JW1160

30V Boost LED Driver

Preliminary Specifications Subject to Change without Notice

DESCRIPTION

The JW1160 are boost converters with a 40-V rated integrated switch FET, that drives LEDs in series. The boost converter has a 40V, 1.5A internal MOSFET; thus, it can drive single or parallel LED strings for backlighting from small to large panel size.

The default white LED current is set with the external sensor resistor Rset, and the feedback voltage is regulated to 200mV, as shown in the Typical Application drawing below. During the operation, the LED current can be controlled using pulse-width-modulation (PWM) signal. It can be applied to the CTRL pin through which the duty cycle determines the feedback reference voltage. The JW1160 does not burst the LED current; therefore, it does not generate audible noises on the output capacitor. For maximum protection, the device features integrated open-LED protection that disables the JW1160 to prevent the output from exceeding its absolute maximum voltage ratings during open LED conditions.

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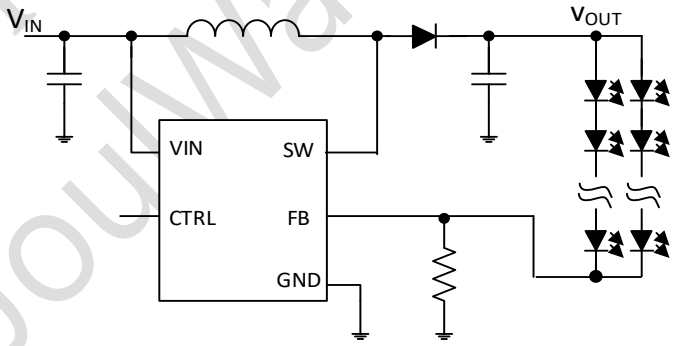
FEATURES

- Input Voltage Range: 2.7V to 5.5V
- Integrated 40V, 1.3A Current Limit MOSFET
- 35V Open LED Protection 1.2MHz Switching Frequency
- 200mV Reference Voltage
- PWM Brightness Control
- Under-Voltage Protection
- Up to 90% Efficiency
- Built-in Soft-Start Function
- Thermal Shutdown
- -40℃ to +85℃ Operating Temperature Range
- Available in Green DFN-2*2-6L，SOT23-5 Package

APPLICATIONS

- Smart Phone Backlighting
- Tablet Backlighting
- PDAs, Handheld Computers, GPS Receivers
- Portable Media Players,
- Portable TVs
- White LED Backlighting for Small and Media Form Factor Displays

TYPICAL APPLICATION



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ORDER INFORMATION

DEVICE[1)]	PACKAGE	TOP MARKING[2)]	ENVIRONMENTAL[3)]
JW1160DFNU#TR	DFN2*2-6	JWPG□ YW□□□	Green
JW1160SOTA#TR	SOT23-5	JWPH□ YW□□□	Green

Notes:

1) JW□□#TR
- Tape and Reel (If TR is not shown, it means Tube)
- Package Code
- Part No.

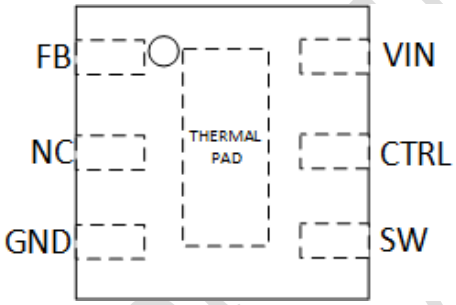
2) Line1: JW □□□
- Lot number
- Product code
- JoulWatt LOGO

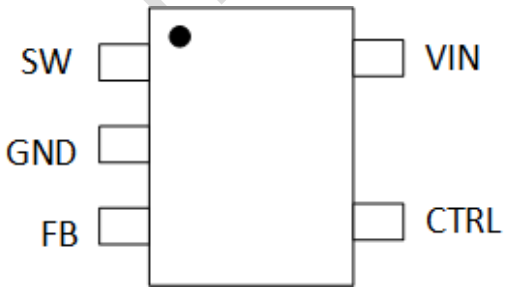
Line2: YW □□□
- Lot number
- Week code
- Year code

3) All JoulWatt products are packaged with Pb-free and Halogen-free materials and compliant to RoHS standards.

