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General connection port and communication protocol of the 18 V lithium-ion battery pack for garden machinery

园林机械用 18 V 锂离子电池包的通用接口及通信协议

(*English Translation*)

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Contents

Foreword

T/CNFMA B is in charge of this English translation. In case of any doubt about the contents of English translation, the Chinese original shall be considered authoritative.

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This document is proposed and prepared by Technical Committee for Standardization of Outdoor Forestry Machinery of China Forestry Machinery Association (T/CNFMA B).

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General connection port and communication protocol of the 18V lithium-ion battery pack for garden machinery

1 Scope

This document specifies the structural dimension requirements, hardware design requirements, communication protocols and interchangeability tests of the universal interface and the"universal · shared"sign (hereinafter referred to as the "interface") of 18 V nominal voltage lithium－ion battery packs (hereinafter referred to as "18 V battery packs") for garden machinery, and the contents of the communication protocols for chargers and garden machinery hosts compatible with 18 V nominal voltage lithium－ion battery packs.

This document is applicable to garden machinery powered with a nominal voltage of 18 V lithium-ion battery pack, and other machinery and tools powered by 18 V nominal voltage lithium-ion battery packs may be used as referenced.

2 Normative references

The contents of the following documents constitute the essential provisions of this document through references in this text. For dated references, only the versions with the dates indicated are applicable to this document; For undated references, the latest edition of the referenced document (including all amendments) applies.

IEC 62841-1:2014, *Electric motor-operated hand-held tools, transportable tools and lawn and garden machinery—Safety—Part 1: General requirements*

IEC 61960-3, *Secondary cells and batteries containing alkaline or other non-acid electrolytes—Secondary lithium cells and batteries for portable applications—Part 3: Prismatic and cylindrical lithium secondary cells and batteries made from them*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61960-3 and the following apply.

3.1
lithium-ion battery pack with a nominal voltage of 18 V

lithium-ion battery pack consisting of five cells in series, with the nominal voltage of single cell multiplied by the number of cells in series equaling 18 V or 18.5 V

NOTE Lithium-ion battery pack with a nominal voltage of 18 V has a nominal voltage of 3.6 V per cell. A lithium-ion battery pack with a nominal voltage of 18.5 V has a nominal voltage of 3.7 V per cell.

4 Interface structural dimension requirements

4.1 Battery pack outline dimensions

The outline dimensions of the battery pack shall comply with the requirements of Figure 1 and Table 1.

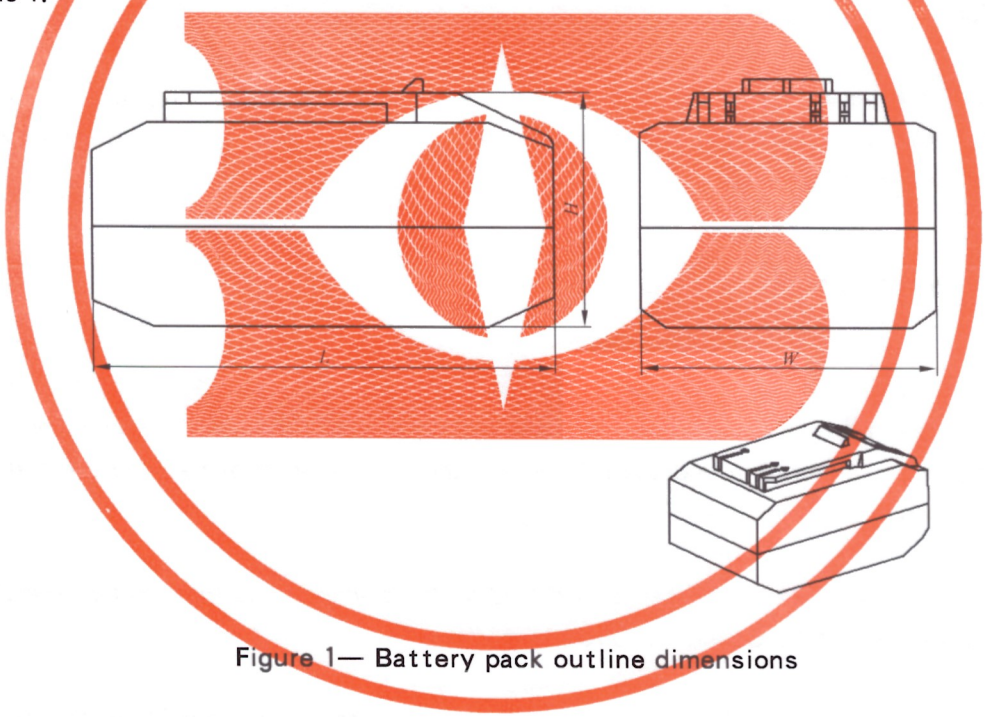


Figure 1— Battery pack outline dimensions

Table 1—Battery pack outline dimensions

Dimensions in millimeters

Item	Code	Dimension
Length	*L*	≤145
Width	*W*	≤90
Height	*H*	≤100

4.2 Interface locking buckle dimensions

The dimensions of the interface locking buckle shall comply with the requirements of Figure 2 and Table 2.

