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INSTRUCTION MANUAL
MODEL 560H
AMPLIFIER

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Ectron Corporation
8159 Engineer Road
San Diego, CA 92111-1907

858-278-0600
800-732-8159
Fax: 858-278-0372

E-mail: sales@ectron.com
Web site: www.ectron.com

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Ectron Corporation
8159 Engineer Road
San Diego, CA 92111-1907

Sales Department
800-732-8159, ext. 675
sales@ectron.com

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SECTION I
DESCRIPTION

GENERAL

The Model 560H amplifier is a wideband, true differential dc instrumentation amplifier. It offers a high level of performance at a moderate cost for a wide variety of applications. The compact design features outstanding linearity, gain stability, and input impedance. Excellent overall accuracy is assured due to direct coupling and very high loop gains. The internal circuitry uses discrete components and integrated circuits to provide "state of the art" performance while keeping the cost and complexity to a minimum. The low power consumption reduces warm-up time and component aging due to internally-generated temperature rise. All components are mounted on a single circuit card. Certain options are included on smaller circuit cards, which are plugged into the amplifier circuit card. The output of the basic amplifier is ±10 V at 10 mA. Filtered outputs and high-current capability are available options.

MODEL 560H FEATURES

- A switch-selectable 100:1 input divider.
- A switchable RTO-zero range control with ranges of 0.1 V, 1 V, and 10 V.
- Front-panel output-monitor jacks.
- Optional filtered output of 10 Hz, 100 Hz, 1 kHz, 10 kHz, and wideband front-panel switch-selectable positions.
- Optional 100 mA peak (50 mA rms or dc) output on either wideband or filtered output.

AVAILABLE AMPLIFIER OPTIONS

Option J

Wideband output of ±10 V at 10 mA.

Option K

Wideband output of ±10 V at 100 mA rms or dc output. (See Footnote 1 on Page 2-2.)

Option L

Wideband output of ±10 V at 10 mA and a selectable filtered output of ±10 V at 10 mA.

Option M

Wideband output of ±10 V at 100 mA rms or dc and a selectable filtered output of ±10 V at 10 mA. (See Footnote 1 on Page 2-2.)

Option N

Wideband output of ±10 V at 10 mA and a selectable, filtered output of ±10 V at 100 mA rms or dc. (See Footnote 1 on Page 2-2.)

SUMMARY OF CONTROLS, TERMINALS, AND INDICATORS

FRONT PANEL

- Output monitor jacks (blue and black).
- Output polarity-indicating LED's.
- Rotary gain switch.
- Vernier gain-control potentiometer.
- Vernier gain in-out toggle switch.
- Rotary output filter switch (Options L, M, and N only).
- RTI-zero potentiometer.

INTERNAL

- Three-position RTO-zero range slide switch.
- 100:1 input-divider slide switch.
- Sensitivity-control potentiometer for the amplifier output-polarity indicator LED's (zero detector).

ENCLOSURES

Enclosures are supplied with a three-wire power cord and mating connectors for the amplifier inputs and outputs unless stated otherwise.

E513-2A

This enclosure with integral power supplies will accept up to two Model 560H units and is intended for bench or portable use. All connections except input power are made to barrier strips on the rear of the enclosure. A rear-panel switch is used to inhibit the operation of the zero-detector LED's in all amplifiers. The

enclosure is 89 mm (3.5″) high, 216 mm (8.5″) wide, and 229 mm (9″) deep.

E513-6A

This enclosure with integral power supplies is also intended for bench or portable use. It will accept up to six Model 560H units. A front-panel switch is used to inhibit the operation of the zero-detector LED's in all amplifiers. The supplied input mating connectors are PT06A-10-6P(SR) (Ectron P/N 1-310506-0), and the amplifier wideband- and filter-output (Options L, M, and N) connectors are isolated BNC (mates not normally supplied). The enclosure is 152 mm (6″) high, 229 mm (9″) wide, and 305 mm (12″) deep.

R513-16

This standard 483 mm (19″) rack-mount enclosure with integral power supplies will accept up to sixteen Model 560H units.

The enclosure includes a front-panel switch to inhibit the operation of the ZERO DETECTOR LED's in all amplifiers.

Three null indicators are used for remote operation to provide isolation and interface flexibility. The couplers are bypassed for local operation using the front-panel mode switch.

Two isolated power supplies are used in each enclosure. One provides the ±16 V necessary for amplifier operation, and the other provides +15.9 V for the excitation supplies and +25 V for remote operation (not used with the Model 560H).

The supplied input mating connectors are PT06A-10P-6P(SR) (Ectron P/N 1-310506-0), the outputs are BNC (mates not normally supplied), and the remote control connector is PT06A-128P(SR) (Ectron P/N 1-310408-0). The enclosure is 133 mm (5.25″) high, 483 mm (19″) wide, and 457 mm (18″) deep.

AVAILABLE ACCESSORIES

	ECTRON PART NUMBER
Extender Board:	560-501-01
Enclosure Filler Panels	
One-channel:	516-503-40
Four-channel:	516-503-55

Table 1-1: Summary of Enclosures

	E513-2A	E513-6A	R513-16
Channels	2	6	16
Height	89 mm (3.5″)	152 mm (6″)	133 mm (5.25″)
Width	216 mm (8.5″)	229 mm (9″)	483 mm (19″)
Depth	229 mm (9.0″)	305 mm (12″)	457 mm (18″)
Line Voltage	120/240 V ac	120/240 V ac	120/240 V ac
Ampl P/S	±16 V dc	±16 V dc	±16 V dc
Excit P/S	+15.9 V dc	+15.9 V dc	+15.9 V dc
Input Mates	Barrier Strip	PT06A-10-6P(SR) (1-310506-0)	PT06A-10-6P(SR) (1-310506-0)
Output Mates	Barrier Strip	BNC (Not supplied)	BNC (Not supplied)
Remote Mate			PT06A-12-8P(SR) (1-310408-0)
Dc-power Mate			PT06A-12-3S(SR) (1-310103-1)

Table 1-2: Enclosure Connector Pin Designations

	E513-2A	E513-6A	R513-16
Noninverting Input	2	B	B
Inverting Input	3	C	C
Shield	5	E	E
Bridge Completion	6	F	F
+ Excitation	1	A	A
– Excitation	4	D	D
Filtered Output High	8	*	*
Filtered Output Low	7	*	*
Wideband Output High	10	*	*
Wideband Output Low	9	*	*

* Models E513-6A and R513-16 enclosures use BNC output connectors.



SECTION II

SPECIFICATIONS

Unless otherwise noted, all specifications apply at 25°C after thirty minutes warm-up with 0 Ω to 1 kΩ source resistance in any unbalance. RTI is referred-to-input. RTO is referred-to-output. The specifications are the maximum from nominal allowed unless stated otherwise.

INPUT CHARACTERISTICS

CONFIGURATION

Differential, direct coupled. May be used inverting, noninverting, or single-ended. An input ground return is not required except for noise pickup problems.

IMPEDANCE

50 MΩ nominal (1 MΩ with 100:1 divider switched in) in parallel with ≤300 pF.

SOURCE CURRENT, STABILITY

±2 nA for 200 hours.

SOURCE CURRENT, TEMPERATURE

±0.5 nA/°C.

MAXIMUM OVERLOAD

±20 V dc or peak ac common or normal mode (±300 V dc or peak ac when 100:1 input divider is in).

GUARD IMPEDANCE

10 MΩ to output common nominal.

COMMON-MODE VOLTAGE

±10 V dc or peak ac operating (±300 V dc or peak ac when 100:1 input divider is in).

ZERO

STABILITY

±4 µV RTI and ±0.35 mV RTO for 200 hours.

TEMPERATURE COEFFICIENT

±1 µV/°C RTI and ±0.35 mV/°C RTO.

RTO RANGE

Three switch-selectable ranges of ±0.1 V, ±1 V, and ±10 V.

RTI RANGE

±350 µV nominal.

COMMON-MODE REJECTION

DC TO 60 HZ WITH 350 Ω UNBALANCE

>50 dB + gain in dB.

DYNAMIC RESPONSE

BANDWIDTH (WITHIN 3 dB)

Small Signal (1 V rms): dc to 200 kHz.

Full signal (20 V p-p): gain of 1, dc to 20 kHz; gain of 2, dc to 50 kHz; gains of 5 to 1000, dc to 100 kHz.

SLEW RATE

Gain of 1, 1.2 V/µs; gain of 2, 2.4 V/µs; gains of 5 to 1000, 6.3 V/µs.

SETTLING TIME

10 µs to within ±0.1% of final value.

OVERLOAD RECOVERY

50 µs to within ±0.1% of final value from a 500% overload.

FILTERED OUTPUT

−3 dB ±1 dB at settings of 10 Hz, 100 Hz, 1 kHz, 10 kHz, and wideband position.

NOISE

RMS

From 0.1 Hz to 200 kHz: 4 µV RTI + 0.5 mV RTO.

From 0.1 Hz to 1 MHz RMS: 4 µV RTI + 1.0 mV RTO.

PEAK

From 0.1 Hz to 10 Hz: 0.75 μV RTI + 50 μV RTO.

GAIN (VERNIER OUT)

STEPS

1, 2, 5, 10, 20, 50, 100, 200, 500, and 1000. (0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, and 10 with 100:1 input divider switched in.)

VERNIER

1 to >2.5 times the step gain.

ACCURACY

Better than ±0.1%.

STABILITY

Time

±0.01%, 90 days.

