GW5511

Automotive 1-CH LED Driver

1 Description

With LEDs being widely used in automotive applications, simple LED drivers are more and more popular. Compared to discrete solutions, a low-cost monolithic solution lowers system-level component count and significantly improves current accuracy and
reliability.
The GW5511 is a single-channel, high side LED driver operating from an automotive car battery. It is a simple, yet elegant, solution to deliver constant current for a single LED string with full LED diagnostics. The one-fails–all-fail feature is able to work together with other LED drivers.

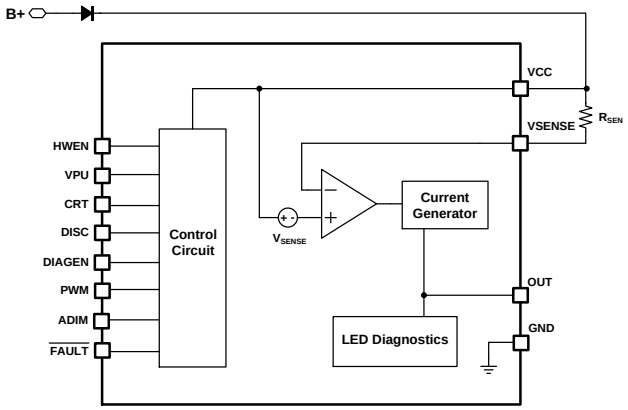
2 Features

- Variable form constant-current driver
- Hardware enables function (Shutdown Current 10uA(max)))
- Two types of PWM Dimming Function
  -. PWM operation with MCU (PWM)
  -. Individual PWM Dimming (CRT, DISC)
- Analog Dimming
- Diagnostics and protection
  -. LED open-circuit and short-circuit
  -. Diagnostic enables with adjustable Vth
  -. Fault bus up to 15 devices, configurable as either one-fails–all-fail or only-failed-channel off (N-1)
  -. Thermal shutdown
- AEC-Q100 Qualified
- PKG Type : E-TSSOP24 Physical Characteristics

3 Typical Applications

- Interior lighting: dome light, reading lamp Dust sensor
- Exterior lighting - small light: door handle, blind-spot detection indicator, charging inlet
- Exterior lighting - rear light: rear lamp, center high-mounted stop lamp, side marker
- General-purpose LED driver applications

4 Basic Application Diagram



5 Ordering Information

Device name	Package	Remark
GW5511APWPRA	7.8mm x 4.4mm, 0.65 mm pitch	E-TSSOP24 Automotive

Table of Contents

6 Revision History

Version	Date	Description
0.1	Nov 25, 2024	Preliminary release

7 Pin Configuration and Function

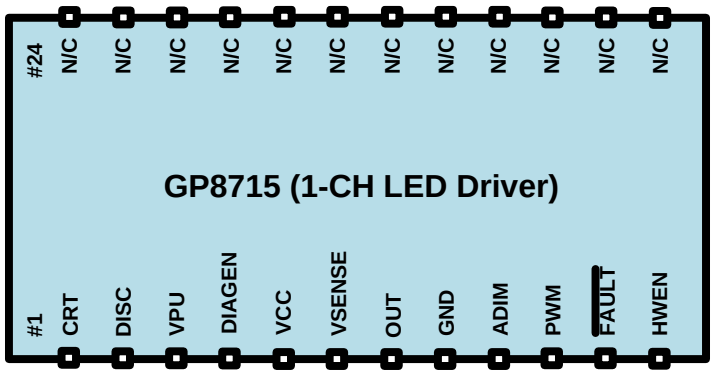


Figure 1 Pin Configuration

Pin Functions

Pin Name	No.	Type	Description
CRT	1	IO	Individual PWM dimming timer setting without MCU
DISC	2	IO	PWM Discharge setting without MCU
VPU	3	I	4.5V Supply for Pull-up
DIAGEN	4	I	Enable pin for LED open-circuit detection to avoid false open diagnostics during low dropout operation
VCC	5	P	Power Supply Input
VSENSE	6		Current Sense Input
OUT	7	O	Current Output
GND	8	P	Ground
ADIM	9	O	Analog Dimming Input using a capacitor
PWM	10	O	PWM input for current output On/Off control with MCU
FAULT	11	O	Fault Output. Support one-false-all-fail fault bus
HWEN	12	I	Hardware Enable
N/C	13~24	P	No Connection. They should be short to ground on PCB.
GND	E-PAD	I	Ground. E-PAD is internally shorted with GND pin.

