1.5MHz 600mA, Synchronous Step-Down Regulator

General Description

EML9206 is designed with high efficiency step down DC/DC converter for portable devices applications. It features with extreme low quiescent current with no load which is the best fit for extending battery life during the standby mode. The device operates from 2.5V to 5.5V input voltage and up to 600mA output current capability. High 1.5MHz internal frequency makes small surface mount inductors and capacitors possible and reduces overall PCB board space. Further, build-in synchronous switch makes external Schottky diode is no longer needed and efficiency is improved. EML9206 is designed base on Pulse Width Modulation (PWM) for low output voltage ripple and fixed frequency noise, while Pulse Frequency Modulation (PFM) is used to improve light load efficiency, and Low Dropout (LDO) Mode provides 100% duty cycle operation. The device is available in fixed output voltages of 1.2V, 1.8V and 3.3V in SOT-23-5 package.

Features

- Achieve 95% efficiency
- Input Voltage : 2.5V to 5.5V
- Output Current up to 600mA
- Quiescent Current 35 μA with No Load
- Internal switching frequency 1.5MHz
- No Schottky Diode needed
- Low Dropout Operation: 100% Duty Cycle
- Shutdown current < 1 μA
- 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

Typical Application (fixed-3.3V)

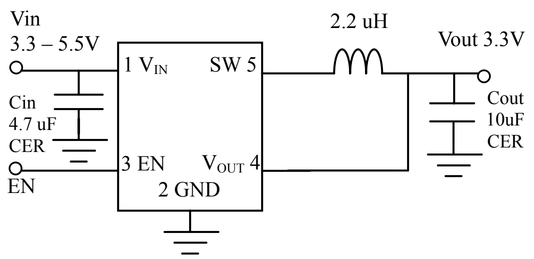


Fig. 1

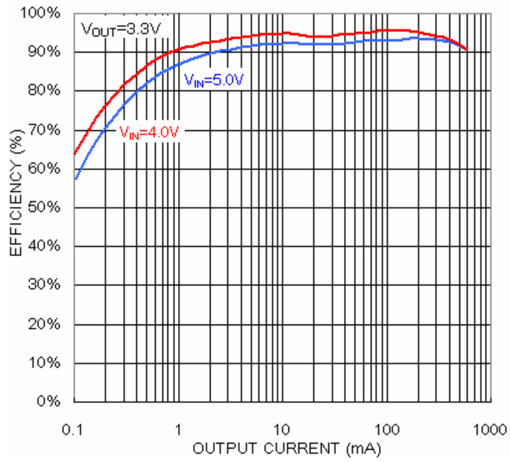
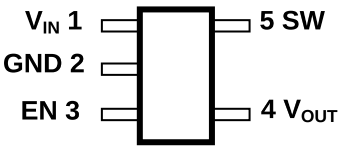


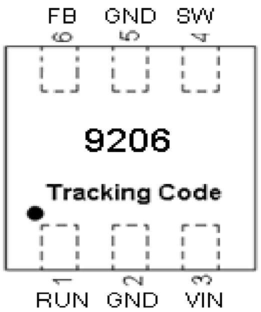
Fig. 2

Connection Diagram

SOT-23-5



TDFN-6

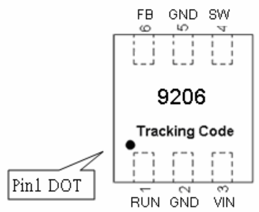
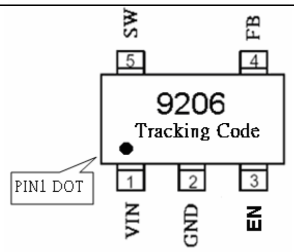


Order Information

EML9206-XXVF05GRR/NRR
XX Output voltage
VF05 SOT-23-5 Package
GRR RoHS (Pb Free)
Rating: -40 to 85°C
Package in Tape & Reel
NRR RoHS & Halogen free (By Request)
Rating: -40 to 85°C
Package in Tape & Reel

EML9206-XXFE06GRR/NRR
XX Output voltage
VF05 TDFN-6 Package
GRR RoHS (Pb Free) (By Request)
Rating: -40 to 85°C
Package in Tape & Reel
NRR RoHS & Halogen free
Rating: -40 to 85°C
Package in Tape & Reel

Order, Mark & Packing Information

Package	Vout	Product ID	Marking	Packing
TDFN-6	1.8	EML9206-18FE06NRR		Tape & Reel 3Kpcs
SOT-23-5	1.2	EML9206-12VF05GRR		Tape & Reel 3Kpcs
	1.8	EML9206-18VF05GRR		
	3.3	EML9206-33VF05GRR		

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Pin Functions

Pin Name	Function
V_{IN}	Input voltage Pin. Must be closely decoupled to GND pin with a 4.7μF or greater ceramic capacitor.
GND	Ground Pin.
EN/RUN	Enable Pin. Minimum 1.2V to enable the device. Maximum 0.4V to shut down the device. Do not leave this pin floating.
V_{OUT}/FB	Output Voltage Pin. An internal resistive divider divides the output voltage down for comparison to the internal reference voltage.
SW	Switch Pin. Must be connected to Inductor. This pin connects to the drains of the internal main and synchronous power MOSFET switches.

