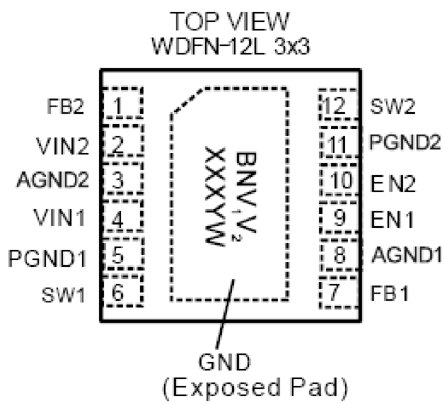
DUAL HIGH-EFFICIENCY PWM STEP-DOWN DC-DC CONVERTER

Description

The PAM2319 is a dual step-down current-mode, DC-DC converter. At heavy load, the constantf requency PWM control performs excellent stability and transient response. To ensure the longest battery life in portable applications, the PAM2319 provides a power-saving Pulse-Skipping Modulation (PSM) mode to reduce quiescent current under light load operation.

The PAM2319 supports a range of input voltages from 2.7V 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 adjustable from 1.0V to 3.3V. Both channels 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, soft-start, short circuit protection and thermal shutdown.

Pin Assignments



Features

- Supply Voltage: 2.7V to 5.5V
- Output Voltage:
  - Vo1 ADJ/1000mA
  - Vo2 ADJ/2000mA
- Low Quiescent Current: Channel 1: 40μA; Channel 2: 55μA
- High Efficiency:
- Switching Frequency: 3MHz(Channel 1)
  2.5MHz(Channel 2)
- Internal Synchronous Rectifier
- Soft Start
- Under-Voltage Lockout
- Short Circuit Protection
- Thermal Shutdown
- Small W-DFN3X3-12L Pb-Free/Halogen Free Package
- RoHS/REACH Compliant

Applications

- Portable Electronics
- Personal Information Appliances
- Wireless and DSL Modems

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Typical Applications Circuit

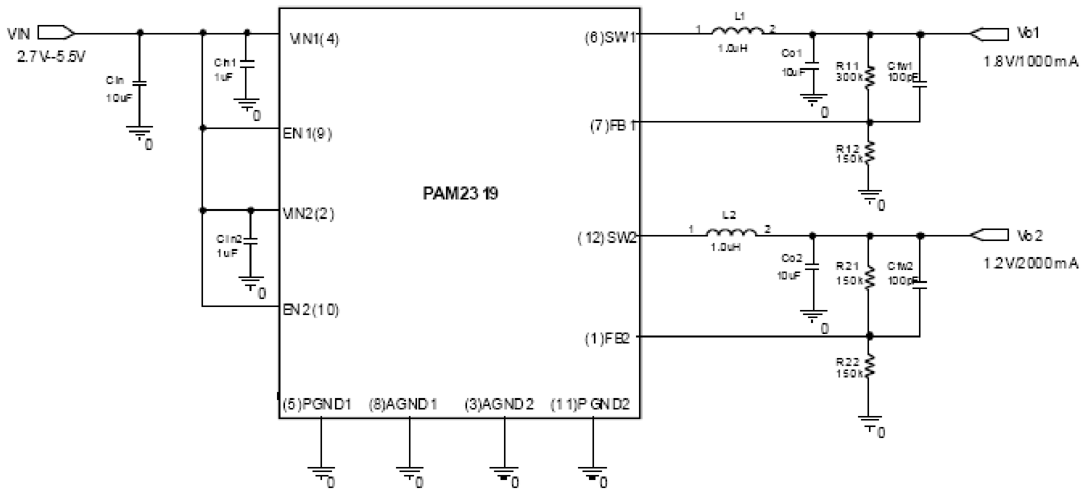

Figure 1. Adjustable Voltage Regulator

Pin Descriptions

Pin Number	W-DFN3x3-12L Pin Name	Function
1	FB2	Channel 2 feedback pin internally set to 0.6V.
2	VIN2	Input voltage pin of channel 2.
3	AGND2	Signal ground of channel 2 for small signal components.
4	VIN1	Input voltage pin of channel 1.
5	PGND1	Main power ground pin of channel 1
6	SW1	Channel 1 switching pin. The drains of the internal main and synchronous power MOSFET.
7	FB1	Channel 1 feedback pin internally set to 0.6V.
8	AGND1	Signal ground of channel 1 for small signal components.
9	EN1	Enable control input. Pull logic high to enable Vo1. Pull logic low to disable.
10	EN2	Enable control input. Pull logic high to enable Vo2. Pull logic low to disable.
11	PGND2	Main power ground pin of channel 2.
12	SW2	Channel 2 switching pin. The drains of the internal main and synchronous power MOSFET.
—	Exposed Pad	Connect to GND

