GP3400

600mA, 1.2 MHz, Micropower Synchronous Step-Up Converter

GENERAL DESCRIPTION

The GP3400 is a 1.2MHz constant frequency, current mode PWM step-up converter. It can supply 3.3V output voltage at 100mA from a single AA Cell. The device integrates a main switch and a synchronous rectifier for high efficiency without an external Schottky diode.A switching frequency of 1.2MHz allows the use of tiny, low profile inductors and ceramic capacitors. The current mode PWM operation with internal compensation provides excellent line and load transient characteristics. The GP3400 features Pulse Skipping Mode operation at light loads to avoid unacceptable ripple voltage.

The GP3400 is offered in a low profile (1mm) small 6-Pin SOT23 Package.

APPLICATIONS

- Cellular and Smart Phones
- Microprocessors and DSP Core Supplies
- Wireless and DSL Modems
- MP3 Player
- Digital Still and Video Cameras
- Portable Instruments

FEATURES

- Input Voltage Range:0.5V to V_{OUT}
- 2.5V to 5V Output Voltage Range
- High Efficiency: Up to 93%
- 1.2MHz Constant Switching Frequency
- 100mA Output from a Single AA Cell Input; 300mA output from a Dual AA Cell Input; 500mA Output from a Single Li+ Cell Input
- Low Start-up Voltage: 0.85V
- Integrated main switch and synchronous rectifier. No External Schottky Diode.
- 1.2A Current Limit
- Over-Current Protection
- Automatic Pulse Skipping Mode Operation
- Tiny External Components
- Low Shutdown Current: < 1μA
- Anti-ringing Control Reduces EMI
- Space Saving 6-Pin Thin SOT23 Package (1mm)

EVALUATION BOARD

Standard Demo Board	Dimensions(mm)
EV34000712	60X x 60Y x 1.6Z

Typical Application

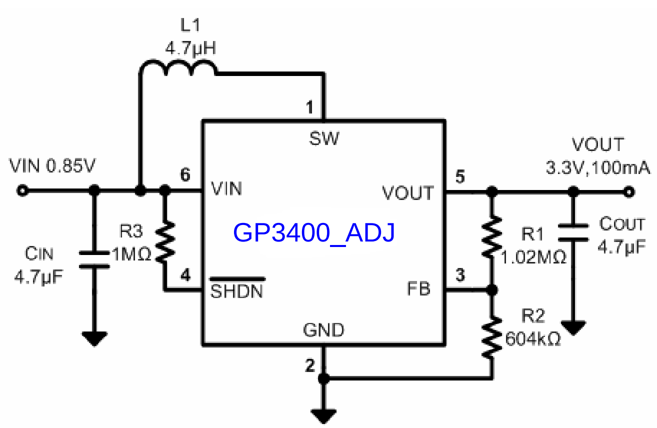
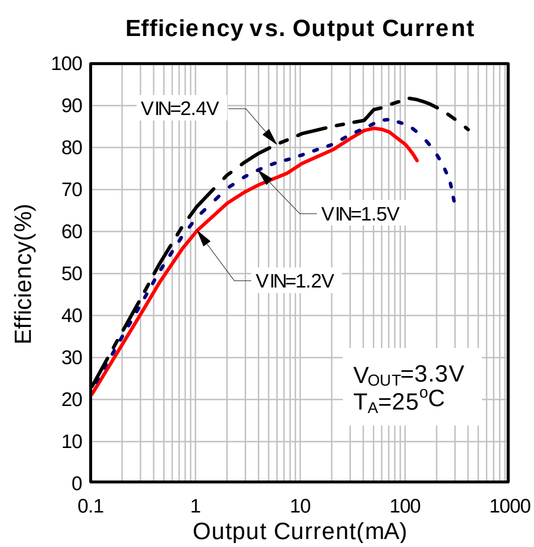


Figure 1. Basic Application Circuit with GP3400 Adjustable Version

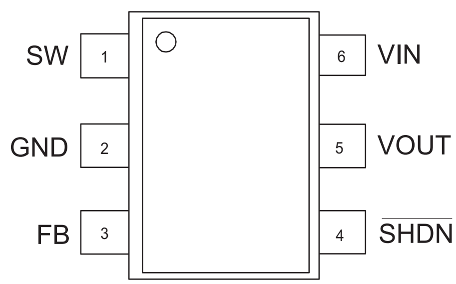


Pin Descriptions

Pin #	Symbol	Function
1	SW	Power Switch Pin. Ties to the drains of the PMOS synchronous rectifier and the NMOS switch.
2	GND	Ground Pin
3	FB	Feedback Input Pin. Connect FB to the center point of the external resistor divider. The feedback threshold voltage is 1.23V.
4	$\overline{SHDN}$	Shutdown Signal Input. Logic high enables the IC. Logic low disables the IC. Shutdown current is <1μA.
5	VOUT	Power Output Pin. Tied to the source of the PMOS synchronous rectifier.
6	VIN	Power Supply Input. Must be closely decoupled to GND, Pin 2, with a 4.7μF or greater ceramic capacitor.

