Technology with Spirit

Product Specification

Product Name	:	Lithium ion rechargeable battery
Product Model	:	HL18650T
Version	:	C
Document No.	:	CTE-CYS-01
Date	:	2020-4-20

Revision Sheet

Version	Amendment	Revision Date	Drafter	Auditor	Approver
A1	Revision issue	2018-11-30	Jerry Wang		
B	Revision B	2019-9-19	Jerry Wang		
C	Revision C	2020-4-20	Jerry Wang		

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1. Scope

This specification shall be applied to Lithium ion rechargeable battery supplied by TWS.

2. Product content

2.1 Product name

Lithium ion rechargeable battery

2.2 Model of product

HL18650T

3. Product specifications

No.	Item	Conditions	Specifications
3.1	Rated capacity	At rated charging[1] and rated discharging[2].	Type: 2000 mAh Min: 1950 mAh
3.2	Nominal voltage	Mean operation voltage during rated discharge after rated charge.	3.60 V
3.3	End of discharge voltage		2.75 V
3.4	Maximum charge voltage		4.20 V
3.5	Maximum continuous charge current	25 ± 2 °C	1 C (1950 mA)
3.6	Maximum continuous discharge current	25 ± 2 °C	5 C (9750 mA)
3.7	Mass		Approx. 42 g

[1] Standard charge: CC: 970 mA and CV: 4.2 V charge for cut-off current 40 mA at 25 ± 2 °C.
[2] Standard discharge: CC: 390 mA=0.2 C discharge till end of discharge voltage=2.75 V at 25 ± 2 °C.

3.8	Operating temperature range	Charge	0 - 60 °C 0＜T≤10 °C, 0.2 C to 4.1 V; 10＜T≤45 °C, 0.5 C to 4.2 V; 45＜T≤60 °C, 0.5 C to 4.1 V
		Discharge[3]	-40 - 85 °C 0＜T≤85 °C, 2.75 V; -20＜T≤0 °C, 2.50 V; -40≤T≤-20 °C, 2.00 V
		Storage (＞60 °C storage, maximum charge voltage ≤4.05 V)	-40 ~ 85 °C
3.9	Storing temperature range (non-condensing)	The 80% or more of capacity recovery rate	
		Within 15 days	0 ~ 85 °C
		Within 30 days	0 ~ 60 °C
		0 – 3 months	0 ~ 45 °C
		0 – 12 months	0 ~ 25 °C

4. Performance and test conditions

No.	Item	Conditions	Specifications
4.1	Outside appearance	Visual check	No prominent stain, deformation, nor damage.
4.2	Outside dimensions	Use caliper (0.05 mm a division) specified in JIS B 7507.	(See attached drawing)

[3] The cell temperature is not allowed to be higher than 90 °C.

<table>
<tr><td rowspan="5">4.3</td><td rowspan="5">Discharge time at different temperatures（In this test, discharge method refer to 3.8）</td><td colspan="4">Measure discharge time at the discharge temperature mentioned hereunder after rated charge at RT.</td><td colspan="4">Discharge time shall be more than the value in the table below.</td></tr>
<tr><td rowspan="3">Discharge current</td><td colspan="7">Discharge temperature（Unit: minute）</td></tr>
<tr><td>-40℃</td><td>-30℃</td><td>-20℃</td><td>0℃</td><td>25℃</td><td>60℃</td><td>85℃</td></tr>
<tr><td>390 mA</td><td>120</td><td>180</td><td>200</td><td>230</td><td>300</td><td>290</td><td>290</td></tr>
<tr><td>1950 mA</td><td>—</td><td>30</td><td>35</td><td>40</td><td>50</td><td>50</td><td>50</td></tr>
<tr><td>4.4</td><td>Internal resistance at delivery</td><td colspan="4">The battery impedance shall be measured by AC method (1kHz) within 1 week after delivery.</td><td colspan="4">40mΩ or less</td></tr>
<tr><td>4.5</td><td>Open circuit voltage</td><td colspan="4">Voltage within 24 hours after rated charge.</td><td colspan="4">4.00 V or more</td></tr>
<tr><td>4.6</td><td>Open circuit voltage at delivery</td><td colspan="4">Voltage within 1 week after delivery</td><td colspan="4">3.60 ± 0.03 V</td></tr>
<tr><td>4.7</td><td>Cycle life</td><td colspan="4">After 300 cycles of rated charge and discharge at 25 ± 2 °C charge at rated charge and then measure discharge time at rated discharge.</td><td colspan="4">Discharge time is 240 minutes or more after cycle.</td></tr>
<tr><td rowspan="2">4.8</td><td>Storage characteristics</td><td colspan="4">The battery under test is rated charged or rated discharged, and then stored in specified environmental temperature for specified period. The battery is rated discharged and discharge time is measured (Residual capacity). The battery is rated charged and then rated discharged measuring discharge time (Recovery capacity).</td><td colspan="4">More than times specified below</td></tr>
<tr><td>Charge state of the battery</td><td colspan="3">Storage temperature[4]</td><td colspan="2">Storage period</td><td colspan="3">Capacity（Unit: min）</td></tr>
</table>

[4] The tests specified above should be performed with new battery packs within 1 week after delivery, ＞60 ℃ storage, the maximum charge voltage of cell is ≤4.05V.

				Residual capacity	Recovery capacity
	Rated charged	20 °C	30 days	255	285
		60 °C	10 days	240	270
		60 °C	20 days	210	240
		85 °C[5]	1000 hours	\	200

5. Safety

No.	Item	Conditions	Specifications
5.1	External short circuit	The battery shall be rated charged. The plus and minus terminals of the battery shall be short circuited with a wire having 80 ± 20mΩ resistance and left for 1 hour.	No explosion, flame
5.2	Over charge	After rated charge, the battery shall be charged for 24 hours using a 12.00 V, 2500 mA power supply.	No explosion, flame.
5.3	Over discharge	The battery shall be rated charged and discharged with 50 Ω resistor load for 24 hours.	No explosion, flame
5.4	Drop	The battery shall be rated charged. At room temperature, it is dropped on concrete floor covered with vinyl tile of 5 mm thickness, one time at each direction, X, Y, Z, from the height of 75 cm.	No explosion, flame.

[5] In 85 °C storage test, charge and discharge voltage range is 4.05 ~ 2.75 V. When voltage drop to 3.70 V, 0.2 C charge the cell at 25 ± 2 °C to 4.05 V and go on with the storage.

5.5	Vibration	A rated charged battery shall be vibrated as specified hereunder. • Vibration waveform: sinusoidal • Frequency: 16.7 Hz • Test time: 1 hours • Vibration direction: arbitrary • Total amplitude: 1 mm After vibration application, the battery is rated charged, and then rated discharged。	No explosion, flame Can be charged and discharged.

6. Welding allowable part on a battery

Welding is not allowed on the central 2 mm diameter in a battery bottom face (negative terminal).

Welding is not allowed on a battery side wall.

7. Charge state at shipment

The battery is approximately 30% charged if there is no special requirement.

8. Warranty

Our corporation warrants the product is to be free from defects in materials and workmanship for a period of one year from the date of delivery. During the one year warranty period, Our corporation will repair or replace with new product free of charge, if any fault, which is due to material or workmanship evidently, occurs.

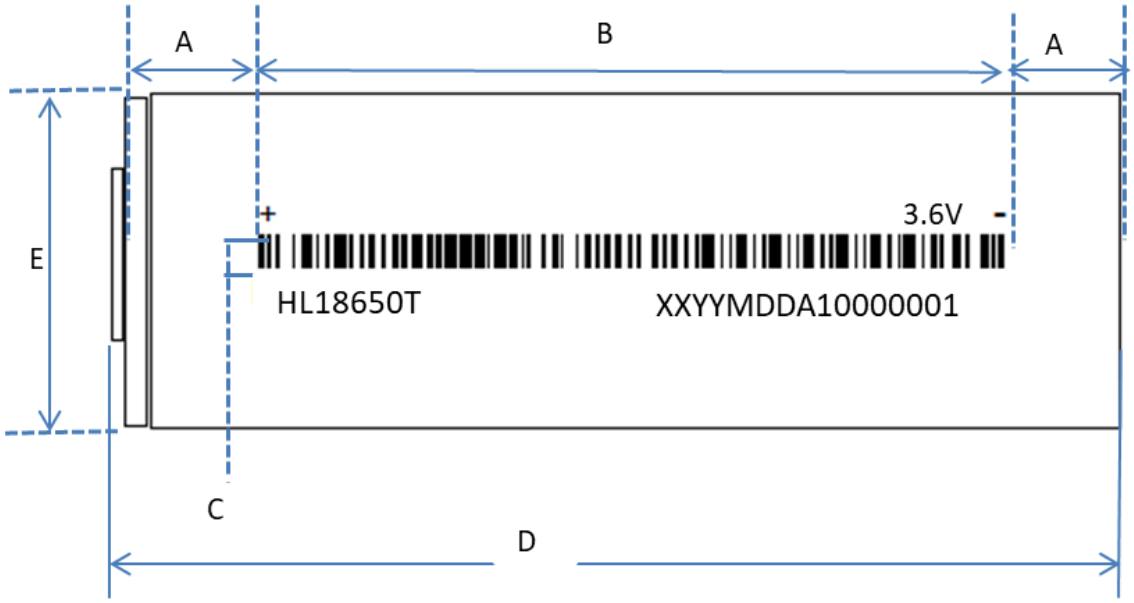
9. Handling warning

For use of this battery, must follow as specified below. Other than conditions listed, may cause major burst, fire, some smokes and it will cause severe performance failure and unsafe for use. Please be sure to follow instructions carefully. In order to eliminate electrical and mechanical stress to the battery from main unit malfunctions, “WARNING” message must be on instruction sheet.

- Use specified charger

- Use specified charge/discharge conditions
- Specified product use only
- Do not short terminals
- Do not immerse in water or pour
- Do not heat or throw in fire
- Store the battery in the warehouse with the temperature lower than 35 °C, relative humidity less than 75%, clean, desiccation and ventilation. Keep the battery away from fire and heat sources, the direct sunlight and corrosive matters.
- Do not attempt to crush or drop
- Do not attempt to disassemble or modify
- Do not solder
- Do not put it in microwave oven, oven or pressure container
- The battery must be packed before shipping. Prevent the battery from severe vibration, attacking, squeezing, direct sunlight and rain during transportation. Being shipped by the automotive, train, ship and plane is suitable. And the temperature around the package must be lower than 45 °C.
- If charging time is longer than specified, stop charge.
- During charging, normal use and storage of battery pack, such as smell, change of color, mechanical abuse are detected, do not use.
- In case of leakage or smells remove from thermal conditions. Also wash off with clean natural water for leaked solvent
- In case of solvent in your eye, wash off with clean natural water and consult your doctor

10. Battery dimension



No.	Items	Dimension	Remark
A	Barcode from head	>6.0 mm	1. Dimension is including PET sleeve 2. Pink PET heat-shrinkable sleeve 3. 5 holes cap
B	Barcode length	48.0 ± 2.0 mm	
C	Barcode height	2.0 ± 0.5 mm	
D	Battery length	64.9 ± 0.3 mm	
E	Battery width	18.3 ± 0.2 mm	

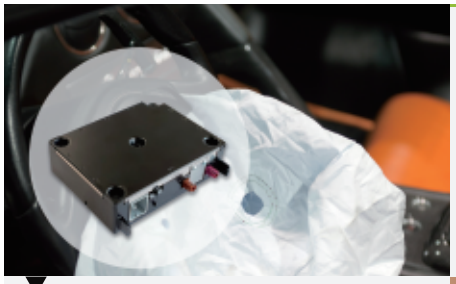
-END-

TWS HL18650T is a lithium ion cell with excellent reliability in extreme working temperature from -40 °C to 85 °C, which is widely used in e-Call, asset tracker, vehicle intelligent device, industrial handheld, etc.

TWS HL18650T Cell Advantage

- Perfect reliability in extreme working temperature from -40 °C to 85 °C.

Application



Industrial handheld

e-Call

Asset tracker

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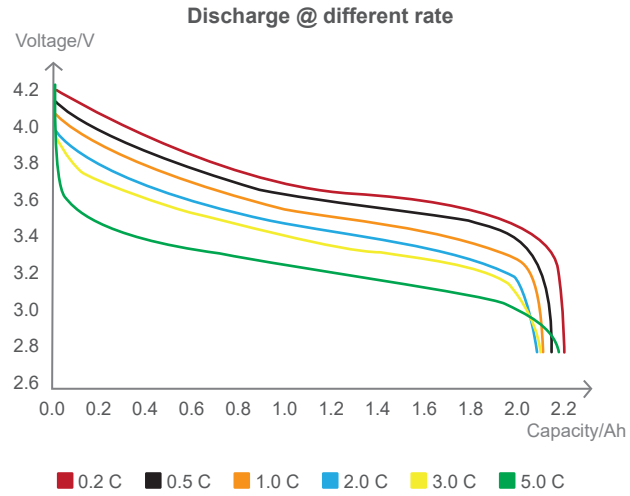
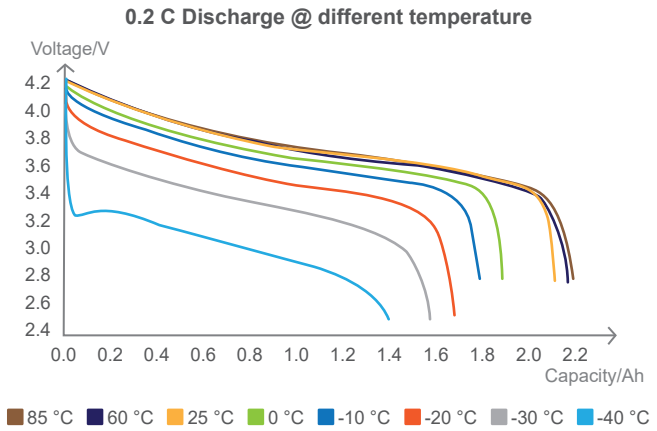
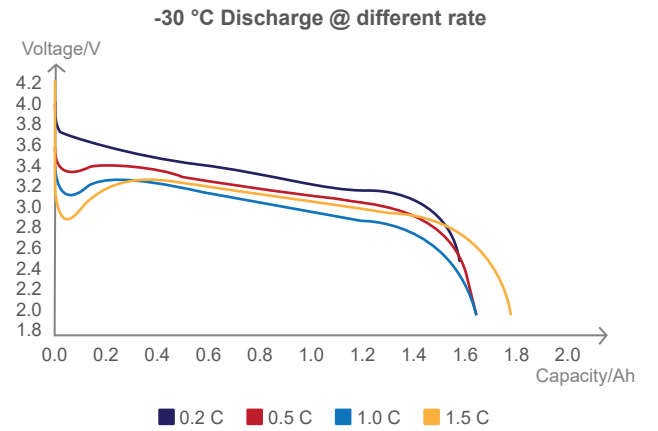
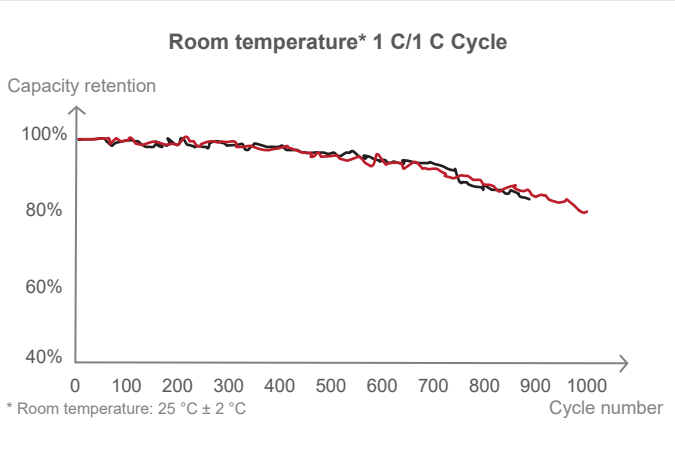
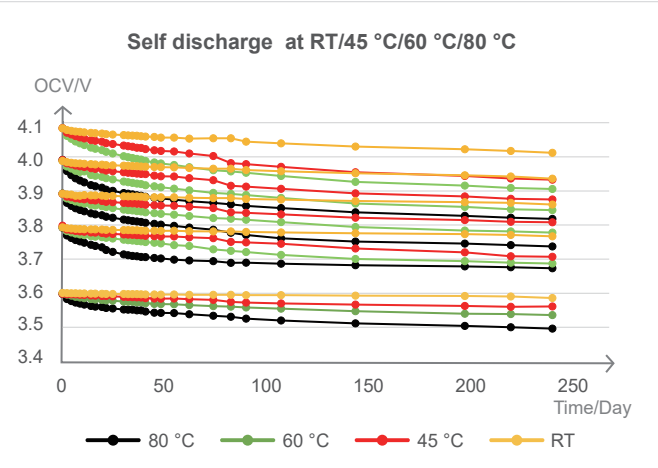
Model name		HL18650T
Dimension	Diameter	18.3 ± 0.2 mm
	Height	64.9 ± 0.3 mm
Capacity	Minimum (0.2 C)	1,950 mAh
	Typical (0.2 C)	2,000 mAh
	Capacity (5.0 C)	1,870 mAh
Typical voltage		3.60 V
Working voltage		2.75 V - 4.20 V
Maximum continuous charge/discharge		1.95 A/10.00 A
Cycle life (RT1.0 C/1.0 C)		> 300 cycles
-40 °C Capacity (0.2 C)		≈ 60%
80 °C 1000 hours aging capacity		> 90% recoverable
Operating temperature	Charge	0 °C ~ 60 °C
	Discharge	-40 °C ~ 85 °C











TWS- Powering Up Your Mobility

TWS is a global and dynamic industry pioneer, focused on portable and large format rechargeable battery solutions.
Our vision is to “Create a better life for people” and our mission is “To be the industry leader in rechargeable energy solutions”.

