



FEATURES

- Extremely Low Supply Current (50μA, Typ.)
- Very Low Dropout Voltage
- Guaranteed 50mA, 100mA, and 150mA Output (TC1014, TC1015, and TC1185, Respectively)
- High Output Voltage Accuracy
- Standard or Custom Output Voltages
- Power-Saving Shutdown Mode
- Reference Bypass Input for Ultra Low-Noise Operation
- Over-Current and Over-Temperature Protection
- Space-Saving 5-Pin SOT-23A 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

TYPICAL APPLICATION



GENERAL DESCRIPTION

The TC1014, TC1015, and TC1185 are high accuracy (typically $\pm 0.5\%$) CMOS upgrades for older (bipolar) low dropout regulators such as the LP2980. Designed specifically for battery-operated systems, the devices' 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!).

Key features for the devices include ultra low-noise operation (plus optional Bypass input), fast response to step changes in load, and very low dropout voltage, typically 85mV (TC1014), 180mV (TC1015), and 270mV (TC1185) at full load. Supply current is reduced to 0.5μ A (max) and V_{OUT} falls to zero when the shutdown input is low. The devices also incorporate both over-temperature and over-current protection.

The TC1014, TC1015, and TC1185 are stable with an output capacitor of only 1 μ F and have a maximum output current of 50mA, 100mA, and 150mA, respectively. For higher output versions, see the TC1107, TC1108, and TC1173 (I_{OUT} = 300 mA) data sheets.

ORDERING INFORMATION

Part Number	Package	Junction Temp. Range
TC1014-xxVCT	5-Pin SOT-23A*	– 40°C to +125°C
TC1015-xxVCT	5-Pin SOT-23A*	- 40°C to +125°C
TC1185-xxVCT	5-Pin SOT-23A*	- 40°C to +125°C
TC1015EV Eva	luation Kit for CMO	S LDO Family
NOTE: *5-Pin SOT-23	A is equivalent to EIAJ S	C-74A.

Available Output Voltages:

1.8, 2.5, 2.7, 2.8, 2.85, 3.0, 3.3, 3.6, 4.0, 5.0 xx indicates ouput voltages

Other output voltages are available. Please contact TelCom Semiconductor for details.

PIN CONFIGURATION



TC1014 TC1015 TC1185

ABSOLUTE MAXIMUM RATINGS*

Input Voltage	6.5V
Output Voltage	(- 0.3) to (V _{IN} + 0.3)
Power Dissipation	Internally Limited
Operating Temperature	$ 40^{\circ}C < T_{J} < 125^{\circ}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: $V_{IN} = V_R + 1V$, $IL = 100\mu$ A, $CL = 3.3\mu$ F, SHDN > V_{IH} , $T_A = 25^{\circ}$ C, unless otherwise noted. **Boldface** type specifications apply for junction temperatures of -40° C to $+125^{\circ}$ C.

Symbol	Parameter	Test Conditions	Min	Тур	Max	Units
V _{IN}	Input Operating Voltage	Note 1	2.7	_	6.0	V
IOUTMAX	Maximum Output Current	TC1014 TC1015 TC1185	50 100 150			mA
V _{OUT}	Output Voltage	Note 2	V _R – 2.5%	V _R ±0.5%	V _R + 2.5%	V
TCV _{OUT}	V _{OUT} Temperature Coefficient	Note 3	_	20 40	_	ppm/°C
$\Delta V_{OUT} / \Delta V_{IN}$	Line Regulation	$(V_R + 1V) \le V_{IN} \le 6V$	_	0.05	0.35	%
$\Delta V_{OUT}/V_{OUT}$	Load Regulation TC1014;TC1015 TC1185	$I_{L} = 0.1 \text{mA to } I_{\text{OUTMAX}}$ $I_{L} = 0.1 \text{mA to } I_{\text{OUTMAX}}$ $Note \ 4$	_	0.5 0.5	2 3	%
V _{IN} – V _{OUT}	Dropout Voltage TC1015; TC1185 TC1185	$I_L = 100\mu A$ $I_L = 20m A$ $I_L = 50m A$ $I_L = 100m A$ $I_L = 150m A$ Note 5	 	2 65 85 180 270	 120 250 400	mV
I _{IN}	Supply Current (Note 8)	$\overline{\text{SHDN}} = V_{\text{IH}}, I_{\text{L}} = 0$	_	50	80	μA
I _{INSD}	Shutdown Supply Current	SHDN = 0V	—	0.05	0.5	μΑ
PSRR	Power Supply Rejection Ratio	$F_{RE} \leq 1 KHz$	—	64	—	dB
IOUTSC	Output Short Circuit Current	$V_{OUT} = 0V$	—	300	450	mA
$\Delta V_{OUT} / \Delta P_D$	Thermal Regulation	Notes 6, 7	—	0.04	—	V/W
T _{SD}	Thermal Shutdown Die Temperature		—	160	—	°C
ΔT_{SD}	Thermal Shutdown Hysteresis			10	—	°C
eN	Output Noise	$I_L = I_{OUTMAX}$, F = 10kHz 470pF from Bypass to GND	_	600		nV/√Hz

