Description

The AL5810Q is an automotive AEC-Q100 linear LED driver offering an excellent temperature and voltage current stability with output adjustable handling capability. The AL5810Q simplifies the design of LED drivers by setting the LED current with an external resistor using standard value resistors.

The AL5810Q has an open-drain output that can swing from 2.0V up to 60V supply voltage enabling it to drive long LED chains for high-side or low-side LED strings. Its low 0.5V R_{SET} pin is outside of the LED current path and can maintain current accuracy while minimizing the required overheads to regulate the LED current. This reduces its power dissipation when compared to traditional linear LED drivers. It makes it ideal for driving LEDs up to 200mA.

The AL5810Q is available in the wettable flank W-DFN2020-3/SWP (Type A) (2mm x 2mm) package featuring power dissipation (P_D) up to 2W and TO252 (DPAK) package with P_D up to 3.85W. The AL5810Q is qualified to AEC-Q100 Grade 2 with automotive compliance supporting PPAPs.

Features

- AEC-Q100 Grade 2 Qualified
- 2.0V to 60V Wide Input Voltage Range
- An External Resistor for Setting Current
- Low Reference Voltage (V_{RSET} = 0.5V)
- Adjustable Sink or Source LED Current up to 200mA/200mA (W-DFN2020-3/SWP (Type A)/TO252 (DPAK))
- ±3% LED Current Tolerance at Room Temperature
- Parallel Devices to Increase Regulated Current
- Overtemperature Shutdown
- -40°C to +105°C Ambient Temperature Range
- Wettable W-DFN2020-3/SWP (Type A) (2mm x 2mm), P_D up to 2W; TO252 (DPAK), P_D up to 3.85W
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **The AL5810Q is suitable for automotive applications requiring specific change control; this part is AEC-Q100 qualified, PPAP capable, and manufactured in IATF16949 certified facilities.**
  https://www.diodes.com/quality/product-definitions/

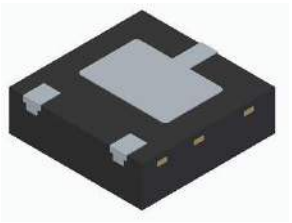
Applications

- Interior and exterior automotive LED lighting
- Puddle lighting
- Side marker lights
- Automotive mirror turning lights
- LED strings for dome and mood lighting
- Instrumentation illumination

Pin Assignments

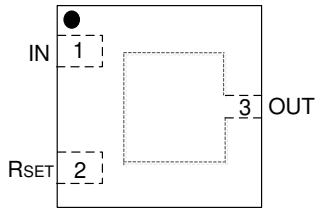
W-DFN2020-3/SWP (Type A)

Top View



Bottom View

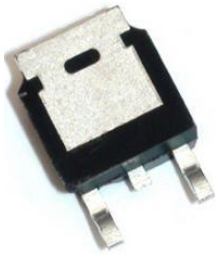
(Top View)



W-DFN2020-3/SWP (Type A)

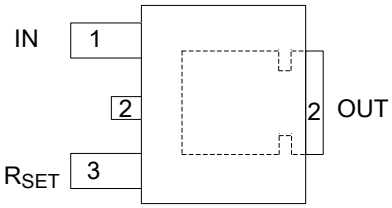
TO252 (DPAK)

Top View



Bottom View

(Top View)



TO252 (DPAK)

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Typical Applications Circuit

