MICROCHIP

TC55

1 µA Low Dropout Positive Voltage Regulator

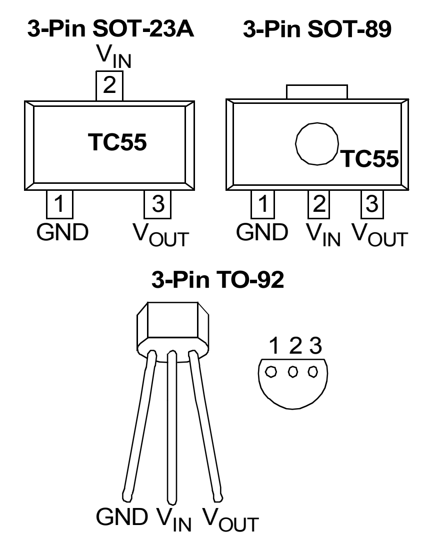
Features

- Very Low Dropout Voltage: 120 mV (typ) at 100 mA, 380 mV (typ) at 200 mA
- High Output Current: 250 mA (V_{OUT} = 5.0V)
- High Accuracy Output Voltage: ±2% (max) (±1% Semi-Custom Version)
- Low Power Consumption: 1.1 µA (typ)
- Low Temperature Drift: ±100 ppm/°C (typ)
- Excellent Line Regulation: 0.2%/V (typ)
- Package Options: 3-Pin SOT-23A, 3-Pin SOT-89 and 3-Pin TO-92
- Short Circuit Protection

Applications

- Battery Powered Devices
- Cameras and Portable Video Equipment
- Pagers and Cellular Phones
- Solar Powered Instruments
- Consumer Products

Package Types



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

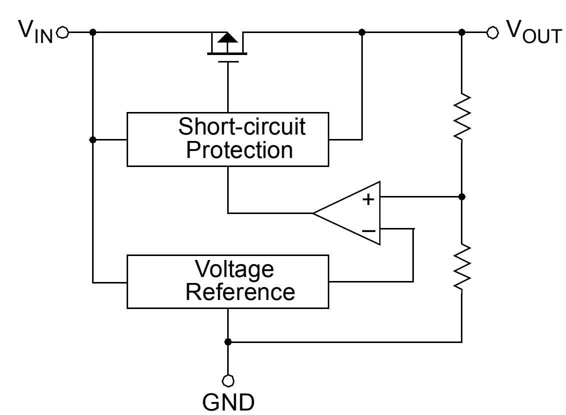
General Description

The TC55 Series is a collection of CMOS low dropout positive voltage regulators that can source up to 250 mA of current, with an extremely low input-output voltage differential of 380 mV (typ) at 200 mA.

The TC55's low dropout voltage, combined with the low current consumption of only 1.1 µA (typ), makes it ideal for battery operation. The low voltage differential (dropout voltage) extends the battery operating lifetime. It also permits high currents in small packages when operated with minimum V_{IN} – V_{OUT} differentials.

The circuit also incorporates short-circuit protection to ensure maximum reliability.

Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

Input Voltage ....+12V
Output Current .... $P_D/(V_{IN} – V_{OUT})$mA
Output Voltage ....(V_{SS} – 0.3V) to (V_{IN} + 0.3V)
Power Dissipation ($T_A \leq 70°C$):
3-Pin SOT-23A..240 mW
3-Pin SOT-89 ....400 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.

ELECTRICAL SPECIFICATIONS

TC55RP50:
Electrical Characteristics: Unless otherwise specified, $V_{OUT}(S)$ = 5.0V, T_A = 25°C (see **Note 1**).

Parameter	Sym	Min	Typ	Max	Units	Test Conditions
Output Voltage	$V_{OUT}(A)$	— 4.90	— 5.0	— 5.10	V	I_{OUT} = 40 mA V_{IN} = 6.0V
Maximum Output Current	I_{OUTMAX}	250	—	—	mA	V_{IN} = 6.0V, $V_{OUT}(A) \geq 4.5V$
Load Regulation	ΔV_{OUT}	—	40	80	mV	V_{IN} = 6.0V, 1 mA $\leq I_{OUT} \leq$ 100 mA
I/O Voltage Difference	V_{DIF}	— —	120 380	300 600	mV	I_{OUT} = 100 mA I_{OUT} = 200 mA
Current Consumption	I_{SS}	—	1.1	3.0	µA	V_{IN} = 6.0V
Voltage Regulation	$\frac{V_{OUT}(A)•100}{\Delta V_{IN}•V_{OUT}(S)}$	—	0.2	0.3	%/V	I_{OUT} = 40 mA 6.0V $\leq V_{IN} \leq$ 10.0V
Input Voltage	V_{IN}	—	—	10	V	
Temperature Coefficient of Output Voltage	$\frac{\Delta V_{OUT}(A)•10^6}{V_{OUT}(S)•\Delta T_A}$	—	±100	—	ppm/°C	I_{OUT} = 40 mA -40°C $\leq T_A \leq$ 85°C
Long Term Stability		—	0.5	—	%	T_A = 125°C, 1000 Hours

