Ordering number : ENA0089

SANYO Semiconductors
DATA SHEET

CMOS IC

LC410591FN — Power Supply IC with Built-in White LED Charge Pump

Overview

The LC410591FN is a power supply IC for white LEDs. It incorporates a charge pump-type DC/DC converter circuit and has four constant-current outputs. The input voltage ranges from 2.7V to 5.5V. The maximum value of the current flowing to the LEDs can be determined by the resistance value of the external resistors. The LC410591FN can supply a total current of 105mA for one to four white LEDs. A maximum current of 26mA can be supplied to one white LED when driving four LEDs, and a maximum current of 35mA can be supplied to one white LED when driving three LEDs. The IC operates at a fixed frequency of 600kHz without using an inductor, resulting in very low EMI noise.

The LED brightness is adjusted by a PWM pulse signal to the BRGT pin. When a low level is applied for 22ms or longer to the BRGT pin, the IC enters the shutdown mode.

This IC comes in the VQFN16 package (4mm × 4mm).

Features

- Built-in low-noise and high-efficiency CMOS charge pump
- Built-in constant-current generating circuit
- Input voltage range of 2.7V to 5.5V
- Driving of 1 to 4 white LEDs at a total current of 105mA
- Automatic switching of charge pump voltage step-up ratio (×1, ×1.5)
- ±1.5% (typ) LED to LED current matching
- Soft start for preventing rush current
- Charge pump frequency of 600kHz
- Brightness adjustment control with a PWM signal
- 1μA maximum shutdown current

Applications

- White LED display backlights
- White LED keypad backlights
- PDAs, cell phones, FPDs, and other equipment that operate with a single lithium-ion battery

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Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	V_{DD}		-0.3 to +7.2	V
Maximum supply voltage	V_{SS}		-0.3 to +0.3	V
Storage Temperature	Tstg		-55 to +125	°C

Allowable Operating Range at Ta=-40°C to 85°C (unless otherwise specified, Ta=25°C)

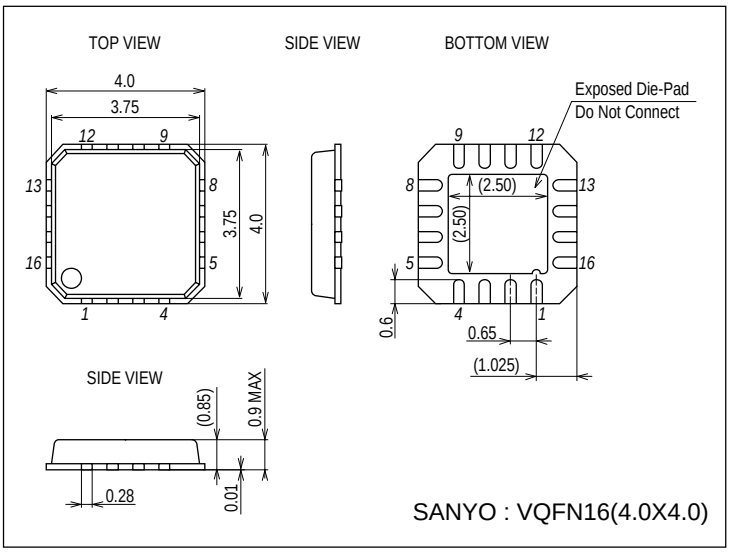
Supply voltage (V_{IN})=3.6V, R_{SET}=3.2kΩ, LED forward voltage (V_F)=3.2V,
input bypass capacitor (C_{IN})=2.2μF, output smoothing capacitor (C_{CP})=2.2μF

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Supply voltage	V_{IN}		2.7		5.5	V
Maximum output current		Ta=25°C	105			mA
Maximum LED current (per 1 LED)		Ta=25°C, 4 LEDs lit	26			mA
		Ta=25°C, 3 LEDs lit	35			mA
No-load supply current (100% I_{LED})		V_{IN}=4.1 to 5.5V (×1 mode)		2		mA
		V_{IN}=2.7 to 4.1V (×1.5 mode)		5		mA
Charge pump frequency				600		kHz
Charge pump mode-switching supply voltage		When switching from ×1 to ×1.5		4.1		V
Charge pump mode-switching supply voltage hysteresis				0.5		V
Reference voltage output				1.2		V
ISET bias				1.2		V
LED current absolute accuracy				±3		%
LED to LED current matching				±1.5		%
Shutdown time supply current		V_{IN}=2.7 to 5.5V,Ta=25°C			1	μA
Input signal frequency (PWM)		BRGT input	100		50k	Hz
BRGT signal high threshold value		Ta=25°C,V_{IN}=4.5 to 5.5V	3			V
		Ta=25°C,V_{IN}=2.7 to 4.5V	2.5			V
BRGT signal low threshold value		Ta=25°C,V_{IN}=2.7 to 5.5V			0.5	V
BRGT input current (H level)		Ta=25°C			1	μA
BRGT input current (L level)		Ta=25°C	-1			μA

