USER MANUAL
c-BPU

LiTHIUM BALANCE
BATTERY MANAGEMENT SYSTEMS

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Introduction

The LiBAL c-BPU100™ is a PCB based Battery protection unit, which contains 4 essential elements in one compact unit:

1. Current Sensor
2. BMS power supply
3. Auto-off relay to enable the sleep mode function
4. Circuit Breaker controlled by BMS

LiBAL c-BPU100™ is a great candidate to be integrated with c-BMS24™, where the integration is very compact and cost efficient. The size of the solution is about 20 times smaller than the traditional PDU solution. This makes it an ideal choice for small compact vehicles, robots and AGV's .

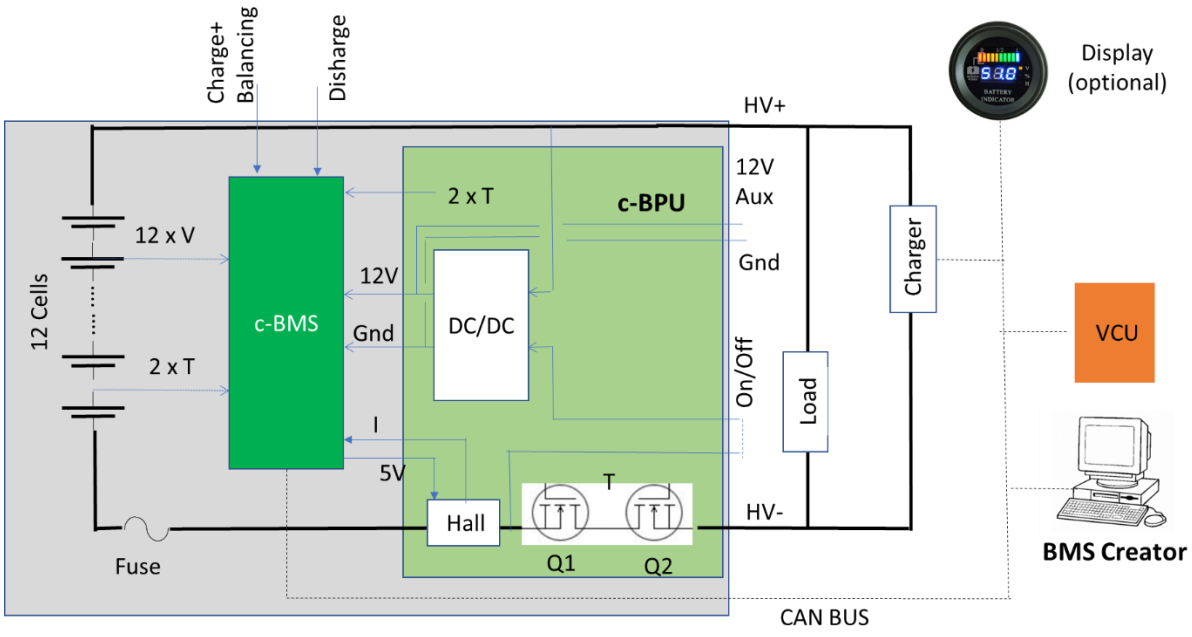


Figure 1 Overview of a Battery Pack system including battery, c-BMS24 and c-BPU100

2. Safety

2.1 Battery safety

To achieve safe operation of lithium-ion batteries, these must operate within the safe limits of:

- cell voltage
- cell/battery current
- cell/battery temperature

Exceeding these limits can trigger chemical processes that may lead to rapid degradation of battery performance. In more extreme cases, exceeding the limits can result in out-gassing from the batteries and in battery fire. In the worst cases, this may have fatal consequences.


Toxic Gas


Risk of fire


Risk of explosion

A battery system including c-BPU and c-BMS (It can be also other BMS) provided by Lithium Balance are tested to ensure that the battery operates within the safe limits for cell voltage, temperature and current under all circumstances.

2.2 Electrical safety

Apart from the chemical related safety aspects of working with batteries and BMSs, batteries are powerful electrical devices with short circuit current levels typically exceeding several hundreds of Amperes.

All personnel working with BPU and BMS systems and batteries should therefore be properly trained in handling high voltage/current installations. The legally required training is regulated by national/regional standards such as EN 50110-1 (EU)

As a general precaution when working with battery systems, Lithium Balance recommends that all personnel:

- wear electrically insulating gloves

- use electrically insulated tools
- disconnect the battery from chargers

2.3 Safe design

The battery system design must be adequately configured and tested to ensure safe and proper operation in all operating conditions. Two important safe design points of the c-BPU are:

1. C-BPU has some input -outputs, which each of them has its own limitation. These limitations must be considered.
2. C-BPU uses a group of MOSFET switches to turn the current on and off. Each MOSFET has an internal resistor and depends on the current, generates heat. To prevent of high temperature on the board, proper heat dissipating must be considered.
3. To be able to quickly block excessive current (e.g. in relation to an external short circuit of the battery a high-speed **fuse** must be placed in the main current path.

