

IS32LT3154A

FOUR-CHANNEL LINEAR LED DRIVER WITH INDIVIDUAL PWM DIMMING AND ANALOG DIMMING

February 2026

GENERAL DESCRIPTION

The IS32LT3154A is a linear programmable LED driver consisting of four output channels capable of sourcing up to 150mA per channel. External power resistors can be used to shunt thermal heat and reduce thermal stress on the driver. Independent resistor sets the maximum current level for each channel. The outputs can be combined to provide a higher current drive capability up to a maximum of 600mA. It supports individual PWM dimming control for each channel. A dedicated current control pin (ICTRL) supports off-board brightness binning resistors to simplify the manufacturing process, or an NTC resistor to provide LED over temperature protection.

For added system reliability, the IS32LT3154A integrates fault detection circuitry for LED string open/short, single LED short, and over temperature thermal conditions. The FAULTB pin is a bi-directional open drain pin for reporting the occurrence of a device fault and for receiving system fault inputs. The system FAULTB pins can all be tied together to disable the IS32LT3154A device and other IS32LT3154A devices on the same parallel circuit to satisfy the “one-fail-all-fail” requirement.

The IS32LT3154A is targeted at the automotive market with end applications to include interior and exterior lighting. For 12V automotive applications, the low dropout driver can support one to several LEDs on the output channels. The device is offered in a small thermally enhanced eTSSOP-24 package.

APPLICATIONS

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

FEATURES

- Wide input voltage range: 4.5V~40V
- Support thermal shunt resistors to lower device thermal stress
- Four current source channels with programmable constant current
 - Up to 150mA output current per channel
 - $\pm 5\%$ current accuracy over the operating temperature range
 - Independent current set resistor
 - Support for off-board brightness binning resistor
 - Support an external NTC for LED over temperature current derating
- Low headroom voltage
 - Max. dropout: 0.6V at 150mA per channel
- Independent logic level PWM dimming per channel
- Low supply current (Typ. 75 μ A) in fault mode
- Fault detection and protection
 - LED string open/short
 - Single LED short
 - External UVLO setting
 - Current reference set resistor open/short
 - Thermal shutdown
 - Shared fault flag for multiple device operation to comply with “one-fail-all-fail” function
- 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

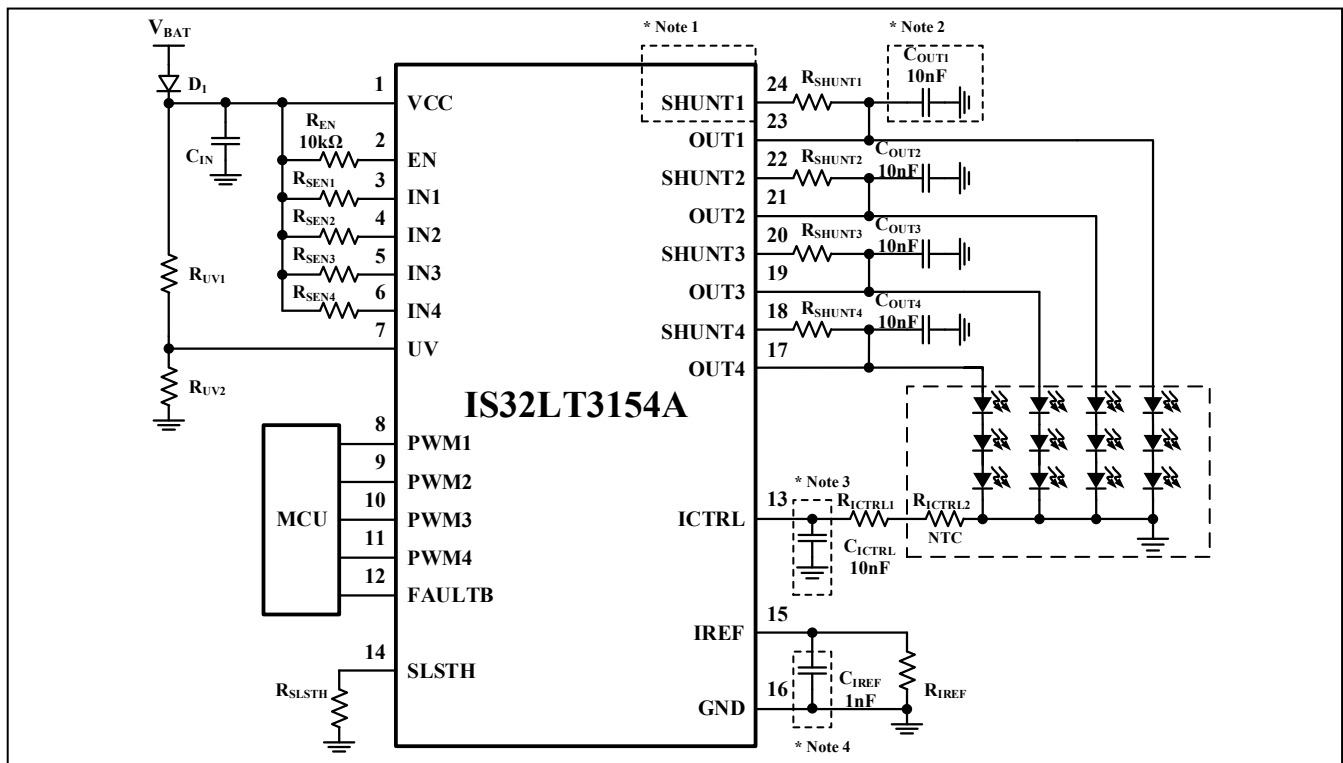


Figure 1 Typical Application Circuit

Note 1: The thermal shunt mechanism ($R_{SHUNT1} \sim R_{SHUNT4}$) is optional and not necessary for stable power supplies exhibiting minimal voltage variation. If not used, connect the SHUNT x pin to the corresponding OUT x pin directly. The SHUNT x pin should not be left floating.

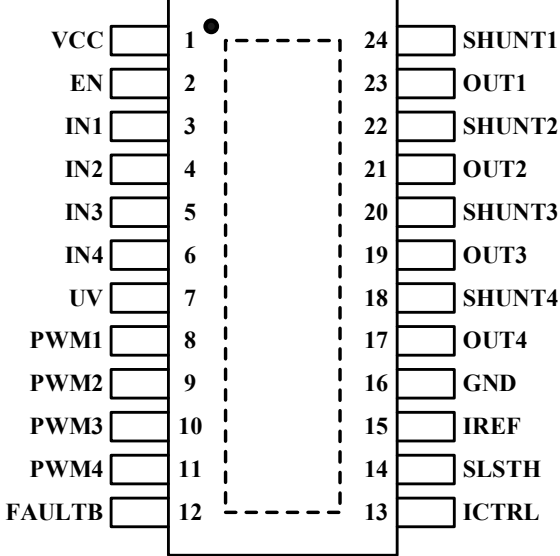
Note 2: OUT x pin needs to be connected to a 10nF capacitor, placing it as close as possible to the IC to achieve noise decoupling.

Note 3: ICTRL pin needs to be connected to a 10nF capacitor, placing it as close as possible to the IC to achieve noise decoupling.

Note 4: IREF pin needs to be connected to a 1nF capacitor, placing it as close as possible to the IC to achieve noise immunity.

Note 5: If any output channel is unused, tie its corresponding PWM pin to ground to disable it, and directly connect the corresponding IN x /OUT x /SHUNT x pins to the VCC pin.

PIN CONFIGURATION

Package	Pin Configuration (Top View)
eTSSOP-24	

PIN DESCRIPTION

No.	Pin	Description
1	VCC	Power supply pin.
2	EN	Device enable pin. When EN is low, the device is in shutdown mode with ultra-low quiescent current.
3~6	IN1~IN4	Current input pin for channel 1 ~ channel 4
7	UV	Under voltage lockout threshold setting pin for LED string open and signal LED short fault detection to avoid false LED string open and single LED short detection during low headroom voltage operation. Pull low will disable the LED string open and single LED short fault detection.
8~11	PWM1~PWM4	PWM input for OUTx and SHUNTx current output ON/OFF control.
12	FAULTB	Fault reporting pin. Supports one-fails-all-fail fault parallel bus connection.
13	ICTRL	Programmable voltage reference pin to adjust the output current for LED binning resistor or NTC resistor.
14	SLSTH	Programmable voltage reference pin for single LED short detection threshold.
15	IREF	Current reference pin. A 12.3kΩ resistor is recommended to be connected between IREF pin and ground.
16	GND	Ground pin.
17,19,21,23	OUT4~OUT1	Current output for channels 4 ~ 1. A 10nF capacitor is recommended from each pin to GND. These capacitors need to be placed as close as possible to the corresponding OUTx pins.
18,20,22,24	SHUNT4 ~SHUNT1	Current output for channel 4 ~ 1 with external thermal shunt resistors. Do not leave them floating.
	Thermal Pad	Must be connected to GND with sufficient copper plate for heat sink.

IS32LT3154A



ORDERING INFORMATION

Automotive Range: -40°C to +125°C

Order Part No.	Package	QTY/Reel
IS32LT3154A-ZLCA3-TR	eTSSOP-24, Lead-free	2500

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- a.) the risk of injury or damage has been minimized;
- b.) the user assume all such risks; and
- c.) potential liability of Lumissil Microsystems is adequately protected under the circumstances

ABSOLUTE MAXIMUM RATINGS (NOTE 6)

Voltage at VCC pin	-0.3V ~ +45V
Voltage at UV, IN1~IN4, PWM1~PWM4, FAULTB, ICTRL, OUT1~OUT4 and SHUNT1~SHUNT4 pins	-0.3V ~ V _{CC} +0.3V
Voltage at IREF and SLSTH pins	-0.3V ~ +5.5V
Operating temperature, T _A =T _J	-40°C ~ +150°C
Storage temperature, T _{STG}	-65°C ~ +150°C
Junction temperature, T _{JMAX}	+150°C
Power dissipation, P _{D(MAX)}	4.55W
Package thermal resistance, junction to ambient (4-layer standard test PCB based on JESD 51-2A), θ_{JA}	27.5°C/W
Package thermal resistance, junction to case (bottom) (4-layer standard test PCB based on JESD 51-14), θ_{JC_BOT}	9.5°C/W
ESD (HBM)	±2kV
ESD (CDM)	±750V

Note 6: 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 condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

Valid are at V_{CC}= 5V~40V, T_J= -40°C to +150°C, unless noted otherwise. Refer to each condition description.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Input Supply						
V _{CC}	Operating input voltage range		4.5		40	V
V _{POR_R}	Supply voltage POR rising threshold	Voltage rising		3.5	4.4	V
V _{POR_F}	Supply voltage POR falling threshold	Voltage falling	2.5	3.3		V
I _{CC}	Quiescent ground current	EN= PWMx= High		2.5	3	mA
I _{SD}	Shutdown mode current	EN= 0V		6.5	50	μA
I _{FAULT}	Supply current in fault mode	PWMx=High, FAULTB externally pulled low		75	200	μA
t _{ST}	Startup time from V _{CC} rising edge to current rising edge after first power-up	V _{OUTx} =6V, V _{SENx} =100mV, R _{SENx} =0.66Ω, R _{SHUNTx} =56Ω, C _{IREF} =C _{ICTRL} =10pF		60	100	μs
Current Regulation						
I _{OUT_R}	Output current range per channel	I _{OUTx} + I _{SHUNTx} , 100% duty cycle	-150		-5	mA
R _{SEN_RG}	Current sense resistor range		0.65		20	Ω
V _{SEN}	Current sense resistor regulation voltage (voltage across VCC and INx)	T _J = -40°C to +125°C, R _{IREF} = 12.35kΩ, R _{ICTRL} = 0.2kΩ	36	40	44	mV
		T _J = -40°C to +125°C, R _{IREF} = 12.35kΩ, R _{ICTRL} = 0.5kΩ	95	100	105	
		T _J = -40°C to +125°C, R _{IREF} = 12.35kΩ, R _{ICTRL} = 1kΩ	192	200	208	
		T _J = -40°C to +125°C, R _{IREF} = 12.35kΩ, R _{ICTRL} = 2kΩ	384	400	416	

ELECTRICAL CHARACTERISTICS (CONTINUE)Valid are at $V_{CC}=5V\sim40V$, $T_J=-40^{\circ}C$ to $+150^{\circ}C$, unless noted otherwise. Refer to each condition description.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{SEN_SAT}	Current sense regulation saturated voltage ($V_{CC}-V_{INx}$)	$T_J=-40^{\circ}C$ to $+125^{\circ}C$, $R_{IREF}=12.35k\Omega$, $R_{ICTRL}=2.3k\Omega$	404	420	436	mV
ΔV_{SEN_MA}	Channel to channel mismatching in one device ($\Delta V_{SEN_MA}=1-V_{SENx}/V_{SEN_AVG}$)	$T_J=25^{\circ}C$, $V_{CC}=12V$, $R_{IREF}=12.35k\Omega$, $R_{ICTRL}=0.5k\Omega$	-2		2	%
		$T_J=-40^{\circ}C$ to $+125^{\circ}C$, $R_{IREF}=12.35k\Omega$, $R_{ICTRL}=0.5k\Omega$	-3		3	
		$T_J=25^{\circ}C$, $V_{CC}=12V$, $R_{IREF}=12.35k\Omega$, $R_{ICTRL}=1k\Omega$	-2		2	
		$T_J=-40^{\circ}C$ to $+125^{\circ}C$, $R_{IREF}=12.35k\Omega$, $R_{ICTRL}=1k\Omega$	-3		3	
ΔV_{SEN_AC}	Device to device accuracy ($\Delta V_{SEN_AC}=1-V_{SEN_AVG}/V_{SEN_NOM}$)	$T_J=25^{\circ}C$, $V_{CC}=12V$, $R_{IREF}=12.35k\Omega$, $R_{ICTRL}=0.5k\Omega$	-2.5		2.5	%
		$T_J=-40^{\circ}C$ to $+125^{\circ}C$, $R_{IREF}=12.35k\Omega$, $R_{ICTRL}=0.5k\Omega$	-4		4	
		$T_J=25^{\circ}C$, $V_{CC}=12V$, $R_{IREF}=12.35k\Omega$, $R_{ICTRL}=1k\Omega$	-2.5		2.5	
		$T_J=-40^{\circ}C$ to $+125^{\circ}C$, $R_{IREF}=12.35k\Omega$, $R_{ICTRL}=1k\Omega$	-4		4	
V_{HR_MIN}	Minimum headroom voltage from INx to $OUTx$, $SHUNTx$ open	Current setting of 100mA		200	400	mV
		Current setting of 150mA		300	600	
	Minimum headroom voltage from INx to $SHUNTx$, $OUTx$ open	Current setting of 100mA		330	600	mV
		Current setting of 150mA		460	800	
I_{SHUNTx}	Ratio of $SHUNTx$ current to total current ($I_{OUTx} + I_{SHUNTx}$)	I_{SHUNTx}/I_{OUTx_TOT} , $V_{INx}-V_{SHUNTx}>1V$, $T_J=25^{\circ}C$ to $+125^{\circ}C$	95			%
V_{IREF}	IREF pin voltage			1.235		V
N_{ICTRL}	ICTRL output current ratio	I_{ICTRL}/I_{IREF}	9.7	10	10.3	
R_{ICTRL_RG}	Analog dimming resistor value range	$R_{IREF}=12.35k\Omega$	0.2		2.0	k Ω
R_{ICTRL_FU}	Analog dimming fully on resistor value	$R_{IREF}=12.35k\Omega$	2.3			k Ω
R_{ICTRL_DIS}	The minimum ICTRL resistor at which disable output current	$R_{IREF}=12.35k\Omega$	50	100	150	Ω
R_{ICTRL_EN}	The minimum ICTRL resistor at which enable output current	$R_{IREF}=12.35k\Omega$	100	150	195	Ω
V_{ICTRL_CLP}	ICTRL pin internally clamp-up voltage	ICTRL pin floating, $C_{ICTRL}=10nF$		4.5		V
Inputs (EN, UV and PWM)						
V_{IL_EN}	EN pin input logic low voltage				0.7	V
V_{IH_EN}	EN pin input logic high voltage		2			V

