JW3653A/JW3653A-1

20V 3A 4-Switch Buck-Boost Charging/Discharging Converter

Parameters Subject to Change Without Notice

DESCRIPTION

The JW®3653A/JW3653A-1 is a buck boost convertertargetsHVDC fast charging and discharging power bank.

The JW3653A/JW3653A-1 supports 1 to3 cells Li-ion battery, the output voltage can be programmable up to 20.0V through external resistor.

The JW3653A/JW3653A-1 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, maximizescharge/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.

JW3653A/JW3653A-1 guarantees robustness with thermal protectionand battery under voltage lockout.

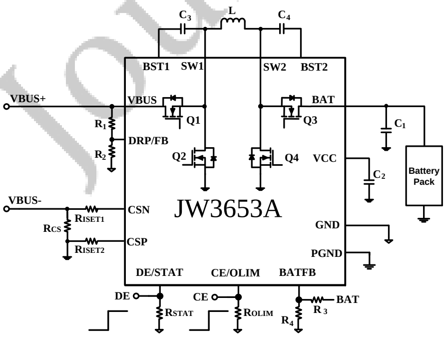
FEATURES

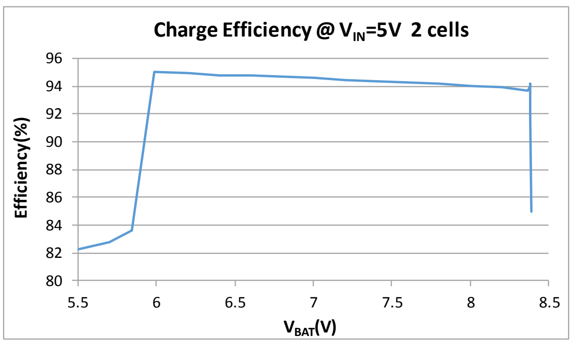
- Integrate low R_{DS} (on) power MOSFET
- Wide input range: 4.2V-20.0V,Support 1to3 cells battery charge/discharge.
- Full charge voltage:1.2V-20.0V through external resistor or selectable by BATFB pin JW3653A (4.2V/cell)/JW3653A-1 (4.35V/cell)
- Wide output range:0.9V-20.0V
- High efficiency buck-boost transition
- 450kHz switching frequency
- Programmable output current limit(up to 3A)
- Output Constant Current Control.
- Quiescent current: <60uA
- Integrate VBUS and Batteryshort protection
- Integrate thermal protection
- QFN3*4 package

APPLICATIONS

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

TYPICAL APPLICATION

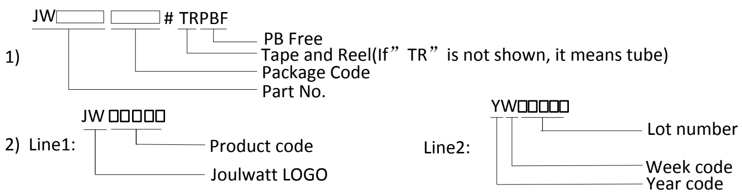




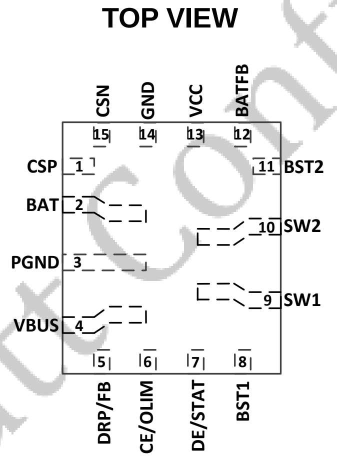
ORDER INFORMATION

DEVICE[1]	PACKAGE	TOP MARKING[2]
JW3653AQFNE#TRPBF	QFN3×4-15	JW3653A YW□□□□□
JW3653A-1QFNE#TRPBF	QFN3×4-15	JW3653A-1 YW□□□□□

Notes：



PIN CONFIGURATION



ABSOLUTE MAXIMUM RATING[1]

VBUS,BAT, SW1, SW2 Pin ....-0.3V to24V
BST1-SW1, BST2-SW2 ....-0.3V to 6.5V
All Other Pins ....-0.3V to 6.5V
JunctionTemperature[2][3] 150ºC
Lead Temperature 260ºC
Storage Temperature.. -65ºC to +150ºC
ESD Susceptibility (Human Body Model) 2kV

RECOMMENDED OPERATING CONDITIONS

BUS Voltage VBUS..0.9V to 20V
Battery Voltage VBAT ....3.0V to 20V

THERMAL PERFORMANCE[4)] θ_{JA} θ_{JC}

QFN3X4-15...48……11ºC/W

Note：

1) Exceeding these ratings may damage the device.

