2.5A 2-Cell Li+ Battery Charger with 2.4A Buck OTG function

DESCRIPTION

ETA6071 is a wide input range, high efficiency, synchronous 2-cell series Li-Ion battery cell boost charger. It accepts input from 2.7V to 7V and is capable of delivering up to 2.5A charge current to two stacked Li-Ion batteries. The charging current and termination voltage can both be programmed through external resistors. There are also an input current limit setting and a dynamic input power management setting. These features can be used for limiting the charging current when a weak power source is plugged in. The boost has a true-shutoff function that disconnects the input from output when short circuit or shut down occurs. A NTC function is also included to configure charging at different temperatures. A STAT function indicates charging status. Furthermore, ETA6071 incorporates an OTG function that when enabled, with the same inductor, one can reversely deliver power from the batteries to VBUS. It can deliver up to 2A at 5V.
ETA6071 is housed in a tiny QFN3x3-20 package.

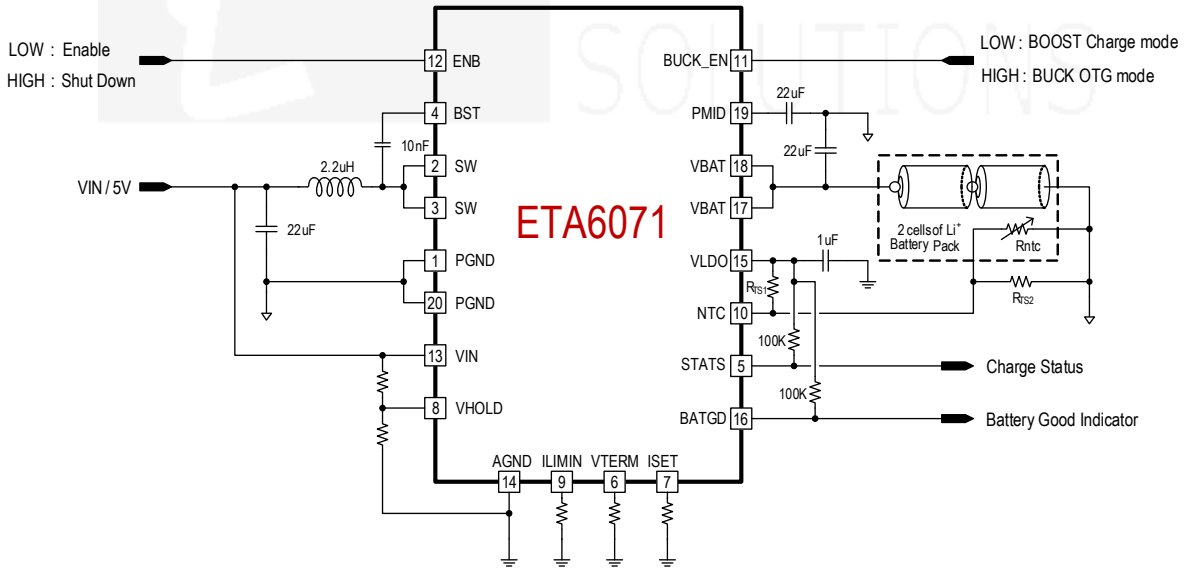
FEATURES

- 2.5A Charging with up to 95% Efficiency
- High voltage input standoff up to 16V
- Input current limit and DPM setting
- External programmable CC/CV setting
- NTC thermistor input
- Charger status indication
- True-Shutoff Boost
- Bi-Directional Power conversion with Single Inductor
- Tiny QFN3x3 package

