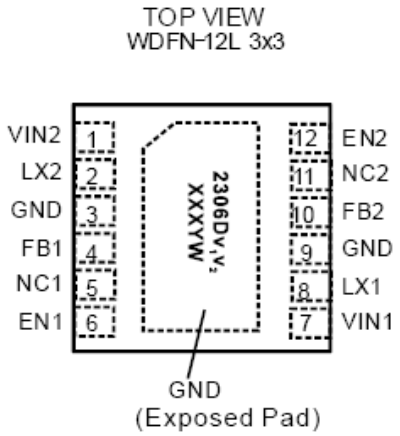
DUAL HIGH-EFFICIENCY PWM STEP-DOWN DC-DC CONVERTER

Description

The PAM2306D is a dual step-down current mode, DC-DC converter. At heavy load, the constant-frequency PWM control performs excellent stability and transient response. To ensure the longest battery life in portable applications, the PAM2306D provides a powersaving Pulse-Skipping Modulation (PSM) mode to reduce quiescent cur rent under light load operation.

The PAM2306D supports a range of input voltages from 2.5V to 5.5V, allowing the use of a single Li+/Li-polymer cell, multiple Alkaline/NiMH cell, USB, and other standard power sources. The dual output voltages are available for adjustment. All versions employ internal power switch and synchronous rectifier to minimize external part count and realize high efficiency. During shutdown, the input is disconnected from the output and the shutdown current is less than 0.1μA. Other key features include under-voltage lockout to prevent deep battery discharge.

Pin Assignments



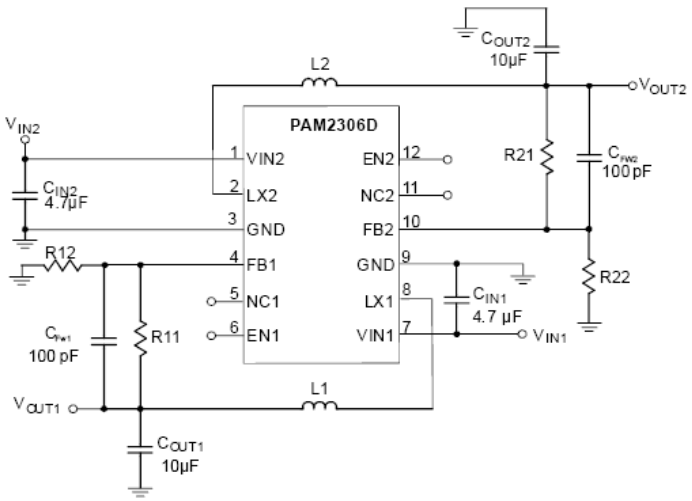
Features

- Efficiency up to 96%
- Only 40μA (Typ per Channel) Quiescent Current
- Output Current: Up to 1A per Channel
- Internal Synchronous Rectifier
- 1.5MHz Switching Frequency
- Soft-Start
- Under-Voltage Lockout
- Short Circuit Protection
- Thermal Shutdown
- Small 12L WDFN3x3 Package
- Pb-Free and RoHS Compliant

Applications

- Cellular Phone
- Portable Electronics
- Personal Information Appliances
- Wireless and DSL Modems
- MP3 Players

Typical Applications Circuit



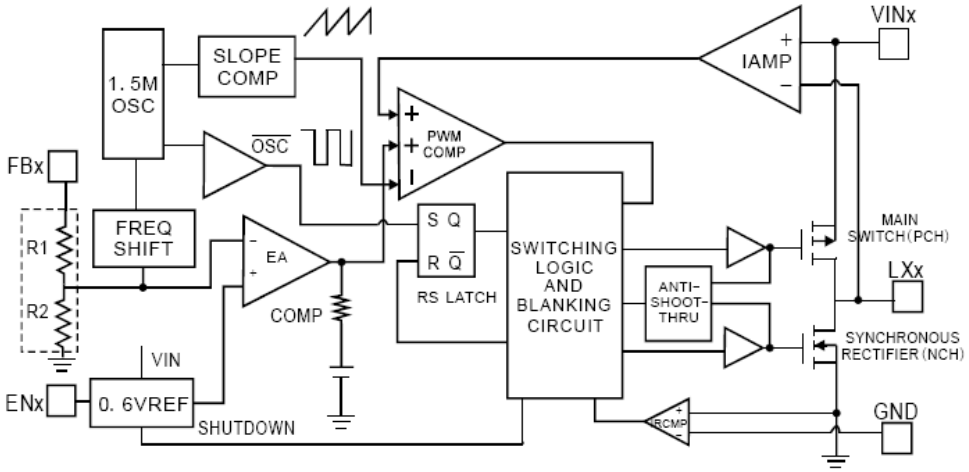
$$V_{OUT} \times V_{REF}\left(1+\frac{Rx1}{Rx2}\right)$$

