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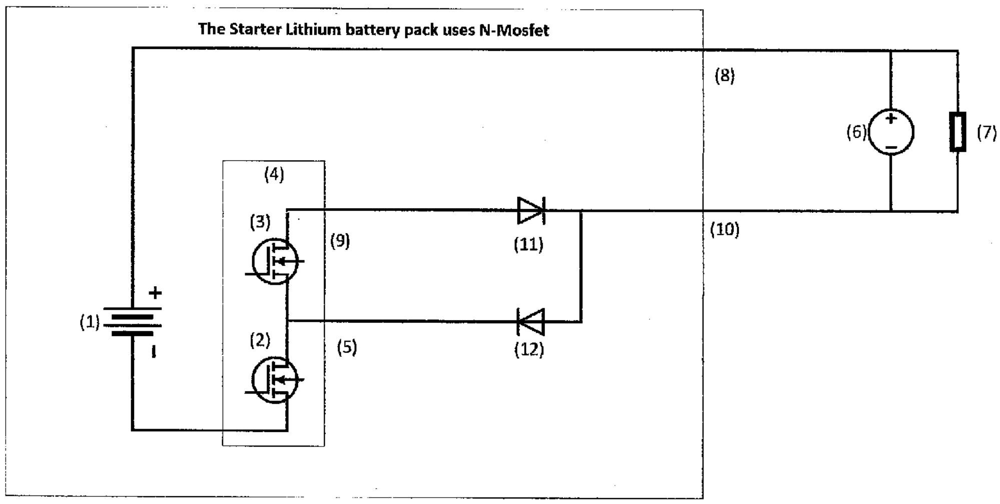

Figure 3: H. 3: The Starter Lithium Battery Diagram (N-Mosfet type)

(57) Abstract: The invention for starting internal combustion engines of lithium battery refers to lithium battery products for starting internal combustion engines; Currently, starting lithium battery products use common 1-port BMS for charging and discharging to adapt to existing electric power systems on cars, motorcycles, generators or boats engines; The difference of the lithium battery product of this invention is that it uses for charging and discharging 2-port BMS type to turn off the charging path without affecting the continuity of the discharge. At the same time, add a set of charging and discharging diodes with appropriate conductivity to combine the separate charging and discharging 2- ports of the BMS into a common charging and discharging 1-port of the battery pack.

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I. Invention name

LITHIUM BATTERY STARTS THE INTERNAL COMBUSTION ENGINE

II. The technical fields mentioned

The invention refers to the use of Lithium battery products to start internal combustion engines on motorcycles, cars, boats or generators.

III. Technical status of the invention

Lithium rechargeable batteries are being applied in many fields to store electricity and provide power for high-power devices. Due to its high - power density, high durability and stability, it is gradually replacing lead-acid batteries and other traditional batteries.

However, in the field of using power sources to start internal combustion engines on cars, motorcycles, boats, generators, construction machines, etc. Lithium batteries cannot replace lead-acid batteries. Some manufacturers have already launched market starter Lithium batteries types in the market, but only in small quantities and the products must sacrifice some other necessary technical characteristics to be able to be used for this purpose.

The reason why lithium batteries are not yet commonly used for engine starting purposes is due to the technical characteristics of traditional battery management circuits.

The physical nature of Lithium batteries cannot withstand overcharging (high voltage above the upper limit) and overdischarging (low voltage below the lower limit). Therefore, batteries always need a battery protection system (BMS - Battery Management System) to eliminate these risks. The general operating principle of BMS is:

- The Integrated circuits (IC) measure and evaluate the voltage levels of upper limit of overcharge status and the lower limit of overdischarge status.
- The IC circuit also measure and evaluate the discharge current compared to the maximum discharge current limit.
- In addition, some IC circuits can measure other factors that require protection, such as overheating and overcharging current.
- The part switch charge and discharge paths to use MOSFET high-power electronic component according to the commands are sent from the above measurement IC

circuits. When the charging exceed the threshold or limit overcurrent, the charging MOSFET will be cut off and will not allow additional charging to the battery. When the discharging exceed the threshold or limit overcurrent or the BMS's temperature is too high, the discharge MOSFET will be cut off and the battery cannot continue to discharge.

There are currently two types of BMS on the market as follows:

1) BMS has common charge and discharge 1- port:

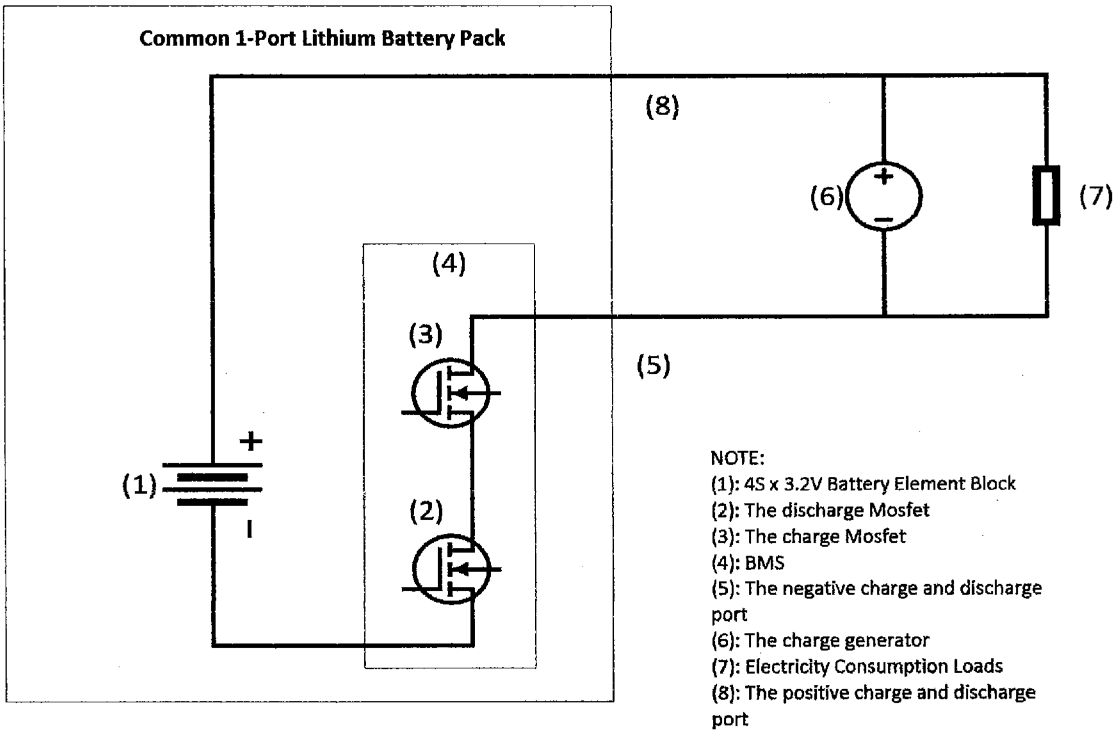
Figure H.1 depicts a lithium battery system with a common 1-port charge-discharge BMS using N-MOSFET type to switch a negative path. In this type, the battery element block (1) has an anode connected directly to the positive port (8) of the battery pack, cathode connected to the discharging MOSFET (2), connected in series with the charging MOSFET (3) and continues to common negative port (5) of the battery pack. The charging generator (6) and the electrical loads (7) are connected in parallel and connected in parallel to the battery pack. When the generator is not running or running at a slower speed, the output voltage is lower than the voltage of the battery pack, so the current will flow from the anode of the battery pack to the load and return to the cathode of the battery pack. The current continue from the cathode through the charging MOSFET (3) and discharging MOSFET (2) to the cathode of the battery block (1). On the contrary, when the voltage of the charging generator (6) is higher than the voltage of the battery block (1), the current from the anode of the charging generator will partly pass through the load (7), and a portion will enter the positive port (8) of the battery pack charge the battery -> and go out to the cathode of the battery block and sequentially passing through the discharging MOSFET (2) and charging MOSFET (3) of the BMS (4). Then go out the common negative port (5) of the battery pack and return to the cathode of the charging generator.

