■ General Description

The OCP8111 is current-regulated charge pump ideal for powering high brightness LEDs for camera flash applications. The charge pump can be set to regulate two current levels for FLASH and TORCH modes.

The OCP8111 automatically switches modes between step-up and step-down ensuring that LED current does not depend on the forward voltage. It switches at 1.8MHz, allowing the use of tiny components. The supply voltage ranges from 2.7V to 5.5V and is ideally suited for all applications powered by a single Li_Ion battery cell or three to four NiCd, NiMH, or Alkaline battery cells.

The OCP8111 also features a very low shutdown current (less than 1uA), an automatic soft-start mode to limit inrush current, as well as over current, over voltage and over temperature shutdown control.

A Low current sense reference voltage (50mV) allows the user of small 0603 current sensing resistors.

The OCP8111 is offered in Green 10-pin DFN package and is specified over an ambient temperature range of -40˚C to 85˚C.

■ Features

- Output Current up to 1.0A at VIN=4.2V
- Up to 94% Efficiency in Torch Mode
- Adjustable FLASH Mode Current
- Minimum External Components: No Inductors
- Automatic Buck/Boost Mode Switchover
- Wide V_{IN} Range: 2.7V to 5.5V
- High Frequency Operation: 1.8MHz
- 50mV Reference for low Loss Sensing
- ISD < 1μA in Shutdown
- PWM Dimming Control
- Automatic Soft Start Limits Inrush Current
- Over Voltage Protection on Output
- Over Current Protection
- Over Temperature Protection
- Low Input and Output Ripple and Low EMI
- Ultra-low Dropout Voltage in Buck Mode
- Space Saving RoHS Compliant, Lead Free Package: 10-pin 3mm x 3mm DFN

■ Applications

- White LED Torch/Flash for Cell Phones, DSCs, and Camcorders
- White LED Backlighting
- Generic Lighting/Flash/Strobe Applications
- General Purpose High Current Boost

■ Pin Configuration

DFN3030-10L (Top View)

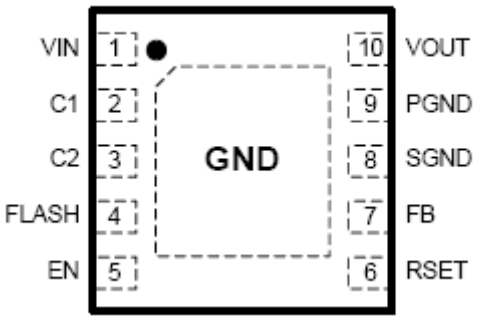


Figure 1, Pin Assignments of OCP8111

Pin Name	Pin No. DFN3030-10	Pin Function
V_{IN}	1	Input Voltage for the charge pump. Decouple with 4.7μF or 10uF ceramic capacitor close to the pins of the IC.
C1	2	Positive input for the external flying capacitor. Connect a ceramic 1 μF capacitor close to the pins of the IC.
C2	3	Negative input for the external flying capacitor. Connect a ceramic 1 μF capacitor close to the pins of the IC.
FLASH	4	Logic input to toggle operation between FLASH and TORCH mode. In TORCH mode FB is regulated to the internal 50mV reference. In FLASH mode FB reference voltage can be adjusted by changing the resistor from R_{SET} pin to ground. Choose the external current sense resistor (R_{SENSE}) based on desired current in TORCH mode. This pin does not have an internal pull-up/pull- down; do not leave this pin floating.
EN	5	Shutdown control input. Connect to V_{IN} for normal operation, connect to ground for shutdown. Don't leave this pin floating.
R_{SET}	6	Connect a resistor from this pin to ground. When in FLASH mode (FLASH = High) this resistor sets the current regulation point according to the following: $V_{FB} = \frac{14uA * R_{SET}}{5}$ (Flash Mode)
FB	7	Feedback input for the current control loop. Connect directly to the current sense resistor.
SGND	8	Internal ground pin. Control circuitry returns current to this pin.
PGND	9	Power ground pin. Flying capacitor current returns through this pin.
VOUT	10	Charge Pump Output Voltage. Decouple with an external capacitor. At least 1 μF is recommended. Higher capacitor values reduce output ripple
GND	Exposed Pad	Exposed pad should be soldered to PCB board and connected to GND.