3. Specification

3.1 Electrical specification

Maximum battery pack voltage	95v
Minimum battery pack voltage	13v
Isolated DC/DC 12v BMS current	150 mA
AUX DC/DC 12v output current	150 mA
Sleep mode consumption	48 mW
Maximum continues switching current	100 A
Maximum pulse current	200 A in 10 seconds
Maximum current measurement	+-200A
Current measurement accuracy	1%
Switch off time	Less than 1.0 ms
Number of on-board temperature sensors	2
Temperature sensor type	NTC,10kΩ @25°C,β=3900

Table 1 :Electrical specification

3.2 Dimensions

Dimension	170 x 50 x 20 mm
Weight without heatsink	90 g
Weight with heatsink	100g

Table2: Physical specification

3.3 Environmental test specification

EMC Emission	ti
EMC, Immunity	ti
Temperature/Humidity	ti
Vibration	ti
RoHS	ti

Table3: Environmental test specification

4. c-BPU printed circuit board mechanical overview

Fig. 2 shows the top side of the c-BPU100™ board, its connectors and some of the copmpnents.

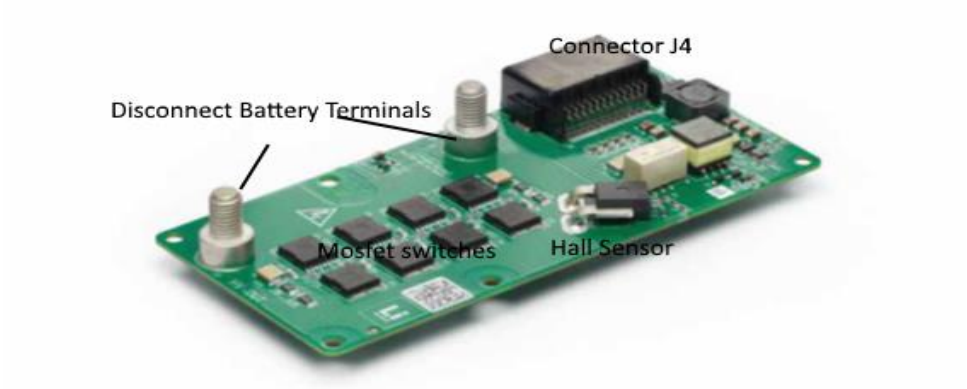


Figure 2: Top and Back side of the c-BPU100TM

4.1 J4 connector

J4 connector is the power and I/O connector of the c-BPU.This connector is male connector with 24 pins (part number: MX34R24HF4T). Fig. 3 shows J4 connector back and front.

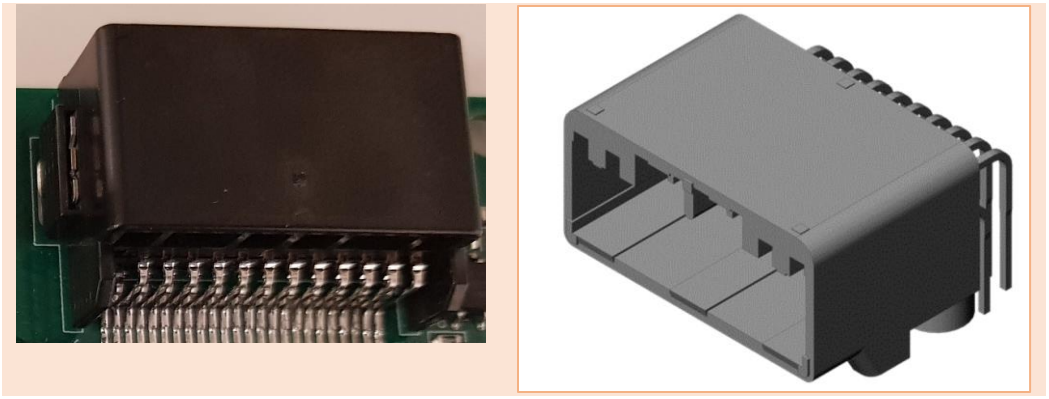
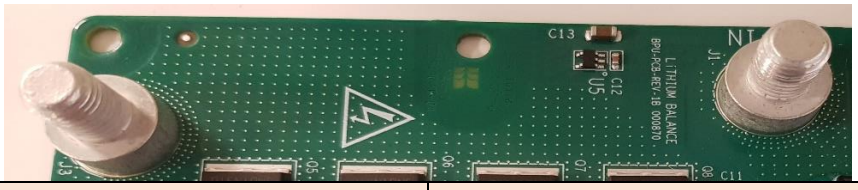


Figure 3: J4 connector

4.2 Disconnect battery terminals J1 and J3

J1 and J3 are the high-power terminals of the c-BPU100™ (ERNI product, Part Nnumber:225854). Fig. 4 shows the picture and specifications of these terminals.



Current Rating	250A
Max Operating Temperature	155°C
Mounting Peg	No
Thread	M8

Figure 4: J1, J3 terminals specification

4.3 Information Label (QR)

The QR label (marked QR on picture 5:) contains information about:

- Part number and revision version of the board
- Serial number including the production date

To read the QR-labels, Lithium Balance suggests using dedicated QR readers. If smart phones are used the “QR Reader from TapMedia Ltd” have been tested successfully.

