DATA SHEET

SA57016-XX

CapFREE™ 150 mA, low-noise, ultra low-dropout regulator with thermal protection

Product data

2003 Dec 12

Philips
Semiconductors

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CapFREE™ 150 mA, low-noise, ultra low-dropout regulator with thermal protection

SA57016-XX

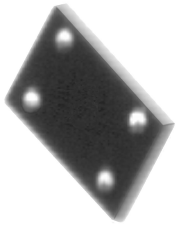
GENERAL DESCRIPTION

The CapFREE™ SA57016 is one of a family of unique low dropout regulators. It needs no external capacitors, offers a low output noise voltage of 25 μVrms which eliminates the BYPASS pin, and an ultra-low dropout voltage of 20 mV max. @ 50 mA output current. Reverse battery current is extremely low, 0.5 μA typical.

The CapFREE™ SA57016 is a drop-in replacement for LP2985 in Chip-Scaled Package with superior performance.

To accommodate high density layouts, it is packaged in a 4-bump Chip-Scale package (WL-CSP4). It is ideal for all portable and cellular phone applications.

Additional features include power and thermal shutdown, output current limitation, external logic-controlled ON-OFF via the PWRON pin, and reverse battery protection. If you are looking for additional PowerOK and thermal warning features, please look up SA57017 device for further information.



WL-CSP4

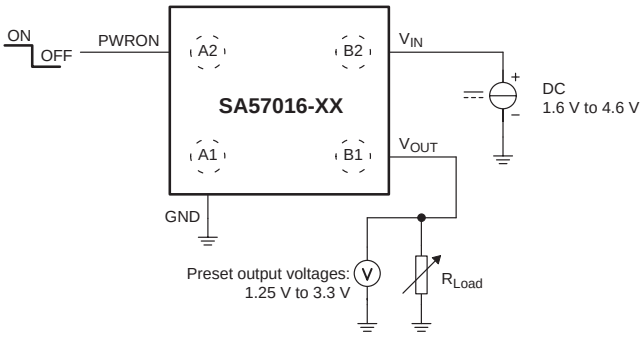
FEATURES

- CapFREE: No output capacitor needed, stable for all capacitive loads, regardless of ESR.
- Wafer level Chip-Scale (WL-CSP4) package
- Low 25 μVrms noise without noise bypass capacitor
- Preset output voltages to 1.25, 1.8, 2.4, 2.6, 2.8, 3.0, and 3.3 V; other voltages available upon request.
- 1% output voltage accuracy
- 150 mA maximum output current with current limitation
- Typical dropout voltage 20 mV max. @ 50 mA output current
- 85 μA typical ground current
- Shutdown (standby) current <1 μA
- Thermal-overload and short-circuit protection
- Reverse Battery Protection
- Max line regulation 0.35%/V
- Max load regulation 0.015%/mA

APPLICATIONS

- Cordless and mobile phones
- Industrial and medical equipment
- Other battery-powered equipment

SIMPLIFIED DEVICE DIAGRAM



Top view (Wafer-level CSP pin assignments using JEDEC standard matrix)

SL02113

Figure 1. Simplified device diagram.

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ORDERING INFORMATION

TYPE NUMBER	PACKAGE		TEMPERATURE RANGE
	NAME	DESCRIPTION	
SA57016-**XX**UK	WL-CSP4	wafer-level, chip-scale package; 4 bumps (see dimensional drawing)	–40 to +85 °C

NOTE:
The device has seven (7) voltage output options, indicated by the **XX** on the Type Number.

XX	VOLTAGE (Typical)
12	1.25 V
18	1.8 V
24	2.4 V
26	2.6 V
28	2.8 V
30	3.0 V
33	3.3 V

PIN CONFIGURATION

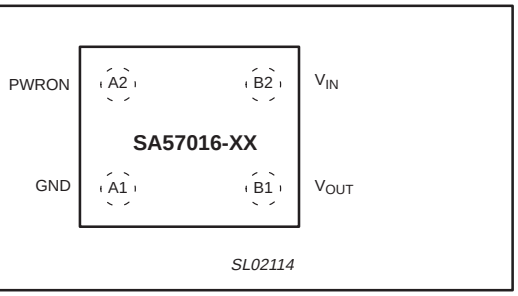


Figure 2. Pin configuration, top view (balls are on the bottom)

