Figure 1. Physical Photos of AT9342

FEATURES

- 230uA Operating Static Current
- Wide Operating Voltage Range of 4.2V to 40V
- Internal Power MOSFET with 500mΩ Resistance
- Fixed Switching Frequency of 1.8MHz
- Internal Compensation
- Voltage Regulation with Ceramic Output Capacitor
- Internal Soft Start
- Precision Surrent Limiting without Sampling Resistor
- High Efficiency: Up to 90%
- Low Quiescent Current
- SOT23-6L Package

APPLICATIONS

- Instrumentation
- Industrial power systems
- Distributed power systems
- Battery-powered systems

DESCRIPTION

AT9342 is a high-frequency (1.8MHz) buck-type switch regulator with internal integration of high-side high-voltage power MOSFET. It offers a maximum efficient output of 0.6A for a single channel, achieving rapid loop response through current mode control.

A wide input voltage range (4.2V to 40V) enables various applications for buck-type power conversion. The low quiescent current is suitable for battery-powered scenarios.

Under light load conditions, efficiency within a wide load range is achieved by reducing switch frequency to minimize losses in both the switch and gate driver. Frequency folding technology helps prevent uncontrolled inductor current during startup. Thermal shutdown ensures reliable and fault-tolerant operation. The AT9342 is packaged in an SOT23-6L package.

PIN CONFIGURATIONS

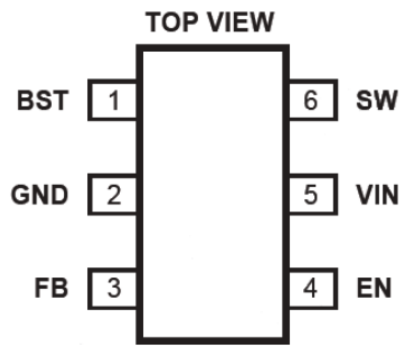

Figure 2. Pin Configurations

ABSOLUTE MAXIMUM RATING

Table 1.

Parameter	Value
Input Voltage Range	−0.3V to 43V
Switch Voltage	−0.3V to $V_{IN(MAX)}$ +0.3V
BST to SW	−0.3V to 6.0V
Other Pins	−0.3V to 5.0V
Continuous Power Dissipation	0.57W
Max Operating Junction Temperature(T_J)	150°C
Pin Temperature	260°C
Storage Temperature(T_S)	−40°C to +150°C
$R_{\theta JA}$ Junction-to-ambient thermal resistance	220°C/W
$R_{\theta JC}$ (top) Junction-to-case (top) thermal resistance	110°C/W

Note: Exceed these limits to damage to the device. Exposure to absolute maximum rating conditions may affect device reliability.

PIN DESCRIPTION

Table 2.

NO.	NAME	DESCRIPTION
1	BST	Bootstrap pin. The positive supply terminal for driving the internal floating high-side MOSFET. Connect a bypass capacitor between this pin and SW.
2	GND	Ground pin. Its connection should be as close as possible to the output capacitor, avoiding high-current switching paths.
3	FB	Feedback input. Input to the error amplifier. An external resistor divider connected between the output and ground, compared to the internal +0.8V reference, sets the regulated voltage.
4	EN	Enable Input. Pulling the voltage on this pin below the specified threshold will disable the chip. Pulling it above the specified threshold will make the chip operational. Floating the chip will result in it being disabled.
5	VIN	Power Input. Supplies power to all internal control circuits, including the switching transistor. It is necessary to connect a decoupling capacitor to ground to reduce switching spikes.
6	SW	Switch Pin. This is a high-side switch output. It is recommended to connect a low VF Schottky diode to ground nearby to reduce switching spikes.

