

DESCRIPTION

The XR3651 is a high performance buck boost converter that the output voltage can be programmed from 0.9V up to 20V through external resistor.

The XR3651 implements the Buck Boost converter with a single inductor architecture that operates from input voltages above, below or equal to the output voltage. And support 2-switch boost mode for higher efficiency.

The integrated low Rds(on) MOSFET minimizes physical footprint, maximizes efficiency, which reduces the power dissipation. Constant current control is utilized to protect the device from overshooting in unwanted conditions. Built-in loop compensation simplifies the circuit and design.

XR3651 guarantees robustness with under voltage lockout, short circuit protection and thermal protection.

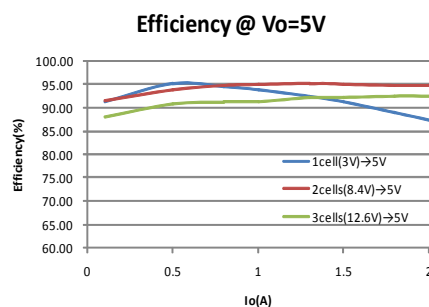
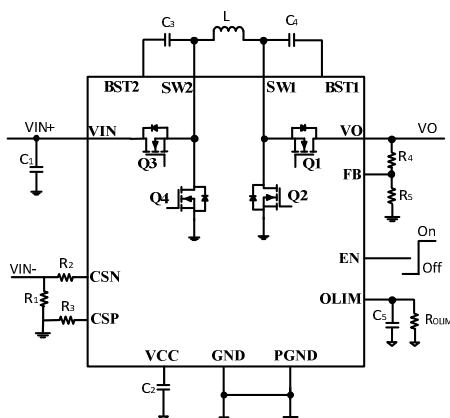
FEATURES

- Integrate low R_{DS} (on) power MOSFET
- Wide V_{IN} range: 3.0V-21V
- Wide V_O range: 0.9V-20V
- Compatible with 4-switch buck-boost mode and 2-switch boost mode.
- Fixed frequency 450kHz
- Programmable input and output current limit
- Output Constant Current Control.
- Quiescent current: <60uA
- Integrate output short protection
- Integrate thermal protection
- QFN3*4 package

APPLICATIONS

- Power bank systems
- USB Power Delivery
- Industrial applications
- Automotive Systems

TYPICAL APPLICATION



ORDER INFORMATION

DEVICE ¹⁾	PACKAGE	TOP MARKING ²⁾
XR3651QFNE#TRPBF	QFN3×4-15	XR3651 XXXXXX

Notes:

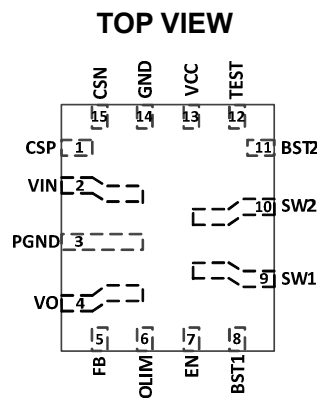
1) XR

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 #TRPBF
└─ PB Free
└─ Tape and Reel (If "TR" is not shown, it means tube)
└─ Package Code
└─ Part No.

2) Line 1 of top marking means Part No., and the line 2 of top marking means Date Code.

PIN CONFIGURATION



ABSOLUTE MAXIMUM RATING¹⁾

VO, VIN, SW1, SW2 Pin	-0.3V to 24V
BST1-SW1, BST2-SW2	-0.3V to 6.5V
All Other Pins	-0.3V to 6.5V
Junction Temperature ²⁾³⁾	150°C
Lead Temperature	260°C
Storage Temperature	-65°C to +150°C
ESD Susceptibility (Human Body Model)	2kV

RECOMMENDED OPERATING CONDITIONS

Input Voltage VIN	3.0V to 21V
Output Voltage VO	0.9V to 20V
Operation Junction Temp (T _J)	-40°C to +125°C

THERMAL PERFORMANCE⁴⁾ $\theta_{JA}\theta_{JC}$

QFN3X4-15	48... 11°C/W
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Note:

- 1) Exceeding these ratings may damage the device.
- 2) The XR3651 guarantees robust performance from -40°C to 150°C junction temperature. The junction temperature range specification is assured by design, characterization and correlation with statistical process controls.
- 3) The XR3651 includes thermal protection that is intended to protect the device in overload conditions. Thermal protection is active when junction temperature exceeds the maximum operating junction temperature. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.
- 4) Measured on JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

