## FEATURES and FUNCTIONAL DIAGRAM

- AEC-Q100 automotive qualified for CHA93X
- Digital Omnipolar-Switch Hall Sensor
- Superior Temperature Stability
- Multiple Sensitivity Options (BOP / BRP):
$\pm 25 / \pm 15$ Gauss; $\pm 70 / \pm 35$ Gauss; $\pm 100 / \pm 50$ Gauss;
- On board voltage regulator for 2.5 V to 22 V range
- Open Drain Output (25 mA Sink)
- Resistant to physical stress
- Output short-circuit protection
- Operation from unregulated supply
- Reverse-battery and freewheeling protection
- Solid-state reliability
- Wide Operating temperature range: -40 to $150{ }^{\circ} \mathrm{C}$
- Small package sizes TO-92S, SOT-23 and SOT-89
- RoHS-compliant material meets directive 2011/65/EU


PACKAGE


SOT-23-3L SOT-89-3L

APPLICATIONS
Docking Detection
Door Open and Close Detection
-Proximity Sensing
-Valve Positioning
-Pulse Counting
Flow rate sensing Robotic control (cylinder position monitoring)
-Float-based fluid level sensing
Speed and RPM sensing in fitness equipment

## DESCRIPTION

The CHA93X/CHI93X Hall-effect sensor is extremely temperature-stable and stress-resistant sensor ICs, especially suited for operation over extended temperature ranges from $-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$. Superior high temperature performance is possible through dynamic offset cancellation, which reduces the residual offset voltage normally caused by device over-molding, temperature dependencies, and thermal stress.

The device includes a voltage regulator, Hall-voltage generator, small-signal amplifier, chopper stabilization, Schmitt trigger, and a short circuit protected open-drain output to sink up to 25 mA .

An on-board regulator permits operation with supply voltages of 2.5 to 22 V . The advantage of operating down to 2.5 V is that the device can used in 2.5 V applications or with additional external resistance in series with the supply pin for greater protection against high-voltage transient events.

The CHA93X/CHI93X series is digital Omnipolar Hall switch. When the applied magnetic flux density exceeds the BOP threshold, the chip open-drain output goes low. The output stays low until the field decreases to less than BRP, and then the output goes to high impedance.

The CHA93X/CHI93X also integrated internal clamps against supply/output transients; output short circuits protection; reverse battery conditions.

Three package styles provide a magnetically optimized package for most applications, SOT-23, TO-92S and SOT-89. Each package type is lead (Pb) free (suffix, -T ), with a $100 \%$ matte-tin-plated lead-frame.

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## 1. Product Family Members