PIN DESCRIPTION

BALL NO.	SYMBOL	DESCRIPTION
A1	GND	Ground
A2	PWRON	Power-On input. Active-HIGH. A logic LOW powers down the regulator. The shutdown quiescent current is typically 50 nA. Connect to V_{IN} for normal operation.
B1	V_{OUT}	Regulator output. Sources up to 150 mA. **No capacitor required.**
B2	V_{IN}	Regulator input. $V_{OUT(nom)}$+0.5V to 4.6 V. Minimum input voltage required is 1.6 V. **No capacitor required.**

MAXIMUM RATINGS

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_{IN}	V_{IN} to GND voltage	–0.3	4.6	V_{DC}
V_{PWRON}	PWRON to GND voltage	–0.3	4.6	V_{DC}
V_{OUT}	OUT to GND voltage	–0.3	V_{IN} + 0.3	V_{DC}
T_{amb}	Operating ambient temperature	–40	+85	°C
T_j	Junction temperature	–	+125	°C
T_{stg}	Storage temperature	–65	+160	°C
P_D	Power dissipation (T_{amb} = 25 °C) Power dissipation degrading factor above 25 °C = 5.1 mW/°C	–	637	mW
$R_{th(j-a)}$	Thermal resistance from junction to ambient	–	140	°C/W

ELECTRICAL CHARACTERISTICS

$V_{IN} = V_{OUT(nom)} + 0.5$ V, $T_{amb} = -40$ °C to +85 °C, unless otherwise noted. (Note 1.)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{IN}	input voltage		$V_{OUT(nom)}$	–	4.6	V
	output voltage accuracy (Note 2)	1.6 V < $V_{OUT(nom)} \leq 3.3$ V; I_{OUT} = 1 mA to 150 mA				
		T_{amb} = +25 °C	–1	–	+1	%
		–40 °C ≤ T_{amb} ≤ +85 °C	–3.0	–	1.5	%
		1.25 V ≤ $V_{OUT(nom)} \leq 1.6$ V				
		I_{OUT} = 1 mA	–3.0	–	2.5	%
		I_{OUT} = 150 mA	–4.0	–	1.5	%
I_{LIM}	current limit		160	300	500	mA
I_Q	GND pin current	I_{OUT} = 1 mA to 150 mA	–	250	400	µA
I_{RBC}	reverse battery current		–	0.5	–	µA
	Dropout voltage (Notes 2 and 4)	I_{OUT} = 50 mA	–	–	25	mV
		I_{OUT} = 100 mA	–	–	50	mV
		I_{OUT} = 150 mA	–	–	75	mV
ΔV_{LNR}	line regulation	1.25 V < $V_{OUT(nom)} \leq 2.4$ V; $V_{out(nom)}$ + 0.1 V ≤ $V_{IN} \leq 4.6$ V	–	–	0.35	%/V
		2.4 V < $V_{OUT(nom)} \leq 3.3$ V; $V_{out(nom)}$ + 0.1 V ≤ $V_{IN} \leq 4.6$ V	–	–	0.4	%/V
ΔV_{LDR}	load regulation	1.25 V < $V_{OUT(nom)} \leq 3.3$ V; I_{OUT} = 1 mA to 150 mA	–	–	0.015	%/ mA
Shutdown						
V_{IH}	PWRON input threshold	$V_{out(nom)} \leq V_{IN} \leq 4.6$ V	0.7 × V_{IN}	–	–	V
V_{IL}			–	–	0.3 × V_{IN}	V
I_{PWRON}	PWRON input bias current	$V_{PWRON} = V_{IN}$	–	1	–	nA
$I_{Q(SHDN)}$	Shutdown supply current	V_{OUT} = 0 V	–	40	–	nA
t_{PWRON}	PWRON start-up time (Note 3)	I_{OUT} = 1 to 50 mA	–	30	50	µs
Thermal protection						
T_{SHDN}	Thermal shutdown temperature		–	163	–	°C
ΔT_{SHDN}	Thermal shutdown hysteresis		–	10	–	°C

NOTES:
1. Limits are production tested at worst case ambient temperature (85 °C)
2. The dropout voltage is defined as V_{IN}–V_{OUT}, where V_{OUT} is 100 mV below the value of V_{OUT} for $V_{IN} = V_{OUT}$ + 0.5 V (only applicable for 1.6 V < $V_{OUT(NOM)} \leq 3.3$ V).
3. Time needed for V_{OUT} to reach 95% of $V_{OUT(nom)}$
4. Minimum input voltage is 1.6 V if selected the 1.25 V preset output voltage.

