

Low Dropout, Negative Output Voltage Regulator

Features

- Low Dropout Voltage
 - Typically 120mV @ 50mA; 380mV @ 100mA for -5.0V Output Part
- Tight Output Voltage Tolerance: $\pm 2\%$ Max
- Low Supply Current: 3.5 μ A, Typ
- Small Package: 3-Pin SOT-23A

Applications

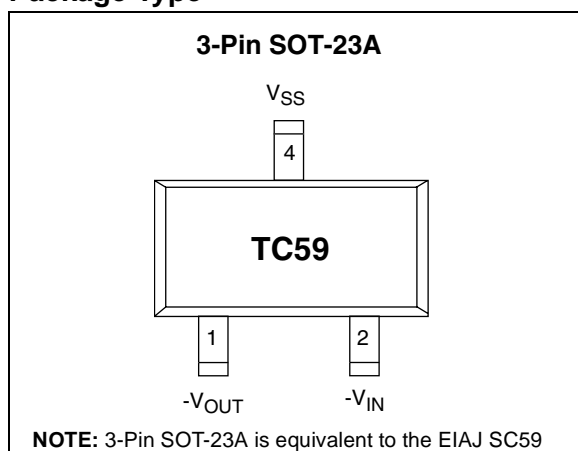
- Cellular Phones
- Battery Operated Systems
- Palmtops
- Portable Cameras

Device Selection Table

| Part Number | Output Voltage | Package | Temperature Range |
|-------------|----------------|---------------|-------------------|
| TC593002ECB | 3.0V | 3-Pin SOT-23A | -40°C to +85°C |
| TC595002ECB | 5.0V | 3-Pin SOT-23A | -40°C to +85°C |

Other output voltages are available. Please contact Microchip Technology Inc. for details.

Package Type

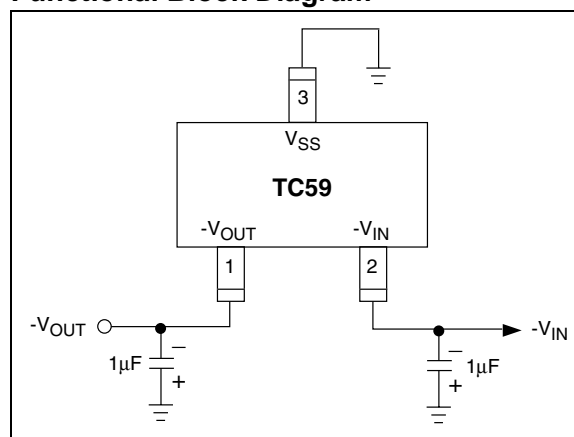


General Description

The TC59 is a low dropout, negative output voltage regulator designed specifically for battery-operated systems. Its full CMOS construction eliminates the wasted ground current typical of bipolar LDOs. This reduced supply current significantly extends battery life, particularly when the TC59 is operated in dropout.

Other TC59 key features include low supply current (typically 3.0 μ A) and low dropout operation (typically 120mV at 50mA). The TC59 is packaged in a small 3-Pin SOT-23A package.

Functional Block Diagram



TC59

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

| | |
|----------------------------------|-------------------------------------|
| Input Voltage | -12V |
| Output Current | 200mA |
| Output Voltage..... | $-V_{DD} - 0.3V$ to $V_{IN} + 0.3V$ |
| Power Dissipation..... | 150mW |
| Operating Temperature Range..... | -40°C to +85°C |
| Storage Temperature Range | -40°C to +125°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.

TC59 ELECTRICAL SPECIFICATIONS

| Electrical Characteristics: $V_{IN} = V_R - 1.0V$ (Note 1), $C_L = 10\mu F$, $T_A = 25^\circ C$ unless otherwise noted. | | | | | | |
|--|--|----------------------------|--|--|----------------------------------|---|
| Symbol | Parameter | Min | Typ | Max | Units | Test Conditions |
| V_{IN} | Input Voltage | — | — | -10 | V | $I_{OUT} = 20mA$ |
| I_{DD} | Supply Current | — | 3 | 7 | μA | |
| $I_{OUT(MAX)}$ | Maximum Output Current | 100 80 60 | — — — | — — — | mA mA mA | $V_{IN} = -6.0V$; $V_R = -5.0V$, $V_{OUT} \leq -4.5V$ $V_{IN} = -5.0V$; $V_R = -4.0V$, $V_{OUT} \leq -3.6V$ $V_{IN} = -4.0V$; $V_R = -3.0V$, $V_{OUT} \leq -2.7V$ |
| V_{OUT} | Output Voltage | $1.02 \times V_R$ | — | $0.98 \times V_R$ | V | $I_{OUT} = 20mA$ |
| TC V_{OUT} | Output Voltage Temperature Coefficient | — | ± 100 | — | ppm/ $^\circ C$ | $I_{OUT} = 20mA$ |
| $\frac{\Delta V_{OUT}}{(\Delta V_{IN} \times V_{OUT})}$ | Line Regulation | — | 0.1 | 0.3 | %/V | $I_{OUT} = 20mA$; $V_R = -5.0V$; $-6.0 < V_{IN} < -10.0V$ $V_R = -4.0V$; $-5.0 < V_{IN} < -10.0V$ $V_R = -3.0V$; $-4.0 < V_{IN} < -10.0V$ |
| ΔV_{OUT} | Load Regulation | — | 40 | 80 | mV | $V_R = -5.0V$; $1mA < I_{OUT} < 50mA$ $V_R = -4.0V$; $1mA < I_{OUT} < 45mA$ $V_R = -3.0V$; $1mA < I_{OUT} < 40mA$ |
| $V_{IN} - V_{OUT}$ | Dropout Voltage | — — — — — — | 120 380 120 380 120 380 | 300 600 300 600 300 600 | mV mV mV mV mV mV | $V_R = -5.0V$; $I_{OUT} = 50mA$ $I_{OUT} = 100mA$ $V_R = -4.0V$; $I_{OUT} = 45mA$ $I_{OUT} = 90mA$ $V_R = -3.0V$; $I_{OUT} = 40mA$ $I_{OUT} = 80mA$ |

Note 1: V_R is the regulator output voltage setting. For example: $V_R = -2.5V, -2.7V, -3.0V, -3.3V, -3.6V, -4.0V, -5.0V$.

2.0 PIN DESCRIPTIONS

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

TABLE 2-1: PIN FUNCTION TABLE

| Pin No. (3-Pin SOT-23A) | Symbol | Description |
|----------------------------|-----------|---------------------------|
| 1 | V_{OUT} | Regulated voltage output. |
| 2 | V_{IN} | Supply voltage input. |
| 3 | V_{SS} | Ground. |

3.0 DETAILED DESCRIPTION

The TC59 is a low quiescent current, precision fixed negative output voltage LDO. Unlike bipolar linear regulators, the TC59 supply current does not increase proportionally with load current.

