

Parameters Subject to Change Without Notice

DESCRIPTION

The JW[®]3510 is a micropower isolated flyback converter. By sampling the isolated output voltage directly from the primary-side flyback waveform, the part requires no third winding or opto-isolator for regulation. The output voltage can be programmed with a single external resistor. Besides, internal compensation and soft-start further reduce external component count.

The JW3510 operates with an input voltage range of 3.0V to 42V and can deliver up to 6W of isolated output power. The primary-side can deliver 1.4A peak current with an internal integrated 65V N-Channel DMOS power switch. The JW3510 is designed with boundary mode, discontinuous mode and burst mode operation at different load to improve load regulation and maintain high efficiency while minimizing the output voltage ripple.

JW3510 is available in the SOT23-5 package. The high level of integration results in a simple to use, low component count, and high efficiency application solution for isolated power delivery.

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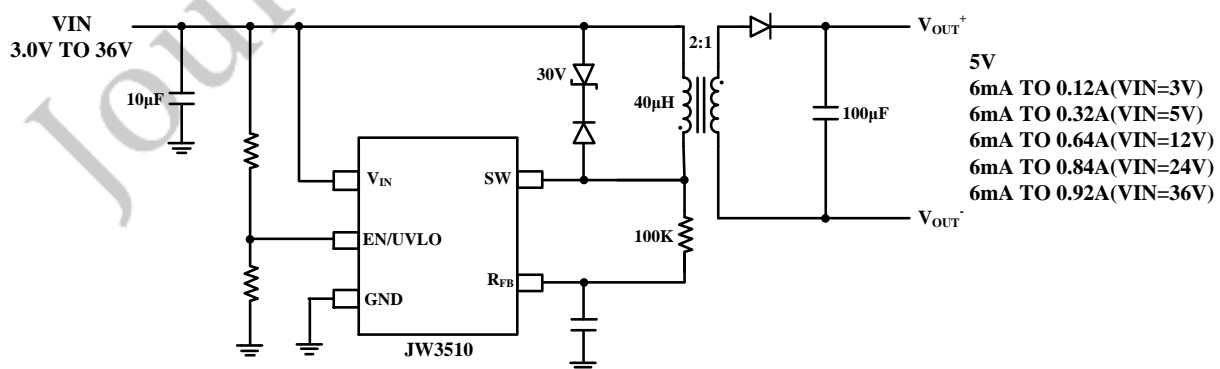
FEATURES

- 3.0V to 42V Operating Input Range
- 1.4A, 65V Internal DMOS Power Switch
- Up to 430KHz Operating Frequency
- Low Quiescent Current
- Boundary Mode Operation at Heavy Load
- Burst Mode Operation at Light Load
- V_{OUT} Set with a Single External Resistor
- Minimum Load < 0.5% (Typ) of Full Output
- No Transformer Third Winding or Opto-Isolator Required for Regulation
- Internal Compensation and Soft-Start
- Input under voltage lockout
- Output Short-Circuit Protection
- Thermal Protection
- SOT23-5 Package

APPLICATIONS

- Isolated Telecom, Automotive, Industrial, Housekeeping Power Supplies
- Isolated Auxiliary Power Supplies
- Wide Input Voltage Range Micropower system.

TYPICAL APPLICATION



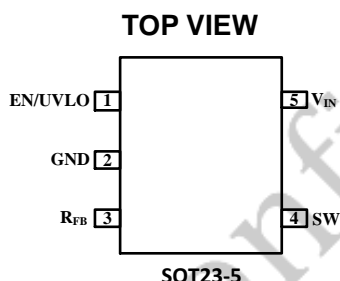
ORDER INFORMATION

DEVICE ¹⁾	PACKAGE	TOP MARKING ²⁾
JW3510SOTA#TRPBF	SOT23-5	JWKB□ YW□□□

Notes:

- 1) JW□□□#TRPBF
 PB Free
 Tape and Reel (If "TR" is not shown, it means tube)
 Package Code
 Part No.
- 2) Line1: JW□□□ Internal control code
 Product code
 Joulwatt LOGO
- Line2: YW□□□ Lot number
 Week code
 Year code

PIN CONFIGURATION

ABSOLUTE MAXIMUM RATING¹⁾

SW.....	65V
V _{IN}	42V
EN/UVLO.....	V _{IN}
R _{FB}	V _{IN} -0.5V to V _{IN}
Current into R _{FB}	200μA
Junction temperature ²⁾	150°C
Storage temperature.....	-65°C to +150°C

RECOMMENDED OPERATION CONDITIONS

Operating Junction Temp (T _J) ²⁾	-40°C to 125°C
SW pin.....	0V to 63V
V _{IN} pin.....	3V to 40V

THERMAL RESISTANCE³⁾

	θ_{JA}	θ_{JC}
SOT23-5	220...130 °C /W	

Note:

- Exceeding these ratings may damage the device.
- The JW3510 guarantees robust performance from -40°C to 150°C junction temperature. The junction temperature range specification is assured by design, characterization and correlation with statistical process controls.
- Measured on JEDEC51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

$T_A=25^{\circ}\text{C}$, unless otherwise noted						
PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input Voltage Range	V_{IN}		3.0		42	V
EN/UVLO Threshold		Rising	1.1	1.2	1.3	V
		Falling	1.0	1.1	1.2	V
V_{IN} Quiescent Current	I_Q	EN=0V		0.1	0.6	μA
		Sleep Mode (Switch Off)	150	170	250	μA
		Active Mode (Switch On)	650	780	900	μA
Thermal Shutdown	T_{SDN}	Shutdown temperature		140		$^{\circ}\text{C}$
		Hysteresis		10		
Minimum Switching Frequency	f_{MIN}		4	7	10	kHz
Minimum Switch-On Time	$t_{ON(MIN)}$		300	350	400	ns
Minimum Switch-Off Time ⁴⁾	$t_{OFF(MIN)}$				800	ns
Maximum SW Current Limit	$I_{SW(MAX)}$		1.20	1.40	1.60	A
Minimum SW Current Limit	$I_{SW(MIN)}$		0.30	0.35	0.40	A
Switch On-Resistance	$R_{DS(ON)}$	$I_{SW} = 500\text{mA}$		0.5	0.6	Ω
R_{FB} Regulation Current	I_{RFB}		95	100	105	μA
R_{FB} Regulation Current Line Regulation		$3.0\text{V} \leq V_{IN} \leq 42\text{V}$			0.1	%/V

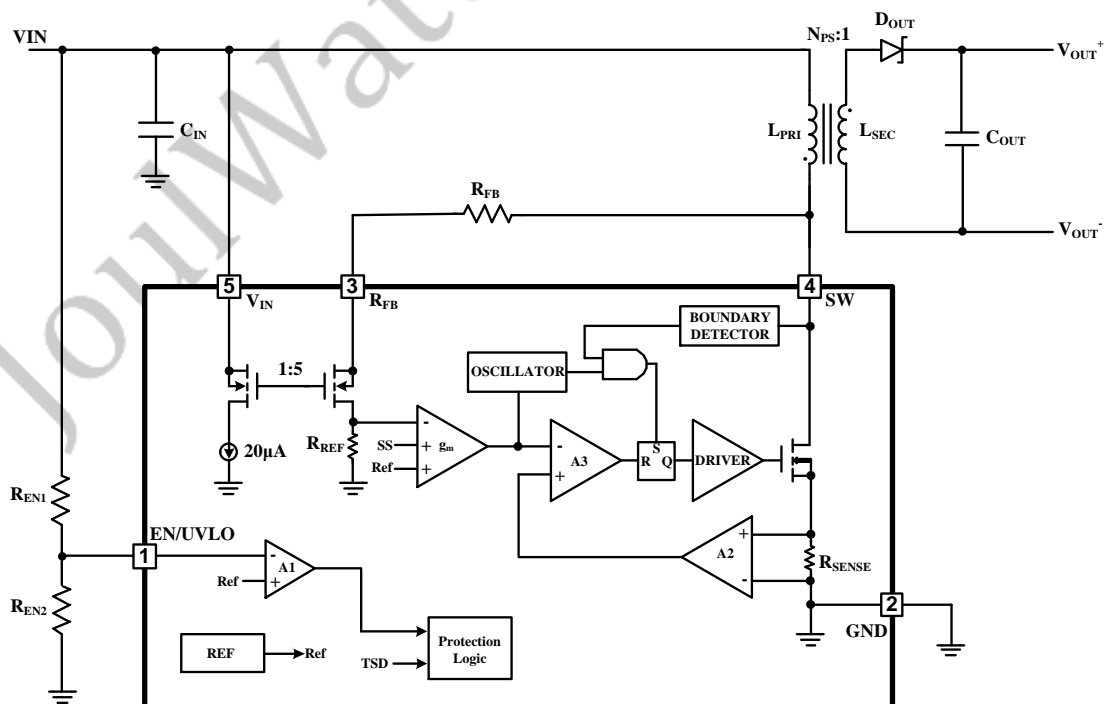
Note:

- 4) The conduction time of secondary diode, T_{OFF} , should be longer than 800ns when SW current is minimum (0.3A). Refer to Figure 1.

PIN FUNCTIONS

Pin#	Name	Description
1	EN/UVLO	Enable/Under voltage Lockout. The EN/UVLO pin is used to enable the JW3510. Pull the pin below 1.1V to shut down the JW3510. This pin also can be used to program a V_{IN} under voltage lockout threshold using a external resistor divider from V_{IN} to ground.
2	GND	Ground. Tie this pin directly to local ground plane.
3	R_{FB}	Input Pin for External Feedback Resistor. Connect a resistor from this pin to the transformer primary SW pin. The ratio of the R_{FB} resistor to an internal 10k resistor, times a trimmed 1V reference voltage, determines the output voltage (plus the effect of any non-unity transformer turns ratio). Minimize trace area at this pin.
4	SW	Collector Node of the Output Switch. This pin has large currents flowing through it. Drain of the 65V internal DMOS Power Switch. Minimize trace area at this pin to reduce EMI and voltage spikes.
5	V_{IN}	Input Voltage. The V_{IN} pin supplies current to internal circuitry and serves as a reference voltage for the feedback circuitry connected to the R_{FB} pin. Locally bypass this pin to ground with a capacitor.

FUNCTIONAL BLOCK DIAGRAM



FEATURE DESCRIPTION

The JW3510 is a current mode switching regulator IC designed for the isolated flyback topology. It samples the isolated output voltage through the primary-side flyback pulse waveform, so that neither opto-isolator nor extra transformer winding is required for regulation. In this manner, it overcomes the deficiencies of opto-isolator, such as wasting output power, increasing extra components, limiting dynamic response, nonlinearity, unit-to-unit variation and aging over lifetime. Circuit employing extra transformer windings also exhibit deficiencies, as using an extra winding adds to the transformer's physical size and cost, and dynamic response is often mediocre.

Since the JW3510 operates in either boundary conduction mode or discontinuous conduction mode, the output voltage is always sampled on the SW pin when the secondary current is almost zero. This method improves load regulation without the need of external load compensation components.

Boundary Conduction Mode

Boundary conduction mode is a variable frequency, variable peak-current mode switching scheme. The JW3510 operates in boundary conduction mode at heavy load, where the chip turns on primary power switch when the secondary current is zero and the transformer primary current increases until an internally controlled peak current limit. After the power switch turns off, the voltage on the SW pin rises to the output voltage multiplied by the primary-to-secondary transformer turns ratio plus the input voltage. When the secondary current through the output diode falls to zero, the SW pin voltage falls and rings around V_{IN} . A boundary mode detector senses this event and turns the power switch back on.

