

## 50 mA, 100 mA and 150 mA CMOS LDOs with Shutdown and ERROR Output

### Features

- Low Ground Current for Longer Battery Life
- Low Dropout Voltage
- Choice of 50 mA (TC1054), 100 mA (TC1055) and 150 mA (TC1186) Output
- High Output Voltage Accuracy
- Standard or Custom Output Voltages:
  - 1.8V, 2.5V, 2.6V, 2.7V, 2.8V, 2.85V, 3.0V, 3.3V, 3.6V, 4.0V, 5.0V
- Power-Saving Shutdown Mode
- ERROR Output Can Be Used as a Low-Battery Detector or Microcontroller-Reset Generator
- Overcurrent and Overtemperature Protection
- 5-Pin SOT-23 Package
- Pin-Compatible Upgrades for Bipolar Regulators

### Applications

- Battery Operated Systems
- Portable Computers
- Medical Instruments
- Instrumentation
- Cellular/GSM/PHS Phones
- Linear Post-Regulators for SMPS
- Pagers

### Typical Application



### General Description

The TC1054, TC1055 and TC1186 are high accuracy (typically  $\pm 0.5\%$ ) CMOS upgrades for older (bipolar) low dropout regulators. Designed specifically for battery-operated systems, the devices' CMOS construction minimizes ground current, extending battery life. Total supply current is typically  $50 \mu\text{A}$  at full load (20 to 60 times lower than in bipolar regulators).

The devices' key features include low noise operation, low dropout voltage – typically  $85 \text{ mV}$  (TC1054),  $180 \text{ mV}$  (TC1055) and  $270 \text{ mV}$  (TC1186) at full load — and fast response to step changes in load. An error output (ERROR) is asserted when the devices are out-of-regulation (due to a low input voltage or excessive output current). ERROR can be used as a low battery warning or as a processor RESET signal (with the addition of an external RC network). Supply current is reduced to  $0.5 \mu\text{A}$  (maximum), with both  $V_{\text{OUT}}$  and ERROR disabled when the shutdown input is low. The devices incorporate both overtemperature and over-current protection.

The TC1054, TC1055 and TC1186 are stable with an output capacitor of only  $1 \mu\text{F}$ , and have a maximum output current of 50 mA, 100 mA and 150 mA, respectively. For higher output current regulators, please refer to the TC1173 ( $I_{\text{OUT}} = 300 \text{ mA}$ ) data sheet (DS21632).

### Package Type



# TC1054/TC1055/TC1186

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

|   |                                      |
|---|--------------------------------------|
| Input Voltage .....                     | 6.75V                                |
| Output Voltage .....                    | (-0.3V) to (V <sub>IN</sub> + 0.3V)  |
| Power Dissipation .....                 | Internally Limited ( <b>Note 6</b> ) |
| Maximum Voltage on Any Pin .....        | V <sub>IN</sub> + 0.3V to -0.3V      |
| Operating Junction Temperature Range .. | -40°C < T <sub>J</sub> < +125°C      |
| Storage Temperature.....                | -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, V<sub>IN</sub> = V<sub>OUT</sub> + 1V, I<sub>L</sub> = 100 μA, C<sub>L</sub> = 3.3 μF, SHDN > V<sub>IH</sub>, T<sub>A</sub> = +25°C. **Boldface** type specifications apply for junction temperatures of -40°C to +125°C.

| Parameters                               | Sym                                 | Min                         | Typ                  | Max                         | Units  | Conditions   |
|--|-------------------------------------|-----------------------------|----------------------|-----------------------------|--------|--|
| Input Operating Voltage                  | V <sub>IN</sub>                     | <b>2.7</b>                  | —                    | <b>6.50</b>                 | V      | <a href="#">Note 8</a>   |
| Maximum Output Current                   | I <sub>OUTMAX</sub>                 | <b>50</b>                   | —                    | —                           | mA     | <b>TC1054</b>  |
|  |                                     | <b>100</b>                  | —                    | —                           |        | <b>TC1055</b>  |
|  |                                     | <b>150</b>                  | —                    | —                           |        | <b>TC1186</b>  |
| Output Voltage                           | V <sub>OUT</sub>                    | <b>V<sub>R</sub> - 2.5%</b> | V <sub>R</sub> ±0.5% | <b>V<sub>R</sub> + 2.5%</b> | V      | <a href="#">Note 1</a>   |
| V <sub>OUT</sub> Temperature Coefficient | TCV <sub>OUT</sub>                  | —                           | 20                   | —                           | ppm/°C | <a href="#">Note 2</a>   |
|  |                                     | —                           | <b>40</b>            | —                           |        |  |
| Line Regulation                          | ΔV <sub>OUT</sub> /ΔV <sub>IN</sub> | —                           | 0.05                 | <b>0.35</b>                 | %      | (V <sub>R</sub> + 1V) ≤ V <sub>IN</sub> ≤ 6V                               |
| <b>Load Regulation</b>                   |                                     |                             |                      |                             |        |  |
| <b>TC1054; TC1055</b>                    | ΔV <sub>OUT</sub> /V <sub>OUT</sub> | —                           | 0.5                  | <b>2</b>                    | %      | <a href="#">(Note 3)</a><br>I <sub>L</sub> = 0.1 mA to I <sub>OUTMAX</sub> |
| <b>TC1186</b>                            |                                     | —                           | 0.5                  | <b>3</b>                    |        |  |

