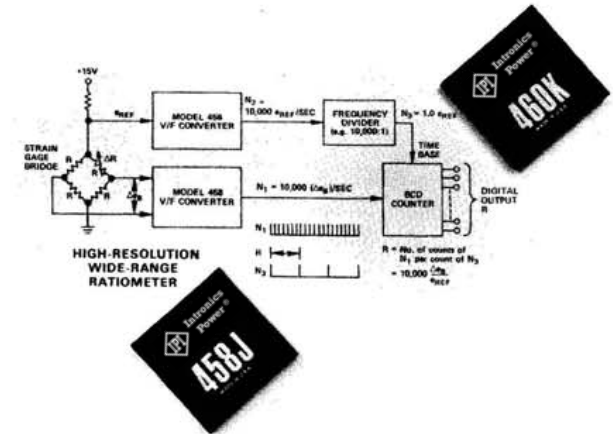


FEATURES

- High Stability:** 5ppm/°C max, Model 458L
15ppm/°C max, Model 460L
- Low Nonlinearity:** 100ppm max, Model 458
150ppm max, Model 460
- Versatility:** Differential Input Stage
Voltage and Current Inputs
Floating Inputs: ±10V CMV
- Wide Dynamic Range:** 6 Decades, Model 460
- TTL/DTL Compatible Output**

APPLICATIONS

- Fast Analog-to-Digital Converter
- High Resolution Optical Data Link
- Ratiometric Measurements
- 2-Wire High Noise Immunity Digital Transmission
- Long Term Precision Integrator



GENERAL DESCRIPTION

Models 458 and 460 are high performance, differential input, voltage to frequency modular converters designed for analog to digital applications requiring accuracy and fast data conversion. Model 458 offers a 100kHz full scale frequency, guaranteed nonlinearity of ±0.01% maximum over five decades (1Hz to 100kHz) of operation and guaranteed low maximum gain drift in three model selections; model 458L: 5ppm/°C max; model 458K: 10ppm/°C max; and model 458J: 20ppm/°C max. Model 460 offers a 1MHz full scale frequency, guaranteed maximum nonlinearity of ±0.015% over six decades (1Hz to 1MHz) of operation and guaranteed low maximum gain drift in three selections; model 460L: 15ppm/°C max; model 460K: 25ppm/°C max; and model 460J: 50ppm/°C max. Model 460L is the industry's first 1MHz V/F converter to offer 15ppm/°C maximum gain drift.

The differential input stage of models 458 and 460 provide the versatility of either direct interface to off-ground 0 to +11V input signals with common mode voltages (CMV) to ±10V, as well as ground referenced positive, 0 to +11V or negative, 0 to -11V signals. Both models also accept positive current signals: 0 to +0.5mA, model 458; 0 to +1mA, model 460 for current to frequency (I/F) applications.

The rated performance of both models 458 and 460 is achieved without the need for external components or adjustments. Optional adjustments are available for trimming full scale frequency and the input offset voltage.

WHERE TO USE MODELS 458 AND 460

The combination of low gain drift, low nonlinearity and the versatility of a differential input with both high speed (100kHz/1MHz) models, offer excellent solutions to a wide variety of demanding applications; in high speed remote data acquisition systems — two wire data transmission over long

wires; in 5½ digit DVM's — featuring high resolution A/D conversion, monotonic performance, no missing codes and high noise rejection; in strain gage bridge weighing applications — accurate ratiometric measurements over wide dynamic range.

DESIGN APPROACH - PRECISION CHARGE BALANCE

Models 458 and 460 incorporate a superior charge balance design that result in high linearity and temperature stability - see Figure 1. Both models accept unipolar, single-ended voltage or current input signals directly. By offsetting the input using the current terminal, models 458 and 460 will accept bipolar input voltages up to ±5V.

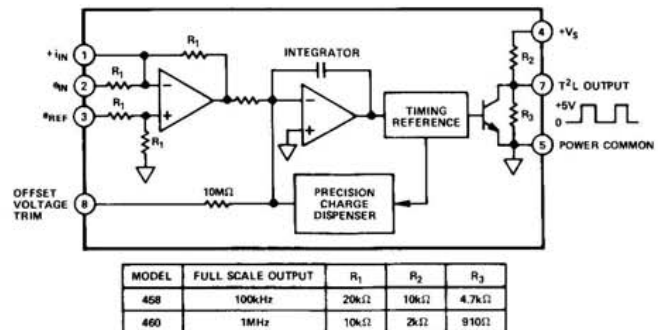


Figure 1. Block Diagram - Models 458, 460

SPECIFICATIONS (typical @ +25°C and $V_S = \pm 15\text{VDC}$ unless otherwise noted)

