## 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 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.

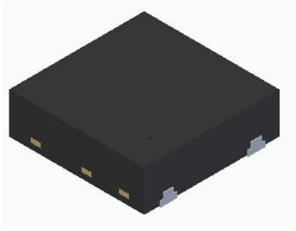
The AL5810Q is available in the Wettable Flank W-DFN2020-3/SWP (Type A) package (2mm x 2mm), power dissipation ($P_D$) up to 2W. The AL5810Q has been qualified to AEC-Q100 Grade 2 with Automotive Compliant supporting PPAPs available.

## Features

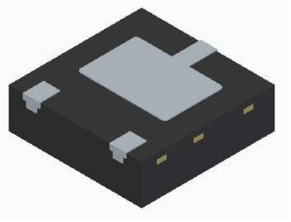
- ACE-Q100 Grade 2 Qualified
- 2.0V to 60V Wide Input Voltage Range
- Low Reference Voltage ($V_{RSET}$ = 0.5V)
- Adjustable Sink or Source LED Current Up to 200mA
- ±5% LED Current Tolerance @Room Temperature
- Parallel Devices to Increase Regulated Current
- Over Temperature Shutdown
- -40°C to +105°C Ambient Temperature Range
- Wettable W-DFN2020-3/SWP (Type A) (2mm x 2mm) $P_D$ up to 2W
- **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 IATF 16949 certified facilities.**
  **https://www.diodes.com/quality/product-definitions/**

## Pin Assignments

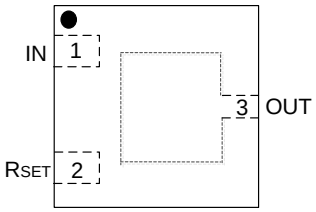
**W-DFN2020-3/SWP (Type A)**



(Top View)



(Bottom View)




(Top View)

## 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

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.


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## Typical Applications Circuit