BLOCK DIAGRAM

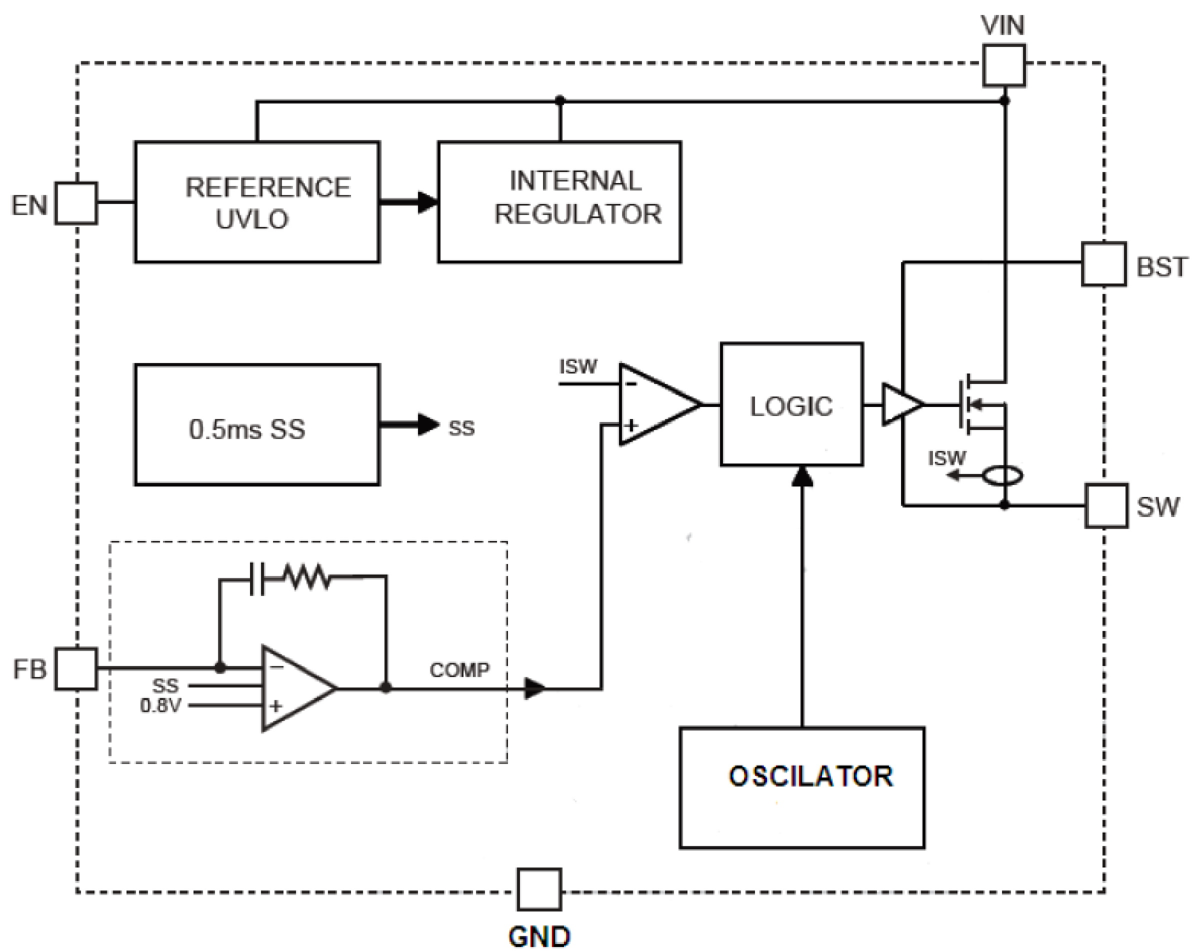

Figure 3. Block Diagram

TYPICAL APPLICATION

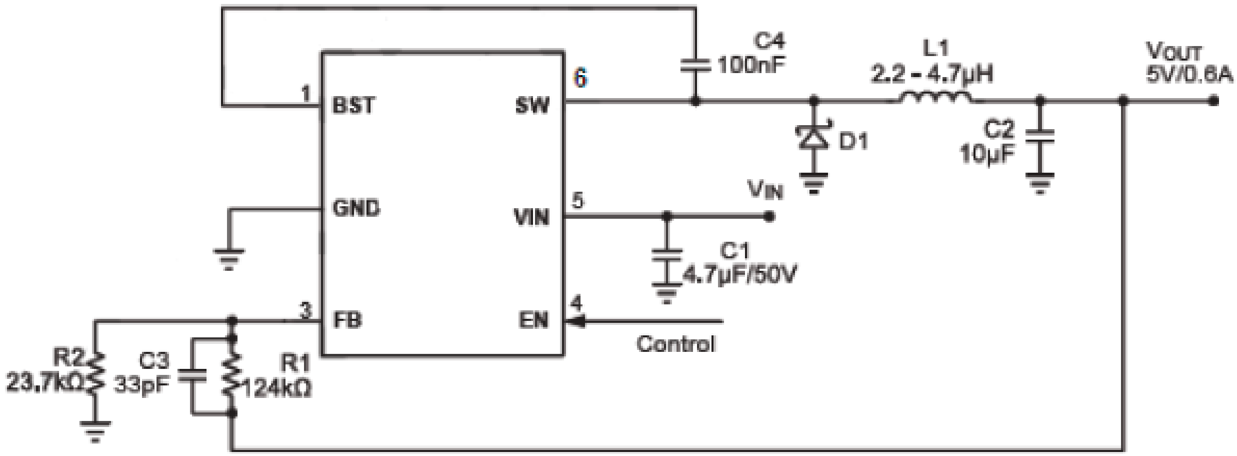

Figure 4. Typical Application Circuit

ELECTRICAL CHARACTERISTICS

(At T_A = +25°C, V_{IN} =12V, V_{EN} =2V, unless otherwise noted.)

Table 3.

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Feedback Voltage	V_{FB}			0.794		V
SW Resistor	R_{SW}	$V_{BST} - V_{SW}$ = 5V		500		mΩ
SW Leakage Current	I_{SWLK}	V_{EN} = 0V, V_{SW} = 0V		0.1	1	μA
Limit Current	I_{LIMIT}			1		A
Minimum Operating Voltage	V_{IN_MIN}		4.2			V
Under Voltage Lockout	V_{UVLO}		3.3		4.2	V
UVLO Hysteresis	V_{UVLO_HY}			0.8		V
Soft Start Time	t_{SS}	V_{FB} = 0V to 1.8V		0.5		s
Switching Frequency	F_{SOC}			1.8		MHz
Minimum Switch On Time	t_{on_min}			100		ns
Shutdown Input Current	$I_{SHUTDOWN}$	EN < 0.3V		3	15	μA
Quiescent Current	I_Q	V_{FB}=0.9, No Load		200		μA
Thermal Shutdown	T_j			150		°C
EN Input High Voltage	I_{H_EN}		1.6		2.0	V
EN Input Voltage Hysteresis	V_{EN_HY}			0.6		V

DETAILED DESCRIPTION

AT9342 is a buck switch-mode voltage regulator circuit with a 1.8 MHz oscillation frequency, asynchronous operation, and an internally integrated high-side high-voltage power MOSFET. It utilizes current mode control and provides an efficient output of up to 0.6A with internal compensation. It features a wide input voltage range, internal soft-start control, and precision current limiting. Its very low static operating current makes it suitable for battery-powered applications

PWM Control

In the case of medium to high output current situations, the circuit operates in a fixed-frequency, peak current control mode to regulate the output voltage. The PWM period is generated by an internal clock, and the power MOSFET remains on until its current reaches the COMP voltage setpoint. When the power transistor turns off, it remains off for at least 100 ns before the next cycle begins. During one PWM cycle, if the current in the MOSFET does not reach the COMP-set current value, the power MOSFET will remain on, saving one switching operation.

Pulse Skipping Mode

In light-load conditions, the circuit enters pulse skipping mode to improve light-load efficiency. The determination of pulse skipping is based on its internal COMP voltage. If the COMP terminal falls below the internal sleep threshold, a pause command is generated to prevent the opening of clock pulses, thus preventing the power MOSFET from turning on as instructed, which saves driver and switching losses. This pause command also puts the entire chip into sleep mode, consuming very low static current to further enhance light-load efficiency.

When the COMP voltage rises above the sleep threshold, the pause signal is reset, and the chip returns to normal PWM operation. Each time the pause command changes state from low to high, an open signal is immediately generated to turn on the power MOSFET.

