

High Performance, Low Cost 4-CH LED Driver

Features

- Wide Input Voltage: 2.5V to 24V
- High Output Voltage: Up to 43V
- Adjustable Channel Current: 6mA to 30mA
- Channel Current Accuracy: $\pm 2.5\%$
- Channel Current Matching: $\pm 1.5\%$
- PWM Dimming Frequency: 120Hz to 30KHz
- Adjustable Switching Frequency: 600KHz to 2.2MHz
- 3 Dimming Methods Support: DC, Mixed mode and Direct PWM
- Disconnects LED in Shutdown
- Over-Current Protection (OCP)
- Over-Temperature Protection (OTP)
- Adjustable Over Voltage Protection
- Current Sink Open/Short Protection
- Disabled LED channel detection
- TQFN3X3-16 Package
- RoHS Compliant and Halogen Free

Applications

- Tablet and Notebook Backlight

General Description

The G2546B is a high-efficiency 4-channel WLED driver. It is designed for LCD panel which employs a WLED array as the lighting source. The G2546B has a wide input voltage range from 2.5V to 24V with an integrated boost converter. It drives 4 strings in parallel and supports up to 12 pieces of LEDs per string. The current of each string is adjustable from 6mA to 30mA. In addition, G2546B is integrated with 43V/2.0A 0.25 Ω power MOSFET, and the boost driver automatically adjusts its output voltage to optimize the WLED forward voltage for better efficiency. Moreover, the internal sink current between each channel can reach a typical of $\pm 1.5\%$ current mismatching for excellent brightness uniformity.

G2546B supports 3 dimming methods including DC-mode, Mixed-mode and Direct PWM-mode that have been widely adopted in nowadays NB display application.

The G2546B is available in a TQFN3X3-16 package.

Ordering Information

ORDER NUMBER	MARKING	TEMP. RANGE	PACKAGE (Green)
G2546BR41U	2546B	-40°C to +85°C	TQFN3X3-16

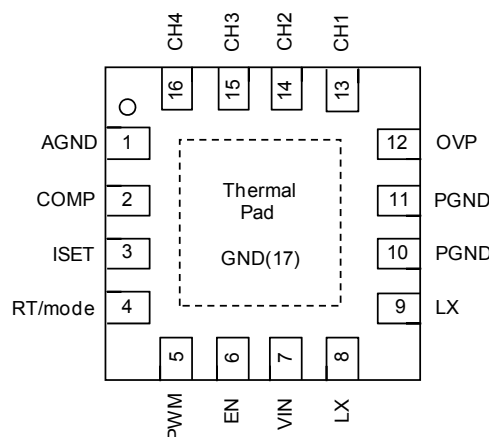
Note: R4: TQFN3X3-16

1: Bonding Code

U : Tape & Reel

Green : Lead Free / Halogen Free

Pin Configuration



G2546B TQFN3X3-16

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

Absolute Maximum Ratings

Supply Input Voltage to GND -0.3V to 26.5V
 EN, PWM, ISET, RT to GND -0.3V to 26.5V
 COMP, OVP to GND -0.3V to 26.5V
 CH1, CH2, CH3, CH4 -0.3V to 20V
 LX to GND -0.3V to 43V
 Thermal Resistance of Junction to Ambient, (θ_{JA})
 TQFN3X3-16. 68°C/W
 Thermal Resistance of Junction to Case, (θ_{JC})
 TQFN3X3-16. 7.5°C/W
 Continuous Power Dissipation ($T_A=+25^\circ\text{C}$)
 TQFN3X3-16. 1.47W
 Reflow Temperature (Soldering, 10sec) 260°C

Junction Temperature. -40°C to +85°C
 Storage Temperature. -55°C to +150°C
 ESD (HBM) 2kV
 ESD (MM) 200V

Recommended Operation Conditions

Supply Input Voltage, V_{IN} 4.2V to 24V
 Ambient Temperature range. -40°C to 85°C
 Junction Temperature range. 40°C to 125°C

Electrical Characteristics

($V_{IN}=4.2\text{V}$, $T_A=25^\circ\text{C}$)