Pin Configuration

TSOT23-6
(Top View)



Absolute Maximum Ratings[1]

Symbol	Description	Value	Units
V_{IN}	Input Supply Voltage	-0.3 to 6	V
V_{SW}	SW Voltage	-0.3 to 6	V
V_{FB}, $V_{\overline{SHDN}}$	FB, $\overline{SHDN}$ Voltages	-0.3 to 6	V
V_{OUT}	VOUT Voltage	-0.3 to 6	V
T_A	Operating Ambient Temperature Range[2]	-40 to 85	°C
$T_{STORAGE}$	Storage Temperature Range	-65 to 150	°C
T_{LEAD}	Lead Temperature (Soldering, 10s)	300	°C
T_J	Operating Junction Temperature Range[2]	-40 to 150	°C

Thermal Information[3]

Symbol	Description		Value	Units
θ_{JA}	Maximum Thermal Resistance	TSOT23-6	190	°C/W
P_D	Maximum Power Dissipation	TSOT23-6	526	mW

1. Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.
2. T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + P_D \times \theta_{JA}$.
3. Mounted on an FR4 board.

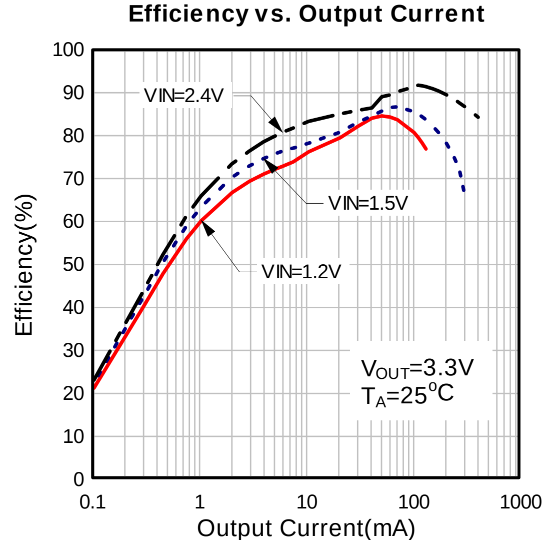
Electrical Characteristics [1]

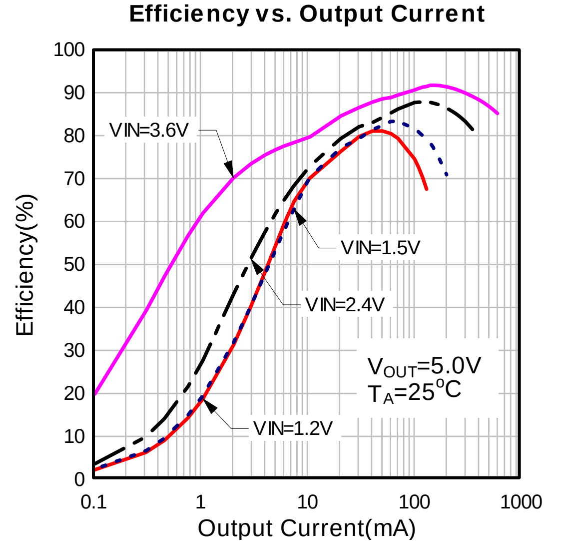
V_{IN} = 1.2V, V_{OUT} = 3.3V, T_A = 25°C,Test Circuit of Figure 1, unless otherwise noted.

