

**PWM Step-Up DC/DC Converter for Panel Backlight (11 WLEDs Driver)****General Description**

The EMD2055 is a highly efficient, step-up DC/DC converter for driving white LEDs. The device can drive up to 11 serially connected white LEDs from a single Li-Ion battery, or to drive multiple serial and parallel combinations with a DC power supply from 2.5V to 5.5V. The EMD2055 uses current mode and pulse-width modulated (PWM) operation. Its high switching operation frequency of 1.0MHz allows the system to use small inductor, input and output capacitors. An internal compensation circuit can reduce the external component count.

To safeguard the system, the EMD2055 includes various protection circuits such as under-voltage lockout, current limit, over voltage and thermal shutdown. EMD2055 are available in the tiny packages of SOT-23-6L and TDFN-8L (2x2mm).

**Applications**

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

**Features**

- Up to 11 WLEDs supports
- Low Quiescent Current: 120  $\mu$ A
- Over Voltage Protection: 36.5V
- Inherently Matched LED Current
- Shutdown Current < 1 $\mu$ A
- Reference Voltage 0.24V
- PWM Dimming Control (100Hz~100kHz)
- Internal Soft Start and Compensation
- 1.5A Internal power MOSFET Switch
- Low Profile SOT-23-6 and TDFN-8L Packages

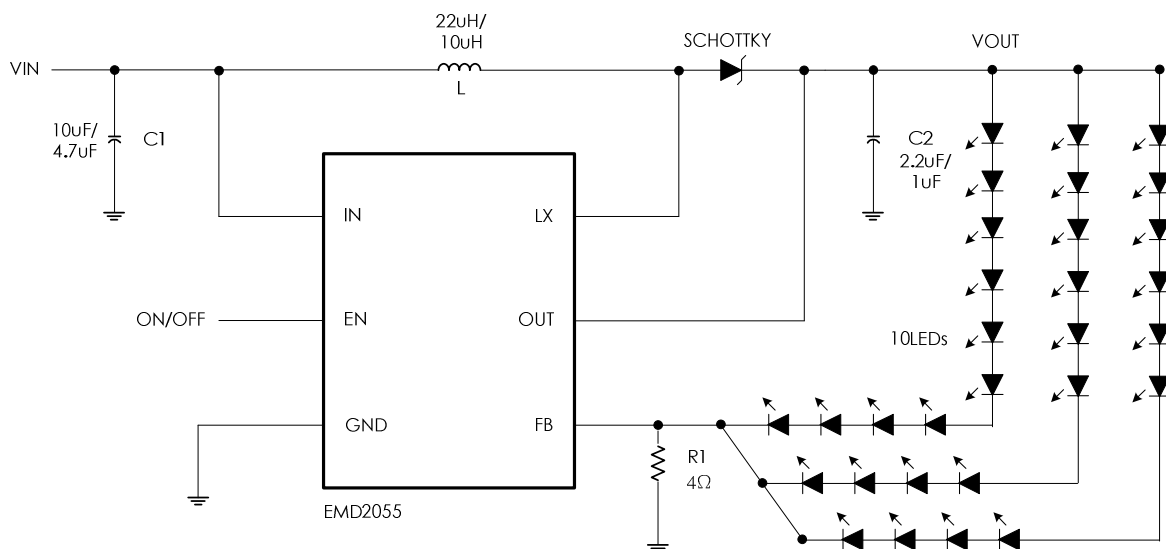
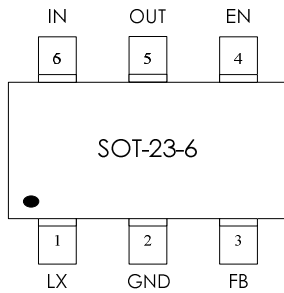
**Typical Application (9S3P)**

