

## PWM Step-Up DC/DC Converter for Panel Backlight

### General Description

The EMD2093 designed with high efficiency step up DC/DC converter for driving white LEDs. The device can drive up 9 white LEDs from a single Li-Ion battery or a DC power 2.5V to 5.5V. The EMD2093 uses current mode and pulse-width modulated (PWM) operation. It switches at 1.2MHz and allows using small inductor and both of input/output capacitors. An internal compensation can reduce external component.

The EMD2093 include under-voltage lockout, current limit, over voltage and thermal shutdown protection. The EMD2093 is also available in SOT-23-6 package and 2x2mm TDFN-8 package.

### Features

- WLEDs supports:
  - Up to 9-LEDs support at VIN=3.7V
  - Up to 60mA current support at VIN=5.0V
- Low Quiescent Current: 55  $\mu$ A
- Over Voltage Protection: 31.5V
- Inherently Matched LED Current
- Shutdown Current < 1 $\mu$ A
- Reference Voltage 0.245V
- Efficiency : 85% (Typ) at VIN=5.0V
- PWM Dimming Control
- Internal Soft Start and Compensation
- 1.3A Internal power MOSFET Switch
- Low Profile SOT-23-6 Package and TDFN 2x2mm 8 pins package

### Applications

- Mobile Phone
- Digital Still Cameras
- Portable applications
- MP3 Players
- GPS Receivers

### Typical Application

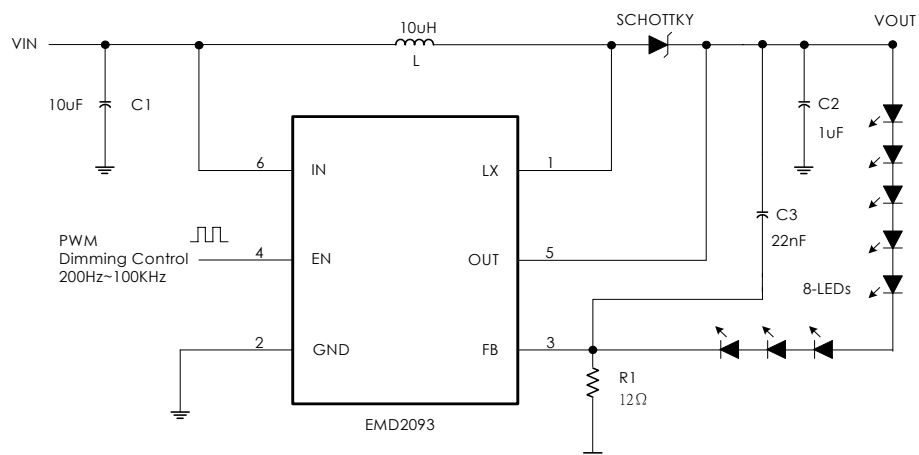
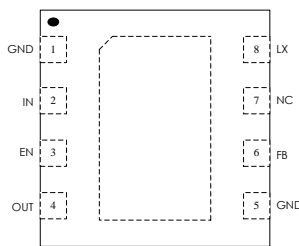
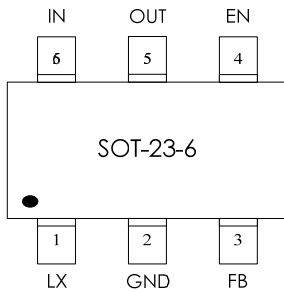


Fig. 1

### Connection Diagram



### Order Information

EMD2093-00VC06NRR  
 00 Output voltage  
 VC06 SOT-23-6 Package  
 NRR RoHS & Halogen free package  
 Rating: -40 to 85°C  
 Package in Tape & Reel

EMD2093-00FE08NRR  
 00 Output voltage  
 FE08 TDFN-8 Package  
 NRR RoHS & Halogen free package  
 Rating: -40 to 85°C  
 Package in Tape & Reel

### Order, Mark & Packing Information

Package	Vout	Product ID	Marking	Packing
SOT-23-6	Adjustable	EMD2093-00VC06NRR	<p>2093 Tracking Code</p> <p>PIN1 DOT</p>	Tape & Reel 3Kpcs
TDFN-8	Adjustable	EMD2093-00FE08NRR	<p>2093 Tracking Code</p> <p>PIN1 DOT</p>	Tape & Reel 3Kpcs

