4-CHANNEL CHARGE PUMP LED DRIVER WITH CURRENT BALANCING AND WIDE RANGE PWM DIMMING

Description

The AP3605 is a step-up DC/DC converter based on 1.5x charge pump current source, it is specially designed for LED supplies in backlight display.

The AP3605 can provide constant current up to 20mA for each LED, which is programmed by an external resistor, so it has a total capability to provide 80mA for 4 LEDs. The chip has a good performance of LED current matching and allows PWM brightness dimming control. Additionally, high switching frequency up to 1MHz enables the use of two small external flying capacitors. Internal soft-start circuitry prevents excessive inrush current during start-up.

The AP3605 supply voltage range is from 2.7V to 5.5V, ideally suited for applications powered by the Li-ion battery.

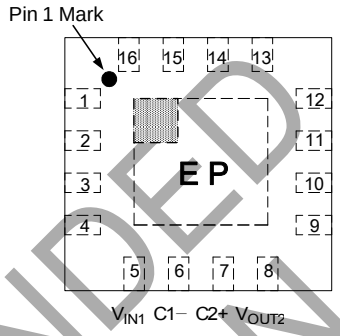
The AP3605 is available in a 3mmx3mm QFN-3x3-16 tiny package. Its operating temperature range is -40°C to +85°C.

Features

- Regulated Output Current with ±3% Matching
- Regulated ±10% Output Current Source
- Drive up to 4 LEDs at 20mA Each
- Wide Operating Voltage Range: 2.7V to 5.5V
- High Efficiency up to 93%
- High Operating Frequency: 1MHz
- Built-In Soft-Start to Limit the Inrush Current
- LED Brightness Control through PWM and Analog Signal
- PWM Dimming Frequency up to 50kHz
- Built-In Standby Mode to Get PWM Dimming Duty Cycle Control Linearity
- Built-In OTSD (Over Temperature Shutdown) Function to Protect the Device from Burn Out

Pin Assignments

(Top View)



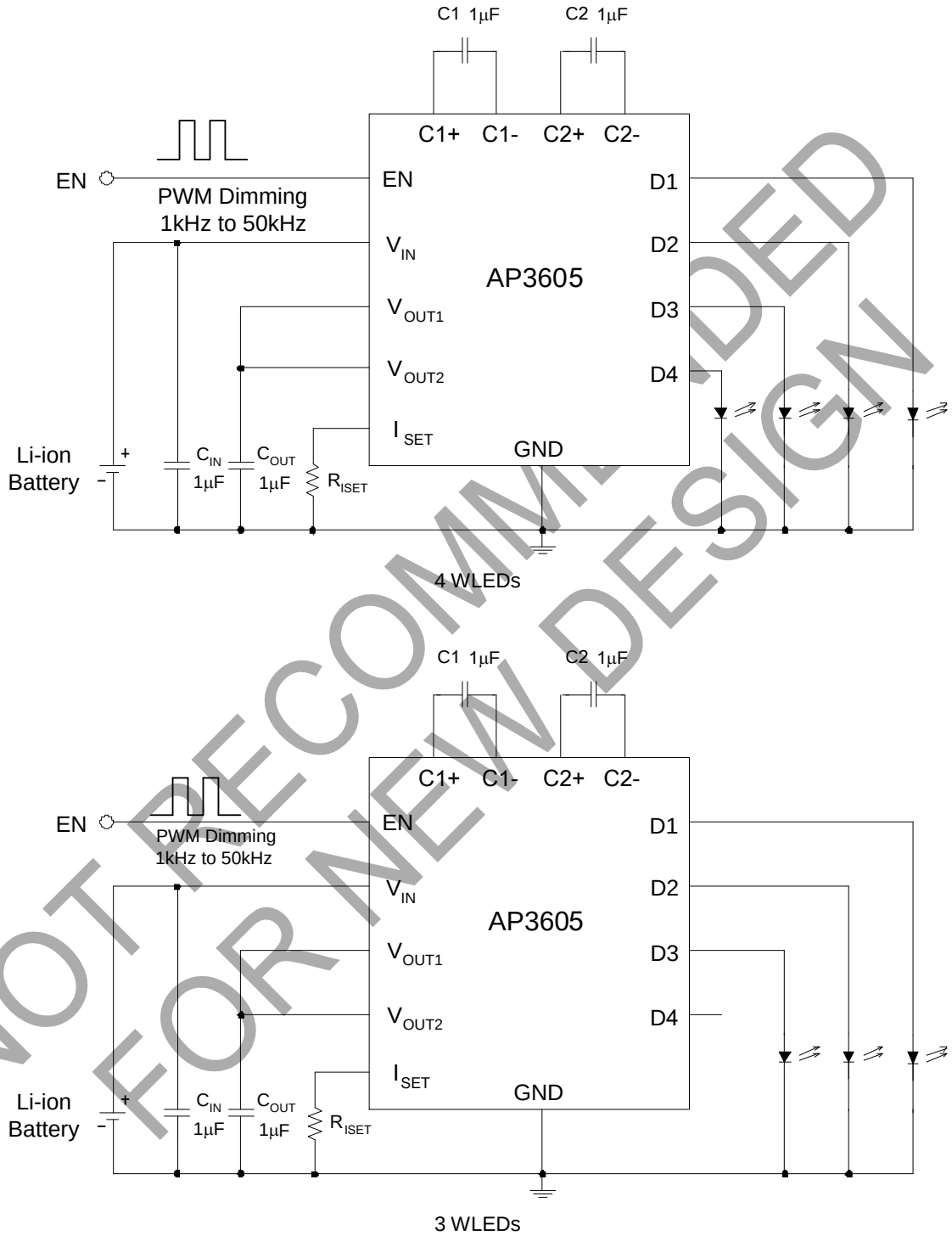
Note: Pin 2 should be connected with Pin 8 and Pin 5 should be connected with Pin 13 on PCB board.

