300mA CMOS LDO with Shutdown, Bypass and Independent Delayed Reset Function

FEATURES

- **LDO with Integrated Microprocessor Reset Monitor Functionality**
- **Extremely Low Supply Current (80µA typ.) for Longer Battery Life!**
- **Stable with Any Type of Capacitor**
- **Very Low Dropout Voltage**
- **10µsec (typ.) Wake Up Time from SHDN**
- **Guaranteed 300mA Output Current**
- **Standard or Custom Output and Detected Voltages**
- **Power-Saving Shutdown Mode**
- **Bypass Input for Ultra-Quiet Operation**
- **Separate Input and Detected Voltage**
- **140msec Guaranteed Minimum RESET Output Duration**
- **Space-Saving MSOP Package**

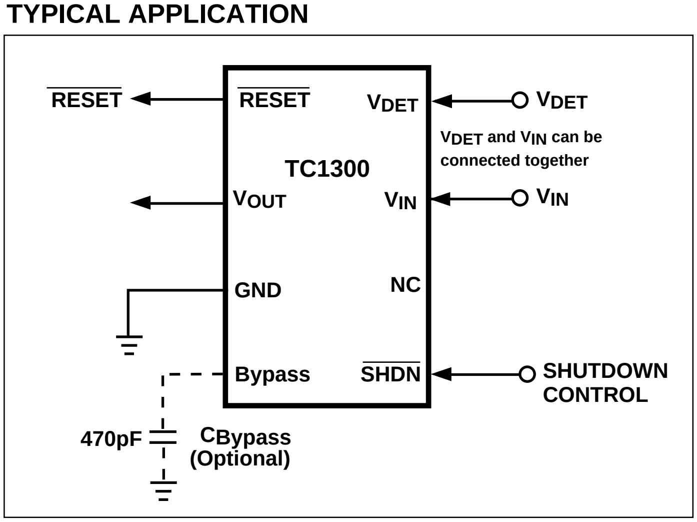
APPLICATIONS

- **Battery-Operated Systems**
- **Portable Computers**
- **Medical Instruments**
- **Pagers**
- **Cellular / GSM / PHS Phones**

RELATED LITERATURE

- **Application Notes: 41, 47 and 66**
- **Article: "TelCom's CMOS LDOs Exhibit Excellent Stability While Offering the Advantages of Low-Value Ceramic Capacitors"**

TYPICAL APPLICATION



GENERAL DESCRIPTION

The TC1300 combines a Low Dropout Regulator and a Microprocessor Reset Monitor in a space-saving 8-Pin MSOP package. Total supply current is 80µA (typical), 20 to 60 times lower than in bipolar regulators.

The TC1300 has an extremely precise output with a typical accuracy of ±0.5%. Other key features include ultra low noise operation, very low dropout voltage and internal feed-forward compensation for fast response to step changes in load. The TC1300 incorporates both over-temperature and over-current protection. When the shutdown control (SHDN) is low, the regulator output voltage falls to zero, RESET output remains valid and supply current is reduced to 30µA (typical). The TC1300 is stable with an output capacitor of only 1µF and has a maximum output current of 300mA.

An active low RESET is asserted when the detected voltage (V_{DET}) falls below the reset voltage threshold. The RESET output remains low for 300msec (typical) after V_{DET} rises above reset threshold. The TC1300 also has a fast wake up response time (10µsec typically) when released from shutdown.

ORDERING INFORMATION

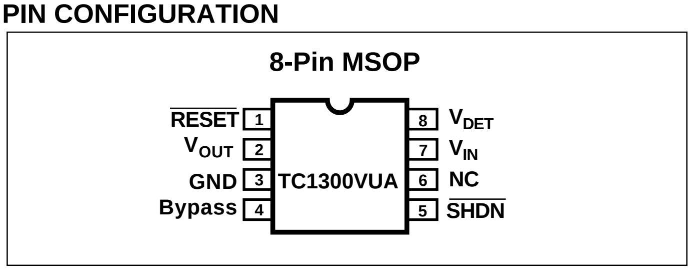
Part Number	Package	Junction Temp. Range
TC1300R-xxVUA	8-Pin MSOP	– 40°C to +125°C