Email: info@tws.com
Website: http://www.tws.com

Vacuum Cleaner Battery BMS Solutions

Solution	Solution A: AFE + MCU	Solution B: Standalone AFE	Solution C: MCU Monitor + Motor Driver	Solution D: Hardware
Configuration	6S1P ~ 10S1P	3S1P ~ 8S1P 3S2P ~ 8S2P	4S1P ~ 7S1P	3S1P ~ 8S1P 3S2P ~ 8S2P
Nominal voltage	21.6 V ~ 36.0 V	10.8 V ~ 28.8 V	14.4 V ~ 25.2 V	10.8 V ~ 28.8 V
Cell type	18650 21700	18650 21700	18650 21700	18650 21700
Capacity	1,800 mAh ~ 3,500 mAh 3,000 mAh ~ 5,000 mAh	3,600 mAh ~ 7,000 mAh 6,000 mAh ~ 10,000 mAh	1,800 mAh ~ 3,500 mAh 3,000 mAh ~ 5,000 mAh	3,600 mAh ~ 7,000 mAh 6,000 mAh ~ 10,000 mAh
Max. continuous charge current	3.5 A	5.0 A	3.5 A	5.0 A
Max. continuous discharge current	20.0 A 30.0 A	30.0 A 60.0 A	20.0 A 30.0 A	30.0 A 60.0 A
Operation temperature	0 °C ~ 45 °C (Charge) -20 °C ~ 80 °C (Discharge)	0 °C ~ 45 °C (Charge) -20 °C ~ 80 °C (Discharge)	0 °C ~ 45 °C (Charge) -20 °C ~ 80 °C (Discharge)	0 °C ~ 45 °C (Charge) -20 °C ~ 60 °C (Discharge)

Solution A AFE + MCU

Feature: Hardware protection, software protection, MCU coulomb counter gas gauge, communication

Basic information:

1.Support 6 ~ 10 series;
2.TI AFE (bq76930) + MCU (ST or NXP) or fully integrated IC (Renesas);
3.Support UART communication;
4.Support cell passive balance (80 mA);
5.Support 10 A charge, 25 A continuous discharge (adding FETs can increase discharge current);
6.Support LED indication SoC (State of Charge);
7.Support over voltage protection, under voltage protection, over charge current protection, over discharge current protection, over temperature protection, short circuit protection;
8.Support firmware update from PC or host device;
9.Standby current ≤ 30 μA;
10.Support MCU coulomb counter gas gauge;
11.Optional second level over voltage protection (IC + SCP fuse), meeting UL2054 requirements.

Solution B Standalone AFE

Feature: Hardware protection, host device provided gas gauging, communication

Basic information:

1.Support 3 ~ 8 series;
2.Intersil ISL94202 AFE;
3.Support I^2C bus communication;
4.Support cell passive balance (50 mA);
5.Support 10 A charge, 22 A continuous discharge (adding FETs can increase discharge current);
6.Support over voltage protection, under voltage protection, over charge current protection, over discharge current protection, over temperature protection, short circuit protection;
7.Standby current ≤ 50 μA;
8.Host device can read battery voltage and current;
9.Optional second level over voltage protection (IC + SCP fuse), meeting UL2054 requirements.

Solution C MCU Monitor + Motor Driver

Feature: Software protection, MCU coulomb counter gas gauge, communication

Basic information:

1.Support 4 ~ 7 series;
2.ST MCU control protection;
3.Support one wire communication;
4.Support 0.5 A charge,10 A discharge;
5.Battery include motor driver;
6.Support LED indication SoC;
7.Support software protection, including over voltage protection, under voltage protection, over charge current protection, over discharge current protection, over temperature protection, short circuit protection;
8.Standby current ≤ 40 μA;
9.Support MCU coulomb counter gas gauge;
10.Optional second level over voltage protection (IC + SCP fuse), meeting UL2054 requirements.

Solution D Hardware

Feature: Hardware protection

Basic information:

1.Support 3 ~ 8 series;
2.Hardware solution, Mitsumi, Seiko, BYD, CELLWISE IC.
3.Support 2 A charge, 7 A continuous discharge (adding FETs can increase discharge current);
4.Support over voltage protection, under voltage protection, over discharge current protection, over temperature protection, short circuit protection;
5.Standby current ≤ 30 μA;
6.Optional second level over voltage protection (IC + SCP fuse), meeting UL2054 requirements.

Email: info@tws.com
Website: http://www.tws.com

TWS

Technology with Spirit

e-Call

e-Call Battery Charge and Discharge Profile

Technology with Spirit

0~60℃ charge

Charge Profile

The charge will be operated at temperatures between 0℃~60℃

Normal Charge

The battery shall support a charging current from 50mA to 1.2A(300mA~400mA typical).

The battery will be charged to the end of charge voltage at ervery vehicle ingition cycle to ensure that the battery is at 100% SoC. The charge process will restart if the voltage is falling below 3.3V. Should the car be parked for a long time, the battery 's "self"discharge can bring it below the 3.3V threshold. As a result, the battery will be recharged up to the nominal 3.60V. The battery will be at full charge most of its life.

e-Call battery will be at full charge most of its life

Discharge/Use Profile

The purpose of the rechargeable battery is to supply power to an electronics module, when the vehicle battery is disconneted. This will only happen very few times in the life of a battery. The module will then perform an emergency call to a call center.

e-Call battery only few times be used in the life

Automotive Components for e-Call

Key Component	Mainstream Brands	Automotive	Comment
Protection IC	Japan Ricoh Japan Mitsumi Japan SII (ABLIC) China Brands USA TI	NO NO Yes NO Yes	/ / only S-19190/S-19100, 1s protection IC / only bq29209-Q1, 2s protection IC
Mosfet	USA Diodes	Yes	
PTC	Taiwan Polytronics(PPTC) China Wayon USA Littelfuse	NO NO Yes (only ≦2.6A)	/ / Only ≦2.6A PTC meet Automotive (only meet 1.5A e-Call battery requirement, can't meet 4A)
NTC	Japan MuRata Taiwan Thinking	Yes Yes	
Fuse	Littelfuse China SART China AEM	Yes Yes Yes	
SCP Fuse (SCP: Self-control protect)	Dexerials USA Littelfuse Polytronics	NO NO NO	
Capacitor	Japan MuRata	Yes	
Resistor	TA-I(大毅)	Yes	

Optional automotive protection IC is limited

Optional automotive PTC is limited

No Automotive SCP Fuse

Cell Information for e-Call

	J Cell US18650FTC1	J Cell US18650FTC2	TWS 18650T
Cell Chemical system	**LFP**	**LFP**	**NCM**
Nominal Capacity	**1100mAh**	**1450mAh**	**2000mAh**
Minimum Capacity	**1050mAh**	**1350mAh**	**1950mAh**
Nominal Voltage	**3.2V**	**3.2V**	**3.6V**
Discharge cut-off voltage	2.0V	2.0V	2.75V
Charge Voltage	3.65V	3.65V	4.2V
Max. continuous Charge Current	1.5A	1.5A	1.95A
Max. continuous Discharge Current	20A	20A	9.75A
Internal Resistance	17mΩ typ.	12mΩ typ.	25mΩ. typ.
Charge Operation Temperature	**0℃~60℃**	**0℃~60℃**	**0℃~60℃** 0~10℃；0.2C to 4.1V 10~45℃；0.5C to 4.2V 45~60℃；0.5C to 4.1V
Discharge Operation Temperature	-40℃~-20℃ (Supplier don't guarantee proper operation) **-20℃~80℃** (Standard spec range) 80℃~90℃ (10hours max across lifetime)	-40℃~-20℃ (Supplier don't guarantee proper operation) **-20℃~80℃** (Standard spec range) 80℃~90℃ (10hours max across lifetime)	**-40℃~85℃** 0~85℃；2.75V -20~0℃；2.5V -40~-20℃；2.0V (Standard spec range)
Storage Temperature	**-40℃~90℃**	**-40℃~90℃**	**-40℃~85℃**
Cycle Life	1000(1.35A discharge)	1000(1.35A discharge)	>300

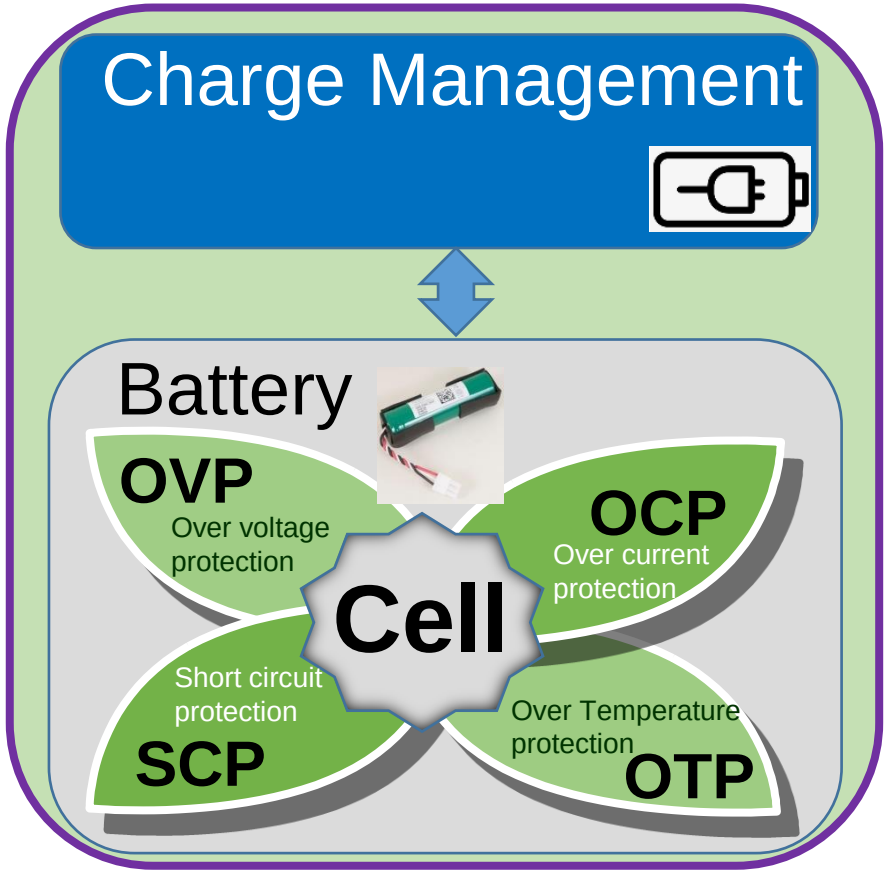
High Capacity
High Voltage

Wide Temp. Range

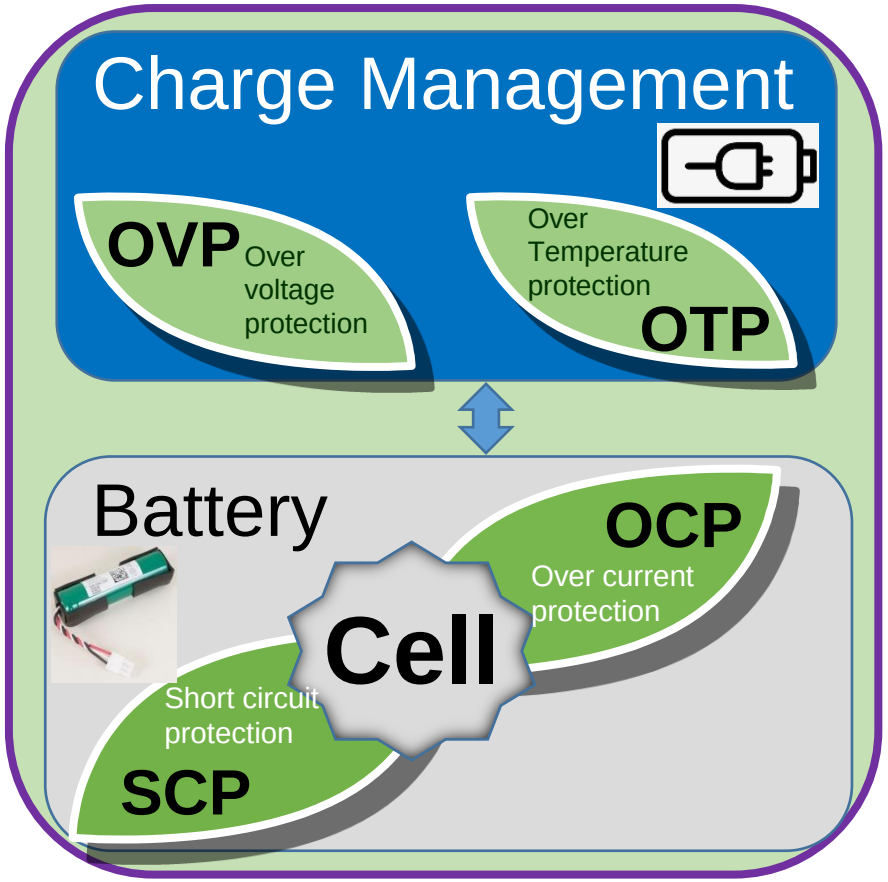
How to Protect e-Call Battery?

Host charge management CC-CV limited charge voltage

E-Call battery with OVP,OCP, OTP,SCP



or



Host charge management integrated the OVP, OTP.

E-Call battery with the OCP,SCP

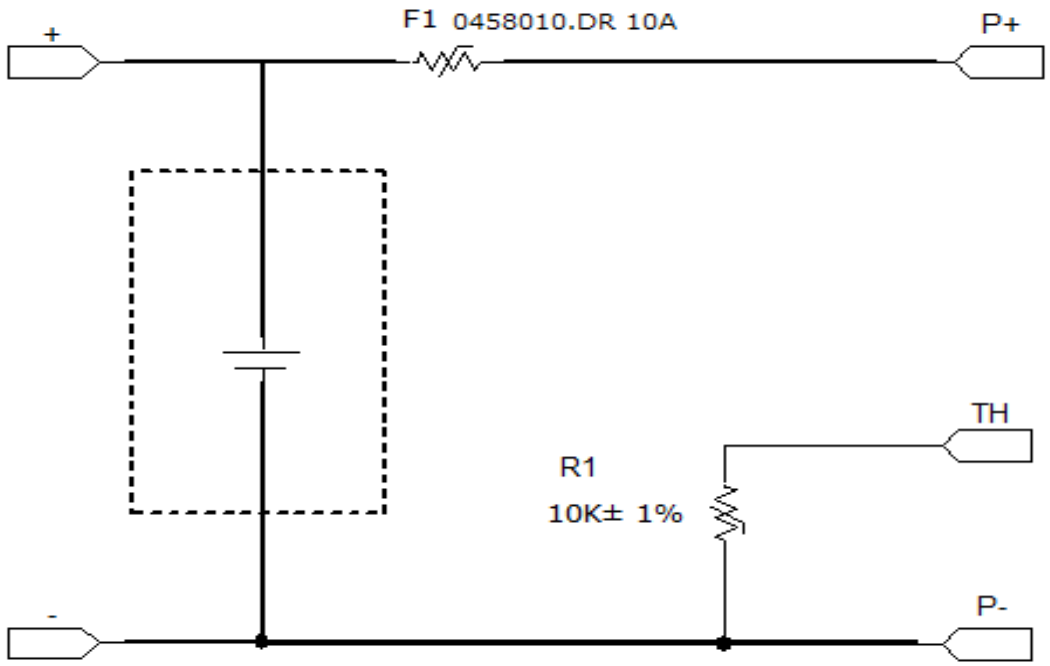
Why no UVP(Under Voltage Protection)？

1. Under voltage almost never meet (100% SoC standby most of its life)
2. Low voltage no safety issue (only impact the cycle life below 1.5V)
3. Host discharge until 2.0V cutoff

Battery Protection Solution

Solution A----Fuse

Block Diagram



Applicable Cell

US18650FTC1 or US18650FTC2
TWS 18650T

Feature

1). No over voltage protective(OVP)
2). With short circuit protection(by Fuse)
3). With NTC output

Low cost
Lower Safety

Key Component and PCM Cost

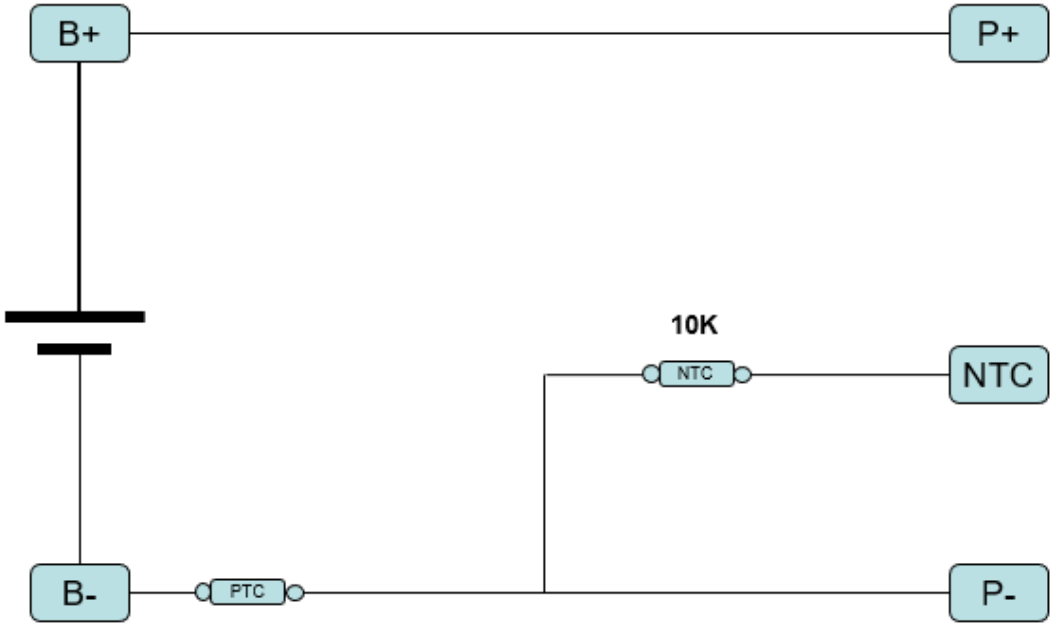
Parts	Brand	Description	Comment	Automotive
NTC	MuRata	NCP18XH103F03RB	10K±1% B3435	NO
Fuse	LittleFuse	0458010.DR	10A	NO

For TWS 18650T cell, if customer select this solution customer **must** design **over voltage** protection in **Host** side and take the safety **responsivity**.