2) The JW3653A/JW3653A-1guarantees 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 JW3653A/JW3653A-1 includes thermal protection that isintendedto protect the device in overload conditions. Thermal protection is active when junctiontemperature exceedsthe maximum operating junction temperature. Continuous operation over the specified absolutemaximum operating junction temperature may damagethe device.

4) Measured on JESD51-7, 4-layer PCB.

ELECTRICAL CHARATERISTICS

V_{BUS}=12V, TA=25 ℃, unless otherwise stated

Item	Symbol	Condition	Min.	Typ.	Max.	Units
Power supply						
VBAT voltage range	V_{BAT}		3.0		20	V
VCC output voltage	V_{CC}	I_{VCC}=2mA	4.7	5	5.3	V
VCC output current limit	I_{VCC}	VCC>2.7V		50		mA
Supply current in shut-down mode	I_Q	V_{BAT}=4V, EN=0V	30		60	µA
Controller						
Switch frequency	F_{sw}[5]		350	450	550	kHz
Switch minimum off time	T_{off_min}[5]		80	100	120	ns
DE/STAT, CE/OLIM Logic HIGH	V_{ENH}	V_{BAT}=8V			2.5	V
DE/STAT, CE/OLIM Logic LOW	V_{ENL}	V_{BAT}=8V	1.6			V
Bucktop switch on-resistance	R_{dsbkTG}[5]			20	28	mΩ
Buck bottom switchon-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
Charge						
Floating BAT Voltage	V_{CV}	V_{BATFB} =GND, JW3653A	8.358	8.4	8.442	V
		V_{BATFB} =GND, JW3653A-1	8.656	8.7	8.743	V
		Set by divider resistance	3.0	-	20	V
BAT feedback voltage	V_{BATFB}	External resistor divider	1.191	1.2	1.209	V
BAT recharge threshold	V_{REC}	V_{BATFB} = GND	8.118	8.2	8.282	V
BAT recharge feedback threshold	V_{RECFB}	JW3653A	1.159	1.171	1.183	V
		JW3653A-1	1.120	1.131	1.142	
CC mode charge current	I_{CC}	R_{CS}=10mΩ, R_{ISET1}=2K R_{ISET2}=1.5K	1.92	2	2.08	A
Charge termination current	I_{TER}	R_{CS}=10mΩ, R_{ISET1}=2K R_{ISET2}=1.5K		10%		I_{CC}
Battery full charge deglitch time	T_{FULL}	I_{CC}< I_{TER}		5		s
Trickle mode charge current	I_{TRI}	R_{CS}=10mΩ, R_{ISET1}=2K R_{ISET2}=1.5K	13%	25%	37%	I_{CC}
Trickle mode battery threshold	V_{TRI}	V_{BATFB} = GND	5.9	6.0	6.1	V
Trickle mode feedback threshold	V_{TRIFB}	JW3653A		0.857		V
		JW3653A-1		0.828		V
Trickle charge time-out duration	T_{TRI}		50	55	60	min

VBUS UVP thresholdin charge mode	V_{BUS_UVP}	VBUS rising	4.0	4.2	4.3	V
		VBUS falling	3.8	4.0	4.1	V
VBUS delay to start charging	t_{chg_delay}			150		ms
DRP reference voltage for adaptive current limit	V_{DRP}		0.885	0.9	0.915	V
DRP pin source current	I_{DRP}		3.5	4.2	5	μA
Input current sensing ratio	K_{RATIO}	R_{CS}=10mΩ, R_{ISET1}=2K R_{ISET2}=1.5K		3		μA/A
Discharge mode						
VBAT UVLO voltage	V_{BAT_UVLO}	VBAT rising	2.8	3.0	3.1	V
		VBAT hysteresis		350		mV
Feedback voltage	V_{FB}		0.885	0.9	0.915	V
OLIM pin regulate voltage	V_{OLIM}			400		mV
Output average current limit	I_{O_LIM}	R_{CS}=10mΩ, R_{ISET1}=2K R_{ISET2}=1.5K, R_{OLIM}=40K		1.5		A
Protection						
Thermal shutdown threshold[5)]	T_{SHUT}			150		°C
Thermal recovery threshold[5)]	T_{REC}			130		°C

