XPB4418

Negative Charge Pump and Adjustable Regulator

FEATURES

- Low I_Q: 220uA
- V_{IN} Range from 2.3V to 5V
- Up to 200mA Output Current
- Only 4 X 4.7uF Capacitors Needed for 60mA
- Auto Power-Save Mode
- EN Control
- No Inrush Current during Start-Up
- Short-Current Protection
- Dual Output:
  1. -1x Charge Pump
  2. Regulated output between 0V and $-V_{IN}$
- Small Space Saving QFN-10 1.4mmx1.8mm Package

APPLICATIONS

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

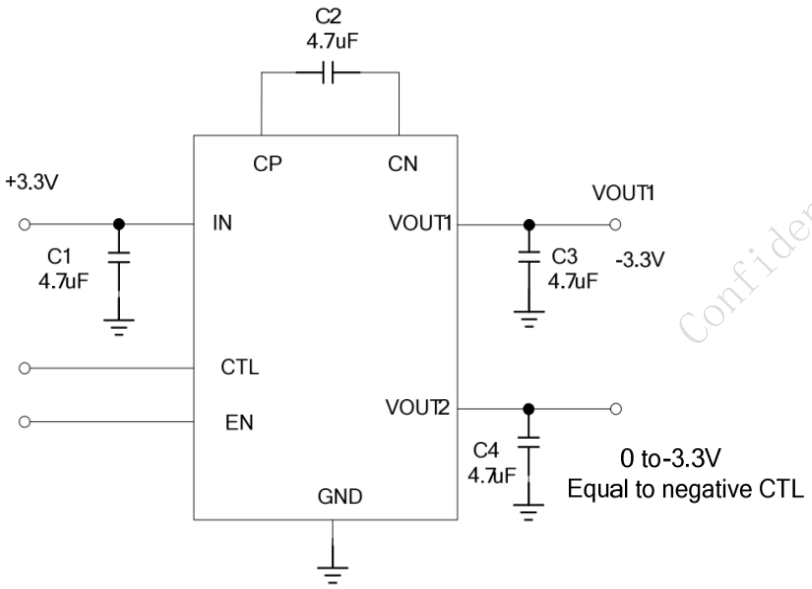
DESCRIPTION

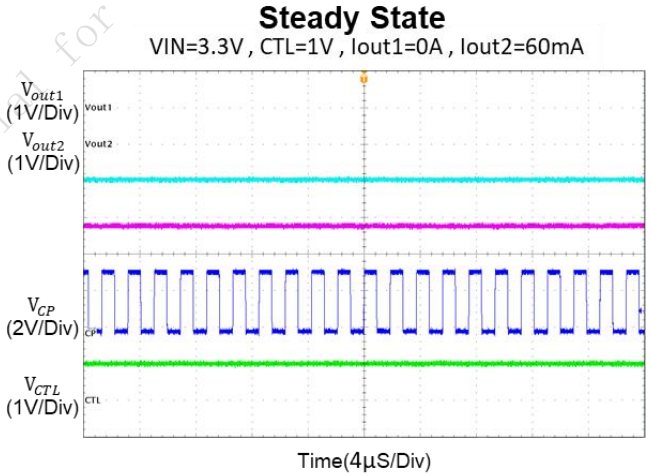
The XPB4418 is a monolithic negative charge pump with a built-in adjustable negative regulator. It has an input range from 2.3V to 5V and provides an unregulated output equal to the negative input voltage. The XPB4418 also provides a regulated output between 0V and the negative input voltage.

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.

The XPB4418 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.

TYPICAL APPLICATION





REVISION HISTORY

Release	Rev	Changes	Date
Preliminary	0.3		02/21/2024

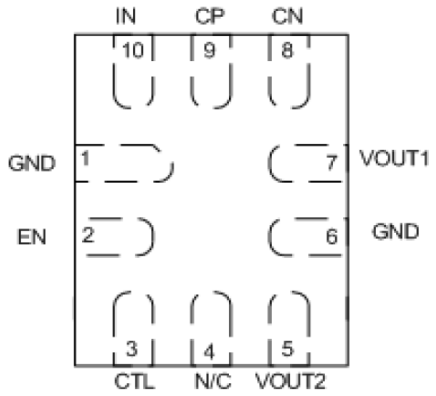
ORDERING INFORMATION

Part Number	Pumping Frequency	Top Marking	MPQ
XPB4418AQ10R	Modulation with output current	4418A	5,000
XPB4418BQ10R	Fixed Frequency	4418B	5,000

MPQ = Minimum Packaging Quantity.
For production orders greater than MPQ, the order must be a multiple of MPQ per package size above.

PIN CONFIGURATION AND DESCRIPTION

Top View



QFN-10 (1.4mmx1.8mm)

Pin Configuration

Pin	Name	Description
1	GND	Ground.
2	EN	On/off control.
3	CTL	Analog input voltage. The VOUT2 voltage will be -1x the CTL pin voltage.
4	N/C	Recommend connecting to ground.
5	VOUT2	Negative linear regulator output. A decoupling capacitor is needed.
6	GND	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	Supply voltage. The XPB4418 operates from a +2.3V to +5V unregulated input. A decoupling capacitor is needed to prevent large voltage spikes from appearing at the input.