## Pin Functions

Pin Name	SOT-23-6 Pin #	TDFN-8 Pin #	Function
LX	1	8	Switch Pin. Connect inductor/diode here.
GND	2	1,5	Ground Pin.
FB	3	6	Feedback Pin. Reference voltage is 0.245V, connect cathode of lowest LED and resistor here.
EN	4	3	Chip Enable Pin. Connect to 1.2V or higher to enable device, 0.4V or less to disable device.
OUT	5	4	Over Voltage Protection Pin.
IN	6	2	Input Voltage Pin.
NC	NA	7	NC pin

## Absolute Maximum Ratings

Devices are subjected to failure if they stay above absolute maximum ratings

Input Voltage	- 0.3V to 6V	Operating Temperature Range	-40°C to 85°C
EN, VFB Voltages	- 0.3V to VIN	Storage Temperature	-65°C to 150°C
LX ,OUT Voltage	- 0.3V to 31.5V	Junction Temperature	150°C
ESD Susceptibility	HBM 2kV MM 200V	Lead Temperature (Soldering, 10 sec)	260°C

## Electrical Characteristics

(V<sub>CC</sub> = 3.7V, T<sub>A</sub> = 25°C, unless otherwise specified.)

PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
Under Voltage Lock Out		1.8		2.4	V
Supply Current	Continuously Switching			1	mA
Quiescent Current	No Switching, VFB = 1V	47	55	70	μA
Shutdown Current	VEN < 0.4V			1	μA
Operation Frequency		0.9	1.2	1.5	MHz
Maximum Duty Cycle		93	95		%
Feedback Voltage		0.2205	0.245	0.2695	V
Thermal Shutdown Protection			160		°C
Thermal Shutdown Hysteresis			20		°C
R <sub>on</sub>	I <sub>sw</sub> = 200mA		0.5	0.8	ohm
Current Limit			1.3		A
Shutdown Voltage Low		0.4			V
Enable Voltage High				1.2	V
EN Leakage Current			1.3		μA
Maximum Output Voltage				31	V
OVP		31.5			V
OVP Hysteresis		0.2	1	3	V

