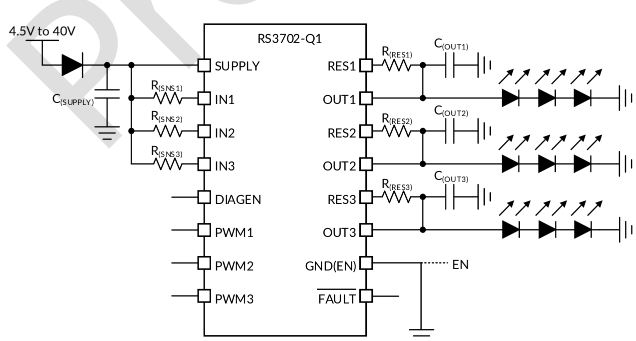
RS3702-Q1 Three-Channel, Automotive High-Side LED Driver with Thermal Sharing Control

1 FEATURES

- **RS3702-Q1 AEC-Q100 Qualification is Ongoing**
- **Wide Input Voltage Range: 4.5 V to 40 V**
- **Thermal Sharing by External Shunt Resistor**
- **Low Supply Current in Fault Mode**
- **Three High-Precision Current Regulation:**
  - **Up to 150mA Current Output for Each Channel**
  - **±5% Accuracy Over Full Temperature Range**
  - **Independent Current Setting by Resistor**
  - **Independent PWM Pin for Brightness Control**
- **Low Dropout Voltage:**
  - **TYP Dropout: 300 mV at 150 mA**
- **Diagnostics and Protection**
  - **LED Open-Circuit with Auto-Recovery**
  - **LED Short-to-GND with Auto-Recovery**
  - **Diagnostic Enable with Adjustable Threshold**
  - **Fault Bus Configurable as either One-Fails–All-Fail or Only-Failed-Channel Off (N-1)**
  - **Thermal Shutdown**
- **Operation Junction Temperature Range: –40°C to 150°C**

2 APPLICATIONS

- **Automotive Exterior Rear Light: Rear Lamp, Center High Mounted Stop Lamp, Side Marker**
- **Automotive Exterior Small Light: Door Handle, Blind Spot Detection Indicator, Charging Inlet**
- **Automotive Interior Light: Overhead Console, Reading Lamp**
- **General-Purpose LED Driver Applications**



Typical Application Diagram

3 DESCRIPTIONS

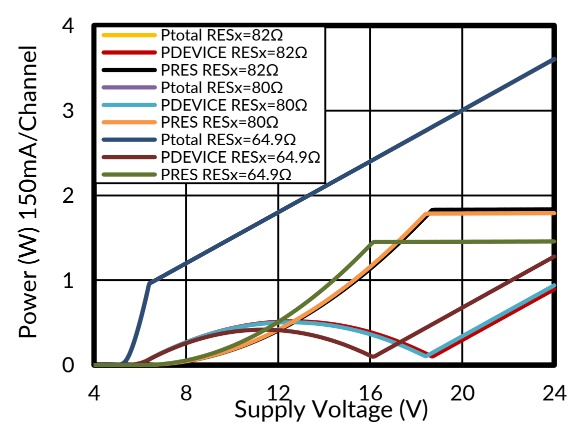
The RS3702-Q1 three-channel LED driver includes a unique thermal management design to reduce temperature rising on the device. The RS3702-Q1 is a linear driver directly powered by automotive batteries with large voltage variations to output full current loads up to 150 mA per channel. External shunt resistors are leveraged to share output current and dissipate power out of the driver. The device's full-diagnostic capabilities include LED open, LED short-to-GND circuit and device overtemperature protection.

The one-fails–all-fail feature of RS3702-Q1 is able to work together with other LED drivers.

Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
RS3702-Q1	ETSSOP16	5.00mm×4.40mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



Power Dissipation On Device

Table of Contents

4 REVISION HISTORY

Note: Page numbers for previous revisions may different from page numbers in the current version.

Version	Change Date	Change Item
A.0	2025/04/11	Preliminary version completed

5 PACKAGE/ORDERING INFORMATION (1)

PRODUCT	ORDERING NUMBER	TEMPERATURE RANGE	PACKAGE LEAD	Lead finish/Ball material (2)	MSL Peak Temp (3)	PACKAGE MARKING (4)	PACKAGE OPTION
RS3702-Q1	RS3702AXETSS16-Q1	-40°C ~+125°C	ETSSOP16	SN	TBD	RS3702A	Tape and Reel, 4000
	RS3702BXETSS16-Q1	-40°C ~+125°C	ETSSOP16	SN	TBD	RS3702B	Tape and Reel, 4000

NOTE:

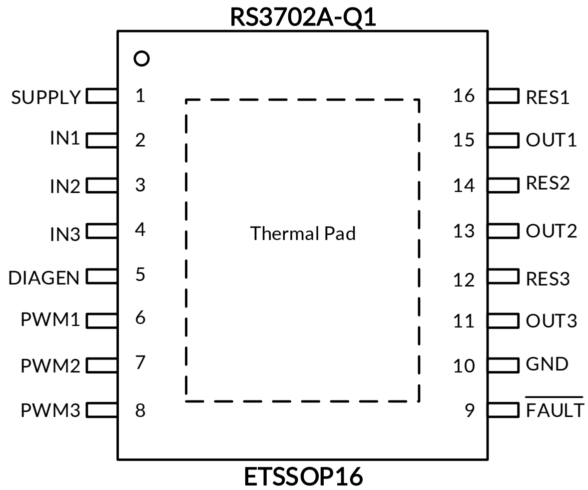
(1) This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the right-hand navigation.

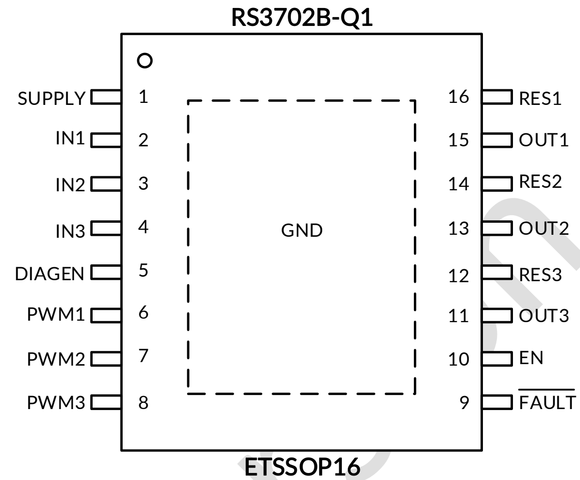
(2) Lead finish/Ball material. Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(3) RUNIC classify the MSL level with using the common preconditioning setting in our assembly factory conforming to the JEDEC industrial standard J-STD-20F. Please align with RUNIC if your end application is quite critical to the preconditioning setting or if you have special requirement.

(4) There may be additional marking, which relates to the lot trace code information (data code and vendor code), the logo or the environmental category on the device.

6 PIN CONFIGURATIONS





PIN DESCRIPTION

PIN		I/O (1)	FUNCTION
NAME	NO.		
SUPPLY	1	I	Device power supply.
IN1	2	I	Current input for channel1.
IN2	3	I	Current input for channel2.
IN3	4	I	Current input for channel3.
DIAGEN	5	I	Enable pin for LED open-circuit detection and single LED short detection to avoid false open and single LED short diagnostics during low-dropout operation.
PWM1	6	I	PWM input for OUT1 and RES1 current output ON/OFF control.
PWM2	7	I	PWM input for OUT2 and RES2 current output ON/OFF control.
PWM3	8	I	PWM input for OUT3 and RES3 current output ON/OFF control.
$\overline{\text{FAULT}}$	9	I/O	Fault output, support one-fails-all-fail fault bus.
GND	10	-	RS3702A-Q1: Ground.
EN		-	RS3702B-Q1: Device enable pin.
OUT3	11	O	Current output for channel 3. A 10nF capacitor is recommended between the pin to GND.
RES3	12	O	Current output for channel 3 with external thermal resistor.
OUT2	13	O	Current output for channel 2. A 10nF capacitor is recommended between the pin to GND.
RES2	14	O	Current output for channel 2 with external thermal resistor.
OUT1	15	O	Current output for channel 1. A 10nF capacitor is recommended between the pin to GND.
RES1	16	O	Current output for channel 1 with external thermal resistor.
Thermal pad	Thermal Pad	-	RS3702A-Q1: Suggest to connect to GND.
GND		-	RS3702B-Q1: Ground.

(1) I=input, O=output.

7 SPECIFICATIONS

7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)

			MIN	MAX	UNIT
Supply	SUPPLY		-0.3	45	V
High-voltage input	DIAGEN, IN1, IN2, IN3, EN, PWM1, PWM2, PWM3		-0.3	V_{SUPPLY}+0.3	V
High-voltage output	OUT1, OUT2, OUT3, RES1, RES2, RES3		-0.3	V_{SUPPLY}+0.3	V
Fault bus	$\overline{FAULT}$		-0.3	V_{SUPPLY}+0.3	V
$θ_{JA}$	Package thermal impedance (2)	ETSSOP16		54	°C/W
T_J	Operating junction temperature (3)		-40	150	°C
T_{stg}	Storage temperature		-40	150	°C

(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.

(2) The package thermal impedance is calculated in accordance with JESD-51.

(3) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{θJA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A) / R_{θJA}$. All numbers apply for packages soldered directly onto a PCB.

7.2 ESD Ratings

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-Body Model (HBM), per AEC Q100-002 (1)	±2000	V
		Charged-Device Model (CDM), per AEC Q100-011	±1000	V
		Latch-Up (LU), per AEC Q100-004	TBD	mA

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

ESD SENSITIVITY CAUTION

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

7.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
SUPPLY	Device supply voltage	4.5	40	V
IN1, IN2, IN3	Sense voltage	V_{SUPPLY}-V_{CS_REG}	V_{SUPPLY}	V
EN	Device EN pin	0	V_{SUPPLY}	V
PWM1, PWM2, PWM3	PWM inputs	0	V_{SUPPLY}	V
DIAGEN	Diagnostics enable pin	0	V_{SUPPLY}	V
OUT1, OUT2, OUT3, RES1, RES2, RES3	Driver output	0	V_{SUPPLY}	V
$\overline{FAULT}$	Fault bus	0	V_{SUPPLY}	V
Operating ambient temperature, T_A		-40	125	°C

7.4 Electrical Characteristics

V_{SUPPLY}=5V to 40V, V_{EN}=5V, T_J=25°C unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN(1)	TYP(2)	MAX(1)	UNIT
BIAS						
V_{POR_rising}	Supply voltage POR rising threshold			3.65		V
$V_{POR\_falling}$	Supply voltage POR falling threshold			3.55		V
I_{SD}	Device shutdown current	V_{EN} = 0V, Only for RS3702B-Q1		TBD		µA
$I_{Quiescent}$	Device standby ground current	EN=HIGH		1.3		mA
I_{Fault}	Device supply current in fault mode	PWM=HIGH, $\overline{FAULT}$ externally pulled LOW		0.26		mA
LOGIC INPUTS (EN, DIAGEN, PWM)						
V_{IL_EN}	Input logic-low voltage, EN	Only for RS3702B-Q1			TBD	V
V_{IH_EN}	Input logic-high voltage, EN	Only for RS3702B-Q1	TBD			V
$I_{EN\_pulldown}$	EN pulldown current	V_{EN}=12V, Only for RS3702B-Q1		TBD		µA
V_{IL_DIAGEN}	Input logic-low voltage, DIAGEN			1.1		V
V_{IH_DIAGEN}	Input logic-high voltage, DIAGEN			1.2		V
V_{IL_PWM}	Input logic-low voltage, PWM			1.1		V
V_{IH_PWM}	Input logic-high voltage, PWM			1.2		V
CONSTANT-CURRENT DRIVER						
I_{OUTx_Tot}	Device output-current for each channel	Duty of PWM=100%	5		150	mA
V_{CS_REG}	Sense-resistor regulation voltage	T_A=-40°C to +125°C		150		mV
ΔV_{CS_c2c}	Channel to channel mismatch	$\Delta V_{CS\_c2c}=1-V_{CS\_REGx}/V_{avg\_CS\_REG}$		±0.5		%
ΔV_{CS_d2d}	Device to Device mismatch	$\Delta V_{CS\_d2d}=1-V_{avg\_CS\_REG}/V_{nom\_CS\_REG}$		±1		%
R_{CS_REG}	Sense-resistor range		0.96		31.2	Ω
$V_{DROPOUT}$	Voltage dropout from INx to OUTx, RESx open	Current setting of 100mA		200		mV
		Current setting of 150mA		300		
	Voltage dropout from INx to RESx, OUTx open	Current setting of 100mA		265		
		Current setting of 150mA		400		
I_{RESx}	Ratio of RESx current to total current	I_{RESx}/I_{OUTx_Tot}, $V_{INx}-V_{RESx}$>1V	95			%
DIAGNOSTICS						
$V_{OPEN\_th\_rising}$	LED open rising threshold, $V_{IN}-V_{OUT}$			340		mV
$V_{OPEN\_th\_falling}$	LED open falling threshold, $V_{IN}-V_{OUT}$			510		mV
$V_{SG\_th\_rising}$	Channel output short-to-ground rising threshold			1.2		V
$V_{SG\_th\_falling}$	Channel output short-to-ground falling threshold			0.9		V
I_{RETRY}	Channel output V_{OUT} short-to-ground retry current			1		mA

(1) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.