SHDN Input

VIH	SHDN Input High Threshold	$V_{IN} = 2.5V$ to $6.5V$	45	 	%V _{IN}
V _{IL}	SHDN Input Low Threshold	$V_{IN} = 2.5V$ to 6.5V		 15	%V _{IN}

NOTES: 1. The minimum V_{IN} has to meet two conditions: $V_{IN} \ge 2.7V$ and $V_{IN} \ge V_R + V_{DROPOUT}$.

2. V_R is the regulator output voltage setting. For example: V_R = 1.8V, 2.5V, 2.7V, 2.8V, 2.85V, 3.0V, 3.3V, 3.6V, 4.0V, 5.0V.

3. TCV_{OUT} = $(V_{OUTMAX} - V_{OUTMIN}) \times 10^{6}$

ν_{ουτ} χ Δτ

4. Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 1.0mA 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 at a 1V differential.
 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.

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, θ_{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. Apply for Junction Temperatures of -40° C to $+85^{\circ}$ C.

PIN DESCRIPTION

Pin No. (5-Pin SOT-23A) Symbol		Description		
1	V _{IN}	Unregulated supply input.		
2	GND	Ground terminal.		
3	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 0.5μ A (max).		
4	Bypass	Reference bypass input. Connecting a 470pF to this input further reduces output noise.		
5	V _{OUT}	Regulated voltage output.		

DETAILED DESCRIPTION

The TC1014, TC1015, and TC1185 are precision fixed output voltage regulators. (If an adjustable version is desired, please see the TC1070, TC1071, or TC1187 data sheets.) Unlike bipolar regulators, the TC1014, TC1015, and TC1185 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 (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) and V_{OUT} falls to zero volts.



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.

Output Capacitor

A 1 μ F (min) capacitor from V_{OUT} to ground is required. The output capacitor should have an effective series resistance of 5 Ω or less. A 1 μ 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.

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:

Figure 1. Typical Application Circuit

TC1014 TC1015 TC1185

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

Where:

 $\label{eq:PD} \begin{array}{l} \mathsf{P}_{\mathsf{D}} = \mathsf{W} \mathsf{orst} \ \mathsf{case} \ \mathsf{actual} \ \mathsf{power} \ \mathsf{dissipation} \\ \mathsf{V}_{\mathsf{IN}_{\mathsf{MAX}}} = \mathsf{M} \mathsf{aximum} \ \mathsf{voltage} \ \mathsf{on} \ \mathsf{V}_{\mathsf{IN}} \\ \mathsf{V}_{\mathsf{OUT}_{\mathsf{MIN}}} = \mathsf{M} \mathsf{inimum} \ \mathsf{regulator} \ \mathsf{output} \ \mathsf{voltage} \\ \mathsf{I}_{\mathsf{LOAD}_{\mathsf{MAX}}} = \mathsf{M} \mathsf{aximum} \ \mathsf{output} \ (\mathsf{load}) \ \mathsf{current} \end{array}$

Equation 1.