Battery Protection Solution

Solution B----PTC

Block Diagram



Applicable Cell

US18650FTC1 or US18650FTC2
TWS 18650T

Feature

1). No over voltage protective(OVP)
2). With over current protection(by PTC)
3). With short circuit protection(by PTC)
4). With over temperature protection(by PTC)
5). With NTC output
6). Current is limited(5.5A@20℃ ,3.0A@85℃)

Low cost
Safety higher than Fuse

Key Component and PCM Cost

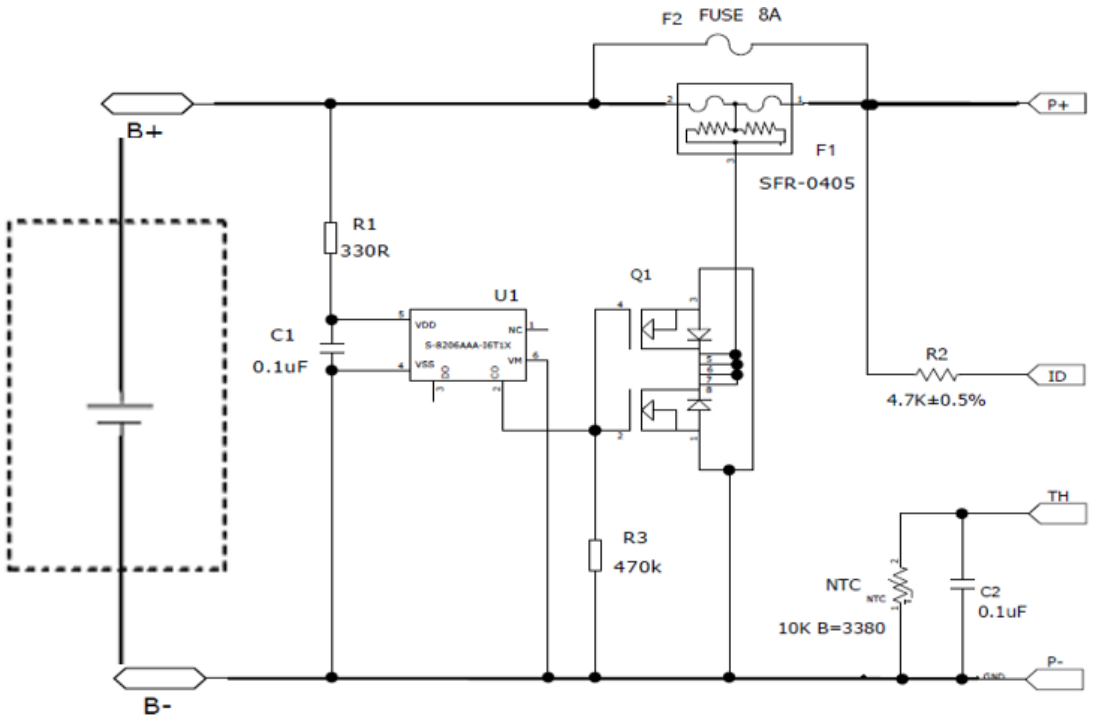
Parts	Brand	Description	Comment	Automotive
NTC	MuRata	NXFS15XH103FEAB	DIP 10K±1% B3435	Yes
PTC	LittleFuse	miniASMDC260F/12 SMD. 1812	Hold 2.6A@20℃ , Hold 1.69A@85℃	Yes
		LR4-550 (Optional) Strap, size 56.1*6.3*1.0mm max.	Hold 5.5A@20℃ , Hold 3.0A@85℃	NO, but meet all the Automotive test

For TWS 18650T cell, if customer select this solution customer **must** design **over voltage** protection in **Host** side and take the safety **responsivity**.

Battery Protection Solution

Solution C----IC+SCP Fuse

Block Diagram



Applicable Cell

US18650FTC1 or US18650FTC2
TWS 18650T

Feature

1). With over voltage protective(by IC)
2). With over current protection(by Fuse)
3). With short circuit protection(by Fuse)
4). With NTC output

Non-Automotive High Safety

Key Component and PCM Cost

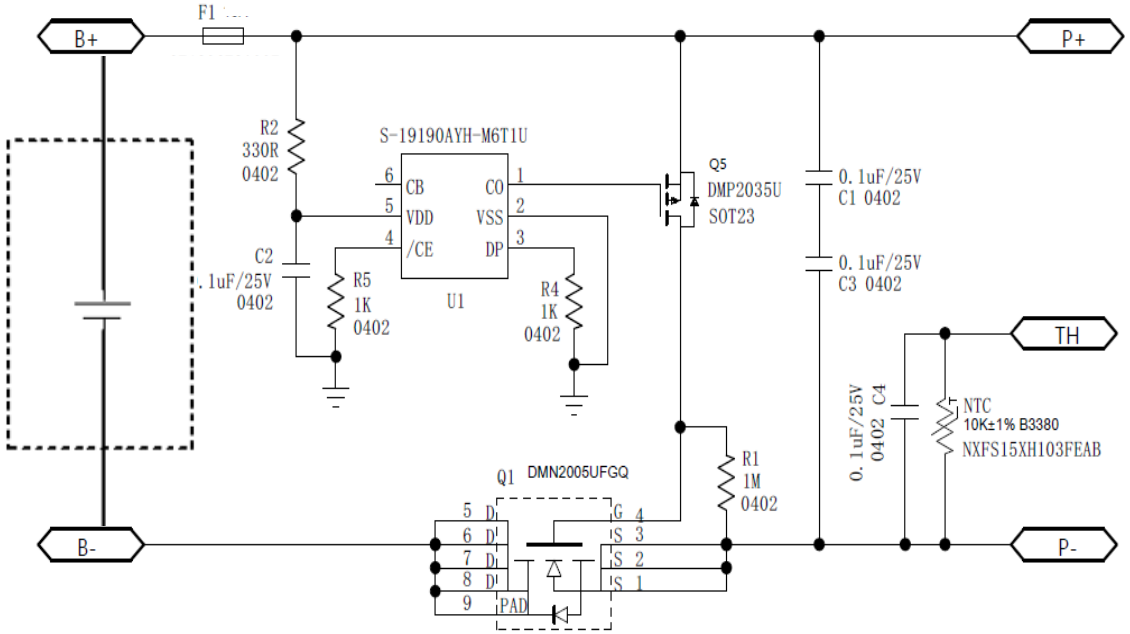
Parts	Brand	Description	Comment	**Automotive**
IC(U1)	ABLIC(SII)	S-8206AAA (Optional)	Protection IC *OVP=4.5V(Optional)	NO
		S-19190BIH(Optional)	Protection IC *OVP=4.4V(optional)	**Yes**
NTC	MuRata	NXFS15XH103FA2B 10K±1% B3435	NTC	**Yes**
MOS	Panasonic	MTM78E2B0LBF	SCP Fuse driver	NO
Fuse	Dexerials	SFR-0405	SCP Fuse, 5A,36V	NO

OVP: Over voltage protection

Battery Protection Solution

NEW Solution D----IC+MOS+Fuse

Block Diagram



Applicable Cell

US18650FTC1 or US18650FTC2
TWS 18650T

Feature

1). With over voltage protective(by IC)
2). With over current protection(by Fuse)
3). With short circuit protection(by Fuse)
4). With NTC output
5). Automotive components

Automotive High Safety

Key Component and PCM Cost

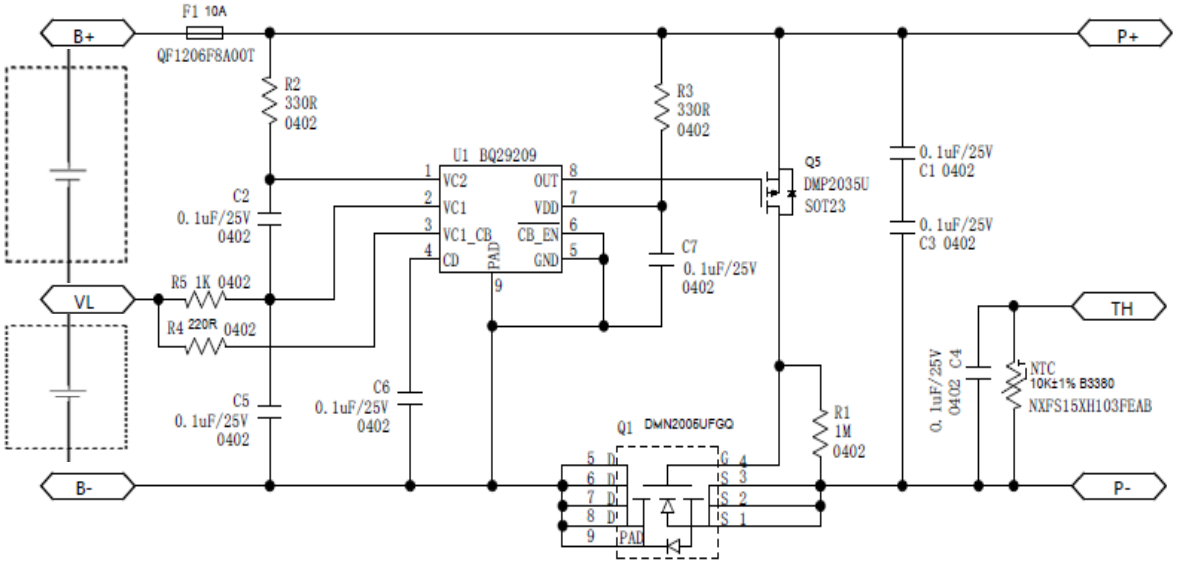
Parts	Brand	Description	Comment	**Automotive**
IC(U1)	ABLIC(SII)	S-19190AYH(Optional)	Protection IC *OVP=4.275V(optional)	**Yes**
NTC	MuRata	NXFS15XH103FEAB	DIP 10K±1% B3435	**Yes**
MOS(Q5)	Diodes	DMP2035U	P-CH	**Yes**
MOS(Q1)	Diodes	DMN2005UFGQ	N-CH, CHG FET	**Yes**
Fuse(F1)	AEM	QF1206F6A00T	SCP Fuse, 5A,36V	**Yes**

OVP: Over voltage protection

Battery Protection Solution

NEW Solution E----2 series

Block Diagram



Applicable Cell

US18650FTC1 or US18650FTC2
TWS 18650T

Feature

1). For 2S special application
2). With over voltage protective(by IC)
3). With over current protection(by Fuse)
4). With short circuit protection(by Fuse)
5). With NTC output
6). Support cell balance (10mA)
7). Automotive components

2S, Automotive High Safety

Key Component and PCM Cost

Parts	Brand	Description	Comment	**Automotive**
IC(U1)	TI	bq29209-Q1	Protection IC *OVP=4.275(optional)	**Yes**
NTC	MuRata	NXFS15XH103FEAB	DIP 10K±1% B3435	**Yes**
MOS(Q5)	Diodes	DMP2035U	P-CH	**Yes**
MOS(Q1)	Diodes	DMN2005UFGQ	N-CH, CHG FET	**Yes**
Fuse(F1)	AEM	QF1206F6A00T	SCP Fuse, 5A,36V	**Yes**

OVP: Over voltage protection

Solution Comparison

For TWS 18650T cell, if customer select solution A or B, customer **must** design **over voltage** protection in **Host** side and take the safety **responsivity**.

Solution	Safety	Cost	Automotive	In Series	Advantages
Solution A----Fuse	★½	Low	NO	1S	Low cost Lower Safety
Solution B----PTC	★★	Low	Yes (Limit 1.5A)	1S	Low cost Lower Safety ,but higher than Fuse
Solution C----IC+SCP Fuse	★★★	High	NO	1S	Non-Automotive High Safety
NEW Solution D----IC+MOS+Fuse	★★★★	High	Yes	1S	Automotive High Safety
NEW Solution E----2S	★★★★	High	Yes	2S	2S, Automotive High Safety

TWS

Technology with Spirit

THANK YOU!

T-GO system introduction

Presenter: Walter | Kenneth
Date: 2020.10.28

Content

- Material handling market introduction
- T-GO system introduction
- Q&A

Proprietary Material of TWS

PART 1

Part 1 Material Handling Market

1. Market status
2. Classification of forklift
3. Strategic fit
4. Industrial value chain
5. Potential customer list

Market at a glance

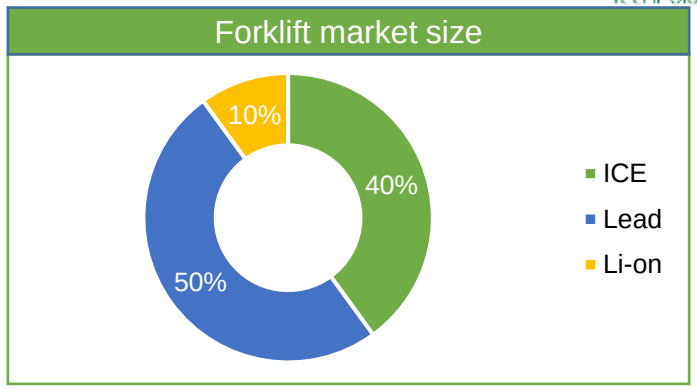
Material Handling Market

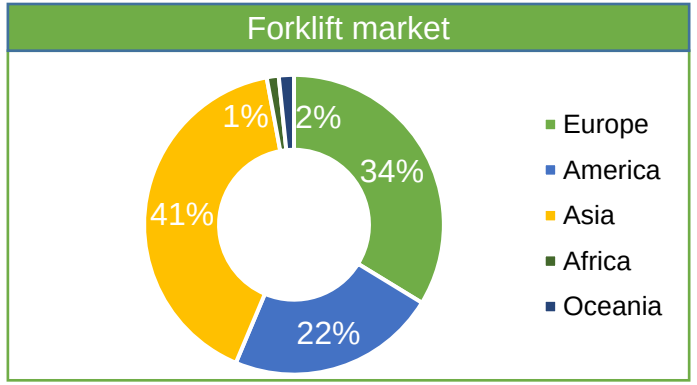
<u>Forklift</u> | AGV | Robotics | Cleaning machine | Lifting platform

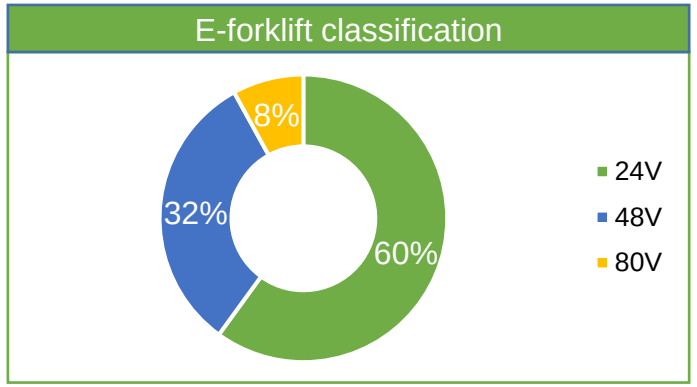
Material handling Market Size: ≈150 Billion (USD)

Forklift market size: ≈ 50 Billion (USD)

E-forklift market size: ≈ 5 Billion (USD)







World top 20 forklift manufacturers

2019 Rank	Company	2018 Rank	2018 Revenue USD M	2019 Revenue USD M	% Change 2018-2019	North American brands	World headquarters
1	Toyota Industries Corporation	1	13292	13356	0.50%	Toyota, Raymond	Aichi, Japan
2	KION Group AG	2	6633	7173	8.10%	Linde, STILL, Baoli	Wiesbaden, Germany
3	Jungheinrich AG	3	4363	4576	4.90%	Sold in NA by Mitsubishi	Hamburg, Germany
4	Mitsubishi Logisnext Co., Ltd.	4	4270	4152	-2.80%	UniCarriers, Mitsubishi, CAT,	Kyoto, Japan
5	Crown Equipment Corp.	5	3480	3720	6.90%	Crown, Hamech	New Bremen, Ohio
6	Hyster-Yale Materials Handling, Inc.	6	3174	3292	3.70%	Hyster, Yale, Nuvera,	Cleveland, Ohio
7	Anhui Forklift Truck Group Co., Ltd	7	1414	1438	1.70%	Heli, CHL	Hefei, Anhui, China
8	Hangcha Group Co., Ltd.	8	1229	1268	3.20%	HC, Hangcha	Hangzhou, China
9	Doosan Industrial Vehicle	10	1121	1166	4.00%	Doosan	Seoul, South Korea
10	Clark Material Handling International, Inc.	9	790	783	-0.90%	Clark	Seoul, South Korea
11	Komatsu Ltd.	11	649	649*	0.00%	Komatsu	Tokyo, Japan
12	Hyundai Heavy Industries	12	400	406	1.50%	Hyundai	Ulsan, South Korea
13	Lonking Forklift Co., Ltd.	13	343	343*	0.00%	Lonking	Shanghai, China
14	Combilift Ltd.	15	293	335	14.30%	Combilift	Monaghan, Ireland
15	EP Equipment, Ltd.	14	294	310	5.40%	Big Joe	Hangzhou, China
16	Manitou	16	218	218*	0.00%	Manitou	Ancenis Cedex, France
17	Konecranes	17	185	185*	0.00%	Konecranes	Hyvink, Finland
18	Liuzhou LiuGong Forklift Co.,Ltd	N/A	89	94	5.60%	LiuGong	Katy, Texas
19	Godrej & Boyce Mfg. Co. Ltd.	18	79	77	-2.50%	Not available in North America	Mumbai, India
20	Hubtex Maschinenbau GmbH & Co. KG	19	72	72*	0.00%	Hubtex	Fulda, Germany
		TOTAL	**42388**	**43613**	**2.90%**		

Source: Industrial Truck Association (ITA)

Market Status of e-forklift market

➢ What are the growth-drivers in the forklift truck sector?

- Lead-acid batteries have been long held to be a cost-effective battery chemistry and have dominated the electric forklift truck market.
- Prediction that the fast development of **Li-ion battery technology** by **2028 electric vehicles, predominantly powered by Li-ion batteries will occupy 70% of the forklift truck market**

➢ Electric power – The Challenges

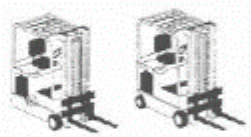
- Our favourable predictions for Li-ion battery power do not mean that there won't be challenges to overcome. Lead-acid battery power already has a strong presence on the shop floor. **Only when companies buy new forklifts will they move from lead-acid to Li-ion technology**. Manufacturers of Li-ion powered trucks will have to spell out clearly **the cost benefits of Li-ion over lead-acid**. The initial higher cost will need to be offset by aggressive marketing of the advantages of this technology, **such as superior energy density, cycle life, efficiency, low maintenance and shorter charging times**.