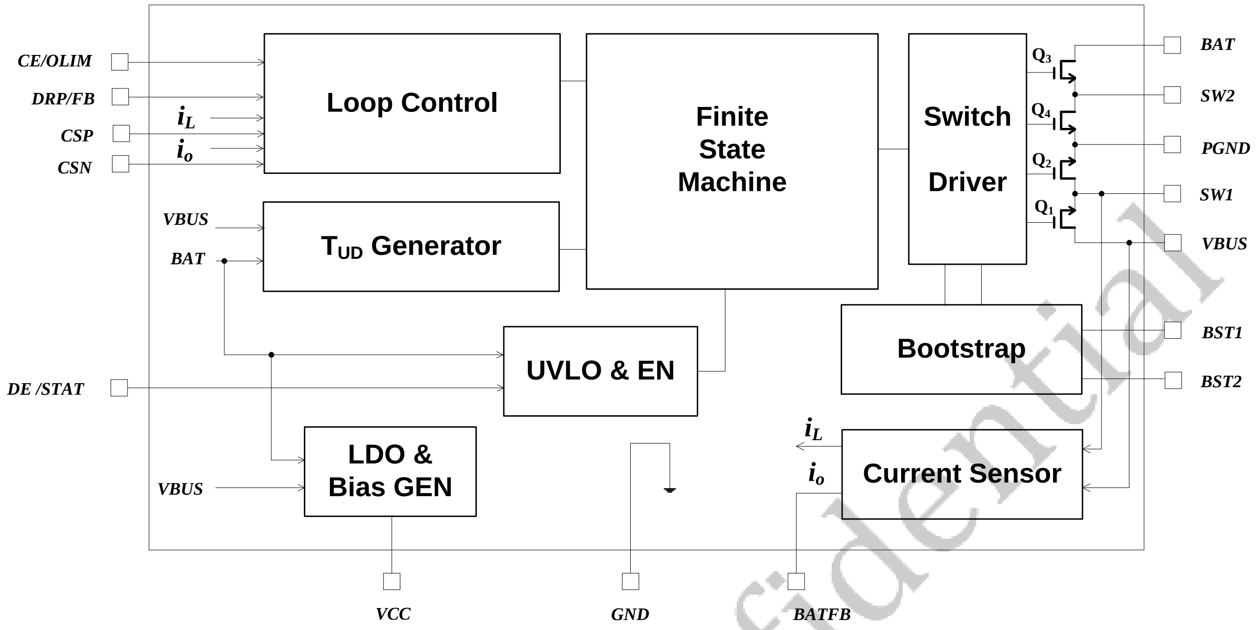
Notes:

5) Guaranteed by design.

