

## HIGH EFFICIENCY 1x/2x CHARGE PUMP LED DRIVER FOR SMALL SCREEN BACKLIGHTING AND FLASHLIGHT

### Description

The 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  $1\mu\text{F}$  flying capacitor and two  $2.2\mu\text{F}$  capacitors at  $V_{\text{IN}}$  and  $V_{\text{OUT}}$ ) make 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  $V_{\text{OUT}}$  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  $V_{\text{IN}}$  to reduce quiescent current less than  $1\mu\text{A}$ .

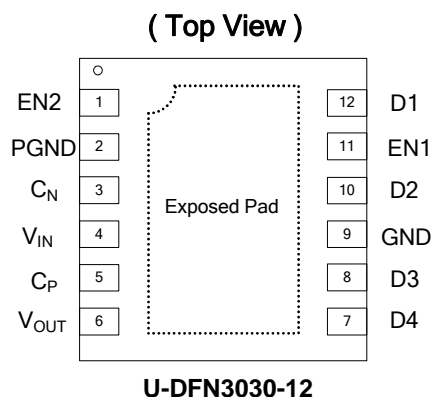
The AL3157 is available in a lead-free, space-saving thermally enhanced 12-pin 3x3mm DFN package.

### Features

- Dual-Mode 1x and 2x Charge Pump
- Up to 300mA drive capability
  - 3-channel for backlight – 30mA/ch
  - 1-channel for Flash/light – 210mA
- $V_{\text{IN}}$  Range: 2.7V to 5.5V
- Two simple PWM dimming control inputs up to 50kHz
- 1.2 MHz Constant Switching Frequency
- Built-In Thermal, Open-Circuit and  $V_{\text{OUT}}$  short circuit Protection
- Soft Start for reducing in-rush current
- $I_{\text{Q}} < 1\mu\text{A}$  in Shutdown
- Thermally-Enhanced DFN3030-12 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)

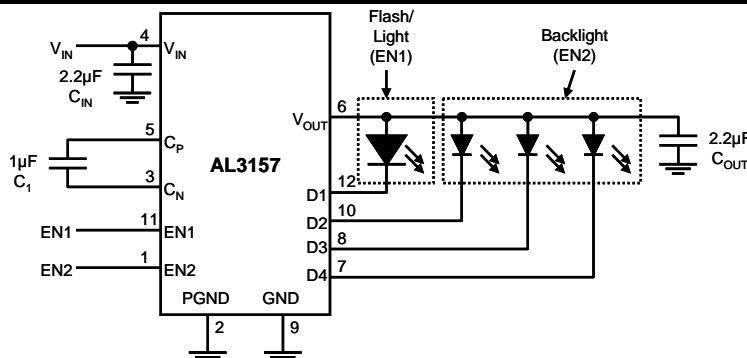
### Pin Assignments



### Applications

- Smart Touch Phone LED Backlighting
- PDA White LED backlighting
- Backlighting + Torch light

