# 3-CHANNEL BACKLIGHT DRIVER PLUS 210mA FLASH DRIVER

## Description

The DIODES™ AL3157 is a low noise, constant frequency charge pump DC/DC converter that uses a dual mode load switch (1x), and doubling (2x) conversion for driving white LEDs. Low external part count (one 1µF flying capacitor and two 2.2µF capacitors at $V_{IN}$ and $V_{OUT}$) makes this part ideally suited for small, battery-powered applications.

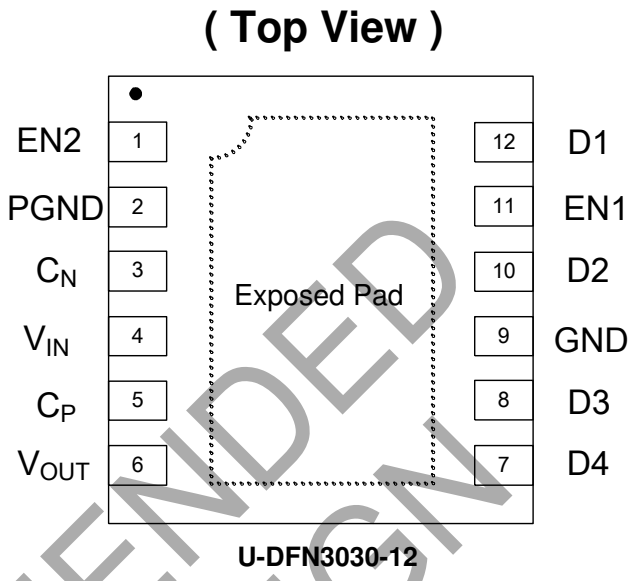
The AL3157 drives 3 channels at up to 30mA for small screen backlighting and an additional channel up to 210mA for LED Flash or LED Flashlight – all from a 2.7V to 5.5V input.

The AL3157 uses two control inputs (EN1/2) to enable/disable it and PWM dim the LED current. EN2 controls/PWM dims the backlight LEDs at 30mA per channel and EN1 controls/PWM dims the Flash/Flashlight LEDs at 210mA.

Each output is equipped with built-in protection for $V_{OUT}$ short circuit and auto-disable for LED failure conditions. Built-in soft-start circuitry prevents excessive in-rush 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 AL3157 is available in a lead-free, space-saving thermally enhanced 12-pin 3mm x 3mm U-DFN3030-12 package.

## Pin Assignments




**U-DFN3030-12**

## Features

- Dual-Mode 1x and 2x Charge Pump
- Up to 300mA Drive Capability
  - 3-Channel for Backlight – 30mA/CH
  - Channel for Flash/Light – 210mA
- $V_{IN}$ Range: 2.7V to 5.5V
- Two Simple PWM Dimming Control Inputs up to 50kHz
- 1.2MHz Constant Switching Frequency
- Built-in Thermal, Open-Circuit and $V_{OUT}$ Short Circuit Protection
- Soft Start for Reducing In-Rush Current
- $I_Q$ < 1µA in Shutdown
- Thermally-Enhanced U-DFN3030-12 Package: Available in "Green" Molding Compound (No Br, Sb)
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**

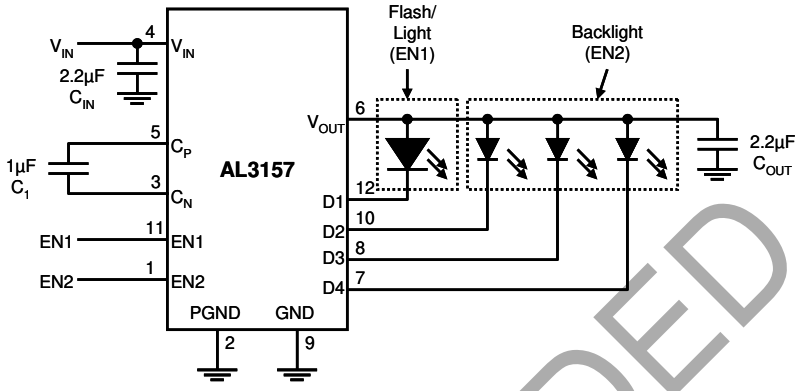
## Applications

- Smart touch phone LED backlighting
- PDA white LED backlighting
- Backlighting + torch light



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.