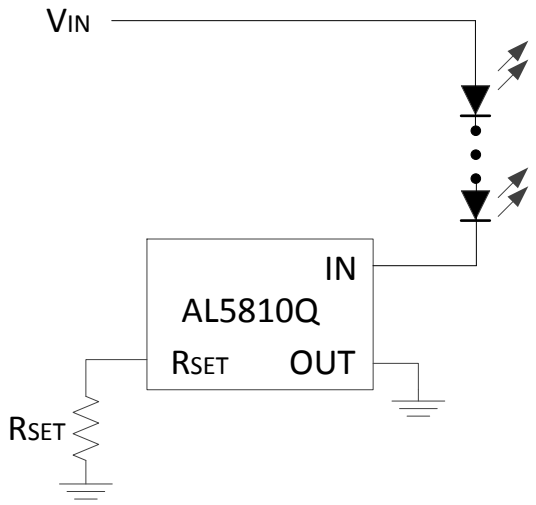



**Figure 1. Low Side LED String Configuration**

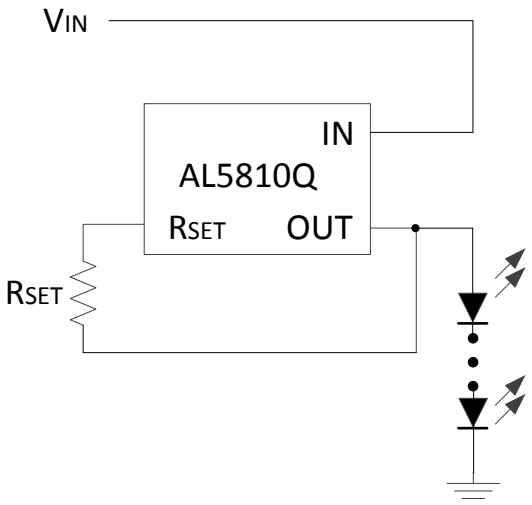



**Figure 2. High Side LED String Configuration**

## Pin Descriptions

| Pin Name | Pin Number | Function |
|---|---|---|
| IN | 1 | LED Current Input Terminal.<br>Current flows **IN** to this pin.<br>For low-side LED string application, connect the LED cathode terminal to the “IN” terminal.<br>For high-side LED string application, connect the LED anode terminal to the “OUT” terminal. |
| $R_{SET}$ | 2 | LED Current Setting Pin.<br>Connect a resistor from this pin to GND:<br>$I_{LED} = 750/R_{SET}$ |
| OUT | 3 | LED Current Output Terminal.<br>Current flows **OUT** of this pin.<br>For low-side LED string application, connect the LED cathode terminal to the “IN” terminal.<br>For high-side LED string application, connect the LED anode terminal to the “OUT” terminal. |


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## Functional Block Diagram

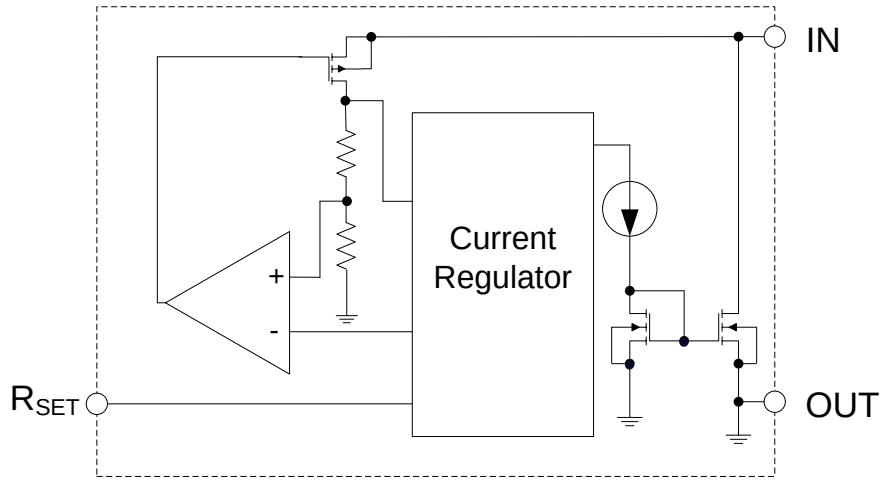



**Figure 3. Functional Block Diagram**

## Absolute Maximum Ratings (Note 4) (@$T_A$ = +25°C, unless otherwise specified.)

| Symbol | Parameter | Rating | Unit |
|---|---|---|---|
| $V_{IN_OUT}$ | 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 |
| $I_{IN_OUT}$ | LED Current from "IN" to "OUT" | 220 | mA |
| ESD HBM | Human Body Model ESD Protection (Note 5) | 4,000 | V |
| ESD CDM | Charged Device Model ESD Protection (Note 5) | 1,000 | V |
| $T_J$ | Operating Junction Temperature | -40 to +150 | °C |
| $T_{STG}$ | Storage Temperature | -55 to +150 | °C |

Notes: 4. Stresses greater than the *Absolute Maximum Ratings* specified above can cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability can be affected by exposure to absolute maximum rating conditions for extended periods of time.
5. Semiconductor devices are ESD sensitive and can be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

## Package Thermal Data

| Symbol | Parameter | Rating | Unit |
|---|---|---|---|
| $\theta_{JC}$ | Thermal Resistance Junction-to-Case (Note 6) | 10.76 | °C/W |
| $\theta_{JA}$ | Thermal Resistance Junction-to-Ambient (Note 6) | 61.66 | °C/W |
| $P_D$ | Power Dissipation $T_A$ = +25°C, $T_J$ = +150°C (Note 7) | 2 | W |

Notes: 6. 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 heat-sink is needed.
7. Dominant conduction path via exposed pad.


