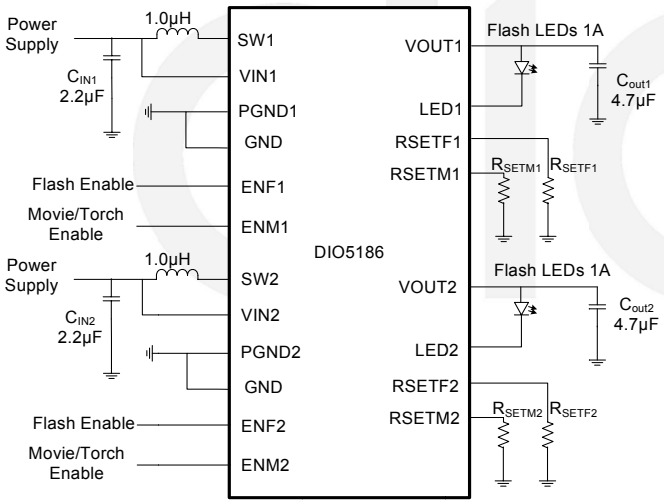
DIO5186
2MHz, 2A Dual Channel Flash LED Driver

Features

- Dual Flash LED Outputs
- Drive Up to Total 2A or 1A per Channel
- Up to 90% Efficiency
- Integrated 2MHz Step-Up Converter
- 3V to 5V Operation Voltage Range
- Very Small Inductor: 1.0μH
- Independent Flash Mode Enable and Movie/Torch Mode Enable Pins
- Flash Mode or Movie/Torch Mode Dimming via PWM Control
- One Resistor Sets Flash Mode LED Current
- One Resistor Sets Movie/Torch Mode LED Current
- Integrated Thermal Regulation Control
- 10kHz to 200kHz PWM Dimming Frequency
- 600ms Flash Timer Control
- 330kΩ Pull-Down Resistor on ENM and ENF Pins
- LED Open or Short Protection
- Output Over-Voltage Protection
- Cycle-by-Cycle Inductor Current Limit
- 0.1μA Shutdown Current
- Available in Green QFN4*4-24 Package
- -40°C to +85°C Operating Temperature Range

Typical Applications



Descriptions

DIO5186 is a Boost-architecture high power flash LED driver, ideally for smart phone camera modules or digital still camera modules. The internal DC/DC switch works at 2MHz and needs few peripheral components, fitting for portable photo flash solution.

DIO5186 has independent Flash mode and Movie/Torch mode enable pins. Flash mode is usually used with 600ms timer control to generate a high intensity flash. The Flash mode and Movie/Torch mode LED current is programmed by external resistors respectively, making the flash LED solution simple to control. If both enable pins are at logic high, the LED current will be programmed by the Movie/Torch mode setting resistor.

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

DIO5186 has many protection features, including cycle-by-cycle input current limit protection, output over-voltage protection, LED fault (open or short) protection and thermal shutdown protection. The leakage current in shutdown is 0.1μA. DIO5186 is available in Green QFN4*4-24 package. It operates over an ambient temperature range of -40°C to +85°C.

Applications

- Single Cell Li-Battery Powered Products
- Portable Audio Players
- Cellular Phones
- Personal Medical Products

Ordering Information

Order Part Number	Top Marking		T_A	Package	
DIO5186CN24	DIO5186	Green	-40 to +85°C	QFN4×4-24	Tape & Reel, 5000

Pin Assignments

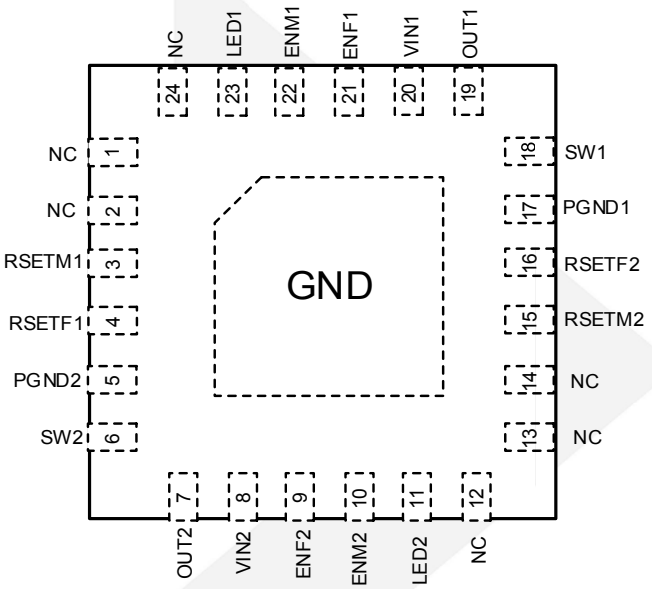


Figure 1 Pin Assignment (Top View)

Pin Definitions

PIN	Pin Name	Description
3	RSETM1	Movie and Torch Mode Current Setting Pin
4	RSETF1	Flash Mode Current Setting Pin
20	VIN1	Input Supply Pin for the IC
18	SW1	Switching Node of the Step-Up Converter
17	PGND1	Power Ground Pin.
19	VOUT1	Output Voltage Pin.
21	ENF1	Flash Mode Enable Pin. This pin has an internal 330k pull-down resistor to GND.
22	ENM1	Movie/Torch Mode Enable Pin. This pin has an internal 330k pull-down resistor to GND.
23	LED1	Regulated Output Sink Current. Up to 1A current.
15	RSETM2	Movie and Torch Mode Current Setting Pin
16	RSETF2	Flash Mode Current Setting Pin
8	VIN2	Input Supply Pin for the IC
6	SW2	Switching Node of the Step-Up Converter

5	PGND2	Power Ground Pin.
7	VOUT2	Output Voltage Pin.
9	ENF2	Flash Mode Enable Pin. This pin has an internal 330k pull-down resistor to GND.
10	ENM2	Movie/Torch Mode Enable Pin. This pin has an internal 330k pull-down resistor to GND.
11	LED2	Regulated Output Sink Current. Up to 1A current.
Exposed pad	GND	Connected to ground for electrical and thermal usage. Exposed pad is Pad internally connected to analog ground pin.
1,2,12,13,14,24	NC	No connect

Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Rating” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maxim rating conditions for extended periods may affect device reliability.

