JW3651

21V 3A 4-Switch Buck-Boost Converter

Parameters Subject to Change Without Notice

DESCRIPTION

The JW®3651 is a high performance buck boost converter that the output voltage can be programmable from 0.9V up to 20V through external resistor.

The JW3651 implements the Buck Boost converter with a single inductor architecture that operates with input voltages above, below or equal to the output voltage. And support 2-switch boost mode for higher efficiency.

The integrated low Rds(on) MOSFET minimizes physical footprint, maximizes efficiency, which reduces the power dissipation. Constant current control is utilized to protect the device from overshooting at fault conditions. Built-in loop compensation simplifies the circuit and design.

JW3651 guarantees robustness with under voltage lockout, short circuit protection and thermal protection.

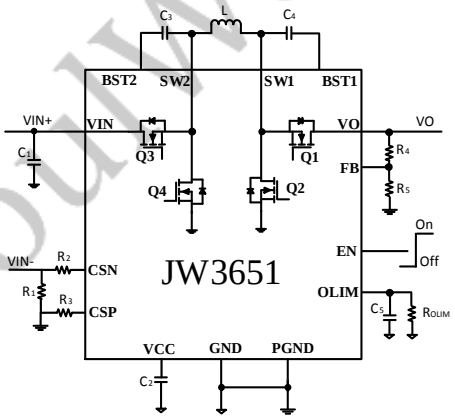
FEATURES

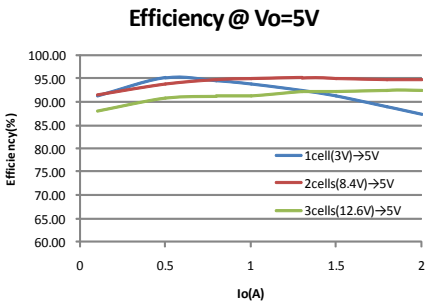
- Integrate low R_{DS} (on) power MOSFET
- Wide V_{IN}range:3.0V-21V
- Wide V_O range:0.9V-20V
- Compatible with 4-switch buck-boost mode and 2-switch boost mode.
- Fixed frequency 450kHz
- Programmable input and output current limit
- Output constant current control.
- Quiescent current: <60μA
- Integrate output short protection (4-swich buck-boost mode)
- Integrate thermal protection
- QFN3X4-15 package

APPLICATIONS

- Power bank systems
- USB power delivery
- Industrial applications
- Automotive systems

TYPICAL APPLICATION





ORDER INFORMATION

DEVICE[1)]	PACKAGE	TOP MARKING[2)]
JW3651QFNE#TRPBF	QFN3×4-15	JW3651 YW□□□□□

Notes:

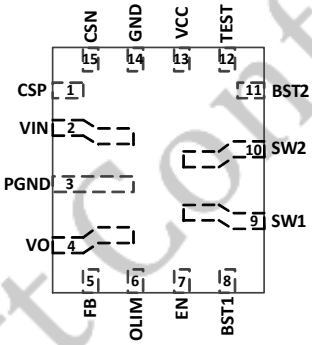
1) JW□□□□ # TRPBF
- PB Free
- Tape and Reel(If "TR" is not shown, it means tube)
- Package Code
- Part No.

2) Line1: JW□□□□
- Product code
- Joulwatt LOGO

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

PIN CONFIGURATION

TOP VIEW



ABSOLUTE MAXIMUM RATING[1)]

VO, VIN, SW1, SW2Pin .....-0.3V to24V
BST1-SW1, BST2-SW2 .....-0.3V to 6.5V
All Other Pins .....-0.3V to 6.5V
JunctionTemperature[2)3)] 150ºC
Lead Temperature 260ºC
Storage Temperature..... -65ºC to +150ºC
ESD Susceptibility (Human Body Model) ..... ±2kV

RECOMMENDED OPERATING CONDITIONS

Input Voltage VIN.....3.0V to 21V
Output Voltage VO.....0.9V to 20V
Operation Junction Temp (T_J) .....-40ºC to +125ºC

THERMAL PERFORMANCE[4)]

	θ_{JA}	θ_{JC}
QFN3X4-15	48	11ºC/W

Note：

1) Exceeding these ratings may damage the device.