ABSOLUTE MAXIMUM RATINGS(1)

Parameter	Min	Max	Units
IN to GND	-0.3	6	V
CP to GND	-0.3	V_{IN}+0.3	V
CN to GND	V_{OUT1}-0.3	0.3	V
VOUT1 to GND	-6	0.3	V
VOUT2 to GND	V_{OUT1}	0.3	V
All Other Pins	-0.3	6	V
Junction Temperature		150	°C
Lead Temperature		260	°C
Continuous Power Dissipation (TA = +25°C)		1.47	W
Storage Temperature	-65	150	°C

(1) Operation of the device outside of these parameters may cause permanent damage.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min	Max	Units
Supply Input Voltage, VIN	V_{IN}	2.3	5	V
Operating Junction Temp	TJ	-40	+125	°C

Thermal Information

Junction to ambient thermal resistance is a function of board layout and ambient air flow condition. This data is based on four layers PCB (30mm x 30mm; 70μm Cu top signal layer) in still air box in accordance with JEDEC standard JESD51 on natural convection.

Parameter	Symbol	Typ	Units
Junction-to-Ambient Thermal Resistance	θ_{JA}	85	°C/W
Junction-to- Case Thermal Resistance	θ_{JC}	45	°C/W

ELECTRICAL SPECIFICATIONS

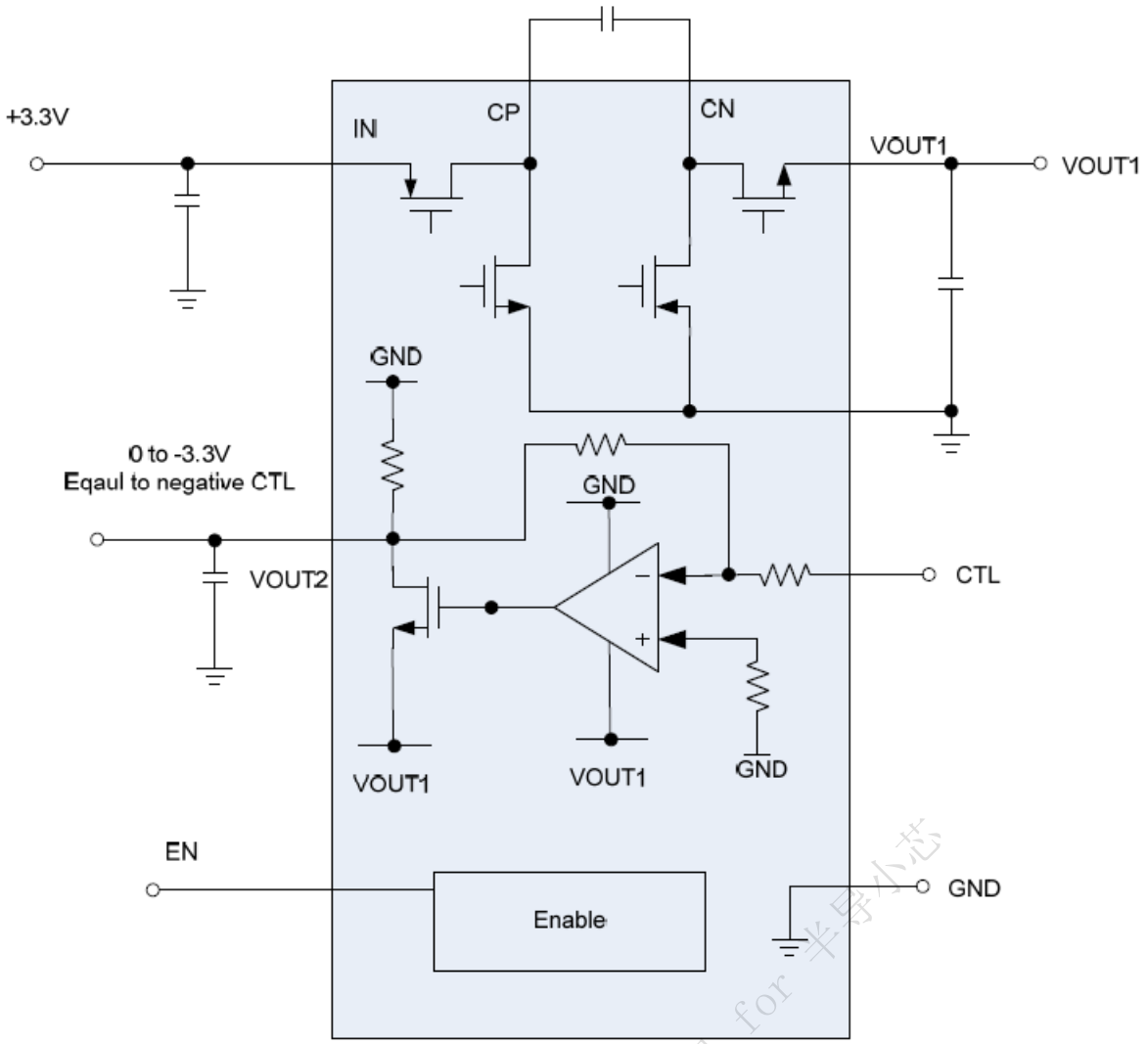
Typical values unless otherwise noted: V_{IN}=3.3V, Ambient Temperature = +25°C.

