SGM3131
120mA 4-Channel Charge Pump White LED Driver with Low Dropout Current Source

GENERAL DESCRIPTION

The SGM3131 is a high performance white LED driver. It integrates current sources and automatic mode selection charge pump. The part maintains the high efficiency by utilizing a 1× / 1.5× fractional charge pump and low dropout current sources. The small equivalent 1× mode open loop resistance and ultra-low dropout voltage of current source extend the operating time of 1× mode and optimize the efficiency of Li-ion battery in white LED applications.

The SGM3131 supports up to 4 white LEDs and regulates a constant current which the initial value can be set by an external resistor. The part implements a 4-bit DAC for brightness control. Users can easily configure the LED current from 0.5mA to 30mA by a serial pulse. The dimming of white LEDs current can be achieved by applying a pulse signal to the EN pin. There are totally 16 steps of current could be set by users. The operating voltage range is 2.7V to 5.5V. Internal soft start circuitry effectively reduces the in-rush current while both start-up and mode transition. The load is disconnected from VIN while shutdown and the shutdown current is less than 1μA.

SGM3131 is available in Green TQFN3×3-16L package. It operates over an ambient temperature range of -40℃ to +85℃.

FEATURES

- **Input Voltage Range: 2.7V to 5.5V**
- **Drives up to 4 LEDs at 30mA Each**
- **LED Brightness Control Through Single Wire Interface**
- **16-Step Brightness Control**
- **High Efficiency by Fractional Conversion with 1× and 1.5× Modes**
- **Switching Frequency: 1MHz**
- **Regulated Output Current with 1% Matching**
- **Internal Softstart Limits Inrush Current**
- **Low Input Ripple and Low EMI**
- **Over Current and Over Temperature Protected**
- **Under Voltage Lockout with Hysteresis**
- **Operating Temperature Range: -40℃ to +85℃**
- **Available in Green TQFN3×3-16L Package**

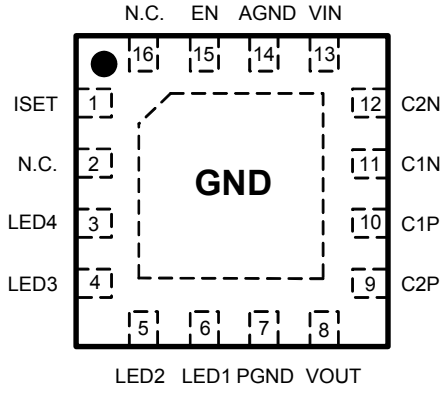
APPLICATIONS

Mobile Phone, DSC, MP3
White LED Backlighting
LCD Display Supply

PACKAGE/ORDERING INFORMATION

MODEL	ORDER NUMBER	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	PACKAGE OPTION	MARKING INFORMATION
SGM3131	SGM3131YTQ16G/TR	TQFN3×3-16L	-40℃ to +85℃	Tape and Reel, 3000	3131TQ

PIN CONFIGURATION (TOP VIEW)



TQFN3x3-16L

CAUTION

This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ABSOLUTE MAXIMUM RATINGS