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Pin Descriptions

Pin Number	Pin Name WDFN3x3-12L	Function
1	VIN2	Power Input of Channel 2.
2	LX2	Pin for Switching of Channel 2.
3, 9 Exposed Pad	GND	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.
4	FB1	Feedback of Channel 1.
5, 11	NC1, NC2	No Connection
6	EN1	Chip Enable of Channel 1 (Active High). $V_{EN1} \leq V_{IN1}$.
7	VIN1	Power Input of Channel 1.
8	LX1	Pin for Switching of Channel 1.
10	FB2	Feedback of Channel 2.
12	EN2	Chip Enable of Channel 2 (Active High). $V_{EN2} \leq V_{IN2}$.

Functional Block Diagram



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Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.)

These are stress ratings only and functional operation is not implied. Exposure to absolute maximum ratings for prolonged time periods may affect device reliability. All voltages are with respect to ground.

Parameter	Rating	Unit
Input Voltage	-0.3 to +6.5	V
EN1, FB1, LX1, EN2, FB2 and LX2 Pin Voltage	-0.3 to (V_{IN} +0.3)	V
Maximum Junction Temperature	150	°C
Storage Temperature Range	-65 to +150	°C
Soldering Temperature	260, 10sec	°C

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Parameter	Rating	Unit
Supply Voltage	2.5 to 5.5	V
Ambient Temperature Range	-40 to +85	°C
Junction Temperature Range	-40 to +125	°C

Thermal Information

Parameter	Symbol	Package	Maximum	Unit
Thermal Resistance (Junction to Ambient)	θ_{JA}	W-DFN3x3-12	60	°C/W
Thermal Resistance (Junction to Case)	θ_{JC}	W-DFN3x3-12	8.5	°C/W
Power Dissipation	P_D	W-DFN3x3-12	1.66	W

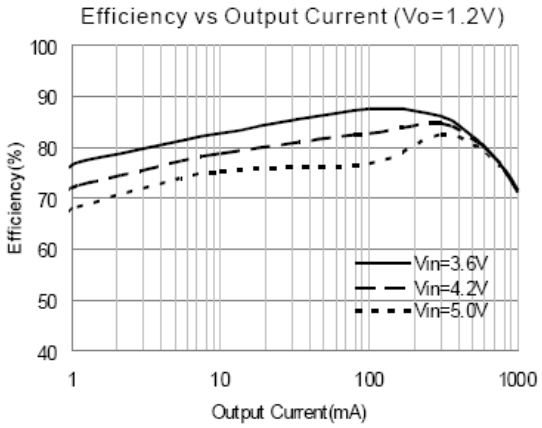
Electrical Characteristics

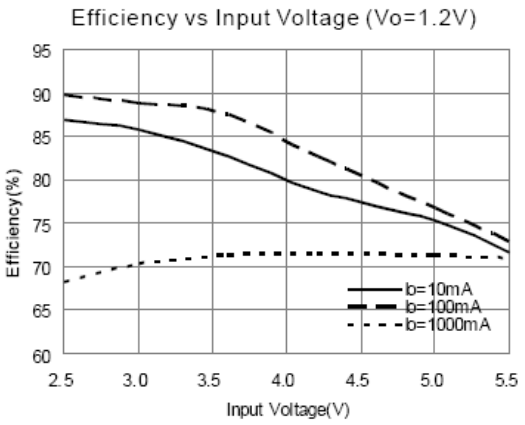
(@T_A = +25°C, V_{IN} = 3.6V, V_O = 1.8V, C_{IN} = 10μF, C_O = 10μF, L = 2.2μH, unless otherwise specified.)

