

Preliminary Specifications Subject to Change without Notice

DESCRIPTION

The JW[®]5056 and JW[®]5056F are monolithic buck switching regulators based on I2 architecture for fast transient response. Operating with an input range of 4.5V~18V, JW5056 and JW5056F deliver 5A 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.

JW5056 and JW5056F guarantee robustness with output short protection, thermal protection, current run-away protection, and input under voltage lockout.

JW5056 and JW5056F are available in TSOT23-6 package, which provide a compact solution with minimal external components.

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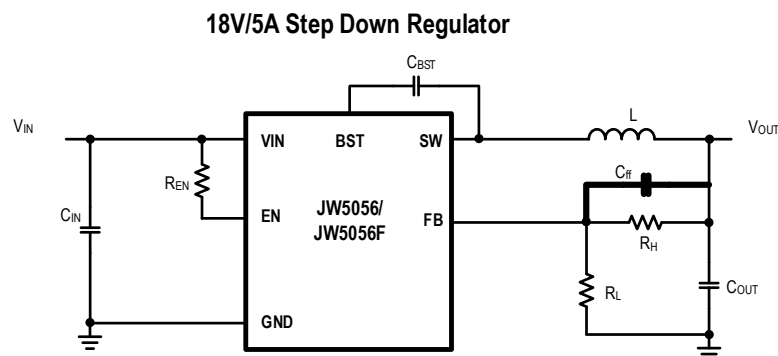
FEATURES

- 4.5V to 18V operating input range
- 5A output current
- 560kHz switching frequency
- 1% feedback voltage accuracy
- Internal soft-start
- PFM operation at light load (JW5056)
- FCCM operation at light load (JW5056F)
- Output short protection
- Thermal protection
- Available in TSOT23-6 package

APPLICATIONS

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

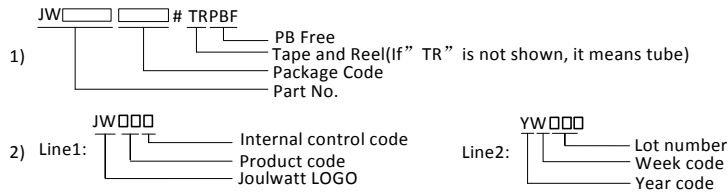
TYPICAL APPLICATION



ORDER INFORMATION

DEVICE ¹⁾	PACKAGE	TOP MARKING ²⁾
JW5056TSOTB#TRPBF	TSOT23-6	JWDB□ YW□□□
JW5056FTSOTB#TRPBF	TSOT23-6	JWDC□ YW□□□

Notes:

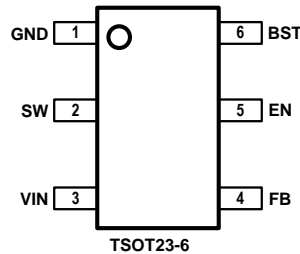


DEVICE INFORMATION

DEVICE	Operation Mode at light load	Function	Package
JW5056TSOTB#TRPBF	PFM	-	TSOT23-6
JW5056FTSOTB#TRPBF	FCCM	-	TSOT23-6

PIN CONFIGURATION

TOP VIEW



ABSOLUTE MAXIMUM RATING¹⁾

VIN, EN Pin.....	-0.3V to 20V
SW Pin	-0.3V(-6V for 10ns) to 20V(22V for 5ns)
BST Pin	SW-0.3V to SW+5V(5.8V for 10ns)
All other Pins	-0.3V to 6V
Junction Temperature ²⁾	150°C
Lead Temperature	260°C
Storage Temperature	-65°C to +150°C

RECOMMENDED OPERATING CONDITIONS³⁾

Input Voltage VIN	4.5V to 18V
Output Voltage V _{OUT}	0.76V to VIN-3V
Operating Junction Temperature	-40°C to 125°C

THERMAL PERFORMANCE⁴⁾

	θ_{JA}	θ_{JC}
TSOT23-6.....	110	55°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 JW5056 and JW5056F 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