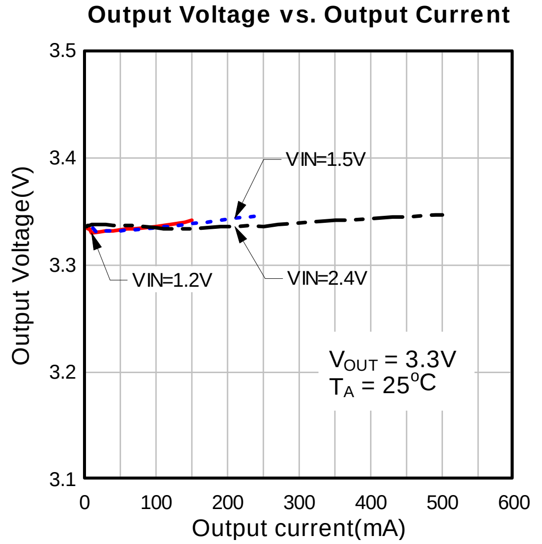
Symbol	Description	Conditions	Min	Typ	Max	Units
V_{IN}	Minimum Start-Up Voltage	I_{OUT} = 1mA		0.85	1	V
	Minimum Operating Voltage	$V_{\overline{SHDN}} = V_{IN}$		0.5	0.65	
V_{OUT}	Output Voltage Range		2.5		5.5	V
	Output Voltage Accuracy[3]	I_{OUT} = 10mA; T_A = -40°C to +85°C	-4		+4	%
V_{FB}	Feedback Voltage	T_A = -40°C to +85°C	1.192	1.230	1.268	V
$\Delta V_{OUT}/V_{OUT}/\Delta V_{IN}$	Feedback Voltage Line Regulation	V_{IN} = 1.2V to 2.4V, I_{OUT} = 10mA, V_{OUT} = 3.3V		0.2		%/V
		V_{IN} = 2.4V to 4.2V, I_{OUT} = 10mA,V_{OUT} = 5.0V		0.4		
$\Delta V_{OUT}/V_{OUT}/\Delta I_{OUT}$	Feedback Voltage Load Regulation	V_{IN} = 1.2V, I_{OUT} = 10mA to 100mA, V_{OUT} = 3.3V		0.003		%/mA
		V_{IN} = 3.6V, I_{OUT} = 10mA to 400mA, V_{OUT} = 5.0V		0.004		
I_Q	Quiescent Current (Shutdown)	$V_{\overline{SHDN}}$ = 0		0.01	1	μA
	Quiescent Current (Active)	Measured on V_{OUT}, $V_{\overline{SHDN}} = V_{IN}$		300	500	
I_{LNMOS}	NMOS Switch Leakage	V_{SW} = 5V		0.1	5	μA
I_{LPMOS}	PMOS Switch Leakage	V_{SW} = 0V		0.1	5	μA
$R_{DS(ON)L}$	NMOS Switch ON Resistance	V_{OUT} = 3.3V		0.35		Ω
		V_{OUT} = 5V		0.30		
$R_{DS(ON)H}$	PMOS Switch ON Resistance	V_{OUT} = 3.3V		0.60		Ω
		V_{OUT} = 5V		0.55		
I_{CL}	NMOS Current Limit		750	1200		mA
$\Delta t(I_{CL})$	Current Limit Delay to Output			40		ns
D_{MAX}	Maximum Duty Cycle	V_{FB} = 1.15V, T_A = -40°C to +85°C	80	85		%
F_{OSC}	Switching Frequency	T_A = -40°C to +85°C	0.9	1.2	1.5	MHz
$V_{\overline{SHDN}}$	$\overline{SHDN}$ Input Low				0.35	V
	$\overline{SHDN}$ Input High		1.00			
$I_{\overline{SHDN}}$	$\overline{SHDN}$ Input Current	$V_{\overline{SHDN}}$ = 5.5V		0.01	1	μA
T_{SD}	Thermal Shutdown			160		°C
		Hysteresis		20		

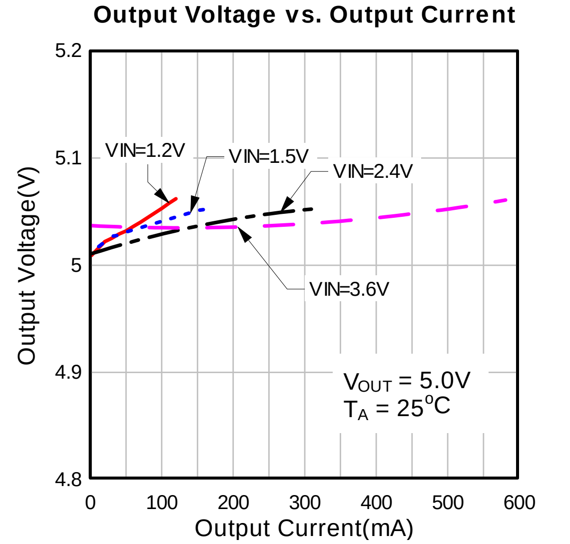
1. Specifications over the temperature range are guaranteed by design, characterization, and correlation with statistical process controls.
2. Not including the current into internal resistance divider.