3.1 Output Capacitor

A minimum of 1 μ F tantalum output capacitor is required. The requirements for the output capacitor are an equivalent series resistance (esr) greater than 0.1 Ω and less than 5 Ω , with a self-resonant frequency greater than 1MHz. To improve supply noise rejection and transient response, larger output capacitors can be used. Care should be taken when increasing C_{OUT} , that the input impedance is not high enough to cause high input impedance oscillation.

3.2 Input Capacitor

A 1 μ F input capacitor is recommended for most applications when the input impedance is on the order of 10 Ω . When operating off of a battery input, or there is a large distance from the input source to the LDO, larger input capacitance may be required for stability. When large values of output capacitance are used, the input capacitance should be increased to prevent high source impedance oscillations.

4.0 THERMAL CONSIDERATIONS

4.1 Power Dissipation

The amount of power dissipated internal to the low drop out linear regulator is the sum of the power dissipation within the linear pass device (P-Channel MOSFET), and the quiescent current required to bias the internal reference and error amplifier. The internal linear pass device power dissipation is calculated multiplying the voltage across the linear device times the current through the device. The input and output voltages are negative for the TC59. The power dissipation is calculated using the absolute value of the voltage difference between the input and output voltage.

TABLE 4-1: MAXIMUM POWER DISSIPATION

| Package Type | Maximum Power Dissipation |
|--------------|---------------------------|
| SOT-23-3 | 150mW |

EQUATION 4-1:

$$P_D (\text{Pass Device}) = (V_{IN} - V_{OUT}) \times I_{OUT}$$

The internal power dissipation as a result of the bias current for the LDO internal reference and error amplifier is calculated by multiplying the ground or quiescent current times the input voltage.

EQUATION 4-2:

$$P_D (\text{Bias}) = V_{IN} \times I_{GND}$$

The total internal power dissipation is the sum of Equation 4-1 and Equation 4-2.

EQUATION 4-3:

$$P_{TOTAL} = P_D (\text{Pass Device}) + P_D (\text{Bias})$$

For the TC59, the internal quiescent bias current is so low (3μA typical), the P_D (Bias) term of the power dissipation equation can be ignored. The maximum power dissipation can be estimated by using the maximum input voltage and the minimum output voltage to obtain a maximum voltage differential between input and output and multiplying the maximum voltage differential by the maximum output current.

EQUATION 4-4:

$$P_{MAX} = (V_{IN (MAX)} - V_{OUT (MIN)}) \times I_{OUT (MAX)}$$

For example, given the following conditions:

$$V_{IN} = -7.0V \pm 5\%$$

$$V_{OUT} = -5.0V \pm 2\%$$

$$I_{OUT} = 1mA \text{ to } 40mA$$

$$T_{AMBIENT (MAX)} = 55^\circ C$$

$$P_{MAX} = (7V \times (1.05) - (5.0V \times 0.98)) \times 40mA$$

$$P_{MAX} = 98.0 \text{ milli-Watts}$$

To determine the junction temperature of the device, the thermal resistance from junction to air must be known. The SOT-23-3 $R_{\theta JA}$ is estimated to be approximately 359°C/W when mounted on a 4-layer board. The $R_{\theta JA}$ will vary with physical layout, airflow and other application specific conditions.

The device junction temperature is determined by calculating the junction temperature rise above ambient, then adding the rise to the ambient temperature.

EQUATION 4-5: JUNCTION TEMPERATURE (SOT-23 EXAMPLE)

$$T_{JUNCTION} = P_D (MAX) \times R_{\theta JA} + T_{AMBIENT}$$

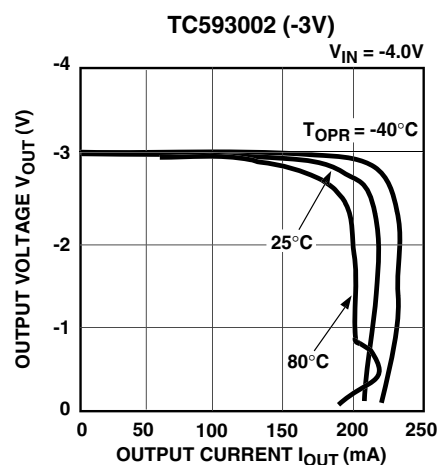
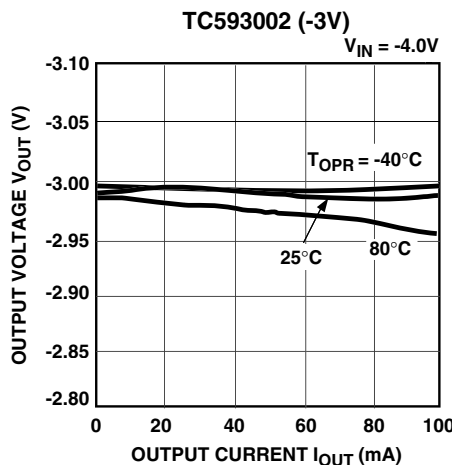
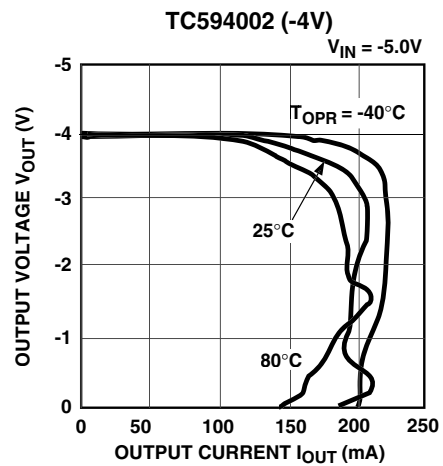
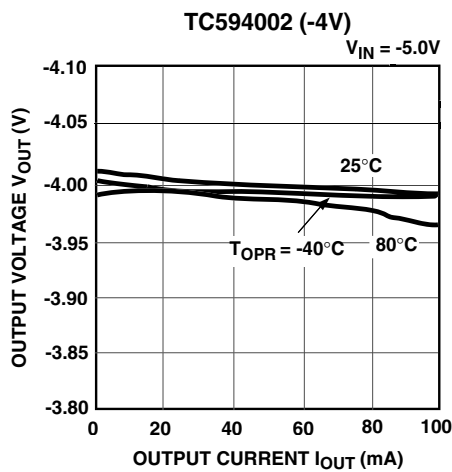
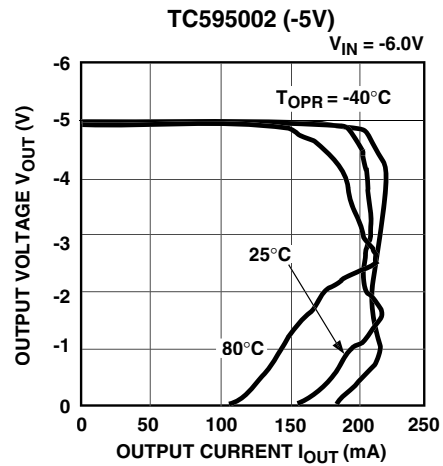
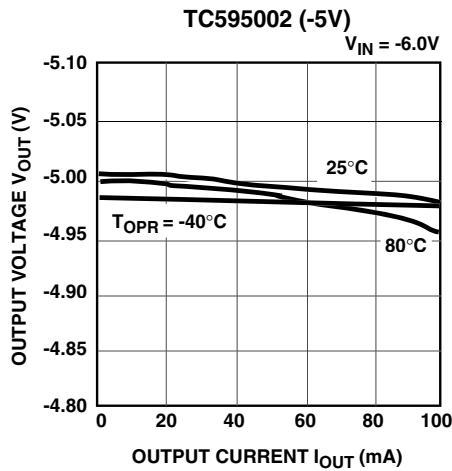
$$T_{JUNCTION} = 98.0 \text{ milli-Watts} \times 359^\circ C/W + 55^\circ C$$

