IS32LT3143

THREE-CHANNEL LINEAR LED DRIVER WITH INDIVIDUAL PWM DIMMING AND SINGLE LED SHORT DETECTION

May 2024

GENERAL DESCRIPTION

The IS32LT3143 device is a linear programmable LED driver consisting of three current source output channels capable of up to 150mA each. It supports individual PWM dimming control to each channel. A single resistor sets the maximum current level for all channels. The output channels can be combined to provide a higher current drive capability up to maximum 450mA.

For added system reliability, the IS32LT3143 integrates fault detection circuitry for LED string open/short, single LED short, current setting resistor open/short, programmable device junction over temperature thermal roll-off and shutdown conditions. Two dedicated fault reporting pins, FAULTB and FAULTS, are able to report fault conditions; the FAULTS pin is dedicated to reporting LED short fault. The fault reporting pins can all be tied together to disable the device and other IS32LT3143 devices on the same parallel circuit to achieve a "one-fail-all-fail" function.

The IS32LT3143 is targeted at the automotive market with end applications to include interior and exterior lighting. For 12V automotive applications, the low headroom driver can support one to several LEDs on the output channels. The device is offered in a small thermally enhanced eTSSOP-16 package.

APPLICATIONS

- Rear light
- Stop or taillight
- Position light
- Daytime running light
- Turn signal Light
- Interior lighting

FEATURES

- Wide input voltage range: 5V~40V
- Three output channels with programmable constant current set by a single resistor
  - 10mA to 150mA per channel
  - ±2% (Typ.) current matching by channel (I_{OUTx} >30mA)
  - ±3% (Typ.) current accuracy by device (I_{OUTx} >30mA)
  - Combined multiple channels or ICs for higher current capability with same current accuracy
- Low headroom voltage
  - Max. headroom: 500mV at 60mA per channel
  - Max. headroom: 1.1V at 150mA per channel
- Independent PWM dimming per channel
- Fault protection and reporting
  - LED string open/short
  - Independent single LED short detection per channel
  - Dedicated fault pin for single LED short fault
  - Current setting resistor open/short
  - Programmable junction over temperature thermal roll-off (not reported)
  - Thermal shutdown
  - Shared fault flag for multiple devices operation to comply with "one-fail-all-fail" function, up to 15 devices
- Operating junction temperature range -40°C to 150°C
- AEC-Q100 Qualified with Temperature Grade 1: -40°C to 125°C
- RoHS & Halogen-Free Compliance
- TSCA Compliance

TYPICAL APPLICATION CIRCUIT

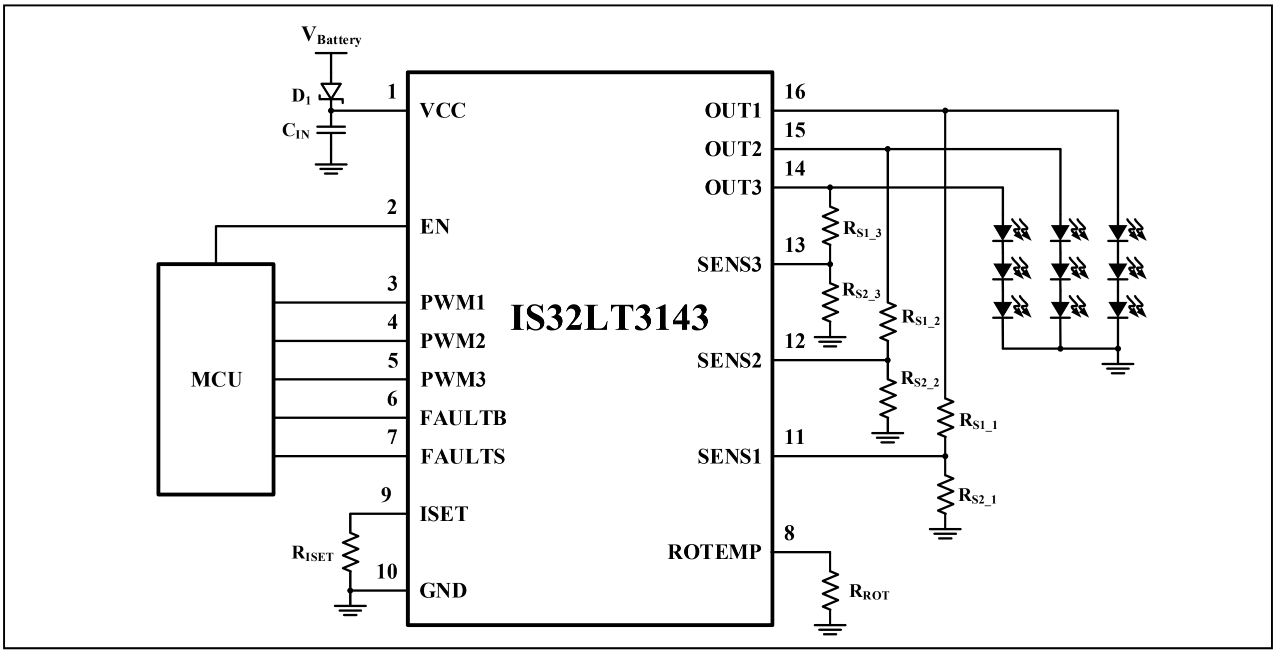
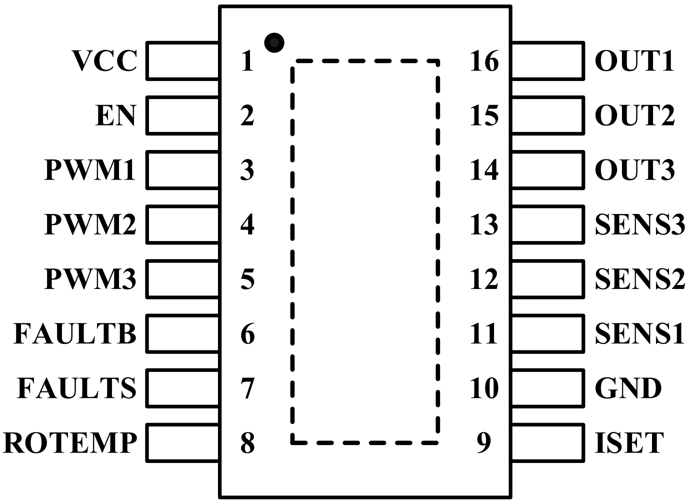


Figure 1 Typical Application Circuit

PIN CONFIGURATION

Package	Pin Configuration (Top View)
eTSSOP-16	

PIN DESCRIPTION

No.	Pin	Description
1	VCC	Power supply pin.
2	EN	Enable and shutdown pin. If not used, it should be connected to VCC pin.
3~5	PWM1~PWM3	PWM input and channel ON or OFF. Connected to VCC pin if PWM dimming is not implemented. Tie to GND if the corresponding channel is not used.
6	FAULTB	Fault reporting pin. Active low output driven by the device when it detects a fault condition (except single LED short fault). As an input, this pin will accept an externally generated FAULTB signal to disable the device output to satisfy the “one fail all fail” function. Leave floating if not used.
7	FAULTS	Single LED short fault reporting pin. Active low output driven by the device when it detects a single LED short fault condition. Leave floating if not used.
8	ROTEMP	Junction temperature thermal roll-off threshold program pin. Tie to GND if not used.
9	ISET	Resistor on this pin to GND sets the maximum output current for channel OUT1~OUT3.
10	GND	Ground pin.
11~13	SENS1~SENS3	String voltage sense for single LED short fault detection. Connect to OUTx if not used.
14~16	OUT3~OUT1	Current output pin. Connect to SENSx if not used.
	Thermal Pad	Must be connected to GND with sufficient copper plate for heat sink.

ORDERING INFORMATION
Automotive Range: -40°C to +125°C

Order Part No.	Package	QTY
IS32LT3143-ZLA3-TR IS32LT3143-ZLA3	eTSSOP-16, Lead-free	2500/Reel 96/Tube

ABSOLUTE MAXIMUM RATINGS (NOTE 1)

VCC pin voltage	-0.3V ~ +45V
ISET pin voltage	-0.3V ~ +7V
Other pins voltage	-0.3V ~ V_{CC}-0.3V
Operating temperature, T_A=T_J	-40°C ~ +150°C
Maximum continuous junction temperature, $T_{J(MAX)}$	+150°C
Storage temperature range, T_{STG}	-65°C ~ +150°C
Package thermal resistance, junction to ambient (4-layer standard test PCB based on JEDEC standard), $θ_{JA}$	45.4°C/W
Package thermal resistance, junction to thermal PAD (4-layer standard test PCB based on JEDEC standard), $θ_{JP}$	1.617°C/W
Maximum power dissipation, P_{DMAX}	2.75W
ESD (HBM) ESD (CDM)	±2kV ±750V

Note 1: Stresses beyond those listed under 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 under Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

T_J= -40°C ~ +150°C, V_{CC}= 12V, the detail refers to each condition description. Typical values are at T_J= 25°C (Note 5).

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
POWER SUPPLY						
V_{CC}	Supply voltage range		5		40	V
V_{UVLO}	VCC undervoltage lockout	Voltage falling		4.1	4.5	V
V_{UVLO_HY}	VCC undervoltage lockout hysteresis			200		mV
I_{CC}	Quiescent current	All PWMx=EN=high, I_{OUTx}= -100mA	2.5	3.5	4.6	mA
I_{SD}	Shutdown current	V_{EN}=0V			15	μA
I_{CC_FAULT}	Shutdown current in fault mode (From VCC)	PWMx=EN=high, FAULTB=low, V_{CC}=5V to 40V, I_{OUTx}= -100mA		1.4	2	mA
t_{ON}	Start-up time	V_{CC}>5V, I_{OUTx}= -60mA, current rises to 50%			200	μs
CURRENT REGULATION						
I_{OUTx}	Regulated output current range	Each channel	-150		-10	mA
		Three channels in parallel mode	-450		-30	mA
I_{OUT_L}	Output current limit per channel	ISET pin grounded		-240		mA
$ΔI_{OUT\_CH}$	Channel-to-channel matching (Note 2)	I_{OUTX}= -10mA, T_J= 25°C	-3		3	%
		I_{OUTX}= -10mA, T_J= -40~125°C	-4		4	
		I_{OUTX}= -30mA, T_J= 25°C	-2		2	
		I_{OUTX}= -30mA, T_J= -40~125°C	-4		4	
		I_{OUTX}= -100mA, T_J= 25°C	-2		2	
		I_{OUTX}= -100mA, T_J= -40~125°C	-2.5		2.5	
		I_{OUTX}= -150mA, T_J= 25°C	-2		2	
		I_{OUTX}= -150mA, T_J= -40~125°C	-2.5		2.5	

ELECTRICAL CHARACTERISTICS (CONTINUE)

T_J= -40°C ~ +150°C, V_{CC}= 12V, the detail refers to each condition description. Typical values are at T_J= 25°C (Note 5).

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
ΔI_{OUT_DE}	Device accuracy (Note 3)	I_{OUTX}= -10mA, T_J= 25°C	-3.5		3.5	%
		I_{OUTX}= -10mA, T_J= -40~125°C	-6		6	
		I_{OUTX}= -30mA, T_J= 25°C	-3		3	
		I_{OUTX}= -30mA, T_J= -40~125°C	-6		6	
		I_{OUTX}= -100mA, T_J= 25°C	-2.5		2.5	
		I_{OUTX}= -100mA, T_J= -40~125°C	-3.5		3.5	
		I_{OUTX}= -150mA, T_J= 25°C	-2.5		2.5	
		I_{OUTX}= -150mA, T_J= -40~125°C	-3.5		3.5	
V_{ISET_REF}	ISET pin reference voltage			1.15		V
V_{HR_MIN}	Minimum headroom voltage	I_{OUTx}= -150mA per channel		0.65	1.1	
		I_{OUTx}= -60mA per channel		0.26	0.5	
t_{SL}	Current rising slew time	Current rising from 10% to 90% at I_{OUTx}= -60mA	6	12	22	µs
		Current rising from 10% to 90% at I_{OUTx}= -150mA	12	25	45	
	Current falling slew time	Current falling from 90% to 10% at I_{OUTx}= -60mA	10	20	35	
		Current falling from 90% to 10% at I_{OUTx}= -150mA	12	20	35	
EN AND PWMx						
V_{ILEN}	EN pin logic input low level	OUTx disabled			0.7	V
V_{IHEN}	EN pin logic input high level	OUTx enabled	2			V
I_{ENPD}	EN pin internal pulldown	V_{EN}=5V to 40V	0.5	2	5	µA
V_{ILPWM}	PWMx pins input low threshold	OUTx disabled	1.29	1.35	1.41	V
V_{IHPWM}	PWMx pins input high threshold	OUTx enabled	1.34	1.4	1.46	V
V_{HYSPWM}	PWMx pins input hysteresis			50		mV
t_{DPWM_R}	Delay time between PWM rising edge to 10% of I_{OUTx}	Two LEDs in series		20	45	µs
t_{DPWM_F}	Delay time between PWM falling edge to 90% of I_{OUTx}	Two LEDs in series		20	45	µs
FAULTB AND FAULTS						
V_{ILFLTB}	FAULTB logic input low level				0.7	V
V_{IHFLTB}	FAULTB logic input high level		2			V

ELECTRICAL CHARACTERISTICS (CONTINUE)

T_J= -40°C ~ +150°C, V_{CC}= 12V, the detail refers to each condition description. Typical values are at T_J= 25°C (Note 5).

