DATA SHEET

SA57017-XX

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

Product data
Supersedes data of 2003 Aug 13

2003 Aug 27

Philips
Semiconductors

PHILIPS

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

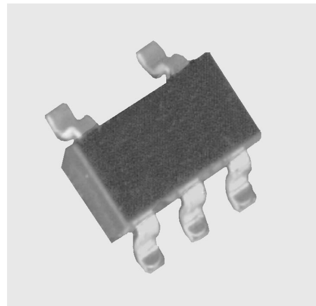
SA57017-XX

GENERAL DESCRIPTION

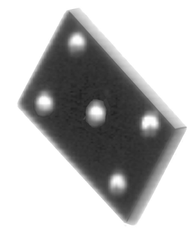
The CapFREE™ SA57017 is one of a family of unique low dropout regulators. It needs no external capacitors, offers a low output noise voltage of 25 μVrms, and an ultra-low dropout voltage of 50 mV max. @ 50 mA output current. Reverse battery current is extremely low, 0.5 μA typical.

To accommodate high density layouts, it is packaged in the small footprint 5 leaded SOT23-5 (SO5) and a 5-bump Chip-Scale package (WL-CSP5). It is ideal for all portable and cellular phone applications.

Additional features include power and thermal shutdown, output current limitation, power OK status via the PWROK pin, thermal warning, and external logic-controlled on-off via the PWRON pin, and reverse battery protection.



SO5 (SOT23)



WL-CSP5

FEATURES

- CapFREE: No output capacitor needed, stable for all capacitive loads, regardless of ESR.
- 5 leaded (SO5) SOT23-5 and Wafer level Chip-Scale (WL-CSP5) packages
- 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 3.3V other voltages available upon request.
- 1% output voltage accuracy.
- 150 mA Maximum Output Current with current limitation.
- Typical dropout voltage 50 mV max. @ 50 mA output current
- 85 μA typical ground current
- Shutdown (standby) current <1 μA
- Thermal-overload and short-circuit protection
- PWROK pin - both power status and thermal warning indicator.
- Reverse Battery Protection
- Max line regulation 0.15%/V
- Max load regulation 0.015%/mA

APPLICATIONS

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

SIMPLIFIED DEVICE DIAGRAM

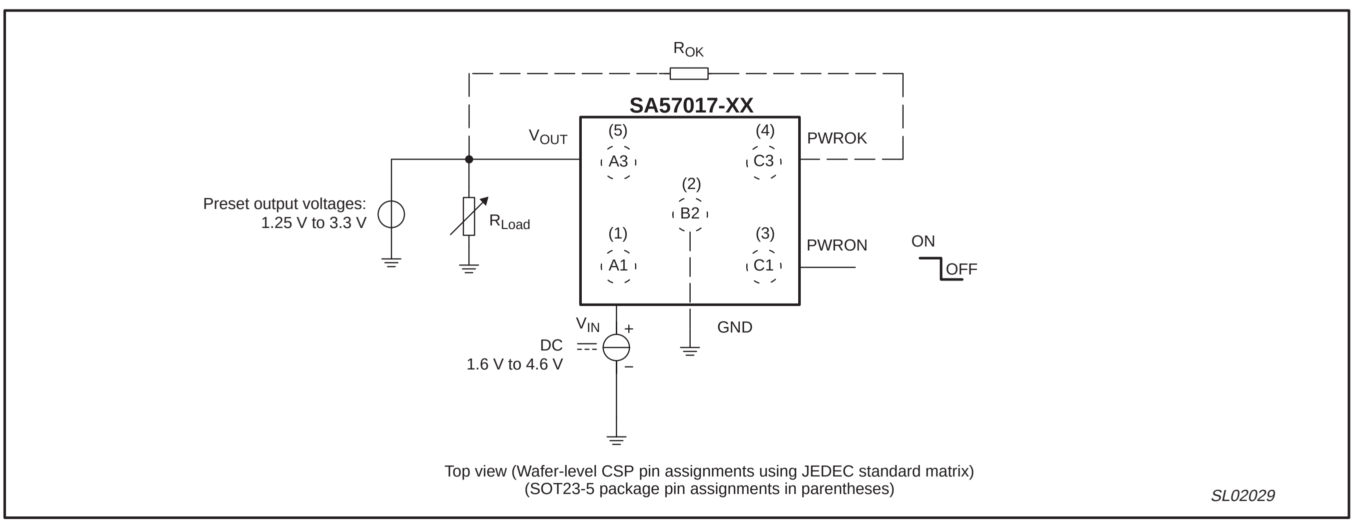


Figure 1. Simplified device diagram.

