

Dual 150mA CMOS LDO With Select Mode™ Operation, Shutdown And RESET Output

FEATURES

- Extremely Low Supply Current for Longer Battery Life
- Select Mode™ Operation: Selectable Output Voltages for High Design Flexibility
- Very Low Dropout Voltage
- 10µsec (Typ.) Wake-Up Time from SHDN
- Maximum 150mA Output Current per Output
- High Output Voltage Accuracy
- Power-Saving Shutdown Mode
- RESET Output Can Be Used as a Low Battery Detector, or Processor Reset Generator
- Over-Current Protection and Over-Temperature Shutdown
- Space-Saving 8-Pin MSOP Package

APPLICATIONS

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

GENERAL DESCRIPTION

The TC1306 combines two CMOS Low Dropout Regulators and a Microprocessor Monitor in a space-saving 8-Pin MSOP package. Designed specifically for battery-operated systems, total supply current for the device is typically 120µA at full load; 20 to 60 times lower than in bipolar regulators.

The TC1306 features selectable output voltages for higher design flexibility. The dual-state SELECT input pin allows the user to select V_{OUT2} from 2 different values (2.8V and 3.0V). V_{OUT1} supplies a fixed 1.8V voltage.

An active low RESET is asserted when the output voltage V_{OUT2} falls below the 2.63V reset voltage threshold. The RESET output remains low for 300msec (typical) after V_{OUT2} rises above reset threshold. When the shutdown control (SHDN1) is low, the regulator output voltage V_{OUT1} falls to zero and RESET output remains valid. When the shutdown control (SHDN2) is low, the regulator output voltage V_{OUT2} falls to zero and RESET output is low.

Other key features for the device include ultra low-noise operation, fast response to step changes in load, and very low dropout voltage (typically 125mV at full load). The device also incorporates both over-temperature and over-current protection.

Each regulator is stable with an output capacitor of only 1µF and has a maximum output current of 150mA.

ORDERING INFORMATION

Part Number	Package	Junction Temp. Range
TC1306R-BDVUA	8-Pin MSOP	- 40°C to +125°C

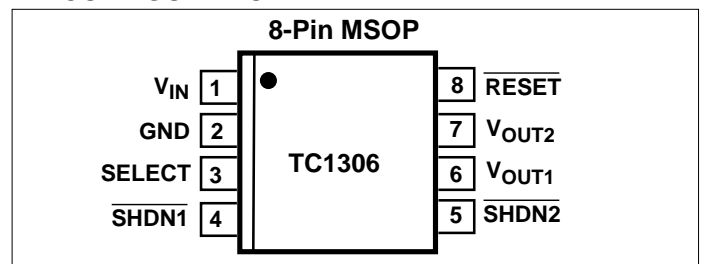
NOTE: The "R" denotes the suffix for the 2.63V RESET threshold

Available Output Voltages:

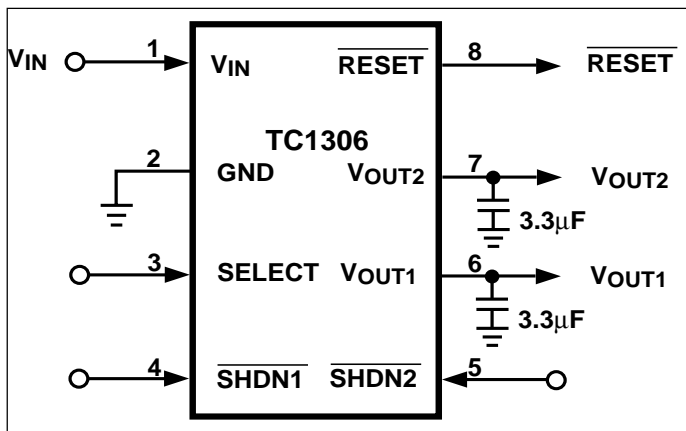
B indicates $V_{out1} = 1.8V$ (fixed)
 D indicates $V_{out2} = 2.8V, 3.0V$ (selectable)

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

PIN CONFIGURATION



TYPICAL APPLICATION



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ABSOLUTE MAXIMUM RATINGS*

Input Voltage	6.5V
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: [Output 1 + Output 2] V_{IN} = V_R + 1V, I_L = 100μA, C_L = 3.3μF, $\overline{\text{SHDN1}} > V_{IH}$, $\overline{\text{SHDN2}} > V_{IH}$, 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	Note 1	2.7	—	6.0	V
I _{OUTMAX}	Maximum Output Current		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
ΔV _{OUT} /ΔV _{IN}	Line Regulation	(V _R + 1V) ≤ V _{IN} ≤ 6V	—	0.05	0.35	%
ΔV _{OUT} /V _{OUT}	Load Regulation	I _L = 0.1mA to I _{OUTMAX} Note 4	—	0.3	2	%
V _{IN} – V _{OUT}	Dropout Voltage	I _L = 100μA I _L = 50mA I _L = 100mA I _L = 150mA Note 5	—	2 45 85 125	— 120 240 360	mV
I _{IN}	Supply Current	$\overline{\text{SHDN1}}, \overline{\text{SHDN2}} = V_{IH}$, I _L = 0	—	120	200	μA
I _{INSD}	Shutdown Supply Current	$\overline{\text{SHDN1}}, \overline{\text{SHDN2}} = 0V$	—	0.05	0.5	μA
PSRR	Power Supply Rejection Ratio	F _{RE} ≤ 120Hz	—	55	—	dB
I _{OUTSC}	Output Short Circuit Current	V _{OUT} = 0V	—	450	—	mA
ΔV _{OUT} /ΔP _D	Thermal Regulation	Notes 6, 7	—	0.04	—	V/W
t _{WK}	Wake Up Time (from Shutdown Mode)	V _{IN} = 5V C _{IN} = 1μF, C _{OUT} = 4.7μF I _L = 30mA, (See Fig. 1)	—	10	—	μsec
t _S	Settling Time (from Shutdown Mode)	V _{IN} = 5V C _{IN} = 1μF, C _{OUT} = 4.7μF I _L = 30mA, (See Fig. 1)	—	40	—	μsec
T _{SD}	Thermal Shutdown Die Temperature		—	160	—	°C
ΔT _{SD}	Thermal Shutdown Hysteresis		—	15	—	°C
eN	Output Noise	F = 10kHz	—	200	—	nV/√Hz