■ Typical Application Circuit

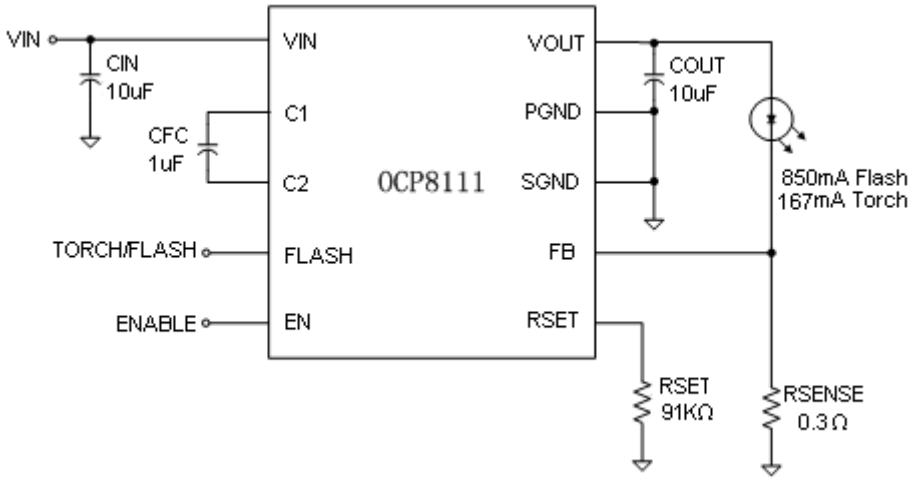


Figure 2, Typical Application Circuit of OCP8111

■ Block Diagram

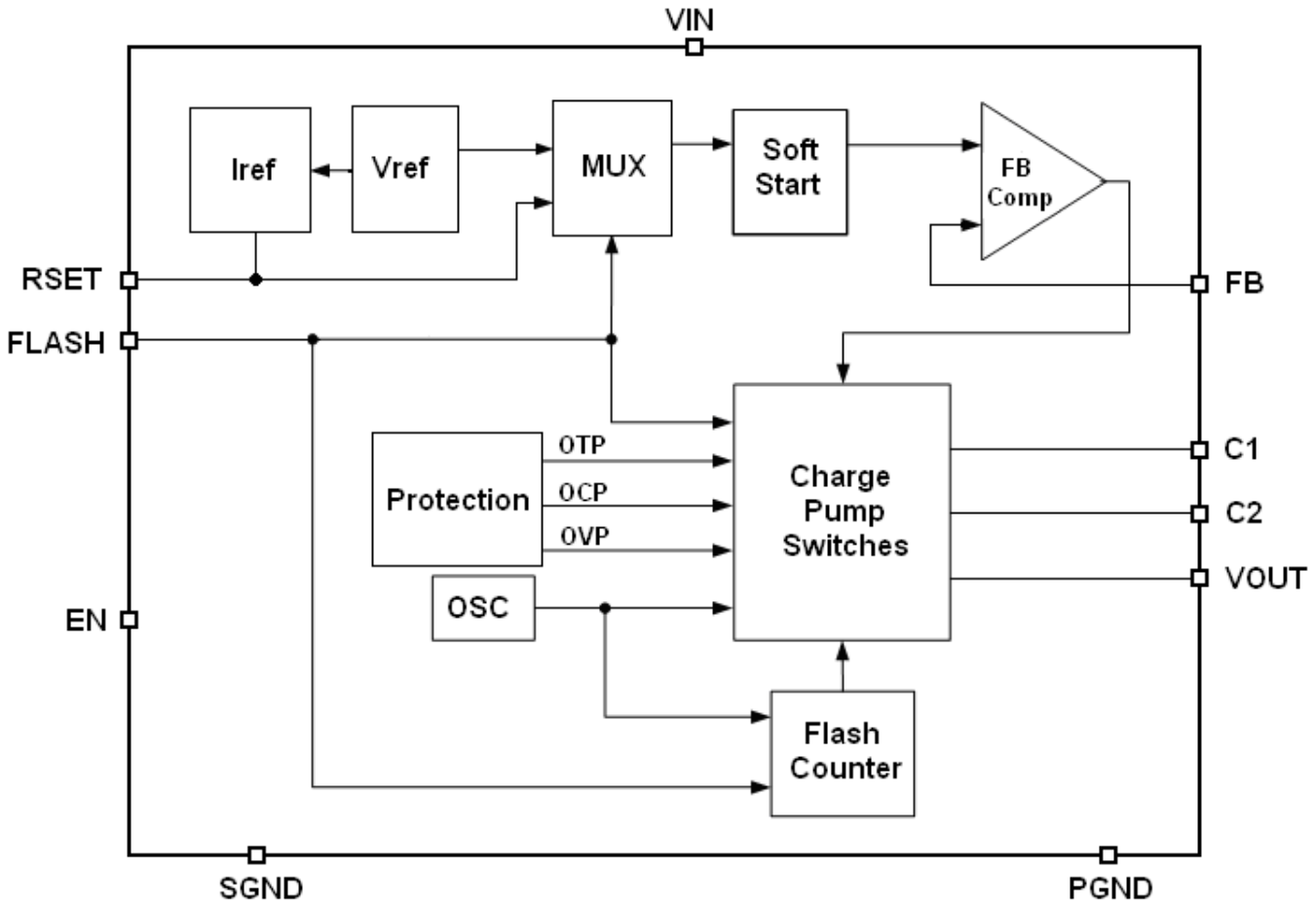


Figure 3, Block Diagram of OCP8111

■ Absolute Maximum Ratings[1] (T_A=25°C unless otherwise noted)

Parameter	Symbol	Rating	Unit
Input Voltage	V_{IN}	-0.3 to 6	V
V_{EN} ,I_{SET},V_{OUT} Voltage		-0.3 to V_{IN}	V
Storage Temperature Range	T_S	-55 to +150	℃
Operating Junction Temperature Range	T_J	-40 to 150	℃
Maximum Power Dissipation	P_D	1.9	W
Maximum Thermal Resistance	θ_{JA}	51	℃/W
ESD (HBM)	ESD	4K	V
Output Current Pulse (Flash)	I_{OUT}	1.6	A
Output Current Continuous (Torch)	I_{OUT}	0.4	A

■ Recommended Operating Conditions (T_A=25°C unless otherwise noted)

Parameter	Symbol	Conditions	Rating	Unit
Supply Voltage	V_{IN}	Operating	2.7 ~ 5.5	V
Operating Temperature Range	T_A	Operating	-40 ~ +85	℃

■ Electrical Characteristics

(Unless otherwise noted，typical values are at T_A=25℃, V_{IN}=3.6V, C_{FC}=1uF, C_{OUT}=10uF)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Input Power Supply						
