43V High Performance White LED Driver

General Description

The uP6007 is a compact high-efficiency step-up converter with integrated switch specifically designed to drive up to 10 white LEDs in series. Series connection of the LEDs provides identical current resulting in uniform brightness. Fixed 1.0MHz/500kHz operation allows smallest output ripple and external component size. With high conversion efficiency and small package, the uP6007 is suitable for portable devices which PCB area is especially concerned.

The white LED current is set by an external resistor and the feedback voltage is regulated to 200mV. During operation, the LED current can be controlled by PWM input signal in which the duty cycle determines the feedback reference voltage.

The uP6007 features over-voltage protection against open LED situation and includes internal soft start, internal compensation, over current protection and over temperature protection.

The uP6007 is available in WDFN2x2 - 8L package.

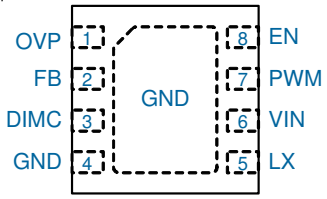
Features

- **Wide Input Voltage Range: 2.7V~24V**
- **High Output Voltage: up to 43V**
- **Direct PWM Dimming Control and Frequency from 100Hz~100KHz**
- **Quiescent Current < 240uA**
- **Internal Soft-Start and Compensation**
- **Programmable Over Voltage Protection**
- **Over-Temperature and Over Voltage Protection**
- **WDFN2x2 - 8L Package**
- **RoHS Compliant and Halogen Free**

Applications

- **Tablet PC, Smart Phone Backlight**
- **GPS, Portable DVD Backlight**
- **UMPC and Notebook Computer Backlight**