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

| Symbol | Parameter | Min | Max | Unit |
|---|---|---|---|---|
| $V_{IN_OUT}$ | "IN" Voltage Range Relative to "OUT" Pin (Note 10) | 2.5 | 60 | V |
| $I_{IN_OUT}$ | LED Current (Notes 8 & 9) | 1 | 200 | mA |
| $t_{PWM(ON)}$ | PWM Pulse Width in Dimming Mode On-Time | 100 | — | µs |
| $T_J$ | Operating Junction Temperature Range (Note 11) | -40 | +150 | °C |
| $T_A$ | Operating Ambient Temperature Range AEC-Q100 Grade 2 (Note 9) | -40 | +105 | °C |

## Electrical Characteristics (@$T_A$ = +25°C, $V_{IN_OUT}$ = 3.5V (Note 10), $R_{SET}$ = 7.5kΩ, unless otherwise specified.)

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{IN_OUT}$ | In-Out Supply Voltage | $I_{OUT}$ ≥ 100mA (Note 12) | $T_A$ = -40°C to +105°C | 2.5 | — | 60 | V |
| | | $I_{OUT}$ < 100mA (Note 12) | | 2.0 | — | 60 | V |
| $V_{RSET}$ | $R_{SET}$ Voltage | — | $T_A$ = -40°C to +105°C | — | 0.5 | — | V |
| $I_{IN_OUT}$ | $I_{IN_OUT}$ 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 | — | % |
| $I_{LINE}$ | $I_{IN_OUT}$ Current Line Regulation | $V_{IN}$ = 3.5V to 60V (Note 11) | $T_A$ = +25°C | — | 4 | — | % |
| $I_{CC}$ | IN Pin Operating Current | $V_{IN}$ = 60V<br>$R_{SET}$ = 1mΩ | $T_A$ = -40°C to +105°C | 300 | 685 | 1000 | µA |
| $V_{MIN}$ | Minimum Power Up Voltage | Increase $V_{IN_OUT}$ (Note 13) | $T_A$ = -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 14 & 15) | — | 100 | — | — | 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 14 & 15) | — | — | — | 10 | µs |
| $T_{SHDN}$ | Thermal Shutdown | Junction Temperature (Note 16) | — | — | 165 | — | °C |
| $T_{HYS}$ | Thermal Shutdown Hysteresis | — | — | — | 30 | — | °C |

Notes:
8. For improved accuracy LED current should be greater than 60mA.
9. 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.
10. All voltages unless otherwise stated are measured with respect to OUT pin.
11. Measured by the percentage degree of LED current variation when $V_{IN_OUT}$ varies from 3.5V to 60V each current option.
12. 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.
13. Apply the power linearly to the chip until the device starts to turn on.
14. $t_{ON_MIN}$ 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.
15. This parameter only guaranteed by design, not tested in production.
16. Ambient temperature at which OTP is triggered may vary depending on application, PCB layout and material used.


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## Typical Performance Characteristics – (100mA, 150mA, 200mA Settings)

