JW5392/JW5392F

18V/2A

Sync. Step-Down Converter

DESCRIPTION

The JW5392 and JW5392F are monolithic buck switching regulators based on I2 architecture for fast transient response. Operating with an input range of 4.5V~18V, JW5392 and JW5392F deliver 2A 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. At light loads, JW5392 operates in low frequency to maintain high efficiency.

JW5392 and JW5392F guarantee robustness with output short protection, thermal protection, current run-away protection and input under voltage lockout.

JW5392 and JW5392F are available in SOT563 package, which provide a compact solution with minimal external components.

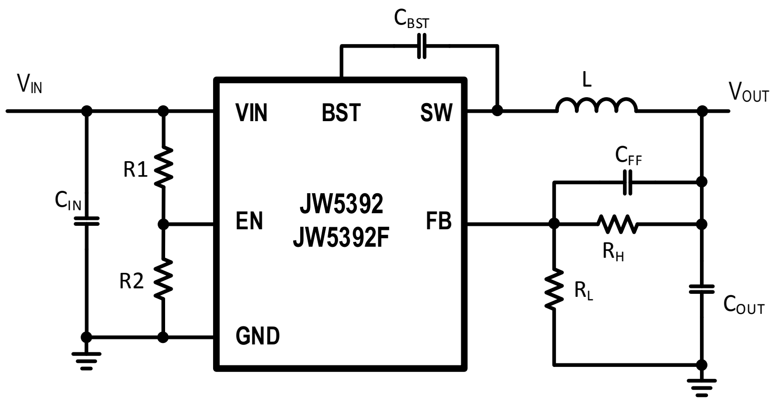
FEATURES

- 4.5V to 18V Operating Input Range
  2A Output Current
- Up to 95% Efficiency
- PFM Mode (JW5392) at Light Load
- FCC Mode (JW5392F) at Light Load
- 600kHz Switching Frequency
- Internal Soft-start
- Input Under Voltage Lockout
- Current Run-away Protection
- Output Short Protection
- Thermal Protection
- Available in SOT563 Package

APPLICATIONS

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

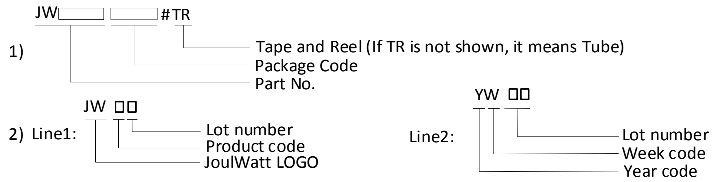
TYPICAL APPLICATION



ORDER INFORMATION

DEVICE[1)]	PACKAGE	TOP MARKING[2)]	ENVIRONMENTAL[3)]
JW5392SOTI#TR	SOT563	JWk□ YW□□	Green
JW5392FSOTI#TR	SOT563	JWm□ YW□□	Green

Notes:



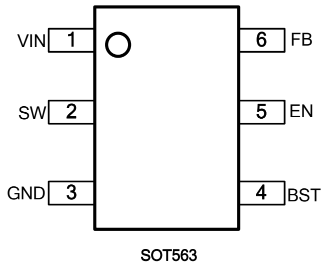
3) All JoulWatt products are packaged with Pb-free and Halogen-free materials and compliant to RoHS standards.

DEVICE INFORMATION

DEVICE	Operation Mode at light load	Function	Package
JW5392SOTI#TR	PFM	-	SOT563
JW5392FSOTI#TR	FCCM	-	SOT563

PIN CONFIGURATION

TOP VIEW



ABSOLUTE MAXIMUM RATING[1)]

VIN, EN Pin………... -0.3V to 20V
SW Pin………………………..…………………………………-0.3V(-5V for 10ns) to 20V(22V for 10ns)
BST Pin.. SW-0.3V to SW+4V (+4.8V for 10ns)
All other Pins .... -0.3V to 4V
Junction Temperature[2)] 150ºC
Lead Temperature 260ºC
Storage Temperature ....-65ºC to +150ºC

RECOMMENDED OPERATING CONDITIONS[3)]

Input Voltage V_{IN} ....4.5V to 18V
Output Voltage V_{OUT} ....0.8V to V_{IN}*Dmax
Operating Junction Temperature…………………………………………………………-40ºC to +125ºC

THERMAL PERFORMANCE[4)] θ_{JA} θ_{Jc}

SOT563...145…...45ºC/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 OPERATING CONDITIONS.

2) The JW5392 and JW5392F include 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

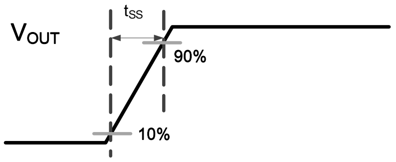
V_{IN}=12V, T_J=25°C, unless otherwise stated.

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
V_{IN} Under Voltage Lock-out Threshold	V_{IN_MIN}	V_{IN} rising	4.0	4.2	4.5	V
V_{IN} Under Voltage Lock-out Hysteresis	$V_{IN\_MIN\_HYST}$			300		mV
Shutdown Supply Current	I_{SD}	V_{EN}=0V			1	μA
Supply Current	I_Q	V_{EN}=5V, V_{FB}=1.2V		130	200	μA
Feedback Voltage	V_{FB}	4.5≤V_{VIN}≤18V	792	800	808	mV
		T_j=-40 ºC~125 ºC	784	800	816	mV
FB Leakage Current	I_{FB}	V_{FB}=0.85V			100	nA
Top Switch Resistance	$R_{DS(ON)T}$			85		mΩ
Bottom Switch Resistance	$R_{DS(ON)B}$			50		mΩ
Top Switch Leakage Current	I_{LEAK_TOP}	V_{IN}=18V, V_{EN}=0V, V_{SW}=0V			1	μA
Bottom Switch Leakage Current	I_{LEAK_BOT}	V_{IN}=18, V_{EN}=0V, V_{SW}=18V			4	μA
Bottom Switch Current Limit	I_{LIM_BOT}	JW5392	2.3	2.8	3.3	A
		JW5392F	1.85	2.5	3	A
Negative Current Limit	I_{LIM_NEG}	JW5392F	-1	-1.25	-1.5	A
Minimum On Time5)	T_{ON_MIN}			100		ns
Minimum Off Time	T_{OFF_MIN}	V_{FB}=0.4V		170		ns
Maximum On Time	T_{ON_Max}			4		us
EN Rising Threshold	V_{EN_H}	V_{EN} rising	1.1	1.2	1.3	V
EN Falling Threshold	V_{EN_L}	V_{EN} falling	0.98	1.05	1.12	V
Switching Frequency	F_{SW}		480	600	720	kHz
Soft-Start Period5)6)	t_{SS}		1	1.4	2	ms
Thermal Shutdown5)	T_{TSD}			160		°C
Thermal Shutdown Hysteresis5)	T_{TSD_HYST}			20		°C