SHDN Input

V _{IH}	$\overline{\text{SHDN}}$ Input High Threshold	V _{IN} = 2.7V to 6.0V	65	—	—	%V _{IN}
V _{IL}	$\overline{\text{SHDN}}$ Input Low Threshold	V _{IN} = 2.7V to 6.0V	—	—	15	%V _{IN}

SELECT Input

V _{SELH}	SELECT Input High Threshold	V _{IN} = 2.7V to 6.0V	65	—	—	%V _{IN}
V _{SELL}	SELECT Input Low Threshold	V _{IN} = 2.7V to 6.0V	—	—	15	%V _{IN}

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ELECTRICAL CHARACTERISTICS: $V_{IN} = V_R + 1V$, $I_L = 100\mu A$, $C_L = 3.3\mu F$, $SHDN1 > V_{IH}$, $SHDN2 > V_{IH}$, $T_A = 25^\circ C$, unless otherwise noted. **Boldface** type specifications apply for junction temperatures of $-40^\circ C$ to $+125^\circ C$.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
RESET Output						
$V_{MIN,IN}$	Minimum V_{IN} Operating Voltage	$T_A = 0^\circ C$ to $+70^\circ C$ $T_A = -40^\circ C$ to $+125^\circ C$	1.0 1.2	—	6.0 6.0	V
V_{TH}	Reset Threshold	$T_A = +25^\circ C$ $T_A = -40^\circ C$ to $+125^\circ C$	2.59 2.55	2.63 —	2.66 2.70	V
	Reset Threshold Tempco		—	30	—	ppm/ $^\circ C$
	V_{OUT2} to Reset Delay	$V_{OUT2} = V_{TH}$ to $(V_{TH} - 100mV)$	—	100	—	μsec
	Reset Active Timeout Period		140	300	560	msec
V_{OL}	RESET Output Voltage Low	$V_{OUT2} = V_{TH}$ min, $I_{SINK} = 1.2mA$ $V_{OUT2} = V_{TH}$ min, $I_{SINK} = 3.2mA$ $V_{OUT2} > 1.0V$, $I_{SINK} = 50\mu A$	— — —	— — —	0.3 0.4 0.3	V
V_{OH}	RESET Output Voltage High	$V_{OUT2} > V_{TH}$ max, $I_{SOURCE} = 500\mu A$ $V_{OUT2} > V_{TH}$ max, $I_{SOURCE} = 800\mu A$	$0.8 V_{OUT2}$ $V_{OUT2} - 1.5$	— —	— —	V

- NOTES:**
- The minimum V_{IN} has to meet two conditions: $V_{IN} \geq 2.7V$ and $V_{IN} \geq V_R + V_{DROPOUT}$
 - V_R is the regulator output voltage setting. For example: $V_R = 2.8V$, $3.0V$.
 - $TCV_{OUT} = \frac{(V_{OUTMAX} - V_{OUTMIN}) \times 10^6}{V_{OUT} \times \Delta T}$
 - Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 0.1mA 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}). Please see **Thermal Considerations** section of this data sheet for more details.

PIN DESCRIPTION

Pin No. (8-Pin MSOP)	Symbol	Description
1	V_{IN}	Power supply input.
2	GND	Ground terminal.
3	SELECT	SELECT control input for setting V_{OUT2} . SELECT=Low for $V_{OUT2} = 2.8V$, SELECT=High for $V_{OUT2} = 3.0V$
4	SHDN1	Shutdown control input for V_{OUT1} . Regulator 1 is fully enabled when a logic high is applied to this input. Regulator 1 enters shutdown when a logic low is applied to this input. During shutdown, regulator output voltage falls to zero, RESET output remains valid.
5	SHDN2	Shutdown control input for V_{OUT2} . Regulator 2 is fully enabled when a logic high is applied to this input. Regulator 2 enters shutdown when a logic low is applied to this input. During shutdown, regulator output voltage falls to zero, and RESET output is low.
6	V_{OUT1}	Regulated voltage output 1.
7	V_{OUT2}	Regulated voltage output 2.
8	RESET	RESET Output. RESET=Low when V_{OUT2} is below the Reset Threshold Voltage. RESET=High when V_{OUT2} is above the Reset Threshold Voltage.

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DETAILED DESCRIPTION

The TC1306 is a precision fixed output voltage regulator that contains two fully independent 150mA outputs. The device also features separate shutdown modes for low-power operation. The Select Mode™ operation allows the user to select V_{OUT2} from two different values (2.8V, 3.0V), therefore providing high design flexibility. V_{OUT1} supplies a fixed 1.8V output voltage. The CMOS construction of the TC1306 results in a very low supply current, which does not increase with load changes. In addition, V_{OUT} remains stable and within regulation at no load currents.