Pin Configuration

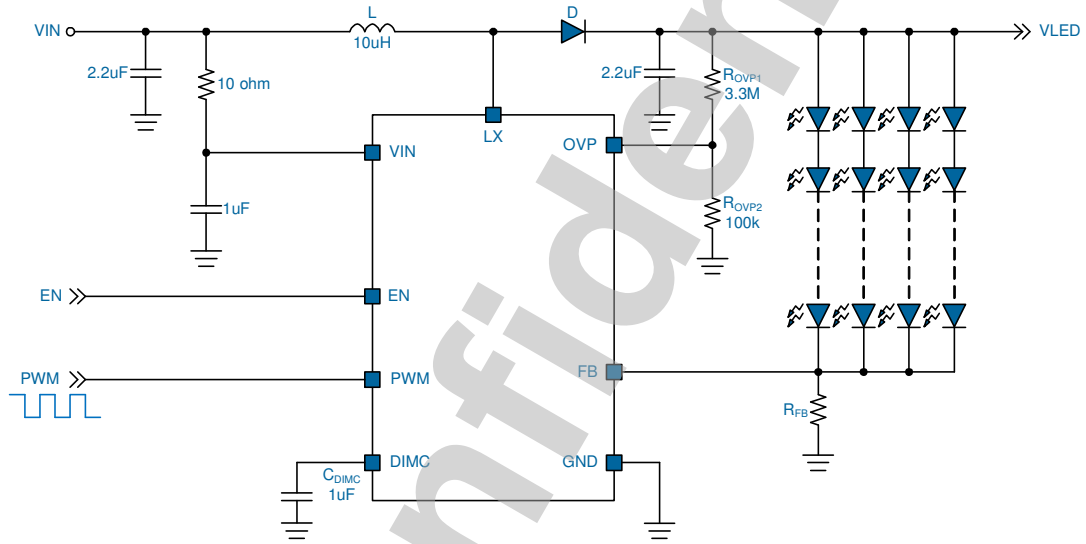


Ordering Information

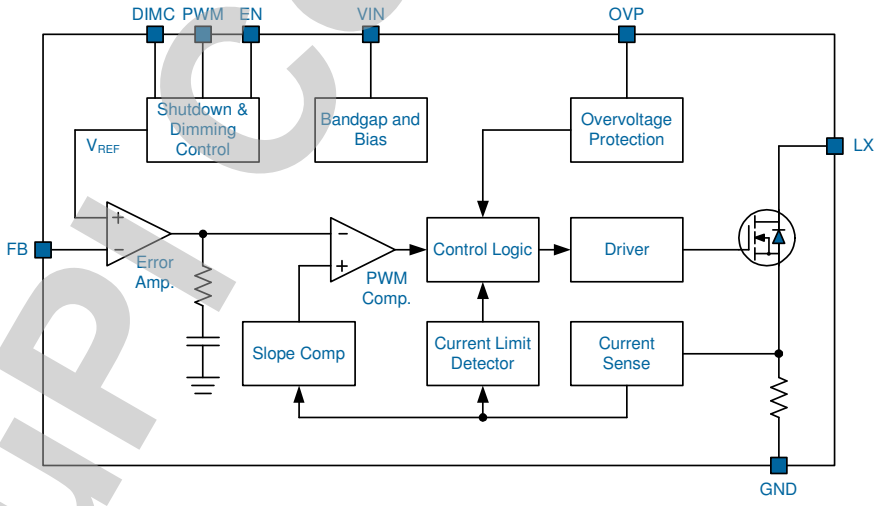
Order Number	Package Type	Remark	Top Marking
uP6007PDN8	WDFN2X2-8L	1MHz	E6
uP6007QDN8		500kHz	ES

Note:
(1) Please check the sample/production availability with uPI representatives.
(2) uPI products are compatible with the current IPC/JEDEC J-STD-020 requirement. They are halogen-free, RoHS compliant and 100% matte tin (Sn) plating that are suitable for use in SnPb or Pb-free soldering processes.

Typical Application Circuit



Functional Block Diagram



Functional Pin Description

Pin No.	Pin Name	Pin Function
1	OVP	**Over Voltage Protection Sense Pin.** This pin is monitored for output overvoltage protection against open-LED.
2	FB	**Current Feedback.** This pin is the inverting-input of error amplifier. The LED current is sensed through a series resistor and regulated to internal reference voltage.
3	DIMC	**PWM Filter Pin.** Filter the PWM signal to a DC voltage.
4	GND	**Ground.** Ties the pin directly to the cathode terminal of CIN and COUT and ground plane with the lowest impedance. All small-signal and feedback components should connect to this pin.
5	LX	**Internal Switch Output.** The pin is the drain of internal NMOSFET. Connect this pin to the boost inductor and anode of external Schottky diode.
6	VIN	**Power Supply Input.** Input voltage that supplies current to the output voltage and powers the internal control circuit. Bypass input voltage with a minimum2.2uF X5R or X7R ceramic capacitor.
