CATALYST SEMICONDUCTOR, INC.
BEYOND MEMORY™

CAT3612

HALOGEN FREE LEAD FREE™ RoHS Compliance

Programmable 300mA Camera Flash LED Driver

FEATURES

- **Dual matched regulated LED channels**
- **300mA output current (150mA per channel)**
- **1-wire EZDim™ Programmable LED Current**
- **32 accurate dimming levels**
- **Power efficiency up to 90%**
- **Fractional pump 1x/1.5x**
- **Low noise input ripple**
- **Fixed High Frequency Operation 1MHz**
- **"Zero" Current Shutdown Mode**
- **Soft start and current limiting**
- **Short circuit protection**
- **Thermal shutdown protection**
- **12-lead TDFN 3mm x 3mm package**

APPLICATION

- **Camera Flash**
- **Cellular Phones**
- **Digital Still Cameras**

ORDERING INFORMATION

Part Number	Package	Quantity per Reel	Package Marking
CAT3612HV2-T2	TDFN-12 3x3 Green *	2000	HAAD

Note *: *Plated lead finish is Matte Tin.*
For other lead finish option, please contact factory.

PRODUCT DESCRIPTION

The CAT3612 is a high-efficiency 1x/1.5x fractional charge pump with programmable current in two LED channels. Each channel delivers accurate regulated current up to 150mA and make CAT3612 ideal for driving one or two flash LEDs.

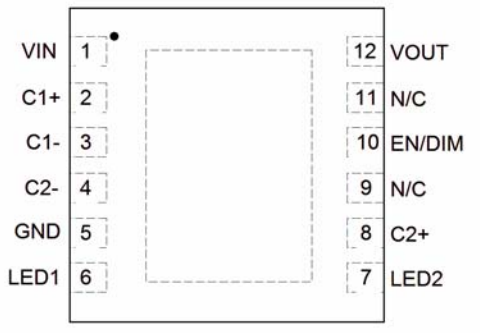
Low noise operation is achieved by operating at a constant switching frequency of 1MHz which allows the use of small external ceramic capacitors. The 1x/1.5x fractional charge pump supports a wide range of input voltages from 3V to 5.5V with efficiency up to 90%, and is ideal for Li-Ion battery powered devices.

The EN/DIM logic input provides a 1-wire EZDim™ interface for dimming control of the LEDs. When enabled, pulsing the EN/DIM reduces the LED current on each negative edge in 31 linear steps from 150mA down to zero current.

The device is available in the tiny 12-lead thin DFN 3mm x 3mm package with a max height of 0.8mm.

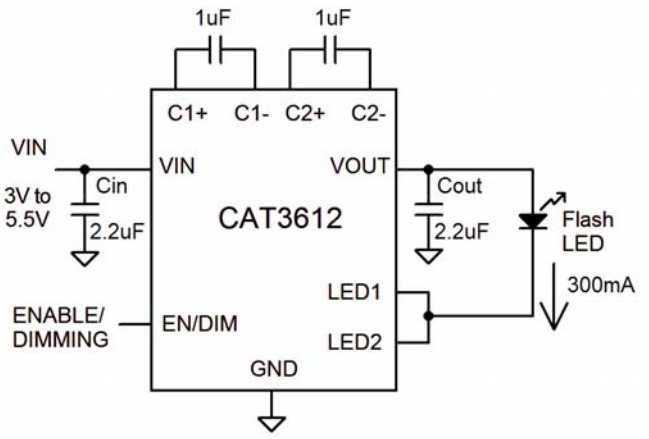
PIN CONFIGURATION

Top View



12-lead TDFN 3mm x 3mm

TYPICAL APPLICATION CIRCUIT



Note: *Unused LED channel must be connected to VOUT*

ABSOLUTE MAXIMUM RATINGS

Parameter	Rating	Unit
VIN, LED1, LED2 voltage	6	V
VOUT, C1±, C2± voltage	7	V
EN/DIM voltage	VIN + 0.7V	V
Storage Temperature Range	-65 to +160	°C
Junction Temperature Range	-40 to +125	°C
Lead Temperature	300	°C

RECOMMENDED OPERATING CONDITIONS

Parameter	Range	Unit
VIN	3 to 5.5	V
Ambient Temperature Range	-40 to +85	°C
I_{LED} per LED pin	0 to 150	mA
Total Output Current	0 to 300	mA

Typical application circuit with external components is shown on page 1.

ELECTRICAL OPERATING CHARACTERISTICS

(over recommended operating conditions unless specified otherwise) VIN = 3.6V, EN = High, ambient temperature of 25ºC.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_Q	Quiescent Current	1x mode, no load 1.5x mode, no load		0.5 3		mA mA
I_{QSHDN}	Shutdown Current	V_{EN} = 0V			1	µA
$I_{LED-ACC}$	LED Current Accuracy	5mA ≤ I_{LED} ≤ 150mA		±3		%
$I_{LED-DEV}$	LED Channel Matching	(I_{LED} - I_{LEDAVG}) / I_{LEDAVG}		±3		%
R_{OUT}	Output Resistance (open loop)	1x mode, I_{OUT} = 100mA 1.5x mode, I_{OUT} = 100mA		0.4 2.6		Ω Ω
F_{OSC}	Charge Pump Frequency		0.8	1	1.3	MHz
I_{SC_MAX}	Output short circuit Current Limit	VOUT < 0.5V		60		mA
I_{IN_MAX}	Input Current Limit	1x mode, VOUT > 1V		350		mA
$I_{EN/DIM}$ V_{HI} V_{LO}	EN/DIM Pin • Input Leakage • Logic High Level • Logic Low Level		 -1 1.3		 1 0.4	 µA V V
T_{SD}	Thermal Shutdown			165		ºC
T_{HYS}	Thermal Hysteresis			20		ºC
V_{UVLO}	Undervoltage lock out (UVLO) Threshold			2		V