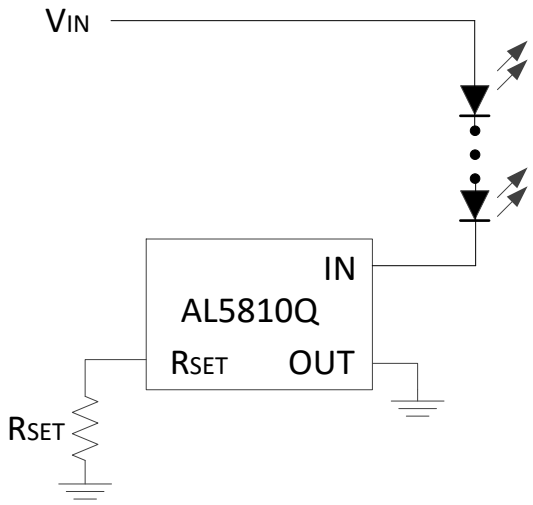


Figure 1. Low-Side Application

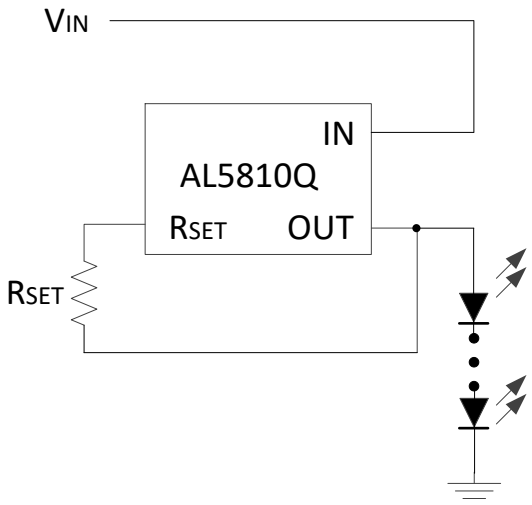


Figure 2. High-Side Application

Pin Descriptions

Pin Name	Pin Number		Function
	W-DFN2020-3/SWP (Type A)	TO252 (DPAK)	
IN	1	1	LED Current Input Terminal Current flows **IN** to this pin. For low-side application, connect the LED cathode terminal to the IN terminal. For high-side application, connect V_{IN} to the IN terminal.
R_{SET}	2	3	LED Current Setting Pin For low-side application, connect a resistor from this pin to GND. For high-side application, connect a resistor in between the R_{SET} and OUT terminal. LED current is determined by this equation: $I_{LED} = 750 / R_{SET}$
OUT	3	2	LED Current Output Terminal Current flows **OUT** of this pin. For low-side application, connect the OUT terminal to GND. For high-side application, connect the LED anode terminal to the OUT terminal.

Functional Block Diagram

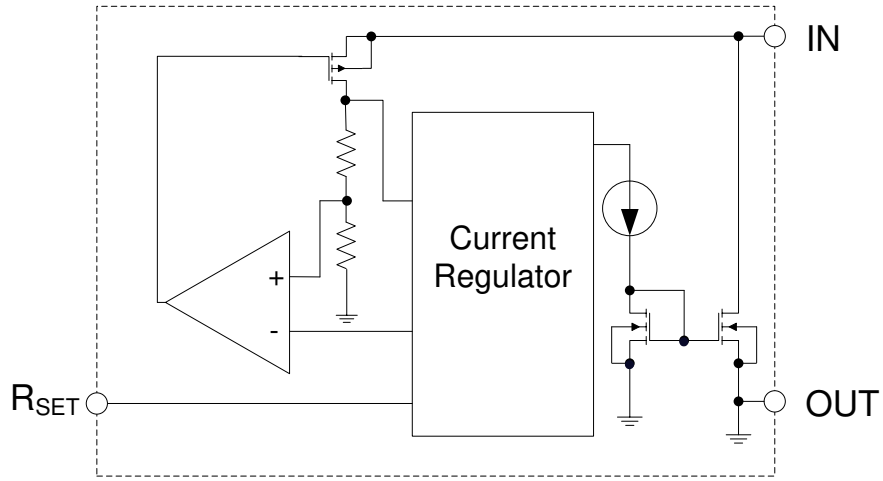


Figure 3. Functional Block Diagram

Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameters	Ratings	Unit
V_{INOUT}	IN Pin Voltage Relative to OUT Pin	-0.3 to +66	V
V_{RSET}	R_{SET} Pin Voltage Relative to OUT Pin	-0.3 to +6	V
I_{INOUT}	LED Current from IN to OUT	250	mA
ESD HBM	Human Body Model ESD Protection	4,000	V
ESD CDM	Charged Device Model ESD Protection	1,000	V
T_J	Operating Junction Temperature	-40 to +150	°C
T_{ST}	Storage Temperature	-55 to +150	°C

Caution: Stresses greater than those listed under *Absolute Maximum Ratings* can 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 Ratings* for extended periods can affect device reliability.
Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

Package Thermal Data

Package	θ_{JC} Thermal Resistance Junction-to-Case	θ_{JA} Thermal Resistance Junction-to-Ambient	P_D T_A = +25°C, T_J = +150°C
W-DFN2020-3/SWP (Type A)	10.76°C/W	61.66°C/W (Note 4)	2W
TO252 (DPAK)	2.81°C/W	31.46°C/W (Note 4)	3.85W

Note: 4. Test condition: device mounted on FR-4 PCB (51mm x 51mm 2oz copper, minimum recommended pad layout on top layer and thermal vias to bottom layer with maximum area ground plane. For better thermal performance, larger copper pad for heatsink is needed.

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
V_{INOUT}	IN Voltage Range Relative to OUT Pin	2.5	60	V
I_{INOUT}	LED Current (Notes 5 & 6)	1	200	mA
$t_{PWM(ON)}$	PWM Pulse Width in Dimming Mode On-Time	500	—	µs
$t_{PWM(OFF)}$	PWM Pulse Width in Dimming Mode Off-Time	500	—	µs
T_J	Operating Junction Temperature Range (Note 7)	-40	+150	°C
T_A	Operating Ambient Temperature Range AEC-Q100 Grade 2 (Note 7)	-40	+105	°C

Electrical Characteristics (@T_A = +25°C, V_{INOUT} = 3.5V (Note 8), R_{SET} = 7.5kΩ, unless otherwise specified.)