ELECTRICAL CHARACTERISTICS (CONTINUE)

Valid are at $V_{CC} = 5V \sim 40V$, $T_J = -40^{\circ}C$ to $+150^{\circ}C$, unless noted otherwise. Refer to each condition description.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
I _{PD_EN}	EN pin internal pull-down current	V _{EN} =12V	1.5	3.3	6	μA
V _{IL_UV}	UV pin input logic low voltage		1.045	1.1	1.155	V
V _{IH_UV}	UV pin input logic high voltage		1.14	1.2	1.26	V
V _{IL_PWM}	PWM pin input logic low voltage		1.045	1.1	1.155	V
V _{IH_PWM}	PWM pin input logic high voltage		1.14	1.2	1.26	V
t _{PWM_RD}	Delay time of PWM rising edge to 10% output current	V _{CC} =12V, V _{OUTx} =6V, V _{SENx} =200mV, R _{SENx} =1.33Ω, R _{SHUNTx} =56Ω		3.5		μs
t _{PWM_FD}	Delay time of PWM falling edge to 90% output current	V _{CC} =12V, V _{OUTx} =6V, V _{SENx} =200mV, R _{SENx} =1.33Ω, R _{SHUNTx} =56Ω		4		μs
t _{SL_R}	Current rising slew time (rising from 10% to 90% levels)	V _{CC} =12V, V _{OUTx} =6V, V _{SENx} =100mV, R _{SENx} =1.33Ω, R _{SHUNTx} =56Ω		5		μs
		V _{CC} =12V, V _{OUTx} =6V, V _{SENx} =200mV, R _{SENx} =1.33Ω, R _{SHUNTx} =56Ω		7		
t _{SL_F}	Current falling slew time (falling from 90% to 10% levels)	V _{CC} =12V, V _{OUTx} =6V, V _{SENx} =100mV, R _{SENx} =1.33Ω, R _{SHUNTx} =56Ω		3		μs
		V _{CC} =12V, V _{OUTx} =6V, V _{SENx} =200mV, R _{SENx} =1.33Ω, R _{SHUNTx} =56Ω		8		
Protections						
V _{OCD_R}	LED string open detection rising threshold	Measured at (V _{INx} -V _{OUTx}), V _{CC} = 5V~30V	180	300	480	mV
V _{OCD_F}	LED string open detection falling threshold	Measured at (V _{INx} -V _{OUTx}) V _{CC} = 5V~30V		450		mV
V _{SCD_R}	LED string short detection rising threshold	Measured at OUTx/SHUNTx to GND	1.14	1.2	1.26	V
V _{SCD_F}	LED string short detection falling threshold	Measured at OUTx/SHUNTx to GND	0.83	0.9	0.97	V
t _{OS_DEG}	LED string open and short detection deglitch time			125		μs
t _{OSRC_DEG}	LED string open and short fault recovery detection deglitch time			125		μs
I _{RTR_OUT}	LED string open/short retry current on OUTx pin		0.64	1.08	1.8	mA
I _{RTR_SHUNT}	LED string open/short retry current on SHUNTx pin		0.64	1.08	1.8	mA
N _{SLSTH}	SLSTH output current ratio	I _{SLSTH} /I _{REF}	0.97	1	1.03	
N _{OUT}	OUT voltage attenuation ratio	V _{OUTx} = 3V to 13V	4.74	5	5.26	
V _{SLSTH_RG}	Voltage threshold range of single LED short detection		3		13	V

ELECTRICAL CHARACTERISTICS (CONTINUE)Valid are at $V_{CC}=5V\sim40V$, $T_J=-40^{\circ}C$ to $+150^{\circ}C$, unless noted otherwise. Refer to each condition description.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
t_{SLS_DEG}	Single LED short detection deglitch time			135		μs
t_{SLS_RT}	Single LED short detection fault retry interval time			10		ms
t_{SLS_RTPR}	Single LED short detection fault retry period time			300		μs
t_{SLS_RTDEG}	Single LED short detection fault retry deglitch time			60		μs
I_{REF_OCD}	IREF pin open threshold			7		μA
V_{REF_SCD}	IREF pin short threshold			0.6		V
t_{REF_DEG}	IREF pin open/short detection deglitch time			125		μs
I_{REF_CLP}	IREF pin current clamp			450		μA
V_{IL_FLT}	FAULTB pin input logic low voltage				0.7	V
V_{IH_FLT}	FAULTB pin input logic high voltage		2			V
V_{FLT_PU}	FAULTB pin internal pull-up voltage			4.3		V
t_{FLT_R}	FAULTB pin detection rising edge deglitch time			65		μs
t_{FLT_F}	FAULTB pin detection falling edge deglitch time			55		μs
t_{FLT_DEL}	Fault recover delay time			60		μs
I_{FLT_PD}	FAULTB pin internal pull-down current	$V_{FAULTB}=0.5V$	2	3	4	mA
I_{FLT_PU}	FAULTB pin internal pull-up current		6	11	18	μA
I_{FLT_LKG}	FAULTB pin leakage current	$V_{FAULTB}=40V$		1	2	μA
I_{OUT_LKG}	Channel leakage current on OUTx pin	PWMx=Low, $V_{OUTx}=0V$			1	μA
I_{SHUNT_LKG}	Channel leakage current on SHUNTx pin	PWMx=Low, $V_{SHUNTx}=0V$			1	μA
T_{SD}	Over temperature shutdown	Temperature increasing (Note 7)		175		$^{\circ}C$
T_{SDHY}	Over temperature hysteresis	Recovery= $T_{SD} - T_{SDHY}$ (Note 7)		20		$^{\circ}C$

Note 7: Guaranteed by design and characterization.

