

### Features

- Low power consumption
- Low temperature coefficient
- High input voltage range (up to 24V)
- Output voltage accuracy: tolerance  $\pm 3\%$
- Built-in hysteresis characteristic
- TO-92, SOT-89 and SOT-25 package

### Applications

- Battery checkers
- Level selectors
- Power failure detectors
- Microcomputer reset
- Battery memory backup
- Non-volatile RAM signal storage protectors

### General Description

The HT70XXA-1 series devices are a set of three terminal low power voltage detectors implemented in CMOS technology. Each voltage detector in the series detects a particular fixed voltage ranging from 2.2V to 5V. The voltage detectors consist of a high-precision and low power consumption standard voltage source as well as a

comparator, hysteresis circuit, and an output driver. CMOS technology ensures low power consumption.

Although designed primarily as fixed voltage detectors, these devices can be used with external components to detect user specified threshold voltages.

### Selection Table

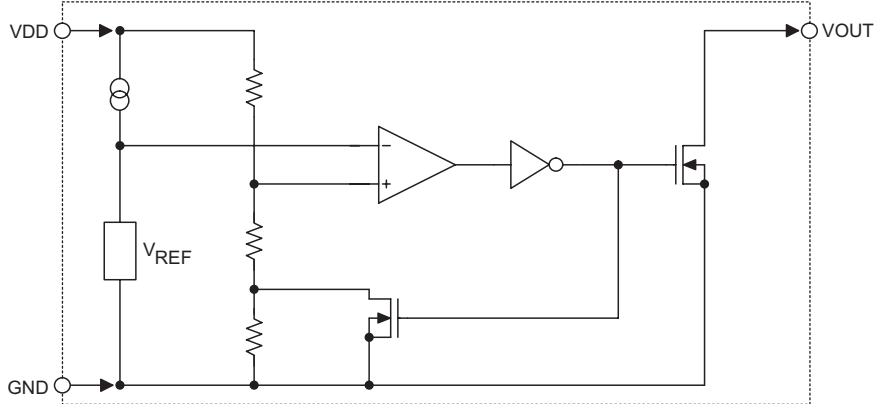
Part No.	Detectable Voltage	Hysteresis Width	Tolerance	Package	Marking
HT7022A-1	2.2V	0.11V	$\pm 3\%$	TO-92 SOT-89 SOT-25	70XXA-1 (for TO-92) 70XXA-1 (for SOT-89) 0XXA (for SOT-25)
HT7024A-1	2.4V	0.12V	$\pm 3\%$		
HT7027A-1	2.7V	0.135V	$\pm 3\%$		
HT7033A-1	3.3V	0.165V	$\pm 3\%$		
HT7039A-1	3.9V	0.195V	$\pm 3\%$		
HT7044A-1	4.4V	0.22V	$\pm 3\%$		
HT7050A-1	5.0V	0.25V	$\pm 3\%$		

Note: "XX" stands for output voltages.

For lead free devices, TO-92 package will add a "#" mark at the end of the date code, whereas SOT-89 & SOT-25 packages will add a "#" mark at the end of the marking.

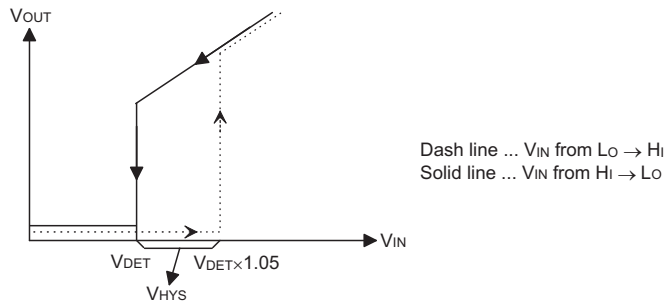
**Block Diagram**

N Channel Open Drain Output (Normal Open; Active Low)

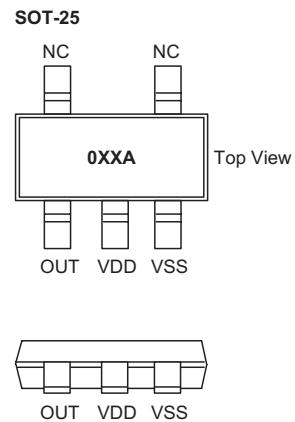
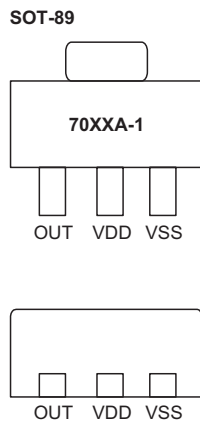
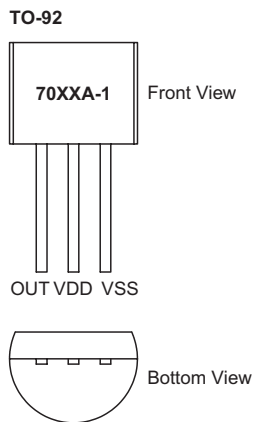


