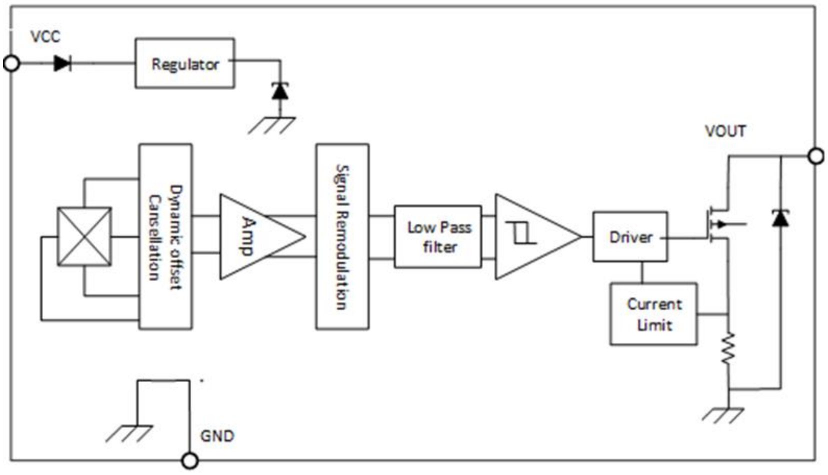
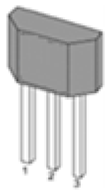
FEATURES and FUNCTIONAL DIAGRAM

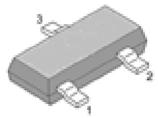
- AEC-Q100 automotive qualified for CHA93X
- Digital Omnipolar-Switch Hall Sensor
- Superior Temperature Stability
- Multiple Sensitivity Options (BOP / BRP):
  ±25 / ±15 Gauss; ±70 /±35 Gauss; ±100/ ±50 Gauss;
- On board voltage regulator for 2.5V to 22V range
- Open Drain Output (25 mA Sink)
- Resistant 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 ºC
- Small package sizes TO-92S, SOT-23 and SOT-89
- RoHS-compliant material meets directive 2011/65/EU



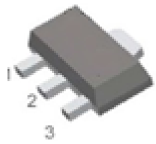
PACKAGE



TO-92S



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°C to 150°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 2.5V is that the device can used in 2.5V 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.