8 Specifications

8.1 Absolute Maximum Ratings

Parameter	Conditions	Min	Max	Unit
Input Power Supply Voltage (VCC)	VCC to GND	-0.3	45	V
Current Sense Input (VSENSE)	VSENSE to GND	-0.3	45	V
Current Output Voltage (OUT)	OUT to GND	-0.3	45	V
Input Voltage (CRT, DISC, DAIGEN, PWM, ADIM, HWEN)	-	-0.3	45	V
Fault Pin Voltage (FAUTL)	FAULT to GND	-0.3	45	V
VPU Pin Output Voltage (VPU)	VPU to GND	-0.3	45	V
VSENSE to OUT	VSENSE - VOUT	-0.3	45	V
VCC to OUT	VCC - OUT	-0.3	1	V
Storage Temperature (T_{STG})	-	-40	150	℃
Operating Junction Temperature (T_J)	-	-40	150	℃
Operating Ambient Temperature (T_A)	-	-40	125	℃
VSENSE to OUT	VSENSE - VOUT	-0.3	45	V

8.2 ESD Ratings

			VALUE	UNIT
V_{ESD}	Electrostatic discharge	Human-body model (HBM), per ANSI/ESD/JEDEC JS-001	2,000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101_Corner pins	750	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101_Other pins	500	V

8.3 Thermal Information

Parameter	Symbol	MIN	TYP	UNIT
Junction to Ambient thermal resistance	$R_{\theta JA}$	FR4, JEDEC Board(3)	33.3	℃/W
Junction to case (top) thermal resistance	$R_{\theta JC(top)}$	FR4, JEDEC Board(3)	TBD	℃/W
Junction to case (bottom) thermal resistance	$R_{\theta JC(bot)}$	FR4, JEDEC Board(3)	5.4	℃/W

(1) AEC Q100-002 indicates HBM stressing is done in accordance with the ANSI/ESDA/JEDEC JS-001 specification.
(2) Charged device model (CDM), per AEC Q100-011
(3) Device mounted on 114.3mm x 76.2mm x 1.6mm Glass-Epoxy 4-layer PCB based on JEDEC

8.4 Electrical Characteristics

* VCC=12V, Ta=25°C, unless otherwise specified

Symbol	Parameter	Conditions	MIN	TYP	MAX	UNIT
IQ	Quiescent current	PWM=High, OUT=Open	-	0.8	-	mA
ISD	Shutdown current	HWEN=0V	-	-	10	uA
VUVLO(on)	UVLO Threshold Voltage	VCC=Rising	3.4	4	4.6	V

Symbol	Parameter	Conditions	MIN	TYP	MAX	UNIT
VUVLO(hys.)	UVLO Hysteresis Voltage	VUVLO(on)-VUVLO(off)	0.15	0.45	0.75	V
VEN_H	HWEN Rising Threshold Voltage	Rising Threshold	3	-	-	V
VEN_L	HWEN Falling Threshold Voltage	Falling Threshold	-	-	1	V
VDIAGEN_TH	DIAGEN Threshold Voltage	Rising Threshold	1.05	1.25	1.45	V
VDIAGEN_HYS	DIAGEN Hysteresis Voltage		20	100	180	mV
IOUT	OUT Current Range	D=100%	10		600	mA
VSENSE	Sense Resistor Regulation Voltage		460	480	500	mV
RSENSE	Sense Resistor Range		0.8		48	Ohm
VDROP	Total Dropout Voltage (VCC-OUT)	IOUT=10mA		0.48	0.78	V
		IOUT=150mA		0.75	1.25	V
		IOUT=300mA		1.10	1.75	V
VIH_FAULT	FAULT Input Mode Rising Voltage		3.5	-	-	V
VIL_FAULT	FAULT Input Mode Falling Voltage		-	-	1	V
IFAULT	FAULT Pull-Up Current	FAULT=1V	-26	-16	-6	uA
VFAULT_OL	FAULT Output Low Voltage	ISOURCE=500uA	-	-	0.4	V
IADIM	ADIM Leakage Current	ADIM=2V	-1	0	1	uA
VADIM	ADIM Voltage Range	-	0.5	-	1.3	V
VPWM_TH	PWM Threshold Voltage	Rising Threshold	0.95	1.15	1.35	V
VPWM_HYS	PWM Hysteresis Voltage		20	100	180	mV
IPWM	PWM Pull-up Current	PWM=2V	-19	-15	-11	uA
ICRT	CRT Charge Current	CRT=0.9V	33	35	37	uA
VCRT_CHA	CRT Charge Voltage		0.95	1.1	1.25	V
VCRT_DCHA1	CRT discharge voltage 1		2.8	3.0	3.2	V
VCRT_DCHA2	CRT discharge voltage 2		3.2	3.5	3.8	V
RDISC1	DISC discharge resistance 1	CRT=3.2V	-	50	100	ohm
RDISC2	DISC discharge resistance 2	CRT=4V	-	5	10	Kohm
VOPEN_R	LED Open Rising Detect Voltage	VIN - VOUT	35	60	85	mV
VOPEN_F	LED Open Falling Detect Voltage	VIN - VOUT	115	185	255	mV
VSC	OUT Short Threshold Voltage		0.7	1.0	1.3	V
VSC_HYS	OUT Short Hysteresis Voltage		190	270	350	mV
ISC	OUT Short Retry Current		0.5	1.0	1.5	mA
VVPU1	VPU Output Voltage 1	VPU=-1uA	4	4.7	5.4	V
VVPU2	VPU Output Voltage 2	VPU=-50uA	3.3	4	4.7	V
TTSD	Thermal Shutdown Temperature		-	175	-	℃
TTSD_HYS	TSD Hysteresis		-	30	-	℃
tPWM_R	PWM Rising Delay	50% PWM voltage to 50% of output current	12	22	32	us
tPWM_F	PWM Falling Delay	50% PWM voltage to 50% of output current	0	9	18	us
tVCC_ST	VCC Start up Delay (1)	VCC rising edge to 50% output current	-	200	-	us
tOPEN	LED Open Fault Deglitch Time (1)		-	5	-	us
tSC	OUT Short Detection Deglitch Time		35	65	95	us