- Note 1:** V<sub>R</sub> is the regulator output voltage setting. For example: V<sub>R</sub> = 1.8V, 2.5V, 2.7V, 2.85V, 3.0V, 3.3V, 3.6V, 4.0V, 5.0V.
- 2:**  $TC V_{OUT} = \frac{(V_{OUTMAX} - V_{OUTMIN}) \times 10^6}{V_{OUT} \times \Delta T}$
- 3:** Regulation is measured at a constant junction temperature using low-duty-cycle pulse testing. Load regulation is tested over a load range from 0.1 mA to the maximum specified output current. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
- 4:** Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its nominal value.
- 5:** Thermal Regulation is defined as the change in output voltage at a time T after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a current pulse equal to I<sub>LMAX</sub> at V<sub>IN</sub> = 6V for T = 10 ms.
- 6:** The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction-to-air (i.e., T<sub>A</sub>, T<sub>J</sub>, θ<sub>JA</sub>). Exceeding the maximum allowable power dissipation causes the device to initiate thermal shutdown. See **Section 5.0 "Thermal Considerations"** for more details.
- 7:** Hysteresis voltage is referenced by V<sub>R</sub>.
- 8:** The minimum V<sub>IN</sub> has to justify the conditions: V<sub>IN</sub> ≥ V<sub>R</sub> + V<sub>DROPOUT</sub> and V<sub>IN</sub> ≥ 2.7V for I<sub>L</sub> = 0.1 mA to I<sub>OUTMAX</sub>.
- 9:** Apply for junction temperatures of -40°C to +85°C.

# TC1054/TC1055/TC1186

## DC CHARACTERISTICS (CONTINUED)

**Electrical Specifications:** Unless otherwise noted,  $V_{IN} = V_{OUT} + 1V$ ,  $I_L = 100 \mu A$ ,  $C_L = 3.3 \mu F$ ,  $\overline{SHDN} > V_{IH}$ ,  $T_A = +25^\circ C$ . **Boldface** type specifications apply for junction temperatures of  $-40^\circ C$  to  $+125^\circ C$ .

| Parameters                            | Sym                         | Min | Typ               | Max        | Units           | Conditions  |
|---------------------------------------|-----------------------------|-----|-------------------|------------|-----------------|---|
| Dropout Voltage                       | $V_{IN} - V_{OUT}$          | —   | 2                 | —          | mV              | $I_L = 100 \mu A$   |
|                                       |                             | —   | 65                | —          |                 | $I_L = 20 mA$   |
|                                       |                             | —   | 85                | <b>120</b> |                 | $I_L = 50 mA$   |
|                                       |                             | —   | 180               | <b>250</b> |                 | $I_L = 100 mA$  |
|                                       |                             | —   | 270               | <b>400</b> |                 | $I_L = 150 mA$ ( <b>Note 4</b> )                                  |
| <b>TC1055; TC1186</b>                 |                             |     |                   |            |                 |   |
| <b>TC1186</b>                         |                             |     |                   |            |                 |   |
| Supply Current                        | $I_{IN}$                    | —   | 50                | <b>80</b>  | $\mu A$         | $\overline{SHDN} = V_{IH}$ ,<br>$I_L = 0 \mu A$ ( <b>Note 9</b> ) |
| Shutdown Supply Current               | $I_{INSD}$                  | —   | 0.05              | 0.5        | $\mu A$         | $\overline{SHDN} = 0V$  |
| Power Supply Rejection Ratio          | PSRR                        | —   | 64                | —          | dB              | $f \leq 1 kHz$  |
| Output Short Circuit Current          | $I_{OUTSC}$                 | —   | 300               | 450        | mA              | $V_{OUT} = 0V$  |
| Thermal Regulation                    | $\Delta V_{OUT}/\Delta P_D$ | —   | 0.04              | —          | V/W             | <b>Notes 5, 6</b>   |
| Thermal Shutdown Die Temperature      | $T_{SD}$                    | —   | 160               | —          | $^\circ C$      |   |
| Thermal Shutdown Hysteresis           | $\Delta T_{SD}$             | —   | 10                | —          | $^\circ C$      |   |
| Output Noise                          | eN                          | —   | 260               | —          | nV/ $\sqrt{Hz}$ | $I_L = I_{OUTMAX}$  |
| <b>SHDN Input</b>                     |                             |     |                   |            |                 |   |
| SHDN Input High Threshold             | $V_{IH}$                    | 45  | —                 | —          | $\%V_{IN}$      | $V_{IN} = 2.5V$ to $6.5V$   |
| SHDN Input Low Threshold              | $V_{IL}$                    | —   | —                 | 15         | $\%V_{IN}$      | $V_{IN} = 2.5V$ to $6.5V$   |
| <b>ERROR Output</b>                   |                             |     |                   |            |                 |   |
| Minimum $V_{IN}$ Operating Voltage    | $V_{INMIN}$                 | 1.0 | —                 | —          | V               |   |
| Output Logic Low Voltage              | $V_{OL}$                    | —   | —                 | 400        | mV              | 1 mA Flows to $\overline{ERROR}$                                  |
| ERROR Threshold Voltage               | $V_{TH}$                    | —   | $0.95 \times V_R$ | —          | V               | See <b>Figure 4-2</b>   |
| ERROR Positive Hysteresis             | $V_{HYS}$                   | —   | 50                | —          | mV              | <b>Note 7</b>   |
| $V_{OUT}$ to $\overline{ERROR}$ Delay | $t_{DELAY}$                 | —   | 2.5               | —          | ms              | $V_{OUT}$ falling from $V_R$ to $V_R - 10\%$                      |

**Note 1:**  $V_R$  is the regulator output voltage setting. For example:  $V_R = 1.8V, 2.5V, 2.7V, 2.85V, 3.0V, 3.3V, 3.6V, 4.0V, 5.0V$ .

