High Efficiency Synchronous Boost Converter For 1.5AWLED Flash

General Description

The OCP8135B is a 2MHz fixed frequency synchronous boost converter, optimized for maximum 1.5A camera flash application and maximum 800mA movie mode applications using high-current white LEDs in all single cell Li-ion powered products. An adaptive regulation method ensures the current for each LED remains in regulation and maximizes efficiency.

Two simple logic control inputs (ENM and ENF) enable and disable flash and movie mode operation of the OCP8135B.Movie-mode and Flash-mode current levels are independently fixed by two separate resistors (RM and RF). For Flash mode, a default timer can be used either to terminate a flash event or as a safety flash timer. One or two LEDs can be connected to the OCP8135B; in the case of two LEDs the output current is matched between each diode.

Thermal regulation is integrated in Flash mode to limit the IC’s temperature and continuously provide the maximum allowed output current.

The OCP8135B contain a thermal management system to protect the device; a internal over-voltage protection (OVP) circuitry prevents damaged to the OCP8135B from open LED or open circuit conditions; and a cycle-by-cycle current limit prevents damage to the OCP8135B. Built-in circuitry prevents excessive inrush current during start-up. The shutdown feature reduces quiescent current to less than 1.0μA.

The 2MHz switching frequency allow for the use of tiny, low profile (1uH or 2.2uH) inductors and 10uF ceramic capacitors. The device is available in 14-pin 2mmX3mm DFN package and is rated over the -40°C to 85°C.

Features

- Input Voltage Range: 2.7V to 5.3 V
- Dual Channel Output
- Drives up to 1.5A Regulated Output Current (0.75A per Channel)
- High Efficiency PWM Boost Converter
- 2.0MHz Fixed Switching Frequency
- Up to 97% Efficiency with Small Inductor 1uH
- Integrated Soft-Start Eliminates Inrush Current
- Under Voltage Lock-Out
- Over-Temperature Protection
- Thermal Sensing and Current Scale Back
- Over Voltage (Open LED) Protection
- LED Short Circuit Protection
- 800mS Flash Timer Control
- Cycle by Cycle Current Limit
- Separate Hardware Flash and Movie Enable
- Independently Set Flash/Movie Currents
  - Flash Mode Current Up to 1.5A
  - Movie Mode Current Up to 800mA
- Two Resistors Set Flash and Movie Current Independently
- Small Solution Size
- Less than 1uA Shutdown Current
- RoHS and Green Compliant
- 14-pin, 2mm X 3mm DFN Packages
- -40℃ to +85 ℃ Temperature Range

Applications

- Camera Flashes and Movies
- Cell Phones or Smart Phones
- PDAs and Digital Camera
- White LED Biasing
- Mobil Handsets
- Tablet PCs and Laptops/Net books
- Camcorder Video Light (Movie Light)

■ Pin Configuration

DFN2030-14L (Top View)

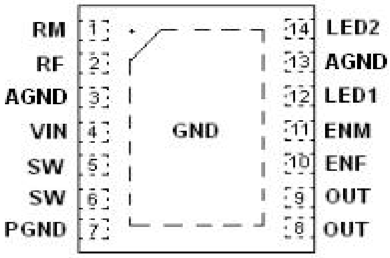


Figure 1, Pin Assignments of OCP8135B

Pin Name	Pin No. DFN2030-14L	I/O	Pin Function
RM	1	I/O	Movie mode current setting input. A71kΩ resistor from RM to GND sets the desired movie current available at LED1 and LED2 up to 200mA total current. Each LED1 and LED2 channel will conduct 50% of the maximum programmed current.
RF	2	I/O	Flash mode current setting input. A11.5kΩ resistor from RF to GND sets the maximum flash current available at LED1 and LED2 up to 1.5A total current. Each LED1 and LED2 channel will conduct 50% of the maximum programmed current.
AGND	3	P	Analog Ground and flash ground.
VIN	4	P	Power input. Connect VIN to the input power supply voltage. Connect a 10uF ceramic capacitor from VIN to GND as close as possible to OCP8135B.
SW	5	O	Drain connection for internal NMOS and Synchronous PMOS Switches.
SW	6	O	Drain connection for internal NMOS and Synchronous PMOS Switches.
PGND	7	P	Boost power ground pin. Connect PGND to GND and AGND at a single point as close as possible to OCP8135B.
OUT	8, 9	O	Power output of the boost converter. Connect a 10uF ceramic capacitor from OUT to PGND as close as possible to the OCP8135B. Connect OUT to the anodes of the Flash LEDs.
ENF	10	I	Flash mode enable pin. A low to high transition on the ENF pin initiates flash mode current level set by RF resistor. ENF is a active high control input with a internal 300kΩ resistance to GND. No matter the status of ENM,only When ENF = “1”, Flash mode is in active and the flashing current is equal to I_{RF} *D , D is the duty cycle of PWM signal at ENM pin ,the frequency of PWM is larger than 15KHz
ENM	11	I	Movie/Torch mode enable pin and PWM Dimming Pin of Flash Mode. ENM is a active high control input with a internal 300kΩ resistance to GND. In Flash Mode, the PWM signal at ENM pin is the flashing current dimming control. When ENF = ‘0’ and the timer of ENM = ‘1’ is not less than 5ms, Movie/Torch mode will be in active. The LED current should be equal to I_{RM} * D,D is the duty cycle of PWM signal at ENM pin . This PWM signal is sent to ENM pin after the first pulse which ‘1’ level time is more than 5ms. When ENF = ‘0’ and the of ENM = ‘0’ is not less than 5ms, the chip will enter into shutdown mode.
LED1	12	O	Channel 1 flash LED pin. Connect cathode of a flash LED to LED1. For a single flash LED, connect LED1 and LED2 together. For two flash LEDs, each output will conduct of 50% of the total flash current. LED1 is high impedance during shutdown.
AGND	13	P	Analog Ground and flash ground.
LED2	14	O	Channel 2 flash LED pin. Connect cathode of a flash LED to LED2. For a single flash LED, connect LED1 and LED2 together. For two flash LEDs, each output will conduct of 50% of the total flash current. LED2 is high impedance during shutdown.
GND	EP	P	Exposed paddle (bottom). Connect EP to PGND as close as possible.