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{INOUT}	In-Out Supply Voltage	I_{OUT} ≥ 100mA (Note 9)	T_A = -40°C to +105°C	2.5	—	60	V
		I_{OUT} < 100mA (Note 9)		2.0	—	60	V
V_{RSET}	R_{SET} Voltage	—	T_A = -40°C to +105°C	—	0.5	—	V
I_{INOUT}	I_{INOUT} Current Accuracy	R_{SET} = 3.75kΩ	T_A = +25°C	186	200	222	mA
		R_{SET} = 5kΩ		141	150	163	
		R_{SET} = 7.5kΩ		95	100	105	
			T_A = -40°C to +105°C	92	100	108	
		R_{SET} = 15kΩ	T_A = -40°C to +105°C	43	50	56	
		R_{SET} = 75kΩ		6	10	14	
		R_{SET} = 150kΩ		3	5	7	
I_{TEMCO}	Temperature Coefficient of Current Accuracy	I_{OUT} = 100mA	T_A = -40°C to +105°C	—	1	—	%
I_{LINE}	I_{INOUT} Current Line Regulation	V_{IN} = 3.5V to 60V (Note 7)	T_A = +25°C	—	1	—	%
I_{CC}	IN Pin Operating Current	V_{IN} = 60V, R_{SET} = 1MΩ	T_A = -40°C to +105°C	300	685	1000	µA
V_{MIN}	Minimum Power up Voltage	Increase V_{INOUT} (Note 10)	T_A = -40°C to +105°C	1	1.5	2	V
t_{ON_MIN}	Minimum On Pulse Width for PWM Dimming	PWM Dimming with External MOSFET Connected to R_{SET}, See PWM Dimming Section. (Notes 11 & 12)	—	500	—	—	µs
t_{OFF_MIN}	Minimum Off Pulse Width for PWM Dimming	PWM Dimming with External MOSFET Connected to R_{SET}, See PWM Dimming Section. (Notes 11 & 12)	—	500	—	—	µs
T_{SHDN}	Thermal Shutdown	Junction Temperature (Note 13)	—	—	+165	—	°C
T_{HYS}	Thermal Shutdown Hysteresis	—	—	—	+30	—	°C

Notes:
5. For improved accuracy LED current should be greater than 60mA.
6. Maximum LED current is also limited by ambient temperature and power dissipation such that junction temperature should be kept less than or equal to +150°C.
7. Measured by the percentage of LED current variation when V_{INOUT} varies from 3.5V to 60V.
8. All voltages unless otherwise stated are measured with respect to OUT pin.
9. Subject to maximum junction temperature of +150°C not being exceeded. The Maximum ambient temperature range is limited by device power dissipation; such that its junction temperature should be kept less than or equal to +150°C. See Page 3 for more information on power dissipation. Devices have been qualified to AEC-Q100 Grade 2.
10. Apply the power linearly to the chip until the device starts to turn on.
11. t_{ON_MIN} time includes the delay and the rise time needed for I_{OUT} to reach 90% of its final value. t_{OFF_MIN} time is the time needed for I_{OUT} to drop below 10% of its final value.
12. This parameter only guaranteed by design, not tested in production.
13. Ambient temperature at which OTP is triggered may vary depending on application, PCB layout and material used.

Typical Performance Characteristics (W-DFN2020-3/SWP (Type A) 100mA, 150mA, 200mA Settings)