CapFREE is a trademark of Philips Electronics North America Corporation.

ORDERING INFORMATION

TYPE NUMBER	PACKAGE		TEMPERATURE RANGE
	NAME	DESCRIPTION	
SA57017-**XX**D	SO5	plastic small outline package; 5 leads; body width 1.5 mm	–40 to +85 °C
SA57017-**XX**UK	WL-CSP5	wafer-level, chip-scale 5 bump package, surface mount	–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
16	1.6 V
18	1.8 V
20	2.0 V
22	2.2 V
24	2.4 V
26	2.6 V
28	2.8 V
30	3.0 V
33	3.3 V

Part marking: Each device is marked with a four letter code. The first three letters designate the product. The fourth, represented by an ‘x’, designates date tracking code.

Part	Marking
SA57017-12D, UK	A C B X
SA57017-16D, UK	A B V X
SA57017-18D, UK	A B U X
SA57017-20D, UK	A B T X
SA57017-22D, UK	A B S X
SA57017-24D, UK	A B R X
SA57017-26D, UK	A C D X
SA57017-28D, UK	A C E X
SA57017-30D, UK	A C F X
SA57017-33D, UK	A C G X

PIN CONFIGURATION

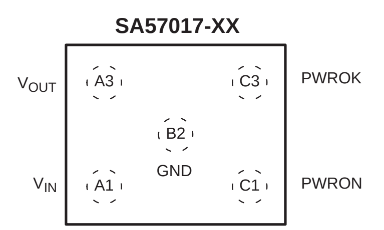


Figure 2. Pin configuration, top view (balls are on the bottom)

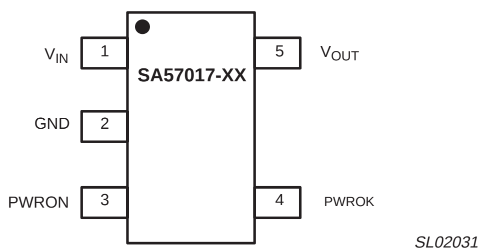


Figure 3. Pin configuration, top view

PIN DESCRIPTION

PIN NO.	BALL NO.	SYM-BOL	DESCRIPTION
1	A1	V_{IN}	Regulator input. $V_{OUT(nom)}$+0.5V to 4.6 V. Minimum input voltage required is 1.6 V. **No capacitor required.**
2	B2	GND	Ground
3	C1	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.
4	C3	PWROK	Connect a 10 kΩ up to 100 kΩ resistor between PWROK and V_{OUT}. Active LOW open-drain output indicates an out-of-regulation condition when power falls typically 6% below $V_{OUT(NOM)}$, or thermal warning (trips at 133 °C ± 2 °C). If not used, leave this pin unconnected.
5	A3	V_{OUT}	Regulator output. Sources up to 150 mA. **No capacitor required.**

MAXIMUM RATINGS

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_{IN}	V_{IN} to GND voltage	–0.3	4.6	Vdc
V_{PWRON}	PWRON to GND voltage	–0.3	4.6	Vdc
V_{OUT}	OUT to GND voltage	–0.3	V_{IN} + 0.3	Vdc
T_{amb}	Operating ambient temperature	–40	+85	°C
Tj	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

NOTE:
1. Maximum Ratings are those values beyond which damage to the device may occur. Exposure to these conditions or conditions beyond those indicated may adversely affect device reliability. Functional operation under absolute maximum-rated condition is not implied. Functional operation should be restricted to the Recommended Operating Condition.

