	RESISTOR CF 1/4W	32033-56010	5K6	5%	01121	ALLEN BRADLEY	CB5625	
R2124	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R2125	RESISTOR CF 1/4W	32033-20010	2K0	5%	01121	ALLEN BRADLEY	CB2025	
R2126	RESISTOR CF 1/4W	32033-10010	1K0	5%	01121	ALLEN BRADLEY	CB1025	
R2128	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R2129	RESISTOR MF 1/4W	32035-49910	4K99	1%	24546	CORNING	SMA4-4.99K-1	
R2130	RESISTOR MF 1/4W	32035-49910	4K99	1%	24546	CORNING	SMA4-4.99K-1	
R2131	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	ALLEN BRADLEY	CB1045	
R2132	RESISTOR CF 1/4W	32033-47020	47K	5%	01121	ALLEN BRADLEY	CB4735	2
R2135	RESISTOR CF 1/4W	32033-33040	3M3	5%	01121	ALLEN BRADLEY	CB3355	2
R2137	RESISTOR CF 1/4W	32033-33040	3M3	5%	01121	ALLEN BRADLEY	CB3355	
R2139	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R2140	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R2141	RESISTOR CF 1/4W	32033-22020	22K	5%	01121	ALLEN BRADLEY	CB2235	
R2142	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R2143	RESISTOR CF 1/4W	32033-22020	22K	5%	01121	ALLEN BRADLEY	CB2235	
R2144	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	ALLEN BRADLEY	CB4725	
R2145	RESISTOR CF 1/4W	32033-33000	330	5%	01121	ALLEN BRADLEY	CB3315	1
R2146	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R2147	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R2148	RESISTOR CF 1/4W	32033-56020	56K	5%	01121	ALLEN BRADLEY	CB5635	
R2149	RESISTOR CF 1/4W	32033-47020	47K	5%	01121	ALLEN BRADLEY	CB4735	
R2150	JUMPER							
R2152	RESISTOR 1/4W CF	32033-10020	10K		01121	ALLEN BRADLEY	CB1035	
R2153	RESISTOR MF 1/4W	32035-10010	1K00	1%	24546	CORNING	SMA4-1K-1	2
R2154	RESISTOR CF 1/4W	32033-10050	10M	5%	01121	ALLEN BRADLEY	CB1065	
R2155	RESISTOR MF 1/4W	32035-10020	10K0	1%	24546	CORNING	SMA4-10K-1	
R2156	RESISTOR MF 1/4W	32035-24910	2K49	1%	24546	CORNING	SMA4-2.49K-1	2
R2157	RESISTOR MF 1/4W	32035-10010	1K00	1%	24546	CORNING	SMA4-1K-1	
R2158	RESISTOR MF 1/4W	32035-75010	7K5	1%	24546	CORNING	SMA4-7.5K-1	
R2159	RESISTOR MF 1/4W	32035-24910	2K49	1%	24546	CORNING	SMA4-2.49K-1	
R2160	RESISTOR MF 1/4W	32035-16520	16K0	1%	24546	CORNING	SMA4-16K-1	1
R2161	RESISTOR MF 1/4W	32035-43210	4K32	1%	24546	CORNING	SMA4-4.32K-1	2

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
R2162	RESISTOR MF 1/4W	32035-45300	453	1%	24546	CORNING	SMA4-453R-1	1
R2163	RESISTOR CF 1/4W	32033-22000	220	5%	01121	ALLEN BRADLEY	CB2215	
R2164	RESISTOR CF 1/4W	32033-22000	220	5%	01121	ALLEN BRADLEY	CB2215	
R2165	RESISTOR CF 1/4W	32033-22000	220	5%	01121	ALLEN BRADLEY	CB2215	
R2166	RESISTOR CF 1/4W	32033-22000	220	5%	01121	ALLEN BRADLEY	CB2215	
R2168	RESISTOR CF 1/4W	32033-62000	620	5%	01121	ALLEN BRADLEY	CB6215	2
R2169	RESISTOR CF 1/4W	32033-82010	8K2	5%	01121	ALLEN BRADLEY	CB8225	1
R2170	RESISTOR CF 1/4W	32033-15000	150	5%	01121	ALLEN BRADLEY	CB1515	1
R2171	RESISTOR CF 1/4W	32033-01000	10	5%	01121	ALLEN BRADLEY	CB1005	
R2172	RESISTOR MF 1/4W	32035-30100	301	1%	24546	CORNING	SMA4-301R-1	4
R2173	RESISTOR MF 1/4W	32035-30100	301	1%	24546	CORNING	SMA4-301R-1	
R2174	RESISTOR CF 1/4W	32033-01000	10	5%	01121	ALLEN BRADLEY	CB1005	
R2175	RESISTOR MF 1/4W	32035-30100	301	1%	24546	CORNING	SMA4-301R-1	
R2176	RESISTOR MF 1/4W	32035-40200	402	1%	24546	CORNING	SMA4-402R-1	2
R2177	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	14
R2178	RESISTOR MF 1/4W	32035-59000	590	1%	24546	CORNING	SMA4-590R-1	12
R2179	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2180	RESISTOR MF 1/4W	32035-59000	590	1%	24546	CORNING	SMA4-590R-1	
R2181	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2182	RESISTOR MF 1/4W	32035-59000	590	1%	24546	CORNING	SMA4-590R-1	
R2183	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2184	RESISTOR MF 1/4W	32035-59000	590	1%	24546	CORNING	SMA4-590R-1	
R2185	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2186	RESISTOR MF 1/4W	32035-59000	590	1%	24546	CORNING	SMA4-590R-1	
R2187	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2188	RESISTOR MF 1/4W	32035-59000	590	1%	24546	CORNING	SMA4-590R-1	
R2189	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2190	RESISTOR MF 1/4W	32035-66500	665	1%	24546	CORNING	SMA4-665R-1	2
R2191	RESISTOR MF 1/4W	32035-93100	931	1%	24546	CORNING	SMA4-931R-1	2
R2192	NOT USED							
R2193	RESISTOR CF 1/4W	32033-01000	10	5%	01121	ALLEN BRADLEY	CB1005	4
R2194	RESISTOR CF 1/4W	32033-01000	10	5%	01121	ALLEN BRADLEY	CB1005	
R2195	RESISTOR CF 1/4W	32033-02200	22	5%	01121	ALLEN BRADLEY	CB2205	4
R2196	RESISTOR CF 1/4W	32033-02200	22	5%	01121	ALLEN BRADLEY	CB2205	
R2197	RESISTOR CF 1/4W	32033-02200	22	5%	01121	ALLEN BRADLEY	CB2205	
R2198	RESISTOR CF 1/4W	32033-02200	22	5%	01121	ALLEN BRADLEY	CB2205	
R2199	RESISTOR MF 1/4W	32035-30100	301	1%	24546	CORNING	SMA4-301R-1	
R2200	RESISTOR MF 1/4W	32035-40200	402	1%	24546	CORNING	SMA4-402R-1	
R2201	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2202	RESISTOR MF 1/4W	32035-59000	590	1%	24546	CORNING	SMA4-590R-1	
R2203	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2204	RESISTOR MF 1/4W	32035-59000	590	1%	24546	CORNING	SMA4-590R-1	
R2205	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2206	RESISTOR MF 1/4W	32035-59000	590	1%	24546	CORNING	SMA4-590R-1	
R2207	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2208	RESISTOR MF 1/4W	32035-59000	590	1%	24546	CORNING	SMA4-590R-1	
R2209	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2210	RESISTOR MF 1/4W	32035-59000	590	1%	24546	CORNING	SMA4-590R-1	
R2211	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2212	RESISTOR MF 1/4W	32035-59000	590	1%	24546	CORNING	SMA4-590R-1	
R2213	RESISTOR MF 1/4W	32035-86600	866	1%	24546	CORNING	SMA4-866R-1	
R2214	RESISTOR MF 1/4W	32035-66500	665	1%	24546	CORNING	SMA4-665R-1	

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R2215	RESISTOR MF 1/4W	32035-93100	931	1%	24546	CORNING	SMA4-931R-1	
R2216	RESISTOR CF 1/4W	32033-22040	2M2	5%	01121	ALLEN BRADLEY	CB2255	
R2217	RESISTOR CF 1/4W	32033-10000	100	5%	01121	ALLEN BRADLEY	CB1015	
R2218	RESISTOR CF 1/4W	32033-20010	2K0	5%	01121	ALLEN BRADLEY	CB2025	
R2219	RESISTOR CF 1/4W	32033-20010	2K0	5%	01121	ALLEN BRADLEY	CB2025	
R2220	RESISTOR MF 1/4W	32035-64900	649	1%	24546	CORNING	SMA4-649R-1	1
R2221	RESISTOR MF 1/4W	32035-75010	7K5	1%	24546	CORNING	SMA4-7.5K-1	
S2001	PUSHBUTTON SWITCH ASSEMBLY	83116-10460			31918	ITT/SCHADOW	F104X6UT6UT6UT2UGR	1
S2002	PUSHBUTTON SWITCH	83116-10460			31918	ITT/SCHADOW	PART/S2001	
S2003	PUSHBUTTON SWITCH	83116-10460			31918	ITT/SCHADOW	PART/S2001	
S2004	PUSHBUTTON SWITCH	83116-10460			31918	ITT/SCHADOW	PART/S2001	
S2005	ROTARY SWITCH 3 POL 11 POS	81113-31319			04426	ITW/RCL	44-614-0002	1
U2001	SEMICON OP AMP BI-FET DUAL	25111-07200			01295	TI	TL-072CP	1
U2002	SEMICON OP AMP PRECISION	25311-31800			27014	NATIONAL	LM318N	1
U2003	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	13
U2004	SEMICON LINEAR DUAL OTA	25430-32800			3L585	RCA	CA3280E	2
U2005	SEMICON OP AMP BI-FET DUAL	25111-06200			01295	TI	TL-062CP	2
U2006	SEMICON OP AMP FET	25312-41100			27014	NATIONAL	LF411CN	3
U2007	SEMICON OP AMP FET	25312-41100			27014	NATIONAL	LF411CN	
U2008	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	
U2009	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	
U2010	SEMICON TRANSISTOR ARRAY SEL	23316-68420			1A223	MOTOROLA	MPQ6842	3
U2011	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	
U2012	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	
U2013	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	
U2014	SEMICON CMOS SWITCH	24021-40530			3L585	RCA	CD4053BPC	2
U2015	SEMICON CMOS SWITCH	24021-40530			3L585	RCA	CD4053BPC	
U2016	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	
U2017	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	
U2018	SEMICON OP AMP BI-FET DUAL	25111-06200			01295	TI	TL-062CP	
U2019	SEMICON OP AMP J FET	25311-35600			27014	NATIONAL	LF356N	1
U2020	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	
U2021	SEMICON LINEAR DUAL OTA	25430-32800			3L585	RCA	CA3280E	
U2022	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	
U2023	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	
U2024	SEMICON BI-FET OP AMP	25111-07100			01295	TI	TL-071CP	1
U2025	SEMICON TRANSISTOR ARRAY	23316-68420			1A223	MOTOROLA	MPQ6842	
U2026	SEMICON NEG REG 15V TO-92	25922-79150			1A223	MOTOROLA	MC79L15CP	1
U2027	SEMICON POS REG 15V TO-92	25922-78150			1A223	MOTOROLA	MC78L15CP	1
U2028	SEMICON OP AMP FET	25312-41100			27014	NATIONAL	LF411CN	
U2029	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	
U2030	SEMICON OP AMP LO NOISE LIN	25311-55340			ICH66	SIGNETICS	NE5534AN	
U2031	SEMICON TRANSISTOR ARRAY	23316-68420			1A223	MOTOROLA	MPQ6842	
V2001	RESISTOR TRIM CONTROL ST TA	51416-50020	50K		32997	BOURNS	3386P-1-503	
V2002	RESISTOR TRIM CONTROL ST TA	51416-50020	50K		32997	BOURNS	3386P-1-503	
V2003	RESISTOR TRIM CONTROL ST TA	51416-10010	1K		32997	BOURNS	3386P-1-102	2
V2004	RESISTOR TRIM CONTROL ST TA	51416-10000	100		32997	BOURNS	3386P-1-101	1
V2005	RESISTOR TRIM CONTROL ST TA	51416-50020	50K		32997	BOURNS	3386P-1-503	8
V2006	RESISTOR TRIM CONTROL ST TA	51416-10020	10K		32997	BOURNS	3386P-1-103	2
V2007	RESISTOR TRIM CONTROL ST TA	51416-50020	50K		32997	BOURNS	3386P-1-503	
V2008	RESISTOR TRIM CONTROL ST TA	51416-50020	50K		32997	BOURNS	3386P-1-503	
V2009	RESISTOR TRIM CONTROL ST TA	51416-50020	50K		32997	BOURNS	3386P-1-503	

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
V2010	RESISTOR TRIM CONTROL ST TA	51416-50020	50K		32997	BOURNS	3386P-1-503	
V2011	RESISTOR TRIM CONTROL ST TA	51416-50020	50K		32997	BOURNS	3386P-1-503	
V2012	RESISTOR TRIM CONTROL ST TA	51416-10020	10K		32997	BOURNS	3386P-1-103	
V2013	RESISTOR TRIM CONTROL ST TA	51416-10010	1K		32997	BOURNS	3386P-1-102	
V2014	RESISTOR MF 1/4W	32035-12110	1K21	1%	24546	CORNING	SMA4-1.21K-1	1
V2015	QUAD COND PLASTIC POT CUSTOM	13501-72010	25K		38047	AMBER	13501-72010	1
V2017	RESISTOR TRIM CONTROL ST TA	51416-20010	2K		32997	BOURNS	3386P-1-201	1
V2106	CONDUCTIVE PLASTIC POT	51126-50014	5K		12697	CLAIROSTAT	VS388-5K	1

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	HARNESS 400	13501-30400			38047	AMBER	13501-30400	1
	PRINTED CIRCUIT BOARD	13501-44006			38047	AMBER	3501-440-06	1
	CABLE TIE WRAPS	58750-00001	8"		06915	RICHCO	WIT-18V	1
	CONNECTOR TRANSISTOR SOCKET	71001-20310	TO-220		27264	MOLEX	10-18-2031	3
	CONNECTOR SOCKET PCB DIL	71014-21439	14 PIN		91506	AUGAT	214-AG39D	3
C401	CAPACITOR ELECTRO 2200/25V	48030-22010	2200	20%	25088	SIEMENS	82000/2200UF/25V	1
C402	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	9
C403	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C404	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C405	CAPACITOR CERAMIC DISC	41033-41000	0.1	20%	51406	MURATA/ERIE		1
C406	CAPACITOR PLASTIC FILM	45042-42201	0.22	5%	68919	WIMA	MKS2 0.22/63/5W	2
C407	CAPACITOR PLASTIC FILM	45042-31502	0.015	20%	68919	WIMA	MKS3 0.015/100/20W	3
C408	CAPACITOR PLASTIC FILM	45042-41000	0.1	5%	68919	WIMA	MSS3 0.1/100/5W	1
C409	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C410	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C412	CAPACITOR PLASTIC FILM	45042-31502	0.015	20%	68919	WIMA	MKS3 0.015/100/20W	
C413	CAPACITOR ELECTRO 22/25V	48030-02200	22	20%	25088	SIEMENS	81000/22UF/25V	1
C414	CAPACITOR PLASTIC FILM	45042-31502	0.015	20%	68919	WIMA	MKS3 0.015/100/20W	
C415	CAPACITOR TANTALUM 1.5/25V	47031-01590	1.5	20%	31918	ITT	TAG 1.5M25	1
C416	CAPACITOR TANTALUM 10/25V	47031-10000	10	20%	31918	ITT	TAG 10M25	2
C417	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C418	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C419	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C420	CAPACITOR ELECTRO 10/40V	48050-01000	10	20%	25088	SIEMENS	85200/10/40V	1
C421	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C422	CAPACITOR TANTALUM 10/25V	47031-10000	10	20%	31918	ITT	TAG 10M25	
C423	CAPACITOR PLASTIC FILM	45042-42201	0.22	5%	68919	WIMA	MKS2 0.22/63/5W	
D401	SEMICON BRIDGE RECT.FULL WAVE	29006-06000			58361	GI	KBF06	1
D405	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	8
D406	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D407	SEMICON RECTIFIER	21135-54040			1A223	MOTOROLA	1N5404	
D409	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D410	SEMICON DIODE ZENER 1W	21207-47440	15V		1A223	MOTOROLA	1N4744	2
D411	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D412	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D413	SEMICON RECTIFIER	21135-54040			1A223	MOTOROLA	1N5404	2
D414	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D415	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D416	SEMICON DIODE GEN PURPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D417	SEMICON DIODE ZENER 1W	21207-47440	15V		1A223	MOTOROLA	1N4744	
J401	CONNECTOR FLAT CABLE	72016-16780	16PIN		26394	ANSLEY	609-1678	1
J402	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	4
J403	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J404	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
J405	CONNECTOR HEADER LATCH	78007-20410	4 PIN		27264	MOLEX	22-29-2041	
Q401	SEMICON TRANSISTOR NPN GP	22522-44010			1A223	MOTOROLA	2N4401	1
Q402	SEMICON SHUNT REGULATOR	25922-43100			01295	TI	TL431CLP	1
Q403	SEMICON TRANSISTOR PNP GP	22622-44030			1A223	MOTOROLA	2N4403	1
R401	RESISTOR CF 1/4W	32033-12010	1K2	5%	01121	A BRADLEY	CB1225	3
R402	RESISTOR WW 3W	34077-01031	0.1	5%	01121	A BRADLEY		1
R403	RESISTOR CF 1/4W	32033-15010	1K5	5%	01121	A BRADLEY	CB1525	3
R404	RESISTOR CF 1/4W	32033-39010	3K9	5%	01121	A BRADLEY	CB3925	1
R405	RESISTOR CF 1/4W	32033-68000	680	5%	01121	A BRADLEY	CB6815	1

