TelCom Semiconductor, Inc.

TC1072

50mA CMOS LDO WITH SHUTDOWN, $\overline{\text{ERROR}}$ OUTPUT AND V$_{\text{REF}}$ BYPASS

FEATURES

- **Zero Ground Current for Longer Battery Life!**
- **Very Low Dropout Voltage**
- **Guaranteed 50mA Output**
- **High Output Voltage Accuracy**
- **Standard or Custom Output Voltages**
- **Power-Saving Shutdown Mode**
- **$\overline{\text{ERROR}}$ Ouput can be Used as a Low Battery Detector, or Processor Reset Generator**
- **Bypass Input for Ultra-quiet Operation**
- **Over-Current and Over-Temperature Protection**
- **Space-Saving SOT-23A-6 Package**
- **Pin Compatible Upgrades for Bipolar Regulators**

APPLICATIONS

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

GENERAL DESCRIPTION

The TC1072 is a high accuracy (typically ±0.5%) CMOS upgrade for older (bipolar) low dropout regulators. Designed specifically for battery-operated systems, the TC1072's
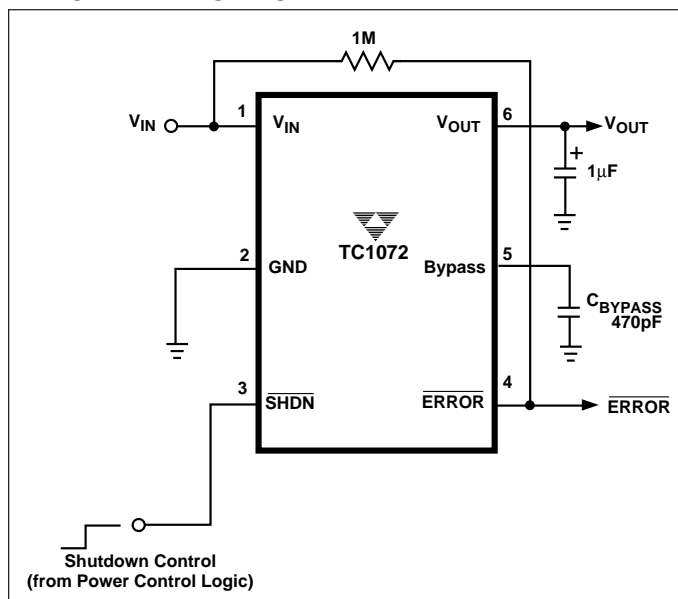
CMOS construction eliminates wasted ground current, significantly extending battery life. Total supply current is typically 50µA at full load (*20 to 60 times lower than in bipolar regulators*!).

TC1072 key features include ultra low noise operation (plus optional Bypass input); very low dropout voltage (typically 100mV at full load) and internal feed-forward compensation for fast response to step changes in load. An error output ($\overline{\text{ERROR}}$) is asserted when the TC1072 is out-of-regulation (due to a low input voltage or excessive output current). $\overline{\text{ERROR}}$ can be used as a low battery warning or as a processor $\overline{\text{RESET}}$ signal (with the addition of an external RC network). Supply current is reduced to less than 1µA, and both V$_{\text{OUT}}$ and $\overline{\text{ERROR}}$ are disabled when the shutdown input is low. The TC1072 incorporates both over-temperature and over-current protection.

The TC1072 is stable with an output capacitor of only 1µF and has a maximum output current of 50mA. For higher output current versions, please see the TC1107, TC1108 and TC1073 (I$_{\text{OUT}}$ = 300mA) data sheets.
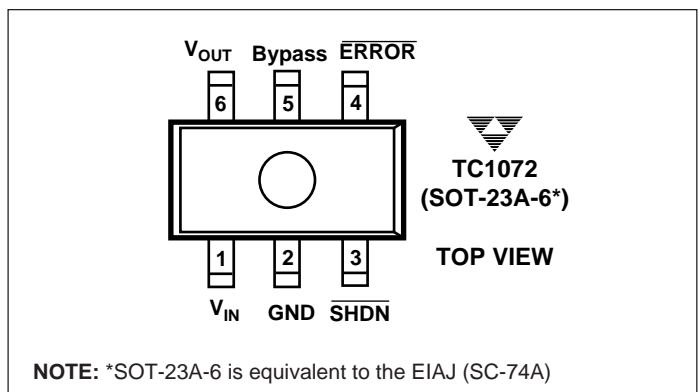
ORDERING INFORMATION

Part No.	Output Voltage **(V)	Package	Junction Temp. Range
TC1072-2.5VCH	2.5	SOT-23A-6*	– 40°C to +125°C
TC1072-2.7VCH	2.7	SOT-23A-6*	– 40°C to +125°C
TC1072-3.0VCH	3.0	SOT-23A-6*	– 40°C to +125°C
TC1072-3.3VCH	3.3	SOT-23A-6*	– 40°C to +125°C
TC1072-5.0VCH	5.0	SOT-23A-6*	– 40°C to +125°C

NOTE: *SOT-23A-6 is equivalent to the EIAJ (SC-74A)
** Other output voltages available. Please contact TelCom Semiconductor for details

TYPICAL APPLICATION

PIN CONFIGURATION

NOTE: *SOT-23A-6 is equivalent to the EIAJ (SC-74A)

50mA CMOS LDO WITH SHUTDOWN, ERROR OUTPUT AND V_REF BYPASS

TC1072

ABSOLUTE MAXIMUM RATINGS*

Input Voltage 7V
Output Voltage .... (− 0.3) to (V_{IN} + 0.3)
Power Dissipation .... Internally Limited (Note 7)
Operating Temperature .... − 40°C < T_J < 125°C
Storage Temperature .... − 65°C to +150°C
Maximum Voltage on Any Pin .... V_{IN} + 0.3V to − 0.3V
Lead Temperature (Soldering, 10 Sec.) .... +260°C

