Compact 350mA Negative Charge Pump and Adjustable Linear Regulator

GENERAL DESCRIPTION

The SLM5418 is a monolithic negative charge pump with a built-in adjustable negative linear regulator. It has an input range from 2.3V to 5.5V and provides an unregulated output equal to the negative input voltage. The SLM5418 also provides a regulated output between 0V and the negative input voltage.

SLM5418 works with a fixed operating frequency of 1MHz.The higher switching frequency devices allow the use of smaller capacitors for space-limited applications. An internal soft-start circuit effectively reduces the in-rush current during start-up.

The SLM5418 is available in an ultra-low profile QFN-10 1.4mmx1.8mm package. It requires only 4 ceramic capacitors for a compact solution size. It is ideal for a wide range of applications, including optical modules, RF amplifiers, and sensor supplies.

FEATURES

- VIN Range from 2.3V to 5.5V
- Up to 350mA Output Current
- Only 4 x 4.7µF Capacitors Needed for 350mA
- 1MHz Fixed Charge Pump Frequency
- EN Control
- CTL for Adjustable Regulator
- No Inrush Current during Start-Up
- Short-Circuit Protection
- Dual Output:
    1. -1x Charge Pump
    2. Regulated output between 0V and -VIN
- Small Space Saving QFN-10
    1.4mmx1.8mm Package

APPLICATION

- Optical Module
- Bias for RF amplifier
- Sensor Supply in Portable Instruments

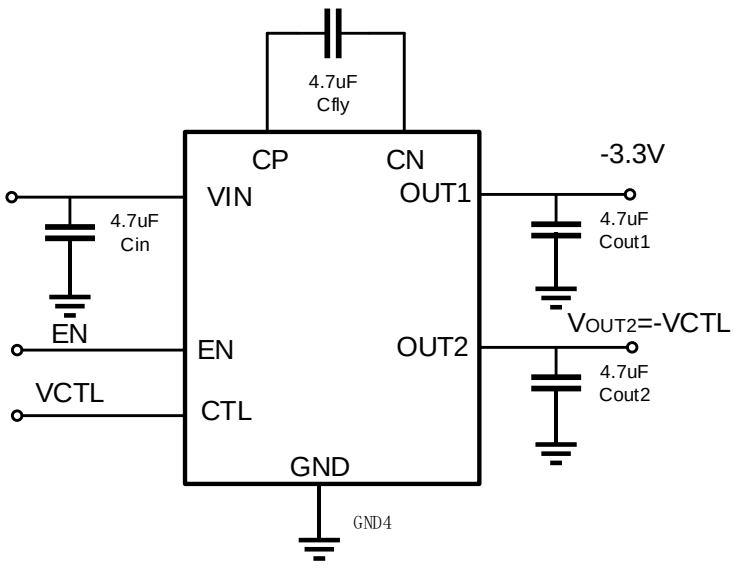
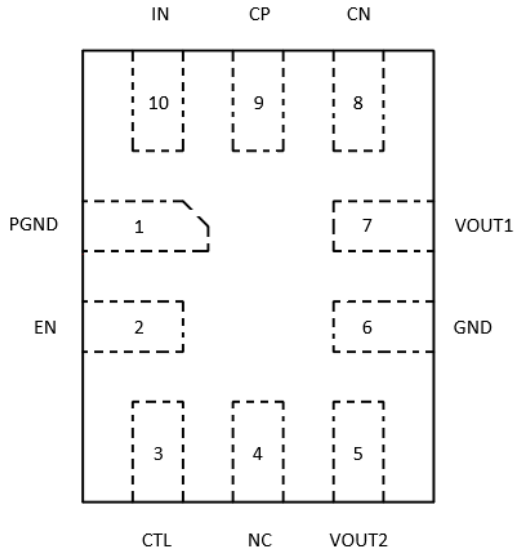


Figure 1. Typical Operation Circuit

PIN CONFIGURATION

Package	Pin Configuration (Top View)
QFN-10(1.4mmx1.8mm)	