Absolute Maximum Ratings

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

Input Voltage -- – 0.3V to 6V
EN, V_{OUT} Voltages ----------------------------------- – 0.3V to V_{IN}
SW Voltage ------------------------------ – 0.3V to (V_{IN} + 0.3V)
PMOS Switch Source Current (DC) ----------------- 800mA
NMOS Switch Sink Current (DC) --------------------- 800mA
Peak Switch Sink and Source Current ----------------- 1.3A

Operating Temperature Range ---------- –40°C to 85°C
Junction Temperature (Notes 1, 3) ------------------- 125°C
Storage Temperature Range ------------ – 65°C to 150°C
Lead Temperature (Soldering, 10 sec)--------------- 240°C
ESD Susceptibility HBM --- 2KV
MM --------------------------------------- 200V

Electrical Characteristics

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are T_A = 25°C. V_{IN} = 3.6V unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{OUT}%	Output Voltage Accuracy	I_{OUT}=200mA	●	-3		+3	%
ΔV_{OVL}	Output Over-voltage Lockout	$\Delta V_{OVL} = V_{OVL} - V_{OUT}$, EML9206-Fixed		2.5	7.8	13	%
ΔV_{OUT}	Output Voltage Line Regulation	V_{IN} = 2.5V to 5.5V, I_{OUT}=200mA	●			0.4	%/V
I_{PK}	Peak Inductor Current	V_{IN} = 3V, V_{OUT} = 90%			1.1		A
I_S	PWM Quiescent Current (Note 2)	V_{OUT} = 90%			180	340	μA
	PFM Quiescent Current	V_{OUT} = 105%			35	70	μA
	Shutdown	V_{EN} = 0V, V_{IN} = 4.2V			0.1		μA
f_{OSC}	Oscillator Frequency	V_{OUT} = 100%	●	1.2	1.5	1.8	MHz
		V_{OUT} = 0V	●		320		kHz
R_{PFET}	$R_{DS(ON)}$ of PMOS	I_{SW} = 100mA			0.45	0.55	Ω
R_{NFET}	$R_{DS(ON)}$ of NMOS	I_{SW} = –100mA			0.40	0.5	Ω
V_{UVLO}	Under Voltage Lock Out			1.44	1.8	2.16	V
I_{LSW}	SW Leakage	V_{EN} = 0V, V_{SW} = 0V or 5V, V_{IN} = 5V				±1	μA
V_{EN}	Enable Threshold		●	1.2			V
	Shutdown Threshold		●			0.4	V
I_{EN}	EN Leakage Current		●			±1	μA

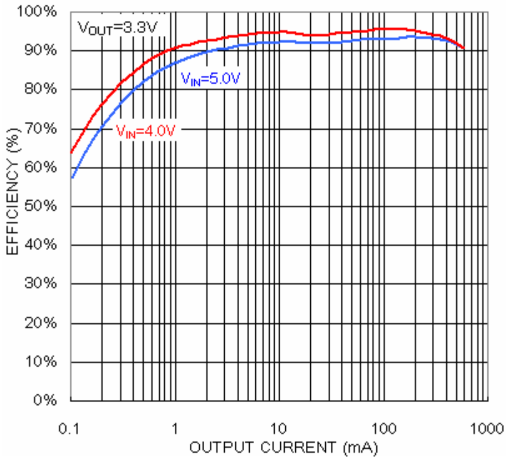
Note 1: T_J is a function of the ambient temperature T_A and power dissipation P_D ($T_J = T_A + (P_D)(250°C/W)$)

Note 2: Dynamic quiescent current is higher due to the gate charge being delivered at the switching frequency.

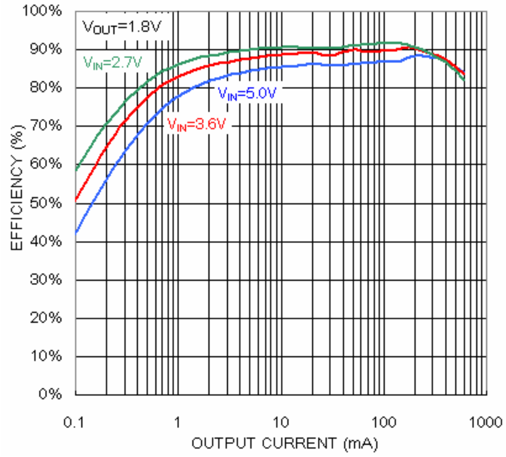
Note 3: This IC is build-in over-temperature protection to avoid damage from overload conditions.