$$T_{JUNCTION} = 90.2^\circ C$$

5.0 TYPICAL CHARACTERISTICS

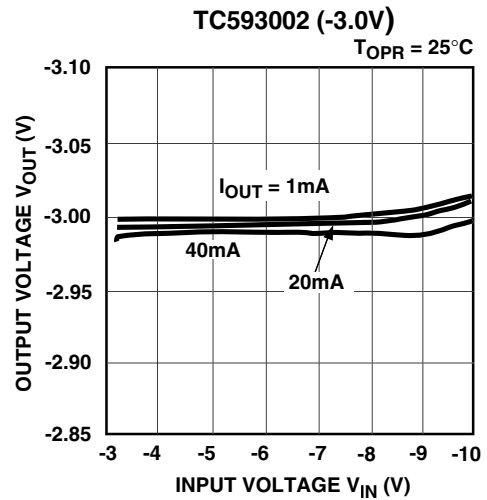
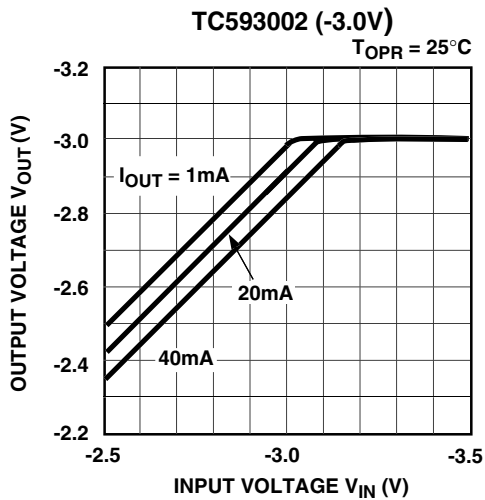
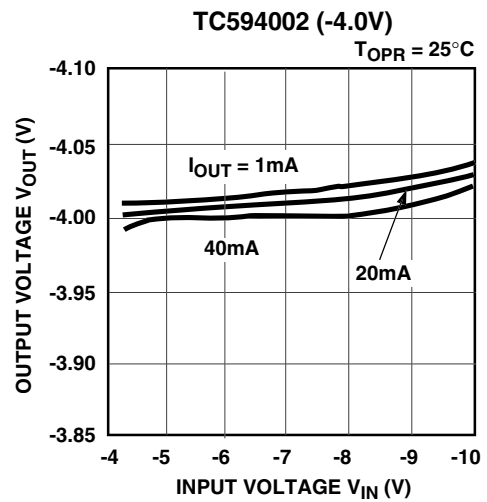
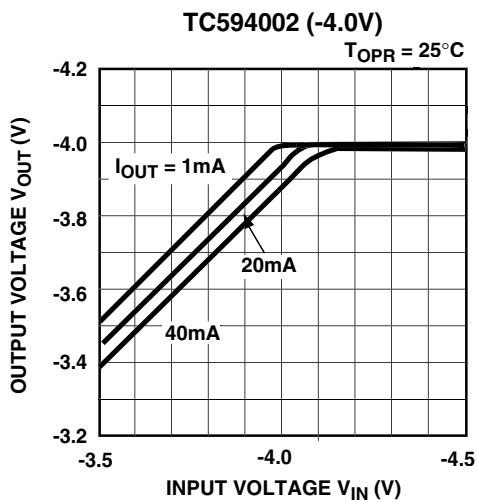
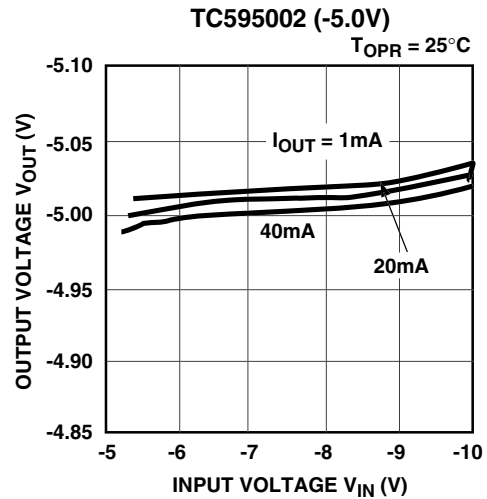
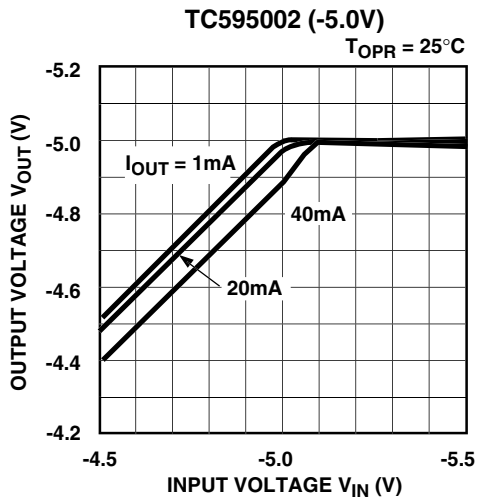
Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