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		Symbol	Test Conditions	Min	Typ	Max	Unit
VIN Quiescent Current		I _Q	V _{COMP} = 0V, no switching	---	1	2	mA
			V _{COMP} = 2V, switching	---	2	4	
VIN Shutdown Current		I _{SHDN}	V _{IN} = 4.5V, EN = 0V	---	---	10	μA
VIN Under Voltage Lockout		UVLO	Rising	---	2.2	---	V
			Falling	---	2.1	---	
Control Input							
EN, PWM Threshold Voltage	Logic-High	V _{IH}	V _{IN} = 4.2V to 24V	1.5	---	---	V
	Logic-Low	V _{IL}		---	---	0.8	
PWM Dimming Frequency		f _{PWM}		120	---	30K	Hz
EN, PWM Leakage Current		I _{LKG}		2	---	6	μA
EN Shutdown Delay		t _{EN}		---	32	---	ms
Dimming mode							
DC Mode		R _{RTD}		5	---	20	kΩ
Direct PWM Mode		R _{RTP}		40	---	160	kΩ
Boost Converter							
Switching Frequency	f _{OSCD C}	DC mode	R _{RT} = 5 kΩ	---	2.2	---	MHz
			R _{RT} = 10 kΩ	---	1.2	---	
			R _{RT} = 20 kΩ	---	0.6	---	
	f _{OSCD PWM}	Direct PWM mode	R _{RT} = 40 kΩ	---	2.2	---	
			R _{RT} = 80 kΩ	---	1.2	---	
			R _{RT} = 160 kΩ	---	0.6	---	
	f _{OSCD MM}	Mixed mode (R _{RT} pin floating)		---	1.2	---	
Switching Frequency Accuracy		f _{OSCD ACC}	f _{OSC} = 1.2MHz	-15	---	15	%
LX On Resistance (N-MOSFET)		R _{DS(ON)_N}	V _{IN} > 4.5V	---	0.2	0.32	Ω
Minimum ON Time		t _{MON}		---	80	---	ns
Maximum Duty		D _{MAX}	V _{COMP} = 2V, switching	---	95	---	%
LX Current Limit		I _{LIM}		---	2.4	---	A

Electrical Characteristics (continued)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
LED Current Programming						
LED Current Matching	I _{LEDM}	2V > CHx > 0.4V calculating (I(MAX) – I(AVG)) / I(AVG) x 100%, RISET = 4.75kΩ	-1.5%	---	+1.5	%
ISET Pin Voltage	V _{ISET}		---	0.6	--	V
LED Current	I _{CHx}	2V > CHx > 0.4V, RISET = 4.75kΩ	19.5	20	20.5	mA
DC Dimming Resolution	B ₁₁	PWM Freq < 4KHz	---	11	---	bits
	B ₁₀	PWM Freq = 4KHz to 8KHz	---	10	---	
	B ₀₉	PWM Freq = 8KHz to 25KHz	---	9	---	
LED Response Time		ISET=20mA PWM Duty=10% to 90% PWM Frequency=100Hz	---	20	25	mS
		ISET=20mA PWM Duty=10% to 90% PWM Frequency=10KHz	---	200	250	μS
Fault Protection						
OVP Threshold	V _{OVP}		1.16	1.2	1.24	V
OVP Fail Threshold	V _{OVPF}		---	50	---	mV
Thermal Shutdown Temperature	T _{SD}		---	160	---	°C
LED Pin Under Voltage Threshold	V _{LSD}	No connection	---	50	---	mV
Regulated VCHx	V _{CHx}	Highest LED string voltage, RISET = 4.75kΩ	---	0.4	---	V

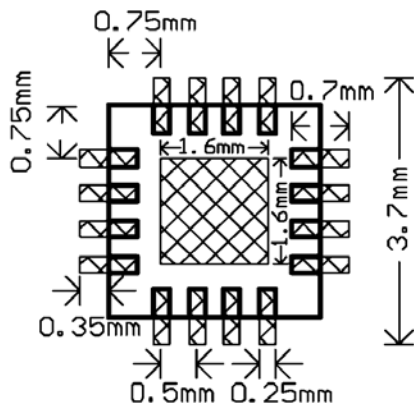
Note 1. Stresses beyond those listed "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2. θ_{JA} is measured under natural convection (still air) at $T_A = 25^{\circ}\text{C}$ with the component mounted on a high effective-thermal-conductivity four-layer test board on a JEDEC 51-7 thermal measurement standard. θ_{JC} is measured at the exposed pad of the package.