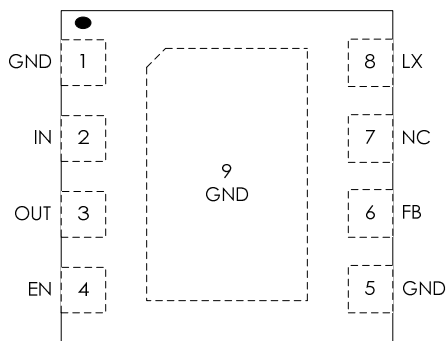
Fig. 1

### Connection Diagram



### Order Information

EMD2055-00VC06NRR  
 00 Output voltage  
 VC06 SOT-23-6L Package  
 NRR RoHS & Halogen free package  
 Rating: -40 to 85°C  
 Package in Tape & Reel



EMD2055-00FK08NRR  
 00 Output voltage  
 FK08 TDFN-8L Package  
 NRR RoHS & Halogen free package  
 Rating: -40 to 85°C  
 Package in Tape & Reel

### Order, Marking & Packing Information

Package	Vout	Product ID	Marking	Packing
SOT-23-6L	Adjustable	EMD2055-00VC06NRR	<p>2055 Tracking Code</p> <p>PIN1 DOT</p>	Tape & Reel 3Kpcs
TDFN-8L (2x2mm)	Adjustable	EMD2055-00FK08NRR	<p>2055 Tracking Code</p> <p>PIN1 DOT</p>	Tape & Reel 3Kpcs