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
R406	RESISTOR CF 1/4W	32033-12010	1K2	5%	01121	A BRADLEY	CB1225	
R407	RESISTOR CF 1/4W	32033-15030	150K	5%	01121	A BRADLEY	CB1515	2
R408	RESISTOR CF 1/4W	32033-04700	47	5%	01121	A BRADLEY	CB4705	1
R409	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	A BRADLEY	CB1035	7
R410	RESISTOR CF 1/4W	32033-12020	12K	5%	01121	A BRADLEY	CB1235	1
R411	RESISTOR CF 1/4W	32033-15010	1K5	5%	01121	A BRADLEY	CB1525	
R412	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	A BRADLEY	CB1035	
R414	RESISTOR CF 1/4W	32033-15010	1K5	5%	01121	A BRADLEY	CB1525	
R415	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	A BRADLEY	CB1035	
R416	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	A BRADLEY	CB4725	4
R417	RESISTOR CF 1/4W	32033-27000	270	5%	01121	A BRADLEY	CB2715	2
R418	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	A BRADLEY	CB1045	5
R419	RESISTOR CF 1/4W	32033-10040	1M0	5%	01121	A BRADLEY	CB1055	4
R420	RESISTOR CF 1/4W	32033-15030	150K	5%	01121	A BRADLEY	CB1515	
R421	RESISTOR CF 1/4W	32033-82020	82K	5%	01121	A BRADLEY	CB8205	1
R422	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	A BRADLEY	CB1045	
R423	RESISTOR CF 1/4W	32033-10040	1M0	5%	01121	A BRADLEY	CB1055	
R424	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	A BRADLEY	CB4725	
R425	RESISTOR CF 1/4W	32033-47040	4M7	5%	01121	A BRADLEY	CB4755	1
R426	RESISTOR CF 1/4W	32033-10010	1K0	5%	01121	A BRADLEY	CB1025	3
R427	RESISTOR CF 1/4W	32033-10010	1K0	5%	01121	A BRADLEY	CB1025	
R428	RESISTOR CF 1/4W	32033-27000	270	5%	01121	A BRADLEY	CB2715	
R429	RESISTOR CF 1/4W	32033-10010	1K0	5%	01121	A BRADLEY	CB1025	
R430	RESISTOR CF 1/4W	32033-10040	1M0	5%	01121	A BRADLEY	CB1055	
R431	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	A BRADLEY	CB1045	
R432	RESISTOR CF 1/4W	32033-47030	470K	5%	01121	A BRADLEY	CB4745	1
R433	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	A BRADLEY	CB1035	
R434	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	A BRADLEY	CB1035	
R435	RESISTOR MF 1/4W	32035-49910	4K99	1%	24546	CORNING	SMA4-4.99K-1	3
R436	RESISTOR MF 1/4W	32035-11520	11K5	1%	24546	CORNING	RN55D 11.5KR	1
R437	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	A BRADLEY	CB4725	
R438	RESISTOR CF 1/4W	32033-27010	2K7	5%	01121	A BRADLEY	CB2725	3
R439	RESISTOR CF 1/4W	32033-27010	2K7	5%	01121	A BRADLEY	CB2725	
R440	RESISTOR MF 1/4W	32035-49910	4K99	1%	24546	CORNING	SMA4-4.99K-1	
R441	RESISTOR MF 1/4W	32035-49910	4K99	1%	24546	CORNING	SMA4-4.99K-1	
R442	RESISTOR CF 1/4W	32033-15020	15K	5%	01121	A BRADLEY	CB1535	1
R443	RESISTOR CF 1/4W	32033-20030	200K	5%	01121	A BRADLEY	CB2045	1
R444	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	A BRADLEY	CB1035	
R445	RESISTOR CF 1/4W	32033-27010	2K7	5%	01121	A BRADLEY	CB2725	
R446	RESISTOR CF 1/4W	32033-10040	1M0	5%	01121	A BRADLEY	CB1055	
R447	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	A BRADLEY	CB1045	
R448	RESISTOR CF 1/4W	32033-22010	2K2	5%	01121	A BRADLEY	CB2225	1
R449	RESISTOR CF 1/4W	32033-10030	100K	5%	01121	A BRADLEY	CB1045	
R450	RESISTOR CF 1/4W	32033-12010	1K2	5%	01121	A BRADLEY	CB1225	
R451	RESISTOR CF 1/4W	32033-20020	20K	5%	01121	A BRADLEY	CB2035	1
R453	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	A BRADLEY	CB1035	
R454	RESISTOR CF 1/4W	32033-47010	4K7	5%	01121	A BRADLEY	CB4725	
U401	SEMICON QUAD OP AMP	25321-32400			27014	NATIONAL	LM324N	2
U402	SEMICON QUAD OP AMP	25321-32400			27014	NATIONAL	LM324N	
U403	QUAD NORGATE CMOS	24021-40010			3L585	RCA	CD4001BPC	1
V401	RESISTOR TRIM CONTROL ST TA	51416-10020	10K	10%	32997	BOURNS	3386P-1-103	2
V403	RESISTOR TRIM CONTROL ST TA	51416-10020	10K	10%	32997	BOURNS	3386P-1-103	

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	PRINTED CIRCUIT BOARD	13501-45004				AMBER	3501-450-05	1
C500	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	12
C501	CAPACITOR TANTALUM 1.5/25V	47031-01590	1.5	20%	31918	ITT	TAG 1.5M25V	1
C502	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C503	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C504	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C505	CAPACITOR TANTALUM 10/25V	47031-10000	10	20%	31918	ITT	TAG 10M25	
C506	NOT USED							
C507	CAPACITOR CERAMIC DISC 50V	41033-31000	0.01	20%	51406	Murata	MULT EF 103Z	2
C508	CAPACITOR TANTALUM 10/25V	47031-10000	10	20%	31918	ITT	TAG 10M25V	2
C509	NOT USED							
C510	CAPACITOR CERAMIC DISC	41033-03000	30P	20%	51406	Murata	MULT GH 300K	1
C511	CAPACITOR CERAMIC DISC	41033-04700	47P	20%	51406	Murata	GH470K	1
C512	NOT USED							
C513	NOT USED							
C514	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C515	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C516	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200 10UF 40V	4
C517	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C518	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C519	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200 10UF 40V	
C520	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C521	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C522	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200 10UF 40V	
C523	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C524	CAPACITOR MONOLYTIC CERAMIC	42031-41000	0.1	20%	04222	AVX	SR205C104MAA	
C525	CAPACITOR ELECT 10/40	48050-01000	10	20%	25088	SIEMENS	85200 10UF 40V	
C526	CAPACITOR CERAMIC DISC	41033-31000	0.01	20%				
C527	CAPACITOR FILM	45042-42201	0.22	5%	68919	WIMA	MKS2 0.22/63/5W	1
D501	SEMICON DIODE GEN PRUPOSE	21136-41500			1A223	MOTOROLA	1N4150	10
D502	SEMICON DIODE GEN PRUPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D503	SEMICON DIODE GEN PRUPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D504	SEMICON DIODE GEN PRUPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D505	SEMICON DIODE GEN PRUPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D506	SEMICON DIODE GEN PRUPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D507	SEMICON DIODE GEN PRUPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D508	SEMICON DIODE GEN PRUPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D509	SEMICON DIODE GEN PRUPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D510	SEMICON DIODE GEN PRUPOSE	21136-41500			1A223	MOTOROLA	1N4150	
D511	NOT USED							
D512	NOT USED							
L501	INDUCTOR 270MA	53102-15374	15MH		73831	HAMMOND	1537-40	7
L502	INDUCTOR CHOKE	53102-15320			73831	HAMMOND	1532A	1
L503	INDUCTOR 270MA	53102-15374	15MH		73831	HAMMOND	1537-40	
L504	INDUCTOR 270MA	53102-15374	15MH		73831	HAMMOND	1537-40	
L505	INDUCTOR 270MA	53102-15374	15MH		73831	HAMMOND	1537-40	
L506	INDUCTOR 270MA	53102-15374	15MH		73831	HAMMOND	1537-40	
L507	INDUCTOR 270MA	53102-15374	15MH		73831	HAMMOND	1537-40	
L508	INDUCTOR 270MA	53102-15374	15MH		73831	HAMMOND	1537-40	
N501	RESISTOR NET 8 PIN 4 RES SIP	39085-10030	100K	5%	32997	BOURNS	4608R-102-104	1
Q501	SEMICON POWER VMOS FET	22318-10000	1A40V		17856	SILICONIX	VN10KM	2
Q502	SEMICON POWER MOS FET	22318-10000	1A40V		17856	SILICONIX	VN10KM	
R501	RESISTOR CF 1/4W	32033-27000	270	5%	01121	ALLEN BRADLEY	CB2715	2

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
R502	RESISTOR CF 1/4W	32033-27000	270	5%	01121	ALLEN BRADLEY	CB2715	
R503	RESISTOR CF 1/4W	32033-10020	10K	5%	01121	ALLEN BRADLEY	CB1035	1
R504	RESISTOR CF 1/4W	32033-10040	1M0	5%	01121	ALLEN BRADLEY	CB1055	1
R505	RESISTOR CF 1/4W	32033-33010	3K3	5%	01121	ALLEN BRADLEY	CB3325	1
R506	RESISTOR CF 1/4W	32033-01000	10	5%	01121	ALLEN BRADLEY	CB1005	2
R507	RESISTOR CF 1/4W	32033-01000	10	5%	01121	ALLEN BRADLEY	CB1005	
T500	TRANSFORMER HI FREQUENCY	53511-23753				NOREAST	2375	1
U501	SEMICON CMOS DUAL JK FLIP FLOP	24021-40270			RL585	RCA	CD4027BCP	1
U502	SEMICON CMOS HEX INVERTER	24021-40490			RL585	RCA	CD4049BCP	1

Amber model 3501 Distortion Measuring Set
Switching Power Supply Box Assembly   Part Number 13501-75000

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	HARNESS 403	13501-30403	6"		38047	AMBER	13501-30403	1
	HARNESS (HOOK UP)	13501-30500	2"		38047	AMBER	13501-30500	1
	HARNESS 1005	13501-31005	6"		38047	AMBER	13501-31005	1
	HARNESS 2005	13501-32005	6"		38047	AMBER	13501-32005	1
	POWER SUPPLY BOX	13501-64505			38047	AMBER	13501-64505	1
	POWER SUPPLY BOX COVER	13501-64606			38047	AMBER	13501-64605	1
	POWER SUPPLY BOX INSULATOR	13501-64701			38047	AMBER	13501-64701	2
	SWITCHER HEATSINK ASSEMBLY	13501-65010			38047	AMBER	13501-65010	1
	SWITCHER PCB ASSEMBLY	13501-75005			38047	AMBER	13501-45005	1
	FEEDTHRU CAPS	49000-15010	1500P		51406	MURATA/ERIE	1203-050	8
	MACHINE SCREW PHIL PH 6-32	61111-16031	5/16			VARIOUS	MS35206-227	6
	MACHINE SPRING NUT	61240-54000	6-32		78553	EATON	TN-226	2
	MACHINE SCREW SELF-TAP #6	61321-36025	3/8		94223	SPAE NAUR	ST372H	8
	WASHER STEP NYLON	61502-56077	#6		86928	SEASTROM	5607-74	2
	WASHER LOCK INTERNAL TOOTH	61520-93660	#6			VARIOUS	AN936-A6	6
	MACHINE SPACER	61699-60813	1"		94223	SPAE NAUR	608-139	1
	FERRITE BEADS	61800-00000				FERROXCUBE	56-59065-4A6	8

Amber Document Number 3501-85000-01

Amber model 3501 Distortion Measuring Set
Switcher Heatsink Assembly   Part Number 13501-75010

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	POWER SUPPLY HEATSINK	13501-64803			38047	AMBER	13501-64803	1
	MACHINE SCREW PHIL PH 4-40	61111-14037	3/8			VARIOUS	MS35206-215	4
	WASHER FLAT	61510-14300	#4			VARIOUS	AN960-4	2
	WASHER LOCK INTERNAL TOOTH	61520-36400	#4			VARIOUS	AN936-A4	4
	WASHER STEP INSULATOR	61540-77210	TO-220		13103	THERMALLOY	7721-7PPS	2
	MICA SHEET	61600-43779	TO-220		13103	THERMALLOY	43-77-9	2
Q503	SEMICON FET VMOS POWER N CH	22392-51000	8A40V		59993	IR	IRF510	2
Q504	SEMICON FET VMOS POWER N CH	22392-51000	8A40V		59993	IR	IRF510	

Amber model 3501 Distortion Measuring Set
Trimpot PCB Assembly Part Number 13501-71101

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	HARNESS 1010 FLAT CABLE ASS'Y	13501-31010	9"		38047	AMBER	13501-31010	1
	PCB TRIM POT BOARD	13501-41102			38047	AMBER	13501-41102	1
	CONNECTOR FLAT CABLE BLUE	72016-16780	16PIN		26394	ANSLEY	609-1678	1
V1001	RESISTOR TRIM CONTROL MT SA	51515-10010	1K		23997	BOURNS	3299X-1-102	1
V1002	RESISTOR TRIM CONTROL MT SA	51515-50020	50K		23997	BOURNS	3299X-1-503	
V1003	RESISTOR TRIM CONTROL MT SA	51515-50020	50K		23997	BOURNS	3299X-1-503	
V1004	RESISTOR TRIM CONTROL MT SA	51515-50020	50K		23997	BOURNS	3299X-1-503	
V1005	RESISTOR TRIM CONTROL MT SA	51515-50020	50K		23997	BOURNS	3299X-1-503	5
V1006	RESISTOR TRIM CONTROL MT SA	51515-50020	50K		23997	BOURNS	3299X-1-503	
V1007	RESISTOR TRIM CONTROL MT SA	51515-50000	500		23997	BOURNS	3299X-1-501	1
V1008	RESISTOR TRIM CONTROL MT TA	51516-10000	100		23997	BOURNS	3299W-1-101	1

Amber Document Number 3501-81101-01

Amber model 3501 Distortion Measuring Set
Heatsink Assembly Part Number 13501-74010

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	HEATSINK (3501)	13501-67901	623k		38047	AMBER	13501-67901	1
	MACHINE SCREW PHIL PH 4-40	61111-14031	5/16			VARIOUS	AN507-440-R5	3
	MACHINE NUT HEX	61220-44000	4-40			VARIOUS	MS35649-242	4
	WASHER INTERNAL TOOTH	61520-36400	#4			VARIOUS	AN936-A4	3
	MACHINE COMPRESSION WASHER	61520-68001	#4		94223	SPAE NAUR	680-001	3
	STEP WASHER INSULATOR	61540-77210	TO-220		13103	THERMALLOY	7721-7PPS	3
	MICA SHEET	61600-43779	TO-220		13103	THERMALLOY	43-77-9	3
Q404	SEMICON TRANSISTOR NPN DAR	22522-12201			01295	TI	TIP122	
Q405	SEMICON TRANSISTOR NPN DAR	22522-12201			01295	TI	TIP122	2
U404	SEMICON 5V REGULATOR 1A	25922-78050	5V		1A223	Motorola	UA7805UCG	1

Amber Document Number 3501-84010-01

Amber model 3501 Distortion Measuring Set
Transformer Assembly Part Number 13501-74015

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	TRANSFORMER POWER	13501-04001	14V		38047	AMBER	13501-04001	1
	TRANSFORMER BRACKET	13501-67602			38047	AMBER	13501-67602	1
	MACHINE SCREW	61132-69162	10-24			VARIOUS	MS35206-270	1
	MACHINE NUT	61220-11000	#10			VARIOUS	MS35649-XXX	1
	TRANSFORMER MOUNTING PLATE	62700-35010			38047	AMBER	62700-35010	1
	WASHER FLAT	62710-01000	#10			VARIOUS	AN960-10	1
	TRANSFORMER WASHER INSULATOR	62910-35010			38047	AMBER	62910-35010	1
	CONNECTOR CRIMP TERMINAL	78009-01020	MINI-KK		27264	MOLEX	08-55-0102	2
	CONNECTOR HOUSING	78010-20450	4 PIN		27264	MOLEX	22-01-2045	1

Amber Document Number 3501-84015

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	PRINTED CIRCUIT BOARD	13501-48008			38047	AMBER	3501-480-08	1
	INPUT/OUTPUT PCB BRACKET	13501-66101			38047	AMBER	13501-66101	1
	CABLE TIE WRAP	58750-00001	8"		06915	RICHCO	WIT-18V	2
	KNOB - KEY CAP DARK BROWN	63803-90114			04426	ITW/LICON	803901140000	1
	KNOB - KEY CAP OLIVE	63803-90116			04426	ITW/LICON	803901160000	1
C801	NOT USED							
C802	NOT USED							0
C803	NOT USED							
C804	NOT USED							
C805	CAPACITOR FILM 400V	45042-51001	1.0	10%	25088	SIEMENS	1.0/400VDC/220VAC	2
C806	CAPACITOR FILM 400V	45042-51001	1.0	10%	25088	SIEMENS	1.0/400VDC/220VAC	0
C807	CAPACITOR FILM	45042-42202	0.22	10%	68919	WIMA	MKS30.22/63/20W	1
CL1	SHORT JUMPER LINK							2
CL2	SHORT JUMPER LINK							0
CL3	NOT USED							
CL4	NOT USED							
D801	SEMICON LED RECT YELLOW	21531-53124			58361	GI	MV53124	1
D802	SEMICON LED RECT GREEN	21531-52124			58361	GI	MV52124	1
D803	SEMICON LED RECT RED	21531-57124			58361	GI	MV57124	1
D804	SEMICON DIODE ZENER	21207-07461	3.3V	5%	1A223	MOTOROLA	1N746ATR	1
D805	NOT USED							
D806	SEMICON DIODE ZENER	21207-07521	5.6V		9J979	HITACHI	1N752A	1
J801	CONNECTOR HEADER LATCH 4 PIN	78007-20410			27264	MOLEX	22-29-2041	8
J802	CONNECTOR HEADER LATCH 4 PIN	78007-20410			27264	MOLEX	22-29-2041	
J803	CONNECTOR HEADER LATCH 4 PIN	78007-20410			27264	MOLEX	22-29-2041	
J804	CONNECTOR HEADER LATCH 4 PIN	78007-20410			27264	MOLEX	22-29-2041	
J805	CONNECTOR FLAT CABLE 16 PIN	72016-16780			91506	AUGAT	609-1678	1
J806	CONNECTOR HEADER LATCH 4 PIN	78007-20410			27264	MOLEX	22-29-2041	
J807	NOT USED							
J808	CONNECTOR HEADER LATCH 4 PIN	78007-20410			27264	MOLEX	22-29-2041	
J809	CONNECTOR HEADER LATCH 4 PIN	78007-20410			27264	MOLEX	22-29-2041	
J810	NOT USED							
J811	CONNECTOR HEADER LATCH 4 PIN	78007-20410			27264	MOLEX	22-29-2041	
J812	CONNECTOR HEADER LATCH 6 PIN	78007-20610			27264	MOLEX	22-29-2061	1
J813	NOT USED							
K801	REED RELAY	84801-42301			71707	COTO	4230-12-3001	1
K802	REED RELAY	84801-26531	2A		71707	COTO	2653-12-300	1
L801	NOT USED							
L802	NOT USED							0
P801	CONNECTOR SOCKET R-T-S PCB	74003-38800				ADC	PC388J	2
P802	CONNECTOR SOCKET R-T-S PCB	74003-38800				ADC	PC388J	
R801	RESISTOR MF 1W	32061-30100	301	1%	24546	CORNING		1
R802	RESISTOR MF 1W	32061-60000	600	1%	24546	CORNING		2
R803	RESISTOR MF 1/4W	32035-16520	16K5	1%	24546	CORNING	SMA4-16.5K-1	1
R804	RESISTOR CF 1/4W	32033-91000	910	5%	01121	ALLEN BRADLEY	CB9115	1
R805	RESISTOR CF 1/4W	32033-13030	130K	5%	01121	ALLEN BRADLEY	CB1345	1
R806	RESISTOR MF 1/4W	32035-75010	7K5	1%	24546	CORNING	SMA4-7.5K-1	1
R807	NOT USED							
R808	NOT USED							
R810	RESISTOR MF 1W	32061-60000	600	1%	24546	CORNING		
R811	NOT USED							
R812	NOT USED							
R813	NOT USED							

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
R814	NOT USED							
S801	SWITCH CUSTOM ARRAY F2UEE	83116-20000			31918	ITT/SCHADOW	F2UEE	
S802	SWITCH CUSTOM ARRAY F2UEE	83116-20000			31918	ITT/SCHADOW	F2UEE	4
S803	SWITCH CUSTOM ARRAY F6UEE	83116-60000			31918	ITT/SCHADOW	F6UEE	1
S804	SWITCH CUSTOM ARRAY F2UEE	83116-20000			31918	ITT/SCHADOW	F2UEE	
S805	SWITCH CUSTOM ARRAY F2UEE	83116-20000			31918	ITT/SCHADOW	F2UEE	
V801	SWITCH ASSEMBLY POT SPDT	51126-25002	25K		12697	CLAIROSTAT	VS388-25K	1

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	HARNESS 801	13501-30801	4"		38047	AMBER	13501-30801	1
	HARNESS 806	13501-30806	16"		38047	AMBER	13501-30801	1
	HARNESS 811	13501-30811	4"		38047	AMBER	13501-30811	1
	HARNESS 812	13501-30812			38047	AMBER	13501-30812	1
	HARNESS 1004	13501-31004	6"		38047	AMBER	13501-31004	1
	FREQUENCY DIAL	13501-42503			38047	AMBER	13501-42503	1
	FRONT PANEL OVERLAY	13501-48701			38047	AMBER	13501-48701	1
	FRONT PANEL UNDERLAY	13501-61005			38047	AMBER	13501-61005	1
	RATIO DRIVE (3501)	13501-61601			38047	AMBER	13501-61601	1
	METER ASSEMBLY	13501-79010	1MA		38047	AMBER	13501-79010	1
	MACHINE SCREW PHIL 4-40 PH	61111-14025	1/4			VARIOUS	MS35206-213	2
	MACHINE HEX NUT	61220-44000	4-40			VARIOUS	MS35649-242	2
	DRESS NUT	61250-70990			09353	C & K	7099	1
	WASHER BNC D STEP	61500-22722	.455		00779	AMP	227223-1	4
	WASHER FLAT FIBER	61501-40000			94223	SPAE NAUR	W-40F	7
	WASHER FLAT	61510-14300	#4			VARIOUS	AN960-4	4
	WASHER INTERNAL TOOTH	61520-36400	#4			VARIOUS	AN936-A4	2
	BUSHING NYLON	61550-56076			86928	SEASTROM	5607-65	5
	KNOB BLACK ROUND	63313-21025	21MM		59270	SIFAM	S210 250	1
	KNOB CAP BLACK	63803-21000	21MM		59270	SIFAM	C210	1
	CONNECTOR PANEL POST BLACK	74001-15170			83330	SMITH	1517	1
	CONNECTOR BNC	77001-79131	GOLD		91836	KINGS	KC79-131	4