Parameter	Rating	Unit
VIN, VOUT, LED1 and LED2 voltage	-0.3 to 6	V
ENF, ENM, RSETF, RSETM	-0.3 to V_{IN}+0.3	V
SW voltage	-0.3 to 6.5	V
Junction Temperature	150	°C
Storage Temperature	-65 to 150	°C
Lead Temperature (soldering, 10s)	260	°C
ESD (HBM)	4000	V
ESD (MM)	200	V

Recommend Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended Operating conditions are specified to ensure optimal performance to the datasheet specifications. DIOO does not Recommend exceeding them or designing to Absolute Maximum Ratings.

Parameter	Rating	Unit
Input Supply Voltage	3 to 5	V
Operating Temperature Range	-40 to 85	°C

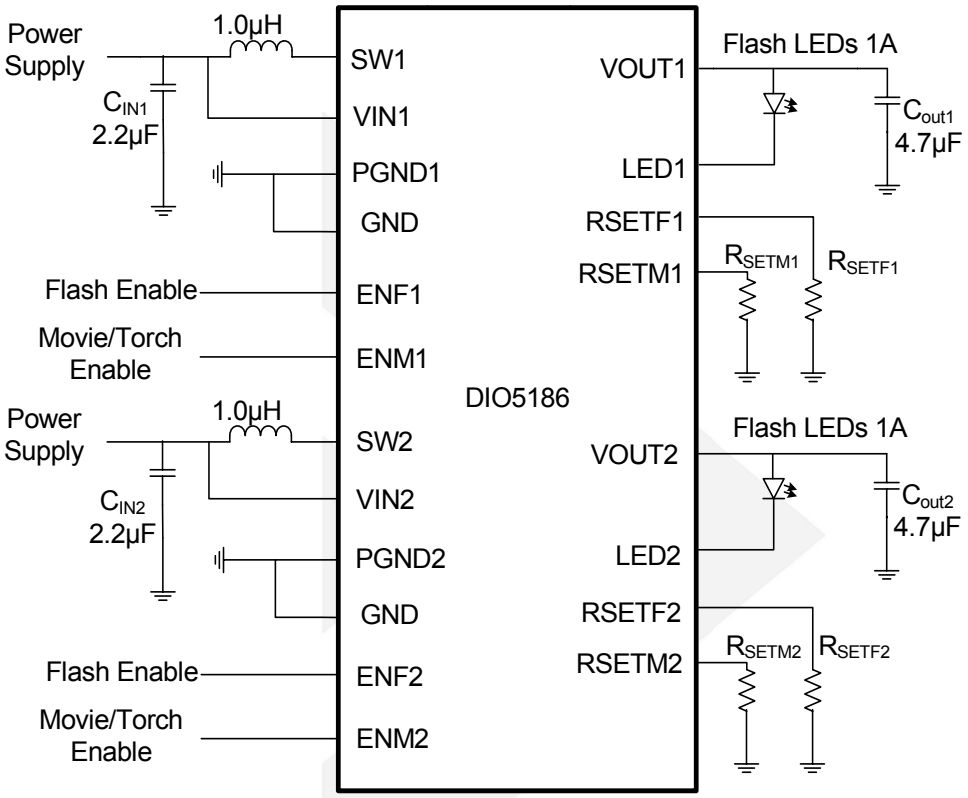
Electrical Characteristics

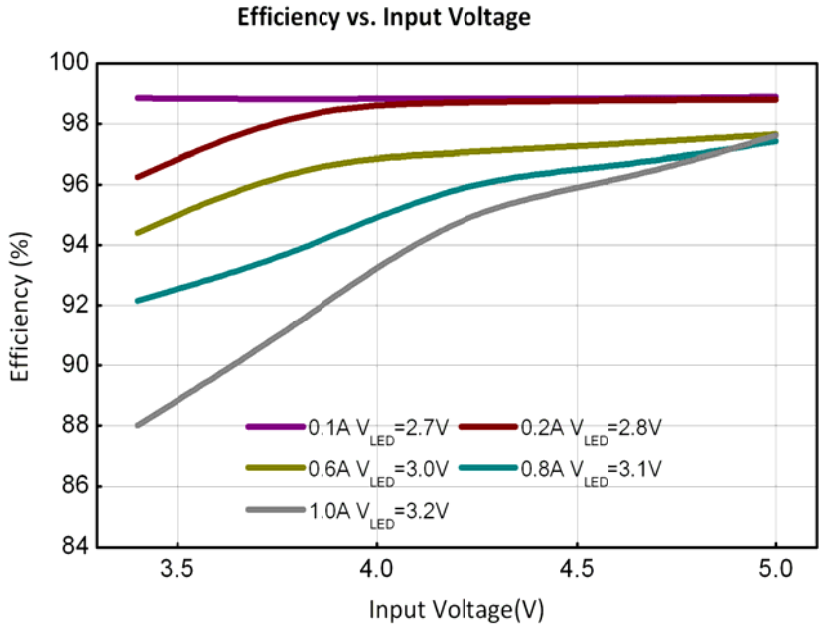
(V_{IN} = V_{EN} =3.6V, typical values at +25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
IC Supply						
Input Voltage Range	V_{IN}		3		5	V
Under-Voltage Lockout Threshold	UVLO	Rising edge		2.4		V
Under-Voltage Lockout Hysteresis	V_{HYS}			0.23		V
Supply Current	I_Q	Not switching		700		μA
Supply Current in Shutdown	I_{SHDN}	ENF=ENM=GND		0.1		μA
Step-up Converter						
Oscillator Frequency	f_S			2		MHz
Internal Over-Voltage Threshold of OUT	V_{OVP}			5.3		V
Flash Mode Soft-Start Time	t_S			200		μs
Current Sink						
Total Output Current, Movie/Torch Mode	I_D	ENM=HIGH, R_{SETM}=136kΩ, LED1+LED2, T_A=25℃		200		mA
Total Output Current, Flash Mode		ENF=HIGH, ENM=GND, R_{SETF}=13.6kΩ, LED1+LED2, T_A=25℃		2		A
LED Short Checking Current	I_{SHORT}			5		mA
Control						
ENF, ENM Pin Logic Low Threshold	V_{IL}				0.4	V
ENF, ENM Pin Logic High Threshold	V_{IH}		1.5			V
ENF Internal Pull-Down Resistance	$R_{PD(ENF)}$			330		kΩ
ENM Internal Pull-Down Resistance	$R_{PD(ENM)}$			330		kΩ
Junction Thermal Shutdown Threshold				145		℃
Junction Thermal Shutdown Hysteresis				17		℃
Delay Time To Shutdown Status In Movie/Torch Mode (For PWM Dimming LED Current)						
Delay Time	t_D			3		ms
Flash Timer						
Hardware Flash Timer	t_{TIME}			600		ms

