1.2A Synchronous Buck LED Driver

Features

- 2.7V~5.5V Input Voltage
- 0.2V Reference Voltage
- 1.2A Peak Output Current
- PWM Control Analog Dimming
- Low Dropout Operating at 100%Duty Cycle
- Over-Temperature Protection
- Over-Current Protection
- Fixed 1.5MHz Switching Frequency
- <1μA Input Current During Shutdown
- DFN 2mm×2mm×0.75mm -6L Package

Applications

IR-LED Driver
NB Camera
VCSEL Driver

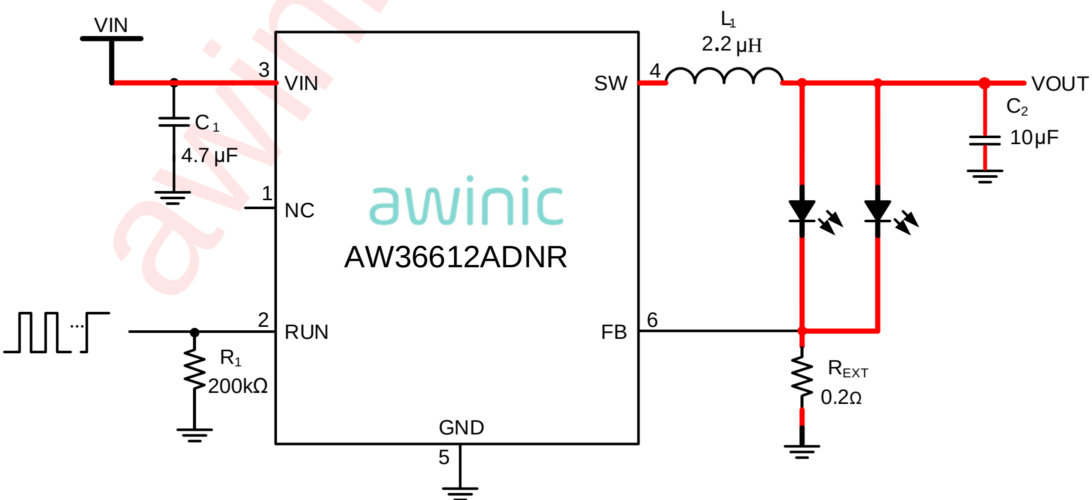
General Description

The AW36612A is a LED driver that designs with current mode. The AW36612A utilizes a 1.5MHz frequency synchronous buck converter to provide power to the 1.2A peak constant current LED sources. The device also provides hardware RUN pin to realize PWM to Analog dimming function. Input voltage from 2.7V to 5.5V makes the AW36612A ideally suited for single Li-Lon battery powered applications.

The device operates over a -40°C to +85°C ambient temperature range. The fault protection includes OCP function which ensure the peak of inductor current is less than 1.7A.The use of synchronous switches instead of external Schottky diode improves the efficiency.

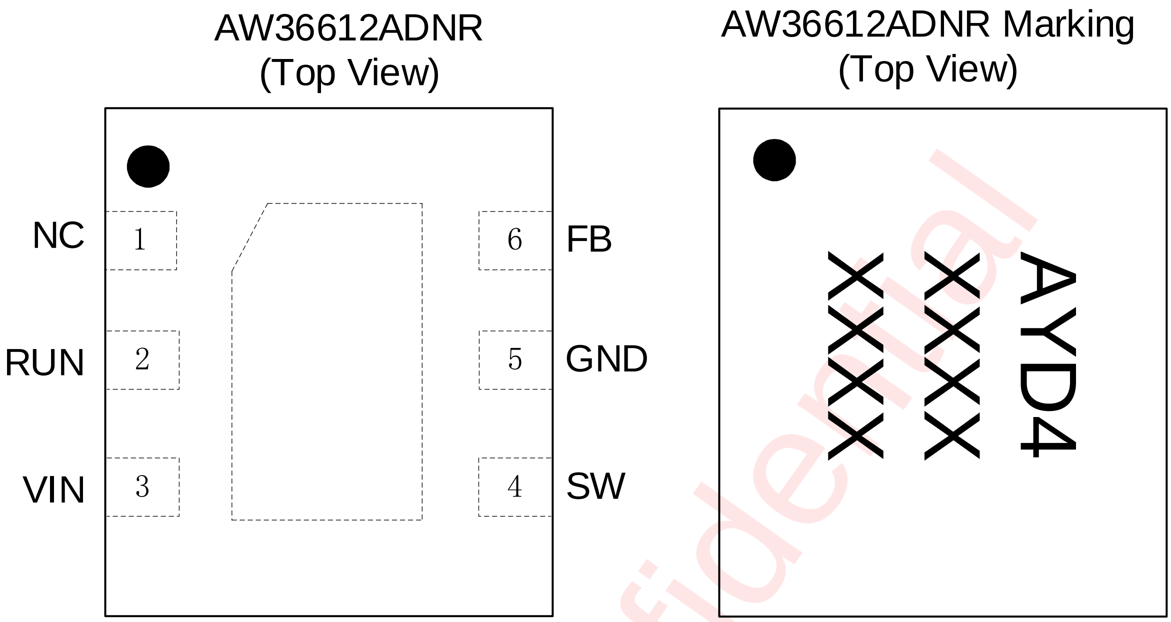
The AW36612A is available in DFN 2mm×2mm ×0.75mm -6L package.

