GP3409

Dual 1.5MHz, 800mA Synchronous Step-Down Converter

◆ General Description

The GP3409 contains two independent 1.5MHz constant frequency, current mode, PWM step-down converters. Each converter integrates a main switch and a synchronous rectifier for high efficiency without need an external Schottky diode. The GP3409 is ideal for powering portable equipment that runs from a single cell Lithium-Ion (Li+) battery. Each converter can supply 800mA of load current from a 2.5V to 5.5V input voltage. The output voltage can be regulated as low as 0.6V. The GP3409 can also run at 100% duty cycle for low dropout applications.

The GP3409 is offered in a space saving 10-Pin TDFN Package, and is available with the Adjustable version.

◆ Features

- Up to 96% Efficiency
- 1.5MHz Constant Switching Frequency
- 800mA Load Current on Each Channel
- 2.5V to 5.5V Input Voltage Range
- Output Voltage as Low as 0.6V
- 100% Duty Cycle in Dropout
- Current Mode Operation
- Short Circuit Protection
- Over Thermal Shutdown Protection
- <1μA Shutdown Current
- Space Saving 10-Pin TDFN Package
- RoHS Compliant and 100% Lead(Pb)-Free

◆ Applications

- Cellular and Smart Phones
- Microprocessors and DSP Core Supplies
- PDAs and Portable Media Players
- Wireless and DSL Modems
- Digital Still and Video Cameras

◆ Typical Application

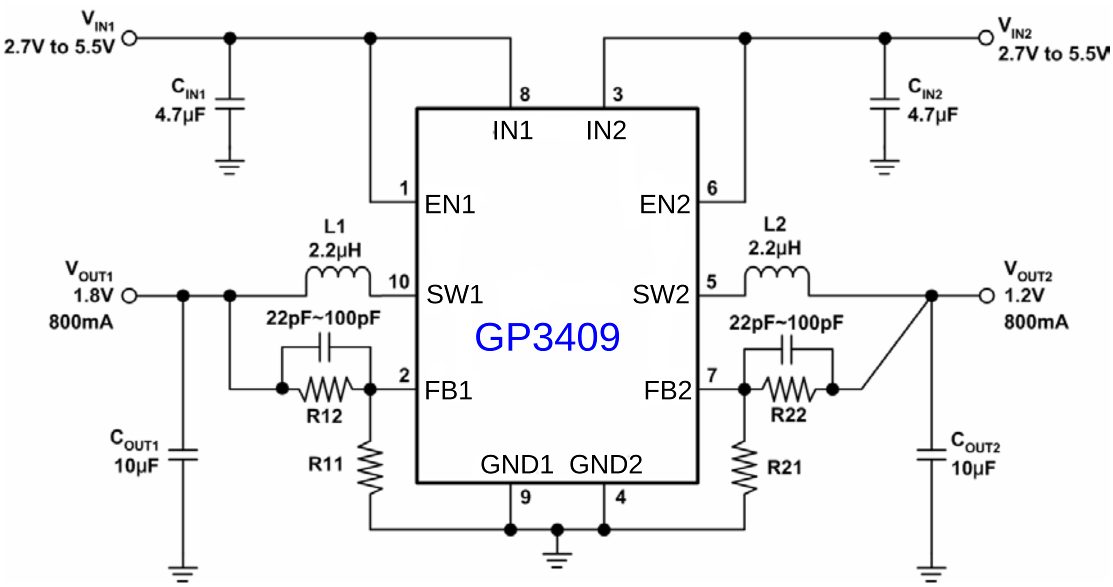
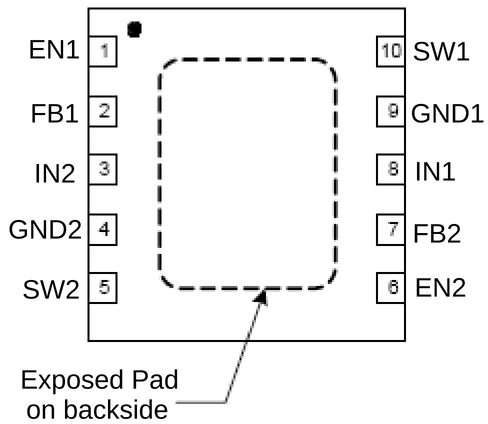


Figure 1. Adjustable Dual channel Step-Down Converter

◆ Pin Descriptions

Pin#	Symbol	Function
1	EN1	Channel 1 Enable Control Input. Drive EN1 above 1.5V to turn on the Channel 1. Drive EN1 below 0.3V to turn it off (shutdown current < 0.1μA). Do not leave EN1 floating.
2	FB1	Channel 1 Feedback.
3	IN2	Channel 2 Supply Input.
4	GND2	Ground 2.
5	SW2	Channel 2 Switch Node Connection to Inductor. This pin connects to the drains of the internal main and synchronous power MOSFET switches.
6	EN2	Channel 2 Enable Control Input. Drive EN2 above 1.5V to turn on the Channel 2. Drive EN2 below 0.3V to turn it off (shutdown current < 0.1μA). Do not leave EN2 floating.
7	FB2	Channel 2 Feedback.
8	IN1	Channel 1 Supply Input.
9	GND1	Ground 1.
10	SW1	Channel 1 Switch Node Connection to Inductor. This pin connects to the drains of the internal main and synchronous power MOSFET switches.