PIN DESCRIPTION

No.	Pin	Description
1	GND	Power ground.
2	EN	Enable. Set this pin high to enable the device.
3	CTL	Analog input voltage. The VOUT2 voltage will be -1x the CTL pin voltage.
4	NC	No Connect. Leave this pin open.
5	VOUT2	Negative linear regulator output. A decoupling capacitor is needed.
6	GND	Power ground.
7	VOUT1	Negative charge pump output. A decouple capacitor is needed
8	CN	Negative terminal of fly capacitor.
9	CP	Positive terminal of fly capacitor.
10	IN	Input power supply pin. A decoupling capacitor is needed to prevent large voltage spikes from appearing at the input.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{IN}) ..... -0.3V to 6V
V_{CP} ..... -0.3V to V_{IN}+0.3V
V_{CN} ..... V_{OUT}-0.3V to 0.3V
V_{OUT1} ..... -V_{IN} to 0.3V
V_{OUT2} ..... V_{OUT1} to 0.3V
All Other Pins ..... -0.3V to 6V
Junction Temperature ..... 150°C
Lead Temperature ..... 260°C

Continuous Power Dissipation (T_A = +25°C)
(2)(4) 1.47W
Storage Temperature ..... -65°C to +150°C

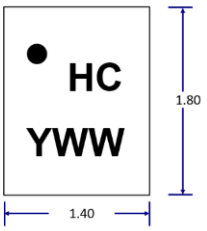
Thermal Resistance	θ_{JA}	θ_{JC}
QFN-10(1.4mmx1.8mm)		
JESD51-7	140	30 °C/W

ORDERING INFORMATION

Industrial Range: -40°C to +125°C

Order Part No.	Package	Packing Type	QTY
SLM5418EJ-7G	QFN 1.4 × 1.8 -10	Tape on reel	3000/Reel

