

**HIGH EFFICIENCY 1x/2x CHARGE PUMP  
FOR WHITE LED APPLICATIONS**
**Description**

The AL3158 is a low noise, constant frequency charge pump DC/DC converter that uses a Dual mode load switch (1x), and (2x) conversion for white LED applications. The AL3158 is capable of driving three groups of three LED channels at 20mA from a 2.7V to 5.5V input. The current sinks may be operated using three simple PWM dimming inputs individually or in parallel for driving higher-current LEDs. Low external part counts (one 1μF flying capacitor and two 2.2μF capacitors at  $V_{IN}$  and  $V_{OUT}$ ) make this part ideally suited for small, battery-powered applications.

AL3158 PWM dimming inputs are used to enable, disable device and dimming LED current with a fixed default current settings at 20mA or other factory programming options available.

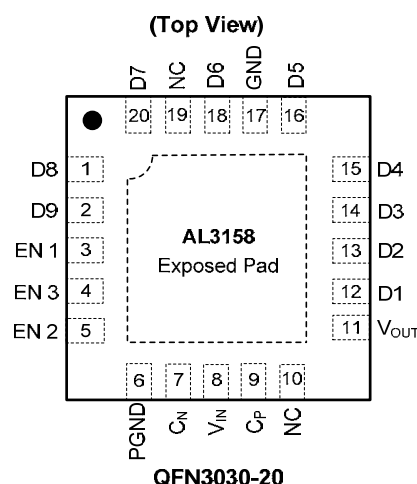
Each output of the AL3158 is equipped with built-in protection for  $V_{OUT}$  short circuit and auto-disable for LED short conditions. Built-in soft-start circuitry prevents excessive inrush current during start-up and mode switching. A low-current shutdown feature disconnects the load from  $V_{IN}$  to reduce quiescent current less than 1μA.

The AL3158 is available in a lead-free, space-saving, thermally enhanced 20-pin 3 x 3mm QFN package.

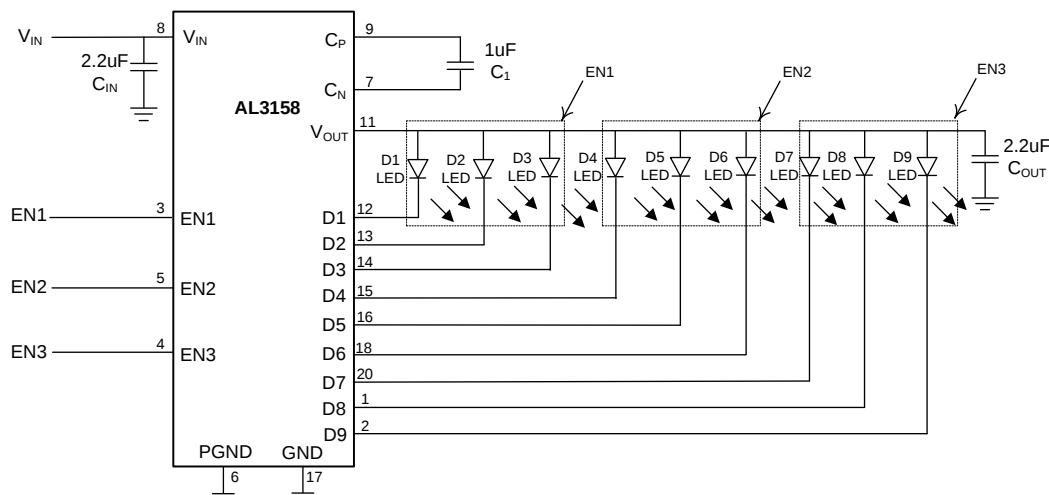
**Features**

- $V_{IN}$  Range: 2.7V to 5.5V
- Up to 93% Max Power Efficiency
- 1% Current Matching Accuracy Between Channels
- Three simple PWM dimming for RGB or WLED
- Low transition threshold voltage typical 150 mV
- Dual-Mode 1x and 2x Charge Pump
- Drives up to 3 + 3 + 3 Channels of LEDs
- 1.2 MHz Constant Switching Frequency
- $V_{OUT}$  short circuit and Thermal Protections
- Soft Start for reducing inrush current
- Under Voltage Lockout Protection
- $I_Q < 1\mu A$  in Shutdown
- Thermally-Enhanced QFN3030-20 Package: Available in "Green" Molding Compound (No Br, Sb)
- Lead Free Finish/ RoHS Compliant (Note 1)