NOTE: The "R" denotes the suffix for the 2.63V V_{DET} threshold

Available Output Voltages:
2.5, 2.8, 2.85, 3.0, 3.3
xx indicates output voltages

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

PIN CONFIGURATION



ABSOLUTE MAXIMUM RATINGS*

Input Voltage 6.5V
Output Voltage .... (V_{SS} – 0.3) to (V_{IN} + 0.3)
Power Dissipation .... Internally Limited (Note 6)
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.) .... +300°C

*Absolute Maximum Ratings indicate device operation limits beyond damage may occur. Device operation beyond the limits listed in is not recommended.

ELECTRICAL CHARACTERISTICS:

$V_{IN} = V_{OUT} + 1V$, $I_L = 0.1mA$, $C_L = 3.3\mu F$, $\overline{SHDN} > V_{IH}$, $T_A = 25°C$, unless otherwise noted. **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		—	—	**6.0**	V
I_{OUTMAX}	Maximum Output Current		**300**	—	—	mA
V_{OUT}	Output Voltage	Note 1	— **V_R - 2.5%**	V_R ± 0.5%	— **V_R + 2.5%**	V
$\Delta V_{OUT}/\Delta T$	V_{OUT} Temperature Coefficient	Note 2	—	**25**	—	ppm/°C
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	$(V_R + 1V) \leq V_{IN} \leq 6V$	—	0.02	**0.35**	%
$\Delta V_{OUT}/V_{OUT}$	Load Regulation	I_L = 0.1mA to I_{OUTMAX} (Note 3)	—	0.5	**2.0**	%
$V_{IN} – V_{OUT}$	Dropout Voltage (Note 4)	I_L = 0.1mA I_L = 100mA I_L = 300mA	—	1 70 210	**30** **130** **390**	mV
I_{SS1}	Supply Current	$\overline{SHDN} = V_{IH}$	—	80	**160**	μA
I_{SS2}	Shutdown Supply Current	$\overline{SHDN}$ = 0V	—	30	**60**	μA
PSRR	Power Supply Rejection Ratio	f ≤ 1kHz	—	60	—	dB
I_{OUTSC}	Output Short Circuit Current	V_{OUT} = 0V	—	800	1200	mA
$\Delta V_{OUT} \Delta P_D$	Thermal Regulation	Note 5	—	0.04	—	%/W
eN	Output Noise	f = 1kHz, $C_{OUT} = 1\mu F$, $R_{LOAD} = 50\Omega$	—	900	—	$nV/\sqrt{Hz}$
t_{WK}	Wake Up Time (from Shutdown Mode)	V_{IN} = 5V $C_{IN} = 1\mu F$, $C_{OUT} = 4.7\mu F$ I_L = 30mA, (See Fig. 2)	—	10	20	μsec
t_S	Settling Time (from Shutdown Mode)	V_{IN} = 5V $C_{IN} = 1\mu F$, $C_{OUT} = 4.7\mu F$ I_L = 30mA, (See Fig. 2)	—	50	—	μsec
T_{SD}	Thermal Shutdown Die Temperature		—	150	—	°C
T_{HYS}	Thermal Shutdown Hysteresis		—	10	—	°C
$\overline{SHDN}$ Input						
V_{IH}	$\overline{SHDN}$ Input High Threshold		**45**	—	—	$\%V_{IN}$
V_{IL}	$\overline{SHDN}$ Input Low Threshold		—	—	**15**	$\%V_{IN}$

ELECTRICAL CHARACTERISTICS: (CONT.)