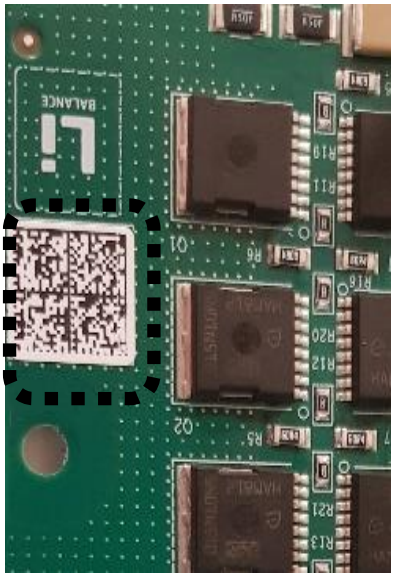


Figure 5: QR label

5. c-BPU connectors and functional Overview

5.1 J4 pins overview

J4 connector has 24 pins (fig. 6). Table 4 shows the pin numbers, names and their functionalities.

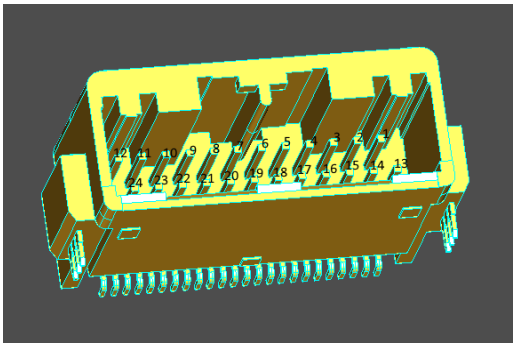


Figure 6: J4 pin number

Pin Number	Pin Name	Functionality
1	NC	
2	HV (-) IN	Main power supply
3	HV (-)	Main power supply
4	CURRENT SENSOR LOW	Hall effect current sensor
5	CURRENT SENSOR +5V	Hall effect current sensor
6	NC	
7	GND	Auxiliary power out (Same as BMS Power)
8	+12V AUX	Auxiliary power out (Same as BMS Power)
9	TEMPERAURE SSENSOR 1 +	MOSFET temperature sensors
10	TEMPERAURE SSENSOR 1 GND	MOSFET temperature sensors
11	TEMPERAURE SSENSOR 2 +	MOSFET temperature sensors
12	TEMPERAURE SSENSOR 2 GND	MOSFET temperature sensors
13	HV (+)	Main power supply
14	AUTO OFF IN	Auto off function (Start Button)
15	AUTO OFF OUT	Auto off function (Start Button)
16	CURRENT SENSOR GND	Hall effect current sensor
17	NC	
18	NC	
19	NC	
20	BMS POWER GND	BMS power supply (Isolated)
21	BMS POWER +12V	BMS power supply (Isolated)
22	HV SWITCH(MOSFET)ON/OFF	Disconnect battery
23	NC	
24	AUTO OFF HOLD	Auto off function

Table4: J4 pin description

5.1.1 Main power supply

Pins 2,3 and 13 of the J4 connector are connected to the battery to supply the c-BPU main power. The negative pole of the battery is connected to the pin 2. The positive pole of the battery is connected to the pin 13. c-BPU is functioning if and only if the pin 3 is connected to the pin 2.

5.1.2 BMS power supply

Pins 20 and 21 of the J4 supply the external BMS by 12v and the max current of 150mA. Pin 20 is 0v and pin 21 is +12v.

5.1.3 Auxiliary power out

If the designed application needs an isolated power supply, then c-BPU provide a 12v supply with the maximum current of 150 mA thru the pins 7 and 8. Pin 7 is 0v and pin 8 is +12v.

5.1.4 Auto off function

Auto off function is designed for disconnecting the BMS power from the c-BPU to reduce the battery consumption. Pins 14, 21 and 24 of the connector J4 are used for auto off function. This function is configured in BMS. Pin 24 must be connected to the BMS auto off hold pin (this pin is defined and configured in BMS, for the *c-BMS, J1: **pin 6** is used*). When the BMS decides to go to auto off, voltage of pin 24 goes to high and BMS power on pins 20 and 21 is disconnected by c-BPU. To turn the BMS on again, we need to connect and disconnect pin 14 to 15 for more than 2 seconds (Pin 15 has an internal connection to pin 13). Figure 7 shows an auto off example diagram.

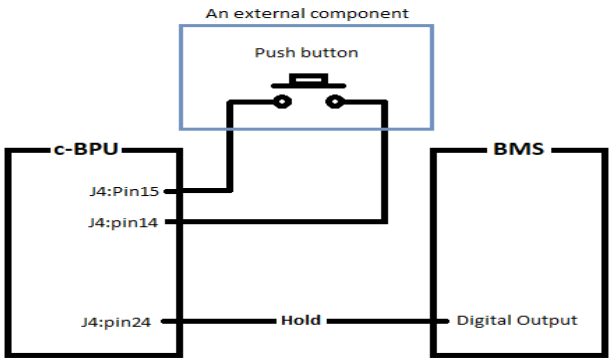


Figure7: Auto off, BMS and push button integration

5.1.5 Hall effect current sensor

C-BPU can measure the battery current in both charge and discharge mode. The c-BPU current sensor is a hall effect current sensor (ACS770ECB-200B-PFF-T) and can measure +-200A with the resolution of 10mv/A. This sensor needs to be supplied by a DC power of 5v(+-0.5v) and minimum current of 20mA. c-BPU checks the hall sensor power and if it is available, then MOSFET switches can be turned on and off.

