USB 3.3V Regulator with Power Good

Features

- 3.3V regulated output up to 500mA (PWR160SA), or 300mA (PWR160MA)
- Quiescent current 35µA (typical)
- Shutdown mode current 7µA (typical)
- Power watch-dog function, 30ms active LOW Power-Outage-Reset ($\overline{POR}$) pulse
- Foldback current limiting protection
- Reverse-current and thermal overload protection
- 8 pin SOIC and MSOP power packages

Applications

- Bus-powered USB peripherals
- Self-powered USB peripherals
- Critical power monitoring, hot-insertion devices
- MP3 Players
- Digital Still Cameras
- PDAs
- Wireless Handsets

Product Description

The SmartOR™ CMPWR160 combines a Low Dropout Regulator (LDO) with a Power-Outage-Reset ($\overline{POR}$) pulse generator, and is intended for Universal Serial Bus (USB) peripherals. To meet the specification requirements of both USB 1.1 and USB 2.0, the CMPWR160 draws a very low quiescent current (35µA), and delivers up to 500mA of load current at a fixed 3.3V output.

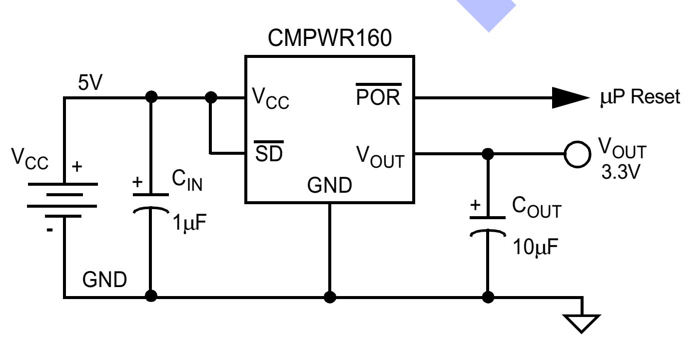
The $\overline{POR}$ pulse (active LOW) has a typical duration of 30ms after the output has exceeded and stabilized above 2.9V. Thus a new $\overline{POR}$ pulse is developed each time the regulator power is interrupted and restored, which occurs often on USB buses when cables are connected (or disconnected) by the user. It is not necessary to have a V_{CC} supply for $\overline{POR}$ to operate, allowing the CMPWR160 to work in Wired-ORed power systems.

When V_{CC} is powered down, the device will automatically enter reverse-current protection mode and maintain isolation between V_{OUT} and V_{CC}. This is useful for applications that can use power from the USB port in addition to internal batteries or an AC adapter supply (Wire-ORed power systems). In the event of V_{CC} collapsing below V_{OUT}, the device will automatically enter shutdown mode and fully isolate the V_{CC} power source from the output.

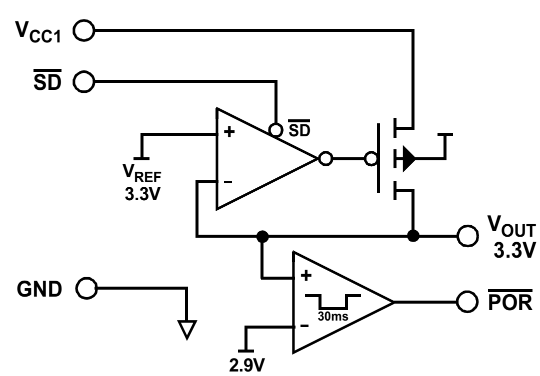
A ShutDown input ($\overline{SD}$) forces the regulator to be powered down on demand. While in shutdown mode the $\overline{POR}$ circuitry will remain active, making the device suitable for systems which contain backup or alternative power sources.

The CMPWR160 is available in 8-pin SOIC, (500mA rated) or 8-pin MSOP (300mA rated) thermally enhanced packages, ideal for applications where space is tight.

Typical Application Circuit

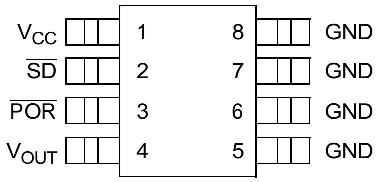


Simplified Electrical Schematic



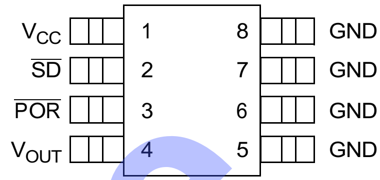
PACKAGE / PINOUT DIAGRAM

Top View



8-pin MSOP
CMPWR160MA

Top View



8-pin SOIC
CMPWR160SA

Note: These drawings are not to scale.

