

High Efficiency Step-Up Converter with a 4A Switch

Features

- Input Voltage Range: 2.5V to 5.5V
- Adjustable Output Voltage: VIN to 6V
±2.2% Total DC Voltage Accuracy
- $I_{OUT} \geq 1.5A$ at $V_{OUT} = 5V$, $V_{IN} \geq 3.3V$
- Up to 93% Efficiency
- 35 μ A Quiescent Current
- 4A switching valley current limit
- Light Load Power Save Mode
- Only Three External Components Required
- Build-in OVP, OTP, UVLO, Short-circuit Protection
- True Load Disconnect During Shutdown
- WLCSP 1.253mm x 1.253mm-9B Package

Applications

Cell Phones, Smart Phones, PADs, Wearable
Power Bank
USB On-The-Go Device
Digital Camera

General Description

The AW3615A is a large current, high-efficiency synchronous boost regulator with adjustable output voltage. With a wide input voltage range of 2.5V to 5.5V, the device supports applications powered by Li-Ion batteries with extended voltage range.

The AW3615A operates at a quasi-constant 2.5MHz switching frequency and enters power save mode operation at light load currents to maintain high efficiency over the entire load current range. The PSM mode extends the battery life by reducing the quiescent current to 44 μ A (typ.) during light load operation.

The AW3615A operates in pass-through mode when input voltage is higher than output voltage. When it enters pass-through mode and the device stops switching. The rectifying PMOS constantly turns on and low-side switch constantly turns off.

AW3615A can adjust the output voltage by applying external resistors to FB pin. Otherwise, FB can be grounded and the VOUT would be set to a fixed output voltage. The AW3615A is available in a tiny WLCSP 1.253mm x 1.253mm-9B package.

Typical Application Circuit

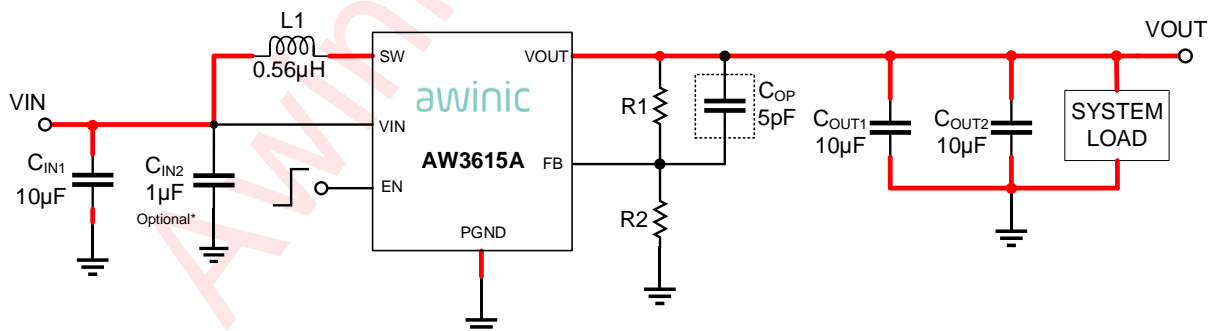
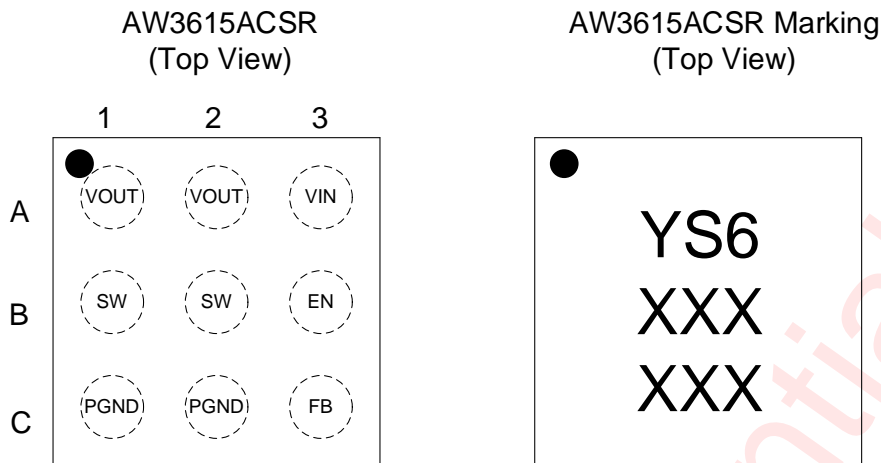


Figure 1 AW3615A adopts external divider resistors at FB pin

Pin Configuration And Top Mark

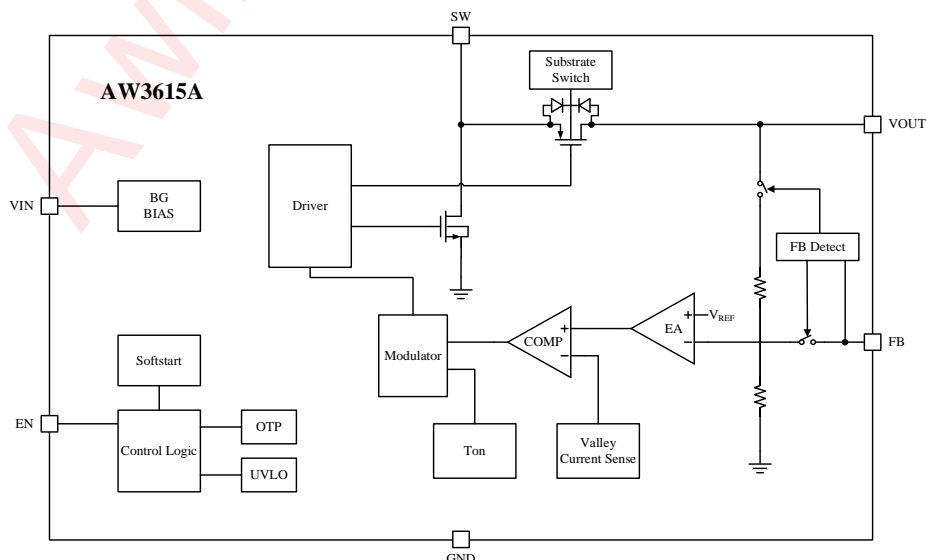


YS6 - AW3615ACSR
XXX/XXX - Production Tracing Code

Pin Definition

No.	NAME	DESCRIPTION
A1, A2	VOUT	Output terminal. Should be bypassed with a C_{OUT} capacitor.
A3	VIN	Power Supply. Connect directly to C_{IN} .
B1, B2	SW	Switching Node. Connected to inductor.
B3	EN	Enable. When this pin is high, the circuit is enabled. A $5M\Omega$ pull-down resistor is integrated.
C1, C2	PGND	Power Ground. This is the power return for the IC, C_{OUT} capacitor should be returned with the shortest path possible to these pins.
C3	FB	Feedback terminal. V_{FB} would be regulated to 1V by the chip if adopting external resistors. Otherwise, this pin should be connected to ground.

