Automotive Single-Channel Linear LED Driver MEQDS7610

General Description

The MEQDS7610 is an automotive single-channel high-side LED driver powered by an automotive battery, capable of providing a constant current to a single string of LED lights, and has LED diagnostics. Its one-fails–all-fail feature is able to work together with other LED drivers, such as the MEDS92630, to address different requirements.

Compared to discrete solutions, low-cost monolithic solutions reduce the number of system-level components and significantly improve current accuracy and reliability. The different package options in this series offer a variety of current ranges and diagnostic options. The MEQDS7610 device in the EMSOP8 package supports LED open circuit detection and ground short circuit detection.

Features

- AEC-Q100 Qualified With the Following Results:
  - Device temperature Grade1:-40~125 ℃ ambient operating temperature range
- Single-Channel Constant-Current LED Driver With PWM Dimming
- Wide Input-Voltage Range: 4.5V ~40V
- Constant Output Current, Adjustable by Sense Resistor
- Precision Current Regulation, Tolerance ±4.6%
- Maximum Current: 300mA
- Heat Sharing With External Resistor
- Low Dropout Voltage (Current-Sense Voltage Drop Included)
  - Maximum Dropout: 400mV at 70mA
  - Maximum Dropout: 1.3V at 300mA
- Diagnostics and Protection
  - LED Open-Circuit and Short-Circuit Detection With Auto-Recovery
  - Diagnostic-Enable With Adjustable Threshold for Low-Dropout Operation
  - Fault Bus up to 15 Devices, Configurable As Either One-Fails–All-Fail or Only-Failed-Channel Off
  - Low Quiescent Current and Fault-Mode Current (<250 µA per Device)

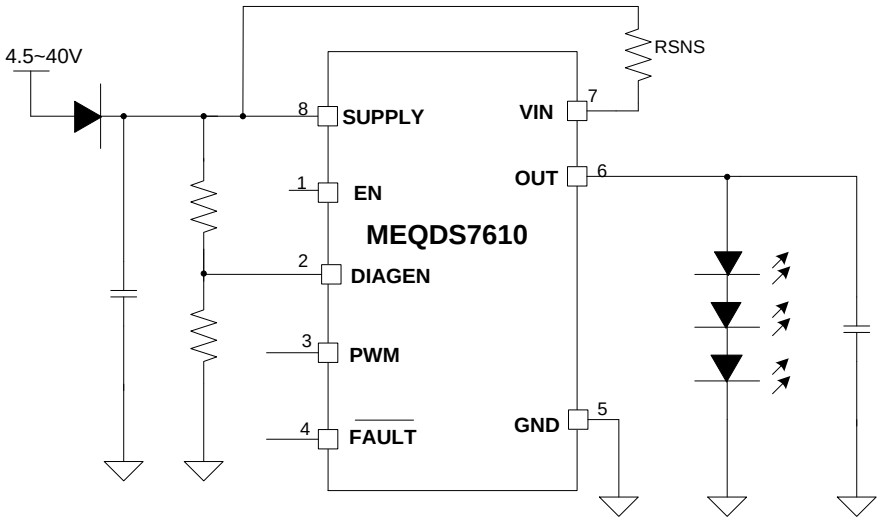
Typical Application

- Automotive Convenience Lighting: Dome Light, Door Handles, Reading Lamp, and Miscellaneous Lamps
- Automotive Rear Lamp, Center High-Mounted Stop Lamp, Side Markers, Blind-Spot Detection Indicator, Charging Inlet Indicator
- General-Purpose LED Driver Application

