Introduction

The SLM2169 is a CMOS step-up switching regulator controller which mainly consists of a reference voltage source, an oscillation circuit, an error amplifier, a phase compensation circuit, and a PWM / PFM switching control circuit.

With an external low-ON-resistance N-channel Power MOS, this product is ideal for applications requiring high efficiency and a high output current.

The SLM2169 efficiently works on voltage's condition of large I/O difference due to the PWM control circuit linearly varies the duty ratio to 90%. During light-load, the SLM2169 switches its operation to the PFM control by the PWM / PFM switching control circuit in order to prevent efficiency decline due to the IC operating current. Ceramic capacitors can be used for output capacitor. Small package SOT-23-5 enables high-density mounting.

Features

- Input voltage range 1.8 V~5.5V
- Oscillation frequency 1.2MHz
- Reference voltage 0.6V±2.0%
- Soft start function 10ms typ
- Low current consumption 50μA typ at switching off
- Duty ratio Built-in PWM / PFM switching control circuit 20%~90%
- Shut-down function Current consumption 1.0 μA max at shutdown
- External component Inductor, diode, capacitor, transistor
- UVLO function 1.7V typ

Applications

- MP3 players, digital audio players, mobile power pack
- Digital cameras, GPS, wireless transceiver
- Portable devices

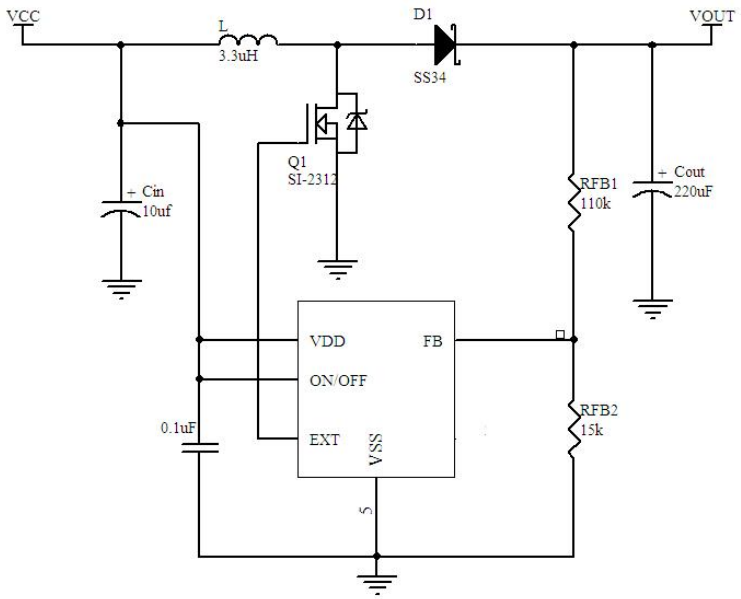
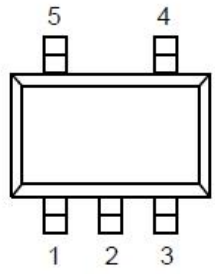


Figure1. SLM2169 Typical Operating Circuit

Pin Configuration



Pin Description

Pin No.	Symbol	Description
1	FB	Output voltage feedback pin
2	VDD	Power Supply Pin
4	ON/OFF	Power-off pin “H” : Power-on (normal operation) “L” : Power-off (standby)
5	GND	GND pin
6	EXT	External transistor connection pin

Absolute Maximum Ratings

(Ta = 25°C, VSS = 0 V unless otherwise specified)

Item	Symbol	Absolute Maximum Rating	Unit
VDD pin voltage	V_{DD}	VSS－0.3 ~ VSS＋6.0	V
FB pin voltage	V_{FB}	VSS－0.3 ~ VDD＋0.3	V
EXT pin voltage	V_{EXT}	VSS－0.3 ~ VDD＋0.3	V
ON/OFF pin voltage	$V_{ON/OFF}$	VSS－0.3 ~ VDD＋0.3	V
Power dissipation	P_D	650	mW
Operating ambient temperature	T_{OPR}	－40 ~＋85	℃
Storage temperature	T_{STG}	－40 ~＋125	℃