**2:**  $TC V_{OUT} = \frac{(V_{OUTMAX} - V_{OUTMIN}) \times 10^6}{V_{OUT} \times \Delta T}$

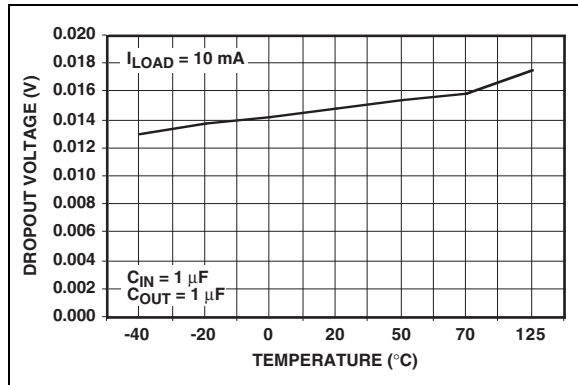
- Regulation is measured at a constant junction temperature using low-duty-cycle pulse testing. Load regulation is tested over a load range from 0.1 mA to the maximum specified output current. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
- Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its nominal value.
- Thermal Regulation is defined as the change in output voltage at a time T after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a current pulse equal to  $I_{LMAX}$  at  $V_{IN} = 6V$  for  $T = 10 ms$ .
- The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction-to-air (i.e.,  $T_A, T_J, \theta_{JA}$ ). Exceeding the maximum allowable power dissipation causes the device to initiate thermal shutdown. See **Section 5.0 "Thermal Considerations"** for more details.
- Hysteresis voltage is referenced by  $V_R$ .
- The minimum  $V_{IN}$  has to justify the conditions:  $V_{IN} \geq V_R + V_{DROPOUT}$  and  $V_{IN} \geq 2.7V$  for  $I_L = 0.1 mA$  to  $I_{OUTMAX}$ .
- Apply for junction temperatures of  $-40^\circ C$  to  $+85^\circ C$ .

# TC1054/TC1055/TC1186

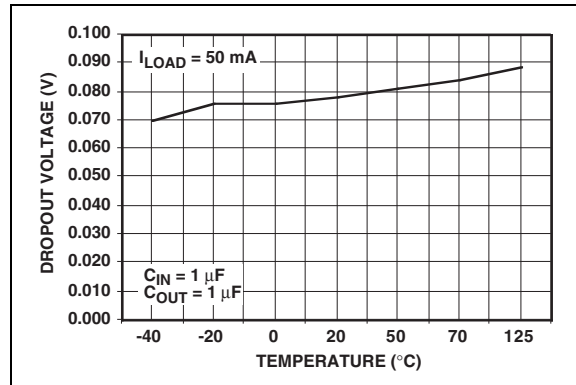
## 2.0 TYPICAL PERFORMANCE CURVES

**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.

**Note:** Unless otherwise indicated,  $V_{IN} = V_{OUT} + 1V$ ,  $I_L = 100 \mu A$ ,  $C_L = 3.3 \mu F$ ,  $\overline{SHDN} > V_{IH}$ ,  $T_A = +25^\circ C$ .



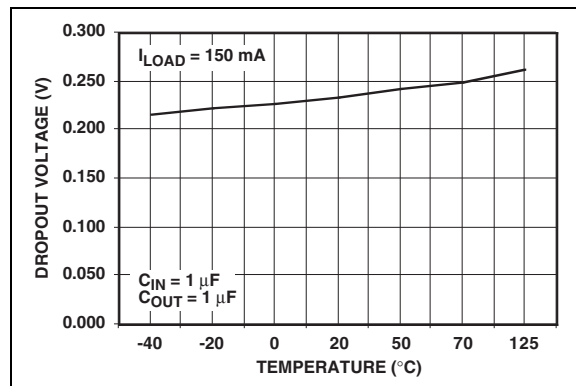
**FIGURE 2-1:** Dropout Voltage vs. Temperature ( $I_{LOAD} = 10 \text{ mA}$ ).



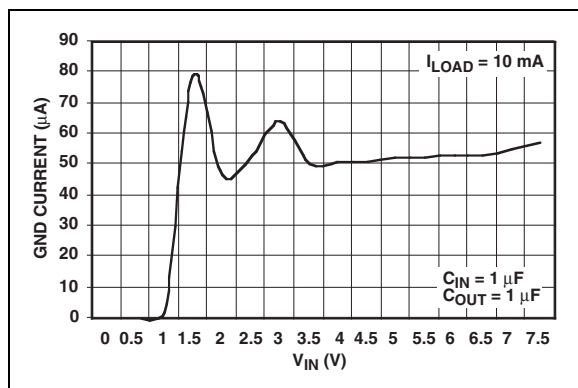
**FIGURE 2-4:** Dropout Voltage vs. Temperature ( $I_{LOAD} = 50 \text{ mA}$ ).



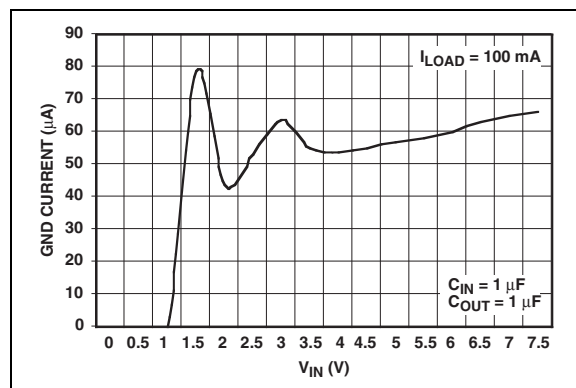
**FIGURE 2-2:** Dropout Voltage vs. Temperature ( $I_{LOAD} = 100 \text{ mA}$ ).