Pins 16 and 5 supply the c-BPU current sensor. Pin 16 is connected to 0v and pin 5 is connected to 5v.

Voltage between Pin 4 and pin 16 (VIout)is a linear function of the measured current by the c-BPU. $I_{(A)}$= 10 x $VIout_{(mv)}$. Figure 8 shows how to connect the c-BPU Hall sensor to a BMS. The 5v power could be supplied by the BMS (For instance: c-BMS24™ can supply the c-BPU100 Hall sensor power)

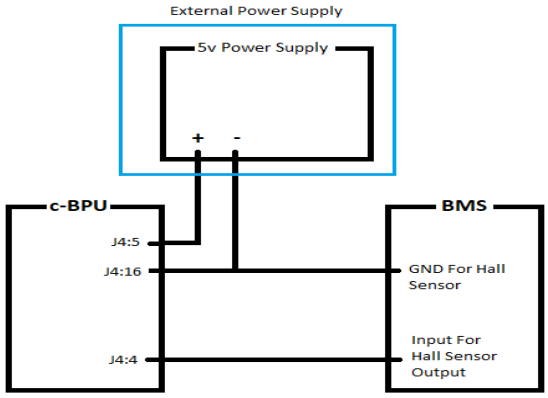


Figure8: Hall Effect Current Sensor and BMS Integration

5.1.6 MOSFET temperature sensors

One of the Maximum rating of the c-BPU is the MOSFETs temperature. Maximum MOSFET temperature is 80°C and must be under the BMS supervision. This temperature is a function of:

1. Passing current thru the terminals J1 and J3 (battery Load or charge current)
2. Heat dissipation

c-BPU has 2 temperature sensors to measure the MOSFETs temperature. These are 2 similar NTC's sensor by the following specification: NTC, 10 kΩ@ 25 °C, β= 3900

Pins 9 and 10 are connected to the NTC number 1.
Pins 11 and 12 are connected to the NTC number 2.

5.1.7 Disconnect battery

Pin 22 is connected to the BMS to open or close the battery circuit by the MOSFET switches. The function name is Disconnect battery. To open and close the c-BMS switch, auto off function must give the on and off possibility to the MOSFETs. If auto off gives the possibility and hall sensor power is available, then c-BPU turn ON and Off the MOSFETs by pin 22. When the voltage of pin 22 is low(0v), the MOSFET switches becomes ON and switch is closed. If pin 22 is high(12v) or disconnected, then MOSFET switches becomes off and switch is open. When c-BPU and c-BMS are used, **pin *5*** from c-BMS J1 *is used.* Table5 shows the MOSFETs on and off logical function.

Auto Off pins 14 and 15(Start Button)	Auto Off Hold pin 24	Auto Off possibility to turn on and off the MOSFETs
connected	Low	Possible
connected	High	Possible
disconnected	Low	Possible
disconnected	High	Not Possible
If Auto Off gives the possibility to turn the MOSFETs on and off, then:		
Hall Sensor power availability on pins 4 and 5	Switch Open/Close pin 22	MOSFETs on/off Status
Available	Low	On
Available	High	Off
Not Available	Low	Off
Not Available	High	Off

Table5: MOSFETs on and off logical function

5.2 Disconnect battery terminal overview

c-BPU conducts the battery current thru the terminals J1 and J3. The following table shows the maximum rate of voltage and current on J1 and J3.

Absolut Maximum Voltage	100v
Maximum continues Current Rating	100A
Maximum transient Current Rating	200A in 10s

Table6: c-BPU maximum current and voltage on J1 and J3

6. Practical Consideration

6.1 Heat dissipation

The heat generated by the MOSFET switches must be dissipated otherwise the MOSFETs temperature increases. The maximum allowed temperature on each of the MOSFETs is 175 °C. The following table shows thermal rate of c-BPU.

c-BPU conduct resistor	1 mΩ
c-BPU thermal resistance	25 °C/W
c-BPU maximum temp	80°C

Table7: c-BPU thermal rates

6.2 Inductive load consideration

c-BPU can switch on and off loads with up to 100uH serial loop inductance.

7.Appendix

7.1 c-BPU and c-BMS Integration

A complete battery pack can be designed by using a c-BPU and c-BMS. In the following, first wire connection for a typical battery pack is explained and then the mechanical consideration is discussed.

7.1.1 Power and I/o connection

Figure 9 and table 6 shows a typical block diagram of a battery pack built by using c-BPU and c-BMS.