| Part Number | Marking ID | Description |
| :--- | :---: | :--- |
| CHA931SR | C931 | Omnipolar-Switch, Hall-effect digital sensor IC, SOT-23-3L package, tape <br> and reel packing (3000 units per reel) |
| CHA931TB | C931 | Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, bulk <br> packing (1000 units per bag) |
| CHA931ER | C931 | Omnipolar-Switch, Hall-effect digital sensor IC, SOT-89-3L package, tape <br> and reel packing (1000 units per reel) |
| CHA932SR | C932 | Omnipolar-Switch, Hall-effect digital sensor IC, SOT-23-3L package, tape <br> and reel packing (3000 units per reel) |
| CHA932TB | C932 | Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, bulk <br> packing (1000 units per bag) |
| CHA932ER | C932 | Omnipolar-Switch, Hall-effect digital sensor IC, SOT-89-3L package, tape <br> and reel packing (1000 units per reel) |
| CHA933SR | C933 | Omnipolar-Switch, Hall-effect digital sensor IC, SOT-23-3L package, tape <br> and reel packing (3000 units per reel) |
| CHA933TB | C933 | Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, bulk <br> packing (1000 units per bag) |
| CHA933ER | C933 | Omnipolar-Switch, Hall-effect digital sensor IC, SOT-89-3L package, tape <br> and reel packing (1000 units per reel) |
| CHI931SR | 1931 | Omnipolar-Switch, Hall-effect digital sensor IC, SOT-23-3L package, tape <br> and reel packing (3000 units per reel) |
| CHI931TB | 1931 | Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, bulk <br> packing (1000 units per bag) |
| CHI931TR | 1931 | Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, tape <br> and reel packing (3000 units per reel) |
| CHI931ER | 1931 | Omnipolar-Switch, Hall-effect digital sensor IC, SOT-89-3L package, tape <br> and reel packing (1000 units per reel) |
| CHI932SR | 1932 | Omnipolar-Switch, Hall-effect digital sensor IC, SOT-23-3L package, tape <br> and reel packing (3000 units per reel) |
| CHI932TB | 1932 | Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, bulk <br> packing (1000 units per bag) |
| CHI932ER | 1932 | Omnipolar-Switch, Hall-effect digital sensor IC, SOT-89-3L package, tape <br> and reel packing (1000 units per reel) |
| CHI933SR | 1933 | Omnipolar-Switch, Hall-effect digital sensor IC, SOT-23-3L package, tape <br> and reel packing (3000 units per reel) |
| CHI933TB | 1933 | Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, bulk <br> packing (1000 units per bag) |
| CHI933ER | 1933 | Omnipolar-Switch, Hall-effect digital sensor IC, SOT-89-3L package, tape <br> and reel packing (1000 units per reel) |


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## 2. Pin Definitions and Descriptions

| SOT-23-3L <br> $($ S $)$ | TO-92S <br> $(T)$ | SOT-89-3L <br> $(E)$ | Name | Type | Function |
| :---: | :---: | :---: | :---: | :---: | :--- |
| 1 | 1 | 1 | VDD | Supply | Supply Voltage pin |
| 2 | 3 | 3 | OUT | Output | Open Collector Output pin |
| 3 | 2 | 2 | GND | Ground | Ground pin |



SOT-23-3L


TO-92S


SOT-89-3L
3. Absolute Maximum Ratings

| Parameter | Symbol | Min | Max | Units |
| :--- | :---: | :---: | :---: | :---: |
| Supply Voltage | $\mathrm{V}_{\text {DD }}$ | - | 24 | V |
| VDD Reverse Voltage VDD | $\mathrm{V}_{\text {RDD }}$ | -22 |  | V |
| Supply Current | $\mathrm{I}_{\mathrm{DD}}$ | - | 20 | mA |
| Output Voltage | $\mathrm{V}_{\text {OUT }}$ | -0.3 | 24 | V |
| Output Current | $\mathrm{I}_{\text {out }}$ | - | 25 | mA |
| Operating Ambient Temperature | $\mathrm{T}_{\mathrm{A}}$ | -40 | 150 | ${ }^{\circ} \mathrm{C}$ |
| Storage Temperature | $\mathrm{T}_{\mathrm{S}}$ | -50 | 150 | ${ }^{\circ} \mathrm{C}$ |
| Junction temperature | $\mathrm{T}_{\mathrm{J}}$ | -50 | 165 | ${ }^{\circ} \mathrm{C}$ |
| Magnetic Flux | B | No Limit |  | Gauss |

Note: Exceeding the absolute maximum ratings may cause permanent damage. Exposure to absolute-maximum- rated conditions for extended periods may affect device reliability.

## 4. ESD Protections

| Parameter | Value | Unit |
| :--- | :---: | :---: |
| All pins ${ }^{1)}$ | $+/-8000$ | V |
| All pins $^{2)}$ | $+/-200$ | V |
| All pins $^{3)}$ | $+/-750$ | V |

1) HBM (Human Body Mode) according to AEC-Q100-002
2) MM (Machine Mode) according to AEC-Q100-003
3) CDM (charged device mode) according to AEC-Q100-011

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## 5. Function Description

The CHA93X/CHI93X exhibits digital Omnipolar switching characteristics. Therefore, it requires only south poles or north poles to operate properly.
When the applied magnetic flux density exceeds the BOP threshold, the chip open-drain output goes low. The output stays low until the field decreases to less than BRP, and then the output goes to high impedance.