➢ Regional Trends

- **In Europe, more than 80% of shipped forklift trucks were electrified in 2019.**

Europe Forklift classifications

Forklift Classes and Lift Codes

Class #	Type of Propulsion and Operation	Lift Code	Description	Picture
I	Electric Motor Rider	4	Counterbalanced, sit-down, 3-wheel	
		5	Counterbalanced, sit-down, cushion (solid) tire	
		6	Counterbalanced, sit-down, pneumatic tire	
III	Electric Motor Walkie	2	Low-lift pallet	
		5	High lift reach type	
		7	High lift counterbalanced	
IV	Internal Combustion Engine Rider	3	Counterbalanced, sit-down, cushion (solid) tire	
V	Internal Combustion Engine Rider	4	Counterbalanced, sit-down, pneumatic tire	
VII	Rough Terrain	1	All types	

Focused Market segment:

A.1. **Forklift (Forklift 24V - 120V || 400V – 730V)**

A1.1. Forklift 24V / 48V / 80V CLASS **1/2/3**

A.1.2. Forklift 400V - 730V CLASS **7**

High Voltage is a Big Upcoming market, demand from System integrators package solution. Applications as Forklift, Crane, AGV and Hybrid

The combination of 24V/48V/80V battery

Technology with Spirit

24V

No.	System Voltage	Lead Capacity	Energy	Container dimension		
	(V)	(Ah)	(KWh)	Depth	Width	High
1	24	150	3,6	648	146	567
2	24(25.6)	225	5,4	645	196	570
3	24(25.6)	300	7,2	656	196	675
4	24(25.6)	250	6	621	209	627
5	24(25.6)	375	9	621	281	627
6	24(25.6)	465	11,16	626	285	784
7	24(25.6)	620	14,88	626	357	784

48V

No.	System Voltage	Lead Capacity	Energy	Container dimension		
	(V)	(Ah)	(KWh)	Depth	Width	High
1	48(51.2)	500	24	827	519	627
2	48(51.2)	625	30	827	627	627
3	48(51.2)	750	36	827	735	627
4	48(51.2)	465	22,32	1032	350	784
5	48(51.2)	620	29,76	1032	440	784
6	48(51.2)	775	37,2	1032	530	784
7	48(51.2)	465	22,32	1218	280	784
8	48(51.2)	620	29,76	1218	352	784
9	48(51.2)	775	37,2	1218	424	784
10	48(51.2)	930	44,64	1218	496	784

80V

No.	System Voltage	Lead Capacity	Energy	Container dimension		
	(V)	(Ah)	(KWh)	Depth	Width	High
1	80(76.8)	500	40	1025	708	627
2	80(76.8)	625	50	1025	852	627
3	80(76.8)	620	49,6	1025	708	784
4	80(76.8)	775	62	1025	852	784
5	80(76.8)	750	60	1025	993	627
6	80(76.8)	930	74,4	1025	993	784

Industrial Value Chain

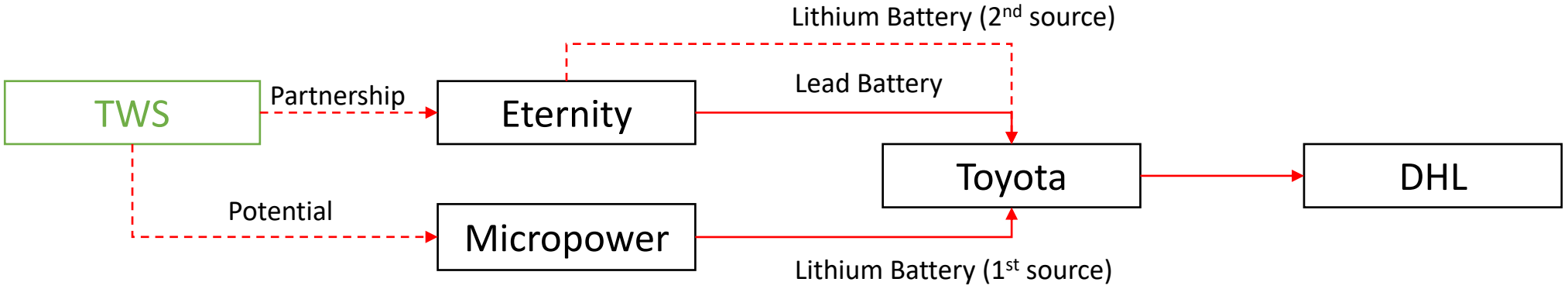
Battery pack manufacturer
- Module
- Connectors
- BMS
- ……

Sales channel
- Distributor
- Pack maker
- Charger maker
- ……

Forklift Manufacturer
- Toyota
- Crown
- Linde
- ……

End-user / customer
- DHL
- FedEx
- UPS
- ……

Example of Europe market business model



Potential customer list

Brand	Market	Market Present	Global % share
TOYOTA IND. EQUIPMENT	Japan	Global	17.7
MITSUBISHI	Japan	Global	7.4
KOMATSU	Japan	Global	2.2
ANHUI	China	Global	4.6
HANGSHA	China	Global	3.8
LONGKING FORKLIFT	China	Global	1.3
EP EQUIPMENT	China	Global	0.8
DOOSAN	Korea	Korea	2.9
Clark	Korea	Korea	2.6
Hyundai	Korea	Korea	1.6
JUNGHEINRICH	Germany	Global	14.9
LINDE *	Germany	Global	13.6
STILL *	Germany	Global	
TOYOTA	Sweden|Italy	Global	17.1
MITSUBISHI LOGINEXT	Finland|Sweden|Spain	Global	7.4
CLARK	Germany	Global	2.6
CROWN	Germany	Global	6.8
HYSTER YALE	UK|NL	Global	6.9
COMBILIFT	UK	Global	1.0
MANITOE	France	Global	0.7
HUBTEX	Germay	Global	0.3

Brand	Market	Market Present	Global % share
Toyota Industries Corporation	USA	Global	17.7
KION Group AG	USA	Global	7.4
Jungheinrich AG	USA	Global	2.2
Mitsubishi Logisnext	USA	Global	
Crown Equipment Corp.	USA	Global	4.6
Hyster-Yale Materials Handling	USA	Global	3.8
Anhui Forklift Truck Group	USA	Global	1.3
Hangcha Group	USA	Global	0.8
Doosan Industrial Vehicle	USA	Global	
Clark Material Handling International	USA	Global	2.9
Komatsu	USA	Global	2.6
Hyundai Heavy Industries	USA	Global	1.6
Lonking Forklift	USA	Global	
Combilift	USA	Global	14.9
EP Equipment	USA	Global	13.6
Manitou	USA	Global	
Konecranes	USA	Global	17.1
Liuzhou LiuGong Forklift	USA	Global	7.4
Godrej & Boyce	USA	Global	2.6
Hubtex Maschinenbau	USA	Global	6.8

PART 2

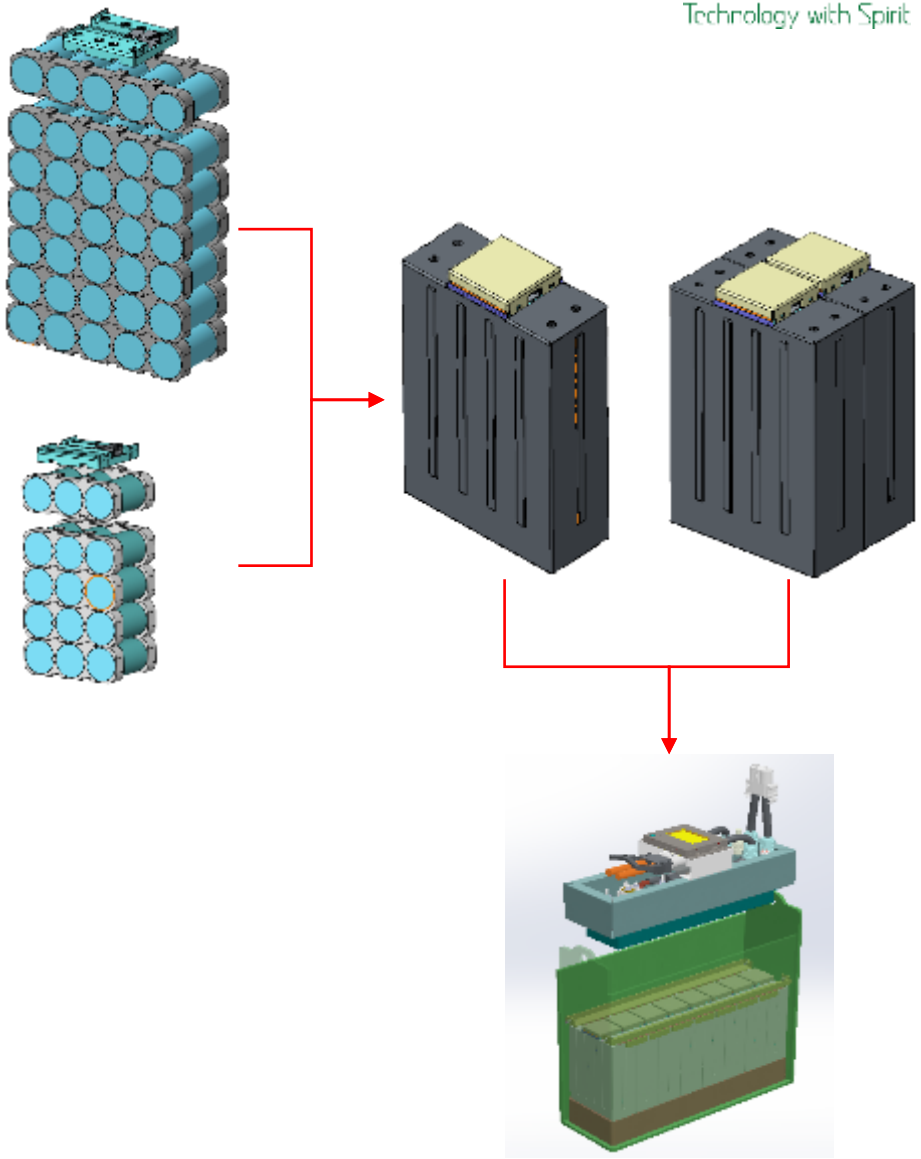
Part 2 T-GO system introduction

1. What’s the idea of T-GO
2. T-GO project introduction
3. T-GO product introduction

What’s the idea of T-GO?

Flexible
Expandable
Wide coverage

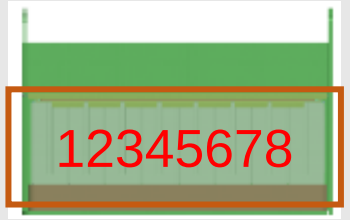
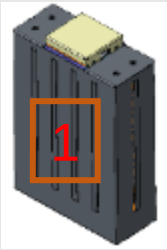
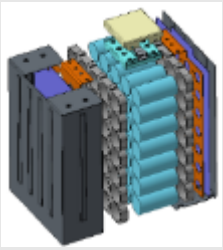
Quick design
Quick RFQ
Low NRE cost



T-GO Project Definition

Develop an e-Forklift LFP 26650 T-GO system, suitable for most of e-forklifts from various manufacturers to replace the Leads battery.

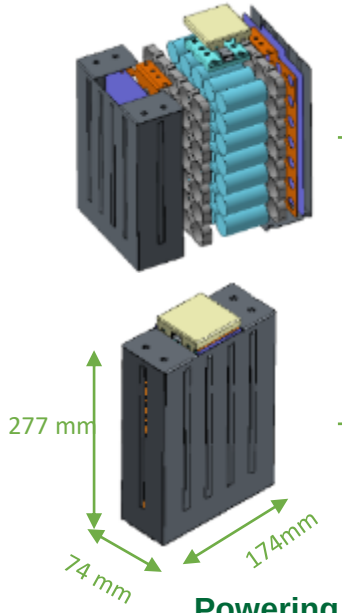
- Common Module Development – pick suitable cell and develop common module, which would fit into as much as possible forklift replacement battery form-factors
- Proof of Concept – pick the most common e-forklift Lead Acid battery replacement – 24V typical working sample with master-slave BMS
- Project Phase I – NPD team & FAE team: develop 1. T-GO core unit and 2. BMS module for Europe market. Europe team: to find system integrator / OEM customers to assemble the product into the power container
- Project key deliverable – 2020 Nov T-GO core unit ready; 2020 Dec prototype ready; 2021 Q2 full system ready for sell

T-GO System	T-GO Module	T-GO Core Unit	Cell
		 	Cylindrical LFP 26650

Project main deliverable

No.	Lead acid capacity System Voltage (V)	Lead Capacity (Ah)	Energy (KWh)	Container dimension configuration Width	Depth	High	Fit
1	24	150	3,6	648	146	567	●
2	24(25.6)	225	5,4	645	196	570	●
3	24(25.6)	300	7,2	656	196	675	●
4	24(25.6)	250	6	621	209	627	●
5	24(25.6)	375	9	621	281	627	●
6	24(25.6)	465	11,16	626	285	784	●
7	24(25.6)	620	14,88	626	357	784	●

Sample A to build



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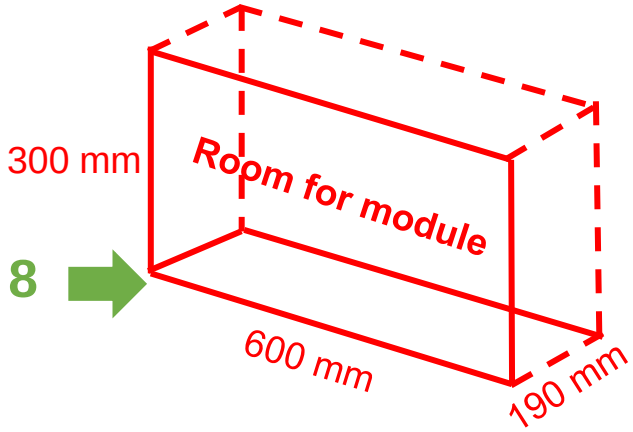
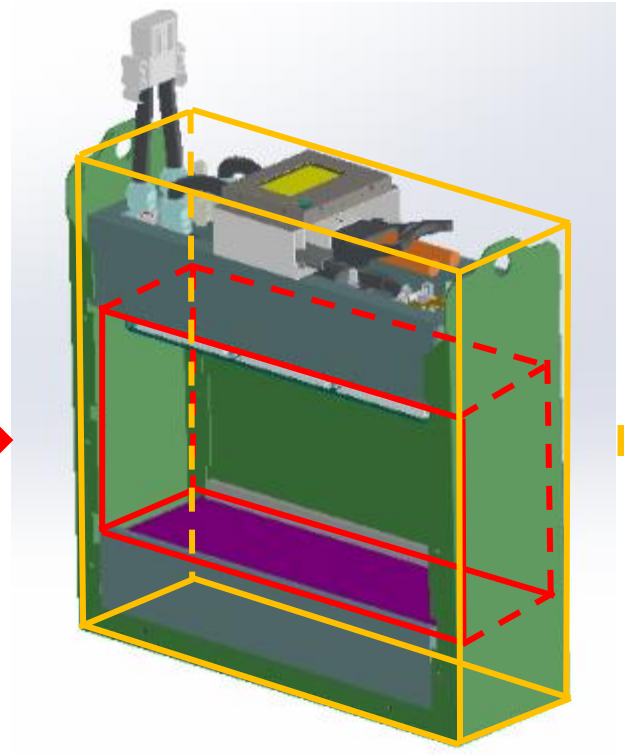
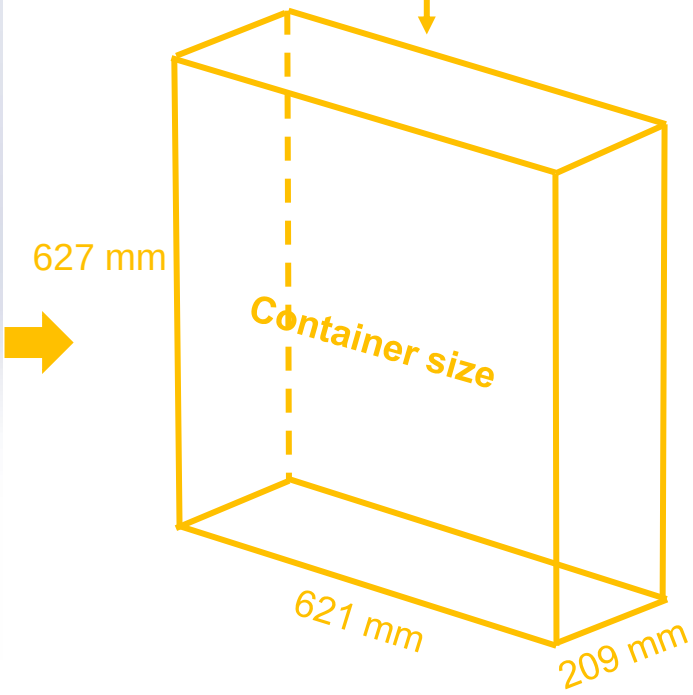
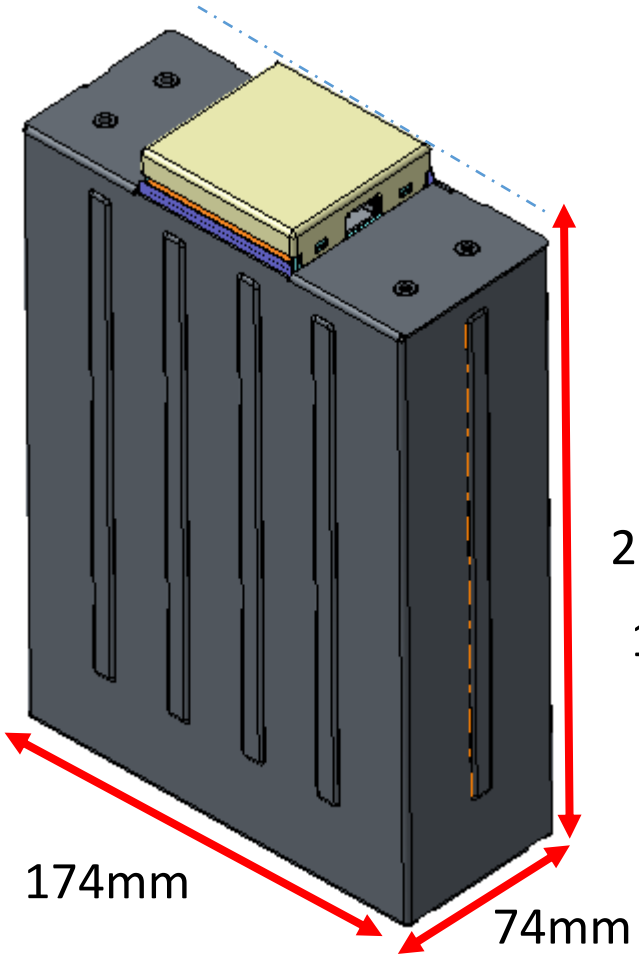