**Output Table & Curve**

V <sub>DD</sub>	V <sub>DD</sub> > V <sub>DET</sub> (+)	V <sub>DD</sub> ≤ V <sub>DET</sub> (-)
V <sub>OUT</sub>	Hi-Z	V <sub>SS</sub>



**Pin Assignment**



**Absolute Maximum Ratings**

Supply Voltage ..... $V_{SS}-0.3V$  to  $V_{SS}+26V$   
 Output Voltage..... $V_{SS}-0.3V$  to  $V_{DD}+0.3V$       Output Current.....50mA  
 Storage Temperature ..... $-50^{\circ}C$  to  $125^{\circ}C$       Power Consumption .....200mW  
 Operating Temperature..... $-40^{\circ}C$  to  $85^{\circ}C$

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

**Electrical Characteristics**
**HT7022A-1**
 $T_a=25^{\circ}C$ 

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		$V_{DD}$	Conditions				
$V_{DET}$	Detection Voltage	—	—	2.134	2.200	2.266	V
$V_{HYS}$	Hysteresis Width	—	—	0.02 $V_{DET}$	0.05 $V_{DET}$	0.1 $V_{DET}$	V
$I_{DD}$	Operating Current	8V	No load	—	4	7	$\mu A$
$V_{DD}$	Operating Voltage	—	—	1.5	—	24	V
$I_{OL}$	Output Sink Current	2V	$V_{OUT}=0.2V$	0.5	1	—	mA
$\frac{\Delta V_{DET}}{\Delta T_a}$	Temperature Coefficient	—	$0^{\circ}C < T_a < 70^{\circ}C$	—	$\pm 1.1$	—	mV/ $^{\circ}C$

**HT7024A-1**
 $T_a=25^{\circ}C$ 

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		$V_{DD}$	Conditions				
$V_{DET}$	Detection Voltage	—	—	2.328	2.400	2.472	V
$V_{HYS}$	Hysteresis Width	—	—	0.02 $V_{DET}$	0.05 $V_{DET}$	0.1 $V_{DET}$	V
$I_{DD}$	Operating Current	8V	No load	—	4	7	$\mu A$
$V_{DD}$	Operating Voltage	—	—	1.5	—	24	V
$I_{OL}$	Output Sink Current	2V	$V_{OUT}=0.2V$	0.5	1	—	mA
$\frac{\Delta V_{DET}}{\Delta T_a}$	Temperature Coefficient	—	$0^{\circ}C < T_a < 70^{\circ}C$	—	$\pm 0.9$	—	mV/ $^{\circ}C$

**HT7027A-1**

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V <sub>DD</sub>	Conditions				
V <sub>DET</sub>	Detection Voltage	—	—	2.619	2.700	2.781	V
V <sub>HYS</sub>	Hysteresis Width	—	—	0.02 V <sub>DET</sub>	0.05 V <sub>DET</sub>	0.1 V <sub>DET</sub>	V
I <sub>DD</sub>	Operating Current	8V	No load	—	4	7	μA
V <sub>DD</sub>	Operating Voltage	—	—	1.5	—	24	V
I <sub>OL</sub>	Output Sink Current	2V	V <sub>OUT</sub> =0.2V	0.5	1	—	mA
$\frac{\Delta V_{DET}}{\Delta T_a}$	Temperature Coefficient	—	0°C<Ta<70°C	—	±0.9	—	mV/°C

**HT7033A-1**

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V <sub>DD</sub>	Conditions				
V <sub>DET</sub>	Detection Voltage	—	—	3.201	3.300	3.399	V
V <sub>HYS</sub>	Hysteresis Width	—	—	0.02 V <sub>DET</sub>	0.05 V <sub>DET</sub>	0.1 V <sub>DET</sub>	V
I <sub>DD</sub>	Operating Current	8V	No load	—	4	7	μA
V <sub>DD</sub>	Operating Voltage	—	—	1.5	—	24	V
I <sub>OL</sub>	Output Sink Current	2.5V	V <sub>OUT</sub> =0.25V	1.2	2.5	—	mA
$\frac{\Delta V_{DET}}{\Delta T_a}$	Temperature Coefficient	—	0°C<Ta<70°C	—	±0.9	—	mV/°C