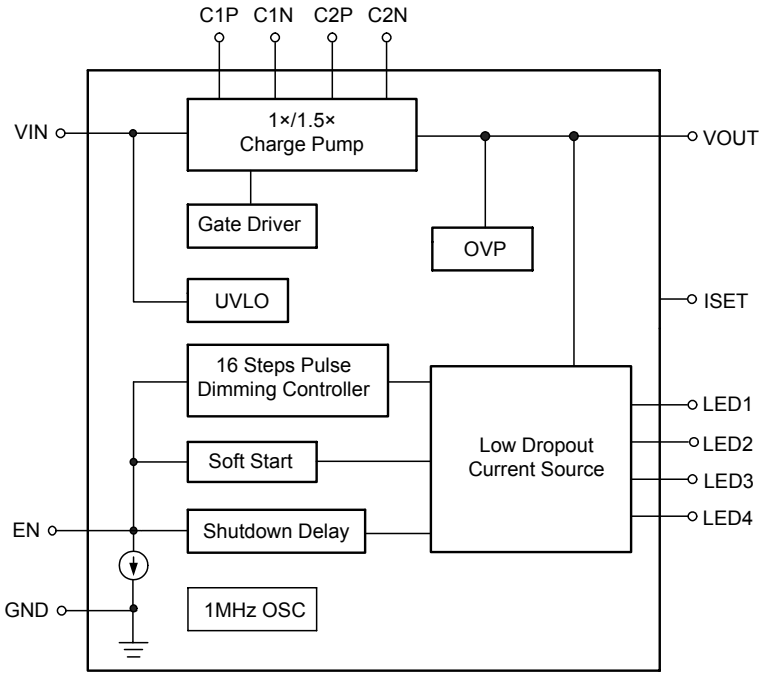
Supply Voltage……..…….-0.3V to 6.0V
The Other Pins to GND…….……..-0.3V to V_{IN}
Power Dissipation, P_D @ T_A = +25℃
TQFN3×3-16L……..……1.47W
Storage Temperature Range……..……-65℃ to +150℃
Junction Temperature ……..……..160℃
Operating Temperature Range…… -40℃ to +85℃
Lead Temperature Range (Soldering 10 sec)
……..…….……260℃
ESD Susceptibility
HBM……..…….…….. 2000V
MM…….…….…….. 200V

NOTE:
Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

PIN DESCRIPTION

PIN	NAME	I/O	FUNCTION
1	ISET	I	Connect a resistor between this pin and GND to set the maximum current through the LEDs.
2, 16	N.C.	-	No internal connection.
3, 4, 5, 6	LED4－LED1	I	Current sink input. Connect the cathode of the white LEDs to these inputs.
7	PGND	-	Power ground.
8	VOUT	O	Connect the output capacitor and the anode of the LEDs to this pin.
9	C2P	-	Positive Terminal of Bucket Capacitor 2.
10	C1P	-	Positive Terminal of Bucket Capacitor 1.
11	C1N	-	Negative Terminal of Bucket Capacitor 1.
12	C2N	-	Negative Terminal of Bucket Capacitor 2.
13	VIN	I	Supply voltage input.
14	AGND	-	Analog ground.
15	EN	I	Chip Enable (Active High), and connects to GPIO pin of MCU.
Exposed Pad	GND	-	Exposed pad should be soldered to PCB board and connected to GND.

FUNCTION BLOCK DIAGRAM



ELECTRICAL CHARACTERISTICS

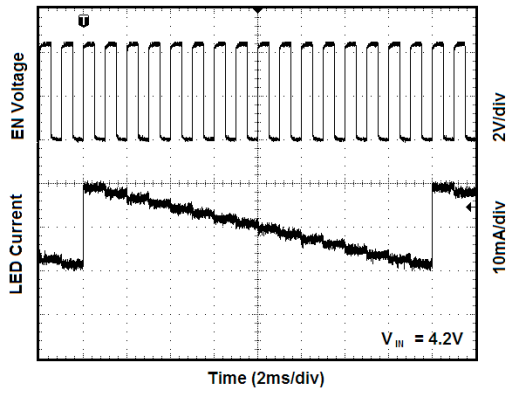
(V_{IN} = 3.6V, EN = V_{IN}, T_A = +25°C, unless otherwise noted.)