Temperature

±0.005%/°C.

INPUT DIVIDER

100:1. (Adds ≤0.1% error to overall gain accuracy.)

LINEARITY

Within ±0.005% of the best straight line through zero.

OUTPUT

VOLTAGE

±10 V dc or peak ac.

SHORT-CIRCUIT PROTECTION

No damage with sustained short circuit on either or both outputs.

IMPEDANCE

0.1 Ω.

CAPACITIVE LOADING (NO INSTABILITY)

Wideband output, up to 0.01 μF; filtered output, up to 0.1 μF.

CURRENT, DC OR AC RMS

	Current	
Option	**Wideband**	**Filtered**
J	10 mA	None
K	100 mA[1]	None
L	10 mA	10 mA
M	100 mA[1]	10 mA
N	10 mA	100 mA[1]

POWER, DIMENSIONS, AND ENVIRONMENT

AMPLIFIER

±16 V to ±18 V, 18 mA + output load.

OPTIONS

K	Adds 16 mA + load.
L	Adds 5 mA + load.
M	Adds 21 mA + load.
N	Adds 21 mA + load.

OPERATING ENVIRONMENT

0°C to +50°C, 90% RH.

STORAGE TEMPERATURE

–25°C to +71°C.

DIMENSIONS

133 mm (5.25″) high, 23 mm (0.9″) wide, and 203 mm (8″) long.

[1] 100 mA rms or dc except when limited by the enclosure power supply. With all amplifiers equally loaded in an R513-16 enclosure, each amplifier can supply 80 mA; in an E513-6A, 100 mA; and in the E513-2A, 70 mA.

SECTION III

UNPACKING AND INSPECTION

GENERAL

This instrument was thoroughly tested and inspected prior to shipment, and unless damaged in transit, it should be ready for use when received.

The shipping carton should be examined for signs of damage before unpacking. If external damage is present, notify the carrier before proceeding.

Remove the contents of the carton and carefully examine all units for any evidence of damage due to excessive shock, vibration, water, etc. If there is evidence of physical damage, notify the carrier.

Account for all items on the packing list, including mating connectors and instruction manuals. If the inventory of equipment does not correspond with the packing slip, notify Ectron Corporation.

If all is satisfactory, proceed with Section IV, INITIAL CHECKOUT.



SECTION IV
INITIAL CHECKOUT

GENERAL

The simple tests described in this section are generally sufficient to check the instrument on receipt. The purpose of these tests is only to establish that the instrument is in operating condition. This procedure is not a substitute for the specification tests in Section VII, which the user may want to perform before placing the unit in service.

Table 4-1: Card-edge Connector J1 Pin Assignments

1	Filtered output high
2	Zero-detect control
3	−16 V Unregulated
4	Wideband output high
5	+16 V Unregulated
KEY	
6	Output and power low
7	Output and power low
8	−16 V Regulated
9	Not used
10	+16 V Regulated
11	Not used
12	Not used
SLOT	To reduce capacitance between Pins 12 and 13.
13	Inverting input
14	Noninverting input
15	Shield
16	Not used
17	Not used
18	Not used

WARNING

When using an enclosure, make sure that its chassis is connected to earth ground, preferably through third-wire ground.

An Ectron Model 560H amplifier can be tested in a 513 Series or 516 Series enclosure or on the bench. If an Ectron 516 Series enclosure is used, please refer to Note 2 on Drawing 560-602 and Figure 5-1 concerning the removal of Jumpers EE and FF.

CAUTION

Failure to remove Jumpers EE and FF will result in damage to the internal power supplies of the 516 series enclosure.

Table 4-1 shows the card-edge connector J1 pin assignments for the Model 560H if it is to be bench-tested. The mating connector is a Cinch 50-18-A-20 (Ectron P/N 1-314018-0) with a polarizing key Cinch 50-PK-2 (Ectron P/N 1-319201-0) installed between Pins 5 and 6.

CAUTION

Ensure that connections to the amplifier are correct before applying power or signal voltages. Refer to Table 4-1 for correct pin assignments. Note that all pins are connected to their complements by plated-through holes.

INPUT CONNECTIONS

The input is applied to J1, Pins 13 (−) and 14 (+). In most installations the input leads are guarded electrostatically by an isolated and insulated shield which is connected to guard J1, Pin 15.

CAUTION

Be sure that the signal source connected to the amplifier input does not exceed 20 V dc or peak ac with respect to output and power low, or serious damage may occur.

OUTPUT CONNECTIONS

The wideband output is available on J1, Pins 4 (high) and 7 (common), and the filtered output on J1, Pin 1 (high) and J1, Pin 6 (common). For these tests either or both common pins should be connected to the low side of all test equipment and connected to power line ground. Tests on both outputs can then be conducted by switching the oscilloscope between J1, Pin 4 and Pin 1.

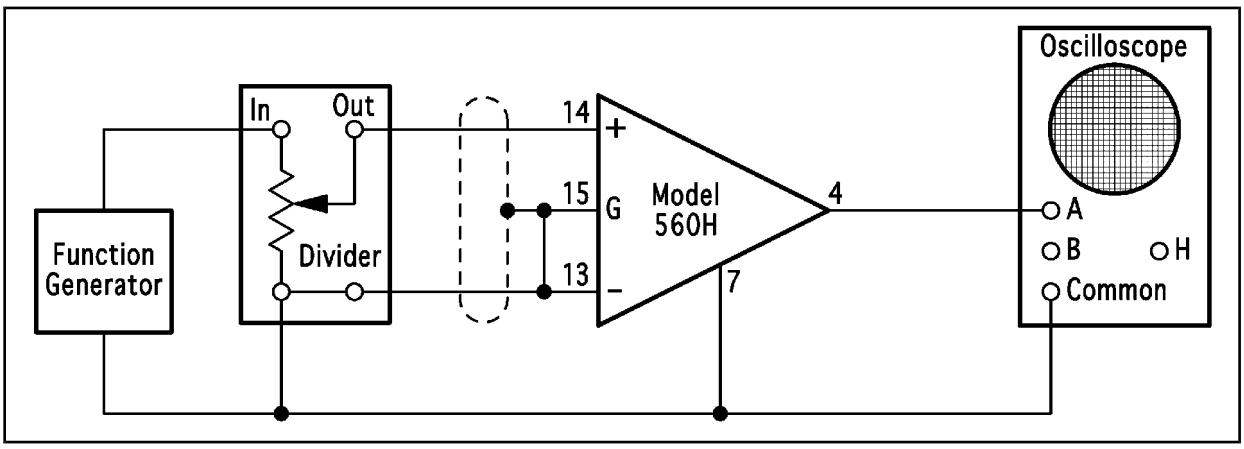


Figure 4-1: Initial Amplifier Test Setup

TEST EQUIPMENT REQUIRED

FUNCTION GENERATOR

Wavetek Model 180 or equivalent.

PRECISION VOLTAGE DIVIDER

ESI RV622A or equivalent. The divider must have an input resistance of 10 kΩ or more.

DIFFERENTIAL OSCILLOSCOPE

Tektronix 5110 main frame, with 5B10N time base and 5A21 differential amplifier or equivalent. Be sure the oscilloscope has been adjusted for common-mode rejection according to the manufacturer's instructions as differential measurements are used in the procedure that follows.

RESISTORS (CARBON FILM OR COMPOSITION, ¼ W)

One 10 kΩ, and one 100 Ω.

PROCEDURE

GAIN (REFER TO FIGURE 4-1)

Although the Model 560H is designed as a differential amplifier, it may also be operated in a single-ended mode. Gain and frequency response tests are made in the single-ended, noninverting mode.

1. Connect the commons of the oscillator, voltage divider, oscilloscope, and the amplifier under test Pins 7 and 13 to a single point. All measurements will be made in reference to this point.
2. Connect the single point to power line ground.
3. Connect the oscillator output to the input of the voltage divider.
4. Connect the output of the divider to the noninverting input J1, Pin 14. The other input J1, Pin 13 is connected to the single-point common.
5. Connect the amplifier wideband output J1, Pin 4 to the oscilloscope input. The oscilloscope must be direct coupled and adjusted to zero. The wideband output can be observed between the blue and black front-panel jacks on the Model 560H.
6. Adjust the output of the oscillator to minimum.
7. Apply power to the amplifier. The trace on the oscilloscope should show that the output of the amplifier is within a few millivolts of zero.
8. Position the vernier switch to out.
9. Position the gain switch to 1000.
10. Adjust the output of the oscillator to 10 V p-p at 100 Hz.
11. Adjust the voltage divider to the reciprocal (0.001) of the gain setting. The oscilloscope should show approximately 10 V p-p.
12. Switch in the 100:1 input divider S5.
13. Adjust the voltage divider to the reciprocal (0.1, or 0.001 times 100) of the new gain setting (10, or 1000 divided by 100). The oscilloscope should again display approximately 10 V p-p.

14. Switch out the 100:1 input divider.

FREQUENCY RESPONSE (REFER TO FIGURE 7-2)

1. Fashion a voltage divider with a ratio of approximately 100:1 using the 10 kΩ and 100 Ω carbon resistors. Do not use a commercial decade voltage divider as most have limited frequency response.
2. Change the gain of the amplifier under test to 100.
3. Adjust the function generator to a 1 V p-p sine wave at 100 Hz.
4. Measure and record the output of the amplifier (1 V p-p).
5. Change the function generator's frequency to 200 kHz. Readjust the amplitude of the generator to 1 V p-p if necessary.
6. Measure the output of the amplifier. It should be 1 V p-p ±30%.