When the battery is over-voltage, that is, when the voltage of any battery element exceeds its maximum threshold (3.65V with 3.2V LFP battery element type), BMS (4) will turn off the charging MOSFET (3) and then the discharging path is also disconnected. To restore discharge capacity, the power supply (6) must be isolated from the battery pack.

On the contrary, when the battery is over-discharged current or low voltage the battery so the BMS will turn off the discharge MOSFET and and at that point, the charging path is also interrupted. To restore the ability to receive charging current, the load must be isolated from the battery.

The BSM type using P-mofet also works similarly, but the MOSFET will be controlled to turn off the positive pass of the battery block.

Figure 1: H. 1: The diagram of a Lithium battery using a common 1-port BMS on the market



2) BMS has separate charging and discharging 2-ports:

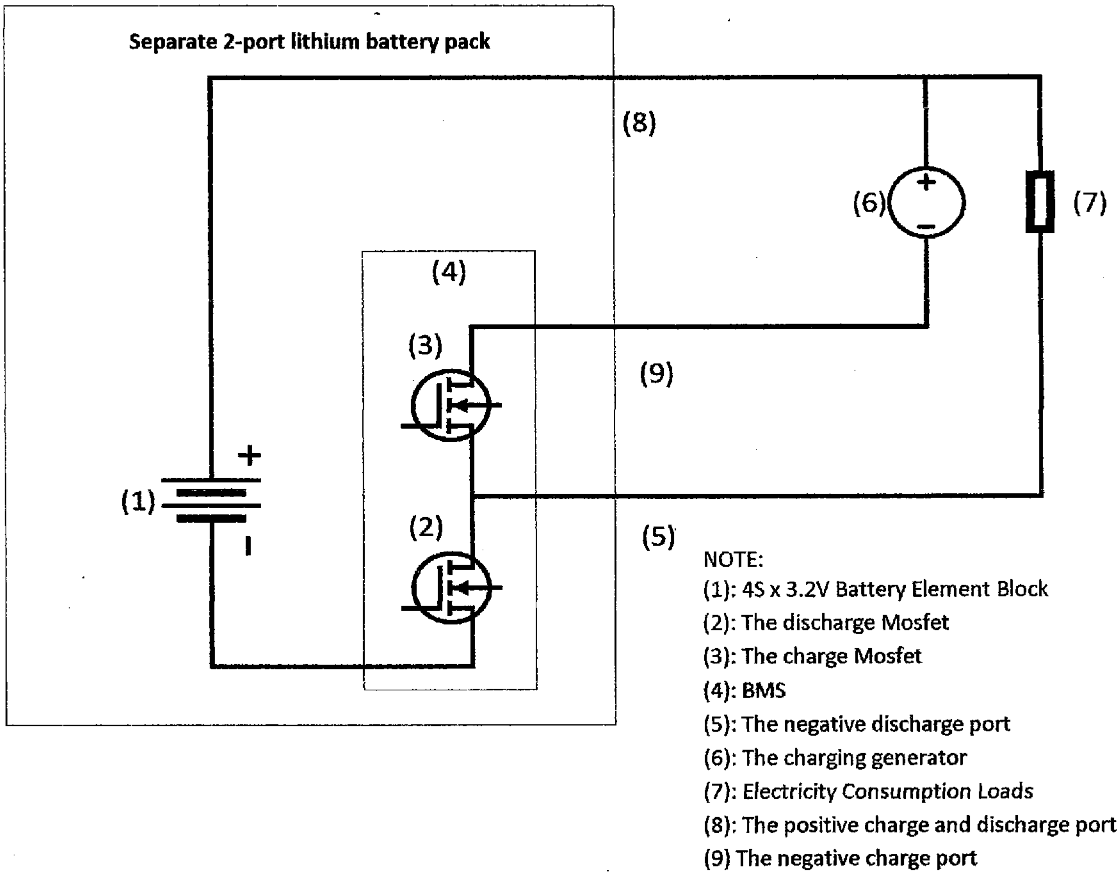
Figure H.2 depicts a lithium battery system with separate charge and discharge 2–ports BMS uses N-MOSFET type negative pass switching. In this system, cathode of the charging generator (6) connects to the negative charging port (9) and cathode of the load (7) connects to the negative discharge port (5) of the battery pack. The operation of this type is only different from the common charge-discharge 1-port type in that when discharging, the discharge current from the cathode of the load (7) passes through the negative discharge port (5) and passes through the MOSFET discharge (2) to return to the cathode of the battery block (1). When charging, the current from cathode of the battery block (1) sequentially passes through the MOSFET discharge (2) and MOSFET (3) charge of the BMS (4), go out the cathode discharge (9) of the battery pack and return to cathode of the charging generator (6).

When the battery is over-voltage, BMS (4) will turn off the charging MOSFET (3). However, the discharge pass through the discharge MOSFET (2) and negative discharge port (5) is still clear.

The situation of over-discharged (low-voltage) is similar to common 1-port BMS. BMS (4) will turn off MOSFET discharge (2) and then the charging path will also be interrupted. To restore the ability to receive current charging, the load must be isolated from the battery. Some 2-port BMS have a way to directly connect MOSFET charging to the cathode of the battery block. When the discharge is interrupted, the charging path is still clear to be ready to receive charging power without isolate the load.

The BSM type using P-mofet also works similarly, but the MOSFETs will be controlled to interrupted the positive path of the battery block.

Figure 2: H. 2 The diagram of a Lithium battery diagram using a common 2-port separate BMS on the market



However, the electrical circuit on a traditional internal combustion engine has characteristics that are not suitable for both types of BMS mentioned above:

1) The engine has only one unique electrical path and all power sources from a direct current generator, power from the starting battery and loads are all connected in parallel to this power path. Thus, the engine electrical system only allows one common port for charging and discharging the starting battery

2) When the engine is running, the starting battery cannot be disconnected from the electrical circuit because the quality of electricity emitted from the charging generator is not good (unstable voltage amplitude, large aliasing). Therefore, the control circuit and other electrical devices of the engine always need to have a battery in the circuit to stabilize the voltage and smooth out this aliasing. This requirement leads to the use of a BMS with independent charge and discharge ports.

