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

FEATURES

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

APPLICATIONS

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

GENERAL DESCRIPTION

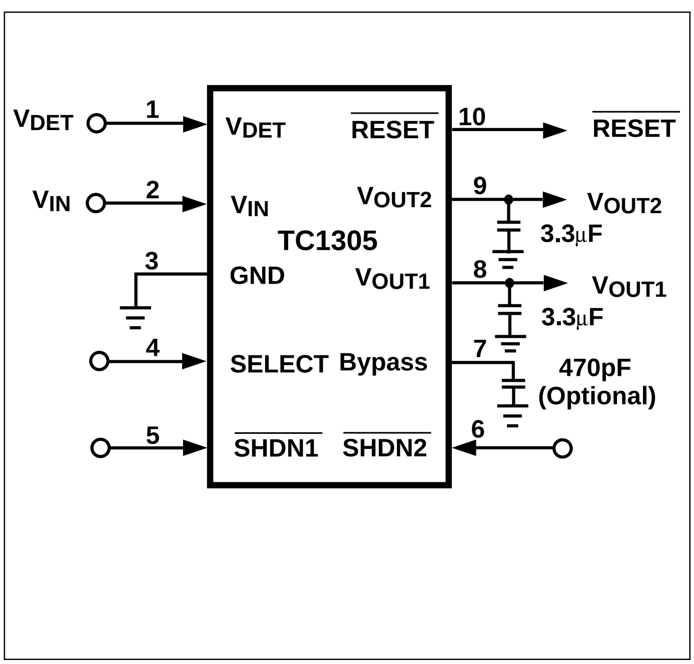
The TC1305 combines two CMOS Low Dropout Regulators and a Microprocessor Monitor in a space-saving 10-Pin MSOP package. Designed specifically for battery-operated systems, total supply current is typically 120µA at full load, 20 to 60 times lower than in bipolar regulators.

The TC1305 features selectable output voltages for higher design flexibility. The tri-state SELECT input pin allows the user to select V_{OUT1} and V_{OUT2} from 3 different values (2.5V, 2.8V and 3.0V).

An active low $\overline{\text{RESET}}$ is asserted when the detected voltage (V_{DET}) falls below the 2.63V reset voltage threshold. The $\overline{\text{RESET}}$ output remains low for 300msec (typical) after V_{DET} rises above the reset threshold. When the shutdown controls ($\overline{\text{SHDN1}}$ and $\overline{\text{SHDN2}}$) are low, the regulator output voltages fall to zero, $\overline{\text{RESET}}$ output remains valid and supply current is reduced to 20µA (typ.).

Other key features for the device include ultra low-noise operation, fast response to step changes in load, and very low dropout voltage (typically 150mV 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. The 1305 is featured in a 10-pin MSOP package with selective output voltages.

TYPICAL APPLICATION



ORDERING INFORMATION

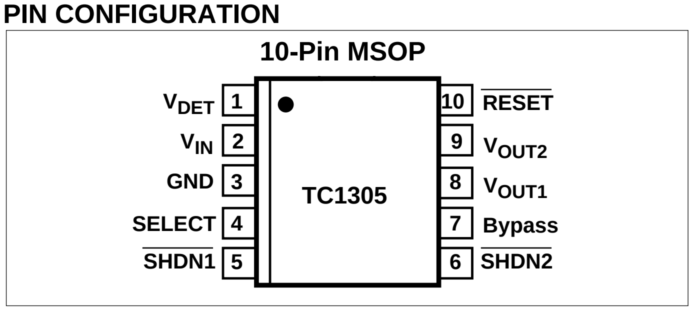
Part Number	Package	Junction Temp. Range
TC1305R-DVUN	10-Pin MSOP	– 40°C to +125°C

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

Available Output Voltages:
D indicates $V_{OUT1} = V_{OUT2}$ = 2.5, 2.8, 3.0 (selectable)

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

PIN CONFIGURATION



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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:

V_{IN} = V_R + 1V, I_L = 100µA, C_L = 3.3µF, $\overline{SHDN1}$ > V_{IH}, $\overline{SHDN2}$ > V_{IH}, T_A = 25°C, unless otherwise noted. **Boldface** type specifications apply for junction temperatures of – 40°C to +125°C. Applies to both V_{OUT1} and V_{OUT2}.

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 (V_{OUT1} and V_{OUT2})	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) ≤ V_{IN} ≤ 6V	—	0.05	**0.35**	%
$\Delta V_{OUT}/V_{OUT}$	Load Regulation	I_L = 0.1mA to I_{OUTMAX} Note 4	—	0.5	**2**	%
$V_{IN} – V_{OUT}$	Dropout Voltage	I_L = 100µA I_L = 50mA I_L = 100mA I_L = 150mA Note 5	— — — —	2 50 100 150	— **120** **240** **360**	mV
I_{IN}	Supply Current	$\overline{SHDN1}$, $\overline{SHDN2}$=V_{IH}, I_L=0	—	120	**160**	µA
I_{INSD}	Shutdown Supply Current	$\overline{SHDN1}$, $\overline{SHDN2}$ = 0V	—	0.05	0.5	µA
PSRR	Power Supply Rejection Ratio	F_{RE} ≤ 120Hz	—	64	—	dB
I_{OUTSC}	Output Short Circuit Current	V_{OUT} = 0V	—	600	—	mA
$\Delta V_{OUT}/\Delta P_D$	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	I_L = 100µA, F = 1kHz, C_{OUT1} = C_{OUT2} = 4.7µF, C_{BYPASS} = 0.01µF	—	200	—	$nV/\sqrt{Hz}$
		F = 10Hz to 100kHz	—	29	—	μV_{RMS}
$\overline{SHDN}$ Input						
V_{IH}	$\overline{SHDN}$ Input High Threshold	V_{IN} = 2.7V to 6.0V	**65**	—	—	$\%V_{IN}$
V_{IL}	$\overline{SHDN}$ 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	**V_{IN} - 0.2**	—	—	V
V_{SELL}	SELECT Input Low Threshold	V_{IN} = 2.7V to 6.0V	—	—	**0.2**	V