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 < $V_{OUT(nom)}$ ≤ 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 ≤ $V_{OUT(nom)}$ ≤ 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	Ground Pin Current	I_{OUT} = 1 mA to 150 mA	–	250	400	µA
I_{RBC}	Reverse Battery Current			0.5		µA
	Dropout Voltage (Note 2, and 6)	I_{OUT} = 50 mA	–		50	mV
		I_{OUT} = 100 mA	–		100	
		I_{OUT} = 150 mA	–		150	
ΔV_{LNR}	Line Regulation	1.6 V < $V_{OUT(nom)}$ ≤ 3.3 V				%/V
		$V_{out(nom)}$ + 0.5 V ≤ V_{IN} ≤ 3.6 V	–		0.15	
		$V_{out(nom)}$ + 0.5 V ≤ V_{IN} ≤ 4.2 V	–		0.25	
		1.25 V < $V_{OUT(nom)}$ ≤ 1.6 V				
		$V_{out(nom)}$ + 0.5 V ≤ V_{IN} ≤ 3.6 V	–		0.25	
		$V_{out(nom)}$ + 0.5 V ≤ V_{IN} ≤ 4.2 V	–		0.35	
ΔV_{LDR}	Load Regulation	1.6 V < $V_{OUT(nom)}$ ≤ 3.3 V				%/ mA
		I_{OUT} = 1 mA to 150 mA	–		0.015	
		1.25 V < $V_{OUT(nom)}$ ≤ 1.6 V				
		I_{OUT} = 1 mA to 150 mA	–		0.02	
en	Output Voltage Noise	f = 10 Hz to 100 kHz, I_{OUT} = 150 mA	–	25	–	µVRMS
Shutdown						
V_{IH}	PWRON input Threshold (HI On)	$V_{out(nom)}$ ≤ V_{IN} ≤ 4.6 V	0.7 x V_{IN}		–	V
V_{IL}			–		0.3 x V_{IN}	
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 Startup Time (Note 3)	I_{OUT} = 1 to 50 mA, T_{amb} = –40 °C to +85 °C	–	30	50	µs
	Load transient, under–voltage (Note 5)	I_{OUT} = 1 to 50 mA in 2 µs	–	–1	–4	%
	Load transient, overshoot (Note 5)	I_{OUT} = 50 to 1 mA in 2 µs		2	4	%
t_r	Recovery Time (Note 4, 5)	I_{OUT} = 1 to 50 mA in 2 µs	–		2	µs
		I_{OUT} = 50 to 100 mA in 2 µs	–		1	µs
		I_{OUT} = 100 to 150 mA in 2 µs	–		1	µs

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Thermal Protection						
T_{SHDN}	Thermal Shutdown Temperature		–	163	–	°C
ΔT_{SHDN}	Thermal Shutdown Hysteresis		–	10	–	°C
Output (Power & Temperature OK) (Note 2)						
	PWROK Trip Temperature		–	133	–	°C
	PWROK Trip Temperature Hysteresis		–	10	–	°C
	PWROK Trip as percentage of $V_{OUT(nom)}$ (Note 5)		–3	–6	–10	%
	PWROK Output (when tripped)	Pull–up resistor = 10 KΩ I_{SINK} = 0.5 mA	–	0.1	0.4	V

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. Output settling time, to within accuracy limits, when there is a pulsed load current.
5. The PWROK has a 10 µs blanking time to allow transient responses to settle within accuracy limits.
6. Minimum input voltage is 1.6 V if selected the 1.25 V preset output voltage.

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TYPICAL PERFORMANCE CURVES

SA57017-18 (1.8 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.

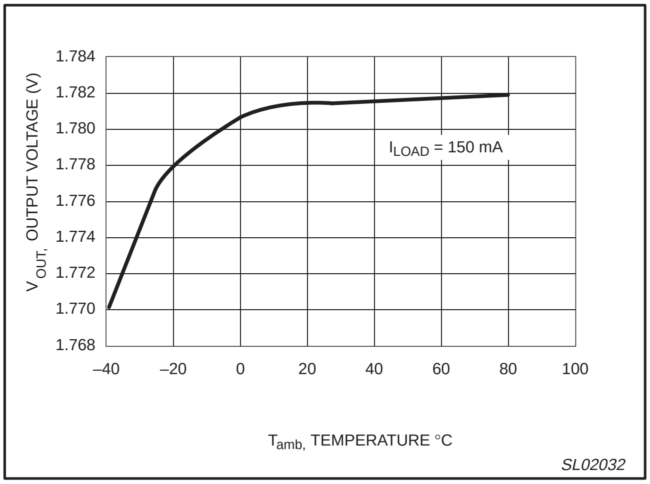


Figure 4. Output voltage versus temperature.