APPLICATIONS

- E-Cigarette
- Power Bank
- Two Cell Li-Ion battery applications

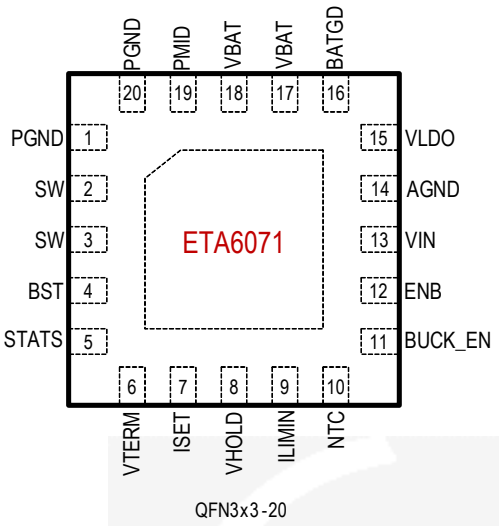
TYPICAL APPLICATION



ORDERING INFORMATION

PART No.	PACKAGE	TOP MARK	Pcs/Reel
ETA6071Q3U	QFN3x3-20	ETA6071 YWW2L	5000

PIN CONFIGURATION



QFN3x3-20

ABSOLUTE MAXIMUM RATINGS

(Note: Exceeding these limits may damage the device. Exposure to absolute maximum rating conditions for long periods may affect device reliability.)

IN Voltage.....–0.3V to 16V
BAT,PMID,SW,STAT Voltage .....–0.3V to 16V
BST Voltage .....V_{SW}–0.3V to V_{SW}+5V
All Other Pin Voltage.....–0.3V to 6V
SW,IN,BAT, VLDO to ground current...Internally limited
Operating Temperature Range.....–40°C to 85°C
Storage Temperature Range.....–55°C to 150°C

Thermal Resistance	Θ_{JA}	Θ_{JC}	
QFN3X3-20	50	12	°C/W

Lead Temperature (Soldering, 10sec).....260°C
ESD HBM (Human Body Mode) 2KV
ESD CDM (Charged Device Mode) 1KV

ELECTRICAL CHARACTERISTICS

(V_{IN} = 5V, unless otherwise specified. Typical values are at TA = 25oC.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
INPUT					
VIN Standoff Voltage			16		V
VIN Range		2.7		7	V
VIN UVLO Voltage	Rising, Hys=300mV		2.6		V
VIN OVP Voltage	Hys=500mV		7.1		V
Input Shutdown Current	V_{IN} = 5V, V_{BAT}=0V, ENB = High		3		μA
Battery leakage Current	V_{IN} = 0V, V_{BAT}=8V, ENB = High		7		μA
POWER FETs					
PMID to BAT FET			56		mΩ
PMID to SW FET			56		mΩ
SW to GND FET			76		mΩ
BOOST BATTERY CHARGER					
Battery CV Voltage	R_{VTERM} float	8.36	8.40	8.44	V
	R_{VTERM}=10K, I_{BAT} =0mA, default		8.70		V
Charger Restart Threshold	V_{CV}=8.40V		-300		mV
Battery Pre-Condition Voltage	V_{BAT} Rising, Hys=230mV		5.7		V
Pre-Condition Charge Current	R_{ISET} =2.8KΩ		150		mA
Fast Charge Current	R_{ISET} =10KΩ		0.5		A
	R_{ISET} =3.34KΩ		1.5		
	R_{ISET} =2KΩ		2.5		

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Fast Charge Current Accuracy		-10		10	%
Charge Termination Current	R_{ISET} =2.8KΩ		150		mA
Input current limit	R_{INLIM}=46K, V_{IN}=5V, V_{BAT}=8V		2		A
Input Dynamic Power Threshold	V_{HOLD}		1.1		V
Deep Discharged V_{BAT} protection threshold	V_{BAT} – V_{IN} , V_{BAT} Falling		330		mV
	V_{BAT} – V_{IN} , V_{BAT} Rising		550		mV
Charge current during Deep Discharged V_{BAT}	R_{ISET} =2.8KΩ		150		mA
Pre-Condition Timer			1		Hour
Fast-Charge Timer			4.5		Hour
Total Charge Timer			12		Hour
EOC Delay Time			30		ms
Boost switching Frequency			1		MHz
Boost Cycle-by-Cycle Peak Current limit			7		A
Battery Remove Detection					
Battery Detection Current			0.6		mA
Battery Detection Timer			256		ms
OTG (BUCK MODE)					
BATT OK Threshold	Rising, HYS=0.5 V		6		V
Output Voltage Range		5.05	5.15	5.25	V
Quiescent Current At BATT	Buck On		350		μA
Shutdown Supply Current At BATT	Idle Mode		7		μA
Switching Frequency	VBATT<4.4V		1		MHz
HS Peak Current Limit			5		A
Short Circuit Hiccup Timer	On Time		4		ms
	Off Time		12		
VHOLD, ISET, VCV,ILIMIN					
VHOLD Threshold	Vout start to reduce charging current		1.1		V
ISET Voltage	V_{BAT}< $V_{PRECOND}$		0.11		V
	V_{BAT} > $V_{PRECOND}$		1.1		
ILIMIN Voltage			1.1		V
VCV Internal Pull-up Current			10		μA
VLDO					
V_{LDO} Voltage			5		V
V_{LDO} Output Current Limit			75		mA
LOGIC INPUTs BUCKEN, ENB					
Logic Input High	ENB=High, Chip Shut Down, BUCK_EN=High,BUCK OTG mode	1.2			V
Logic Input Low	ENB=Low, Chip Enable,			0.4	V

