

ELM6M003SA 5V input 1.5A synchronous step-down DC/DC converter module

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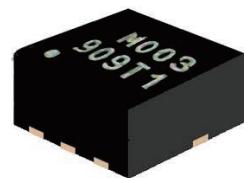
■General description

ELM6M003SA is a complete 1.5A, synchronous step-down DC/DC convertor module with built-in switching regulator, output capacitor and Inductor for small dimension application. ELM6M003SA uses constant-on-time (COT) control architecture which simplifies loop compensation and offers excellent load transient response. ELM6M003SA consumes extremely low 15 μ A quiescent current hence achieves superior light load efficiency. The high gain error amplifier in the control loop provides excellent load and line regulation. Proprietary adaptive on-time helps ELM6M003SA to achieve nearly constant switching frequency across load range. ELM6M003SA can operate with input voltage from 2.5V to 6V and provide output range from 0.6V to input level, thanks to 100% duty cycle operation. ELM6M003SA has cycle-by-cycle current limit and hiccup mode to protect over-load or short circuit fault conditions.

ELM6M003SA is available in compact and low profile 7 leads LGA 3mm × 3mm packages.

■Features

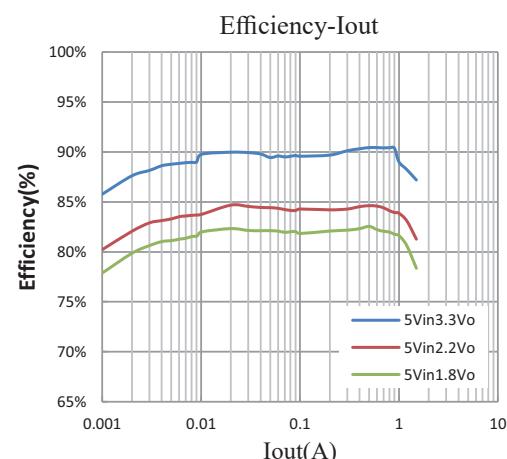
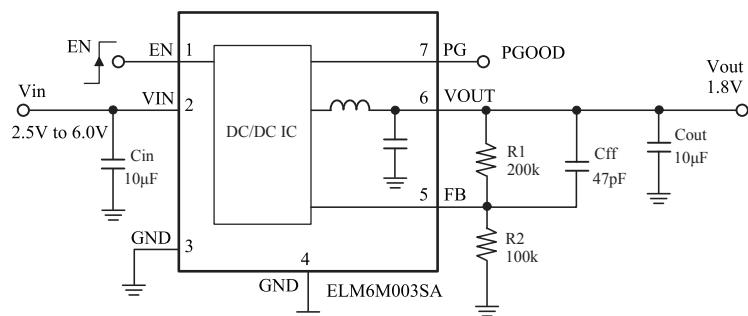
- Cycle-by-cycle current limit protection
- Over-load and short circuit hiccup mode
- Open drain power good indication
- Output discharging function
- Thermal shutdown protection
- Built-in inductor and output capacitors
- 1.5A continuous, 2A peak
- Internal soft-start : Typ.0.95ms
- Input range : 2.5V to 6.0V
- Minimum output voltage : 0.6V±2%
- Built-in power switches : Typ.100mΩ/80mΩ
- Switching Frequency : Typ.2.5MHz
- Low quiescent current : Typ.15 μ A
- Accurate enable threshold : Typ.1.21V
- Efficiency : More than 90%
- Maximum duty cycle : 100%
- Package : LGA7-3×3



■Application

- Solid-state and hard disk drives
- USB-TypeC earphone
- Smartphone and tablets
- WiFi RF modules
- DC/DC micro modules

■Typical applications



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■Recommended operating conditions

Parameter	Symbol	Limit	Unit
Input voltage	Vin	+2.5 to +6.0	V
Output voltage	Vout	+0.6 to Vin	V
Operating temperature range	Top	-40 to +85	°C

* Note: The device is not guaranteed to function outside of the recommended operating conditions.