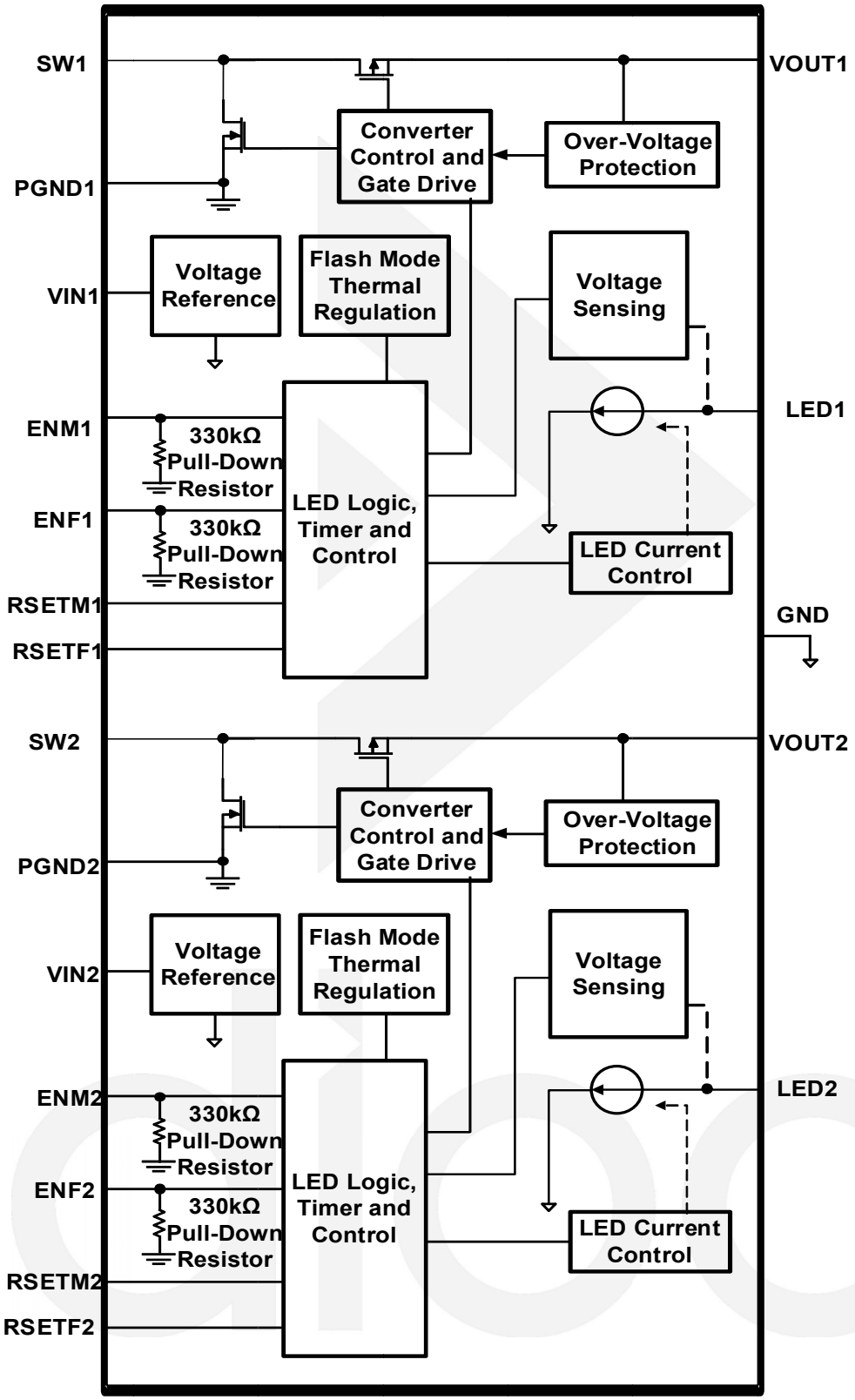
Specifications subject to changes without notice.

