TC54

Voltage Detector

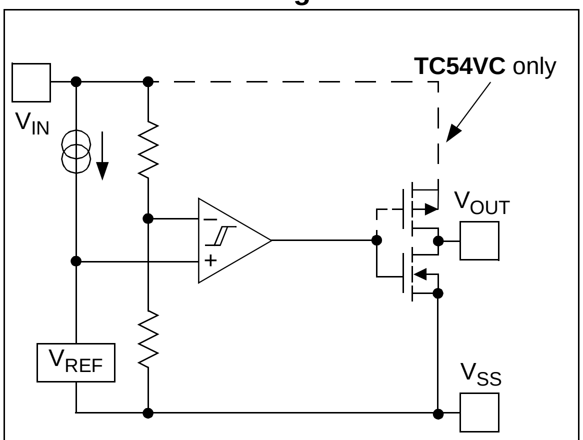
Features

- ±2.0% Detection Thresholds
- Small Packages: 3-Pin SOT-23A, SOT-89, and TO-92
- Low Current Drain: 1 µA, typical
- Wide Detection Range: 1.1V to 6.0V
- Wide Operating Voltage Range: 0.7V to 10V

Applications

- Battery Voltage Monitoring
- Microprocessor Reset
- System Brown-Out Protection
- Switching Circuit in Battery Backup
- Level Discriminator

Functional Block Diagram



TC54VN has open-drain output.

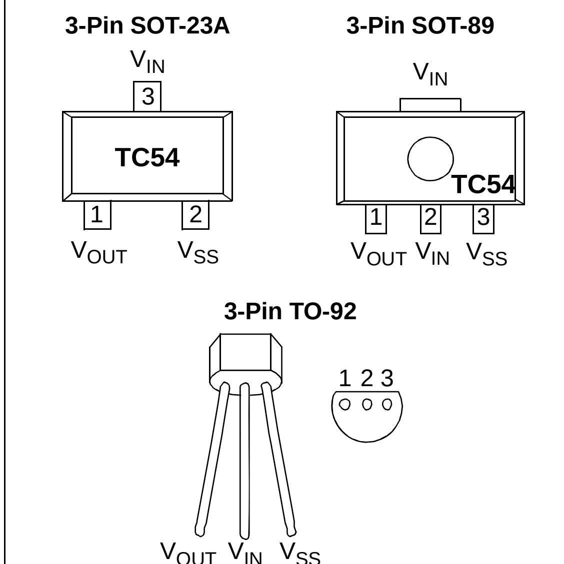
TC54VC has complementary (push-pull) output.

General Description

The TC54 series are CMOS voltage detectors that are especially well suited for battery-powered applications because of their extremely low 1 µA operating current and small surface-mount packaging. Each part is laser-trimmed to the desired threshold voltage, which can be specified from 1.4V to 6.0V with a 2% tolerance.

The TC54 is available with either an open-drain or complementary output stage. During operation, the output (V_{OUT}) remains in the logic-high state as long as V_{IN} is greater than the specified threshold voltage ($V_{DET}-$). When V_{IN} falls below $V_{DET}-$, the output is driven to a logic-low. V_{OUT} remains low until V_{IN} rises above $V_{DET}-$ by an amount V_{HYST}, when it resets to a logic-high state.

Package Types



Note: 3-Pin SOT-23A is equivalent to the EIAJ SC-59.

Device Features

Device	Output		Reset Delay	Std. Trip Points[(1)] (typical)
	Type	State		
TC54VN	Open-Drain	Active Low	No	1.4V, 2.1V, 2.7V, 2.9V
TC54VC	Push-Pull	Active Low	No	3.0V, 4.2V, 4.3V

Note 1: Custom Trip Points available. Minimum order requirement. Information available upon request.

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Input Voltage ....+12V

Output Current ....50 mA

Output Voltage: CMOS................(V_{SS} – 0.3V) to (V_{IN} + 0.3V)
Open-Drain....................(V_{SS} – 0.3V) to 12V

Power Dissipation ($T_A \leq 70°C$):
3-Pin SOT-23A ....240 mW
3-Pin SOT-89...500 mW
3-Pin TO-92 ....300 mW

Operating Temperature Range.......................-40°C to +85°C

Storage Temperature Range........................-65°C to +150°C

† Notice: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operation sections of the specifications is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

DC CHARACTERISTICS

Electrical Specifications: Unless otherwise noted, T_A = +25°C.