FILTERED OUTPUT (OPTIONS L, M, AND N)

The frequency response on each bandwidth setting can be checked at the filtered output J1, Pin 1. The response should be −3 dB ±1 dB at the appropriate cut-off frequency decreasing by 12 dB/octave at higher frequencies. (The rolloff in the wideband position will be 3 dB/octave.)



SECTION V
APPLICATIONS

SAFETY

When using the Model 560H in an ac-powered enclosure, ensure that the chassis is connected to "earth" ground. This is normally accomplished using the ac-line cord that accompanies the enclosure.

MODEL 560H OPERATING CONTROLS

A number of controls are available on the front panel of all Model 560H amplifiers. In addition, two operating controls, RTO offset and the 100:1 divider, are located on the circuit card. The switchable filter control is available only on those amplifiers having Option L, M, or N.

GAIN CONTROLS

The step-gain control provides an accuracy of ±0.1% of the indicated step-gain position when the VERNier IN/OUT switch is OUT. The VERNier control increases the fixed gain step by more than 2.5 times, so the overall gain range without divider is from 1 to more than 2500.

The 100:1 gain divider IN/OUT switch is located at the connector end of the main circuit card of the Model 560H. This control reduces the front-panel gain settings by a factor of 100 thereby affording a total gain range from 0.01 to more than 2500. With the divider in use, input impedance drops from the nominal 50 MΩ to 1 MΩ.

ZERO CONTROLS

The 560H has two controls that affect amplifier zero: RTI zero and RTO zero with its associated three-step range switch. (RTI stands for referred-to-input and RTO stands for referred-to-output.)

The RTO-zero potentiometer, located on the front panel, produces an offset at the output of the amplifier that has a range determined by a three-position switch located at the connector end of the circuit card. The range switch is labeled with its full-scale ranges of ±0.1 V, ±1 V, and ±10 V. That is, the front-panel RTO-zero potentiometer can offset the output by ±0.1 V, ±1 V, or ±10 V. Note that the resolution of the RTO-zero control diminishes as range increases.

The RTI-zero potentiometer, also located on the front panel, affects the input zero of the amplifier ahead of the gain-multiplying circuits. Thus the effect at the output of the amplifier of the RTI-zero control increases with increasing gain (whereas the RTO-zero control setting is independent of gain). For example, if the amplifier's input is shorted and the RTI-zero control is set such that there is an input offset of 20 μV, assuming the RTO-zero control is set for zero output at low gain; as gain increases, output zero will become increasingly further from zero by an amount equal to the gain times the 20 μV offset. Although amplifier operation will be normal with the zero controls set off zero, the proper method of setting zero controls is to set RTO zero at low gain and RTI zero at high gain. By repeating this procedure a few times the output will remain at zero when gain is varied throughout its total range.

ZERO INDICATORS, OUTPUT MONITOR JACKS

The amplifier's output signal is available on the front-panel monitor jacks labeled HI and LO. These jacks can be connected to a meter to determine the output level or to set zeros. Also located on the front panel are two LED indicators that show the output condition of the amplifier. One LED, labeled +, is energized when the offset is plus and the other LED, labeled −, is energized for minus. When both LED's are extinguished, the amplifier output is within approximately 2 mV of zero. (The range is from 2 mV to 20 mV depending on the setting of R84.) Noise will cause both LED's to turn on and if it is sufficient may mask a null condition.

SIGNAL WIRING

Two-conductor, twisted-pair shielded cable is recommended for wiring to the inputs of the amplifier. A dc return path from input to output low is not required unless it is needed for noise reduction.

The wire should be copper to minimize thermal effects, and the shielding should be 100% coverage to minimize degradation in common-mode rejection. The shield should be continued as close as possible to the connector termination. The input signal leads should neither be routed near conductors which carry high ac currents nor be near equipment producing magnetic fields.

Output wiring should be two-conductor twisted pair with or without shield. If shielded, the shield should be tied to output common at the amplifier, not the load. The pin assignments for the card-edge connector are listed in Table 4-1.

COMMON-MODE EFFECTS

The common-mode potential of an input signal is that floating potential common to both input leads with respect to output common. For example, if the amplifier is measuring the voltage drop across a shunt located in the +5 V lead of a power supply, the common-mode voltage is the 5 V supply voltage and the desired signal is the millivolt drop across the shunt. (This assumes that the common of the 5 V supply is tied to output common of the amplifier.) The common-mode rejection of the amplifier is the ability of the amplifier to reject the 5 V signal and amplify only the millivolt shunt signal.

The Model 560H has the ability to reject common-mode signals by 50 dB plus gain in dB for voltages from dc to 60 Hz having an amplitude up to ±10 V dc or peak ac and with an unbalanced resistance of up to 350 Ω. In the power supply example, operating with a gain of 100 (40 dB), the Model 560H would reduce the effects of the 5 V common-mode signal by at least 90 dB or to an equivalent 160 µV or less. Multiplied by the gain of 100, this would produce an output offset of no more than 16 mV. Note that this offset can be canceled by zeroing the amplifier with no load on the power supply.

The unbalanced-resistance part of the specification would be the resistance of the shunt, or the difference in resistance present in the two inputs to the amplifier. Unbalanced resistance is only significant for ac common-mode signals.

In order to maximize common-mode rejection, several precautions must be observed when wiring the input to the amplifier. Shielding should be as complete as possible; and, for ac-common-mode signals, unbalanced resistance should be minimized. If the signal leads are coupled through connectors, the shells of the connectors should be connected to the common-mode signal the same as the cable shield.

COMMON-MODE VOLTAGE

The maximum operating common-mode voltage rating of this amplifier is ±10 V dc or peak ac. For signals over a few tenths of a volt, the maximum common-mode voltage must be reduced so that the sum of common-mode and signal (normal-mode) voltages does not exceed the 10 V rating. When the 100:1 divider is used, the common-mode voltage rating of the amplifier is ±300 V dc or peak ac.

ENCLOSURES

WARNING

When using an enclosure, make sure that its chassis is connected to earth ground, preferably through third-wire ground.

Three enclosures are available for use with the Model 560H amplifier. The Model R513-16 accepts 16 amplifiers and is designed to fit a standard 19-inch EIA rack enclosure. The Model E513-6A is a bench-mounting enclosure that accepts up to six amplifiers. The Model E513-2A, also a bench-mounting enclosure, holds two amplifiers. Each of these enclosures includes an integral ac power supply which provides all necessary amplifier power.

MODEL R513-16 (DRAWING 513-622)

This sixteen-channel enclosure provides all necessary power for the amplifiers. It operates from 100 V ac to 240 V ac.

MODEL E513-6A ENCLOSURE (DRAWING 513-613)

This six-unit enclosure, designed for bench use, includes two 115/230 V ac power supplies and rear-panel connectors with mates for all inputs and outputs. The power supplies generate the necessary voltages for the amplifiers. The zero-detector switch S2, located on the front panel, allows the user to turn off the null-indicating LED's on the amplifiers. The output connectors P7-P18 contain

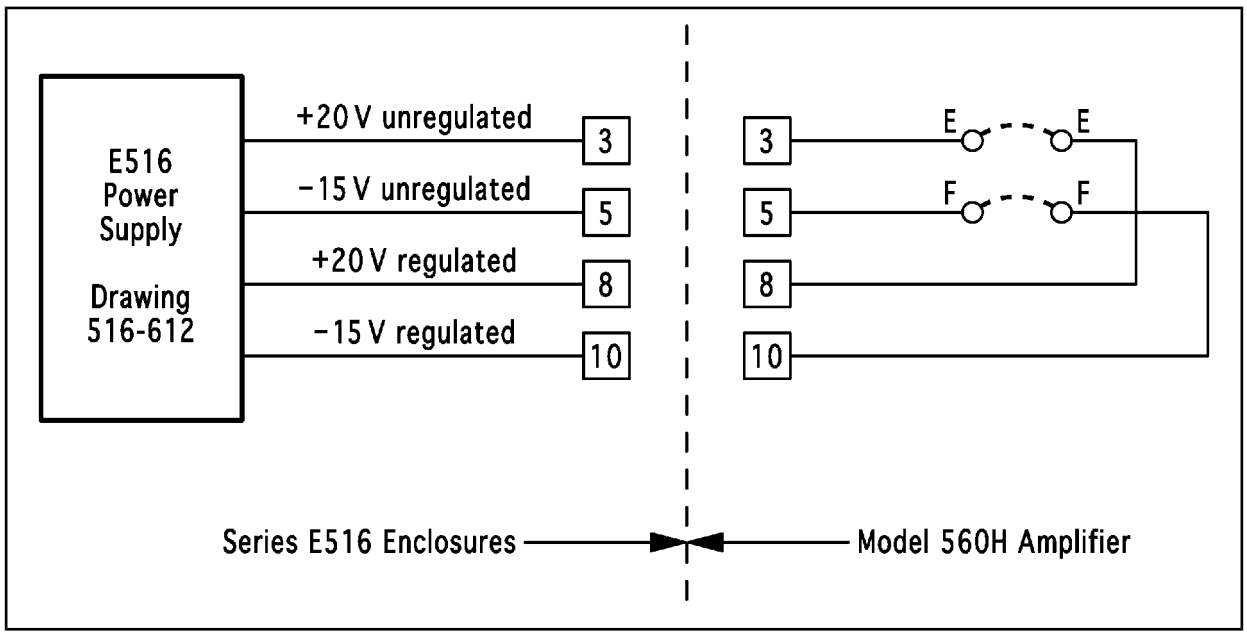


Figure 5-1: Jumper Removal for a Model 560H in an E516 Series Enclosure

high and low outputs for both the wideband and filtered outputs of the amplifiers. Note that only amplifiers equipped with switchable filters (Options L, M, and N) will have a second output.