Notes：

5) Guaranteed by design.

6) Soft-Start Period is tested from 10% to 90% of the steady state output voltage.

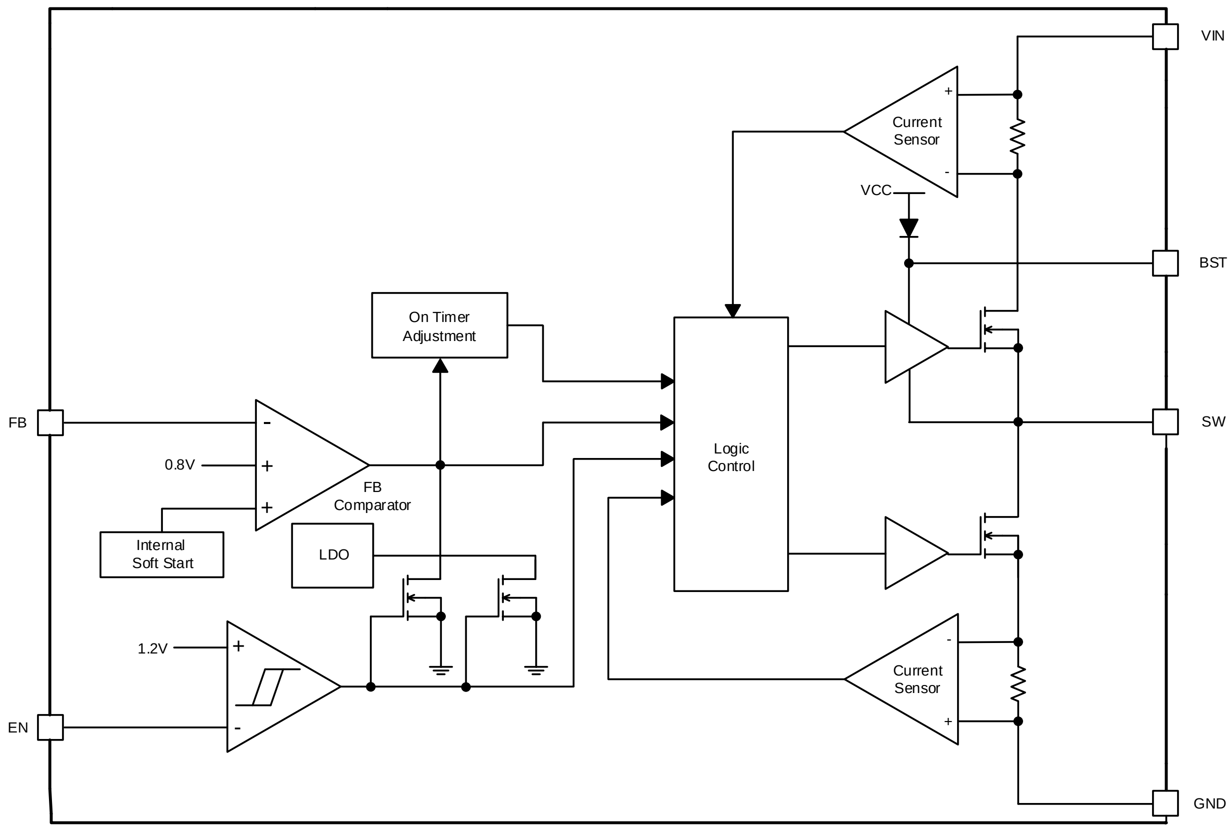


t_{SS} Waveform

PIN DESCRIPTION

SOT563	Name	Description
1	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.
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	GND	Ground pin.
4	BST	Connect a 0.1μF capacitor between BST and SW pin to supply current for the top switch driver.
5	EN	Drive EN pin high to turn on the regulator and low to turn off the regulator.
6	FB	Output feedback pin. FB senses the output voltage and is regulated by the control loop to 0.8 V. Connect a resistive divider at FB.

BLOCK DIAGRAM



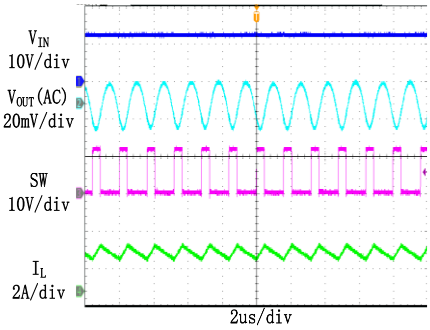
TYPICAL PERFORMANCE CHARACTERISTICS (JW5392)

V_{IN} =12V, V_{OUT} = 3.3V, L = 4.7µH, C_{OUT} = 22µF, C_{FF}=22pF, TA = +25°C, unless otherwise noted