ELECTRICAL CHARACTERISTICS: $V_{IN} = V_{OUT} + 1V$, $I_L = 0.1mA$, $C_L = 3.3\mu F$, SHDN > V_{IH}, $T_A = 25°C$, unless otherwise noted. **BOLDFACE** type specifications apply for junction temperatures of – 40°C to +125°C

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
$\overline{\text{RESET}}$ Output						
V_{DET}	V_{DET} Voltage Range	T_A = 0°C to +70°C T_A = – 40°C to +125°C	1.0 1.2	— —	6.0 6.0	V
V_{TH}	Reset Threshold	T_A = +25°C T_A = – 40°C to +125°C	2.59 2.55	2.63 —	2.66 2.70	V
	Reset Threshold Tempco		—	30	—	ppm/°C
	V_{DET} to Reset Delay	$V_{DET} = V_{TH}$ to (V_{TH} – 100mV)	—	160	—	µsec
	Reset Active Timeout Period		140	300	560	msec
V_{OL}	$\overline{\text{RESET}}$ Output Voltage Low	$V_{DET} = V_{TH}$ min, I_{SINK} = 1.2mA	—	—	0.3	V
V_{OH}	$\overline{\text{RESET}}$ Output Voltage High	$V_{DET} > V_{TH}$ max, I_{SOURCE} = 500µA	0.8 V_{DET}	—	—	V

NOTES:
1. V_R is the regulator output voltage setting.
2. $T_C V_{OUT} = \frac{(V_{OUTMAX} - V_{OUTMIN}) \times 10^6}{V_{OUT} \times \Delta T}$
3. Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 0.1mA 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 measured at a 1V differential.
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_{LMAX} at V_{IN} = 6V for t = 10msec.
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_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.

DETAILED DESCRIPTION

The TC1300 is a combination of a fixed output, low drop-out regulator and a microprocessor monitor. Unlike bipolar regulators, the TC1300 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) as well as with any type of capacitor (see * below). TC1300 pin functions are detailed below:

PIN DESCRIPTIONS

Pin No.	Symbol	Description
1	$\overline{\text{RESET}}$	$\overline{\text{RESET}}$ output remains low while V_{DET} is below the reset voltage threshold, and for 300msec after V_{DET} rises above reset theshold.
2	V_{OUT}	Regulated Voltage Output
3	GND	Ground Terminal
4	Bypass	Reference Bypass Input. Connecting a 470pF to this input further reduces output noise.
5	$\overline{\text{SHDN}}$	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, regulator output voltage falls to zero, $\overline{\text{RESET}}$ output remains valid and supply current is reduced to 30µA (typ.).
6	NC	No connect
7	V_{IN}	Power Supply Input
8	V_{DET}	Detected Input Voltage. V_{DET} and V_{IN} can be connected together.

Figure 1 shows a typical application circuit. The regulator is enabled any time the shutdown input ($\overline{\text{SHDN}}$) is above V_{IH}, and shutdown (disabled) when $\overline{\text{SHDN}}$ is at or below V_{IL}. $\overline{\text{SHDN}}$ may be controlled by a CMOS logic gate, or I/O port of a microcontroller. If the $\overline{\text{SHDN}}$ input is not required, it should be connected directly to the input supply. While in shutdown, supply current decreases to 30µA (typical), V_{OUT} falls to zero and $\overline{\text{RESET}}$ remains valid.

$\overline{\text{RESET}}$ Output

The $\overline{\text{RESET}}$ output is driven active low within 160 µsec of V_{DET} falling through the reset voltage threshold. $\overline{\text{RESET}}$ is maintained active for a minimum of 140msec after V_{DET} rises above the reset threshold. The TC1300 has an active-low $\overline{\text{RESET}}$ output. The output of the TC1300 is guaranteed valid down to V_{DET} = 1V and is optimized to reject fast transient glitches on the V_{DET} line.