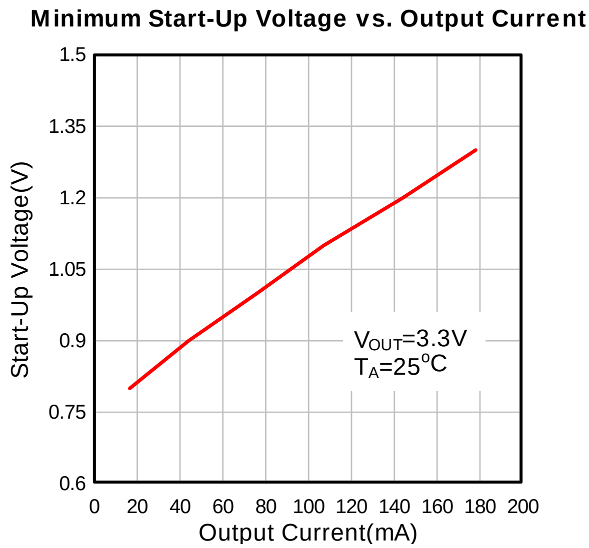
Typical Performance Characteristics

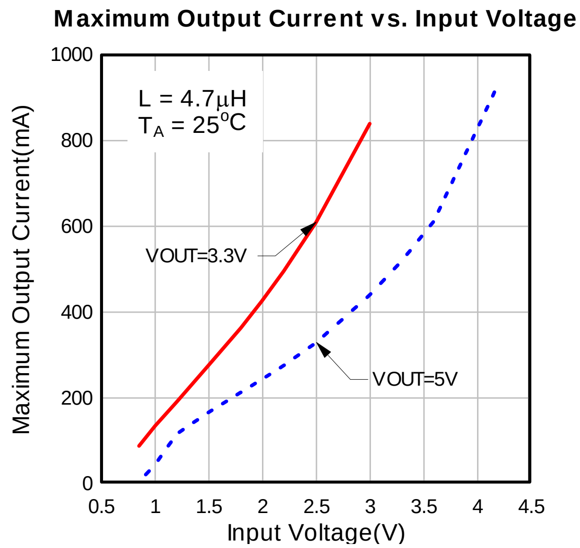




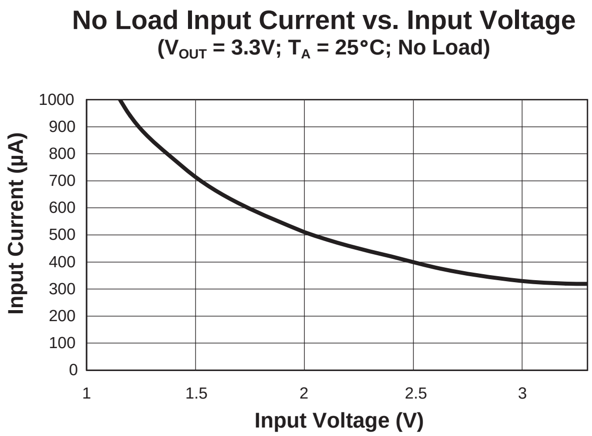


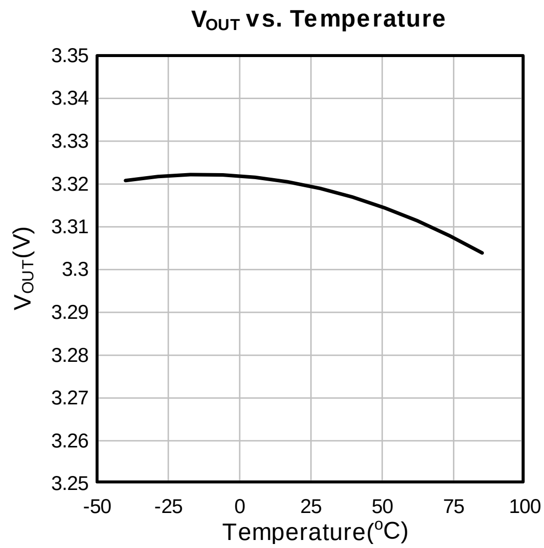


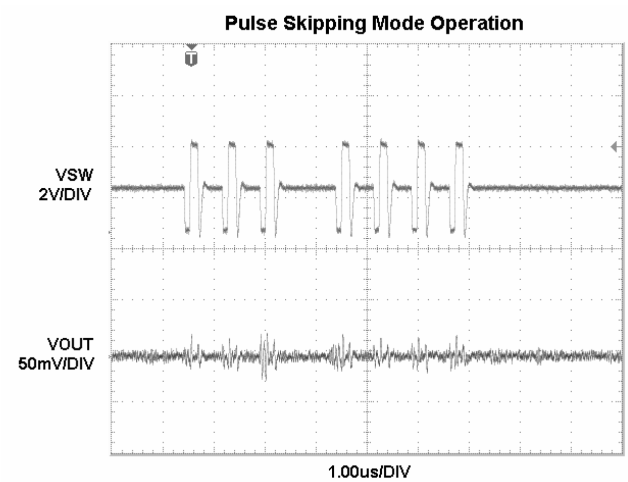


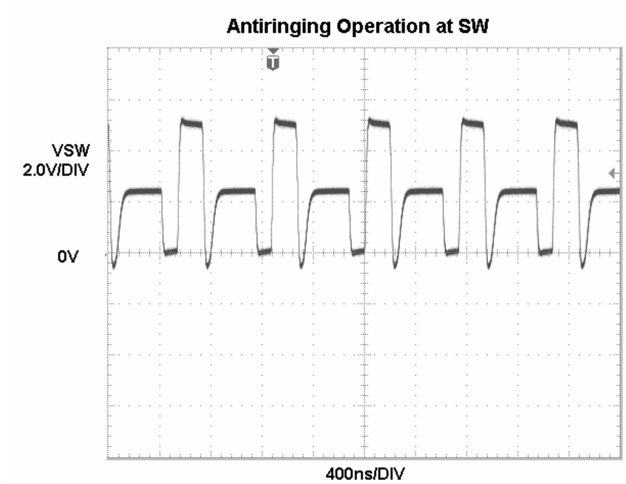


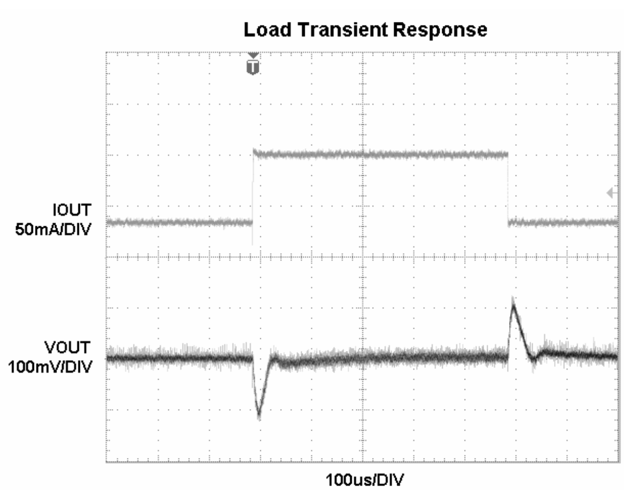
Typical Performance Characteristics (Continued)