The TC1306 also features an integrated microprocessor supervisor that monitors the V_{OUT2} output. The active low RESET signal is asserted when the voltage of V_{OUT2} falls below the reset voltage threshold (2.63V). The RESET output remains low for 300msec (typical) after V_{OUT2} rises above the reset threshold. The RESET output of the TC1306 is optimized to reject fast transient glitches on the monitored output line.

APPLICATION INFORMATION

Input and Output Capacitor

The TC1306 is stable with a wide range of capacitor values and types. A capacitor with a minimum value of 1 μ F from V_{OUT} to Ground is required. The output capacitor should have an effective series resistance (ESR) of 0.1 Ω to 10 Ω for a 1 μ F capacitor and 0.01 Ω to 10 Ω for a 10 μ F capacitor. A 1 μ F capacitor should be connected from the V_{IN} to GND if there is more than 10 inches of wire below 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 -20°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.

Shutdown Mode

Applying a logic high to each of the shutdown pins turns on the corresponding output. Each regulator enters shutdown mode when a logic low is applied to the corresponding input. During shutdown mode, output voltage falls to zero, and regulator supply current is reduced to 0.5 μ A (max). If shutdown mode is not necessary, the pins should be connected to the V_{IN} .

Select Mode™ Operation

The Select Mode™ operation is a dual-state input that allows the user to select V_{OUT2} from two different values. By applying a logic low to the SELECT pin, V_{OUT2} is set to supply a 2.8V output voltage. A logic high signal at the SELECT pin sets V_{OUT2} to 3.0V. This output voltage functionality provides high design flexibility and minimizes cost associated with inventory, time-to-market and new device qualifications.

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 TC1306 has a fast Wake Up Time (10 μ sec 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 (40 μ sec 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).

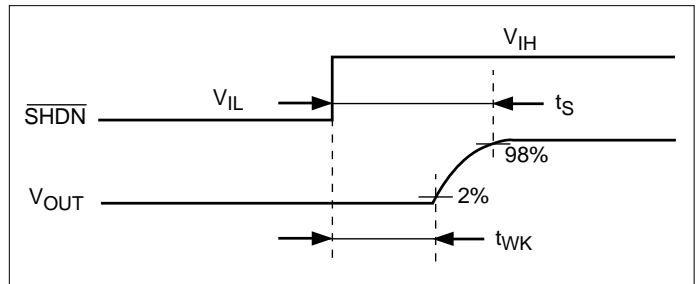


Figure 1: Wake-Up Response Time

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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 145°C.

Thermal shutdown is intended to protect the device under accidental overload conditions. Thermal Shutdown may not protect the LDO while operating above junction temperatures of 125°C continuously. Sufficient thermal evaluation of the design needs to be conducted to ensure that the junction temperature does not exceed 125°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:

$$P_D \approx (V_{INMAX} - V_{OUT1MIN})I_{LOAD1MAX} + (V_{INMAX} - V_{OUT2MIN})I_{LOAD2MAX}$$

Where: P_D = worst case actual power dissipation
 V_{INMAX} = maximum voltage on V_{IN}
 $V_{OUT1MIN}$ = minimum regulator output voltage 1
 $I_{LOAD1MAX}$ = maximum output (load) current 1
 $V_{OUT2MIN}$ = minimum regulator output voltage 2
 $I_{LOAD2MAX}$ = maximum output (load) current 2

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 MSOP-8 package has a θ_{JA} of approximately 200°C/W; when mounted on a four 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:

$$\begin{aligned} V_{INMAX} &= 3.8V \pm 5\% \\ V_{OUT1MIN} &= 1.8V \pm 2.5\% \\ V_{OUT2MIN} &= 3.0V \pm 2.5\% \\ I_{LOAD1MAX} &= 60mA \\ I_{LOAD2MAX} &= 120mA \\ T_{JMAX} &= 125^\circ C \\ T_{AMAX} &= 55^\circ C \\ \theta_{JA} &= 200^\circ C/W \end{aligned}$$

FIND:

1) Actual power dissipation:

$$\begin{aligned} P_D &\approx [(V_{INMAX} - V_{OUT1MIN}) \times I_{LOAD1MAX} \\ &+ [(V_{INMAX} - V_{OUT2MIN}) \times I_{LOAD2MAX} \\ &[(3.8 \times 1.05) - (1.8 \times .975)] \times 60 \times 10^{-3} \\ &+ [(3.8 \times 1.05) - (3.0 \times .975)] \times 120 \times 10^{-3} \\ &= \underline{262mW} \end{aligned}$$

2) Maximum allowable power dissipation:

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

In this example, the TC1306 dissipates a maximum of only 262mW; 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 $V_{INMAX} = 4.5V$.