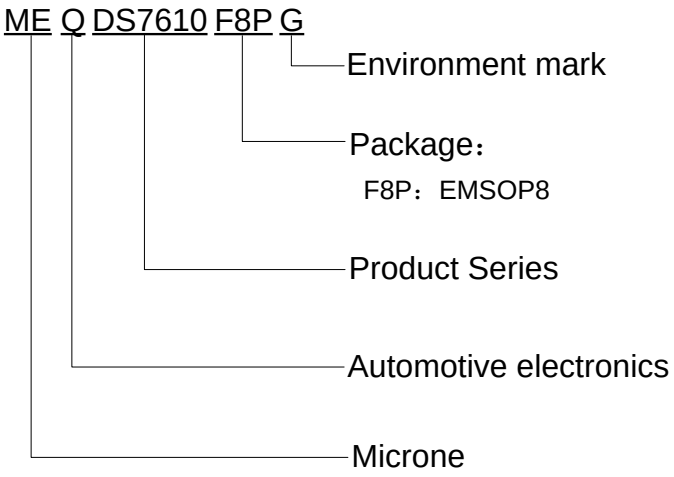
Package

- 8-pin EMSOP8

Typical Application Diagram

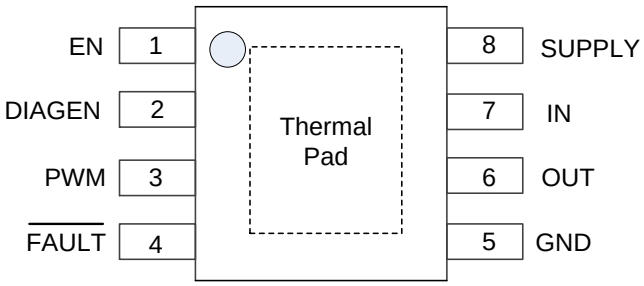


Selection Guide



product series	product description
MEQDS7610F8PG	Package：EMSOP8

PIN Configuration

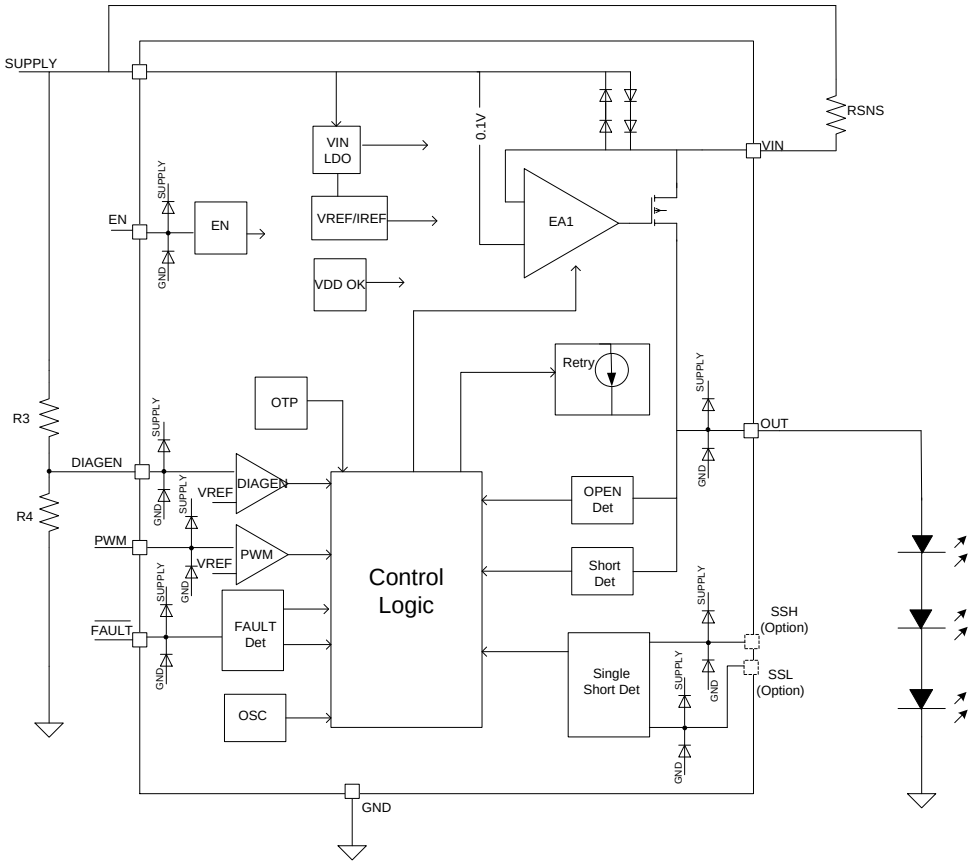


EMSOP8

Pin Assignment

Pin Number	Symbol	Functions
1	EN	Device enable
2	DIAGEN	Diagnostics enable, to avoid false open-circuit diagnostics during low-voltage operation
3	PWM	PWM input
4	$\overline{\text{FAULT}}$	One-fails–all-fail fault bus
5	GND	Ground
6	OUT	Constant-current output
7	IN	Current input
8	SUPPLY	Device supply voltage

Functional Block Diagram



Absolute Maximum Ratings

Parameter		Symbol	Rating	Unit
SUPPLY Voltage		V_{SUPPLY}	-0.3~45	V
IN Voltage		V_{IN}	-0.3~V_{SUPPLY}+0.3	V
EN Voltage		V_{EN}	-0.3~V_{SUPPLY}+0.3	V
DIAGEN Voltage		V_{DIAGEN}	-0.3~V_{SUPPLY}+0.3	V
PWM Voltage		V_{EN}	-0.3~V_{SUPPLY}+0.3	V
$\overline{FAULT}$		V_{FAULT}	-0.3~V_{SUPPLY}+0.3	V
OUT Voltage		V_{OUT}	-0.3~V_{SUPPLY}+0.3	V
V_{OUT} Voltage		I_{OUT}	1000	mA
Package thermal impedance (Junction to air)		θ_{JA}	1.98	W
Power Dissipation		P_d	63	℃/W
Operating Ambient Temperature Range		T_{Opr}	-40~+125	℃
Storage Temperature range		T_{stg}	-55~+150	℃
Junction temperature		T_J	-40~+150	℃
Human-body model（HBM）		ESD(HBM)	±2000	V
Charged-device model （CDM）	Corner Pins	ESD(CDM)	±750	V
	All Pins	ESD(CDM)	±500	V

Note:

1) Use this IC within the stated maximum ratings. Operation beyond these limits may cause degrading or permanent damage to the device.

2) The maximum allowable power dissipation is a function of the maximum junction temperature $T_{J\,(MAX)}$, the junction-to- ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by $P_{D(MAX)}=(T_{J(MAX)}-T_A)/\theta_{JA}$.

3) The θ_{JA} values given in this table are for comparison with other packages only and cannot be used for design purposes. They do not represent the performance achieved in real-world applications.

Electrical Characteristic

Test conditions：V(SUPPLY) = 5V~ 40V, TJ = –40°C~150°C, unless otherwise specified.