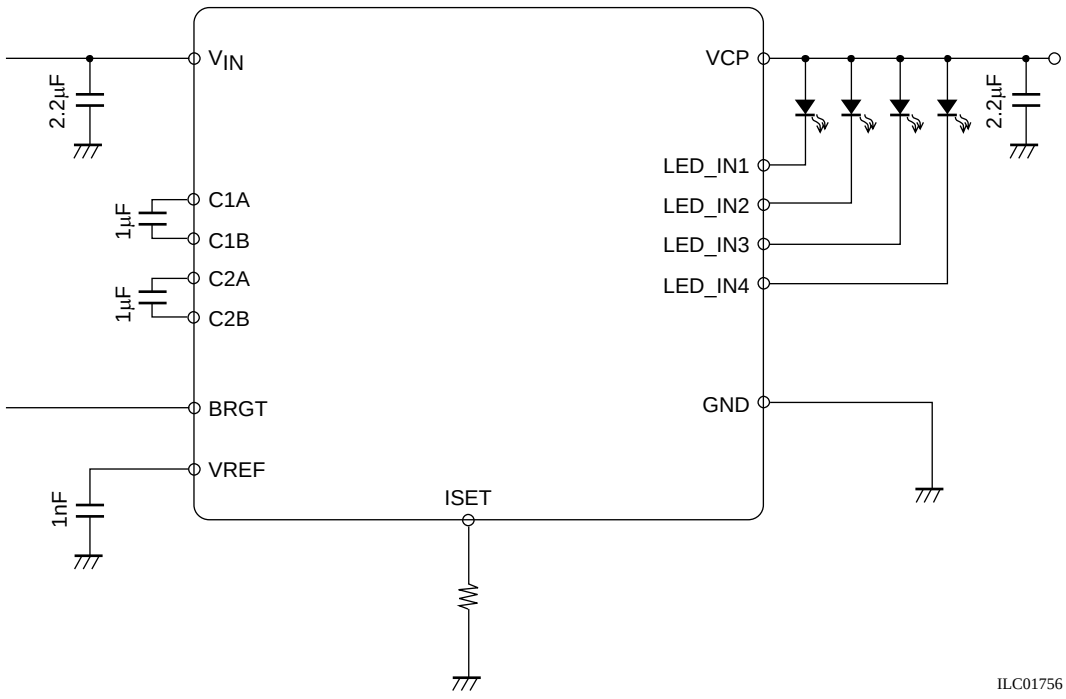
(Note 1) Electrical characteristics at Ta=-40°C indicate design guaranteed values.