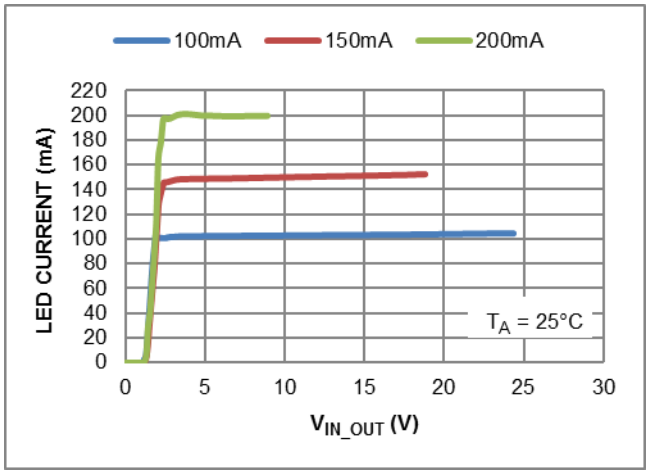



**Figure 4. LED Current vs. $V_{IN_OUT}$**

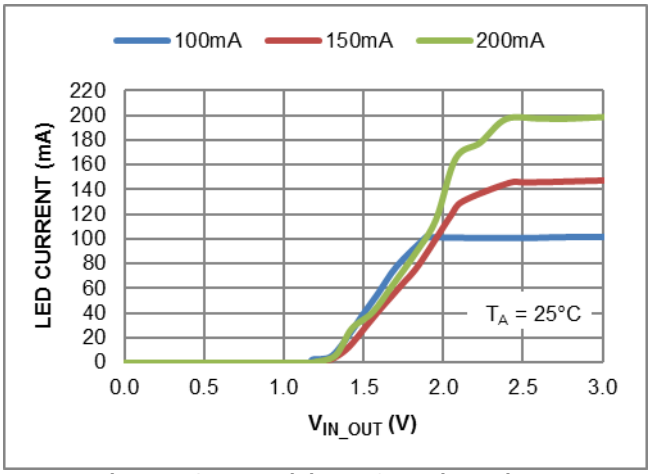



**Figure 5. Startup Minimum Operating Voltage**

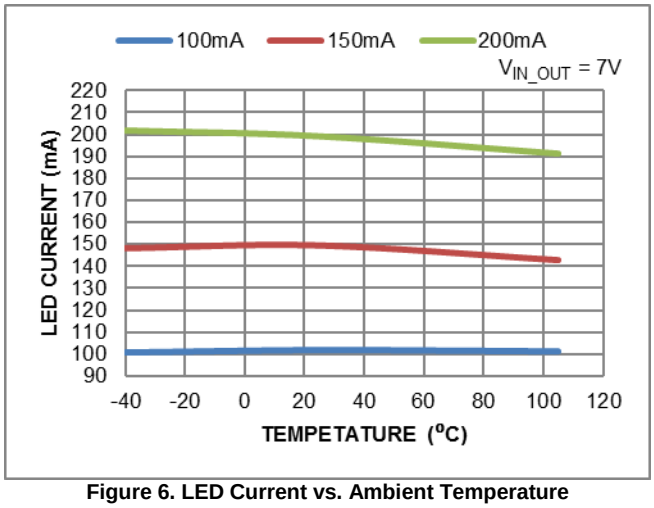



**Figure 6. LED Current vs. Ambient Temperature**


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## Application Information

### Description

The AL5810Q is a linear LED driver and regulates the LED current by sinking current to the IN pin. The AL5810Q can support up to 200mA LED current, with ±5% accuracy @+25°C. The LED current is set by an external resistor, $R_{SET}$, connected from the $R_{SET}$ pin to GND. 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 LED 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 operation from supply rails up to 60V and/or directly drive LED chains up to 60V as shown in Figures 7 and 8.

