

Preliminary Specifications Subject to Change without Notice

DESCRIPTION

The JW[®]5306 and JW[®]5306F are monolithic buck switching regulators based on I2 architecture for fast transient response. Operating with an input range of 4.5V~18V, JW5306 and JW5306F deliver 6A 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.

JW5306 and JW5306F guarantee robustness with output short protection, thermal protection, current run-away protection, and input under voltage lockout.

JW5306 and JW5306F are available in ESOP8 package, which provide a compact solution with minimal external components.

Company's Logo is Protected, "JW" and "JOULWATT" are Registered Trademarks of JoulWatt technology Inc.

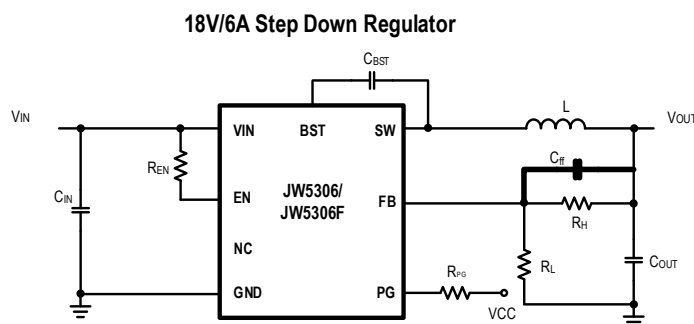
FEATURES

- 4.5V to 18V operating input range
- 6A output current
- 580kHz switching frequency
- 1% feedback voltage accuracy
- Internal soft-start
- Power good indicator
- PFM operation at light load (JW5306)
- FCCM operation at light load (JW5306F)
- Output short protection
- Thermal protection
- Available in ESOP8 package

APPLICATIONS

- Distributed Power Systems
- Networking Systems
- FPGA, DSP, ASIC Power Supplies
- Green Electronics/ Appliances
- Notebook Computers

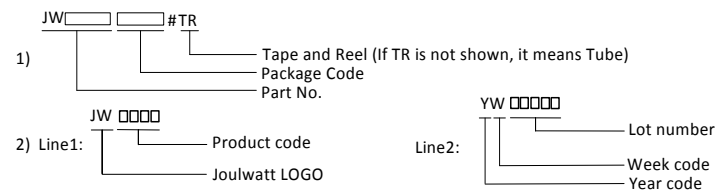
TYPICAL APPLICATION



ORDER INFORMATION

DEVICE ¹⁾	PACKAGE	TOP MARKING ²⁾	ENVIRONMENTAL ³⁾
JW5306ESOP#TR	ESOP8	JW5306 YW□□□□□	Green
JW5306FESOP#TR	ESOP8	JW5306F YW□□□□□	Green

Notes :

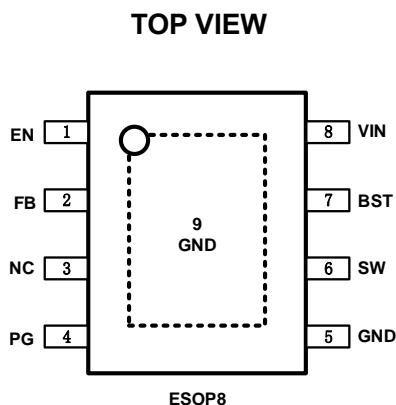


3) All Joulwatt products are packaged with Pb-free and Halogen-free materials and compliant to RoHS standards.

DEVICE INFORMATION

DEVICE	Operation Mode at light load	Function	Package
JW5306ESOP#TR	PFM	-	ESOP8
JW5306FESOP#TR	FCCM	-	ESOP8

PIN CONFIGURATION

**ABSOLUTE MAXIMUM RATING¹⁾**

VIN, EN Pin.....	-0.3V to 20V
SW Pin	-0.3V(-4V for 10ns) to 20V(22V for 5ns)
BST Pin	SW-0.3V to SW+5V
All other Pins	-0.3V to 6V
Junction Temperature ²⁾	150°C
Lead Temperature	260°C
Storage Temperature	-65°C to +150°C
ESD Susceptibility (Human Body Model).....	2kV
ESD Susceptibility (Charged Device Model).....	500V

RECOMMENDED OPERATING CONDITIONS³⁾

Input Voltage VIN	4.5V to 18V
Output Voltage V _{OUT}	0.765V to VIN-3V
Operating Junction Temperature	-40°C to 125°C

THERMAL PERFORMANCE⁴⁾

	θ_{JA}	θ_{JC}
ESOP8.....	42	2.5°C/W

Note:

- 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 OPERATING CONDITIONS.
- 2) The JW5306 and JW5306F 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

ELECTRICAL CHARACTERISTICS

VIN=12V, TA= TA=-40℃~125℃, Unless otherwise stated.						
Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
VIN Under Voltage Lock-out Threshold	VIN_MIN	VIN rising	4	4.2	4.45	V
VIN Under voltage Lockout Hysteresis	VIN_MIN_HYST			300		mV
Shutdown Current	ISD	VEN=0V			1	μA
Quiescent Current	IQ	VEN=5V, VFB=1.2V		130	200	μA
Feedback Voltage	VFB	4.5V≤VIN≤18V TA=25℃	757	765	773	mV
		TA = -40 to 125℃	751	765	779	mV
Top Switch Resistance ⁵⁾	RDS(ON)T			35		mΩ
Bottom Switch Resistance ⁵⁾	RDS(ON)B			25		mΩ
Top Switch Leakage Current ⁵⁾	I _{LEAK_TOP}	VIN=18V, VEN=0V, VSW=0V			1	μA
Bottom Switch Leakage Current ⁵⁾	I _{LEAK_BOT}	VIN=18V, VEN=0V, VSW=18V			1	μA
Bottom Switch Current Limit	I _{LIM_BOT}		5.8	7.5	9	A
Negative Current Limit	I _{LIM_NEG}	JW5306F	-5.2	-3	-2.6	A
Minimum On Time ⁵⁾	T _{ON_MIN}			120		ns
Minimum Off Time ⁵⁾	T _{OFF_MIN}	VFB=0.4V		200		ns
Switching Frequency	Fs		493	580	667	kHz
EN rising Threshold	V _{EN_H}		1.15	1.35	1.55	V
EN falling Threshold	V _{EN_L}		0.9	1.1	1.3	V
Power Good Upper Threshold	PG _{TH_Upper}	FB rising	120%	124%	128%	V _{REF}
Power Good Lower Threshold	PG _{TH_lower}	FB rising	87%	90%	94%	V _{REF}
		FB falling	82%	85%	89%	V _{REF}
Power Good Sink Current	I _{PG}	PG=0.5V	0.6			mA
Soft-start Time ⁵⁾	t _{ss}	10%-90% Vref		0.86		ms
Thermal Shutdown ⁵⁾	T _{TSD}			160		℃
Thermal Shutdown Hysteresis ⁵⁾	T _{TSD_HYST}			40		℃