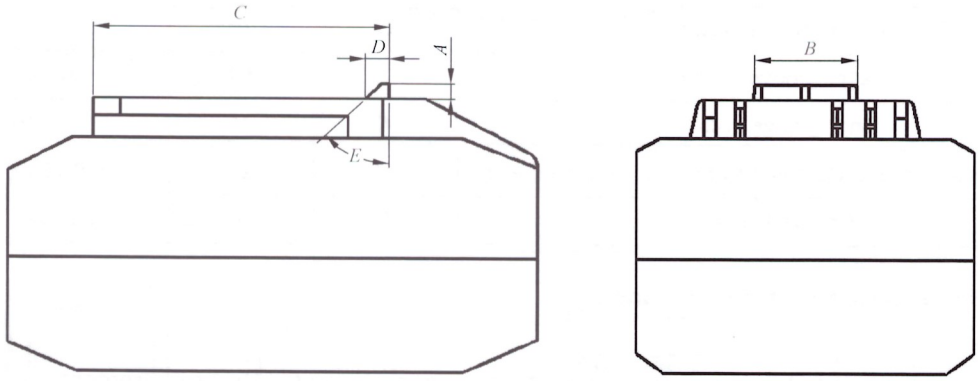


Figure 2— Interface locking buckle dimensions

Table 2—Interface locking buckle dimensions

Item	Code	Dimension	Tolerance
Locking buckle height/mm	*A*	4	−0.25 to 0
Locking buckle width/mm	*B*	25	−0.2 to 0
Distance from locking buckle to front end of groove/mm	*C*	72.5	−0.25 to +0.25
Locking buckle thickness/mm	*D*	6	−0.05 to +0.05
Locking buckle angle/(°)	*E*	45	−0.1 to +0.1

4.3 Interface chute dimensions

The dimensions of the Interface chute shall comply with the requirements of Figure 3 and Table 3.

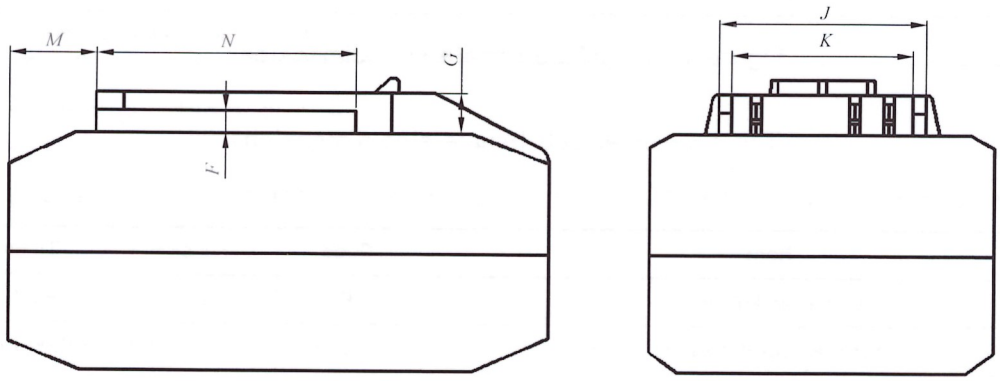


Figure 3—Interface chute dimensions

Table 3—Interface chute dimensions

Dimensions in millimeters

Item	Code	Dimension	Tolerance
Inner groove height	*F*	5.5	−0.05 to +0.05
Outer groove height	*G*	10	−0.075 to +0.075
Outer groove width	*J*	50	+0.1 to +0.3
Inner groove width	*K*	44	+0.1 to +0.3
Distance from groove front end to battery pack front end	*M*	21	−0.15 to +0.15
Groove length	*N*	≥63	—

4.4 Interface female slot dimensions

The dimensions of the Interface female slot shall comply with the requirements of Figure 4 and Table 4.

Dimensions in millimeters

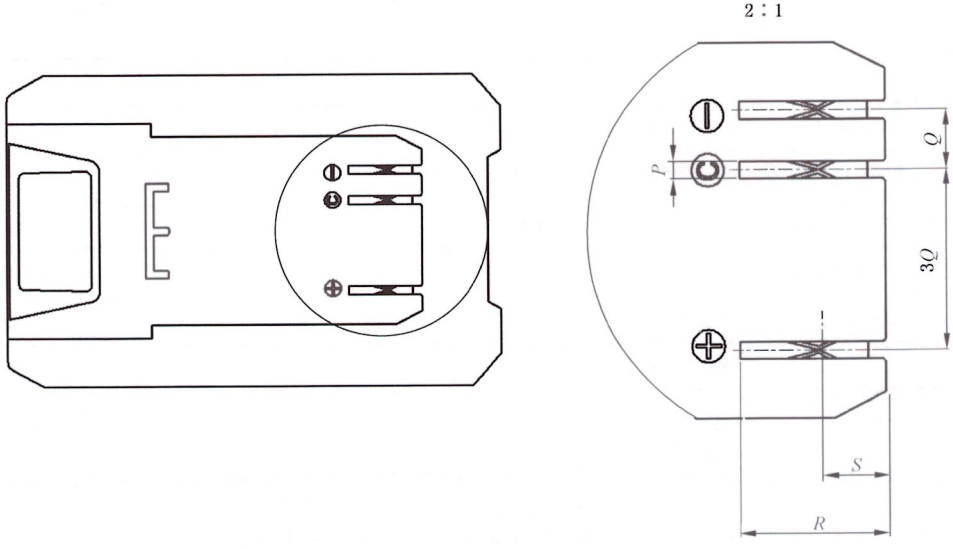


Figure 4—Interface female slot dimensions

Table 4—Interface female slot dimensions

Dimensions in millimeters

Item	Code	Dimension	Tolerance
Female socket width	*P*	2	−0.1 to 0
Female socket spacing	*Q*	8	−0.05 to +0.05
Female socket length	*R*	20 to 25	—
Distance from groove front end to contact point of female socket	*S*	5 to 10	—