MODEL	100kHz Full Scale 458			1MHz Full Scale 460		
	J	K	L	J	K	L
TRANSFER FUNCTION Voltage Input Current Input	$f_{\text{OUT}} = (10^4 \text{ Hz/V}) e_{\text{IN}}$ $f_{\text{OUT}} = (2 \times 10^5 \text{ Hz/mA}) i_{\text{IN}}$			$f_{\text{OUT}} = (10^5 \text{ Hz/V}) e_{\text{IN}}$ $f_{\text{OUT}} = (10^6 \text{ Hz/mA}) i_{\text{IN}}$		
ANALOG INPUT Configuration Voltage Signal Range e_{IN} Terminal ($e_{\text{REF}} = 0$) e_{REF} Terminal ($e_{\text{IN}} = 0$) Differential ($e_{\text{IN}} - e_{\text{REF}}$) Overrange Current Signal Range (i_{IN}) Common Mode Voltage Common Mode Rejection Impedance, e_{IN} Terminal e_{REF} Terminal i_{IN} Terminal Max Safe Input	Differential 0 to +10V dc min 0 to -10V dc min 0 to +10V dc min +10% min 0 to +0.5mA min $\pm 10\text{V}$ 40dB 20k Ω 40k Ω 0 Ω $\pm V_S$			Differential 0 to +10V dc min 0 to -10V dc min 0 to +10V dc min +10% min 0 to +1mA min $\pm 10\text{V}$ 40dB 10k Ω 20k Ω 0 Ω $\pm V_S$		
ACCURACY Warm Up Time Nonlinearity, $e_{\text{IN}} = +0.1\text{mV}$ to +11V $e_{\text{IN}} = -0.1\text{mV}$ to -11V Full Scale Error ¹ Gain vs. Temperature (0 to +70°C) vs. Supply Voltage vs. Time Input Offset Voltage ² vs. Temperature (0 to +70°C) vs. Supply Voltage vs. Time	5 Seconds to 0.01% $\pm 0.01\%$ of Full Scale, max $\pm 0.01\%$ of Full Scale +0.1% to +2%, max $\pm 20\text{ppm}/^\circ\text{C}$ max $\pm 10\text{ppm}/^\circ\text{C}$ max $\pm 5\text{ppm}/^\circ\text{C}$ max $\pm 15\text{ppm}/\%$ $\pm 10\text{ppm}/\text{day}$ $\pm 10\text{mV}$ max $\pm 30\mu\text{V}/^\circ\text{C}$ max $\pm 10\mu\text{V}/\%$ $\pm 20\text{ppm}/\text{day}$			2 Minutes to 0.02% $\pm 0.015\%$ of Full Scale, max $\pm 0.015\%$ of Full Scale +0.1% to +2%, max $\pm 50\text{ppm}/^\circ\text{C}$ max $\pm 25\text{ppm}/^\circ\text{C}$ max $\pm 15\text{ppm}/^\circ\text{C}$ max $\pm 25\text{ppm}/\%$ $\pm 10\text{ppm}/\text{day}$ $\pm 10\text{mV}$ max $\pm 30\mu\text{V}/^\circ\text{C}$ max $\pm 10\mu\text{V}/\%$ $\pm 10\text{ppm}/\text{day}$		
RESPONSE Settling Time, $\pm 0.01\%$ +10V Step Overload Recovery Time	3 Output Pulses Plus 2 μs 10ms			2 Output Pulses Plus 2 μs 1ms		
FREQUENCY OUTPUT ³ Waveform Pulse Width Rise and Fall Time Pulse Polarity Logic "1" (High) Level Logic "0" (Low) Level Capacitive Loading Fan Out Loading Impedance	TTL/DTL Compatible Pulses 5 μs 300ns/50ns Positive +2.4V min +0.4V max 500pF max 10 TTL Loads min 3k Ω (High State)			TTL/DTL Compatible Pulses 500ns 60ns/50ns Positive +2.4V min +0.4V max 500pF max 10 TTL Loads min 670 Ω (High State)		
POWER SUPPLY ⁴ Voltage, Rated Performance Voltage, Operating Current, Quiescent	$\pm 15\text{V}$ dc $\pm (13 \text{ to } 18)\text{V}$ dc (+25, -8)mA			$\pm 15\text{V}$ dc $\pm (13 \text{ to } 18)\text{V}$ dc (+25, -8)mA		
TEMPERATURE RANGE Rated Performance Operating Storage	0 to +70°C -25°C to +85°C -55°C to +125°C			0 to +70°C -25°C to +85°C -55°C to +125°C		
MECHANICAL Case Size Weight Mating Socket	2" x 2" x 0.4" 45 Grams AC1016			2" x 2" x 0.4" 45 Grams AC1016		

¹ Adjustable to zero using 500 Ω potentiometer.

