

## Voltage Detector

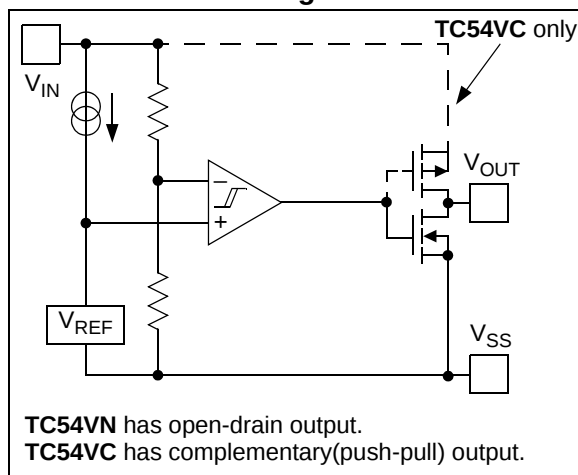
### Features

- $\pm 2.0\%$  Detection Thresholds
- Small Packages: 3-Pin SOT-23A, 3-Pin SOT-89, and TO-92
- Low Current Drain:  $1\ \mu\text{A}$  (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

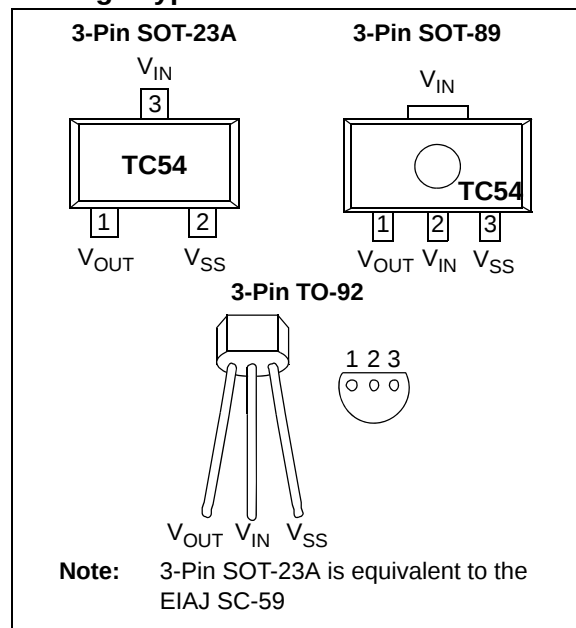


### General Description

The TC54 series are CMOS voltage detectors that are especially well suited for battery-powered applications because of their extremely low  $1\ \mu\text{A}$  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 TC54's 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  $V_{HYST}$ , whereupon it resets to a logic-high.

### Package Types



### Device Features

| Device | Output     |            | Reset Delay | Std. Trip Points <sup>(1)</sup> (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 †

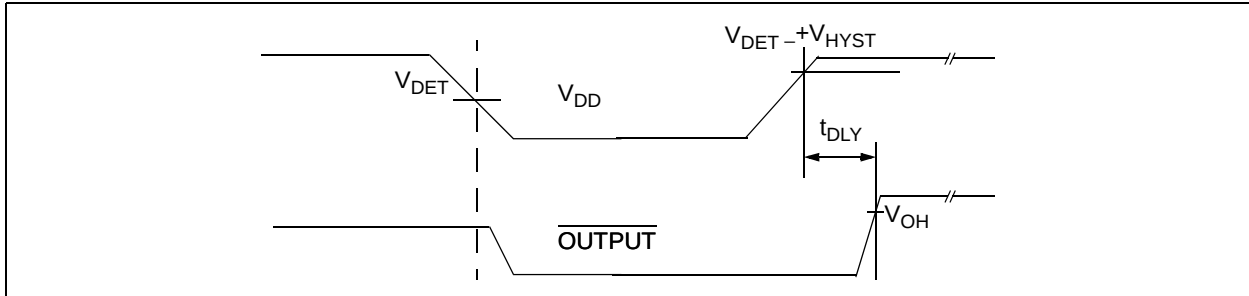
Input Voltage .....+12V  
 Output Current .....50 mA  
 Output Voltage: CMOS.....( $V_{SS} - 0.3V$ ) to ( $V_{IN} + 0.3V$ )  
 Open-Drain.....( $V_{SS} - 0.3V$ ) to 12V  
 Power Dissipation ( $T_A \leq 70^\circ C$ ):  
   3-Pin SOT-23A .....240 mW  
   3-Pin SOT-89 .....500 mW  
   5-Pin SOT-23A .....240 mW  
   3-Pin TO-92 .....300 mW  
 Operating Temperature Range.....-40°C to +85°C  
 Storage Temperature Range .....-65°C to +150°C