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
	BUCK_EN=Low, BOOST Charge mode				
Internal Pull-down Resistance			2		MΩ
Open Drain Outputs STAT, BATGD					
Output Low Voltage	I_{SINK}=10mA			0.1	V
Output Leakage Current	V_{HIGH}=5V			1	μA
NTC THERMISTOR MONITOR					
NTC Threshold, Cold	Charger Suspended		75		%V_{LDO}
NTC Threshold, Hot	Charger Suspended		25		%V_{LDO}
NTC Threshold Hysteresis			2		%V_{LDO}
NTC Disable Threshold	V_{LDO}-V_{NTC}		0.4		V
NTC Input Leakage			0	5	μA
THERMAL PROTECTION					
Charging Thermal Regulation threshold			120		°C
Thermal Shutdown	Rising, Hys=20°C		160		°C

PIN DESCRIPTION

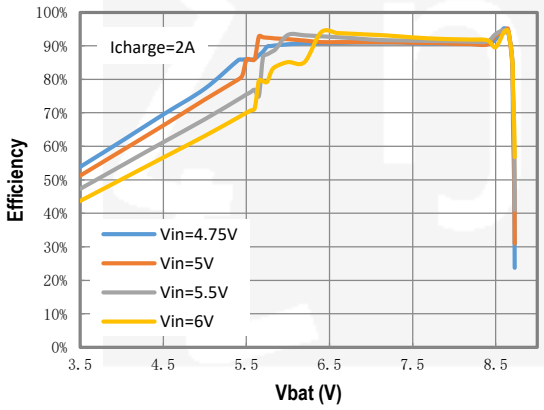
PIN #	NAME	DESCRIPTION
1	PGND	Power Ground pin
2,3	SW	Switching Pin. Connect with an inductor between this pin and VIN
4	BST	Bootstrap capacitor connection for the high-side FET gate driver. Connect a 10nF ceramic capacitor (voltage rating ≥ 10 V) from BOOT pin to SW pin.
5	STATS	Status pin for Boost charging. Internally pulled low when charge in progress. It becomes high impedance when charging is done.
6	VTERM	Charge termination voltage (V_{TERM}) configuration pin. There is an internal pull up current 10μA. Connect a resistor (R_{VTERM}) from V_{TERM} pin to GROUND to set battery regulation voltage. V_{TERM}= 8.4V + 3*R_{VTERM}*10 μA
7	ISET	Boost Fast Charging current setting pin. Connect a resistor between this pin and analog ground to set the current level.
8	VHOLD	Input Dynamic Power Setting Pin. Connect VHOLD pin to a middle point of a resistor network from VIN to GND. When VHOLD voltage fall to 1.1V, charger reduces charge current.
9	ILIMIN	Input Current limit configuration pin. Connect a resistor to ground to set input current limit.
10	NTC	Thermistor Input Pin. Connect to the battery thermistor sensing network.
11	BUCK_EN	Buck mode enable pin when ENB=0. Internal pull to GND by 2.3Mohm Resistor, Pull this pin high to enable a “BUCK”OTG mode. Float or pull to GND to enable charger
12	ENB	Chip disable pin. Internal pull to GND by 2.3Mohm Resistor. Connect ENB to a Logic High to disable IC