(2) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.

Electrical Characteristics (continued)

V_{SUPPLY}=5V to 40V, V_{EN}=5V, T_J=25°C unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN(1)	TYP(2)	MAX(1)	UNIT
FAULT						
V_{IL_FAULT}	Logic input low threshold				0.7	V
V_{IH_FAULT}	Logic input high threshold		2			V
t_{FAULT_rising}	Fault detection rising edge deglitch time			10		µs
$t_{FAULT\_falling}$	Fault detection falling edge deglitch time			20		µs
$I_{FAULT\_pulldown}$	$\overline{FAULT}$ internal pulldown current	$V_{\overline{FAULT}}$=0.4V		3		mA
I_{FAULT_pullup}	$\overline{FAULT}$ internal pullup current			10		µA
$I_{FAULT\_leakage}$	$\overline{FAULT}$ leakage current	$V_{\overline{FAULT}}$=40V		0.3		µA
THERMAL PROTECTION						
T_{TSD}	Thermal shutdown junction temperature threshold			170		°C
T_{TSD_HYS}	Thermal shutdown junction temperature hysteresis			15		°C

(1) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.

(2) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.

7.5 Timing Requirements

PARAMETER		TEST CONDITIONS	MIN[(1)]	TYP[(2)]	MAX[(1)]	UNIT
$t_{PWM\_delay\_rising}$	PWM rising edge delay(V_{IH_PWM}) to 10% output	V_{SUPPLY}=12V, V_{OUT}=6V, V_{CS_REG}=150mV, R_{SNSx}=1Ω, R_{RESx}=80Ω		5		µs
		V_{SUPPLY}=12V, V_{OUT}=6V, V_{CS_REG}=150mV, R_{SNSx}=30Ω, R_{RESx}=80Ω		5		µs
$t_{Current\_rising}$	Output current rising from 10% to 90%	V_{SUPPLY}=12V, V_{OUT}=6V, V_{CS_REG}=150mV, R_{SNSx}=1Ω, R_{RESx}=80Ω		2		µs
		V_{SUPPLY}=12V, V_{OUT}=6V, V_{CS_REG}=150mV, R_{SNSx}=30Ω, R_{RESx}=80Ω		1		µs
$t_{PWM\_delay\_falling}$	PWM falling edge delay(V_{IL_PWM}) to 90% output	V_{SUPPLY}=12V, V_{OUT}=6V, V_{CS_REG}=150mV, R_{SNSx}=1Ω, R_{RESx}=80Ω		4		µs
		V_{SUPPLY}=12V, V_{OUT}=6V, V_{CS_REG}=150mV, R_{SNSx}=30Ω, R_{RESx}=80Ω		4		µs
$t_{Current\_falling}$	Output current falling from 90% to 10%	V_{SUPPLY}=12V, V_{OUT}=6V, V_{CS_REG}=150mV, R_{SNSx}=1Ω, R_{RESx}=80Ω		3		µs
		V_{SUPPLY}=12V, V_{OUT}=6V, V_{CS_REG}=150mV, R_{SNSx}=30Ω, R_{RESx}=80Ω		1		µs
$t_{STARTUP}$	SUPPLY rising edge to 10% output current	V_{SUPPLY}=12V, V_{OUT}=6V, V_{CS_REG}=150mV, R_{SNSx}=1Ω, R_{RESx}=80Ω		85		µs
t_{OPEN_deg}	LED-open fault deglitch time			125		µs
t_{SG_deg}	Output short-to-ground detection deglitch time			125		µs
$t_{Recover\_deg}$	Open and Short fault recovery deglitch time			125		µs
$t_{FAULT\_recovery}$	Fault recovery delay time			50		µs
t_{TSD_deg}	Thermal over temperature deglitch time			50		µs

(1) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.

(2) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.

7.6 Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

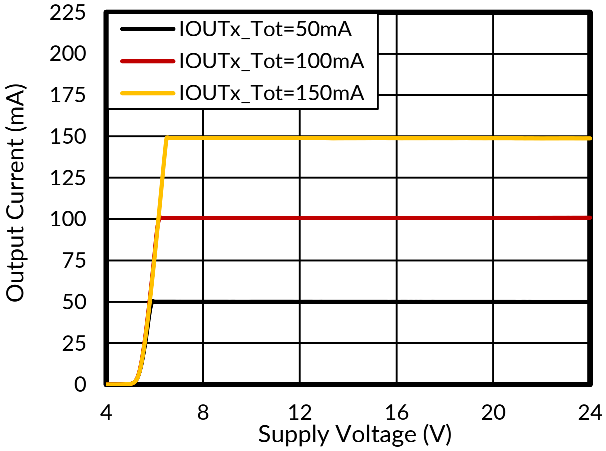


Figure 1. Output Current vs Supply Voltage

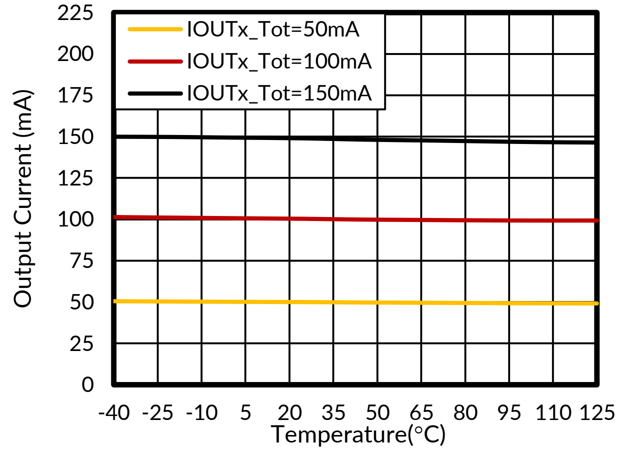


Figure 2. Output Current vs Temperature

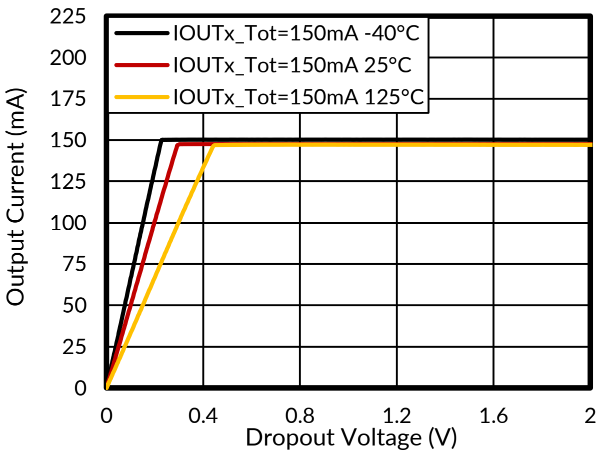


Figure 3. Output Current vs Dropout Voltage

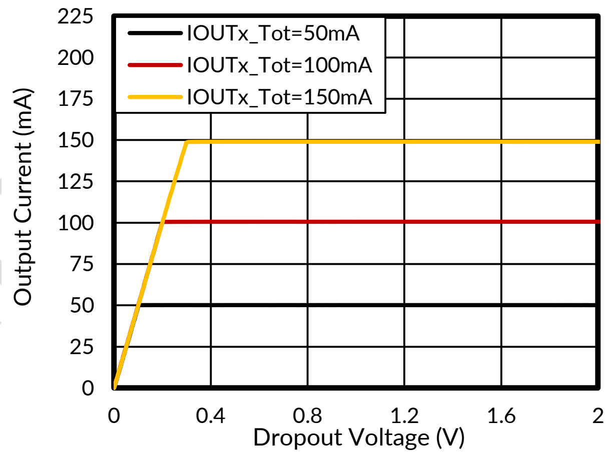


Figure 4. Output Current vs Dropout Voltage

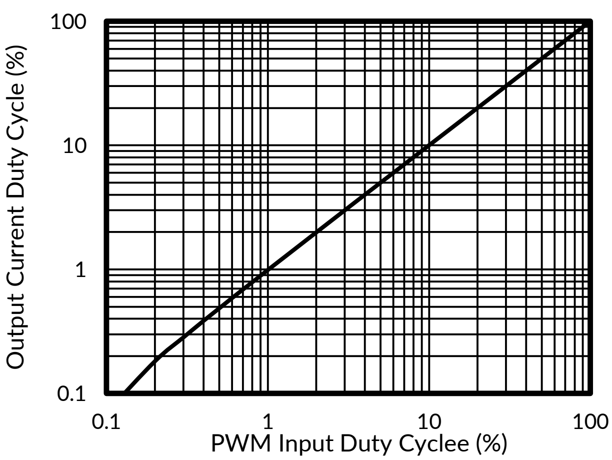


Figure 5. PWM Output Duty Cycle vs PWM Input Duty Cycle

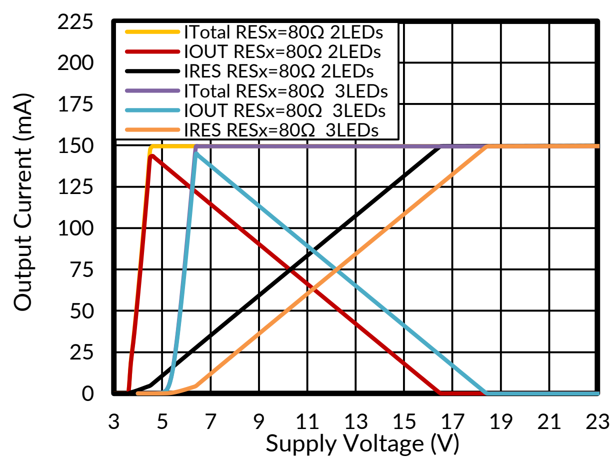


Figure 6. Output Current Distribution vs Supply Voltage

Typical Characteristics (continued)

