



3-Channel LED Driver in 3 x 3mm Package



FEATURES

- Drives up to 3 LEDs
- Current setting resistor
- Compatible with supply voltage of 3V to 5.5V
- Power efficiency up to 91%
- Output Current up to 30mA per LED
- 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
- 12-lead TDFN 3mm x 3mm package

APPLICATION

- LCD Display Backlight
- Cellular Phones
- Digital Still Cameras
- Handheld Devices

ORDERING INFORMATION

| Part Number | Package | Quantity per Reel | Package Marking |
|-------------|--------------------|-------------------|-----------------|
| CAT3603HV2 | TDFN-12 3x3 Green* | 2,000 | HABB |

* Lead Finish Matte-Tin

For Ordering Information details, see page 11.

DESCRIPTION

The CAT3603 is a charge pump LED driver operating in either 1x (LDO) mode or 1.5x fractional mode regulating current through each of the 3 LED pins. Operation at a constant switching frequency of 1MHz allows the use of very small value ceramic capacitors.

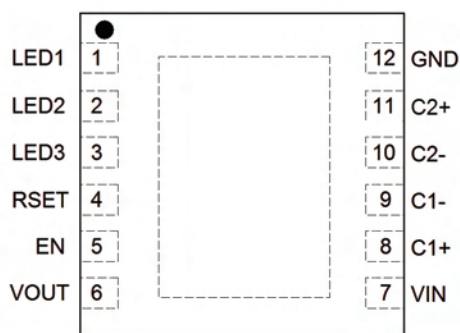
The CAT3603 drives 3 white LEDs in parallel and provides tightly matched regulated current to achieve uniform brightness in LCD backlighting applications. An external resistor, RSET, controls the output current level. The device can deliver up to 30mA over an input voltage supply range from 3V to 5.5V, making it ideal for battery-powered applications

LED dimming can be accomplished using several methods; using a DC voltage to set the RSET pin current, applying a PWM signal on the EN pin, or adding a switched resistor in parallel with RSET. The EN input pin allows the device to be placed in power-down mode with “near-zero” quiescent current.

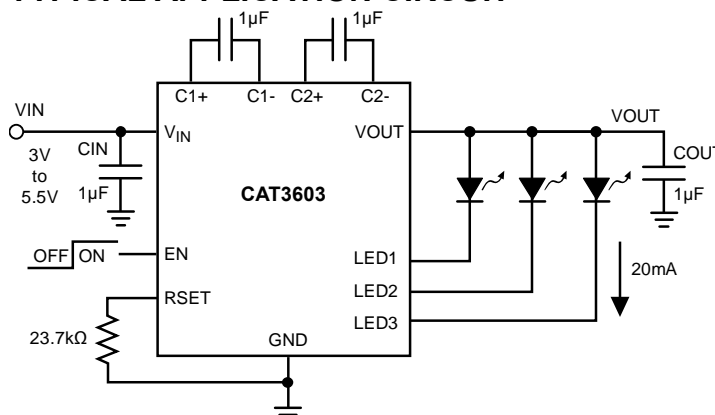
The device is available in the tiny 12-lead thin DFN 3mm x 3mm package with a max height of 0.8mm.

PIN CONFIGURATION

12-lead TDFN 3mm (Top view)



TYPICAL APPLICATION CIRCUIT



Note: Unused LED channels must be connected to VOUT.

ABSOLUTE MAXIMUM RATINGS

| Parameter | Rating | Unit |
|----------------------------|-------------|------|
| VIN, VOUT, LEDx voltage | -0.3 to 7.0 | V |
| EN voltage | -0.3 to VIN | V |
| RSET voltage | -0.3 to VIN | V |
| Junction Temperature Range | -40 to +150 | °C |
| Storage Temperature Range | -65 to +160 | °C |
| Lead Temperature | 300 | °C |
| ESD Ratings | | |
| Human Body Model (HBM) | 2000 | V |
| Machine Model (MM) | 200 | V |

RECOMMENDED OPERATING CONDITIONS

| Parameter | Range | Unit |
|----------------------------------|----------------|------|
| VIN | 3 to 5.5 | V |
| Ambient Temperature Range | -40 to +85 | °C |
| Input, Output, Bucket Capacitors | 1 ±20% typical | µF |
| I _{LED} per LED pin | 0 to 30 | mA |

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

ELECTRICAL OPERATING CHARACTERISTICS

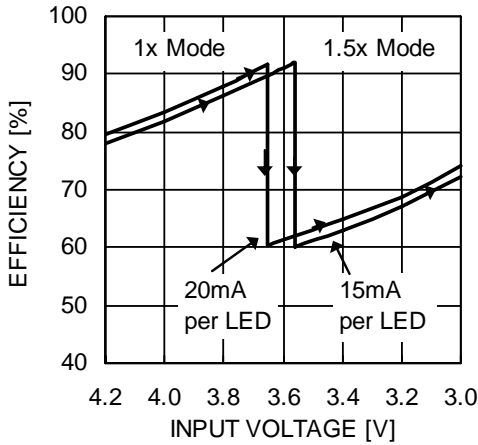
VIN = 3.6V, EN = High, ambient temperature of 25°C (over recommended operating conditions unless specified otherwise).

