resolver/inductosyn™ to digital converter
parallel output 12 bit
series 168L500

FEATURES

- Inductosyn or resolver input
- Ratiometric conversion
- Resistive input scaling
- Direction output
- Ripple clock (revolution or pitch count)
- Dc velocity output with integral active filter
- True type II tracking converter
- High tolerance to frequency variations
- High noise immunity
- Ac coupled inputs
- Four frequency options (400 Hz, 2.6 kHz, 5 kHz, or 10 kHz)

APPLICATIONS

Robot Axis Control - Machine Tool Control - Encoder Replacement

™Farrand Controls - Valhalla, New York

GENERAL DATA

The 168L500 series is a low cost, high performance, 12-bit Inductosyn™ or resolver-to-digital converter. The unit accepts inputs from either a resolver or from an Inductosyn slider via external preamps and outputs 4096 counts per resolver revolution or Inductosyn pitch. A direction output is also provided as well as a ripple clock output. The ripple clock gives a pulse every time the resolver input passes through the zero position or the Inductosyn slider moves to an adjacent pitch. The converter is a continuous tracking type employing a type II servo loop principle and operates for input rates of up to 170 RPS.

The converters are available in 4 different frequency options; 400 Hz, 2.6 kHz, 5 kHz, and 10 kHz. The signal and reference inputs accept 2.5 volts rms and can be resistively scaled to accommodate the user's particular voltage levels.

In addition to the digital outputs, the 168L500 series also provides a dc velocity signal which is proportional to the rate at which the input is changing. An internal active filter is included to reduce output ripple and increase output drive capability.

ANALOG INTERFACE

The SIN and COS are ac coupled inputs internally scaled for 2.5 volts rms. Higher voltages may be accommodated by the addition of external scaling resistors whose value is 2.22 kohms per extra volt required. Matching is more important than the absolute value. Resistors should be within ±5% of the calculated value and be matched to better than 0.1%. A mismatch of 0.1% will create an additional 1.7 arc-minutes of error.

The reference input (RH-RL) is an ac coupled differential input scaled to 2.5 volts rms. Either RH or RL may be grounded. Higher voltages may be accommodated by the addition of an external resistor with a value of 2.2 kohms per additional volt. This resistor is not critical and may differ from the calculated value by as much as 20% without compromising performance.

An example of resistive scaling is shown in Figure 1 where a resolver with a signal voltage of 11.8 volts rms and a reference voltage of 26 volts rms is being used with the 168L500.

ELECTRICAL SPECIFICATIONS

Parameter	Value
Resolution	12 bits or 1/4096 of a revolution or pitch
Accuracy(1)	±8.5 minutes
Power Supplies(2)	
+15V	30 mA max (25 mA typ)
−15V	30 mA max (25 mA typ)
+5V	125 mA max (100 mA typ)
Digital Outputs	
Parallel Binary Angle	2 TTL loads
Converter Busy Loading	1 TTL load
Pulse Width	350 ns max
Direction Output (DR)	Logic "0" = up, Logic "1" down
Ripple Clock Output (RC)	2 TTL loads

Input Rates	**400 Hz**	**2600 Hz**	**5 kHz to 10 kHz**
Maximum Tracking Rate	67 RPS	87 RPS	170 RPS
Acceleration Constant (Ka)	90,000 sec^{-2}	500,000 sec^{-2}	1,015,000 sec^{-2}
Settling Time for 179° step	38 ms	33 ms	12 ms