Functional Block Diagram



Typical Application Circuit

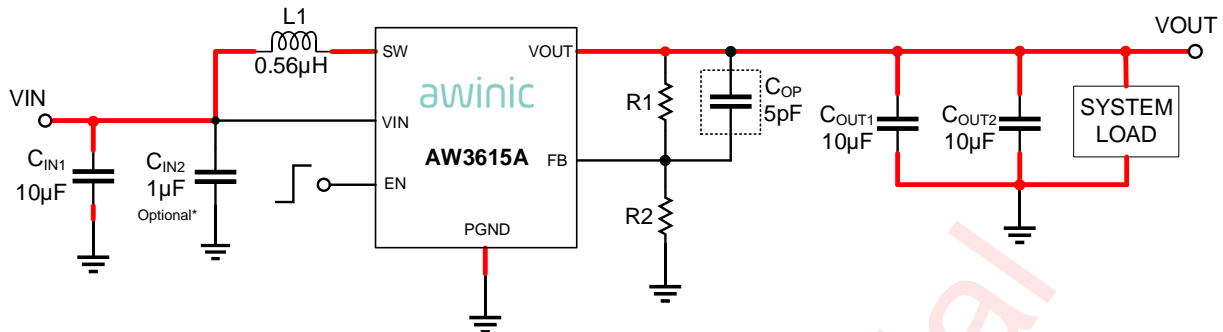


Figure 2 AW3615A adopts external divider resistors at FB pin

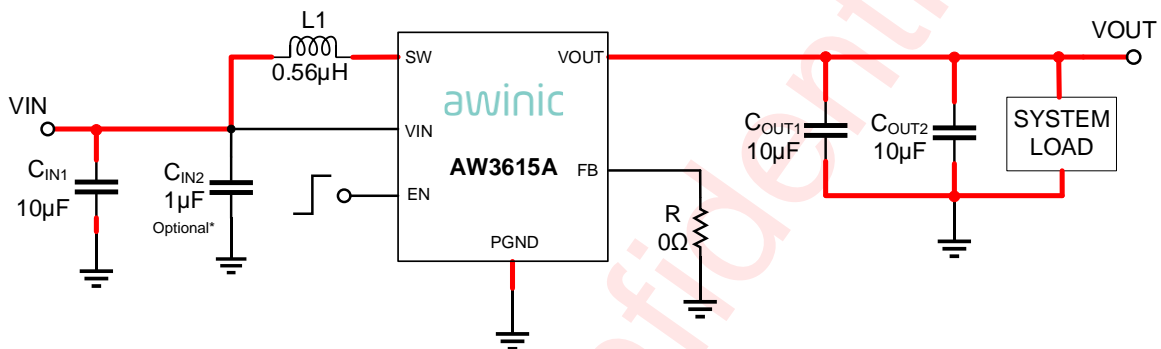


Figure 3 AW3615A adopts internal divider resistors by set FB grounded

Notice for typical application circuits:

Note1: Inductor L1 is recommended to choose 0.56µH.

Note2: The large current path is used red line. For the sake of driving capability, the routes VIN-SW should be short and wide. The proposed width of VIN-SW route is 100mil, and the VOUT trace 60mil.

Note3: Place C_{IN1} and inductor close to VIN pin, an optional C_{IN2} should be added if C_{IN1} is far from VIN pin. Place C_{OUT1} and C_{OUT2} close to VOUT, the distance between C_{OUT} and VOUT pin must not be beyond 5mm. The C_{OUT} of 20µF is recommended. When VOUT exceeds 4.5V and the input and output voltage differential is less than 0.4V, it is recommended to increase the output capacitor to 44µF.

Note4: When the FB pin is connected to the resistance divider, and the VOUT can be set to $V_{FB} \cdot (R1 + R2) / R2$. The total resistance of the R1 and R2 should be maintained below 2MΩ, when the total resistance exceeds 400kΩ, a C_{OP} capacitor should be added. Otherwise, FB can be grounded and the VOUT would be set to fixed 5V.

Ordering Information

Part Number	Temperature	Package	Marking	Moisture Sensitivity Level	Environmental Information	Delivery Form
AW3615ACSR	-40°C~85°C	WLCSP 1.253mmX1.253mm -9B	YS6	MSL1	ROHS+HF	3000 units/ Tape and Reel

Absolute Maximum Ratings^(NOTE1)

PARAMETERS		RANGE
Input voltage range	VIN, FB, EN	-0.3V to 6.5V
Output voltage range	VOUT	-0.3V to 7V
SW	DC	-0.3V to 7V
	Transient: 10ns, 3MHz	-1V to 8V
Junction-to-ambient thermal resistance θ_{JA}		69.5°C /W
Maximum operating junction temperature T_{JMAX}		150°C
Operating free-air temperature range		-40°C to 85°C
Storage temperature T_{STG}		-65°C to 150°C
Lead temperature (soldering 10 seconds)		260°C
ESD(Including CDM ^(NOTE 2) HBM ^(NOTE 3))		
HBM		±2kV
CDM		±1.5kV
Latch-Up		
Test condition: JESD78F		+IT: 200mA -IT: -200mA

NOTE1: Conditions out of those ranges listed in "absolute maximum ratings" may cause permanent damages to the device. In spite of the limits above, functional operation conditions of the device should within the ranges listed in "recommended operating conditions". Exposure to absolute-maximum-rated conditions for prolonged periods may affect device reliability.