<i>V_{IN}=12V, T_A=25 °C, unless otherwise stated</i>						
Item	Symbol	Condition	Min.	Typ.	Max.	Units
General parameters						
VIN voltage range	V _{IN}		3.0		21	V
VIN under voltage lockout	V _{INUVLO}	V _{IN} falling	2.8	3.0	3.1	V
		V _{IN} falling	2.45	2.6	2.75	V
VCC output voltage	V _{CC}		4.7	5	5.3	V
VCC output current limit	I _{VCC}	V _{VCC} =0V		50		mA
Supply current in shut-down mode	I _Q	V _{IN} =4V, V _{EN} =0V	30		60	μA
EN Logic HIGH	V _{ENH}	V _{EN} rising			2.5	V
EN Logic LOW	V _{ENL}	V _{EN} falling	1.6			V
Switch frequency	F _{sw} ⁵⁾		350	450	550	kHz
Switch minimum off time	T _{off_min} ⁵⁾		80	100	120	ns
Bucktopswitch on-resistance	R _{dsbkTG} ⁵⁾			20	28	mΩ
Buck bottom switch on-resistance	R _{dsbkBG} ⁵⁾			20	28	mΩ
Boost top switch on-resistance	R _{dsbstTG} ⁵⁾			20	28	mΩ
Boost bottom switch on-resistance	R _{dsbstBG} ⁵⁾			20	28	mΩ
Feedback voltage	V _{FB}		0.885	0.9	0.915	V
Input average current limit	I _{IN_LIM}	R ₁ =10mΩ; R ₂ =R ₃ =3kΩ;	2.85	3	3.15	A
OLIM pin output current sense ratio	K _{OLIM}	I _O =2A	4	5	6	μA/A
OLIM pin regulate voltage	V _{OLIM}			400		mV
Output average current limit	I _{O_LIM}	R _{OLIM} =40KΩ	1.9	2	2.1	A
Buck region, (IL Valley)	I _{COMP(MAX)} ⁵⁾	V _{VCC} >4.8V		7		A
Boost region, (IL Peak)		V _{VCC} >4.8V		7		
Protection						
Thermal shutdown threshold ⁵⁾	T _{SHUT}			150		°C
Thermal recovery threshold ⁵⁾	T _{REC}			130		°C

Notes:

5) Guaranteed by design.