Note 3. Devices are ESD sensitive. Handling precaution is recommended.

Note 4. The device is not guaranteed to function outside its operating conditions.

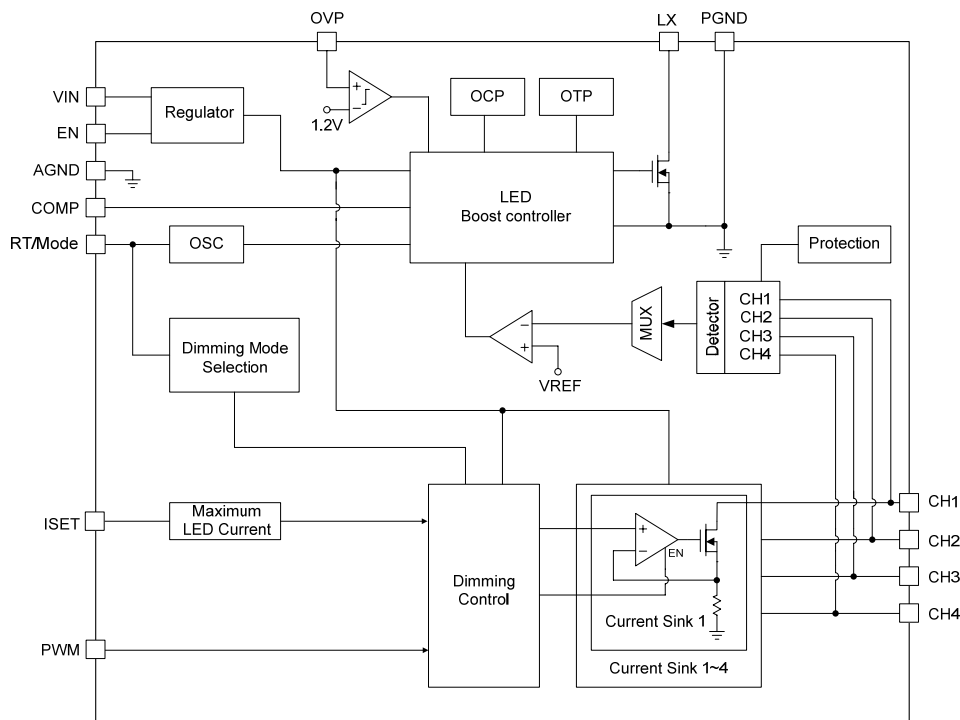
Note 5. Guaranteed by design; not subject to production testing.

Minimum Footprint PCB Layout Section
TQFN3X3-16


Pin Description

Pin No.	Pin Name	Pin Function
1	AGND	Analog ground of LED driver.
2	COMP	Compensation pin for error amplifier. Connect a compensation network to ground.
3	ISET	LED current setting pin. LED current is set by the value of the resistor R_{ISET} connected from the ISET pin to ground. Do not short the ISET pin to ground. V_{ISET} is typically 0.6V. $I_{LED} = \frac{95}{R_{ISET}}$
4	RT/Mode	Frequency adjust and mode selection pin. 1. Frequency adjust : By connecting a resistor from RT pin to ground, the switching frequency is adjustable from 600KHz to 2.2MHz. 2. Mode selection : Three dimming methods are defined by different resistors : By connecting a resistor (5kΩ ~ 20kΩ), DC mode dimming method. By connecting a resistor (40kΩ ~ 160kΩ), Direct PWM mode dimming method. By floating this pin, Mixed mode dimming with a fixed 1.2MHz switching frequency selected.
5	PWM	PWM signal input pin for LED Dimming
6	EN	Chip enable (Active High). Note that this pin is high impedance. There should be a pull low 100kΩ resistor connected to GND when the control signal is floating.
7	VIN	Power supply input.
8, 9	LX	Switching pin of boost converter.
10, 11	PGND	Power ground of boost converter.
12	OVP	Sense input for VLED over voltage protection. The detecting threshold is 1.2V.
13, 14, 15, 16	CH1 to CH 4	Current sink for LED. Leave the pin unconnected, if not used.
17 (Exposed Pad)	GND	The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.