Functional Block Diagram

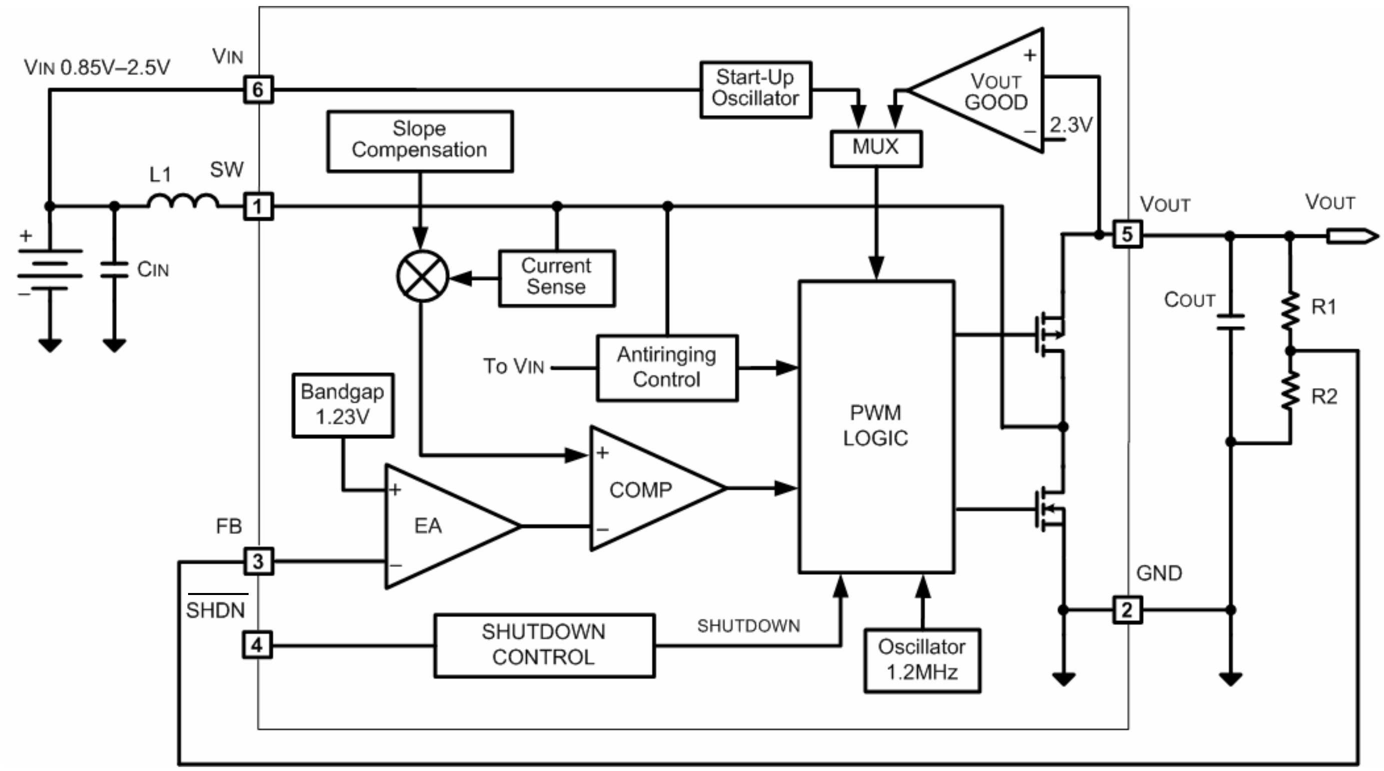


Figure 2. Function Block Diagram of GP3400

Function Description

The GP3400 is a synchronous step-up DC-DC converter. It utilizes internal MOSFETs to achieve high efficiency over the full load current range. It operates at a fixed switching frequency of 1.2MHz, and uses the slope compensated current mode architecture. The device can operate with input voltage even below 1V and the typical start-up voltage is 0.85V.

Synchronous Rectification

The GP3400 integrates a synchronous rectifier to improve efficiency as well as to eliminate the external Schottky diode. The synchronous rectifier is used to reduce the conduction loss contributed by the forward voltage of Schottky diode. The synchronous rectifier is realized by a P-ch MOSFET with gate control circuitry that incorporates relatively complicated timing concerns.

