JW5712/JW5712A

Ultra-Low Quiescent Current Synchronous Step-Down Converter

Preliminary Specifications Subject to Change without Notice

DESCRIPTION

The JW®5712/A provides an ultra-low power solution for products powered by either one rechargeable Li-Ion batteries, Li-primary battery chemistries such as Li-MnO2 or two to three cell alkaline batteries. The output voltage of the buck converter is set with three VSEL pins between 0.7V and 3.3V. JW5712/A features low output ripple voltage and low noise with a small output capacitor. Once the input voltage comes close to the output voltage the device enters the 100% duty cycle operation mode to prevent an increase of output ripple voltage. In this operation mode the device stops switching and turns the high-side MOSFET switch on.

JW5712/A is available in 8 ball WLCSP 1.6mmx0.9mm package, which provide a compact solution with minimal external components.

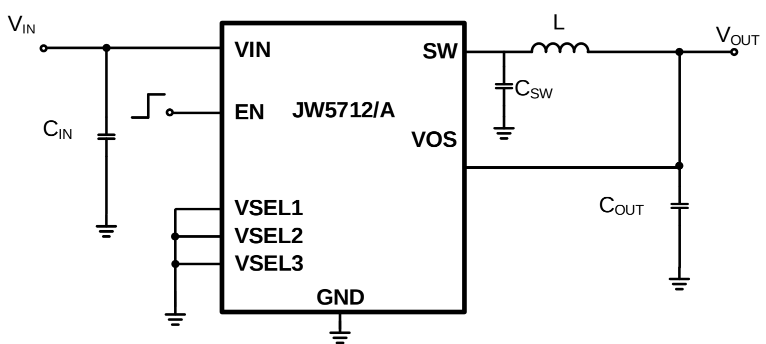
FEATURES

- 2.3V to 5.5V operating input range
- Output current
  JW5712/A: 600mA, peak to 800mA
- Typical 360nA quiescent current
- Up to 90% efficiency with load current>15uA
- Low output ripple voltage
- 8 selectable output voltages
  JW5712: 1.2V to 3.3V
  JW5712A: 0.7V to 3.1V
- Output short protection
- Output voltage discharge
- Automatic transition to 100% duty cycle operation
- Thermal protection
- Available in WLCSP8 package

APPLICATIONS

- IOT
- Wearable and Personal Electronics
- Health Monitoring and Medical Accessories
- Industrial Metering
- Energy Harvesting

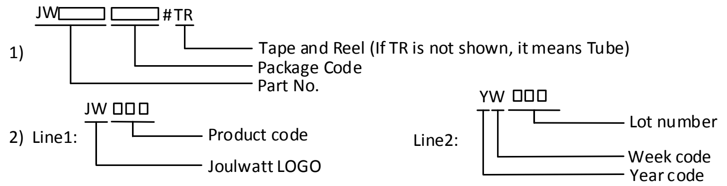
TYPICAL APPLICATION



ORDER INFORMATION

DEVICE[1]	PACKAGE	TOP MARKING[2]	ENVIRONMENTAL[3]
JW5712WLCSPC#TR	WLCSP1.575x0.875-8	JWNJ□ YW□□□	Green
JW5712AWLCSPC#TR	WLCSP1.575x0.875-8	JWNH□ YW□□□	Green

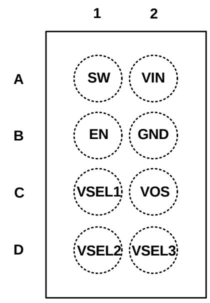
Note：



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

PIN CONFIGURATION

Top View



ABSOLUTE MAXIMUM RATING[1]

VIN, SW Pins .... -0.3V to 6V
All other Pins .... -0.3V to 6V
Junction Temperature[2] 150ºC
Lead Temperature 260ºC
Storage Temperature .... -65ºC to +150ºC
ESD (HBM) ....±2kV
ESD (CDM) ....±500V

RECOMMENDED OPERATING CONDITIONS[3]