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{OLFLT}	FAULTB and FAULTS logic output low level	Tested with 500μA external pull-up			0.7	V
V_{OHFLT}	FAULTB and FAULTS logic output high level	Tested with 1μA external pull-down	2			V
V_{FLT_PU}	FAULTB and FAULTS pin internal pull-up voltage			3.3		V
I_{PD}	FAULTB and FAULTS strong pull-down current	Pulled up to 5V	500	1000	1400	μA
I_{PU}	FAULTB and FAULTS weak pull-up current	Pulled down to ground	3.2	8	17	μA
PROTECTION						
V_{SENS_TH}	SENSx pins detection voltage threshold	V_{CC}> V_{CCTH}	1.35	1.38	1.41	V
I_{LKG}	SENSx pins leakage current	V_{SENSx}= 3V			500	nA
t_{SENS}	Single LED short detection deglitch		1	2	3	ms
		During PWM dimming, count the number of continuous cycles when V_{SENSx} < V_{SENS_TH}	7		8	Cycles
V_{CCTH}	LED string open and single LED short detection enabling VCC threshold	Voltage rising	8		9	V
V_{CCTH_HY}	LED string open and single LED short detection enabling VCC threshold hysteresis			270		mV
V_{OCD}	LED string open detection voltage	(V_{CC} - V_{OUTx}) voltage falling	50	116	180	mV
V_{OCD_HYS}	LED string open detection hysteresis	(V_{CC} - V_{OUTx}) voltage rising	90	180	300	mV
t_{OCD}	LED string open detection deglitch		1	2	3	ms
		During PWM dimming, count the number of continuous cycles when (V_{CC} - V_{OUTx}) < V_{OCD}	7		8	Cycles
V_{SCD}	LED string short detection voltage	Measured at OUTx pin, voltage falling	0.70	0.78	0.86	V
t_{SCD}	LED string short detection deglitch		1	2	3	ms
		During PWM dimming, count the number of continuous cycles when V_{OUTx} < V_{SCD}	7		8	Cycles
R_{ISET_OC}	ISET pin resistor open detection	FAULTB goes low	135	165	190	kΩ
R_{ISET_SC}	ISET pin resistor short detection	FAULTB goes low	1.55	1.89	2.3	kΩ

ELECTRICAL CHARACTERISTICS (CONTINUE)

T_J= -40°C ~ +150°C, V_{CC}= 12V, the detail refers to each condition description. Typical values are at T_J= 25°C (Note 5).

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
THERMAL MONITOR						
T_{SD}	Thermal shutdown	(Note 4)		175		°C
T_{SD_HYS}	Thermal shutdown hysteresis	(Note 4)		15		°C
T_{RO_90}	Thermal roll-off activation temperature	90% of I_{OUTx} (ROTEMP pin floating) (Note 4)	95	110	125	°C
I_{RO_MIN}	Minimum thermal roll-off current	(Note 4)	40	50	60	%

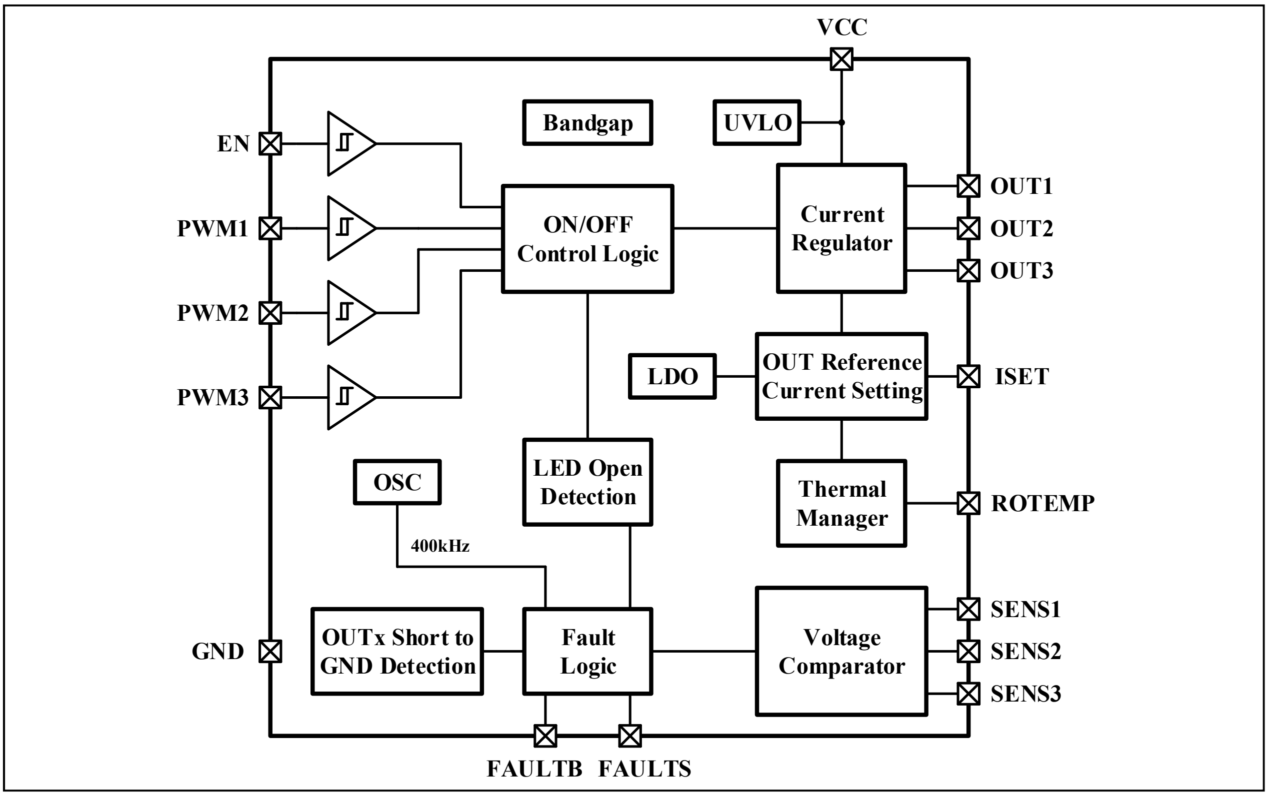
Note 2: $I_{AVG} = (I_{OUT1} + I_{OUT2} + I_{OUT3})/3$, $\Delta I_{OUT\_CH}=(I_{OUTx}-I_{AVG})/I_{AVG}$

Note 3: $I_{SETTING}$ is the target current set by R_{ISET}. $\Delta I_{OUT\_DE}=(I_{OUTx}-I_{SETTING})/I_{SETTING}$

Note 4: Guaranteed by design.

Note 5: Limits are 100% production tested at 25ºC. Limits over the operating temperature range verified through either bench and/or tester testing and correlation using Statistical methods.