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

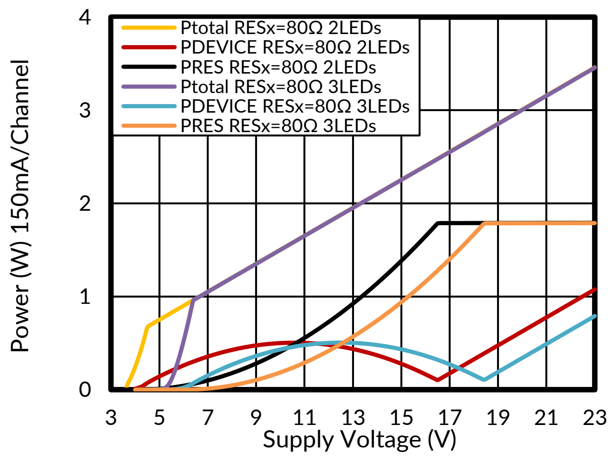


Figure 7. Power Dissipation vs Supply Voltage

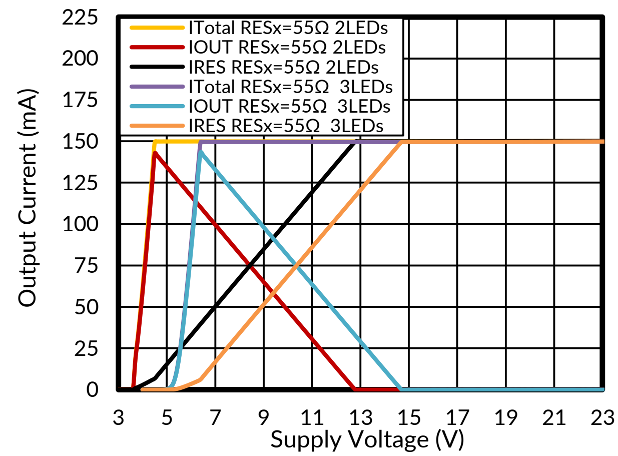


Figure 8. Output Current Distribution vs Supply Voltage

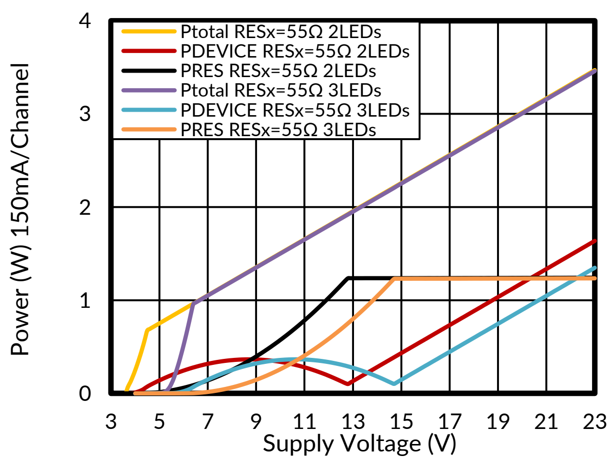


Figure 9. Power Dissipation vs Supply Voltage

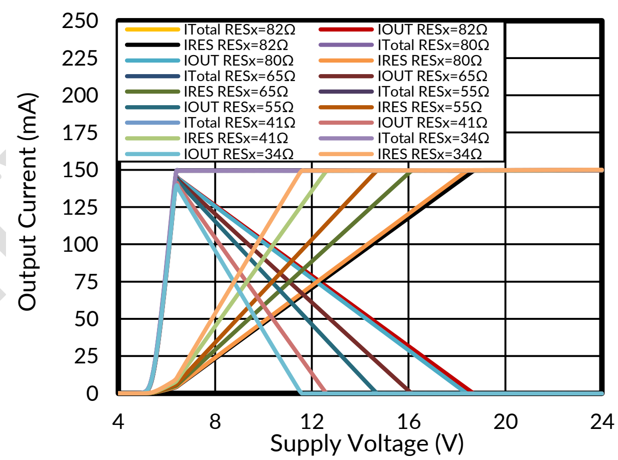


Figure 10. Output Current Distribution vs Supply Voltage

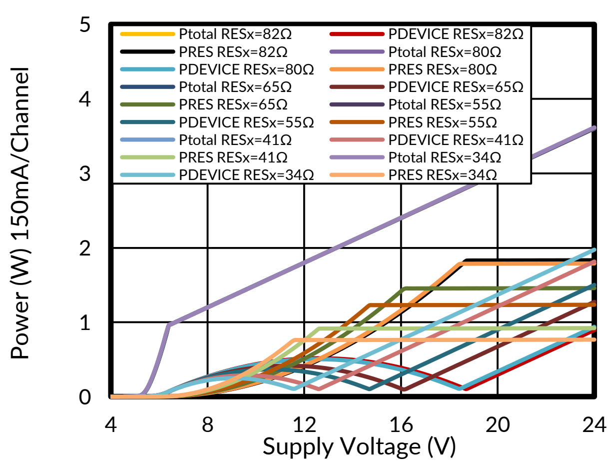


Figure 11. Power Dissipation vs Supply Voltage

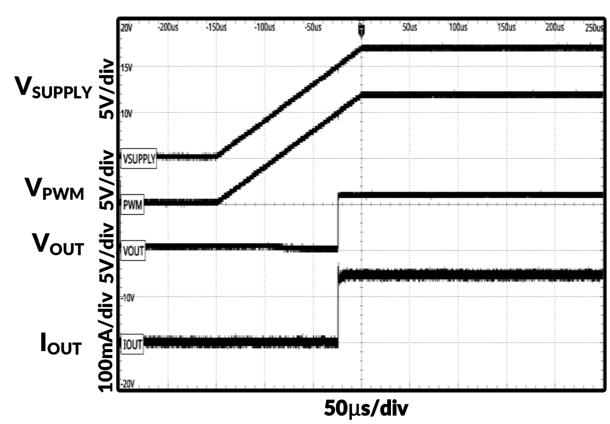


Figure 12. Power Up Sequence

Typical Characteristics (continued)

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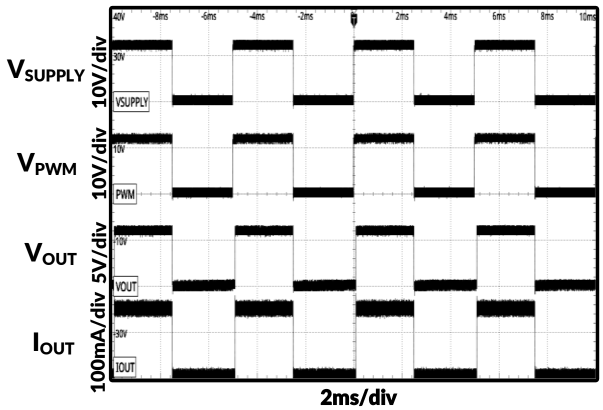


Figure 13. Supply Dimming at 200 Hz

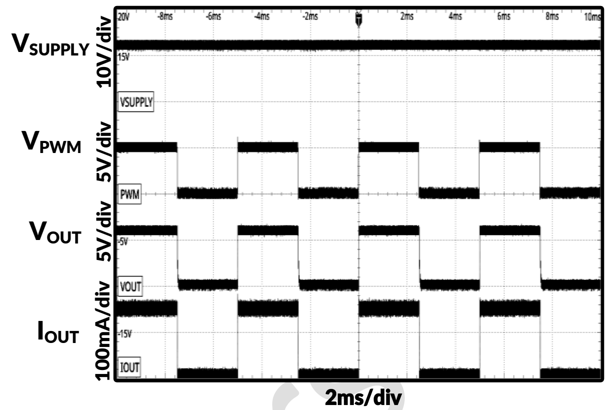


Figure 14. PWM Dimming at 200 Hz

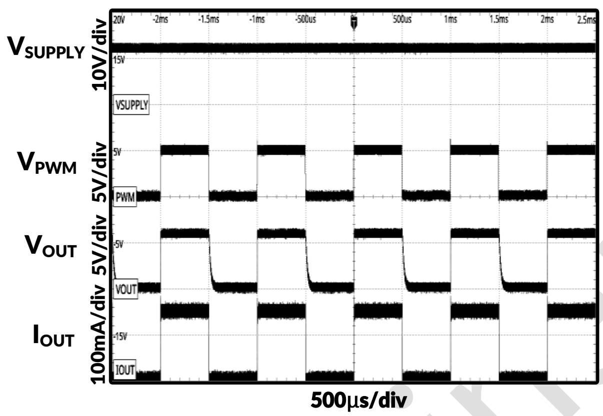


Figure 15. PWM Dimming at 1 kHz

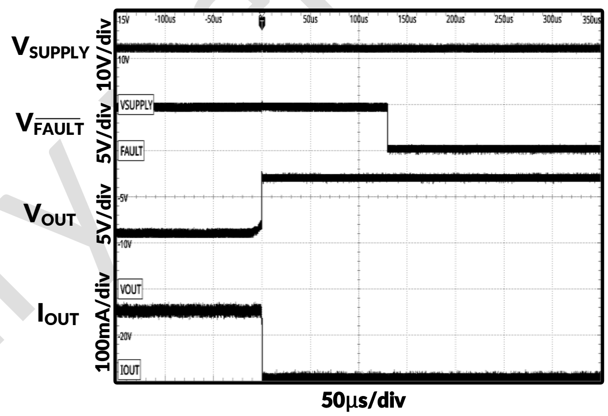


Figure 16. LED Open Protection

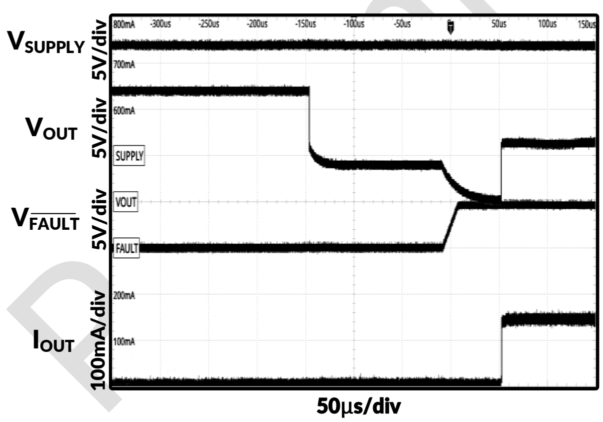


Figure 17. LED Open Protection Recovery

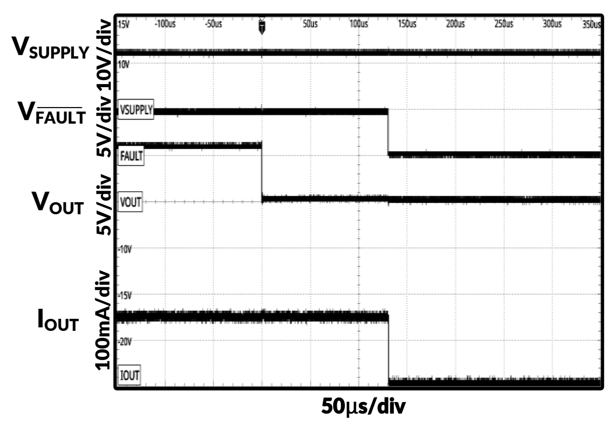


Figure 18. LED Short-Circuit Protection

Typical Characteristics (continued)

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

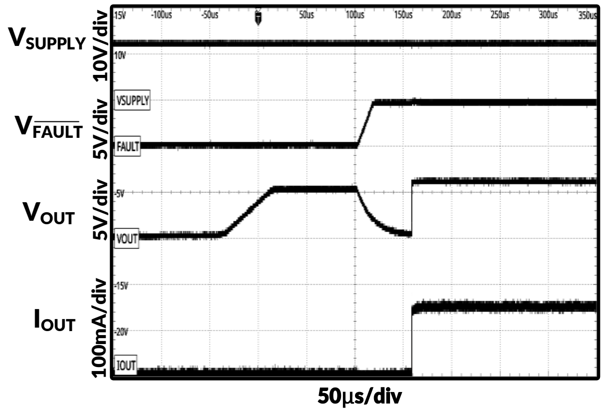


Figure 19. LED Short-Circuit Protection Recovery

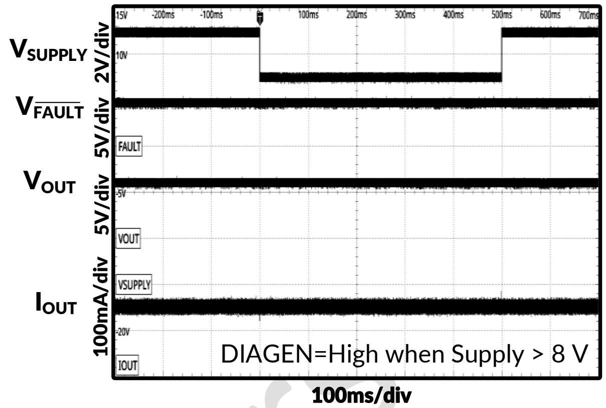


Figure 20. Transient Undervoltage

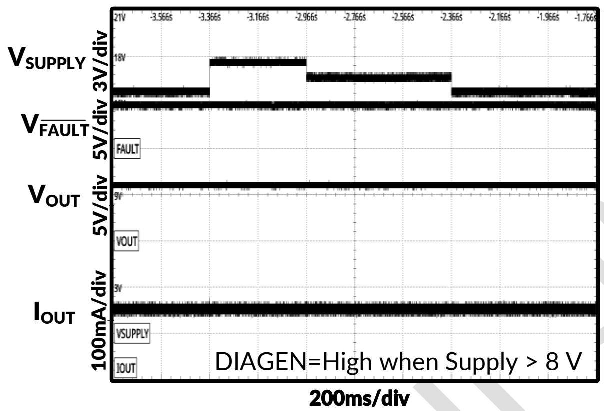


Figure 21. Transient Overvoltage

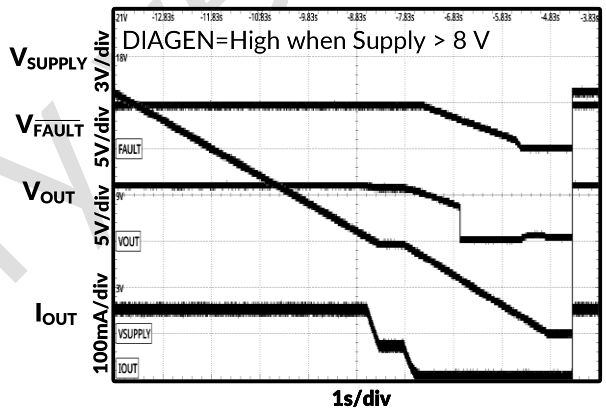


Figure 22. Slow Decrease and Quick Increase of Supply Voltage

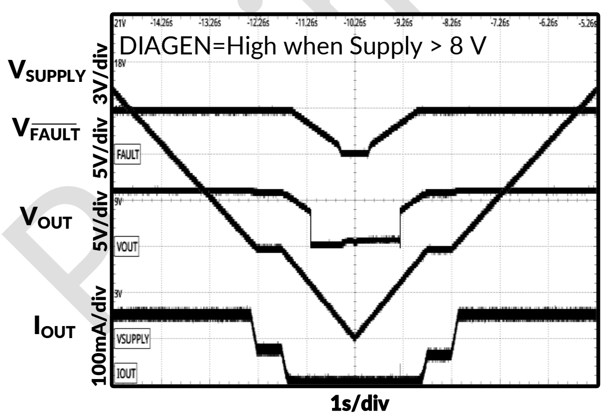


Figure 23. Slow Decrease and Slow Increase of Supply Voltage

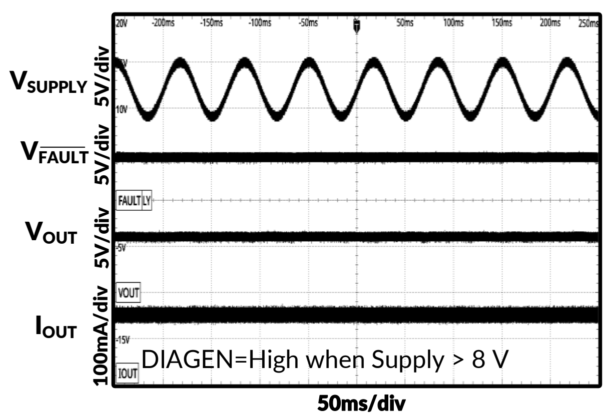


Figure 24. Superimposed Alternating Voltage 15Hz

Typical Characteristics (continued)