2) The JW3651guarantees robust performance from -40°Cto 150°C junction temperature. The junction temperature range specification is assured by design, characterization and correlation with statistical process controls.

3) The JW3651 includes thermal protection that is intended to protect the device in overload conditions. Thermal protection is active when junction temperature exceeds the maximum operating junction temperature. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.

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

ELECTRICAL CHARATERISTICS

V_{IN}=12V, T_A=25℃, unless otherwise stated						
Item	**Symbol**	**Condition**	**Min.**	**Typ.**	**Max.**	**Units**
General parameters						
VIN voltage range	V_{IN}		3.0		21	V
VIN under voltage lockout	V_{IN_UVLO}	V_{IN} rising	2.8	3.0	3.1	V
		V_{IN} falling	2.45	2.6	2.75	V
VCC output voltage	V_{CC}		4.7	5	5.3	V
VCC output current limit	I_{VCC}	V_{VCC}=0V		50		mA
Supply current in shut-down mode	I_Q	V_{IN}=4V, V_{EN}=0V	30		60	μA
EN Logic HIGH	V_{ENH}	V_{EN} rising			2.5	V
EN Logic LOW	V_{ENL}	V_{EN} falling	1.6			V
Switch frequency	F_{sw} [5]		350	450	550	kHz
Switch minimum off time	T_{off_min} [5]		80	100	120	ns
Buck top switch on-resistance	R_{dsbkTG} [5]			20	28	mΩ
Buck bottom switch on-resistance	R_{dsbkBG} [5]			20	28	mΩ
Boost top switch on-resistance	$R_{dsbstTG}$ [5]			20	28	mΩ
Boost bottom switch on-resistance	$R_{dsbstBG}$ [5]			20	28	mΩ
Feedback voltage	V_{FB}		0.885	0.9	0.915	V
Input average current limit	I_{IN_LIM}	R_1=10mΩ; R_2=R_3=3kΩ;	2.85	3	3.15	A
OLIM pin output current sense ratio	K_{OLIM}	I_O=2A	4	5	6	μA/A
OLIM pin regulate voltage	V_{OLIM}			400		mV
Output average current limit	I_{O_LIM}	R_{OLIM}=40kΩ	1.9	2	2.1	A
Buck region, (IL Valley)	$I_{COMP(MAX)}$ [5]	V_{VCC}＞4.8V		7		A
Boost region, (IL Peak)		V_{VCC}＞4.8V		7		
Protection						
Thermal shutdown threshold[5]	T_{SHUT}			150		°C
Thermal recovery threshold[5]	T_{REC}			130		°C

Notes:

5) Guaranteed by design.