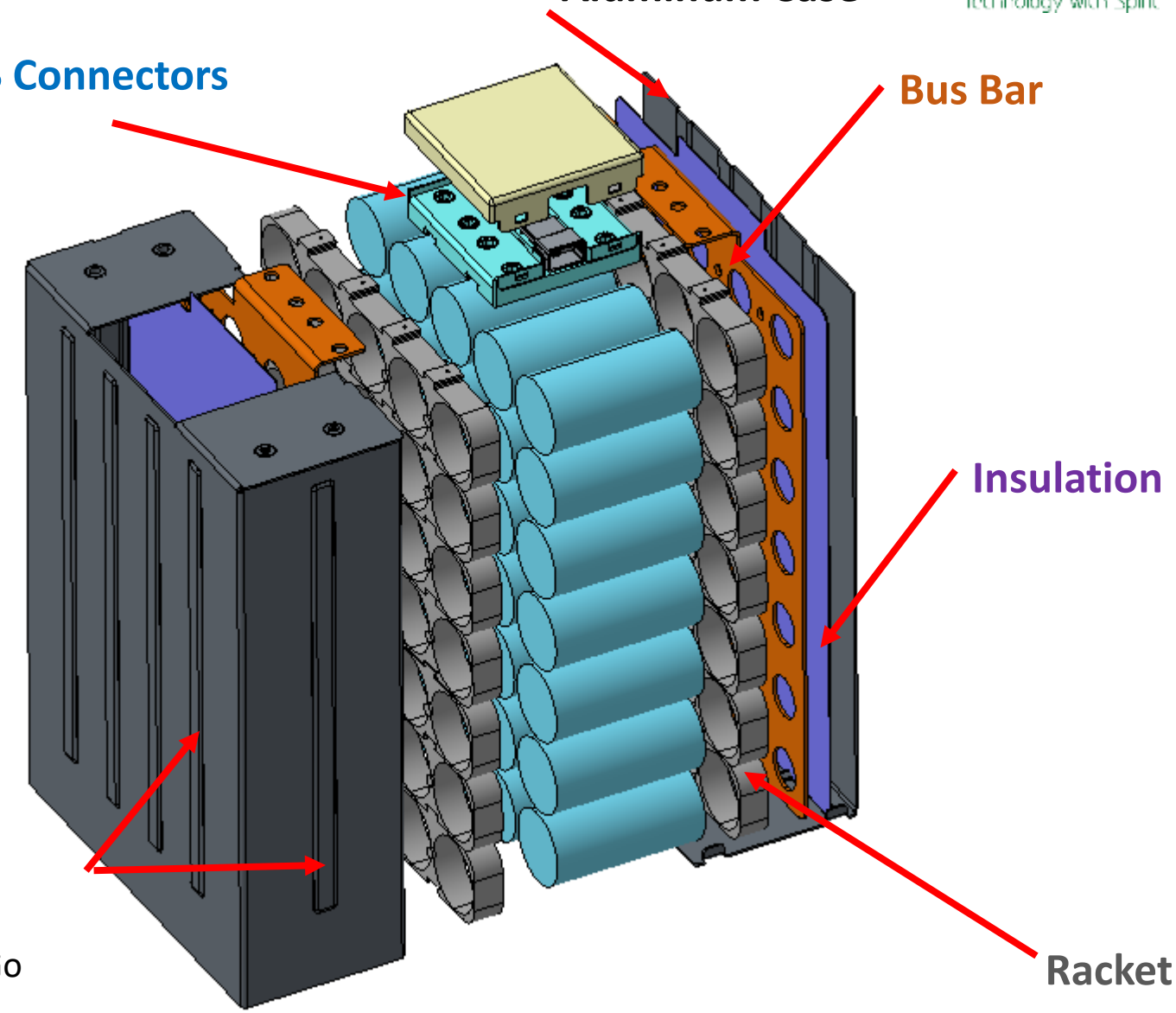


T-GO module introduction

T-Go Module Design

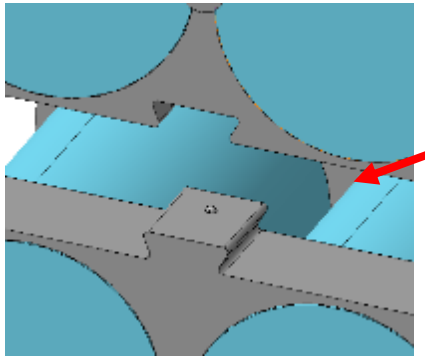


Configurations reference to Sample A

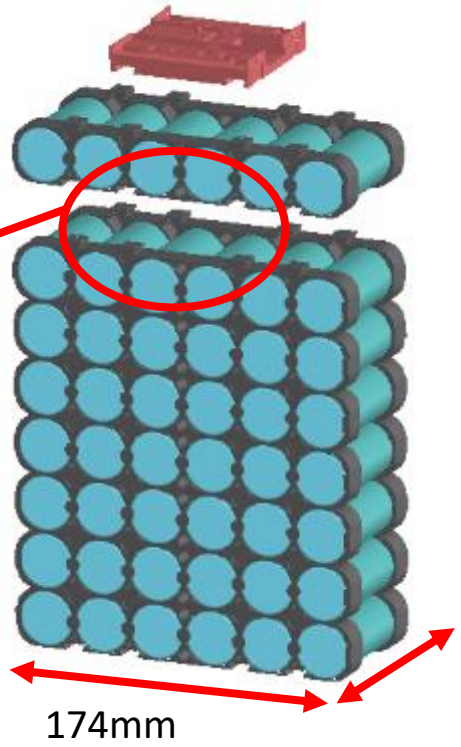


Reinforcement Rib
for Mating between T-Go

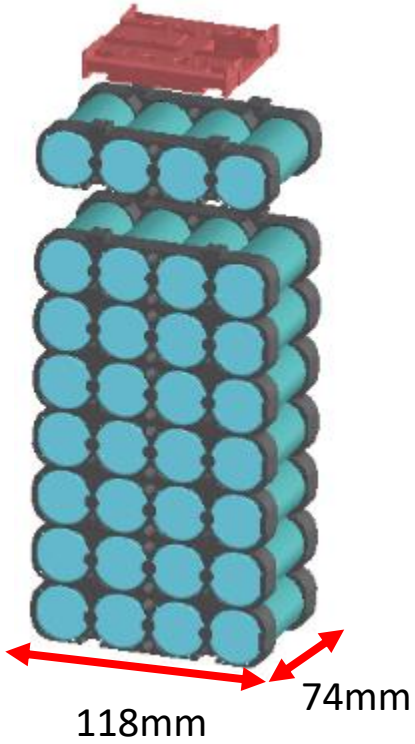
T-Go Module Design



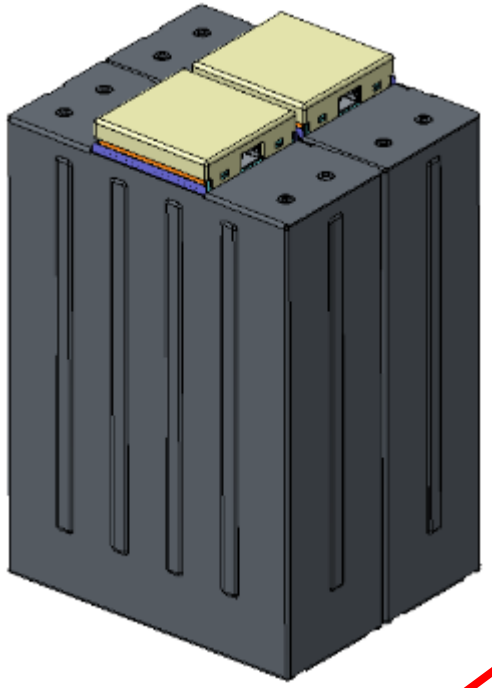
“Stackable” cell modules
for flexible capacity to max. the energy



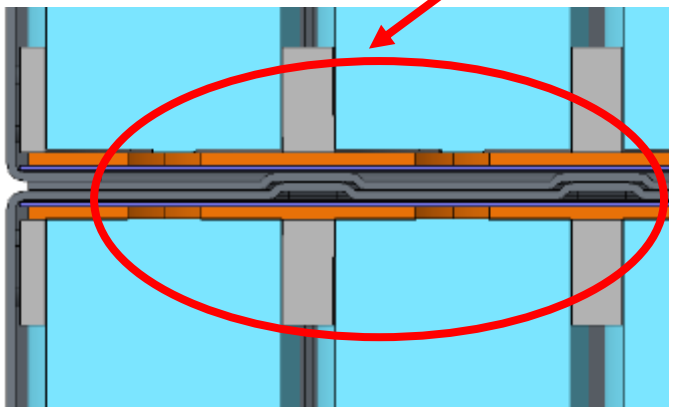
6 x Module



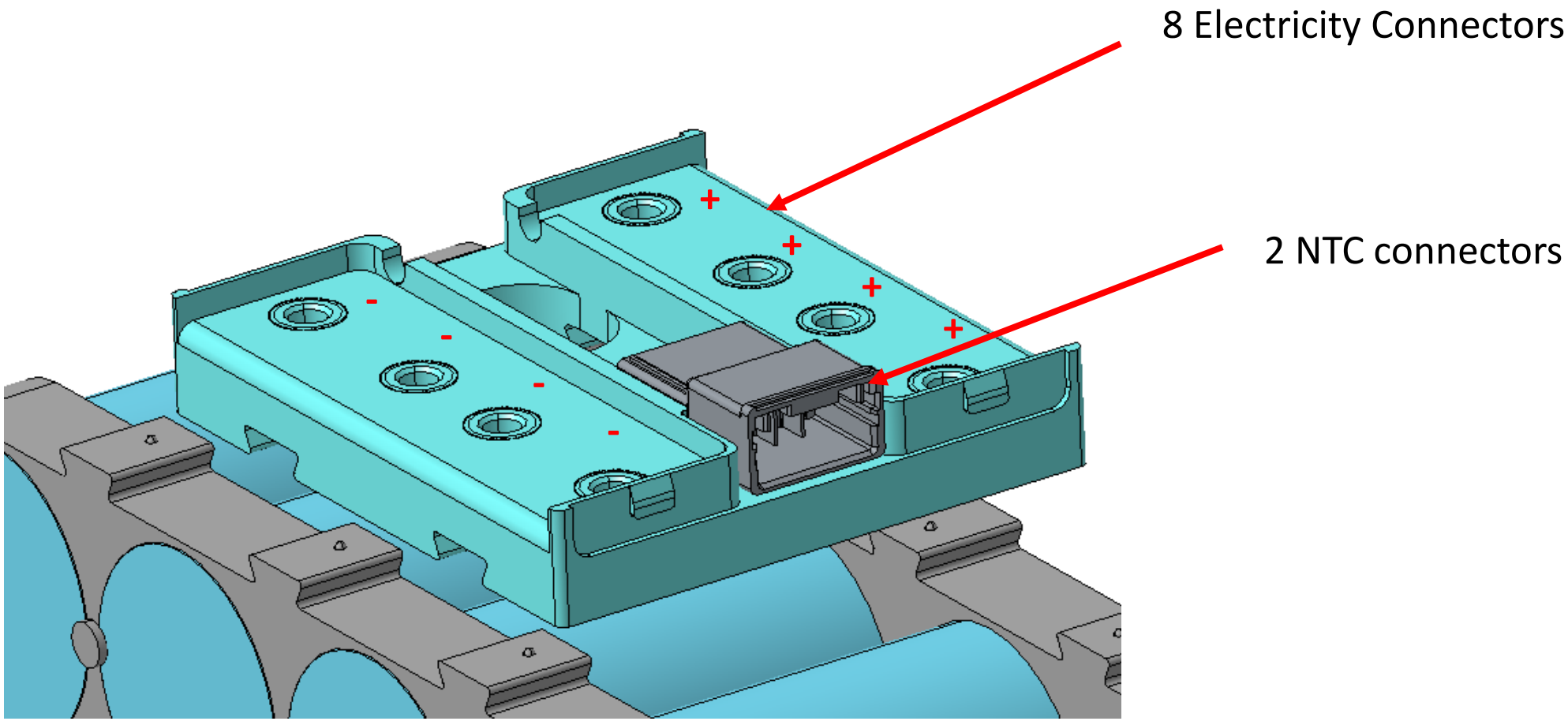
4 x Module



Mating between modules



T-Go Module Design

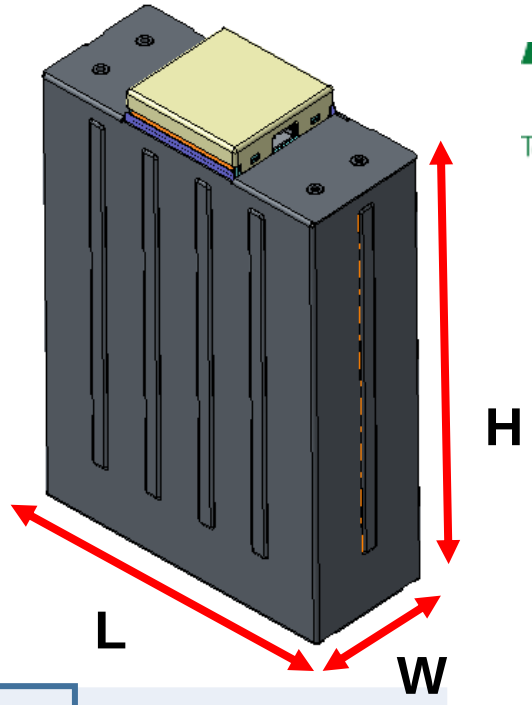


Cell Performance

Cell Parameters

Item	Parameter
Cell	CBAK: 26650FS3 Cylindrical
Cell Type	LFP
Nominal capacity	3600mAh (at 0.2，25℃)
Minimum capacity	3500mAh (at 0.2，25℃)
Nominal voltage	3.2V
Working voltage	2.0-3.6V
Internal Impedance	≤20mΩ,AC1kHZ
Standard Charge / Discharge	0.5C/ 0.5C
Maximum Charge	1.5C ,20℃ ~ 45℃;0.2C,0℃~10℃
Maximum Discharge	3C(Continuous)
Operating Temperature	Charge:0-45℃,Discharge:-20~60℃
Cycle life	3000 cycles,0.5C/0.5C,25℃,DOD 80%

T-Go Module Families



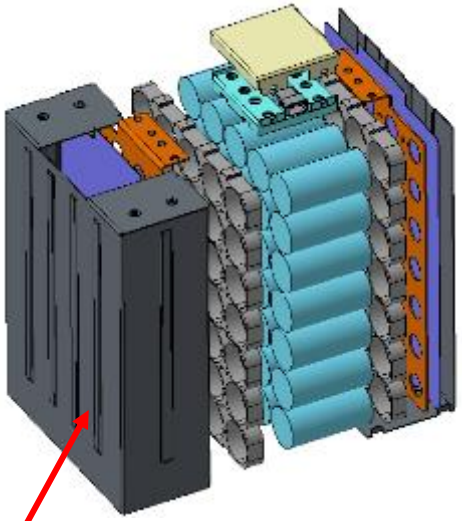
Capacity (Ah)	115	144	172	216
Cell Layout	32P(4X8)	40P(4X10)	48P(6X8)	60P(6X10)
Size (L X W X H, mm)	118X74X252	118X74X305	174X74X252	174X74X305
Voltage (V)	**3.2**	**3.2**	**3.2**	**3.2**

Sample A Building

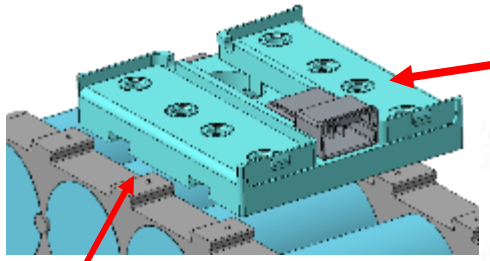
Advantage and Value Proposition of T-Go Module - 1

Cylindrical cell modules with flexibility on capacity and energy filled-up

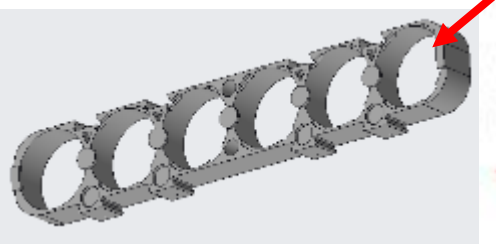
- Cell：LFP & NCM
- Good for **High Mix / Low Volume** customer requirements

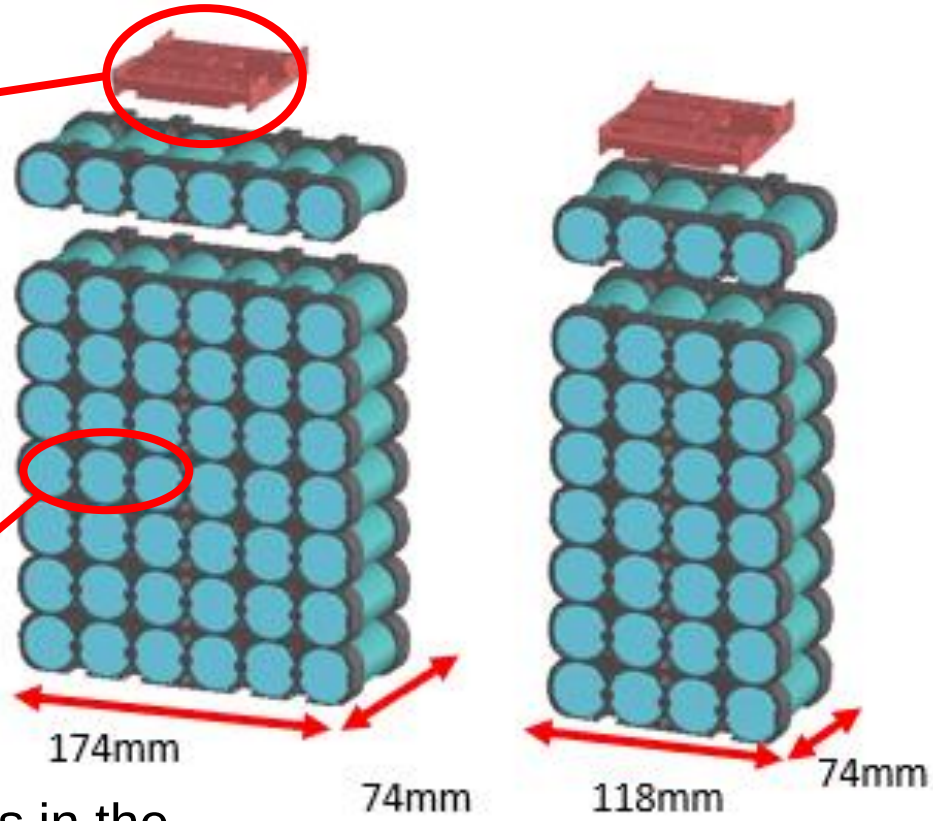


✓ Standard steel case design



✓ Standard design electricity terminals





✓ Standard cell holders in the market for 18650 / 26650 / 32650

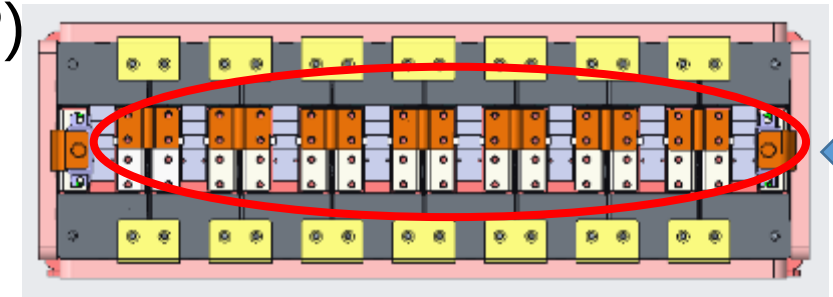
Advantage and Value Proposition of T-Go Module - 2

Robustness for High Out-put Power

- Standard voltage: 3.2V (LFP) / 3.6V (NCM)
- Robustness design for **High Discharge current**

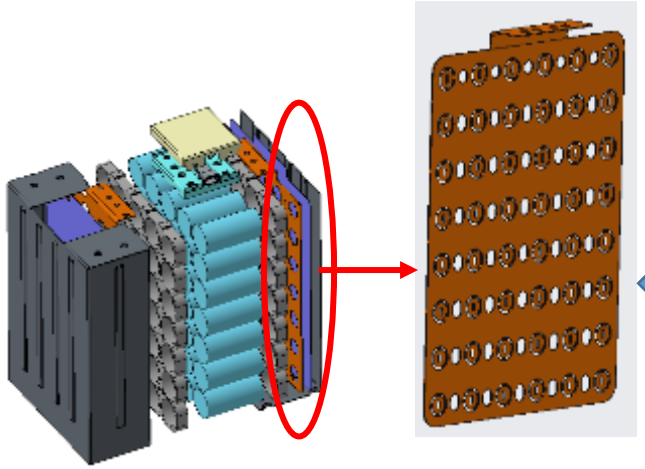
✓ Module - continual 200A+ current

✓ System - continual 600A+ current



Vs.