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
$\overline{RESET}$ 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
I_{VDET}	Reset Circuit Supply Current	$\overline{RESET}$ = Open	—	20	**40**	µA
	Reset Threshold Tempco		—	30	—	ppm/°C
	V_{DET} to Reset Delay	$V_{DET} = V_{TH}$ to (V_{TH} – 100mV)	—	100	—	µsec
	Reset Active Timeout Period		**140**	300	**560**	msec
V_{OL}	$\overline{RESET}$ Output Voltage Low	$V_{DET} = V_{TH}$ min, I_{SINK} = 1.2mA $V_{DET} = V_{TH}$ min, I_{SINK} = 3.2mA V_{DET} > 1.0V, I_{SINK} = 50µA	— — —	— — —	**0.3** **0.4** **0.3**	V
V_{OH}	$\overline{RESET}$ Output Voltage High	$V_{DET} > V_{TH}$ max, I_{SOURCE} = 500µA $V_{DET} > V_{TH}$ max, I_{SOURCE} = 800µA	0.8 V_{DET} V_{DET} – 1.5	— —	—	V

NOTES:
1. The minimum V_{IN} has to meet two conditions: $V_{IN} \geq 2.7V$ and $V_{IN} \geq V_R + V_{DROPOUT}$.
2. V_R is the regulator output voltage setting. For example: V_R = 2.5V, 2.8V, 3.0V.
3. $TCV_{OUT} = \frac{(V_{OUT_{MAX}} - V_{OUT_{MIN}}) \times 10^6}{V_{OUT} \times \Delta T}$
4. 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.
5. 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.
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, θ_{JA}). Please see **Thermal Considerations** section of this data sheet for more details.

PIN DESCRIPTION

Pin No. (10-Pin MSOP)	Symbol	Description
1	V_{DET}	Detected input voltage. V_{DET} and V_{IN} can be connected together.
2	V_{IN}	Power supply input.
3	GND	Ground terminal.
4	SELECT	Tri-state input for setting V_{OUT1} and V_{OUT2} . SELECT = GND for $V_{OUT1} = V_{OUT2}$ = 2.5V, SELECT = V_{IN} for $V_{OUT1} = V_{OUT2}$ = 3.0V and SELECT = No connect for $V_{OUT1} = V_{OUT2}$ = 2.8V.
5	$\overline{SHDN1}$	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, $\overline{RESET}$ output remains valid.
6	$\overline{SHDN2}$	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, $\overline{RESET}$ output remains valid.
7	Bypass	Reference bypass input. Connecting a 0.01µF to this input further reduces output noise.
8	V_{OUT1}	Regulated voltage output 1.
9	V_{OUT2}	Regulated voltage output 2.
10	$\overline{RESET}$	$\overline{RESET}$ Output. $\overline{RESET}$ = Low when V_{DET} is below the Reset Threshold Voltage. $\overline{RESET}$ = High when V_{DET} is above the Reset Threshold Voltage.

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DETAILED DESCRIPTION

The TC1305 is a precision fixed output voltage regulator that contains two fully independent 150mA regulator outputs. The device features seperate shutdown modes for low-power operation, and a common bypass pin that can be used to further reduce output noise. The Select Mode™ operation allows the user to select V_{OUT1} and V_{OUT2} from three different values (2.5V, 2.8V, 3.0V), therefore providing high design flexibility. The CMOS construction of the TC1305 results to 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 TC1305 also features an integrated microprocessor supervisor that monitors power-up, power-down, and brown-out conditions. The active low $\overline{RESET}$ signal is asserted when the detected voltage V_{DET} falls below the reset voltage threshold (2.63V). The $\overline{RESET}$ output remains low for 300msec (typical) after V_{DET} rises above the reset threshold. The $\overline{RESET}$ output of the TC1305 is ensured valid down to V_{DET}=1V and is optimized to reject fast transient glitches on the moinitored power supply line.

APPLICATION INFORMATION

Input and Output Capacitor

The TC1305 is stable with a wide range of capacitor values and types. A capacitor with a minimum value of 1µF from V_{OUT} to Ground is required. The output capacitor should have an effective series resistance (ESR) of 0.1Ω to 10Ω for a 1µF capacitor and 0.01Ω to 10Ω for a 10µF capacitor. A 1µF capacitor should be connected from the 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 –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.

Bypass Capacitor

A 0.01µF 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 result in a longer time period to rated output voltage when power is initially applied.

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 in the corresponding input. During shutdown mode, the output voltage falls to zero, and regulator supply current is reduced to 0.5µA (max). If shutdown mode is not necessary, the pins should be connected to V_{IN}.

Select Mode™ Operation

The Select Mode™ operation is a tri-state input that allows the user to select V_{OUT1} and V_{OUT2} from three different values. By connecting the SELECT pin to GND, both output voltages (V_{OUT1}, V_{OUT2}) supply 2.5V. Connecting the SELECT pin to V_{IN} results to both output channels supplying a fixed 3.0V output. Last but not least, leaving the SELECT pin floating sets both voltages to 2.8V. This output voltage functionality provides high design flexibility and minimizes costs associated with inventory, time-to-market and new device qualifications.

$\overline{RESET}$ Output

The microprocessor supervisor of the TC1305 provides accurate supply voltage monitoring and reset timing during power-up, power-down and brown-out conditions. The $\overline{RESET}$ output is valid to V_{DET}=1.0V (below this point it becomes an open circuit and does not sink current) and is able to reject negative going transients (glitches) on the power supply line. Transient immunity can further be improved by adding a capacitor close to the V_{DET} pin of the TC1305.

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 TC1305 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 (40µsec 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).

