Boost WLED Driver for Backlights

Features

- 5V to 24 V Input Supply Voltage
- Boost Converter
  - Automatically Adjusting Output Voltage
  - 1.0MHz Switching Frequency
  - Integrated 2.0A 40V NFET
  - Internal Loop Compensation and Soft Start
  - Over Current Protection
  - Over Voltage Protection
  - Over 90% High Efficiency
- Six Channel Current Sink
  - Maximum 30mA Current Sink
  - 3% Current Matching and Accuracy
  - 100:1 PWM Brightness Dimming Range
- Open/Short LED protection
- Thermal Shutdown
- Small 16-pin 3mmx3mm TQFN package

Applications

- Notebook Displays LED Backlighting
- LCD Monitor LED Backlighting

General Description

The G5966 is a 6-channel boost WLED driver for backlight applications. It features a high-performance boost converter, six channel current sink with 3% current matching and accuracy, and PWM brightness dimming control.

The boost converter automatically provides the regulated output voltage for the WLED backlight without the need to calculate the output for different LED types. The switching frequency is 1MHz. It also integrates a 40V NFET that provides high output power.

The 6-channel current sink is ideal for constant current driving, and, well matched less than 3% (typical). To set the maximum driving current, the ISET pin is used to determine reference current. Each channel of the current sink is set to 1000 times of this reference current. A PWM pin can be used for PWM dimming.

The G5966 provides many protection schemes to avoid any abnormal operation. Over current protection is designed to protect internal NFET. It also provides over voltage and over temperature protection. The G5966 can detect open or short LED and offer protections.

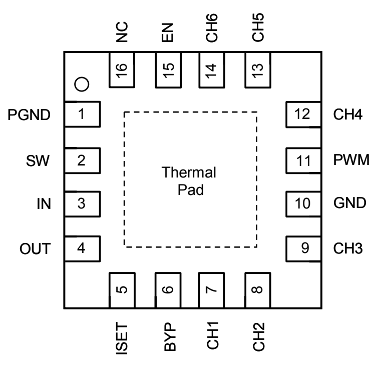
The G5966 is available in a 16-pin 3x3mm TQFN package.

Ordering Information

ORDER NUMBER	MARKING	TEMP. RANGE	PACKAGE (Green)
G5966R41U	5966	-40°C to 85°C	TQFN3X3-16

Note: R4: TQFN3X3-16
1: Bonding Code
U: Tape & Reel

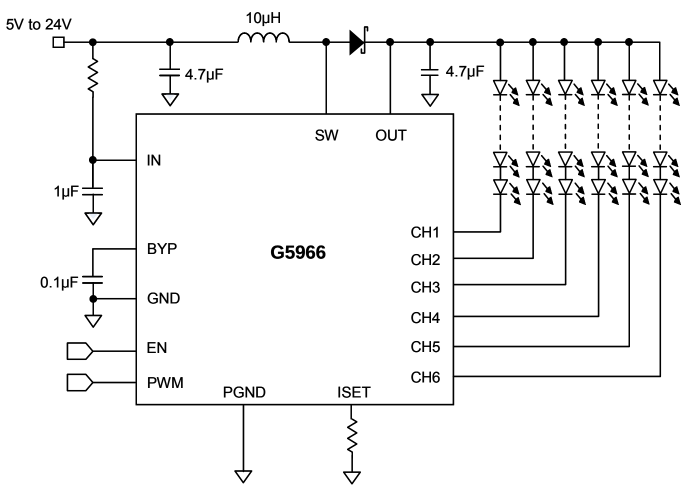
Pin Configuration



G5966 TQFN3X3-16

Note: Recommend connecting the Thermal Pad to the Ground for excellent power dissipation.

Typical Application Circuit



Absolute Maximum Ratings

IN to GND. . . . .-0.3V to 24V
SW, OUT, CH1~6 to GND . . . .-0.3V to 40V
BYP, EN, PWM, ISET to GND. . . . .-0.3V to 7V
Thermal Resistance Junction to Ambient, (θ_{JA})*
TQFN3X3-16 . . . . .103°C/W
Continuous Power Dissipation (T_A=25°C)*
TQFN3X3-16 . . . . 1.21W

Thermal Resistance Junction to Case, (θ_{JC})
TQFN3X3-16 . . . . 13°C/W
Operating Temperature Range . . . .-40°C to +85°C
Junction Temperature . . . . +150°C
Storage Temperature . . . . -65°C to +150°C
Reflow Temperature (soldering, 10sec) . . . . . . .260°C

* Please refer to Minimum Footprint PCB Layout Section.

