DESCRIPTION

The A7415 is a current mode monolithic buck switching regulator. Operating with an input range of 4.5V~40V, the A7415 delivers 1.5A of continuous output current with two integrated N-Channel MOSFETs. The internal synchronous power switches provide high efficiency without the use of an external Schottky diode. At light loads, the regulator operates in low frequency to maintain high efficiency and low output ripple. Current mode control provides tight load transient response and cycle-by-cycle current limit.

The A7415 guarantees robustness with short-circuit protection, thermal protection, current run-away protection, and input under voltage lockout.

The A7415 is available in SOT-26 package.

ORDERING INFORMATION

<table>
<tr><th>Package Type</th><th colspan="2">Part Number</th></tr>
<tr><td rowspan="2">SOT-26
SPQ: 3,000psc/Reel</td><td rowspan="2">E6</td><td>A7415E6R</td></tr>
<tr><td>A7415E6VR</td></tr>
<tr><td>Note</td><td colspan="2">V: Halogen free Package
R: Tape & Reel</td></tr>
<tr><td colspan="3">AiT provides all RoHS products</td></tr>
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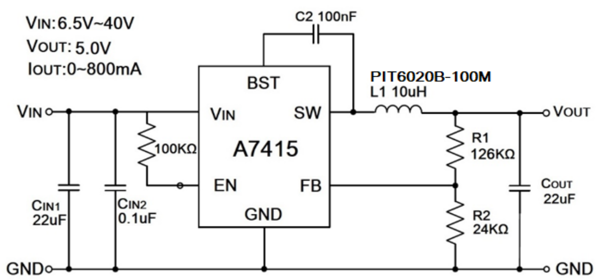
FEATURES

- 4.5V to 40V Input Voltage Range
  1.5A output current
- High Efficiency: Up to 95%
- No Schottky Diode Required
- 0.8V Reference
- Slope Compensated Current Mode Control for Excellent Line and Load Transient Response
- Integrated internal compensation
- Stable with Low ESR Ceramic Output Capacitors
- Input under voltage lockout
- Short circuit protection
- Thermal Shutdown
- Inrush Current Limit and Soft Start
- -40°C to +125°C Temperature Range

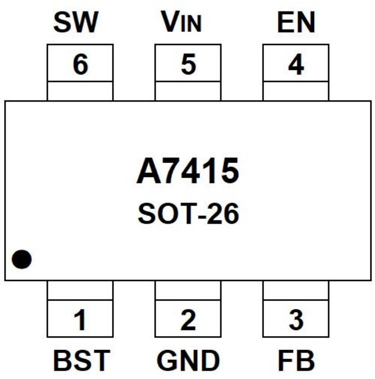
APPLICATION

- Distributed Power Systems
- Automotive Systems
- High Voltage Power Conversion
- Industrial Power Systems
- Battery Powered Systems

TYPICAL APPLICATION



PIN DESCRIPTION



SOT-26, E6

Top View

Pin #	Symbol	Function
1	BST	Bootstrap pin. Connect a 100nF capacitor from this pin to SW.
2	GND	Ground.
3	FB	Feedback Input. Connect an external resistor divider from the output to FB and GND to set V_{OUT}.
4	EN	Enable pin for the IC. Drive this pin high to enable the part, low to disable.
5	V_{IN}	Supply Voltage. Bypass with a 22μF ceramic capacitor to GND.
6	SW	Inductor Connection. Connect an inductor Between SW and the regulator output.

ABSOLUTE MAXIMUM RATINGS

V_{IN}, Input Voltage		V_{SS}-0.3V ~ V_{SS}+45V
SW Voltage		V_{SS}-0.3V ~ V_{IN}+0.3V
BST Voltage		V_{SW}-0.3V ~ V_{SW}+6V
FB Voltage		V_{SS}-0.3V ~ V_{SS}+6V
EN Voltage		V_{SS}-0.3V ~ V_{SS}+45V
P_D, Power Dissipation	SOT-26	600mW
θ_{JC}, Thermal Resistance θ_{JC}		130°C/W
θ_{JA}, Thermal Resistance θ_{JA}		170°C/W
T_{OPR}, Operating Ambient Temperature		-40°C ~ +125°C
T_{STG}, Storage Temperature Range		-40°C ~ +150°C
ESD HBM (Human Body Mode)		2KV