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
DC Characteristics						
V_{IN} range			2.3		5	V
Under-voltage lockout threshold rising	UVLO+			2.2	2.3	V
Under-voltage lockout threshold hysteresis	UV_{HYST}		100	180	260	mV
Supply current (shutdown)	I_{Q_SHDN}			1.5	3	A
Supply current (quiescent)	I_Q	VEN=2V, no load, TJ=+25℃		240	260	μA
Charge pump frequency	F_{PUMP}		30		550	kHz
Charge pump MOS R_{ON}	R_{ON}			0.24		Ω
Charge pump current limit	I_{LIM}		0.6	1		A
Negative Linear Regulator						
Load current limit	I_{LOAD}	Vin=3.3V, Vout2=-2.5V		200	250	mA
Output Accuracy		Iout2=10mA	-1		1	%
Output offset	OFFSET	VIN=2.5V, Iout2=10mA	-20	0	20	mV
Dropout voltage	DROP	VIN=2.5V, Iout2=60mA		25.5	50	mV
		VIN=3.3V, Iout2=60mA		21	40	mV
Load Regulation	LOADREG	VOUT1=-3.3V, CTL=1V		0.0058	0.01	%/mA
PSRR	PSRR	100Hz, COUT1=100pF, COUT2=1μF, I_{OUT2}=10mA		60		dB
		50kHz, COUT1=100pF, dB COUT2=1μF, I_{OUT2}=10mA		50		
		300kHz, COUT1=100pF, COUT2=1μF, I_{OUT2}=10mA		40		
Soft-start slew-rate	SR			5		V/mS
EN turn-on delay	EN_DLY		135	216	285	μS
EN input logic low voltage	ENL				0.4	V
EN input logic high voltage	ENH		1.2			V
Output discharge resistor	Rdis1	V_{EN}=0V, VOUT1 rail	170	230	310	Ω
	Rdis2	V_{EN}=0V, VOUT2 rail	80		146	Ω
EN input current	I_{EN}	V_{EN}=2V	1.4		2.2	μA
		V_{EN}=0V		0		μA
Thermal Shutdown	OTP			160		°C
Thermal Hysteresis	OTP_{HYST}			30		°C
System Level						
Recommended input capacitance	C_{IN}	VIN=3.3V		4.7		μF
Recommended fly capacitance	C_{Fly}			4.7		μF
Recommended V_{OUT1} capacitance	C_{OUT1}			4.7		μF
Recommended V_{OUT2} capacitance	C_{OUT2}			4.7		μF

Typical values unless otherwise noted: V_{IN}=3.3V, Ambient Temperature = +25°C.

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
VOUT1 voltage				-1x		V_{IN}
Output ripple	V_{Ripple_OUT1}	VIN=3.3V, VOUT1=-3.3V, CFLY=COUT1=4.7μF, IOUT1=60mA		50		mV
	V_{Ripple_OUT2}	VIN=3.3V, VOUT2=2.5V, COUT2=1μF, IoUT2=60mA		1		mV

BLOCK DIAGRAM

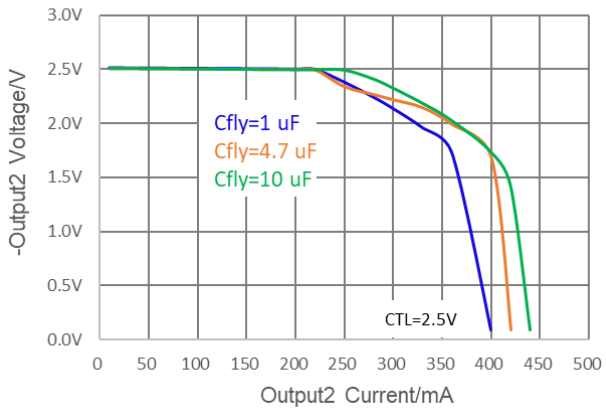


Functional Block diagram

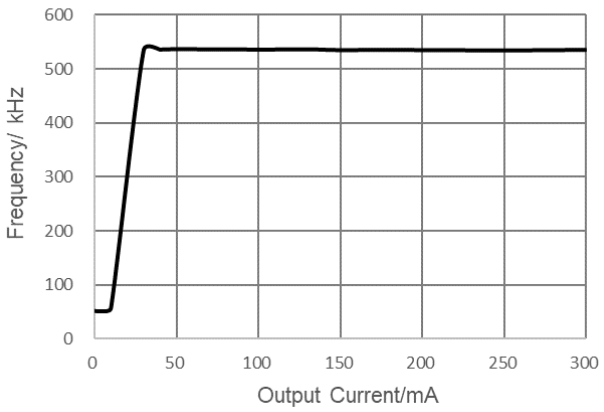
TYPICAL PERFORMANCE AND OPERATING CHARACTERISTICS

V_{IN}= 3.3V , V_{OUT1}= -3.3V , C_{IN}=C_{FLY}=C_{OUT1}=C_{OUT2}=4.7μF , Ambient Temperature = +25°C.