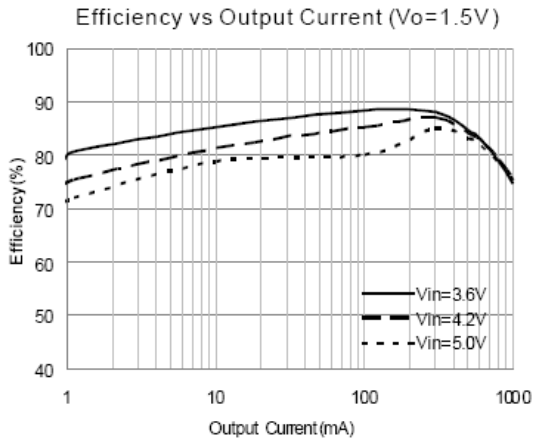
Parameter	Symbol	Test Conditions		Min	Typ	Max	Units
Input Voltage Range	V_{IN}			2.5		5.5	V
Regulated Feedback Voltage	V_{FB}	Io = 100mA		0.588	0.6	0.612	V
Reference Voltage Line Regulation	ΔV_{FB}				0.3		%/V
Regulated Output Voltage Accuracy	V_O	I_O = 10mA		-3		+3	%
Peak Indictor Current	I_{PK}	V_{IN} = 3V, V_{FB} = 0.5V or V_O = 90%			1.5		A
Output Voltage Line Regulation	LNR	V_{IN} = 2.5V to 5V, I_O = 10mA			0.2	0.5	%/V
Output Voltage Load Regulation	LDR	I_O = 1mA to 1A			1.5		%
Quiescent Current (per channel)	I_Q	No load			40	70	μA
Shutdown Current (per channel)	I_{SD}	V_{EN} = 0V			0.1	1	μA
Oscillator Frequency	f_{OSC}	V_O = 100%		1.2	1.5	1.8	MHz
		V_{FB} = 0V or V_O = 0V			500		kHz
Drain-Source On-State Resistance	$R_{DS(ON)}$	I_{DS} = 100mA	P MOSFET		0.30	0.45	Ω
			N MOSFET		0.35	0.50	Ω
SW Leakage Current (per channel)	I_{LSW}				±0.01	1	μA
EN Threshold High	V_{EH}			1.5			V
EN Threshold Low	V_{EL}					0.3	V
EN Leakage Current	I_{EN}				±0.01		μA
Over Temperature Protection	OTP				150		°C
OTP Hysteresis	OTH				30		°C

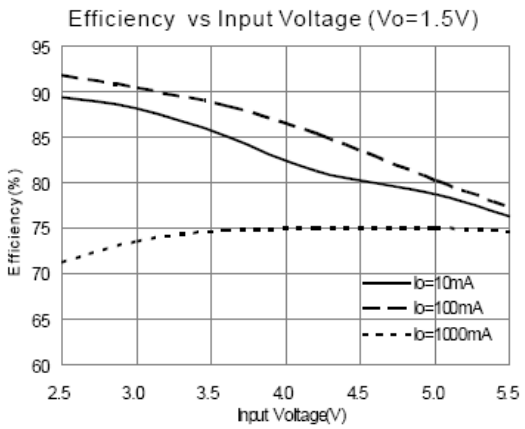
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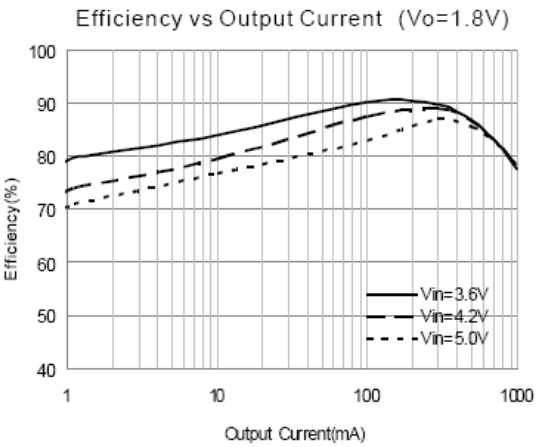
Typical Performance Characteristics (@T_A = +25°C, C_{IN} = 10µF, C_O = 10µF, L = 4.7µH, unless otherwise specified.)