† 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, $T_A = +25^\circ C$ . |                  |      |           |      |         |                                                         |
|--------------------------------------------------------------------------|------------------|------|-----------|------|---------|---------------------------------------------------------|
| Parameter                                                                | Sym              | Min  | Typ       | Max  | Units   | Test Conditions                                         |
| Operating Voltage                                                        | $V_{IN}$         | 0.7  | —         | 10.0 | V       | $(V_{DET-}) \geq 1.6V$                                  |
|                                                                          |                  | 0.7  | —         | 6.0  | V       | $(V_{DET-}) < 1.6V$                                     |
| Quiescent Current                                                        | $I_{SS}$         | —    | 0.8       | 2.7  | $\mu A$ | $V_{IN} = 2.0V$                                         |
|                                                                          |                  | —    | 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<br>(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:<br>$V_{OH} = V_{IN} - 2.1V, V_{IN} = 8.0V$ |
| Tempco of ( $V_{DET-}$ )                                                 | $T_C (V_{DET-})$ | —    | $\pm 100$ | —    | ppm/°C  | $-40^\circ C \leq T_A \leq 85^\circ C$                  |
| Delay Time                                                               | $t_{DLY}$        | —    | —         | 0.2  | ms      | $V_{DET-} \rightarrow V_{OUT}$ inversion                |

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



**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**

| Pin No.<br>(3-Pin SOT-23A) | Pin No.<br>(3-Pin SOT-89) | Pin No.<br>(3-Pin TO-92) | Symbol    | Description     |
|----------------------------|---------------------------|--------------------------|-----------|-----------------|
| 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.

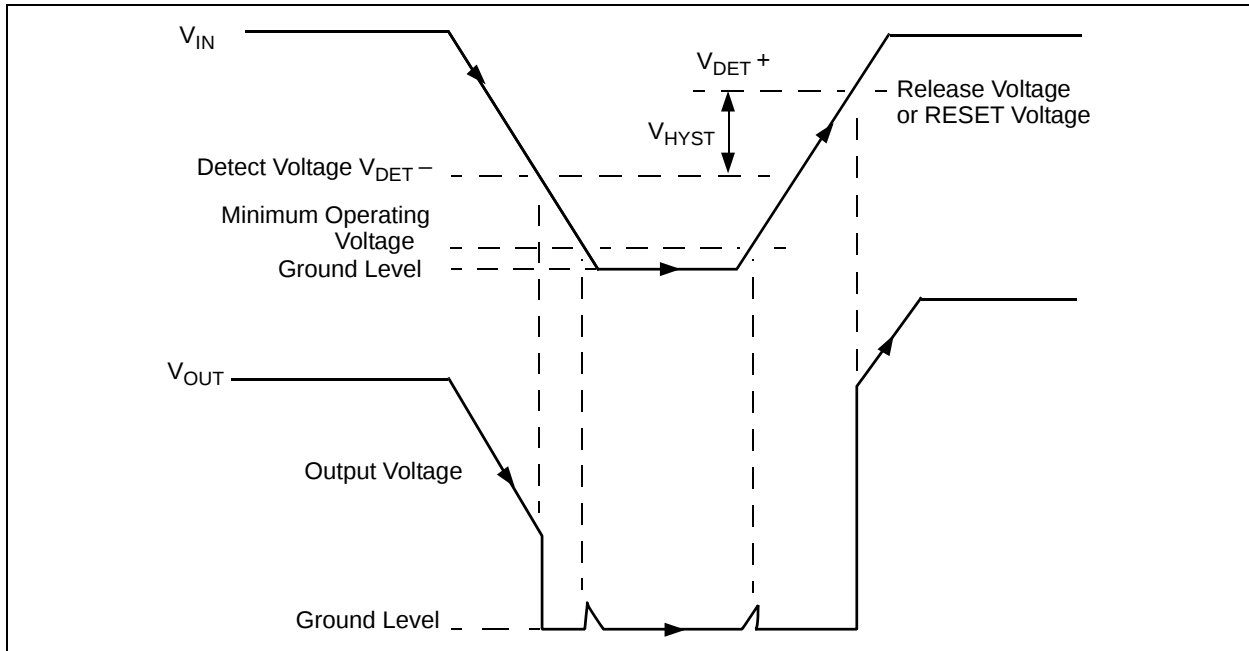
### 2.4 No Connect (NC)