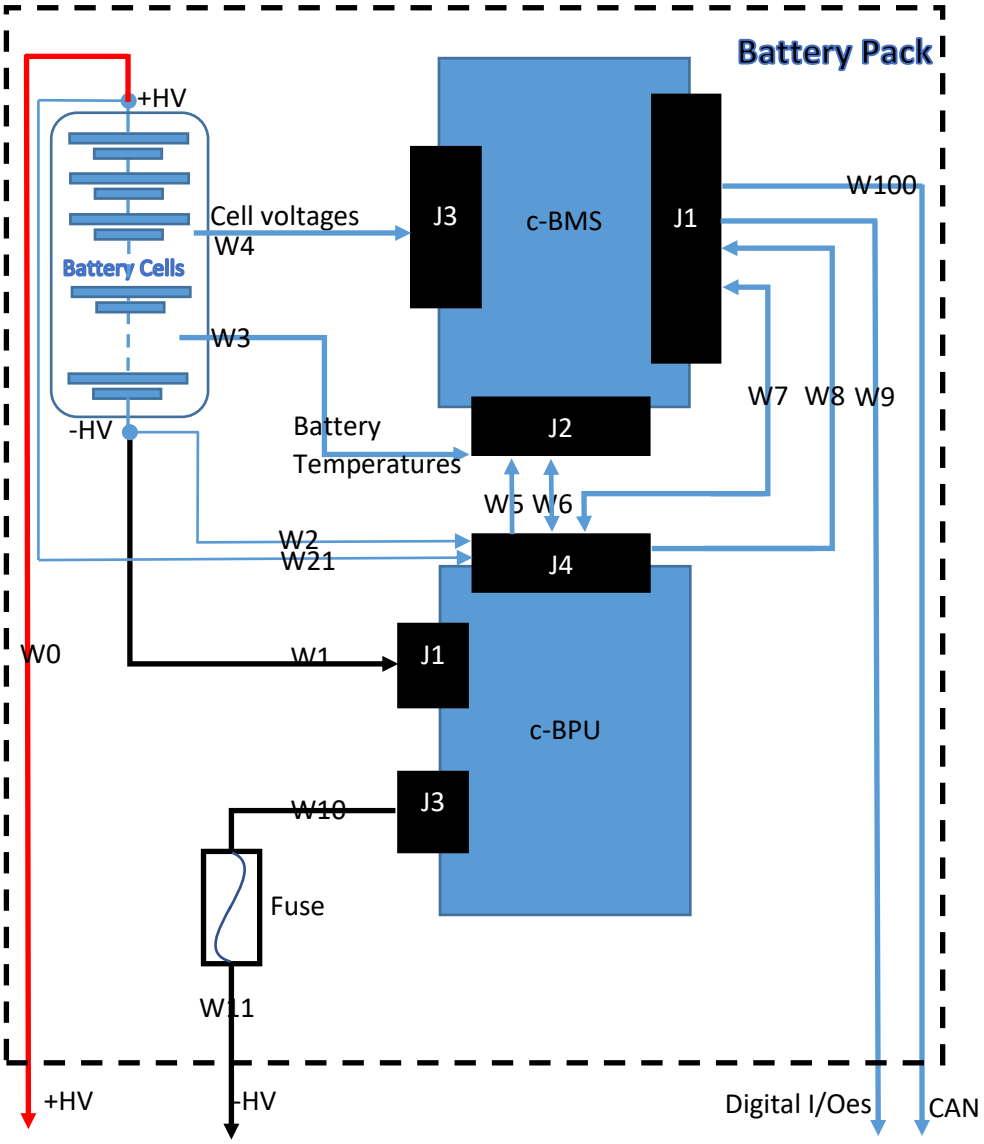


Figure 9: A complete battery pack integration, using c-BPU and c-BMS

Name	Number of wires	Functionality	Description
W0	1	High voltage + output	A power cable with proper specification to carry the battery pack current.
W1	1	High voltage – to c_BPU:J1	Same cable specifiaction as w0
W10	1	c_BPU:J3 to the fuse	Same cable specifiaction as w0
W11	1	From the fuse to high voltage - output	Same cable specifiaction as w0
W2	2	c-BPU main power -	c-BPU:J4:pin2(green) and c-BPU:J4:pin3(gray) from Harness kit **#100933 c-BPU:J4**
W21	1	c-BPU main power +	c-BPU:J4:pin13(Brwon wire) from Harness kit **#100933 c-BPU:J4**
W3	8	4 NTC temperature sensors (T1 to T4) from the battey pack connecting to c_BMS	c-BMS:J2:Pins 7(blue),8(blue),9(blue),10(blue),17(light blue),18(yellow),19(green),20(orange) from Harness kit **#100933 c-BMS:J2**
W4	36	Battery cell voltages Connected to c-BMS:J3	Harness kit **#100932 c-BMS:J3**
W5	4	2 NTC temperature sensors (T5 and T6) from c_BPU connecting to c_BMS	Harness kit **#100933 c-BMS:J2** and **c-BPU:J4** (connections are ready in Harness kit **#100933**)
W6	3	c-BPU hall sensor connectionto c-BMS	Harness kit **#100933 c-BMS:J2** and **c-BPU:J4** (This connection is ready in Harness kit **#100933**)
W7	2	Auto off and MOSFET on/off	Harness kit **#100933 c-BMS:J1:pin3** and **c-BPU:J4:pin24(violet)** for auto off hold Harness kit **#100933 c-BMS:J1:pin4** and **c-BPU:J4:pin22(green)** for MOSFET on/off (connections are ready in Harness kit **#100933**)
W8	2	c-BMS power supply	Harness kit **#100933 c-BMS:J1:pin16** and **c-BPU:J4:pin21(red)** for +12v Harness kit **#100933 c-BMS:J1:pin15 & pin 7** and **c-BPU:J4:pin20(black)** for GND (connections are ready in Harness kit **#100933**)

W9	7	c-BMS (GPIO)	c-BMS:J1:Pins 5(light blue),6(blue),8(violet),11(green),12(brown),13(blue),14(light blue),from Harness kit **#100933 c-BMS:J1**
W100	2	CAN	Paar-Tronic Cable 1x2x0.25 Grey DIN 47100 Harness kit **#100933 c-BMS:J1**

Table 8: Wire description of figure 6

7.1.2 c-BPU and c-BMS Integration using Harness kit

Figure 10 shows the connection of lithium balance harnesses 100932 and 100933 using in a typical battery pack. Table 9 explains the harness 100932 open wires.

