

400 SERIES DIFFERENTIAL DC AMPLIFIERS AND SIGNAL CONDITIONERS



MODEL 414

Photos Actual Size

MODEL 418

RUGGED APPLICATIONS

- Vehicle Crash Testing
- Helicopters
- Flight Testing
- Shipboard
- Rocketry

ENVIRONMENTAL RATINGS

- 100 G Shock
- 20 G Continuous Vibration
- -55°C to $+100^{\circ}\text{C}$
- 100% Relative Humidity
- Thermal Shock Resistant

PERFORMANCE HIGHLIGHTS

- True Differential Amplifiers
- $.5 \mu\text{V}/^{\circ}\text{C}$ stability
- Bridge Excitation
- Bridge Bal. & Calibration
- Thermocouple Ref. Junctions

GENERAL DESCRIPTION, ALL MODELS

All models are true differential amplifiers with transformer isolation between input, output and the power source. An internal DC/DC converter provides bi-polar voltages for the circuitry while accepting power from a single external DC power supply or battery. This is 12 volts for automotive applications or 28 volts for airborne systems. In addition to the high performance DC amplifier, the units can be optionally supplied with integral strain gage excitation supplies and bridge balance or thermocouple reference junction compensation. Transformer coupling contributes to high common mode rejection and the chopper design results in superior zero stability. The use of top grade components and a rigorous testing program ensures reliable operation over a wide range of ambient temperatures.

The amplifiers are packaged in rugged, compact steel cases and will withstand high shock and vibration levels under fully operational conditions. A full one year warranty applies when the equipment is used under any environmental conditions within its rating. Additional physical description of the various models follows.

Description, Models 414, 434

These models are all physically identical and differ only in performance characteristics. Their steel case

is 1.1" by 2" by 3" with stud mounting bolts installed as shown on the front cover. On special order, flange mounting may be substituted. All adjustment potentiometers are installed on one end and a DAM-15 input/output connector is on the opposite end.

Four fixed gain steps are provided which are selected by jumpers in the input/output connector. These, combined with the gain vernier, allow any gain between 20 and 1000 to be set. See the option section for other controls.

Description, Model 418

This amplifier is electrically identical to the premium model 414 in the preceding group and differs only in physical configuration. The 418 is intended for rack mounting and is equipped with a front panel gain switch. Zero controls are also located on the front panel in accordance with the options selected. A typical unit is shown on the front cover. The front panel dimensions are 1.1" by 2.37" and the depth is 4" (plus connector and controls). The R418 series enclosures are 3.5" high and optionally contain 115V AC power supplies.

Although the model 418 is individually as rugged as the other models, it does not meet the full, 400 series, shock and vibration specifications when installed in standard R418 rack mounting enclosures. If full environmental specifications are a requirement, custom cases with heavy duty guide rods and special enclosures can be provided.

OPTIONS, ALL MODELS

All basic models are available as amplifiers only or they may be equipped with signal conditioning options and/or special features. These options include bridge excitation supplies, several zero control options, a choice of power supply voltages and several output options. The latter includes normal ± 10 volt output, a ± 5 V high current output, and output limiting.

The zero control options include auto zero, a passive bridge balance control or a unique ± 40 millivolt RTI zero suppression capability. With this option, expanded scale operation is possible or it will alternately fulfill the function of bridge balance. The circuit utilizes highly selected and matched components, therefore, it can be used without seriously affecting the basic stability of the amplifier. (See zero stability under Option P.)

Under bridge excitation supply options, the user has a choice of no excitation, a supply which is derived directly from the primary power source or a fully isolated supply as follows:

Option T This no charge option indicates that no strain gage excitation supply is provided.

Option U This option includes a stable regulator to provide excitation voltage to one or more strain gage bridges. It derives its power directly from the primary power source and the output is factory set to within 1% of a user specified voltage. This voltage may be between 3 and 15 volts for 28 volt models and between 3 and 7 volts if the primary power is 12 volts. Regardless of the specified voltage, the output current capability is 100 mA.

Option W This option includes an isolated excitation supply which derives its power from a separate winding on the amplifier's DC to DC converter transformer. The regulated output is factory set within 1% of any desired potential between 3 and 10 volts. The maximum load is 33 mA, or 50 mA with load regulation reduced by a factor of two.

It is intended that only one option be selected from each option group, however, in a few instances it is possible to elect more than one. The factory should be consulted if this is deemed necessary.