In fact, some lithium battery manufacturers have launched lithium battery products for starter engine with acknowledge their shortcomings as follows:

1) The battery uses common port BMS type so it can connect to the engine without having to change the engine 's existing circuit.

2) Overcharging protection function sacrifice (possibly by raising the fill voltage threshold above the level that the engine charge generator can output). However, this method leads to the risk of battery overcharging, overheating and possibly exploding, for some reason, charging generator on the vehicle, generate a voltage higher than the allowable charging voltage of the battery.

   Example:

   - In the engine starting BMS model SB78ot-F-12-110 12V110A Car Starter BMS from Soontop Technology (Taiwan): https://www.soontop.com.tw/product/car-cranking-battery-bms/12v-4s-car-starter-lifepo4-battery-bms/sb78ot-f-12-110-12v110a-car-starter-bms

   - Or in BMS used for engine starting Peak 1500A Car Start up 12V 24V 460A BMS 4S 3S 7S 8S Lipo Lifepo4 Battery protection Board from ChengDu Sunmall Electronic Technology (China): https://heltec-bms.com/product/peak-1500a-car-start-up-12v-24v-460a-bms-4s-3s-7s-8s-lipo-lifepo4-battery-protection-board/

3) Both companies produce engine starting BMS using LFP 3.2V battery elements including 4 elements connected in series (4S). Although this type of battery element requires limiting the charging voltage to ≤ 3.65V for each element. However, both set

the overvoltage protection threshold to 3.85V, equivalent to 15.4V of the entire battery pack. This level is lower than the highest charging voltage level of the existing charging generator on the engine which is 13.8 - 14.5V (design level for lead batteries). That means unless the charging generator has a damaged voltage regulator, the actual charging voltage never reaches to 15.4V to activate the charging cut-off function. Instructions on how to restore the battery by manual intervention when the battery is interrupted for self-protection. This is not suitable for most car and motorbike users as they do not have a deep understanding of it.

For example, the ATZ7-RS starting battery from Antigravity Batteries (USA) is equipped with a "Re-start" button to wake up the battery after the charging and discharging path are interrupted: https://antigravitybatteries.com/products/starter-batteries/restart-oem/atz7-rs/

4) The Starter batteries are mainly launched on the market for use in sports cars (motorsport), vehicles with special uses, vehicles have professional personnel to monitor the technical status and be able to handle problems

Perhaps for above reason, in fact, lead-acid batteries are still dominating absolutely on the starter battery market, despite they have many drawbacks compared to lithium batteries.

IV. The technical nature of the invention.

The purpose of the Lithium Starter Battery invention is to improve the Battery Management System (BMS) to overcome the shortcomings of the two commonly used BMS systems. This will facilitate the easy and widespread use of lithium batteries for engine starting purposes and completely replace lead-acid batteries.

The specific requirements for the lithium battery management system startup are as follows:

- Connect to the common power supply of the conventional internal combustion engine system without the need to modify the existing system.
- Maintain the charging interruption function to protect the battery without affecting the continuity of the discharging function.

To achieve this, the Lithium Starter Battery invention proposes the following improvements:

1) Utilize all commonly used types of Lithium battery cells for the starter battery,

including, but not limited to, LFP, LNMC, and LTO.

2) Use a BMS with 2 independent ports (4) with N-type Mosfets on the circuit diagram shown in Figure H.3, using common electronic components, including:

- Centralized or distributed type of charge and discharge protection IC
- Passive or active balancing IC

3) Add a common charging and discharging port (10) to the H.3 diagram of the battery pack by installing diodes or similar direct current conducting components in series from the charging ports (charging diode (11)) and the discharging port (discharging diode (12)) of the aforementioned common port BMS (4). By arranging the appropriate conduction direction of the diodes, the charging current and discharging current from the common port of the battery pack will be separated and directed to the respective charging ports (9) and discharging port (5).

4) The diode charging and discharging component mentioned above can be arranged on a separate electrical circuit to connect with commonly used 2-port BMSs on the market, or it can be integrated into the 2-port BMS circuit to create a completely new type of BMS, which can be called a startup BMS.

5) In this system, the cathode of the charge transmitter (6) and the cathode of the load (7) are both connected to the common negative terminal (10) of the battery pack. The cathode (10) is connected to the charging cathode (9) of the Battery Management System (BMS) (4) through a charging diode (11) or multiple parallel charging diodes in the forward direction. The cathode (10) is also connected to the discharging cathode (5) of the BMS (4) through one or more discharging diodes (12). When the battery is overcharged, the BMS (4) will turn off the charging MOSFET (3). However, the discharge path in turn passes through the common negative terminal (10), the discharging diode (12), the negative discharge terminal (5), and the discharging MOSFET (2) to the cathode of the battery pack.

When the situation of excessive discharge (low voltage) occurs, it is similar to a common BMS (Battery Management System) where a shared BMS port (4) will cut off the discharge MOSFET (2), and at that point, the charging path is also interrupted. In order to restore the ability to accept charging current, it is necessary to isolate the load from the battery. Some BMSs with two ports have a direct connection of the charging MOSFET to the cathode of the battery. In this case, when the discharge is cut off, the charging path remains open to be ready to receive the charging current without the need for load isolation.

The improved content and operating principles for a battery management system (BMS) using P-type Mosfet for battery are shown in Figure H.4.

Figure 3: H. 3: The Starter Lithium Battery Diagram (N-Mosfet type)

