## DESCRIPTION

The A7312 is a fully integrated, high efficiency 2A synchronous rectified step-down converter. The A7312 operates at high efficiency over a wide output current load range.

This A7312 offers two operation modes, PWM control and PFM Mode switching control, which allows a high efficiency over the wider range of the load.

The A7312 is available in SOT-26 Packages.

## APPLICATION

- Power System
- Set Top Box
- Wireless & DSL Modems
- System Monitoring
- Computing

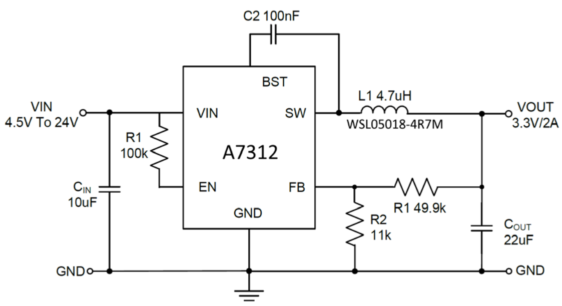
## ORDERING INFORMATION

| Package Type | Part Number | |
|---|---|---|
| SOT-26<br>SPQ: 3,000pcs/Reel | E6 | A7312E6R |
| | | A7312E6VR |
| Note | V: Halogen free Package<br>R: Tape & Reel | |
| AiT provides all RoHS products | | |

## FEATURES

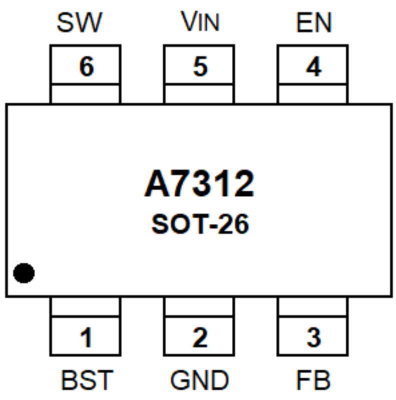
- High Efficiency: Up to 95%
- 750KHz Frequency Operation
- 2A Output Current
- No Schottky Diode Required
- 4.5V to 24V Input Voltage Range
- 0.6V Reference
- Slope Compensated Current Mode Control for
- Excellent Line and Load Transient Response
- Integrated internal compensation
- Stable with Low ESR Ceramic Output Capacitors
- Over Current Protection with Hiccup-Mode
- Thermal Shutdown
- Inrush Current Limit and Soft Start
- Operating Temperature Range: -40°C to +85°C
- Available in SOT-26 Packages

## TYPICAL PPLICATION




A7312 + WSL05018-4R7M

## PIN DESCRIPTION




SOT-26, E6

Top View

| PIN# SOT-26 | 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 IC；Drive this pin low to disable the IC and enter shutdown mode |
| 5 | VIN | Supply Voltage |
| 6 | SW | Inductor Connection；Connect an inductor Between SW and the regulator output. |

## ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)

| | |
|---|---|
| $V_{IN}$, Input Voltage | $V_{SS}$-0.3V ~ $V_{SS}$+25V |
| $V_{ON/OFF}$, Input Voltage | $V_{SS}$-0.3V ~ $V_{IN}$+0.3V |
| SW Voltage | $V_{SS}$-0.3V ~ $V_{IN}$+0.3V |
| BST Voltage | $V_{SS}$-0.3V ~ SW+6V |
| FB Voltage | $V_{SS}$-0.3V ~ $V_{SS}$+6V |
| $P_D$, Power Dissipation | 600mW |
| $T_{opr}$, Operating Ambient Temperature | -40℃ ~ +85℃ |
| $T_{stg}$, Storage Temperature | -40℃ ~ +125℃ |
| 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 are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

$T_A$ = +25°C, VIN=12V, VOUT=3.3V, unless otherwise noted.