QFN-3×3-16

Applications

- Mobile Phone
- MP3, MP4
- White LED Backlight in Mobile Phone, PDA

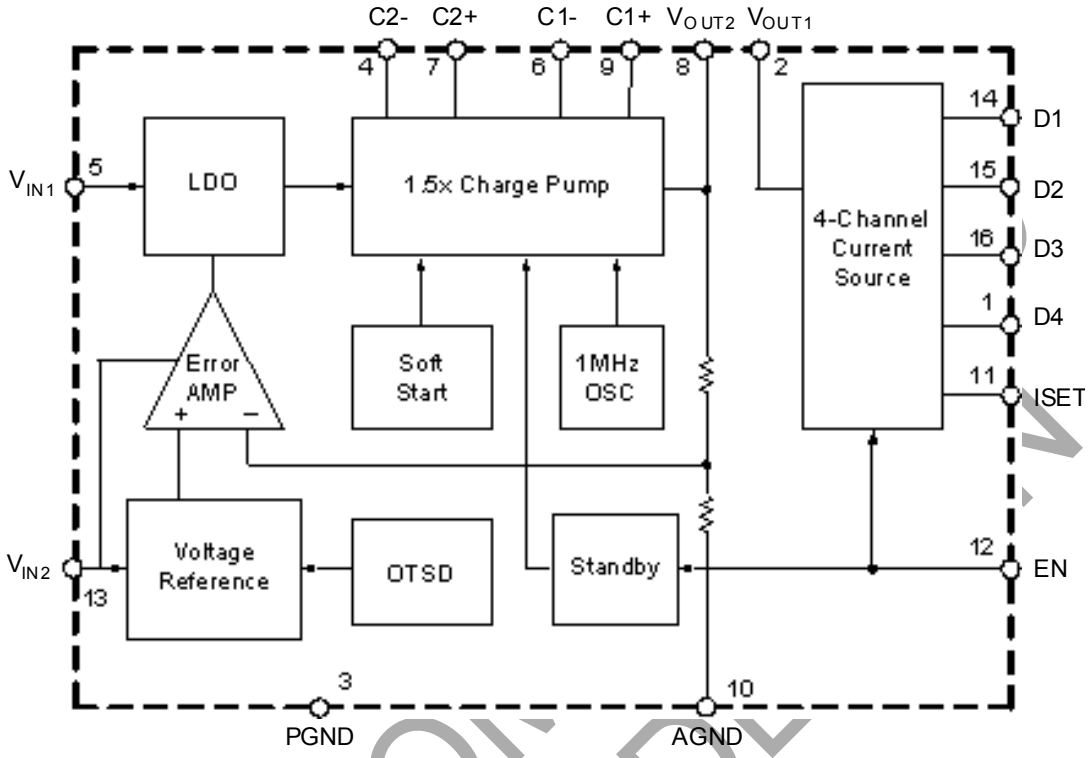
Typical Applications Circuit



Pin Descriptions

Pin Number	Pin Name	Function
1, 16, 15, 14	D4 to D1	Current Source Output. Connect the anode of the white LEDs to these outputs
2, 8	V_{OUT1}, V_{OUT2}	Output Pin 1 and 2, must be connected together. The output capacitor should be placed closely to these pins
3	PGND	Power Ground. Connect this pin with power ground plane
4	C2-	Flying Capacitor 2 Negative Terminal. The flying capacitor 2 should be connected as close to this pin as possible
5, 13	V_{IN1}, V_{IN2}	Supply Voltage Input 1 and 2, must be connected together
6	C1-	Flying Capacitor 1 Negative Terminal. The flying capacitor 1 should be connected as close to this pin as possible
7	C2+	Flying Capacitor 2 Positive Terminal. The flying capacitor 2 should be connected as close to this pin as possible
9	C1+	Flying Capacitor 1 Positive Terminal. The flying capacitor 1 should be connected as close to this pin as possible
10	AGND	Analog Ground. Connect this pin with control signal ground plane. PGND, AGND and the exposed PAD should be connected together
11	ISET	Current Source Set Pin. Connect a resistor between this pin and GND to set the maximum LED current
12	EN	Enable Control Input. Logic high enables the IC; while logic low forces the device into shut-down mode to reduce the supply current to less than 1μA. Add a PWM signal to this pin to achieve brightness control

Functional Block Diagram



Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Value	Unit
V_{IN}	Input Voltage	-0.3 to 6	V
V_{EN}	EN Pin Voltage	-0.3 to 6	V
V_{OUT1}	V_{OUT1} Pin Voltage	-0.3 to 6	V
V_{OUT2}	V_{OUT2} Pin Voltage	-0.3 to 6	V
V_{ISET}	ISET Pin Voltage	-0.3 to 6	V
I_{OUT2}	Output Current at V_{OUT2} Pin	150	mA
$R_{\theta JA}$	Thermal Resistance (Junction to Ambient, no Heat sink)	60	°C/W
T_J	Operating Junction Temperature	+150	°C
T_{STG}	Storage Temperature Range	-65 to +150	°C
T_{LEAD}	Lead Temperature (Soldering, 10sec)	+260	°C
_	ESD (Human Body Model)	2000	V

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

Symbol	Parameter	Min	Max	Unit
V_{IN}	Input Voltage	2.7	5.5	V
T_A	Operating Temperature	-40	+85	°C
R_{ISET}	Current Source Set Resistor	1.44	_	kΩ

Electrical Characteristics

(V_{IN}=3.5V, V_{EN}=V_{IN}, R_{ISET}=1.8kΩ, C_{FLY1}=C_{FLY2}=C_{IN}=C_{OUT}=1μF, T_A=+25℃, V_{D1}=V_{D2}=V_{D3}=V_{D4}=3.4V, unless otherwise specified.)