EMI/RFI (OPTION I*)

All DC amplifiers produce some error when subjected to conducted or radiated RF signals of sufficient magnitude. If this error appears in the form of spikes or an AC waveform at the output, it is readily recognized. Unfortunately, the error is often a DC offset which changes in magnitude as the level of the interference signal changes. This is due to the fact that the signals are rectified by the amplifiers.

In a direct coupled amplifier, any DC level produced by this rectification is amplified and appears as an error signal at the output. On the other hand, a chopper amplifier will not necessarily do this. Referring to the 400 series amplifier block diagram

note that the design incorporates an "AC" amplifier which is capacitively coupled to the output demodulator. This means that RFI can produce a DC level shift in the amplifier without affecting the output.

Although the standard 400 series can outperform most other types of amplifiers in side by side comparisons, it is not totally immune to RFI, therefore, special models (or systems) can be provided which include supplementary protection. When so equipped, the 400 series amplifiers have demonstrated their ability to function properly in RF environments which cause other amplifiers to lock up at full scale output. One such application is operation in the immediate proximity of a telemetry transmitter.

(*Adds 1" to length of Model 414)

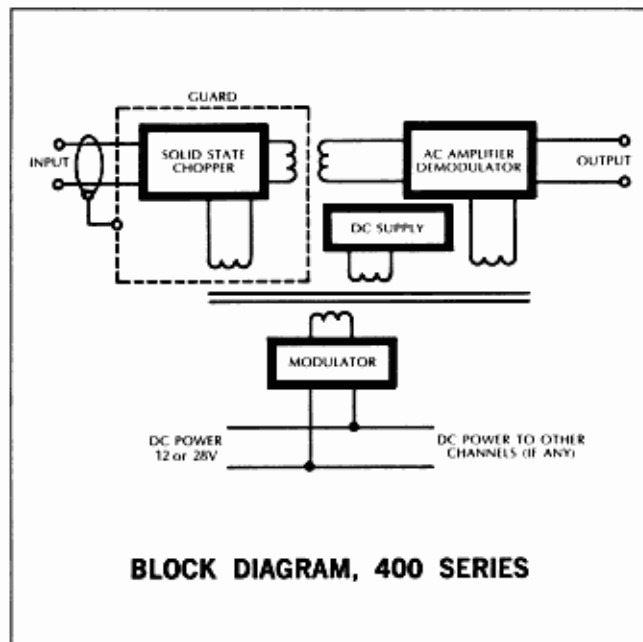
RUGGED CONSTRUCTION

Ectron Series 400 Differential DC Amplifiers and Signal Conditioners are designed for reliable operation in the most severe and dramatically changing environments. The amplifiers have produced outstanding data while subjected to the vibration of helicopters, the impact of rocket test sleds, the abrupt temperature and altitude shifts of supersonic aircraft and the general abuse encountered on automotive proving grounds. In these and many similar applications, the Ectron signal conditioners are a well established leader.

The amplifiers are housed in a steel casing and fully protected from moisture, including condensation. One hundred percent factory testing assures normal operation over the ambient temperature range of -25°C to $+71^{\circ}\text{C}$ on premium models, with extremes of -55°C to $+100^{\circ}\text{C}$ certified on special order. Shock, static acceleration and vibration capabilities exceed the rigorous requirements of most existing military specifications.

ISOLATION

True ohmic isolation is provided between input, output and power source by means of transformer coupling (see block diagram below). This results in excellent common mode rejection and the ability to operate with common mode potentials of 100V DC or peak AC.



The above diagram shows operation from a single DC power source. This may be 12 or 28 volts allowing operation in vehicles or aircraft. For operation in conventional industrial or laboratory applications, the R418 series enclosures may be optionally equipped with heavy duty 115V AC (or 220V ac) power supplies which provide 12 or 28V DC power to all amplifiers within the enclosure. Although this supply is common to all amplifiers within the enclosure, it does not place any restriction on the routing or location of output grounds of any given amplifier since each amplifier is isolated from the primary power source by an integral transformer coupled DC to DC converter (see block diagram above).