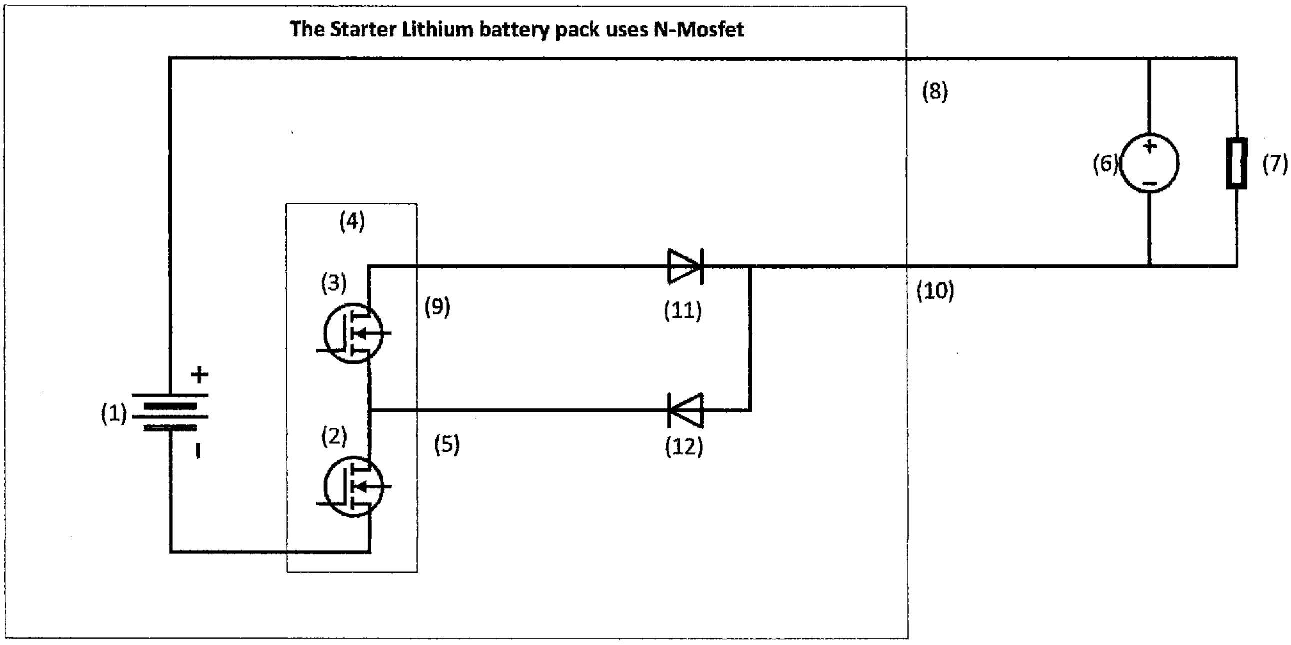
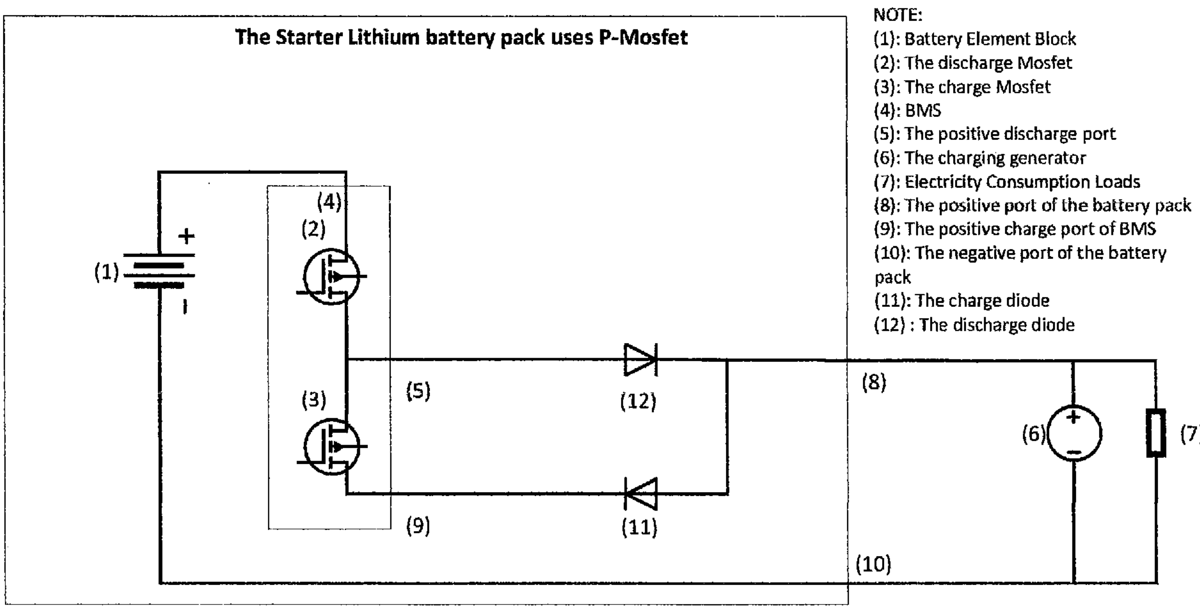


Figure 4: H. 4: The Starter Lithium Battery Diagram (P-Mosfet type)



V. Briefly describe the illustrations.

Figure 1: H. 1: The diagram of a Lithium battery using a common 1-port BMS on the market

Figure 2: H. 2 The diagram of a Lithium battery diagram using a common 2-port separate BMS on the market

Figure 3: H. 3: The Starter Lithium Battery Diagram (N-Mosfet type)

Figure 4: H. 4: The Starter Lithium Battery Diagram (P-Mosfet type)

Figure 5: H. 5: The invention's BPS106 starter battery diagram

Figure 6: H. 6 The invention's BP140 starter battery diagram

VI. Detailed description of the invention.

From the aforementioned technical solution, a motor starting battery product can be created as follows.

1) Select the battery element and configure the connection according to the nominal voltage, charging voltage, charging current, and discharge current. For example:

- To obtain a voltage level of 12V, a configuration of 3-element LNMC battery with a voltage of 3.7V each can be used. The nominal voltage will be 11.1V.
- Alternatively, use a configuration of 4-element LFP battery with a voltage of 3.2V, resulting in a nominal voltage of 12.8V.
- The minimum charging voltage required from the engine's charging generator for a 3S LNMC battery configuration is 12.6V, calculated as 4.2 x 3.
- The 4S LFP battery configuration requires a minimum charging voltage of 13.8V(3.65 x 4)from the engine's charging generator.
- To start a motor with a starting power of 2.0 kW and a voltage of 12V, a starting current of 173A(2000W/ 12V) needs to be supplied. Select a battery element or a parallel combination of battery elements with a minimum allowable discharge current of 173A.
- To install on a car with a maximum charging current generator, for example, 55A, it is necessary to select a battery element or a combination of battery elements in parallel

with a minimum allowable charging current of 55A.

2) Select the operational parameters of the BMS based on the number of battery cells, type of cells (voltage), charging current, and maximum discharge current. For example:

- To start a DC motor, for example, a 2kW motor, it is necessary to select a BMS with a minimum short-circuit discharge current of 173A and an overcurrent protection threshold of approximately 2-3 times the short-circuit discharge current to avoid circuit interruption when the start button is pressed.

- BMS also needs to select according to the high and low voltage protection thresholds of the battery element type and the number of battery elements.

3) Select the charging diode based on the charging voltage and charging current specifications of the charging generator, as well as the required charging voltage of the battery element. If there is a voltage difference across the diode, a heat sink aluminum plate needs to be added. For example:

- The selected charging diode should have a forward voltage drop close to the difference between the charging voltage of the battery and the maximum allowable charging voltage. For a 3S LNMC battery with a charging voltage of 12.6V and a charging generator with a voltage of 14V, a forward voltage drop of approximately 1.4V(14.0 – 12.6) should be chosen. Specifically, this can be achieved by using two series-connected silic diodes.

- With a 4S LFP battery having a charging voltage of 13.8V and a charging generator voltage of 14V, it is necessary to select a diode with the lowest possible voltage drop, not exceeding 0.2V (14.0 - 13.8). Specifically, a low voltage Schottky diode or an ideal diode should be chosen.

4) Select a discharge diode based on the starting current specifications. Due to the high starting current, it is also necessary to calculate and arrange an aluminum heat sink plate.

- To provide the starting discharge current for a motor, for example, a 2kW motor, a discharge diode or a parallel combination of diodes with a forward current of not less than 173A and an instantaneous current of 2-3 times is required.

- The discharge diode used should be selected with a low forward voltage drop (such as a low voltage Schottky diode) or with no voltage drop (ideal diode) in order to maximize power losses during startup and reduce heat generation.