² Adjustable to zero using 50k Ω potentiometer.

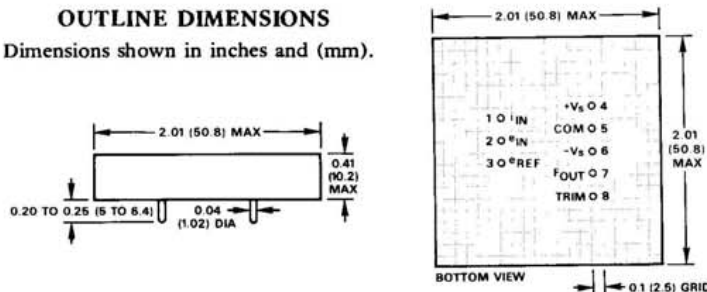
³ Protected for continuous short-circuits to ground and momentary (less than 1 sec) shorts to the + V_S supply. Output is not protected for shorts to the - V_S supply.

⁴ Recommended power supply, ADI model 904, $\pm 15\text{V}$ @ 50mA output.

Specifications subject to change without notice.

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).



MATING SOCKET: AC1016

Applying the Voltage to Frequency Converter

VOLTAGE TO FREQUENCY OPERATION

Models 458 and 460 provide accurate conversion of analog signals into a train of constant width and constant amplitude pulses at a rate directly proportional to the analog signal amplitude. The output continuously tracks the input signal, responding directly to changes in the input signal; external clock synchronization is not required. The output pulse train is TTL/DTL compatible, permitting direct interface to digital processing circuits.

BASIC V/F HOOK-UP AND OPTIONAL TRIMS

Models 458 and 460 can be applied directly to achieve rated performance without external trim potentiometers or other components. Figures 2, 3 and 4 below illustrate the basic wiring connections for either V/F converter model. Using the basic hookup without trims, full scale ($e_{IN} = 10V$) accuracy is +0.1% to +2% and the input offset voltage is $\pm 10mV$ max. The full scale and input offset voltage errors can be eliminated by using the FINE TRIM PROCEDURE.

FINE TRIM PROCEDURE

Connect the optional trims as shown in Figure 2, 3 or 4 and allow a five minute warm-up after initial power turn-on. Using a precision, stable voltage source, set the input voltage, e_S , to 10mV. Adjust the OFFSET trim, R_O , for an output pulse interval of 0.1 sec (model 458) or 0.01 sec (model 460).

Set the input voltage to +10.000V and adjust the FULL SCALE SCALE trim for an output pulse frequency of 100kHz (model 458), or 1MHz (model 460). The V/F converter may now be used without further adjustment.

DIFFERENTIAL INPUT

The e_{IN} and e_{REF} input terminals represent a true differential input capable of accepting a signal from a strain gage bridge, a balanced line, or a signal source sitting at a common mode voltage. The differential input eliminates the need for a differential amplifier to handle these signals.

To apply the 458 or 460 voltage inputs differentially, the e_{IN} pin must always be positive with respect to the e_{REF} pin as shown in Figure 4. The differential signal source may be completely floating with common mode voltages up to $\pm 10V$ max. For differential inputs the output frequency is:

$$F_{OUT} = \left[\underbrace{(e_1 - e_2)}_{\text{INPUT SIGNAL}} + \underbrace{\left(\frac{e_1 + e_2}{2} \right) \times \left(\frac{1}{CMR} \right)}_{\text{CMR ERROR}} \right] K_g$$

$$K_g = 10^4 \text{ Hz/V; model 458}$$

$$10^5 \text{ Hz/V; model 460}$$

OFFSETTING INPUT FOR BIPOLAR INPUTS

The input summing terminal, $+i_{IN}$, may be used to improve dynamic response as well as scale the output frequency to directly convert bipolar input voltages. An offset current is fed through an external resistor from a stable voltage reference. As shown in Figure 5, input voltages of $\pm 5V$ min can be converted directly.