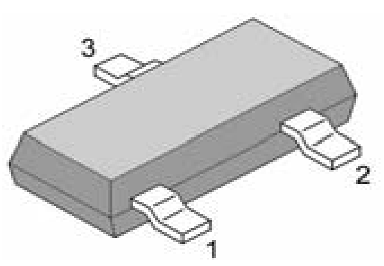
Table of Contents

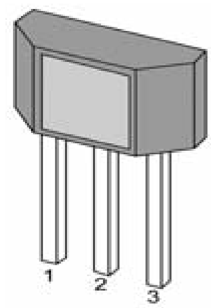
1. Product Family Members

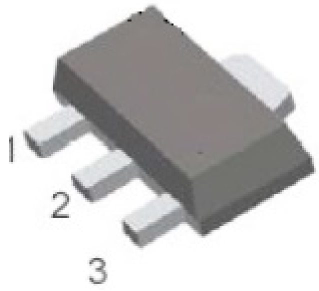
Part Number	Marking ID	Description
CHA931SR	C931	Omnipolar-Switch, Hall-effect digital sensor IC, SOT-23-3L package, tape and reel packing (3000 units per reel)
CHA931TB	C931	Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, bulk packing (1000 units per bag)
CHA931ER	C931	Omnipolar-Switch, Hall-effect digital sensor IC, SOT-89-3L package, tape and reel packing (1000 units per reel)
CHA932SR	C932	Omnipolar-Switch, Hall-effect digital sensor IC, SOT-23-3L package, tape and reel packing (3000 units per reel)
CHA932TB	C932	Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, bulk packing (1000 units per bag)
CHA932ER	C932	Omnipolar-Switch, Hall-effect digital sensor IC, SOT-89-3L package, tape and reel packing (1000 units per reel)
CHA933SR	C933	Omnipolar-Switch, Hall-effect digital sensor IC, SOT-23-3L package, tape and reel packing (3000 units per reel)
CHA933TB	C933	Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, bulk packing (1000 units per bag)
CHA933ER	C933	Omnipolar-Switch, Hall-effect digital sensor IC, SOT-89-3L package, tape and reel packing (1000 units per reel)
CHI931SR	I931	Omnipolar-Switch, Hall-effect digital sensor IC, SOT-23-3L package, tape and reel packing (3000 units per reel)
CHI931TB	I931	Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, bulk packing (1000 units per bag)
CHI931TR	I931	Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, tape and reel packing (3000 units per reel)
CHI931ER	I931	Omnipolar-Switch, Hall-effect digital sensor IC, SOT-89-3L package, tape and reel packing (1000 units per reel)
CHI932SR	I932	Omnipolar-Switch, Hall-effect digital sensor IC, SOT-23-3L package, tape and reel packing (3000 units per reel)
CHI932TB	I932	Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, bulk packing (1000 units per bag)
CHI932ER	I932	Omnipolar-Switch, Hall-effect digital sensor IC, SOT-89-3L package, tape and reel packing (1000 units per reel)
CHI933SR	I933	Omnipolar-Switch, Hall-effect digital sensor IC, SOT-23-3L package, tape and reel packing (3000 units per reel)
CHI933TB	I933	Omnipolar-Switch, Hall-effect digital sensor IC, flat, TO-92S package, bulk packing (1000 units per bag)
CHI933ER	I933	Omnipolar-Switch, Hall-effect digital sensor IC, SOT-89-3L package, tape and reel packing (1000 units per reel)

2. Pin Definitions and Descriptions

SOT-23-3L (S)	TO-92S (T)	SOT-89-3L (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	V_{DD}	-	24	V
VDD Reverse Voltage VDD	V_{RDD}	-22		V
Supply Current	I_{DD}	-	20	mA
Output Voltage	V_{OUT}	-0.3	24	V
Output Current	I_{OUT}	-	25	mA
Operating Ambient Temperature	T_A	-40	150	°C
Storage Temperature	T_S	-50	150	°C
Junction temperature	T_J	-50	165	°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

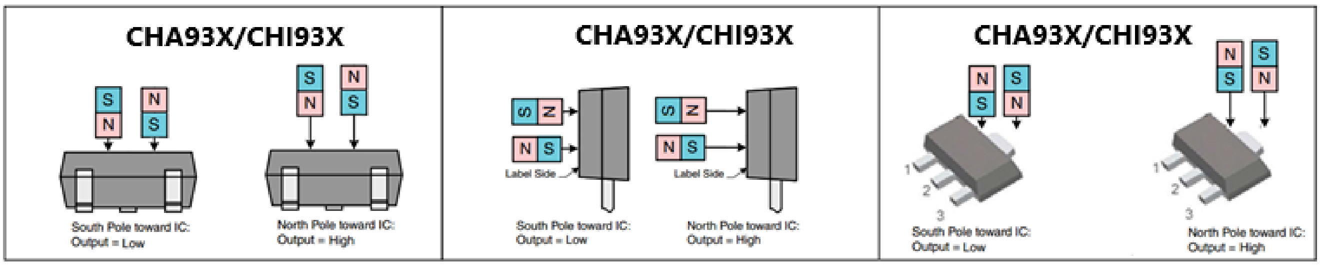
5. Function Description

The CHA93X/CHI93X exhibits digital Omnipolar switching characteristics. Therefore, it requires only south poles or north poles to operate properly.

