JW3653 JW3653-1

16V/3A 4-Switch Buck-Boost Charging/Discharging Converter

Parameters Subject to Change Without Notice

DESCRIPTION

The JW3653 is a buck boost converter targets HVDC fast charging and discharging power bank. The JW3653 support 1 to3 cells Li-ion battery, the output voltage can be programmable up to 16.0V through external resistor.

The JW3653 implements the Buck Boost converter with an H-bridge, which can maintain output regulation for input voltage whether greater or less than output voltage.

The integrated low Rds(on) MOSFET minimizes physical footprint, maximizes charge/discharge efficiency, which reduces the power dissipation during discharge. Constant current control is utilized to protect the device from overshooting in unwanted conditions. Built-in loop compensation simplifies the circuit and design. PFM is engaged to maintain high efficiency at light load current.

JW3653 guarantees robustness with thermal protection and battery under voltage lockout.

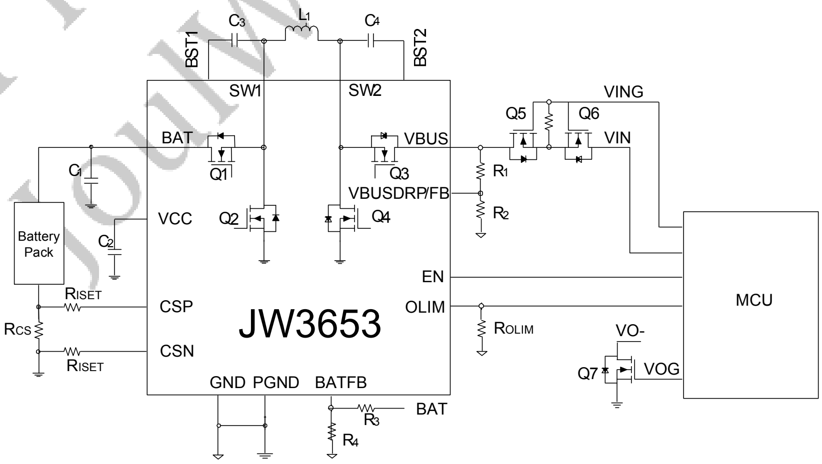
FEATURES

- Integrate low R_{DS} (on) power MOSFET
- Wide input range: 3.0V-16.0V, Support 1to3 cells battery charge/discharge.
- Wide output range:1.2V-16.0V
- High efficiency buck-boost transition
- 500kHz Switching frequency
- Programmable output current limit, up to 3A
- Output Constant Current Control.
- Quiescent current: <50uA
- Integrate output overvoltage protection and output short protection
- Integrate thermal protection
- QFN3*4 package

APPLICATIONS

- Power bank systems
- Battery and Super capacitor Charging
- USB Power Delivery
- Industrial applications
- Automotive Systems

TYPICAL APPLICATION



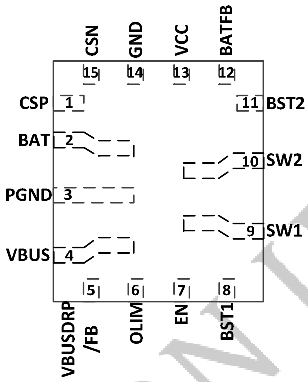
ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PACKAGE	TOP MARKING
JW3653QFNE#PBF	JW3653QFNE#TRPBF	QFN3X4-15	JW3653
JW3653-1QFNE#PBF	JW3653-1QFNE#TRPBF	QFN3X4-15	JW3653-1

Note：

PIN CONFIGURATION

TOP VIEW



ABSOLUTE MAXIMUM RATING1)

VBUS,BAT, SW1, SW2Pin ....-0.3V to 20V
BST1-SW1, BST2-SW2 ……..-0.3V to 6.5V
All Other Pins ....-0.3V to 6.5V
JunctionTemperature2)3) 150ºC
Lead Temperature 260ºC
Storage Temperature .... -65ºC to +150ºC

RECOMMENDED OPERATING CONDITIONS

Output Voltage VBUS..1.2V to 16V
Battery Voltage VBAT ....3.0V to 16V
Operation Junction Temp (T_J) ……..-40ºC to +125ºC

THERMAL PERFORMANCE4) θ_{JA} θ_{JC}

QFN3X4-15..48……11ºC/W

Note：

1) Exceeding these ratings may damage the device.
2) The JW3653guarantees robust performance from -40°Cto 150°C junction temperature. The junction temperature range specification is assured by design, characterization and correlation with statistical process controls.
3) The JW3653 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 CHARATERISTICS