Typical Application Circuit



Typical Application Circuit of AW36612ADNR

Pin Configuration And Top Mark



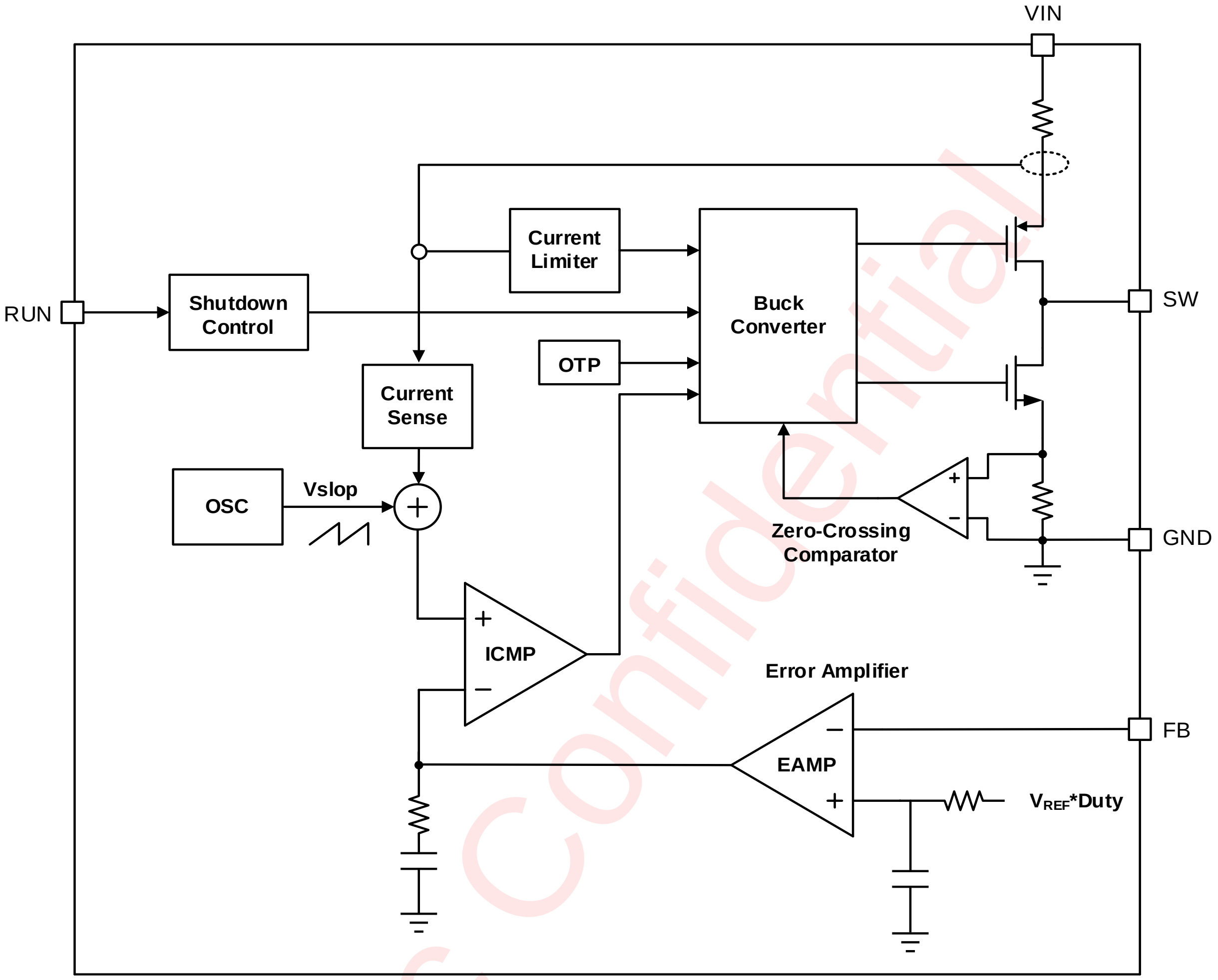
AYD4 - AW36612ADNR
XXXX/XXXX - Production Tracing Code