Parameter	Sym	Min	Typ	Max	Units	Test Conditions
Operating Voltage	V_{IN}	0.7	—	10.0	V	(V_{DET} –) ≥ 1.6V
		0.7	—	6.0	V	(V_{DET} –) < 1.6V
Quiescent Current	I_{SS}	—	0.8	2.7	µA	V_{IN} = 2.0V
		—	0.9	3.0		V_{IN} = 3.0V
		—	1.0	3.2		V_{IN} = 4.0V
		—	1.1	3.6		V_{IN} = 5.0V
Threshold Voltage (Note 1)	V_{DET} –	1.37	1.4	1.43	V	**TC54VX14**
		2.06	2.1	2.14		**TC54VX21**
		2.65	2.7	2.75		**TC54VX27**
		2.84	2.9	2.96		**TC54VX29**
		2.94	3.0	3.06		**TC54VX30**
		4.12	4.2	4.28		**TC54VX42**
		4.21	4.3	4.39		**TC54VX43**
Hysteresis Voltage	V_{HYST}	28	70	112	mV	V_{DET} = 1.4V (typical)
		42	105	168		V_{DET} = 2.1V (typical)
		54	135	216		V_{DET} = 2.7V (typical)
		58	145	232		V_{DET} = 2.9V (typical)
		60	150	240		V_{DET} = 3.0V (typical)
		84	210	336		V_{DET} = 4.2V (typical)
		86	215	344		V_{DET} = 4.3V (typical)
Output Current	I_{OUT}	3.0	7.7	—	mA	V_{OL} = 0.5V, V_{IN} = 2.0V
		5.0	10.1	—		V_{OL} = 0.5V, V_{IN} = 3.0V
		6.0	11.5	—		V_{OL} = 0.5V, V_{IN} = 4.0V
		7.0	13.0	—		V_{OL} = 0.5V, V_{IN} = 5.0V
		—	-10.0	-2.0		**TC54VC Only:** V_{OH} = V_{IN} – 2.1V, V_{IN} = 8.0V
Tempco of (V_{DET} –)	T_C (V_{DET} –)	—	±100	—	ppm/°C	-40°C ≤ T_A ≤ 85°C
Delay Time	t_{DLY}	—	—	0.2	ms	V_{DET} – → V_{OUT} inversion

Note 1: For other voltage options, please contact your regional Microchip sales office.

TEMPERATURE SPECIFICATIONS

Electrical Characteristics: Unless otherwise indicated, all limits are specified for: V_{DD} =+1.8V to +5.5V, V_{SS}=GND.						
Parameters	**Sym**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
Temperature Ranges						
Operating Temperature Range	T_A	-40	—	+85	°C	
Storage Temperature Range	T_A	-65	—	+150	°C	
Thermal Package Resistances						
Thermal Resistance, 3L-SOT-23A	θ_{JA}	—	308	—	°C/W	
Thermal Resistance, 3L-SOT-89	θ_{JA}	—	131.7	—	°C/W	
Thermal Resistance, 3L-TO-92	θ_{JA}	—	146	—	°C/W	

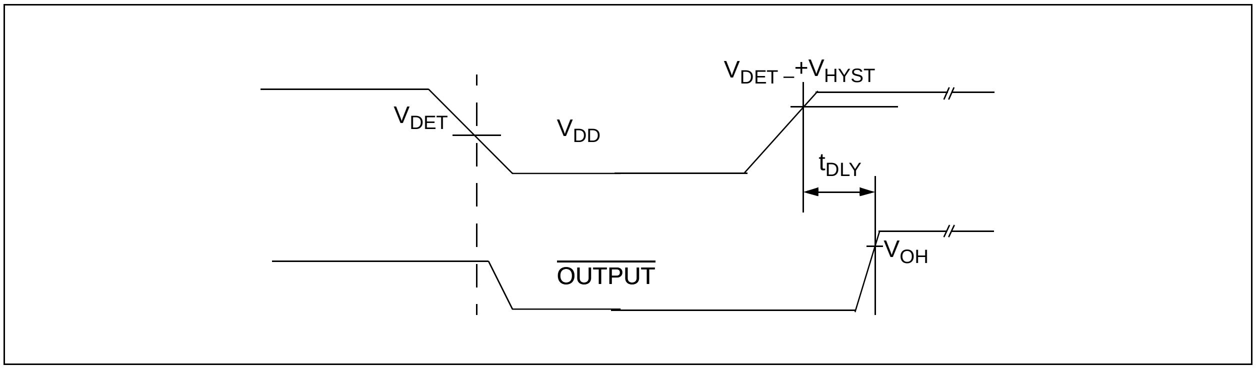


FIGURE 1-1: *Timing Diagram.*

2.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 2-1.

TABLE 2-1: PIN FUNCTION TABLE

TC54			Symbol	Description
SOT-23A	SOT-89	TO-92		
1	1	1	V_{OUT}	Digital Output
3	2	2	V_{IN}	Analog Input
2	3	3	V_{SS}	Ground Terminal
—	Tab	—	V_{IN}	Analog Input

2.1 Digital Output (V_{OUT})

V_{OUT} goes low when V_{IN} drops below $V_{DET}-$ and returns high when V_{IN} rises above $V_{DET}- + V_{HYST}$. (See Figure 3-1).

2.2 Analog Input (V_{IN})

V_{IN} can be used for power supply monitoring or a voltage level that requires monitoring.

2.3 Ground Terminal (V_{SS})

V_{SS} provides the negative reference for the analog input voltage. Typically, the circuit ground is used.