■ Typical Application Circuit

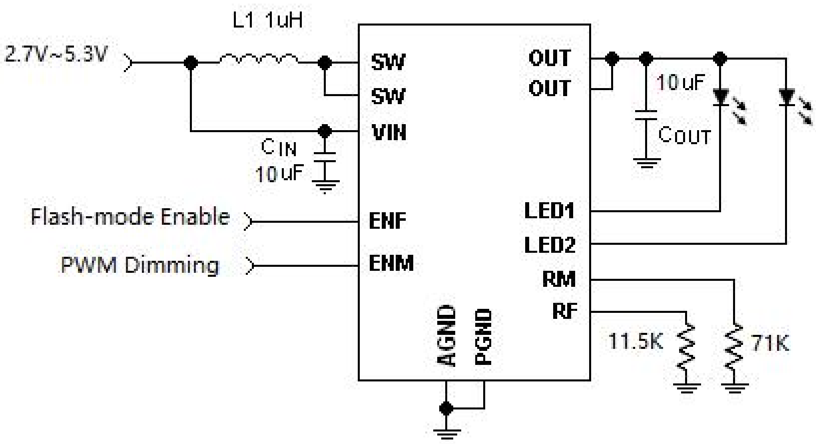


Figure 2, Typical Application Circuit of OCP8135B

■ Block Diagram

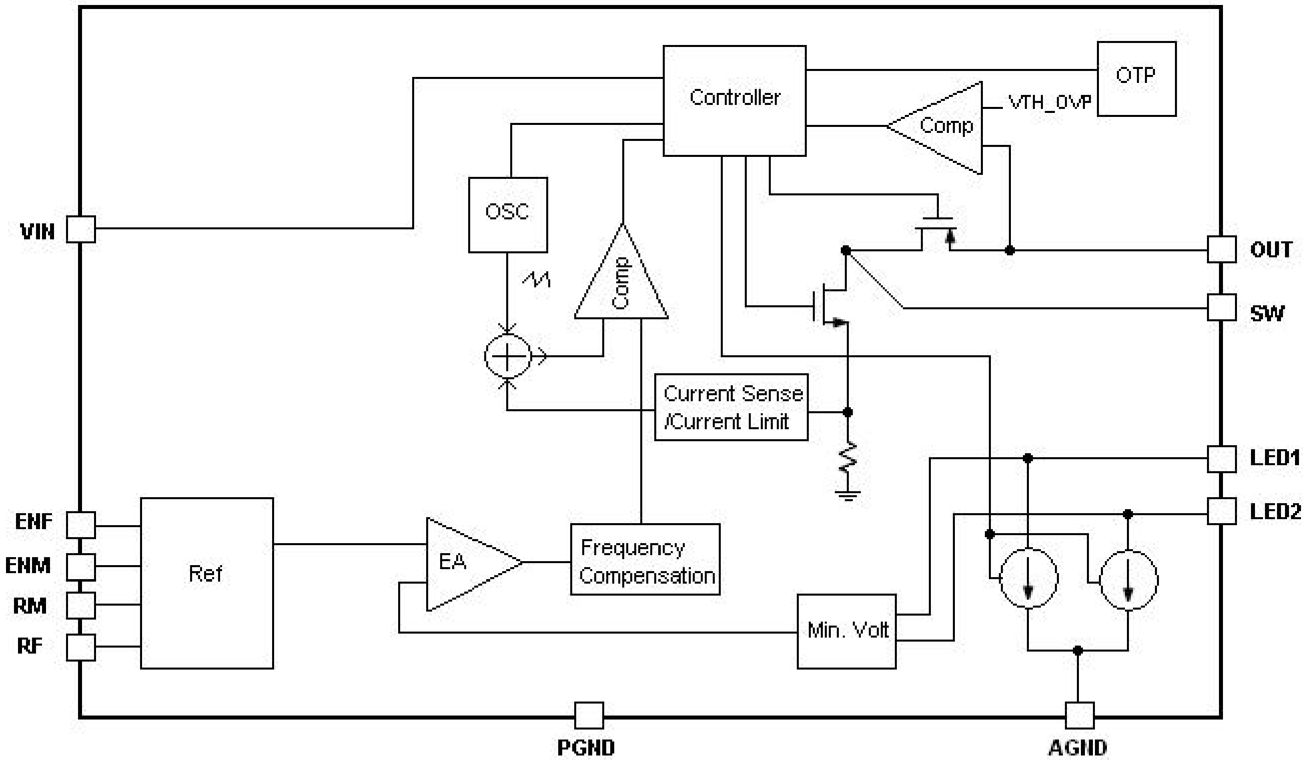


Figure 3, Block Diagram of OCP8135B

Absolute Maximum Ratings[1] (TA=25°C, unless otherwise noted)

Parameter	Symbol	Rating	Unit
V_{IN} Pin to GND	V_{IN}	-0.3 to +6.0	V
All Other Pins to GND		-0.3 to V_{IN}+ 0.3	V
Storage Temperature Range	T_S	-55 to +150	℃
Operating Junction Temperature Range	T_J	-40 to +150	℃
Maximum Soldering Temperature (at leads, 10 sec)	T_{LEAD}	300	℃

Recommended Operating Conditions[2]

Parameter		Symbol	Rating	Unit
V_{IN} Pin Voltage to GND		V_{IN}	+2.7 to +5.3	V
Flash LED Current		I_{FLASH}	Up to 1500	mA
Movie LED Current		I_{MOVIE}	Up to 800	mA
Operating Temperature Range		T_{OP}	-40 to +85	℃
Maximum Thermal Resistance	DFN2030-14L	Θ_{JA}	75	℃/W
Maximum Power Dissipation	T_A<25°C	P_D	1.35	W

Note:1:Stresses above those listed in absolute maximum ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one absolute maximum rating should be applied at any one time.

2: The device is not guaranteed to function outside of its operating conditions.