A magnetic hysteresis BHYST keeps BOP and BRP separated by a minimal value. This hysteresis prevents output oscillation near the switching point.

## 6. Magnetic Activation



## 7. Temperature Characteristics



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## 8. Parameters Specification (VCC=3.3V supply, TA= $-40{ }^{\circ} \mathrm{C}$ to $150{ }^{\circ} \mathrm{C}$ except where otherwise specified.)

| Symbol | Parameter | Test Condition | Min | Typ. | Max | Units |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $V_{\text {DD }}$ | Supply voltage | $-40^{\circ} \mathrm{C}$ to $150{ }^{\circ} \mathrm{C}$ | 2.5 | - | 22 | V |
| ldo | Supply Current | $\mathrm{V}_{\mathrm{DD}}=3.3 \mathrm{~V}$ | - | 1.6 | 3 | mA |
| Vzsupply | Supply <br> VoltageZener Clamp | $\mathrm{Icc}^{\text {c }}=7 \mathrm{~mA} ; \mathrm{TA}=25^{\circ} \mathrm{C}$ | 24 |  |  | V |
| Vzout | Output <br> VoltageZener Clamp | l Out $=3 \mathrm{~mA}$ | 24 |  |  | V |
| $\mathrm{V}_{\text {RCC }}$ | Reverse Battery Zener |  |  |  | -22 | V |
| $\mathrm{I}_{\mathrm{RCC}}$ | Reverse Battery Current | $\mathrm{V}_{\mathrm{cc}}=-22 \mathrm{~V}$ | -5 |  |  | mA |
| $\mathrm{F}_{\mathrm{C}}$ | Chopping Frequency |  |  | 500 |  | KHz |
| tpo | Power-On Time | $\mathrm{TA}=25^{\circ} \mathrm{C} ; \mathrm{C}_{\mathrm{LOAD}}=10$ $\mathrm{pF}$ | - | _ | 30 | $\mu \mathrm{s}$ |
| $\mathrm{V}_{\text {DSon }}$ | Output saturation voltage | at 20 mA , Gauss >BOP | - | - | 0.4 | V |
| loff | Output Leakage Current | $\begin{aligned} & \text { VOUT = } 24 \mathrm{~V} \text {; Switch } \\ & \text { state = Off } \end{aligned}$ | - | - | 10 | uA |
| lout(lim) | Output Current Limit | Short-Circuit Protection | 30 | - | 90 | mA |
| TR | Output rise time | $\begin{aligned} & \mathrm{R}_{\text {LOAD }}=820 \Omega, \mathrm{C}_{\text {LOAD }} \\ & =10 \mathrm{pF} ; \end{aligned}$ | - | 0.2 | 2 | uS |
| TF | Output fall time | $\begin{aligned} & \text { RLOAD }=820 \Omega, \text { CLOAD }= \\ & 10 \mathrm{pF} ; \end{aligned}$ | - | 0.1 | 2 | uS |
| Td | Output delay Time | B=Brp-100G to $B o p+100 G$ in 1us |  | 13 | 25 | $\mu \mathrm{s}$ |
| $\mathrm{R}_{\text {TH }}$ | Thermal resistance: SOT-23-3L TO-92S SOT-89-3L | - |  | $\begin{aligned} & 303 \\ & 203 \\ & 230 \end{aligned}$ | - | $\begin{aligned} & { }^{\circ} \mathrm{C} / \mathrm{W} \\ & { }^{\circ} \mathrm{C} / \mathrm{W} \\ & { }^{\circ} \mathrm{C} / \mathrm{W} \\ & \hline \end{aligned}$ |
| $\mathrm{Fsw}^{(2)}$ | Maximum Switching Frequency |  | 20 | 30 |  | KHz |
| T | Operating temperature | - | -40 | - | 150 | ${ }^{\circ} \mathrm{C}$ |
| Ts | Storage temperature: | - | -40 | - | 150 | ${ }^{\circ} \mathrm{C}$ |
| CHA931/CHI931 |  |  |  |  |  |  |
| Bop | Magnetic operating point | $\mathrm{T}_{\mathrm{A}}=-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$ | $\pm 15$ | $\pm 30$ | $\pm 55$ | Gauss |
| $\mathrm{B}_{\text {RP }}$ | Magnetic release point | $\mathrm{T}_{\mathrm{A}}=-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$ | $\pm 5$ | $\pm 20$ | $\pm 45$ | Gauss |
| Bhyst | Magnetic hysteresis window \|BOP|-|BRP| | $\mathrm{T}_{\mathrm{A}}=-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$ | 4 | 10 | 30 | Gauss |
| B | $\begin{aligned} & \text { Magnetic offset; } \mathrm{Bo}=(\|\mathrm{BOP}\| \\ & +\|\mathrm{BRP}\|) / 2 \end{aligned}$ | $\mathrm{T}_{\mathrm{A}}=-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$ |  | 20 |  | Gauss |
| CHA932/CHI932 |  |  |  |  |  |  |
| Bop | Magnetic operating point | $\mathrm{T}_{\mathrm{A}}=-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$ | $\pm 30$ | $\pm 60$ | $\pm 90$ | Gauss |
| $\mathrm{B}_{\text {RP }}$ | Magnetic release point | $\mathrm{T}_{\mathrm{A}}=-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$ | $\pm 15$ | $\pm 30$ | $\pm 60$ | Gauss |
| Bhyst | Magnetic hysteresis window \|BOP|-|BRP| | $\mathrm{T}_{\mathrm{A}}=-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$ | 20 | 30 | 50 | Gauss |
| B | $\begin{aligned} & \text { Magnetic offset; } \mathrm{Bo}=(\|\mathrm{BOP}\| \\ & +\|\mathrm{BRP}\|) / 2 \end{aligned}$ | $\mathrm{T}_{\mathrm{A}}=-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$ |  | 45 |  | Gauss |
| CHA933/CHI933 |  |  |  |  |  |  |
| Bop | Magnetic operating point | $\mathrm{T}_{\mathrm{A}}=-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$ | $\pm 70$ | $\pm 100$ | $\pm 150$ | Gauss |