TYPICAL PERFORMANCE CHARACTERISTICS

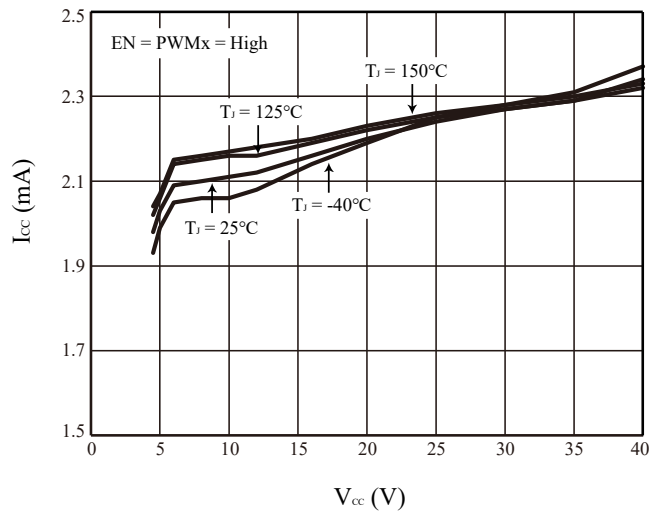


Figure 2 I_{CC} vs. V_{CC}

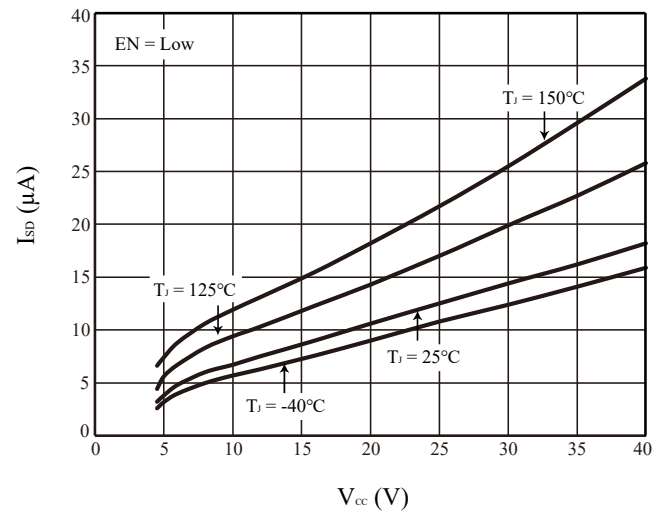


Figure 3 I_{SD} vs. V_{CC}

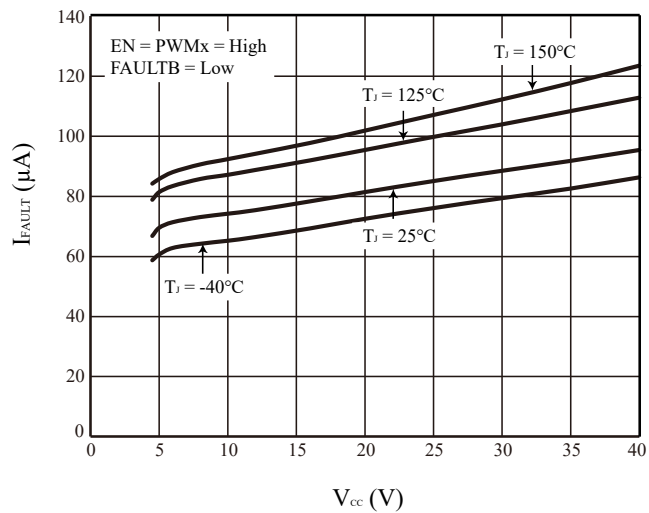


Figure 4 I_{FAULT} vs. V_{CC}

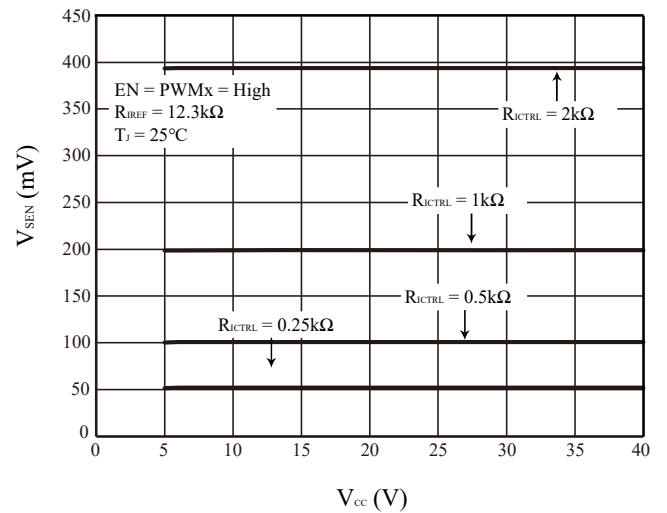


Figure 5 V_{SEN} vs. V_{CC}

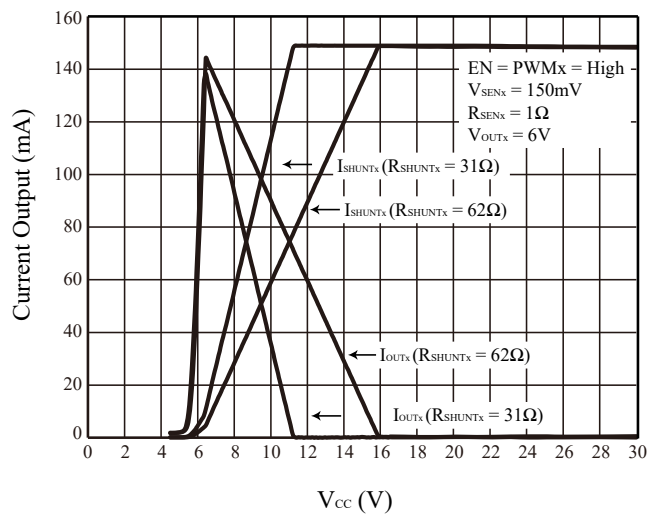


Figure 6 Output Current Distribution vs. V_{CC}

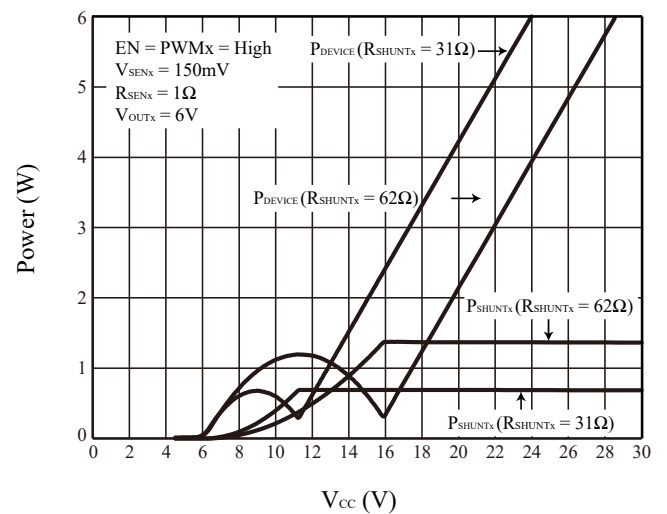


Figure 7 Power Dissipation vs. V_{CC}

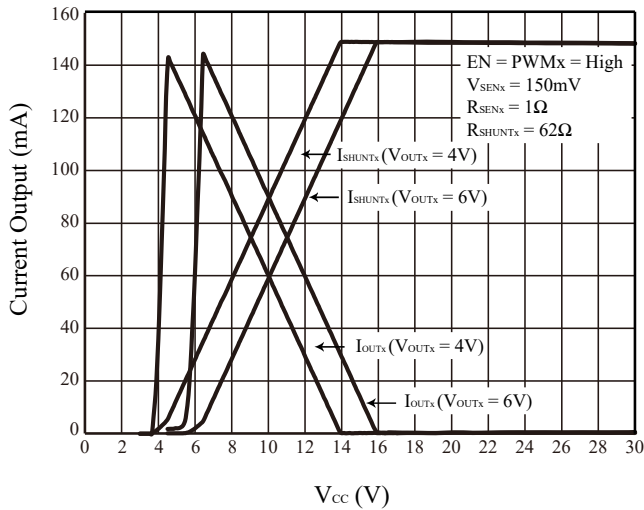


Figure 8 Output Current Distribution vs. V_{CC}

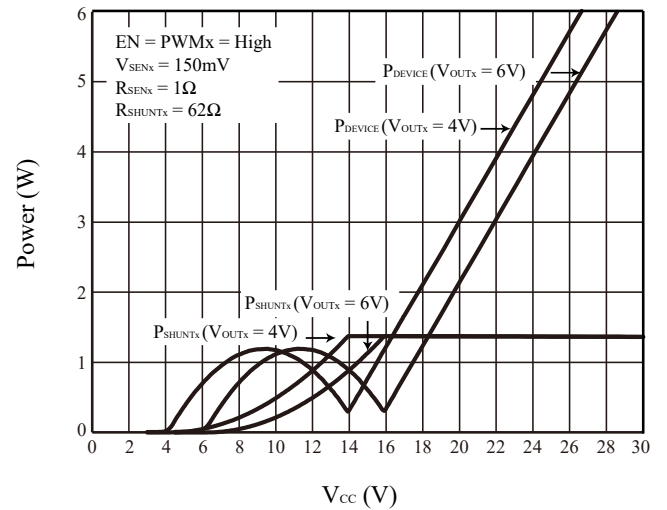


Figure 9 Power Dissipation vs. V_{CC}

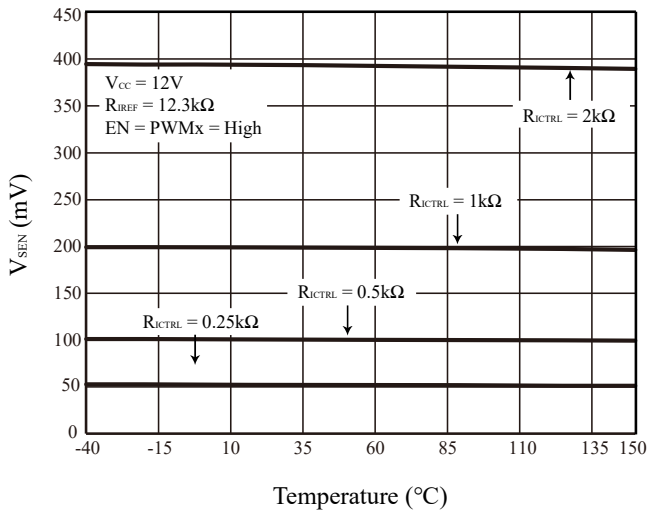


Figure 10 V_{SEN} vs. Temperature

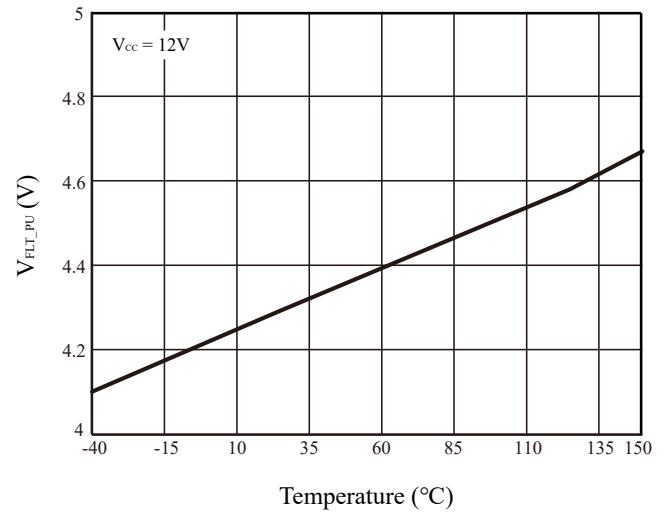


Figure 11 V_{FLT_PU} vs. Temperature

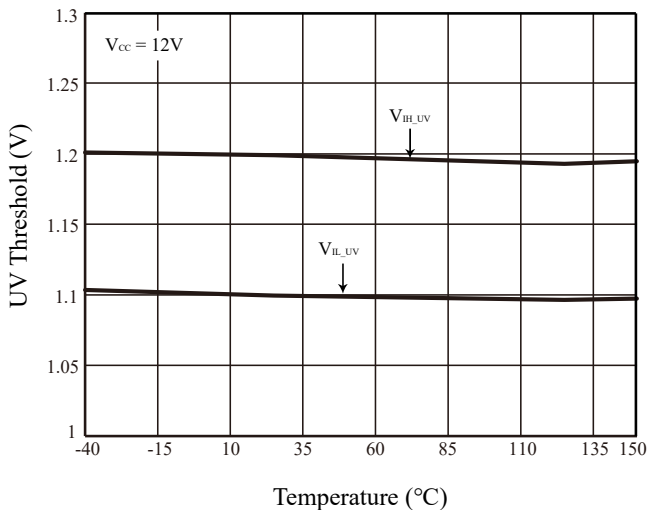


Figure 12 UV Threshold vs. Temperature

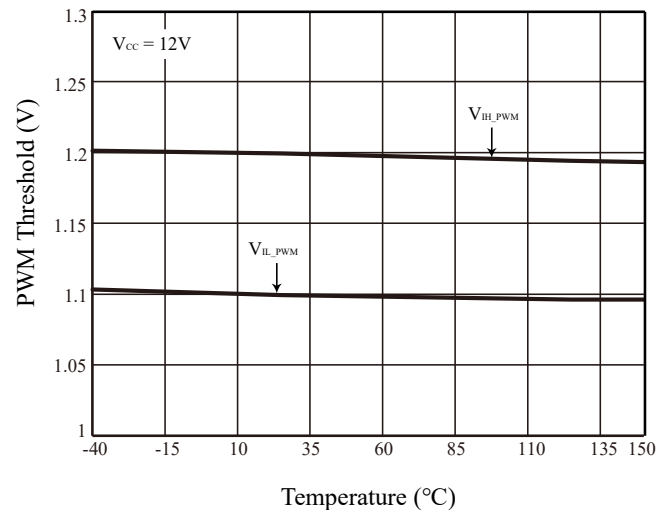


Figure 13 PWM Threshold vs. Temperature

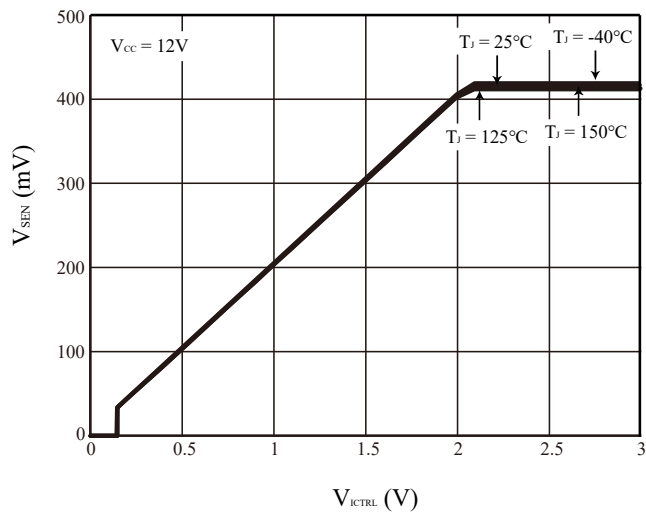


Figure 14 V_{SEN} vs. V_{ICTRL}

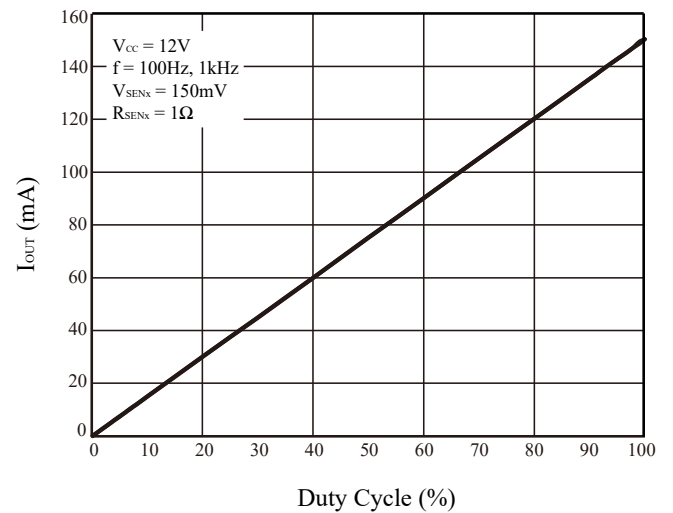


Figure 15 I_{OUT} vs. Duty Cycle

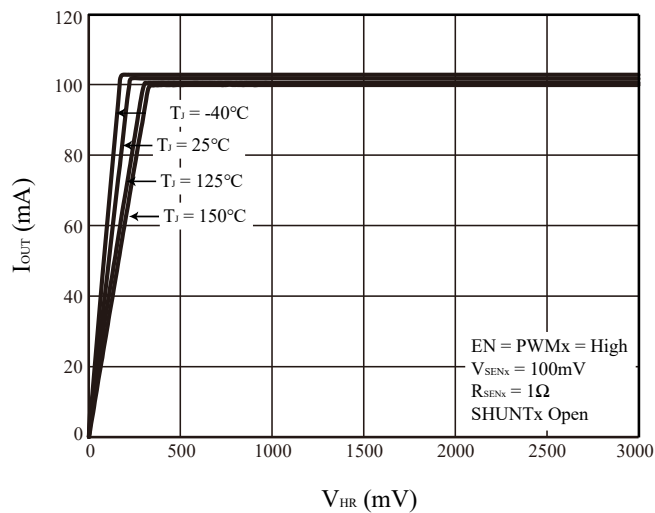


Figure 16 I_{OUT} vs. V_{HR}

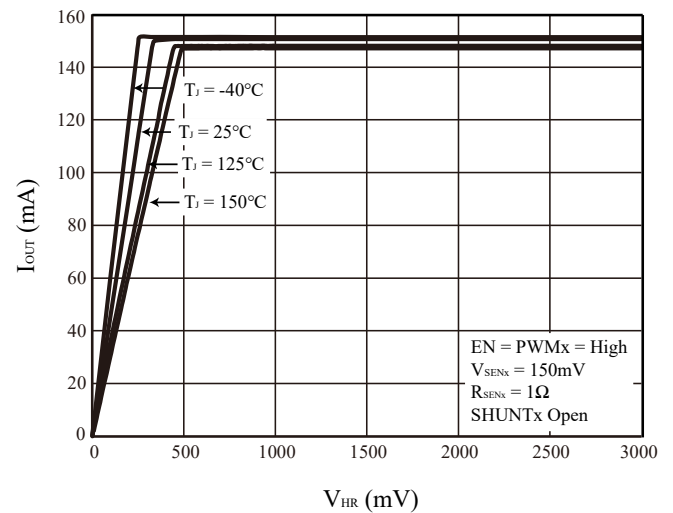


Figure 17 I_{OUT} vs. V_{HR}

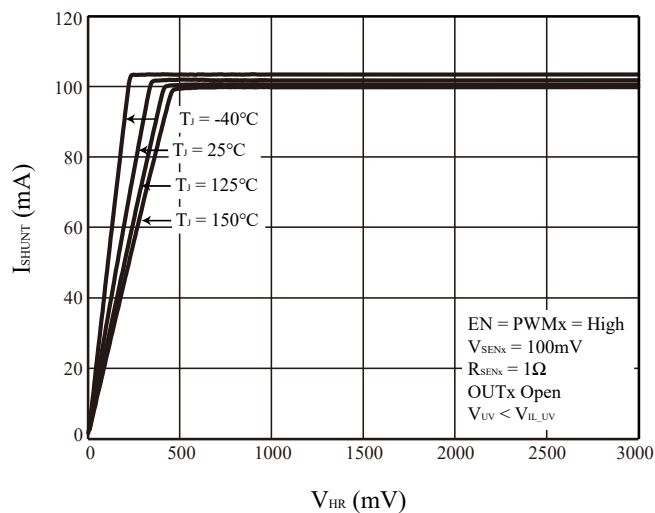


Figure 18 I_{SHUNT} vs. V_{HR}

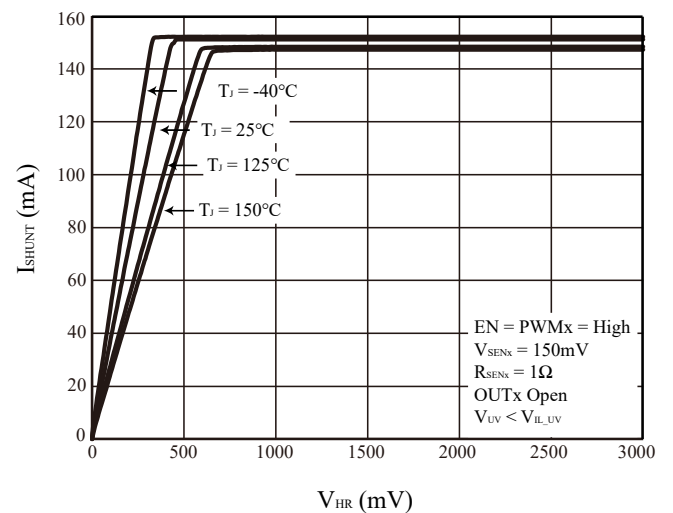


Figure 19 I_{SHUNT} vs. V_{HR}

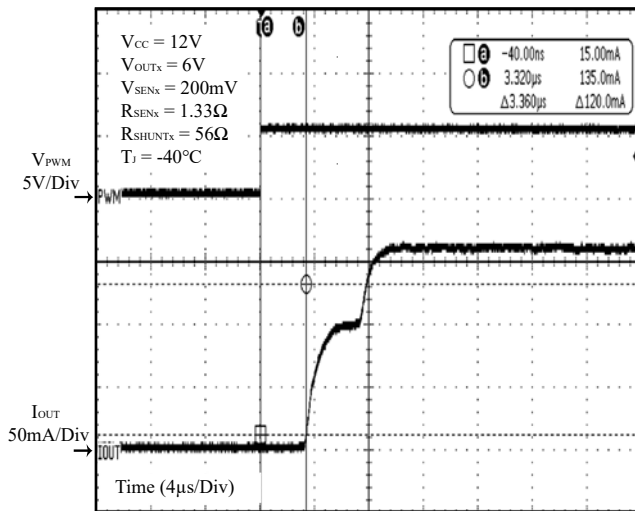


Figure 20 PWM On Delay Time

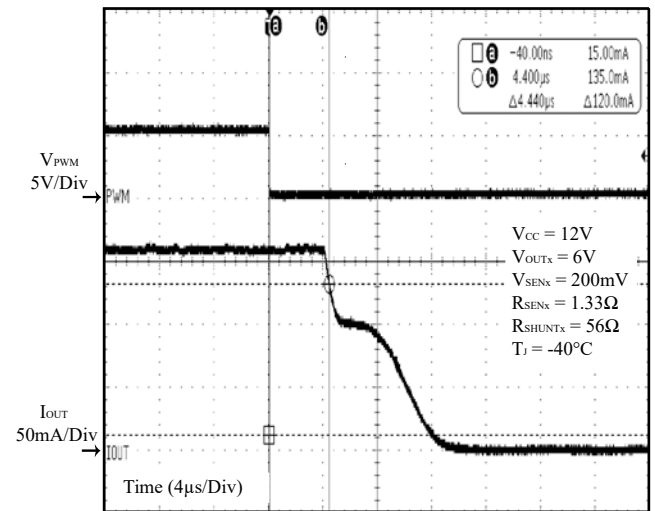


Figure 21 PWM Off Delay Time

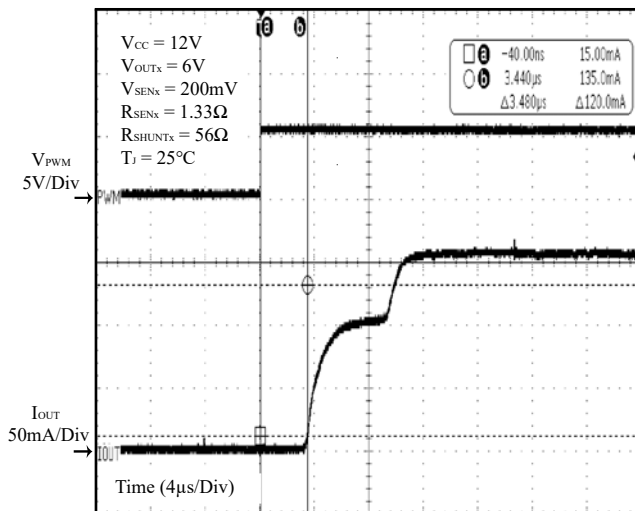


Figure 22 PWM On Delay Time

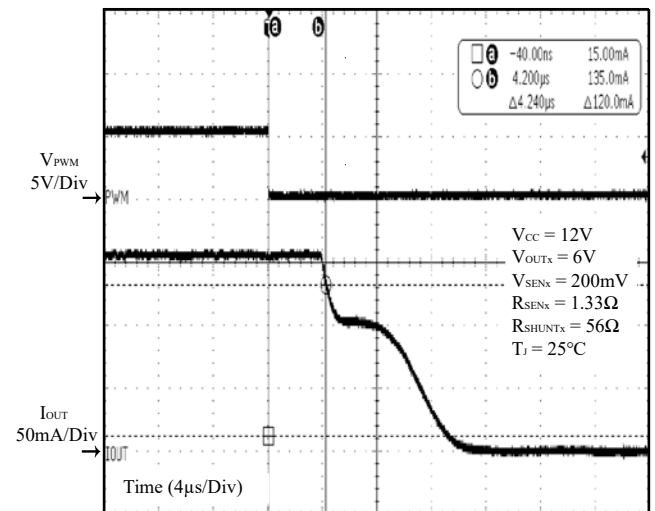


Figure 23 PWM Off Delay Time

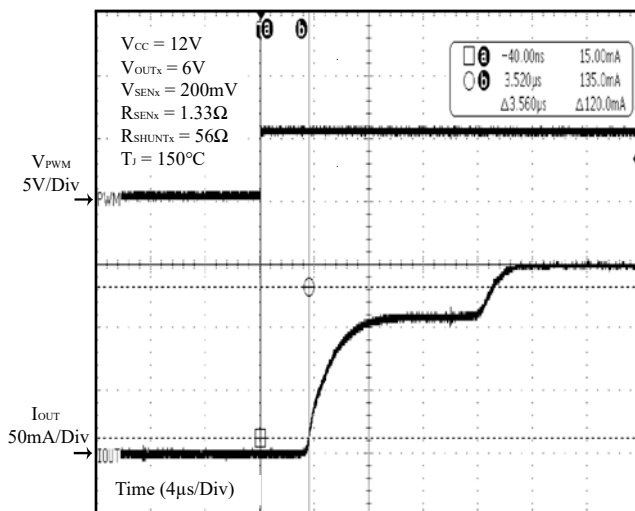


Figure 24 PWM On Delay Time

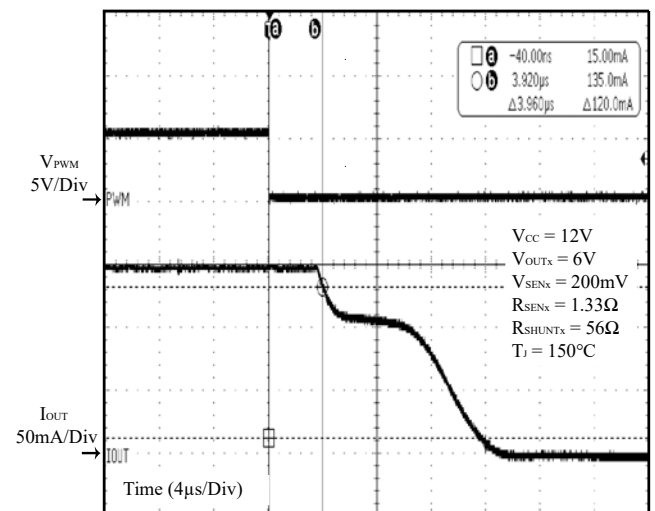


Figure 25 PWM Off Delay Time

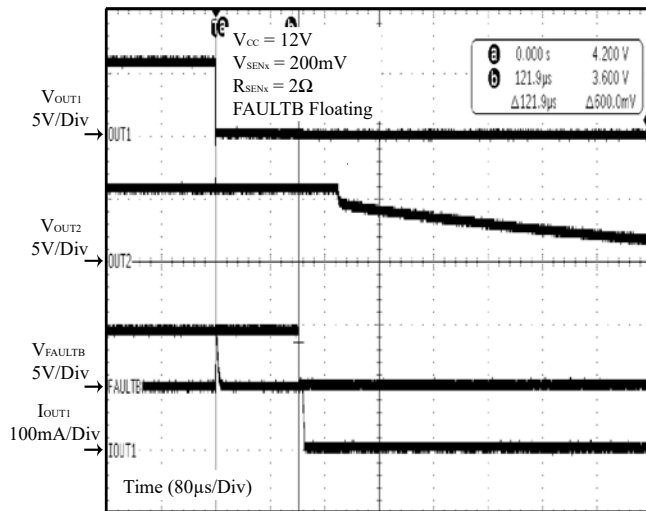


Figure 26 LED Short To GND

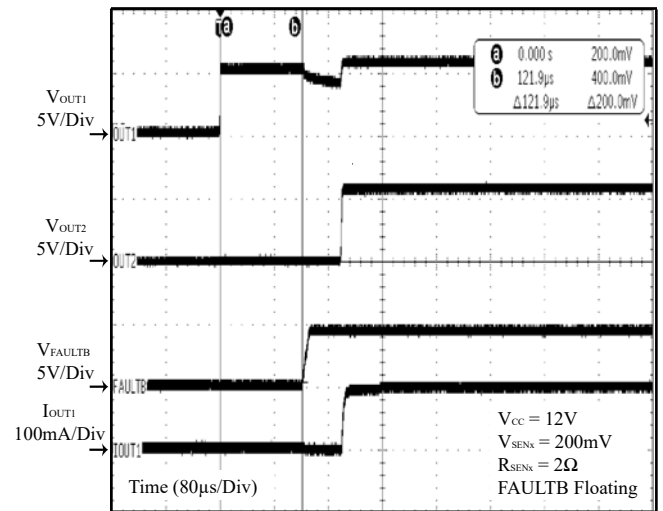


Figure 27 LED Short Remove

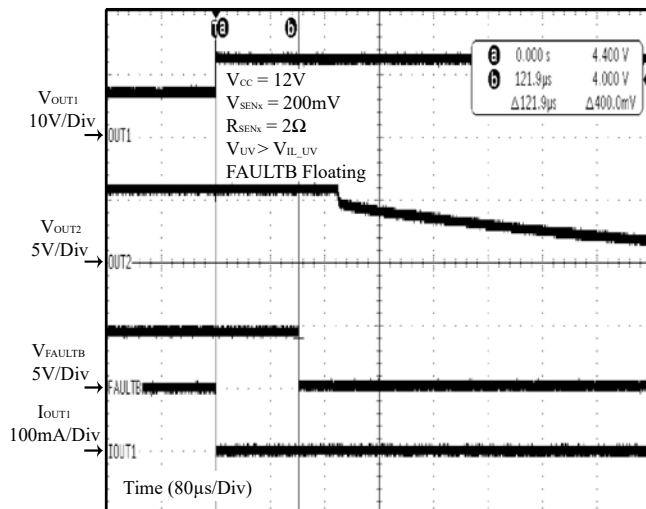


Figure 28 LED Open

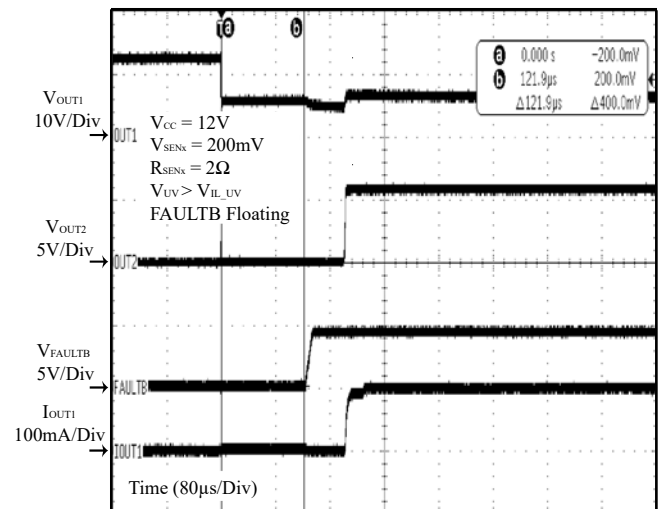


Figure 29 LED Open Remove

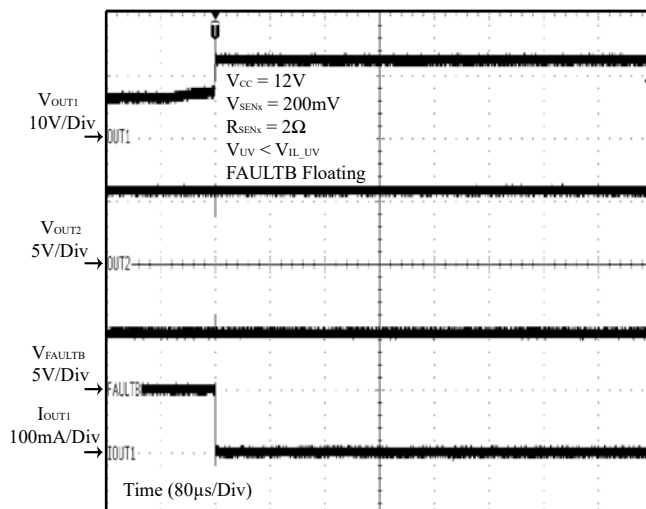


Figure 30 LED Open

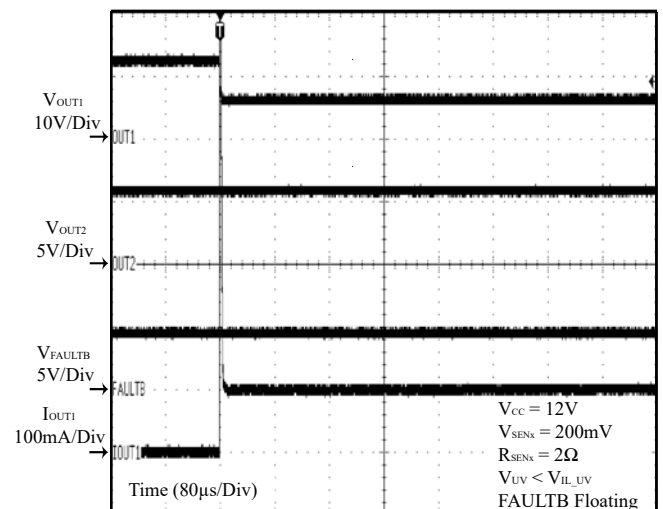


Figure 31 LED Open Remove

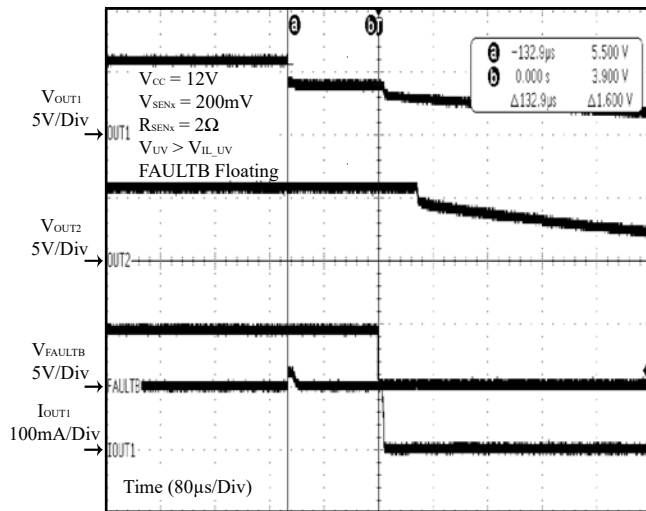


Figure 32 Single LED Short

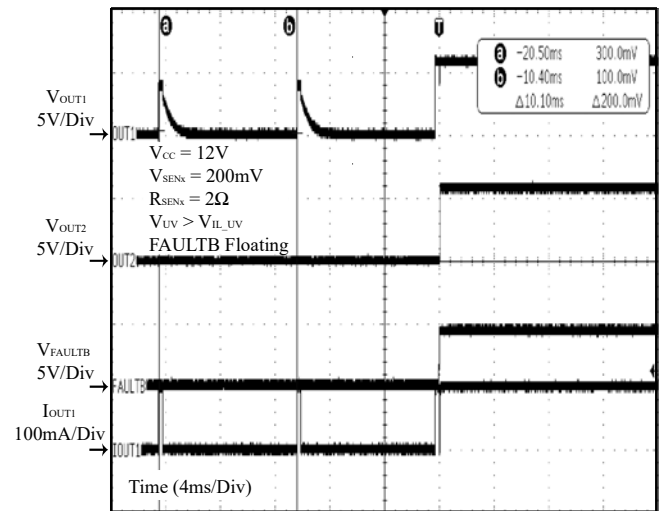


Figure 33 Single LED Short Remove

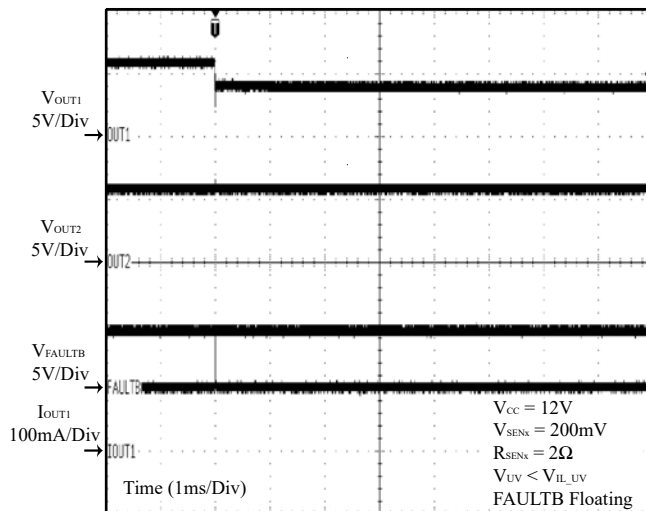


Figure 34 Single LED Short

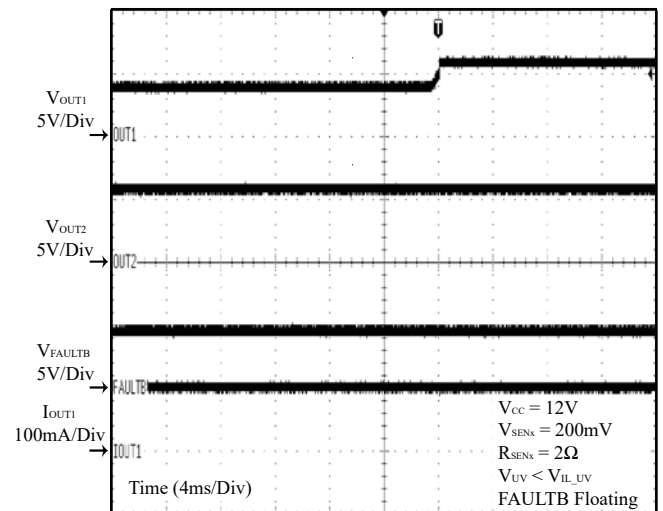
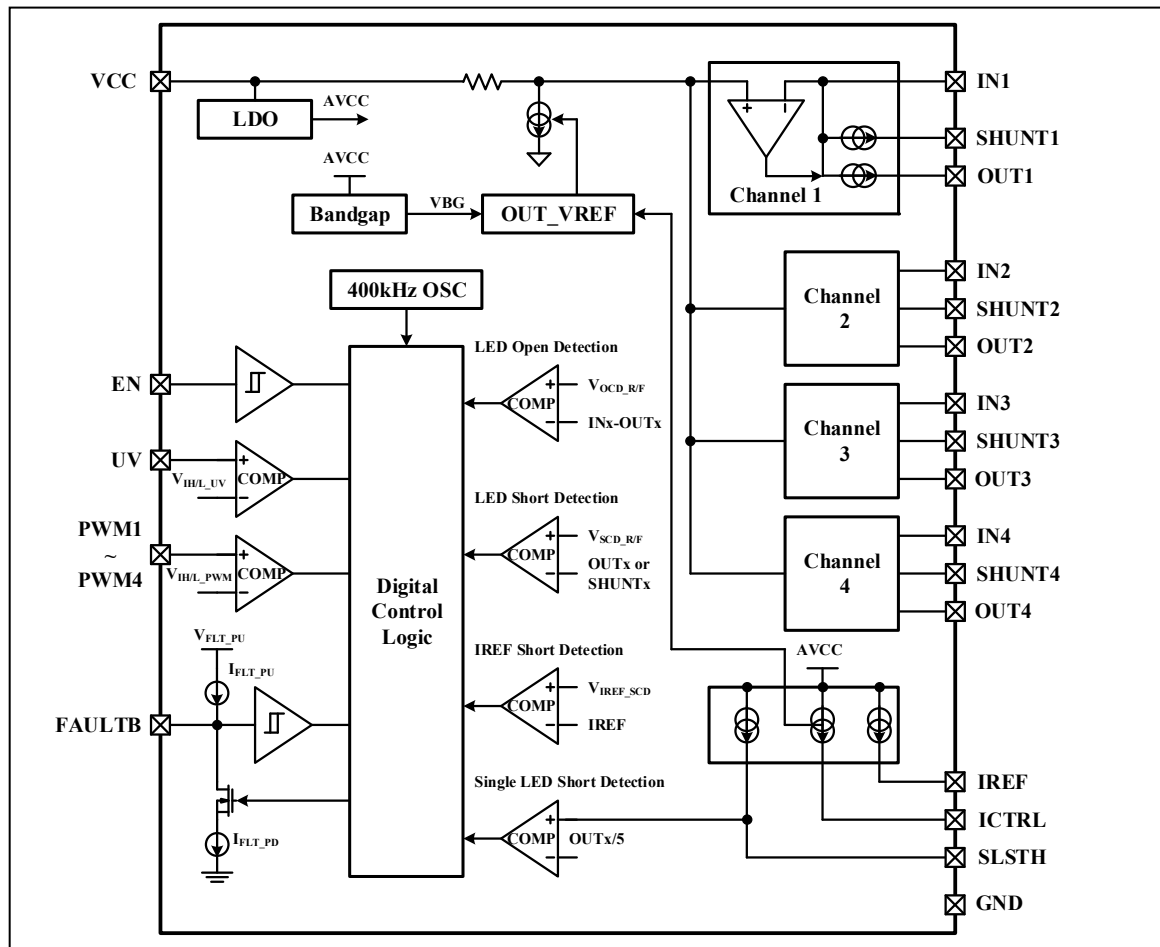


Figure 35 Single LED Short Remove

FUNCTIONAL BLOCK DIAGRAM



APPLICATION INFORMATION

The IS32LT3154A is a four-channel, high-side linear LED driver with individual PWM dimming. Each channel has up to 150mA current capability. The output current for each channel is independently adjustable using external R_{SENx} resistors on the INx pins. Current flows from the power supply through the R_{SENx} resistor into the INx pin, then through the integrated current regulator circuit to the LED string via the OUTx and SHUNTx pins. The device monitors the voltage drop across the R_{SENx} resistor to ensure a stable current output and an internal regulation loop adjusts the output current source to maintain a consistent V_{SEN} voltage drop across the R_{SENx} resistor. The current for all four channels can be scaled down with an external resistor connected to the analog dimming ICTRL pin. This pin can also accommodate either an NTC resistor for LED temperature monitoring or a resistor for LED brightness binning whether on the same board or off-board. Additionally, the thermal shunt mechanism helps to efficiently manage thermal stress on the driver.

A high-side current source output architecture allows common-cathode LED strings to connect directly to ground, requiring only a single return wire. In contrast, a driver with a low-side current sink architecture would require two return wires for each LED string.

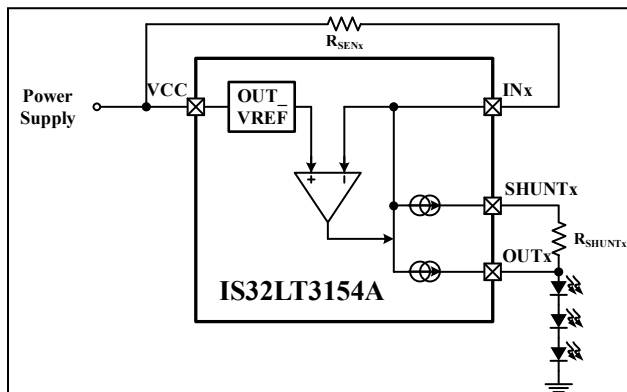


Figure 36 Constant Current Regulation

The IS32LT3154A supports both power supply modulation and PWM control for turning LEDs ON and OFF. The LED brightness can be adjusted by applying a variable-duty cycle to either the VCC or PWMx pins, with a frequency above 100Hz.