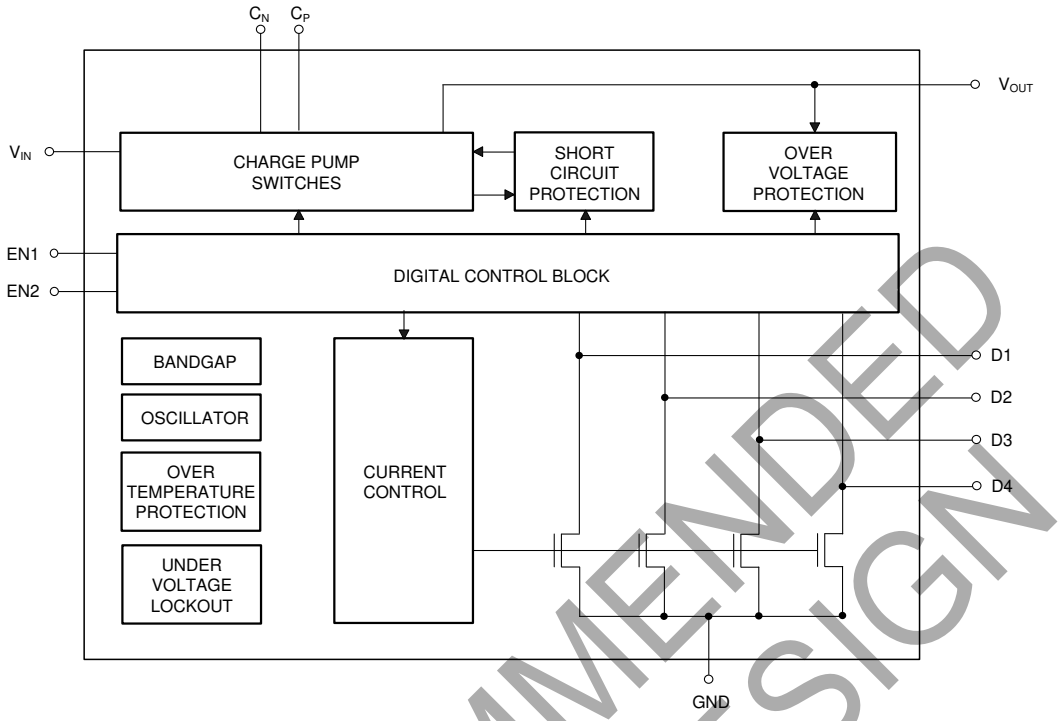
## Typical Application Circuit




## Pin Descriptions

| Pin Name | Pin Number | Description |
|---|---|---|
| EN2 | 1 | Enable Pin 2: Controls outputs D2, D3 and D4 |
| PGND | 2 | Charge Pump Switch Ground: Connect to GND |
| $C_N$ | 3 | Negative Terminal of Flying Capacitor |
| $V_{IN}$ | 4 | Input Power Supply. Decouple with a 2.2µF capacitor between this pin and ground. |
| $C_P$ | 5 | Positive Terminal of Flying Capacitor |
| $V_{OUT}$ | 6 | Charge Pump Output to Drive D1 to D4 Load Circuit. Decouple with a 2.2µF capacitor between this pin and ground. |
| D4 | 7 | Current Sink Input #4. Drive up to 30mA LED current. Connect to $V_{OUT}$ when unused. |
| D3 | 8 | Current Sink Input #3. Drive up to 30mA LED current. Connect to $V_{OUT}$ when unused. |
| GND | 9 | Ground |
| D2 | 10 | Current Sink Input #2. Drive up to 30mA LED current. Connect to $V_{OUT}$ when unused. |
| EN1 | 11 | Enable Pin 1: Controls output D1 |
| D1 | 12 | Current Sink Input #1. Drive up to 210mA LED current. Connect to $V_{OUT}$ when unused. |
| Exposed Pad | EP Pad | Exposed Pad (bottom). Connect to GND directly underneath the package. |

## Functional Block Diagram






## Absolute Maximum Ratings (Note 4)

| Symbol | Description | Rating | Unit |
|---|---|---|---|
| ESD HBM | Human Body Model ESD Protection | 2 | kV |
| ESD MM | Machine Model ESD Protection | 200 | V |
| $V_{IN}$ | Input Voltage | -0.3 to 6 | V |
| $V_{EN1, 2, 3}$ | EN1, EN2, EN3 to GND Voltage | -0.3 to $V_{IN}$ +0.3 | V |
| $I_{OUT}$ | Maximum DC Output Current | 300 | mA |
| $T_J$ | Operating Junction Temperature | +125 | °C |
| $T_{LEAD}$ | Maximum Soldering Temperature (at leads, 10 sec) | +300 | °C |

Note: 4. 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.