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|----------------------|---|---|------|---------------------|-------------|----------------|
| I _Q | Quiescent Current | V _{EN} = 0V, shutdown mode 1x Mode, No Load 1.5x Mode, No Load | | 0.1 0.4 2.7 | 1 1 5 | µA mA mA |
| V _{RSET} | RSET Regulated Voltage | | 1.17 | 1.2 | 1.23 | V |
| I _{LED} | Programmed LED Current | I _{RSET} = 5µA I _{RSET} = 37µA I _{RSET} = 78µA | | 2.4 15.0 30.0 | | mA mA mA |
| I _{LED-ACC} | LED Current Accuracy | 0.5mA ≤ I _{LED} ≤ 3mA 3mA ≤ I _{LED} ≤ 30mA | | ±15 ±5 | | % % |
| I _{LED-DEV} | LED Channel Matching | (I _{LED} - I _{LEDAVG}) / I _{LEDAVG} | | ±3 | | % |
| R _{OUT} | Output Resistance (Open Loop) | 1x Mode 1.5x Mode, I _{OUT} = 100mA | | 1.4 6.5 | 2.5 10 | Ω Ω |
| f _{OSC} | Charge Pump Frequency | | 0.8 | 1.0 | 1.3 | MHz |
| T _{DROPOUT} | 1x to 1.5x Mode Transition Dropout Delay | | 0.4 | 0.6 | 0.9 | ms |
| I _{EN} | Input Leakage Current | On Input EN | | | 1 | µA |
| V _{EN} | High Detect Threshold Low Detect Threshold | On Input EN | 0.4 | 0.8 0.7 | 1.3 | V V |
| I _{SC} | Short Circuit Output Current | VOUT = GND | 30 | 45 | 60 | mA |
| I _{LIM} | Maximum Input Current | VOUT > 1V | 200 | 400 | 600 | mA |
| T _{SD} | Thermal Shutdown | | | 150 | | °C |
| T _{HYS} | Thermal Hysteresis | | | 20 | | °C |
| V _{UVLO} | Undervoltage lock out (UVLO) threshold | | | 2 | | V |

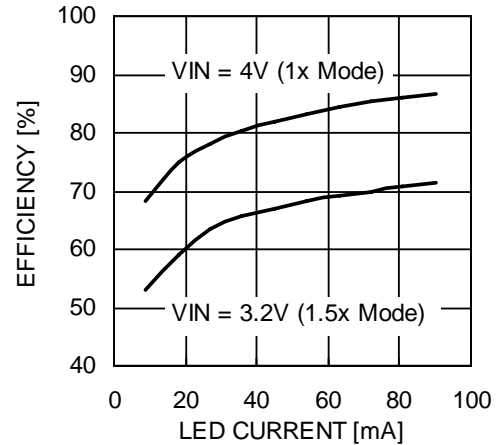
TYPICAL CHARACTERISTICS

$V_{IN} = 3.6V$, $I_{OUT} = 60mA$ (3 LEDs at 20mA), $C_1 = C_2 = C_{IN} = C_{OUT} = 1\mu F$, $T_{AMB} = 25^\circ C$ unless otherwise specified.

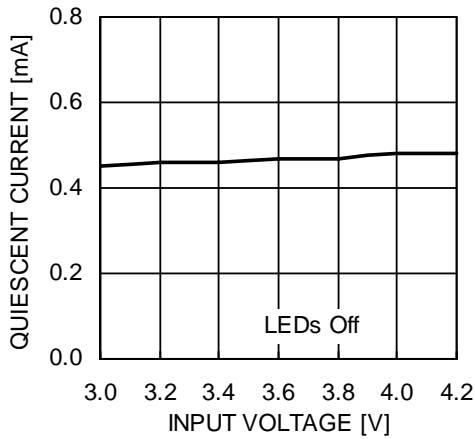
Efficiency vs. Input Voltage (3 LEDs on)



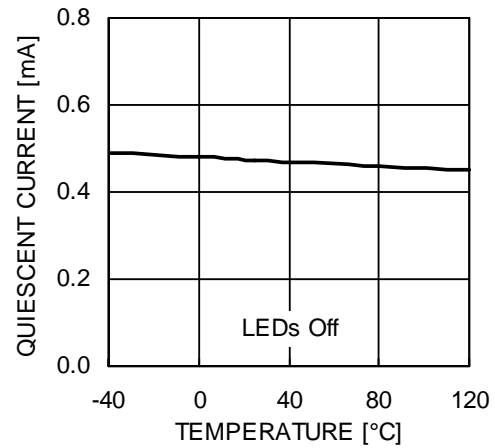
Efficiency vs. Total LED Current (3 LEDs)