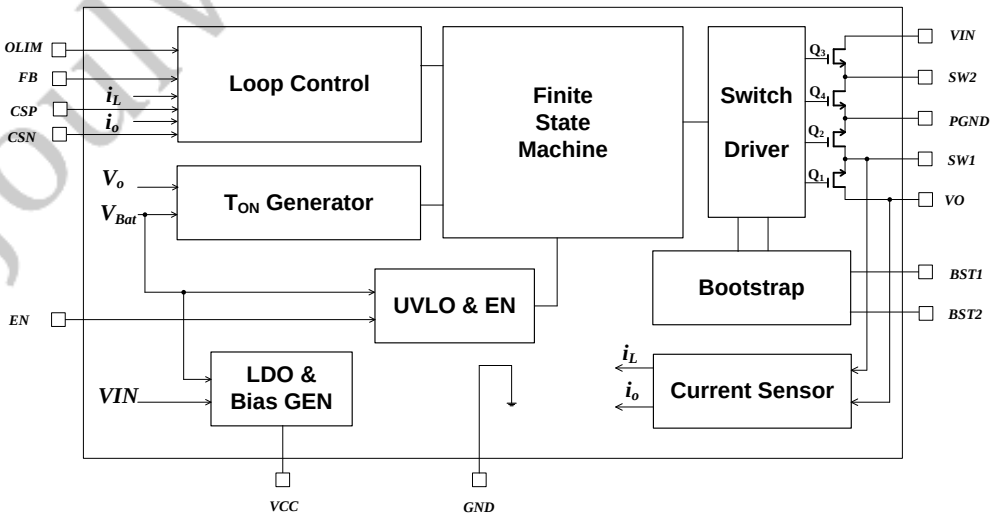
PIN DESCRIPTION

Pin No.	Name	Description
1	CSP	Positive terminal of current sense.
2	**VIN**	**Input pin, place bypass capacitor close to this pin.**
3	**PGND**	**Power Ground.**
4	**VO**	**Output pin, place bypass capacitor close to this pin.**
5	FB	Output feedback pin.
6	OLIM	Output current limit program pin. Connect a resistor to GND to set the maximum average current. And in the light load, it could be used as output current monitor pin.
7	EN	Enable control pin. Forcing the pin below 1.6V shuts down the converter, reducing quiescent current. Once the EN pin rises above 2.5V, the IC is turned on.
8	BST1	VO side bootstrap supply pin for top switch. A0.1μF capacitor is connected between BST1 and SW1 pins.
9	**SW1**	**VO side power switching node.**
10	**SW2**	**VIN side power switching node. Connect to SW1 with inductor**
11	BST2	VIN side bootstrap supply pin for top switch. A 0.1μF capacitor is connected between BST2 and SW2 pins.
12	TEST	Test pin. Tie this pin to GND for normal operation.
13	VCC	5V LDO for power driver and internal circuit. Must be bypassed to GNDwith a minimum of 10μF ceramic capacitor for stable operation.
14	GND	Signal GND.
15	CSN	Negative terminal of current sense.

Notes:

Highlighted pins are high current pins.

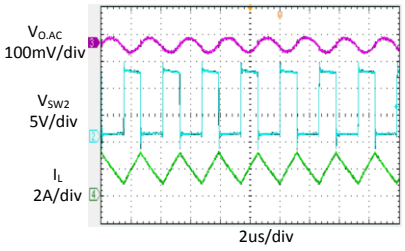
BLOCK DIAGRAM



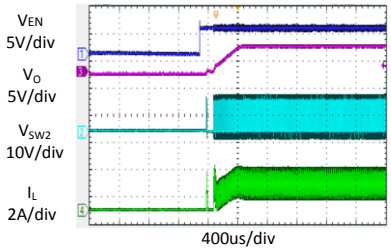
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} =12V, V_O = 5.0V, L = 3.3μH, C_O = 40μF, TA = +25°C, unless otherwise noted

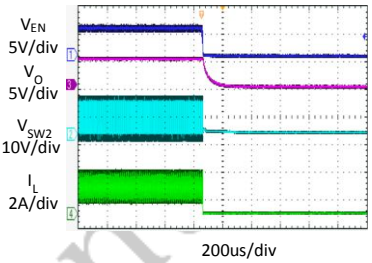
Steady State Test
V_{IN}=12V, V_O=5.0V
I_O=2A



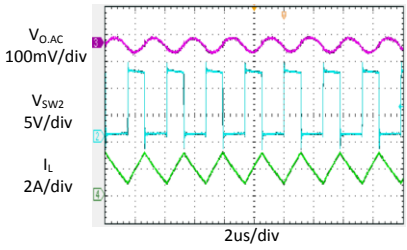
Startup through Enable
V_{IN}=12V, V_O=5.0V
I_O=2A(Resistive load)