**FIGURE 2-5:** Dropout Voltage vs. Temperature ( $I_{LOAD} = 150 \text{ mA}$ ).



**FIGURE 2-3:** Ground Current vs.  $V_{IN}$  ( $I_{LOAD} = 10 \text{ mA}$ ).



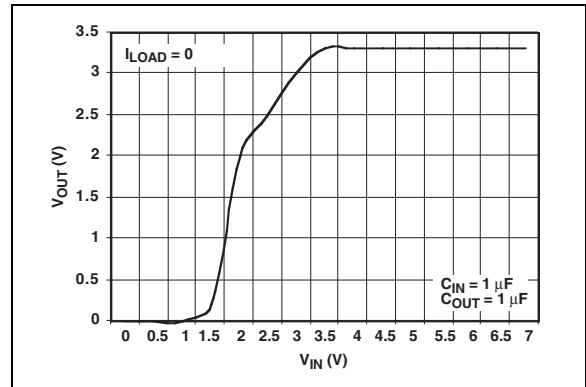
**FIGURE 2-6:** Ground Current vs.  $V_{IN}$  ( $I_{LOAD} = 100 \text{ mA}$ ).

# TC1054/TC1055/TC1186

**Note:** Unless otherwise indicated,  $V_{IN} = V_{OUT} + 1V$ ,  $I_L = 100 \mu A$ ,  $C_L = 3.3 \mu F$ ,  $\overline{SHDN} > V_{IH}$ ,  $T_A = +25^\circ C$ .



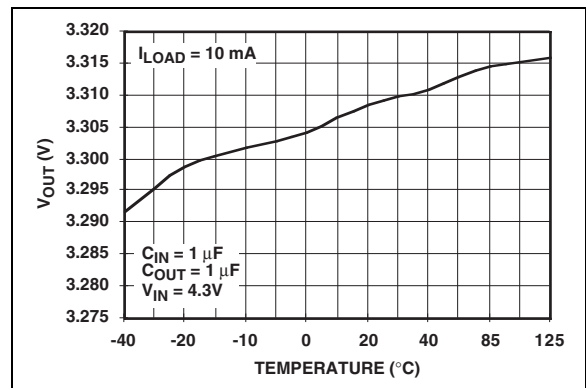
**FIGURE 2-7:** Ground Current vs.  $V_{IN}$   
( $I_{LOAD} = 150 mA$ ).



**FIGURE 2-10:**  $V_{OUT}$  vs.  $V_{IN}$   
( $I_{LOAD} = 0 mA$ ).



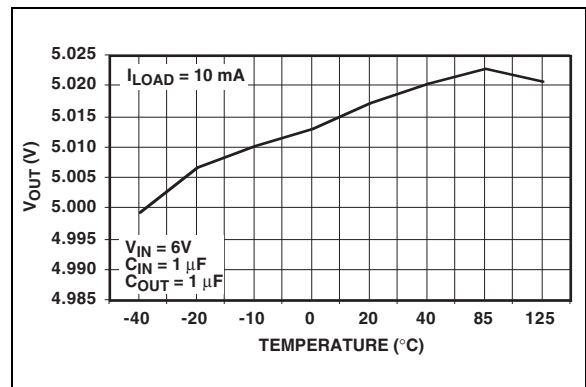
**FIGURE 2-8:**  $V_{OUT}$  vs.  $V_{IN}$   
( $I_{LOAD} = 100 mA$ ).



**FIGURE 2-11:** Output Voltage (3.3V) vs. Temperature ( $I_{LOAD} = 10 mA$ ).



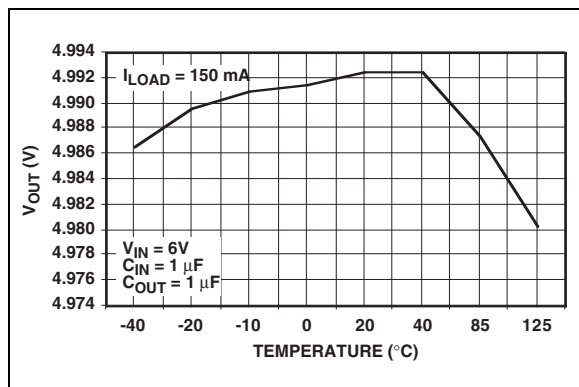
**FIGURE 2-9:**  $V_{OUT}$  vs.  $V_{IN}$   
( $I_{LOAD} = 150 mA$ ).



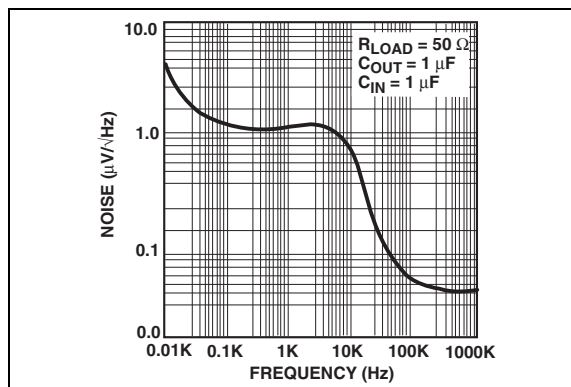
**FIGURE 2-12:** Output Voltage (5V) vs. Temperature ( $I_{LOAD} = 10 mA$ ).