**Function Block**

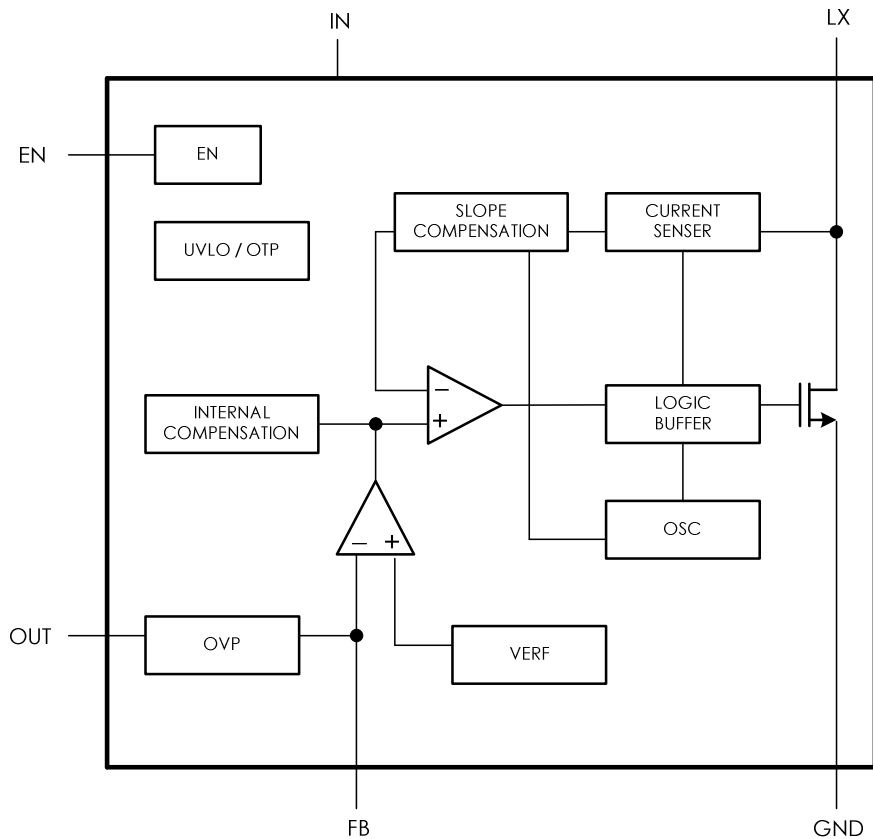


Fig. 2

**Pin Functions**

Pin Name	SOT-23-6L Pin #	TDFN-8L Pin #	Function
LX	1	8	<b>Switch Pin.</b> Connect inductor/diode here.
GND	2	1, 5, 9	<b>Ground Pin.</b>
FB	3	6	<b>Feedback Pin.</b> Reference voltage is 0.24V, connect cathode of lowest LED and resistor here.
EN	4	4	<b>Chip Enable Pin and PWM Dimming Control Pin.</b> Connect to 1.2V or higher to enable device, 0.4V or less to disable device.
OUT	5	3	<b>Over Voltage Protection Pin.</b>
IN	6	2	<b>Input Voltage Pin.</b>
NC	N/A	7	<b>Not connected.</b>

## 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 37V	Junction Temperature	150°C
ESD Susceptibility	HBM 2kV MM 200V	Lead Temperature (Soldering, 10 sec)	260°C

## Thermal data

Package	Thermal resistance	Parameter	Value
SOT-23-5	$\theta_{JA}$ (Note 2)	Junction-ambient	250°C/W
	$\theta_{JC}$ (Note 3)	Junction-case	81°C/W
TDFN-8 (2x2 mm)	$\theta_{JA}$ (Note 2)	Junction-ambient	165°C/W
	$\theta_{JC}$ (Note 3)	Junction-case	24°C/W

**Note 1:**  $T_J$  is a function of the ambient temperature  $T_A$  and power dissipation  $P_D$  ( $T_J = T_A + (P_D) * (165^\circ\text{C/W})$ ).

**Note 2:**  $\theta_{JA}$  is measured in the natural convection at  $T_A=25^\circ\text{C}$  on a highly effective thermal conductivity test board (2 layers , 2SOP ) according to the JEDEC 51-7 thermal measurement standard.

**Note 3:**  $\theta_{JC}$  represents the heat resistance between the chip and the package top case.

## Electrical Characteristics

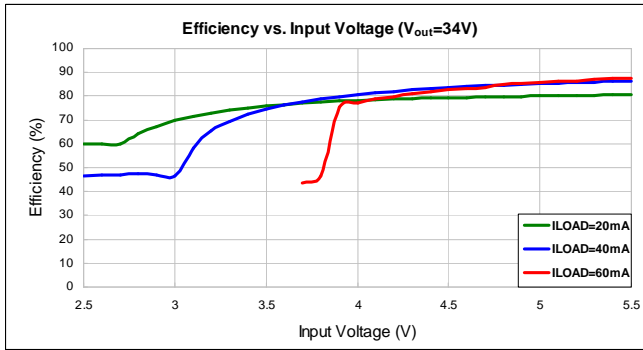
( $V_{CC} = 3.7V$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.)

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		120		$\mu\text{A}$
Shutdown Current	VEN < 0.4V			1	$\mu\text{A}$
Operation Frequency		0.8	1.0	1.2	MHz
Maximum Duty Cycle		93	95		%
Feedback Voltage		0.228	0.240	0.252	V
Thermal Shutdown Protection			165		$^\circ\text{C}$
Thermal Shutdown Hysteresis			20		$^\circ\text{C}$
Ron	IsW = 200mA		0.5	0.8	ohm
Current Limit			1.5		A
Shutdown Voltage Low		0.4			V
Enable Voltage High				1.2	V
EN Leakage Current			1.3		$\mu\text{A}$
Maximum Output Voltage			36		V
OVP			41		V
OVP Hysteresis		0.2	1	3	V