**HT7039A-1**

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V <sub>DD</sub>	Conditions				
V <sub>DET</sub>	Detection Voltage	—	—	3.783	3.900	4.017	V
V <sub>HYS</sub>	Hysteresis Width	—	—	0.02 V <sub>DET</sub>	0.05 V <sub>DET</sub>	0.1 V <sub>DET</sub>	V
I <sub>DD</sub>	Operating Current	8V	No load	—	4	7	μA
V <sub>DD</sub>	Operating Voltage	—	—	1.5	—	24	V
I <sub>OL</sub>	Output Sink Current	2.5V	V <sub>OUT</sub> =0.25V	1.2	2.5	—	mA
$\frac{\Delta V_{DET}}{\Delta T_a}$	Temperature Coefficient	—	0°C<Ta<70°C	—	±0.9	—	mV/°C

**HT7044A-1**

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V <sub>DD</sub>	Conditions				
V <sub>DET</sub>	Detection Voltage	—	—	4.268	4.400	4.532	V
V <sub>HYS</sub>	Hysteresis Width	—	—	0.02 V <sub>DET</sub>	0.05 V <sub>DET</sub>	0.1 V <sub>DET</sub>	V
I <sub>DD</sub>	Operating Current	8V	No load	—	4	7	μA
V <sub>DD</sub>	Operating Voltage	—	—	1.5	—	24	V
I <sub>OL</sub>	Output Sink Current	3.6V	V <sub>OUT</sub> =0.36V	3	6	—	mA
$\frac{\Delta V_{DET}}{\Delta T_a}$	Temperature Coefficient	—	0°C<Ta<70°C	—	±0.9	—	mV/°C

**HT7050A-1**

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V <sub>DD</sub>	Conditions				
V <sub>DET</sub>	Detection Voltage	—	—	4.850	5.000	5.150	V
V <sub>HYS</sub>	Hysteresis Width	—	—	0.02 V <sub>DET</sub>	0.05 V <sub>DET</sub>	0.1 V <sub>DET</sub>	V
I <sub>DD</sub>	Operating Current	8V	No load	—	4	7	μA
V <sub>DD</sub>	Operating Voltage	—	—	2.1	—	24	V
I <sub>OL</sub>	Output Sink Current	3.6V	V <sub>OUT</sub> =0.36V	3	6	—	mA
$\frac{\Delta V_{DET}}{\Delta T_a}$	Temperature Coefficient	—	0°C<Ta<70°C	—	±0.9	—	mV/°C

**Functional Description**

The HT70XXA-1 series is a set of voltage detectors equipped with a high stability voltage reference which is connected to the negative input of a comparator—denoted as V<sub>REF</sub> in the following figure for NMOS output voltage detector.

When the voltage drop to the positive input of the comparator (i.e., V<sub>B</sub>) is higher than V<sub>REF</sub>, V<sub>OUT</sub> goes high, M1 turns off, and V<sub>B</sub> is expressed as V<sub>BH</sub>=V<sub>DD</sub> × (R<sub>B</sub>+R<sub>C</sub>) / (R<sub>A</sub>+R<sub>B</sub>+R<sub>C</sub>). If V<sub>DD</sub> is decreased so that V<sub>B</sub> falls to a value less than V<sub>REF</sub>, the comparator output inverts from high to low, V<sub>OUT</sub> goes low, V<sub>C</sub> is high, M1 turns on, R<sub>C</sub> is bypassed, and V<sub>B</sub> becomes: V<sub>BL</sub>= V<sub>DD</sub> × R<sub>B</sub> / (R<sub>A</sub>+R<sub>B</sub>), which is less than V<sub>BH</sub>. By so doing, the comparator output will stay low to prevent the circuit from oscillating when V<sub>B</sub> ≈ V<sub>REF</sub>.

If V<sub>DD</sub> falls below the minimum operating voltage, the output becomes undefined. When V<sub>DD</sub> goes from low to V<sub>DD</sub> × R<sub>B</sub> / (R<sub>A</sub>+R<sub>B</sub>) > V<sub>REF</sub>, the comparator output and V<sub>OUT</sub> goes high.

The detectable voltage is defined as:

$$V_{DET} (-) = \frac{R_A + R_B + R_C}{R_B + R_C} \times V_{REF}$$

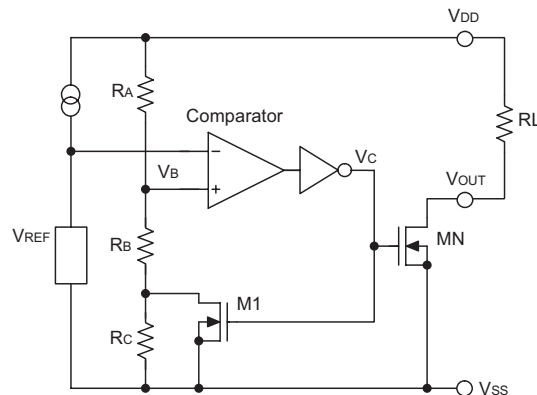
The release voltage is defined as:

$$V_{DET} (+) = \frac{R_A + R_B}{R_B} \times V_{REF}$$

The hysteresis width is:

$$V_{HYS} = V_{DET} (+) - V_{DET} (-)$$

The figure demonstrates the NMOS output type with positive output polarity (V<sub>OUT</sub> is normally open, active low). The HT70XXA-1 series also supplies options for other output types with active high outputs. Application circuits shown are examples of positive output polarity (normally open, active low) unless otherwise specified.



