1.4MHz, 2A Synchronous Step-Down Converter

FEATURES

- High Efficiency: Up to 96%
- 1.4MHz Constant Frequency Operation
- 2A Output Current
- No Schottky Diode Required
- 2.5V to 5.5V Input Voltage Range
- Output Voltage as Low as 0.6V
- 100% Duty Cycle in Dropout
- Low Quiescent Current: 40μA
- Slope Compensated Current Mode Control for Excellent Line and Load Transient Response
- Short Circuit Protection
- Thermal Fault Protection
- Inrush Current Limit and Soft Start
- <1μA Shutdown Current
- DFN33-10 package

APPLICATIONS

- Cellular and Smart Phones
- Wireless and DSL Modems
- PDAs
- Portable Instruments

GENERAL DESCRIPTION

The JM2420 is a 1.4MHz constant frequency current mode PWM step-down converter. It is ideal for portable equipment requiring very high current up to 2A from single-cell Lithium-ion batteries while still achieving over 90% efficiency during peak load conditions. The JM2420 also can run at 100% duty cycle for low dropout operation, extending battery life in portable systems while light load operation provides very low output ripple for noise sensitive applications. The JM2420 can supply up to 2A output load current from a 2.5V to 5.5V input voltage and the output voltage can be regulated as low as 0.6V. The high switching frequency minimizes the size of external components while keeping switching losses low. The internal slope compensation setting allows the device to operate with smaller inductor values to optimize size and provide efficient operation. The JM2420 is available in adjustable (0.6V to VIN) and fixed (1.8V) output voltage versions. The device is available in a Pb-free, 3x3mm 10-lead TDFN package and is rated over the -40°C to +85°C temperature range.

This device offers two operation modes, PWM control and PFM Mode switching control, which allows a high efficiency over the wider range of the load.

Typical Application

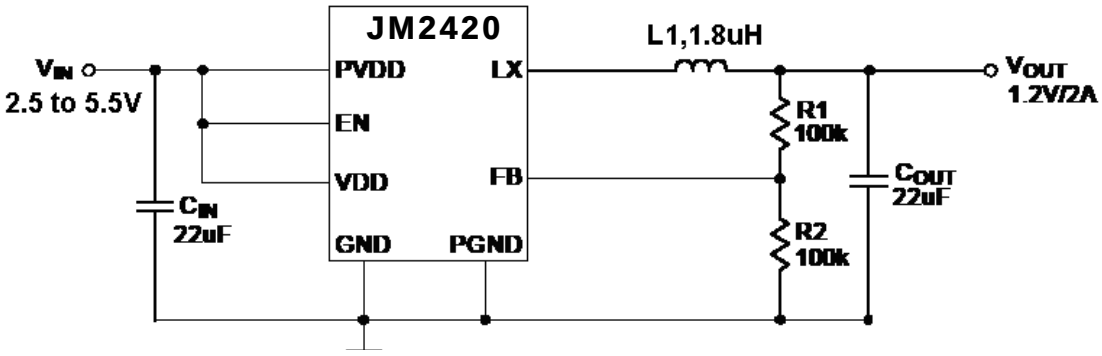


Figure 1. Basic Application Circuit

Absolute Maximum Ratings (Note 1)

Input Supply Voltage …… -0.3V to 6V
EN,VFB Voltages…….-0.3 to (Vin+0.3V)
LX Voltage ……-0.3V to (Vin+0.3V)
Operating Temperature Range … -40°C to +85°C
Lead Temperature(Soldering,10s) ……..+300°C
Storage Temperature Range .....-65°C to 150°C

Thermal Information (Note 2)

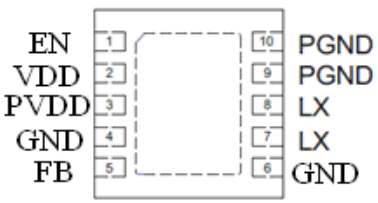
Thermal Resistance……45oC/W
Maximum Thermal Dissipation at Ta=25oC