1. OUTPUT VOLTAGE vs. OUTPUT CURRENT



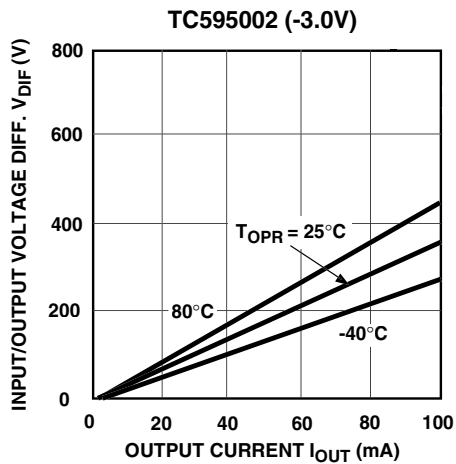
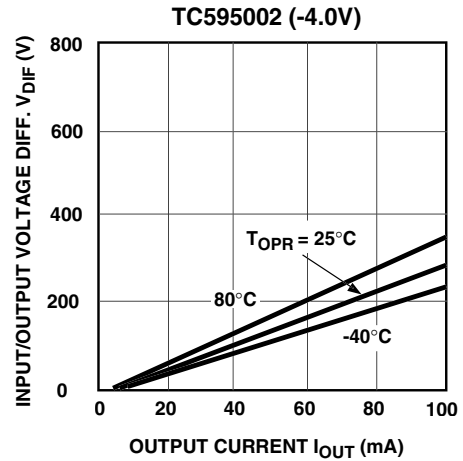
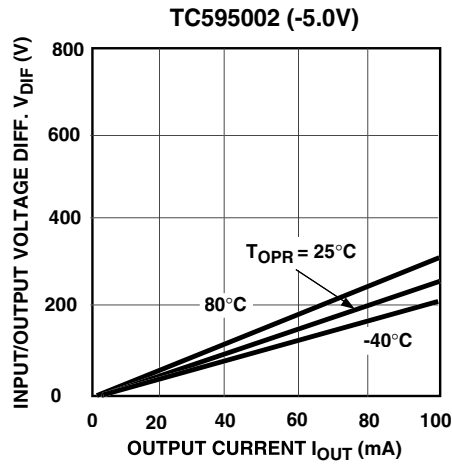
5.0 TYPICAL CHARACTERISTICS (CONTINUED)

2. OUTPUT VOLTAGE vs. INPUT VOLTAGE

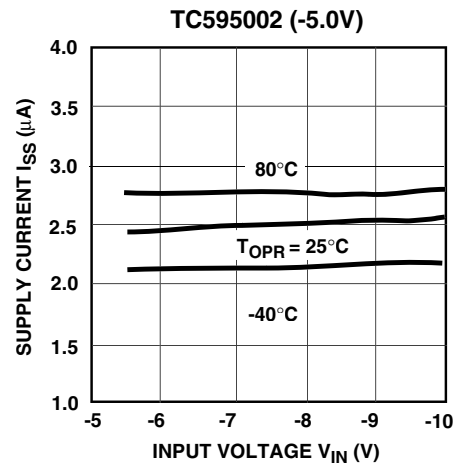
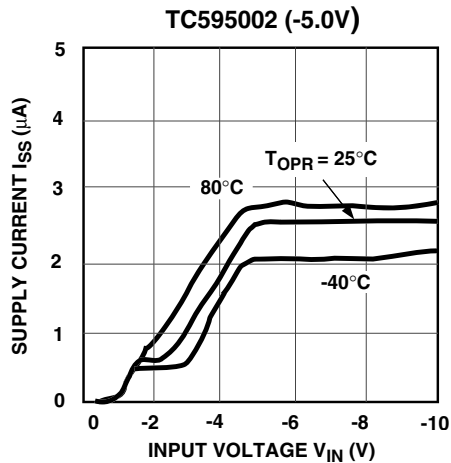


5.0 TYPICAL CHARACTERISTICS (CONTINUED)

3. INPUT/OUTPUT VOLTAGE DIFFERENTIAL vs. OUTPUT CURRENT

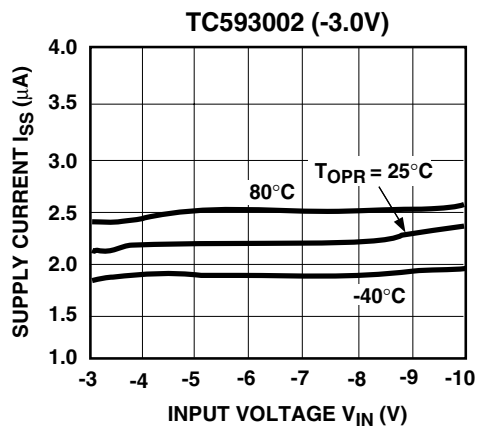
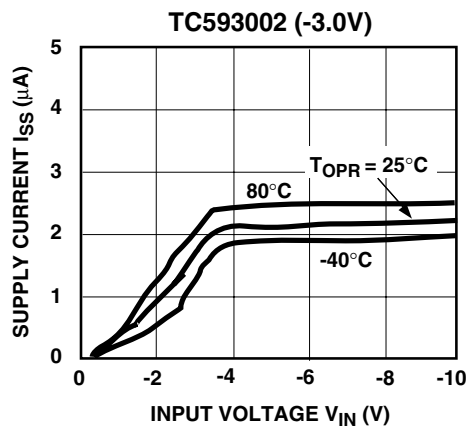
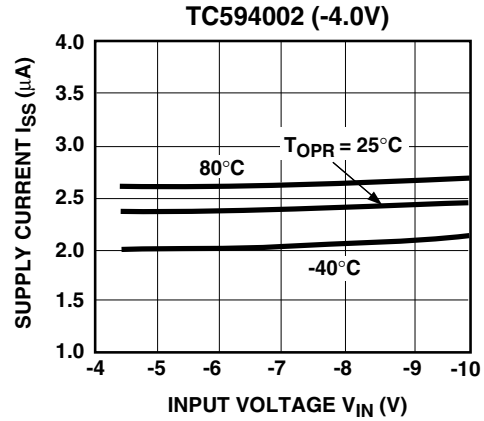
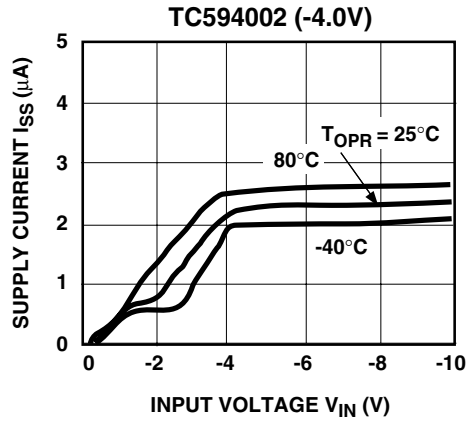


4. SUPPLY CURRENT vs. INPUT VOLTAGE

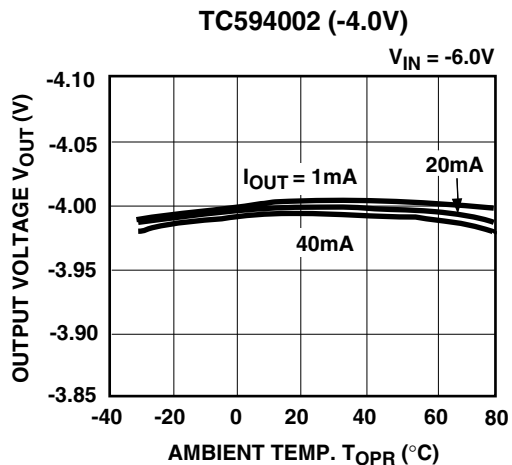
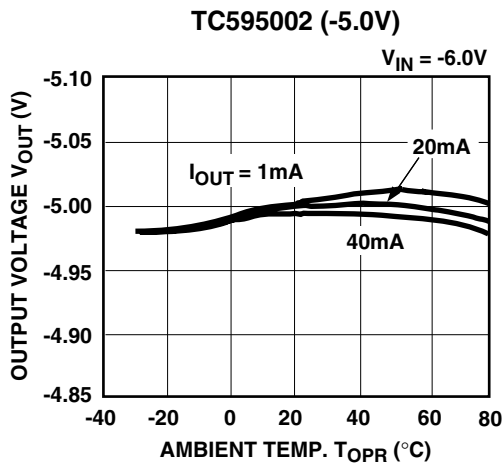