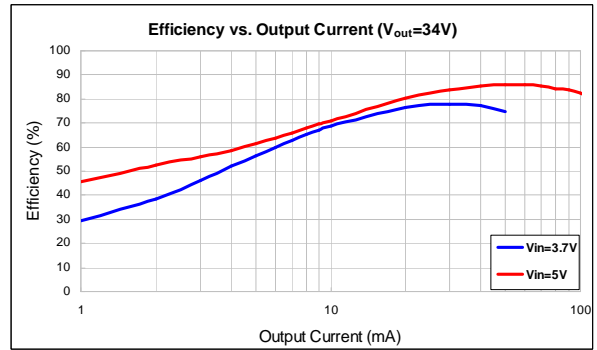
## Typical Performance Characteristics

V<sub>IN</sub>=3.7V, unless otherwise specified

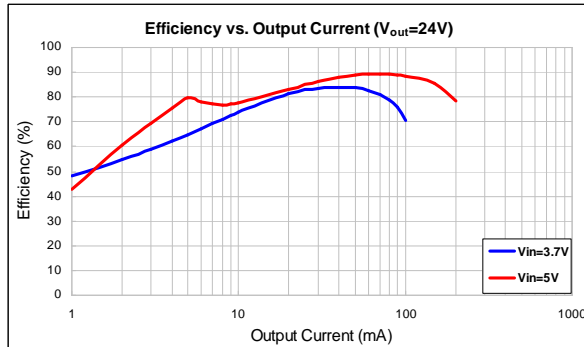
Efficiency vs. Input Voltage (V<sub>out</sub>=34V)



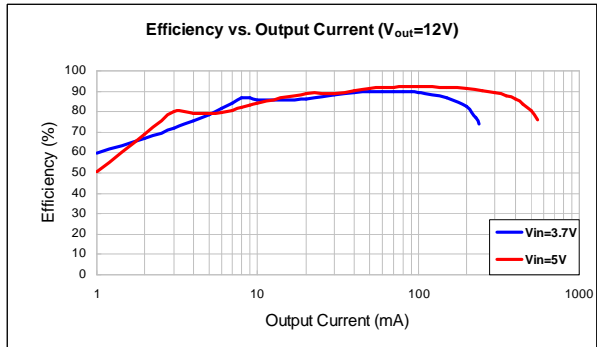
Efficiency vs. Output Current (V<sub>out</sub>=34V)



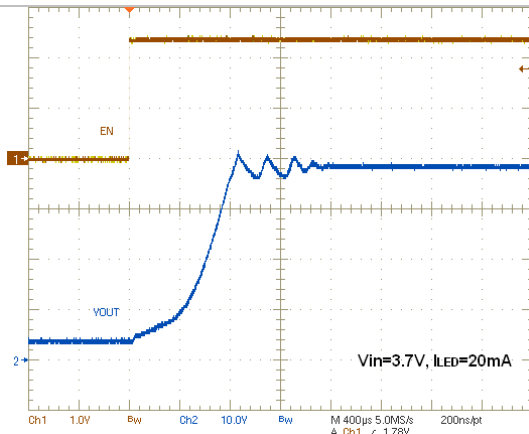
Efficiency vs. Output current (V<sub>out</sub>=24V)



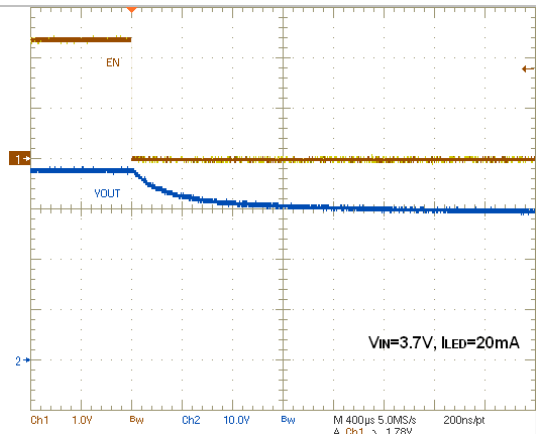
Efficiency vs. Output current (V<sub>out</sub>=12V)