NOTE2: Test method: ESDA/JEDEC JS-002-2022;

NOTE3: The human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin. Test method: ESDA/JEDEC JS-001-2023;

Recommended Operating Conditions

Symbol	Parameter	Min.	Typ.	Max.	Unit
V _{IN}	Input Voltage Range	2.5		5.5	V
V _{OUT}	Output Voltage Range	V _{IN}		6	V
L	Inductance	0.47	0.56	1	μH
C _{OUT}	Output Capacitor ^(NOTE 4)	12.2	20	50	μF

NOTE4: We recommend C_{OUT} at least a 10μF 10V and a 2.2μF 10V capacitors that is actually a 4.6μF capacitor when biased at 5V;

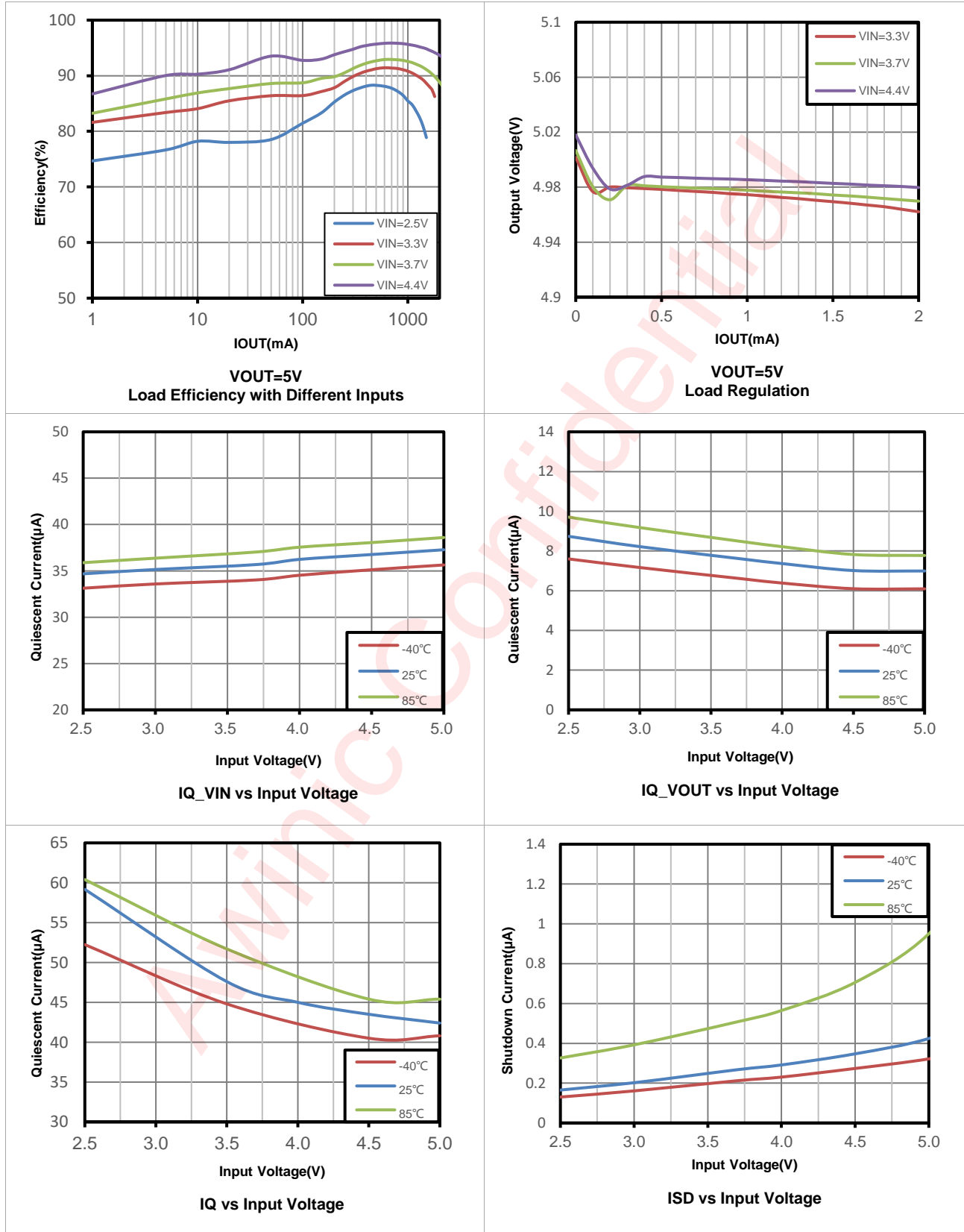
Electrical Characteristics

VIN=2.5V~5.5V, VOUT=5V. Typical values are at VIN=3.7V and TA=25°C, unless otherwise noted.

PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT	
SUPPLY CURRENT						
I _Q	Quiescent current (Device Normal Switching)	EN=VIN, I _{OUT} =0		44	μA	
I _{Q_VIN}	Quiescent current (Device Not Switching)	EN=VIN, I _{OUT} =0, not switching		35	μA	
I _{Q_VOUT}				7		
I _{SD}	Shutdown current	EN=0		0.3	μA	
V _{UVLO}	Under-Voltage Lockout	VIN Rising		2.4	V	
V _{UVLO_HYS}	Under-Voltage Lockout Hysteresis			100	mV	
OUTPUT VOLTAGE						
V _{OUT}	Output Voltage Range	Adjustable version	VIN		6	V
	Output accuracy	PWM mode, I _{OUT} =300mA	4.89	5.0	5.11	V
V _{FB}	Feedback reference voltage		0.99	1	1.01	V
V _{OVP}	Output overvoltage protection threshold	VOUT rising	6.2	6.4	6.6	V
	OVP hysteresis			100	200	mV
I _{FB_LKG}	Leakage current into FB pin			0.5	μA	
R _{DIS}	VOUT discharge resistor	VIN=3.7V, EN=0V		20	kΩ	
POWER SWITCHES						
f _{sw}	Switching Frequency	VIN=3.7V, I _{OUT} =500mA		2.5		MHz
R _{DS(on)_LS}	Low side switch on resistance	VOUT=5.0V		40		mΩ
R _{DS(on)_HS}	Rectifier on resistance	VOUT=5.0V		50		mΩ
I _{LIM_SW}	Switching valley current limit			4		A
	Startup current limit			0.5		A
CONTROL LOGIC						
V _{EN_H}	Enable High voltage		0.9			V
V _{EN_L}	Enable Low voltage				0.3	V
R _{EN}	EN pin Pull-down resistor			5		MΩ
I _{EN_LKG}	Leakage current into EN pin	V _{EN} = 5.0V		1.4		μA
T _{OTP}	Over temperature protection			150		°C
T _{OTP_HYS}	OTP hysteresis			20		°C