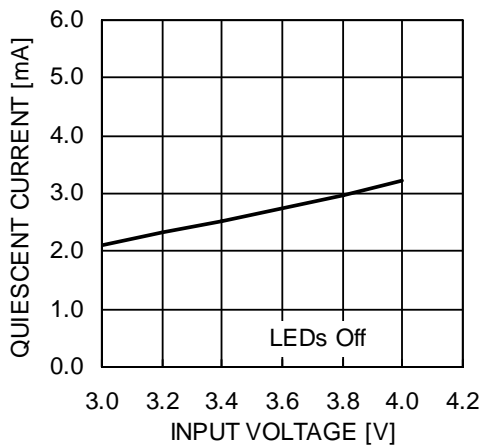
Quiescent Current vs. Input Voltage (1x Mode)



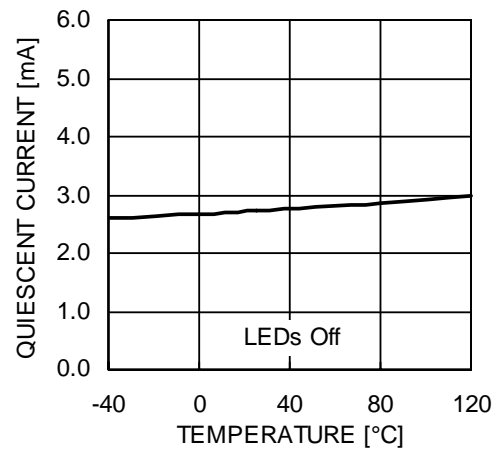
Quiescent Current vs. Temperature (1x Mode)



Quiescent Current vs. Input Voltage (1.5x Mode)



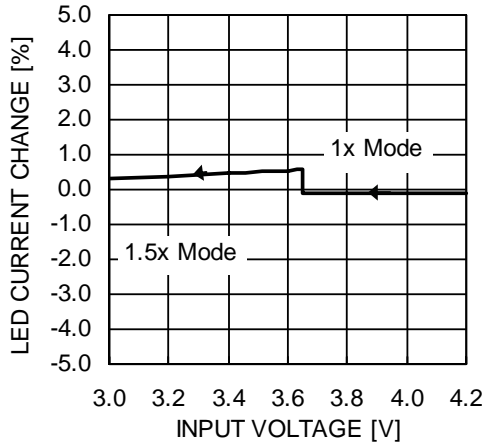
Quiescent Current vs. Temperature (1.5x Mode)



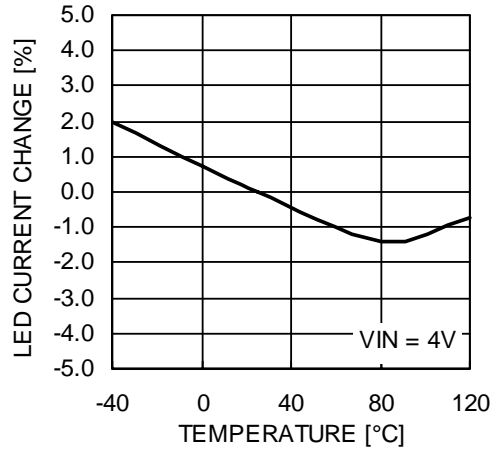
TYPICAL CHARACTERISTICS

$V_{IN} = 3.6V$, $I_{OUT} = 60mA$ (3 LEDs at 20mA), $C_1 = C_2 = C_{IN} = C_{OUT} = 1\mu F$, $T_{AMB} = 25^\circ C$ unless otherwise specified.