FUNCTIONAL BLOCK DIAGRAM



TYPICAL PERFORMANCE CHARACTERISTICS

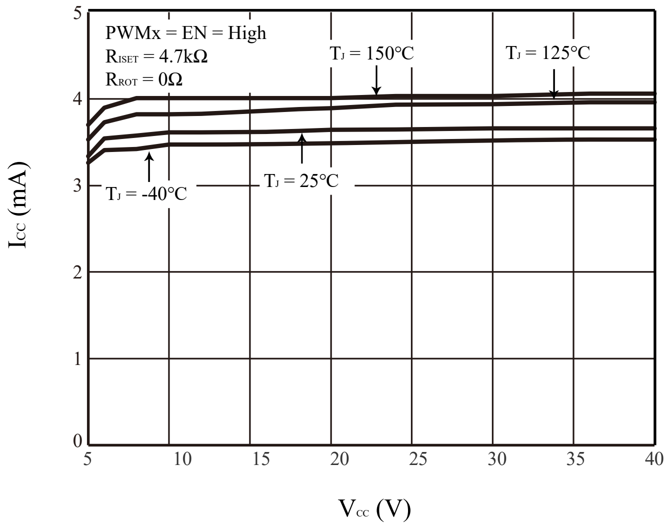


Figure 2 I_{CC} vs. V_{CC}

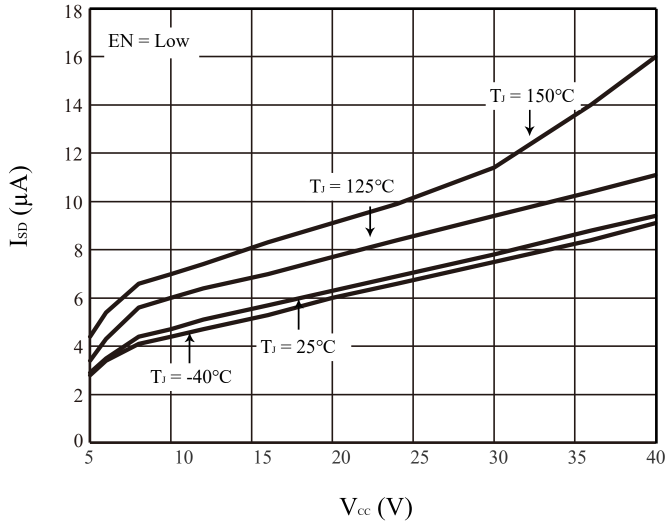


Figure 3 I_{SD} vs. V_{CC}

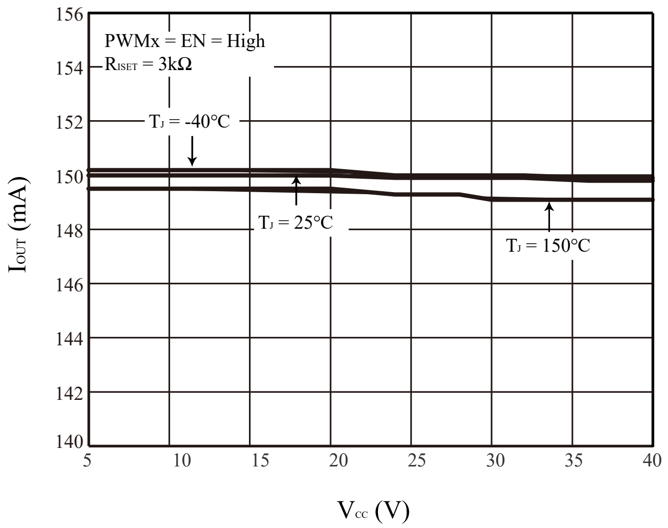


Figure 4 I_{OUT} vs. V_{CC}

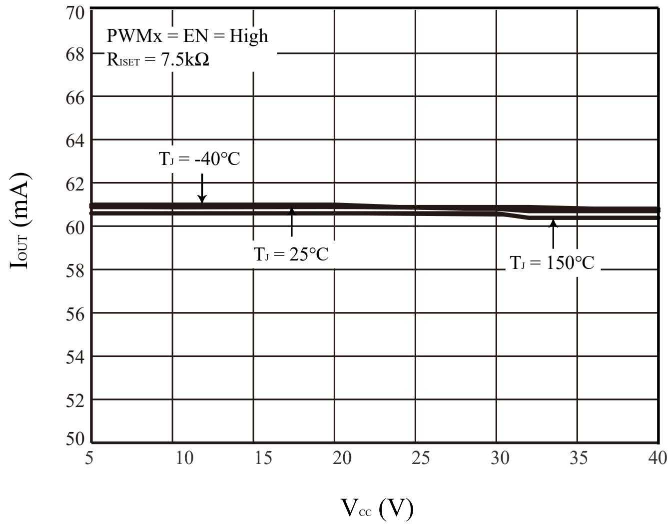


Figure 5 I_{OUT} vs. V_{CC}

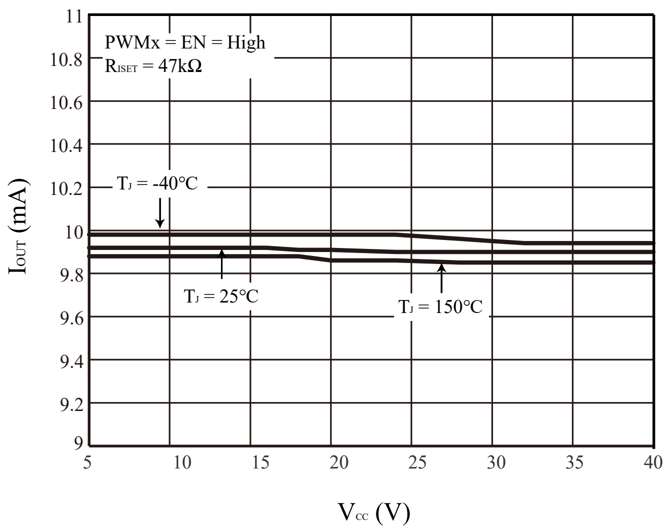


Figure 6 I_{OUT} vs. V_{CC}

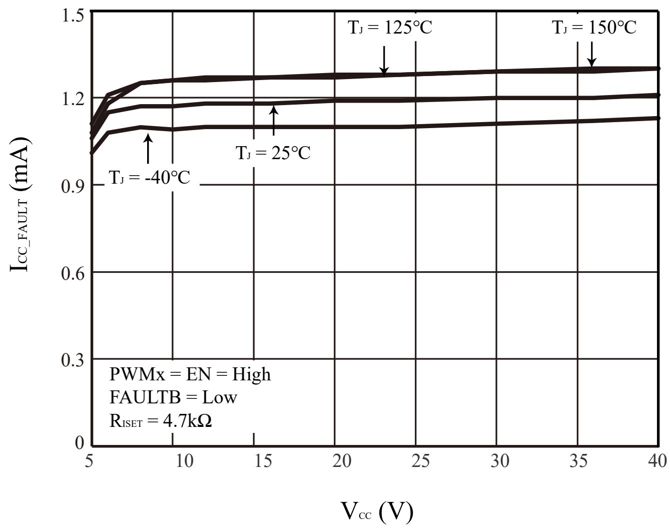


Figure 7 I_{CC_FAULT} vs. V_{CC}

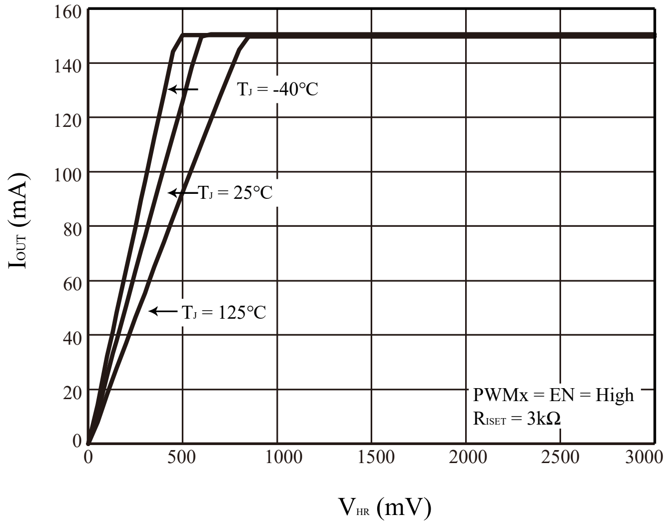


Figure 8 I_{OUT} vs. V_{HR}

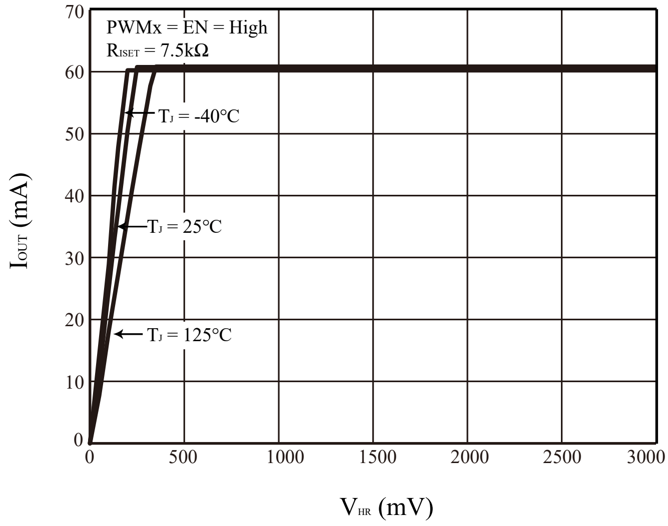


Figure 9 I_{OUT} vs. V_{HR}

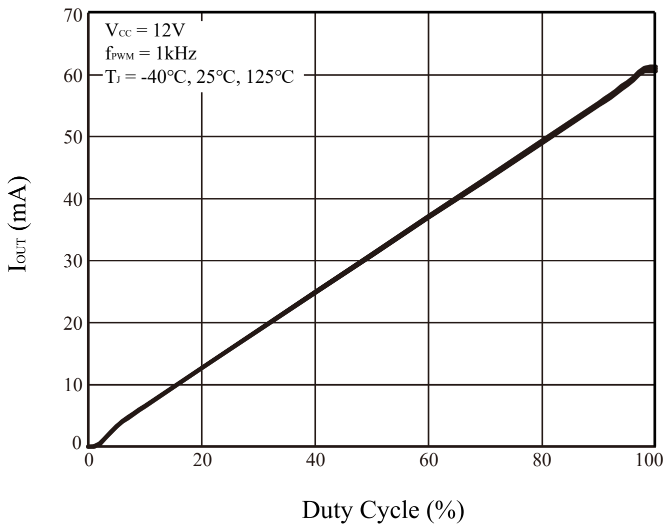


Figure 10 I_{OUT} vs. Duty Cycle

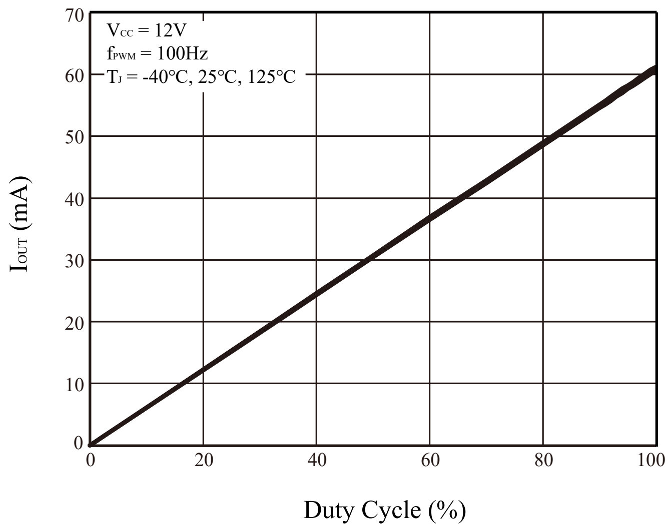


Figure 11 I_{OUT} vs. Duty Cycle

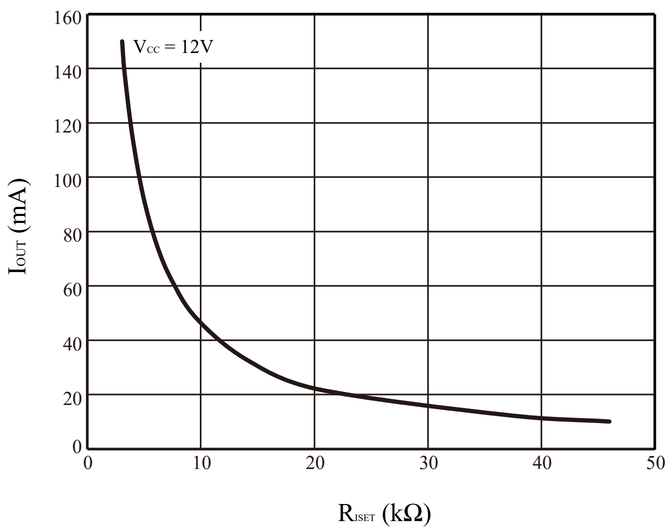


Figure 12 I_{OUT} vs. R_{ISET}

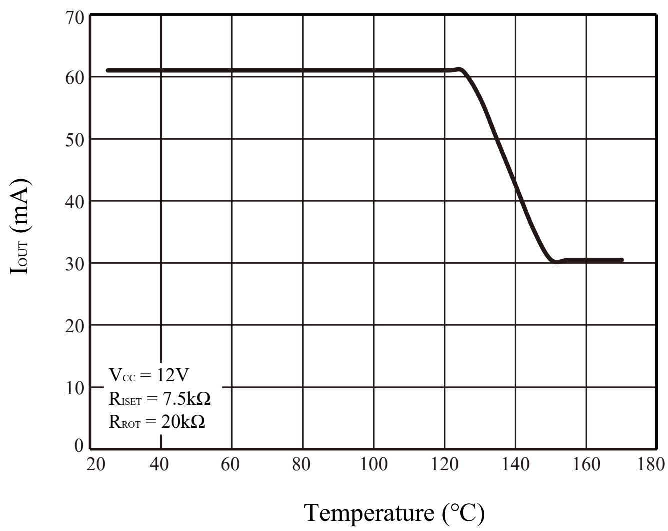


Figure 13 I_{OUT} vs. Temperature (Thermal Roll-Off)