Error Amplifier

The error amplifier consists of an internal operational amplifier and a resistor-capacitor feedback network connected between its output (internal COMP node) and the negative input (FB). When FB falls below its internal reference voltage (REF), the COMP output is driven higher by the op-amp, resulting in a higher peak current output from the switch, and thus, more energy is transferred to the output, and vice versa.

Typically, FB is connected to a voltage divider consisting of RUP and RDN, where RDN is connected between FB and ground, and RUP is connected between the voltage output node and FB. Meanwhile, RUP, along with the internal compensation RC network, collectively controls the gain of the error amplifier.

Internal Voltage Regulator

Most of the internal circuits are powered by an internal 2.6V voltage regulator. The regulator takes VIN as input and operates across the full VIN range. When VIN is greater than 4.0V, the regulator provides a normal output. When VIN is lower than that, the output decreases as well.

EN Control

The circuit has a dedicated enable control terminal EN. When VIN is sufficiently high, the chip can be enabled and disabled via the EN terminal. It operates with a high-level logic. The lower threshold is 1.6V with a 0.6V hysteresis. When left unconnected, the EN terminal is internally pulled to ground, disabling the chip. When EN is pulled to 0V, the chip enters its lowest shutdown current mode. When EN is higher than zero but below its threshold, the chip remains in the shutdown mode but with a slightly increased shutdown current.

UVLO

The Undervoltage Lockout (UVLO) for input voltage is a protection mechanism to prevent the chip from operating under insufficient power supply voltage conditions.

Soft-start

Soft start is employed to prevent the converter's output voltage from overshooting during startup. When the chip initiates startup, an internal circuit generates a soft start voltage (SS) that starts from 0V and rises slowly at a rate set by the soft start time. When SS is below the internal reference (REF), SS takes precedence, and the error amplifier uses SS as a reference instead of REF. When SS is higher than REF, REF takes precedence. SS is also associated with FB. SS can be significantly lower than FB but only slightly higher than FB. If FB unexpectedly drops, SS will track the drop in FB. This functionality is designed to address short-circuit recovery situations. When the short circuit is cleared, the SS slope rises as if it were a fresh soft start process, preventing output voltage overshoot.

Thermal shutdown

Thermal shutdown protection limits total power dissipation in the device. When the junction temperature exceeds T_J= +150°C, a thermal sensor forces the device into shutdown, allowing the die to cool. The thermal sensor reactivates the device when the temperature drops below the lower threshold, causing intermittent pulsing output in continuous overload conditions.

Floating Driver and Bootstrap Charging

The floating power MOSFET driver is powered by an external bootstrap capacitor. This floating driver has its own UVLO protection. The UVLO's turn-on threshold is approximately 2.9V with a hysteresis of around 300 mV. During UVLO, the SS voltage resets to zero. When UVLO is removed, the controller initiates the soft start process.

The bootstrap capacitor is charged and maintained at approximately 5V by an internal bootstrap voltage source. When the voltage between BST and SW falls below the regulated value, a PMOS switch, connecting VIN to BST, opens, allowing the charging current to flow from VIN, through BST, and then to SW. The external circuit should provide sufficient voltage margin to facilitate charging.

The bootstrap capacitor can be charged as long as VIN is sufficiently higher than SW. When the power MOSFET is on, VIN is approximately equal to SW, so the bootstrap capacitor cannot be charged. The greatest voltage difference between VIN and SW, allowing for optimal charging, occurs when the external freewheeling diode is open. When there is no current in the inductor, SW equals the output voltage VOUT, and the voltage between VIN and VOUT can be used to charge the bootstrap capacitor. Under high duty cycle operating conditions, the charging time for the bootstrap capacitor is reduced, and it may not charge effectively.

In cases where the external circuit does not provide sufficient voltage and time for charging the bootstrap capacitor, additional external circuitry can be used to ensure the bootstrap voltage stays within the normal operating range.

The UVLO of the floating driver is not transmitted to the controller.

The DC static current of the floating driver is approximately 20μA. Ensure that the supply current at the SW terminal is higher than this value.

