

## General Description

The AP3615 is a step-up DC-DC converter based on 1x/1.5x charge pump and low dropout current sink, which helps it maintain the highest efficiency. The AP3615 is specially designed to drive up to 5 WLEDs in backlight display.

The AP3615 provides up to 20mA current for each WLED. There are totally 16 steps of current control, which is achieved through a digital pulse dimming function on EN pin. Additionally, 1MHz high switching frequency enables the use of small external capacitors. Internal soft-start circuitry prevents excessive inrush current during start-up and mode transition.

The supply voltage of AP3615 ranges from 2.8V to 5.5V which make it ideally suit for applications powered by Li-ion battery.

The AP3615 is available in the tiny package of QFN-3x3-16.

## Features

- Regulated Output Current with  $\pm 3\%$  Matching
- Drives up to 5 WLEDs at 20mA Each
- 16 Steps Brightness Control Using Pulse Signal Dimming
- Wide Operating Voltage Range: 2.8V to 5.5V
- High Operating Frequency: 1MHz
- Auto 1x/1.5x Charge Pump Mode Selection
- Built-in Soft-start
- Output Over Voltage Protection
- Built-in UVLO
- Built-in OTSD
- Operating Temperature Range:  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

## Applications

- Mobile Phone
- PDA
- MP3/4

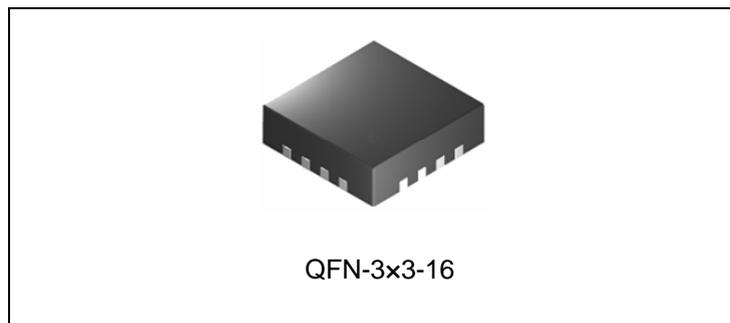
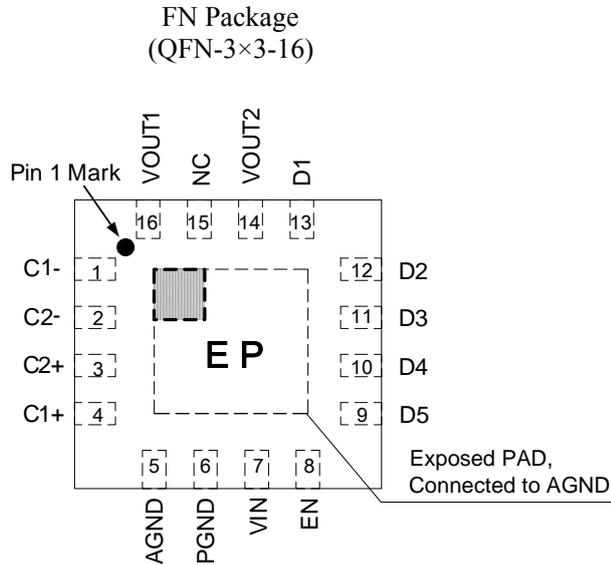


Figure 1. Package Type of AP3615

### Pin Configuration



Note: Pin 14 should be connected with Pin 16 on PCB Board.

Figure 2. Pin Configuration of AP3615 (Top View)

### Pin Description

Pin Number	Pin Name	Function
1	C1-	Flying capacitor 1 negative terminal. The flying capacitor should be connected as close to this pin as possible
2	C2-	Flying capacitor 2 negative terminal. The flying capacitor should be connected as close to this pin as possible
3	C2+	Flying capacitor 2 positive terminal. The flying capacitor should be connected as close to this pin as possible
4	C1+	Flying capacitor 1 positive terminal. The flying capacitor should be connected as close to this pin as possible
5	AGND	Analog ground
6	PGND	Power ground
7	VIN	Supply voltage input
8	EN	Enable control input. Logic high enables the IC; while logic low forces the IC into shutdown mode. It is used for digital dimming by applying a pulse signal on it.
9, 10, 11, 12, 13	D5 ~ D1	Current sink for WLED5, 4, 3, 2, 1. Connect the cathode of WLEDs to these pins. If not used, these pins must be connected with VIN
14	VOUT2	Output pin 2. It powers 5 channels current sink
15	NC	No connection
16	VOUT1	Output Pin 1. It's the charge pump output. The output capacitor should be placed closely to this pin