RECOMENDED EN/DIM TIMING

For 3V ≤ VIN ≤ 5.5V, over full ambient temperature range -40°C to +85°C.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
T_{SETP}	EN/DIM setup from shutdown		10			µs
T_{LO}	EN/DIM program low time		0.3		200	µs
T_{HI}	EN/DIM program high time		0.3			µs
T_{OFF}	EN/DIM low time to shutdown		1.5			ms
T_D	LED current enable			40		µs
T_{DEC}	LED current decrement			0.1		µs

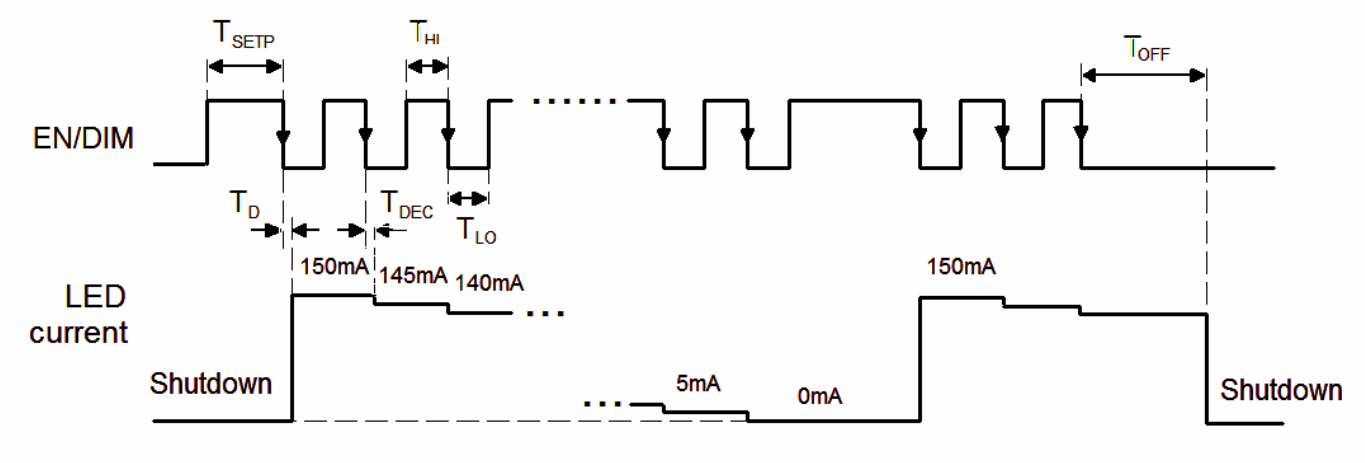
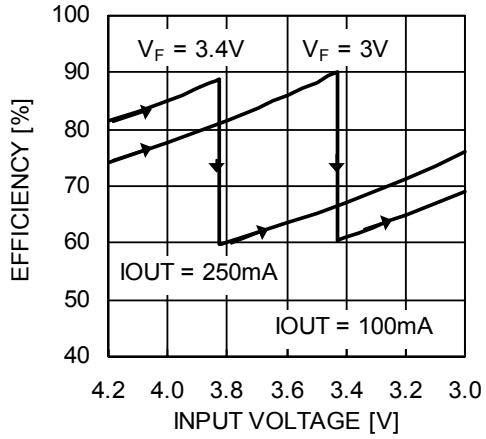


Figure 1. LED Dimming Timing Diagram

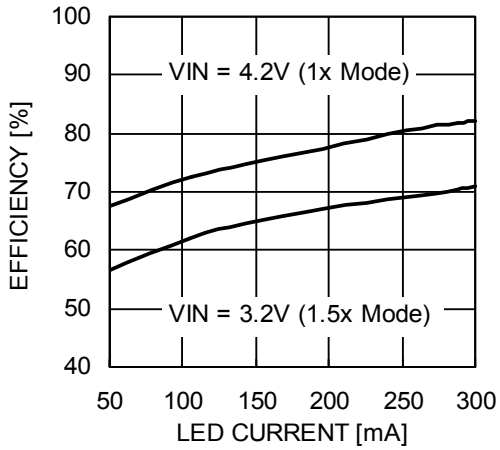
TYPICAL CHARACTERISTICS

VIN = 3.6V, I_{OUT} = 100mA, C_{IN} = C_{OUT} = 2.2µF, C_1 = C_2 = 1µF, T_{AMB} = 25°C unless otherwise specified.