7	PWM	**Dimming Control Input.** This pin receives pluses for LED dimming control.
8	EN	**Shutdown Control.** Pulling this pin low shuts down the converter and reduces its supply current down to 0.1uA.

Functional Description

The uP6007 is a compact high-efficiency step-up converter with integrated switch specifically designed to drive up to white LEDs in series. Series connection of the LEDs provides identical LED current resulting in uniform brightness. Fixed 1MHz/500kHz operation allows smallest output ripple and external component size. With high conversion efficiency and small package, the uP6007 is suitable for portable devices where PCB area is especially concerned.

Power on Reset

The uP6007 continuously monitors supply input voltage at VIN pin for power on reset (POR). Once the rising POR threshold is exceeded, the uP6007 sets itself to active state and is ready to accept chip enable command. The POR threshold is typically 2.5V at VIN rising with 0.1V hysteresis.

Enable/Disable

Pulling the EN pin higher than 1.6V enables the device and initiates its soft start cycle. Pulling the EN pin lower than 0.8V disables the device and reduces its shutdown current less than 1uA typically. When the EN pin pulls low, the uP6007 does not shuts down immediately but reduces the LED current gradually.

Soft Start

The uP6007 limits the in-rush current at start-up by increasing the current limit. This prevents unwanted shutdown otherwise may be triggered by voltage drop due to large inrush current.