5 Interface hardware design requirements

5.1 General requirements for interface terminals

The design requirements for battery pack interface terminals shall comply with the requirements of Figure 5 and Table 5.

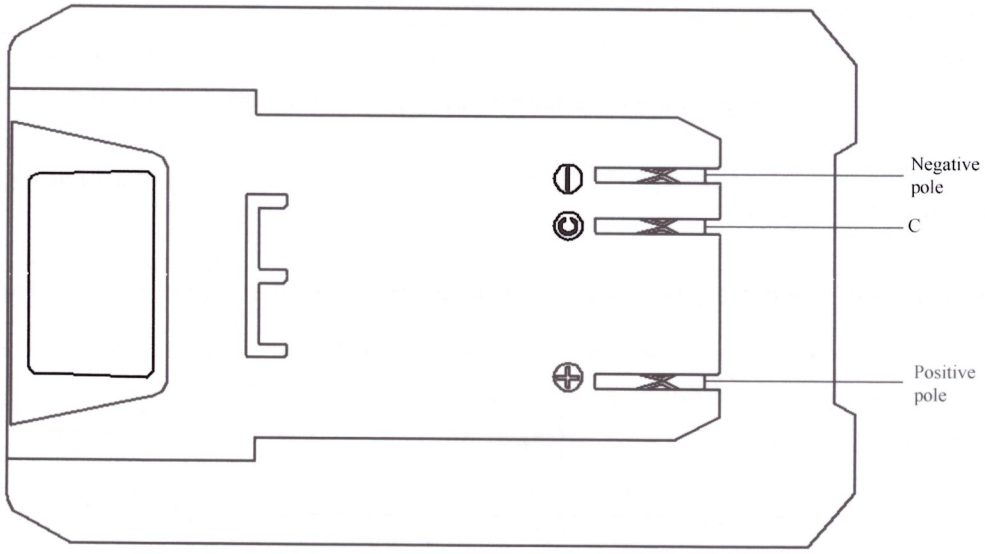


Figure 5—Battery pack interface terminals

Table 5—Battery pack interface terminals

Item	Interface terminal definition
Negative pole	Charge/Discharge negative pole
C	Communication
Positive pole	Charge/Discharge positive pole
NOTE "C" is close to the negative pole.	

5.2 Interface circuit block diagram

The circuit block diagram of the battery pack interface shall comply with the requirements of Figure 6.

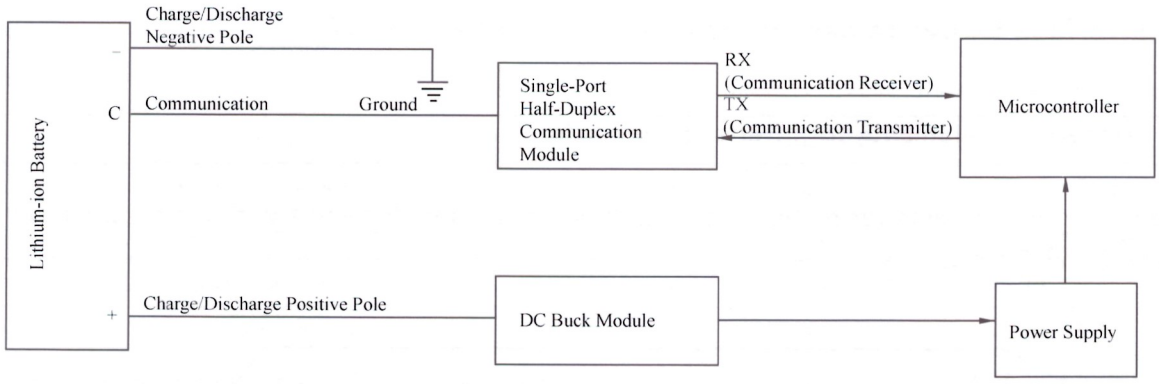
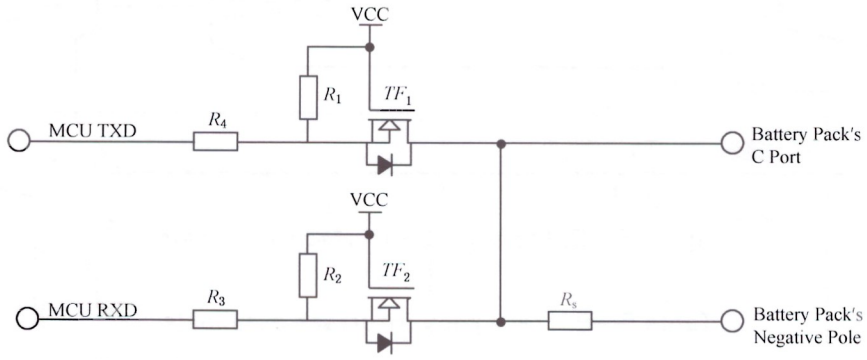


Figure 6—Interface circuit block diagram

5.3 Interface circuit diagram

The circuit diagram of the battery pack's C port shall comply with the requirements of Figure 7.



