Description

The AP3606 and AP3607 are step-up DC-DC converters based on 1x/1.5x charge pump and low dropout current sink, which helps them maintain the highest efficiency. The AP3606 is specially designed to drive up to 4 WLEDs in backlight display while the AP3607 is designed for 6 WLEDs.

These devices provide 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 ranges of AP3606 and AP3607 are from 2.7V to 5.5V which make them ideally suit for applications powered by Li-ion battery.

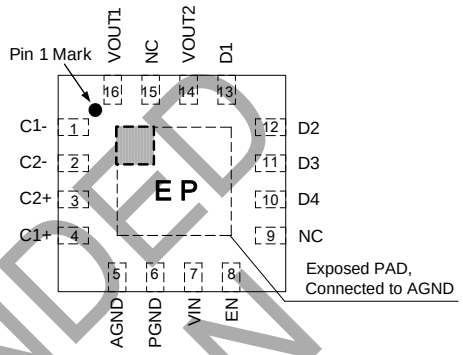
These ICs are available in the tiny package of QFN-3×3-16.

Features

- Regulated Output Current with ±3% Matching
- Drives up to 4 WLEDs at 20mA Each (AP3606)
  Drives up to 6 WLEDs at 20mA Each (AP3607)
- 16 Steps Brightness Control Using Pulse Signal Dimming
- Wide Operating Voltage Range: 2.7V 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°C to +85°C

Pin Assignments

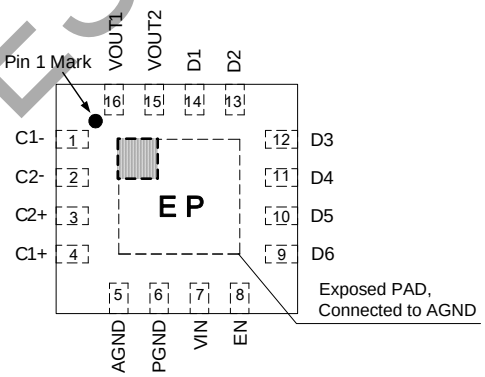
(Top View)



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

QFN-3×3-16 (AP3606)

(Top View)



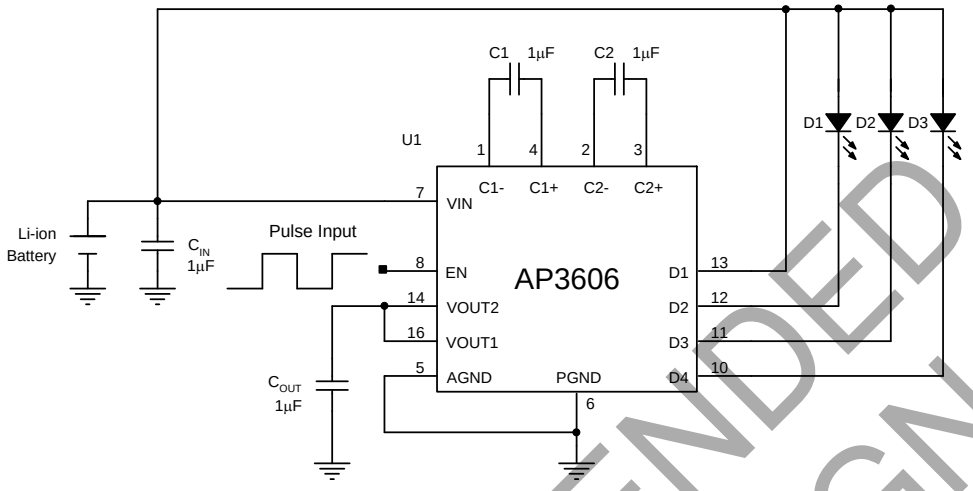
Note: Pin 15 should be connected with Pin 16 on PCB Board.

QFN-3×3-16 (AP3607)