* Article: "TelCom's CMOS LDOs Exhibit Excellent Stability While Offering the Advantage of Low-Value Ceramic Capacitors"

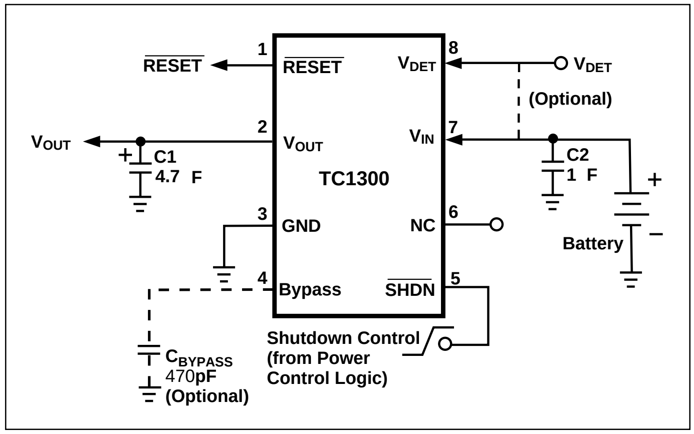


Figure 1: Typical Application Circuit

Output Capacitor

A 1µF (min) capacitor from V_{OUT} to ground is required. A 1µF capacitor should also 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, ceramic 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 (optional)

A 470pF capacitor connected from the Bypass input to ground reduces noise present on the internal reference, which in turn significantly reduces output noise. 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.

Turn On Response

The turn on response is defined as two separate response categories, **Wake Up Time (t_{WK})** and **Settling Time (t_S).**

The TC1300 has a fast Wake Up Time (10µsec typical) when released from shutdown. See Figure 2 for the **Wake Up Time** designated as **t_{WK}**. The **Wake Up Time** is defined as the time it takes for the output to rise to 2% of the V_{OUT} value after being released from shutdown.

The total turn on response is defined as the **Settling Time (t_S)**, see Figure 2. **Settling Time** (inclusive with t_{WK}) is defined as the condition when the output is within 2% of its fully enabled value (50µsec typical) when released from shutdown. The settling time of the output voltage is dependent on load conditions and output capacitance on V_{OUT} (RC response).

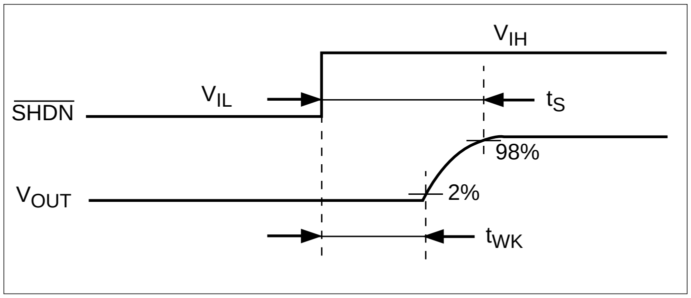


Figure 2: Wake Up Response Time

Thermal Considerations

Thermal Shutdown

Integrated thermal protection circuitry shuts the regulator off when die temperature exceeds 150°C. The regulator remains off until the die temperature drops to approximately 140°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:

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

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

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}). The SOIC-8 package has a θ_{JA} of approximately **160°C/Watt,** while the MSOP-8 package has a θ_{JA} of approximately **200°C/Watt;** both when mounted on a single layer FR4 dielectric copper clad PC board.

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

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_{INMAX} = 4.0V ± 10%
V_{OUTMIN} = 3.3V ± 2.5%
$I_{LOADMAX}$ = 200mA
T_{JMAX} = 125°C
T_{AMAX} = 55°C
θ_{JA} = 200°C/W
MSOP-8 Package

FIND: 1. Actual power dissipation

Actual power dissipation:

$$P_D \approx (V_{INMAX} - V_{OUTMIN}) I_{LOADMAX}$$
$$= [(4.0 \times 1.1) - (3.03 \times .975)]200 \times 10^{-3}$$
$$= \underline{236.5mW}$$

Maximum allowable power dissipation:

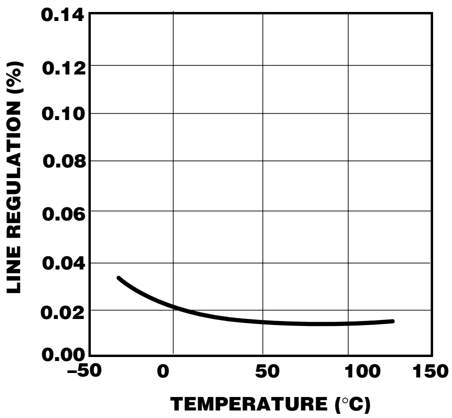
$$P_D \approx \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}}$$
$$= \frac{(125 - 55)}{200}$$
$$= \underline{350mW}$$

In this example, the TC1300 dissipates a maximum of only 236.5mW; far below the allowable limit of 350mW. 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 350mW into Equation 1, from which V_{INMAX} = 4.1V.