PARAMETER		SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SUPPLY VOULTAGE AND CURRENT							
Input Voltage Range		V_{IN}		2.7		5.5	V
Quiescent Power Supply Current		I_Q	V_{IN} = 4.2V, 1× Mode, EN = 1, I_{SET} = 0μA		100		μA
		I_Q	V_{IN} = 4.2V, 1× Mode, EN= 1, I_{SET} = 20μA		200		μA
			I_{OUT} = 0mA, 1.5× Mode		2		mA
Shutdown Supply Current		I_{SHDN}	EN = GND			1	μA
CHARGE PUMP STAGE							
Overvoltage Limit		V_{OUT}	LEDx unconnected, V_{IN} = 4.2V		5.7		V
Startup Time			C_{OUT} = 1μF, I_{LEDx} ≥ 0.9 × $I_{LEDx\text{-}SET}$		235		μs
Softstart Duration					220		μs
Switching Frequency		f		0.6	1	1.4	MHz
Efficiency		η	V_{IN} = 3.5V, I_{LEDx} = 15mA each, V_{LEDx} = 3.15V		90		%
Thermal Shutdown Temperature			Temperature rising		150		°C
Hysteresis Temperature					15		°C
Input Current Llimit			EN = 1, I_{SET} = 100μA		270		mA
CURRENT SINKS							
Recommended Maximum Current per Current Sink		I_{LEDx}	3.2V ≤ V_{IN} ≤ 5.5V		30		mA
Current into Each Current Sink when ISET is Shorted to GND		I_{LEDx}	3.0V ≤ V_{IN} ≤ 5.5V, ISET shorted to GND		40		mA
Current Matching between Any Two Outputs			V_{LEDx} = 3.1V, T_A = 25℃	-3	1	+3	%
Line Regulation			3V < V_{IN} < 5.5V, V_{LEDx} = 3.1V, EN = 1, I_{SET} = 80μA		2		%
Reference Voltage for Current Set		V_{ISET}	EN = 1	580	600	620	mV
Recommended ISET Pin Current Range		I_{SET}		2		130	μA
I_{LEDx} to I_{SET} Current Ratio		K	EN = 1, I_{SET} = 80μA	230	260	280	
Voltage at LEDx to GND		V_{SOURCE}	EN = 1, I_{LEDx} = 30mA		400		mV
Enable							
EN Low Time for Shutdown		T_{SHDN}		3			ms
EN Low Time for Dimming		T_{LO}		0.5		500	μs
EN High Time for Dimming		T_{HI}		0.5			μs
EN Threshold	Logic-High Voltage	V_{IH}		1.2			V
	Logic-Low Voltage	V_{IL}				0.6	V

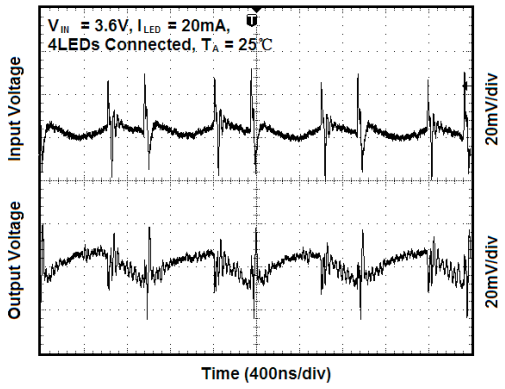
Specifications subject to changes without notice.