PIN DESCRIPTION

Pin No.	Name	Description
1	CSP	Positive terminal of battery charge current sense.
2	BAT	Battery positive terminal.
3	PGND	Power Ground.
4	VBUS	In charge mode, main supply pin, connect to adaptor. In discharge mode, output voltage sense pin, connect this pin to Vout.
5	DRP/FB	In charge mode, VBUS droop allowance program pin. In discharge mode, Output feedback pin.
6	CE/OLIM	Charge Enable control pin or Discharge output current limit program pin. This is a dual-purposePin. When the CE/OLIM pin rises above 2.5V, the IC charge is enabled. When the charge is not used, in discharge mode, the pin set output average current limit. Connect a resistor to GND to set the maximum average current.And in the light load, it could be output current detection pin.
7	DE/STAT	Discharge Enable control pin or Fault state output pin or Charge state detection output pin. This is also a multi-purposePin. When the DE/STAT pin is above 2.5V and the CE/OLIM pin below 1.6V, the IC discharge is enabled. When the discharge is not used, in charge mode, the pin as Fault state output pin, asserted during overtemperature or trickle charge time out conditions. And the pin also as charge state detection output pin. In the CC charge mode, the pin source current is 6μA. In the full charge mode, the pin is pulled to high.
8	BST1	VBUS side bootstrap supply pin for top switch. 0.1μF capacitor is connected between BST1 and SW1 pins.
9	SW1	VBUS side power switching node. connect to SW2 with inductor.
10	SW2	BAT side power switching node.
11	BST2	BAT side bootstrap supply pin for top switch. 0.1μF capacitor is connected between BST2 and SW2 pins.
12	BATFB	Battery float voltage configuration pin. 1. his pin tied to GND, sets 2 cells float voltage. Pin short to GND: 8.4V/8.7V. 2. And the float voltage could be set to any value (3.0V-20.0V) by the external divider resistor.
13	VCC	5V LDO for power driver and internal circuit. Must be bypassed toGNDwith a minimum of 10μF ceramic capacitor for stable operation.
14	GND	Signal GND.
15	CSN	Negative terminal of battery charge current sense.

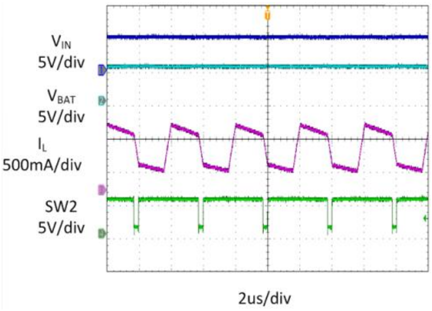
BLOCK DIAGRAM



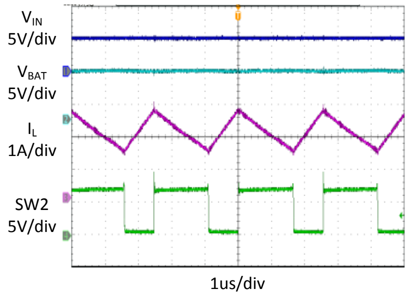
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 5V, V_{BUS}=5V, L = 3.3µH, C_{BUS} = 20µF, C_{BAT}=20uF, 2 Cells, TA = +25°C, unless otherwise noted.