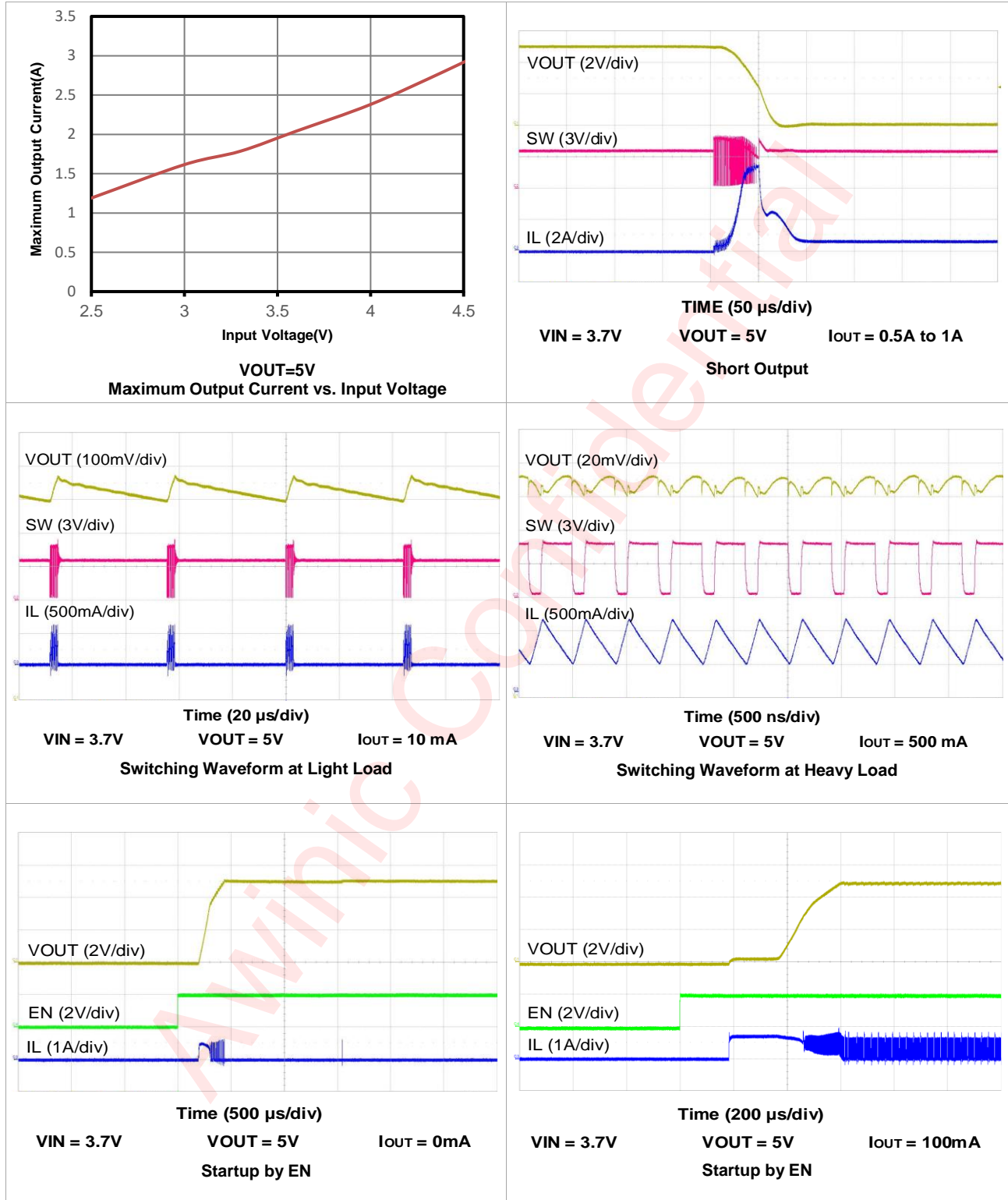
Typical Characteristics

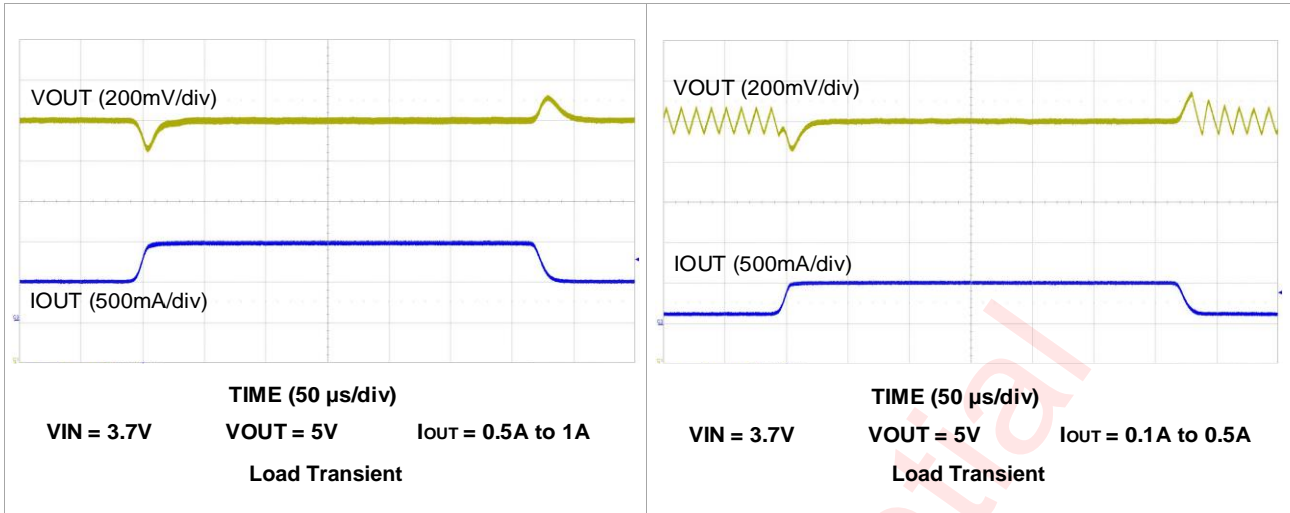
$T_A=25^\circ\text{C}$, $C_{IN} = 10\mu\text{F}$, $C_{OUT} = 20\mu\text{F}$, $V_{IN}=3.7\text{V}$, unless otherwise noted.