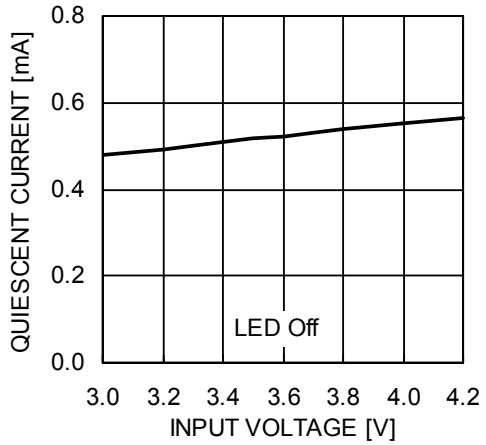
Efficiency vs. Input Voltage



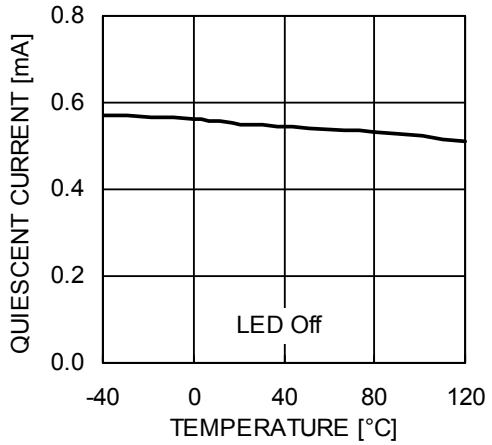
Efficiency vs. LED Current



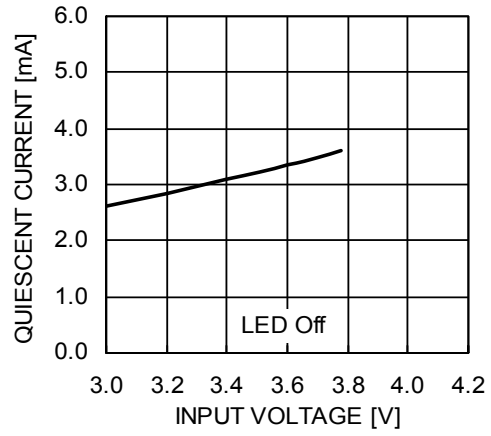
Quiescent Current vs. Input Voltage (1x mode)



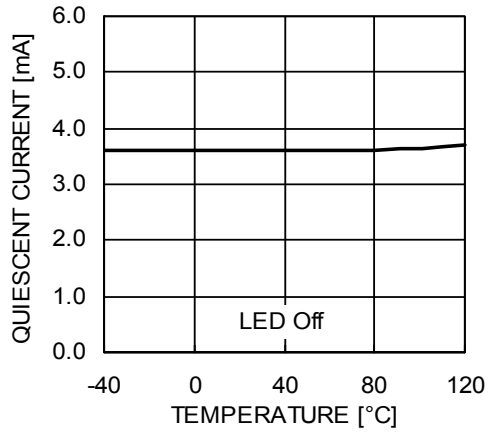
Quiescent Current vs. Temperature (1x mode)



Quiescent Current vs. Input Voltage (1.5x mode)



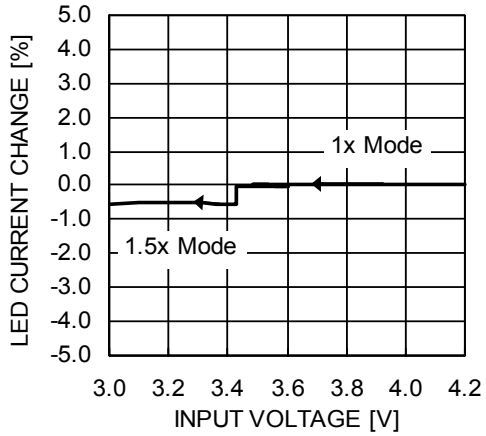
Quiescent Current vs. Temperature (1.5x mode)



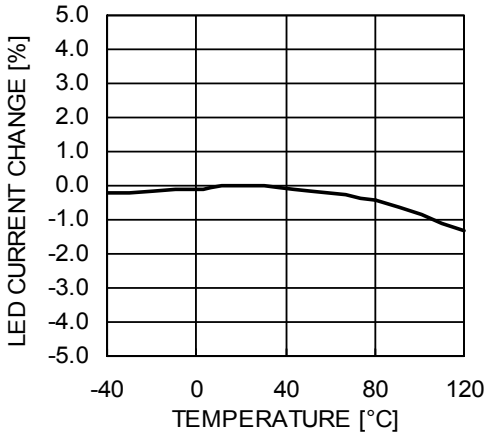
TYPICAL CHARACTERISTICS

VIN = 3.6V, I_{OUT} = 100mA, C_{IN} = C_{OUT} = 2.2µF, C_1 = C_2 = 1µF, T_{AMB} = 25°C unless otherwise specified.