PIN DESCRIPTIONS

PIN(S)	NAME	DESCRIPTION
1	V_{CC}	V_{CC} is the input power source for the Low Drop Out Regulator capable of delivering 3.3V at the rated maximum output current even when the input voltage is as low as 4.2V. Internal loading on this pin is typically 35µA when the regulator is enabled, which reduces to only 7µA whenever the regulator is shutdown. In the event of V_{CC} dropping below V_{OUT}, the loading at V_{CC} will immediately reduce to less than 0.1µA. If the V_{CC} pin is within a few inches of the main input filter, a capacitor may not be necessary. Otherwise an input filter capacitor in the range of 1µF to 10µF will ensure adequate filtering.
2	$\overline{SD}$	$\overline{SD}$ is the regulator shutdown input logic signal which is Active Low. This is a true CMOS input signal referenced to V_{CC} supply. When the pin is tied High (V_{CC}) the regulator fully operates. When the pin is taken to GND, the device enters shutdown mode and the regulator is fully disabled. In this mode all critical $\overline{POR}$ circuitry remains fully powered consuming less than 7µA (typical).
3	$\overline{POR}$	$\overline{POR}$ is the Power-Outage-Reset output pin (Active Low). Whenever V_{OUT} falls below the V_{POR} threshold (typically 2.9V), this logic output pin is driven low. Upon V_{OUT} rising above V_{POR}, this pin remains at logic low for an additional 30ms duration after which it is driven to a logic high level. The Power-Outage-Reset circuitry is powered by, and draws a very low current (7µA typical) from the V_{OUT} rail. It remains enabled as long as is V_{OUT} present and produces valid logic output signals at the pin, even when V_{CC} is not present, as would be the case when V_{OUT} is driven by an external source.
4	V_{OUT}	V_{OUT} is the regulator output voltage used to power the load. An output capacitor of 10µF is required to provide the necessary phase compensation and prevent oscillation. The capacitor also helps to minimize the peak output disturbance during line or load transients. Whenever V_{CC} drops below V_{OUT}, the device immediately enters reverse protection mode to prevent any current flow back into the regulator pass transistor. Under these conditions V_{OUT} will also be used to provide the necessary quiescent current for the internal reference and $\overline{POR}$ circuits. This ensures excellent start-up characteristics for the regulator.
5-8	GND	GND is the negative reference for all voltages. The current that flows in the GND pin is very low (35µA with the regulator enabled and 7µA with the regulator disabled).

Ordering Information

PART NUMBERING INFORMATION				
Regulator	**Pins**	**Package**	**Ordering Part Number[1]**	**Part Marking**
CMPWR160	8	Power MSOP	CMPWR160MA	160M
CMPWR160	8	Power SOIC	CMPWR160SA	CMPWR160SA

Note 1: Parts are shipped in Tape & Reel form unless otherwise specified.

Specifications

ABSOLUTE MAXIMUM RATINGS		
PARAMETER	**RATING**	**UNITS**
ESD Protection (HBM)	±2000	V
Pin Voltages		
V_{CC}	[GND - 0.5] to [+6.0]	V
V_{OUT}	[GND - 0.5] to [+6.0]	V
$\overline{SD}$	[GND - 0.5] to [V_{CC} + 0.5]	V
$\overline{POR}$	[GND - 0.5] to [V_{OUT} + 0.5]	V
Storage Temperature Range	-40 to +150	°C
Operating Temperature Range		
Ambient	0 to +70	°C
Junction	0 to +125	°C
Power Dissipation	Internally Limited	

Note 1: The SOIC package used is thermally enhanced through the use of a fused integral leadframe. The power rating is based on a printed circuit board heat spreading capability equivalent to 2 square inches of copper connected to the GND pins. Typical multi-layer boards using power plane construction will provide this heat spreading ability without the need for additional dedicated copper area. (Please consult with factory for thermal evaluation assistance.)

STANDARD OPERATING CONDITIONS		
PARAMETER	**RATING**	**UNITS**
V_{CC} Input Voltage	4.2 to 5.5	V
Ambient Operating Temperature Range	0 to +70	°C
C_{EXT}	10 ±10%	μF

Specifications (cont'd)