Power On from EN

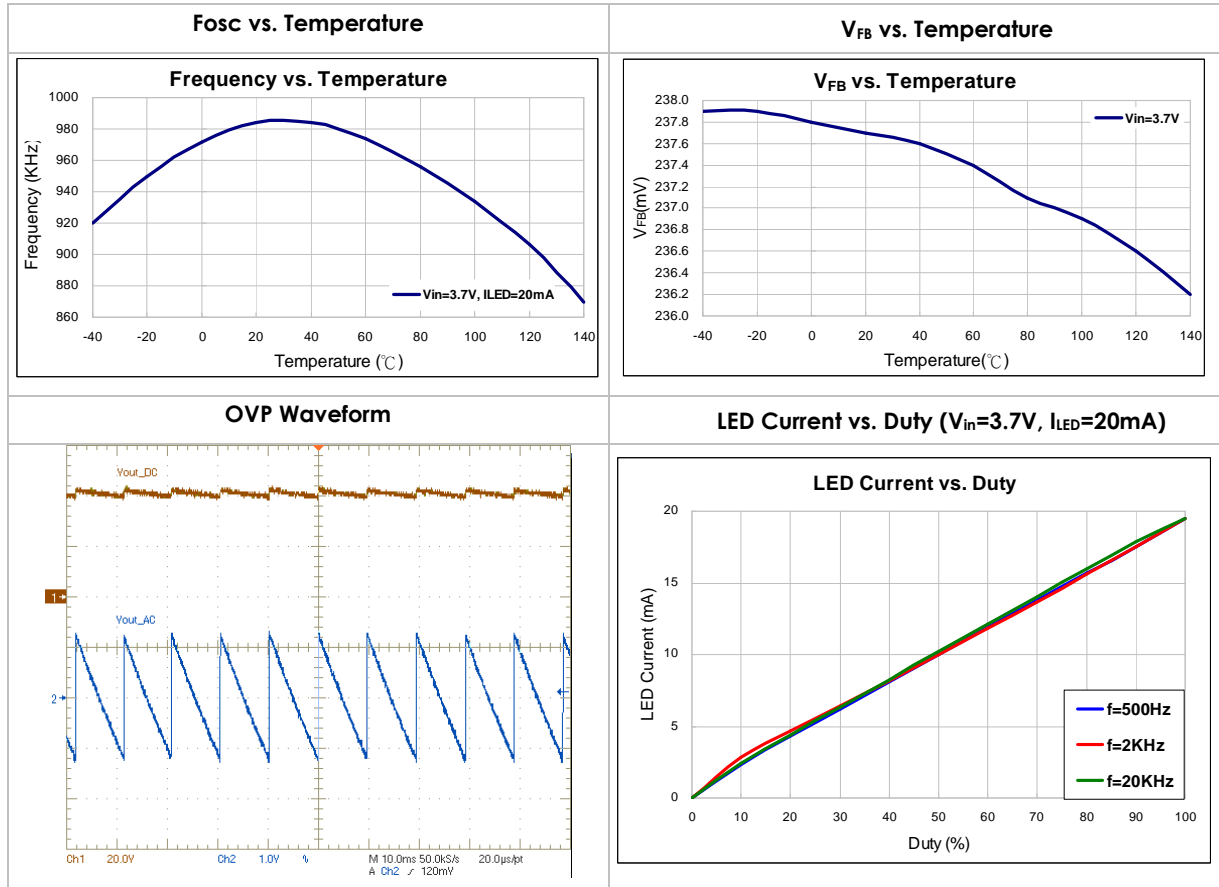


Power Off from EN



## Typical Performance Characteristics

V<sub>IN</sub>=3.7V, unless otherwise specified



## **Application Information**

### **Detailed Description**

The EMD2055 is a constant frequency, current-mode boost DC-DC converter which can drive up to WLEDs 11S1P ~ 9S3P, depending on the input voltage range. The device can provide the well matched output current through each WLED serial chain to obtain uniform illumination. The fast operation frequency allows smaller inductor and input/output capacitors to be used.