Low Voltage Start-Up

The GP3400 can start up at supply voltage down to 0.85V. During start-up, the internal low voltage start-up circuitry controls the NMOS switch to maximum peak inductor current. The device leaves the start-up mode once the V_{OUT} exceeds 2.3V. A Comparator (V_{OUT} GOOD Comp) monitors the output voltage and allows the chip into normal operation once the V_{OUT} exceeds 2.3V. The device is biased by V_{IN} during start-up while biased by V_{OUT} once V_{OUT} exceeds V_{IN} then the operation will be independent of V_{IN}.

Current Mode PWM Control

The GP3400 is based on a slope compensated current mode control topology. It operates at a fixed frequency of 1.2MHz. At the beginning of each clock cycle, the main switch(NMOS) is turned on and the inductor current starts to ramp. After the maximum duty cycle or the sense current signal equals to the error amplifier(EA) output, the main switch is turned off and the synchronous switch(PMOS) is turn on. This control topology features cycle by cycle current limiting which can prevent the main switch from overstress and prevent external inductor from saturation.

Pulse Skipping Mode

At very light load, the GP3400 automatically switches into Pulse Skipping Mode to improve efficiency. During this mode, the PWM control will skip some pulses to maintain regulation. If the load increases and the output voltage drops, the device will automatically switch back to normal PWM mode and maintain regulation.

Anti-ringing Control

An anti-ringing circuitry is included to remove the high frequency ringing that appears on the SW pin when the inductor current goes to zero. In this case, a ringing on the SW pin is induced due to remaining energy stored in parasitic components of switch and inductor. The anti-ringring circuitry clamps the voltage internally to battery voltage and therefore dampens this ringing.

Device Shutdown

When $\overline{SHDN}$ is set logic high, the GP3400 is put into operation. If $\overline{SHDN}$ is set logic low, the device is put into shutdown mode and consumes lower than 1µA current. After start-up timing, the internal circuitry is supplied by V_{OUT}, however, if shutdown mode is enabled, the internal circuitry will be supplied by battery again.

Application Information

Setting the Output Voltage

An external resistor divider is used to set the output voltage. The output voltage of the switching regulator (V_{OUT}) is determined by the following equation:

$$V_{OUT} = 1.23V \times \left(1 + \frac{R1}{R2}\right)$$

Table 1 list the resistor selection for output voltage setting.

Table 1. Resistor selection for output voltage setting

V_{OUT}	R1(Ω)	R2(Ω)
3.3V	1.02M	604k
5.0V	1.02M	332k

Inductor Selection

The high switching frequency of 1.2MHz allows for small surface mount inductors. For most designs, the GP3400 operates with inductors of 4.7µH to 10µH.The equation below can help to select the inductor, the maximum output current can be get by this equation; where η is the efficiency, I_{PEAK} is the peak current limit, f is the switching frequency, L is the inductance value and D is the duty cycle.

$$I_{OUT} = \eta \times \left(Ipeak - \frac{VIN \times D}{2 \times f \times L} \right) \times (1 - D)$$

Larger inductors mean less inductor current ripple and usually less output voltage ripple. Larger inductors also mean more load power can be delivered. But large inductors are also with large profile and costly. The inductor ripple current is typically set for 20% to 40% of the maximum inductor current. When selecting an inductor, the DC current rating must be high enough to avoid saturation at peak current. For optimum load transient and efficiency, the low DCR should be selected. Table 2 lists some typical surface mount inductors that meet target applications for the GP3400:

Table2. Typical Surface Mount Inductors

Part Number	L (µH)	Max DCR (mΩ)	Rated D.C. Current (A)	Size WxLxH (mm)
Sumida CR43	4.7 10	108.7 182	1.15 1.04	4.3x4.8x3.5
Sumida CDRH4D28	4.7 5.6 6.8 10	72 101 109 128	1.32 1.17 1.12 1.00	5.0x5.0x3.0
Toko D53LC	4.7 6.8 10	45 68 90	1.87 1.51 1.33	5.0x5.0x3.0

Output Capacitor Selection

The output capacitor is required to keep the output voltage ripple small and to ensure regulation loop stability. A 2.2µF to 10µF output capacitor is sufficient for most applications. If output capacitor is larger than 10µF, a phase lead capacitor must be included to maintain enough phase margin. 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.

Input Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. A minimum 4.7µF input capacitor is needed for most applications. 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.

Output Diode Selection

An Schottky diode should be included when the output voltage is above 4.5V. The Schottky diode is optional for the output voltage not more than 4.5V, but can improve efficiency by about 2% to 3%.

Load Disconnect in Shutdown

In conventional synchronous step-up converter, a conduction path exists from battery to output through the backgate of the P-ch MOSFET during shutdown. A special applicati on circuitry is provided to disconnect the load from the battery during shutdown as below.