Pin Configuration and Top Mark

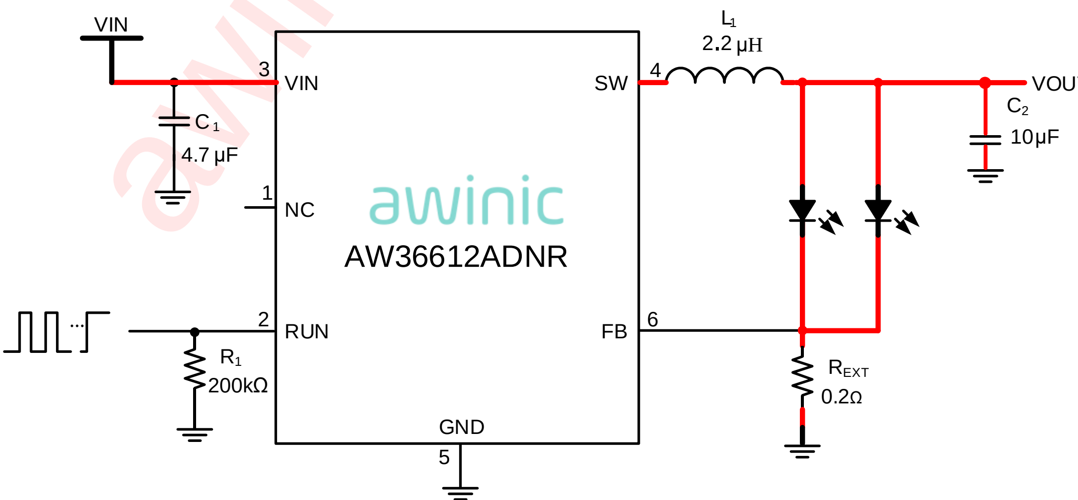
Pin Definition

No.	NAME	DESCRIPTION
1	NC	Not connect
2	RUN	Enable control pin and PWM signal input. Do not leave RUN pin floating
3	VIN	Power supply: 2.7V~5.5V
4	SW	Switch node connected to inductor
5	GND	Ground
6	FB	Feedback input pin. The buck regulator senses feedback voltage via FB

Functional Block Diagram



Typical Application Circuits



AW36612ADNR Application Circuit

Ordering Information

Part Number	Temperature	Package	Marking	Moisture Sensitivity Level	Environmental Information	Delivery Form
AW36612ADNR	-40℃～85℃	DFN 2mm×2mm×0.75 mm -6L	AYD4	MSL1	ROHS+HF	3000 units/ Tape and Reel

Absolute Maximum Ratings(NOTE1)

PARAMETERS		RANGE
Supply voltage range VIN		-0.3V to 6V
Input voltage range	RUN, FB	−0.3V to (VIN+0.3)V
Output voltage range	SW	−0.3V to (VIN+0.3)V
Junction-to-ambient thermal resistance θ_{JA}		105°C /W
Maximum operating junction temperature T_{JMAX}		150°C
Storage temperature T_{STG}		-65°C to 150°C
Lead temperature (soldering 10 seconds)		260°C
ESD(Including CDM HBM)(NOTE 2)		
VBUS PIN HBM		±2kV
Other PINS HBM		±2kV
CDM		±1.5kV
Latch-Up		
Test condition: JEDEC JESD78F.01-2022		+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: The human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin.

Test method: ANSI/ESDA/JEDEC JS-001-2023. ANSI/ESDA/JEDEC JS-002-2022 *(CDM).*

Recommended Operating Conditions

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{IN}	Input voltage	2.7		5.5	V
C_{IN}	Input capacitance	4.7		100	μF
C_{OUT}	Output capacitance	4.7	10	100	μF
L_1	Converter Output Inductor	2.2		4.7	μH
T_A	Operating free-air temperature range	-40		85	°C

Electrical Characteristics

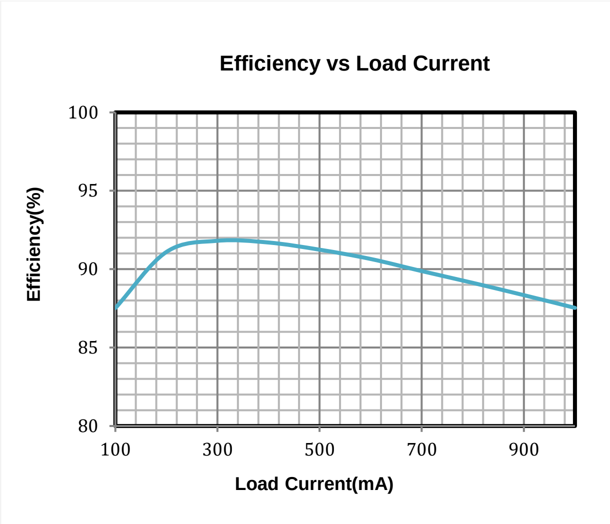
VIN=5V and T_A=25°C for typical values (unless otherwise noted)

