

## 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 4.7 $\mu$ F 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

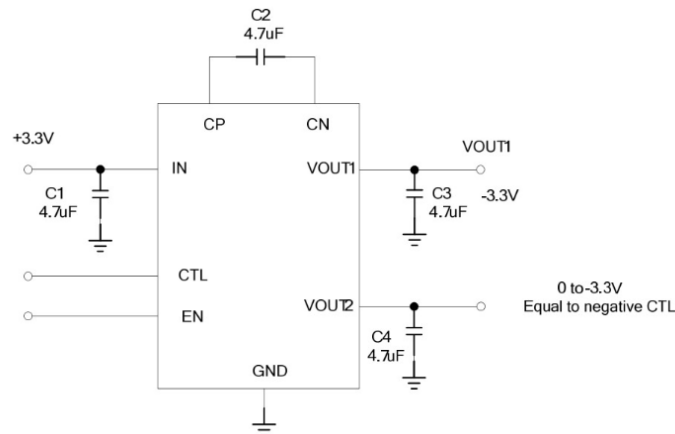
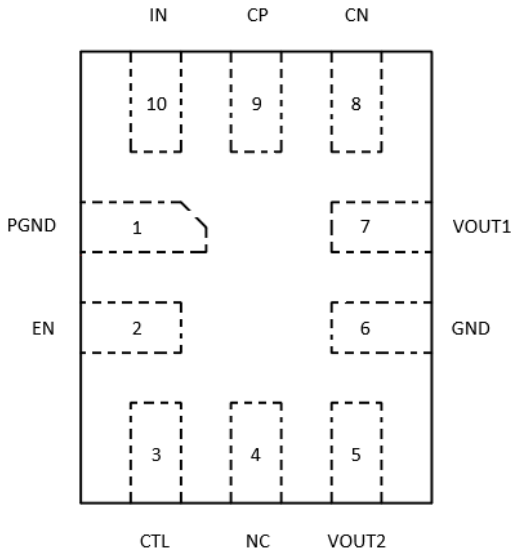


Figure. 1 TYPICAL OPERATION CIRCUIT

**PIN CONFIGURATION**

Package	Pin Configuration (Top View)
QFN-10(1.4mmx1.8mm)	 <p>The diagram shows a top view of a 10-pin QFN package. The pins are arranged in a 3x3 grid with the center pin missing. Pin 10 is at the top-left, 9 is top-middle, and 8 is top-right. Pin 1 is on the left side, 7 is on the right side. Pin 2 is in the middle-left, 6 is in the middle-right. Pin 3 is at the bottom-left, 4 is bottom-middle, and 5 is bottom-right. Labels around the package indicate functions: IN, CP, CN at the top; PGND, EN on the left; CTL, NC, VOUT2 at the bottom; and VOUT1, GND on the right.</p>

**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

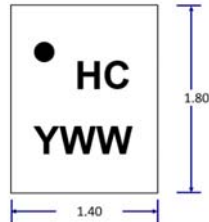
Continuous Power Dissipation ( $T_A = +25^\circ C$ )  
**(2)(4)** ..... 1.47W  
 Storage Temperature ..... -65°C to +150°C

Thermal Resistance                       $\theta_{JA}$      $\theta_{JC}$   
 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