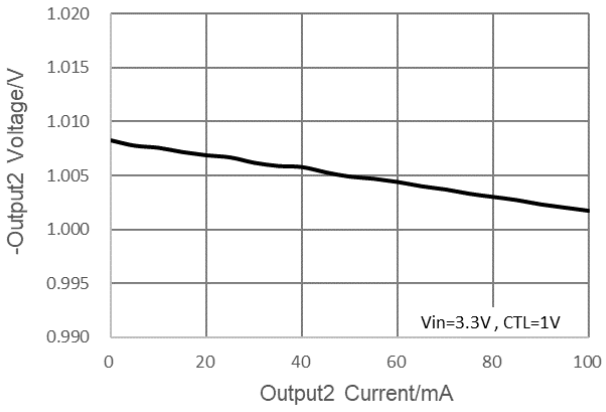
Load Capability



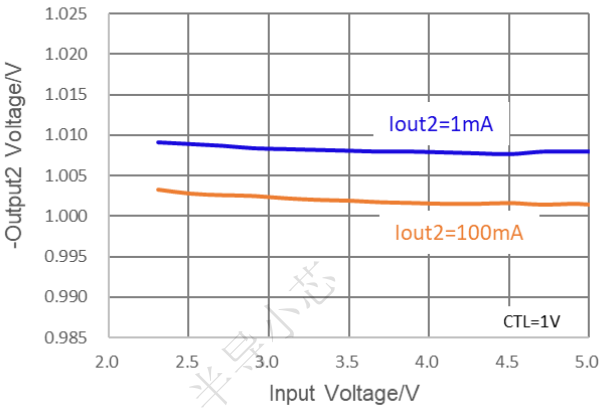
Frequency vs. Output Current



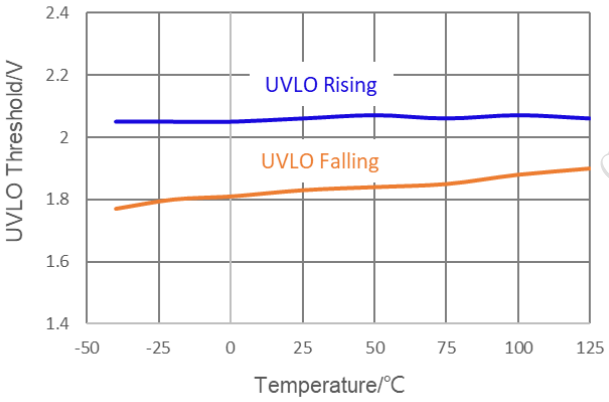
Load Regulation



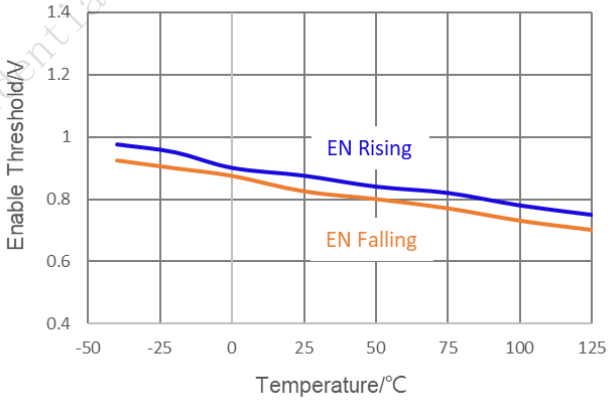
Line Regulation



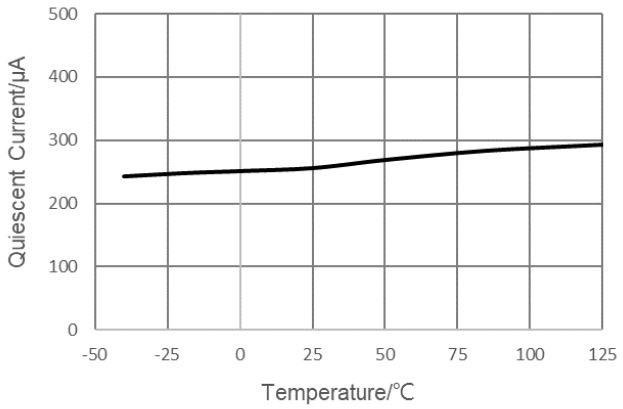
UVLO Threshold vs. Temperature



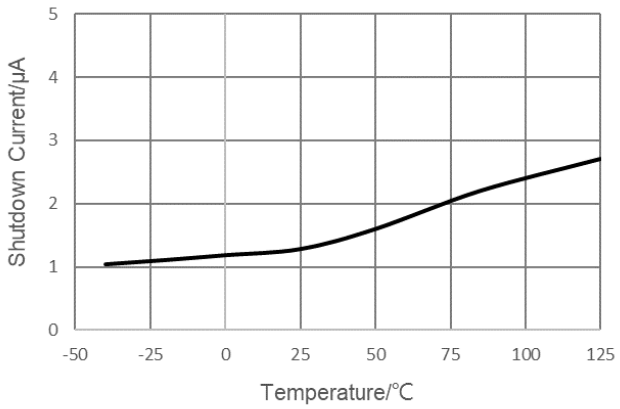