<i>V_{IN}=12V, T_A=-40 °C~125 °C, Unless otherwise stated.</i>						
Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
V _{IN} Under Voltage Lock-out Threshold	V _{IN_MIN}	V _{IN} rising	4	4.2	4.45	V
V _{IN} Under voltage Lockout Hysteresis	V _{IN_MIN_HYST}			300		mV
Shutdown Current	I _{SD}	V _{EN} =0V			1	μA
Quiescent Current	I _Q	V _{EN} =5V, V _{FB} =1.2V		130	200	μA
Feedback Voltage	V _{FB}	4.5V ≤ V _{IN} ≤ 18V , T _A =25 °C	753	760	767	mV
		T _A = -40 to 125 °C				mV
Top Switch Resistance	R _{DS(ON)T}			25		mΩ
Bottom Switch Resistance	R _{DS(ON)B}			14		mΩ
Top Switch Leakage Current ⁵⁾	I _{LEAK_TOP}	V _{IN} =18V, V _{EN} =0V, V _{SW} =0V			1	μA
Bottom Switch Leakage Current ⁵⁾	I _{LEAK_BOT}	V _{IN} =18V, V _{EN} =0V, V _{SW} =18V			1	μA
Bottom Switch Current Limit	I _{LIM_BOT}		5	7	8.5	A
Negative Current Limit	I _{LIM_NEG}	JW5056F	-5.2	-3	-2.6	A
Minimum On Time ⁵⁾	T _{ON_MIN}			120		ns
Minimum Off Time ⁵⁾	T _{OFF_MIN}	V _{FB} =0.4V		200		ns
Switching Frequency	F _s		476	560	644	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
Soft-start Time ⁵⁾	t _{ss}	10%-90% V _{ref}		0.86		ms
Thermal Shutdown ⁵⁾	T _{TSD}			160		°C
Thermal Shutdown Hysteresis ⁵⁾	T _{TSD_HYST}			40		°C

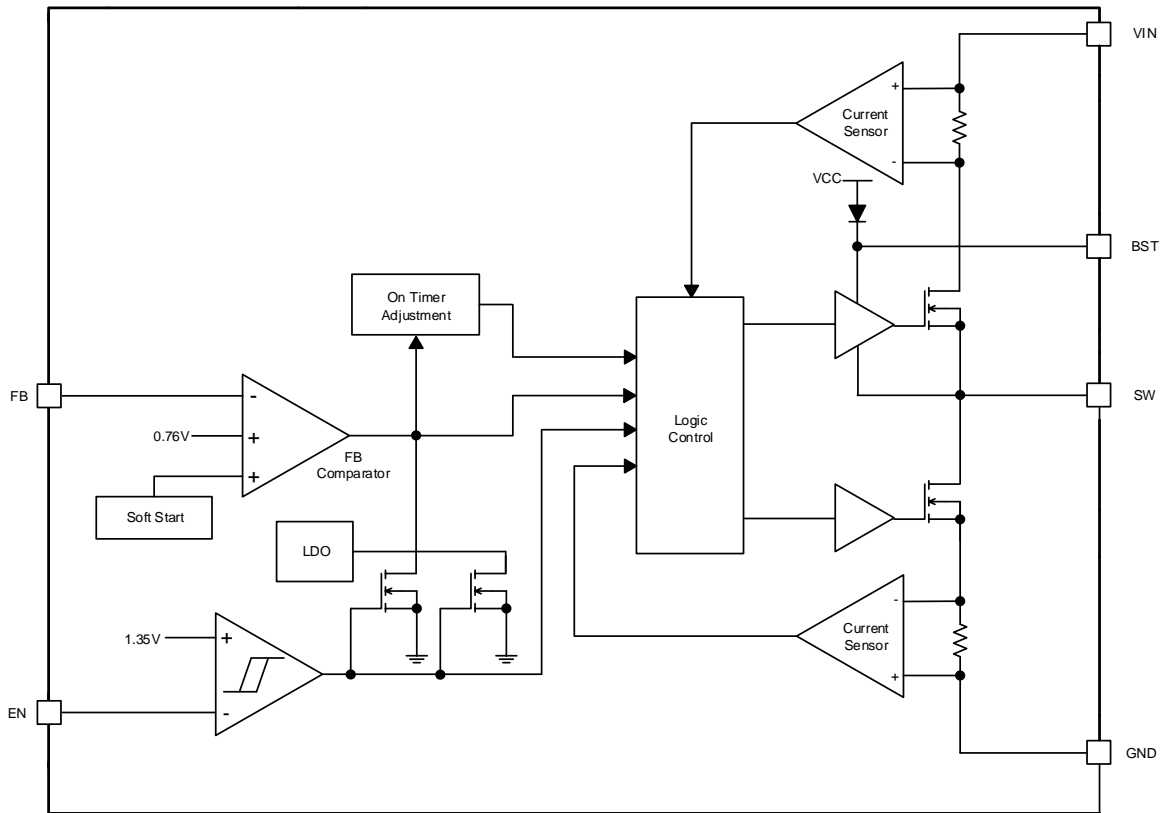
Note:

5) Guaranteed by design.

PIN DESCRIPTION

Pin TSOT23-6	Name	Description
1	GND	Power ground pin
2	SW	SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load.
3	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.
4	FB	Output feedback pin. FB senses the output voltage and is regulated by the control loop to 0.76V. Connect a resistive divider at FB.
5	EN	Drive EN pin high to turn on the regulator and low to turn off the regulator.
6	BST	Connect a 0.1uF capacitor between BST and SW pin to supply current for the top switch driver.