TC55RP40
Electrical Characteristics: Unless otherwise specified, $V_{OUT}(S)$ = 4.0V, T_A = 25°C (see **Note 1**).

Parameter	Symbol	Min	Typ	Max	Units	Test Conditions
Output Voltage	$V_{OUT}(A)$	— 3.92	— 4.0	— 4.08	V	I_{OUT} = 40 mA V_{IN} = 5.0V
Maximum Output Current	I_{OUTMAX}	200	—	—	mA	V_{IN} = 5.0V, $V_{OUT}(A) \geq 3.6V$
Load Regulation	ΔV_{OUT}	—	45	90	mV	V_{IN} = 5.0V, 1 mA $\leq I_{OUT} \leq$ 100 mA
I/O Voltage Difference	V_{DIF}	— —	170 400	330 630	mV	I_{OUT} = 100 mA I_{OUT} = 200 mA
Current Consumption	I_{SS}	—	1.0	2.9	µA	V_{IN} = 5.0V
Voltage Regulation	$\frac{\Delta V_{OUT}(A)•100}{\Delta V_{IN}•V_{OUT}(S)}$	—	0.2	0.3	%/V	I_{OUT} = 40 mA 5.0V $\leq V_{IN} \leq$ 10.0V
Input Voltage	V_{IN}	—	—	10.0	V	
Temperature Coefficient of Output Voltage	$\frac{\Delta V_{OUT}(A)}{V_{OUT}(S)•\Delta T_A}$	—	±100	—	ppm/°C	I_{OUT} = 40 mA -40°C $\leq T_A \leq$ 85°C
Long Term Stability		—	0.5	—	%	T_A = 125°C, 1000 Hours

Note 1: $V_{OUT}(S)$: Preset value of output voltage; $V_{OUT}(A)$: Actual value of output voltage; V_{DIF}: Definition of I/O voltage difference = {$V_{IN}1 – V_{OUT}(A)$}; $V_{OUT}(A)$: Output voltage when I_{OUT} is fixed and $V_{IN} = V_{OUT}(S)$ + 1.0 V; $V_{IN}1$: Input voltage when the output voltage is 98% $V_{OUT}(A)$.

ELECTRICAL SPECIFICATIONS (CONTINUED)

TC55RP30
Electrical Characteristics: Unless otherwise specified, $V_{OUT}(S) = 3.0V$, $T_A = 25°C$ (see **Note 1**).

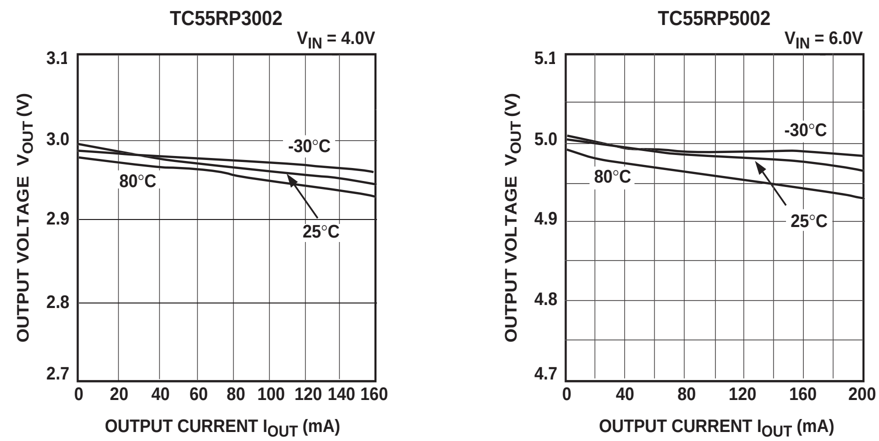
Parameter	Symbol	Min	Typ	Max	Units	Test Conditions
Output Voltage	$V_{OUT}(A)$	— 2.94	— 3.0	— 3.06	V	$I_{OUT} = 40$ mA $V_{IN} = 4.0V$
Maximum Output Current	I_{OUTMAX}	150	—	—	mA	$V_{IN} = 4.0V$, $V_{OUT}(A) \geq 2.7V$
Load Regulation	ΔV_{OUT}	—	45	90	mV	$V_{IN} = 4.0V$, $1\text{ mA} \leq I_{OUT} \leq 80\text{ mA}$
I/O Voltage Difference	V_{DIF}	— —	180 400	360 700	mV	$I_{OUT} = 80$ mA $I_{OUT} = 160$ mA
Current Consumption	I_{SS}	—	0.9	2.8	µA	$V_{IN} = 4.0V$
Voltage Regulation	$\frac{V_{OUT}(A) \bullet 100}{\Delta V_{IN} \bullet V_{OUT}(S)}$	—	0.2	0.3	%/V	$I_{OUT} = 40$ mA $4.0V \leq V_{IN} \leq 10.0V$
Input Voltage	V_{IN}	—	—	10.0	V	
Temperature Coefficient of Output Voltage	$\frac{\Delta V_{OUT}(A) \bullet 10^6}{\Delta T_A \bullet V_{OUT}(S)}$	—	±100	—	ppm/°C	$I_{OUT} = 40$ mA $-40°C \leq T_A \leq 85°C$
Long Term Stability		—	0.5	—	%	$T_A = 125°C$, 1000 Hours