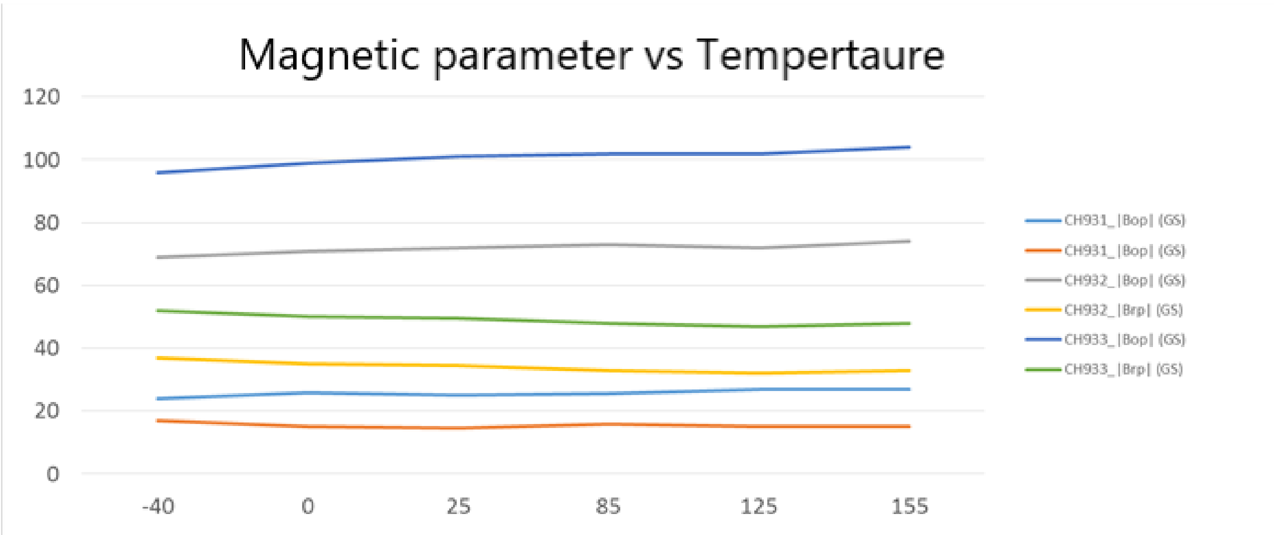
When the applied magnetic flux density exceeds the BOP threshold, the chip open-drain output goes low. The output stays low until the field decreases to less than BRP, and then the output goes to high impedance.

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



8. Parameters Specification (VCC=3.3V supply, TA= -40 ºC to 150 ºC except where otherwise specified.)

Symbol	Parameter	Test Condition	Min	Typ.	Max	Units
V_{DD}	Supply voltage	-40 °C to 150 °C	2.5	-	22	V
I_{DD}	Supply Current	V_{DD} = 3.3V	-	1.6	3	mA
$V_{ZSUPPLY}$	Supply Zener Clamp Voltage	I_{CC} =7 mA; TA = 25°C	24			V
V_{ZOUT}	Output Zener Clamp Voltage	I_{OUT} = 3mA	24			V
V_{RCC}	Reverse Battery Zener				-22	V
I_{RCC}	Reverse Battery Current	V_{CC} = –22 V	-5			mA
F_C	Chopping Frequency			500		KHz
t_{PO}	Power-On Time	TA = 25°C; C_{LOAD} = 10 pF	–	–	30	μs
V_{DSon}	Output saturation voltage	at 20mA, Gauss >BOP	-	-	0.4	V
I_{OFF}	Output Leakage Current	VOUT = 24 V; Switch state = Off	-	-	10	uA
$I_{OUT(lim)}$	Output Current Limit	Short-Circuit Protection	30	–	90	mA
T_R	Output rise time	R_{LOAD} = 820 Ω, C_{LOAD} = 10 pF;	-	0.2	2	uS
T_F	Output fall time	R_{LOAD} = 820Ω, C_{LOAD} = 10 pF;	-	0.1	2	uS
T_d	Output delay Time	B=Brp-100G to Bop+100G in 1us		13	25	μs
R_{TH}	Thermal resistance: SOT-23-3L TO-92S SOT-89-3L	-	- - -	303 203 230	- - -	°C /W °C/W °C/W
$F_{SW}^{(2)}$	Maximum Switching Frequency		20	30		KHz
T	Operating temperature	-	-40	-	150	°C
T_S	Storage temperature:	-	-40	-	150	°C
CHA931/CHI931						
B_{OP}	Magnetic operating point	T_A=-40ºC to 150ºC	±15	±30	±55	Gauss
B_{RP}	Magnetic release point	T_A=-40ºC to 150ºC	±5	±20	±45	Gauss
B_{HYST}	Magnetic hysteresis window |BOP|-|BRP|	T_A=-40ºC to 150ºC	4	10	30	Gauss
B_o	Magnetic offset; B_O = (|BOP| + |BRP|) / 2	T_A=-40ºC to 150ºC		20		Gauss
CHA932/CHI932						
B_{OP}	Magnetic operating point	T_A=-40ºC to 150ºC	±30	±60	±90	Gauss
B_{RP}	Magnetic release point	T_A=-40ºC to 150ºC	±15	±30	±60	Gauss
B_{HYST}	Magnetic hysteresis window |BOP|-|BRP|	T_A=-40ºC to 150ºC	20	30	50	Gauss
B_o	Magnetic offset; B_O = (|BOP| + |BRP|) / 2	T_A=-40ºC to 150ºC		45		Gauss
CHA933/CHI933						
B_{OP}	Magnetic operating point	T_A=-40ºC to 150ºC	±70	±100	±150	Gauss

