MPQ7200 DRL-PL-TI
Lamp Reference Design
Synchronous Buck-Boost Mode LED Driver for Automotive Systems

Contents

1 Overview

1.1 Description

This reference design proposes a dual-channel buck-boost system for daytime running lamp (DRL), position lamp (PL), and turn indicator (TI) applications using the MPQ7200-AEC1. The MPQ7200-AEC1 is a high-frequency, constant-current LED driver with integrated power MOSFETs. The device offers a compact solution to achieve 1.2A of continuous output current (I_{OUT}) across a wide input supply range, with excellent load and line regulation.

The EVQ7200-DRL-PL-TI-00A is a fully assembled and tested buck-boost mode LED driver reference design board. It has two buck-boost channels and generates an LED current up to 1A from a 6V to 20V input range.

1.2 Features

- Wide 6V to 42V Operating Input Range
- Buck-Boost Mode: Configurable 1.2A Continuous Output Current (I_{OUT})
- 44mΩ/40mΩ Internal Power MOSFETs
- Default 1.15MHz Switching Frequency (f_{SW}) for Buck-Boost Mode with Spread Spectrum Meets CISPR25 Class 5
- PWM Dimming (100Hz to 2kHz Dimming Frequency)
- Internal, 500Hz Two-Step Dimming with Configurable Duty Cycle
- Fault Indication for LED Short (to GND and Battery), LED Open, Output Over-Voltage (OV) and Thermal Shutdown Conditions
- Over-Current Protection (OCP)
- Configurable Thermal Derating via NTC Remote Temperature Sensing
- EMI Reduction
- Available in a QFN-19 (3mmx4mm) Package with Wettable Flanks
- Available in AEC-Q100 Grade 1

1.3 Applications

- Daytime Running Lights (DRLs)
- Position Lights (PLs)
- Turn Indicator Lights (TIs)

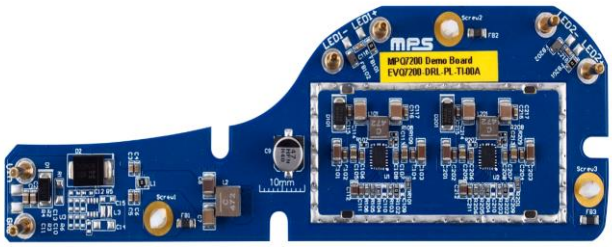


Figure 1: EVQ7200-DRL-PL-TI-00A

2 Reference Design

2.1 Block Diagram

The reference design offers a dual-channel buck-boost LED driver solution. It uses 2 LED drivers (MPQ7200-AEC1) to drive DRL-PL-TI lamps (see Figure 2).

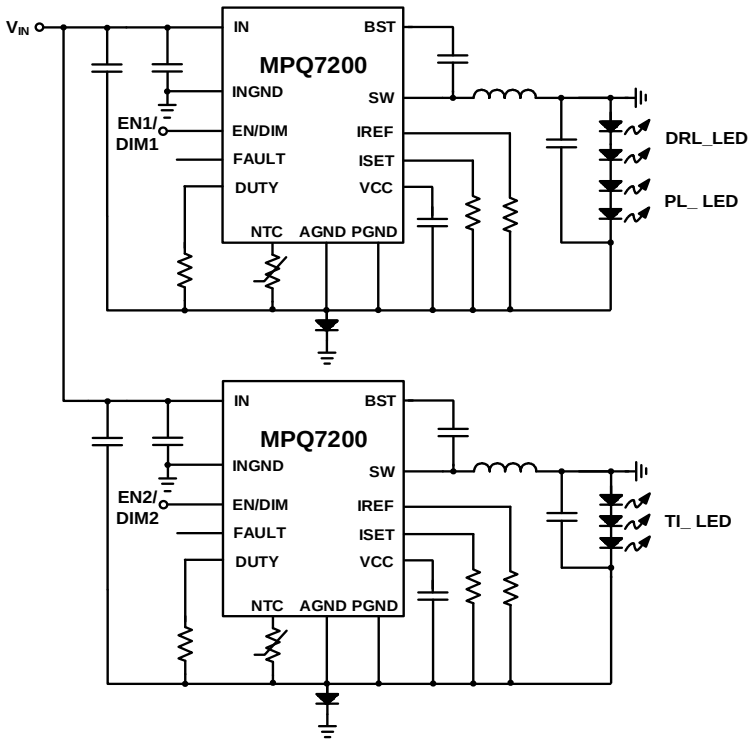


Figure 2: Buck-Boost Topology

2.2 Related Solutions

This reference design is based on the following MPS solutions:

Table 1: Related Solutions

MPS Integrated Circuit	Description
MPQ7200-AEC1	42V, 1.2A buck-boost or 3A buck, synchronous LED driver, AEC-Q100 qualified

2.3 System Specifications

Table 2: System Specifications

Parameter	Specifications
Input voltage (V_{IN}) range	$6V_{DC}$ to $20V_{DC}$
Output LEDs	4 LEDs and 3 LEDs
Output current (I_{OUT})	1A