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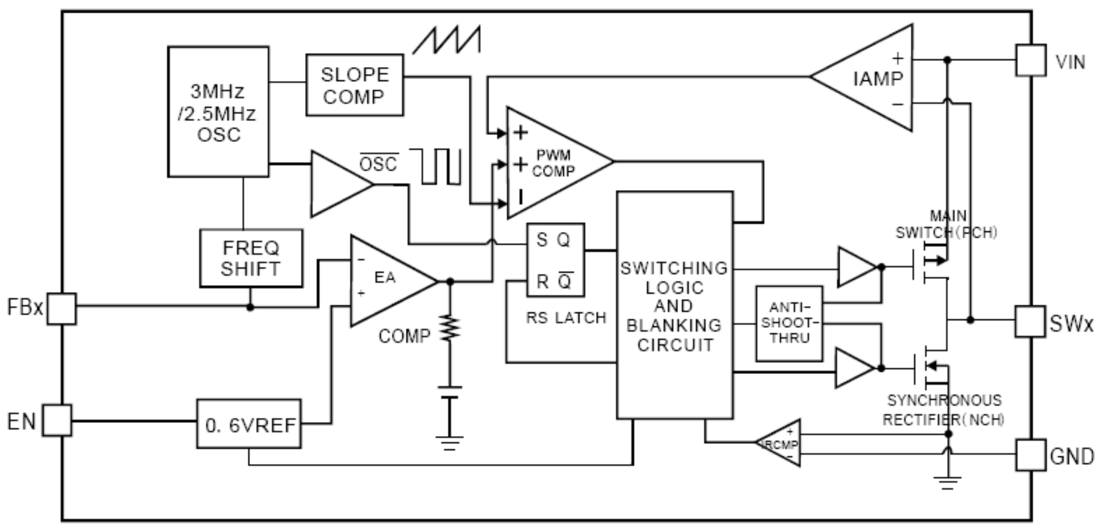
Functional Block Diagram



Note: 1. The diagram above just shows one channel.

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, SW1, EN2, FB2 and SW2 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	2.7 to 5.5	V
Ambient Temperature Range	-40 to +85	°C
Junction Temperature Range	-40 to +1255	

Thermal Information

Parameter	Symbol	Package	Max	Unit
Thermal Resistance (Junction to Ambient)	θ_{JA}	W-DFN3x3-12L	60	°C/W
Thermal Resistance (Junction to Case)	θ_{JC}	W-DFN3x3-12L	8.5	

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Electrical Characteristics (@T_A = +25°C, V_{IN} = 3.3V, V_O = 1.8V, C_{IN} = 10µF, C_O = 10µF, L = 1µH, unless otherwise specified.)

Channel 1

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Input Voltage Range	V_{IN}		2.7		5.5	V
UVLO Threshold	V_{UVLO}	V_{IN} Rising		2.4	2.5	V
		Hysteresis		240		mV
		V_{IN} Falling	1.8			V
Regulated Feedback Voltage	V_{FB}		0.588	0.600	0.612	V
Reference Voltage Line Regulation	ΔV_{FB}			0.3		%/V
Regulated Output Voltage Accuracy	V_O	I_O = 100mA	-3		+3	%
Peak Inductor Current	I_{PK}	V_O = 90%		1.5		A
Output Voltage Line Regulation	LNR	V_{IN} = 2.7V to 5V, I_O = 10mA		0.2	0.5	%/V
Output Voltage Load Regulation	LDR	I_O = 1mA to 1000mA	-2		+2	%
Quiescent Current	I_Q	No Load		40	80	µA
Shutdown Current	I_{SD}	V_{EN} = 0V		0.1	1	µA
Oscillator Frequency	f_{OSC}	V_O = 100%		3		MHz
		V_{FB} = 0V or V_O =0V		1		MHz
Drain-Source On-State Resisitance	$R_{DS(ON)}$	P MOSFET		0.35	0.45	Ω
		N MOSFET		0.35	0.45	Ω
SW Leakage Current	ILSW			±0.01	1	µA
Efficiency	η	Output1, I_O = 500mA, V_{IN} = 3.3V		84		%
PSM Threshold	I_{TH}	V_{IN} = 3.3V		100		mA
EN Threshold High	V_{EH}		1.5			V
EN Threshold Low	V_{EL}				0.3	V
EN Leakage Current	I_{EN}			±0.01		µA
Soft-Start	T_{ON}	From EN1 to Output		2		ms
Over Temperature Protection	OTP			150		°C
OTP Hysteresis	OTH			30		°C