ELECTRICAL OPERATING CHARACTERISTICS[1]						
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
I_{OUT}	Regulator Output Current CMPWR160SA CMPWR160MA				 500 300	 mA mA
V_{OUT}	Regulator Output Voltage	$0mA < I_{LOAD} < I_{OUT}$ max.	3.135	3.300	3.465	V
I_{LIM}	Regulator Current Limit			550		mA
I_{SC}	Short-circuit Current Limit			300		mA
$V_{R\ LOAD}$	Load Regulation	V_{CC}=5V, I_{LOAD}=5mA to I_{OUT} max.		75		mV
$V_{R\ LINE}$	Line Regulation	V_{CC}=4.2 to 5.5V, I_{LOAD}=5mA		2		mV
V_{DO}	Regulator Dropout Voltage	min. V_{CC}-V_{OUT} for I_{LOAD}=I_{OUT} max.		0.60	0.90	V
I_Q	Quiescent Supply Current	Regulator Enabled, I_{LOAD}=0mA		35	65	µA
I_{SD}	Shutdown Supply Current	Regulator Disabled		7	15	µA
I_{RCC}	V_{CC} Pin Reverse Leakage	V_{OUT}=3.3V; V_{CC} = 0.0V		1	10	µA
$V_{IH\ \overline{SD}}$	Shutdown High Detect	V_{CC} = 5.0V		3.0		V
$V_{IL\ \overline{SD}}$	Shutdown Low Detect	V_{CC} = 5.0V		1.0		V
$V_{\overline{POR}}$	$\overline{POR}$ Detect Threshold	4.2V < V_{CC} < 5.5V	2.8	2.9	3.0	V
$T_{\overline{POR}}$	$\overline{POR}$ Pulse Duration		20	30	40	mS
$R_{\overline{POR}}$	$\overline{POR}$ Output Impedance	After $\overline{POR}$ threshold detected; sinking to GND/Sourcing from V_{CC}	0.2	0.5	2	kΩ
$T_{DISABLE}$	Shutdown Temperature			160		°C
T_{HYST}	Thermal Hysteresis			20		°C

Note 1: Operating Characteristics are over Standard Operating Conditions unless otherwise specified.

Typical DC Characteristics

(Nominal operating conditions unless specified otherwise)

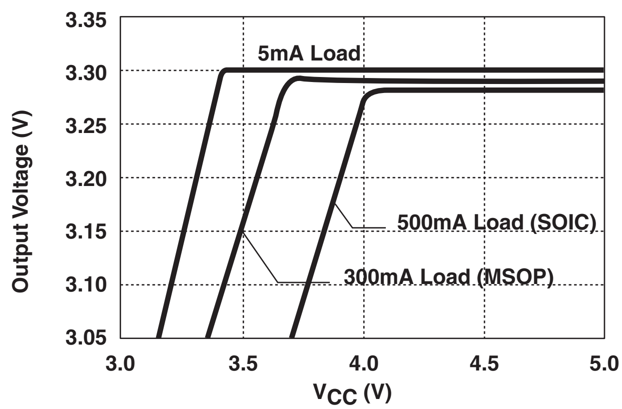


Figure 1. Line Regulation

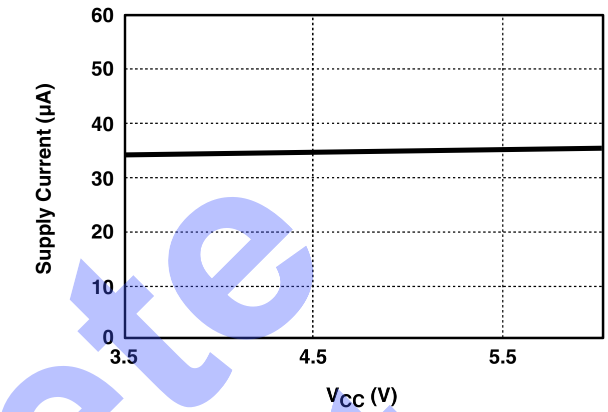


Figure 4. V_{CC} Operating Current (no load)

