

# 1A, 500KHz PWM Synchronous Boost Converter with Output Isolated During Shutdown

## General Description

The EMH7021 is a high efficiency, synchronous fixed frequency, current-mode step-up DC/DC converter. During shutdown mode, the output is completely isolated from the input without drawing any battery current. The fixed 500KHz switching frequency obtains maximum efficiency up to 96% and uses only a few external components.

With  $150\Omega$  loading, the minimum start-up voltage can be as low as 0.93V, provided by a one or two-cell alkaline or one-cell Li-Lon battery.

The features of EMH7021 include current limit, low battery comparator, open-drain power good output, short circuit, and thermal shutdown protection. The EMH7021 is also available in 3X3mm TDFN-10 package.

## Applications

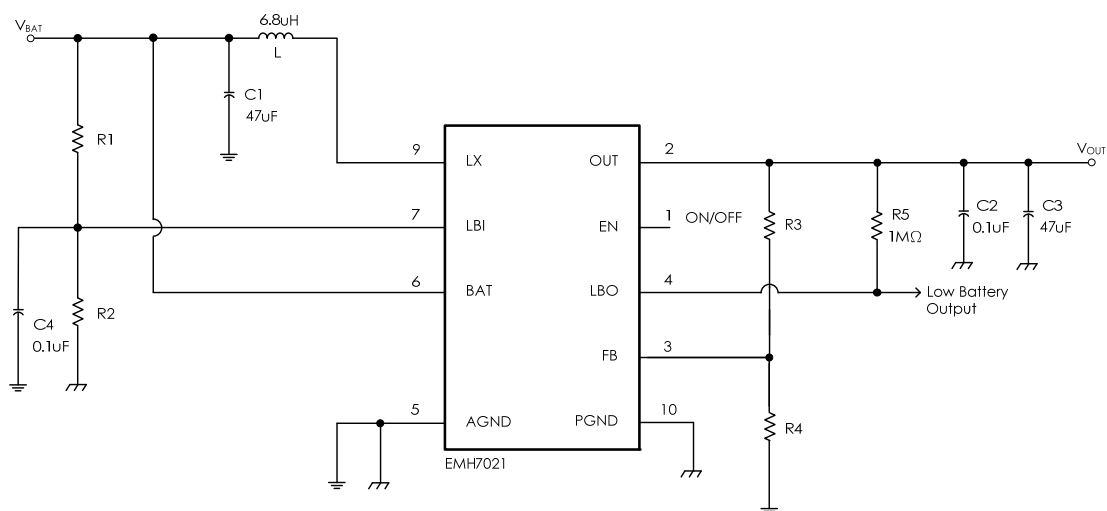
- Mobile Phone

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

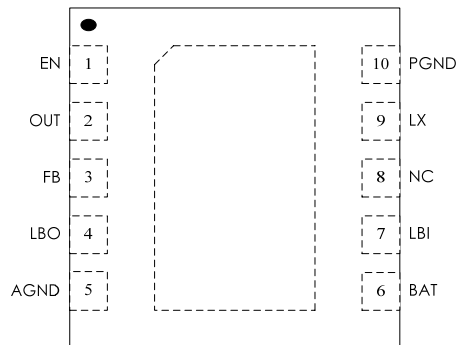
## Features

- Up to 96% efficiency
- Reference voltage: 0.5V
- Output to input disconnect at shutdown mode
- Current delivery
  - $1A@V_{OUT}=3.3V, V_{BAT}=2.4V$
  - $1A@V_{OUT}=5.0V, V_{BAT}=3.6V$
- Switch current limit protection
- 500KHz fixed switching frequency
- Thermal shutdown protection
- 0.5V Low-battery comparator
- Min-start up voltage: 0.93V
- Low quiescent current: 48uA (Typ.)
- Low shutdown current < 1uA
- TDFN 3x3mm 10 pins package

## Typical Application



## Connection Diagrams



## Order information

EMH7021-XXFF10NRR  
 XX Output voltage  
 00 Adj output  
 FF10 TDFN-10 Package  
 NRR RoHS & Halogen free package  
 Rating: -40 to 85°C  
 Package in Tape & Reel

## Order, Marking & Packing Information

Package	Product ID.	Marking	Packing
TDFN-10	EMH7021-00FF10NRR		Tape & Reel 5Kpcs

## Pin Functions

Pin Name	Pin #	Function
EN	1	Chip enable pin (1: enabled ; 0: disabled)
OUT	2	Boost converter output
FB	3	Output voltage feedback input pin, using resistor divider to set the output voltage from 1.8V to 5.0V.
LBO	4	Open-drain low battery comparator output
AGND	5	Analog ground
BAT	6	Battery input
LBI	7	Low battery comparator input It should be connected to BAT pin if the comparator is not used.
NC	8	NC pin
LX	9	Boost and rectifying switch input
PGND	10	Power ground
Thermal land	11	Must be soldered this to PCB ground to achieve appropriate power dissipation.