Steady State Test

V_{IN}=12V, V_{OUT}=3.3V

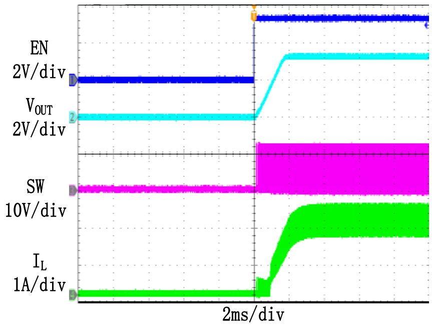
I_{OUT}=2A



Startup through Enable

V_{IN}=12V, V_{OUT}=3.3V

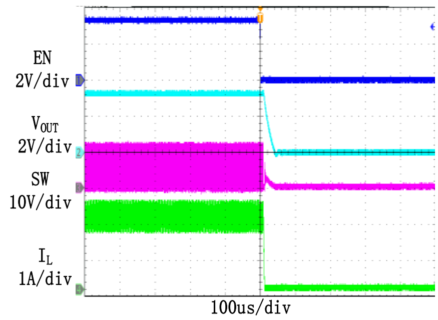
I_{OUT}=2A (Resistive load)



Shutdown through Enable

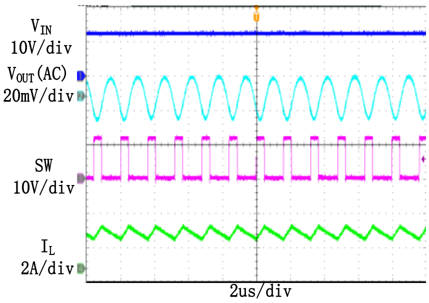
V_{IN}=12V, V_{OUT}=3.3V

I_{OUT}=2A (Resistive load)



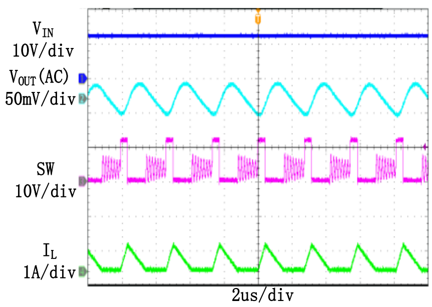
Heavy Load Operation

2A LOAD



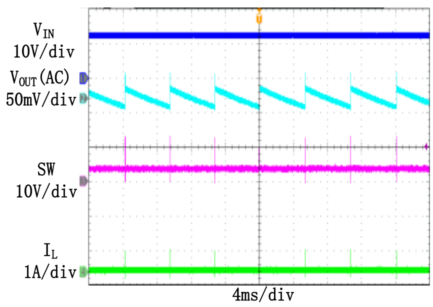
Medium Load Operation

0.2A LOAD



Light Load Operation

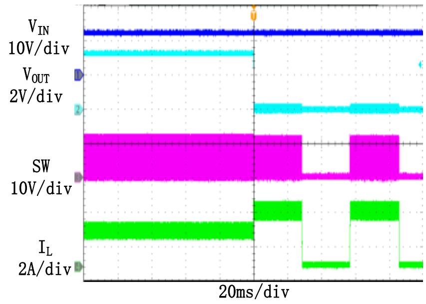
0 A LOAD



Short Circuit Protection

V_{IN}=12V, V_{OUT}=3.3V

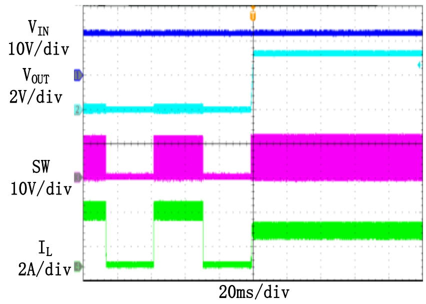
I_{OUT}=2A- Short



Short Circuit Recovery

V_{IN}=12V, V_{OUT}=3.3V

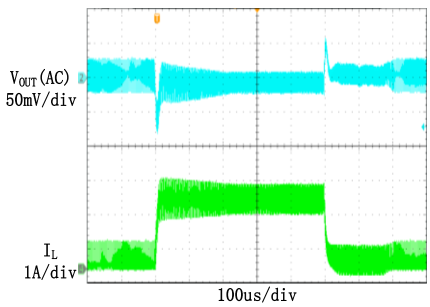
I_{OUT}= Short-2A



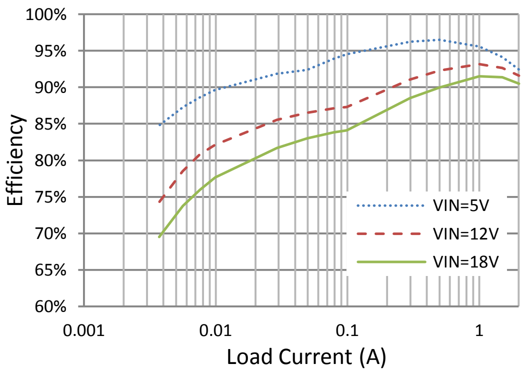
Load Transient

C_{FF}=47pF

0.2A LOAD → 2A LOAD → 0.2A LOAD

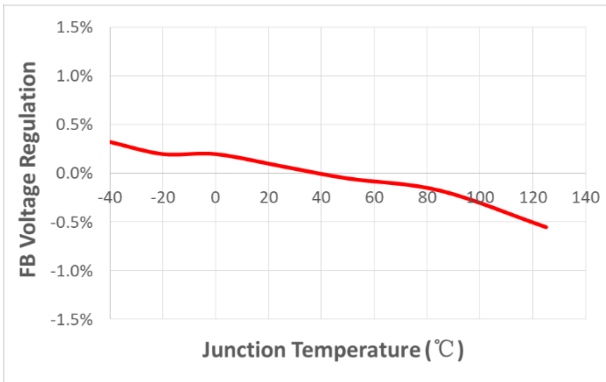


TYPICAL PERFORMANCE CHARACTERISTICS (JW5392)