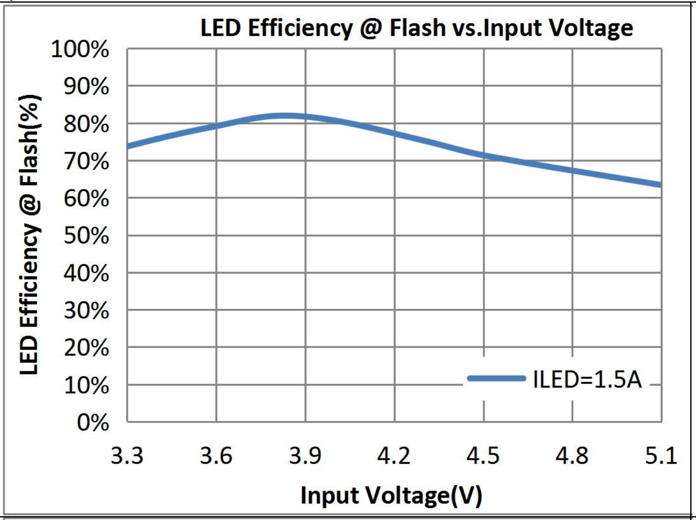
Electrical Characteristics

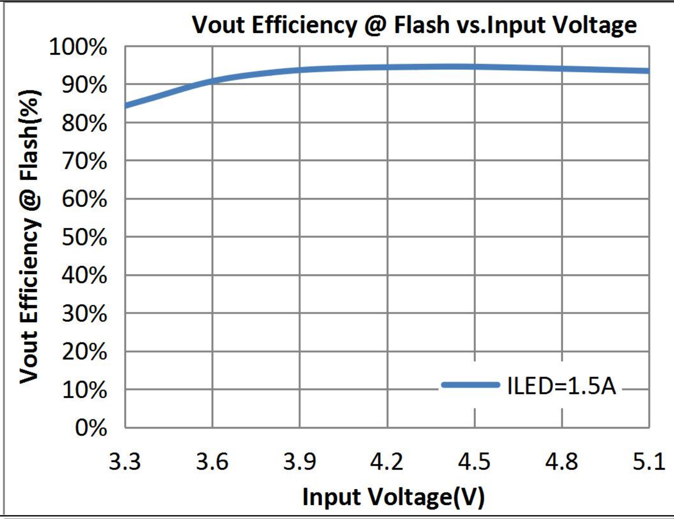
(T_A = -40 to +85℃ unless otherwise noted. Typical values are at T_A= +25℃,.V_{IN}= V_{EN} = 3.6V, C_{IN}=C_{OUT}=10uF, L=1.0uH, R_{RF}=11.5kΩ, R_{RM}=71kΩ)

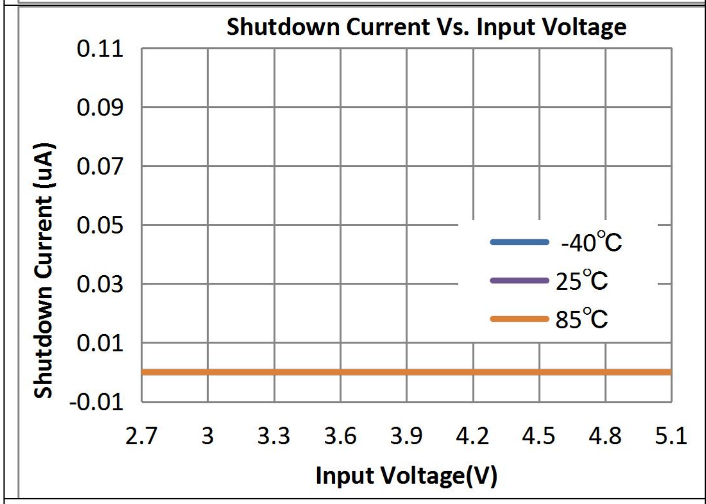
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Supply						
V_{IN}	Input Voltage		2.7	-	5.3	V
I_Q	Supply Current(non switching)	V_{OUT} = 3.0V	-	450	900	μA
	Supply Current(switching)	V_{OUT} = 4.5V	-	1.5	2.5	mA
I_{SHDN}	Supply CurrentShutdown	V_{ENM} = V_{ENF}= 0V	-	0.1	1	μA
V_{UV}	VIN Under Voltage Lockout	V_{IN} Rising	-	2.50	2.70	V
V_{UVLO}	Under Voltage Lockout Hysteresis		-	150		mV
Boost DC-DC Converter						
R_{NMOS}	NMOS Switch On-Resistance	I_{NMOS}=1A	-	100	-	mΩ
R_{PMOS}	PMOS Switch On-Resistance	I_{PMOS}=1A	-	100	-	mΩ
I_{CL}	Switch Current Limit	3.0V < V_{IN}< 4.2V	3.0	3.5	4.0	A
F_{SW}	Switching Frequency	3.0V < V_{IN}< 4.2V	-	2.0	-	MHz
D_{MAX}	Maximum Duty Cycle		65	75	-	%
V_{OVP}	Ouput Over Voltage Protection		-	5.3	-	V
	Output Over Voltage Hystersis		-	0.2	-	V
η1	Boost Output Efficiency	I_{FLASH} = 1.5A	-	97	-	%
η2	LED Efficiency	I_{LED} = 200mA	-	85	-	%
LED Current Sink						
I_{FLASH}	Maximum Flash Current	R_{RF}=11.5kΩ, LED1+LED2	-	1.5	-	A
I_{MOVIE}	Maximum Movie Current	R_{RM}=71kΩ, LED1+LED2	-	200	-	mA
I_{LED_ACC}	Current Sink Current Accuracy	I_{LED1}=I_{LED2}=0.75A		1		%
I_{LED_DIS}	LED1 and LED2 Dismatch	I_{LED1}=I_{LED2}=0.75A		1		%
$V_{LED1/2}$	Current Sink Saturation Voltage	I_{LED1}=I_{LED2}=0.75A	-	350	-	mV
T_{CT}	Maximum Flash ON Time		0.6	0.8	1.0	S
I_{LEDSC}	LED Short Circuit Sink Current		-	2.5	-	mA
ENM and ENF Enable Specifications						
V_{ENL}	EN OFF Threshold	V_{EN} Falling	0	-	0.4	V
V_{ENH}	EN ON Threshold	V_{EN} Rising	1.4	-	V_{IN}	V
R_{EN}	EN Pin Pull-down Resistor		200	300	400	kΩ
Thermal Shutdown						
T_{TH}	Thermal Shutdown		-	150	-	℃
T_{HS}	Thermal Shutdown Hysteresis		-	25	-	℃