*Stresses beyond 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 beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS:

V_{IN} = V_{OUT} + 1V, I_L = 0.1mA, C_L = 3.3µF, $\overline{SHDN}$ > V_{IH}, T_A = 25°C, unless otherwise specified. **BOLDFACE** type specifications apply for junction temperatures of − 40°C to +125°C.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V_{IN}	Input Operating Voltage		—	—	**6.5**	V
I_{OUTMAX}	Maximum Output Current		**50**	—	—	mA
V_{OUT}	Output Voltage	Note 1	**V_R − 2.5%**	V_R ±0.5%	**V_R + 2.5%**	V
TC V_{OUT}	V_{OUT} Temperature Coefficient	Note 2		— **40**	—	ppm/°C
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	(V_R + 1V) ≤ V_{IN} ≤ 6V	—	0.05	—	%/V
$\Delta V_{OUT}/V_{OUT}$	Load Regulation	I_L = 0.1mA to I_{OUTMAX} (Note 3)	—	0.5	—	%
$V_{IN} − V_{OUT}$	Dropout Voltage (Note 4)	I_L = 0.1mA I_L = 20mA I_L = 50mA (Note 4)	—	5 65 95	—	mV
I_{GND}	Ground Pin Current	I_L = I_{OUTMAX}, (Note 5)	—	**0**	—	µA
I_{IN}	Supply Current	$\overline{SHDN}$ = V_{IH}, I_L = 0	—	50	—	µA
I_{INSD}	Shutdown Supply Current	$\overline{SHDN}$ = 0V	—	—	0.05	µA
PSRR	Power Supply Rejection Ratio	F_{RE} ≤ 1kHz	—	64	—	dB
I_{OUTSC}	Output Short Circuit Current	V_{OUT} = 0V	—	200	450	mA
$\Delta V_{OUT}/\Delta P_D$	Thermal Regulation	Note 6	—	0.04	—	%/W
eN	Output Noise	I_L = I_{OUTMAX} 470pF from Bypass to GND	—	260	—	nV/√Hz
$\overline{SHDN}$ Input						
V_{IH}	$\overline{SHDN}$ Input High Threshold	V_{IN} = 2.5V to 6.5V	45	—	—	%V_{IN}
V_{IL}	$\overline{SHDN}$ Input Low Threshold	V_{IN} = 2.5V to 6.5V	—	—	15	%V_{IN}

ELECTRICAL CHARACTERISTICS: $V_{IN} = V_{OUT} + 1V$, $I_L = 0.1mA$, $C_L = 3.3\mu F$, $\overline{SHDN} > V_{IH}$, $T_A = 25^{\circ}C$, unless otherwise noted.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
$\overline{ERROR}$ Open Drain Output						
V_{MIN}	Minimum Operating Voltage		1.0	—	—	V
V_{OL}	Output Logic Low Voltage	1mA Flows to $\overline{ERROR}$	—	—	400	mV
V_{TH}	$\overline{ERROR}$ Threshold Voltage	See Figure 2	—	$0.95 \times V_R$	—	V
V_{HYS}	$\overline{ERROR}$ Positive Hysteresis	Note 8	—	50	—	mV

NOTES:
1. V_R is the regulator output voltage setting. $V_R = 2.5V$, $2.7V$, $3.0V$, $3.2V$, $3.3V$, $3.8V$ $5.0V$.
2. $TC\ V_{OUT} = \dfrac{(V_{OUT_{MAX}} - V_{OUT_{MIN}}) \times 10^6}{V_{OUT} \times \Delta T}$
3. Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 0.1mA 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. Ground pin current is the regulator pass transistor gate current. The total current drawn from the input supply is the sum of the load current, ground current and supply current (i.e. $I_{IN} = I_{SUPPLY} + I_{GND} + I_{LOAD}$).
6. 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 $T = 10msec$.
7. 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, q_{JA}). Exceeding the maximum allowable power dissipation causes the device to initiate thermal shutdown. Please see *Thermal Considerations* section of this data sheet for more details.
8. Hysteresis voltage is referenced by V_R.

PIN DESCRIPTION

Pin No. (SOT-23A-6)	Symbol	Description
1	V_{IN}	Unregulated supply input.
2	GND	Ground terminal.
3	$\overline{SHDN}$	Shutdown control input. The regulator is fully enabled when a logic high is applied to this input. The regulator enters shutdown when a logic low is applied to this input. During shutdown, output voltage falls to zero and supply current is reduced to 0.05 microamp (typical).
4	$\overline{ERROR}$	Out-of-Regulation Flag. (Open drain output). This output goes low when V_{OUT} is out-of-tolerance by approximately – 5%.
5	Bypass	Reference bypass input. Connecting a 470pF to this input further reduces output noise.
6	V_{OUT}	Regulated voltage output.

50mA CMOS LDO WITH SHUTDOWN, ERROR OUTPUT AND V_{REF} BYPASS

TC1072

DETAILED DESCRIPTION

The TC1072 is a precision fixed output voltage regulator. (If an adjustable version is desired, please see the TC1070 or TC1071 data sheets.) Unlike the bipolar regulators, the TC1072 supply current does not increase with load current. In addition, V_{OUT} remains stable and within regulation at very low load currents (an important consideration in RTC and CMOS RAM battery back-up applications).