V_{IN}	Input Voltage range		2.7	-	5.5	V
I_{SD}	Shutdown Current	EN=0V,Shutdown mode	-	0.1	1	μA
I_Q	Quiescent Current	V_{IN} = 2.7 - 5.5V, FLASH = GND, 1X Mode, I_{LOAD} =100μA	-	0.34	2	mA
		FLASH = HIGH, 2X Mode	-	1.75	-	mA
V_{FB}	FB Reference voltage	FLASH = GND	45	50	55	mV
		FLASH = High, RSET = 53.6 kΩ	138	150	162	mV
V_{FBR}	FB Reference Voltage Range	FLASH = High. Guaranteed by design.	100	-	400	mV
I_{FB}	FB Pin Current	V_{FB}= 0.3V	-	-	1	μA
Charge Pump Section						
R_{2X}	Charge Pump Equivalent Resistance (x2 mode)	V_{FB} = 0.0V, V_{IN}= 3.6V	-	4	-	Ω
R_{1X}	Charge Pump Equivalent Resistance (x1 mode)	V_{IN}= 3.6V	-	0.4	0.7	Ω
T_{SS}	V_{OUT} Turn-on Time	VIN= 3.6V, FB within 90% of regulation	-	140	250	μs
F_{OSC}	Switching Frequency		-	1.8	-	MHz
V_{OUT}	Over-voltage Limit	LED unconnected, V_{IN} =4.2V	-	5.1	-	V
TSD	Shutdown Temperature	Temperature rising	-	145	-	℃
TRT	Recovery Temperature	Temperature falling	-	135	-	℃
ENABLE						
V_{ENL}	Enable Threshold Low		-	-	0.4	V
V_{ENH}	Enable Threshold High		1.4	-	-	V
I_{LK}	EN, FLASH Pin Current		-	-	1	μA
T_{FLASH}	Maximum Flash ON time	FLASH = High	1.2	-	3.8	s