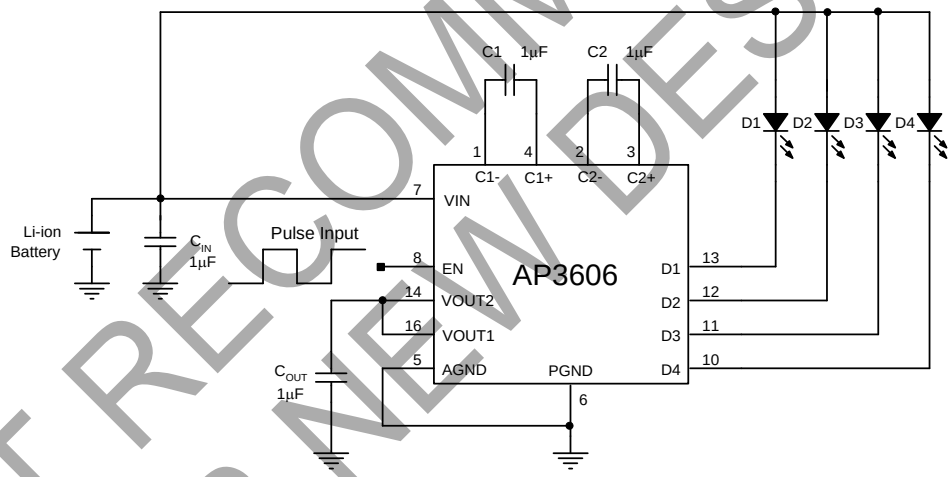
Applications

- Mobile Phone
- PDA
- MP3/4

Typical Applications Circuit

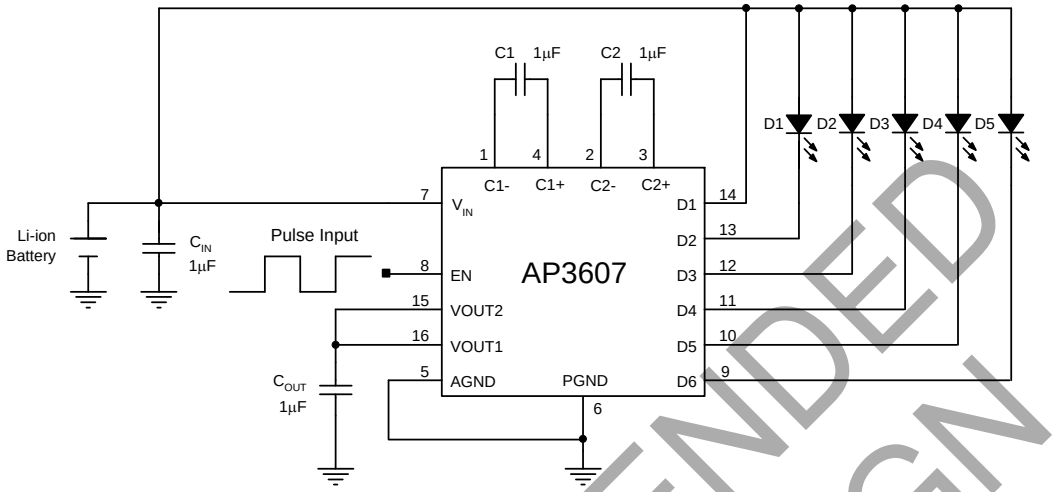


3 WLEDs

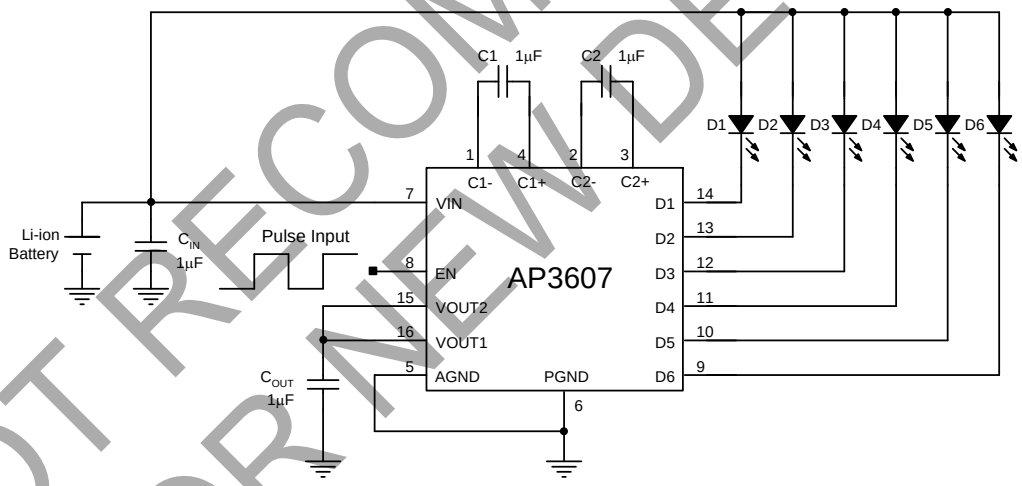


4 WLEDs

Typical Applications Circuit (Cont.)



5 WLEDs



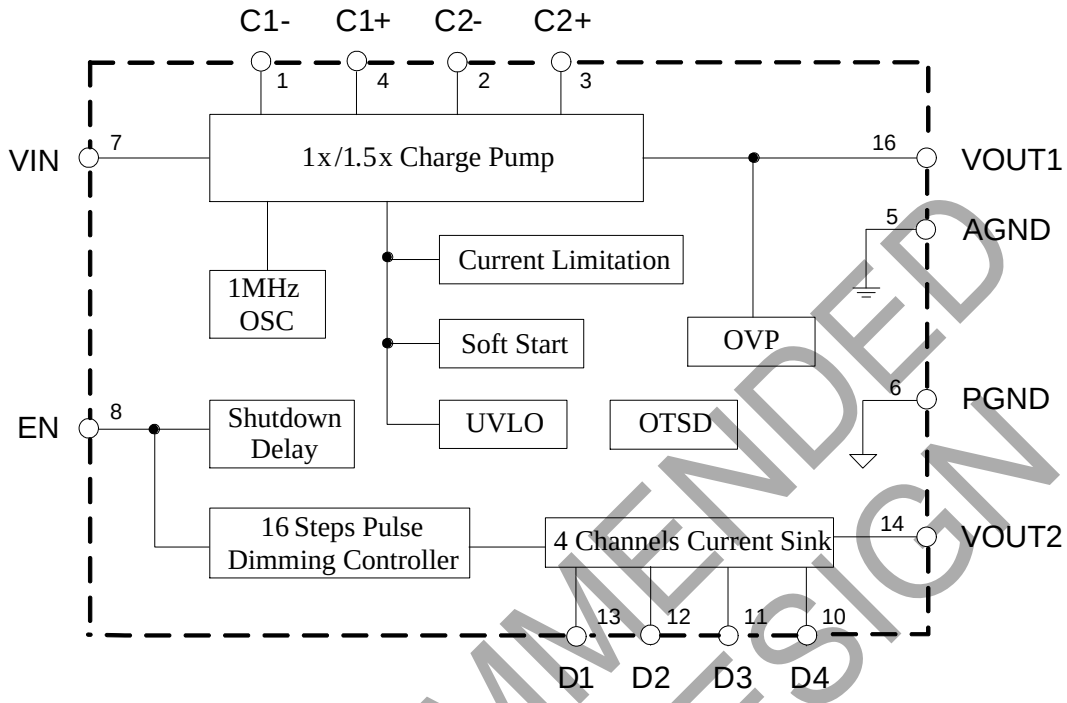
6 WLEDs

Detailed application information, please refer to AP3606/AP3607 application note.