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	REAR PANEL (SCREENED)	13501-67704			38047	AMBER	13501-67704	1
	LINEAR REGULATOR PCB ASSEMBLY	13501-74006			38047	AMBER	13501-74006	1
	HEATSINK ASSEMBLY	13501-74010			38047	AMBER	13501-74010	1
	TRANSFORMER ASSEMBLY	13501-74015			38047	AMBER	13501-74015	1
	MACHINE SCREW PHIL PH 6-32	61111-16037	3/8			VARIOUS	MS35206-228	4
	MACHINE SCREW PHIL PH 6-32	61111-16087	7/8			VARIOUS	MS35206-233	4
	MACHINE SCREW PHIL FH 6-32	61113-16025	1/4			VARIOUS	AN507-632-R4	4
	MACHINE SCREW PHIL FH 6-32	61113-16037	3/8			VARIOUS	AN507-632-6	4
	MACHINE HEX NUT	61220-63200	#6			VARIOUS	MS35649-262	1
	WASHER FLAT	61510-16400	#6			VARIOUS	AN960-6	4
	WASHER LOCK INTERNAL TOOTH	61520-93660	#6			VARIOUS	AN936-A6	9
	RUBBER FEET	65300-00000			94223	SPAE NAUR	RB-187	4
	TERMINAL LUG	67100-2400	#6		94223	SPAE NAUR	WT-24	1
	PLUG BUTTON PLASTIC	67200-00000	BLACK		94223	SPAE NAUR	245-049	6
	CONNECTOR AC POWER FILTER	71000-37200	6A		1N137	SCHAFFNER	FN 372-6/22	1

DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
	PRINTED CIRCUIT BOARD	13501-46003				AMBER	3501-460-04	1
	CONNECTOR SOCKET IC DIL	71008-20839	8 PIN			AUGAT	208-AG39D	1
	CONNECTOR SOCKET IC DIL	71016-21639	16PIN			AUGAT	216-AG39D	6
	CONNECTOR HEADER LATCH	73104-20410	4 PIN			MOLEX	22-29-2041	3
C601	CAPACITOR PLASTIC FILM	46000-22030	0.22	20%		WIMA	CK068X224K	3
C602	CAPACITOR PLASTIC FILM	45049-22030	0.22	20%		WIMA	MKS2/0.22	
C603	CAPACITOR PLASTIC FILM	45042-47020	0.047	10%		WIMA	MKS3/0.047	1
C604	CAPACITOR PLASTIC FILM	45049-22030	0.22	20%		WIMA	MKS2/0.22	
C605	CAPACITOR ALUM ELE RAD 10/40	48050-01000	10	20%		SIEMENS	85200/10/40V	5
C606	CAPACITOR ALUM ELE RAD 10/40	48050-01000	10	20%		SIEMENS	85200/10/40V	
C607	CAPACITOR CERAMIC DISC	41033-10030	0.01	20%				
C608	CAPACITOR CERAMIC DISC	41033-10030	0.01	20%			MULT EF 103Z	2
C609	CAPACITOR TANTALUM 25V	47031-01000	10	20%			COM TAG 10UF 25V	2
C610	CAPACITOR TANTALUM 25V	47121-10050	10	20%				
C611	CAPACITOR ALUM ELE AXIL 100/25	48030-10000	100	20%		SIEMENS	81009/100/25V	2
C612	CAPACITOR ALUM ELE AXIL 100/25	48030-10000	100	20%		SIEMENS	81009/100/25V	
C613	CAPACITOR CERAMIC DESC	41031-10090	10P	20%			GG100K	
C621	CAPACITOR PLASTIC FILM	46000-10030	0.01	5%		WIMA	MKS3 0.01/100/5W	9
C622	CAPACITOR PLASTIC FILM	45043-10020	0.01	5%		WIMA	MKS3 0.01/100/5W	
C623	CAPACITOR PLASTIC FILM	45043-10020	0.01	5%		WIMA	MKS3 0.01/100/5W	
C624	CAPACITOR PLASTIC FILM	45043-10020	0.01	5%		WIMA	MKS3 0.01/100/5W	
C625	CAPACITOR PLASTIC FILM	45043-10020	0.01	5%		WIMA	MKS3 0.01/100/5W	
C626	CAPACITOR PLASTIC FILM	45043-10020	0.01	5%		WIMA	MKS3 0.01/100/5W	
C627	CAPACITOR PLASTIC FILM	45043-10020	0.01	5%		WIMA	MKS3 0.01/100/5W	
C628	CAPACITOR PLASTIC FILM	45043-10020	0.01	5%		WIMA	MKS3 0.01/100/5W	
C629	CAPACITOR CERAMIC DISC	41033-01000	10P	20%			831-000-COGO-100D	2
C630	CAPACITOR CERAMIC DISC	41033-03000	30P	20%			GH300K	1
C631	CAPACITOR PLASTIC FILM	45042-15020	0.015	5%		WIMA	MKS3 0.015/100/5W	4
C632	CAPACITOR PLASTIC FILM	45043-15020	0.015	5%		WIMA	MKS3 0.015/100/5W	
C633	CAPACITOR PLASTIC FILM	45043-15020	0.015	5%		WIMA	MKS3 0.015/100/5W	
C634	CAPACITOR PLASTIC FILM	45043-15020	0.015	5%		WIMA	MKS3 0.015/100/5W	
C635	CAPACITOR PLASTIC FILM	45042-22020	0.022	10		WIMA	MKS3 0.022/100/20W	1
C636	CAPACITOR PLASTIC FILM	45043-10020	0.01	5%		WIMA	MKS3 0.01/100/5W	
C637	CAPACITOR PLASTIC FILM	45042-68010	6800P	5%		WIMA	FKC3 6800/160/5W	1
C638	CAPACITOR PLASTIC FILM	45042-13300	0.033	5%		WIMA	MKS3 0.033/100/5W	1
C639	CAPACITOR PLASTIC FILM	45042-22010	2200P	5%		WIMA	FKC3 2200/160/5W	2
C640	CAPACITOR PLASTIC FILM	45042-10030	0.1	20%		WIMA	MKS3 0.1/100/20W	
C641	CAPACITOR ALUM ELE RAD 10/40	48050-01000	10	20%		SIEMENS	85200/10/40V	
C642	CAPACITOR PLASTIC FILM	45042-10030	0.1	20%		WIMA	MKS3 0.1/100/20W	2
C644	CAPACITOR ALUM ELE RAD 10/40	48050-01000	10	20%		SIEMENS	85200/10/40V	
C645	NOT USED							
C646	CAPACITOR ALUM ELE RAD 10/40	47121-10050	10	20%		SIEMENS	85200/10/40V	
C647	NOT USED							
C648	CAPACITOR PLASTIC FILM	45043-22010	2200P	5%		WIMA	FKC3/2200	
C649	CAPACITOR PLASTIC FILM	45042-10010	1000P	5%		WIMA	FKC3 1000/160/5W	1
C650	CAPACITOR PLASTIC FILM	45042-22000	220P	5%		WIMA	FKC3 220/160/20W	1
D601	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	16
D602	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	

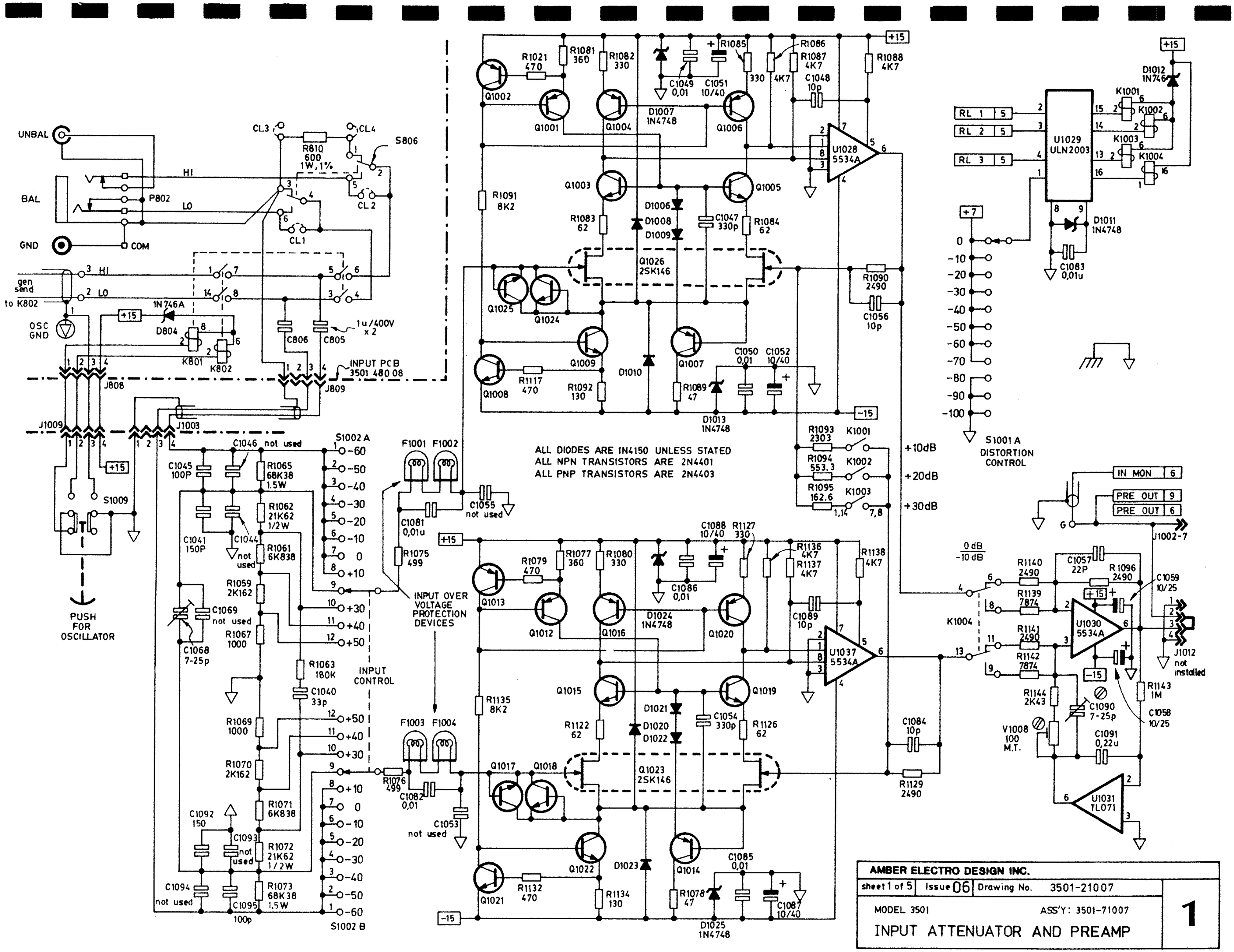
DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
D603	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D604	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D605	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D606	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D607	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D608	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D609	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D610	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D611	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D612	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D613	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D614	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D615	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
D616	SEMICON DIODE GEN PURPOSE	21135-41500				MOTOROLA	1N4150	
J602	CONNECTOR HEADER FLAT CABLE	72016-16780	16PIN			ANSLEY	609-1678	1
Q601	SEMICON FET N CHANNEL	22318-48610				MOTOROLA	2N4861	1
Q602	SEMICON TRANSISTOR NPN GP	22292-44010				MOTOROLA	2N4401	1
Q603	SEMICON SHUNT REGULATOR	25992-43100					TL431CLP	1
R601	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	14
R602	RESISTOR MF 1/4W	32035-82520	82K5	1%		CORNING	8252F	1
R603	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R604	RESISTOR MF 1/4W	32035-12120	12K1	1%		CORNING	RN55D 12.1KR	3
R605	RESISTOR MF 1/4W	32035-12120	12K1	1%		CORNING	1212F	
R606	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R607	RESISTOR MF 1/4W	32035-47500	475	1%		CORNING	RN55D 4775R	3
R608	RESISTOR CF 1/4W	32033-10030	100K	5%		ALLEN BRADLEY	CF1/4 100KR	3
R609	RESISTOR CF 1/4W	32033-10030	100K	5%		ALLEN BRADLEY		
R610	RESISTOR CF 1/4W	32033-10030	100K	5%		ALLEN BRADLEY		
R611	RESISTOR CF 1/4W	32033-33030	330K	5%		ALLEN BRADLEY		1
R612	RESISTOR MF 1/4W	32035-33230	332K	1%		CORNING	3323F	1
R613	RESISTOR MF 1/4W	32035-43230	432K	1%		CORNING		1
R614	RESISTOR MF 1/4W	32035-40220	40K2	1%		CORNING	RN55D 40.2KR	2
R615	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R616	RESISTOR MF 1/4W	32035-47500	475	1%		CORNING	4750F	
R617	RESISTOR MF 1/4W	32035-47500	475	1%		CORNING	4750F	
R618	RESISTOR CF 1/4W	32033-10020	10K	5%		ALLEN BRADLEY	CB1035	8
R619	RESISTOR CF 1/4W	32035-10020	10K	5%		ALLEN BRADLEY	CB1035	
R620	RESISTOR CF 1/4W	32035-10020	10K	5%		ALLEN BRADLEY	CB1035	
R621	RESISTOR MF 1/4W	32035-78710	7K87	1%		CORNING	RN55D 7.87KR	1
R622	RESISTOR MF 1/4W	32035-80610	8K06	1%		CORNING	SMA4-8.06K-1	1
R623	RESISTOR MF 1/4W	32035-66510	6K65	1%		CORNING	6651F	1
R624	RESISTOR MF 1/4W	32035-95310	9K53	1%		CORNING	9531F	1
R625	RESISTOR MF 1/4W	32035-44210	4K42	1%		CORNING	4421F	1
R626	RESISTOR MF 1/4W	32035-14320	14K3	1%		CORNING	RN55D 14.3KR	1
R627	RESISTOR MF 1/4W	32035-15410	1K54	1%		CORNING	1541F	1
R628	RESISTOR MF 1/4W	32035-40220	40K2	1%		CORNING	4022F	
R629	RESISTOR MF 1/4W	32035-49910	4K99	1%		CORNING	RN555D 4.99KR	2
R630	RESISTOR MF 1/4W	32035-51120	51K1	1%		CORNING	5112F	1

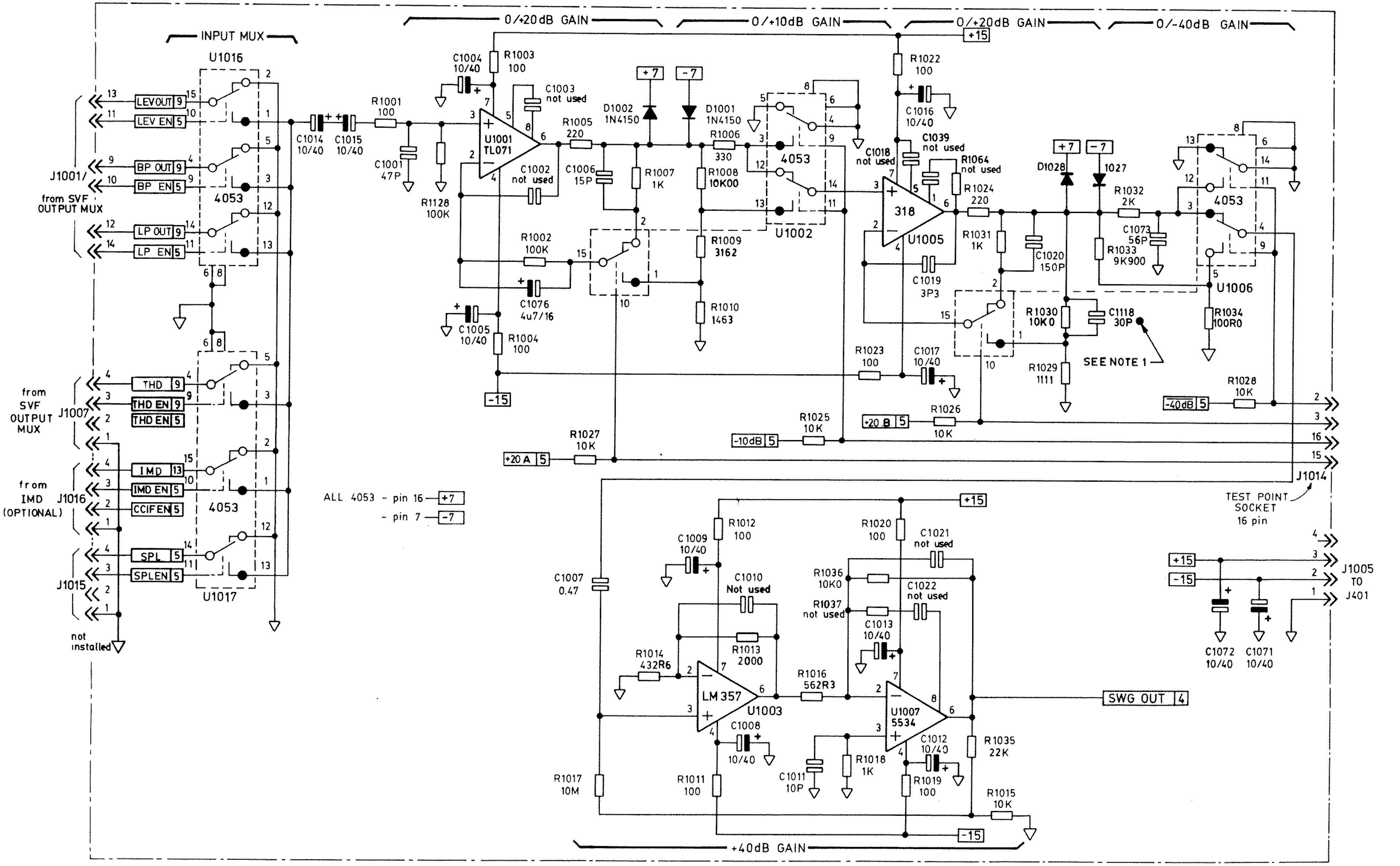
DESIG	DESCRIPTION	AMBER PART NUMBER	ELECT VALUE	TOL	FSC	MANUFACTURER	MANUFACTURER PART NUMBER	QTY USED
R631	RESISTOR CF 1/4W	32033-10050	10M	5%		ALLEN BRADLEY		1
R632	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R633	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R634	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R635	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R636	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R637	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R638	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R639	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R640	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R641	RESISTOR MF 1/4W	32035-10020	10K0	1%		CORNING	SMA4-10K-1	
R642	RESISTOR CF 1/4W	32033-10020	10K	5%		ALLEN BRADLEY	CB1035	
R643	RESISTOR CF 1/4W	32033-10000	100	5%		ALLEN BRADLEY	CB1015	5
R644	RESISTOR MF 1/4W	32035-12120	12K1	1%		CORNING	1212F	
R645	RESISTOR MF 1/4W	32035-20020	20K0	1%		CORNING	RN55D 20KR	1
R646	RESISTOR CF 1/4W	32033-10020	10K	5%		ALLEN BRADLEY	CB1035	
R647	RESISTOR CF 1/4W	32033-10020	10K	5%		ALLEN BRADLEY	CB1035	
R648	RESISTOR CF 1/4W	32033-10020	10K	5%		ALLEN BRADLEY	CB1035	
R649	JUMPER							
R650	RESISTOR MF 1/4W	32035-80600	806	1%		CORNING	SMA4-806R-1	1
R651	RESISTOR CF 1/4W	32033-10000	100	5%		ALLEN BRADLEY	CB1015	
R652	RESISTOR CF 1/4W	32033-10020	10K	5%		ALLEN BRADLEY	CB1035	
R653	RESISTOR MF 1/4W	32035-64900	649	1%		CORNING	RN55D 6490F	1
R654	RESISTOR CF 1/4W	32033-10000	100	5%		ALLEN BRADLEY	CB1015	
R655	RESISTOR CF 1/4W	32033-10000	100	5%		ALLEN BRADLEY	CB1015	
R656	RESISTOR MF 1/4W	32035-49910	4K99	1%		CORNING	4991F	
R657	RESISTOR CF 1/4W	32033-10000	100	5%		ALLEN BRADLEY	CB1015	
RL601	RELAY REED 2A	89100-92512	12V				925A12C2A	2
RL602	RELAY REED 2A	89100-92512	12V				925A12C2A	
U600	SEMICON OP AMP BI-FET DUAL	25111-06200				TI	TL-062CP	
U601	SEMICON OP AMP BI-FET DUAL	25111-06200				TI	TL-062CP	
U602	SEMICON OP AMP BI-FET DUAL	25111-07200				TI	TL-072CP	
U603	SEMICON OP AMP BI-FET DUAL	25111-06200				TI	TL-062CP	
U604	SEMICON OP AMP BI-FET DUAL	25111-06200				TI	TL-062CP	
U605	SEMICON OP AMP BI-FET DUAL	25111-07200				TI	TL-072CP	5
U606	SEMICON OP AMP BI-FET DUAL	25111-07200				TI	TL-072CP	
U607	RESISTOR NETWORK	38434-22020	22K	2%			4116R001223	1
U608	SEMICON OP AMP BI-FET DUAL	25111-07200				TI	TL-072CP	
U609	SEMICON OP AMP BI-FET DUAL	25111-07200				TI	TL-072CP	
U610	SEMICON CMOS SWITCH	24021-40530					MC14053BCP	1
V601	RESISTOR TRIM CONTROL ST	51415-10020	10K	10%		BOURNS	3386P-1-103	1