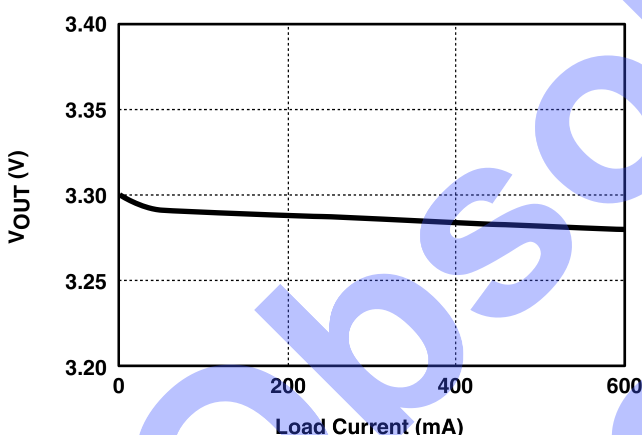


Figure 2. Load Regulation

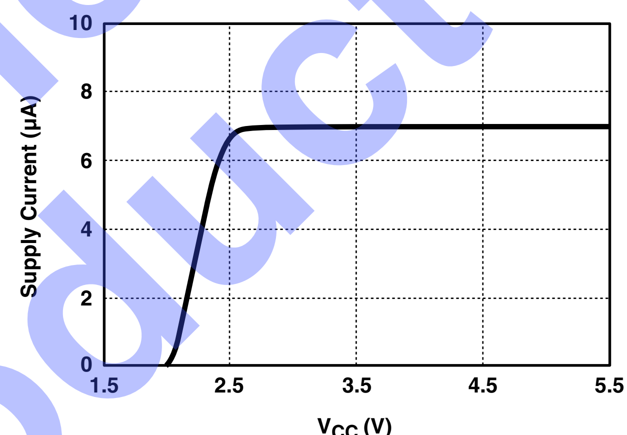


Figure 5. V_{CC} Shutdown Current

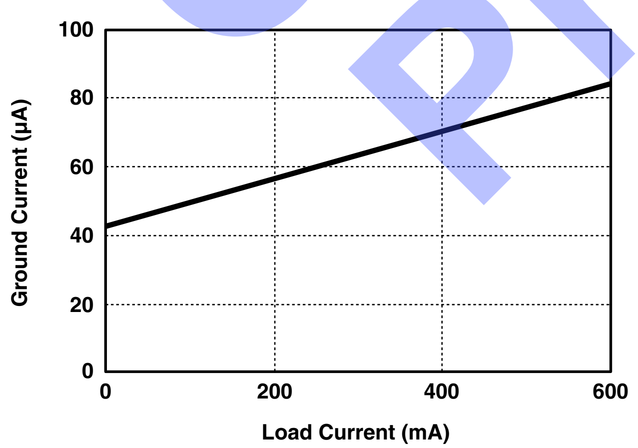


Figure 3. Ground Current vs. Output Load

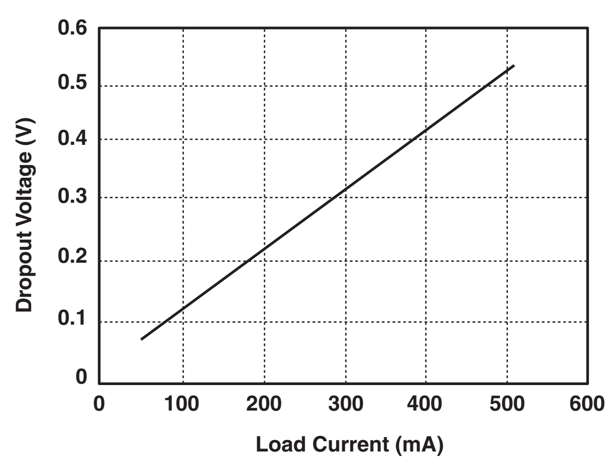


Figure 6. Dropout Voltage vs. Load Current

Typical Transient Characteristics (Nominal operating conditions unless specified otherwise)

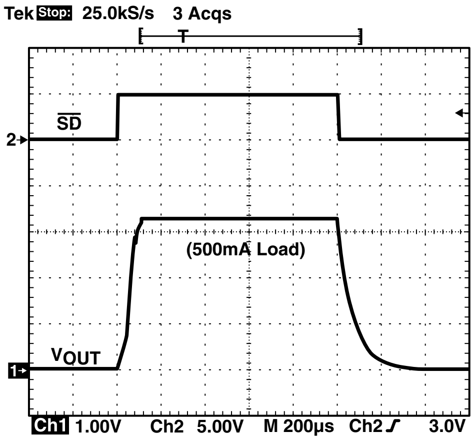


Figure 7. Shutdown Transient Response

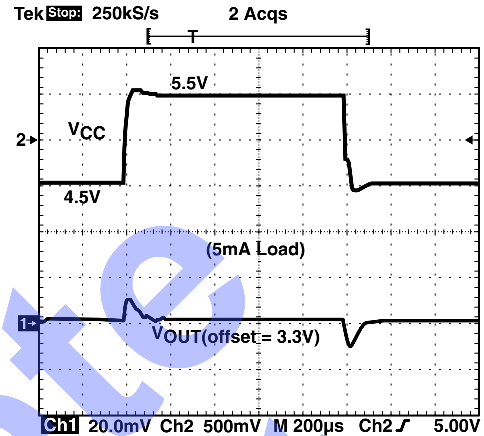


Figure 10. Line Step Response

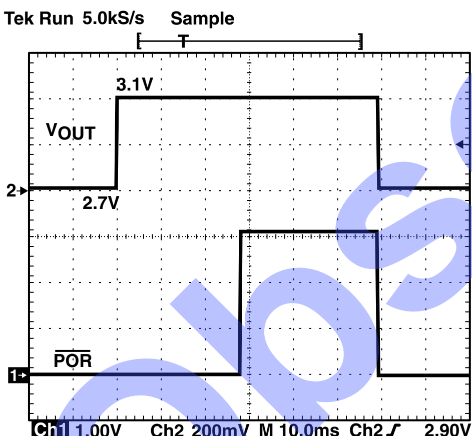


Figure 8. $\overline{\text{POR}}$ Response to V_{OUT} (Driven Externally)