REFERENCE CURRENT

The IS32LT3154A features an IREF pin that generates a high accuracy, low temperature drift current reference. The I_{REF} can be set using an external resistor, R_{REF} , within a range of 25 μ A to 250 μ A. The calculated result for I_{REF} is 100 μ A when R_{REF} is 12.35k Ω . The voltage V_{IREF} on the IREF pin is regulated to 1.235V (Typ.), and the current output at the IREF pin is calculated by using the following equation:

$$I_{IREF} = \frac{V_{IREF}}{R_{IREF}} \quad (1)$$

For most applications, the recommended value of R_{IREF} is 12.3k Ω with 1% accuracy. To minimize noise interference, place the R_{IREF} resistor as close as possible to the IREF pin and use a 1nF ceramic capacitor in parallel. Off-board R_{IREF} setup is not allowed due to potential reference current instability.

OUTPUT CURRENT SETTING

The current sense resistor R_{SENx} sets the regulated maximum LED current. R_{SEN1} sets the total current of OUT1 and SHUNT1, R_{SEN2} sets the total current of OUT2 and SHUNT2, R_{SEN3} sets the total current of OUT3 and SHUNT3 and R_{SEN4} sets the total current of OUT4 and SHUNT4. The value of R_{SENx} can be calculated using the following equation:

$$R_{SENx} = \frac{V_{SEN}}{I_{LEDx}} \quad (2)$$

Where x = 1, 2, 3 or 4 for output channel 1, 2, 3 or 4, I_{LEDx} is the desired LED current in Amps and R_{SENx} is in ohms. V_{SEN} is the current sense regulation voltage, which varies according to the reference current pin IREF and analog dimming pin ICTRL.

It is recommended to use a 1% resistor with good temperature characteristics for R_{SENx} to ensure stable and precise output current. For optimal PCB layout and minimize noise interference, place the R_{SENx} resistor as close as possible to the VCC and INx pins.

If the supply voltage drops below the sum of the total LED string forward voltage plus the required headroom voltage (sum of V_{HR_MIN} and V_{SEN}), the IS32LT3154A will be unable to deliver the current set by R_{SENx} , resulting in a voltage drop across R_{SENx} that is less than V_{SEN} .

Never leave the INx pins floating. If a channel is unused, its INx pin should be connected directly to the VCC pin.

ANALOG DIMMING

The IS32LT3154A supports analog current control for all four output channels by adjusting the V_{SEN} voltage. It regulates each channel's output current by maintaining the voltage drop across each R_{SENx} resistor equal to V_{SEN} . The V_{SEN} voltage is adjustable using an external resistor on the ICTRL pin. The device outputs a constant current, I_{ICTRL} , on the ICTRL pin and measures the voltage, V_{ICTRL} , to determine V_{SEN} . The I_{ICTRL} current is 10 times that of the I_{IREF} , and V_{ICTRL} is calculated by multiplying I_{ICTRL} and R_{ICTRL} . The device clamps V_{ICTRL} to a maximum of 4.5V (Typ.) when ICTRL pin floating.

The output is full current when the ICTRL pin voltage is above 2.0V (Typ.). Recommended analog dimming voltage range is between 0.2V~2.0V. Turn off output

current when ICTRL pin voltage is lower than 100mV (Typ.). Turn on output current when ICTRL pin voltage higher than 150mV (Typ.). Within the analog dimming voltage range, the V_{SEN} voltage can be calculated using the following equation:

$$V_{SEN} = \frac{I_{REF} \times R_{ICTRL} \times 40}{20} \quad (3)$$

Where I_{REF} is the reference current in Amps, R_{ICTRL} is the resistor from the ICTRL pin to GND in ohms and V_{SEN} is the current sense regulation voltage in Volts.

For example, with R_{REF} is 12.3k Ω , R_{ICTRL} is 1k Ω and R_{SENx} is 2 Ω , the calculated LED current is:

$$I_{LEDx} = \frac{V_{REF} \times R_{ICTRL} \times 40}{R_{REF} \times R_{SENx} \times 20} = 100.4mA$$

When analog dimming is not implemented, the ICTRL pin should be connected by a resistor to GND. The recommended values are 0.5k Ω , 1.0k Ω or 2.0k Ω . This resistor should be placed as close to the ICTRL pin as possible to avoid noise interference.

LED Binning