PARAMETER		TESTCONDTITION	MIN	TYP	MAX	UNIT
BIAS						
V(POR_rising)	Supply voltage POR rising threshold		--	3.2	4	V
V(POR_falling)	Supply voltage POR falling threshold		2.2	3		V
I(Shutdown)	Device shutdown current	EN = LOW	--	5	10	uA
I(Quiescent)	Device quiescent current	PWM = HIGH, EN = HIGH	0.1	0.2	0.25	mA
I(FAULT)	Device current in fault mode	EN = HIGH, PWM = HIGH, FAULT externally pulled LOW	0.1	0.2	0.25	mA
LOGIC INPUTS (DIAGEN, PWM, EN)						
VIL(DIAGEN)	Input logic-low voltage, DIAGEN		1.045	1.1	1.155	V
VIH(DIAGEN)	Input logic-high voltage, DIAGEN		1.14	1.2	1.26	V
VIL(PWM)	Input logic-low voltage, PWM		1.045	1.1	1.155	V
VIH(PWM)	Input logic-high voltage, PWM		1.14	1.2	1.26	V
VIL(EN)	Input logic-low voltage, EN		--	--	0.7	V
VIH(EN)	Input logic-high voltage, EN		2	--	--	V
IPD(EN)	EN pin pulldown current		1.5	3.3	4.5	uA
CONSTANT-CURRENT DRIVER						
I(OUT)	Device output-current range	100% duty-cycle	4	--	300	mA
V(CS_REG)	Sense-resistor regulation voltage	T = 25℃, V = 4.5V to 18V	94	98	102	mV
		TA=–40℃ to 125℃, V(SUPPLY)=4.5V to 18V	93.5	98	102.5	mV
R(SNS)	Sense-resistor range		--	--	24.5	Ω
V(DROPOUT)	Voltage dropout from SUPPLY to OUT	V(CS_REG) voltage included, current setting=10mA	--	120	150	mV
		V(CS_REG) voltage included, current setting=70mA	--	250	400	
		V(CS_REG) voltage included, current setting=150mA	--	430	700	
		V(CS_REG) voltage included, current setting=300mA	--	800	1300	
DIAGNOSTICS						
V(OPEN_th_rising)	LED open rising threshold, V(IN)–V(OUT)		70	100	135	mV
V(OPEN_th_falling)	LED open falling threshold, V(IN)–V(OUT)		235	290	335	mV
V(SG_th_falling)	Channel output V(OUT) short-to-ground falling threshold		1.14	1.2	1.28	V
V(SG_th_rising)	Channel output V(OUT) short-to-ground rising threshold		0.82	0.865	0.94	V
I(Retry)	Channel output retry current	V(OUT) = 0V	0.64	1.08	1.528	mA
FAULT						
V(SSH_th)	Single-LED short-detection high-side threshold	V(SSL)– V(SSH)	140	190	235	mV
V(SSL_th)	Single-LED short-detection low-side threshold		0.8	0.86	0.91	V
VIL(FAULT)	Logic-input low threshold		--	--	0.7	V
VIH(FAULT)	Logic-input high threshold		2			V
VOL(FAULT)	Logic-output low voltage	With 500-µA external pullup	--	--	0.4	V
VOH(FAULT)	Logic-output high voltage	With 1-µA external pulldown, V(SUPPLY)=12V	5	--	7	V

I(FAULT_pulldown)	FAULT internal pulldown current		500	750	1000	uA
I(FAULT_pullup)	FAULT internal pullup current		5	8	12	uA
THERMAL PROTECTION						
T(TSD)	Thermal shutdown junction temperature threshold		167	172	178	℃
T(TSD_HYS)	Thermal shutdown junction temperature hysteresis		--	15	--	℃
Timing Requirements						
t(PWM_delay_rising)	PWM rising edge delay, 50% PWM voltage to 10% of output current, t2 – t1 as shown in Figure 1		10	17	25	us
t(PWM_delay_falling)	PWM falling edge delay, 50% PWM voltage to 90% of output current, t5 – t4 as shown in Figure 1		15	21	30	us
t(TSD_deg)	Thermal overtemperature deglitch time		--	60	--	us
t(DEVICE_STARTUP)	EN rising edge to 10% output current at 150mA set current and 12V supply voltage		--	100	150	us
t(OPEN_deg)	LED open-circuit fault-deglitch time		80	125	175	us
t(SG_deg)	Channel-output short-to-ground detection deglitch time		80	125	175	us
t(SS_deg)	Single-LED short-detection deglitch time		80	125	175	us
t(Recover_deg)	Recovery deglitch time		--	16	--	us