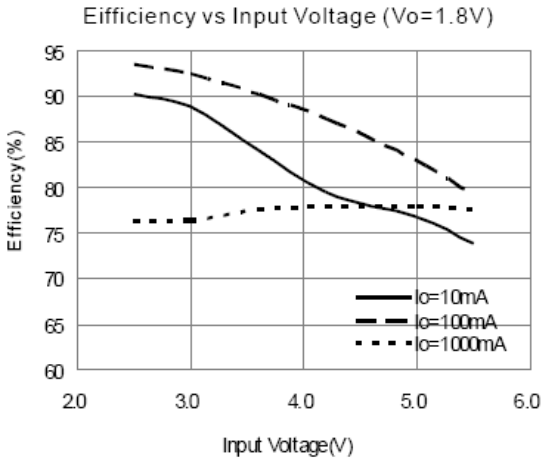








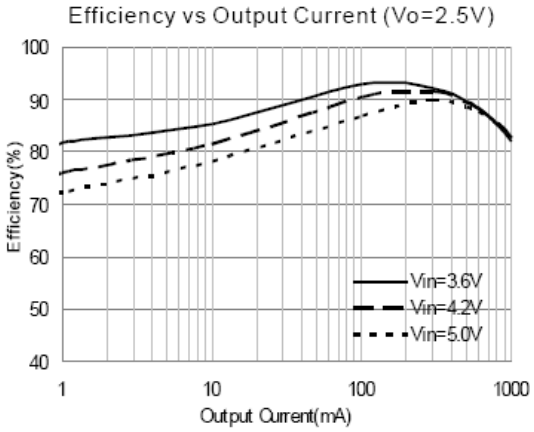


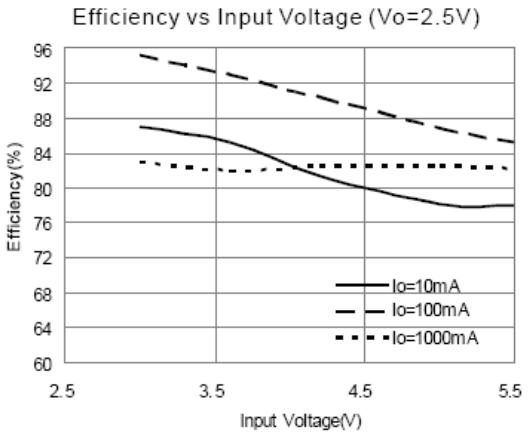


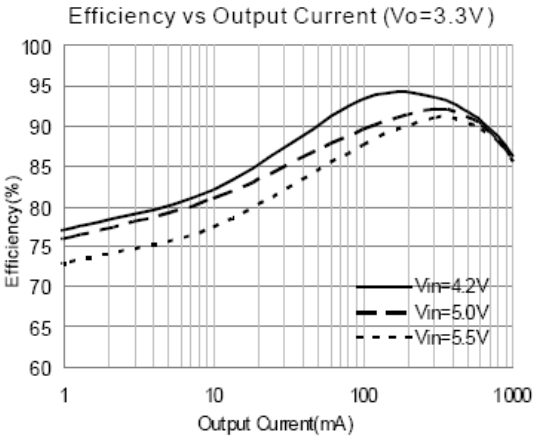
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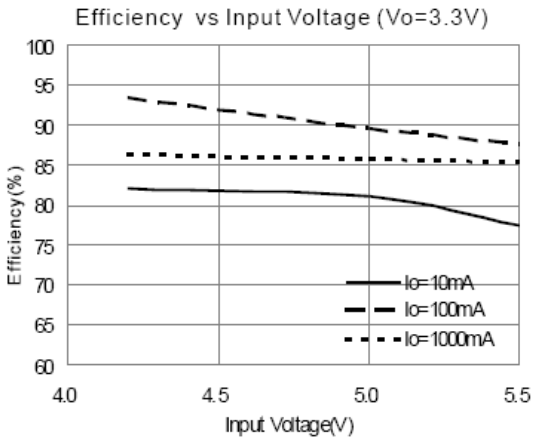
Typical Performance Characteristics (cont.)

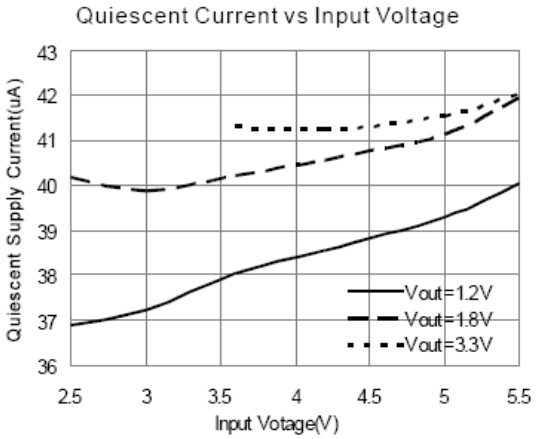
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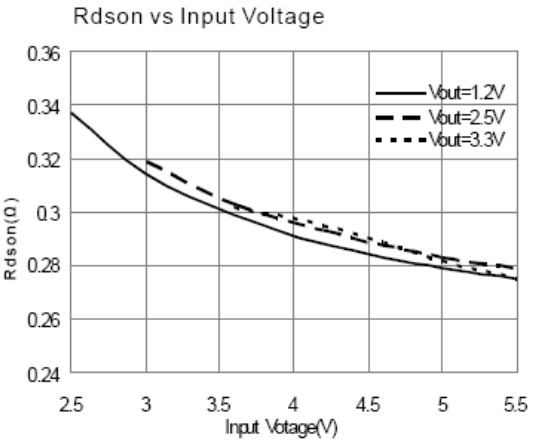