Pin Description

PIN	NAME	FUNCTION
1	EN	Chip Enable Pin. Drive EN above 1.5V to turn on the part. Drive EN below 0.3V to turn it off. Do not leave EN floating.
2	PVDD	Power Supply Input. Must be closely decoupled to GND with a 10μF or greater ceramic capacitor.
3	VDD	Analog supply input pin.
4,6	GND	Analog ground pin
5	FB	Output Voltage Feedback Pin. An internal resistive divider divides the output voltage down for comparison to the internal reference voltage.
7,8	LX	Power Switch Output. It is the switch node connection to Inductor. This pin connects to the drains of the internal P-ch and N-ch MOSFET switches.
9,10	PGND	Power Ground Pin
	EP	Power Ground exposed pad, Must be connected to bare copper ground plane

Pin Configuration

TDFN-10
(Top View)



Electrical Characteristics (Note 3)

(V_{IN}=V_{EN}=3.6V, V_{OUT}=1.8V, T_A = 25°C, unless otherwise noted.)

Parameter	Conditions	MIN	TYP	MAX	unit
Input Voltage Range		2.5		5.5	V
UVLO Threshold		1.7	1.9	2.1	V
Input DC Supply Current PWM Mode PFM Mode Shutdown Mode	(Note 4) Vout = 90%, Iload=0mA Vout = 105%, Iload=0mA V_{RUN} = 0V, V_{IN}=4.2V		 150 40 0.1	 300 75 1.0	μA μA μA μA
Regulated Feedback Voltage	T_A = 25°C	0.588	0.600	0.612	V
	T_A = 0°C ≤ T_A ≤ 85°C	0.586	0.600	0.613	V
	T_A = -40°C ≤ T_A ≤ 85°C	0.585	0.600	0.615	V
Reference Voltage Line Regulation	Vin=2.5V to 5.5V		0.1		%/V
Output Voltage Accuracy	V_{IN} = 2.5V to 5.5V, Iout=10mA to 2000mA	-3		+3	%Vout
Output Voltage Load Regulation	Iout=10mA to 2000mA		0.2		%/A
Oscillation Frequency	Vout=100%		1.4		MHz
	Vout=0V		300		KHz
On Resistance of PMOS	I_{SW}=100mA		100	150	mΩ
On Resistance of NMOS	I_{SW}=-100mA		90	150	mΩ
Peak Current Limit	V_{IN}= 3V, Vout=90%		4		A
EN Threshold		0.30	1.0	1.50	V
EN Leakage Current			±0.01	±1.0	μA
SW Leakage Current	V_{RUN}=0V,V_{IN}=Vsw=5V		±0.01	±1.0	μA

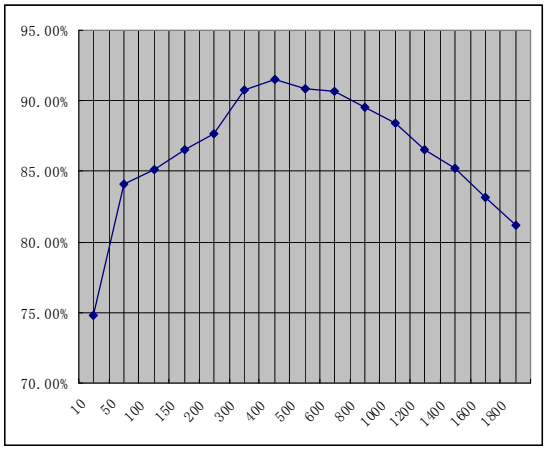
Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + (P_D) \times (250°C/W)$.

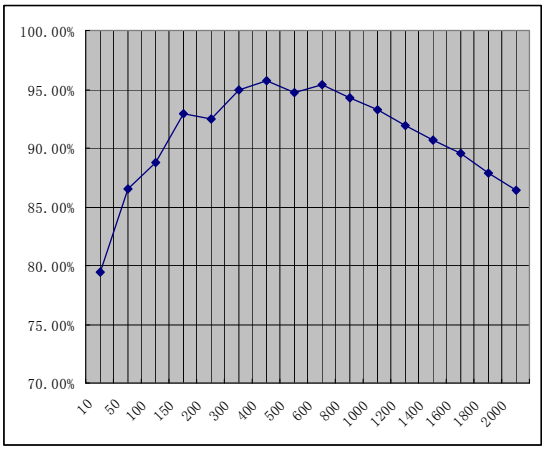
Note3: 100% production test at +25°C. Specifications over the temperature range are guaranteed by design and characterization.