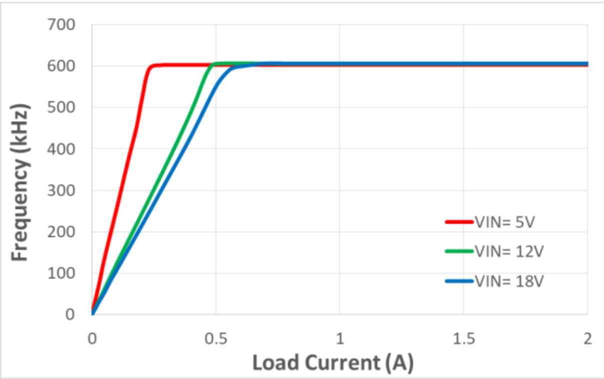


Efficiency vs. Load Current

(V_{OUT}=3.3V, L=4.7μH)

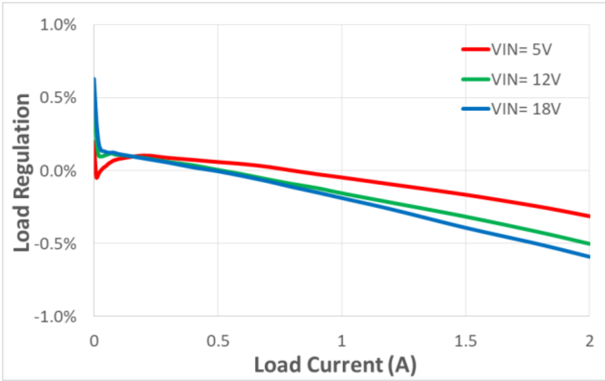


FB Voltage Regulation vs Junction Temperature



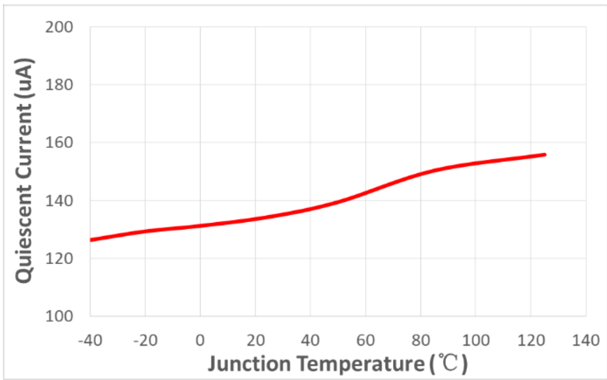
Frequency vs Load Current

(V_{OUT}=3.3V, L=4.7μH)

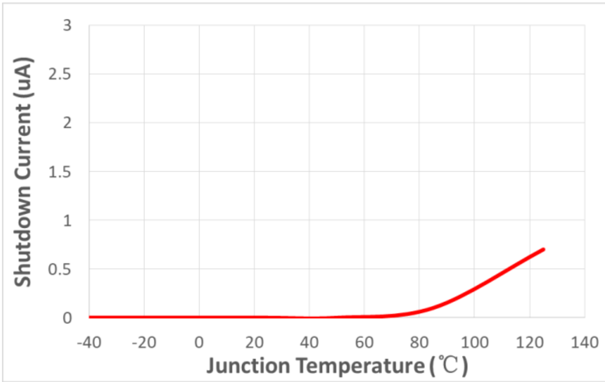


Load Regulation vs Load Current

(V_{OUT}=3.3V, L=4.7μH)



Supply Current vs Junction Temperature



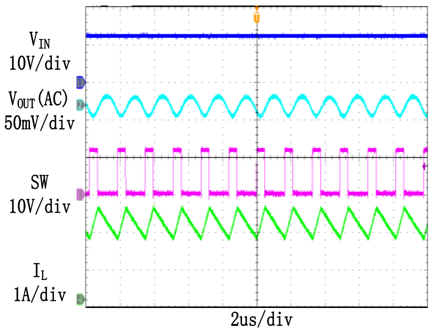
Shutdown Current vs Junction Temperature

TYPICAL PERFORMANCE CHARACTERISTICS (JW5392F)

V_{IN} =12V, V_{OUT} = 3.3V, L = 4.7μH, C_{OUT} = 22μF, C_{FF}=22pF, TA = +25°C, unless otherwise noted

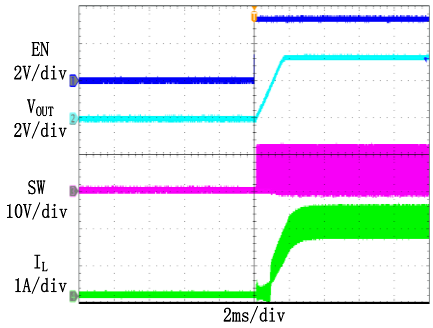
Steady State Test

V_{IN}=12V, V_{OUT}=3.3V
I_{OUT}=2A



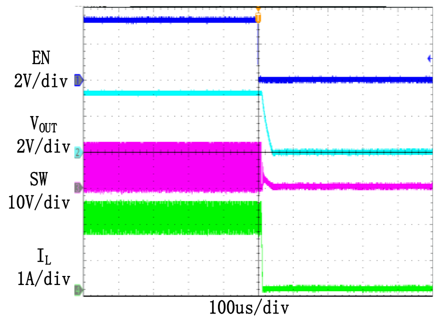
Startup through Enable

V_{IN}=12V, V_{OUT}=3.3V
I_{OUT}=2A (Resistive load)



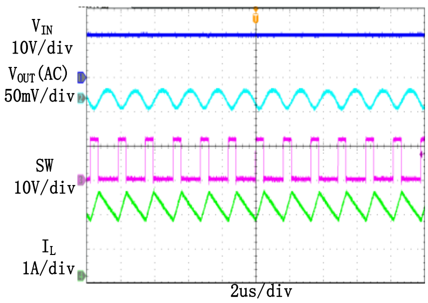
Shutdown through Enable

V_{IN}=12V, V_{OUT}=3.3V
I_{OUT}=2A (Resistive load)