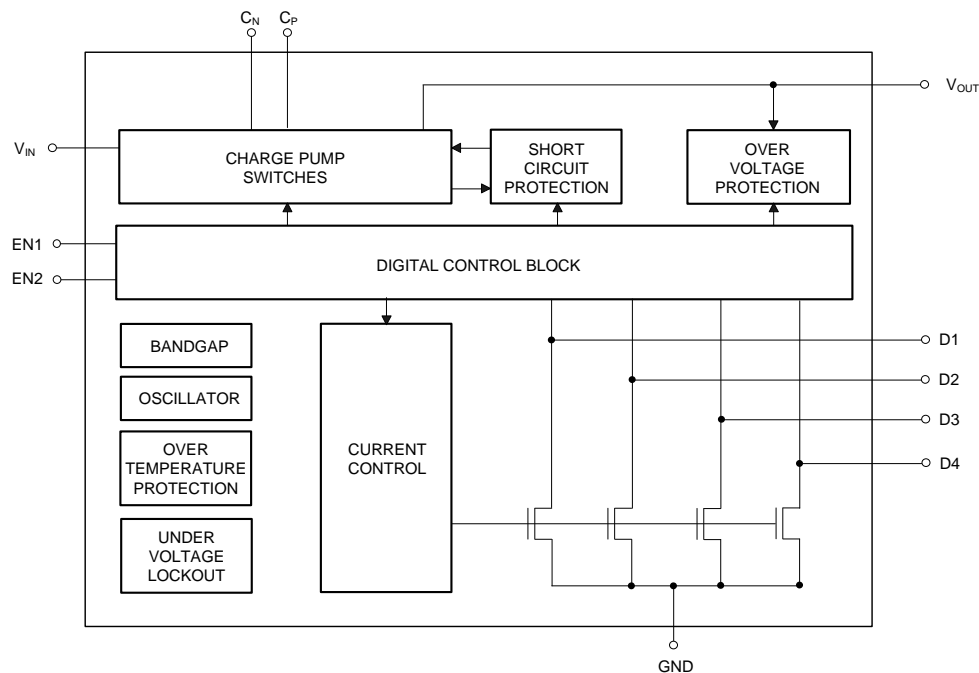
### Typical Application Circuit



## 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 <sub>N</sub>	3	Negative Terminal of Flying Capacitor
V <sub>IN</sub>	4	Input Power Supply. Decouple with a 2.2μF capacitor between this pin and ground.
C <sub>P</sub>	5	Positive Terminal of Flying Capacitor
V <sub>OUT</sub>	6	Charge pump output to drive D1~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 <sub>OUT</sub> when un-used.
D3	8	Current sink input #3. Drive up to 30mA LED current. Connect to V <sub>OUT</sub> when un-used.
GND	9	Ground
D2	10	Current sink input #2. Drive up to 30mA LED current. Connect to V <sub>OUT</sub> when un-used.
EN1	11	Enable Pin 1: Controls output D1
D1	12	Current sink input #1. Drive up to 210mA LED current. Connect to V <sub>OUT</sub> when un-used.
EP	EP PAD	Exposed Pad (bottom). Connect to GND directly underneath the package.

## Functional Block Diagram



**HIGH EFFICIENCY 1x/2x CHARGE PUMP LED DRIVER  
 FOR SMALL SCREEN BACKLIGHTING AND FLASHLIGHT**
**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	300	mA
T <sub>J</sub>	Operating Junction Temperature Range	125	°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
V <sub>ENL(1,2)</sub>	EN1,2 Threshold Low	0	0.4	V
V <sub>ENH(1,2)</sub>	EN1,2, Threshold High	1.4	V <sub>IN</sub>	V
T <sub>A</sub>	Operating Ambient Temperature	-40	85	°C

**Electrical Characteristics**

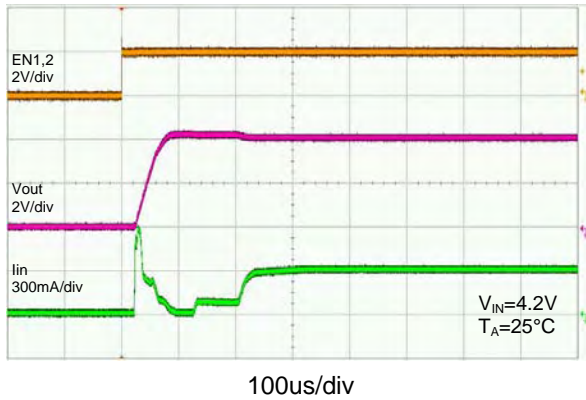
V<sub>IN</sub> = 4V, C<sub>IN</sub> = C<sub>OUT</sub> = 2.2μF, C<sub>1</sub> = 1μF; T<sub>A</sub> = 25°C unless otherwise noted.