Note 1: $V_{OUT}(S)$: Preset value of output voltage; $V_{OUT}(A)$: Actual value of output voltage; V_{DIF}: Definition of I/O voltage difference = $\{V_{IN}1 - V_{OUT}(A)\}$; $V_{OUT}(A)$: Output voltage when I_{OUT} is fixed and $V_{IN} = V_{OUT}(S) + 1.0$ V; $V_{IN}1$: Input voltage when the output voltage is 98% $V_{OUT}(A)$.

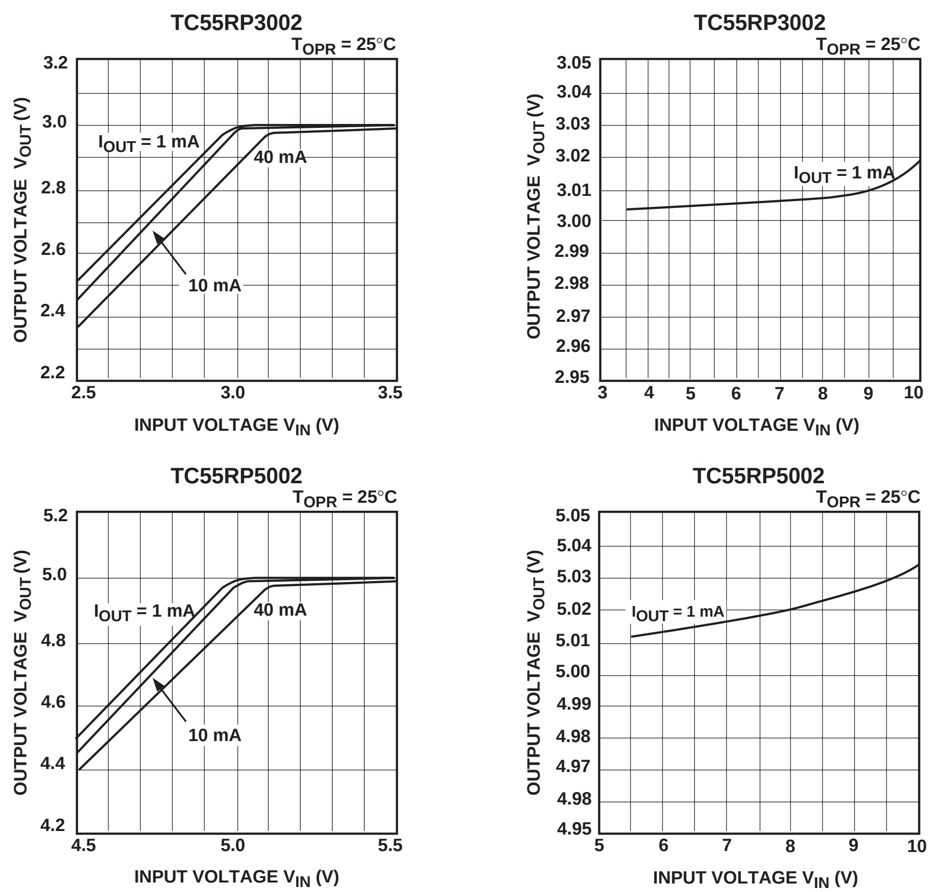
2.0 TYPICAL PERFORMANCE CURVES

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



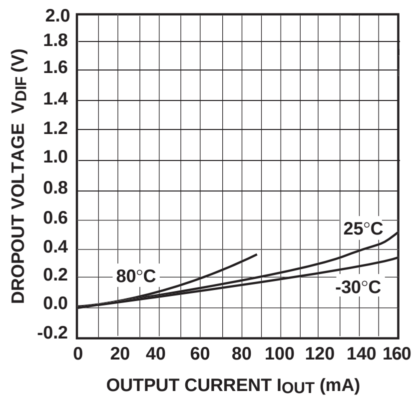
2. OUTPUT VOLTAGE vs. INPUT VOLTAGE



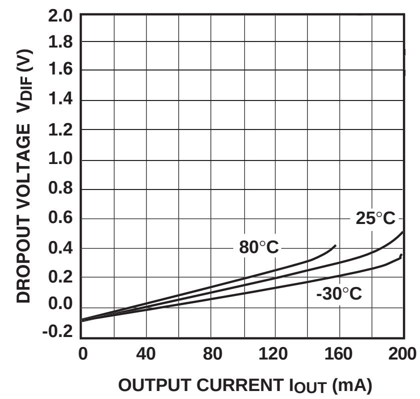
TYPICAL CHARACTERISTICS (CONTINUED)