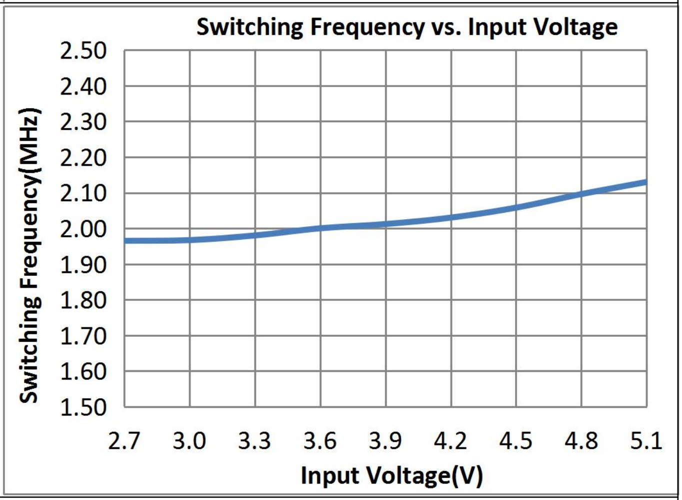
■ Typical Characteristics

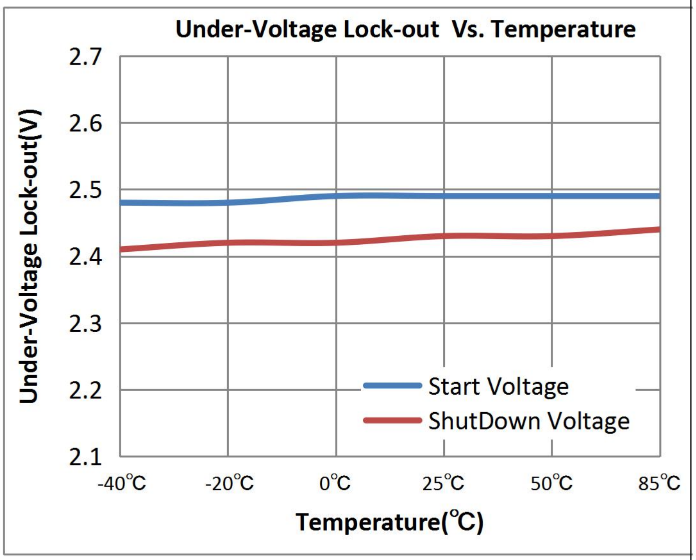
(Unless otherwise noted, V_{IN}= V_{EN} = 3.6V, C_{IN}=C_{OUT}=10uF, L=1.0uH, R_{RF}=11.5kΩ, R_{RM}=71kΩ)

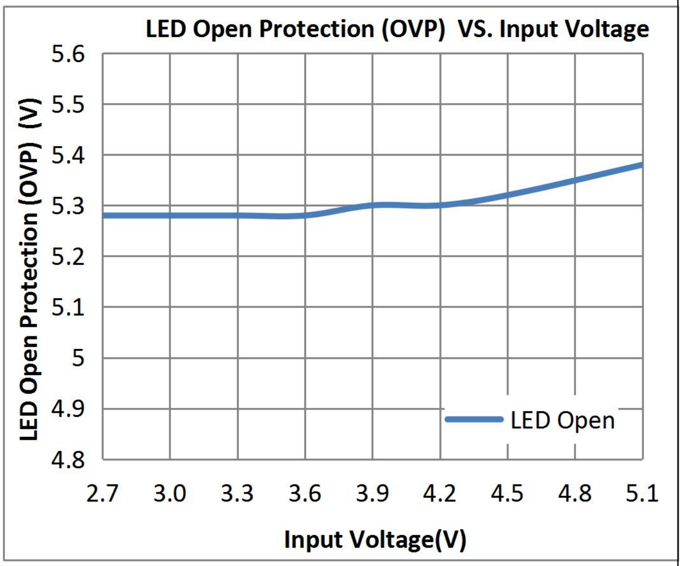






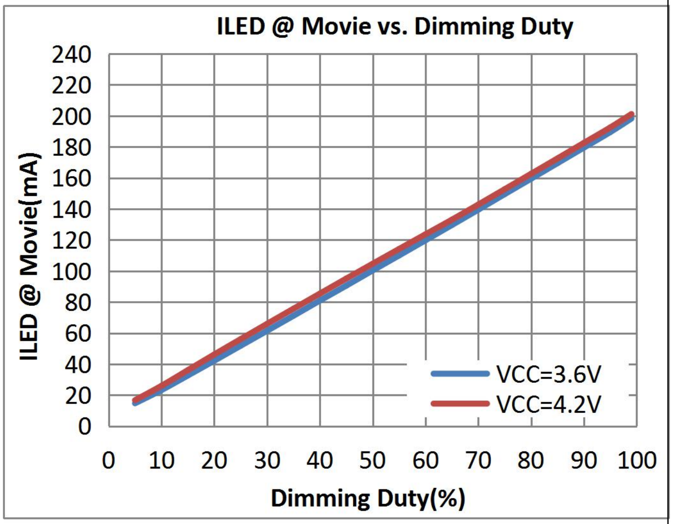


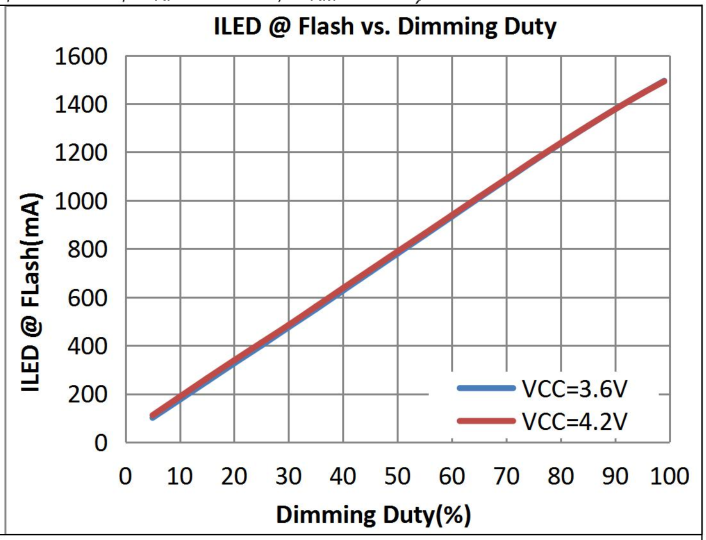




■ Typical Characteristics(continued)