Notes: 1. EU Directive 2002/95/EC (RoHS). All applicable RoHS exemptions applied. Please visit our website at [http://www.diodes.com/products/lead\\_free.html](http://www.diodes.com/products/lead_free.html)

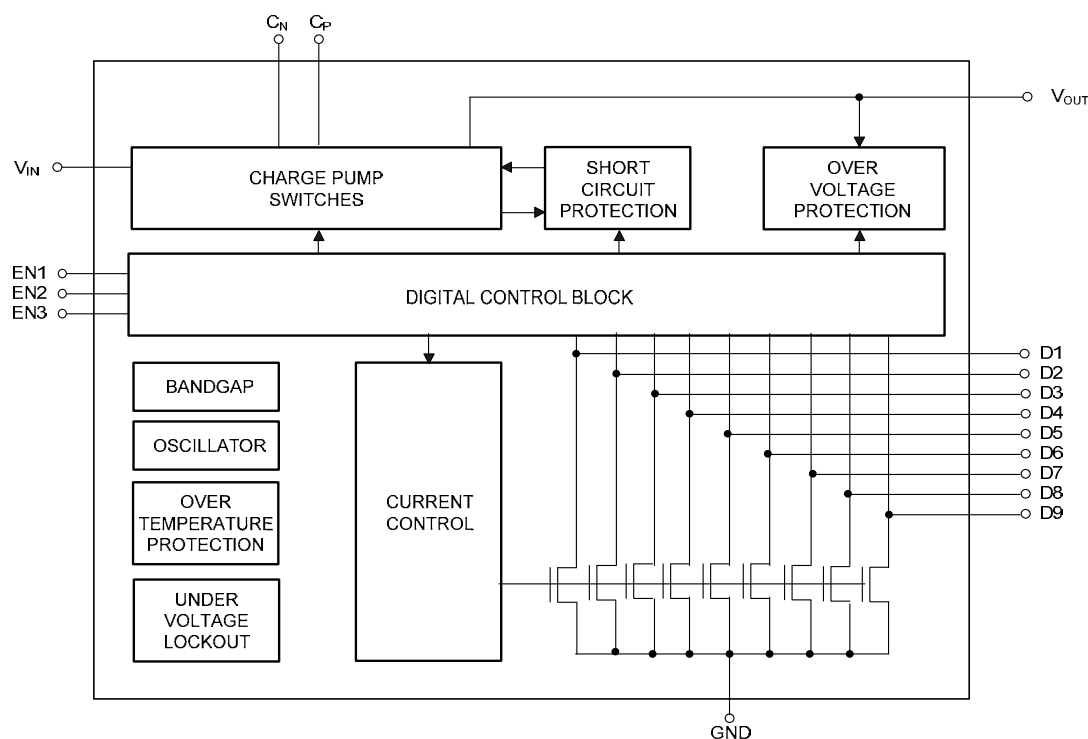
**Pin Assignments**

**Applications**

- Mobile Phone White LED Backlighting and Indicators
- PDA White LED Backlighting
- Battery-operated Phone Main and Sub Screen White LED Backlighting

**Typical Application Circuit**


**HIGH EFFICIENCY 1x/2x CHARGE PUMP  
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**Pin Descriptions**

| Pin Name         | Pin Number | Description                                                                                     |
|------------------|------------|-------------------------------------------------------------------------------------------------|
| D8               | 1          | Current sink input #8. Connected to V <sub>OUT</sub> when un-used.                              |
| D9               | 2          | Current sink input #9. Connected to V <sub>OUT</sub> when un-used.                              |
| EN1              | 3          | Enable Pin 1                                                                                    |
| EN3              | 4          | Enable Pin 3                                                                                    |
| EN2              | 5          | Enable Pin 2                                                                                    |
| PGND             | 6          | Charge Pump Switch Ground                                                                       |
| CN               | 7          | Negative Terminal of Flying Capacitor                                                           |
| VIN              | 8          | Input Power Supply. Requires 2.2μF capacitor between this pin and ground.                       |
| CP               | 9          | Positive Terminal of Flying Capacitor                                                           |
| NC               | 10,19      | No-Connect                                                                                      |
| V <sub>OUT</sub> | 11         | Charge pump output to drive load circuit. Requires 2.2μF capacitor between this pin and ground. |
| D1               | 12         | Current sink input #1. Connected to V <sub>OUT</sub> when un-used.                              |
| D2               | 13         | Current sink input #2. Connected to V <sub>OUT</sub> when un-used.                              |
| D3               | 14         | Current sink input #3. Connected to V <sub>OUT</sub> when un-used.                              |
| D4               | 15         | Current sink input #4. Connected to V <sub>OUT</sub> when un-used.                              |
| D5               | 16         | Current sink input #5. Connected to V <sub>OUT</sub> when un-used.                              |
| D6               | 18         | Current sink input #6. Connected to V <sub>OUT</sub> when un-used.                              |
| GND              | 17         | Ground                                                                                          |
| D7               | 20         | Current sink input #7. Connected to V <sub>OUT</sub> when un-used.                              |
| GND              | EP PAD     | Exposed Pad (bottom). Connected to GND directly underneath the package.                         |