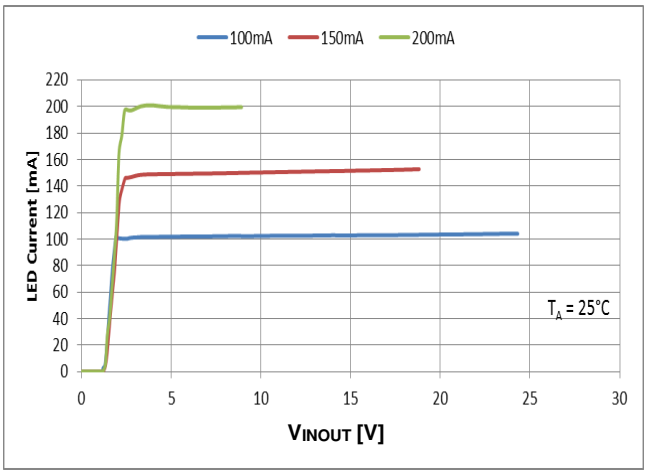


Figure 4. LED Current vs. V_{INOUT}

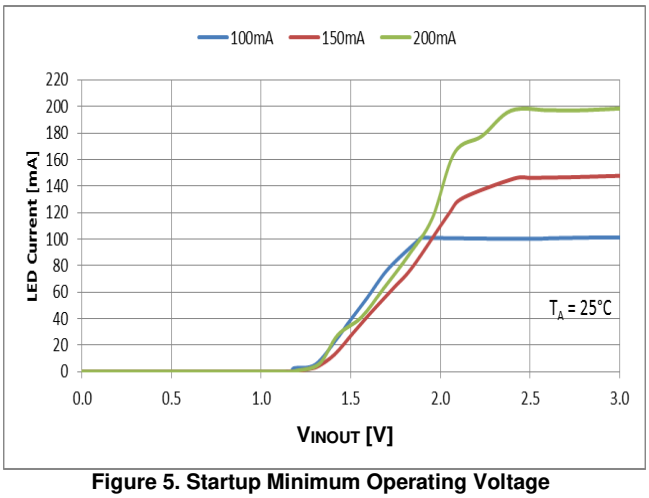


Figure 5. Startup Minimum Operating Voltage

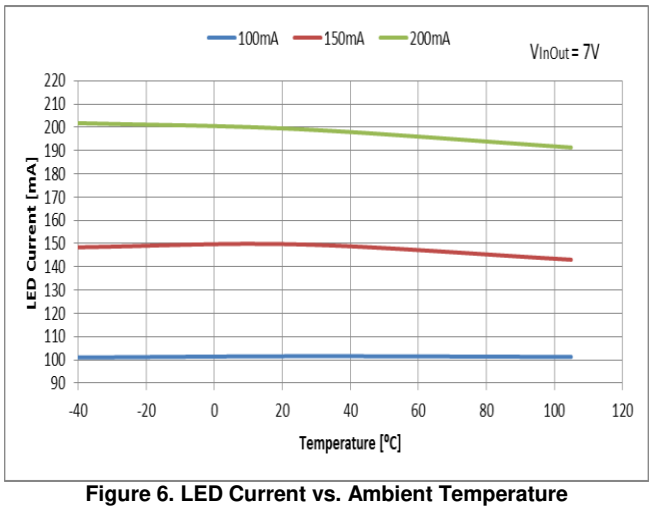


Figure 6. LED Current vs. Ambient Temperature

Typical Performance Characteristics (TO252 (DPAK) 150mA, 200mA, 250mA (Note 14) Settings)

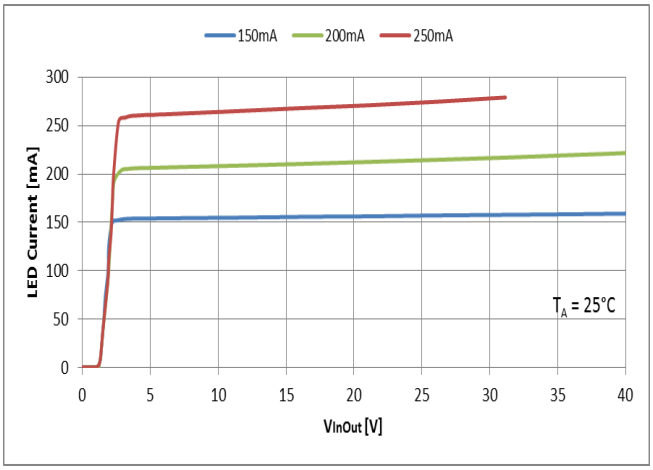


Figure 7. LED Current vs. V_{INOUT}

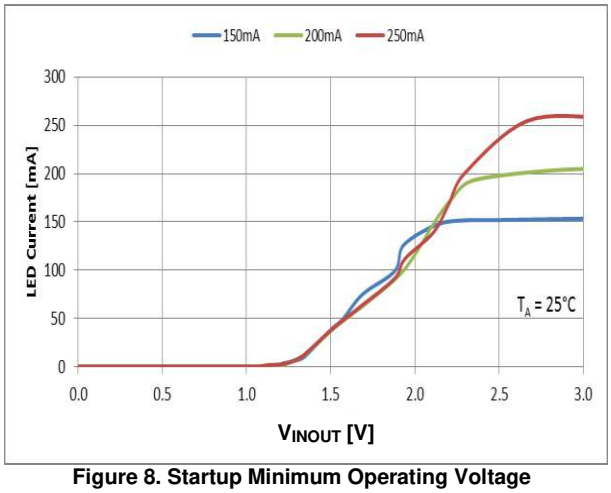


Figure 8. Startup Minimum Operating Voltage

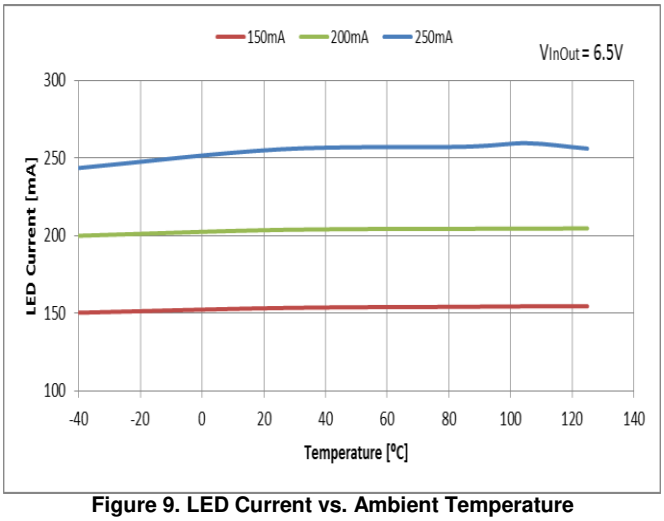


Figure 9. LED Current vs. Ambient Temperature

Note: 14. 250mA data are for reference only, not guaranteed by design and not tested in production.