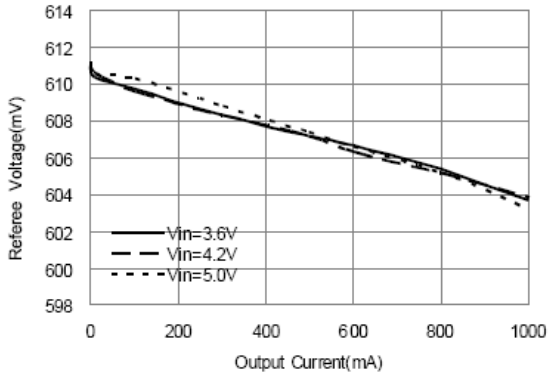


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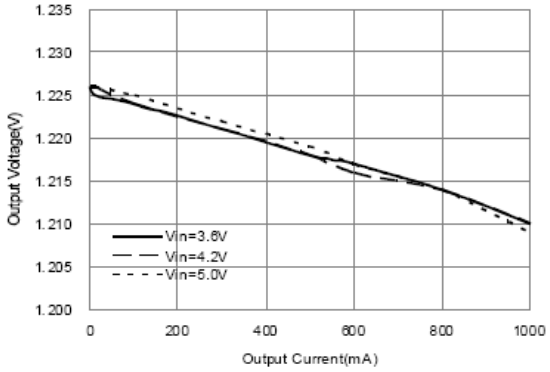
Typical Performance Characteristics (cont.)

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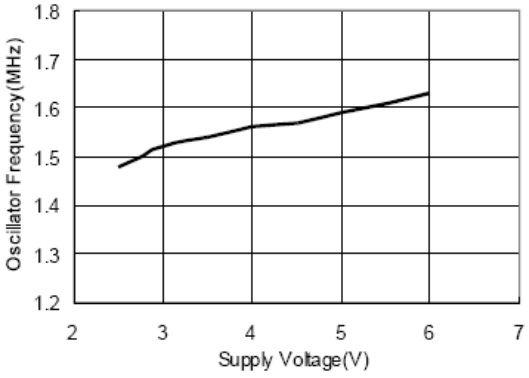
Reference Voltage vs Load Current