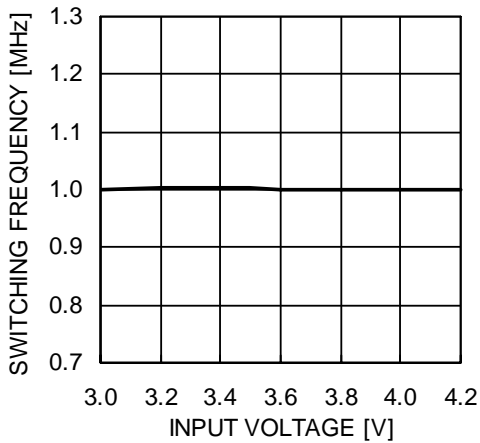
LED Current Change vs. Input Voltage



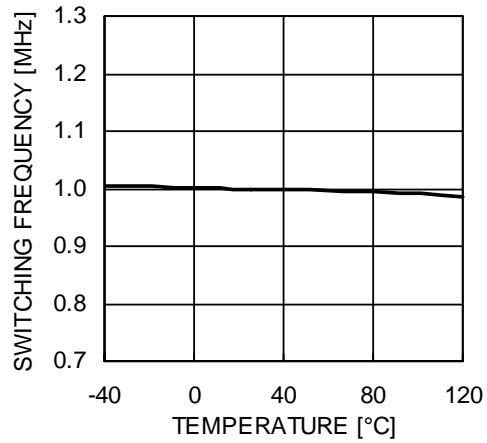
LED Current Change vs. Temperature



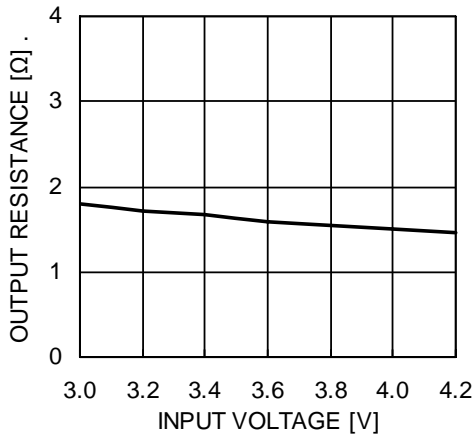
Switching Frequency vs. Input Voltage



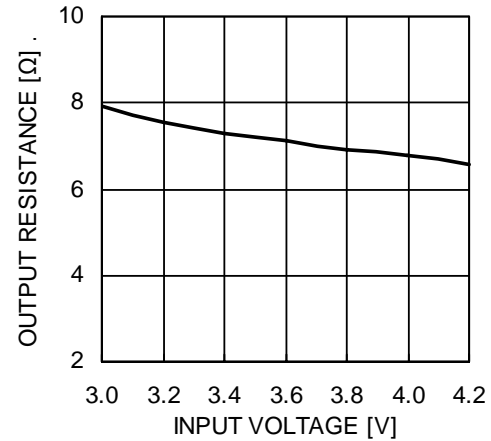
Switching Frequency vs. Temperature



Output Resistance vs. Input Voltage (1x Mode)



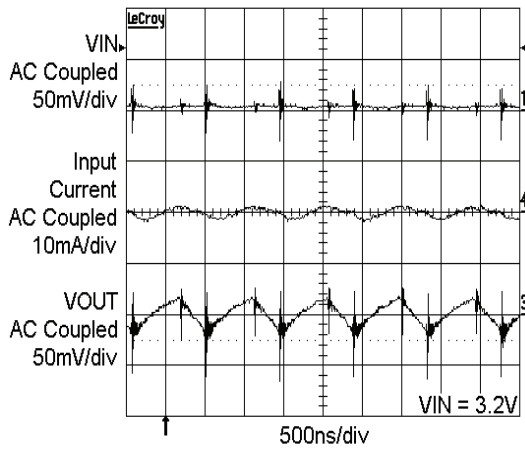
Output Resistance vs. Input Voltage (1.5x Mode)



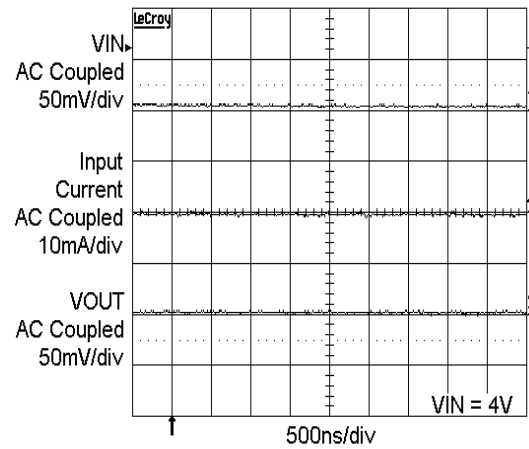
TYPICAL CHARACTERISTICS

$V_{IN} = 3.6V$, $I_{OUT} = 60mA$ (3 LEDs at 20mA), $C_1 = C_2 = C_{IN} = C_{OUT} = 1\mu F$, $T_{AMB} = 25^\circ C$ unless otherwise specified.