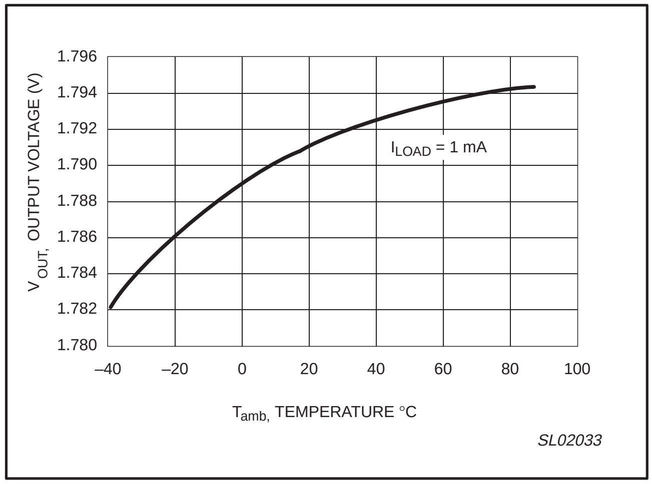


Figure 5. Output voltage versus temperature.

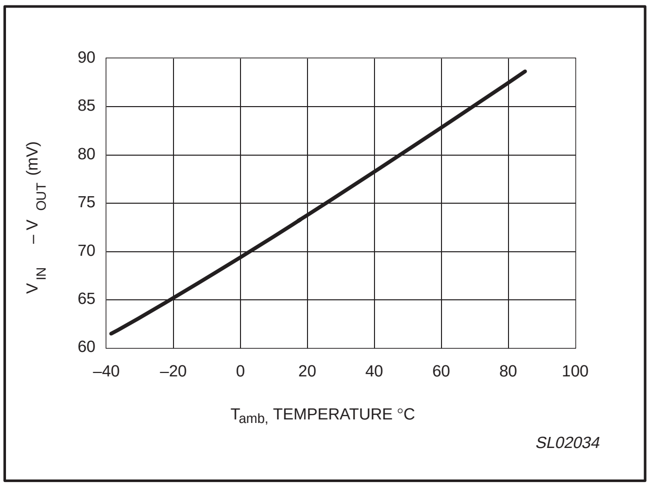


Figure 6. Drop-out voltage versus temperature.

TECHNICAL DISCUSSION

The SA57017 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, and 2.6 V, 2.8 V, 3.0 V, and 3.3 V for both SOT 23-5 and 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 Vout 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 cutoff 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.

Temperature Sensor

The temperature sensor block monitors the die temperature and flags Power OK when the temperature crosses 133 °C. If the die temperature goes beyond 165 °C typical value the output amplifier is shut down. Both the temperatures corresponding to PWROK or PWRON have 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 1mA when this protective circuit is active, preventing the battery from rapidly discharging through the device. Reverse battery current is extremely low, 0.5 mA typical.

PWROK Output

PWROK goes low when the output voltage goes out of regulation as during drop-out, current limit or thermal shutdown. PowerOK is an open-drain N-channel MOSFET. To obtain a logic-level output, connect a 10 kΩ pull-up resistor from PWROK pin to V_{OUT} pin. To minimize current consumption, make this resistor as large as practical. A 100 kΩ resistor works well for most applications. The PowerOK is not active during shutdown. PWROK has a 10 µs blanking time to allow transient responses to settle within accuracy limits.

Current Limit

The SA57017 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.