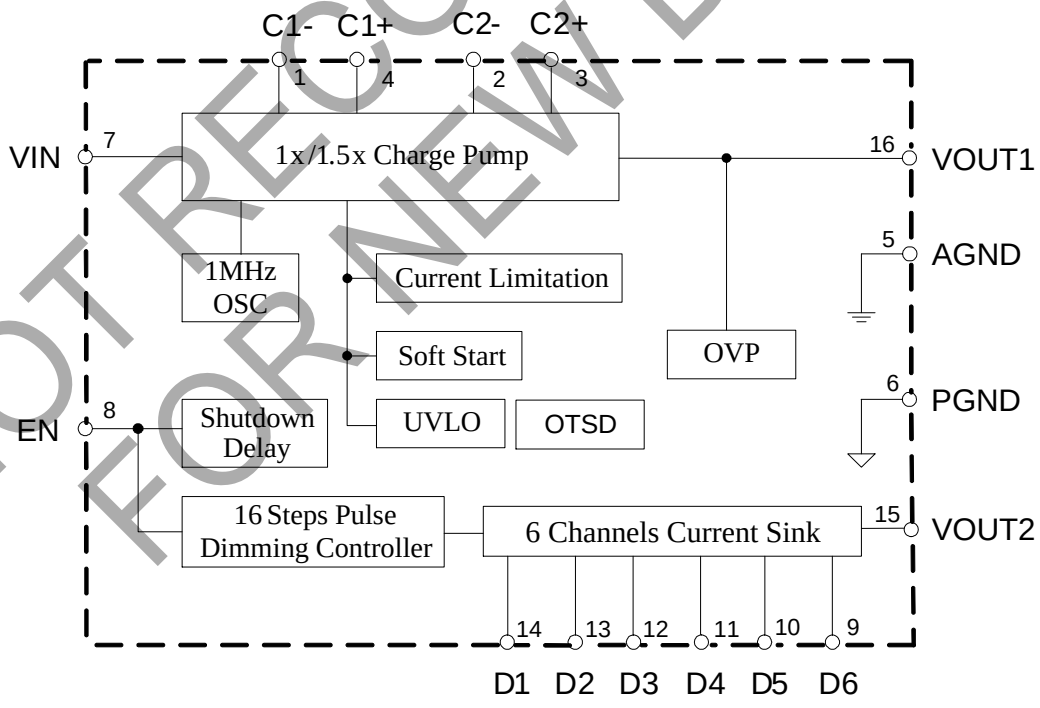
Pin Descriptions

Pin Number		Pin Name	Function
AP3606	AP3607		
1	1	C1-	Flying capacitor 1 negative terminal. The flying capacitor should be connected as close to this pin as possible
2	2	C2-	Flying capacitor 2 negative terminal. The flying capacitor should be connected as close to this pin as possible
3	3	C2+	Flying capacitor 2 positive terminal. The flying capacitor should be connected as close to this pin as possible
4	4	C1+	Flying capacitor 1 positive terminal. The flying capacitor should be connected as close to this pin as possible
5	5	AGND	Analog ground
6	6	PGND	Power ground
7	7	VIN	Supply voltage input
8	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, 15	–	NC	No connection (AP3606 only)
–	9, 10	D6 , D5	Current sink for WLED6 and WLED5. Connect the cathode of WLEDs to these pins. If not used, these pins must be connected with VIN (AP3607 only)
10, 11, 12, 13	11, 12, 13, 14	D4 ~ D1	Current sink for WLED4, 3, 2, 1. Connect the cathode of WLEDs to these pins. If not used, these pins must be connected with VIN
14	15	VOUT2	Output pin 2. It powers 4 channels current sink (AP3606) and 6 channels current sink (AP3607)
16	16	VOUT1	Output Pin 1. It's the charge pump output. The output capacitor should be placed closely to this pin

Functional Block Diagram



AP3606



AP3607

Absolute Maximum Ratings (Note 1)

Symbol	Parameter		Value	Unit
V_{IN}	Input Voltage		-0.3 to 6	V
V_{OUT}	VOUT Pin Voltage (VOUT1 & VOUT2)		-6 to 0.3	V
V_{EN}	EN Pin Voltage		-0.3 to 6	V
V_{C+}	C1+, C2+ Pin Voltage		-0.3 to 6	V
V_{C-}	C1-, C2- Pin Voltage		-6 to 0.3	V
V_D	D1, D2, D3, D4 Pin Voltage	AP3606	V_{OUT} to V_{IN}	V
	D1, D2, D3, D4, D5, D6 Pin Voltage	AP3607		
θ_{JA}	Thermal Resistance (Junction to Ambient, No Heat Sink, Free Air)		60	°C/W
T_J	Operating Junction Temperature		+150	°C
T_{STG}	Storage Temperature		-65 to +150	°C
T_{LEAD}	Lead Temperature (Soldering, 10sec)		+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}	2.7	5.5	V
Operating Ambient Temperature	T_A	-40	+85	°C

Electrical Characteristics

(V_{IN}=3.6V, V_{EN}=V_{IN}, T_A=+25°C, C_{IN}=C1=C2=C_{OUT}=1μF, V_F(forward voltage)=3.2V, unless otherwise noted.)

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
Input Section							
V_{IN}	Input Voltage	I_D=0mA to 80mA		2.7	_	5.5	V
_	Under Voltage Lockout Threshold	V_{IN} Falling		_	2.2	_	V
_	Under Voltage Lockout Hysteresis	_		_	250	_	mV
I_{CC}	Supply Current	No Load		_	1.7	3	mA
I_{SHDN}	Shutdown Supply Current	V_{EN}=GND		_	3	10	μA
Charge Pump Section							
f_{OSC}	Switch Frequency	V_{IN}=3.0V, 1.5x Mode		0.7	1	1.3	MHz
$V_{1.5X}$	1x Mode to 1.5x Mode Transition Voltage (V_{IN} Falling)	AP3606	V_D=3.2V, I_{D1}=I_{D2}=I_{D3}=I_{D4}=20mA	_	3.5	3.6	V
		AP3607	V_D=3.2V, I_{D1}=I_{D2}=I_{D3}=I_{D4}= I_{D5}=I_{D6}=20mA				
V_{1X}	1.5x Mode to 1x Mode Transition Voltage (V_{IN} Rising)	AP3606	V_D=3.2V, I_{D1}=I_{D2}=I_{D3}=I_{D4}=20mA	_	3.7	3.8	V
		AP3607	V_D=3.2V, I_{D1}=I_{D2}=I_{D3}=I_{D4}= I_{D5}=I_{D6}=20mA				
Current Source Section							
I_D	WLED Current	100% Setting, 3.0V≤V_{IN}≤5.0V T_A=-40°C to +85°C		18.5	20	21.5	mA

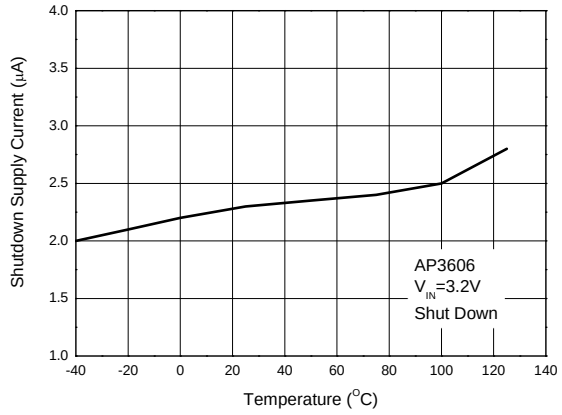
Electrical Characteristics (Cont. V_{IN}=3.6V, V_{EN}=V_{IN}, T_A=+25°C, C_{IN}=C1=C2=C_{OUT}=1μF, V_F(forward voltage)=3.2V, unless otherwise noted.)

