

## 200mA 1-Wire Configurable Front Flash LED Driver with Ultra Small Package

### FEATURES

- Front Flash LED Driving
- 200mA Maximum LED Current
- 16 LED Current Levels Selectable by 1-wire Interface
- LED Current Accuracy:  $\pm 8\%$
- Low Dropout Voltage: 50mV@200mA
- LED Short Protection
- Under Voltage Lock Out (UVLO)
- Over Thermal Protection(OTP)
- Ultra Small 1.5mm×1.0mm DFN-6 Package  
Compatible with AW3640

### APPLICATION

- Cell Phone

### GENERAL DESCRIPTION

The AW36402 is a low voltage-drop current sink LED driver, which supports both flash and torch applications. The current-regulation sink integrated in the chip makes the LED current be capable of keeping constant when input voltage, LED forward voltage or temperature are changing. The LED current can be adjusted among 16 steps by sending 1-wire pulses into the EN pin, and the maximum value is 200mA.

The AW36402 is available in an ultra-small 1.5mm×1.0mm DFN-6 package, and only one multi-layer ceramic capacitor is needed for the peripheral of the solution.

In shut down mode, the AW36402 turns off all internal circuits and the consumption is less than 1 $\mu$ A.

The device requires 2.7V~5.5V input voltage range and an operating temperature range of -40~85 $^{\circ}$ C.

### TYPICAL APPLICATION CIRCUIT

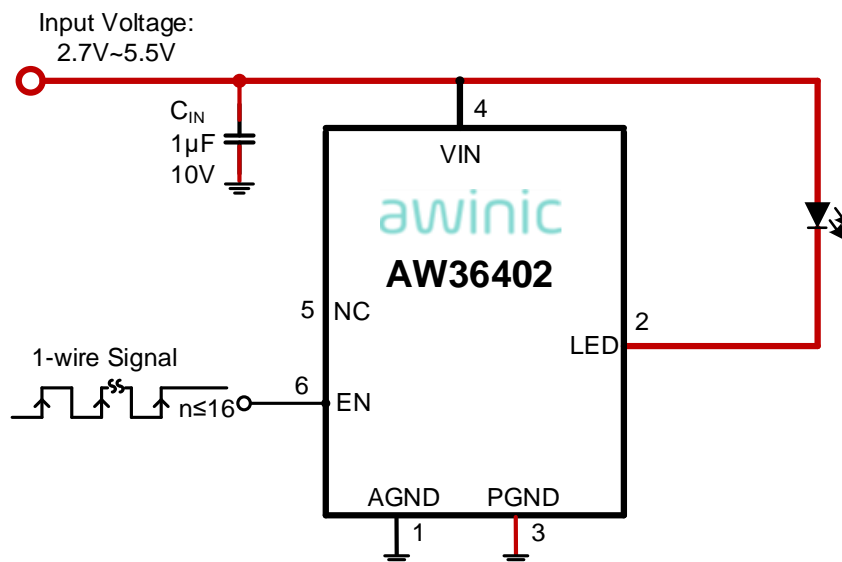
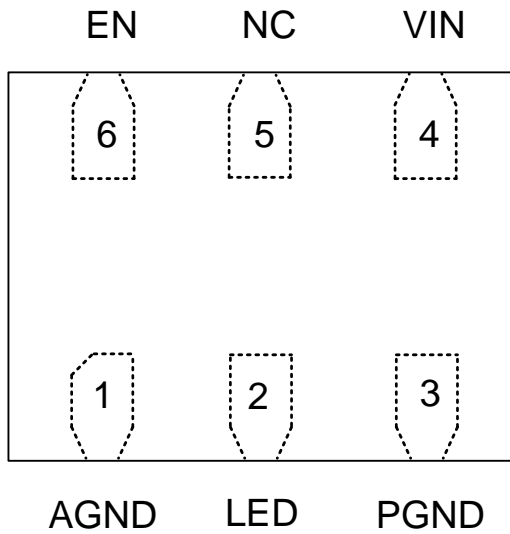


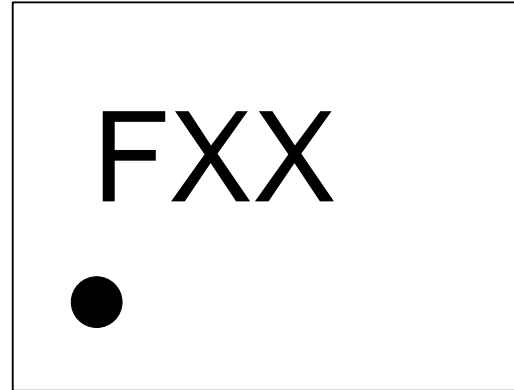
Figure 1. The AW36402 Application Circuit for Single LED

## PIN CONFIGURATION AND TOP MARK

### AW36402DNR Pin Configuration (Top View)



### AW36402DNR Marking (Top View)



F -- AW36402DNR  
XX -- Production Tracking Code

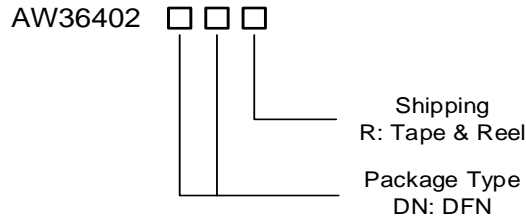
Figure 2. The AW36402 Pin Configuration and Top Mark

## PIN DEFINITION

No.	NAME	TYPE	DESCRIPTION
1	AGND	Ground	Analog Ground.
2	LED	I/O	Low-Side Current Sink Output for LED.
3	PGND	Ground	Power Ground.
4	VIN	Power	Power Supply (2.7V-5.5V).
5	NC	I/O	No Connect.
6	EN	I/O	Enable Pin. LED Current Can be Adjusted by Sending 1-wire Pulse into This Pin.