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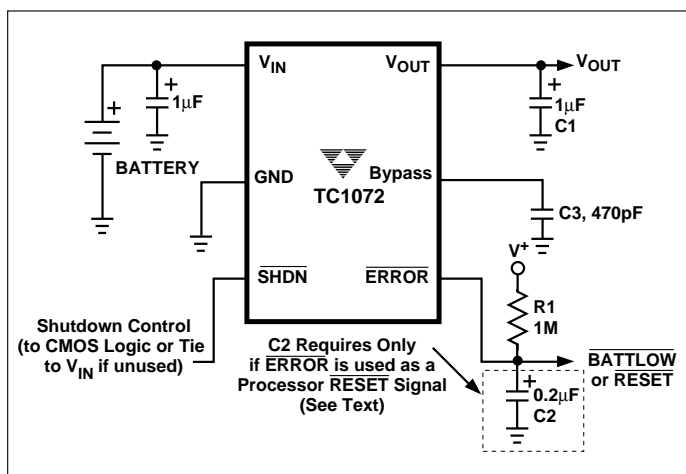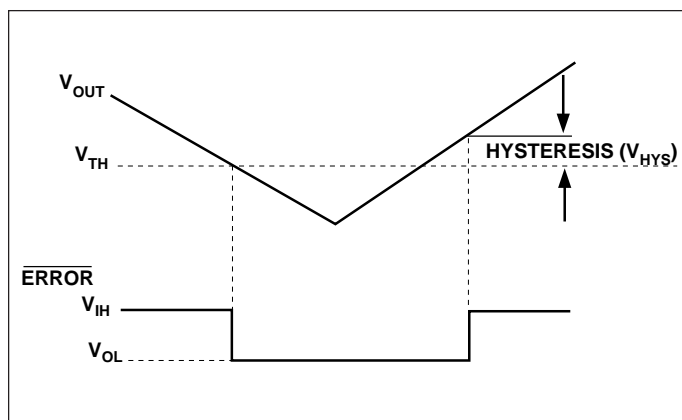

Figure 1. Typical Application Circuit

$\overline{ERROR}$ Open Drain Output

$\overline{ERROR}$ is driven low whenenver V_{OUT} falls out of regulation by more than – 5% (typical). The condition my be caused by low input voltage, output current limiting, or thermal limiting. The $\overline{ERROR}$ output voltage value (e.g. $\overline{ERROR} = V_{OL}$ at 4.75 (typ) for a 5.0V regulator and 2.85 (typ) for a 3.0V regulator). ERROR ouput operation is shown in Figure 2.

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

As shown in Figure 1, $\overline{ERROR}$ can be used as a battery low flag, or as a processor RESET signal (with the addition of timing capacitor C2). R1 x C2 should be chosen to maintain $\overline{ERROR}$ below V_{IH} of the processor $\overline{RESET}$ input for at least 200msec to allow time for the system to stabilize. Pull-up resistor R1 can be tied to V_{OUT}, V_{IN} or any other voltage less than (V_{IN} +0.3V).

Figure 2. $\overline{ERROR}$ Output Operation

Output Capacitor

A 1µF (min) capacitor from V_{OUT} to ground is recommended. The output capacitor should have an effective series resistance of 5Ω or less, and a resonant frequency above 1MHz. A 1µF 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.

Bypass Input

A 470pF capacitor connected from the Bypass input to ground reduces noise present on the internal reference, which in turn significantly reduces output noise. If output noise is not a concern, this input may be left unconnected. Larger capacitor values may be used, but results in a longer time period to rated output voltage when power is initially applied.

Thermal Considerations

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.

Power Dissipation

The amount of power the regulator dissipates is primarily a function of input and output voltage, and output current.

The following equation is used to calculate worst case *actual* power dissipation:

$$P_D \approx (V_{IN_{MAX}} - V_{OUT_{MIN}})I_{LOAD_{MAX}}$$

Where:

P_D = Worst case actual power dissipation
$V_{IN_{MAX}}$ = Maximum voltage on V_{IN}
$V_{OUT_{MIN}}$ = Minimum regulator output voltage
$I_{LOAD_{MAX}}$ = Maximum output (load) current

Equation 1.

The maximum *allowable* power dissipation (Equation 2) is a function of the maximum ambient temperature (T_{AMAX}), the maximum allowable die temperature (125°C) and the thermal resistance from junction-to-air (θ_{JA}). SOT-23A-6 packag has a θ_{JA} of approximately *220°C/Watt* when mounted on a single layer FR4 dielectric copper clad PC board.

$$P_{D\,MAX} = \frac{(T_{J_{MAX}} - T_{A_{MAX})}}{\theta_{JA}}$$

Where all terms are previously defined.

Equation 2.

Equation 1 can be used in conjunction with Equation 2 to ensure regulator thermal operation is within limits. For example:

Given:

$V_{IN_{MAX}}$ = 3.0V ±10%
$V_{OUT_{MIN}}$ = 2.7V ±0.5V
I_{LOAD} = 40mA
T_{AMAX} = 55°C

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

Actual power dissipation:

$P_D \approx (V_{IN_{MAX}} - V_{OUT_{MIN}})I_{LOAD_{MAX}}$
= [(3.0 x 1.05) − (2.7 x .995)]40 x 10^{-3}
= 18.5mW

Maximum allowable power dissipation:

$P_{D_{MAX}} = \frac{(T_{J_{MAX}} - T_{A_{MAX}})}{\theta_{JA}}$

$$= \frac{(125 - 55)}{220}$$
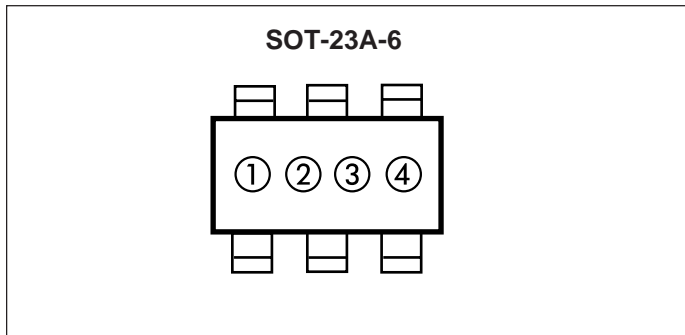
$$= 318mW$$

In this example, the TC1072 dissipates a maximum of only 60mW; far below the allowable limit of 318mW. In a similar manner, Equation 1 and Equation 2 can be used to calculate maximum current and/or input voltage limits.

