synchro/resolver to digital converter
high accuracy 16 bit
series 468H100

FEATURES
- ±1.3 arc minute accuracy
- 2.0" x 2.5" module outline
- 47 to 3000Hz frequency range
- Tracking to 5rps
- Synthesized reference
- 3-state BAM's output
- Velocity output
- Built-in-test output
- Loss of signal output
- Loss of reference output

APPLICATIONS
- Precise angle measurement
- Machine tool control
- Robotic control
- Antenna monitoring

GENERAL DATA

The series 468H100 is a miniature 16 bit synchro/resolver to digital converter featuring an accuracy of ±1.3 arc minutes. The converter measures 2.00" x 2.50" x 0.52" and weighs only 2.0 ounces.

Operation is specified over a frequency range of 47 to 3000Hz. The converter employs a "Type II" servo loop that exhibits no velocity errors and only minor acceleration errors. Ratiometric conversion techniques are used to ensure high-noise immunity and tolerance to long lead-length.

The parallel binary angle is buffered through 3-state latches and provides either two 8 bit bytes or a single 16 bit word. Three diagnostic outputs are provided indicating: 1) loss of signal, 2) loss of reference, and 3) excessive converter error.

THEORY OF OPERATION

The synchro/resolver to digital converter determines the value of the input angle Θ, see block diagram, by comparing a digital feedback angle Φ with the input angle. When the difference between the input angle and the feedback angle is zero, the output angle contained in the up-down counter is equal to the input angle.

The Solid State Control Transformer performs the trigonometric computation:

$$\sin(\Theta-\Phi) = \sin\Theta\cos\Phi - \cos\Theta\sin\Phi$$

Note that for small angles, $\sin(\Theta-\Phi) = \Theta-\Phi$. The equality given by the above equation is true only in the first quadrant, i.e., 0° to 90°. The analog inputs to the Solid State Control Transformer have different values depending on the quadrant in which the input angle lies.

$\Theta-\Phi$ is an analog representation of the error between Θ and Φ. This analog error voltage is first demodulated, then fed to an analog integrator whose output controls the frequency of a voltage-controlled oscillator. The VCO clocks an up-down counter that is functionally an integrator. Therefore, the converter in itself is a closed-loop servomechanism with two lags, making it a "Type II" tracking converter. The "Type II" tracking converter exhibits no velocity errors and only minor acceleration errors.

SPECIFICATIONS

Parameter	Value
Resolution	16 bits (0.0055°)
Accuracy(1)	±1.3 arc minutes (0.022°)
Power Supplies(2)	
+V	45mA max.
-V	45mA max.
+5V	15mA max.
Reference input(3)	
Voltage	1 to 130Vrms
Frequency	47 to 3000Hz
Impedance	400KΩ
Stator Input(3)	
Voltage L-L	2.5 to 115Vrms
Impedance	$9(V_{L-L})K\Omega$
Digital Outputs(4)	
Binary Angle	3-state positive logic 1 = 180° 16 = 0.0055°
Built-in-Test	"0"=normal operation "1"=excessive error
Loss of Signal	"0"=signal present "1"=no signal
Loss of Reference	"0"=reference present "1"=no reference
Converter Busy	1-4μsecond positive pulse
Digital Inputs(5)	
Inhibit	"0"=binary angle latched "1"= binary angle tracks
Enable M	"0"=1-8 enabled, "1"=1-8 @ hi-Z
Enable L	"0"=9-16 enabled, "1"=9-16 @ hi-Z
Velocity Output	
Range	±10V for max. tracking
Polarity	Positive for increasing angle
Scale Factor Error	±20%
Reversal Error	±5%
Linearity	
0-50%	6%
0-100%	15%
Zero Offset	±3mV max.
Load	8KΩ min.
Temperature Ranges	
Operating	0° to +70°C
Storage	-55° to +125°C
Dimensions	2.015" x 2.515" x 0.52"
Weight	2.0 oz.

NOTES:

1. Accuracy applies for:
   a) +10%, -20% stator amplitude variation.
   b) over the specified reference voltage and frequency range.
   c) 10% reference and stator harmonic distortion.
   d) over the specified power supply ranges.
   e) over the operating temperature range.
   f) ±45° rotor to stator phase shift.
2. Power supply tolerances are:
   a) ±V range is ±11.5 to ±16V.
   b) +5V range is +4.75V to +5.25V.
3. See Ordering Information for specific voltage and frequency ranges.
4. Digital outputs are TTL/CMOS capable of sinking -4mA.
5. Digital inputs are CMOS; do not leave open.

