

# MODEL 441A FREQUENCY-TO-VOLTAGE CONVERTER



### FEATURES

- 1 Hz to 50 kHz Frequency Range
- Fast Response
- Crystal-controlled Accuracy
- Digital Periodic Filter
- Adjustable Input Sensitivity and Filtering
- Front-panel Display of Frequency to 5 Digits
- Precise Control of Output Voltage vs. Input Frequency
- Automatically Accepts 10 mV to 100 V Input Signal Range
- Output Noise Independent of Frequency

### APPLICATIONS

- Engine Monitoring
- ABS Evaluation
- Cruise-control Test
- Drive-line Analysis
- Overspeed Monitor/Control
- Failure Analysis
- Governor Studies
- Flow Meters



**With Exclusive Digital Periodic Filter**

# GENERAL DESCRIPTION

The Model 441A produces an analog output that precisely represents the frequency of an applied input signal. Adjustable “input frequency to output voltage” set points allow the user to closely bracket the frequency of interest.

A unique crystal-controlled microcontroller design provides fast response, high conversion accuracy, and low output noise that is independent of frequency. The front-panel display shows the input frequency with up to five-digit resolution. All operating parameters are set using the display and one other front-panel control. The input signal conditioner automatically provides stable operation for a wide range of pulse-, square-, and sine-wave signals from under 10 millivolts to 100 volts in amplitude. Three selections of input sensitivity and input bandwidth are provided, plus a unique digital periodic filter that cancels unwanted output variation caused by an input signal whose frequency varies in a periodic manner.

# FEATURES

The Model 441A combines the latest electronic microcontroller technology with surface-mount construction to produce a true breakthrough in frequency-to-voltage products. Indeed, this instrument represents a worthy addition to the Ectron line of 400 Series products that have provided exceptional performance and reliability in rugged applications for the past 25 years.

Designed into the Model 441A are rapid response to any change in frequency, low output noise that is independent of input frequency, and input-signal conditioning that automatically provides correct operation for a great variety of input signals, both in wave shape and amplitude. Included is a selectable digital filter which eliminates output noise due to the effects of an input signal whose frequency varies in a periodic manner. Setting the digital filter to the number of input pulses per revolution of a rotating device eliminates the periodic variation and provides a much more precise frequency conversion.

Gone is the clutter of switches, knobs, pots, etc. associated with other frequency-to-voltage converters. All that has been replaced with two easy-to-use, front-panel controls: the display and the encoder.

The backlit digital display/push button has the dual function of display and screen selection. Seven easy-to-use setup screens, six less frequently used screens, and the operate screen are accessible at the touch of the display.

The encoder, a rotary/push-button control, has the dual function of character selection and change. The user can easily configure the Model 441A to any specific application desired.

With an input frequency range of 1 Hz to 50 kHz and an output voltage range of -10 to +10 V, the Model 441A offers precise frequency-to-voltage conversion for almost any application.

Because the Model 441A operates from any dc power from 10.5 to 32 V, uses the same connector, and has the same pin assignments for signal input, output, and power as all other Ectron 400 Series products, it can be used — even intermixed — with Models 352, 418, and 428 Amplifier/Conditioners in all standard Ectron enclosures designed for these products.

# SPECIFICATIONS

## INPUT

**Configuration:** Differential with a common-mode-voltage rating of up to 100 V dc or peak ac.

**Impedance:** 200 k $\Omega$  in parallel with 300 pF nominal.

**Frequency Range:** 1 Hz to 50 kHz.

**Sensitivity and Filtering:** Three steps of input sensitivity and three steps of input filtering are provided to optimize input signal-to-noise ratio.

## Square- and Sine-wave Amplitude

**Range:** 10 mV to 100 V peak.

**Pulse Amplitude Range:** 40 mV to 100 V peak (2.5% to 97.5% duty cycle, 5  $\mu$ s minimum pulse width).

## Response to Rapid Change in

**Amplitude:** The Model 441A will recover and provide the proper output within  $0.2s + 1/f_{in}$  following a 10:1 change in amplitude of the input signal, where  $f_{in}$  is the frequency of the input signal.

## OUTPUT

**Voltage:** The linear range of the analog output is from -10 V to +10 V with up to 10 mA current. The output limits are approximately  $\pm 10.5$  V. Output voltage versus frequency is determined by voltage and frequency set points.