The ICTRL pin can be used to fine-tune the output current during mass production. LEDs are typically sorted into various bins based on luminous intensity and forward voltage. To correct brightness deviations during mass production, the mean output current can be adjusted by varying the voltage level on the ICTRL pin. A binning resistor can be placed off-board next to the LED units.

For optimal noise rejection and ESD protection, set the I_{ICTRL} current to 2mA and use two resistors in series. Place one resistor, R_{ICTRL1} , as close as possible to the ICTRL pin on the same PCB board as the device, and the other, R_{ICTRL2} (the real binning resistor), on the PCB with the LED units. The recommended value for R_{ICTRL1} should be at least 100 Ω .

As shown in the below figure, the R_{ICTRL1} resistor and 10nF ceramic capacitor (C_{ICTRL}) must be placed as close as possible to the ICTRL pin for noise decoupling. The off-board R_{ICTRL2} resistor can be placed on the LED board as the actual binning resistor.

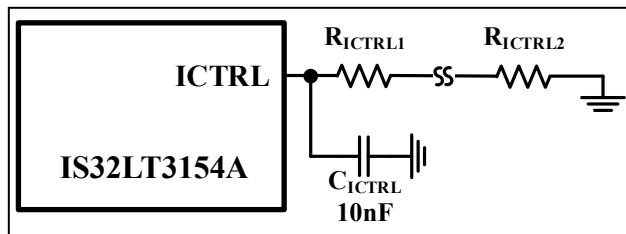


Figure 37 ICTRL for LED Binning

LED Over Temperature Thermal Roll-off

The ICTRL pin can also be used with an NTC thermistor to provide over-temperature current roll-off protection for the LED load or the system. The

resistance of the NTC thermistor decreases as the temperature increases, which in turn lowers the equivalent resistance of R_{ICTRL} on the ICTRL pin and reduces the output current.

As shown in the figure below, the resistor values of R_{ICTRL1} and R_{ICTRL2} work with the NTC thermistor to adjust the equivalent resistance curve based on the temperature, thereby achieving the system's required current derating. The R_{ICTRL1} resistor and a 10nF ceramic (C_{ICTRL}) must be placed as close as possible to the ICTRL pin for noise decoupling. The NTC thermistor can be placed on the LED board for temperature monitoring.

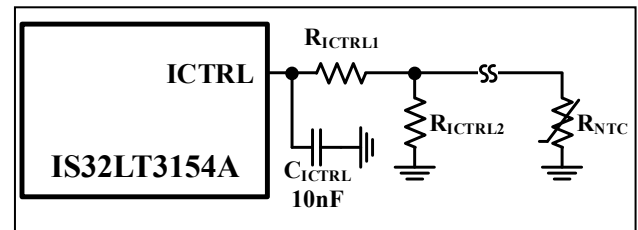


Figure 38 ICTRL with NTC for Thermal Roll-off

Dual Brightness Level Output

In automotive applications, some lamps require dual brightness outputs. For example, the daytime running light (DRL) and the position light (POL) can both use the same LED string, since these two lamps won't be active at the same time. The DRL is active in the daytime, while the POL is active at a lower brightness during nighttime. Two brightness levels are achieved by using two independent power supply rails. The analog dimming can be used for this dual brightness output function.

As shown in the figure below, when the input logic at the MOSFET Q_1 GATE is high, the R_{ICTRL2} resistor is shorted by Q_1 , and the output current is determined by the R_{ICTRL1} resistor alone. If the GATE of the MOSFET Q_1 is pulled low, the output current is determined by the series combination of R_{ICTRL1} and R_{ICTRL2} resistors, resulting in higher brightness. All components, including the R_{ICTRL1} and R_{ICTRL2} resistors, the C_{ICTRL} ceramic capacitor, and the Q_1 MOSFET, must be placed as close as possible to the ICTRL pin to minimize noise interference.

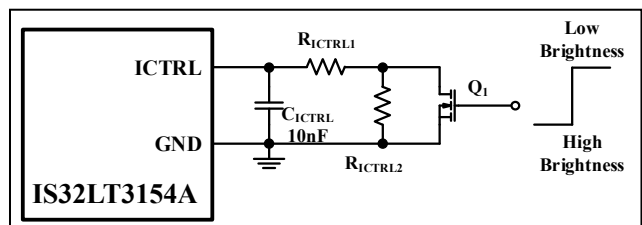


Figure 39 ICTRL for Dual Brightness Output

PWM DIMMING

The IS32LT3154A features a dedicated PWM pin for each output channel to control the current source. The PWM1 input controls the output channel 1 (OUT1

and SHUNT1), PWM2 controls the output channel 2 (OUT2 and SHUNT2), PWM3 controls output channel 3 (OUT3 and SHUNT3) and PWM4 controls output channel 4 (OUT4 and SHUNT4). The voltage at each PWMx pin must be higher than V_{IH_PWM} to enable the corresponding output channel and lower than V_{IL_PWM} to disable it. An external PWM signal on the PWMx pins can modulate the output current to dim the LED light output. The PWM dimming output current is based on the PWM signal's duty cycle and can be calculated by the following equation:

$$I_{LEDx_PWM} = I_{LEDx} \times D_{PWM} \quad (4)$$

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

The recommended frequency range for the external PWM signal is 100Hz to 1kHz, and the duty cycle range can be from 0 to 100%. Lower frequency PWM signals provide better dimming linearity and contrast ratio due to the output current slew rate control for EMI considerations and the propagation delay time from the PWM rising edge to the output activity.