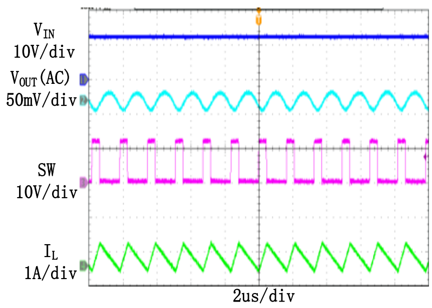
Heavy Load Operation

2A LOAD



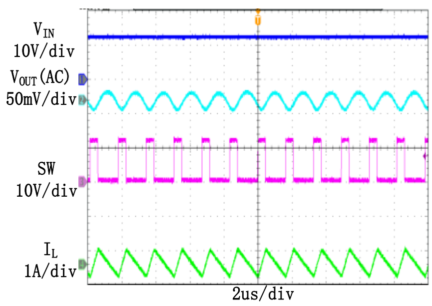
Medium Load Operation

0.2A LOAD



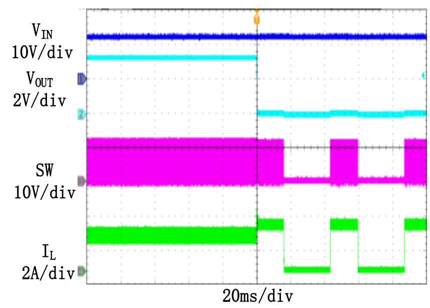
Light Load Operation

0 A LOAD



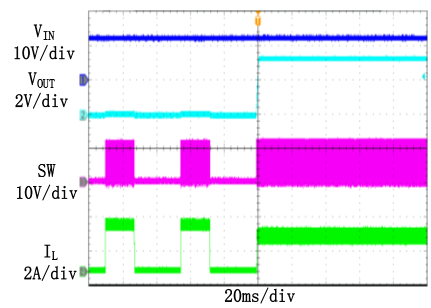
Short Circuit Protection

V_{IN}=12V, V_{OUT}=3.3V
I_{OUT}=2A- Short



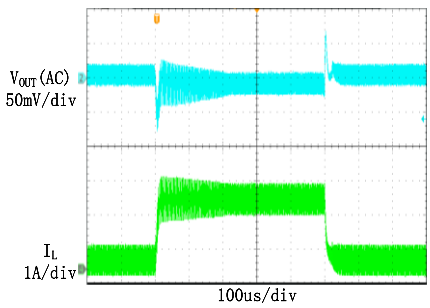
Short Circuit Recovery

V_{IN}=12V, V_{OUT}=3.3V
I_{OUT}= Short-2A

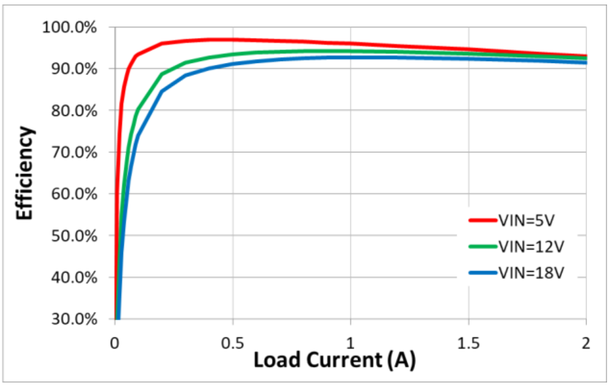


Load Transient

C_{FF}=47pF
0.2A LOAD → 2A LOAD → 0.2A LOAD

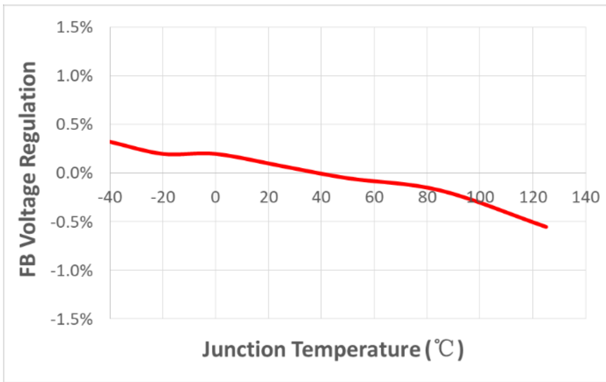


TYPICAL PERFORMANCE CHARACTERISTICS (JW5392F)

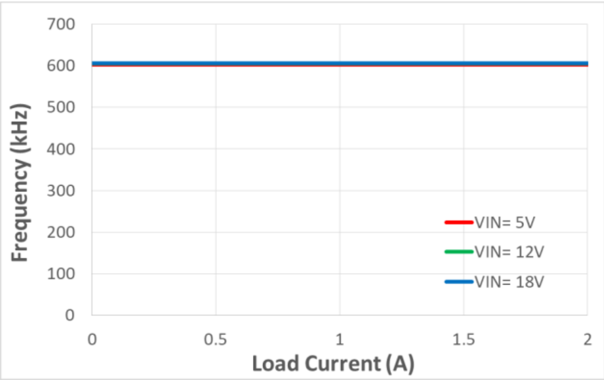


Efficiency vs. Load Current

(V_{OUT}=3.3V, L=4.7μH)

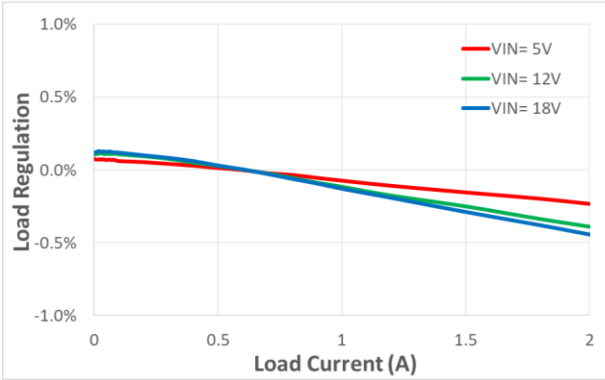


FB Voltage Regulation vs Junction Temperature



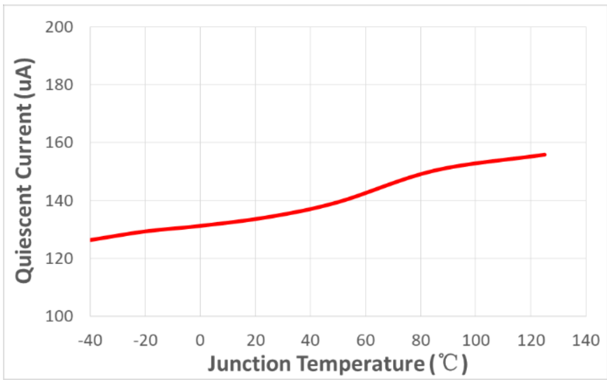
Frequency vs Load Current

(V_{OUT}=3.3V, L=4.7μH)