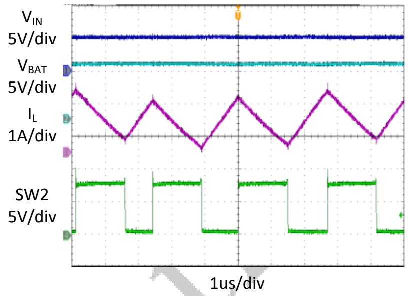
Trickle charge



Constant current charge

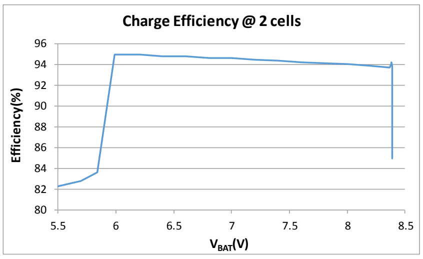


Constant voltage charge



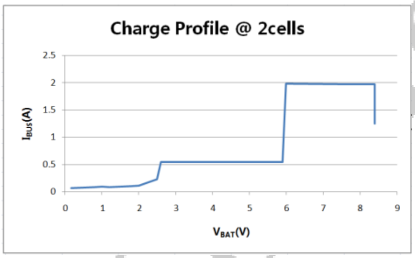
Charge efficiency

V_{IN}=5V



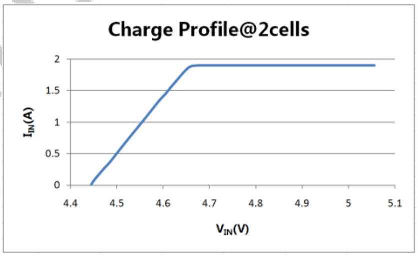
Charge current vs. V_{BAT}

V_{IN}=5V

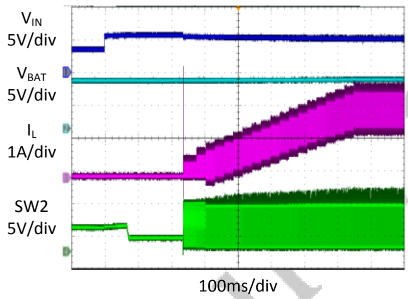


Charge current vs. V_{IN}

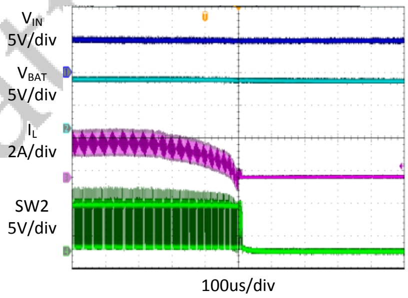
V_{BAT}=7.4V



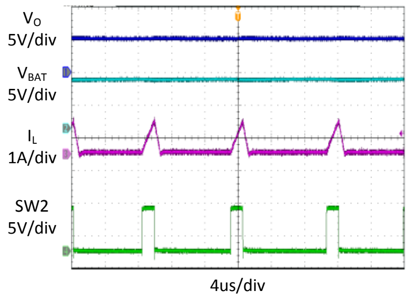
V_{IN} ON



V_{IN} OFF



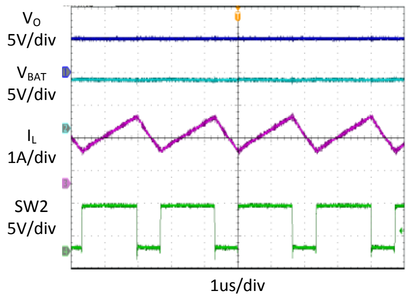
Discharge V_{BAT}=7.4V I_O=0.1A



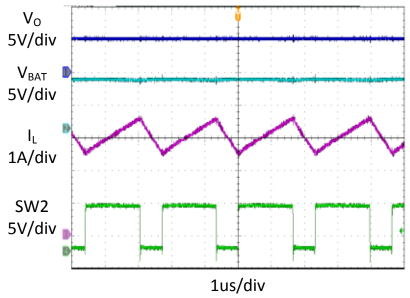
TYPICAL PERFORMANCE CHARACTERISTICS*(Continued)*

V_{IN} = 5V, V_{BUS}=5V, L = 3.3μH, C_{BUS} = 20μF, C_{BAT}=20uF, 2 Cells, TA = +25°C, unless otherwise noted.

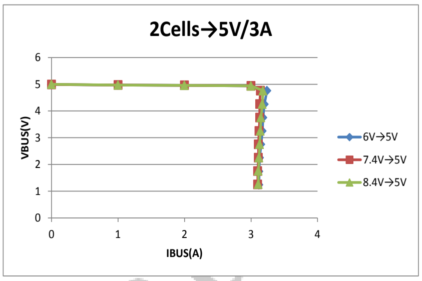
Discharge V_{BAT}=7.4V I_O=1.5A



Discharge V_{BAT}=7.4V I_O=3A

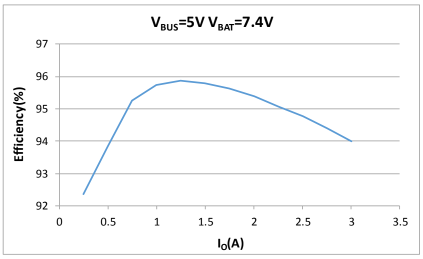


Discharge V_{BUS} vs. I_{BUS}



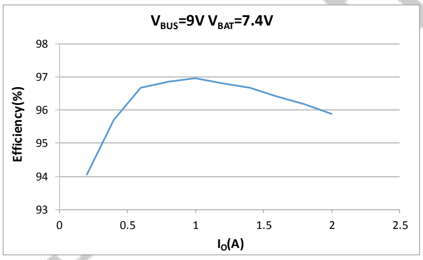
Discharge efficiency

V_{BUS}=5V



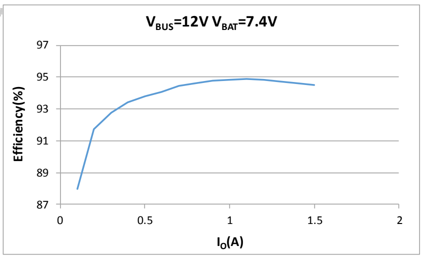
Discharge efficiency

V_{BUS}=9V



Discharge efficiency

V_{BUS}=12V



FUNCTIONAL DESCRIPTION

JW3653A/JW3653A-1 is a monolithic buck-boost DC to DC converter that can operate over a wide input voltage range of 4.2V to 20V. The output voltage can be programmed between 0.9V to 20V. Internal low R_{DSON} N-channel power switches reduce the solution complexity and efficiency.