The PWM pin is a high impedance input. If the PWM dimming function for any channel is not used, connect its corresponding PWM pin to the VCC pin via a 10kΩ series resistor. If any output channel is unused, tie its corresponding INx/OUTx/SHUNTx pins to the VCC pin.

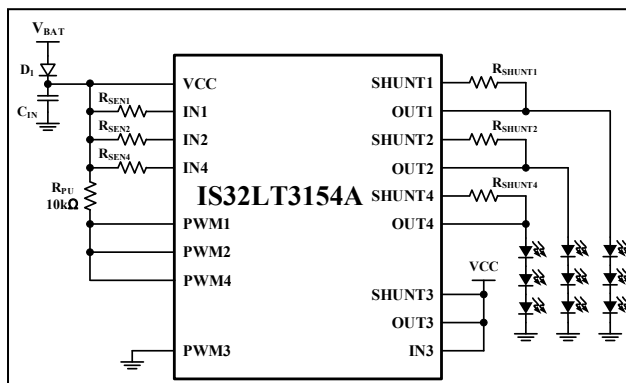


Figure 40 Example of No PWM Dimming and Third Channel Unused

DEVICE ENABLE AND SHUTDOWN

The device has an enable (EN) input pin. When it is pulled low, the device enters shutdown mode with an ultra-low standby current. This feature is beneficial for conserving system-level current consumption in applications where the battery voltage is connected directly to the device without the use of high-side switches. Conversely, when the EN pin is pulled high, the device will be enabled allowing normal operation.

VCC UNDERVOLTAGE-LOCKOUT (UVLO)

The IS32LT3154A includes a Power-On Reset (POR) function designed to prevent indeterminate operation at low input voltages. The POR threshold is an internally fixed value and cannot be adjusted. The

device becomes operational when the V_{CC} voltage exceeds V_{POR_R} and enters a reset state when the V_{CC} voltage drops below V_{POR_F} .

In addition to this internal fixed POR threshold, there may be applications where setting an external higher VCC UVLO threshold is preferred. This can be achieved by configuring a precise UVLO threshold voltage using a resistor voltage divider between VCC and GND, with the center point connected to the PWMx pin.

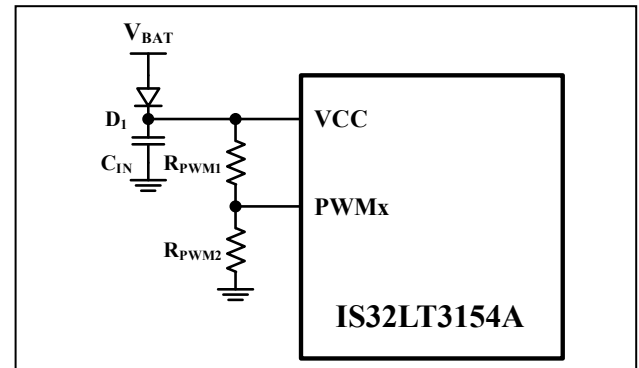


Figure 41 External VCC UVLO Defined by PWMx Pins

The external VCC UVLO threshold voltage can be calculated using the following equations:

$$V_{UVLO_EXF} = V_{IL_PWM} \times \frac{R_{PWM1} + R_{PWM2}}{R_{PWM2}} \quad (5)$$

$$V_{UVLO_EXR} = V_{IH_PWM} \times \frac{R_{PWM1} + R_{PWM2}}{R_{PWM2}} \quad (6)$$

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} .

For precise detection, it is recommended that R_{PWM1} and R_{PWM2} be 1% resistors with good temperature characteristics. The resistor divider should be placed as close to the corresponding PWM pin as possible to prevent noise coupling into the UVLO detection circuit.

POWER SUPPLY MODULATION (PSM) DIMMING

Besides PWM dimming, the IS32LT3154A also supports Power Supply Modulation (PSM), which enables LED dimming by pulse width modulating the power supply rail while maintaining the stability of the IS32LT3154A's current regulation loop. In PSM dimming scenarios, it's recommended to use the external VCC UVLO defined by PWMx pins. The V_{UVLO_EXR} threshold voltage should be set to be higher than the LED string forward voltage plus sufficient headroom voltage.

When the voltage applied to the VCC pin exceeds the V_{UVLO_EXR} threshold voltage, the output current is turned on and is well regulated. However, if the voltage applied to the VCC pin is lower than the V_{UVLO_EXF} threshold voltage, the output current is turned off. By varying the duty cycle of the power supply voltage at a fixed frequency (above 100Hz),

the LED brightness can be adjusted using the following equation:

$$I_{LEDx_PSM} = I_{LEDx} \times D_{PSM} \quad (7)$$

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

For better dimming linearity, it's recommended to use a PSM frequency in the range of 100Hz to 300Hz (typically 200Hz), and the input capacitor, C_{IN} , should be a low value (0.1μF Typ.) to ensure rapid discharge during the PSM low period. Lower frequency PSM signals provide better dimming linearity and contrast ratio due to the output current's power-on response time.

THERMAL SHUNT MECHANISM

For any linear constant current LED driver, the power dissipation within the driver is determined by the voltage drop across the driver and the output current passing through it.

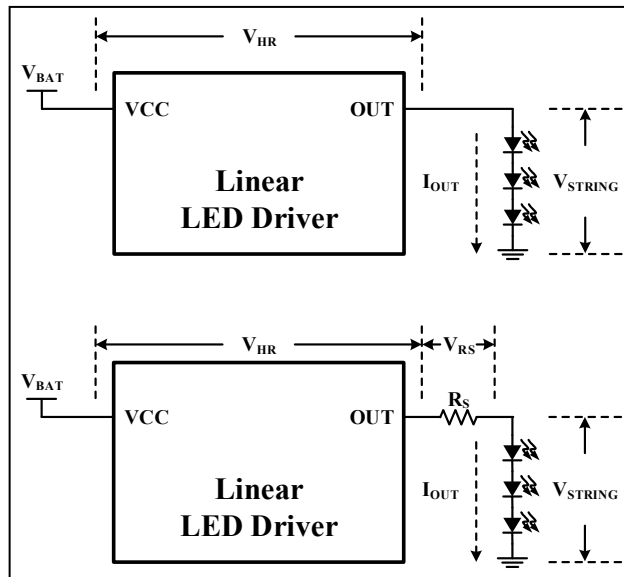


Figure 42 Typical Linear LED Driver Power Dissipation

As in the above figure, the power dissipation on the driver can be calculated by following equation:

$$P_{DRIVER} = V_{HR} \times I_{OUT} = (V_{BAT} - V_{STRING}) \times I_{OUT} \quad (8)$$

According to above equation, a higher input voltage will result in more power dissipation on the driver. A power resistor, R_S , can be added to shunt some power away from the driver. The power dissipation on the driver becomes:

$$P_{DRIVER} = V_{HR} \times I_{OUT} = (V_{BAT} - R_S \times I_{OUT} - V_{STRING}) \times I_{OUT} \quad (9)$$

Since the internal current consumption of the linear LED driver is negligible compared to I_{OUT} , I_{VCC} is essentially equal to I_{OUT} .

A larger R_S value can significantly reduce the power dissipation on the driver, especially for high voltage inputs. However, it is important to consider the automotive battery voltage range (typically 9V to 16V)

when selecting the R_S value. Using a large R_S may lead to insufficient operating headroom voltage (V_{HR}) for the driver at low input voltages, resulting in a drop in the output current.

To address this issue, the IS32LT3154A features a thermal shunt mechanism with two current output paths for each channel, OUTx pin and SHUNTx pin. The OUTx pin is directly connected to the LED string, while the SHUNTx pin is connected to the LED string via a thermal shunt resistor, R_{SHUNTx} . This series arrangement allows for part of the power dissipation to be shared and reduces thermal accumulation in the IS32LT3154A. As shown in the below figure.

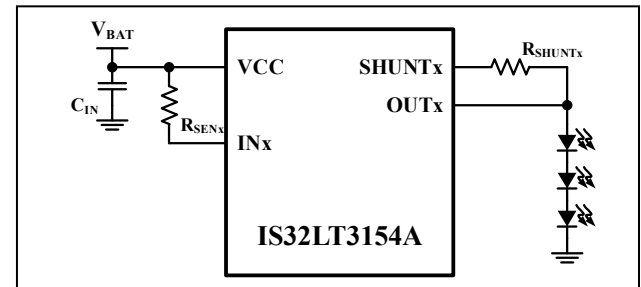


Figure 43 Thermal Shunt Topology

The IS32LT3154A features independent current regulation on both the OUTx and SHUNTx pins to achieve the total required current output for the LED string. Current flows from the supply through the R_{SENx} resistor into the integrated current regulation circuit, and then to the LED string through OUTx pin and SHUNTx pins. The summed current of OUTx and SHUNTx is equal to the current through the R_{SENx} resistor in the channel. The IS32LT3154A dynamically adjusts the output current on both OUTx and SHUNTx pins to maintain a stable summed current for the LED string.

By default, the thermal shunt mechanism directs current through the SHUNTx pin. The device regulates the current output to the SHUNTx pin as much as possible until the SHUNTx current path is saturated. Any remaining current is regulated out the OUTx pin. However, at low V_{BAT} input voltages, the thermal shunt resistor R_{SHUNTx} will limit the current through the SHUNTx path, causing most of the current to flow through the OUTx path. This current diversion to the OUTx path will ensure sufficient headroom operating voltage (V_{HR}) so the driver can maintain a constant output current to the LED string.

As V_{BAT} increases, more output current is gradually diverted from the OUTx path to the SHUNTx path. The resistor R_{SHUNTx} can significantly shunt power from the driver at high input voltages to maintain the driver's junction temperature at an acceptable level.

It's important to note that SHUNTx pins should never be left floating. If the thermal shunt mechanism is not implemented, connect the SHUNTx pin to the corresponding OUTx pin directly.

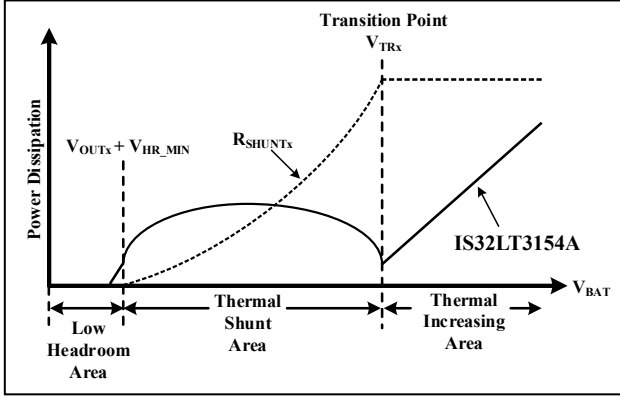


Figure 44 Power Dissipation Distribution

As shown in the above figure, the IS32LT3154A has different operating areas when using the thermal shunt mechanism. Within the Low Headroom Area, the input voltage is too low for current regulation. Even though all output current flows through the OUT_x path, the headroom voltage is insufficient to reach the required operating value, resulting in minimal power dissipation. When the input voltage exceeds (V_{OUTx} + V_{HR_MIN}), the transition voltage V_{TRx} divides the operation into two areas: Thermal Shunt Area and Thermal Increasing Area.

Thermal Shunt Area:

The IS32LT3154A's output channels operate in constant regulator mode once the input voltage exceeds (V_{OUTx} + V_{HR_MIN}). The majority of the output current gradually shifts from the OUT_x path to the SHUNT_x path. Therefore, power dissipation on the R_{SHUNTx} resistor increases while the power dissipation on the driver remains relatively low. The SHUNT_x current path can be calculated by:

$$I_{SHUNTx} = \frac{V_{BAT} - V_{OUTx} - V_{SEN} - V_{HR_MIN}}{R_{SHUNTx}} \quad (10)$$

Where, V_{OUTx} is the voltage at the OUT_x pin. V_{HR_MIN} is the minimum headroom voltage for the target current. x = 1, 2, 3 or 4 for output channel 1, 2, 3 or 4.

The current through the OUT_x path:

$$I_{OUTx} = I_{LEDx} - I_{SHUNTx} \quad (11)$$

Where, I_{LEDx} is the LED current set by the R_{SENx} resistor.

The power dissipation on the R_{SHUNTx} resistor is:

$$P_{SHUNTx} = \frac{(V_{BAT} - V_{OUTx} - V_{SEN} - V_{HR_MIN})^2}{R_{SHUNTx}} \quad (12)$$

The power dissipation on the IS32LT3154A can be calculated as:

$$P_{3154A_TSA} = V_{BAT} \times I_{CC} + \sum_{x=1}^N (V_{BAT} \times I_{LEDx} - P_{SHUNTx} - V_{OUTx} \times I_{LEDx}) \quad (13)$$

Where, I_{CC} is the IS32LT3154A's quiescent current. N is the number of channels in use.

Thermal Increasing Area:

When the input voltage is equal to or greater than the Transition Voltage V_{TRx}, nearly all the output current (greater than 95% of I_{LEDx}, assumed to be 100% in below calculation) flows through the SHUNT_x path to the LED string. The power dissipation on the R_{SHUNTx} resistor remains constant while the power dissipation on the driver increases linearly. The V_{TRx} voltage point of each channel can be independently adjusted by changing the resistance value of R_{SHUNTx}.

$$V_{TRx} = R_{SHUNTx} \times I_{LEDx} + V_{OUTx} + V_{SEN} + 1V \quad (14)$$

To optimize the power dissipation on the driver, the R_{SHUNTx} value should be chosen to make sure V_{TRx} equals the maximum input voltage, which is typically 16V for 12V automotive systems.

$$R_{SHUNTx_16V} = \frac{16V - V_{OUTx} - V_{SEN} - 1V}{I_{LEDx}} \quad (15)$$

Where, R_{SHUNT_16V} is the thermal shunt resistor value to achieve V_{TRx}=16V.

The constant maximum power dissipation on the R_{SHUNTx} resistor can be calculated by:

$$P_{SHUNTx_MAX} = R_{SHUNTx} \times I_{LEDx}^2 \quad (16)$$

The power rating of R_{SHUNTx} should be carefully considered. It can either be a single high wattage resistor or multiple smaller wattage resistors in parallel to handle the maximum power dissipation.