The maximum *allowable* power dissipation (Equation 2) is a function of the maximum ambient temperature (T_{AMAX}) , the maximum allowable die temperature $(125^{\circ}C)$ and the thermal resistance from junction-to-air (θ_{JA}) . The 5-Pin SOT-23A package 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:

$$V_{IN_{MAX}} = 3.0V + 10\%$$

 $V_{OUT_{MIN}} = 2.7V - 2.5\%$
 $I_{LOAD_{MAX}} = 40mA$
 $T_{JMAX} = 125^{\circ}C$
 $T_{AMAX} = 55^{\circ}C$

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

Actual power dissipation:

$$\begin{split} \mathsf{P}_{\mathsf{D}} &\approx (\mathsf{V}_{\mathsf{IN}_{\mathsf{MAX}}} - \mathsf{V}_{\mathsf{OUT}_{\mathsf{MIN}}}) \mathsf{I}_{\mathsf{LOAD}_{\mathsf{MAX}}} \\ &= [(3.0 \text{ x } 1.1) - (2.7 \text{ x } .975)] 40 \text{ x } 10^{-3} \\ &= 26.7 \text{mW} \end{split}$$

Maximum allowable power dissipation:

$$P_{D_{MAX}} = (\underbrace{T_{J_{MAX}} - T_{A_{MAX}}}_{\theta_{JA}})$$
$$= \underbrace{(125 - 55)}_{220}$$
$$= 318 \text{mW}$$

In this example, the TC1014 dissipates a maximum of only 26.7 mW; far below the allowable limit of 318 mW. 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.



TYPICAL CHARACTERISTICS: (Unless otherwise specified, all parts are measured at Temperature = 25°C)



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TYPICAL CHARACTERISTICS

















50mA, 100mA, 150mA CMOS LDOs with Shutdown and Reference Bypass

TYPICAL CHARACTERISTICS

Measure Rise Time of 3.3V LDO with Bypass Capacitor

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $C_{BYP} = 470 pF$, $I_{LOAD} = 100 mA$ $V_{IN} = 4.3V$, Temp = 25°C, Rise Time = 448 μ S



Measure Rise Time of 3.3V LDO without Bypass Capacitor

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $C_{BYP} = 0pF$, $I_{LOAD} = 100mA$ $V_{IN} = 4.3V$, Temp = 25°C, Rise Time = 184 μ S



Measure Fall Time of 3.3V LDO with Bypass Capacitor

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $C_{BYP} = 470pF$, $I_{LOAD} = 50mA$ $V_{IN} = 4.3V$, Temp = 25°C, Fall Time = 100 μ S



Measure Fall Time of 3.3V LDO without Bypass Capacitor



TYPICAL CHARACTERISTICS

Measure Rise Time of 5.0V LDO with Bypass Capacitor





Measure Fall Time of 5.0V LDO with Bypass Capacitor

Conditions: C_{_{\rm IN}} = 1µF, C_{_{\rm OUT}} = 1µF, C_ $_{_{\rm BYP}}$ = 470pF, I $_{_{\rm LOAD}}$ = 50mA \textbf{V}_{IN} = 6V, Temp = 25°C, Fall Time = 167 μ S



Measure Fall Time of 5.0V LDO without Bypass Capacitor

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $C_{BYP} = 0pF$, $I_{LOAD} = 100mA$ V_{IN} = 6V, Temp = 25°C, Fall Time = 88µS



Measure Rise Time of 5.0V LDO without Bypass Capacitor

TC1014 TC1015 **TC1185**

TC1014 TC1015 TC1185

TYPICAL CHARACTERISTICS

Load Regulation of 3.3V LDO

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 2.2\mu F$, $C_{BYP} = 470pF$, $V_{IN} = V_{OUT} + 0.25V$, Temp = 25°C



Load Regulation of 3.3V LDO



Load Regulation of 3.3V LDO



Line Regulation of 3.3V LDO

Conditions: $V_{IN} = 4V,+ 1V$ Squarewave @ 2.5kHz,



TYPICAL CHARACTERISTICS

Line Regulation of 5.0V LDO



Thermal Shutdown Response of 5.0V LDO

TC1014 TC1015 TC1185



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

TC1014 TC1015 TC1185

TAPING FORM



MARKING



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

<u>(V)</u>	TC1014 Code	<u>TC1015 Code</u>	TC1185 Code
1.8	AY	BY	NY
2.5	A1	B1	N1
2.7	A2	B2	N2
2.8	AZ	BZ	NZ
2.85	A8	B8	N8
3.0	A3	B3	N3
3.3	A5	B5	N5
3.6	A9	B9	N9
4.0	A0	B0	N0
5.0	A7	B7	N7

③ represents date code

④ represents lot ID number

TC1014 TC1015 TC1185

PACKAGE DIMENSIONS



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