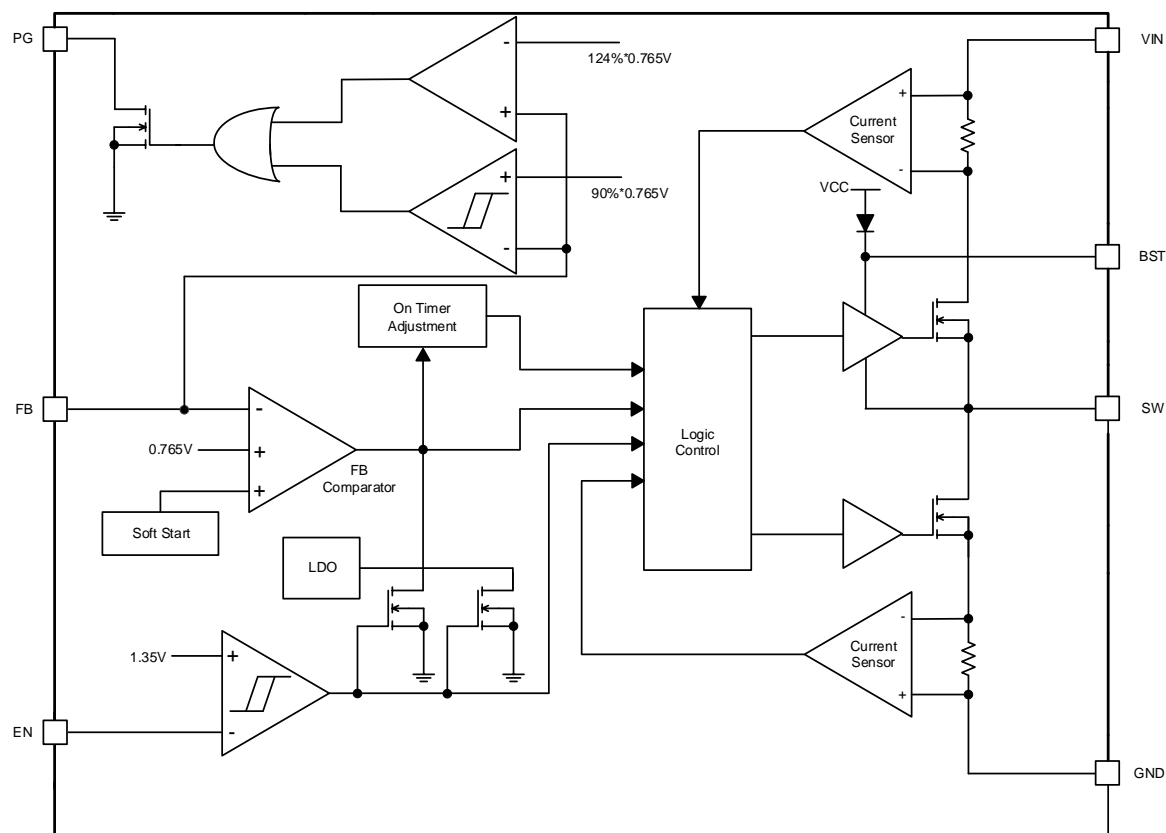
Note:

5) Guaranteed by design.

PIN DESCRIPTION

Pin ESOP8	Name	Description
1	EN	Drive EN pin high to turn on the regulator and low to turn off the regulator.
2	FB	Output feedback pin. FB senses the output voltage and is regulated by the control loop to 0.765V. Connect a resistive divider at FB.
3	NC	
4	PG	Power good monitor output. This is an open-drain output so a resistor should be connected at this pin to the V _{OUT} node or other power rail.
5	GND	Power ground pin
6	SW	SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load.
7	BST	Connect a 0.1uF capacitor between BST and SW pin to supply current for the top switch driver.
8	VIN	Input voltage pin. VIN supplies power to the IC. Connect a 4.5V to 18V supply to VIN and bypass VIN to GND with a suitably large capacitor to eliminate noise on the input to the IC.
9	GND	Power ground pin

BLOCK DIAGRAM

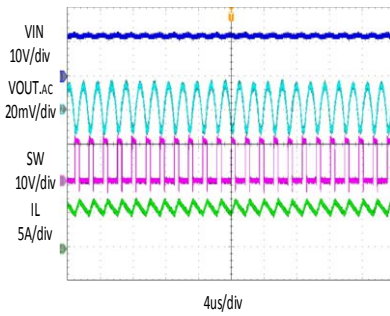


TYPICAL PERFORMANCE CHARACTERISTICS(PFM Mode)

VIN =12V, VOUT = 3.3V, L = 2.2 μ H, COUT= 44 μ F, Cff=51pF, TA = +25°C, unless otherwise noted