MODEL E513-2A ENCLOSURE

Also designed for bench use, this enclosure accommodates two Model 560H amplifiers. On the rear panel is a barrier strip for each channel for all input and output connections along with the zero-detector switch which allows the user to turn off the null-indicating LED's on the amplifiers. The internal power supply ±16 V for amplifier power.

MODEL 516 SERIES ENCLOSURE

The 560H amplifier can be used in a 516 Series enclosure; but first, two jumpers identified as EE and FF on the 560H must be removed. Figure 5-1 shows the reason. If the jumpers are not removed, the plus and minus unregulated supplies will be connected to the regulated supplies. The jumpers are installed in the 560H when shipped.

Model 563H transducer conditioner-amplifiers can be used in the 513 Series enclosures directly, and the Models 560 and 561 can be used in them with certain limitations. The specification for common-mode voltage will be degraded because the Model 513 enclosures supply ±16 V to the amplifiers, whereas the Model 516 enclosures supply +20 V and −15 V. In addition, the Model 513 enclosures do not contain the ±20 V unregulated supplies to power the high-current options K, M, and N. This can be overcome by jumpering Pin 10 to Pin 5 and Pin 8 to Pin 3 on the required channels in the enclosure. This will supply ±16 V to the high current option.

OTHER APPLICATION NOTES

LOADS

Because of its low output impedance and the available high-current output (Options K, M, and N) the Model 560H can satisfy most load requirements. R64, R65, and R66 (as shipped from the factory, R64 is not used and R65 and R66 are jumpered) are available for a variety of load-matching needs. These could include matching the characteristic impedance of an output cable, adding an output divider, or adding a "T" network to match for example the impedance of a light-beam galvanometer.

OUTPUT GROUNDING PROBLEMS

Since all amplifiers in one enclosure operate from the same power supply, the output common of one amplifier will be connected to the commons of all other amplifiers in that enclosure. For most

applications this should cause no problems. For example, when all outputs feed a single load such as a recorder or a multiplexer, no grounding problems should occur. If, however, the amplifiers feed different loads and these loads have different grounds, ground loops could occur. Fortunately, signal levels at the output are usually high, and small ground currents will not be significant. In some cases, however, noise problems will occur. In these cases, the user should try to lift the ground tie point of some of the loads, if possible. Using heavy drain wires to interconnect loads may be another remedy. In any event, the output leads, both high and low, should normally be wired separately from amplifier to load.

SECTION VI
THEORY OF OPERATION

GENERAL CIRCUIT DESCRIPTION

Figure 6-1 is a simplified schematic of the Model 560H derived from Drawing 560-602. The input signals are applied to the bases of Q2, a dual NPN transistor with small geometry and monolithic construction to provide matched characteristics. The outputs of Q2 drive the inverting inputs of A1-a and A1-b. Gain switching is accomplished by changing feedback resistors which allow gains of 1 to 1000.

The outputs of A1-a and A1-b drive the input of high-level differential amplifier A2-a. Amplifier A2-a is connected in a bridge configuration with a differential voltage gain of 1. Any common-mode voltage present is applied to the inputs of A2-a where attenuation is achieved due to the balanced bridge configuration. The single-ended output of A2-a is connected to the minus input of A3-a. The output of A3-a at Pin 1 is connected to the input of A2-b, the RTO-zero amplifier. The output of A2-b is connected to the amplifier wideband output Pin 4 and the inputs of the optional filter assembly and 100 mA output assemblies.

Table 6-1: Gain combinations to provide the indicated gain step

GAIN STEP	Q1, A1	A3-a/A2-b
1	1	1
2	1	2
5	1.6	3
10	3.3	3
20	6.6	3
50	16.6	3
100	33.3	3
200	66.6	3
500	166.6	3
1000	333.3	3

GAIN RESISTORS

In gain positions 1 and 2, there is no gain resistor for Q2 and A1, so the gain of that portion is one. The gain of the inverting amplifier A3-a is –1 on a gain position of 1 and –2 on a gain position of 2. On gains of 5 to 1000, the gain of A3-a remains constant at –3; and various feedback ratios are achieved by switching resistors R21-R31.

DETAILED CIRCUIT DESCRIPTION

AMPLIFIER

Referring to Drawing 560-602 at the rear of the manual, the input signals from J1, Pins 13 and 14 and the guard from J1, Pin 15 are connected to T1, which is a transformer with tight coupling between windings. This is a common-mode filter that rejects high-frequency common-mode voltages. R6, R7, and R8 minimize the pumpout current from the bases of Q2.

R91 through R96 comprise the 100:1 input divider. When S5 is switched to the IN position, the divider is activated. The gain steps in this mode are 0.01 through 10 in the 1-2-5 step sequence. The input impedance becomes 1 MΩ, and the maximum common-mode voltage goes to 300 V dc or peak ac.

Q1 with its associated circuitry is a constant-current generator which biases the critical input stages. Potentiometer R11 functions as an RTI-zero control with a nominal range of ±350 μV. CR3 and CR4 are low-leakage diodes which limit reverse bias on the base-emitter junctions of Q2. CR5 and CR8 are reverse biased in normal operation and prevent common-mode latch-up when power is applied. The noninverting inputs of A1 are biased from Q1 through resistive divider R17-R18. Amplifier A1-a with Q2-a and A1-b with Q2-b form two separate feedback amplifiers that are connected by the gain-determining resistors R21 through R31. R23 adjusts the overall gain of the amplifier at gains of 5 through 1000. The voltage at the junction of a divider across the outputs (R32, R33) is fed back to the input circuitry, including the input bias compensation resistors R7 and R8. When driven in this manner, resistors R7 and R8 do not present a common-mode leakage path at the input terminals. The voltage at the junction in respect to common is a

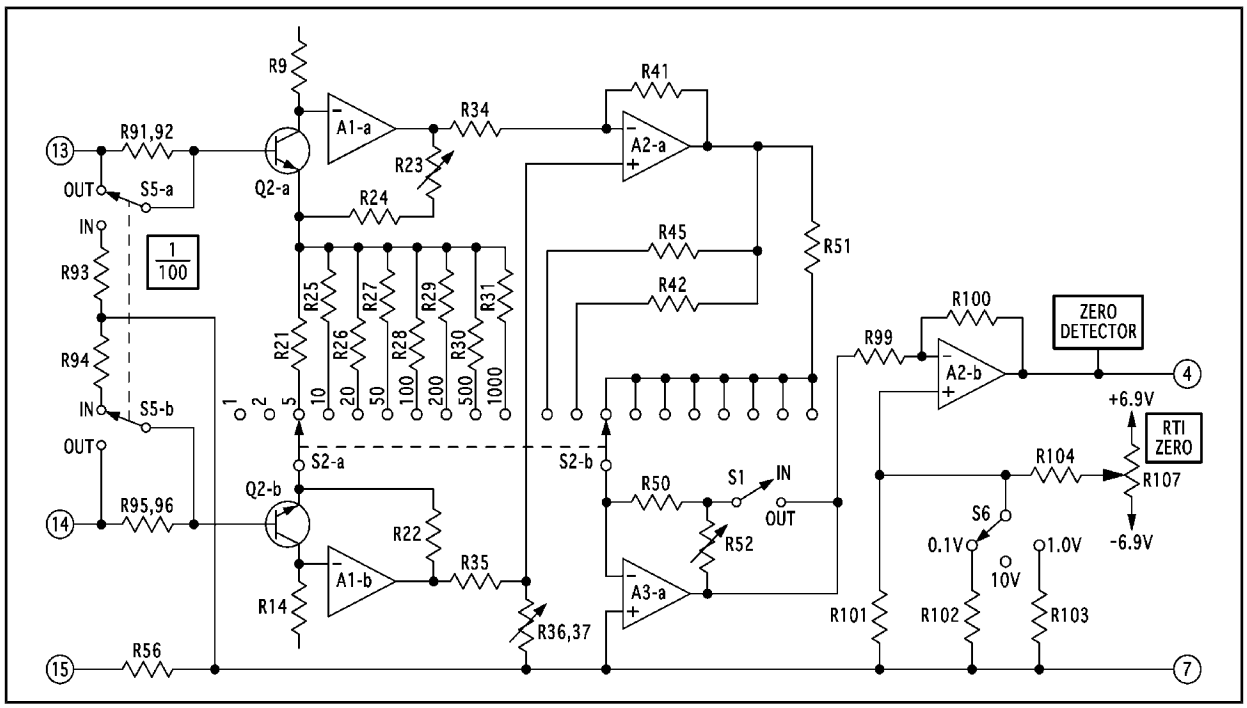


Figure 6-1: Model 560H Simplified Amplifier Schematic

function of any common-mode voltage which may be present and is fed back to enhance the CMR of the amplifier.

The outputs of A1 drive the inputs of the high-level bridge differential amplifier A2-a. The bridge resistors consist of R34 through R37, R39, R41, and R97. Potentiometer R37 is used to balance the bridge for optimum dc common-mode rejection. The bridge resistors are scaled so that the amplifier has a differential gain of –1. The output of A2-a is connected to the inverting input of A3-a. A3-a has a gain of –1 on gain step 1, a gain of –2 on gain step 2, and a gain of –3 on steps 5 through 1000. The output of A3-a is connected to the inverting input of A2-b, the RTO-zero amplifier. The output of that stage is fed to the amplifier wideband output J1, Pin 4 by jumper Y-Z, and the filter and 100 mA output amplifiers if either or both of these options are present.