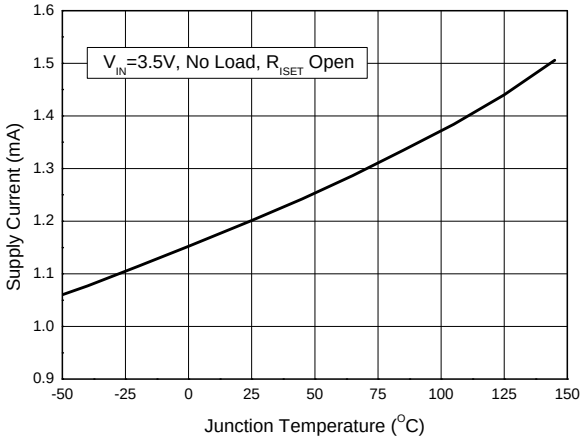
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Input Section						
V_{IN}	Input Voltage	I_D=0 to 40 mA	2.7	_	5.5	V
I_{CC}	Supply Current	No Load, ISET floating	_	1.5	2.5	mA
I_{SHDN}	Shutdown Supply Current	V_{EN}=GND	_	0.1	1	μA
Charge Pump Section						
f_{OSC}	Switching Frequency	_	0.65	1	1.35	MHz
η	Efficiency	V_{IN}=3.5V, I_D=40mA Total	_	93	_	%
Current Source Section						
I_{DX}	Maximum Output Current per Source	3.2V≤V_{IN}≤5.5V, T_A=-40°C to +85°C	18	20	22	mA
$I_{D-MATCH}$	Current Matching between Any Two Outputs	_	-3	_	3	%
$(\Delta I_D/I_D)/\Delta V$	Output Current Line Regulation	3.5V≤V_{IN}≤5.5V	-2	_	2	%/V
$\Delta I_D/I_D$	Current Matching between Any Two Outputs under Different LED Forward Voltage	3.0V≤V_D≤4.0V, V_{IN}=3.5V	-5	_	5	%
V_{ISET}	Reference Voltage for Current Set	_	1.193	1.23	1.267	V
K	I_D to I_{SET} Current Ratio	_	100	120	140	_
Enable Section						
V_{IH}	EN High Level Threshold Voltage	_	1.4	_	_	V
V_{IL}	EN Low Level Threshold Voltage	_	_	_	0.5	V
I_{EN}	EN Input Leakage Current	V_{EN}=5.5V	-1	_	1	μA
t_{STB}	EN Low Threshold Time for Standby State	_	_	2	_	ms

Electrical Characteristics (V_{IN}=3.5V, V_{EN}=V_{IN}, R_{ISET}=1.8kΩ, C_{FLY1}=C_{FLY2}=C_{IN}=C_{OUT}=1μF, T_A=+25℃, V_{D1}=V_{D2}=V_{D3}=V_{D4}=3.4V, unless otherwise specified.) (Cont.)

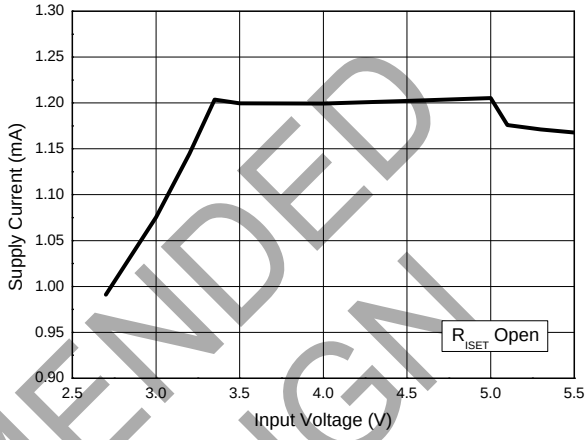
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Total Device						
t_{SS}	Soft-Start Time	I_D=80mA Total	_	400	_	μs
T_{OTSD}	Thermal Shutdown	_	_	+160	_	°C
T_{HYS}	Thermal Shutdown Hysteresis	_	_	+20	_	°C

Typical Performance Characteristics (V_{IN}=3.5V, V_{EN}=V_{IN}, R_{ISET}=1.8kΩ, C_{FLY1}=C_{FLY2}=C_{IN}=C_{OUT}=1μF, T_A=+25°C, V_{D1}=V_{D2}=V_{D3}=V_{D4}=3.4V, unless otherwise specified. V_{OUT} is the output voltage when V_{OUT1} and V_{OUT2} are connected.)