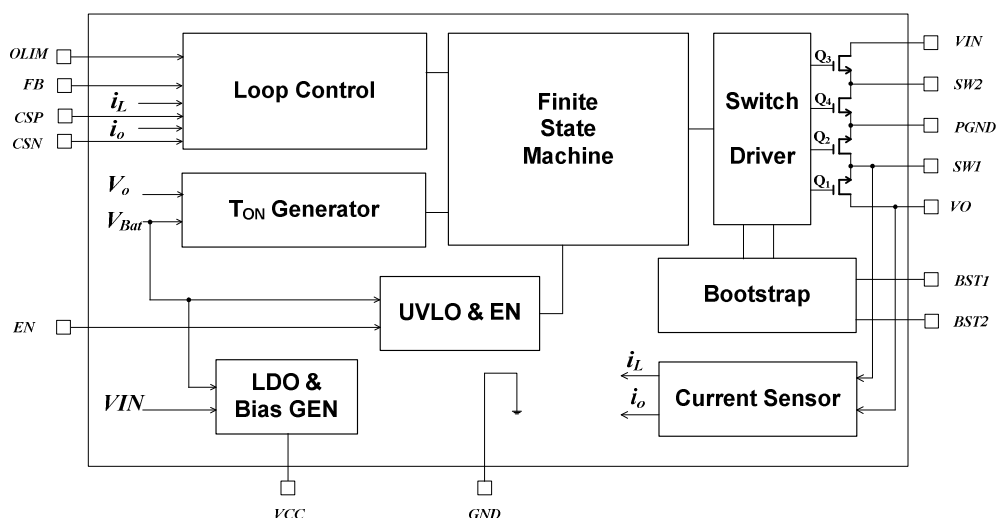
PIN DESCRIPTION

Pin No.	Name	Description
1	CSP	Positive terminal of current sense.
2	VIN	Input pin, place bypass capacitor close to this pin.
3	PGND	Power Ground.
4	VO	Output pin, place bypass capacitor close to this pin.
5	FB	Output feedback pin.
6	OLIM	Output current limit program pin. Connect a resistor to GND to set the maximum average current. And in the light load, it could be output current detection pin.
7	EN	Enable control pin. Forcing the pin below 1.6V shuts down the converter, reducing quiescent current. Once the EN pin rises above 2.5V, the IC is turned on.
8	BST1	VO side bootstrap supply pin for top switch. 0.1uF capacitor is connected between BST1 and SW1 pins.
9	SW1	VO side power switching node.
10	SW2	VIN side power switching node. Connect to SW1 with inductor
11	BST2	VIN side bootstrap supply pin for top switch. 0.1uF capacitor is connected between BST2 and SW2 pins.
12	TEST	Test pin. Tie this pin to GND for normal operation.
13	VCC	5V LDO for power driver and internal circuit. Must be bypassed to GND with a minimum of 10uF ceramic capacitor for stable operation.
14	GND	Signal GND.
15	CSN	Negative terminal of current sense.

Notes:

Highlighted pins are high current pins

BLOCK DIAGRAM

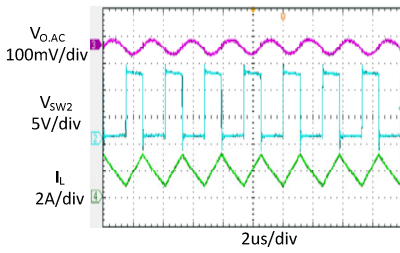


TYPICAL PERFORMANCE CHARACTERISTICS

$V_{IN} = 12V$, $V_O = 5.0V$, $L = 3.3\mu H$, $C_O = 40\mu F$, $T_A = +25^\circ C$, unless otherwise noted

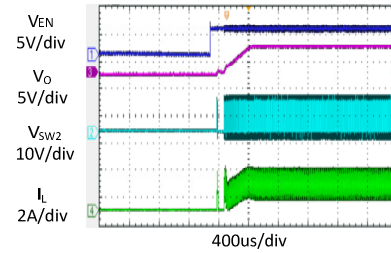
Steady State Test

$V_{IN} = 12V$, $V_O = 5.0V$
 $I_O = 2A$



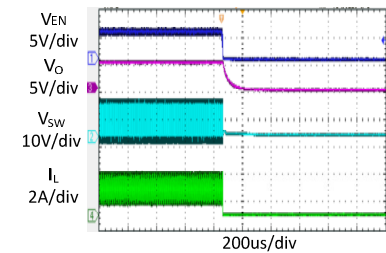
Startup through Enable

$V_{IN} = 12V$, $V_O = 5.0V$
 $I_O = 2A$ (Resistive load)



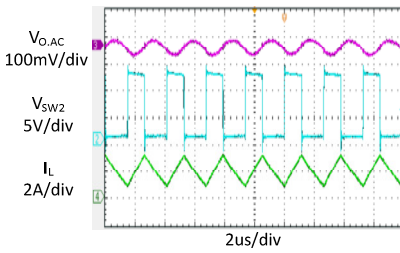
Shutdown through Enable

$V_{IN} = 12V$, $V_O = 5.0V$
 $I_O = 2A$ (Resistive load)