**Functional Block Diagram**

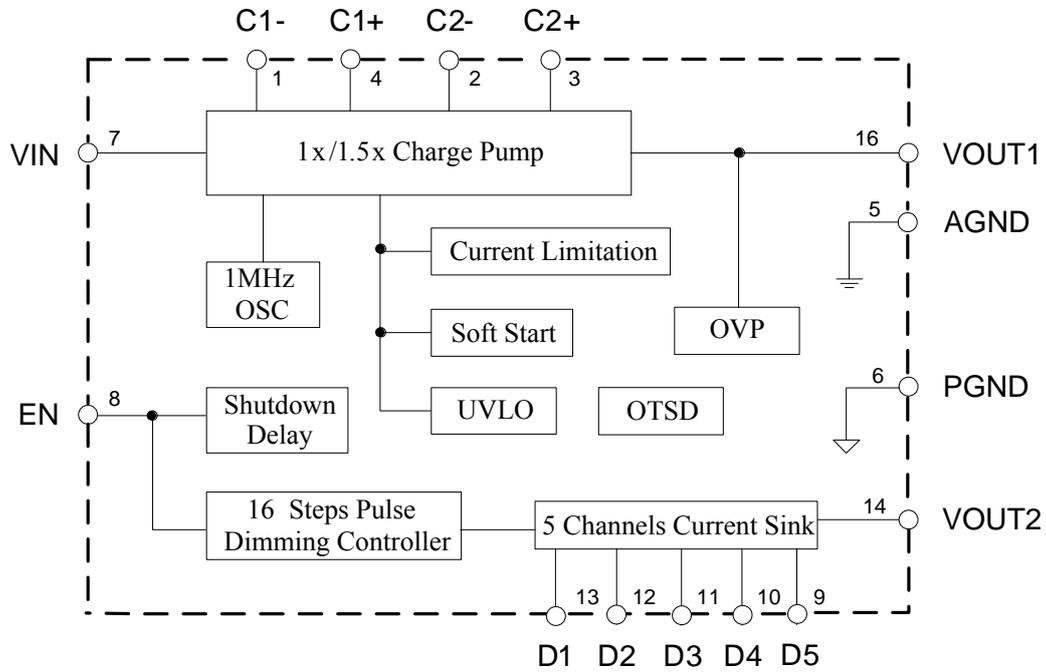
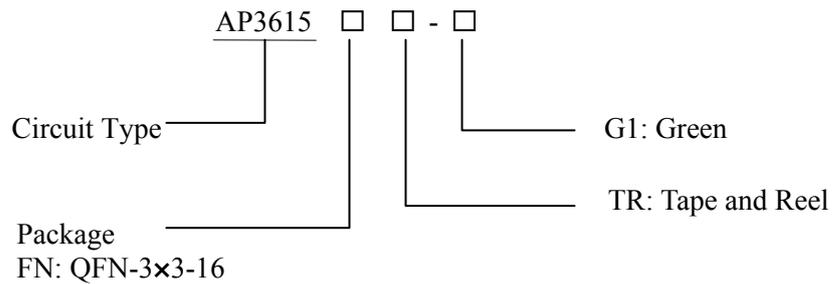


Figure 3. Functional Block Diagram of AP3615

**Ordering Information**



Package	Temperature Range	Part Number	Marking ID	Packing Type
QFN-3x3-16	-40 to 85°C	AP3615FNTR-G1	B2B	Tape & Reel

BCD Semiconductor's Pb-free products, as designated with "G1" suffix in the part number, are RoHS compliant and green.

**5 CHANNEL CHARGE PUMP CURRENT SINK FOR LED DRIVER****AP3615****Absolute Maximum Ratings (Note 1)**

Parameter	Symbol	Value	Unit
Input Voltage	$V_{IN}$	-0.3 to 6	V
VOUT Pin Voltage (VOUT1 & VOUT2)	$V_{OUT}$	-6 to 0.3	V
EN Pin Voltage	$V_{EN}$	-0.3 to 6	V
C1+, C2+ Pin Voltage	$V_{C+}$	-0.3 to 6	V
C1-, C2- Pin Voltage	$V_{C-}$	-6 to 0.3	V
D1, D2, D3, D4 and D5 Pin Voltage	$V_D$	$V_{OUT}$ to $V_{IN}$	V
Thermal Resistance (Junction to Ambient, No Heat Sink, Free Air)	$\theta_{JA}$	60	°C/W
Operating Junction Temperature	$T_J$	150	°C
Storage Temperature	$T_{STG}$	-65 to 150	°C
Lead Temperature (Soldering, 10sec)	$T_{LEAD}$	260	°C

Note 1: Stresses greater than those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “Recommended Operating Conditions” is not implied. Exposure to “Absolute Maximum Ratings” for extended periods may affect device reliability.