LED Current Regulation

The uP6007 operates in a constant-frequency, slope-compensated peak-current-mode control to regulate the LED current. The LED current is sensed at FB pin by a current sensing resistor (R_{FB}): $V_{FB} = R_{FB} \times ILED$. The error amplifier compares the feedback voltage with internal 0.2V reference and compensates the error signal to get current command level.

The internal NMOSFET turns on at the beginning of each switching cycle and lets the inductor current ramp up linearly. The NMOSFET turns off when the inductor current reaches the current command level. The uP6007 modulates on-time of NMOSFET by changing the current command to regulate the LED current.

Dimming Control

The uP6007 receives a PWM signal at PWM pin for LED brightness control. The PWM signal is flatted by a low pass filter to get a reference voltage that is proportional to the duty cycle of the PWM signal. The PWM frequency range from 100Hz to 100kHz is acceptable and yield linear brightness control.

Current Limit Function

The uP6007 features cycle-by-cycle current to prevent the device from damage due to over current that might be result from abnormal operation. The uP6007 turns off the NMOSFET when its current exceeds the current limit of 2.2A typical, preventing the indcutor current from continuously ramping up. The NMOSFET is turned on at next switching cycle. This minimizes the power dissipation and components stresses under over load and short-circuits conditions.

Over Voltage Protection

The over voltage protection prevents damage to uP6007 during high output voltage conditions. When the output voltage is higher than Threshold Limit, the converter stops switching and the output voltage decays. Switching would be turned on again when the voltage of the OVP pin drops below the below the lower hysteresis limit.

Over Temperature Protection

The excessive internal dissipation of thermal protection will malfunction uP6007. The junction over-temperature threshold is 160°C with 30°C of temperature hysteresis. The output voltage resumes when the over temperature fault condition is removed.

Absolute Maximum Rating

(Note 1)

VIN, EN, PWM, DIMC to GND ---------- -0.3V to +26.5V
LX, FB, OVP to GND ---------- -0.3V to +48V
Storage Temperature Range ---------- -65°C to +150°C
Junction Temperature ---------- 150°C
Lead Temperature (Soldering, 10 sec) ---------- 260°C
ESD Rating (Note 2)
HBM (Human Body Mode) ---------- 2kV
MM (Machine Mode) ---------- 200V

Thermal Information

Package Thermal Resistance (Note 3)
WDFN2x2 -8L θ_{JA} ---------- 155°C/W
WDFN2x2 -8L θ_{JC} ---------- 20°C/W
Power Dissipation, P_D @ T_A = 25°C
WDFN2x2 -8L ---------- 0.64W

Recommended Operation Conditions

(Note 4)

Operating Junction Temperature Range ---------- -40°C to +125°C
Operating Ambient Temperature Range ---------- -40°C to +85°C
Supply Input Voltage, V_{IN} ---------- +2.7V to +24V

Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2. Devices are ESD sensitive. Handling precaution recommended.

Note 3. θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

Note 4. The device is not guaranteed to function outside its operating conditions.

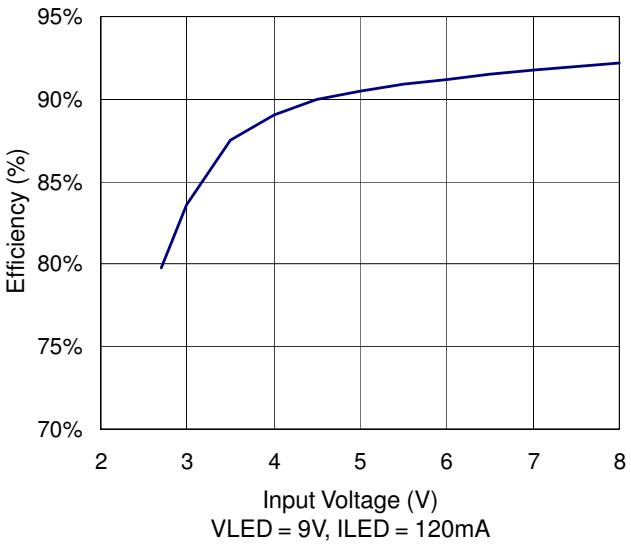
Electrical Characteristics

(V_{IN} = 4.5V, T_A=25°C, unless otherwise specified)