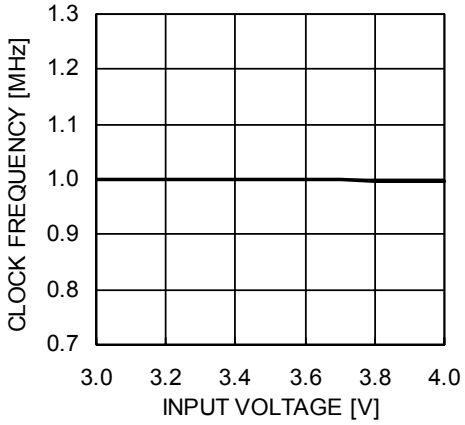
LED Current Change vs. Input Voltage



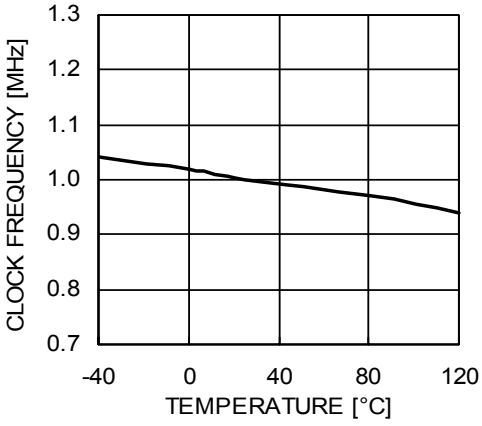
LED Current Change vs. Temperature



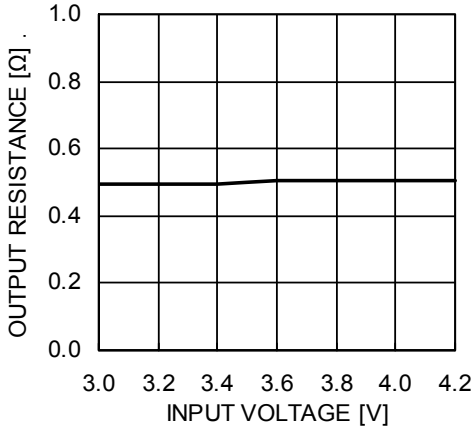
Oscillator Frequency vs. Input Voltage



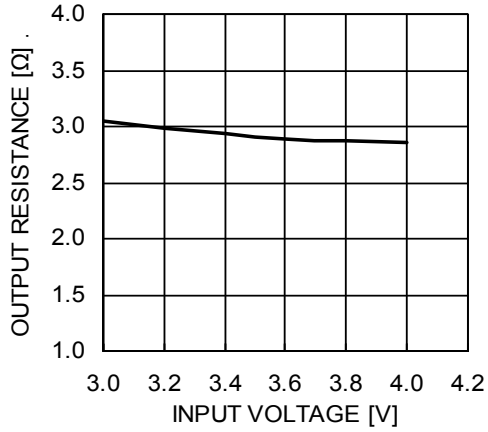
Oscillator Frequency vs. Temperature



Output Resistance vs. Input Voltage (1x mode)



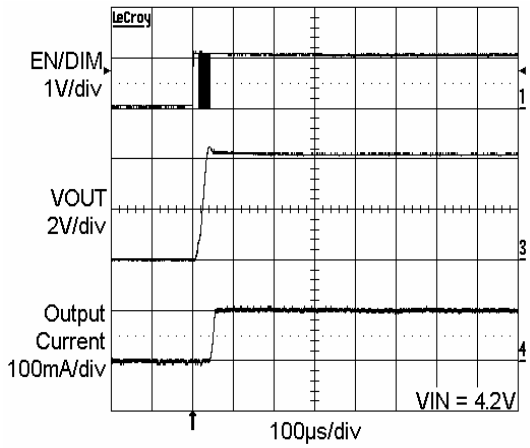
Output Resistance vs. Input Voltage(1.5x mode)



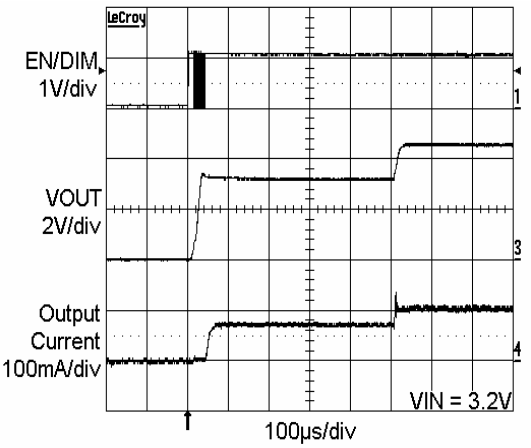
TYPICAL CHARACTERISTICS

VIN = 3.6V, I_{OUT} = 100mA, C_{IN} = C_{OUT} = 2.2µF, C_1 = C_2 = 1µF, T_{AMB} = 25°C unless otherwise specified.

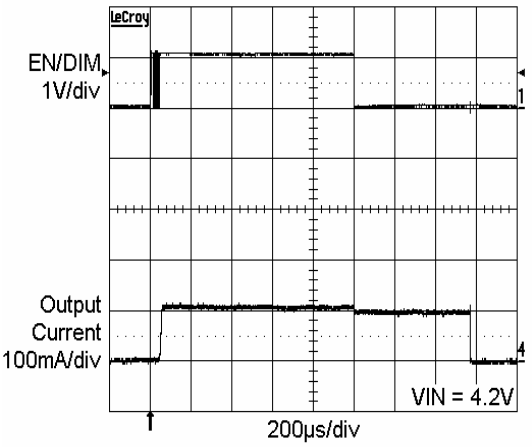
Power Up with 1 LED at 100mA (1x Mode)



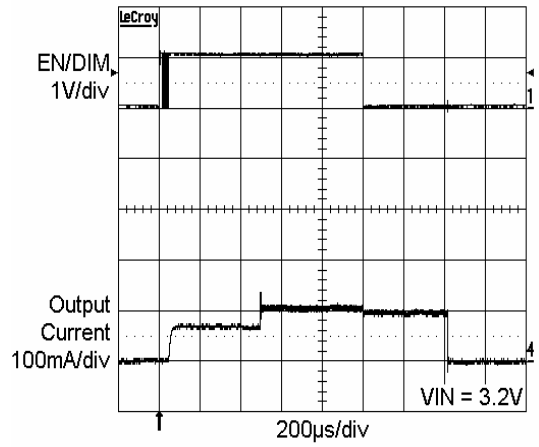
Power Up with 1 LED at 100mA (1.5x Mode)



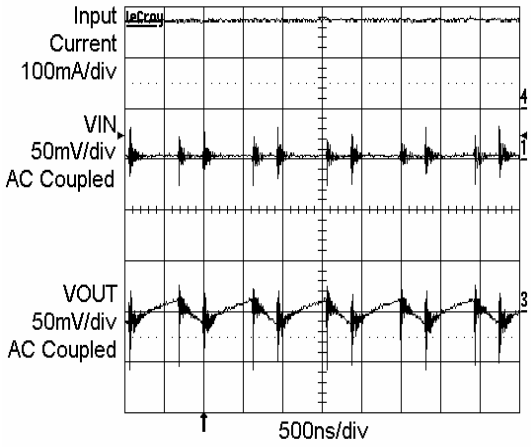
Enable Power Down Delay (1x Mode)