3 Design

3.1 Schematic

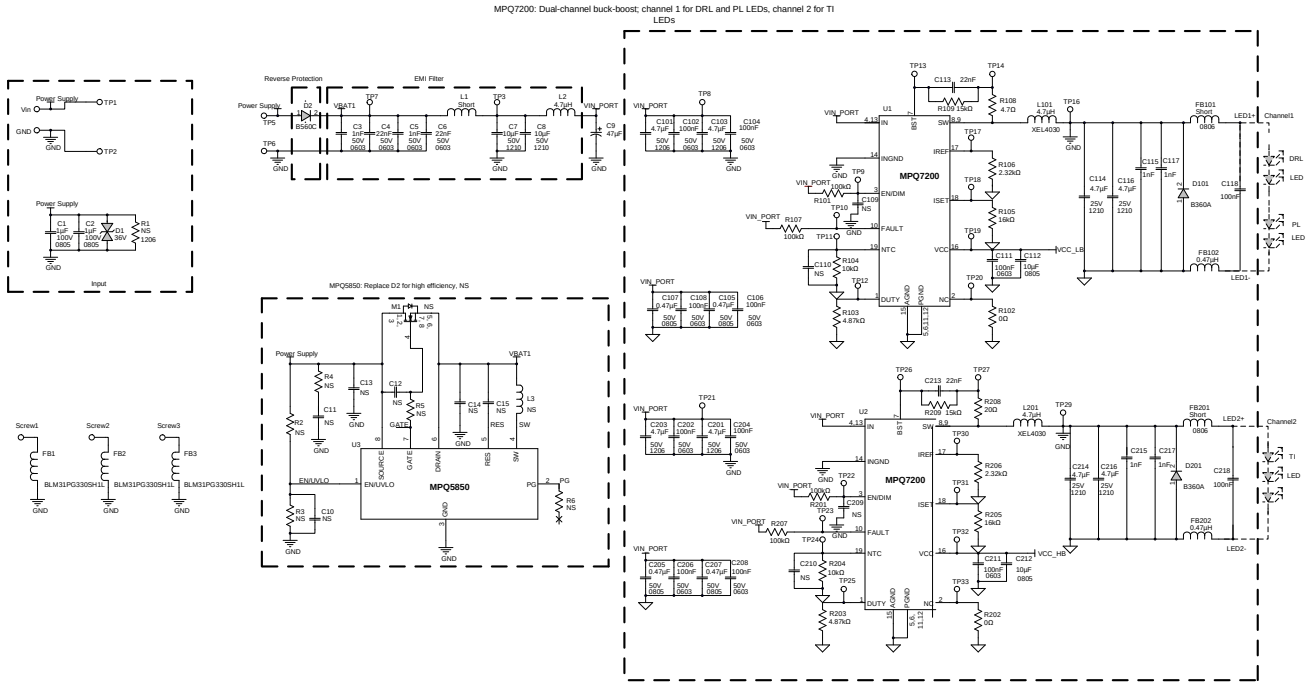


Figure 3: Reference Design Board Schematic

3.2 BOM

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
2	C1, C2	1μF	Ceramic capacitor, 100V, X7S	0805	TDK	C2012X7S2A105KT000N
5	C3, C5, C115, C117, C215, C217	1nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H102KA01D
2	C4, C6	22nF	Ceramic capacitor, 50V, X7R	0603	Murata	GCM188R71H223KA37D
2	C7, C8	10μF	Ceramic capacitor, 50V, X7R	1210	Murata	GRM32ER71H106KA12L
1	C9	47μF	Electrolytic capacitor, 50V	SMD	Panasonic	EEEFN1H470XP
4	C10, C11, C12, C13	NS	Ceramic capacitor, 50V, X7R	0603		
1	C14	NS	Ceramic capacitor, 50V, X5R	1206		
1	C15, C109, C110, C209, C210	NS	Ceramic capacitor, 50V, X5R	0805		
4	C101, C103, C201, C203	4.7μF	Ceramic capacitor, 50V, X7R	1206	Murata	GRM31CR71H475KA12L
2	C113,C213	22nF	Ceramic capacitor, 50V, X7R	0402	Murata	GCM155R71H223JA
10	C102, C104, C106, C108, C111,C202, C204, C206, C208, C211	100nF	Ceramic capacitor, 50V, X7R	0603	Murata	GCJ188R71H104KA12D
4	C105, C107, C205, C207	470nF	Ceramic capacitor, 100V, X7R	0805	Murata	GRM21BR72A474KA73L
2	C112, C212	10μF	Ceramic capacitor, 16V, X7S	0805	Murata	GRM21BC71C106KE11L
2	C114, C116, C214, C216	4.7μF	Ceramic capacitor, 25V, X7R	1210	TDK	C3225X7R1E475M
1	C118, C218	100nF	Ceramic capacitor, 25V, X7R	0603	Murata	GCJ188R71E104KA12D
1	D1	36V	TVS, 36V	DO-214AC	Bourns	SMAJ36CA-Q
1	D2	60V	Diode, 60V, 5A	SMC	Diodes	B560C-13-F
2	D101, D201	60V	Diode, 60V, 3A	SMA	Diodes	B360A-13-F
3	FB1, FB2, FB3	6A	Magnetic bead, 6A	1206	Murata	BLM31PG330SH1L
2	FB101, FB201	Short	Film resistor, 1%	0805	Yageo	RC0805FR-070RL
1	L1	Short	Film resistor, 1%	0805	Yageo	RC0805FR-070RL
1	L2	4.7μH	Inductor, 4.7ΩH, 36mΩ, 5.9A	SMD	Coilcraft	XAL5030-472MEB
1	L3	NS	Inductor	SMD		

1	L101, L201	4.7µH	Inductor, 4.7µH, 44.1mΩ, 5.1A	SMD	Coilcraft	XEL4030-472MEB
1	M1	NS	N-channel MOSFET	SO-8		
1	R1	NS	Film resistor	1206		
1	R2	NS	Film resistor, 5%	0603		
3	R3, R4, R6	NS	Film resistor, 5%	0603		
1	R5	NS	Film resistor, 5%	0603		
3	R101, R201	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
2	R102, R202	0Ω	Film resistor, 1%	0603	Yageo	RC0603FR-070RL
2	R103, R203	4.87kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-074K87L
2	R104, R204	10kΩ	Film resistor, 1%	0603	Murata	RC0603FR-0710KL
2	R105, R205	16kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0716KL
2	R106, R206	2.32kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-072K32L
1	R107, R207	100kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-07100KL
2	R108, R208	20Ω	Film resistor, 1%	0402	Yageo	RC0402FR-0720RL
2	R109, R209	15kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-0715KL
2	GND, Vin, LED1+, LED1-, LED2+, LED2-	2mm	Golden pin	DIP	Custom	Any
2	FB102, FB202	MPL-AT2010-R47	Inductor, 470nH, 27mΩ, 4.4A	SMD	MPS	MPL-AT2010-R47
2	U1, U2	MPQ7200-AEC1	Synchronous LED driver	QFN-19 (3mmx 4mm)	MPS	MPQ7200GLE-AEC1
1	U3	MPQ5850 (optional)	Smart diode controller, 36V	TSOT23-8 (2mmx 3mm)	MPS	MPQ5850GJ-AEC1