Electrical Characteristics

V_{IN}= 12V, T_A = 25°C.

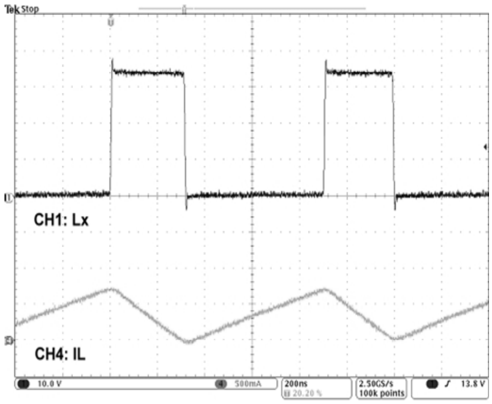
The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Input Voltage		5.0	---	24	V
Bypass Output Voltage		3.5	4	4.5	V
Operating Quiescent Current		---	---	3	mA
Input UVLO	Falling	---	4.2	4.5	V
	Hysteresis	---	300	---	mV
EN/PWM Input Level	V_{IH}	1.5	---	---	V
	V_{IL}	---	---	0.6	V
EN/PWM Pull Down Resistor		50	100	200	kΩ
Oscillator Frequency		0.8	1.0	1.2	MHz
Minimum Regulation Voltage of CH1 to CH6		---	700	---	mV
Boost NFET on Resistance		---	0.25	0.45	Ω
Boost NFET Leakage Current	V_{SW}=35V	---	---	1	µA
Boost NFET Current Limit		2	2.5	3	A
Maximum Duty Cycle		85	93	---	%
Minimum Duty Cycle		---	7	---	%
ISET Voltage		1.204	1.229	1.253	V
Channel-to-Channel Current Matching	Channel current = 20mA	---	1	2.5	%
Current Accuracy	Channel current = 20mA	---	---	3	%
Maximum Channel Output Current		30	---	---	mA
Channel Leakage Current	CH voltage=20V	---	---	3	µA
Output Overvoltage Threshold		38	39	40	V
Short Circuit Detection Blanking Time		---	12	---	ms
Over Temperature	Trigger	---	160	---	°C
	Hysteresis	---	15	---	°C

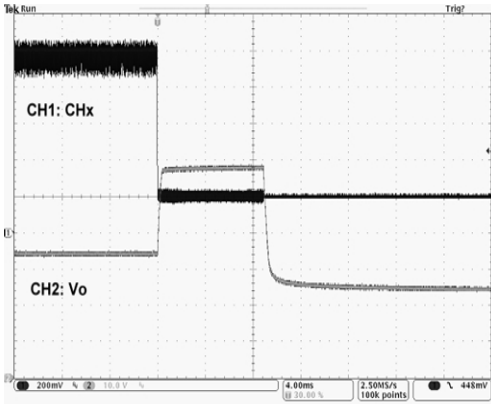
Typical Performance Characteristics

L=10μH, C_{IN}=4.7μF, C_{OUT}=2.2μFx3, ILEDx=20mA.

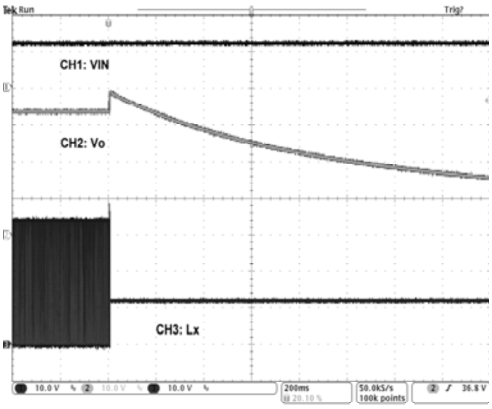
Lx – rise / fall time



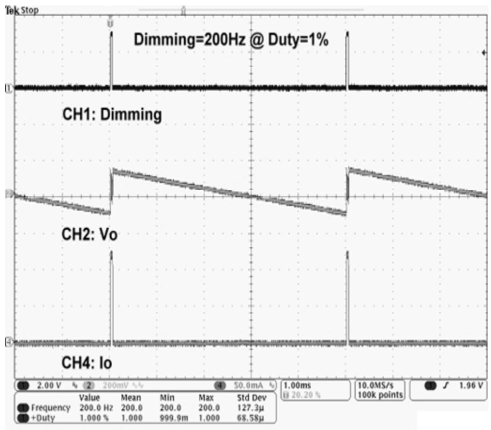
SCP (Short Circuit Protection)