Caution :The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

Electrical Characteristics

(VDD = 3.3 V, Ta = 25℃ (unless otherwise specified)

Item	Symbol	Condition	Min	Typ	Max	Unit	Test Circuit
Input voltage*	VDD	---	1.8		5.5	V	2
FB voltage	VFB	---	0.588	0.6	0.612	V	2
FB pin input current	IFB	VDD=1.8 V~5.5 V	-0.1	---	0.1	uA	2
Current consumption at operation*1	ISS1	VFB=VFB(S)×0.95	---	350	---	uA	1
Current consumption at switching off	ISS2	VFB=VFB(S)×1.5	---	35	---	uA	1
Current consumption at shutdown	ISS0	VON/OFF=0V	---	0	1	uA	1
EXT pin output current	IEXTH	VEXT=VDD-0.4V	---	30	60	mA	1
	IEXTL	VEXT=0.4V	100	200	---	mA	
Oscillation frequency	FOSC	----	1.0	1.2	1.4	MHz	1
Maximum duty ratio	MAX DUTY	VFB=VFB(S)×0.95	80	85	90	%	1
PWM / PFM switching Duty ratio*2	PFM DUTY	VDD=VOUT(S)－0.1V，无负载	---	20	---	%	2
UVLO release voltage	VUVLO+	---	1.6	1.7	1.78	V	1
UVLO hysteresis width	VUVLOHYS	---	0.05	0.10	0.15	V	1
High level input voltage	VSH	VDD=1.8V~5.5V	0.75	---	---	V	1
Low level input voltage	VSL	VDD=1.8 V~5.5V	---	---	0.3	V	1
High level input current	ISH	VDD=1.8 V~5.5V，VON/OFF=0.75V	-0.1	---	0.1	uA	1
Low level input current	ISL	VDD=1.8 V~5.5V，VON/OFF=0V	-0.1	---	0.1	uA	1
Soft-start time	tss	---	---	10	---	mS	2

*1. VFB(S) is a setting value for FB voltage.

*2. VOUT(S) is a setting value for output voltage. VOUT is the typical value of actual output voltage.

VOUT(S) can be set by using the rate of VFB and the output voltage setting resistors (RFB1, RFB2).