5) Select the auxiliary components: battery bridge, conductor wire, aluminum heat sink plate, enclosure shell.

6) Installation of prototype product.

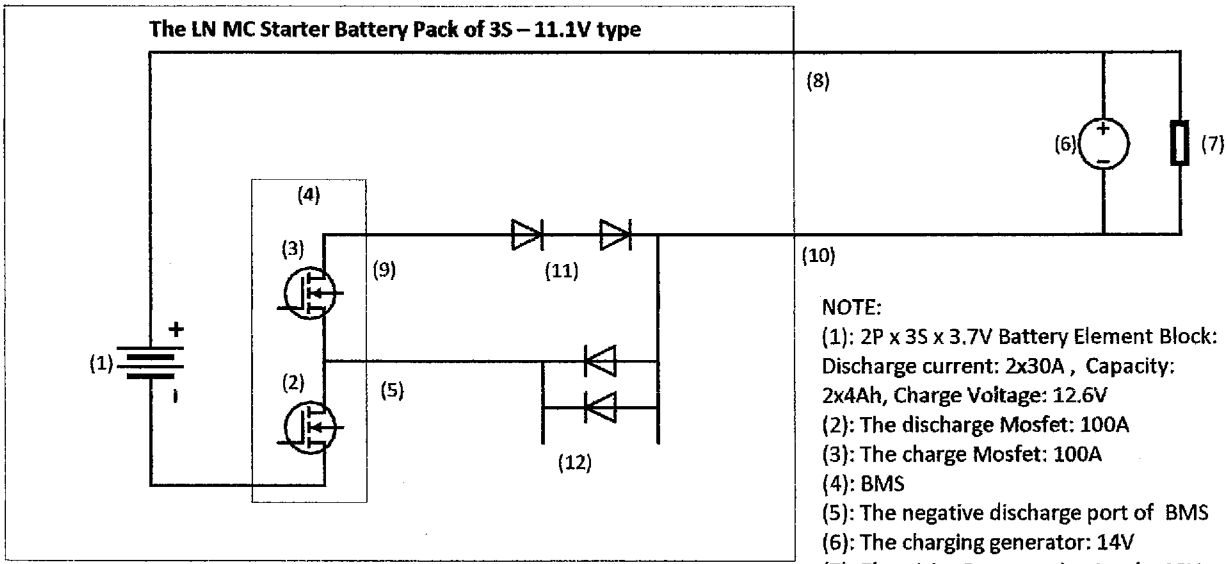
7) Prepare a table of working parameters and perform measurements and adjustments to achieve the requirements. The minimum requirements include having a constant current and voltage power supply, simulated loads at various levels, and electrical measuring instruments for voltage, current, capacity, and temperature.

VII. Example of patent implementation.

1) BPS106 Motorcycle Starter Battery

- Battery element type: LNMC (3.7V)
- Nominal voltage: 11.1V
- Charging voltage: 12.6V
- Overdischarge voltage: 8.1V
- Capacity: 8Ah
- Allowed charging current: 8A
- Starting current: 60A
- Overcurrent protection threshold: 200A
- Dimensions: 112 x 70 x 88mm
- Weight: 0.8kg
- Intended use: to start common motorcycles with engine displacements up to 150cc.

Figure 5: H. 5: The invention's BPS106 starter battery diagram

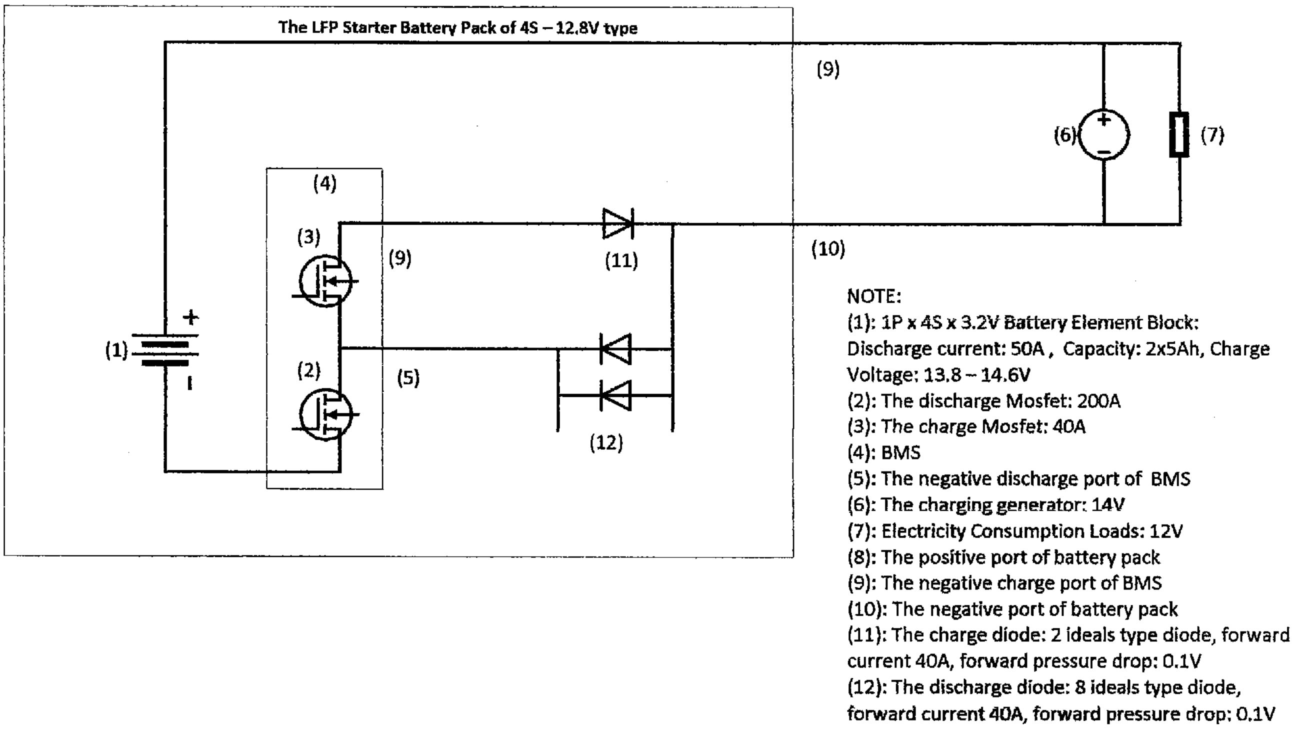


NOTE:
(1): 2P x 3S x 3.7V Battery Element Block: Discharge current: 2x30A , Capacity: 2x4Ah, Charge Voltage: 12.6V
(2): The discharge Mosfet: 100A
(3): The charge Mosfet: 100A
(4): BMS
(5): The negative discharge port of BMS
(6): The charging generator: 14V
(7): Electricity Consumption Loads: 12V
(8): The positive port of battery pack
(9): The negative charge port of BMS
(10): The negative port of battery pack
(11): The GBJ5010 diode bridge: 25A - forward pressure drop: 1.4V
(12): The discharge diode: 2 ideals type diode, forward current 35A, forward pressure drop: 0.1V

BP140 Car Starter Battery

- Battery element type: LFP (3.2V)
- Nominal voltage: 12.8V
- Charging voltage: 13.6V
- Overdischarge voltage: 8.0V
- Capacity: 16Ah
- Allowed charging current: 45A
- Starting current: 320A
- Overcurrent protection threshold: 800A
- Dimensions: 165 x 126 x 175mm
- Weight: 4.0kg
- Intended use: to start gasoline-powered cars with engine displacement up to 2200cc.

