High Accuracy, 100kHz and 1MHz Voltage to Frequency Converters

MODEL 485/460

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
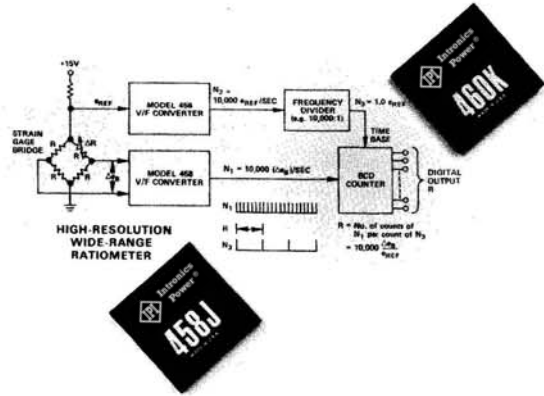
GENERAL DESCRIPTION

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.
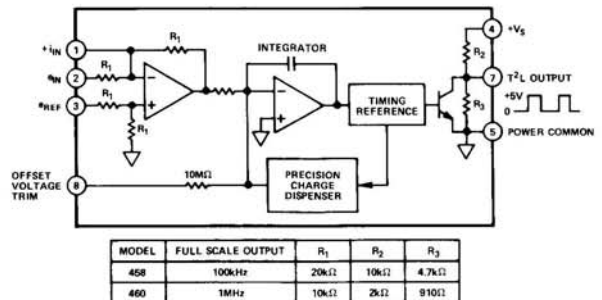

MODEL	FULL SCALE OUTPUT	R_1	R_2	R_3
458	100kHz	20kΩ	10kΩ	4.7kΩ
460	1MHz	10kΩ	2kΩ	910Ω

Figure 1. Block Diagram - Models 458, 460

SPECIFICATIONS (typical @ +25°C and $V_S = \pm15VDC$ unless otherwise noted)

MODEL	100kHz Full Scale 458 J	K	L	1MHz Full Scale 460 J	K	L
TRANSFER FUNCTION						
Voltage Input	$f_{OUT} = (10^4 \, Hz/V) \, e_{IN}$			$f_{OUT} = (10^5 \, Hz/V) \, e_{IN}$		
Current Input	$f_{OUT} = (2 \times 10^5 \, Hz/mA) \, i_{IN}$			$f_{OUT} = (10^6 \, Hz/mA) \, i_{IN}$		
ANALOG INPUT						
Configuration	Differential			Differential		
Voltage Signal Range						
e_{IN} Terminal ($e_{REF} = 0$)	0 to +10V dc min			0 to +10V dc min		
e_{REF} Terminal ($e_{IN} = 0$)	0 to –10V dc min			0 to –10V dc min		
Differential ($e_{IN} - e_{REF}$)	0 to +10V dc min			0 to +10V dc min		
Overrange	+10% min			+10% min		
Current Signal Range (i_{IN})	0 to +0.5mA min			0 to +1mA min		
Common Mode Voltage	±10V			±10V		
Common Mode Rejection	40dB			40dB		
Impedance, e_{IN} Terminal	20kΩ			10kΩ		
e_{REF} Terminal	40kΩ			20kΩ		
i_{IN} Terminal	0Ω			0Ω		
Max Safe Input	$\pm V_S$			$\pm V_S$		
ACCURACY						
Warm Up Time	5 Seconds to 0.01%			2 Minutes to 0.02%		
Nonlinearity, e_{IN} = +0.1mV to +11V	±0.01% of Full Scale, max			±0.015% of Full Scale, max		
e_{IN} = –0.1mV to –11V	±0.01% of Full Scale			±0.015% of Full Scale		
Full Scale Error[1]	+0.1% to ±2%, max			+0.1% to ±2%, max		
Gain vs. Temperature (0 to +70°C)	±20ppm/°C max	±10ppm/°C max	±5ppm/°C max	±50ppm/°C max	±25ppm/°C max	±15ppm/°C max
vs. Supply Voltage	±15ppm/%			±25ppm/%		
vs. Time	±10ppm/day			±10ppm/day		
Input Offset Voltage[2]	±10mV max			±10mV max		
vs. Temperature (0 to +70°C)	±30µV/°C max			±30µV/°C max		
vs. Supply Voltage	±10µV/%			±10µV/%		
vs. Time	±20ppm/day			±10ppm/day		
RESPONSE						
Settling Time, ±0.01% +10V Step	3 Output Pulses Plus 2µs			2 Output Pulses Plus 2µs		
Overload Recovery Time	10ms			1ms		
FREQUENCY OUTPUT[3]						
Waveform	TTL/DTL Compatible Pulses			TTL/DTL Compatible Pulses		
Pulse Width	5µs			500ns		
Rise and Fall Time	300ns/50ns			60ns/50ns		
Pulse Polarity	Positive			Positive		
Logic "1" (High) Level	+2.4V min			+2.4V min		
Logic "0" (Low) Level	+0.4V max			+0.4V max		
Capacitive Loading	500pF max			200pF max		
Fan Out Loading	10 TTL Loads min			10 TTL Loads min		
Impedance	3kΩ (High State)			670Ω (High State)		
POWER SUPPLY[4]						
Voltage, Rated Performance	±15V dc			±15V dc		
Voltage, Operating	±(13 to 18)V dc			±(13 to 18)V dc		
Current, Quiescent	(+25, –8)mA			(+25, –8)mA		
TEMPERATURE RANGE						
Rated Performance	0 to +70°C			0 to +70°C		
Operating	–25°C to +85°C			–25°C to +85°C		
Storage	–55°C to +125°C			–55°C to +125°C		
MECHANICAL						
Case Size	2" x 2" x 0.4"			2" x 2" x 0.4"		
Weight	45 Grams			45 Grams		
Mating Socket	AC1016			AC1016		