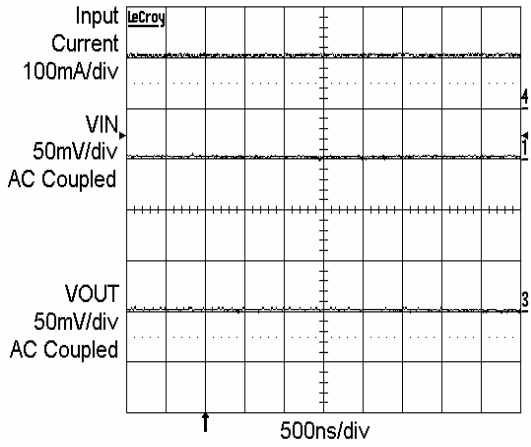
Enable Power Down Delay (1.5x Mode)



Switching Waveforms in 1.5x Mode



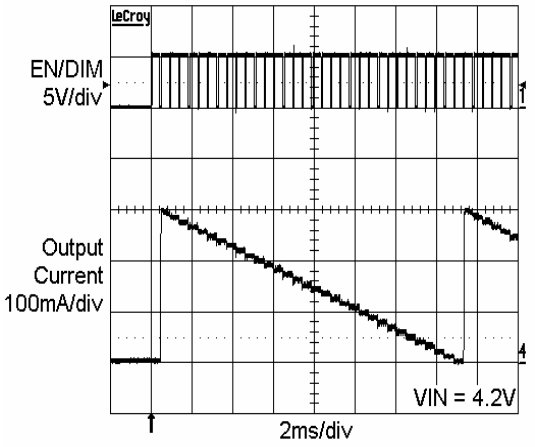
Operating Waveforms in 1x Mode



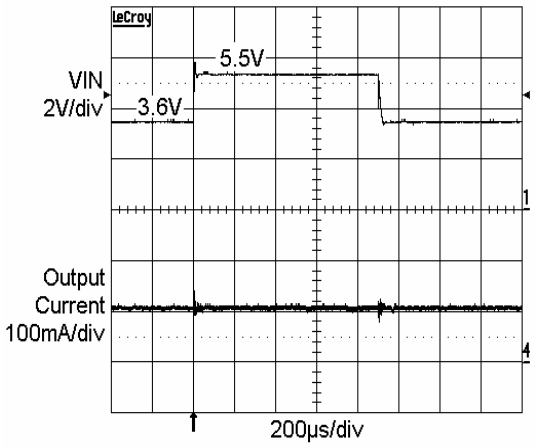
TYPICAL CHARACTERISTICS

VIN = 3.6V, I_{OUT} = 100mA, C_{IN} = C_{OUT} = 2.2µF, C_1 = C_2 = 1µF, T_{AMB} = 25°C unless otherwise specified.

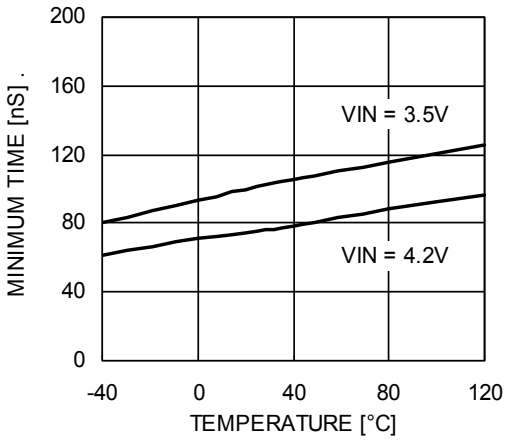
Enable and Output Current Dimming Waveforms



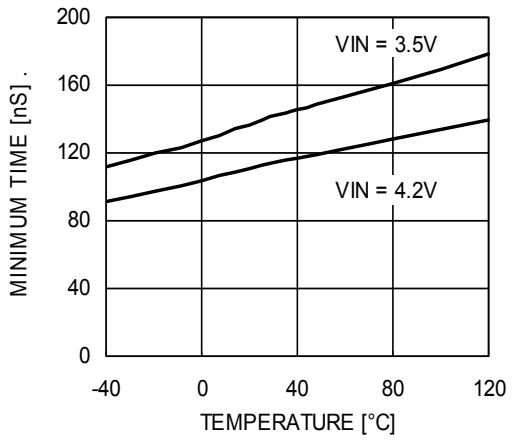
Line Transient Response (3.6V to 5.5V) 1x Mode



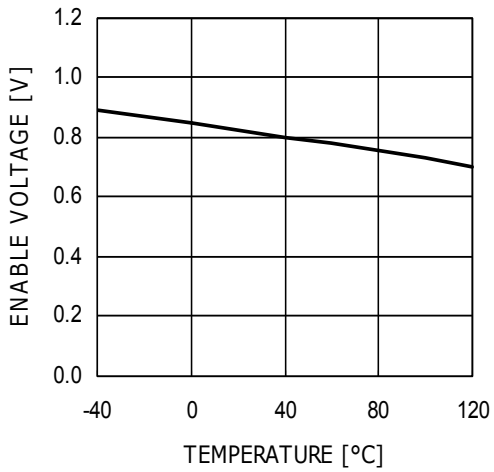
Enable High Minimum Program Time vs. Temperature