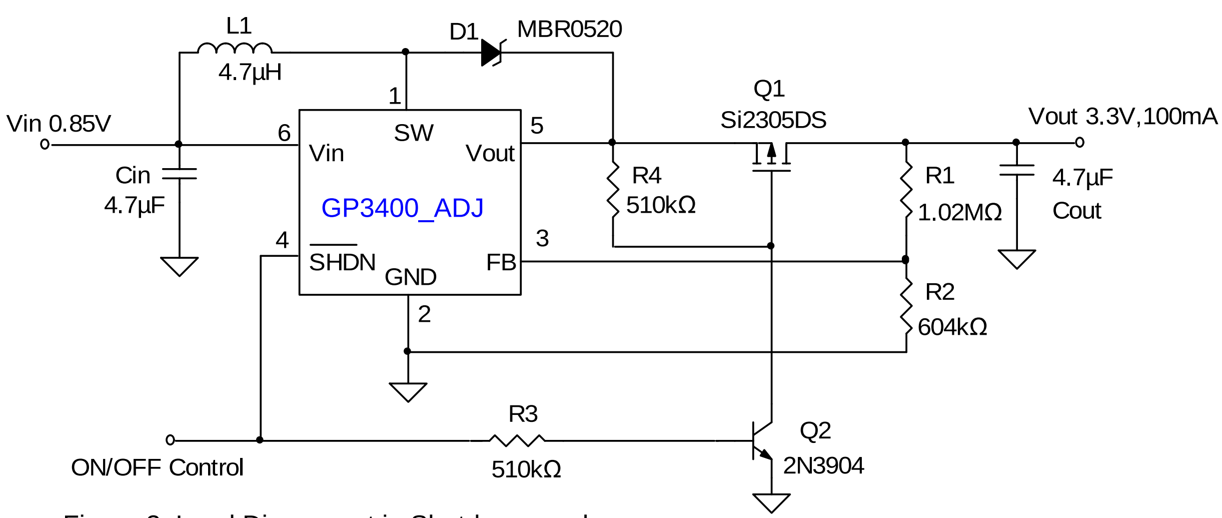


Figure 3. Load Disconnect in Shutdown mode

PCB Layout Guidance

The GP3400 operate s at 1.2MHz typically. This is a considerably high frequency for dc-dc converters. In such case PCB layout is important to guarantee satisfactory performance. It is recommended to make traces of the power loop, especially where switching node is involved as short and wide as possible. First of all, the inductor, input and output capacitor should be close to the device. Feedback and shut down circuit should avoid the proximity of large AC signals, e.g. the power inductor and switching nodes. The optional rectifier diode (D1 on Fig.3) can improve efficiency and alleviate the stress on the integrated MOSFET. The diode should also be close to the inductor and the chip to form the shortest possible switching loop. While 2 layer PCB shown in Fig.5 is enough for most applications. Large and integral multi layer ground planes are ideal for high power applications. Large area of copper has lower resistance and helps to dissipate heat on the device. The converter's ground should join the system ground to which it supplies power at one point only. Figure 4 is the schematic for a typical application for GP3400. Figure 5 is an example PCB layout for GP3400.

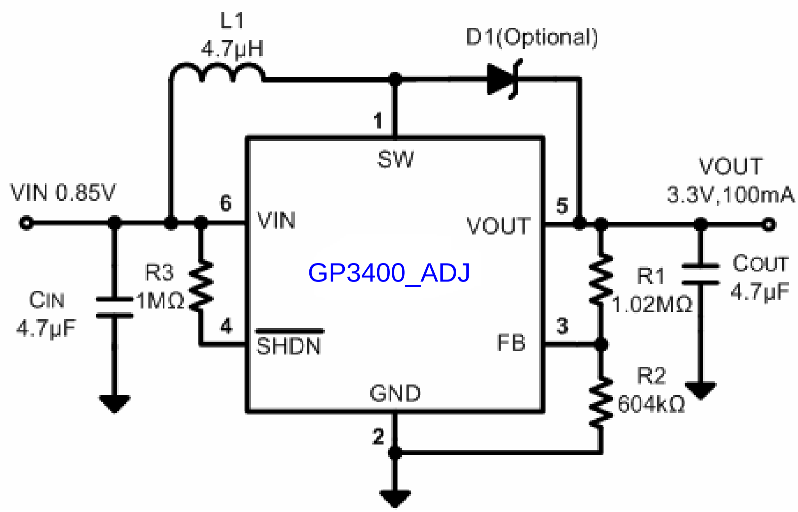
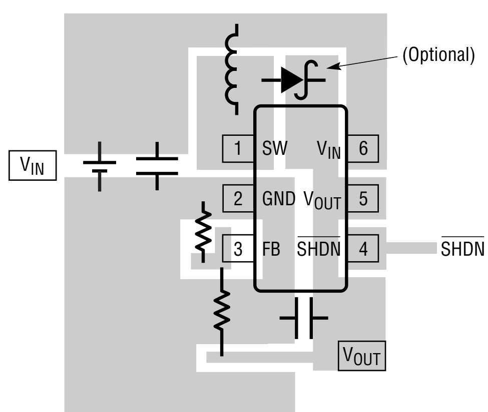