Package Dimensions

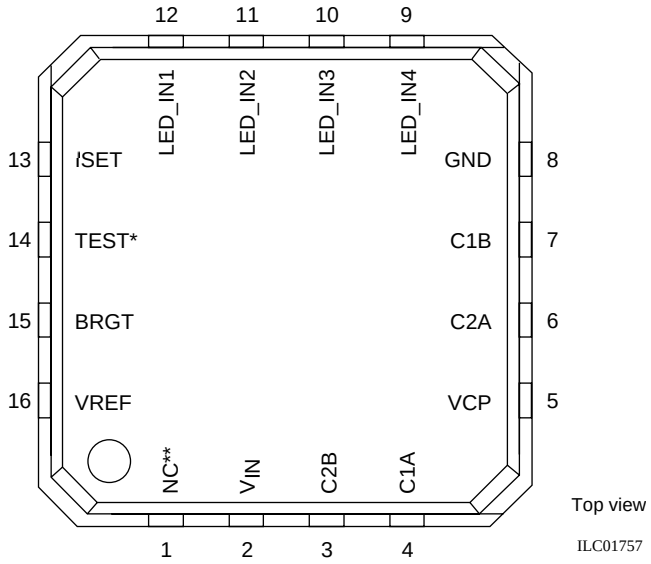
unit : mm (typ)
3316



Application Example



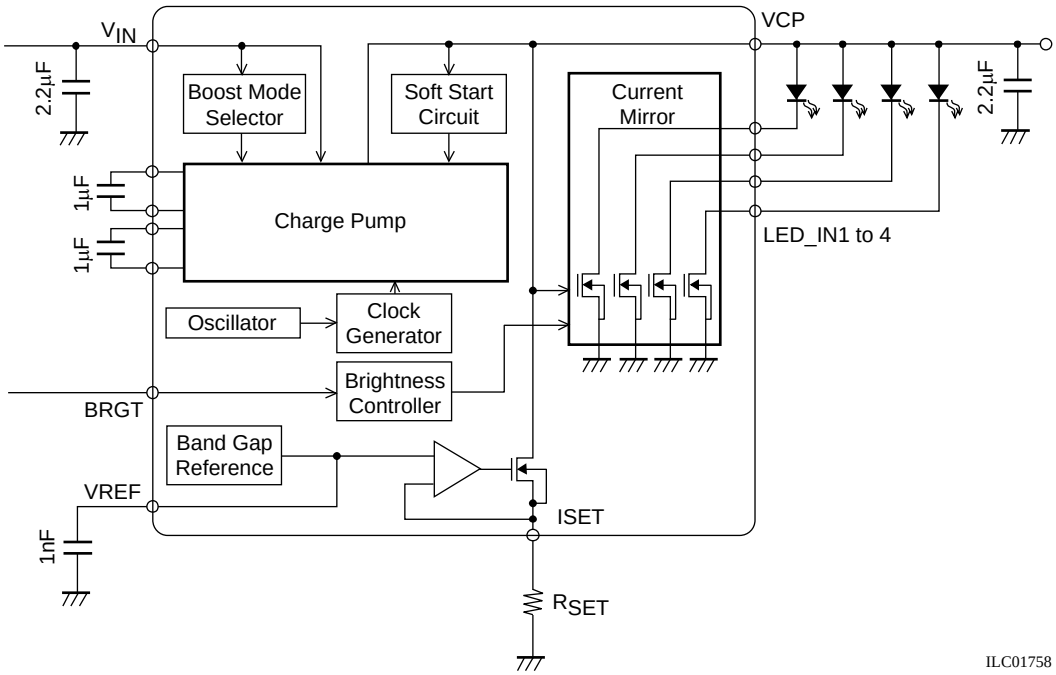
Pin Assignment



Pin Functions

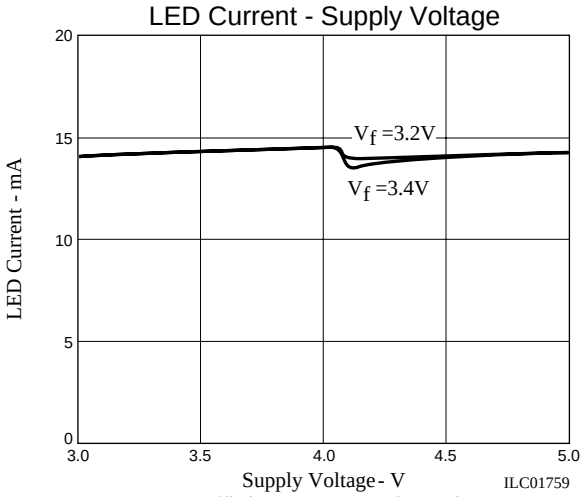
Pin Name	Pin No.	Pin Description
V_{IN}	2	Power supply input pin. Connects a capacitor of 2.2μF between the V_{IN} pin and GND pin.
C1A	4	Flying capacitor (1)+
C1B	7	Flying capacitor (1)-
C2A	6	Flying capacitor (2)+
C2B	3	Flying capacitor (2)-
BRGT	15	LED brightness adjustment signal input. LED current is adjusted by PWM signal (max. 50kHz). The LED current changes linearly with respect to the PWM signal duty ratio and the brightness changes. When the low level continues for 22ms or longer, the LC410591FN enters the shutdown mode, and the LED turns off.
ISET	13	External resistor pin. The maximum LED current is determined by $I_{LED}(mA)=48/R_{SET}(k\Omega)$.
VREF	16	Internal reference voltage output (standard 1.2V). Connect a capacitor of 1nF between the VREF pin and GND pin. The VREF pin must always be set to a high impedance state.
GND	8	Power supply GND. The switching current of the charge pump flows to this pin.
LED_IN1 to 4	9-12	Connect LEDs between the VCP pin and LED_IN1 to IN4. If not connected, set these pins to OPEN or connect to GND.
VCP	5	Charge pump output. Connect a capacitor of 2.2μF between the VCP pin and GND pin.
TEST	14	Not used. Always set to OPEN.