**Recommended Operating Conditions**

Parameter	Symbol	Min	Max	Unit
Input Voltage	$V_{IN}$	2.8	5.5	V
Operating Ambient Temperature	$T_A$	-40	85	°C



**5 CHANNEL CHARGE PUMP CURRENT SINK FOR LED DRIVER**

**AP3615**

**Electrical Characteristics**

$V_{IN}=3.6V$ ,  $V_{EN}=V_{IN}$ ,  $T_A=25^{\circ}C$ ,  $C_{IN}=C1=C2=C_{OUT}=1\mu F$ ,  $V_F$ (forward voltage)=3.2V, unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
<b>Input Section</b>						
Input Voltage	$V_{IN}$	$I_D=0mA$ to 100mA	2.8		5.5	V
Under Voltage Lockout Threshold		$V_{IN}$ Falling		2.2		V
Under Voltage Lockout Hysteresis				250		mV
Supply Current	$I_{CC}$	No Load		1.7	3	mA
Shutdown Supply Current	$I_{SHDN}$	$V_{EN}=GND$		3	10	$\mu A$
<b>Charge Pump Section</b>						
Switch Frequency	$f_{OSC}$	$V_{IN}=3.0V$ , 1.5x Mode	0.7	1	1.3	MHz
1x Mode to 1.5x Mode Transition Voltage ( $V_{IN}$ Falling)	$V_{1.5X}$	$V_D=3.2V$ , $I_{D1}=I_{D2}=I_{D3}=I_{D4}=I_{D5}=20mA$		3.5	3.6	V
1.5x Mode to 1x Mode Transition Voltage ( $V_{IN}$ Rising)	$V_{1X}$	$V_D=3.2V$ , $I_{D1}=I_{D2}=I_{D3}=I_{D4}=I_{D5}=20mA$		3.7	3.8	V
<b>Current Source Section</b>						
WLED Current	$I_D$	100% Setting, $3.0V \leq V_{IN} \leq 5.0V$ $T_A=-40^{\circ}C$ to $85^{\circ}C$	18.5	20	21.5	mA
Current Matching Between any Two Outputs	$I_{D-Match1}$	$V_{D1}=V_{D2}=V_{D3}=V_{D4}=V_{D5}=3.2V$	-3		3	%
Current Matching Between any Two Outputs	$I_{D-Match2}$	$V_{D1}=V_{D2}=V_{D3}=V_{D4}=V_{D5}=3.0V$ to 4.0V $V_{IN}=3.2V$ to 5.0V	-3.5		3.5	%
<b>Enable Section</b>						
EN High Level Threshold Voltage	$V_{IH}$		1.5			V
EN Low Level Threshold Voltage	$V_{IL}$				0.5	V
EN Input Current	$I_{EN}$	$V_{EN}=0V$ to 5V		1	10	$\mu A$
EN Low to Shutdown Delay	$t_{SHDN}$		1			ms
EN Low Time for Dimming	$t_{LO}$		0.1		0.3	ms
EN High Time for Dimming	$t_{HI}$		0.1			ms
<b>Total Device</b>						
Soft-start Time	$t_{SS}$	$I_D=100mA$ Total		200		$\mu s$
Inrush Current	$I_{INRUSH}$	$V_{IN}=3.2V$ , $I_D=100mA$ Total		320		mA
Over Voltage Protection	$V_{OVP}$	Note 2		5.5		V
Thermal Shutdown	$T_{OTSD}$			160		$^{\circ}C$
Thermal Shutdown Hysteresis	$T_{HYS}$			20		$^{\circ}C$
Thermal Resistance (Junction to Case)	$\theta_{JC}$	QFN-3x3-16		15		$^{\circ}C/W$

Note 2: Open circuit at any WLED that is programmed to be in the on state.

### Typical Performance Characteristics

$T_A=25^\circ\text{C}$ ,  $C_{IN}=C_1=C_2=C_{OUT}=1\mu\text{F}$ ,  $V_F=3.2\text{V}$ , unless otherwise noted.