BLOCK DIAGRAM

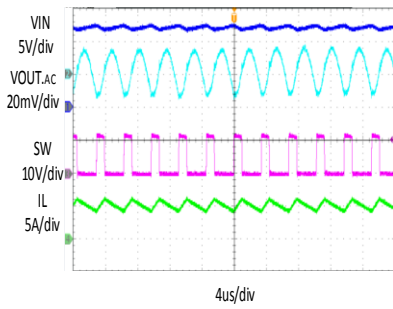


TYPICAL PERFORMANCE CHARACTERISTICS(PFM Mode)

$V_{IN} = 12V$, $V_{OUT} = 3.3V$, $L = 2.2\mu H$, $C_{OUT} = 44\mu F$, $C_{ff} = 51pF$, $T_A = +25^{\circ}C$, unless otherwise noted

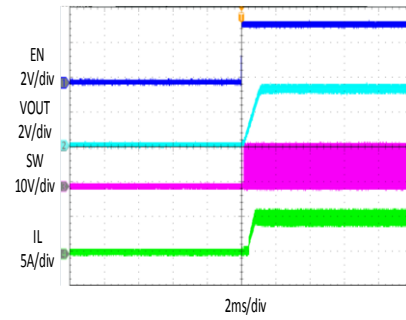
Steady State Test

$V_{IN} = 12V$, $V_{OUT} = 3.3V$
 $I_{OUT} = 5A$



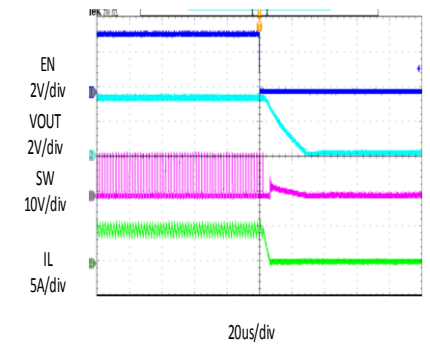
Startup through Enable

$V_{IN} = 12V$, $V_{OUT} = 3.3V$
 $I_{OUT} = 5A$ (Resistive load)



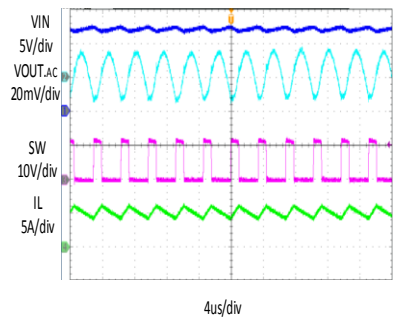
Shutdown through Enable

$V_{IN} = 12V$, $V_{OUT} = 3.3V$
 $I_{OUT} = 5A$ (Resistive load)