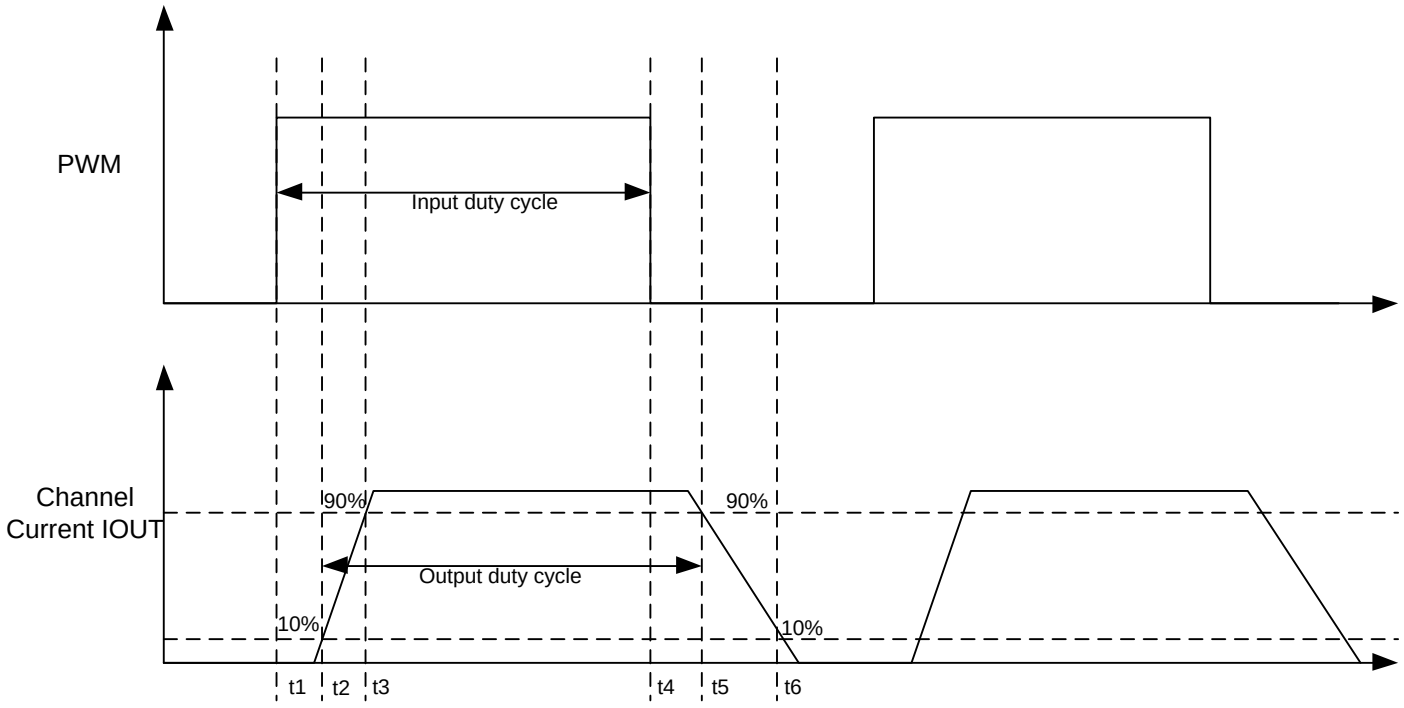


Fig 1. Output Timing Diagram

Typical Performance Characteristics

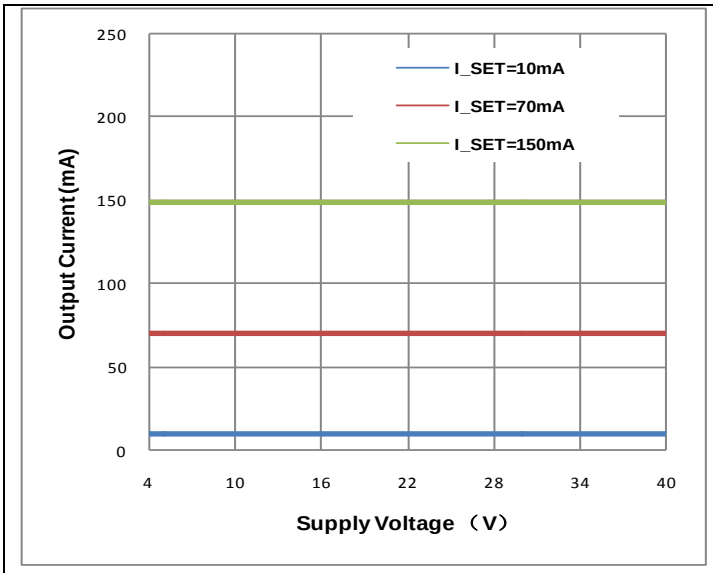


Fig 2. Output Current vs Supply Voltage

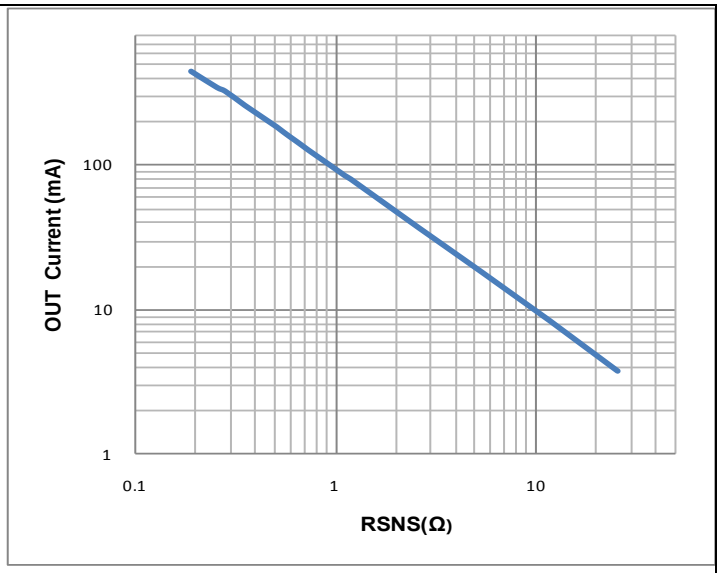


Fig 3. Output Current vs Current-Sense Resistor

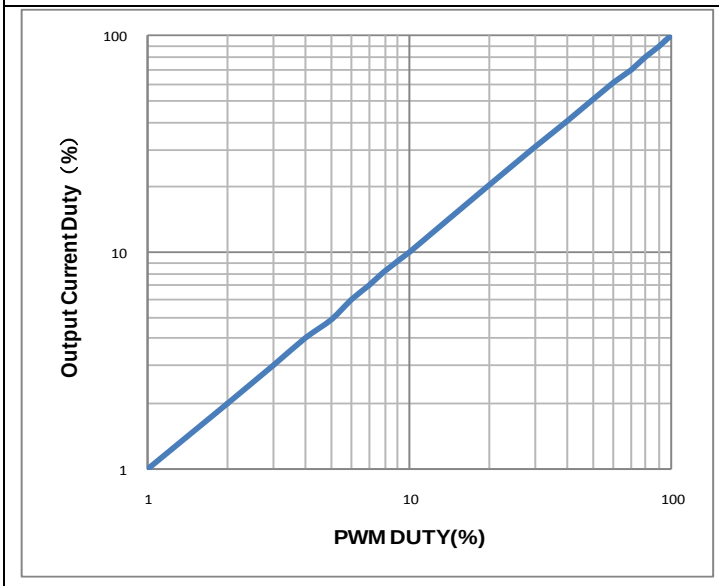