Layout Considerations

The primary path of heat conduction out of the package is via the package leads. Therefore, layouts having a ground plane, wide traces at the pads, and wide power supply bus lines combine to lower θ_{JA} and therefore increase the maximum allowable power dissipation limit.
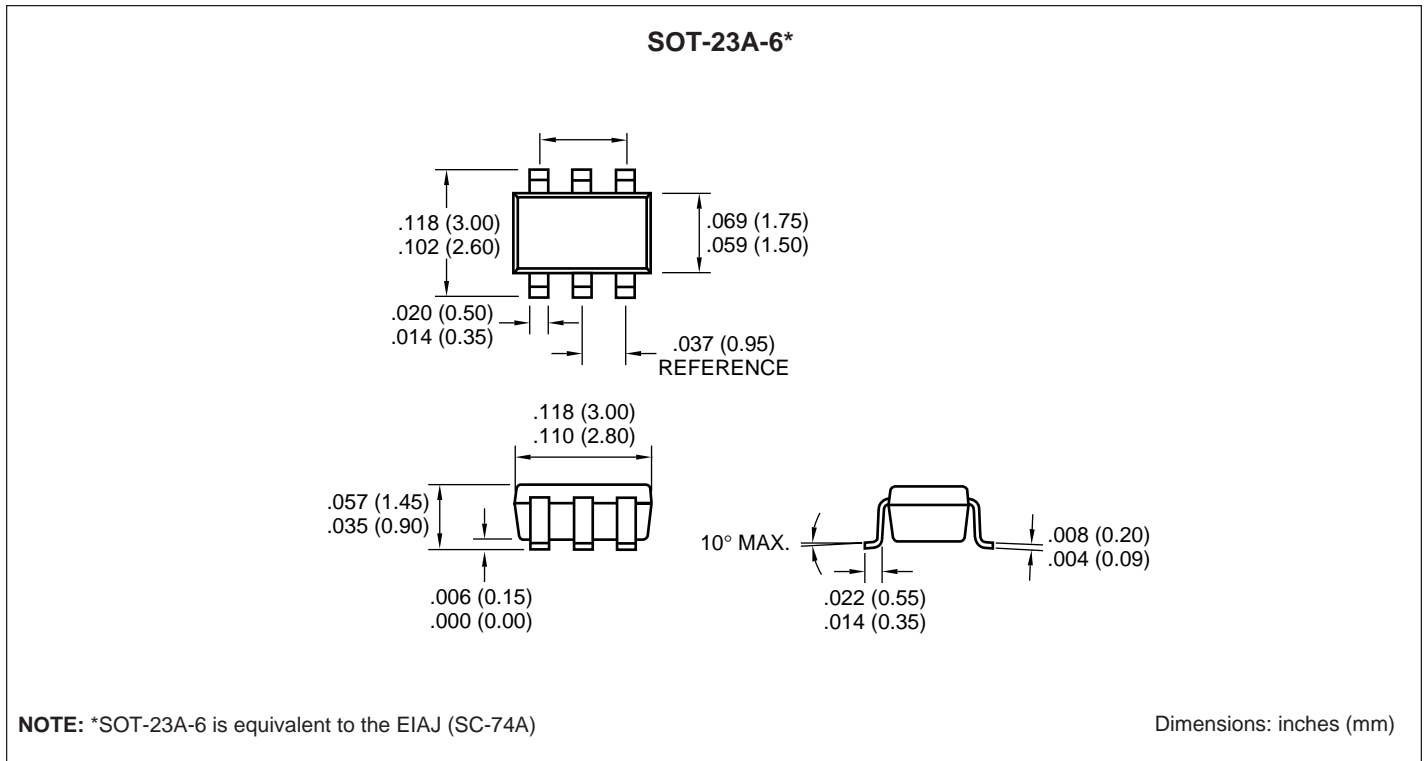
50mA CMOS LDO WITH SHUTDOWN, ERROR OUTPUT AND V$_{REF}$ BYPASS

TC1072

SOT-23A-6

① & ② = part number code + temperature range and voltage

TC1072 (V)	Code
2.5	E1
2.7	E2
3.0	E3
3.3	E4
5.0	E6

③ represents year and quarter code

④ represents lot ID number

PACKAGE DIMENSIONS

SOT-23A-6*

.118 (3.00)
.102 (2.60)

.069 (1.75)
.059 (1.50)

.020 (0.50)
.014 (0.35)

.037 (0.95)
REFERENCE

.118 (3.00)
.110 (2.80)

.057 (1.45)
.035 (0.90)

10° MAX.