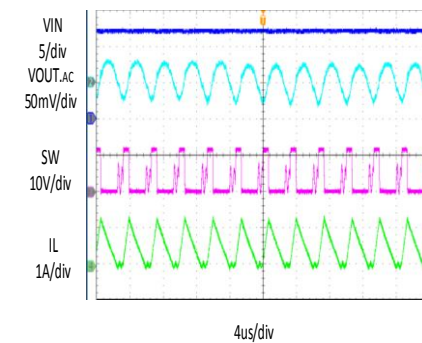
Heavy Load Operation

5A LOAD



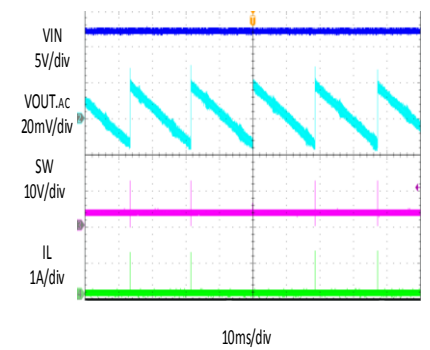
Medium Load Operation

0.5A LOAD



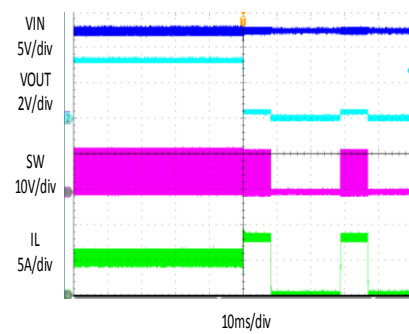
Light Load Operation

0 A LOAD



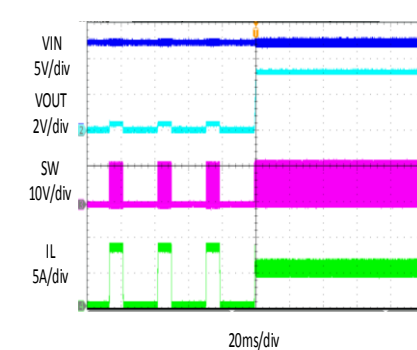
Short Circuit Protection

$V_{IN} = 12V$, $V_{OUT} = 3.3V$
 $I_{OUT} = 5A$ - Short



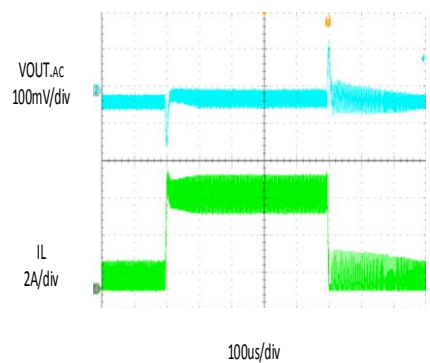
Short Circuit Recovery

$V_{IN} = 12V$, $V_{OUT} = 3.3V$
 $I_{OUT} = \text{Short} - 5A$



Load Transient

0.5A LOAD \rightarrow 5A LOAD \rightarrow 0.5A LOAD



TYPICAL PERFORMANCE CHARACTERISTICS (PFM Mode)

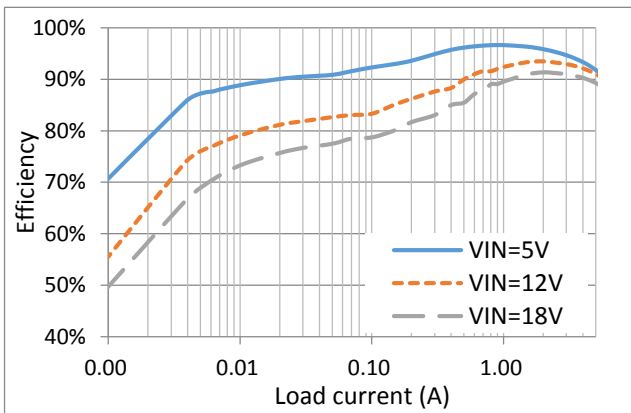


Figure 1. Efficiency vs IOUT
(VOUT = 3.3V, L = 2.2uH)

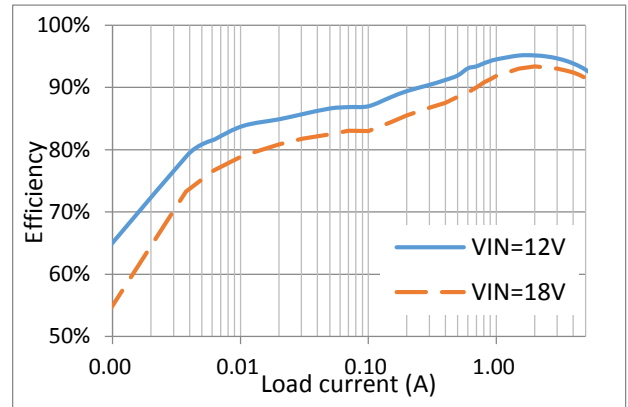


Figure 2. Efficiency vs IOUT
(VOUT = 5V, L = 3.3uH)

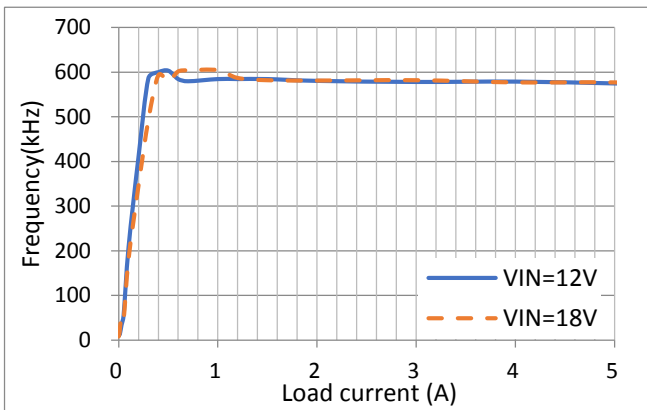


Figure 3. Frequency vs IOUT
(VOUT = 3.3V, L = 2.2uH)