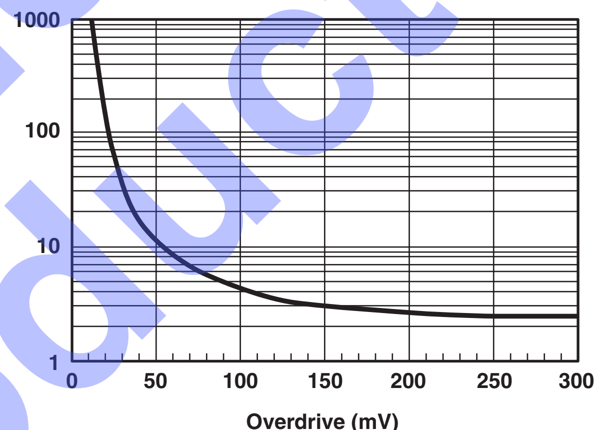


Figure 11. $\overline{\text{POR}}$ Reset Response Time with Overdrive (V_{POR}-V_{OUT})

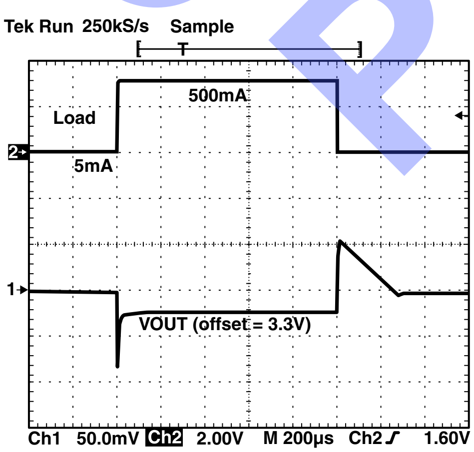


Figure 9. Load Step Response

Typical Thermal Characteristics

Thermal dissipation of junction heat consists primarily of two paths in series. The first path is the junction to the case (θ_{JC}) thermal resistance which is defined by the package style, and the second path is the case to ambient (θ_{CA}) thermal resistance, which is dependent on board layout.

The overall junction to ambient (θ_{JA}) thermal resistance is equal to:

$$\theta_{JA} = \theta_{JC} + \theta_{CA}$$

For a given package style and board layout, the operating junction temperature is a function of junction power dissipation P_{JUNC}, and the ambient temperature, resulting in the following thermal equation:

$$T_{JUNC} = T_{AMB} + P_{JUNC}\,(\theta_{JC}) + P_{JUNC}\,(\theta_{CA})$$

$$= T_{AMB} + P_{JUNC}\,(\theta_{JA})$$

The CMPWR160 is housed in a thermally enhanced package where all the GND pins (5 through 8) are integral to the leadframe (fused leadframe). When the device is mounted on a double sided printed circuit board with two square inches of copper allocated for “heat spreading”, the resulting θ_{JA} is 50°C/W for the CMPWR160SA (SOIC), and 70°C/W for the CMPWR160MA (MSOP).

Based on a maximum power dissipation of 1.0W (2Vx500mA) with an ambient of 70°C the resulting junction temperature for the CMPWR160SA will be:

$$T_{JUNC} = T_{AMB} + P_{JUNC}\,(\theta_{JA})$$

$$= 70°C + 1.0W\,(50°C/W)$$

$$= 70°C + 50°C = 120°C$$

In the case of the CMPWR160MA, the maximum power dissipated is 0.6W (2V x 300mA). So for an ambient of 70°C, the junction temperature will be:

$$T_{JUNC} = 70°C + 0.6\,(70°C/W)$$

$$= 70°C + 42°C$$

$$= 112°C$$

All thermal characteristics were measured using a double sided board with two square inches of copper area connected to the GND pins for “heat spreading”.

Measurements showing performance up to junction temperature of 125°C were performed under light load conditions (5mA). This allows the ambient temperature to be representative of the internal junction temperature.

Note: The use of multi-layer board construction with power planes will further enhance the thermal performance of the package. In the event of no copper area being dedicated for heat spreading, a multi-layer board construction, using only the minimum size pad layout, will typically provide the CMPWR160SA with an overall θ_{JA} of 70°C/W which allows up to 780mW to be safely dissipated.