3.0 DETAILED DESCRIPTION

In normal steady-state operation when $V_{IN} > V_{DET}-$, the output will be at a logic-high (see Figure 3-1). In the case of the TC54VN, this is an open-drain condition. If the input falls below $V_{DET}-$, the output will pull down (Logic 0) to V_{SS}. Generally, V_{OUT} can pull down to within 0.5V of V_{SS} at rated output current and input voltage. (See **Section 1.0 "Electrical Characteristics"**).

The output (V_{OUT}) will stay valid until the input voltage falls below the minimum operating voltage (V_{INMIN}) of 0.7V. Below this minimum operating voltage, the output is undefined. During power-up (or anytime V_{IN} has fallen below V_{INMIN}), V_{OUT} will remain undefined until V_{IN} rises above V_{INMIN}. When this occurs, the output will become valid. V_{OUT} will be in its Active-low state, while $V_{INMIN} < V_{IN} < V_{DET}+$ (therefore, $V_{DET}+ = V_{DET}- + V_{HYST}$). If the input rises above $V_{DET}+$, the output will assume its Inactive state (high for TC54VC, open-drain for TC54VN).

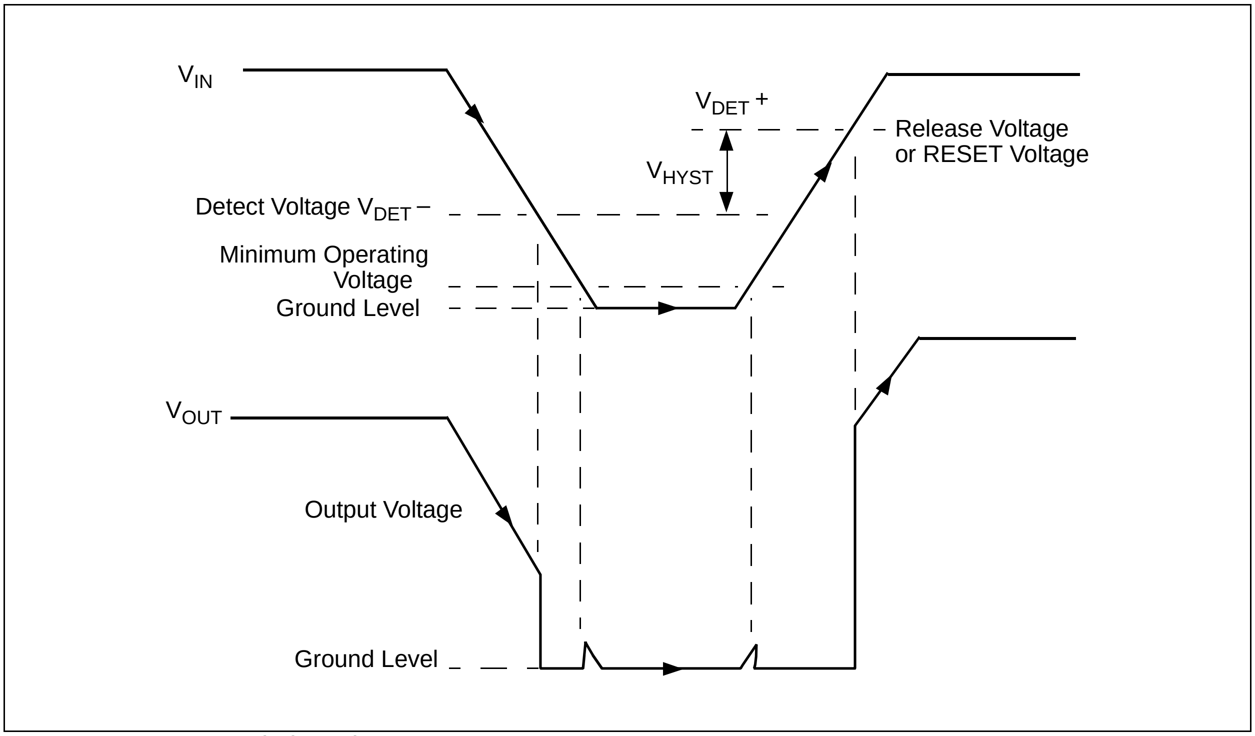


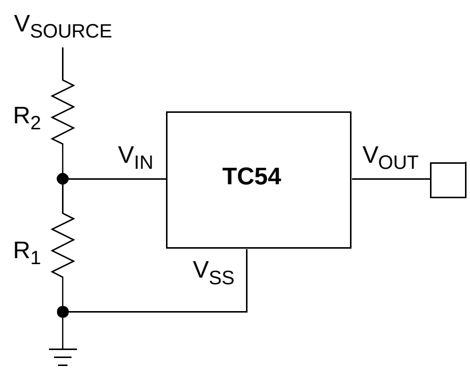
FIGURE 3-1: *Timing Diagram.*

4.0 APPLICATIONS INFORMATION

4.1 Modifying the Trip Point, $V_{DET}-$

Although the TC54 has a pre-programmed $V_{DET}-$, it is sometimes necessary to make adjustments during prototyping. This can be accomplished by connecting an external resistor divider to a TC54, which has a $V_{DET}-$ lower than that of V_{SOURCE} (Figure 4-1).