TYPICAL PERFORMANCE CHARACTERISTICS

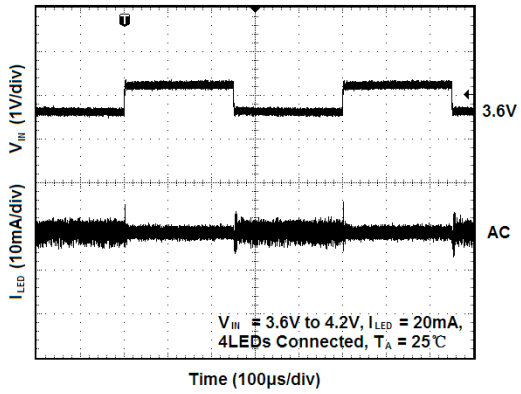
1× Mode Dimming Operation



1.5× Mode Input and Output Voltage Ripple



Line Transient



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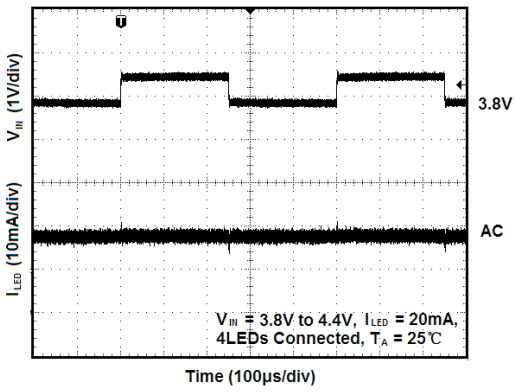
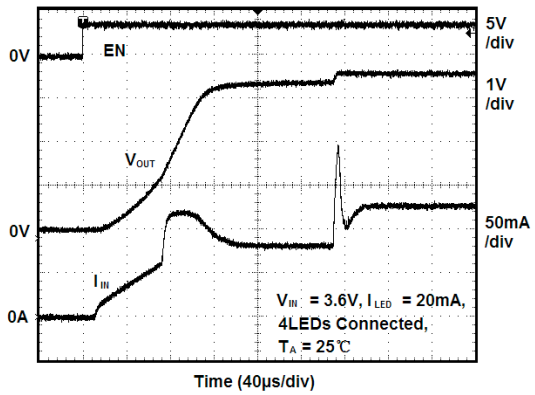


Startup Timing



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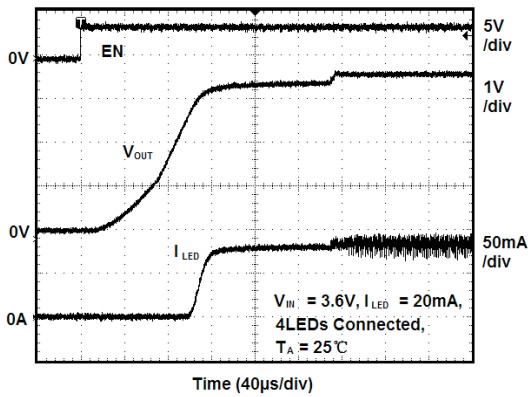
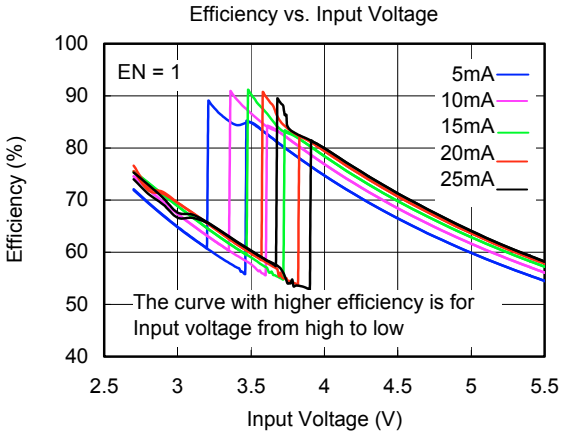
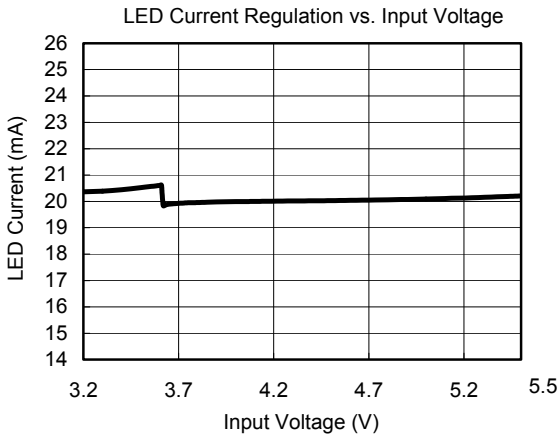