◆ Pin Configuration



◆ Absolute Maximum Ratings

Symbol	Description	Value	Units
V_{IN1},V_{IN2}	Input Supply Voltage	-0.3 to 6.0	V
V_{EN1},V_{EN2}	Enable Control input Voltage	-0.3 to $V_{IN1/in2}$ + 0.3	V
V_{FB1},V_{FB2}	Feedback Voltage	-0.3 to $V_{IN1/IN2}$ + 0.3	V
V_{SW1},V_{SW2}	Switch Node Connection Voltage	-0.3 to $V_{IN1/IN2}$ + 0.3	V
T_J	Junction Temperature	150	℃
T_S	Storage Temperature Range	-65~150	℃
T_{LEAD}	Lead Temperature	260	℃

◆ Recommended Operating Conditions

Symbol	Description	Value	Units
V_{IN1},V_{IN2}	Input Supply Voltage	2.5 to 5.5	V
V_{OUT1},V_{OUT2}	Output Voltage	0.6 to 5	V
T_o	Operation Temperature Range	-40 to 85	℃
$θ_{JA}$	Thermal Resistance	50	℃/W
$θ_{JC}$	Thermal Resistance	12	℃/W

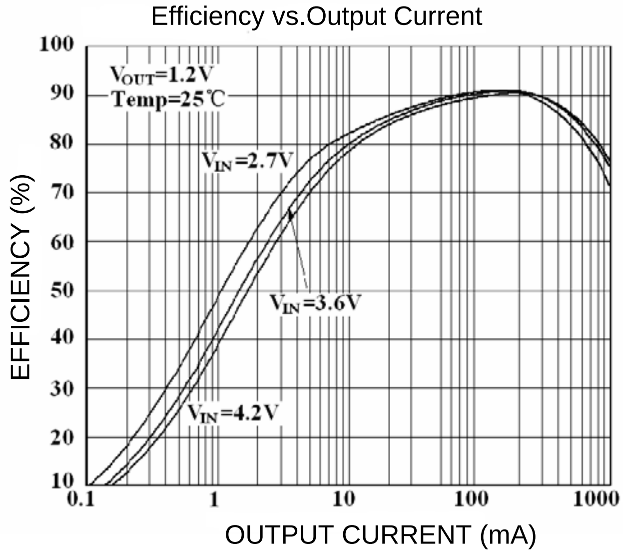
◆ Electrical Characteristics (Note1)

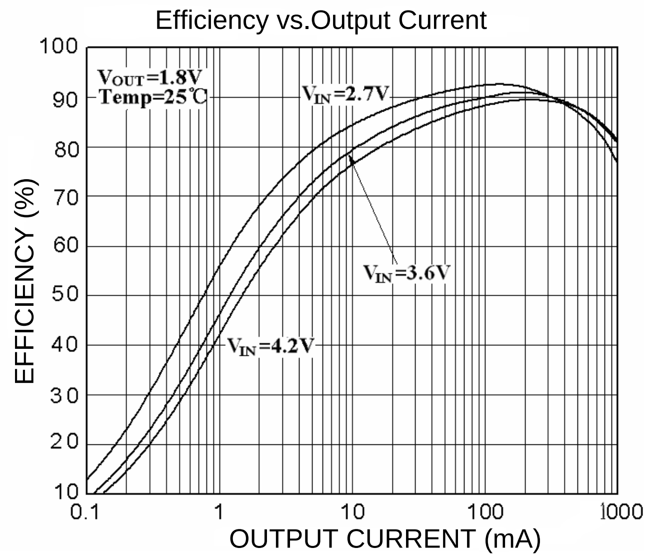
(V_{INX}=V_{ENX}=3.6V, T_A=25℃, Unless otherwise specified)

