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 150Ω 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.

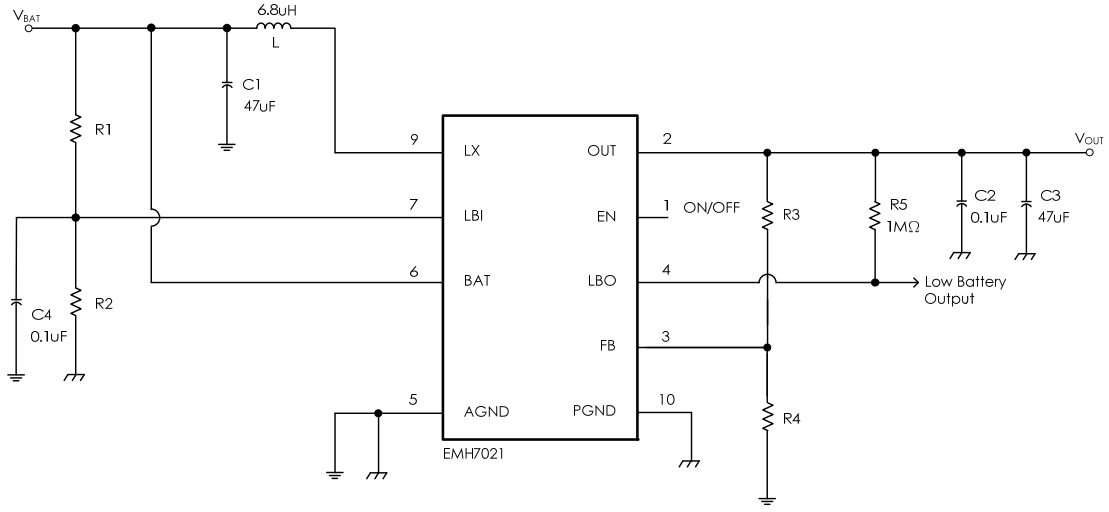
Applications

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

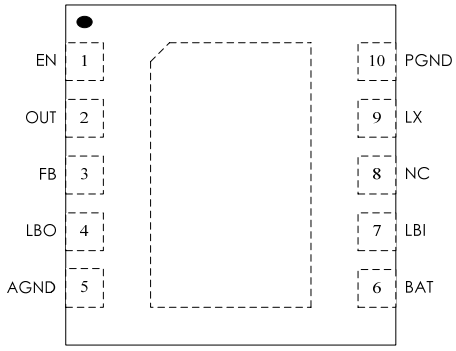
Features

- 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 (Tpy.)
- Low shutdown current < 1uA
- TDFN 3x3mm 10 pins package

Typical Application



Connection Diagrams

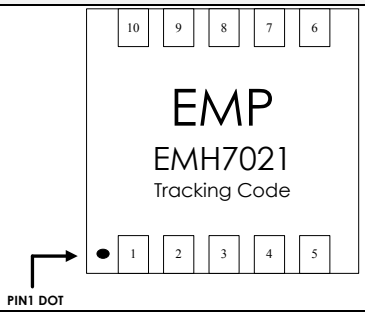


Order information

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

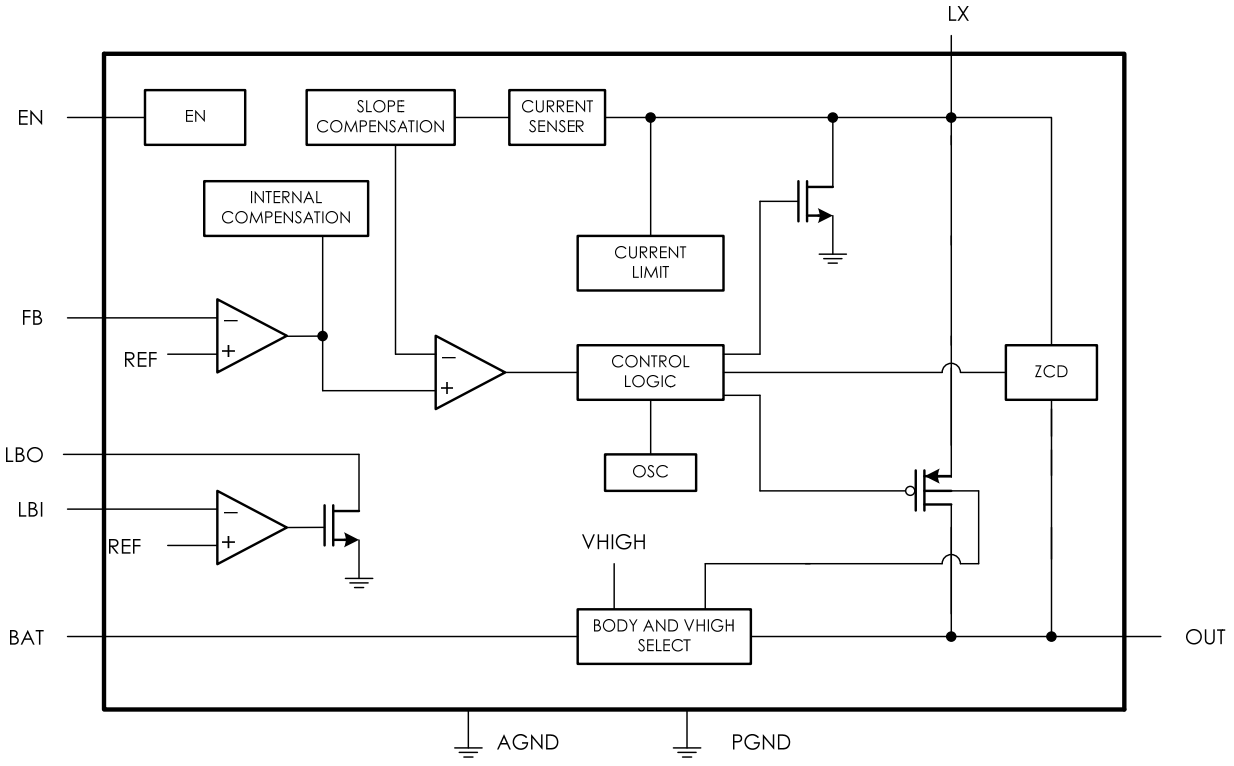


FIG.1 Functional block diagram of EMH7021

Absolute Maximum Ratings (Notes 1, 2)