■Maximum absolute ratings (*1)

Parameter	Symbol	Limit	Unit
Input voltage	Vin	-0.3 to +6.5	V
The other pins	Vother	-0.3 to +6.5	V
Power dissipation at Ta=+25°C (* 2, 3)	Pd	1.0	W
Storage temperature range	Tstg	-65 to +150	°C
Junction temperature range	Tj	-40 to +150	°C
Thermal resistance (* 2, 3)	θja	125	°C/W
Thermal resistance (* 2, 3)	θjc	65	°C/W

* : 1. Stress exceeding those listed "Maximum absolute ratings" may damage the device.

2. Measured on JESD51-7, 4-Layer PCB.

3. The maximum allowable power dissipation is a function of the maximum junction temperature TJ_MAX, the junction to ambient thermal resistance θja, and the ambient temperature Ta. The maximum allowable continuous power dissipation at any ambient temperature is calculated by $Pd_{max} = (Tj_{max}-Ta)/\theta ja$. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.

■Selection Guide

ELM6M003SA-N

Symbol	Part No.	ELM6M003
a	Part No.	ELM6M003
b	Package	S: LGA7-3×3
c	Product version	A
d	Taping direction	N: Please refer to page 11

* Taping direction is one way.

ELM6M003 S A - N

↑ ↑ ↑ ↑
a b c d

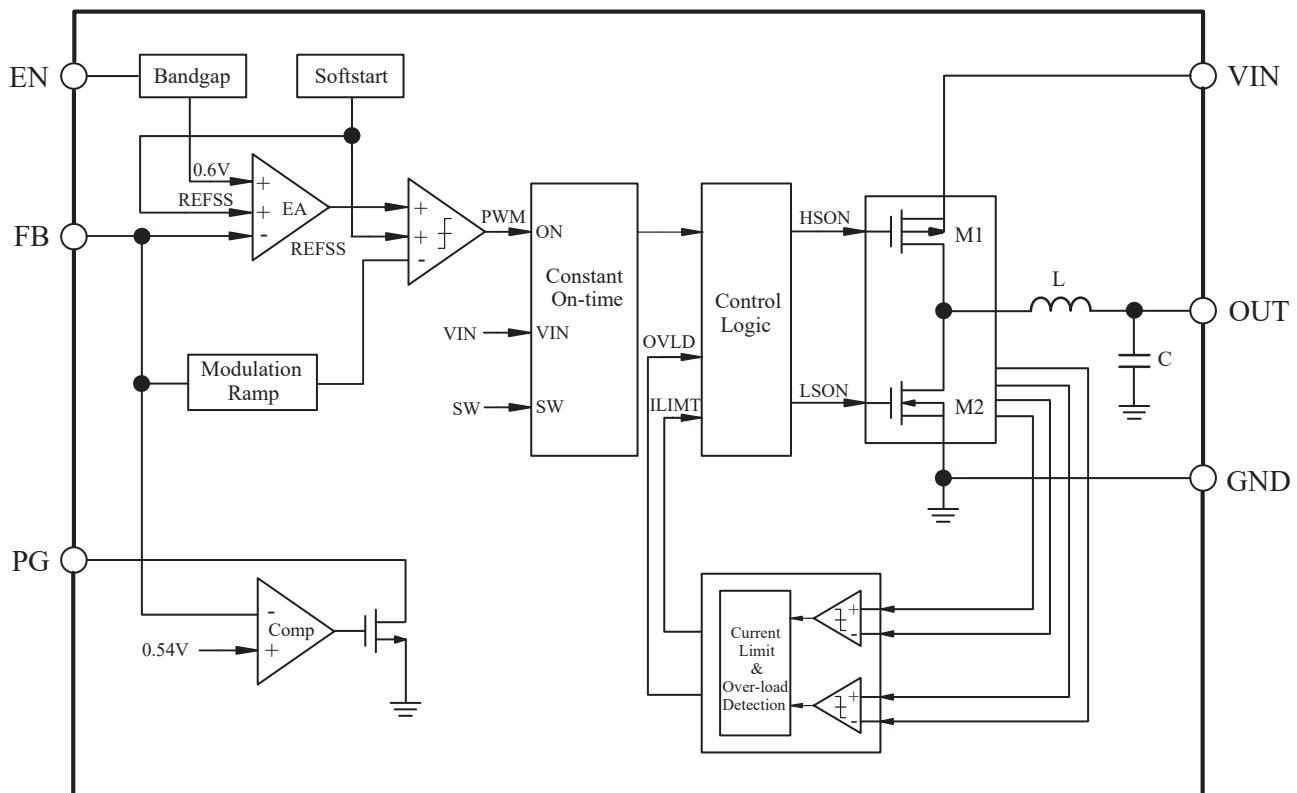
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■Pin configuration