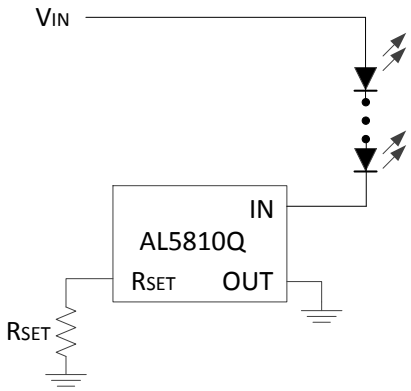



**Figure 7. Low Side LED String Setting**

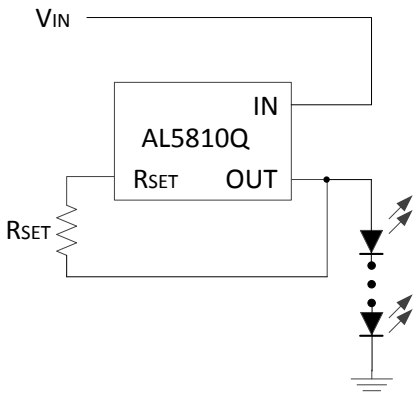
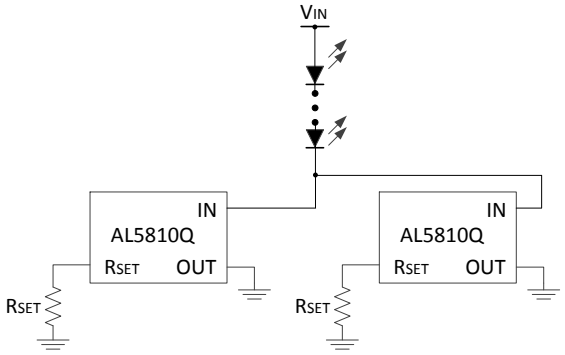
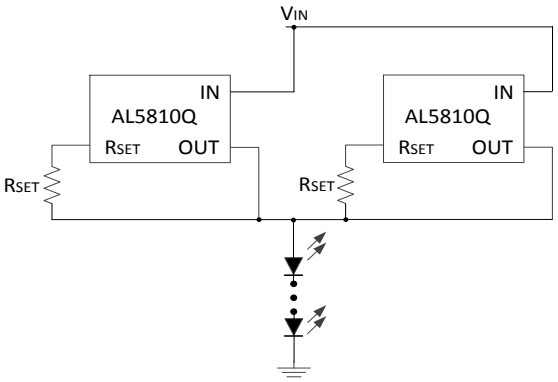



**Figure 8. High Side Current LED String**

The LED current can be increased by connecting two or more the AL5810Q in parallel shown in Figure 9.




**(a) Low-Side Configuration**




**(b) High-Side Configuration**

**Figure 9. Higher LED Current by Parallel Configuration of AL5810Q**


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## Application Information (continued)

### PWM Dimming

The AL5810Q can be used to provide LED current dimming driving the $R_{SET}$ pin via the current setting resistor ($R_{SET}$) and a series MOSFET switch to ground (Figure 10). 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 11.

Test conditions: $V_{IN}$ = 6V, 1LED low side configuration, $R_{SET}$ = 7.5kΩ, $I_{LED}$ = 100mA, N-Channel MOSFET (P/N: ZXMN6A11Z),

PWM frequency 200Hz to 500Hz Square wave, 0V to 4V gate voltage.