BAT, EN, OUT, FB and LBO Voltage	-0.3V to 6V	Junction Temperature (T_J)	150°C
LBI Voltage	-0.3V to VBAT	Lead Temperature (Soldering, 10 sec.)	260°C
LX Voltage	-0.3V to (VBAT + 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_{BAT})	0.9V to 5.0V	Thermal Resistance (θ_{JA} , Note 3))	110°C/W
Operating Temperature Range	-40°C to 85°C	Thermal Resistance (θ_{JC} , Note 4))	8.5°C/W

Electrical Characteristics

Unless otherwise specified, all limits guaranteed for V_{OUT}=3.3V, V_{EN}=1.2V, T_A = 25°C; **Boldface** limits apply for the operating temperature extremes: -40°C and 85°C.

Symbol	Parameter	Conditions	Min	Typ (Note 6)	Max	Units
$V_{START-UP}$	Start-Up V_{BAT}	RL=150Ω		0.93	**1.2**	V
		RL=3.3KΩ		0.85		V
V_{OUT}	Output voltage		1.8		5.0	V
V_{FB}	Feedback voltage		485	500	515	mV
F_{SW}	Operation Frequency		400	500	600	kHz
I_{CL}	Current limit		1.84	2.3	2.76	A
	Current limit @ start-up			0.4*I_{CL}		A
R_{DS-ON}	RON(NMOS)	I_{SW} = 500mA		245		mΩ
	RON(PMOS)	I_{SW} = 500mA		315		mΩ
I_Q	V_{OUT}	VFB=0.6V		48		μA
	V_{BAT}				**1**	μA
I_{SD}	Shutdown current	VBAT≦4.2			**1**	μA
T_{SENSOR}	OTP			150		℃
	hysteresis			30		℃
V_{IH}		(V_{BAT} or V_{OUT} >1.8V)	**0.9**			V
		(V_{BAT} or V_{OUT} <1.8V)	0.9*V_{BAT}			V
V_{IL}		(V_{BAT} or V_{OUT} >1.8V)			**0.4**	V
		(V_{BAT} or V_{OUT} <1.8V)			0.1*V_{BAT}	V
	Line regulation	I_{LOAD}=100mA, V_{OUT}=5.0V, V_{BAT}=2.4V to 3.6V			0.6%	(Vomax-vomin)/ (Vimax-vimin)
	Load regulation	V_{BAT}=3.6V, V_{OUT}=5.0V I_{LOAD}=50mA to 800mA			0.6%	(Vomax-vomin)/ vomin
V_{LBI}	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: θ_{JA} is measured in the natural convection at T_A=25℃ on a highly effective thermal conductivity test board (2 layers, 2S0P).

Note 4: θ_{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:

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

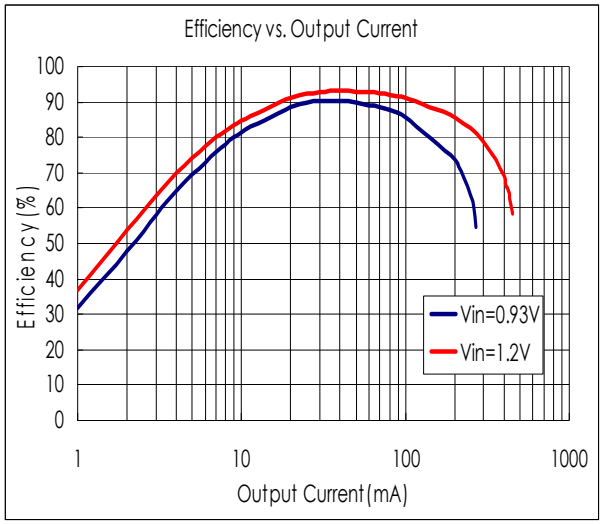
Where T_J(MAX) is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction-to-ambient thermal resistance. For example, for the TDFN-10 package θ_{JA} = 110°C/W, T_J (MAX) = 150°C and using T_A = 25°C, the maximum power dissipation is 1.136W. The derating factor (-1/θ_{JA})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

Note 6: Typical Values represent the most likely parametric norm

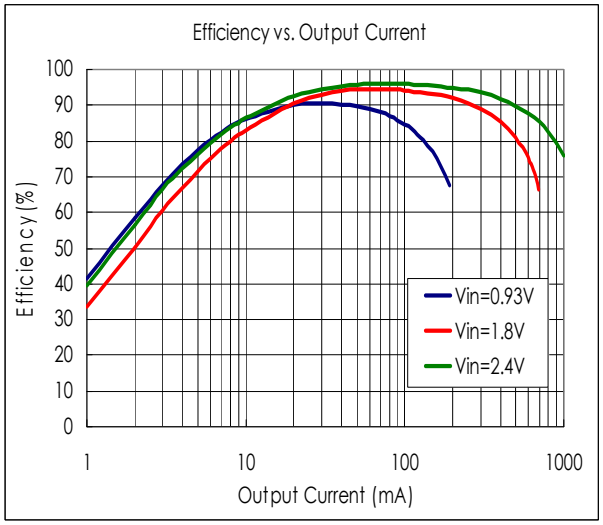
Typical Performance Characteristics

Unless otherwise specified, V_{BAT}=1.2V, V_{EN}=1.2V, V_{OUT}= 3.3V and T_A = 25°C ,L=6.8µH, C_{IN}= C_{out} =47µF