Fig 4. PWM Output Duty Cycle vs Input Duty Cycle

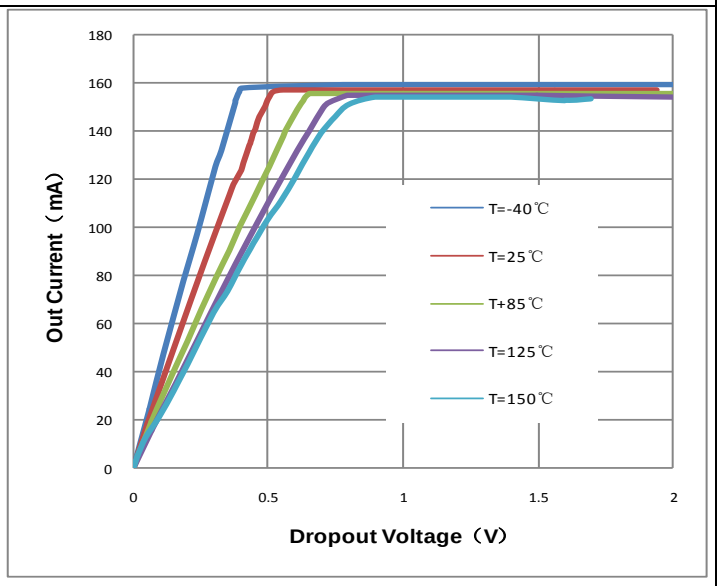


Fig 5. Output Current vs Dropout Voltage

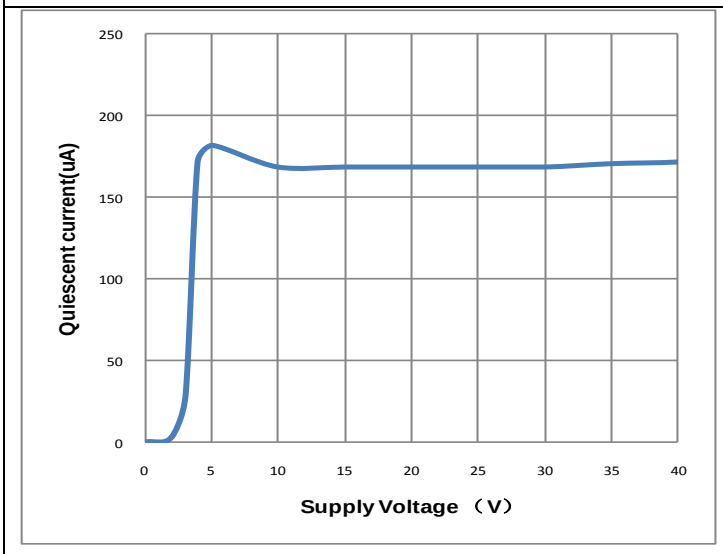


Fig 6. Quiescent Current vs Supply Voltage

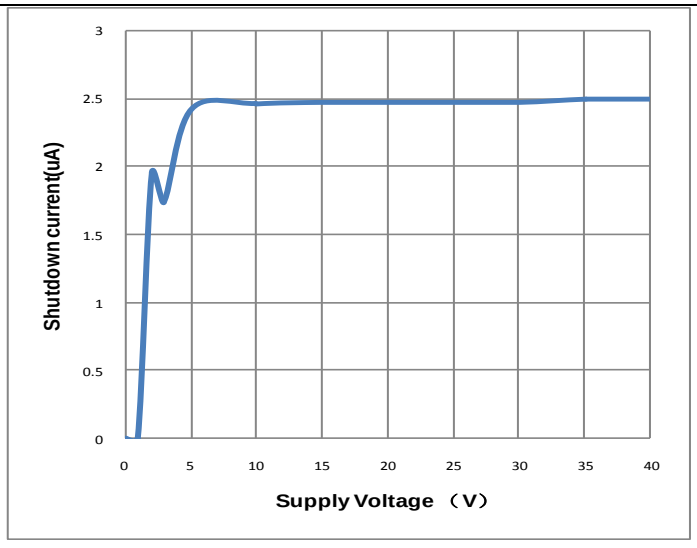
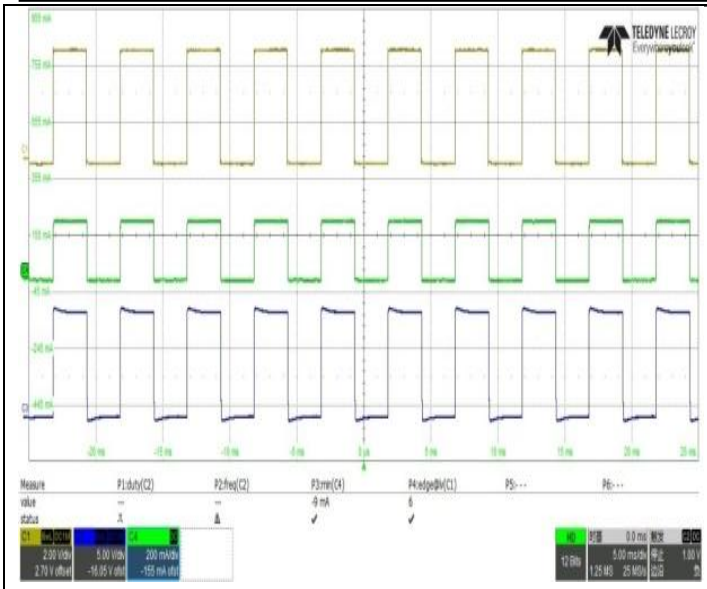
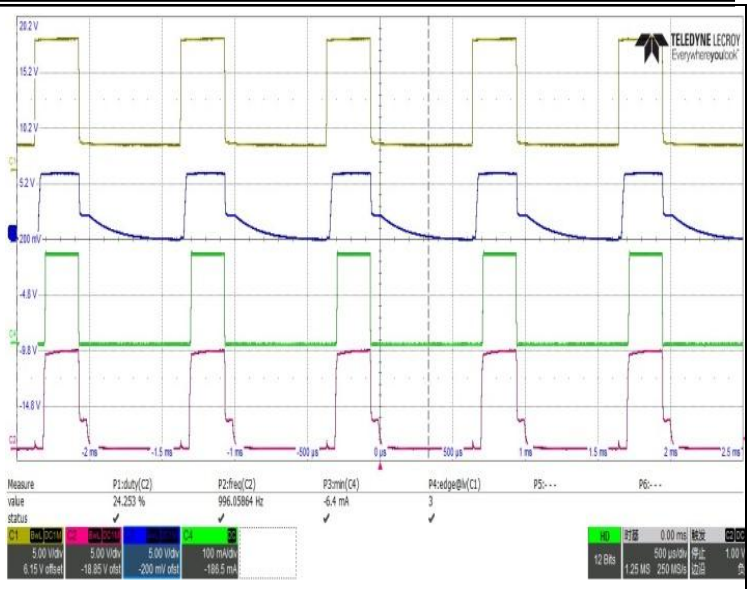


