2 Channel Power Management IC For Portable Devices

GENERAL DESCRIPTION

The EMQ9920 is a high efficiency, 2-channel power management IC for battery-powered, portable devices application. It integrates two high efficiency step-down DC/DC converters.

The two Synchronous Buck converters (CH3, CH4) operate from 2.5V to 5.5V input voltage, up to 600mA loading capability and regulate adjustable output voltage from 0.6V to 5.5V. It features low quiescent current, 1.5MHz internal frequency operation.

The EMQ9920 is available in TQFN16 3x3 package.

It is **Green compliant** (RoHS and Halogen-free).

FEATURES

Two Synchronous Buck Converters

- Achieve 95% efficiency
- Input Voltage : 2.5V to 5.5V
- Output Current up to 600mA
- Reference voltage 0.6V
- Quiescent Current 200 μ A with No Load
- Internal switching frequency 1.5MHz
- No Schottky Diode needed
- Low Dropout Operation: 100% Duty Cycle
- Shutdown current < 1 μ A
- Excellent Line and Load Transient Response
- Over-temperature Protection

APPLICATIONS

- Blue-Tooth devices
- Cellular and Smart Phones
- Personal multi-media Player (PMP)
- Wireless networking
- Digital Still Cameras
- Portable applications

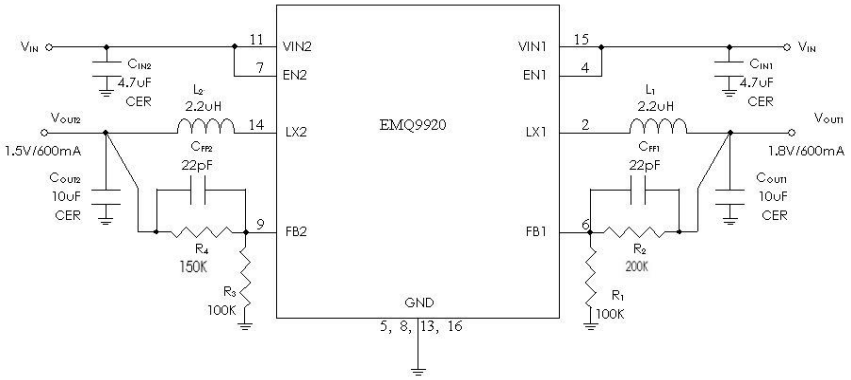
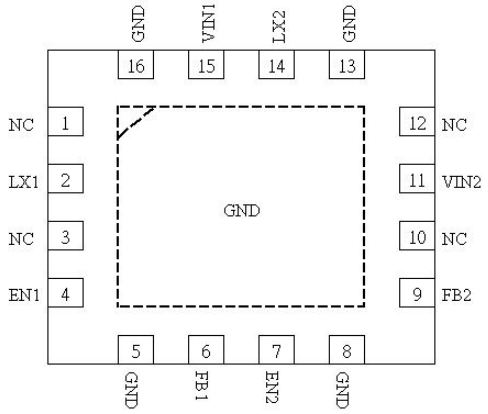


Figure 1. Typical Application

CONNECTION DIAGRAM

TQFN16 3x3



ORDER INFORMATION

EMQ9920-00HB16NRR

00	Adjustable output voltage
HB16	TQFN16 Package
N	Green(RoHS and Halogen-free)
R	Commercial Grade Temperature Rating: -40 to 85°C
R	Package in Tape & Reel

MARKING & PACKING INFORMATION

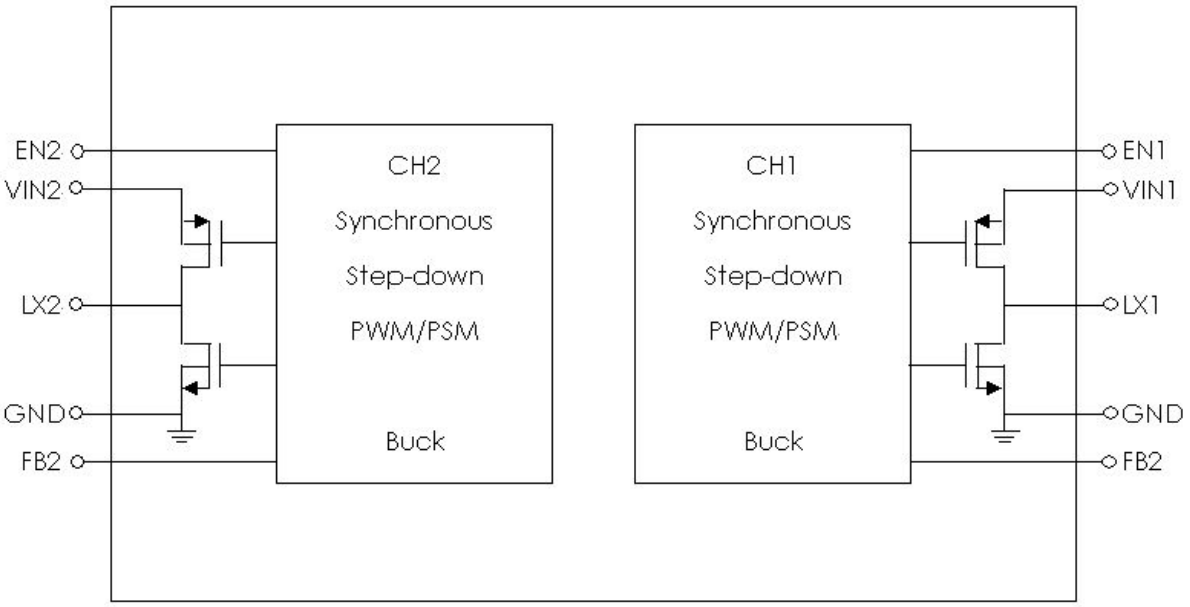
Package	Product ID	Marking	Packing
TQFN16	EMQ9920-00HB16NRR	EMP EMQ9920 Tracking Code Pin#1	5K units Tape & Reel

TERMINAL FUNCTIONS

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
NC	1, 3, 10, 12	N/A	Non-connection.
LX1	2	O	CH1 Switch PIN. Must be connected to Inductor. This pin connects to the drains of the internal main and synchronous power MOSFET switches.
EN1	4	I	CH1 Enable Input. Minimum 1.3V to enable the device. Maximum 0.5V to shut down the device. Do not leave this pin floating and enable the chip after V_{IN1} is in the input voltage range.
GND	5, 8, 13, 16	I	Ground PIN.
FB1	6	I	CH1 Voltage Feedback PIN.