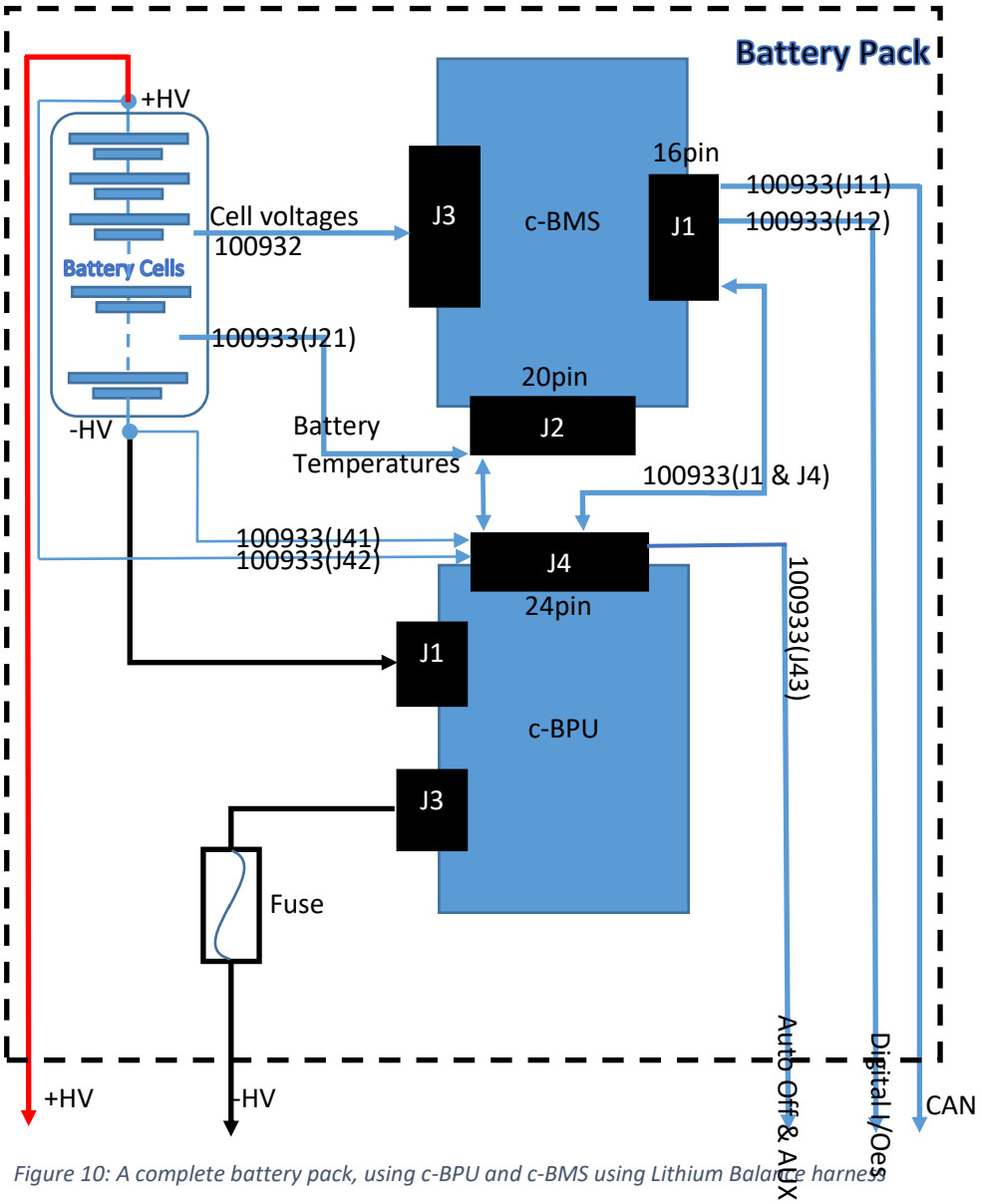


Figure 10: A complete battery pack, using c-BPU and c-BMS using Lithium Balance harness