3. DROPOUT VOLTAGE vs. OUTPUT CURRENT

TC55RP3002

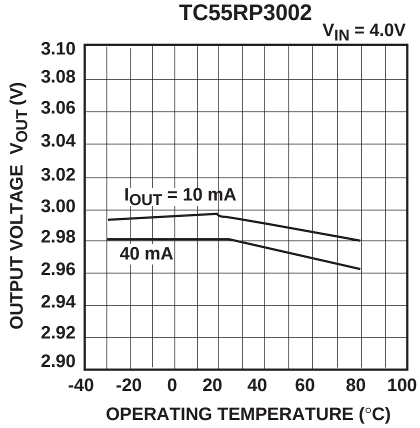


TC55RP5002

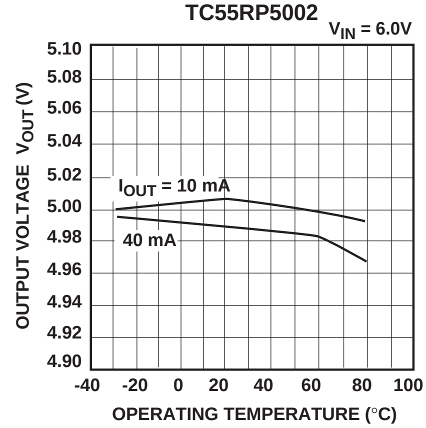


4. OUTPUT VOLTAGE vs. OPERATING TEMPERATURE

TC55RP3002

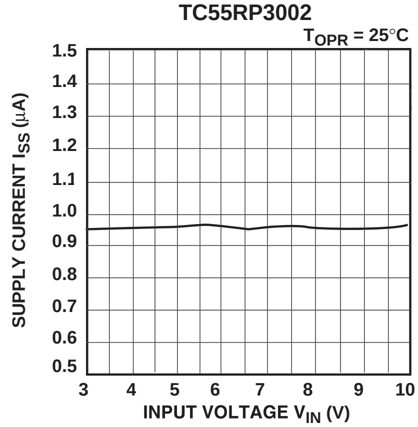


TC55RP5002

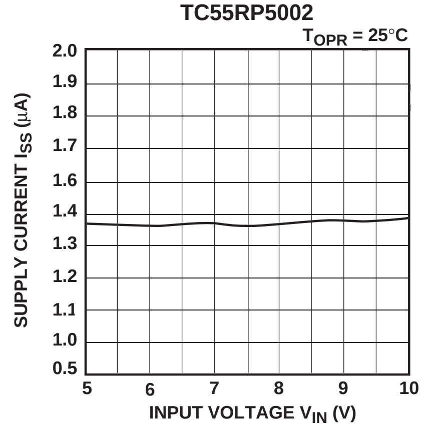


5. SUPPLY CURRENT vs. INPUT VOLTAGE

TC55RP3002

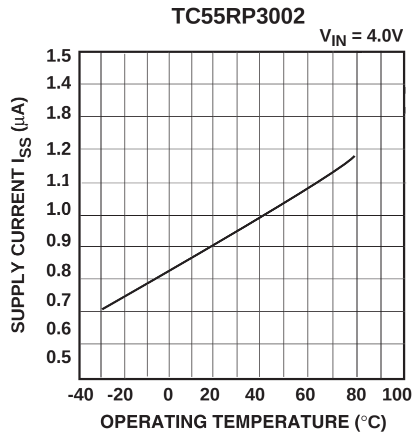


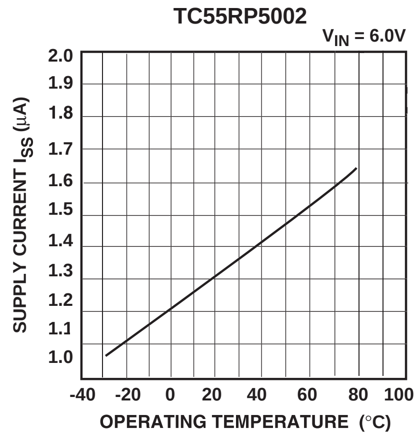
TC55RP5002



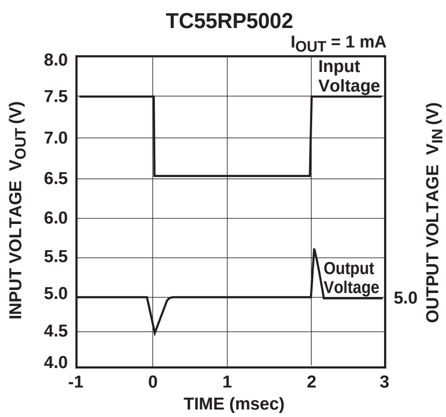
TYPICAL CHARACTERISTICS (CONTINUED)

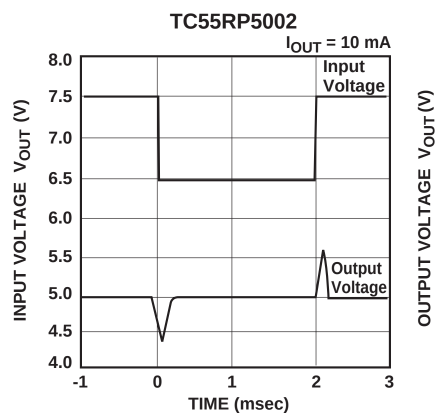
6. SUPPLY CURRENT vs. OPERATING TEMPERATURE



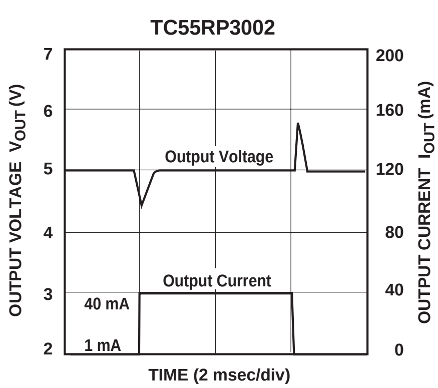


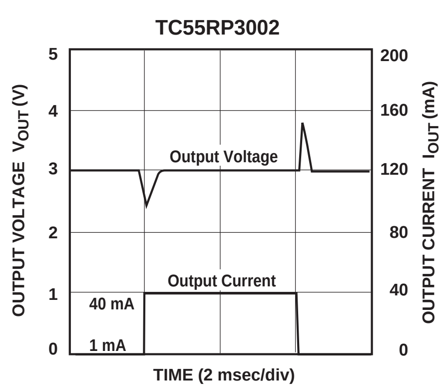
7. INPUT TRANSIENT RESPONSE





8. LOAD TRANSIENT RESPONSE





3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Pin No.	Symbol	Description
1	GND	Ground Terminal
2	V_{IN}	Unregulated Supply Input
3	V_{OUT}	Regulated Voltage Output

4.0 DETAILED DESCRIPTION

The TC55 is a low quiescent current, precision, fixed output voltage LDO. Unlike bipolar regulators, the TC55 supply current does not increase proportionally with load current.

4.1 Output Capacitor

A minimum of 1 µF output capacitor is required. The output capacitor should have an effective series resistance greater than 0.1Ω and less than 5Ω, plus a resonant frequency above 1 MHz. Larger output capacitors can be used to improve supply noise rejection and transient response. Care should be taken when increasing C_{OUT} to ensure that the input impedance is not high enough to cause high input impedance oscillation.