# TC1054/TC1055/TC1186

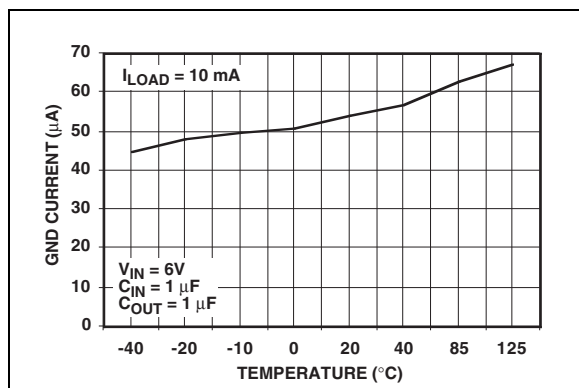
**Note:** Unless otherwise indicated,  $V_{IN} = V_{OUT} + 1V$ ,  $I_L = 100 \mu A$ ,  $C_L = 3.3 \mu F$ ,  $\overline{SHDN} > V_{IH}$ ,  $T_A = +25^\circ C$ .



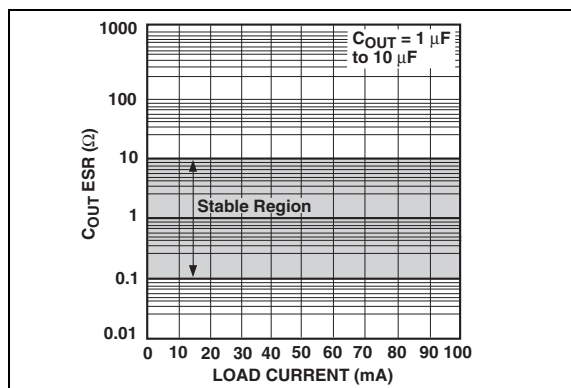
**FIGURE 2-13:** Output Voltage (5V) vs. Temperature ( $I_{LOAD} = 10 \text{ mA}$ ).



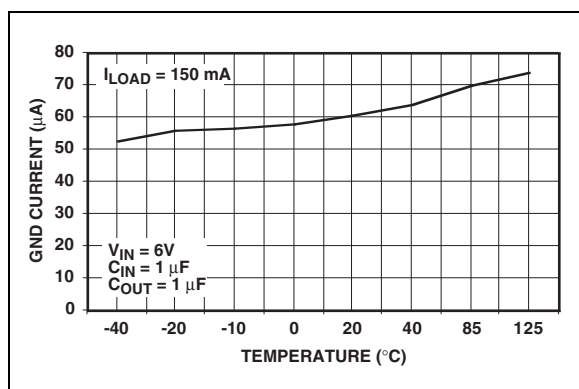
**FIGURE 2-16:** Output Noise vs. Frequency.



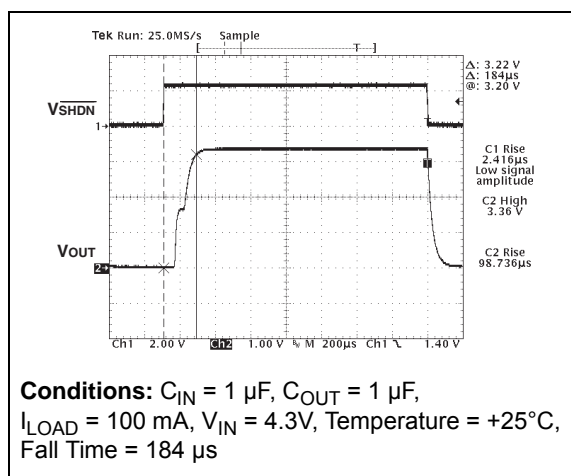
**FIGURE 2-14:** GND Current vs. Temperature ( $I_{LOAD} = 10 \text{ mA}$ ).



**FIGURE 2-17:** Stability Region vs. Load Current.



**FIGURE 2-15:** GND Current vs. Temperature ( $I_{LOAD} = 150 \text{ mA}$ ).



**FIGURE 2-18:** Measure Rise Time of 3.3V LDO.

# TC1054/TC1055/TC1186

**Note:** Unless otherwise indicated,  $V_{IN} = V_{OUT} + 1V$ ,  $I_L = 100 \mu A$ ,  $C_L = 3.3 \mu F$ ,  $\overline{SHDN} > V_{IH}$ ,  $T_A = +25^\circ C$ .



**Conditions:**  $C_{IN} = 1 \mu F$ ,  $C_{OUT} = 1 \mu F$ ,  
 $I_{LOAD} = 100 \text{ mA}$ ,  $V_{IN} = 6V$ , Temperature =  $+25^\circ C$ ,  
 Fall Time =  $192 \mu s$

**FIGURE 2-19:** Measure Rise Time of 5.0V LDO.



**Conditions:**  $C_{IN} = 1 \mu F$ ,  $C_{OUT} = 1 \mu F$ ,  
 $I_{LOAD} = 100 \text{ mA}$ ,  $V_{IN} = 4.3V$ , Temperature =  $+25^\circ C$ ,  
 Fall Time =  $52 \mu s$

**FIGURE 2-21:** Measure Fall Time of 3.3V LDO.



**Conditions:**  $V_{IN} = 6V$ ,  $C_{IN} = 0 \mu F$ ,  $C_{OUT} = 1 \mu F$

$I_{LOAD}$  was increased until temperature of die reached about  $+160^\circ C$ , at which time integrated thermal protection circuitry shuts the regulator off when die temperature exceeds approximately  $+160^\circ C$ . The regulator remains off until die temperature drops to approximately  $+150^\circ C$ .