## Functional Block Diagram

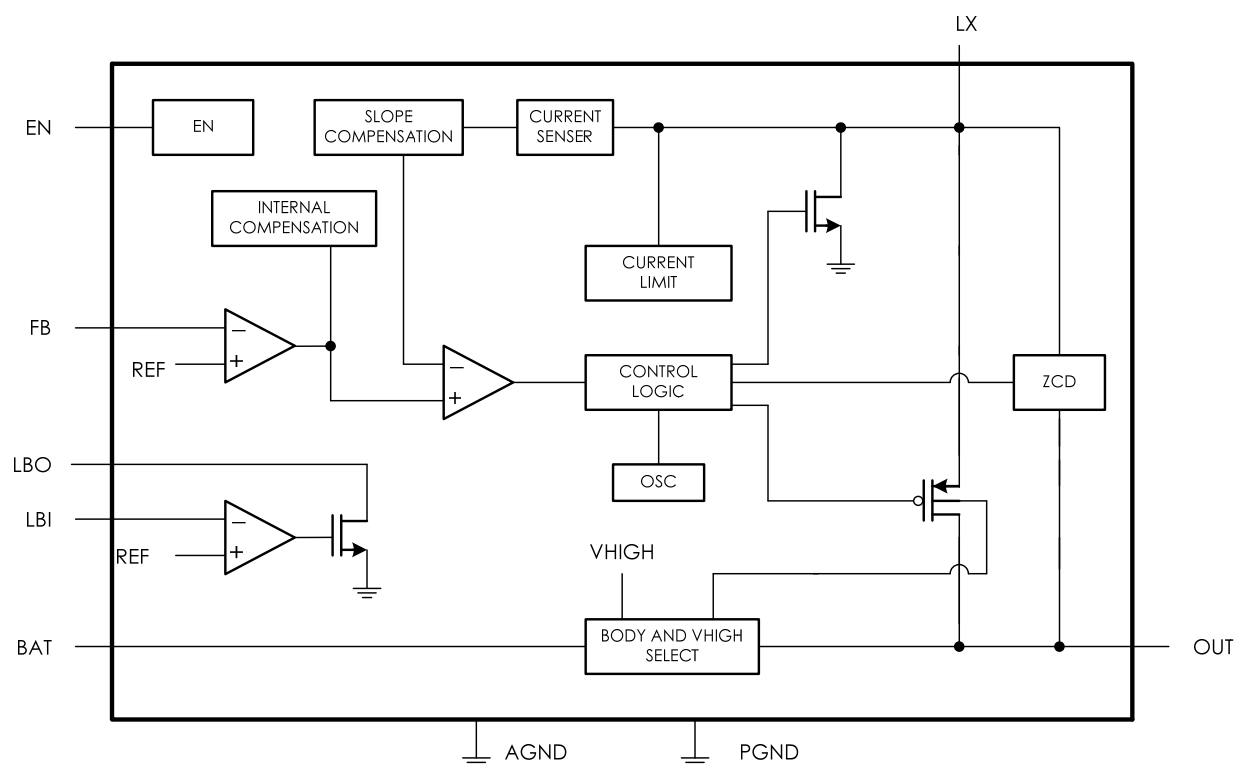


FIG.1 Functional block diagram of EMH7021

**Absolute Maximum Ratings** (Notes 1, 2)

BAT, EN, OUT, FB and LBO Voltage	-0.3V to 6V	Junction Temperature (T <sub>J</sub> )	150°C
LBI Voltage	-0.3V to V <sub>BAT</sub>	Lead Temperature (Soldering, 10 sec.)	260°C
LX Voltage	-0.3V to (V <sub>BAT</sub> + 0.3V)	ESD Rating	
Power Dissipation	(Note 5)	Human Body Model	2KV
Storage Temperature Range	-65°C to 150°C	Machine model	200V

**Operating Ratings** (Note 1, 2)

Supply Voltage (V <sub>BAT</sub> )	0.9V to 5.0V	Thermal Resistance (θ <sub>JA</sub> , Note 3))	110°C/W
Operating Temperature Range	-40°C to 85°C	Thermal Resistance (θ <sub>JC</sub> , Note 4))	8.5°C/W

**Electrical Characteristics**

Unless otherwise specified, all limits guaranteed for V<sub>OUT</sub>=3.3V, V<sub>EN</sub>=1.2V, T<sub>A</sub> = 25°C; **Boldface** limits apply for the operating temperature extremes: -40°C and 85°C.

Symbol	Parameter	Conditions	Min	Typ (Note 6)	Max	Units
V <sub>START-UP</sub>	Start-Up V <sub>BAT</sub>	RL=150Ω		0.93	<b>1.2</b>	V
		RL=3.3KΩ		0.85		V
V <sub>OUT</sub>	Output voltage		1.8		5.0	V
V <sub>FB</sub>	Feedback voltage		485	500	515	mV
F <sub>SW</sub>	Operation Frequency		400	500	600	kHz
I <sub>CL</sub>	Current limit		1.84	2.3	2.76	A
	Current limit @ start-up			0.4*I <sub>CL</sub>		A
R <sub>DS-ON</sub>	RON(NMOS)	I <sub>SW</sub> = 500mA		245		mΩ
	RON(PMOS)	I <sub>SW</sub> = 500mA		315		mΩ
I <sub>Q</sub>	V <sub>OUT</sub>	V <sub>FB</sub> =0.6V		48		μA
	V <sub>BAT</sub>				<b>1</b>	μA
I <sub>SD</sub>	Shutdown current	V <sub>BAT</sub> ≤ 4.2			<b>1</b>	μA
T <sub>SENSOR</sub>	OTP			150		°C
	hysteresis			30		°C
V <sub>IH</sub>		(V <sub>BAT</sub> or V <sub>OUT</sub> > 1.8V)	<b>0.9</b>			V
		(V <sub>BAT</sub> or V <sub>OUT</sub> < 1.8V)	0.9*V <sub>BAT</sub>			V
V <sub>IL</sub>		(V <sub>BAT</sub> or V <sub>OUT</sub> > 1.8V)			<b>0.4</b>	V
		(V <sub>BAT</sub> or V <sub>OUT</sub> < 1.8V)			0.1*V <sub>BAT</sub>	V
	Line regulation	I <sub>LOAD</sub> =100mA, V <sub>OUT</sub> =5.0V, V <sub>BAT</sub> =2.4V to 3.6V			0.6%	(V <sub>omax</sub> -v <sub>omin</sub> )/ (V <sub>imax</sub> -v <sub>imin</sub> )
	Load regulation	V <sub>BAT</sub> =3.6V, V <sub>OUT</sub> =5.0V I <sub>LOAD</sub> =50mA to 800mA			0.6%	(V <sub>omax</sub> -v <sub>omin</sub> )/ v <sub>omin</sub>
V <sub>LBI</sub>	LBI voltage threshold		475	500	525	mV
	LBI input hysteresis			35		mV

**Note 1:** Absolute Maximum ratings indicate limits beyond which damage may occur.

**Note 2:** All voltages are in respect to the potential of the ground pin.

**Note 3:**  $\theta_{JA}$  is measured in the natural convection at  $T_A=25^{\circ}\text{C}$  on a highly effective thermal conductivity test board (2 layers, 2SOP).