Discontinuous Conduction Mode

As the load gets lighter, boundary conduction mode will increase the switching frequency and losses. To avoid this scenario, the JW3510 has an additional internal oscillator which clamps the maximum switching frequency to be less than 430kHz (typ), meanwhile decreases the peak current limit level to a lower value. Once the switching frequency hits the internal frequency clamp, the system starts to delay the switch turn-on and operates in discontinuous conduction mode.

Burst Mode

Unlike traditional flyback converters, the JW3510 has to turn on and off at least for a minimum amount of time and with a minimum frequency to allow accurate sampling of the output voltage. The inherent minimum switch current limit and minimum switch-off time are necessary to guarantee the correct operation of specific applications.

As the load gets very light, the JW3510 starts to fold back the switching frequency while keeping the minimum switch current limit. So the load current is able to decrease while still allowing minimum switch-off time for the sample-and-hold error amplifier. Meanwhile, the part switches between sleep mode and active mode, thereby reducing the effective quiescent current to improve light load efficiency. In this condition, the JW3510 operates in low ripple Burst Mode. The 10kHz (typ) minimum switching frequency determines how often the output voltage is sampled and also the minimum load requirement.

Output Voltage

The R_{FB} resistor as depicted in the Block Diagram is the only external resistor used to program the output voltage. The JW3510 operates similar to

traditional current mode switchers, except in the use of a unique flyback pulse sense circuit and a sample-and-hold error amplifier, which sample and therefore regulate the isolated output voltage from the flyback pulse.

An internal trimmed reference voltage, V_{REF} 1.0V, feeds to the non-inverting input of the sample-and-hold error amplifier. The relatively high gain in the overall loop causes the voltage across R_{REF} resistor to be nearly equal to V_{REF} .

The resulting relationship between R_{FB} and V_{REF} can be expressed as:

$$\frac{N_{PS} \cdot (V_o + V_F)}{R_{FB}} = \frac{V_{REF}}{R_{REF}} = 100\mu A \quad (1)$$

Rearrangement of the expression for V_o in the Output Voltage section yields the starting value for R_{FB} :

$$R_{FB} = \frac{N_{PS} \cdot (V_o + V_F)}{100\mu A} \quad (2)$$

Where, N_{PS} is the transformer primary-to-secondary turns ratio, V_F is the output diode forward voltage. Usually, the R_{FB} is no more than 100K.

Minimum Load Requirement

In order to sample the isolated output voltage from the primary-side flyback pulse waveform, the JW3510 has to turn on and off at least for a minimum amount of time and with a minimum frequency. The JW3510 delivers a minimum amount of energy even during light load conditions to ensure accurate output voltage information. The minimum energy delivery creates a minimum load requirement, which can be approximately estimated as:

$$I_{O(MIN)} = \frac{L_m \cdot I_{SW(MIN)}^2 \cdot f_{MIN}}{2V_o} \quad (3)$$

Where, L_m is the transformer primary inductance, $I_{SW(MIN)}$ is the minimum switch current limit, f_{MIN} is the minimum switch frequency.

Output Short-Circuit Protection

When the output is heavily overloaded or shorted, the reflected SW pin waveform rings longer than the internal blanking time. If no protection scheme is applied, after the minimum switch-off time, the excessive ring might falsely trigger the boundary mode detector and turn the power switch back on again before the secondary current falls to zero. The part then runs into continuous conduction mode at maximum switching frequency, and the switch current may run away. To prevent this condition, the JW3510 gradually folds back both maximum switch current limit and switching frequency as the output voltage drops from regulation. This output short protection prevents the switch current from running away and limits the average output diode current.

Leakage Inductance and Snubbers

SW pin has voltage spike after the inner MOSFET turning off, causing by leakage inductance, so it is very important to minimize the leakage. The RCD snubber or DZ snubber is recommended to reduce the voltage spike of SW.