| Parameter | Symbol | Conditions | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Input Voltage Range | $V_{IN}$ | - | 4.5 | - | 24 | V |
| Under Voltage Protect | $V_{UVLO}$ | - | - | 3.8 | - | V |
| $V_{UVLO}$ Hysteresis | $V_{UVLO\_H}$ | - | - | 0.3 | - | V |
| Supply Current | $I_{SS}$ | $V_{EN}$=5V, $V_{FB}$=1.2V | - | 50 | - | μA |
| Supply Shutdown Current | $I_{SD}$ | $V_{EN}$=0V | -1 | - | 1 | μA |
| FB Voltage | $V_{FB}$ | $T_A$ = +25°C, 3.7V≤VIN≤20V | 0.59 | 0.60 | 0.61 | V |
| Switching Frequency | $F_{OSC}$ | - | - | 750 | - | KHz |
| Maximum Duty Cycle | $D_{MAX}$ | - | - | 95 | - | % |
| FB Hiccup Threshold | $V_{FB\text{-}HT}$ | - | - | 0.15 | - | V |
| High Side Switch on Resistance | $R_{DSON\_H}$ | - | - | 160 | - | mΩ |
| Low Side Switch on Resistance | $R_{DSON\_L}$ | - | - | 80 | - | mΩ |
| Minimum on Time | $T_{ON\_MIN}$ | - | - | 100 | - | nS |
| Minimum off Time | $T_{OFF\_MIN}$ | - | - | 150 | - | nS |
| High Side Current Limit | $I_{LM}$ | - | - | 3.8 | - | A |
| EN Shutdown Threshold | $V_{CE}$ | - | - | 1.2 | - | V |
| EN Shutdown Hysteresis | $V_{CEH}$ | EN Rising | - | 100 | - | mV |
| EN Input Current | $I_{EN}$ | VEN=2V | - | 1 | - | uA |
| Thermal Shutdown | $T_{SHD}$ | Rising, Hysteresis =40°C | - | 145 | - | °C |
| Thermal Shutdown Hysteresis | $T_{SHD\_HYS}$ | - | - | 20 | - | °C |