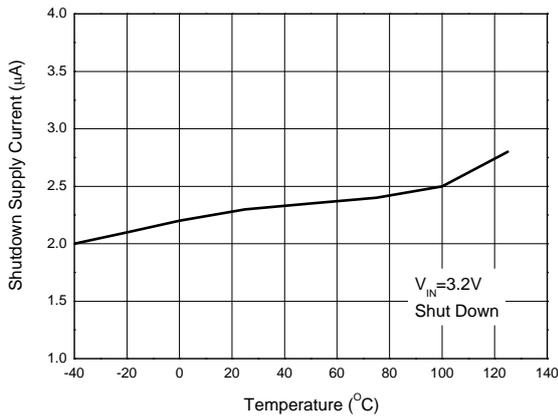


Figure 4. Shutdown Supply Current vs. Temperature

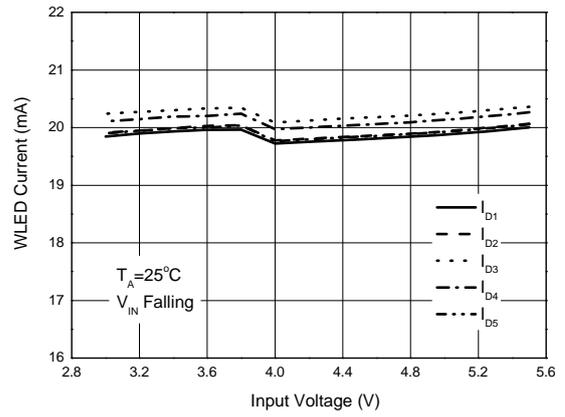


Figure 5. WLED Current vs. Input Voltage

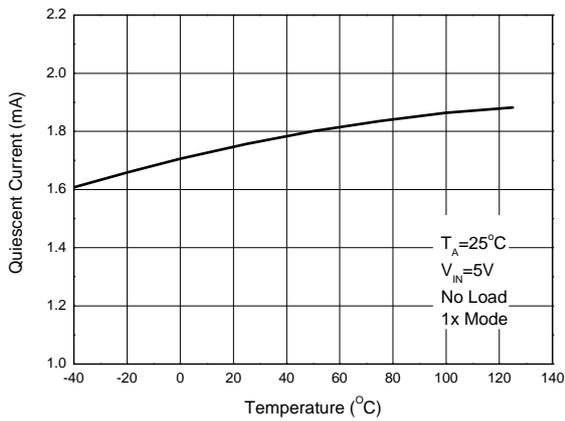


Figure 6. 1x Mode Quiescent Current vs. Temperature

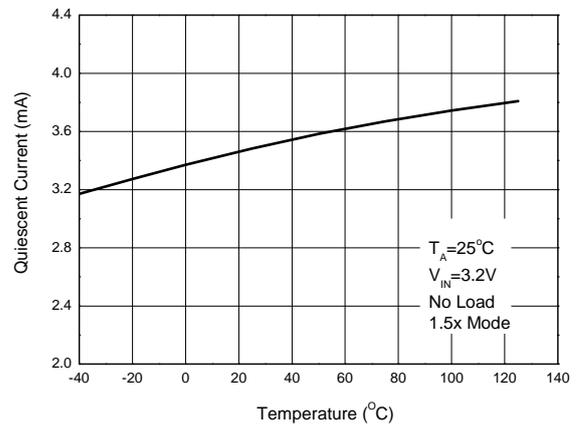


Figure 7. 1.5x Mode Quiescent Current vs. Temperature

**Typical Performance Characteristics (Continued)**

$T_A=25^\circ\text{C}$ ,  $C_{IN}=C_1=C_2=C_{OUT}=1\mu\text{F}$ ,  $V_F=3.2\text{V}$ , unless otherwise noted.