Input Voltage VIN .... 2.3V to 5.5V
JW5712/A Output Current Iout 600mA
Junction Temperature Range ....-40ºC to 125ºC

THERMAL PERFORMANCE[4] θ_{JA} θ_{Jctop}

WLCSP8..103....1ºC/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 JW5712/JW5712A 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=3.6V, T_A= -40℃ to 85℃, typical values are at T_A= 25℃, Unless otherwise stated。						
Item	**Symbol**	**Conditions**	**Min.**	**Typ.**	**Max.**	**Unit**
V_{IN} Under-voltage Lockout Threshold	V_{IN_MIN}	V_{IN} rising	2.09	2.16	2.25	V
V_{IN} Under-voltage Lockout Hysteresis	$V_{IN\_MIN\_HYST}$			100		mV
Shutdown Supply Current	I_{SD}	V_{EN}=0V		40	300	nA
Supply Current	I_Q	device not switching		360	600	nA
		device switching[5)]		460	800	nA
High Side MOSFET On-resistance	$R_{DS(ON)T}$	V_{IN}=3.6V, I_{OUT}=50mA		380	470	mΩ
Low Side MOSFET On-resistance	$R_{DS(ON)B}$	V_{IN}=3.6V, I_{OUT}=50mA		250	450	mΩ
High Side MOSFET Switch Current Limit	I_{LIM_Peak}	3V≤V_{IN}≤5.5V	1.3	1.5	1.7	A
Low Side MOSFET Switch Current Limit	I_{LIM_Valley}	3V≤V_{IN}≤5.5V	1	1.2	1.4	A
Output Discharge Resistance	R_{DISCH}	EN=GND, I_{VOS}=-10mA into VOS pin		30	65	Ω
Bias Current Into VOS Pin	I_{IN_VOS}	V_{OUT}=2V, EN=V_{IN}		100	200	nA
Output Voltage Accuracy	V_{OUT}	V_{OUT}=1.8V	-2%		+2	%
Output Voltage Load Regulation[5)]		V_{OUT}=1.8V,CCM operation, I_{OUT}=0~600mA		0.01		%/mA
		V_{OUT}=1.8V, I_{OUT}=100mA, 2.3V≤V_{IN}≤5.5V		0.002		%/mA
Output Voltage Line Regulation[5)]		V_{OUT}=1.8V, I_{OUT}=100mA, 2.3V≤V_{IN}≤5.5V		0.1		%/V
Minimum On Time	T_{ON_MIN}	I_{OUT}=0mA, V_{OUT}=2V		500		ns
Minimum Off Time[5)]	T_{OFF_MIN}			80		ns
Soft-start Delay Time[5)]	T_{SS_DLY}	From EN=low to high until device starts switching		8		ms
Soft-start Time[5)]	T_{SS}	2.3V≤V_{IN}≤5.5V, EN=V_{IN}		830		us
High Side MOSFET Switch Current Limit During Soft-start[5)]	$I_{LIM\_Peak\_SS}$	EN=low to high		150		mA

VIN=3.6V, T_A= -40℃ to 85℃, typical values are at T_A= 25℃, Unless otherwise stated。						
Item	**Symbol**	**Conditions**	**Min.**	**Typ.**	**Max.**	**Unit**
Low Side MOSFET Switch Current Limit During Soft-start[5)]	$I_{LIM\_Valley\_SS}$	EN=low to high		128		mA
Input High Threshold	V_{IH}	2.3V≤V_{IN}≤5.5V, EN, VSELs pins	1.2			V
Input Low Threshold	V_{IL}	2.3V ≤V_{IN}≤5.5V, EN, VSELs pins			0.4	V
Input Pin Bias Current	I_{IN}			10		nA
Auto 100% Mode Leave Detection Threshold	V_{TH_100+}	Rising V_{IN}, 100% mode is left with V_{IN}=V_{OUT}+V_{TH_100+}	150	250	350	mV
Auto 100% Mode Enter Detection Threshold	V_{TH_100-}	Falling V_{IN}, 100% mode is entered with V_{IN}=V_{OUT}+V_{TH_100-}	85	200	290	mV
Thermal Shutdown[5)]	T_{TSD}			150		°C
Thermal Shutdown Hysteresis[5)]	T_{TSD_HYST}			20		°C

Note:

5) Guaranteed by design.