## Recommended Operating Conditions

| Symbol | Parameter | Min | Max | Unit |
|---|---|---|---|---|
| $V_{IN}$ | Input Voltage | 2.7 | 5.5 | V |
| $V_{ENL(1, 2)}$ | EN1, 2 Threshold Low | 0 | 0.4 | V |
| $V_{ENH(1, 2)}$ | EN1, 2 Threshold High | 1.4 | $V_{IN}$ | V |
| $T_A$ | Operating Ambient Temperature | -40 | +85 | °C |

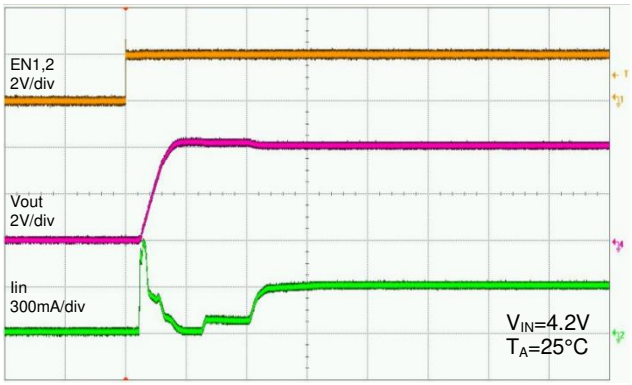
## Electrical Characteristics ($V_{IN}$ = 4V, $C_{IN}$ = $C_{OUT}$ = 2.2µF, $C_1$ = 1µF; $T_A$ = +25°C, unless otherwise noted.)

| Symbol | Parameter | Test Conditions | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| $I_Q$ | Quiescent Current | 1x Mode, 3.0 ≤ $V_{IN}$ ≤ 5.5, Active No Load Current | — | 0.3 | 0.6 | mA |
| | | 2x Mode, 3.0 ≤ $V_{IN}$ ≤ 5.5, Active No Load Current | — | 2 | 5 | |
| $I_{SHDN}$ | Shutdown Current | EN1, EN2 = 0 | — | — | 1 | µA |
| $I_{D2-4}$ | Backlight LED Drive Sink Current Accuracy (Note 5) | $I_{DX}$ = 30mA | 28.5 | 30 | 31.5 | mA |
| $I_{D1}$ | Flash/Light LED Drive Sink Current Accuracy (Note 5) | $I_{D1}$ = 210mA | 199.5 | 210 | 220.5 | mA |
| $I_{D-Match}$ | Current Matching Between Any Two Backlight LED Drive Current Sink Outputs (Note 6) | $V_F$: D2:D4 = 4V | — | 1 | 2 | % |
| $R_{OUT}$ | Charge Pump $V_{OUT}$ Open Loop Resistance | 1x Mode | — | 0.5 | — | Ω |
| | | 2x Mode | — | 4.5 | — | |
| $V_{TH-Dx}$ | 1x to 2x Transition Threshold at D2, D3 and D4 Pins | $I_D$ = 30mA | — | 150 | — | mV |
| $V_{TH-D1}$ | 1x to 2x Transition Threshold at D1 Pin | $I_{D1}$ = 210mA | — | 150 | — | mV |
| $V_{HS}$ | Mode Transition Threshold | — | — | — | 500 | mV |
| $t_{SS}$ | Soft-Start Time | — | — | 100 | — | µs |
| $f_{SW}$ | Switching Frequency | — | — | 1.2 | — | MHz |
| $t_{EN1, 2}$ | EN1, 2 Off Timeout | — | — | — | 20 | ms |
| UVLO | $V_{IN}$ Under-Voltage Lockout | — | 1.8 | 2 | 2.2 | V |
| $I_{EN1, 2}$ | EN1, 2 Input Leakage | — | -1 | — | 1 | µA |
| $T_{SHDN}$ | Thermal Shutdown Protection | — | — | +160 | — | °C |
| $T_{HYS}$ | Thermal Shutdown Hysteresis | — | — | +10 | — | °C |
| $\theta_{JA}$ | Thermal Resistance Junction-to-Ambient | U-DFN3030-12 (Note 7) | — | 55.29 | — | °C/W |

Notes:
5. Determined by the mean of channels 2, 3 and 4 currents, EG ($I_{D2}$ + $I_{D3}$ + $I_{D4}$)/3.
6. 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 as the matching data.
7. Device mounted on FR-4 substrate, 2" x 2", 2oz copper, double-sided PC board.