Typical Application

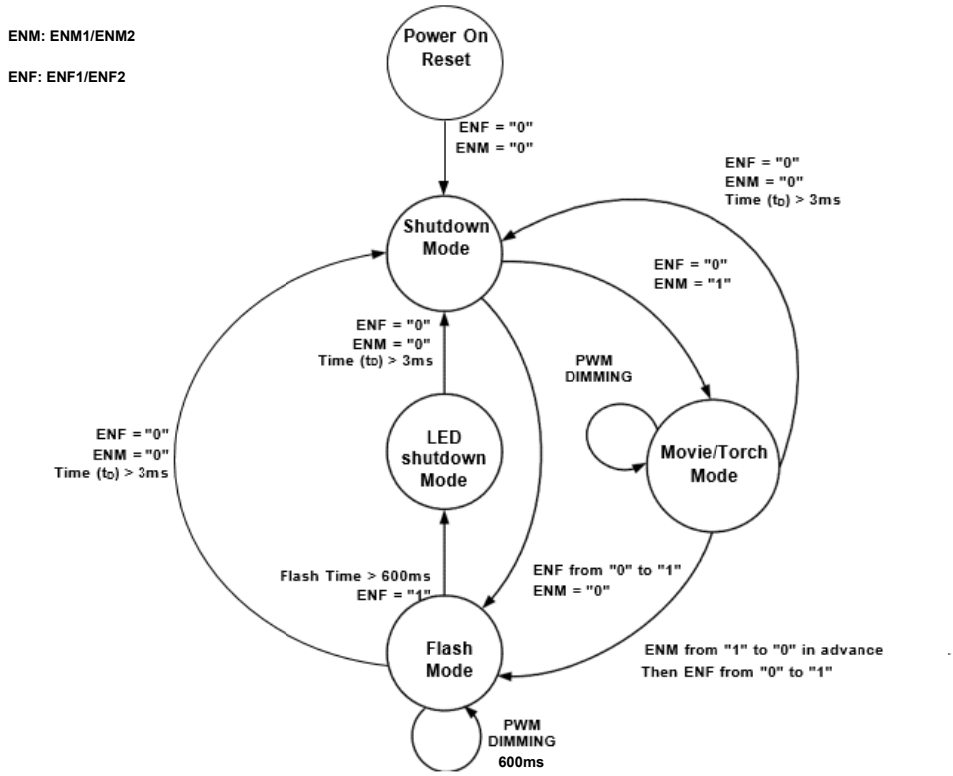




Functional Block Diagram



State Diagram



Application Information

The DIO5186 is a very high switching frequency step-up (boost) flash LED driver. Two current regulating devices are integrated to drive up to 2 flash LEDs.

The voltage step-up is accomplished by a boost topology, using an inductor-based DC/DC switching converter, in which the inductor serves as an energy storage device. By integrating optimized power MOSFETs, the DIO5186 internal switching frequency is 2MHz while still maintaining high power efficiency. Unlike a traditional DC/DC boost converter with a fixed output voltage, the DIO5186 dynamically changes its output voltage depending on the flash LED forward voltage and current. The use of unique control schemes maintains accurate current regulation in each of the two current sinks while leaving the output voltage at a minimum, increasing the overall conversion efficiency. The internal step-up converter boosts the output voltage high enough to drive the LEDs with the highest forward voltage.

The control interface is designed for maximum design flexibility and compatibility with various types of system controls. When the ENF is pulled high while the ENM is low, the LED current will be ramped up to the Flash mode current level which is programmed by RSETF resistor. When ENM is pulled high while the ENF is low, the LED current will be ramped up to the Movie/Torch mode current level which is programmed by RSETM resistor. However, if both ENM and ENF are high, the LED current will be set to Movie/Torch mode current. The driver IC and the flash LEDs will be shutdown when both ENF and ENM are at logic low.

Flash Mode LED Current

LED1 and LED2 Flash mode LED current can be programmed up to a maximum total current of 2A or up to 1A per channel. The Flash mode current in each channel is set by the RSETF resistor. For the desired Flash mode current in each output, the resistor value can be calculated using the following equation:

$$I_{FLASH\ (D1)} = I_{FLASH\ (D2)} = 13600/R_{SETF}$$

For DIO5186, A flash event is initiated by asserting the ENF pin while ENM is at logic low level. A flash event is automatically terminated when ENF is dessert or when ENM is asserted. For additional flexibility, a lower Flash mode current than the value calculated above can be realized by applying a PWM dimming signal at ENF pin while ENM is held low. The average Flash mode current will be proportional to the PWM duty ratio. The range of PWM dimming frequency is from 10kHz to 200kHz.

Automatic thermal regulation control is active when DIO5186 is in Flash mode. If Flash mode is enabled and the flash current is set to a high current value, the temperature of the IC can increase quickly. Once the IC's temperature goes above 100℃, the two sinks' currents will be automatically decreased according to the thermal regulation control loop. This can prevent the IC from triggering thermal shutdown and causing the LEDs to flicker. Depending on the thermal layout of the PCB and the Flash mode current setting, the DIO5186 sink current can be lower than the programmed value due to the thermal regulation protection feature.

For DIO5186, the flash time is 600ms. This hardware timer will protect DIO5186. This timer will turn off the LED flashing current after time is over.

LED Short Protection

When the DIO5186 is enabled, there is a 5mA (typical) LED sensing current through each current sink. It is used to detect whether either LED is shorted by generating a voltage drop through each LED. The IC internally compares the voltage difference between VOUT and each sink node (LED1 and LED2). If this difference is below a preset threshold, the IC will treat the respective LED as shorted and disable its Flash/Movie mode current through this LED channel. However, the 5mA sensing current will be kept to generate the LED's voltage drop. Because some normal flash LEDs may have larger than desired leakage current (up to hundreds of micro-amps) even it's not fully turned on, this 5mA sensing current can guarantee that a properly functioning LED will not mistakenly be treated as a shorted LED. If the short circuit is removed during operation, the channel will automatically recover to the programmed current setting.

LED Open Protection

In case of LED open, the open channel will control the loop first so that VOUT will reach OVP (approximately 5.3V), and then DIO5186 will automatically detect which channel's LED is open and disable that channel. From that point, the other channel with properly operating LED will control the loop and VOUT will be regulated down to a 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 the active channel. Not only does this protect from open LEDs failures, but also allows 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.

Movie/Torch Mode LED Current

LED1 and LED2 Movie/Torch mode LED current can be programmed up to a maximum total current of 400mA or up to 200mA per channel. The Movie/Torch mode current in each channel is set by the RSETM resistor. For the desired Movie/Torch mode current in each output, the resistor value can be calculated using the following equation:

$$I_{MOVIE\ (D1)} = I_{MOVIE\ (D2)} = 13600/R_{SETM}$$

A Movie/Torch mode event is initiated by asserting the ENM pin. For additional flexibility, a lower Movie/Torch mode current than the value calculated above can be realized by applying a PWM dimming signal at ENM pin while ENF is held low. The average Movie/Torch mode current will be proportional to the PWM duty ratio.

Inductor Selection

The DIO5186 is designed to use a 1.0μH to 2.2μH inductor. To prevent core saturation, ensure that the inductor-saturation current rating exceeds the peak inductor current for the application. The worst-case peak inductor current can be calculated with the following formula:

$$I_{PEAK(L)} = \frac{V_{O(MAX)} \times I_{LED(MAX)}}{0.8 \times V_{IN(MIN)}} + \frac{V_{IN(MIN)} \times t_{ON(MAX)}}{2 \times L}$$

If the inductor value is smaller, the inductor peak current will increase. To maintain stable operations for the boost converter, the inductor peak current must be less than both the DIO5186 current limit threshold (2.9A TYP) and the inductor saturation current rating. Manufacturer's specifications of inductors list both the inductor DC current rating, which is a thermal limitation, and peak inductor current rating, which is determined by the saturation characteristics. Measurements at full load and high ambient temperature should be performed to ensure that the inductor does not saturate or overheat due to its parasitic resistance. Bench measurements are recommended to confirm actual inductor peak current I_{PEAK} and to ensure that the inductor does not saturate at maximum LED current and minimum input supply voltage.