.008 (0.20)
.004 (0.09)

.006 (0.15)
.000 (0.00)

.022 (0.55)
.014 (0.35)

NOTE: *SOT-23A-6 is equivalent to the EIAJ (SC-74A)

Dimensions: inches (mm)

TC1073

100mA CMOS LDO WITH SHUTDOWN, $\overline{\text{ERROR}}$ OUTPUT AND V$_{\text{REF}}$ BYPASS

FEATURES

- ■ **Zero Ground Current for Longer Battery Life!**
- ■ **Very Low Dropout Voltage**
- ■ **Guaranteed 100mA Output**
- ■ **High Output Voltage Accuracy**
- ■ **Standard or Custom Output Voltages**
- ■ **Power-Saving Shutdown Mode**
- ■ **$\overline{\text{ERROR}}$ Ouput can be Used as a Low Battery Detector, or Processor Reset Generator**
- ■ **Bypass Input for Ultra-quiet Operation**
- ■ **Over-Current and Over-Temperature Protection**
- ■ **Space-Saving SOT-23A-6 Package**
- ■ **Pin Compatible Upgrades for Bipolar Regulators**

APPLICATIONS

- ■ **Battery Operated Systems**
- ■ **Portable Computers**
- ■ **Medical Instruments**
- ■ **Instrumentation**
- ■ **Cellular / GSM / PHS Phones**
- ■ **Linear Post-Regulator for SMPS**
- ■ **Pagers**
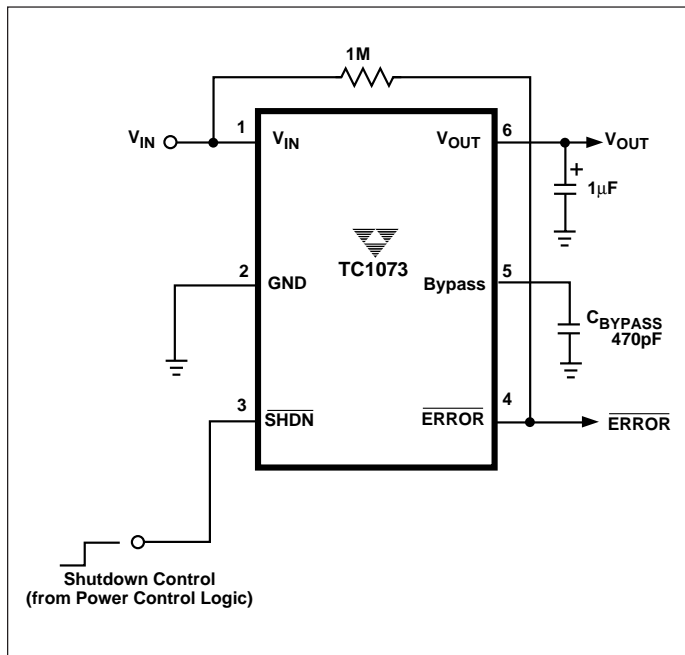
GENERAL DESCRIPTION

The TC1073 is a high accuracy (typically ±0.5%) CMOS upgrade for older (bipolar) low dropout regulators such as the LP2980. Designed specifically for battery-operated systems, the TC1073's CMOS construction eliminates wasted ground current, significantly extending battery life. Total supply current is typically 50µA at full load (*20 to 60 times lower than in bipolar regulators*!).

TC1073 key features include ultra low noise operation (plus optional Bypass input); very low dropout voltage (typically 200mV at full load) and internal feed-forward compensation for fast response to step changes in load. An error output ($\overline{\text{ERROR}}$) is asserted when the TC1073 is out-of-regulation (due to a low input voltage or excessive output current). $\overline{\text{ERROR}}$ can be used as a low battery warning or as a processor $\overline{\text{RESET}}$ signal (with the addition of an external RC network). Supply current is reduced to less than 1µA, and both V$_{\text{OUT}}$ and $\overline{\text{ERROR}}$ are disabled when the shutdown input is low. The TC1073 incorporates both over-temperature and over-temeprature protection.
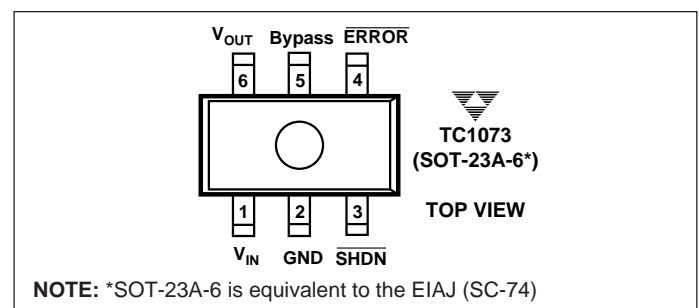
The TC1073 is stable with an output capacitor of only 1µF and has a maximum output current of 100mA. For higher output current versions, please see the TC1107, TC1108 (I$_{\text{OUT}}$ = 300mA) data sheets.

TYPICAL APPLICATION

ORDERING INFORMATION

Part No.	Output Voltage**	Package	Junction Temp. Range
TC1073-2.5VCH	2.5V	SOT-23A-6*	– 40°C to +125°C
TC1073-2.7VCH	2.7V	SOT-23A-6*	– 40°C to +125°C
TC1073-3.0VCH	3.0V	SOT-23A-6*	– 40°C to +125°C
TC1073-3.3VCH	3.3V	SOT-23A-6*	– 40°C to +125°C
TC1073-5.0VCH	5.0V	SOT-23A-6*	– 40°C to +125°C

NOTE: *SOT-23A-6 is equivalent to the EIAJ (SC-74)
** Other output voltages available. Please contact TelCom Semiconductor for details

PIN CONFIGURATION

NOTE: *SOT-23A-6 is equivalent to the EIAJ (SC-74)

100mA CMOS LDO WITH SHUTDOWN, ERROR OUTPUT AND V_{REF} BYPASS

100mA CMOS LDO WITH SHUTDOWN, ERROR OUTPUT AND V_{REF} BYPASS

TC1073

ABSOLUTE MAXIMUM RATINGS*

Input Voltage 7V
Output Voltage .... (− 0.3) to (V_{IN} + 0.3)
Power Dissipation ....Internally Limited (Note 7)
Operating Temperature .... − 40°C < T_J < 125°C
Storage Temperature .... − 65°C to +150°C
Maximum Voltage On Any Pin .... V_{IN} + 0.3V to − 0.3V