**Note 4:**  $\theta_{JC}$  represents the thermal resistance between the chip and the top of the package case.

**Note 5:** Maximum Power dissipation for the device is calculated using the following equation:

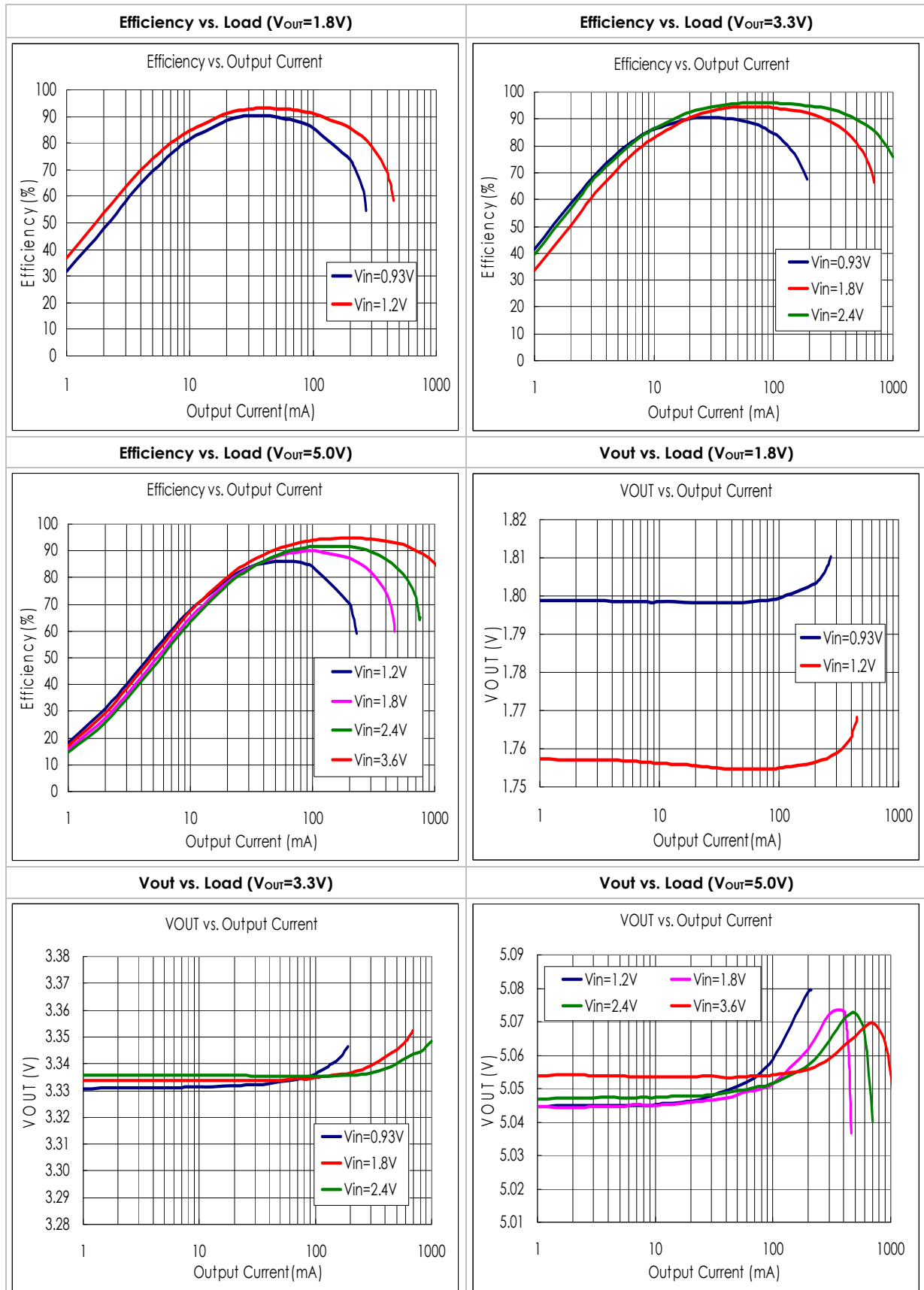
$$P_D = \frac{T_{J(\text{MAX})} - T_A}{\theta_{JA}}$$

Where  $T_{J(\text{MAX})}$  is the maximum junction temperature,  $T_A$  is the ambient temperature, and  $\theta_{JA}$  is the junction-to-ambient thermal resistance. For example, for the TDFN-10 package  $\theta_{JA} = 110^{\circ}\text{C/W}$ ,  $T_{J(\text{MAX})} = 150^{\circ}\text{C}$  and using  $T_A = 25^{\circ}\text{C}$ , the maximum power dissipation is 1.136W. The derating factor ( $-1/\theta_{JA}$ ) =  $-9.09\text{mW}/^{\circ}\text{C}$ . Below  $25^{\circ}\text{C}$  the power dissipation figure can be increased by  $9.09\text{mW}$  per degree and similarly decreased by this factor for temperatures above  $25^{\circ}\text{C}$ .