3.3 PCB Layout

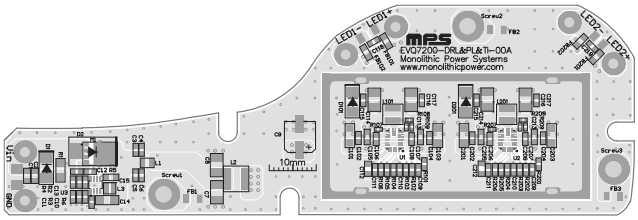


Figure 4: Top Silk and Top Layer

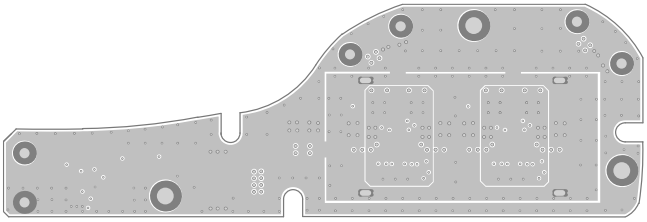


Figure 6: Mid-Layer 1

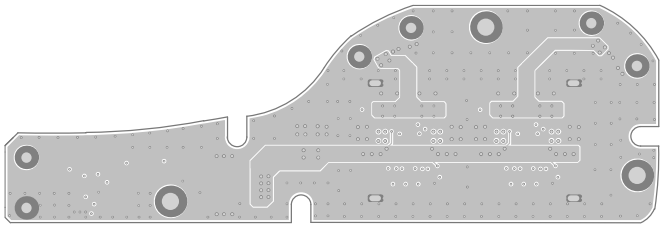


Figure 7: Mid-Layer 2

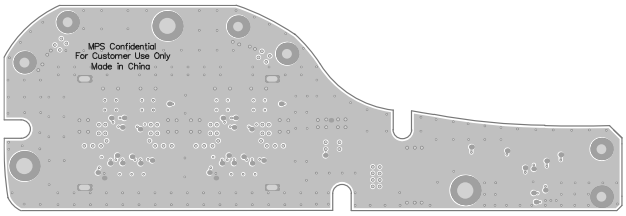


Figure 5: Bottom Silk and Bottom Layer

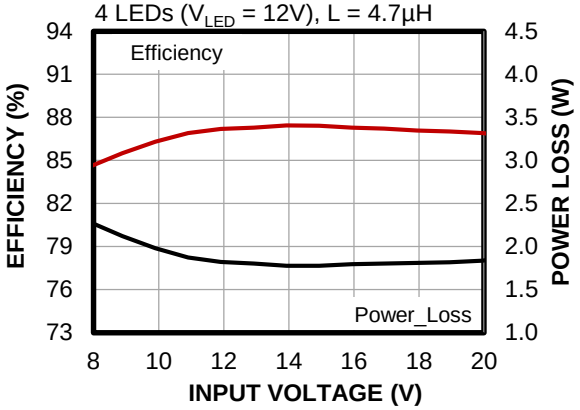
4 Test Results

4.1 Efficiency

Buck-boost mode, L = 4.7µH, I_{LED} = 1A, f_{SW} = 1.15MHz, channel 1: 4 LEDs (V_{LED1} = 12V), channel 2: 3 LEDs (V_{LED2} = 9V), T_A = 25°C, unless otherwise noted.

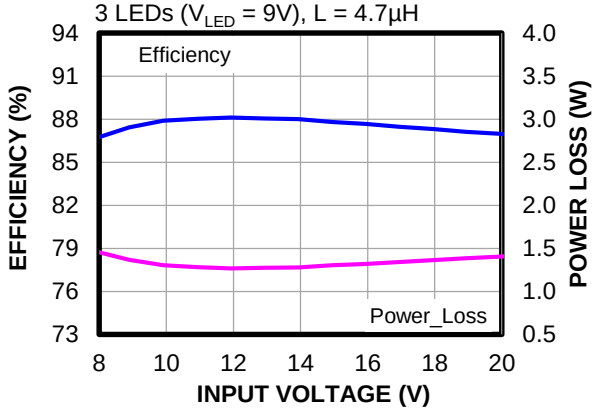
Efficiency vs. Input Voltage vs. Power Loss

4 LEDs (V_{LED} = 12V), L = 4.7µH



Efficiency vs. Input Voltage vs. Power Loss

3 LEDs (V_{LED} = 9V), L = 4.7µH

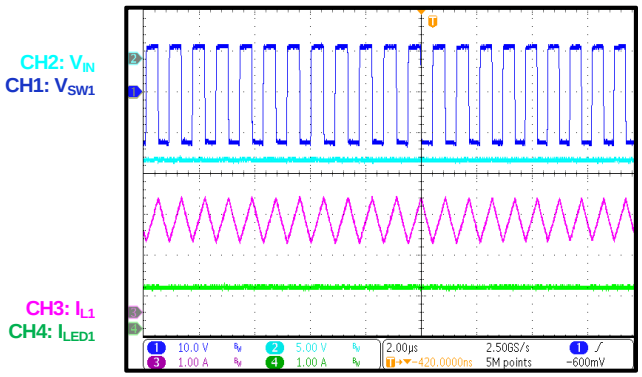


4.2 Time Domain Waveforms

Buck-boost mode, L = 4.7µH, I_{LED} = 1A, f_{SW} = 1.15MHz, channel 1: 4 LEDs (V_{LED1} = 12V), T_A = 25°C, unless otherwise noted.