CR12 and CR13 comprise a stable +6.9 V dc power supply which is used to generate the voltage for the three ranges of RTO zero. R105 and R106 provide the proper operating current for the two precision zener diodes. Because the RTO potentiometer R107 is connected directly across the supplies, its wiper feeds a voltage of from –6.9 to +6.9 to R104. In the 10 V range, R104 forms a voltage divider with R101 to inject the proper voltage into Pin 5 of A2-b. In the 1 V RTO range, R103 is placed in parallel with R101 to alter the divider appropriately. Similarly, in the 0.1 V RTO range, R102 is placed in parallel with R101.

FILTER AMPLIFIER (DRAWING 550-602)

The input to the filter-amplifier assembly, which plugs into J2 on the main board, is connected to the wideband amplifier output J1, Pin 4. The filter amplifier output appears on J1, Pin 1. Both outputs are available simultaneously. Switch S1 connects various resistor and capacitor combinations across the inputs of A1 to select the cut-off frequencies. Potentiometer R11 adjusts the dc offset of A1 to match the wideband output.

HIGH-CURRENT AMPLIFIER (DRAWING 563-603)

The current amplifier has unity gain and consists of an input buffer A1 and a high-current driver A2. The components are mounted on a plug-in board which is installed on J3 of the main amplifier assembly. Transistors Q1 and Q2 provide current limiting. The current limit (130 mA) is established

by CR1, CR4, R5, and R9. The operating point of A2 is set by R7.

ZERO DETECTOR

Two front-panel LED indicators DS1 and DS2 allow the user to adjust the output of the amplifier to zero without external equipment when no input is applied to the amplifier. One or the other LED will be lighted if the output of the amplifier is not zero. As zero volts output is approached, the LED will dim. When zero is reached, it will extinguish. As the amplifier output continues through zero to the other polarity, the other LED will light.

The output of the amplifier J1, Pin 4 is applied to A3-b, Pin 5 through RC filter C17 and R80. The voltage at A3-b, Pin 7 is adjusted to zero using R81 when no output signal is present at J1, Pin 4. If J1, Pin 4 becomes positive, A3-b, Pin 7 will be positive, and DS1 will be illuminated. Potentiometer R84 adjusts the sensitivity of the detector from 2 mV to 20 mV. (With R84 in a fully clockwise position, the sensitivity is 2 mV.)

R513-16 ENCLOSURE (DRAWING 513-622)

The NULL INDICATORS switch S1, when in the OFF position, applies −16 V to the gate of Q4 on each amplifier (Drawing 560-602) and inhibits indicators DS1 and DS2.

The enclosure power supplies provide ±15.9 V at up to 1.5 A for amplifier power including 100 mA Options K, M, and N.

E513-6A ENCLOSURE (DRAWING 513-613)

Front-panel controls are POWER S1 and ZERO DETECTOR S2. Above the power switch is the power indicator DS1. The ZERO DETECTOR switch applies −16 V to the individual conditioner-amplifiers to disable their front-panel zero detector indicators. Power supply PS1 is adjusted for ±16 V with a current capability of 1.5 A. It may be wired for 120 V ac or 240 V ac. See Table 1 and Flag Note 8 on Drawing 513-613 for fuse ratings. (PS2 supplies power for the excitation supply and is not used by the Model 560H.)

E513-2A ENCLOSURE (DRAWINGS 513-603 AND 513-604)

The front panel has a power switch S1 and indicator DS1. The rear panel has two terminal strips TS101 and TS102 for input and output connections. The rear panel has an access hole to the 120/240 V ac switch S2. Refer to Drawing 513-604, Flag Note 2, for the proper fuse rating.

Drawing 513-603 shows two power supplies. Bridge rectifier CR2 supplies plus and minus power for U2-a and U3. These integrated-circuit regulators supply the ±16 V at up to 0.18 A for the Model 560H amplifier. (Bridge rectifier CR5 supplies U1 to provide +15.9 V at up to 0.2 A for the excitation supplies, not present in the Model 560H.)



SECTION VII

CALIBRATION AND MAINTENANCE

GENERAL

The calibration controls can be identified on the circuit board by reference designation. Instructions for their proper use and associated test procedures are given in the following paragraphs. The Model 560H to be tested must be energized and allowed to reach thermal stability. Ectron recommends a warm-up period of 30 minutes.

TEST EQUIPMENT REQUIRED

POWER SUPPLY

Fluke Model 731B or equivalent 10 V dc supply.

PRECISION VOLTAGE DIVIDER

ESI Model RV622A. The divider must have an input impedance of 10 kΩ.

DIFFERENTIAL OSCILLOSCOPE

Tektronix 5110 main frame, with 5B10N time base and 5A21 differential amplifier or equivalent. Be sure the oscilloscope has been adjusted for common-mode rejection according to the manufacturer's instructions as differential measurements are used in the following procedure.

SWITCHES

Five	Single-pole two-position
One	Single-pole three-position

RESISTORS (CARBON FILM OR COMPOSITION, ¼ W)

One	100 Ω
Two	350 Ω
Three	1 kΩ
One	100 kΩ

NULL DETECTOR

Keithley Model 155 or equivalent.

FUNCTION GENERATOR

Wavetek Model 180 or equivalent.

RMS METER

HP Model 427A or equivalent.

MATING CONNECTOR

The mating connector for the amplifier card-edge J1 is a Cinch 50-18-A-20 (Ectron P/N 1-314018-0) which must be keyed between Pins 5 and 6.

DMM

HP Model 3478A or equivalent.

PRELIMINARY ADJUSTMENTS (FIGURE 7-1)

1. Set all switches to 1.
2. Set the voltage source PS1 to 10.000 V dc ±0.1 V dc.
3. Adjust both inputs of the oscilloscope to 10 mV/cm dc.
4. Set S3 to 2.
5. Set S1 from 1 to 2 several times and adjust the differential input balance on the oscilloscope for minimum deflection.
6. Restore S1 and S3 to Position 1.

ZERO ADJUSTMENTS (FIGURE 7-1)

All of the following adjustments are made with all switches in Position 1 and Jumper J1 installed. RTO means referred-to-output. RTI means referred-to-input.

RTO

1. Set the amplifier gain to 5. Connect the DMM to A2, Pin 1 and adjust R49 for 0 V ±1 mV.
2. Connect the DMM to A3, Pin 1 and adjust R48 for 0 V ±1 mV.
3. Set S6 on the amplifier (RTO Range Switch) to the 0.1 position.
4. Connect the DMM to A2, Pin 7 and adjust R107 for 0 V ±1 mV.

RTO (OPTIONS K, L, M, AND N)

The offset on the filter assembly may be adjusted to equal the offset at the wideband

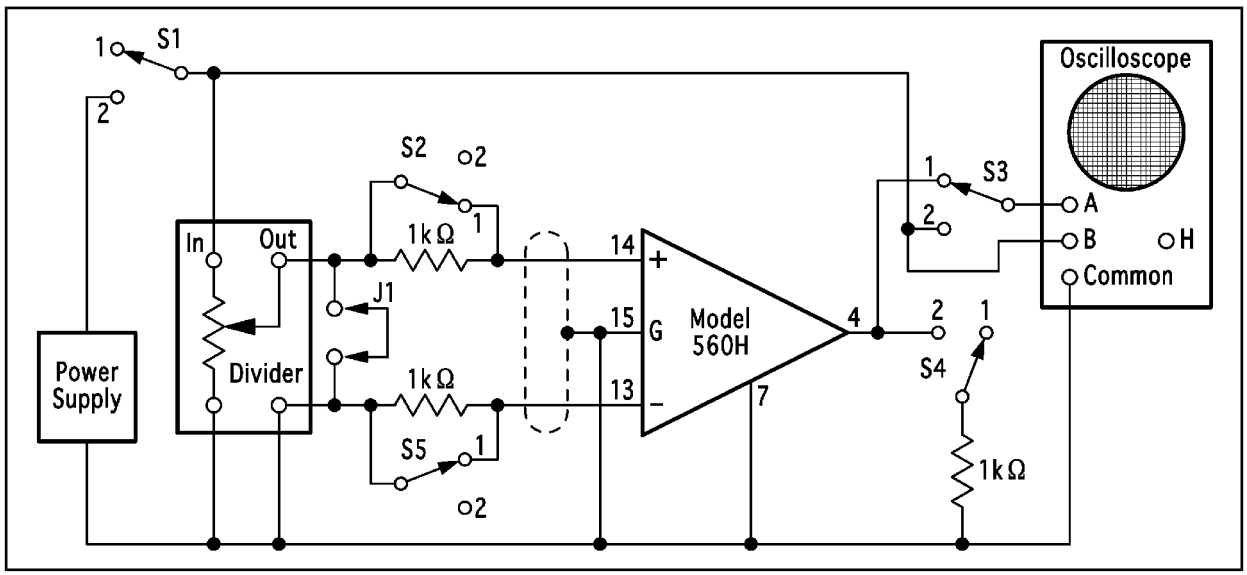


Figure 7-1: Basic Test Setup

output if necessary by adjusting R11 on the filter card.