TOP Marking



HC: Product Code
Y: Year code
WW: Week code

FUNCTIONAL BLOCK DIAGRAM

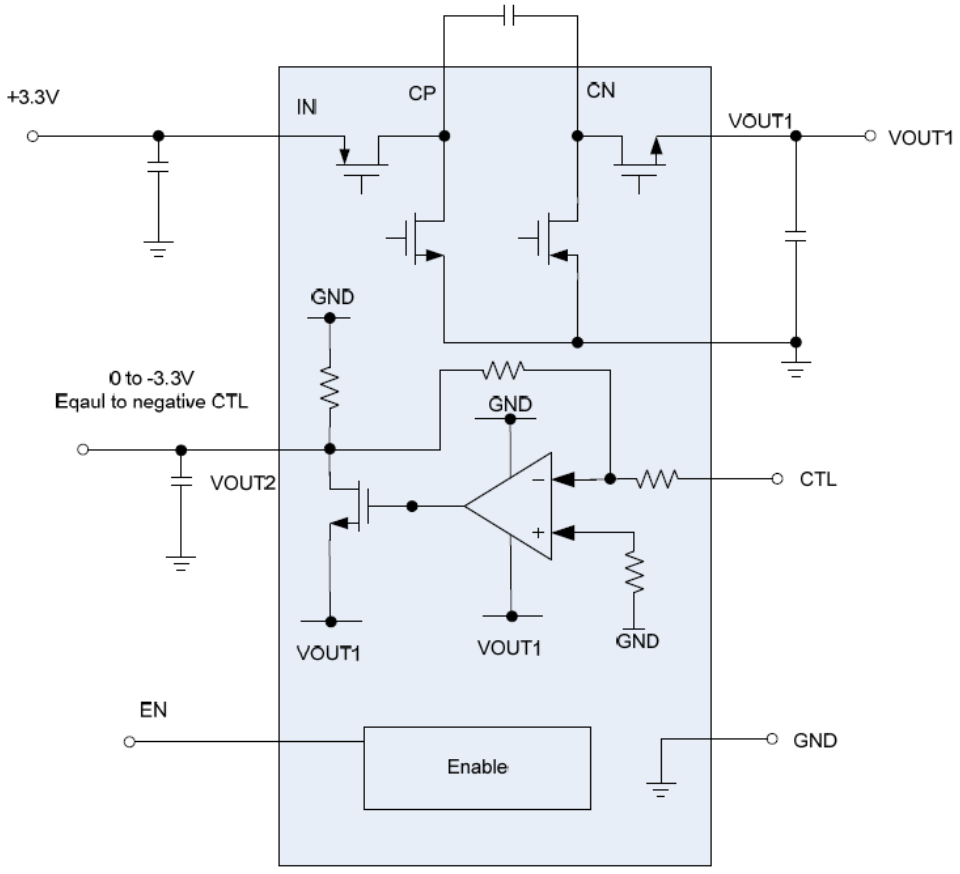


Figure 2. Functional Block Diagram Of Slm5418

ELECTRICAL CHARACTERISTICS

Test condition is V_{IN} = 2.3 V to 5.5 V, T_J = −40°C ~ +125°C for minimum/maximum specifications, and T_A = 25°C for typical specifications, unless otherwise specified.

Parameter	Symbol	Condition	Min	Typ	Max	Units
VIN Range	V_{IN}		2.3		5.5	V
Under-voltage lockout threshold rising	UVLO			2.2		V
Under-voltage lockout threshold Hysteresis				0.15		V
Supply current (shutdown)	I_{SD}	V_{EN} =0V， V_{IN}=3.3V		2		uA
Supply current (switching)		V_{EN} =3.3V, no load, TJ=+25°C		2.8		mA
		V_{EN} =3.3V, no load, TJ > -40°C &TJ < +125°C		3.3		mA
Charge pump frequency	Fsw			1		MHz
Charge pump equivalent output resistance	R_{ON}	V_{IN}=3.3V, I_{OUT1}=100mA		0.134		Ω
Charge pump current limit				2		A
Negative Linear Regulator						
Load current limit(7)		V_{IN}=3.3V, V_{OUT2}=-2.5V		240		mA
Output accuracy		Compared with CTL voltage, room temp, I_{OUT2}=10mA		1		%
		Over temp , I_{OUT2}=10mA		2		%
Output offset IOUT2=10mA				20		mV
Dropout voltage	V_{DROP}	V_{IN}=2.7V,I_{OUT2}=60mA		20		mV
		V_{IN} =3.3V, I_{OUT2}=60mA		15		mV
Load regulation(7)		V_{OUT1}=-3.3V, CTL=1V		0.005		%/mA
PSRR		100Hz, C_{OUT1}=1uF C_{OUT2}=1uF, I_{OUT2}=10mA		60		dB
		50kHz, C_{OUT1}=1uF, C_{OUT2}=1uF, I_{OUT2}=10mA		50		dB
		300kHz, C_{OUT1}=1uF, C_{OUT2}=1uF, I_{OUT2}=10mA		40		dB
Soft-start slew-rate				5		V/ms
EN turn-on delay				200		us
EN input logic low voltage	V_{IH}			0.71		V
EN input logic high voltage	V_{IL}			0.91		V
Output discharge resistor	R_{DIS1}	V_{EN}=0V, V_{OUT1} rail	170		310	Ω
	R_{DIS2}	V_{EN} =0V, V_{OUT2} rail	80		160	Ω
EN input current		V_{EN} =2V		2		uA
Thermal shutdown(7)				160		°C
Thermal hysteresis(7)				25		°C
Output ripple	V_{Ripple_OUT1}	V_{IN}=3.3V, V_{OUT1}=-3.3V, C_{FLY}=C_{OUT1}=4.7uF, I_{OUT1}=60mA		8		mV
	V_{Ripple_OUT2}	V_{IN}=3.3V, V_{OUT2}=2.5V,C_{OUT2}=1uF, I_{OUT2}=60mA		1		mV

TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 3.3V, V_{OUT1} = -3.3V, V_{OUT2}=-1.2V, C_{IN}=C_{FLY}=C_{OUT1}=C_{OUT2}=4.7F, T_A = +25°C, unless otherwise noted.