To maintain detector accuracy, the bleeder current through the divider should be significantly higher than the 1 µA operating current required by the TC54. A reasonable value for this bleeder current is 100 µA (100 times the 1 µA required by the TC54). For example, if $V_{DET}- = 2V$ and the desired trip point is 2.5V, the value of $R_1 + R_2$ is 25 kΩ (2.5V/100 µA). The value of $R_1 + R_2$ can be rounded to the nearest standard value and plugged into the equation of Figure 4-1 to calculate values for R_1 and R_2. 1% tolerance resistors are recommended.



$$V_{SOURCE} \times \frac{R_1}{R_1 + R_2} = V_{DET}-$$

Where:

V_{SOURCE} = Voltage to be monitored

$V_{DET}-$ = Threshold Voltage setting of TC54

Note: In this example, V_{SOURCE} must be greater than ($V_{DET}-$)

FIGURE 4-1: *Modify Trip-Point of the TC54 using External Resistor Divider.*

4.2 Other Applications

Low operating power and small physical size make the TC54 series ideal for many voltage detector applications, such as those shown in Figures 4-2, 4-3 and 4-4. Figure 4-2 shows a low-voltage gate drive protection circuit that prevents the overheating of the logic-level MOSFET due to insufficient gate voltage. When the input signal is below the threshold of the TC54VN, its output grounds the gate of the MOSFET. Figures 4-3 and 4-4 show the TC54 in conventional voltage monitoring applications.

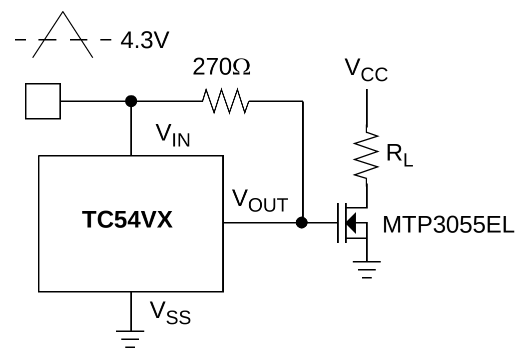


FIGURE 4-2: *MOSFET Low Drive Protection.*

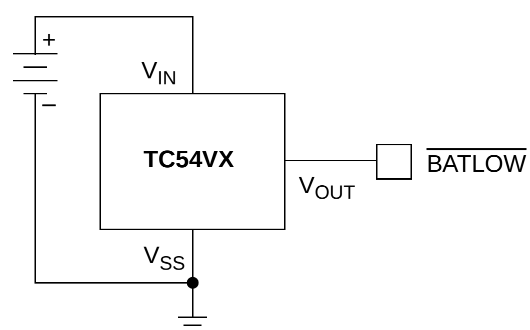


FIGURE 4-3: *Battery Voltage Monitor.*

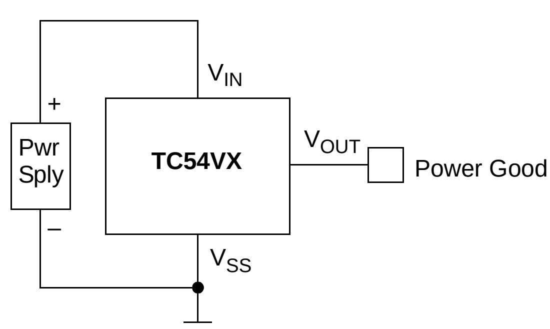
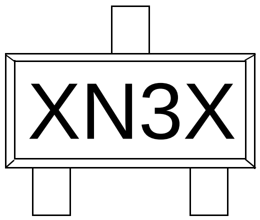


FIGURE 4-4: *Power Good Monitor.*

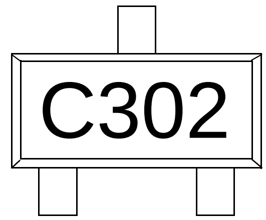
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

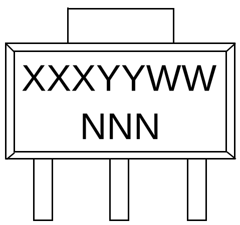
3-Lead SOT-23A



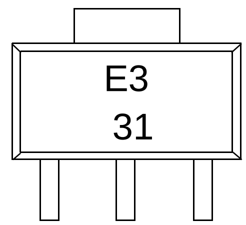
Example



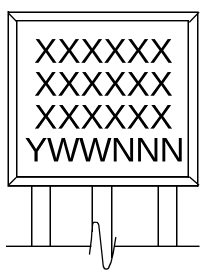
3-Lead SOT-89



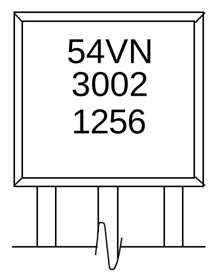
Example



3-Lead TO-92



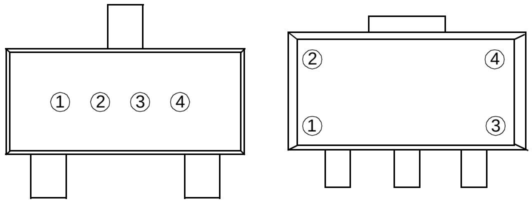
Example



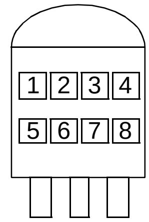
Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	e3	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