Key

R_1——1 000 000 Ω

R_2——1 000 000 Ω

R_3——100 Ω

R_4——100 Ω

R_s——27 000 Ω to 100 000 Ω

When the C port of the battery pack is connected to the charger or machine, the 10,000 Ω resistor of the charger or machine needs to be pulled up to VCC (5 V or 3.3 V) (The following VCC all represents 5 V or 3.3 V), and the resistance value of the internal Rs of the battery pack is between 27 000 Ω and 100 000 Ω.

Figure 7—Circuit diagram of C port

6 Communication protocol

6.1 General requirements of communication protocol

6.1.1 Communication port: The battery pack communicates with the machine or charger through

the C port in single-wire serial mode.

6.1.2 Communication rate: 9 600 baud rate.

6.1.3 Communication period: The battery pack communicates with the machine or charger every 100 ms ± 20 ms. After receiving the data packet sent by the battery pack, the machine or charger shall respond to the battery pack's data packet within 10 ms.

6.1.4 Communication format: The communication data adopts hexadecimal format, using LSB mode of UART, with a data frame structure consisting of 1 start bit (low), 8 data bits, and 1 stop bit (high), without parity bit.

6.2 Design requirements for communication protocol data packet

6.2.1 General requirements

The communication protocol data packet is divided into handshake data packet, operation data packet, and response data packet. The handshake data packet and operation data packet are sent from the battery pack to the machine or charger, and the response data packet is sent from the machine or charger to the battery pack.

The three types of data packet formats are: header + data + checksum (negated sum plus one), as follows:

Byte 1	Byte 2	···	Byte *N*
Header	Data···		Checksum (negated sum plus one)

6.2.2 Requirements for handshake data packet

6.2.2.1 The handshake data packet shall comply with the following requirements:

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
Header	Battery pack capacity	Number of cells in parallel	Maximum continuous discharging current of the battery pack	Maximum continuous charging current of the battery pack	Number of cells in series	Battery pack status	Checksum (negated sum plus one)

6.2.2.2 Each byte of the handshake data packet shall comply with the following requirements:

a) Byte 1: Header, with a fixed value of 0xA5.

b) Byte 2: Battery pack capacity, with a value of 0.1 A • h × the decimal number of Byte 2 (see Example 1).

EXAMPLE 1

Byte 2 (hexadecimal)	Byte 2 (decimal)	Battery pack capacity A • h
0x14	20	2.0
0x28	40	4.0
...	...	...

c) Byte 3: Number of cells in parallel, with a value of 1 P × the decimal number of Byte 3 (see Example 2).

EXAMPLE 2

Byte 3 (hexadecimal)	Byte 3 (decimal)	Number of cells in parallel P
0x01	1	1
0x12	18	18
...	...	...

d) Byte 4: Maximum continuous discharging current of the battery pack, with a value of 1 A × the decimal number of Byte 4 (see Example 3).

EXAMPLE 3

Byte 4 (hexadecimal)	Byte 4 (decimal)	Maximum continuous discharging current of the battery pack A
0x14	20	20
0x32	50	50
...	...	...

e) Byte 5: Maximum continuous charging current of the battery pack, with a value of 1 A × the decimal number of Byte 5 (see Example 4).

EXAMPLE 4

Byte 5 (hexadecimal)	Byte 5 (decimal)	Maximum continuous charging current of the battery pack A
0x04	4	4
0x0A	10	10
...	...	...

f) Byte 6: Number of cells in series, with a value of 1 S × the decimal number of Byte 6 (see Example 5).

EXAMPLE 5

Byte 6 (hexadecimal)	Byte 6 (decimal)	Number of cells in series S
0x05	05	5
0x0F	15	15
...	...	...

g) Byte 7: Byte of battery pack status, which shall comply with the requirements of Table 6.

Table 6 —Battery pack status byte (Byte 7)

Bit number	Bit definition	Value	Machine response	Charger response
Bit 0	Reserved (default is 0)	0	Not applicable	Not applicable
Bit 1	Battery pack fault flag bit	0	Function normal, machine discharging normally	Function normal, charger operating normally
		1	Function abnormal, machine stops discharging[a]	Function abnormal, charger stops charging[a]
Bit 2	Battery pack fully charged fag bit	0	Not applicable	Battery pack not fully charged, charger charging normally
		1	Not applicable	Battery pack fully charged, charger stops charging[b]
Bit 3	Overcurrent flag bit	0	Normal current, machine discharging normally	Normal current, charger normal operation
		1	Overcurrent alarm, machine stops discharging	Overcurrent alarm, charger stops charging

Table 6 (*continued*)