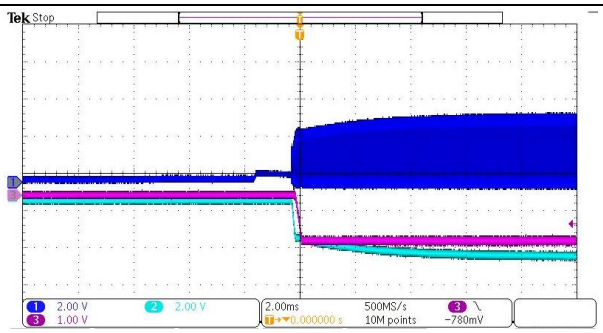


Figure 3.VIN power on

Line1: CP,Line2: Vout1,Line3:Vout2

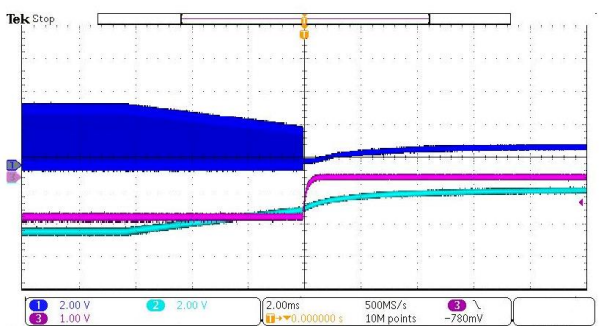


Figure 4. VIN power off

Line1: CP,Line2: Vout1,Line3:Vout2

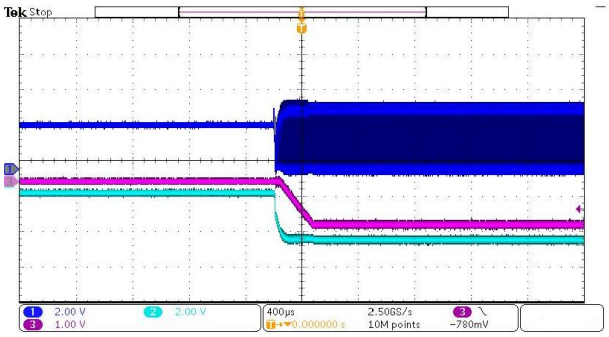


Figure 5. Enable ON

Line1: CP,Line2:Vout1,Line3:Vout2

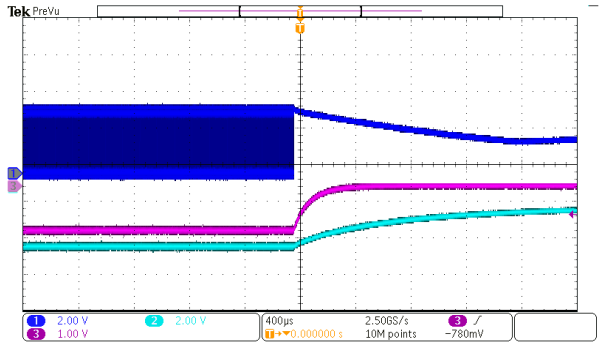


Figure 6. Enable Off

Line1: CP,Line2: Vout1,Line3:Vout2

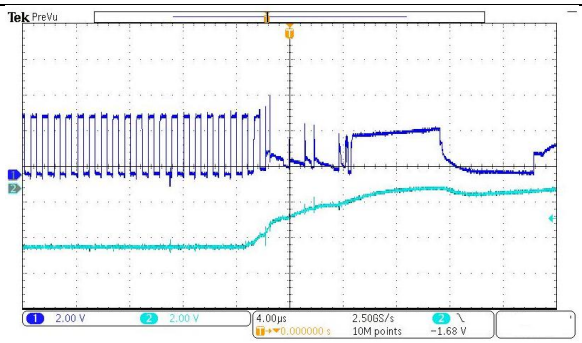


Figure 7. Vout1 short to GND

Line1: CP,Line2: Vout1

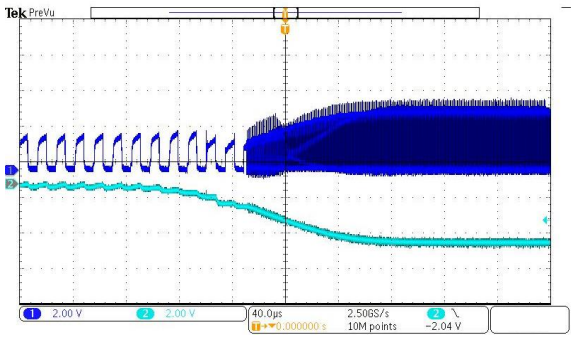


Figure 8. Vout1 Recovery from Short

Line1: CP,Line2: Vout1

FEATURE DESCRIPTION

Operation

The SLM5418 is a monolithic, negative charge pump with a built-in adjustable negative regulator. It has an input range from 2.3V to 5.5V and provides an unregulated output equal to the negative input voltage. The SLM5418 also provides a regulated output between 0V and the negative input voltage. No external inductor is required, which reduces space and simplifies design. An internal soft-start circuit effectively reduces the in-rush current during start-up.

Negative Charge Pump

The SLM5418 uses a switched capacitor charge pump to get an unregulated negative voltage; the absolute value is VIN. The switching signal, which drives the charge pump, is created by an integrated oscillator within the control circuit block. The oscillator charge pump switching frequency is 1MHz. 1MHz fixed switch frequency reduces output ripple especially at light load.

When the absolute value of V_{OUT1} is less than 1.2V, the charge pump treats it as an over-current condition. The SLM5418 will force the oscillator frequency to 62.5kHz for fold-back. There is a diode between V_{OUT1} and GND. When the V_{OUT1} voltage is higher than 0.3V, the diode will discharge V_{OUT1}.

Negative Linear Regulator