■ Typical Performance Characteristics:

(Unless otherwise noted，T_A=25℃, V_{IN}=3.6V, C_{IN}=10uF, C_{FC}=1uF, C_{OUT}=10uF)

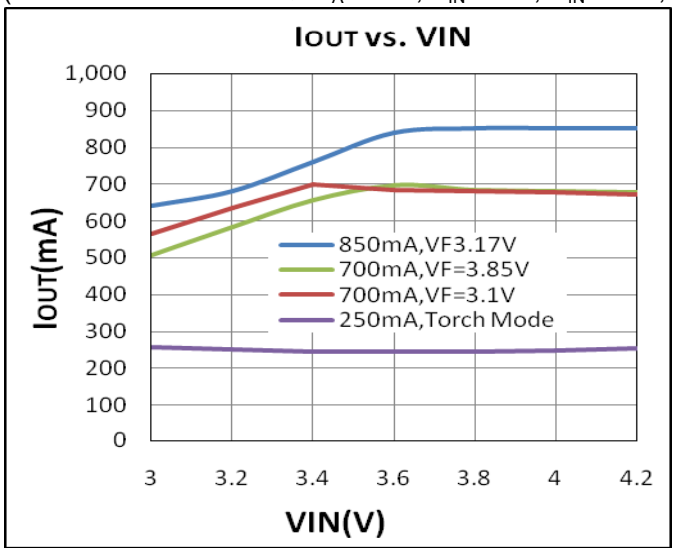


Figure 4, Output Current vs. Supply Voltage

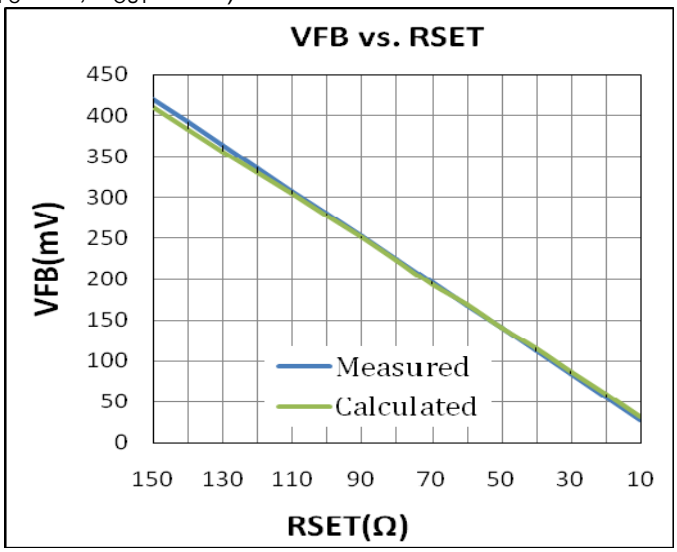


Figure 5, VFB vs. RSET Resistance

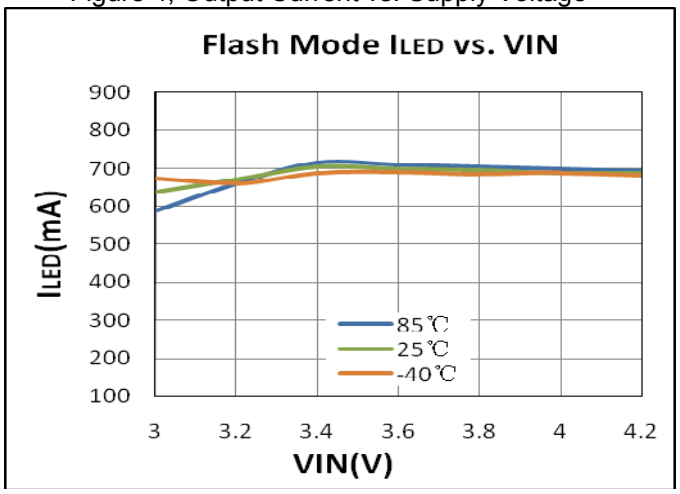


Figure 6, Flash 700mA Output Current vs. VIN

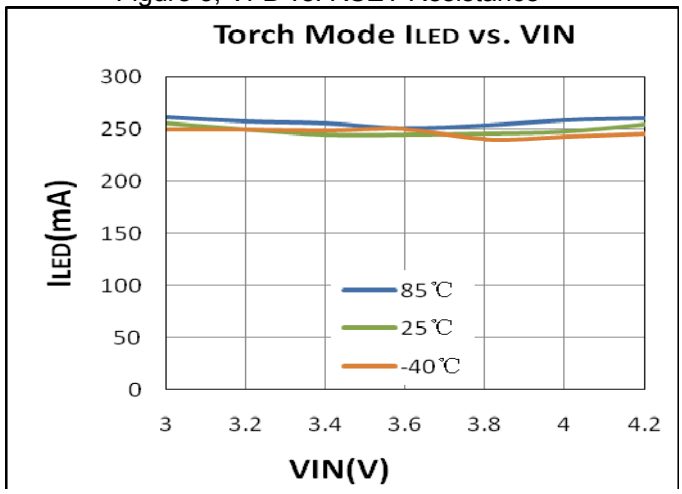


Figure 7, Torch Output Current vs. VIN

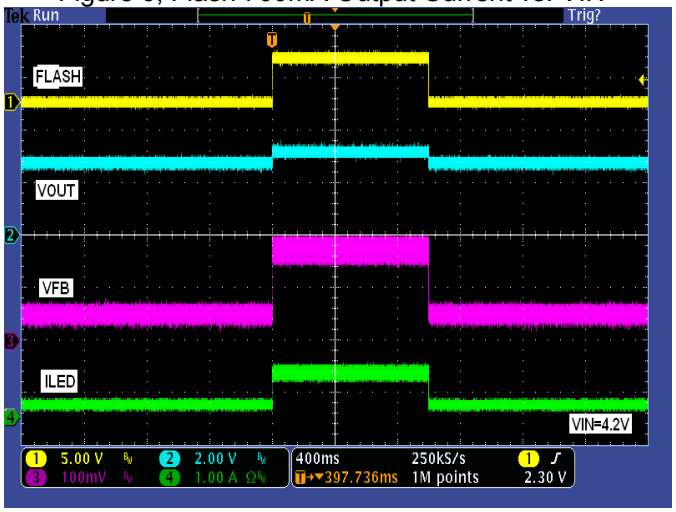


Figure 8, Torch in 1X to Flash in 1X, VIN=4.2V

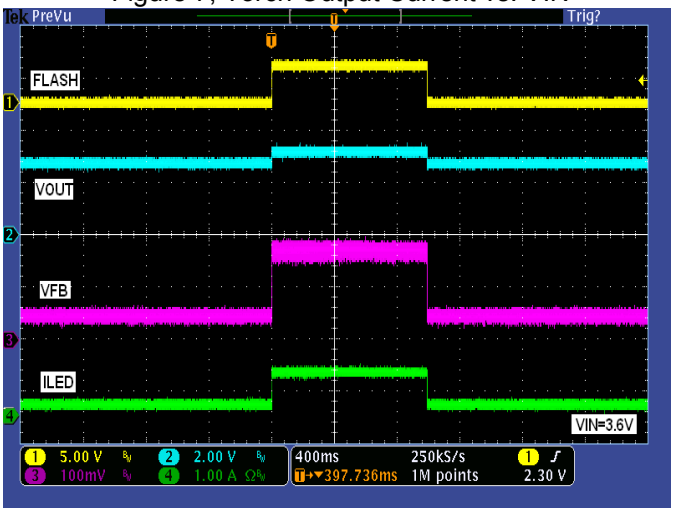


Figure 9, Torch in 1X to Flash in 2X, VIN=3.6V

■ Typical Performance Characteristics:

(Unless otherwise noted, T_A=25℃, V_{IN}=3.6V, C_{IN}=10uF, C_{FC}=1uF, C_{OUT}=10uF)