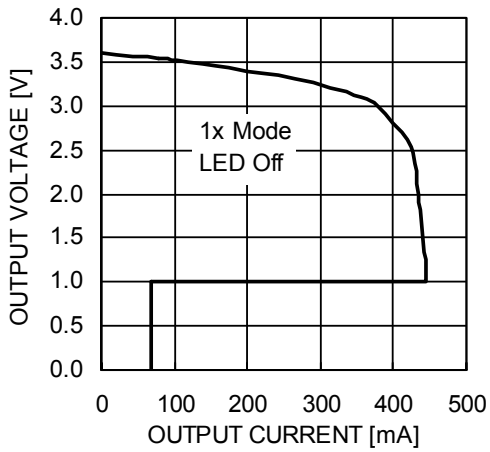
Enable Low Minimum Program Time vs. Temperature



Enable Voltage Threshold vs. Temperature



Foldback Current Limit



PIN DESCRIPTIONS

Pin #	Name	Function
1	VIN	Supply voltage.
2	C1+	Bucket capacitor 1 terminal
3	C1-	Bucket capacitor 1 terminal
4	C2-	Bucket capacitor 2 terminal
5	GND	Ground reference
6	LED1	LED1 cathode terminal (if not used, connect to VOUT)[1].
7	LED2	LED2 cathode terminal (if not used, connect to VOUT)[1].
8	C2+	Bucket capacitor 2 terminal
9	-	Not connected
10	EN/DIM	Device enable (active high) and dimming control input.
11	-	Not connected
12	VOUT	Charge pump output connected to the LED anodes.
TAB	TAB	Connect to GND on the PCB.

Note 1: *LED1, LED2 pins should not be left floating. They should be connected to the LED cathode, or tied to the VOUT pin if not used.*

PIN FUNCTION

VIN is the supply pin for the device. A small 1μF ceramic bypass capacitor is required between the VIN pin and ground near the device. The operating input voltage range is up to 5.5V. When the input supply falls below the undervoltage threshold (2V), all LEDs channels are disabled.

EN/DIM is the enable and dimming control logic input for all LED channels. Guaranteed levels of logic high and logic low are set at 1.3V and 0.4V respectively. When EN/DIM is initially taken high, the device becomes enabled and the LED currents remain at 0mA. The falling edge of the first pulse on EN/DIM sets the LED currents to the full scale 150mA.

On each consecutive falling edge of the pulse on EN/DIM, the LED current decreases by 150/31mA. On the 32nd pulse, the LED current is set to zero. The next pulse on EN/DIM resets the current back to full scale 150mA.

To place the device into zero current shutdown mode, the EN/DIM pin must be held low for 1.5ms or more.

VOUT is the charge pump output that is connected to the LED anodes. A small 1μF ceramic bypass capacitor is required between the VOUT pin and ground near the device.

GND is the ground reference for the charge pump. The pin must be connected to the ground plane on the PCB.

C1+, C1- are connected to each side of the 1μF ceramic bucket capacitor C1.

C2+, C2- are connected to each side of the 1μF ceramic bucket capacitor C2.

LED1, LED2 provide the internal regulated current for each of the LED cathodes. These pins enter a high impedance zero current state whenever the device is in shutdown mode. In applications using only one LED channel, the unused channel should be tied directly to VOUT. The disabled channel only draws about 0.5mA.

TAB is the exposed pad underneath the package. For best thermal performance, the tab should be soldered to the PCB and connected to the ground plane.