PIN CONFIGURATION

TOP VIEW





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ABSOLUTE MAXIMUM RATING[1)]

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

VIN, CTRL, FB…….. .-0.3V to 6V

SW .....-0.3V to 42V

JunctionTemperature[2)].....150ºC

Lead Temperature.....260ºC

Storage Temperature..... -65ºC to 150ºC

ESD Ring (Human Body Model, HBM) ..... ±2kV

ESD Ring (Charged Device Mode, CDM)..... ±1kV

RECOMMENDED OPERATING CONDITIONS[3)]

VIN.....2.7V to 5.5V

Vout .....VIN to 30V

Inductor 10μH

Input Capacitor .....1μF(MIN)

Output Capacitor.....1μF to 10μF

Operating Junction Temperature.....-40ºC to 125ºC

THERMAL PERFORMANCE[4)]

	θ_{JA}	θ_{JC}
DFN2*2-6	72	11.1 ºC/W
SOT-23-5	200	130 ºC/W

Notes:

1) Exceeding these ratings may damage the device. These stress ratings do not imply function operation of the device at any other conditions beyond those indicated under RECOMMENDED OPERATION CONDITIONS.

2) The JW1160 includes thermal protection that is intended to protect the device in overload conditions. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.

3) The device is not guaranteed to function outside of its operating conditions.

4) Measured on JESD51-7, 4-layer PCB.

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ELECTRICAL CHARACTERISTICS

V_{IN} =3.6V, C_{IN}=10μF, T_A=25 ºC, unless otherwise stated

Advance Information, not production data, subject to change without notice.

ITEM	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNITS
Input Power Supply						
Input voltage	V_{IN}		2.7		5.5	V
Under-Voltage Lockout Threshold	V_{UVLO}	V_{IN} Falling		2.2		V
		V_{IN} Rising		2.4	2.5	V
Under-Voltage Lockout Hysteresis	ΔV_{UVLO}			200		mV
Quiescent Current	I_Q	V_{FB} = 400mV, no switching		0.2		mA
Shutdown Current	I_{SHDN}	CTRL=GND			1	μA
Boost Converter						
Feedback Regulation Voltage	V_{REF}	PWM duty cycle 100%	193.5	200	205.3	mV
		PWM duty cycle 10%	18.5	20	22.5	mV
		PWM duty cycle 1%	1.65	2.2	3.25	mV
FB Pin Bias Current	I_{FB}	V_{FB}=200mV		0.001		μA
VREF Filter Time Constant	t_{REF}			0.43		ms
Boost Switch RDS(ON)	$R_{DS(ON)}$			0.5		Ω
Switching Frequency	f_{SW}	PWM duty cycle 100%	0.9	1.2	1.45	MHz
Switching Current Limitation	I_{OCP}			1.3		A
Over-Voltage Protection	V_{SW}	LED open detection		35		V
CONTROL						
CTRL Logic High Voltage	V_H		1.5			V
CTRL Logic Low Voltage	V_L				0.4	V
CTRL Internal Pull-Down Resistor	R_{PD}			600		kΩ
CTRL Logic Low Time to Shutdown	t_{SD}	CTRL high to low	1			ms
PWM Dimming Frequency Range			10		100	KHz
Minimum PWM On-Time			40			ns

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Stable Dimming Range			1		100	%
LED Current						
Thermal Shutdown Temperature	T_{OTP}			160		ºC
Thermal Shutdown Hysteresis	T_{OTP_hys}			20		ºC

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PIN DESCRIPTION

PIN		NAME	DESCRIPTION
DFN	SOT		
1	3	FB	Feedback Pin for Current. Connect the sense resistor from FB to GND.
2	NA	NC	No connection.(Only DFN)
3	2	GND	Ground.
4	1	SW	Switch Node of Boost Converter.
5	4	CTRL	PWM Dimming Control Input.
6	5	VIN	Power Supply Input.