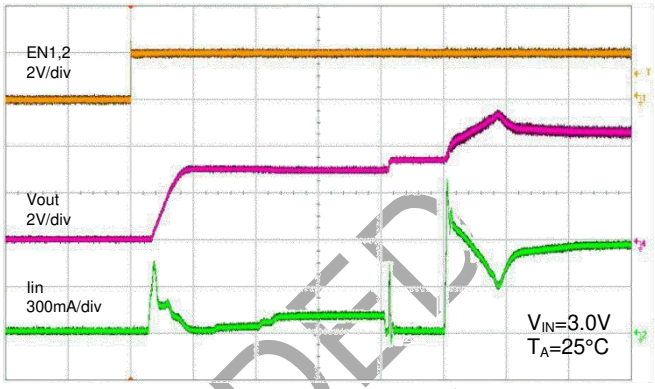
## Typical Performance Characteristics

### Turn-On in 1x Mode



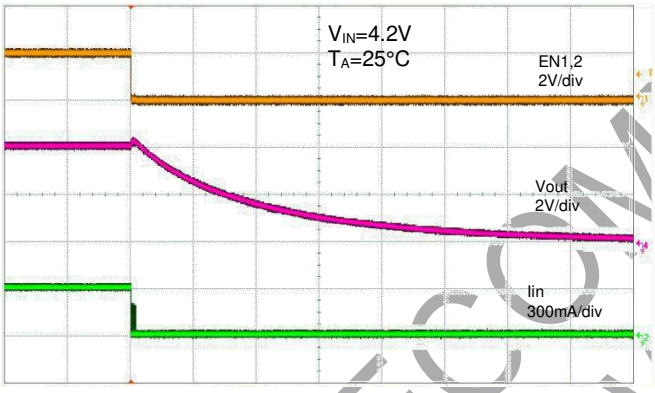

100µs/div

### Turn-On in 2x Mode



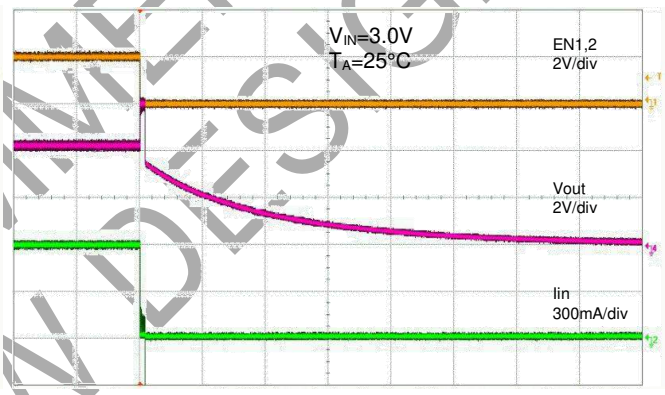

100µs/div

### Turn-Off in 1x Mode



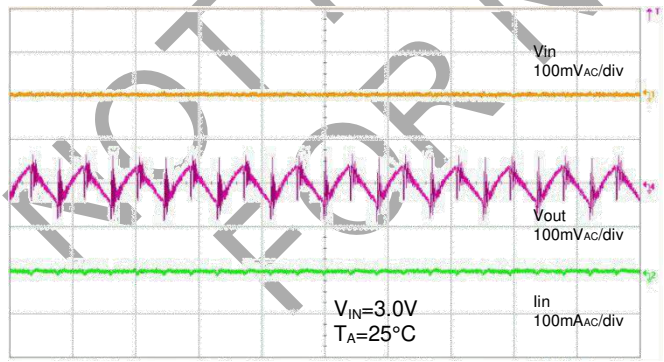