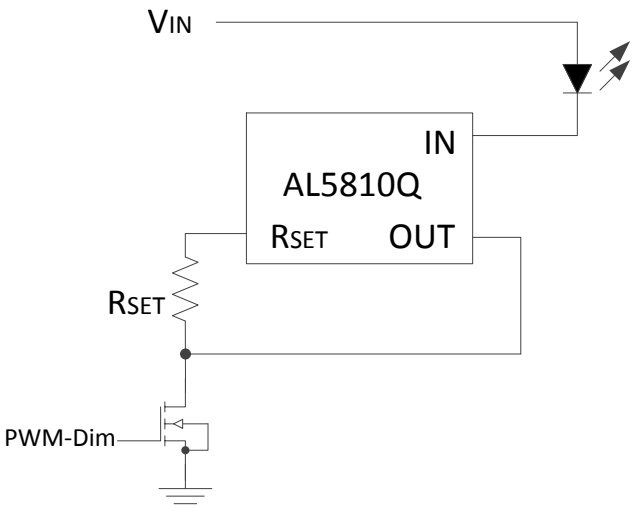



**Figure 10. PWM Dimming by External MOSFET**

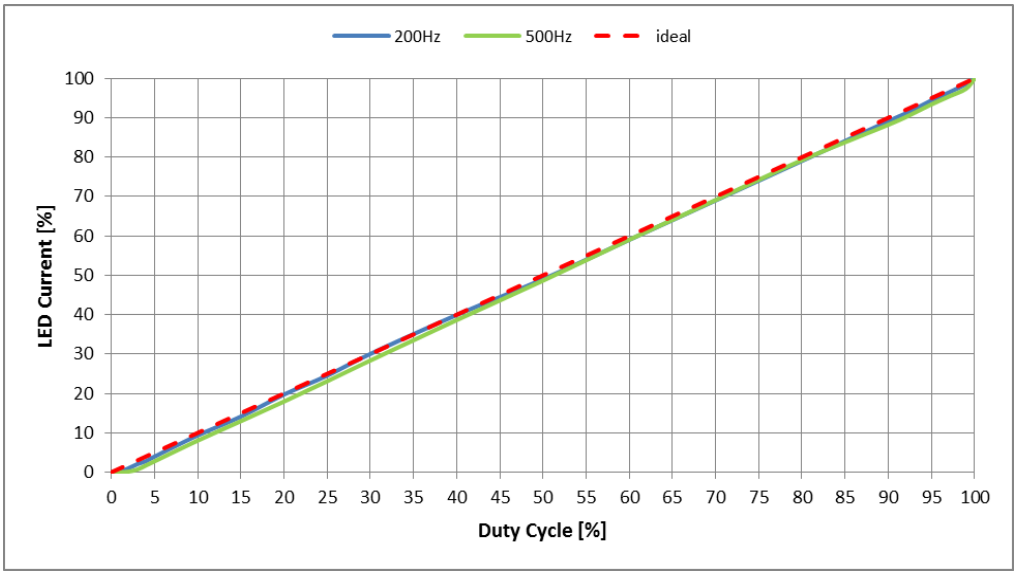



**Figure 11. PWM Dimming Linearity**


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## Application Information (continued)

### Recommended PWM Frequency and Dimming Range

| PWM Frequency (Hz) | Duty Cycle (%) | |
|---|---|---|
| | Min | Max |
| 200 | 2 | 99.8 |
| 500 | 5 | 99.5 |

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: $t_{ON_MIN}$ = 0.1ms (Min. value), and $t_{OFF_MIN}$ = 0.01ms (Min. value) are listed in the Electrical Characteristics table on page 4.

### Thermal Considerations

When designing linear LED driver's 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 power dissipation than anticipated.

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

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

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

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

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

2.5V * 100mA = 250mW

Under maximum input conditions (14.7V), $V_{IN_OUT}$ = 14.7V to 6.5V (2 LEDs Voltage) the AL5810Q's power dissipation will be:

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

So for the 100mA AL5810Q this equals:

8.2V * 100mA = 820mW

Figure 12 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.

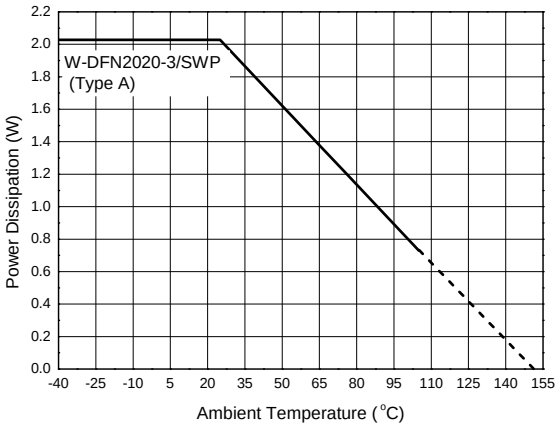
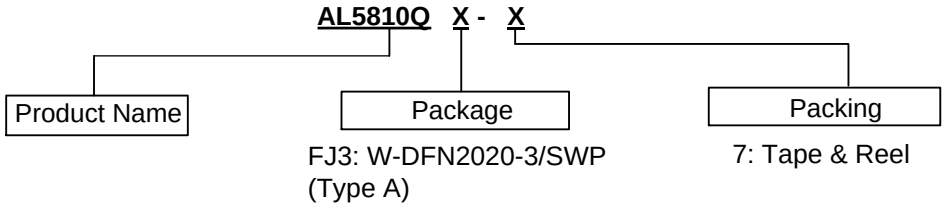