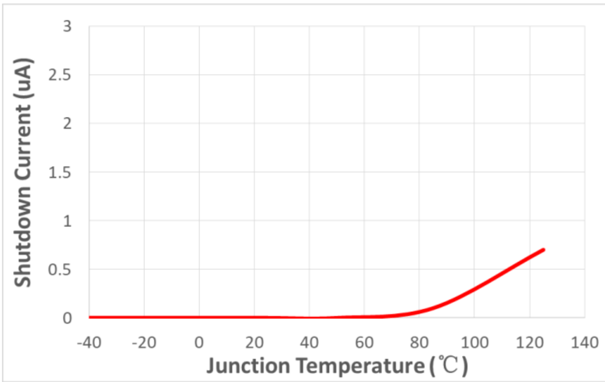


Load Regulation vs Load Current

(V_{OUT}=3.3V, L=4.7μH)



Supply Current vs Junction Temperature



Shutdown Current vs Junction Temperature

FUNCTIONAL DESCRIPTION

JW5392 and JW5392F 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 0.8V, and is capable of supplying up to 2A of load current.

Shut-Down Mode

The regulator shuts down when voltage at EN pin is driven below 0.4V. The entire regulator is off and the supply current consumed by the regulator drops below 1μA.

Power Switch

N-Channel MOSFET switches are integrated on the JW5392 and JW5392F 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 3.3V rail when SW is low.

CCM Operation

Continuous conduction mode (CCM) occurs when the output current is high, and the inductor current is always above zero amps.
JW5392F is configured to operate in forced CCM operation (FCCM) when the output current is low. In FCCM operation, the switching frequency is fairly constant; hence the output ripple keeps almost the same throughout the whole load range.

PFM Operation

At light load condition, JW5392 is configured to work in PFM mode to optimize the efficiency. When the load decreases, the inductor current will decrease as well. Once the inductor current reaches zero, the part transitions from CCM to PFM mode.
In PFM operation, the high side MOSFET is turned off by the peak current reference and the low side MOSFET turns on until the inductor current reaches zero. At this time, the output voltage is still higher than the target value which causes the internal COMP voltage lower than a clamp value, and the high side MOSFET is not allowed to turn on until the COMP voltage rises above its clamp voltage.

V_{IN} 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 1.05V 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 JW5392 and JW5392F 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 2048 cycles. If the short condition is cleared within this period, then the regulator resumes normal operation. If the short condition is still present after 2048 switching cycles, then no switching is allowed and the regulator enters hiccup mode for 6144 cycles. After the 6144 hiccup cycles, the regulator will try to start-up again. If the short condition still exists after 2048 cycles of switching, 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 regulator rises above 160°C, it is forced into thermal shut-down. Only when core temperature drops below 140°C can the regulator become active again.

APPLICATION INFORMATION

Output Voltage Set

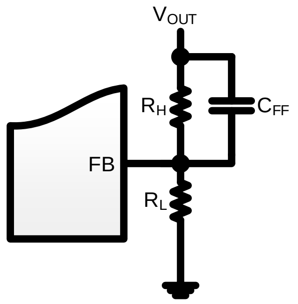
The output voltage is determined by the resistor divider connected at the FB pin, and the voltage ratio is:

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

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

If R_L is determined, and then R_H can be calculated by:

$$R_H = R_L * \left(\frac{V_{OUT}}{0.8} - 1\right)$$



Feedforward Capacitor

In order to ensure stability, a feedforward capacitor C_{FF} about dozens of picofarads is needed to be in parallel with R_H.

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:

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

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.

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

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

A 22μF/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:

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

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 22μF~44μF 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, and It should be no less than 20% of the maximum current limit. Thus the inductance value can be calculated by:

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

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

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

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 JW5392/JW5392F (VIN pin and GND pin) 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 V_{IN}, V_{OUT} 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.

SOT563:

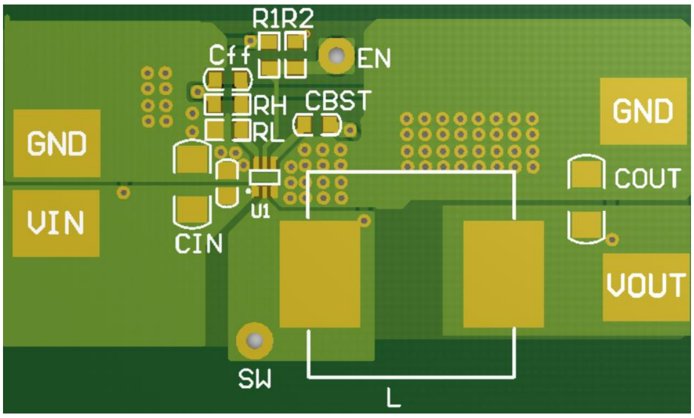


Figure 1. PCB Layout Recommendation

REFERENCE DESIGN

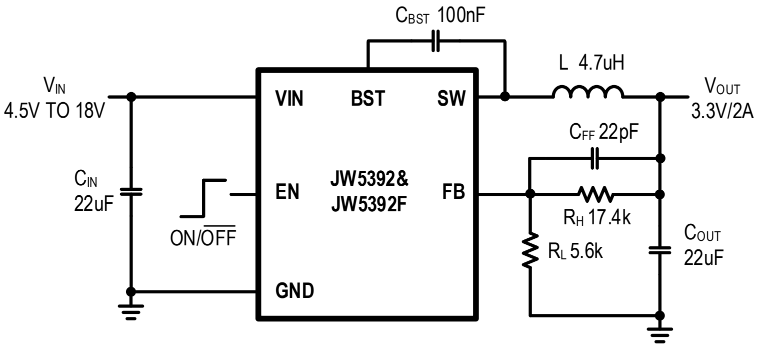
Note: Information in the following reference design sections is not part of JoulWatt component specification. Customers are responsible for determining suitability of components chosen for their purposes and should validate their design implementation to make sure the proper system functionality.