Enable Threshold vs. Temperature



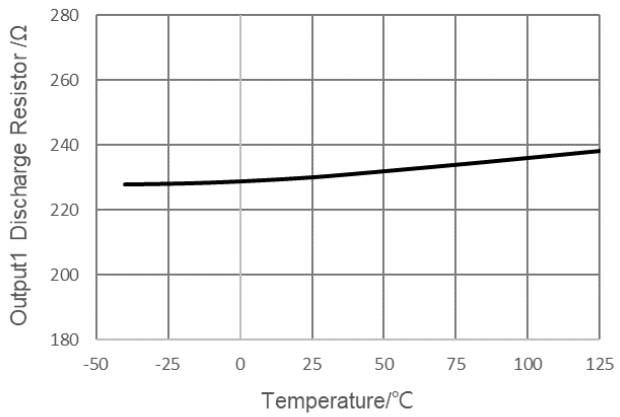
Quiescent Current vs. Temperature



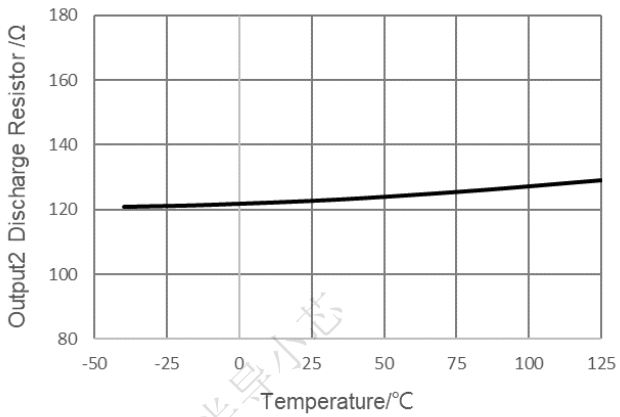
Shutdown Current vs. Temperature



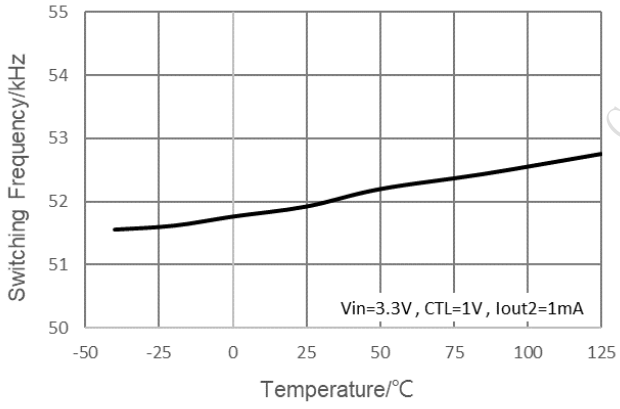
Output1 Discharge Resistor vs. Temperature



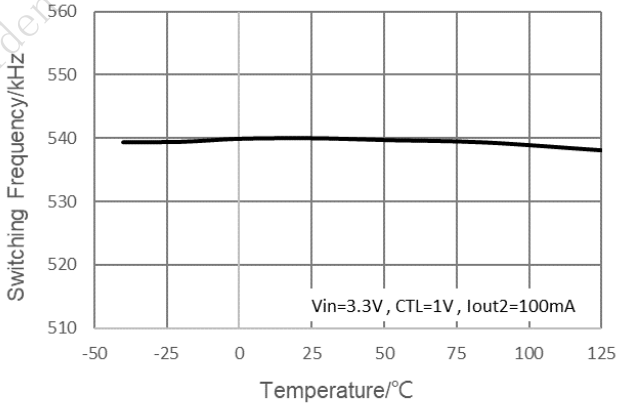
Output2 Discharge Resistor vs. Temperature