TYPICAL PERFORMANCE CURVES

SA57016-33 (3.3 volt output). $V_{IN} = V_{OUT(nom)} + 0.5$ V; $C_{OUT} = C_{IN} = 0$ µF, $T_{amb} = -40$ to +85 °C, unless otherwise specified.

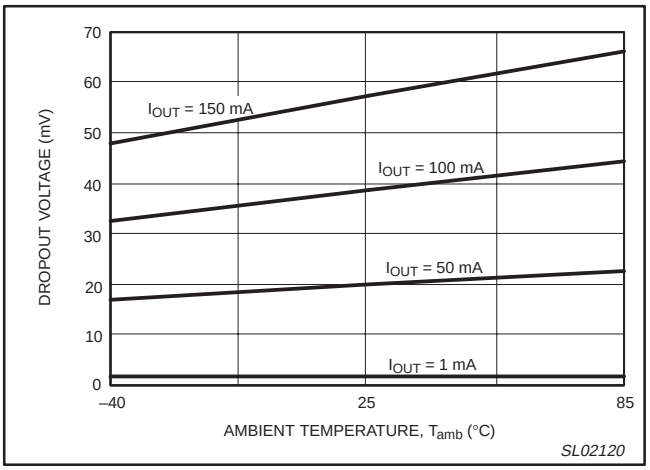


Figure 3. Drop-out voltage versus temperature.

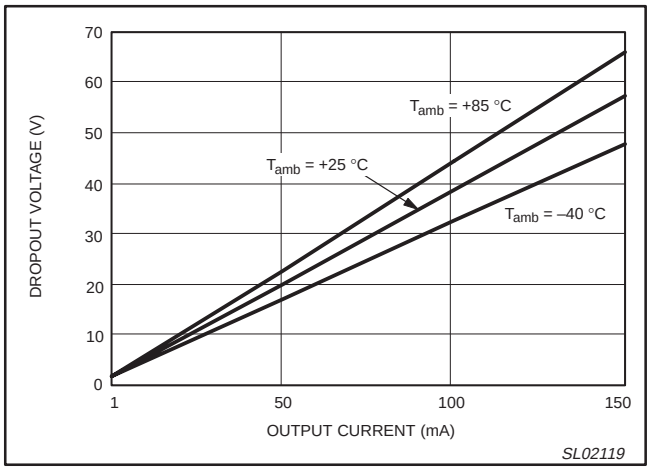


Figure 4. Dropout voltage versus output current.

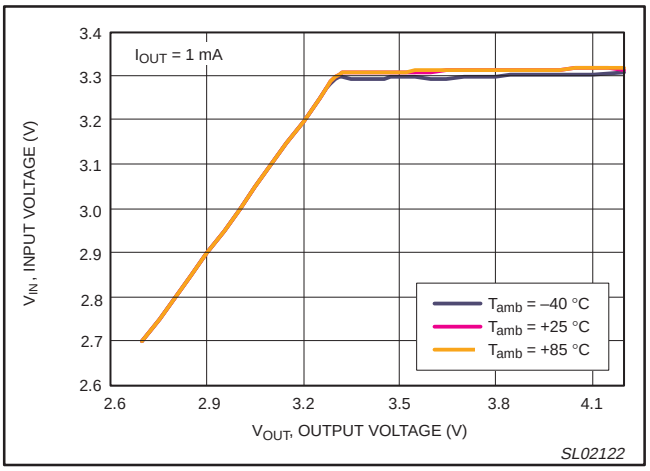


Figure 5. Input voltage versus output voltage.

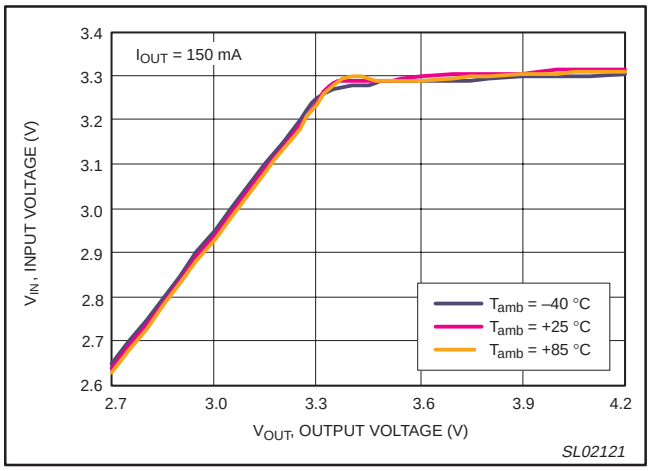


Figure 6. Input voltage versus output voltage.

