Dual 150mA CMOS LDO With Select Mode™, SHUTDOWN And $\overline{\text{RESET}}$ Output

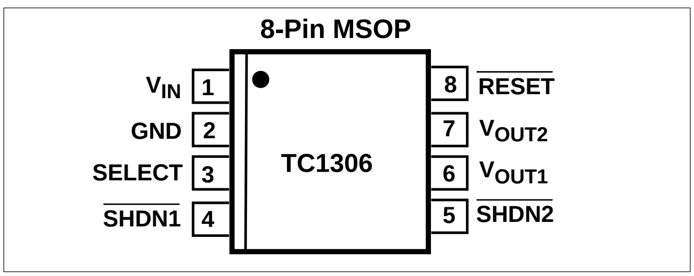
FEATURES

- **Extremely Low Supply Current for Longer Battery Life!**
- **Select Mode™: Selectable Output Voltages for High Design Flexibility**
- **Very Low Dropout Voltage**
- **10µsec (Typ.) Wake Up Time from $\overline{\text{SHDN}}$**
- **Guaranteed 150mA Output Current**
- **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 and Over-Temperature Protection**
- **Space-Saving 8-Pin MSOP Package**

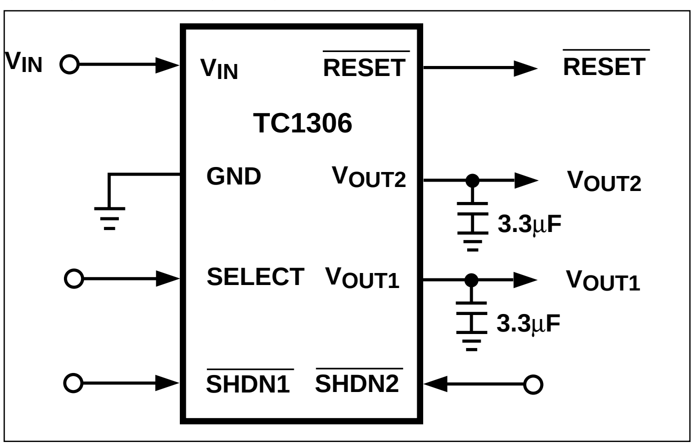
APPLICATIONS

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

PIN CONFIGURATION



TYPICAL APPLICATION



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, the device's CMOS construction eliminates wasted ground current, significantly extending battery life. Total supply current for this 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 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 $\overline{\text{RESET}}$ is asserted when the output voltage V_{OUT2} falls below the 2.63V reset voltage threshold. The $\overline{\text{RESET}}$ output remains low for 300msec (typical) after V_{OUT2} rises above reset threshold. When the shutdown control ($\overline{\text{SHDN1}}$) is low, the regulator output voltage V_{OUT1} falls to zero and $\overline{\text{RESET}}$ output remains valid. When the shutdown control ($\overline{\text{SHDN2}}$) is low, the regulator output voltage V_{OUT2} falls to zero and $\overline{\text{RESET}}$ 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 240mV 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 Vout1 = 1.8V (fixed)
D indicates Vout2 = 2.8V, 3.0V (selectable)

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

ABSOLUTE MAXIMUM RATINGS*

Input Voltage 6.5V
Output Voltage .... (– 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.) .... +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:

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V_{IN}	Input Operating Voltage		**2.7**	—	**6.0**	V
I_{OUTMAX}	Maximum Output Current		**150**	—	—	mA
V_{OUT}	Output Voltage	Note 1	**V_R – 2.5%**	V_R ±0.5%	**V_R + 2.5%**	V
TCV_{OUT}	V_{OUT} Temperature Coefficient	Note 2	— **—**	20 **40**	— **—**	ppm/°C
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	$(V_R + 1V) \leq V_{IN} \leq 6V$	—	0.05	**0.35**	%
$\Delta V_{OUT}/V_{OUT}$	Load Regulation	I_L = 0.1mA to I_{OUTMAX} Note 3	—	0.5	**2**	%
$V_{IN} – V_{OUT}$	Dropout Voltage	$I_L = 100\mu A$ I_L = 50mA I_L = 100mA I_L = 150mA Note 4	— — — —	2 80 160 240	— **120** **240** **360**	mV
I_{IN}	Supply Current	$\overline{SHDN1}$, $\overline{SHND2}=V_{IH}$, I_L=0	—	120	**200**	µA
I_{INSD}	Shutdown Supply Current	$\overline{SHDN1}$, $\overline{SHDN2}$ = 0V	—	0.05	0.5	µA
PSRR	Power Supply Rejection Ratio	$F_{RE} \leq$ 1KHz	—	64	—	dB
I_{OUTSC}	Output Short Circuit Current	V_{OUT} = 0V	—	450	600	mA
$\Delta V_{OUT}/\Delta P_D$	Thermal Regulation	Notes 5,6	—	0.04	—	V/W
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)	—	40	—	µsec
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	—	$nV/\sqrt{Hz}$
$\overline{SHDN}$ 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	**65**	—	—	$\%V_{IN}$
V_{SELL}	SELECT Input Low Threshold	V_{IN} = 2.7V to 6.0V	—	—	**15**	$\%V_{IN}$