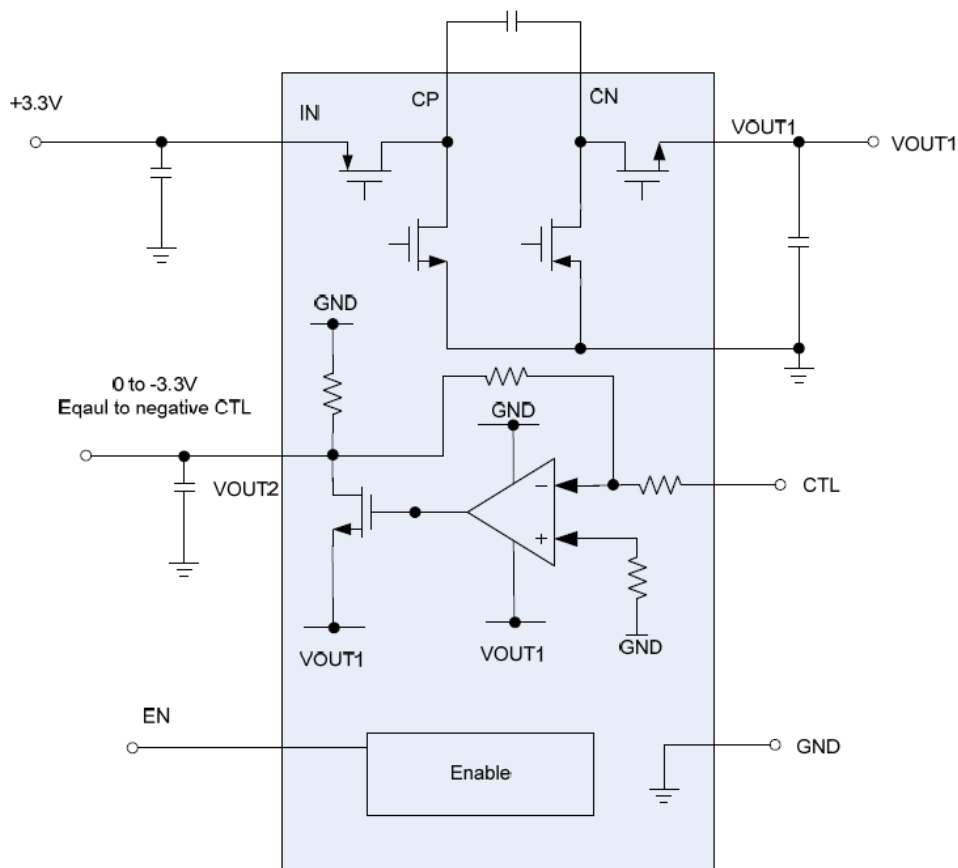
**FUNCTIONAL BLOCK DIAGRAM**


Figure. 2 FUNCTIONAL BLOCK DIAGRAM of SLM5418

**ELECTRICAL CHARACTERISTICS (TBD)**

Test condition is  $V_{IN} = 2.3\text{ V to }5.5\text{ V}$ ,  $T_J = -40^\circ\text{C} \sim +125^\circ\text{C}$  for minimum/maximum specifications, and  $T_A = 25^\circ\text{C}$  for typical specifications, unless otherwise specified.

Parameter	Symbol	Condition	Min	Typ	Max	Units
VIN Range			2.3		5.5	V
Under-voltage lockout threshold rising				2.2		
Under-voltage lockout threshold Hysteresis				0.15		
Supply current (shutdown)		$V_{EN}=0\text{V}, V_{IN}=3.3\text{V}$		2		$\mu\text{A}$
Supply current (switching)		$V_{EN}=3.3\text{V}$ , no load, $T_J=+25^\circ\text{C}$		2.8		mA
		$V_{EN}=3.3\text{V}$ , no load, $T_J > -40^\circ\text{C} \ \& \ T_J < +125^\circ\text{C}$		3.3		mA
Charge pump frequency				1		MHz
Charge pump MOS $R_{ON}$	$R_{ON}$			0.134		$\Omega$
Charge pump current limit				2		A
<b>Negative Linear Regulator</b>						
Load current limit(7)		$V_{IN}=3.3\text{V}, V_{OUT2}=-2.5\text{V}$		240		mA
Output accuracy		Compared with CTL voltage, room temp, $I_{OUT2}=10\text{mA}$		1		%
		Over temp, $I_{OUT2}=10\text{mA}$		2		%
Output offset $I_{OUT2}=10\text{mA}$				20		mV
Dropout voltage	$V_{DROP}$	$V_{IN}=2.7\text{V}, I_{OUT2}=60\text{mA}$		20		mV
		$V_{IN}=3.3\text{V}, I_{OUT2}=60\text{mA}$		15		mV
Load regulation(7)		$V_{OUT1}=-3.3\text{V}, CTL=1\text{V}$		0.005		%/mA
PSRR		100Hz, $C_{OUT1}=100\text{pF}$ , $C_{OUT2}=1\mu\text{F}, I_{OUT2}=10\text{mA}$		60		dB
		50kHz, $C_{OUT1}=100\text{pF}$ , $C_{OUT2}=1\mu\text{F}, I_{OUT2}=10\text{mA}$		50		dB
		300kHz, $C_{OUT1}=100\text{pF}$ , $C_{OUT2}=1\mu\text{F}, I_{OUT2}=10\text{mA}$		40		dB
Soft-start slew-rate				5		V/ms
EN turn-on delay				200		$\mu\text{s}$
EN input logic low voltage				0.71		V
EN input logic high voltage				0.91		V
Output discharge resistor	$R_{DIS1}$	$V_{EN}=0\text{V}, V_{OUT1}$ rail	170		310	
	$R_{DIS2}$	$V_{EN}=0\text{V}, V_{OUT2}$ rail	80		160	
EN input current		$V_{EN}=2\text{V}$		2		$\mu\text{A}$
Thermal shutdown(7)				160		$^\circ\text{C}$
Thermal hysteresis(7)				25		$^\circ\text{C}$
Output ripple	$V_{Ripple\_OUT1}$	$V_{IN}=3.3\text{V}, V_{OUT1}=-3.3\text{V}$ , $C_{FLY}=C_{OUT1}=4.7\mu\text{F}$ , $I_{OUT1}=60\text{mA}$		8		mV
	$V_{Ripple\_OUT2}$	$V_{IN}=3.3\text{V}$ , $V_{OUT2}=2.5\text{V}, C_{OUT2}=1\mu\text{F}$ , $I_{OUT2}=60\text{mA}$		1		mV