Function Block



Application Information

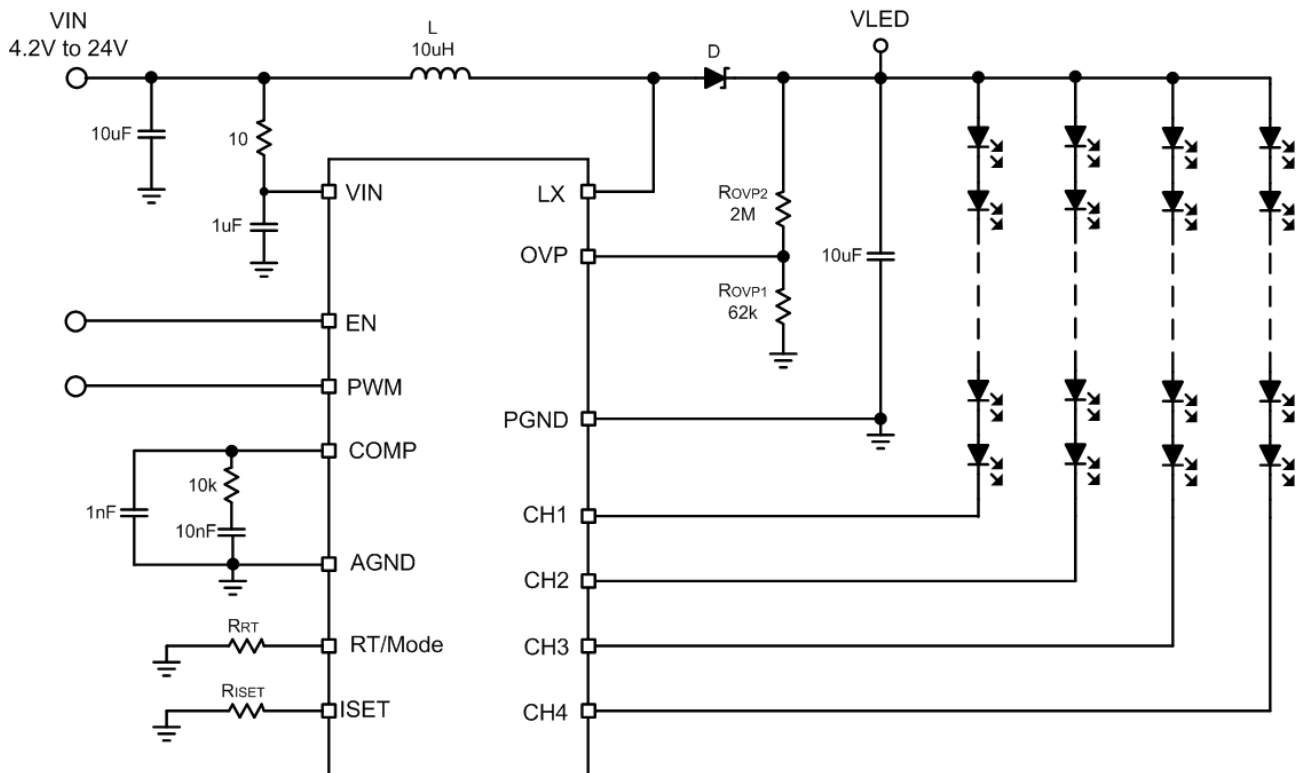


Figure 1. General Application Circuit

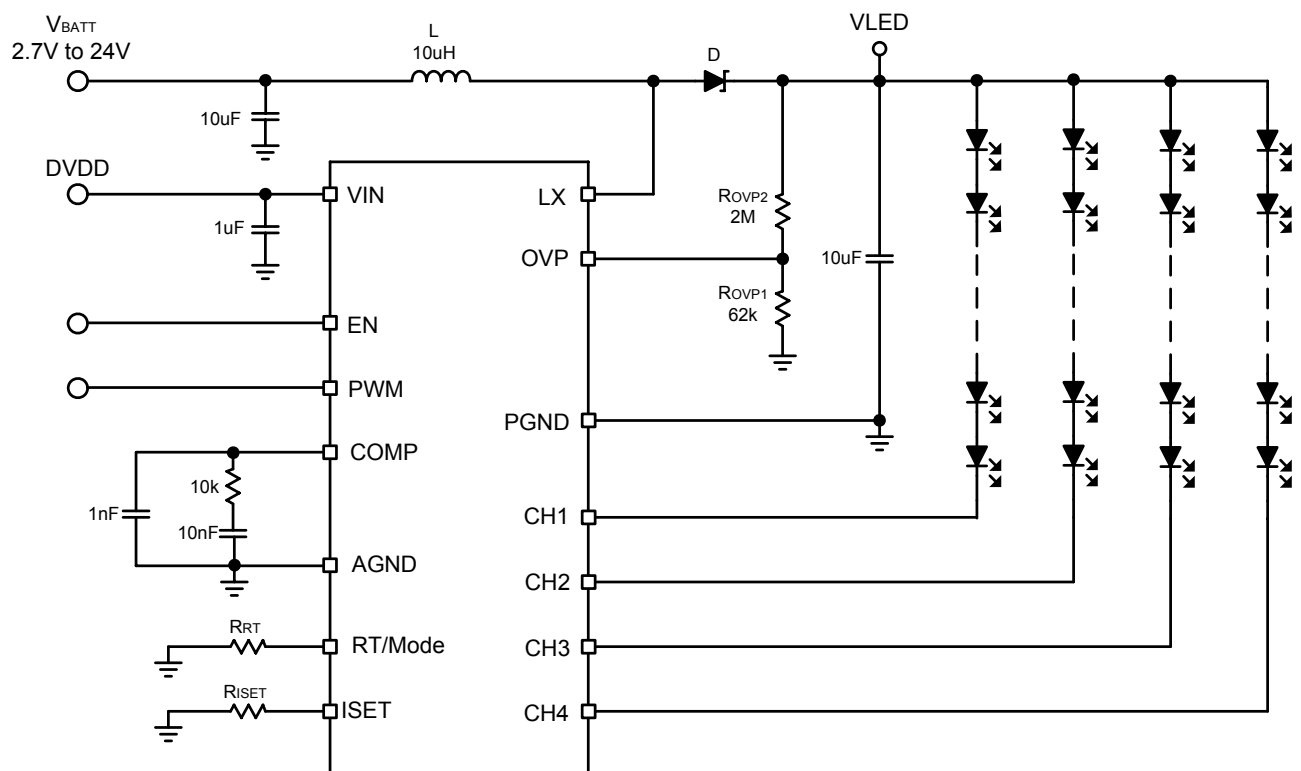


Figure 2. Low Input Voltage Application Circuit

Application Information

The G2546B is a general purpose 4-CH LED driver capable of delivering an adjustable 6 to 30mA LED current. The IC is a current mode boost converter integrated with a 43V/2A power switch and can cover a wide VIN range from 2.5V to 24V. The switching frequency is adjustable from 600KHz to 2.2MHz by an external resistor R_{RT} . The G2546B integrates built-in soft start with PWM dimming control; moreover, it provides over voltage, over temperature and current limiting protection features.

Soft-Start

The G2546B equips a built-in soft-start feature to prevent high inrush current during start-up. The soft-start function prevents excessive input current and input voltage droop during power on state.

Compensation

The control loop can be compensated by adjusting the external components connected to the COMP pin. The COMP pin is the output of the internal error amplifier.