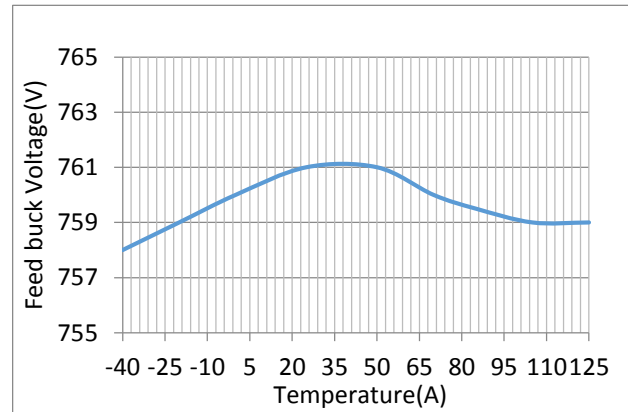


Figure 4. FB Voltage vs Ambient temperature

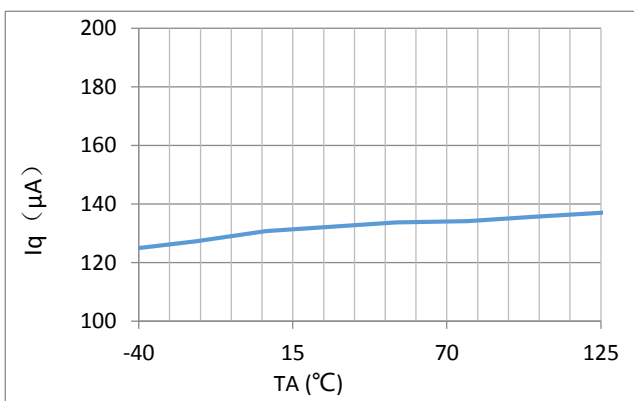


Figure 5. Quiescent Current vs Ambient temperature

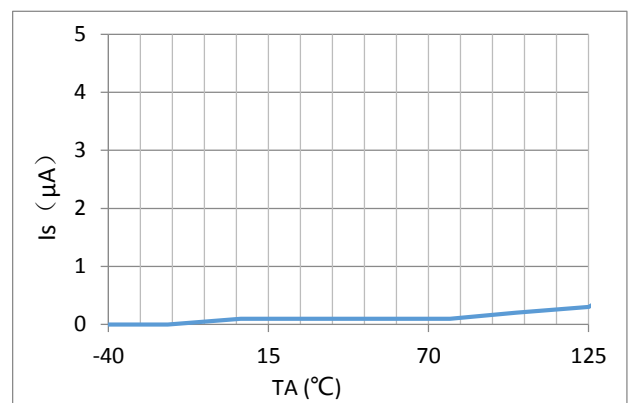


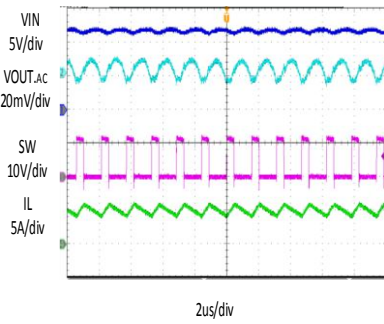
Figure 6. Shutdown Current vs Ambient temperature

TYPICAL PERFORMANCE CHARACTERISTICS (FCCM Mode)

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

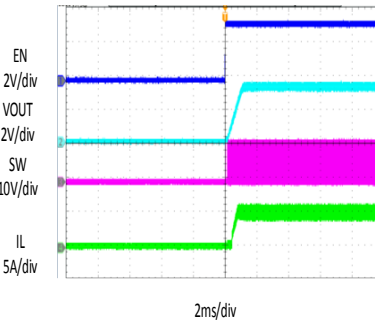
Steady State Test

VIN=12V, VOUT=3.3V
IOUT=5A



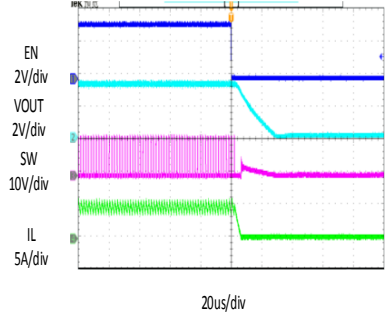
Startup through Enable

VIN=12V, VOUT=3.3V
IOUT=5A (Resistive load)



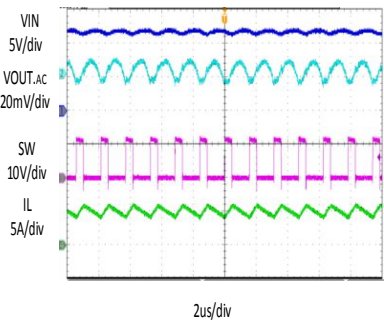
Shutdown through Enable

VIN=12V, VOUT=3.3V
IOUT=5A (Resistive load)