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

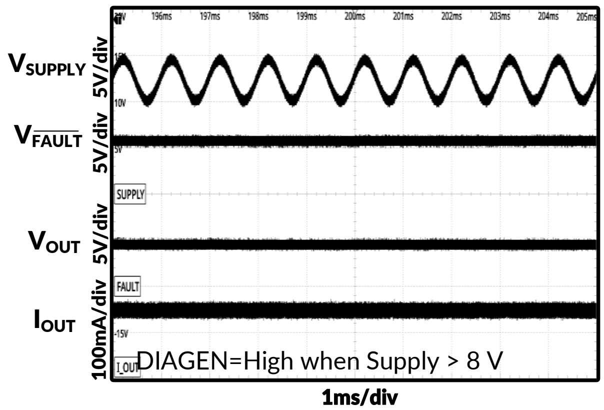


Figure 25. Superimposed Alternating Voltage 1kHz

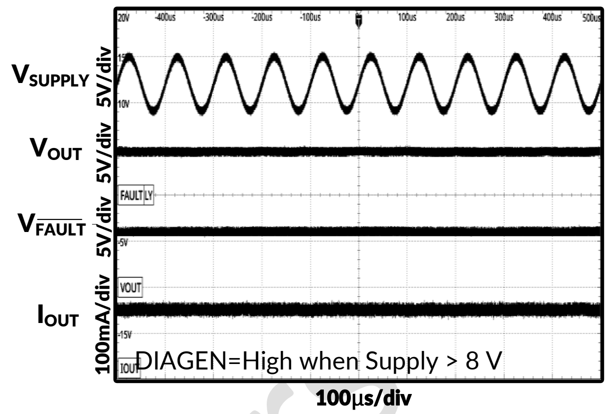


Figure 26. Superimposed Alternating Voltage 10kHz

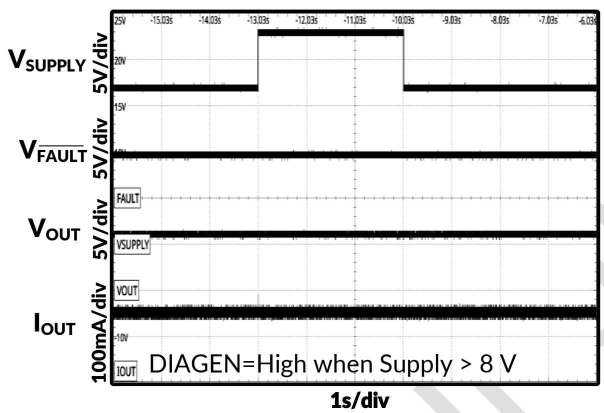


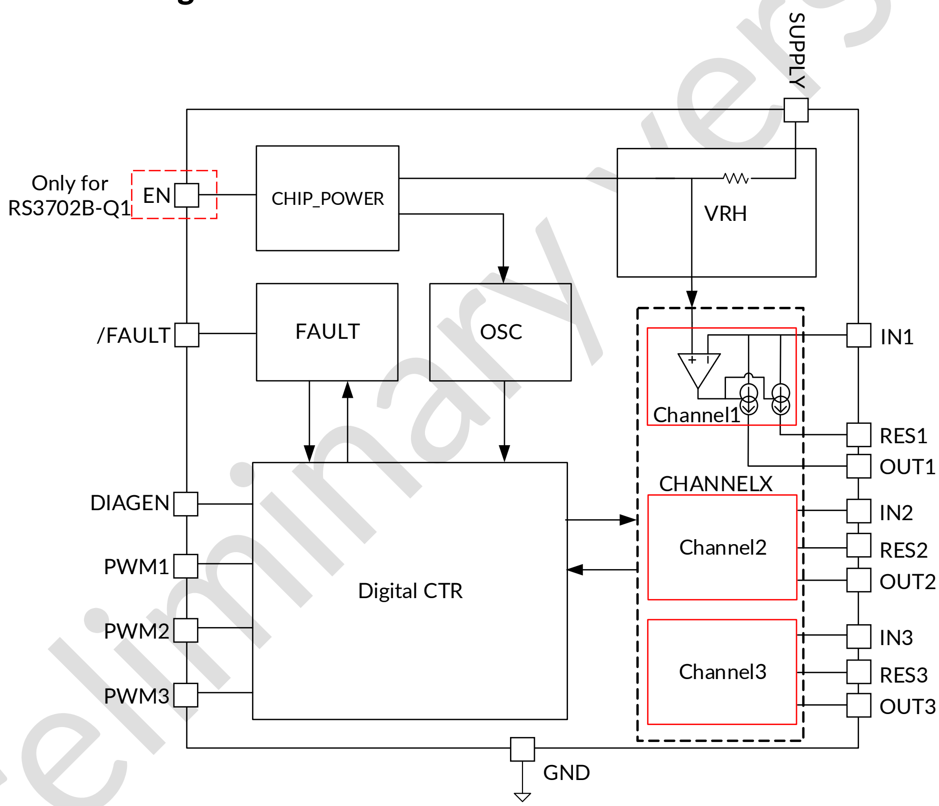
Figure 27. Jump Start

8 DETAILED DESCRIPTION

8.1 Overview

The RS3702-Q1 is a three-channel, high-side linear LED driver supporting external thermal sharing resistor to achieve the controllable junction temperature rising. The device can be directly powered by automotive battery and output full load up to 450-mA current to LED with limited power dissipation on the device. The current output at each channel can be independently set by external $R_{(SNSx)}$ resistors. Current flows from the supply through the $R_{(SNSx)}$ resistor into the integrated current regulation circuit and to the LEDs through OUTx pin and RESx pin. RS3702-Q1 device supports both supply control and PWM control to turn LED ON and OFF. The LED brightness is also adjustable by voltage duty cycle applied on either SUPPLY or PWMx pins with frequency above 100 Hz. The RS3702-Q1 provides full diagnostics to keep the system operating reliably including LED open/short circuit detection, supply POR and thermal shutdown protection. RS3702-Q1 device is in a ETSSOP package with total 16 leads. The RS3702-Q1 can be used with other family devices together to achieve one-fails-all-fail protection by tying all $\overline{\text{FAULT}}$ pins together as a fault bus.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Power Supply (SUPPLY)

8.3.1.1 Power-On Reset (POR)

The RS3702-Q1 device has an internal power-on-reset (POR) function. When power is applied to the SUPPLY pin, the internal POR circuit holds the device in reset state until $V_{(SUPPLY)}$ is above $V_{(POR\_rising)}$.

8.3.1.2 Suppply Current in Fault Mode

The RS3702-Q1 device consumes minimal quiescent current, $I_{(FAULT)}$, into SUPPLY when the $\overline{\text{FAULT}}$ pin is externally pulled LOW. At the same time, the device shuts down all three output drivers.

If device detects an internal fault, it pulls down the $\overline{\text{FAULT}}$ pin by an internal typical 3-mA constant current as a fault indication to the fault bus.

8.3.2 Enable and Shutdown

The RS3702A-Q1 device starts to operate as long as the SUPPLY voltage is higher than $V_{(POR\_rising)}$. The RS3702A-Q1 shuts down when SUPPLY voltage is lower than $V_{(POR\_falling)}$.

The RS3702B-Q1 device has an enable input. When EN is low, the device is in sleep mode with ultralow quiescent current $I_{(SD)}$. This low current helps to save system-level current consumption in applications where battery voltage directly connects to the device without high-side switches.

8.3.3 Constant-Current Output and Setting (INx)

The RS3702-Q1 device is a high-side current driver for driving LEDs. The device controls each output current through regulating the voltage drop on an external high-side current-sense resistor, $R_{(SNSx)}$ independently for each channel. An integrated error amplifier drives an internal power transistor to maintain the voltage drop on the current-sense resistor $R_{(SNSx)}$ to $V_{(CS\_REG)}$ and therefore regulates the current output to target value. When the output current is in regulation, the current value for each channel can be calculated by using Equation 1.

$$I_{(OUTx\_Tot)} = \frac{V_{(CS\_REG)}}{R_{(SNSx)}} \quad (1)$$

where

- $V_{(CS\_REG)}$ = 150 mV
- x = 1, 2 or 3 for output channel 1, 2 or 3

When the supply voltage drops below total LED string forward voltage plus required headroom voltage, the sum of $V_{(DROPOUT)}$ and $V_{(CS\_REG)}$, the RS3702-Q1 is not able to deliver enough current output as set by the value of $R_{(SNSx)}$, and the voltage across the current-sense resistor $R_{(SNSx)}$ is less than $V_{(CS\_REG)}$.

8.3.4 Thermal Sharing Resistor (OUTx and RESx)

The RS3702-Q1 device provides two current output paths for each channel. Current flows from the supply through the $R_{(SNSx)}$ resistor into the integrated current regulation circuit and to the LEDs through OUTx pin and RESx pin. The current output on both OUTx pin and RESx pin is independently regulated to achieve total required current output. The summed current of OUTx and RESx is equal to the current through the $R_{(SNSx)}$ resistor in the channel. The OUTx connects to anode of LEDs load in serial directly, however RESx connects to the LEDs through an external resistor to share part of the power dissipation and reduce the thermal accumulation in RS3702-Q1.

The integrated independent current regulation in RS3702-Q1 dynamically adjusts the output current on both OUTx and RESx output to maintain the stable summed current for LED. The RS3702-Q1 always regulates the current output to the RESx pin as much as possible until the RESx current path is saturated, and the rest of required current is regulated out of the OUTx. As a result, the most of the current to LED outputs through the RESx pin when the voltage dropout is large between SUPPLY and LED required total forward voltage. In the opposite case, the most of the current to LED outputs through the OUTx pin when the voltage headroom is relative low between SUPPLY and LED required forward voltage.

8.3.5 PWM Control (PWMx)

The pulse width modulation (PWM) input of the RS3702-Q1 functions as enable for the output current. When the voltage applied on the PWM pin is higher than $V_{IH(PWM)}$, the relevant output current is enabled. When the voltage applied on PWM pin is lower than $V_{IL(PWM)}$, the output current is disabled as well as the diagnostic features. Besides output current enable and disable function, the PWM input of RS3702-Q1 also supports adjustment of the average current output for brightness control if the frequency of applied PWM signal is higher than 100 Hz, which is out of visible frequency range of human eyes. RUNIC recommends a 200-Hz PWM signal with 1% to 100% duty cycle input for brightness control. Please refer to Figure 44 for typical PWM dimming application.

The RS3702-Q1 device has three PWM input pins: PWM1, PWM2, and PWM3 to control each of current output channel independently. PWM1 input controls the output channel1 for both OUT1 and RES1, PWM2 input controls the output channel2 for both OUT2 and RES2, and PWM3 input controls the output channel3 for both OUT3 and RES3. Figure 28 illustrates the timing for PWM input and current output.

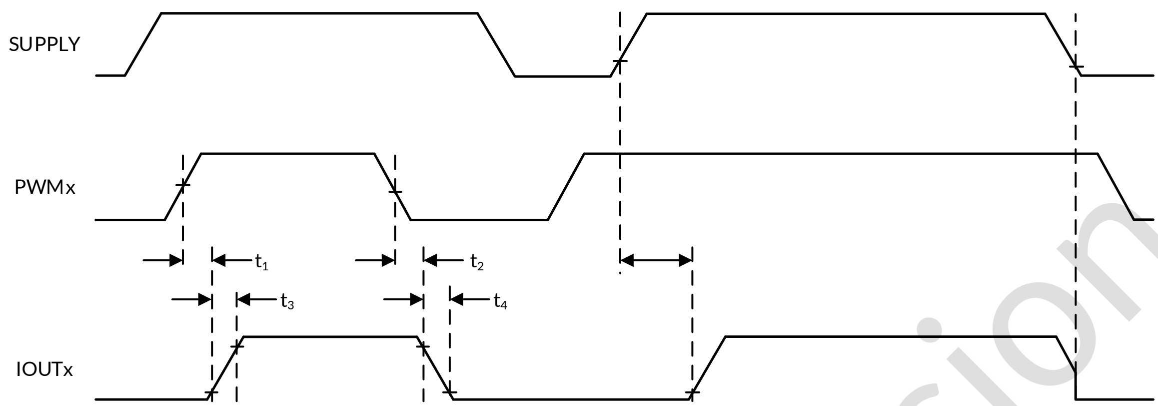


Figure 28. Power On Sequence and PWM Dimming Timing

The detailed information and value of each time period in Figure 28 is described in Electrical Characteristics.

8.3.6 Supply Control

The RS3702-Q1 can support supply control to turn ON and OFF output current. When the voltage applied on the SUPPLY pin is higher than the LED string forward voltage plus needed headroom voltage at required current, and the PWM pin voltage is high, the output current is turned ON and well regulated. However, if the voltage applied on the SUPPLY pin is lower than $V_{(POR\_falling)}$, the output current is turned OFF. With this feature, the power supply voltage in designed pattern can control the output current ON and OFF. The brightness is adjustable if the ON and OFF frequency is fast enough. Because of the high accuracy design of PWM threshold in RS3702-Q1, RUNIC recommends a resistor divider on the PWM pin to set the SUPPLY threshold higher than LED forward voltage plus required headroom voltage as shown in Figure 29. The headroom voltage is basically the summation of $V_{(DROPOUT)}$ and $V_{(CS\_REG)}$. When the voltage on the PWM pin is higher than $V_{IH(PWM)}$, the output current is turned ON. However, when the voltage on the PWM is lower than $V_{IL(PWM)}$, the output current is turned OFF. The SUPPLY threshold voltage can be calculated by using Equation 2.