Typical Thermal Characteristics (cont'd) (Nominal operating conditions unless specified otherwise)

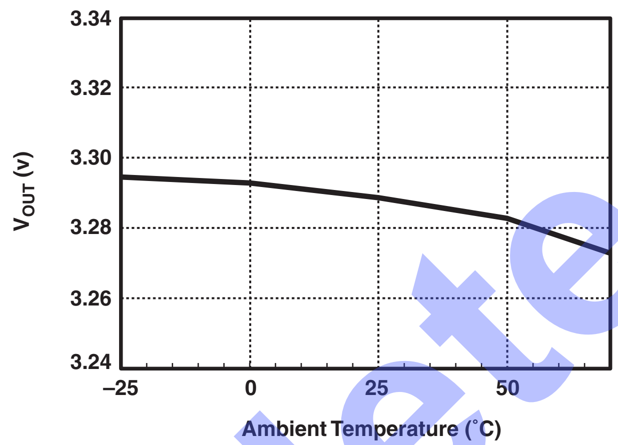


Figure 12. V_{OUT} Temperature Variation (500mA)

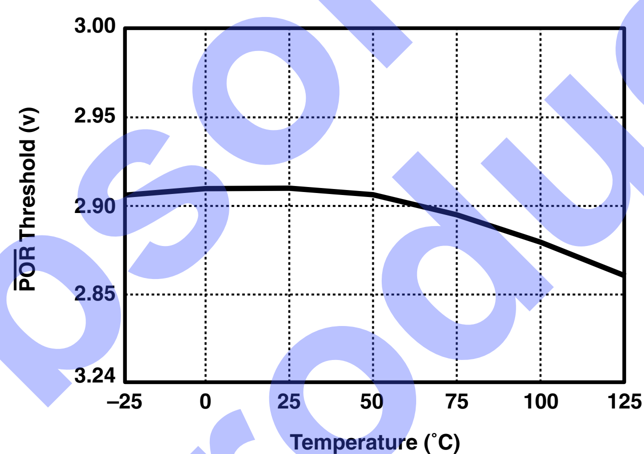


Figure 13. $\overline{\text{POR}}$ Threshold Temperature Variation

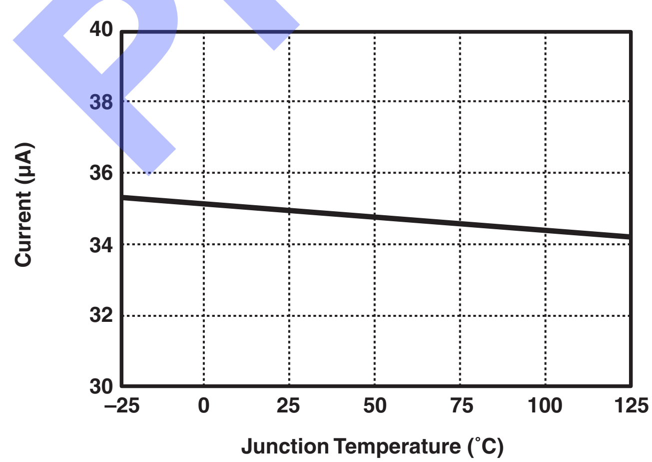


Figure 14. V_{CC} Supply Current vs. Junction Temperature

Applications Information

USB Bus-powered Peripheral Applications

Universal Serial Bus (USB) peripherals can be powered from the USB port. The cable carries signal on 2 lines, a V_{BUS} line which is nominally 5V at the source and a GND wire. See Figure 15. For example, an external modem (USB device or peripheral) draws its power from the USB port of a personal computer (USB host), and one definite advantage of bus-powered devices is that they do not need extra power cords and plugs.

The USB specification (revisions 1.1 and 2.0) sets various limitations on the power distribution. A bus-powered device must draw no more than 500mA in operating mode. A "Suspend" mode is entered when no data is exchanged on the bus between the host and the peripheral device. In this mode the current drawn by the peripheral is reduced and may not exceed 500µA. The CMPWR160 addresses these requirements by providing regulations up to 500mA, with overload current limit, short-circuit current limit, and a very low quiescent current.

Each peripheral is required to have one data line, D+ or D–, connected to a 1.5kΩ pull-up resistor terminated to a 3.3V reference. The resistor is either connected to the D+ data line for selecting high-speed mode, or to the D– data line for low-speed mode. The pull-up resistor draws 200µA current on all USB devices. In Suspend mode, there is only 300µA (500µA - 200µA) left to power the controller and the regulator. Clearly, the low quiescent current (35µA typical) of the CMPWR160 is a definite advantage. The CMPWR160 3.3V output can be used as a reference voltage for the pull-up resistor.