			Receives the feedback voltage from an external resistive divider across the output V_{OUT1}.
EN2	7	I	CH2 Enable Input. Minimum 1.3V to enable the device. Maximum 0.5V to shut down the device. Do not leave this pin floating and enable the chip after V_{IN2} is in the input voltage range.
FB2	9	I	CH2 Voltage Feedback PIN. Receives the feedback voltage from an external resistive divider across the output V_{OUT1}.
VIN2	11	I	CH2 Input Voltage. Must be closely decoupled to GND pin with a 4.7μF or greater ceramic capacitor.
LX2	14	O	CH2 Switch PIN. Must be connected to Inductor. This pin connects to the drains of the internal main and synchronous power MOSFET switches.
VIN1	15	I	CH1 Input Voltage. Must be closely decoupled to GND pin with a 4.7μF or greater ceramic capacitor.

FUNCTION BLOCK DIAGRAM


EN2
VIN2
LX2
GND
FB2
CH2
Synchronous
Step-down
PWM/PSM
Buck
CH1
Synchronous
Step-down
PWM/PSM
Buck
EN1
VIN1
LX1
GND
FB2

ABSOLUTE MAXIMUM RATINGS

Supply Input Voltage (VIN1, VIN2)	-0.3V to 6.0V	**ESD Susceptibility**	**TBD**
		Junction Temperature	150°C
LX1 Switch PIN Voltage	-0.3V to (VIN1+0.3V)	**Thermal Resistance**	
LX2 Switch PIN Voltage	-0.3V to (VIN2+0.3V)	θ_{JA} (TQFN16 3x3)	55°C/W
Other I/O PIN Voltage	-0.3V to VIN (VN1, VIN2)	**Operating Ratings**	
Storage Temperature	-65°C to +150°C	Temperature Range	-40°C ≦ T_A ≦ 85°C
Switch Source Current (DC)	800mA	Supply Voltage	2.5V ≦ V_{DD} ≦ 5.5V
Switch Sink Current (DC)	800mA	(VIN1, VIN2)	

ELECTRICAL CHARACTERISTICS

Apply for V_{IN1} = 3.6V, V_{IN2} = 3.6V and T_A = 25°C (unless otherwise noted), Boldface limits apply for the operating temperature extremes: -40°C and 85°C.

Symbol	Parameter	Conditions	EMQ9920			Units
			Min	Typ	Max	
CH1 (Note 4)						
I_{VFB1}	Feedback Current				±30	nA
V_{FB1}	Regulated Feedback Voltage	T_A = 25°C	0.588	0.600	0.612	V
		–40°C ≤ T_A ≤ 85°C	**0.585**	**0.600**	**0.615**	
ΔV_{FB1}	Reference Voltage Line Regulation	V_{IN1} = 2.5V to 5.5V			**0.4**	%/V
ΔV_{OVL1}	Output Over-voltage Lockout	$\Delta V_{OVL1} = V_{OVL1} - V_{FB1}$	20	50	80	mV
ΔV_{OUT1}	Output Voltage Line Regulation	V_{IN1} = 2.5V to 5.5V			**0.4**	%/V
	Output Voltage Load Regulation			0.5		%
I_{PK1}	Peak Inductor Current	V_{IN1} = 3V, V_{FB1} = 0.5V or V_{OUT1} = 90%, Duty Cycle < 35%		1.0		A
I_{Q1}	Quiescent Current (Note 5)	V_{FB1} = 0.5V or V_{OUT1} = 90%		200	340	µA
	Shutdown	V_{EN1} = 0V, V_{IN1} = 4.2V		0.1	1	µA
f_{OSC1}	Oscillator Frequency	V_{FB1} = 0.6V or V_{OUT1} = 100%	**1.2**	**1.5**	**1.8**	MHz
		V_{FB1} = 0V or V_{OUT1} = 0V		**290**		kHz
R_{PFET1}	$R_{DS(ON)}$ of PMOS	I_{LX1} = 100mA		0.45	0.55	Ω
R_{NFET1}	$R_{DS(ON)}$ of NMOS	I_{LX1} = –100mA		0.40	0.5	Ω
I_{LX1}	LX1 Leakage	V_{EN1} = 0V, V_{LX1} = 0V or 5V, V_{IN1} = 5V			±1	µA
V_{EN1}	EN1 Threshold		0.5		1.3	V
I_{EN1}	EN1 Leakage Current				**±1**	µA
CH2 (Note4)						

I_{VFB2}	Feedback Current				±30	nA
V_{FB2}	Regulated Feedback Voltage	T_A = 25°C	0.588	0.600	0.612	V
		–40°C ≤ T_A ≤ 85°C	**0.585**	**0.600**	**0.615**	
ΔV_{FB2}	Reference Voltage Line Regulation	V_{IN2} = 2.5V to 5.5V			**0.4**	%/V
ΔV_{OVL2}	Output Over-voltage Lockout	$\Delta V_{OVL2} = V_{OVL2} - V_{FB2}$	20	50	80	mV
ΔV_{OUT2}	Output Voltage Line Regulation	V_{IN2} = 2.5V to 5.5V			**0.4**	%/V
	Output Voltage Load Regulation			0.5		%
I_{PK2}	Peak Inductor Current	V_{IN2} = 3V, V_{FB2} = 0.5V or V_{OUT2} = 90%, Duty Cycle < 35%		1.0		A
I_{Q2}	Quiescent Current (Note 5)	V_{FB2} = 0.5V or V_{OUT2} = 90%		200	340	µA
	Shutdown	V_{EN2} = 0V, V_{IN2} = 4.2V		0.1	1	µA
f_{OSC2}	Oscillator Frequency	V_{FB2} = 0.6V or V_{OUT2} = 100%	**1.2**	**1.5**	**1.8**	MHz
		V_{FB2} = 0V or V_{OUT2} = 0V		**290**		kHz
R_{PFET2}	$R_{DS(ON)}$ of PMOS	I_{LX2} = 100mA		0.45	0.55	Ω
R_{NFET2}	$R_{DS(ON)}$ of NMOS	I_{LX2} = –100mA		0.40	0.5	Ω
I_{LX2}	LX2 Leakage	V_{EN2} = 0V, V_{LX2} = 0V or 5V, V_{IN2} = 5V			±1	µA
V_{EN2}	EN2Threshold		0.5		1.3	V
I_{EN2}	EN2 Leakage Current				**±1**	µA

Note 1: Absolute Maximum ratings indicate limits beyond which damage may occur. Electrical specifications do not apply when operating the device outside of its rated operating conditions.

Note 2: All voltages are with respect to the potential at the ground pin.

Note 3: Maximum Power dissipation for the device is calculated using the following equations:

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

where TJ(MAX) is the maximum junction temperature, TA is the ambient temperature, and θ_{JA} is the junction-to-ambient thermal resistance.

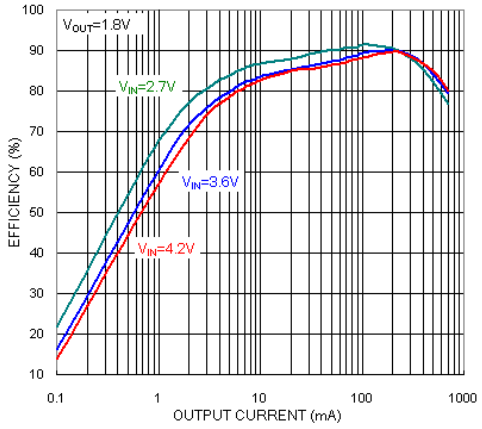
Note 4: Build-in internal over-temperature protection to prevent over-load condition.