Typical Performance Characteristics

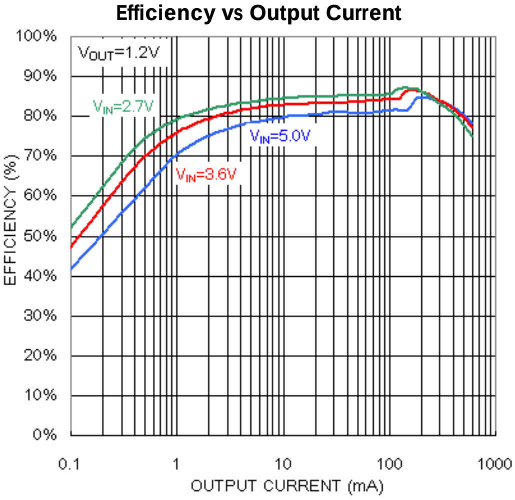
Efficiency vs Output Current



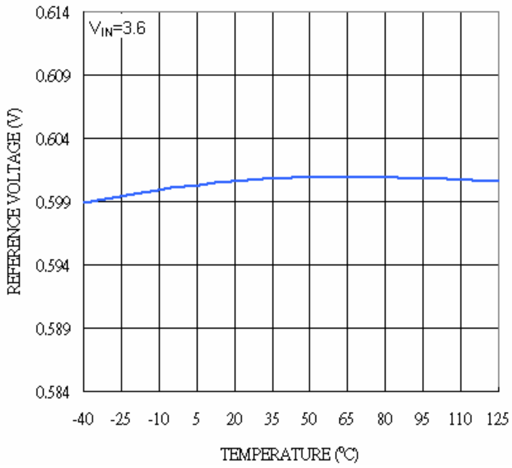
Efficiency vs Output Current



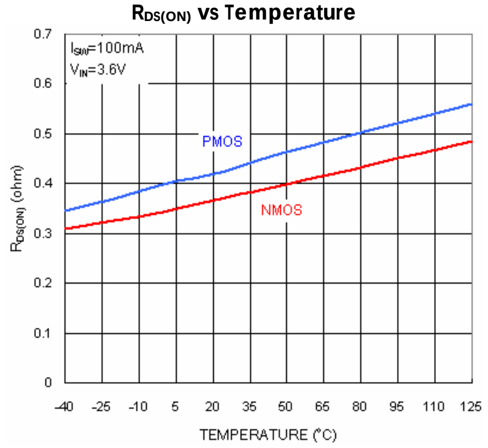
Efficiency vs Output Current



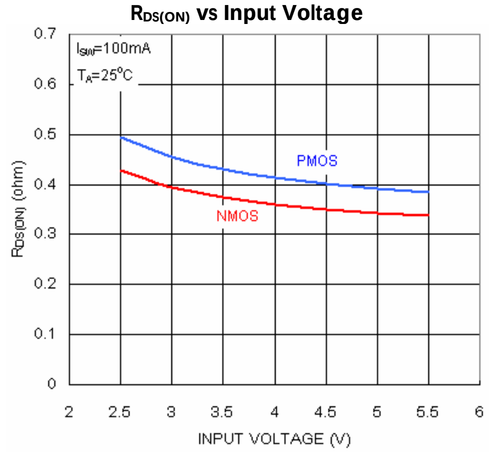
Reference voltage vs Temperature



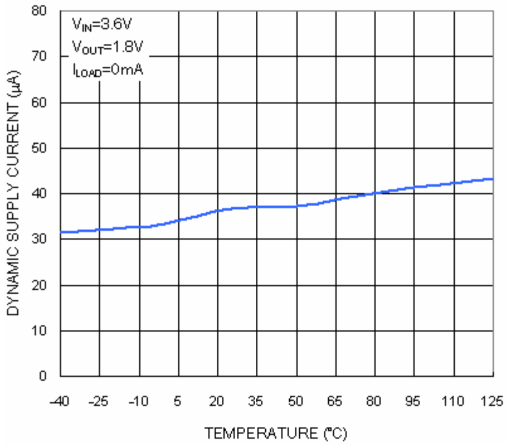
$R_{DS(ON)}$ vs Temperature



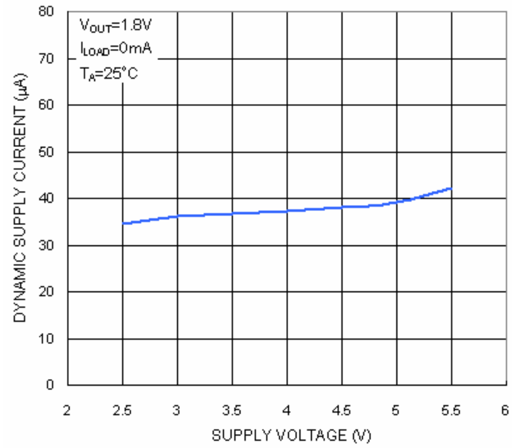
$R_{DS(ON)}$ vs Input Voltage



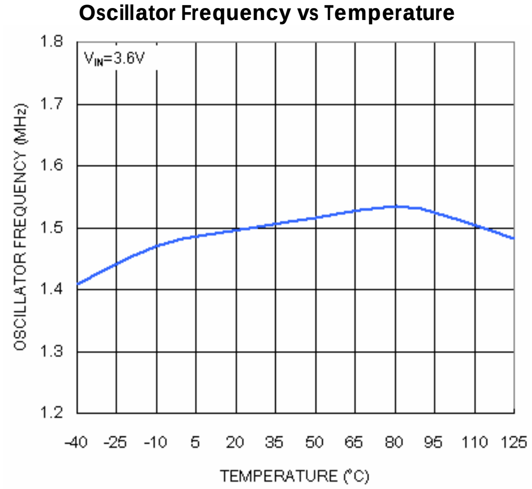