Recommend Power Inductor and Parameters

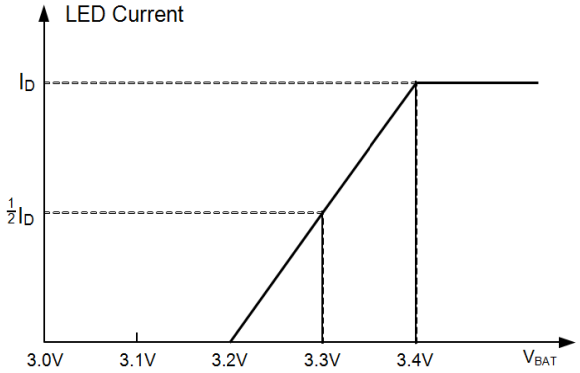
Manfacturer	P/N	Inductance	DCR	Isat(A)		Irms(A)		Dimension
		uH	Ω	MAX	TPY	MAX	TYP	mm
Sunlord	WPN201610H1R0MT	1.0±20%	0.075	3.35	3.85	2.05	2.35	2.0*1.6*1.0
Sunlord	WPN252010H1R0MT	1.0±20%	0.076	3.1	3.5	2.5	2.9	2.5*2.0*1.0

Capacitor Selection

For good input voltage filtering low ESR ceramic capacitors are recommended. At least a 2.2μF input capacitor is recommended for high current flash LEDs to improve transient behavior of the regulator and EMI behavior of the total power supply circuit. The input capacitor should be placed as close as possible to the input pin and the PGND pin of the DIO5186. The output capacitance required depends on the required LED current. A 2.2μF or 4.7μF ceramic capacitor works well in most situations.

LED Current Control When VIN < 3.4V

In order to protect battery damaging by big LED current in low battery voltage status, DIO5186 can linearly reduce the LED current; the control curve is shown in Figure:



Layout Guidelines

It is very important to PCB layout, especially to high switching transition and high current converter. Careful PCB layout is required, or the regulator maybe happen unstable problem, as well as EMI problem. Therefore, wide and short traces will be considered for the main switching current paths and ground. The below guidelines will be recommended.

1. Input capacitor, output capacitor, inductor and flash LED should be placed as possible as close to the DIO5186 chip.

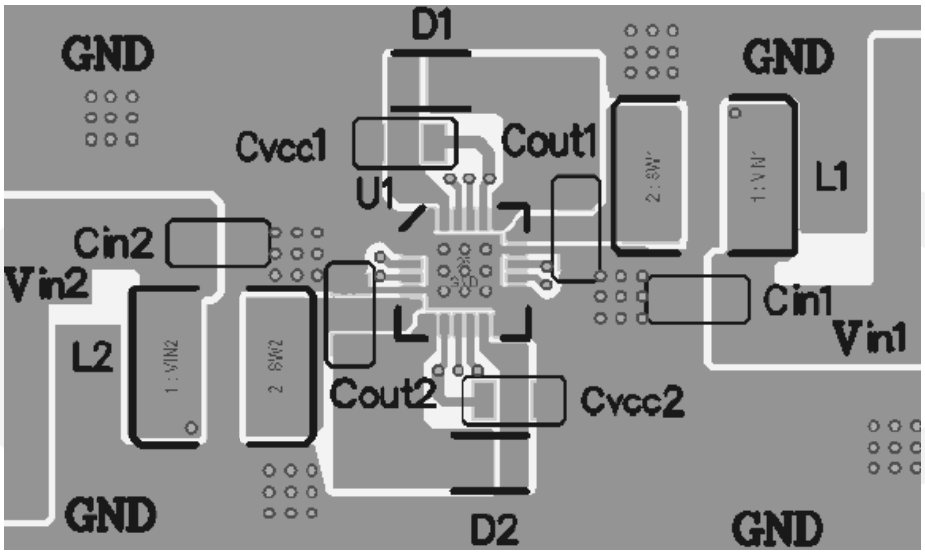
2. Input and output capacitors ground should be placed as possible as close to GND PIN, and wide traces will be recommended as well.

3. Inductor should be placed as possible as close to SW PIN, and wide traced will be recommended as well.

4. Flash LED should be placed as possible as close to D1/D2, and wide traced will be recommended as well.

5. Analog trace, such as RSETM and RSETF, should be routed far away from SW areas.

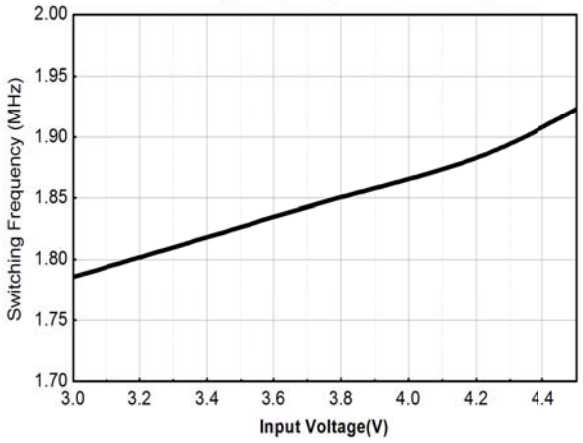
6. Ground nodes should be placed as possible as close to GND PIN.



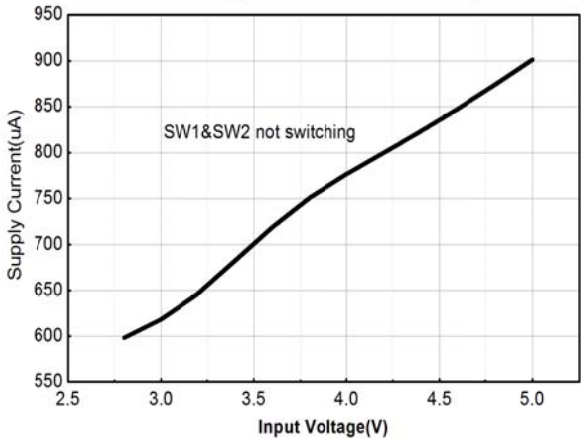
Typical Performance Characteristics

Unless otherwise noted, T_A=25℃, V_{IN}=3.6V, L_1=L_2=1.0μH, C_{IN1}= C_{IN2}=2.2μF, C_{OUT1}= C_{OUT2}=4.7μF, R_{SETM1}= R_{SETM2}=136Kohm, R_{SETF1}= R_{SETF2}=13.6Kohm.