Figure 4. GP3400 Typical Application Circuit

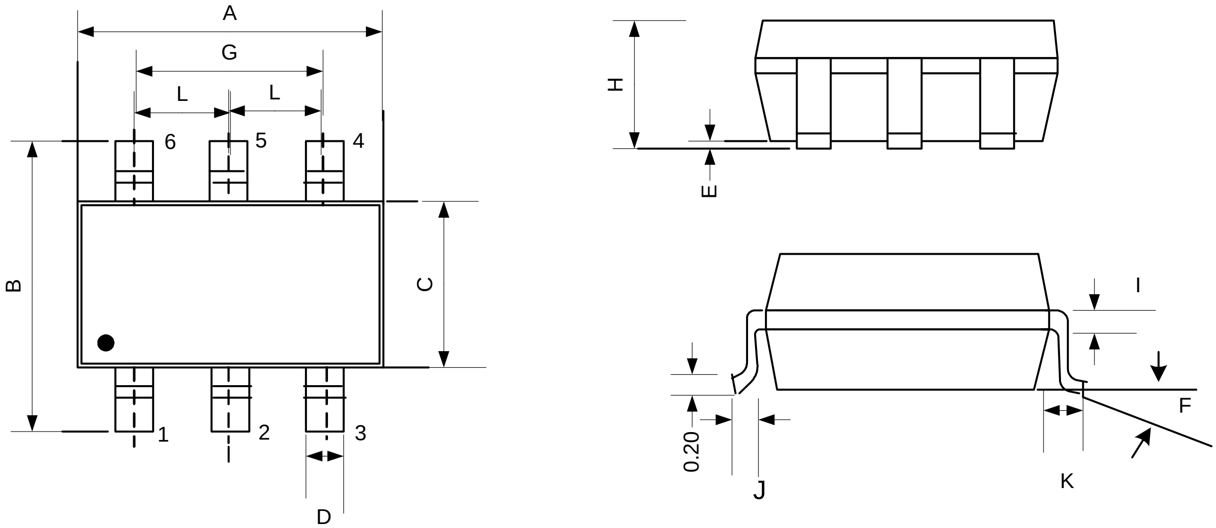


RECOMMENDED COMPONENT PLACEMENT. TRACES CARRYING HIGH CURRENT ARE DIRECT. TRACE AREA AT FB PIN IS SMALL. LEAD LENGTH TO BATTERY IS SHORT

(Top View)

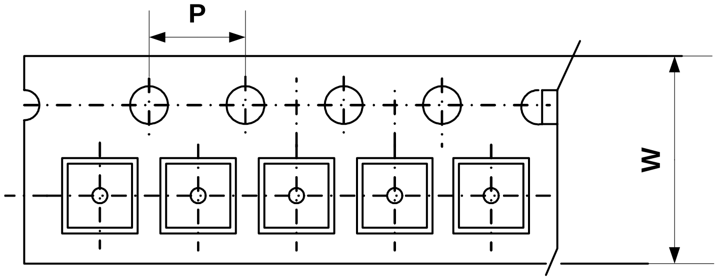
Figure 5. GP3400 Layout Example

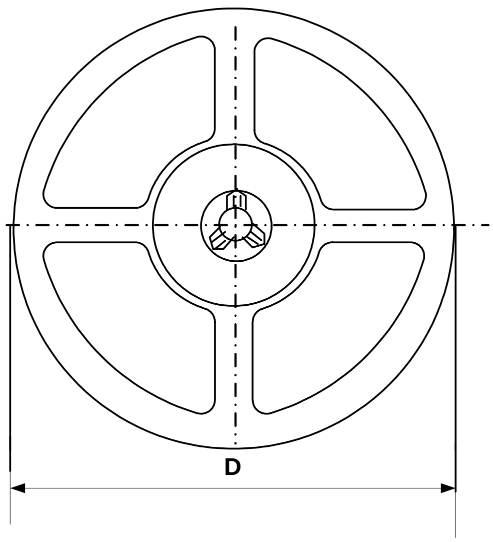
Package Information



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	2.80	3.10	0.1102	0.1220
B	2.50	3.10	0.0984	0.1220
C	1.50	1.70	0.0591	0.0669
D	0.30	0.50	0.0118	0.0197
E	0.01	0.13	0.0004	0.0051
F	0°	10°	0°	10°
G	1.90Ref		0.0748Ref	
H	0.90	1.10	0.0354	0.0433
I	0.09	0.20	0.0035	0.0079
J	0.20	0.55	0.0079	0.0217
K	0.35	0.80	0.0138	0.0315
L	0.95Ref		0.0374 Ref	

Package Information





Package Type	Carrier Width (W)	Pitch (P)	Reel Size(D)	Packing Minimum
TSOT23-6L	8.0±0.1 mm	4.0±0.1 mm	180±1 mm	3000pcs

Note: Carrier Tape Dimension, Reel Size and Packing Minimum

Ordering Information

Output Voltage[1]	Package	Marking[2]	Part Number (Tape and Reel)[3]
Adj.	TSOT23-6	VZMYM	**GP3400CA-1.2-T1**

1. Please contact sales for other voltage options.
2. YM = Manufacturing Date Code.
3. Sample stock is generally held on part numbers listed in **BOLD**.