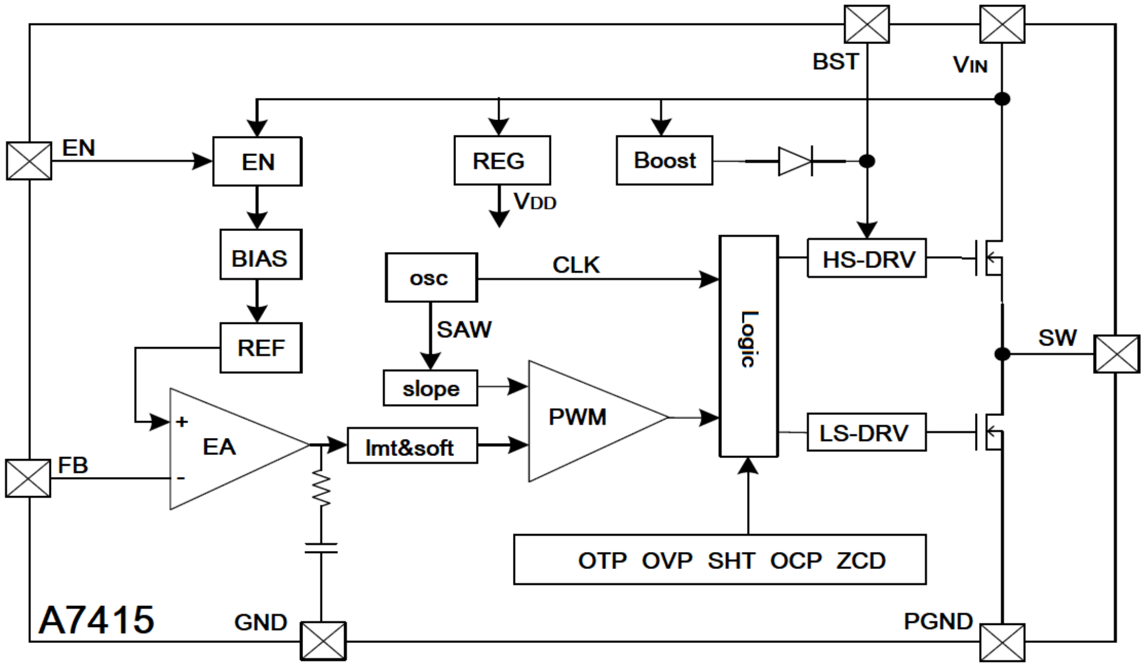
Stresses above may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the Electrical Characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

V_{IN}=12V, V_{OUT}=5V,T_A=25℃ ,unless otherwise noted

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Input Voltage	V_{IN}		4.5	-	40	V
V_{IN} Under Voltage Protect	V_{UV}		-	4.3	-	V
V_{IN} Under Voltage Protect Hys.	U_{UV_HYS}		-	0.2	-	V
Supply Current	I_{Q1}	V_{EN}=2V , V_{FB}=0.85V	-	40	60	µA
Supply Shutdown Current	I_{SD}		-1	-	1	µA
FB Voltage	V_{FB}	T_A=25°C,4.5V≤V_{IN}≤40V	0.776	0.800	0.824	V
Switching Frequency	F_{OSC}		-	800	-	kHz
Minimum on Time	T_{ON_MIN}		-	200	-	ns
Maximum Duty Cycle	D_{MAX}		-	90	-	%
High Side Switch On Resistance	R_{DSON_H}		-	450	-	mΩ
Low Side Switch On Resistance	R_{DSON_L}		-	270	-	mΩ
High Side Current Limit	I_{LIM}		-	2.5	-	A
EN Rising Threshold	V_{ENH}		-	1.3	-	V
EN Falling Threshold	V_{ENL}		-	1.2	-	V
EN Input Current	I_{EN}	V_{EN}=5V	-	2	-	µA
Thermal Shutdown	T_{SHD}		-	160	-	℃
Thermal Shutdown Hys.	T_{SHD_HYS}		-	20	-	℃

BLOCK DIAGRAM



TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN}=12V , V_{OUT}=5.0V , L=10uH , C_{OUT}=22uF , T_A=+25℃