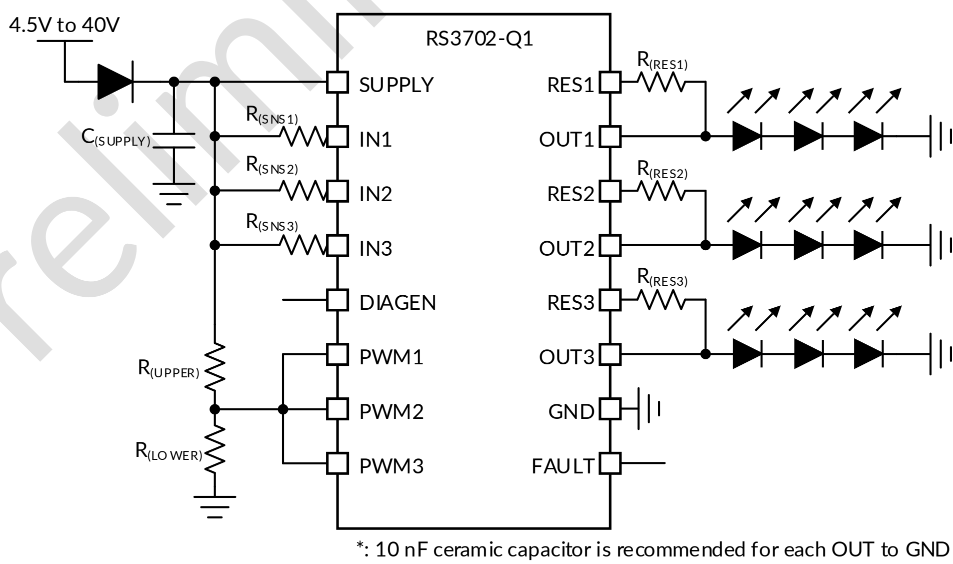


Figure 29. Application Schematic for Supply Control LED Brightness

$$V_{(SUPPLY\_PWM\_th\_rising)} = V_{IH(PWM)} \times \left(1 + \frac{R_{(UPPER)}}{R_{(LOWER)}}\right) \quad (2)$$

where

- $V_{IH(PWM)}$ = 1.2 V (typical)

8.3.7 Diagnostics

The RS3702-Q1 device provides advanced diagnostics and fault-protection features for automotive exterior lighting systems. The device is able to detect and protect fault from LED-string short-to-GND, LED-string open-circuit and junction over-temperature scenarios. The device also supports a one-fails–all-fail fault bus design that can flexibly fit different regulatory requirements.

8.3.7.1 LED Short-to-GND Detection

The RS3702-Q1 device has LED short-to-GND detection. The LED short-to-GND detection monitors the output voltage when the output current is enabled. Once a short-to-GND LED failure is detected, the device turns off the faulty channel and retries automatically, regardless of the state of the PWM input. If the retry mechanism detects the removal of the LED short-to-GND fault, the device resumes to normal operation.

The RS3702-Q1 monitors both $V_{(OUTx)}$ voltage and $V_{(RESx)}$ voltage of each channel and compares it with the internal reference voltage to detect a short-to-GND failure. If $V_{(OUTx)}$ or $V_{(RESx)}$ voltage falls below $V_{(SG\_th\_falling)}$ longer than the deglitch time of $t_{(SG\_deg)}$, the device asserts the short-to-GND fault and pulls low the $\overline{FAULT}$ pin. During the deglitching time period, if $V_{(OUTx)}$ and $V_{(RESx)}$ rises above $V_{(SG\_th\_rising)}$, the timer is reset.

Once the RS3702-Q1 has asserted a short-to-GND fault, the device turns off the faulty output channel and retries automatically with a small current. During retrying, the device sources a small current $I_{(Retry)}$ from SUPPLY to OUT and RES to pull up the LED loads continuously. After auto-retry detects output voltage rising above $V_{(SG\_th\_rising)}$, it clears the short-to-GND fault and resumes to normal operation. Figure 30 illustrates the timing for LED short-circuit detection, protection, retry and recovery.

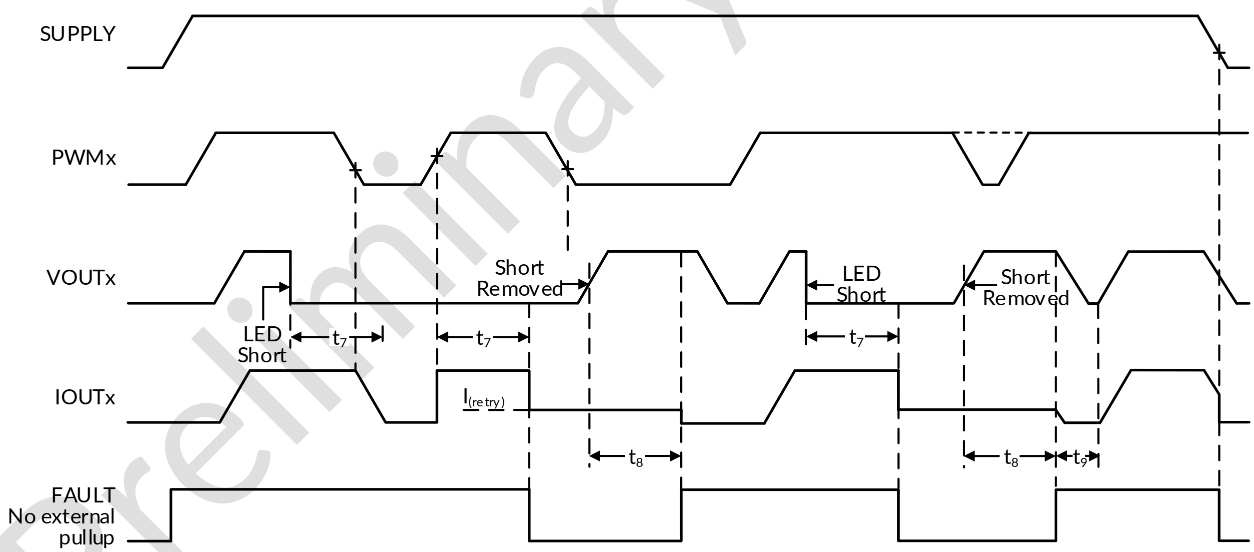


Figure 30. LED Short-to-GND Detection and Recovery Timing Diagram

The detailed information and value of each time period in Figure 30 is described in Electrical Characteristics.

8.3.7.2 LED Open-Circuit Detection

The RS3702-Q1 device has LED open-circuit detection. The LED open-circuit detection monitors the output voltage when the current output is enabled. The LED open-circuit detection is only enabled when DIAGEN is HIGH. A short-to-battery fault is also detected and recognized as an LED open-circuit fault.

The RS3702-Q1 monitors dropout-voltage differences between the IN and OUT pins for each LED channel when PWM is HIGH. The voltage difference $V_{(INx)} - V_{(OUTx)}$ is compared with the internal reference voltage $V_{(OPEN\_th\_rising)}$

to detect an LED open-circuit incident. If $V_{(OUTx)}$ rises and causes $V_{(INx)} - V_{(OUTx)}$ less than the $V_{(OPEN\_th\_rising)}$ voltage longer than the deglitch time of $t_{(OPEN\_deg)}$, the device asserts an open-circuit fault. After a LED open-circuit failure is detected, the internal constant-current sink pulls down the $\overline{FAULT}$ pin voltage. During the deglitch time period, if $V_{(OUTx)}$ falls and makes $V_{(INx)} - V_{(OUTx)}$ larger than $V_{(OPEN\_th\_falling)}$, the deglitch timer is reset.

The RS3702-Q1 shuts down the output current regulation for the error channel after LED open-circuit fault is detected. The device sources a small current $I_{(Retry)}$ from SUPPLY to OUT and RES when DIAGEN input is logic High. After the fault condition is removed, the device resumes normal operation and releases the $\overline{FAULT}$ pin. Figure 31 illustrates the timing for LED open-circuit detection, protection, retry and recovery.

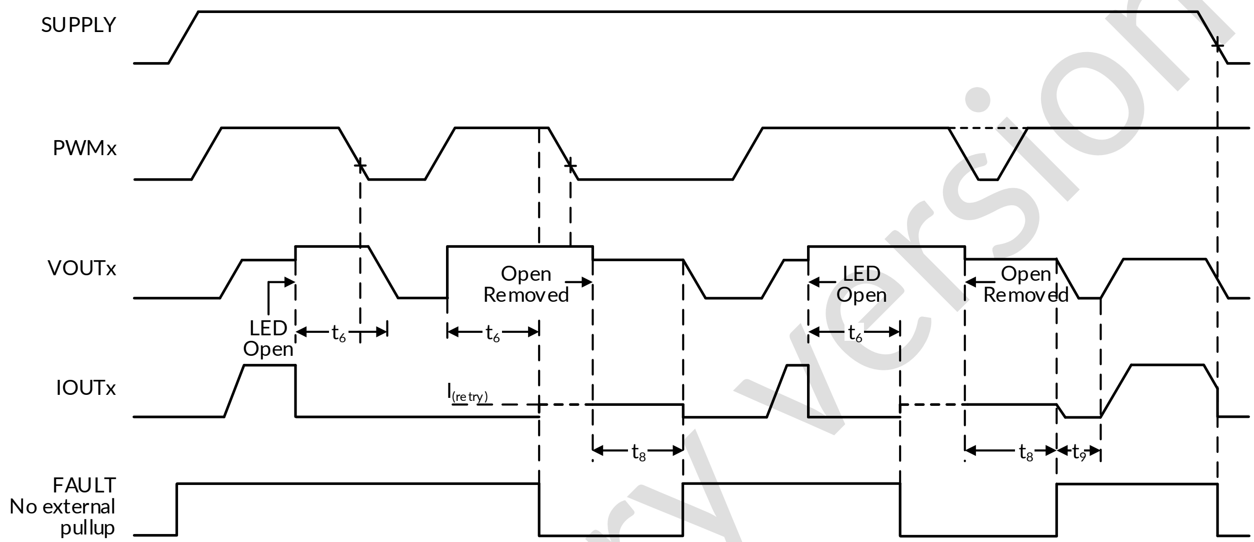


Figure 31. LED Open-Circuit Detection and Recovery Timing Diagram

The detailed information and value of each time period in Figure 31 is described in Electrical Characteristics.

8.3.7.3 LED Open-Circuit Detection Enable (DIAGEN)

The RS3702-Q1 device supports the DIAGEN pin with an accurate threshold to disable the LED open-circuit. The DIAGEN pin can be used to enable or disable LED open-circuit detection based on SUPPLY pin voltage sensed by an external resistor divider as illustrated in Figure 32. When the voltage applied on DIAGEN pin is higher than the threshold $V_{IH(DIAGEN)}$, the device enables LED open-circuit detection. When $V_{(DIAGEN)}$ is lower than the threshold $V_{IL(DIAGEN)}$, the device disables LED open-circuit detection.

Only LED open-circuit detection can be disabled by pulling down the DIAGEN pin. The LED short-to-GND detection and overtemperature protection cannot be turned off by pulling down the DIAGEN pin. The SUPPLY threshold voltage can be calculated by using Equation 3.

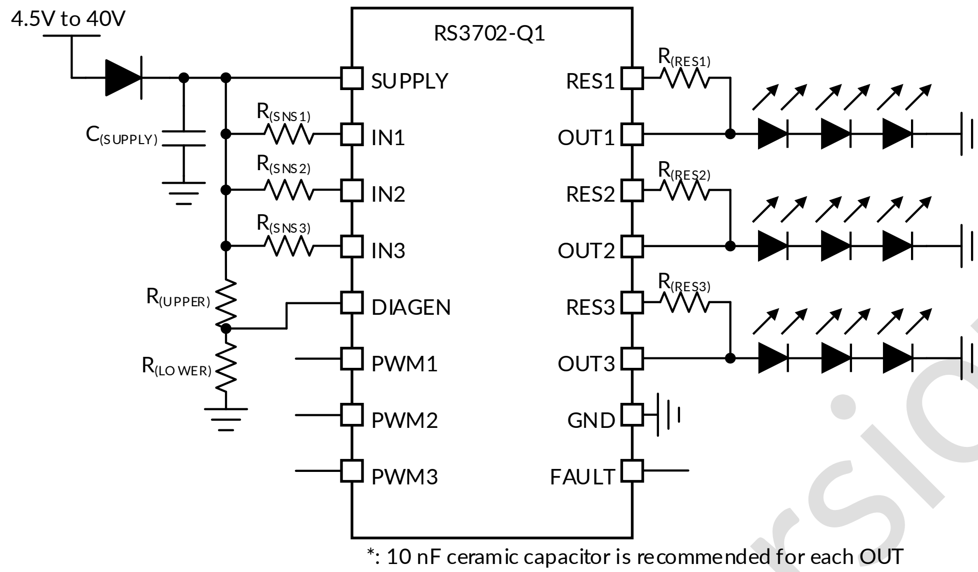


Figure 32. Application Schematic For DIAGEN

$$V_{(SUPPLY\_DIAGEN\_th\_falling)} = V_{IL(DIAGEN)} \times \left(1 + \frac{R_{(UPPER)}}{R_{(LOWER)}}\right) \tag{3}$$

where

- $V_{IL(DIAGEN)}$ = 1.1 V (typical)

8.3.7.4 Overtemperature Protection

The RS3702-Q1 device monitors device junction temperature. When the junction temperature reaches thermal shutdown threshold $T_{(TSD)}$, the output shuts down. After the junction temperature falls below $T_{(TSD)}$ – $T_{(TSD\_HYS)}$, the device recovers to normal operation. During overtemperature protection, the $\overline{FAULT}$ pin is pulled low.