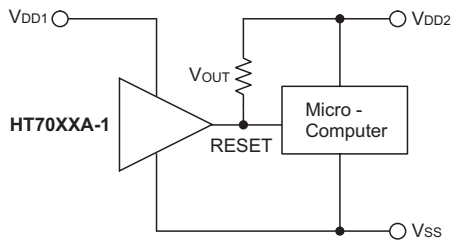
**NMOS Output Voltage Detector (HT70XXA-1)**

### Application Circuits

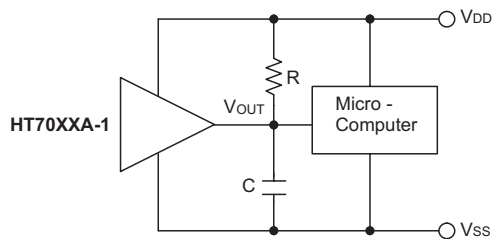
#### Microcomputer Reset Circuit

Normally a reset circuit is required to protect the microcomputer system from malfunctions due to power line interruptions. The following examples show how different output configurations perform a reset function in various systems.

- NMOS open drain output application for separate power supply

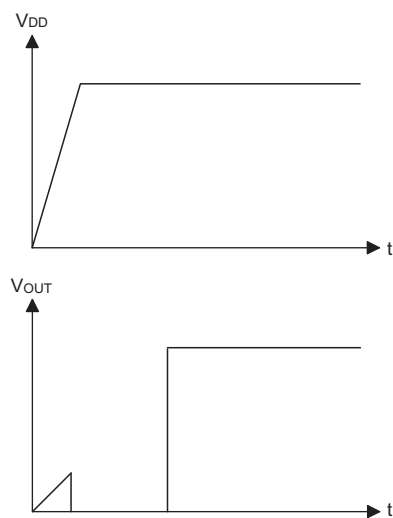
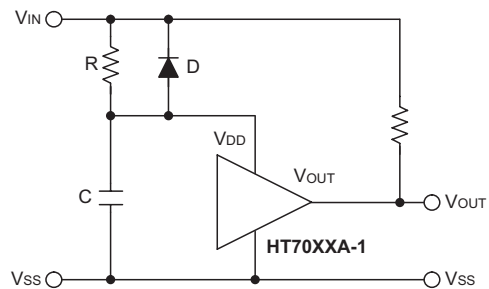


- NMOS open drain output application with R-C delay



#### Power-on Reset Circuit

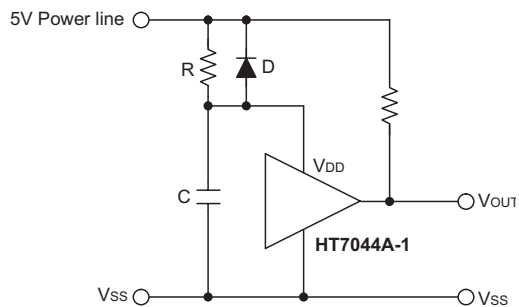
With several external components, the NMOS open drain type of the HT70XXA-1 series can be used to perform a power-on reset function as shown:



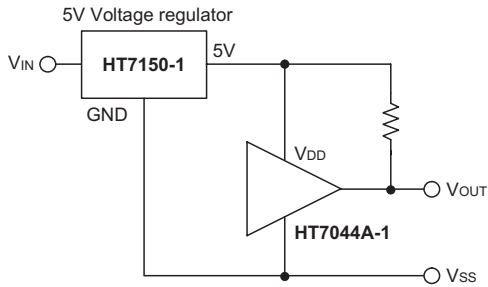
#### 5V Power Line Monitoring Circuit

Generally, a minimum operating voltage of 4.5V is guaranteed in a 5V power line system. The HT7044A-1 is recommended for use as 5V power line monitoring circuit.