## ORDERING INFORMATION

Part Number	Temperature	Package	Marking	Moisture Sensitivity Level	Environmental Information	Delivery Form
AW36402DNR	-40°C~85°C	DFN-6 1.5mm*1mm	FXX	MSL1	ROHS+HF	3000 units/ Tape and Reel



## AWINIC FLASH LED DRIVER SERIES

Product	Channels	Type	Description	Package
AW3644	2	Boost	High Efficiency, Dual Independent 1.5A Flash LED Driver	CSP-12
AW36414	2	Boost	High Efficiency, Dual Independent 1.5A Flash LED Driver	CSP-12
AW3643	2	Boost	High Efficiency, Dual 1.5A Flash LED Driver	CSP-12
AW36413	2	Boost	High Efficiency, Dual 1.5A Flash LED Driver	CSP-12
AW3648	1	Boost	High Efficiency, 1.5A Flash LED Driver	CSP-12
AW3641E	1	Charge Pump	Flash Current & Flash Timer Programmable 1A Flash LED Driver	DFN-10
AW3640	1	Current Sink	200mA 1-Wire Configurable Front Flash LED Driver	DFN-6
AW36402	1	Current Sink	200mA 1-Wire Configurable Front Flash LED Driver	DFN-6
AW36404	1	Current Sink	400mA 1-Wire Configurable Front Flash LED Driver	DFN-8
AW36406	1	Current Sink	600mA PWM Configurable Front Flash LED Driver	DFN-8

## TYPICAL APPLICATION CIRCUIT

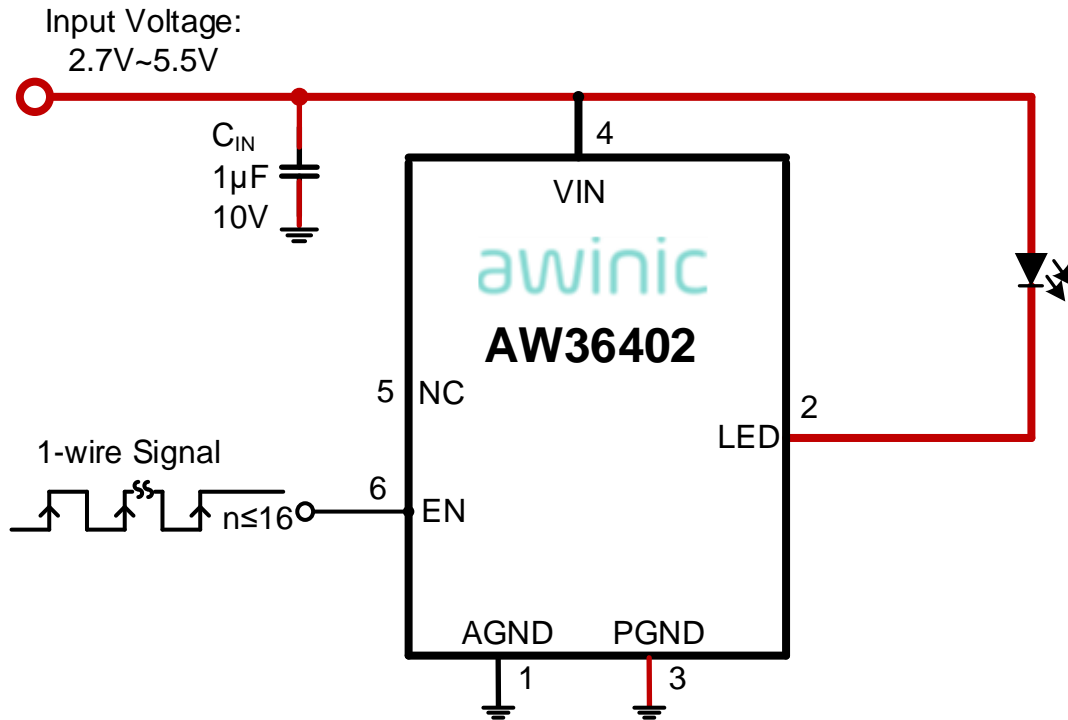


Figure 3. Application Circuit for Single LED

**Notice for Typical Application Circuits:**

1.  $C_{IN}$  should be close to the pin of VIN.
2. Red line is high current path. Considering driving ability, for example, the power path INPUT--VIN--LED should be as short and wide as possible.
3. For better thermal performance and noise performance, GND pins (PIN1, and PIN3) should be connected directly to a large area of the PCB ground plane.