Layout Considerations

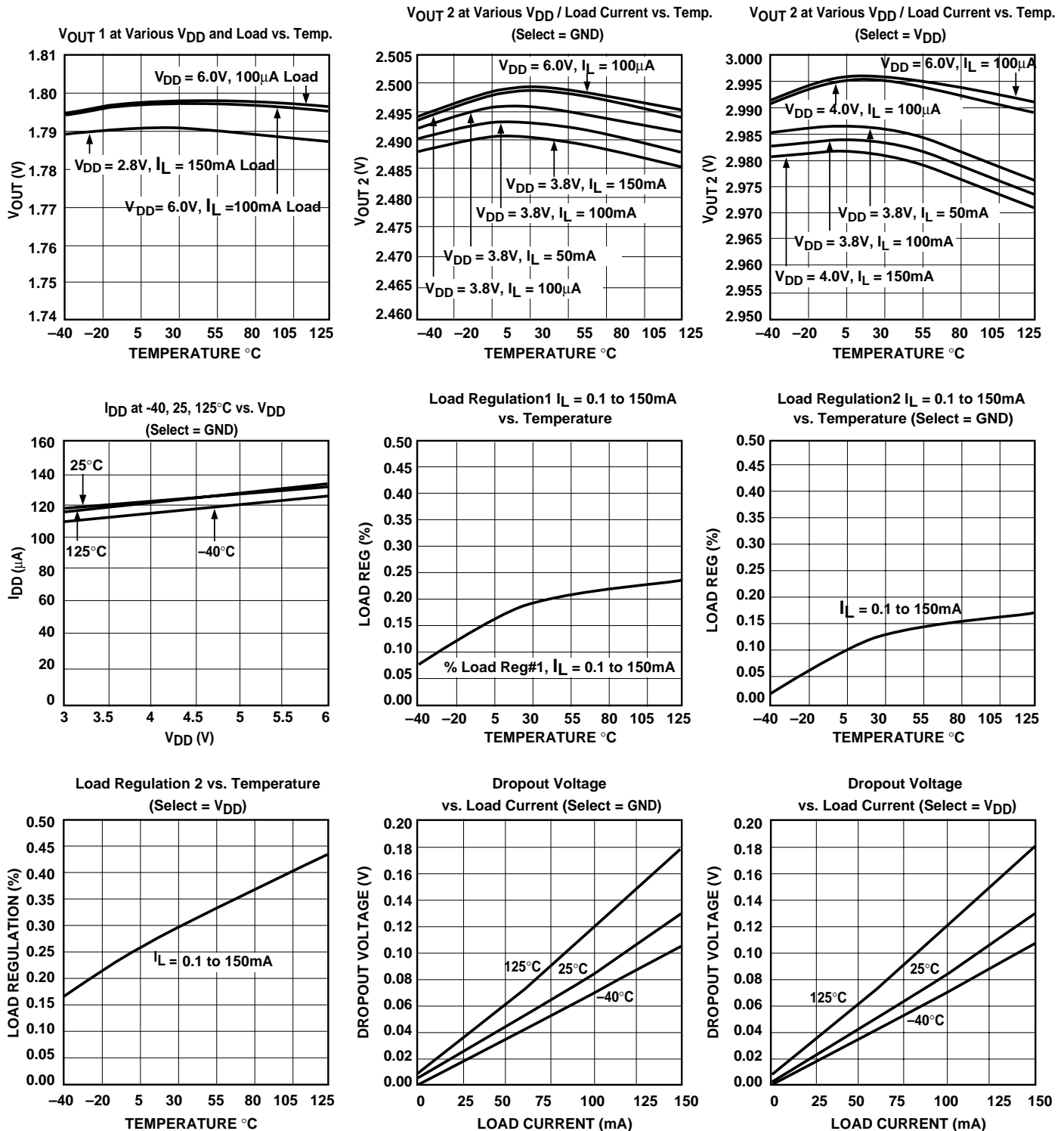
The primary path of heat conduction out of the package is via the package leads. Therefore, layouts having a ground plane, wide traces at the pads, and wide power supply bus lines combine to lower θ_{JA} and, therefore, increase the maximum allowable power dissipation limit.

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TYPICAL CHARACTERISTICS

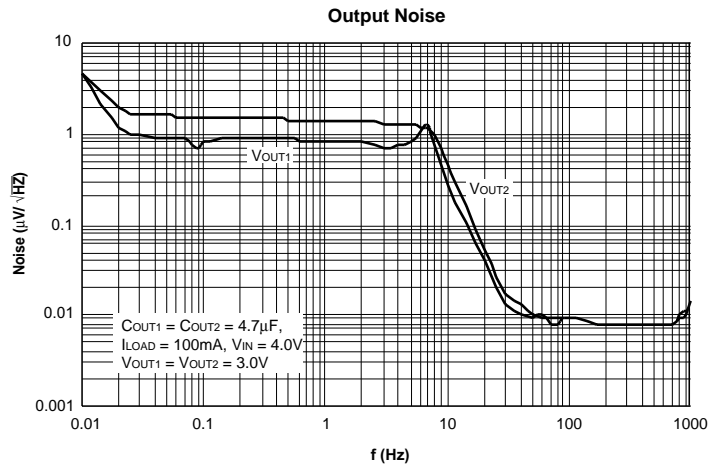
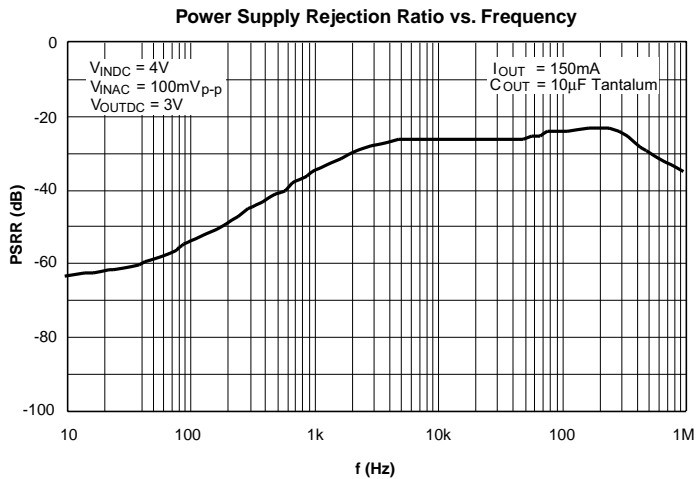
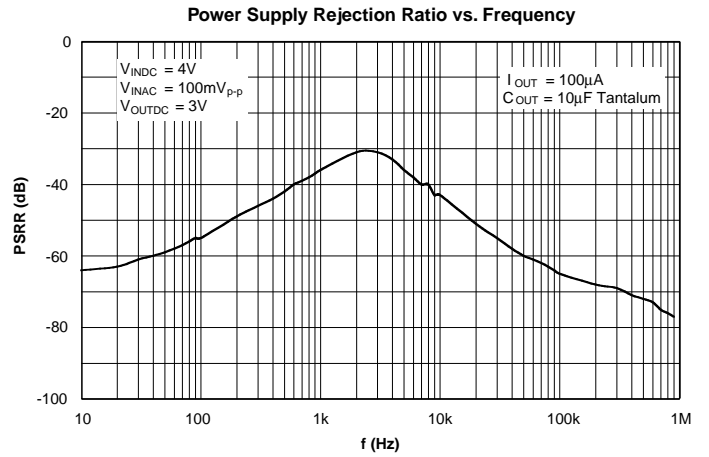
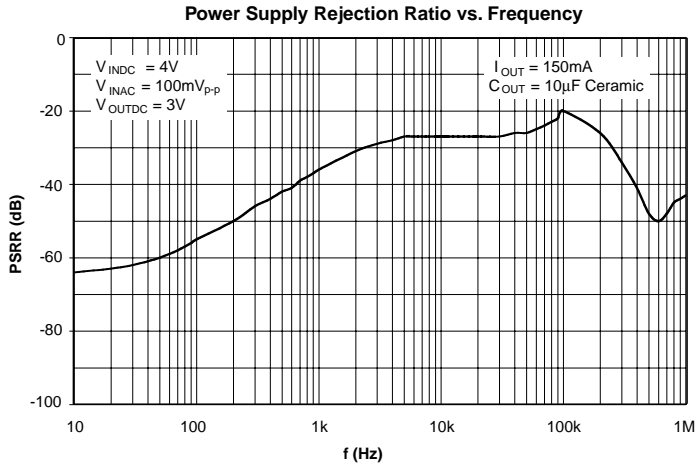
The graphs and tables provided following this note are statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.