B_{RP}	Magnetic release point	T_A=-40ºC to 150ºC	±30	±50	±100	Gauss
B_{HYST}	Magnetic hysteresis window |BOP|-|BRP|	T_A=-40ºC to 150ºC		50		Gauss
B_o	Magnetic offset; B_O = (|BOP| + |BRP|) / 2	T_A=-40ºC to 150ºC		75		Gauss

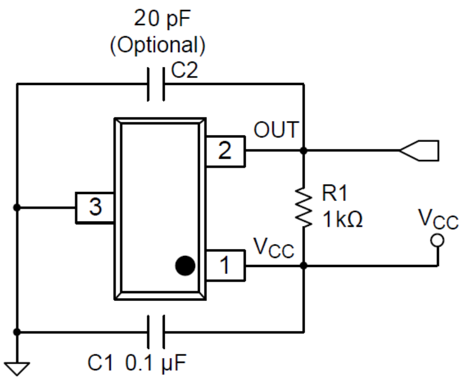
(1) 1 mT = 10 Gauss
(2) Bandwidth describes the fastest changing magnetic field that can be detected and translated to the output.

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

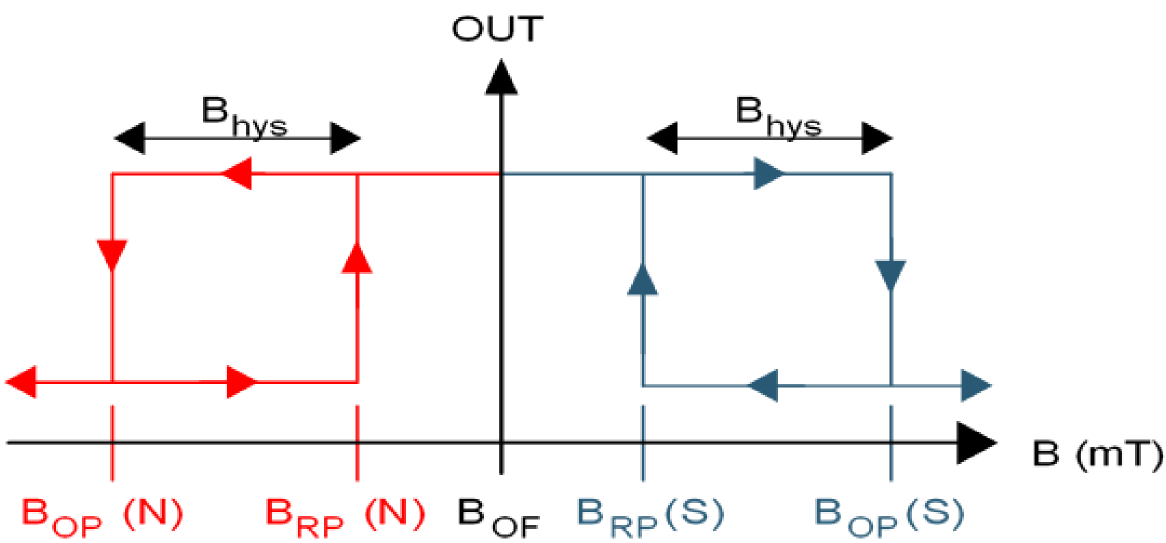
It is recommended that an external capacitor C1 is connected to the supply. This can reduce the noise injected into the device. Normal 0.1uF is suggested.