Block Diagram

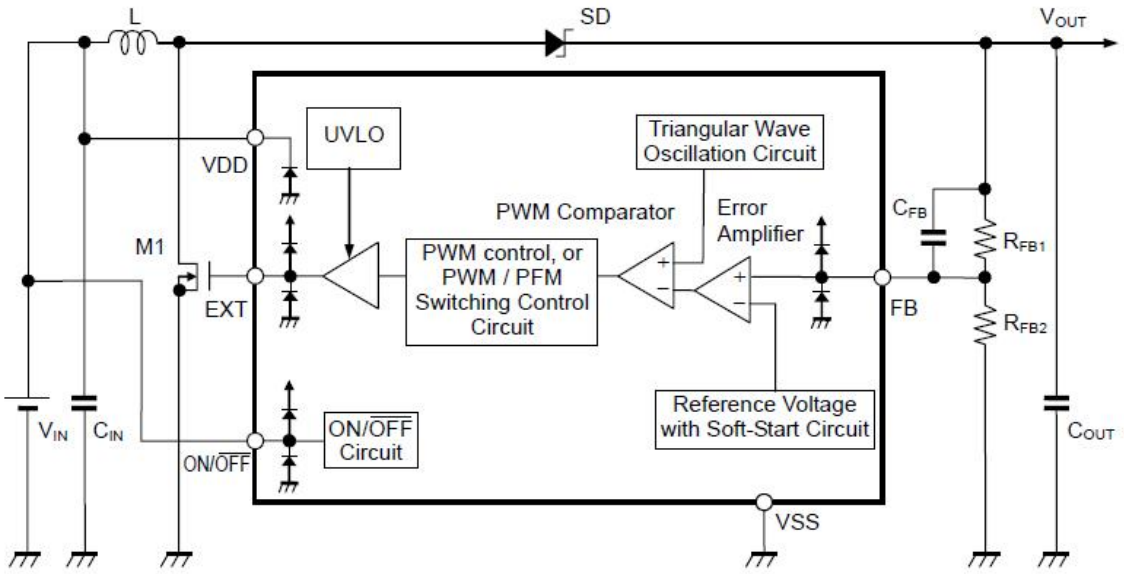
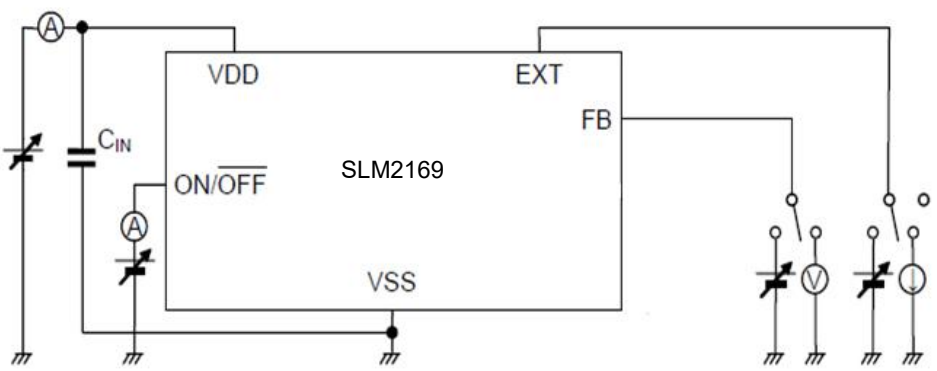


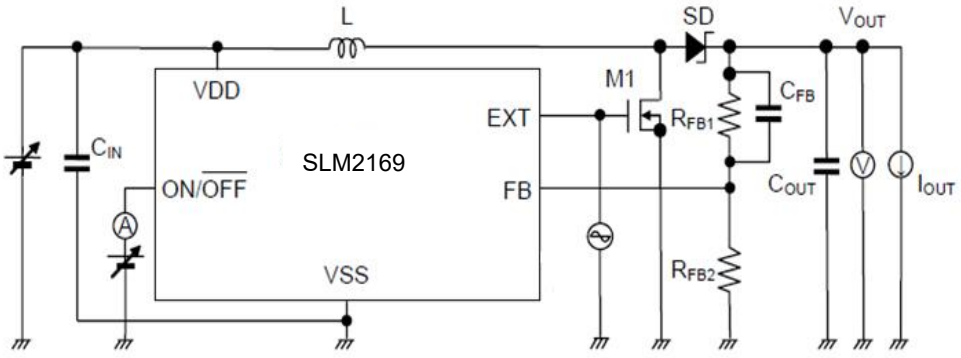
Figure 2

Test Circuit

1.



2.



Operation

Switching Control Method

The SLM2169 switching regulator controller automatically switches between the pulse width modulation method (PWM) and pulse frequency modulation method (PFM) according to the load current. A low ripple power can be supplied by operating on PWM control for which the pulse width changes from 20% to 90% in the range where the output load current is large.The SLM2169 operates on PFM control when the output load current is small and the fixed pulses which have the width of 20% are skipped according to the load current amount. Therefore, the oscillation circuit intermittently oscillates, reducing the self-current consumption. This avoids decreased efficiency when the output load current is small.

Soft-start Function

The SLM2169 has a soft-start circuit. The output voltage (VOUT) gradually rises after power-on or startup when the ON/OFF pin is set to high, suppressing rush current and overshooting the output voltage. The soft-start time (tss) for the SLM2169 is defined as the time from startup until VOUT reaches 90% of the output set voltage value (VOUT(S)). A reference voltage adjustment method is used as the soft-start method and the reference voltage gradually rises from 0 V after soft-start.