Typical Characteristics(Continue)

$T_A=25^{\circ}\text{C}$, $C_{IN} = 10\mu\text{F}$, $C_{OUT} = 20\mu\text{F}$, $V_{IN}=3.7\text{V}$, unless otherwise noted.





Detailed Functional Description

AW3615A is a high current and high efficiency synchronous step-up converter, which can supply up to 1.5A@VIN=3.3V and 5V output voltage.

AW3615A adopts valley current mode which can use a very small size LC filter circuit and has a good load transient response characteristics. The internal soft-start circuit and loop compensation circuitry also reduces the number of external components and system costs, and simplifies the design.

AW3615A integrates low $R_{DS(on)}$ Power MOSFETs (low-side NMOS and high-side PMOS). In medium and heavy load conditions, the chip operates at a quasi-constant 2.5MHz frequency in the continuous conduction of the PWM mode. In light load conditions, the chip will automatically switch to the Power Save mode which can optimize the efficiency of light load. In the PSM mode, which will close or de-biased most of the circuit except the output voltage detection module, only when VOUT dropped to a target voltage threshold, the circuit began to resume work. In Power Save mode, the quiescent current would reduce to only 44 μ A. AW3615A achieves the high efficiency in all load range by reducing the conduction loss and switching losses.

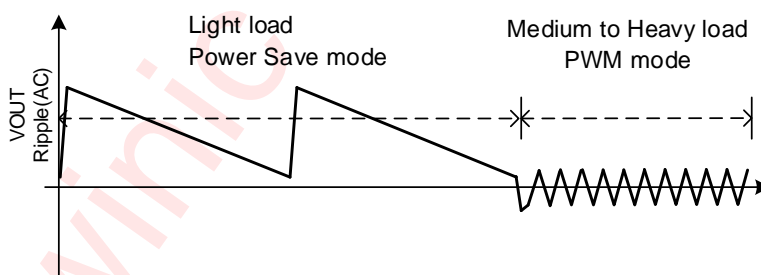
PWM mode

In medium and heavy load conditions, AW3615A operates at a quasi-constant 2.5MHz frequency (typ.). At the beginning of the switching cycle, the low-side NMOS switch is turned-on and the inductor current ramps up to a peak current that is defined by the on-time and the inductance. In the second phase, once the on-timer has expired, the rectifier is turned-on and the inductor current decays to a preset valley current threshold. Finally, the switching cycle repeats by setting the on timer again and activating the low-side NMOS switch.

Power Save Mode

AW3615A integrates a Power Save Mode to improve efficiency at light load. In Power Save mode, the converter only operates when the output voltage trips below a set threshold voltage. It ramps up the output voltage and goes into power save mode once the output voltage exceeds the set threshold voltage.

The following figure shows the VOUT ripple in PWM mode and Power Save mode.



Soft Start

AW3615A integrates soft start function in order to limit the surge current during the start of the power supply. During the start-up period, the chip linearly activates output terminal using the internal constant current source to charge the VOUT to allow VOUT rise gradually. When VOUT is close to VIN, the converter starts to switch. When the VOUT reaches to the target value, the loop stabilizes VOUT at the target value. In order to avoid inrush current and overshoot on VOUT, during soft start phase, the valley current limit is limited to 0.5A. Thus, it is recommended to add load after the AW3615A has completed start-up process. If the device is started with a load, it is recommended that the load does not exceed 400mA(typ.).

True Isolation and Reverse Current Protection

AW3615A through the substrate selection circuit to truly achieve the electrical isolation of VIN and VOUT. When the chip is turn-off, VOUT will drop to 0V, and will not draw current from VIN, meanwhile, when supply voltage to VOUT, it also will not lead current flow from VOUT to VIN.

Current Limit Operation

AW3615A provides a cycle by cycle valley current limiting function to protect the switch FET. When the inductor valley current reaches the current limit threshold, the current limiting circuit turns off the power MOSFET to allow the current to decrease to this threshold before the next cycle turns on. When the current limit is reached, the output voltage decreases during further load increase.

The current limit function is implemented by the scheme, refer to Figure 2.

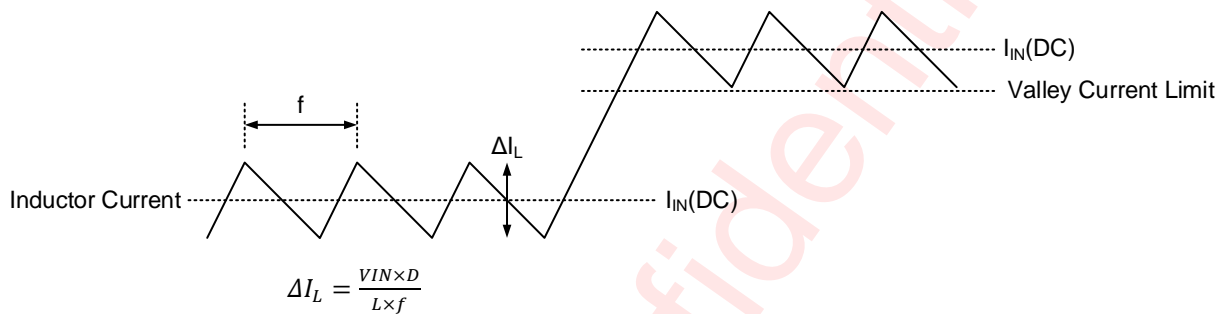


Figure 2. Inductor Currents In Current Limit Operation

Enable and Disable

The AW3615A operates when the input voltage is above UVLO rising threshold and the EN is high. In shutdown mode with a low EN voltage, the device stops switching and the rectifying PMOS turns off as well. This isolates the load from the input, so that the output voltage can drop below the input voltage during shutdown. In shutdown mode, input current is less than 0.3μA.

UVLO

UVLO circuit prevents the malfunction when the chip operate in low voltage. When VIN drops to under-voltage protection threshold V_{UVLO} (typ: 2.3V), it turns off. When VIN rises to 100mV higher than V_{UVLO} (typ: 2.4V), it resumes operate.

FB Mode Detection

Each time VIN power-on-reset occurs, the FB pin would detect external resistance between FB and ground. The detecting process runs as follow: a 300μA (typ.) current source charges the FB pin from VIN, meanwhile the chip starts a 20μs timer. If V_{FB} rises to higher than 2V (typ.) during the timer operating, which means the R_{FB} is greater than 6.7kΩ, the chip would enter external-resistor mode and the VOUT is set to $1V \cdot (R1 + R2) / R2$. On the other hand, if V_{FB} stays below 2V, the VOUT would be set to fixed 5V (typ.) with internal resistors.