8.3.7.5 Low Dropout Operation

When the supply voltage drops below LED string total forward voltage plus headroom voltage at required current, the RS3702-Q1 device operates in low-dropout conditions to deliver current output as close as possible to target value. The actual current output is less than preset value due to insufficient headroom voltage for power transistor. As a result, the voltage across the sense resistor fails to reach the regulation target. The headroom voltage is the summation of $V_{(DROPOUT)}$ and $V_{(CS\_REG)}$.

If the RS3702-Q1 is designed to operate in low-dropout condition, the open-circuit diagnostics must be disabled by pulling the DIAGEN pin voltage lower than $V_{IL(DIAGEN)}$. Otherwise, the RS3702-Q1 detects an open-circuit fault and reports a fault on the $\overline{FAULT}$ pin. The DIAGEN pin is used to avoid false diagnostics due to low supply voltage.

8.3.8 FAULT Bus Output with One-Fails-All-Fail

During normal operation, The $\overline{FAULT}$ pin of RS3702-Q1 is weakly pulled up by an internal pullup current source, $I_{(FAULT\_pullup)}$. If any fault scenario occurs, the $\overline{FAULT}$ pin is strongly pulled low by the internal pulldown current sink, $I_{(FAULT\_pulldown)}$ to report out the fault alarm.

Meanwhile, the RS3702-Q1 also monitors the $\overline{FAULT}$ pin voltage internally. If the $\overline{FAULT}$ pin of the RS3702-Q1 is pulled low by external current sink below $V_{IL(FAULT)}$, the current output is turned off even though there is no fault detected on owned outputs. The device does not resume to normal operation until the $\overline{FAULT}$ pin voltage rises above $V_{IH(FAULT)}$.

Based on this feature, the RS3702-Q1 device is able to construct a FAULT bus by tying $\overline{FAULT}$ pins from multiple RS3702-Q1 devices to achieve one-fails-all-fail function as Figure 33 showing. The lower side RS3702-Q1 (B) detects any kind of LED fault and pulls low the $\overline{\text{FAULT}}$ pin. The low voltage on $\overline{\text{FAULT}}$ pin is detected by upper side RS3702-Q1 (A) because the $\overline{\text{FAULT}}$ pins are connected of two devices. The upper side RS3702-Q1 (A) turns off all output current for each channel as a result. If the $\overline{\text{FAULT}}$ pins of each RS3702-Q1 are all connected to drive the base of an external PNP transistor as illustrated in Figure 34, the one-fails–all-fail function is disabled and only the faulty channel device is turned off.

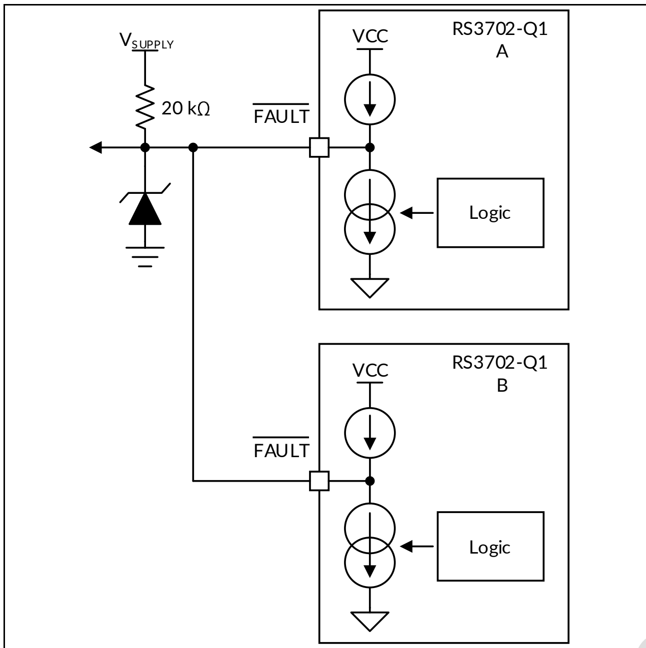


Figure 33. FAULT Bus for One-Fails-All-Fail Application

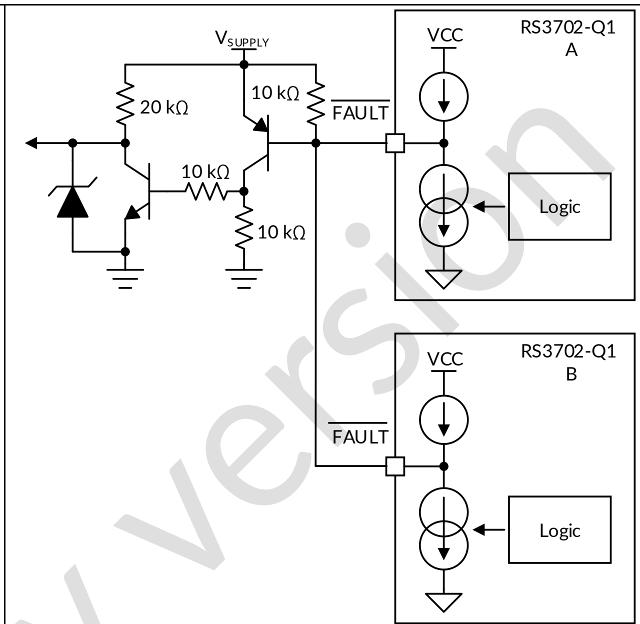


Figure 34. FAULT Bus for One-Fails-Others-On Application

8.3.9 FAULT Table

Table 1. Fault Table With DIAGEN = HIGH (Full Function)

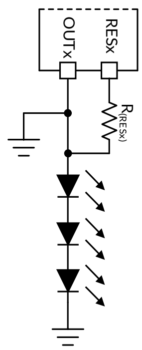
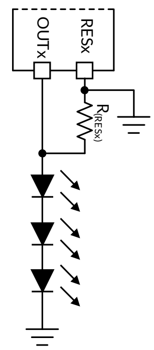
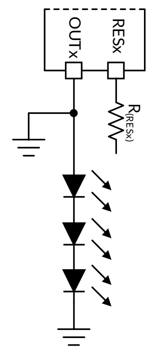
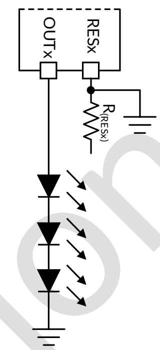
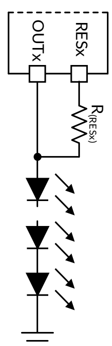
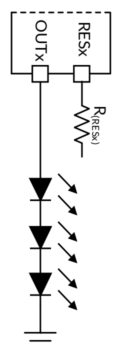
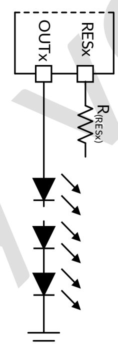
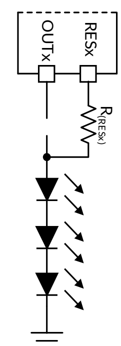
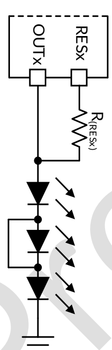
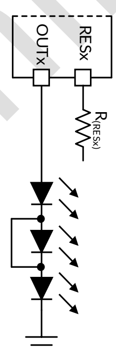
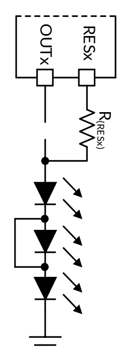
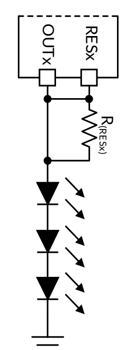
FAULT BUS STATUS	FAULT TYPE	DETECTION MECHANISM	CONTROL INPUT	DEGLITCH TIME	FAULT BUS	FAULT HANDLING ROUTINE	FAULT RECOVERY
$\overline{FAULT}$=H	Open-circuit or short-to-supply	$V_{(IN)} - V_{(OUT)} < V_{(OPEN\_th\_rising)}$	PWMx = H	$t_{(OPEN\_deg)}$	Constant-current pulldown	Device turns failed output off and retries with constant current $I_{(retry)}$, ignoring the PWM input.	Auto recovery
	Short-to-ground	$V_{(OUT)} < V_{(SG\_th\_falling)}$ OR $V_{(RES)} < V_{(SG\_th\_falling)}$	PWMx = H	$t_{(SG\_deg)}$	Constant-current pulldown	Device turns failed output off and retries with constant current $I_{(retry)}$, ignoring the PWM input.	Auto recovery
	Over-temperature	$T_J > T_{(TSD)}$	$T_J > T_{(TSD)}$	$t_{(TSD\_deg)}$	Constant-current pulldown	Device turns all output channels off.	Auto recovery
$\overline{FAULT}$=L	Fault is detected	Device turns all remained channels off and keeps retry on the failed channels. After the $\overline{Fault}$ pin is released, all channels are turned on after $t_{(FAULT\_recovery)}$ time.					
	No fault is detected	Device turns all output channels off.					

Table 2. Fault Table With DIAGEN = LOW (Full Function)

FAULT BUS STATUS	FAULT TYPE	DETECTION MECHANISM	CONTROL OUTPUT	DEGLITCH TIME	FAULT BUS	FAULT HANDLING ROUTINE	FAULT RECOVERY
$\overline{FAULT}$=H	Open-circuit or short-to-supply	Ignored					
	Short-to-ground	$V_{(OUT)} < V_{(SG\_th\_falling)}$ OR $V_{(OUT)} < V_{(SG\_th\_falling)}$	PWMx = H	$t_{(SG\_deg)}$	Constant-current pulldown	Device turns output off and retries with constant current $I_{(retry)}$, ignoring the PWM input.	Auto recovery
	Over-temperature	$T_J > T_{(TSD)}$		$t_{(TSD\_deg)}$	Constant-current pulldown	Device turns all output channels off.	Auto recovery
$\overline{FAULT}$=L	Fault is detected	Device turns all remained channels off and keeps retry on the failed channels. After the $\overline{Fault}$ pin is released, all channels are turned on after $t_{(FAULT\_recovery)}$ time.					
	No fault is detected	Device turns all output channels off.					

8.3.10 LED Fault Summary

Table 3. LED Connection Fault Summary

Case 1	Case 2	Case 3	Case 4
			
LED Short-to-GND Fault	LED Short-to-GND Fault	LED Short-to-GND Fault	LED Short-to-GND Fault
Case 5	**Case 6**	**Case 7**	**Case 8**
			
LED Open Fault	No Fault	LED Open Fault	LED Open Fault
Case 9	**Case 10**	**Case 11**	**Case 12**
			
No Fault	No Fault	LED Open Fault	No Fault

8.3.11 IO Pins Inner Connection

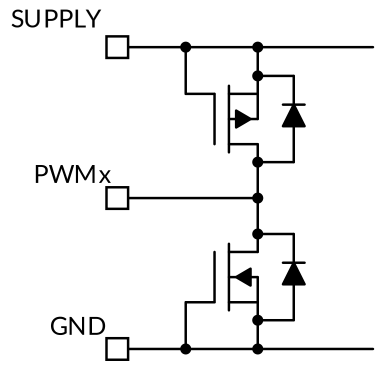


Figure 35. PWMx Pins

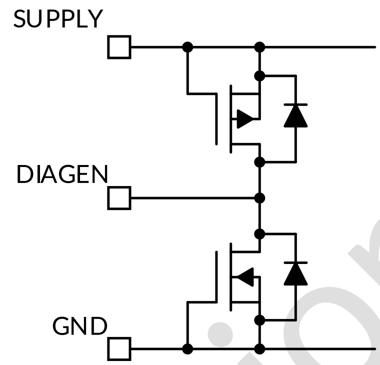


Figure 36. DIAGEN Pin

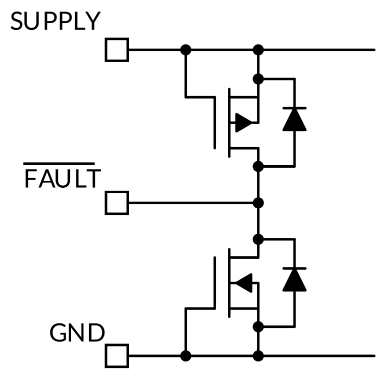


Figure 37. $\overline{\text{FAULT}}$ Pin

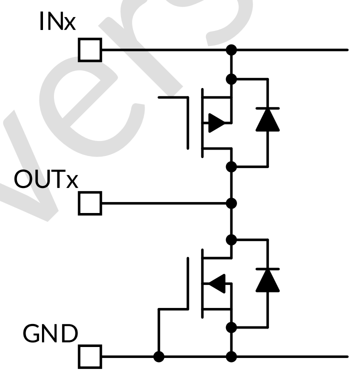


Figure 38. OUTx Pins

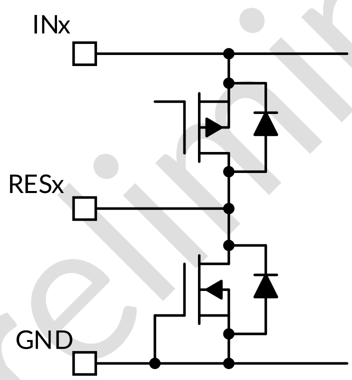


Figure 39. RESx Pins

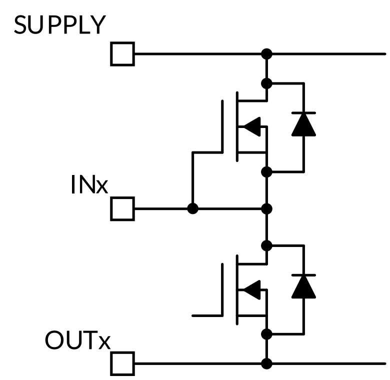


Figure 40. INx Pins

8.4 Device Functional Modes

8.4.1 Undervoltage Lockout, $V_{(SUPPLY)} < V_{(POR\_rising)}$

When the device is in undervoltage lockout status, the RS3702-Q1 device disables all functions until the supply rises above the $V_{(POR\_rising)}$ threshold.