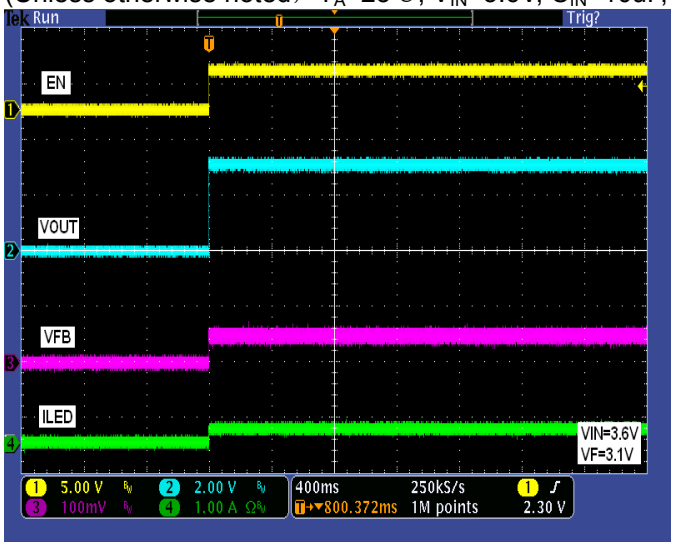


Figure 10, 250mA Torch, VIN=3.6V, VF=3.1V

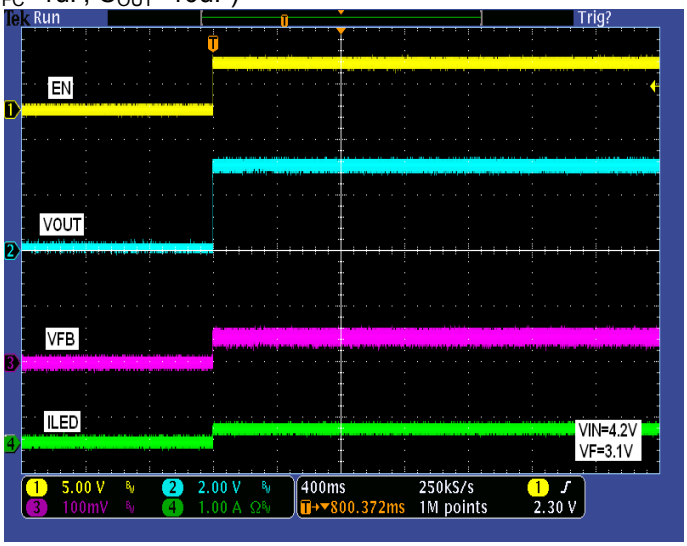


Figure 11, 250mA Torch, VIN=4.2V, VF=3.1V

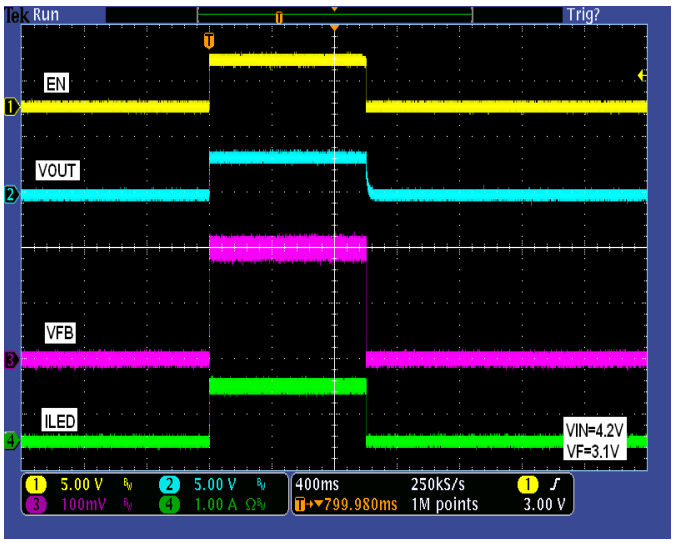


Figure 12, 850mA Flash in 1X, VIN=4.2V, VF=3.1V

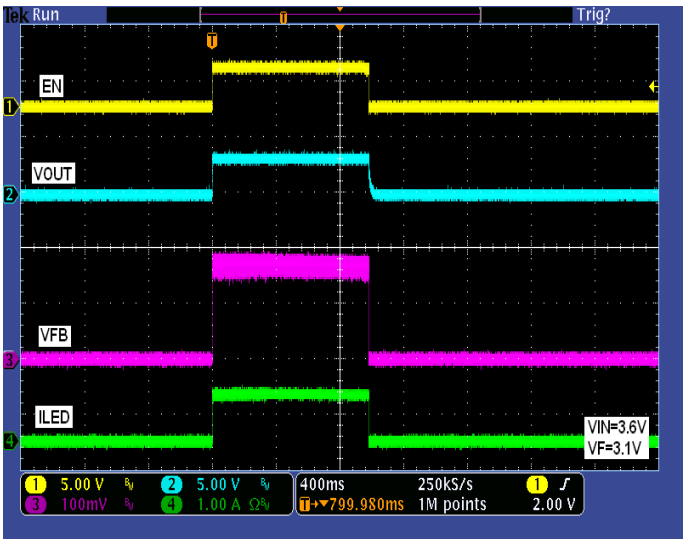


Figure 13, 850mA Flash in 2X, VIN=3.6V, VF=3.1V

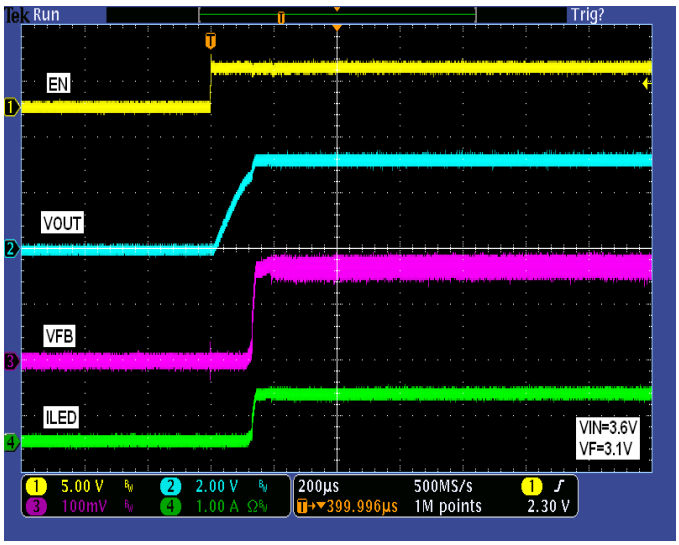


Figure 14, Start Up 850mA Flash, VIN=3.6V, VF=3.1V

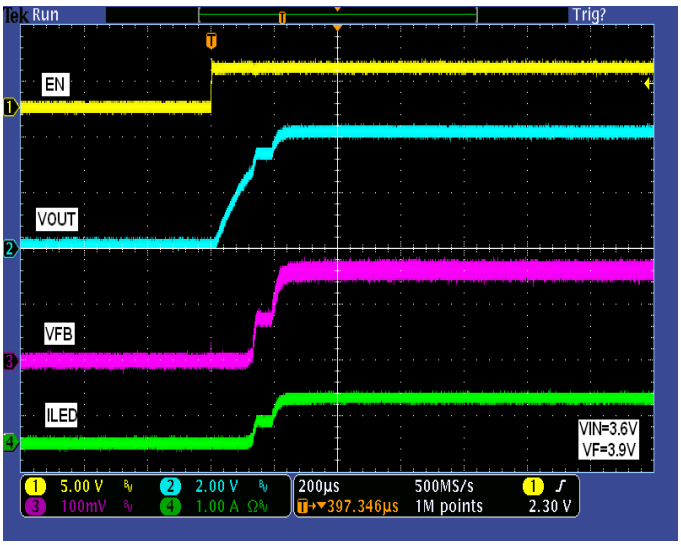


Figure 15, Start Up 850mA Flash, VIN=3.6V, VF=3.9V

■ Typical Performance Characteristics:

(Unless otherwise noted， T_A=25℃, V_{IN}=3.6V, C_{IN}=10uF, C_{FC}=1uF, C_{OUT}=10uF)