- 5V power line monitor with power-on reset

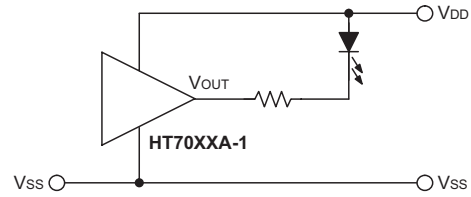


- with 5V voltage regulator



**Malfunction Analysis**

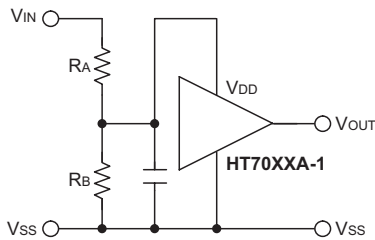
The following circuit demonstrates the way a circuit analyzes malfunctions by monitoring the variation or spike noise of power supply voltage.



**Change of Detectable Voltage**

If the required voltage is not found in the standard product selection table, it is possible to change it by using external resistance dividers or diodes.

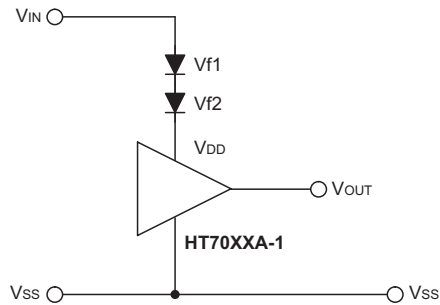
- Varying the detectable voltage with a resistance divider



$$\text{Detectable voltage} = \frac{R_A + R_B}{R_B} \times V_{DET}$$

$$\text{Hysteresis width} = \frac{R_A + R_B}{R_B} \times V_{HYS}$$

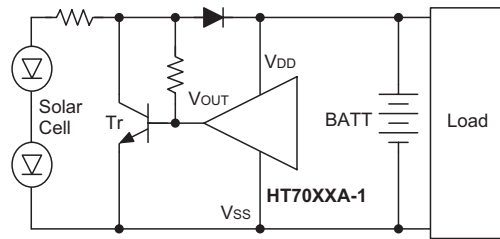
- Varying the detectable voltage with a diode



$$\text{Detectable Voltage} = V_{f1} + V_{f2} + V_{DET}$$

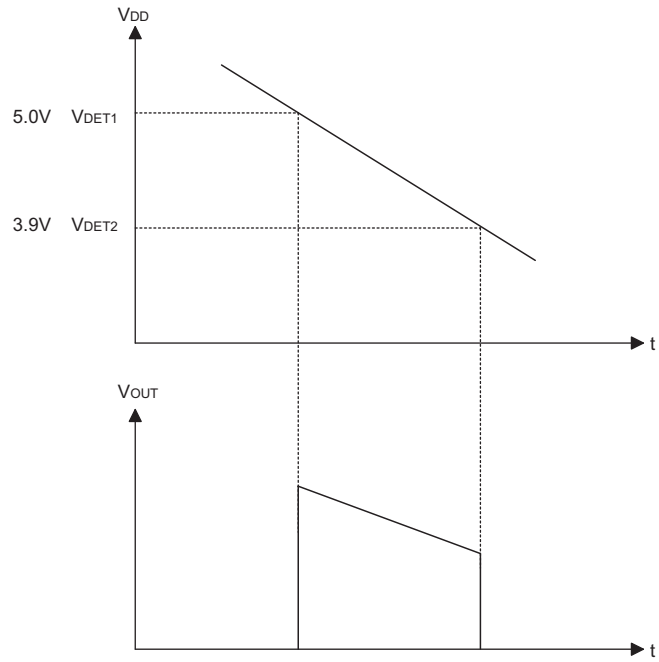
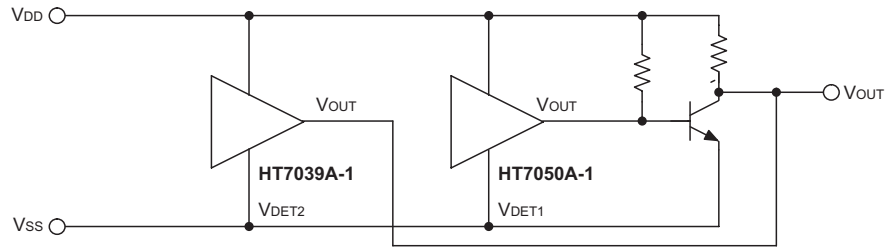
**Charge Monitoring Circuit**

The following circuit shows a charged monitor for protection against battery deterioration by overcharging. When the voltage of the battery is higher than the set detectable voltage, the transistor turns on to bypass the charge current, protecting the battery from overcharging.