The SLM5418 integrates a negative linear regulator, which is powered from the negative charge pump output. It provides a low dropout voltage and low quiescent supply, low output noise linear regulator. Its output range is from 0 to the V_{OUT1} voltage.

The regulator uses an internal feedback loop to control the output voltage, which equals -1x the CTL pin voltage. This is an easy interface for DAC. Using efficient DAC, its output voltage can be set by an external signal. The PSRR of the linear regulator is specially designed for its charge pump. The negative linear regulator will have a low output ripple.

Load Capability

The SLM5418 load capability is 350mA; the sum of $I_{OUT}1$ and I_{OUT2} is less than 350mA. This load capability is related to the fly and output capacitor. The smaller the capacitor, the smaller the load capability.

Over-Current Protection (OCP)

The charge pump current is limited internally. The device is protected against over-load and over-temperature conditions. The peak charge pump input current is limited to 2A.

The negative linear regulator output current is limited internally also. The typical current limit is 240mA.

Over-Temperature Protection (OTP)

When the junction temperature is too high, the thermal sensor sends a signal to the control logic that will shut down the IC. The IC will restart when the temperature has sufficiently cooled. The maximum power output current is a function of the package's maximum power dissipation for a given temperature.

Enable (EN)

When the input voltage is greater than the under-voltage lockout threshold (UVLO), typically 2.2V, the SLM5418 can be enabled by pulling EN higher than 0.9V. Floating EN or pulling it down to ground will disable the device. There is an internal 1MΩ resistor from EN to ground.

When the device is disabled, the part goes into output discharge mode automatically, and its internal discharge MOSFET provides a resistive discharge path for the output capacitor.