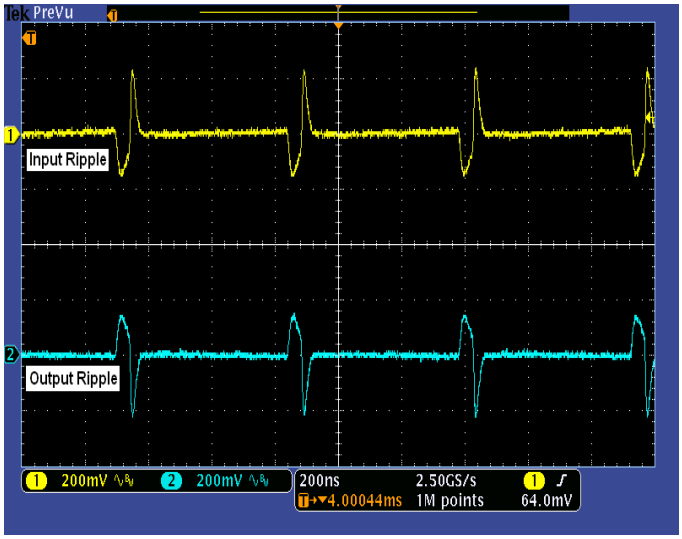


Figure 16, Ripple Torch 250mA in 1X, VIN=4.2V

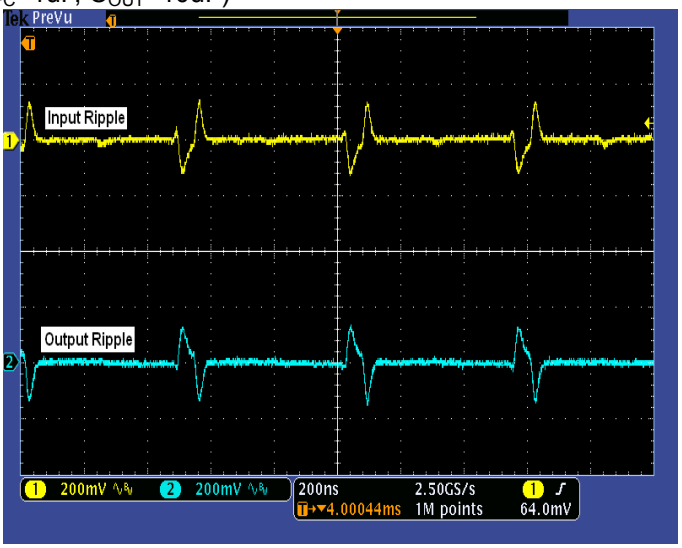


Figure 17, Ripple Torch 250mA in 2X, VIN=3V

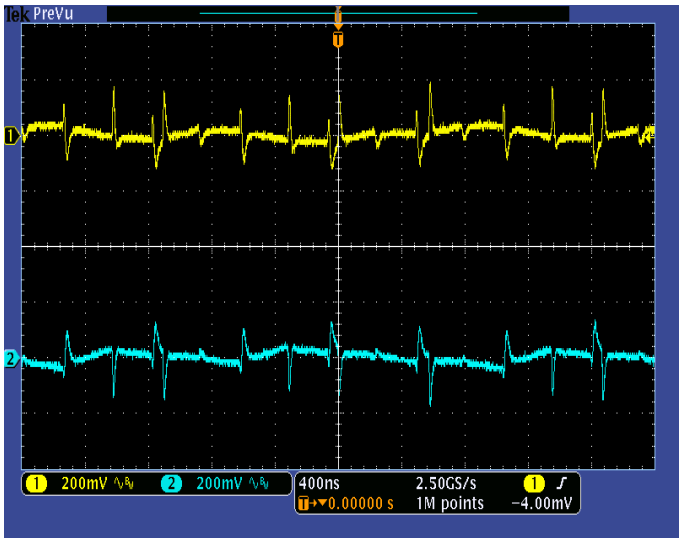


Figure 18, Ripple Flash 700mA in 2X Mode, VIN=3.6V

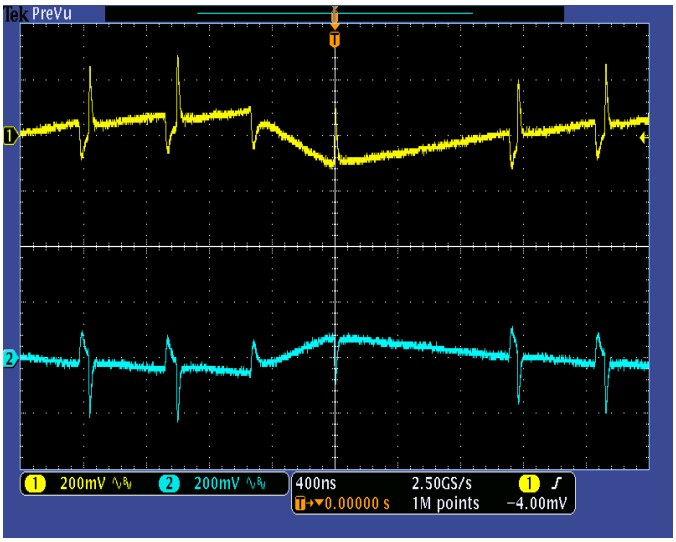


Figure 19, Ripple Flash 700mA in 1X Mode, VIN=4.2V

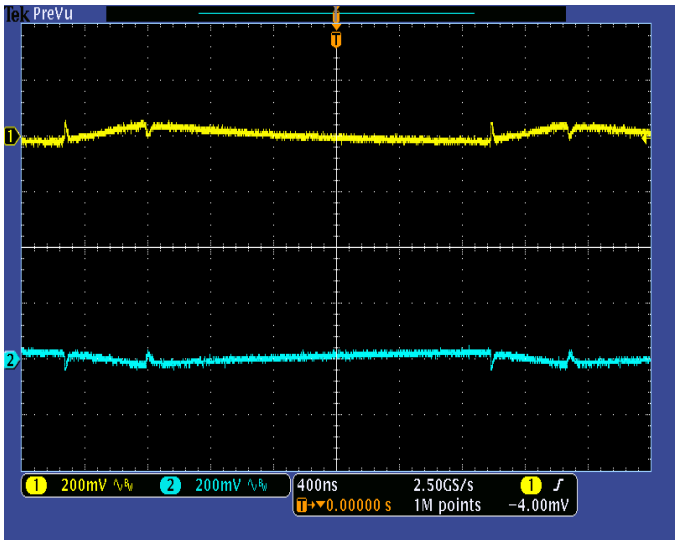


Figure 20, Ripple Flash 850mA in 2X Mode, VIN=3.6V

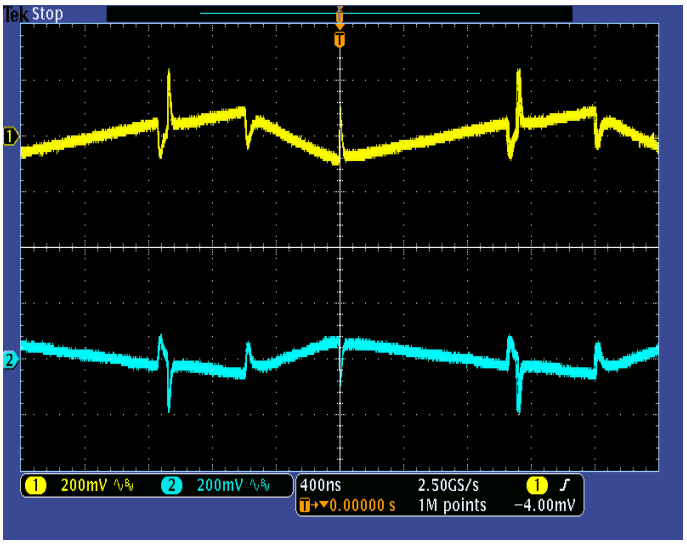


Figure 21, Ripple Flash 850mA in 1X Mode, VIN=4.2V

■ Typical Performance Characteristics:

(Unless otherwise noted，T_A=25℃, V_{IN}=3.6V, C_{IN}=10uF, C_{FC}=1uF, C_{OUT}=10uF)