Function block

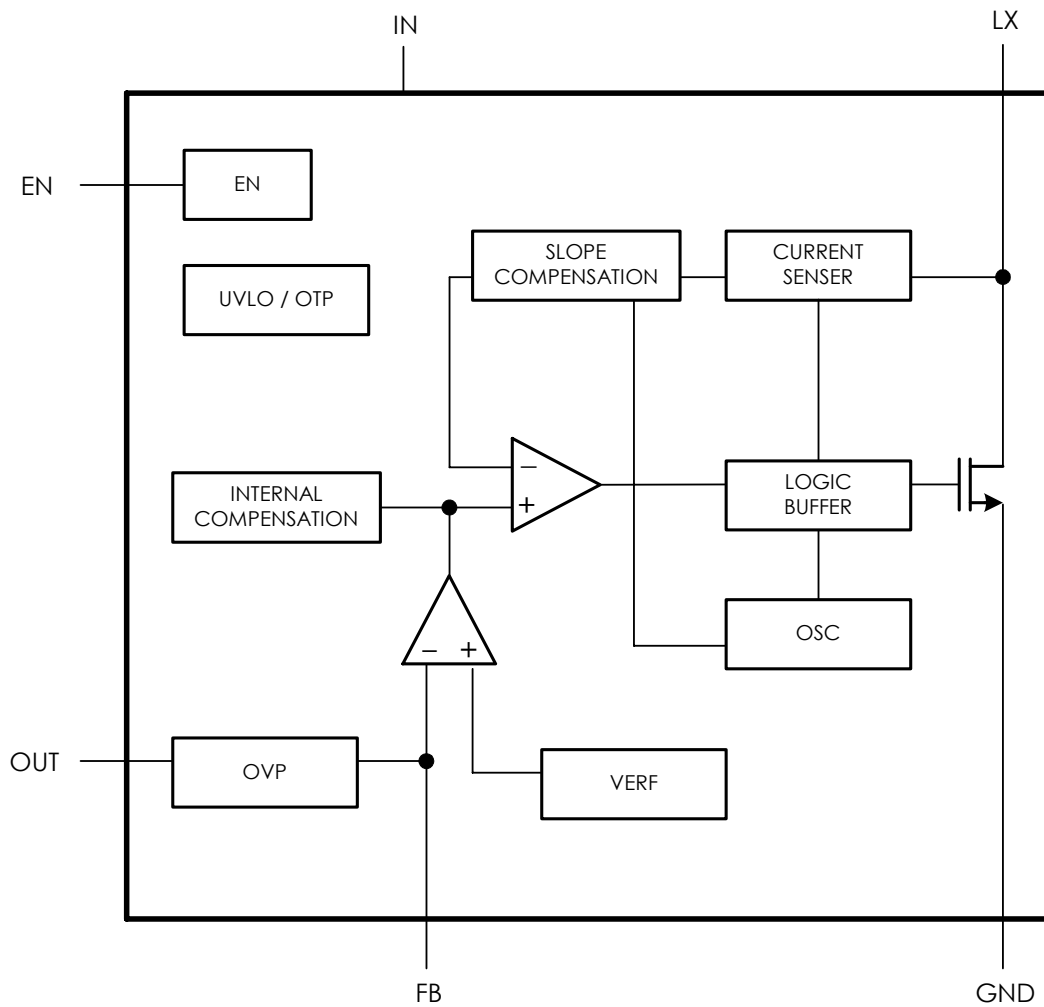
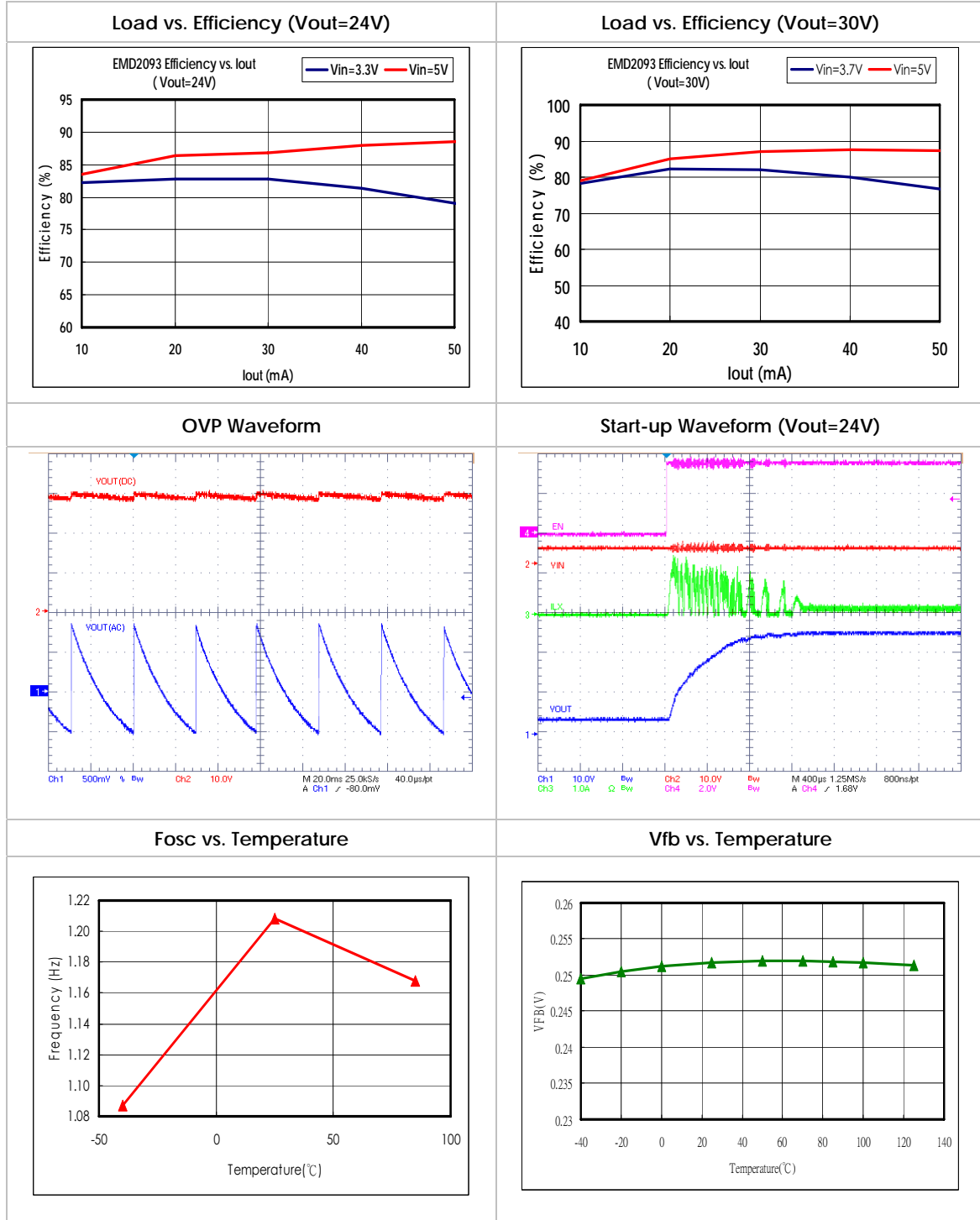