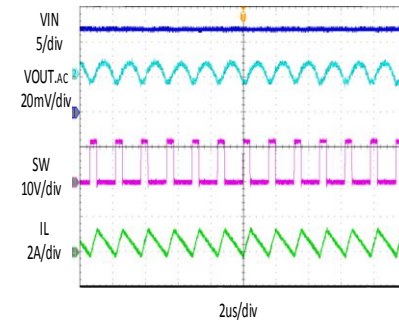
Heavy Load Operation

5A LOAD



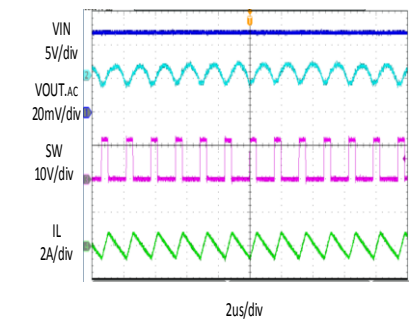
Medium Load Operation

0.5A LOAD



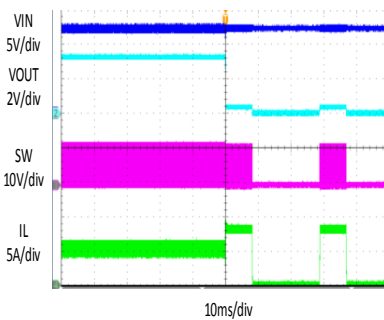
Light Load Operation

0 A LOAD



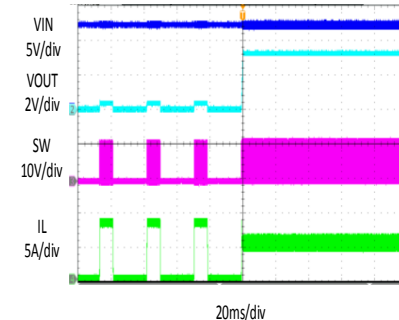
Short Circuit Protection

VIN=12V, VOUT=3.3V
IOUT =5A- Short



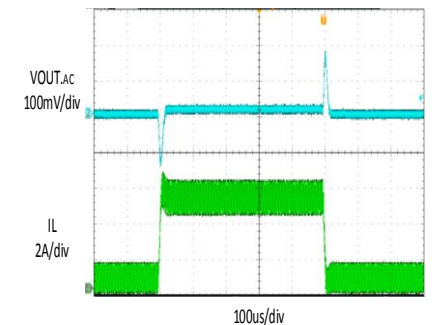
Short Circuit Recovery

VIN=12V, VOUT=3.3V
IOUT =5A- Short



Load Transient

0.5A LOAD → 5A LOAD → 0.5A LOAD



TYPICAL PERFORMANCE CHARACTERISTICS (FCCM Mode)

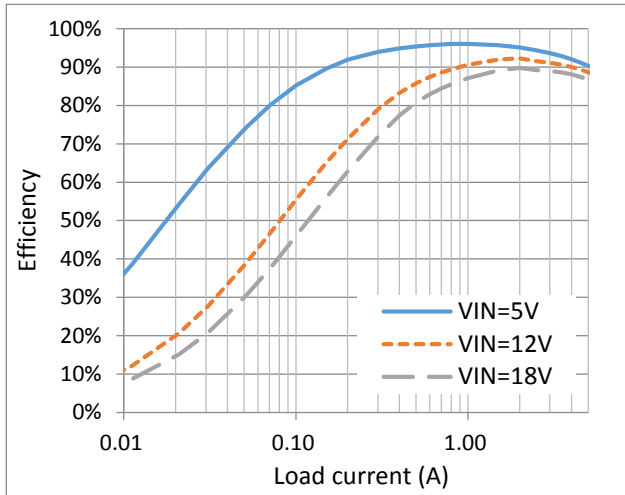


Figure 7. Efficiency vs Load Current
($V_{OUT}=3.3V$, $L=2.2\mu H$)

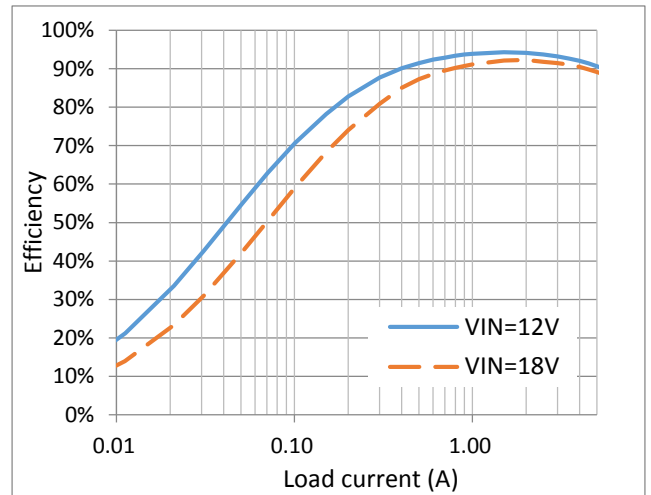


Figure 8. Efficiency vs Load Current
($V_{OUT}=5V$, $L=3.3\mu H$)

