synchro/resolver to digital converter
3-state tracking 12 or 14 bit
series 468A300/100

FEATURES
- **High-speed tracking**
- **2.0" x 2.5" module outline**
- **47 to 5000Hz excitation**
- **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 468A300 and 468A100 are high performance 12 and 14 bit synchro/resolver to digital converters. The converters measure 2.00" x 2.50" x 0.52" and weigh only 2.0 ounces.

Operation is specified over a frequency range of 47 to 5000Hz. The converters employ 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 byte or a single word read. 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	
468A100	14 bits (0.022°)
468A300	12 bits (0.088°)
Accuracy(1)	
468A100	±4.0 arc minutes (0.066°)
468A300	±8.5 arc minutes (0.143°)
Power Supplies(2)	
±V	45mA max.
+5V	15mA max.
Reference input(3)	
Voltage	2.5 to 130Vrms
Frequency	47 to 5000Hz
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° 14 = 0.022°
Built-in-Test	"0"=normal "1"=excessive error
Loss of Signal	"0"=normal "1"=no signal
Loss of Reference	"0"=normal "1"=no reference
Converter Busy	
0.047-5KHz models	8µsec max. positive pulse
0.360-5KHz models	2µsec max. positive pulse
2.000-5KHz models	1.5µsec max. 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"=9-14 enabled, "1"=9-14 @ 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

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 ±11.5V 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 14, pin 1 being the MSB, 180°, and pin 14 being the LSB, 0.022°. This output is a 3-state output and can be configured as a two byte or a single word read. 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 9-14 are enabled. When these pins are at logic "1", their respective outputs are in the high-impedance state. When using the 12 bit converter (468A300), bit pins 13 and 14 are inactive and are permanently set to logic "0".

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 a maximum CB interval.
3. Transfer the digital angle data.
4. Set Inhibit input back to logic "1".

DYNAMIC CHARACTERISTICS

The 468A100 and 468A300 are "Type II" tracking converters 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 (in degrees) can be calculated from the following equation:

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

The converter dynamics are determined by the operating frequency and output resolution. Refer to the Dynamic Characteristics chart for dynamic performance of the various converter types.

DYNAMIC CHARACTERISTICS				
CONVERTER RESOLUTION	REFERENCE FREQUENCY	TRACKING RATE	Ka	SETTLING TIME
14 bit	47-5KHz	3rps	5K	1.6 sec
14 bit	360-5KHz	14rps	50K	150msec
14 bit	2K-5KHz	20rps	700K	40msec
12 bit	47-5KHz	20rps	2K	650msec
12 bit	360-5KHz	50rps	12K	150msec
12 bit	2K-5KHz	100rps	500K	40msec

*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°, 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.

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.

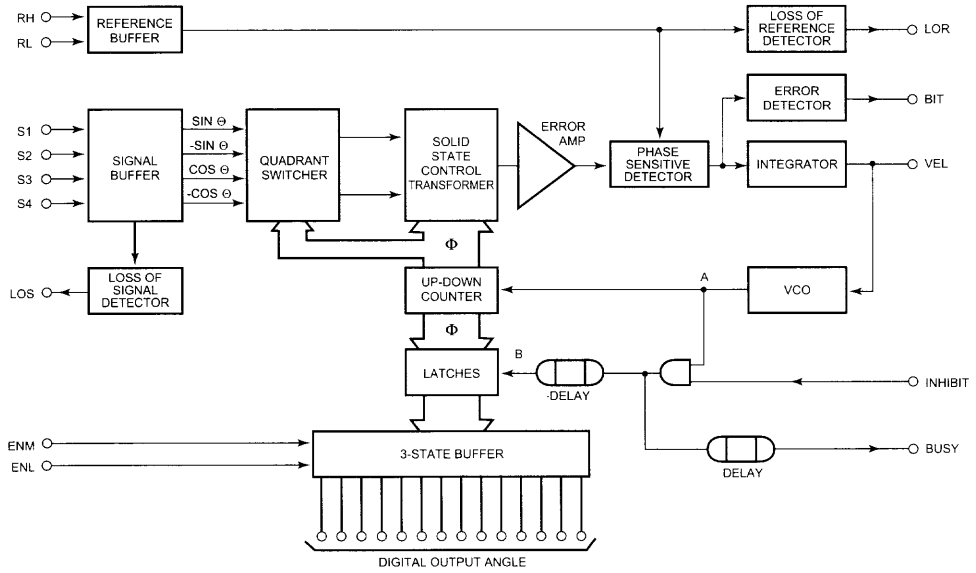
In the case of a synchro, the convention for the stator inputs are as follows:

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

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

$$E_{S1\text{-}S3} = E_{RL\text{-}RH}\sin\Theta$$
$$E_{S4\text{-}S2} = E_{RL\text{-}RH}\cos\Theta$$

BLOCK DIAGRAM



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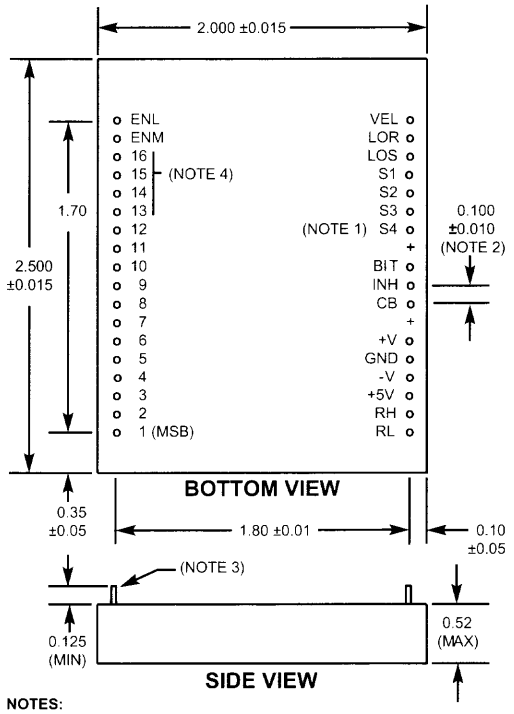
MECHANICAL OUTLINE



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. Pins 13-16 are permanently set to logic "0" on the 468A300. Pins 15 and 16 are set to logic "0" on the 468A100. These pins are to be left unconnected.
5. Dimensions are in inches.

ORDERING INFORMATION

468A	STATOR		REFERENCE		
SUFFIX	TYPE	VOLT	VOLTAGE	FREQ	BITS
100	SYNC	90.0	20-130	47-5KHz	14
101	SYNC	11.8	20-130	360-5KHz	14
102	SYNC	90.0	20-130	360-5KHz	14
103	RSVR	11.8	20-130	360-5KHz	14
104	RSVR	2.5	2.5-30	360-5KHz	14
105	RSVR	5.0	2.5-30	360-5KHz	14
106	RSVR	2.5	2.5-30	2K-5KHz	14
107	RSVR	5.0	2.5-30	2K-5KHz	14
300	SYNC	90.0	20-130	47-5KHz	12
301	SYNC	11.8	20-130	360-5KHz	12
302	SYNC	90.0	20-130	360-5KHz	12
303	RSVR	11.8	20-130	360-5KHz	12
304	RSVR	2.5	2.5-30	360-5KHz	12
305	RSVR	2.5	2.5-30	360-5KHz	12
306	RSVR	5.0	2.5-30	2K-5KHz	12
307	RSVR	5.0	2.5-30	2K-5KHz	12

NOTES:
1. Contact factory for non-standard input voltages and dynamic characteristics.
2. Standard temperature range is 0° to +70°C; add suffix IT to part number for -25° to +85°C operation.