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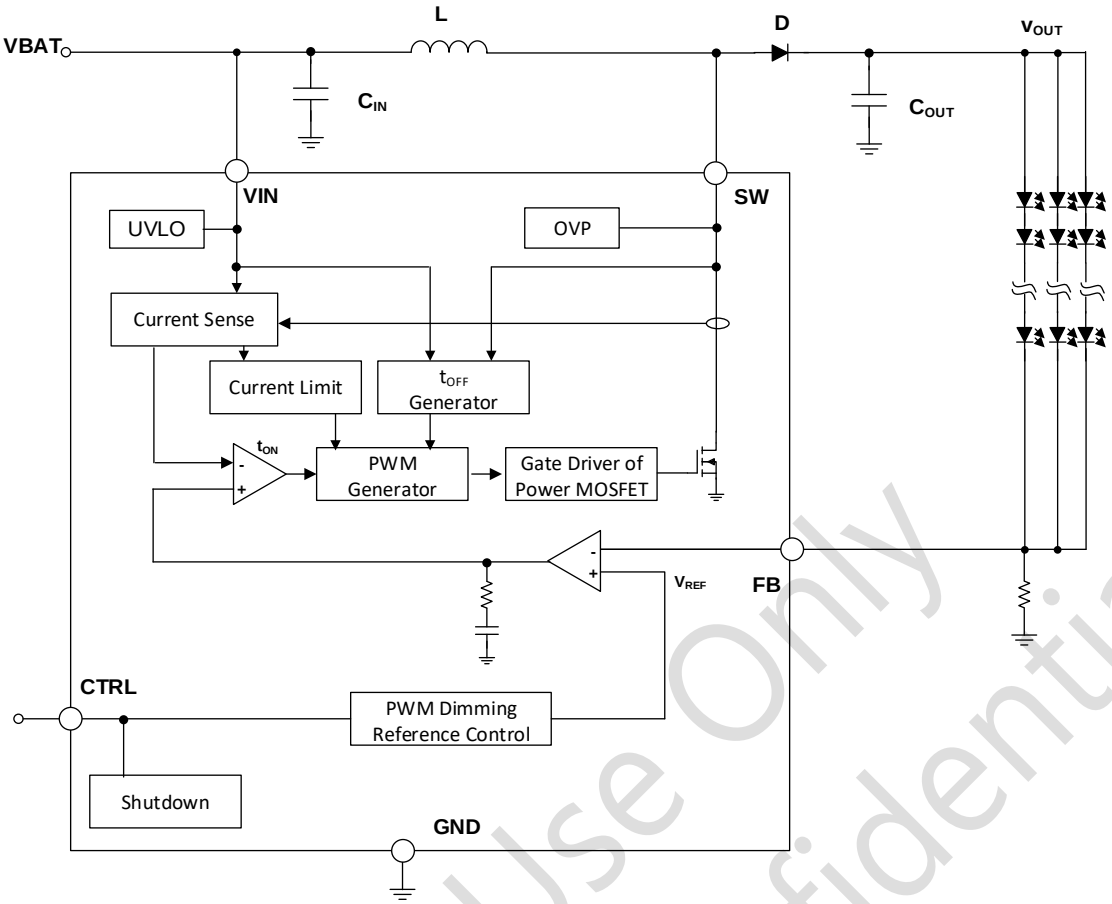
BLOCK DIAGRAM



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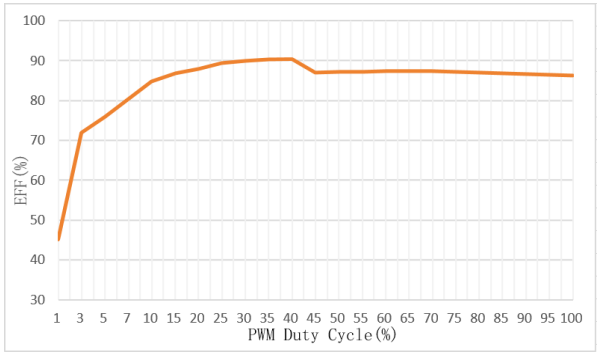
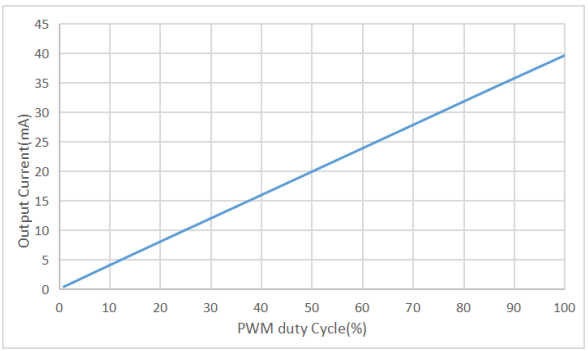
TYPICAL PERFORMANCE CHARACTERISTICS

T_A = +25℃, L = 10μH, C_{IN} = 2.2μF, C_{OUT} = 1μF, unless otherwise noted.

Efficiency vs Iout (vin=3.8V with 2p10s)

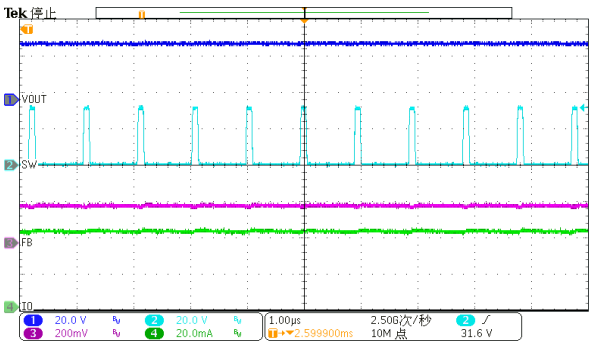


Iout vs PWM duty cycle (2p10s, vin=3.8V)