Top view	Pin No.	Pin name	Description
	1	EN	Regulator enable control input with accurate 1.21V enable threshold which can be used to build precision R-C turn-on delay and input under-voltage lockout. This pin has a typical 1MegΩ pull-down resistor to GND. • Drive EN above 1.21V to turn on the converter • Drive EN below 1.11V to turn off the converter and discharge output
	2	VIN	Input supply voltage
	3, 4	GND	Ground
	5	FB	Voltage feedback input. Connect FB pin to the middle point of a resistor divider between output and GND to program the output voltage.
	6	VOUT	Output pin that supplies current to the load.
	7	PG	Power good open-drain output. Connect a 100kΩ pull-up resistor to Vin or Vout.

■Block diagram



ELM6M003SA 5V input 1.5A synchronous step-down DC/DC converter module

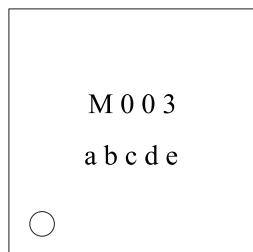
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■Electrical characteristics

Top=+25°C, Vin=5V, Unless otherwise noted. Typical values are at Vin=Ven=5V and Vout=1.8V.

Parameter	Symbol	Test conditions	Min.	Typ.	Max.	Unit
Input voltage range	Vin		2.5		6.0	V
Shutdown current	Is	Ven=0V, Vin=5.5V		0.1	1.0	µA
Input under voltage lockout threshold	Vuvlo	Vin Increasing	2.3	2.4	2.5	V
Input under voltage lockout hysteresis	Vhysu			280		mV
Quiescent current	Iq	Vfb or Vout above regulation		15	20	µA
Feedback regulation voltage	Vfbref	Iout=1A	588	600	612	mV
High side switch peak current limit	Ilim		2.6	3.3	5.0	A
PWM switching frequency	Fsw	Vin=5V, Vout=3.3V, Iout=1A	2.27	2.50	3.14	MHz
PGOOD output low voltage	Vopg	Vfb=0.5V, sink 1mA		0.2	0.3	V
PGOOD output leakage current	Ileak_pg	Vfb or Vout above regulation Vpgood=5.5V		0.01	0.20	µA
PGOOD under voltage rise threshold	Vpg	Vfb ramp up from undervoltage, % with respect to Vfbref	-13	-10	-7	%
PGOOD hysteresis	Vpghys	% with respect to Vfbref		5		%
PGOOD delay	tdpg	PGOOD low to high transition		30		µs
On-time for HS switch	t_sw	Vin=5V, Vout=3.3V	210		290	ns
EN Pin on threshold	Ven_on	Ven ramp up	1.18	1.21	1.24	V
EN Pin off threshold	Ven_off	Ven ramp down	1.05	1.11	1.17	V
EN internal pull down resistor	Ren		1000			kΩ
Output discharge resistance	Rdsc			1.4		kΩ
Soft start time	Tss	From CE=L→H to 90% of Vout		0.95		ms
Thermal shutdown	Tsd			160		°C
Thermal shutdown hysteresis	Tsdhys			30		°C

■Marking



Mark	Content
M003	Product code
a to e	Lot No.

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■ Theory of operation

ELM6M003SA is a complete 1.5A, synchronous step-down DC/DC convertor module with built-in switching regulator, output capacitor and Inductor for small dimension application. ELM6M003SA uses constant on-time (COT) control scheme which offers excellent transient response over a wide range of input voltage and achieves superior light-load efficiency with extremely low quiescent current.