Typical Application Circuit

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 Hi-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.

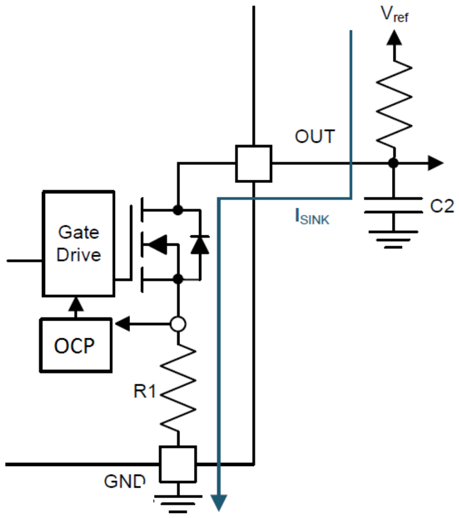


9.3 Output Stage

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.

$$\frac{V_{ref}\,\max}{30\text{ mA}} \leq R1 \leq \frac{V_{ref}\,\min}{100\ \mu\text{A}} \qquad (1)$$

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 Ω 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.

$$2 \times f_{BW}\ (\text{Hz}) < \frac{1}{2\pi \times R1 \times C2} \qquad (2)$$

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)

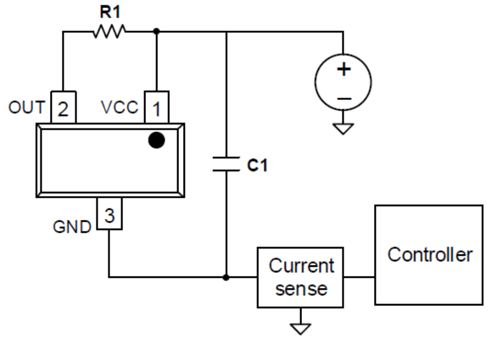
An analog current-limit circuit limits the current through the FET. The driver current is clamped to IOCP. During this clamping, the rDS(on) of the output FET is increased from the nominal value.

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).

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.



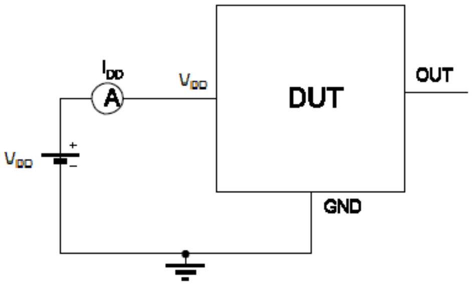
2-Wire Application

Current can be sensed using a shunt resistor or other circuitry.

10. Test Conditions

Note: DUT=Device Under Test

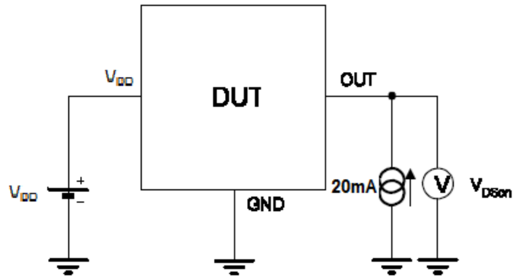
Supply Current



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<BRP

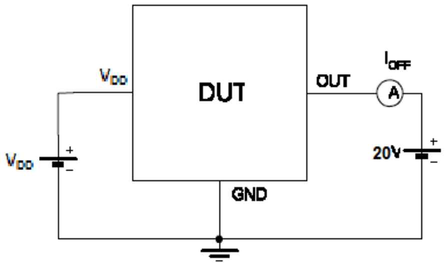
Output Saturation Voltage



Note 1 - The output saturation voltage VDSon is measeured at VDD=3.3V and VDD=20V