Note 5: Dynamic quiescent current is higher due to the gate charge being delivered at the switching frequency.

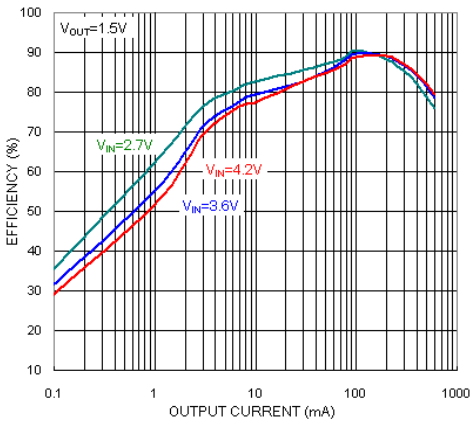
TYPICAL PERFORMANCE CHARACTERISTICS

V_{EN1} = V_{IN1}, C_{IN1}=4.7µF, L_1=2.2µH, C_{OUT1}=4.7µF, C_{IN2}=4.7µF, L_2=2.2µH, C_{OUT2}=4.7µF, V_{EN2} = V_{IN2} T_A = 25°C, unless otherwise specified

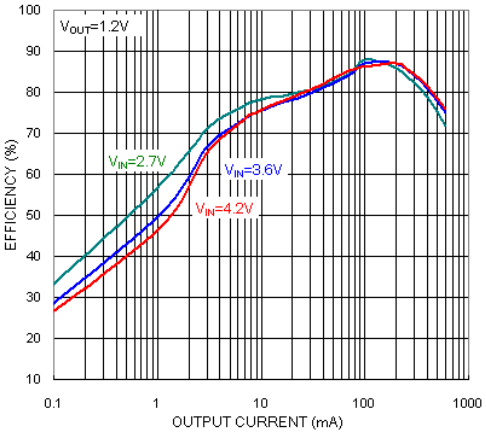
CH1 Efficiency vs Output Current



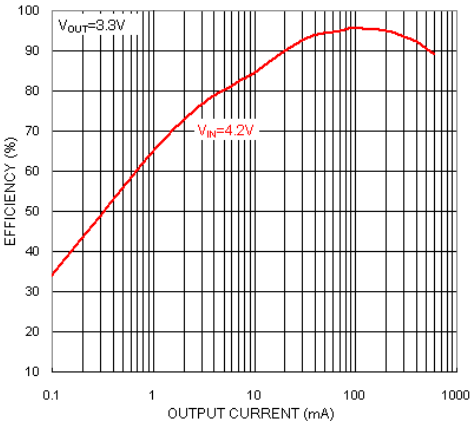
CH1 Efficiency vs Output Current



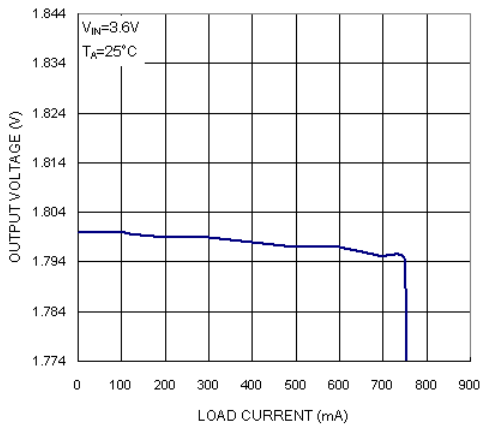
CH1 Efficiency vs Output Current



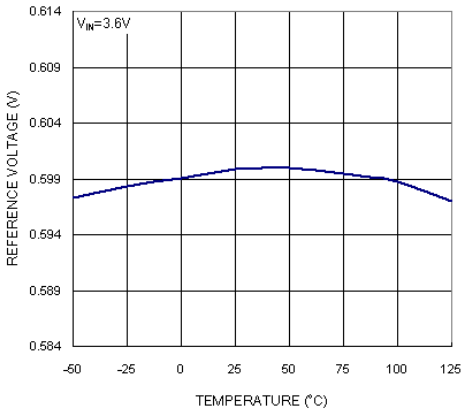
CH1 Efficiency vs Output Current



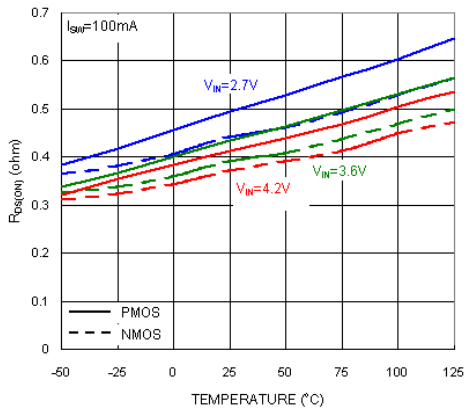
CH1 Output Voltage vs Load Current



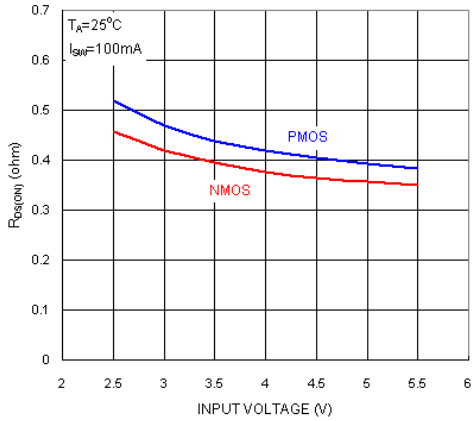
CH1 Reference voltage vs Temperature



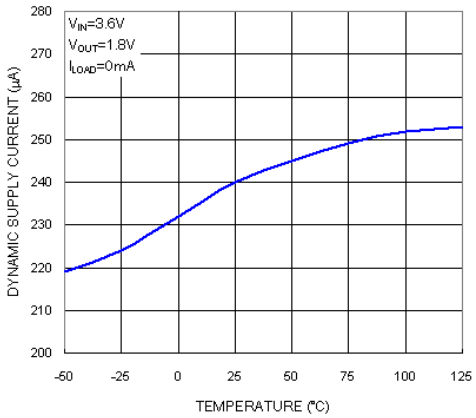
CH1 $R_{DS(ON)}$ vs Temperature



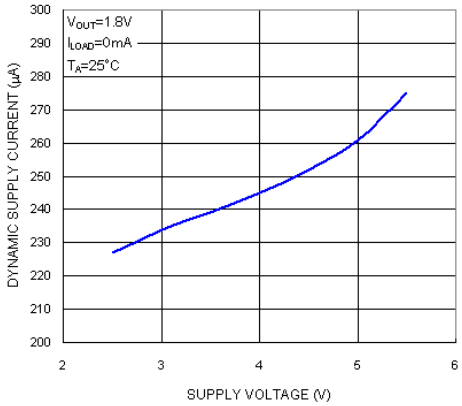
CH1 $R_{DS(ON)}$ vs Input Voltage



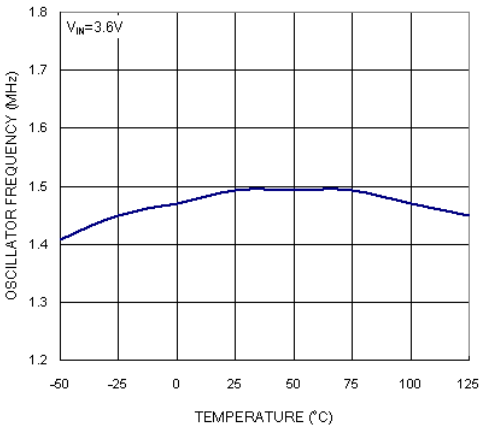
CH1 Dynamic Supply Current vs Temperature