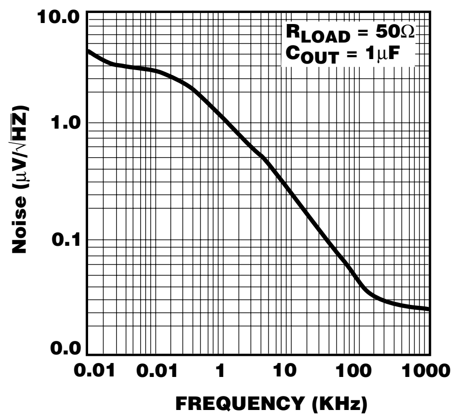
Layout Considerations

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.

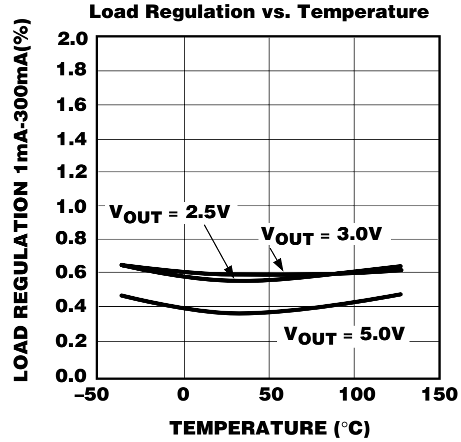
TYPICAL CHARACTERISTICS



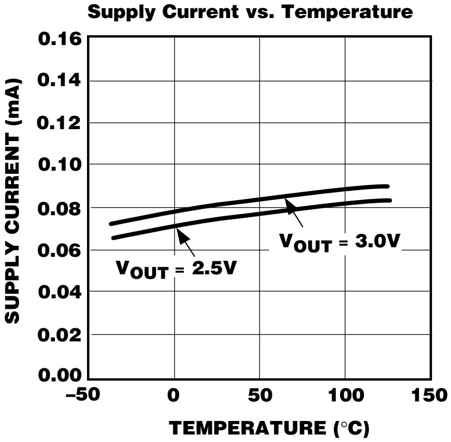
Line Regulation vs. Temperature



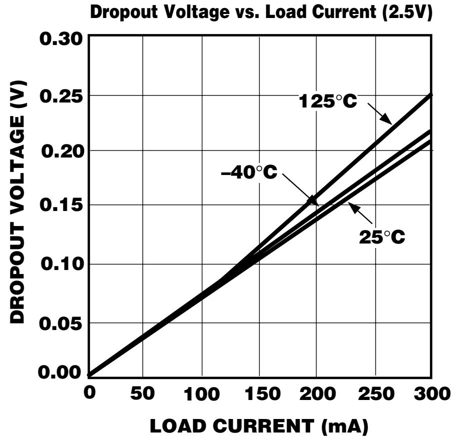
Output Noise vs. Frequency