4.2 Input Capacitor

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

5.0 THERMAL CONSIDERATIONS

5.1 Power Dissipation

The amount of power dissipated internal to the low dropout 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 by multiplying the voltage across the linear device by the current through the device.

EQUATION

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

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 by the input voltage.

EQUATION

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

The total internal power dissipation is the sum of P_D (Pass Device) and P_D (Bias).

EQUATION

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

For the TC55, the internal quiescent bias current is so low (1 µA typical) that 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. The next step would be to multiply the maximum voltage differential by the maximum output current.

EQUATION

$$P_D = (V_{INMAX} - V_{OUTMIN}) \times I_{OUTMAX}$$

Given:

V_{IN} = 3.3V to 4.1V

V_{OUT} = 3.0 V ± 2%

I_{OUT} = 1 mA to 100 mA

T_{AMAX} = 55°C

P_{MAX} = (4.1V – (3.0V x 0.98)) x 100 mA

P_{MAX} = 116.0 milliwatts

To determine the junction temperature of the device, the thermal resistance from junction to air must be known. The 3-pin SOT-23 thermal resistance from junction to air ($R_{\theta JA}$) is estimated to be approximately 359°C/W when mounted on a 4-layer board. The SOT-89 $R_{\theta JA}$ is estimated to be approximately 110°C/W when mounted on 1 square inch of copper. The TO-92 $R_{\theta JA}$ is estimated to be 131.9°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

Junction Temperature

SOT-23 Example:

$T_J = P_{DMAX} \times R_{\theta JA} + T_A$

T_J = 116.0 milliwatts x 359°C/W + 55°C

T_J = 96.6°C

SOT-89 Example:

T_J = 116.0 milliwatts x 110°C/W + 55°C

T_J = 67.8°C

TO-92 Example:

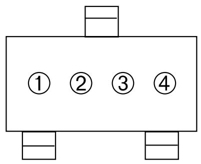
T_J = 116.0 milliwatts x 131.9°C/W + 55°C

T_J = 70.3°C

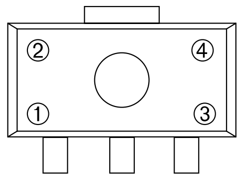
6.0 PACKAGING INFORMATION

6.1 Package Marking Information

3-Pin SOT-23A



3-Pin SOT-89



① represents first voltage digit
2 3 4 5 6
ex: 3.xV = ③○○○

② represents first decimal place voltage (x.0 - x.9)

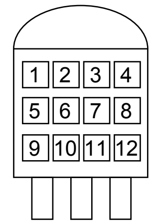
A = x.0	E = x.4	L = x.8
B = x.1	F = x.5	M = x.9
C = x.2	H = x.6	
D = x.3	K = x.7	

ex: 3.4V = ③Ⓔ○○

③ represents polarity
0 = Positive (fixed)

④ represents assembly lot number

3-Pin TO-92



①, ②, ③ & ④ = 55RP (fixed)

⑤ represents first voltage digit (2-6)

⑥ represents first voltage decimal (0-9)

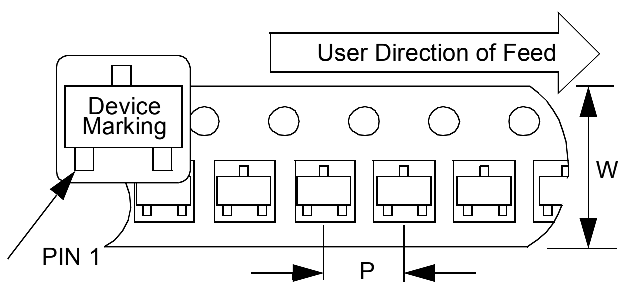
⑦ represents extra feature code: fixed: 0

⑧ represents regulation accuracy
1 = ±1.0% (custom), 2 = ±2.0% (standard)

⑨, ⑩, ⑪ & ⑫ represents assembly lot number

6.2 Taping Form

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



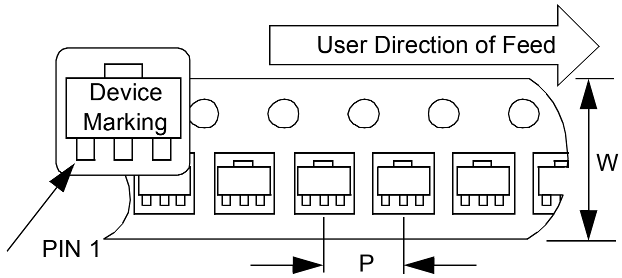
Standard Reel Component Orientation
For TR Suffix Device
(Mark Right Side Up)

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.