**Level Selector**

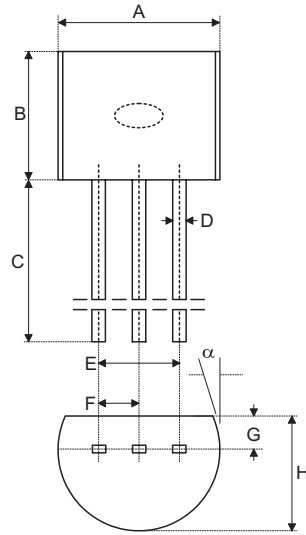
The following diagram illustrates a logic level selector.





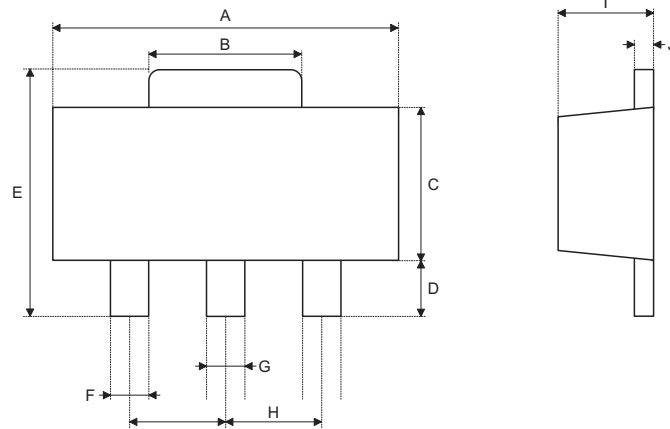
**Package Information**

**3-Pin TO-92 Outline Dimensions**



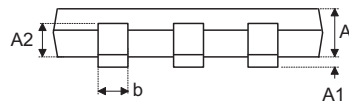
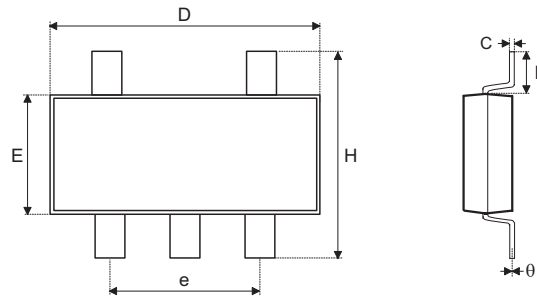
Symbol	Dimensions in mil		
	Min.	Nom.	Max.
A	170	—	200
B	170	—	200
C	500	—	—
D	11	—	20
E	90	—	110
F	45	—	55
G	45	—	65
H	130	—	160
I	8	—	18
$\alpha$	4°	—	6°

**3-Pin SOT-89 Outline Dimensions**



Symbol	Dimensions in mil		
	Min.	Nom.	Max.
A	173	—	181
B	64	—	72
C	90	—	102
D	35	—	47
E	155	—	167
F	14	—	19
G	17	—	22
H	—	59	—
I	55	—	63
J	14	—	17