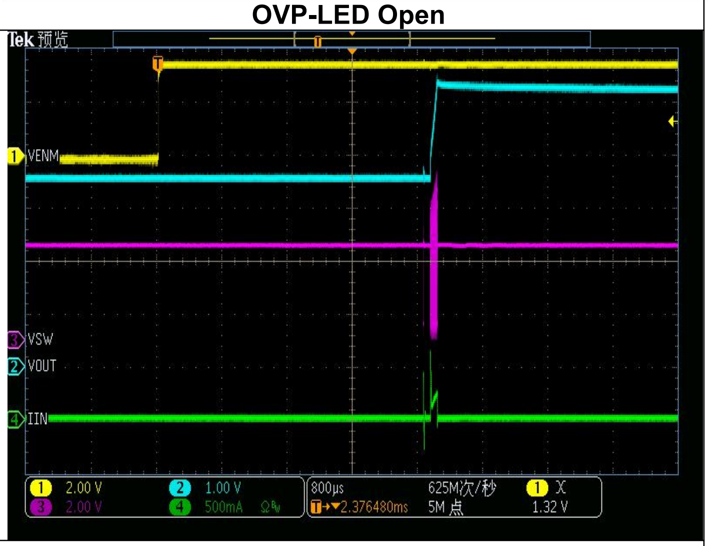
(Unless otherwise noted, V_{IN}= V_{EN} = 3.6V, C_{IN}=C_{OUT}=10uF, L=1.0uH, R_{RF}=11.5kΩ, R_{RM}=71kΩ)



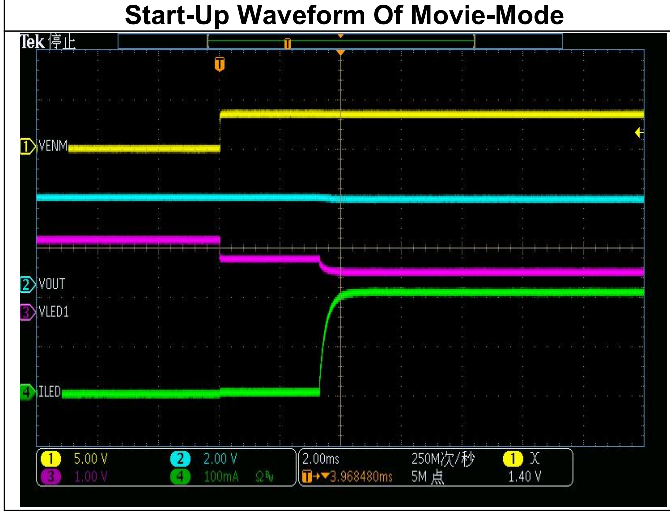


Switching Waveform

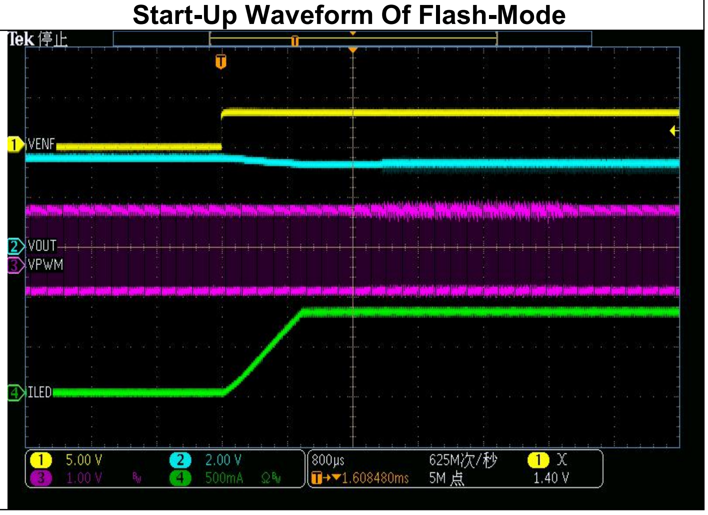
OVP-LED Open



Start-Up Waveform Of Movie-Mode



Start-Up Waveform Of Flash-Mode



Functional Description

The OCP8135B is a 2MHz fixed frequency synchronous boost converter, optimized for maximum 1.5A camera flash application and maximum 800mA movie mode applications using high-current white LEDs in all single cell Li-ion powered products. The PWMDC/DC converter switches and boosts the output to maintain at least 350mV across both current sink (LED1 and LED2).The uses of unique control schemes maintains accurate current regulation in each of two current sinks while leaving the output voltage at a minimum, increasing the overall conversion efficiency.

Two simple logic control inputs (ENM and ENF) enable and disable flash and movie mode operation of the OCP8135B.Movie-mode and Flash-mode current levels are independently fixed by two separate resistors (RM and RF). For Flash mode, a default timer can be used either to terminate a flash event or as a safety flash timer. One or two LEDs can be connected to the OCP8135B; In the case of two LEDs the output current is matched between each diode.

The OCP8135B contains a thermal management system to protect the device; A internal over-voltage protection (OVP) circuitry prevents damage to the OCP8135Bfrom open LED or open circuit conditions; And a cycle-by-cycle current limit prevents damage to the OCP8135B. The shutdown feature reduces quiescent current to less than 1.0μA.The 2MHz switching frequency allow for the use of tiny, low profile (1uH or 2.2uH) inductors and 10uF ceramic capacitors.

Open-LED Protection

When VOUT reaches OVP(5.3V,typ.), the overvoltage comparator will trip and turn off both the internal FETs. When VOUT falls below 5.1V(typ.), the OCP8135Bwill begin switching again.

When VOUT reaches OVP and the channel of lower voltage is less than 100mV(typ.), then OCP8135B will predicate open of this channel and disable it, the other channel with properly operating LED will control the loop and VOUT will be regulated down to normal operating voltage. This protection feature avoids unnecessary power consumption in the current sink by regulating the output voltage at the lowest level possible to maintain regulation for active channel. Not only does this protect from open LEDs failures, but also allow only single flash LED operation with the unused channel floating or open. Open-circuit LED fault protection is reset when the IC is powered down and up again.

Short-LED Protection

When the IC is enabled and start up, a test current of 2mA (typical) is forced through each sink channel. The channel will be disabled if the voltage of that particular sink pin does not drop to a certain threshold. This feature is very convenient for disabling an unused channel or during an LED fail-short event. This small test current should be added to the set output current in both flash and movie mode conditions.

Under-Voltage Lockout

The OCP8135Bcontains under-voltage-lockout (UVLO)circuitry that disables the IC until VIN is greater than2.50V.

MOSFET Current Limit

The OCP8135B features current limit of 3.5A. When the current limit is reached, the OCP8135B stops switching for the remainder of the switching cycle.

Since the 3.5A current limit is sensed in the NMOS switch there is no mechanism to limit the current when the device operates in Pass Mode. In situations where there could potentially be large load currents at OUT, and the OCP8135Bis operating in Pass Mode, the load current must be limited to 2.5A.

Over Thermal Protection

Thermal protection disables the OCP8135Bwhen internal power dissipation becomes excessive, as it disables both MOSFETs. The junction over-temperature threshold is150°C with 25°C of temperature hysteresis. The output voltage automatically recovers when the over-temperature fault condition is removed.