INTERFACING WITH THE CONVERTER

The digital output angle is pins 1 thru 16, pin 1 being the MSB, 180°, and pin 16 being the LSB, 0.0055°. This output is a 3-state output and can be configured as two 8 bit bytes or a single 16 bit word. When the Enable M (ENM) pin is at logic "0", bits 1-8 are enabled and when the Enable L (ENL) pin is at logic "0", bits 9-16 are enabled. When these pins are at logic "1", their respective outputs are in the high-impedance state.

The Inhibit (INH) input and the Converter Busy (CB) output are used to interface to a computer. The Converter Busy is a positive pulse that occurs during the digital angle code changes; this pulse brackets the code changes. The Inhibit input is used to lock the internal output latches, causing the digital output bits to remain stable while data is being transferred. This latch also prevents the transmission of invalid data when there is an overlap between the Converter Busy and the Inhibit command.

There are two methods of transferring data; one is by transferring data on the trailing edge of the Converter Busy pulse and the other is by using the Inhibit input. A logic "0" applied to the Inhibit input locks the output latches and does not affect converter tracking, no matter what the duration of the Inhibit command. A simple method of interfacing to a computer using the Inhibit input is to:

1. Set Inhibit input to logic "0".
2. Wait 4.0μseconds minimum.
3. Transfer the digital angle data.
4. Set Inhibit input back to logic "1".

REFERENCE SYNTHESIZER

Rotor to stator phase shift encountered in most synchros and resolvers is a source for static and dynamic angular errors. When attempting to measure synchro/resolver angles to an accuracy better than 3 minutes of arc, it is mandatory that this phase shift be corrected for. The 468H100 contains a "reference synthesizer" that corrects for any appreciable phase lead or lag between rotor and stator signals. Phase shifts up to ±45° are corrected for, allowing for high accuracies under both static and dynamic conditions. The "reference synthesizer" is completely insensitive to reference voltage and frequency variations.

DYNAMIC CHARACTERISTICS

The 468H100 is a "Type II" tracking converter with very high acceleration constants. The loop dynamics are completely independent of power supply variations within their specified ranges. As long as the maximum tracking rate is not exceeded, there will be no velocity lag and only minor acceleration lag at the digital angle output.

Acceleration lag error (in degrees) can be calculated from the following equation:

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

Refer to table below for dynamic performance of the converter at various reference frequency ranges.

DYNAMIC CHARACTERISTICS				
REF FREQ	TRACKING RATE	K_a	SETTLING TIME*	BANDWIDTH
0.047-3KHz	2.5RPS	1K	1.5sec	10Hz
0.360-3KHz	5.0RPS	35K	200msec	60Hz
2-3KHz	5.0RPS	350K	80msec	175Hz

*Settling time for 179° step

VELOCITY OUTPUT (VEL)
The Velocity output is a DC voltage proportional to the angular velocity of the synchro or resolver shaft. Refer to Specification section for its characteristics.

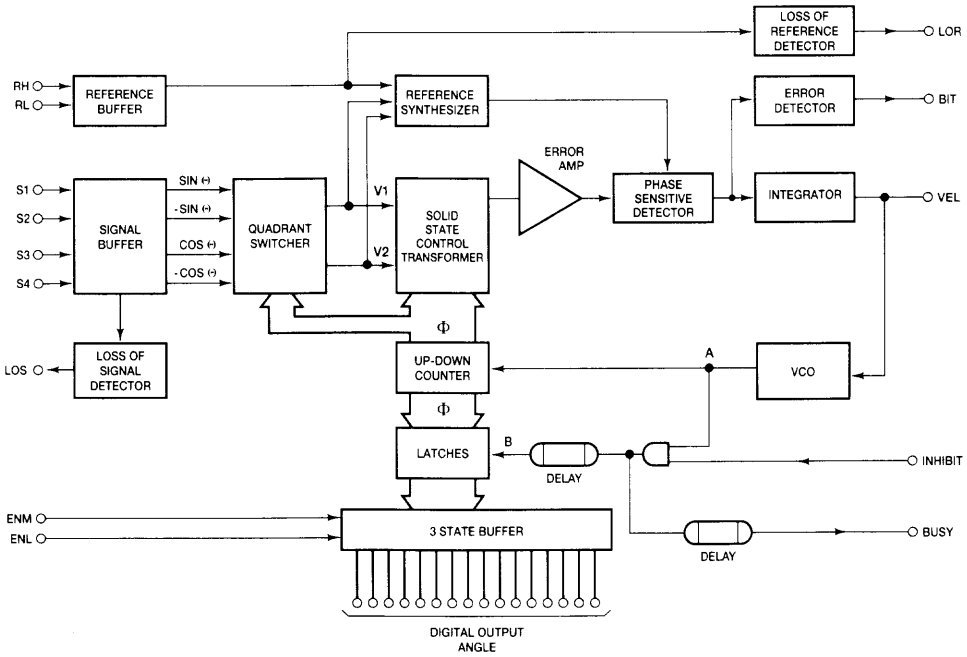
BUILT-IN-TEST OUTPUT (BIT)
The Built-in-Test monitors the magnitude of the phase-sensitive detector output. This output represents the difference angle between the input synchro or resolver angle and the digital output angle. If the magnitude of this output exceeds 0.35° (65 LSB's), the BIT output will change from logic "0" to logic "1". A logic "1" will occur under the following conditions:

1. During a large input angle step.
2. An over-velocity condition.
3. Converter malfunction condition.

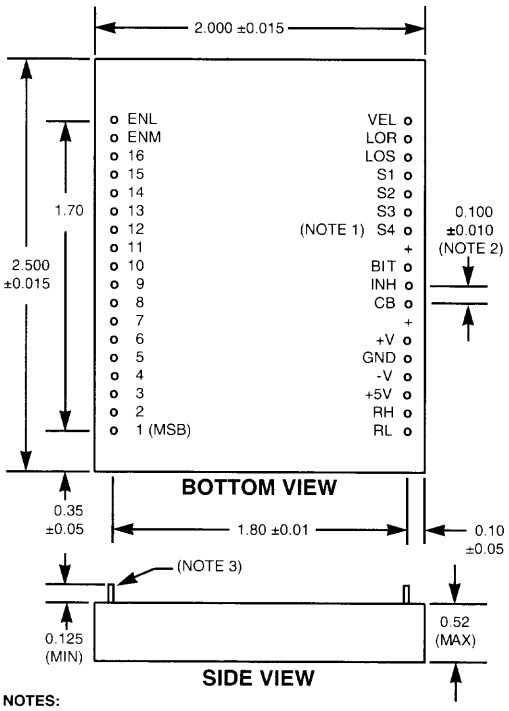
LOSS OF SIGNAL OUTPUT (LOS)
The Loss of Signal output indicates the presence or absence of the synchro or resolver stator signals. A logic "0" indicates the presence of stator signals and a logic "1" indicates the absence of stator signals.

LOSS OF REFERENCE OUTPUT (LOR)
The Loss of Reference output is an indication of the presence or absence of the reference excitation voltage. A logic "0" indicates the presence of the excitation voltage and a logic "1" indicates the absence of the excitation voltage.

BLOCK DIAGRAM



MECHANICAL OUTLINE



NOTES:
1. S4 pin appears on resolver input models only.
2. Non-cumulative.
3. Rigid 0.025 diameter pins suitable for solder-in or plug-in applications.
4. Dimensions are in inches.

CONNECTING THE CONVERTER

The DC power lines, that must not be reversed, should be connected to the +V, -V and +5V pins with the common connected to the GND pin.

In the case of a synchro, the convention for the stator inputs are as follows:

$$E_{S1\text{-}S3} = E_{RL\text{-}RH}\text{SIN}\Theta$$
$$E_{S3\text{-}S2} = E_{RL\text{-}RH}\text{SIN}(\Theta + 120°)$$
$$E_{S2\text{-}S1} = E_{RL\text{-}RH}\text{SIN}(\Theta + 240°)$$

For a resolver, the convention for the stator inputs are as follows:

$$E_{S1\text{-}S3} = E_{RL\text{-}RH}\text{SIN}\Theta$$
$$E_{S4\text{-}S2} = E_{RL\text{-}RH}\text{COS}\Theta$$

ORDERING INFORMATION

468H	STATOR INPUT		REFERENCE INPUT	
SUFFIX	TYPE	VOLT	VOLTAGE	FREQUENCY
100	SYNC	90.0V	10-130V	47-3000Hz
101	SYNC	11.8V	10-130V	360-3000Hz
102	SYNC	90.0V	10-130V	360-3000Hz
103	RSVR	11.8V	10-130V	360-3000Hz
104	RSVR	2.5V	2.5-30V	360-3000Hz
105	RSVR	5.0V	2.5-30V	360-3000Hz
106	RSVR	2.5V	2.5-30V	2.0-3.0KHz
107	RSVR	5.0V	2.5-30V	2.0-3.0KHz

Consult factory for non-standard input voltages and dynamic characteristics.