Fig. 2

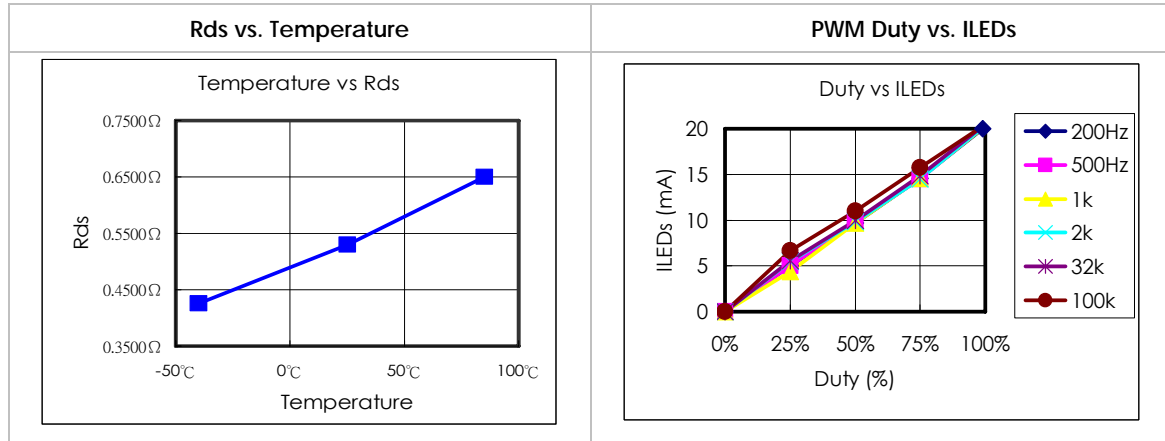
## Typical Performance Characteristics

VIN=3.7V, unless otherwise specified



## Typical Performance Characteristics

VIN=3.7V, unless otherwise specified



## Application Information

### Detailed Description

The EMD2093 is a constant frequency current-mode boost converter, which can driver 9 series of WLED. The device provides the same output current through each WLED that get even illumination. The fast operation frequency allows for small inductor and input/output capacitors.

During normal operation, the internal oscillators send a pulse signal to set latch and turn on internal MOSFET each duty circle. A current sense voltage sums MOSFET current and slope signal connected to the negative terminal of the PWM comparator. When this signal voltage exceeds output voltage of error amplifier, the PWM comparator will send a signal to reset latch and turn off internal MOSFET. The output voltage of error amplifier is magnified from the difference between reference voltage and feedback voltage. If reference voltage is higher than feedback voltage, more current is delivered to the output, the other way, less current is delivered.

### UVLO

The EMD2093 provides under voltage lock out protection. When VIN is down close to UVLO threshold, the UVLO block will send a signal to turn off power MOSFET. The device stops to supply current to output. The 100mV hysteresis prevents supply transients from causing a restart. Once the VIN exceed UVLO threshold, the device unlocks latch and turn power MOSFET.

### Enable / Disable

The EMD2093 enter shutdown mode when EN pin voltage is less 0.4V. When in shutdown mode, all internal circuits of the EMD2093 are turn off and quiescent current is reduced to 1uA. When driver EN pin voltage is higher than 1.2V, start-up begins.