Fig1. Efficient @V_{OUT}=5.0V and 3.3V
C_{VIN}=22uF , C_{OUT}=22uF , C_{BST}=0.1uF L_{IND}=10uH

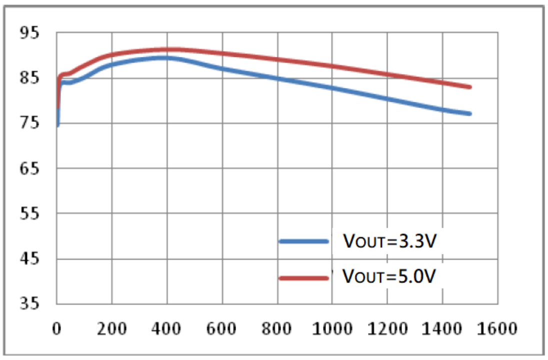


Fig2. Max Load @V_{OUT}=3.3V and 5.0V
C_{VIN}=22uF , C_{OUT}=22uF , C_{BST}=0.1uF L_{IND}=10uH

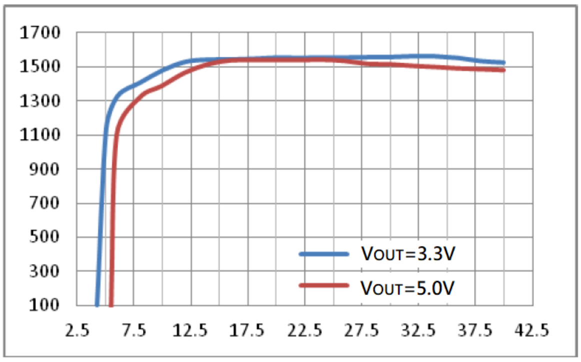


Fig3. Steady State Test
V_{IN}=12V , V_{OUT}=5.0V , L_{OUT}=800mA

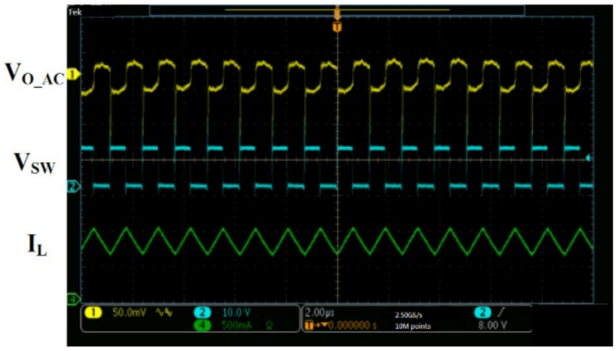


Fig4. Light Load Operation
V_{IN}=12V , V_{OUT}=5.0V , I_{OUT}=0A

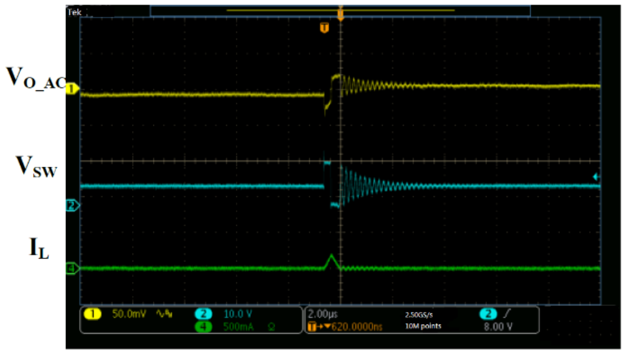


Fig5. Startup through Enable
V_{IN}=12V , V_{OUT}=5.0V , L_{OUT}=800mA (Resistive load)

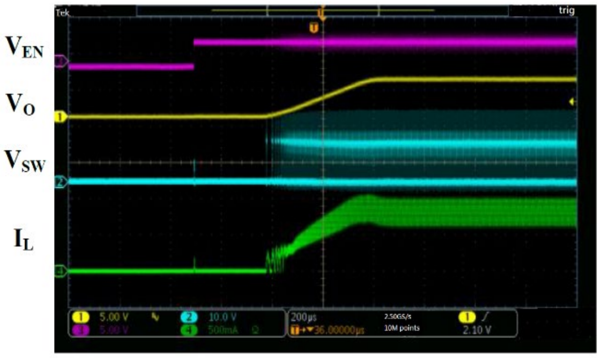


Fig6. Shutdown through Enable

V_{IN}=12V，V_{OUT}=5.0V，L_{OUT}=800mA (Resistive load)