Switching Frequency vs. Input Voltage

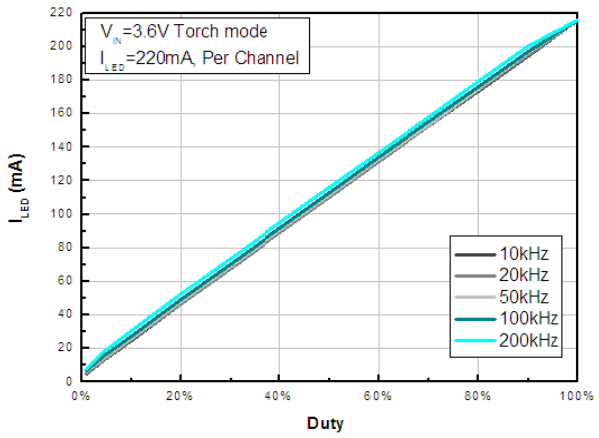


Supply Current Vs. Input Voltage



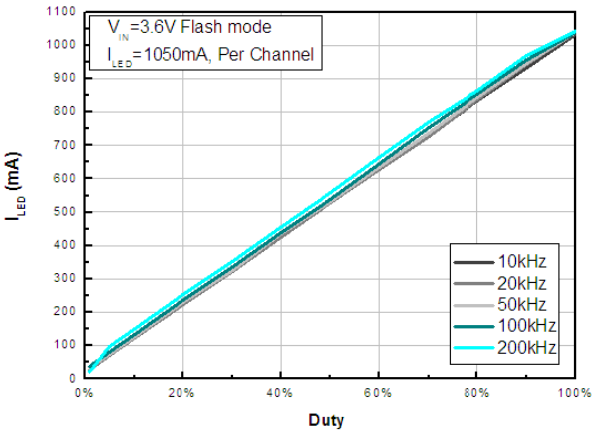
Torch-Mode PWM Dimming

I_{LED} vs. Duty

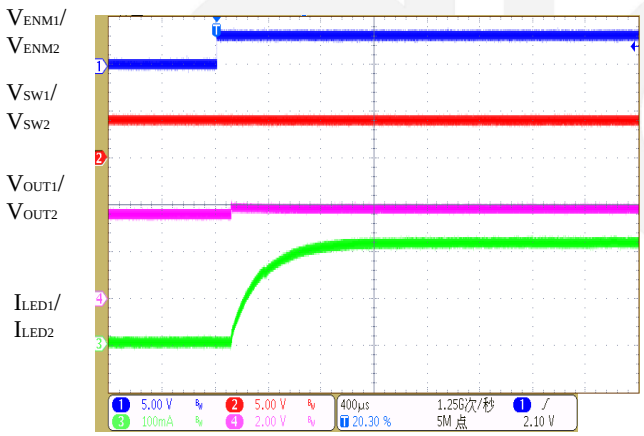


Flash-Mode PWM Dimming

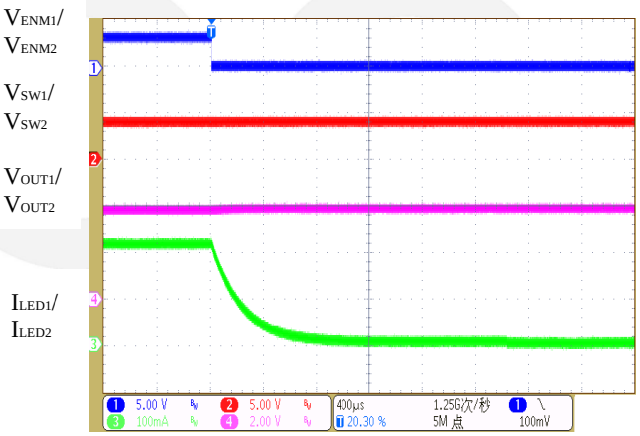
I_{LED} vs. Duty



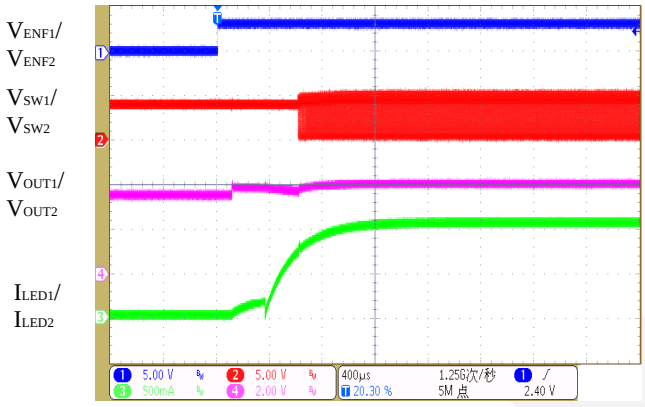
Torch-Mode Turn On Sequence



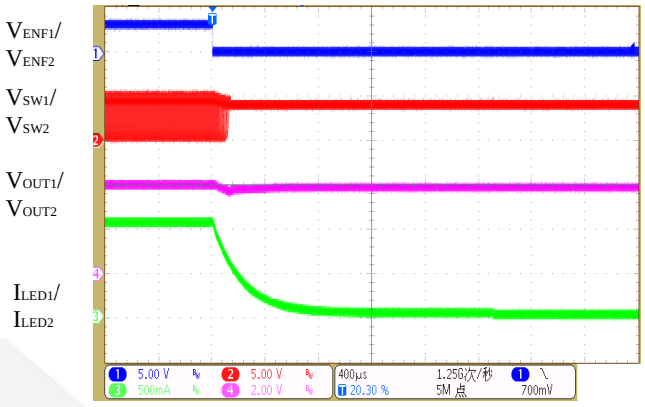
Torch-Mode Turn Off Sequence



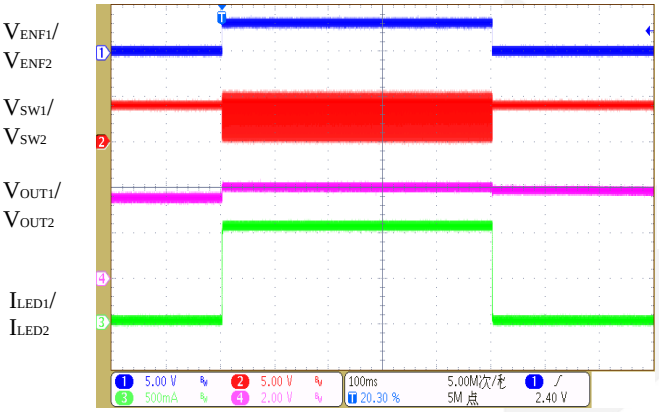