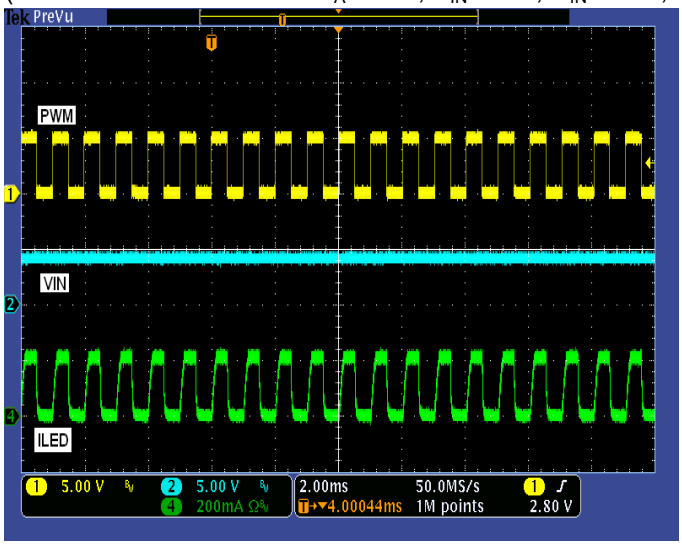


Figure 22, PWM Dimming, VIN=4.2

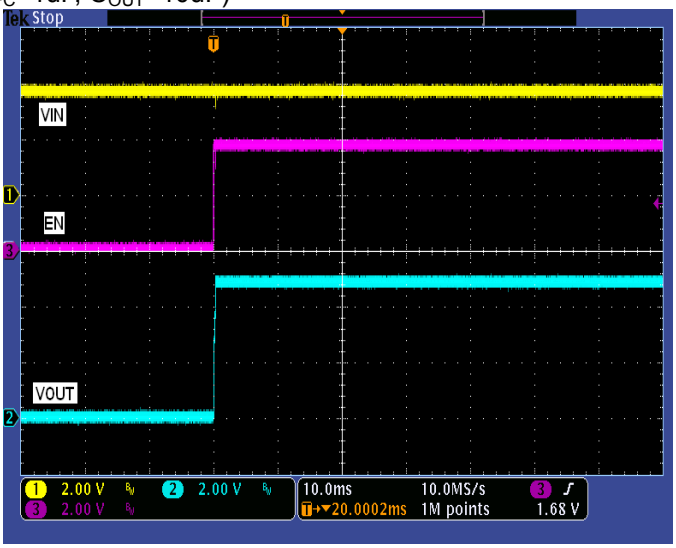


Figure 23, Over-Voltage Protection Waveform

Figure 24, 1A Application Waveform

■ Functional Description

The OCP8111 is a charge pump regulator designed for converting a Li-Ion battery voltage of 2.7V to 4.2V to drive a white LED used in digital still camera Flash and Torch applications. The OCP8111 has two modes of operation which are pin-selectable for either Flash or Torch. Flash mode is usually used with a pulse of about 200 to 300 milliseconds to generate a high intensity Flash. Torch can be used continuously at a lower output current than Flash and is often used for several seconds in a digital still camera "movie" mode.

The OCP8111 also has two modes of operation to control the output current: the 1 X mode and 2X mode. Operation begins after the enable pin EN receives a logic high, then OCP8111 goes through a soft-start mode designed to reduce inrush current. The OCP8111 starts in the 1X mode, which acts like a linear regulator to control the output current by continuously monitoring the feedback pin FB. In 1 X mode, if the OCP8111 auto detects a dropout condition, which is when the FB pin is below the regulation point for more than 64 cycles of the internal clock, the OCP8111 automatically switches to the 2X mode. The OCP8111 remains in the 2X mode until one of three things happens:

1) The enable pin EN has been toggled
2) The Flash pin has changed from high to low
3) VIN is cycled

The 2X mode is the charge pump mode where the output can be pumped as high as two times the input voltage, provided the output does not exceed the maximum voltage for the OCP8111, which is internally limited to about 5.1V. In the 2X mode, as in the 1 X mode, the output current is regulated by the voltage at the FB pin.

In the Torch mode, (Flash = GND) the Flash pin is set to logic low and the OCP8111 FB pin regulates to 50mV output:

V_{FB} = 50mV (Torch Mode)

When in Flash mode, (Flash = VIN), the FB regulation voltage is set by the resistor R_{SET} connected between the R_{SET} pin and SGND and the equation:

$$V_{FB} = \frac{14uA * R_{SET}}{5} \quad \text{(Flash Mode)}$$

Where 14μA is an internal regulated current and 5 is an internal factor used to scale the V_{SET} voltage to the V_{FB} voltage. Typical values of $_{RSET}$ are 140KΩ to 35KΩ for a range of V_{FB} = 400mV to 100mV in Flash mode.

The output current is then set in either Flash or Torch mode by the equation:

$$I_{OUT} = \frac{V_{FB}}{R_{SENSE}}$$

FLASH Timeout Protection:

Due to the high currents typically available in Flash mode, it is necessary to protect the white LED from damage if left on too long. The OCP8111 has a timeout in Flash mode of about 1.2seconds to 3.8seconds after which it will shut down operation. Operation will not begin again in Flash mode until the Enable pin or Flash pin have been set Low and then High again.

Over-voltage Protection:

The OCP8111 has over voltage protection. If the output voltage rises above the 5.1V threshold, the over voltage protection shuts off all of the output switches to prevent the output voltage from rising further. When the output decreases below 5.1V, the device resumes normal operation.

Over-current Protection:

The over current protection circuitry monitors the average current out of the VOUT pin. If the average output current exceeds approximately 1.6 Amps, then the over current protection circuitry shuts off the output switches to protect the chip.

Brightness Control using PWM:

Dimming control can be achieved by applying a PWM control signal to the EN pin. The brightness of the white LEDs is controlled by increasing and decreasing the duty cycle of the PWM signal. While the operating frequency range of the PWM control is from 60Hz to 700Hz, the recommended maximum brightness frequency range of the PWM signal is from 60Hz to 200Hz. A repetition rate of at least 60Hz is required to prevent flicker.

Over-temperature Protection:

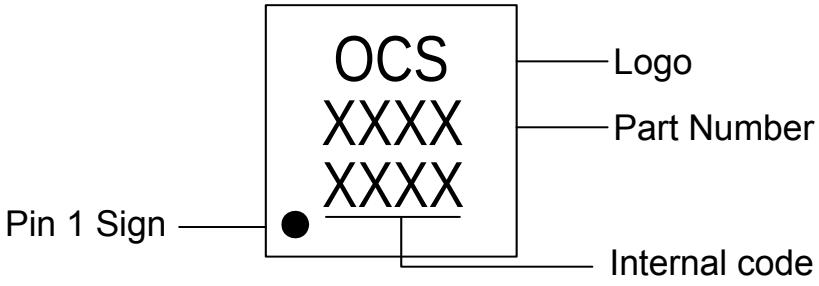
When the temperature of the OCP8111 rises above 145℃, the over temperature protection circuitry turns off the output switches to prevent damage to the device. If the temperature drops back down below 135 degrees Celsius, the part automatically recovers and executes a soft start cycle.