**Note 6:** Typical Values represent the most likely parametric norm

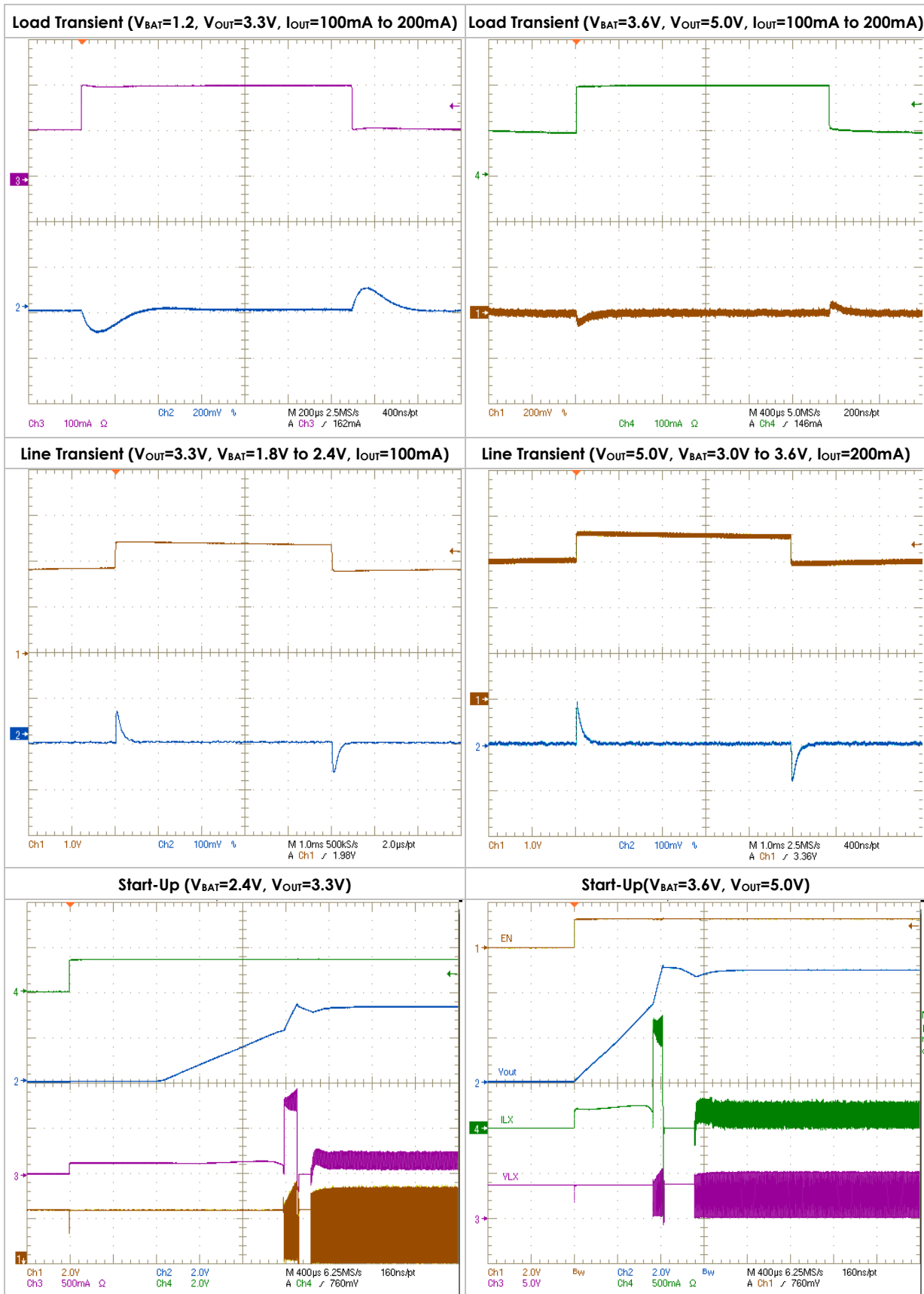
## Typical Performance Characteristics

Unless otherwise specified,  $V_{BAT}=1.2V$ ,  $V_{EN}=1.2V$ ,  $V_{OUT}=3.3V$  and  $T_A = 25^{\circ}C$ ,  $L=6.8\mu H$ ,  $C_{IN}=C_{OUT}=47\mu F$