5.0 TYPICAL CHARACTERISTICS (CONTINUED)

4. SUPPLY CURRENT vs. INPUT VOLTAGE (CONTINUED)

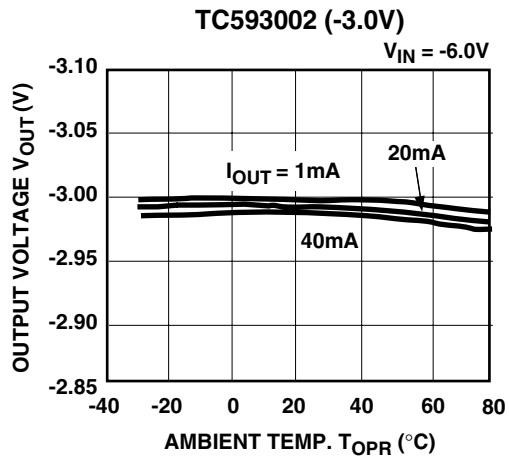


5. OUTPUT VOLTAGE vs. AMBIENT TEMPERATURE

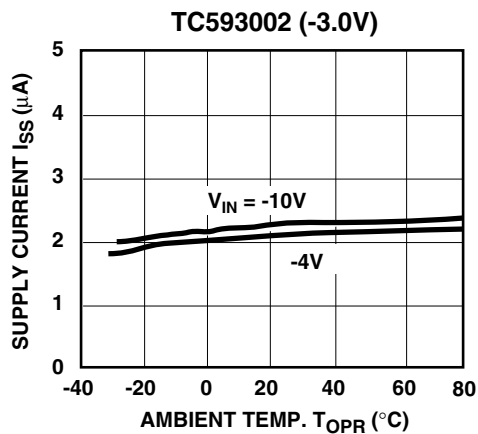
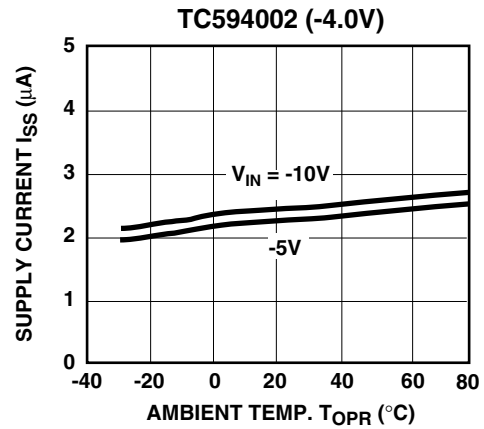
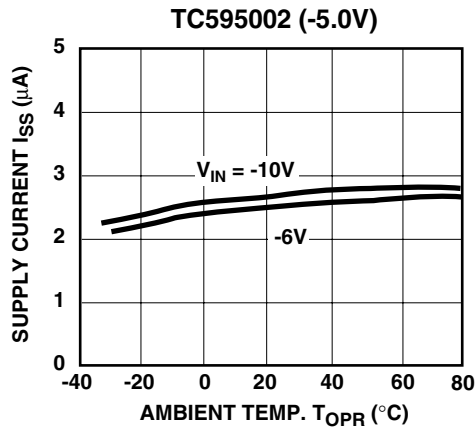


5.0 TYPICAL CHARACTERISTICS (CONTINUED)

5. OUTPUT VOLTAGE vs. AMBIENT TEMPERATURE (CONTINUED)

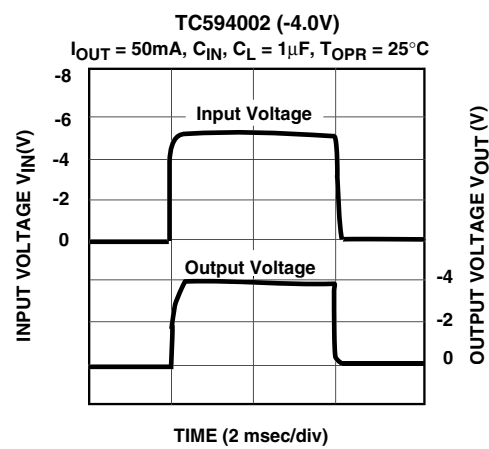
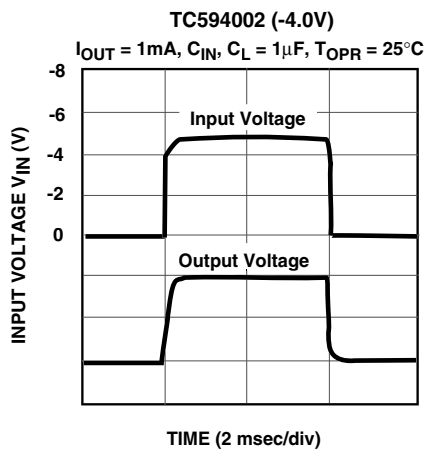
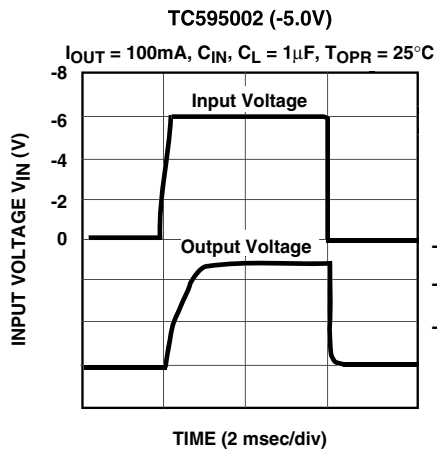
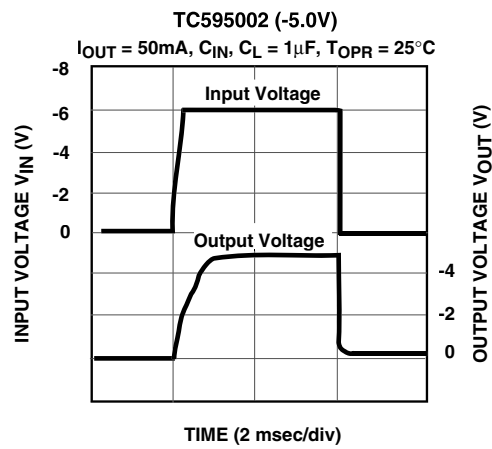
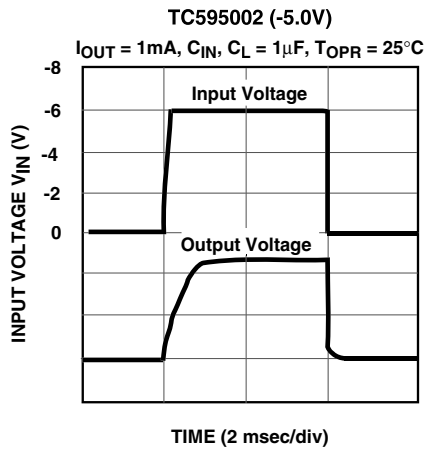