No internal connection.

## 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  $V_{INMIN}$ . Once 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).



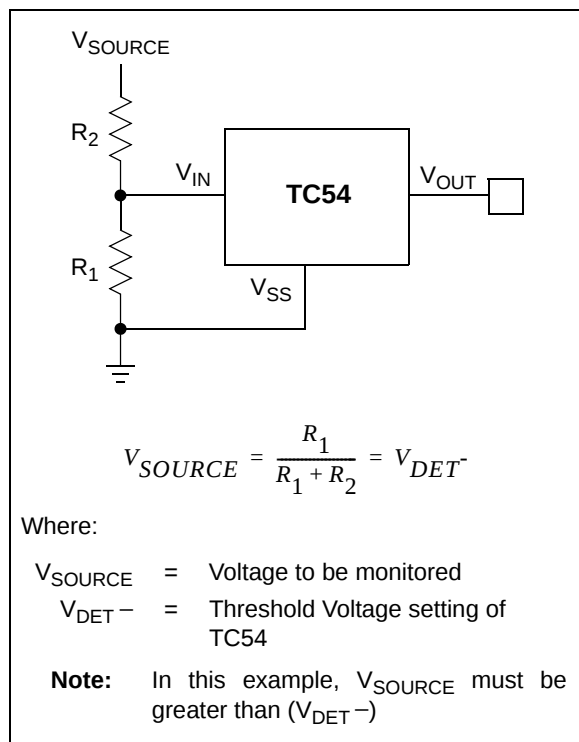
**FIGURE 3-1:** Timing Diagram.

## 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).

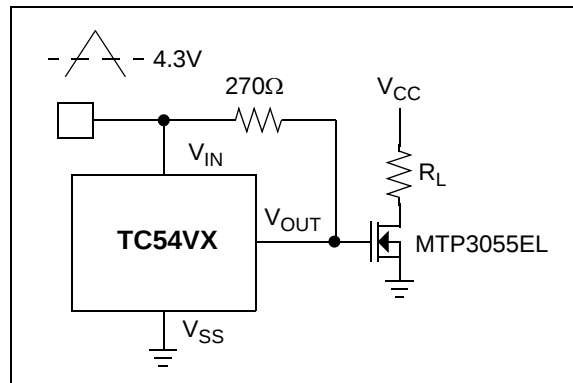
To maintain detector accuracy, the bleeder current through the divider should be significantly higher than the 1  $\mu A$  operating current required by the TC54. A reasonable value for this bleeder current is 100  $\mu A$  (100 times the 1  $\mu A$  required by the TC54). For example, if  $V_{DET-}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



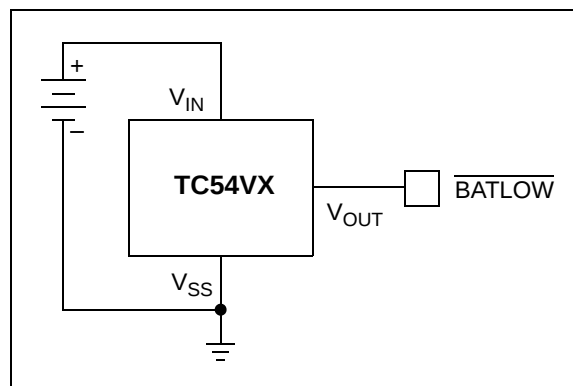
**FIGURE 4-1:** Modify Trip-point of the TC54 using External Resistor Divider.