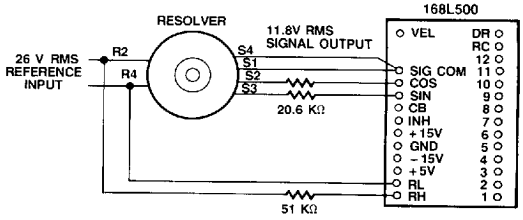
Signal & Reference Input	
Frequency	400 Hz, 2600 Hz, 5 kHz, and 10 kHz
Voltage	2.5V rms nominal
Impedance	5.6 kohms
Dc Isolation	100V
Velocity Output	
Voltage Range	±5V for maximum tracking rate
Polarity	Positive voltage for increasing angle
Zero Offset	±5 mV max @ 25°C ±10 mV max over operating temperature range
Gain Tempco	0.07%/°C typ, 0.2%/°C max
Linearity	2% to 1/5 maximum tracking rate
Output Noise	Less than 5 mV in 0 to 20 Hz bandwidth
Temperature Ranges	
Operating	0° to 70°C −55° to 105°C (ET)
Storage	−65° to 125°C
Dimensions	3.125" x 2.625" x 0.4"
Weight	3.5 oz.

NOTES:

1. Accuracy applies for:
   (a) ±10% signal amplitude variation
   (b) 10% signal and reference harmonic distortion
   (c) over power supply range
   (d) over operating temperature range

2. Although specified at ±15V, all units can operate on voltages between ±11.5V to ±16.5V with no degradation in performance. The tolerance on +5V supply is ±5%.

INPUT RESISTIVE SCALING
Figure 1



DIGITAL INTERFACE

Figure 2 shows the timing of the converter. Whenever an input angle change occurs, the converter changes the digital angle in steps of 1 LSB and generates a CB pulse. The CB pulse is a 200 to 350-nanosecond positive pulse and data changes on the leading edge of this pulse. Output data can safely be transfered 200 nanosecond after the leading edge of the CB pulse.

A ripple clock output (RC) is provided from the most significant end of the counter and a direction output (DR) is also provided. The converter busy (CB) output is derived from the clock used to drive the internal counters. These three outputs in conjunction with external 74LS169A counters can extend the counting chain (see Figure 3).

There are two methods of transferring data, (1) asynchronously and (2) synchronously. The asynchronous method is to transfer data at or following the negative going transition of the CB pulse. The synchronous method of transferring the data is by applying the INHIBIT (taking it to a logic "0" state), waiting for at least the width of a CB pulse, transferring the data and releasing the INHIBIT.

Note that sustained application of the INHIBIT opens the internal control loop and the converter may take appreciable time to recover to full accuracy when the loop is restored.

DYNAMIC ACCURACY vs. RESOLVER PHASE SHIFT

Most resolvers, particularly brushless types, exhibit a phase lead signal to reference. This phase shift will give rise under dynamic conditions to an additional error defined by:

$$\frac{\text{Shaft Speed (RPS)} \times \text{Phase Shift (Deg)}}{\text{Reference Frequency}}$$

This effect can be eliminated by setting a phase lead in the reference to the converter equivalent to the phase shift in the resolver.

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DYNAMIC PERFORMANCE

The 168L500 series employs a Type II servo loop ($K_V = \infty$) and very high acceleration constants. The loop dynamics are completely independent of power supply variations over their specified ranges. As long as the maximum tracking rate is not exceeded there will be no velocity lag and only minor acceleration lag in the converter output. Acceleration lag can be computed from the following equation:

$$E_a = \frac{\text{acceleration } (°/\text{sec}^2)}{K_a}$$

The nominal open loop transfer functions are given by:

$$G_{168L500} = \frac{300^2\left(\frac{S}{212} + 1\right)}{S^2\left(\frac{S}{788} + 1\right)}$$

$$G_{168L501} = \frac{707^2\left(\frac{S}{500} + 1\right)}{S^2\left(\frac{S}{1782} + 1\right)}$$

$$G_{168L502} = \frac{1000^2\left(\frac{S}{722} + 1\right)}{S^2\left(\frac{S}{2576} + 1\right)}$$

VELOCITY OUTPUT

The velocity output (VEL) is a dc voltage proportional to the angular velocity of a resolver shaft or inductosyn slider. Voltage polarity is positive for an increasing digital angle and negative for a decreasing digital angle. The velocity output is internally filtered using a 2-pole Butterworth active filter with cutoff frequencies as shown below:

Model	Cutoff Frequency
168L500	150 Hz
168L501	700 Hz
168L502	1000 Hz
168L503	1000 Hz

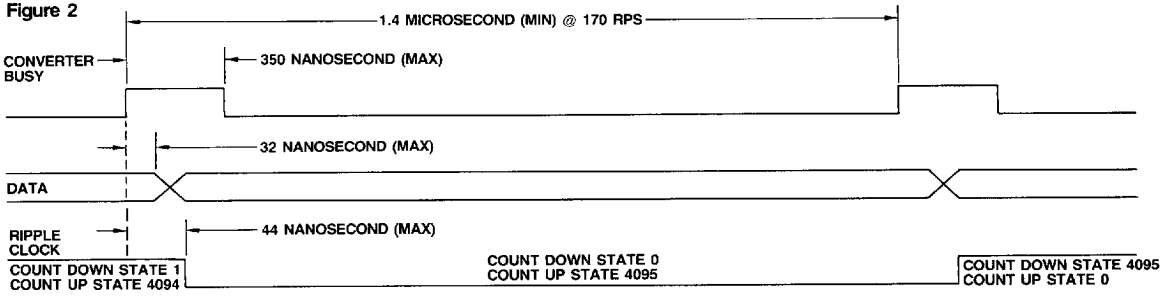
The active Butterworth filter is incorporated to provide lower output impedance, better attenuation, and better response than a single pole passive filter.

Scaling of the VEL output is ±5V for maximum specified tracking rate. The output voltage is nonlinear with velocity and may be calculated from the following equation:

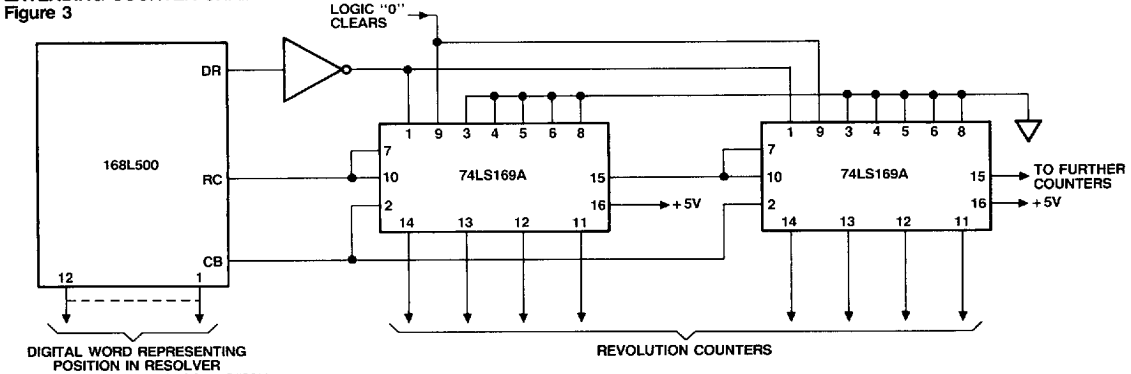
$$VEL = \frac{A \times V}{1 - 2.73 \times 10^{-5}V}$$

Where: VEL is in volts
V is velocity in RPM
$A = 1.04 \times 10^{-3}$ for 168L500
$A = 7.6 \times 10^{-4}$ for 168L501
$A = 3.54 \times 10^{-4}$ for 168L502 & 168L503