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| $B_{\text {RP }}$ | Magnetic release point |  | $\mathrm{T}_{\mathrm{A}}=-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$ | - $\quad \pm 30$ | $\pm 50$ | $\pm 100$ | Gauss |
| Bhyst | Magnetic hysteresis window \|BOP|-|BRP| |  | $\mathrm{T}_{\mathrm{A}}=-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$ |  | 50 |  | Gauss |
| B | $\begin{aligned} & \text { Magnetic offset; } \mathrm{Bo}_{\mathrm{o}}=(\|\mathrm{BOP}\| \\ & +\|\mathrm{BRP}\|) / 2 \end{aligned}$ |  | $\mathrm{T}_{\mathrm{A}}=-40^{\circ} \mathrm{C}$ to $150^{\circ} \mathrm{C}$ |  | 75 |  | Gauss |

(1) $1 \mathrm{mT}=10$ Gauss
(2) Bandwidth describes the fastest changing magnetic field that can be detected and translated to the output.

## NOTICE

The magnetic field strength (Gauss) required to cause the switch to change state (operate and release) will be as specified in the magnetic characteristics. To test the switch against the specified magnetic characteristics, the switch must be placed in a uniform magnetic field.

## 9. Application Information

### 9.1 Typical Application

It is recommended that an external capacitor C 1 is connected to the supply. This can reduce the noise injected into the device. Normal 0.1 uF is suggested.