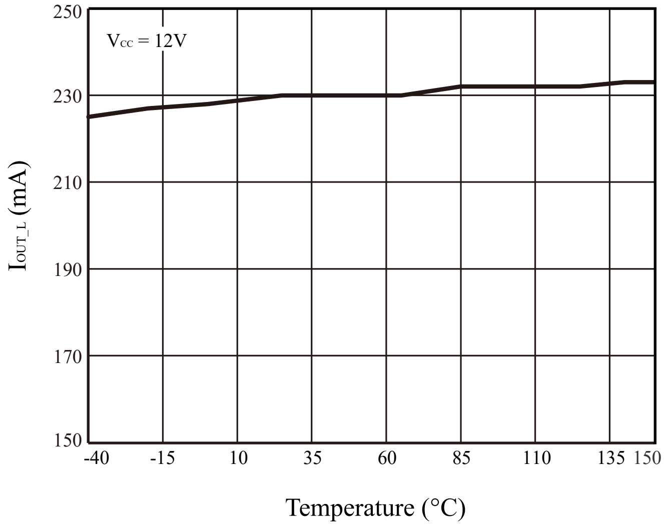


Figure 14 I_{OUT_L} vs. Temperature

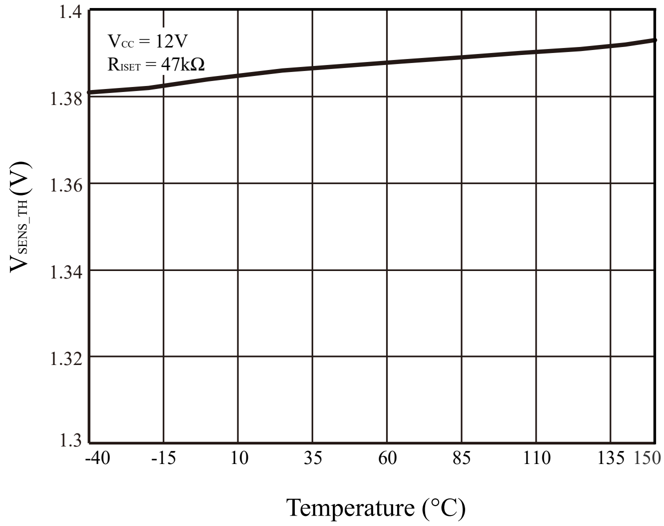


Figure 15 V_{SENS_TH} vs. Temperature

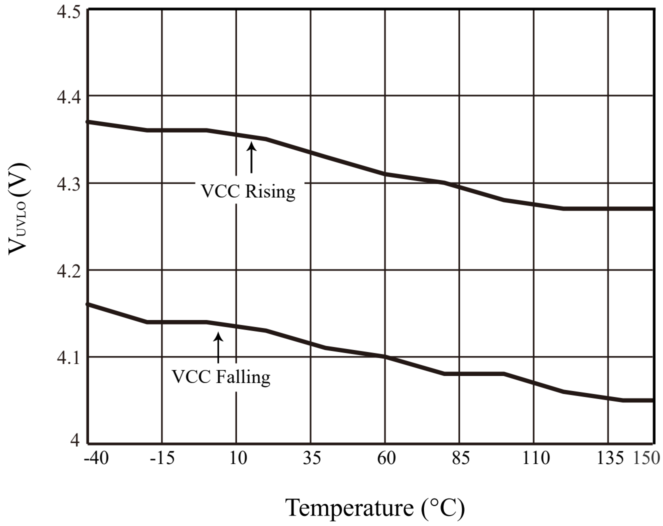


Figure 16 V_{UVLO} vs. Temperature

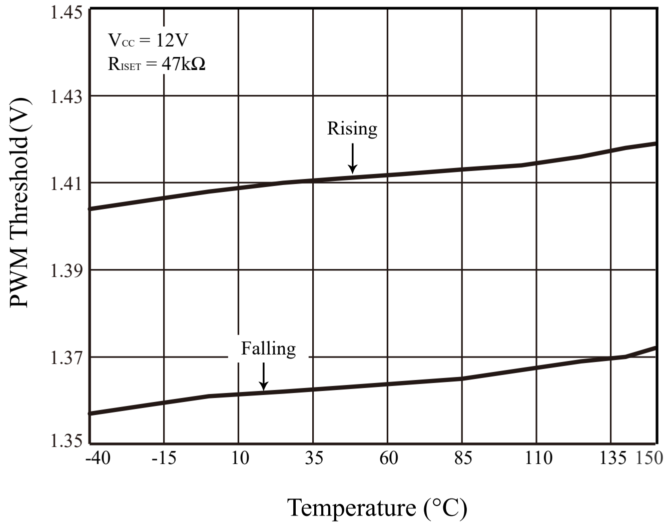


Figure 17 PWM Threshold vs. Temperature

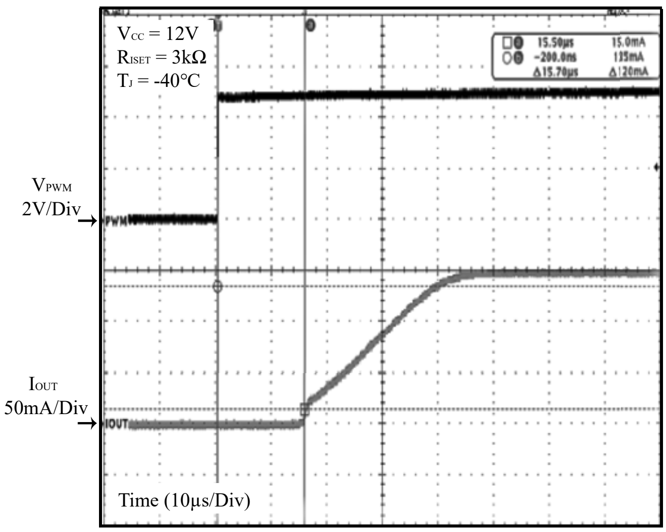


Figure 18 PWM On

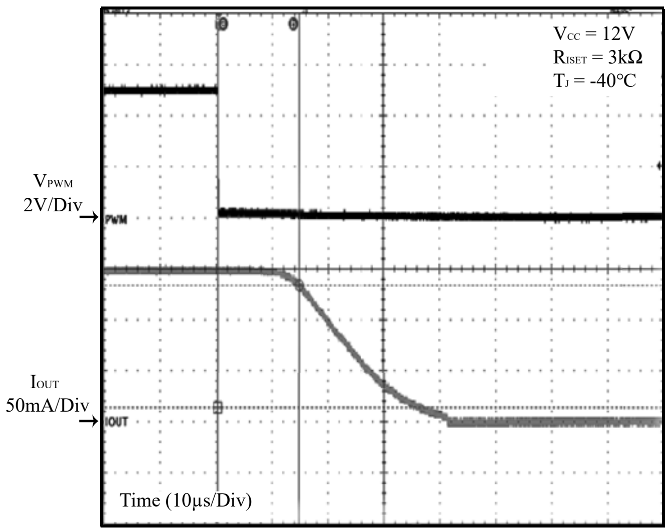


Figure 19 PWM Off

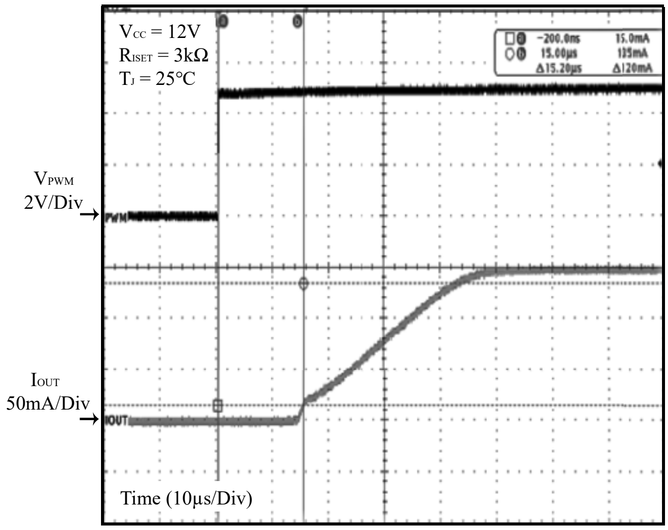


Figure 20 PWM On

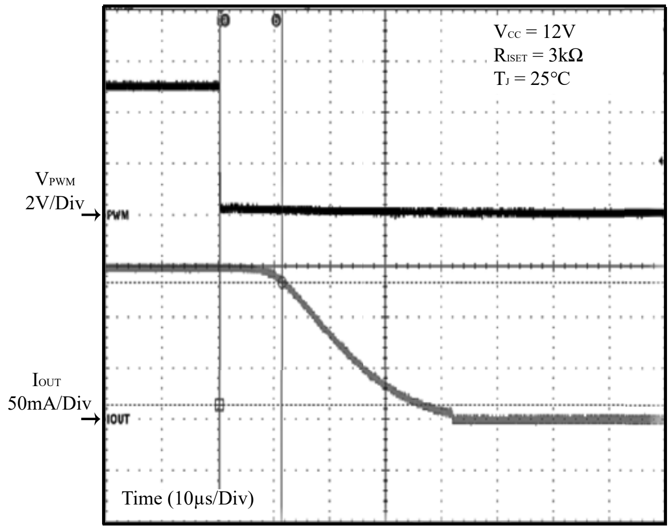


Figure 21 PWM Off

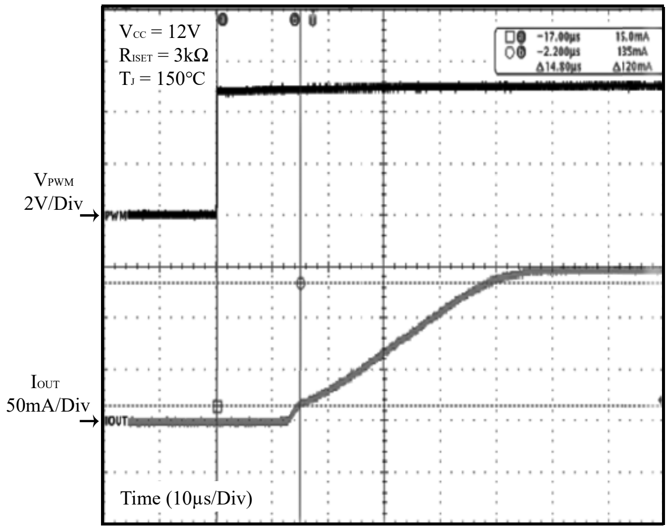


Figure 22 PWM On

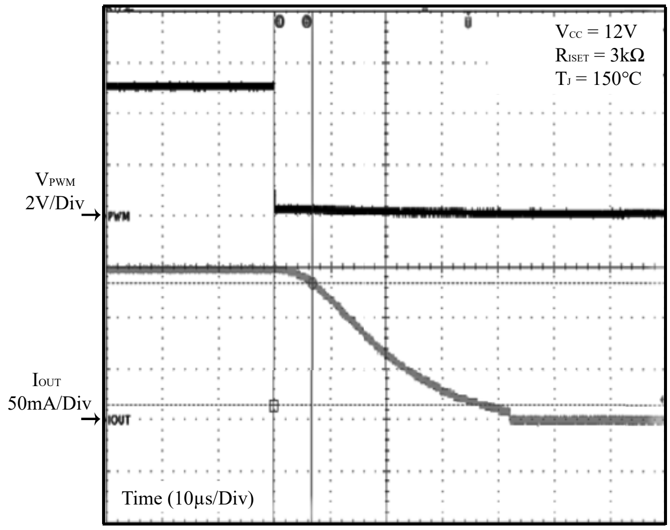


Figure 23 PWM Off

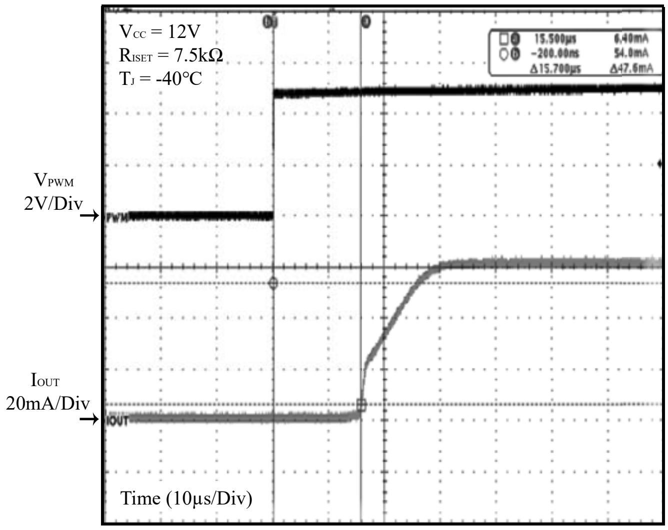


Figure 24 PWM On

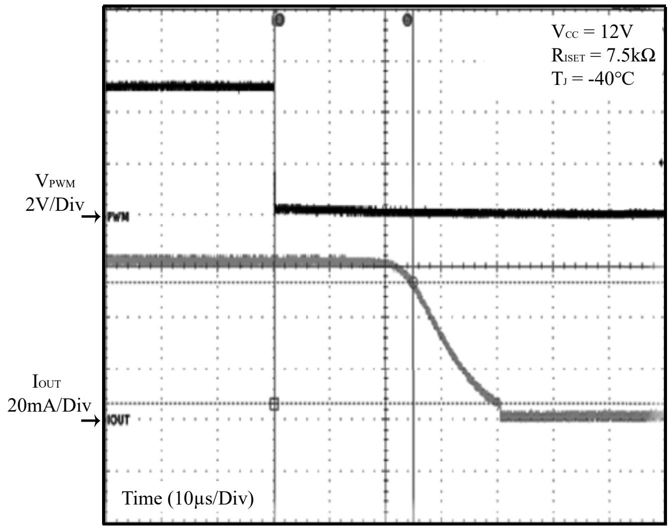


Figure 25 PWM Off

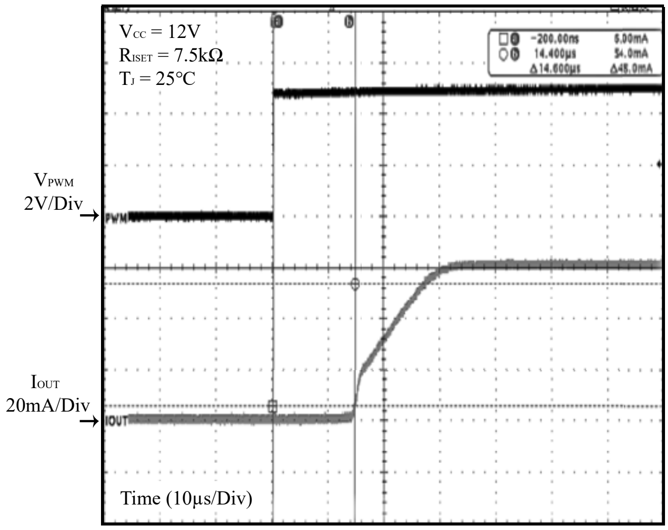


Figure 26 PWM On

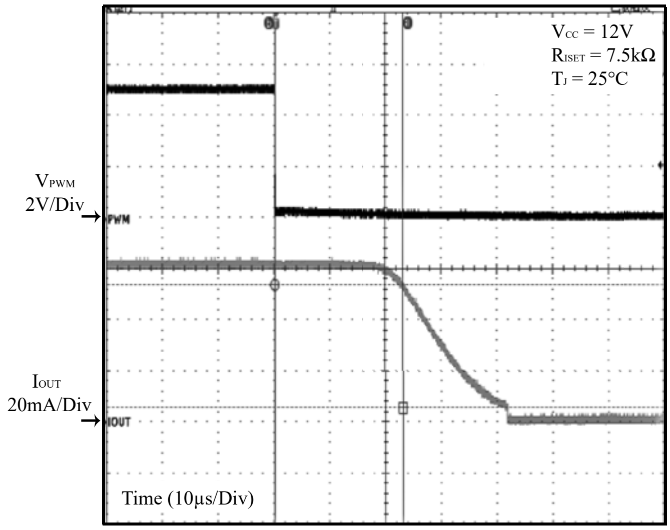


Figure 27 PWM Off

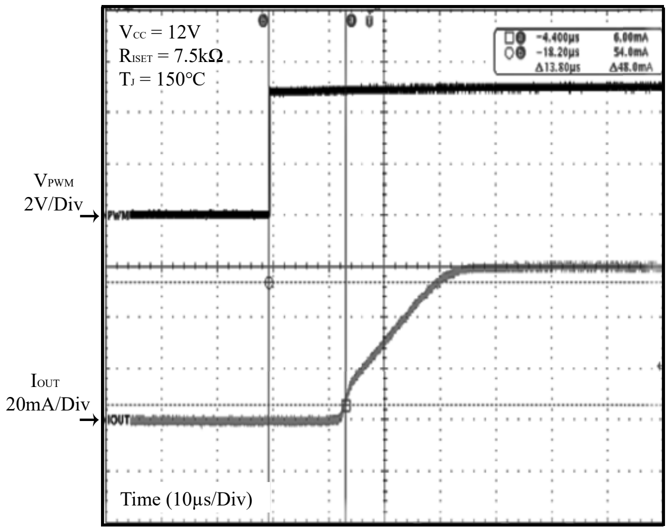


Figure 28 PWM On

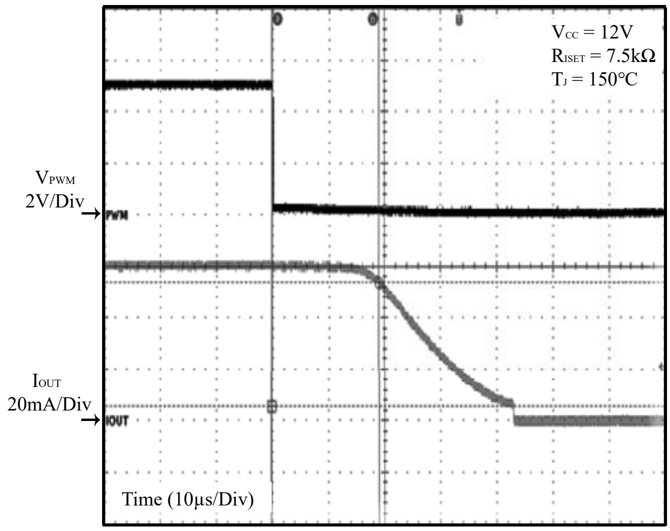


Figure 29 PWM Off

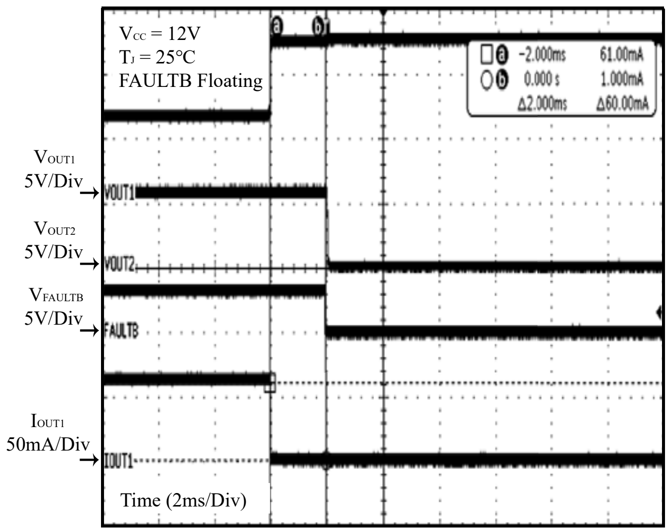


Figure 30 Output Open

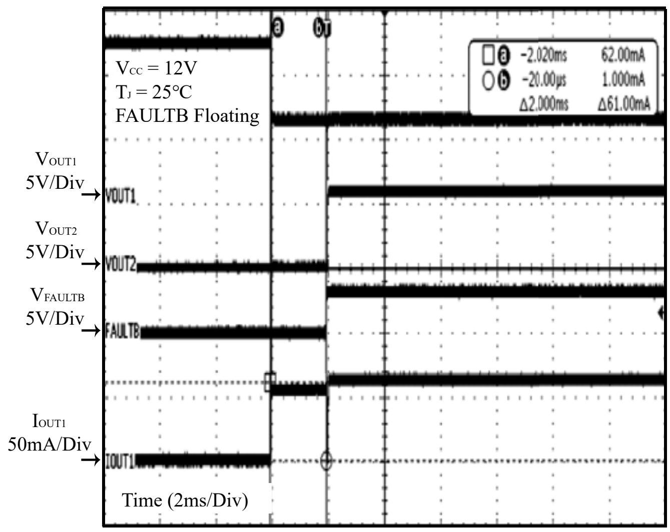


Figure 31 Output Open Remove

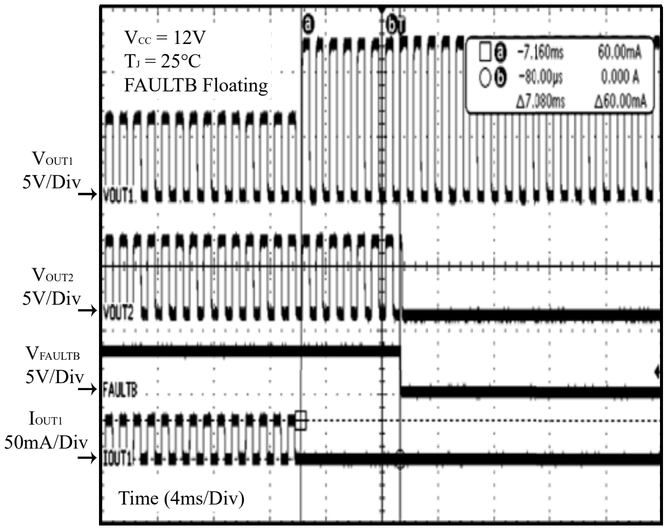


Figure 32 Output Open (PWM Dimming)