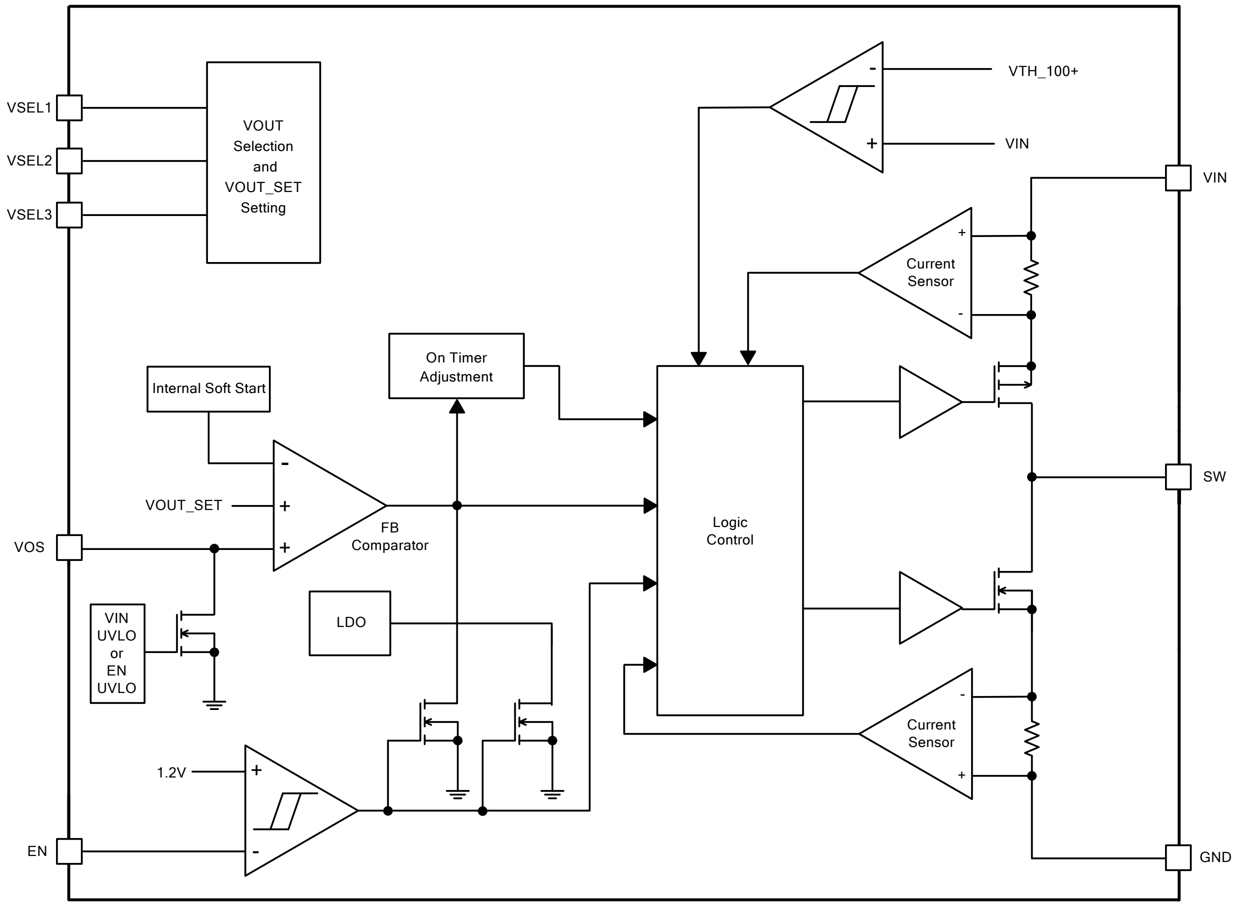
Table 1. Output Voltage Setting

JW5712 VOUT/V	JW5712A VOUT/V	VSEL3	VSEL2	VSEL1
1.2	0.7	0	0	0
1.5	1	0	0	1
1.8	1.3	0	1	0
2.1	0.75	0	1	1
2.5	1.9	1	0	0
2.8	1.05	1	0	1
3.0	2.9	1	1	0
3.3	3.1	1	1	1