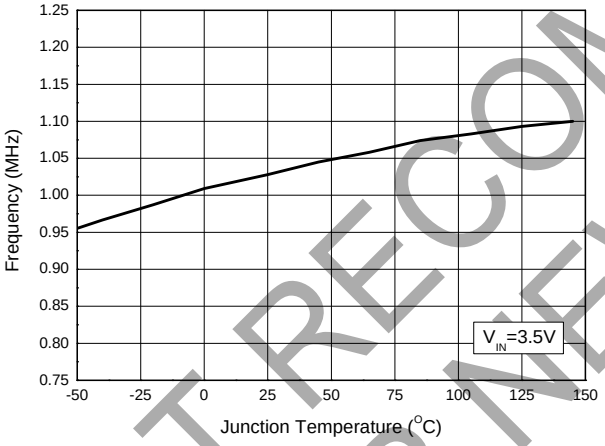
Supply Current vs. Junction Temperature



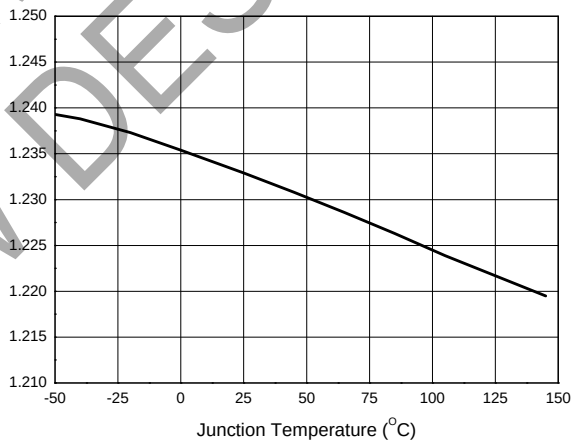
Supply Current vs. Input Voltage



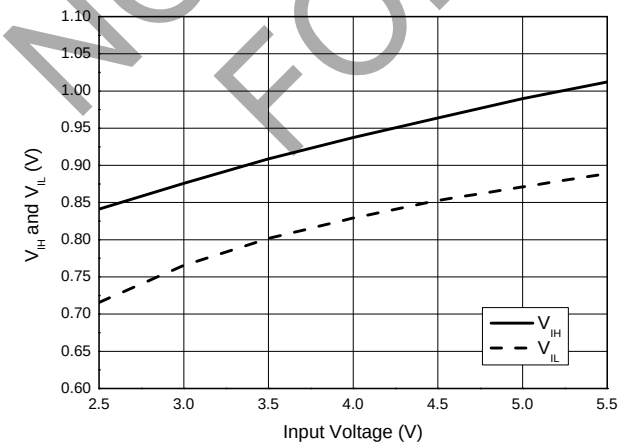
Frequency vs. Junction Temperature



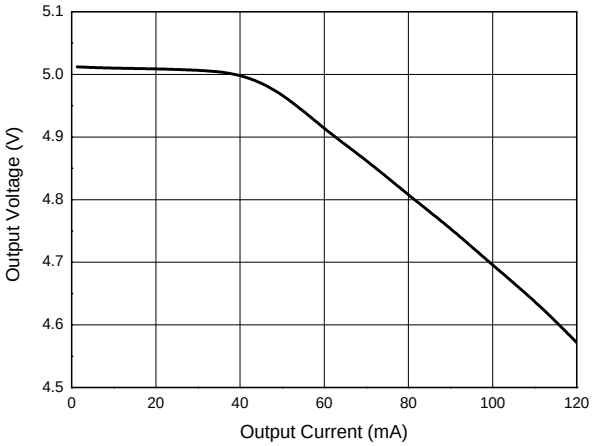
Reference Voltage vs. Junction Temperature