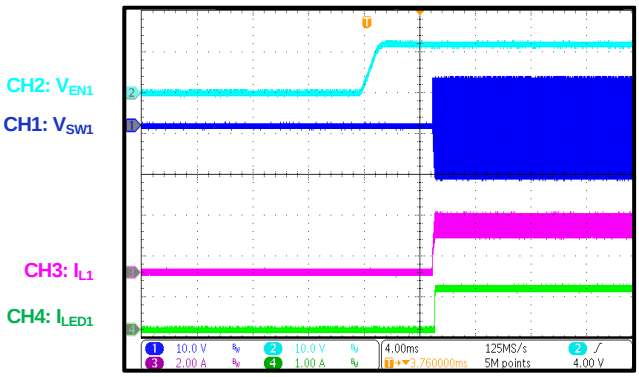
Steady State

I_{LED} = 1A



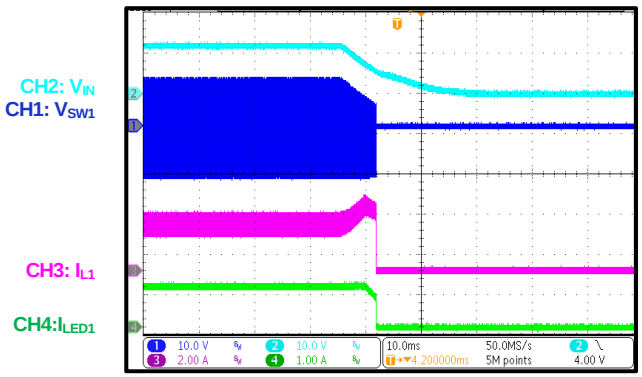
Start-Up through VIN

I_{LED} = 1A



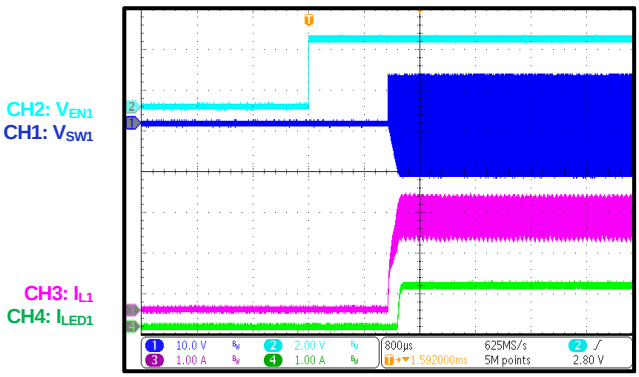
Shutdown through VIN

I_{LED} = 1A



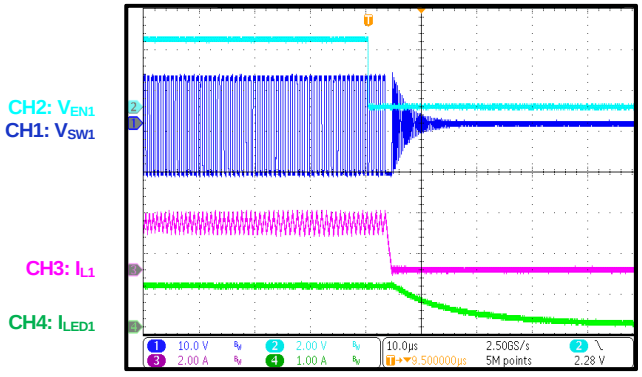
Start-Up through EN

I_{LED} = 1A



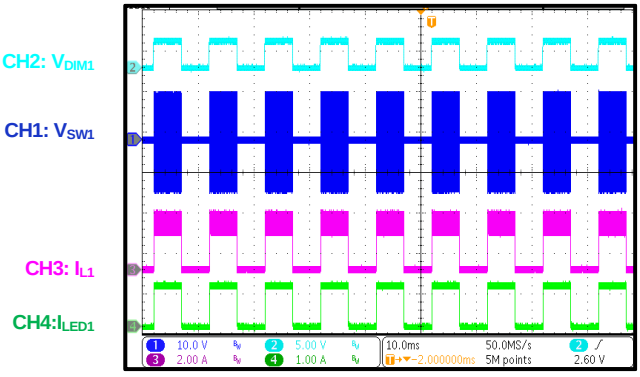
Shutdown through EN

I_{LED} = 1A



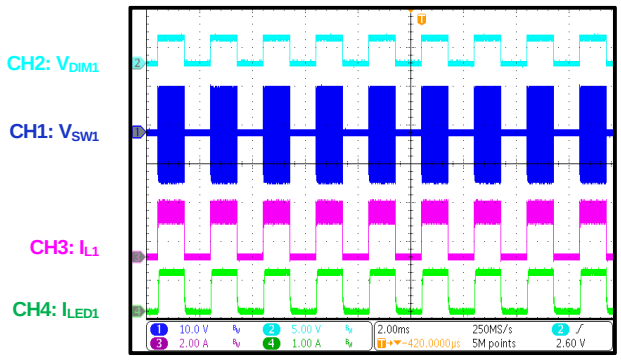
PWM Dimming Steady State

Dimming frequency =100Hz

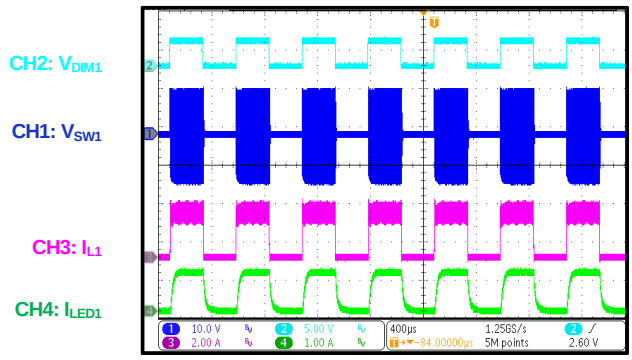


Buck-boost mode, L = 4.7µH, I_{LED} = 1A, f_{SW} = 1.15MHz, channel 1: 4 LEDs (V_{LED1} = 12V), T_A = 25°C, unless otherwise noted.

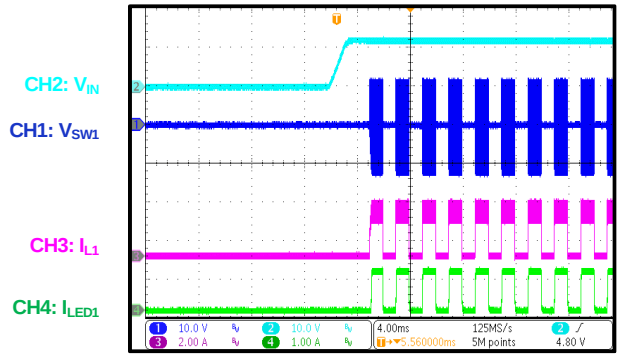
PWM Dimming Steady State
Dimming frequency = 500Hz



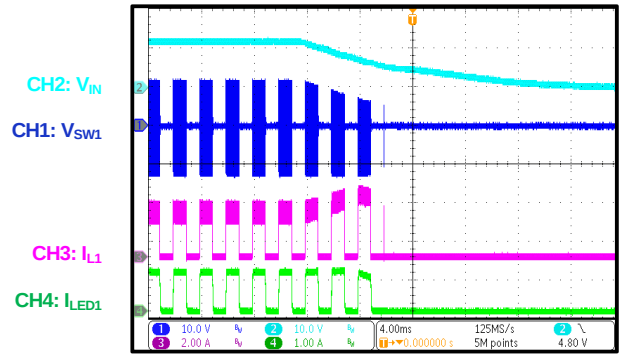
PWM Dimming Steady State
Dimming frequency = 2kHz