Note 4: Dynamic supply current is higher due to the gate charge being delivered at the switching frequency

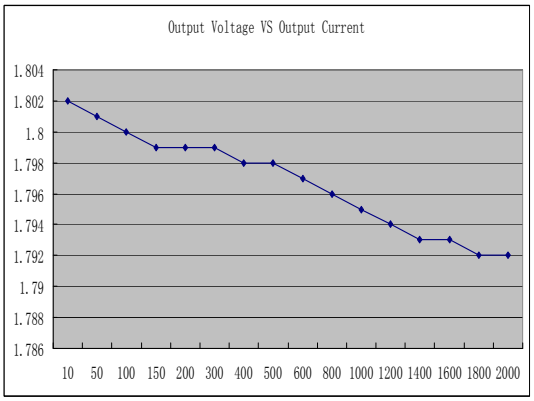
Typical Performance Characteristics



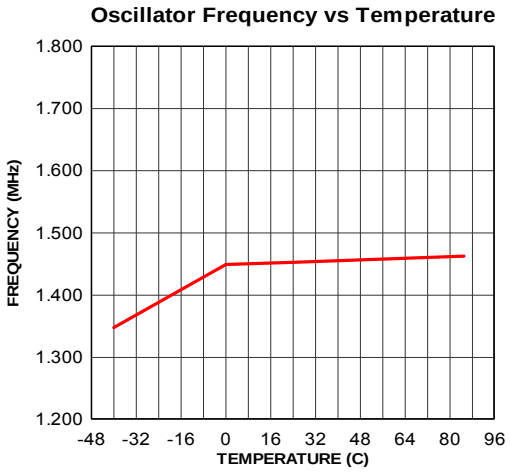
Vin=5V, Vout=1.8V

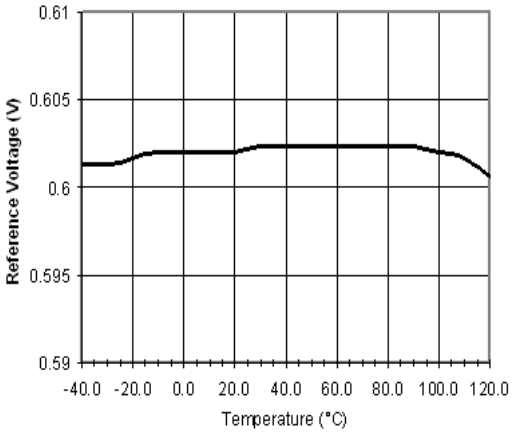


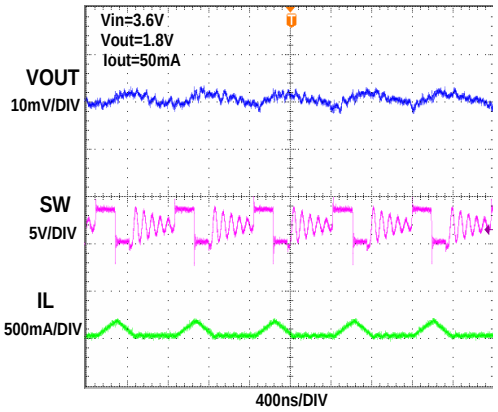
Vin=5V, Vout=3.3V



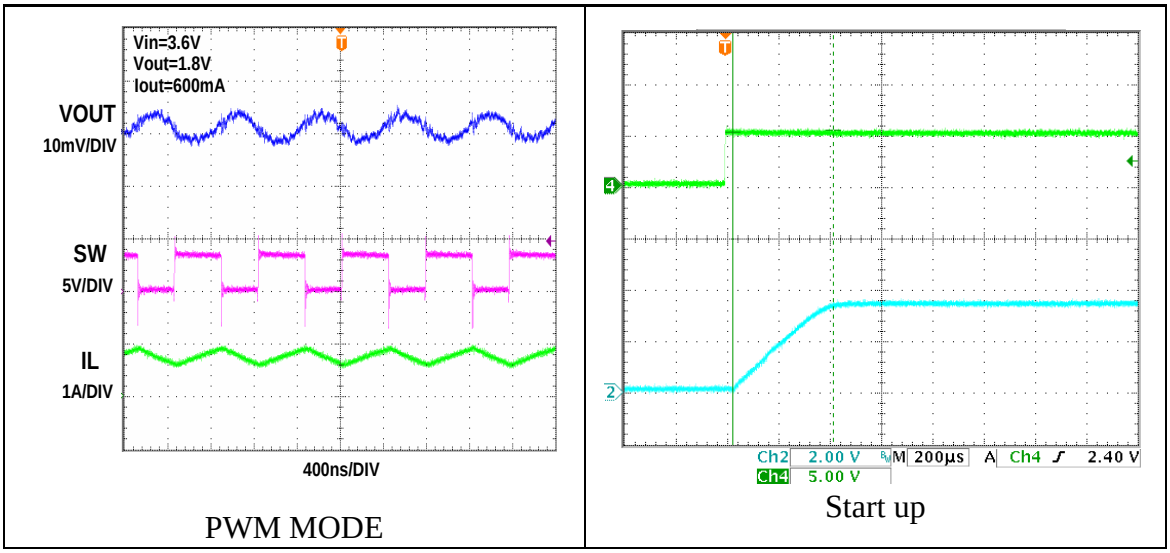
Vin=3.6V Vout=1.8V







PFM MODE



PWM MODE

Start up

Functional Block Diagram

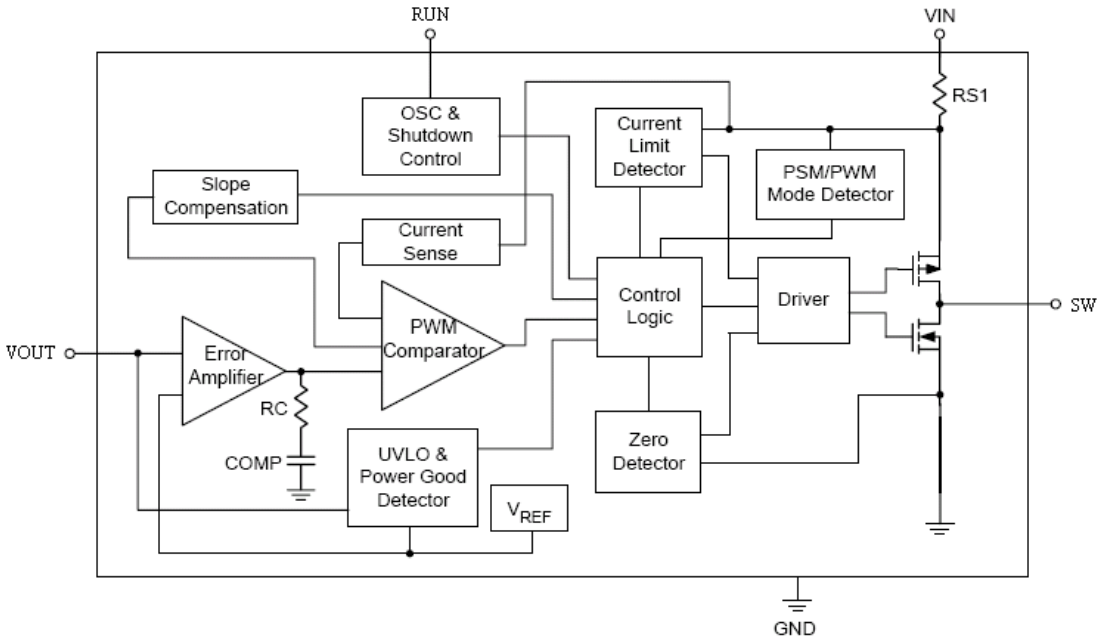


Figure 2. JM2420 Block Diagram

Functional Description

The JM2420 is a high output current monolithic switch mode step-down DC-DC converter. The device operates at a fixed 1.4MHz switching frequency, and uses a slope compensated current mode architecture. This step-down DC-DC converter can supply up to 2000mA output current at V_{IN} = 3.6V and has an input voltage range from 2.5V to 5.5V. It minimizes external component size and optimizes efficiency at the heavy load range. The slope compensation allows the device to remain stable over a wider range of inductor values so that smaller values (1μH to 4.7μH) with lower DCR can be used to achieve higher efficiency. Apart from the small bypass input capacitor, only a small L-C filter is required at the output. The fixed output version requires only three external power components (C_{IN}, C_{OUT}, and L). The adjustable version can be programmed with external feedback to any voltage, ranging from 0.6V to near the input voltage. It uses internal MOSFETs to achieve high efficiency and can generate very low output voltages by using