Symbol	Parameter	Conditions	MIN	TYP	MAX	UNIT
tTSD	TSD Fault Deglitch Time (1)		-	2.5	-	us

8.5 (1) Ensured by design and characterization, not production tested

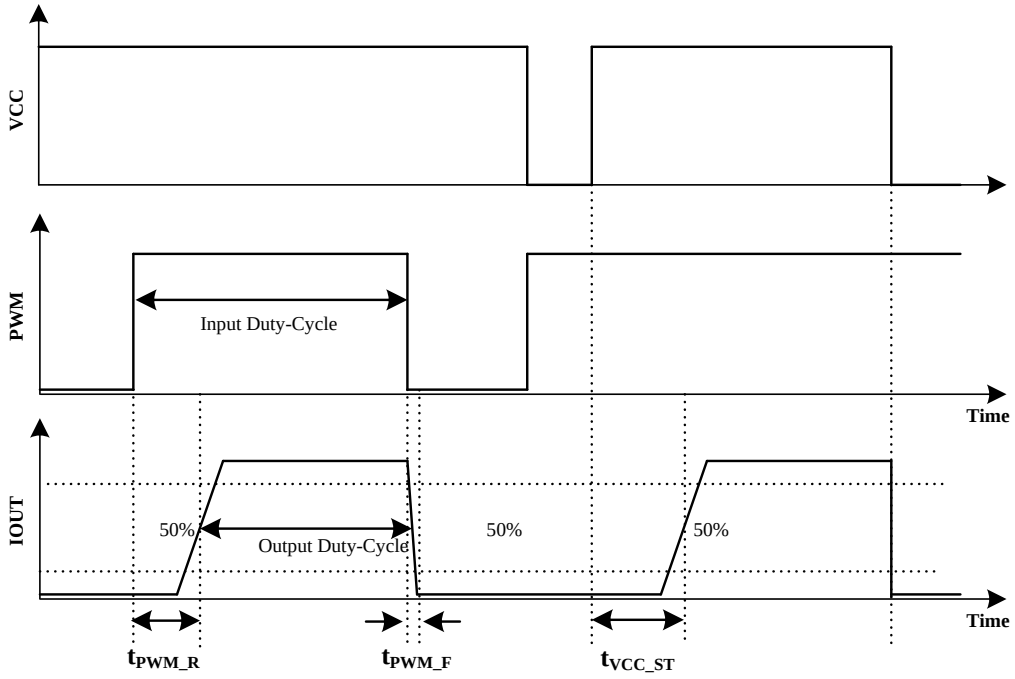
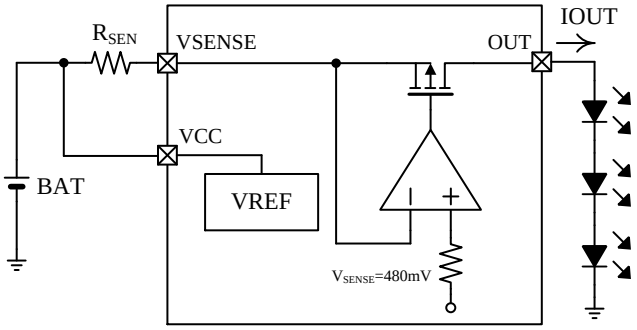


Figure 2 ???????

9 Functional Description

9.1 Output Current Setting

The LED Current IOUT can be set as below depending on values of current setting resistance R_{SEN} .



$$I_{OUT} = \frac{V_{SENSE}}{R_{SEN}} [A]$$

$$V_{SENSE} = 480mV$$

Figure 3 Functional Block Diagram

9.2 FAULT

FAULT terminal is an input/output terminal for outputting trouble and inputting trouble detection. In cases where trouble occurred due to LED open, it is possible to notify the trouble outside by switching FAULT terminal output from High to Low. It is possible to turn OFF output current by externally controlling FAULT from High→Low. The FAULT pin of GW5511 is pulled up by an internal pullup resistance(250K). In case where you use multiple number of the GW5511 to drive multiple LEDs, as shown in the drawing below, it is possible to turn off all rows of LEDs even if some LEDs are opened by connecting FAULT terminal of each CH.