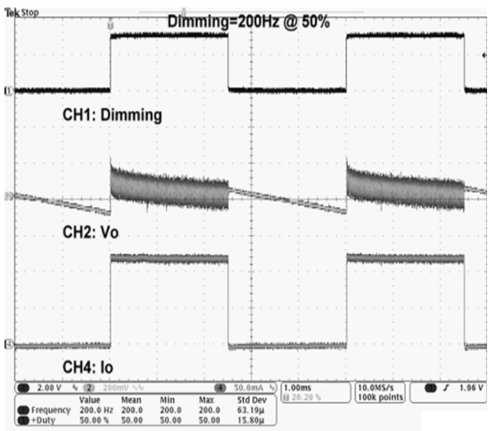
OVP



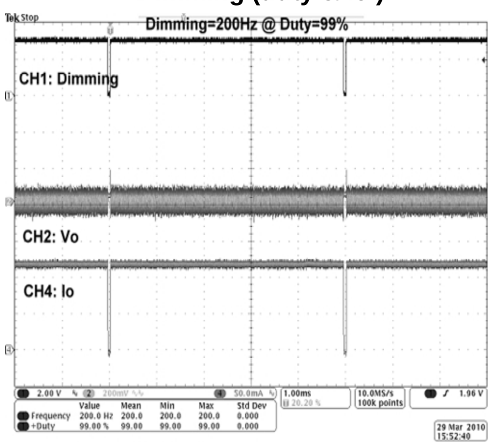
Dimming (duty & io)



Dimming (duty & io)

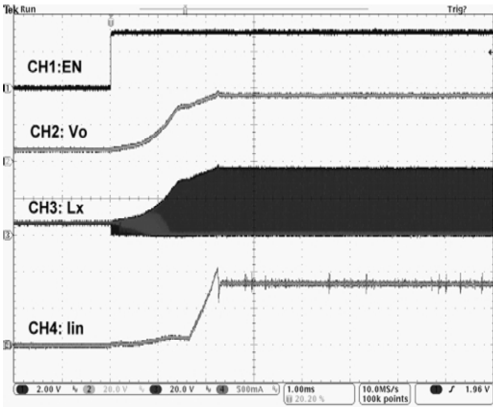


Dimming (duty & io)

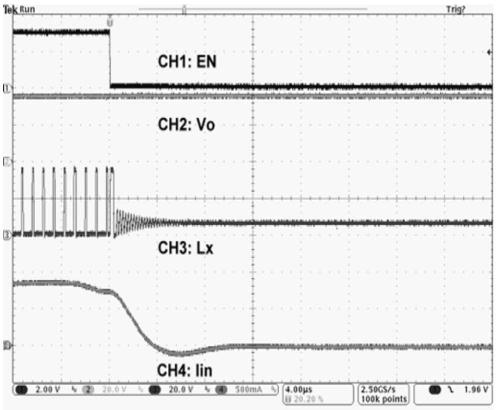


Typical Performance Characteristics (Continued)