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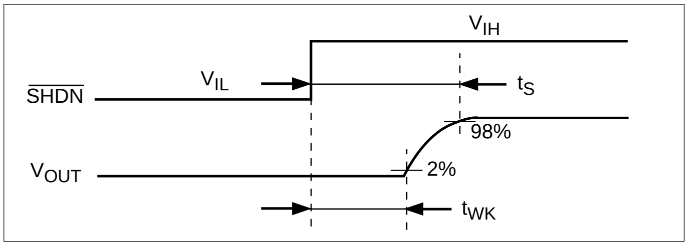

Figure 1: Wake-Up Response Time

Thermal Considerations

Thermal Shutdown

Integrated thermal protection circuitry shuts the regulator off when die exceeds approximately 160°C. The regulator remains off until the die temperature drops to approximately 145°C.

Thermal shutdown is intended to protect the device under transient accidental (fault) 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:

$$P_D \approx (V_{INMAX} - V_{OUTMIN1})I_{LOADMAX1} + (V_{INMAX} - V_{OUTMIN2})I_{LOADMAX2}$$

Where:
- P_D = worst case actual power dissipation
- V_{INMAX} = maximum voltage on V_{IN}
- $V_{OUTMIN1}$ = minimum regulator output voltage1
- $I_{LOADMAX1}$ = maximum output (load) current1
- $V_{OUTMIN2}$ = minimum regulator output voltage2
- $I_{LOADMAX2}$ = maximum output (load) current2

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-10 package has a θ_{JA} of approximately ***113°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:

V_{INMAX} = 3.8V ± 5%
$V_{OUT1MIN}$ = 3.0V±2.5%
$V_{OUT2MIN}$ = 3.0V±2.5%
$I_{LOAD1MAX}$ = 120mA
$I_{LOAD2MAX}$ = 120mA
T_{JMAX} = 125°C
T_{AMAX} = 55°C
θ_{JA} = 113°C/W

FIND:

1) Actual power dissipation:

$$P_D \approx [(V_{INMAX} - V_{OUT1MIN}) \times I_{LOAD1MAX} + [(V_{INMAX} - V_{OUT2MIN}) \times I_{LOAD2MAX}$$
$$[(3.8 \times 1.05) - (3.0 \times .975)] \times 120 \times 10^{-3} + [(3.8 \times 1.05) - (3.0 \times .975)] \times 120 \times 10^{-3}$$
$$= \underline{256mW}$$

2) Maximum allowable power dissipation:

$$P_D \approx \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}}$$
$$= \frac{(125 - 55)}{113}$$
$$= \underline{620mW}$$

In this example, the TC1305 dissipates a maximum of 256mW; below the allowable limit of 620mW. 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 620mW into Equation 1, from which V_{INMAX} = 5.6V.

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, may increase the maximum allowable power dissipation limit.

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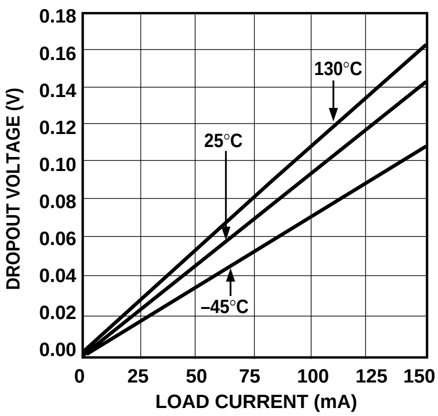
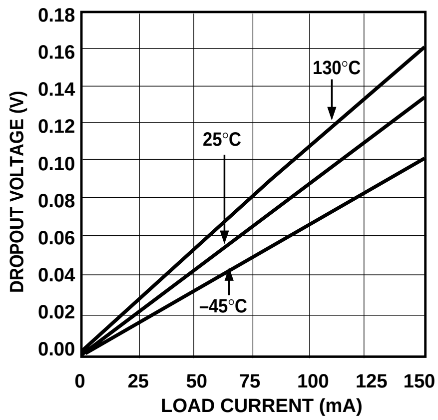
TYPICAL CHARACTERISTICS

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.

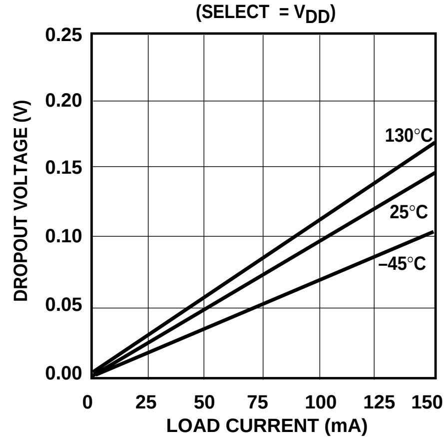
Dropout Voltage1 vs. Load Current (SELECT = NC)



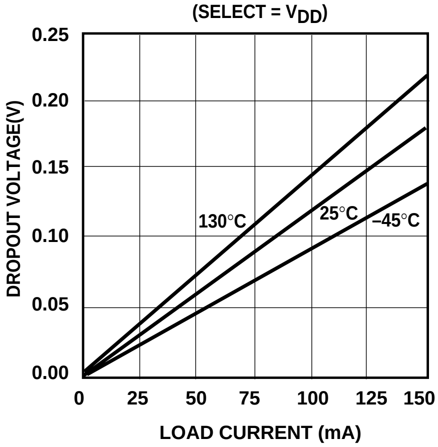
Dropout Voltage1 vs. Load Current (SELECT = V_{DD})



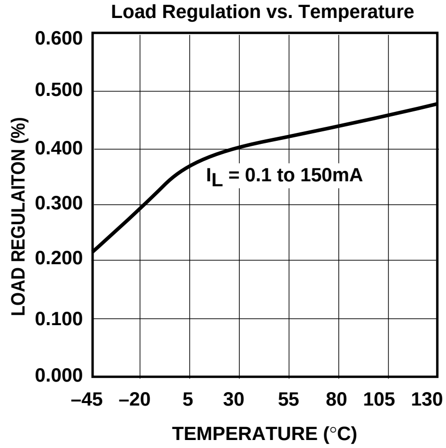
Dropout Voltage2 vs. Load Current (SELECT = V_{DD})