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TYPICAL CHARACTERISTICS (CONT)

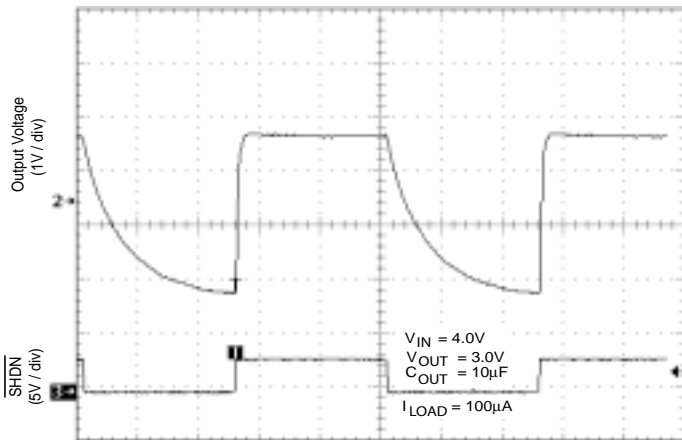


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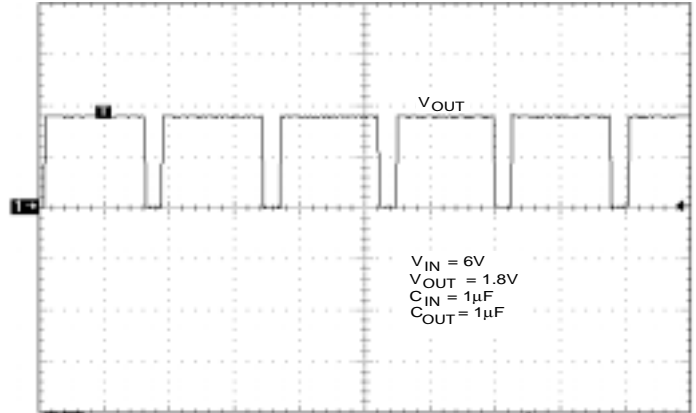
TYPICAL CHARACTERISTICS (CONT)

Shutdown Response



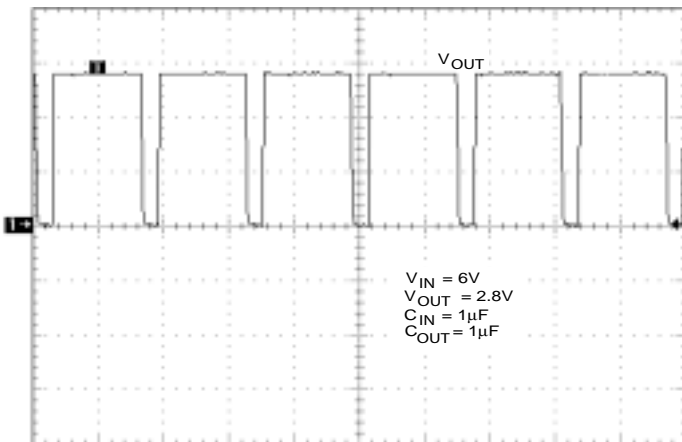
Time (200ms / div)