During normal operation, the internal oscillator sends 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 the error amplifier, the PWM comparator sends a signal to reset the latch and turn off internal MOSFET. The output voltage of the error amplifier is magnified from the difference between reference voltage and feedback voltage. If the reference voltage is higher than feedback voltage, more current is delivered to the output; otherwise, less current is delivered.

### **UVLO**

The EMD2055 provides Under-Voltage-Lock-Out (UVLO) protection. When VIN is lowered below UVLO threshold, the UVLO circuit will send a signal to turn off the internal power MOSFET, which will stop supplying output current. The 100mV hysteresis circuit in the UVLO circuit can prevent supply transients from causing a false restart. Once the VIN exceeds UVLO threshold again, the device will unlock the latch and turn on the internal power MOSFET to continue the normal operation.

### **Enable / Disable**

The EMD2055 enters shutdown mode when EN pin voltage is less than 0.4V. During shutdown mode, all internal circuits of the EMD2055 are turned off and the quiescent current is reduced to less than 1uA. When the EN pin voltage is higher than 1.2V, the device will start operation.

The EN pin can also be used for dimming control by using a PWM modulated signal. The frequency of this PWM signal can range from 100Hz to 100kHz. The average LED driving current is directly proportional to the duty cycle of the PWM duty cycle, i.e., 0% duty cycle corresponding to zero WLEDs current and 100% duty cycle corresponding to full WLEDs current.

### **OVP**

When any of the serially connected WLEDs chain is open, the boost control loop behaves as an open loop operation, which may cause damage on the LX pin due to excessive voltage. In order to prevent this damage from happening, the EMD2055 provides an Over-Voltage-Protection (OVP) circuit, with the protection threshold set at 41V. When LX pin exceeds 41V, the internal operation will be shut off.

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## **OTP**

The internal thermal sensor will turn off the internal power MOSFET when the junction temperature exceeds 165°C. This Over-Temperature-Protection (OVT) circuit has a built-in 20°C hysteresis.

## **LED Current Setting**

Referring to a typical application shown in Figure 1 the brightness of the WLED is controlled by adjusting the operating current. The EMD2055 regulates its operating current by adjusting the sense resistor (R1), which is given by:

$$\text{LED current} = 0.240\text{V} / R1$$

## **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 4.7μF is required for the EMD2055, 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 EMD2055.

## **Diode Selection**

Referring to Figure 1 of the typical application, the EMD2055 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.