UVLO Function

The SLM2169 has a UVLO (under-voltage lockout) circuit for avoiding IC malfunctions due to power supply voltage drops. The SLM2169 stops switching operation upon UVLO detection and retains the external transistor in the off state. After entering the UVLO detection status once, the soft-start function is reset. Note, however, that the other internal circuits operate normally and that the status differs from the power-off status.

Inductor

The recommended inductor value of the SLM2169 is 2.2uH. The inductance (L) has a strong influence on the maximum output current (IOUT) and efficiency (η). The inductor peak current (IPK) increases when L is decreased, which improves the circuit stability and increases the IOUT users can obtain. If L is decreased further, the ability of the external transistor to drive the current becomes insufficient, reducing the efficiency and decreasing IOUT. The loss due to the IPK of the switching transistor is decreased by increasing L and the efficiency maximizes at a certain L value. If L is increased further, the loss due to the serial resistance of the inductor increases, lowering the efficiency.

Caution : When selecting an inductor, be careful about its allowable current. If a current exceeding the allowable current flows through the inductor, magnetic saturation occurs, substantially lowering the efficiency and destroying IC due to large current. Therefore, select an inductor such that IPK does not exceed the allowable current. The following equations express IPK in the ideal statuses in the discontinuous and continuous modes :

$$I_{PK} = \sqrt{\frac{2 \times I_{OUT} \times (V_{OUT} + V_D{}^{*2} - V_{IN})}{f_{OSC}{}^{*1} \times L}}$$

$$I_{PK} = \frac{V_{OUT} + V_D{}^{*2}}{V_{IN}} \times I_{OUT} + \frac{(V_{OUT} + V_D{}^{*2} - V_{IN}) \times V_{IN}}{2 \times (V_{OUT} + V_D{}^{*2}) \times f_{OSC}{}^{*1} \times L}$$

fosc : oscillation frequency.

VD is the forward voltage of a diode. The reference value is 0.4 V.

Diode

- Use an externally mounted that meets the following conditions.
- Low forward voltage (Schottky barrier diode or similar type)
- High switching speed
- Reverse withstand voltage of VOUT + spike voltage or more
- Rated current of IPK or more

Input capacitor & Output capacitor

To improve efficiency, an input capacitor (CIN) lowers the power supply impedance and averages the input current. The recommended capacitance is 10 µF for the SLM2169.

An output capacitor (COUT), which is used to smooth the output voltage, requires a capacitance larger than that of the step-down type because the current is intermittently supplied from the input to the output side in the step-up type. Surface mount ceramic capacitor is recommended for the SLM2169. 100uF or 47uF*2 surface mount capacitance is recommended for 2A applications.

External MOSFET

Use an Nch power MOS FET. A MOS FET that has low ON-resistance (RON) and input capacitance (CISS) is ideal for gaining efficiency. The input voltage (VDD) is supplied as the gate voltage of a MOS FET, so select a MOS FET for which the gate withstand voltage is higher than the maximum value used for the input voltage, and for which the drain withstand voltage is greater than or equal to the output voltage (VOUT) + the forward voltage of the diode (VD). If a MOSFET for which the threshold value is near the UVLO detection voltage is used, a high current flows upon power-on, and, in the worst case, the output voltage might not increase and the timer latch type short-circuit protection circuit might operate. Therefore, select a MOS FET for which the threshold value is sufficiently lower than the UVLO detection voltage.

Output voltage setting resistors (RFB1, RFB2), capacitor for phase compensation (CFB)

For the SLM2169, VOUT can be set to any value by using external divider resistors. Connect the divider resistors between the VOUT and VSS pins. Because VFB = 0.6 V, VOUT can be calculated by using the following equation:

$$V_{OUT} = \frac{R_{FB1}+R_{FB2}}{R_{FB2}} \times 0.6$$

RFB1=110k, RFB2=15k is recommended

CFB, which is connected in parallel with RFB1, is a capacitor for phase compensation.