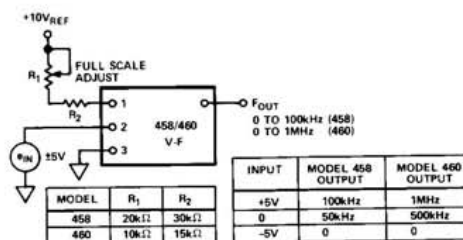
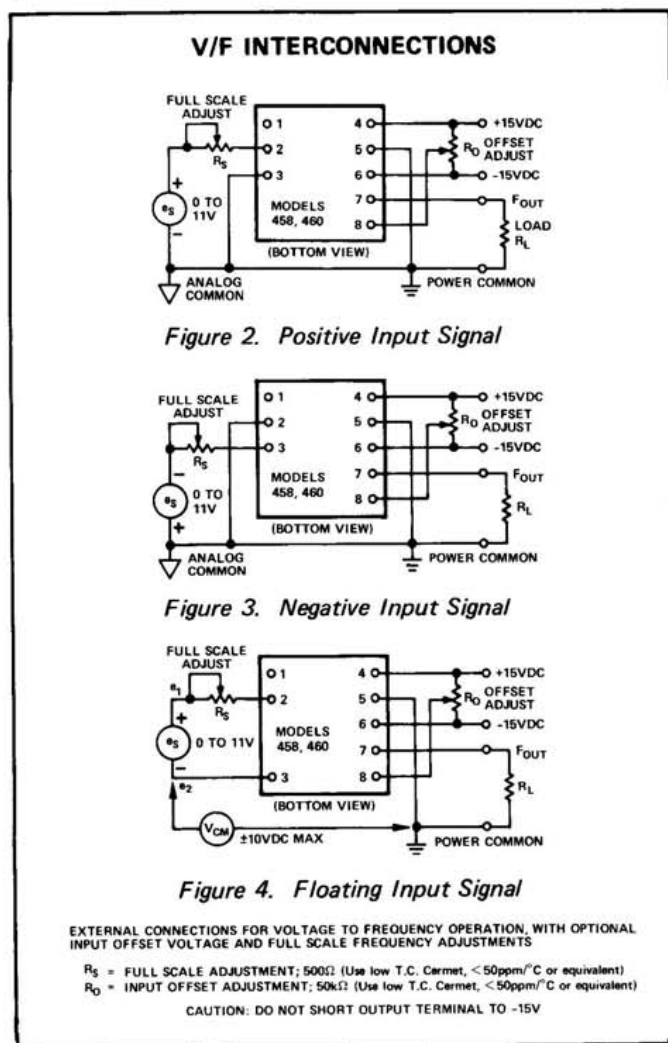


Figure 5. Offsetting Input to Accept $\pm 5V$ Bipolar Inputs

The output may also be scaled up so that low amplitude signals, such as 1V will give full scale output frequency; 100kHz model 458 or 1MHz model 460. By scaling the output frequency for low level signals, the step response will significantly improve. As shown in Figure 6 for model 458, the step response for a 1 volt input decreases from 200 μs before input scaling, to 20 μs with scaling.

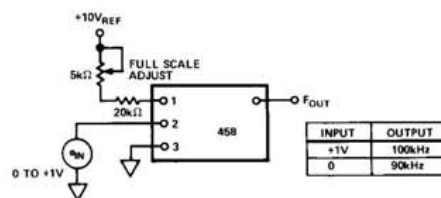


Figure 6. Offsetting Input to Achieve Improved Dynamic Response for Small Signal Inputs

PERFORMANCE SPECIFICATIONS

Nonlinearity: Nonlinearity error is specified as a % of 10V full scale input and is guaranteed over the 0.1mV to 11V operating signal range; $\pm 0.01\%$ max, models 458J/K/L, $\pm 0.015\%$ max, models 460J/K/L. Typical nonlinearity performance is illustrated in Figure 7.

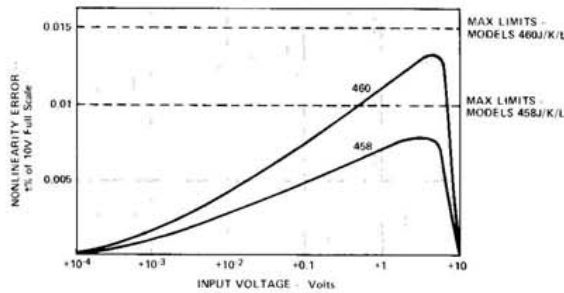


Figure 7. Nonlinearity Error Versus Input Voltage

Gain Temperature Stability: Gain drift is specified in ppm of output signal and is guaranteed for each model over the 0 to $+70^{\circ}\text{C}$ temperature range; $5\text{ppm}/^{\circ}\text{C}$ (458L), $10\text{ppm}/^{\circ}\text{C}$ (458K), $20\text{ppm}/^{\circ}\text{C}$ (458J), $15\text{ppm}/^{\circ}\text{C}$ (460L), $25\text{ppm}/^{\circ}\text{C}$ (460K) and $50\text{ppm}/^{\circ}\text{C}$ (460J) max.