Flexible Bidirectional Buck-Boost Converter

The JW3653A/JW3653A-1 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 inductorcurrent-mode control to guarantee smooth transitionbetween buck and boost operation with better dynamic response and cycle-by-cycle current protection.

Compensation is done internally onthe chip. The JW3653A/JW3653A-1 operates in PFM mode at light load. In PFM mode, switching frequency is continuouslycontrolled in proportion to the load current, i.e. switch frequency is decreased when load current drops to increase power efficiency at light load by reducing switching-loss, minimizing the circuit.

The JW3653A/JW3653A-1 can operate in charge, discharge and shutdown mode according to CE/OLIM, DE/STAT and VBUS voltage. The state is given by Table1:

CE	DE	VBUS	State
1	1/0	>4.2V, delay 150ms	Charge
1	1/0	＜4V, delay 2s	Shutdown
0	1		Discharge
0	0		Shutdown

Table1: operating states

If the DE/STAT is high and the CE/OLIM is low, the device operates in discharge mode. If the CE/OLIM is high and the VBUS is larger than $V_{BUS_UVP}$for 150ms, the JW3653A/JW3653A-1 operates in charge mode.

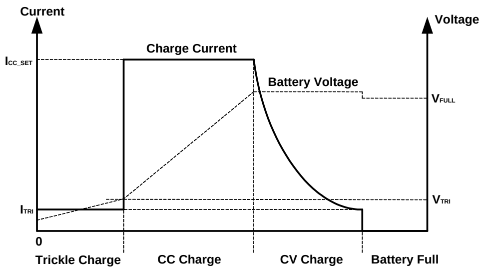
Either in charge or discharge mode, the JW3653A/JW3653A-1 can operate in buck or boost state.

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

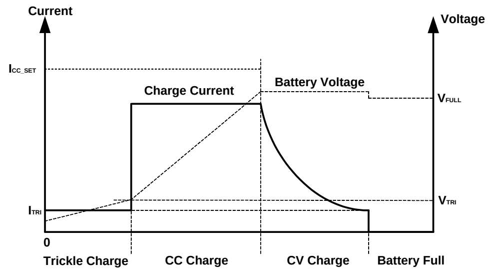
Similarly, the JW3653A/JW3653A-1 can operate as a buck or boost converter according to VBUS voltage and battery voltage in discharge mode.

Charge mode

In charge mode, JW3653A/JW3653A-1 regulates the input 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 1(a) is a typical charge profile. Figure 1(b) is a charge profile with input current limit. When the input current is limited, the system decreases the charge current.



a) Withoutinput current limit



b) With input current limit

Figure 1 Typical Charge Profile

Trickle charge

The JW3653A/JW3653A-1 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 JW3653A/JW3653A-1 can set the charge current through $R_{ISET1}$and $R_{CS.}$ The maximum charge current is up to 3.4A.

$$I_{CC}(A)=\frac{10(A)R_{ISET1}(k\Omega)}{R_{CS}(m\Omega)}$$

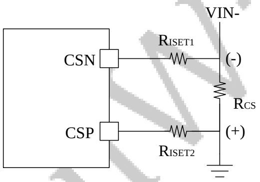


Figure 2 Typical Charge Profile

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 cells or program the V_{CV} through BATFB pin. Connect BATFB to GND selects 2 cells.The V_{CV}can also be programmable by resistor divider connected to BATFB, when the JW3653A/JW3653A-1 detects a resistor connect to this pin. We recommend the 1‰ accuracy resistor should be used in order to achieve the accuracy of full charge voltage.The full charge voltage configure shows in figure 3.

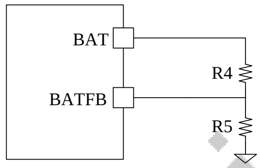


Figure 3 Full Charge Voltage Configure

$$V_{CV}(V)=\frac{1.2V\times(R_4+R_5)}{R_5}$$

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.