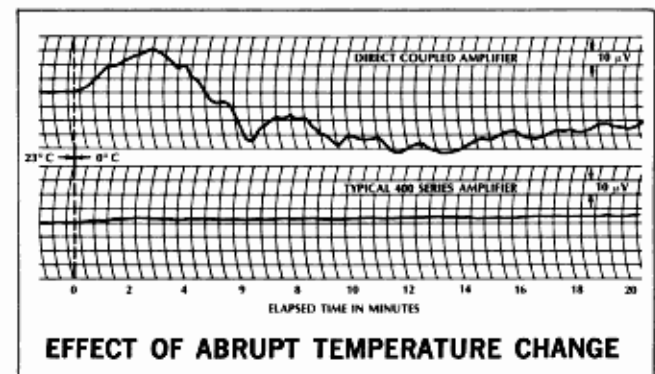
TEMPERATURE STABILITY

Ectron Series 400 Amplifiers have a "built-in" temperature stability that does not require delicate balancing of large, offset-producing components.

Direct-coupled amplifiers, by contrast, depend on temperature compensation circuits to balance the characteristics of transistor pairs. The technique is reasonably effective for gradual temperature changes, but provides an ineffective solution to the problems that occur when the operating environment is changing rapidly.

Temperature shifts of this type can occur during warmup, with changes in altitude or even when a single amplifier is removed from the rack and there is a resulting change in the airflow through the system.

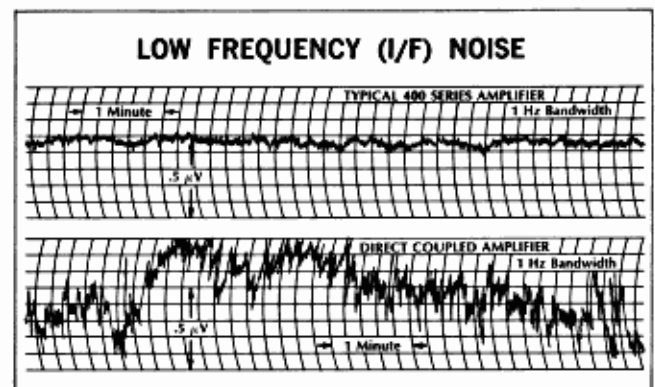
The recording below compares the zero stability of a 400 series amplifier with a direct coupled amplifier when the temperature is changed abruptly from 23°C to 0°C . This illustrates why direct coupled amplifiers do not include "dynamic zero stability" as a specification item.



LOW 1/F NOISE

In very low level, high resolution systems, the noise generated by the amplifier becomes a significant factor in determining the accuracy that can be achieved. In narrow band systems, the use of low pass filtering is helpful but its effectiveness in amplifiers is limited by a low frequency component referred to as 1/f noise. Well designed chopper amplifiers such as the 400 series are significantly superior in this area.

A comparative recording of the 400 series and a direct coupled amplifier is shown below. Since very low frequency phenomena is illustrated, the chart speed is slow and both outputs are prefiltered with a low-pass 1 Hz filter.



THERMOCOUPLE AMPLIFIERS

GENERAL DESCRIPTION

Series 400 amplifiers are available with reference junction compensation for thermocouple inputs. This feature is identified by the letter "T" ahead of the basic model designation, i.e., T414, T418, etc. A suffix is then added which identifies the standard options to be included. These are selected from the same options offered on strain gage or general purpose models. The only exception is that options M, U and W cannot be included in thermocouple amplifiers. A typical model designation (partial) would be T414AKTX.

After completing the selection of options a hyphen is then added to the model number. This is followed by a letter indicating the thermocouple type (i.e., K is Chromel-Alumel) and the letter C or F (Centigrade or Fahrenheit). A final hyphen is then added followed by the "zero set point" in degrees. A typical complete model would be T418AKTY-TC-O. The last portion of this nomenclature identifies a type T thermocouple and zero degrees Centigrade as the zero set point.

The zero set point is the temperature of the measurement thermocouple which produces zero output from the amplifier. In many cases this is 0°F or 0°C but it can be factory set for any positive or negative temperature. The table below lists the standard zero set points which can be chosen. Others can be supplied on special order.

The set point table also includes the accuracy of the reference junction compensation over a range of ambient temperatures. Specifications include the zero temperature coefficient of the amplifier and apply over a span of $\pm 25^\circ\text{C}$ from a calibration temperature of 25°C . Improved accuracy can be offered for narrower ranges of ambient temperatures or conversely the compensation can be optimized for a wider range with reduced accuracy. The limits in the latter case are -55°C to $+90^\circ\text{C}$. A factory quotation is required for special ambient temperature spans.