Fig 7. Shutdown Current vs Supply Voltage



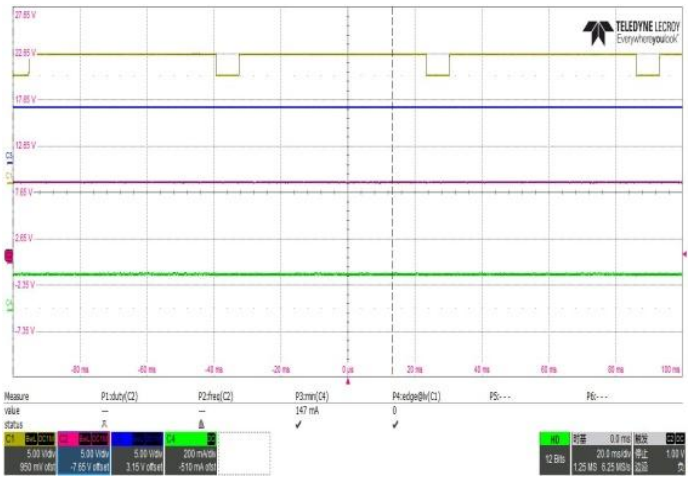
C1-PWM C4-IOUT C3-VOUT

Fig 8. PWM Dimming via External Input



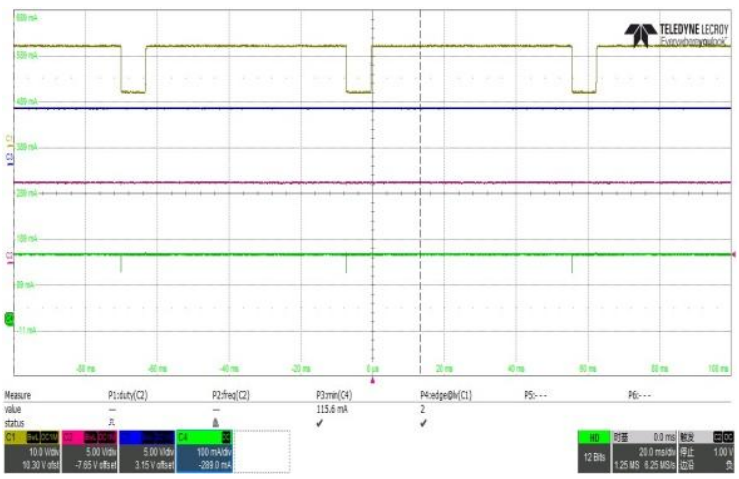
C1-SUPPLY C2-VOUT C3-FAULT C4-IOUT

Fig 9. PWM Dimming via Power Supply



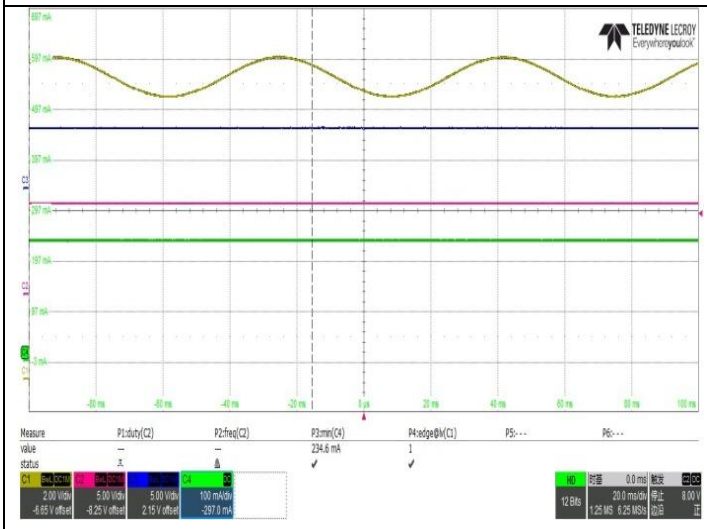
C1-SUPPLY C2-VOUT C3-FAULT C4-IOUT

Fig 10. Transient Undervoltage



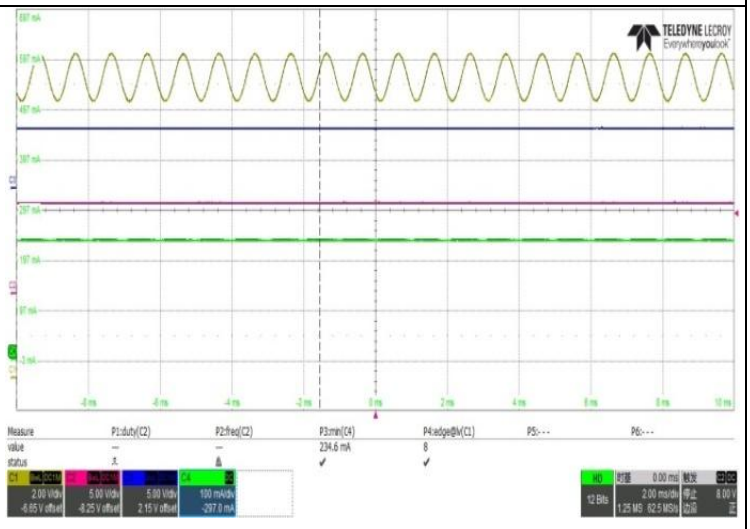
C1-SUPPLY C2-VOUT C3-FAULT C4-IOUT

Fig 11. Jump Start



C1-SUPPLY C2-VOUT C3-FAULT C4-IOUT

Fig 12. Superimposed Alternating Voltage, 15-Hz



C1-SUPPLY C2-VOUT C3-FAULT C4-IOUT

Fig 13. Superimposed Alternating Voltage, 1kHz

Application Information

- **Constant-Current Driver**

The MEQDS7610 device has a high-side constant-current integrated driver. The device senses channel current with an external high-side current-sense resistor, R (SNS) . A current regulation loop drives an internal transistor and regulates the current-sense voltage at the current-sense resistor to V (CS_REG) . When the output driver is in regulation, the output current can be set using the following equation.