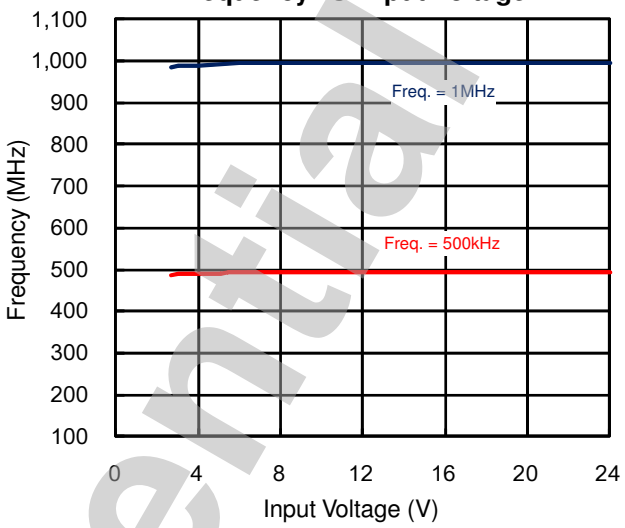
Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Supply Input						
VIN Quiescent Current	I_Q	V_{FB} = 1.5V, No Switching	--	240	--	uA
	I_{Q_SW}	V_{FB} = 0V, Switching	--	1	2	mA
VIN Shutdown Current	I_{SHDN}	V_{IN} = 4.5V, V_{EN} = 0V	--	1	4	uA
Control Input						
EN, PWM Threshold Voltage	V_{IH}	V_{IN} = 2.7V to 24V	1.6	--	--	V
	V_{IL}	V_{IN} = 2.7V to 24V	--	--	0.8	V
EN Sink Current	I_{IH}	V_{EN} = 3V	1	--	10	uA
PWM Dimming Frequency			0.1	--	100	KHz
Boost Converter						
Switching Frequency	f_{OSC}	V_{IN} = 2.7V to 24V, uP6007P	0.8	1	1.2	MHz
		V_{IN} = 2.7V to 24V, uP6007Q	0.4	0.5	0.6	MHz
LX On Resistance (N-MOSFET)	$R_{DS(ON)}$	V_{IN} = 2.7V to 24V	--	0.4	0.6	Ω
Minimum ON Time			--	100	--	ns
Maximum Duty Cycle	D_{MAX}	V_{FB} = 0V, Switching	--	92	--	%
LED Current						
Minimum PWM Dimming Duty Cycle	D_{MIN}	Dimming Freq. = 100Hz to 100kHz	1	--	--	%
Dimming Control Accuracy		PWM Duty = 100% at 100Hz ~ 20kHz	-2.5	--	+2.5	%
		PWM Duty = 50% at 100Hz ~ 20kHz	-2.5	--	+2.5	%
		PWM Duty = 20% at 100Hz ~ 20kHz	-5	--	+5	%
		PWM Duty = 5% at 100Hz ~ 20kHz	-10	--	+10	%
		PWM Duty = 4% at 100Hz ~ 20kHz	-15	--	+15	%
		PWM Duty = 3% at 100Hz ~ 20kHz	-20	--	+20	%
		PWM Duty = 2% at 100Hz ~ 20kHz	-30	--	+30	%
		PWM Duty = 1% at 100Hz ~ 20kHz	-50	--	+50	%
Minimum PWM Pulse Width	t_{PWM_Width}		1	--	--	us
Feedback Voltage	V_{FB}		196	200	204	mV
Fault Protection						
LX Current Limit	I_{LIM}		1.66	2.2	2.74	A
Over Voltage Protection Threshold	V_{OVP}		1.14	1.20	1.26	V
Thermal Shutdown Temperature	T_{SD}		--	160	--	°C
Thermal Shutdown Hysteresis	ΔT_{SD}		--	30	--	°C