*Stresses beyond 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 beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS: V_{IN} = V_{OUT} + 1V, I_L = 0.1mA, C_L = 3.3μF, $\overline{SHDN}$ > V_{IH}, T_A = 25°C, unless otherwise noted.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V_{IN}	Input Operating Voltage	Note 9	—	—	**6.5**	V
I_{OUTMAX}	Maximum Output Current	Note 9	**100**	—	—	mA
V_{OUT}	Output Voltage	Notes 1, 9	**V_R − 2.5%**	V_R ±0.5%	**V_R + 2.5%**	V
TC V_{OUT}	V_{OUT} Temperature Coefficient	Note 2, 9		20 **40**	—	ppm/°C
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	(V_R + 1V) ≤ V_{IN} ≤ 6V	—	0.05	—	%
$\Delta V_{OUT}/V_{OUT}$	Load Regulation	I_L = 0.1mA to I_{OUTMAX} (Note 3)	—	0.5	—	%
V_{IN} − V_{OUT}	Dropout Voltage (Note 4)	I_L = 0.1mA I_L = 20mA I_L = 50mA I_L =100mA (Note 4)	—	20 70 100 200	—	mV
I_{GND}	Ground Pin Current	I_L = $I_{OUTMAX,}$ (Note 5, 9)	—	**0**	—	μA
I_{IN}	Supply Current	$\overline{SHDN}$ = V_{IH}, I_L = 0	—	50	80	μA
I_{INSD}	Shutdown Supply Current	$\overline{SHDN}$ = 0V	—	—	0.05	μA
R_{OUT}	Output Resistance during Shutdown	$\overline{SHDN}$ < V_{IL}	100 x V_R	160 x V_R	—	kΩ
PSRR	Power Supply Rejection Ratio	F_{RE} ≤ 1kHz	—	64	—	dB
I_{OUTSC}	Output Short Circuit Current	V_{OUT} = 0V	—	300	500	mA
$\Delta V_{OUT}/\Delta P_D$	Thermal Regulation	Note 6	—	0.04	—	%/W
T_{SD}	Thermal Shutdown Die Temperature		—	160	—	°C
ΔT_{SD}	Thermal Shutdown Hysteresis		—	10	—	°C
eN	Output Noise	I_L = I_{OUTMAX} 470pF from Bypass to GND	—	260	—	nV/√Hz
$\overline{SHDN}$ Input						
V_{IH}	$\overline{SHDN}$ Input High Threshold	V_{IN} = 2.5V to 6.5V	45	—	—	%V_{IN}
V_{IL}	$\overline{SHDN}$ Input Low Threshold	V_{IN} = 2.5V to 6.5V	—	—	15	%V_{IN}

ELECTRICAL CHARACTERISTICS: V$_{IN}$ = V$_{OUT}$ + 1V, I$_L$ = 0.1µA, C$_L$ = 3.3µF, $\overline{SHDN}$ > V$_{IH}$, T$_A$ = 25°C, unless otherwise noted.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
$\overline{ERROR}$ Open Dranin Output						
V$_{MIN}$	Minimum Operating Voltage		1.0	—	—	V
V$_{OL}$	Output Logic Low Voltage	1mA Flows to $\overline{ERROR}$	—	—	400	mV
V$_{TH}$	$\overline{ERROR}$ Threshold Voltage	See Figure 2	—	0.95 x V$_R$	—	V
V$_{HYS}$	$\overline{ERROR}$ Positive Hysteresis	Note 8	—	50	—	mV

NOTES:
1. V$_R$ is the regulator output voltage setting. (V$_R$ = 2.5V, 2.7V, 3.0V, 3.3V, 5.0V).
2. TC V$_{OUT}$ = $\dfrac{(V_{OUT_{MAX}} - V_{OUT_{MIN}}) \times 10^6}{V_{OUT} \times \Delta T}$
3. Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 0.1mA 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. Ground pin current is the regulator pass transistor gate current. The total current drawn from the input supply is the sum of the load current, ground current and supply current (i.e. I$_{IN}$ = I$_{SUPPLY}$ + I$_{GND}$ + I$_{LOAD}$).
6. 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 = 10msec.
7. 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$_J$, q$_{JA}$). Exceeding the maximum allowable power dissipation causes the device to initiate thermal shutdown. Please see *Thermal Considerations* section of this data sheet for more details.
8. Hysteresis voltage is referenced by V$_R$.
9. Boldface type specifications apply for junction temperatures of – 40°C to +125°C.

PIN DESCRIPTION

Pin No. (SOT-23A-6)	Symbol	Description
1	V$_{IN}$	Unregulated supply input.
2	GND	Ground terminal.
3	$\overline{SHDN}$	Shutdown control input. The regulator is fully enabled when a logic high is applied to this input. The regulator enters shutdown when a logic low is applied to this input. During shutdown, output voltage falls to zero and supply current is reduced to 0.05 microamp (typical).
4	$\overline{ERROR}$	Out-of-Regulation Flag. (Open drain output). This output goes low when V$_{OUT}$ is out-of-tolerance by approximately – 5%.
5	Bypass	Reference bypass input. Connecting a 470pF to this input further reduces output noise.
6	V$_{OUT}$	Regulated voltage output.

100mA CMOS LDO WITH SHUTDOWN, ERROR OUTPUT AND V_{REF} BYPASS

TC1073

DETAILED DESCRIPTION

The TC1073 is a precision fixed output voltage regulator. (If an adjustable version is desired, please see the TC1070 or TC1071 data sheets.) Unlike the bipolar regulators, the TC1073 supply current does not increase with load current. In addition, V_{OUT} remains stable and within regulation at very low load currents (an important consideration in RTC and CMOS RAM battery back-up applications).