Bit number	Bit definition	Value	Machine response	Charger response
Bit 4	Low temperature flag bit	0	Normal temperature, machine discharging normally	Normal temperature, charger charging normally
		1	Low temperature alarm, machine stops discharging	Low temperature alarm, charger stops charging[c]
Bit 5	High temperature flag bit	0	Normal temperature, machine discharging normally	Normal temperature, charger charging normally
		1	High temperature alarm, machine stops discharging	High temperature alarm, charger stops charging[d]
Bit 6	Low voltage flag bit	0	Normal voltage, machine discharging normally	Not applicable
		1	Discharge cutoff, machine stops discharging	Not applicable
Bit 7	High voltage flag bit	0	Not applicable	Normal voltage, charger charging normally
		1	Not applicable	Charge cutoff, charger stops charging
NOTE During the handshake, Bit 4 and Bit 5 of the battery pack status byte are set to 0 by default.				
[a] Function abnormal refers to battery pack disconnection fault, cell fault, NTC open or short circuit fault, etc. [b] The charger shall have a fully charged indicator. [c] If the low temperature alarm is cleared (the low temperature flag bit changes from 1 to 0), the charger resumes charging. [d] If the high temperature alarm is cleared (the high temperature flag bit changes from 1 to 0), the charger resumes charging.				

h) Byte 8: Checksum: The negated sum plus one of the totals of seven bytes from Byte 1 to Byte 7 (see Example 6).

EXAMPLE 6 For a battery pack with 5 cells in series with 2 parallel connections, capacity of 4 A · h, maximum continuous discharging current of 25 A, and maximum continuous charging current of 4 A, during normal operation, the handshake data packet sent by the battery pack would contain the following:

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
0xA5	0x28	0x02	0x19	0x04	0x05	0x00	0x0F

6.2.3 Requirements for operation data packet

6.2.3.1 The operation data packet shall comply with the following requirements:

Byte 1	Byte 2	Byte 3	Byte 4
Header	Reserved	Battery pack status	Checksum

6.2.3.2 Each byte of the operation data packet shall comply with the following specifications:

a) Byte 1: Header, with a fixed value of 0xA6;

b) Byte 2: Reserved;

c) Byte 3: Battery pack status, with each bit defined as in Table 6;

d) Byte 4: Checksum.

EXAMPLE The content of a normal operation data packet is as follows.

Byte 1	Byte 2	Byte 3	Byte 4
0xA6	0x00	0x00	0x5A

6.2.4 Requirements for response data packet sent by the machine

6.2.4.1 The machine shall send a response data packet within 10 ms after receiving the data packet sent by the battery pack.

6.2.4.2 The format of the response data packet sent by the machine is: Header + Data + Checksum (negated sum plus one), as follows:

Byte 1	Byte 2	Byte 3	Byte 4
Header	Machine status code	Machine working current value	Checksum (negated sum plus one)

6.2.4.3 Each byte of the response data packet sent by the machine shall comply with the following specifications:

a) Byte 1: The header is a fixed value of 0x5A;

b) Byte 2: Machine status code, specifically:

1) 0x01: Machine status normal;

2) 0x02: Machine status abnormal;

3) 0x03: Reserved;

4) 0x04: Machine received a data packet with checksum error;

5) 0x05: Battery pack and machine mismatch (e.g., mismatch in battery pack voltage, series count, or parallel count).

c) Byte 3: Machine working current value, with a value of 1 A × the decimal number of Byte 3 (see Example 1).

EXAMPLE 1

Byte 3 (hexadecimal)	Byte 3 (decimal)	Working Current Value A
0x05	5	5
0x14	20	20
...	...	...

d) Byte 4: Checksum, with a value of the negated sum plus one of the total of 3 bytes from Byte 1 to Byte 3 (see Example 2).

EXAMPLE 2 The response data packet sent by a machine with normal status and a working current value of 20A to the battery pack is as follows:

Byte 1	Byte 2	Byte 3	Byte 4
0x5A	0x01	0x14	0x91

6.2.5 Requirements for response data packet sent by the charger

6.2.5.1 The format of the response data packet sent by the charger is: Header + Data + Checksum (negated sum plus one), as follows:

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Header	Charger status code	Charger output voltage (high byte)	Charger output voltage (low byte)	Charger output current	Checksum (negated sum plus one)

6.2.5.2 Each byte of the response data packet sent by the charger shall comply with the following specifications:

a) Byte 1: The header is a fixed value of 0x55;

b) Byte 2: Charger status code, specifically:

1) 0x01: Charger status normal;

2) 0x02: Charger status abnormal;

3) 0x03: Charger received a data packet with checksum error;

4) 0x04: Battery pack and charger mismatch (e.g., mismatch in voltage, series count, or parallel count);

5) 0x05: Battery pack fully charged (charger determines that the charged battery pack is fully charged).

c) Byte 3: Charger output voltage (high byte);

d) Byte 4: Charger output voltage (low byte), with a value of 0.1V × (256 × the decimal number of Byte 3 + the decimal number of Byte 4) (see Example 1).

EXAMPLE 1

Byte 3 (hexadecimal)	Byte 4 (hexadecimal)	Byte 3 (decimal)	Byte 4 (decimal)	Charger output voltage V
0x0	0xC8	0	200	20
0x02	0x58	2	88	60
...	...	...	...	...

e) Byte 5: Charger output current, with a value of 0.1 A × the decimal number of Byte 5 (see Example 2).