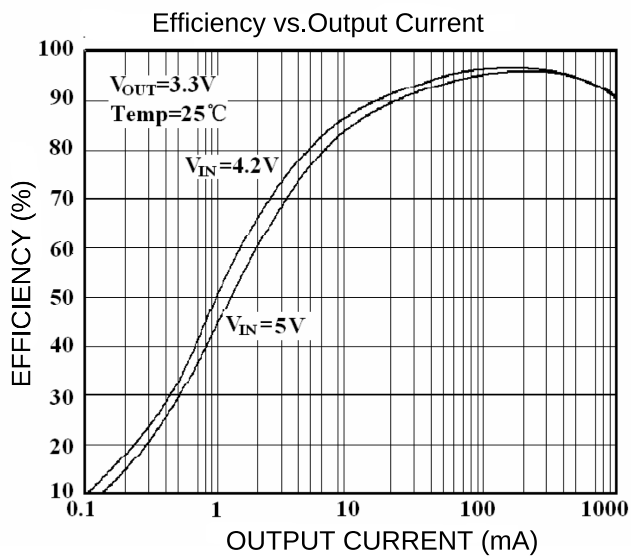
Parameter	Conditions	Min.	Typ.	Max.	Units
Input Voltage Range		2.5		5.5	V
Each Converter Supply Current	V_{FBX}=0.5V, SWX Open		270	400	μA
Each Converter Shutdown Current	V_{ENX}=0V, V_{INX}=4.2V		0.08	1	μA
Peak Inductor Current	V_{INX}=3V,V_{FBX}=0.5V	1.05	1.25		A
Regulated Feedback Voltage	T_A=25℃	0.5880	0.6000	0.6120	V
	-40℃≤ T_A≤ 85℃	0.5850	0.6000	0.6150	V
Reference Voltage Line Regulation	VINX=2.5V to 5.5V		0.11	0.40	%/V
FB Input Bias Current	V_{FBX}=0.65V			±30	nA
$R_{DS(ON)}$ of P-Channel FET	I_{swX}=300mA		0.3	0.5	Ω
$R_{DS(ON)}$ of N-Channel FET	I_{swX}=300mA		0.2	0.45	Ω
Each Converter Oscillator Frequency	V_{FBX}=0.6V	1.2	1.5	1.8	MHz
	V_{FBX}=0V		0.7		MHz
SW Leakage Current	VINX=5V, V_{ENX}=0V, V_{SWX}=0 or 5V		±0.01	±1	μA
EN Threshold Voltage	-40℃≤ T_A≤ 85℃	0.3	1.0	1.5	V
EN Leakage Current			±0.1	±1	μA

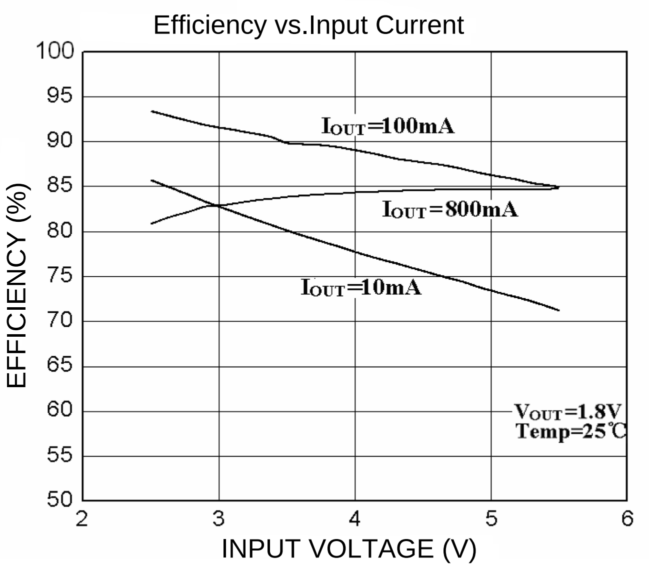
Note 1: 100% production test at +25 ℃. Specifications over temperature range are guaranteed by design and characterization.