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.

Charging status indication description

In charge mode, the charge current is monitored continuously through STAT pin.In the CC charge mode, the pin source current is 6μA, and if the I_{CC} is 2A, the current sensing ratio is 3μA/A.

When Charge process terminates, the STAT pin is pulled to high.

If over temperature protection or trickle charge time beyond T_{TRI}, the JW3653A/JW3653A-1 is in fault mode. The STAT pin will send out high and low voltage alternatively with 1.25Hz.

Dynamic input Current Tracking Scheme

Afterthe CE pin is pulled high, the device detects the VIN pin, if the VIN pin voltage is higher than V_{IN_UVP}rising threshold for 150ms, the JW3653A/JW3653A-1 starts charging with a limited charging current.And the DRP/FB pin source 4.2μA current for VIN droop allowance voltage set conveniently.When the adaptor is over load, the DRP pin drops below the internal reference 0.9V, JW3653A/JW3653A-1 will decrease the charging current. The input voltage sense shows in figure 4, choose R1, R2 to set the input voltage threshold.

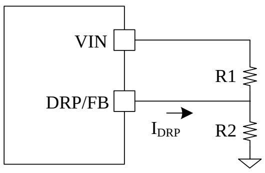


Figure 4 VIN Droop Voltage Configure

$$V_{IN\_ALLOWANCE}(\mathrm{V}) = \frac{V_{DRP}(\mathrm{V}) \times (R_1 + R_2)}{R_2} - R_1 \times I_{DRP}$$

Discharge Mode

In discharge mode, JW3653A/JW3653A-1 regulates the output voltage and output current.

Output current sensing

The JW3653A/JW3653A-1 senses the output current through CE/OLIM pin when the output current is less than I_{O_LIM}. If the output current is larger than I_{O_LIM}, the CE/OLIM output a fixed voltage 400mV, the output current limit can be programmed through the resistor on CE/OLIM pin.

Battery UVLO

When battery voltage decreases to V_{BAT_UVLO} falling threshold, the discharging process is terminated.When the battery voltage recovers and is higher than V_{BAT_UVLO} rising threshold, the JW3653A/JW3653A-1 can re-discharge if the DE/STAT is still high.

Output constant current control

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

$$V_O(\mathrm{V}) = \frac{0.9(\mathrm{V}) \times (R_1 + R_2)}{R_2}$$

The output current limit can be programmed by R_{OLIM}.

$$I_{OLIM}\,(\mathrm{A}) = \frac{0.4(\mathrm{V})}{R_{OLIM}\,(\mathrm{k}\Omega)} \times \frac{R_{ISET2}\,(\mathrm{k}\Omega)}{R_{CS}\,(\mathrm{m}\Omega)} \times 1000$$

We recommend R_{ISET1}/R_{ISET2} is equal to 4/3.

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, theJW3653A/JW3653A-1 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 JW3653A/JW3653A-1 rises above 135°C, it begins to reduce the output power to prevent the temperature from rising further. If the junction temperature of the JW3653A/JW3653A-1 rises above 150°C, the discharging process stops.

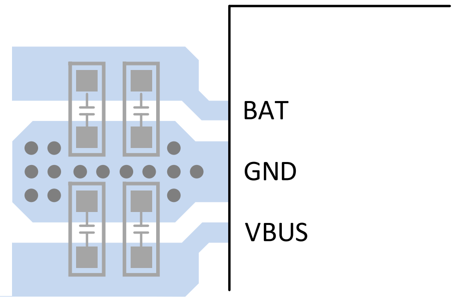
Shut-down Mode

The JW3653A/JW3653A-1 shuts down when voltage at CE/OLIM pin and DE/STAT pin is below 1.6V. The entire regulator is off.