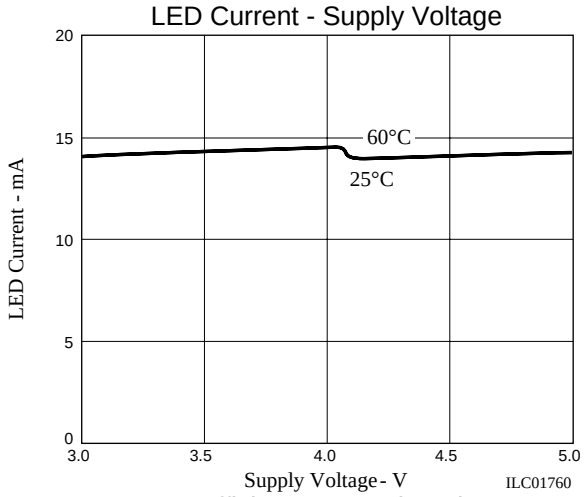
Block Diagram

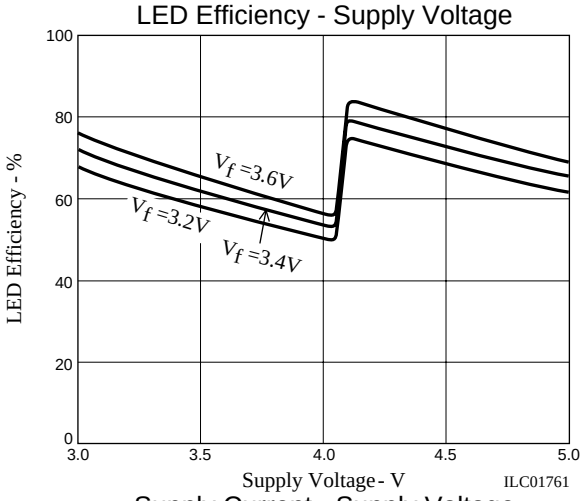


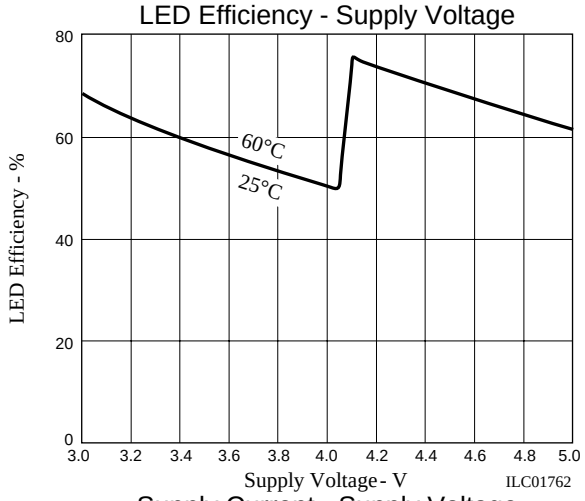
Standard Electrical Characteristics

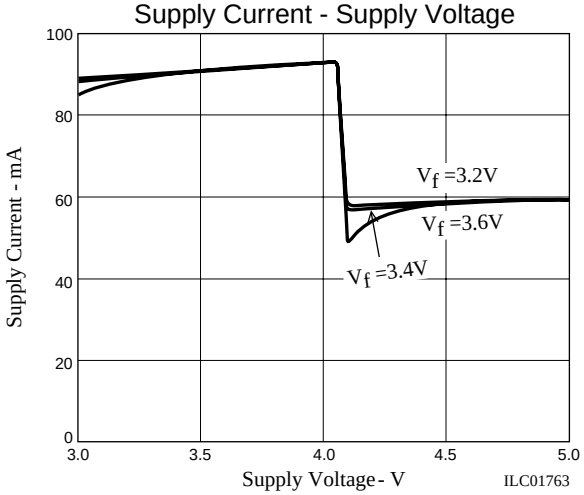
Unless otherwise specified,
Supply voltage (V_{IN})=3.6V, R_{SET}=3.2kΩ, LED forward voltage (V_F)=3.2V, Ta=25°C, 4-light control input bypass capacitor (C_{IN})=2.2μF, output smoothing capacitor (C_{CP})=2.2μF, flying capacitor (C1,C2)=1μF