V_{IH} and V_{IL} vs. Input Voltage

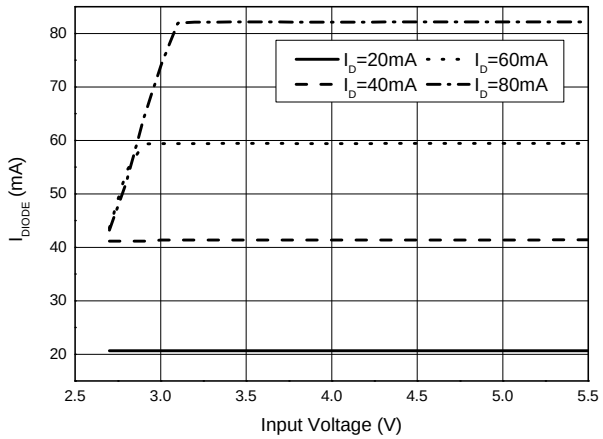


Output Voltage vs. Output Current

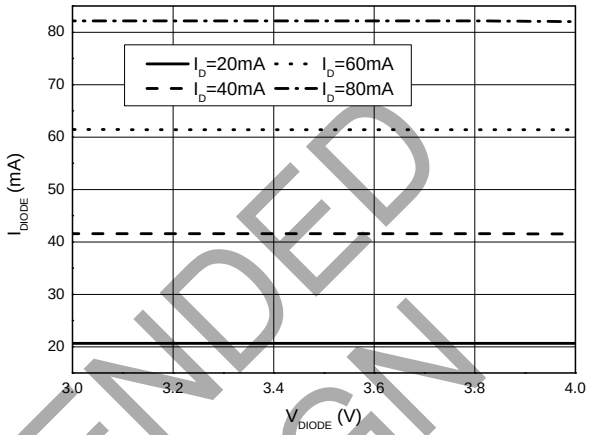


Typical Performance Characteristics (V_{IN}=3.5V, V_{EN}=V_{IN}, R_{ISET}=1.8kΩ, C_{FLY1}=C_{FLY2}=C_{IN}=C_{OUT}=1μF, T_A=+25℃, V_{D1}=V_{D2}=V_{D3}=V_{D4}=3.4V, unless otherwise specified. V_{OUT} is the output voltage when V_{OUT1} and V_{OUT2} are connected.) (Cont.)