Torch-Mode Turn On Sequence



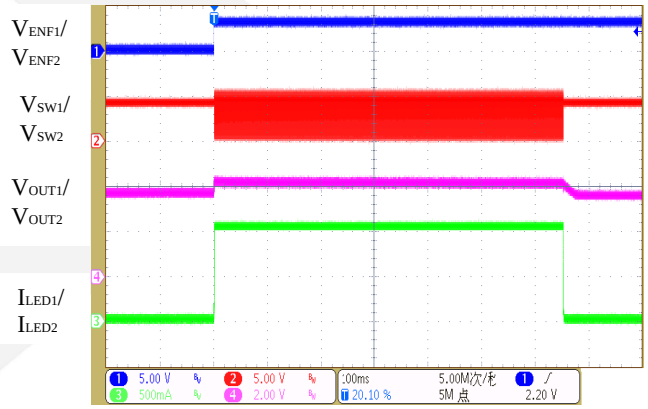
Torch-Mode Turn Off Sequence



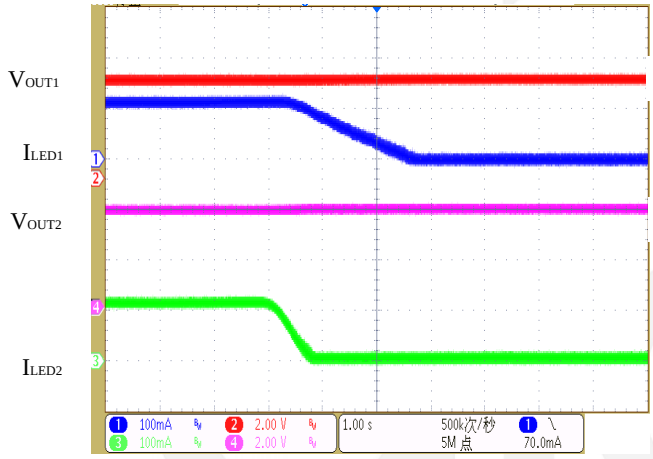
Flash EN Operation



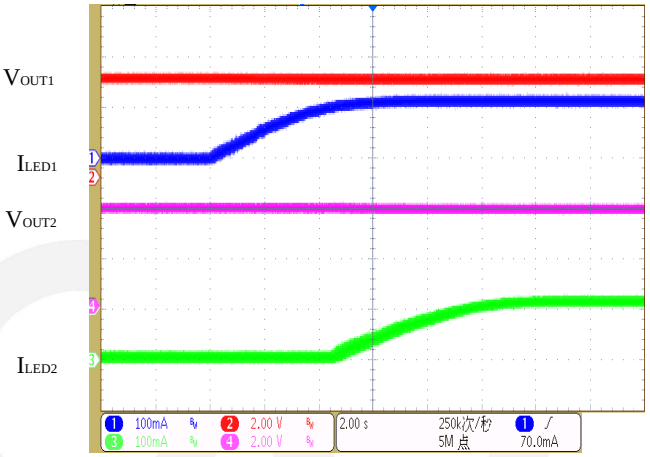
Flash Timer Operation



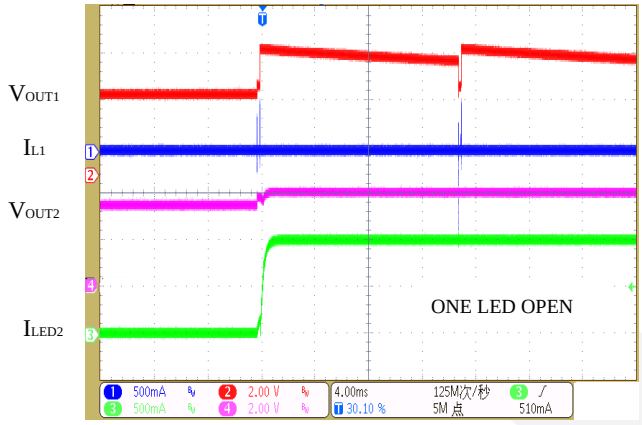
Thermal Regulation Protection



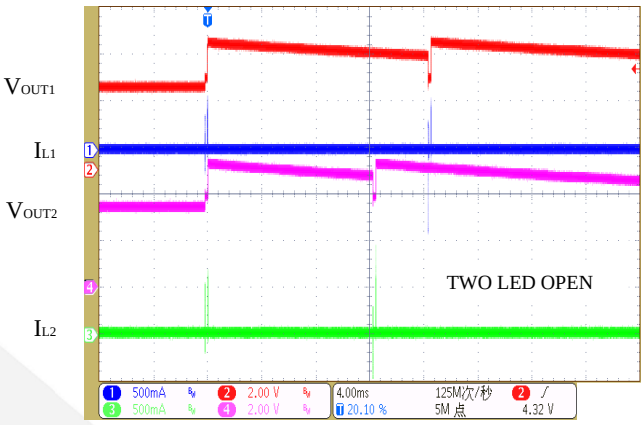
Thermal Regulation Recovery



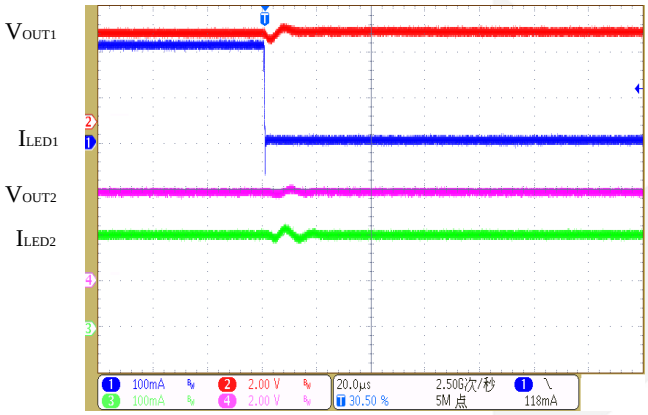
LED Open Circuit Protection



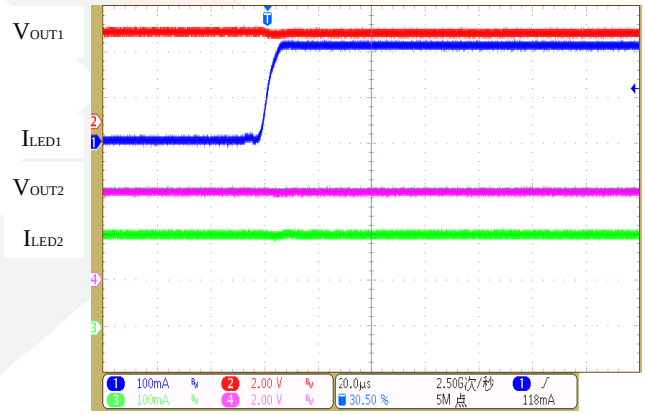