SIMPLIFIED BLOCK DIAGRAM

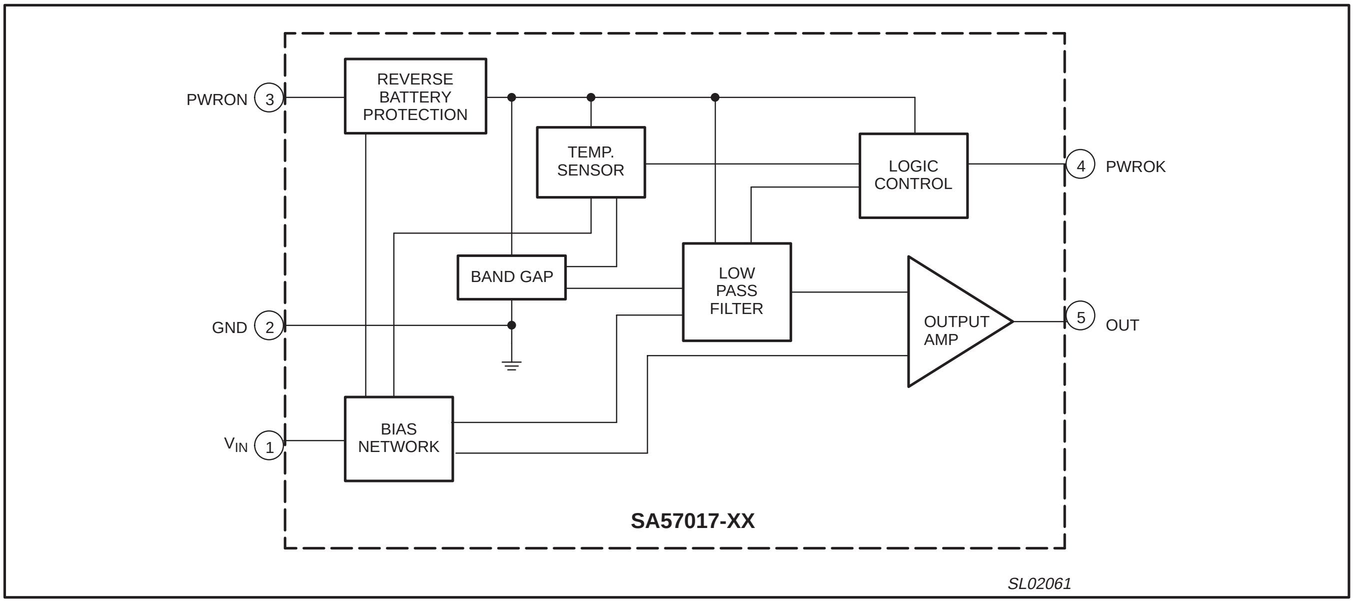


Figure 7. Simplified block diagram.