PIN DESCRIPTION

Pin	Name	Description
A1	SW	Switch pin which is connected to the internal MOSFET switches. Connect inductor to this terminal.
A2	VIN	VIN power supply pin. Connect this pin close to the VIN terminal of the input capacitor. A minimum of 4.7μF ceramic capacitor from this pin to GND is required.
B1	EN	Enable pin. Drive EN pin high to turn on the regulator and low to turn off the regulator.
B2	GND	Ground pin.
C1	VSEL1	Output voltage selection pins.
D1	VSEL2	
D2	VSEL3	
C2	VOS	Feedback pin for the internal feedback divider network and regulation loop. Connect this pin directly to the output capacitor with a short trace.

BLOCK DIAGRAM



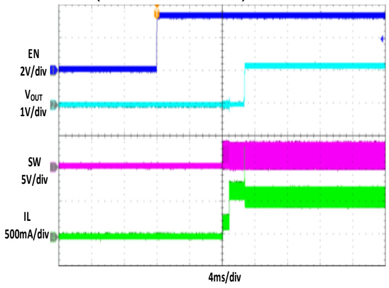
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} =3.6V, V_{OUT}= 1.2V, L = 2.2μH, C_{OUT} = 10μF, T_A = +25°C, unless otherwise noted

Startup through Enable

V_{IN}=3.6V, V_{OUT}=1.2V

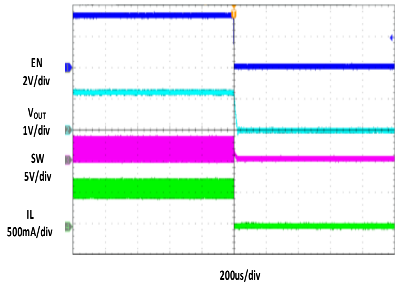
I_{OUT}=0.6A (Electronic load)



Shutdown through Enable

V_{IN} =3.6V, V_{OUT} =1.2V

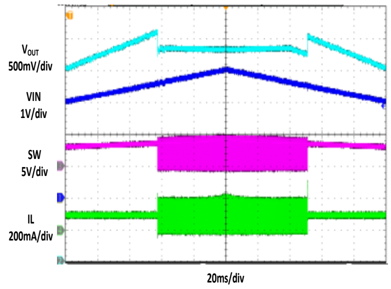
I_{OUT}=0.6A (Electronic load)