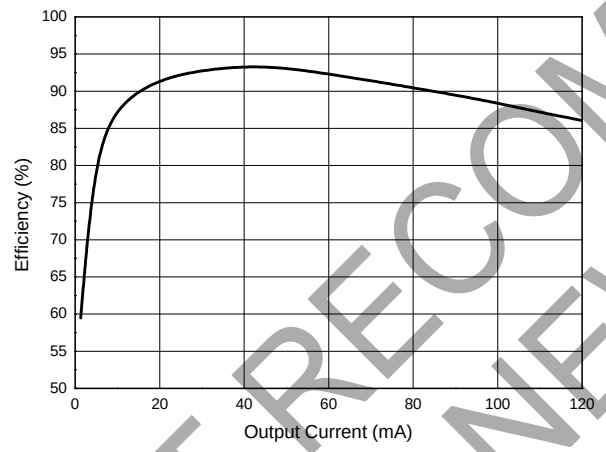
I_{DIODE} vs. Input Voltage



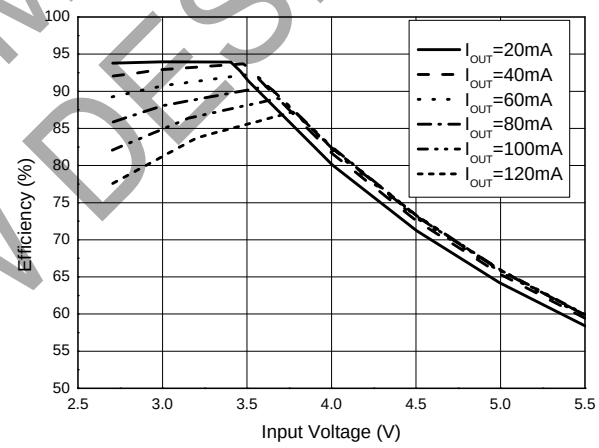
I_{DIODE} vs. V_{DIODE}



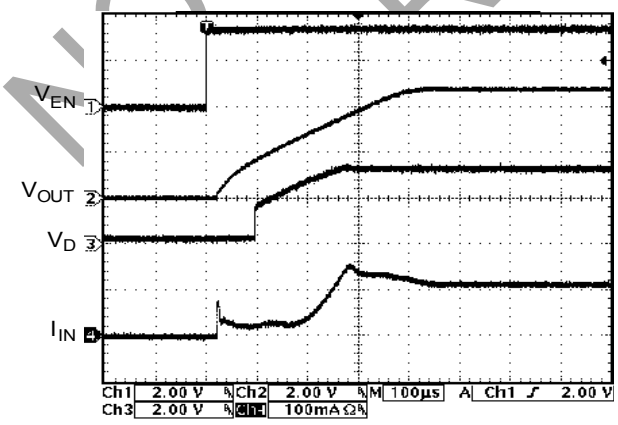
Efficiency vs. Output Current



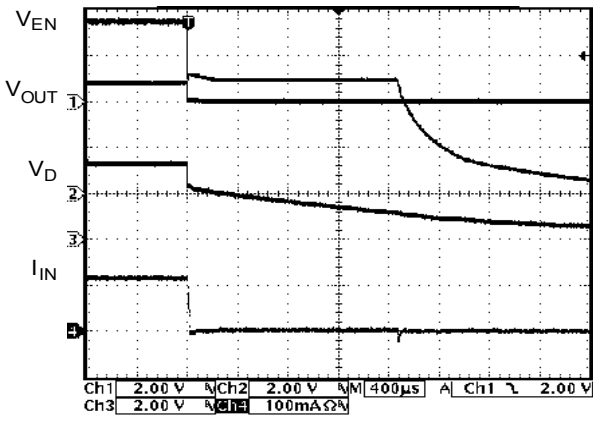
Efficiency vs. Intput Current



Turn on Characteristic

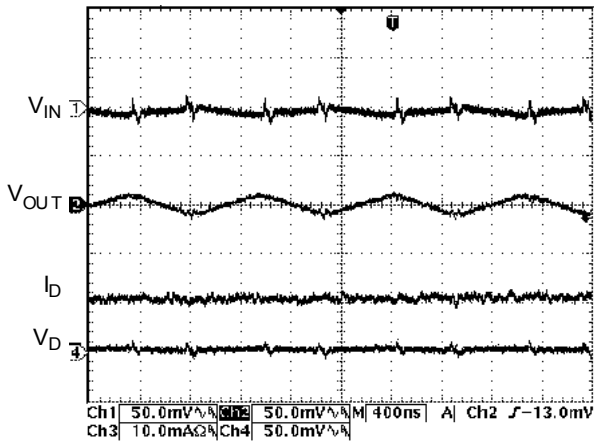


Turn off Characteristic

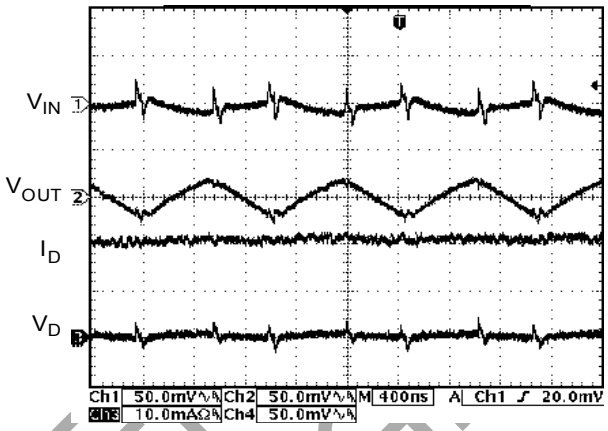