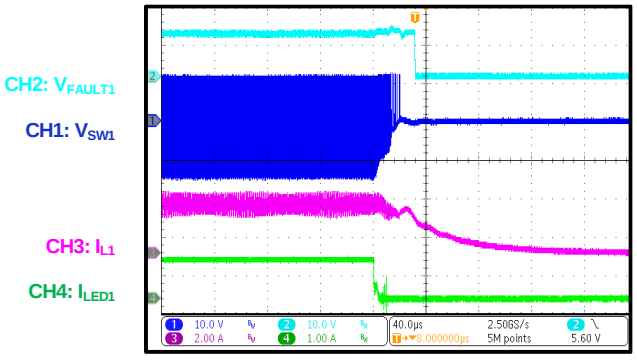
PWM Dimming
Start-up through VIN



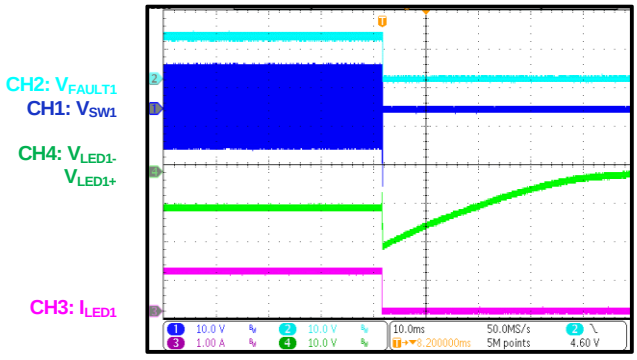
PWM Dimming
Shutdown through VIN



LED+ Short LED- Entry



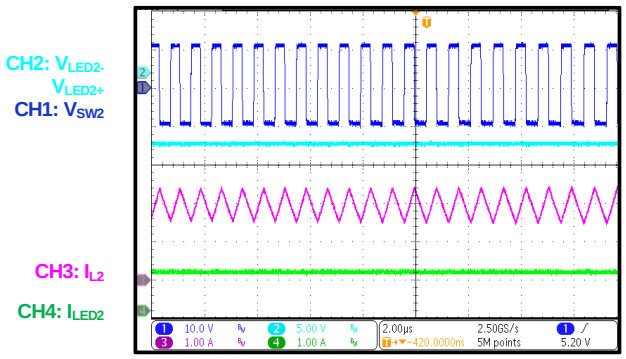
LED Open Entry



Buck-boost mode, L = 4.7µH, I_{LED} = 1A, f_{SW} = 1.15MHz, channel 2: 3 LEDs (V_{LED2} = 9V), T_A = 25°C, unless otherwise noted.