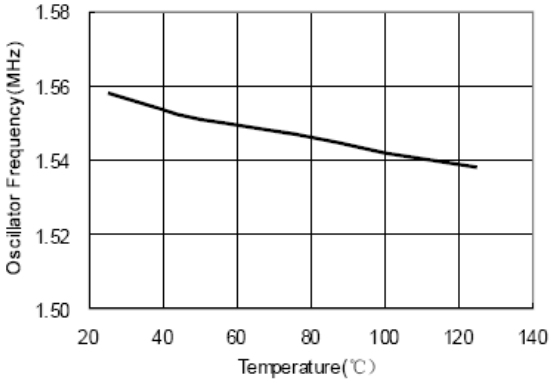
Output Voltage vs Load Current



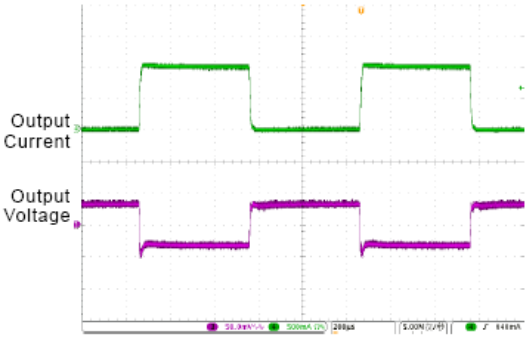
Oscillator Frequency vs Supply Voltage



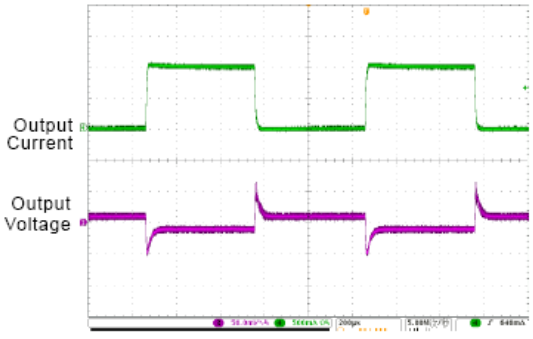
Oscillator Frequency vs Temperature



Load Transient
Io=0-1A, Vo=3.3V, Vin=5V



Load Transient
Io=0-1A, Vo=1.2V, Vin=5V



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Application Information

The basic PAM2306D application circuit is shown in Page 1. External component selection is determined by the load requirement, selecting L first and then C_{IN} and C_{OUT}.

Inductor Selection

For most applications, the value of the inductor will fall in the range of 1μH to 4.7μH. Its value is chosen based on the desired ripple current. Large value inductors lower ripple current and small value inductors result in higher ripple currents. Higher V_{IN} or V_{OUT} also increases the ripple current as shown in Equation 1. A reasonable starting point for setting ripple current is ΔI_L = 400mA (40% of 1A).

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

The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation. Thus, a 1.4A rated inductor should be enough for most applications (1A + 400mA). For better efficiency, choose a low DC-resistance inductor.

V_O	1.2V	1.5V	1.8V	2.5V	3.3V
L	2.2 μH	2.2 μH	2.2 μH	4.7 μH	4.7μH

C_{IN} and C_{OUT} Selection

In continuous mode, the source current of the top MOSFET is a square wave of duty cycle V_{OUT}/V_{IN}. To prevent large voltage transients, a low ESR input capacitor sized for the maximum RMS current must be used. The maximum RMS capacitor current is given by:

$$C_{IN}\text{required} I_{RMS} \cong I_{OMAX} \frac{[V_{OUT}(V_{IN} - V_{OUT})]^{1/2}}{V_{IN}}$$

This formula has a maximum at V_{IN} =2V_{OUT}, where I_{RMS} = I_{OUT}/2. This simple worst-case condition is commonly used for design because even significant deviations do not offer much relief. Note that the capacitor manufacturer's ripple current ratings are often based on 2000 hours of life. This makes it advisable to further derate the capacitor, or choose a capacitor rated at a higher temperature than required. Consult the manufacturer if there is any question.

The selection of C_{OUT} is driven by the required effective series resistance (ESR).

Typically, once the ESR requirement for C_{OUT} has been met, the RMS current rating generally far exceeds the I_{RIPPLE} (P-P) requirement. The output ripple ΔV_{OUT} is determined by:

$$\Delta V_{OUT} \cong \Delta I_L \left(ESR + \frac{1}{8fC_{OUT}}\right)$$

Where f = operating frequency, C_{OUT} = output capacitance and ΔI_L = ripple current in the inductor. For a fixed output voltage, the output ripple is highest at maximum input voltage since ΔI_L increases with input voltage.

Using Ceramic Input and Output Capacitors

Higher values, lower cost ceramic capacitors are now becoming available in smaller case sizes. Their high ripple current, high voltage rating and low ESR make them ideal for switching regulator applications. Using ceramic capacitors can achieve very low output ripple and small circuit size.

When choosing the input and output ceramic capacitors, choose the X5R or X7R dielectric formulations. These dielectrics have the best temperature and voltage characteristics of all the ceramics for a given value and size.

Thermal Consideration

Thermal protection limits power dissipation in the PAM2306D. When the junction temperature exceeds 150°C, the OTP (Over Temperature Protection) starts the thermal shutdown and turns the pass transistor off. The pass transistor resumes operation after the junction temperature drops below 120°C.

For continuous operation, the junction temperature should be maintained below 125°C. The power dissipation is defined as:

$$P_D = I_O{}^2 \frac{V_O R_{DS(ON)H} + (V_{IN} - V_O) R_{DS(ON)L}}{V_{IN}} + (t_{SW} F_S I_O + I_Q) V_{IN}$$

I_Q is the step-down converter quiescent current. The term tsw is used to estimate the full load step-down converter switching losses.

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Application Information (cont.)