SCHEMATICS

1	Input Attenuator & Preamp
3	Input Multiplexer & Switched Gain
4	Weighting Filters
5	Function & Gain Logic
6	Detectors & Meter Drive
7	Oscillator & AGC
8	Power Amp & Output Attenuator
9	Notch Filter
10	Notch Servo Null
11	Linear Regulator & Battery Charger
12	IMD LF Oscillator
13	IMD Analyzer
14	Switching Power Supply
15	Input/Output board
16	System Interconnect
17	Signal Path Output Configuration
18	Signal Path simplified
20	Rear Panel Schematic

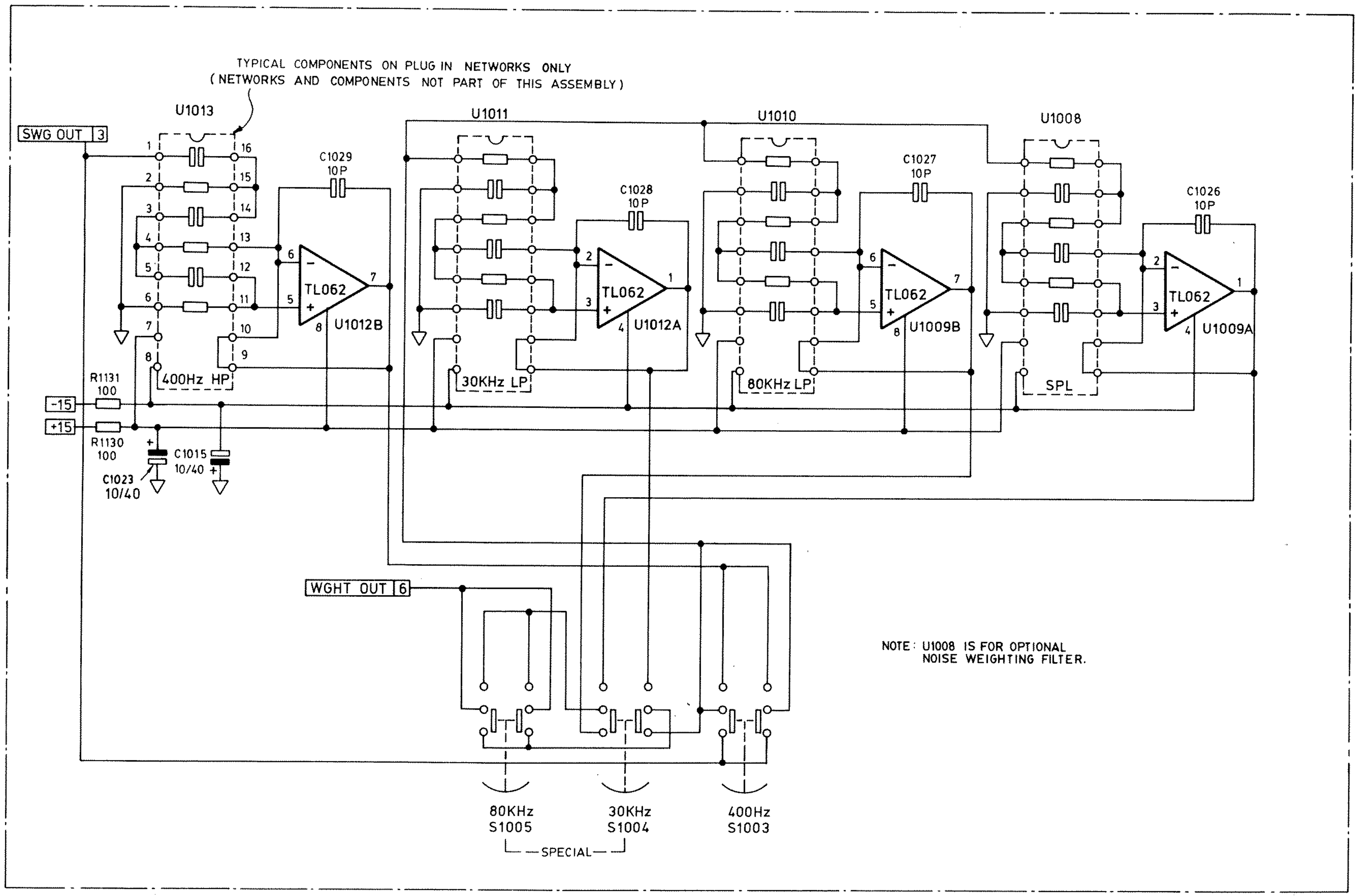
Input/Meter Board	3501-410-07
Filter/Oscillator Board	3501-420-04
Linear Regulator & Battery Charger	3501-440-06
Switching Power Supply	3501-450-05
IMD Board	3501-460-03
Input/Output Board	3501-480-08


ALL DIODES ARE 1N4150 UNLESS STATED
ALL NPN TRANSISTORS ARE 2N4401
ALL PNP TRANSISTORS ARE 2N4403
UNBAL
BAL
GND
PUSH FOR OSCILLATOR
INPUT PCB 3501 480 08
INPUT OVER VOLTAGE PROTECTION DEVICES
INPUT CONTROL
S1002 A
S1002 B
S1001 A DISTORTION CONTROL
+10dB
+20dB
+30dB
IN MON 6
PRE OUT 9
PRE OUT 6
J1012 not installed
AMBER ELECTRO DESIGN INC.
sheet 1 of 5
Issue 06
Drawing No. 3501-21007
MODEL 3501
ASS'Y: 3501-71007
INPUT ATTENUATOR AND PREAMP
1



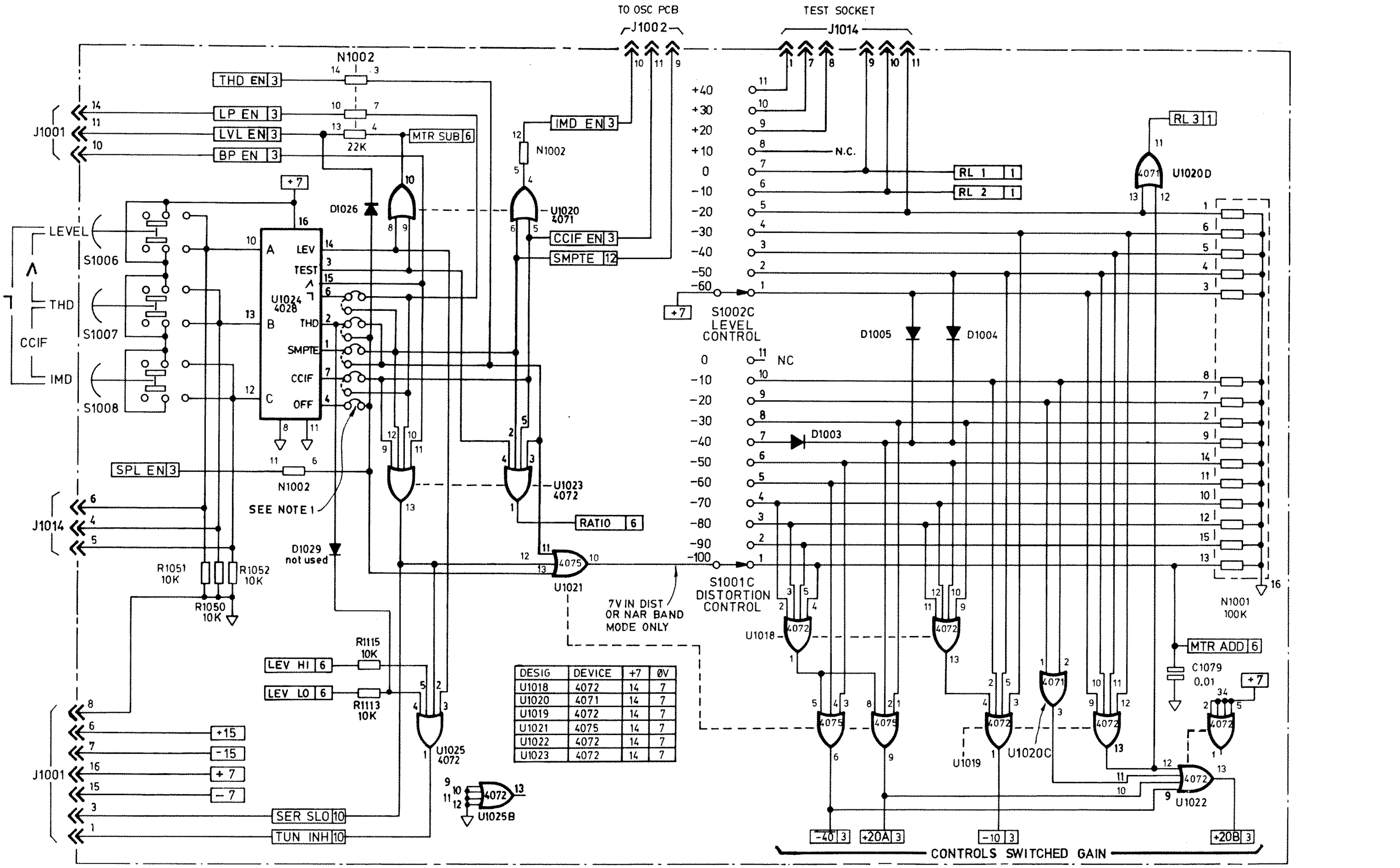
NOTE 1. ● DENOTES NO DESIGNATION ON P.C.B.

AMBER ELECTRO DESIGN INC			
sheet 2 of 5	Issue 06	Drawing No. 3501-21007	3
MODEL 3501		ASS'Y: 3501-71007	
INPUT MULTIPLEXER & SWITCHED GAIN			



AMBER ELECTRO DESIGN INC.

sheet 3 of 5	Issue 06	Drawing No. 3501-21007	4
MODEL 3501		ASS'Y: 3501-71007	
WEIGHTING FILTERS			

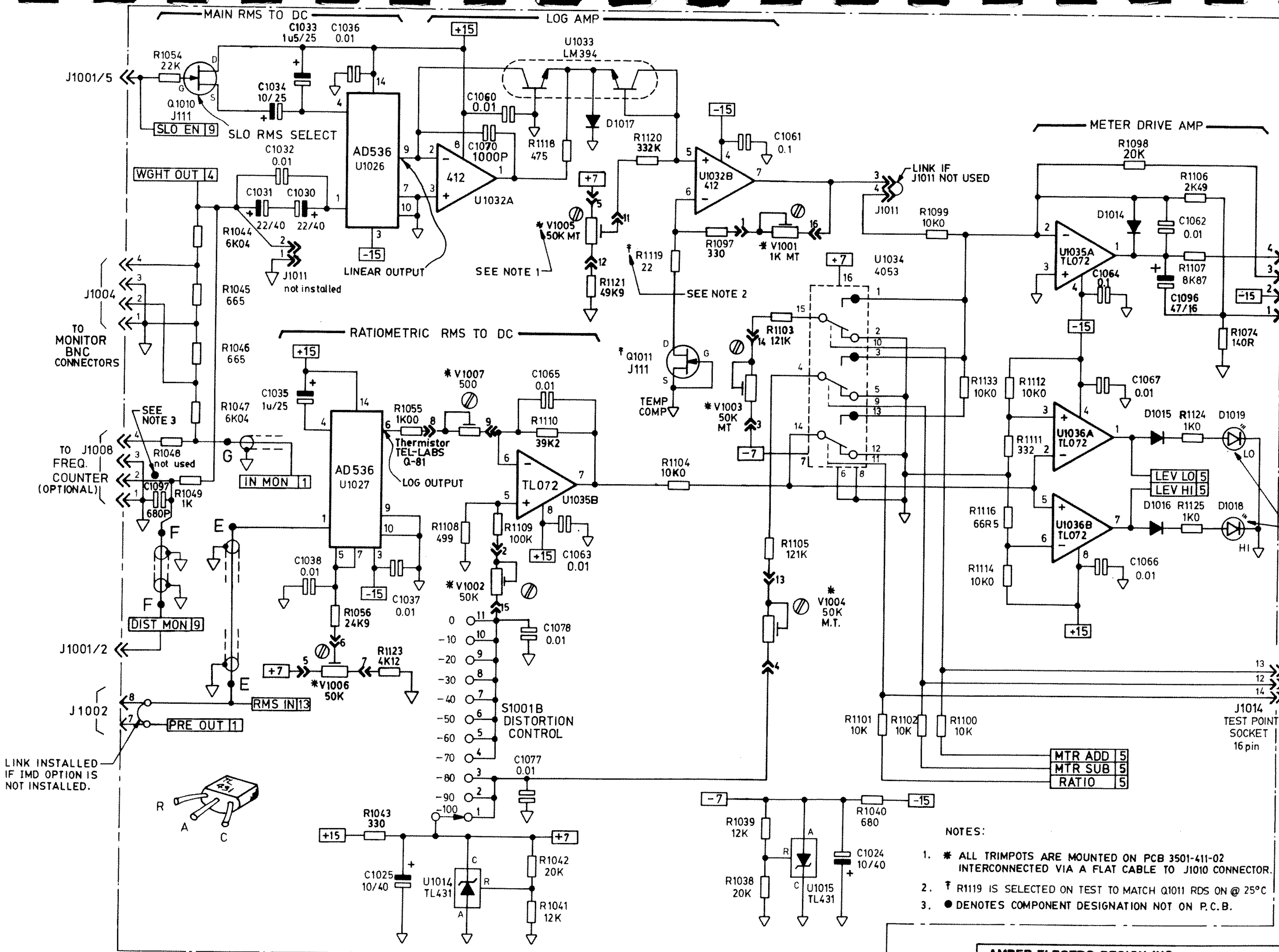


DESIG	DEVICE	+7	0V
U1018	4072	14	7
U1020	4071	14	7
U1019	4072	14	7
U1021	4075	14	7
U1022	4072	14	7
U1023	4072	14	7

ALL DIODES ARE 1N4150

NOTE 1. JUMPERS SHOWN ARE STANDARD FACTORY SETTINGS FOR MODEL 3501. SEE DOCUMENTATION FOR MODEL 3501a FOR DIFFERENT SETTINGS. ALTERNATE JUMPER MAY BE USED TO PROVIDE DIFFERENT INSTRUMENT FUNCTIONS.

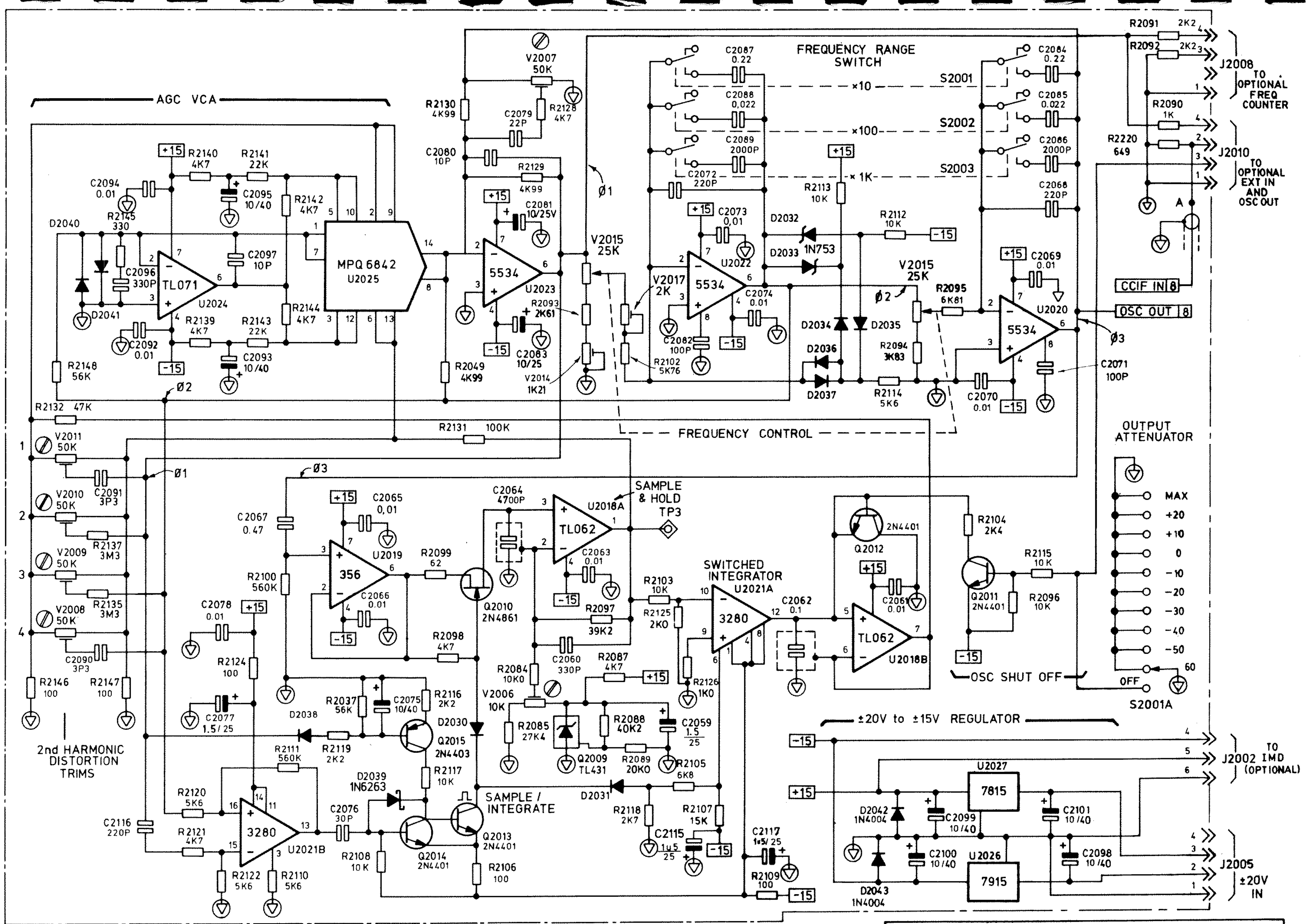
AMBER ELECTRO DESIGN INC.			
sheet 4 of 5	Issue 06	Drawing No. 3501-21007	5
MODEL 3501	ASSY: 3501-71007		
FUNCTION AND GAIN LOGIC			



NOTES:

1. ✱ ALL TRIMPOTS ARE MOUNTED ON PCB 3501-411-02 INTERCONNECTED VIA A FLAT CABLE TO J1010 CONNECTOR.
2. ↑ R1119 IS SELECTED ON TEST TO MATCH Q1011 RDS ON @ 25°C
3. ● DENOTES COMPONENT DESIGNATION NOT ON P.C.B.