Typical Operation Characteristics

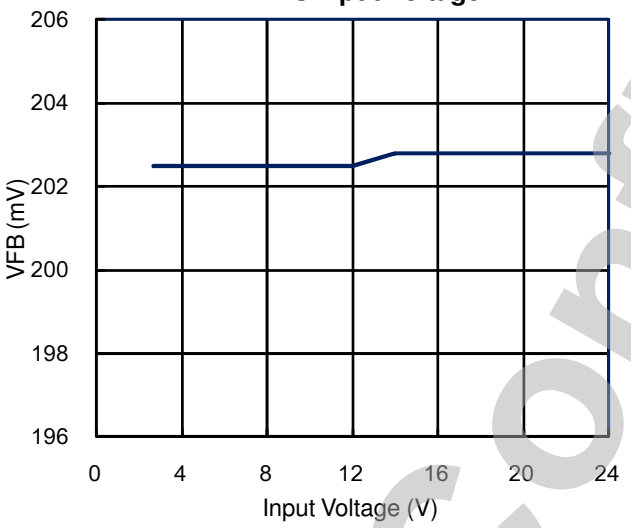
Efficiency vs.Input Voltage



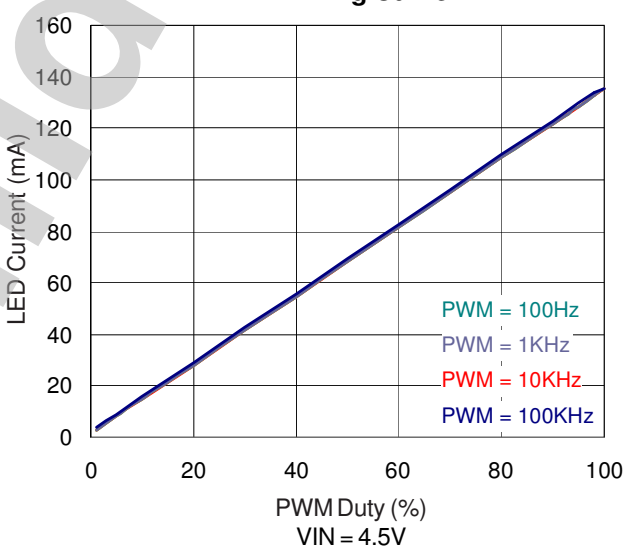
Frequency vs. Input Voltage



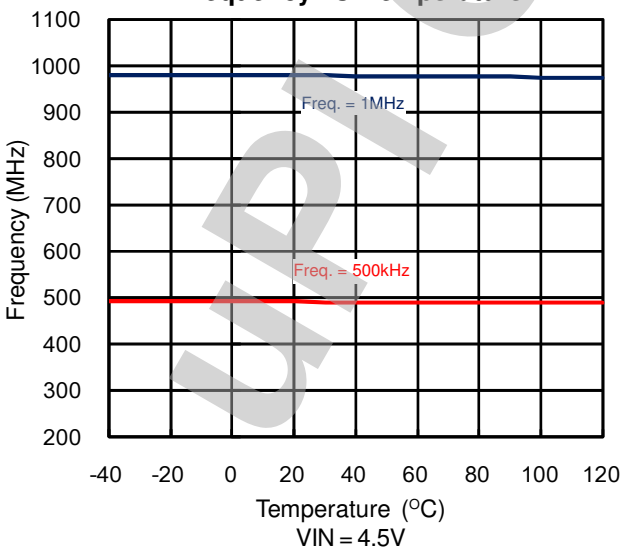
VFB vs.Input Voltage



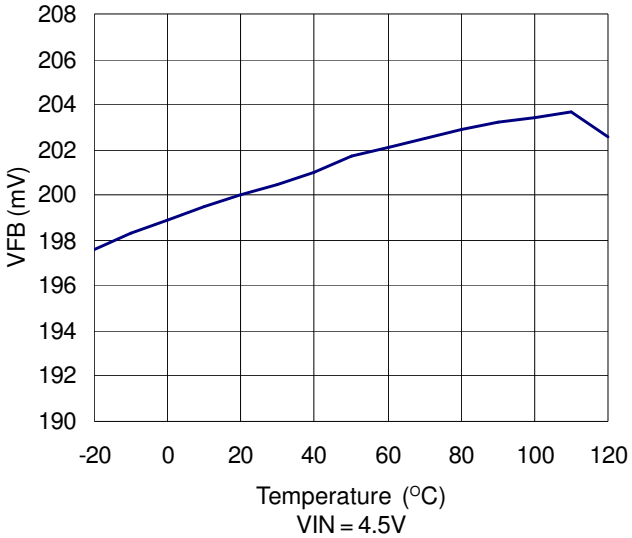
Dimming Curve



Frequency vs. Temperature



VFB vs. Temperature



Application Information

Component Selection

External component selection begins with inductor value selection based on the considerations of the output voltage, output current, and the maximum/minimum input voltages. Catch diode and input/output capacitors can be selected according to the inductor value L.

Inductor Selection

Inductor selection should consider the inductor value, rated current, DCR, size, core material, and cost. The inductor value is selected based on the consideration of inductor ripple current. Depending on the application, inductor values between 4.7uH and 10uH are recommended.

Diode Selection

The catch diode should be capable of handling the output voltage and the peak switch current. Make sure that the diode peak current rating is at least ISW,PK and that its breakdown voltage exceeds VOUT. Schottky diodes are commended due to its low forward voltage and low reverse recovery current. The capability for handling power dissipation should be considered. The power dissipation at the catch diode can be approximated as:

$PD = I_{OUT}$ x VD

Where IOUT is the load current, VD is the forward voltage of the catch diode.

Layout Guideline

For best performance of the uP6007, the following guidelines must be strictly followed.

1. Input and output capacitors should be placed close to the IC and connected to ground plane to reduce noise coupling.
2. The GND should be connected to a strong ground plane for heat sinking and noise protection.
3. Keep the main current traces as short and wide as possible.
4. LX node of DC-DC converter is with high frequency voltage swing. It should be kept at a small area.
5. Place the feedback components as close as possible to the IC and keep away from the noisy devices.