BLOCK DIAGRAM

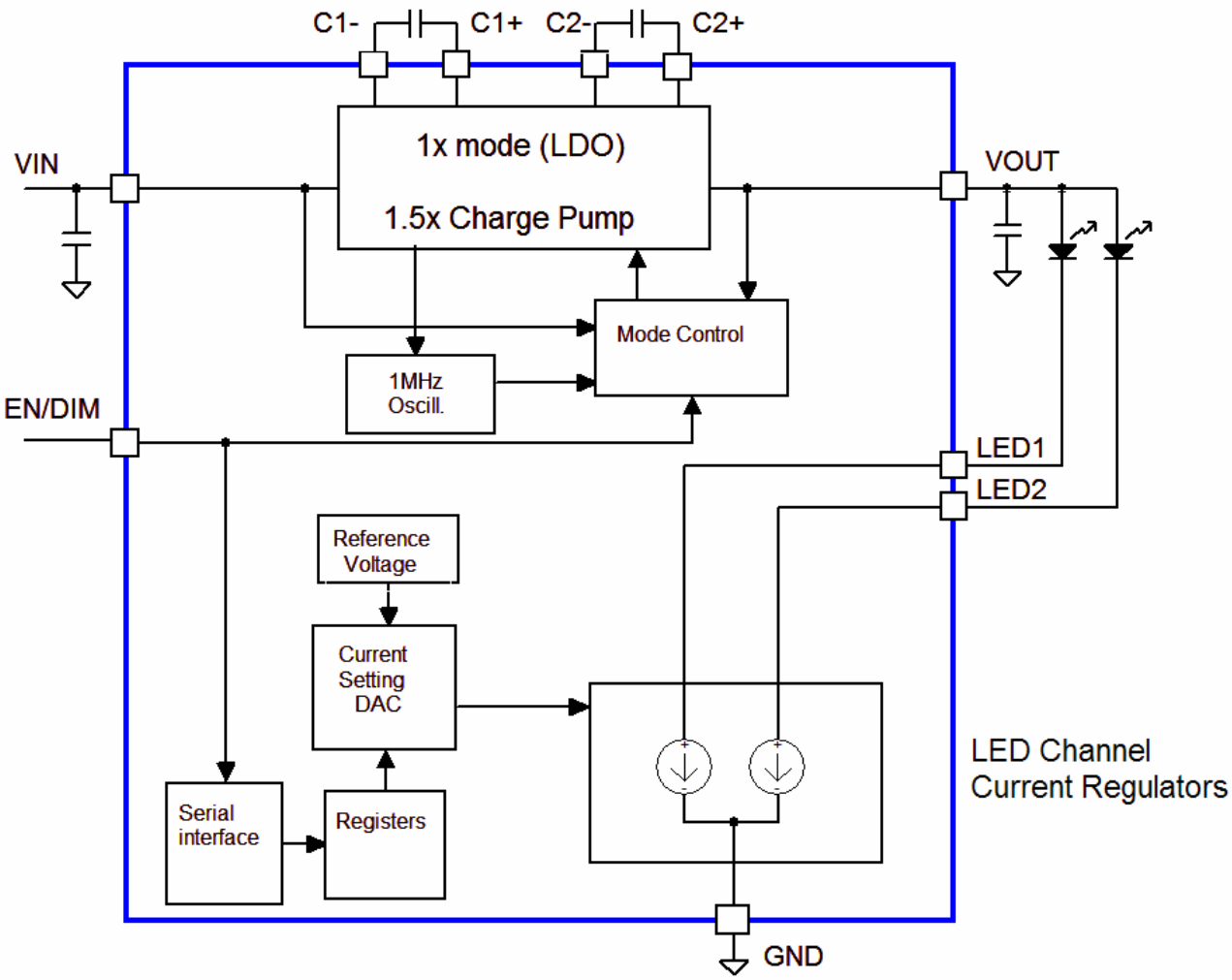


Figure 2. CAT3612 Functional Block Diagram

BASIC OPERATION

At power-up, the CAT3612 starts operating in 1x mode where the output will be approximately equal to the input supply voltage (less any internal voltage losses). If the output voltage is sufficient to regulate all LEDs currents the device remains in 1x operating mode.

If the input voltage is insufficient or falls to a level where the regulated currents cannot be maintained, the device automatically switches (after a fixed of 400µs) into 1.5x mode.

In 1.5x mode, the output is approximately equal to 1.5 times the input supply voltage (less any internal voltage losses).

The above sequence is repeated each and every time the chip is powered-up or is taken out of shutdown mode (via EN/DIM pin).

LED Current Setting

Figure 1 shows the EN/DIM input timing diagram for setting the LED currents. The EN/DIM set-up time requires the signal to be held high for 10μs or longer to ensure the initialization of the driver at power-up. Each subsequent pulse on the EN/DIM (300ns to 200μs pulse duration) steps down the LED current from full scale of 150mA to zero with nearly 5mA resolution. The selection of the LED current per channel is shown in Table 1. Consecutive pulses should be separated by 300ns or longer. Pulsing beyond the 0mA level restores the current level back to full scale and the cycle repeats. Pulsing frequencies from 5kHz up to 1MHz can be supported during dimming operations. When the EN/DIM is held low for 1.5ms or more, the CAT3612 enters the shutdown mode and draws “zero” current.

For applications with a single LED connected to one LED pin only, the unused LED pin must be tied to VOUT, as shown on Figure 3.

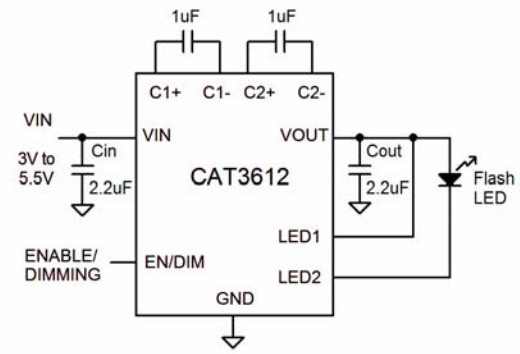


Figure 3. Single LED on one LED pin

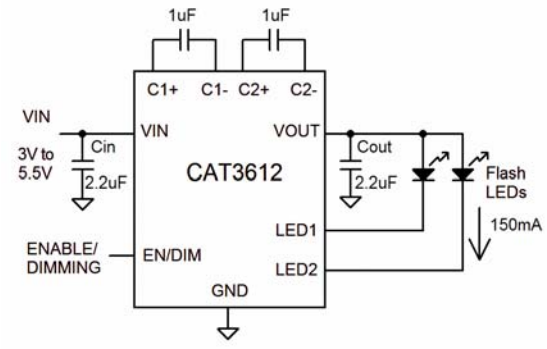


Figure 4. Application with 2 LEDs

Table 1. Selection of LED current per Channel

Number of pulses on EN/DIM	LED current (mA)
1	150
2	145
3	140
4	135.5
5	131
6	126
7	121
8	116
9	111
10	106.5
11	101.5
12	97
13	92
14	87
15	82
16	77.5
17	72.5
18	68
19	63
20	58
21	53
22	48.5
23	43.5
24	39
25	34
26	29
27	24
28	19
29	14.5
30	10
31	5
32	0

Protection mode

If an LED becomes open-circuit, the output voltage VOUT is internally limited to about 5.5V. This is to prevent the output pin from exceeding its absolute maximum rating.

The driver enters a thermal shutdown mode as soon as the die temperature exceeds about +165ºC. When the device temperature drops down by about 20ºC, the device resumes normal operation.

External components

The driver requires a total of four external 1μF ceramic capacitors: two for decoupling input and output, and two for the charge pump. Both capacitor types X5R and X7R are recommended for the LED driver application. In the 1.5x charge pump mode, the input current ripple is kept very low by design, and an input bypass capacitor of 1μF is sufficient. In 1x mode, the device operating in linear mode does not introduce switching noise back onto the supply.