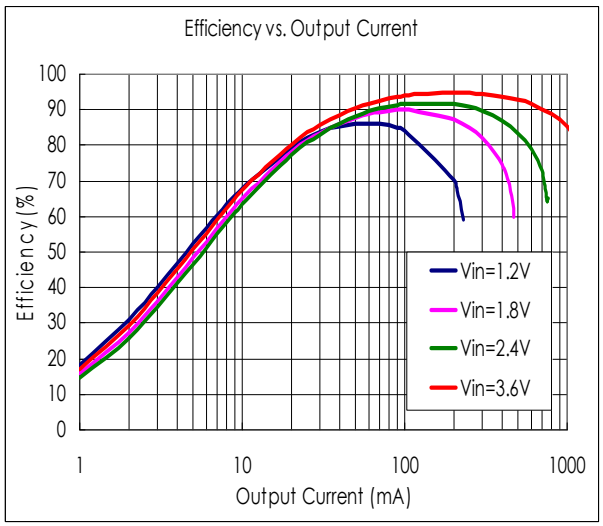
Efficiency vs. Load (V_{OUT}=1.8V)



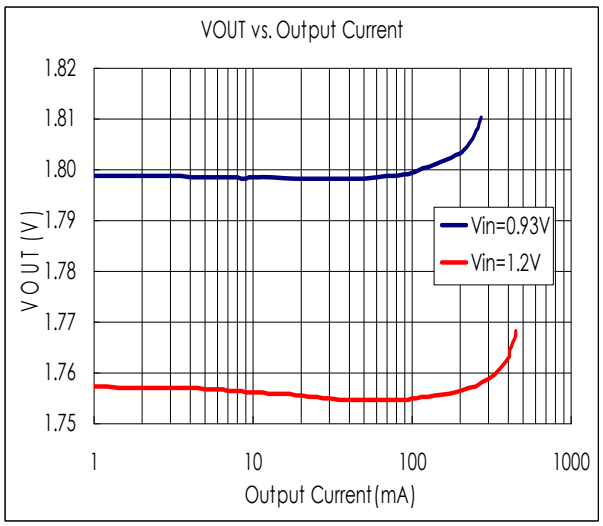
Efficiency vs. Load (V_{OUT}=3.3V)



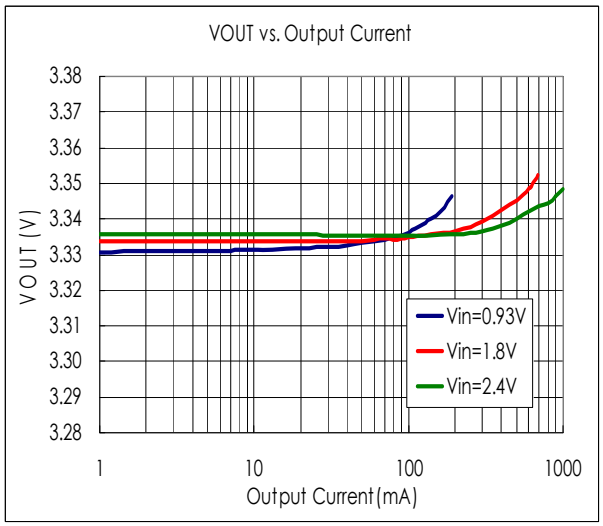
Efficiency vs. Load (V_{OUT}=5.0V)



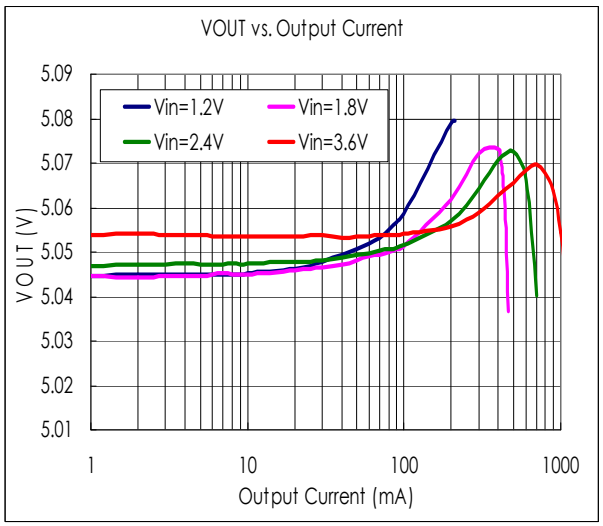
Vout vs. Load (V_{OUT}=1.8V)



Vout vs. Load (V_{OUT}=3.3V)