TIMING DIAGRAM
Figure 2



EXTENDING COUNTER CHAIN
Figure 3



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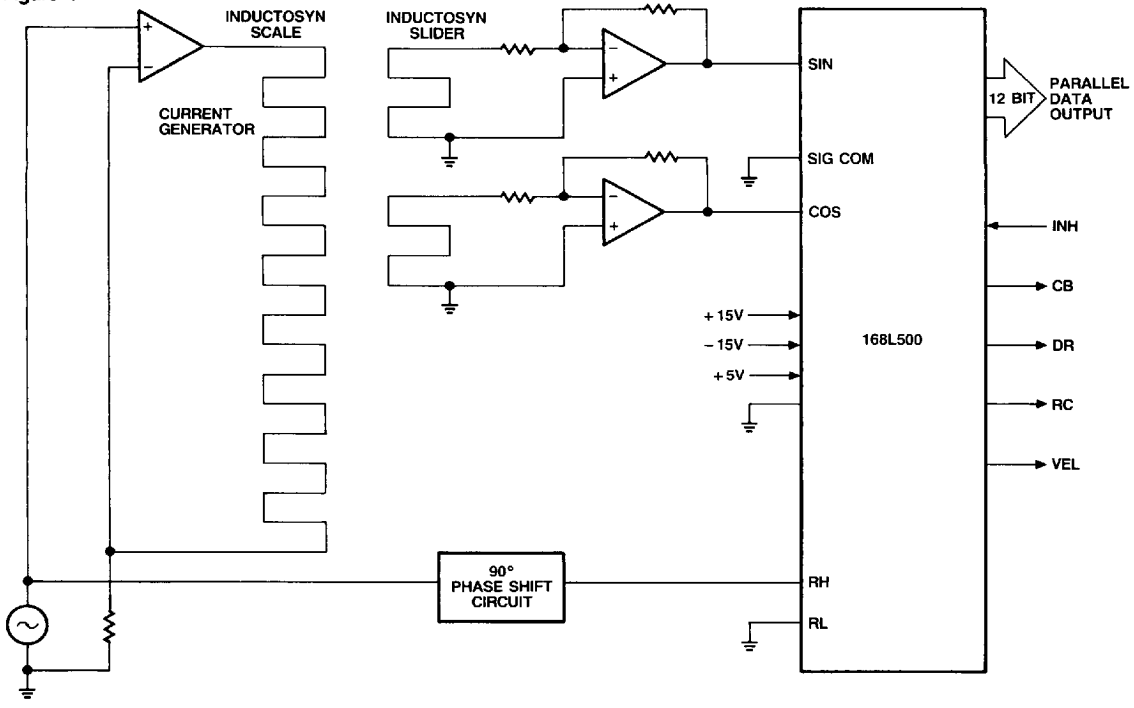
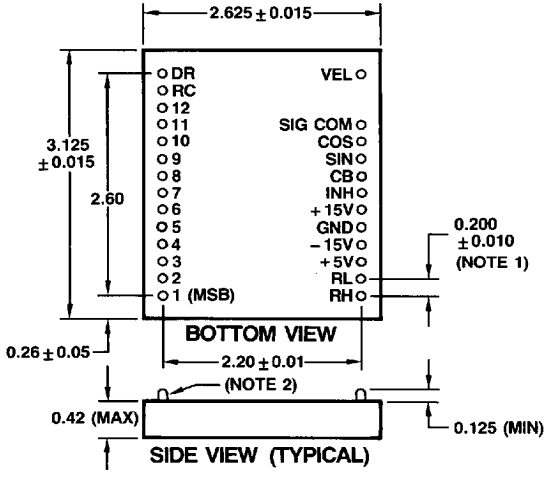
TYPICAL INDUCTOSYN CONNECTION
Figure 4



MECHANICAL OUTLINE



NOTES:

1. Noncumulative.
2. Rigid 0.040 diameter pins for solder-in or plug-in applications.
3. Dimensions are in inches unless otherwise specified.

ORDERING INFORMATION

168L Suffix	Operating Frequency	
500	400 Hz	
501	2.6 kHz	
502	5 kHz	
503	10 kHz	(NOT AVAILABLE)

Standard temperature range (0° to 70°C); add suffix ET to part number for extended temperature range (−55° to +105°C).

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