Recommended Layout

In 1.5x charge pump mode, the driver switches internally at a high frequency of 1MHz. It is recommended to minimize trace length to all four capacitors. A ground plane should cover the area under the driver IC as well as the bypass capacitors. Short connection to ground on capacitors Cin and Cout can be implemented with the use of multiple via. A copper area matching the TDFN exposed pad (GND) must be connected to the ground plane underneath. The use of multiple via improves the package heat dissipation.

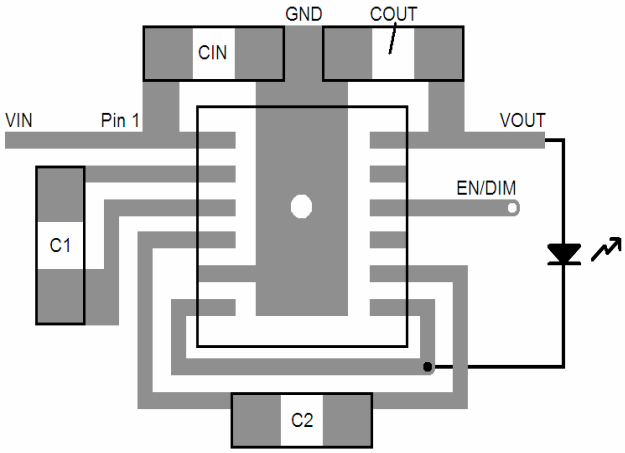
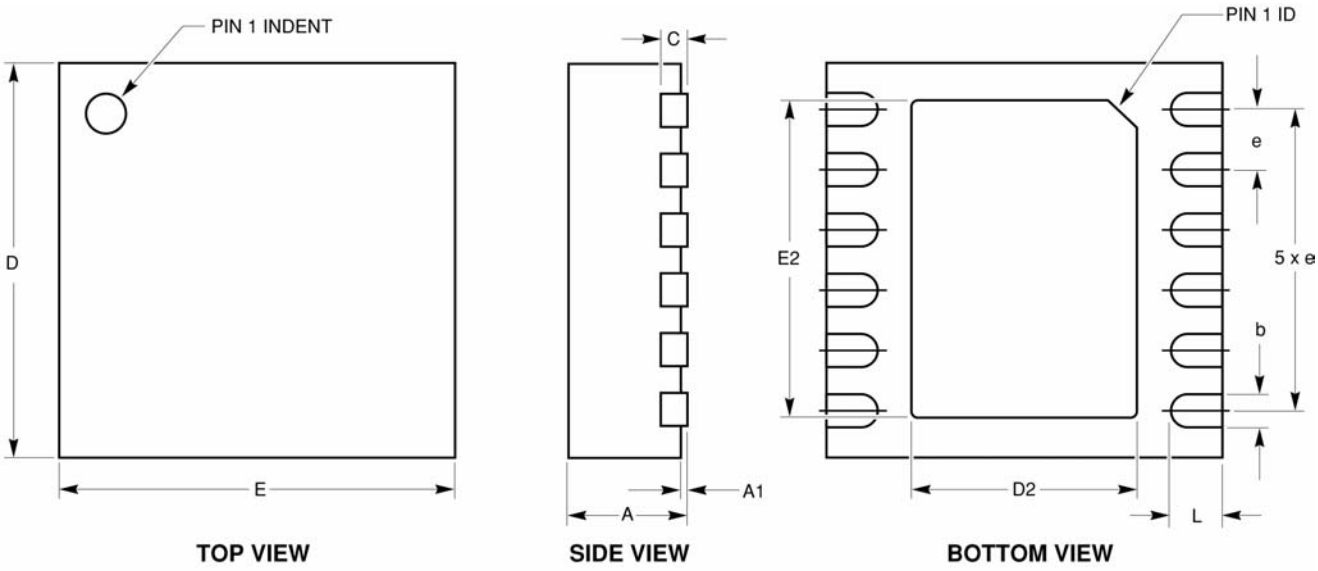


Figure 5. Recommended Layout

PACKAGE DRAWING AND DIMENSIONS

Thin DFN 12-Lead 3mm x 3mm, 0.45mm Pitch



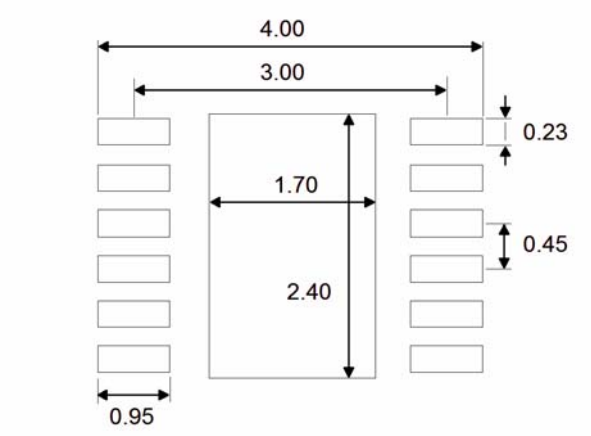
SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
b	0.18	0.23	0.30
C		0.20 REF	
D	2.90	3.00	3.10
D2	1.60	1.70	1.80
E	2.90	3.00	3.10
E2	2.30	2.40	2.50
e		0.45	
L	0.35	0.45	0.55

NOTE:
1. ALL DIMENSIONS IN MILLIMETERS. ANGLES IN DEGREES.
2. REFER JEDEC MO-229

TDFN-12L-3X3_(02).eps

RECOMMENDED LAND PATTERN

Dimensions in millimeters



REVISION HISTORY

Date	Rev.	Reason
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