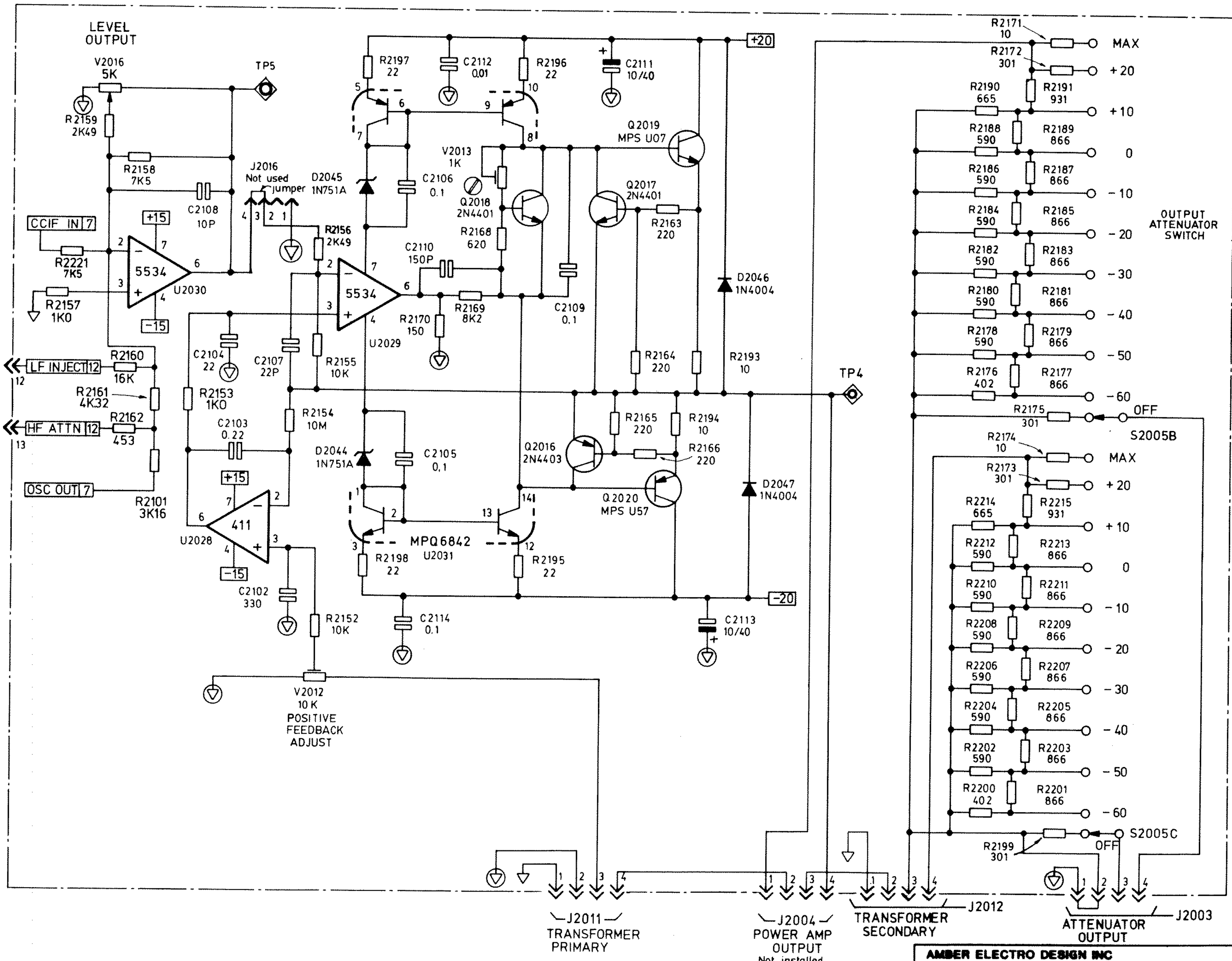
AMBER ELECTRO DESIGN INC			
sheet 5 of 5	Issue 06	Drawing No. 3501-21007	6
MODEL 3501		ASS'Y 3501-71007	
DETECTORS & METER DRIVE			



ALL DIODES ARE 1N4150 UNLESS STATED

OSCILLATOR FLOATING GROUND

AMBER ELECTRO DESIGN INC.			
sheet 1 of 4	Issue 07	Drawing No. 3501-22004	7
MODEL 3501		ASS'Y 3501-72004	
OSCILLATOR AND AGC			



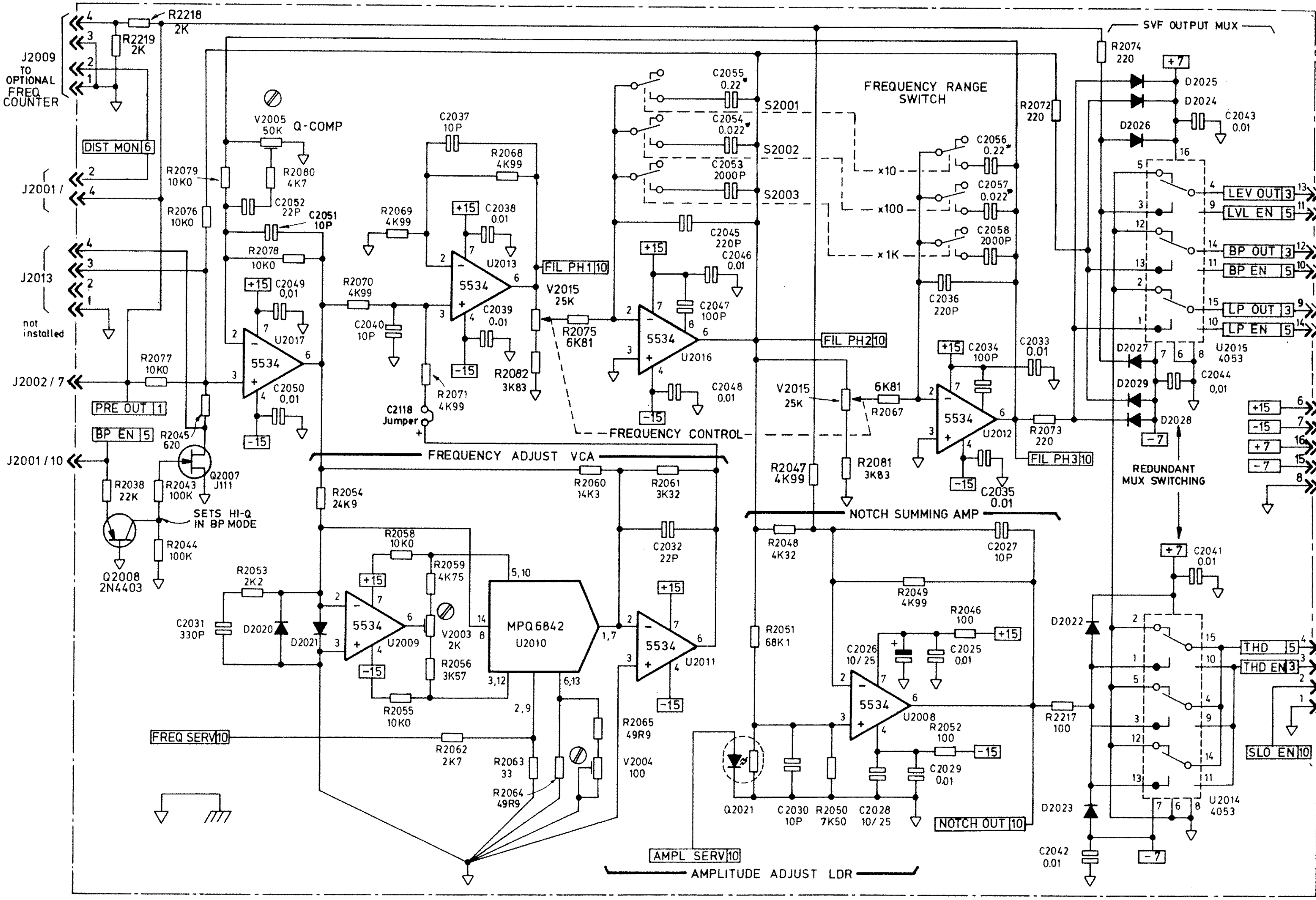
AMBER ELECTRO DESIGN INC

sheet 2 of 4	Issue 07	Drawing No. 3501-22004

MODEL 3501 ASS'Y 3501-72004

POWER AMP & OUTPUT ATTENUATOR

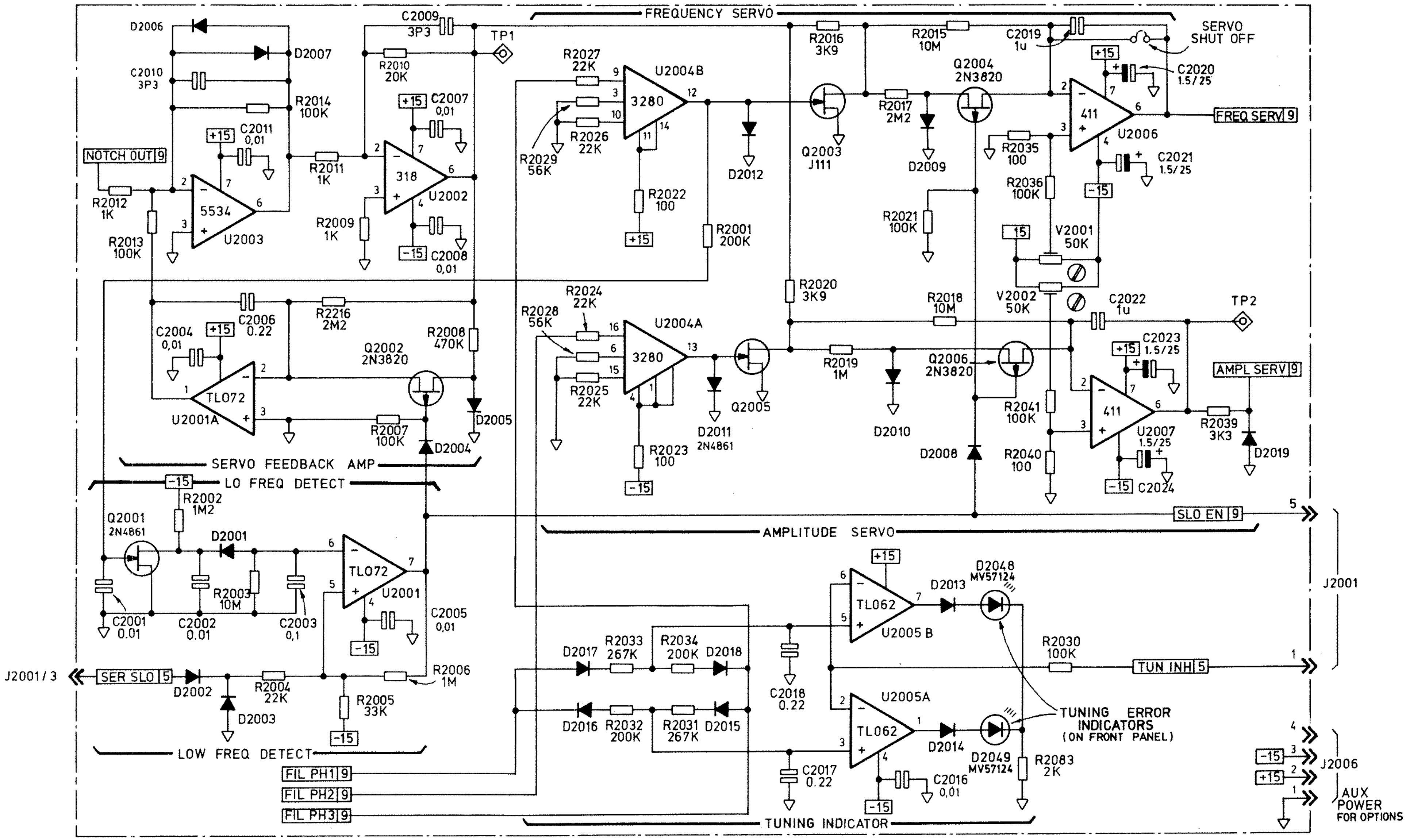
8



ALL DIODES ARE 1N4150

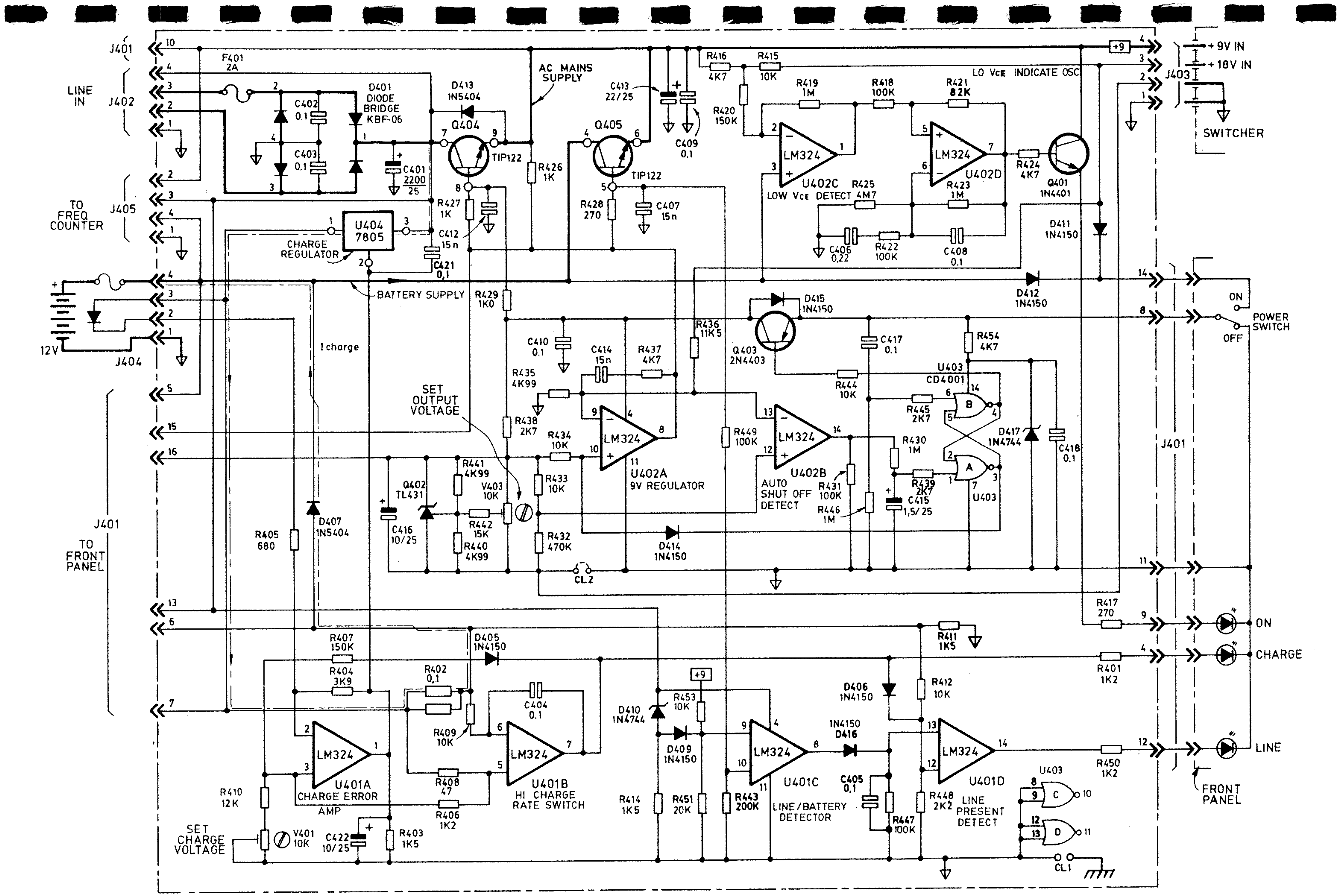
* SELECTED VALUES

AMBER ELECTRO DESIGN INC			
sheet 3 of 4	Issue 07	Drawing No. 3501-22004	9
MODEL 3501 NOTCH FILTER		ASS'Y 3501-72004	



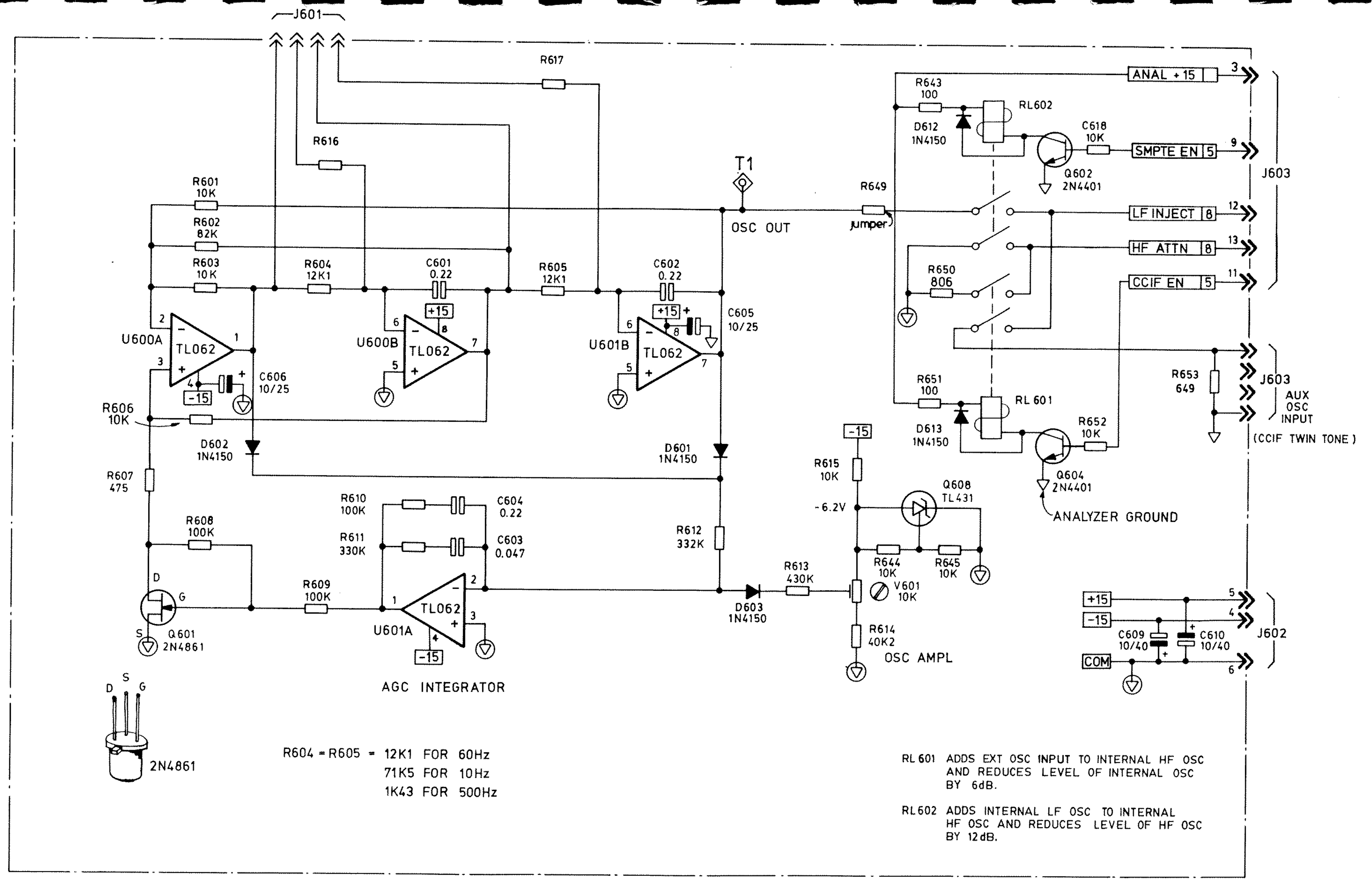
UNLESS OTHERWISE SPECIFIED ALL DIODES TO BE 1N4150.