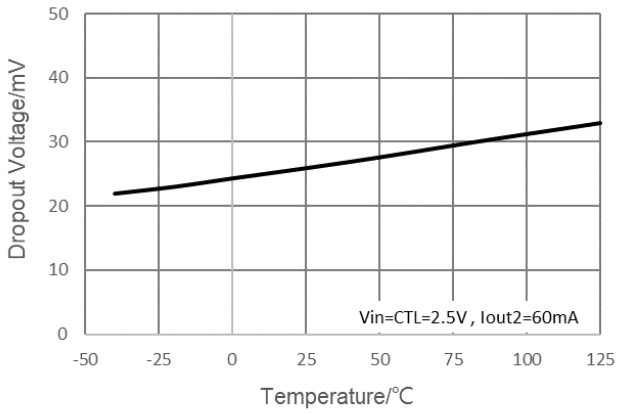
Frequency vs. Temperature



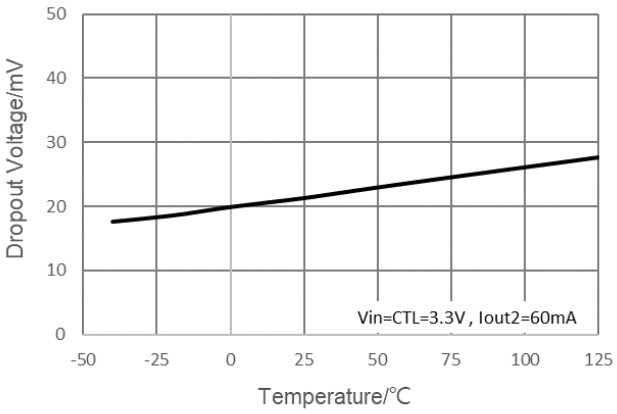
Frequency vs. Temperature



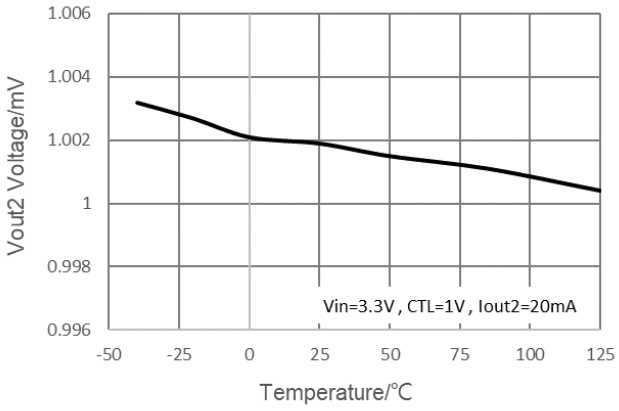
Vout2 Dropout Voltage vs. Temperature



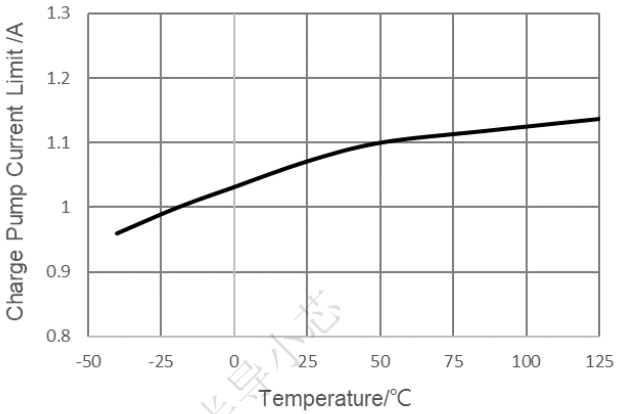
Vout2 Dropout Voltage vs. Temperature



Vout2 Voltage vs. Temperature

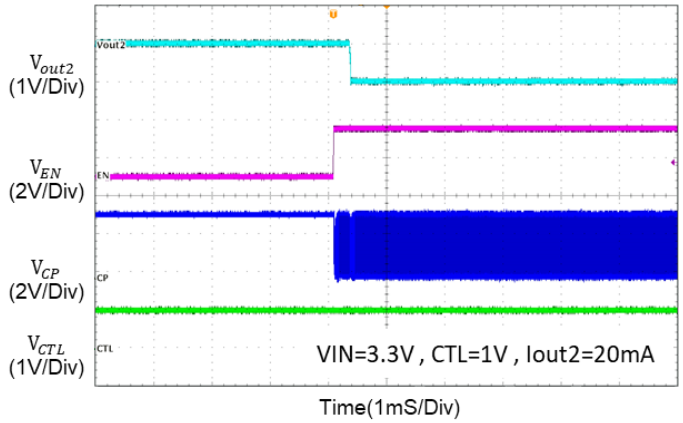


Charge Pump Current Limit vs. Temperature

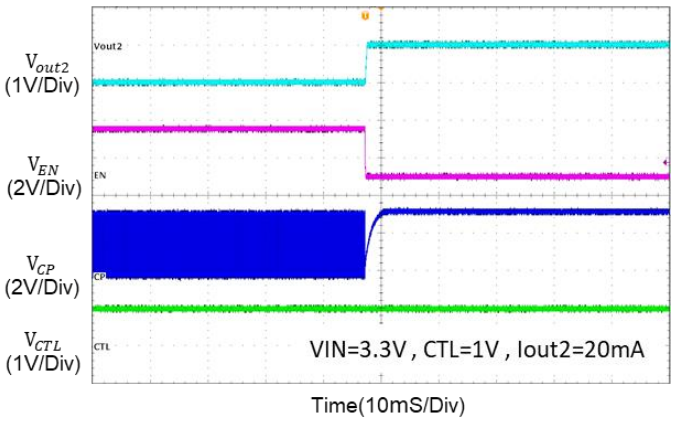


V_{IN}= 3.3V , V_{OUT1}= -3.3V , C_{IN}=C_{FLY}=C_{OUT1}=C_{OUT2}=4.7μF , Ambient Temperature = +25°C.