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Electrical Characteristics (@T_A = +25°C, V_{IN} = 3.3V, V_O = 1.2V, C_{IN} = 10µF, C_O = 10µF, L = 1µH, unless otherwise specified.)

Channel 2

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Input Voltage Range	V_{IN}		2.7		5.5	V
UVLO Threshold	V_{UVLO}	V_{IN} Rising		2.6	2.7	V
		Hysteresis		250		mV
		V_{IN} Falling	12			V
Regulated Feedback Voltage	V_{FB}		0.588	0.600	0.612	V
Reference Voltage Line Regulation	ΔV_{FB}			0.3		%/V
Regulated Output Voltage Accuracy	V_O	I_O = 100mA	-3		+3	%
Peak Inductor Current	I_{PK}	V_O = 90%		3		A
Output Voltage Line Regulation	LNR	V_{IN} = 2.7V to 5V, I_O = 10mA		0.2	0.5	%/V
Output Voltage Load Regulation	LDR	I_O = 1mA to 1000mA	-2		+2	%
Quiescent Current	I_Q	No Load		55	100	µA
Shutdown Current	I_{SD}	V_{EN} = 0V		0.1	1.0	µA
Oscillator Frequency	f_{OSC}	V_O = 100%		2.5		MHz
Drain-Source On-State Resisitance	$R_{DS(ON)}$	P MOSFET		0.11		Ω
		N MOSFET		0.85		Ω
SW Leakage Current	ILSW			±0.01	1	µA
Efficiency	η	Output1, I_O = 500mA, V_{IN} = 3.3V		87		%
PSM Threshold	I_{TH}	V_{IN} = 3.3V		250	450	mA
EN Threshold High	V_{EH}		1.5			V
EN Threshold Low	V_{EL}				0.3	V
EN Leakage Current	I_{EN}			±0.01		µA
Soft-Start	T_{ON}	From EN1 to Output		250		ms
Over Temperature Protection	OTP			150		°C
OTP Hysteresis	OTH			30		°C

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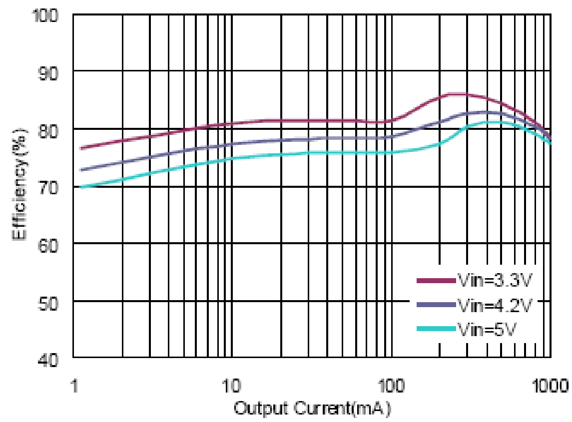
Typical Performance Characteristics