Reference:

V_{IN}: 4.5V~18V

V_{OUT}: 3.3V

I_{LOAD}: 0~2A



External Components Suggestion (V_{IN}=12V):

V_{OUT}(V)	R_L (kΩ)	R_H (kΩ)	C_{FF} (pF)	L (μH)	C_{OUT_NOM} (μF)	C_{OUT_EFF} (μF)
0.8	NC	10	47	1.5	44	30
1.2	20	10	47	2.2	44	30
1.5	11.2	10	33	2.2	44	30
1.8	8.2	10.2	22	3.3	32	20
2.5	4.7	10	22	4.7	22	10
3.3	5.6	17.4	22	4.7	22	10
5	3.92	20.5	22	6.8	22	10

Notes:

1) In order to ensure stability, a feedforward capacitor C_{FF} about dozens of picofarads is needed to be in parallel with R_H.

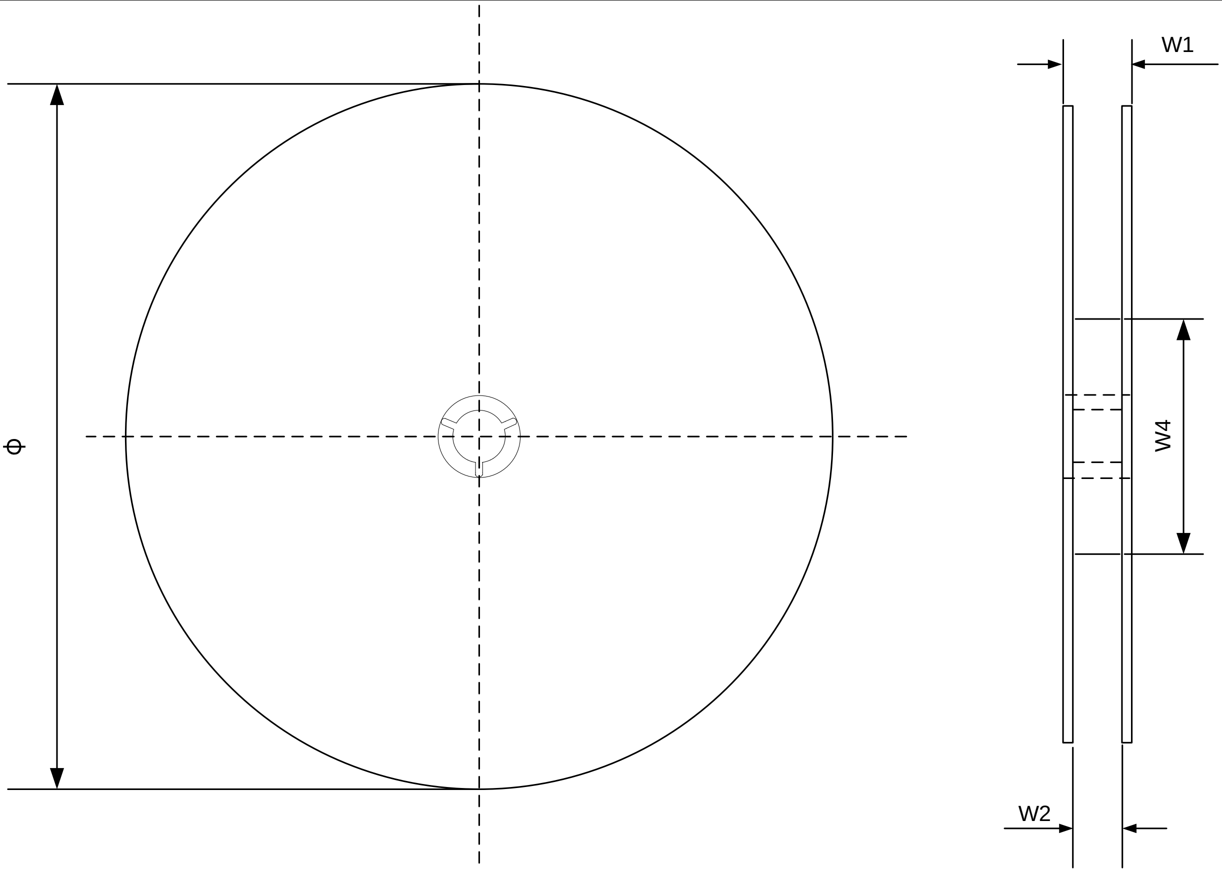
2) Capacitor tolerance and bias voltage de-rating should be considered. The effective capacitance can vary by +20% and -80%. Please refer to the datasheet of the capacitor.

3) C_{OUT_NOM} is the minimum nominal capacitance value of C_{OUT} (output capacitance). C_{OUT_EFF} is the minimum effective capacitance value of C_{OUT}.

4) The inductance value L should not be too large to ensure that the peak-to-peak inductor ripple current is not less than 20% of the maximum current limit.