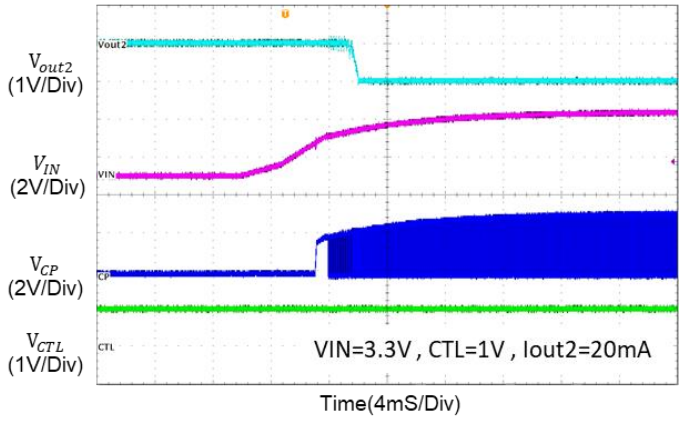
Power On from EN



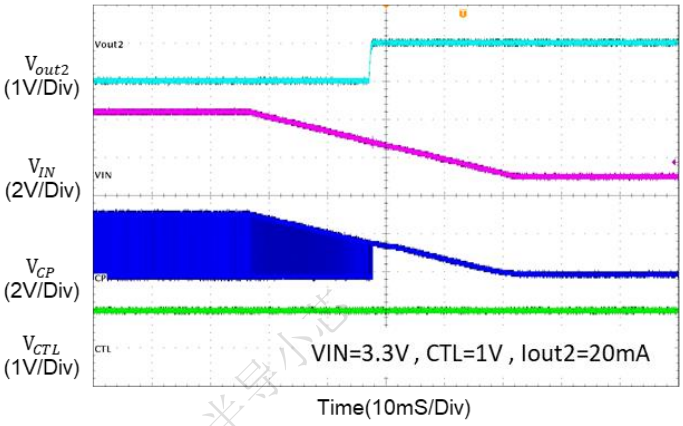
Power Off from EN



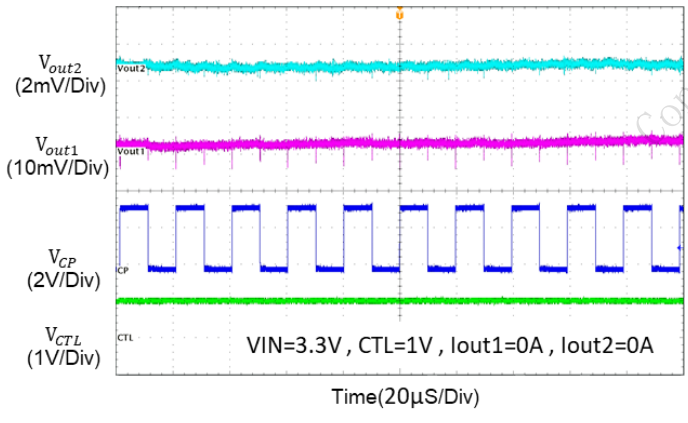
Power On from VIN



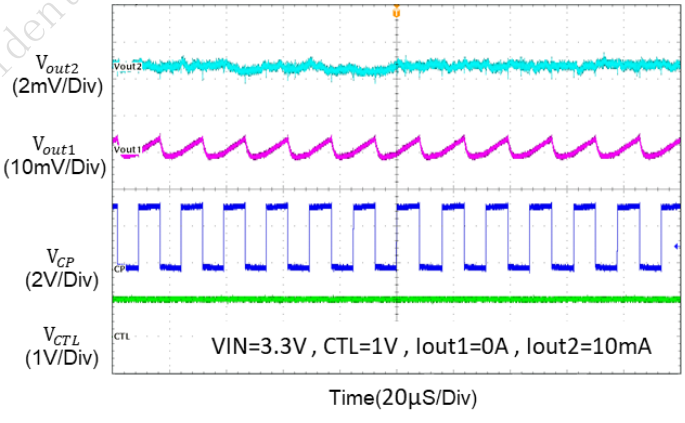
Power Off from VIN



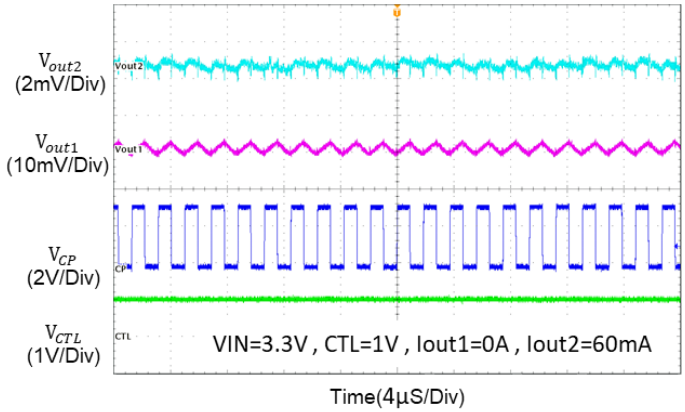
Steady State



Steady State



Steady State



FUNCTIONAL DESCRIPTION

Function Description

The XPB4418 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 XKB4418 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 XPB4418 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 ranges from 30k to 550kHz. The XPB4418 will auto adjust the frequency according to the V_{IN} and V_{OUT1} voltage gap. In theory, the oscillator frequency will increase as the load increases. The higher frequency will compensate the output ripple when in a heavy-load condition.

When the absolute value of V_{OUT1} is less than 1V, the charge pump treats it as an over-current condition. The XPB4418 will force the oscillator frequency to 45kHz for fold-back.

The charge pump frequency of XPB4418B is fixed to 470kHz.

There is a diode between VOUT1 and GND. When the V_{OUT1} voltage is higher than 0.3V, the diode will discharge V_{OUT1}.

Negative Linear Regulator

The XPB4418 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 XPB4418 load capability is 200mA; the sum of I_{OUT1} and I_{OUT2} is less than 200mA. 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 1A.

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 XPB4418 can be enabled by pulling EN higher than 0.8V. 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 XPB4418 is related to the charge pump frequency and fly capacitor. See Equation:

$$Ro=1/(f*C_{Fly})+8*R_{ON}$$

R_{ON} is the on-resistance of each switch MOSFET in the charge pump. The charge pump output OUT1 voltage is related to I_O and R_O. See Equation:

$$V_{OUT1}=-(V_{IN}-Io*Ro)$$

Soft Start

The XPB4418 linear regulator has an internal soft-start pin that ramps up the output voltage at a controlled slew rate to avoid overshoot at start-up.The soft start slew-rate is set internally to 5V/ms, typical

Application Information

Selecting the Output Capacitor

The output capacitors (C_{OUT1} and C_{OUT2}) stabilize the DC output voltage. For stable operation, use a X5R or X7R ceramic capacitor. Using a 1μF capacitor for C_{OUT1} and a 1μF-10μF capacitor for C_{OUT2} is recommended. Larger C_{OUT2} values improve load transient response and reduce noise. Output capacitors of other dielectric types may be used but are not recommended, as their capacitance can deviate greatly from their rated value over temperature.

The characteristics of the output capacitor also affect the stability of the regulation system.

Selecting the Input Capacitor

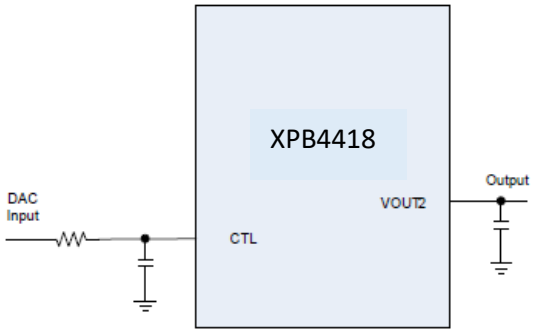
Place a ceramic, dielectric X5R/X7R capacitor (C_{IN}) between 1μF-10μF between the input pin and ground. Larger values in this range will improve line transient response.

Selecting the Fly Capacitor

The fly capacitor will affect the output resistance and OUT1 voltage. If the output current is high, a larger fly capacitor is recommended. Placing the fly capacitor close to C_{IN} and C_{OUT1} is recommended. Using the same capacitor for C_{IN}, C_{OUT1} and C_{FLY} is ideal.