**Functional Block Diagram**


**HIGH EFFICIENCY 1x/2x CHARGE PUMP  
FOR WHITE LED APPLICATIONS**
**Absolute Maximum Ratings (Note 2)**

| Symbol               | Description                                      | Rating                       | Unit |
|----------------------|--------------------------------------------------|------------------------------|------|
| ESD HBM              | Human Body Model ESD Protection                  | 2                            | KV   |
| ESD MM               | Machine Model ESD Protection                     | 200                          | V    |
| V <sub>IN</sub>      | Input Voltage                                    | -0.3 to 6                    | V    |
| V <sub>EN1,2,3</sub> | EN1, EN2, EN3 to GND Voltage                     | -0.3 to V <sub>IN</sub> +0.3 | V    |
| I <sub>OUT</sub>     | Maximum DC Output Current                        | 270                          | mA   |
| T <sub>J</sub>       | Operating Junction Temperature Range             | 150                          | °C   |
| T <sub>LEAD</sub>    | Maximum Soldering Temperature (at leads, 10 sec) | 300                          | °C   |

Notes: 2. Exceeding Absolute Maximum Ratings will cause permanent damage to the device.

**Recommended Operating Conditions**

| Symbol          | Parameter                     | Min | Max | Unit |
|-----------------|-------------------------------|-----|-----|------|
| V <sub>IN</sub> | Input Voltage                 | 2.7 | 5.5 | V    |
| T <sub>A</sub>  | Operating Ambient Temperature | -40 | 85  | °C   |

**Electrical Characteristics (T<sub>A</sub> = 25°C, V<sub>IN</sub> = 3.6V, C<sub>IN</sub> = C<sub>OUT</sub> = 2.2μF, C<sub>1</sub> = 1μF Unless otherwise noted)**

| Symbol                  | Parameter                                                     | Test Conditions                                               | Min | Typ. | Max | Unit |
|-------------------------|---------------------------------------------------------------|---------------------------------------------------------------|-----|------|-----|------|
| I <sub>Q</sub>          | Quiescent Current                                             | 1x Mode, 3.0 ≤ V <sub>IN</sub> ≤ 5.5, Active, No Load Current |     | 0.3  | 0.6 | mA   |
|                         |                                                               | 2x Mode, 3.0 ≤ V <sub>IN</sub> ≤ 5.5, Active, No Load Current |     | 2    | 5   |      |
| I <sub>SHDN</sub>       | Shutdown Current                                              | EN1, EN2, EN3 = 0                                             |     |      | 1   | μA   |
| I <sub>DX</sub>         | I <sub>SINK</sub> Current Accuracy (Note 3)                   |                                                               | 19  | 20   | 21  | mA   |
| I <sub>D-Match</sub>    | Current Matching Between Any Two Current Sink Inputs (Note 4) | V <sub>F</sub> : D1:D9 = 3.6V                                 |     | 1    | 2   | %    |
| R <sub>out</sub>        | Open Loop V <sub>OUT</sub> Resistance                         | 1x mode                                                       |     | 0.5  |     | Ω    |
|                         |                                                               | 2 x mode                                                      |     | 4.5  |     |      |
| V <sub>TH</sub>         | 1x to 2x Transition Threshold at Any I <sub>SINK</sub> Pin    | I <sub>DX</sub> = 20mA                                        |     | 150  |     | mV   |
| V <sub>HS</sub>         | Mode Transition Hysteresis                                    |                                                               |     | 250  |     | mV   |
| T <sub>SS</sub>         | Soft-Start Time                                               |                                                               |     | 100  |     | μs   |
| F <sub>sw</sub>         | Switching Frequency                                           |                                                               |     | 1.2  |     | MHz  |
| V <sub>EN1,2,3(L)</sub> | EN1,2,3 Threshold Low                                         | V <sub>IN</sub> = 2.7V                                        |     |      | 0.4 | V    |
| V <sub>EN1,2,3(H)</sub> | EN1,2,3 Threshold High                                        | V <sub>IN</sub> = 5.5V                                        | 1.4 |      |     | V    |
| T <sub>EN1,2,3</sub>    | EN1,2,3 Off Timeout                                           |                                                               |     |      | 20  | ms   |
| UVLO                    | V <sub>IN</sub> Under-Voltage Lockout                         |                                                               | 1.8 | 2    | 2.2 | V    |
| I <sub>EN1,2,3</sub>    | EN1,2,3 Input Leakage                                         |                                                               | -1  |      | 1   | μA   |
| T <sub>SHDN</sub>       | Thermal shutdown Protection                                   |                                                               |     | 160  |     | °C   |
| T <sub>HYS</sub>        | Thermal shutdown hysteresis                                   |                                                               |     | 10   |     | °C   |
| θ <sub>JA</sub>         | Thermal Resistance Junction-to-Ambient                        | QFN3030-20 (Note 5)                                           |     | 52   |     | °C/W |