Current Comparator and Current Limiting

The current in the power MOSFET is accurately sampled through a current-sensing MOSFET. It is then sent to a high-speed current comparator for current mode control. This sampled current serves as one of the inputs to the current comparator. When the power MOSFET is turned on, the comparator first blanks and then turns on to avoid noise. Subsequently, the comparator compares the power switch current with the COMP voltage. When the sampled current exceeds the COMP voltage, the comparator output goes low, turning off the power MOSFET. The maximum current of the internal power MOSFET is limited internally on a per-cycle basis.

Startup and Shutdown

When both VIN and EN are above their respective thresholds, the chip begins operation. The reference supply section starts up first, generating a stable reference voltage and current. Then, the internal voltage regulator source starts to enable, providing a stable voltage for the rest of the circuits. When the internal voltages reach the upper threshold, an internal timer keeps the power MOSFET off for 50μs to prevent startup transients. The internal soft-start section begins operation, initially keeping the SS output low to ensure readiness of the remaining circuits, and then gradually ramps up.

The chip can be shut down in three situations: when EN is low, when VIN is low, or due to thermal shutdown. In the shutdown sequence, signal paths are first blocked to prevent any fault triggers. Then, COMP voltage and internal power supply voltage decrease. The floating driver is not subject to this shutdown command, but its charging path is disabled.

APPLICATION

Setting Output Voltages

Output voltages are set by external resistors.

VFB=VOUT*R2/(R1+R2)

The feedback resistor R1, along with the internal compensation capacitor, is set to configure the feedback loop bandwidth. Choosing R1 to be approximately 124K ohms will yield the optimal transmission response.

Inductor

When switching the input voltage, an inductor is used to provide continuous current to the output load, and larger inductors result in lower output ripple. However, this comes at the cost of increased size, higher series resistance, and lower saturation current.

Typically, the choice of inductor involves selecting one where the peak-to-peak current in the inductor is 30% of the maximum load current. This ensures that the peak current remains below the maximum switch current and does not lead to saturation at the peak inductor current.

Input Capacitor

The input capacitor (C1) can be an electrolytic, tantalum, or ceramic capacitor. When using electrolytic or tantalum capacitors, a small ceramic capacitor, e.g., 0.1uF, should be placed nearby in the circuit. When using ceramic capacitors, ensure they have sufficient capacitance value to prevent excessive input voltage ripple.

Output Capacitor

The output capacitor (C2) is used to maintain the output DC voltage. It is recommended to use low ESR electrolytic capacitors to keep the output voltage ripple low. The characteristics of the output capacitor can affect the stability of the voltage regulation system.

Compensation Components

The design goal is to derive the transfer function of the converter to achieve an ideal loop gain and ensure fast transient response and good stability.