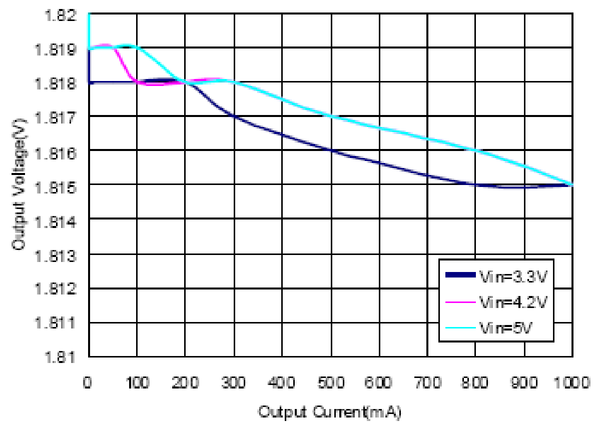
(@T_A = +25°C, V_O = 1.8V C_{IN} = 10µF, C_O = 10µF, L = 1µH, unless otherwise specified.)

Channel 1

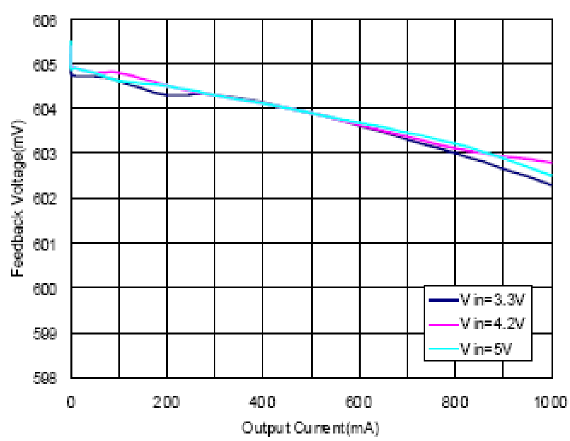
Efficiency vs Output Current



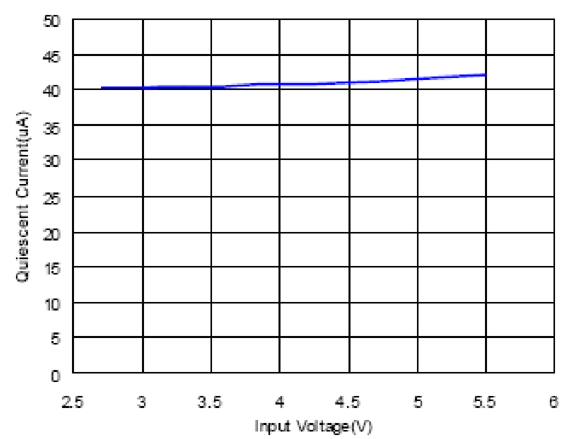
Output Voltage vs Output Current



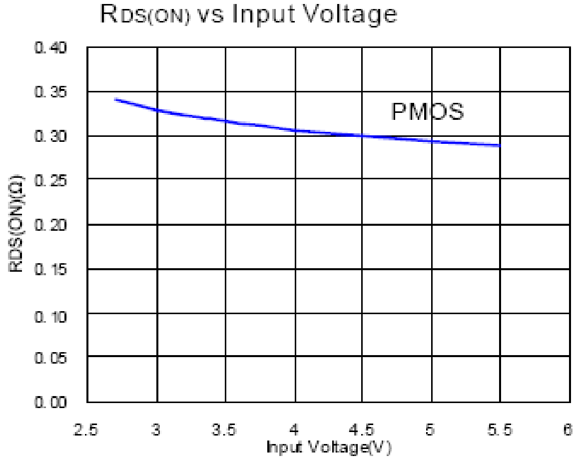
Feedback Voltage vs Output Current



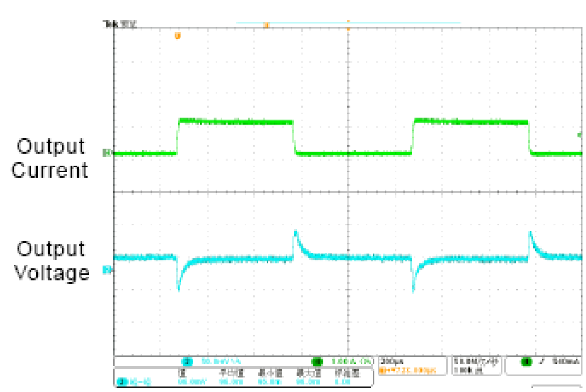
Quiescent Current vs Input Voltage