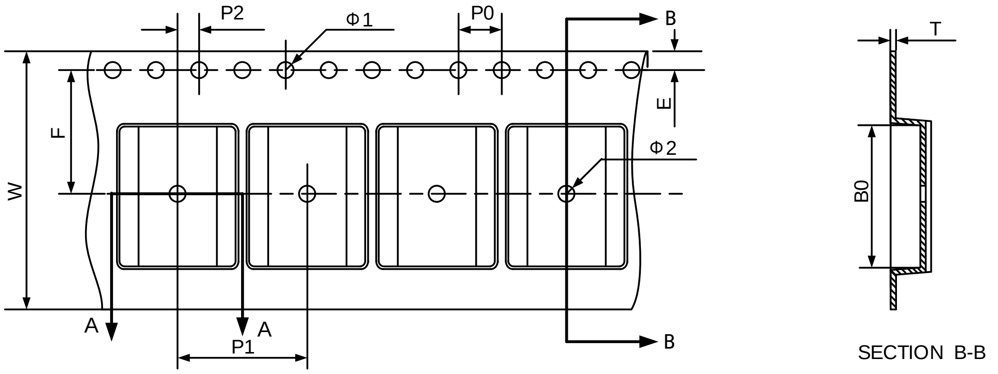
TAPE AND REEL INFORMATION

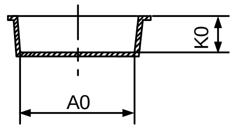
Reel UNIT: mm



Package	Diameter Φ	Thckness W1	Width W2	W4
SOT563	178±2	12.30±2	9.5±2	58±4

Carrier Tape UNIT: mm





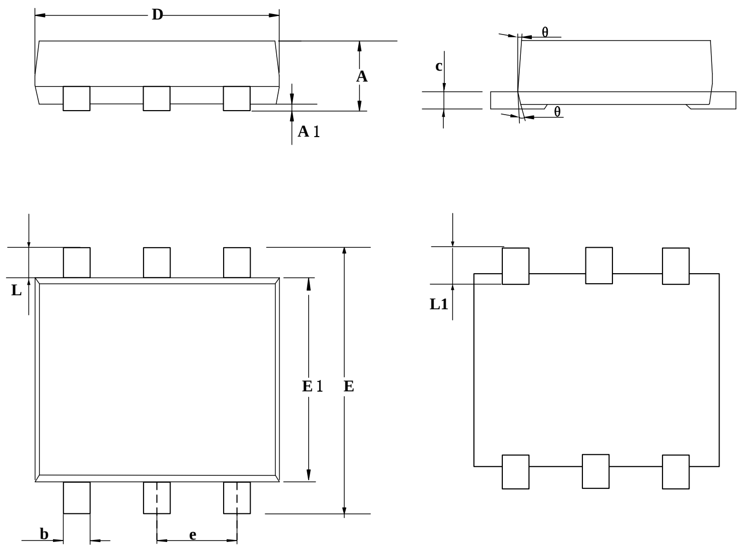
Note :

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.

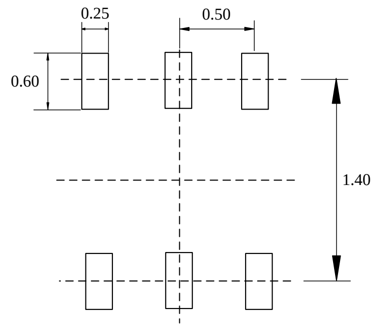
Package	Tape dimensions(mm)										
	P0	P2	P1	A0	B0	W	T	K0	Φ1	Φ2	E	F
SOT563	4.0±0.1	2.0±0.1	4.0±0.1	1.78±0.3	1.78±0.3	8.0±0.3	0.20±0.2	0.69±0.2	1.50min	0.50±0.10	1.75±0.1	3.50±0.10

PACKAGE OUTLINE

SOT563 UNIT: mm



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.525	—	0.60
A1	0.00	—	0.05
b	0.17	0.22	0.27
c	0.09	—	0.18
D	1.50	1.60	1.70
E	1.50	1.60	1.70
E1	1.10	1.20	1.30
e	0.45	0.50	0.55
L	0.10	0.20	0.30
L1	0.20	0.30	0.4
θ	9° REF		



RECOMMENDED LAND PATTERN

NOTE:

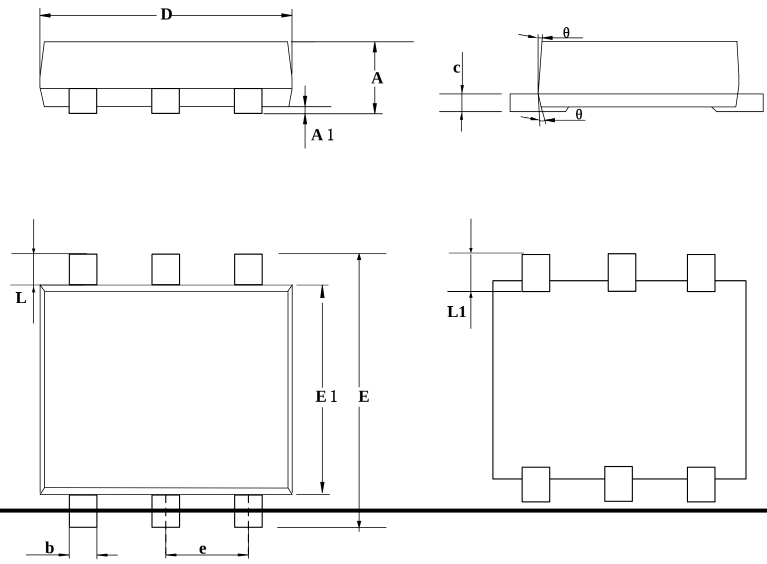
1) ALL DIMENSIONS AREIN MILLIMETERS

2) PACKAGE LENGTH DOES NOTINCLUDE MOLD FLASHPROTRUSION OR GATE BURR.

3) PACKAGE WIDTH DOES NOTINCLUDE INTERLEAD FLASHOR PROTRUSION.

4) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING)SHALL BE 010 MILLIMETERS MAX

5) DRAWINGIS NOT TO SCALE



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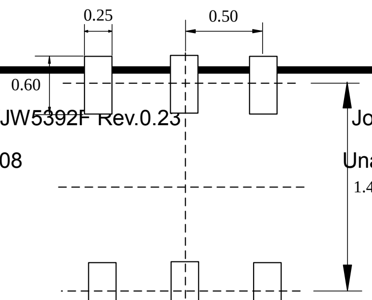

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