■ Ordering Information

Part Number	Driver Capability	Package Type	Package Qty	Temperature	Eco Plan	Lead
OCP8111VAD	1.0A	DFN3030-10L	13-in reel 3000pcs/reel	-40～85℃	Green	Cu

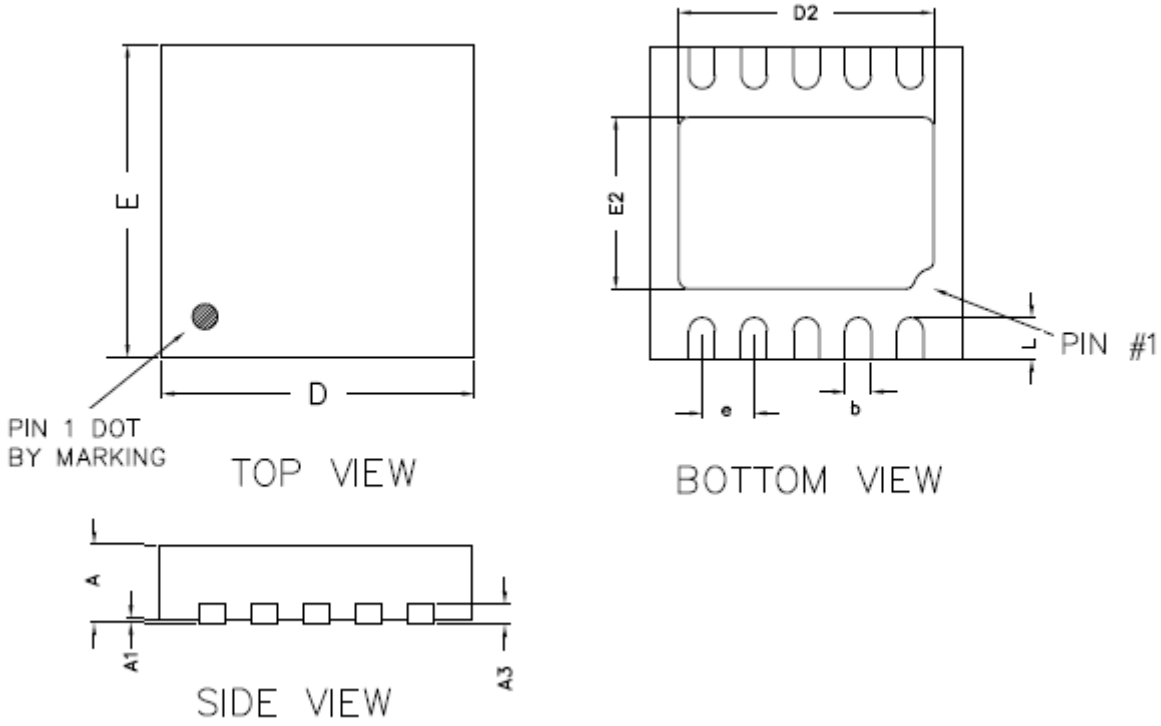
■ Marking Information

DFN3030-10L



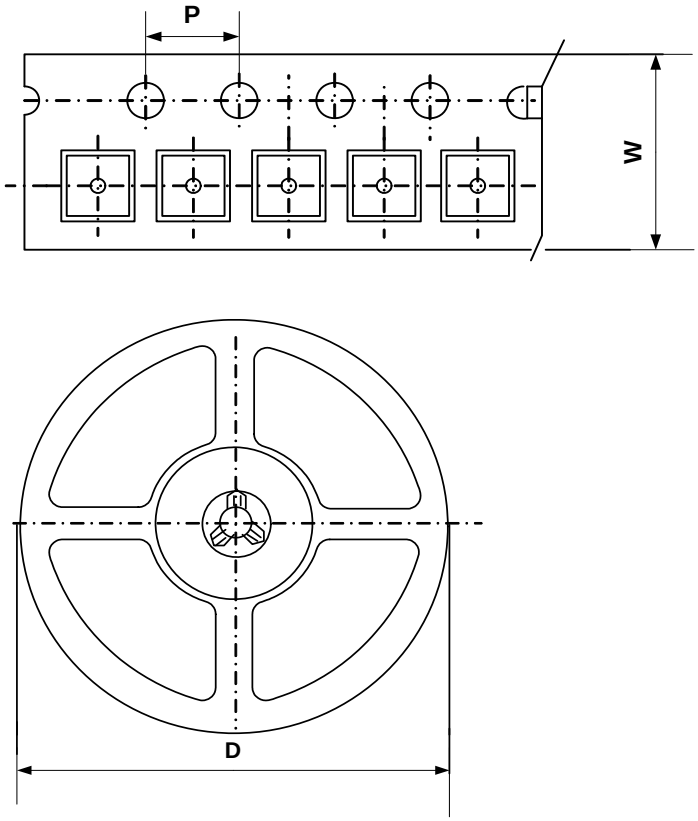
■ Package Information

DFN3030-10L:



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	0.70	0.75	0.80	0.027	0.029	0.031
A1	0.00	-	0.05	0.00	-	0.002
A3	0.20 REF			0.008 REF		
D	2.95	3.00	3.05	0.116	0.118	0.120
E	2.95	3.00	3.05	0.116	0.118	0.120
b	0.18	0.25	0.30	0.007	0.010	0.012
L	0.30	0.40	0.50	0.011	0.016	0.020
D2	2.30	2.45	2.55	0.091	0.096	0.100
E2	1.50	1.65	1.75	0.059	0.064	0.069
e	0.50 BSC			0.020 BSC		

■ Packing Information



Package Type	Carrier Width(W)	Pitch(P)	Reel Size(D)	Packing Minimum
DFN3030-10L	12.0±0.1 mm	4.0±0.1 mm	330±1 mm	3000pcs

Note: Carrier Tape Dimension, Reel Size and Packing Minimum