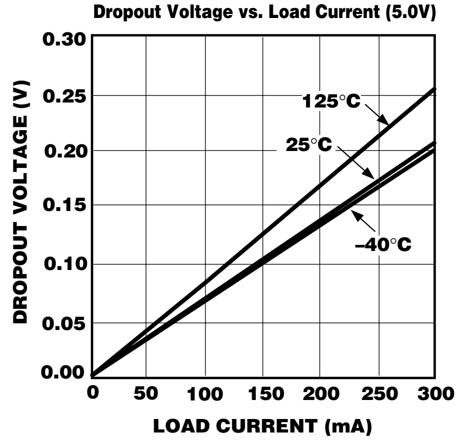
Load Regulation vs. Temperature



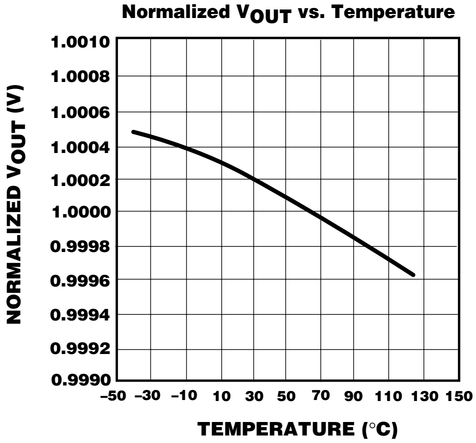
Supply Current vs. Temperature



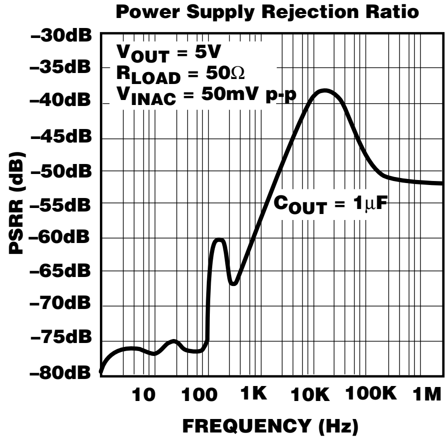
Dropout Voltage vs. Load Current (2.5V)



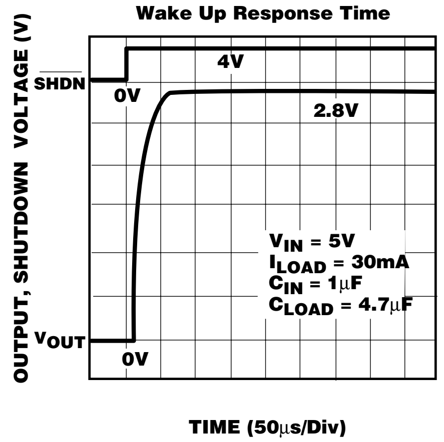
Dropout Voltage vs. Load Current (5.0V)