I(OUT=V(CS_REG)/R(SNS)

- **Device Enable**

The MEQDS7610 device has an enable input EN. When EN is low, the device is in sleep mode with ultralow quiescent current I (Shutdown) . This low current helps to save system-level current consumption in applications (Shutdown) where battery voltage directly connects to the device without high-side switches.

- **PWM Dimming**

The MEQDS7610 devicesupports PWM dimming via PWM input dimming and supply dimming.

The PWM input functions as an enable for the output current. When the PWM input is low, the device also disables the diagnostic features.

Supply dimming applies PWM dimming on the power input.For an accurate PWM threshold, TI recommends using a resistor divider on the PWM input stage to set the PWM threshold higher than V (POR_rising).

- **Diagnostics**

The MEQDS7610 device provides advanced diagnostics and fault protection features for automotive exterior lighting systems. The device is able to detect and protect from LED string short-to-GND and LED string open-circuit faults.It also supports a one-fails–all-fail fault bus that could flexibly fit different regulatory requirements.

- **DIAGEN**

The MEQDS7610 device supports the DIAGEN pin with an accurate threshold to disable the open-load diagnostic function. With a resistor divider, the DIAGEN pin can be used to sense SUPPLY voltage with a resistor-programmable threshold. With the DIAGEN feature, the device is able to avoid false error reports due to low dropout voltage and to drive maximum current in low-dropout mode when the input voltage is not high enough for current regulation.

When V (DIAGEN) is higher than the V IH(DIAGEN) threshold, the device enables the LED open-circuit diagnostic. WhenV (DIAGEN) is lower than the V IL(DIAGEN) threshold, the device disables the LED open-circuit diagnostic.

- **Low-Dropout Mode**

When the supply voltage drops, the MEQDS7610 device tries to regulate current by driving internal transistors in the linear region, also known as low-dropout mode, because the voltage across the sense resistor fails to reach the regulation target.

In low-dropout mode, the open-circuit diagnostic must be disabled. Otherwise, the device treats the low-dropout mode as an open-circuit fault. The DIAGEN pin is used to avoid false diagnostics on the output channel due to low supply voltage.

When the DIAGEN voltage is low, open-circuit detection is ignored. When the DIAGEN voltage is high, open-

circuit detection returns to normal operation.

In low-dropout mode, a parallel diode and current-limiting resistor are recommended to clamp between SUPPLY and IN (across the sense resistor) in case of a large current pulse during recovery.

- **Open-Circuit Detection**

The MEQDS7610 device has LED open-circuit detection. Open-circuit detection monitors the output voltage when the channel is in the ON state. Open-circuit detection is only enabled when DIAGEN is HIGH. A short-to-battery fault is also detected as an LED open-circuit fault.

The device monitors dropout-voltage differences between the IN and OUT pins when PWM is HIGH. The voltage difference V (IN) – V (OUT) is compared with the internal reference voltage V (OPEN_th_rising) to detect an LED open-circuit failure. If V (IN) – V (OUT) falls below the V (OPEN_th_rising) voltage longer than the deglitch time of t (OPEN_deg) , the device detects an open-circuit fault. Once an LED open-circuit failure is detected, the constant-current source pulls the fault bus down. During the deglitch time period, if V (IN) – V (OUT) rises above V (OPEN_th_falling) , the deglitch timer is reset.

When the PWM input is in auto-retry, the device keeps the output ON to retry if the PWM input is HIGH; the device sources a small current I (retry) from IN to OUT to retry when the PWM input is LOW. In either scenario, once a faulty channel recovers, the device resumes normal operation and releases the FAULT pulldown.

- **Short-to-GND Detection**

The MEQDS7610 device has LED short-to-GND detection. Short-to-GND detection monitors the output voltage when the channel is in the ON state. Once a short-to-GND LED failure is detected, the device turns off the output channel and retries automatically, ignoring the PWM input. If the retry mechanism detects removal of the LED short-to-GND fault, the device resumes normal operation.

The device monitors the V (OUT) voltage and compares it with the internal reference voltageto detect a short-to-(OUT) GND failure. If V (OUT) falls below V (SG_th_rising) longer than the deglitch time of t (SG_deg) , the device asserts the (OUT) (SG_th_rising) (SG_deg) short-to-GND fault and pulls FAULT low. During the deglitching time period, if V (OUT) rises above V (SG_th_falling) , the timer is reset.

Once the device has detected a short-to-GND fault, the device turns off the output channel and retries automatically with a small current. When retrying, the device sources a small current I (retry) from IN to OUT to pull up the LED loads continuously. Once auto-retry detects output voltage rising above V (SG_th_falling) , it clears the short-to-GND fault and resumes normal operation.

- **Overtemperature Protection**

The MEQDS7610 device monitors device junction temperature. When the junction temperature reaches thermal shutdown threshold T (TSD) , the output shuts down. Once junction temperature falls below T (TSD) – T (TSD_HYS) , the device resumes normal operation. During overtemperature protection, the fault bus is pulled low.

- **Fault-Bus Output With One-Fails–All-Fail**

The MEQDS7610 device has a fault bus for diagnostics output. In normal operation, FAULT is weakly pulled up by an internal pullup current source I (FAULT_pullup) higher than V OH(FAULT) . If any fault occurs, the fault bus is strongly pulled low by the internal pulldown current source I (FAULT_pulldown) . Once V (FAULT) falls below V IL(FAULT) , all outputs shut down for protection. The faulty channel keeps retrying until the fault is removed.

If FAULT is externally pulled up with a current larger than I (FAULT_pulldown) , the one-fails–all-fail function is disabled and only the faulty channel is turned off.

The fault bus is able to support up to 15 pieces of MEQDS7610 or MEDS92630.