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 = 0			1	μA
I <sub>D2-4</sub>	Backlight LED Drive Sink Current Accuracy (Note 3)	I <sub>DX</sub> = 30mA	28.5	30	31.5	mA
I <sub>D1</sub>	Flash/light LED Drive Sink Current Accuracy (Note 3)	I <sub>D1</sub> = 210mA	199.5	210	220.5	mA
I <sub>D-Match</sub>	Current Matching Between Any Two Backlight LED Drive Current Sink Outputs (Note 4)	V <sub>F</sub> : D2:D4 = 4V		1	2	%
R <sub>out</sub>	Charge Pump V <sub>OUT</sub> Open Loop Resistance	1x mode		0.5		Ω
		2x mode		4.5		
V <sub>TH-Dx</sub>	1x to 2x Transition Threshold at D2, D3 and D4 Pins	I <sub>D</sub> = 30mA		150		mV
V <sub>TH-D1</sub>	1x to 2x Transition Threshold at D1 Pin	I <sub>D1</sub> = 210mA		150		mV
V <sub>HS</sub>	Mode Transition Threshold				500	mV
t <sub>SS</sub>	Soft-Start Time			100		μs
f <sub>SW</sub>	Switching Frequency			1.2		MHz
t <sub>EN1,2</sub>	EN1,2 Off Timeout				20	ms
UVLO	V <sub>IN</sub> Under-Voltage Lockout		1.8	2	2.2	V
I <sub>EN1,2</sub>	EN1, 2 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	U-DFN3030-12 (Note 5)		55.29		°C/W

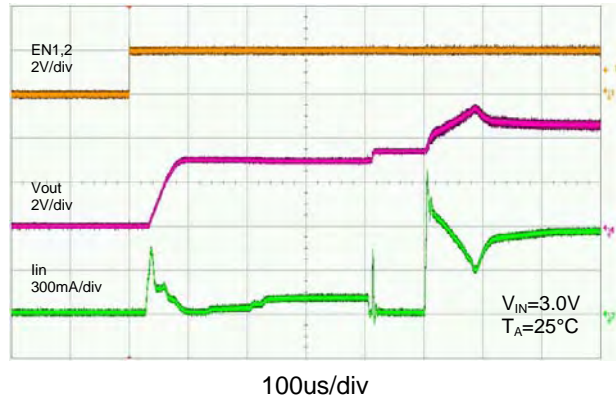
- Notes:
3. Determined by the mean of channels 2,3 and 4 currents, EG (I<sub>D2</sub> + I<sub>D3</sub> + I<sub>D4</sub>)/3
  4. Determined by the maximum sink current (MAX), the minimum sink current (MIN), and the average sink current (AVG). Two matching numbers are calculated as (MAX-AVG)/AVG and (AVG-MIN)/AVG. The largest number of the two (worst case) is as the matching data.
  5. Device mounted on FR-4 substrate, 2"×2", 2oz, copper, double-sided PC board.