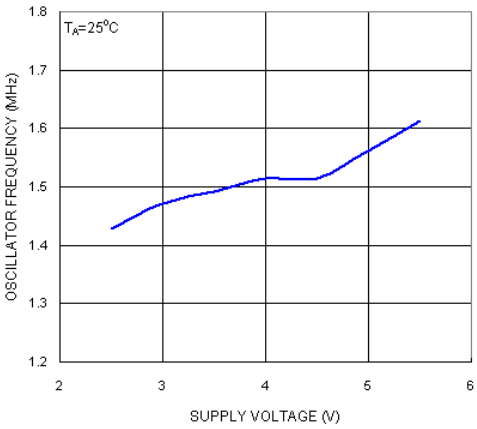
CH1 Dynamic Supply Current vs Supply Voltage



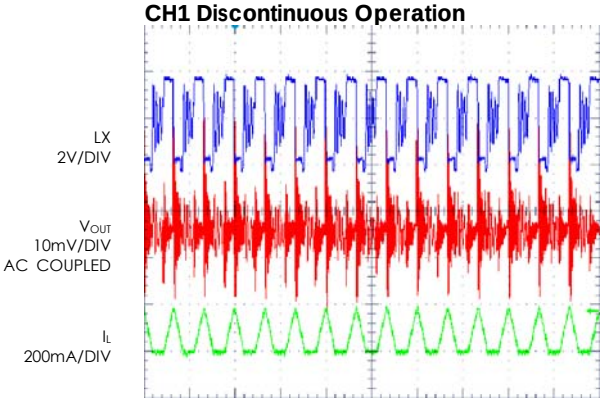
CH1 Oscillator Frequency vs Temperature



CH1 Oscillator Frequency vs Supply Voltage

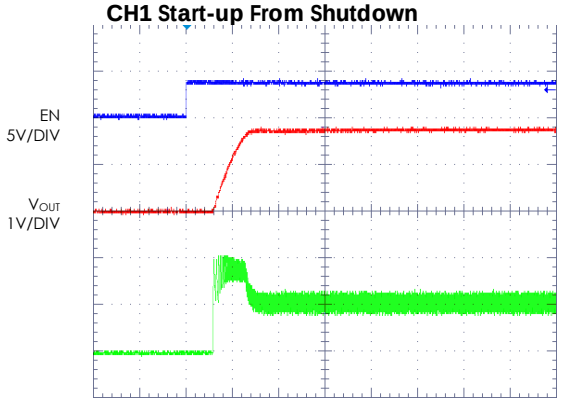


CH1 Discontinuous Operation



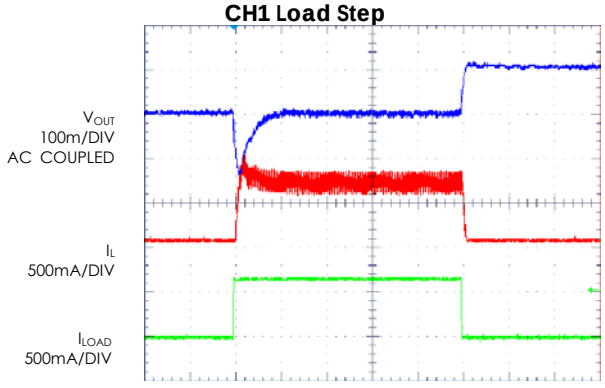
V_{IN}=3.6V 1 μs/DIV
V_{OUT}=1.8V
I_{LOAD}=50mA

CH1 Start-up From Shutdown



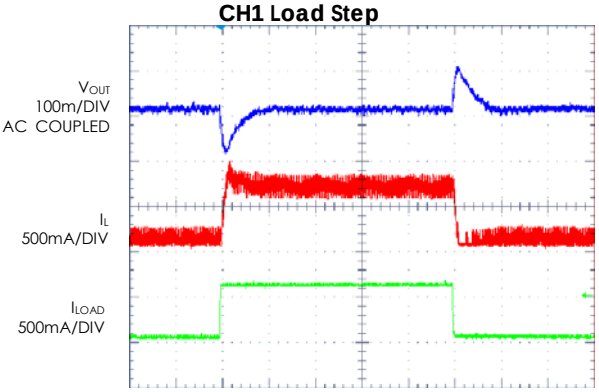
V_{IN}=3.6V 40 μs/DIV
V_{OUT}=1.8V
I_{LOAD}=600mA (3Ω RESISTOR)

CH1 Load Step



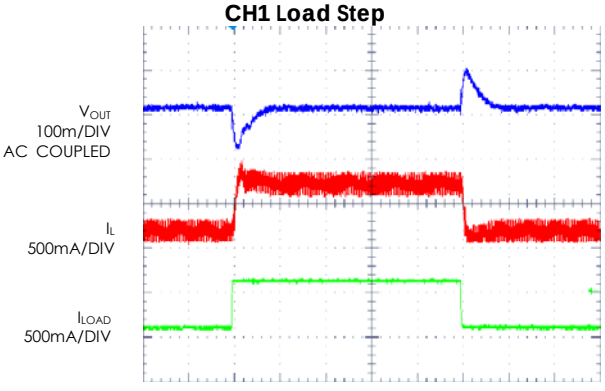
V_{IN}=3.6V 20 μs/DIV
V_{OUT}=1.8V
I_{LOAD}=0mA to 600mA

CH1 Load Step



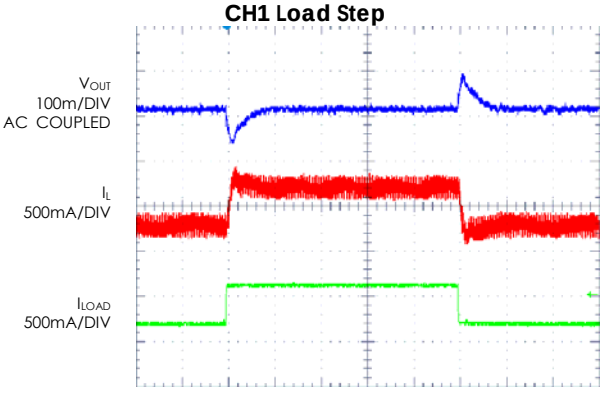
V_{IN}=3.6V 20 μs/DIV
V_{OUT}=1.8V
I_{LOAD}=50mA to 600mA