## TYPICAL PERFORMANCE CHARACTERISTICS

Fig 1. Load Regulation

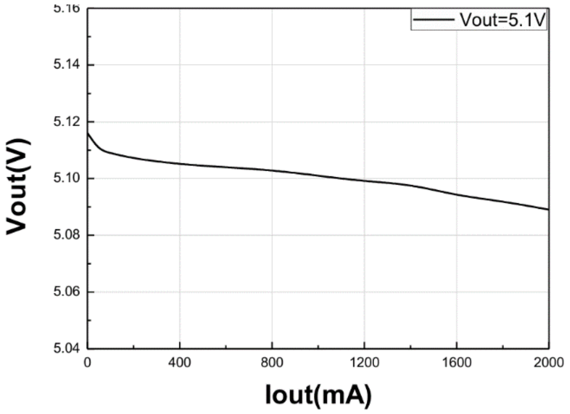



Fig 2. Linear Adjustment

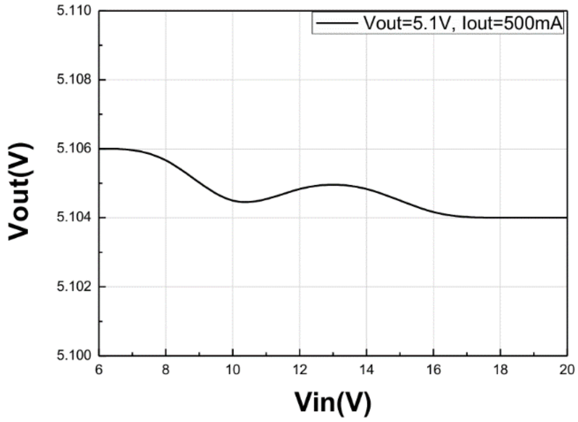



Fig 3. Output Temperature Drift, $V_{OUT}$=3.3V

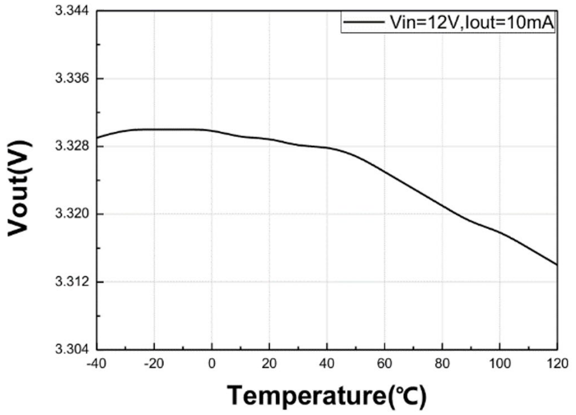



Fig 4. Output Temperature Drift, $V_{OUT}$=5.1V

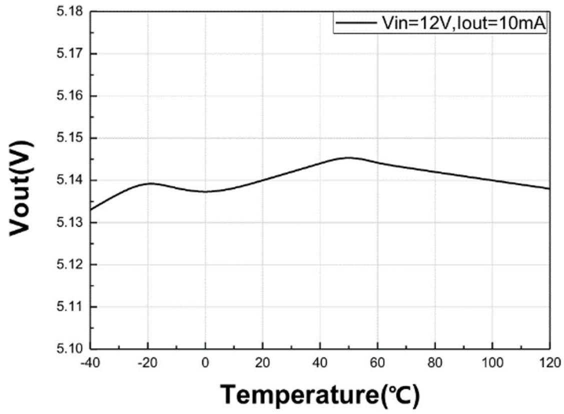
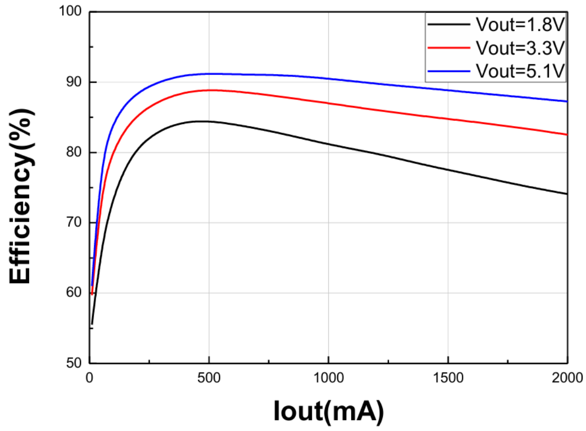



Fig 5. Efficiency



Testing conditions: $V_{IN}$=CE=12V, L=22uH (PIA6045-220M) , $C_{IN}$=$C_{OUT}$=22uF