The preceding noted that the zero temperature coefficient of the amplifier was included within the specification given for the reference junction stability. This statement applies when the amplifiers are being used with direct thermocouple inputs but does not apply when they are used as conventional millivolt amplifiers. In this mode, the reference junction compensation is de-activated and the zero stability becomes the same as the units general purpose counterpart, i.e., the temperature coefficient of a T414AKTY-TC-O would be the same as a 414AKTY.

For performance specifications other than zero stability with thermocouple inputs, the specifications of the general purpose counterparts apply (T414 --- versus 414 ---, etc.). A general exception to this is bandwidth. Unless otherwise specified, the bandwidth of thermocouple amplifiers is nominally limited to 10 Hz

by a three-pole, low pass filter. If a wider bandwidth is desired, it can be provided at extra charge (up to 3 KHz). A second exception is gain accuracy of the model T418. This is not a controlled parameter since the vernier gain control is active at all times.

Physical Description, Model T414

These models are completely self-contained and the thermocouple input is made through 18 inch pigtail leads of thermocouple extension wire. The amplifier will also accept standard millivolt input signals. Except for the thermocouple extension wire, all models are physically identical to the models 414 and 434, respectively.

Physical Description, Model T418

This unit is physically identical to the general purpose 418 except that the vernier in-out switch is replaced with a switch which turns the internal reference junction circuits on and off. With this switch off, the T418 accepts conventional millivolt input signals.

When the internal reference circuits are activated, the T418 indirectly performs the function of thermocouple reference junction compensation. The physical reference junction occurs on a model 683 Universal Thermocouple Adapter. This adapter screws into the input connectors at the rear of the appropriate 400 series mounting enclosure. It contains a temperature sensitive element which is connected into the T418 through the enclosure wiring. This sensing device combines with the T418 circuits to provide stable reference junction compensation.

The proper enclosure for the T418 is model R418-7. This enclosure accepts up to 14 model T418's or 418's in any combination. A model 683 adapter must be procured for each thermocouple channel but mating connectors for non-thermocouple inputs are supplied with the enclosure. Any channel can be used for thermocouple, strain gage or millivolt inputs by simply choosing between the thermocouple adapter or the conventional mating connector.

Other enclosures, accessories and/or features may be added to this series between printings of this brochure. These will be included and briefly described in Bulletin 2070 (price list) which is regularly updated.

STANDARD ZERO SET POINTS & REFERENCE STABILITY

Thermocouple Types	E	J	K	T
Set Points				
0°C	Yes	Yes	Yes	Yes
0°F	Yes	Yes	Yes	Yes
-300°F	Yes*	No	Yes*	Yes*
-200°C	No	No	No	Yes*
Reference Stability				
@ 25° ± 25°C				
Models T414 & T418 ± 75°C	± 1°C	± 1.2°C	± 1.4°C	

* Requires factory quotation

DC POWER, AMPLIFIERS	Option X	Option Y
Voltage	24 to 32V DC	10.5 to 15V DC
Current, Nominal		
Basic Amplifier	50 mA + load	90 mA + 2X load
Option P (RTI Zero)	30 mA	60 mA
Option W (Excitation)	5 mA + load	10 mA + 2X load
T414, T418	80 mA	150 mA
Reflected AC less than 5 mA peak into 1 ohm source		

OUTPUT— See Ordering Information For Options	
Isolation	Transformer isolated from input and power. Each amplifier can operate grounded or floating regardless of common supply.
Voltage	±10V DC or peak AC
Current	4 mA @ 10V, 10 mA @ 5V
Impedance	1 ohm max. DC to 3 KHz
Capacitive load	0.02 μf for full output
Short Circuit	No damage with short circuit

GAIN	
Model 418	
Steps	Front panel switch selects steps of 10, 20, 50, 100, 200, 500, 1000 (.5% accuracy)
Vernier	Gain multiplier adjustable x 1 to >x 2.5
Models 414, 434	Continuously adjustable from 20 to 1000 by 4 fixed steps (jumpers in connectors) plus 20 turn vernier.
Gain Stability, Time	
Models 414, 418	± .02% for 200 hours
Model 434	± .08% for 200 hours
Gain Stability, Temp.	
Models 414, 418	± .01%/°C
Model 434	± .04%/°C