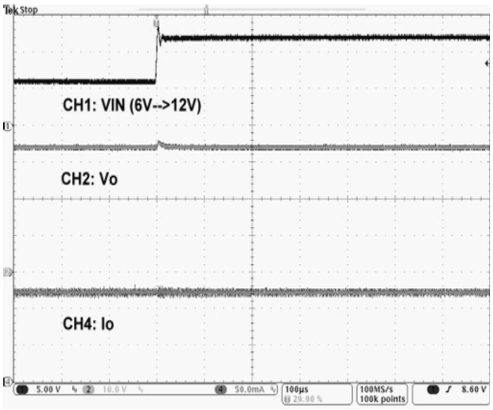
Sofe Start Waveform & Inrush Current



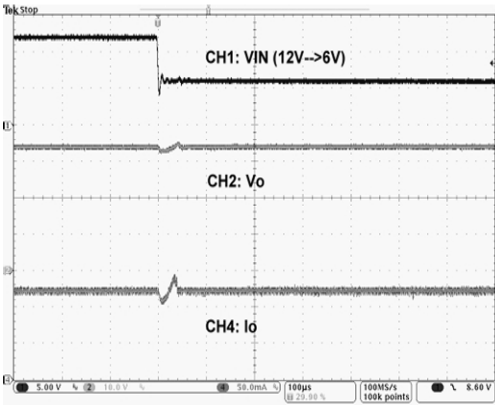
Sofe Start Waveform & Inrush Current



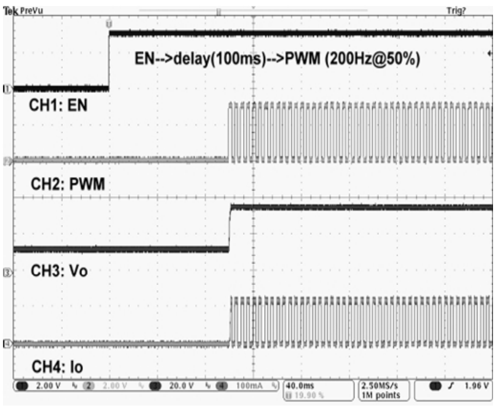
Line Transient



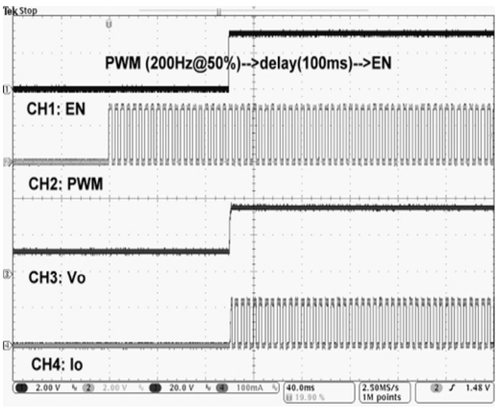
Line Transient



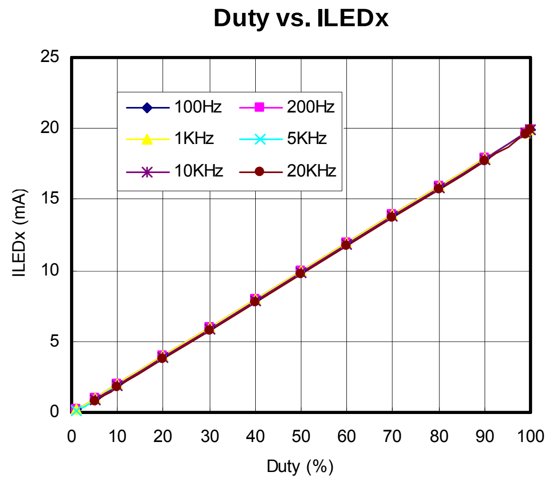
Start up with EN/PWM sequence

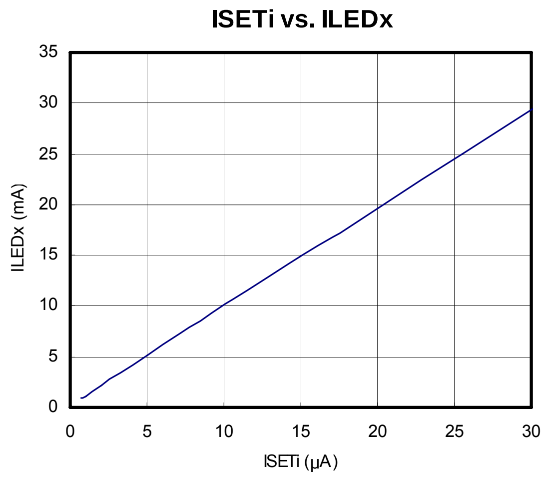


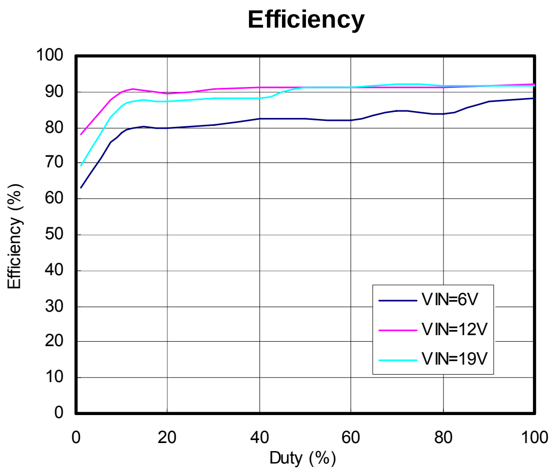
Start up with EN/PWM sequence



Typical Performance Characteristics (Continued)