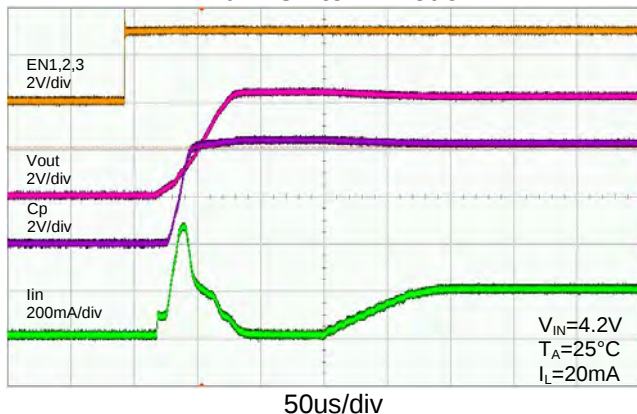
Notes: 3. Determined by the average current levels of all active channels.

4. Determined by the maximum sink current (MAX), the minimum sink current (MIN), and the average sink current (AVG). Two matching numbers are calculated as (MAX-AVG)/AVG and (AVG-MIN)/AVG. The largest number of the two (worst case) is considered as the matching data.

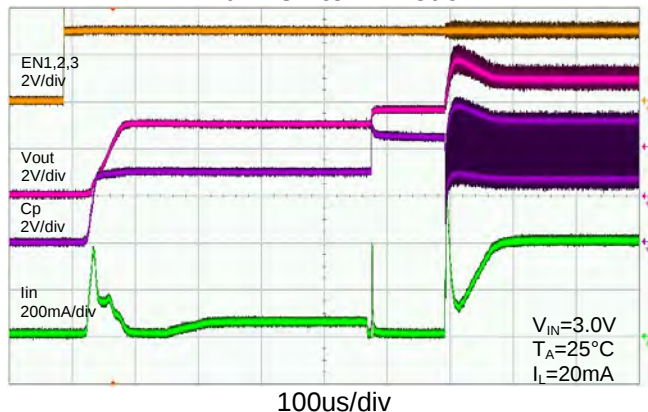
5. Device mounted on FR-4 substrate, 2"×2", 2oz copper, double-sided PC board, with minimum recommended pad on top layer and 4 vias to bottom layer.