6. SUPPLY CURRENT vs. AMBIENT TEMPERATURE



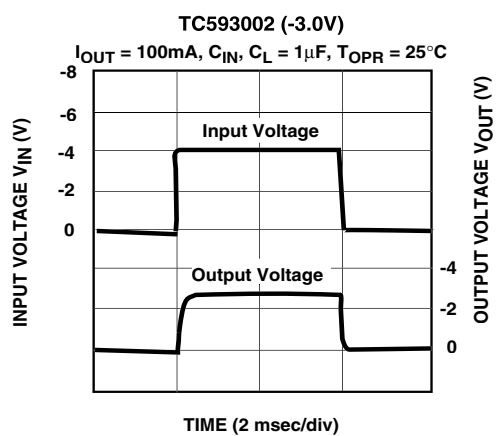
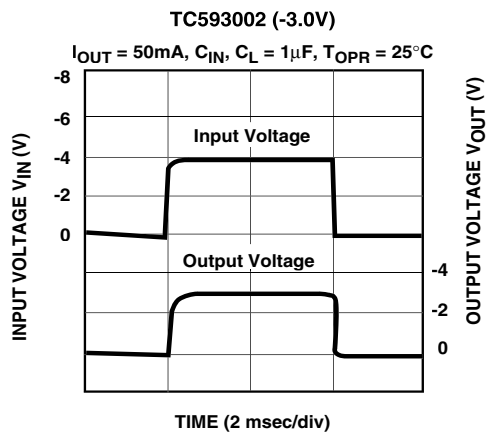
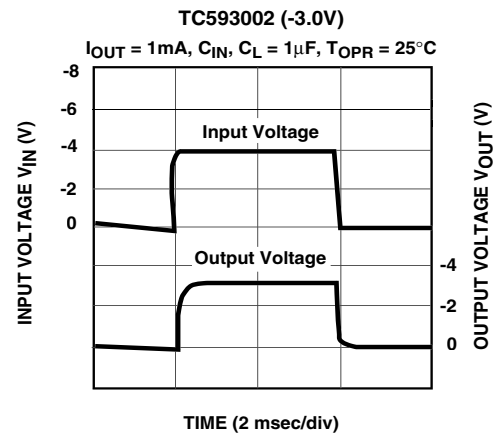
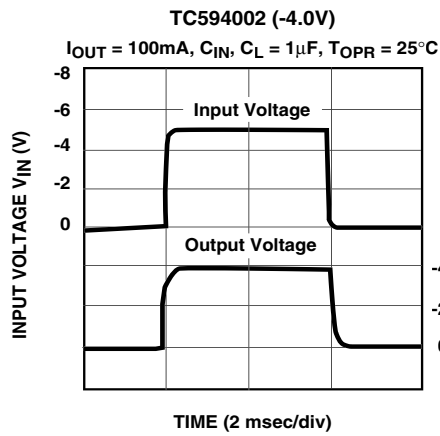
5.0 TYPICAL CHARACTERISTICS (CONTINUED)

7. INPUT TRANSIENT RESPONSE



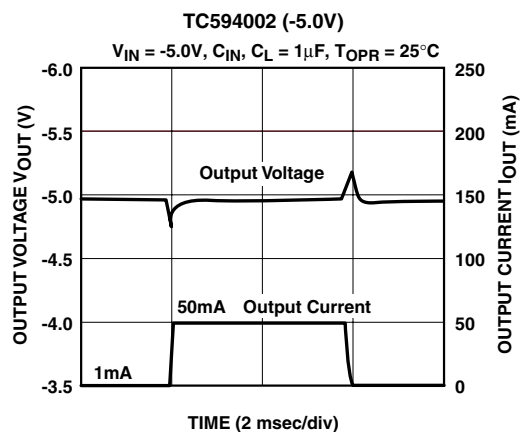
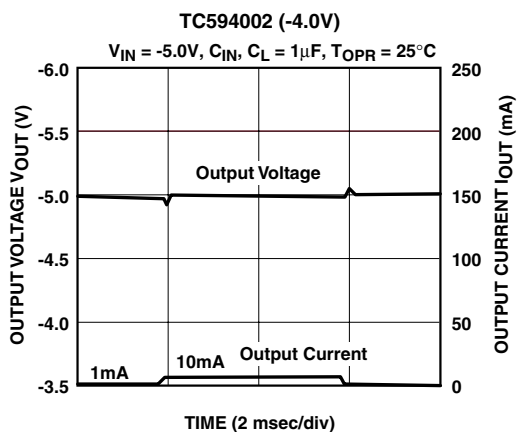
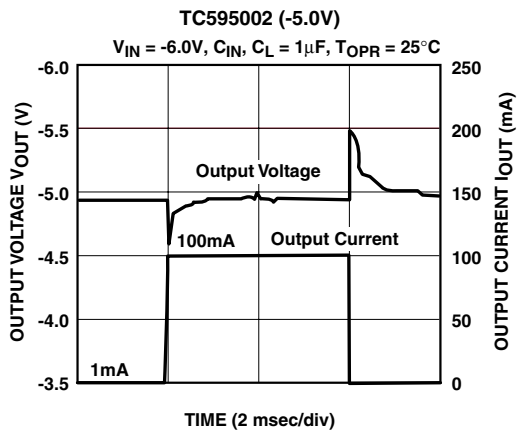
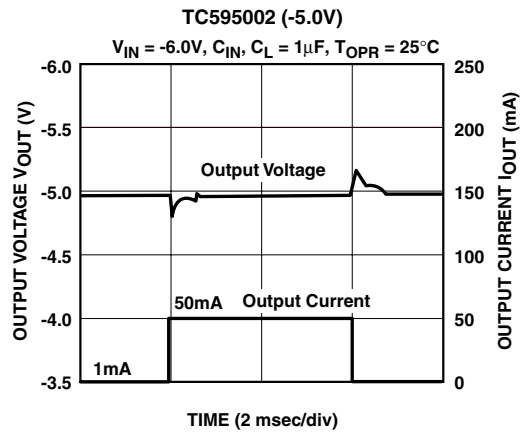
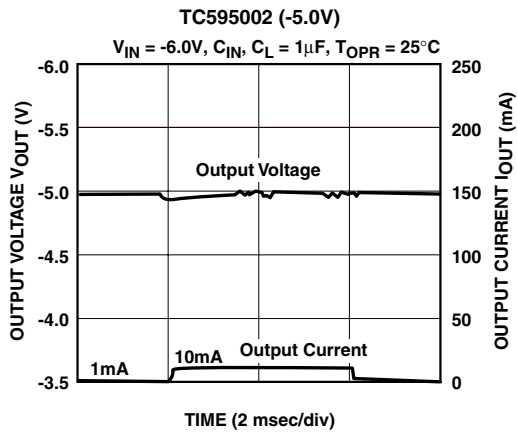
5.0 TYPICAL CHARACTERISTICS (CONTINUED)