The power dissipation on IS32LT3154A is calculated by:

$$P_{3154A_TIA} = V_{BAT} \times I_{CC} + \sum_{x=1}^N (V_{BAT} \times I_{LEDx} - P_{SHUNTx_MAX} - V_{OUTx} \times I_{LEDx}) \quad (17)$$

FAULT PROTECTION AND REPORTING

For robust system reliability, the IS32LT3154A integrates detection circuitry to detect various fault conditions and report the occurrence via the FAULTB, which can be monitored by an external host. The fault detections include LED string open/short, single LED short, IREF pin open/short and thermal shutdown. The FAULTB pin has an internal low current source I_{FLT_PU} pulled up to an internal voltage source V_{FLT_PU} and a strong current sink I_{FLT_PD}, pulled down to ground. As shown in figure below, the FAULTB pin will be strongly pulled low by the internal current sink when a fault condition is detected.

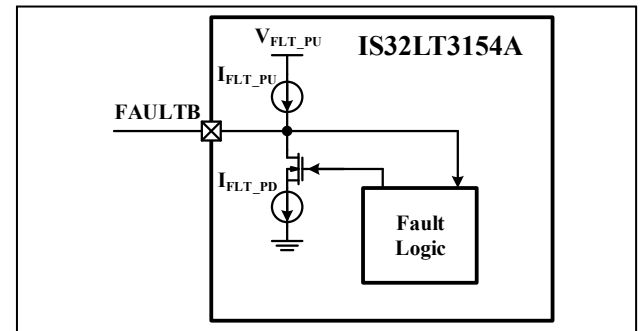


Figure 45 FAULTB Pin Internal Circuit

The FAULTB pin also supports an input function. If the FAULTB pin voltage drops below the input logic low level V_{IL_FLT} , whether due to an external circuit pulling it down or the internal pull-down current sink I_{FLT_PD} , all output channels (except the failing one) will be turned off to satisfy the “one-fail-all-fail” requirement. The device will not resume normal operation until the FAULTB pin voltage rises above the input logic high level V_{IH_FLT} . If the FAULTB pin is externally pulled down, the device enters fault mode and consumes a fault current of I_{FAULT} .

In lighting systems with multiple IS32LT3154As that require the complete lighting system to be shut down when a fault is detected, the system FAULTB pins can be connected in parallel. A fault output by one device will pull down the FAULTB pins of the other parallel connected devices, turning them off simultaneously and satisfying the system “one-fail-all-fail” requirement.

Placing an external 200Ω pull up resistor on the FAULTB pin will prevent the internal pull-down current sink I_{FLT_PD} from pulling down the FAULTB pin below V_{IL_FLT} ; this will ensure the fault actions will keep other channels in normal operation to satisfy the “one-fail-other-on” requirement. Refer to Table 1 for detailed fault actions.

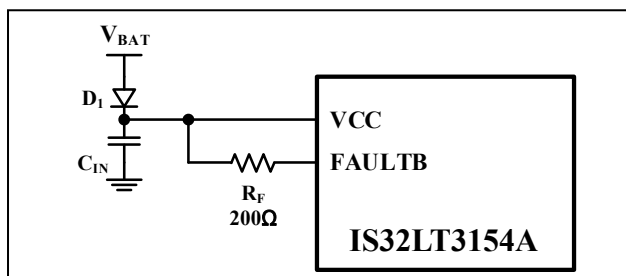


Figure 46 Externally Forced FAULTB High Without Reporting

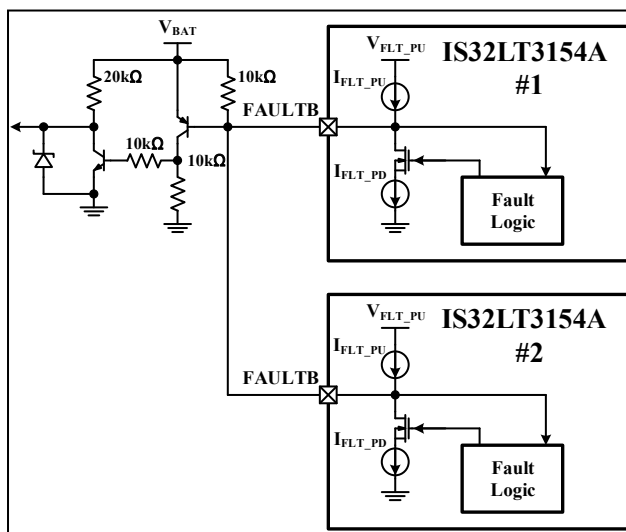


Figure 47 Externally Forced FAULTB High With Reporting

LED STRING OPEN AND SINGLE LED SHORT PROTECTION ENABLE

The IS32LT3154A includes a UV pin with an accurate threshold that can disable the LED string open and single LED short detection functions. These detections are enabled when the UV pin voltage is above its rising threshold, V_{IH_UV} , and disabled when it is below its falling threshold, V_{IL_UV} . A proper resistor divider (R_{UV1} and R_{UV2}) connected from the VCC pin to the UV pin can set a UVLO function. This configuration prevents insufficient V_{CC} from falsely triggering the LED string open and single LED short detection functions. The UVLO voltage threshold is determined by the resistor divider.

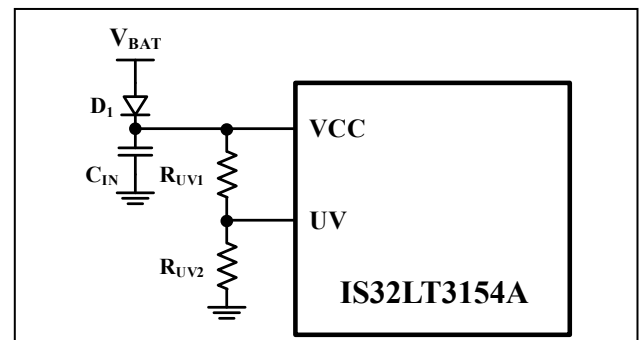


Figure 48 UVLO for LED String Open and Single LED Short Protection

$$V_{UVLO_FLTF} = V_{IL_UV} \times \frac{R_{UV1} + R_{UV2}}{R_{UV2}} \quad (18)$$

$$V_{UVLO_FLTR} = V_{IH_UV} \times \frac{R_{UV1} + R_{UV2}}{R_{UV2}} \quad (19)$$

It is recommended to set V_{UVLO_FLT} at least 0.5V higher than the LED string forward voltage. Select resistors R_{UV1} and R_{UV2} with 1% accuracy and good temperature characteristics to ensure stable and precise detection. Place the resistor divider as close to the UV pin as possible on the PCB layout to minimize noise interference. If the UV pin is unused, connect it to the VCC pin using a 10k Ω resistor.

Only LED string open and single LED short detection can be disabled by pulling down the UV pin. The LED string short and thermal shutdown detection cannot be turned off by pulling down the UV pin.

LED STRING OPEN PROTECTION

The LED string open detection monitors the output voltage when the current detection is enabled. If any LED string is open, the corresponding OUTx pin will be pulled up close to the INx pin voltage by the current source. If $V_{CC} > V_{UVLO_FLTR}$ and PWMx is high, and if the voltage drops between the INx pin and OUTx pin, ($V_{INx} - V_{OUTx}$), falls below the open LED detect voltage threshold, V_{OCD_R} , and this condition persists for longer than the deglitch time t_{OS_DEG} , the LED string open detection will be triggered, causing the FAULTB pin to go low, indicating a fault condition. The channel with the open LED string condition will reserve a small current (I_{RTR_OUT} through OUTx pin and I_{RTR_SHUNT}

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through SHUNT_x pin) for recovery detection, ignoring the PWM input. The other channels will be turned off due to the FAULTB pin being low, which satisfies the “one-fail-all-fail” condition. If the FAULTB pin is externally forced high (for example, pulled up by a 200Ω resistor to VCC), the other channels will remain turned on, which satisfies the “one fail other on” condition.

The IS32LT3154A will return to normal operation and FAULTB pin will go high once the LED string open condition is resolved, with (V_{INx}-V_{OUTx}) rising above the open LED detect voltage threshold, V_{OCD_F}.

LED STRING SHORT PROTECTION

The LED string short detection function monitors the output voltage when the current output is enabled. The LED string short condition is detected if either one of the OUT_x or SHUNT_x pin voltage drops below the short detect voltage threshold, V_{SCD_F}. Once a short condition occurs and persists for longer than the deglitch time t_{OS_DEG}, the LED string short detection function will be triggered and the FAULTB pin will go low to indicate a fault condition. The shorted channel will reserve a small current (I_{RTR_OUT} through OUT_x pin and I_{RTR_SHUNT} through SHUNT_x pin) for recovery detection, ignoring the PWM input. The other channels will be turned off due to the FAULTB pin low, that satisfies “one-fail-all-fail”. If the FAULTB pin is externally forced high (for example, pulled up by a 200Ω resistor to VCC), the other channels will remain turned on that satisfies the “one-fail-other-on” condition.

The device will resume normal operation and FAULTB pin will return to a high state once the short condition is removed, both OUT_x pin and SHUNT_x pin voltage rising above the short detect voltage threshold, V_{SCD_R}.

SINGLE LED SHORT PROTECTION

The IS32LT3154A device supports single LED short detection. The single LED short detection monitors the channel output voltage when the output current is enabled. Once a single LED short failure is detected, the device turns off the faulty channel and retries automatically. If the retry mechanism detects the removal of the single LED short fault, the device resumes normal operation.

If V_{CC}>V_{UVLO_FLTR} and PWM_x is high, the IS32LT3154A monitors the V_{OUTx} voltage of each channel and internally compares the scale down voltage of V_{OUTx} with an external resistor programmable reference voltage on the SLSTH pin to detect a single LED short failure. When the voltage of V_{OUTx} falls below V_{SLS_THF} for longer than the deglitch time of t_{SLS_DEG}, the single LED short fault is triggered, and the FAULTB pin will go low to report the fault condition. The internal timer is reset if the V_{OUTx} rises above V_{SLS_THR} during the deglitch time period.

Once the IS32LT3154A has reported a single LED short fault, the device turns off the faulty output channel and retries automatically. During retrying and if the faulty channel PWM input is high, the device sources full current on the faulty channel to pull up the LED load every 10ms for a 300μs period. Once retrying detects the V_{OUTx} voltage rising above V_{SLS_THR}, it clears the single LED short fault and resumes normal operation. The V_{SLS_THR} is about 2.5% higher than the V_{SLS_THF}. The scale down ratio for V_{OUTx} is N_{OUT}. The following figure shows the internal single LED short detection circuit. The V_{SLS_THF} threshold voltage for a single LED short is calculated by using the equation:

$$V_{SLS_THF} = \frac{N_{OUT} \times V_{IREF} \times R_{SLSTH} \times N_{SLSTH}}{R_{IREF}} \quad (20)$$

Where, R_{SLSTH} is the resistor connected from SLSTH pin to GND, in Ω. N_{OUT} is the output voltage attenuation ratio (Typ. 5 times). N_{SLSTH} is the SLSTH pin current ratio (Typ. 1 times). The V_{SLS_THF} threshold must be set within V_{SLSTH_RG} for proper detection. So the maximum V_{SLS_THF} is 13V. It is recommended that R_{SLSTH} be a 1% accuracy resistor with good temperature characteristics to ensure stable and precise detection. On the PCB layout, this resistor must be placed as close to the SLSTH pin as possible to avoid any noise interference.

For example, if R_{IREF} is 12.3kΩ and R_{SLSTH} is 10kΩ, the calculated result of the single LED short detection falling threshold is 5.02V.

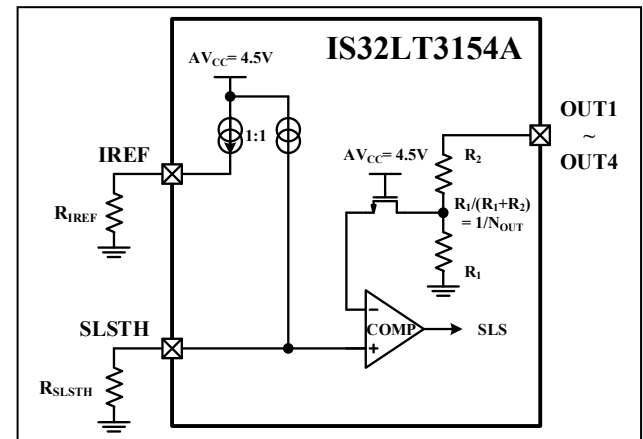


Figure 49 Single LED Short Detection Circuit

To achieve accurate single LED short detection and avoid false triggering, the single LED short detection threshold should be set according to the minimum and maximum of the LED forward voltage:

$$(Y - 1) \times V_{F_MAX} < V_{SLS_THF} < Y \times V_{F_MIN} \quad (21)$$

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

Connect the SLSTH pin to GND if single LED short detection is not implemented.

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IREF PIN SHORT PROTECTION

The IS32LT3154A has IREF pin short detection by monitoring the voltage on the IREF pin. If the IREF pin voltage, V_{IREF} , is lower than V_{IREF_SCD} for longer than the deglitch time of t_{IREF_DEG} , the IREF pin short fault will be triggered, and the FAULTB pin will go low to report the fault condition. When an IREF pin short fault is detected, the current for all output channels and ICTRL pin are turned off, and the current out of IREF pin is clamped to I_{IREF_CLP} . The device returns to normal operation and the FAULTB pin will go back to a high state once the V_{IREF} voltage rises above V_{IREF_SCD} .

IREF PIN OPEN PROTECTION

The IS32LT3154A can detect an IREF open fault by monitoring the current through the IREF pin. When the current through the IREF pin, I_{IREF} , is lower than I_{IREF_OCD} for longer than the deglitch time of t_{IREF_DEG} , the IREF pin open fault will be triggered, and the

FAULTB pin will go low to report the fault condition. The current for all output channels and ICTRL pin are turned off when an IREF pin open fault is detected.

The device returns to normal operation and the FAULTB pin goes back to a high state once the I_{IREF} voltage rises above I_{IREF_OCD} .

THERMAL SHUTDOWN

In the event the device junction temperature exceeds T_{SD} (Typ. 175°C), all output channels will go to the "OFF" state and FAULTB pin will be pulled low to report the fault condition. At this point, the IS32LT3154A will begin to cool off. Any attempt to enable the channels back to the source condition before the IC has cooled below $(T_{SD}-T_{SDHY})$ (Typ. 155°C) will be blocked and the IC will not be allowed to restart. The device returns to normal operation and the FAULTB pin goes back to a high state once the IS32LT3154A has cooled down.