DIMENSIONS, ENVIRONMENT	
Storage Temperature, All Models	-60°C to +125°C
Operating Temp.	
Models 414, 418	-25°C to +71°C
Model 434	-20°C to +60°C
Relative Humidity	100% per MIL-E-5272C
Altitude	No limit
Static Acceleration	100 G's (except 418)
Shock (6 ms sawtooth)	100 G's (except 418)
Vibration	
5 Hz to 55 Hz	0.12" DA (except 418)
55 Hz to 2 kHz	20 G's (except 418)
Case Dimensions, 418, less panel	1.125" W, 2" H, 4" D, plus connector
414,434 (Option I adds 1")	2" W, 1.1" H, 3" D, plus connector
Weight	Model 418, 9 oz.—others 7 oz. nominal
Connector	DAM-15P (DAM-15S mate supplied)

DYNAMIC RESPONSE	
Frequency Response	±5% DC to 3 KHz to full output
Linearity	±.05% except 434 is 0.1%
Overload Recovery from 10 times FS but less than 17 volts	5 ms to .1% FS

COMMON MODE	
Voltage, Operating	100V DC or peak AC
CMR, DC 100 ohm unbal.	140 dB
60 Hz, Balanced	120 dB
60 Hz, 100 unbal.	100 dB
400 Hz, Balanced	100 dB
400 Hz, 100 unbal.	90 dB

ZERO OPTIONS	Option M	Option K	Option P
Zero Controls, RTI*	Passive Bridge Bal.	None	±40 mV
RTO*	±100 mV		None
Zero Stability, Static			
Time, 200 hours, Models 414, 418	±2 μV RTI, ±200 μV RTO		±4 μV RTI, ±200 μV RTO
Model 434	±6 μV RTI, ±200 μV RTO		±8 μV RTI, ±200 μV RTO
Per degree C	Models 414, 418		
Models 434	±0.5 μV RTI, ±200 μV RTO		±1.5 μV RTI, ±200 μV RTO
Models 434	±1.5 μV RTI, ±300 μV RTO		±4 μV RTI, ±300 μV RTO
Per degree C, Bridge Bal. (% of bal. range)	±.005%	N/A	N/A
Zero Stability, Dynamic (abrupt temp. chg.)	Static Temperature Specification Times 2		
Zero Stability, with power line change	0.2 mV RTO shift with power line change of 1%		

BRIDGE EXCITATION	Option T	Option U	Option W
Type of Regulation	No Excitation	Constant Voltage	Constant Voltage
Fixed output level			
28V Models (Option X)	N/A	3 to 15 V	3 to 10 V
12V Models (Option Y)	N/A	3 to 7 V	3 to 10 V
Accuracy of Fixed level	N/A	1%	1%
Maximum Output Current	N/A	100 mA	33 mA
Regulation, no load to full load	N/A	0.1%	0.1%
Over Range Capability	N/A	NONE	50 mA, derate regulation by 2
Noise	N/A	1 mV RMS	
Temperature Coefficient			
Models 414, 418	N/A	±.005%/°C	±.005%/°C
Model 434	N/A	±.02%/°C	±.02%/°C
Isolated or Grounded (Pwr line comm.)	N/A	Grounded	Isolated

NOISE	
Definition	Noise specifications apply when measured with a bandpass system with first order roll offs adjusted for -3 dB at 0.1 Hz and the upper frequencies listed below.
Peak, 3 Sigma	Models 414, 418 Model 434
10 Hz, RTI	1 μV 2 μV
RTO	1 mV 2 mV
50 KHz, RTI	5 μV 10 μV
RTO	2.5 mV 5 mV

INPUT CHARACTERISTICS	
Configuration	True differential, transformer isolation between input, output power. Can operate from isolated source.
Input Impedance	100K ohms min., Models 414, 418. 50K ohms min., Models 434.
Signal Source	All specifications apply with a fixed source resistance of 0 to 500 ohms.
Max. Input Signal	
To meet specs	0.5V DC or peak AC.
Overload	17V DC or peak AC Max.
Common Mode Voltage	100V DC or peak AC.

*RTI is Referred to Input. RTO is Referred to Output.