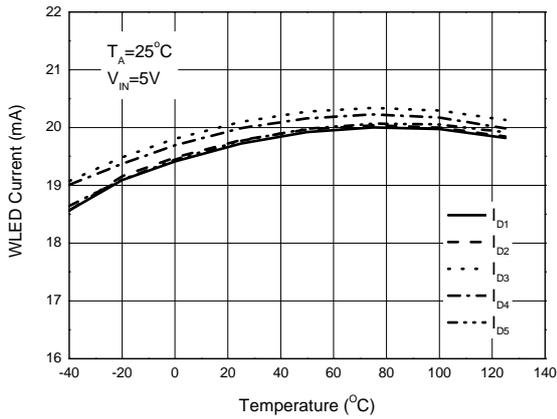


Figure 8. 1x Mode WLED Current vs. Temperature

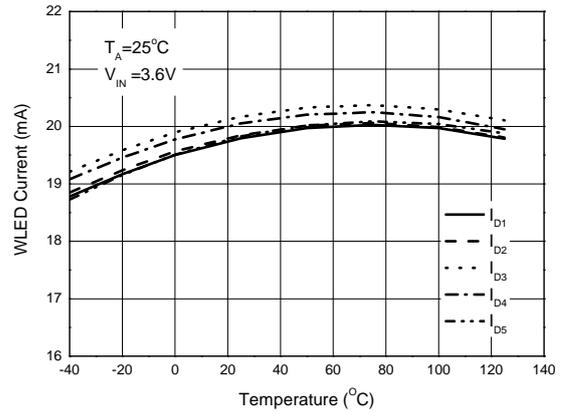


Figure 9. 1.5x Mode WLED Current vs. Temperature

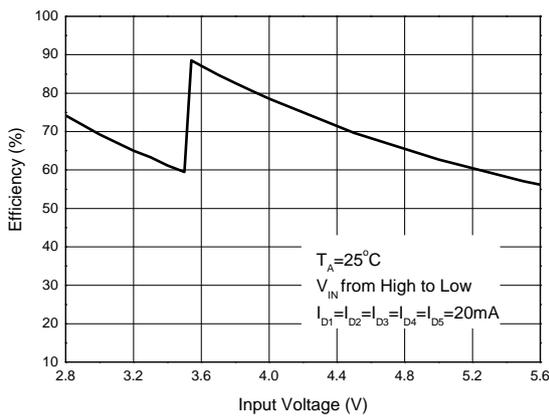


Figure 10. Efficiency vs. Input Voltage

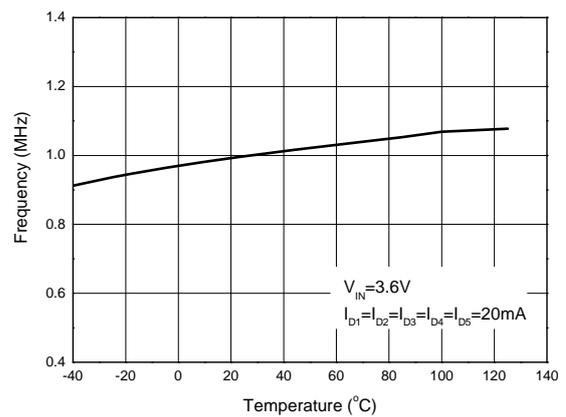


Figure 11. Frequency vs. Temperature

**Typical Performance Characteristics (Continued)**

$T_A=25^{\circ}\text{C}$ ,  $C_{IN}=C_1=C_2=C_{OUT}=1\mu\text{F}$ ,  $V_F=3.2\text{V}$ , unless otherwise noted.