EN pin can be used for dimming control, the PWM frequency range is from 100Hz to 100kHz. The average LED current is proportional to the PWM duty cycle, while 0% duty cycle triggers zero WLEDs current and 100% duty cycle triggers full WLEDs current.

### OVP

When WLEDs are open, the boost control loop just like open loop operation, it may causes over voltage damage on LX pin. In order to prevent this damage, the EMD2093 provides OVP function to provide it. The protection threshold is set at 31.5V.

### OTP

The internal thermal sensor turn off power MOSFET when junction temperature is exceeded 160°C, the OTP is designed with a 20°C hysteresis.



## LED Current Setting

Referring to Figure 1 of the typical application, adjusting the output current changes the brightness of WLEDs, the EMD2093 regulates output current by sense resistor (R1). The output current is given by:

$$\text{LED current} = 0.245\text{V} / R1$$

## Cin and Cout Selection

It is recommended to use the X5R or X7R which have best temperature and voltage characteristics of all the ceramics for a give value and size. A minimum input capacitance of 1μF is required for the EMD2093, the capacitor value may be increased without limit. The typical output capacitor value is 1μF, higher capacitance can be used to reduce voltage ripple.

## Inductor Selection

The inductor values range from 4.7μH to 22μH. The typical inductor value is 10μH. The low DCR inductor is preferred. In addition, the limit saturation current of inductor must exceed current limit of the EMD2093.

## Diode Selection

Referring to Figure 1 of the typical application, the EMD2093 is high switching control devise which demands a high speed rectification diode for optimum efficiency. The schottky diode is preferred, for high efficiency, schottky diode provide fast recovery time and low forward voltage that reduce power loss. The recover breakdown voltage of schottky diode must exceed output voltage.

## Application Circuit

- Application circuit for 9S3P

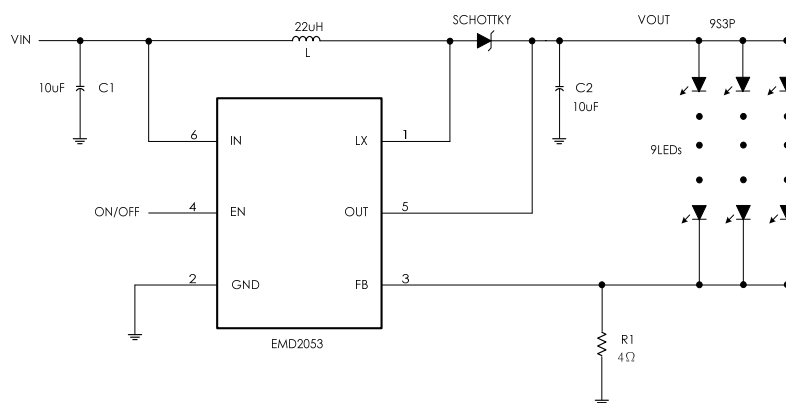
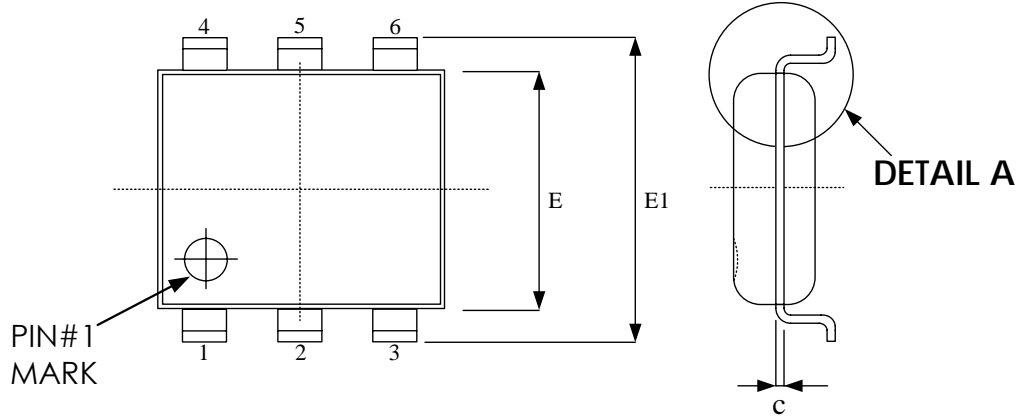