### 9.2 Device Output

If the device is powered on with a magnetic field strength between BRP and BOP, then the device output is indeterminate and can either be $\mathrm{Hi}-\mathrm{Z}$ or Low. If the field strength is greater than BOP, then the output is pulled low. If the field strength is less than BRP, then the output is released.


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### 9.3 Output Stage

The CHA93X/CHI93X output stage uses an open-drain NMOS, and it is rated to sink up to 30 mA of current. For proper operation, calculate the value of the pullup resistor R1 using Equation 1.
$\frac{\mathrm{V}_{\text {ref }} \text { max }}{30 \mathrm{~mA}} \leq \mathrm{R} 1 \leq \frac{\mathrm{V}_{\text {ref }} \text { min }}{100 \mu \mathrm{~A}}$
The size of R1 is a tradeoff between the OUT rise time and the current when OUT is pulled low. A lower current is generally better, however faster transitions and bandwidth require a smaller resistor for faster switching. In addition, ensure that the value of R1 > $500 \Omega$ to ensure the output driver can pull the OUT pin close to GND.


Select a value for C2 based on the system bandwidth specifications as shown in Equation 2.

$$
\begin{equation*}
2 \times f_{\mathrm{BW}}(\mathrm{~Hz})<\frac{1}{2 \pi \times \mathrm{R} 1 \times \mathrm{C} 2} \tag{2}
\end{equation*}
$$

Most applications do not require this C2 filtering capacitor.

### 9.4 Protection Circuits

The CHA93X/CHI93X device is fully protected against overcurrent and reverse-supply conditions.

### 9.5 Overcurrent Protection (OCP)

An analog current-limit circuit limits the current through the FET. The driver current is clamped to IOCP. During this clamping, the rDS(on) of the output FET is increased from the nominal value.

### 9.6 Reverse Supply Protection

The CHA93X/CHI93X device is protected in the event that the VCC pin and the GND pin are reversed (up to -22 V).

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### 9.7 Alternative Two-Wire Application

For systems that require minimal wire count, the device output can be connected to VCC through a resistor, and the total supplied current can be sensed near the controller.


2-Wire Application
Current can be sensed using a shunt resistor or other circuitry.

## 10. Test Conditions

Note: DUT=Device Under Test

## Supply Current



Note 1 - The supply current IDD represents the static supply current. OUT is left open during measurement

Note 2 - The device is put under magnetic field with $B<B R P$

## Output Leakage Current



Note 1 - The device is put under magnetci field with $B<B_{R P}$

Output Saturation Voltage


Note 1 - The output saturation voltage VDSon is measeured at $V_{D D}=3.3 \mathrm{~V}$ and $\mathrm{V}_{\mathrm{DD}}=20 \mathrm{~V}$

Note 2 - The device is put under magnetic field with $B>B o p$

> Magenetic Thresholds


Note 1 - Bop is determined by putting the device under magnetic field swept from BRPmin up to BoPmax until the output is switched on.
Note 2 - BRP is determined by putting the device under magnetic field swept from Bopmax down to BrPmin until the output is switched off.

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## 11. Package and Packing Information:

## For CHA93XTB and CH193XTB:

## Package Designator



| Symbol | Dimensions in Millimeters |  |  |
| :---: | :---: | :---: | :---: |
|  | Min. | Typ. | Max. |
| A | 2.9 | 3 | 3.1 |
| b | 0.35 | 0.39 | 0.56 |
| b1 |  | 0.44 |  |
| c | 0.36 | 0.38 | 0.51 |
| D | 3.9 | 4 | 4.1 |
| E | 1.42 | 1.52 | 1.62 |
| E1 |  | 0.75 |  |
| e |  | 1.27 |  |
| e1 |  | 2.54 |  |
| L | 13.5 | 14.5 |  |
| L1 |  | 1.6 |  |
| $\theta 1$ |  | $6^{\circ}$ |  |
| $\theta 2$ |  | $3^{\circ}$ |  |
| $\theta 3$ |  | $3^{\circ}$ |  |
| $\theta 4$ |  | $3^{\circ}$ |  |