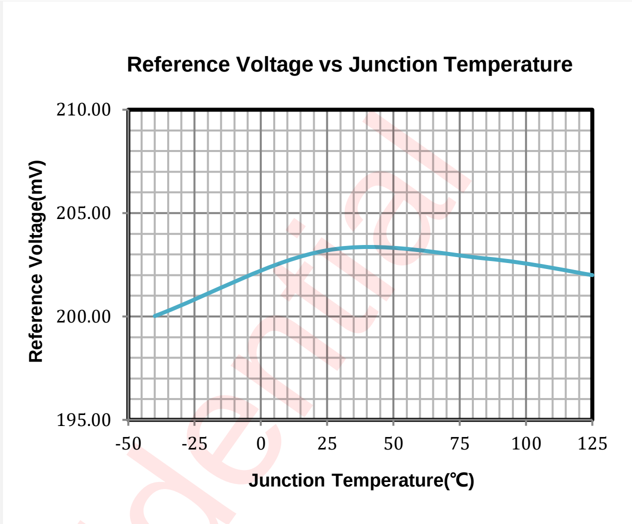
PARAMETER		TEST CONDITION	MIN	TYP	MAX	UNIT
SUPPLY VOLTAGE AMD CURRENT						
V_{IN}	Input Voltage Range		2.7		5.5	V
I_{SD}	Shutdown Input Current	RUN=GND			1	μA
POWER-ON-RESET						
V_{POR}	Rising POR Threshold		2.05	2.2	2.6	V
V_{POR_HYS}	POR Hysteresis			100		mV
REFERENCE VOLTAGE						
V_{FB}	Voltage of FB		0.19	0.2	0.21	V
I_{FB}	FB Input Current	V_{IN}=5V	-100		100	nA
INTERNAL POWER MOSFETS						
F_{SW}	Switching Frequency		1.2	1.5	1.9	MHz
R_{P_FET}	High Side P-FET Switch ON Resistance	I_{SW}=10mA		260		mΩ
R_{N_FET}	Low Side N-FET Switch ON Resistance	I_{SW}=10mA		140		mΩ
T_{ON_MIN}	Minimum On-Time	(note 3)		100		ns
D_{max}	Maximum Duty Cycle				100	%
PROTECTION						
I_{LIM}	Maximum inductor Current-Limit	I_{P_FET},VIN=5V	1.3	1.7	2.2	A
T_{OTP}	Over-Temperature Protection	(note 3)		160		°C
T_{OTP_HYS}	Over-Temperature Protection hysteresis			30		°C
START-UP AND SHUTDOWN						
VIH	RUN Input High Threshold	V_{IN}=2.7V~5.5V	1			V
VIL	RUN Input Low Threshold	V_{IN}=2.7V~5.5V			0.4	V
I_{RUN}	RUN Leakage Current	V_{IN}=5V, V_{RUN}=5V	-0.1		0.1	μA
PWM DIMMING						
F_{PWM}	PWM Dimming Frequency		20		200	kHz
D_{PWM}	PWM Dimming Duty		5		100	%

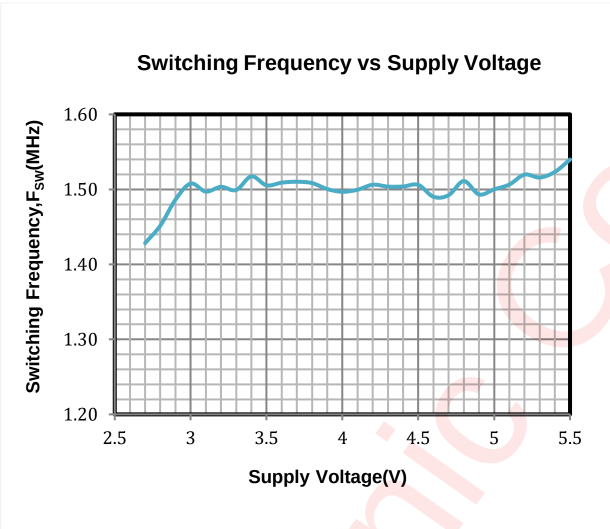
NOTE3:Guarantee by design, not production test.

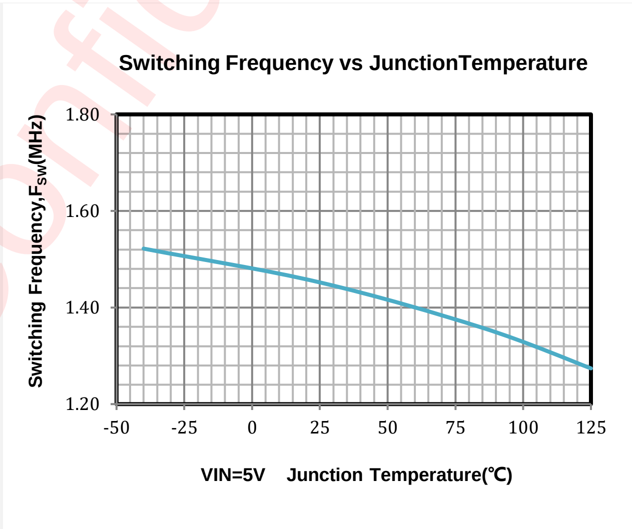
Typical Characteristics

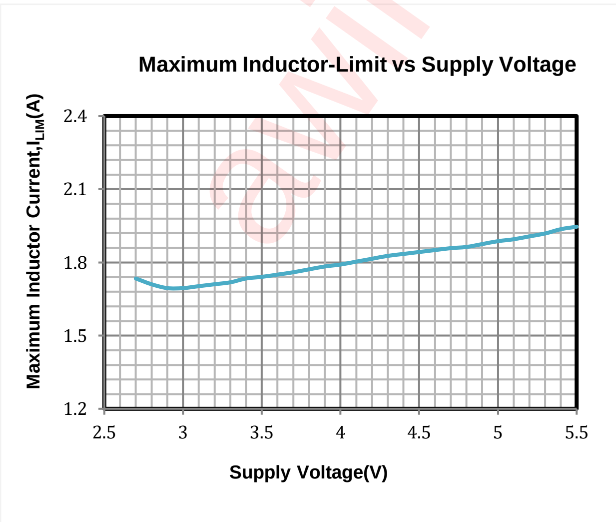
VIN=5V and T_A=25°C for typical values (unless otherwise noted)