AMBER ELECTRO DESIGN INC			
sheet 4 of 4	Issue 07	Drawing No. 3501-22004	10
MODEL 3501		ASS'Y 3501-72004	
NOTCH SERVO NULL			

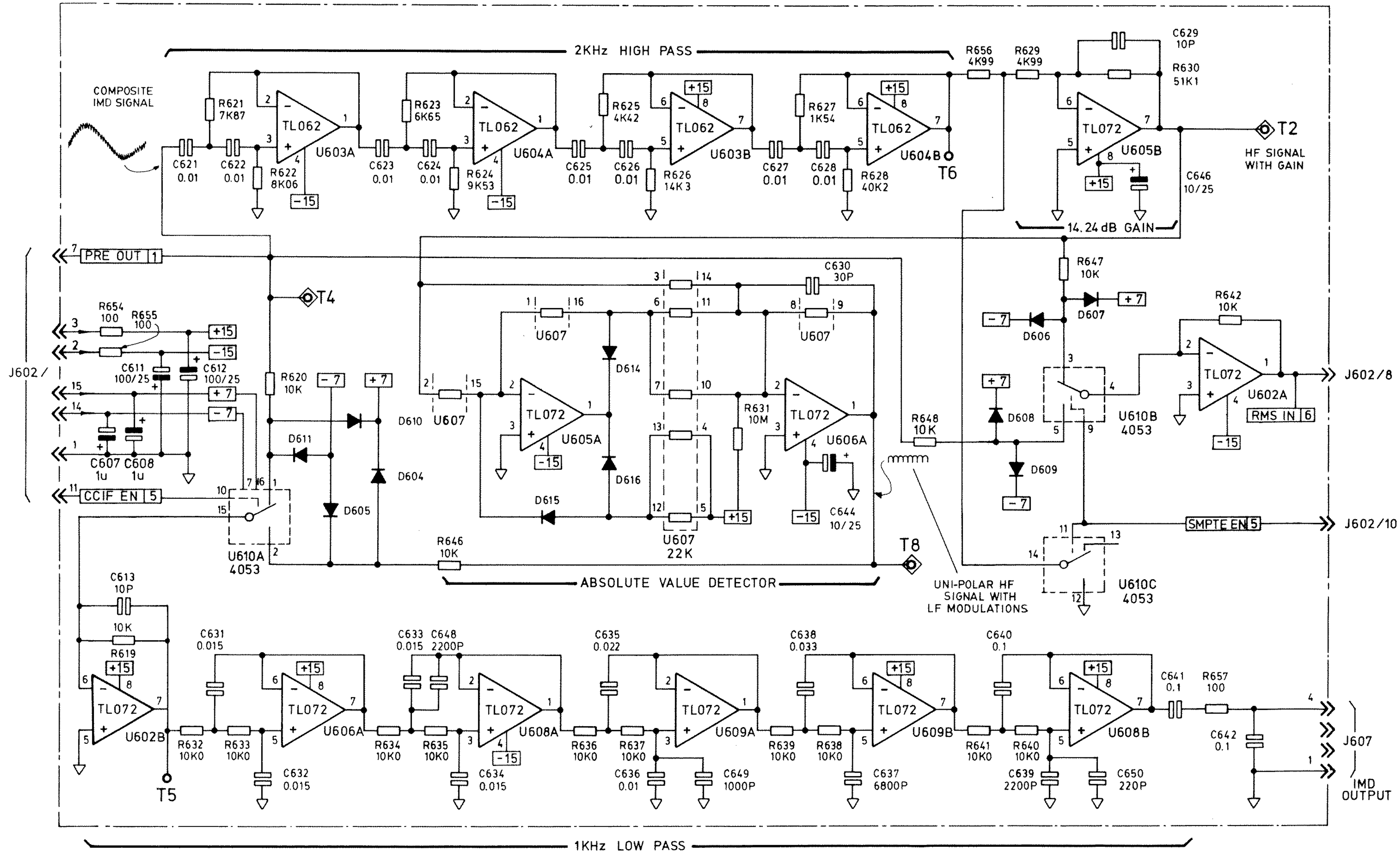


Q404, Q405 AND U404 ON HEATSINK

AMBER ELECTRO DESIGN INC.		
sheet 1 of 1	Issue 06	Drawing No. 3501-24006
MODEL 3501	ASS'Y 3501-74006	11
LINEAR REGULATOR AND BATTERY CHARGER		

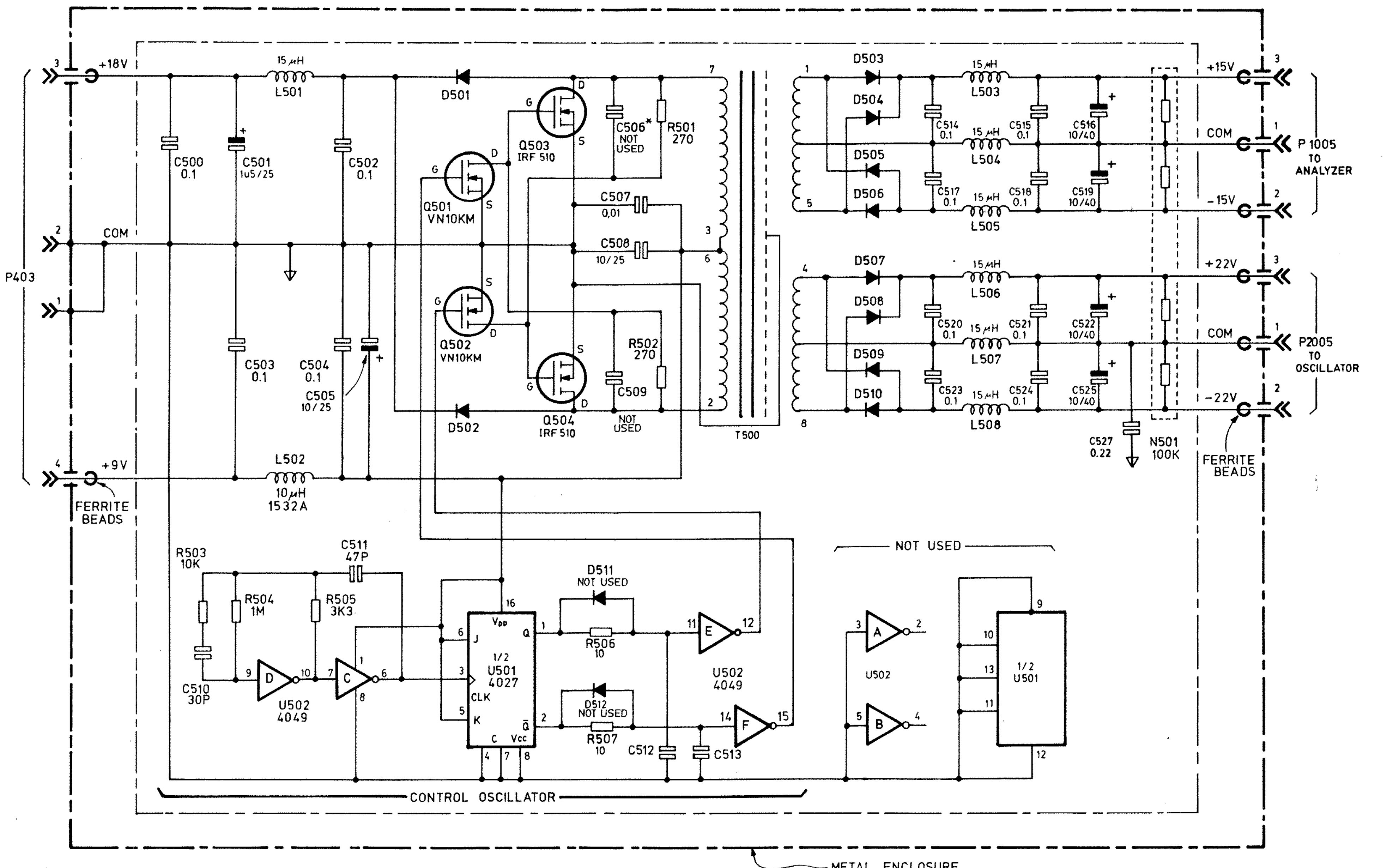


AMBER ELECTRO DESIGN INC.			
sheet 1 of 2	Issue 03	Drawing No. 3501-26003	12
MODEL 3501		ASS'Y 3501-76003.	
IMD LF OSCILLATOR			

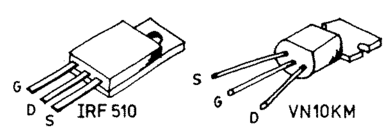


ALL DIODES ARE 1N4150

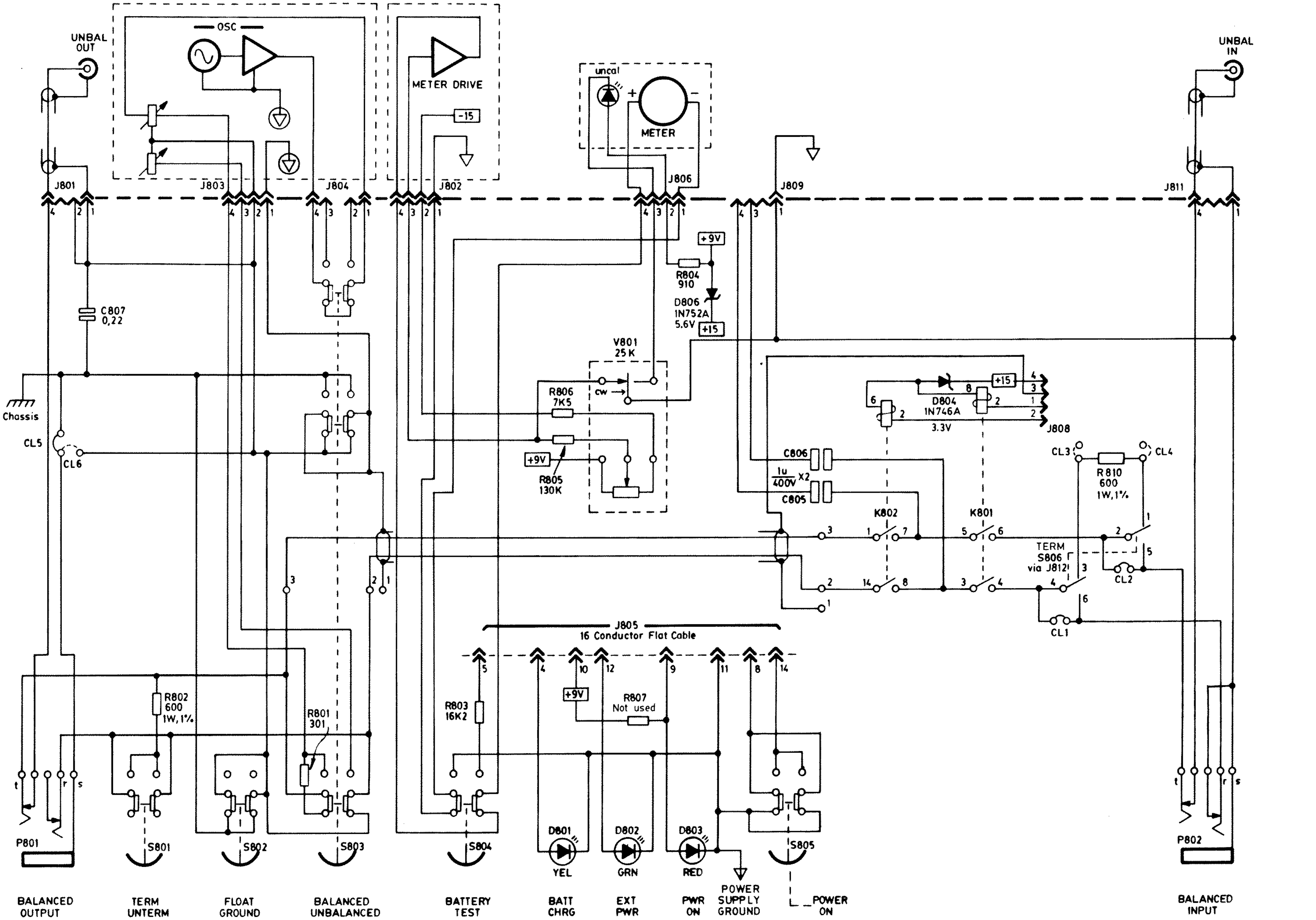
AMBER ELECTRO DESIGN INC.			
sheet 2 of 2	Issue 03	Drawing No. 3501-26003	13
MODEL 3501		ASS'Y 3501-76003	
IMD ANALYZER			



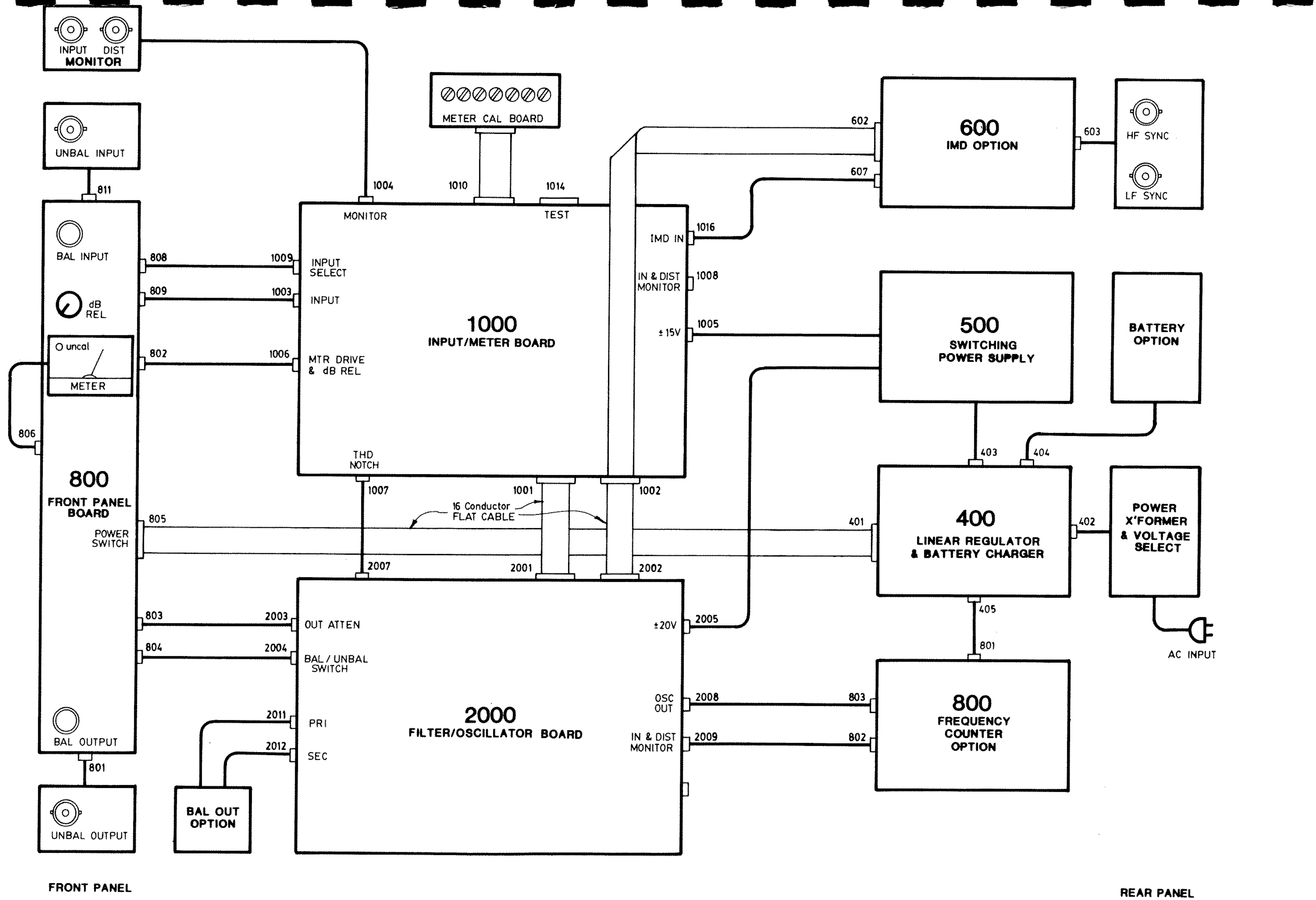
ALL DIODES ARE 1N4150



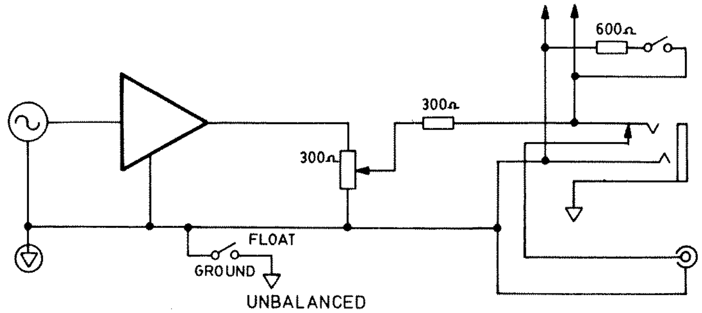
AMBER ELECTRO DESIGN INC			
sheet 1 of 1	Issue 05	Drawing No 3501-25005	14
MODEL 3501		ASS'Y 3501-75005	
SWITCHING POWER SUPPLY			



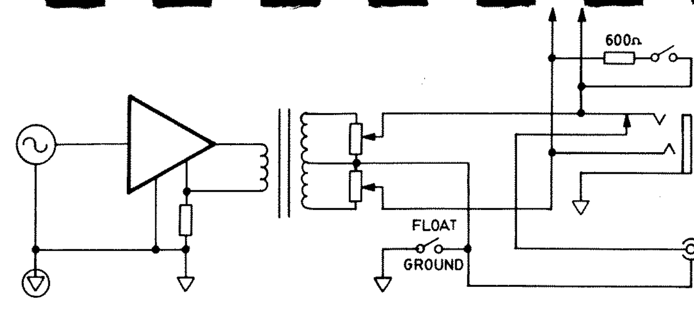
AMBER ELECTRO DESIGN INC.			
sheet 1 of 1	Issue 08	Drawing No 3501-28008	15
MODEL 3501		ASS'Y 3501-78008	
INPUT/OUTPUT BOARD			