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
RESET Output						
$V_{MIN,IN}$	Minimum V_{IN} Operating Voltage	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_{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} = 50µA	— — —	— — —	**0.3** **0.4** **0.3**	V
V_{OH}	$\overline{RESET}$ Output Voltage High	$V_{OUT2} > V_{TH}$ max, I_{SOURCE} = 500µA $V_{OUT2} > V_{TH}$ max, I_{SOURCE} = 800µA	0.8 V_{OUT2} V_{OUT2} – 1.5	— —	—	V

NOTES:
1. V_R is the regulator output voltage setting. For example: V_R = 2.8V, 3.0V.
2. $TCV_{OUT} = \frac{(V_{OUTMAX} - V_{OUTMIN}) \times 10^6}{V_{OUT} \times \Delta T}$
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 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.

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	$\overline{SHDN1}$	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.
5	$\overline{SHDN2}$	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, and $\overline{RESET}$ output is low.
6	V_{OUT1}	Regulated voltage output 1.
7	V_{OUT2}	Regulated voltage output 2.
8	$\overline{RESET}$	$\overline{RESET}$ Output. $\overline{RESET}$=Low when V_{OUT2} is below the Reset Threshold Voltage. $\overline{RESET}$=High when V_{OUT2} is above the Reset Threshold Voltage.

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 (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).

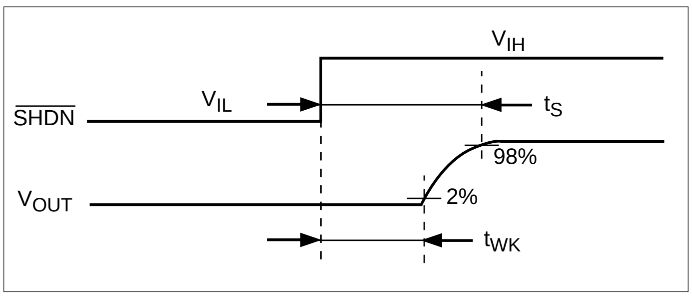


Figure 2: Wake Up Response Time

Thermal Considerations

Thermal Shutdown

Integrated thermal protection circuitry shuts the regulator off when die temperature exceeds 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:

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

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 MSOP-8 package has a θ_{JA} of approximately 200°C/W; 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} = 3.8V ± 5%
$V_{OUT}1_{MIN}$ = 3.0V ± 2.5%
$V_{OUT}2_{MIN}$ = 2.8V ± 2.5%
$I_{LOAD1MAN}$ = 120mA
$I_{LOAD2MAX}$ = 60mA
T_{JMAX} = 125°C
T_{AMAX} = 55°C
θ_{JA} = 200°C/W

FIND:

1) Actual power dissipation:

$$P_D \approx [(V_{INMAX} - V_{OUT}1_{MIN}) \times I_{LOAD}1_{MAX} + [(V_{INMAX} - V_{OUT}2_{MIN}) \times I_{LOAD}2_{MAX}$$

$$[(3.8 \times 1.05) - (3.0 \times .975)] \times 120 \times 10^{-3} + [(3.8 \times 1.05) - (2.8 \times .975)] \times 60 \times 10^{-3}$$

$$= \underline{203.4\text{mW}}$$

2) Maximum allowable power dissipation:

$$P_D \approx \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}}$$

$$= \frac{(125 - 55)}{200}$$

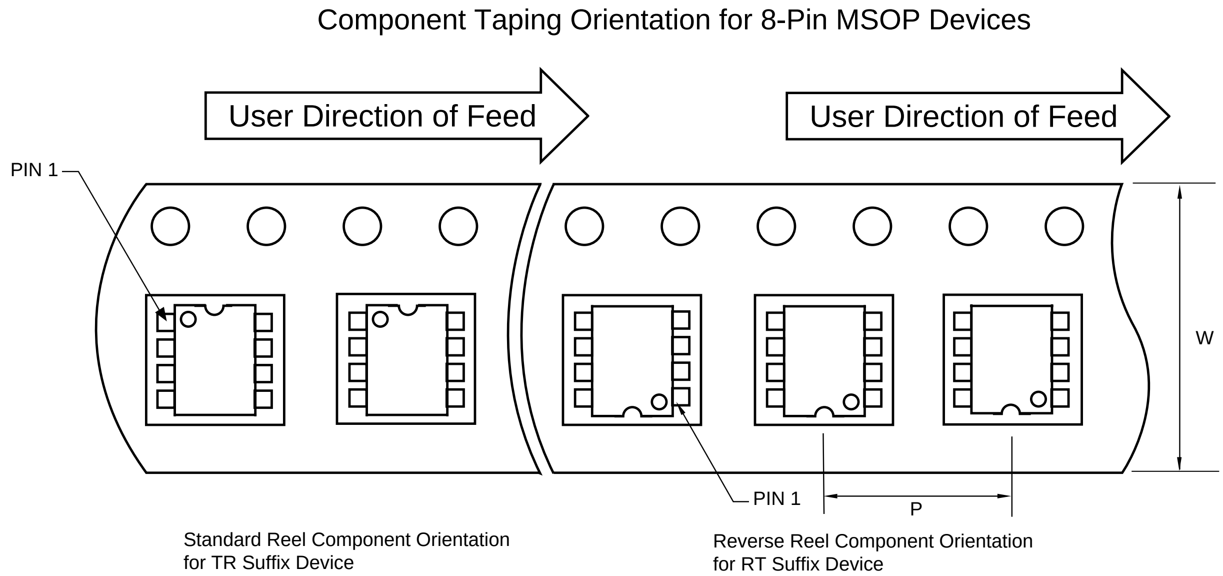
$$= \underline{350\text{mW}}$$

In this example, the TC1306 dissipates a maximum of only 203.4mW; 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} = 4.6V.

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, increase the maximum allowable power dissipation limit.

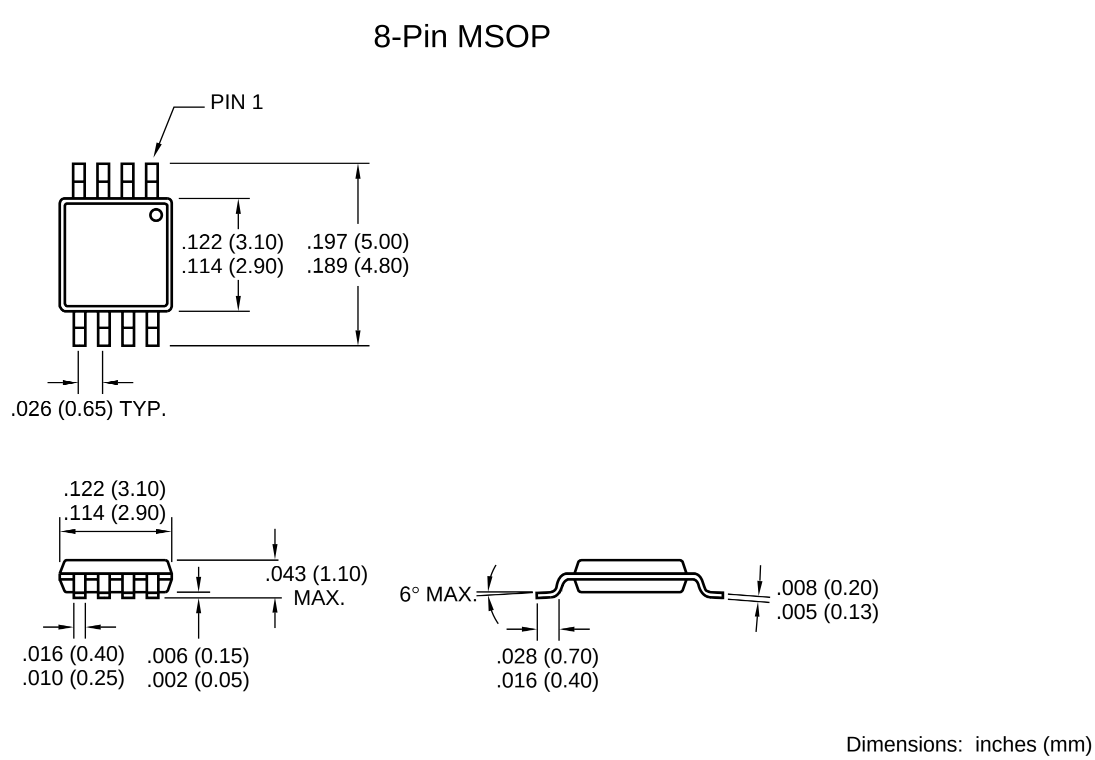
TAPE AND REEL DIAGRAMS



Carrier Tape, Number of Components Per Reel and Reel Size

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

PACKAGE DIMENSIONS



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