**Typical Performance Characteristics**

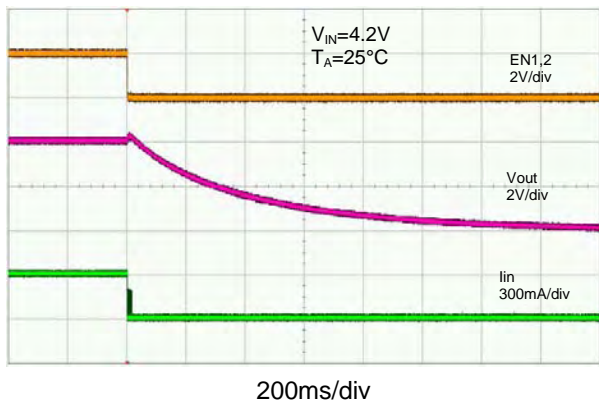
**Turn-On in 1x Mode**



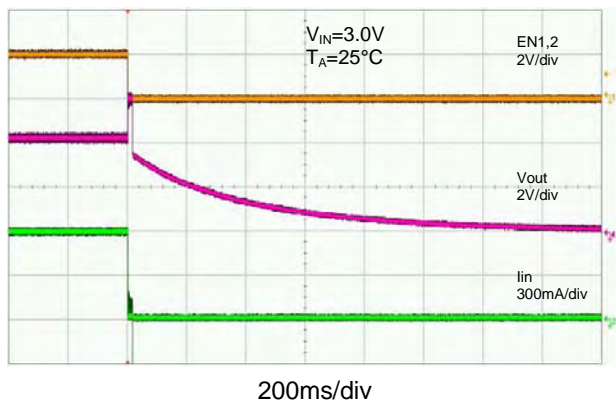
**Turn-On in 2x Mode**



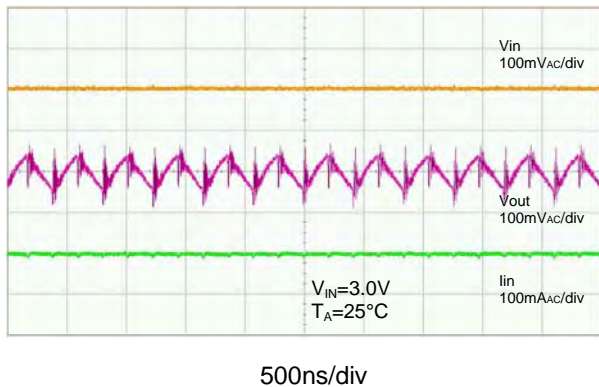
**Turn-Off in 1x Mode**



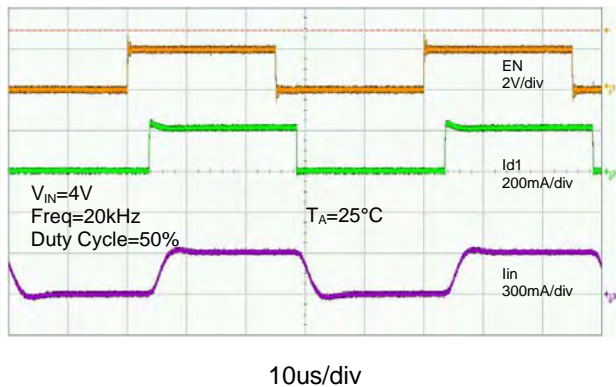
**Turn-Off in 2x Mode**



**Load Characteristics in 2x Mode**

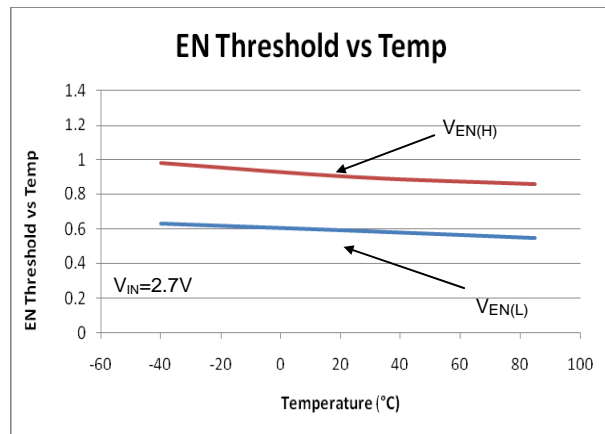
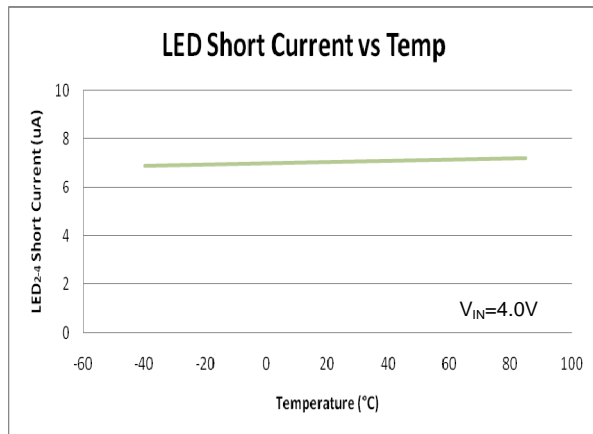
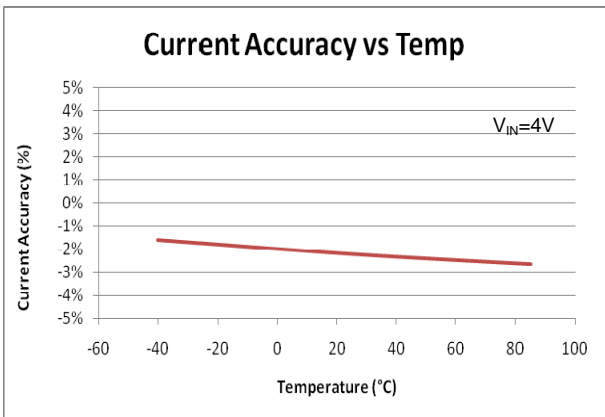
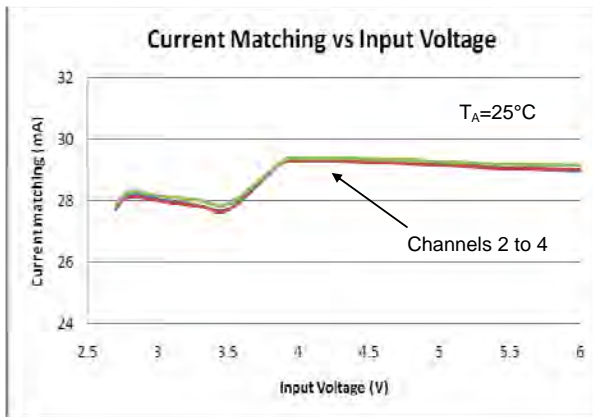
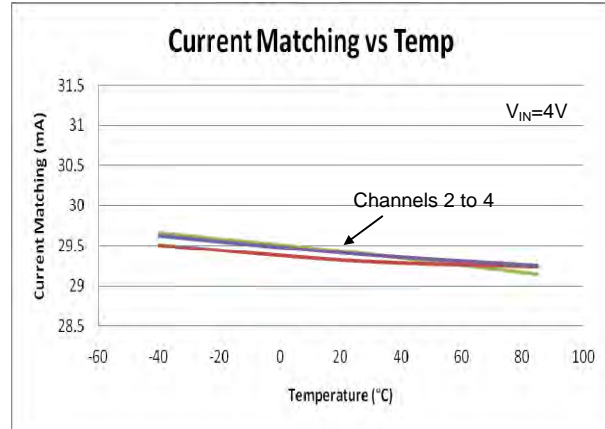