USB peripherals are classified in two groups: low-power and high-power bus-powered devices. Low-power functions draw less that 100mA when operational and must be capable of operating with input V_{BUS} voltage as low as 4.40V. High-power functions can draw up to 500mA when operational and must be capable of operating with an input V_{BUS} voltage as low as 4.75V. The CMPWR160 operates with input voltage down to 4.2V under full rated load (500mA for the CMPWR160SA, 300mA for the CMPWR160MA). It is suited for any type of function even under transient conditions with 330mV drop on V_{BUS}.

Power-Outage-Reset Operation

The CMPWR160 asserts a reset signal ($\overline{POR}$) whenever the output voltage V_{OUT} drops below the V_{POR} threshold of 2.9V typical, keeping it asserted for 30ms after V_{OUT} has risen above the reset threshold. The reset signal is active-low, and its high level voltage is set by V_{OUT}.

The device provides immunity to short-duration negative-going pulse applied to V_{OUT}. The data sheet Figure 11 shows typical transient duration versus reset comparator overdrive ($V_{\overline{POR}}$ - V_{OUT}), below which the CMPWR160 will not generate a reset pulse. In other words, the graph shows the maximum pulse duration on a transient on V_{OUT} that will not cause a reset pulse. For example, a V_{OUT} transient of 100mV below the 2.9V threshold is detected only if it lasts for 4ms or more.

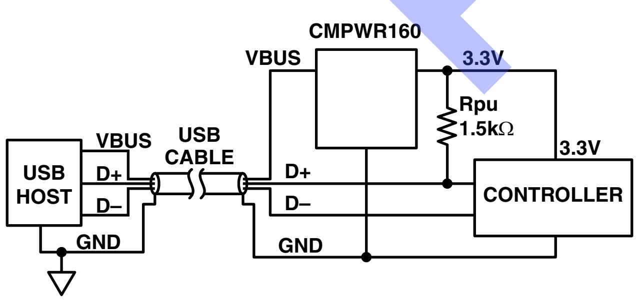


Figure 15. High-speed Device Cable and Pull-up Resistor Connection

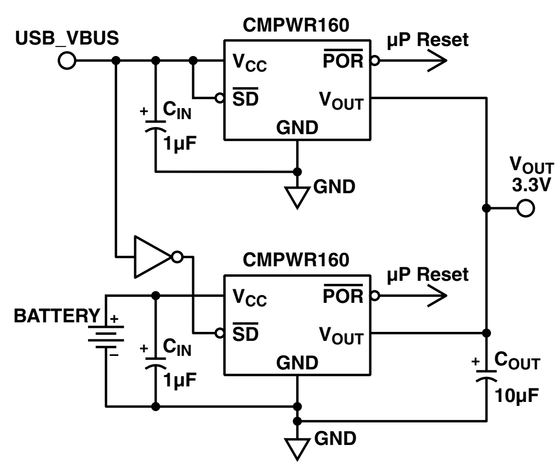


Figure 16. Dual Power USB/Battery Application

Applications Information (cont'd)

Dual Power Battery and USB Applications

Some hand-held devices can be powered from two independent supplies: either a battery or a computer USB port 5V.

These devices could also require a regulated 3.3V. A dual CMPWR160 configuration, as shown in Figure 16, provides uninterrupted power, so that the device can remain fully "on" when plugged into the USB port.

Possible usage for this configuration is in portable equipment such as PDAs, wireless PDAs, cellular phones, video camcorders, digital cameras, CD players, MP3 players, and games.

The regulator is compatible with various battery configurations using non-rechargeable alkaline "AA" batteries of 1.5V each, or rechargeable Nickel-Metal Hydride (NiMH) batteries of 1.2V per cell.

- 4 "AA" batteries (1.5V per cell): 4 X 1.5V = 6.0V
- 4 NiMH cell (1.2V per cell): 4 X 1.2V = 4.8V
- 3 "AA" batteries (1.5V per cell): 3 X 1.5V = 4.5V
- 3 NiMH cell (1.2V per cell): 3 X 1.2V = 3.6V
  (200mA MAX rated)

References

1.California Micro Devices Application Note AP211, "Instantly Available PCI Card Power Management".