**ABSOLUTE MAXIMUM RATINGS**<sup>(NOTE1)</sup>

PARAMETERS		Range	Unit
VIN, LED		-0.3 to 6	V
EN		-0.3 to (VIN+0.3)	V
Max Junction Temperature T <sub>JMAX</sub>		155	°C
Storage Temperature T <sub>STG</sub>		-65 to 150	°C
Maximum lead temperature (soldering)		260	°C
Junction to Ambient Thermal Resistance $\theta_{JA}$		142	°C/W
ESD, All Pins <sup>(NOTE2)</sup>	HBM	±2000	V
	MM	±200	V
	CDM	±2000	V
Latch-Up JEDEC STANDARD NO.78B DECEMBER 2008		+IT: +350 -IT: -350	mA

**RECOMMENDED OPERATING CONDITIONS**

PARAMETERS	Range	Unit
VIN	2.7 to 5.5	V
Junction temperature (T <sub>J</sub> )	-40 to 125	°C
Ambient temperature (T <sub>A</sub> )	-40 to 85	°C

*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: MIL-STD-883G Method 3015.7*

**ELECTRICAL CHARACTERISTICS**

VIN=3.6V, TA=25°C for typical values (unless otherwise noted)。

Symbol	Description	Test Conditions	Min	Typ	Max	Units
<b>Power supply</b>						
VIN	Input Operation Voltage		2.7		5.5	V
UVLO	Input Under Voltage Lock Out	Rising edge		2.4		V
		Falling edge	1.9	2.2	2.5	V
ISD	Current In Shutdown Mode	EN=0		0.1	1	μA
IQ	Quiescent Current	EN=1, LED pin open		160		μA
<b>LED Driver</b>						
I <sub>LED</sub>	Total Output Current, Flash/Torch Mode	Step NUM=1	-8%	200	8%	mA
V <sub>DROP</sub>	Dropout Voltage	I <sub>LED</sub> =200mA		50	125	mV
I <sub>SHORT</sub>	LED Short Detecting Current			2.5		mA
T <sub>SOFTSTART</sub>	Current Rising Time			200		μs
<b>Control</b>						
V <sub>IL</sub>	Logic Input Low Level				0.4	V
V <sub>IH</sub>	Logic Input High Level		1.3			V
R <sub>EN</sub>	Pull Down Resistor Inside			500		kΩ
T <sub>SD</sub>	Thermal Shutdown Threshold			155		°C
	Thermal Shutdown Hysteresis			20		°C
<b>1-Wire Dimming Pulse Timing</b>						
T <sub>LO</sub>	EN Pulse Low Time		0.5	2	10	μs
T <sub>HI</sub>	EN Pulse High Time		0.5	2	10	μs
T <sub>ON_DELAY</sub>	Time Between EN Pulled To High and Soft-Start			350	450	μs
T <sub>SHDN</sub>	Chip Shutdown Delay	Measure from EN falling edge to the chip entering into shut down mode	0.5		2.5	ms

## TYPICAL CHARACTERISTICS

VIN=3.6V, TA=25°C, Unless otherwise noted.