There is no extra zero adjustment on the high current assembly. The output can be adjusted to zero by the RTO control on the previous stage (R11 on Filter Card for Option N).

RTI

1. The amplifier RTI-zero control R11 is accessible at the front panel. Set the amplifier for a gain of 1000 to make this adjustment. The amplifier inputs must be connected to guard.
2. Adjust R11 for the same offset at the output as at a gain of 5.
3. Recheck all RTO adjustments.
4. Remove jumper J1.

ZERO DETECTOR

1. Connect a jumper from the junction of R80 and C17 to the amplifier output low.
2. Adjust R81 for zero ±20 mV at A3, Pin 7 with respect to the amplifier output low.
3. Remove the jumper from R80 to the output low.
4. The zero-detector sensitivity adjustment R84 can be adjusted at this time. The range of the adjustment is 2 to 20 mV. (It is set at the factory to 2 mV, full clockwise position.)

SOURCE-CURRENT ADJUSTMENTS (FIGURE 7-1)

1. Set all switches to 1.
2. Connect jumper J1.
3. Adjust the gain of the amplifier to 1000.
4. Connect a null detector to the amplifier output.
5. Set S2 to 2. Record the offset voltage.
6. Set S2 to 1 and S5 to 2. Record the offset voltage.
7. Algebraically add the recorded voltages, then divide by 2. Adjust R6 to this value.
8. Repeat Steps 5 through 7 until the recorded value is less than ±2 mV.
9. Remove jumper J1 and set all switches to Position 1.

COMMON-MODE-REJECTION ADJUSTMENT (FIGURE 7-3)

1. Set S1 to Position 2.
2. Adjust the amplifier to a gain of 10.
3. Connect the amplifier as shown in Figure 7-3.
4. Adjust the function generator for a 20 V p-p, 20 Hz square wave .
5. Adjust R37 for minimum deflection as seen on the oscilloscope.
6. Reset RTO zero as necessary.

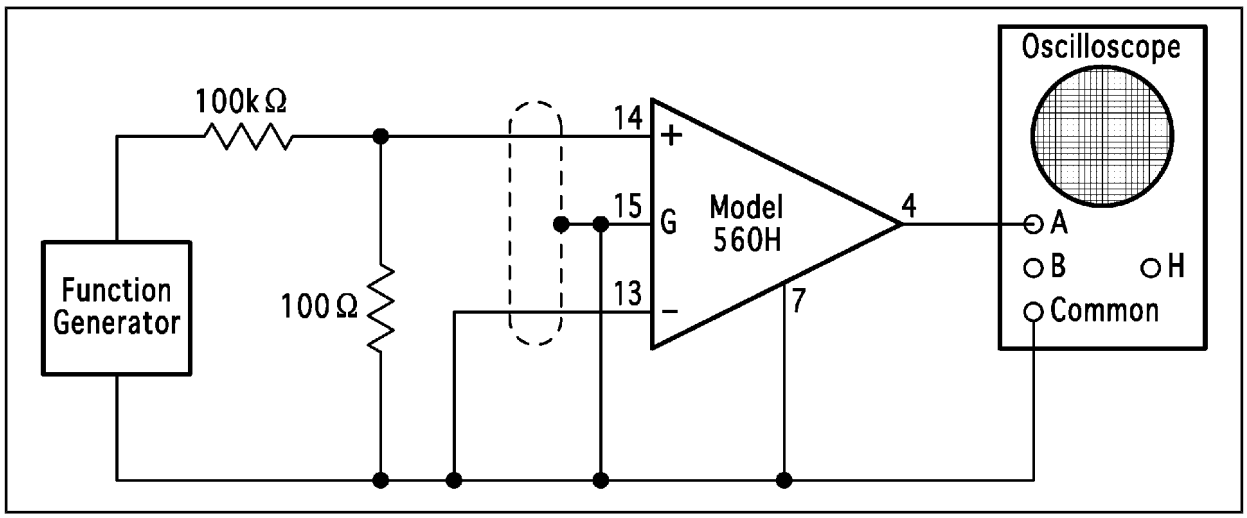


Figure 7-2: Test Setup for Frequency Response

GAIN CALIBRATION (FIGURE 7-1)

1. Connect the amplifier as shown in Figure 7-1, but without jumper J1.
2. Set all switches to 1.
3. Set the amplifier gain switch to 1000 and the vernier switch out.
4. Center the trace on the oscilloscope using the vertical position control.
5. Adjust the voltage divider R2 to .001000.
6. Set S1 to 2.
7. Adjust R23 until the oscilloscope trace is centered.
8. Return all switches to Position 1.

TEST PROCEDURES

The following test procedure describes the methods currently used at Ectron to test Model 560H. The procedure consists of comparing the amplifier output with an input signal on an oscilloscope using the differential (A-B) input. Using high oscilloscope sensitivity, the deviation between input and output can be easily measured. A precision divider is used at the input so that the amplifier output can be exactly equal to the signal applied to the divider. The basic setup is shown in Figure 7-1. In duplicating or simulating this procedure, considerable attention should be given to proper shielding. A millivolt nullmeter may be used instead of the oscilloscope to make the differential measurements.

Differential measurement offers several advantages over the usual procedures that incorporate digital voltmeters or other input-output comparison methods. For instance, to measure linearity the differential measurement requires only that a signal voltage be varied from zero to full scale (usually by a potentiometer) while the deviation on the oscilloscope is observed (0.005% measurements are easily made with a simple filter). Other methods of measuring linearity offer many difficulties, including accounting for the inaccuracies of the instrumentation.

1. Refer to TEST EQUIPMENT REQUIRED on Page 7-1.
2. Perform the preliminary adjustments outlined on Page 7-1.
3. Set all switches to Position 1 at the start of each test unless otherwise specified.
4. Remove jumper J1 unless otherwise specified.

GAIN ACCURACY (FIGURE 7-1)

1. Adjust the amplifier to the gain position to be verified. Set the gain vernier switch to out.
2. Adjust the precision divider R2 to the reciprocal of the gain in step 1.
3. Center the trace on the oscilloscope using the vertical positioning control.
4. Set S1 to 2.
5. The gain error in percent is the deviation in volts multiplied by 10.

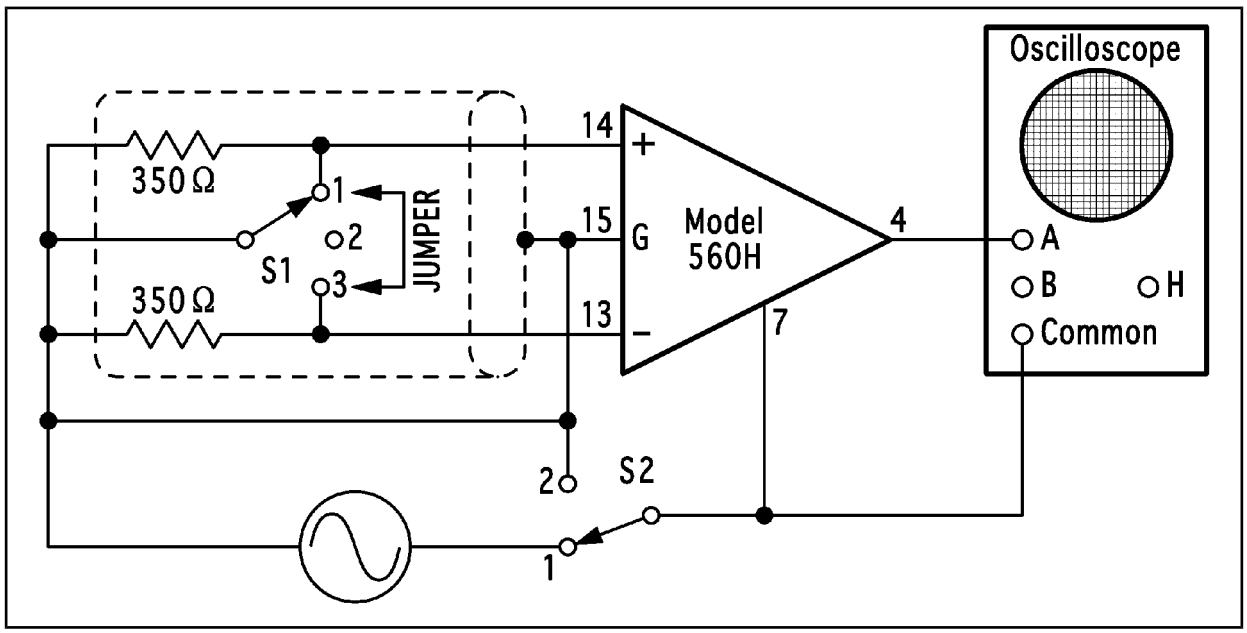


Figure 7-3: Test Setup for Noise and Common-mode Rejection

LINEARITY (FIGURE 7-1)

1. If the filtered output is to be used for this test then the filter switch should be set to the W/B position to eliminate phase shift error in the measurement.
2. Adjust the amplifier to a gain of 1.
3. Adjust the precision divider to the reciprocal of the gain.
4. Substitute the function generator for the power supply in Figure 7-1.
5. Adjust the function generator for a triangular output of 20 V p-p at 1 Hz.
6. Connect a jumper from the B input to the H input on the oscilloscope.
7. Set S1 and S3 to 2.
8. Note and record the maximum and minimum deviation on the oscilloscope (best straight line through zero).

$$\text{Linearity (\%FS)} = \frac{\text{max. dev.}}{20} \times 100.$$

9. The linearity test may be repeated for other gains by repeating steps 3 through 8.

INPUT IMPEDANCE (FIGURE 7-1)

1. Adjust the amplifier to a gain of 10.
2. Adjust the precision divider R2 to .100000.
3. Connect the DMM to the amplifier output pins. (Do not use the monitor jacks on the front of the amplifier.)
4. Set S1 to 2.
5. Record the deviation (E_o) at the amplifier output when S2 is switched from Position 1 to Position 2.

$$Z_{in} = \frac{1 \cdot 10^7\ \Omega}{\Delta E_o \text{ (in mV)}} .$$

OUTPUT IMPEDANCE (FIGURE 7-1)

1. Adjust the amplifier to a gain of 10.
2. Adjust the precision divider R2 to .100000.
3. Connect the DMM directly to the amplifier output pins. (Do not use the monitor jacks on the front of the amplifier.)
4. Set S1 to 2.
5. Record the deviation at the amplifier output (E_o) when S4 is switched from Set 1 to 2.

$$Z_{out} = \frac{\Delta E_o \text{ (change in dc output)}}{0.01 \text{ A (output current)}} .$$

FREQUENCY RESPONSE (FIGURE 7-2)

1. Adjust the amplifier to a gain of 1000.
2. Adjust the function generator to a 2 V p-p 100 Hz sine wave as seen on the oscilloscope.