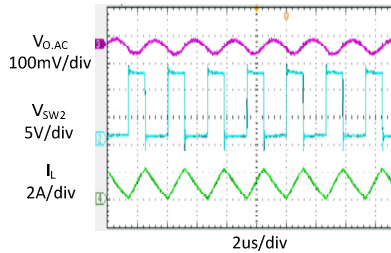
Heavy Load Operation

2A LOAD



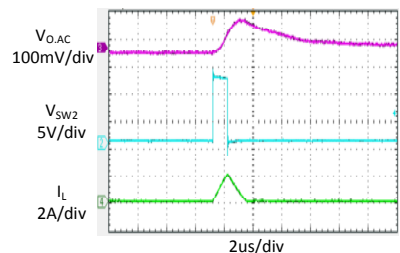
Medium Load Operation

1A LOAD



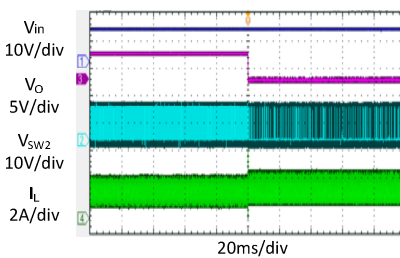
Light Load Operation

0 A LOAD



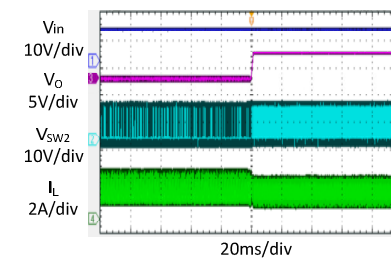
Short Circuit Protection

$V_{IN} = 12V$, $V_O = 5.0V$
 $I_O = 1.93A$ -Short



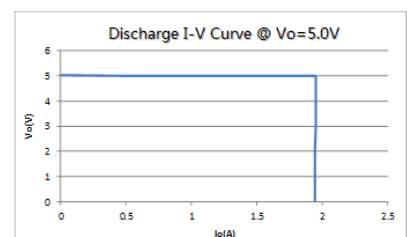
Short Circuit Recovery

$V_{IN} = 12V$, $V_O = 5.0V$
 $I_O = \text{Short}-1.93A$



Discharge I-V Curve

$V_{IN} = 12V$, $V_O = 5.0V$
 $I_{O_LIM} = 2A$



FUNCTIONAL DESCRIPTION

XR3651 is a monolithic buck-boost DC to DC converter that can operate over a wide input voltage range of 3.0V to 21V. The output voltage can be programmed between 0.9V to 20V and deliver 3A of load current. Internal, low $R_{DS(ON)}$ N-channel power switches reduce the solution complexity and efficiency.

Flexible Buck-Boost Converter

The XR3651 contains flexible buck-boost converter for either buck or boost converter. When V_{IN} is higher than output voltage, it is a buck converter. When V_{IN} is lower than output voltage, it is a boost converter.

The DC-DC converter utilizes proprietary single inductor current-mode control to guarantee smooth transition between buck and boost operation with better dynamic response and cycle-by-cycle current protection.

XR3651 regulates the output voltage and output current.

Output Voltage

The output voltage is set by an external feedback resistive divider. The feedback signal is compared with internal precision 0.9V voltage reference by the error amplifier. The output voltage is given by the equation:

$$V_o(V) = \frac{0.9(V) \times (R_4 + R_5)}{R_5}$$

Where R_4 and R_5 are defined in typical application figure.

Programmable Input/Output Current Limit

As shown in figure1, the current sense resistor R_{CS} should be placed input terminal or output terminal and closed to the R_{ISET} . The input/output current limit is set by R_{ISET} and R_{CS} ,

which is optional. If the input/output current limit is not desired, the CSN pin should be shorted to VCC, and the CSP pin shorted to GND.

$$I_{IN/IO_LIM}(A) = \frac{R_{ISET}(k\Omega)}{R_{CS}(m\Omega)} \times 10(\mu A/A)$$

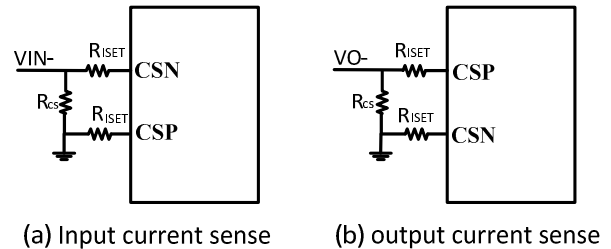


Figure1. Programmable current limit

If the input and output current limit are all necessary. The secondary output current limit can be programmable by R_{OLIM} pin.

$$I_{O_LIM}(A) = \frac{0.4(V)}{R_{OLIM}(k\Omega)} \times 0.2(A/\mu A) \times 1000$$

If the output current equals to the I_{O_LIM} , the output current loop begins to work, it turns down output voltage to limit the output power. When $OLIM$ is not used, it should be shorted to GND. When output is shorted to ground, the XR3651 works as a buck converter, the output current is continuously sensed and limited to I_{O_LIM} . When the output short is removed, the regulator comes into normal operation again.

VIN UVLO

When V_{IN} decreases to V_{IN_UVLO} , the discharging process is terminated. When the V_{IN} recovers and is larger than V_{IN_UVLO} , the XR3651 can re-discharge if the V_{EN} is still high.

Thermal Control

When the junction temperature of the XR3651 rises above 135°C, it begins to reduce the output power to prevent the temperature from rising further. If the junction temperature of

the XR3651 rises above 150°C, the discharging process stops.

Shut-down Mode

The XR3651 shuts down when voltage at EN pin is below 1.6V. The entire regulator is off.

PCB Layout Note

For minimum noise problem and best operating performance, the PCB is preferred to following the guidelines as reference.