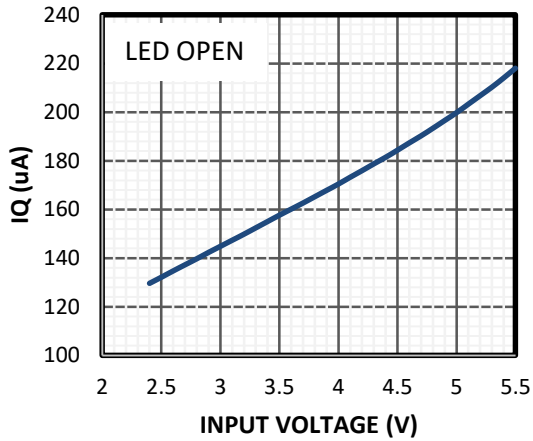


Figure 4. Quiescent Current

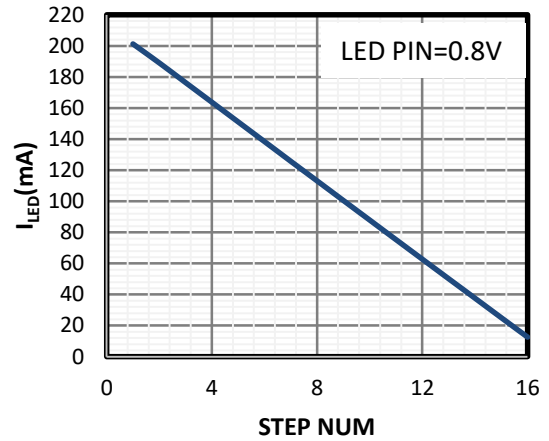


Figure 5. LED Current vs Step Num

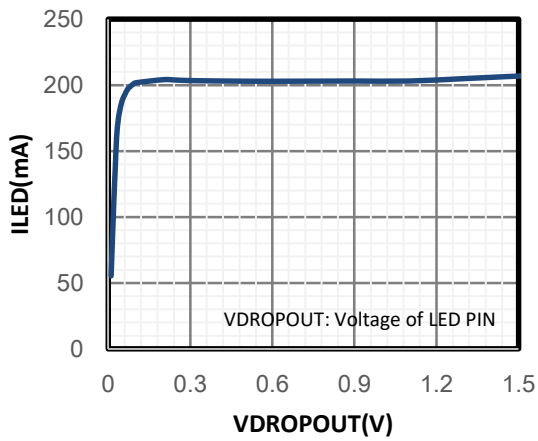


Figure 6. LED Current vs Dropout Voltage

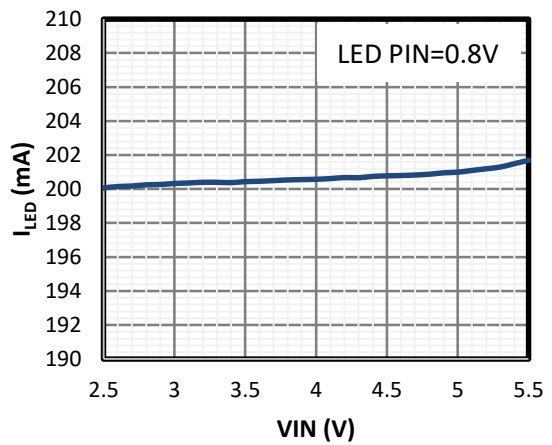


Figure 7. LED Current vs VIN

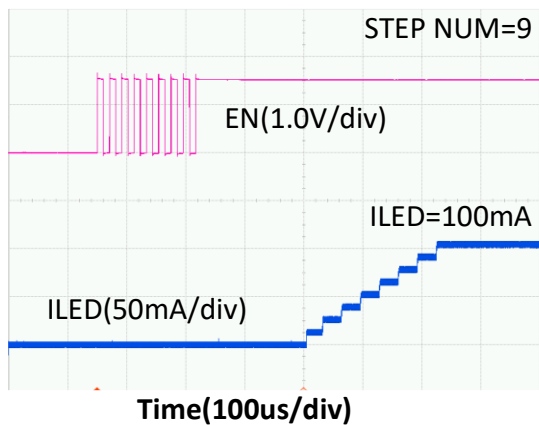


Figure 8. Startup Wave

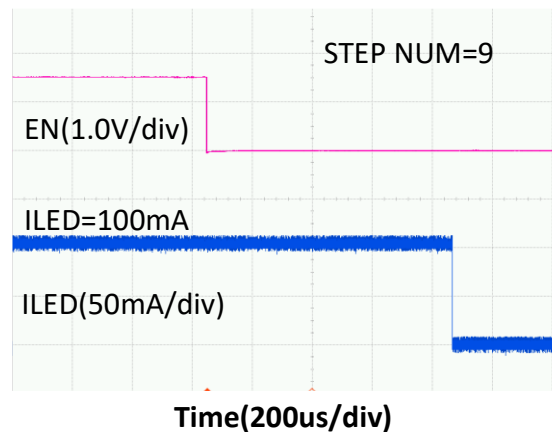


Figure 9. Shutdown Wave

## FUNCTION BLOCK

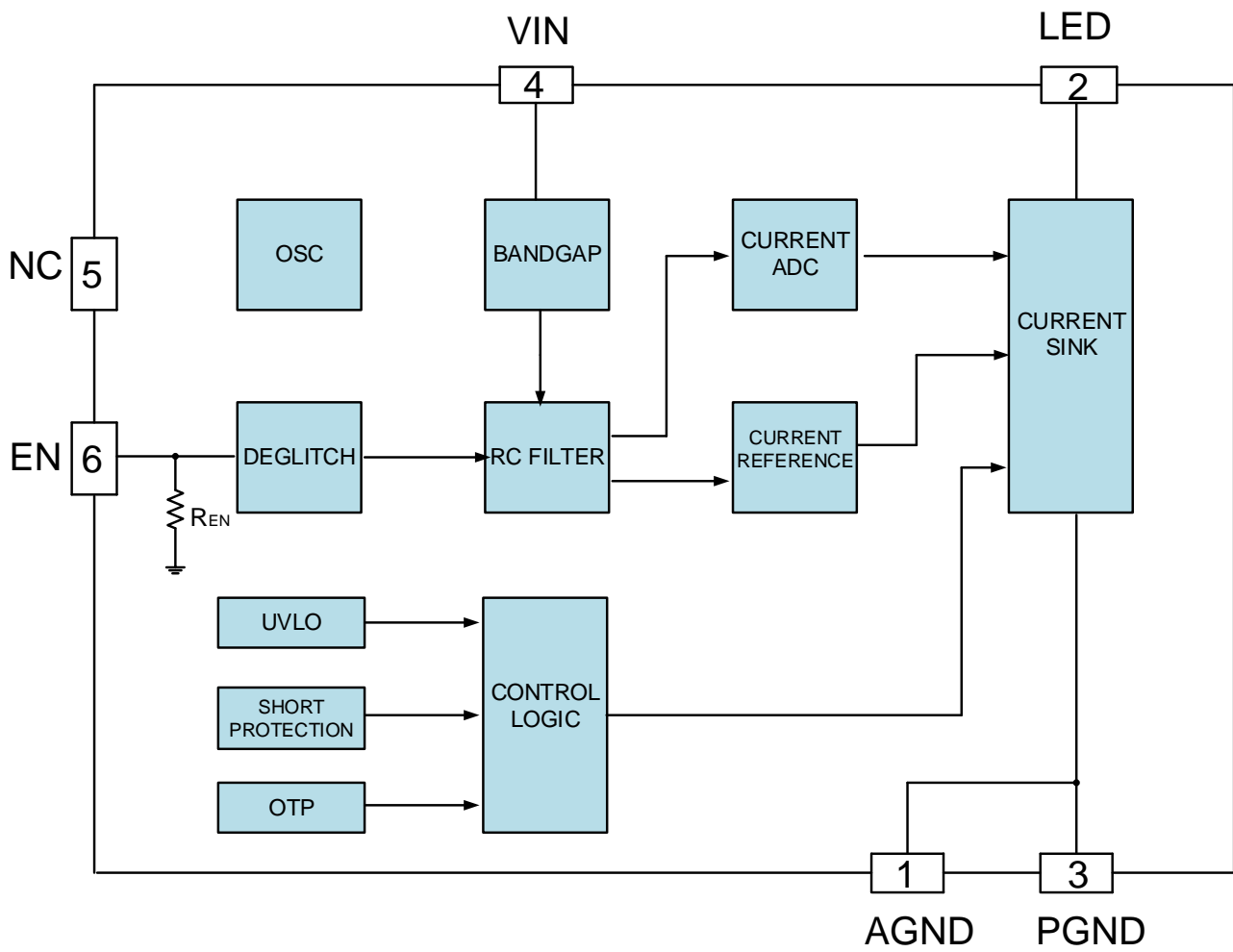


Figure 10. The AW36402 Function Block



## DETAILED DESCRIPTION

The AW36402 is a low voltage-drop current sink LED driver, which supports both flash and torch applications. The current-regulation sink integrated in the chip makes the LED current capable of keeping constant when input voltage, LED forward voltage or temperature are changing. The LED current can be adjusted among 16 steps by sending 1-wire pulse into the EN pin, and the maximum value is 200mA.

### **EN Control**

The voltage level at EN pin determines the operation state of the chip. When the EN pin is set to high, the AW36402 operates in normal state. And the chip would enter shutdown mode if the EN pin is set to low for over 2.5ms, as a built-in shutdown delay circuit in the AW36402. The shutdown current dissipated by the AW36402 is less than 1 $\mu$ A.

The AW36402 built in deglitch circuit. The interference between signals inside the portable device is unavoidable, thus deglitch circuit is necessary at the EN pin. The deglitch circuit inside the AW36402 is capable of eliminating the glitch which is narrower than 80ns, preventing the incorrect trigger at the EN pin effectively.

### **Soft-Start**

To decrease VBAT voltage fluctuation caused by inrush current, the AW36402 built in soft-start function. It takes 8 steps to ramp up to setting current and the ramp time is about 200 $\mu$ s.

### **UVLO**

The device has under voltage lock-out (UVLO) function to monitor the input voltage. Once the input voltage VIN drops below UVLO falling threshold (around 2.2V), the output current is disabled. Once the input voltage increases above UVLO rising threshold (around 2.4V), the output current resumes its previous setting.