## Uncertainty:

Within  $\pm 0.0022 V + \left( \frac{f_{in}}{2 \times 10^4} \times \frac{V_U - V_L}{f_U - f_L} \right)$  where  $f_{in}$  is the input frequency and  $V_U$  and  $V_L$  are  $f_U$  and  $f_L$  are the upper and lower voltage and frequency settings of the instrument, respectively.

**Resolution:** For input frequencies above 1 kHz, resolution in volts at the output is:

$0.0012 V$  or  $\left( \frac{f_{in}^2}{1500F} \times \frac{V_U - V_L}{f_U - f_L} \right)$  whichever is greater, where  $f_{in}$  is the input frequency,  $F$  is  $f_{in}/1000$  rounded down to the nearest integer,  $V_U$  and  $V_L$  are the voltage setting and  $f_U$  and  $f_L$  are the frequency settings.

For input frequencies at or below 1 kHz, the resolution at the output is:

$0.0012 V$  or  $\left( \frac{f_{in}^2}{1.5 \times 10^6} \times \frac{V_U - V_L}{f_U - f_L} \right)$  whichever is greater, where  $f_{in}$  is the input frequency,  $V_U$  and  $V_L$  are the

voltage setting, and  $f_U$  and  $f_L$  are the frequency settings.

**Impedance:** Less than 1  $\Omega$  at dc.

**Noise:** Less than or equal to 10 mV p-p independent of input frequency.

(Measured with a bandwidth of 0.1 Hz to 1 MHz.) For slower rise-time signals such as sine waves, output noise depends on input-signal noise and amplitude since accurate timing is hampered by noise.

**Response Time:** Response to an abrupt frequency change is  $0.005 s + 1/f_{in}$ , where  $f_{in}$  is the frequency of the input, with the filter set to wideband. For other filter frequencies add  $5/f_{co}$ , where  $f_{co}$  is the filter cutoff frequency.

**Update Rate:** 1 ms or  $1/f_{in}$ , where  $f_{in}$  is the frequency of the input, whichever is a longer period of time.

**Filter:** Selectable output filter frequencies of 1, 10, and 100 Hz plus wideband (approximately 1.5 kHz). The filter has a two-pole Bessel characteristic.

## FREQUENCY-TO-VOLTAGE CONVERSION

**Conversion Circuit:** Following the input conditioner-agc circuit, a microcontroller converts the input frequency to equivalent analog using a unique algorithm. The output is then scaled to a 14-bit DAC based on the user-controlled frequency and voltage set points.

## Upper- and Lower-Frequency Set

**Points:** These set points determine the input frequency at which the upper- and lower-voltage set points are reached. The frequency set points can be any two frequencies between 0 Hz and 50 kHz with a resolution of 1 Hz. (The upper- and lower-frequency set points can be within 10 Hz of each other.)

## Upper- and Lower-Voltage Set Points:

These set points determine the output voltages corresponding to the upper- and lower-frequency set points, respectively. The voltage set points may be any voltage from -10 V to +10 V with a resolution of 0.1 V. (The upper- and lower-voltage set points can be within 0.1 V of each other.)

**Digital Periodic Filter:** Selectable, from 1 to 999 pulses per revolution, this periodic filter eliminates output noise and periodic wander caused by irregularly spaced wheel cogs, unequally spaced pick-ups, run-out problems and periodic amplitude/frequency modulation for input frequencies up to 1 kHz.

## CALIBRATION

When in the CAL mode of operation, an internally generated calibration signal can be set to any frequency between 0 Hz and 50 kHz in 1-Hz increments. When enabled, the analog output

assumes a value according to the frequency and voltage set points. The calibration signal can be activated only when in the CAL mode. It can be used for system linearity check.

#### ALIGNMENT

Alignment of the Model 441A is performed using the  $-10\text{ V}$  and  $+10\text{ V}$  alignment modes. This calibration feature allows field alignment and calibration of the instrument using only a digital voltmeter.

#### INPUT POWER

**Range:** 10.5 to 32 V dc unregulated.  
**Overvoltage Protection:** Up to  $+60\text{ V}$  for 15 seconds,  $+32\text{ V}$  and  $-50\text{ V}$  continuous.