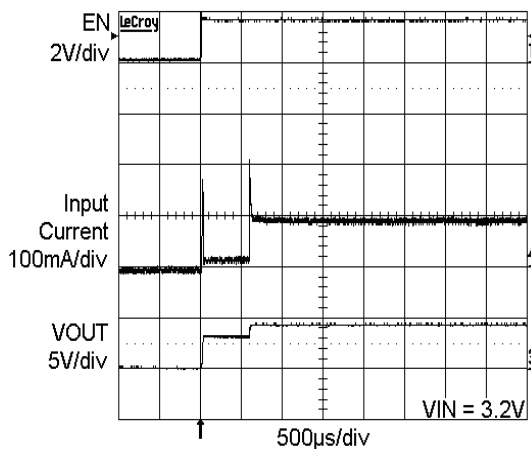
Switching Waveforms in 1.5x Mode



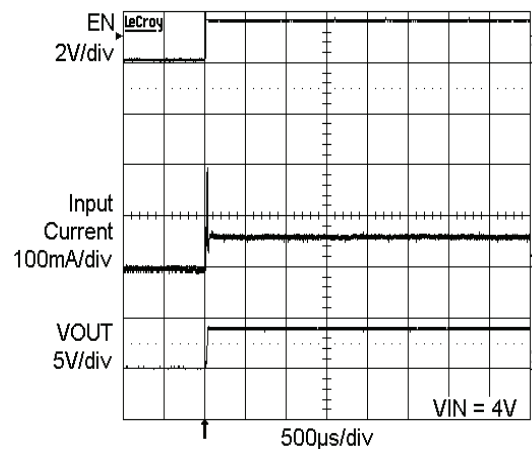
Operating Waveforms in 1x Mode



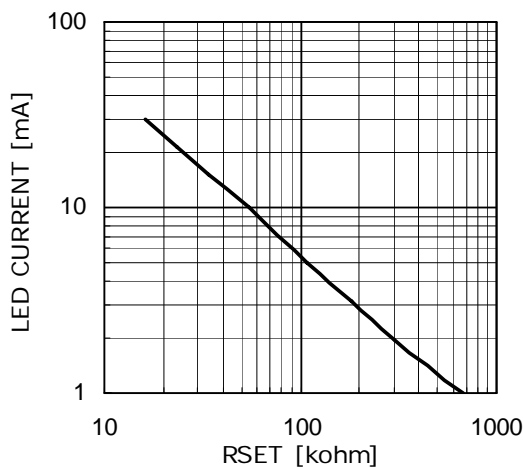
Power Up 3 LEDs at 20mA, $V_{IN} = 3.2V$ (1.5x Mode)



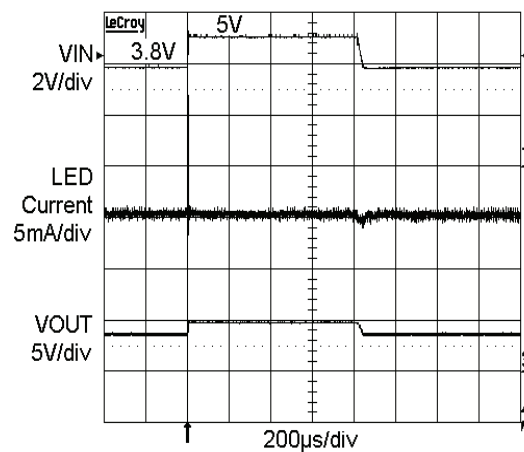
Power Up 3 LEDs at 20mA, $V_{IN} = 4V$ (1x Mode)



LED Current vs. R_{SET}

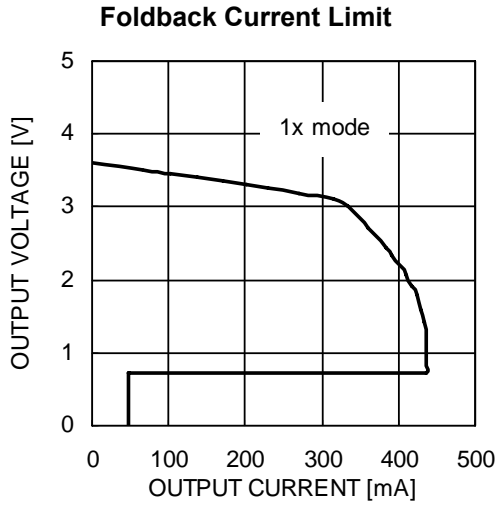


Line Transient Response in 1x Mode



TYPICAL CHARACTERISTICS

VIN = 3.6V, IOUT = 60mA (3 LEDs at 20mA), C1 = C2 = CIN = COUT = 1μF, TAMB = 25°C unless otherwise specified.



PIN DESCRIPTIONS

| Pin # | Name | Function |
|-------|------|--|
| 1 | LED1 | LED1 cathode terminal (if not used, connect to VOUT) ⁽¹⁾ |
| 2 | LED2 | LED2 cathode terminal (if not used, connect to VOUT) ⁽¹⁾ |
| 3 | LED3 | LED3 cathode terminal (if not used, connect to VOUT) ⁽¹⁾ |
| 4 | RSET | The LED output current is set by the current sourced out of the RSET pin |
| 5 | EN | Device enable (active high) |
| 6 | VOUT | Charge pump output connected to the LED anodes |
| 7 | VIN | Supply voltage |
| 8 | C1+ | Bucket capacitor 1 terminal |
| 9 | C1- | Bucket capacitor 1 terminal |
| 10 | C2- | Bucket capacitor 2 terminal |
| 11 | C2+ | Bucket capacitor 2 terminal |
| 12 | GND | Ground Reference |
| | TAB | Connect to GND on the PCB |

Note:

(1) LED1, LED2, LED3 pins should not be left floating. They should be connected to the LED cathode, or tied to VOUT pin if not used.

PIN FUNCTION

VIN is the supply pin for the charge pump. A small 1 μ F ceramic bypass capacitor is required between the VIN pin and ground near the device. The operating input voltage range is from 3.0V to 5.5V.