3-Pin SOT-23A **3-Pin SOT-89**



3-Pin TO-92



① represents output configuration (CMOS or Nch) and first integer of voltage

Ex: CMOS 3.x = Ⓓ ◯ ◯ ◯

Symbol	Output	Voltage
B	CMOS	1.
C	CMOS	2.
D	CMOS	3.
E	CMOS	4.
F	CMOS	5.
H	CMOS	6.
I	CMOS	7.

Symbol	Output	Voltage
L	Nch	1.
M	Nch	2.
N	Nch	3.
P	Nch	4.
R	Nch	5.
S	Nch	6.
T	Nch	7.

② represents first decimal of output voltage (0-9)

Ex: CMOS 3.x = Ⓓ ④ ◯ ◯

Symbol	Voltage	Symbol	Voltage
0	.0	6	.6
1	.1	7	.7
2	.2	8	.8
3	.3	9	.9
4	.4		
5	.5		

③ & ④ represents assembly lot code

①, ②, & ③ = 54X (fixed)

④ represents output configuration (CMOS or Nch)
Ex: CMOS 3.x = Ⓒ ◯ ◯ ◯

Symbol	Output
C	CMOS
N	N-Channel

⑤ represents first integer of detect voltage

Symbol	Voltage
2	2.
3	3.
4	4.
5	5.
6	6.

⑥ represents first decimal of detect voltage

Symbol	Voltage	Symbol	Voltage
0	.0	5	.5
1	.1	6	.6
2	.2	7	.7
3	.3	8	.8
4	.4	9	.9

⑦ represents the output delay time

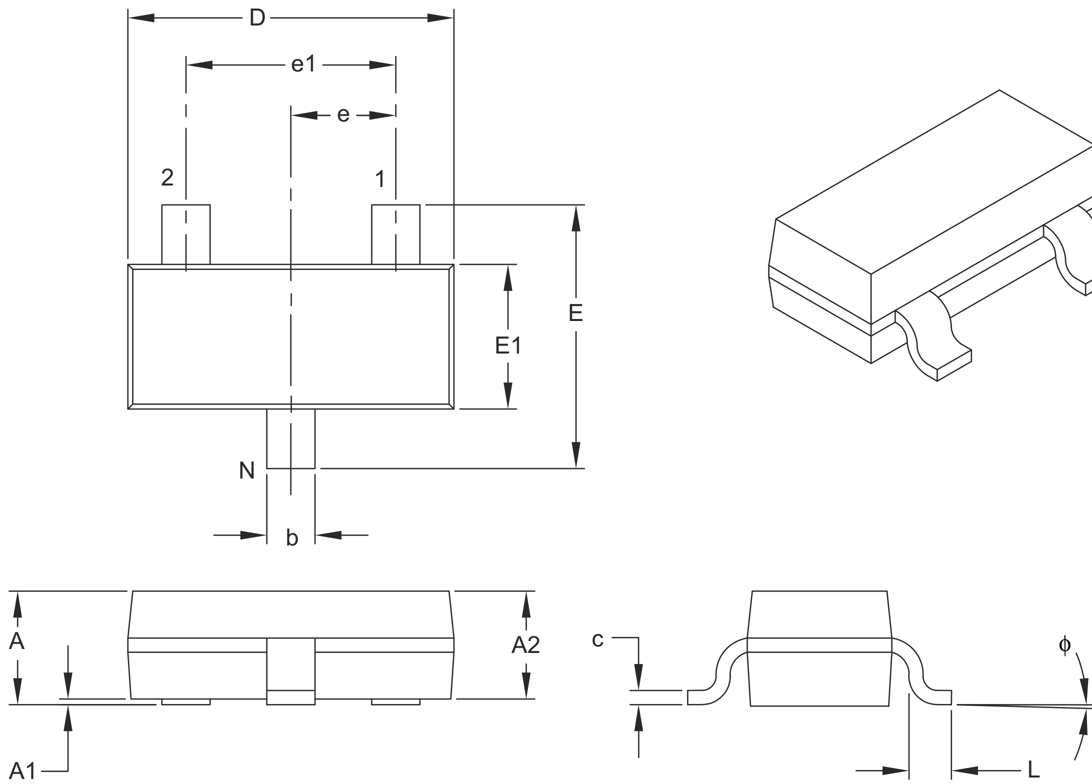
Symbol	Delay Time
0	No Delay

⑧ represents the device accuracy

Symbol	Accuracy
1	±1.0% (custom)
2	±2.0% (standard)

3-Lead Plastic Small Outline Transistor (CB) [SOT-23A]