Nickel Bus-Bar with Power Cable



TWS: Cu-Ni Bus-Bar for high discharge power

Advantage and Value Proposition of T-Go Module - 3

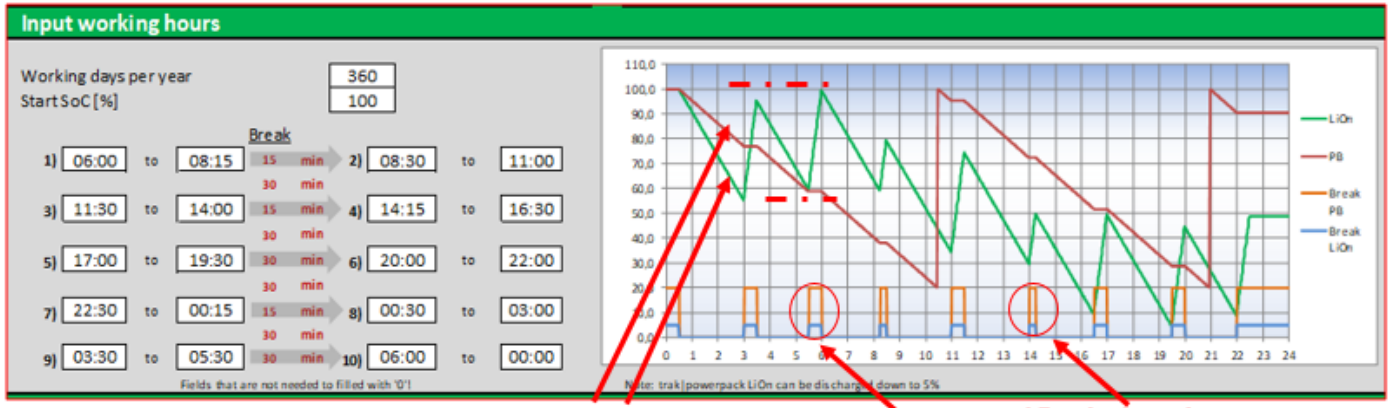
Fast Charging & High Discharge Power

- Fast charging / step charging at 1C max.
- Continual discharge @3C max, for instant out-put power

Customer Application / Usage Analysis

Research of the need of the customer, combined with OEM related specification:

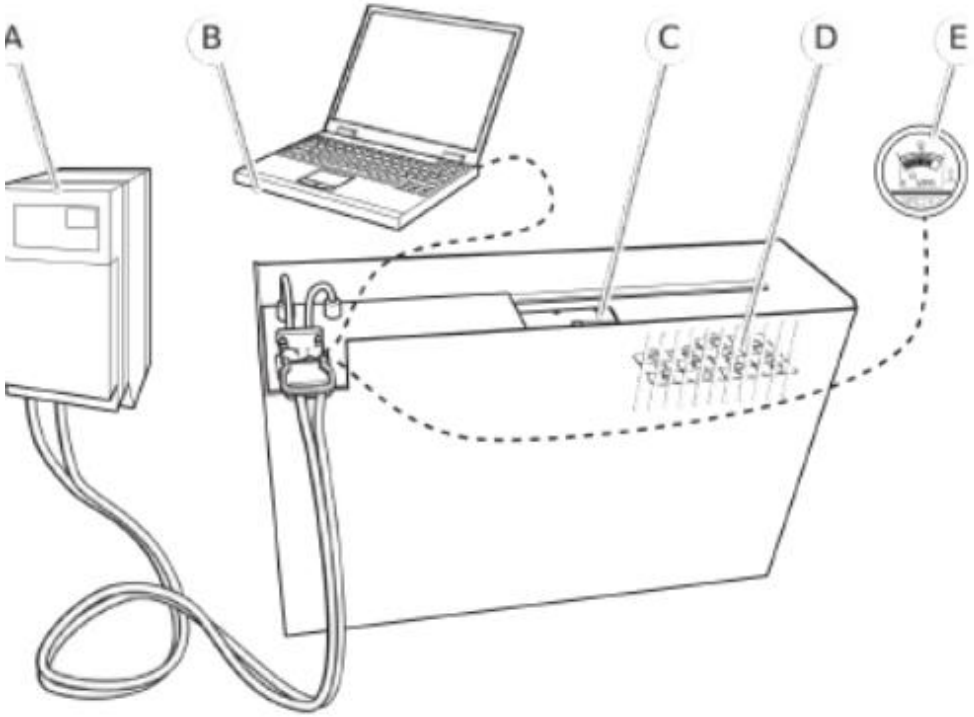
- Use <25% of Lead-Acid capacity in 3 hrs.?
- 30 Min break every 3 hours, and two breaks of 15minute break twice / day?
- Crucial to re-charge in 15-30min break, which needs to fill up 40% capacity?
- Lithium: Min 50% Lead-Acid Capacity with 1C charger, for 30min?



PART 3.1

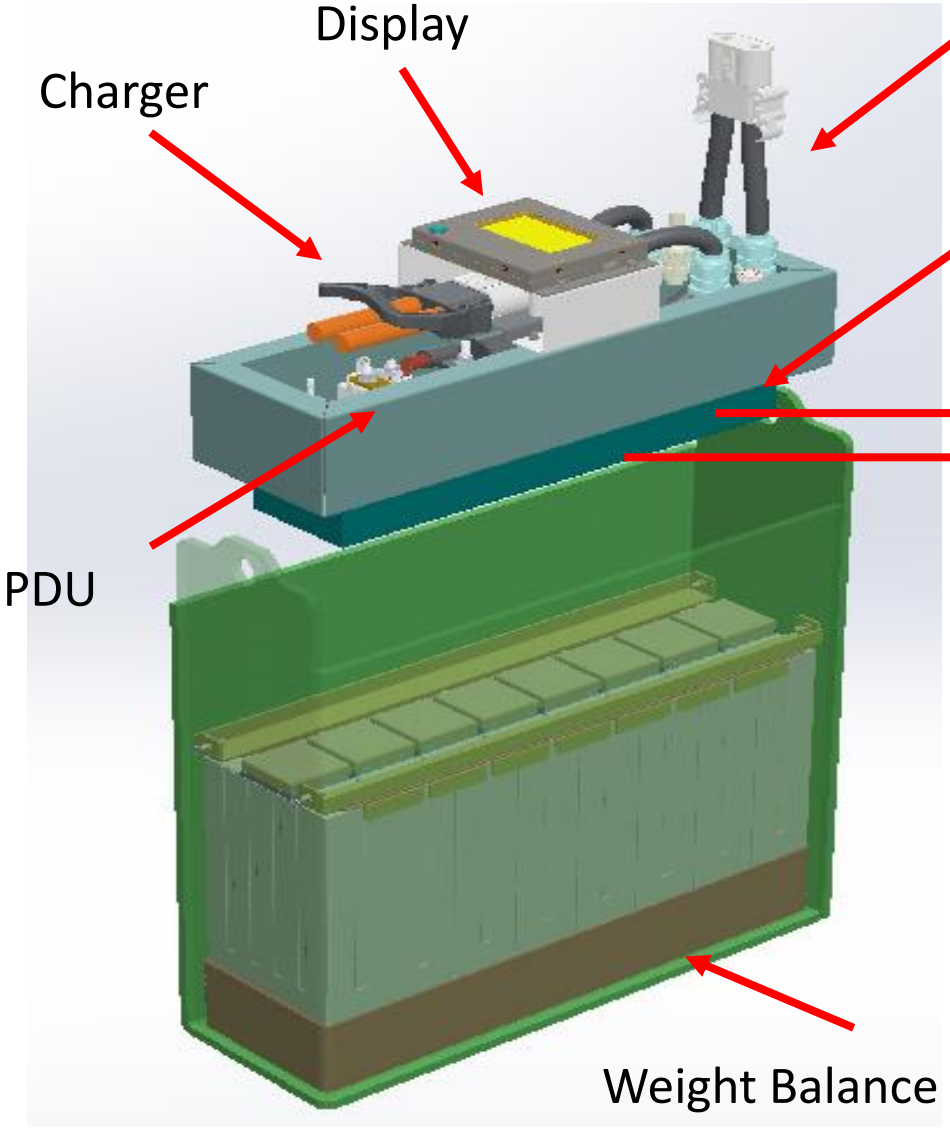
Part 3.2 T-GO System Introduction

T-Go System



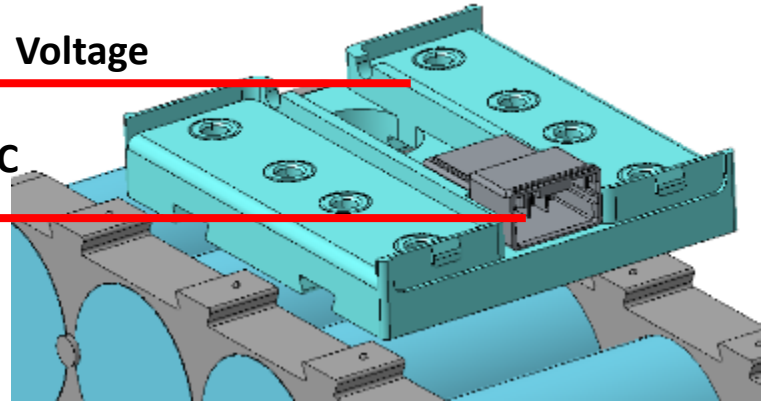
A: Charger
B: PC Software for Service and BMS Configuration
C: Battery Management System
D: T-Go Module
E: Battery Status Indicator

T-Go System



BMS

Each Slave – 9 series for 8 modules / 16 NTC ports

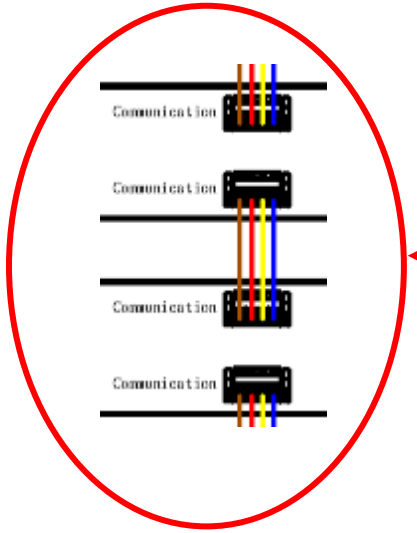


<u>Configurations reference to Sample A</u>

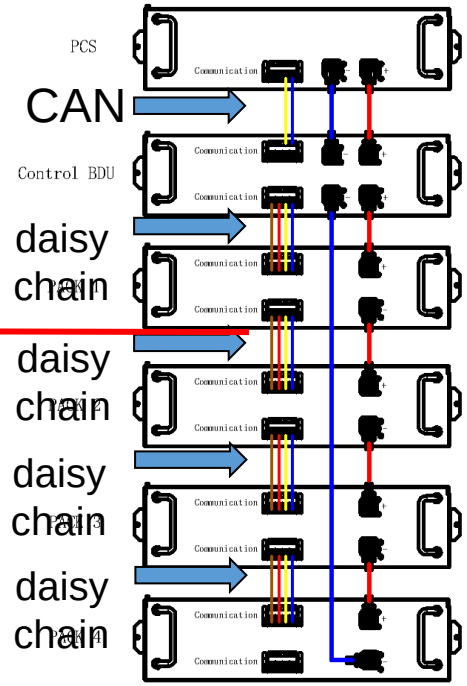
Advantage and Value Proposition of T-Go System - 1

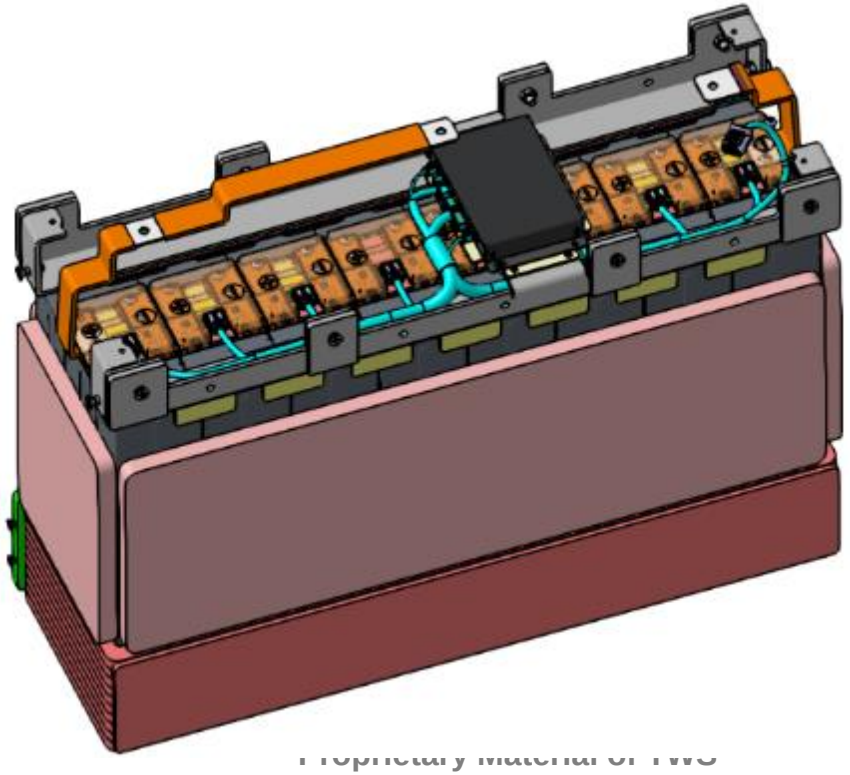
Assembly friendly and standard components

- Modulized design for easy assembly
- Daisy Chain BMS for easy assembly



Daisy chain



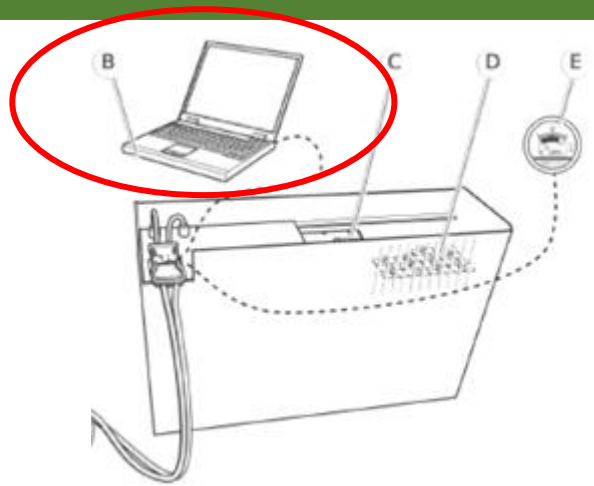


Advantage and Value Proposition of T-Go System - 3

User friendly user interface for battery status indicator

PC Software for Service

- System configuration
- System checking and analysis



Powering Up Your Mobility

Technology with Spirit

TWS TraX 1S2P Battery

Best Solution for Extreme Temperature Applications

TWS TraX 1S2P battery is specially designed for the applications which are under extreme temperature conditions. It works well in the temperature from -40℃ to +85℃, with very low performance deterioration after long time & high temperature storage, and was widely used in GPS trackers, industrial handheld, truck dash camera, etc..

TWS TraX Advantage

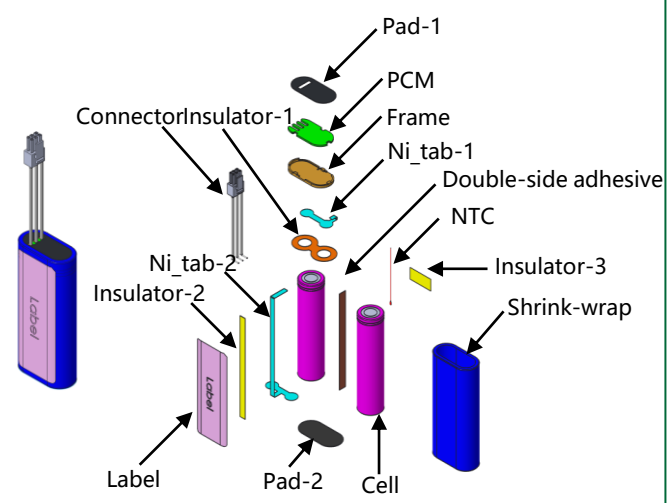
Perfect reliability in extreme working temperature from -40 ℃ to +85 ℃ and very low performance deterioration after a long time & high temperature storage.

Applications

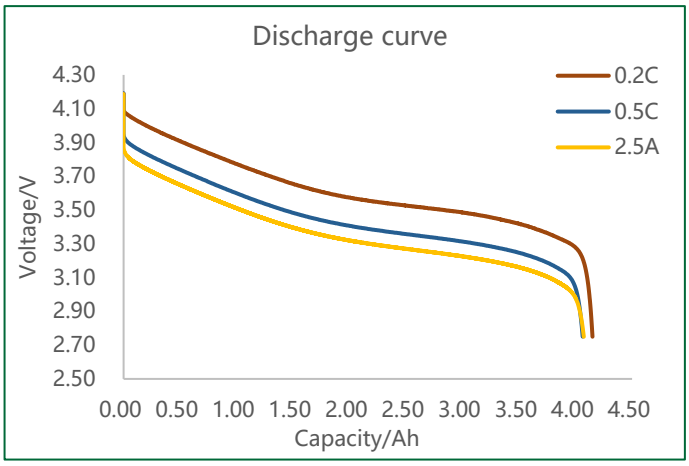
Industrial Handheld

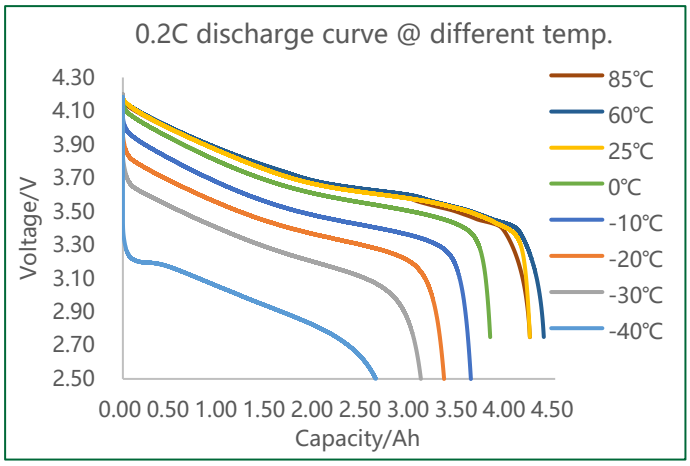
GPS Tracker

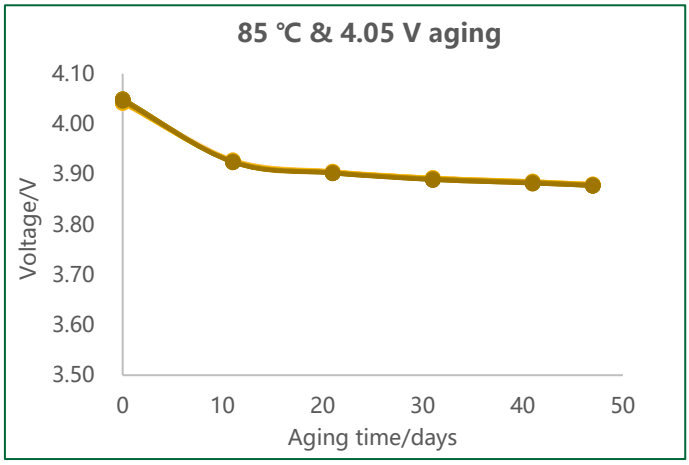
Truck Dash Camera



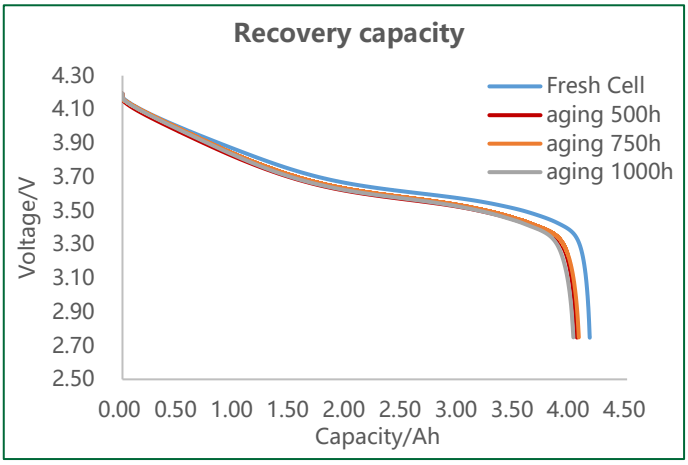
Model Name		TraX 1S2P
Cell Type		TWS HL 18650T
Charging method		CC-CV
Dimension		L 67.9±0.5 mm W 37.1±0.5 mm H 19.5 ±0.5 mm
Capacity	Minimum (0.2 C)	3900 mAh
	Typical (0.2 C)	4000 mAh
	Capacity (1.0 C)	~3800 mAh
Typical voltage		3.60 V
Working Voltage		2.5 V~4.2 V
Max. continuous charge/discharge		2000 mA/2500 mA
Standard continuous charge/discharge		800 mA/800 mA
Cycle life (RT 0.5 C/2.5 A)		>300 cycles, ≥70% capacity
-40 ℃ Capacity (0.2 C)		~60%
Internal resistance		<150 mΩ
80 ℃ 1000 hours aging Capacity		>90% recoverable
Operating temperature	Charge	0 < T≤10℃, 0.2 C to 4.10 V 10 < T≤45℃, 0.5 C to 4.20 V 45 < T≤60℃, 0.5 C to 4.10 V
	Discharge	0 < T≤85 ℃, 2.75 V -40 < T≤ 0 ℃, 2.50 V