Constant On-time control

Constant on-time control step-down DC/DC converters turn on HS immediately when FB droops below reference. The HS is turned on for a pre-determined period (on-time) of time to ramp up the inductor current, and then the LS will be turned on to ramp down the inductor current. The cycle repeats itself if FB droops below reference again. ELM6M003SA uses proprietary adaptive on-time control technique to take into account the load current impact and adjusts the on-time accordingly to achieve a constant switching frequency over entire load current range.

For ELM6M003SA, the on-time is approximately:

$$T_{on} = \frac{V_{out}}{V_{in}} \cdot 0.4\mu s$$

Due to its immediate response on FB voltage droop and simplified loop compensation, constant on-time offers a superior transient response compare to traditional fixed frequency PWM control step-down converters.

Light load operation

In light load condition where the converter operates in discontinuous mode, ELM6M003SA cuts down its quiescent current to as low as 15uA and achieves excellent light load efficiency.

Enable

When input voltage is above the under voltage lock-out threshold, ELM6M003SA can be enabled by pulling the EN pin to above 1.21V. ELM6M003SA is disabled if the EN pin is pulled below 1.11V. The enable/disable threshold for EN pin is accurately designed to be 1.21V and 1.11V respectively, so one can also use external resistor divider to program the desired input under-voltage lockout level.

Soft start

ELM6M003SA has built-in 0.95msec soft start to limit input inrush current. During the soft start period, output voltage is ramped up linearly to the regulation voltage, independent of the load current level and output capacitor value.

Current limit and hiccup mode

ELM6M003SA has cycle-by-cycle HS current limit protection to prevent inductor current from running away. Once HS current limit is triggered, ELM6M003SA will turn on LS and wait for the inductor to drop down to a pre-determined level before the HS can be turned on again. If this current limit condition is repeated for a sustained long period of time, ELM6M003SA will consider it over-load or short circuit. Either way, ELM6M003SA will enter hiccup mode, where it stop switching for a pre-determined period of time before automatically re-try to start up again. It always starts up with soft-start to limit inrush current and avoid output overshoot.

Power good indication

ELM6M003SA has open drain Power Good indicator PG pin. When PG is connected with an external pull up resistor, it is pulled up if output voltage is higher than 90% of regulation, otherwise PG is pulled down by the internal open drain NMOS.

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■Application information

Setting the output voltage

External feedback resistors are used to set the output voltage. Refer to typical application circuit on page1. Choose the top feedback resistor R1 in the range between $100k\Omega$ ~ $200k\Omega$ to achieve high efficiency at light load while providing acceptable noise sensitivity. For any chosen R1, the bottom feedback resistor R2 can be calculated as:

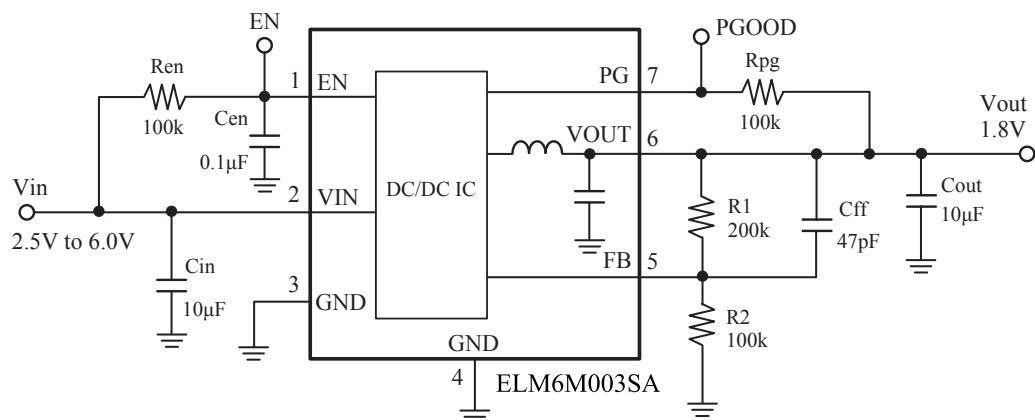
$$R2 = \frac{R1}{\frac{Vout}{0.6} - 1}$$

PCB Layout recommendation

The physical design of the PCB is the final stage in the design of power converter. If designed improperly, the PCB could radiate excessive EMI and contribute instability to the power converter. Therefore, following the PCB layout guidelines below can ensure better performance of ELM6M003SA.