Fig 6. $I_{OUT}$=10mA, $V_{OUT}$=3.3V

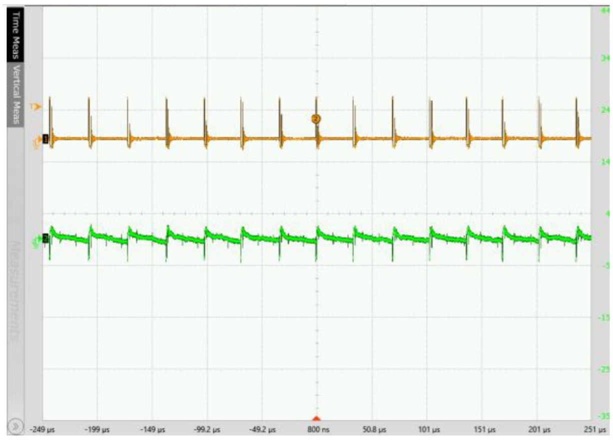


Fig 7. $I_{OUT}$=10mA, $V_{OUT}$=5.1V

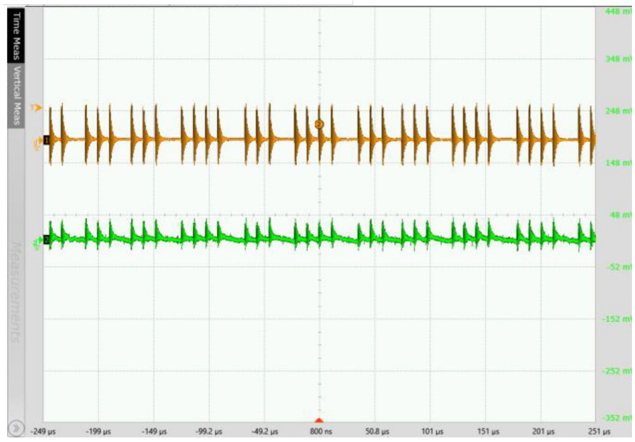


Fig 8. $I_{OUT}$=1A, $V_{OUT}$=3.3V

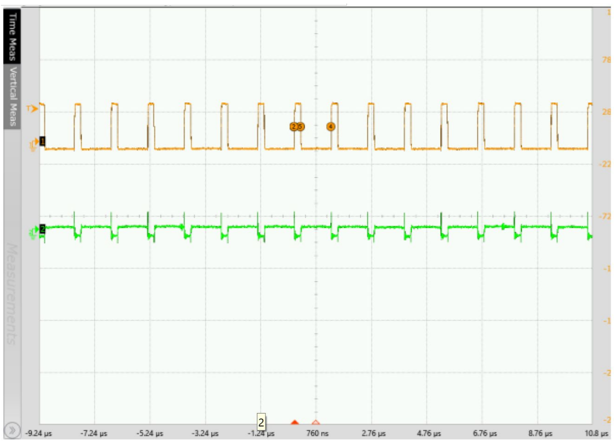
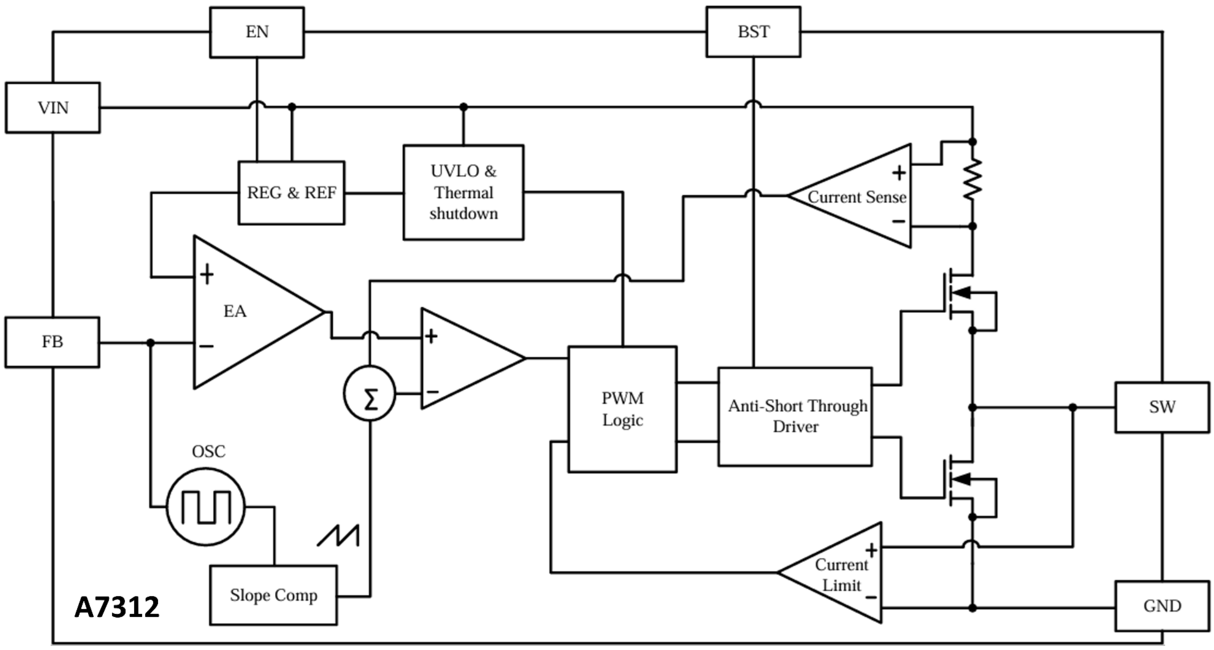


Fig 9. $I_{OUT}$=1A, $V_{OUT}$=5.1V

## BLOCK DIAGRAM



## DETAILED INFORMATION

### Internal Regulator

The A7312 is a current mode step down DC/DC converter, provides excellent transient response without extra external compensation components. The A7312 contains an internal, low resistance, high voltage power MOSFET, and operates at a high 750K operating frequency to ensure a compact, high efficiency design with excellent AC and DC performance.