RDS(ON) vs Input Voltage



Load Transient



Vin=3.3V,Vo=1.8V,Io=0~1A,f=1kHz

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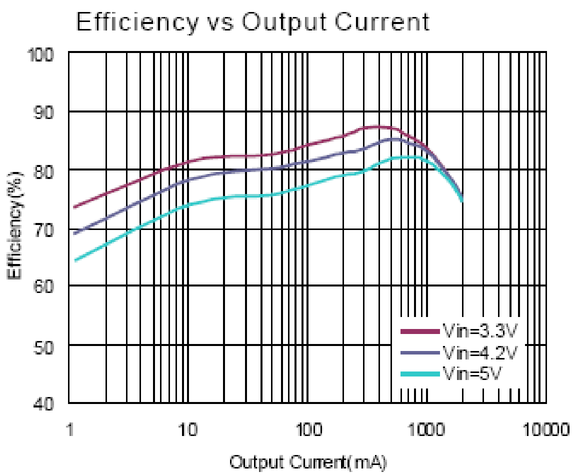
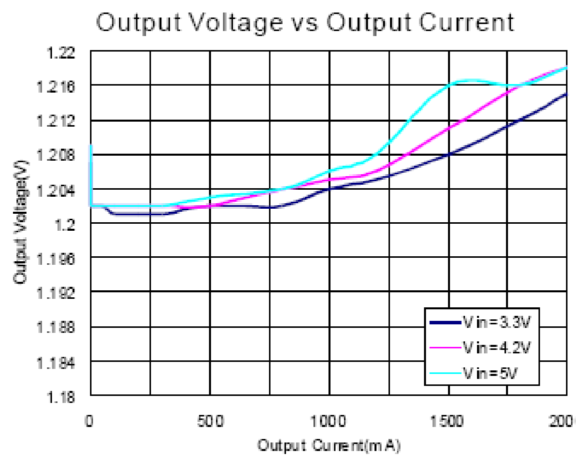
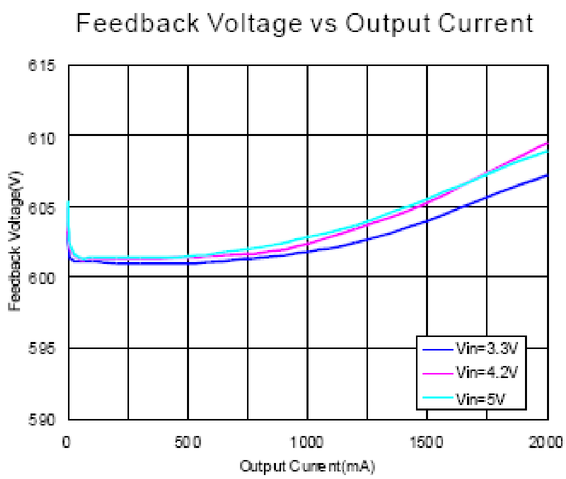
Typical Performance Characteristics (cont.)

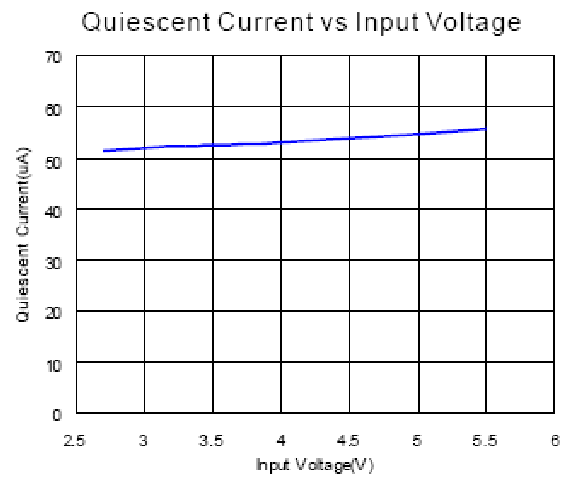
(@T_A = +25°C, V_O = 1.2V C_{IN} = 10μF, C_O = 10μF, L = 1μH, unless otherwise specified.)