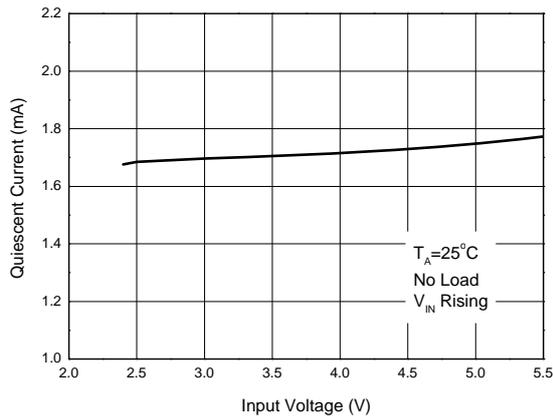


Figure 12. 1x Mode Quiescent Current vs. Input Voltage

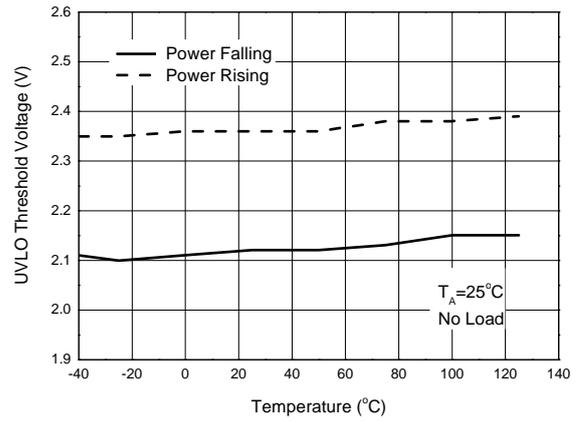


Figure 13. UVLO Threshold Voltage vs. Temperature

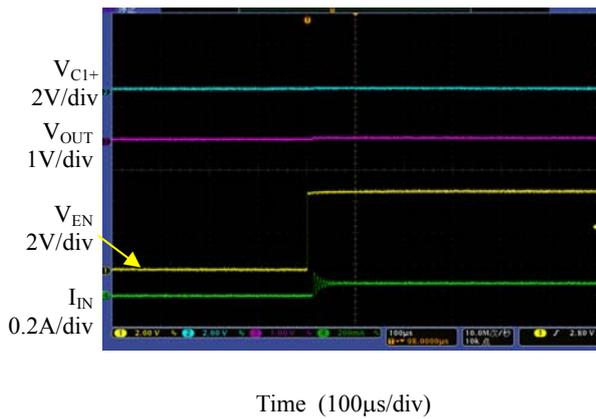


Figure 14. 1x Mode Turn on Characteristic

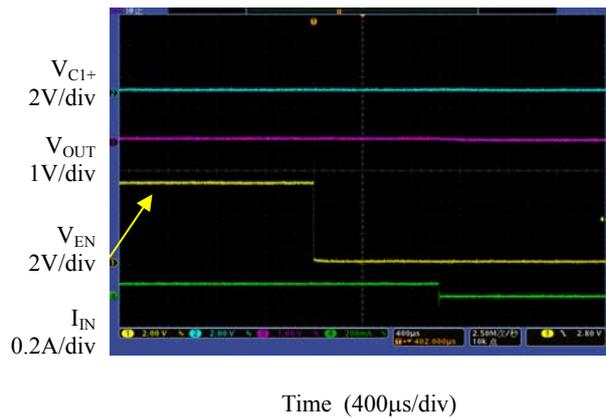


Figure 15. 1x Mode Turn off Characteristic

Typical Performance Characteristics (Continued)

$T_A=25^{\circ}\text{C}$ ,  $C_{IN}=C_1=C_2=C_{OUT}=1\mu\text{F}$ ,  $V_F=3.2\text{V}$ , unless otherwise noted.



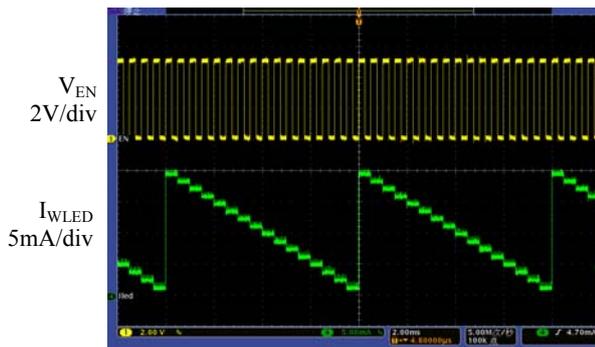
Time (100µs/div)

Figure 16. 1.5x Mode Turn on Characteristic



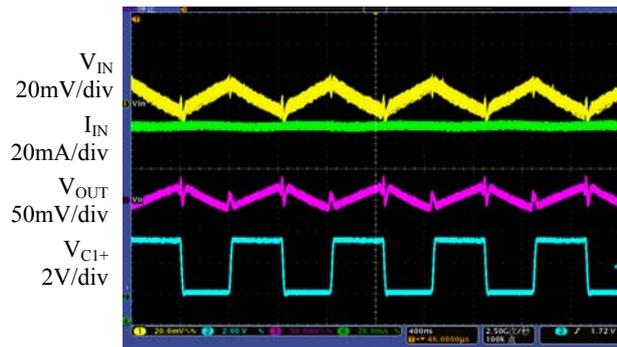
Time (400µs/div)

Figure 17. 1.5x Mode Turn off Characteristic



Time (2ms/div)

Figure 18. 1x Mode Dimming Operation ( $V_{IN}=5\text{V}$ ,  $f_{EN}=2\text{kHz}$ )



Time (400ns/div)

Figure 19. Output Ripple ( $V_{IN}=3.3\text{V}$ ,  $I_D=100\text{mA}$ )