Over-Voltage Protection

AW3615A features over-voltage protection(OVP) for maximum safety. When the output voltage of the AW3615A exceeds the OVP threshold of 6.4V, the device stops switching. The device will start operating again until the output voltage falling to 6.3V.

Pass-Through Mode

The AW3615A works in pass-through mode when VIN is higher than VOUT. With VIN raising, the AW3615A automatically into pass-through mode. During the pass-through mode, the high-side FET is fully turned on and the low side switch is turned off. The output voltage follows input voltage with the drop caused by the inductor resistance and the high-side FET resistance.

In the pass-through mode, the current limit is about 0.7A. When the load rises quickly, the system exits the pass-through mode due to the output voltage falling rapidly, and the time of exiting the pass-through mode is less than the internal current limit signal flip time(typ:15μs), then the circuit works in boost mode. When the load rises slowly, the internal current limit signal flips normally, then the output voltage gradually drops to 0V, and the circuit constantly tries to restart.

Thermal Shutdown

The AW3615A has an integrated thermal protection. The protection circuit senses the internal temperature of the chip and stop switching when temperature reaches 150°C. After the temperature returns to a safe value 20°C below the shutdown temperature, the system starts operating again.

Application Information

Programming the Output Voltage

There are two ways to set the output voltage of the AW3615A.

For fixed output voltage version, the FB pin is connected to GND, the VOUT would be set to fixed 5V.

For adjustable output voltage version, the output voltage could be adjusted by connecting FB to the tap of an external voltage divider from VOUT to ground, as shown in following Equation, and the typical voltage at the FB pin is 1.0V.

$$V_{OUT} = V_{FB} \cdot \frac{R_1 + R_2}{R_2}$$

For the best accuracy and low quiescent current, R1 and R2 value usually are large. The current following through R2 should be 100 times larger than FB pin leakage current. Reducing the R2 value can improve the robustness against noise injection. Increasing the R2 value reduces the FB divider current for achieving the highest efficiency at low load current. The total resistance of the R1 and R2 should be maintained below 2MΩ, when the total resistance exceeds 400kΩ, a COP capacitor should be added.

Maximum Output Current

The maximum output current of the AW3615A can be estimated by following Equation. It determined by the input to output ratio and the current limit of the step-up converter.

$$I_{OUT(MAX)} = \frac{VIN \cdot \left(I_{LIM} - \frac{\Delta I_L}{2} \right) \cdot \eta}{V_{OUT}}$$

Where η is the conversion efficiency, using 85% for estimation; ΔIL is the current ripple value and ILIM is the switch current limit.

Typically, the maximum output current of the typical application circuit is as follows in this table. The adjustable output voltage is 5V and the DCR of the inductor is 16mΩ.

VIN	2.5V	3.3V	3.7V	4.4V
Maximum output current	1.2A	1.8A	2.0A	2.8A

Voltage across the DCR decreases the effective voltage across the inductor, which will affects the maximum output current. Especially at low input voltage, the voltage across the DCR and the low-side switch become

large enough that could not be ignored for the effect on maximum output current.

Inductor Selection

Inductor is the most important component in power regulator design. In order to ensure proper operation of the steady state, transient behavior, and loop stability, inductor value, saturation current, and dc resistance (DCR) deserve careful consideration.

The inductor peak current varies as a function of the load, the input and output voltages. It can be estimated using follow equations.

$$I_{IN} = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times \eta} \quad (1)$$

$$\Delta I_L = \frac{V_{IN} \times D}{L \times f} \quad (2)$$

$$D = 1 - \frac{V_{IN}}{V_{OUT}} \quad (3)$$

$$I_{LIM} = I_{IN} + \frac{1}{2} \times \Delta I_L \quad (4)$$

For example, $V_{IN}=3.3V$, $V_{OUT}=5V$, $I_{OUT}=1.5A$, converter efficiency=90%, Frequency=2.5MHz.

The recommended nominal inductance value is 0.56 μ H. It is recommended to use inductor with DC saturation current $\geq 3A$. However, considering the short condition, we recommend that the saturation current is greater than 5A.

Input Capacitor Selection

Multilayer ceramic capacitors are an excellent choice for input decoupling of the step-up converter since they have extremely low ESR and are available in small footprints. Input capacitors should be placed as close as possible to the device. While a 10 μ F input capacitor is sufficient for most applications, larger values can be used to reduce input current ripple without limitations.

A 47 μ F or higher capacitance capacitor is recommended to damp the wiring harness inductance, while the AW3615A is located far away from the input source.

Output Capacitor Selection

For the output capacitor, it is recommended to use small ceramic capacitors placed as close as possible to the VOUT and GND pins of the IC. The output capacitors of step-up converter dictate the output voltage ripple and load transient response.

To get an estimate of the recommended minimum output capacitance, equation 5 can be used. where ΔV is the maximum allowed output ripple.

$$C_{MIN} = \frac{I_{OUT} \times (V_{OUT} - V_{IN})}{f \times \Delta V \times V_{OUT}} \quad (5)$$