6.2 Taping Form (Continued)

Component Taping Orientation for 3-Pin SOT-89 Devices

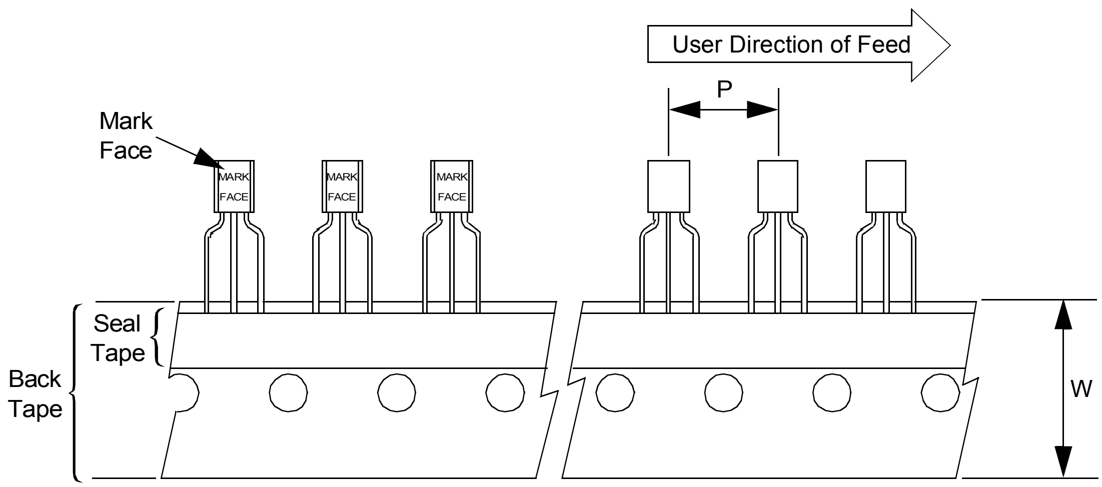


Standard Reel Component Orientation
For TR Suffix Device
(Mark Right Side Up)

Carrier Tape, Number of Components Per Reel and Reel Size:

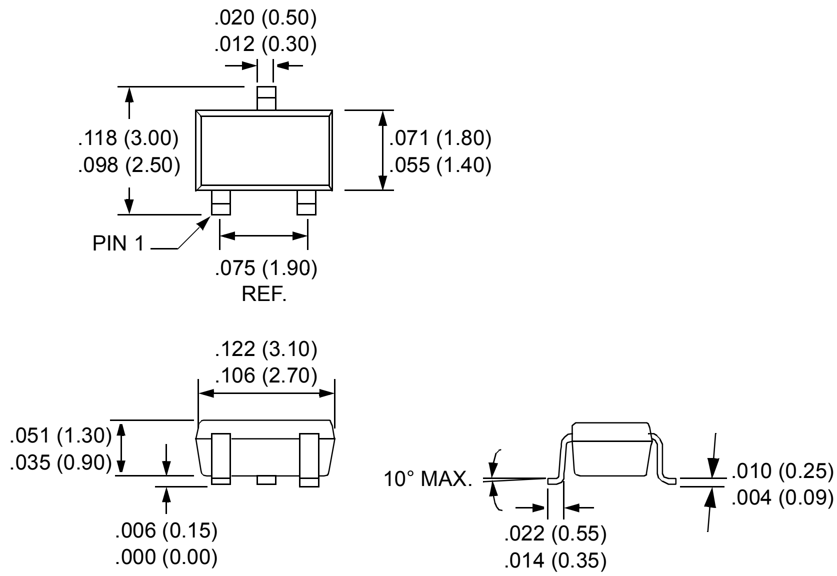
Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
3-Pin SOT-89	12 mm	8 mm	1000	7 in.