- (1). The loop (Vin-Vout-Cout-GND) indicates a high current path. The traces within the loop should be kept as wide and short as possible to reduce parasitic inductance and high-frequency loop area. It is also good for efficiency improvement.
- (2). Input capacitor shall be placed as close as possible to the IC Pins (Vin and GND) and the input loop area should be as small as possible to reduce parasitic inductance, input voltage spike and noise emission.
- (3). Feedback components (R1, R2 and Cff) should be routed as short as possible to minimize noise issue.

■Application schematic



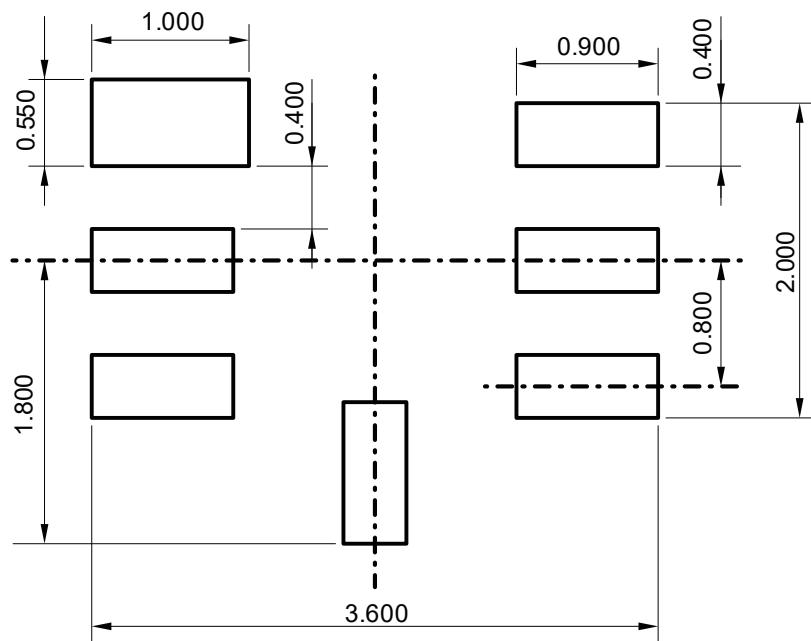
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EVB BOM List

Qty	Ref	Value	Description	Package
1	Cin	10µF	Ceramic capacitor, 10V, X5R	0805
1	Cout	10µF	Ceramic capacitor, 10V, X5R	0805
2	Cen	0.1µF	Ceramic capacitor, 10V, X5R	0603
1	Cff	47pF	Ceramic capacitor, 10V, X5R	0603
1	R1	Vout=3.3V	200KΩ	0603
		Vout=2.5V	240KΩ	
		Vout=1.8V	200KΩ	
		Vout=1.2V	200KΩ	
		Vout=1.0V	100KΩ	
1	R2	Vout=3.3V	43KΩ	0603
		Vout=2.5V	75KΩ	
		Vout=1.8V	100KΩ	
		Vout=1.2V	200KΩ	
		Vout=1.0V	150KΩ	
2	Rpg, Ren	100KΩ	Resistor, ±1%	0603
1	Power IC	ELM6M003SA	Step-down DC/DC converter module	LGA7-3x3