EXAMPLE 2

Byte 5 (hexadecimal)	Byte 5 (decimal)	Charger output current A
0x28	40	4
0x06	60	6
...	...	...

f) Byte 6: Checksum, with a value of the negated sum plus one of Byte 1 to Byte 5, totaling five bytes (see Example 3).

EXAMPLE 3 A charger with normal status and an output of 20 V/4 A sends the following response data packet to the battery pack:

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte6
0x55	0x01	0x0	0xC8	0x28	0xBA

6.3 Execution logic and protection mechanism of communication protocol

The execution logic and protection mechanism of the communication protocol shall comply with the requirements of Annex A.

7 Interchangeability test

7.1 General requirements

To achieve interchangeability between the battery pack and the machine or charger, the battery pack shall undergo interface structure size compatibility testing and safety testing between the battery pack, machine, and charger.

Unless otherwise specified, the tests in this chapter shall be conducted under the following conditions:

a) Temperature: 23 ℃ ± 2 ℃;

b) Humidity: 50%RH to 70%RH.

7.2 Artificial male pin compatibility test

The dimensions of the artificial male pin structure shall comply with the requirements of Figure 8 and Table 7, and when performing insertion and withdrawal tests, the following requirements shall be met:

a) The insertion and withdrawal of the battery pack shall be smooth;

b) When the battery pack is placed on a smooth horizontal surface (ignoring the frictional force between the battery pack and the smooth horizontal surface), the locking buckle is vertically upward, and then the interface locking buckle is pressed, the horizontal insertion force of the battery pack shall be less than 40 N;

c) When the battery pack is placed on a smooth horizontal surface (ignoring the frictional force between the battery pack and the smooth horizontal surface), the locking buckle is vertically upward, and then the interface locking buckle is pressed, the horizontal withdrawal force of the battery pack shall be less than 40 N;

d) With the interface locking buckle locked with the artificial male pin, and without operating the

interface locking buckle, the withdrawal force shall not be less than "10 times the weight of the battery pack".

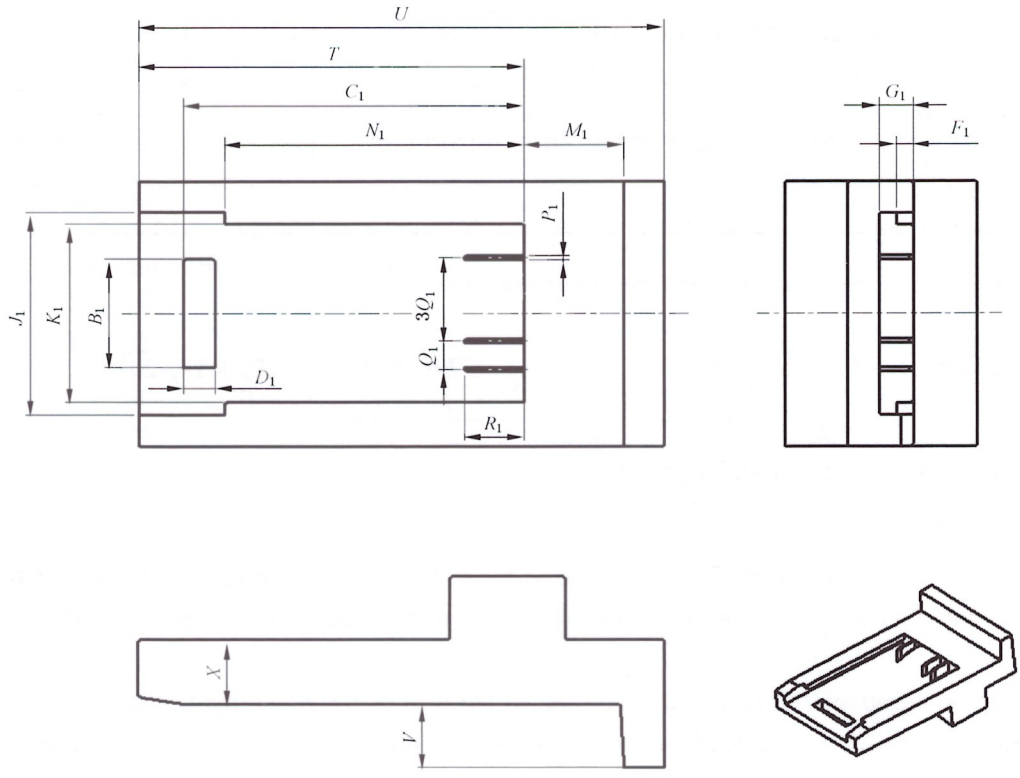


Figure 8—Dimensions of artificial male pin structure

Table 7—Dimensions of analog pin structure

Dimensions in millimeters

Code	Dimension	Tolerance
B_1	4.5	+0.35 to +0.5
C_1	10	−0.2 to 0
D_1	51	−0.2 to +0.2
F_1	45	−0.15 to +0.15
G_1	22	−0.15 to +0.15
J_1	62	−0.2 to +0.2
K_1	≥26	—
M_1	73	0 to +0.3
N_1	7	−0.2 to 0
P_1	1	−0.1 to 0
Q_1	8	−0.05 to +0.05

Table 7 (*continued*)

Code	Dimension	Tolerance
R_1	15 to 20	—
T	80	0 to +0.5
U	≥100	—
V	≥10	—
X	≥15	—

7.3 Battery pack, charger, and machine safety test

Compliance is checked by the safety test according to Annex K of IEC 62841-1:2014.