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## Application Circuit

- Application circuit for 10S1P

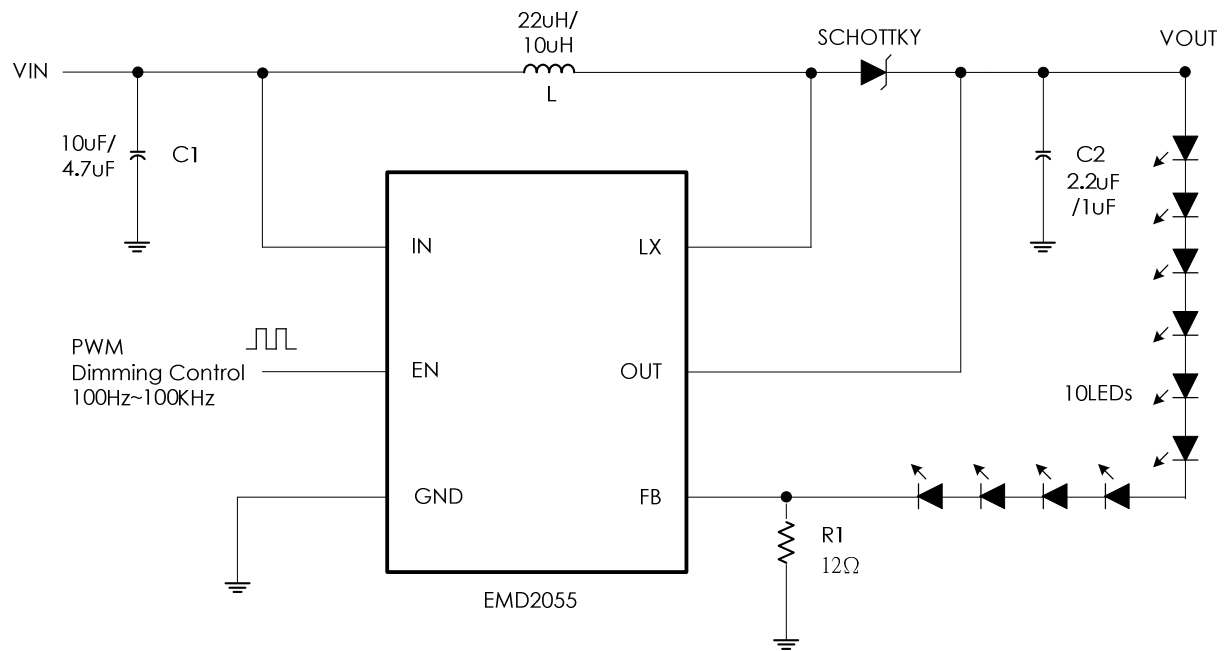


Fig. 3

- Application circuit for 9S3P

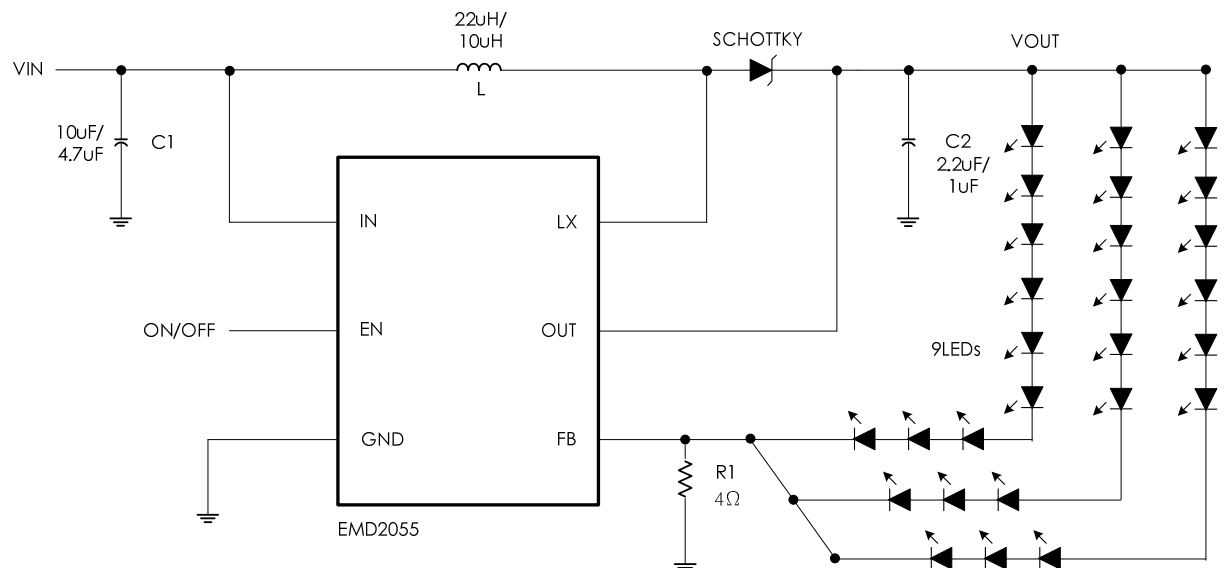
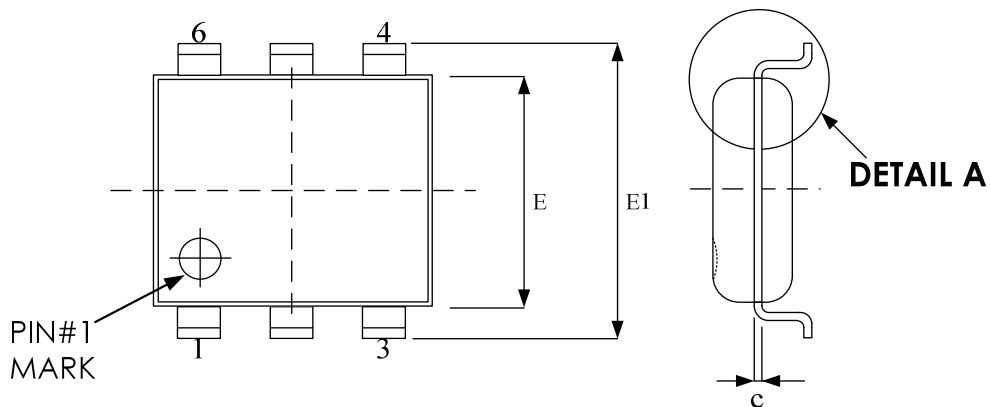