Connector/Tag/Usage	Pin Number	Wire Color	Description
J1(16pins)/J11/CAN	1	brown	c-BMS CAN Low
	9	white	c-BMS CAN High
J1(16pins)/J12 /IOes	5	white	c-BMS Input2
	6	blue	c-BMS Input1
	8	red	c-BMS IGNITION
	11	green	c-BMS GPIO8
	12	orange	c-BMS GPIO7
	13	blue	c-BMS Input4
	14	white	c-BMS Input3
J2(20pins)/J21 /Shunt	1	blue	c-BMS Shunt-
	11	gray	c-BMS Shunt+
J2(20pins)/J22 /Battery Temp.	7	blue	c-BMS T4 Gnd
	17	white	c-BMS T4
	8	blue	c-BMS T3 Gnd
	18	yellow	c-BMS T3
	9	blue	c-BMS T2Gnd
	19	green	c-BMS T2
	10	blue	c-BMS T1Gnd
	20	orange	c-BMS T1
J4(24pins)/J41 /Power	2	green	c-BPU HV(-)IN
	3	gray	c-BPU HV(-)
J4(24pins)/J42 /Power	13	gray	c-BPU HV(+)
J4(24pins)/J43 /Auto Off	14	orange	c-BPU Auto Off IN
	15	orange	c-BPU Auto Off Out
J4(24pins)/J43 /Aux 12v	7	blue	c-BPU GND
	8	Red	c-BPU +12V AUX