### **LED Short Protection**

Short protection function will be enabled after the 1<sup>st</sup> step of soft-start. The IC internally compares the voltage difference between VIN and the sink node (LED pin) with a preset threshold. If this difference is below the preset threshold, AW36402 will treat the LED as shorted and disable its Flash/Torch mode current through the LED pin. However, a 2.5mA detecting current will be kept to generate the LED's voltage drop. Because some normal flash LEDs may have larger than desired leakage current (up to hundreds of micro-amps) even if it's not fully turned on, this 2.5mA sensing current can guarantee that a properly functioning LED will not mistakenly be treated as a shorted LED. If the short circuit is removed during operation, the LED will automatically recover to the programmed current setting.

### **Thermal Shutdown**

In flash or torch mode, the device has thermal shutdown protection, when the IC temperature goes above thermal shutdown rising threshold (around 155 $^{\circ}$ C), the output current is disabled. There are 2 conditions should be satisfied at the same time to resume output current: one is the IC temperature drops below thermal shutdown falling threshold (around 135 $^{\circ}$ C); the other is that the chip is reset through EN.

## APPLICATION INFORMATION

### 1-Wire Pulse Dimming

The AW36402 adopts the 1-wire pulse dimming to avoid the switch noise. A 4-bit DAC inside the AW36402 allows counting the rising edge at the EN pin to set the LED current (refer to Figure 11). Figure 11 shows that high level time  $0.5\mu\text{s} < T_{\text{HI}} < 10\mu\text{s}$ ; and low level time  $0.5\mu\text{s} < T_{\text{LO}} < 10\mu\text{s}$ . If high time of EN is larger than  $T_{\text{ON\_DELAY}}$ , then LED current will start to ramp up to setting value. But if add another pulse after soft-start, LED current will be changed to a new setting value directly. If low time of EN is larger than  $T_{\text{SHDN}}$ , then the AW36402 will be shut down.