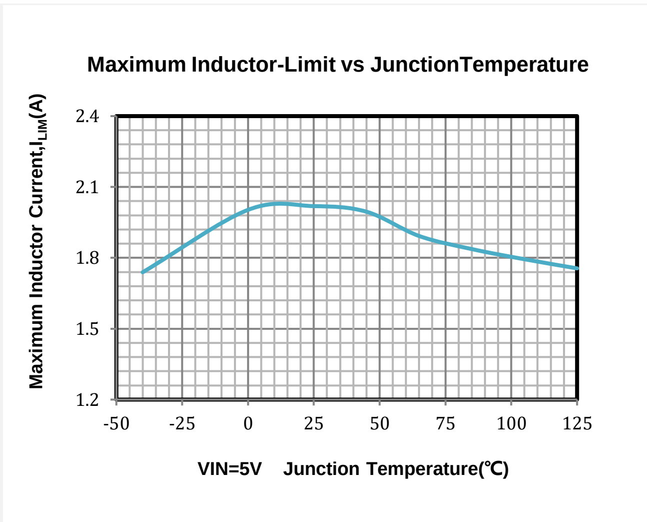


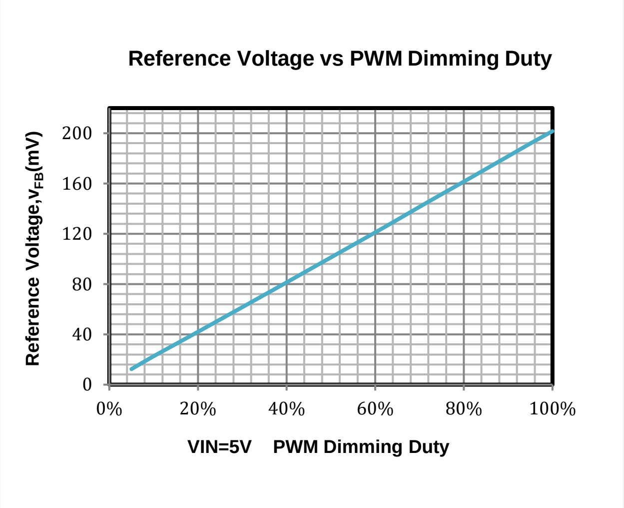












Detailed Functional Description

Main Control Loop

The AW36612A is a LED driver that designs with current mode. Input voltage from 2.7V to 5.5V makes the AW36612A ideally suited for single Li-Lon battery powered applications. In normal operation, the internal P-channel power MOSFET is turns on each cycle. The P-FET is turned by the voltage on the ICMP node, which is controlled by output of the error amplifier(EAMP).

The current output can be set by external R_{EXT} resistors. The R_{EXT} resistor connected between V_{OUT} and ground allows the EAMP to receive an output feedback voltage V_{FB} at FB pin. The voltage on the FB pin is regulated to the 0.2V typically when the logic level of RUN is high. The R_{EXT} resistor needs to be placed as close as possible to the FB pin. When the load current increases, it causes a slightly decrease in V_{FB} relative to the 0.2V reference until the average inductor current matches the new load current.

Enable/Shutdown

The AW36612A device has an enable pin for RUN. The device starts to operate as long as the RUN voltage is higher than VIH. When RUN voltage is lower than VIL, the device is in shut down mode, The internal power MOSFETs turn off, the quiescent current I_{SD} reduces to 1μA maximum.

PWM to Analog Dimming

The AW36612A supports PWM to analog dimming to adjust the LED current by simply supply a PWM signal to the RUN pin. In this condition, the LED current is continues and the current magnitude is adjusted by changing PWM duty cycle. It is because the internal reference voltage is filter from the PWM signal by RC circuit. The dimming frequency is recommended between 20kHz to 200kHz.

Slop Compensation

The AW36612A device incorporates a 1.5MHz constant frequency-synchronous peak current mode. To prevent sub-harmonic oscillations, the AW36612A sense the peak current and add slop compensation to stable the converter. It is accomplished by adding a compensating ramp to the inductor current.

Over-Temperature Protection(OTP)

The AW36612A device monitors device junction temperature. When the junction temperature reaches thermal shutdown threshold T_{OTP}(TYP:160°C), the device turns off the both power MOSFETs, allowing the junction temperature to decrease. Once the junction temperature falls below T_{OTP_HYS}(TYP:30°C), the device recovers to normal operation.

Over-Current Protection(OCP)

The current limit is sensed by P-channel MOSFET, when the inductor current limit reaches I_{LIM}(TYP:1.7A), the AW36612A device turns off P-channel power MOSFET until the next switching period. If the over-current condition persists, the device operates continuously in current limit.