Normalized V_{OUT} vs. Temperature

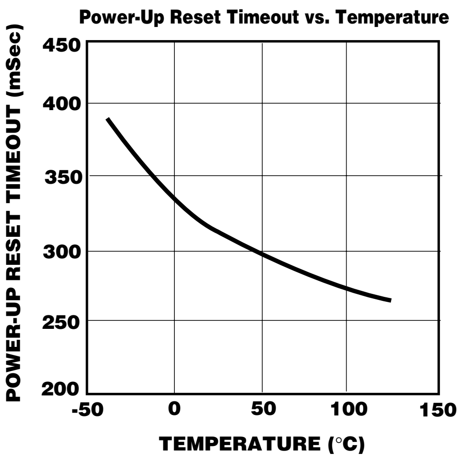


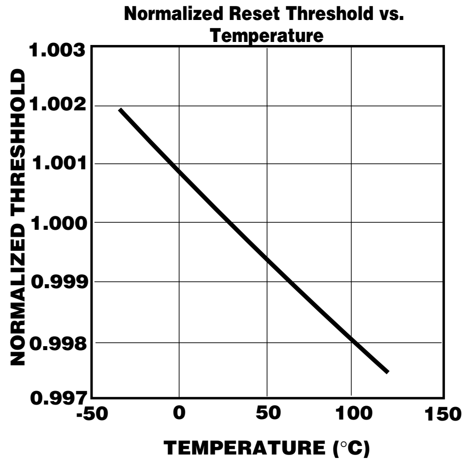
Power Supply Rejection Ratio

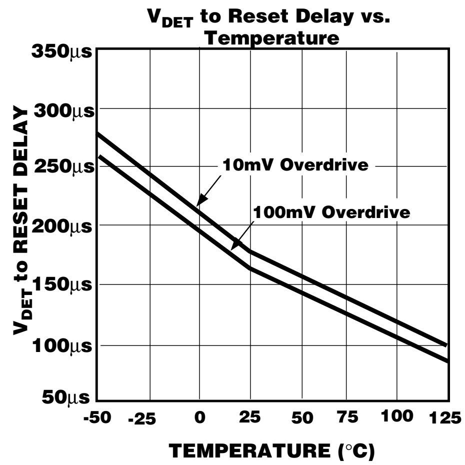


Wake Up Response Time

TYPICAL CHARACTERISTICS

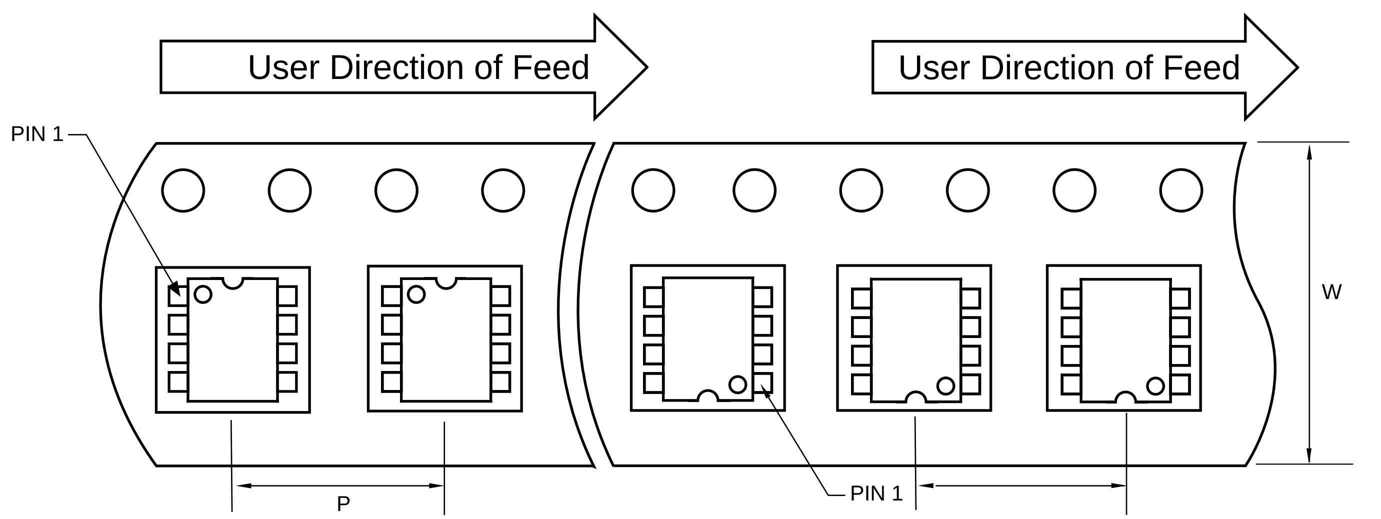






TAPE AND REEL DIAGRAMS

Component Taping Orientation for 8-Pin SOIC (Narrow) Devices



Standard Reel Component Orientation
for TR Suffix Device

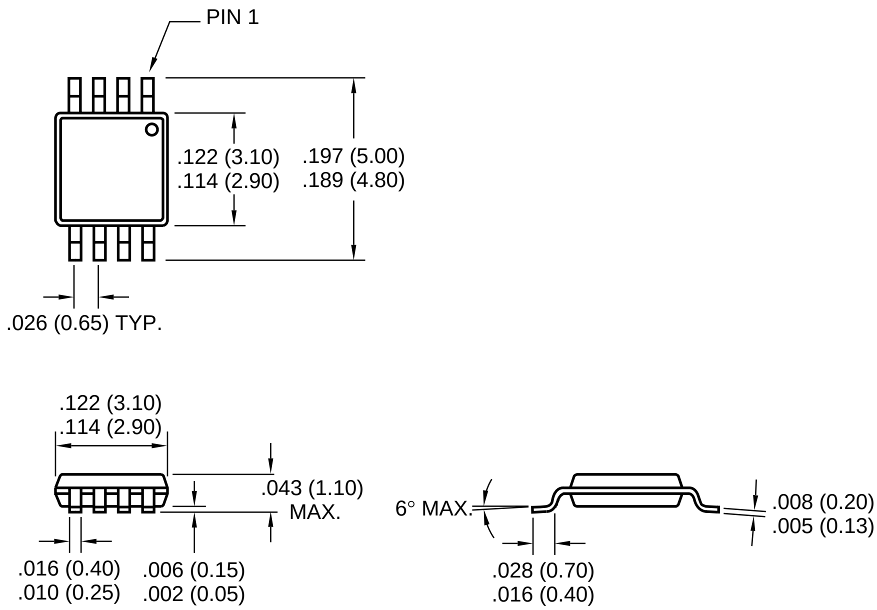
Standard Reel Component Orientation
for RT Suffix Device

Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin SOIC (N)	12 mm	8 mm	2500	13 in

PACKAGE DIMENSIONS

8-Pin MSOP



Dimensions: inches (mm)

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WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office
2355 West Chandler Blvd.
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Chandler, AZ 85224-6199
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Analog Product Sales
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Chicago
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Itasca, IL 60143
Tel: 630-285-0071 Fax: 630-285-0075

Dallas
4570 Westgrove Drive, Suite 160
Addison, TX 75001
Tel: 972-818-7423 Fax: 972-818-2924

Dayton
Two Prestige Place, Suite 130
Miamisburg, OH 45342
Tel: 937-291-1654 Fax: 937-291-9175

Detroit
Tri-Atria Office Building
32255 Northwestern Highway, Suite 190
Farmington Hills, MI 48334
Tel: 248-538-2250 Fax: 248-538-2260

Los Angeles
18201 Von Karman, Suite 1090
Irvine, CA 92612
Tel: 949-263-1888 Fax: 949-263-1338

Mountain View
Analog Product Sales
1300 Terra Bella Avenue
Mountain View, CA 94043-1836
Tel: 650-968-9241 Fax: 650-967-1590

New York
150 Motor Parkway, Suite 202
Hauppauge, NY 11788
Tel: 631-273-5305 Fax: 631-273-5335

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