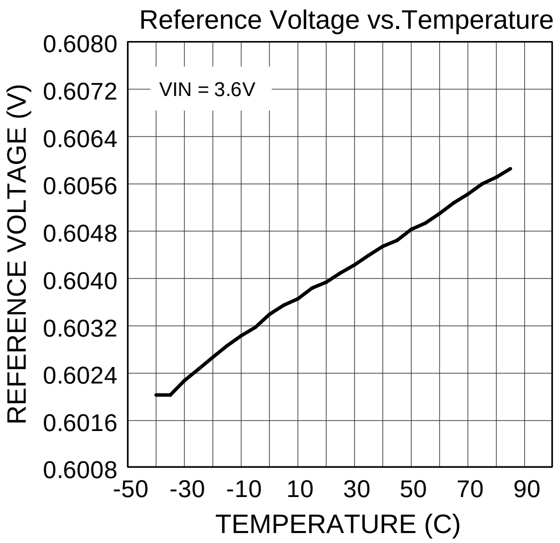
◆ Typical Operating Characteristics

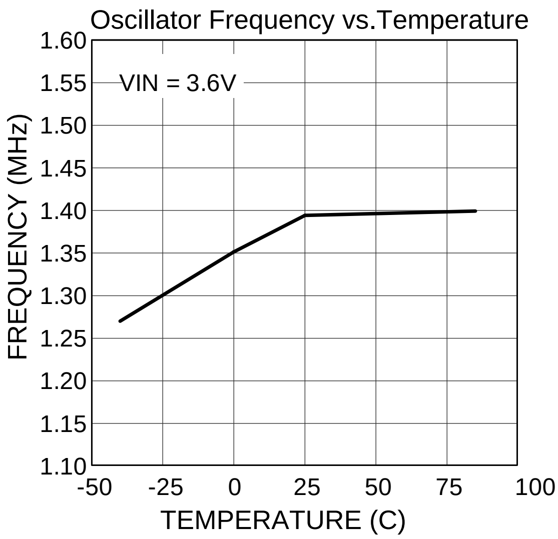


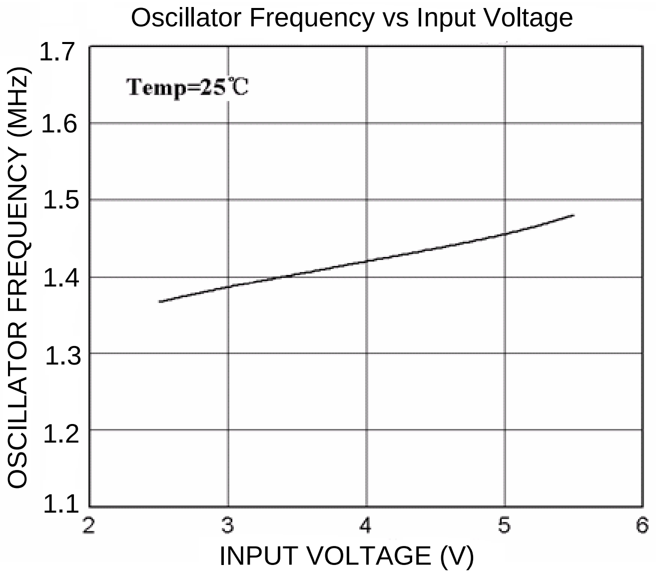


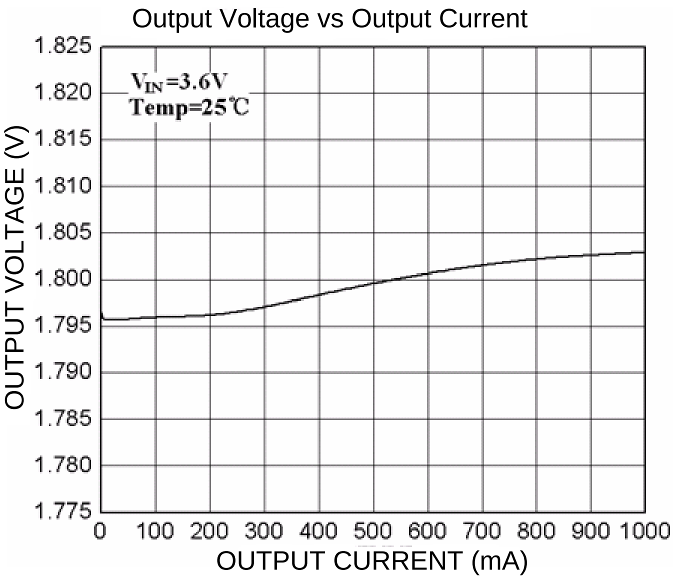


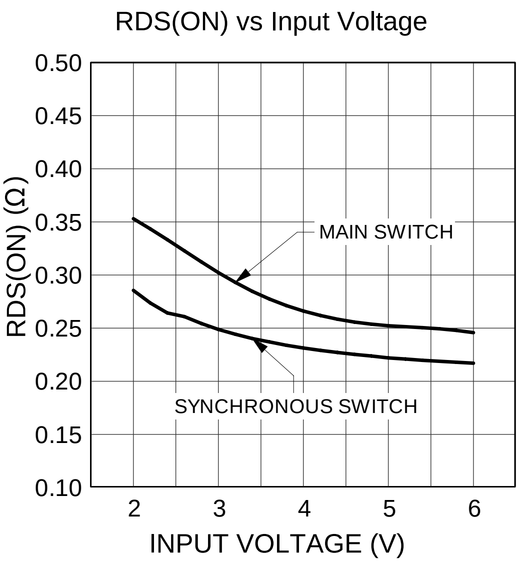


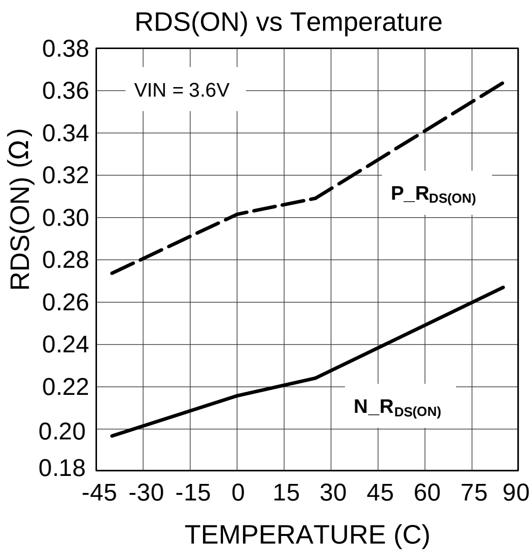


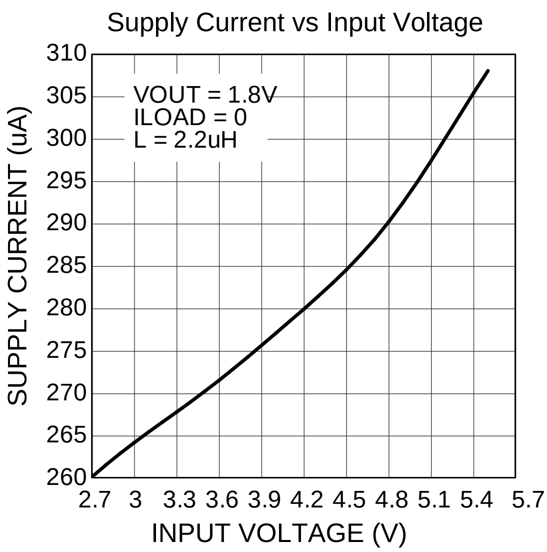


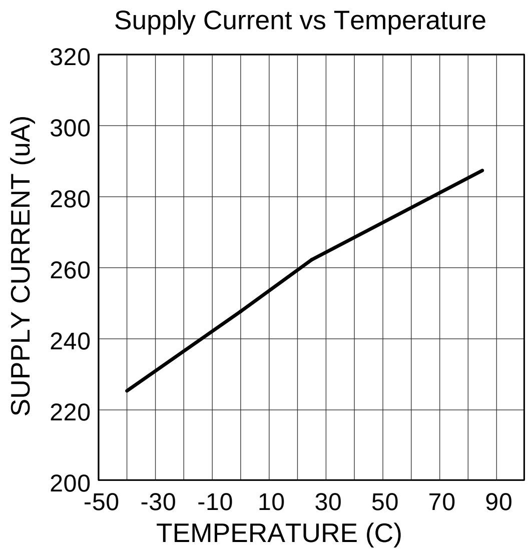

Oscillator Frequency vs Input Voltage
Temp=25℃
OSCILLATOR FREQUENCY (MHz)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
2
3
4
5
6
INPUT VOLTAGE (V)


Output Voltage vs Output Current
VIN=3.6V
Temp=25℃
OUTPUT VOLTAGE (V)
1.825
1.820
1.815
1.810
1.805
1.800
1.795
1.790