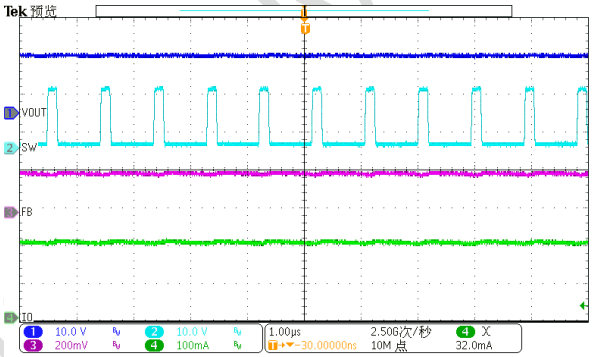
Switching Waveform

vin=3.8V with 10s 40mA

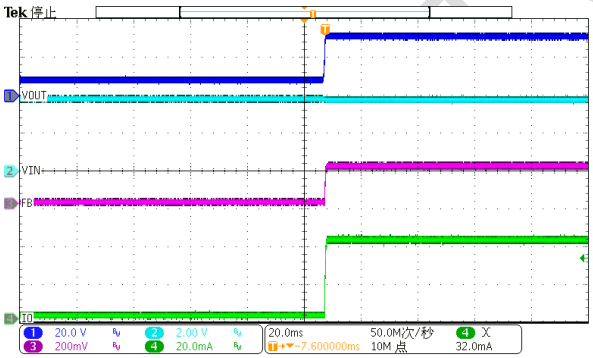


Switching Waveform

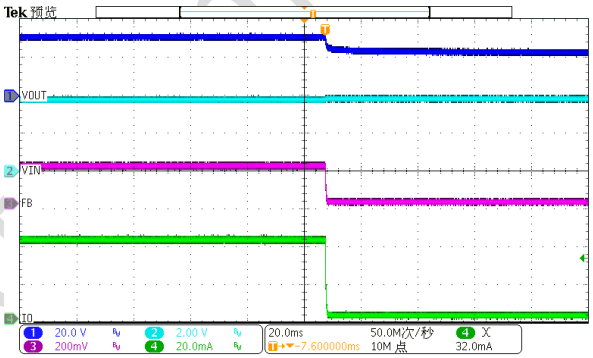
vin=3.8V with 3s 200mA



Startup



Shut down



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FUNCTIONAL DESCRIPTION

The JW1160 is a high efficiency, high output voltage backlight driver in small package size. The device integrates 40V switch FET and is designed for output voltage up to 30V with a switch peak current limit of 1.3A. Its large driving capability can drive single or parallel LED strings for small to large size panel backlighting.

The JW1160 is a current mode, quasi-constant frequency boost converter. The compensated is integrated internally for maximum flexibility and stability. The switching frequency is 1.2MHz, and the minimum input voltage is 2.7V. During the on-time, the current rises into the inductor. When the current reaches a threshold value set by the internal GM amplifier, the power switch MOSFET is turned off, and the Schottky diode is forward biased which lets the current flow towards the output of the boost converter.

The JW1160 topology also has the benefits of providing very good load and line regulations, and excellent line and load transient responses.

The feedback loop regulates the FB pin to a low reference voltage (200mV typical), reducing the power dissipation in the current sense resistor.

Soft Start-Up

Soft-start is integrated into the IC to avoid high inrush current spike during start-up. After the device is enabled, the GM amplifier output voltage ramps up very slowly, which ensures that the output voltage rises slowly to ensure the smooth start-up and reduce the inrush current.

Open LED Protection

Open LED protection circuitry prevents IC damage as the result of LED load disconnection during startup. The circuitry turns off the switch FET and shuts down the IC when the SW voltage exceeding the V_{OVP} threshold persists for 3 switching cycles. As a result, the output voltage falls to the level of the input voltage. The device remains in shutdown mode until it is enabled by toggling the CTRL pin.

Shutdown

The JW1160 enters shutdown mode when the CTRL voltage is logic low for more than 1ms. Although the internal switch FET does not switch in shutdown, there is still a DC current path between the input and the LEDs through the inductor and Schottky diode. The minimum forward voltage of the LED array must exceed the maximum input voltage to ensure the LEDs remain off in shutdown.

Current Program

The FB voltage is regulated by a 200mV reference voltage. The LED current is programmed by an external current-sense resistor in series with the LED string(s). The value of the RSET is calculated using Equation :

$$I_{LED} = \frac{V_{FB}}{R_{SET}}$$

Where:

I_{LED} = total output current of LED string(s)

V_{FB} = regulated voltage of FB pin

R_{SET} = current sense resistor

The output current tolerance depends on the FB accuracy and the current sensor resistor accuracy.