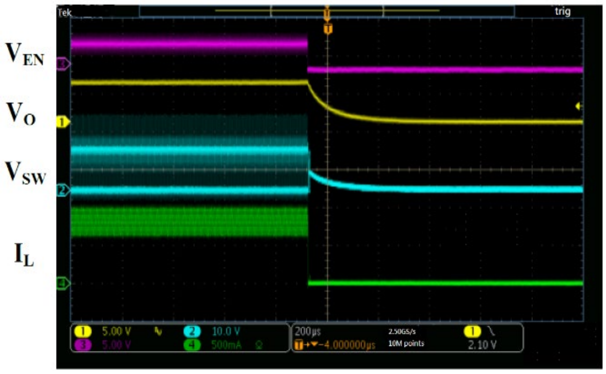


Fig7. Load Transient

Load：300mA ->800mA ->300mA

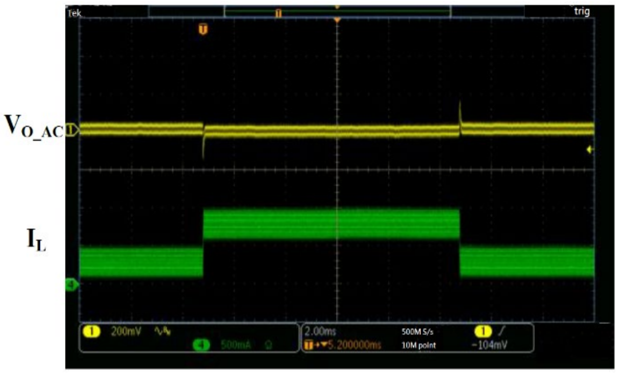
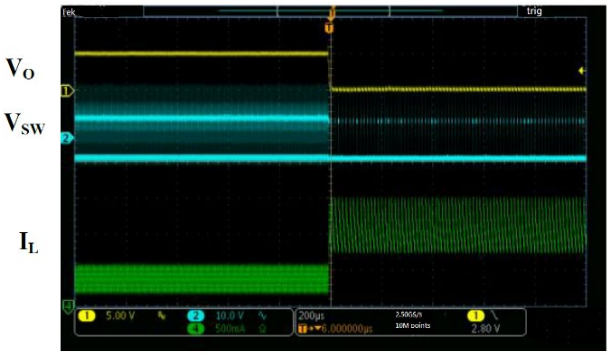


Fig8. Short Circuit Protection

V_{IN}=12V，V_{OUT}=5.0V，L_{OUT}=800mA - Short



DETAILED INFORMATION

The A7415 is a synchronous, current-mode, step-down regulator. It regulates input voltages from 4.5V to 40V, and is capable of supplying up to 1.5A of load current.

Current-Mode Control

The A7415 utilizes current-mode control to regulate the output voltage. The output voltage is measured at the FB pin through a resistive voltage divider and the error is amplified by the internal trans-conductance error amplifier. Output of the internal error amplifier is compared with the switch current measured internally to control the output current.

PFM Mode

The A7415 operates in PFM mode at light load. In PFM mode, switch frequency decreases when load current drops to boost power efficiency at light load by reducing switch-loss, while switch frequency increases when load current rises, minimizing output voltage ripples.

Shutdown Mode

The A7415 shuts down when voltage at EN pin is below 0.3V. The entire regulator is off and the supply current consumed by the A7415 drops below 0.1uA.

Power Switch

N-Channel MOSFET switches are integrated on the A7415 to down convert the input voltage to the regulated output voltage. Since the top MOSFET needs a gate voltage great than the input voltage, a boost capacitor connected between BST and SW pins is required to drive the gate of the top switch. The boost capacitor is charged by the internal 4.0V rail when SW is low.

V_{IN} Under Voltage Protection

A resistive divider can be connected between V_{IN} and ground, with the central tap connected to EN, so that when Vin drops to the pre-set value, EN drops below 1.2V to trigger input under voltage lockout protection.

Over-Current-Protection and Hiccup

At start-up, due to the high voltage at input and low voltage at output, current inertia of the output inductance can be easily built up, resulting in a large start-up output current. In the A7415 used current limit of low side power mosfet to control the output current at start-up.