**Typical Performance Characteristics**

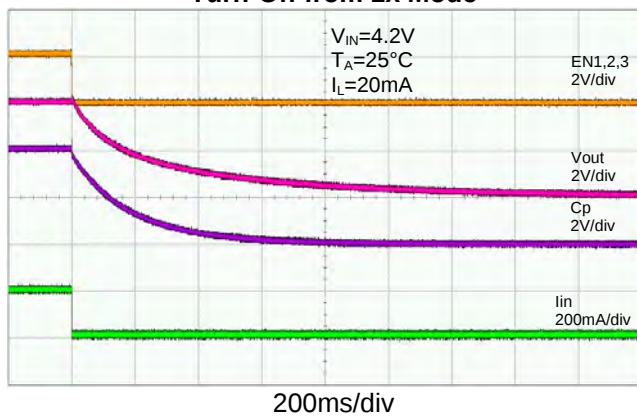
**Turn-On to 1x Mode**



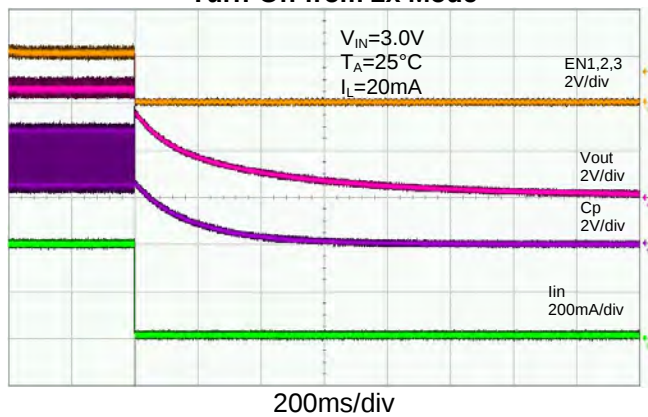
**Turn-On to 2x Mode**



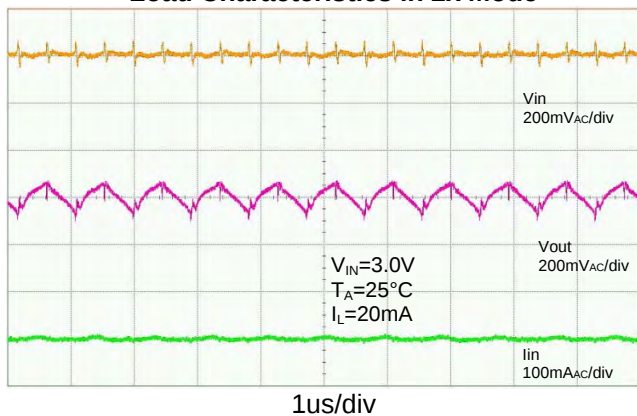
**Turn-Off from 1x Mode**



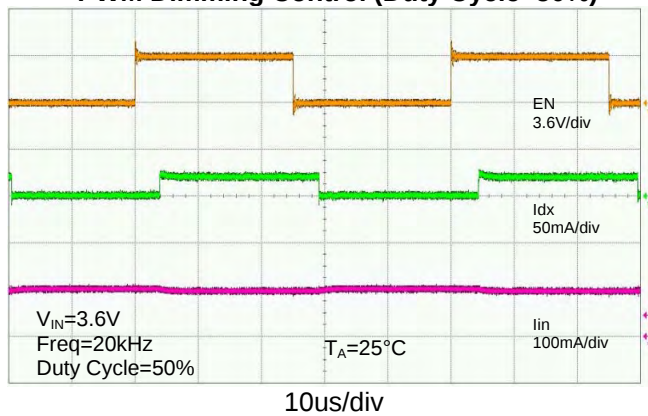