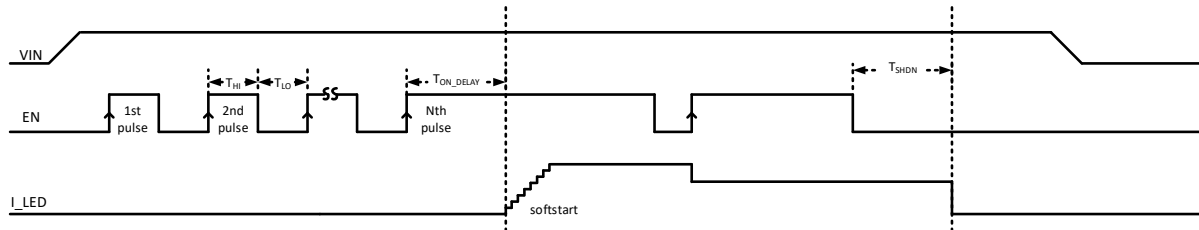


Figure 11. The AW36402 1-wire Dimming Timing Diagram

The LED current steps down along with the increasing EN pulse rising edge number. After the current setting process, the EN pin should set to high level.

LED current can be calculate as below:

$$I_{\text{LED}} \approx 12.5\text{mA} * (17 - N)$$

N is number of EN pulse rising edge. N is integer and changed from 1 to 16. Please note that every 16 pulses is a cycle when  $N > 16$ .

### Efficiency

The AW36402 is a low voltage-drop current sink LED driver, its operation efficiency can be approximately calculated as below.

$$\eta = \frac{P_{\text{OUT}}}{P_{\text{IN}}} = \frac{V_F \times I_{\text{OUT}}}{V_{\text{IN}} \times I_{\text{IN}}} \approx \frac{V_F \times I_{\text{OUT}}}{V_{\text{IN}} \times I_{\text{OUT}}} = \frac{V_F}{V_{\text{IN}}}$$

$V_F$  in the formula represents the forward voltage of LED. If  $V_{\text{IN}}$  is 3.6V,  $V_F$  is 3.4V, the chip efficiency is about 94%.

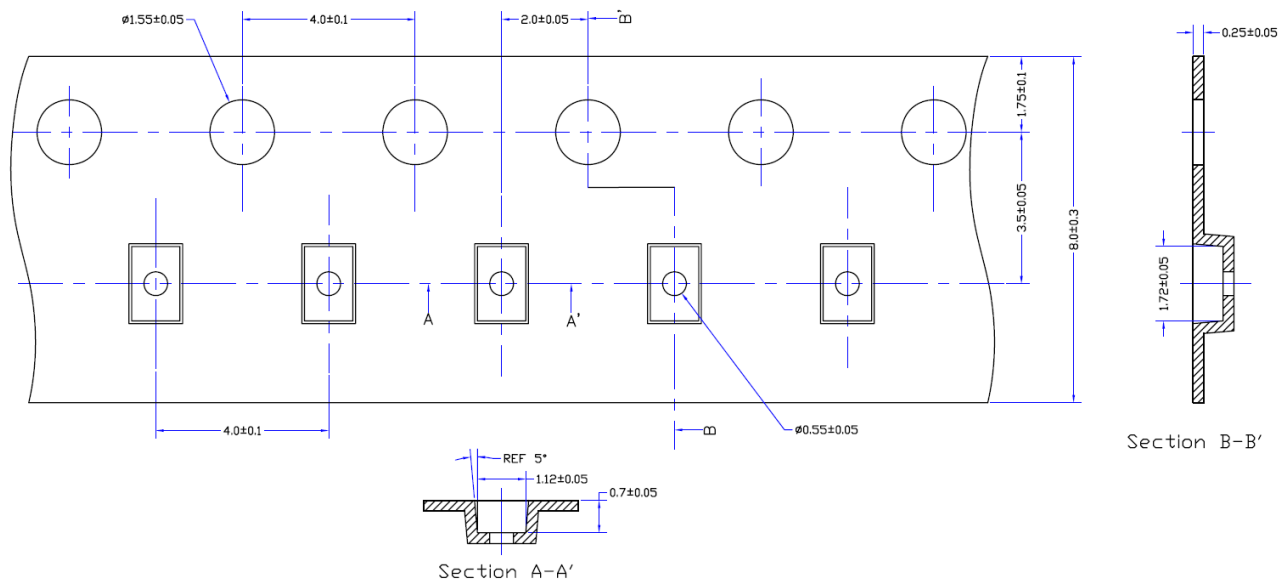
## PCB LAYOUT CONSIDERATION

To make fully use of the performance of the AW36402, the guidelines below should be followed:

1. All the peripherals should be placed as close to the device as possible. Place the input capacitor  $C_{\text{IN}}$  on the top layer (same layer as the AW36402) and close to  $V_{\text{IN}}$  (pin4).
2. Route the power line (shown in Figure 3) as widely and shortly as possible to reduce parasitic impedance.
3. To optimize the heat dissipation performance, the GND pins (pin1 & 3) should be connected to the PCB ground plane using as many vias as possible.