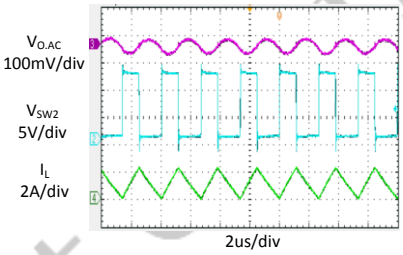
Shutdown through Enable
V_{IN}=12V, V_O=5.0V
I_O=2A(Resistive load)



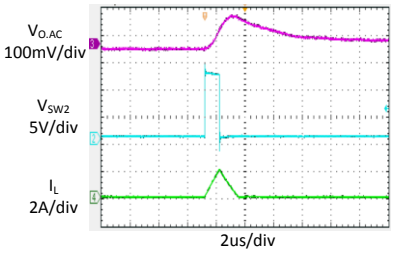
Heavy Load Operation
2A LOAD



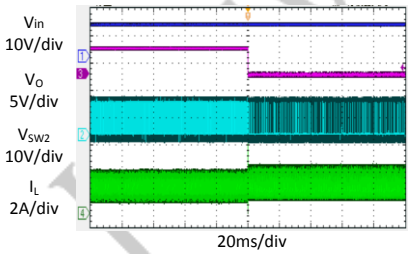
Medium Load Operation
1A LOAD



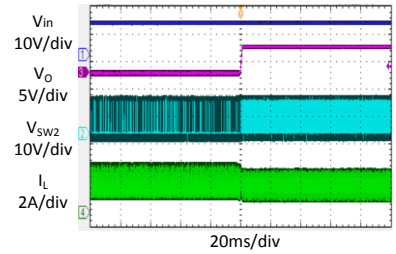
Light Load Operation
0 A LOAD



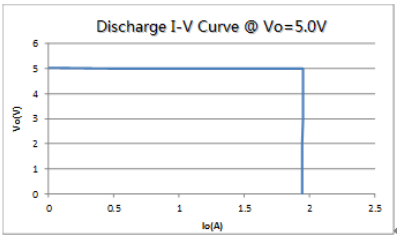
Short Circuit Protection
V_{IN}=12V, V_O=5.0V
I_O=1.93A-Short



Short Circuit Recovery
V_{IN}=12V, V_O=5.0V
I_O=Short-1.93A



Discharge I-V Curve
V_{IN}=12V, V_O=5.0V
I_{O_LIM}=2A



FUNCTIONAL DESCRIPTION

JW3651 is a monolithic buck-boost DC to DC converter that can operate over a wide input voltage range of 3.0V to 21V. The output voltage can be programmable between 0.9V to 20V. Internal, low R_{DSON} N-channel power switches reduce the solution complexity and increase system efficiency.

Flexible Buck-Boost Converter

The JW3651 contains flexible buck-boost converter for either buck or boost converting. When V_{IN} is higher than output voltage, it is a buck converter. When V_{IN} is lower than output voltage, it is a boost converter.

The DC-DC converter utilizes proprietary single inductor current-mode control to guarantee smooth transition between buck and boost operation with better dynamic response and cycle-by-cycle current protection.

JW3651 regulates the output voltage and output current.

Output Voltage

The output voltage is set by an external feedback divider resistor. The feedback signal is compared with internal precise 0.9V voltage reference by the error amplifier. The output voltage is given by the equation:

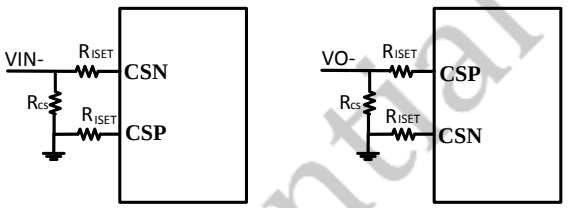
$$V_O(\mathrm{V}) = \frac{0.9(\mathrm{V}) \times (R_4 + R_5)}{R_5}$$

Where R_4 and R_5 are defined in typical application figure.