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$I_{D-Match1}$	Current Matching Between any Two Outputs	AP3606	V_{D1}=V_{D2}=V_{D3}=V_{D4}= 3.2V	-3	–	3	%
		AP3607	V_{D1}=V_{D2}=V_{D3}=V_{D4}= V_{D5}=V_{D6}=3.2V				
$I_{D-Match2}$	Current Matching Between any Two Outputs	AP3606	V_{D1}=V_{D2}=V_{D3}=V_{D4}=3.0V to 4.0V V_{IN}=3.2V to 5.0V	-3.5	–	3.5	%
		AP3607	V_{D1}=V_{D2}=V_{D3}=V_{D4}= V_{D5}=V_{D6}=3.0V to 4.0V V_{IN}=3.2V to 5.0V				
Enable Section							
V_{IH}	EN High Level Threshold Voltage	–		1.5	–	–	V
V_{IL}	EN Low Level Threshold Voltage	–		–	–	0.5	V
I_{EN}	EN Input Current	V_{EN}= 0V to 5V		–	1	10	μA
t_{SHDN}	EN Low to Shutdown Delay	–		–	–	1	ms
t_{LO}	EN Low Time for Dimming	–		0.45	–	500	μs
t_{HI}	EN High Time for Dimming	–		0.45	–	–	μs
Total Device							
t_{SS}	Soft-start Time	AP3606	I_D=80mA Total	–	200	–	μs
		AP3607	I_D=120mA Total				
I_{INRUSH}	Inrush Current	AP3606	V_{IN}=3.2V, I_D=80mA Total	—	200	–	mA
		AP3607	V_{IN}=3.2V, I_D=120mA Total	–	320	–	
V_{OVP}	Over Voltage Protection	Note 2		–	5.5	–	V
T_{OTSD}	Thermal Shutdown	–		–	+160	–	°C
T_{HYS}	Thermal Shutdown Hysteresis	–		–	+20	–	°C
$θ_{JC}$	Thermal Resistance (Junction to Case)	QFN-3×3-16		–	15	–	°C/W

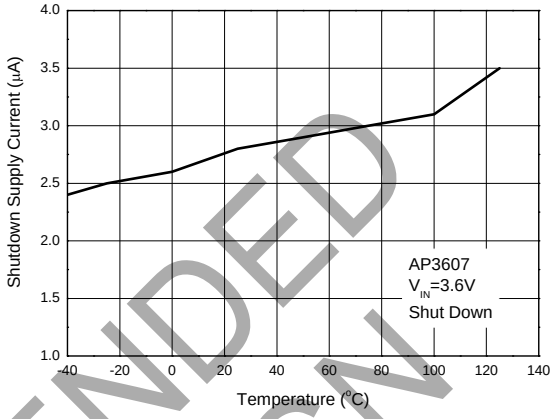
Note 2: Open circuit at any WLED that is programmed to be in the on state.

Typical Performance Characteristics (T_A=+25°C, C_{IN}=C1=C2=C_{OUT}=1μF, V_F=3.2V, unless otherwise noted.)

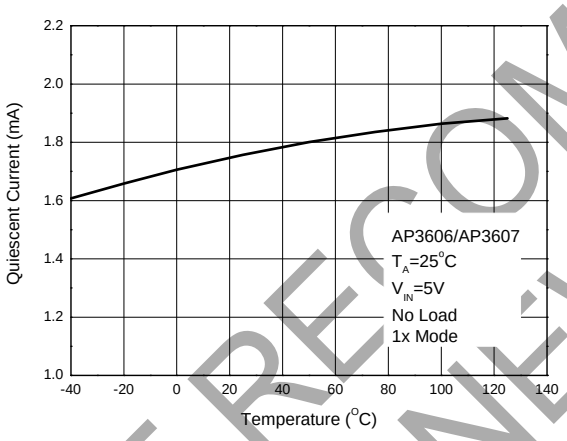
Shutdown Supply Current vs. Temperature



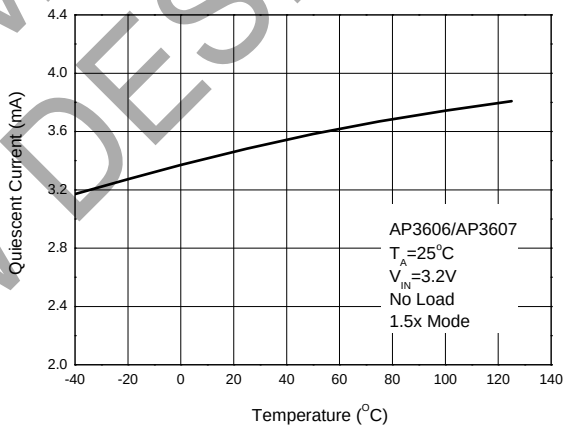
Shutdown Supply Current vs. Temperature



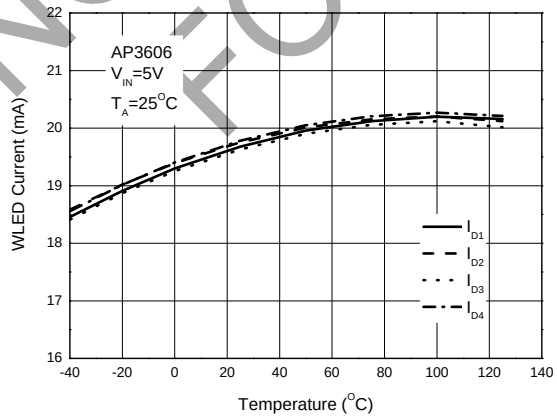
1x Mode Quiescent Current vs. Temperature