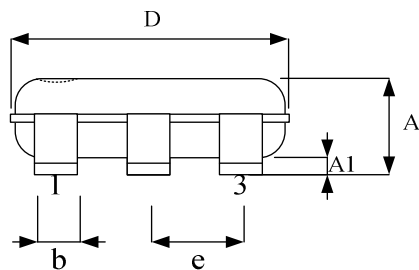
Fig. 4

# ESMT/EMP

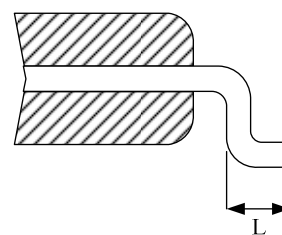
## Package Outline Drawing SOT-23-6



### TOP VIEW



### SIDE VIEW

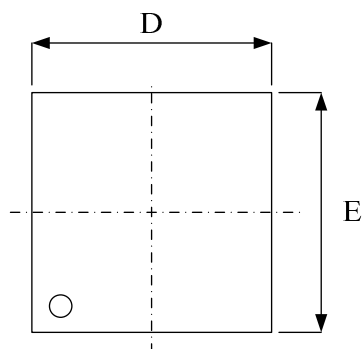


### DETAIL A

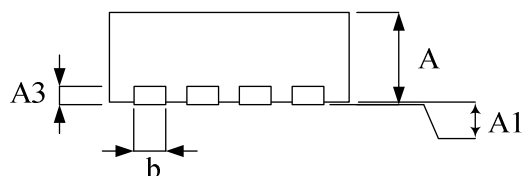
Symbol	Dimension in mm	
	Min.	Max.
A	0.90	1.45
A1	0.00	0.15
b	0.30	0.50
c	0.08	0.25
D	2.70	3.10
E	1.40	1.80
E1	2.60	3.00
e	0.95 BSC	
L	0.30	0.60

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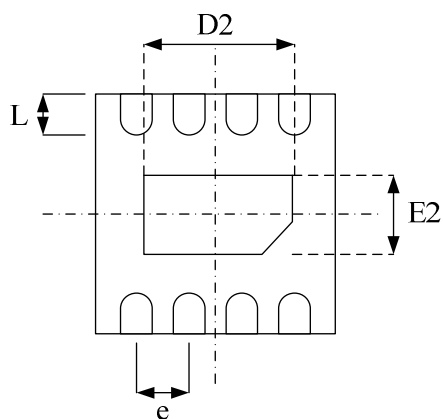
## Package Outline Drawing TDFN-8L (2x2 mm)



**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**

<b>Revision</b>	<b>Date</b>	<b>Description</b>
0.01	1/4/2013	Draft version.
0.02	1/7/2013	Draft version, reduced Cin & Cout capacitor requirement.
0.03	1/16/2013	Updated measurement data into this datasheet.

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