LED Brightness Dimming

The JW1160 receives PWM dimming signal at

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CTRL pin to control the total output current. When the CTRL pin is constantly high, the FB voltage is regulated to 200mV typically. When the duty cycle of the input PWM signal is low, the regulation voltage at FB pin is reduced, and the total output current is reduced; therefore, it achieves LED brightness dimming. The relationship between the duty cycle and FB regulation voltage is given by Equation:

$$V_{FB} = Duty * 200\,mV$$

Where:

Duty = duty cycle of the PWM signal

200mV = internal reference voltage

Thus, the user can easily control the WLED brightness by controlling the duty cycle of the PWM signal. The PWM frequency is in the range from 10kHz to 100kHz, and the recommended minimum PWM duty cycle is 1% for no blind dimming.

As shown in Figure 1, the IC chops up the internal 200mV reference voltage at the duty cycle of the PWM signal. The pulse signal is then filtered by an internal low pass filter. The output of the filter is connected to the GM amplifier as the reference voltage for the FB pin regulation. Therefore, although a PWM signal is used for brightness dimming, only the WLED DC current is modulated, which is often referred to analog dimming. This eliminates the audible noise which often occurs when the LED current is pulsed in replica of the frequency and duty cycle of PWM control.

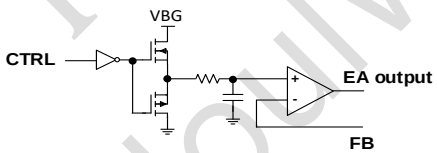

Figure 1. Programmable FB Voltage Using PWM Signal.

Under-Voltage Lockout

An under-voltage lockout prevents operation of the device at input voltages below typical 2.2V. When the input voltage is below the under-voltage threshold, the device is shut down, and the internal switch FET is turned off. If the input voltage rises by under-voltage lockout hysteresis, the IC restarts.

Thermal Shutdown

If the typical junction temperature of 160℃ is exceeded, an internal thermal shutdown turns off the device. The device is released from shutdown automatically when the junction temperature decreases by 20℃.

Operation with CTRL

The enable rising edge threshold voltage is 1.5V and the falling edge threshold voltage is 0.4V. With the CTRL terminal is held below the falling edge threshold voltage the device is disabled and switching is inhibited. The IC quiescent current is reduced in this state. When input voltage is above the UVLO threshold, and the CTRL terminal voltage is increased above the rising edge threshold, the device becomes active. Switching enables and the soft-start sequence initiates.

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APPLICATION INFORMATION

The JW1160 device is a boost converter which can drive single or parallel LED strings for small to large size panel backlighting and illumination.

Design Requirements

For this design example, use the parameters listed in Table 1 as the input parameters.

Table 1. Design Parameters

Design Parameter	Example Value
Input Voltage Range	2.7V to 5.5V
Output LED Number in a String	8
Output LED String number	2
Output LED Current per String	40mA

Inductor Selection

The selection of the inductor affects power efficiency, steady state operation as well as transient behavior and loop stability. These factors make it the most important component in power regulator design. There are three important inductor specifications, inductor value, DC resistance and saturation current. Considering inductor value alone is not enough. The inductor value determines the inductor ripple current. Choose an inductor that can handle the necessary peak current without saturating. Following Equation 3 to Equation 4 to calculate the inductor's peak current. To calculate the current in the worst case, use the minimum input voltage, maximum output voltage and maximum load current of application. In a boost regulator, the input DC current can be calculated as Equation:

$$I_{L(DC)} = \frac{V_{OUT} * I_{OUT}}{V_{IN} * \eta}$$

Where:

V_{OUT} = Boost output voltage

I_{OUT} = Boost output current

V_{IN} = Boost input voltage

η = Power conversion efficiency

The inductor current peak-to-peak ripple can be calculated as Equation:

$$\Delta I_{L(P-P)} = \frac{1}{L * \left(\frac{1}{V_{OUT} - V_{IN}} + \frac{1}{V_{IN}} \right) * f_S}$$

Where:

$\Delta I_{L(P-P)}$ = inductor peak-to-peak ripple

L = Inductor value

f_S = Boost switching frequency

V_{OUT} = Boost output voltage

V_{IN} = Boost input voltage

Therefore, the peak current $I_{L(P)}$ seen by the inductor is calculated with Equation :

$$\Delta I_{L(P)} = I_{L(DC)} + \frac{\Delta I_{L(P-P)}}{2}$$

Inductor values can have ±20% tolerance with no current bias. When the inductor current approaches saturation level, its inductance can decrease 20% to 35% from the 0A value depending on how the inductor vendor defines saturation current. Using an inductor with a smaller inductance value forces discontinuous PWM when the inductor current ramps down to zero before the end of each switching cycle. This reduces the boost converter's maximum output current, causes large input voltage ripple and reduces efficiency. Large inductance value provides much more output current and higher conversion efficiency. For these reasons, a 10μH

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inductor value range is recommended for most applications.