an internal reference of 0.6V. At dropout, the converter duty cycle increases to100% and the output voltage tracks the input voltage minus the low $R_{DS(ON)}$ drop of the P-channel high-side MOSFET and the inductor DCR. The internal error amplifier and compensation provides excellent transient response, load and line regulation. Internal soft start eliminates any output voltage overshoot when the enable or the input voltage is applied.

Setting the Output Voltage

Figure 1 shows the basic application circuit for the JM2420. The JM2420 can be externally programmed. Resistors R1 and R2 in Figure 1 program the output to regulate at a voltage higher than 0.6V. To limit the bias current required for the external feedback resistor string while maintaining good noise immunity, the minimum suggested value for R2 is 59kΩ. Although a larger value will further reduce quiescent current, it will also increase the impedance of the feedback node, making it more sensitive to external noise and interference. Table 1 summarizes the resistor values for various output voltages with R2 set to either 59kΩ for good noise immunity or 316kΩ for reduced no load input current.

The JM2420, combined with an external feed forward capacitor (C3 in Figure 1), delivers enhanced transient response for extreme pulsed load applications. The addition of the feed forward capacitor typically requires a larger output capacitor C2 for stability. The external resistor sets the output voltage according to the following equation:

$$Vout=0.6X(1+R1/R2)$$

$$R1=(Vout/0.6-1)XR2$$

Table 1 shows the resistor selection for different output voltage settings.