TYPICAL PERFORMANCE CHARACTERISTICS





TYPICAL APPLICATION

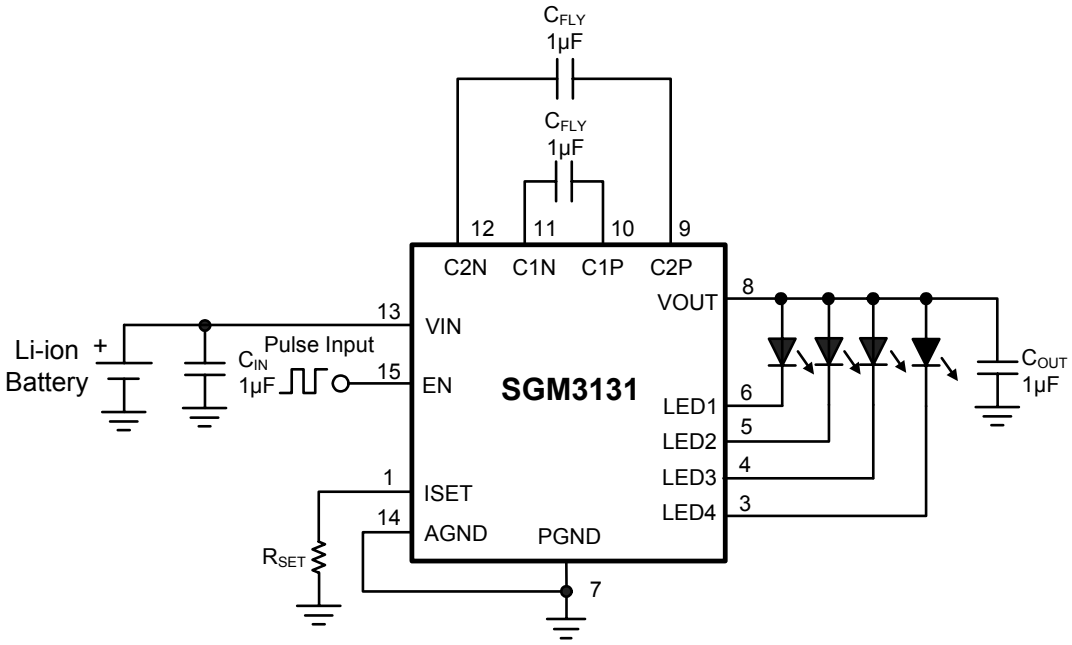


Figure 1. For 4-WLEDs Application Circuit

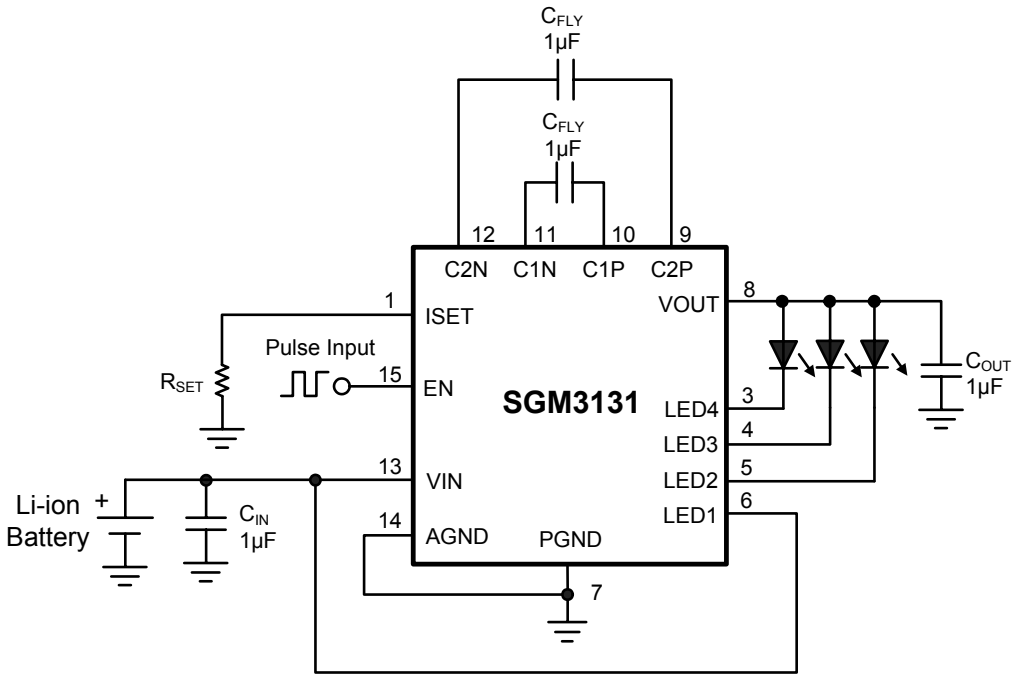


Figure 2. For 3-WLEDs Application Circuit

APPLICATIONS INFORMATION

The SGM3131 uses a fractional switched capacitor charge pump to power up to four white LEDs with a programmable current for uniform intensity. The part integrates current sources and automatic mode selection charge pump. It maintains the high efficiency by utilizing a 1×/ 1.5× fractional charge pump and current sources. The small equivalent 1× mode open loop resistance and ultra-low dropout voltage of current source extend the operating time of 1× mode and optimize the efficiency in white LED applications.

Input UVLO

The input operating voltage range of the SGM3131 is 2.7V to 5.5V. An input capacitor at the VIN pin could reduce ripple voltage. It is recommended to use a ceramic 1μF or larger capacitance as the input capacitor. This IC provides an under voltage lockout (UVLO) function to prevent it from unstable issue when startup. The UVLO threshold of input rising voltage is set at 2.15V typically with a hysteresis 50mV.

Soft Start

The SGM3131 employs a soft start feature to limit the inrush current. The soft-start circuit prevents the excessive inrush current and input voltage droop. The soft-start clamps the input current over a typical period of 200μs.

Mode Decision

The SGM3131 uses a smart mode selection method to decide the working mode for optimizing the efficiency. Mode decision circuit senses the output and LED voltage for up/down selection. The SGM3131 automatically switches to 1.5× mode whenever the dropout condition is detected from the current source and returns to 1× mode whenever the dropout condition releases.

LED Connection