**FIGURE 2-20:** Thermal Shutdown Response of 5.0V LDO.



**Conditions:**  $C_{IN} = 1 \mu F$ ,  $C_{OUT} = 1 \mu F$ ,  
 $I_{LOAD} = 100 \text{ mA}$ ,  $V_{IN} = 6V$ , Temperature =  $+25^\circ C$ ,  
 Fall Time =  $88 \mu s$

**FIGURE 2-22:** Measure Fall Time of 5.0V LDO.

# TC1054/TC1055/TC1186

## 3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in [Table 3-1](#).

**TABLE 3-1: PIN FUNCTION TABLE**

| Pin No.<br>SOT-23 | Symbol                    | Description                                |
|-------------------|---------------------------|--|
| 1                 | $V_{IN}$                  | Unregulated supply input                   |
| 2                 | GND                       | Ground terminal                            |
| 3                 | $\overline{\text{SHDN}}$  | Shutdown control input                     |
| 4                 | $\overline{\text{ERROR}}$ | Out-of-Regulation Flag (Open-drain output) |
| 5                 | $V_{OUT}$                 | Regulated voltage output                   |

### 3.1 Unregulated Supply Input ( $V_{IN}$ )

Connect unregulated input supply to the  $V_{IN}$  pin. If there is a large distance between the input supply and the LDO regulator, some input capacitance is necessary for proper operation. A 1  $\mu\text{F}$  capacitor connected from  $V_{IN}$  to ground is recommended for most applications.

### 3.2 Ground Terminal (GND)

Connect the unregulated input supply ground return to GND. Also connect the negative side of the 1  $\mu\text{F}$  typical input decoupling capacitor close to GND and the negative side of the output capacitor  $C_{OUT}$  to GND.

### 3.3 Shutdown Control Input ( $\overline{\text{SHDN}}$ )

The regulator is fully enabled when a logic-high is applied to  $\overline{\text{SHDN}}$ . The regulator enters shutdown when a logic-low is applied to  $\overline{\text{SHDN}}$ . During shutdown, output voltage falls to zero,  $\overline{\text{ERROR}}$  is open-circuited and supply current is reduced to 0.5  $\mu\text{A}$  (maximum).

### 3.4 Out Of Regulation Flag ( $\overline{\text{ERROR}}$ )

$\overline{\text{ERROR}}$  goes low when  $V_{OUT}$  is out-of-tolerance by approximately -5%.

### 3.5 Regulated Voltage Output ( $V_{OUT}$ )

Connect the output load to  $V_{OUT}$  of the LDO. Also connect the positive side of the LDO output capacitor as close as possible to the  $V_{OUT}$  pin.



## 4.0 DETAILED DESCRIPTION

The TC1054, TC1055 and TC1186 are precision fixed output voltage regulators (If an adjustable version is desired, please see the TC1070/TC1071/TC1187 data sheet (DS21353)). Unlike bipolar regulators, the TC1054, TC1055 and TC1186 supply current does not increase with load current.

Figure 4-1 shows a typical application circuit, where the regulator is enabled any time the shutdown input (SHDN) is at or above  $V_{IH}$ , and shutdown (disabled) when SHDN is at or below  $V_{IL}$ . SHDN may be controlled by a CMOS logic gate or I/O port of a microcontroller. If the SHDN input is not required, it should be connected directly to the input supply. While in Shutdown, supply current decreases to 0.05  $\mu$ A (typical),  $V_{OUT}$  falls to zero volts, and  $\overline{ERROR}$  is open-circuited.

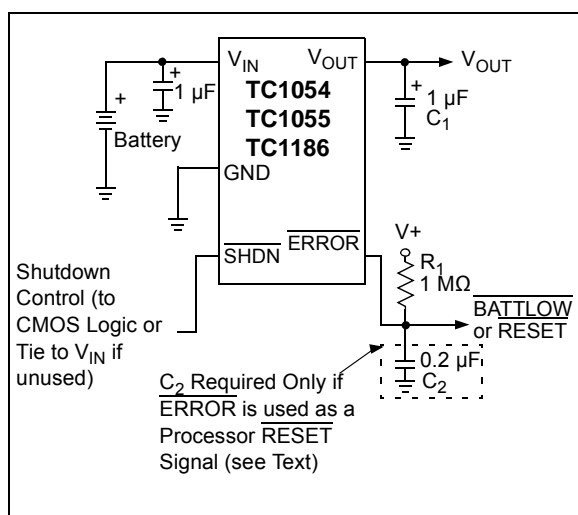


FIGURE 4-1: Typical Application Circuit.

## 4.1 $\overline{ERROR}$ Open-Drain Output

$\overline{ERROR}$  is driven low whenever  $V_{OUT}$  falls out of regulation by more than -5% (typical). This condition may be caused by low input voltage, output current limiting or thermal limiting. The  $\overline{ERROR}$  threshold is 5% below rated  $V_{OUT}$ , regardless of the programmed output voltage value (e.g.  $\overline{ERROR} = V_{OL}$  at 4.75V (typical) for a 5.0V regulator and 2.85V (typical) for a 3.0V regulator).  $\overline{ERROR}$  output operation is shown in Figure 4-2.

Note that  $\overline{ERROR}$  is active when  $V_{OUT}$  falls to  $V_{TH}$  and inactive when  $V_{OUT}$  rises above  $V_{TH}$  by  $V_{HYS}$ .

As shown in Figure 4-1,  $\overline{ERROR}$  can be used either as a battery low flag or as a processor  $\overline{RESET}$  signal (with the addition of timing capacitor  $C_2$ ).  $R_1 \times C_2$  should be chosen to maintain  $\overline{ERROR}$  below  $V_{IH}$  of the processor  $\overline{RESET}$  input for at least 200 ms to allow time for the system to stabilize. Pull-up resistor  $R_1$  can be tied to  $V_{OUT}$ ,  $V_{IN}$  or any other voltage less than  $(V_{IN} + 0.3V)$ .