8.4.2 Normal Operation $V_{(SUPPLY)} \geq 4.5$ V

The device drives an LED string in normal operation. With enough voltage drop across SUPPLY and OUT, the device is able to drive the output in constant-current mode.

8.4.3 Low-Voltage Dropout Operation

When the device drives an LED string in low-dropout operation, if the $V_{(DROPOUT)}$ is less than the open-circuit detection threshold, the device can report a false open-circuit fault. RUNIC recommends only enabling the open-circuit detection when the voltage across the IN and OUTx is higher than the maximum voltage of LED open rising threshold to avoid a false open-circuit detection.

8.4.4 Fault Mode

When the RS3702-Q1 detects a fault, the device tries to pull down the $\overline{\text{FAULT}}$ pin with a constant current. If the FAULT bus is pulled down, the device switches to fault mode and consumes a fault current of $I_{(FAULT)}$.

9 APPLICATION AND IMPLEMENTATION

Information in the following applications sections is not part of the RUNIC component specification, and RUNIC does not warrant its accuracy or completeness. RUNIC's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

In automotive lighting applications, thermal performance and LED diagnostics are always design challenges for linear LED drivers.

The RS3702-Q1 device is capable of detecting LED open-circuit and LED short-circuits. To increase current driving capability, the RS3702-Q1 device supports using an external shunt resistor to help dissipate heat as the following section, Thermal Sharing Resistor (OUTx and RESx), describes. This method provides a low-cost solution of using external resistors to minimize thermal accumulation on the device itself due to large voltage difference between input voltage and LED string forward voltage, while still keeping high accuracy of the total current output.

9.2 Typical Applications

9.2.1 BCM Controlled Rear Lamp With One-Fails-All-Fail Setup

The multiple RS3702-Q1 devices are capable of driving different functions for automotive rear lamp including stop, turn indicator, tail, fog, reverse and center-high-mounted-stop-lamp. The one-fails-all-fail single lamp mode can be easily achieved by FAULT bus by shorting the $\overline{\text{FAULT}}$ pins.

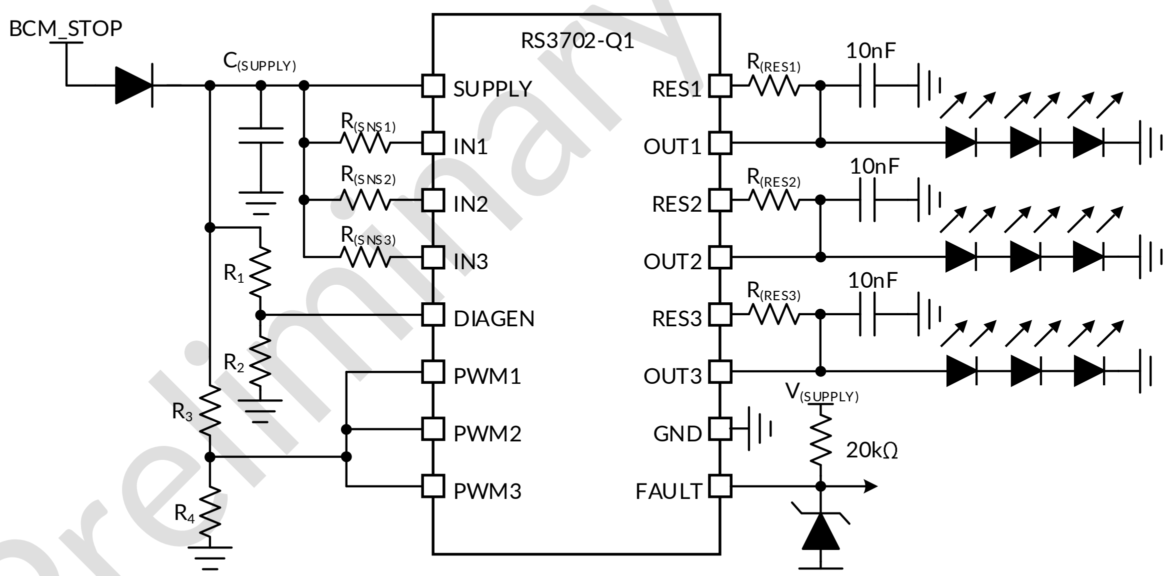


Figure 41. Typical Application Schematic

9.2.1.1 Design Requirements

Input voltage range is from 9 V to 16 V, and a total 9 strings with 3 LEDs in each string are required to achieve stop function. The LED maximum forward voltage, V_{F_MAX} is 2.5 V for each LED, while the minimum forward voltage, V_{F_MIN} is 1.9 V. The current requirement for each LED, $I_{(LED)}$ is 130 mA. The LED brightness and ON and OFF control is manipulated by body control module (BCM) directly by connecting and disconnecting the power supply to the LED load.

9.2.1.2 Detailed Design Procedure

Step 1: Determine the current sensing resistor, $R_{(SNSx)}$, by using Equation 4.

$$R_{(SNSx)} = \frac{V_{(CS\_REG)}}{I_{(OUTx\_Tot)}} \quad (4)$$

where

- $V_{(CS\_REG)}$ = 150 mV (typical)
- $I_{(OUTx\_Tot)}$ = 130 mA

According to design requirements, output current for each channel is same so that the $R_{(SNS1)} = R_{(SNS2)} = R_{(SNS3)}$ = 1.15 Ω. Two resistors in parallel can be used to achieve equivalent resistance when sense resistor is not a standard decade resistance value.

Step 2: Design the current distribution between $I_{(OUTx)}$ and $I_{(RESx)}$, and calculate the current sharing resistor, $R_{(RESx)}$, by using Equation 5. The $R_{(RESx)}$ value actually decides the current distribution for $I_{(OUTx)}$ path and $I_{(RESx)}$ path. RUNIC recommends the current sharing resistor $R_{(RESx)}$ to consume 50% of the total current at typical supply operating voltage.

$$R_{(RESx)} = \frac{V_{(SUPPLY)} - V_{(OUTx)}}{I_{(OUTx\_Tot)} \times 0.5} \quad (5)$$

where

- $V_{(SUPPLY)}$ = 12 V (typical)
- $I_{(OUTx\_Tot)}$ = 130 mA

The calculated result for $R_{(RESx)}$ resistor value including $R_{(RES1)}$, $R_{(RES2)}$ and $R_{(RES3)}$ is 85.4 Ω when $V_{(OUTx)}$ is typical 3 × 2.15 V = 6.45 V.

Step 3: Design the threshold voltage of SUPPLY to enable the LED open-circuit diagnostics, and calculate voltage divider resistor value for R1 and R2 on DIAGEN pin.

The maximum forward voltage of LED-string is 3 × 2.5 V = 7.5 V. To avoid the open-circuit fault reported in low-dropout operation conditions, additional headroom between SUPPLY and OUTx must be considered. The RS3702-Q1 device must disable open-circuit detection when the supply voltage is below LED-string maximum forward voltage plus $V_{(OPEN\_th\_rising)}$ and $V_{(CS\_REG)}$. The voltage divider resistor, R1 and R2 value can be calculated by Equation 6.

$$R_1 = \left(\frac{V_{(OPEN\_th\_rising)} + V_{(CS\_REG)} + V_{(OUTx)}}{V_{IL(DIAGEN)}} - 1 \right) \times R_2 \quad (6)$$

where

- $V_{(OPEN\_th\_rising)}$ = 340 mV (typical)
- $V_{(CS\_REG)}$ = 156 mV
- $V_{IL(DIAGEN)}$ = 1.1 V (typical)
- R_2 = 10 kΩ (recommended)

The calculated result for R1 is 62.7 kΩ when $V_{(OUTx)}$ maximum voltage is 7.5 V and $V_{(CS\_REG)}$ is 156 mV.

Step 4: Design the threshold voltage of SUPPLY to turn on and off each channel of LED, and calculate voltage divider resistor value for R3 and R4 on PWM input pin.

The minimum forward voltage of LED string is 3 × 1.9 V = 5.7 V. To make sure the current output on each of LED-string is normal, each LED-string must be turned off when SUPPLY voltage is lower than LED minimum required forward voltage plus dropout voltage between INx to OUTx and $V_{(CS\_REG)}$. The voltage divider resistor, R3 and R4 value can be calculated by Equation 7.

$$R_3 = \left(\frac{V_{(DROPOUT)} + V_{(CS\_REG)} + V_{(OUTx)}}{V_{IH(PWM)}} - 1\right) \times R_4 \quad (7)$$

where

- $V_{(DROPOUT)}$ = 300 mV (typical)
- $V_{(CS\_REG)}$ = 150 mV (typical)
- $V_{IH(PWM)}$ = 1.2 V (typical)
- R_4 = 10 kΩ (recommended)

The calculated result for R_3 is 41.3 kΩ when $V_{(OUTx)}$ minimum voltage is 5.7 V and $V_{(CS\_REG)}$ is 150 mV.

9.2.1.3 Application Curves

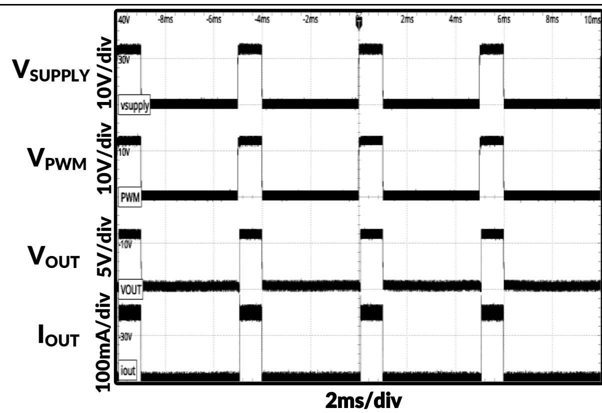


Figure 42. 200-Hz Supply Dimming 20% Brightness

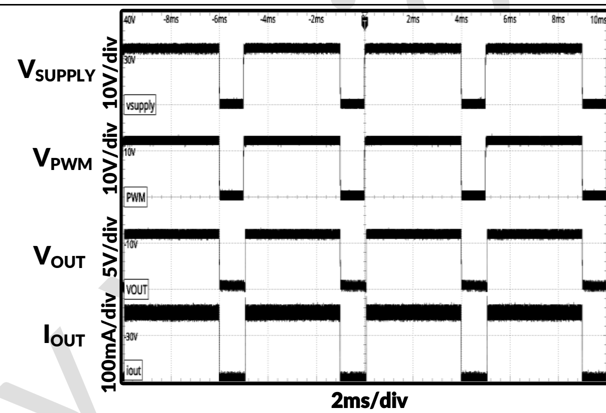


Figure 43. 200-Hz Supply Dimming 80% Brightness

9.2.2 Independent PWM Controlled Rear Lamp By MCU

The RS3702-Q1 device is able to drive the each current output channel independently by PWM input at PWM1, PWM2 and PWM3 pins. The PWM input signals comes from MCU to achieve sequential turn indicator feature.