Table 9: Wire description of Harness 100933

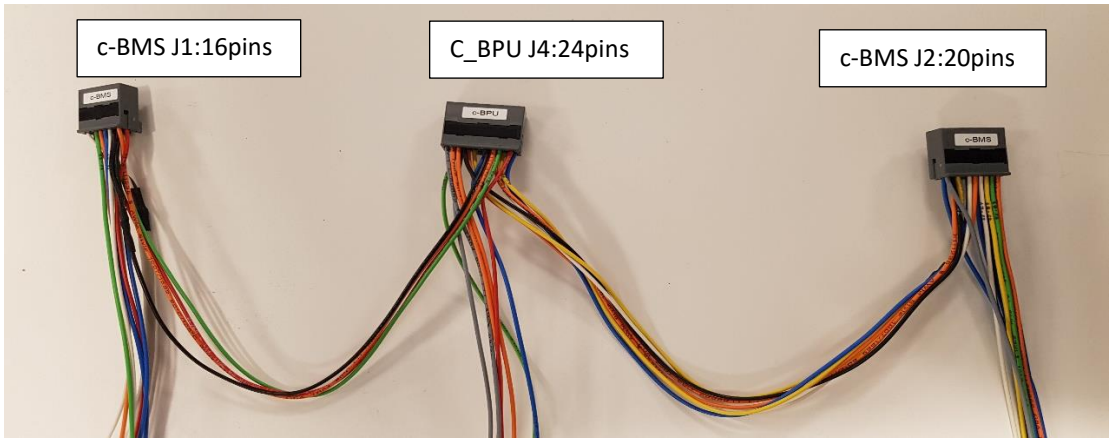


Figure 11: Lithium Balance Harness Kit 100933

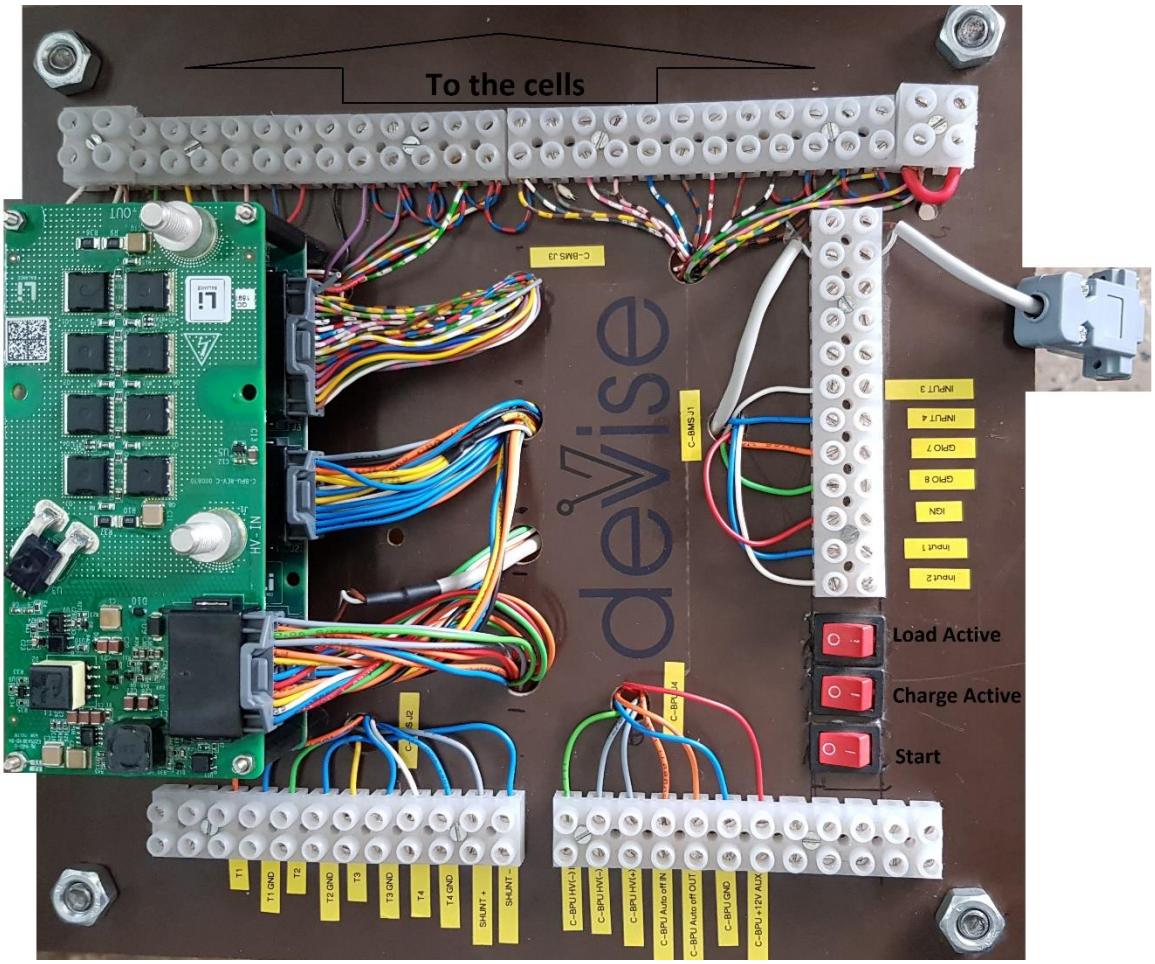


Figure 12: c-BPU, c-BMS test board

7.1.3 Battery Pack wire diagram using c-BMS and c-BPU

BY using harness kits 100932 and 100933, designing a battery pack is very convenient.
Figure 13 shows the wire diagram of a battery pack including 12 cells, built in Lithium Balance.

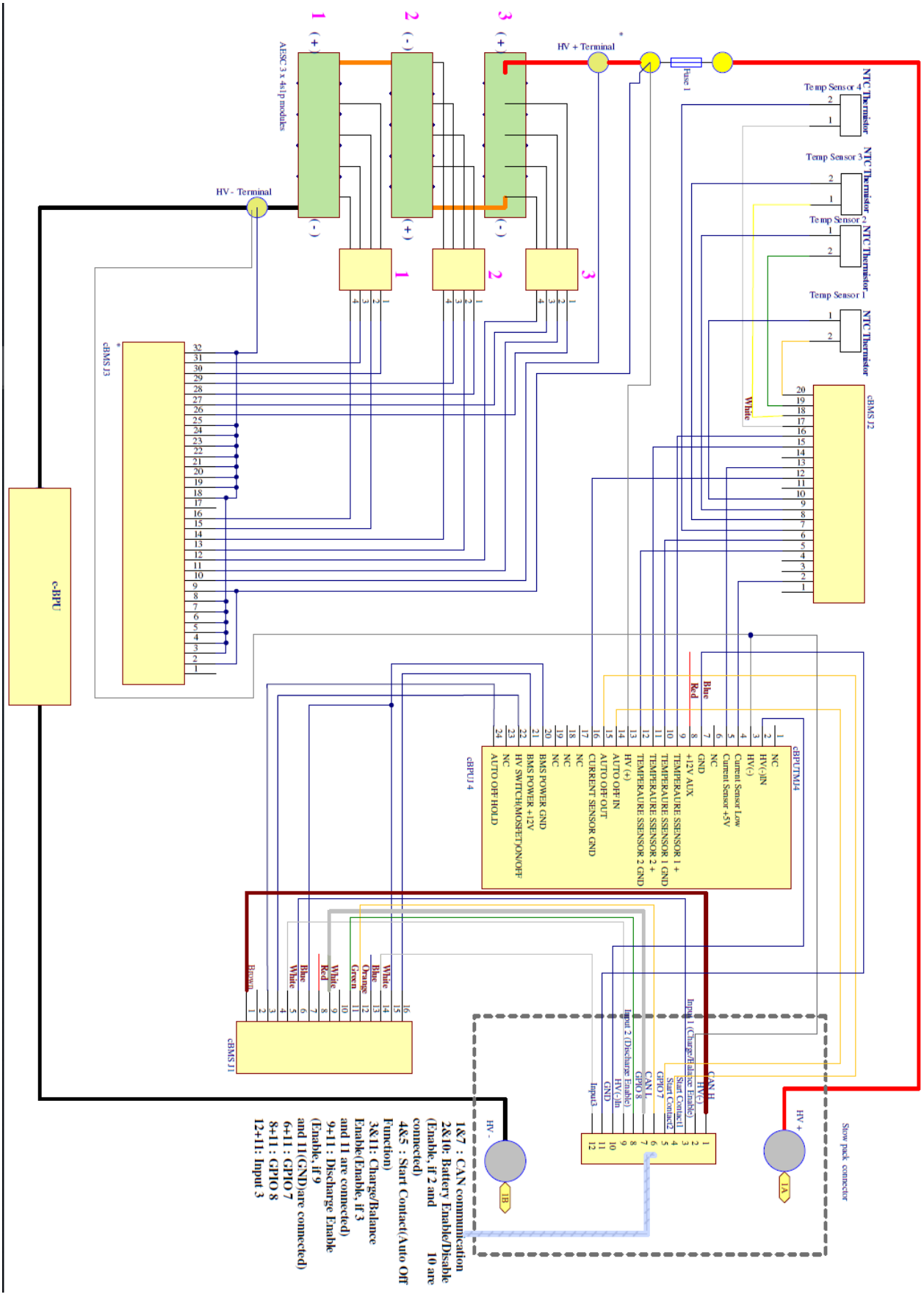


Figure 13: c-BPU, c-BMS Battery Pack example wire diagram

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