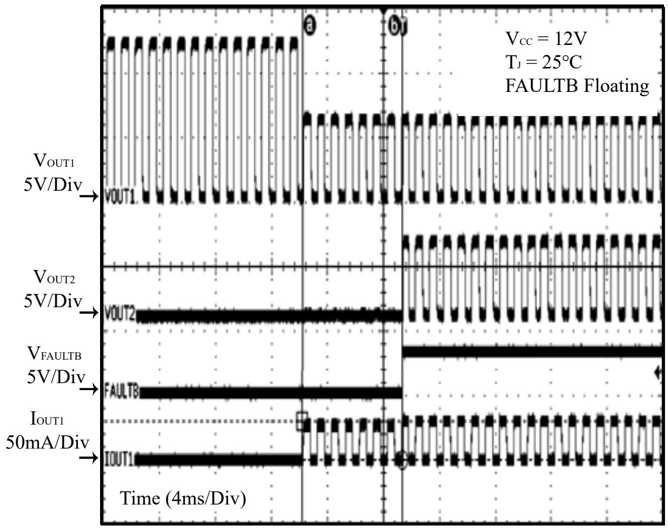


Figure 33 Output Open Remove (PWM Dimming)

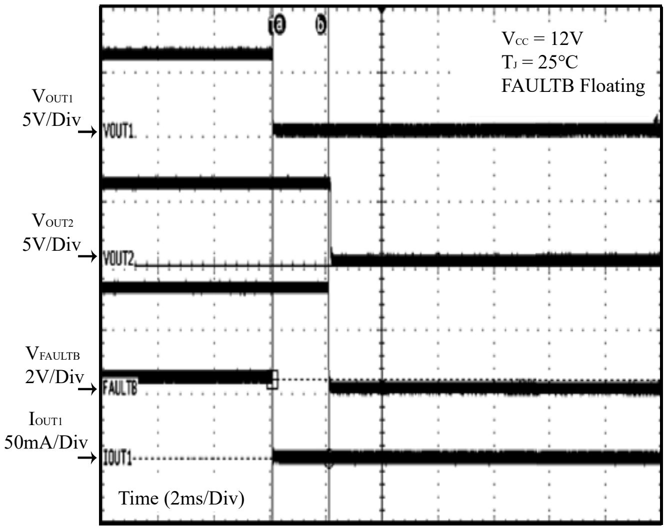


Figure 34 Output Short

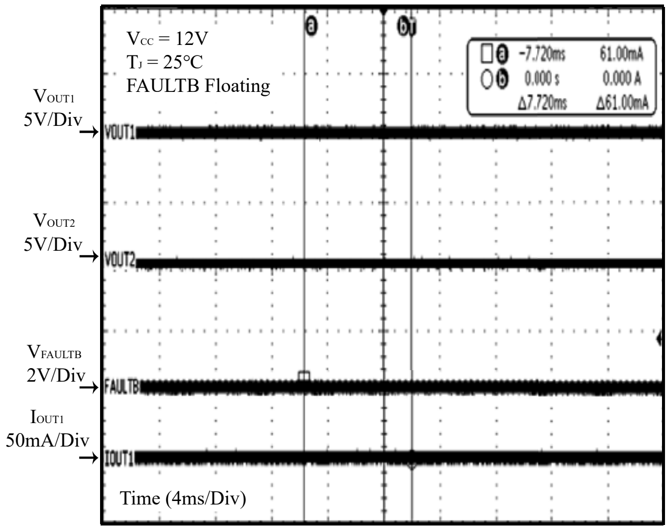


Figure 35 Output Short Remove

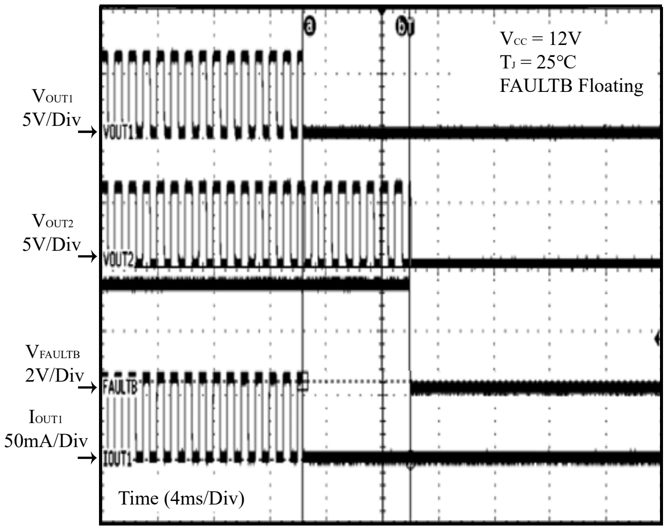


Figure 36 Output Short (PWM Dimming)

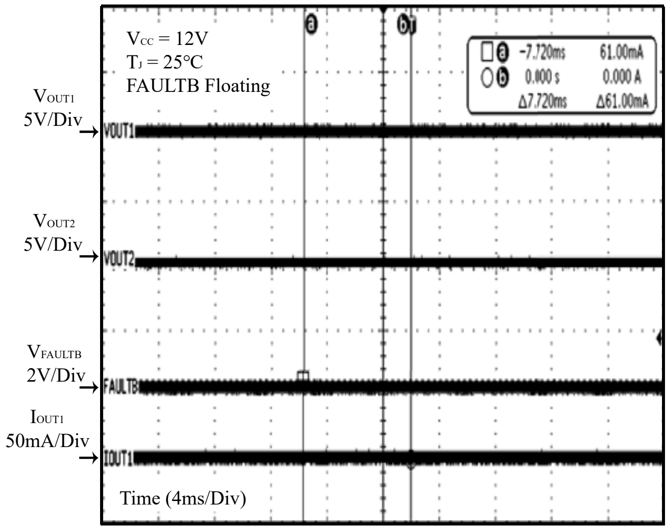


Figure 37 Output Short Remove (PWM Dimming)

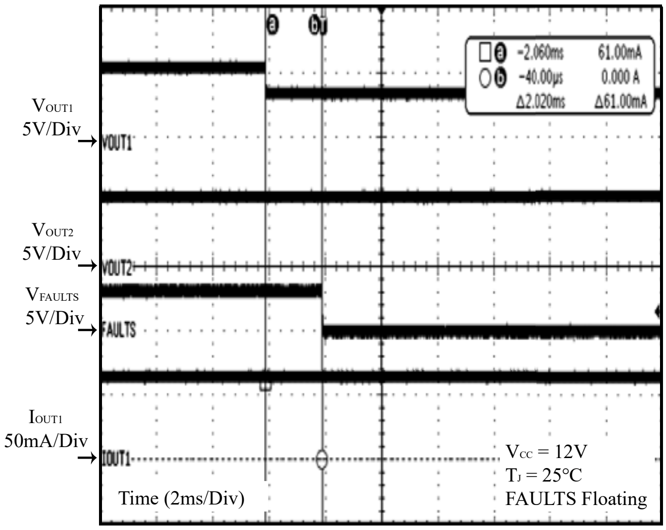


Figure 38 Single LED Short

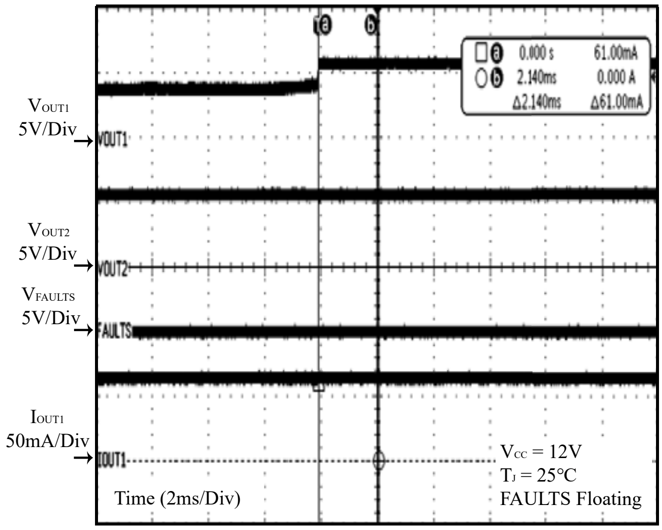


Figure 39 Single LED Short Remove

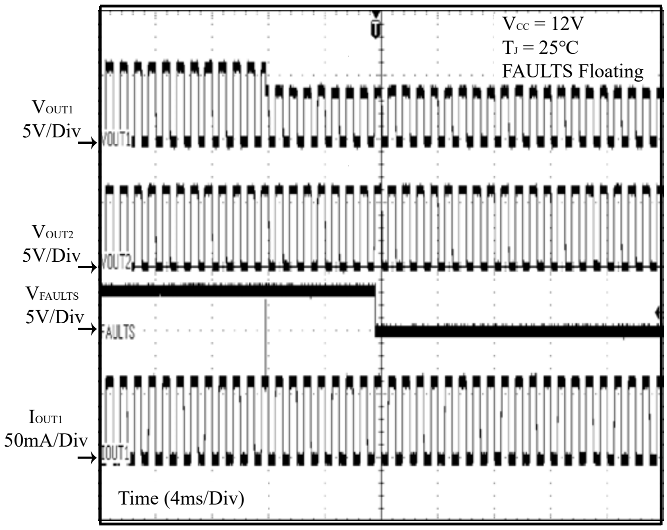


Figure 40 Single LED Short (PWM Dimming)

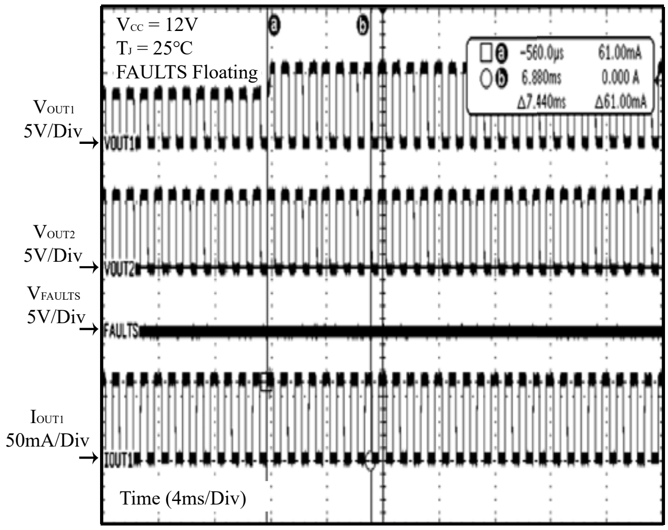


Figure 41 Single LED Short Remove (PWM Dimming)