EN is the enable control logic input for all LED channels. Guaranteed levels of logic high and logic low are set at 1.3V and 0.4V respectively.

RSET pin is regulated at 1.2V. An external resistor RSET connected from the RSET pin to GND sets the LED current.

VOUT is the charge pump output that is connected to the LED anodes. A small 1 μ F 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 1 μ F ceramic bucket capacitor C1.

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

LED1 to LED3 provide the internal regulated current for each of the LED cathodes. These pins enter a high impedance, zero current state whenever the device is placed in shutdown mode. In applications using less than three LEDs, all unused channels should be wired directly to VOUT. This ensures the channel is automatically disabled dissipating less than 200 μ A.

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

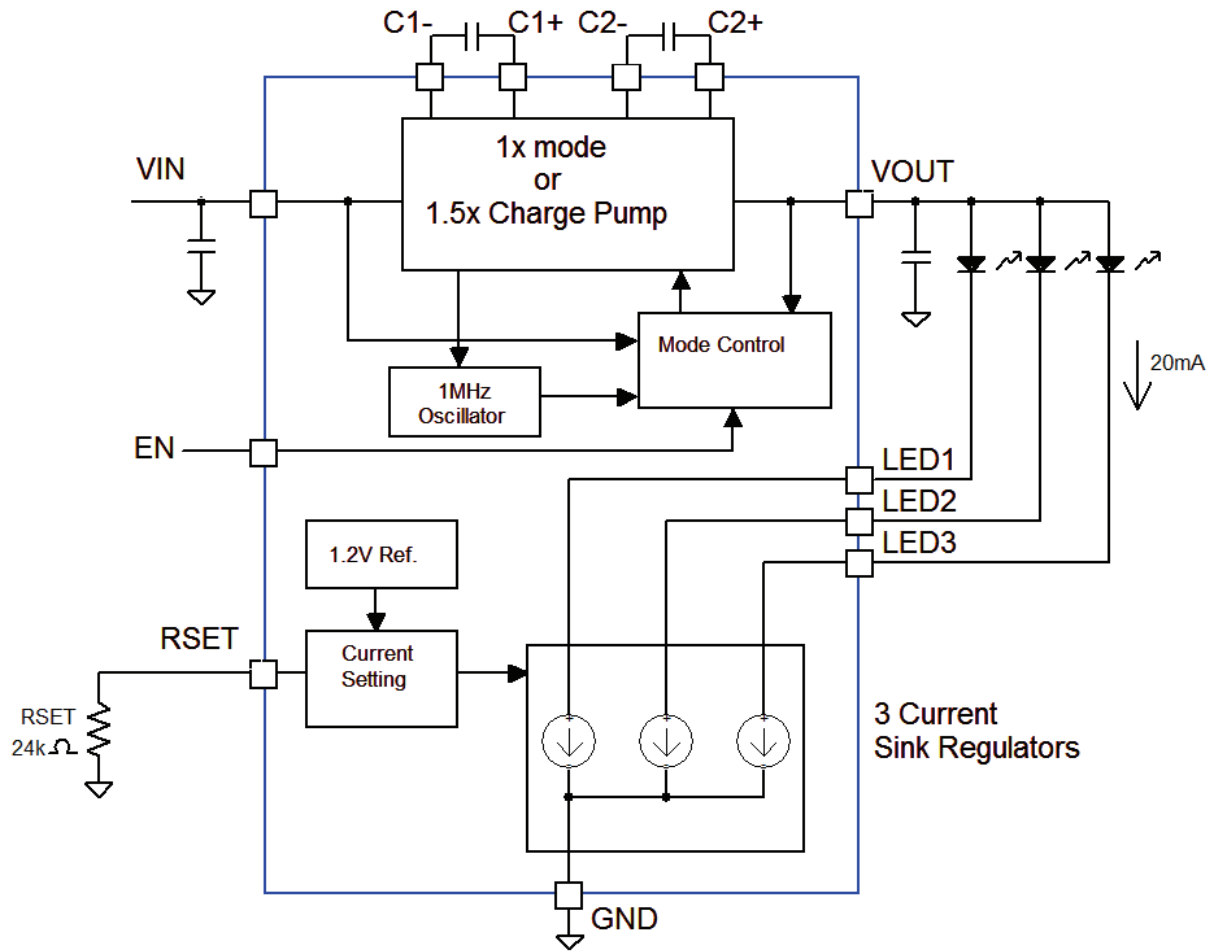


Figure 2. CAT3603 Functional Block Diagram

BASIC OPERATION

At power-up, the CAT3603 starts operating in 1x mode where the output will be approximately equal to the input supply voltage (minus any internal voltage losses). If the output voltage is sufficient to regulate all LED currents, the device remains in 1x operating mode.

If the input voltage falls to a level where the regulated currents cannot be maintained, the device automatically switches into 1.5x mode.