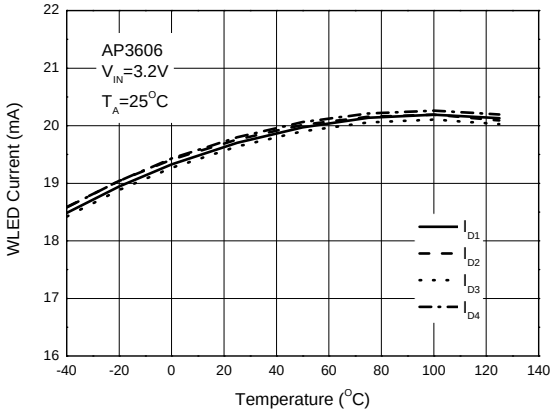
1.5x Mode Quiescent Current vs.Temperature



1x Mode WLED Current vs. Temperature

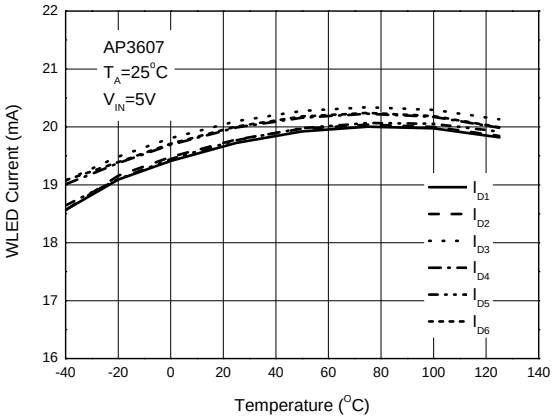


1.5x Mode WLED Current vs. Temperature

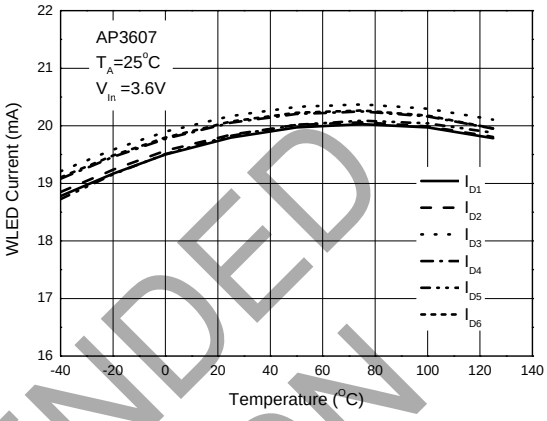


Typical Performance Characteristics (Cont. T_A=+25°C, C_{IN}=C1=C2=C_{OUT}=1μF, V_F=3.2V, unless otherwise noted.)