Dynamic Supply Current vs Temperature



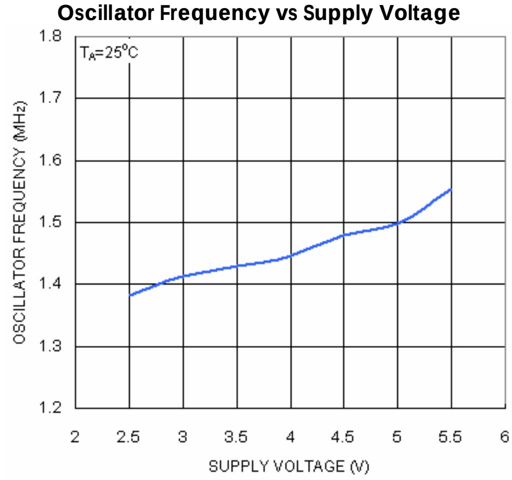
Dynamic Supply Current vs Supply Voltage



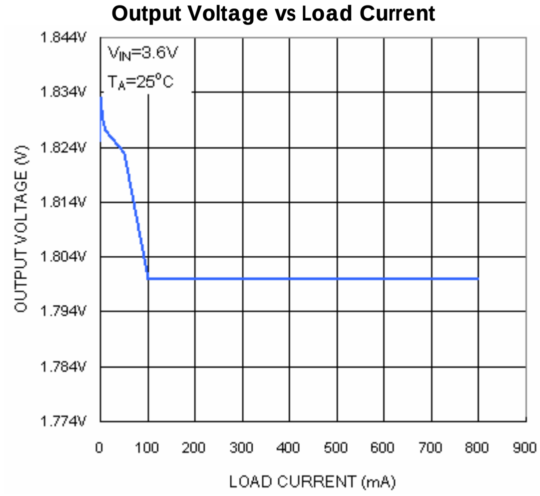
Oscillator Frequency vs Temperature



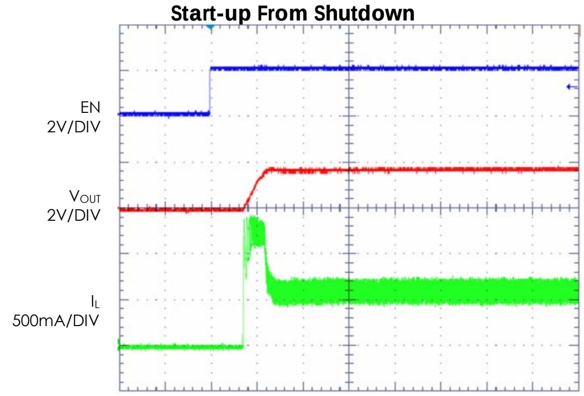
Oscillator Frequency vs Supply Voltage



Output Voltage vs Load Current

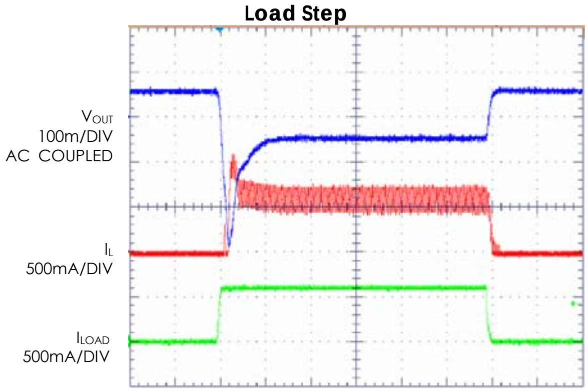


Start-up From Shutdown



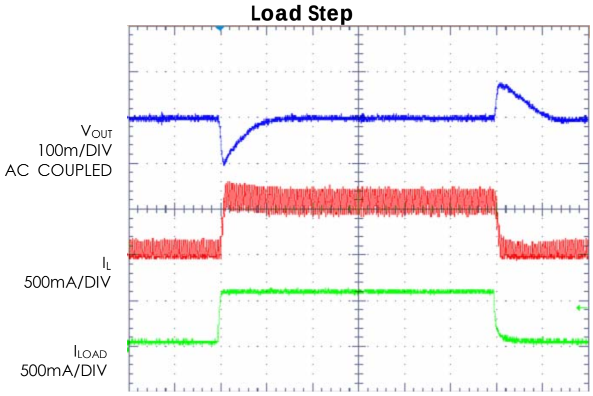
V_{IN}=3.6V 40μs/DIV
V_{OUT}=1.8V
I_{LOAD}=600mA (3Ω RESISTOR)