APPLICATION CIRCUIT

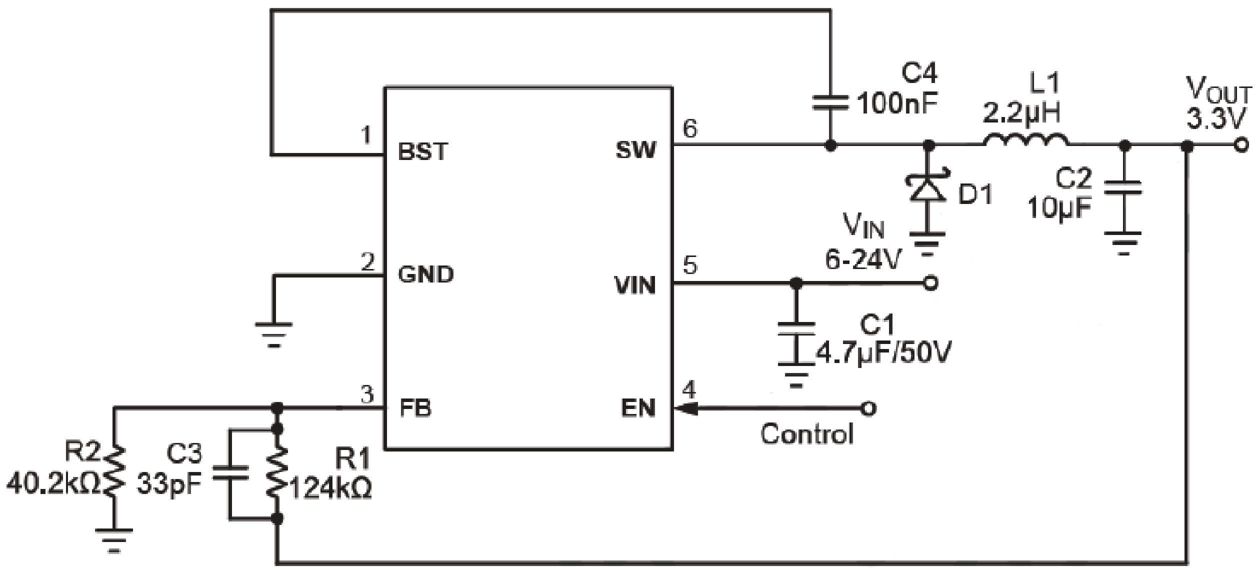

Figure 5. 3.3V Output Typical Application Circuit

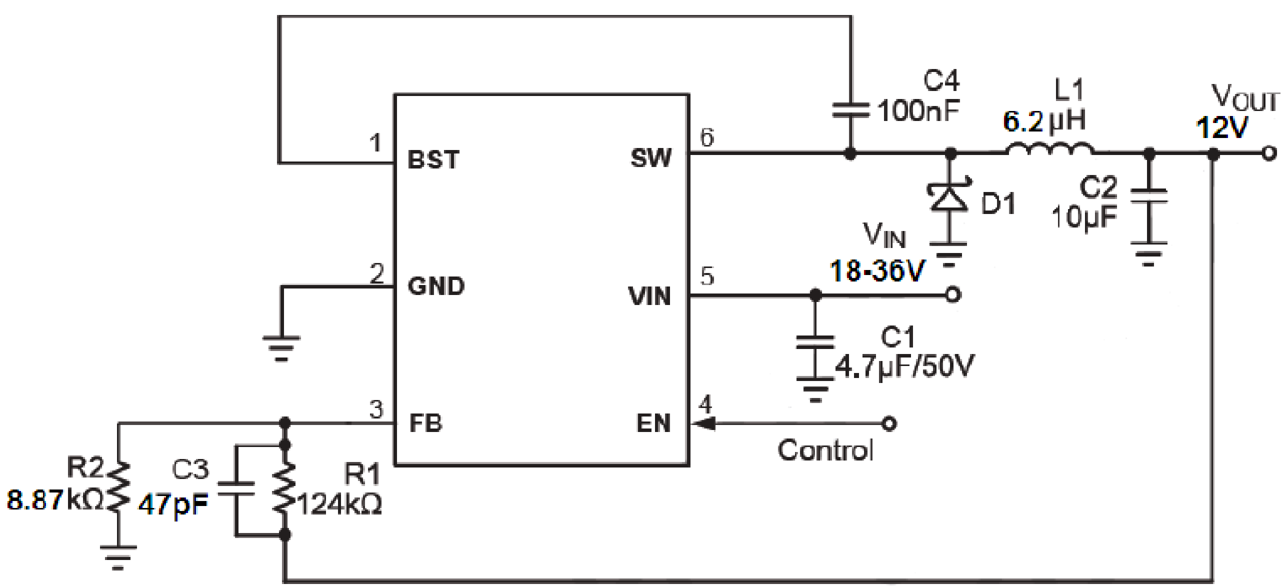

Figure 6. 12V Output Typical Application Circuit

LAYOUT GUIDE

PCB layout is crucial for the stable operation of the circuit. Here are some recommendations:

1. Keep the switch current paths as short as possible, and minimize the loop area formed by the input capacitor, high-side MOSFET, and external switch diode.
2. Place bypass ceramic capacitors as close to the VIN terminal as possible.
3. Keep all feedback circuit connections short and direct, and place feedback resistors and compensation components as close to the chip as feasible.
4. Route the SW trace away from sensitive analog areas like FB.
5. Connect SW, IN, and especially ground to separate large copper areas to dissipate heat, improve thermal performance, and enhance long-term reliability.