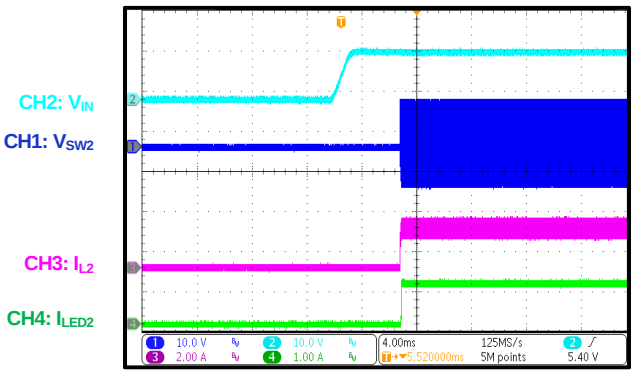
Steady State

I_{LED} = 1A



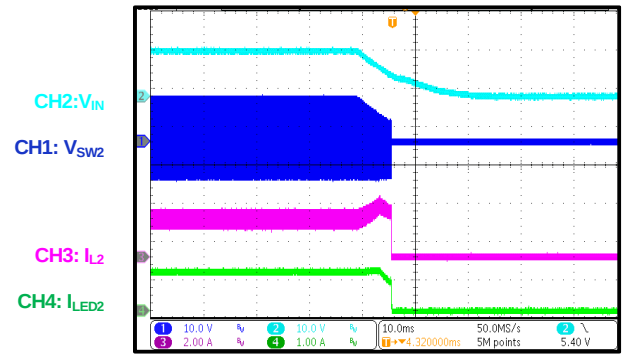
Start-Up through VIN

I_{LED} = 1A



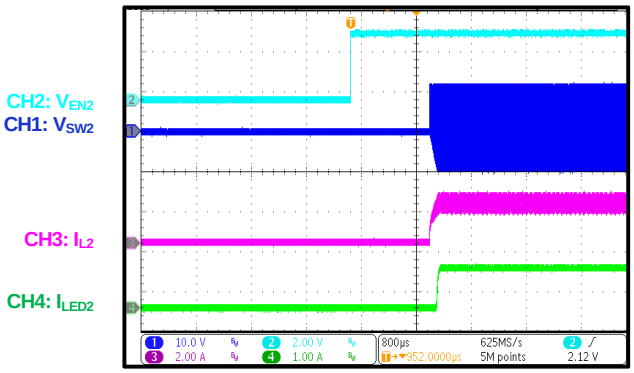
Shutdown through VIN

I_{LED} = 1A



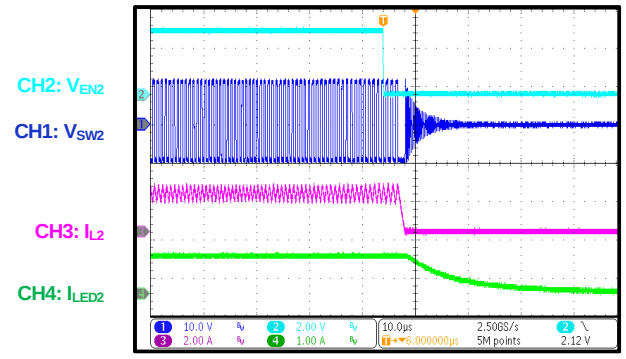
Start-Up through EN

I_{LED} = 1A



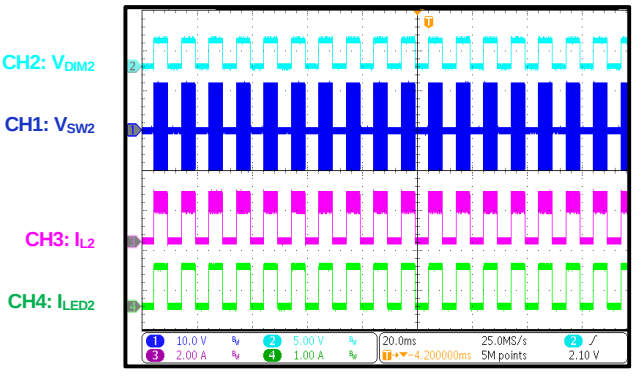
Shutdown through EN

I_{LED} = 1A



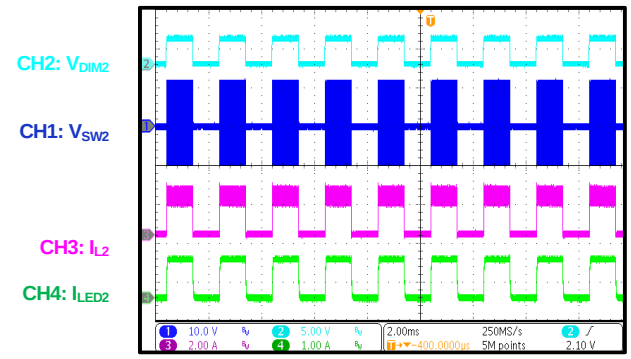
PWM Dimming Steady State

Dimming frequency = 100Hz

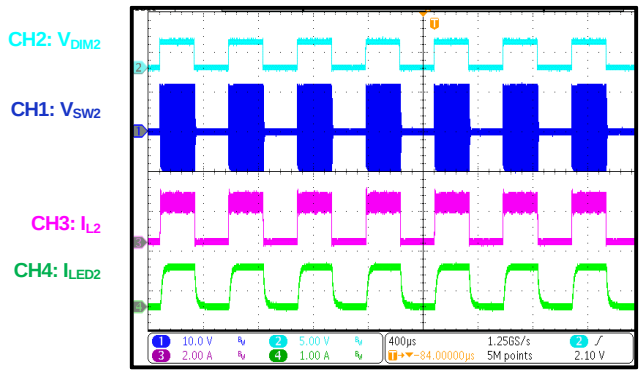


Buck-Boost mode, L = 4.7µH, I_{LED} = 1A, f_{SW} = 1.15MHz, channel2: 3LEDs (V_{LED2} = 9V), T_A=25°C, unless otherwise noted.

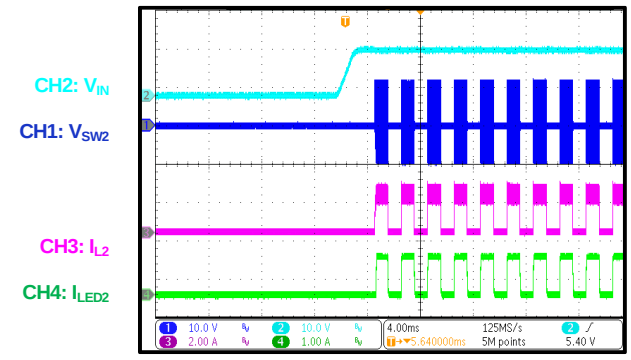
PWM Dimming Steady State
Dimming frequency = 500Hz



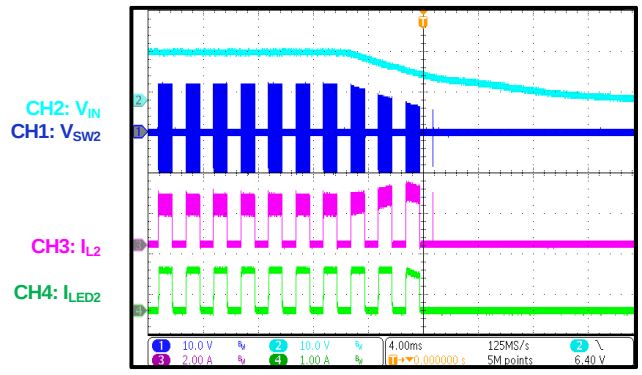
PWM Dimming Steady State
Dimming frequency = 2kHz