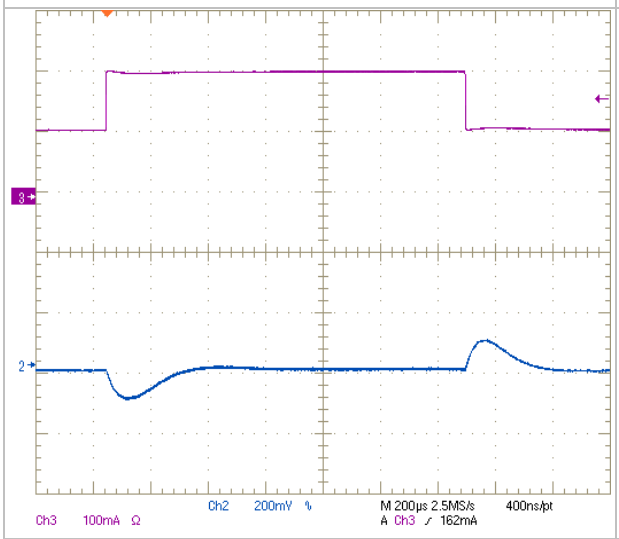
Vout vs. Load (V_{OUT}=5.0V)



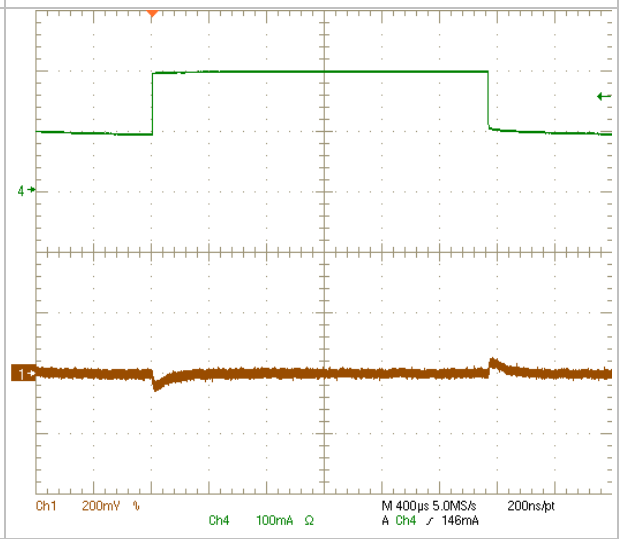
Typical Performance Characteristics (cont.)

Unless otherwise specified, V_{BAT}=1.2V, V_{EN}=1.2V, V_{OUT}= 3.3V and T_A = 25°C ,L=6.8µH, C_{IN}= C_{out} =47µF

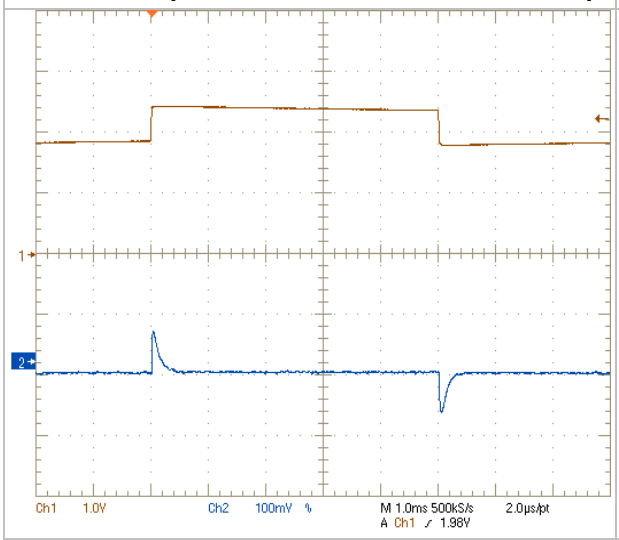
Load Transient (V_{BAT}=1.2, V_{OUT}=3.3V, I_{OUT}=100mA to 200mA)



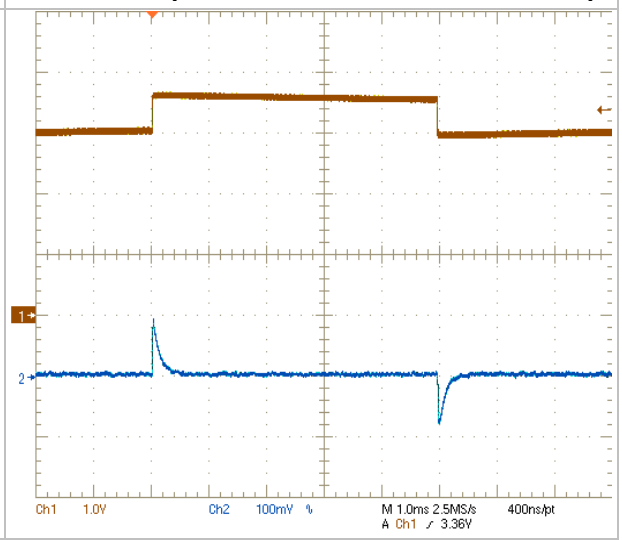
Load Transient (V_{BAT}=3.6V, V_{OUT}=5.0V, I_{OUT}=100mA to 200mA)



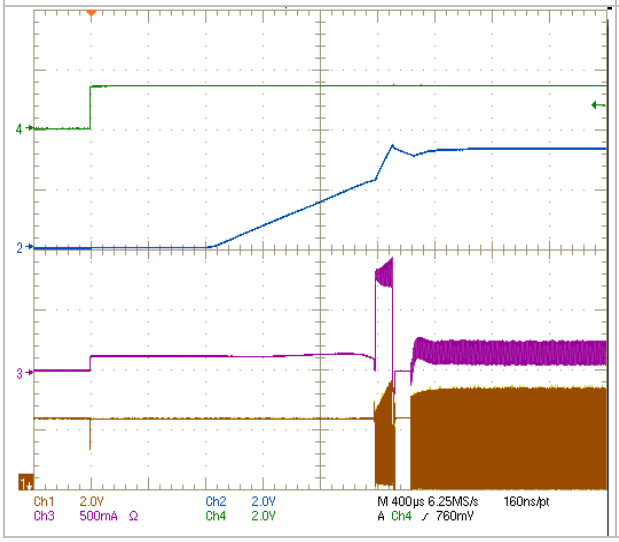
Line Transient (V_{OUT}=3.3V, V_{BAT}=1.8V to 2.4V, I_{OUT}=100mA)