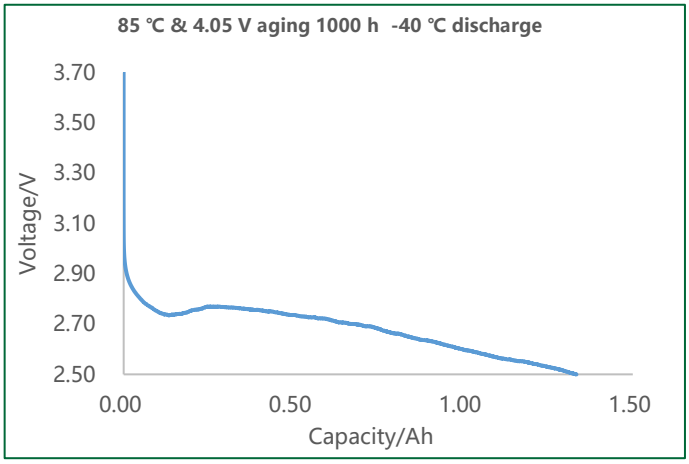




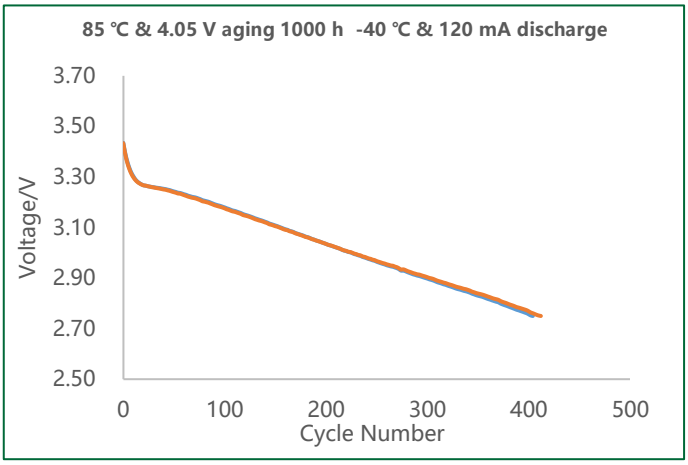
★ After aging at 85 ℃ for 42 days (~1000h), the OCV >3.80 V.



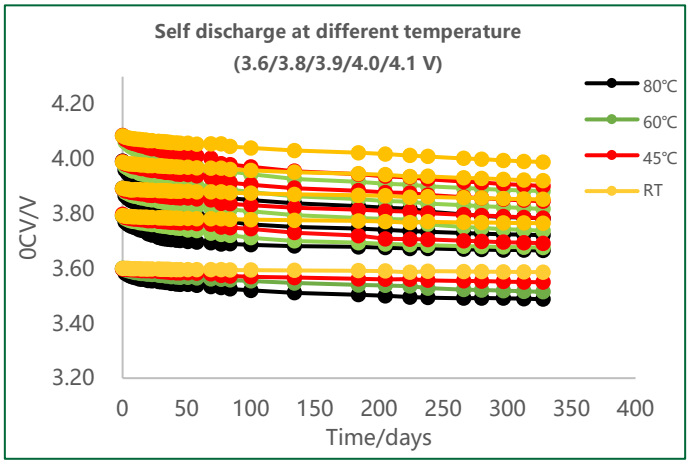
★ After aging for 42 days (~1000 h), the recovery capacity is ~4.0 Ah.

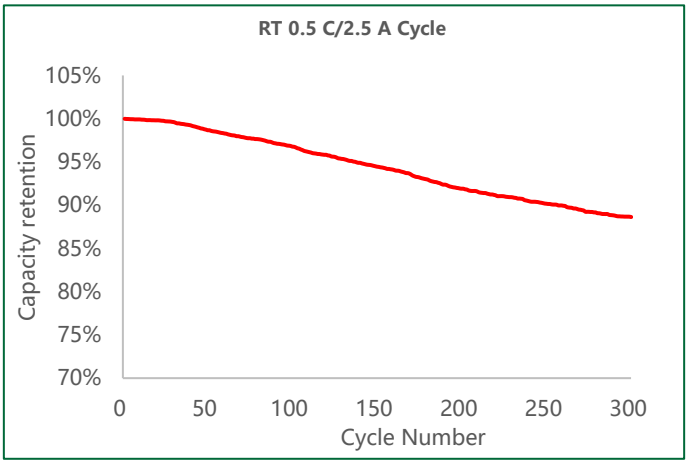


★ After aging for 42 days (~1000 h), the pack can be discharged with high current (800mA) at -40 ℃.



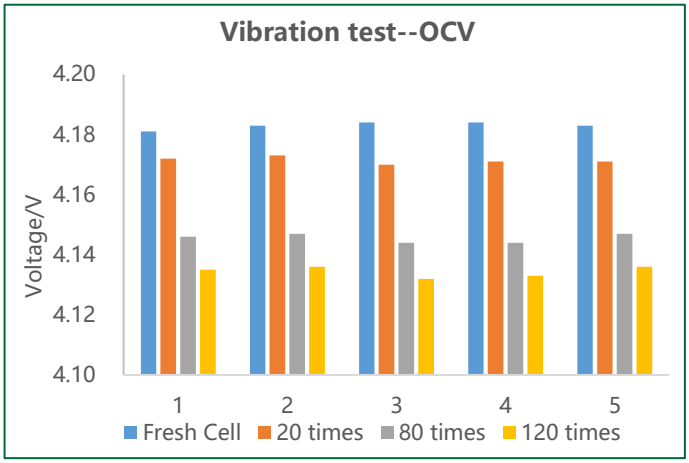
★ After aging for 42 days (~1000 h), the pack can work continuously for more than one year at -40 ℃ (without charging, signal once a day).

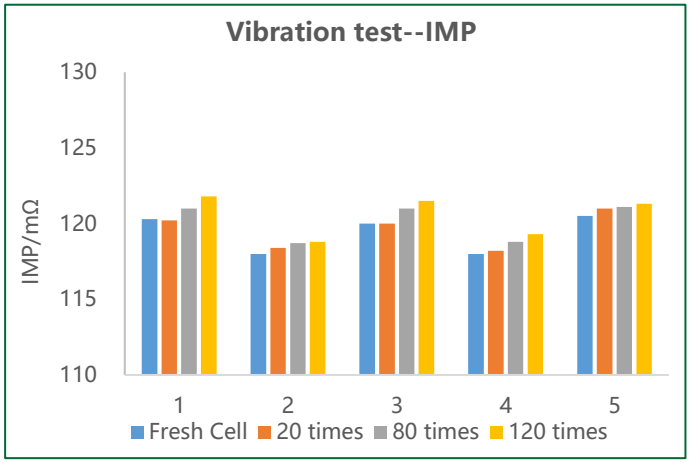




★ RT 0.5 C/2.5 A 300 cycles >85%

Vibration Test





No.	0 time		20 times		80 times		120 times	
	OCV/V	IMP/mΩ	OCV/V	IMP/mΩ	OCV/V	IMP/mΩ	OCV/V	IMP/mΩ
1#	4.181	120.3	4.172	120.2	4.146	121.0	4.135	121.8
2#	4.183	118.0	4.173	118.4	4.147	118.7	4.136	118.8
3#	4.184	120.0	4.170	120.0	4.144	121.0	4.132	121.5
4#	4.184	118.0	4.171	118.2	4.144	118.8	4.133	119.3
5#	4.183	120.5	4.171	121.0	4.147	121.1	4.136	121.3

★ After 120 times vibration tests, the internal resistance and the voltage is normal.

Vibration test method

- Fully charge the pack at room temperature; simple harmonic motion(10-55Hz/min, 90-100min, 0.8mm, 3 directions (X/Y/Z)); repeat for 120 times; check the OCV & IMP of pack.

About TWS Technology

Dynamic Leadership in Innovative Rechargeable Lithium-ion Battery Solutions

TWS, a dynamic and global industry leader focused on providing innovative Lithium-based battery technology solutions, was founded in 1998. With over 2 decades of development, we have now grown to over 2,500 global employees to service the worldwide markets. TWS always follows the practice of customer-focused values and we're committed to providing innovative solutions in response to the rapid growth of new lithium-ion battery applications.

Product Specification

TWS-6S1P-102-NCM

Technology with Spirit

22.2 V 102 Ah Lithium Battery Module

TWS-6S1P-102-NMC is a compact standard cell-stack VDA module with built-in low leakage & intrinsic safety which target for e-Mobility (EV/MH/AGV/eForklift) & ESS applications.

Specifications	
Configuration	6S1P
Nominal capacity	102 Ah @ 0.33 C
Nominal voltage	22.2 V @ 0.33 C
Charge cut-off voltage	25.8 V
Discharge cut-off voltage	16.8 V
Energy	2,264 Wh @ 0.33 C
Module weight	11.3 ± 0.2 kg
Module size	L 355.0 mm H 151.5 mm W 108.0 mm
Energy density	200 Wh/kg 389 Wh/L
Charge current	Continuous: Max.100 A Peak: 300 A @ 10 s
Discharge current	Continuous: Max.150 A Peak: 400 A @ 10 s
Battery cell	NMC, 102 Ah, Prismatic

Common specifications	
Charge temperature	-20 ℃ ~ 55 ℃
Discharge temperature	-30 ℃ ~ 55 ℃
Best storage temperature	-10 ℃ ~ 35 ℃
Dielectric strength	2,700V DC
Factory test of insulation resistance	> 100 MΩ
Voltage difference of sets	≤ 20 mV

Main features

- No memory effect
- Following protections are needed externally to ensure normal & safe operations :
  - **Over current**
  - **Over/Under voltage**
  - **Over/Under temperature**
  - **Short circuit**
- Cell balancing is recommended
- Flame retardant material
- Interface
  - B+, B-
  - Cell voltage sensing
  - Temperature sensing (NTC)

Product Specification

TWS-9S1P-135-NCM

Technology with Spirit

33.3 V 135 Ah Lithium Battery Module

TWS-9S1P-135-NCM is a compact standard cell-stack module with built-in low leakage & intrinsic safety which target for e-Mobility (EV/MH/AGV/Forklift) & ESS applications.

Specifications

Configuration	9S1P
Nominal capacity	135 Ah @ 0.33 C
Nominal voltage	33.3 V @ 0.33 C
Charge cut-off voltage	38.7 V
Discharge cut-off voltage	25.2 V
Energy	4,496 Wh @ 0.33 C
Module weight	23.5 ± 0.5 kg
Module size	L 490.3 mm W 178.1 mm H 143.3 mm
Energy density	191 Wh/kg 360 Wh/L
Charge current	Continuous: Max. 67.5 A Peak: 270 A @ 30 s
Discharge current	Continuous: Max.135 A Peak: 400 A @ 30 s
Battery cell	NCM, 135 Ah, Prismatic

Common specifications

Charge temperature	-20 ℃ ~ 55 ℃
Discharge temperature	-30 ℃ ~ 55 ℃
Best storage temperature	-10 ℃ ~ 35 ℃
Dielectric strength	2,700V DC
Factory test of insulation resistance	> 100 MΩ
Voltage difference of sets	≤ 20 mV

Main features

- No memory effect
- Following protections are needed externally to ensure normal & safe operations :
  - **Over current**
  - **Over/Under voltage**
  - **Over/Under temperature**
  - **Short circuit**
- Cell balancing is recommended
- Flame retardant material
- Interface
  - B+, B-
  - Cell voltage sensing
  - Temperature sensing (NTC)

TWS

Technology with Spirit

STD Pack for Asset Tracker

By: NPD

Design proposal

1. Battery information

1. Nominal voltage： 3.6V
2. Capacity： Typ.4000mAh, Min 3900mAh 1S2P
3. Cell type: Charging method： CC-CV
4. Charge voltage： 4.2V max.
5. Discharge end voltage: 3.0 V
6. Max. continuous charge current: 2000 mA (Standard: 800mA)
7. Max. continuous discharge draw: 2500 mA (Standard: 200mA)
8. Cycle life： 300 cycles ≥70% capacity
9. Internal resistance： Less than 80mΩ
10. Connector output: 3-pins (power, ground, temperature)
11. Pack dimensions: L69mm x W37.5 X H19.5mm
12. Storage temperature： 1 year: 0~25 ℃
    3 months: 0~45 ℃
    1 month: 0~60 ℃
13. Charge temperature： 0＜T≤10℃, 0.2C to 4.1V
    10＜T≤45℃, 0.5C to 4.2V
    45＜T≤60℃, 0.5C to 4.1V
14. Discharge temperature： 0＜T≤85℃, 2.75V
    -20＜T≤0℃, 2.5V

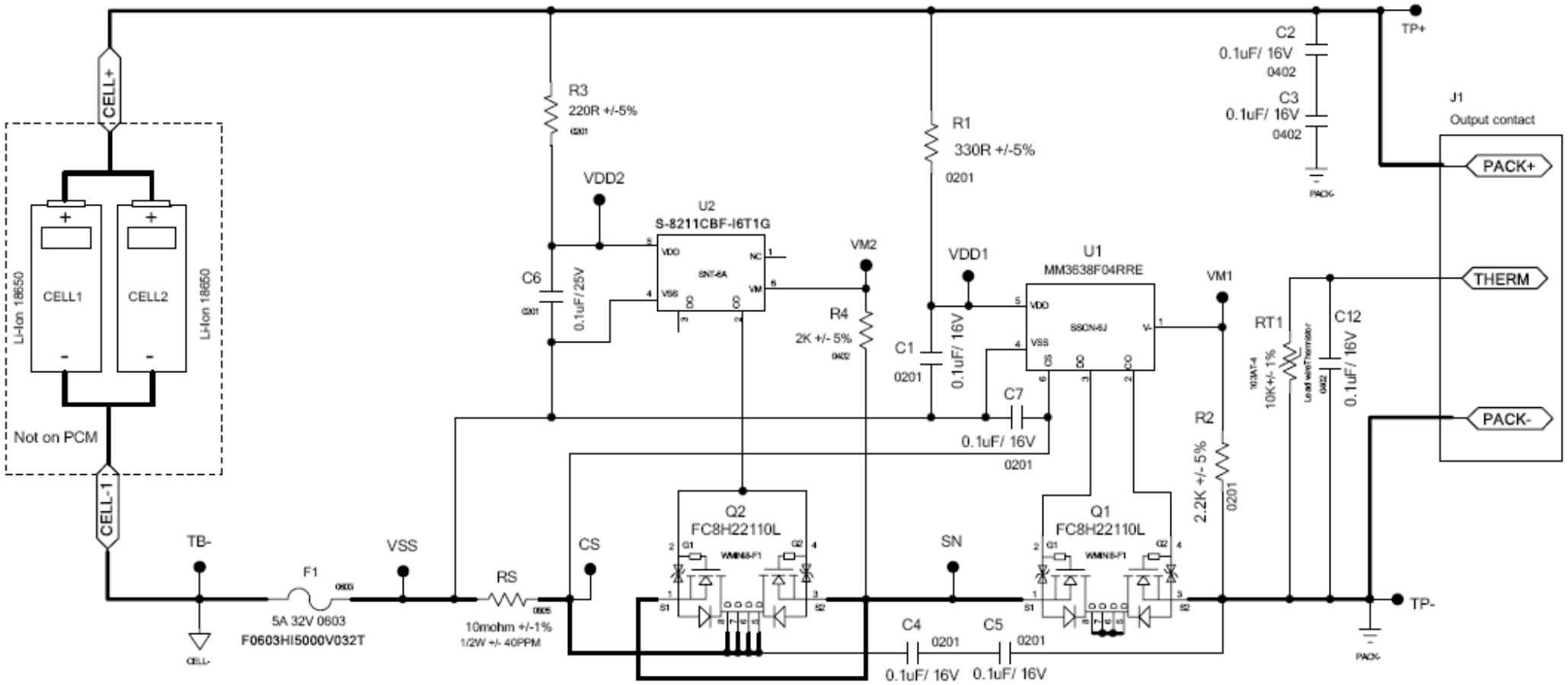
Design proposal

2. Cell information

Battery Information	Data
Cell model	18650T
Minimum Capacity	1950mAh
Nominal Capacity	2000mAh
Nominal Voltage	3.6V
Maximum charge voltage	4.2V
Max Charge Current	1950mA
Max. continuous Discharge Current	9.75A
Charge Operation Temperature	0℃~60℃ 0~10℃；0.2C to 4.1V 10~45℃；0.5C to 4.2V 45~60℃；0.5C to 4.1V
Discharge Operation Temperature	-40℃~85℃ 0~85℃；2.75V -20~0℃；2.5V -40~-20℃；2.0V