In 1.5x mode, the output is approximately equal to 1.5 times the input supply voltage (minus any internal voltage losses), and high enough to achieve the nominal LED current.

The above sequence is reinitialized every time the chip is powered-up or is taken out of shutdown mode (via EN pin).

LED CURRENT SETTING

The LED current is set by the external resistor R_{SET} connected between the RSET pin and ground. Table 1 lists various LED currents and the associated R_{SET} resistor value for standard 1% precision surface mount resistors.

Table 1. RSET Resistor Selection

| LED Current (mA) | R_{SET} (k Ω) |
|------------------|-------------------------|
| 1 | 649 |
| 2 | 287 |
| 5 | 102 |
| 10 | 49.9 |
| 15 | 32.4 |
| 20 | 23.7 |
| 30 | 15.4 |

The unused LED channels must be disabled by connecting the respective LED pins to VOUT. A disabled channel sinks only 0.2mA typical. When the following equation is true on any channel, the driver turns off the LED channel:

$$V_{OUT} - V_{LED} \leq 1V \text{ (LED channel OFF)}$$

Note: The CAT3603 is designed to drive LEDs with forward voltage greater than 1V and is not compatible with resistive loads less than 5k Ω .

External Components

The driver requires a total of four external 1 μ F 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 1 μ F 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.

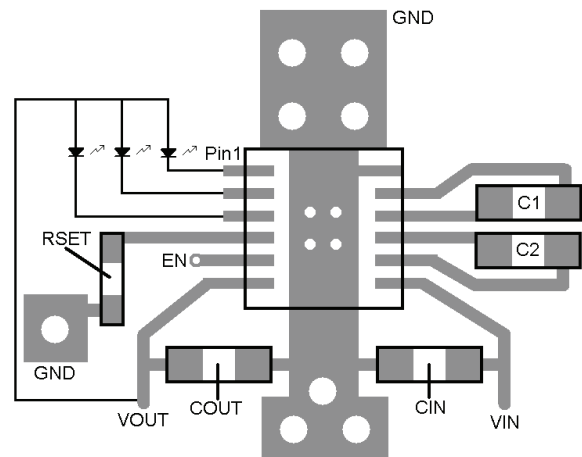
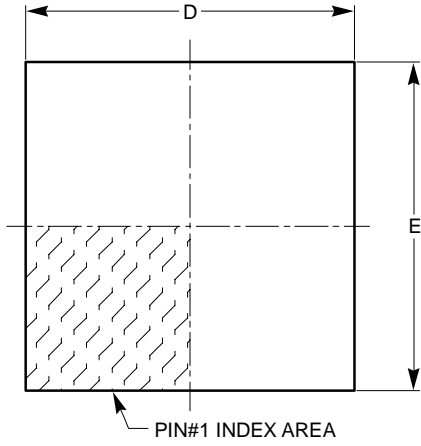