### EA Amplifier

The error amplifier compares the FB pin voltage with the internal FB reference (VFB) and outputs a current proportional to the difference between the two. This output current is then used to charge or discharge the internal compensation network to form the COMP voltage, which is used to control the power MOSFET current. The optimized internal compensation network minimizes the external component counts and simplifies the control loop design.

### Enable

EN is a digital control pin that turns the A7312 on and off. Drive EN High to turn on the regulator, drive it Low to turn it off. An internal 1MΩ resistor from EN pin to GND allows EN to float to shut down the chip. Connecting the EN pin through a pull up resistor or shorted EN to IN will automatically turn on the chip whenever plug in IN.

### Internal Soft-Start

The soft-start is implemented to prevent the converter output voltage from overshooting during startup. When the chip starts, the internal circuitry generates a soft-start voltage (SS) ramping up from 0V to 0.6V. When it is lower than the internal reference (REF), SS overrides REF so the error amplifier uses SS as the reference. When SS is higher than REF, REF regains control. The SS time is internally fixed to 1 ms.

### Over-Temperature Protection

Thermal protection disables the output when the junction temperature rises to approximately 145°C, allowing the device to cool down. When the junction temperature cools to approximately 125°C, the output circuitry is again enabled. Depending on power dissipation, thermal resistance, and ambient temperature, the thermal protection circuit may cycle on and off. This cycling limits regulator dissipation, protecting the device from damage as a result of overheating.

## Over-Current-Protection and Hiccup

The A7312 has cycle-by-cycle over current limit when the inductor current peak value exceeds the set current limit threshold. Meanwhile, output voltage starts to drop until FB is below the Under-Voltage (UV) threshold, typically 30% below the reference. Once a UV is triggered, the A7312 enters hiccup mode to periodically restart the part. This protection mode is especially useful when the output is dead-short to ground. The average short circuit current is greatly reduced to alleviate the thermal issue and to protect the regulator. The A7312 exits the hiccup mode once the over current condition is removed.

## Startup and Shutdown

If both $V_{IN}$ and EN are higher than their appropriate thresholds, the chip starts. The reference block starts first, generating stable reference voltage and currents, and then the internal regulator is enabled. The regulator provides stable supply for the remaining circuitries. Three events can shut down the chip: EN low, $V_{IN}$ low and thermal shutdown. In the shutdown procedure, the signaling path is first blocked to avoid any fault triggering. The COMP voltage and the internal supply rail are then pulled down. The floating driver is not subject to this shutdown command.

## Application Information

## Setting the Output Voltage

The external resistor divider is used to set the output voltage (see Typical Application on page 1). The feedback resistor R1 also sets the feedback loop bandwidth with the internal compensation capacitor. Choose R1 to be around 100kΩ for optimal transient response. R2 is then given by:

$$R2 = \frac{R1}{\frac{V_{OUT}}{V_{FB}} - 1}$$

## Inductor Selection

A 4.7μH to 22μH inductor 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.

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where is the inductor ripple current. Choose inductor ripple current to be approximately 30% if the maximum load current, 2A. The maximum inductor peak current is:

$$I_{L(MAX)} = I_{LOAD} + \frac{\Delta I_L}{2}$$

Under light load conditions below 100mA, larger inductance is recommended for improved efficiency. Where: VFB =0.6V typically (the internal reference voltage) Resistors R2 has to be between 1kOhm to 20KOhm and thus R1 is calculated by following equation.

## 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. A large value may be used for improved input voltage filtering.