TIMING DIAGRAM

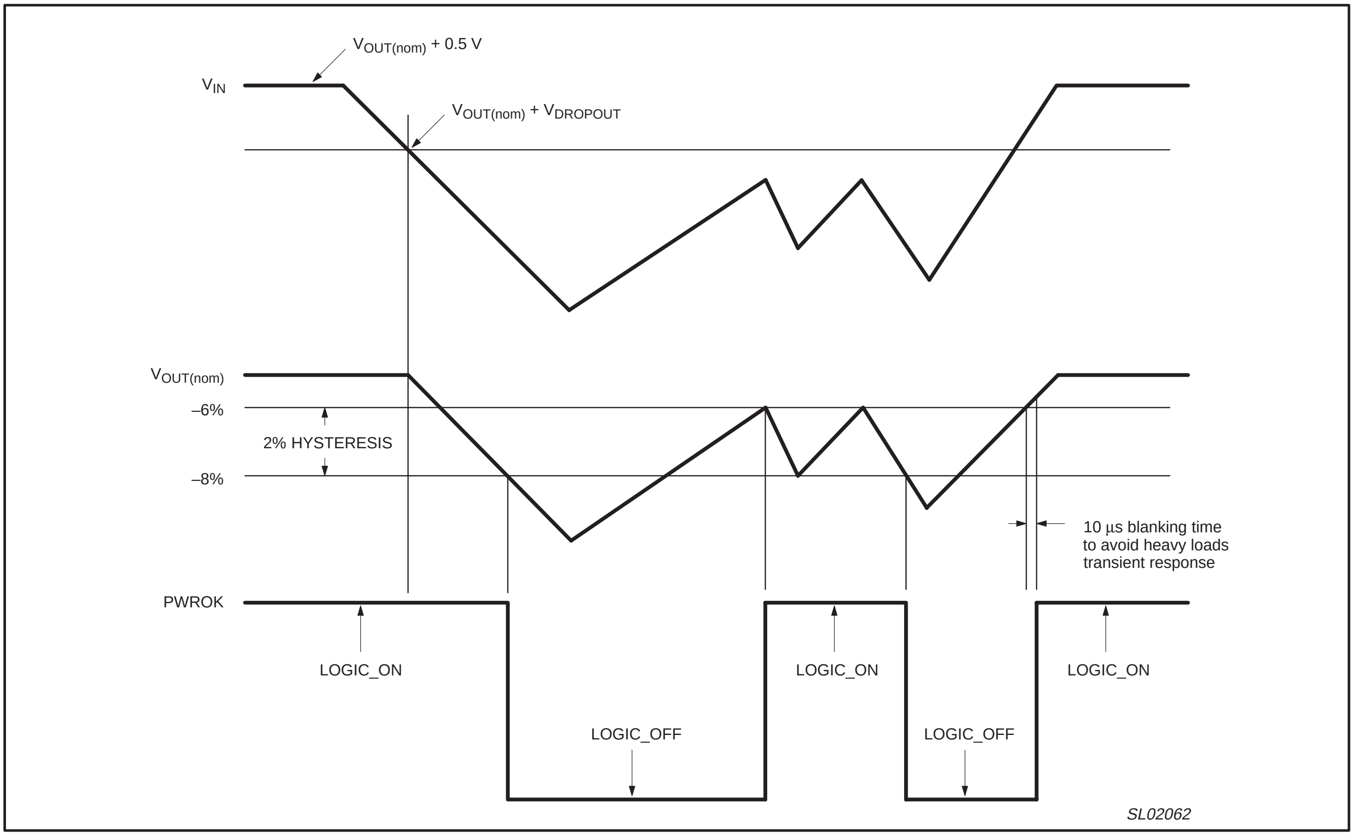
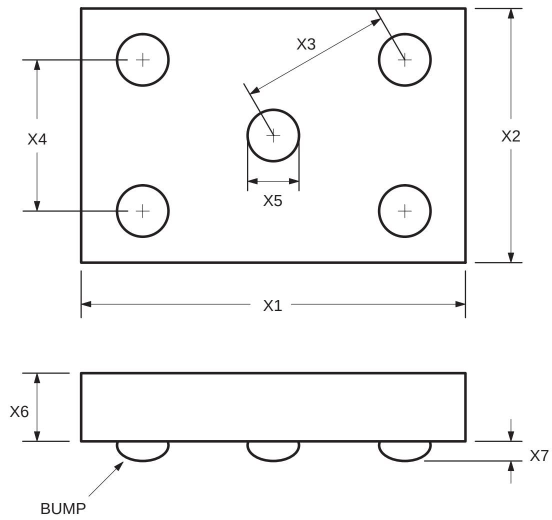


Figure 8. Timing diagram.

WL-CSP5: wafer level, chip-scale package; 5 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	0.195 0.165	0.568 0.548	0.145 0.115