Component Taping Orientation for 3-Pin TO-92



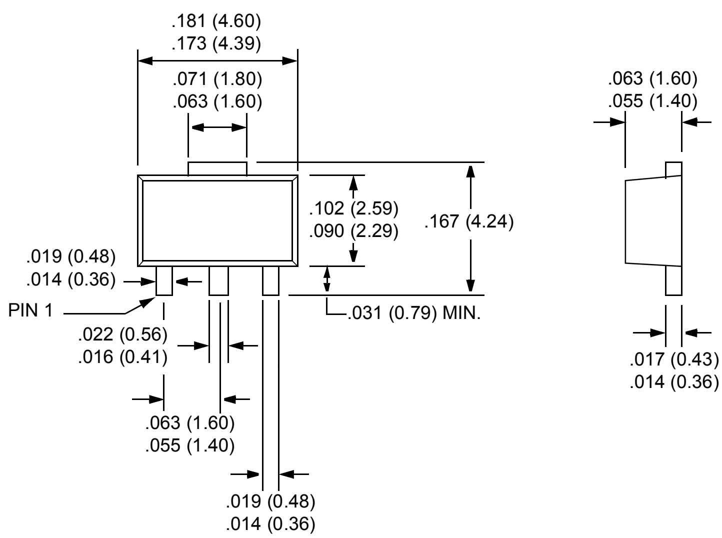
6.3 Package Dimensions

SOT-23A-3



Dimensions: inches (mm)

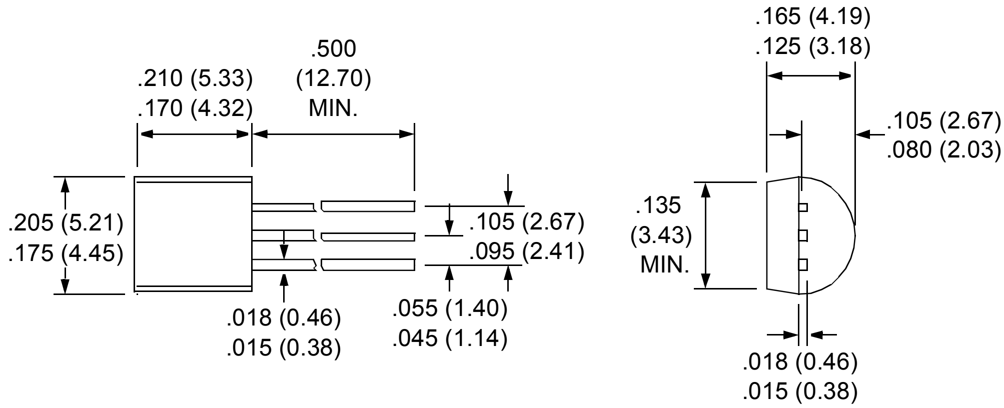
SOT-89-3



Dimensions: inches (mm)

6.3 Package Dimensions (Continued)

TO-92-3



Dimensions: inches (mm)

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7. How would you improve this document?

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.	XX	X	X	X	XX	XX
Device	Output Voltage	Feature Code	Tolerance	Temp.	Package	Taping Direction

Device:	TC55:	1 µA Low Dropout Positive Voltage Regulator
Output Voltage:	18 = 1.8V "Standard" 25 = 2.5V "Standard" 30 = 3.0V "Standard" 33 = 3.3V "Standard" 50 = 5.0V "Standard"	
Extra Feature Code:	0 = Fixed	
Tolerance:	1 = 1.0% (Custom) 2 = 2.0% (Standard)	
Temperature:	I = -40°C to +85°C	
Package Type:	CB = 3-Pin SOT-23A (equivalent to EIAJ SC-59) MB = 3-Pin SOT-89 ZB = 3-Pin TO-92	
Taping Direction:	TR = Standard 713 = Standard	

Examples:

a) TC55RP1802ECB713: 1.8V LDO Positive Voltage Regulator, 2% Tol. SOT23-A-3 package.
b) TC55RP2502EMB713: 1.8V LDO Positive Voltage Regulator, 2% Tolerance. SOT89-3 package.
c) TC55RP2502ECB713: 2.5V LDO Positive Voltage Regulator, 2% Tolerance. SOT23-A-3 package.
d) TC55RP3002ECB713: 3.0V LDO Positive Voltage Regulator, 2% Tolerance. SOT23-A-3 package.
e) TC55RP3002EMB713: 3.0V LDO Positive Voltage Regulator, 2% Tolerance. SOT89-3 package.
f) TC55RP3302ECB713: 3.3V LDO Positive Voltage Regulator, 2% Tolerance. SOT23-A-3 package.
g) TC55RP3302EMB713: 3.3V LDO Positive Voltage Regulator, 2% Tolerance. SOT89-3 package.
h) TC55RP5002ECB713: 5.0V LDO Positive Voltage Regulator, 2% Tolerance. SOT23-A-3 package.
i) TC55RP5002EMB713: 5.0V LDO Positive Voltage Regulator, 2% Tolerance. SOT89-3 package.

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