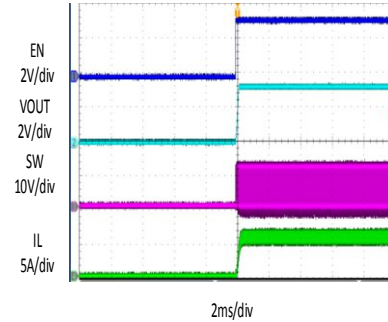
Steady State Test

VIN=12V, VOUT=3.3V
IOUT=6A



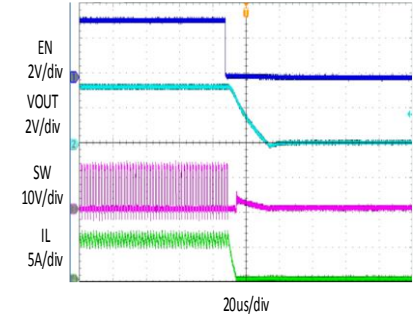
Startup through Enable

VIN=12V, VOUT =3.3V
IOUT =6A(Resistive load)



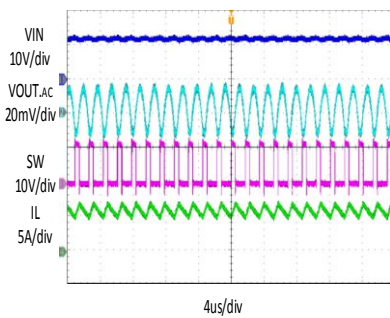
Shutdown through Enable

VIN=12V, VOUT =3.3V
IOUT =6A (Resistive load)



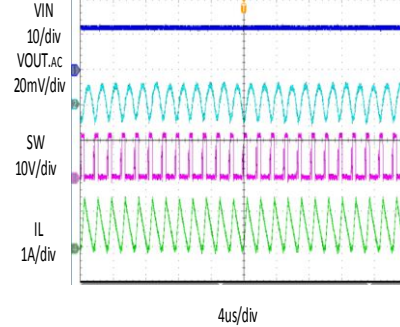
Heavy Load Operation

6A LOAD



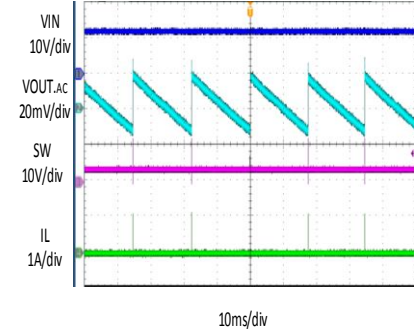
Medium Load Operation

0.6A LOAD



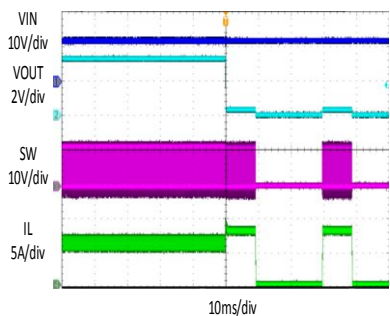
Light Load Operation

0 A LOAD



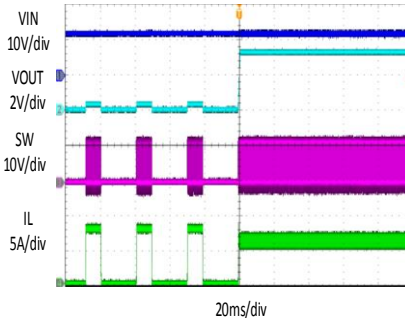
Short Circuit Protection

VIN=12V, VOUT =3.3V
IOUT =6A- Short



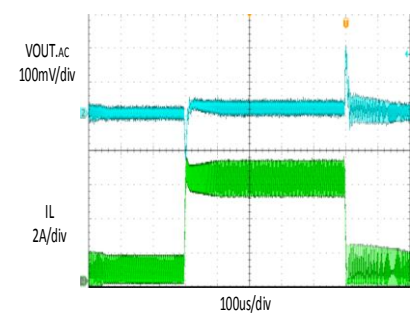
Short Circuit Recovery

VIN=12V, VOUT =3.3V
IOUT = Short-6A



Load Transient

0.6A LOAD \rightarrow 6A LOAD \rightarrow 0.6A LOAD



TYPICAL PERFORMANCE CHARACTERISTICS (PFM Mode)

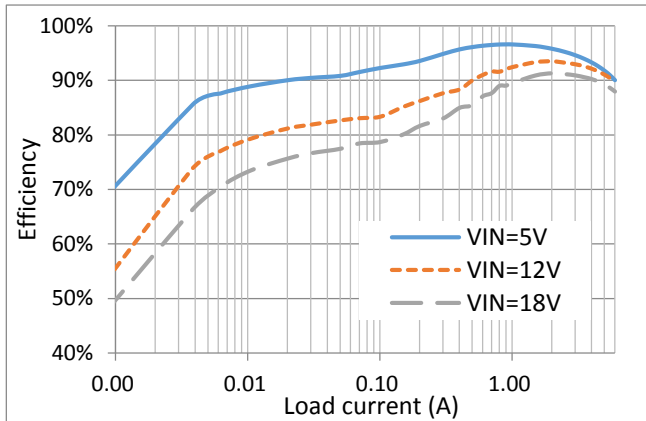


Figure 1. Efficiency vs Load Current
($V_{OUT}=3.3V$, $L=2.2\mu H$)

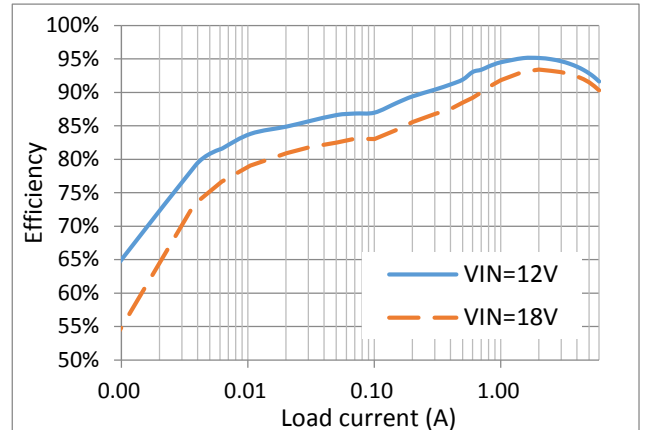


Figure 2. Efficiency vs Load Current
($V_{OUT}=5V$, $L=3.3\mu H$)