As the Figure 1 shows, the reflected output voltage plus V_{IN} should be below 50V for practical design. This leaves at least 15V headroom for the voltage spikes caused by the leakage inductance. Generally, the maximum spike voltage should be less than 65V with reasonable margin, such as 5-10% of the device voltage rating, for example 2-5V. A proper design of transformer turns ration and snubber circuit is necessary to achieve these requirements.

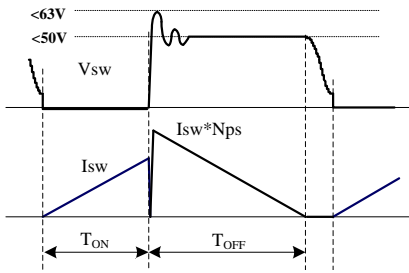


Figure 1. the operation waveform of SW

Layout Guidelines

In order to increase the reliability and feasibility of the project it is recommended to adhere to the following guidelines for PCB layout. A typical design schematic is shown in Figure 2.A.

- Arrange the components to minimize the loop areas of the switching currents as much as possible. These areas include such loops as the transformer primary winding current

loop (1), the secondary output current loop (2), and the primary snubber loop (3).

- Place a decoupling ceramic capacitor from V_{IN} to GND close to the IC for adequate filtering.
- In order to avoid the coupling of switching noise, it is strongly recommended that the R_{FB} pin path should be as far away from the transformer as possible.
- To improve thermal performance increase the copper area connected to GND pins.

Layout Example

Figure 2.B demonstrates a 5V-5V layout with trade-offs to minimize the loops while effectively placing components on a double-layer printed circuit board.