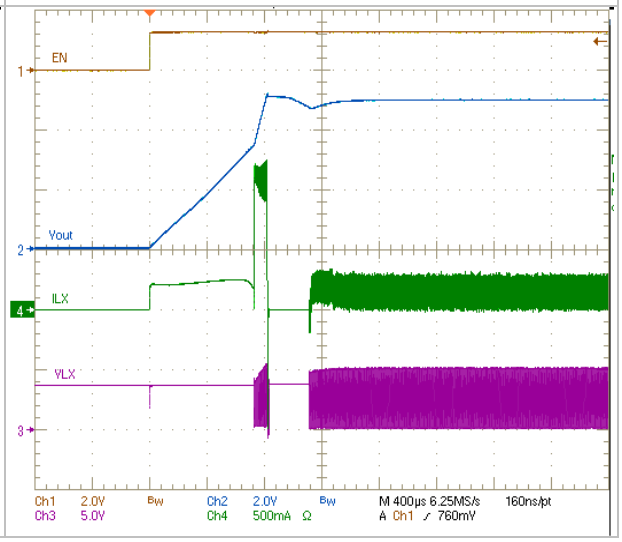
Line Transient (V_{OUT}=5.0V, V_{BAT}=3.0V to 3.6V, I_{OUT}=200mA)



Start-Up (V_{BAT}=2.4V, V_{OUT}=3.3V)



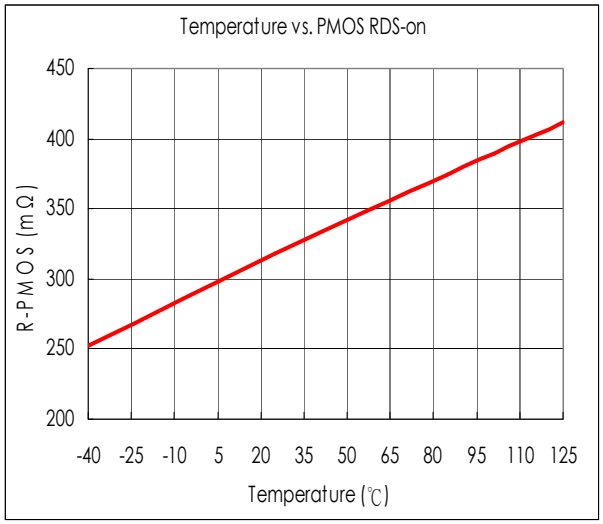
Start-Up(V_{BAT}=3.6V, V_{OUT}=5.0V)



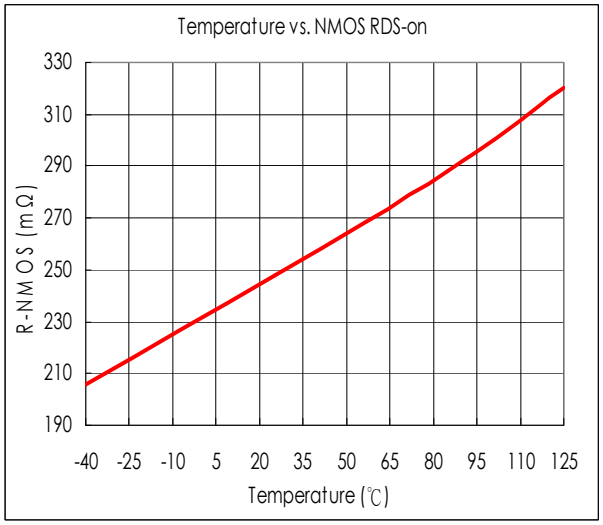
Typical Performance Characteristics (cont.)

Unless otherwise specified, V_{BAT}=1.2V, V_{EN}=1.2V, V_{OUT}= 3.3V and T_A = 25°C ,L=6.8µH, C_{IN}= C_{out} =47µF