Functional description：

Table1. Fault Table With DIAGEN = HIGH

FAULT BUS STATUS	FAULT TYPE	DETECTION MECHANISM	CHANNEL STATE	DEGLITCH TIME	FAULT BUS	FAULT HANDLING ROUTINE	FAULT RECOVERY
FAULT floating or externally pulled up	Open-circuit or short-to-supply	V(IN)–V(OUT) <V(OPEN_the_rising)	On	t(OPEN_deg)	Constant - current pulldown	Device works normally with FAULT pin pulled low. Device sources I(retry) current when PWM is LOW. Device keeps output normal when PWM is HIGH.	Auto recover
	Short-to-ground	V(OUT)<V(SG_the_rising)	On	t(SG_deg)	Constant - current pulldown	Device turns output off and retries with constant current I(retry), ignoring the PWM input	Auto recover
	Over-temperature	TJ > T(TSD)	On or off	t(TSD_deg)	Constant - current pulldown	Devices turns output off.	Auto recover
Externally pulled low	Device turns output off						

Table2. Fault Table With DIAGEN = LOW

FAULT BUS STATUS	FAULT TYPE	DETECTION MECHANISM	CHANNEL STATE	DEGLITCH TIME	FAULT BUS	FAULT HANDLING ROUTINE	FAULT RECOVERY
FAULT floating or externally pulled up	Open-circuit or short-to-supply	Ignored					
	Short-to-ground	V(OUT)<V(SG_the_rising)	On	t(SG_deg)	Constant - current pulldown	Device turns output off and retries with constant current I(retry), ignoring the PWM input	Auto recover
	Over-temperature	TJ > T(TSD)	On or off	t(TSD_deg)	Constant - current pulldown	Devices turns output off	Auto recover
Externally pulled low	Device turns output off						

- **Functional Modes**

Undervoltage Lockout, V (SUPPLY) < V (POR_rising)

When the device is in undervoltage lockout mode, the MEQDS7610 device disables all functions until the supply rises above the POR-rising threshold.

Normal Operation V (SUPPLY) ⩾ 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.

Low-Voltage Dropout

When the device drives an LED string in low-dropout mode, if the voltage drop is less than the open-circuit detection threshold, the device may report a false open. Set the DIAGEN threshold higher than the LED string voltage to avoid a false open-circuit detection.。

Fault Mode

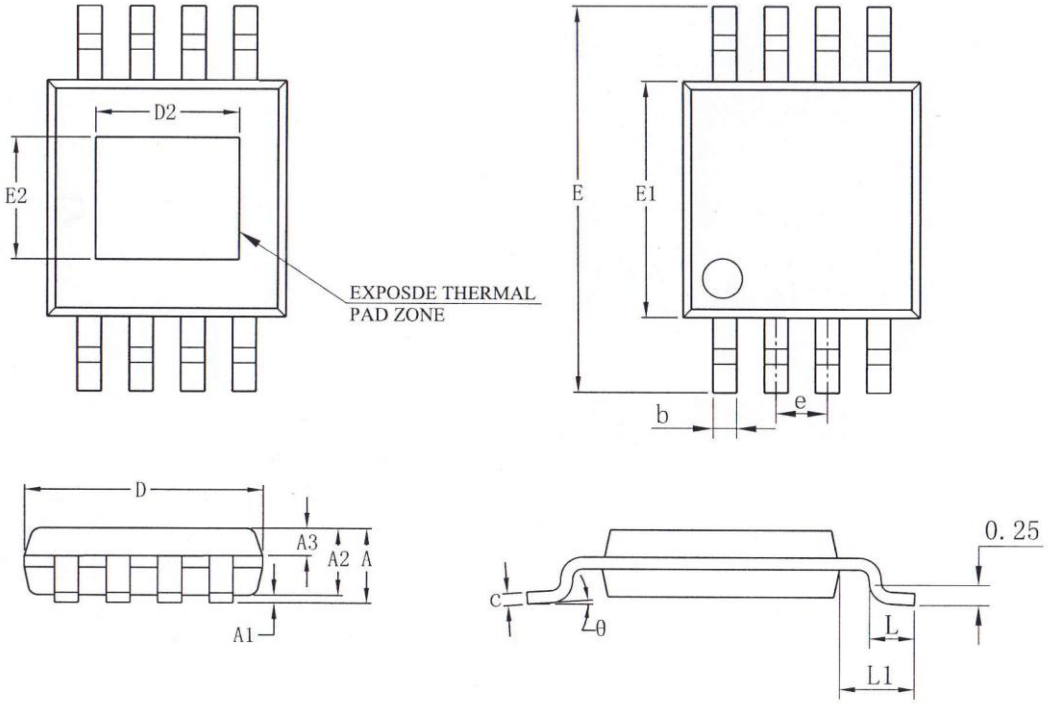
When the device detects an open or shorted LED, the device tries to pull down the FAULT pin with a constant current. If the fault bus is pulled down, the device switches to fault mode and consumes a fault current of I (FAULT).

Package Quantity

Package Type	Minimum Packing QTY	UNITS	Small Box	Large BOX
EMSOP8	3000	Tape & Reel	6k	48k

Packaging Information

- **Package Type: EMSOP8**



DIM	Millimeters		Inches	
	Min	Max	Min	Max
A	-	1.1	-	0.0433
A1	0.05	0.15	0.0020	0.0059
A2	0.75	0.95	0.0295	0.0374
A3	0.3	0.4	0.0118	0.0157
b	0.28	0.36	0.0110	0.0142
c	0.15	0.19	0.0059	0.0075
D	2.9	3.1	0.1142	0.1220
D2	1.8 REF		0.0709 REF	
e	0.65 BSC		0.0256 BSC	
E	4.7	5.1	0.1850	0.2008
E1	2.9	3.1	0.1142	0.1220
E2	1.55 REF			
L	0.4	0.7	0.0157	0.0276
L1	0.95 REF		0.0374 REF	
θ	0	8°	0	8°

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