Load Step



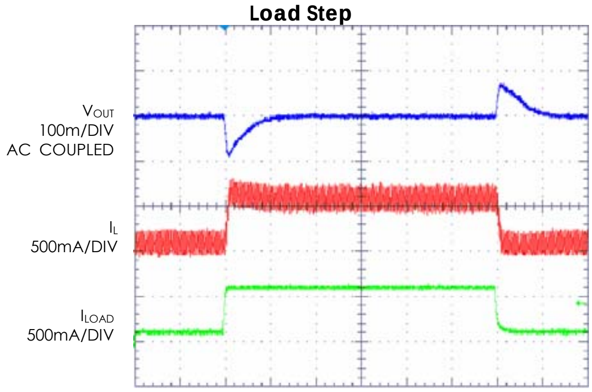
V_{IN}=3.6V 20μs/DIV
V_{OUT}=1.8V
I_{LOAD}=0mA to 600mA

Load Step



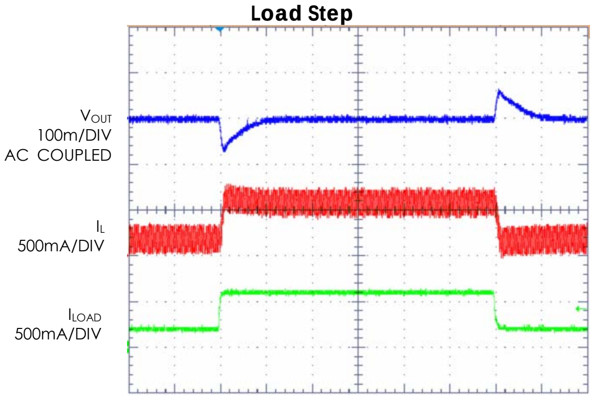
V_{IN}=3.6V 20μs/DIV
V_{OUT}=1.8V
I_{LOAD}=50mA to 600mA

Load Step



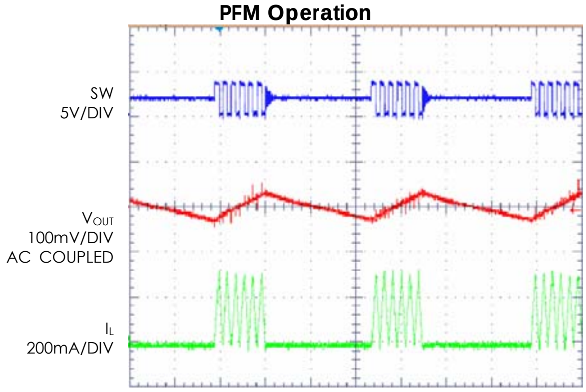
V_{IN}=3.6V 20μs/DIV
V_{OUT}=1.8V
I_{LOAD}=100mA to 600mA

Load Step



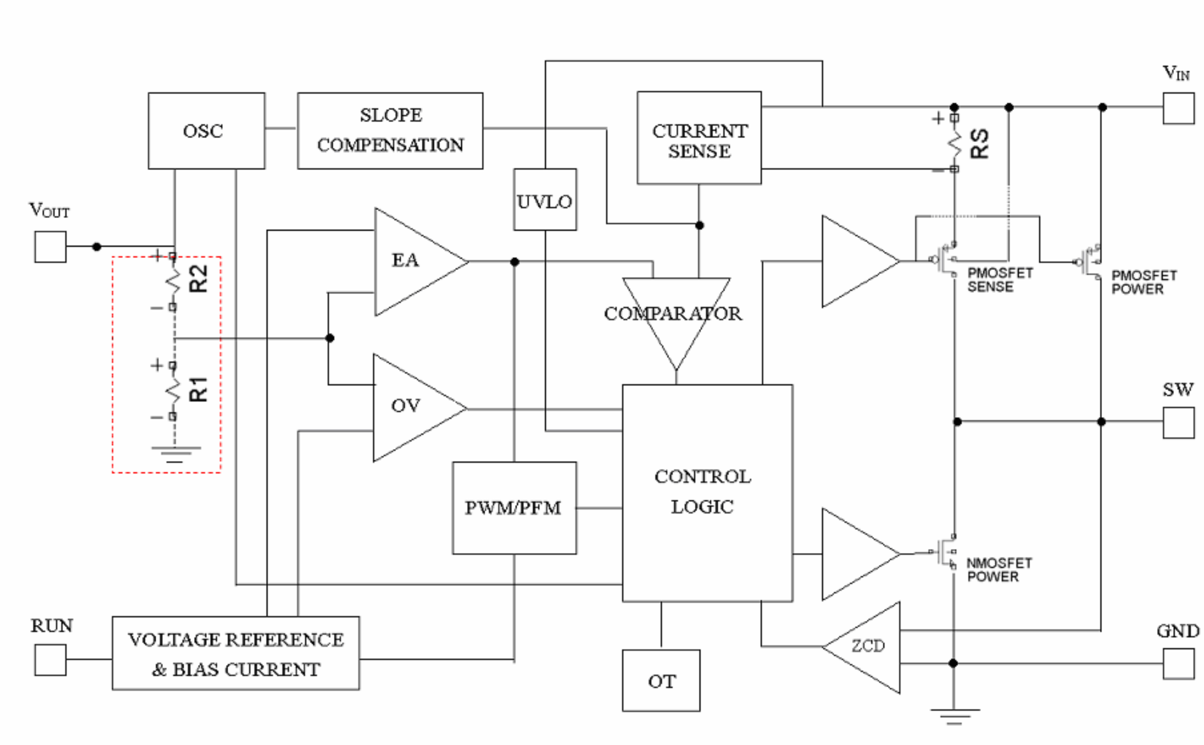
V_{IN}=3.6V 20μs/DIV
V_{OUT}=1.8V
I_{LOAD}=200mA to 600mA