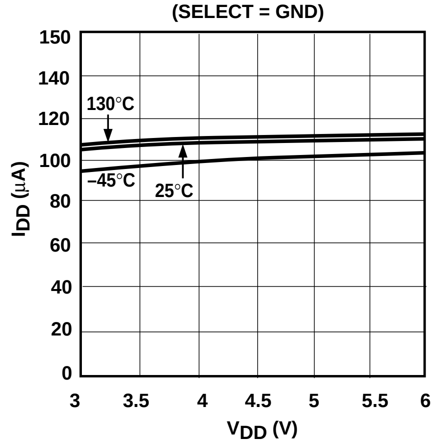
Dropout Voltage2 vs. Load Current (SELECT = V_{DD})



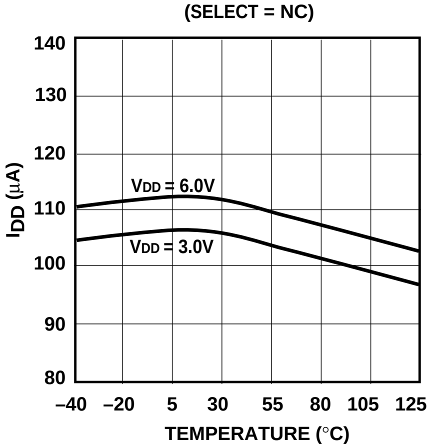
Load Regulation vs. Temperature



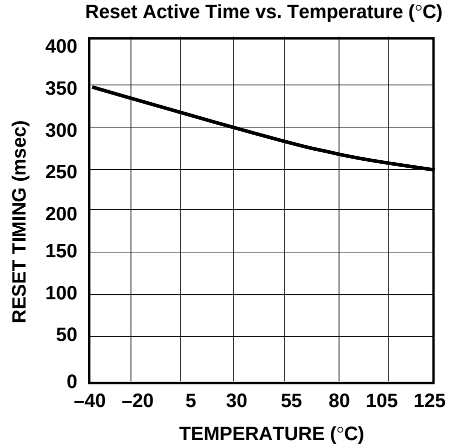
I_{DD} vs. V_{DD} (SELECT = GND)



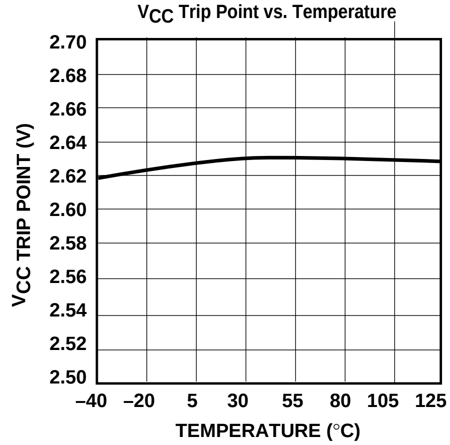
I_{DD} vs. Temperature (SELECT = NC)



Reset Active Time vs. Temperature (°C)



V_{CC} Trip Point vs. Temperature



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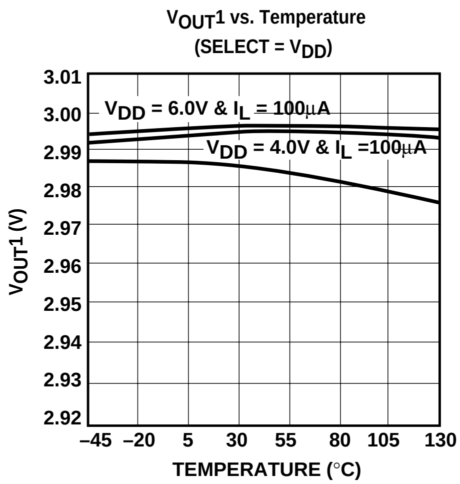
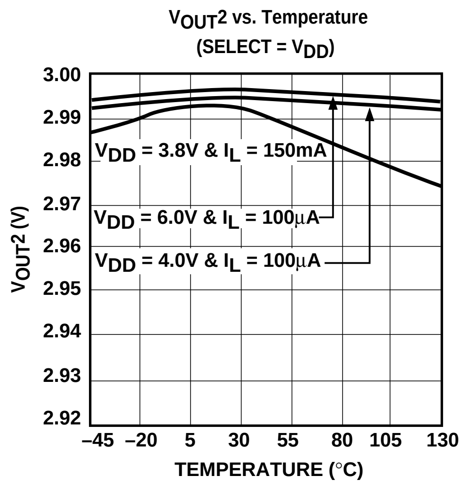
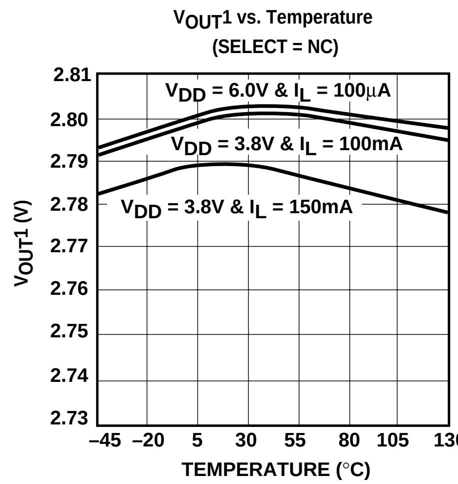
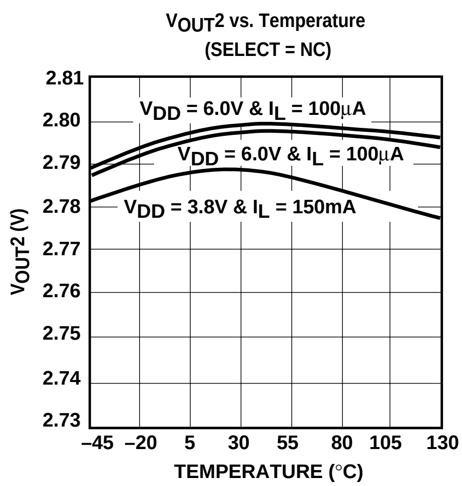
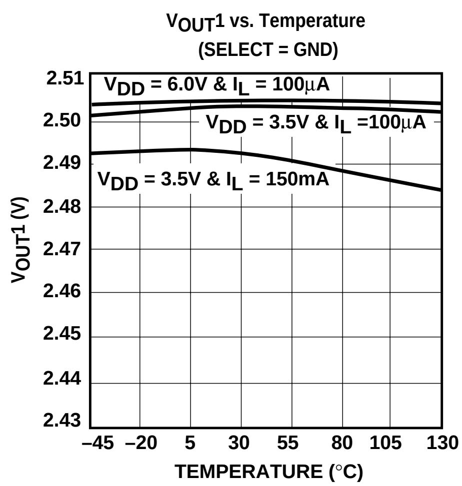
TYPICAL CHARACTERISTICS