■Reference land pattern

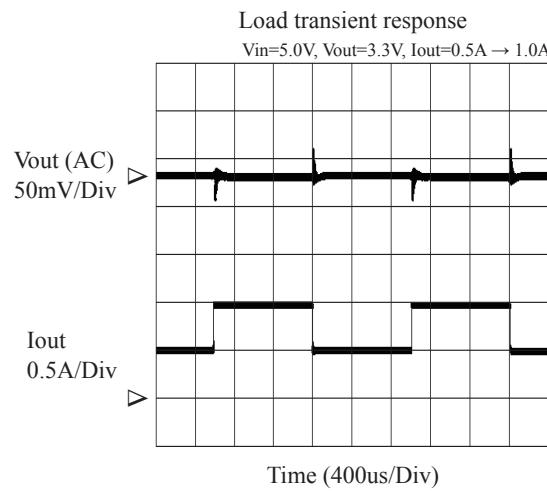
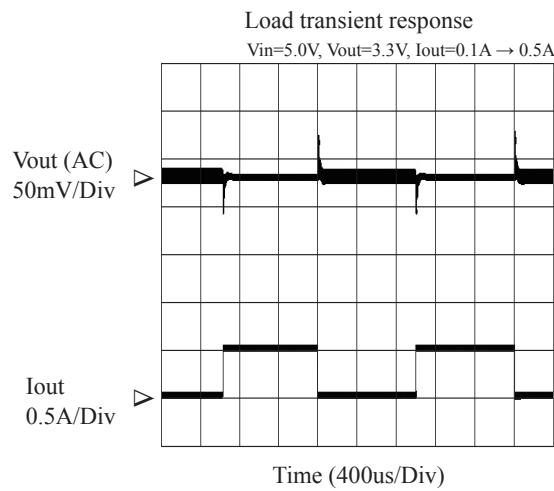
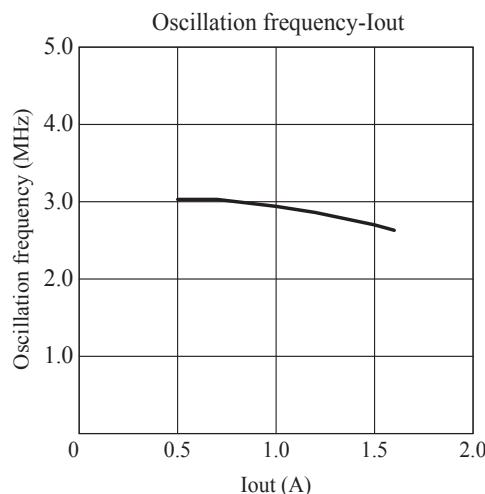
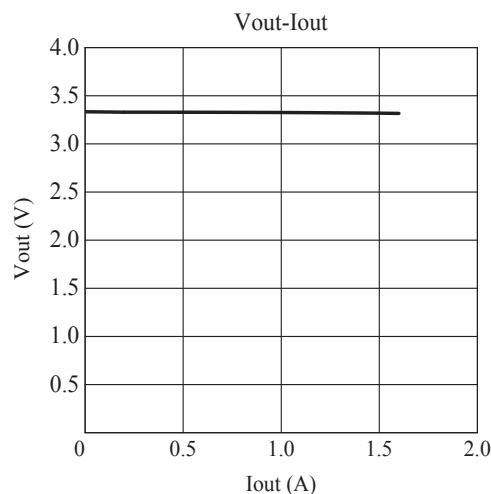
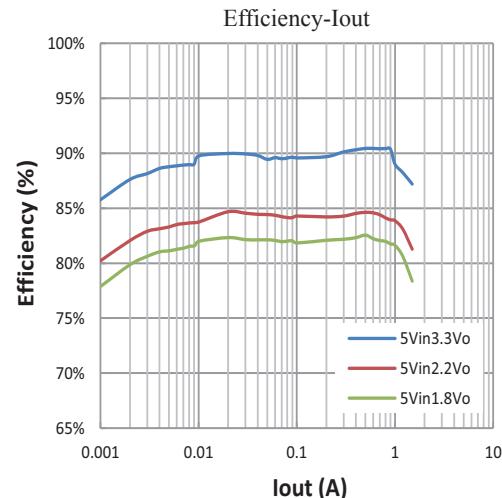
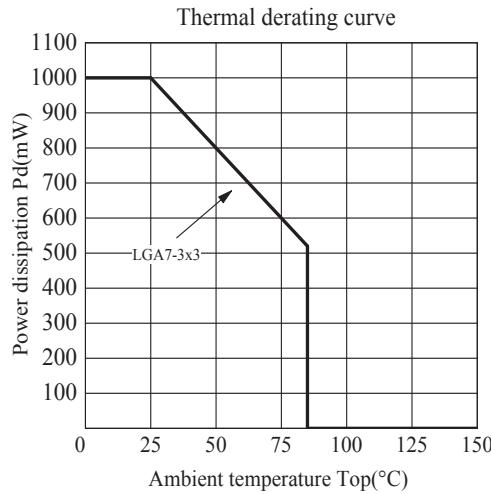