[1] Adjustable to zero using 500Ω potentiometer.
[2] Adjustable to zero using 50kΩ 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, ±15V @ 50mA output.

Specifications subject to change without notice.

OUTLINE DIMENSIONS
Dimensions shown in inches and (mm).
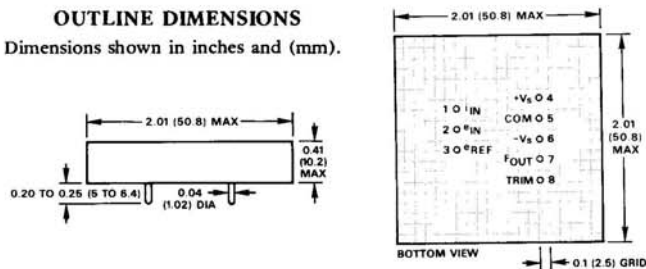
MATING SOCKET: AC1016

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 ±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 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 ±10V max. For differential inputs the output frequency is:

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

$$K_g = 10^4\,Hz/V;\ model\ 458$$
$$10^5\,Hz/V;\ model\ 460$$

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 ±5V min can be converted directly.
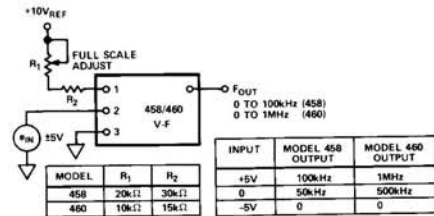

MODEL	R_1	R_2
458	20kΩ	30kΩ
460	10kΩ	15kΩ

INPUT	MODEL 458 OUTPUT	MODEL 460 OUTPUT
+5V	100kHz	1MHz
0	50kHz	500kHz
-5V	0	0

Figure 5. Offsetting Input to Accept ±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 200µs before input scaling, to 20µs with scaling.
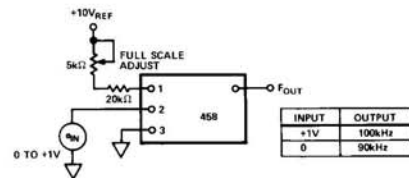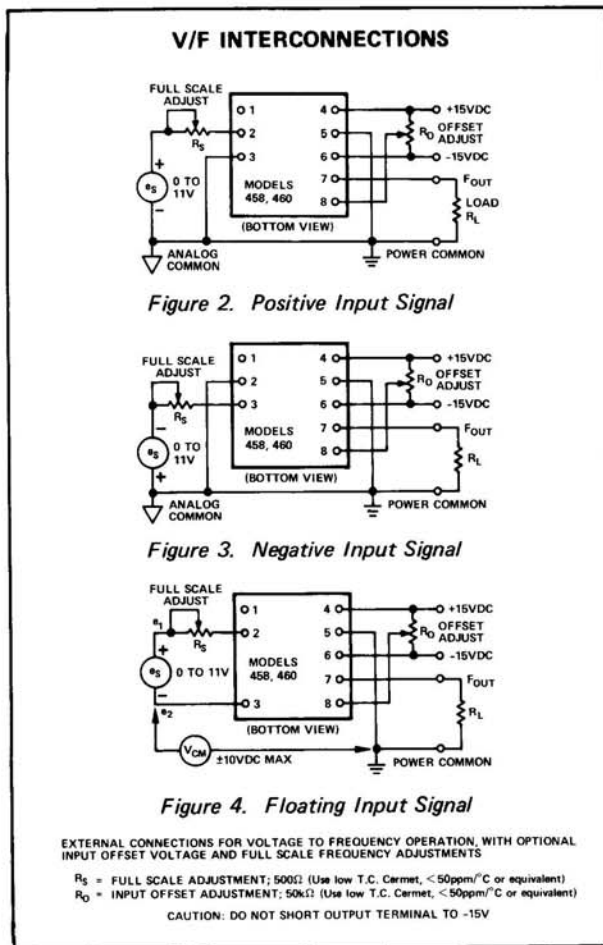