Programmable Input and Output Current Limit

As shown in figure1, the current sense resistor R_{CS} should be placed at input terminal or output terminal and closed to the R_{ISET}. The input/output current limit is set by R_{ISET} and R_{CS}, which is optional. If the input/output current limit is not desired, the CSN pin should be shorted to VCC, and the CSP pin shorted to GND.

$$I_{IN/O\_LIM}(\mathrm{A}) = \frac{R_{ISET}(\mathrm{k\Omega})}{R_{CS}(\mathrm{m\Omega})} \times 10(\mu\mathrm{A/A})$$



(a) Input current sense (b) output current sense

Figure1. Programmable current limit

If the input and output current limit are all necessary. The secondary output current limit can be programmable by OLIM pin.

$$I_{O\_LIM}(\mathrm{A}) = \frac{0.4(\mathrm{V})}{R_{OLIM}(\mathrm{k\Omega})} \times 0.2(\mathrm{A}/\mu\mathrm{A}) \times 1000$$

If the output current equals to the I_{O_LIM}, the output current loop begins to work, it turns down output voltage to limit the output power. When OLIM is not used, it should be shorted to GND.

When output is shorted to ground, the JW3651 works as a buck converter, the output current is continuously sensed and limited to I_{O_LIM}. When the output short is removed, the regulator comes into normal operation again.

VIN UVLO

When V_{IN} decreases to V_{IN_UVLO}, the device is disabled from switching. When the V_{IN} recovers and is larger than V_{IN_UVLO}, the JW3651 starts operating if the V_{EN} is still high.

Thermal Control

When the junction temperature of the JW3651rises above 135°C, it begins to reduce the output power to prevent the temperature from rising further. If the junction temperature of

the JW3651 rises above 150°C, the switching stops.

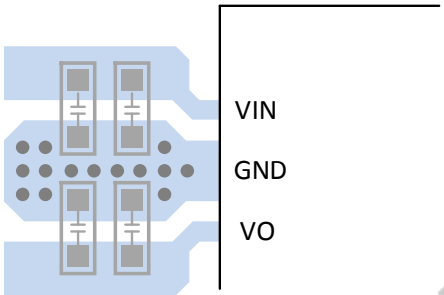
Shut-down Mode

The JW3651 shuts down when voltage at EN pin is below 1.6V. The entire regulator is off.

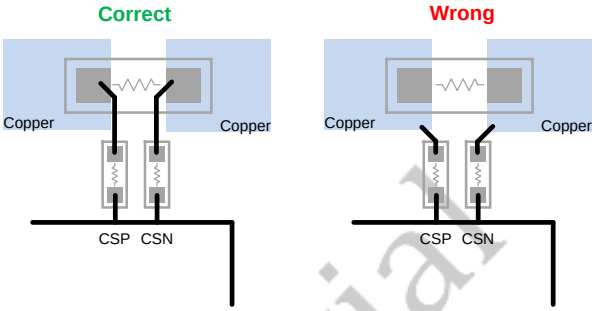
PCB Layout Note

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 JW3651 (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 current sense resistor R_{CS} as close as possible to the current set resistors R_{ISET} for better current accuracy.



3. Put the feedback trace as far away from the inductor and noisy power traces as possible.
4. The ground plane on the PCB should be as large as possible for better heat dissipation

REFERENCE DESIGN

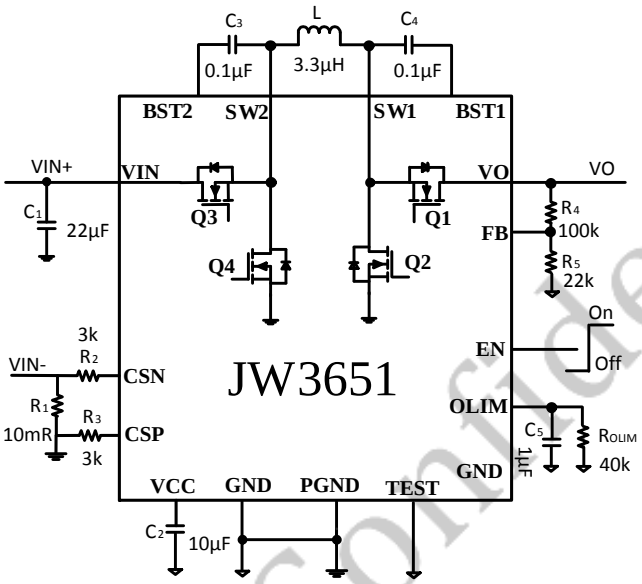
Reference 1：Input and output current limit set