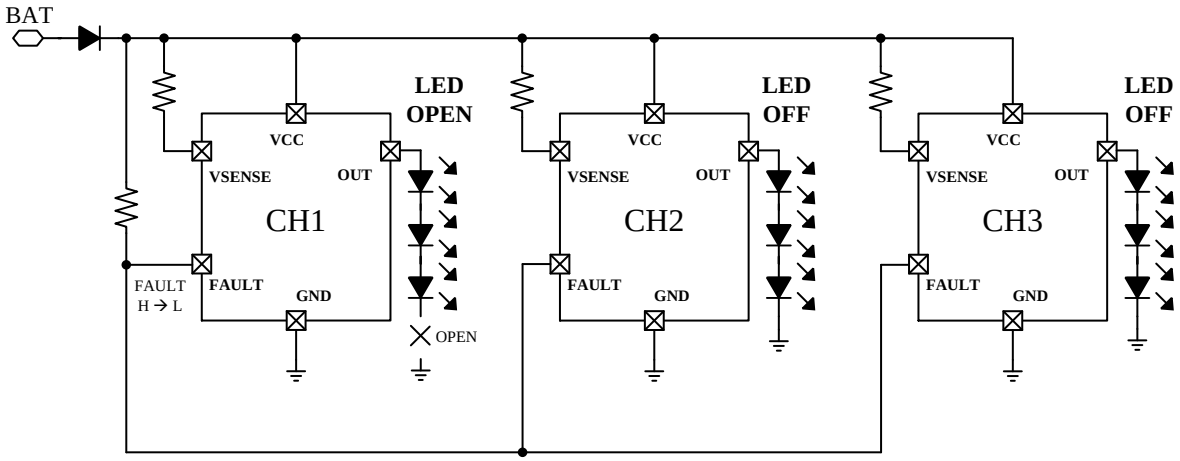


Figure 4 FAULT Function

9.3 HWEN

The GW5511 device has an enable input HWEN. When HWEN is low, the device is in sleep mode with ultralow quiescent current (ISD). This low current helps to save system-level current consumption in applications where battery voltage directly connects to the device without high-side switches.

9.4 Protection

The GW5511 device provides advanced diagnostics and fault protection.
The device is able to detect and protect fault from LED-string short-to-GND, LED-string open circuit and thermal shutdown protection.

- Open-Circuit Detection

The GW5511 monitors dropout-voltage differences between the VCC and OUT pins. The voltage difference VCC – V(OUT) is compared with the internal reference voltage V_{OPEN_R} to detect an LED open-circuit incident. Once an LED open-circuit failure is detected, FAULT pin is pulled low. The fault condition is removed, the device resumes normal operation and releases the FAULT pin.

- Short-to-GND Detection

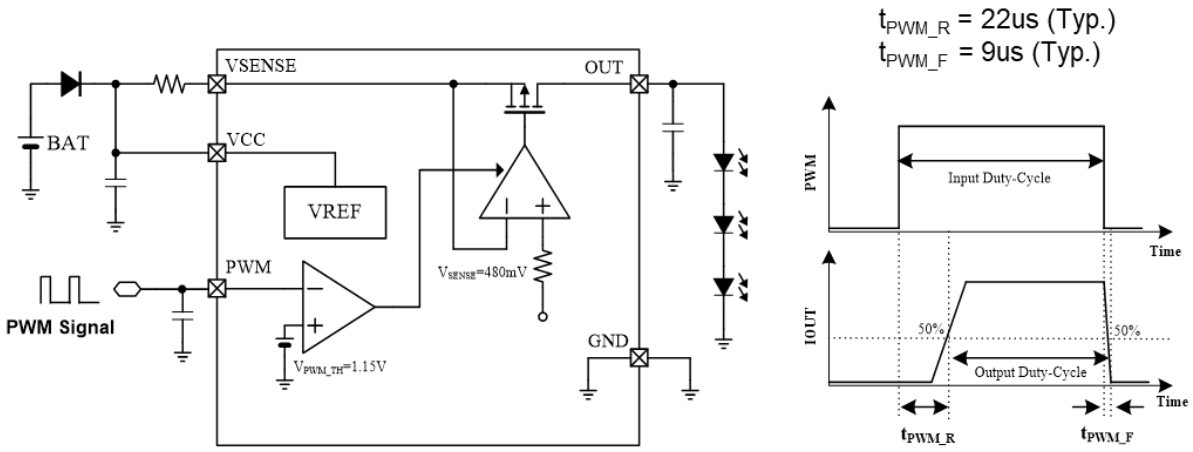
The GW5511 device has LED short-to-GND detection. The LED short-to-GND detection monitors the output voltage when the output current is enabled. If the retry mechanism detects the removal of the LED short-to-GND fault, the device resumes to normal operation. The GW5511 monitors the V(OUT) voltage and compares it with the internal reference voltage to detect a short-to-GND failure. If V(OUT) falls below V_{SC} longer than the deglitch time of t_{SC}, the device asserts the short-to-GND fault and pulls low the FAULT pin. Once the GW5511 has asserted a short-to-GND fault, the device turns off the output channel and retries automatically with a small current. During retrying the device sources a small current I_{SC} to pull up the LED loads continuously. Once auto-retry detects output voltage rising above V_{SC}, it clears the short-to-GND fault and resumes to normal operation.