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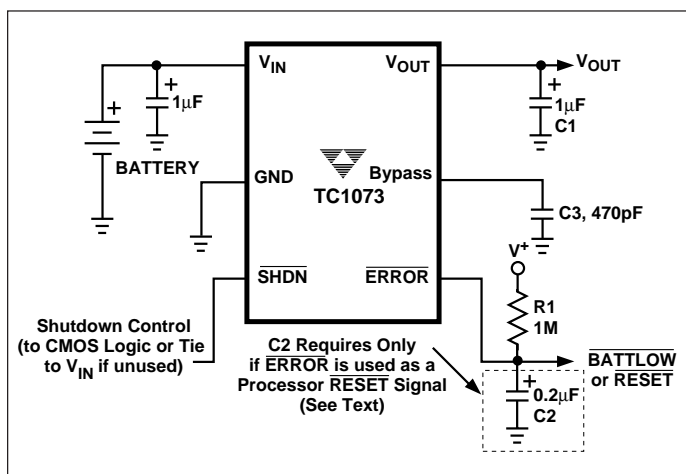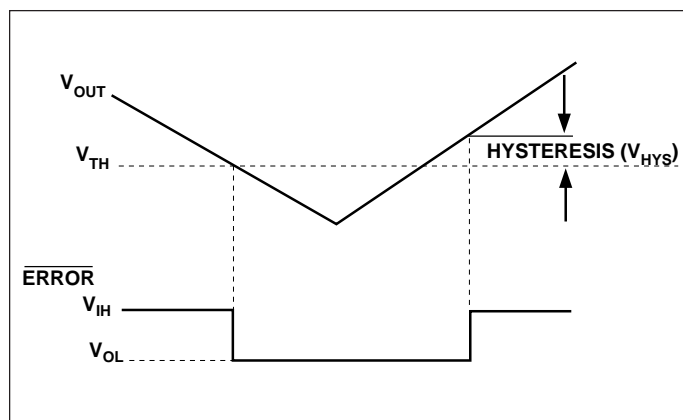

Figure 1. Typical Application Circuit

$\overline{ERROR}$ Open Drain Output

$\overline{ERROR}$ is driven low whenenver V_{OUT} falls out of regulation by more than – 5% (typical). The condition my be caused by low input voltage, output current limiting, or thermal limiting. The $\overline{ERROR}$ output voltage value (e.g. $\overline{ERROR} = V_{OL}$ at 4.75 (typ) for a 5.0V regulator and 2.85 (typ) for a 3.0V regulator). ERROR ouput operation is shown in Figure 2.

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

As shown in Figure 1, $\overline{ERROR}$ can be used as a battery low flag, or as a processor RESET signal (with the addition of timing capacitor C2). R1 x C2 should be chosen to maintain $\overline{ERROR}$ below V_{IH} of the processor $\overline{RESET}$ input for at least 200msec to allow time for the system to stabilize. Pull-up resistor R1 can be tied to V_{OUT}, V_{IN} or any other voltage less than (V_{IN} +0.3V).

Figure 2. $\overline{ERROR}$ Output Operation

Output Capacitor

A 1µF (min) capacitor from V_{OUT} to ground is recommended. The output capacitor should have an effective series resistance of 5Ω or less, and a resonant frequency above 1MHz. A 1µF 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.

Bypass Input

A 470pF capacitor connected from the Bypass input to ground reduces noise present on the internal reference, which in turn significantly reduces output noise. If output noise is not a concern, this input may be left unconnected. Larger capacitor values may be used, but results in a longer time period to rated output voltage when power is initially applied.

Thermal Considerations

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.

Power Dissipation

The amount of power the regulator dissipates is primarily a function of input and output voltage, and output current.

The following equation is used to calculate worst case *actual* power dissipation:

$$P_D \approx (V_{IN_{MAX}} - V_{OUT_{MIN}})I_{LOAD_{MAX}}$$

Where:

P_D = Worst case actual power dissipation
$V_{IN_{MAX}}$ = Maximum voltage on V_{IN}
$V_{OUT_{MIN}}$ = Minimum regulator output voltage
$I_{LOAD_{MAX}}$ = Maximum output (load) current

Equation 1.

The maximum *allowable* power dissipation (Equation 2) is a function of the maximum ambient temperature ($T_{A_{MAX}}$), the maximum allowable die temperature (125°C) and the thermal resistance from junction-to-air (θ_{JA}). SOT-23A-6 packag has a θ_{JA} of approximately *220°C/Watt* when mounted on a single layer FR4 dielectric copper clad PC board.

$$P_{D\ MAX} = \frac{(T_{J_{MAX}} - T_{J_{MAX})}}{\theta_{JA}}$$

Where all terms are previously defined.

Equation 2.

Equation 1 can be used in conjunction with Equation 2 to ensure regulator thermal operation is within limits. For example:

Given:

$V_{IN_{MAX}}$ = 3.0V ±10%
$V_{OUT_{MIN}}$ = 2.7V ±0.5V
I_{LOAD} = 98mA
$T_{A_{MAX}}$ = 55°C

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

Actual power dissipation:

$P_D \approx (V_{IN_{MAX}} - V_{OUT_{MIN}})I_{LOAD_{MAX}}$
= [(3.0 x 1.1) − (2.7 x .995)]40 x 10^{−3}
= 60mW

Maximum allowable power dissipation:

$$P_{D_{MAX}} = \frac{(T_{J_{MAX}} - T_{A_{MAX}})}{\theta_{JA}}$$

$$= \frac{(125 - 55)}{220}$$

$$= 318mW$$

In this example, the TC1073 dissipates a maximum of only 60mW; far below the allowable limit of 318mW. In a similar manner, Equation 1 and Equation 2 can be used to calculate maximum current and/or input voltage limits. For example, the maximum allowable V_{IN} is found by substituting the maximum allowable power dissipation of 318mW into Equation 1, from which $V_{IN_{MAX}}$ = 5.9V.