**TYPICAL PERFORMANCE CHARACTERISTICS**

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

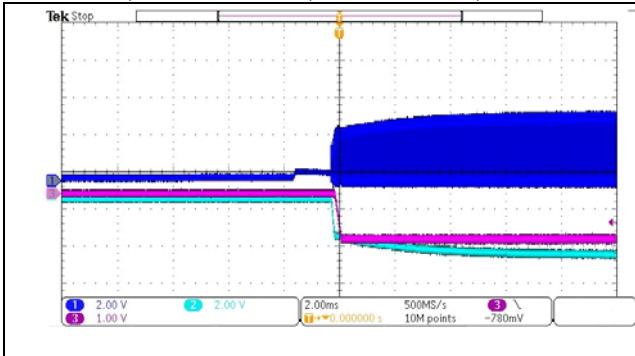


Fig.3 VIN power on (Line1:CP,Line2: Vout1,Line3:Vout2)

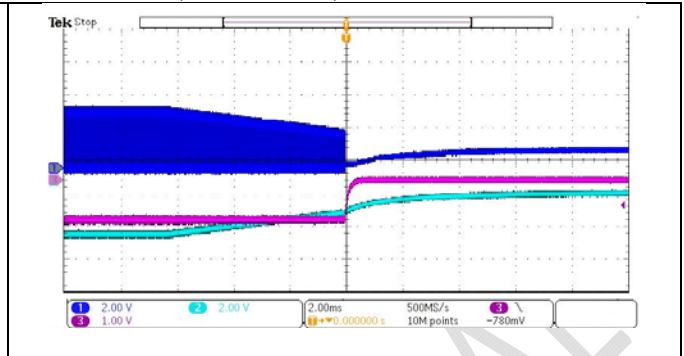


Fig.4 VIN power off (Line1:CP,Line2: Vout1,Line3:Vout2)

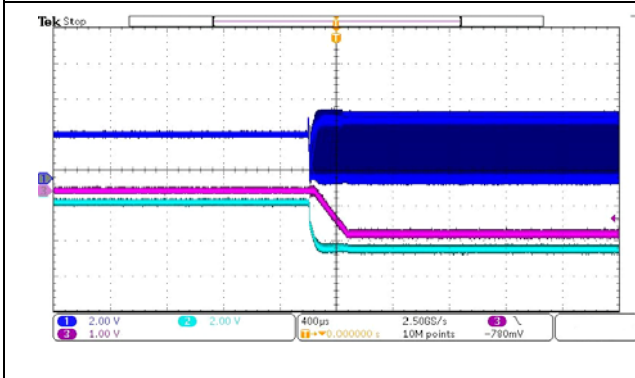


Fig.5 Enable ON(Line1:CP,Line2:Vout1,Line3:Vout2)