LED Open Circuit Protection



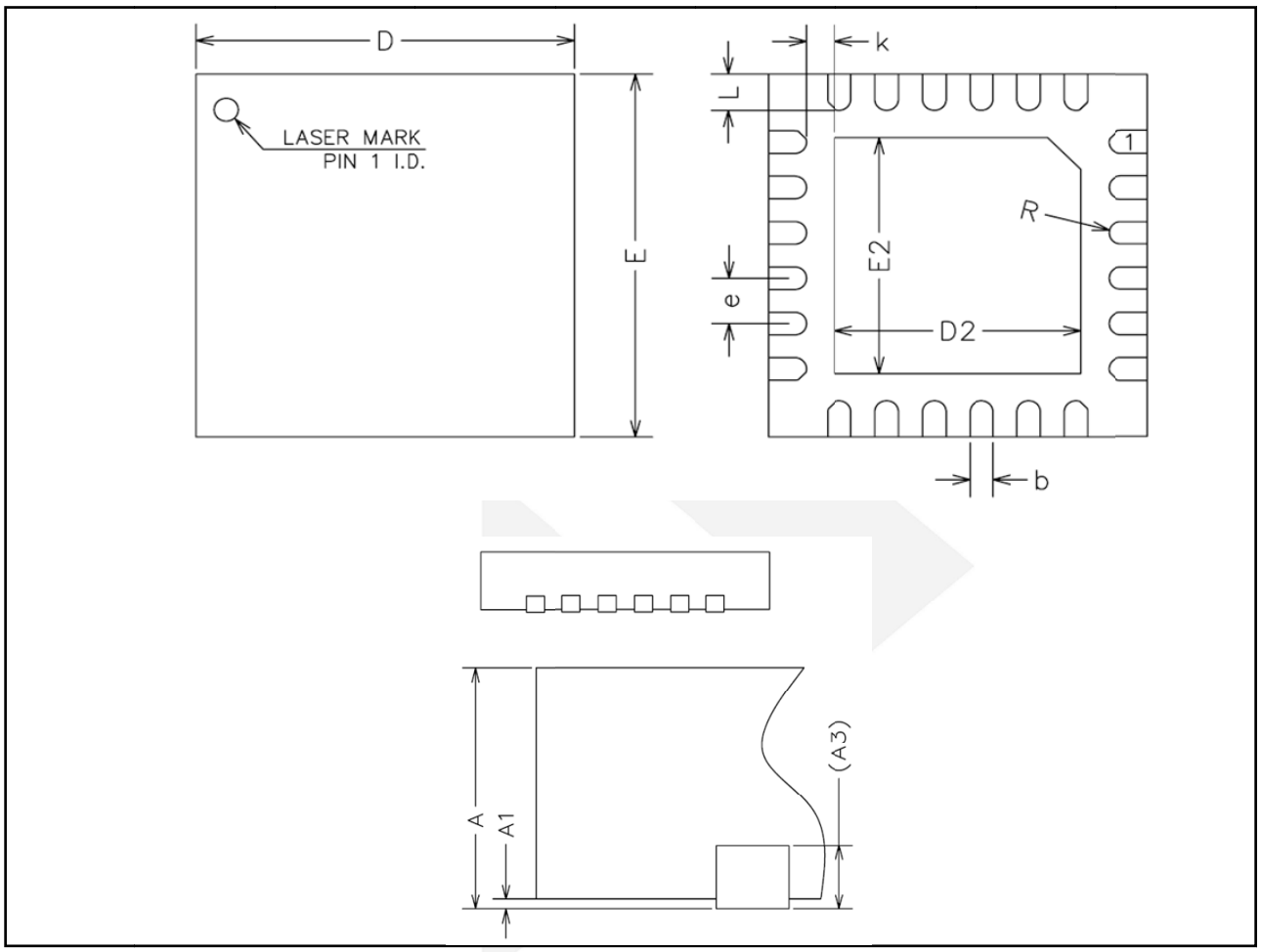
LED Short Circuit Protection



LED Short Circuit Recovery



Physical Dimensions: QFN-24



COMMON DIMENSIONS (UNITS OF MEASURE=MILLIMETER)			
Symbol	**MIN**	**NOM**	**MAX**
A	0.70	0.75	0.80
A1	0	0.02	0.05
A3		0.20REF	
b	0.20	0.25	0.30
D	3.90	4.00	4.10
E	3.90	4.00	4.10
D2	2.50	2.60	2.70
E2	2.50	2.60	2.70
e	0.40	0.50	0.60
K	0.20	-	-
L	0.35	0.40	0.45
R	0.09	-	-

CONTACT US

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