1.785
1.780
1.775
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT CURRENT (mA)

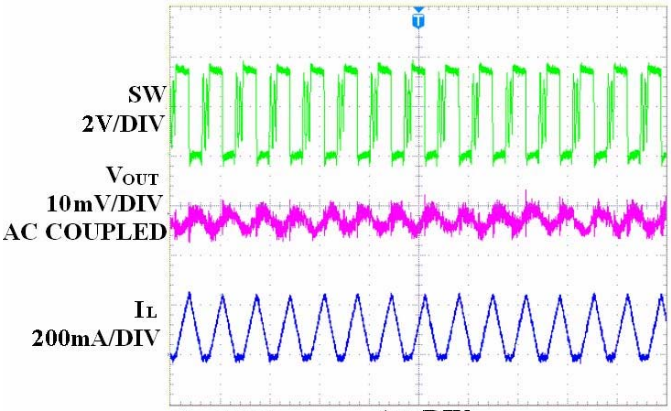

RDS(ON) vs Input Voltage
RDS(ON) (Ω)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
MAIN SWITCH
SYNCHRONOUS SWITCH
2
3
4
5
6
INPUT VOLTAGE (V)


RDS(ON) vs Temperature
VIN = 3.6V
RDS(ON) (Ω)
0.38
0.36
0.34
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
P_RDS(ON)
N_RDS(ON)
-45
-30
-15
0
15
30
45
60
75
90
TEMPERATURE (C)


Supply Current vs Input Voltage
VOUT = 1.8V
ILOAD = 0
L = 2.2uH
SUPPLY CURRENT (uA)
310
305
300
295
290
285
280
275
270
265
260
2.7
3
3.3
3.6
3.9
4.2
4.5
4.8
5.1
5.4
5.7
INPUT VOLTAGE (V)