Automatic 100% Mode Transition

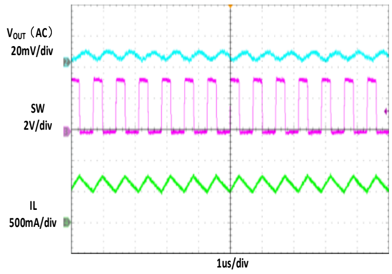
V_{IN} =3V to 4V, V_{OUT} =3.3V

I_{OUT}=0.1A



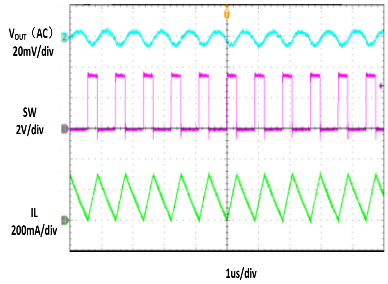
Heavy Load Operation

0.6A LOAD



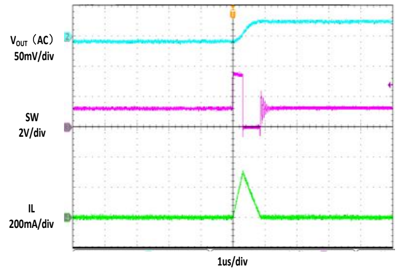
Light Load Operation

0.15A LOAD



No Load Operation

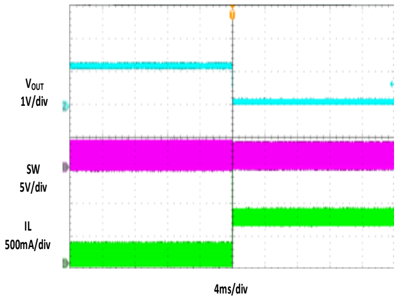
0 A LOAD



Short Circuit Protection

V_{IN} =3.6V, V_{OUT} =1.2V

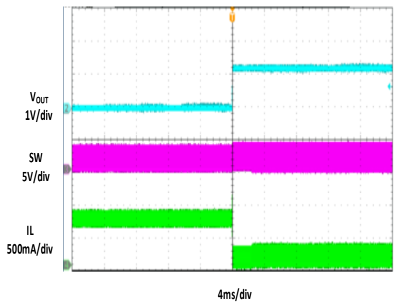
I_{OUT}=0.1A- Short



Short Circuit Recovery

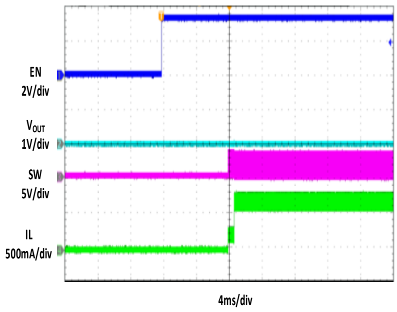
V_{IN} =3.6V, V_{OUT} =1.2V

I_{OUT}= Short-0.1A



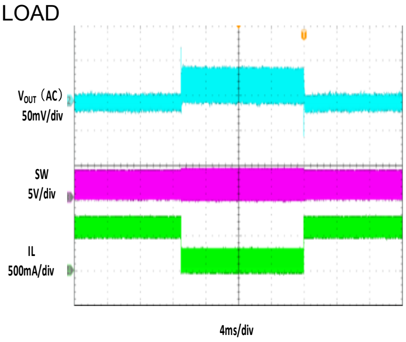
Short Circuit EN ON

V_{IN} =3.6V, I_{OUT}= Short



Load Transient

50mA LOAD → 0.6A LOAD → 50mA LOAD



TYPICAL PERFORMANCE CHARACTERISTICS

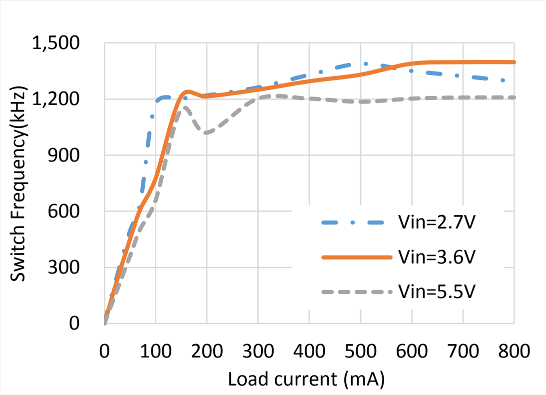


Figure1：Frequency VS Load Current V_{OUT} =1.2V