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■Typical characteristic curves

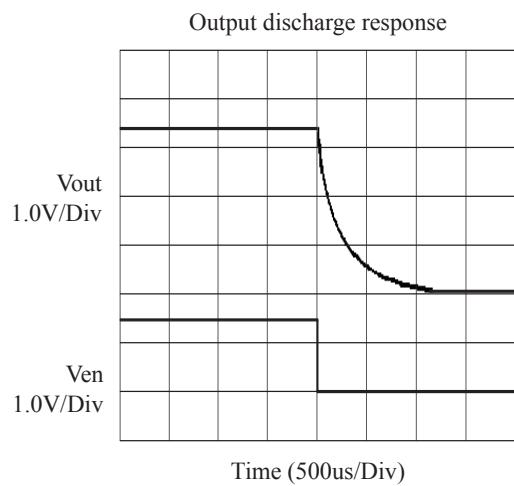
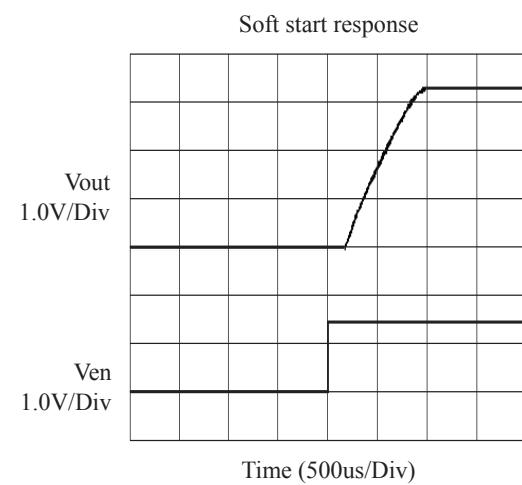
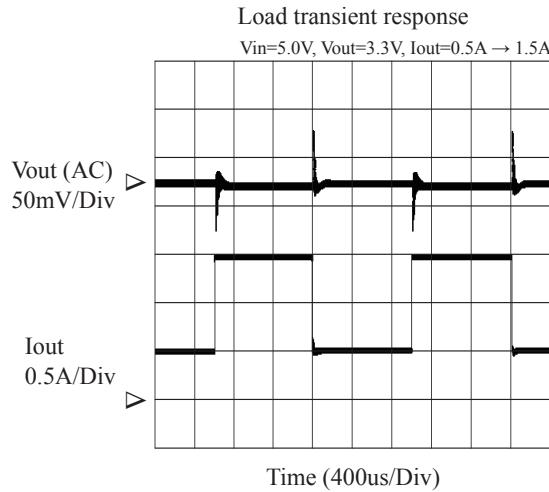
- Unless otherwise noted, $C_{in}=10\mu F$, $C_{out}=10\mu F$ (External), $Top=25^{\circ}C$