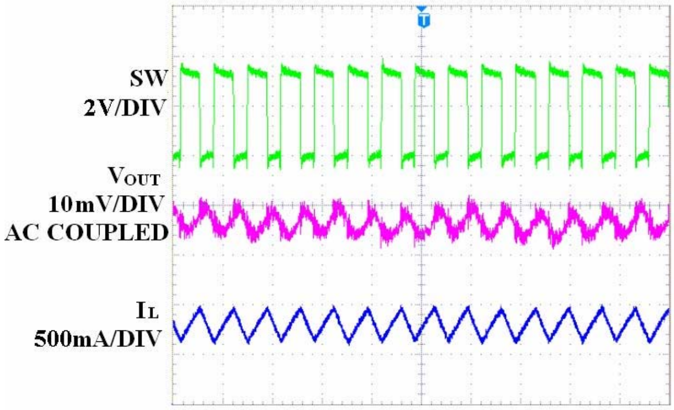

Supply Current vs Temperature
SUPPLY CURRENT (uA)
320
300
280
260
240
220
200
-50
-30
-10
10
30
50
70
90
TEMPERATURE (C)

Discontinuous Operation



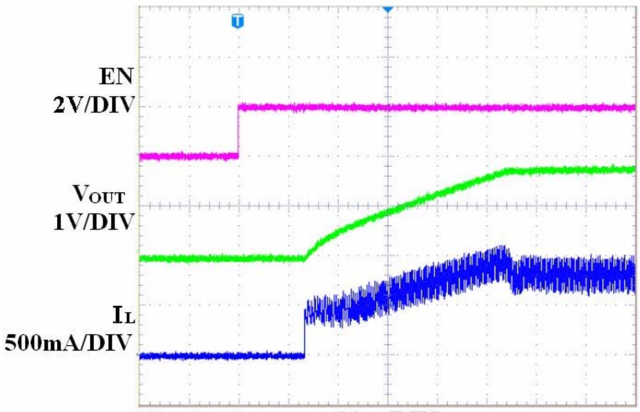
V_{IN}=3.6V
V_{OUT}=1.8V
I_{LOAD}=100mA

Normal Operation



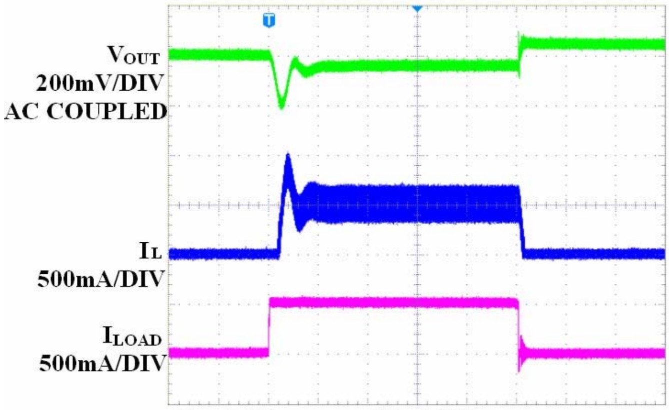
V_{IN}=3.6V
V_{OUT}=1.8V
I_{LOAD}=800mA

Start-Up from Shutdown



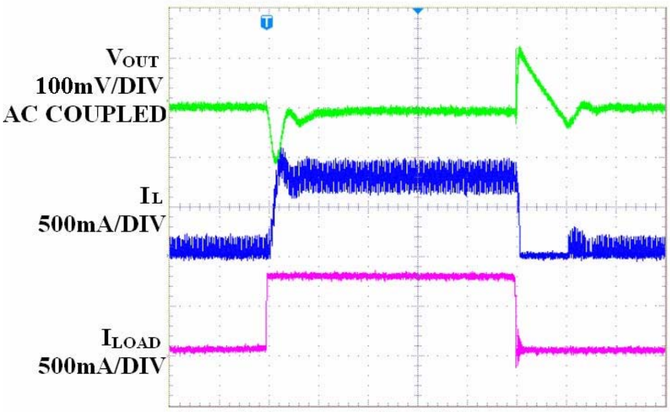
V_{IN}=3.6V
V_{OUT}=1.8V
I_{LOAD}=800mA(LOAD:2.25Ω RESISTOR)

Load Transient



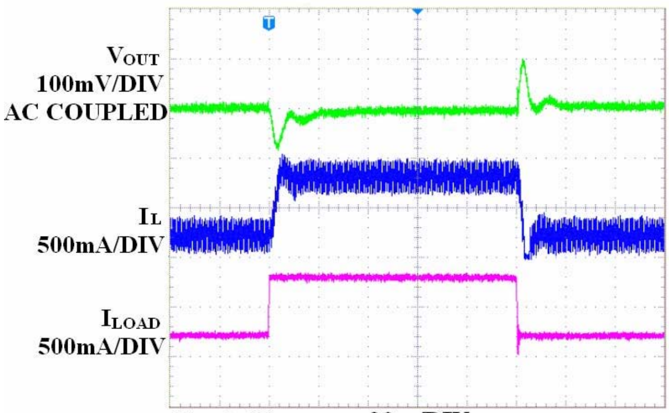
V_{IN}=3.6V
V_{OUT}=1.8V
I_{LOAD}=0mA TO 500mA