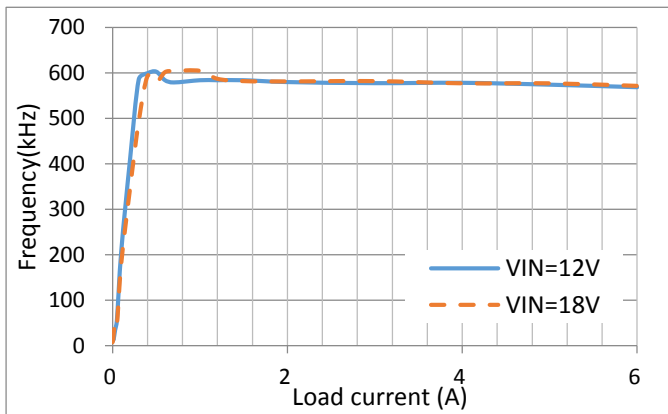


Figure 3. Frequency vs I_{OUT}
($V_{OUT}=3.3V$, $L=2.2\mu H$)

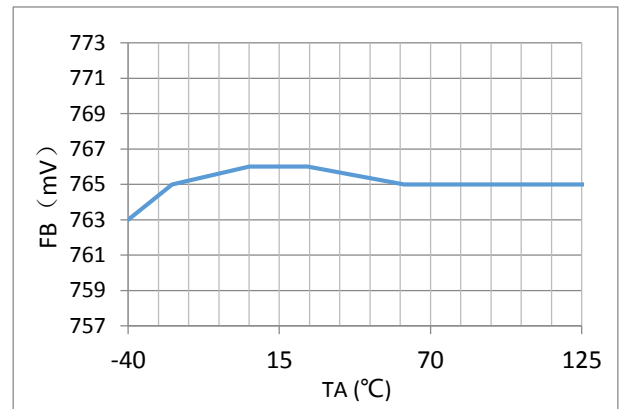


Figure 4. FB Voltage vs Ambient temperature

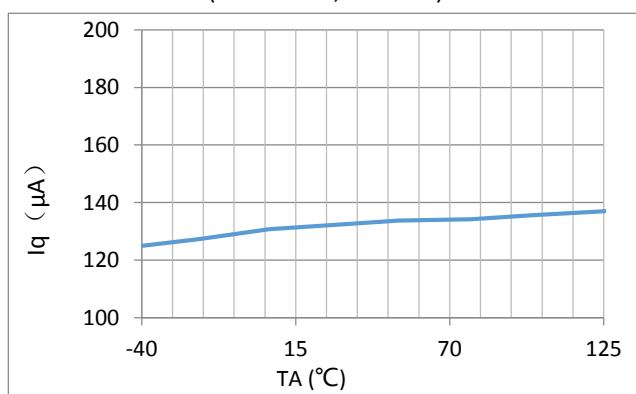


Figure 5. Quiescent Current vs Ambient temperature

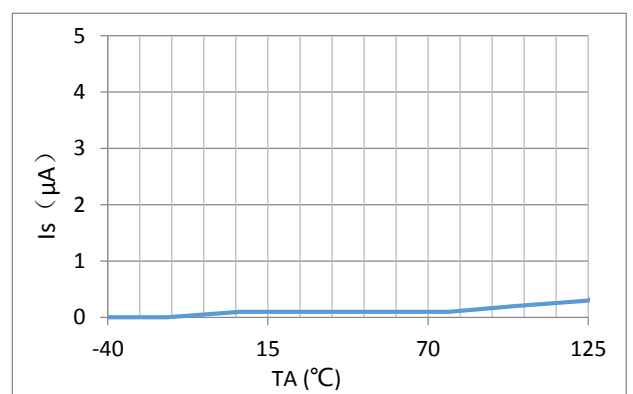


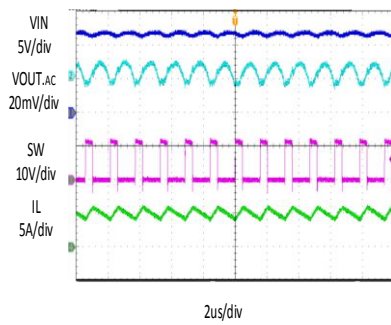
Figure 6. Shutdown Current vs Ambient temperature

TYPICAL PERFORMANCE CHARACTERISTICS (FCCM Mode)

VIN =12V, VOUT= 3.3V, L = 2.2 μ H, COUT= 44 μ F, Cff=51pF, TA = +25°C, unless otherwise noted

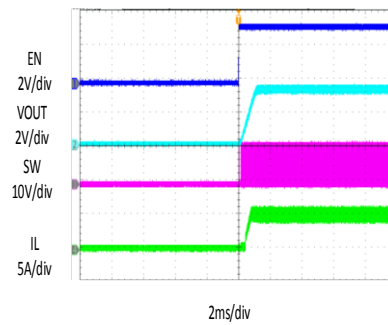
Steady State Test

VIN=12V, VOUT =3.3V
IOUT =6A



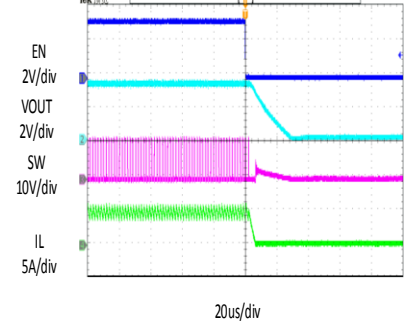
Startup through Enable

VIN=12V, VOUT=3.3V
IOUT =6A(Resistive load)



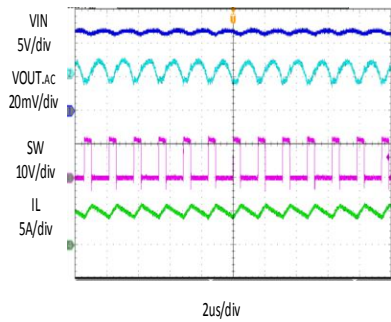
Shutdown through Enable

VIN=12V, VOUT =3.3V
IOUT=6A (Resistive load)