Thermal Shutdown Response



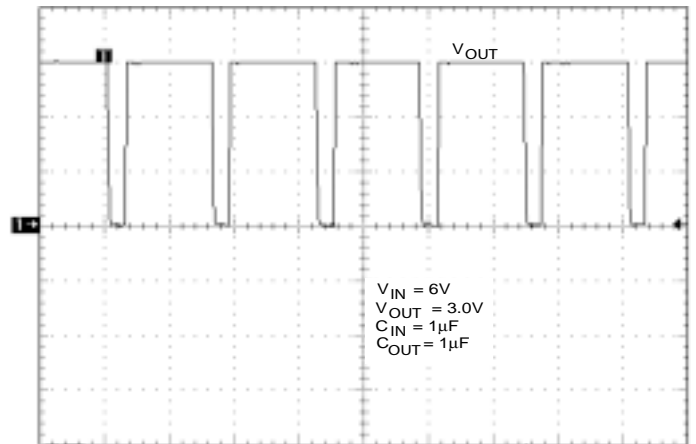
Time (500ms / div)

Thermal Shutdown Response



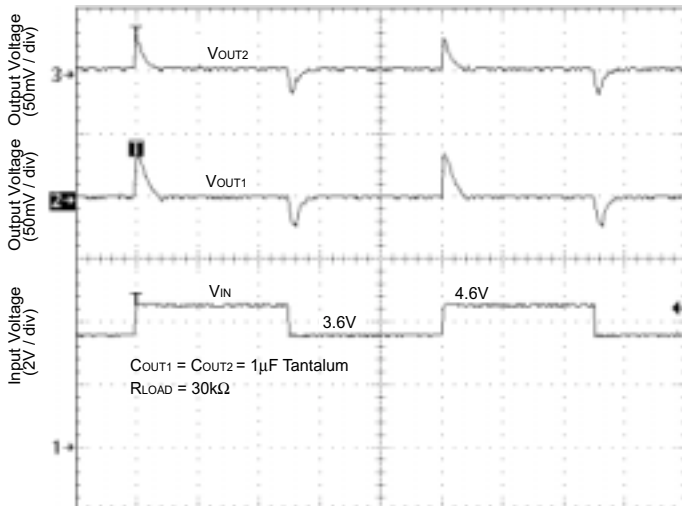
Time (500ms / div)

Thermal Shutdown Response

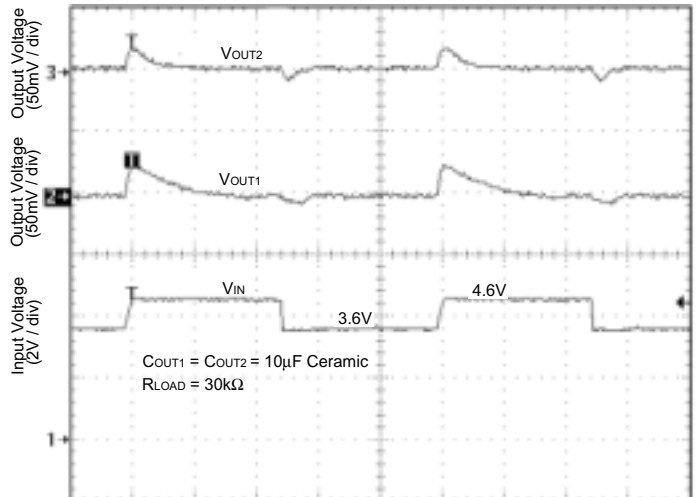


Time (500ms / div)

Line Transient Response



Line Transient Response

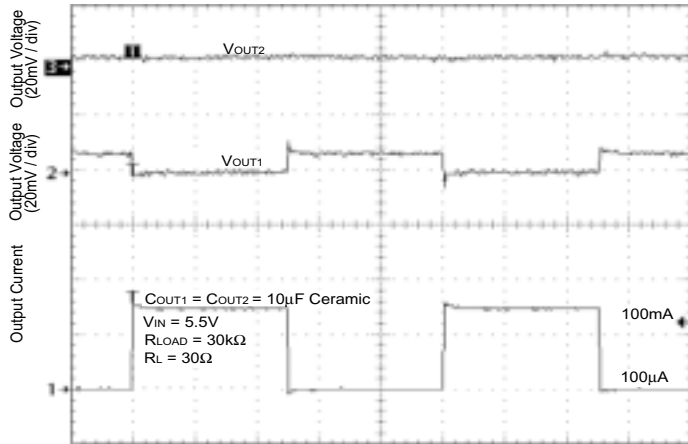


Dual 150mA CMOS LDO With Select Mode™ Operation, Shutdown and $\overline{\text{RESET}}$ Output

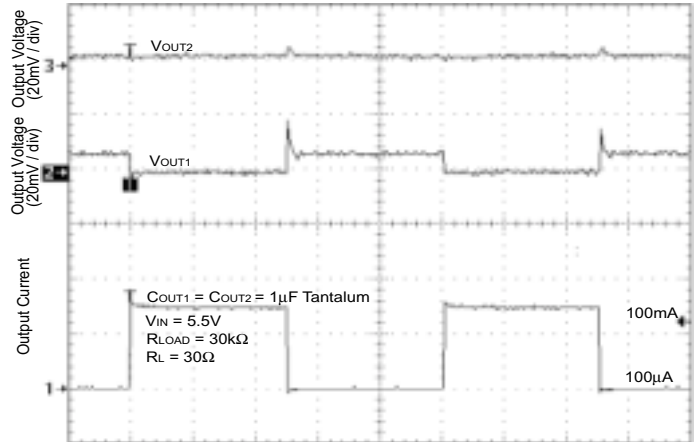
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TYPICAL CHARACTERISTICS (CONT)