3. Adjust the function generator to higher frequencies. The peak-to-peak amplitude should remain within ±30% of nominal over the specified bandwidth of the amplifier.

NOISE (FIGURE 7-3)

NOTE: Use caution when wiring the input circuit for this test to avoid introducing additional noise.

1. Substitute an rms meter with an RC filter of the appropriate cut-off frequency connected in series for the oscilloscope.
2. Remove the oscillator from the test fixture in Figure 7-3.
3. Set S1 to 2.
4. Connect the jumper as shown in the figure.
5. Adjust the amplifier to a gain of 1.
6. Record the rms RTO noise.
7. Adjust the amplifier to a gain of 1000.
8. Record the rms RTI noise.

BENCH TESTING

The Model 560H operates from an isolated power supply that provides ±16 V regulated for the amplifier.

However, all amplifiers can be tested using an extender board as listed in Section VIII, or they can be bench tested using a ±16 V supply. A ±15 V supply can be used but the maximum CMV is reduced to ±7.5 V and the output amplitude and drive capability will be degraded somewhat.



SECTION VIII

PARTS LIST

ABBREVIATIONS

The following are the abbreviations used for manufacturers:

AB	ALLEN BRADLEY
AD	ANALOG DEVICE
AL	ALCO
AM	AMPHENOL
AR	ARCO
BE	VOLEX-BELDEN
BN	BENDIX
BO	BOURNS
CA	CAPAR
CE	CENTRALAB
CI	TRW CINCH
CK	C&K
CO	CORNING
CS	CHICAGO SWITCH
DL	DALE
EC	ECTRON CORPORATION
EL	ELCO
ER	ERIE
EV	ELECTROVERT
FA	FAIRCHILD
GE	GENERAL ELECTRIC
GI	GENERAL INSTRUMENTS
GR	GRAYHILL
GS	GENERAL SEMICONDUCTOR
HP	HEWLETT PACKARD
IM	IMB
IP	INTERPOWER
KE	KEMET
KO	KOA SPEER
LF	LITTLEFUSE
LT	LINEAR TECHNOLOGY
ME	MEPCO-ELECTRA
MN	MONSANTO
MO	MOTOROLA
MU	MURA
MX	MOLEX
NA	NAT'L SEMICONDUCTOR
NY	NYTRONICS
PA	PANASONIC
PO	POWER ONE
RO	ROGAN
SL	SIGNAL
SE	SIEMENS
SG	SIGNETICS
SI	SILICONIX
SP	SPRAGUE
ST	STANCOR
SW	SWITCHCRAFT
TI	TEXAS INSTRUMENTS

MODEL 560H AMPLIFIER

REF DESIG	DESCRIPTION	MFR	MFR P/N	ECTRON P/N
A1	Op amp, dual	AD	OP270GP	1-100270-1
A2, 3	Op amp	NA	LF412CN	1-100412-0
C1	Cap, 0.01 µF ceramic disc	SP	TGS10	1-421004-0
C3, 4, 10	Cap, 10 pF silver mica	AR	DM5CC100J03	1-400103-0
C5, 8	Cap, 6.8 µF 35 V tantalum	KE	CSR13F685KL	1-446800-0
C9	Cap, 4.7 µF 35 V tantalum	SP	196D475X0035JA1	1-444700-1
C11, 13	Cap, 0.02 µF ceramic disc	SP	TGS-20	1-422004-1
C15	Cap, 27 pF 300 V	AR	DM5FY270J	1-400273-0
C17	Cap, 0.1 µF metal mylar	ME	712A1BC104PK101LA	1-431009-1
C19	Cap, 0.1 µF DISC 25 V	SP	HY550	1-431004-0
CR1, 2, 6, 7, 11	Diode, signal	FA	1N4148	1-194148-0
CR3-5, 8	Diode, signal	MO	1N457	1-190457-0
CR12, 13	IC, ref	NA	LM329D	1-130329-1
DS1, 2	LED, yellow	HP	HLMP1719	4-120028-0
J2, J3	Connector, 9-pin	EL	00-8129-009-603-002	1-314009-0
L1, 2	Inductor, 10UH	DL	IR2-10UH	1-308020-0
Q1	Transistor, PNP	FA	PN4248-18	1-214248-0
Q2	Transistor, Dual NPN selected	EC	031-006-01	031-006-01
Q4	FET	SI	J113	1-240113-0
R1	Res, 22 kΩ carbon film	KO	CF ¼ 22 kΩ	6-172220-0
R2-4	Res, 2.2 kΩ carbon film	KO	CF ¼ 2.2 kΩ	6-171220-0
R5	Res, 1.40 kΩ metal film 50 ppm tc	CO	RN55C1141F	6-101140-0
R6, 49, 107	Potentiometer, 20 kΩ	BO	3009Y-1-203	6-452200-2
R7, 8	Res, 22 MΩ carbon composition	KO	CF ¼ 22 MΩ	6-175220-0
R9, 14	Res set, matched metal film	EC	550-003-01	550-003-01
R10, 12, 83	Res, 10 kΩ carbon film	KO	CF ¼ 10 kΩ	6-172100-0
R11, 37	Potentiometer, 500 Ω	BO	3006P-1-500	6-450500-0
R15, 16, 53, 105, 106	Res, 4.7 kΩ carbon FIL	KO	CF ¼ 4.7 kΩ	6-171470-0
R17	Res, 17.4 kΩ metal film 50 ppm tc	CO	RN55C1742F	6-102174-0
R18	Res, 124 kΩ metal film 50 ppm tc	CO	RN55C1243F	6-103124-0
R19	Res, 732 Ω metal film 50 ppm tc	CO	RN55C7320F	6-100732-0
R21, 22, 24-31, 42, 45, 51, 99, 100	Res set, matched metal film	EC	563-002-01	563-002-01
R23	Potentiometer, 2 kΩ	BO	3006P-1-202	6-451200-2
R32, 33	Res, 6.8 kΩ carbon film	KO	CF ¼ 6.8 kΩ	6-171680-0
R34-36, 41	Res, 16.9 kΩ metal film 25 ppm tc	CO	RN55E1692F	6-121169-0
R38	Res, 68 kΩ carbon film	KO	CF ¼ 68 kΩ	6-172680-0
R39	Res, 680 kΩ carbon film	KO	CF ¼ 680 kΩ	6-173680-0
R40, 89	Res, 22 Ω carbon film	KO	CF ¼ 22 Ω	6-170022-0
R48	Potentiometer, 100 kΩ	BO	3006P-1-104	6-453100-0
R50	Res, 24.9 kΩ metal film 25 ppm tc	CO	RN55E2492F	6-122249-0
R52, 81	Potentiometer, 50 kΩ	BO	3006P-1-503	6-452500-0
R54, 58	Res, 470 Ω carbon film	KO	CF ¼ 470 Ω	6-170470-0
R56	Res, 10 MΩ carbon film	KO	CF ¼ 10 MΩ	6-175100-0
R80	Res, 2.7 MΩ carbon film	KO	CF ¼ 2.7 MΩ	6-174270-0
R85	Res, 120 Ω carbon film	KO	CF ¼ 120 Ω	6-170120-0
R86	Res, 3.9 kΩ carbon film	KO	CF ¼ 3.9 kΩ	6-171390-0
R87	Res, 1 MΩ carbon film	KO	CF ¼ 1 MΩ	6-174100-0
R91-96	Res set, matched metal film	EC	563-001-01	563-001-01
R97	Res, 75 Ω carbon film	KO	CF ¼ 75 Ω	6-170075-0
R98	Res, 33 kΩ carbon film	KO	CF ¼ 33 kΩ	6-162330-0

REF DESIG	DESCRIPTION	MFR	MFR P/N	ECTRON P/N
R101	Res, 113 kΩ metal film 25 ppm tc	CO	RN55E1133F	6-123113-0
R102	Res, 274 Ω metal film 50 ppm tc	KO	RN55C2740F	6-100274-0
R103	Res, 3.01 kΩ metal film 50 ppm tc	CO	RN55C3011F	6-101301-0
R104	Res, 33.2 kΩ metal film 25 ppm tc	CO	RN55E3322F	6-122332-0
S1	Switch, SPDT	CK	7101MD9AVZBE	7-110000-1
S2	Switch, 2P10POS	GR	71AY231545	7-100019-1
S5	Switch, slide DPDT	AL	AS2DG-PC	7-130003-0
S6	Switch, slide SPDT	AL	AS1EG-PC	7-130002-0
T1	Transformer, trifilar	BO	4259-0003	8-220000-0
	Assembly, filter	EC	550-501-01	550-501-01
	Assembly, high current	EC	550-519-01	550-519-01