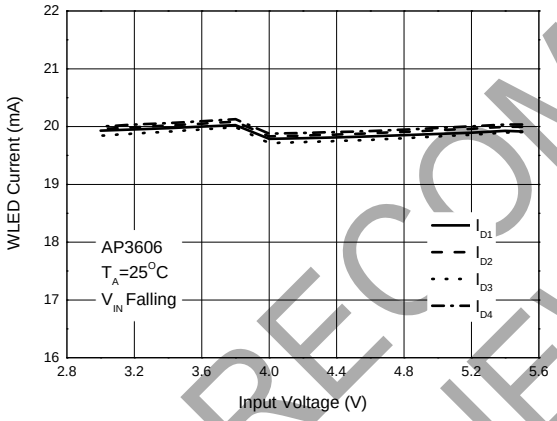
1x Mode WLED Current vs. Temperature



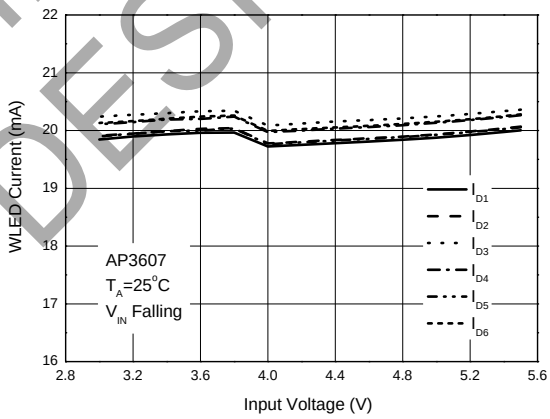
1.5x Mode WLED Current vs.Temperature



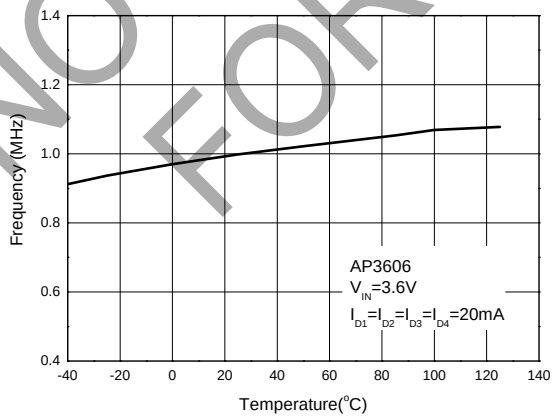
WLED Current vs. Input Voltage



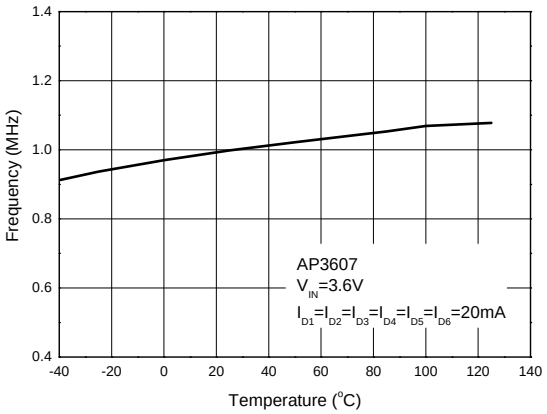
WLED Current vs. Input Voltage



Frequency vs. Temperature

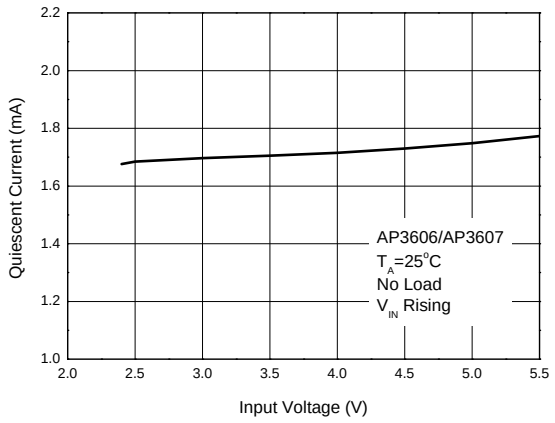


Frequency vs. Temperature

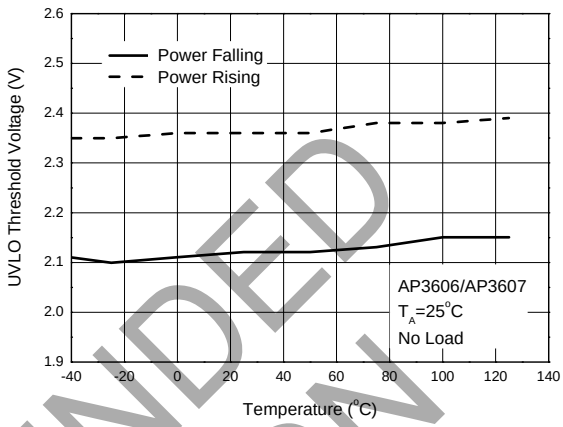


Typical Performance Characteristics (Cont. T_A=+25°C, C_{IN}=C1=C2=C_{OUT}=1μF, V_F=3.2V, unless otherwise noted.)

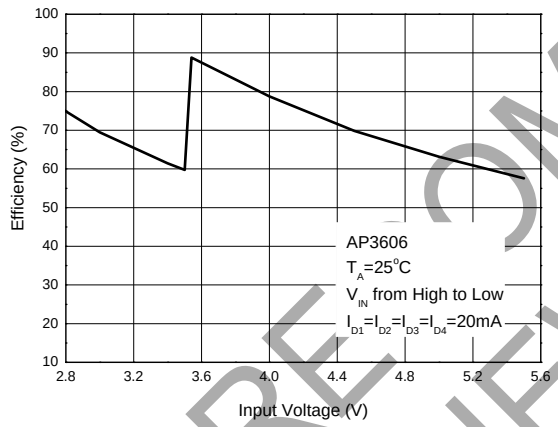
1x Mode Quiescent Current vs. Input Voltage



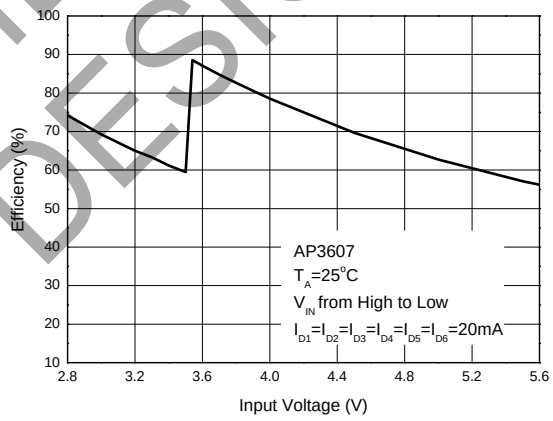
UVLO Threshold Voltage vs. Temperature



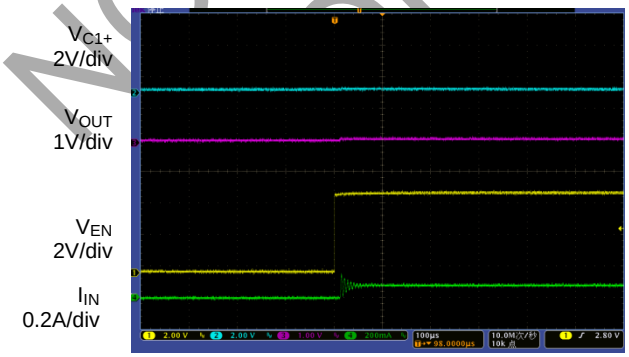
Efficiency vs. Input Voltage



Efficiency vs. Input Voltage

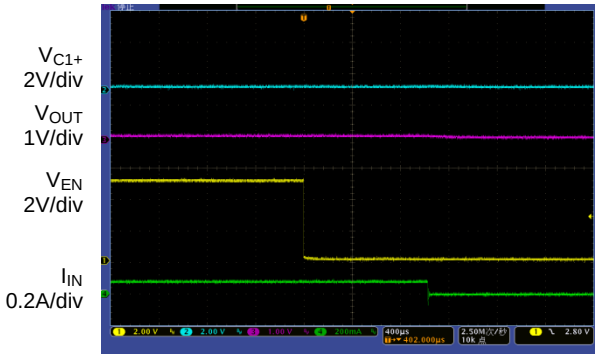


1x Mode Turn on Characteristic (AP3606)



Time (100μs/div)

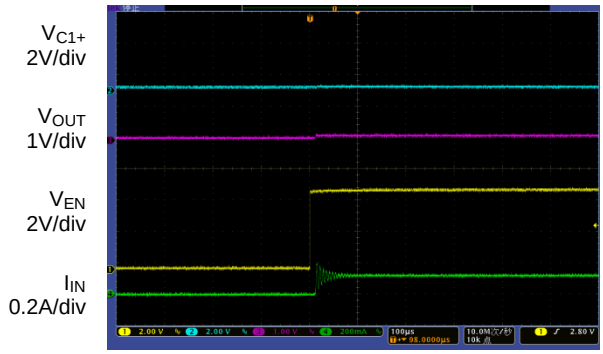
1x Mode Turn off Characteristic (AP3606)



Time (400μs/div)

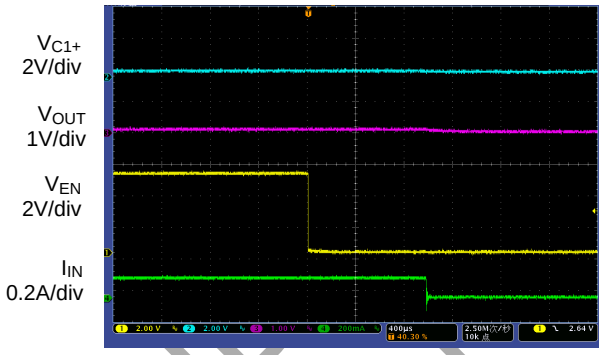
Typical Performance Characteristics (Cont. T_A=+25°C, C_{IN}=C1=C2=C_{OUT}=1μF, V_F=3.2V, unless otherwise noted.)