## Output Capacitor Selection

The output capacitor (COUT) is required to maintain the DC output voltage. Ceramic, tantalum, or low ESR electrolytic capacitors are recommended. Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by:

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

Where L is the inductor value and RESR is the equivalent series resistance (ESR) value of the output capacitor. In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly caused by the capacitance. For simplification, the output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{V_{IN} \times {f_{OSC}}^2 \times L \times C_{OUT}} \times (1 - \frac{V_{OUT}}{V_{IN}})$$

In the case of tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_{OSC} \times L} \times (1 - \frac{V_{OUT}}{V_{IN}}) \times R_{ESR}$$

The characteristics of the output capacitor also affect the stability of the regulation system. The A7312 can be optimized for a wide range of capacitance and ESR values.

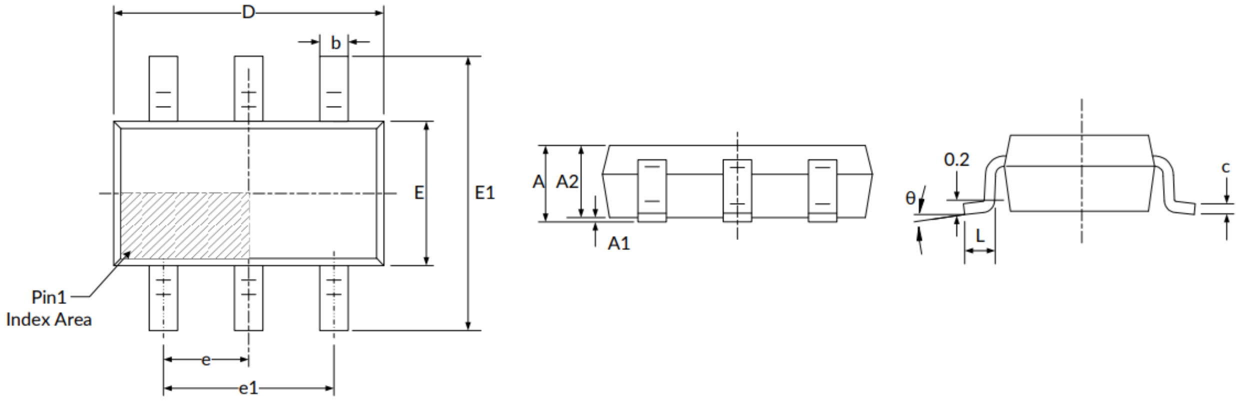
## Application Information

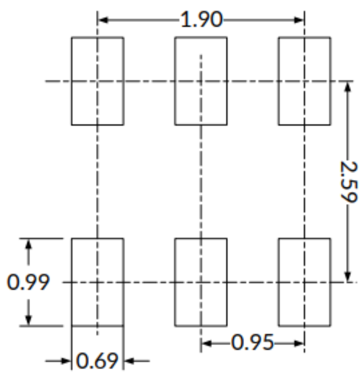
PCB layout is very important to achieve stable operation. It is highly recommended to duplicate EVB layout for optimum performance. If change is necessary, please follow these guidelines and take Figure 3 for reference.

- Keep the path of switching current short and minimize the loop area formed by Input capacitor, high-side MOSFET and low-side MOSFET.
- Bypass ceramic capacitors are suggested to be put close to the $V_{IN}$ Pin.
- Ensure all feedback connections are short and direct. Place the feedback resistors and compensation components as close to the chip as possible.
- $V_{OUT}$, SW away from sensitive analog areas such as FB.
- Connect IN, SW, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.

## PACKAGE INFORMATION

Dimension in SOT-26 (Unit: mm)




**Recommended Land Pattern (Unit: mm)**

| Symbol | Millimeters | |
|---|---|---|
| | 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 | 0.950 BSC | |
| e1 | 1.800 | 2.000 |
| E | 1.500 | 1.700 |
| E1 | 2.650 | 2.950 |
| L | 0.300 | 0.600 |
| θ | 0° | 8° |

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