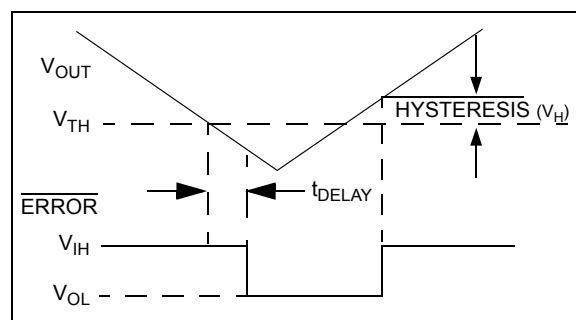


FIGURE 4-2:  $\overline{ERROR}$  Output Operation.

## 4.2 Output Capacitor

A 1  $\mu$ F (minimum) capacitor from  $V_{OUT}$  to ground is recommended. The output capacitor should have an effective series resistance greater than 0.1 $\Omega$  and less than 10.0 $\Omega$ , with a resonant frequency above 1 MHz. A 1  $\mu$ F capacitor should be connected from  $V_{IN}$  to GND if there is more than 10 inches of wire between the regulator and the AC filter capacitor, or if a battery is used as the power source. Aluminum electrolytic or tantalum capacitor types can be used (since many aluminum electrolytic capacitors freeze at approximately -30°C, solid tantalums are recommended for applications operating below -25°C). When operating from sources other than batteries, supply-noise rejection and transient response can be improved by increasing the value of the input and output capacitors and employing passive filtering techniques.

# TC1054/TC1055/TC1186

## 5.0 THERMAL CONSIDERATIONS

### 5.1 Thermal Shutdown

Integrated thermal protection circuitry shuts the regulator off when die temperature exceeds +160°C. The regulator remains off until the die temperature drops to approximately +150°C.

### 5.2 Power Dissipation

The amount of power the regulator dissipates is primarily a function of input voltage, output voltage and output current. The following equation is used to calculate worst-case actual power dissipation:

#### EQUATION 5-1:

$$P_D \approx (V_{INMAX} - V_{OUTMIN})I_{LOADMAX}$$

Where:

$P_D$  = Worst-case actual power dissipation

$V_{INmax}$  = Maximum voltage on  $V_{IN}$

$V_{OUTmin}$  = Minimum regulator output voltage

$I_{LOADmax}$  = Maximum output (load) current

The maximum allowable power dissipation (Equation 5-2) is a function of the maximum ambient temperature ( $T_{AMAX}$ ), the maximum allowable die temperature ( $T_{JMAX}$ ) and the thermal resistance from junction-to-air ( $\theta_{JA}$ ). The 5-Pin SOT-23 package has a  $\theta_{JA}$  of approximately 220°C/Watt.

#### EQUATION 5-2:

$$P_{DMAX} = \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}}$$

Where all terms are previously defined.

Equation 5-1 can be used in conjunction with Equation 5-2 to ensure regulator thermal operation is within limits.

For example:

Given:

$$V_{INMAX} = 3.0V + 5\%$$

$$V_{OUTMIN} = 2.7V - 2.5\%$$

$$I_{LOADMAX} = 40 \text{ mA}$$

$$T_{JMAX} = +125^\circ\text{C}$$

$$T_{AMAX} = +55^\circ\text{C}$$

- Find:
1. Actual power dissipation
  2. Maximum allowable dissipation

Actual power dissipation:

$$\begin{aligned} P_D &\approx (V_{INMAX} - V_{OUTMIN})I_{LOADMAX} \\ &= [(3.0 \times 1.05) - (2.7 \times 0.975)]40 \times 10^{-3} \\ &= 20.7mW \end{aligned}$$

Maximum allowable power dissipation:

$$\begin{aligned} P_{DMAX} &= \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}} \\ &= \frac{(125 - 55)}{220} \\ &= 318mW \end{aligned}$$

In this example, the TC1054 dissipates a maximum of 20.7 mW; below the allowable limit of 318 mW. In a similar manner, Equation 5-1 and Equation 5-2 can be used to calculate maximum current and/or input voltage limits.

### 5.3 Layout Considerations

The primary path of heat conduction out of the package is via the package leads. Layouts having a ground plane, wide traces at the pads and wide power supply bus lines, combine to lower  $\theta_{JA}$  and increase the maximum allowable power dissipation limit.

## 6.0 PACKAGING INFORMATION

### 6.1 Package Marking Information

5-Lead SOT-23



Example



| (V)  | TC1054 Code | TC1055 Code | TC1186 Code |
|------|-------------|-------------|-------------|
| 1.8  | CYNN        | DYNN        | PYNN        |
| 2.5  | C1NN        | D1NN        | P1NN        |
| 2.6  | CTNN        | DTNN        | PVNN        |
| 2.7  | C2NN        | D2NN        | P2NN        |
| 2.8  | CZNN        | DZNN        | PZNN        |
| 2.85 | C8NN        | D8NN        | P8NN        |
| 3.0  | C3NN        | D3NN        | P3NN        |
| 3.3  | C4NN        | D4NN        | P5NN        |
| 3.6  | C9NN        | D9NN        | P9NN        |
| 4.0  | C0NN        | D0NN        | P0NN        |
| 5.0  | C6NN        | D6NN        | P7NN        |