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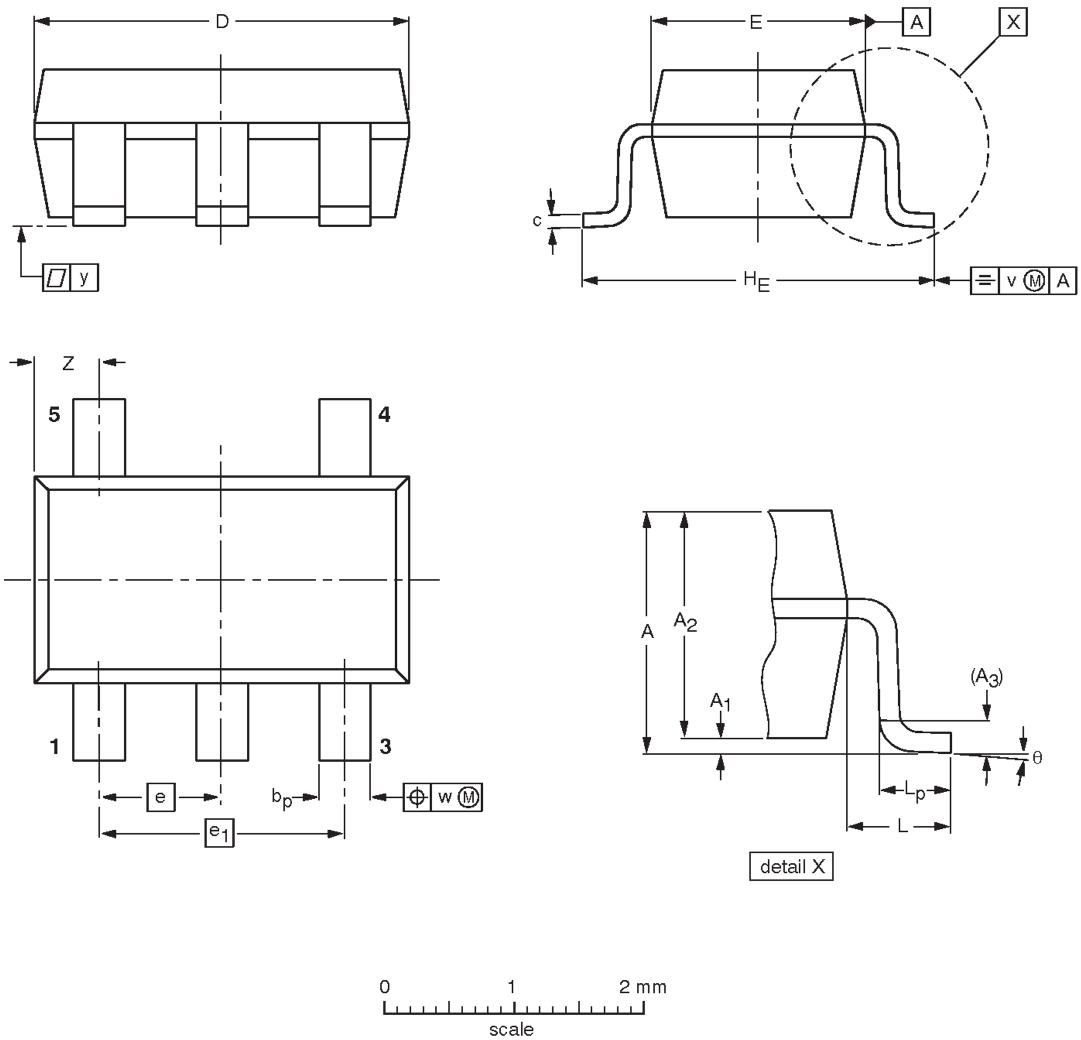
SOT23-5: plastic small outline package; 5 leads; body width 1.5 mm



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D[(1)]	E[(1)]	e	e_1	H_E	L	L_p			y		θ
mm	1.35	0.15 0.05	1.2 1.0	0.25	0.55 0.41	0.22 0.08	3.00 2.70	1.70 1.50	0.95	1.90	3.00 2.60	0.60	0.55 0.35			0.1		8° 0°

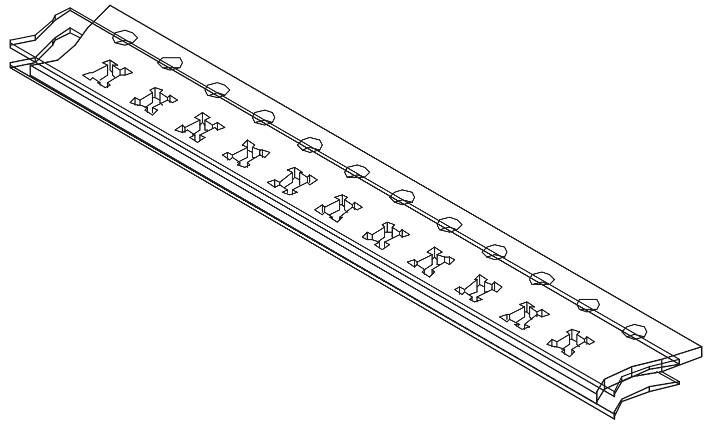
Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