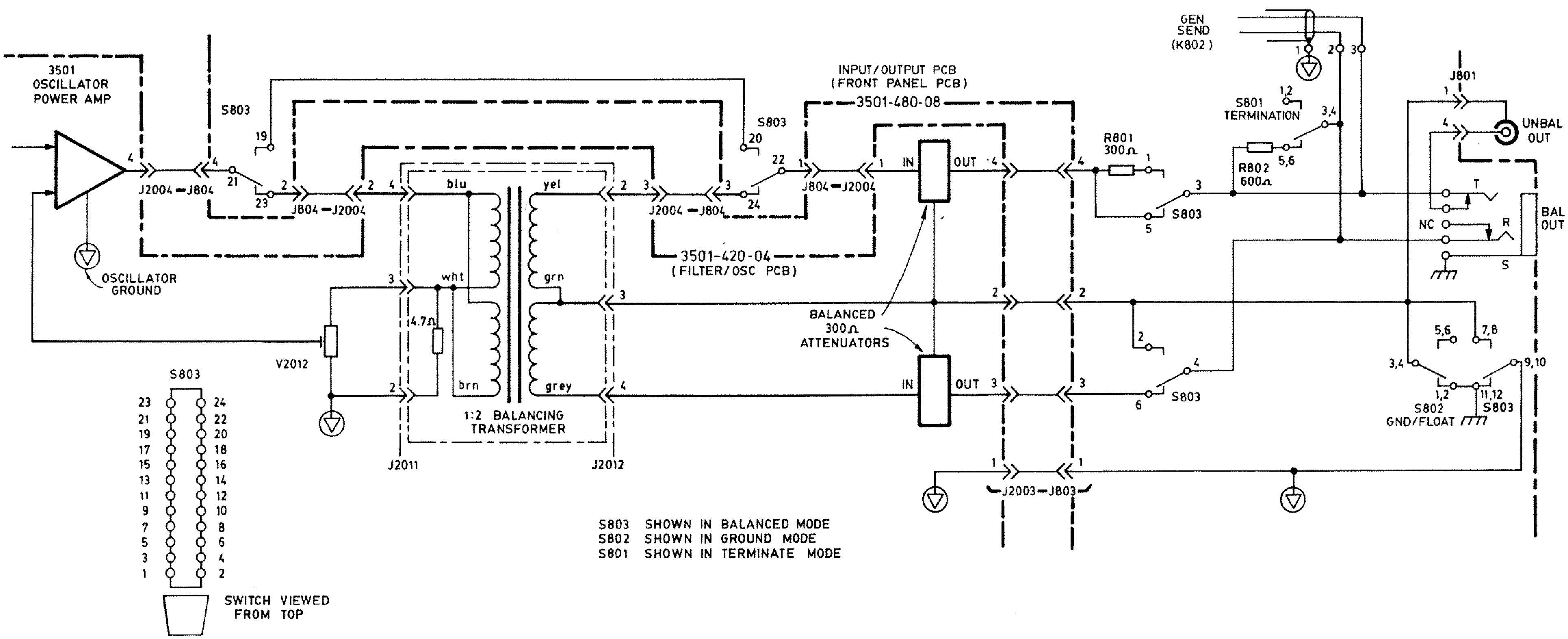
AMBER ELECTRO DESIGN INC.			
sheet 1 of 1	Issue 05	Drawing No. 3501- 10000	16
MODEL 3501			
SYSTEM INTERCONNECT			



UNBALANCED



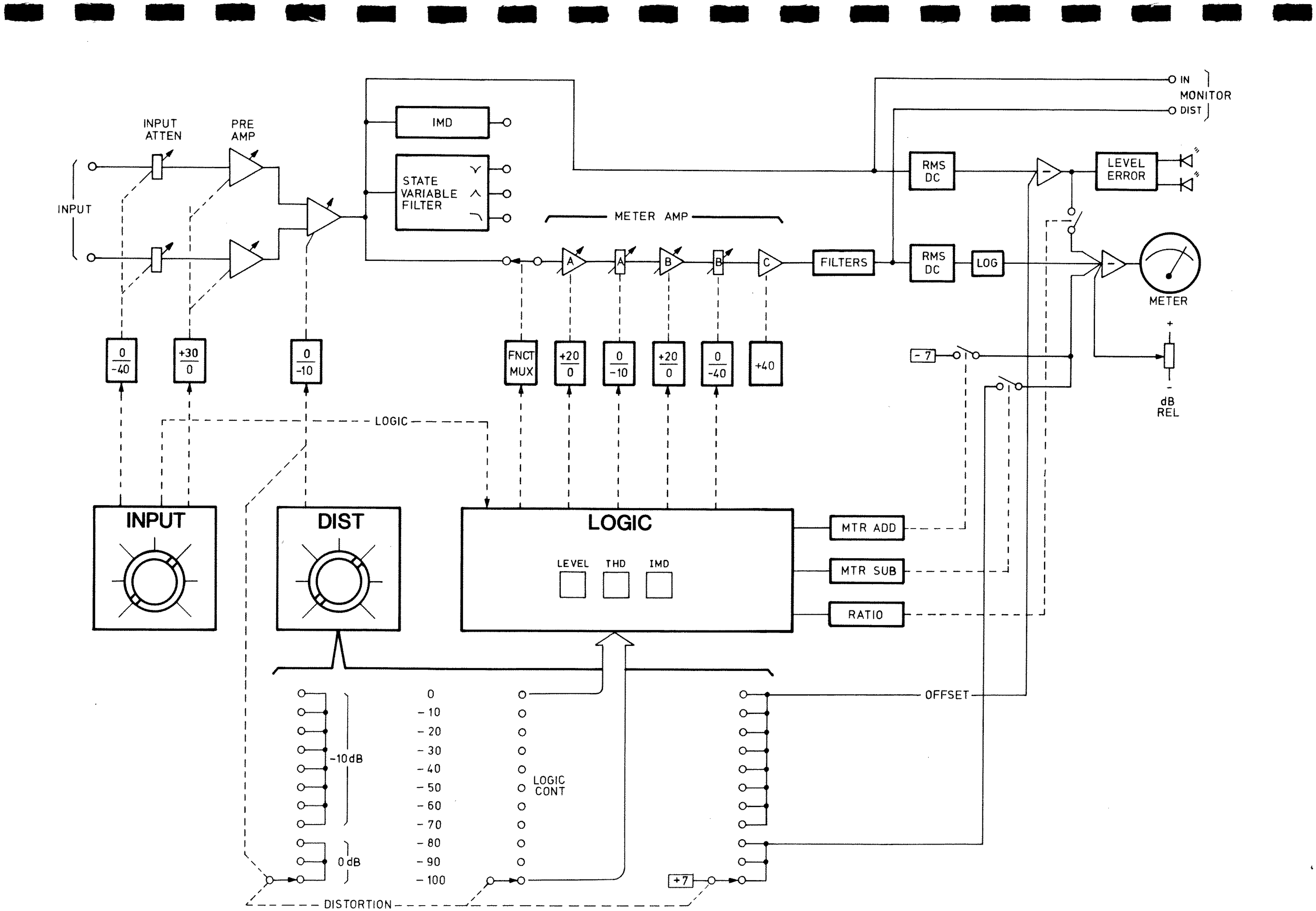
BALANCED



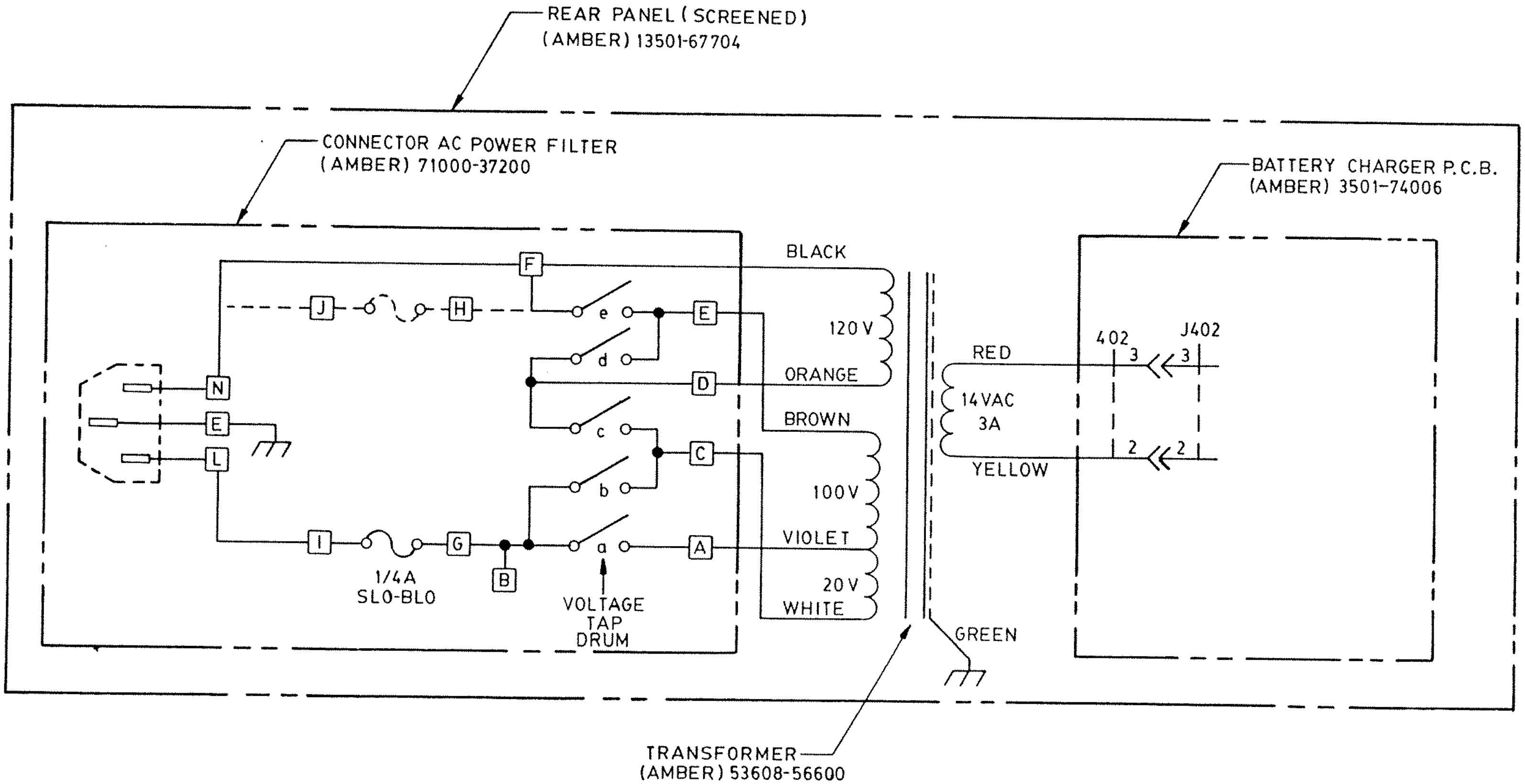
S803 SHOWN IN BALANCED MODE
S802 SHOWN IN GROUND MODE
S801 SHOWN IN TERMINATE MODE

PERTAINS TO UNIT WITH SERIAL NOS. 87441604 AND AND ABOVE

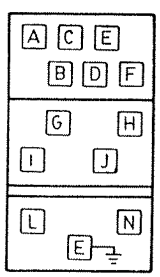
AMBER ELECTRO DESIGN INC.			
sheet 1 of 1	Issue 05	Drawing No 3501-10001	17
MODEL 3501 SIGNAL PATH OUTPUT CONFIGURATION			



AMBER ELECTRO DESIGN INC.			
sheet 1 of 1	Issue 01	Drawing No. 3501-10002	**18**
MODEL 3501 **SIGNAL PATH** SIMPLIFIED GAIN AND METER DRIVE CIRCUIT			



VOLTAGE	CONTACT
100 V	a,c,e
120 V	b,c,e
220 V	a,d
240 V	b,d

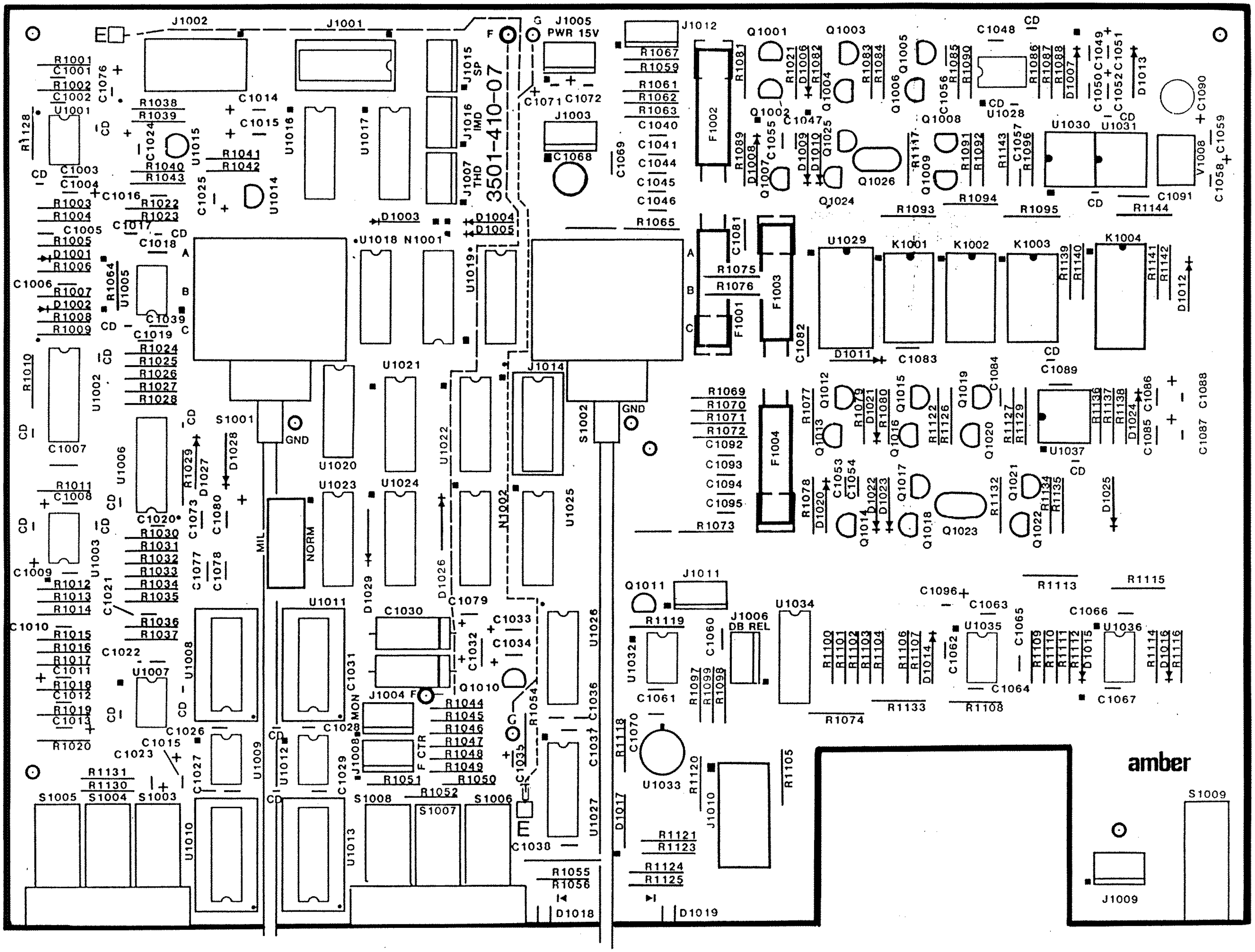


AMBER ELECTRO DESIGN INC.