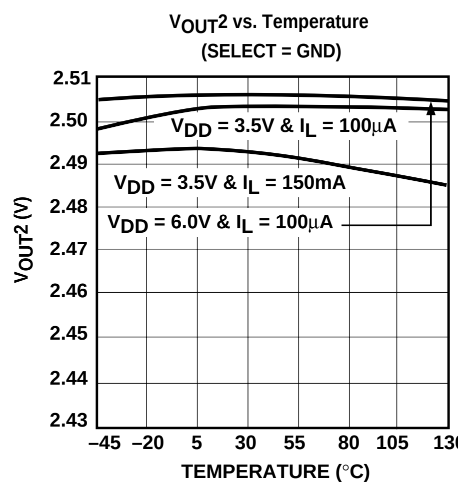






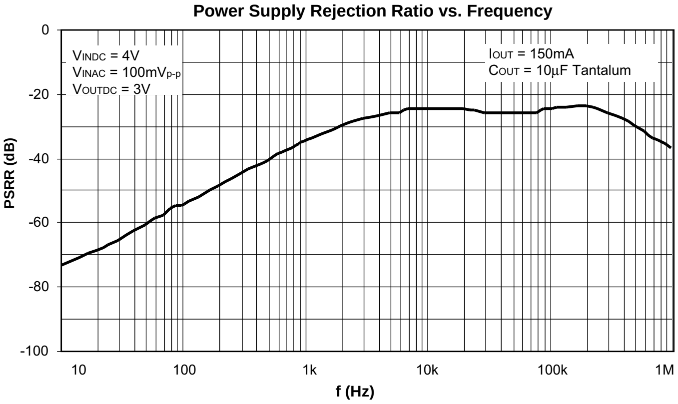




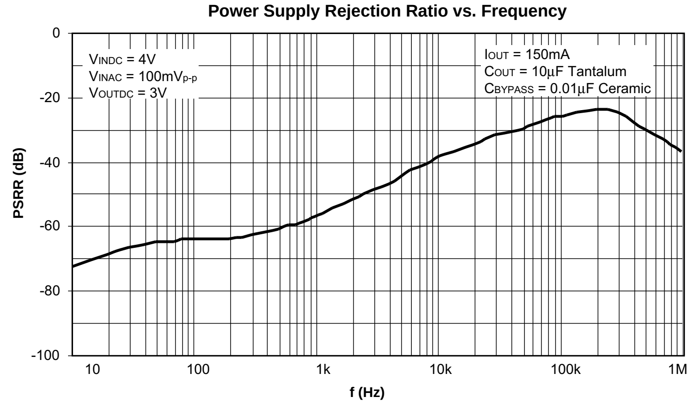


TYPICAL CHARACTERISTICS

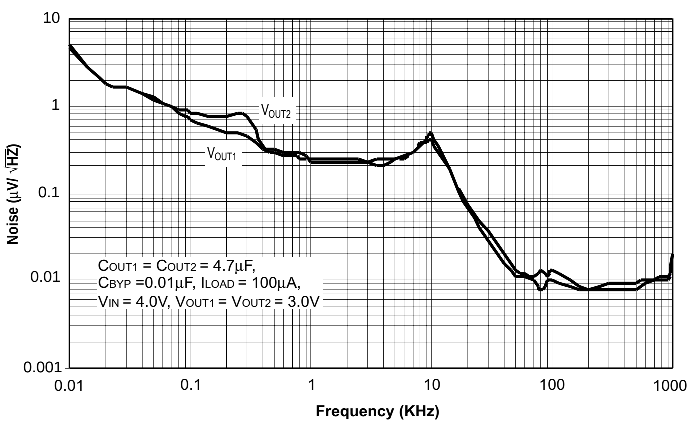
Power Supply Rejection Ratio vs. Frequency



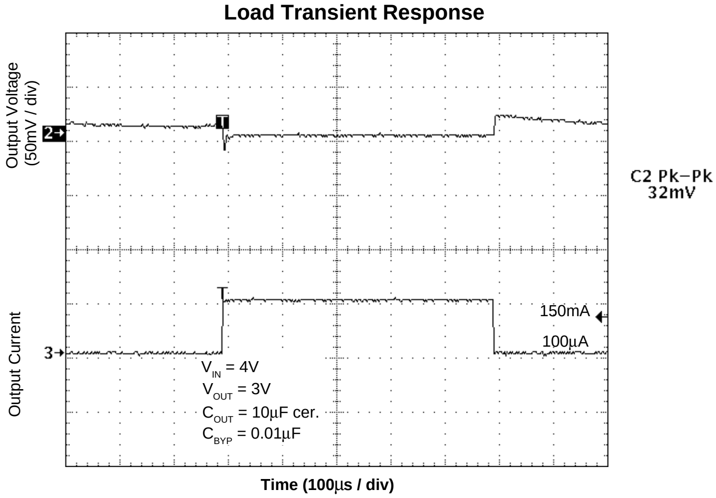
Power Supply Rejection Ratio vs. Frequency