Typical Performance Characteristics (V_{IN}=3.5V, V_{EN}=V_{IN}, R_{ISET}=1.8kΩ, C_{FLY1}=C_{FLY2}=C_{IN}=C_{OUT}=1μF, T_A=+25℃, V_{D1}=V_{D2}=V_{D3}=V_{D4}=3.4V, unless otherwise specified. V_{OUT} is the output voltage when V_{OUT1} and V_{OUT2} are connected.) (Cont.)

Output Ripple @I_D=40mA



Output Ripple @I_D=80mA



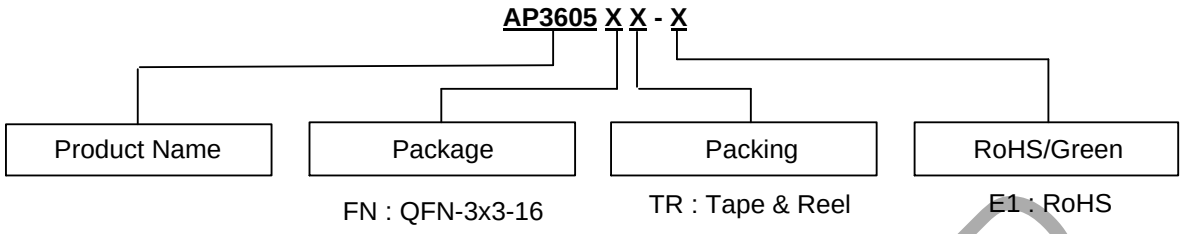
Operation

The AP3605 is a high efficiency 1.5x fractional charge pump with 4 channels of integrated current source for white LED backlight applications.