VIN=12V, TA=25℃, unless otherwise stated						
Item	**Symbol**	**Condition**	**Min.**	**Typ.**	**Max.**	**Units**
Power supply						
VBAT voltage range	V_{BAT}		3.0		16	V
VCC UVLO voltage	V_{CCUVLO}	VBUS=0V	1.8	2.1	2.4	V
BST UVLO voltage	$V_{BSTUVLO}$		2.3	2.4	2.5	V
VCC output voltage	V_{CC}		4.75	4.8	4.85	V
VCC output current limit	I_{VCC}	VCC>2.7V	70	80	90	mA
		VCC<2.7V	15	20	25	mA
Supply current in shut-down mode	I_Q	V_{BAT}=8V, EN=0V	40	50	60	μA
Controller						
Switch frequency	F_{sw}	Optional switch frequency through trim	235	250	275	kHz
			450	500	550	
Switch minimum off time	T_{off_min}		80	100	120	ns
EN Logic HIGH	V_{ENH}	V_{BAT}=8V	1.5			V
EN Logic LOW	V_{ENL}	V_{BAT}=8V			0.4	V
Buck top switch on-resistance	R_{dsbkTG}			20	28	mΩ
Buck bottom switch on-resistance	R_{dsbkBG}			20	28	mΩ
Boost top switch on-resistance	$R_{dsbstTG}$			20	28	mΩ
Boost bottom switch on-resistance	$R_{dsbstBG}$			20	28	mΩ
Charge						
Floating BAT Voltage	V_{CV}	V_{BATFB} =GND, JW3653	8.35	8.4	8.45	V
		V_{BATFB} =GND, JW3653-1	8.65	8.7	8.76	V
		V_{BATFB} = VCC, JW3653	12.52	12.6	12.68	V
		V_{BATFB} = VCC, JW3653-1	12.97	13.05	13.13	V
		Set by divider resistance	3.0	-	16	V
BAT feedback voltage	V_{BATFB}	External resistor divider	1.194	1.2	1.206	V
BAT Recharge threshold	V_{REC}	V_{BATFB} = GND	7.95	8.0	8.05	V
		V_{BATFB} = VCC	11.25	12.0	12.75	V
BAT recharge feedback threshold	V_{RECFB}		1.136	1.143	1.15	V
CC mode charge current	I_{CC}	R_{CS}=10 mΩ, R_{ISET}=2K	1.8	2	2.2	A
Charge termination current	I_{TER}			$0.05I_{CC}$		mA
Battery current sensing ratio	K_{RATIO}		9	10	11	uA/A
Trickle mode charge current	I_{TRI}			$0.1I_{CC}$		mA

Trickle mode battery threshold	V_{TRI}	Referred to one battery cell		3.0V/cell		
Trickle charge time-out duration	T_{TRI}		50	55	60	min
VBUS UVP threshold	V_{BUS_UVP}	rising	3.98	4.1	4.22	V
		falling	3.7	3.85	4	V
VBUS delay to start charging	t_{chg_delay}		360	150	440	mS
Initial charge current	I_{CHG_ini}		300	400	500	mA
Charge current increase step	I_{STEP1}		150	100	250	mA
Charge current increase period	t_{STEP1}		40	50	60	mS
VBUS droop voltage to foldback charge current	V_{DRP}		R1*3.8μA	R1*4μA	R1*4.2μA	V
Charge current limit decline step	I_{STEP2}		180	100	220	mA
Charge current limit decline period	t_{STEP2}		2.25	2.5	2.75	S
Buck exit time	t_{buck_exit}		1.8	2	2.2	S
Protection						
VBUS OVP threshold	V_{BUS_OVP}	rising	16.8	17.4	17.9	V
		falling	15.15	15.8	16.35	V
VBUS OVP deglitch time	t_{BUS_OVP}		1.8	2	2.2	μS
Thermal shutdown threshold[5)]	T_{SHUT}			150		°C
Thermal recovery threshold[5)]	T_{REC}			130		°C

Notes:

5) Guaranteed by design.