LED Connection

The G2546B equips 4-CH LED drivers with each channel supporting up to 12 LEDs. The LED strings are connected from the output of the boost converter to pins 13, 14, 15 and 16 respectively. If one of the LED channels is not used, the CHx pin should be short to GND.

Light Load Mode

When the input voltage is close to the output voltage, VOUT ripple will increase. The VOUT should be set at higher than $1.2 \times V_{IN}$. If duty pulse is close to minimum on-time and smaller than 80ns, the duty pulse will be skipped. Figure 3 shows the timing diagram with skipped pulse.

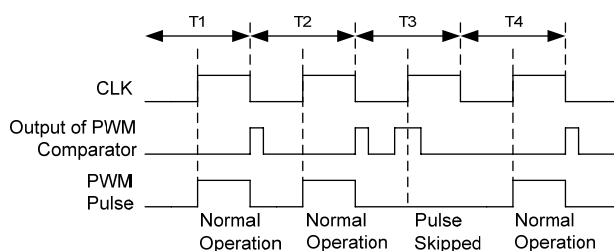


Figure 3. Pulse Skip Mode

Setting and Regulation of LED Current

The LED current can be calculated by the following equation:

$$I_{LED} = \frac{95}{R_{ISET}}$$

where R_{ISET} is the resistor between the ISET pin and GND. This setting is the reference for the LED current at channel 1-4 and represents the sensed LED current for each string. The DC/DC converter regulates the LED current according to R_{ISET} .