- Thermal Shutdown Protection

The GW5511 device monitors device junction temperature. When the junction temperature reaches thermal shutdown threshold T_{TSD}, the output shuts down. Once the junction temperature falls below T_{TSD} – T_{TSD_HYS}, the device recovers to normal operation. During thermal shutdown protection, the FAULT pin is pulled low.

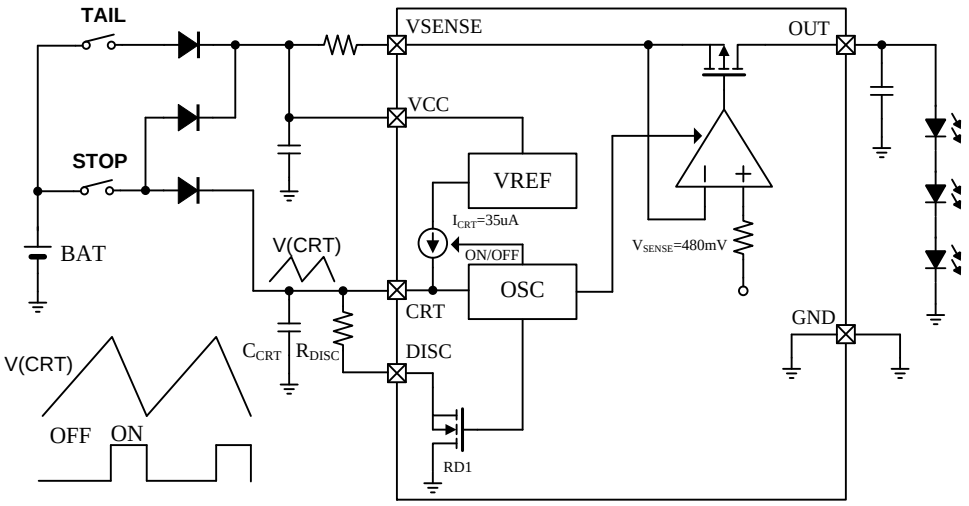
9.5 External PWM (with MCU)

The PWM (Pulse Width Modulation) input of the GW5511 functions as enable for the output current. The PWM pin of GW5511 is pulled up by an internal pullup resistance(200K). When the voltage applied on the PWM pin is higher than VPWM_TH, the relevant output current is enabled. When the voltage applied on PWM pin is lower than VPWM_TH – VPWM_HYS, the output current is disabled as well as the diagnostic features. The GW5511 recommends a 200Hz PWM signal with 5% to 100% duty cycle input for brightness control.



9.6 Internal PWM (Individual PWM)

Internal PWM Dimming is performed if CRT terminal is the following circuit. Dimming cycle and Duty width can be set through external resistance value and capacitance. CR timer function in the GW5511 is activated if DC_in is OPEN. In order to perform PWM light control of LED current, triangular waveform is generated at CRT terminal. Output is controlled so that LED current is turned OFF while CRT voltage is ramping up, and LED current is turned ON while CRT voltage is ramping down. Ramp up/down time of CRT voltage can be set by values of external components (C_{CRT}, R_{DISC}). When CRT terminal voltage surpasses V_{CRT_DCAH2}, dimming mode turns to Linear Control, and discharge resistance of DISC terminal changes from R_{DISC1} to R_{DISC2}



CRT Ramp up Time T1 (s)

CRT ramp up time can be obtained from the following equations:

$$T1 = \frac{\Delta VCRT \times CCRT}{I_{CRT}}$$

I_{CRT}=35uA, R_{D1}=38ohm, V_{CRT_CHA}=1.1V, V_{CRT_DCHA1}=3V

$\Delta VCRT = V_{CRT\_DCHA1} - V_{CRT\_CHA}$

CRT Ramp up Time T2 (s)