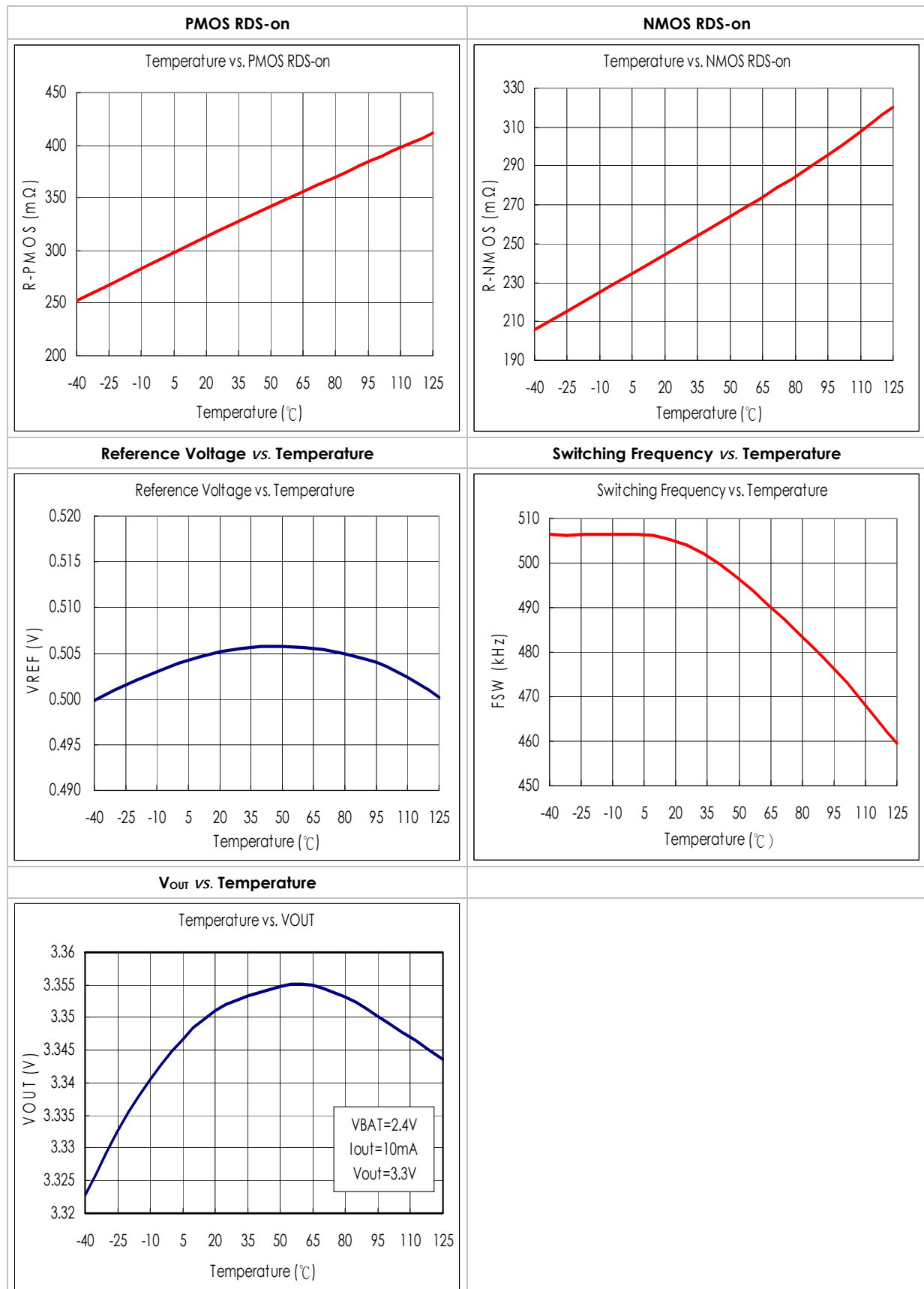
## Typical Performance Characteristics (cont.)

Unless otherwise specified,  $V_{BAT}=1.2V$ ,  $V_{EN}=1.2V$ ,  $V_{OUT}=3.3V$  and  $T_A = 25^{\circ}C$ ,  $L=6.8\mu H$ ,  $C_{IN}=C_{OUT}=47\mu F$



## Typical Performance Characteristics (cont.)

Unless otherwise specified,  $V_{BAT}=1.2V$ ,  $V_{EN}=1.2V$ ,  $V_{OUT}=3.3V$  and  $T_A = 25^{\circ}C$ ,  $L=6.8\mu H$ ,  $C_{IN}=C_{OUT}=47\mu F$





## Application Information

### Detailed Description

The EMH7021 is a high efficiency, synchronous fixed frequency, current-mode step-up DC/DC converter. During shutdown mode, the output is completely isolated from the input without drawing any battery current. The device can provide up to 500mA output current and maintains at least 90% efficiency from two-cell alkaline batteries. The EMH7021 also provide 1A at 5V from a 3.6V rail of a Li-Ion battery. With Synchronous structure, an external Schottky diode is not needed.

During normal operation, the internal oscillator sends a pulse signal to set latch and turn on/off internal NMOSFET/PMOSFET during each clock cycle. A current sense voltage sums NMOSFET 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/on internal NMOSFET/PMOSFET. 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, otherwise, less current is delivered.

### Enable/Disable

The EMH7021 enters shutdown mode when EN pin voltage is less 0.4V ( $V_{BAT}$  or  $V_{OUT} > 1.8V$ ). When in shutdown mode, all internal circuits of the EMH7021 are turn off and quiescent current is reduced to 1uA. When driver EN pin voltage is higher than 0.9V ( $V_{BAT}$  or  $V_{OUT} > 1.8V$ ), start-up begins.

During  $V_{BAT}$  or  $V_{OUT} < 1.8V$ , the EN pin voltage should be less than 0.2  $V_{BAT}$  to disable the device , otherwise, the EN pin voltage should be higher than 0.9  $V_{BAT}$  to enable the device.

### Low Battery Detection ---- LBI/LBO

The EMH7021 provides an on-chip comparator with 35mV internal hysteresis for low battery detection. If the LBI pin voltage falls below the internal reference voltage (0.5V.), the LBO pin (an open-drain output) sinks current to GND. The LBI pin should be connected to BAT pin if the low battery comparator is not used.

### OTP

The internal thermal sensor turns off internal NMOSFET/PMOSFET when junction temperature is exceeded 150°C, the OTP is designed with a 30°C hysteresis.