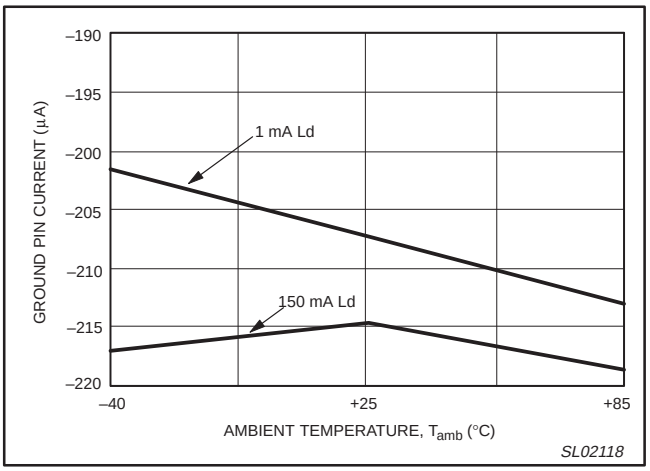


Figure 7. Ground pin current versus temperature.

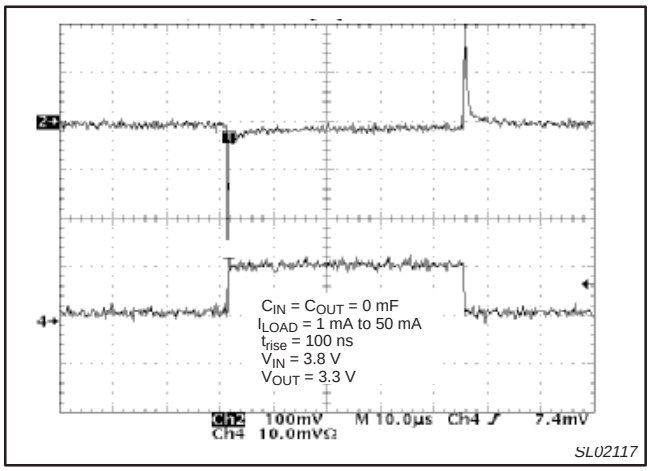


Figure 8. Load transient response.

TECHNICAL DISCUSSION

The SA57016 is a low drop-out, low-quiescent current linear regulator designed primarily for battery-powered applications and stabilizes with or without input/output capacitors. The device delivers up to 150 mA and is available with preset output voltages of 1.25 V, 1.6 V, 1.8 V, 2.0 V, 2.2 V, 2.4 V, 2.6 V, 2.8 V, 3.0 V, and 3.3 V for WL-CSP packages.

The 1.25 band-gap reference is connected to the error amplifier's inverting input. The error amplifier compares this reference with the feedback voltage and amplifies the difference. If the feedback voltage is lower than the reference voltage, the pass-transistor gate is pulled lower, which allows more current to pass to the output. The output voltage is fed back through an internal resistor voltage divider connected to the V_{OUT} pin.

Band-gap

The band-gap circuitry generates a temperature independent voltage by properly adding two voltages with negative and positive temperature coefficient. The band-gap voltage is typically 1.25 volts with a temperature variation of 5 mV over the temperature range from –40 °C to +125 °C.

Low-pass filter

Low-pass filter is basically an RC filter with a low cut-off frequency. **No external capacitor is used**. There is one comparator, which turns on the bypass paths to charge or discharge the capacitor if the output of the filter is higher or lower than the band-gap voltage by a specified amount.

Output amplifier

The output amplifier is a folded cascode PMOS amplifier which controls the gate of the output transistor and sources the load current. A portion of the output voltage is compared to the reference voltage and a constant voltage is maintained at output. The output is also monitored by a comparator which trips the PWROK if the output voltage falls below the nominal output level by a specified amount due to low battery condition or any other reason. The current limiter circuit monitors the output current and limits the load current to a certain value to avoid any damage due to short circuit.

Bias circuit

The bias block provides bias currents and voltages for the other blocks. It has a self start-up circuit and it can establish the bias currents and voltages very fast.