PFM Operation



V_{IN}=3.6V 4μs/DIV
V_{OUT}=1.8V
I_{LOAD}=50mA

Functional Block Diagram



Applications

Inductor Selection

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

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

The Eq. 1 shows the inductor ripple current is a function of frequency, inductance, Vin and Vout. It is recommended to set ripple current to 40% of max. load current. A low ESR inductor is preferred.

C_{IN} and C_{OUT} Selection

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

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

ESR is an important parameter to select C_{OUT}. The output ripple V_{OUT} is determined by:

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

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 Cout selection since Cout 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.

Thermal Considerations

Although thermal shutdown is build-in in EML9206 that protect the device from thermal damage, the total power dissipation that EML9206 can sustain should be base on the package thermal capability. The formula to ensure the safe operation is shown in Note 1.

To avoid the EML9206 from exceeding the maximum junction temperature, the user will need to do some thermal analysis.

Guidelines for PCB Layout

To ensure proper operation of the EML9206, please note the following PCB layout guidelines:

1. The GND trace, the SW trace and the V_{IN} trace should be kept short, direct and wide.
2. V_{OUT} pin must be connected directly to the output voltage terminal of the load.
3. The Input capacitor C_{IN} must be connected to pin V_{IN} as closely as possible.
4. Keep SW trace away from the sensitive V_{OUT} pin since this node is with high frequency and voltage swing.
5. Keep the (–) plates of C_{IN} and C_{OUT} as close as possible.

Design Example

Assume the EML9206 is used in a single lithium-ion battery-powered application. The V_{IN} range will be about 2.7V to 4.2V. Output voltage 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, ΔI_L = 240mA and f = 1.5MHz in eq. 1 gives:

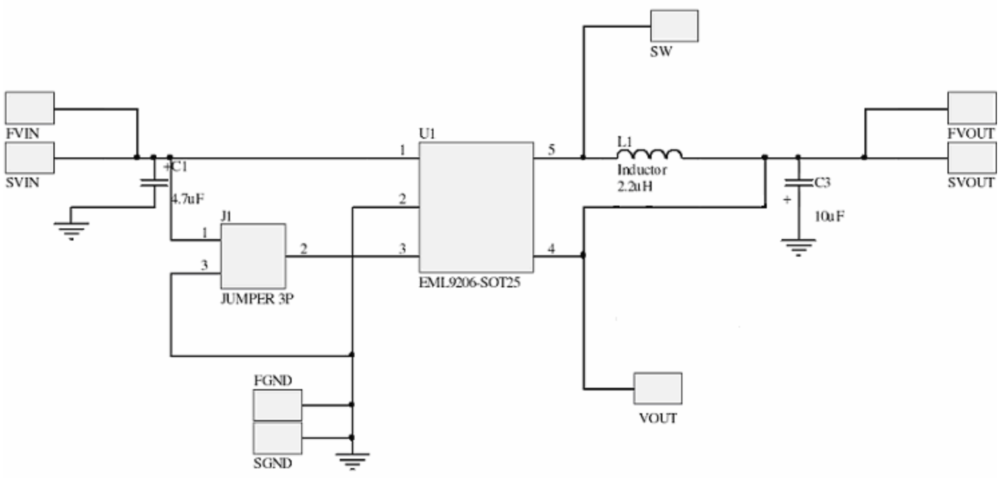
$$L = \frac{1.8\text{V}}{1.5\text{MHz} \cdot 240\text{mA}} \left(1 - \frac{1.8\text{V}}{4.2\text{V}}\right) = 2.86\mu\text{H}$$