## Digital Dimming Operating Diagram

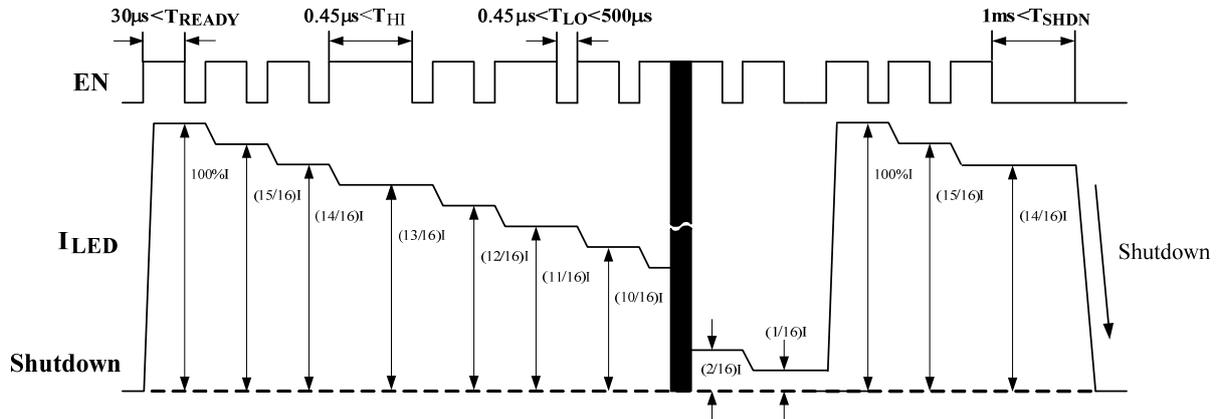
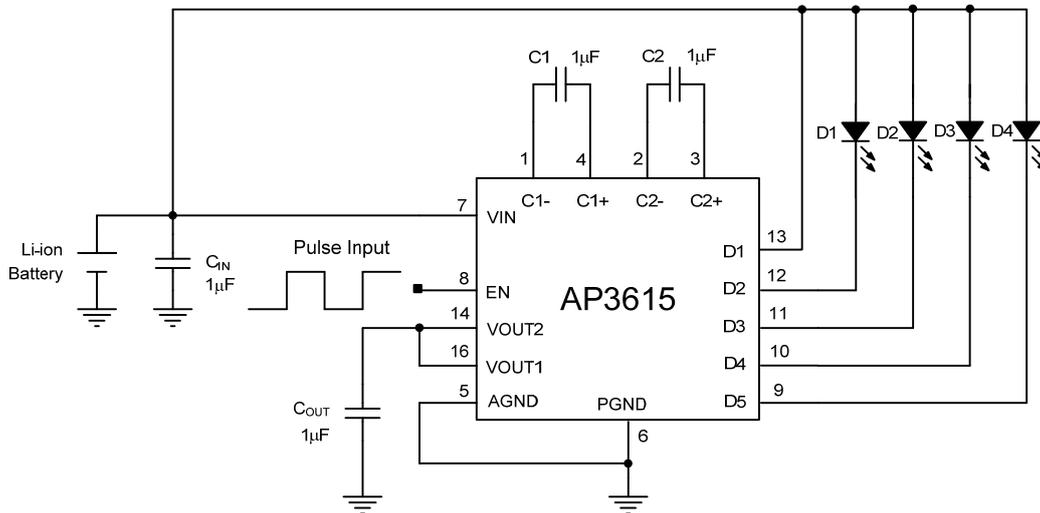


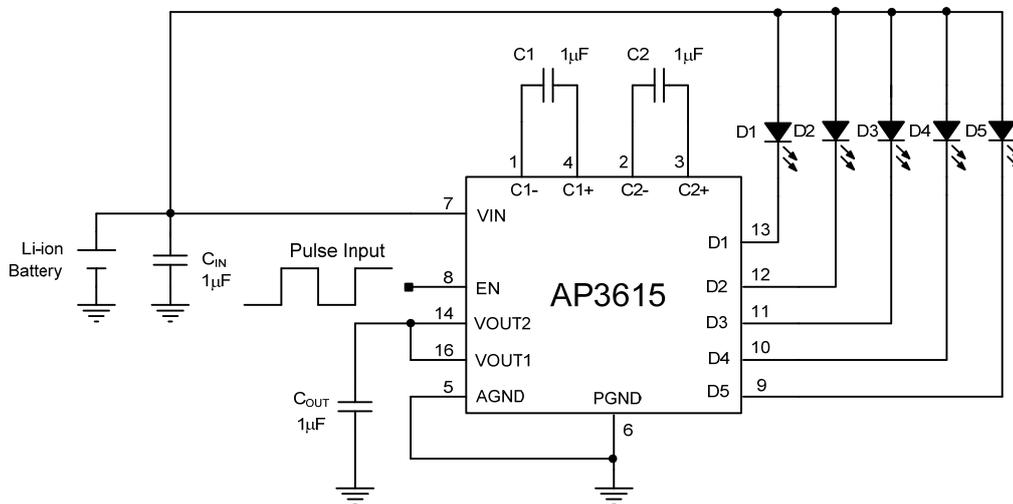
Figure 20. Digital Dimming Operating Diagram of AP3615

Note 3: The dimming control can be achieved by applying a pulse to the EN pin. When the low level duration time of pulse is between  $T_{LOmin}$  and  $T_{LOmax}$ , and the high level duration time is larger than  $T_{HImin}$ , the LED current will decrease 1/16. If the low level duration time is larger than  $T_{SHDNmax}$ , the IC will be turned off. When AP3615 is powered on, the WLED is in full brightness. And it will keep maximum current until the pulse is detected. After 15 pulses the WLED current decreases to 1/16 of full brightness. It will increase to full brightness if a pulse is added to EN pin then.