Figure 6: H. 6 The invention's BP140 starter battery diagram



VIII. The effectiveness of the invention.

1) Efficiency in terms of convenience for users:

- Traditional lead-acid batteries have a short lifespan of about 2-3 years. However, before they fail and are discarded, batteries have an unstable operating period, sudden power loss... This causes inconvenience for users of vehicles, machines, and even leads to significant damage in cases where the generator fails to start in time during a power outage

- Lithium batteries, on the other hand, have a long lifespan of up to 10 years, and even after that, they can still be used because they only experience a decrease in capacity of up to 80%. Lithium batteries always provide stable electrical quality throughout their lifespan.

2) Economic efficiency:

- Lithium batteries have a selling price that is about double compared to other types of batteries, but they have a lifespan that is five times longer and do not require maintenance like lead-acid batteries. Therefore, besides the convenience mentioned above, using lithium batteries is also more advantageous than lead-acid batteries in terms of economics.

- When lithium batteries are damaged, they can be repaired without the need for complete disposal. This further enhances their economic value.

3) Effectiveness of technical development strategy:

- Helps popularize Lithium batteries as a superior type of battery compared to lead-acid batteries in many aspects: high energy density, compact size, stability
- Paves the way for the complete elimination of lead-acid batteries to protect the environment as lead is a toxic substance.

IX. Protection claim:

1. The Lithium batteries start the engine using a separate 2-port BMS battery protection circuit, which has the unique characteristic of using a diode or electronic component with direct current conductivity, allowing only charging current from the common port of the battery pack to pass through the charging port of the BMS and allowing only discharge current from the common port of the battery pack to pass through the discharge port of the BMS;

   Principle diagram of battery using BMS with N-type Mosfet as Figure H.3 and battery using BMS with P type Mosfet as Figure H.4 above.

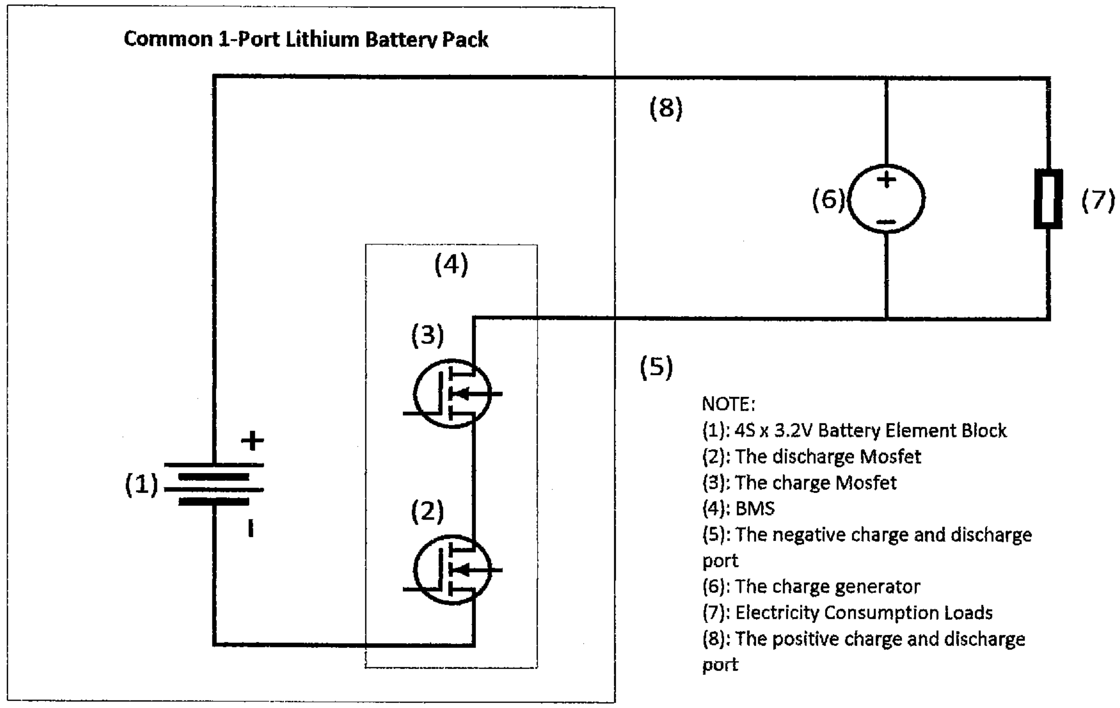


Figure 1: H. 1: The diagram of a Lithium battery using a common 1-port BMS on the market