1. Place the input decoupling capacitor as close to XR3651 (VIN pin and PGND) as possible to eliminate noise at the input pin. The loop area formed by input capacitor and GND must be minimized.
2. Put the feedback trace as far away from the inductor and noisy power traces as possible.
3. The ground plane on the PCB should be as large as possible for better heat dissipation

Reference Design

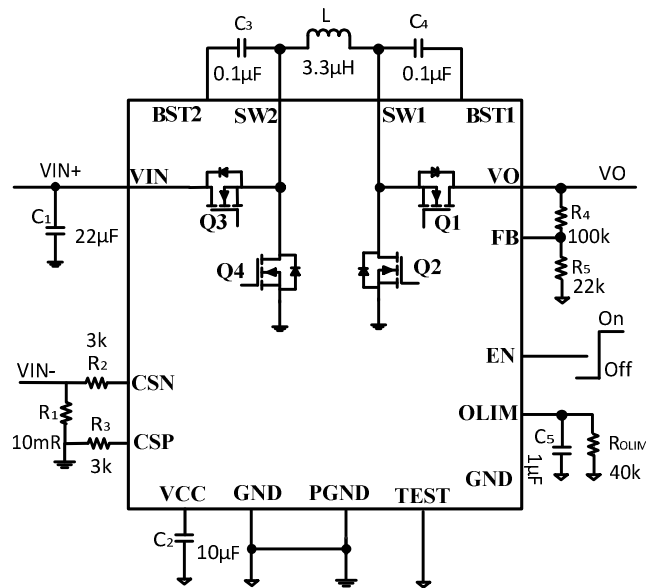
Reference 1: Input and output current limit set

V_{IN} : 3.0V ~ 21V

V_{OUT} : 5.0V

I_{IN_LIM} : 3A

I_{O_LIM} : 2A

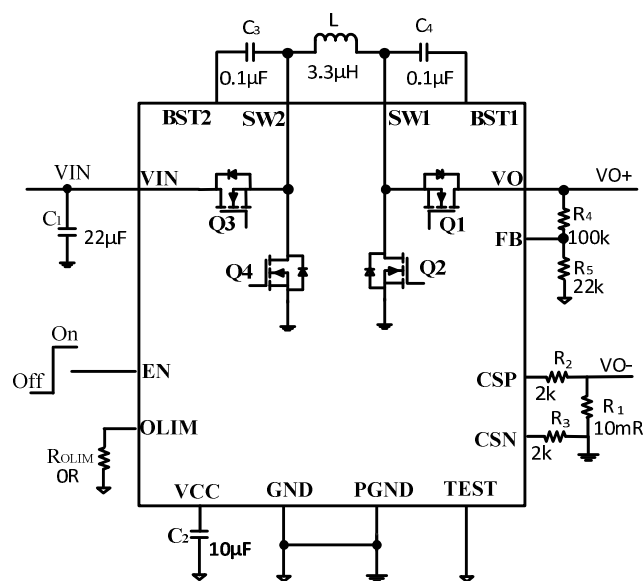


Reference 2: Only output current limit set

V_{IN} : 3.0V ~ 21V

V_{OUT} : 5.0V

I_{O_LIM} : 2A

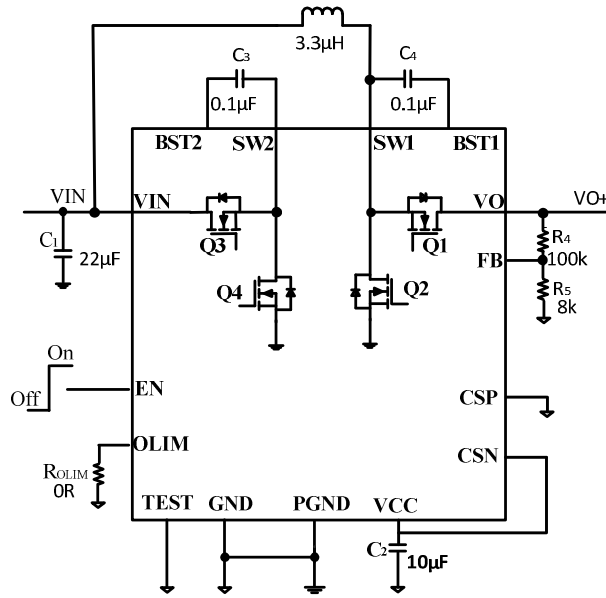


Reference 3: 2-switch mode and no current limit

V_{IN} : 5.0V ~ 10 V

V_{OUT} : 12V

I_O : 0~2A



PACKAGE OUTLINE