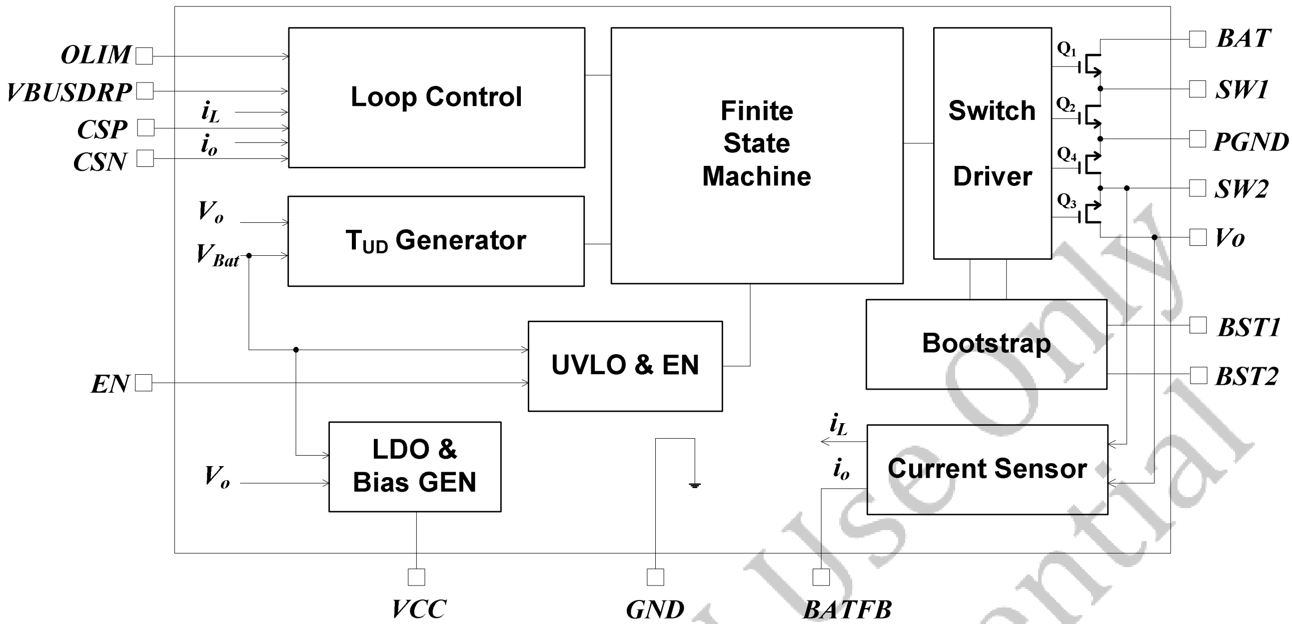
PIN DESCRIPTION

Pin No.	Name	Description
1	CSP	Positive terminal of battery charge current sense.
2	BAT	Battery positive terminal.
3	PGND	Power Ground.
4	VBUS	Main supply pin, connect to adaptor.
5	VBUSDRP/FB	VBUS droop allowance program pin.
6	OLIM	Battery charge current output pin and it is pulled up to indicate full charge.
7	EN	Enable control pin. In charge mode, forcing the pin below 0.4V turns on the controller. In discharge mode, the EN pin rises above 1.5V, the IC is turned on.
8	BST2	VBUS side bootstrap supply pin for top switch. 0.1uF capacitor is connected between BST2 and SW2 pins.
9	SW2	VBUS side power switching node. connect to SW2 with inductor
10	SW1	BAT side power switching node.
11	BST1	BAT side bootstrap supply pin for top switch. 0.1uF capacitor is connected between BST1 and SW1 pins.
12	BATFB	Battery float voltage configuration pin. 1. This pin tied to GND or VCC, sets different float voltage. Pin short to GND: 8.4V/8.7V. Pin shorts toLDO:12.6V/13.05V. 2. And the float voltage could be set to any value (3.0V-16.0V) by the external divider resistor.
13	VCC	4.8V 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 battery charge current sense.

Notes:

Highlighted pins are high current pins

BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

JW3653 is a monolithic buck-boost DC to DC converter that can operate over a wide input voltage range of 3.0V to 16V. The output voltage can be programmed between 1.2V to 16V and deliver 3A of load current. Internal, low R_{DSON} N-channel power switches reduce the solution complexity and efficiency.

Flexible Bidirectional Buck-Boost Converter

The JW3653 contains flexible bidirectional DC-DC converter for either buck or boost converter. When battery voltage is higher than output voltage, it is a buck converter. When input voltage is lower than battery 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.