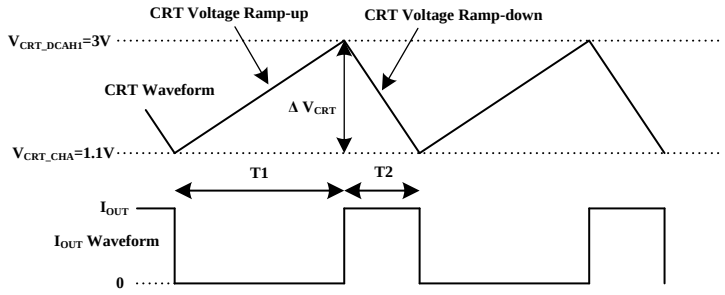
CRT ramp down time is defined by discharge period due to external capacity C_{CRT} and resistance (R_{CRT} + R_{D1}). (CRT Terminal Charge Current is OFF at CRT ramp down)

$$T2 = -CCRT \times (RDISC + RD_1) \times \ln\left(\frac{V_{CRT\_CHA}}{V_{CRT\_DCHA1}}\right)$$

Dimming Frequency f_{PWM}

PWM frequency is defined by T1 and T2.

$$f_{PWM} = \frac{1}{T1 + T2}\ [Hz] \qquad DON = \frac{T2}{T1 + T2}$$



Internal PWM

The internal PWM also drives the internal channels and via the PWM(Output mode) pin, the PWM control can be used to synchronize slave GW5511 devices.

(PWM Output Mode : CRT < 3.2V , PWM Input Mode : CRT > 3.8V)

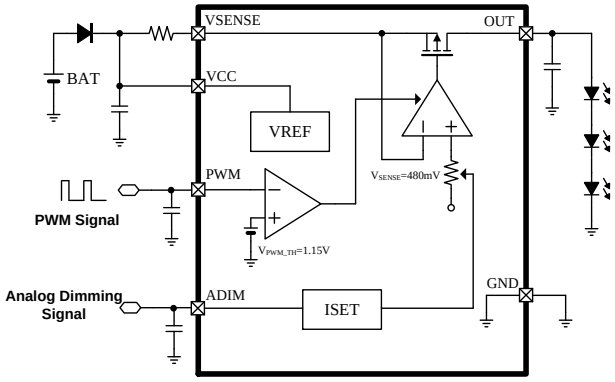
9.7 ADIM

The GW5511 supports analog dimming which regulates the LED current through the ADIM pin. The LED current IOUT can be calculated from the following equation. (**Refer to the Graph & Table**)

ADIM Input Range : 0.5V - 1.3V (**Linearity section : 0.5V ~ 1.1V [44%~90%]**)

$$I_{OUT}(ADIM) = \left(\frac{V_{SENSE}}{R_{SEN}}\right) \times \left[\left(\frac{VADIM}{1.25V}\right) \times 0.94 + 0.07\right][A]$$

Supply high voltage(e.g. VCC, 5V, VPU only for Pull-up) for 100% analog dimming: ADIM > 1.5V for Full Current(100%)



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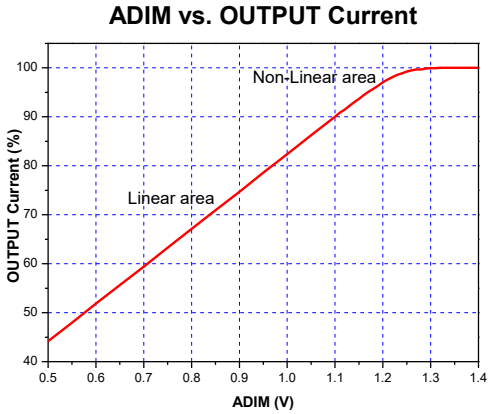
9.8 DIAGEN

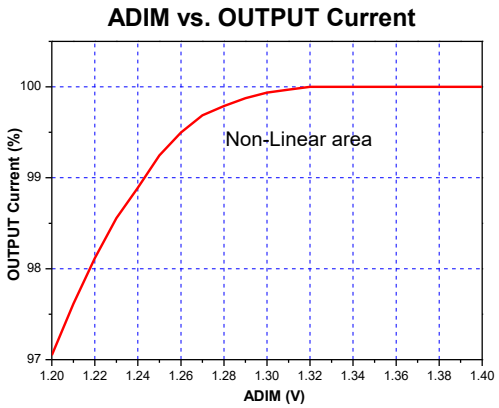
The GW5511 device supports the DIAGEN pin with an accurate threshold to disable the LED open-circuit diagnostic functions. The DIAGEN pin can be used to enable or disable LED open-circuit protection based on VCC pin voltage sensed by an external resistor divider. When the voltage applied on DIAGEN pin is higher than the threshold V_{DIAGEN_TH} , the device enables LED open-circuit diagnosis. When V_{DIAGEN_TH} is lower than the threshold V_{DIAGEN_TH} - V_{DIAGEN_HYS} , the device disables LED-open-circuit detection. Alive Block

The GW5511 is equipped with an internal "Alive" block that effectively manages the external LDO/switch, enabling the power-off of VDDB for deep-sleep mode operation.