The AP3605 consists of a linear regulator followed by a 1.5x charge pump which operates at 1MHz, 4 channels current source, a reference and other control circuits. The linear regulator regulates its output voltage to supply charge pump, guarantees that the charge pump always operates at 5V output with 1.5x mode. This configuration minimizes the output ripple.

The charge pump can generate 80mA of output current, so each of the 4 WLED can be powered with up to 20mA of current. The maximum LED current is set by a resistor connected to the ISET pin which programs a reference current, then the reference current is mirrored to set the LED current. Applying a PWM signal to the EN pin can be used to achieve LED brightness dimming. Integrated 2ms standby function helps to enhance the dimming control. Detailed descriptions please see the related application note.

Ordering Information

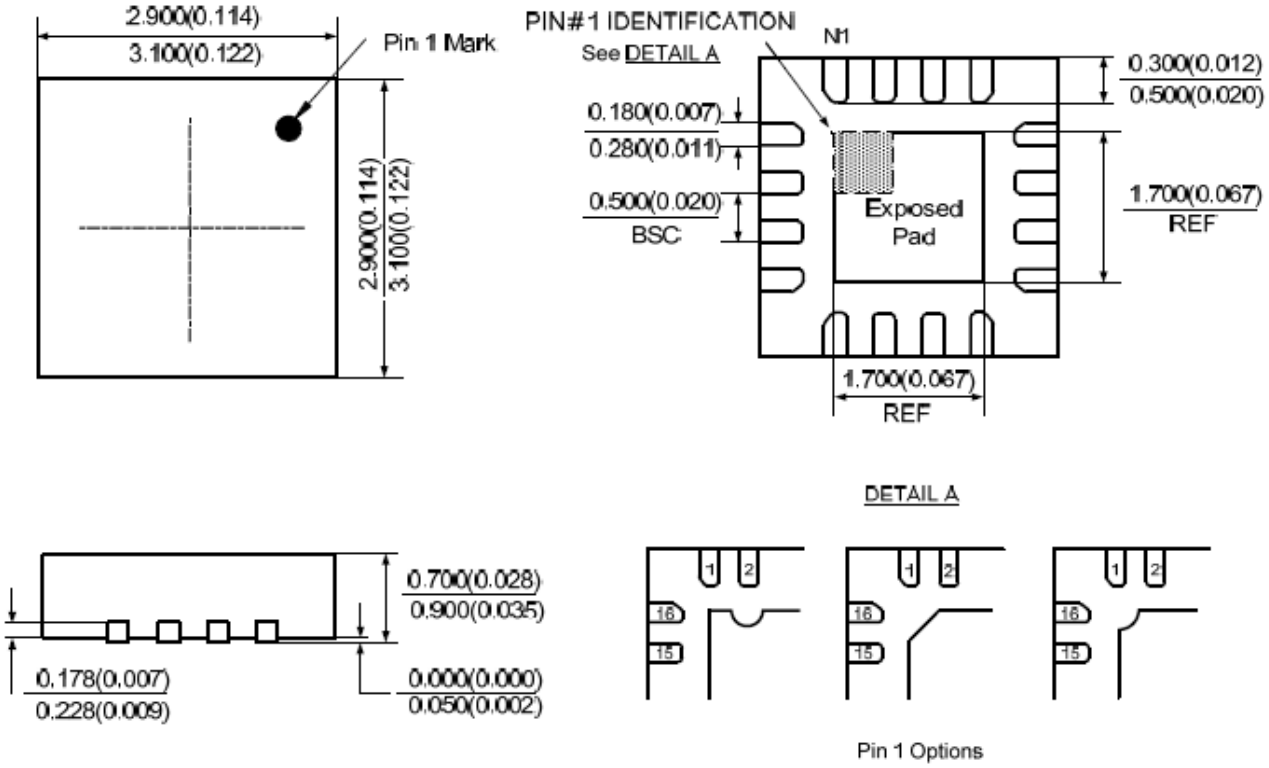


Package	Temperature Range	Part Number	Marking ID	Packing
QFN-3x3-16	-40 to +85°C	AP3605FNTR-E1 (Note 2)	F1A	Tape & Reel

Note 2: AP3605FNTR-E1 is a green product.

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

(1) Package Type: QFN-3×3-16



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