200ms/div

### Turn-Off in 2x Mode



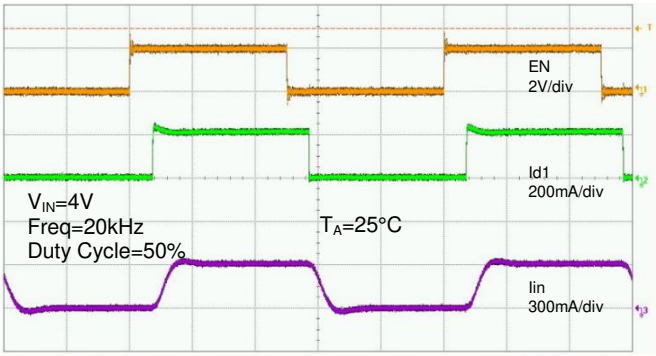

200ms/div

### Load Characteristics in 2x Mode



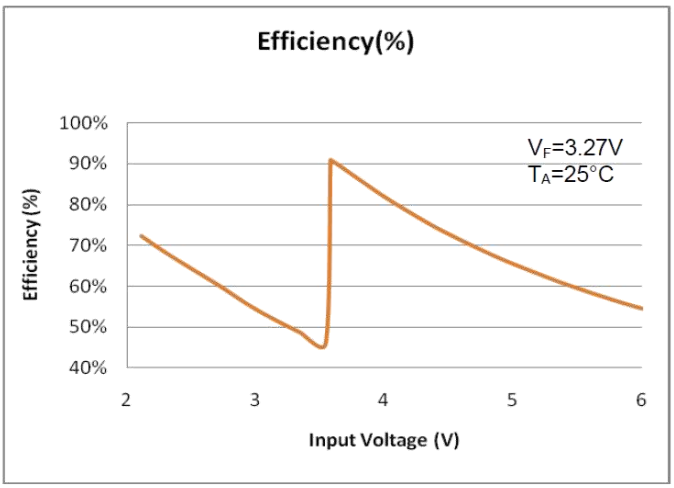

500ns/div

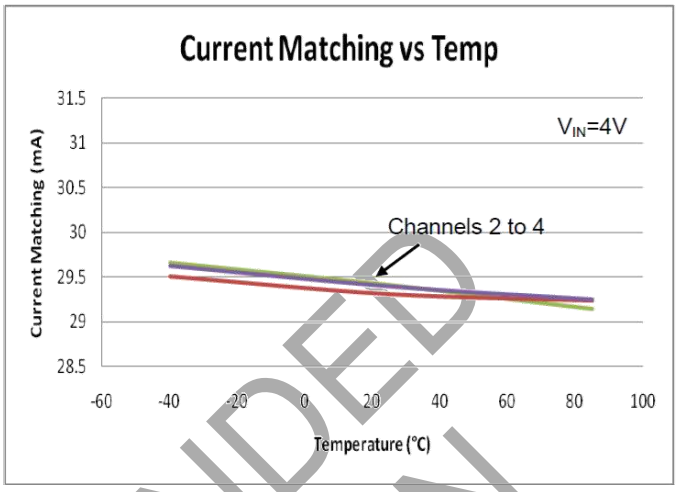
### PWM Dimming Control (Duty Cycle=50%)