### 4.2 Other Applications

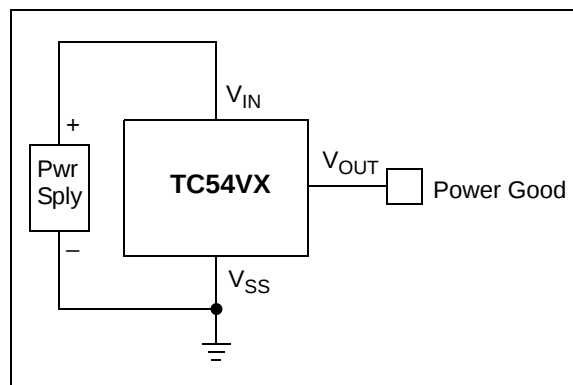
Low operating power and small physical size make the TC54 series ideal for many voltage detector applications, such as those shown in Figures 4-2, 4-3 and 4-4. Figure 4-2 shows a low-voltage gate drive protection circuit that prevents overheating of the logic-level MOSFET due to insufficient gate voltage.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



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



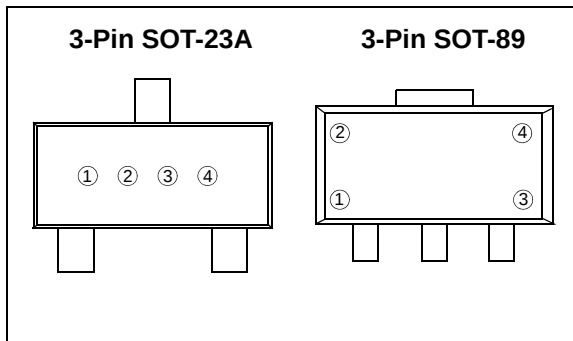
**FIGURE 4-3:** Battery Voltage Monitor.



**FIGURE 4-4:** Power Good Monitor.

## 5.0 PACKAGING INFORMATION

### 5.1 Package Marking Information



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

Ex: CMOS 3.x = ① ③ ③ ③

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

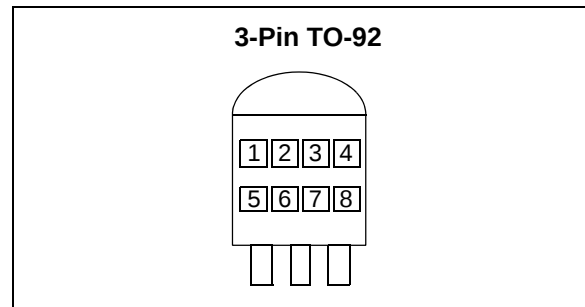
| Symbol | Output | Voltage |
|--------|--------|---------|
| L      | Nch    | 1.      |
| M      | Nch    | 2.      |
| N      | Nch    | 3.      |
| P      | Nch    | 4.      |
| R      | Nch    | 5.      |
| S      | Nch    | 6.      |
| T      | Nch    | 7.      |