SIGNAL CONDITIONING SYSTEMS

Thousands of Ectron 400 Series Amplifiers are presently in service in many diversified applications. Many of these were delivered as portions of multi-channel signal conditioning systems specifically tailored for a particular job. There is a wide selection of such systems which can be duplicated without costly engineering charges or perform in new applications with only minor modifications. A few of the custom features built into these systems include: Data during 100 G impact — RFI protection — Uninterruptable service — Overload indicators and Alarms — Monitor meters and Selection Switches — Special Filters and Gains — Solid state Calibration Switches — Special Filters and Gains — Solid state Calibration Circuits.

Two typical signal conditioning systems are described below. For additional information or applications assistance, contact your local Ectron representative listed below.

Model 4001, Signal Conditioning System

The typical 4000 series signal conditioning system shown below is designed for airborne, vehicular or marine service involving moderate G forces. It accommodates up to 14 stable 400 series amplifiers and includes a monitor meter, individual CAL switches on each channel and is wired to accept amplifiers with integral bridge excitation supplies. The channel selector switch chooses one of the 14 channels and the switch associated with the monitor meter permits the excitation voltage to be read or the amplifier's output can be observed on one of three full scale



ranges: 50 millivolts, 500 millivolts or 5 volts.

Individual input connectors are provided for each channel on the right hand side of the system. These are normally WK-5 twist-lock type connectors and mating connectors are supplied. Fourteen individual XLR Series output connectors are provided across the top. Also included in this area are replaceable calibration resistors for each channel. The system comes equipped with handle and detachable covers to prevent damage during transit. Nominal system dimensions are 14" x 9" x 9".

Model 4020

This system (not shown) was designed for operation under extremely high shock and vibration levels. It actually functions and delivers reliable data during a 100 G shock. It is intended and has reliably performed in automobile crash testing where vehicles are deliberately impacted at speeds up to 60 miles per hour. The system includes 14 custom 400 series amplifiers and an isolated solid state calibration circuit. The system includes space and wiring for integral VCO's.

The system is designed for floor mounting in the trunk or rear seat area of a vehicle. Options available include VCO package and rechargeable battery pack. Consult the factory for your specific application.

ORDERING INFORMATION

STRAIN GAGE AND GENERAL PURPOSE AMPLIFIERS

Model 434 Basic Amplifier, less options
 Model 414 Basic Amplifier, less options
 Model 418 Basic Amplifier, less options

THERMOCOUPLE AMPLIFIERS

Model T414 Basic Amplifier, less options
 Model T418 Basic Amplifier, less options
 Model 683 Thermocouple Adapter (for T418)

OPTIONS SELECT ONE OPTION FROM EACH GROUP

Output:

- A. $\pm 10V$ per specification sheet
- B. Limited to -0.8 and $+6$ volts
- D. ± 5 volts @ 100 mA. Add 0.05% to linearity spec. (For model 418 only)

EMI Filter

- I. add EMI/RFI filtering (Not available with option "O")

Zero controls

- K. ± 100 mV RTO Zero control.
- M. Same as "K" plus bridge balance.
- O. Auto Zero (Deletes Vern. Gain In/Out Switch)
- P. ± 40 mV RTI Zero suppression with coarse and fine controls

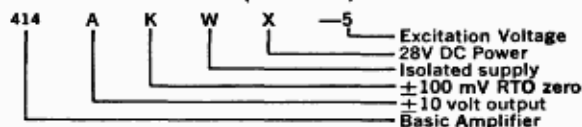
Excitation:

- T. No excitation supplied.
- U. 100 mA supply.
- W. Isolated supply.

Supply Voltage:

- X. 28V DC $\pm 4V$
- Y. 12V DC (10.5 to 15)

TYPICAL COMPOSITE MODEL (414AKWX-5)



R418 ENCLOSURES

For 418 amplifiers, standard 19" rack mounting, 3.5 inches high by 12.5 inches deep.

Model No.	AC Input Voltage	DC to Amplifiers
R418-7AX	No internal ac supply	28V
R418-7AY	No internal ac supply	12V
R418-7BX	115V	28V
R418-7CY	115V	12V
R418-7DX	230V	28V
R418-7EY	230V	12V

418-278-11 3.5 inch filler panels (single channel)

Prices and Specifications subject to change without notice.



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Represented by:

OTHER ECTRON PRODUCTS: Premium Wideband Amplifiers — Brochure 2003 • Economy DC Amplifiers — Brochure 2004 • Industrial Signal Conditioners — Brochure 2005 • Thermocouple Simulator/Calibrators — Brochure 2006 and 2012