Flash Mode Operation

By transmitting the ENF input pin low-to-high, a flash pulse and the internal timer are initiated. The maximum flash current in the OCP8135Bis set by an external resistor, RF.

$$I_{FLASH(LED1)} = I_{FLASH(LED2)} = \frac{8625}{R_{RF}(K\Omega)}(\text{mA})$$

The flash timer will terminate the flash current regardless of the status of the ENF pin. This can be either used as a simple flash timing pulse or can be used as a safety timer in the event of a control logic malfunction to prevent the LED from overheating.

In flash mode, intelligent temperature control is achieved by increasing chip temperature in the range of approximately 110°C to 150°C, when the internal temperature 110°C, the flash setting current start to decrease; when temperature 150°C, the flash current decrease to zero.

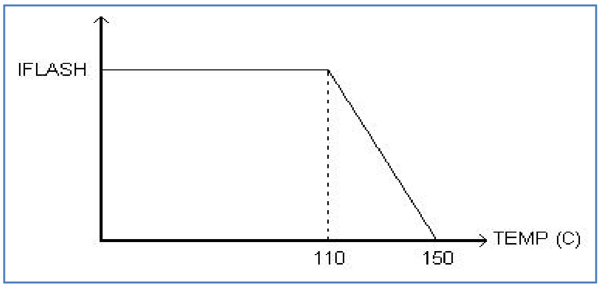


Figure 4, Intelligent Temperature Control

Movie Mode Operation

The movie mode is enabled when the ENM input pin transitions from low to high and will remain on until input is pulled back to a low logic level. The movie-mode current level is set by an external resistor connected between RM and GND. Channel current outputs(LED1 and LED2) in movie mode operate in the same manner as they do in flash mode, only at a current level as set by the RM resistor.

$$I_{MOVIE(LED1)} = I_{MOVIE(LED2)} = \frac{7100}{R_{RM}\,(K\Omega)}\,(\mathrm{mA})$$

The flash timer function is disabled in movie mode to permit constant LED illumination.

In applications where only one LED is connected to either LED1 or LED2, the unused current channel must be directly connected to OUT, thereby disabling that channel.

■ Operation Timing Diagram

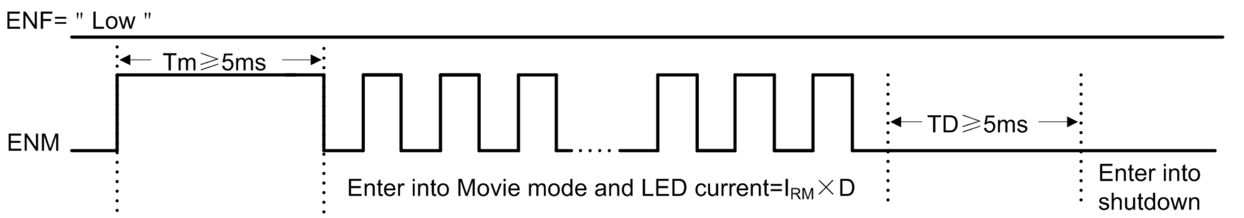


Figure 5, Movie Mode Timing Diagram

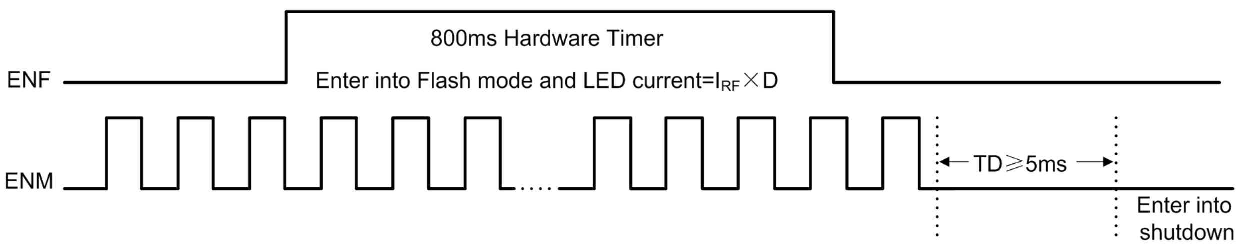


Figure 6, Flash Mode Timing Diagram

Application Information

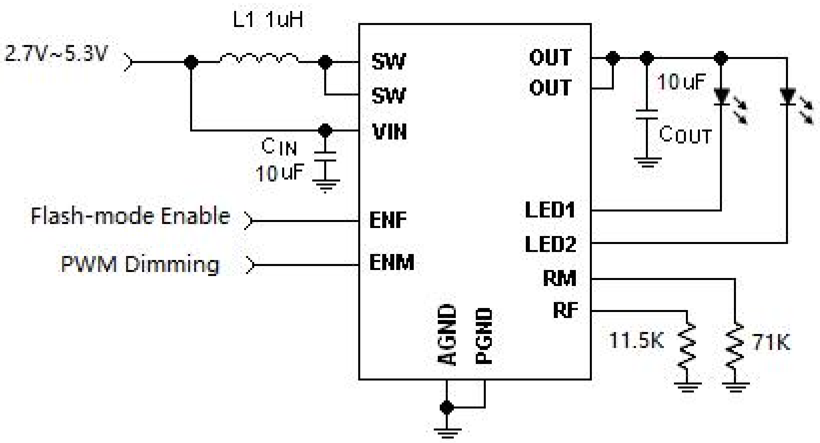


Figure 7, Typical Application Circuit of OCP8135B

Flash LED Connection

The OCP8135B supports up to two 0.75A Flash WLEDs. The two LEDs are connected from OUT pin to LED1 pin and LED2 pin respectively. We can connect LED1 pin and LED2 pin together to driver one 1.5AWLED. If LED1 pin or LED2 pin is not used, the LED1 pin or LED2 pin should be connected to OUT.

LED Selection

The OCP8135Bis specifically designed to drive ultra bright flash LEDs with typical forward voltage of 2.5V to 4.2Vwithin 0.75A forward current. Since the LED1 and LED2 pins have internal current-mirror circuitry which matches both channels with tight accuracy up to 0.75A per channel; the LED-to-LED brightness will be matched regardless of the individual LED forward voltage (VF). Circuit designers should consult the LED supplier for LED specifications.

Shutdown

The current sink devices (LED1 and LED2) are the power returns for all loads, there is no leakage current through load if the current sink devices are disabled. When ENF and ENF are both held at logic low level, theOCP8135Bis disabled and draws less than 1uA of leakage current from VIN.