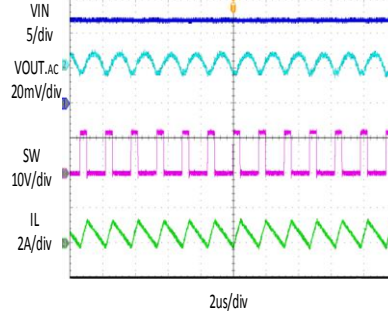
Heavy Load Operation

6A LOAD



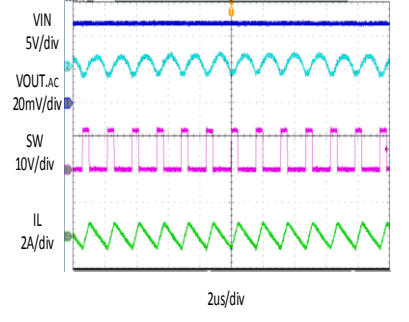
Medium Load Operation

0.6A LOAD



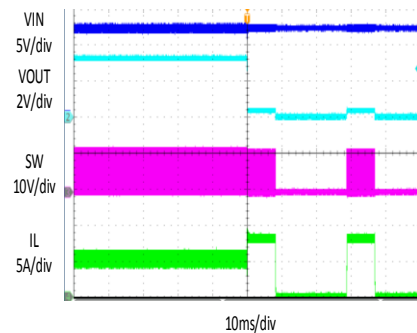
Light Load Operation

0 A LOAD



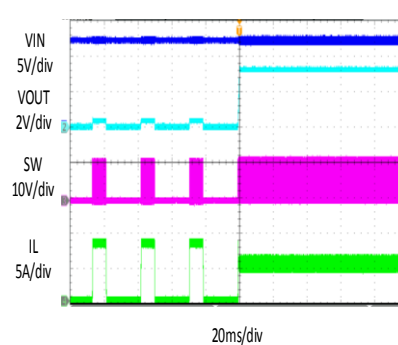
Short Circuit Protection

VIN=12V, VOUT =3.3V
IOUT =6A- Short



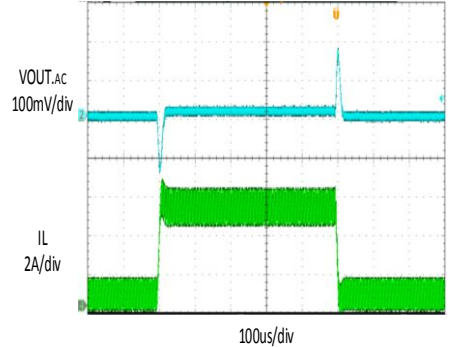
Short Circuit Recovery

VIN=12V, VOUT =3.3V
IOUT = Short-6A



Load Transient

0.5A LOAD → 5A LOAD → 0.5A LOAD



TYPICAL PERFORMANCE CHARACTERISTICS (FCCM Mode)

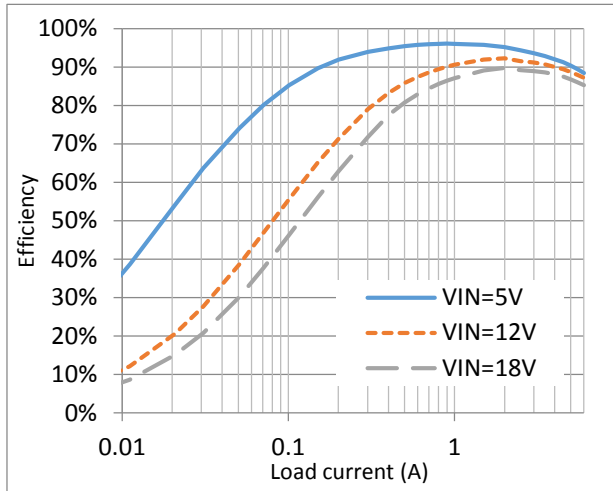


Figure 7. Efficiency vs Load Current
($V_{OUT}=3.3V$, $L=2.2\mu H$)

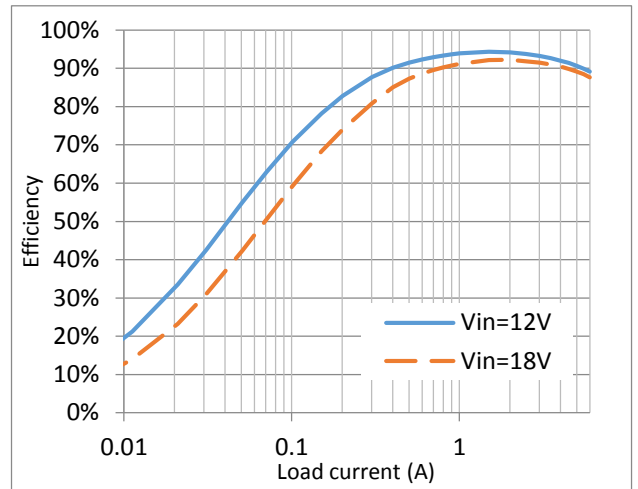


Figure 8. Efficiency vs Load Current
($V_{OUT}=5V$, $L=3.3\mu H$)

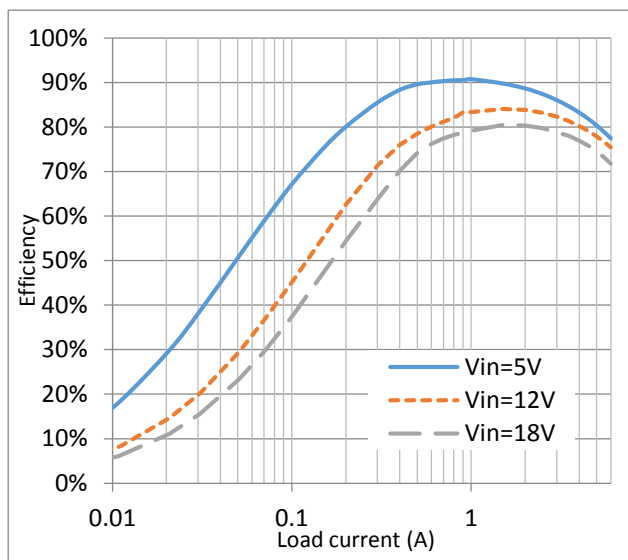


Figure 9. Efficiency vs Load Current
($V_{OUT}=1V$, $L=1\mu H$)

FUNCTIONAL DESCRIPTION

JW5306 and JW5306F are synchronous step-down regulators based on I2 control architecture. It regulates input voltages from 4.5V to 18V down to an output voltage as low as 0.765V, and is capable of supplying up to 6A of load current.