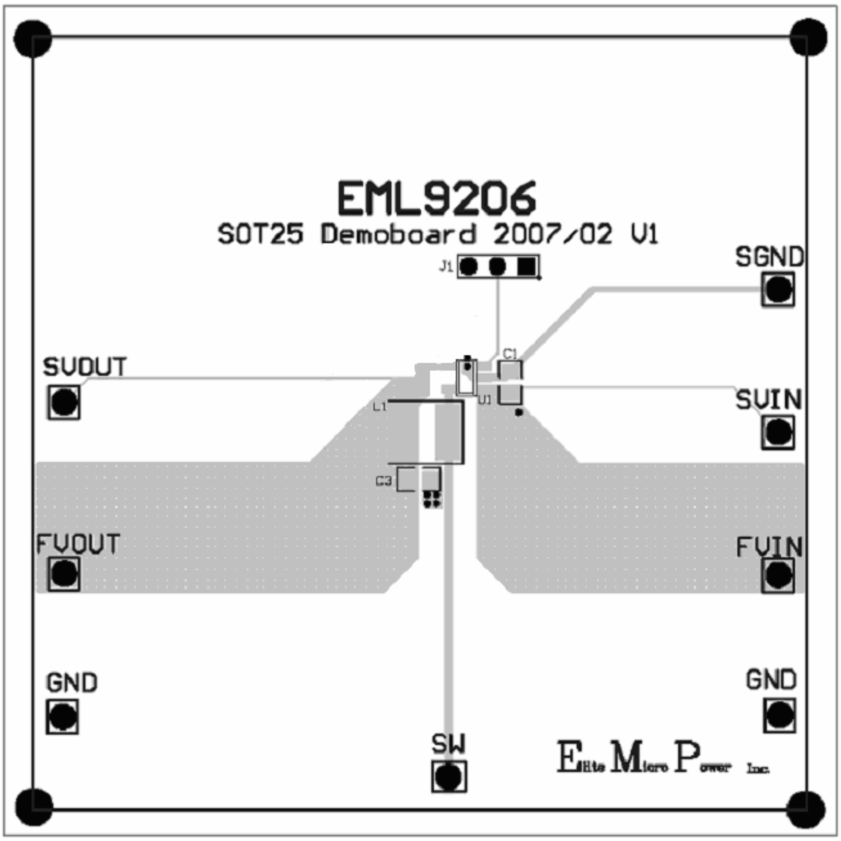
A 2.2µH inductor could be chose with this application.

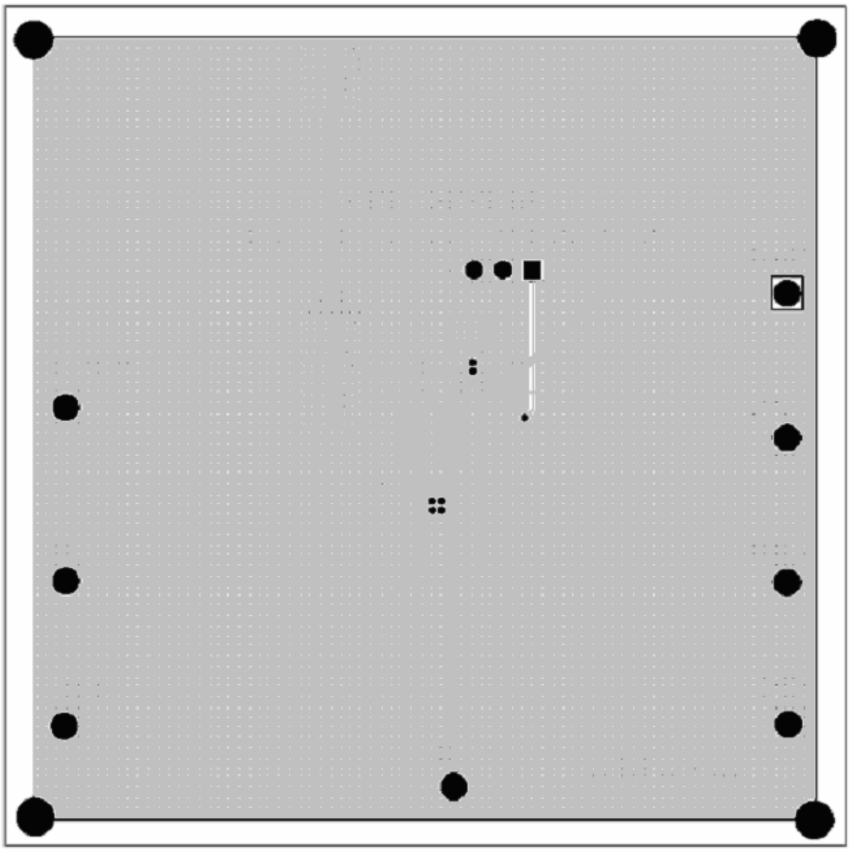
A greater inductor with less equivalent series resistance makes best efficiency. C_{IN} will require an RMS current rating of at least $I_{LOAD(MAX)}/2$ and low ESR. In most cases, a ceramic capacitor will satisfy this requirement.

Application (Continued)