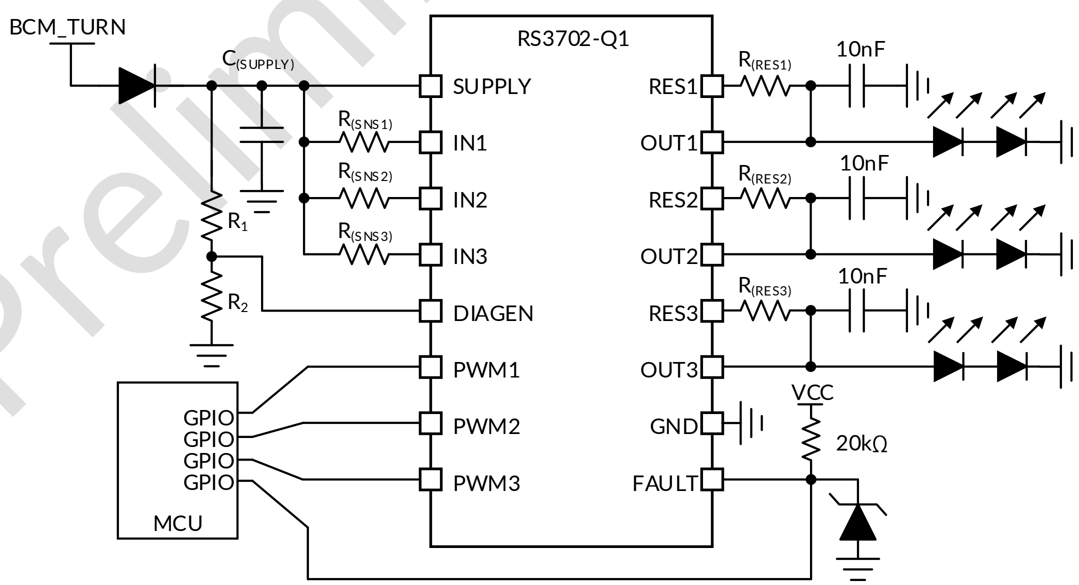


Figure 44. Typical Application Schematic

9.2.2.1 Design Requirements

Input voltage range is from 9 V to 16 V, and a total 6 strings with 2 LEDs in each string are required to achieve turn indicator function. The LED maximum forward voltage, V_{F_MAX} is 2.5 V for each LED, however the minimum forward voltage, V_{F_MIN} is 1.9 V. Each LED current is 130 mA and each output channel is independent controlled by MCU through individual GPIO.

9.2.2.2 Detailed Design Procedure

Step 1: Determine the current sensing resistor, $R_{(SNSx)}$ by using Equation 8.

$$R_{(SNSx)} = \frac{V_{(CS\_REG)}}{I_{(OUTx\_Tot)}} \quad (8)$$

where

- $V_{(CS\_REG)}$ = 150 mV (typical)
- $I_{(OUTx\_Tot)}$ = 130 mA

According to design requirements, output current for each channel is same so that the calculated $R_{(SNS1)}$ = $R_{(SNS2)}$ = $R_{(SNS3)}$= 1.15 Ω.

Step 2: Design the current distribution between $I_{(OUTx)}$ and $I_{(RESx)}$, and calculate the current sharing resistor, $R_{(RESx)}$, by using Equation 9. The $R_{(RESx)}$ value actually decides the current distribution for $I_{(OUTx)}$ path and I= path, basic principle is to design the $R_{(RESx)}$ to consume appropriate 50% total power dissipation at typical supply operating voltage.

$$R_{(RESx)} = \frac{V_{(SUPPLY)} - V_{(OUTx)}}{I_{(OUTx\_Tot)} \times 0.5} \quad (9)$$

where

- $V_{(SUPPLY)}$ = 12 V (typical)
- $I_{(OUTx\_Tot)}$ = 130 mA

The calculated result for $R_{(RESx)}$ resistor value including $R_{(RES1)}$, $R_{(RES2)}$ and $R_{(RES3)}$ is 117 Ω when $V_{(OUTx)}$ is typical 2 × 2.2 V = 4.4 V.

Step 3: Design the threshold voltage of SUPPLY to enable the LED open-circuit, and calculate voltage divider resistor value for R1 and R2 on DIAGEN pin.

The maximum forward voltage of LED-string is 2 × 2.5 V = 5 V. To avoid the open-circuit fault reported in low-dropout operation conditions, additional headroom between SUPPLY and OUTx must be considered. The RS3702-Q1 device must disable open-circuit detection when the supply voltage is below LED-string maximum forward voltage plus $V_{(OPEN\_th\_rising)}$ and $V_{(CS\_REG)}$. The voltage divider resistor, R1 and R2 value can be calculated by Equation 10.

$$R_1 = \left(\frac{V_{(OPEN\_th\_rising)} + V_{(CS\_REG)} + V_{(OUTx)}}{V_{IL(DIAGEN)}} - 1 \right) \times R_2 \quad (10)$$

where

- $V_{(OPEN\_th\_rising)}$ = 340 mV (typical)
- $V_{(CS\_REG)}$ = 150 mV (typical)
- $V_{IL(DIAGEN)}$ = 1.1 V (typical)
- R_2 = 10 kΩ (recommended)

The calculated result for R1 is 39.9 kΩ when $V_{(OUTx)}$ maximum voltage is 5 V and $V_{(CS\_REG)}$ is 150 mV.

9.2.2.3 Application Curves

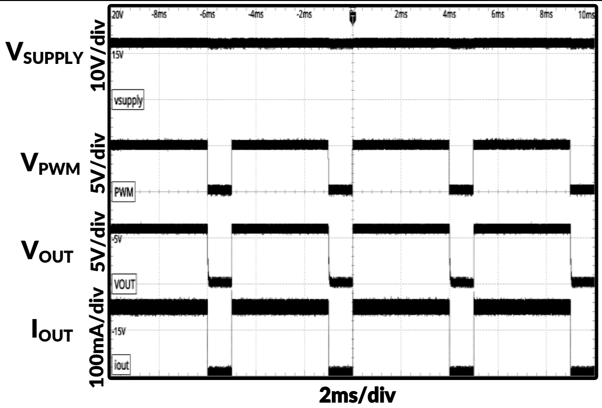


Figure 45. 200-Hz PWM Dimming at 80% Duty Cycle

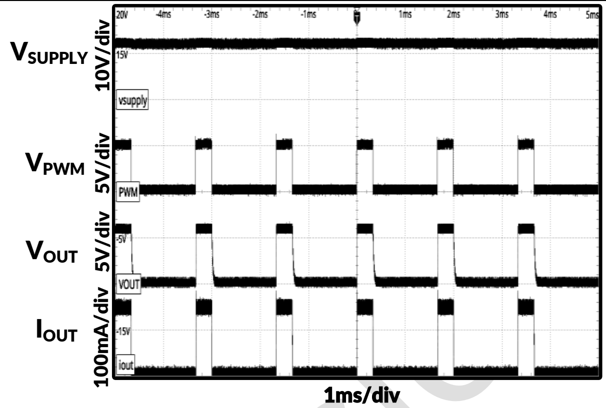


Figure 46. 600-Hz PWM Dimming at 20% Duty Cycle

10 POWER SUPPLY RECOMMENDATIONS

The RS3702-Q1 is designed to operate from an automobile electrical power system within the range specified in Power Supply. The $V_{(SUPPLY)}$ input must be protected from reverse voltage and voltage dump condition over 40 V. The impedance of the input supply rail must be low enough that the input current transient does not cause drop below LED string required forward voltage. If the input supply is connected with long wires, additional bulk capacitance can be required in addition to normal input capacitor.

11 LAYOUT

11.1 Layout Guideline

Thermal dissipation is the primary consideration for RS3702-Q1 layout.

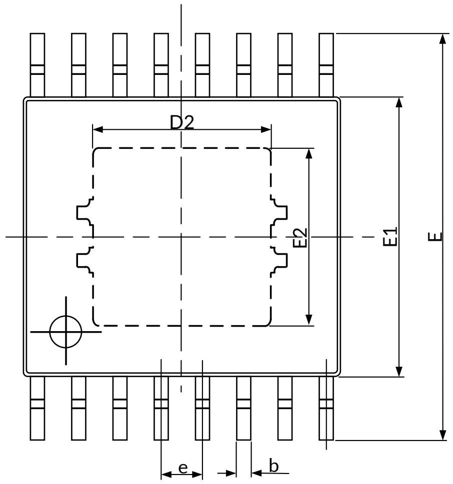
- RUNIC recommends large thermal dissipation area in both top and bottom layers of PCB. The copper pouring area in same layer with RS3702-Q1 footprint must directly cover the thermal pad land of the device with wide connection as much as possible. The copper pouring in opposite PCB layer or inner layers must be connected to thermal pad directly through multiple thermal vias.
- RUNIC recommends to place $R_{(RESx)}$ resistors away from the RS3702-Q1 device with more than 20-mm distance, because $R_{(RESx)}$ resistors are dissipating some amount of the power as well as the RS3702-Q1. Place two heat source components apart to reduce the thermal accumulation concentrated at small PCB area. The large copper pouring area is also required surrounding the $R_{(RESx)}$ resistors for helping thermal dissipating.

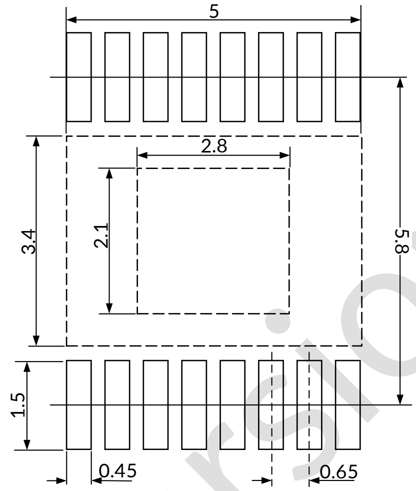
The noise immunity is the secondary consideration for RS3702-Q1 layout.

- RUNIC recommends to place the noise decoupling capacitors for SUPPLY pin as close as possible to the pins.
- RUNIC recommends to place the $R_{(SNSx)}$ resistor as close as possible to the INx pins with the shortest PCB track to SUPPLY pin.

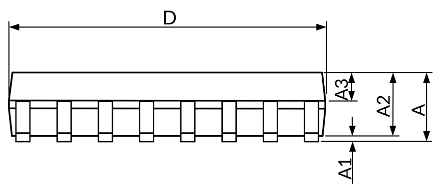
12 PACKAGE OUTLINE DIMENSIONS

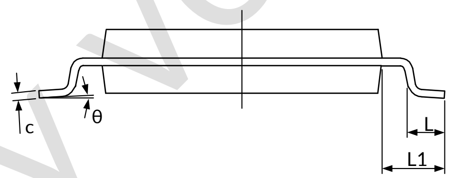
ETSSOP16 (4)





RECOMMENDED LAND PATTERN (Unit: mm)



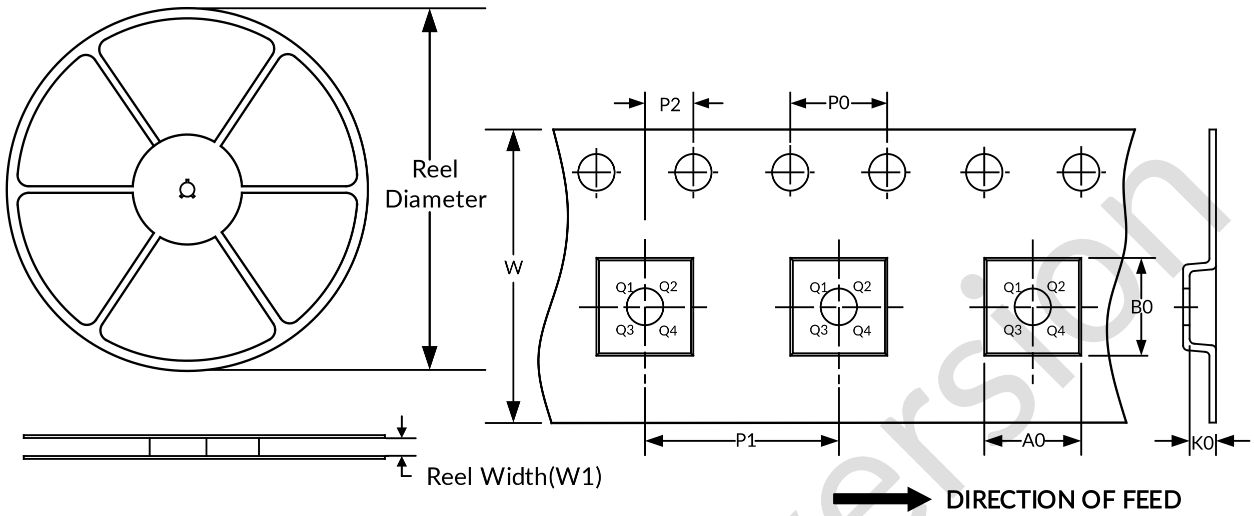


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	-	1.200	-	0.047
A1	0.000	0.150	0.000	0.006
A2	0.900	1.050	0.035	0.041
A3	0.390	0.490	0.015	0.019
b	0.300	0.280	0.012	0.011
c	0.130	0.170	0.005	0.007
D (1)	4.900	5.100	0.193	0.201
D2	2.800 REF (2)		0.110 REF (2)	
E	6.200	6.600	0.244	0.260
E1 (1)	4.300	4.500	0.169	0.177
E2	2.100 REF (2)		0.083 REF (2)	
e	0.650 BSC (3)		0.026 BSC (3)	
L	0.450	0.750	0.018	0.030
L1	1.000 BSC (3)		0.039 BSC (3)	
θ	0°	8°	0°	8°

NOTE:
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. REF is the abbreviation for Reference.
3. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
4. This drawing is subject to change without notice.

13 TAPE AND REEL INFORMATION

REEL DIMENSIONS **TAPE DIMENSION**



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width(mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
ETSSOP16	13"	12.4	6.90	5.60	1.20	4.0	8.0	2.0	12.0	Q1

NOTE:
1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

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