**Current (nominal):** 150 mA.

#### ENVIRONMENT

**EMI/RFI:** Internal RFI filters are provided on all connector leads.

**Operating Temperature:**  $0^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$ .

**Storage Temperature:**  $-40^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$ .

**Altitude:** No limit with adequate heat dissipation.

**Static Acceleration Resistance:**  $200\text{ m/s}^2$  (approximately 20 g) in any plane.

**Shock Resistance:**  $200\text{ m/s}^2$  (approximately 20 g), 11 ms in any plane.

**Vibration Resistance:**  $100\text{ m/s}^2$  (approximately 10 g) in any plane.

#### DIMENSIONS

**Height (panel):** 60.2 mm (2.37 in)

**Height (case):** 50.8 mm (2.00 in)

**Width:** 28.4 mm (1.12 in)

**Depth:** 101.6 mm (4.00 in)

**Weight:** 255g (9 oz.) nominal

**Connector:** DA-15P (mate DA-15S)

#### COMPATIBILITY

The Model 441A will operate in all standard Ectron enclosures designed for Amplifier/Conditioner Models 352, 418, T418 and 428. See back page.

#### FRONT PANEL

**Display:** The front-panel back-lit LCD display shows the input frequency and status of the periodic filter when in the operate position shown. Five digits of resolution are indicated even at lower frequencies.

When pressed, the display cycles through the following setup screens:

- (1) Upper- and lower-frequency set points
- (2) Upper- and lower-voltage set points
- (3) Periodic filter
- (4) Input sensitivity
- (5) Input bandwidth
- (6) Output filter
- (7) Calibration frequency
- (8)\* LCD view angle
- (9)\* Alignment,  $-10\text{ V}$
- (10)\* Alignment,  $+10\text{ V}$
- (11) Memory error
- (12) Alignment required
- (13)\* Reset

\*Screens (8), (9), and (10) are secondary setup screens accessed by pressing the display button for more than one second. When in screen (10), pressing the rotary switch for over one second displays screen (13). When a memory error occurs, screen (11) is displayed. Pressing any control when viewing screen (11) produces screen (12). Unless the  $-10\text{ V}$  and  $+10\text{ V}$  alignment settings have been reset following a memory error, screen (12) is displayed whenever the unit is powered up. Screen (13) allows the operator to reset all user-controlled parameters to their default values.

**Controls:** The display/push button allows the operator to sequence through the various setup screens. The second switch has both push-button and rotary action. The push button moves the cursor to the digit to be changed and the rotary switch is used to change the selected digit. All operating parameters are set using these controls in conjunction with the display.

**Input LED:** The green LED on the front panel indicates that a valid input signal is present and that the output represents the input frequency.

#### RETENTION OF SETTINGS

All settings of the Model 441A are retained in nonvolatile memory unless they are reset to default values by a memory error or the user commands a master reset.

*Specifications are subject to change without notice.*



Operate position displays the current input frequency using floating-point display and status of digital periodic filter.

### Screens

Operate position displays the current input frequency using floating-point display and status of digital periodic filter.



(1) Allows setting of upper- and lower-frequency set points. Frequencies between zero and 50 kHz can be set in 1 Hz increments.



(2) Allows setting of upper- and lower-voltage set points. Voltages between  $-10.0\text{ V}$  to  $+10.0\text{ V}$  can be set in 0.1 V increments.



(3) Allows selection of the digital periodic filter and number of periodic pulses, 1 to 999, per revolution.



(4) Allows one of three input sensitivities, MIN, MID, or MAX, to be selected. MIN 200 mV nom. MID 25 mV nom. MAX  $<10\text{ mV}$ .



(5) Allows one of three input bandwidths, MIN, MID or MAX, to be selected. MIN 10 Hz NOM. MID 500 Hz NOM. MAX  $>50\text{ kHz}$



(6) Allows selection of output filter cutoff frequency of 1, 10, or 100 Hz. Wideband (approximately 1.5 kHz) is also available.



(7) Allows setting of calibration frequency between zero and 50 kHz in 1 Hz increments. Calibration can be turned on and off.



(8) Allows setting of the optimum display viewing angle.