**Turn-Off from 2x Mode**



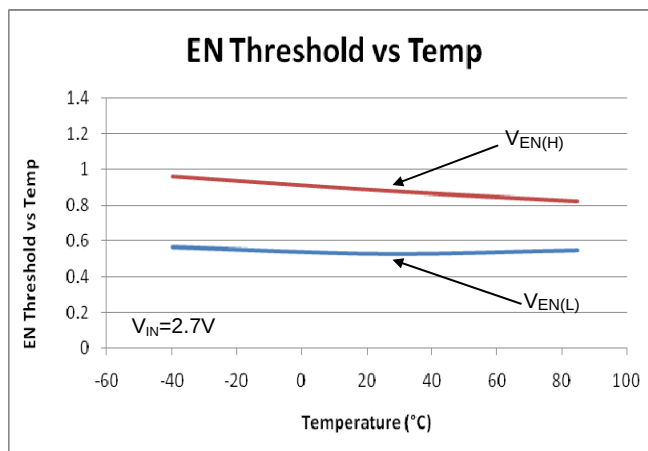
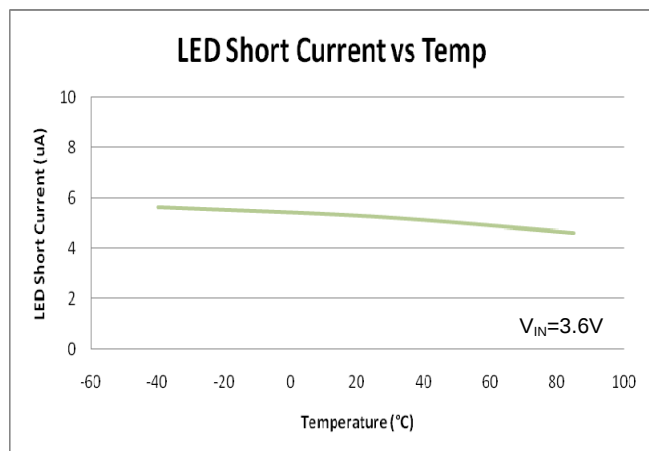
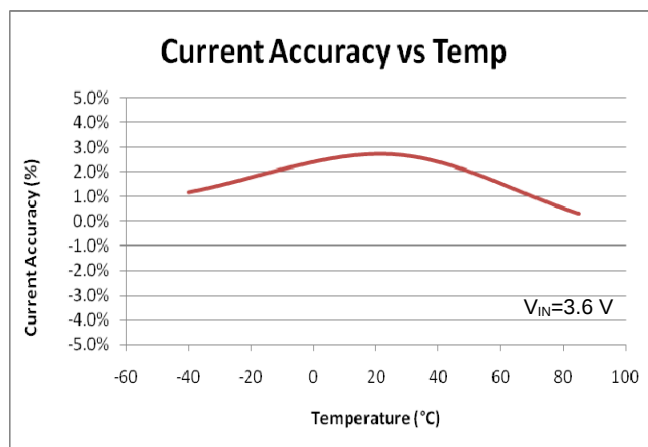
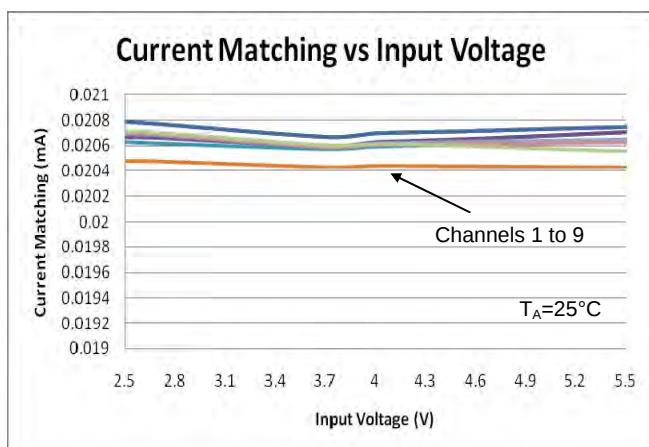
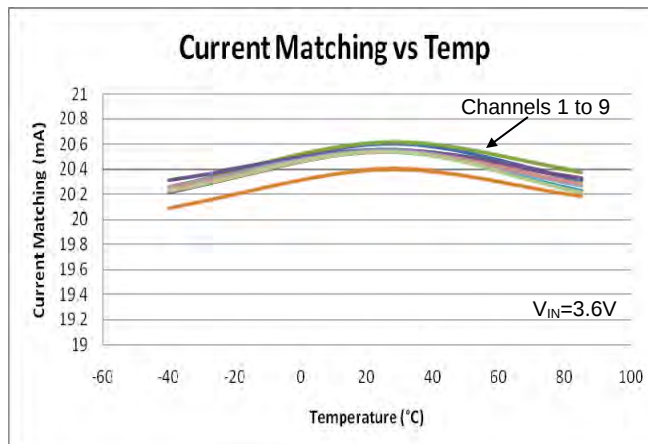
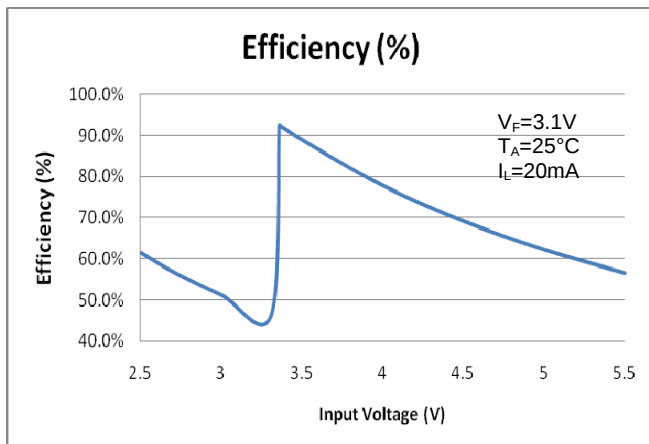
**Load Characteristics in 2x Mode**