For the condition where the step-down converter is in dropout at 100% duty cycle, the total device dissipation reduces to:

$$P_D = I_O^2 R_{DS(ON)H} + I_Q V_{IN}$$

Since $R_{DS(ON)}$, quiescent current, and switching losses all vary with input voltage, the total losses should be investigated over the complete input voltage range. The maximum power dissipation depends on the thermal resistance of IC package, PCB layout, the rate of surrounding airflow and temperature difference between junction and ambient. The maximum power dissipation can be calculated by the following formula:

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

Where $T_{J(MAX)}$ is the maximum allowable junction temperature 125°C. T_A is the ambient temperature and θ_{JA} is the thermal resistance from the junction to the ambient. Based on the standard JEDEC for a two layers thermal test board, the thermal resistance θ_{JA} of WDFN3X3 is 60°C/W. The maximum power dissipation at T_A = +25°C can be calculated by following formula:

P_D = (125°C - 25°C)/60°C/W = 1.66W

Selecting the Output Voltage

The internal reference is 0.6V (Typical). The output voltage is calculated as below:

$$V_O = 0.6 \times \left(1 + \frac{R1}{R2}\right)$$

The output voltage is given by Table 1.

Table 1: Resistor selection for output voltage setting.

V_O	R1	R2
1.2V	100k	100k
1.5V	150k	100k
1.8V	200k	100k
2.5V	380k	120k
3.3V	540k	120k

100% Duty Cycle Operation

As the input voltage approaches the output voltage, the converter turns the P-Channel transistor continuously on. In this mode the output voltage is equal to the input voltage minus the voltage drop across the P-Channel transistor:

$$V_{OUT} = V_{IN} - I_{LOAD} (R_{DS(ON)} + R_L)$$

where $R_{DS(ON)}$ = P-Channel switch ON resistance, I_{LOAD} = Output Current, R_L = Inductor DC Resistance

UVLO and Soft-Start

The reference and the circuit remain reset until the V_{IN} crosses its UVLO threshold.

The PAM2306D has an internal soft-start circuit that limits the in-rush current during start-up. This prevents possible voltage drops of the input voltage and eliminates the output voltage overshoot. The soft-start acts as a digital circuit to increase the switch current in several steps to the P-Channel current limit (1500mA).

Short Circuit Protection

The switch peak current is limited cycle-by-cycle to a typical value of 1500mA. In the event of an output voltage short circuit, the device operates with a frequency of 400kHz and minimum duty cycle, therefore the average input current is typically 200mA.

Thermal Shutdown

When the die temperature exceeds 150°C, a reset occurs and the reset remains until the temperature decrease to 120°C, at which time the circuit can be restarted.

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Application Information (cont.)

PCB Layout Check List

When laying out the printed circuit board, the following checklist should be used to ensure proper operation of the PAM2306D. These items are also illustrated graphically in Figure 1. Check the following in your layout:

1. The power traces, consisting of the GND trace, the SW trace and the V_{IN} trace should be kept short, direct and wide.
2. Does the FB pin connect directly to the feedback resistors? The resistive divider R1/R2 must be c onnected between the (+) plate of C_{OUT} and ground.
3. Does the (+) plate of C_{IN} connect to V_{IN} as closely as possible? This capacitor provides the AC current to the internal power MOSFETs.
4. Keep the switching node, SW, away from the sensitive FB node.
5. Keep the (–) plates of C_{IN} and C_{OUT} as close as possible.