Equivalent Output Resistance

The equivalent output resistance of the SLM5418 is related to the charge pump frequency, fly capacitor and on-resistance of MOSFETs. See Equation (1):

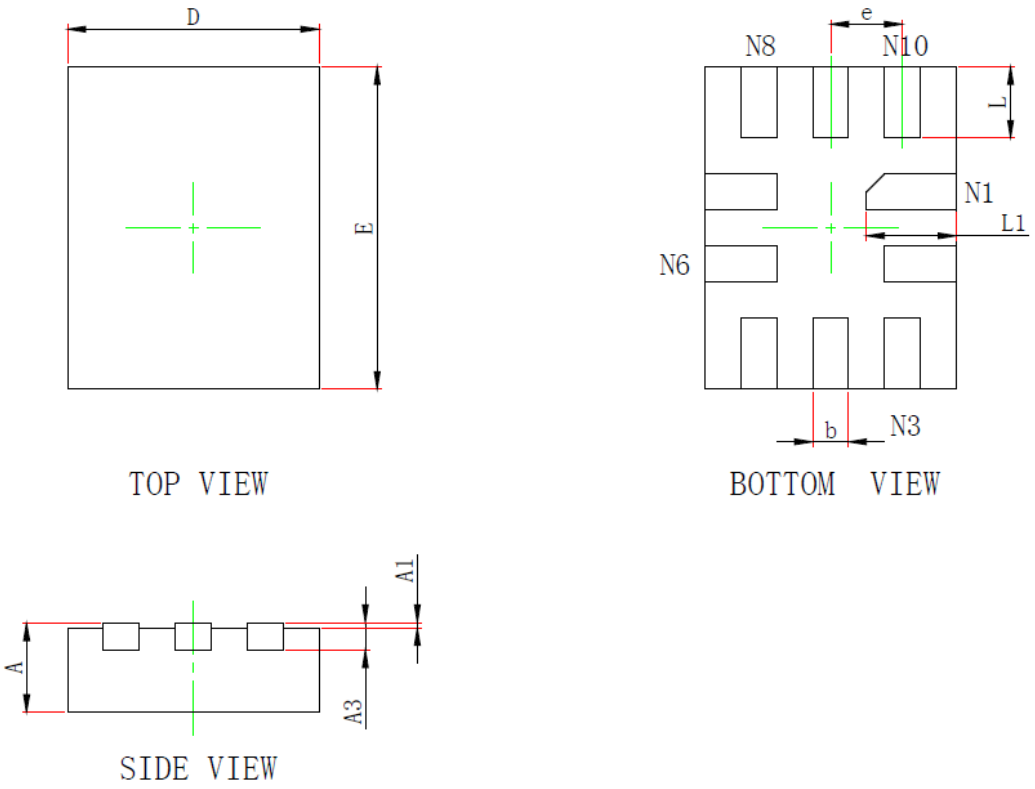
$$R_O = 8 * R_{ON} + {}^{1}/_{(f * C_{FLY})} \quad (1)$$

R_{ON} is the on-resistance of each switch MOSFET in the charge pump, f is the switching frequency and C_{FLY} is fly capacitor.

The charge pump output voltage V_{OUT1} is related to I_O and R_O. See Equation (2):

$$V_{OUT1} = -(V_{IN} - I_O * R_O) \quad (2)$$

PACKAGE CASE OUTLINES



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.550	0.650	0.018/0.022	0.022/0.026
A1	0.000	0.050	0.000	0.002
A3	0.152REF.		0.006REF.	
D	1.350	1.450	0.053	0.057
E	1.750	1.850	0.069	0.073
D1	—	—	—	—
E1	—	—	—	—
k	—		—	
b	0.150	0.250	0.006	0.010
e	0.400TYP.		0.016TYP.	
L	0.350	0.450	0.014	0.018
L1	0.450	0.550	0.018	0.022

Figure 9. QFN-10 Outline Dimensions

REVISION HISTORY

Note: page numbers for previous revisions may differ from page numbers in current version

Page or Item	Subjects (major changes since previous revision)
Rev 1.0 datasheet, 2020-09-18	
Whole document	Initial datasheet draft
Rev 1.1 datasheet, 2023-09-25	
Whole document	Change datasheet format

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