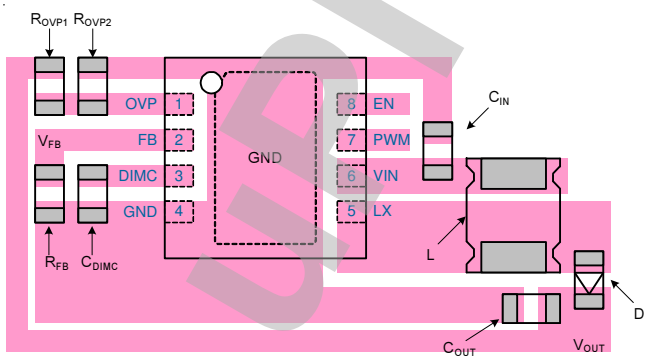


Figure 1. WDFN - 8L Layout Reference

Maximum Output Current vs. Output Voltage

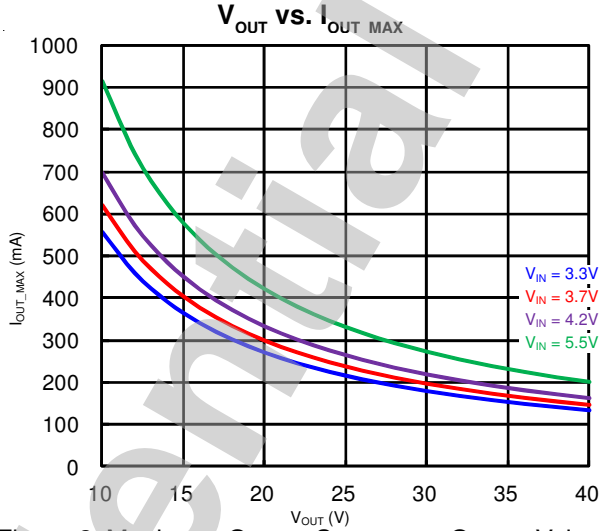


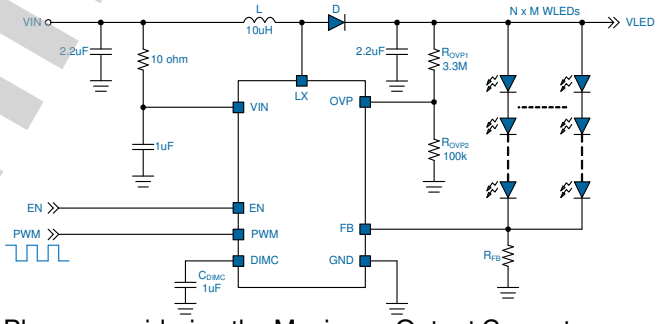
Figure 2. Maximum Output Current vs. Output Voltage

$$I_{OUT(MAX)} = (1-D)\times\eta\times\left(I_{LX} - \frac{1}{2}\times\frac{V_{IN}}{f_{OSC}\times L}\times D\right)$$

Calculation conditions:

$L = 10uH$, $f_{OSC} = 500kHz$, $\eta = 0.85$, $I_{LX} = 2.2A$

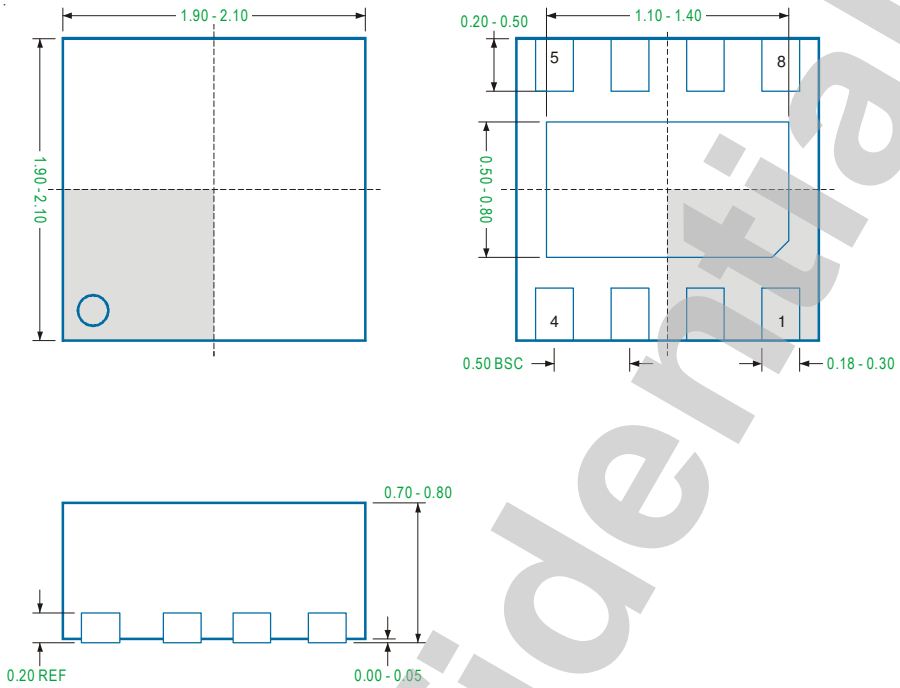
Multi-strings Application



Please considering the Maximum Output Current vs. Output Voltage relationship when used for NxM WLEDs application.

Package Information

WDFN2x2-8L



Note

1. Package Outline Unit Description:
   BSC: Basic. Represents theoretical exact dimension or dimension target
   MIN: Minimum dimension specified.
   MAX: Maximum dimension specified.
   REF: Reference. Represents dimension for reference use only. This value is not a device specification.
   TYP. Typical. Provided as a general value. This value is not a device specification.
2. Dimensions in Millimeters.
3. Drawing not to scale.
4. These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.

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