Over Voltage Protection

The G2546B integrates over voltage protection (OVP) function. When the voltage at the OVP pin reaches the threshold voltage, the internal switch will be turned off. The internal switch will be turned on again once the voltage at OVP pin drops below its threshold voltage.

The OVP threshold voltage is adjustable and can be clamped at a certain voltage level. It can be calculated by the following equation:

$$V_{OUT(OVP)} = V_{OVP} \times \left(1 + \frac{R_{OVP2}}{R_{OVP1}}\right)$$

where $V_{OVP} = 1.2V$ (typ.).

R_{OVP1} and R_{OVP2} are the resistors in the voltage divider connected to the OVP pin. If at least one string is in normal operation, the controller will automatically ignore the open strings and continue to regulate the current for the strings in normal operation. It is suggested to use $2M\Omega$ for R_{OVP2} to reduce loading effect. It is highly recommended that target $V_{OUT(OVP)}$ trigger point should be set ranging from $1.1X$ to $1.2X$ VLED.

Current Limit Protection

The G2546B can limit the peak current to achieve over current protection. The G2546B senses the inductor current during the "ON" period that flows through the LX pin. The duty cycle depends on the current signal and internal slope compensation in comparison with the error signal. The internal switch will be turned off when the current signal is larger than the internal slope compensation. In the "OFF" period, the inductor current will be decreased until the internal switch is turned on by the oscillator.

Power Sequence

LED Driver is without power sequence concern. Figure 4. and 5. are different power sequences respectively. There is no concern in the above condition.

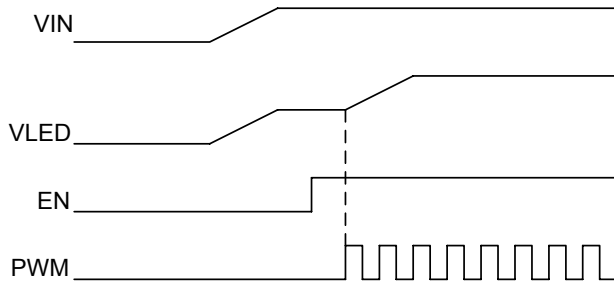


Figure 4.1. Power On mode 1

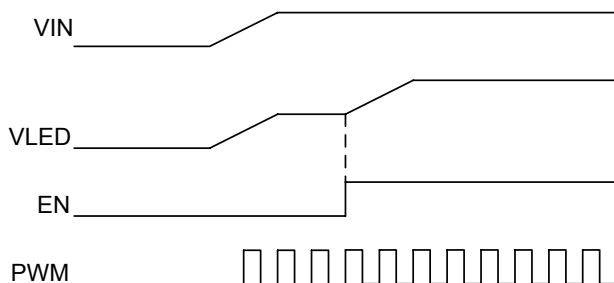


Figure 4.2. Power On mode 2

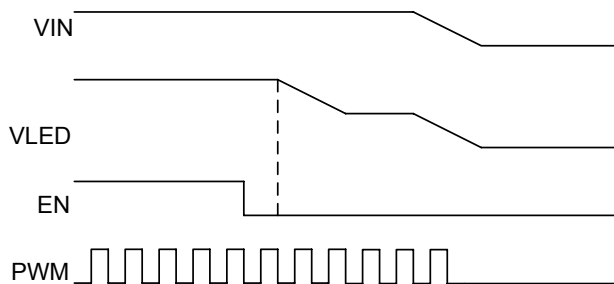


Figure 5.1. Power Off mode 1

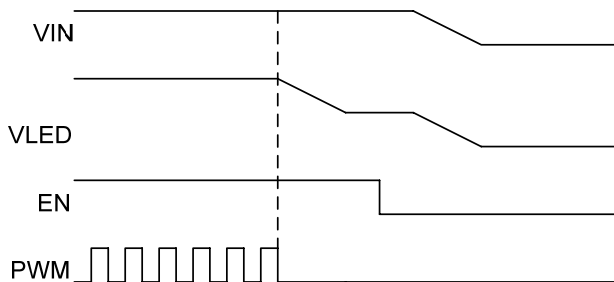


Figure 5.2. Power Off mode 2

Switching Frequency and Dimming Selection

Both dimming method and boost switching frequency are determined by the value of resistor R_{RT} connected between RT/Mode pin and ground.