V_{OUT} (V)	R2 = 59kΩ R1 (kΩ)	R2 = 316kΩ R1 (kΩ)
0.8	19.6	105
0.9	29.4	158
1.0	39.2	210
1.1	49.9	261
1.2	59.0	316
1.3	68.1	365
1.4	78.7	422
1.5	88.7	475
1.8	118	634
1.85	124	655
2.0	137	732
2.5	187	1000
3.3	267	1430

Table 1: Resistor selections for different output voltage settings (standard 1% resistors substituted for calculated values).

APPLICATIONS INFORMATION

Inductor Selection

For most designs, the JM2420 operates with inductors of 1μH to 4.7μH. Low inductance values are physically smaller but require faster switching, which results in some efficiency loss. The inductor value can be derived from the following equation:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where ΔI_L is inductor Ripple Current.

Large value inductors result in lower ripple current and small value inductors result in high ripple current. For optimum voltage-positioning load transients, choose an inductor with DC series resistance in the 50mΩ to 150mΩ range.

Manufacturer	***Part Number***	***Ind (uH)***	***DCR (Ohm)***	***Max DC Current(A)***	***Size L*W*H(mm3)***
Sumida	CDRH5D16	2.2	28.7	3	5.8x5.8x1.8
		3.3	35.6	2.6	
		4.7	19	3.4	8.3x8.3x3.0
Sumida	CDRH5D16	2.2	23	3.3	5.2x5.2x3.0
		3.3	29	2.6	
		4.7	39	2.1	

Table2.Recommend Surface Mount Inductors

Input Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. The input capacitor impedance at the switching frequency should be less than input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. A 22μF ceramic capacitor for most applications is sufficient. A large value may be used for improved input voltage filtering.