9.9 ADIM

VCC=12V, RSEN=3ohm

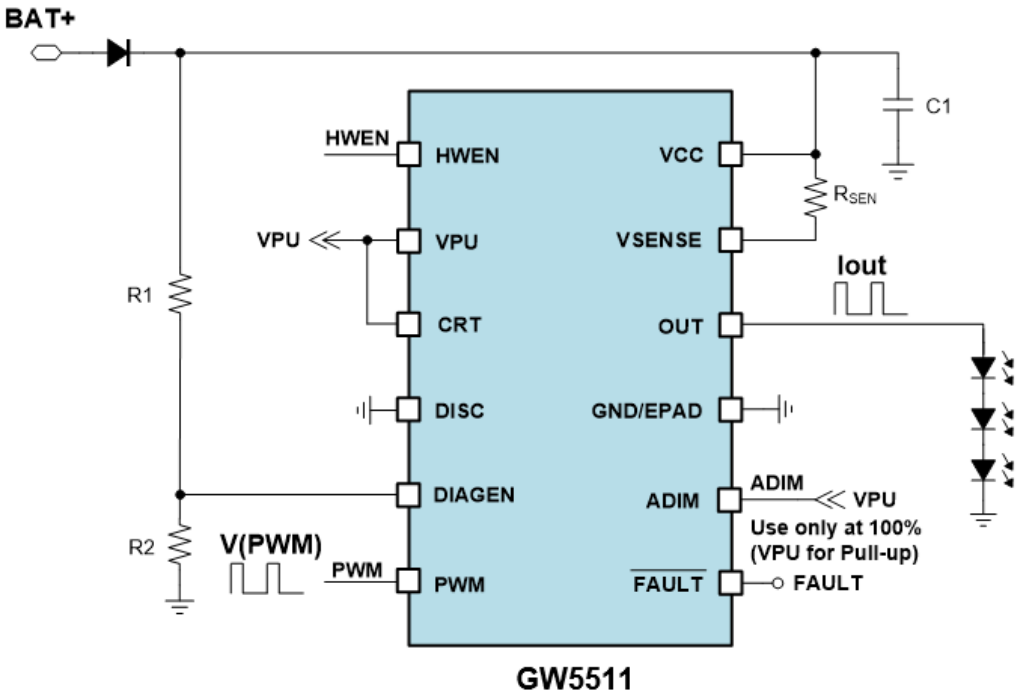




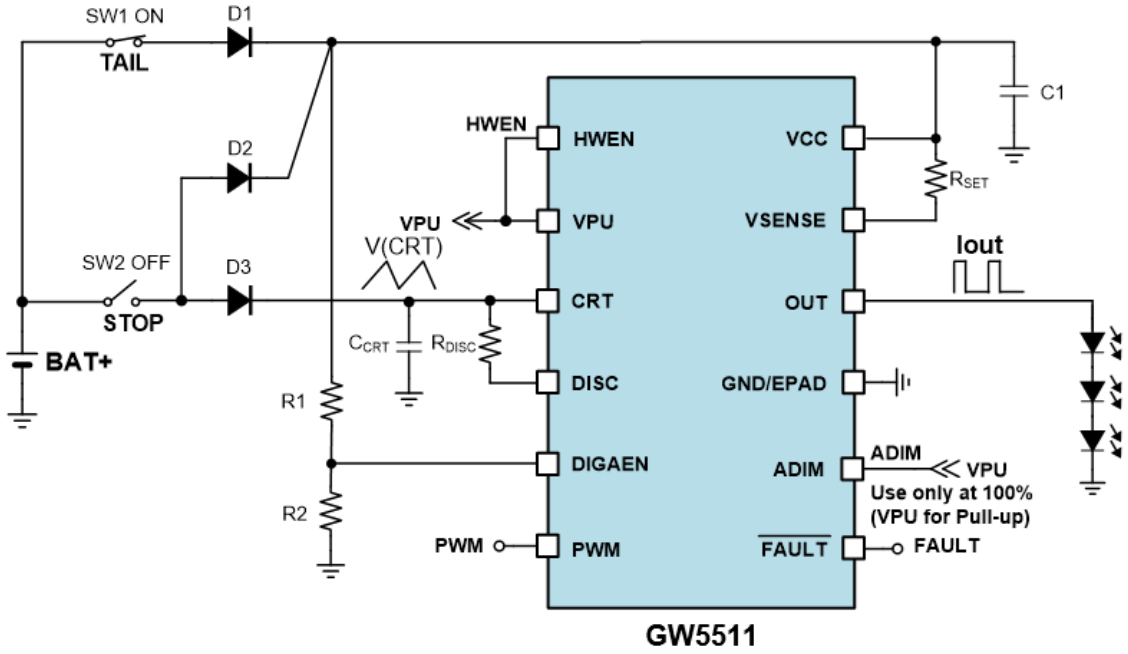
ADIM(V)	OUTPUT Current(%)	ADIM(V)	OUTPUT Current(%)	ADIM(V)	OUTPUT Current(%)
1.4	100%	1.25	99.2%	0.90	74.7%
1.35	100%	1.24	98.9%	0.85	70.9%
1.34	100%	1.23	98.6%	0.80	67.1%
1.33	100%	1.22	98.1%	0.75	63.3%
1.32	100%	1.21	97.6%	0.70	59.4%
1.31	99.9%	1.20	97.0%	0.65	55.6%
1.30	99.9%	1.15	93.7%	0.60	51.9%
1.29	99.9%	1.10	90.0%	0.55	48.0%
1.28	99.7%	1.05	86.3%	0.50	44.2%
1.27	99.7%	1.00	82.4%		
1.26	99.5%	0.95	78.6%		