7. INPUT TRANSIENT RESPONSE (CONT.)



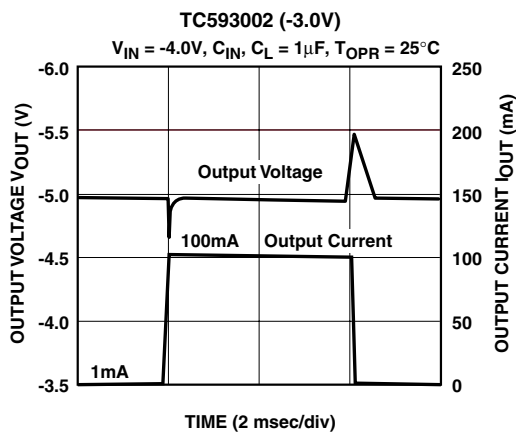
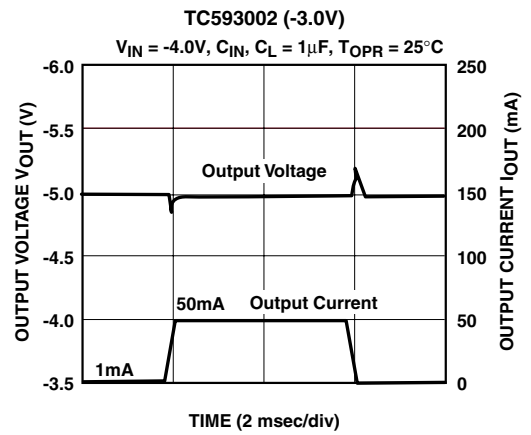
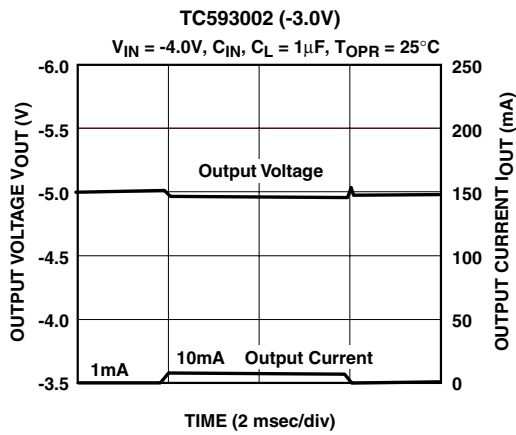
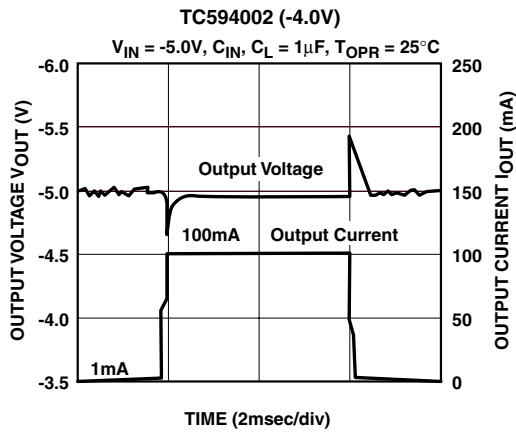
5.0 TYPICAL CHARACTERISTICS (CONTINUED)

8. LOAD TRANSIENT RESPONSE



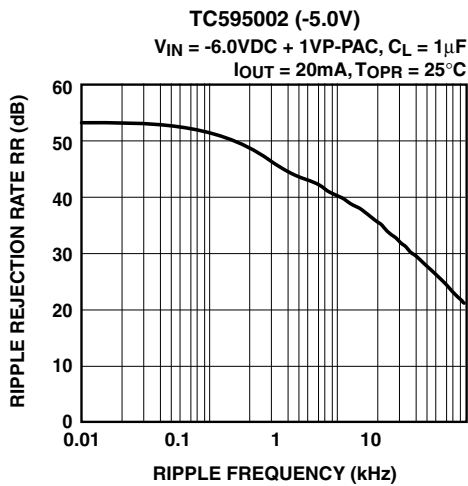
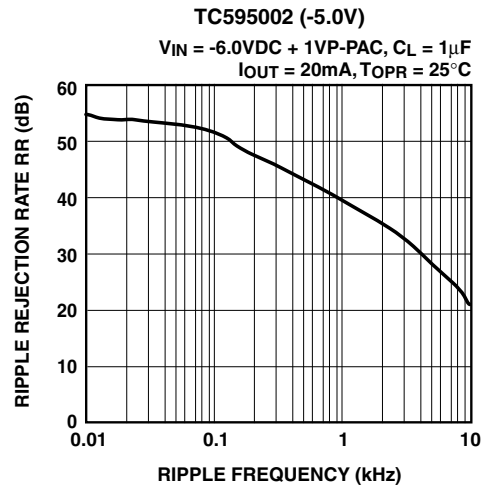
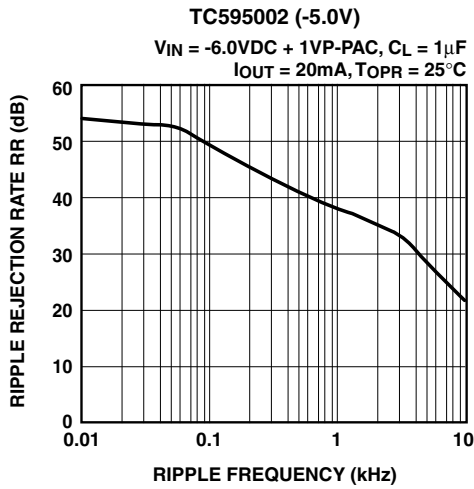
5.0 TYPICAL CHARACTERISTICS (CONTINUED)

8. LOAD TRANSIENT RESPONSE (CONT.)



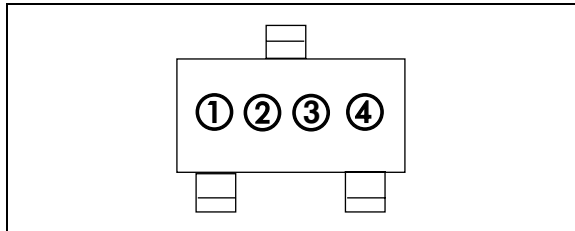
5.0 TYPICAL CHARACTERISTICS (CONTINUED)

9. RIPPLE REJECTION RATE



6.0 PACKAGING INFORMATION

6.1 Package Marking Information



① represents first integer of output voltage

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

② represents first decimal of output voltage

| Symbol | Voltage | Symbol | Voltage |
|--------|---------|--------|---------|
| A | .0 | F | .5 |
| B | .1 | H | .6 |
| C | .2 | K | .7 |
| D | .3 | L | .8 |
| E | .4 | M | .9 |