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

Ex: CMOS 3.x = ① ④ ③ ③

| 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 = ④ ③ ③ ③

| 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

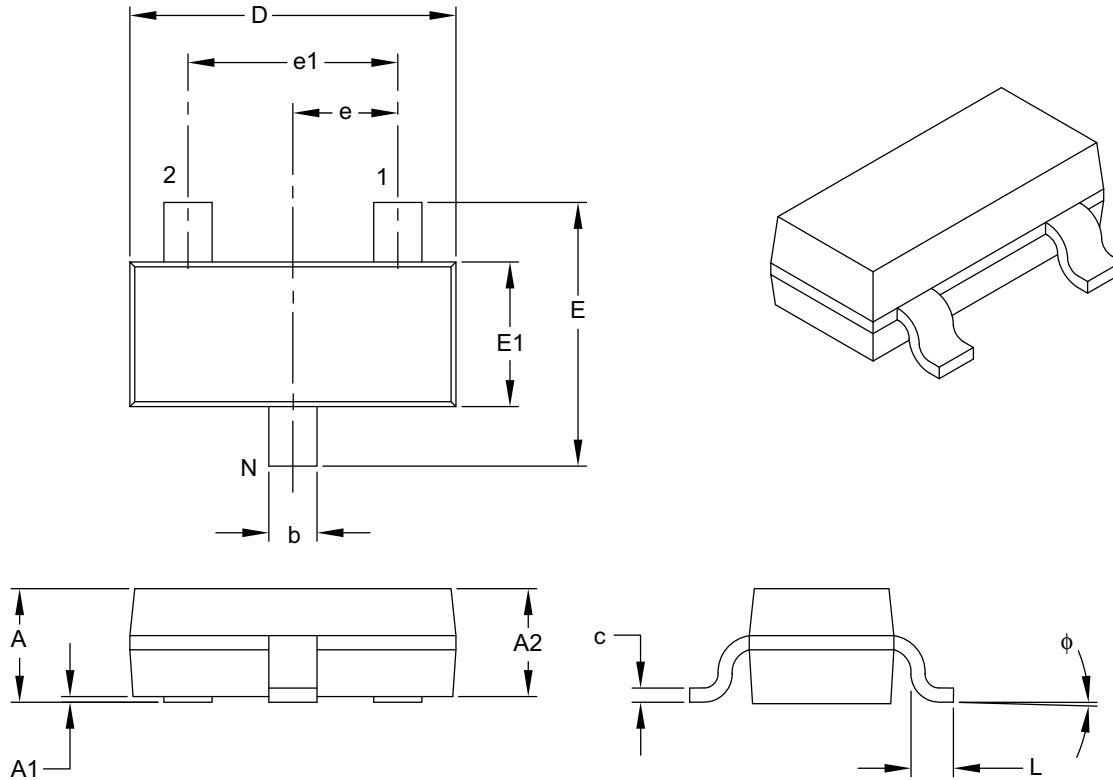
| Symbol | Delay Time |
|--------|------------|
| 0      | No Delay   |