Layout Considerations

The primary path of heat conduction out of the package is via the package leads. Therefore, layouts having a ground plane, wide traces at the pads, and wide power supply bus lines combine to lower θ_{JA} and therefore increase the maximum allowable power dissipation limit.
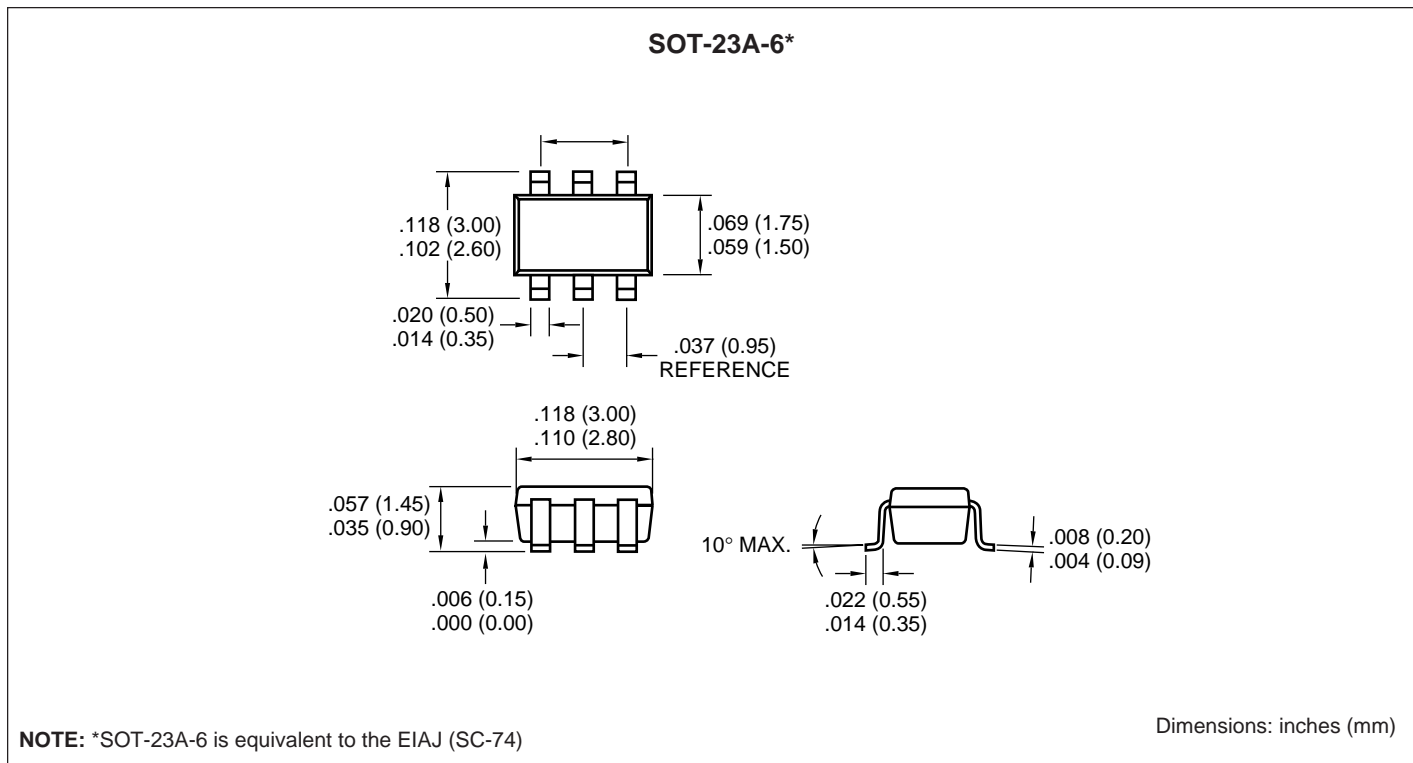
100mA CMOS LDO WITH SHUTDOWN, ERROR OUTPUT AND V$_{REF}$ BYPASS

TC1073

MARKING

SOT-23A-6
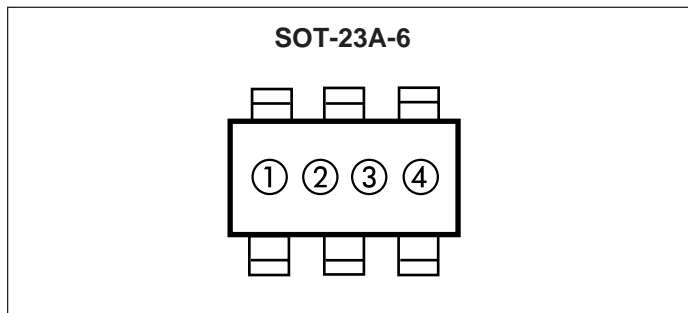
① & ② = part number code + temperature range and voltage

TC1073 (V)	Code
2.5	F1
2.7	F2
3.0	F3
3.3	F4
5.0	F6

③ represents year and quarter code

④ represents lot ID number

PACKAGE DIMENSIONS

SOT-23A-6*

.118 (3.00)
.102 (2.60)

.069 (1.75)
.059 (1.50)

.020 (0.50)
.014 (0.35)

.037 (0.95)
REFERENCE

.118 (3.00)
.110 (2.80)

.057 (1.45)
.035 (0.90)

.006 (0.15)
.000 (0.00)

10° MAX.

.022 (0.55)
.014 (0.35)

.008 (0.20)
.004 (0.09)

Dimensions: inches (mm)

NOTE: *SOT-23A-6 is equivalent to the EIAJ (SC-74)

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