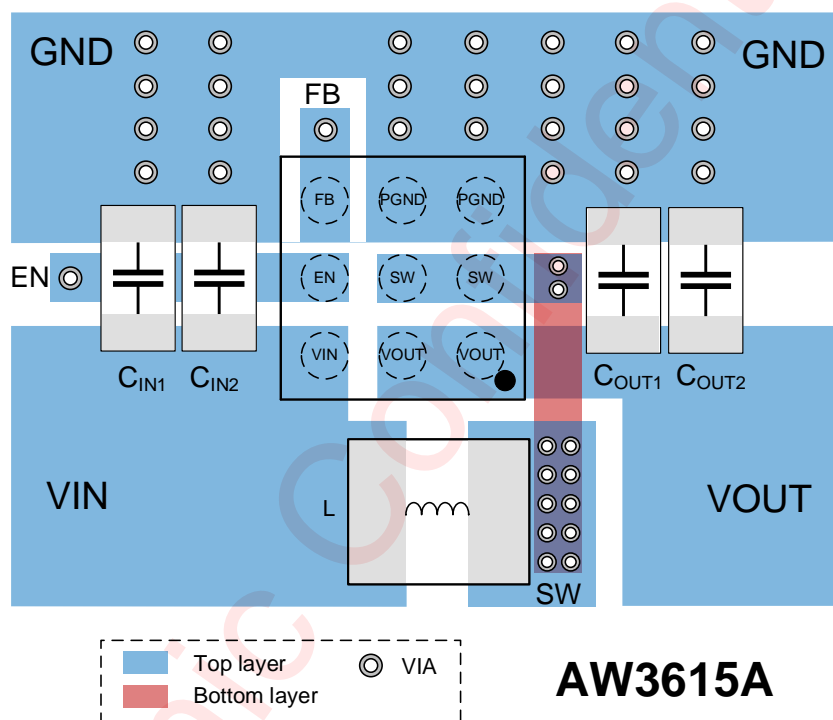
Since AW3615A is an internally compensated device, the loop response is optimized for capacitor in the range of 12.2 μ F to 50 μ F. The value of 20 μ F is recommended. Due to the DC bias nature of ceramic capacitors, care should be taken by verifying manufacture's datasheet to ensure enough effective capacitance at desired output voltage. When VOUT exceeds 4.5V and the input and output voltage differential is less than 0.4V, it is recommended to increase the output capacitor to 44 μ F.

DC bias effect: ceramic capacitors exhibit DC bias effects, which have a strong influence on the effective capacitance of the device. Therefore, the right capacitor value has to be chosen very carefully. Package size and voltage rating in combination with material are responsible for differences between the rated capacitor value and effective capacitance. For instance, a 10 μ F X5R 6.3V 0603 MLCC capacitor would typically show an effective capacitance of less than 4 μ F under 5V bias condition.

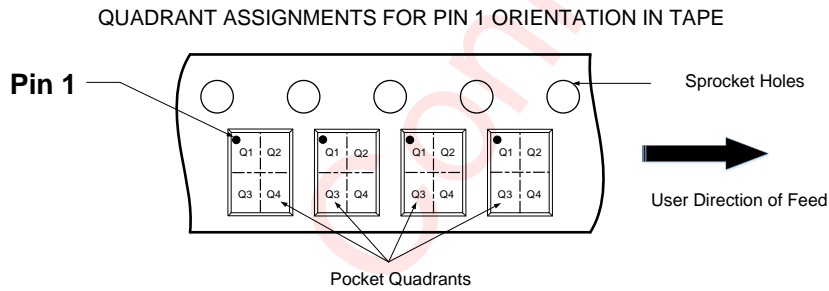
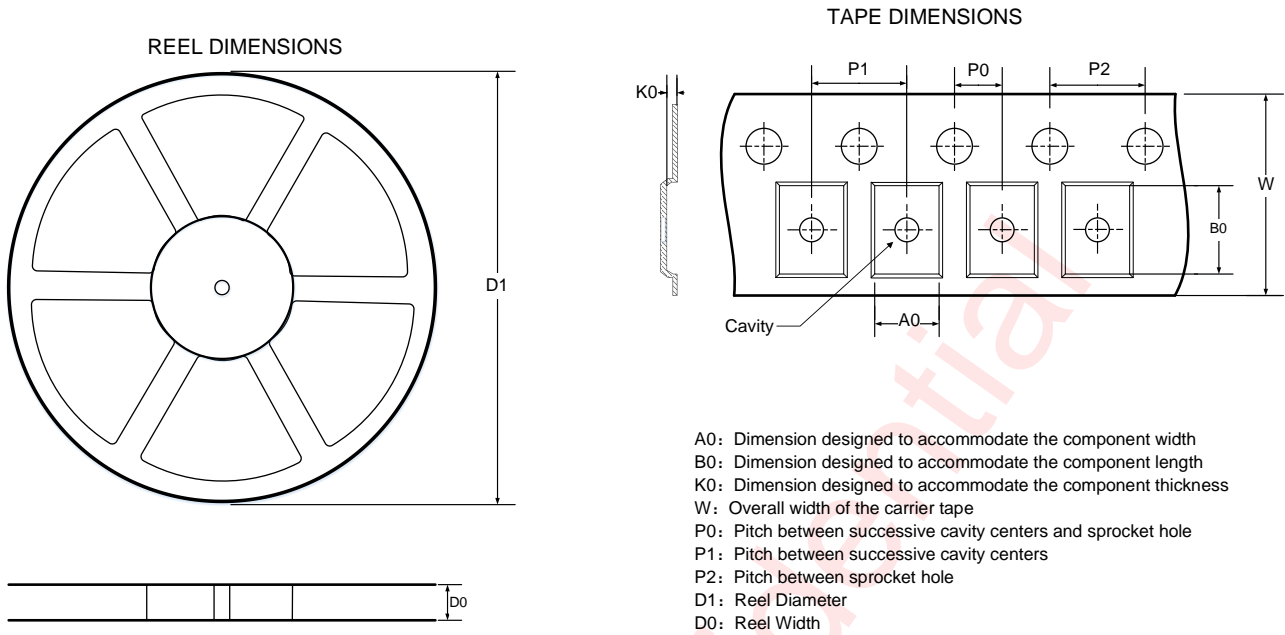
PCB Layout Consideration

AW3615A is a boost convert, to obtain the optimal performance, PCB layout should be considered carefully. Here are some guidelines:

1. C_{IN1} , C_{IN2} , C_{OUT1} , C_{OUT2} should be placed as close to chip as possible.
2. Wide and short traces should be used for main current path and the power ground paths.
3. For thermal reasons, it is suggested to maximize the pour area for VIN, VOUT and PGND. Especially the ground pour should be set to fill all available PCB surface area and tied to internal layers with a cluster of thermal vias.
4. For step-up converter, the current loop of the output capacitor's from VOUT pin back to the GND pin should be as small as possible.
5. It is recommended to use a four-layer board to improve the stability of the circuit.