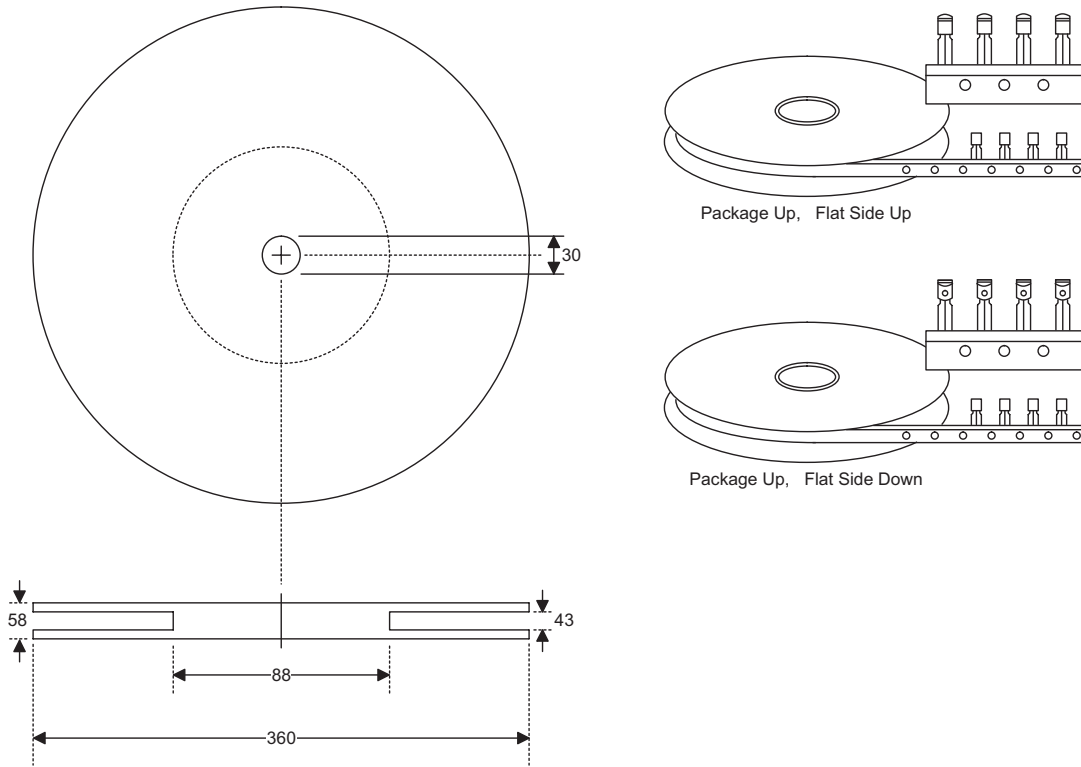
5-Pin SOT-25 Outline Dimensions



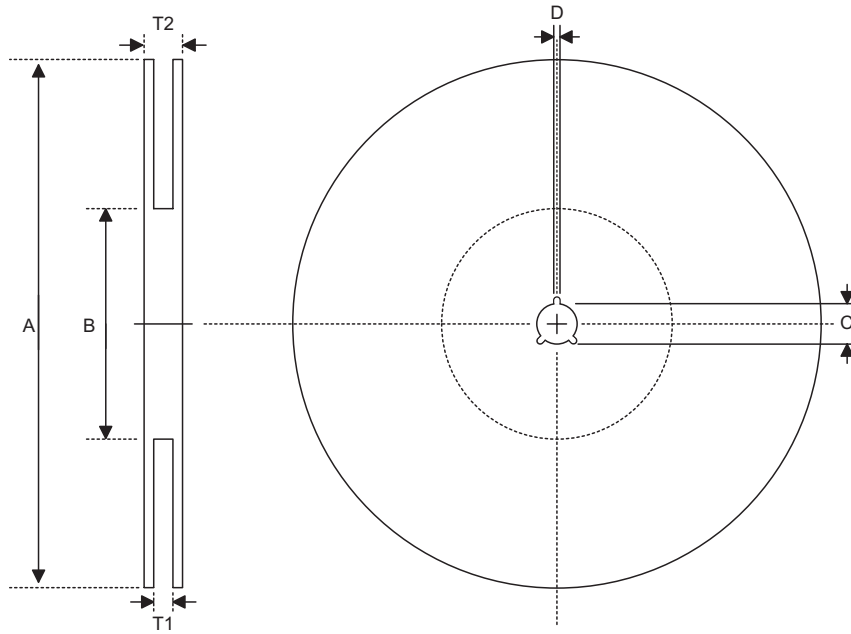
Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	1.00	—	1.30
A1	—	—	0.10
A2	0.70	—	0.90
b	0.35	—	0.50
C	0.10	—	0.25
D	2.70	—	3.10
E	1.40	—	1.80
e	—	1.90	—
H	2.60	—	3
L	0.37	—	—
θ	1°	—	9°

**Product Tape and Reel Specifications**

TO-92 Reel Dimensions (Unit: mm)



Reel Dimensions

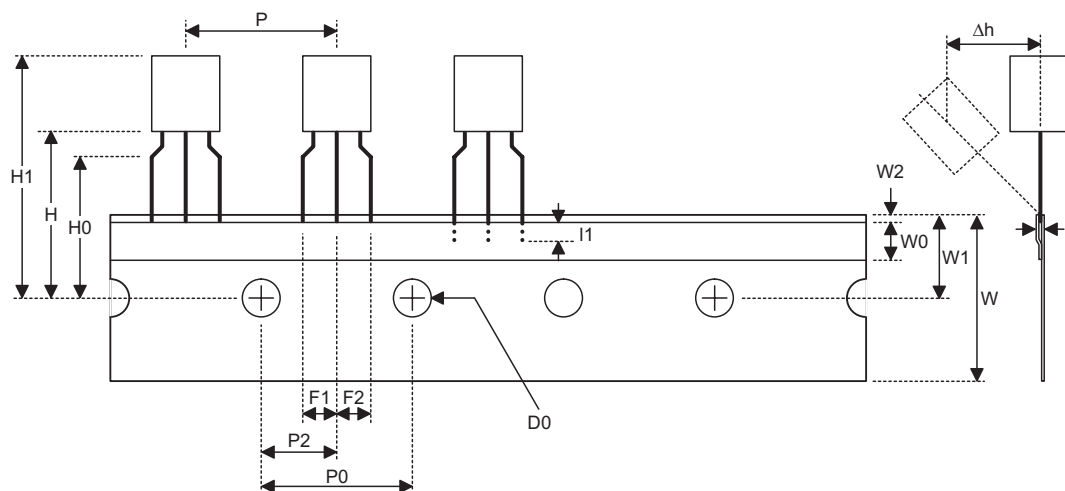


SOT-89

Symbol	Description	Dimensions in mm
A	Reel Outer Diameter	180±1.0
B	Reel Inner Diameter	62±1.5
C	Spindle Hole Diameter	12.75+0.15
D	Key Slit Width	1.9±0.15
T1	Space Between Flange	12.4+0.2
T2	Reel Thickness	17-0.4