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:**

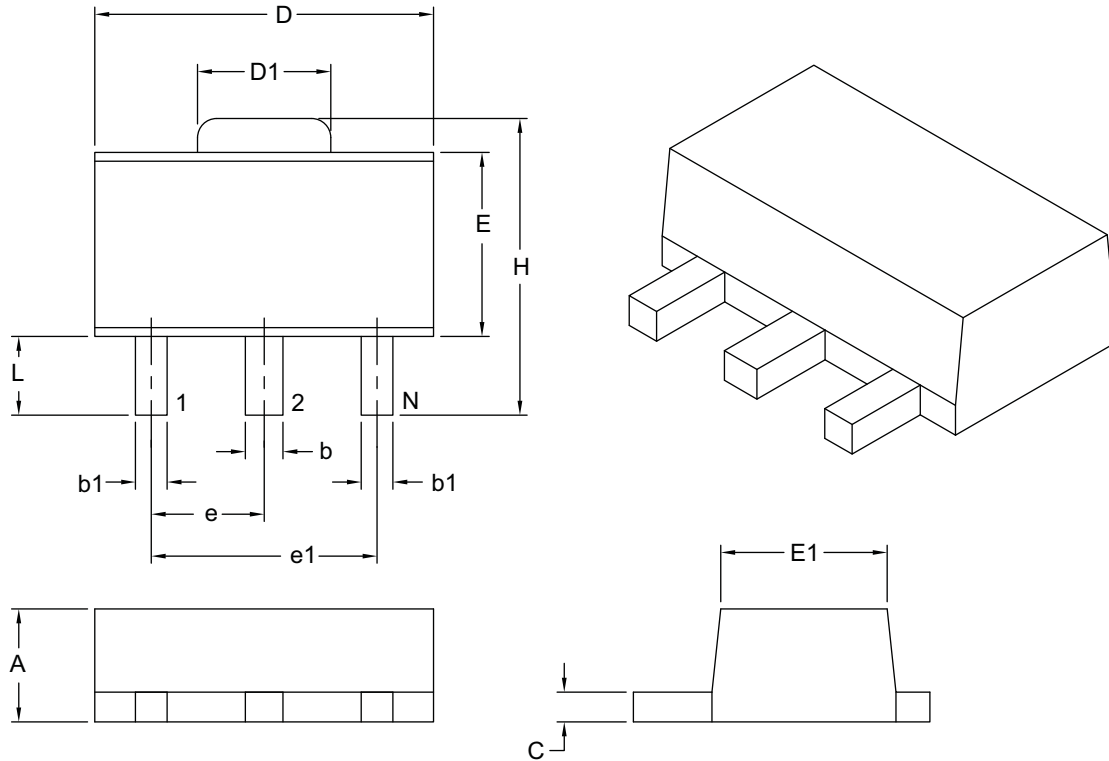
- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
- Dimensioning and tolerancing per ASME Y14.5M.

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

Microchip Technology Drawing C04-130B

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

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



| Dimension Limits             | Units | MILLIMETERS |      |
|------------------------------|-------|-------------|------|
|                              |       | 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:**

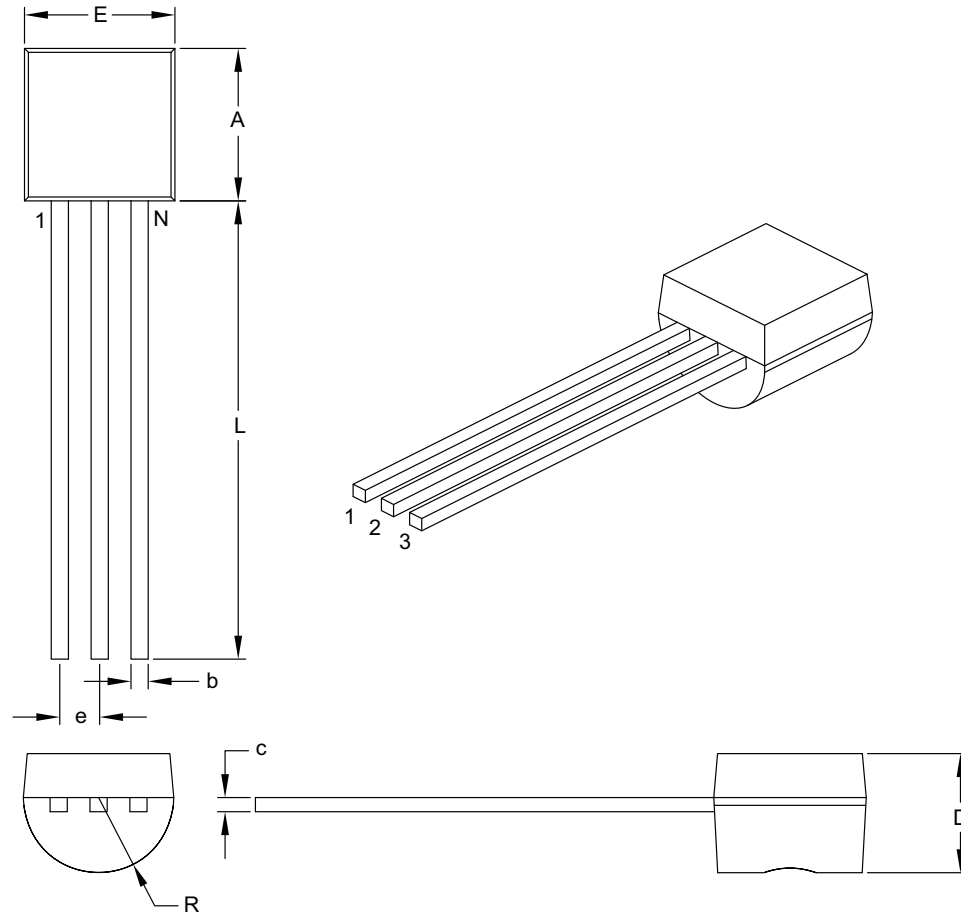
- Dimensions D and E do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
- Dimensioning and tolerancing per ASME Y14.5M.