PIN #	NAME	DESCRIPTION
13	VIN	Input Power pin. Bypass with a 22µF capacitor from this pin to ground.
14	AGND	Analog Ground pin. Short to PGND as guided in PCB layout guide
15	VLDO	5V Linear regulator output pin. Bypass with 1µF capacitor from this pin to ground
16	BATGD	Battery status indication pin. Low when Battery voltage is less than 6V, High when Battery voltage is greater than 6V even ENB is high level
17,18	VBAT	Battery Positive terminal. Connect a 22µF to Ground
19	PMID	Midpoint of the Boost output and current limit switch. Connect a 22µF to Ground. Do not overload or short this pin
20	PGND	Power Ground pin

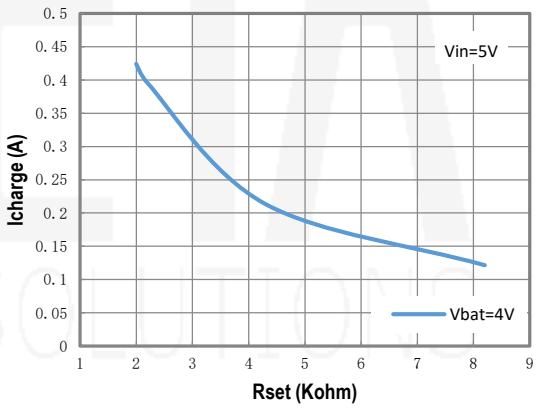
TYPICAL CHARACTERISTICS

(Vin=5V, T_A=25°C, unless otherwise specified)