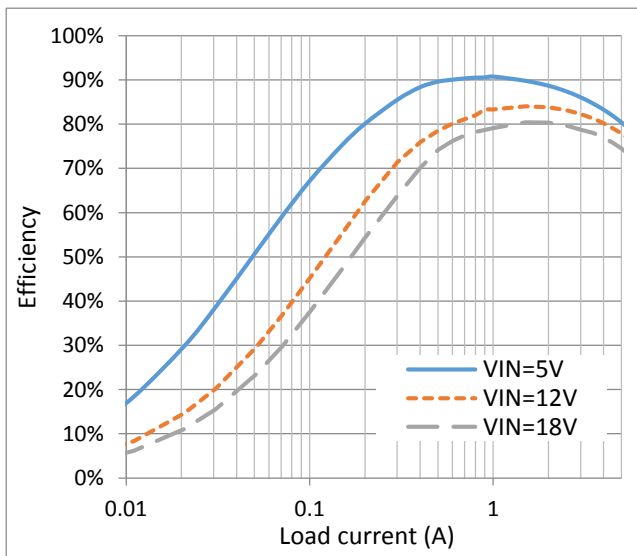


Figure 9. Efficiency vs Load Current
($V_{OUT}=1V$, $L=1\mu H$)

FUNCTIONAL DESCRIPTION

JW5056 and JW5056F 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 0.76V, and is capable of supplying up to 5A of load current.

Shut-Down Mode

JW5056 and JW5056F shut down when voltage at EN pin is driven below 0.3V. The entire regulator is off and the supply current consumed by JW5056 or JW5056F drops below 1uA.

Power Switch

N-Channel MOSFET switches are integrated on the JW5056 and JW5056F 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 JW5056 and JW5056F. PFM mode is integrated on JW5056 and FCCM mode is integrated on JW5056F. 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 V_{IN} and ground, with the central tap connected to EN, so that when V_{IN} 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 JW5056 and JW5056F 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.

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:

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

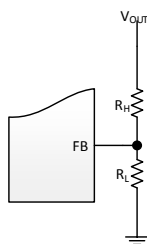
where V_{FB} is the feedback voltage and V_{OUT} is the output voltage.

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

$$R_H = R_L \cdot \left(\frac{V_{OUT}}{0.76} - 1 \right)$$

The following table lists the recommended values.

VOUT(V)	RL(kΩ)	RH(kΩ)
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.

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. 0.1uF, should be placed as close to the IC as possible when using electrolytic capacitors.

2*10uF/25V~3*10uF/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 44uF 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:

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

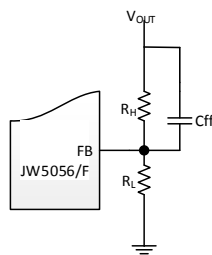
where V_{IN} is the input voltage, V_{OUT} is the output voltage, f_s is the switching frequency, and ΔI_L is the peak-to-peak inductor ripple current.

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 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 JW5056/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.

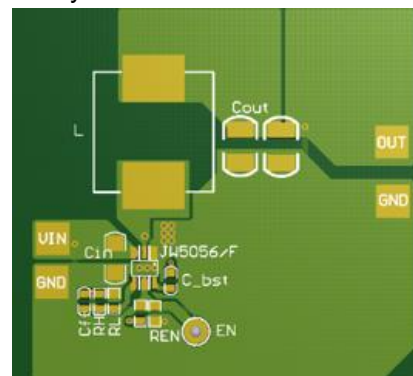
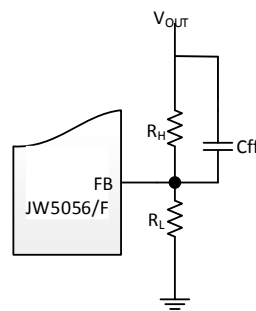


Figure 10. JW5056/F_TSOT23-6 PCB Layout Recommendation

External Components Suggestion:

Vin(V)	Vout(V)	R _L (kΩ)	R _H (kΩ)	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



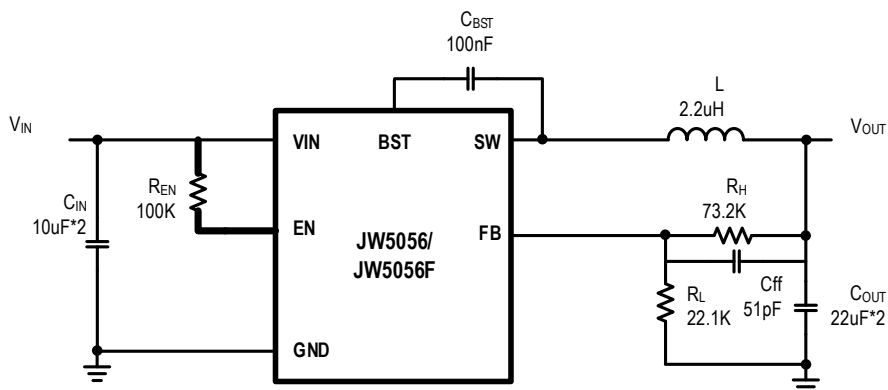
REFERENCE DESIGN

Reference 1:

V_{IN} : 12V

V_{OUT} : 3.3V

I_{OUT} : 0~5A

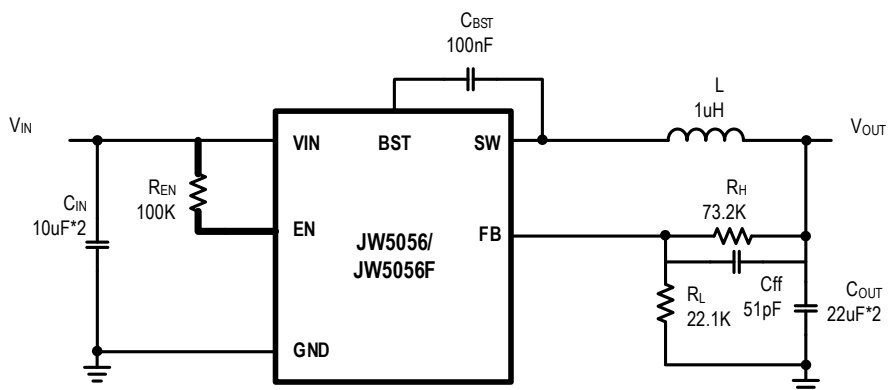


Reference 2:

V_{IN} : 5V

V_{OUT} : 3.3V

I_{OUT} : 0~5A

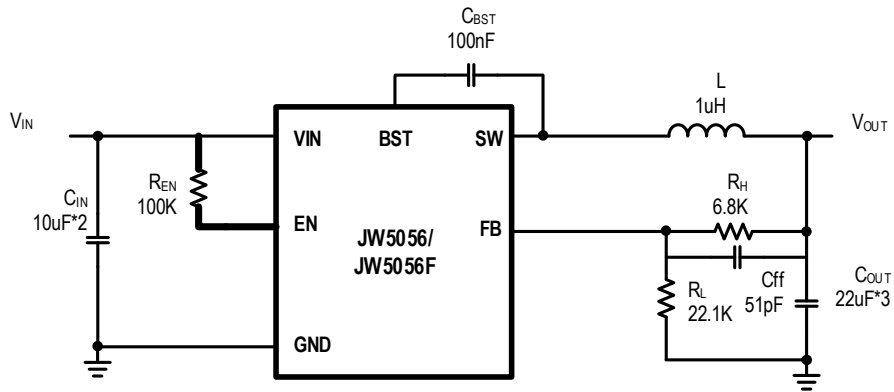


Reference 3:

V_{IN} : 12V

V_{OUT} : 1V

I_{OUT} : 0~5A

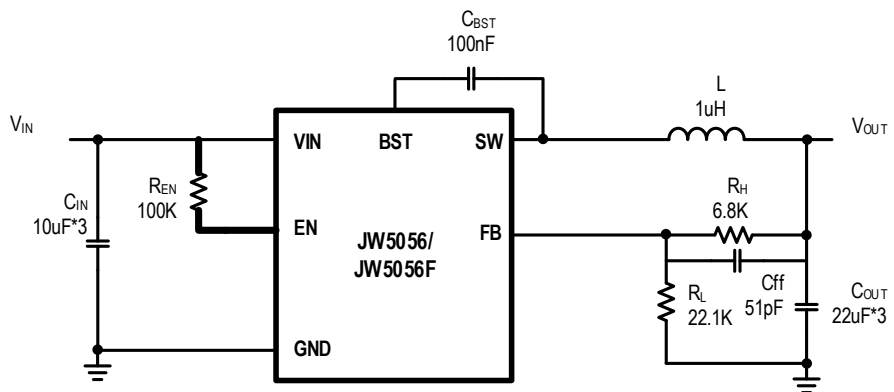


Reference 4:

V_{IN} : 5V

V_{OUT} : 1V

I_{OUT} : 0~5A



PACKAGE OUTLINE

TSOT23-6 UNIT: mm

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.10
A1	0	—	0.15
A2	0.55		1.00
b	0.30	0.40	0.50
c	0.08	0.15	0.30
D	2.70	2.90	3.10
E	2.60	2.80	3.00
E1	1.50	1.60	1.70
e	0.95 (BSC)		
L	0.30	0.45	0.60
θ	0°	—	10°

TSOT23-6:

Reel

1pin

Direction of feed

*Order quantity needs to be multiple of the minimum quantity.

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