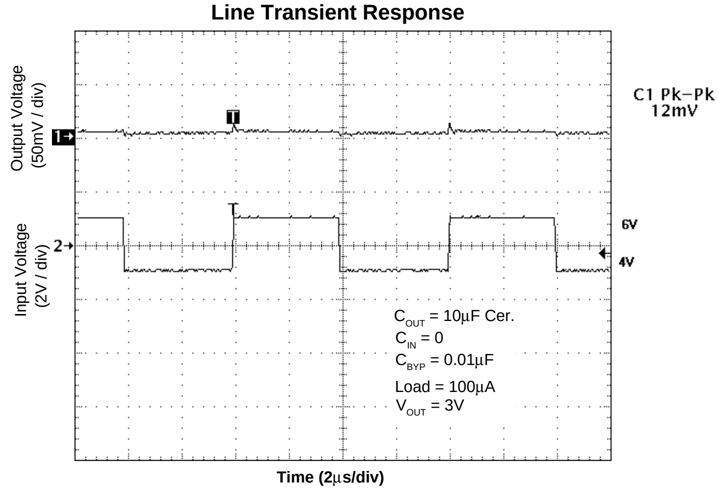
Output Noise



Load Transient Response



Line Transient Response



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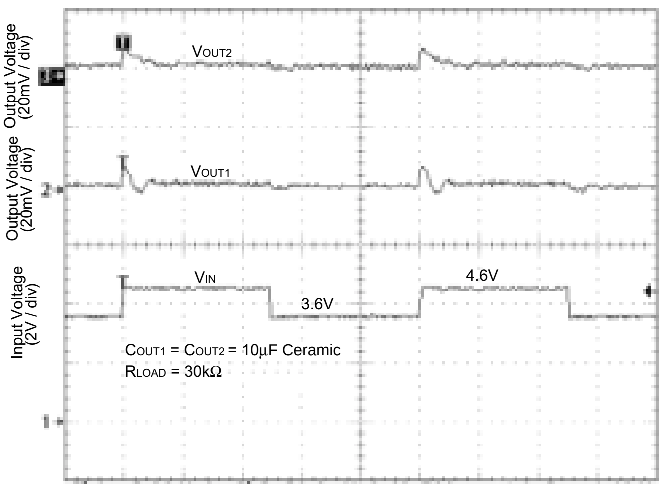
TYPICAL CHARACTERISTICS (CONT)

Line Transient Response



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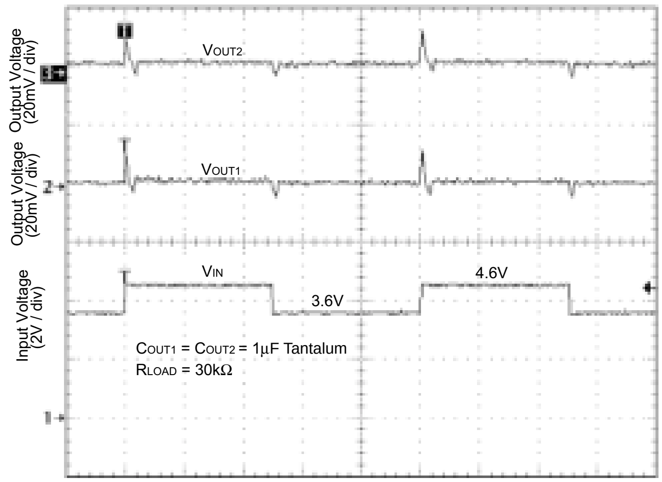
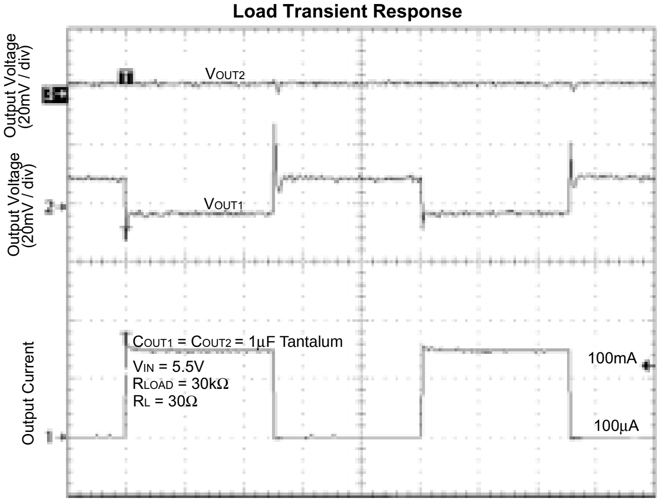


Load Transient Response



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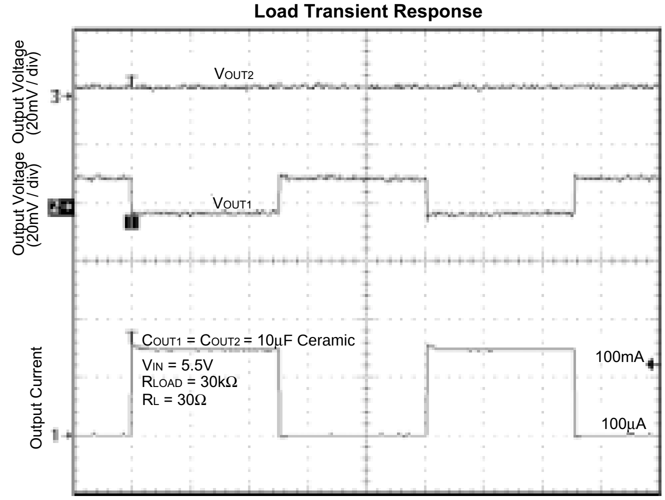