V_{IN}: 3.0V ~ 21V

V_O: 5.0V

I_{IN_LIM}: 3A

I_{O_LIM}: 2A

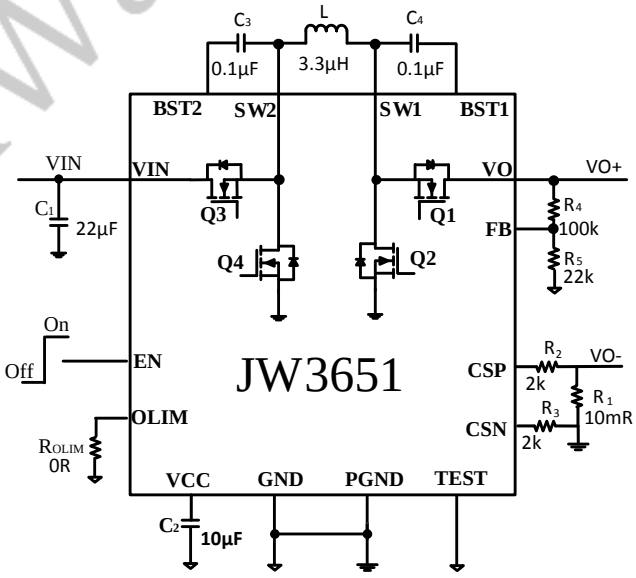


Reference 2：Only output current limit set

V_{IN}: 3.3V ~ 21V

V_O: 5.0V

I_{O_LIM}: 2A

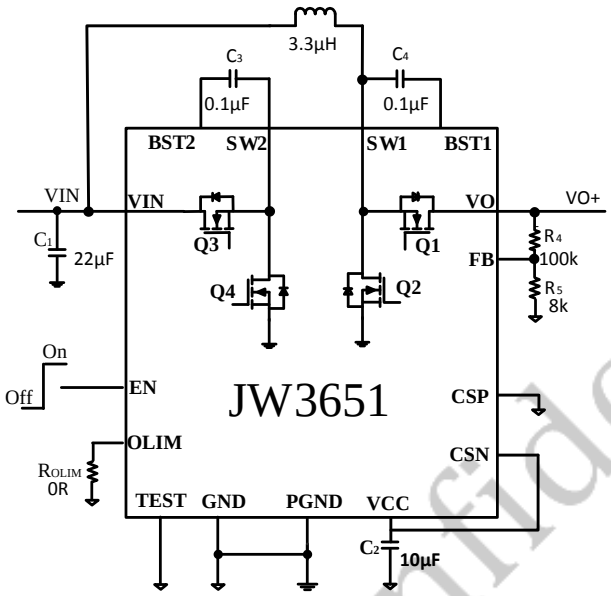


Reference 3：2-switch mode and no current limit

V_{IN}: 9V ~ 10V

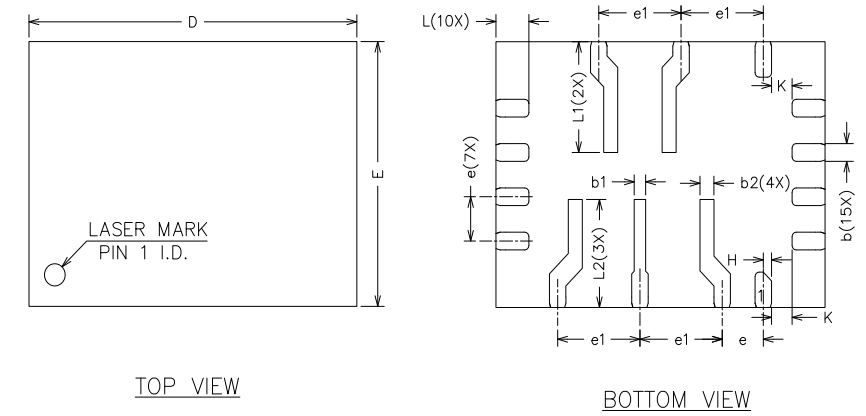
V_O: 12V

I_O: 2A



PACKAGE OUTLINE

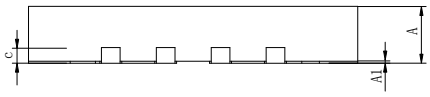
QFN3X4-15 UNIT: mm



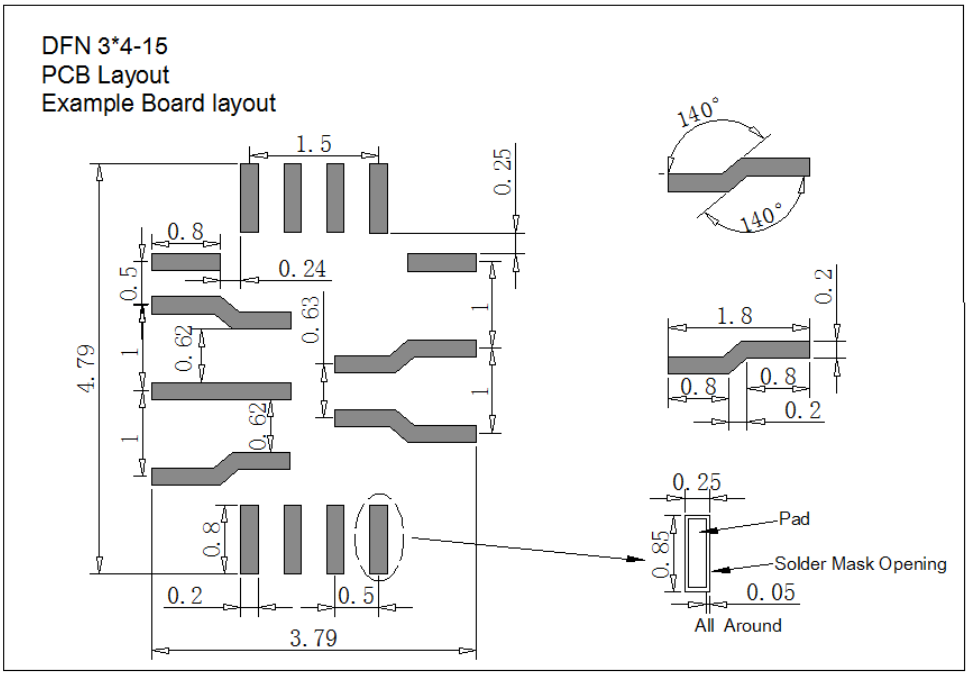
TOP VIEW

BOTTOM VIEW

	MIN	NOM	MAX
A	0.50	0.55	0.60
A1	0.00	0.02	0.05
c		0.15REF	
b	0.15	0.20	0.25
b1	0.09	0.14	0.19
b2	0.12	0.17	0.22
D	3.90	4.00	4.10
E	2.90	3.00	3.10
e	0.40	0.50	0.60
e1	0.90	1.00	1.10
H		0.10REF	
K	0.15	0.25	0.35
L	0.30	0.40	0.50
L1	1.15	1.25	1.35
L2	1.12	1.22	1.32



SIDE VIEW



Note:

1) All dimensions are in millimeters.
2) Drawing is not to scale.
3) It is recommended to be solder-mask for all pads.
4) Recommended drawing size does not take into account PCB production size error.
5) This drawing is subject to change without notice.

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