Schottky Diode Selection

The JW1160 demands a low forward voltage, high-speed and low capacitance Schottky diode for optimum efficiency. Ensure that the diode average and peak current rating exceeds the average output current and peak inductor current. In addition, the diode reverse breakdown voltage must exceed the open LED protection voltage. ONSemi MBR0540 is recommended for the JW1160.

Output Capacitor Selection

The output capacitor is mainly selected to meet the requirement for the output ripple and loop stability. This ripple voltage is related to capacitor capacitance and its equivalent series resistance (ESR). Assuming a capacitor with zero ESR, the minimum capacitance needed for a given ripple can be calculated with Equation :

$$C_{OUT} = \frac{(V_{OUT} - V_{IN}) * I_{OUT}}{V_{OUT} * f_S * V_{RIPPLE}}$$

Where:

V_{RIPPLE} = peak-to-peak output ripple

The additional part of the ripple caused by ESR is calculated using: VRIPPLE_ESR = IOUT × RESR.

Due to its low ESR, V_{RIPPLE_ESR} could be neglected for ceramic capacitors, a 1μF to 10μF capacitor is recommended for typical application.

A 1μF output capacitor is suggested for 10/8/6-Series LED applications. For high output current applications like 3S6P, larger value output capacitors of 2.2μF is recommended to minimize the output ripple.

LED Current Set Resistor

The LED current set resistor can be calculated by

Equation:

$$I_{LED} = \frac{V_{FB}}{R_{SET}}$$

Thermal Considerations

The allowable IC junction temperature should be considered under normal operating conditions. This restriction limits the power dissipation of the JW1160. The allowable power dissipation for the device can be

determined by Equation :

$$P_D = \frac{160°C - T_A}{\theta_{JA}}$$

Where:

TA is the ambient temperature for the application. θ_{JA} is the thermal resistance junction-to-ambient given in Power Dissipation Table.

Power Supply recommendations

The device is designed to operate from an input voltage supply range between 2.7V and 5.5V. This input supply must be well regulated. If the input supply is located more than a few inches from the JW1160, additional bulk capacitance may be required in addition to the ceramic bypass capacitors.

Layout Considerations

As for all switching power supplies, especially those high frequency and high current ones, layout is an important design step. Use wide and short traces for high current paths. The input capacitor C_{IN} needs to be close to V_{IN} pin and GND pin in order to reduce the input ripple seen by the

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IC. If possible, choose higher capacitance value for it. The SW pin carries high current with fast rising and falling edge, therefore, the connection between the SW pin to the inductor should be kept as short and wide as possible. The output capacitor C_{OUT} should be put close to V_{OUT}. It is also beneficial to have the ground of C_{OUT} close to the GND pin since there is large ground return current flowing between them. FB resistor should be put close to FB pin. When laying out signal ground, it is recommended to use short traces separated from power ground traces and connect them together at a single point close to the GND pin.

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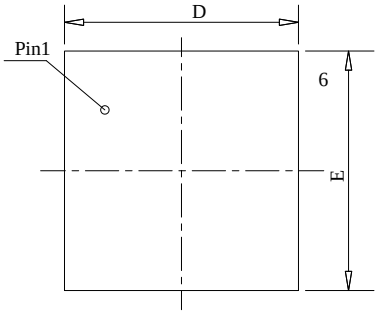
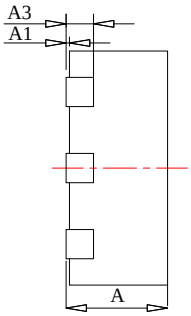
PACKAGE OUTLINE

DFN2*2-6 **UNIT: mm**

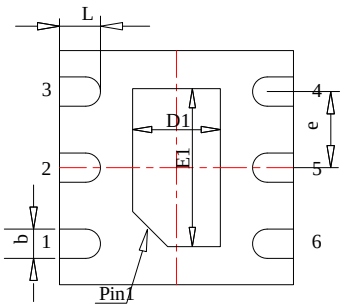


TOP VIEW

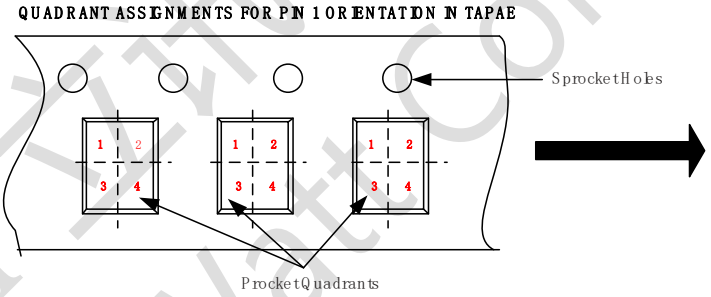


SIDE VIEW

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3		0.203 REF	
b	0.25	0.30	0.35
D		2.0BSC	
E		2.0BSC	
E1	1.50	1.60	1.70
D1	0.90	1.00	1.10
e		0.65 BSC	
L	0.174	0.25	0.326