2.Universal Serial Bus Specification Revision 1.1 and 2.0

Mechanical Details

MSOP-8 Mechanical Specifications:

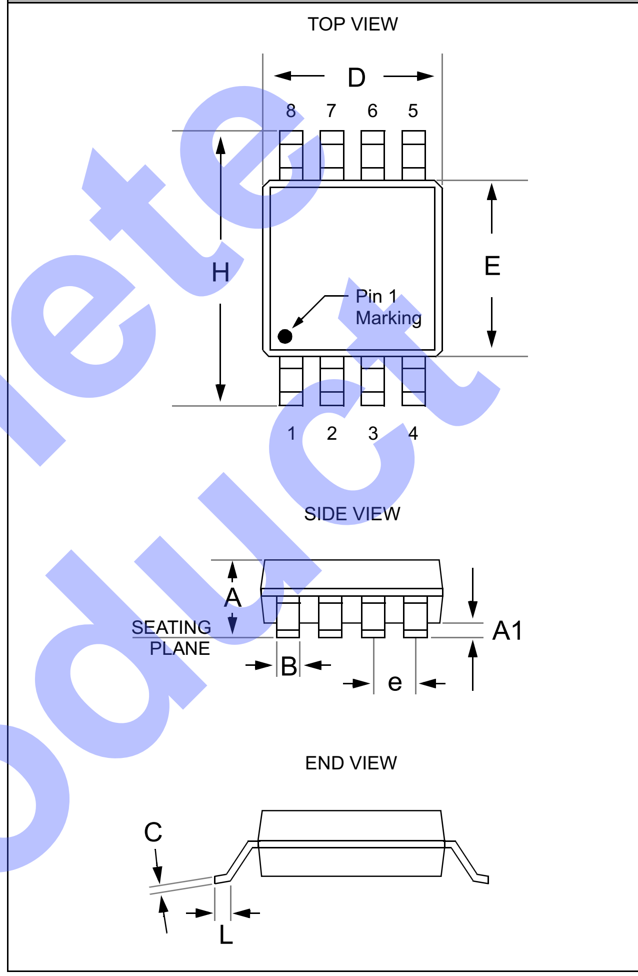
CMPWR160 devices are packaged in 8-pin MSOP packages. Dimensions are presented below.

For complete information on the MSOP-8 package, see the California Micro Devices MSOP Package Information document.

PACKAGE DIMENSIONS				
Package	MSOP			
Pins	8			
Dimensions	**Millimeters**		**Inches**	
	Min	**Max**	**Min**	**Max**
A	0.87	1.17	0.034	0.046
A1	0.05	0.25	0.002	0.010
B	0.30 (typ)		0.012 (typ)	
C	0.18		0.007	
D	2.90	3.10	0.114	0.122
E	2.90	3.10	0.114	0.122
e	0.65 BSC		0.025 BSC	
H	4.78	4.98	0.188	0.196
L	0.52	0.54	0.017	0.025
# per tube	80 pieces*			
# per tape and reel	4000 pieces			
Controlling dimension: inches				

* This is an approximate amount which may vary.

Mechanical Package Diagrams



Package Dimensions for MSOP-8

Mechanical Details (cont'd)

SOIC-8 Mechanical Specifications

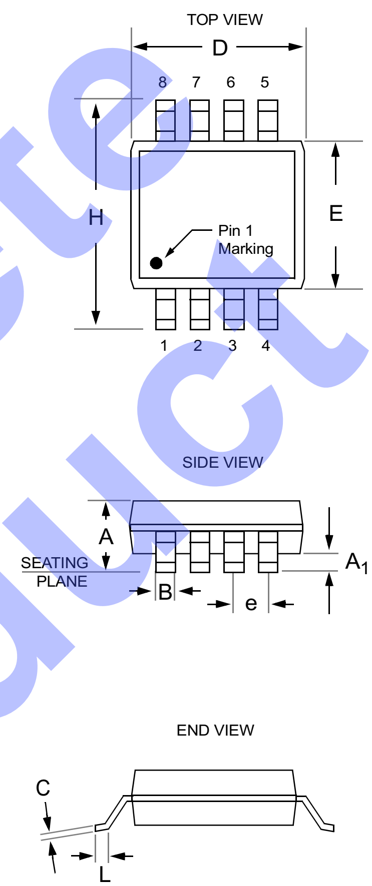
Dimensions for CMPWR160 devices packaged in 8-pin SOIC packages are presented below.

For complete information on the SOIC-8 package, see the California Micro Devices SOIC Package Information document.

PACKAGE DIMENSIONS				
Package	SOIC			
Pins	8			
Dimensions	**Millimeters**		**Inches**	
	Min	**Max**	**Min**	**Max**
A	1.35	1.75	0.053	0.069
A_1	0.10	0.25	0.004	0.010
B	0.33	0.51	0.013	0.020
C	0.19	0.25	0.007	0.010
D	4.80	5.00	0.189	0.197
E	3.80	4.19	0.150	0.165
e	1.27 BSC		0.050 BSC	
H	5.80	6.20	0.228	0.244
L	0.40	1.27	0.016	0.050
# per tube	100 pieces*			
# per tape and reel	2500 pieces			
Controlling dimension: inches				

* This is an approximate number which may vary.

Mechanical Package Diagrams



Package Dimensions for SOIC-8