CH1 Load Step



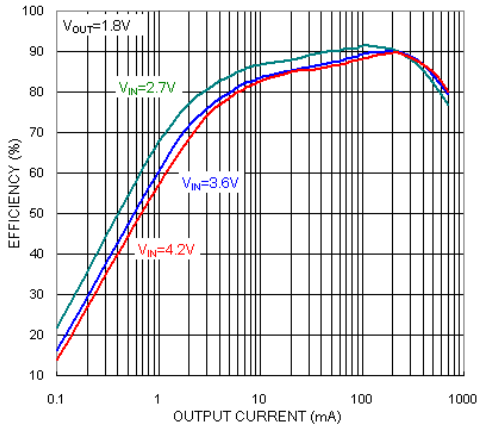
V_{IN}=3.6V 20 μs/DIV
V_{OUT}=1.8V
I_{LOAD}=100mA to 600mA

CH1 Load Step

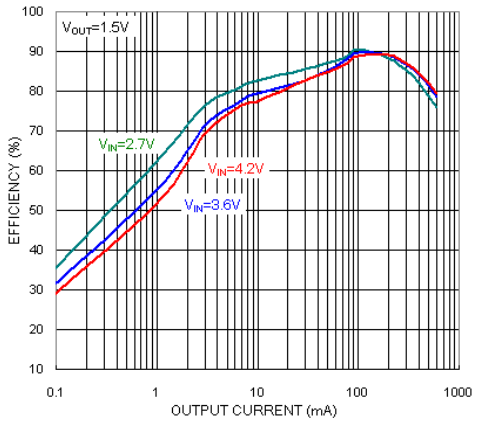


V_{IN}=3.6V 20 μs/DIV
V_{OUT}=1.8V
I_{LOAD}=200mA to 600mA

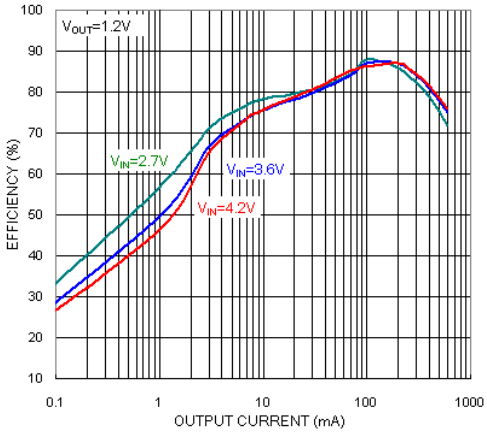
CH2 Efficiency vs Output Current



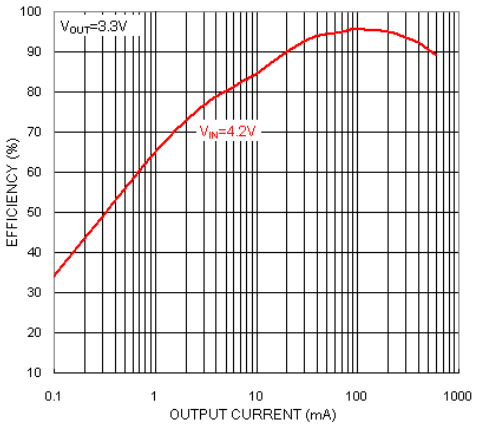
CH2 Efficiency vs Output Current



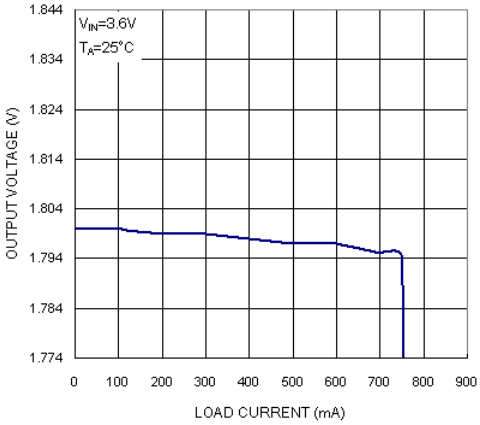
CH2 Efficiency vs Output Current



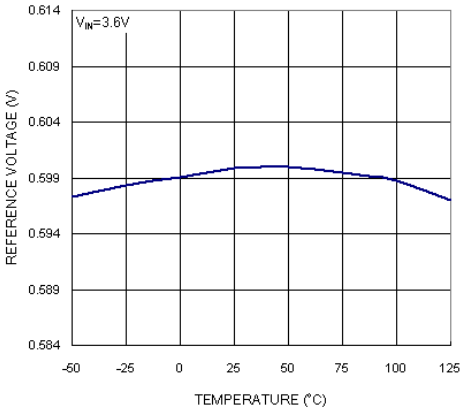
CH2 Efficiency vs Output Current



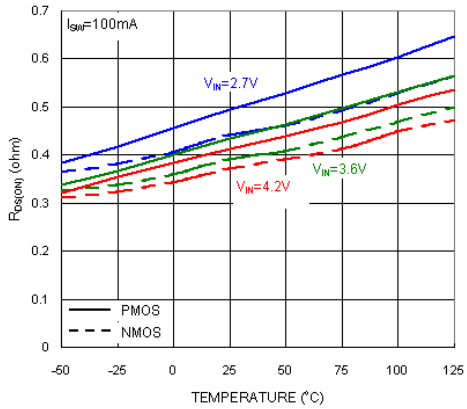
CH2 Output Voltage vs Load Current



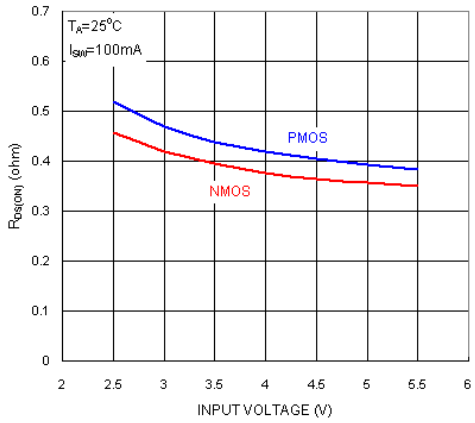
CH2 Reference voltage vs Temperature



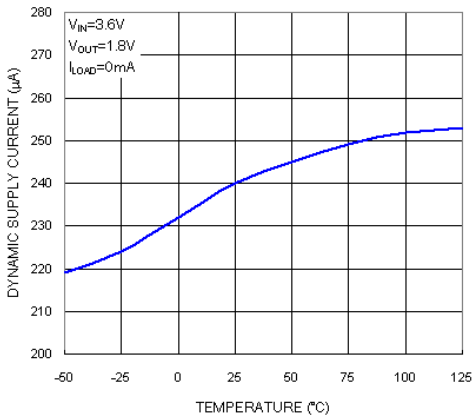
CH2 $R_{DS(ON)}$ vs Temperature