Application Information

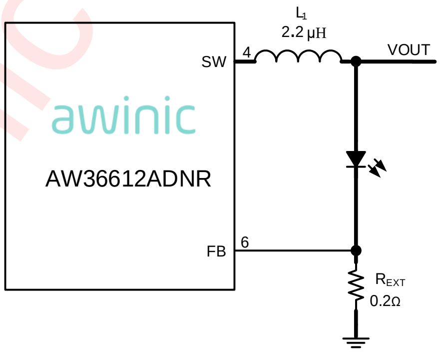
Output Current Setting

The current output can be set by external R_{EXT} resistors. The R_{EXT} resistor connected between V_{OUT} and ground allows the EAMP to receive an output feedback voltage V_{FB} at FB pin. The voltage on the FB pin is regulated to the 0.2V typically, and the current output on V_{FB} pin can be calculated by using:

$$I_{LED} = \frac{V_{FB} \cdot D_{PWM}}{R_{EXT}}$$

Where

- V_{FB}=0.2V (typical)
- R_{EXT}=0.2Ω recommended
- D_{PWM}=5%~100% recommended



External Resistor Configuration

Inductor Selection

For high efficiencies, the inductor should have a low DC resistance to minimize conduction losses. Especially at high-switching frequencies the core material has a higher impact on efficiency. When using small chip inductors, the efficiency is reduced mainly due to higher inductor core losses. This needs to be considered when selecting the appropriate inductor. The inductor value determines the inductor ripple current. The larger the inductor value, the smaller the inductor ripple current and lower the conduction losses of the converter. Conversely, lager inductor values cause a slower load transient response. The recommended inductor value can be calculated as below:

$$L \geq \frac{V_{OUT}(1-D)}{fsw \cdot \Delta I_L}$$

Where D is duty cycle of main switch

$$D = \frac{V_{OUT}}{V_{IN}}$$

And f_{sw} =1.5MHz.

$$I_{L\_max} = I_L + \frac{1}{2}\Delta I_L$$

To avoid the saturation of the inductor, the inductor should be rated at least for the maximum output current of the converter plus the inductor ripple current.

Input Capacitor Selection

Choosing the correct size and type of input capacitor helps minimize the voltage ripple caused by the switching of the AW36612A buck converter and reduce noise on the buck converter's input pin that can feed through and disrupt internal analog signals. In the typical application circuit a 4.7-μF ceramic input capacitor works well. It is important to place the input capacitor as close as possible to the AW36612A input (VIN) pin. This reduces the series resistance and inductance that can inject noise into the device due to the input switching currents.

Output Capacitor Selection

The AW36612A is designed to operate with a 10μF ceramic output capacitor. When the buck converter is running, the output capacitor supplies the load current during the buck converter off-time. When the P-channel power MOSFET turns off, the inductor energy is discharged through the internal NMOS switch, supplying power to the load and restoring charge to the output capacitor. This causes a sag in the output voltage during the off-time and a rise in the output voltage during the on-time. The output capacitor is therefore chosen to limit the output ripple to an acceptable level depending on load current and input/output voltage differentials and also to ensure the converter remains stable.

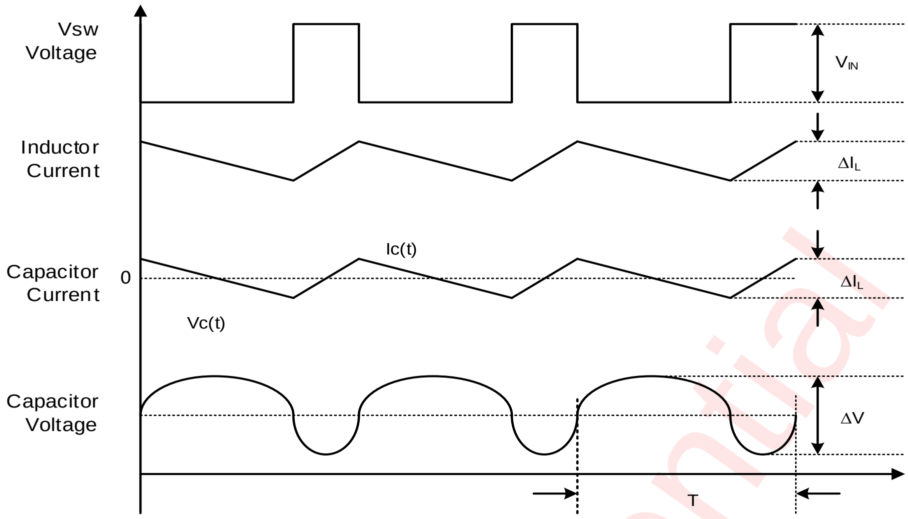
Larger capacitors or capacitors in parallel can be used if lower output voltage ripple is desired. The output ripple is the sum of the voltage across the ESR and the ideal output capacitor:

$$\Delta V = \Delta I_L \left(ESR + \frac{1}{8 \cdot fsw \cdot C_{OUT}}\right)$$

Where

$$\Delta I_L = \frac{V_{OUT} \times (1-D)}{fsw \cdot L}$$

$$T = \frac{1}{fsw}$$



Output Ripple

When choosing the input and output ceramic capacitors, choose the X5R or X7R dielectric formulations. These dielectrics have the best temperature and voltage characteristics of all the ceramics for a given value and size.

Thermal Consideration

In most applications, the AW36612A does not dissipate much heat due to its high efficiency. But, in applications where the AW36612A is running at high ambient temperature with low supply voltage and high duty cycles, the heat dissipated may exceed the maximum junction temperature reaches approximately 160°C, both power switches will be turned off and the SW node will become high impedance.