**PWM Dimming Control (Duty Cycle=50%)**



**Typical Performance Characteristics (Continued)**



### Functional Description

The AL3158 is a dual-mode high efficiency charge pump (1x and 2x) device, driving three groups of three LED channels at 30mA maximum each, intended for white LED backlight applications. An internal comparator circuit compares the voltage at each constant current sink input against a reference voltage. To ensure maximum power efficiency, the most appropriate switching mode (1x and 2x) is automatically selected.

The AL3158 requires only three external components: one 1 $\mu$ F ceramic flying capacitor ( $C_1$ ) for the charge pump, one 2.2 $\mu$ F ceramic input capacitor ( $C_{IN}$ ), and one 2.2 $\mu$ F ceramic charge pump output capacitor ( $C_{OUT}$ ).

The each output channel of the AL3158 can drive three groups of three individual LED channels with a maximum current of fixed manufacture setting (20mA or 30mA) per channel. These can be paralleled to give a total output current of 270mA.

| EN<3:1> | LED ON/OFF CONTROL |
|---------|--------------------|
| XX0     | LED1~LED3 OFF      |
| XX1     | LED1~LED3 ON       |
| X0X     | LED4~LED6 OFF      |
| X1x     | LED4~LED6 ON       |
| 0XX     | LED7~LED9 OFF      |
| 1xX     | LED7~LED9 ON       |

#### Disabled Current Sinks

Unused current channels must be disabled by connecting the sinks to VOUT with only a small sense current flowing through the disabled channel.

#### Soft-Start

Soft-start is incorporated to prevent excessive inrush current during power-up, mode switching, and transitioning out of stand-by mode.

#### Short-Circuit Protection

Short-circuit protection function is incorporated to prevent excessive load current when either flying cap terminals or output pin electrically tied to a very lower voltage or ground.

#### Over-Voltage Protection

Over-Voltage Protection function is incorporated to limit the output voltage under a safe value to avoid on-chip device breakdown.

#### Under-Voltage Lockout

Under-Voltage lockout feature disables the device when the input voltage drops below UVLO threshold.

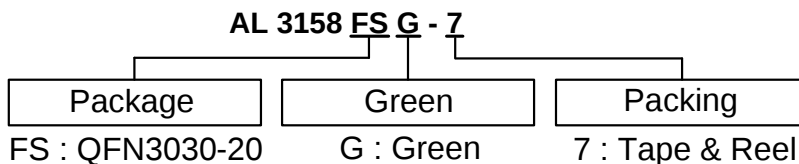
#### Thermal Auto Shutdown

When the die temperature exceeds the thermal limit, the device will be disabled and enter stand-by mode. The operation resumes whenever the die cools off sufficiently.

#### PWM Dimming Control

The AL3158 provides simple PWM dimming control through ENx pins, and the current is adjusted by the duty cycle of the signal applied on ENx pin. The recommended PWM frequency is from 200Hz to 50KHz depending on applications.

## Ordering Information



| Device      | Package Code | Packaging<br>(Note 7 and 8) | 7" Tape and Reel |                    |
|-------------|--------------|-----------------------------|------------------|--------------------|
|             |              |                             | Quantity         | Part Number Suffix |
| AL3158FSG-7 | FS           | QFN3030-20                  | 3000/Tape & Reel | -7                 |

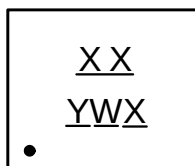


Notes: 7. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at <http://www.diodes.com/datasheets/ap02001.pdf>  
8. EU Directive 2002/95/EC (RoHS). All applicable RoHS exemptions applied. Please visit our website at [http://www.diodes.com/products/lead\\_free.html](http://www.diodes.com/products/lead_free.html)