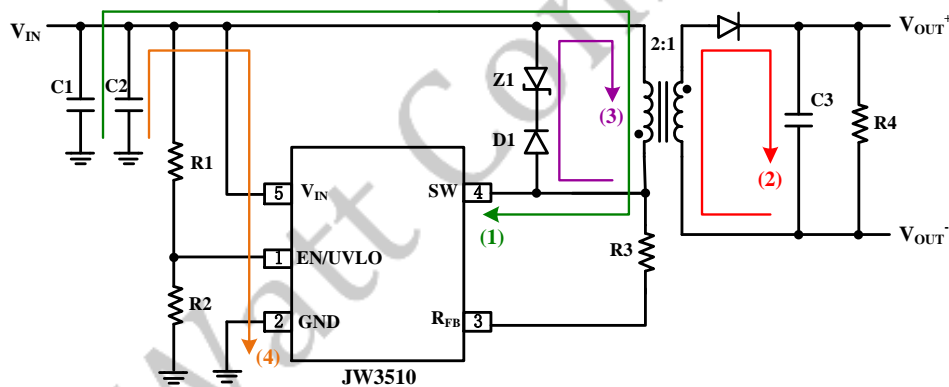


Figure 2. A Typical Design Schematic

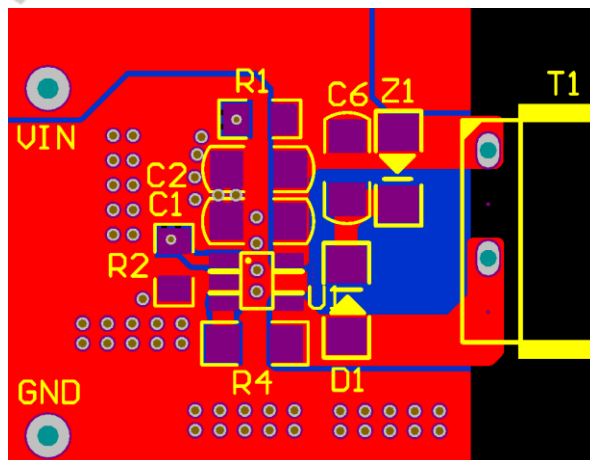
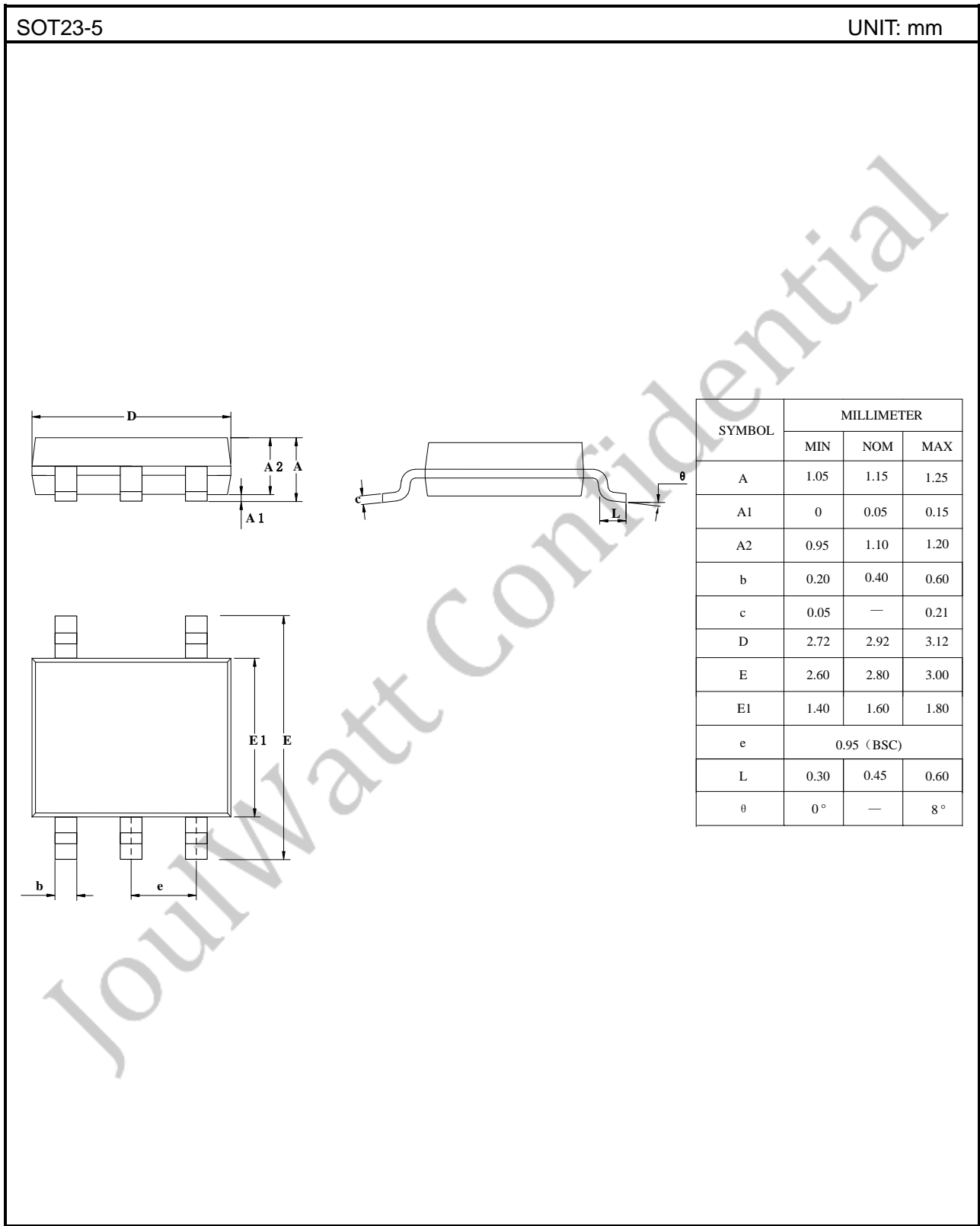


Figure 2.B Layout Example

PACKAGE OUTLINE



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