BOTTOM VIEW



Package Type	Pin1 Quadrant
DFN-2*2-6L	Q1

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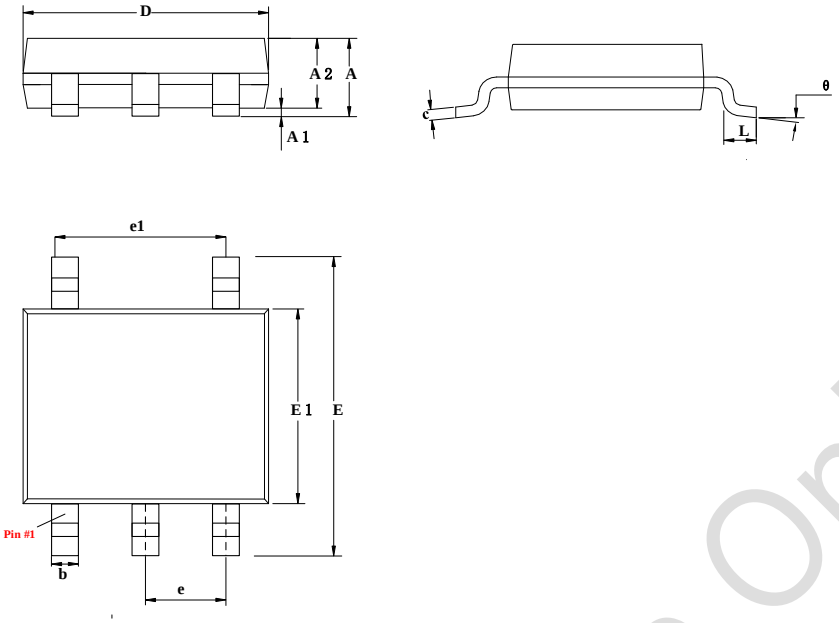
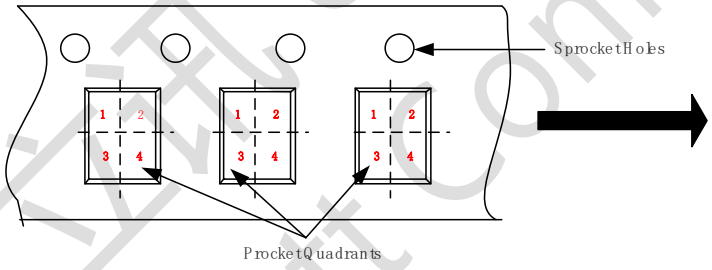
PACKAGE OUTLINE

SOT23-5 **UNIT: mm**



SYMBOL	MILLMETER		
	MIN	NOM	MAX
A	1.05	--	1.25
A1	0.00	--	0.15
A2	1.00	1.10	1.20
b	0.30	--	0.50
c	0.10	--	0.20
D	2.82	2.92	3.02
E	2.60	2.80	3.00
E1	1.41	--	1.71
e	0.95(BSC)		
L	0.27	--	0.60
θ	0°	--	8°

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Package Type	Pin1 Quadrant
SOT23-5	Q3