Inductor Selection

The selection of the inductor affects steady state operation as well as transient behavior and loop stability. These factors make it the most important component in power regulator design. There are three important inductor specifications, inductor value, DC resistance and saturation current. Considering inductor value alone is not enough.

The inductor value determines the inductor ripple current. Choose an inductor that can handle the necessary peak current without saturating, according to half of the peak-to-peak ripple current given by I_P equation, pause the inductor DC current given by:

$$I_{IN\_DC} = \frac{V_{OUT} * I_{OUT}}{V_{IN} * \eta}$$

Inductor peak-to-peak current ripple:

$$I_{L\_PP} = \frac{V_{IN} * (V_{OUT} - V_{IN})}{V_{OUT} * L * F_S}$$

Inductor peak current:

$$I_{L\_PPEAK} = I_{IN} + \frac{I_{L\_PP}}{2} = \frac{V_{OUT} * I_{LED}}{V_{IN} * \eta} + \frac{V_{IN} * (V_{OUT} - V_{IN})}{2 * V_{OUT} * L * F_S}$$

Inductor values can have ±20% tolerance with no current bias. When the inductor current approaches saturation level, its inductance can decrease 20% to 35% from the 0A value depending on how the inductor vendor defines saturation current. Using an inductor with a smaller inductance value forces discontinuous PWM when the inductor current ramps down to zero before the end of each switching cycle. This reduces the boost converter's maximum output current, cause's large input voltage ripple and reduces efficiency.

For these reasons, a 1μH to 2.2μH inductor value range is recommended. The inductor parameters, current rating, DCR and physical size, should be considered. The DCR of inductor with lowest DCR is chosen for highest efficiency. The saturation current rating of inductor must be greater than the switch peak current, typically 4.5A. These factors affect the efficiency, output load capability, output voltage ripple, and cost. A 1μH inductor optimized the efficiency for most application while maintaining low inductor peak to peak ripple. Customers need to verify the inductor in their application if it is different from there commended values.

For a given inductor type, smaller inductor size leads to an increase in DCR winding resistance and, in most cases, increased thermal impedance. Winding resistance degrades boost converter efficiency and increases the inductor's operating temperature:

$$P_{LOSS(INDUCTOR)} = I_{RMS}^2 * DCR$$

Capacitor Selection

For good input voltage filtering low ESR ceramic capacitors are recommended. A 10uF input capacitor is recommended for high current flash LEDs to improve transient behavior of regulator and EMI behavior of the total power supply circuit. The input capacitor should be placed as close as possible to input pin and the PGND of the IC.

The output capacitance requires depends on required current. A 10uF ceramic capacitor works well in most situations.

Thermal Considerations

The maximum IC junction temperature should be restricted to 125°C under normal operating conditions. This restriction limits the power dissipation of the OCP8135B. Calculate the maximum allowable dissipation, $P_{D(max)}$,and keep the actual dissipation less than or equal to $P_{D(max)}$. The maximum-power-dissipation limit is determined using following equation:

$$P_{D(MAX)} = \frac{125^\circ C - T_A}{R_{\theta JA}}$$

Where, T_A is the maximum ambient temperature for the application. $R_{\theta JA}$ is the thermal resistance junction-to-ambient given in Power Dissipation Table.

Layout Considerations

The high switching frequency and large switching currents of the OCP8135B make the choice of layout important. The following steps should be used as a reference to ensure the device is stable and maintains proper LED current regulation across its intended operating voltage and current range.

1. Place CIN on the top layer (same layer as the OCP8135B)and as close to the device as possible. The input capacitor conducts the driver currents during the low side MOSFET turn-on and turn-off and can see current spikes over 0.85A in amplitude. Connecting the input capacitor through short wide traces to both the IN and GND terminals will reduce the inductive voltage spikes that occur during switching and which can corrupt the VIN line.

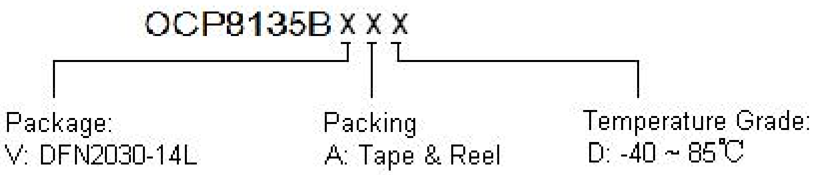
2. Place C_{OUT} on the top layer (same layer as the OCP8135B)and as close as possible to the OUT and GND terminal. The returns for both CIN and COUT should come together at one point, and as close to the GND pin as possible. Connecting COUT through short wide traces will reduce the series inductance on the OUT and GND terminals that can corrupt the VOUT and GND line and cause excessive noise in the device and surrounding circuitry.

3. Connect the inductor on the top layer close to the SW pin. There should be a low-impedance connection from the inductor to SW due to the large DC inductor current, and at the same time the area occupied by the SW node should be small so as to reduce the capacitive coupling of the high dV/dt present at SW that can couple into nearby traces.

4. Avoid routing logic traces near the SW node so as to avoid any capacitively coupled voltages from SW onto any high-impedance logic lines such as ENM, ENF, RF and RM. A good approach is to insert an inner layer GND plane underneath the SW node and between any nearby routed traces. This creates a shield from the electric field generated at SW.

5. For Flash LEDs that are routed relatively far away from the OCP8135B, a good approach is to sandwich the forward and return current paths over the top of each other on two layers. This will help in reducing the inductance of the LED current paths. Consider additional PCB exposed area for the flash LEDs to maximize heat sinking capability. This may be necessary when using high current application and long flash duration application.