LONG TERM PRECISION INTEGRATOR

In critical measurement applications, such as pollution monitoring where it is required to integrate for periods greater than 1 hour with overall accuracy of 0.05%, the V/F converter offers a superior low cost approach when compared to the traditional operational integrator circuit. As shown in Figure 8, the analog signal is applied to a precision input amplifier, model 52K and then to the V/F input. The V/F output is connected to a large capacity counter and display, operating as a totalizer. The total pulse count is equal to the time integral of the analog input signal. Since the output displayed is an accumulated pulse count, there is no integrator drift error. A feature of this approach is the infinite hold capability without errors due to time drift, since the counter may be held at any time without affecting the output reading.

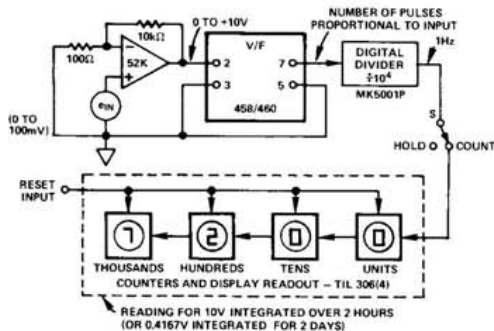


Figure 8. Models 458/460 as Long Term Integrator with Arbitrary Display Calibration. Frequency Division Ratio can Otherwise be Chosen to Provide Direct Readout in any Desired Units.

CMOS/HNIL COMPATIBLE OUTPUT

The circuit shown in Figure 9 may be used to shift the output of the 458/460 from 0 to +5V to 0 to +12V, to provide a 4V noise immunity for driving high noise immunity logic (HNIL) and CMOS logic.

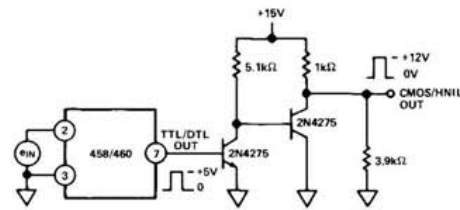


Figure 9. Circuit for Shifting the Output of the 458/460 to Drive CMOS/HNIL Logic

PRECISION HIGH CMV ANALOG ISOLATOR

By combining the V/F converter with a floating power supply and optical isolator as shown in Figure 10, accurate low level measurements in the presence of high common mode voltages may be achieved. Only the CMV rating of the optical isolator and the breakdown rating of the power supply limit the CMV rating. Using this approach for isolating transducers, ground loop problems are eliminated. Cost and complexity are minimized since only a single optical isolator is required to couple the serial pulse output from the V/F to the digital readout.

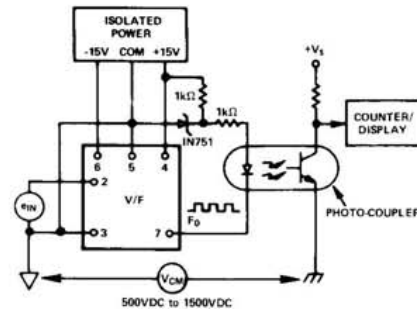


Figure 10. Optical Isolation Using LED Photo Isolator to Provide Up to 1500V dc CMV Isolation

APPLICATION IN DATA ACQUISITION SYSTEMS

High Noise Immunity Data Transmission: A method of accurately transmitting analog data through high noise environments is illustrated in Figure 11. This approach utilizes the self clocking output of models 458 and 460 and eliminates the need for costly additional twisted pair for external synchronization. Model 610 amplifies the low level differential transducer signal up to the 10V full scale V/F input level. A differential line driver is used to drive a twisted pair cable. The differential line driver and receiver offer high noise immunity to common mode noise signals.

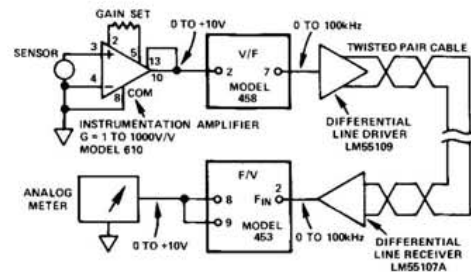


Figure 11. Application of Model 458 V/F Converter in a High Performance, High Noise Rejection Two-Wire Data Transmission System