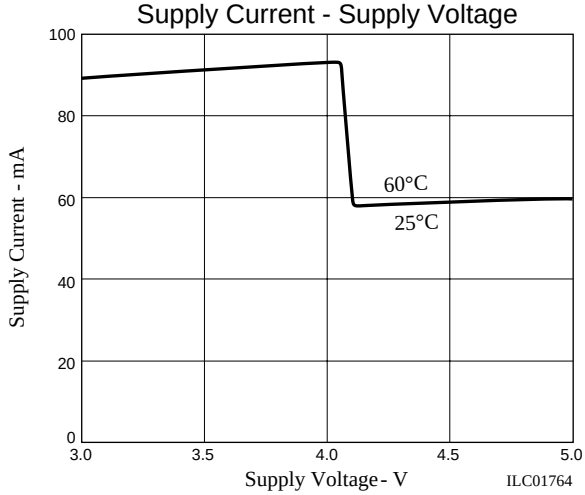












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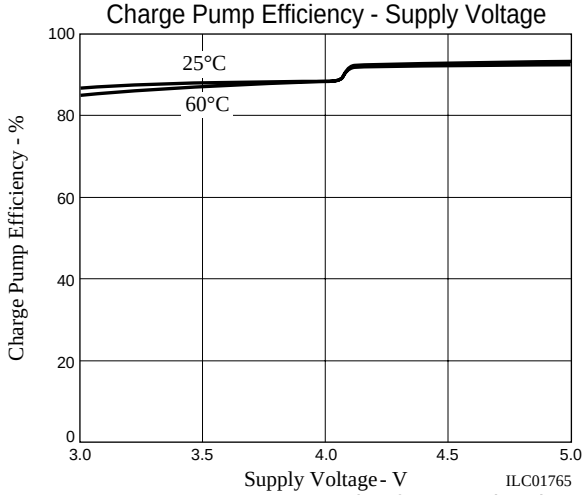
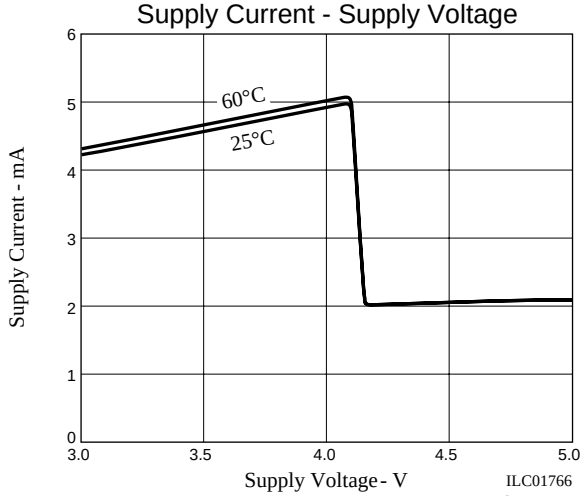
Supply voltage (V_{IN})=3.6V, R_{SET}=3.2kΩ, LED forward voltage (V_F)=3.2V, Ta=25°C, 4-light control input bypass capacitor (C_{IN})=2.2μF, output smoothing capacitor (C_{CP})=2.2μF, flying capacitor (C1,C2)=1μF