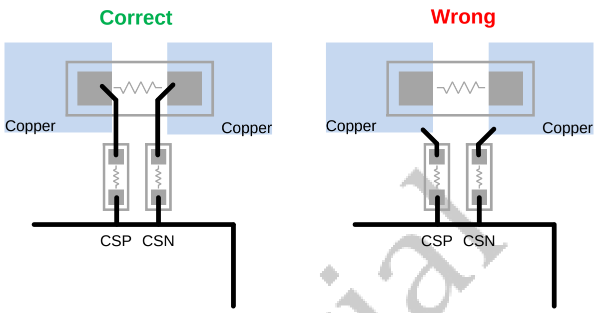
PCB Layout Note

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

1. Placethe input decoupling capacitor as close to JW3653A/JW3653A-1 (VBUS pin and PGND) as possible to eliminate noise at the input pin. The loop area formed by input capacitor and GND must be minimized.



Put the current sense resistor R_{CS} as close as possible to the current set resistors R_{ISET} for better current accuracy.



2. The ground plane on the PCB should be as large as possible for better heat dissipation.

REFERENCE DESIGN

Reference 1：2 cells charge with 5V adapter and discharge to 12V output

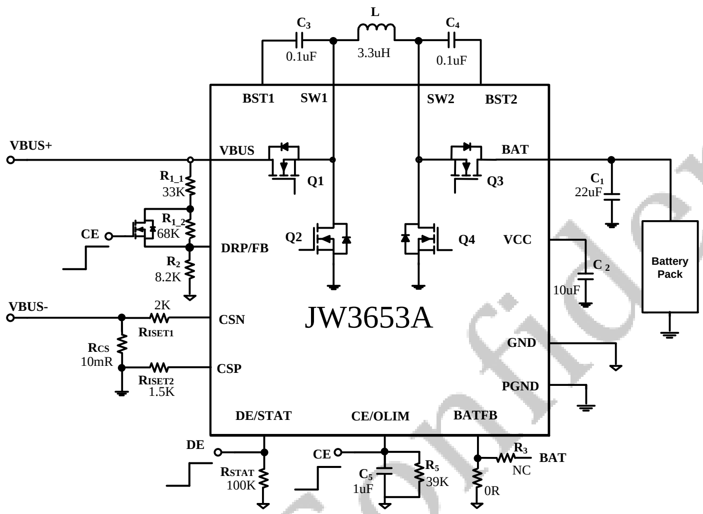
V_{IN}: 4.6V ~ 5V

I_{IN_LIM}: 2A

V_{BAT}: 6V ~ 8.4V

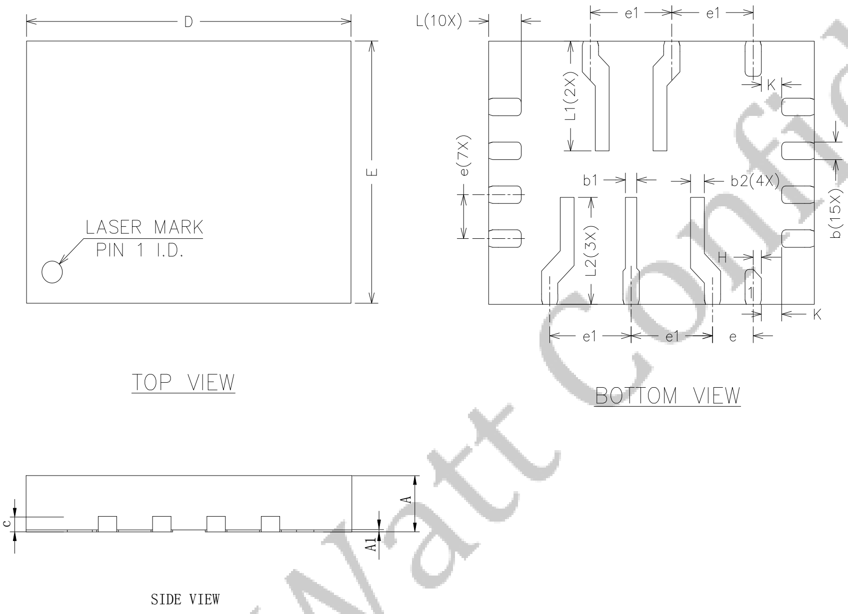
V_{BUS} : 12V

I_{O_LIM}: 1.5A



PACKAGE OUTLINE

QFN3X4-15 **unit: mm**



	MIN	NOM	MAX
A	0.50	0.55	0.60
A1	0.00	0.02	0.05
c	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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