10 Applications

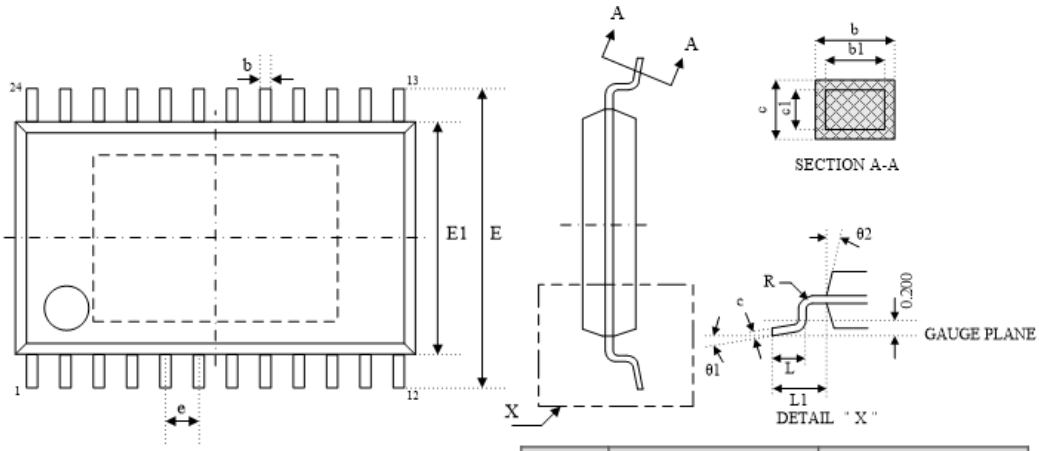
10.1 Typical Application

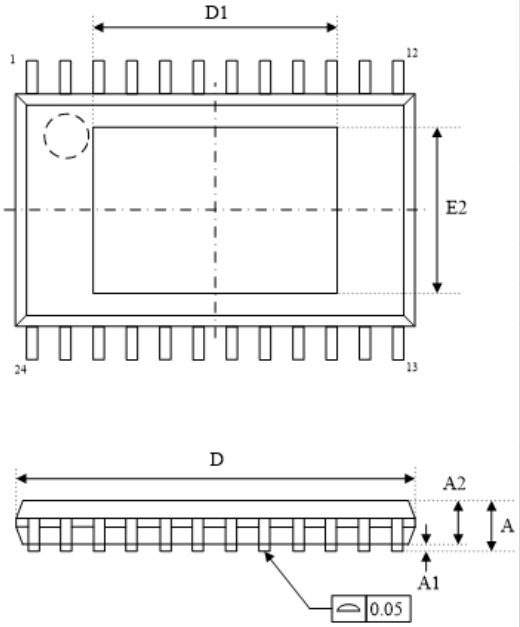


[PWM operation with MCU]



11 Package Information





Symbol	DIMENSION (MM)			DIMENSION (MIL)		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.20	-	-	47.0
A1	0.00	-	0.15	0.0	-	5.9
A2	0.80	1.00	1.05	31.5	39.4	41.3
b	0.19	-	0.30	7.5	-	11.8
b1	0.19	0.22	0.25	7.5	8.7	9.8
c	0.09	-	0.20	3.5	-	7.9
c1	0.09	-	0.16	3.5	-	6.3
D	7.70	7.8	7.90	303.1	307.1	311.0
D1	4.430	4.630	4.830	174.4	182.2	190.1
E	6.30	6.40	6.50	248.0	252.0	255.9
E1	4.30	4.40	4.50	169.3	173.2	177.2
E2	2.70	2.90	3.10	106.3	114.2	122.0
e	0.65 BSC			25.6 BSC		
L	0.45	0.60	0.75	17.7	23.6	29.5
L1	1.00 REF			39.4 REF		
R	0.127	-	-	5.0	-	-
θ1	0°	-	8°	0°	-	8°

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