MODEL 560H FILTER ASSEMBLY (OPTIONS L, M, AND N)

ASSY 550-501-01 (DWG 550-602)

REF DESIG	DESCRIPTION	MFR	MFR P/N	ECTRON P/N
A1	Op amp	NA	LF356N	1-100356-1
C1	Cap, 0.15 µF metal mylar	IM	XA2B154J	1-431501-0
C2	Cap, 0.0015 µF metal mylar	IM	XA2B152J	1-411501-0
C3, 4	Cap, 0.12 µF metal mylar	IM	XA2B124J	1-431201-0
C5	Cap, 0.0012 µF metal mylar	IM	XA2B122J	1-411201-0
C6, 7	Cap, 0.1 µF ceramic disc	ER	RPE121Z5U104M100V	1-431009-0
J2	Connector, 9-pin	EL	00-8129-009-603-002	1-314009-0
R1, 3, 5, 7	Res, 93.1 kΩ metal film 50 ppm tc	CO	RN55C9312F	6-102931-0
R2, 4, 6, 8	Res, 9.31 kΩ metal film 50 ppm tc	CO	RN55C9311F	6-101931-0
R9	Res, 470 Ω carbon film	KO	CF ¼W 470 Ω	6-170680-0
R11	Potentiometer, 10 kΩ	BO	3006P-1-103	6-452100-0
S1	Switch, rotary 2P5POS	GR	71AY231546-2-5S	7-100015-1

MODEL 560H HIGH-CURRENT ASSEMBLY (OPTIONS K, M, AND N)

ASSY 550-519-01 (DWG 563-603)

REF DESIG	DESCRIPTION	MFR	MFR P/N	ECTRON P/N
A1	Op amp	NA	LF411CN	1-100411-1
A2	Op amp, power	LT	LT1010CT	1-101010-0
C1, 2	Cap, 0.1 µF ceramic disc	CE	CZ201A1D4M	1-431009-0
C3, 5	Cap, 4.7 µF tantalum	SP	196D475X0035JA1	1-444700-1
C4	Cap, 220 pF ceramic disc	KE	C410C221J1G5CA	1-402209-0
CR1-4	Diode, power	FA	1N4002	1-194002-0
L1	Bead, ferrite	EC	750-051-01	750-051-01
Q1	Transistor, PNP	TI	TIP42B	1-230042-0
Q2	Transistor, NPN	TI	TIP41B	1-220041-0
*R1, 2	Res, 1 kΩ carbon film	ME	5043CX1K000J	6-171100-0
R3	Res, 270 Ω carbon film	ME	5043CX270R0J	6-170270-0
R4, 8	Res, 5.6 kΩ carbon film	ME	5043CX5K600J	6-171560-0
R5, 9	Res, 5.1 Ω carbon film	ME	5043CX5R100J	6-170005-1
R6	Res, 10 kΩ carbon film	ME	5043CX10K00J	6-172100-0
R7	Res, 150 Ω carbon film	ME	5043CX560R0J	6-170150-0

* R1 is used for Options K and M, R2 for Option N.

MODEL E513-2A ENCLOSURE

(DWG 513-604)

REF DESIG	DESCRIPTION	MFR	MFR P/N	ECTRON P/N
C1, 3, 6	Cap, 47 µF 25 V	SP	CSR13E476KL	1-454700-1
C2, 5, 7	Cap, 1000 µF 35 V	CA	CAE1000/35	1-471000-0
CR1-3, 6-9, 11-14	Diode, signal	FA	1N4148	1-194148-0
CR5-10	Diode, bridge	GE	W02M	1-190075-0
DS1	Lamp, power indicator	HP	5082-4655	4-120014-0
F101	Fuse, 115 V ac 0.187 amp SB	LF	313.187	2-160187-1
F101	Fuse, 230 V ac 0.1 amp SB	LF	313.100	2-160100-1
J101, 102	Connector, card-edge	CI	50-18-S10	1-314118-0
J103	Receptacle, power line	SW	EAC-301	3-840026-1
R1	Res, 1 kΩ carbon film	KO	CF ¼ 1 kΩ	6-171100-0
S1	Switch, SPST	CK	7101MD9AV2BE	7-110001-1
S2	Switch, 115-230 V	SW	EPS-2-PC3	2-170011-0
S101	Switch, DPDT	CS	23-021-114	7-130001-0
T1	Transformer, power	SL	MPL-12-15	8-200012-0
TS101, 102	Terminal strip	EV	814S/10.25.135.1053	3-830050-0
U1, 2A	Regulator, +15 V	FA	78M15UC	1-137815-0
U3	Regulator, −15 V	FA	7915UC	1-137915-0
	Case	EC	513-505-01	513-505-01

MODEL E513-6A

(DWG 513-613)

REF DESIG	DESCRIPTION	MFR	MFR P/N	ECTRON P/N
DS1	Lamp, power indicator	MU	L-28/40-RLC-R	4-121007-0
J1-6	Connector, 6-pin input	BN	PT02A-10-6S	1-310506-1
J7-18	Connector, output	AM	31-010	1-311102-0
J19-24	Connector, amplifier	CI	50-18-A-20	1-314018-0
J25	Receptacle, power line	SW	EAC-301	3-840026-1
P1-6	Connector, input mate	BN	PT06A-10-6P(SR)	1-310506-0
PS1	Power supply, ±15 V	EC	513-506-01	513-506-01
PS2	Power supply	EC	513-510-01	513-510-01
S1	Switch, power	CK	7201SYZGE	7-110006-0
S2	Switch, null indicators	CK	7101SYZGE	7-110001-0

MODEL R513-16 ENCLOSURE

(DWG 513-622)

REF DESIG	DESCRIPTION	MFR	MFR P/N	ECTRON P/N
C1-3	Capacitor, 4.7 µF/35 V tantalum	SP	199D475X903CA2	1-444700-1
C4	Capacitor, 1 µF/100 V met plyester	PA	ECQ-E1105KZ	1-441006-0
CR1-3	Zener	FA	1N752A	1-190752-1
CR4-5	Diode, signal	NA	1N4148	1-194148-0
CR6	Zener	MO	1962B	1-190962-0
DS1	Lamp, power indicator	MU	L-28/40-RLC-R	4-121007-0
F1	Fuse, 1 A SB 115 V	LF	313.001	2-161000-1
F1	Fuse, 0.5 A SB 230 V	LF	313.500	2-160500-1
J1-16	Connector, 6-pin input	BN	PT02A-10-6S	1-310506-1
J17-48	Connector, BNC	AM	31-010	1-311102-0
J49	Connector, 8-pin remote	BN	PT02A-12-8S	1-310408-1
J50	Receptacle, power line	SW	EAC-309	3-840043-0
J51-66	Connector, amplifier	CI	50-18-A-20	1-314018-6
P1-16	Connector, 6-pin input mate	BN	PT06A-10-6P(SR)	1-310506-0
P49	Connector, 8-pin remote mate	BN	PT06A-12-8P(SR)	1-310408-0
PS1	Power supply	CL	MMB50U-6-N	5-120028-0
PS2	Power supply	CL	R15U-15	5-120029-0
Q1-32	FET, n-channel	SI	VN0300M	1-240030-0
Q33	FET, n-channel	SE	BUZ71A	1-240071-0
Q34	Transistor	GE	2N3415	1-203415-1
R1-6	Res, 560 Ω carbon film	KO	CF ¼ 560 Ω	6-170560-0
R7-12	Res, 47 kΩ carbon film	KO	CF ¼ 47 kΩ	6-172470-0
R13	Res, 3.9 kΩ carbon film	KO	CF ¼ 3.9 kΩ	6-171390-0
R14	Res, 390 Ω carbon film	KO	CF ¼ 390 Ω	6-170390-0
S1	Switch, null indicators	CK	7201SYZGE	7-110001-0
S2	Switch, mode 1P5POS	GR	56P30-01-1-05N-F	7-100074-0
S3	Switch, power	CK	T101S1T-C-G-E	7-110061-0
U1-U3	Optical isolator	MN	MCT-2	1-280000-0
U4	IC, converter	SI	7661CJ	1-147661-0

ACCESSORIES FOR ALL ENCLOSURES

DESCRIPTION	MFR	MFR P/N	ECTRON P/N
One-channel filler panel	EC	516-503-40	516-503-40
Four-channel filler panel	EC	516-503-55	516-503-55
Extender-board assembly	EC	560-501-01	560-500-01
Line cord, power USA/Canada	BE	17250B	3-840026-0
Line cord, power Europe	IP	86511052	3-840040-0
Line cord, power UK	IP	86240060	3-840041-0
Line cord, power Switzerland	IP	86515050	3-840047-0
Line cord, power China	IP	86517040	3-840054-0
Line cord, power Japan	IP	86589000	3-840055-0
Line cord, power Australia	IP	86210030	3-840057-0
Line cord, power Argentina	IP	86270010	3-840058-0
Line cord, power Israel	IP	86275010	3-840042-0
Line cord, power India	IP	86265010	3-840046-0



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