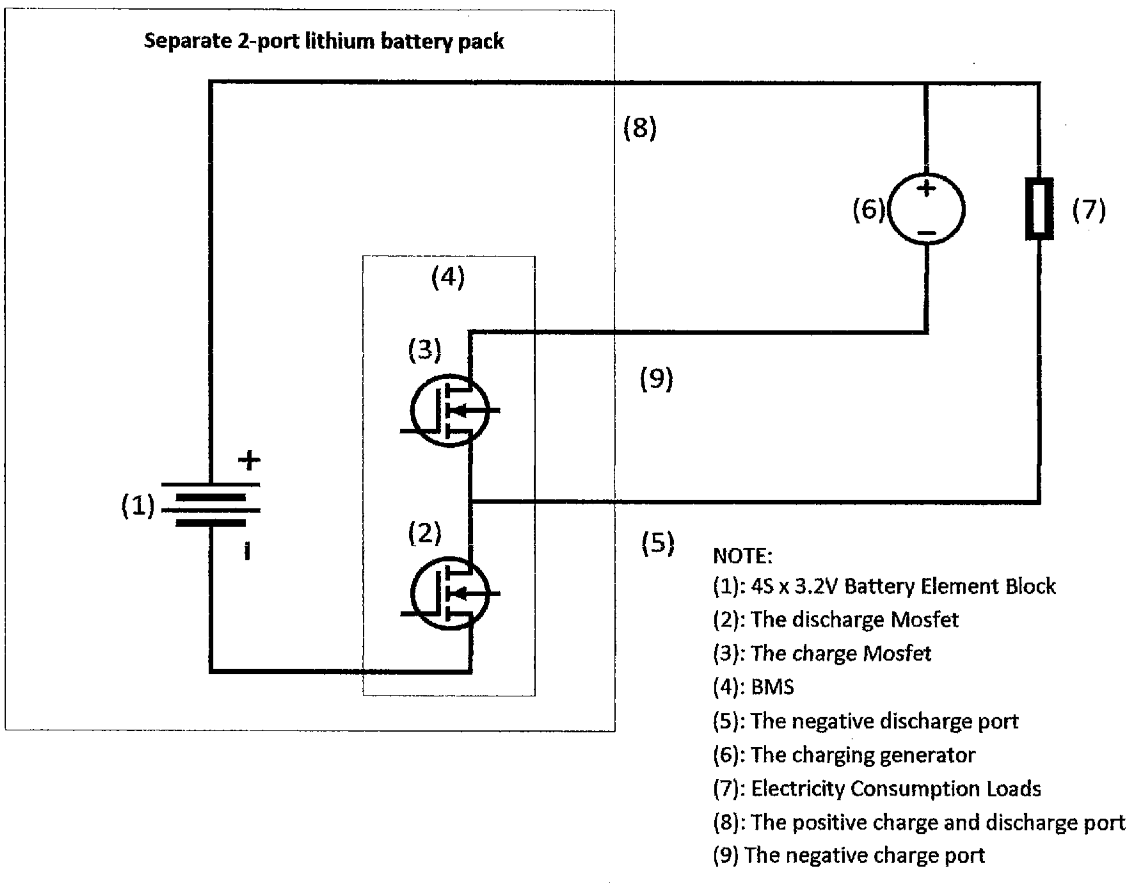


Figure 2: H. 2 The diagram of a Lithium battery diagram using a common 2-port separate BMS on the market

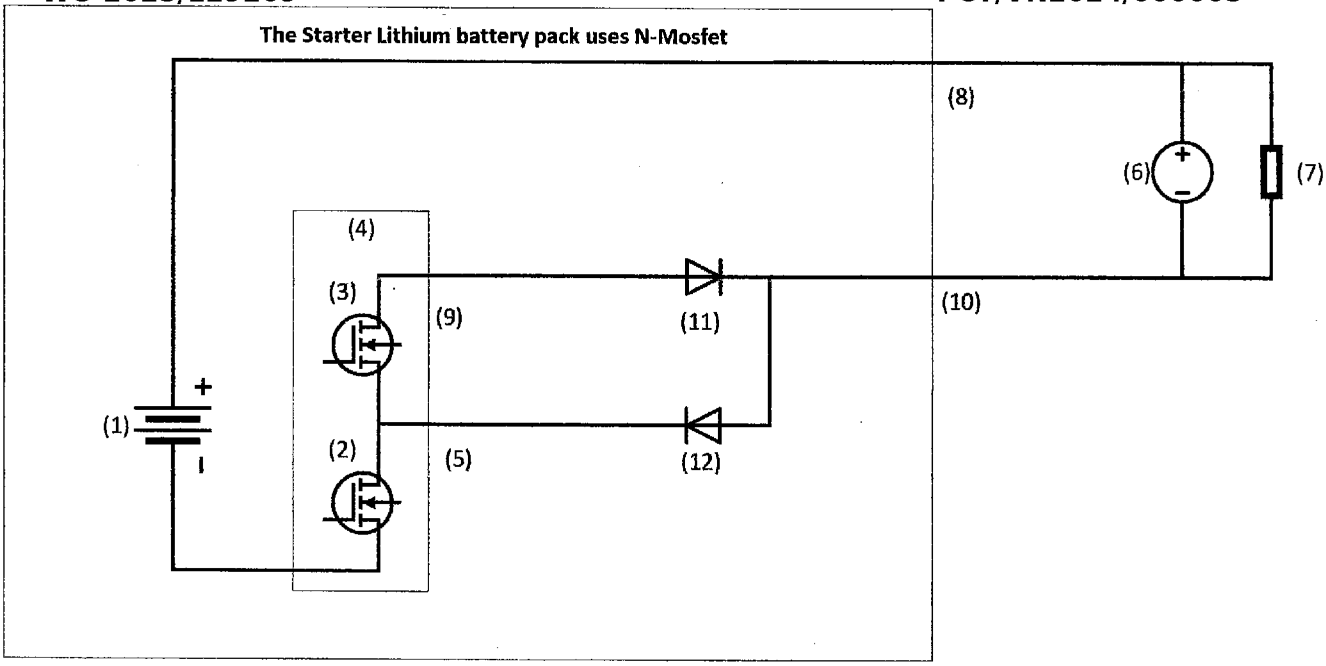


Figure 3: H. 3: The Starter Lithium Battery Diagram (N-Mosfet type)

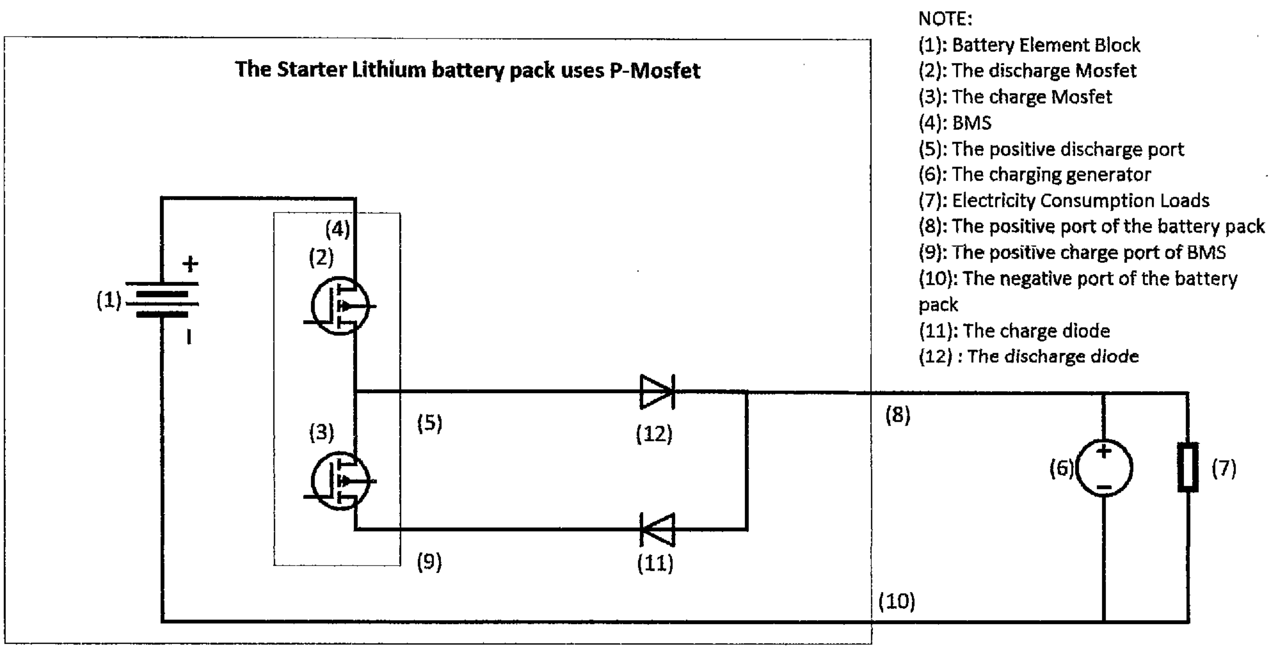
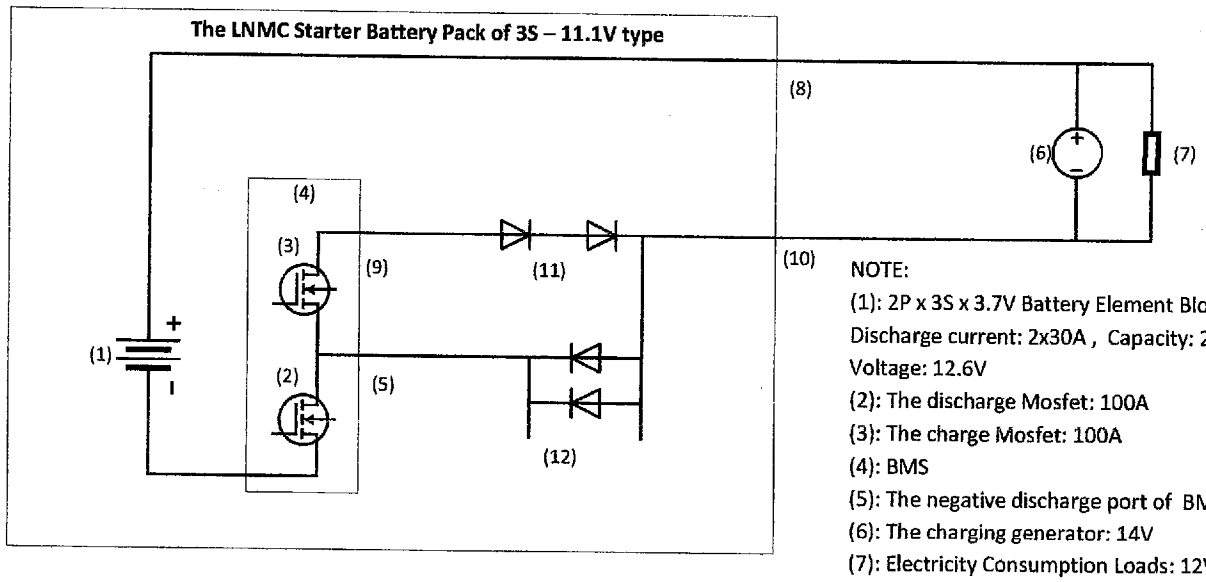