Table 1 Fault Actions With UV Pin Voltage High

$V_{UV} > V_{IH_UV}$							
FAULTB Status	Fault Type	Fault Condition	Control Input	Deglitch Time	FAULTB Action	Output State	Recovery
High	IREF pin short	$V_{IREF} < V_{IREF_SCD}$	EN = H	t_{IREF_DEG}	Constant current pulldown	Turn all channels and ICTRL pin current off. IREF pin current clamps to I_{IREF_CLP}	$V_{IREF} > V_{IREF_SCD}$
	IREF pin open	$I_{IREF} < I_{IREF_OCD}$	EN = H	t_{IREF_DEG}	Constant current pulldown	Turn all channels and ICTRL pin current off	$I_{IREF} > I_{IREF_OCD}$
	SLSTH pin short	No detection	EN = H	-	No action	$V_{SLS_THF}=0V$	Short condition removal
	SLSTH pin open	No detection	EN = H	-	No action	Disabled single LED short detection	Open condition removal
	ICTRL pin short	No detection	EN = H	-	No action	Turn all channels off	Short condition removal
	ICTRL pin open	No detection	EN = H	-	No action	$V_{SEN}=420mV$	Open condition removal
	LED string open	$(V_{INx}-V_{OUTx}) < V_{OCD_R}$	EN = H and PWMx=H	t_{OS_DEG}	Constant current pulldown	Faulty channel outputs I_{RTR} for recovery detection, Ignores the PWM input	$(V_{INx}-V_{OUTx}) > V_{OCD_F}$
	LED string short	$V_{OUTx} < V_{SCD_F}$ or $V_{SHUNTx} < V_{SCD_F}$	EN = H and PWMx=H	t_{OS_DEG}	Constant current pulldown	Faulty channel outputs I_{RTR} for recovery detection, Ignores the PWM input	$V_{OUTx} > V_{SCD_R}$ or $V_{SHUNTx} > V_{SCD_R}$
	Single LED short	$V_{OUTx} < V_{SLS_THF}$	EN = H and PWMx=H	t_{SLS_DEG}	Constant current pulldown	Faulty channel retries every 10ms by turning output on for 300µs when PWM input is high	$V_{OUTx} > V_{SLS_THR}$
	Thermal shutdown	$T_J > T_{SD}$	EN = H	-	Constant current pulldown	Turn all channels, SLSTH and ICTRL pins current off	$T_J < (T_{SD}-T_{SDHY})$
Low	Fault detected	Device turns all remained channels off and keeps retry on the failed channels.					
	No Fault detected	Device turns all channels, IREF, SLSTH and ICTRL pins current off.					

Table 2 Fault Actions With UV Pin Voltage Low

$V_{UV} < V_{IL_UV}$							
FAULTB Status	Fault Type	Fault Condition	Control Input	Deglitch Time	FAULTB Action	Output State	Recovery
High	IREF pin short	$V_{IREF} < V_{IREF_SCD}$	EN = H	t_{IREF_DEG}	Constant current pulldown	Turn all channels and ICTRL pin current off. IREF pin current clamps to I_{IREF_CLP}	$V_{IREF} > V_{IREF_SCD}$
	IREF pin open	$I_{IREF} < I_{IREF_OCD}$	EN = H	t_{IREF_DEG}	Constant current pulldown	Turn all channels and ICTRL pin current off	$I_{IREF} > I_{IREF_OCD}$
	SLSTH pin short	No detection	EN = H	-	No action	$V_{SLS_THF}=0V$	Short condition removal
	SLSTH pin open	No detection	EN = H	-	No action	Disabled single LED short detection	Open condition removal
	ICTRL pin short	No detection	EN = H	-	No action	Turn all channels off	Short condition removal
	ICTRL pin open	No detection	EN = H	-	No action	$V_{SEN}=420mV$	Open condition removal
	LED string open	Ignored					
	LED string short	$V_{OUTx} < V_{SCD_F}$ or $V_{SHUNTx} < V_{SCD_F}$	EN = H and PWMx=H	t_{OS_DEG}	Constant current pulldown	Faulty channel outputs I_{RTR} for recovery detection, Ignores the PWM input	$V_{OUTx} > V_{SCD_R}$ or $V_{SHUNTx} > V_{SCD_R}$
	Single LED short	Ignored					
	Thermal shutdown	$T_J > T_{SD}$	EN = H	-	Constant current pulldown	Turn all channels, SLSTH and ICTRL pins current off	$T_J < (T_{SD} - T_{SDHY})$
Low	Fault detected	Device turns all remained channels off and keeps retry on the failed channels.					
	No Fault detected	Device turns all channels, IREF, SLSTH and ICTRL pins current off.					

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 ($^{\circ}C/W$). The junction temperature, T_J , can be calculated by the rise of the silicon temperature, ΔT , the power dissipation on IS32LT3154A, P_{3154A} , and the package thermal resistance, θ_{JA} , as in following equation:

$$T_J = T_A + \Delta T = T_A + P_{3154A} \times \theta_{JA} \quad (22)$$

The P_{3154A} is described in the "THERMAL SHUNT MECHANISM" section.

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 $T_A=25^{\circ}C$ can be calculated using the following equation:

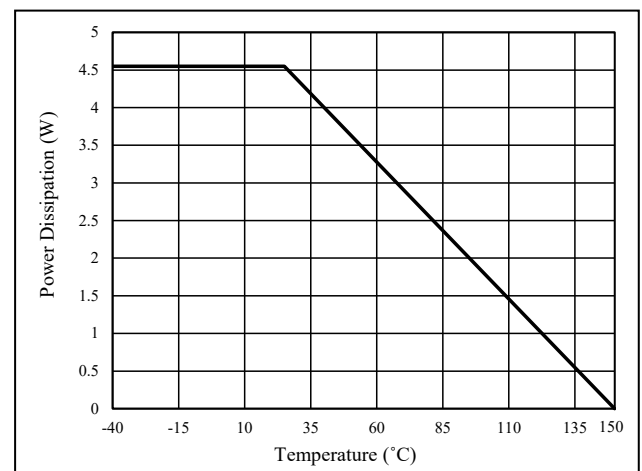
$$P_{D(MAX)} = \frac{150^{\circ}C - 25^{\circ}C}{\theta_{JA}} \quad (23)$$

So,

$$P_{D(MAX)} = \frac{150^{\circ}C - 25^{\circ}C}{27.5^{\circ}C/W} \approx 4.55W$$

for eTSSOP-24 package.

Below figure shows the power derating of the IS32LT3154A on a JEDEC board (in accordance with JESD 51-5 and JESD 51-7) standing in still air.

**Figure 50** Dissipation Curve

IS32LT3154A

The R_{SHUNTx} will experience significant power dissipation during a thermal shunt function, so the selected resistor package power rating should be adequate to prevent thermal runaway.

When designing the Printed Circuit Board (PCB) layout, use a double-sided PCB with a large copper area on each side of the board directly under the IS32LT3154A and the thermal shunt resistor. Multiple thermal vias, as shown in following figure, will help to conduct heat away from the exposed pad of the IS32LT3154A and the thermal shunt resistor to the copper on each side of the board. The thermal shunt resistor can be composed of multiple parallel connected resistors spread out on the PCB board and placed at a distance from IS32LT3154A, so they don't contribute to the IS32LT3154A's thermal buildup.

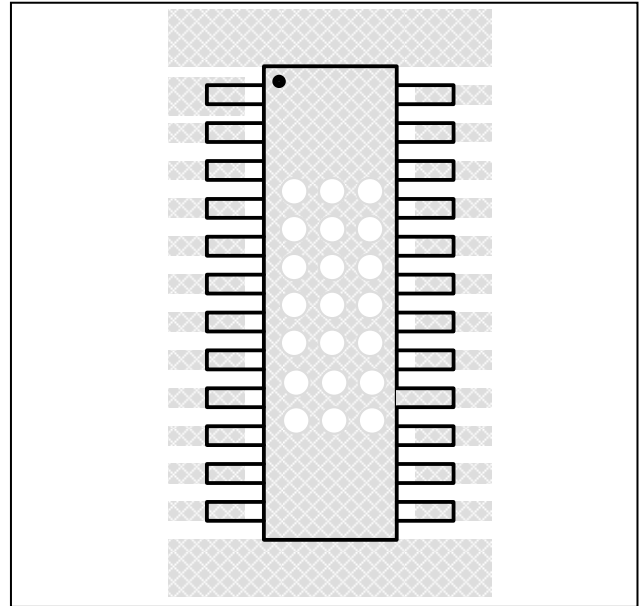


Figure 51 Board Via Layout For Thermal Dissipation

CLASSIFICATION REFLOW PROFILES

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature min (T _{smin}) Temperature max (T _{smax}) Time (T _{smin} to T _{smax}) (t _s)	150°C 200°C 60-120 seconds
Average ramp-up rate (T _{smax} to T _p)	3°C/second max.
Liquidous temperature (T _L) Time at liquidous (t _L)	217°C 60-150 seconds
Peak package body temperature (T _p)*	Max 260°C
Time (t _p)** within 5°C of the specified classification temperature (T _c)	Max 30 seconds
Average ramp-down rate (T _p to T _{smax})	6°C/second max.
Time 25°C to peak temperature	8 minutes max.

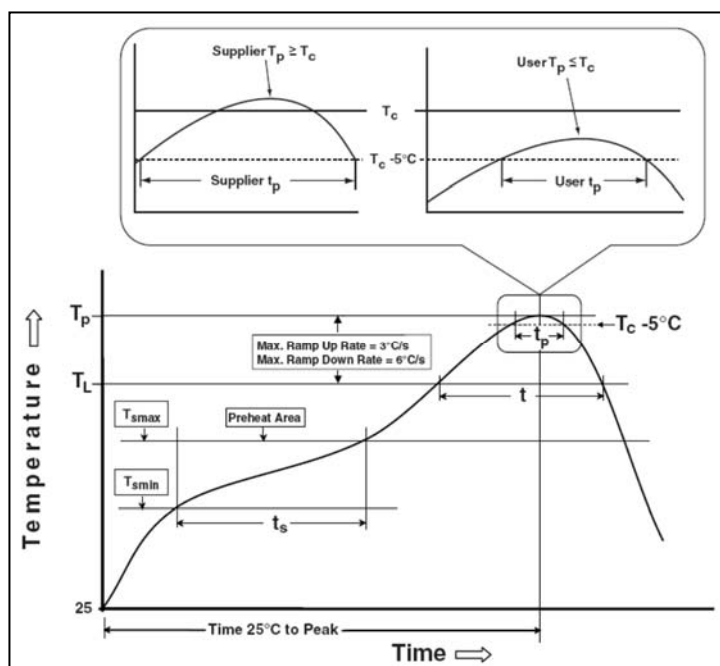
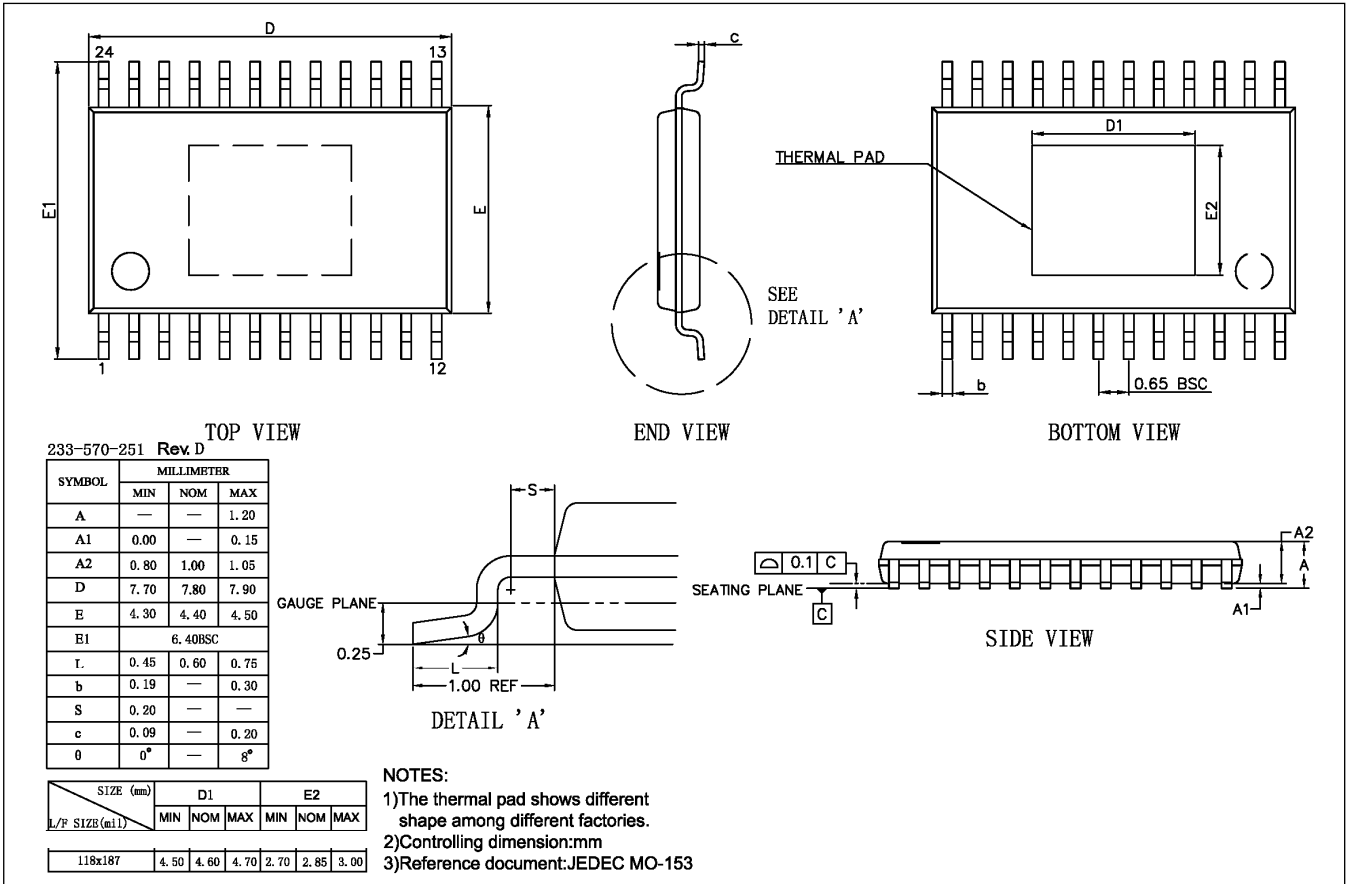


Figure 52 Classification Profile

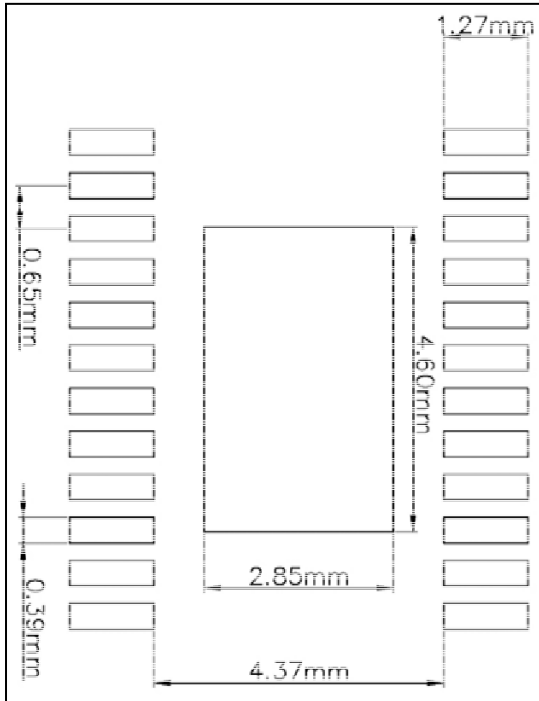
PACKAGE INFORMATION

eTSSOP-24



RECOMMENDED LAND PATTERN

eTSSOP-24



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
0A	Initial release	2025.04.25
A	Update EC table and add PERFORMANCE CHARACTERISTICS	2026.02.10