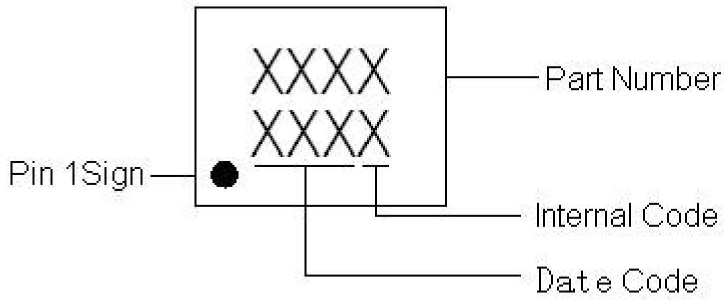
■ Ordering Information



Part Number	Driver Capability	Package Type	Package Qty	Temperature	Eco Plan	Lead
OCP8135BVAD	1.5A or 2*0.75A	DFN2030-14L	7-in reel3000pcs/reel	-40～85℃	Green	Cu

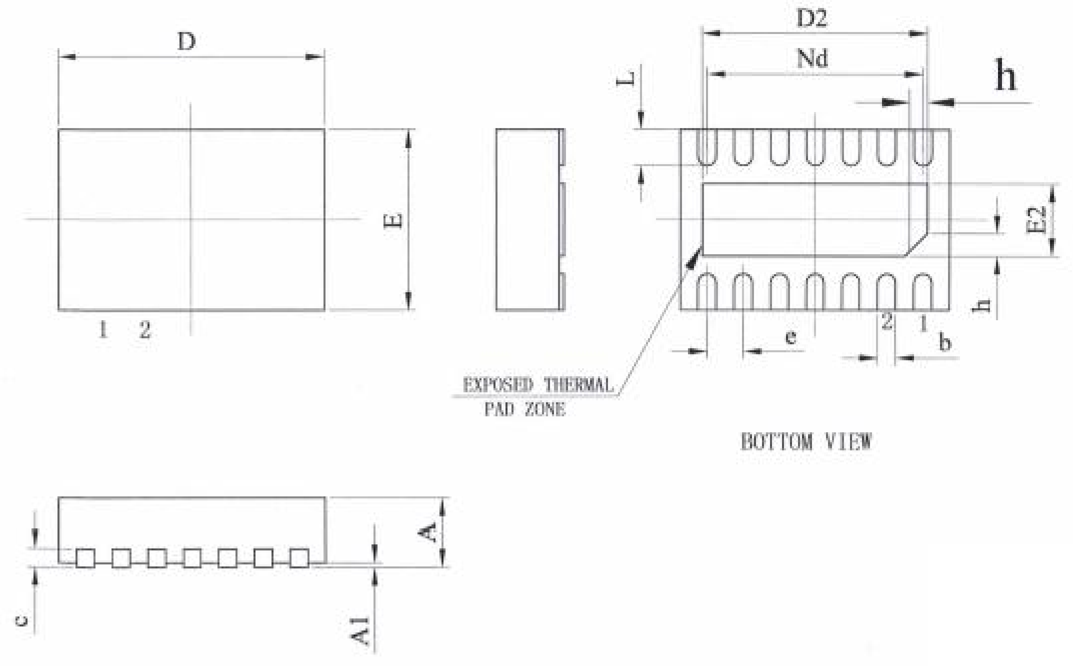
■ Marking Information

DFN2030-14L



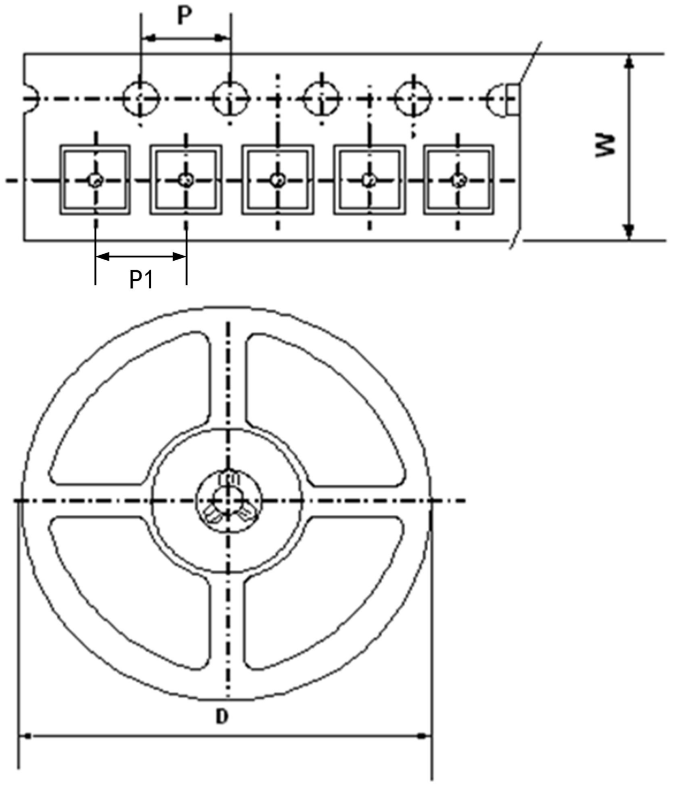
■ Package Information

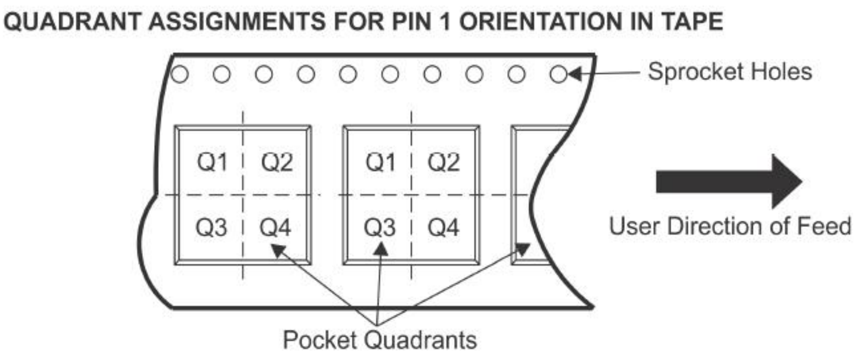
DFN2030-14L:



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	0.02	0.05	0.00	0.001	0.002
b	0.15	0.18	0.25	0.006	0.007	0.010
c	0.18	0.20	0.25	0.007	0.008	0.010
D	2.90	3.00	3.10	0.115	0.118	0.122
D2	2.40	2.50	2.60	0.094	0.098	0.102
e	0.40 BSC			0.016 BSC		
Nd	2.40 BSC			0.094BSC		
E	1.90	2.00	2.10	0.075	0.079	0.083
E2	0.70	0.80	0.90	0.028	0.031	0.035
L	0.30	0.35	0.40	0.012	0.014	0.016
h	0.20	0.25	0.30	0.008	0.010	0.012

■ **Packing Information**





Package Type	MSL	Carrier Width(W)	Pitch(P/P1)	Reel Size(D)	Packing Minimum	Pin Quadrant
DFN2030-14L	Level-3-260C	8.0±0.1 mm	4.0±0.1 mm	180±1 mm	3000pcs	Q1

Note: Carrier Tape Dimension, Reel Size and Packing Minimum

IMPORTANT NOTICE

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