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

Microchip Technology Drawing C04-029B

## 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:**

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

Microchip Technology Drawing C04-101B

## APPENDIX A: REVISION HISTORY

### Revision H (December 2007)

- Updated Features section.
- Removed 5-Pin SOT-23 related information.
- Updated Output Current ( $I_{OUT}$ ) Electrical Specification.
- Removed 7.7V (typical) Voltage Trip Point Option. Max Trip Point Voltage is now 6.0V.
- Updated Pin Function Table.
- Updated Packaging Specification Information.
- Added Revision History section.
- 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.

# TC54

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NOTES:

## PRODUCT IDENTIFICATION SYSTEM

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

| <u>PART NO.</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | X              | XX               | X                  | X         | X     | XX  | XX               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------------|--------------------|-----------|-------|-----|------------------|
| Device                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Output Config. | Detected Voltage | Extra Feature Code | Tolerance | Temp. | Pkg | Taping Direction |
| <div>Device: TC54V: Voltage Detector</div> <div>Output Configuration: N = Nch Open-Drain<br/>C = CMOS Output</div> <div>Detected Voltage: 14 = 1.4V<br/>21 = 2.1V<br/>27 = 2.7V<br/>29 = 2.9V<br/>30 = 3.0V<br/>42 = 4.2V<br/>43 = 4.3V</div> <div>Extra Feature Code: 0 = Fixed</div> <div>Tolerance: 2 = 2%</div> <div>Temperature: E = -40°C to +85°C</div> <div>Package: CB = Plastic Small Outline Transistor, SOT-23A, 3-lead,<br/>MB = Plastic Small Outline Transistor, SOT-89, 3-lead,<br/>ZB = Plastic Transistor Outline, TO-92, 3-lead</div> <div>Taping Direction: 713 = Standard Taping</div>                                                                                                                                                                                                  |                |                  |                    |           |       |     |                  |
| <b>Examples:</b> <div>a) TC54VC1402ECB713: Tape and Reel, 1.4V Voltage Detector, 2% Tol., SOT-23A-3.</div> <div>b) TC54VC1402EMB713: Tape and Reel, 1.4V Voltage Detector, 2% Tol., SOT-89-3.</div> <div>c) TC54VC1402EZB: 1.4V Voltage Detector, 2% Tol., TO-92.</div> <div>d) TC54VC2102ECB713: Tape and Reel, 2.1V Voltage Detector, 2% Tol., SOT-23A-3.</div> <div>e) TC54VC2102EMB713: Tape and Reel, 2.1V Voltage Detector, 2% Tol., SOT-89-3.</div> <div>f) TC54VC2102EZB: 2.1V Voltage Detector, 2% Tol., TO-92.</div> <div>g) TC54VC2702ECB713: Tape and Reel, 2.7V Voltage Detector, 2% Tol., SOT-23A-3.</div> <div>h) TC54VC3002ECB713: Tape and Reel, 3.0V Voltage Detector, 2% Tol., SOT-23A-3.</div> <div>i) TC54VN4202ECB713: Tape and Reel, 4.2V Voltage Detector, 2% Tol., SOT-23A-3.</div> |                |                  |                    |           |       |     |                  |

# TC54

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NOTES:

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**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."

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