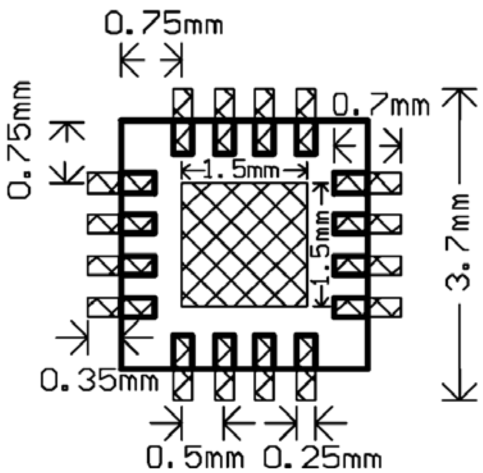






Minimum Footprint PCB Layout Section

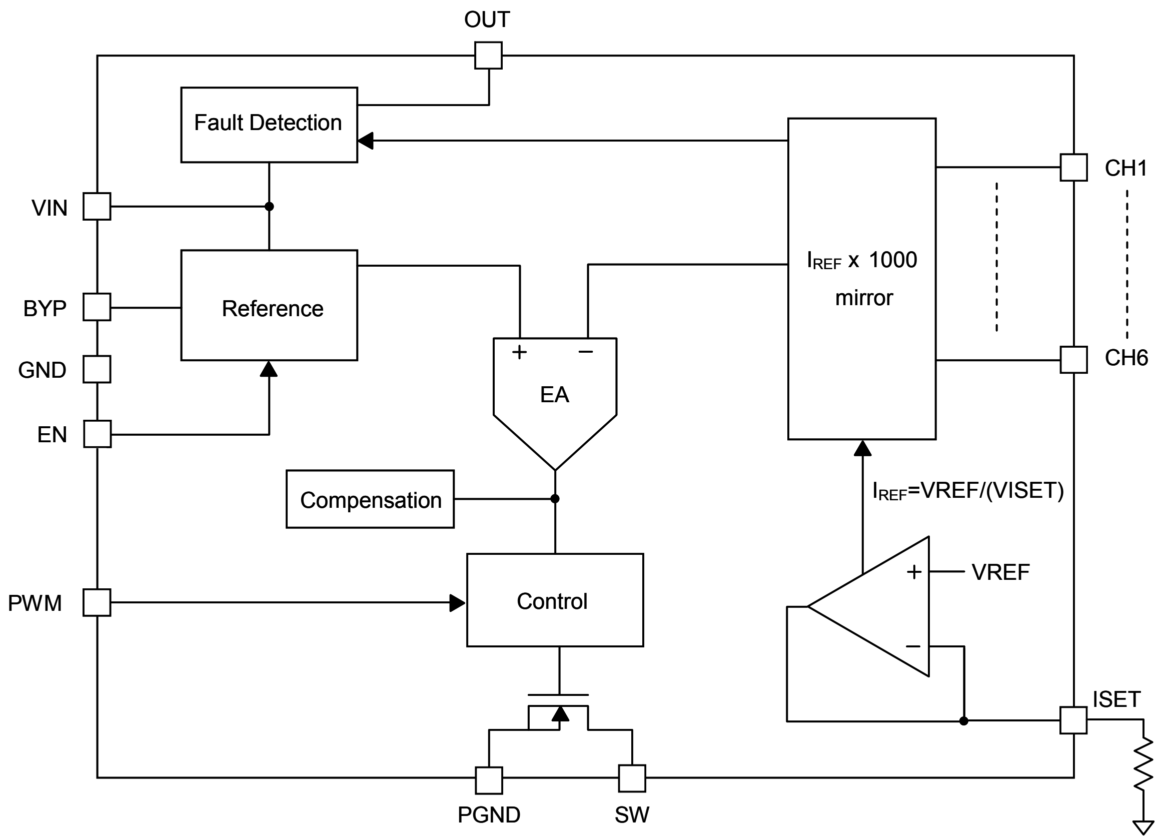
TQFN3X3-16



Pin Descriptions

PIN	Name	FUNCTION
1	PGND	Power ground pin.
2	SW	Switching node. NFET drain.
3	IN	Power input pin.
4	OUT	Output sense pin.
5	ISET	Current setting pin.
6	BYP	Regulator output bypass pin.
7	CH1	Current sink pins.
8	CH2	Current sink pins.
9	CH3	Current sink pins.
10	GND	Analog ground pin.
11	PWM	PWM brightness dimming pin.
12	CH4	Current sink pins.
13	CH5	Current sink pins.
14	CH6	Current sink pins.
15	EN	Enable pin.
16	NC	

Block Diagram



Function Description

PWM Boost Converter

The current mode PWM boost converter produces the minimal voltage needed to enable the LED stack with the highest forward voltage drop to run at the programmed current. The feedback to the boost loop controller is taken from the CHx pins. The numbers of LEDs that can be driven by G5966 depends on the type of LED chosen in the application. The G5966 is capable of boosting up to 40V and capable to drive 10 white LEDs in series for each of the 6 channels, enabling a total of 60 pieces of the 3.6V/30mA type of LEDs.