Thermal shutdown protection

The temperature sensor block monitors the die temperature. If the die temperature goes beyond 163 °C typical value, the output amplifier is shut down with a hysteresis of 10 °C.

Reverse battery protection

The reverse battery protection circuit prevents damage to the device if the supply battery is accidentally installed backwards. This circuit compares V_{IN} and PWRON to ground and disconnects the device's internal circuits if it detects reversed polarity. Reverse supply current is limited to 1 mA when this protective circuit is active, preventing the battery from rapidly discharging through the device. Reverse battery current is extremely low, 0.5 µA typical.

Current limit

The SA57016 includes a current limiter that monitors and controls the pass transistor's gate voltage, limiting the output current to 300 mA typical value. For design purposes, consider the current limit to be 160 mA minimum value. The output can be shorted to ground for an indefinite period of time without damaging the part.

PWROK output

The Power OK and temperature warning features are offered in the SA57017 family and pin-for-pin compatible to LP3988 with better performance. Please contact Philips local sales department for further information.

SIMPLIFIED BLOCK DIAGRAM

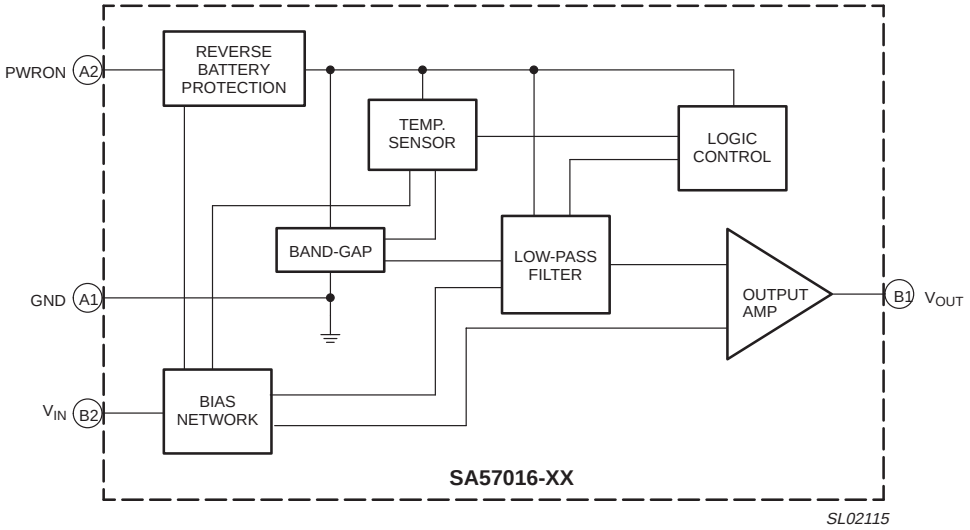
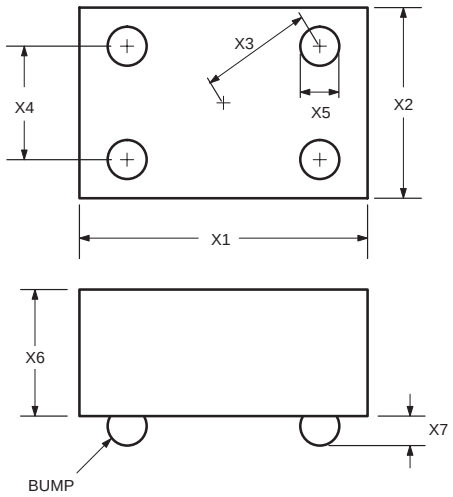


Figure 9. Simplified block diagram.

WL-CSP4: wafer level, chip-scale package; 4 bumps



DIMENSIONS (mm are the original dimensions)

UNIT	X1	X2	X3	X4	X5	X6	X7
mm	1.30 1.24	0.87 0.81	0.5	0.5	0.17	0.568 0.548	0.145 0.115

SL02116

CSP TAPE AND REEL

CapFREE™ 150 mA, low-noise, ultra low-dropout regulator with thermal protection

SA57016-XX

REVISION HISTORY

Rev	Date	Description
_1	2003 Dec 12	**Product data (9397 750 11878); ECN 853-2439 01-A14974 of 12 December 2003.**

Data sheet status

Level	Data sheet status [1]	Product status [2] [3]	Definitions
I	Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
II	Preliminary data	Qualification	This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.
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[2] The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL http://www.semiconductors.philips.com.

[3] For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

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Limiting values definition — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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