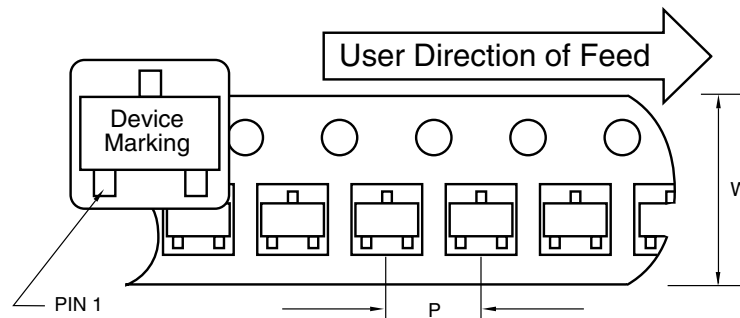
③ represents voltage polarity

| Symbol | Polarity |
|--------|----------|
| 5 | - |

④ represents assembly lot code

6.2 Taping Form

Component Taping Orientation for 3-Pin SOT-23A (EIAJ SC-59) Devices



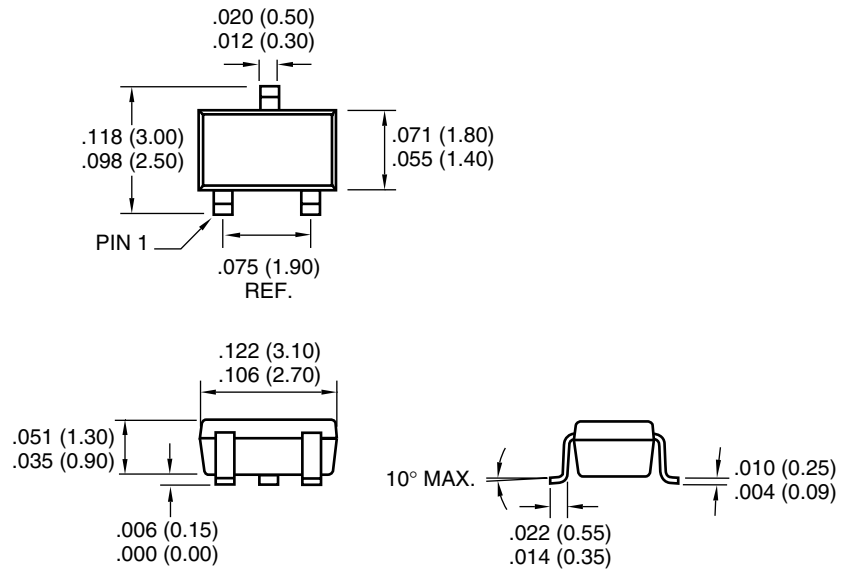
Standard Reel Component Orientation
for TR Suffix Device
(Mark Right Side Up)

Carrier Tape, Number of Components Per Reel and Reel Size

| Package | Carrier Width (W) | Pitch (P) | Part Per Full Reel | Reel Size |
|---------------|-------------------|-----------|--------------------|-----------|
| 3-Pin SOT-23A | 8 mm | 4 mm | 3000 | 7 in |

6.3 Package Dimensions

SOT-23A-3



Dimensions: inches (mm)

PRODUCT IDENTIFICATION SYSTEM

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

| | | | | | |
|-----------------------------|---------------------------------|-----------|-----------|------------|-----------|
| PART CODE | TC59 | 30 | 02 | ECB | XX |
| | TC59 | 50 | 02 | ECB | XX |
| Output Voltage: | _____ | | | | |
| | 50 = -5.0V; 30 = -3.0V | | | | |
| Tolerance: | _____ | | | | |
| | 02 = 2% | | | | |
| Temperature/Package: | _____ | | | | |
| | -40°C to +85°C 3-Pin SOT-23A | | | | |
| Taping Direction: | _____ | | | | |
| | TR: Standard Taping | | | | |

Sales and Support

Data Sheets

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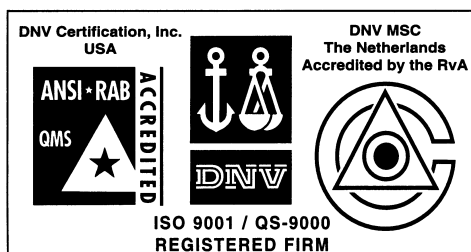
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San Jose

Microchip Technology Inc.
2107 North First Street, Suite 590
San Jose, CA 95131
Tel: 408-436-7950 Fax: 408-436-7955

Toronto

6285 Northam Drive, Suite 108
Mississauga, Ontario L4V 1X5, Canada
Tel: 905-673-0699 Fax: 905-673-6509

ASIA/PACIFIC

Australia

Microchip Technology Australia Pty Ltd
Suite 22, 41 Rawson Street
Epping 2121, NSW
Australia
Tel: 61-2-9868-6733 Fax: 61-2-9868-6755

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Microchip Technology Consulting (Shanghai)
Co., Ltd., Beijing Liaison Office
Unit 915
Bei Hai Wan Tai Bldg.
No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100 Fax: 86-10-85282104

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Far East International Plaza
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Rm. 1315, 13/F, Shenzhen Kerry Centre,
Renminnan Lu
Shenzhen 518001, China
Tel: 86-755-2350361 Fax: 86-755-2366086

China - Hong Kong SAR

Microchip Technology Hongkong Ltd.
Unit 901-6, Tower 2, Metroplaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2401-1200 Fax: 852-2401-3431

India

Microchip Technology Inc.
India Liaison Office
Divyasree Chambers
1 Floor, Wing A (A3/A4)
No. 11, O'Shaugnessey Road
Bangalore, 560 025, India
Tel: 91-80-2290061 Fax: 91-80-2290062

Japan

Microchip Technology Japan K.K.
Benex S-1 6F
3-18-20, Shinyokohama
Kohoku-Ku, Yokohama-shi
Kanagawa, 222-0033, Japan
Tel: 81-45-471-6166 Fax: 81-45-471-6122

Korea

Microchip Technology Korea
168-1, Youngbo Bldg. 3 Floor
Samsung-Dong, Kangnam-Ku
Seoul, Korea 135-882
Tel: 82-2-554-7200 Fax: 82-2-558-5934

Singapore

Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore, 188980
Tel: 65-6334-8870 Fax: 65-6334-8850

Taiwan

Microchip Technology Taiwan
11F-3, No. 207
Tung Hua North Road
Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

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Microchip Technology Nordic ApS
Regus Business Centre
Lautrup høj 1-3
Ballerup DK-2750 Denmark
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Microchip Technology SARL
Parc d'Activite du Moulin de Massy
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91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

Germany

Microchip Technology GmbH
Gustav-Heinemann Ring 125
D-81739 Munich, Germany
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Italy

Microchip Technology SRL
Centro Direzionale Colleoni
Palazzo Taurus 1 V. Le Colleoni 1
20041 Agrate Brianza
Milan, Italy
Tel: 39-039-65791-1 Fax: 39-039-6899883

United Kingdom

Microchip Ltd.
505 Eskdale Road
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