## Pre-Boost Current and Short Circuit Protect

Initially output voltage is lower than battery voltage, and the EMH7021 enters pre-boost phase. During pre-boost phase, the internal NMOSFET/PMOSFET is turned off/on and a constant current is provided from battery to output until the output voltage close to the battery voltage. The constant current is limited by internal controller. If the output short to ground, the EMH7021 also limits the output current to avoid damage condition. Figure 2 shows the typical pre-boost current vs. output voltage for specific battery voltages:

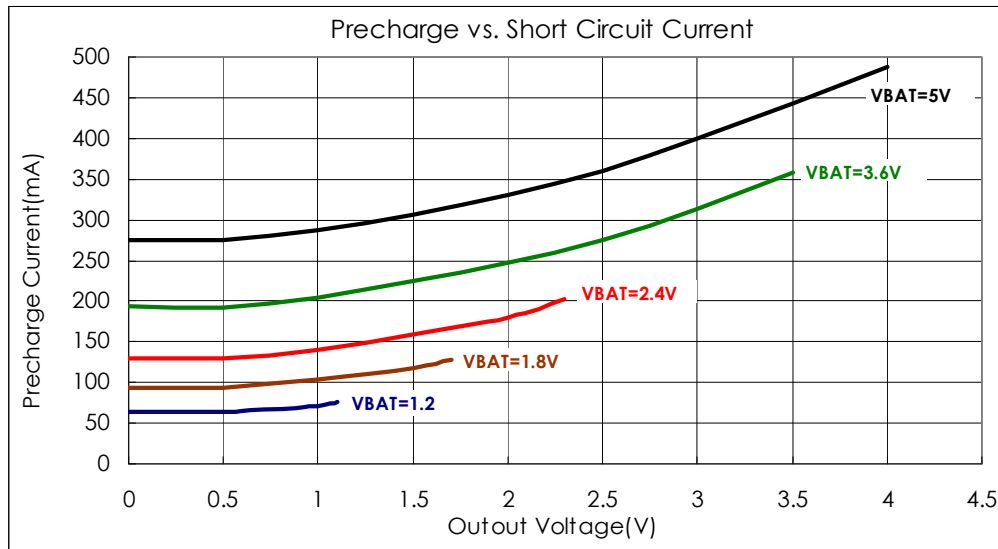


FIG.2 Short circuit current during pre-boost phase

## Selecting the Output Voltage

The output voltage is set using the FB pin and a resistor divider connected to OUT, FB, and GND. The feedback pin voltage typical is 0.5V, The  $V_{OUT}$  can be calculated by the following equation:

$$R3 = R4[(V_{OUT}/V_{FB}) - 1] \quad (1)$$

Where  $V_{REF}=0.5V$  and  $V_{OUT}$  ranges from 1.8V to 5.0V.

The recommended table:

Table 1

$V_{OUT}$	R3	R4
5V	1.02M $\Omega$	113K $\Omega$
3.3V	1.02M $\Omega$	182K $\Omega$
1.8V	510K $\Omega$	200K $\Omega$

## Inductor Selection

The Inductor is required to force the output voltage higher while being driven by a lower input voltage. For most applications, a 6.8uH inductor is used. An inductor with higher peak inductor current tends to provide a higher output voltage ripple ( $I_{PEAK} * \text{output filter capacitor ESR}$ ). The inductor's DC resistance can significantly affect efficiency. The maximum output current can be calculated as follows:

$$I_{OUT(max)} = \frac{V_{BAT}}{V_{OUT}} [I_{CL} - T_{off}(\frac{V_{OUT} - V_{BAT}}{2 \times L})] \eta \quad (2)$$

$I_{OUT(max)}$  = Maximum loading

$V_{BAT}$  = Input voltage

$L$  = Inductor value in  $\mu H$

$\eta$  = efficiency ( $\sim 0.9$  typically)

$T_{off}$  = LX switch's off - time in  $\mu s$

$I_{CL} = 2.3A$

Table 2

VENDOR	SERIES	VALUE	ISAT	DCR
Sumida	CDRH5D28R	6.8 $\mu H$	1.5A	37m $\Omega$
EPCOS	B82462-G4	6.8 $\mu H$	1.65A	51m $\Omega$
WURTH ELEKTRONIK	7447789	6.8 $\mu H$	2.75A	44m $\Omega$
CYNTEC CO.	PCMC063T	6.8 $\mu H$	4.5A	54m $\Omega$
	PCMB063T	6.8 $\mu H$	4.5A	43.9m $\Omega$
COILCRAFT	MSSZ260-682MLD	6.8 $\mu H$	4.9A	23m $\Omega$

## Input Capacitor Selection

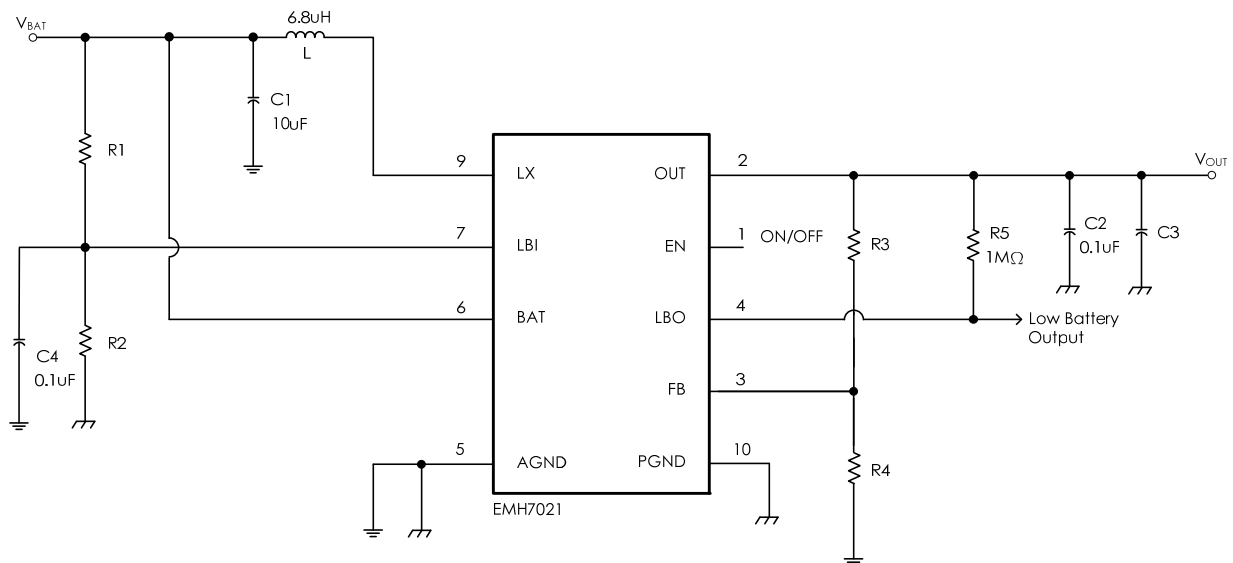
A low ESR 10 $\mu F$  input capacitor is recommended to improve transient behavior and reduce the peak current drawn from the battery. Ceramic capacitors are also a good choice for input decoupling and should be located as close as possible to the device.