SOT-25

Symbol	Description	Dimensions in mm
A	Reel Outer Diameter	178±1.0
B	Reel Inner Diameter	62±1.0
C	Spindle Hole Diameter	13.0±0.2
D	Key Slit Width	2.5±0.25
T1	Space Between Flange	8.4+1.5 -0.0
T2	Reel Thickness	11.4+1.5

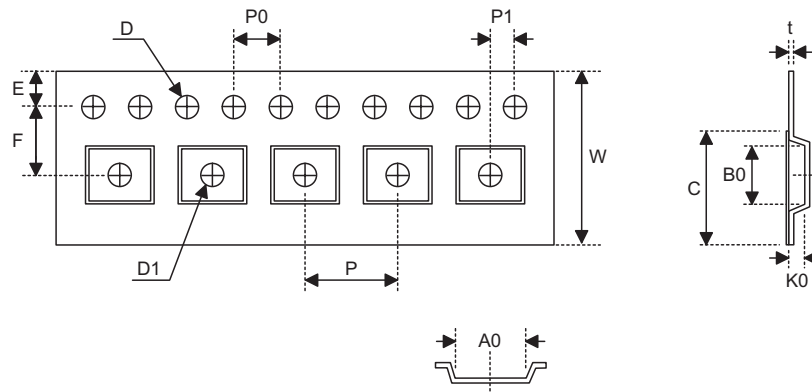
**TO-92 Carrier Tape Dimensions**

**TO-92**

Symbol	Description	Dimensions in mm
l1	Taped Lead Length	(2.5)
P	Component Pitch	12.7±1.0
P <sub>0</sub>	Perforation Pitch	12.7±0.3
P <sub>2</sub>	Component to Perforation (Length Direction)	6.35±0.4
F <sub>1</sub>	Lead Spread	2.5+0.4 -0.1
F <sub>2</sub>	Lead Spread	2.5+0.4 -0.1
Δh	Component Alignment	0±0.1
W	Carrier Tape Width	18.0+1.0 -0.5
W <sub>0</sub>	Hold-down Tape Width	6.0±0.5
W <sub>1</sub>	Perforation Position	9.0±0.5
W <sub>2</sub>	Hold-down Tape Position	(0.5)
H <sub>0</sub>	Lead Clinch Height	16.0±0.5
H <sub>1</sub>	Component Height	Less than 24.7
D <sub>0</sub>	Perforation Diameter	4.0±0.2
t	Taped Lead Thickness	0.7±0.2
H	Component Base Height	19.0±0.5

Note: Thickness less than 0.38±0.05mm~0.5mm

P<sub>0</sub> Accumulated pitch tolerance: ±1mm/20pitches.

( ) Bracketed figures are for consultation only

**Carrier Tape Dimensions**

**SOT-89**

Symbol	Description	Dimensions in mm
W	Carrier Tape Width	12.0+0.3 -0.1
P	Cavity Pitch	8.0±0.1
E	Perforation Position	1.75±0.1
F	Cavity to Perforation (Width Direction)	5.5±0.05
D	Perforation Diameter	1.5+0.1
D1	Cavity Hole Diameter	1.5+0.1
P0	Perforation Pitch	4.0±0.1
P1	Cavity to Perforation (Length Direction)	2.0±0.10
A0	Cavity Length	4.8±0.1
B0	Cavity Width	4.5±0.1
K0	Cavity Depth	1.8±0.1
t	Carrier Tape Thickness	0.30±0.013
C	Cover Tape Width	9.3

**SOT-25**

Symbol	Description	Dimensions in mm
W	Carrier Tape Width	8.0±0.3
P	Cavity Pitch	4.0
E	Perforation Position	1.75
F	Cavity to Perforation (Width Direction)	3.5±0.05
D	Perforation Diameter	1.5+0.1
D1	Cavity Hole Diameter	1.5+0.1
P0	Perforation Pitch	4.0
P1	Cavity to Perforation (Length Direction)	2.0
A0	Cavity Length	3.15
B0	Cavity Width	3.2
K0	Cavity Depth	1.4
t	Carrier Tape Thickness	0.20±0.03
C	Cover Tape Width	5.3

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