## TAPE AND REEL INFORMATION

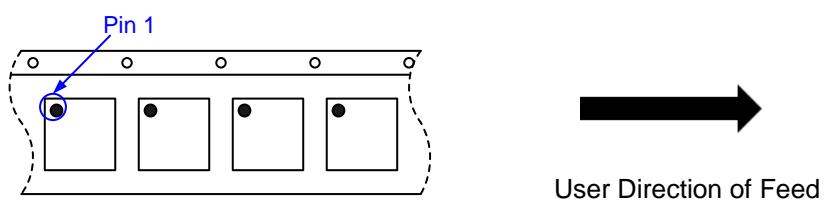
## Carrier Tape



## NOTES:

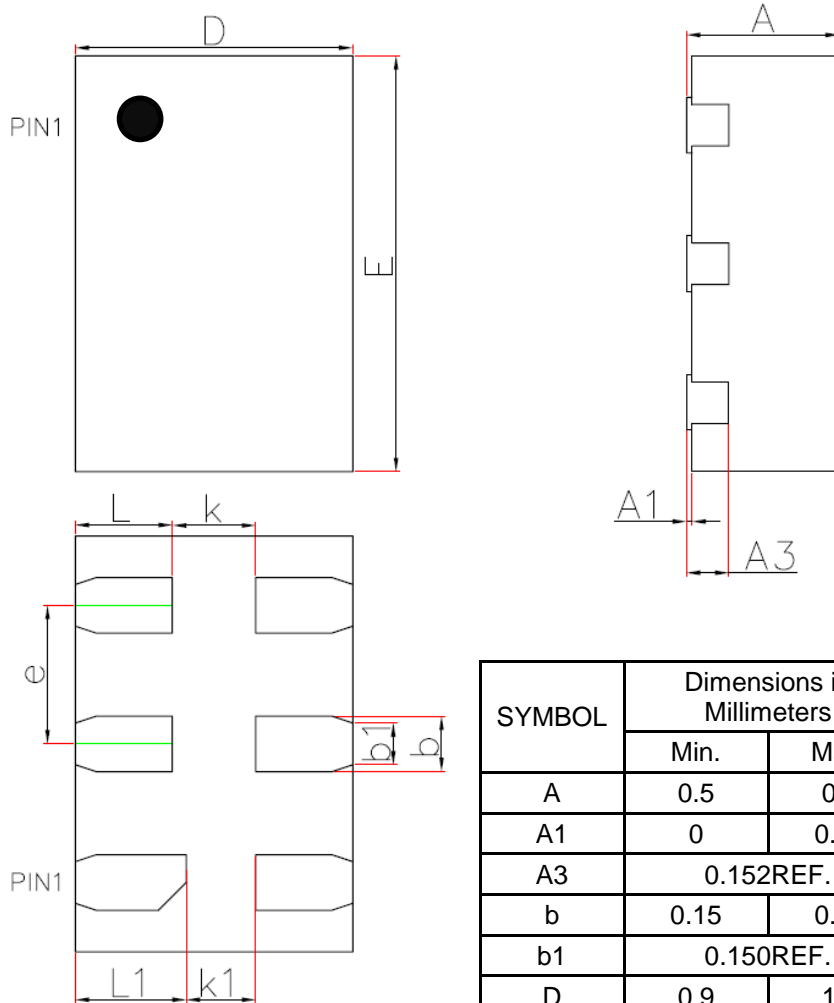
1. 10 pocket hole pitch cumulative tolerance  $\pm 0.2$ .
2. The meander of tape is assumed with 1mm or less every 100mm between 250mm.
3. Material: CONDUCTIVE POYSTYRENE.
4. All DIMS in MM.
5. Surface resistance  $1 \times 10^{11}(\text{max})$  OHMS/SQ612-UDFN1.5\*1.0.