Output Capacitor Selection

The output capacitor is required to keep the output voltage ripple small and to ensure regulation loop stability. The output capacitor must have low impedance at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended due to their low ESR and high ripple current ratings. The output ripple V_{OUT} is determined by:

$$\Delta V_{OUT} \le \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times f_{OSC} \times L} \times \left(ESR + \frac{1}{8 \times f_{osc} \times C3} \right)$$

A 22μF ceramic can satisfy most applications.

PC Board Layout Checklist

When laying out the PC board, the following layout guideline should be followed to ensure proper operation of the MT3412:

1. The exposed pad (EP) must be reliably soldered to the GND plane. A PGND pad below EP is strongly recommended.
2. The power traces, including the GND trace, the LX trace and the IN trace should be kept short, direct and wide to allow large current flow. The L1 connection to the LX pins should be as short as possible. Use several VIA pads when routing between layers.
3. The input capacitor (C1) should connect as closely as possible to IN and AGND to get good power filtering.

4. Keep the switching node, LX away from the sensitive FB/OUT node.

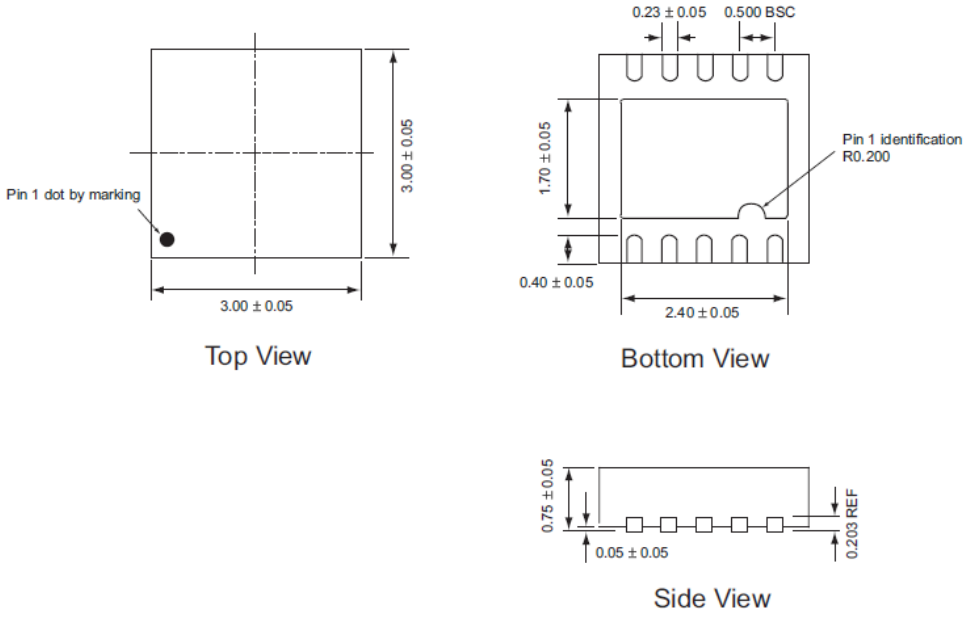
5. The feedback trace or OUT pin should be separate from any power trace and connect as closely as possible to the load point. Sensing along a high-current load trace will degrade DC load regulation. If external feedback resistors are used, they should be placed as closely as possible to the FB pin to minimize the length of the high impedance feedback trace.

6. The output capacitor C2 and L1 should be connected as closely as possible. The connection of L1 to the LX pin should be as short as possible and there should not be any signal lines under the inductor.

7. The resistance of the trace from the load return to PGND should be kept to a minimum. This will help to minimize any error in DC regulation due to differences in the potential of the internal signal ground and the power ground.

Package Description

TDFN33-10



CROSS REFERENCE

AAT1145,AAT1153,AP2420,AS1308,OCP2182QAD