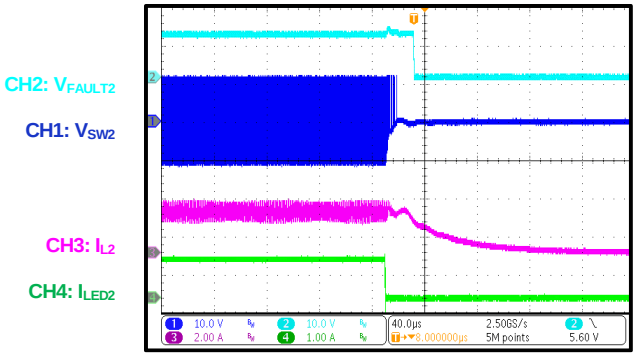
PWM Dimming
Start-Up through VIN



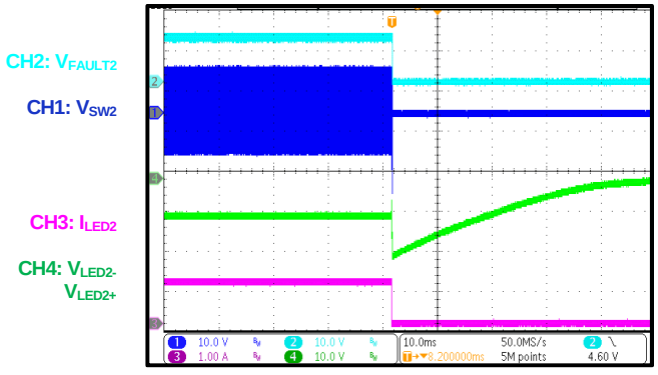
PWM Dimming
Shutdown through VIN



LED+ Short LED- Entry



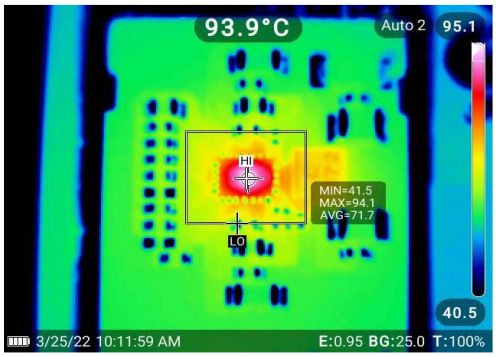
LED Open Entry



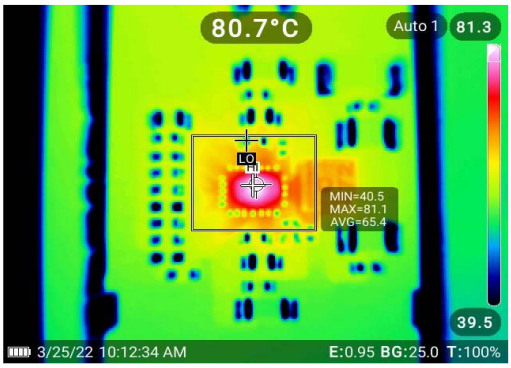
4.3 Thermal Measurements

Buck-boost mode, V_{IN} = 12V, L = 4.7µH, I_{LED} = 1A, f_{SW} = 1.15MHz, channel 1: 4 LEDs (V_{LED1} = 12V), channel 2: 3 LEDs (V_{LED2} = 9V), T_A = 25°C, unless otherwise noted.

Channel 1 Thermal Measurements



Channel 2 Thermal Measurements

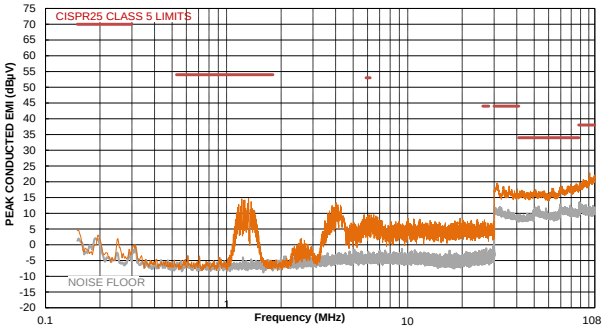


4.4 EMC Measurements

Buck-boost mode, V_{IN} = 12V, L = 4.7µH, I_{LED} = 1A, f_{SW} = 1.15MHz, channel 1: 4 LEDs (V_{LED1} = 12V), channel 2: 3 LEDs (V_{LED2} = 9V), T_A = 25°C, unless otherwise noted.

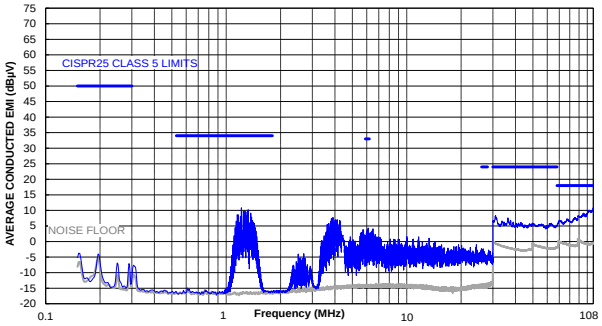
CISPR25 Class 5 Peak Conducted Emissions

150kHz to 108MHz



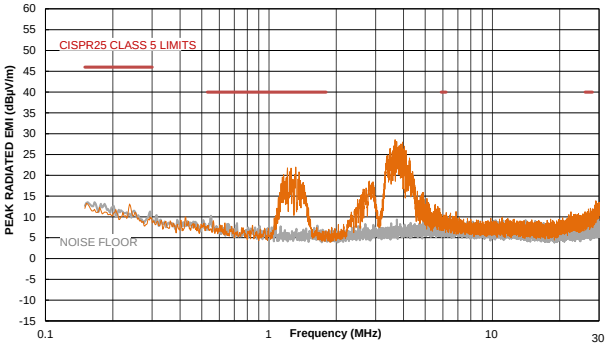
CISPR25 Class 5 Average Conducted Emissions

150kHz to 108MHz



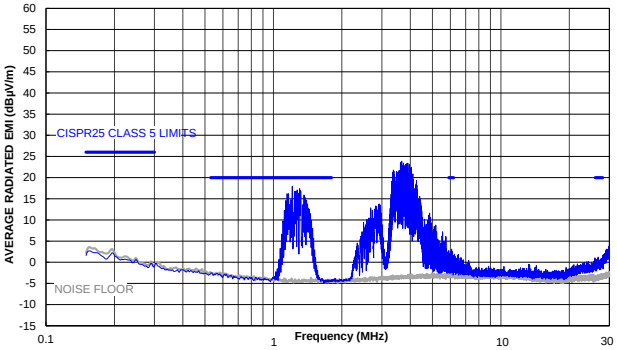
CISPR25 Class 5 Peak Radiated Emissions

150kHz to 30MHz



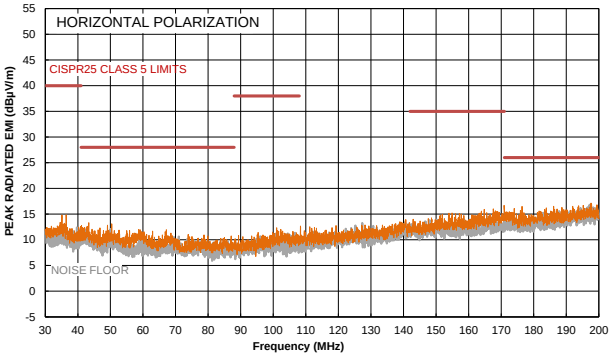
CISPR25 Class 5 Average Radiated Emissions