Application Information

Description

The AL5810Q is a linear LED driver and regulates the LED current by sinking current into the IN pin. The AL5810Q can support up to 200mA LED current, with ±3% accuracy at +25°C. The LED current is set by an external resistor, R_{SET}, connected from the R_{SET} pin to the OUT pin. This resistor supplies the bias current of the AL5810Q together with current regulator to set the LED current.

The LED current is determined by this equation:

$$I_{LED} = 1500 * \frac{0.5}{R_{SET}}$$ where 1500 is the current ratio between the IN pin current and R_{SET} pin current.

With R_{SET} = 15k

$$I_{LED} = 1500 * \frac{0.5}{15k} = 50mA$$

The AL5810Q, with its 60V capability on the IN pin, allows supply rails up to 60V directly driving LED chains as shown in Figures 10 and 11.

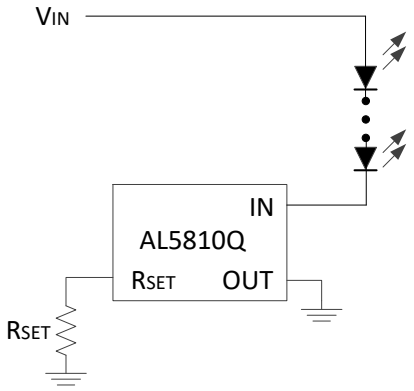


Figure 10. Low-Side Configuration

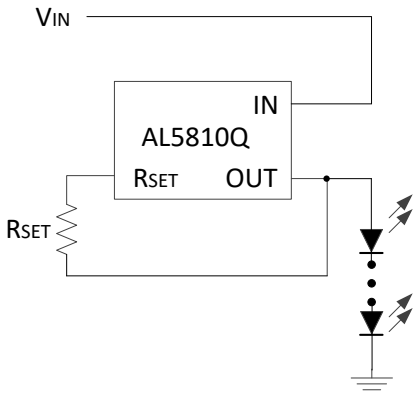
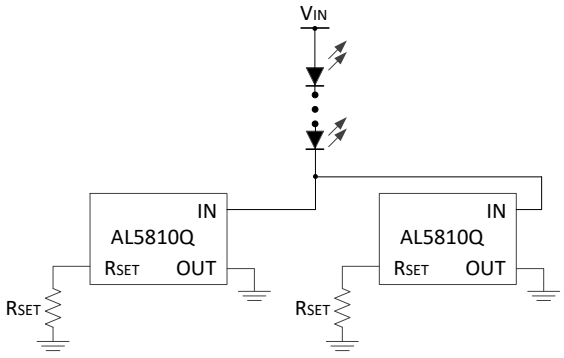
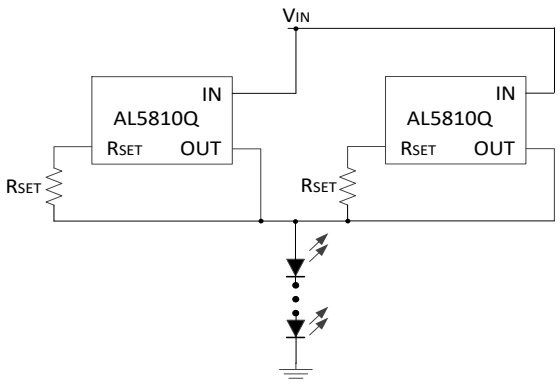


Figure 11. High-Side Configuration

The LED current can be increased by connecting two or more AL5810Q in parallel shown in Figure 12.



(a) Low-Side Parallel Configuration



(b) High-Side Parallel Configuration

Figure 12. Higher LED Current by Parallel Configuration of AL5810Q

Application Information (continued)

PWM Dimming

The AL5810Q can be used to provide LED current dimming by driving the R_{SET} pin via the current setting resistor (R_{SET}) and a series MOSFET switch to ground (Figure 13). The R_{SET} pin current is then effectively switched on and off causing the LED current to turn on and off. The linearity is shown in Figure 14.

Test conditions (Figure 14): V_{IN} = 6V, 1 LED low side configuration, R_{SET} = 7.5kΩ, I_{LED} = 100mA, n-channel MOSFET, PWM frequency 200Hz to 500Hz square wave, 0 to 4V gate voltage.