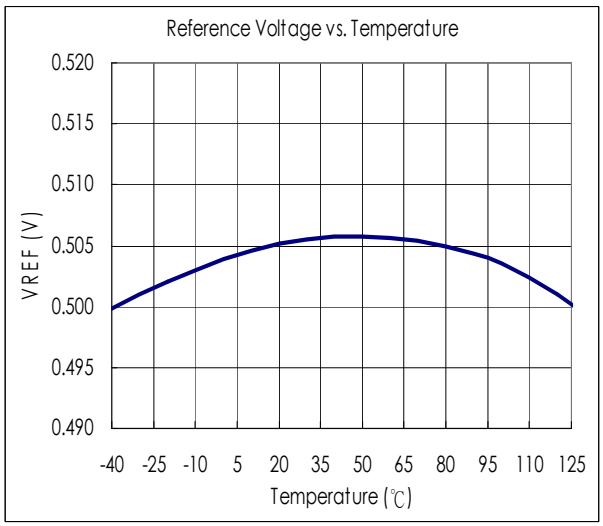
PMOS RDS-on



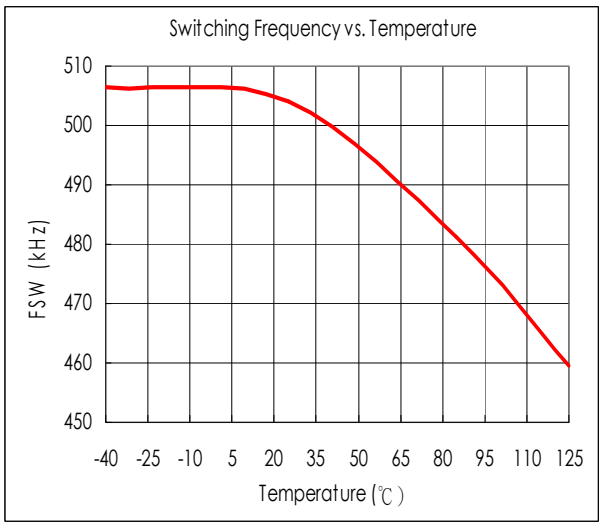
NMOS RDS-on



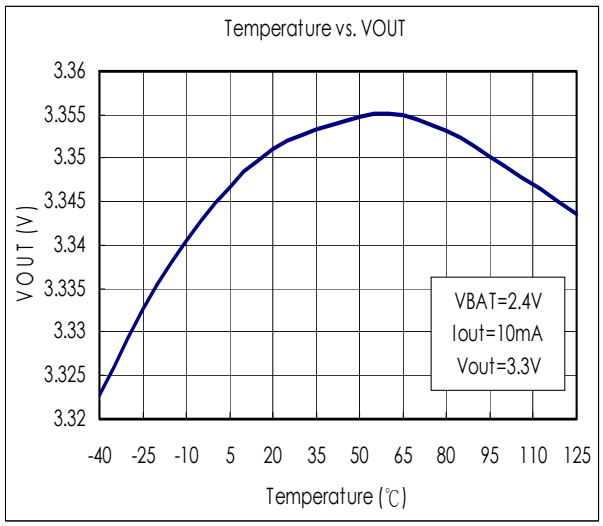
Reference Voltage *vs.* Temperature



Switching Frequency *vs.* Temperature



V_{OUT} *vs.* Temperature



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℃, the OTP is designed with a 30℃ 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:

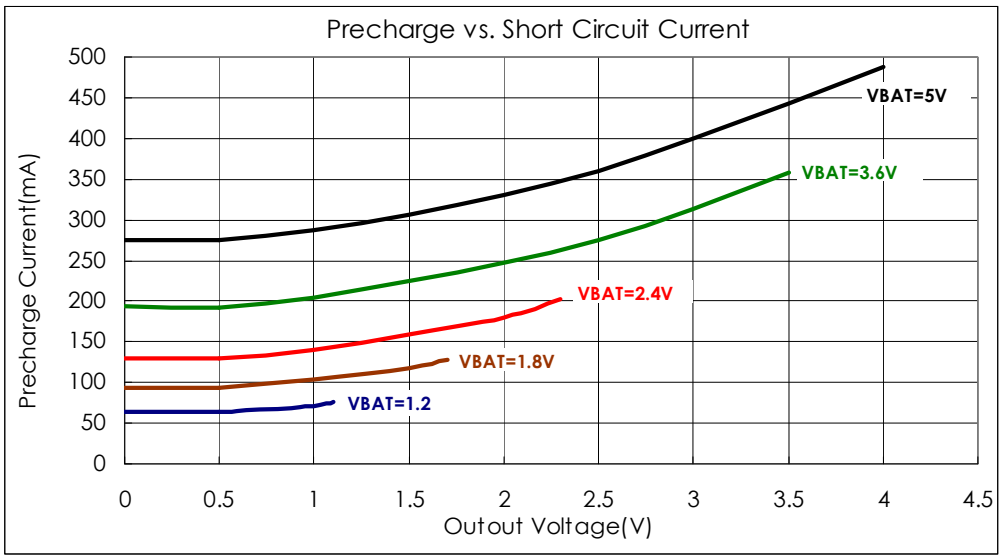


FIG.2 Short circuit current during pre-boost phase

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:

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

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	1.02MΩ	113KΩ
3.3V	1.02MΩ	182KΩ
1.8V	510KΩ	200KΩ

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} * output filter capacitor ESR). The inductor's DC resistance can significantly affect efficiency. The maximum output current can be calculated as follows:

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

$I_{OUT(max)}$ = Maximum loading
V_{BAT} = Input voltage
L = Inductor value in μH
η = efficiency (~ 0.9 typically)
Toff = LX switch's off - time in μs
I_{CL} = 2.3A

Table 2

VENDOR	SERIES	VALUE	ISAT	DCR
Sumida	CDRH5D28R	6.8μH	1.5A	37mΩ
EPCOS	B82462-G4	6.8μH	1.65A	51mΩ
WURTH ELEKTRONIK	7447789	6.8μH	2.75A	44mΩ
CYNTEC CO.	PCMC063T	6.8μH	4.5A	54mΩ
	PCMB063T	6.8μH	4.5A	43. 9mΩ
COILCRAFT	MSSZ260-682MLD	6.8μH	4.9A	23mΩ