INPUT	OUTPUT
+1V	100kHz
0	90kHz

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

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V/F INTERCONNECTIONS

Figure 2. Positive Input Signal

Figure 3. Negative Input Signal

Figure 4. Floating Input Signal

EXTERNAL CONNECTIONS FOR VOLTAGE TO FREQUENCY OPERATION, WITH OPTIONAL INPUT OFFSET VOLTAGE AND FULL SCALE FREQUENCY ADJUSTMENTS

R_S = FULL SCALE ADJUSTMENT; 500Ω (Use low T.C. Cermet, <50ppm/°C or equivalent)
R_O = INPUT OFFSET ADJUSTMENT; 50kΩ (Use low T.C. Cermet, <50ppm/°C or equivalent)

CAUTION: DO NOT SHORT OUTPUT TERMINAL TO -15V

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; ±0.01% max, models 458J/K/L, ±0.015% max, models 460J/K/L. Typical nonlinearity performance is illustrated in Figure 7.
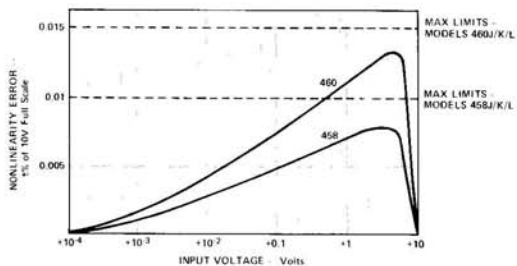

Figure 7. Nonlinearity Error Versus Input Voltage

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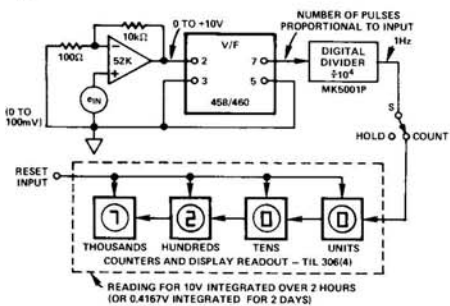

Figure 8. Models 458/460 as Long Term Integrator with Arbitrary Display Calibration. Frequency Division Ratio can Otherwise be Chosen to Provide Direct Readout in any Desired Units.

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.
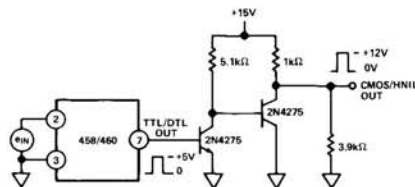

Figure 9. Circuit for Shifting the Output of the 458/460 to Drive CMOS/HNIL Logic

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.
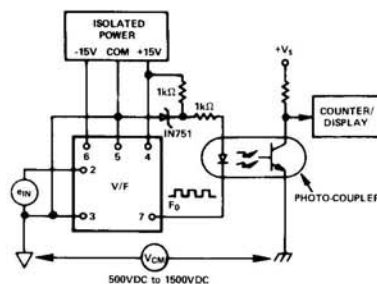

Figure 10. Optical Isolation Using LED Photo Isolator to Provide Up to 1500V dc CMV Isolation

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.
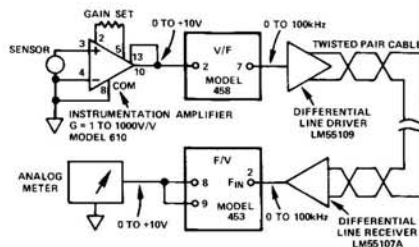

Figure 11. Application of Model 458 V/F Converter in a High Performance, High Noise Rejection Two-Wire Data Transmission System