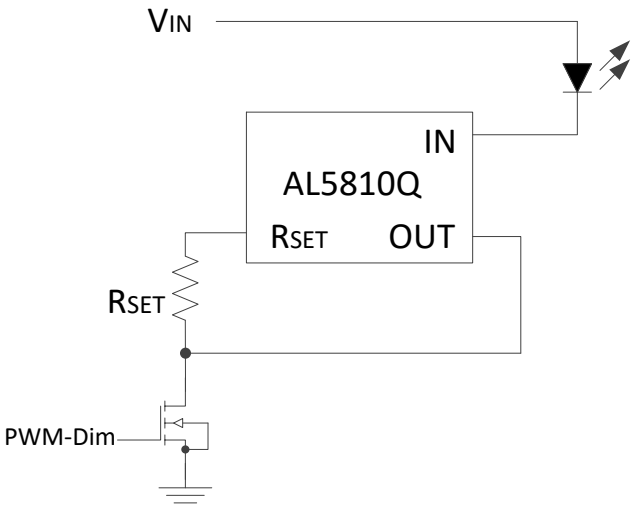


Figure 13. PWM Dimming by External MOSFET

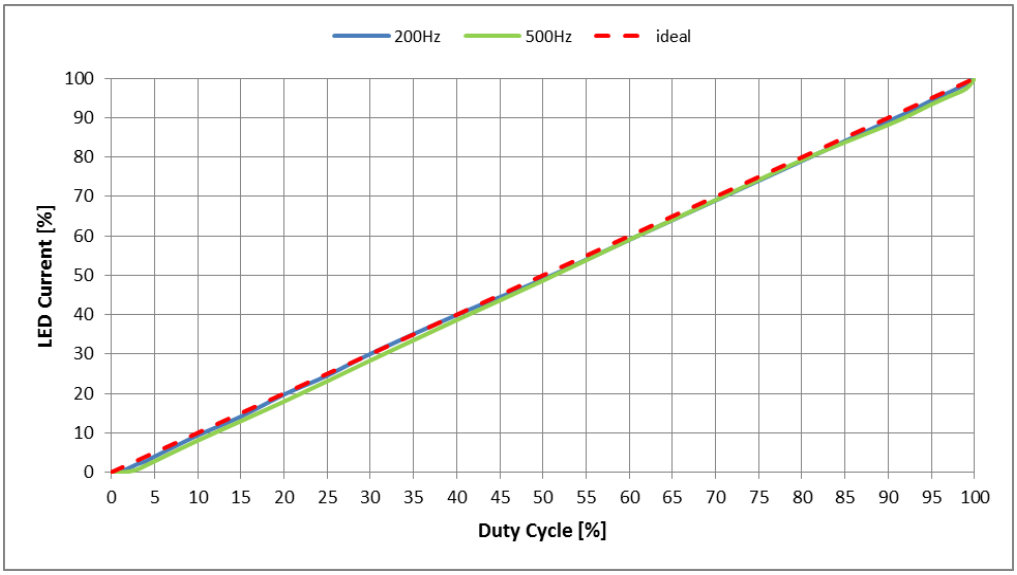


Figure 14. PWM Dimming Linearity

Application Information (continued)

Recommended PWM Frequency and Dimming Range

PWM Frequency (Hz)	Duty Cycle (%)	
	Min	Max
200	10	90
500	25	75

Use the following formula to calculate the Min and Max duty cycle:

Min. duty cycle (%) = (t_{ON_MIN}) / (time period of the PWM signal)
Max. duty cycle (%) = 100% - ((t_{OFF_MIN}) / (time period of the PWM signal))

Note: t_{ON_MIN} = 500µs (Min. value), and t_{OFF_MIN} = 500µs (Min. value) are listed in the *Electrical Characteristics* table on page 4.

Thermal Considerations

When designing linear LED drivers careful consideration must be given to the power dissipation within the LED driver and PCB layout/heat sinking. A Linear LED driver has to be able to handle the large potential input voltage variations due to the supply voltage tolerance and also the variation in LED forward voltage due to binning and temperature. This can cause a large potential difference across the LED driver resulting in a larger than anticipated power dissipation.

In automotive applications when the engine is running, the typical input voltage range varies from 13.5V to 14.7V.

The recommended minimum V_{INOUT} voltage of 2.5V enables the AL5810Q to drive 2 LEDs in series from the 12V battery voltage (assuming V_{LED} < 3.25V).

The AL5810Q's power dissipation under these conditions will be:

$$V_{INOUT} * I_{LED} = 2.5 * I_{LED}$$

So for the 100mA AL5810Q under these conditions this equals:

2.5V * 100mA = 250mW

Under maximum input conditions (14.7V), V_{INOUT} = 14.7V – 6.5V (2 LEDs voltage) the AL5810Q's power dissipation will be:

$$V_{INOUT} * I_{LED} = 8.2 * I_{LED}$$

So for the 100mA AL5810Q this equals:

8.2V * 100mA = 820mW

Figure 15 shows the AL5810Q's power dissipation capability, which varies with PCB size and area of metal associated with the ground plane used for heat sinking. By increasing the area on the top layer, the thermal impedance could be improved.