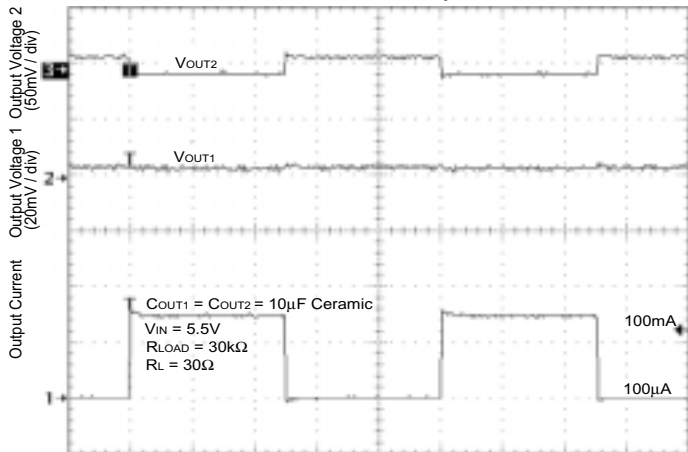
Load Transient Response



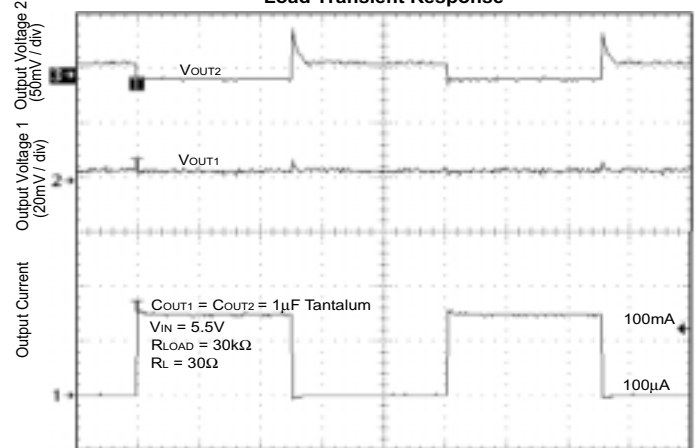
Load Transient Response



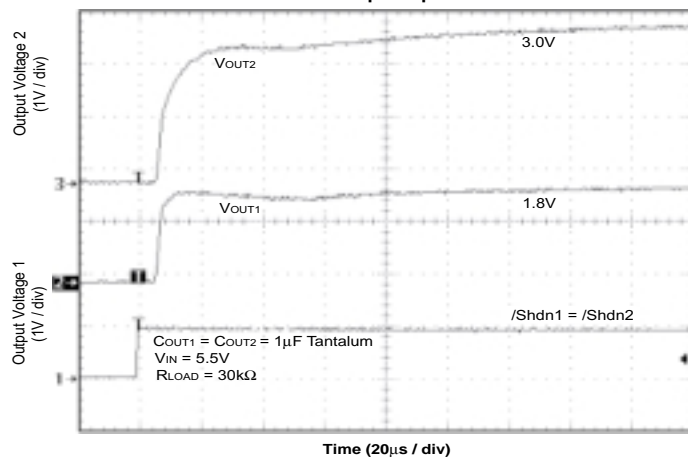
Load Transient Response



Load Transient Response



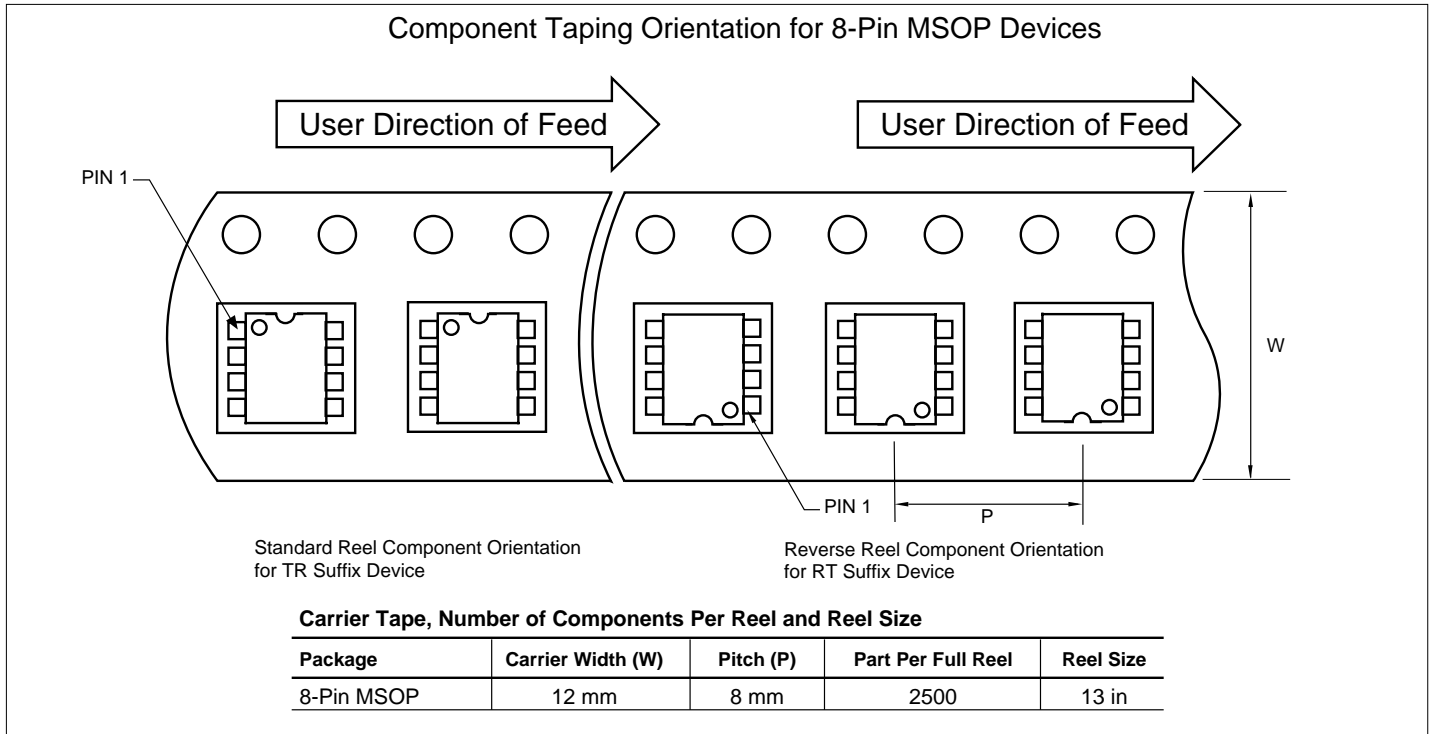
Wake-Up Response