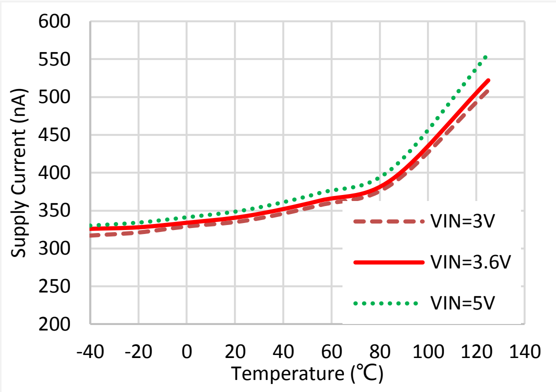


Figure2：IQ VS Temperature

Device not switching

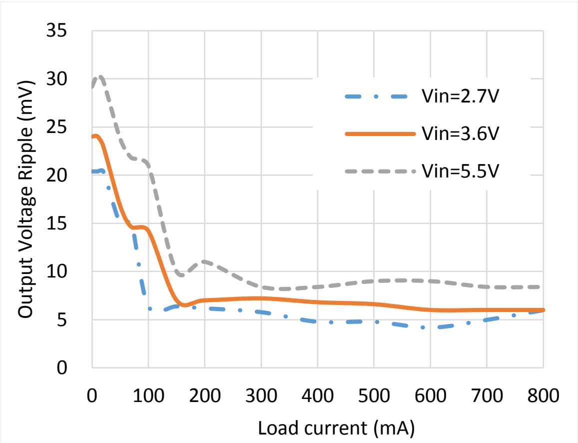


Figure3：V_{OUT} Ripple voltage VS Load Current

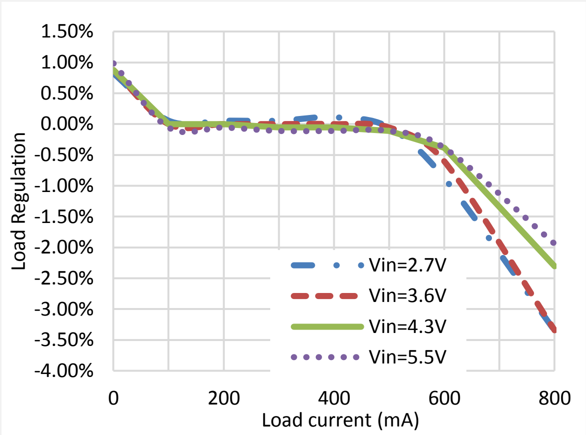


Figure4：Load Regulation vs Load Current

(V_{OUT} =1.8V, L=2.2μH)

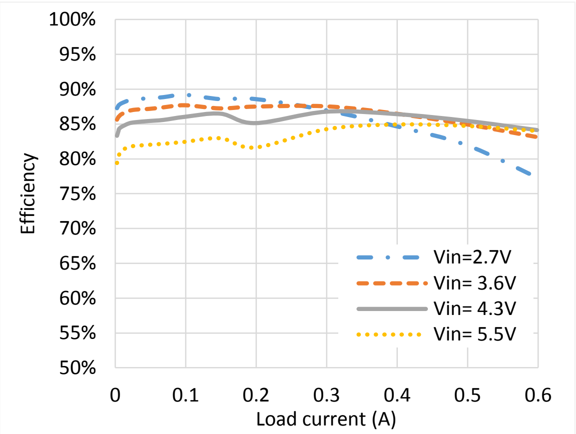


Figure5：Efficiency vs Load Current

(V_{OUT} =1.2V, L=2.2μH)

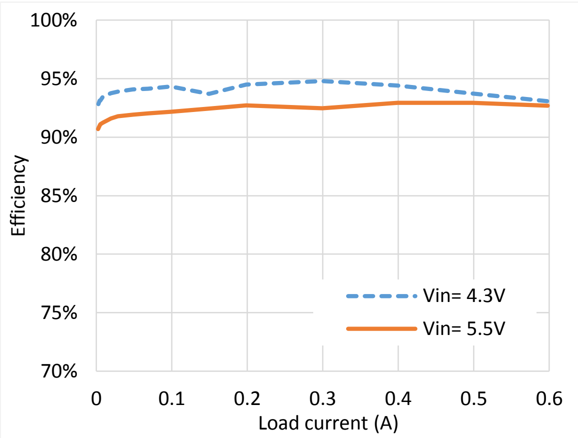


Figure6：Efficiency vs Load Current

(V_{OUT} =3.3V, L=2.2μH)

FUNCTIONAL DESCRIPTION

JW5712/A is an ultra-low power synchronous step-down regulator. It regulates input voltages from 2.3V to 5.5V down to an output voltage range from 0.7V to 3.3V with ultra low quiescent current consumption (360nA typical) and is capable of supplying to 600mAof continue load current and 800mA of peak load current .