OUTLINE DIMENSIONS

SOT23-6L(UNIT: mm)

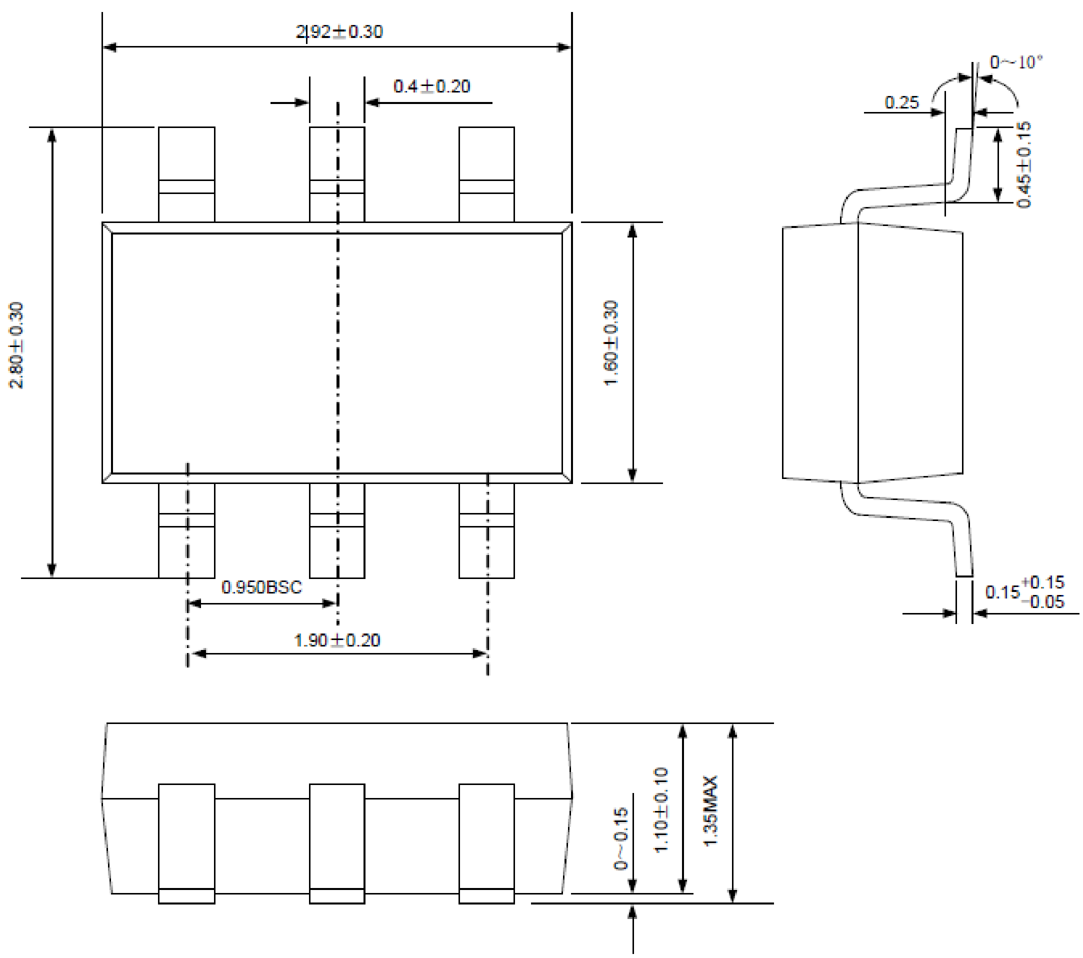

Figure 7. Outline Dimensions

ORDERING INFORMATION

Table 4. Ordering Information

Part Number	Buy Now
AT9342	* *

*: both and are our online store icons. Our products can be ordered from either one of them with the same pricing and delivery time.

NOTICE

1. It is important to carefully read and follow the warnings, cautions, and product-specific notes provided with electronic components. These instructions are designed to ensure the safe and proper use of the component and to prevent damage to the component or surrounding equipment. Failure to follow these instructions could result in malfunction or failure of the component, damage to surrounding equipment, or even injury or harm to individuals. Always take the necessary precautions and seek professional assistance if unsure about proper use or handling of electronic components.
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