**Figure 12. Power Dissipation Derating**


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## Ordering Information

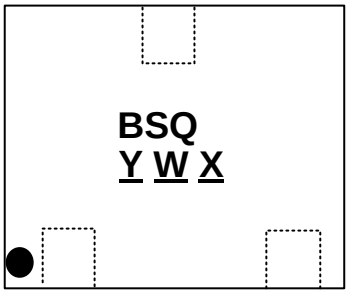



| Part Number | Package Code | Packaging | Tape and Reel | |
|---|---|---|---|---|
| | | | Quantity | Part Number Suffix |
| AL5810QFJ3-7 | FJ3 | W-DFN2020-3 /SWP(Type A) | 3,000/Tape & Reel | -7 |

## Marking Information

**W-DFN2020-3 /SWP (Type A)**

**( Top View )**




BSQ : Identification Code

Y : Year: 0 to 9

W : Week: A to Z: 1 to 26 Week;
a to z; 27 to 52 Week; z Represents 52 and 53 Week

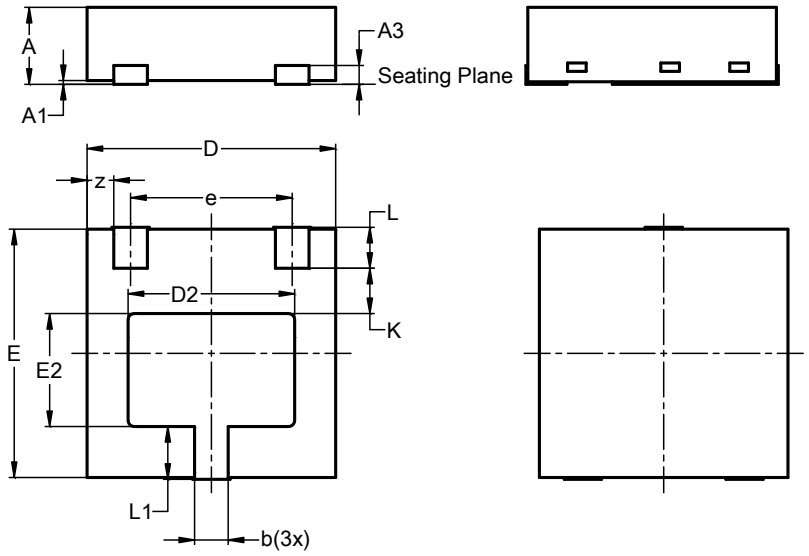
X : Internal Code


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## Package Outline Dimensions

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

**W-DFN2020-3/SWP (Type A)**

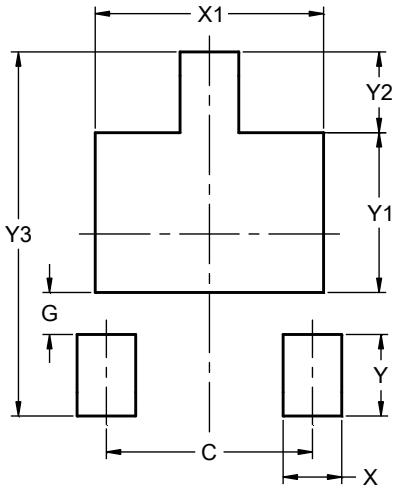



| W-DFN2020-3 /SWP (Type A) | | | |
|---|---|---|---|
| **Dim** | **Min** | **Max** | **Typ** |
| **A** | 0.57 | 0.67 | 0.62 |
| **A1** | 0.00 | 0.05 | 0.03 |
| **A3** | — | — | 0.152 |
| **b** | 0.22 | 0.32 | 0.27 |
| **D** | 1.95 | 2.05 | 2.00 |
| **D2** | 1.24 | 1.44 | 1.34 |
| **D4** | 0.56 | 0.76 | 0.66 |
| **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 |
| **All Dimensions in mm** | | | |

## Suggested Pad Layout

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

**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 |

## Mechanical Data

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


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