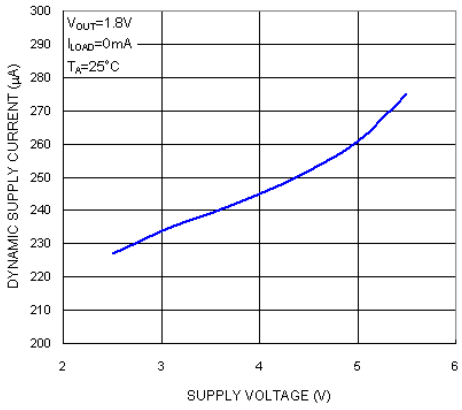
CH2 $R_{DS(ON)}$ vs Input Voltage



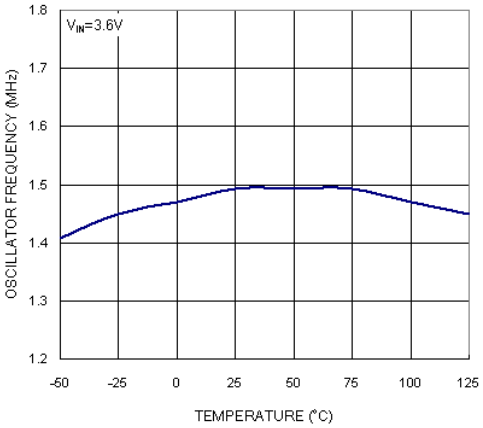
CH2 Dynamic Supply Current vs Temperature



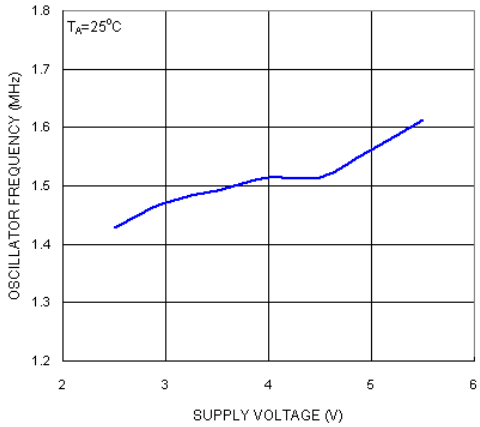
CH2 Dynamic Supply Current vs Supply Voltage



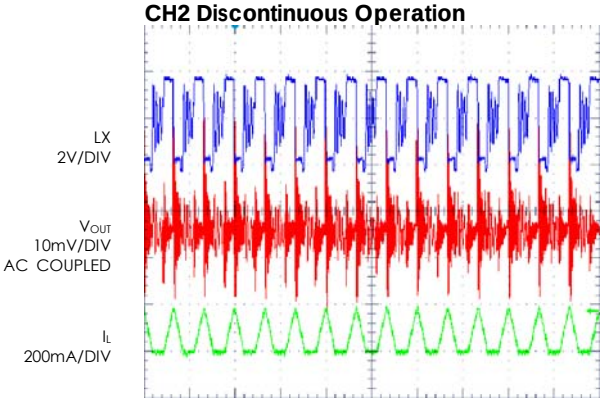
CH2 Oscillator Frequency vs Temperature



CH2 Oscillator Frequency vs Supply Voltage

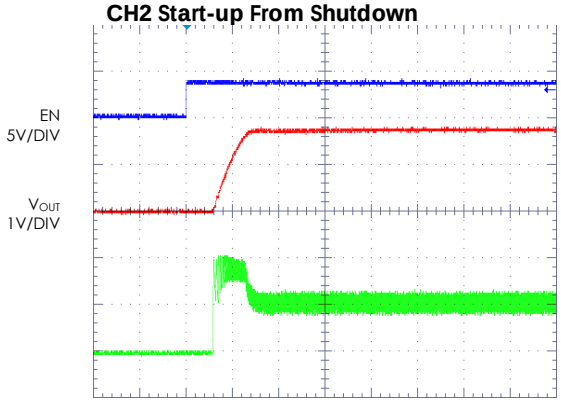


CH2 Discontinuous Operation



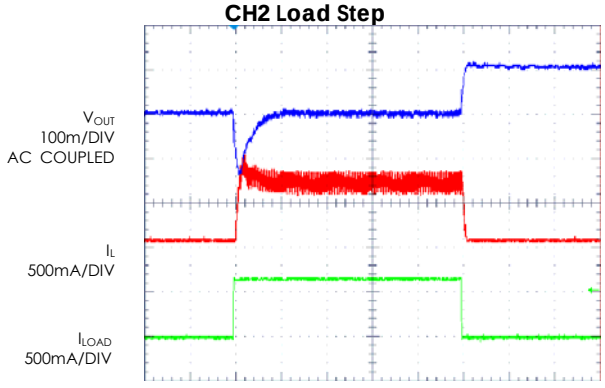
V_{IN}=3.6V 1 μs/DIV
V_{OUT}=1.8V
I_{LOAD}=50mA

CH2 Start-up From Shutdown



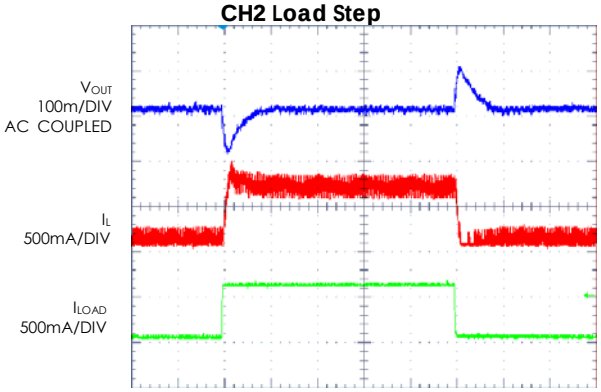
V_{IN}=3.6V 40 μs/DIV
V_{OUT}=1.8V
I_{LOAD}=600mA (3Ω RESISTOR)

CH2 Load Step



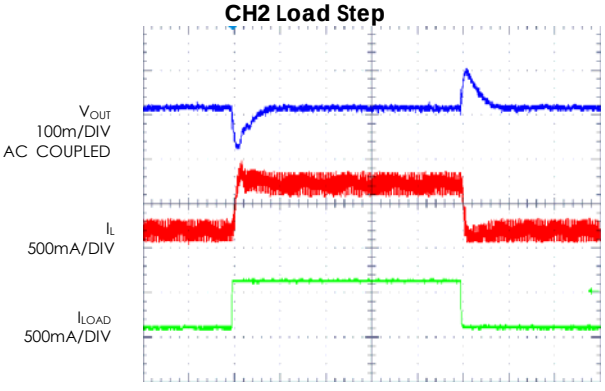
V_{IN}=3.6V 20 μs/DIV
V_{OUT}=1.8V
I_{LOAD}=0mA to 600mA