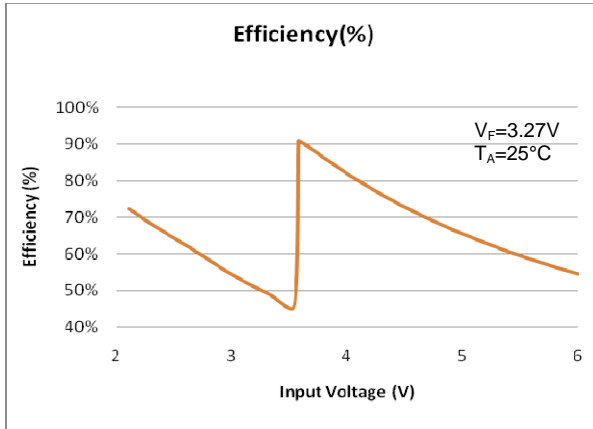


**PWM Dimming Control (Duty Cycle=50%)**



**Typical Performance Characteristics (Continued)**

NEW PRODUCT



### 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 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 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 VOUT 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

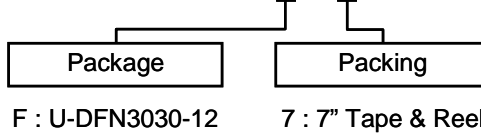
When the die temperature exceeds the thermal limit, the device will be disabled and enter stand-by mode. The operation resumes whenever the die cools off sufficiently.