**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.

# TC1054/TC1055/TC1186

## 5-Lead Plastic Small Outline Transistor (CT) [SOT-23]

**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      |       | 5           |     |      |
| Lead Pitch               | e      |       | 0.95 BSC    |     |      |
| Outside Lead Pitch       | e1     |       | 1.90 BSC    |     |      |
| Overall Height           | A      | 0.90  | –           |     | 1.45 |
| Molded Package Thickness | A2     | 0.89  | –           |     | 1.30 |
| Standoff                 | A1     | 0.00  | –           |     | 0.15 |
| Overall Width            | E      | 2.20  | –           |     | 3.20 |
| Molded Package Width     | E1     | 1.30  | –           |     | 1.80 |
| Overall Length           | D      | 2.70  | –           |     | 3.10 |
| Foot Length              | L      | 0.10  | –           |     | 0.60 |
| Footprint                | L1     | 0.35  | –           |     | 0.80 |
| Foot Angle               | $\phi$ | 0°    | –           |     | 30°  |
| Lead Thickness           | c      | 0.08  | –           |     | 0.26 |
| Lead Width               | b      | 0.20  | –           |     | 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 C04-091B

## 5-Lead Plastic Small Outline Transistor (CT) [SOT-23]

**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         | NOM  | MAX  |
| Contact Pitch           | E     | 0.95 BSC    |      |      |
| Contact Pad Spacing     | C     |             | 2.80 |      |
| Contact Pad Width (X5)  | X     |             |      | 0.60 |
| Contact Pad Length (X5) | Y     |             |      | 1.10 |
| Distance Between Pads   | G     | 1.70        |      |      |
| Distance Between Pads   | GX    | 0.35        |      |      |
| Overall Width           | Z     |             |      | 3.90 |

**Notes:**

1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2091A

# TC1054/TC1055/TC1186

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NOTES:

## APPENDIX A: REVISION HISTORY

### Revision E (December 2012)

The following is the list of modifications:

1. Updated the Input Voltage value in [Absolute Maximum Ratings †](#) section.
2. Updated [Section 6.0, Packaging Information](#).
3. Updated [Product Identification System](#).

### Revision D (February 2007)

- Corrected standard output voltages on page 1 and in [Section , Product Identification System](#).
- Added  $T_{DELAY}$  parameter in DC Characteristics table in [Section 1.0, Electrical Characteristics](#).
- Changes to [Figure 4-2](#).
- [Section 6.0, Packaging Information](#): Corrected SOT-23 Packaging Information.

### Revision C (March 2003)

- Undocumented changes.

### Revision B (May 2002)

- Undocumented changes.

### Revision A (March 2002)

- Original Release of this Document.

# TC1054/TC1055/TC1186

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NOTES:



# TC1054/TC1055/TC1186

## 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.X   | X                           | XXXXX   |  |
|---------------------------|---|---|-----------------------------|---------|--|
| Device                    |   | Output Voltage  | Temperature Range           | Package | <b>Examples:</b>   |
| <b>Device:</b>            |   | TC1054: 50 mA LDO with Shutdown and <u>ERROR</u> output<br>TC1055: 100 mA LDO with Shutdown and <u>ERROR</u> output<br>TC1186: 150 mA LDO with Shutdown and <u>ERROR</u> output   |                             |         | a) TC1054-1.8VCT713: 1.8V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>b) TC1054-2.5VCT713: 2.5V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>c) TC1054-2.6VCT713: 2.6V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>d) TC1054-2.7VCT713: 2.7V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>e) TC1054-2.8VCT713: 2.8V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>f) TC1054-2.85VCT713: 2.85V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>g) TC1054-3.0VCT713: 3.0V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>h) TC1054-3.3VCT713: 3.3V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>i) TC1054-3.6VCT713: 3.6V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>j) TC1054-4.0VCT713: 4.0V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>k) TC1054-5.0VCT713: 5.0V LDO Regulator, Various Temp., 5LD SOT-23 Package |
| <b>Output Voltage *:</b>  |   | 1.8 = 1.8V "Standard"<br>2.5 = 2.5V "Standard"<br>2.6 = 2.6V "Standard"<br>2.7 = 2.7V "Standard"<br>2.8 = 2.8V "Standard"<br>2.85 = 2.85V "Standard"<br>3.0 = 3.0V "Standard"<br>3.3 = 3.3V "Standard"<br>3.6 = 3.6V "Standard"<br>4.0 = 4.0V "Standard"<br>5.0 = 5.0V "Standard"<br>*Contact factory for other output voltage options. |                             |         | a) TC1055-1.8VCT713: 1.8V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>b) TC1055-2.5VCT713: 2.5V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>c) TC1055-2.6VCT713: 2.6V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>d) TC1055-2.7VCT713: 2.7V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>e) TC1055-2.8VCT713: 2.8V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>f) TC1055-2.85VCT713: 2.85V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>g) TC1055-3.0VCT713: 3.0V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>h) TC1055-3.3VCT713: 3.3V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>i) TC1055-3.6VCT713: 3.6V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>j) TC1055-4.0VCT713: 4.0V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>k) TC1055-5.0VCT713: 5.0V LDO Regulator, Various Temp., 5LD SOT-23 Package |
| <b>Temperature Range:</b> | V |   | = -40°C to +125°C (Various) |         | a) TC1186-1.8VCT713: 1.8V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>b) TC1186-2.5VCT713: 2.5V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>c) TC1186-2.6VCT713: 2.6V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>d) TC1186-2.7VCT713: 2.7V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>e) TC1186-2.8VCT713: 2.8V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>f) TC1186-2.85VCT713: 2.85V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>g) TC1186-3.0VCT713: 3.0V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>h) TC1186-3.3VCT713: 3.3V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>i) TC1186-3.6VCT713: 3.6V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>j) TC1186-4.0VCT713: 4.0V LDO Regulator, Various Temp., 5LD SOT-23 Package<br>k) TC1186-5.0VCT713: 5.0V LDO Regulator, Various Temp., 5LD SOT-23 Package |
| <b>Package:</b>           |   | CT713 = Plastic Small Outline Transistor (SOT-23), Tape and Reel  |                             |         |  |

# TC1054/TC1055/TC1186

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NOTES:

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