8 The "Universal • Shared" symbol

Battery packs, chargers, and machines produced by different manufacturers, if claimed to comply with this document, shall use the "Universal • Shared" symbol as specified in Annex B.

If the indication is reduced or enlarged according to the size of the equipment, the proportions given in the drawing must be respected. However, the vertical dimension of the indication shall, if possible, not be less than 10 mm.

Annex A
(normative)
Execution logic and protection mechanism of communication protocol of battery pack and machine, charger

A.1 Execution logic of communication protocol between the battery pack and the machine

The execution logic of the communication protocol between the battery pack and the machine shall comply with the requirements of Figure A.1.

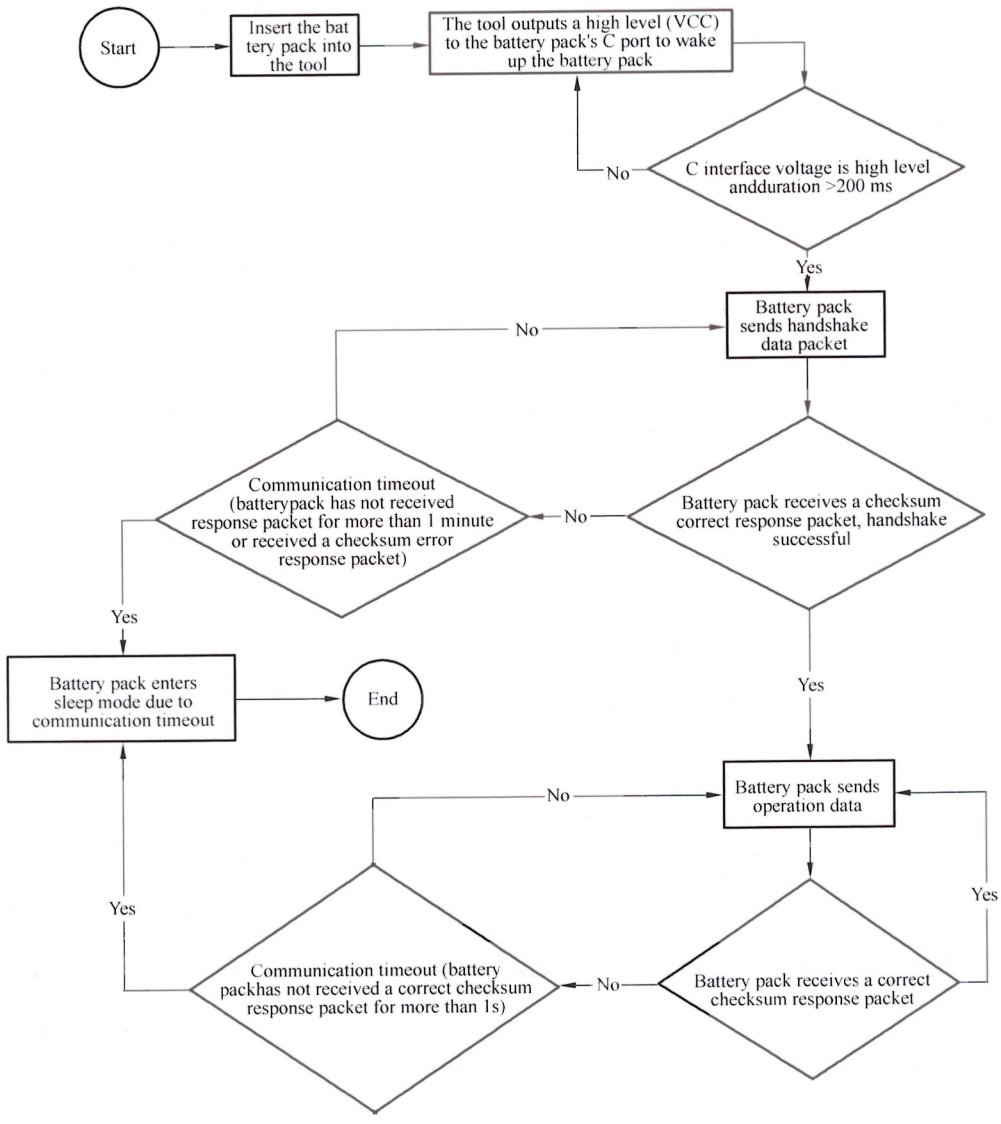


Figure A.1—Execution logic of the communication protocol between the battery pack and the machine

A.2 Execution logic of communication protocol between the battery pack and the charger

The execution logic of the communication protocol between the battery pack and the charger shall comply with the requirements of Figure A.2.