## Output Capacitor Selection

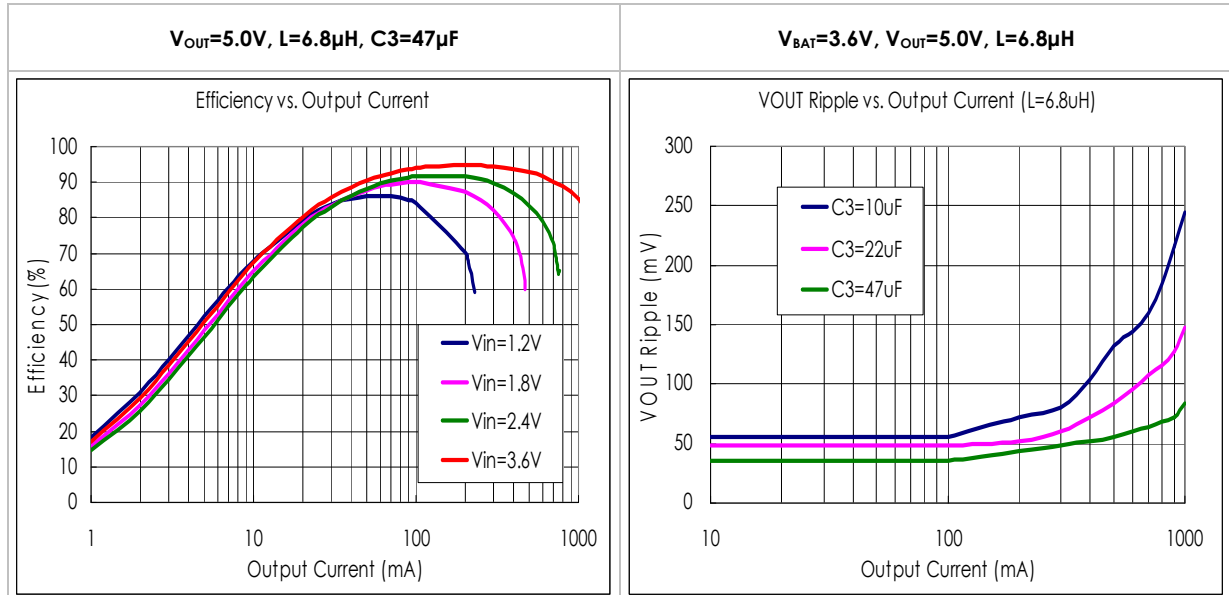
The output ripple voltage relates with the peak inductor current and the output capacitor's ESR. Multilayer ceramic capacitors are an excellent choice as they have extremely low ESR. A 47 $\mu F$  output capacitor is sufficient for most applications.