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N	3		
Lead Pitch	e	0.95 BSC		
Outside Lead Pitch	e1	1.90 BSC		
Overall Height	A	0.89	–	1.45
Molded Package Thickness	A2	0.90	–	1.30
Standoff	A1	0.00	–	0.15
Overall Width	E	2.10	–	3.00
Molded Package Width	E1	1.20	–	1.80
Overall Length	D	2.70	–	3.10
Foot Length	L	0.15	–	0.60
Foot Angle	ϕ	0°	–	30°
Lead Thickness	c	0.09	–	0.26
Lead Width	b	0.30	–	0.51

Notes:

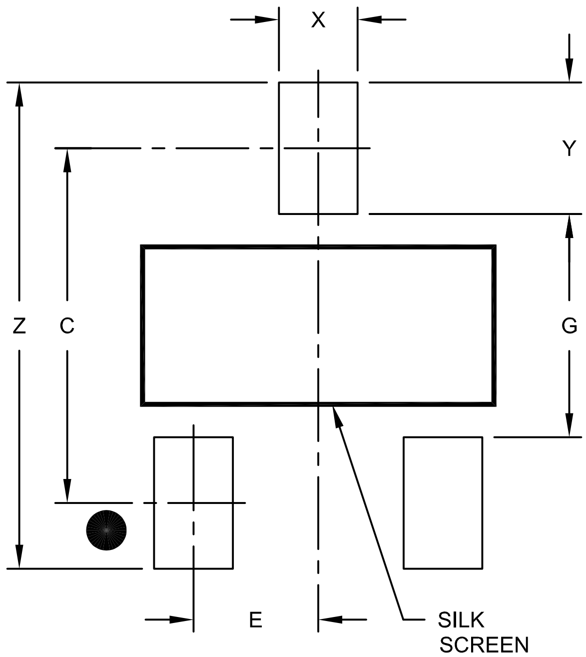
1. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
2. Dimensioning and tolerancing per ASME Y14.5M.

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-130B

3-Lead Plastic Small Outline Transistor (CB) [SOT-23A]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

		Units	MILLIMETERS		
		Dimension Limits	MIN	NOM	MAX
Contact Pitch	E		0.95 BSC		
Contact Pad Spacing	C			2.70	
Contact Pad Width (X3)	X				0.60
Contact Pad Length (X3)	Y				1.00
Distance Between Pads	G		1.70		
Overall Width	Z				3.70

Notes:

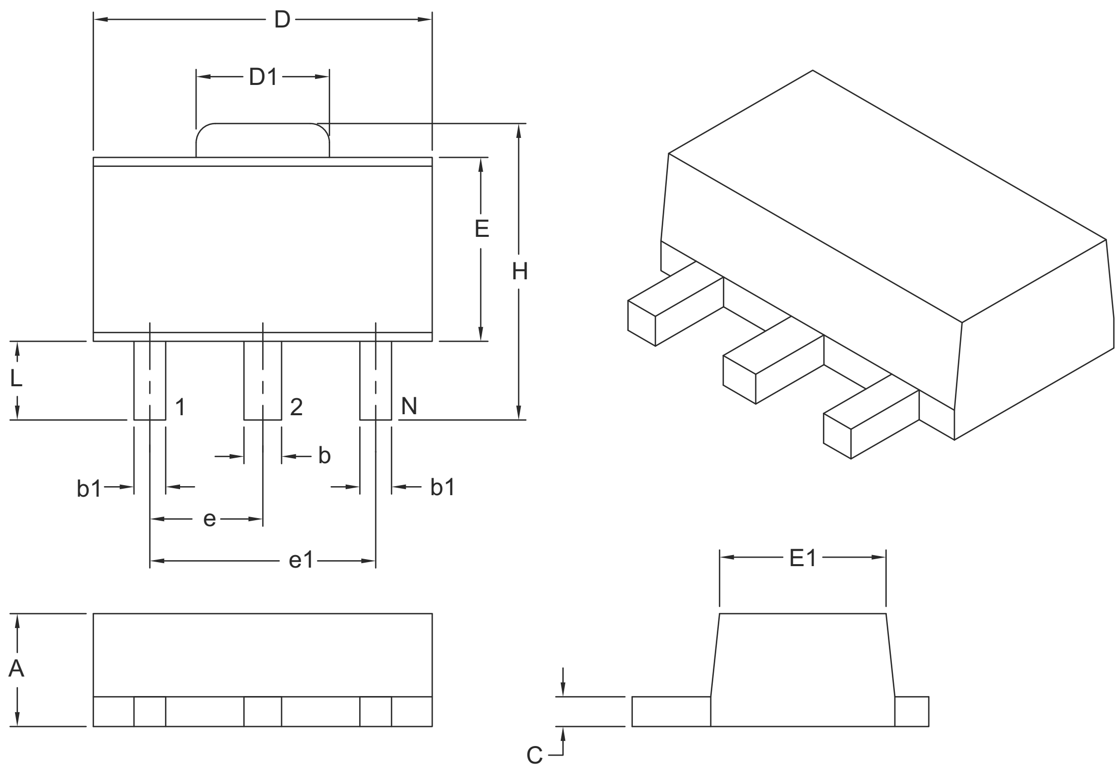
1. Dimensioning and tolerancing per ASME Y14.5M