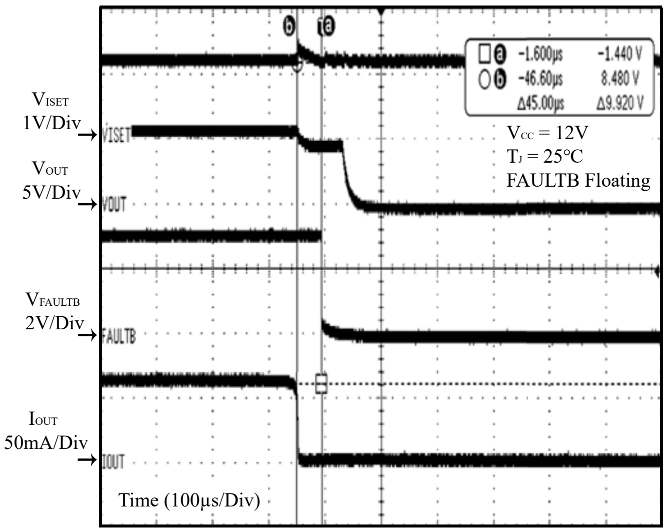


Figure 42 RISET Open

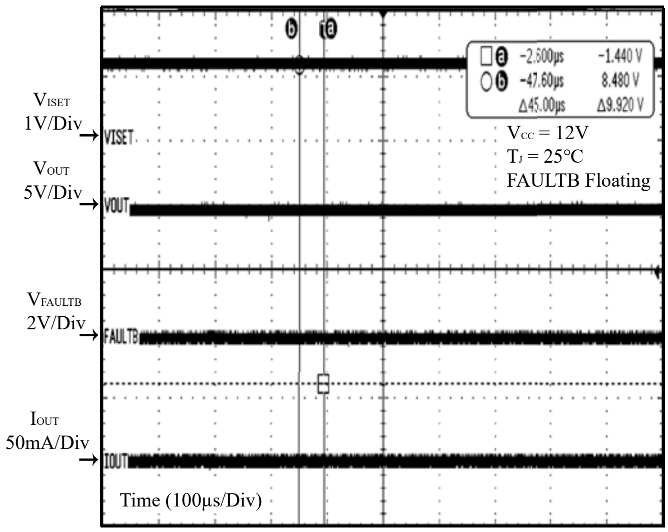


Figure 43 RISET Open Remove

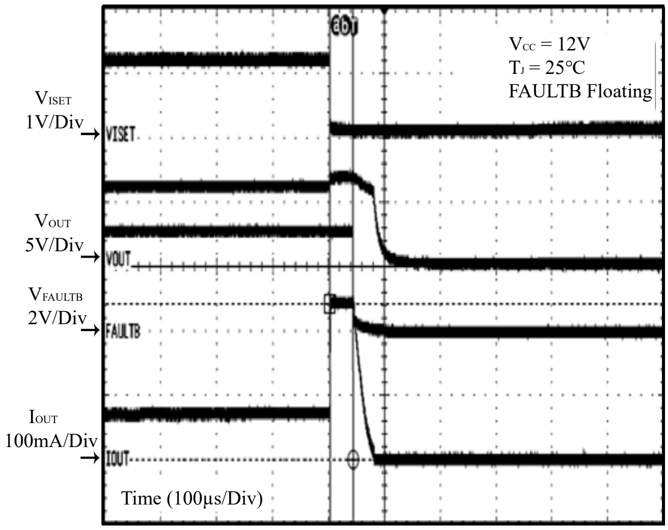


Figure 44 RISET Short

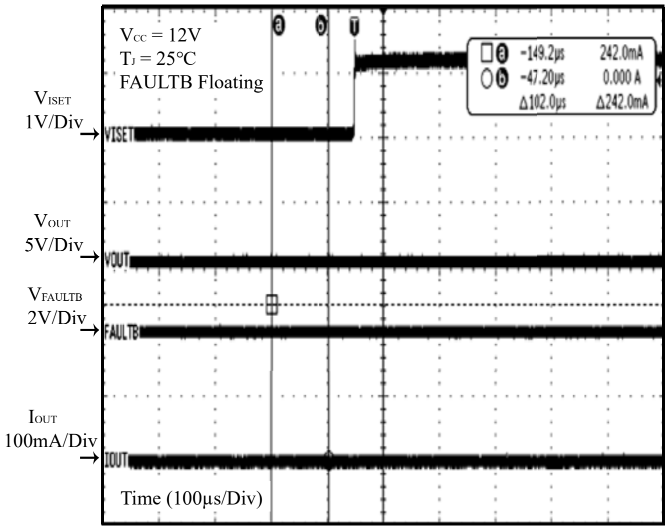


Figure 45 RISET Short Remove

APPLICATION INFORMATION

The IS32LT3143 is a three-channel constant current LED driver with individual PWM dimming, designed for a single string or multiple strings of high brightness LEDs in automotive lighting applications. A single resistor R_{ISET} is able to simultaneously set the output current of all output channels, up to 150mA per channel. A high-side current source output architecture allows common-cathode LED string connection to ground. So, the application only requires a single return wire instead of one return wire per LED string that a driver with low-side current sink output architecture would need. The advanced control loop allows high accuracy between channels and devices. A separate PWM pin can be used to dim or enable/disable each channel. The IS32LT3143 monitors various fault conditions and reports on the FAULTB and FAULTS pins.

OUTPUT CURRENT SETTING

The regulated maximum output current (up to 150mA) from each output channel is simultaneously set by the current setting resistor R_{ISET}. The R_{ISET} resistor value can be calculated using the following equation:

$$R_{ISET} = \frac{V_{ISET\_REF}}{I_{OUT+0.21}} \times 420.75 - 0.11 \qquad (1)$$

(3.11kΩ ≤ R_{ISET} ≤ 47.28kΩ)

Where I_{OUT} is the desired output current of each output channel in mA and R_{ISET} is in kΩ. V_{ISET_REF} is the ISET pin reference voltage, 1.15V typical.

It is recommended that R_{ISET} be a 1% accuracy resistor with good temperature characteristic to ensure stable and precise output current. On the PCB layout, this R_{ISET} resistor must be placed as close to ISET pin and GND pin as possible to avoid noise interference and ground bounce.

The device is protected from an output overcurrent condition caused by R_{ISET} resistor. The output current is limited to an I_{OUT_L} value of 240mA (Typ.) for cases when a low value resistor is connected to ISET and GND pins or ISET pin is shorted to ground.

DEVICE ENABLE AND SHUTDOWN

The EN pin is an enable input for the device, pull it higher than V_{IHEN} to enable the device; pull it lower than V_{ILEN} to force the device into shutdown mode with an ultralow shutdown current. The EN pin is high-voltage tolerant. If the shutdown mode is unused, directly connect the EN pin to the VCC pin. However, due to the inherent parasitic ESD diode across the EN pin and VCC pin, if a voltage applied on EN pin is possibly higher than the VCC pin voltage at any time, a series resistor (recommended value is 10kΩ) is required to limit the current flowing into it. This series resistor is recommended to be added in most applications (refer to Figure 46).

PWM DIMMING

The device features a separate PWM dimming control pin for each output channel. PWM pin control the corresponding output channel. The PWM pin voltage should be higher than V_{IHPWM} to enable the corresponding output channel and lower than V_{ILPWM} to disable it. If any output channel is unused, tie the corresponding PWM pin to ground to disable it and connect the OUTx pin to the corresponding SENSx pin.

An external PWM signal on the PWMx pins can be used to modulate the output current to dim the LED light output. The PWM dimming LED current is based on the PWM signal's duty cycle and can be calculated by the following Equation:

$$I_{OUT\_PWM} = I_{OUT} \times D_{PWM} \qquad (2)$$

Where D_{PWM} is the duty cycle of PWM signal.

The recommended frequency range of the external PWM signal is 100Hz~1kHz and the duty cycle can be from 0 to 100%. Due to the output's current slew rate control for EMI consideration plus the propagation delay time from PWM rising edge to the output activity, a lower frequency PWM will provide a better dimming linearity and contrast ratio.

All PWMx pins are high-voltage tolerant. If the PWM dimming of any channel is not implemented, directly connect its corresponding PWM pin to the VCC pin. However, due to the inherent parasitic ESD diode across PWMx pin and VCC pin, if a voltage applied on PWMx is possibly higher than the VCC pin voltage at any time, a series resistor (recommended value is 10kΩ) is required for each pin to limit the current flowing into it. This series resistor is recommended to be added in most applications.

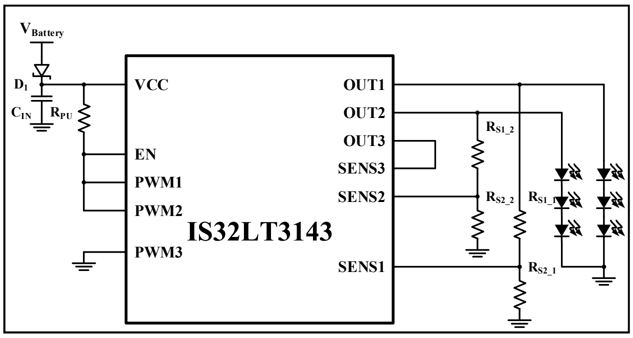


Figure 46 Example of No PWM Dimming and OUT3 Unused

UNDERVOLTAGE LOCKOUT (UVLO)

The IS32LT3143 features an undervoltage lockout (UVLO) function on the VCC pin to prevent indeterminate operation at low input voltages. The UVLO threshold is an internally fixed value and cannot be adjusted. The device is enabled when the V_{CC} voltage exceeds (V_{UVLO}+V_{UVLO_HY}) (Typ. 4.3V) and disabled when the V_{CC} voltage falls below V_{UVLO} (Typ. 4.1V).

Besides this internal, fixed UVLO, it may be desirable to externally set a higher UVLO threshold for some applications. The PWMx pins have precise threshold, which can be used to define an external undervoltage-lockout (UVLO) function for its corresponding output channel with a resistor voltage divider between VCC and GND with the center connected to the PWMx pin. As shown in Figure 47.

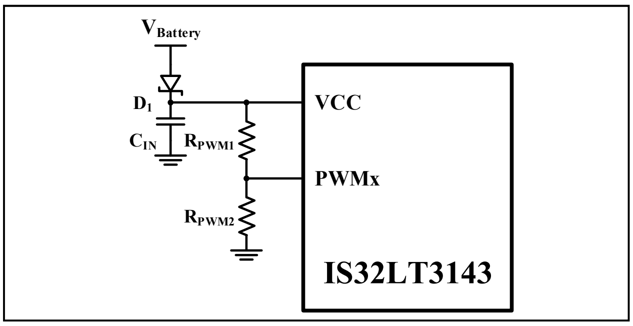


Figure 47 External UVLO Defined by PWMx Pins

The external UVLO threshold voltage can be computed by the following Equations:

$$V_{UVLO\_EXF} = V_{ILPWM} \times \frac{R_{PWM1}+R_{PWM2}}{R_{PWM2}} \quad (3)$$

$$V_{UVLO\_EXR} = V_{IHPWM} \times \frac{R_{PWM1}+R_{PWM2}}{R_{PWM2}} \quad (4)$$

The corresponding output channel is enabled when the V_{CC} voltage exceeds V_{UVLO_EXR}, and disabled when the V_{CC} voltage falls below V_{UVLO_EXF}.

It is recommended that R_{PWM1} and R_{PWM2} be 1% accuracy resistors with good temperature characteristics to ensure a precise detection. On the PCB layout, this resistor divider must be placed as close as possible to the corresponding PWM pin to avoid noise coupling into the UVLO detection.

FAULT PROTECTION AND REPORTING

For robust system reliability, the IS32LT3143 integrates the detection circuitry to protect various fault conditions and report the fault conditions on the fault reporting pins, FAULTB and FAULTS, which can be monitored by an external host. The fault reporting pins will go low when the device detects a fault condition. FAULTS is a dedicated fault reporting pin for single LED short fault condition and the FAULTB is for general fault conditions, including LED string open/short, current setting resistor open/short and thermal shutdown. Both fault reporting pins have an internal weak current source I_{PU} pulled up to an internal voltage source V_{FLT_PU} (Typical 3.3V) and an internal strong current sink I_{PD} pulled down to ground. As shown in Figure 48.

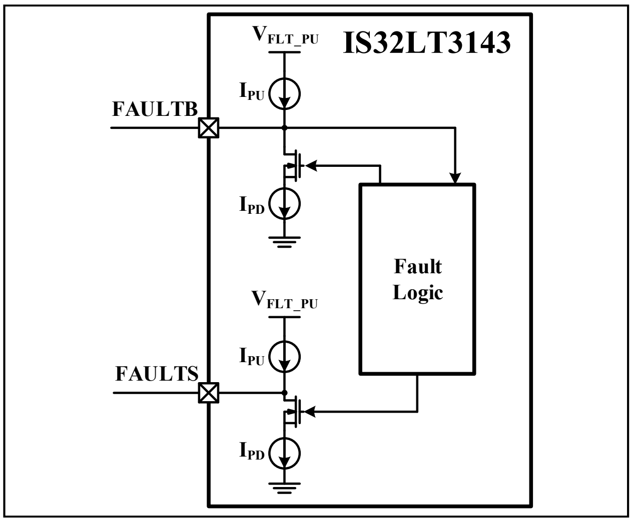


Figure 48 FAULTB and FAULTS Pin Internal Circuit

The FAULTB pin also supports an input function. As long as the FAULTB pin voltage drops below the logic input low level V_{ILFLTB}, no matter if it is pulled down by an external circuit or the internal pull-down current sink I_{PD}, all output channels (excluding the failing channel) will be turned off to satisfy the "one fail all fail" operating requirement. For lighting systems with multiple IS32LT3143 drivers which requires the complete lighting system be shut down when a fault is detected, the FAULTB pin can be used in a parallel connection. A fault output by one device will pull low the FAULTB pins of the other parallel connected devices and simultaneously turn them off. This satisfies the system "one fail all fail" operating requirement. The allowed fault reporting parallel pin (FAULTB and FAULTS) connection is up to 15 devices.

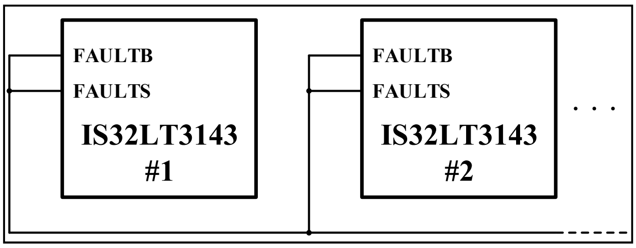


Figure 49 FAULTB/FAULTS Parallel Connection

If the FAULTB pin is externally forced high (for example, pulled up by a 1kΩ resistor to VCC) so that the internal pull-down current sink I_{PD} of fault actions is not capable to pull the FAULTB pin below the logic input low level V_{ILFLTB}, the fault actions (including LED string open/short fault) will keep other channels normal operation that satisfies the "one fail other on" operating requirement. Refer to Table 1 for detailed fault actions.

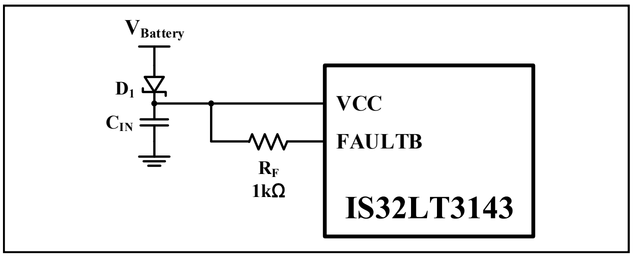


Figure 50 Externally Forced FAULTB High

LED STRING OPEN PROTECTION

The LED string open detection is enabled if the VCC pin voltage is greater than the detection enabling threshold, V_{CCTH}, and disabled if the VCC voltage drops below (V_{CCTH}-V_{CCTH_HY}).