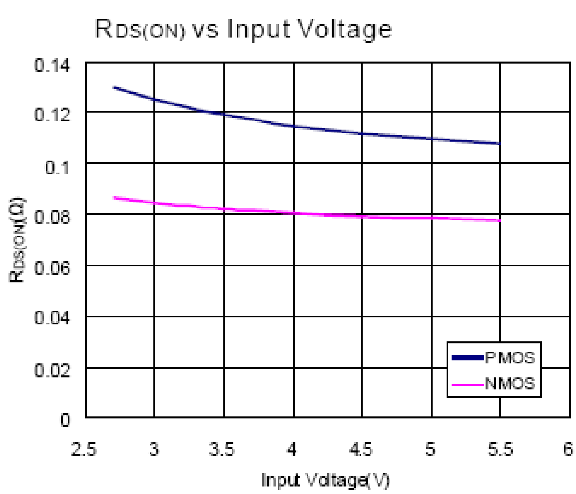
Channel 2

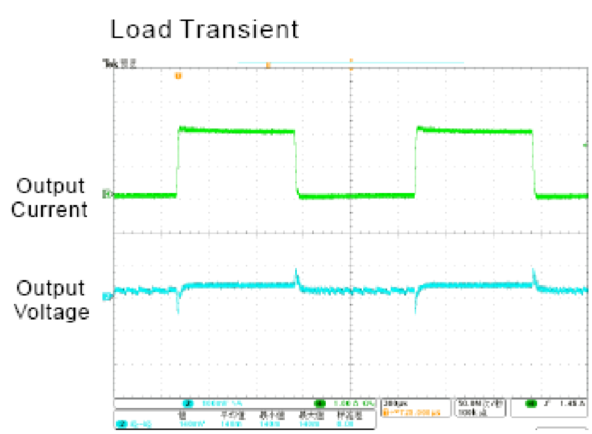












Vin=3.3V,Vo=1.2V,Io=0~2A,f=1kHz

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Application Information

The basic PAM2319 application circuit is shown in Page 2. 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 0.47μH to 2μH. Its value is chosen based on the desired ripple current and efficiency. 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. For channel 1, 1A reasonable starting point for setting ripple current is ΔI_L = 400mA (40% of 1A) and for channel 2, 2A setting ripple current is 800mA.

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

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 4.2A rated inductor should be enough for most applications (3A + 1.2A). For better efficiency, choose a low DC-resistance inductor.

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

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:

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

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:

$$\Delta V_{OUT} \approx \Delta I_L \left(ESR + 1/8f\,C_{OUT}\right)$$

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 formul ations. 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 PAM2319. 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:

$$P_D = (125°C - 25°C) / 60°C/W = 1.67W$$

Setting the Output Voltage

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

The output voltage is given by Table 1.

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

Table 1: Resistor selection for output voltage setting.

V_O	R1	R2
1.2V	150k	150k
1.5V	150k	100k
1.8V	300k	150k
2.5V	380k	120k
3.3V	680k	150k

Pulse Skipping Mode (PSM) Description

When load current decreases, the peak switch current in Power-PMOS will be lower than skip current threshold and the device will enter into Pulse Skipping Mode.

In this mode, the device has two states, working state and idle state. First, the device enters into working state controlled by internal error amplifier.When the feedback voltage gets higher than internal reference voltage, the device will enter into low I_Q idle state with most of internal blocks disabled. The output voltage will be reduced by loading or leakage current. When the feedback voltage gets lower than the internal reference voltage, the convertor will start a working state again.

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:

$$V_{OUT} = V_{IN} - I_{LOAD}\left(R_{DSON} + R_L\right)$$

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 PAM2319 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.

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.)

Short Circuit Protection

Channel 1:

The swich peak current is limited cycle-by-cycle to a typical vaule in the event of an output voltage short circuit. The device operates with a frequency of 1MHz and minimum duty clycle. Therefore the average input current is typical 350mA (V_{IN} = 3.3V).