By setting the zero point (the phase feedback) by adding capacitor CFB to output voltage setting resistor RFB1 in parallel, the phase margin increases, improving the stability of the feedback loop. To effectively use the feedback portion of the phase based on the zero point, define CFB by using the following equation:

$$C_{FB} \cong \frac{\sqrt{L \times C_{OUT}}}{3 \times R_{FB1}} \times \frac{V_{OUT}}{V_{DD}}$$

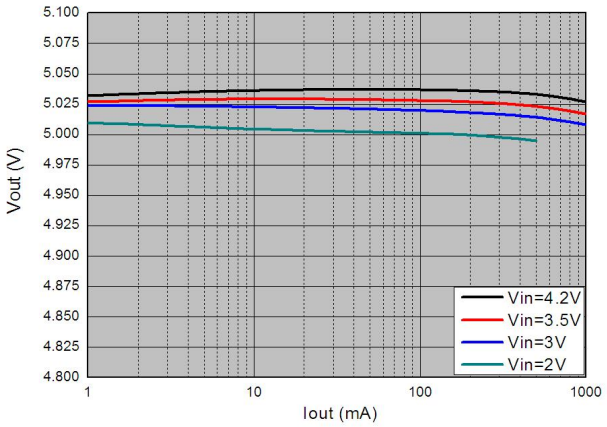
Notice

- Mount external capacitors and inductor as close as possible to the IC. Set single point ground.
- Place RFB1, RFB2 as close as to the FB pin of SLM2169, and make sure the FB pin is far away from the switching point.
- The 0.1 µF capacitor connected between the VDD and VSS pins is a bypass capacitor. It stabilizes the power supply in the IC when

application is used with a heavy load, and thus effectively works for stable switching regulator operation. Allocate the bypass capacitor as close to the IC as possible, prioritized over other parts.

- Although the IC contains a static electricity protection circuit, static electricity or voltage that exceeds the limit of the protection circuit should not be applied.
- The power dissipation of the IC greatly varies depending on the size and material of the board to be connected. Perform sufficient evaluation using an actual application before designing.

IOUT-VOUT

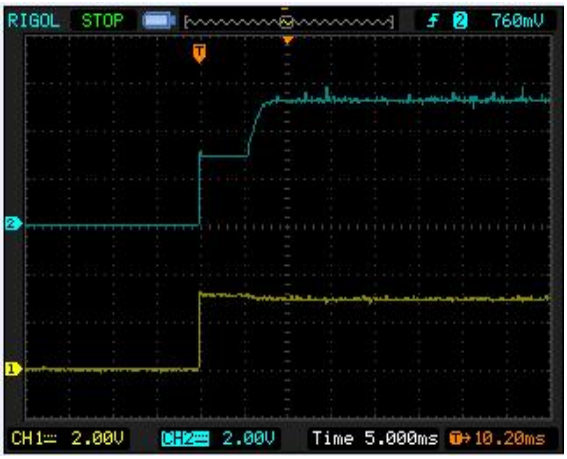


Vout Ripple

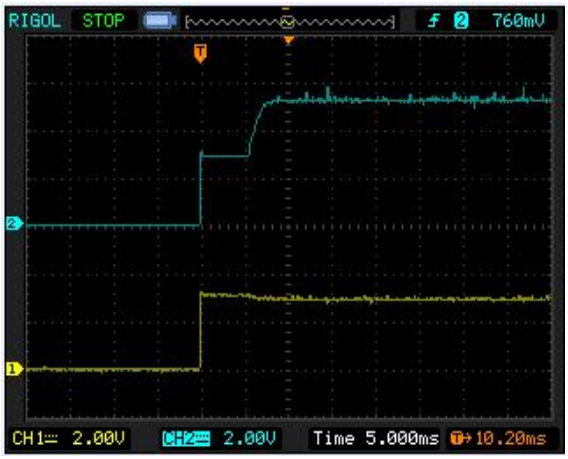
Iout=500mA

Iout=500mA

Vin-Vout (Vin:0-3V)



Iout=500mA



Iout=500mA

Package Size