Load Transient



V_{IN}=3.6V
V_{OUT}=1.8V
I_{LOAD}=50mA TO 800mA

Load Transient



V_{IN}=3.6V
V_{OUT}=1.8V
I_{LOAD}=200mA TO 800mA

◆ Functional Block Diagram

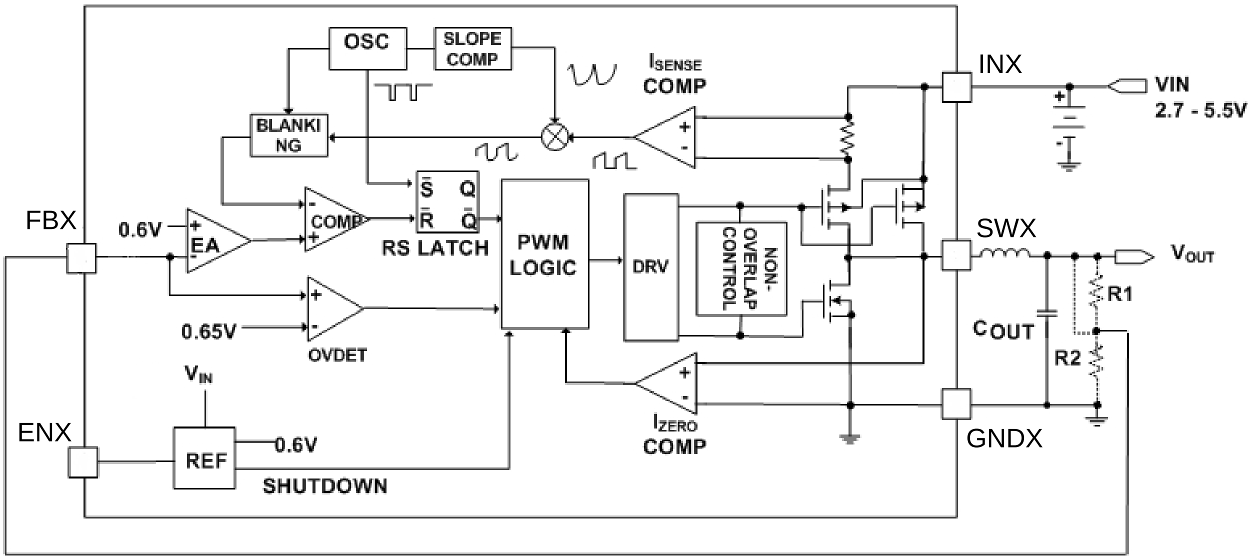


Figure 2. GP3409 Block Diagram

◆ Operation

The GP3409 has dual independent slop-compensated constant frequency current mode PWM step-down converters. Both the main (P-channel MOSFET) and synchronous (N-channel MOSFET) switches are internal. During normal operation, the GP3409 regulates output voltage by switching at a constant frequency and then modulating the power transferred to the load each cycle using PWM comparator. The duty cycle is controlled by three weighted differential signals: the output of error amplifier, the main switch sense voltage and the slope-compensation ramp. It modulates output power by adjusting the inductor-peak current during the first half of each cycle. An N-channel, synchronous switch turns on during the second half of each cycle (off time). When the inductor current starts to reverse or when the PWM reaches the end of the oscillator period, the synchronous switch turns off. This keeps excess current from the output capacitor to GND, or through the main and synchronous switch to GND.

◆ Application Information

Inductor Selection

For most designs, the GP3409 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 is inductor Ripple Current. Large value inductors lower ripple current and small value inductors result in high ripple currents. Choose inductor ripple current approximately 40% of the maximum load current 800mA, or ΔIL=320mA (40% of 800mA).

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 shall 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 4.7μF ceramic capacitor for most applications is sufficient.

Where ΔI_L is inductor Ripple Current.

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. The output ripple V_{OUT} is determined by:

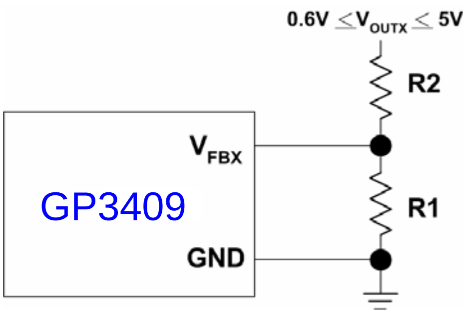
$$\Delta V_{OUT} \le \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times f_{OSC} \times L} \times \left(ESR + \frac{1}{8 \times f_{OSC} \times C_{OUT}} \right)$$

Setting the Output Voltage

The output voltage is set by a resistive divider according to the following formula:

$$V_{OUT} = 0.6V\left(1 + \frac{R_{X2}}{R_{X1}}\right)$$

The external resistive divider is connected to the output, allowing remote voltage sensing as shown in below figure.