Channel 2:

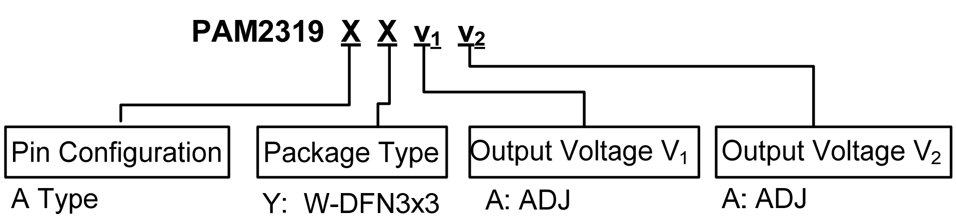
When the converter output is shorted or the device is overloaded, each high-side MOSFET current-limit event (3A typ) turns off the high-side MOSFET and turns on the low-side MOSFET. An internal counter is used to count the each current-limit event. The counter is reset after consecutive high-side MOSFETs turn on without reaching current limit. If the current-limit condition persists, the counter fills up. The control logic then stops both high-side and lowside MOSFETs and waits for a hiccup period, before attemping a new soft-start sequence. The counter bits is decided by V_{FB} voltage. If V_{FB} 0 2, the counter is 3-bit counter; if VFB > 0.2 the counter is 6-bit counter. The typical hicuup made duty cycle is 1.7%. The hiccup mode is disable during soft-start time.

PCB Layout Check List

When laying out the printed circuit board, the following checklist should be used to ensure proper operation of the PAM2319. Check the following in your layout:

1. The input capacitor should be close to IC as close as possible.
2. Minimize the switching loop area to avoid excessive switching noise.
3. Two parts GND should be separately layout to avoid disturbing by each other.
4. Must put a small decoupling capacitor between Vin2 Pin and AGND2 Pin.
5. Vo2 output capacitor should be close to output connector to minimize PCB t race resistance affect on ripple voltage. Recommend use two output capacitor, one close to inductor and IC, another close to output connector.
6. PGND1 Pin should not directly connect to the thermal pad (PGND), it should connect to input capacitor GND then to other GND.
7. AGND should connect to PGND at input capacitor GND.
8. For the good thermal dissipation, PAM2316 has a heat dissipate pad in the bottom side, it should be soldered to PCB surface. For the copper area can't be large in the component side, so we can use multiple vias connect to other side of the PCB.
9. Avoid using vias in the high-current paths. If vias are unavoidable, use multiple vias in parallel to reduce resistance and inductance.

Ordering Information



Part Number	Part Marking	Package Type	Standard Package
PAM2319AYAA	BNAA XXXYW	W-DFN3x3-12L	3000 Units/Tape & Reel

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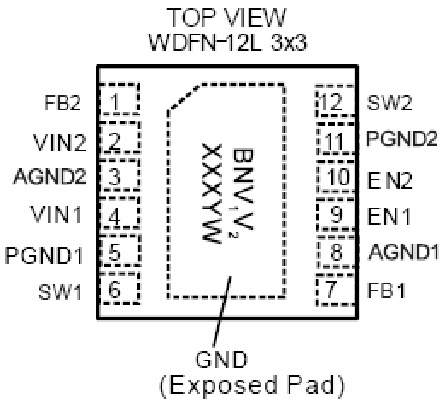
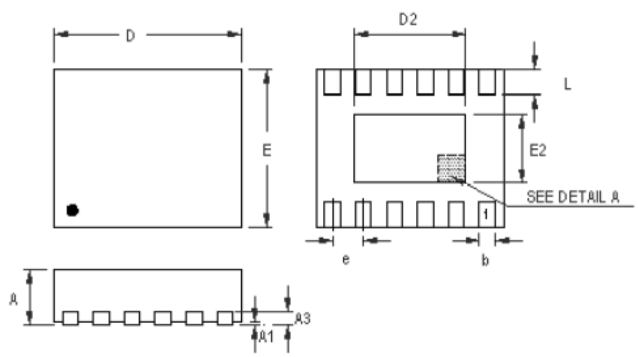
Marking Information

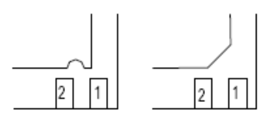


BN: Product Code of PAM2319
V_1: Output Voltage 1
V_2: Output Voltage 2
(refer to "Ordering Information")
X: Internal Code
Y: Year
W: Week

Package Outline Dimensions (All dimensions in mm.)

W-DFN3x3-12





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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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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Поставка электронных компонентов

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- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения **«JONHON»**, а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов **«FORSTAR»**.

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