1x Mode Turn on Characteristic (AP3607)



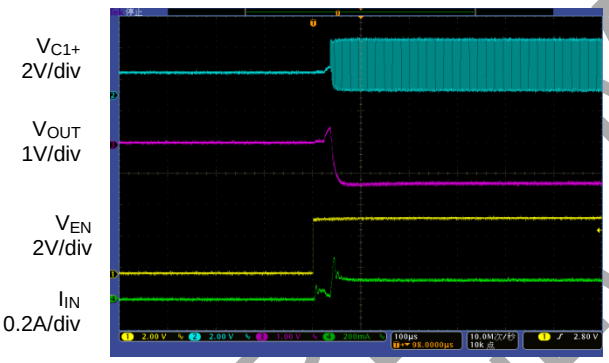
Time (100μs/div)

1x Mode Turn off Characteristic (AP3607)



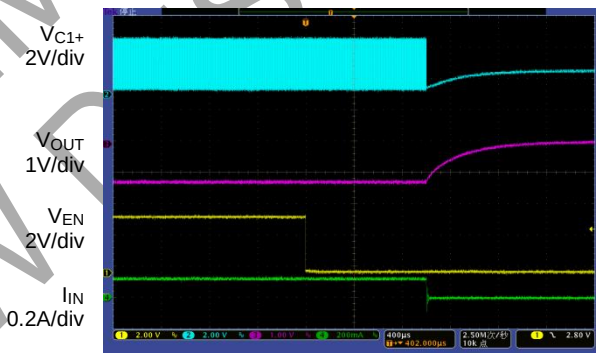
Time (400μs/div)

1.5x Mode Turn on Characteristic (AP3606)



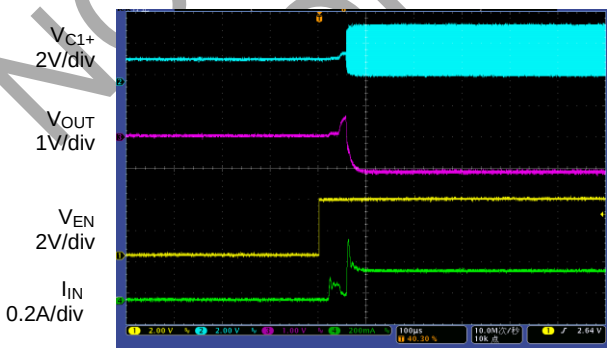
Time (100μs/div)

1.5x Mode Turn off Characteristic (AP3606)



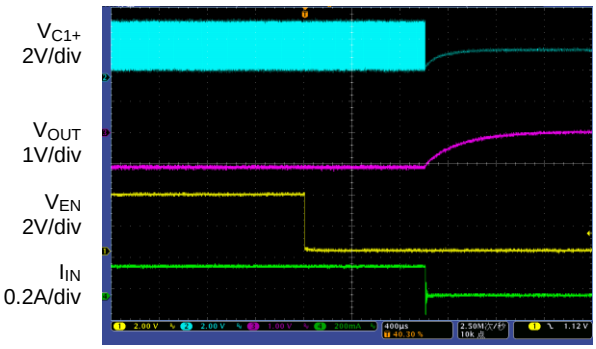
Time (400μs/div)

1.5x Mode Turn on Characteristic (AP3607)



Time (100μs/div)

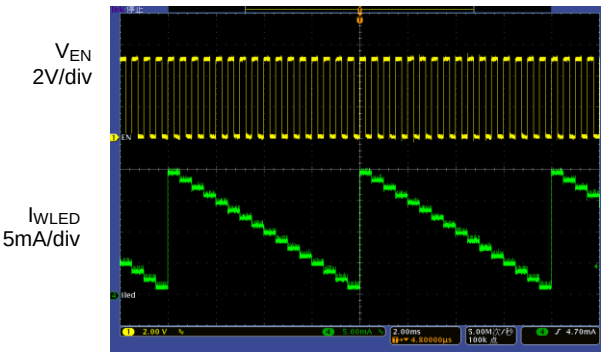
1.5x Mode Turn off Characteristic (AP3607)



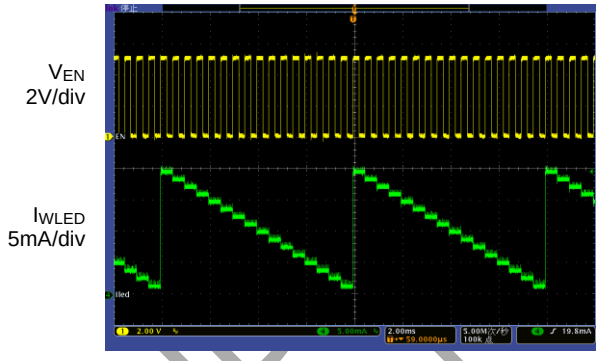
Time (400μs/div)

Typical Performance Characteristics (Cont. T_A=+25°C, C_{IN}=C1=C2=C_{OUT}=1μF, V_F=3.2V, unless otherwise noted.)

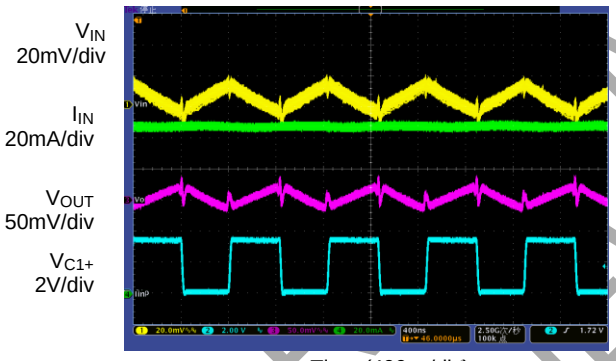
1x Mode Dimming Operation
(AP3606, V_{IN}=5V, f_{EN}=2kHz)



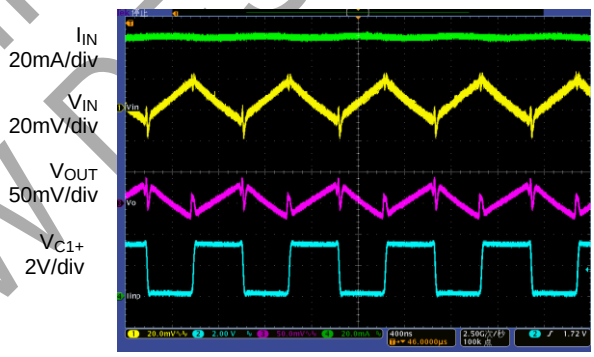
1x Mode Dimming Operation
(AP3607, V_{IN}=5V, f_{EN}=2kHz)