To avoid the AW36612A from exceeding the maximum junction temperature, the user will need to do some thermal analysis. The goal of the thermal analysis is to determine whether the power dissipated exceeds the recommended junction temperature of the part. The power dissipated by the part is approximated:

$$P_D \cong {I_{OUT}}^2 \left(R_{P\_FET} \cdot D + R_{N\_FET} \cdot (1 - D)\right)$$

The temperature rise is given by:

$$T_R = P_D \cdot \theta_{JA}$$

Where P_D is the power dissipated by the regulator, The θ_{JA} is the thermal resistance from the junction of the die to the ambient temperature. The junction temperature, T_J is given by:

$$T_J = T_A + T_R$$

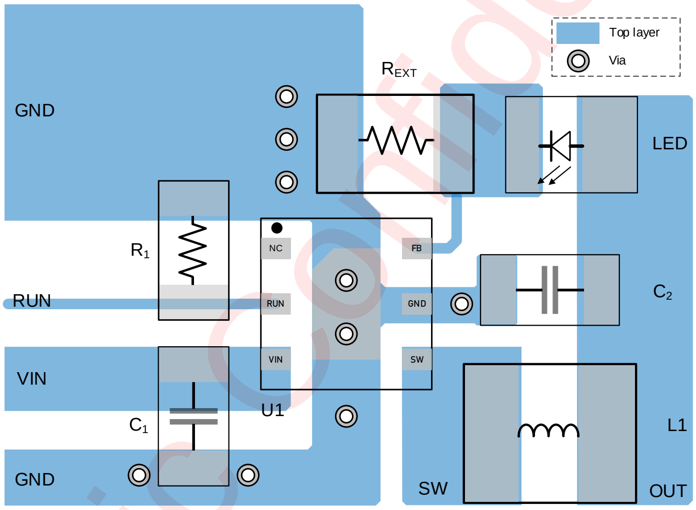
Where T_A is the ambient temperature.

PCB Layout Consideration

Layout Guidelines

The high switching frequency of the AW36612A makes the design of PCB Layout important. The following steps give some guidelines to help ensure a proper layout for optimal performance.

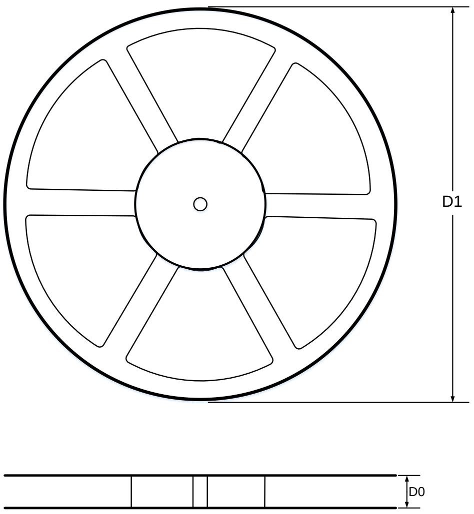
1. Place the input capacitors as close to the device as possible. The traces which connect the input capacitors to both the VIN and GND pins should be short and wide to reduce parasitic inductance and resistance.
2. The trace between the inductor and the SW pin should be as short as possible to minimize the radiated noise.
3. Keep the trace of FB as short as possible and away from the switching signal. The FB trace must be shield with a ground plane.
4. Maximize the area of PCB copper connected to the GND pin for good thermal and noise performance.



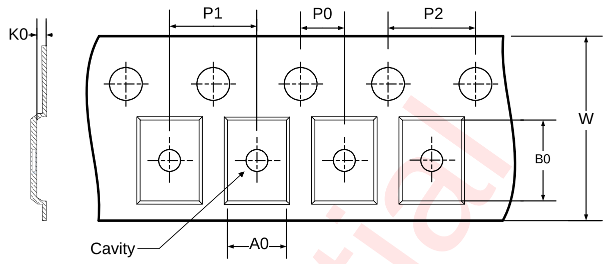
AW36612ADNR Layout Example

Tape And Reel Information

REEL DIMENSIONS

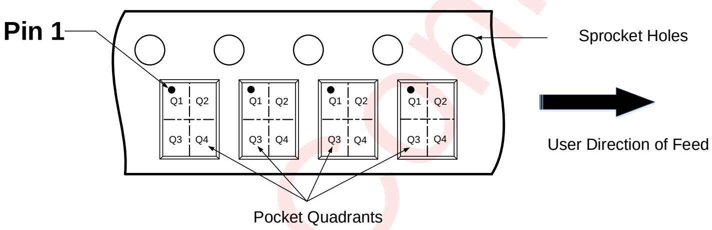


TAPE DIMENSIONS



A0：Dimension designed to accommodate the component width
B0：Dimension designed to accommodate the component length
K0：Dimension designed to accommodate the component thickness
W：Overall width of the carrier tape
P0：Pitch between successive cavity centers and sprocket hole
P1：Pitch between successive cavity centers
P2：Pitch between sprocket hole
D1：Reel Diameter
D0：Reel Width