sheet 1 of 1 | Issue 01 | Drawing No. 3501-24000

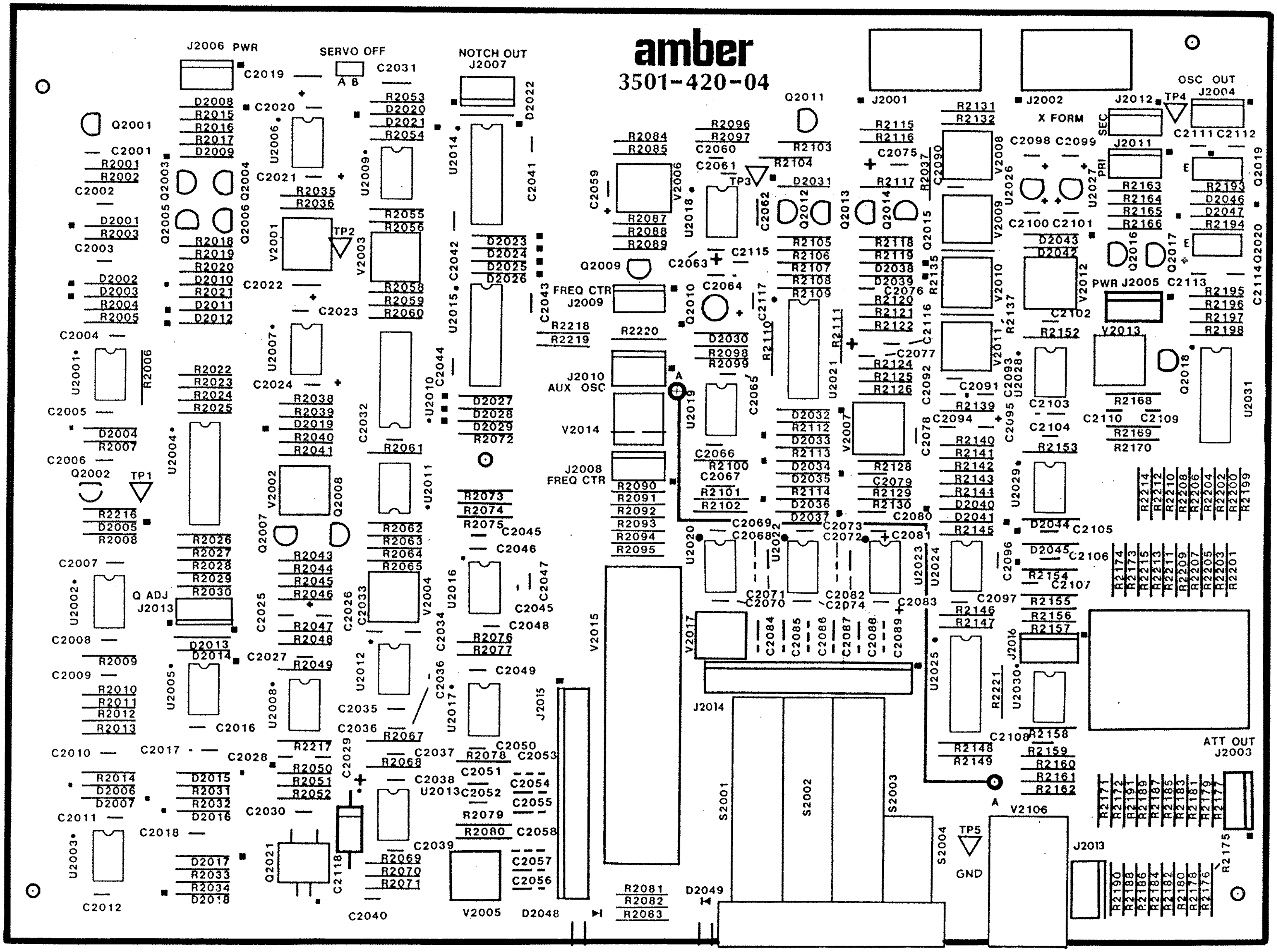
MODEL 3501

REAR PANEL SCHEMATIC



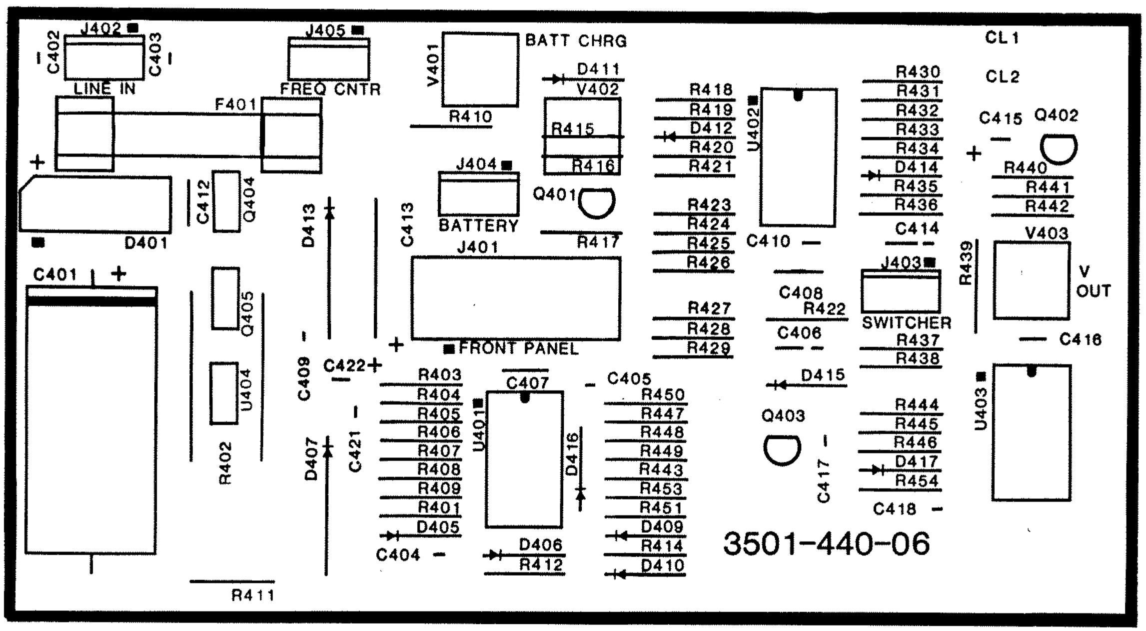
INPUT/METER BOARD

ASSEMBLY 13501-71007



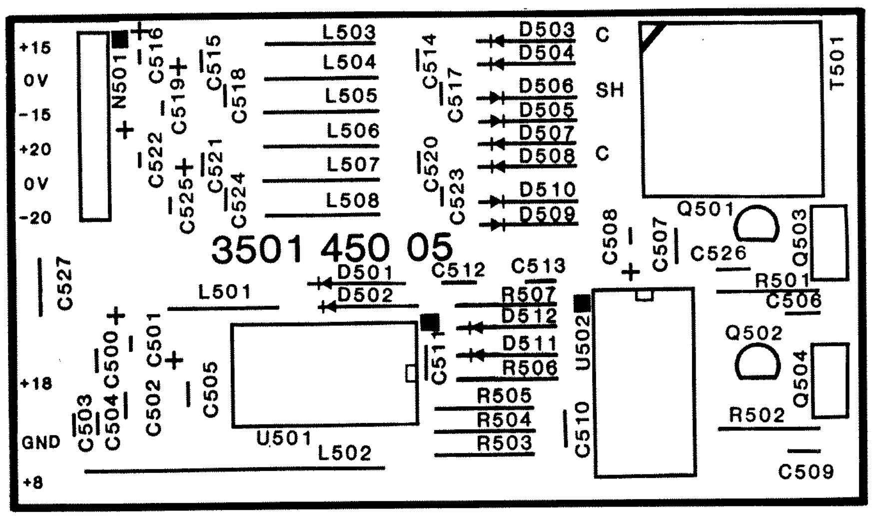
FILTER/OSCILLATOR BOARD

ASSEMBLY 13501-72004



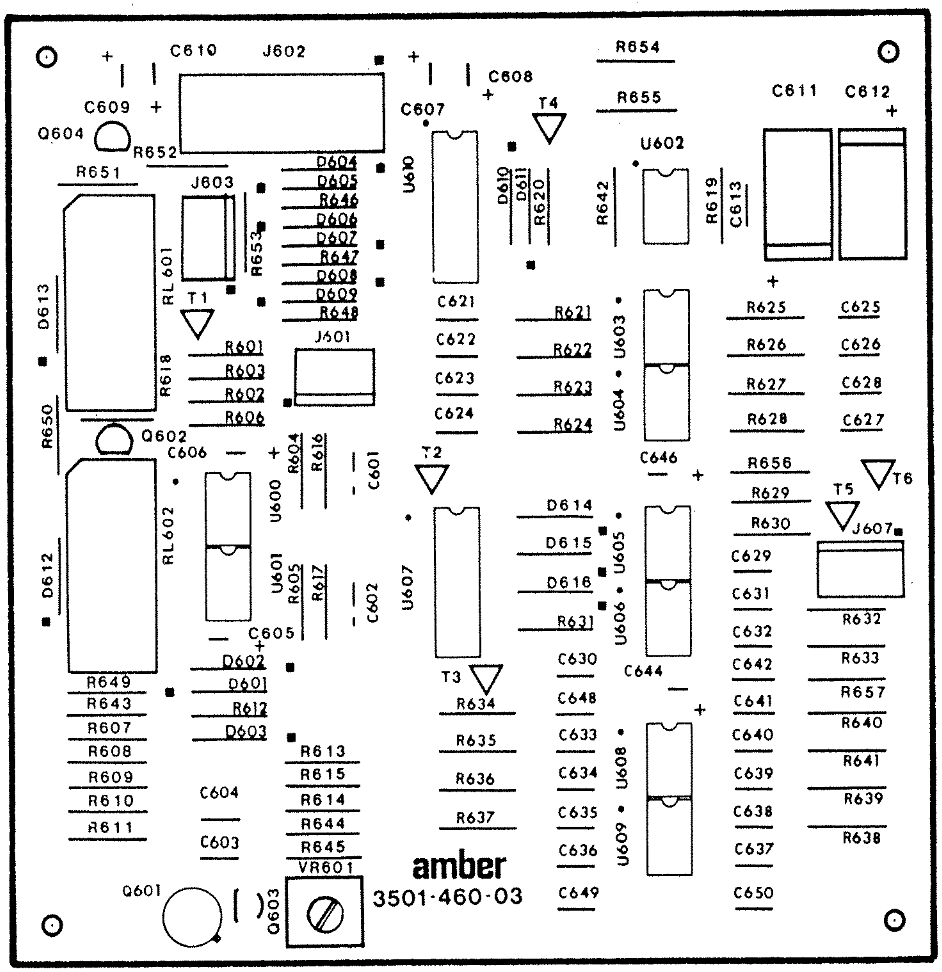
LINEAR REGULATOR & BATTERY CHARGER

ASSEMBLY 13501-74006



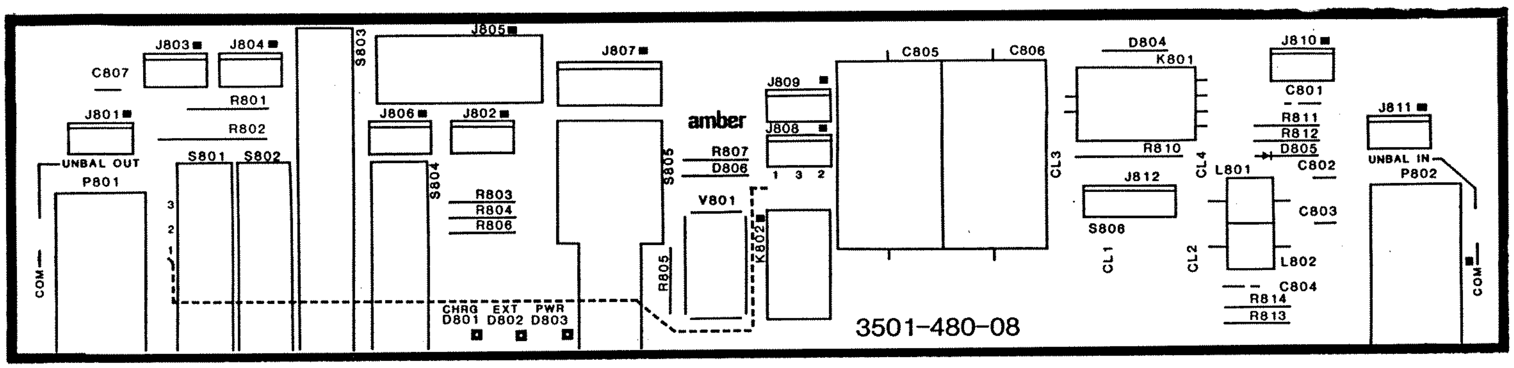
SWITCHING POWER SUPPLY

ASSEMBLY 13501-75005



IMD BOARD

ASSEMBLY 13501-76003

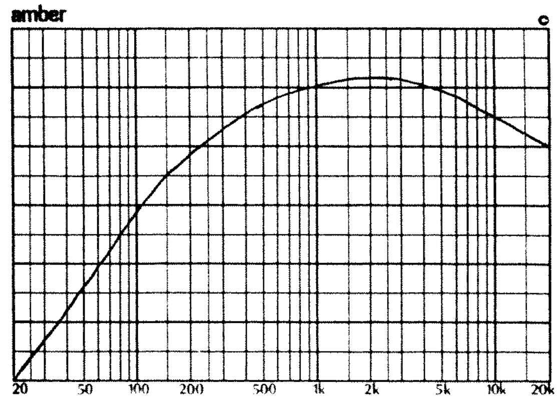


INPUT/OUTPUT BOARD

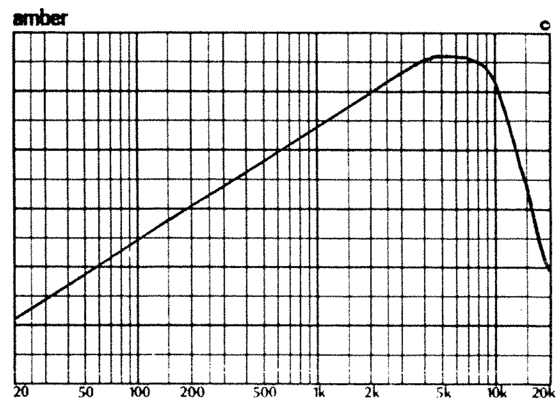
ASSEMBLY 13501-78008

amber Noise Weighting Filters

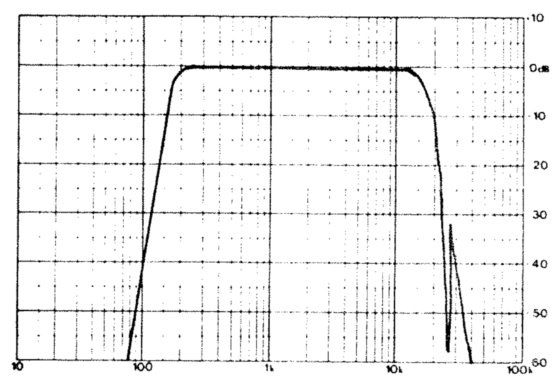
Amber model No : 1201
ANSI/IEC "A" Weighting
Applicable Standard :
ANSI S-1.4-1971, IEC 123, IEC 179
Application : Audio, tape recorder
and acoustics noise
measurement



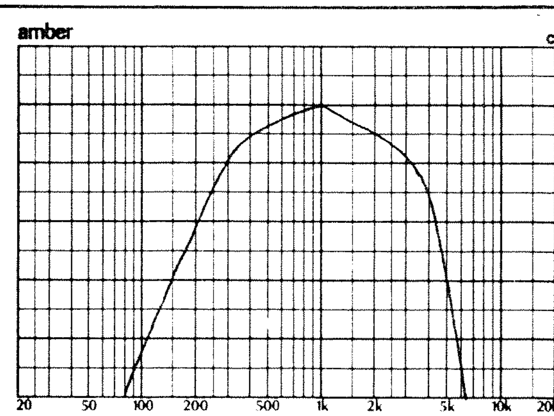
Amber model No : 1202
CCIR Weighting (Former "Radio II")
Applicable Standard : CCIR 468-2
(May be set to unity gain reference
at 1kHz or 2kHz)
Application : Audio and tape
recorder noise
measurement



Amber model No : 1203
Receiver/tuner Band Pass (200Hz to 15kHz
Band Pass plus 19kHz Notch)
Applicable Standard :
IEEE 185-1975
IHF T-200-1975
Application : Audio, consumer Hi-Fi,
tuner, noise measurement

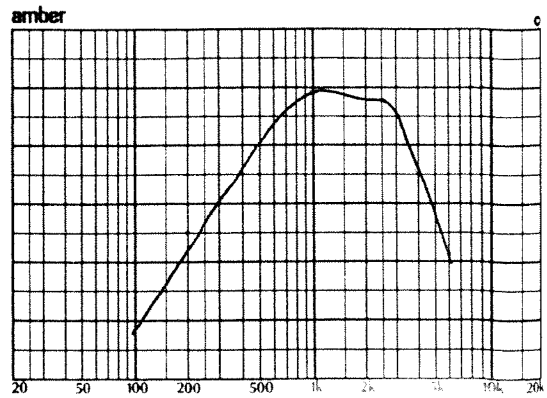


Amber model No : 1204
Psophometric Weighting (telephone)
Applicable Standard :
CCITT P-53A
DIN 45405
Application : Communications
equipment, telephone
channel noise
measurement

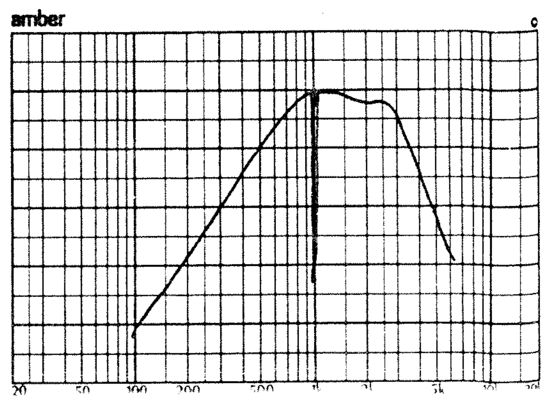


amber Noise Weighting Filters

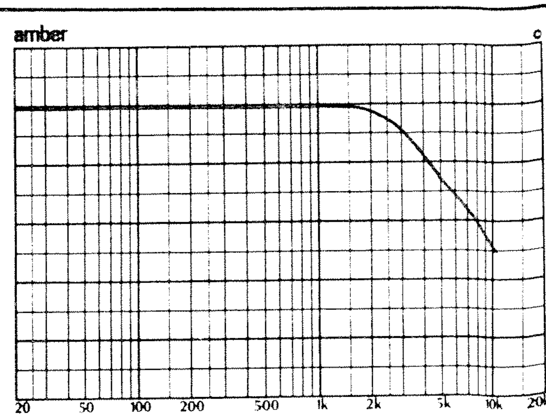
Amber model No : 1205
Telecommunications "C" Message Filter
Applicable Standard :
Bell System Technical Reference
41009 for telephone message circuit
noise measurement
Applications : Telephone circuit
noise measurement



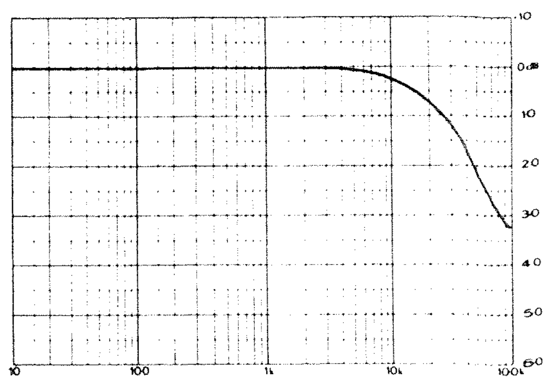
Amber model No : 1206
Telecommunications "C" Message
with 1010Hz notch
Applicable Standard :
Bell System Technical Reference
41009 for telephone message
circuit noise measurement
Applications : Telephone circuit noise
measurement with holding
tone present



Amber model No : 1207
3kHz Flat Weighting
Applicable Standard :
Bell System Technical Reference
41009 for telephone message
circuit noise measurement
Applications : Telephone and
communication
circuits noise
measurements

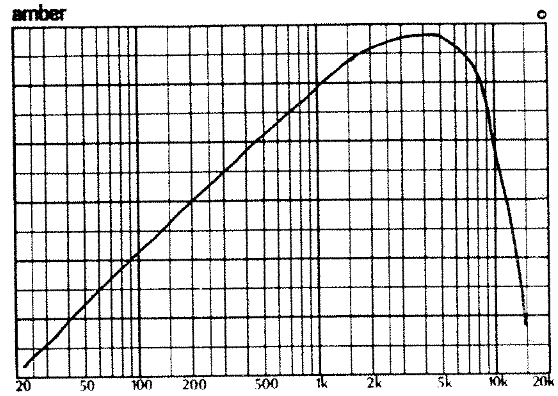


Amber model No : 1208
15kHz Flat Weighting
Applicable Standard :
Bell System Technical Reference
41009 for telephone message
circuit noise measurement
Applications : Noise in telephone
program channels
(broadcast lines)

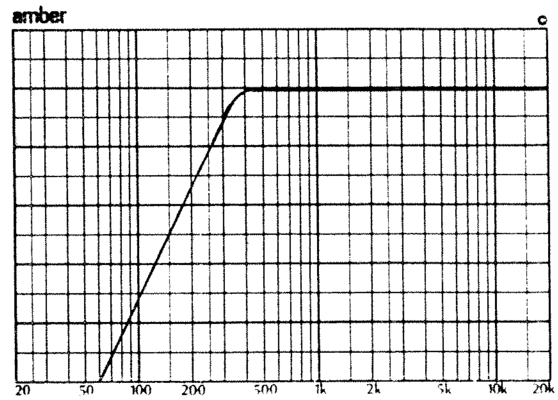


amber Noise Weighting Filters

Amber model No : 1209
Program Weighting (Former "Radio I")
Applicable Standard : DIN 45405
CCITT Rec P53B
Bell System
Pub 41009
Applications : transmission line noise measurement

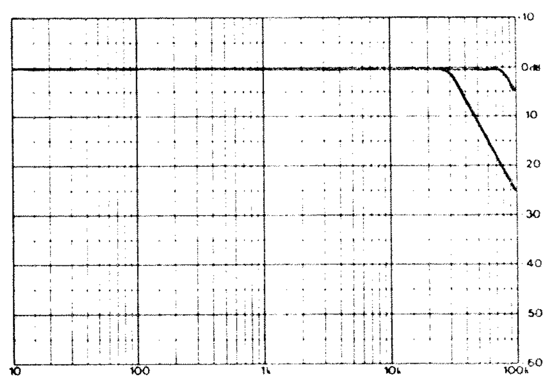


Amber model No : 1214
400Hz High Pass.. 3 Pole, 18dB/octave
Applications : Audio measurements, mains hum rejection



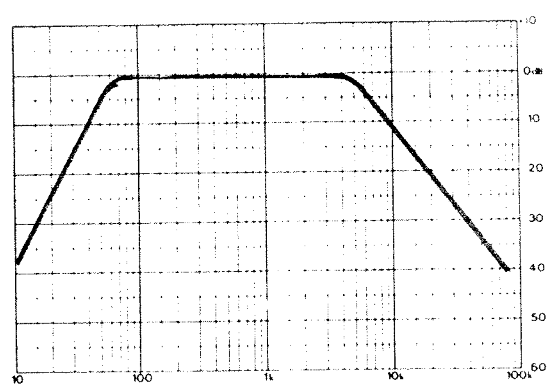
Amber model No : 1223
30kHz Low Pass. 3 Pole, 18dB/octave

Amber model No : 1228
80kHz Low Pass. 3 Pole, 18dB/octave
Applications : Audio measurements, band limited noise measurements



Amber model No : 1219 (specify parameters)
1 to 3 pole Custom High Pass Filter
Application : rejection of low frequency noise

Amber model No : 1229 (specify parameters)
1 to 3 pole Custom Low Pass Filter
Applications : Band limited noise measurements



ORDERING INFORMATION

MODEL	TYPE	DESCRIPTION
1201	A	ANSI/IEC "A" Network
1202	B	CCIR Filter (specify 1kHz or 2kHz ref)
1203	C	IHF band pass (200Hz to 15kHz/19kHz Notch)
1204	C	Psophometric (CCITT P53A)
1205	C	C Message
1206	C	C Message & Notch
1207	A	3kHz Flat
1208	A	15kHz Flat
1209	B	Program (DIN 45405)
1214	A	400Hz HP (3 pole/18dB per octave)
1219	A	1 to 3 pole custom HP (specify frequency)
1223	A	30kHz LP (3 pole/18dB per octave)
1228	A	80kHz LP (3 pole/18dB per octave)
1229	A	1 to 3 pole custom LP (specify frequency)
1231	C	20Hz to 20kHz 12dB/octave Audio
1232	C	Inverse RIAA Filter

All 1200 series weighting filters may be used in any Amber product that provides a standard 16 contact receptacle such as :

model 4400A Audio Test Set
model 3500 Distortion Measurement Set
model 3501 Distortion & Noise Measuring System
(Type C filters may present a space problem in the 3500.)

The above filters come in one of three possible physical formats:

Type A : Plug-in module. A small 16-pin module about one half cubic inch which plugs directly into the appropriate 16-pin dual-in-line socket on the host equipment. Contains only passive components.

Type B : A small circuit board with attached harness terminating in a 16-pin plug. Board mounts in any convenient location and harness plugs into the host 16-pin dual-in-line socket. Contains active and passive components and a reference level setting adjustment.

Type C : Universal filter circuit board. A 5 inch by 5 inch board with provision for several types of multipole filters. Mounts with four stand-offs. Interconnect harness plugs into host 16-pin dual-in-line socket. Contains several active and passive components as well as calibration controls.