In case of any LED string is open, the corresponding OUTx pin will be pulled up close to VCC pin voltage by the current source. When V_{CC}>V_{CCTH} and the VCC pin to OUTx pin voltage drop, (V_{CC}-V_{OUTx}), falls below the LED string open detection voltage, V_{OCD}, and persists for longer than the deglitch time t_{OCD} (2ms when PWM is 100% on or one PWM on-time is more than 2ms, or seven continuous PWM duty cycles when in PWM dimming mode), the FAULTB pin will go low to report the fault condition. The open channel will stay on and the other channels will be turned off due to the FAULTB pin low, that satisfies "one fail all fail" condition. If the FAULTB pin is externally forced high, the other channels will remain turned on that satisfies the "one fail other on" condition.

The device will recover to normal operation and FAULTB pin will go back high once the open condition is removed, (V_{CC}-V_{OUTx}) rising above the LED string open detection voltage, (V_{OCD}+V_{OCD_HYS}).

Note that the device can detect a LED string open if the forward voltage of the LED string is close to or greater than the VCC voltage. When the input voltage V_{CC} is lower than V_{CCTH}, the device prevents LED string open fault detection. Even though a LED string open fault occurs, the device does not report the fault with the FAULTB pin.

LED STRING SHORT PROTECTION

The LED string short condition is detected if any one of the OUTx pin voltage is lower than LED string short detection voltage, V_{SCD}. Once a short condition occurs and persists for longer than the deglitch time t_{SCD} (2ms when PWM is 100% on or one PWM on-time is more than 2ms, or seven continuous PWM duty cycles when in PWM dimming mode), the FAULTB pin will go low to report the fault condition and the faulty channel will be latched in off state. The other channels will be turn off due to the FAULTB pin low, that satisfies "one fail all fail". If the FAULTB pin is externally forced high, the other channels will remain turned on that satisfies the "one fail other on" condition. This fault protection and reporting are not self-clearing, a toggling of EN or power cycle is required.

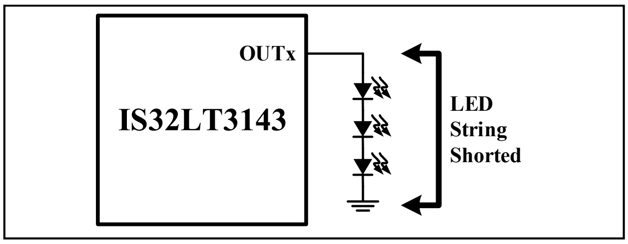


Figure 51 LED String Shorted

SINGLE LED SHORT PROTECTION

The IS32LT3143 supports independent single LED short detection for each channel, which is enabled if the VCC pin voltage is greater than V_{CCTH} and disabled if the VCC voltage drops below (V_{CCTH}-V_{CCTH_HY}). There are three comparators (CMPx) inside the device used to monitor each LED string voltage with external resistor dividers connected to the SENSx pins.

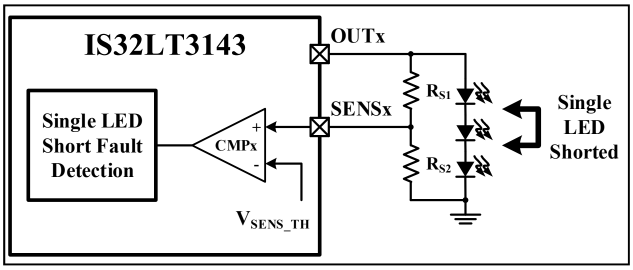


Figure 52 Single LED Short Detection Circuit

In case of V_{CC}>V_{CCTH} and any one of SENSx pins voltage drops below the internal reference V_{SENS_TH} persists for longer than the deglitch time t_{SENS} (2ms when PWM is 100% on or one PWM on-time is more than 2ms, or seven continuous PWM duty cycles when in PWM dimming mode), the FAULTS pin will be latched in low state to report the fault condition but no other action results. The FAULTS pin latched low is not self-clearing, a toggling of EN or power cycle is required.

If the FAULTS pin is externally tied to the FAULTB pin, the FAULTS pin will pull the FAULTB pin low to turn off all output channels (including the faulty channel) to satisfy the "one fail all fail" operating requirement.

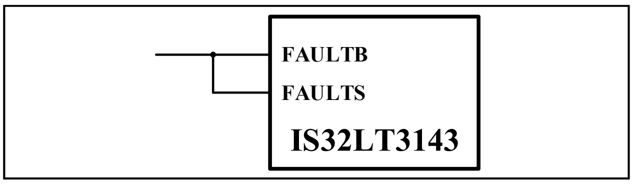


Figure 53 FAULTS Tied to FAULTB for "One Fail All Fail"

To achieve proper single LED short detection and avoid false triggering, the resistor divider, R_{S1} and R_{S2}, should be chosen according to the minimum and maximum of the LED forward voltage:

$$(N-1) \times V_{F\_MAX} < V_{SENS\_TH} \times \frac{R_{S1}+R_{S2}}{R_{S2}} < N \times V_{F\_MIN}$$
(5)

Where, N is the number of LEDs in the string. V_{F_MAX} and V_{F_MIN} are the maximum and minimum forward voltage of a single LED.

It is recommended that R_{S1} and R_{S2} be 1% accuracy resistors with good temperature characteristics to ensure a precise detection. On the PCB layout, this resistor divider must be placed as close as possible to the corresponding SENSx pin to avoid noise coupling into the single LED short detection.

When multiple output channels are combined to provide a higher current to one LED string, the SENSx pins can share one resistor divider for single LED short fault detection.

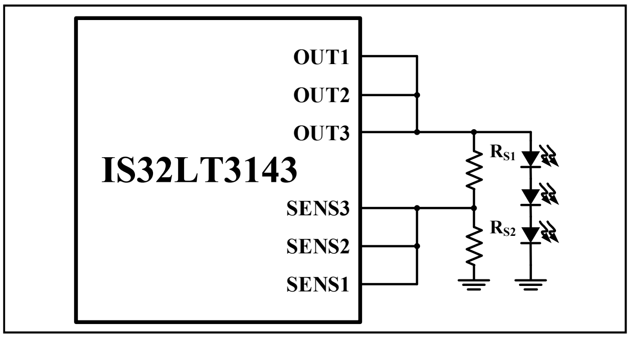


Figure 54 Single LED Short Detection Circuit of Multiple Channels in Parallel

When the input voltage V_{CC} is lower than V_{CCTH}, the device prevents single LED short fault detection. Even though a single LED short fault occurs, the device does not report the fault with the FAULTS pin.

All SENSx pins are high-voltage tolerant. If the single LED short protection of any channel is unused, the SENSx pin should be directly connected to its corresponding OUTx pin. Figure 55 shows connection when the single LED short protection of the OUT3 is unused.

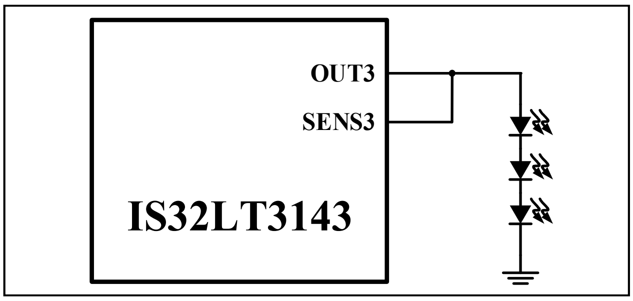


Figure 55 SENS3 Pin Unused Example

ISET PIN OPEN/SHORT PROTECTION

If the ISET pin is left open or a large value resistor (>R_{ISET_OC}) is connected to it and persists for longer than fault detection deglitch time (Typ. 40μs), the ISET pin open protection will be triggered. All output channels will be latched in off state and the FAULTB pin will go low to report the fault condition.

The device is protected from an output overcurrent condition caused by R_{ISET} resistor. Each output channel current is limited to an I_{OUT_L} value of 240mA in case of the ISET pin is shorted or too low value resistor (<R_{ISET_SC}) is connected to the ISET pin. If the condition persists for longer than fault detection deglitch time (typ. 40μs), the ISET pin short protection will be triggered. All output channels will be latched in off state and the FAULTB pin will go low to report the fault condition.

Both ISET pin open and short fault protection and reporting are not self-clearing, a toggling of EN or power cycle is required.

THERMAL SHUTDOWN

In the event that the junction temperature exceeds T_{SD} (Typ. 175˚C), all output channels will go to the OFF state and FAULTB pin will pull low to report the fault condition. At this point, the IC presumably begins to cool off. Any attempt to toggle the channels back to the source condition before the IC has cooled to below (T_{SD}-T_{SD_HYS}) (Typ. 160˚C) will be blocked and the IC will not be allowed to restart. The FAULTB pin will recover high once the IC has cooled down.

THERMAL ROLL-OFF PROTECTION

The device integrates thermal shutdown protection to prevent the device from overheating. In addition, to preventing the LEDs from flickering due to rapid thermal changes, the device also includes a programmable thermal roll-off feature to reduce power dissipation at high junction temperature.

The output current will be equal to the set value I_{OUT} as long as the junction temperature of the IC remains below the programmed thermal roll-off activation temperature threshold T_{RO}. If the junction temperature exceeds the threshold, the output current of all channels will begin to reduce at a rate of about typical 2% of I_{OUT} per °C until 50% (Typ.) of I_{OUT} following the junction temperature ramping up. Thermal roll-off protection is not reported by the fault reporting pins.

By mounting the IS32LT3143 device on the same thermal substrate as the LEDs, use of this feature can also limit the dissipation of the LEDs.

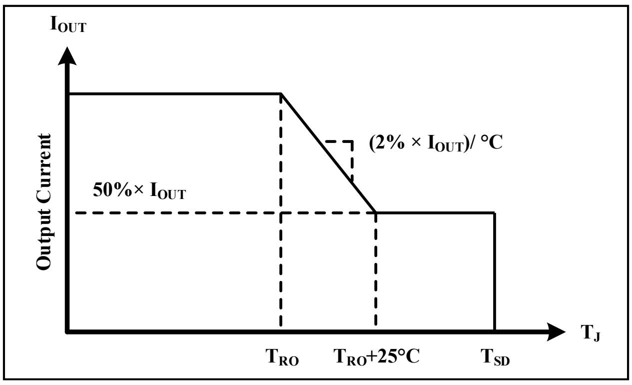


Figure 56 Thermal Roll-off

The ROTEMP pin is used to program the thermal roll-off activation temperature threshold, T_{RO}, at which the current reduction begins. With ROTEMP pin floating, the thermal roll-off activation temperature threshold, T_{RO}, is about 105°C (Typ.). The specification of T_{RO_90} in the characteristics table is the temperature at the 90% current level. The thermal roll-off activation temperature threshold T_{RO} can be programmed by a resistor, R_{ROT}, connected to the ROTEMP pin. The resistor R_{ROT} between the ROTEMP pin and GND increases T_{RO}, and between the ROTEMP pin and an external 3.3V or 5V reference voltage reduces T_{RO}. If the ROTEMP pin is directly connected to ground, the thermal roll-off activation temperature threshold, T_{RO}, is about 160°C (Typ.).

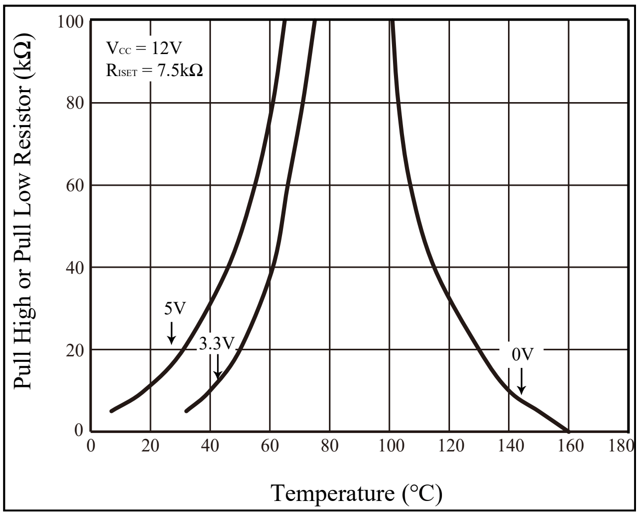


Figure 57 T_{RO} vs Pullup or Pulldown Resistors

Figure 57 shows how the nominal value of the thermal roll-off activation temperature threshold varies with the voltage at the ROTEMP pin and with either a pulldown resistor to GND or with a pullup resistor to 3.3V or 5V.