**Typical Application**



4 WLEDs



5 WLEDs

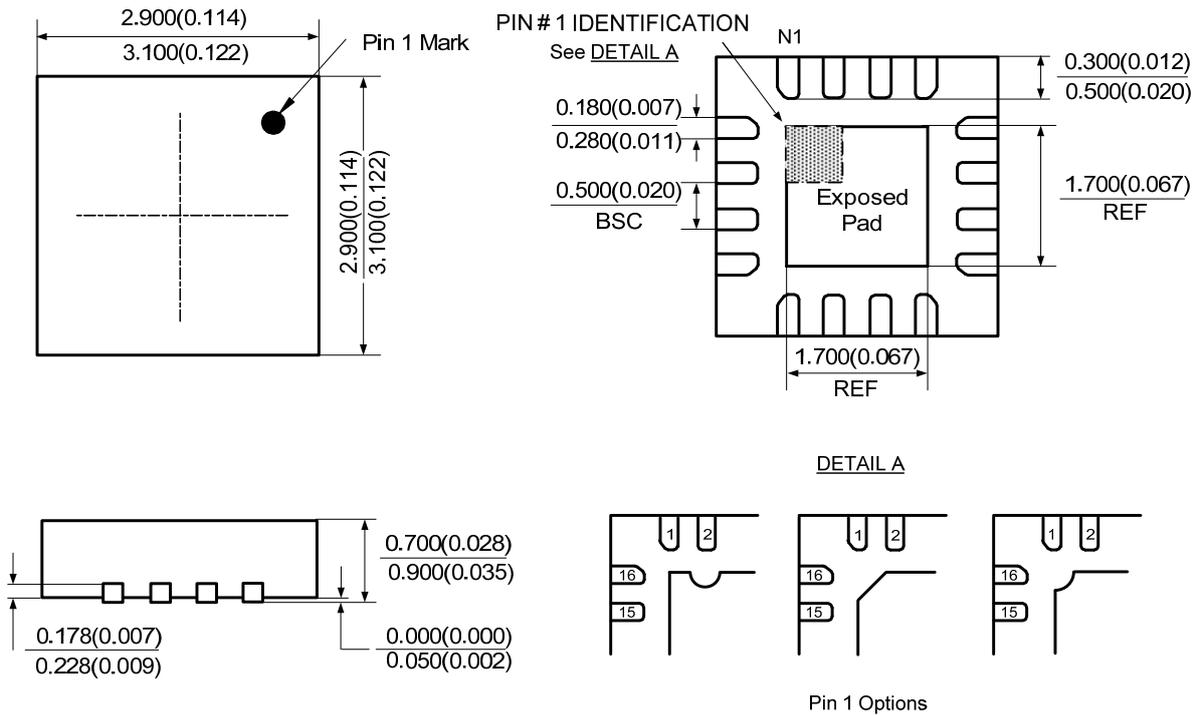
Figure 21. Typical Applications of AP3615

Detailed application information, please refer to AP3615 application note.

**Mechanical Dimensions**

**QFN-3x3-16**

**Unit: mm(inch)**





## **BCD Semiconductor Manufacturing Limited**

<http://www.bcdsemi.com>

### **IMPORTANT NOTICE**

BCD Semiconductor Manufacturing Limited reserves the right to make changes without further notice to any products or specifications herein. BCD Semiconductor Manufacturing Limited does not assume any responsibility for use of any its products for any particular purpose, nor does BCD Semiconductor Manufacturing Limited assume any liability arising out of the application or use of any its products or circuits. BCD Semiconductor Manufacturing Limited does not convey any license under its patent rights or other rights nor the rights of others.

---

#### **MAIN SITE**

##### **- Headquarters**

##### **BCD Semiconductor Manufacturing Limited**

No. 1600, Zi Xing Road, Shanghai Zizhu Science-based Industrial Park, 200241, China  
Tel: +86-21-24162266, Fax: +86-21-24162277

##### **- Wafer Fab**

##### **Shanghai SIM-BCD Semiconductor Manufacturing Co., Ltd.**

800 Yi Shan Road, Shanghai 200233, China  
Tel: +86-21-6485 1491, Fax: +86-21-5450 0008

#### **REGIONAL SALES OFFICE**

##### **Shenzhen Office**

##### **Shanghai SIM-BCD Semiconductor Manufacturing Co., Ltd., Shenzhen Office**

Unit A Room 1203, Skyworth Bldg., Gaoxin Ave. 1.S., Nanshan District, Shenzhen, China  
Tel: +86-755-8826 7951  
Fax: +86-755-8826 7865

##### **Taiwan Office**

##### **BCD Semiconductor (Taiwan) Company Limited**

4F, 298-1, Rui Guang Road, Nei-Hu District, Taipei, Taiwan  
Tel: +886-2-2656 2808  
Fax: +886-2-2656 2806

##### **USA Office**

##### **BCD Semiconductor Corp.**

30920 Huntwood Ave. Hayward, CA 94544, USA  
Tel : +1-510-324-2988  
Fax: +1-510-324-2788

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Diodes Incorporated:](#)

[AP3615FNTR-G1](#)