Figure 4: H. 4: The Starter Lithium Battery Diagram (P-Mosfet type)



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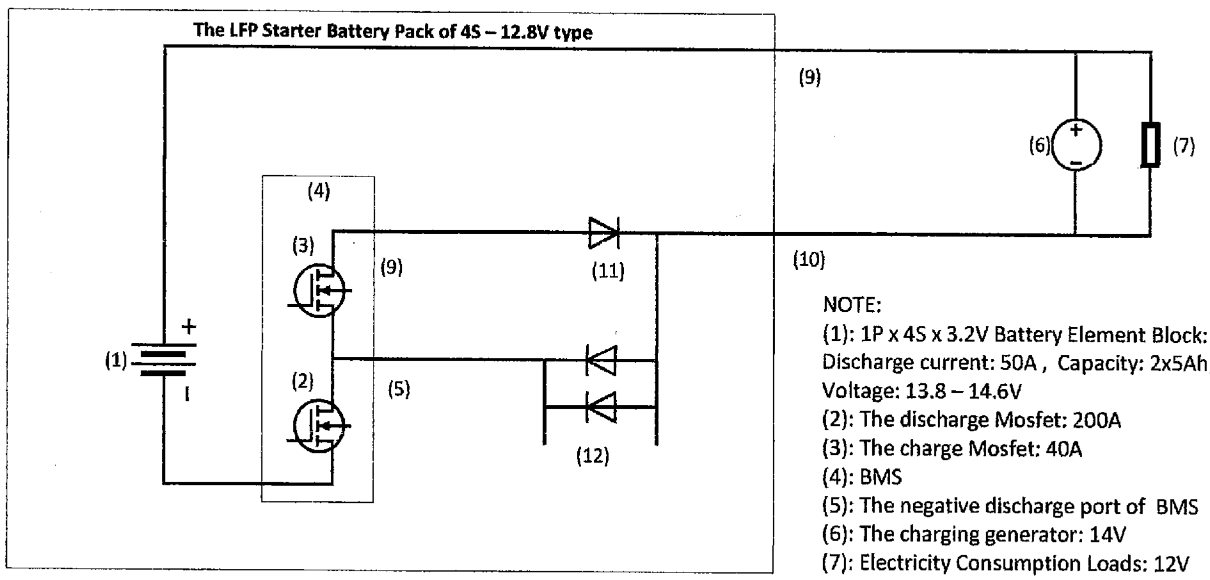
(11): The GBJ5010 diode bridge: 25A - forward pressure drop: 1.4V
(12): The discharge diode: 2 ideals type diode, forward current 35A, forward pressure drop: 0.1V

Figure 5: H. 5: The invention's BPS106 starter battery diagram



NOTE:
(1): 1P x 4S x 3.2V Battery Element Block: Discharge current: 50A , Capacity: 2x5Ah, Charge Voltage: 13.8 – 14.6V
(2): The discharge Mosfet: 200A
(3): The charge Mosfet: 40A
(4): BMS
(5): The negative discharge port of BMS
(6): The charging generator: 14V
(7): Electricity Consumption Loads: 12V
(8): The positive port of battery pack
(9): The negative charge port of BMS
(10): The negative port of battery pack
(11): The charge diode: 2 ideals type diode, forward current 40A, forward pressure drop: 0.1V
(12): The discharge diode: 8 ideals type diode, forward current 40A, forward pressure drop: 0.1V

Figure 6: H. 6 The invention's BP140 starter battery diagram

INTERNATIONAL SEARCH REPORT

International application No.
PCT/VN2024/000005

A. CLASSIFICATION OF SUBJECT MATTER

H02J 7/00(2006.01)i; **H01M 10/42**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H02J 7/00(2006.01); H02H 7/18(2006.01); H02J 7/04(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: lithium battery, 2-port BMS (battery management system), diode, mosfet, charging, discharging

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Battery management system BMS, In avdweb [online], pp 1-11, 18 November 2023 [retrieved on 2024-09-10]. Retrieved from <https://avdweb.nl/solar-bike/electronics/battery-management-system-bms>. pages 2, 5	1
Y	US 2011-0101921 A1 (JIN-HONG AN et al.) 05 May 2011 (2011-05-05) paragraphs [0039]-[0041]; and figure 4	1
A	US 2009-0295334 A1 (JONGWOON YANG et al.) 03 December 2009 (2009-12-03) paragraphs [0048]-[0050]; and figure 1	1
A	US 2008-0106235 A1 (HUNG SEN HUANG) 08 May 2008 (2008-05-08) paragraphs [0021]-[0022]; and figures 1-2B	1
A	US 2019-0356138 A1 (SAMSUNG SDI CO., LTD) 21 November 2019 (2019-11-21) paragraphs [0057]-[0058]; and figures 1-5	1

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 October 2024	**31 October 2024**

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/VN2024/000005

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