Table 1 FAULT ACTION TABLE

Failure Mode	Judgment Condition			Diagnostic Output Pins	Action	FAULTB And FAULTS	Device Reaction	Failure Removed	Self-Clearing
	Detection VCC Voltage	Channel Status	Detection Mechanism						
LED string shorted (1 or several LED strings)	V_{CC}> 5V	ON	V_{OUTx}<V_{SCD}	FAULTB	Pulled low	Externally forced high	Failing strings turned OFF, other channels ON	Toggle EN, power cycle	No
						Floating	All strings turned OFF	Toggle EN, power cycle	
Single LED shorted (1 or several LED strings)	V_{CC}> 9V	ON	V_{SENSx}< V_{SENS_TH}	FAULTS	Pulled low	Externally forced high	All strings stay ON	Toggle EN, power cycle	No
						Floating	All strings stay ON	Toggle EN, power cycle	
LED string open (1 or several LED strings)	V_{CC}> 9V	ON	(V_{CC}-V_{OUTx})< V_{OCD}	FAULTB	Pulled low	Externally forced high	All strings stay ON	(V_{CC}-V_{OUTx})> (V_{OCD}+V_{OCD_HYS})	Yes
						Floating	Failing string stays ON, other channels turned OFF	(V_{CC}-V_{OUTx})> (V_{OCD}+V_{OCD_HYS})	
Shorted to battery (1 or several LED strings)	V_{CC}> 9V	ON or OFF	(V_{CC}-V_{OUTx})< V_{OCD}	FAULTB	Pulled low	Externally forced high	All strings stay ON	(V_{CC}-V_{OUTx})> (V_{OCD}+V_{OCD_HYS})	Yes
						Floating	Failing string stays ON, other channels turned OFF	(V_{CC}-V_{OUTx})> (V_{OCD}+V_{OCD_HYS})	
Thermal shutdown	V_{CC}> 5V	ON or OFF	Temperature > T_{SD}	FAULTB	Pulled low	Externally forced high	All strings turned OFF	Temperature< (T_{SD}-T_{SD_HYS})	Yes
						Floating			
Thermal roll-off	V_{CC}> 5V	ON or OFF	Temperature > T_{RO}	N/A	None	N/A	All strings with reduced current	Temperature< T_{RO}	Yes
ISET pin open	V_{CC}> 5V	ON or OFF	R_{ISET}> R_{ISET_OC}	FAULTB	Pulled low	N/A	All strings turned OFF	Toggle EN, power cycle	No
ISET pin shorted	V_{CC}> 5V	ON or OFF	R_{ISET}< R_{ISET_SC}	FAULTB	Pulled low	N/A	All strings turned OFF	Toggle EN, power cycle	No

THERMAL CONSIDERATIONS

The package thermal resistance, θ_{JA}, determines the amount of heat that can pass from the silicon die to the surrounding ambient environment. The θ_{JA} is a measure of the temperature rise created by power dissipation and is usually measured in degree Celsius per watt (°C/W). The junction temperature, T_J, can be calculated by the rise of the silicon temperature, ΔT, the power dissipation on IS32LT3143, P_{3143}, and the package thermal resistance, θ_{JA}, as in following equations:

$$P_{3143} = V_{CC} \times I_{CC} + \sum_{x=1}^{3}(V_{CC} - V_{LEDx}) \times I_{OUT} \quad (6)$$

and,

$$T_J = T_A + \Delta T = T_A + P_{3143} \times \theta_{JA} \quad (7)$$

Where, I_{CC} is the IC quiescent current, V_{LEDx} is the voltage of the OUTx pin to ground, I_{OUT} is the output current of OUTx pin and T_A is the ambient temperature.

When operating the chip at high ambient temperatures, or when the supply voltage is high, care must be taken to avoid exceeding the package power dissipation limits. The maximum power dissipation at T_A=25˚C can be calculated using the following equation:

$$P_{D(MAX)} = \frac{150°C - 25°C}{\theta_{JA}} \quad (8)$$

So,

$$P_{D(MAX)} = \frac{150°C - 25°C}{45.4°C/W} \approx 2.75W$$

for eTSSOP-16 package.

Figure 58 shows the power derating of the IS32LT3143 on a JEDEC board (in accordance with JESD 51-5 and JESD 51-7) standing in still air.

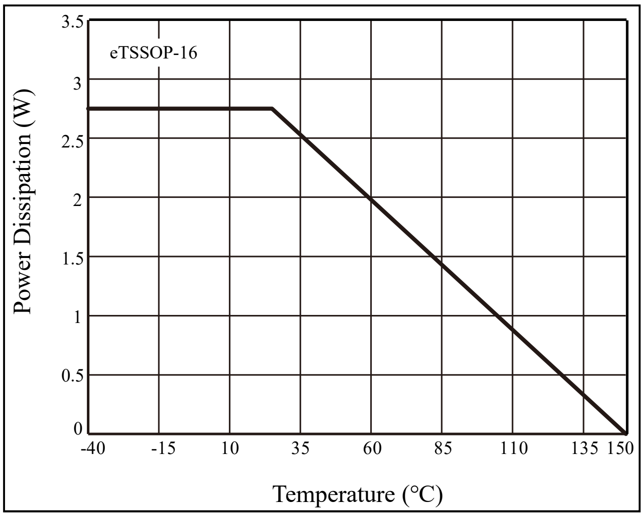


Figure 58 Dissipation Curve

When designing the Printed Circuit Board (PCB) layout, double-sided PCB with a large copper area on each side of the board directly under the IS32LT3143 and the thermal shunt resistor. Multiple thermal vias, as shown in Figure 59, will help to conduct heat from the exposed pad of the IS32LT3143 and the thermal shunt resistor to the copper on each side of the board.

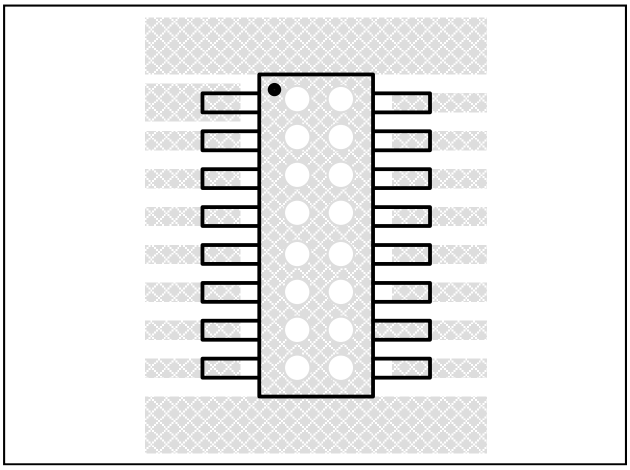


Figure 59 Board Via Layout For Thermal Dissipation

CLASSIFICATION REFLOW PROFILES

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature min (Tsmin) Temperature max (Tsmax) Time (Tsmin to Tsmax) (ts)	150°C 200°C 60-120 seconds
Average ramp-up rate (Tsmax to Tp)	3°C/second max.
Liquidous temperature (TL) Time at liquidous (tL)	217°C 60-150 seconds
Peak package body temperature (Tp)*	Max 260°C
Time (tp)** within 5°C of the specified classification temperature (Tc)	Max 30 seconds
Average ramp-down rate (Tp to Tsmax)	6°C/second max.
Time 25°C to peak temperature	8 minutes max.

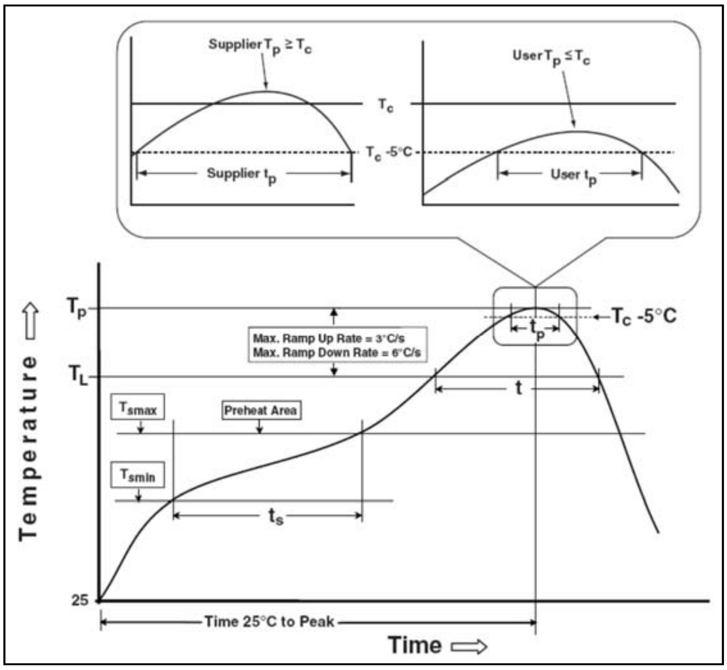


Figure 60 Classification Profile

PACKAGE INFORMATION

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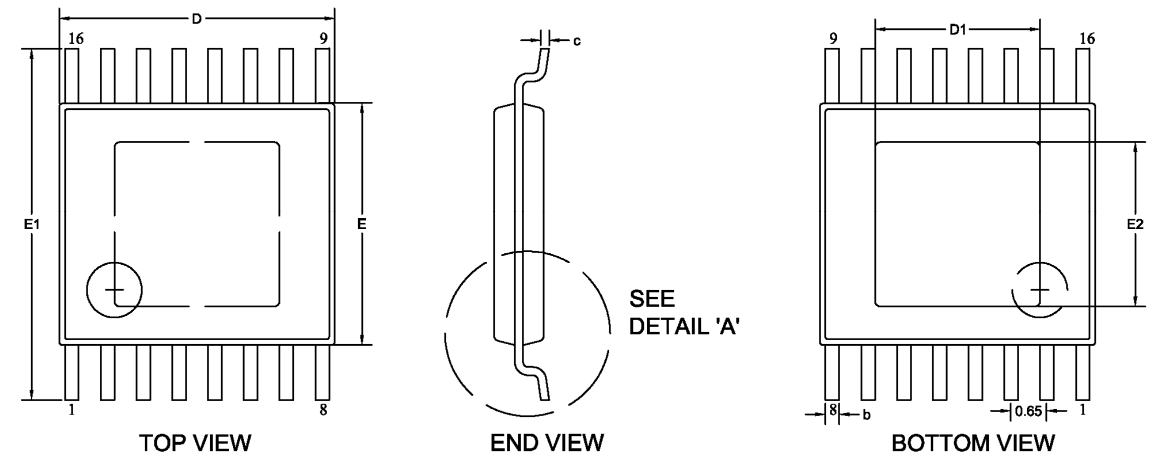

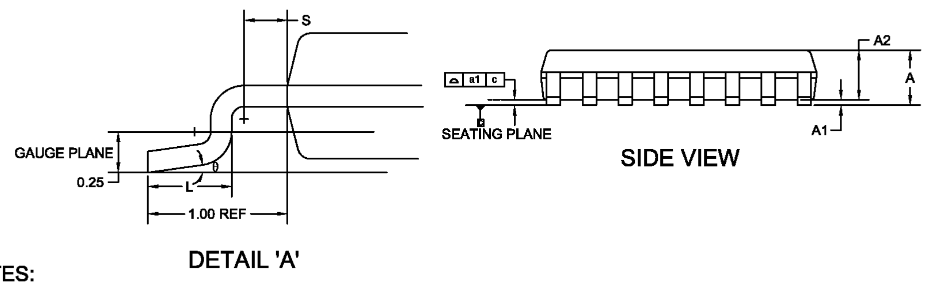

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1. 20
A1	0.00	—	0. 15
A2	0. 80	0.90	1. 05
D	4. 90	5.00	5. 10
D1	1. 70	—	—
E	4. 30	4. 40	4. 50
E1	6. 40BSC		
E2	1. 50	—	—
L	0. 45	0. 60	0. 75
b	0. 19	—	0. 30
S	0. 20		
c	0. 09	—	0. 20
θ	0°		8°
a1	0. 10		

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NOTES:

1)The thermal pad shows different shape among different factories.

2)Controlling dimension:mm

3)Reference document:JEDEC MO-153

RECOMMENDED LAND PATTERN

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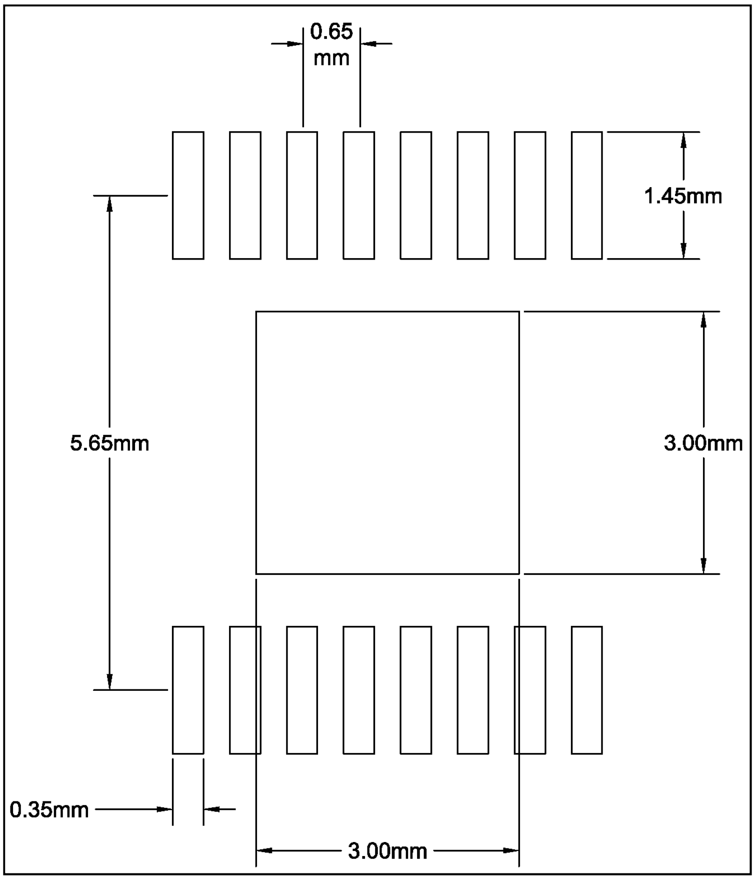

Note:

1. Land pattern complies to IPC-7351.
2. All dimensions in MM.
3. This document (including dimensions, notes & specs) is a recommendation based on typical circuit board manufacturing parameters. Since land pattern design depends on many factors unknown (eg. user's board manufacturing specs), user must determine suitability for use.

REVISION HISTORY

Revision	Detail Information	Date
A	Initial release	2023.06.25
B	1. Update to new Lumissil logo 2. Update description about deglitch time 3. EC condition “TA=TJ=” changes to “TJ=”	2024.05.08