150kHz to 30MHz



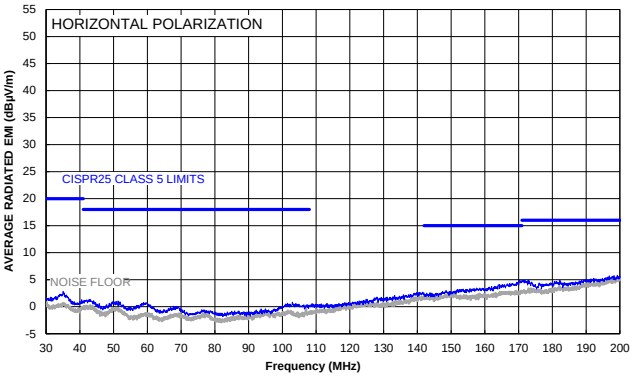
CISPR25 Class 5 Peak Radiated Emissions

Horizontal, 30MHz to 200MHz



CISPR25 Class 5 Average Radiated Emissions

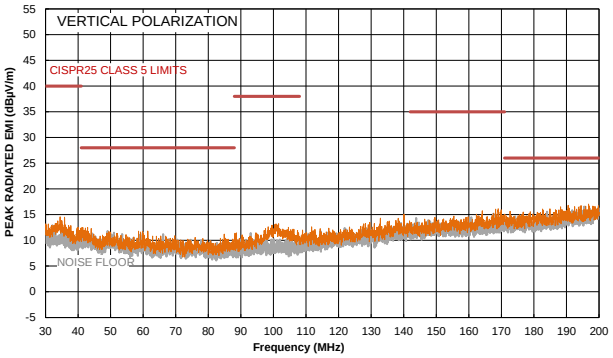
Horizontal, 30MHz to 200MHz



Buck-boost mode, V_{IN} = 12V, L = 4.7µH, I_{LED} = 1A, f_{SW} = 1.15MHz, channel 1: 4 LEDs (V_{LED1} = 12V), channel 2: 3 LEDs (V_{LED2} = 9V), T_A = 25°C, unless otherwise noted.

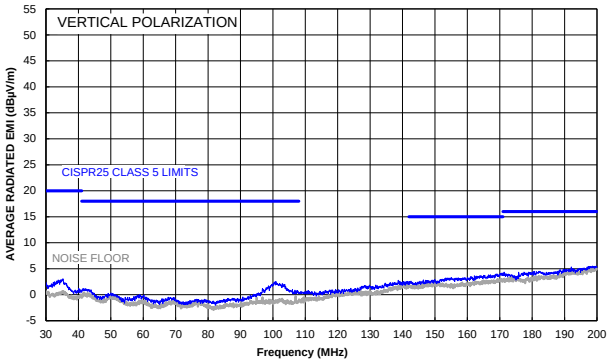
CISPR25 Class 5 Peak Radiated Emissions

Vertical, 30MHz to 200MHz



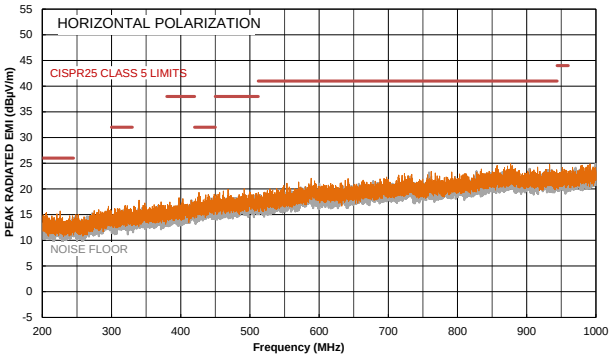
CISPR25 Class 5 Average Radiated Emissions

Vertical, 30MHz to 200MHz



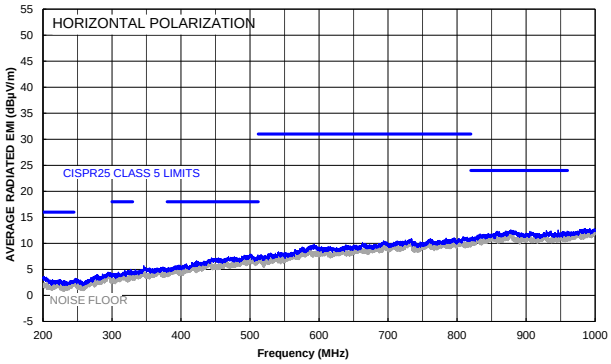
CISPR25 Class 5 Peak Radiated Emissions

Horizontal, 200MHz to 1GHz



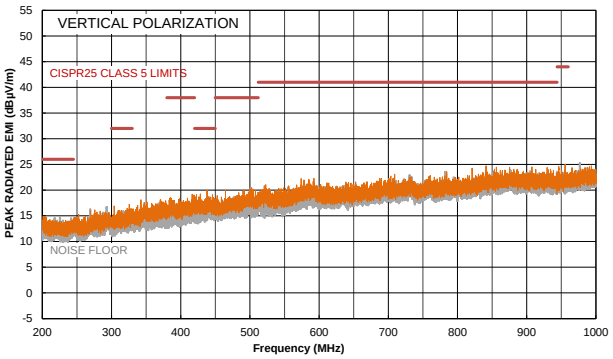
CISPR25 Class 5 Average Radiated Emissions

Horizontal, 200MHz to 1GHz



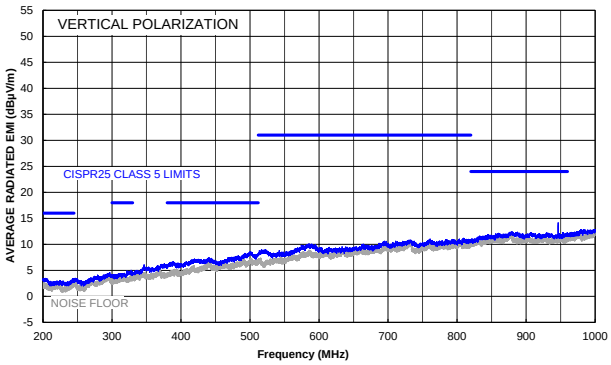
CISPR25 Class 5 Peak Radiated Emissions

Vertical, 200MHz to 1GHz



CISPR25 Class 5 Average Radiated Emissions

Vertical, 200MHz to 1GHz



5 Start-Up

1. Preset the power supply between 6V and 20V. Note that the sum of the input voltage (V_{IN}) and output voltage (V_{LED}) should be below 40V.
2. Connect the power supply terminals to:
   a. Positive (+): VIN
   b. Negative (-): GND
3. Connect the load terminals to:
   a. Positive (+): LED+
   b. Negative (-): LED-

   It is recommended to use 4 LEDs in series for the LED1 channel, 2 LEDs for the daytime running lamp (DRL), 2 LEDs for the position lamp (PL), and 3 LEDs in series for the LED2 channel, which functions as the turn indicator (TI).
4. After making the connections, turn the power supply on.

6 Disclaimer

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MPS semiconductors are typically used in power supplies in which high voltages are present during operation. High-voltage safety precautions should be observed in design and operation to minimize the chance of injury.

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	6/24/2022	Initial Release	-