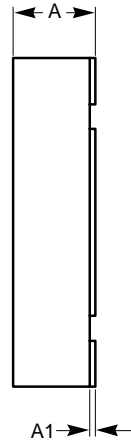
Figure 3. Recommended Layout

PACKAGE OUTLINE DRAWING

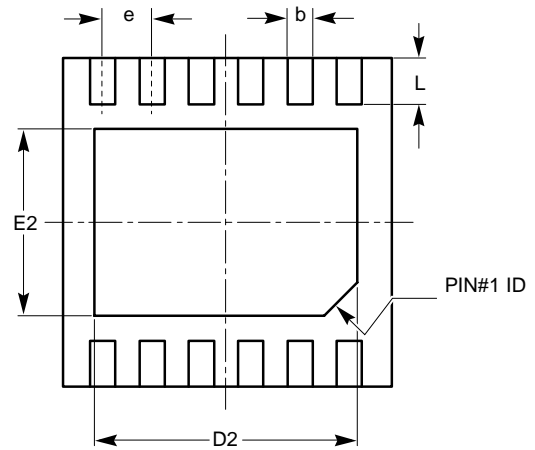
TDFN 12-Pad 3 x 3mm (HV2) ⁽¹⁾⁽²⁾



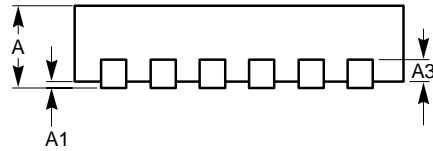
TOP VIEW



SIDE VIEW

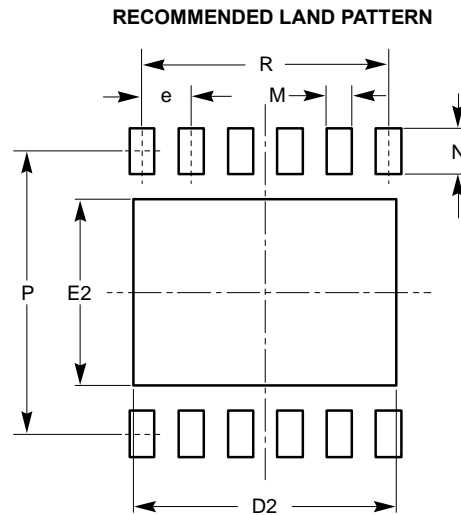


BOTTOM VIEW



FRONT VIEW

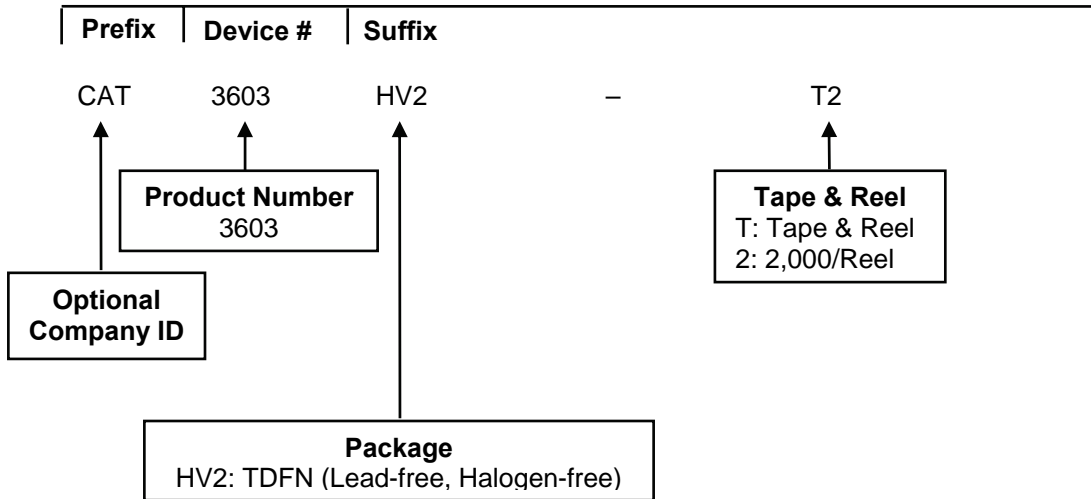
| SYMBOL | MIN | NOM | MAX |
|--------|----------|-------|-------|
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0.00 | 0.02 | 0.05 |
| A3 | 0.178 | 0.203 | 0.228 |
| b | 0.18 | 0.23 | 0.30 |
| D | 2.90 | 3.00 | 3.10 |
| D2 | 2.30 | 2.40 | 2.50 |
| E | 2.90 | 3.00 | 3.10 |
| E2 | 1.55 | 1.70 | 1.75 |
| e | 0.45 BSC | | |
| L | 0.30 | 0.40 | 0.50 |
| M | 0.25 | 0.30 | 0.35 |
| N | 0.60 | 0.70 | 0.80 |
| P | 2.70 | 3.00 | 3.10 |
| R | 2.25 TYP | | |



Notes:

- (1) All dimensions are in millimeters.
- (2) Complies with JEDEC standard MO-229.

EXAMPLE OF ORDERING INFORMATION ⁽¹⁾⁽²⁾




Notes:

- (1) All packages are RoHS-compliant (Lead-free, Halogen-free).
- (2) The standard lead finish is Matte-Tin.
- (3) The device used in the above example is a CAT3603HV2 -T2 (TDFN, Tape & Reel, 2,000/Reel).
- (4) For additional package and temperature options, please contact your nearest ON Semiconductor Sales office.

REVISION HISTORY

| Date | Revision | Description |
|-----------|----------|---|
| 28-May-06 | A | Initial Issue |
| 03-Jun-06 | B | Update Description Update Recommended Operating Conditions |
| 10-Jul-06 | C | Update Pin Configuration Update Pin Description |
| 17-Jul-08 | D | Update Recommended Operating Conditions table Update Package Outline Drawing Add MD- to the document number |
| 11-Nov-08 | E | Change logo and fine print to ON Semiconductor |
| 06-Apr-09 | F | Update Typical Application Circuit Update LED Current Setting – Table RSET Resistor Selection |

ON Semiconductor and  are registered trademarks of Semiconductor Components Industries, LLC (SCILLC). SCILLC reserves the right to make changes without further notice to any products herein. SCILLC makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does SCILLC assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. "Typical" parameters which may be provided in SCILLC data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. SCILLC does not convey any license under its patent rights nor the rights of others. SCILLC products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the SCILLC product could create a situation where personal injury or death may occur. Should Buyer purchase or use SCILLC products for any such unintended or unauthorized application, Buyer shall indemnify and hold SCILLC and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that SCILLC was negligent regarding the design or manufacture of the part. SCILLC is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
Phone: 303-675-2175 or 800-344-3860 Toll Free USA/Canada
Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800-282-9855 Toll Free
USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910
Japan Customer Focus Center:
Phone: 81-3-5773-3850

ON Semiconductor Website: www.onsemi.com
Order Literature: <http://www.onsemi.com/orderlit>
For additional information, please contact your local Sales Representative