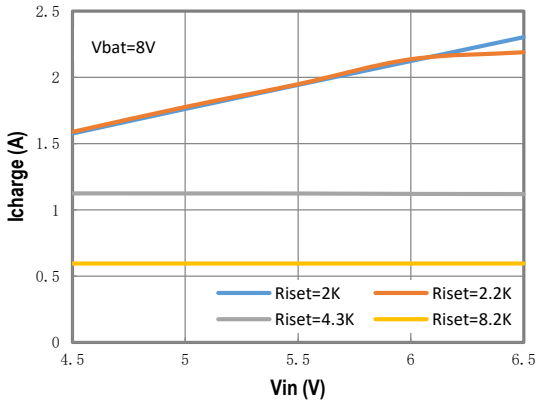
Charger Eff. Vs. Vbat



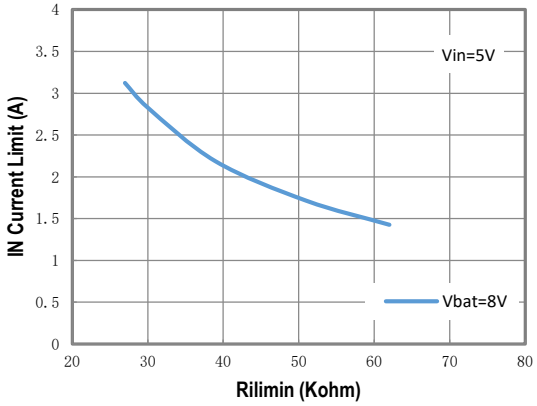
Trickle Charge Current Vs. Riset

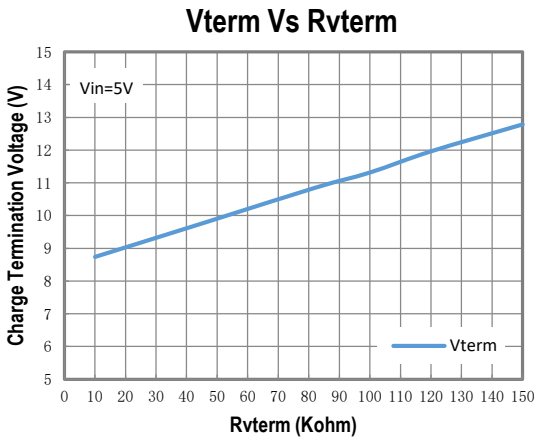


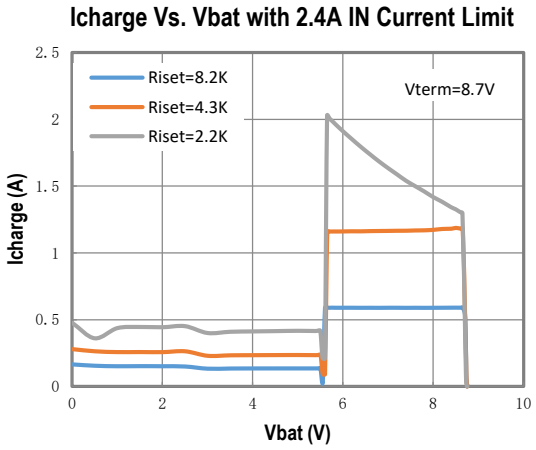
Fast Charge Current Vs. Vin w. 3A IN Limit

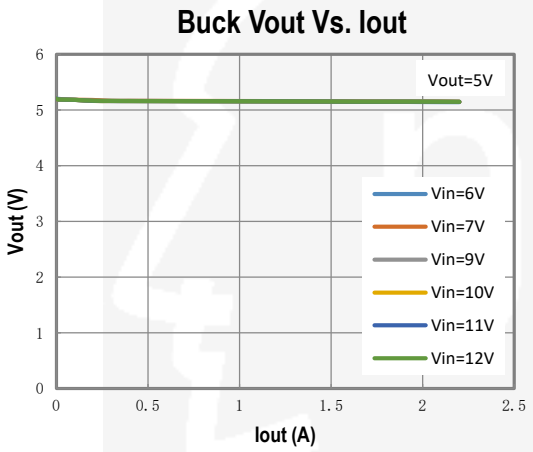


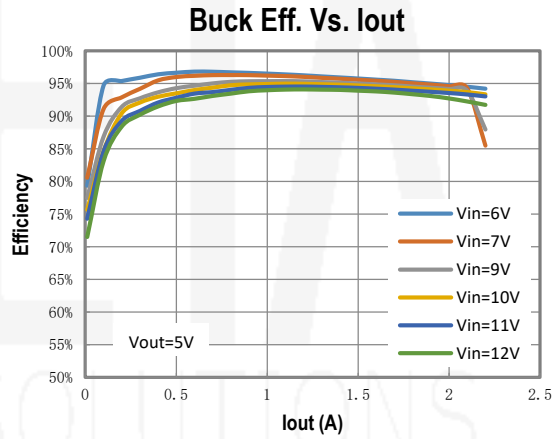
IN Current Limit Vs. Rilimin











APPLICATION INFORMATION

Setting Charge Termination Voltage

Charge termination voltage can be programmed externally in a small range by connecting a resistor from VTERM pin to ground. There is an internal 10uA pull-up current. The charge termination voltage is calculated by the following equation:

$$V_{TERM}=8.4V + 3\times R_{VTERM}\times 10\mu A$$

Setting Fast Charging Current

Fast charge current can be programmed externally by connecting a resistor from ISET pin to ground. Please see below equation for Icharge setting:

$$R_{ISET}=\frac{1.1\times 4550}{I_{CHARGE}}$$

Charge current (A)	R_{ISET} (Kohm)
0.5	10
1	5
1.5	3.34
2	2.5
2.5	2

Setting Input Current limit

The input current of the ETA6071 can be programmed externally by connecting a resistor from ILINMIN pin to ground. This is for the user to configure a limit so that the front-end adapter or charging device is not overloaded. The Input current limit is calculated by the following equation:

$$I_{ILIMIN} = \frac{1.1 \times 74500}{R_{ILIMIN}} + 0.24$$

Input current limit (A)	R_{ILIMIN} (Kohm)
0.5	315
1	108
1.5	65
2	46
2.5	36

Setting Input Dynamic Power Range, DPM, VHOLD

Then input of the ETA6071 can be furthered protected by an input dynamic power setting, i.e. DPM function. When an input source current limit is unknown, this setting can help to prevent overloaded the input source by reducing charge current when the input voltage drops to a preset voltage. This preset voltage can be set by connected a resistor ladder from VIN to VHOLD to GND. The threshold of the VHOLD is 1.1V.