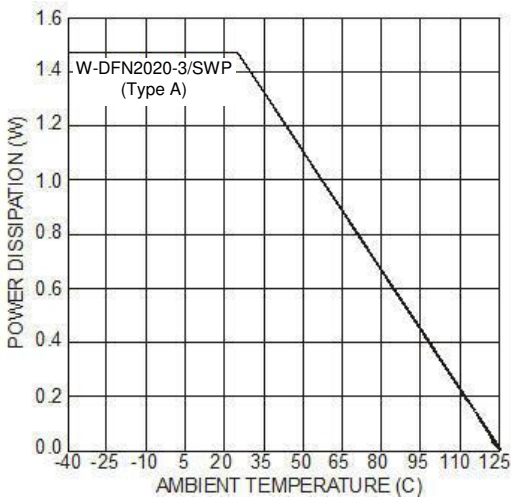
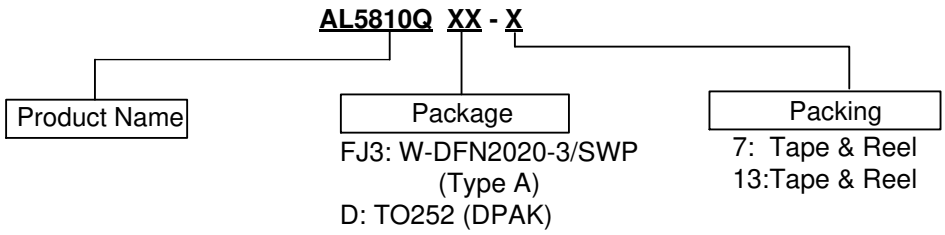


Figure 15. Power Dissipation Derating

Ordering Information (Note 15)



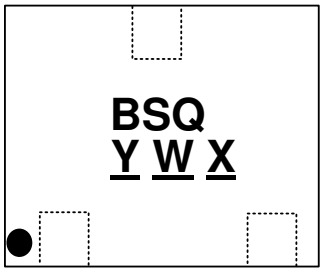
Part Number	Part Number Suffix	Package Code	Package	Packing	
				Qty.	Carrier
AL5810QFJ3-7	-7	FJ3	W-DFN2020-3/SWP (Type A)	3000	Tape & Reel
AL5810QD-13	-13	D	TO252 (DPAK)	2500	Tape & Reel

Note: 15. For packaging details, go to our website at https://www.diodes.com/design/support/packaging/diodes-packaging/.

Marking Information

Package: W-DFN2020-3/SWP (Type A)

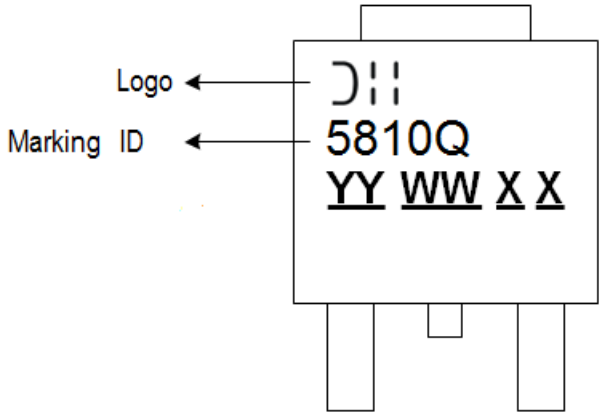
(Top View)



BSQ : Identification Code
Y : Year: 0 to 9 (ex: 3 = 2023)
W : Week: A to Z: Week 1 to 26;
a to z; Week 27 to 52; z Represents Week 52 and 53
X : Internal Code

Package: TO252 (DPAK)

(Top View)

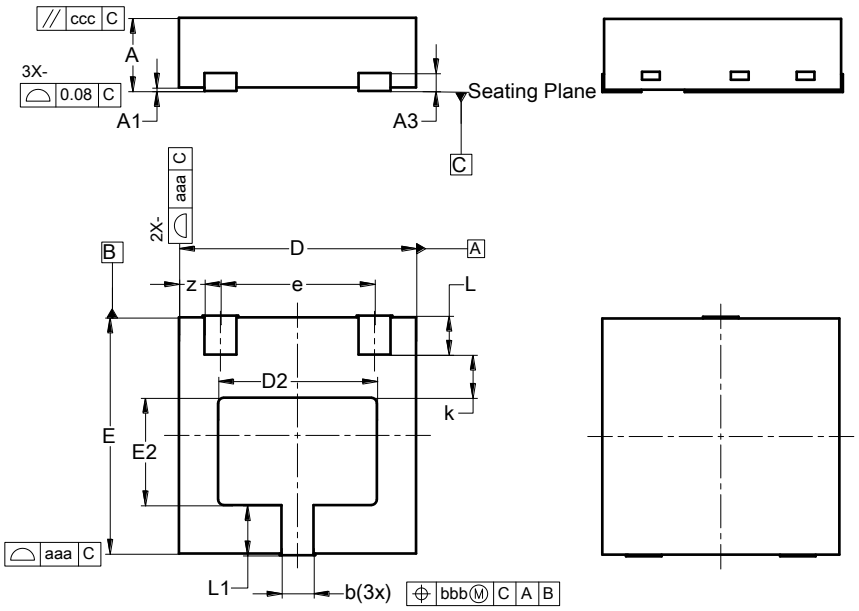


YY : Year: 01 to 09 (ex: 03 = 2023)
WW : Week: 01 to 52, 52 Represents Week 52 and 53
XX : Internal Code