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2130A

3-Lead Plastic Small Outline Transistor Header (MB) [SOT-89]

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



		Units	MILLIMETERS	
		Dimension Limits	MIN	MAX
Number of Leads	N		3	
Pitch	e		1.50 BSC	
Outside Lead Pitch	e1		3.00 BSC	
Overall Height	A		1.40	1.60
Overall Width	H		3.94	4.25
Molded Package Width at Base	E		2.29	2.60
Molded Package Width at Top	E1		2.13	2.29
Overall Length	D		4.39	4.60
Tab Length	D1		1.40	1.83
Foot Length	L		0.79	1.20
Lead Thickness	c		0.35	0.44
Lead 2 Width	b		0.41	0.56
Leads 1 & 3 Width	b1		0.36	0.48

Notes:

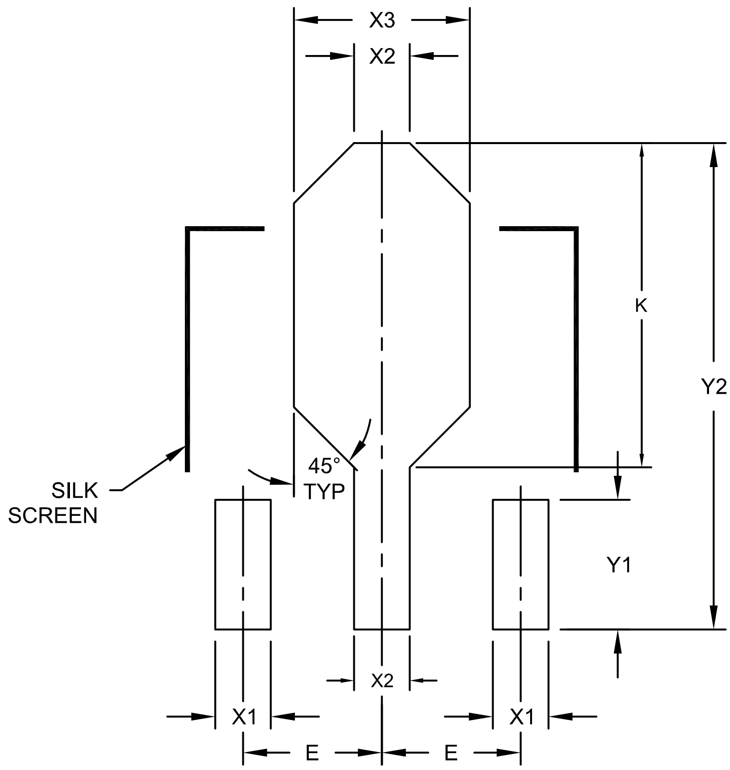
1. Dimensions D and E do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
2. Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-029B

3-Lead Plastic Small Outline Transistor Header (MB) [SOT-89]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

	Units	MILLIMETERS		
	Dimension Limits	MIN	NOM	MAX
Contact Pitch	E	1.50 BSC		
Contact Pads 1 & 3 Width	X1			0.48
Contact Pad 2 Width	X2			0.56
Heat Slug Pad Width	X3			1.20
Contact Pads 1 & 3 Length	Y1		1.40	
Contact 2 Pad Length	Y2			4.25
-	K	2.60		2.85

Notes:

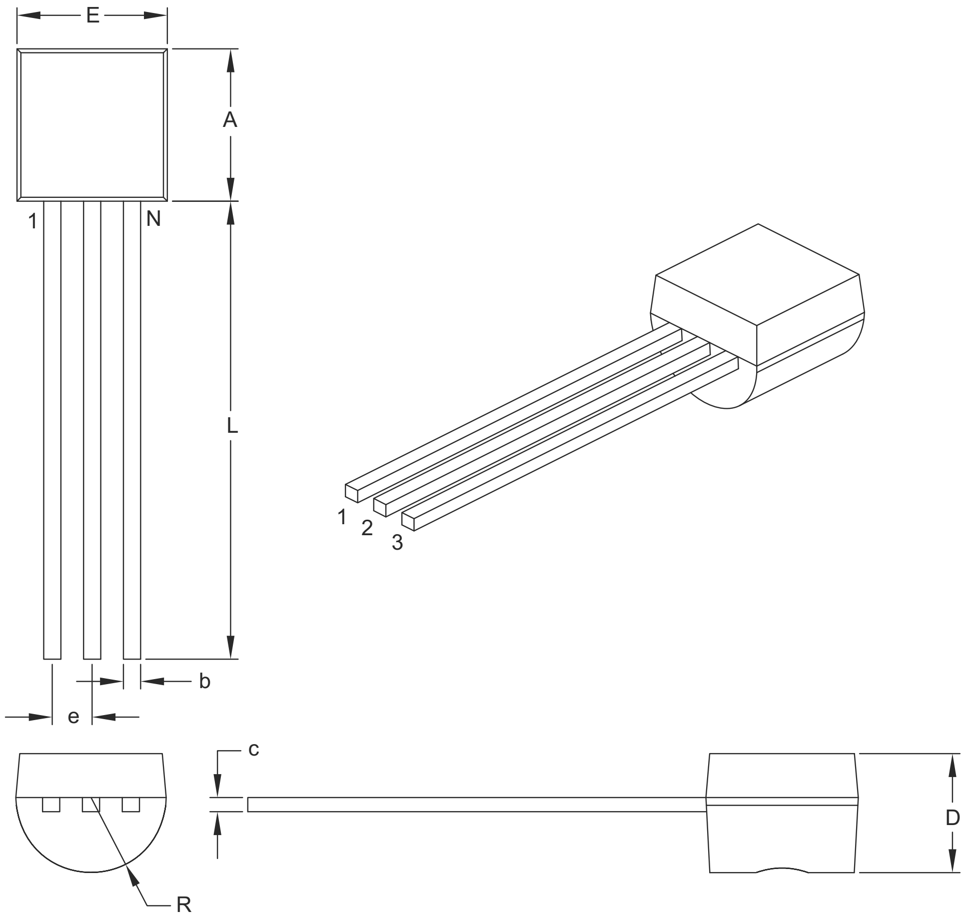
1. Dimensioning and tolerancing per ASME Y14.5M