OTG BUCK Mode

ETA6071 also comes with an OTG BUCK feature that it can be configured to deliver power from the battery pack to VIN, by utilizing the same inductor that is used for charging. To turn on this buck mode, pull BUCK_EN high, ETA6071 enables the buck operation that steps the two cells battery voltage down to 5V at VIN. This is particular useful for power bank applications.

STATS Indication

A STATS pin can be used to drive an indication LED to indicate charging status. In normal charging mode, it is pulled down; otherwise, it is floating.

Setting Thermistor, NTC

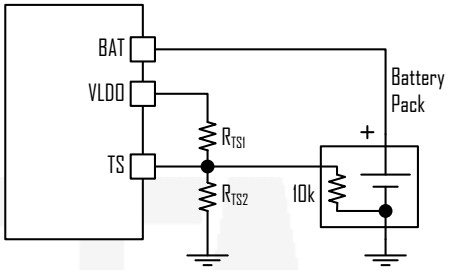
The ETA6071 has a built-in NTC resistance window comparator, which allows ETA6071 to monitor the battery temperature via the battery integrated thermistor. Connect an appropriate resistor from VLDO to the NTC pin and connect the thermistor from the NTC pin to GND. The resistor divider determines the NTC voltage depending on the battery temperature. If the NTC voltage falls outside of the NTC window, the ETA6071

stops charging or discharging. The charger will then restart if the temperature goes back into NTC window range.
To disable the NTC function, connect 1kOmm resistor from NTC to VLDO

Following picture shows that an internal resistor divider sets the low temperature threshold (V_{TL}) and high temperature threshold (V_{TH}) at 75%*VLDO and 25%*VLDO, respectively. For a given NTC thermistor, select an appropriate R_{TS1} and RTS2 to set the NTC window.

$$\frac{V_{TL}}{V_{LDO}} = \frac{R_{TS2} \text{ II } R_{NTC\_COLD}}{R_{TS1} + R_{TS2} \text{ II } R_{NTC\_COLD}} = TL = 0.75$$

$$\frac{V_{TH}}{V_{LDO}} = \frac{R_{TS2} \text{ II } R_{NTC\_HOT}}{R_{TS1} + R_{TS2} \text{ II } R_{NTC\_HOT}} = TH = 0.25$$



Where R_{NTC_HOT} is the value of the NTC resistor at the upper bound of its operating temperature range, and R_{NTC_COLD} is its lower bound. The two resistors, R_{TS1} and R_{TS2}, independently determine the upper and lower temperature limits. This flexibility allows the ETA6071 to operate with most NTC resistors for different temperature range requirements. Calculate R_{TS1} and R_{TS2} as follows:

$$R_{TS1} = \frac{R_{NTC\_HOT} \times R_{NT} \times (TL-TH)}{TH \times TL \times (R_{NTC\_COLD} - R_{NTC\_HOT})}$$

$$R_{TS2} = \frac{R_{NTC\_HOT} \times R_{NTC\_COLD} \times (TL-TH)}{TH \times (1-TL) \times R_{NTC\_COLD} - TL \times (1-TH) \times R_{NTC\_HOT}}$$

BATGD indication

A BATGD pin can be used to drive an indication LED to indicate battery voltage level. In both charge and discharge mode, BATGD is pulled low when battery voltage < 6V.