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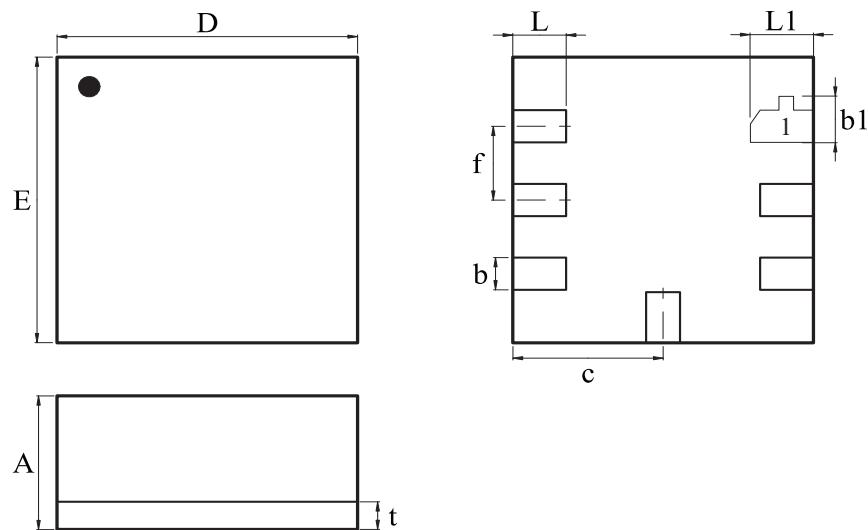


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■LGA7-3×3 Outline dimensions

- Unit: inches/mm



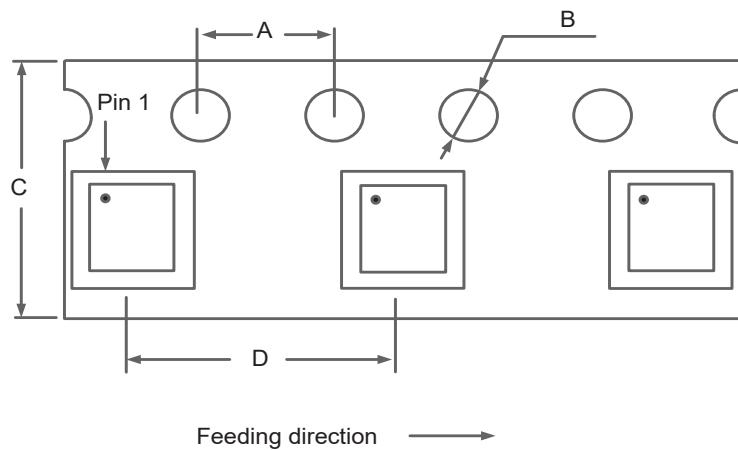
Symbols	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.35	1.45	0.053	0.057
t	0.30	TYP	0.012	TYP
b	0.25	0.35	0.010	0.014
b1	0.40	0.50	0.016	0.02
c	1.50 BSC		0.059 BSC	
D	2.90	3.10	0.114	0.122
E	2.90	3.10	0.114	0.122
f	0.80 BSC		0.031 BSC	
L	0.45	0.55	0.018	0.022
L1	0.55	0.65	0.022	0.026

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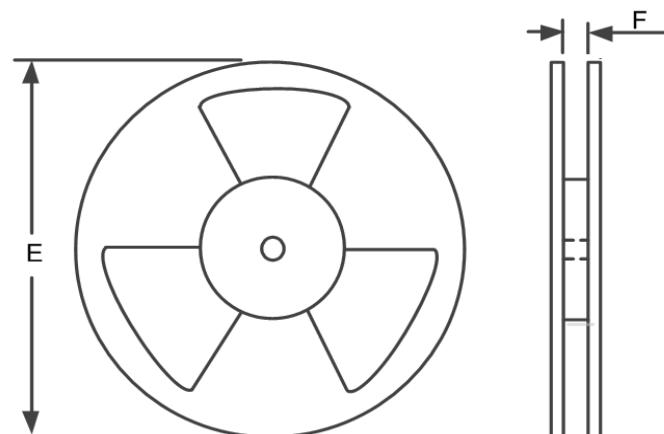
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■Reel & carrier tape dimension

- Orientation / Carrier tape information



- Reel information



- Dimension details

PKG Type	A	B	C	D	E	F	Q'ty/Reel
LGA3x3_7L	4.0 mm	1.5 mm	12.0 mm	8.0 mm	13 inches	13.0 mm	3,000