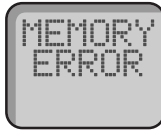
(9) Allows alignment of the analog section at  $-10\text{ V}$  using a voltmeter connected to the output.



(10) Allows alignment of the analog section at  $+10\text{ V}$  using a voltmeter connected to the output.



(11) This screen is displayed if the data in the internal nonvolatile memory is corrupt. Pressing any front-panel control will clear this screen and reset the internal memory to default values.



(12) After resetting internal memory to default values (either through a memory error or through the RESET screen) and until both the minus and plus ten-volt alignment points have been adjusted, this screen is displayed each time the unit is turned on.



(13) Allows resetting the internal nonvolatile memory to default values.



# Model 441A Frequency-to-voltage Application

Using a fifth-wheel speed detector having an output of 10 pulses per foot and speeds from 1 to 120 mph produces 14.7 to 1760 pulses per second.

To set up the Model 441A, simply enter appropriate frequency and voltage ranges. To give some margin, the upper and lower frequencies could be set to 1800 and 0 Hz respectively. The upper and lower voltage setting could be 10 and 0 V, if that fits the voltage range of the instrumentation that follows. However, if a different voltage range is desired, the output limits could be set to +5 V and -5 V or even +8.6 V and +1.4 V if needed. The output filter could be set to its low end if fast speed variations were of no interest.

Perhaps the application requires monitoring the speed variations of a cruise control while operating at 60 mph. If minimum speed is 55 mph and maximum is 65 mph, the lower and upper frequencies of the Model 441A could be set to 806 and 954 Hz. The corresponding output voltage limits would be set to the requirements of the load device, say 0 and 10 V. At 60 mph, the output would be 5.0 V, and a one-mile-per-hour speed variation would produce an output change of 1 V. If it would be helpful to have the output voltage correspond to miles per hour, the lower voltage could be set to 5.5 V and the upper to 6.5 V. Then 55 mph would correspond to 5.5 V, 65 mph would correspond to

6.5 V, and a change of 1 mile per hour would produce a change of 0.1 V at the output of the Model 441A.

Changes can be quickly and precisely made using the front-panel controls and digital readout. Frequency can be set to within 1 Hz over the total 50-kHz range; output voltages can be set to within 0.1 V over the  $\pm 10$  V range.

If either the upper or lower frequency setting is exceeded, the Model 441A will continue to indicate the correct input frequency on the readout until it exceeds 62 kHz or is less than 1 Hz.

## ENCLOSURES

### COMPATIBILITY

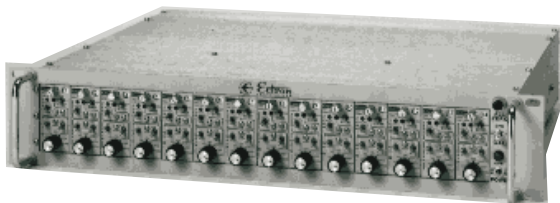
The Model 441A will operate in all standard Ectron enclosures designed for Models 352, 418, T418, and 428 Amplifier/Conditioners. These include Models E408, R408, 4001, and 4005 enclosures.



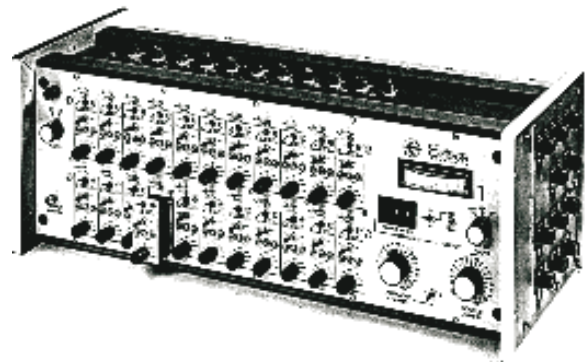
Model E408-6 Six-channel Portable Enclosure



Model 4001 Fourteen-channel Ruggedized Portable Enclosure



Model R408-14 Fourteen-channel Rack-mount Enclosure



Model 4005 Twenty-two-channel Ruggedized Portable Enclosure



8159 Engineer Road, San Diego, CA 92111  
Telephone:(858) 278-0600 • Fax:858-278-0372  
E-mail: sales@ectron.com  
Visit our Web site: <http://www.ectron.com>

**Call Toll Free (800) 732-8159**

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