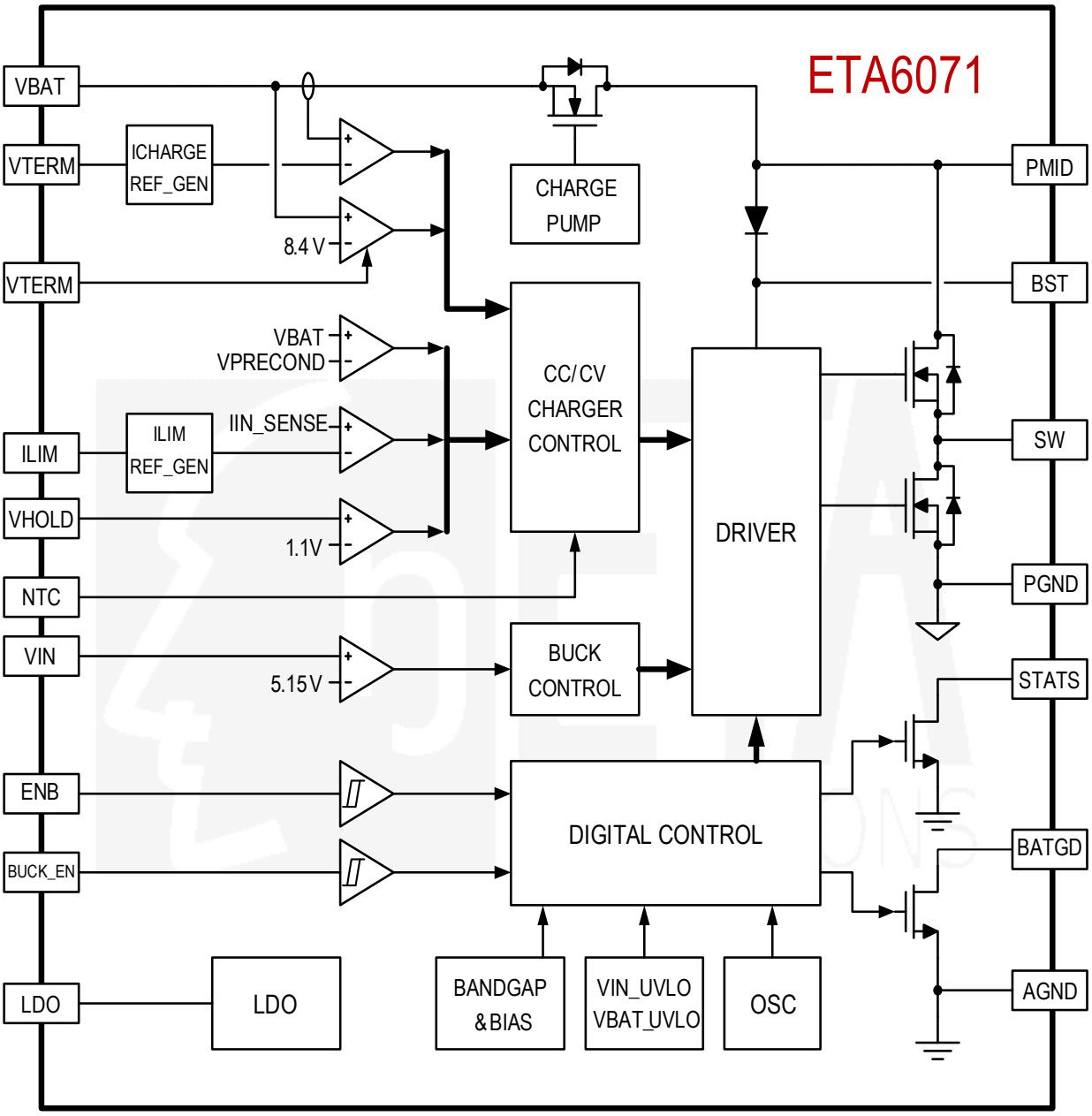
VIN>VBAT operation

In some occasions, the battery pack could be deeply discharged due to idle for a long period of time. So, the battery voltage can be quite low, sometimes even lower than the input voltage. In these occasions, upon plugging in the input, the ETA6071 enters a deeply discharged battery mode, unlike a regular boost converter that cannot maintain regulation when VIN is greater than VBAT, ETA6071 would regulate the charging current through the PMID to VBAT MOSFET providing a safer operation.