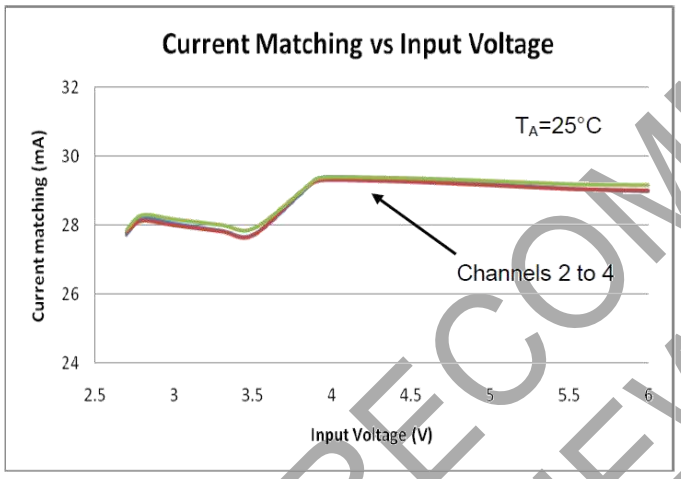


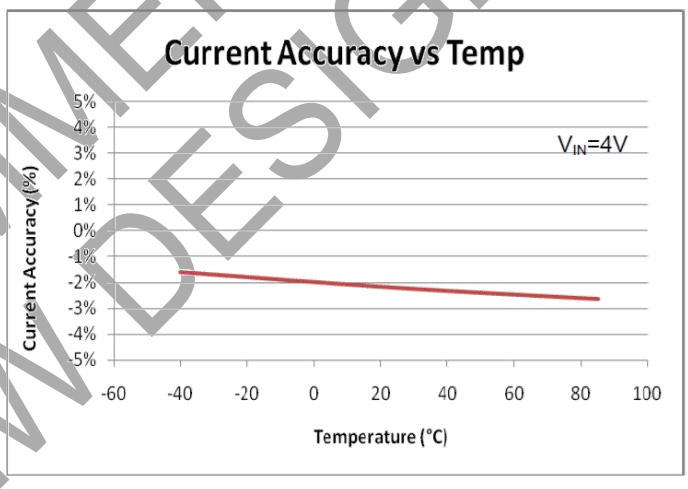

10µs/div

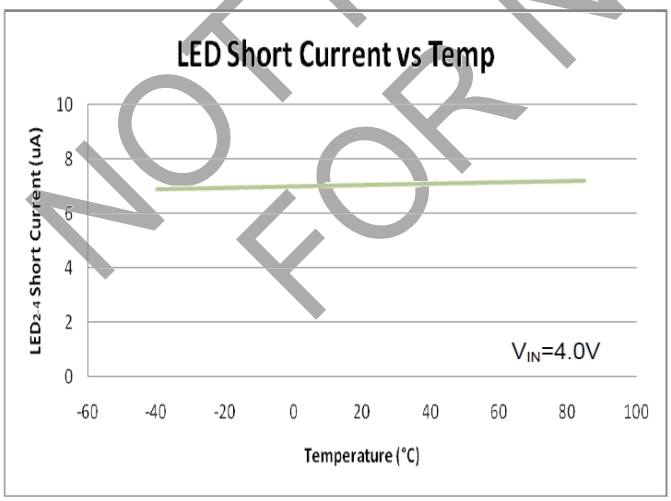
## Typical Performance Characteristics (continued)

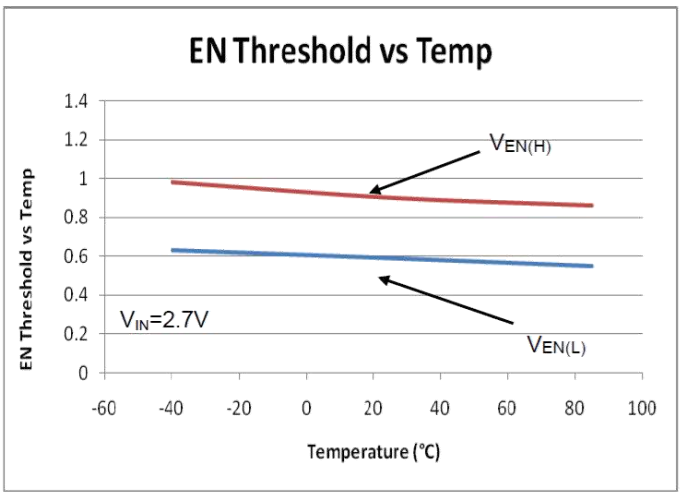


## Functional Description

The AL3157 is a dual-mode high efficiency charge pump (1x and 2x) device, driving 3-channel standard backlight LEDs and one high-current Flash/Torch LED, 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 APL3157 requires only three external components: one 1μF ceramic flying capacitor ($C_1$) for the charge pump, one 2.2μF ceramic input capacitor ($C_{IN}$), and one 2.2μF ceramic charge pump output capacitor ($C_{OUT}$).

Each output channel of the AL3157 can drive three individual LEDs with a maximum current of 30mA per channel and a Flash/Torch LED with a maximum current of 210mA. These can be paralleled to give a total output current of 300mA.

**LED Control Table**

| EN1 | EN2 | D1 | D2, D3, D4 |
|---|---|---|---|
| 0 | 0 | OFF | OFF |
| 0 | 1 | OFF | ON |
| 1 | 0 | ON | OFF |
| 1 | 1 | ON | ON |

**Disabled Current Sinks**

Unused current channels must be disabled by connecting the sinks to $V_{OUT}$ with only a small sense current flowing through the disabled channel.