Typical schematic for PCB layout

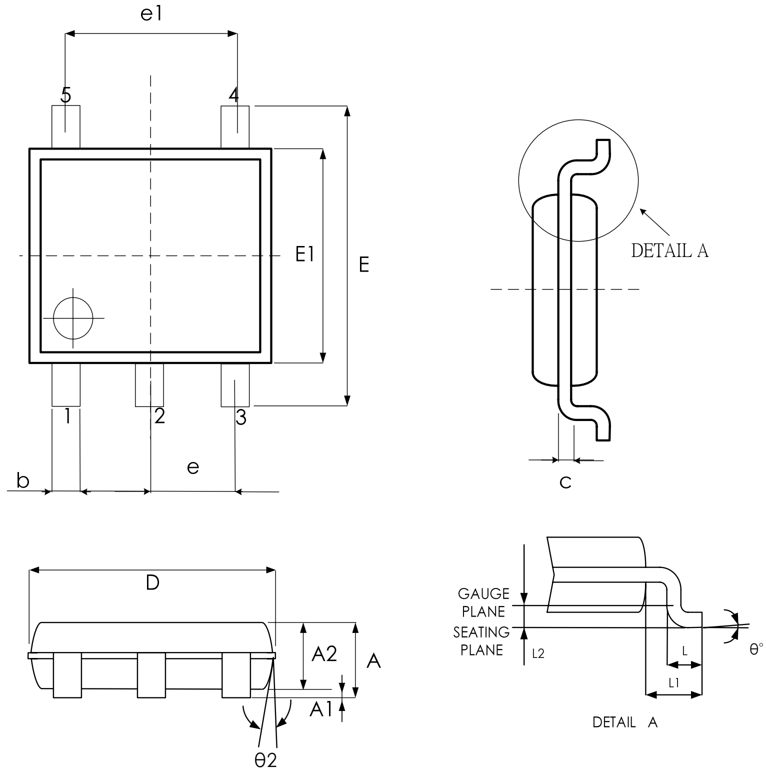



EML9206
SOT25 Demoboard 2007/02 V1
J1
SGND
SVOUT
C1
U1
L1
SVIN
C3
FVOUT
FVIN
GND
GND
SW



Package Information

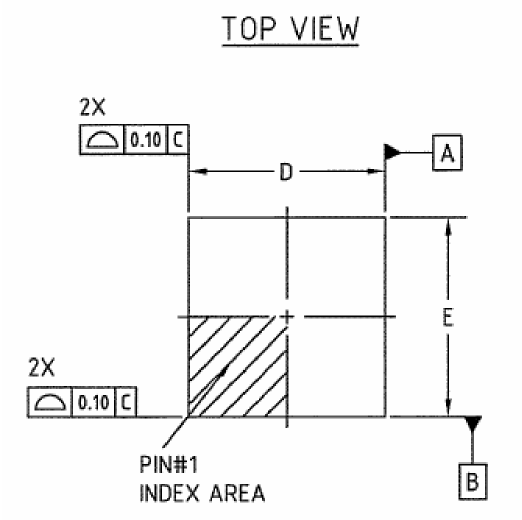
SOT-23-5

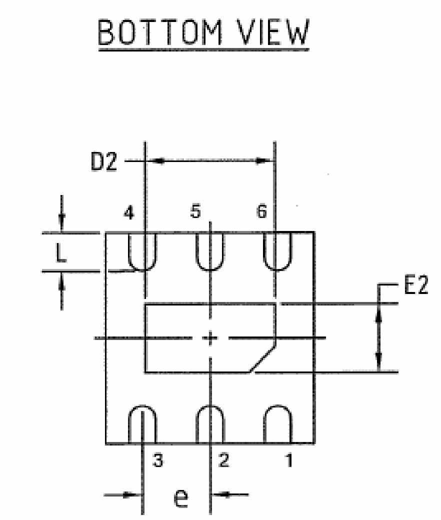


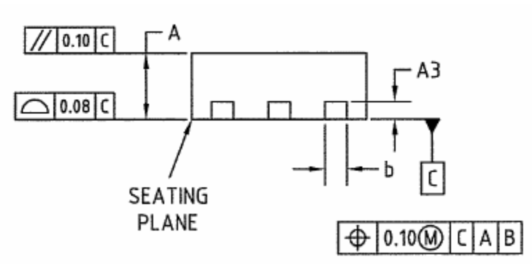
SYMBPLS	MIN.	NOM.	MAX.
A	1.05	1.20	1.35
A1	0.05	0.10	0.15
A2	1.00	1.10	1.20
b	0.30	—	0.50
c	0.08	—	0.20
D	2.80	2.90	3.00
E	2.60	2.80	3.00
E1	1.50	1.60	1.70
e	0.95 BSC		
e1	1.90 BSC		
L	0.30	0.45	0.55
L1	0.60 REF		
θ°	0	5	10
θ2°	6	8	10

UNIT: MM

TDFN-6







SYMBOL	COMMON					
	DIMENSIONS MILLIMETER			DIMENSIONS INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.027	0.029	0.031
A3	0.200 BSC			0.008 BSC		
b	0.25	0.30	0.35	0.010	0.012	0.014
D	2.00 BSC			0.079 BSC		
D2	1.35	1.40	1.45	0.053	0.055	0.057
E	2.00 BSC			0.079 BSC		
E2	0.55	0.60	0.65	0.022	0.024	0.026
e	0.650 BSC			0.026 BSC		
L	0.25	0.30	0.35	0.010	0.012	0.014

Revision History

Revision	Date	Description
2.0	2009.06.05	EMP transferred from version 1.0
2.1	2009.06.23	1. Add TDFN-6 package, order information (P2) 2. Delete pin number (P3) 3. Add TDFN-6 outline (P13)
2.2	2011.01.28	Revise electrical characteristics (VEN)

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