## Pin 1





## PACKAGE INFORMATION

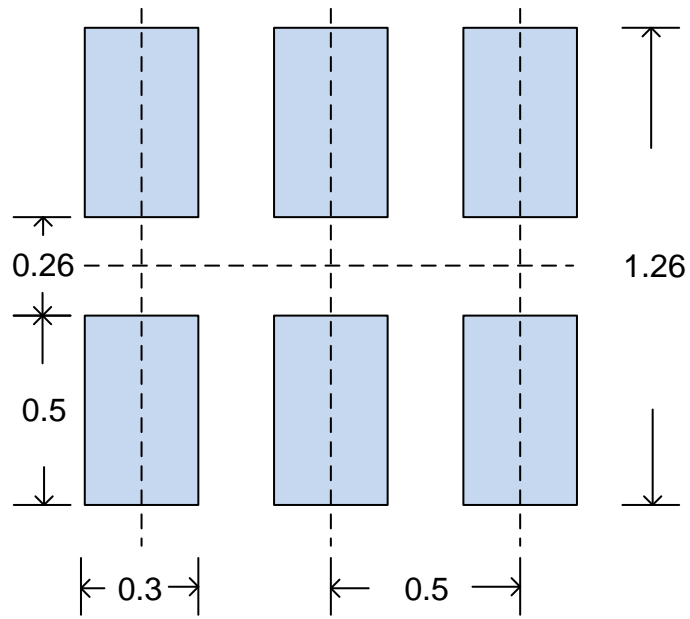


SYMBOL	Dimensions in Millimeters		Dimensions in Inches	
	Min.	Max.	Min.	Max.
A	0.5	0.6	0.02	0.024
A1	0	0.05	0	0.002
A3	0.152REF.		0.006REF.	
b	0.15	0.25	0.006	0.01
b1	0.150REF.		0.006REF.	
D	0.9	1.1	0.035	0.043
E	1.4	1.6	0.055	0.063
e	0.500BSC.		0.020BSC.	
k	0.300REF.		0.012REF.	
k1	0.250REF.		0.010REF.	
L	0.3	0.4	0.012	0.016
L1	0.35	0.45	0.014	0.018

## NOTE:

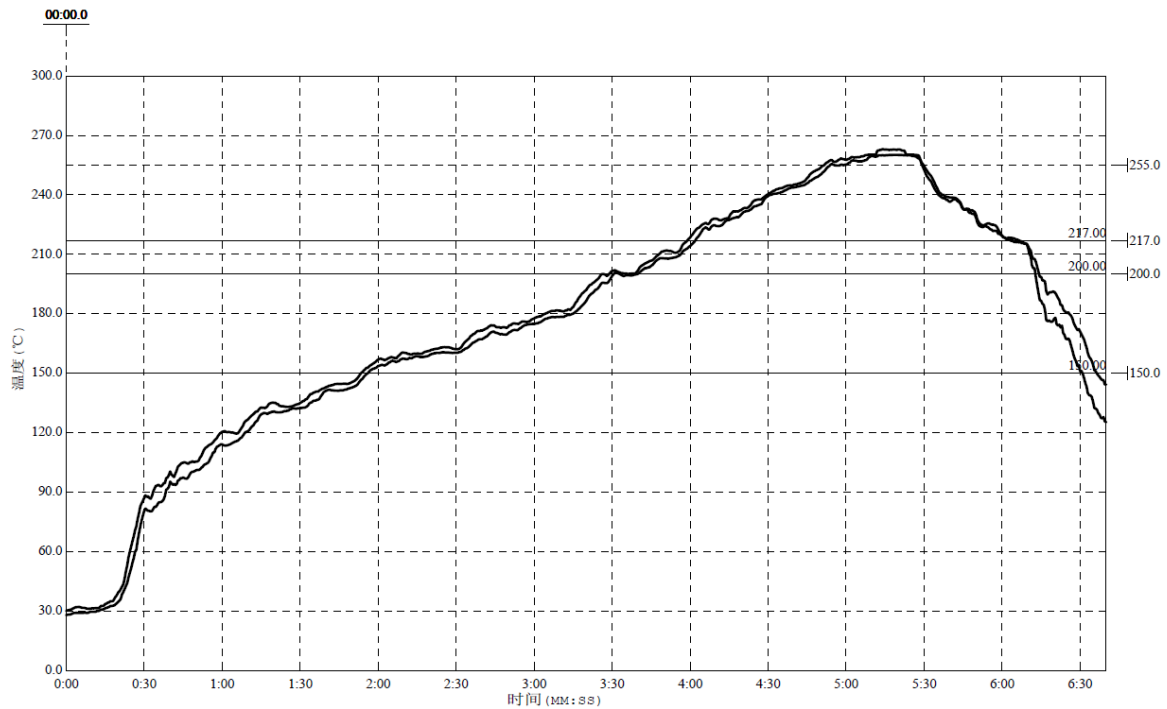
- 1、 All DIMS in mm.
- 2、 General Tolerance  $\pm 0.25\text{mm}$ .

## LAND PATTERN EXAMPLE



NOTE: Dimensions are in millimeters.

## REFLOW



Reflow Note	Spec
Average ramp-up rate (217°C to Peak)	Max. 3°C /sec
Time of Preheat temp.(from 150°C to 200°C)	60-120sec
Time to be maintained above 217°C	60-150sec
Peak Temperature	>260°C
Time within 5°C of actual peak temp	20-40sec.
Ramp-down rate	Max. 6°C /sec
Time from 25°C to peak temp	Max. 8min.

## Version information

VERSION	DATE	Change Record
V1.0	2017.10	Datasheet V1.0 Released.
V1.1	2018.1	1. Add User Direction of Feed. (P11) 2. Modify Spec of T <sub>ON_DELAY</sub> .(P6) 3. Modify Description of Test Conditions of T <sub>SHDN</sub> . (P6)
V1.2	2018.4	1. Add Spec of Torch Current.(P6) 2. Rotate Pin Configuration(Figure 2) by 90 degrees.(P2) 3. Add upper limit of V <sub>DROP</sub> . (P6)
V1.3	2018.5	1.Modify "Max Junction Temperature T <sub>JMAX</sub> " from125°C to 155°C.(P5)



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