Compensation is done internally on the chip. The JW3653 operates in PFM mode at light load. In PFM mode, switching frequency is continuously controlled in proportion to the load current, i.e. switch frequency is decreased when load current drops to boost power efficiency at light load by reducing switching-loss, minimizing the circuit.

The JW3653 can operate in charge and discharge mode according to EN and VBUS voltage. If the EN is high, the device operates in discharge mode. If the EN is low and the VBUS is larger than V_{BUS_UVP} for 400ms, the JW3653 operates in charge mode.

Either in charge or discharge mode, the JW3653 can operate in buck or boost state.

In charge mode, if the VBUS voltage is lower than battery voltage，it is a buck converter. When the VBUS voltage is larger than battery voltage, it is a boost converter.

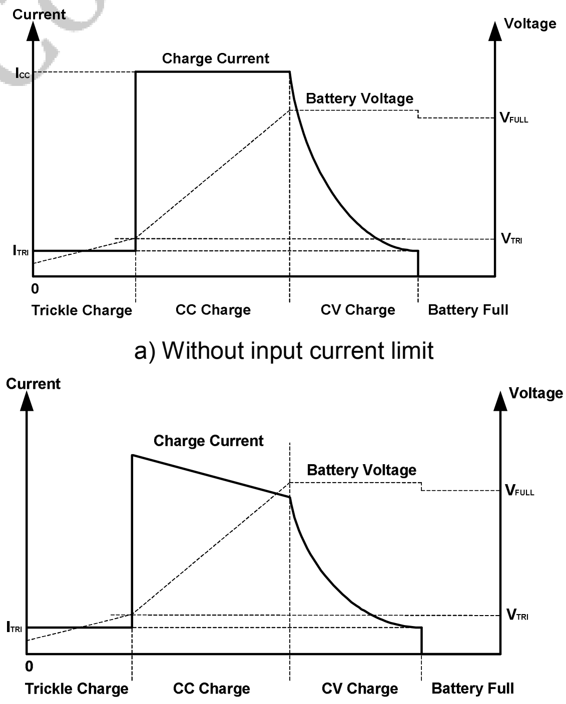
Similarly, the JW3653 can operate as a buck or boost converter according to VBUS voltage and battery voltage in discharge mode.

BST UVLO

If the BST1-SW1 or BST2-SW2 voltage is lower than BST UVLO Voltage, the switch is turned off.

Charge mode

In charge mode, JW3653regulates the battery current according to input voltage and battery voltage. It charges battery with three phases: trickle charge, constant current charge, constant voltage charge and charge termination. Figure 7(a) is a typical charge profile. Figure 7(b) is a charge profile with input current limit. When the input current is limited, the system decreases the charge current.



b) With input current limit

Figure 5 Typical Charge Profile

Trickle charge

The JW3653 charges the battery with I_{TRI} when battery voltage is less than V_{TRI}. If charging remains in TC mode beyond the trickle-charge time T_{TRI}, charging terminates.

CC charge

When the battery is higher than V_{TRI}, the device charges the battery with I_{CC} if the input current is sufficient. When input current limit is hit, the device reduces the charge current automatically. The JW3653 can set the charge current through $R_{ISET.}$ The maximum charge current is up to 3A.

$$I_{CC}(A) = \frac{10(A) R_{ISET}(K\Omega)}{R_{CS}(m\Omega)}$$

CV charge

When battery voltage equals to V_{CV}, the device regulates the battery voltage and reduces the charge current reduces automatically.

The customer can select 2 or 3 cells or program the V_{CV} through BATFB pin. Connect BATFB to GND selects 2 cells. Connect BATFB to VCC selects 3 cells. The V_{CV} also can be programmable by resistor divider connected to BATFB when the JW3653 detect a resistor connect to this pin.

$$V_{CV}(V) = \frac{1.2\,V \times (R_3 + R_4)}{R_4}$$

Charge termination

If the battery voltage is higher than V_{FULL}, and the charge current is less than charge termination current I_{TER} for T_{FULL}, the charge process terminates, the OLIM pin is pulled high.

Auto recharge

Once the battery charge cycle completes, the charger remains off. A new charge cycle automatically begins when the battery voltage falls below the auto-recharge threshold V_{REC} if the input adaptor is present. The idle mode to charge mode transition also restarts the charge cycle.

Battery current sensing

In charge mode, the battery current is monitored continuously. The JW3653 senses the battery current and output through OLIM pin.