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2029A

3-Lead Plastic Transistor Outline (ZB) [TO-92]

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		INCHES	
Dimension Limits		MIN	MAX
Number of Pins	N	3	
Pitch	e	.050 BSC	
Bottom to Package Flat	D	.125	.165
Overall Width	E	.175	.205
Overall Length	A	.170	.210
Molded Package Radius	R	.080	.105
Tip to Seating Plane	L	.500	–
Lead Thickness	c	.014	.021
Lead Width	b	.014	.022

Notes:

1. Dimensions A and E do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .005" per side.
2. Dimensioning and tolerancing per ASME Y14.5M.
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-101B

NOTES:

APPENDIX A: REVISION HISTORY

Revision J (June 2011)

The following is the list of modifications:

1. Updated temperature values in Temperature Specifications table.
2. Corrected equation in Figure 4-1.
3. Added new examples layout in Section 5.1, Package Marking Information.

Revision H (December 2007)

The following is the list of modifications:

1. Updated Features section.
2. Removed 5-Pin SOT-23 related information.
3. Updated Output Current (I_{OUT}) Electrical Specification.
4. Removed 7.7V (typical) Voltage Trip Point Option. Max Trip Point Voltage is now 6.0V.
5. Updated Pin Function Table.
6. Updated Packaging Specification Information.
7. Added Revision History section.
8. Updated Product Identification System page.

Revision G (August 2004)

Undocumented changes.

Revision F (July 2004)

Undocumented changes.

Revision E (April 2003)

Undocumented changes.

Revision D (October 2002)

Undocumented changes.

Revision C (July 2002)

Undocumented changes.

Revision B (May 2002)

Undocumented changes.

Revision A (March 2001)

Original Release of this Document.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

PART NO.	X	XX	X	X	X	XX	XX
Device	Output Config.	Detected Voltage	Extra Feature Code	Tolerance	Temp.	Pkg	Taping Direction

Device:	TC54V:	Voltage Detector
Output Configuration:	N = Nch Open-Drain C = CMOS Output	
Detected Voltage:	14 = 1.4V 21 = 2.1V 27 = 2.7V 29 = 2.9V 30 = 3.0V 42 = 4.2V 43 = 4.3V	
Extra Feature Code:	0 = Fixed	
Tolerance:	2 = 2%	
Temperature:	E = -40°C to +85°C	
Package:	CB = Plastic Small Outline Transistor, SOT-23A, 3-lead MB = Plastic Small Outline Transistor, SOT-89, 3-lead ZB = Plastic Transistor Outline, TO-92, 3-lead	
Taping Direction:	713 = Standard Taping	

Examples:

a) TC54VC1402ECB713: Tape and Reel, 1.4V Voltage Detector, 2% Tol., SOT-23A-3.

b) TC54VC1402EMB713: Tape and Reel, 1.4V Voltage Detector, 2% Tol., SOT-89-3.

c) TC54VC1402EZB: 1.4V Voltage Detector, 2% Tol., TO-92.

d) TC54VC2102ECB713: Tape and Reel, 2.1V Voltage Detector, 2% Tol., SOT-23A-3.

e) TC54VC2102EMB713: Tape and Reel, 2.1V Voltage Detector, 2% Tol., SOT-89-3.

f) TC54VC2102EZB: 2.1V Voltage Detector, 2% Tol., TO-92.

g) TC54VC2702ECB713: Tape and Reel, 2.7V Voltage Detector, 2% Tol., SOT-23A-3.

h) TC54VC3002ECB713: Tape and Reel, 3.0V Voltage Detector, 2% Tol., SOT-23A-3.

i) TC54VN4202ECB713: Tape and Reel, 4.2V Voltage Detector,2% Tol., SOT-23A-3.

NOTES:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

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Microchip received ISO/TS-16949:2002 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

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