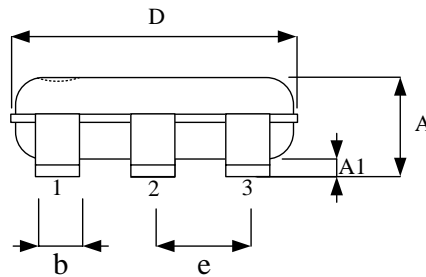
Fig. 3

# ESMT/EMP

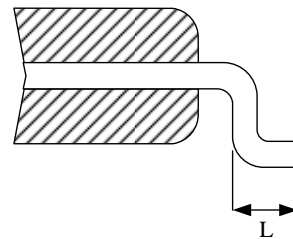
## Package Outline SOT-23-6



### TOP VIEW



### SIDE VIEW

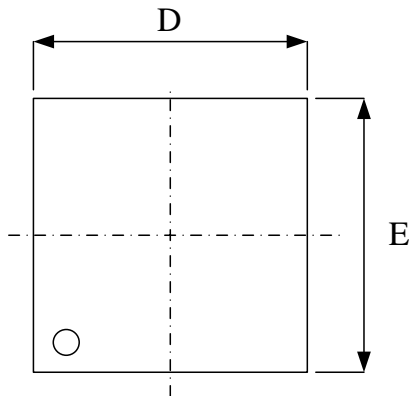


### DETAIL A

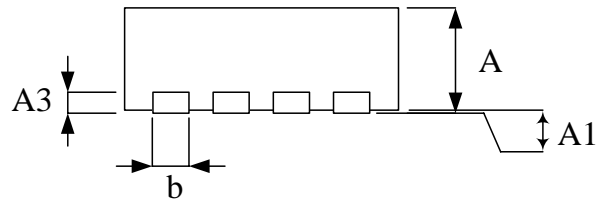
Symbol	Dimension in mm	
	Min.	Max.
A	0.90	1.45
A1	0.00	0.15
b	0.30	0.50
c	0.08	0.25
D	2.70	3.10
E	1.40	1.80
E1	2.60	3.00
e	0.95 BSC	
L	0.30	0.60

# ESMT/EMP

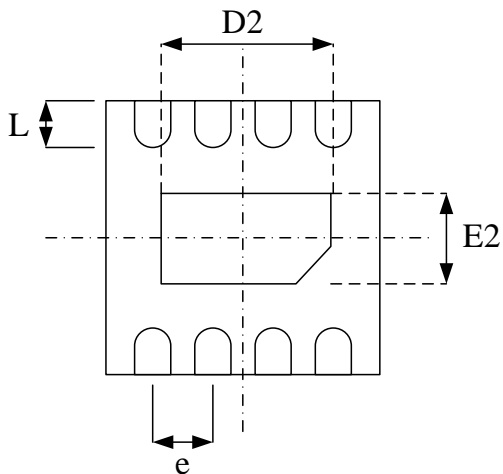
## Package Outline TDFN-8 (2x2 mm)



**TOP VIEW**



**SIDE VIEW**



**BOTTOM VIEW**

Symbol	Dimension in mm	
	Min	Max
A	0.70	0.80
A1	0.00	0.05
A3	0.18	0.25
b	0.18	0.30
D	1.95	2.05
E	1.95	2.05
e	0.50 BSC	
L	0.20	0.45

### Exposed pad

	Dimension in mm	
	Min	Max
D2	1.10	1.25
E2	0.55	0.70

# ESMT/EMP

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## Revision History

Revision	Date	Description
0.1	2009.05.14	Original.
1.0	2009.10.30	Removed the letters of "Preliminary".
1.1	2011.09.29	<ol style="list-style-type: none"><li>1. Changed the current limit from 800mA to 1.3A</li><li>2. Add 2x2mm TDFN-8 package option</li><li>3. Change outline spec for SOT-23-6 package</li><li>4. Change OVP spec</li></ol>
1.2	2012.02.17	Changed White LEDs supports from 8S1P to 9S3P and added 9S3P application circuit.

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