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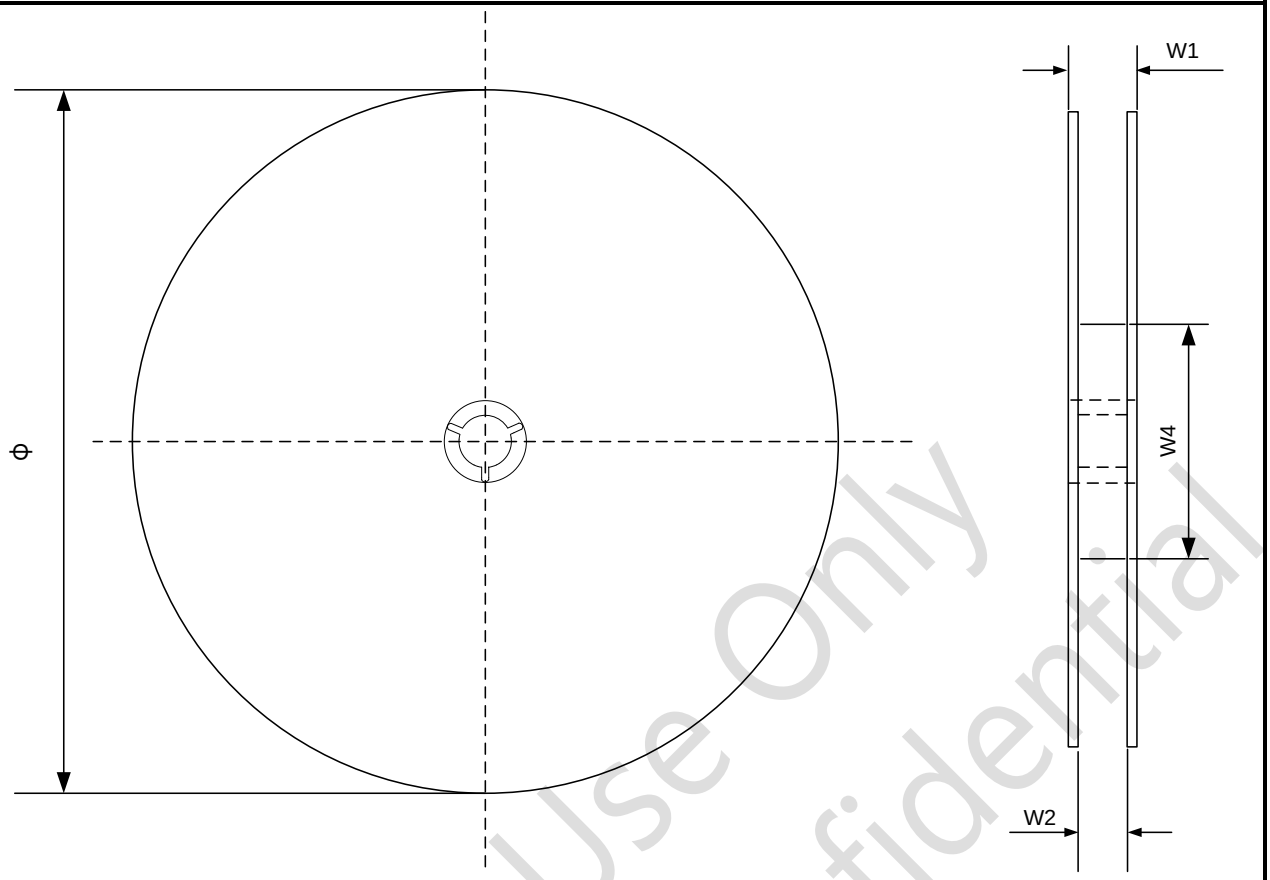
TAPE AND REEL INFORMATION

Reel UNIT: mm



Package	Diameter Φ	Thickness W1	Width W2	W4
DFN2*2-6	178±2	12.30±2	9.5±2	58±4
SOT23-5	178±2	12.30±2	9.5±2	58±4

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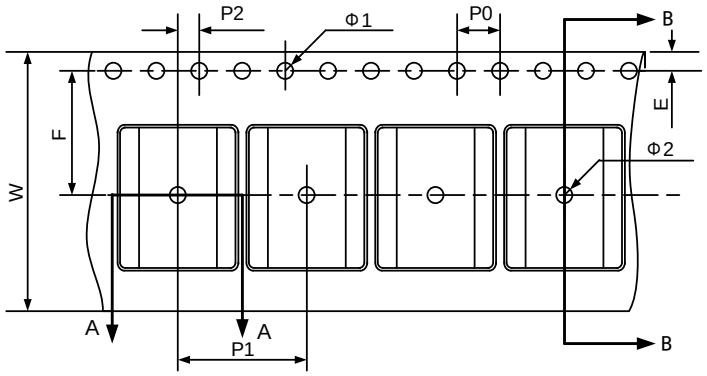
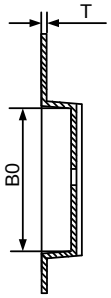
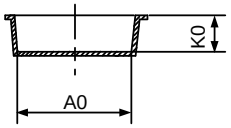
Carrier Tape UNIT: mm





SECTION B-B



SECTION A-A

Note:

1) The carrier type is black, and colorless transparent.
2) Carrier camber is within 1mm in 100mm.
3) 10 pocket hole pitch cumulative tolerance:±0.20.
4) All dimensions are in mm.

Package	Tape dimensions (mm)											
	P0	P2	P1	A0	B0	W	T	K0	Φ1	Φ2	E	F
DFN 2*2-6	4.00±0.10	2.00±0.10	4.00±0.10	2.30±0.20	2.30±0.20	8.00±0.30	0.25±0.20	1.10±0.35	1.50min	1.00min	1.75±0.10	3.50±0.10
SOT23-5	4.0±0.1	2.0±0.1	4.0±0.1	3.23±0.2	3.13±0.3	8.0±0.3	0.25±0.2	1.37±0.2	1.55±0.15	1.00min	1.75±0.1	3.50±0.1

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