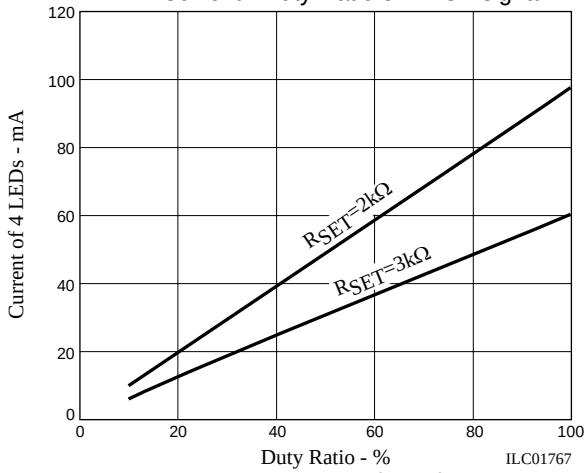
Charge Pump Efficiency - Supply Voltage



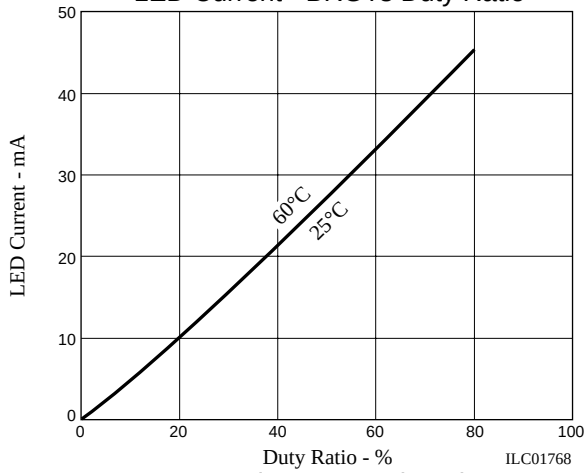
Supply Current - Supply Voltage



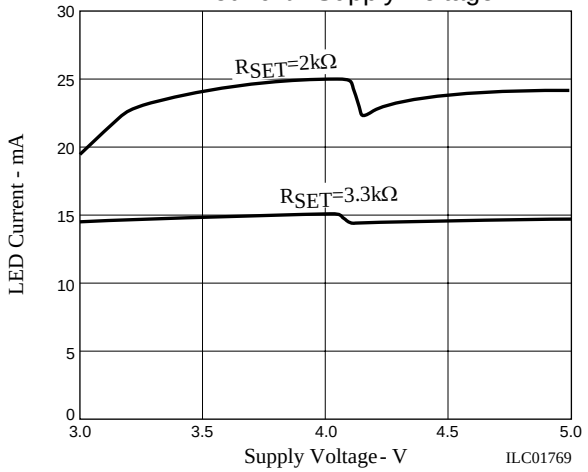
LED Current - Duty Ratio of BRGT signal



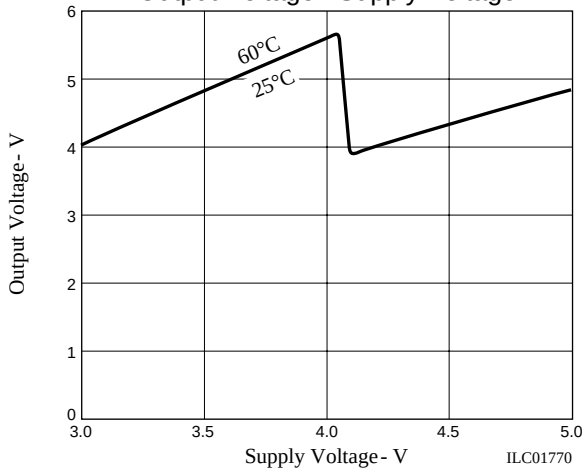
LED Current - BRGTs Duty Ratio



LED Current - Supply Voltage



Output Voltage - Supply Voltage



Functional Description

Circuit description

The LC410591FN is a white LED driver that uses a Li-ion battery as its power supply. The output voltage range of the Li-ion battery is approximately 2.7V to 5.5V, and a typical white LED forward voltage (V_F) is approximately 3.6V. Therefore, when the supply voltage is 3.6V or less, the voltage must be stepped up internally. The LC410591FN incorporates a charge pump that steps up the supply voltage 1.5 times. This charge pump automatically switches to the optimum step-up mode.

The 100% LED current is determined by the resistance values of the external resistors. In other words, the internal reference voltage (V_{REF}≠1.2) is applied precisely to the external resistors by the internal Op amplifier, and the current flowing to the external resistors (I_{RSET}) becomes $I_{RSET}=V_{REF}/R_{SET}$. The LED current (I_{LED}) is regulated by a current mirror circuit so that 40 times the I_{RSET} current flows. For example, if V_{REF}=1.2V and R_{SET}=2kΩ, then I_{RSET}=0.6mA, and $I_{LED}=I_{RSET}\times40$=24mA. In this case, for 4-light control, the total current flowing to the LED is 24mA×4=96mA. However, this formula does not include the variation in the resistance values of the external resistors. If accurate LED current is required, high-precision resistors (with a variation of 1% or less, for instance) may be required.