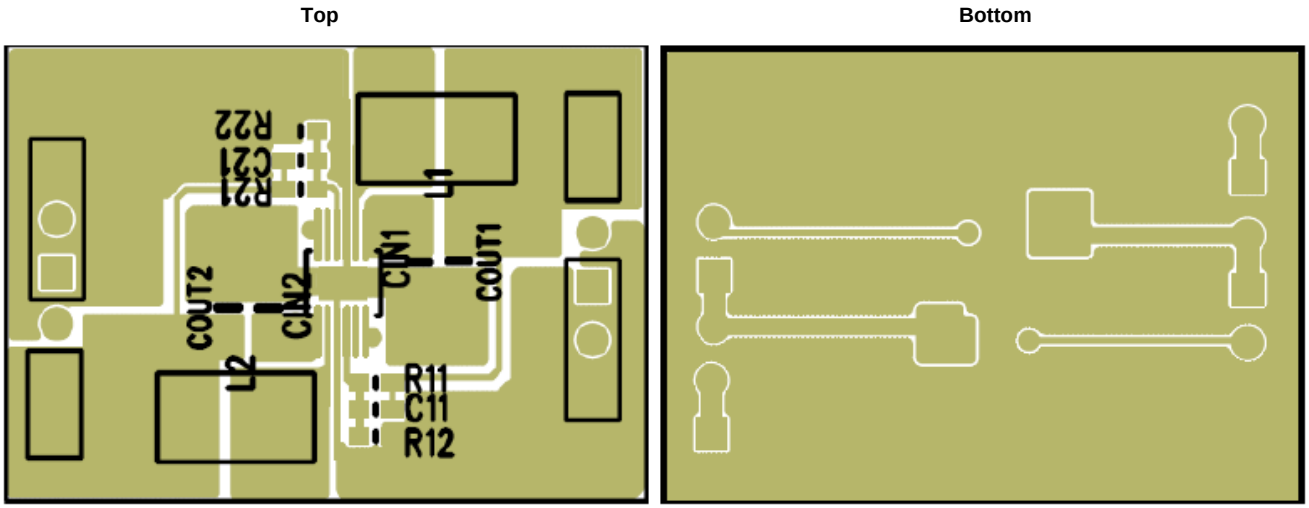
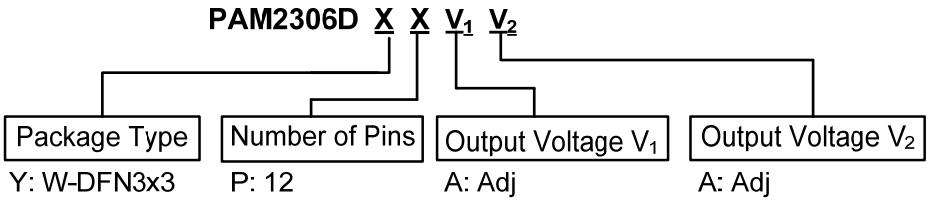


Figure 1. PAM2306D Suggested Layout

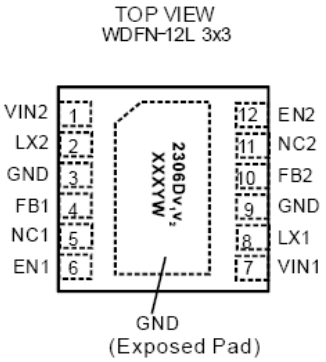
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Ordering Information



Part Number	Marking	Package Type	Packaging
PAM2306DYPv_1v_2	2306Dv_1v_2 X XXYW	W-DFN3x3-12	3000 Units/ Tape&Reel

Marking Information

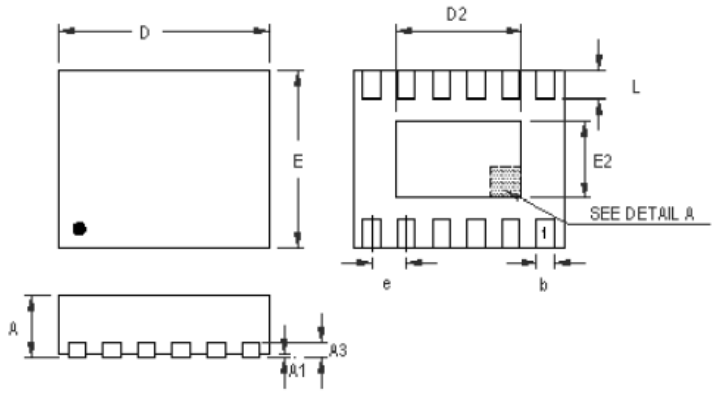


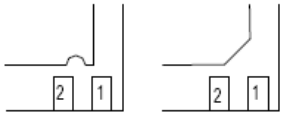
v_1: Output Voltage 1
v_2: Output Voltage 2
(refer to "Ordering Information")
X: Internal Code
Y: Year
W: Week

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Package Outline Dimensions (All dimensions in mm.)

3x3 mm WDFN 12





DETAIL A

Pin #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.150	0.250	0.006	0.010
D	2.950	3.050	0.116	0.120
D2	2.300	2.650	0.091	0.104
E	2.950	3.050	0.116	0.120
E2	1.400	1.750	0.055	0.069
e	0.450		0.018	
L	0.350	0.450	0.014	0.018

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LIFE SUPPORT

Diodes Incorporated products are specifically not authorized for use as critical components in life support devices or systems without the express written approval of the Chief Executive Officer of Diodes Incorporated. As used herein:

A. Life support devices or systems are devices or systems which:

1. are intended to implant into the body, or

2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

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