Shut-Down Mode

JW5306 and JW5306F shut down when voltage at EN pin is driven below 0.3V. The entire regulator is off and the supply current consumed by JW5306 or JW5306F drops below 1uA.

Power Switch

N-Channel MOSFET switches are integrated on the JW5306 and JW5306F 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 5V rail when SW is low.

PFM Mode/FCC Mode

Different operation mode at light load is design in JW5306 and JW5306F. PFM mode is integrated on JW5306 and FCCM mode is integrated on JW5306F. 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. In FCC mode, switch frequency keeps constant to prevent low frequency interference.

Internal Soft-start.

Soft-start makes output voltage rising smoothly follow an internal SS voltage until SS voltage is

higher than the internal reference voltage. It can prevent overshoot of output voltage when startup. The soft-start time is typically 0.86ms.

VIN Under-Voltage Protection

A resistive divider can be connected between Vin and ground, with the central tap connected to EN, so that when Vin drops to the pre-set value, EN drops below 1.1V to trigger input under voltage lockout protection.

Output Current Run-Away Protection

At start-up, due to the high voltage at input and low voltage at output, current inertia of the output inductor can be easily built up, resulting in a large start-up output current.

A valley current limit is designed in JW5306 and JW5306F so that only when output current drops below the valley current limit can the top power switch be turned on. By such control mechanism, the output current at start-up is well controlled.

Output Short Protection

When the output is shorted to ground, the regulator is allowed to switch for 7ms. If the short condition is cleared within this period, then the regulator resumes normal operation. If the short condition is still present after 7ms, then no switching is allowed and the regulator enters hiccup mode for 21ms. After the 21ms the regulator will try to start-up again. If the short condition still exists after 7ms, the regulator enters hiccup mode. This process of start-up and hiccup iterate itself until the short condition is removed.

Power Good

The power good function is activated after soft start has finished. When the output voltage

becomes within 90% of the target value, internal comparators detect power good state and the power good signal becomes high. The power good output, PG is an open drain output. If the FB voltage goes under 15% of the target value, the power good signal becomes low. When the output voltage goes higher than 24% of the target value, the power good signal becomes low.

The resistance value which is connected between PG and V_{OUT} is required from 15k Ω to

150k Ω .

If the JW5306F needs to use the PG function, it is not recommended to use a FB feedforward capacitor larger than the recommended parameters.

Thermal Protection

When the temperature of the device rises above 160°C, it is forced into thermal shut-down. Only when core temperature drops below 120°C can the regulator becomes active again.

APPLICATION INFORMATION

Output Voltage Set

The output voltage is determined by the resistor divider connected at the FB pin, and the voltage ratio is:

$$V_{FB} = V_{OUT} \cdot \frac{R_L}{R_L + R_H}$$

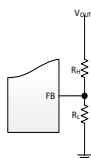
where V_{FB} is the feedback voltage and V_{OUT} is the output voltage.

Choose R_L around 16k Ω , and then R_H can be calculated by:

$$R_H = R_L \cdot \left(\frac{V_{OUT}}{0.765} - 1 \right)$$

The following table lists the recommended values.

VOUT(V)	R _L (k Ω)	R _H (k Ω)
1	22.1	6.8
1.2	28	16
1.5	16	15.4
2.5	20.5	46.4
3.3	22.1	73.2
5	22.1	124



Input Capacitor

The input capacitor is used to supply the AC input current to the step-down converter and maintaining the DC input voltage. Estimate the RMS current in the input capacitor with:

$$I_{CIN} = I_{OUT} \cdot \sqrt{\frac{V_{OUT}}{V_{IN}} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}} \right)}$$

where I_{OUT} is the load current, V_{OUT} is the output voltage, V_{IN} is the input voltage.

When using ceramic capacitors, make sure that they have enough capacitance to provide

sufficient charge to prevent excessive voltage ripple at the input. Thus the input capacitor can be calculated by the following equation when the input ripple voltage is determined.

$$C_{IN} = \frac{I_{OUT}}{f_s \cdot \Delta V_{IN}} \cdot \frac{V_{OUT}}{V_{IN}} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}} \right)$$

where C_{IN} is the input capacitance value, f_s is the switching frequency, ΔV_{IN} is the input ripple voltage.

The input capacitor can be electrolytic, tantalum or ceramic. To minimizing the potential noise, a small X5R or X7R ceramic capacitor, i.e. 0.1 μ F, should be placed as close to the IC as possible when using electrolytic capacitors.

2*10 μ F/25V~3*10 μ F/25V ceramic capacitor is recommended in typical application.

Output Capacitor

The output capacitor 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:

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

where C_{OUT} is the output capacitance value and R_{ESR} is the equivalent series resistance 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 output capacitors also affect the system stability and transient response, and a 44 μ F ceramic capacitor is recommended in typical application.

Inductor

The inductor is used to supply constant current to the output load, and the value determines the ripple current which affect the efficiency and the output voltage ripple. The ripple current is typically allowed to be 40% of the maximum switch current limit, thus the inductance value can be calculated by:

$$L = \frac{V_{OUT}}{f_s \cdot \Delta I_L} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}} \right)$$

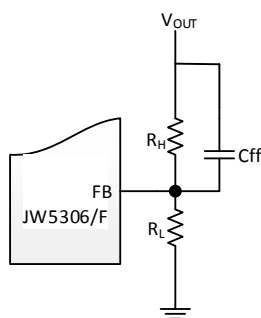
where V_{IN} is the input voltage, V_{OUT} is the output voltage, f_s is the switching frequency, and ΔI_L is the peak-to-peak inductor ripple current.