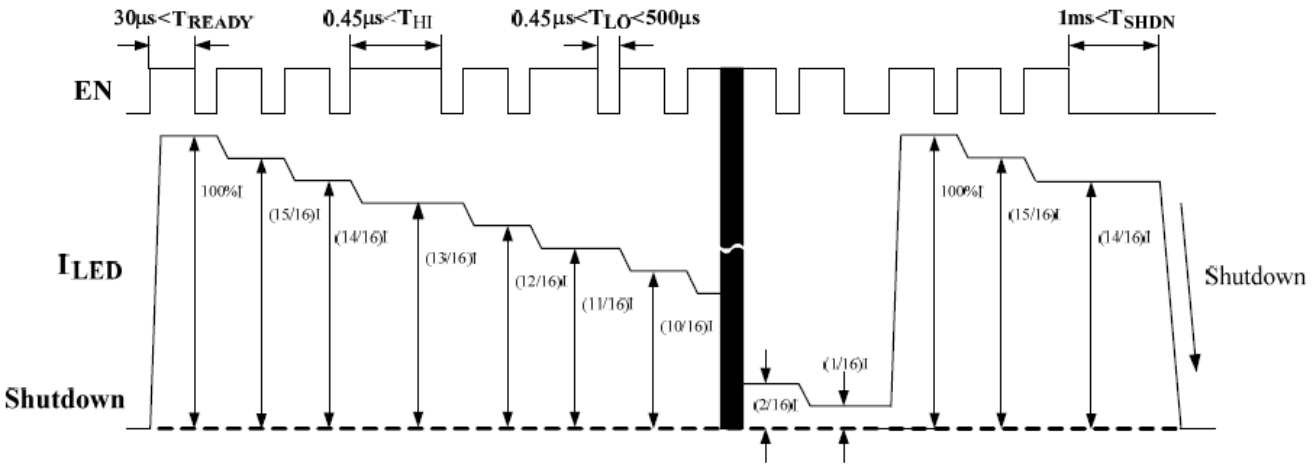
Output Ripple
(AP3606, V_{IN}=3.3V, I_D=80mA)



Output Ripple
(AP3607, V_{IN}=3.3V, I_D=120mA)



Digital Dimming Operating Diagram (Note 3)



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 $t_{LO(MIN)}$ and $t_{LO(MAX)}$, and the high level duration time is larger than $t_{HI(MIN)}$, the LED current will decrease 1/16. If the low level duration time is larger than $t_{SHDN(MAX)}$, the IC will be turned off. When AP3606/AP3607 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.

Ordering Information

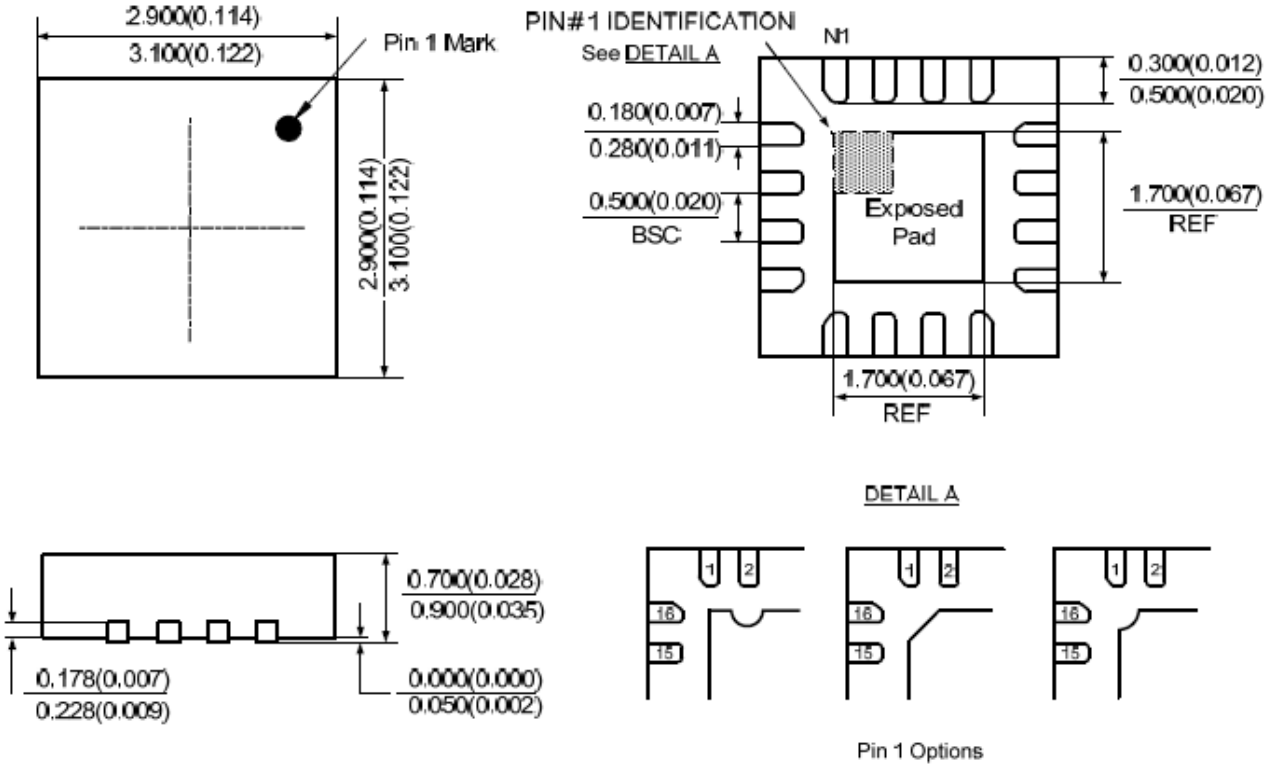
AP36XX X X - X

Product Name	Product Version	Package	Packing	RoHS/Green
	06 : AP3606 07 : AP3607	FN : QFN-3x3-16	TR : Tape & Reel	G1 : Green

Package	Temperature Range	Part Number	Marking ID	Packing
QFN-3×3-16	-40 to +85°C	AP3606FNTR-G1	B1B	Tape & Reel
		AP3607FNTR-G1	B1C	

Package Outline Dimensions (All dimensions in mm(inch).)

(1) Package Type: QFN-3×3-16



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