**Soft-Start**

Soft-start is incorporated to prevent excessive in-rush 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 AL3157 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

**AL3157 X - 7**

| Package | Packing |
|---|---|
| F : U-DFN3030-12 | 7 : 7” Tape & Reel |

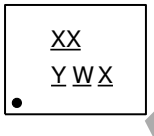
| Part Number | Part Number Suffix | Package Code | Package (Note 8) | Packing | |
|---|---|---|---|---|---|
| | | | | Qty. | Carrier |
| AL3157F-7 | -7 | F | U-DFN3030-12 | 3000 | 7” Tape and Reel |

Note: 8. Pad layout as shown on Diodes Incorporated’s suggested pad layout, which can be found on our website at http://www.diodes.com/package-outlines.html.

## Marking Information

**U-DFN3030-12**

**( Top View )**



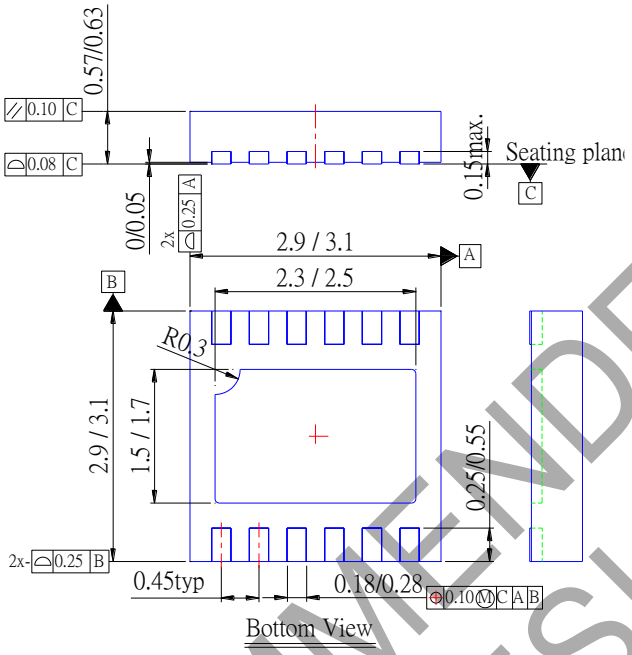

XX : B7 : AL3157
Y : Year : 0 to 9 (ex: 2 = 2022)
W : Week : A to Z : week 1 to 26;
a to z : week 27 to 52;
z represents week 52 and 53
X : A to Z : Green

| Part Number | Package | Identification Code |
|---|---|---|
| AL3157F-7 | U-DFN3030-12 | B7 |

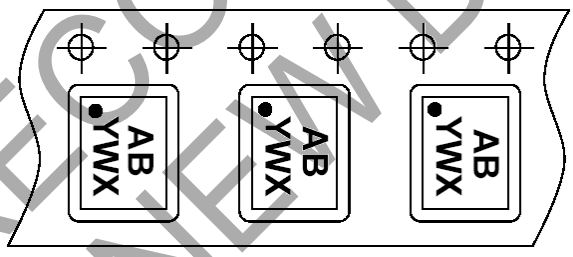
## Package Information

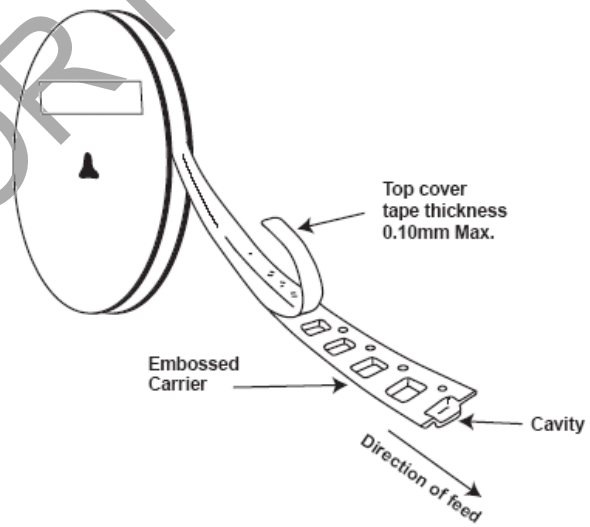
Please see http://www.diodes.com/package-outlines.html for the latest version.

**Package Type: U-DFN3030-12**




## Tape Orientation (Note 9)






Note: 9. The taping orientation of the other package type can be found on our website at https://www.diodes.com/assets/Packaging-Support-Docs/ap02007.pdf.

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