Design proposal

3. Circuit Schematic



Above design circuit could meet the UL2054(including LPS), cUL/CSA, UN 38.3 Transportation, RoHs,CE,CB, BIS, GB Cert. requirements.
Protect IC: 2 levels protect IC + MOSFET + Fuse

Design proposal

4. Protection IC Parameters

IC Mitsumi MM3638F04RRE SSON-6J			
Protection IC 25℃ Analysis			
Parameters	Voltage(V)		
	Min	Typ.	Max
Overcharge voltage detection	4.260	4.280	4.300
Overcharge voltage release	4.250	4.280	4.300
Overdischarge voltage detection	2.365	2.400	2.435
Overdischarge voltage release	2.365	2.400	2.490
Overcharge current detection	-0.026	-0.030	-0.035
Overdischarge current detection	0.027	0.032	0.037
Load short-circuiting detection	0.45	0.60	0.75
Parameters	Min	Typ.	Max
Overcharge voltage delay time	0.8	1	1.2
Overdischarge voltage delay time	100	125	150
over charge current delay time	6.4	8	9.6
over discharge current delay time	6.4	8	9.6
short-circuiting delay time	175	250	350
Parameters	Min	Typ.	Max
over charge current protection	-2.52	-3.00	-3.48
over discharge current protection	2.69	3.20	3.72
short Current protection	9.83	16.33	23.29

2nd Protection IC: S-8211CBF-I6T1G SNT-6A			
	Min.	typ.	Max.
Overcharge detection voltage (V)	4.275	4.300	4.325
Overcharge release voltage (V)	4.050	4.100	4.150

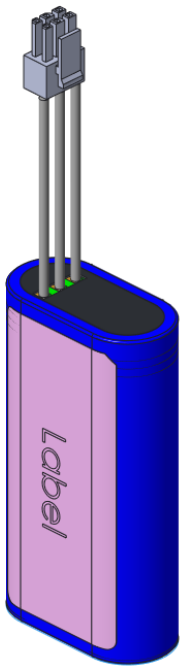
Design proposal

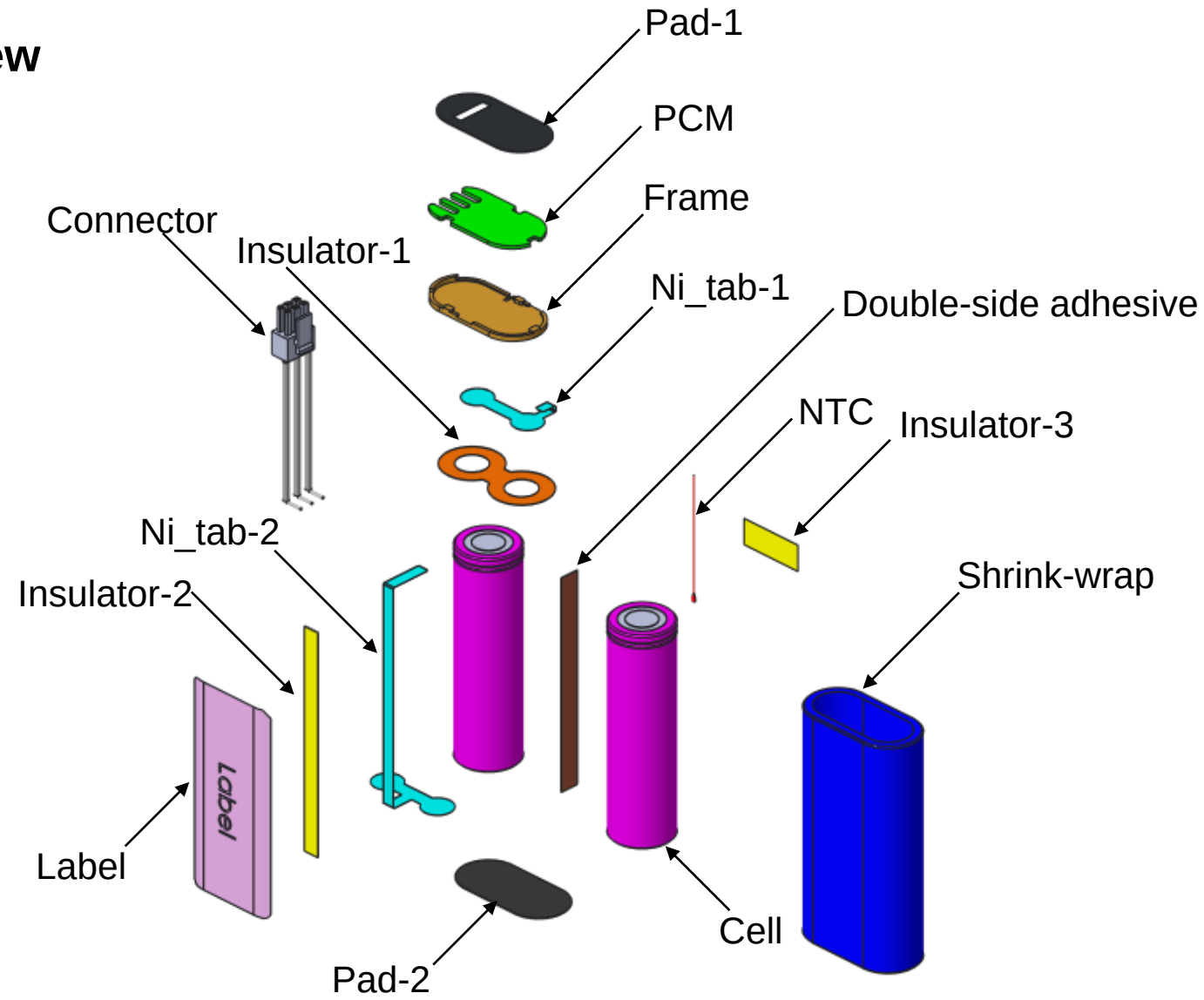
5. PCM BOM Components List

Item	P/N	Des.	QTY.	Units	Symble	Part Number	Martks
1	130100277A11	IC Mitsumi MM3638F04RRE SSON-6J	1	EA	U1	MM3638F04RRE	1st Protect IC
2	130100137A11	IC Seiko S-8211CBF-I6T1G SNT-6A	1	EA	U2	S-8211CBF-I6T1G	2nd Protect IC
3	130200060A11	MOSFET N-ch Panasonic FC8H22110L WMini8-F1	1	EA	Q1,Q2	FC8H22100L	MOSFET
4	130700013A11	Fuse AEM F0603HI5000V032T5A32V 0603	1	EA	F1	F0603HI5000V032T5A32V	Current Fuse
5	130300052A11	Capacitor Murata 0201 0.1μF ±10% 16V X5R	5	EA	C1,C4,C5,C7,C8	CL03A104KP3NNNC	Capacitor
6	130300014A11	Capacitor Murata 0402 0.1μF ±10% 25V X5R	3	EA	C2,C3,C12	GRM155R61E104KA87D	Capacitor
7	130400143A11	Resistor YAGEO 0201 330Ω ±5% 1/20W	1	EA	R1	RC0201JR-07330RL	Resistor
8	130400092A11	RES YAGEO 0201 220Ω ±5% 1/20W	1	EA	R3	RC0201JR-07220RL	Resistor
9	130400165A11	Resistor YAGEO 0201 2.2KΩ ±5% 1/20W	1	EA	R2	RC0201JR-072K2L	Resistor
10	130400073A11	RES YAGEO 0201 2KΩ ±5% 1/20W	1	EA	R4	RC0201JR-072KL	Resistor
11	130400036A11	Resistor Walter 0805 10mΩ ±1% 1/2W ±40PPM	1	EA	RS	STC0805CW75R010F	Current sense resistor
12	140300171A11	CONN-CS PB02 NI200H1/4 L5W4T0.3 RA	2	EA	CELL+,CELL1	L5W4T0.3	Ni-tab
13	1000025001	NTC SEMITEC 10K±1% 103AT B3435	1	EA	RT1	103AT	Lead wire Thermistor

Design proposal

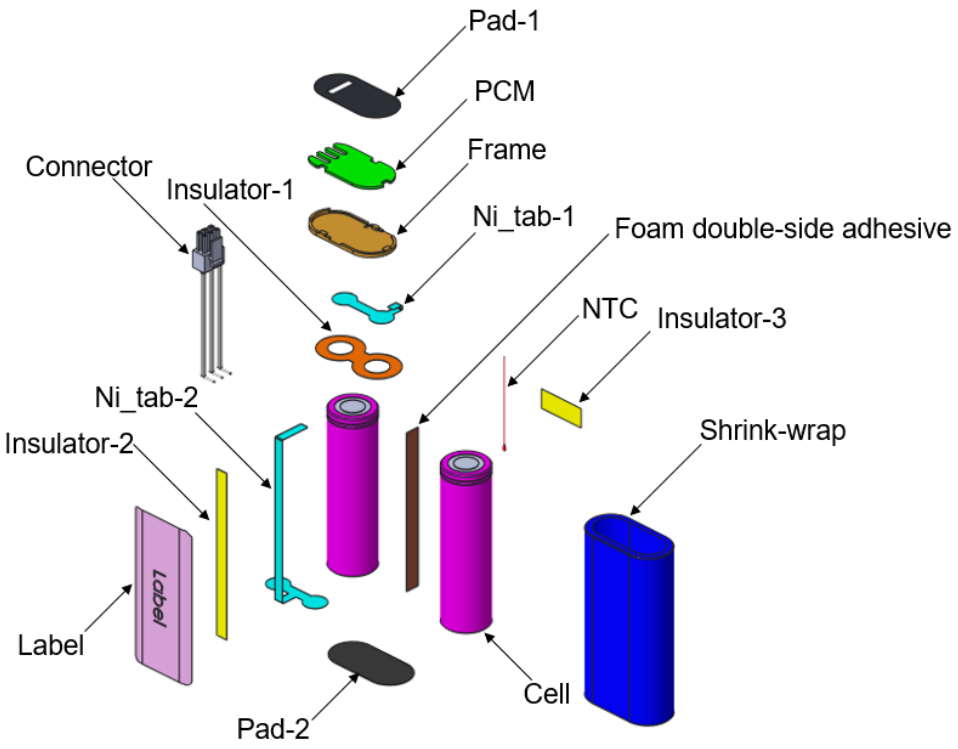
6. Battery exploded view





Design proposal

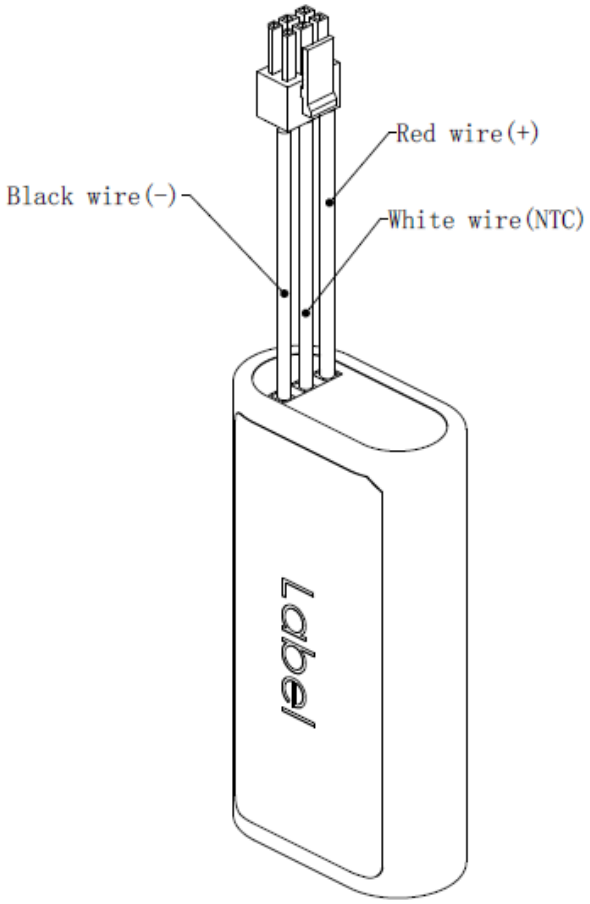
7. Mechanical BOM

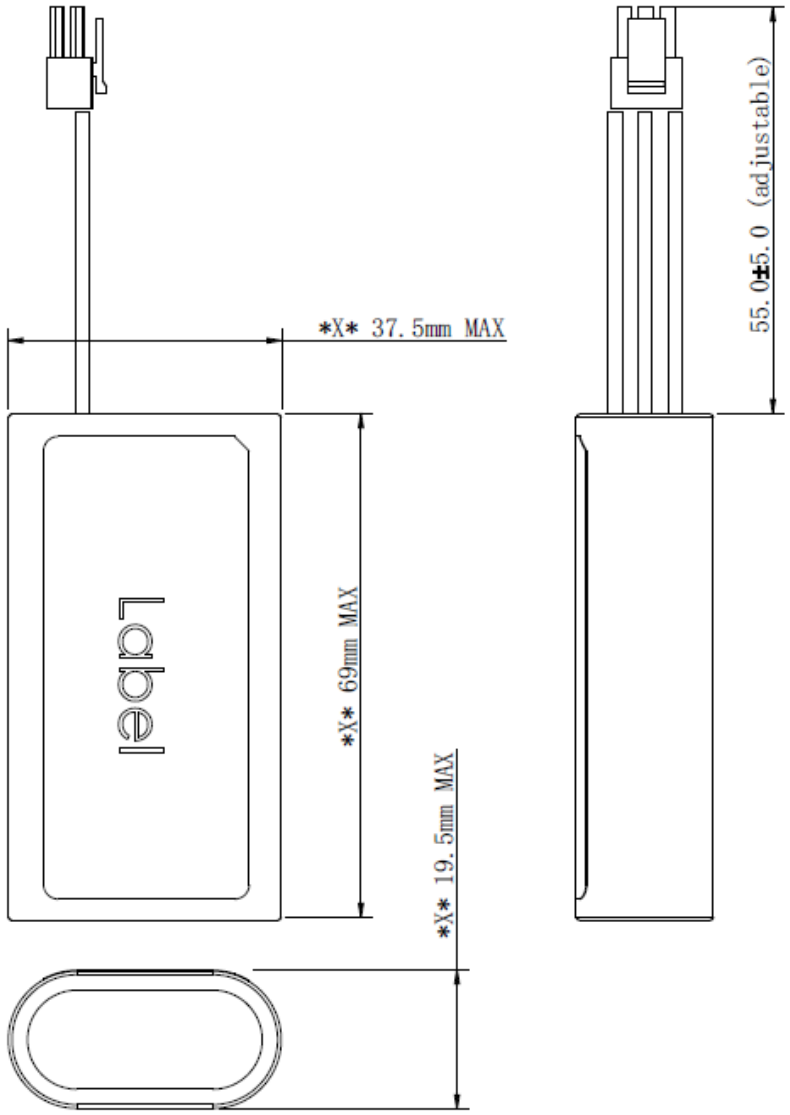


Item	Description	Quantity	Units
1	Connector, JST SPH-002T-P0.5S，3 Wires，L60mm UL94V-0，AWG#24	1	EA
2	Pad-1，PC，L37W18.0T0.2mm，HF，RoHS	1	EA
3	PCM	1	EA
4	Frame，PC，HF，RoHS	1	EA
5	Ni_tab-1，NI200, 1/4H，HF	1	EA
6	Insulator-1，PI，T0.18mm Double-side adhesive, HF	1	EA
7	Ni_tab-2，NI200, 1/4H，HF	1	EA
8	NTC	1	EA
9	Cell，18650T	2	EA
10	Double-side adhesive，L65W6T0.2mm，HF, RoHS	1	EA
11	Pad-2，PC，L37W18.0T0.2mm, HF, RoHS	1	EA
12	Insulator-2，PI，L67W5T0.05mm，HF, RoHS	1	EA
13	Insulator-3，PI，L20W8T0.05mm，HF, RoHS	1	EA
14	Shrink-wrap, PET，HF，RoHS	1	EA
15	Label，L63W27T0.1mm，HF，RoHS	1	EA

Design proposal

8. Battery dimensions

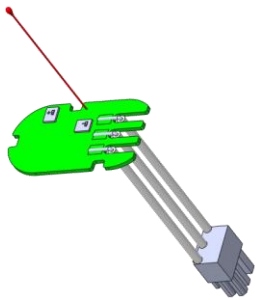




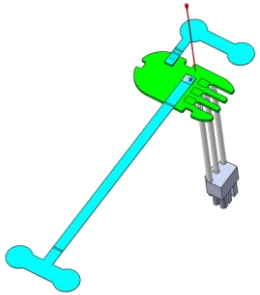
Design proposal

9. Battery key process

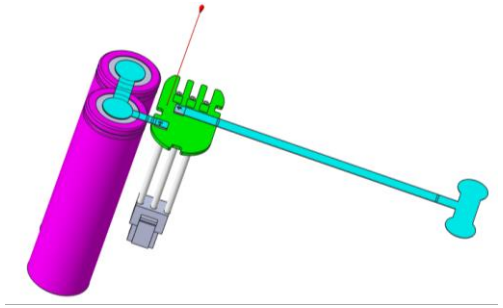
1. Solder connector and NTC to the PCM



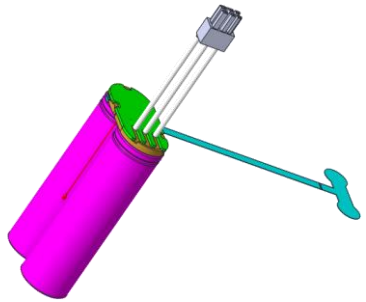
2. RSW ni-tabs to PCM



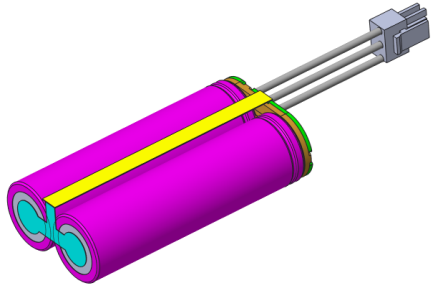
3. RSW Ni_tab-1 to CELLS



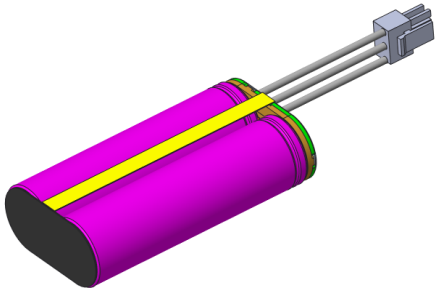
4. Fix PCM with Frame and bend



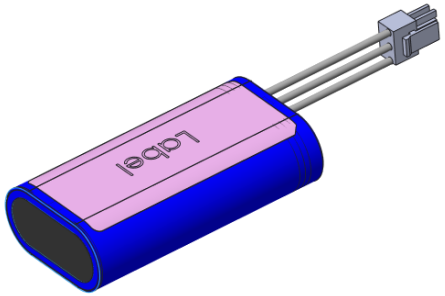
5. RWS Ni_tab-2 to CELLS



6. Attach Pads



7. Shrink wrap and attach label



TWS

Technology with Spirit

THANK YOU!