External Bootstrap Capacitor

A bootstrap capacitor is required to supply voltage to the top switch driver. A 0.1uF low ESR ceramic capacitor is recommended to be connected to the BST pin and SW pin.

Feedforward Capacitor

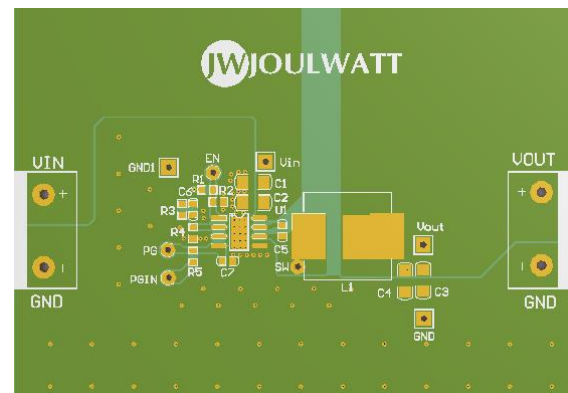
In order to improve the stability and the performance at load transient, a feedforward capacitor should be in parallel to the upper divider resistor. Choose C_{ff} around 51pF.



PCB Layout Note

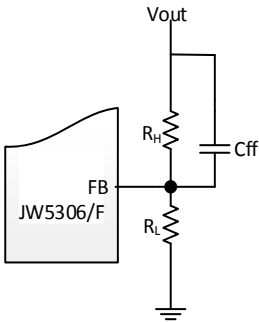
For minimum noise problem and best operating performance, the PCB is preferred to following the guidelines as reference.

1. Place the input decoupling capacitor as close to JW5306/F (VIN pin and PGND) 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 short as possible, and far away from the inductor and noisy power traces like SW node.
3. The ground plane on the PCB should be as large as possible for better heat dissipation.
4. Keep the switching node SW short to prevent excessive capacitive coupling
5. Make VIN, VOUT and ground bus connections as wide as possible. This reduces any voltage drops on the input or output paths of the converter and maximizes efficiency.



External Components Suggestion:

$V_{IN}(V)$	$V_{OUT}(V)$	$R_L(k\Omega)$	$R_H(k\Omega)$	$C_{ff}(pF)$	$L(uH)$	$C_{OUT}(uF)$
12	1	22.1	6.8	51	1	44~88
12	1.2	28	16	51	1	44~88
12	1.5	16	15.4	51	1	44~88
12	2.5	20.5	46.4	51	1.5	44
12	3.3	22.1	73.2	51	2.2	44
12	5	22.1	124	20	3.3	44



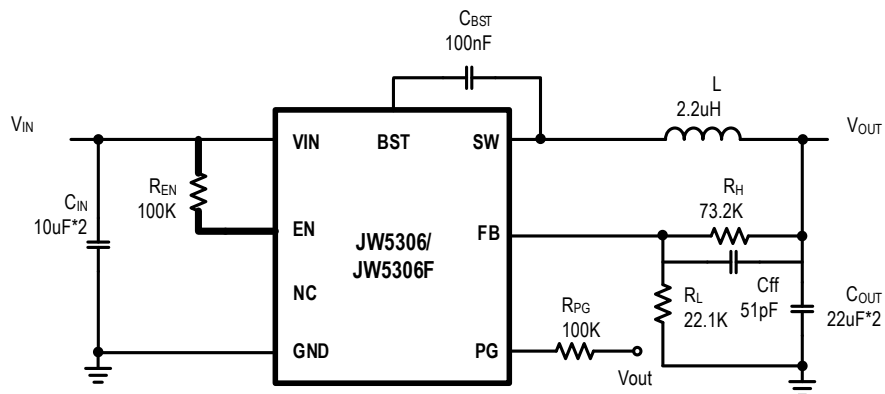
REFERENCE DESIGN

Reference 1:

V_{IN} : 12V

V_{OUT} : 3.3V

I_{OUT} : 0~6A

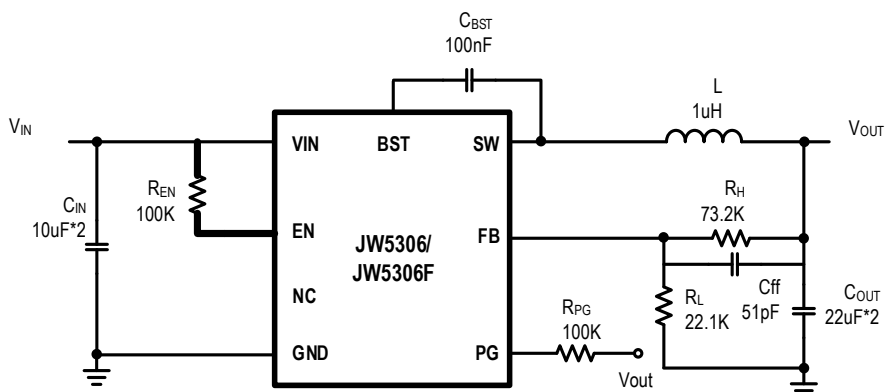


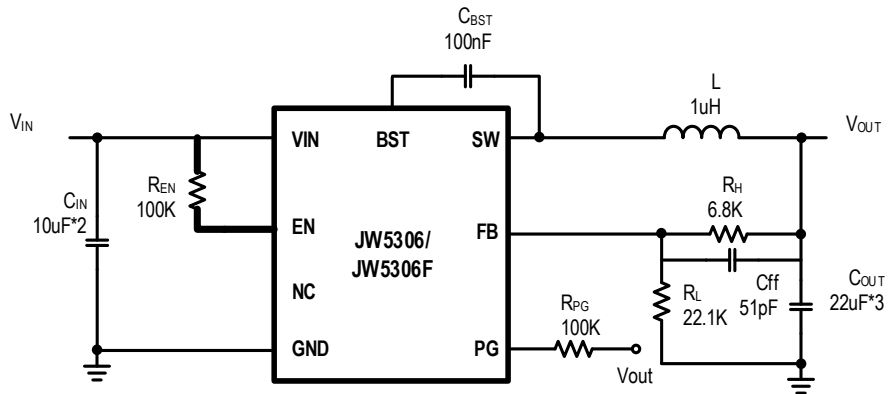
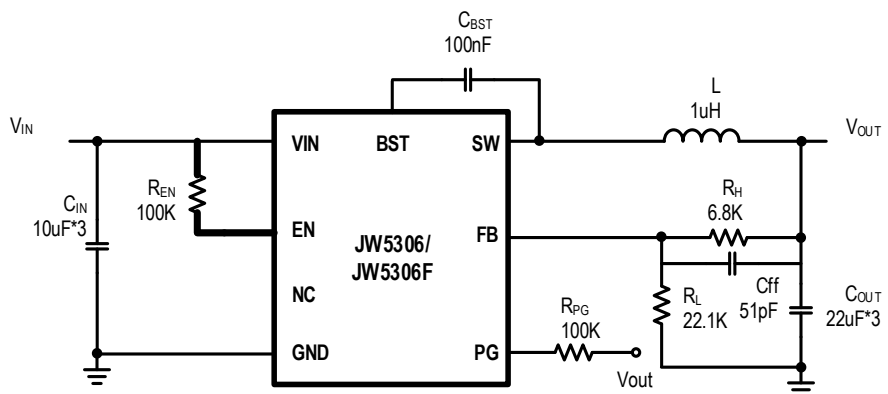
Reference 2:

V_{IN} : 5V

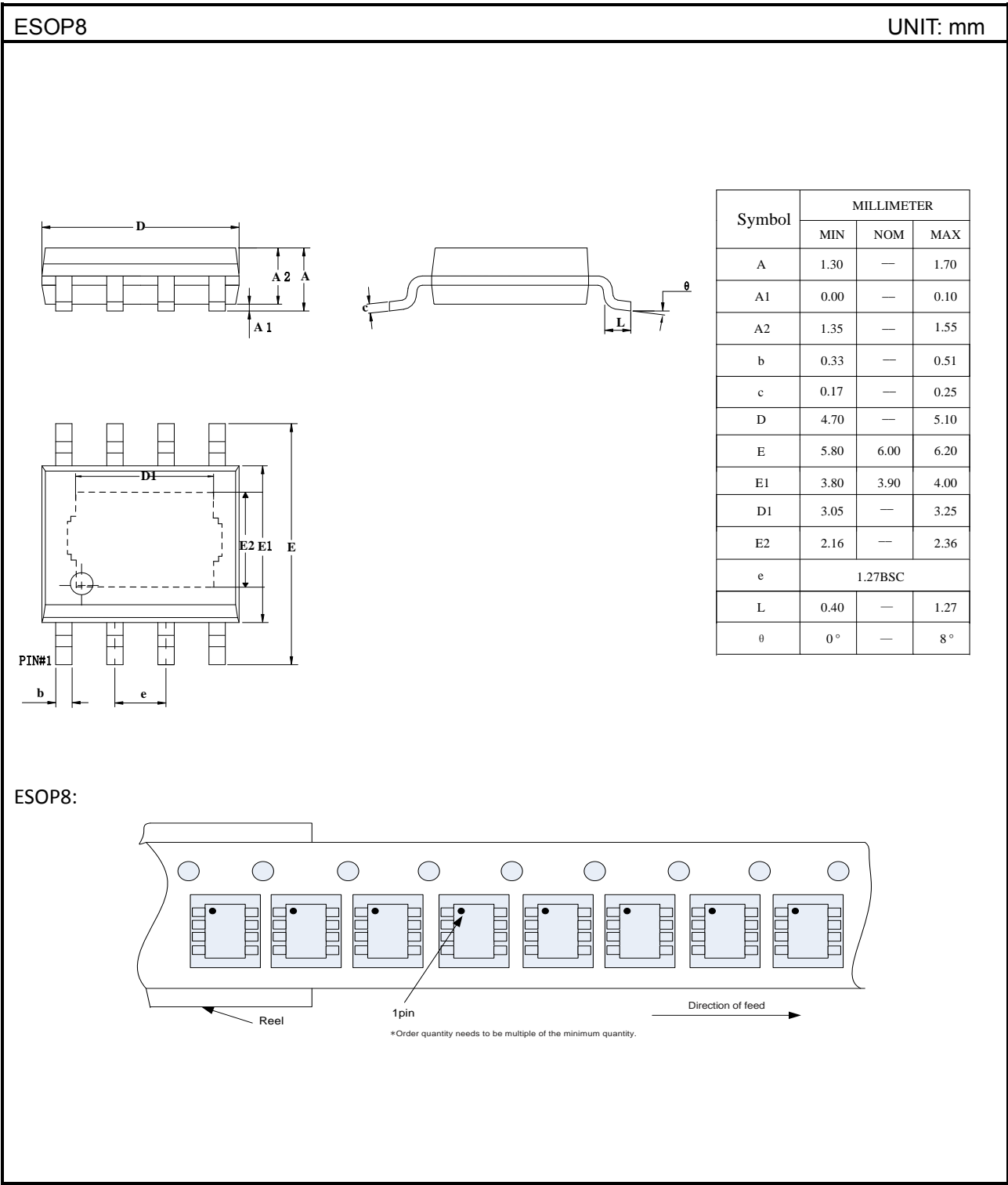
V_{OUT} : 3.3V

I_{OUT} : 0~6A



Reference 3:
 $V_{IN} : 12V$
 $V_{OUT} : 1V$
 $I_{OUT} : 0\sim6A$

Reference 4:
 $V_{IN} : 5V$
 $V_{OUT} : 1V$
 $I_{OUT} : 0\sim6A$


PACKAGE OUTLINE



IMPORTANT NOTICE

- Joulwatt Technology Inc. reserves the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein.
- Any unauthorized redistribution or copy of this document for any purpose is strictly forbidden.
- Joulwatt Technology Inc. does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel.

Copyright © 2021 JW5306/JW5306F Incorporated.

All rights are reserved by Joulwatt Technology Inc.