According to the range of this resistor, the G2546B determines the dimming method with a corresponding switching frequency, as shown in Table 1:

Table. 1

Resistor value to GND	Dimming mode Selected	SW Frequency
5k Ω ~20k Ω	DC mode	$f_{OSC} = \frac{12k}{R_{RT}}$ (MHz)
40k Ω ~160k Ω	Direct PWM mode	$f_{OSC} = \frac{96k}{R_{RT}}$ (MHz)
Floating	Mixed mode	1.2MHz

Dimming Control

3 dimming methods, including Direct PWM mode, DC mode and Mixed mode, are supported by G2546B.

Dimming control is determined by the signal on the PWM pin with a suggested PWM frequency range from 120Hz to 30KHz.

During the Direct PWM dimming, the current-source turn-on/off is synchronized with the PWM signal. The LED Current frequency is equivalent to PWM input frequency, as shown in Figure 6.

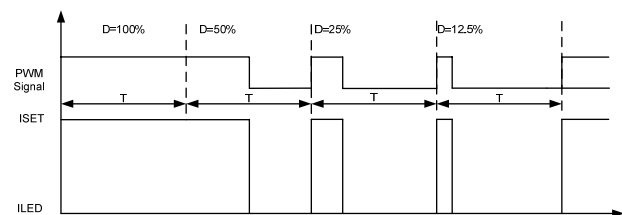


Figure 6. LED Current Control Using Direct PWM Mode

If the dimming mode operates in DC mode, the PWM and ILED dimming cycle would delay 2 periods, as shown in figure 7. First cycle delay is for Duty Counter. Second cycle delay is for Duty rate calculation. The current-source outputs a dc current, and the amplitude of the current is modulated by the PWM duty.

If the Mixed mode is selected, the PWM and ILED Dimming cycle also delay 2 periods, as shown in Figure 8. First cycle delay is for Duty Counter. Second cycle delay is for Duty rate calculation.

When $25\% \leq \text{PWM duty} \leq 100\%$, the current-source outputs are DC dimming and the PWM duty cycle modulates the amplitude of the currents. Below 25%, the DC Dimming will translate to Mixed PWM Dimming to control the LED current. And the LED current is fixed at $0.25 \times I_{LED}$ and the Dimming duty is $4 \times \text{PWM Duty}$.