Dynamic input Current Tracking Scheme

When the adaptor is plugged in for 0.4s, the JW3653 starts charging with a limited charging current, in the meanwhile, the adaptor voltage is detected and stored as initial input voltage. Then the JW3653 increases charge current step by step, during this process, VBUS is continuously monitored. As long as VBUS drops preset level (ΔV_{DRP})below VBUS initial voltage, the system step by step lower the input current limit to bring back VBUS100mV higher to maintain a healthy adaptor output. After that the new input current limit is locked up unless the adaptor is plugged out. This is proprietary dynamic input current tracking scheme.

$$\Delta V_{DRP} = R_1 \times 4uA$$

Discharge Mode

In discharge mode, JW3653 regulates the output voltage and output current.

Output current sensing

The JW3653 senses the output current and output through OLIM when the output current is less than I_{OLL}. If the output current is larger than I_{OLL}, the OLIM output a fixed voltage, the output current limit can be programmable through the resistor on OLIM pin.

Battery UVLO

When battery voltage decreases to V_{BAT_UVLO1}, the discharging process is terminated. When the battery voltage recovers and is larger than V_{BAT_UVLO2}, the JW3653 can re-discharge if the EN is still high.

Output constant current control

In discharge mode, the output voltage is regulated to setting value which can be programmable through FB pin.

$$V_O = \frac{1.1(V)\times(R_1+R_2)}{R_2}$$

The output current limit can be programmable by R_{OLIM}. The maximum output current limit is up to 3.4A.

$$I_{OLIM} = \frac{0.5(V)}{R_{OLIM}(K\Omega)}\times 0.8(A/uA)$$

If the output current equals to theI_{O_LIMIT}, the output current loop begins to work, it turns down output voltage to limit the output power.

When output is shorted to ground, the JW3653 works as a buck converter, the output current is continuously sensed and limited to I_{O_LIMIT}. When the output short is removed, the regulator comes into normal operation again.

Thermal Control

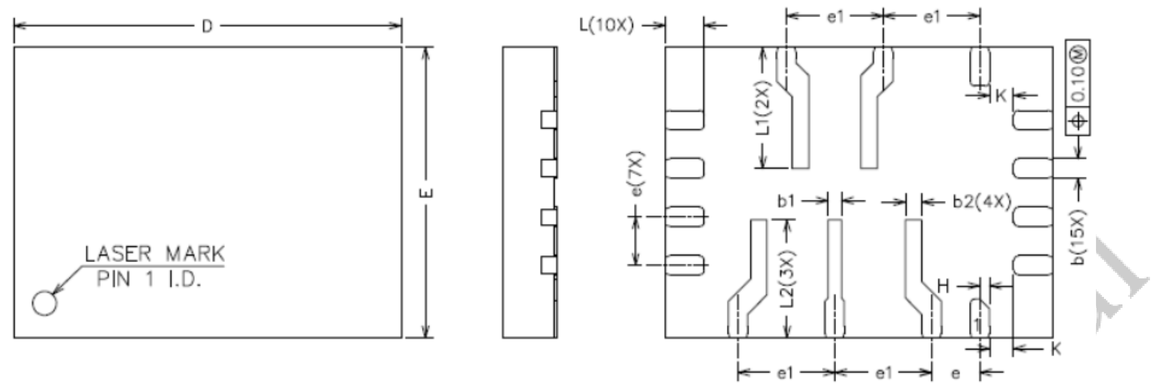
When the junction temperature of the JW3653rises above 135°C, it begins to reduce the output power to prevent the temperature from rising further. If the junction temperature of the JW3653rises above 150°C, the discharging process stops.

Shut-down Mode

The JW3653 shuts down when voltage at EN pin is below 0.4V. The entire regulator is off.

PACKAGE OUTLINE

QFN3X4-15 **unit: mm**



TOP VIEW SIDE VIEW BOTTOM VIEW

SIDE VIEW

SYMBOL	MIN	NOM	MAX
A	0.50	0.55	0.60
A1	0.00	0.02	0.05
A3		0.15REF	
b	0.15	0.20	0.25
b1	0.09	0.14	0.19
b2	0.12	0.17	0.22
D	3.90	4.00	4.10
E	2.90	3.00	3.10
e	0.40	0.50	0.60
e1	0.90	1.00	1.10
H		0.10REF	
K	0.15	0.25	0.35
L	0.30	0.40	0.50
L1	1.15	1.25	1.35
L2	1.12	1.22	1.32

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