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

ASIA/PACIFIC

China - Beijing
Microchip Technology Beijing Office
Unit 915
New China Hong Kong Manhattan Bldg.
No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100 Fax: 86-10-85282104

China - Shanghai
Microchip Technology Shanghai Office
Room 701, Bldg. B
Far East International Plaza
No. 317 Xian Xia Road
Shanghai, 200051
Tel: 86-21-6275-5700 Fax: 86-21-6275-5060

Hong Kong
Microchip Asia Pacific
RM 2101, Tower 2, Metroplaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2401-1200 Fax: 852-2401-3431

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

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

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

ASIA/PACIFIC (continued)

Singapore
Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore, 188980
Tel: 65-334-8870 Fax: 65-334-8850

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

EUROPE

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

Denmark
Microchip Technology Denmark ApS
Regus Business Centre
Lautrup hoj 1-3
Ballerup DK-2750 Denmark
Tel: 45 4420 9895 Fax: 45 4420 9910

France
Arizona Microchip Technology SARL
Parc díActivite du Moulin de Massy
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Batiment A - ler Etage
91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

Germany
Arizona Microchip Technology GmbH
Gustav-Heinemann Ring 125
D-81739 Munich, Germany
Tel: 49-89-627-144 0 Fax: 49-89-627-144-44

Germany
Analog Product Sales
Lochhamer Strasse 13
D-82152 Martinsried, Germany
Tel: 49-89-895650-0 Fax: 49-89-895650-22

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

United Kingdom
Arizona Microchip Technology Ltd.
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921 5869 Fax: 44-118 921-5820

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