The LED brightness is adjusted by a serial signal to the BRGT pin.

Shutdown mode

The LC410591FN enters a shutdown mode when the low level is applied to the BRGT pin for 22ms or longer. In the shutdown mode, the LEDs turn off, and the supply current is reduced to 1μA or less.

Soft start

The LC410591FN performs a soft start to prevent rush current, and then 100% current flows to the LEDs. A rush current is generated if the charge pump is activated when the flying capacitor is discharged. If the impedance of the capacitor is low, an excessive current will flow in from the battery. Soft start is performed to reduce the stress on the battery and external components. During the soft start, the resistance of the switch connected to the flying capacitor and output smoothing capacitor is adjusted to prevent a rush current.

Brightness adjustment

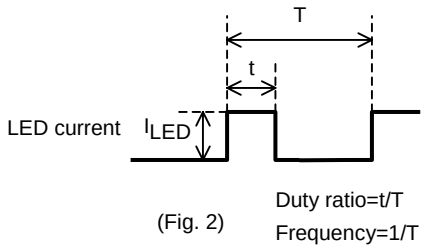
LED brightness can be adjusted by controlling the current to the LED with the PWM signal supplied to the BRGT pin. The average current flowing to the LEDs depends on the PWM signal.

[LED average current=$I_{LED}\times$Duty ratio] …(Fig. 2)

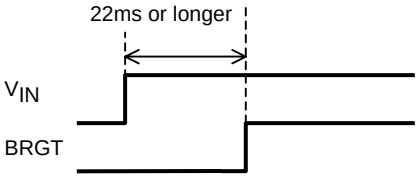
The current flowing to the LED (average value) changes in a nearly linear fashion with respect to the duty ratio of the PWM signal input to the BRGT pin. …(Fig. 3)

The upper limit of the PWM signal frequency is 50kHz.

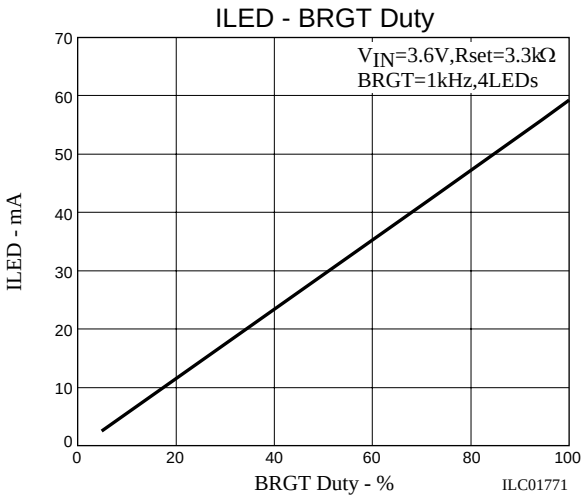
Fix the BRGT signal to the low level for at least 22ms from power supply (V_{IN}) rising.…(Fig. 4)



(Fig. 2)



(Fig. 4)



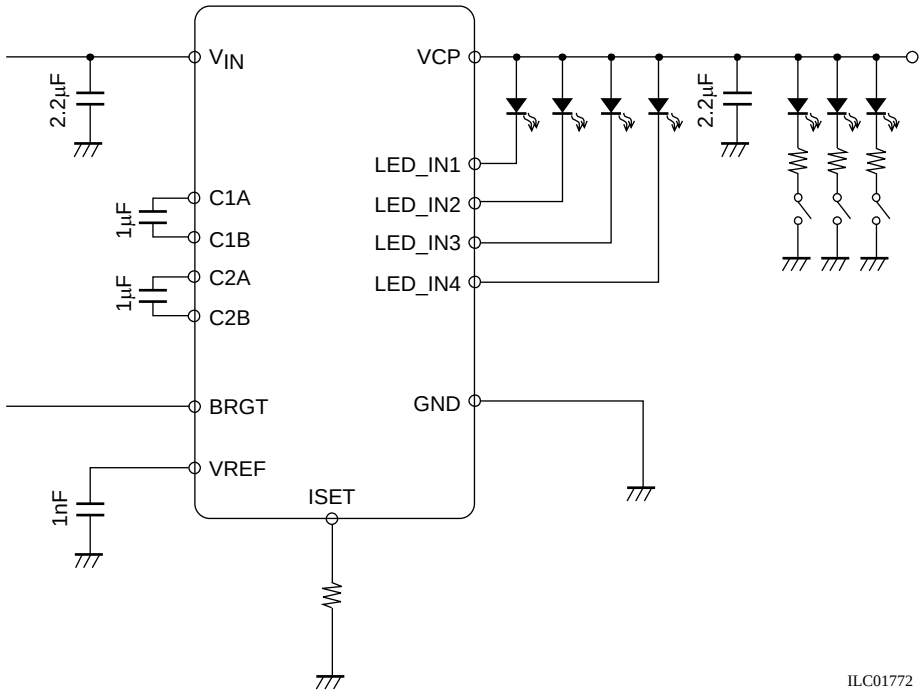
(Fig. 3)