Package Outline Dimensions

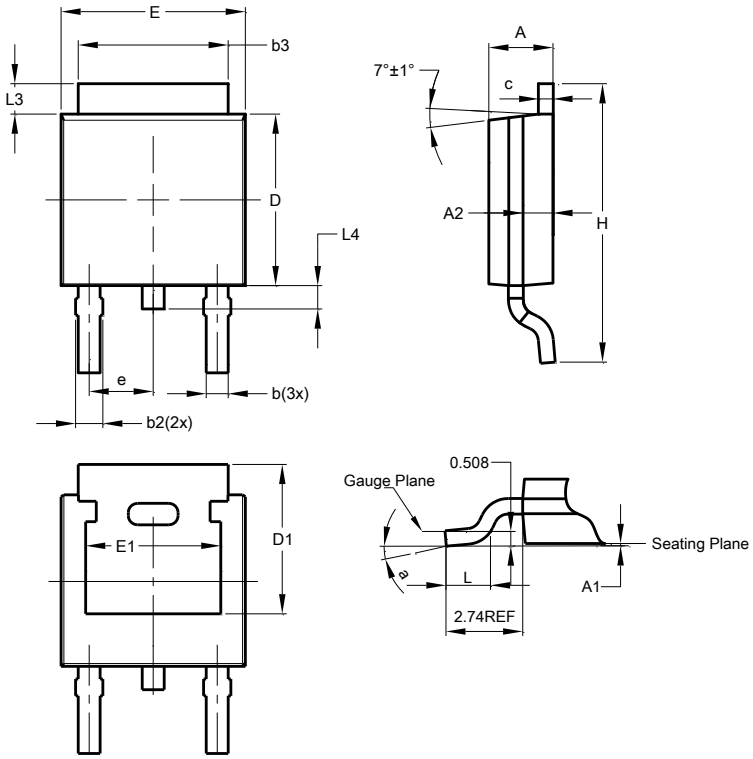
Please see http://www.diodes.com/package-outlines.html for the latest version.

Package: W-DFN2020-3/SWP (Type A)



W-DFN2020-3 /SWP (Type A)			
Dim	**Min**	**Max**	**Typ**
A	0.57	0.67	0.62
A1	0.00	0.05	0.03
A3	0.100	--	0.152
b	0.22	0.32	0.27
D	1.95	2.05	2.00
D2	1.24	1.44	1.34
E	1.95	2.05	2.00
E2	0.81	1.01	0.91
e	--	--	1.30
k	--	--	0.365
L	0.28	0.38	0.33
L1	0.375	0.475	0.425
z	--	--	0.215
aaa	0.25		
bbb	0.10		
ccc	0.10		
All Dimensions in mm			

Package: TO252 (DPAK)

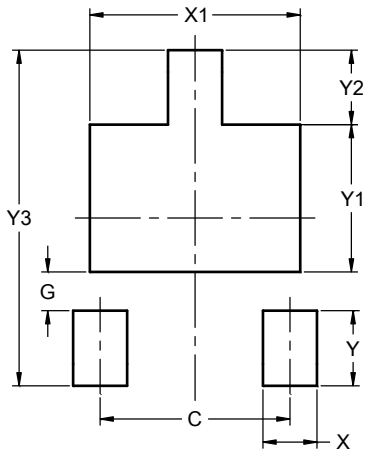


TO252 (DPAK)			
Dim	**Min**	**Max**	**Typ**
A	2.19	2.39	2.29
A1	0.00	0.13	0.08
A2	0.97	1.17	1.07
b	0.64	0.88	0.783
b2	0.76	1.14	0.95
b3	5.21	5.50	5.33
c	0.45	0.58	0.531
D	6.00	6.20	6.10
D1	5.21	--	--
e	2.286 BSC		
E	6.45	6.70	6.58
E1	4.32	--	--
H	9.40	10.41	9.91
L	1.40	1.78	1.59
L3	0.88	1.27	1.08
L4	0.64	1.02	0.83
a	0°	10°	--
All Dimensions in mm			

Suggested Pad Layout

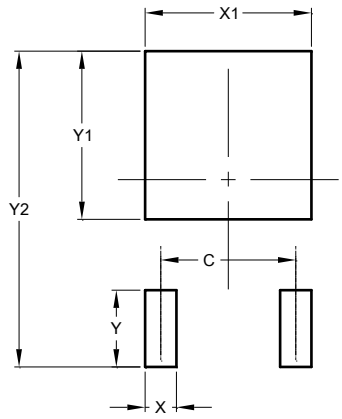
Please see http://www.diodes.com/package-outlines.html for the latest version.

Package: W-DFN2020-3/SWP (Type A)



Dimensions	Value (in mm)
C	1.300
G	0.265
X	0.370
X1	1.440
Y	0.515
Y1	1.010
Y2	0.510
Y3	2.300

Package: TO252 (DPAK)



Dimensions	Value (in mm)
C	4.572
X	1.060
X1	5.632
Y	2.600
Y1	5.700
Y2	10.700

Mechanical Data

Package: W-DFN2020-3/SWP (Type A)

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish - Matte Tin Plated Leads, Solderable per JESD22-B102 (e3)
- Weight: 0.0071 grams (Approximate)

Package: TO252 (DPAK)

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish - Matte Tin Plated Leads, Solderable per JESD22-B102 (e3)
- Weight: 0.33 grams (Approximate)

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