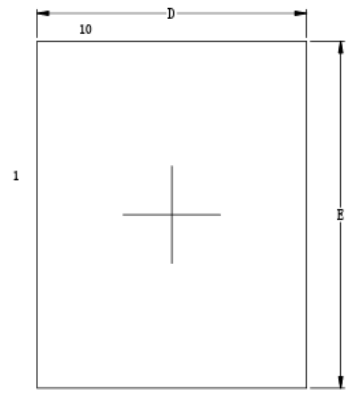
Selecting the Output Voltage

The linear regulator will follow the CTL voltage. The output value is regulated to -1x the CTL voltage. CTL is an analog input and can be directly connected to the DAC output. Figure shows the application circuit.

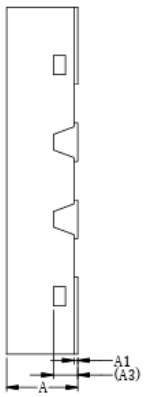


Physical Dimensions

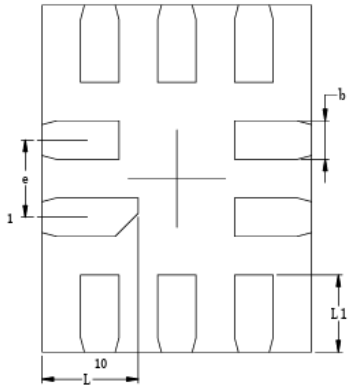
QFN-10 (1.4mmx1.8mm) Package



TOP VIEW
[顶视图]



SIDE VIEW
[侧视图]

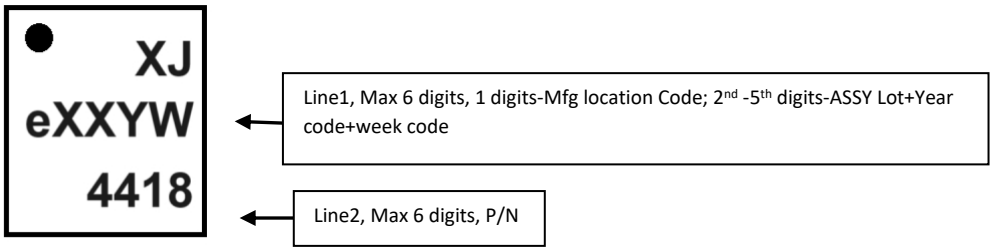


BOTTOM VIEW
[背视图]

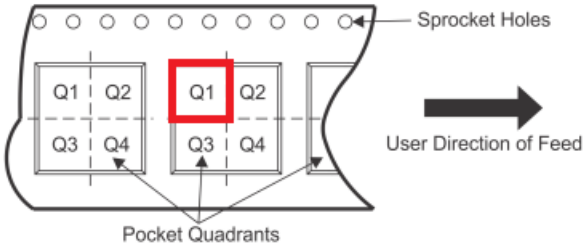
		SYMBOL	MIN	NOM	MAX
TOTAL THICKNESS		A	0.4	0.45	0.5
STAND OFF		A1	0	0.02	0.05
L/F THICKNESS		A3		0.127 REF	
LEAD WIDTH		b	0.15	0.2	0.25
BODY SIZE	X	D	1.3	1.4	1.5
	Y	E	1.7	1.8	1.9
LEAD PITCH		e		0.4 BSC	
LEAD LENGTH		L	0.45	0.5	0.55
		L1	0.35	0.4	0.45

Marking and Reel Information

Format:



Pin 1 located in Q1 direction in T&R



Remark:

Font: Arial

Letter height of 0.5mm

Side pitch of 0.4mm

Line space of 0.25mm

Logo of XINJI should be required and placed on assigned Logo position as upside illustration.

Trace-ability Code:

1. Manufacturing Location Code + Assembly lot#+Year Code+WK code Line 1

a) 1st digit: Assembly location code: e

b) 2nd & 3rd digit: Assembly lot number

c) 4nd digit: Year code.

Year Code 2020-2051

Year	Code
2020	0
2021	1
2022	2
2023	3
2024	4
2025	5
2026	7
2027	C

Year	Code
2028	D
2029	E
2030	F
2031	H
2032	I
2033	J
2034	K
2035	L

Year	Code
2036	N
2037	P
2038	R
2039	S
2040	T
2041	U
2042	V
2043	X

Year	Code
2044	Y
2045	Z
2046	b
2047	c
2048	d
2049	h
2050	i
2051	j

d)5th digit: Week code, 1～9， A～Z（10~35)， a～z (36~53)

WK01 means the 1st Work Week based on XinJi's calendar.

WK01	WK02	WK03	WK04	WK05	WK06	WK07	WK08	WK09
1	2	3	4	5	6	7	8	9

WK10	WK11	WK12	WK13	WK14	WK15	WK16	WK17	WK18
A	B	C	D	E	F	G	H	I

WK19	WK20	WK21	WK22	WK23	WK24	WK25	WK26	WK27
J	K	L	M	N	O	P	Q	R

WK28	WK29	WK30	WK31	WK32	WK33	WK34	WK35	WK36
S	T	U	V	W	X	Y	Z	a

WK37	WK38	WK39	WK40	WK41	WK42	WK43	WK44	WK45
b	c	d	e	f	g	h	i	j

WK46	WK47	WK48	WK49	WK50	WK51	WK52	WK53
k	l	m	n	o	p	q	r

2. Product Number Code: Line 2

Product Name	P/N Code	Remark
XPB4418AQ10R	4418A	