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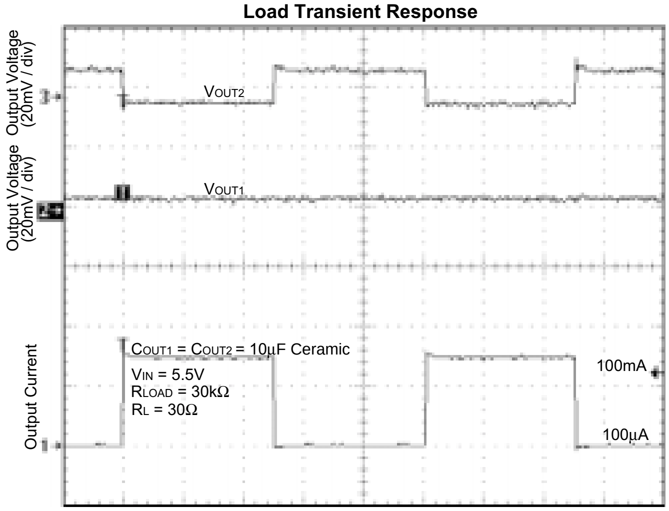

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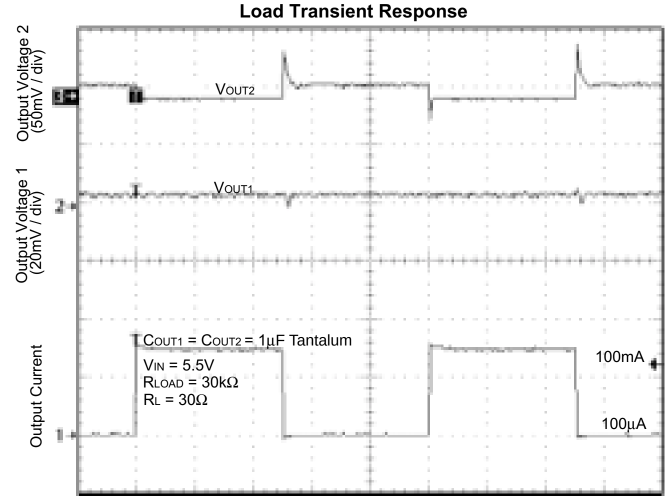
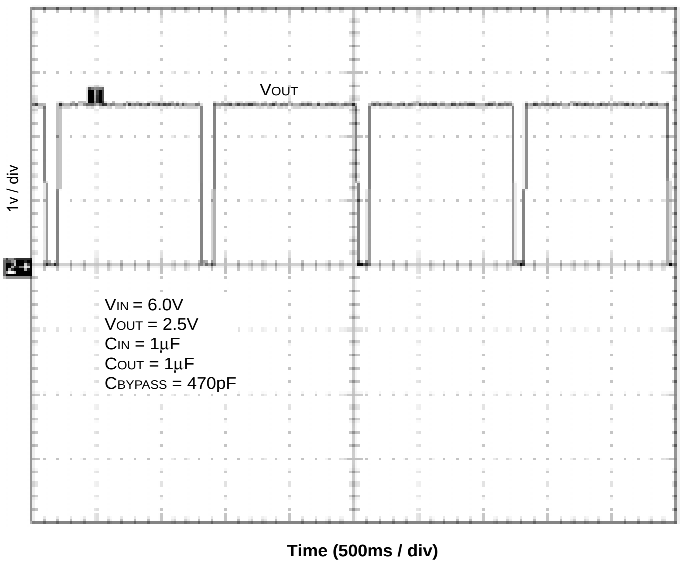
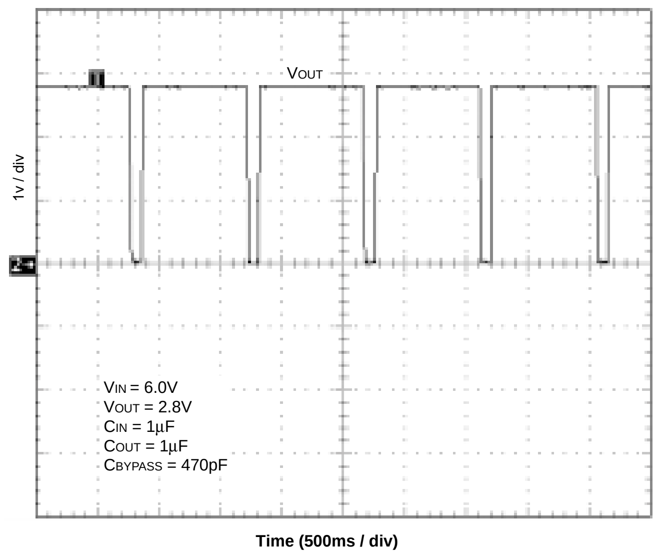


TYPICAL CHARACTERISTICS (CONT)