Input Capacitor Selection

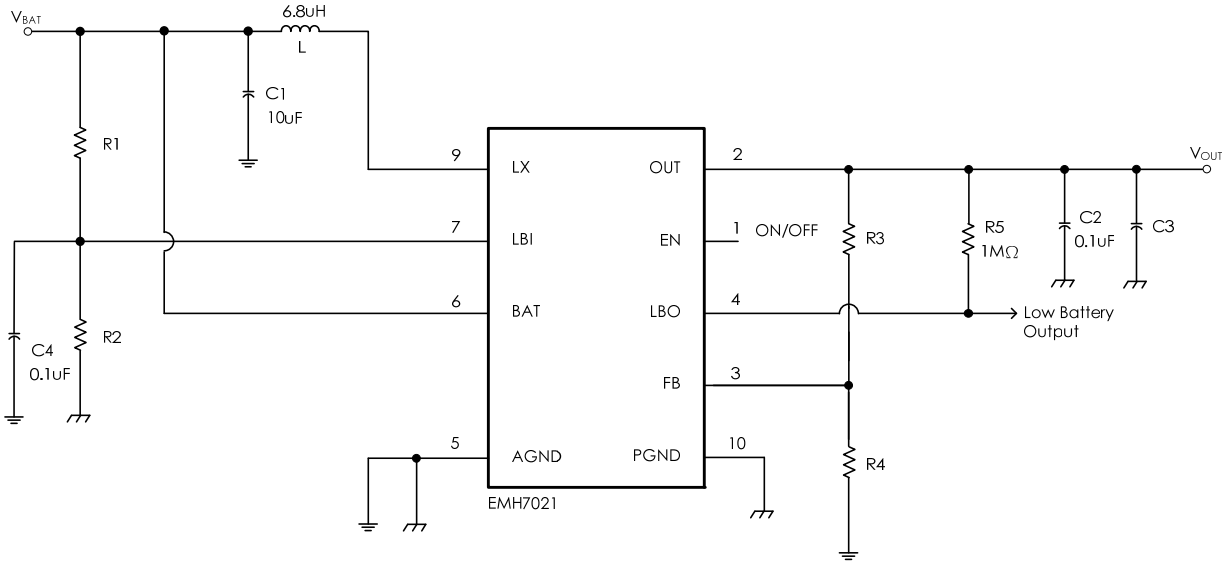
A low ESR 10μF input capacitor is recommended to improve transient behavior and reduce the peak current drawn from the battery. Ceramic capacitors are also a good choice for input decoupling and should be located as close as possible to the device.

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 47μF output capacitor is sufficient for most applications.