The SGM3131 supports up to 4 white LEDs. The four LEDs are connected from VOUT to pin 3, 4, 5 and 6 respectively (Figure 1). If the LED is not used, the LED pin should be connected to VIN directly. Figure 2 shows the connection for 3-WLEDs application.

LED Current Adjustment (ISET)

A resistor programs a reference current, which is current mirrored to set the LED current. The 100% current (16/16) in each LED is typically 260 times the current through the resistor at ISET (see Table 1).

$$R_{SET} = \frac{V_{ISET}}{I_{LED}} \times K$$

V_{ISET} — Voltage from ISET pin (0.6V) to GND
I_{LED} — 100% Current per LED from LEDx pin to GND
K — LEDx to ISET current ratio (typically 260)

The LED current varies linearly from 0mA to I_{LED} (100%) by the single wire interface, totally 16-step brightness dimming.

SET DRIVE CURRENT (100%)	R_{SET} COMPUTATION VALUE(KΩ)	STANDARD RESISTOR VALUE (KΩ) (1%)
30mA	5.2	5.1
25mA	6.24	6.19
20mA	7.8	7.68
10mA	15.6	15.4
5mA	31.2	30.9

Table 1. R_{SET} Values

Selecting Capacitors

To get the better performance of SGM3131, the selection of peripherally appropriate capacitor and value is very important. These capacitors determine some parameters such as input/output ripple voltage, power efficiency, and maximum supply current by charge pump. To reduce the input and output ripple effectively, the low ESR ceramic capacitors are recommended. For LED driver applications, the input voltage ripple is more important than output ripple. Input ripple is controlled by input capacitor C_{IN}, increasing the value of input capacitance can further reduce the ripple. Practically, the input voltage ripple depends on the power supply impedance. The flying capacitors (C_{FLY}) determine the supply current capability of the charge pump and to influence the overall efficiency of system. The lower value will improve efficiency, but it will limit the LED's current at low input voltage. For 4 × 30mA load over the entire input range of 2.7V to 5.5V, it is recommended to use a 1μF ceramic capacitor on the flying capacitors.