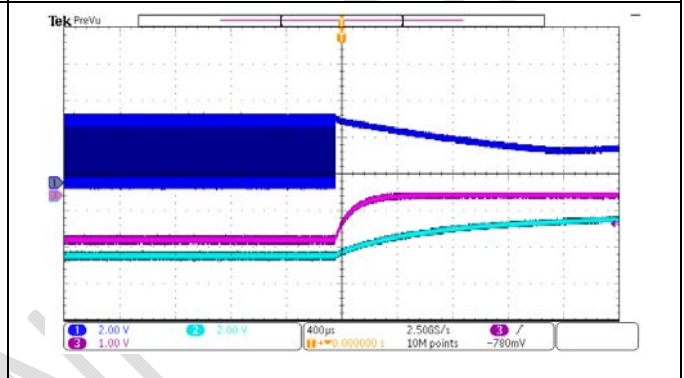


Fig.6 Enable Off(Line1:CP,Line2: Vout1,Line3:Vout2)

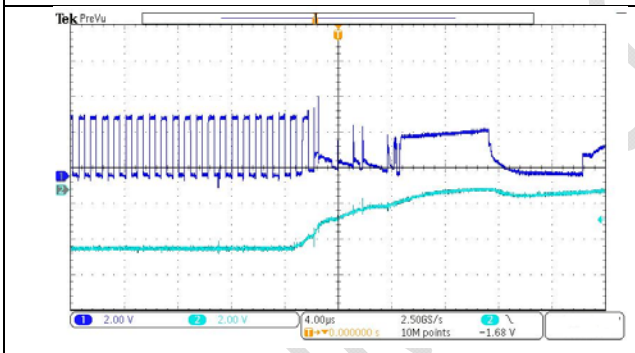


Fig.7 Vout1 short to GND (Line1:CP,Line2: Vout1)

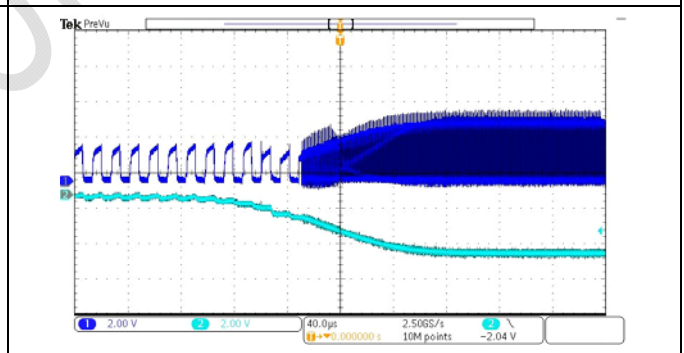


Fig.8 Vout1 Recovery from Short (Line1:CP,Line2: Vout1)

## 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 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  $V_{IN}$ . 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  $-1 \times$  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  $I_{OUT1}$  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.

### 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 1M $\Omega$  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):

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

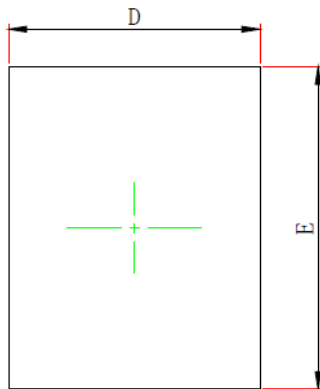
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$R_{ON}$  is the on-resistance of each switch MOSFET in the charge pump,  $f$  is the switching frequency and  $C_{FLY}$  is fly capacitor.

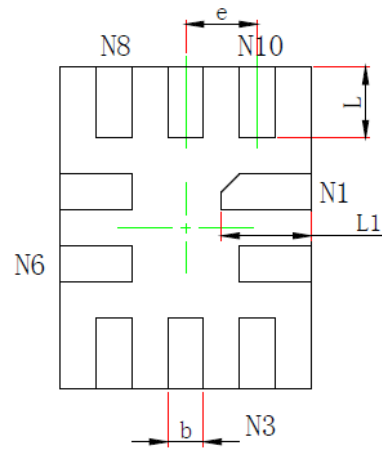
The charge pump output voltage  $V_{OUT1}$  is related to  $I_O$  and  $R_O$ . See Equation (2):

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

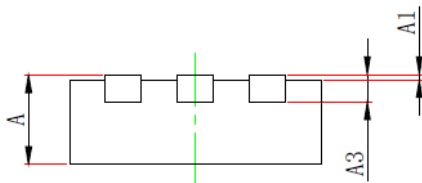
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**PACKAGE CASE OUTLINES**


TOP VIEW



BOTTOM VIEW



SIDE VIEW

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

**Revision History**