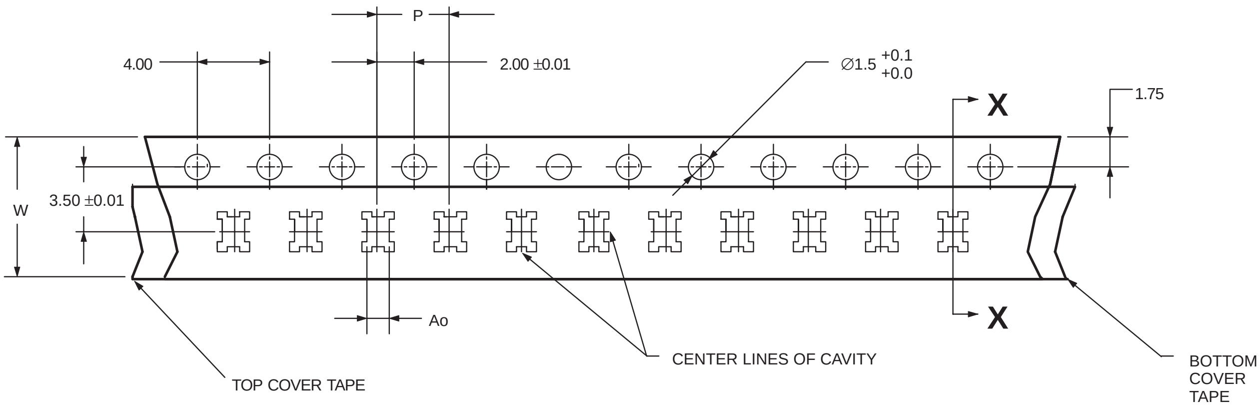
OUTLINE VERSION	REFERENCES			
	IEC	JEDEC	EIAJ	
		MO-178		

CSP TAPE AND REEL

LOADED TAPE DIRECTION OF FEED



NOTES:
All dimensions in millimeters.
10 sprocket hole pitch cumulative tolerance ±0.20
Material: conductive polystyrene
Camber not to exceed 1.0 mm in 100 mm.
Cover tape shown for illustrative purposes only.



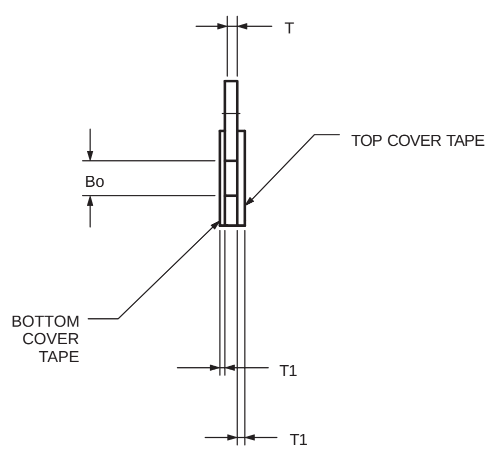
DIMENSIONS (mm are the original dimensions)

UNIT	Ao	Bo	T	T1	P	W
mm	1.09 0.99	1.598 1.498	0.76 0.74	0.10 (max.)	4.05 3.95	8.3 7.9

Heat seal cover tape for carrier tape width 8 mm

Type tape: clear static dissipative tape
Base material: transparent polyester
Cover tape width: 5.3 ± 0.1 mm
Cover tape length: 480 m/reel

Supplier: Advanced Integrated Materials (AIM)
Part Number: CT5–00530–0480



SECTION 'X – X'

SL02056

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

SA57017-XX

REVISION HISTORY

Rev	Date	Description
_3	2003 Aug 27	**Product data (9397 750 11971); ECN 853-2429 30264 of 27 August 2003** Modifications: – Adjusted part marking code table – Adjusted voltage output options table
_2	2003 Aug 13	**Product data (9397 750 11912); ECN 853-2429 30151 of 28 July 2003**
_1	2003 May 29	**Product data (9397 750 11567); ECN 853-2429 29965 of 29 May 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.
III	Product data	Production	This data sheet contains data from the product specification. Philips Semiconductors reserves the right to make changes at any time in order to improve the design, manufacturing and supply. Relevant changes will be communicated via a Customer Product/Process Change Notification (CPCN).

[1] Please consult the most recently issued data sheet before initiating or completing a design.

[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.

Definitions

Short-form specification — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

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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Contact information

For additional information please visit
http://www.semiconductors.philips.com. Fax: **+31 40 27 24825**

For sales offices addresses send e-mail to:
sales.addresses@www.semiconductors.philips.com.

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