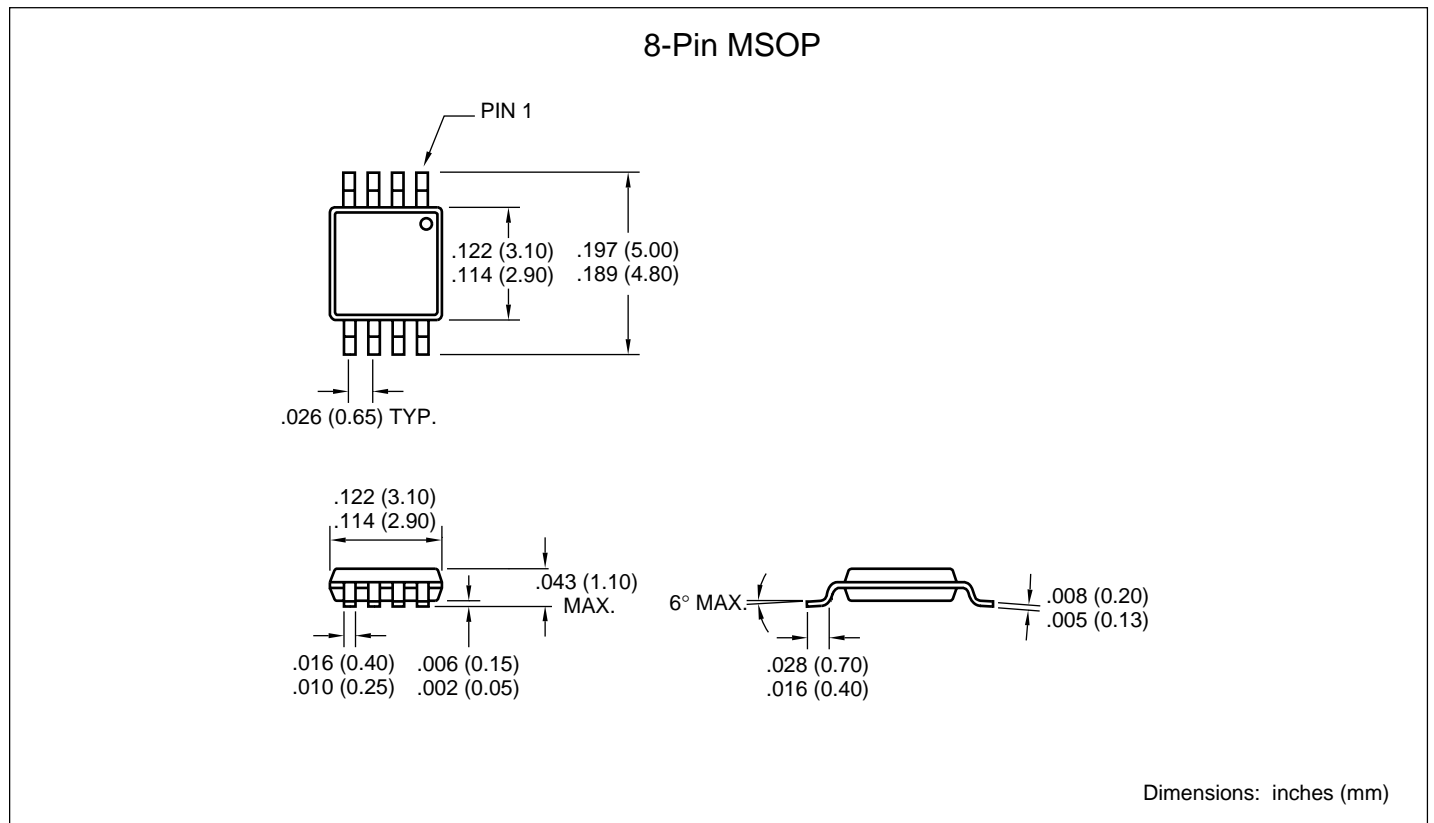
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TAPE AND REEL DIAGRAMS



PACKAGE DIMENSIONS



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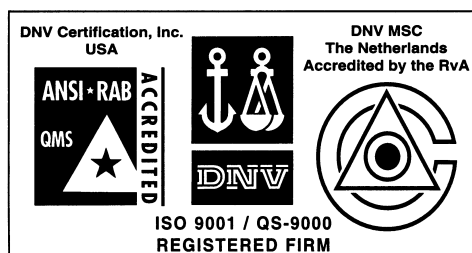
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