Output Short Protection

When output is shorted to ground, output current rapidly reaches its peak current limit and the top power switch is turned off. And the bottom power switch is turned on and stay on until the output current falls below the current limit. When output current is below the current limit, the top power switch will be turned on again and if the output short is still present, the top power switch is turned off when the peak current limit is reached and the bottom power switch is turned on. This cycle goes on until the output short is removed and the regulator comes into normal operation again.

Thermal Protection

When the temperature of the A7415 rises above 160°C, it is forced into thermal shut-down. Only when core temperature drops below 140°C can the regulator become active again.

APPLICATION INFORMATION

Setting the Output Voltage

The external resistor divider is used to set the output voltage. Choose R1 and R2 follow the next table or calculated by following equation, where the internal reference voltage V_{REF}=0.8V.

$$\frac{R1}{R2} = \frac{V_{OUT} - V_{REF}}{V_{REF}}$$

V_{OUT}(V)	R2(kΩ)	R1(kΩ)
2.5	24	51
3.3	24	75
5.0	24	126

Inductor Selection

A 4.7μH to 22μH inductor (AiT SEMi's #PIT4018B) with a DC current rating of at least 25% percent higher than the maximum load current is recommended for most applications. For highest efficiency, the inductor DC resistance should be less than 15mΩ. For most designs, the inductance value can be derived from the following equation.

$$L > \frac{V_{OUT} x (V_{IN} - V_{OUT})}{V_{IN} x \Delta I_L x F_{OSC}}$$

Where ΔI_L is the inductor ripple current.

Choose ΔI_L to be approximately 30% of the maximum load current.

Under light load conditions below 100mA, larger inductance is recommended for improved efficiency.
Note：If the output voltage is less than 2.5V, it is recommended to use a larger inductance and add a small capacitance（10nF） parallel to R1.

Input Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. The input capacitor impedance at the switching frequency should be less than input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. A 22μF ceramic capacitor for most applications is sufficient. Include a capacitor with a value of 0.1 μF for high-frequency filtering and place it as close as possible to the device pins.

Output Capacitor Selection

The output capacitor (C_{OUT}) is required to maintain the DC output voltage, and the capacitance value determines the output ripple voltage. The output voltage ripple can be calculated by:

$$\Delta V_{OUT} = \frac{V_{OUT} X (V_{IN} - V_{OUT})}{V_{IN} X f_{OSC} X L} X \left(R_{ESR} + \frac{1}{8 X f_{OSC} X C_{OUT}}\right)$$

Where L is the inductor value and R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor. The output capacitor can be low ESR electrolytic, tantalum or ceramic, which lower ESR capacitors get lower output ripple voltage.

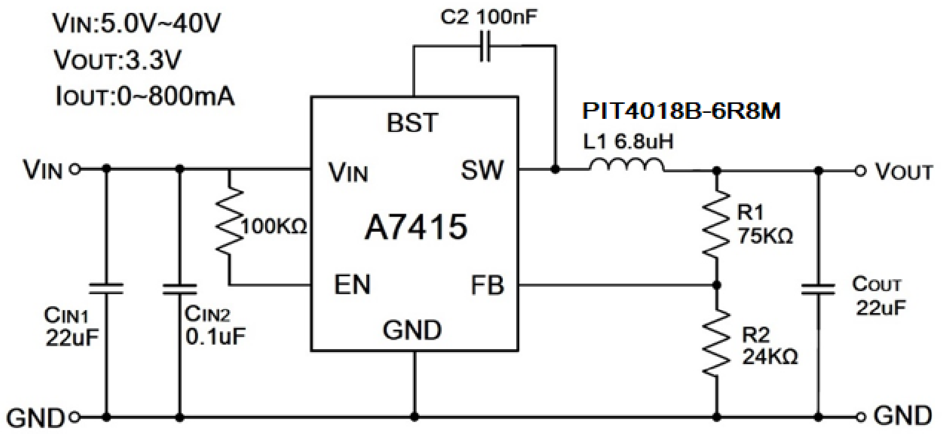
The characteristics of the output capacitor also affect the stability of the regulation system, and a 10uF ceramic capacitor is recommended in typical application. The A7415 can be optimized for a wide range of capacitance and ESR values.