The junction temperature, T_J , is given by:

$$T_J = T_A + T_R$$

Where T_A is the ambient temperature.

T_J should be below the maximum junction temperature of 150°C.

Thermal Considerations

Power Dissipation shall be considered when both channels of the GP3409 provide maximum 800mA output current to the loads at high ambient temperature with low input supply voltage. If the junction temperature rises above 150℃, the two channels of GP3409 will be shutdown. To avoid the GP3409 from exceeding the maximum junction temperature, the user will need to do a thermal analysis. The goal of the thermal analysis is to determine whether the operating conditions exceed the maximum junction temperature of the part. The temperature rise is given by:

$$T_R = (P_D)(\theta_{JA})$$

Where $P_D = I_{LOAD}{}^2 \times R_{DS(ON)}$ is the power dissipated by the regulator ; θ_{JA} is the thermal resistance from the junction of the die to the ambient temperature.

Layout Guidance

When laying out the printed circuit board, the following guidelines should be used to ensure proper operation of the GP3409.

1. The input capacitor C_{INX} should connect to V_{INX} as closely as possible. This capacitor provides the AC current to the internal power MOSFETs.
2. The power traces, consisting of the GND trace, the SWX trace and the V_{INX} trace should be kept short, direct and wide.
3. The FBX pin should connect directly to the feedback resistors. The resistive divider R11/R12 and R21/R22 must be connected between the C_{OUTX} and ground.
4. Keep the switching node, SWX, away from the sensitive FBX node.

◆ Ordering Information

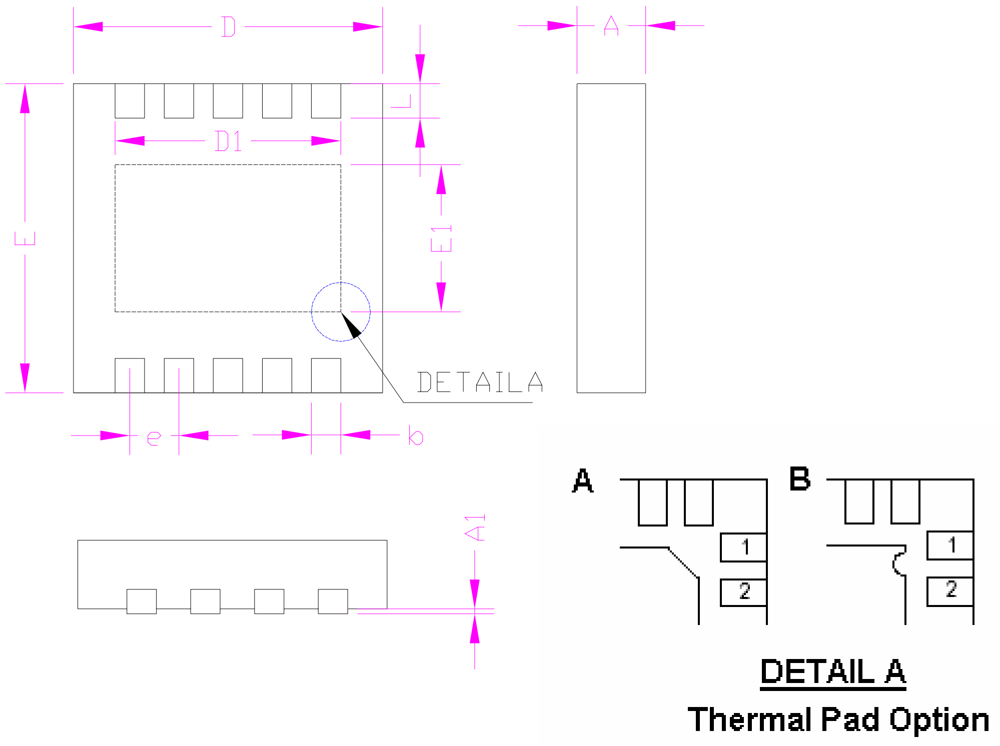
Part Number (Tape & Reel)[1]	Package	Marking[2]
GP3409D-ADJR	TDFN-10	G9YM

Note 1: Sample stock is generally held on part numbers list in **BOLD**.

2: YM = Manufacturing data code: Y=Year, M=Month.

◆ Package Description

TDFN-10



SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
D	2.90	3.10	0.114	0.122
E1	1.70		0.067	
E	2.90	3.10	0.114	0.122
L	0.30	0.50	0.012	0.020
b	0.18	0.30	0.007	0.012
e	0.50		0.020	
D1	2.40		0.094	