CH2 Load Step



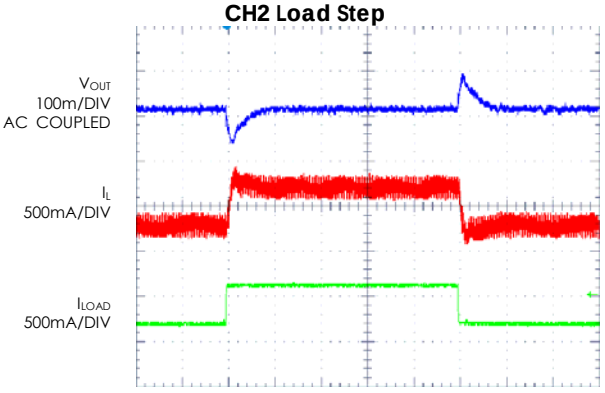
V_{IN}=3.6V 20 μs/DIV
V_{OUT}=1.8V
I_{LOAD}=50mA to 600mA

CH2 Load Step



V_{IN}=3.6V 20 μs/DIV
V_{OUT}=1.8V
I_{LOAD}=100mA to 600mA

CH2 Load Step



V_{IN}=3.6V 20 μs/DIV
V_{OUT}=1.8V
I_{LOAD}=200mA to 600mA

APPLICATION INFORMATION

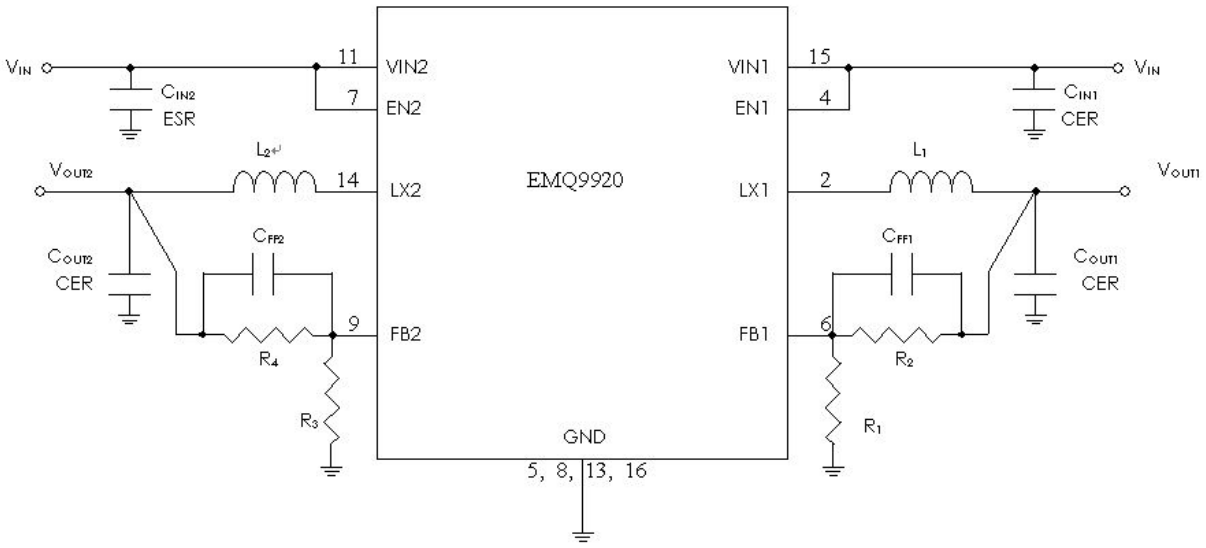


Figure 2. Typical EM9920 Application Circuit That Supports Two Adjustable Output Voltage

Application Information

The EMQ9920 is a high efficiency, 2-channel power management IC for battery-powered, portable devices application.

The two channels are listed as following：

CH1/2：600mA Synchronous Buck converters

All 2 channels are Vout adjustable

CH1/2：600mA Synchronous Buck converters

The typical application circuit of the current mode DC/DC converters is shown in Fig.3.

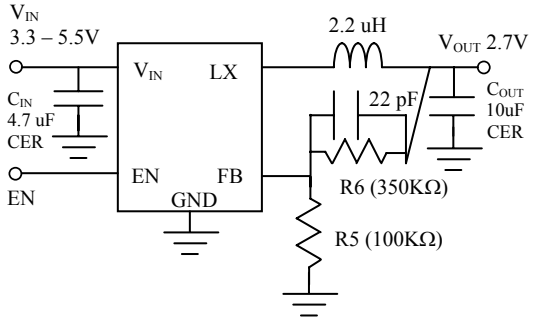


Fig. 3

CH1, CH2 Inductor Selection

Basically, inductor ripple current and core saturation are two factors considered to decide the Inductor value.

$$\Delta I_L = \frac{1}{f \cdot L} V_{OUT}\left(1 - \frac{V_{OUT}}{V_{IN}}\right) \quad \text{..... (1)}$$

The Eq. 1 shows the inductor ripple current is a function of frequency, inductance, V_{IN} (V_{IN1}, V_{IN2})

and V_{OUT} (V_{OUT1}, V_{OUT2}). It is recommended to set ripple current to 40% of max. load current. A low ESR inductor is preferred.

CH1, CH2 C_{IN} and C_{OUT} Selection

A low ESR input capacitor can prevent large voltage transients at V_{IN} (V_{IN1}, V_{IN2}). The RMS current of input capacitor is required larger than I_{RMS} calculated by:

$$I_{RMS} \cong I_{OMAX} \frac{\sqrt{V_{OUT}(V_{IN} - V_{OUT})}}{V_{IN}} \quad \text{..... (2)}$$

ESR is an important parameter to select C_{OUT} (C_{OUT1}, C_{OUT2}). The output ripple $\triangle V_{OUT}$ ($\triangle V_{OUT1}$, $\triangle V_{OUT2}$) is determined by:

$$\Delta V_{OUT} \cong \Delta I_L \left(ESR + \frac{1}{8 \cdot f \cdot C_{OUT}} \right) \quad \text{.....(3)}$$

Higher values, lower cost ceramic capacitors are now available in smaller sizes. These ceramic capacitors have high ripple currents, high voltage ratings and low ESR that make them ideal for switching regulator applications. Optimize very low output ripple and small circuit size is doable from C_{OUT} selection since C_{OUT} does not affect the internal control loop stability. It is recommended to use the X5R or X7R which have the best temperature and voltage characteristics of all the ceramics for a given value and size.

CH1, CH2 Output Voltage (V_{OUT1}, V_{OUT2})

The output voltage can be determined by following equation:

$$V_{OUT} = 0.6\,V\left(1 + \frac{R_2}{R_1}\right) \quad \text{.....(4)}$$

CH1 Case, Replace R_1 as R_3, R_2 as R_4 in CH2 case.