Shut-Down Mode

JW5712/A shuts down when voltage at EN pin is driven below 0.3V. The entire regulator is off and the supply current consumed by JW5712/A drops below 40nA .

Output Voltage Selection

JW5712/A does not require an external resistor divider network to program the output voltage. The device integrates a high impedance feedback resistor divider network which is programmed by VSEL1-3 pins. JW5712/A supports an output voltage ranges of 0.7V to 3.3V. The output voltage can be changed during operation and supports simple dynamic output voltage scaling. The output voltage is programmed according to **Table 1**.

Soft Start

The JW5712/A has an internal soft-start function to minimize input voltage drop during start-up. This allows the operation from high impedance battery cells. Once the device is enabled the device starts switching after a typical delay time of 8ms, then the soft-start time of typical 830μs begins with a reduced current limit of typical 128 mA. When this time passed by the device enters full current limit operation. This allows a smooth start-up and the device can start into full load current. Furthermore, larger output capacitors impact the start-up behavior of the DC/DC converter especially when the output voltage does not reach its nominal value after the typical soft-start time of 830μs has passed.

Output Current Run-Away Protection

JW5712/JW5712A ingrates a current limit on the high side as well on the low side MOSFETs to protect the device against overload or short circuit conditions. The peak current in the switches is monitored cycle by cycle. If the high side MOSFET current limit is reached, the high side MOSFET is turned off and the low side MOSFET is turned on until the current decreases below the low side MOSFET current limit. When the voltage of FB decrease below to 0.4V, the current limit will decrease to 1/2 current limit.

Output Discharge

The device provides automatic output voltage discharge once it is disabled. This feature prevents residual charge voltage on the output capacitor, which may impact proper power up of the system connected to the converter. The discharge circuit at VOS pin becomes active once the EN pin is pulled to low or the input voltage drops below UVLO comparator threshold.

100% Duty Cycle Operation Mode

Once the input voltage comes close to the output voltage, the DC/DC converter stops switching and enters 100% duty cycle operation mode and the output voltage V_{OUT} tracks the input voltage V_{IN}. Once the input voltage VIN falls below the 100% mode enter threshold, V_{TH_100-}, the DC/DC regulator is turned off, switching stops and therefore no output voltage ripple is generated. The voltage difference between V_{IN} and V_{OUT} is the voltage drop across the power inductor and the internal high side

MOSFET switch. Once the input voltage increases and trips the 100% mode exit threshold, V_{TH_100+} , the DC/DC regulator turns on and starts switching again.

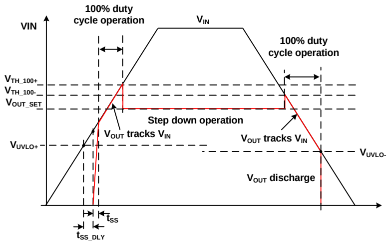


Figure7. Automatic 100% Mode Transition

Thermal Protection

When the temperature of the JW5712/A rises above 150°C, it is forced into thermal shut-down. Only when core temperature drops below 130°C can the regulator becomes active again.

APPLICATION INFORMATION

Input Capacitor

The input capacitor is used to supply the AC input current to the step-down converter and maintaining the DC input voltage. The ripple current through the input capacitor can be calculated by:

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

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.

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

where C_{IN} is the input capacitance value, f_{sw} 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 4.7μF 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:

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

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 10μF ceramic capacitor is recommended in typical application.

Inductor

The recommended power inductor is 2.2uH and inductor saturation current rating choose follow over current protection design consideration. In applications, it needs to select an inductor with the low DCR to provide good performance and efficiency.