Program LED Current

The brightness should be set by choosing a R_{SET} resistor that sets the LED maximum current as:

$$I_{LED} = \frac{1.23V}{R_{SET}} \times 1000$$

Brightness Control

Digital PWM control signal to PWM pin makes LED current follows the control signal duty.
The average LED current can be calculated as:

$$I_{LED(AVERAGE)} = \frac{1.23V}{R_{SET}} \times 1000 \times D$$

where D denotes to the duty of digital control signal.

The table list below represents the relation between the frequency and duty of the digital PWM control signal.

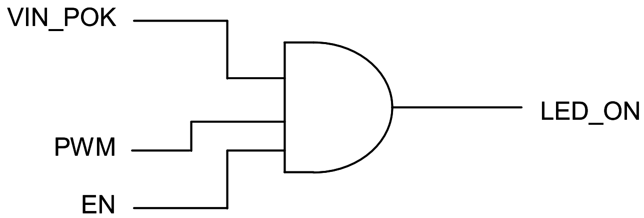
Dim F_{PWM} (Hz)	D_{MIN}	D_{MAX}
$100 < F_{PWM} \leqq 200$	0.1%	100%
$200 < F_{PWM} \leqq 500$	0.25%	100%
$500 < F_{PWM} \leqq 1k$	0.5%	100%
$1k < F_{PWM} \leqq 2k$	1%	100%
$2k < F_{PWM} \leqq 5k$	2.5%	100%
$5k < F_{PWM} \leqq 10k$	5%	100%
$10k < F_{PWM} \leqq 20k$	10%	100%
$20k < F_{PWM} \leqq 30k$	15%	100%

Over Voltage Protection

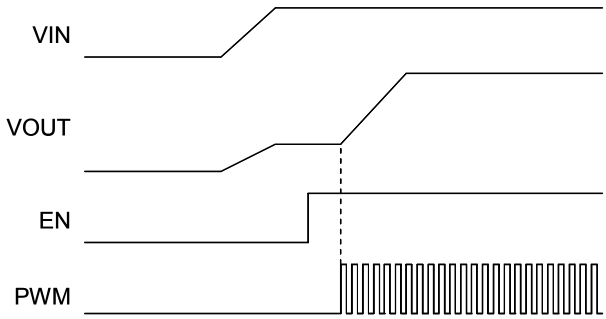
Once all the LED arrays are opened, the CHx feedback will be 0V. It makes the boost output to rise to over-voltage threshold (39V typical). The IC will shut down and remains off until there is VIN POR toggling.

LED Control Sequence

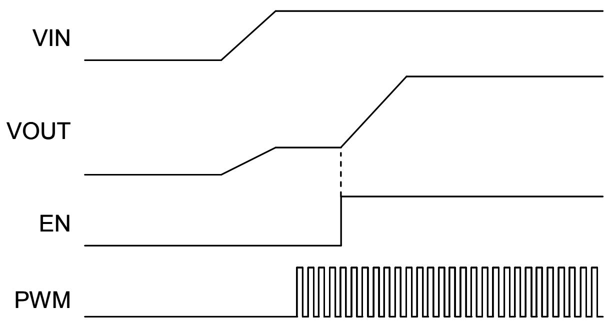
When VIN beyond their UVLO threshold, the control circuit will be ready for PWM pin and EN pin input control. Only PWM ="1" and EN="1" powers up the VOUT and the current driver starts to regulate LED current. A simple logic diagram is shown below:



Hence, even VIN ready, the control circuit still waiting for the last arrive of PWM and EN:

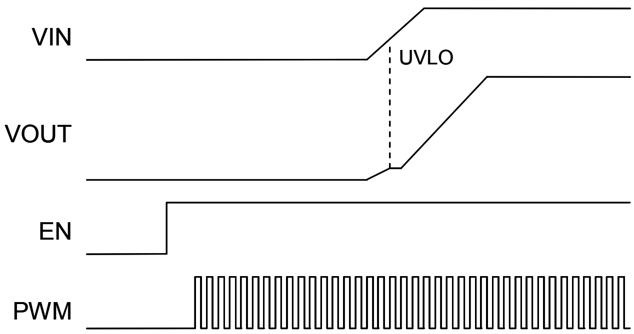


EN prior than PWM signal



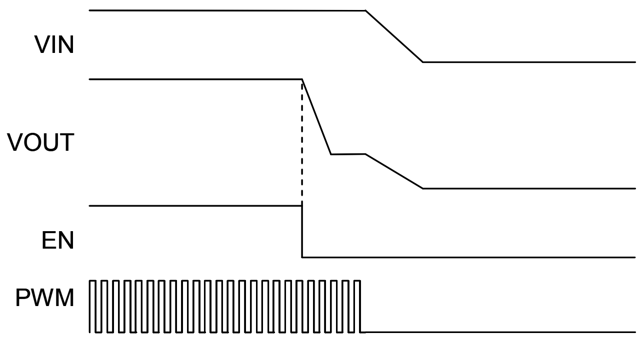
PWM prior than EN signal

If PWM and EN control from system are ready before input power supply (VIN), the control circuit will start to turn on LED driver after the input power established:

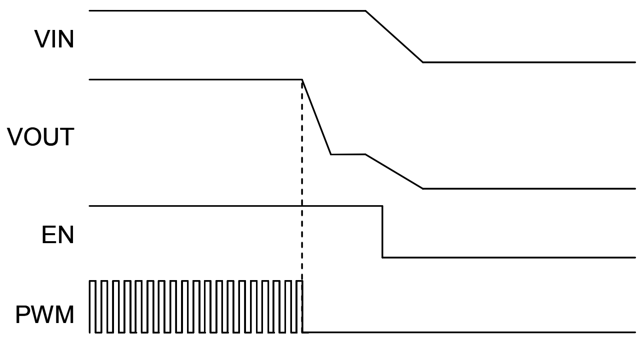


EN / PWM prior than VIN

It turns off the LED either the PWM pin or EN pin set to "0":

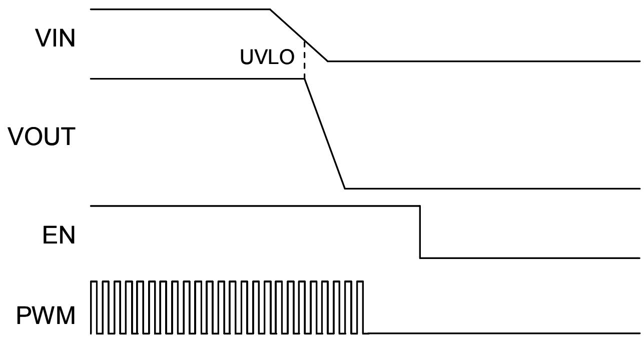


EN prior than PWM signal



PWM prior than EN signal

Or the input power supply lost before the control signal (PWM and EN) inactivate the LED driver:



VIN turn off prior than EN / PWM

Open LED Protection (OLP)

Once the CHx pin is opened, the voltage on CHx will drop to zero. It will be detected and disabled of CHx feedback until the LED load is closed again.

Over-Current And Short Circuit Protection

The G5966 has cycle by cycle over-current protection of 2.5A (Typical). The PWM switch turns off when the inductor current reaches the over-current protection threshold. The PWM switch remains off until the beginning of the next switching cycle. When there is sustained over-current condition that makes VOUT far lower the voltage that LED regulated current needed for more than 12ms, the IC would turn off and require VIN POR or the EN pin toggling to restart.

Over Temperature Protection

The G5966 has over temperature protection function to prevent the excessive power dissipation from over-heating. OTP shut down the switching regulator if the junction temperature exceeds 150°C. And it will start switching again after the junction temperature cool down 20°C.

Inductor Selection

A 4.7μH ~ 22μH inductor is recommended for small ripple applications. Small form factor and high efficiency are the major concerns for most G5966 applications. Inductor with low core losses and small DCR (cooper wire resistance) are good choice for G5966 applications.

To keep all current load conditions are in the continuous current mode (CCM), we can calculate the approximate inductor value by the following formula:

$$L > \frac{\eta_{TYP} \times (V_{OUT} - V_{IN}) \times V_{IN}^2}{2 \times f_{OSC} \times I_{OUT(MIN)} \times V_{OUT}^2}$$

Where $I_{OUT(MIN)}$ is the minimum loading current, and the expected efficiency (η_{TYP}) is taken from an appropriate curve in the Typical Performance Characteristics.