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



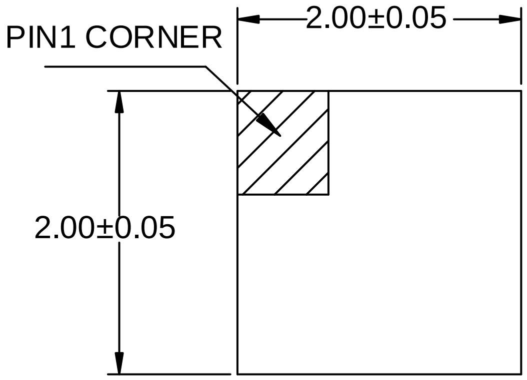
Note：The above picture is for reference only. Please refer to the value in the table below for the actual size

DIMENSIONS AND PIN1 ORIENTATION

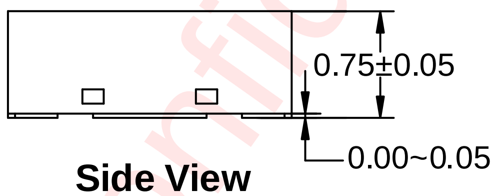
D1 (mm)	D0 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
178	8.4	2.3	2.3	1	2	4	4	8	Q1

All dimensions are nominal

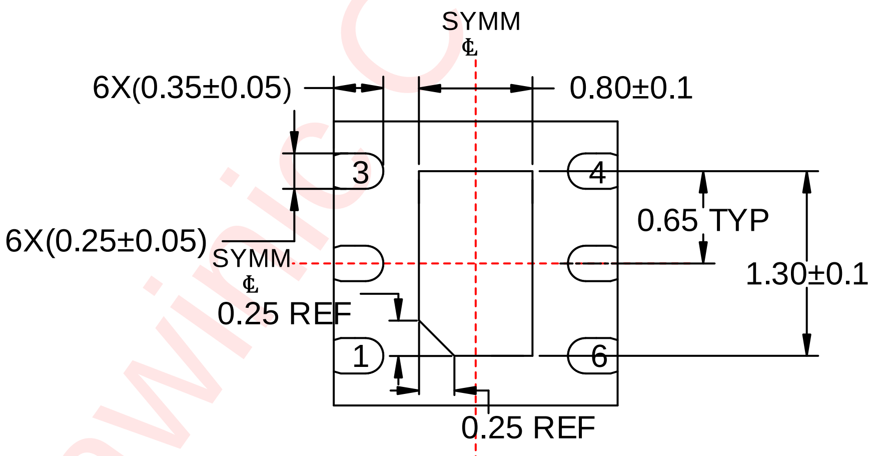
Package Description



Top View



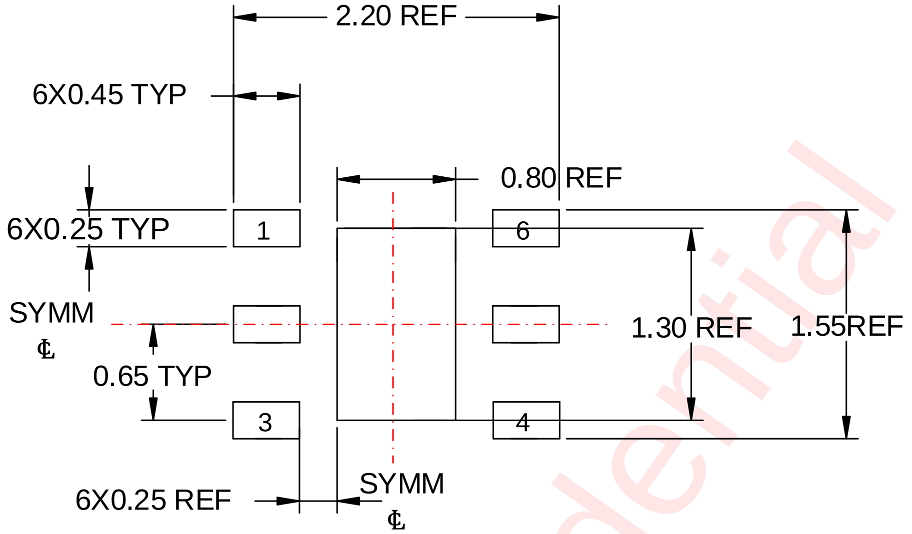
Side View

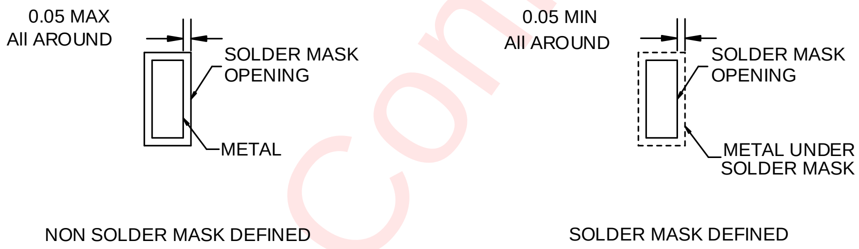


Bottom View

Unit：mm

Land Pattern Data





Unit：mm

Revision History

Version	Date	Change Record
V1.0	Sept. 2023	Officially released

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