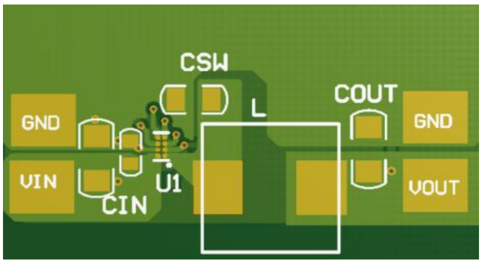
External Csw Capacitor

The C_{SW} capacitor must be added between SW pin and GND pin. A 1nF low ESR ceramic capacitor is recommended to connected between the SW pin and GND pin. Keep the C_{SW} as close as close to SW pin and GND pin.

PCB Layout Note

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

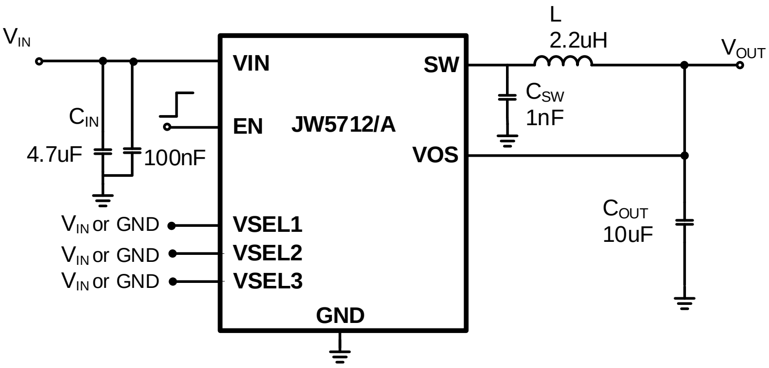
1. Place the input decoupling capacitor as close to JW5712 and JW5712A (VIN pin and GND pin) as possible to eliminate noise at the input pin. The loop area formed by input capacitor and GND must be minimized.
2. Keep the C_{SW} as close as close to SW pin and GND pin.
3. Keep the switching node SW short to prevent excessive capacitive coupling
4. 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.



REFERENCE DESIGN

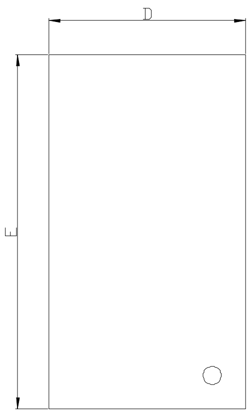
V_{IN}: 2.7V~5.5V

I_{OUT}: 0~0.6A

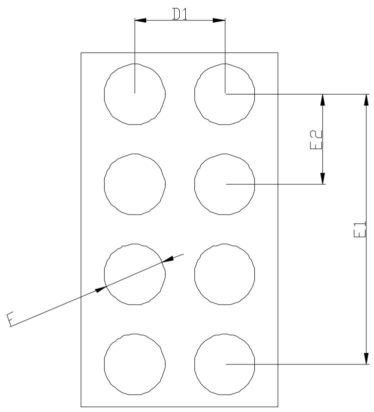


PACKAGE OUTLINE

WLCSP8 UNIT: mm

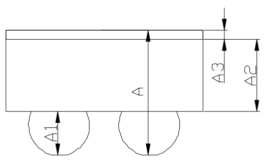


TOP VIEW



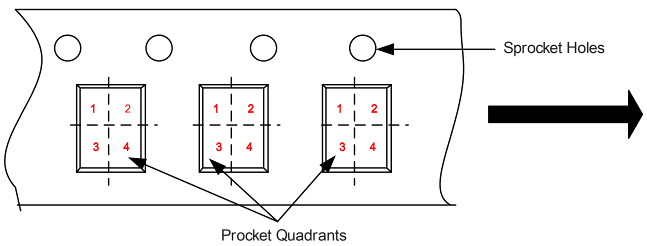
BOTTOM VIEW

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.515	0.555	0.595
A1	0.175	0.195	0.225
A2	0.300	0.320	0.350
A3	0.035	0.040	0.045
D	0.830	0.875	0.900
E	1.530	1.575	1.600
F	0.230	0.270	0.290
D1	0.400 TYP		
E1	1.200 TYP		
E2	0.400 TYP		



SIDE VIEW

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPAE



Package Type	Pin1 Quadrant
WLCSP8	1

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