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## For CHI931TR only:

TO-92S PACKAGE TAPEING DIMENSION


| Item | Symbol | Value \& Tolerance |
| :--- | :---: | :---: |
| Body width | A 1 | $4.0 \pm 0.1$ |
| Body height | A | $3.15 \pm 0.1$ |
| Body thickness | T | $1.52 \pm 0.1$ |
| Lead wire diameter | d | $0.38+0.1,-0.05$ |
| Lead wire diameter1 | d 1 | $0.46+0.05,-0.06$ |
| Pitch of component | P | $12.7 \pm 0.3$ |
| Feed hole pitch | P 0 | $12.7 \pm 0.2$ |
| Hole center to component center | F 2 | $6.35 \pm 0.3$ |
| Lead to lead distance | F 2 | $2.5 \pm 0.3$ |
| Component alignment, $\mathrm{F}-\mathrm{R}$ | W | $0 \pm 1.0$ |
| Type width | W 0 | $18.0+1.0,-0.5$ |
| Hole down tape width | W 1 | $6.0 \pm 0.5$ |
| Hole position | W 2 | $9.0 \pm 0.5$ |
| Hole down tape position | H | 1.0 MAX |
| Height of component from tape center | H 0 | $19.0+2.0,-1.0$ |
| Lead wire clinch height | L 1 | $16.0 \pm 0.5$ |
| Lead wire(tape portion) | D 0 | 2.50 MIN. |
| Feed hole diameter | t 1 | $4.0 \pm 0.2$ |
| Carrier Tape Thickness | t 2 | $0.4 \pm 0.05$ |
| Taped Lead Thickness | P 1 | $0.2 \pm 0.05$ |
| Position of hole | $\triangle \mathrm{P}$ | $3.85 \pm 0.3$ |
| Component alignment |  | $0 \pm 1.0$ |
|  | $\mathrm{Unit}: \mathrm{mm}$ |  |


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## PACKAGE DESIGNATOR

SOT-23-3L


| Symbol | Dimensions In Millimeters |  | Dimensions In Inches |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Min | Max | Min | Max |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| C | 0.100 | 0.200 | 0.004 | 0.008 |
| D | 2.820 | 3.020 | 0.111 | 0.119 |
| E | 1.500 | 1.700 | 0.059 | 0.067 |
| E1 | 2.650 | 2.950 | 0.104 | 0.116 |
| e | 0.950 |  | BSC) | $0.037(B S C)$ |
| e1 | 1.800 | 2.000 | 0.071 | 0.079 |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| $\theta$ | $0^{\circ}$ | $8^{\circ}$ | $0^{\circ}$ | $8^{\circ}$ |


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PACKAGE DESIGNATOR
SOT-89-3L


| Symbol | Dimensions In Millimeters |  | Dimensions In Inches |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Min. | Max. | Min. | Max. |
| A | 1.400 | 1.600 | 0.055 | 0.063 |
| b | 0.320 | 0.520 | 0.013 | 0.020 |
| b1 | 0.400 | 0.580 | 0.016 | 0.023 |
| c | 0.350 | 0.440 | 0.014 | 0.017 |
| D | 4.400 | 4.600 | 0.173 | 0.181 |
| D1 | 1.550 REF. |  | 0.061 REF. |  |
| E | 2.300 | 2.600 | 0.091 | 0.102 |
| E1 | 3.940 | 4.250 | 0.155 | 0.167 |
| e | 1.500 TYP. |  | 0.060 TYP. |  |
| e1 | 3.000 TYP. |  | 0.118 TYP. |  |
| L | 0.900 | 1.200 | 0.035 | 0.047 |


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