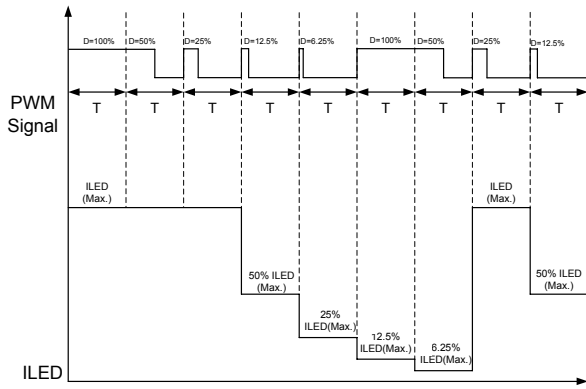


Figure 7. LED Current Control Using DC Dimming Mode

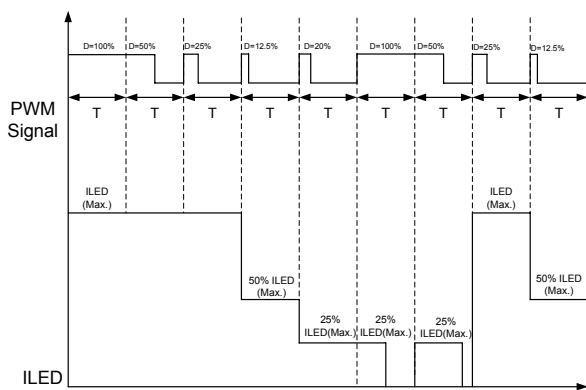


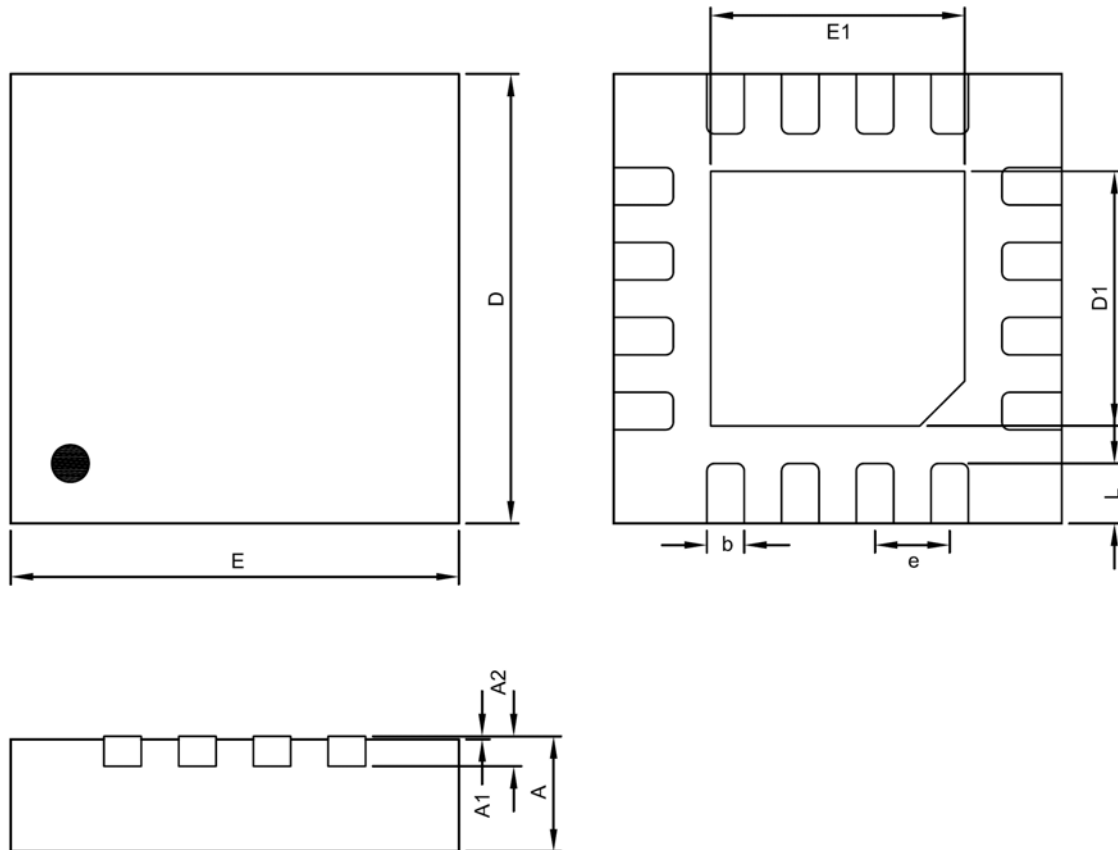
Figure 8. LED Current Control Using Mixed Dimming Mode

Table. 2 The minimum duty in table 2 is base on the application circuit and does not consider the deviation of current linearity.

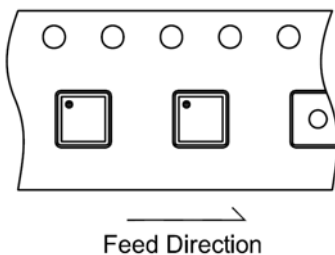
Dimming Frequency (Hz)	Duty (Min.)	Duty (Max.)
$100 < f_{PWM} \leq 2K$	0.20%	100%
$2K < f_{PWM} \leq 8K$	0.40%	100%
$8K < f_{PWM} \leq 16K$	1.00%	100%
$16K < f_{PWM} \leq 25K$	2%	100%

Over Temperature Protection

The G2546B has over temperature protection function to prevent the IC from overheating due to excessive power dissipation. The OTP function will shut-down the IC when junction temperature exceeds 150°C.

Package Information

TQFN3X3-16 Package

Symbol	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	0.20 REF			0.0079 REF		
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	1.60	1.70	1.80	0.0630	0.0669	0.0689
E1	1.60	1.70	1.80	0.0630	0.0669	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/BY REEL
TQFN3X3-16	3,000 ea

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