## Application Examples

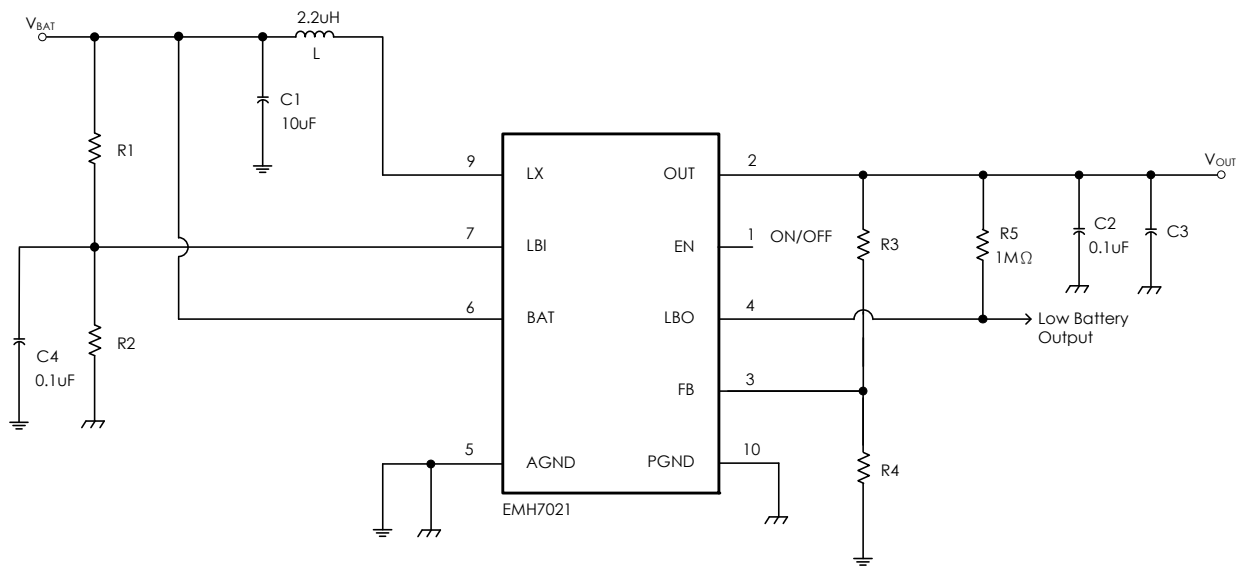
Inductor=6.8uH



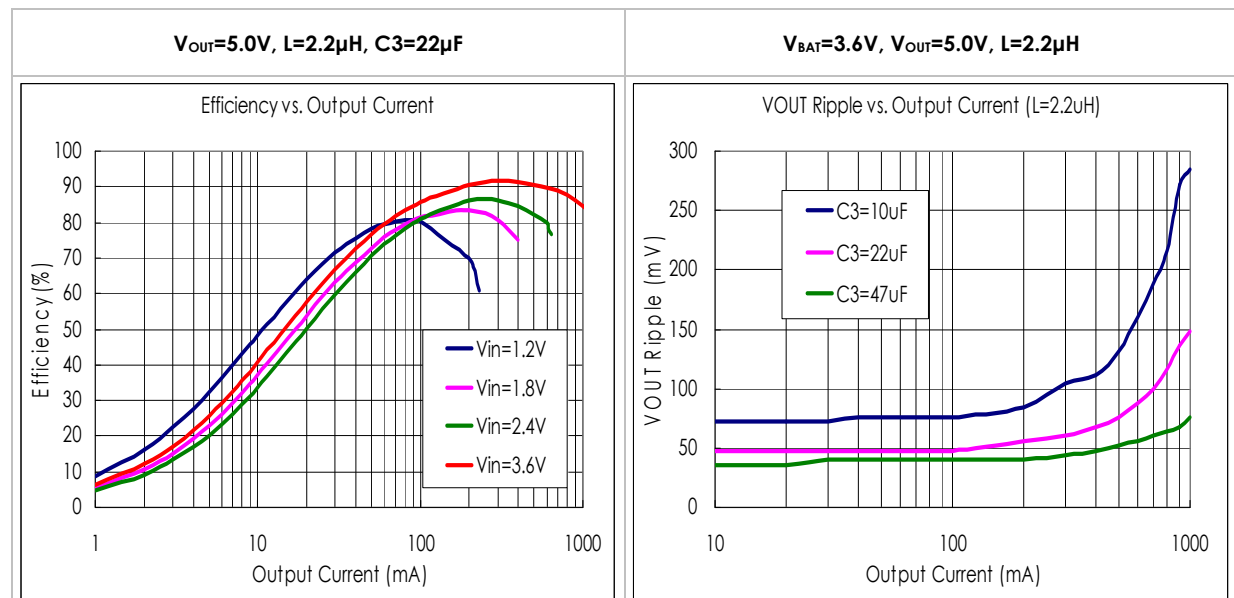
L= CYNTEC CO. PCMB063T  
C1, C2, C3 = X7R Ceramic



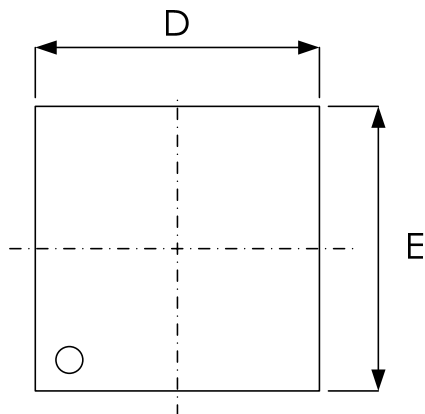
Inductor=2.2uH



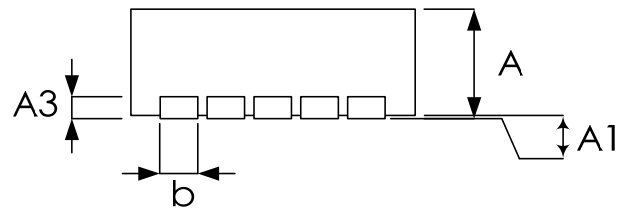
L= CYNTEC CO. PCMB063T  
C1, C2, C3 = X7R Ceramic



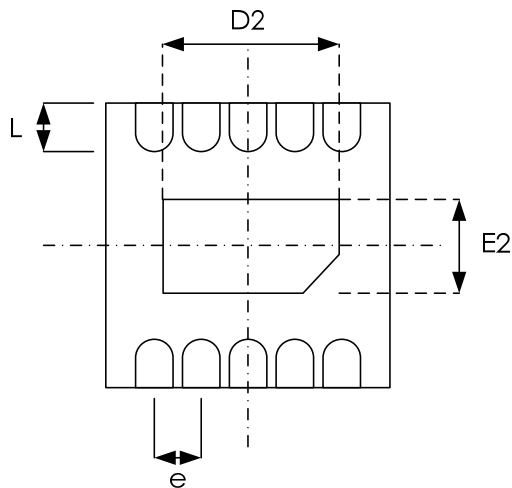
## Package Outline Drawing TDFN-10 (3x3 mm)



**TOP VIEW**



**SIDE VIEW**



**BOTTOM VIEW**

Symbol	Dimension in mm	
	Min	Max
A	0.70	0.85
A1	0.00	0.05
A3	0.18	0.25
b	0.18	0.30
D	2.95	3.05
E	2.95	3.05
e	0.5 BSC	
L	0.30	0.50

### Exposed pad

	Dimension in mm	
	Min	Max
D2	2.20	2.70
E2	1.40	1.75

**Revision History**

Revision	Date	Description
0.1	2010.07.28	Original
0.2	2010.12.07	1.LBI voltage threshold update 2.V <sub>IH</sub> / V <sub>IL</sub> (as V <sub>BAT</sub> or V <sub>OUT</sub> <1.8V) update
0.3	2011.02.11	VO <sub>UT</sub> divider resistor is incorrect, the recommended table 1, R4 Value is 200K $\Omega$
1.0	2011.04.06	Skip "Preliminary"
1.1	2012.05.24	1.Modify the typical application and application examples 1.Modify the Condition of ISD 2.Modify the Package Outline Drawing

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