Tape And Reel Information



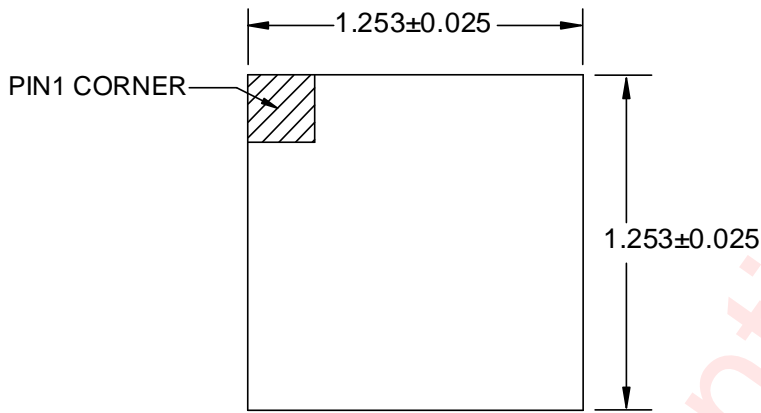
Note: The above picture is for reference only. Please refer to the value in the table below for the actual size

DIMENSIONS AND PIN1 ORIENTATION

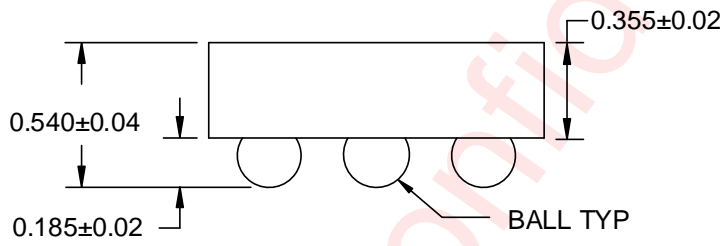
D1 (mm)	D0 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
180.00	8.60	1.38	1.38	0.65	2.00	4.00	4.00	8.00	Q1

All dimensions are nominal

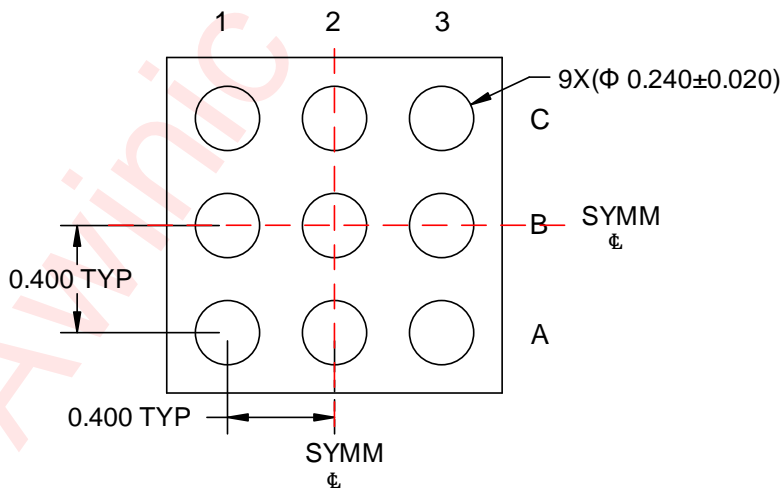
Package Description



Top View



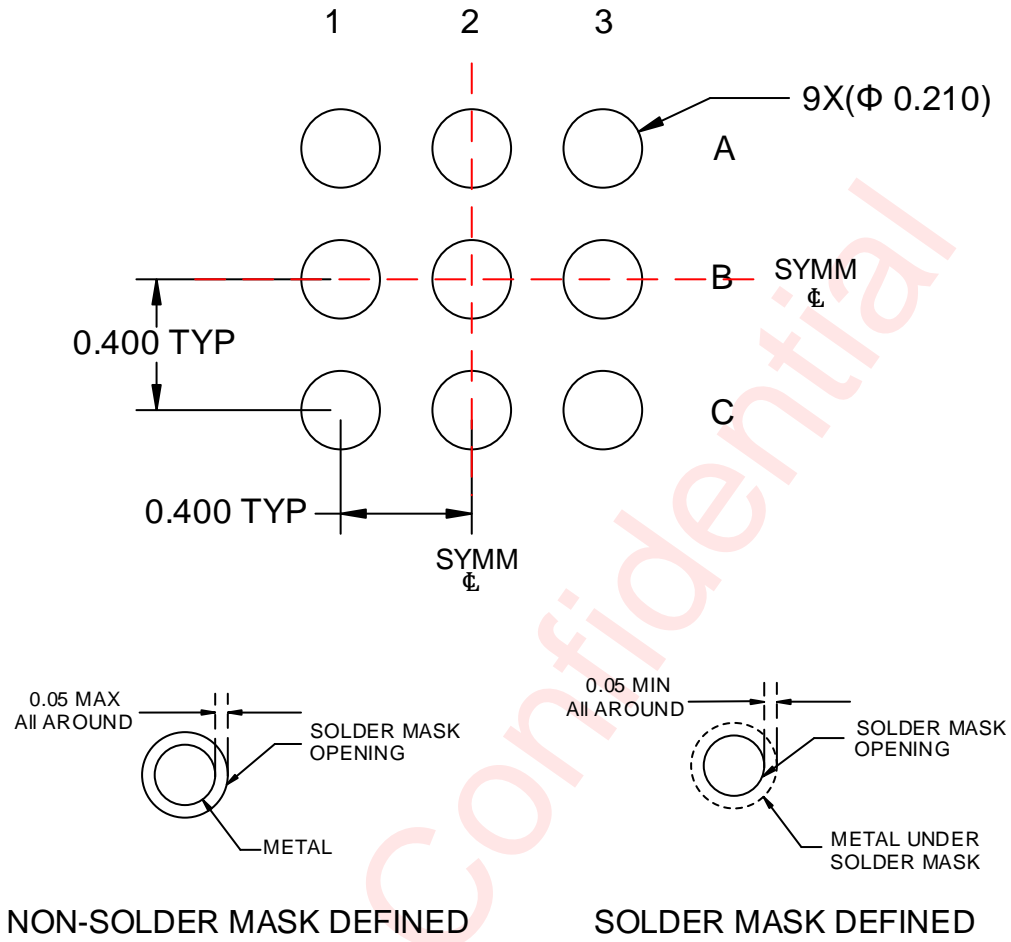
Side View



Bottom View

Unit: mm

Land Pattern Data



Unit: mm

Revision History

Version	Date	Change Record
V1.0	Jun. 2024	Officially released
V1.1	Jul. 2025	<ol style="list-style-type: none">1. Update the typical application circuits(P1/P3)2. Modify the inductance range(P4)3. Update the efficiency curve(P6)4. Update the “Soft Start” section in “Detailed Functional Description”(P9)5. Update the “Programming the Output Voltage” section and the “Output Capacitor Selection” section in “Application Information”(P11/P12)

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