Battery balancing

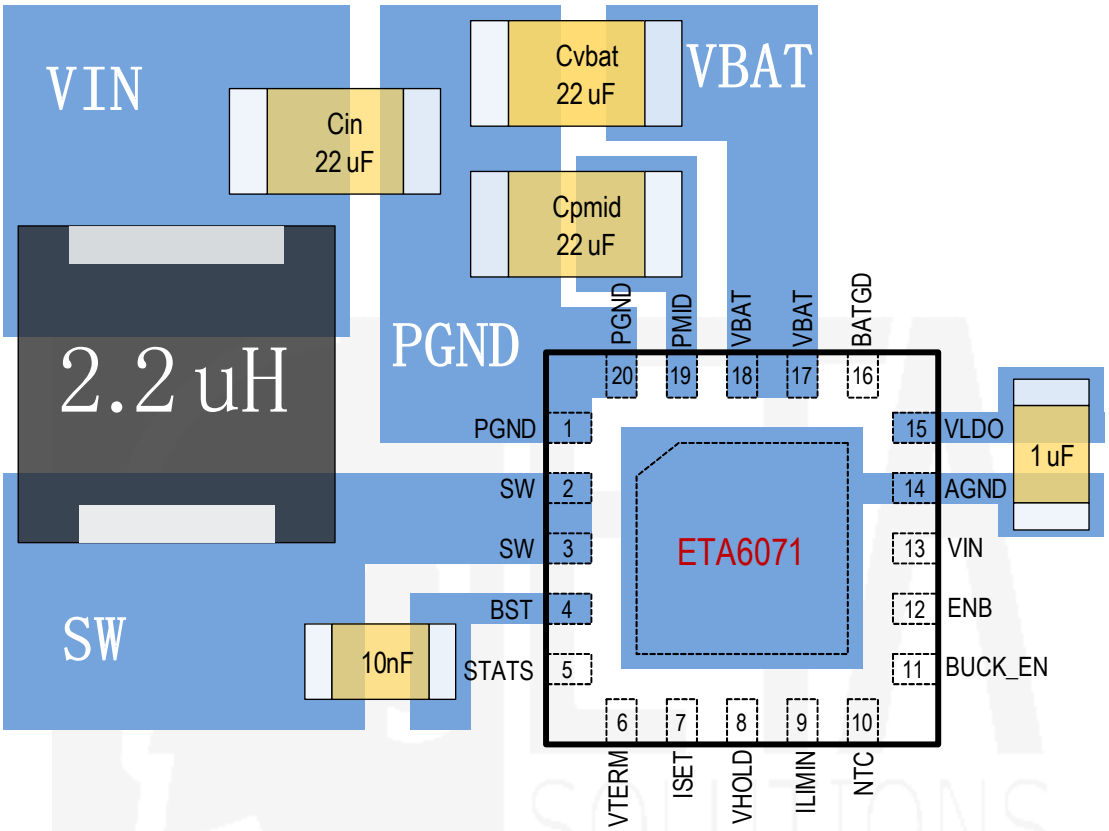
For batteries operate in series, it is imperative that the two cells are balanced to extend battery life. ETA provides a switching balance solution ETA3000 to achieve this. Please consult ETA3000 datasheet for detail.

BLOCK DIAGRAM



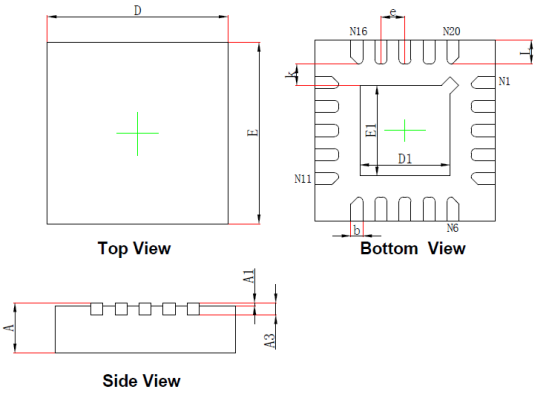
PCB GUIDELINES

Please try to place the Cvbat, inductor, Cpmid and Cin as suggested by the illustration below. The Cvbat and Cpmid have to be placed just next to the chip with shortest wire to the VBAT and PMID pins.



PACKAGE OUTLINE

Package: QFN3x3-20



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700/0.800	0.800/0.900	0.028/0.031	0.031/0.035
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	2.924	3.076	0.115	0.121
E	2.924	3.076	0.115	0.121
D1	1.400	1.600	0.055	0.063
E1	1.400	1.600	0.055	0.063
k	0.200MIN.		0.008MIN.	
b	0.150	0.250	0.006	0.010
e	0.400TYP.		0.016TYP.	
L	0.324	0.476	0.013	0.019