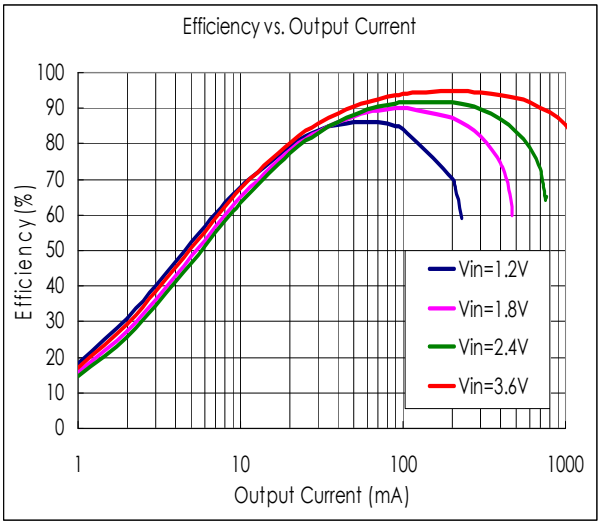
Application Examples

Inductor=6.8uH

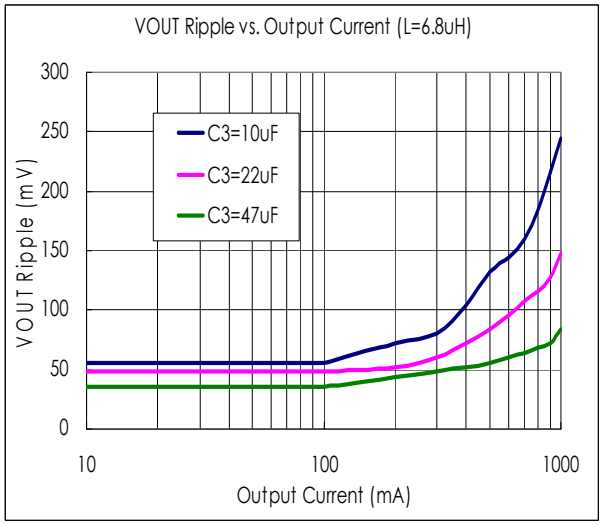


L= CYNTEC CO. PCMB063T
C1, C2, C3 = X7R Ceramic

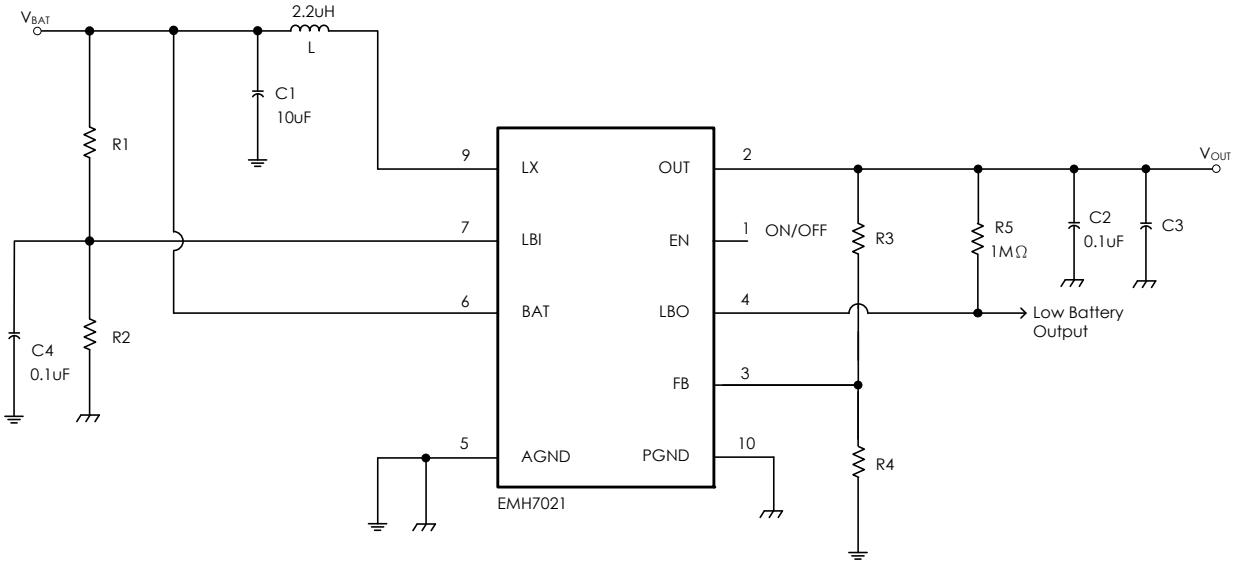
V_{OUT}=5.0V, L=6.8μH, C3=47μF



V_{BAT}=3.6V, V_{OUT}=5.0V, L=6.8μH

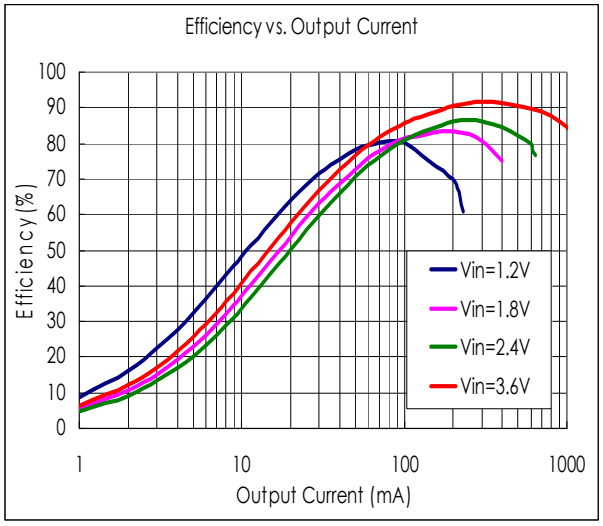


Inductor=2.2uH

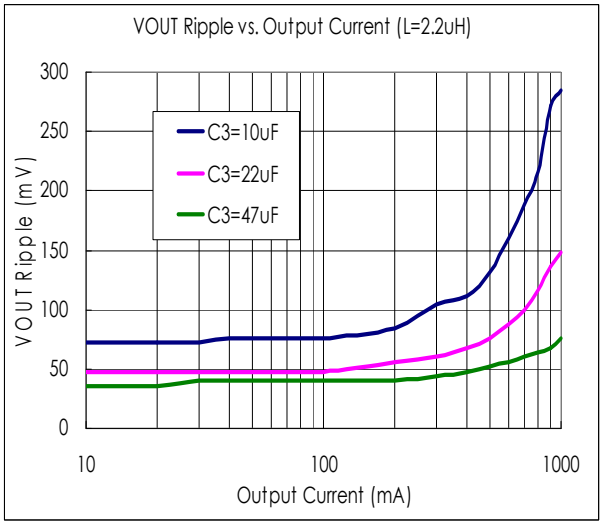


L= CYNTEC CO. PCMB063T
C1, C2, C3 = X7R Ceramic

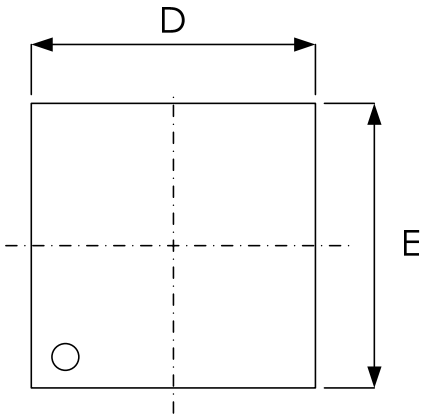
V_{OUT}=5.0V, L=2.2μH, C3=22μF



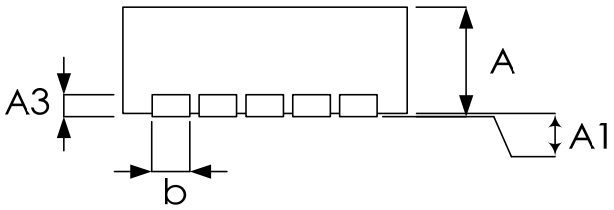
V_{BAT}=3.6V, V_{OUT}=5.0V, L=2.2μH



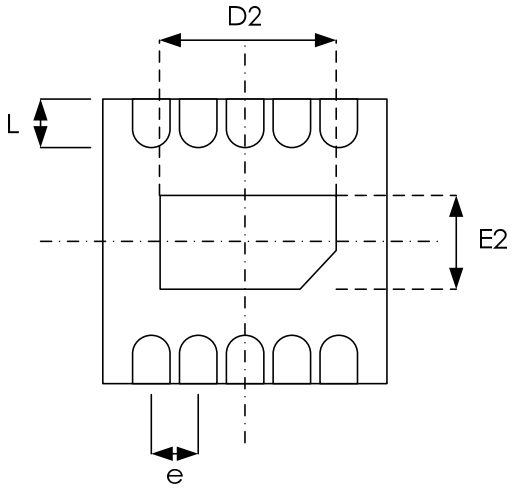
Package Outline Drawing
TDFN-10 (3x3 mm)



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_{IH} / V_{IL} (as V_{BAT} or V_{OUT}<1.8V) update
0.3	2011.02.11	VOUT divider resistor is incorrect, the recommended table 1, R4 Value is 200KΩ
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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