Selection of external capacitors

Low ESR capacitors are recommended for the input bypass capacitor, output smoothing capacitor, and charge pump flying capacitor. Also, ceramic capacitors are recommended for their low fluctuations due to temperature (such as X5R or X7R).

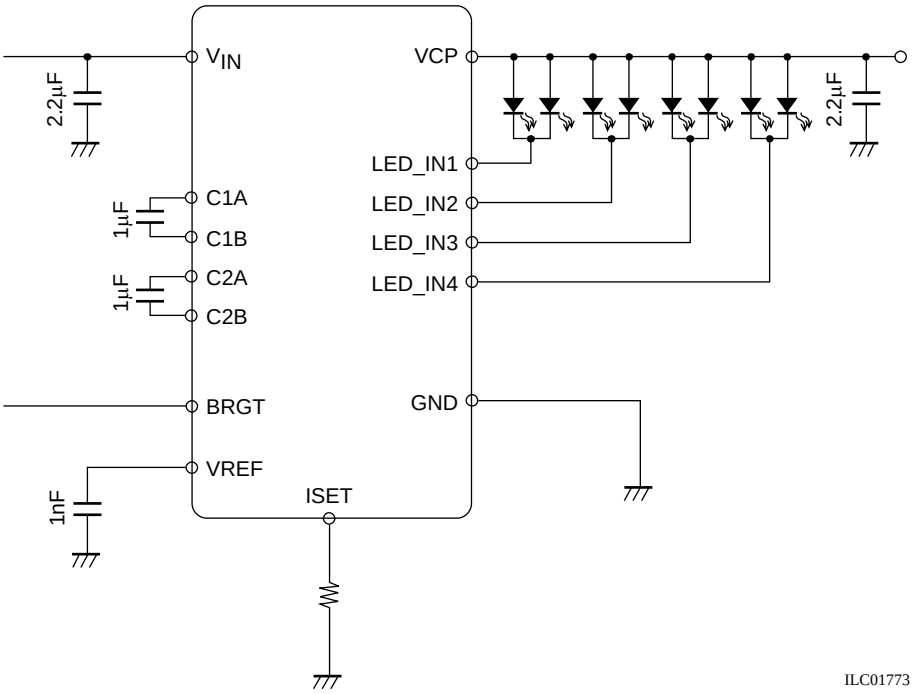
Adding LEDs for driving

Shown in Figures 5 and 6 are sample circuit diagrams illustrating the use of output voltage (VCP) of this IC when an LED is added. Note that the IC may not be able to conform to its specifications if the total LED current exceeds 105mA. To limit the amount of current to the additional LED, or to control the on/off switching of the current, it is necessary to connect a resistor or switch in series with the added LED.



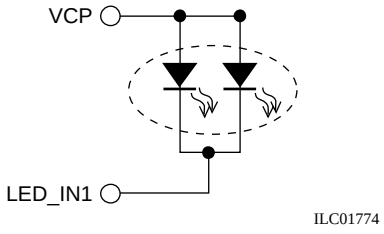
(Fig. 5)

The connection shown in the figure below is also possible.



(Fig.6)

However, in the case of the above connection, LED current differences due to the characteristic differences of the LEDs connected to the same LED_IN by the cathode (Fig. 7) are not adjusted.



(Fig.7)