### 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



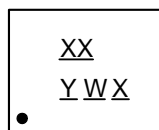
Device	Package Code	Packaging (Note 7)	7" Tape and Reel	
			Quantity	Part Number Suffix
AL3157F-7	F	U-DFN3030-12	3000/Tape & Reel	-7

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>

## Marking Information

### (1) U-DFN3030-12

#### ( Top View )

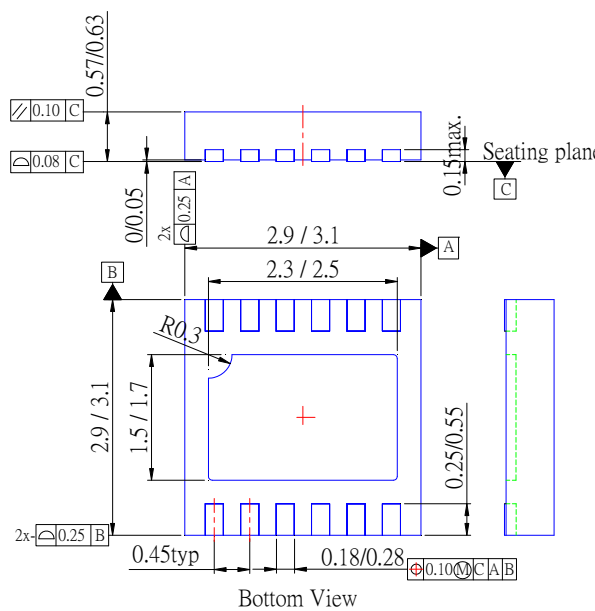


XX : B7 : AL3157  
Y : Year : 0~9  
W : Week : A~Z : 1~26 week;  
           a~z : 27~52 week;  
           z : represents 52 and 53  
X : A~Z : Green

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

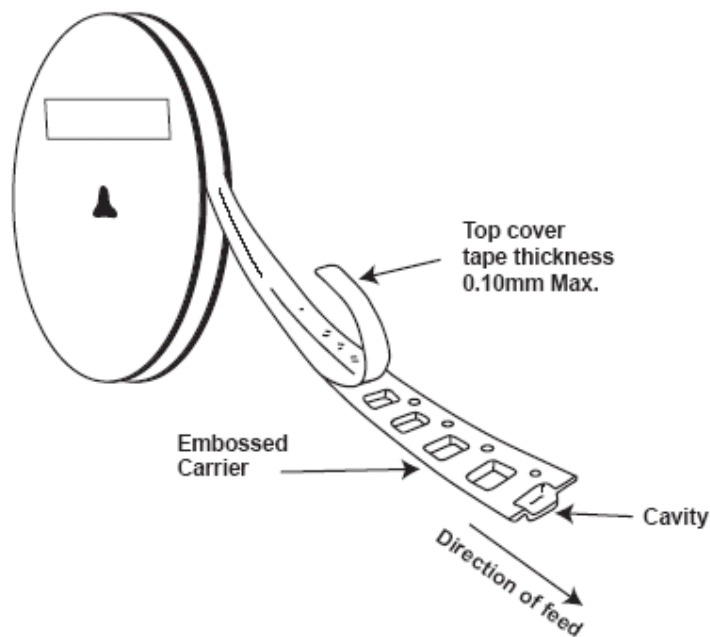
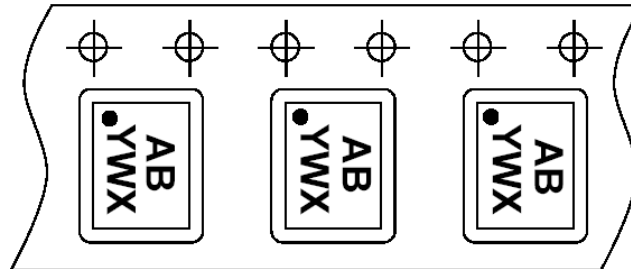
## Package Information

### (1) Package type: U-DFN3030-12





**Tape Orientation (Note 8)**



Notes: 8. The taping orientation of the other package type can be found on our website at <http://www.diodes.com/datasheets/ap02007.pdf>



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NEW PRODUCT

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