Capacitor Selection

The total output voltage ripple has two components: the capacitive ripple caused by the charging and discharging of the output capacitance, and the ohmic ripple due to the capacitor's equivalent series resistance (ESR):

$$V_{RIPPLE} = V_{RIPPLE(C)} + V_{RIPPLE(ESR)}$$

$$V_{RIPPLE(C)} \approx \frac{I_{OUT} \times (V_{OUT} - V_{IN})}{C_{OUT} \times f_{OSC} \times V_{OUT}}$$

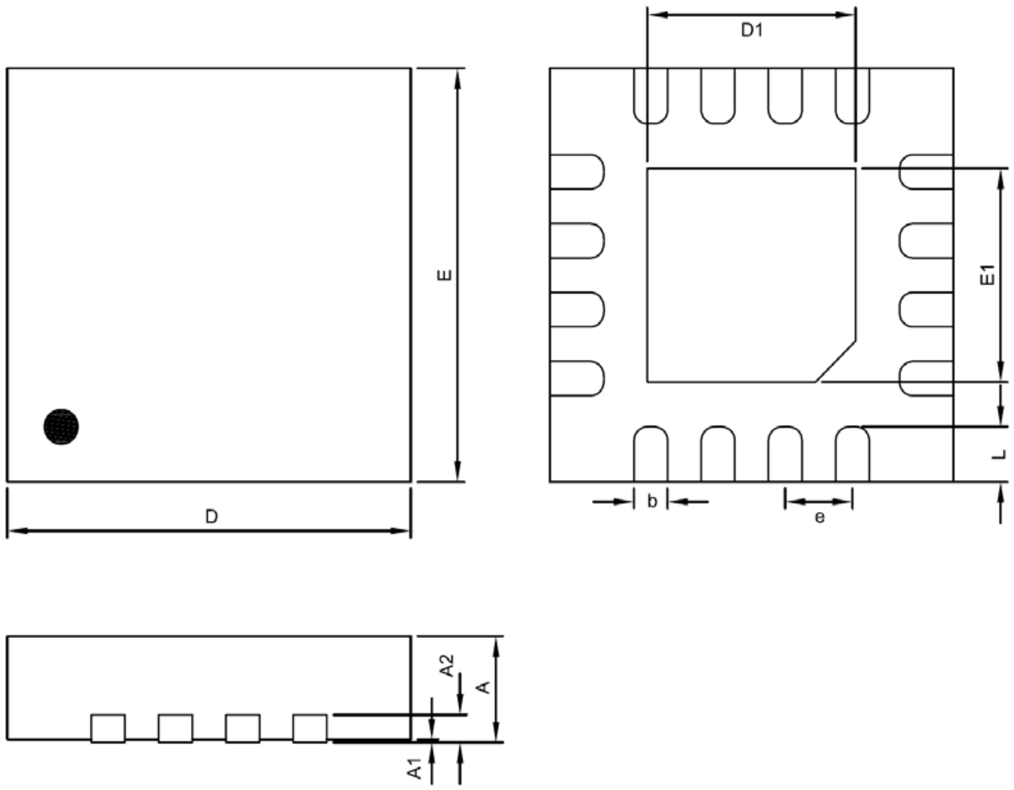
$$V_{RIPPLE(ESR)} \approx I_{PEAK} \times R_{ESR(COUT)}$$

where I_{PEAK} is the peak inductor current. For ceramic capacitors, the output voltage ripple is typically dominated by $V_{RIPPLE(C)}$. The voltage rating and temperature characteristics of the output capacitor must also be considered.

Diode Selection

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for G5966 applications. The forward voltage drop of a Schottky diode represents the conduction losses in the diode, while the diode capacitance (CT or CD) represents the switching losses. For diode selection, both forward voltage drop and diode capacitance need to be considered. Schottky diodes with higher current ratings usually have lower forward voltage drop and larger diode capacitance, which can cause significant switching losses at the 1MHz switching frequency of the G5966. A Schottky diode rated at 2~3A is sufficient for most G5966 applications.

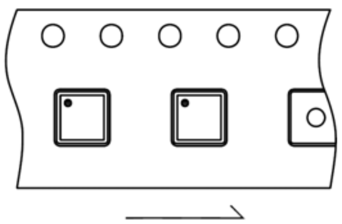
Package Information



TQFN3X3-16 Package

Symble	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.0276	0.0295	0.0315
A1	0.00	- - -	0.05	0.0000	- - -	0.0020
A2	0.19	0.20	0.21	0.0075	0.0079	0.0083
D	2.95	3.00	3.05	0.1161	0.1181	0.1201
E	2.95	3.00	3.05	0.1161	0.1181	0.1201
D1	1.50	1.60	1.75	0.0591	0.0630	0.0689
E1	1.50	1.60	1.75	0.0591	0.0630	0.0689
b	0.18	0.25	0.30	0.0071	0.0098	0.0118
e	0.50 BSC			0.0197 BSC		
L	0.35	0.40	0.45	0.0138	0.0157	0.0177

Taping Specification



PACKAGE	Q'TY/REEL
TQFN3X3-16	3,000 ea