Brightness Control

The SGM3131 implements a pulse dimming method to control the brightness of white LEDs. Users can easily configure the LED current from 0.5mA to 30mA by a serial pulse. The dimming of white LEDs' current can be achieved by applying a pulse signal to the EN pin. There are totally 16 steps of current could be set by users. The detail operation of brightness dimming is showed in the Figure 3.

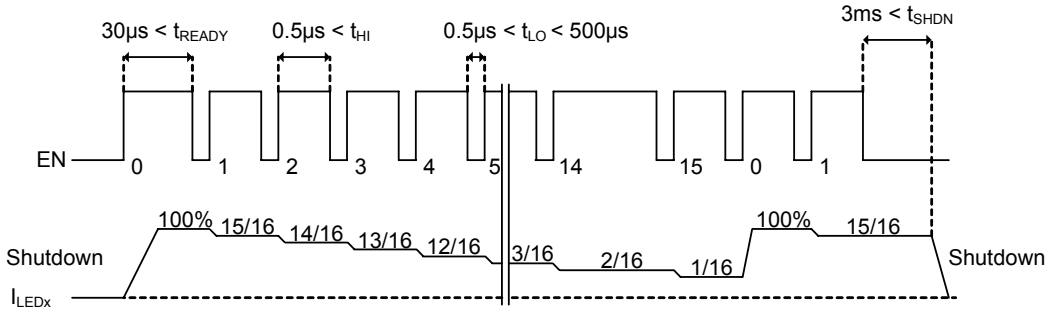
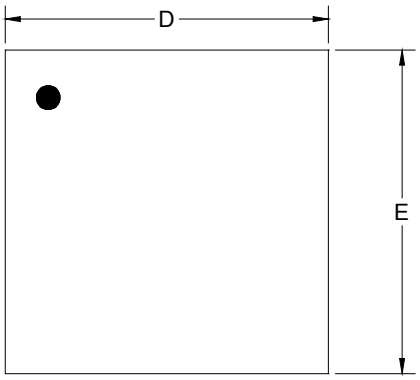


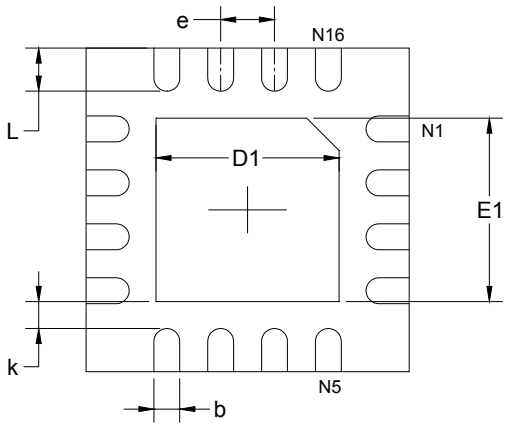
Figure 3. Brightness Control by Pulse Dimming

PACKAGE OUTLINE DIMENSIONS

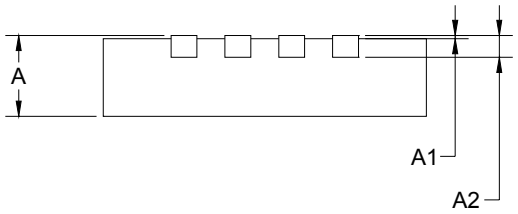
TQFN3×3-16L



TOP VIEW



BOTTOM VIEW



SIDE VIEW

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	1.600	1.800	0.063	0.071
E	2.900	3.100	0.114	0.122
E1	1.600	1.800	0.063	0.071
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
L	0.300	0.500	0.012	0.020