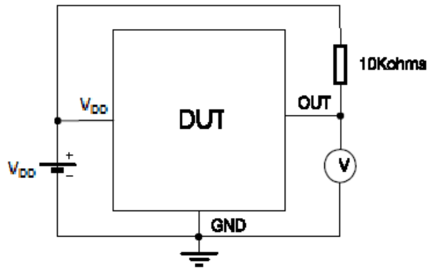
Note 2 - The device is put under magnetic field with B>BOP

Output Leakage Current



Note 1 - The device is put under magnetci field with B<BRP

Magenetic Thresholds



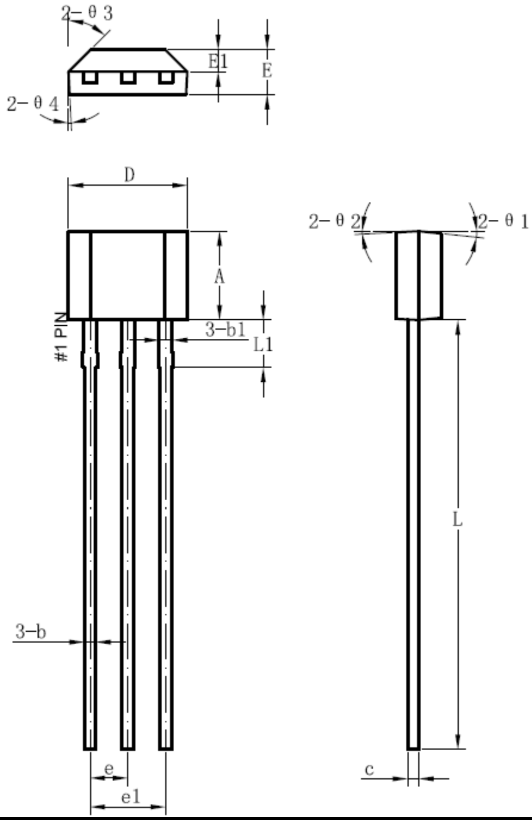
Note 1 - BOP is determined by putting the device under magnetic field swept from BRPmin up to BOPmax until the output is switched on.

Note 2 - BRP is determined by putting the device under magnetic field swept from BOPmax down to BRPmin until the output is switched off.

11. Package and Packing Information:

For CHA93XTB and CHI93XTB:

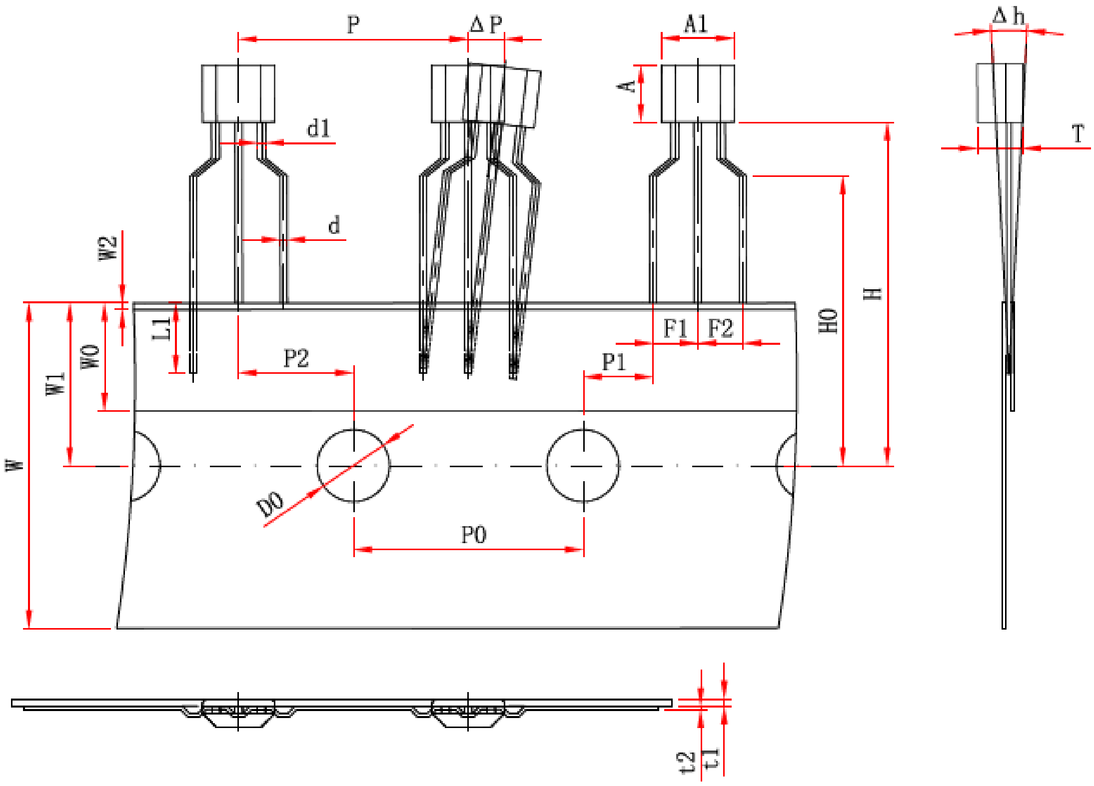
Package Designator
TO-92S



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	15.5
L1		1.6	
θ1		6°	
θ2		3°	
θ3		45°	
θ4		3°	

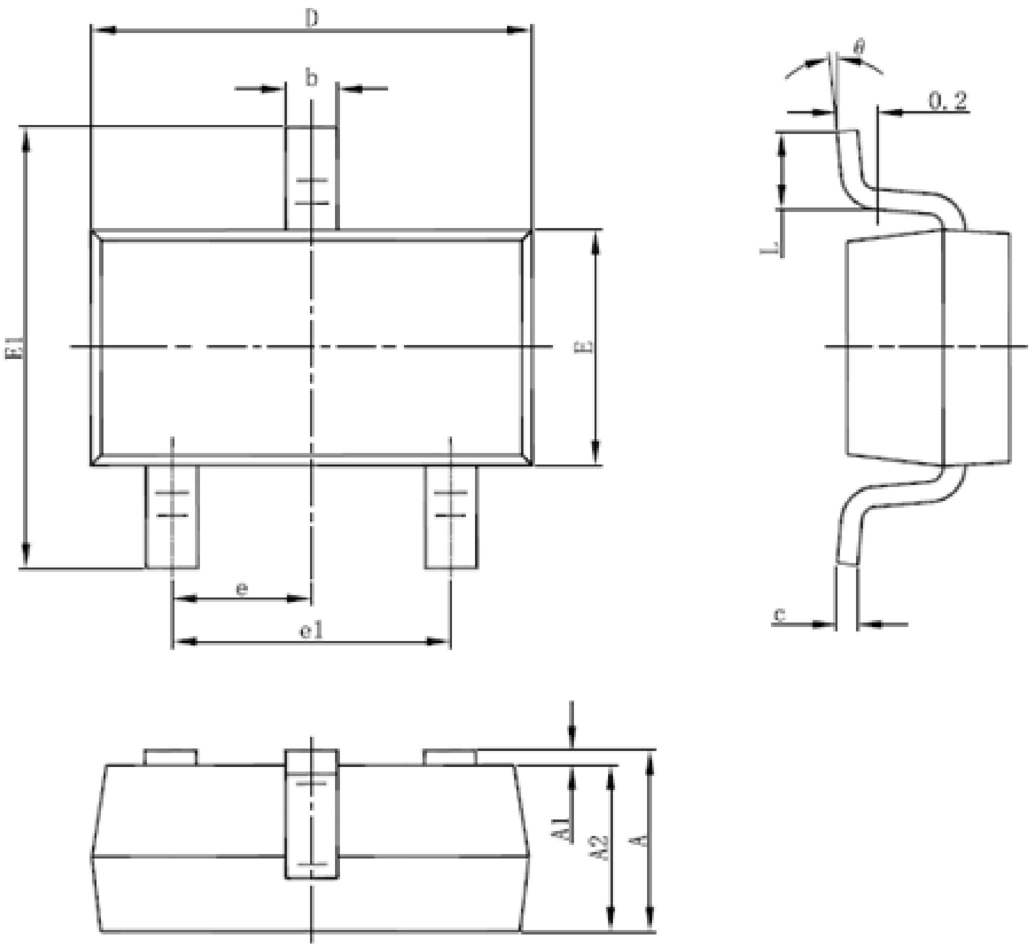
For CHI931TR only:

TO-92S PACKAGE TAPEING DIMENSION



Item	Symbol	Value & Tolerance
Body width	A1	4.0 ± 0.1
Body height	A	3.15 ± 0.1
Body thickness	T	1.52 ± 0.1
Lead wire diameter	d	0.38+0.1, - 0.05
Lead wire diameter1	d1	0.46+ 0.05, - 0.06
Pitch of component	P	12.7 ± 0.3
Feed hole pitch	P0	12.7 ± 0.2
Hole center to component center	P2	6.35 ± 0.3
Lead to lead distance	F1,F2	2.5 ± 0.3
Component alignment, F-R	△h	0 ± 1.0
Type width	W	18.0 + 1.0, - 0.5
Hole down tape width	W0	6.0 ± 0.5
Hole position	W1	9.0 ± 0.5
Hole down tape position	W2	1.0MAX.
Height of component from tape center	H	19.0 +2.0, -1.0
Lead wire clinch height	H0	16.0 ± 0.5
Lead wire(tape portion)	L1	2.50 MIN.
Feed hole diameter	D0	4.0 ± 0.2
Carrier Tape Thickness	t1	0.4 ± 0.05
Taped Lead Thickness	t2	0.2 ± 0.05
Position of hole	P1	3.85±0.3
Component alignment	△P	0 ± 1.0
		Unit : mm

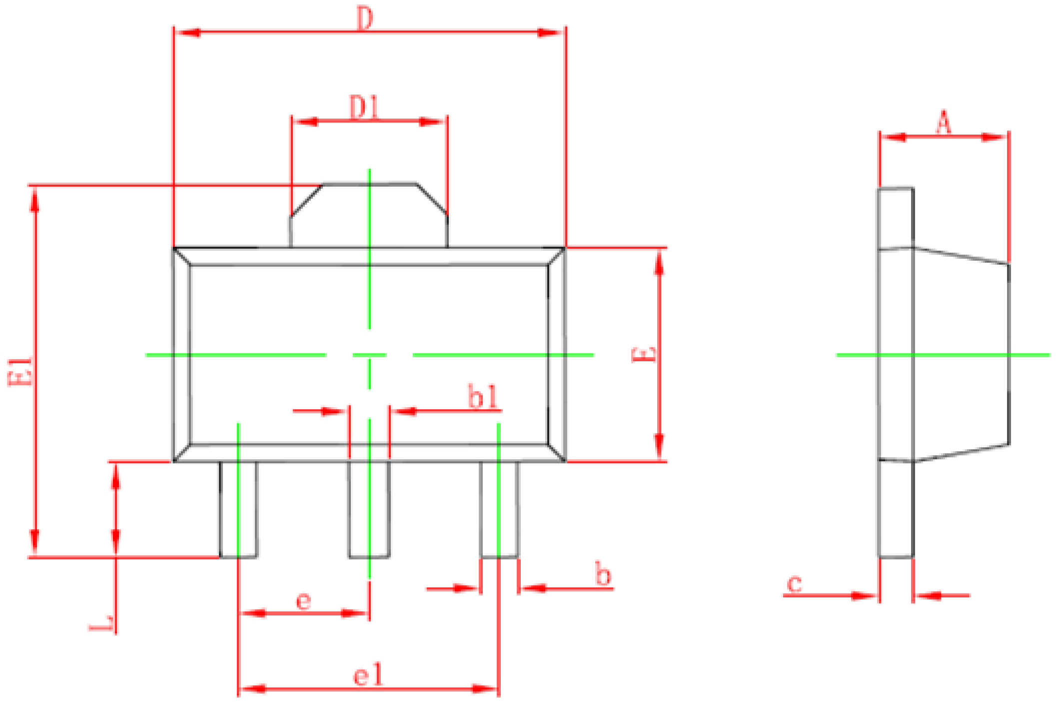
PACKAGE DESIGNATOR
SOT-23-3L



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(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

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