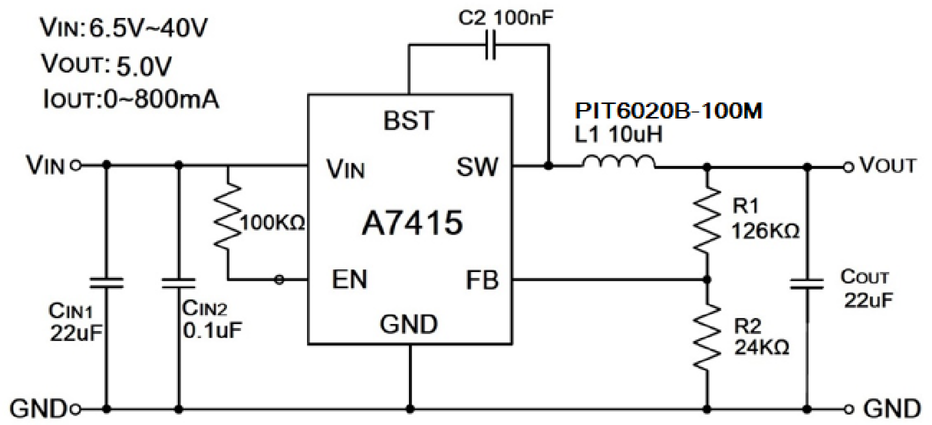
Application Information

For minimum noise problem and best operating performance, the PCB is preferred to following the guidelines as reference.

1. Place the input decoupling capacitor as close to A7415 (V_{IN} pin and GND) as possible to eliminate noise at the input pin. The loop area formed by input capacitor and GND must be minimized.
2. Put the feedback trace as far away from the inductor and noisy power traces as possible.
3. The ground plane on the PCB should be as large as possible for better heat dissipation

Reference Design

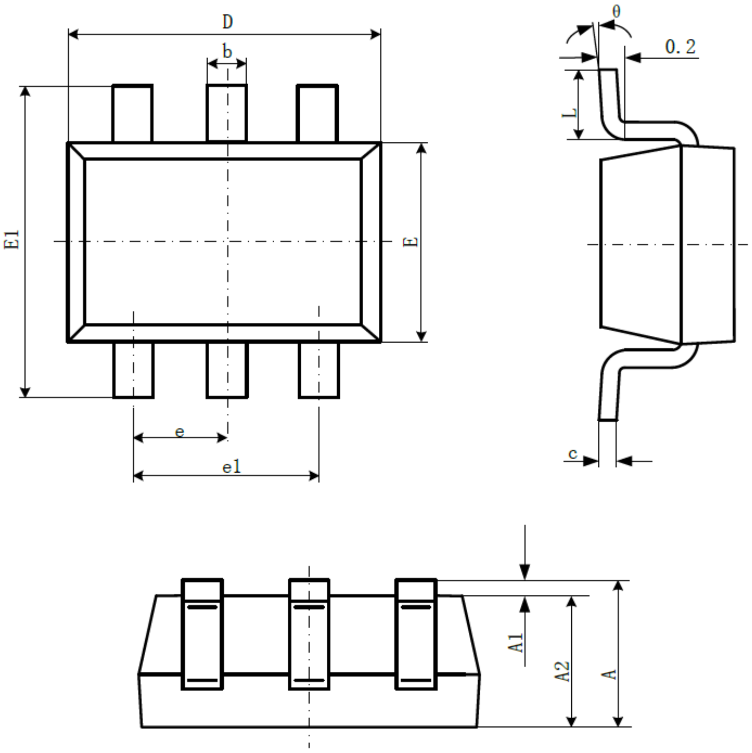




Note: Electrolytic capacitor is recommended for C_{IN1}, if C_{IN1} use ceramic capacitors, must connect a 3.3Ω resistor in series

PACKAGE INFORMATION

Dimension in SOT-26(Unit: mm)



Symbol	Min.	Max.
A	1.050	1.250
A1	0.000	0.100
A2	1.050	1.150
b	0.300	0.500
c	0.100	0.200
D	2.820	3.020
E	1.500	1.700
E1	2.650	2.950
e	0.950 BSC	
e1	1.800	2.000
L	0.300	0.600
θ	0°	8°

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