CH1, CH2 Thermal Considerations

Although thermal shutdown is build-in in the step-down DC/DC converter(s) that protects the device from thermal damage, the total power dissipation that the converter(s) can sustain should be base on the package thermal capability. The formula to ensure the safe operation is shown in Note 3.

To avoid the DC/DC converter(s) from exceeding the maximum junction temperature, the user will need to do some thermal analysis.

CH1, CH2 Guidelines for PCB Layout

To ensure proper operation of the DC/DC converter(s), please note the following PCB layout

guidelines:

1. The GND trace, the LX (LX1, LX2) trace and the V_{IN} (V_{IN1}, V_{IN2}) trace should be kept short, direct and wide.

2. V_{FB} (FB1, FB2) pin must be connected directly to the feedback resistors. Resistive divider R_1/R_2 (CH1); R_3/R_4 (CH2) must be connected and parallel to the output capacitor C_{OUT} (C_{OUT1}, C_{OUT2}).

3. The Input capacitor C_{IN} (C_{IN1}, C_{IN2}) must be connected to pin V_{IN} (V_{IN1}, V_{IN2}) as closely as possible.

4. Keep LX (LX1, LX2) node away from the sensitive V_{FB} (FB1, FB2) node since this node is with high frequency and voltage swing.

5. Keep the (–) plates of C_{IN} (C_{IN1}, C_{IN2}) and C_{OUT} (C_{OUT1}, C_{OUT2}) as close as possible.

CH1, CH2 Self-Enable Application

A self-enable function could be used when the step-down DC/DC converter(s) is (are) connected as fig. 4.

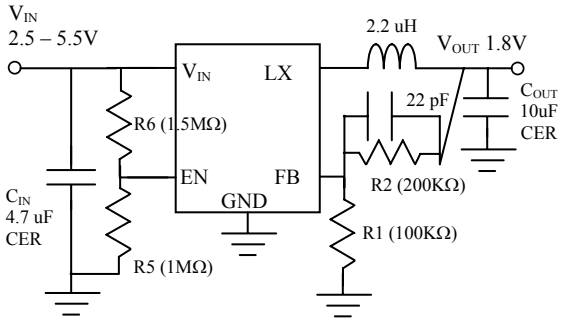


Fig. 4

The resistor ratio R5:R6=1:1.5 is recommended.

CH1, CH2 Design Example

Assume the Step-down DC/DC converter(s) is (are) used in a single lithium-ion battery-powered application. The V_{IN} (V_{IN1}, V_{IN2}) range will be about 2.7V to 4.2V. Output voltage (V_{OUT1}, V_{OUT2}) is 1.8V.

With this information we can calculate L using equation:

$$L = \frac{1}{f \cdot \Delta I_L} V_{OUT}\left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

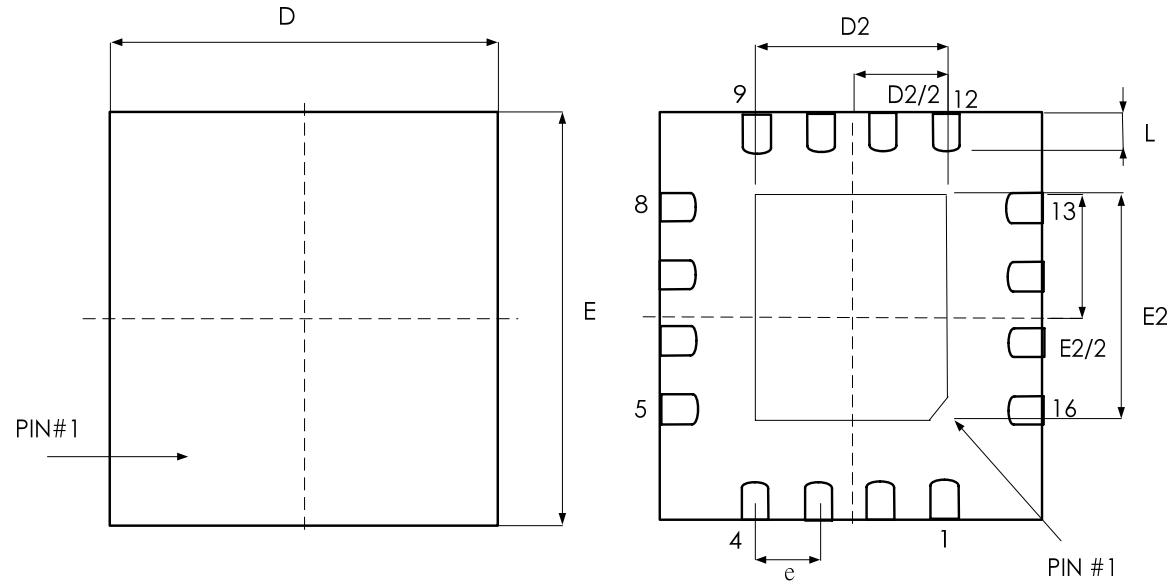
Substituting V_{OUT} = 1.8V, V_{IN} = 4.2V, I_L = 240mA and f = 1.5MHz in eq. 1 gives:

$$L = \frac{1.8V}{1.5MHz \cdot 240mA}\left(1 - \frac{1.8V}{4.2V}\right) = 2.86\mu H$$

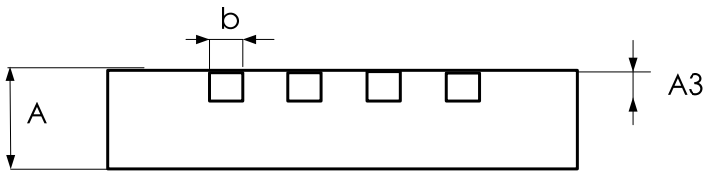
A 2.2µH inductor could be chose with this application.

A greater inductor with less equivalent series resistance makes best efficiency. C_{IN} (C_{IN1}, C_{IN2}) will require an RMS current rating of at least $I_{LOAD(MAX)}/2$ and low ESR. In most cases, a ceramic capacitor will satisfy this requirement.

TQFN-16 OUTLINE DIMENSION



TOP VIEW BOTTOM VIEW



SIDE VIEW

SYMBOL	COMMON					
	DIMENSIONS MILLIMETER			DIMENSIONS INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.700	0.750	0.800	0.027	0.029	0.031
A3	0.195	0.203	0.211	0.0077	0.0080	0.0083
b	0.180	0.230	0.300	0.007	0.009	0.012
D	2.950	3.000	3.050	0.116	0.118	0.120
E	2.950	3.000	3.050	0.116	0.118	0.120
e	0.50 BSC			0.020 BSC		
L	0.350	0.400	0.450	0.014	0.016	0.018
D2	1.500	1.625	1.750	0.059	0.064	0.069
E2	1.500	1.625	1.750	0.059	0.064	0.069

Revision History

Revision	Date	Description
2.0	2009.03.18	EMP transferred from version 1.0

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