## Marking Information

### (1) QFN3030-20

#### (Top View)

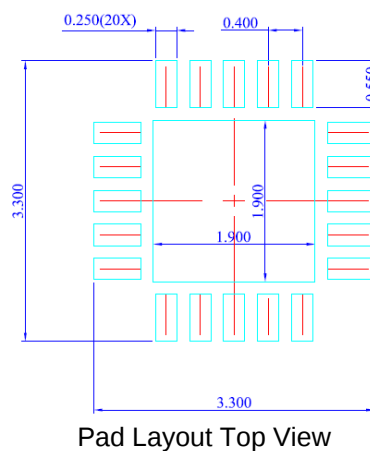
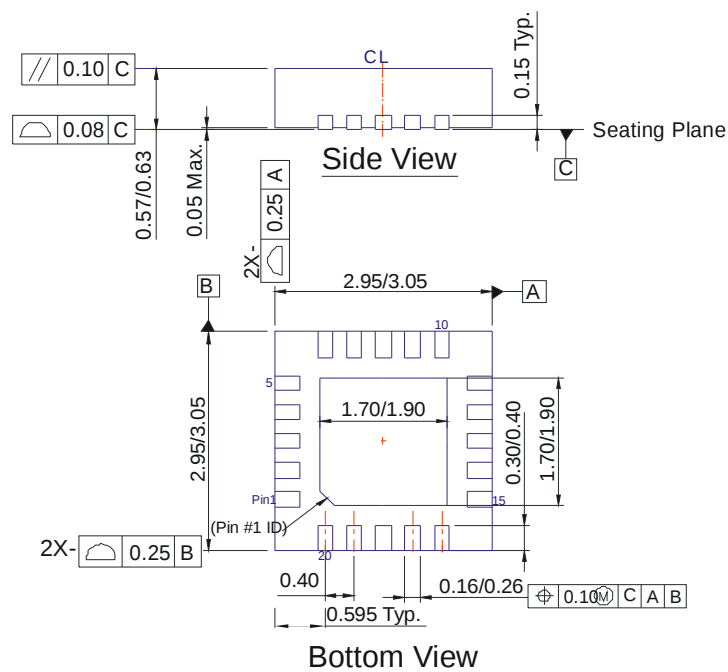


XX : B8 : AL3158  
Y : Year : 0~9  
W : Week : A~Z : 1~26 week;  
a~z : 27~52 week; z represents  
52 and 53 week  
X : A~Z : Green

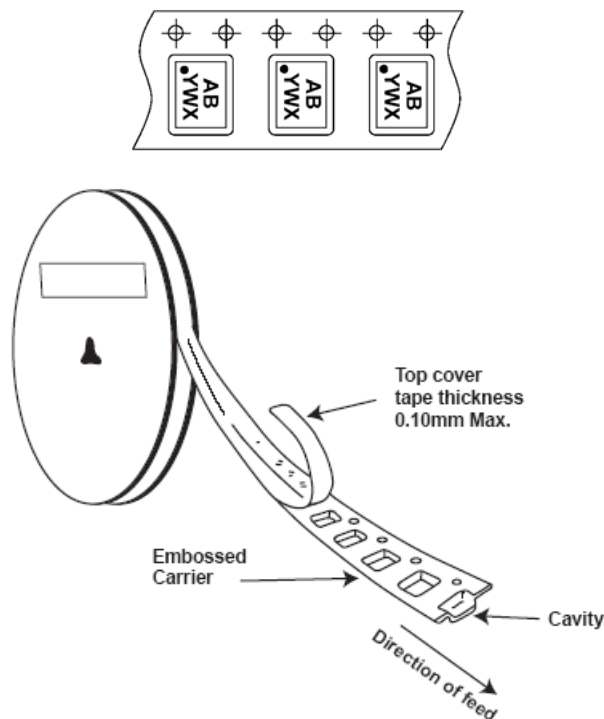
| Part Number | Package    | Identification Code |
|-------------|------------|---------------------|
| AL3158FSG   | QFN3030-20 | B8                  |

**Package Outline Dimensions (All Dimensions in mm)**

Package type: QFN3030-20



**Taping Orientation (Note 9)**



Notes: 9. The taping orientation of the other package type can be found on our website at <http://www.diodes.com/datasheets/ap02007.pdf>

**HIGH EFFICIENCY 1x/2x CHARGE PUMP  
FOR WHITE LED APPLICATIONS****IMPORTANT NOTICE**

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