# CSI

## synchro/resolver to digital converter
## high accuracy                          14 bit
### series 468H200

## FEATURES
- ■ ±2.6 arc minute accuracy
- ■ 2.0" x 2.5" module outline
- ■ 47 to 5000Hz frequency range
- ■ Tracking to 20rps
- ■ 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 468H200 is a miniature 14 bit synchro/resolver to digital converter featuring an accuracy of ±2.6 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 5000Hz. 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.

Θ-Φ 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** | 14 bits (0.022°) |
| **Accuracy**[1] | ±2.6 arc minutes (0.044°) |
| **Power Supplies**[2] | |
| ±V | 45mA max. |
| +5V | 15mA max. |
| **Reference input**[3] | |
| Voltage | 1 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 operation "1"=excessive error |
| Loss of Signal | "0"=signal present "1"=no signal |
| Loss of Reference | "0"=reference present "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"=9-16 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 |
| **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 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 two bytes read or a single 14 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 9-14 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 a maximum CB interval.
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 468H200 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 468H200 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:

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

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 | 3RPS | 5K | 1.6sec | 25Hz |
| 0.360-3KHz | 14RPS | 50K | 150msec | 70Hz |
| 2-5KHz | 20RPS | 700K | 40msec | 275Hz |

*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° (16 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.
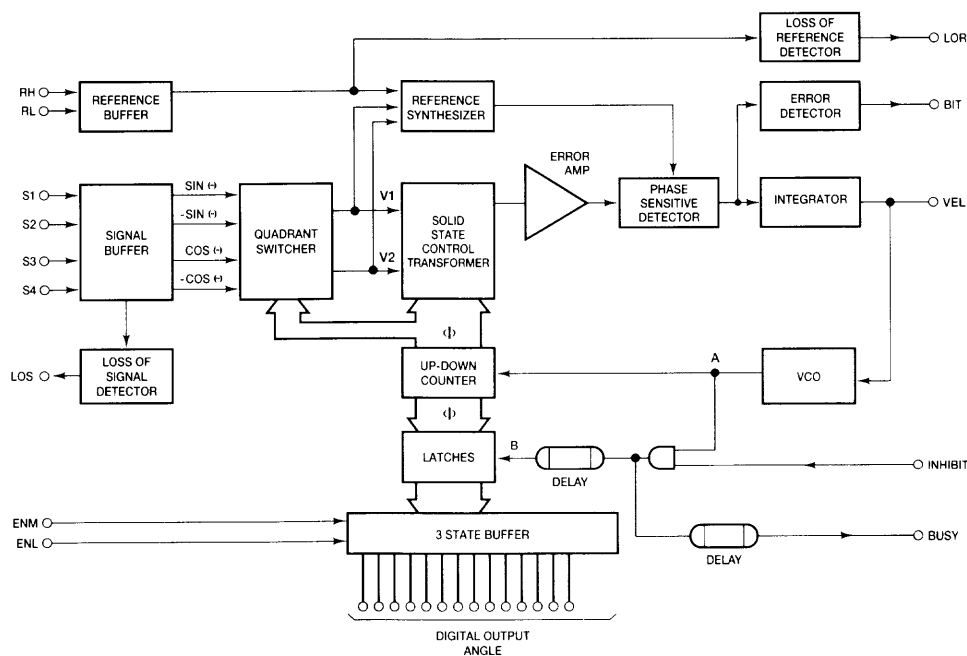3. Converter malfunction condition.

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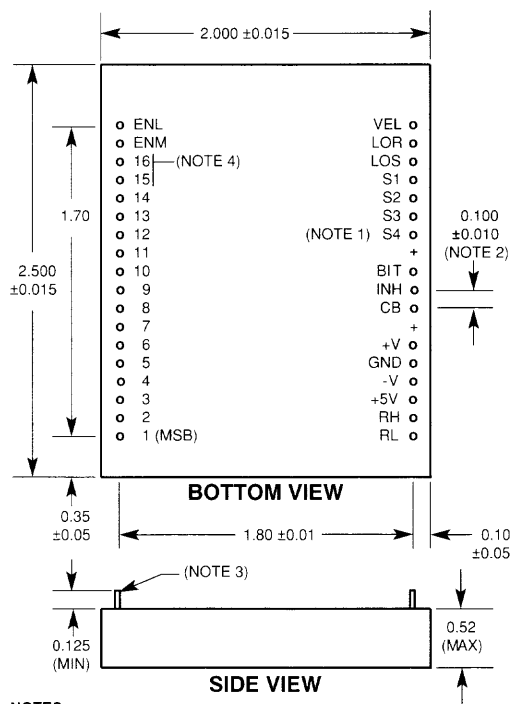
### LOSS OF REFERENCE OUTPUT (LOR)
The Loss of Reference output is an indication of the presence or absence of the reference excitation voltage. A logic "0" indicates the presence of the excitation voltage and a logic "1" indicates the absence of the excitation voltage.

## BLOCK DIAGRAM

## MECHANICAL OUTLINE



**BOTTOM VIEW**

2.000 ±0.015

2.500 ±0.015

1.70

0.100 ±0.010 (NOTE 2)

| Pin | Label |
|---|---|
| | o ENL |
| | o ENM |
| 16 | o 16 —(NOTE 4) |
| 15 | o 15 |
| 14 | o 14 |
| 13 | o 13 |
| 12 | o 12 |
| 11 | o 11 |
| 10 | o 10 |
| 9 | o 9 |
| 8 | o 8 |
| 7 | o 7 |
| 6 | o 6 |
| 5 | o 5 |
| 4 | o 4 |
| 3 | o 3 |
| 2 | o 2 |
| 1 | o 1 (MSB) |

VEL o
LOR o
LOS o
S1 o
S2 o
S3 o
(NOTE 1) S4 o
+
BIT o
INH o
CB o
+
+V o
GND o
-V o
+5V o
RH o
RL o

**SIDE VIEW**

0.35 ±0.05
1.80 ±0.01
0.10 ±0.05

(NOTE 3)

0.125 (MIN)

0.52 (MAX)

**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 15 and 16 are permanently set to logic "0". The pins are to be left unconnected.
5. 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:

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

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

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

## ORDERING INFORMATION

| 468H SUFFIX | STATOR INPUT TYPE | STATOR INPUT VOLT | REFERENCE INPUT VOLTAGE | REFERENCE INPUT FREQUENCY |
|---|---|---|---|---|
| 200 | SYNC | 90.0V | 10-130V | 47-5000Hz |
| 201 | SYNC | 11.8V | 10-130V | 360-5000Hz |
| 202 | SYNC | 90.0V | 10-130V | 360-5000Hz |
| 203 | RSVR | 11.8V | 10-130V | 360-5000Hz |
| 204 | RSVR | 2.5V | 2.5-30V | 360-5000Hz |
| 205 | RSVR | 5.0V | 2.5-30V | 360-5000Hz |
| 206 | RSVR | 2.5V | 2.5-30V | 2.0-5.0KHz |
| 207 | RSVR | 5.0V | 2.5-30V | 2.0-5.0KHz |

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