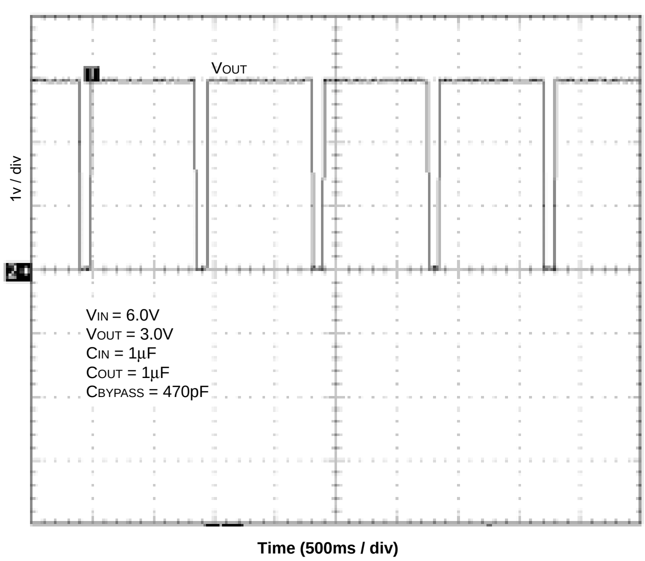
Thermal Shutdown Response



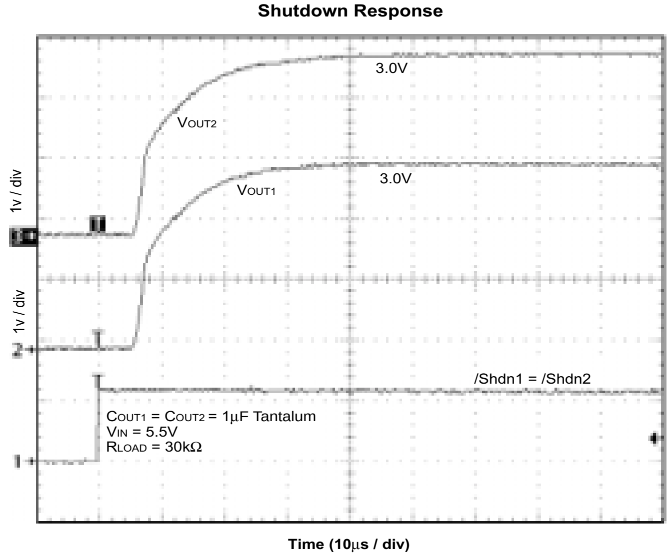
Thermal Shutdown Response



Thermal Shutdown Response



Shutdown Response



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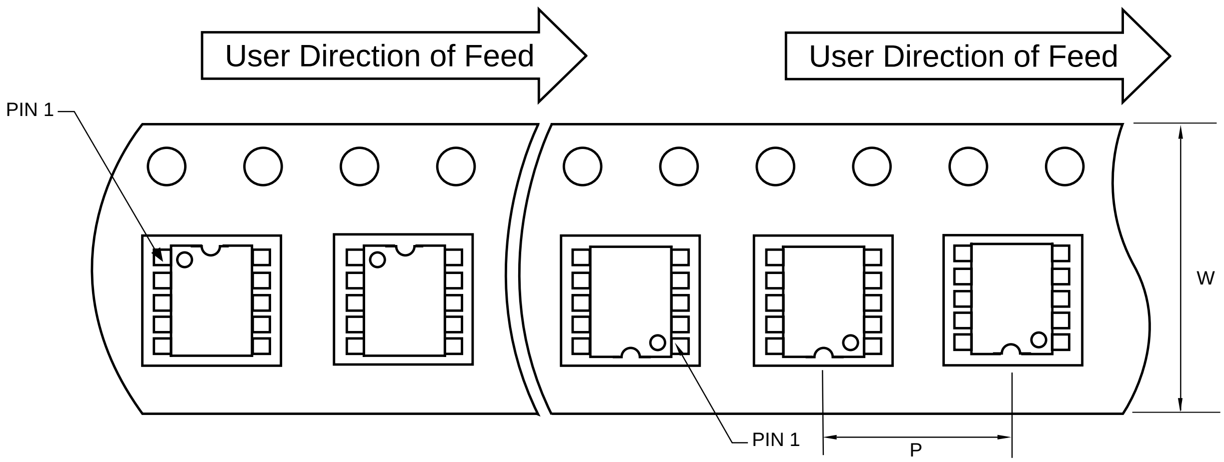
TAPE AND REEL DIAGRAMS

Component Taping Orientation for 10-Pin MSOP Devices



Standard Reel Component Orientation
for TR Suffix Device

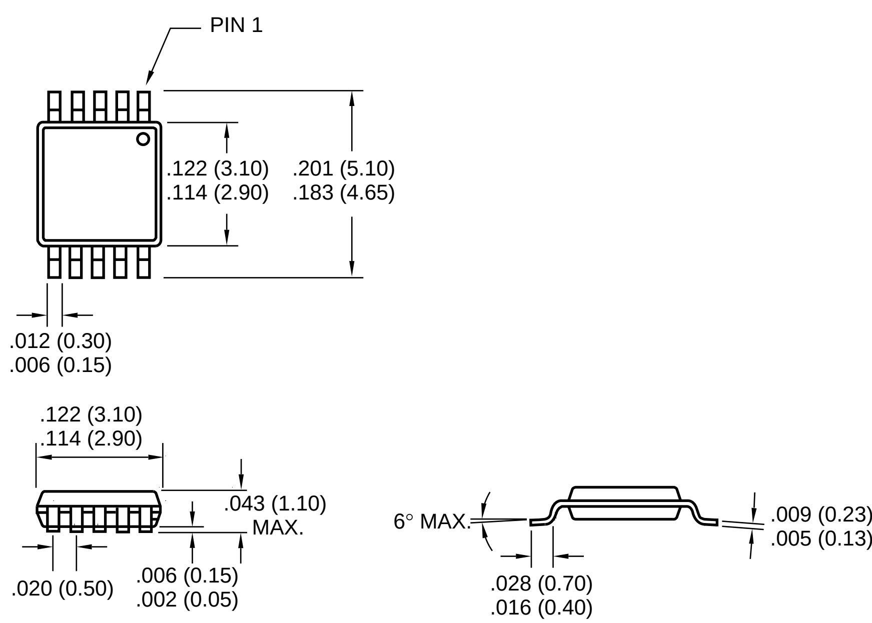
Reverse Reel Component Orientation
for RT Suffix Device

Carrier Tape, Number of Components Per Reel and Reel Size

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

PACKAGE DIMENSIONS

10-Pin MSOP



Dimensions: inches (mm)

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