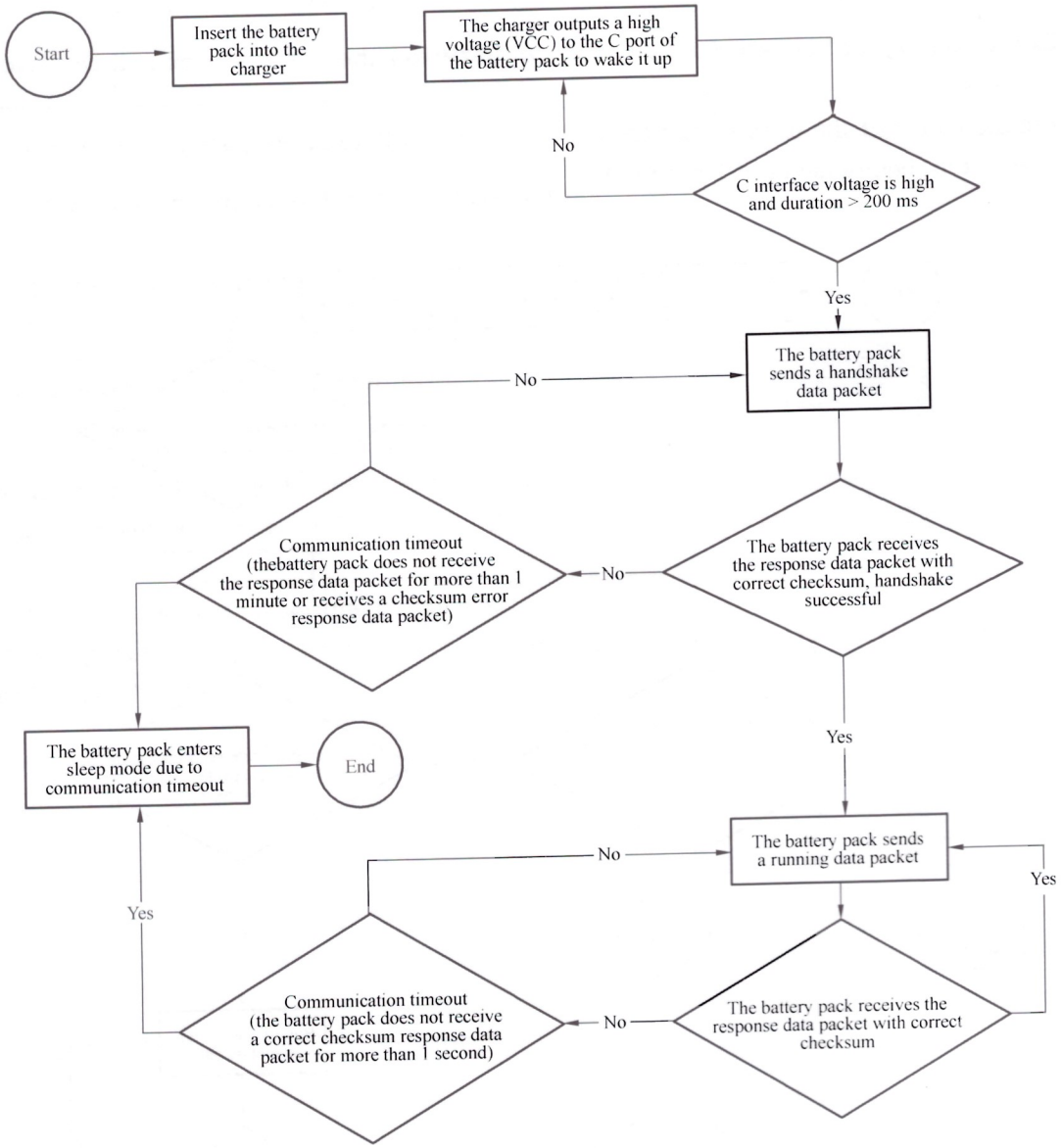


Figure A.2—Execution logic of the communication protocol between the battery pack and charger

A.3 Protection mechanism

A.3.1 General requirements for protection mechanism

Battery packs, machines, and chargers complying with this document shall have MCU and program control, and shall exchange data with each other according to the protocol requirements.

Each bit of the battery pack status byte in the protocol shall represent different states of the battery pack. This state (0 or 1) shall be recognized by the battery pack program to determine whether it is undergoing overcurrent, overcharge, overdischarge, high temperature, or low temperature. For example, Bit 5 (high-temperature flag), under discharge state, different manufacturers will set different temperature protection thresholds according to their own requirements, as shown in Table A.1.

Table A.1—Examples of different temperature protection thresholds set by manufacturer A and B

	Manufacturer A	Manufacturer B
Bit 5 = 0	Cell temperature < 75 ℃	Cell temperature < 72 ℃
Bit 5 = 1	Cell temperature ≥ 75 ℃	Cell temperature ≥ 72 ℃
Reason	(1) Cell specifications used by manufacturer A (2) Battery pack structure and heat dissipation design requirements of manufacturer A, etc.	(1) Cell specifications used by manufacturer B (2) Battery pack structure and heat dissipation design requirements of manufacturer B, etc.

A.3.2 Execution requirements for protection mechanism

A.3.2.1 General requirements

The protection mechanism is divided into standard protection mechanism and dual protection mechanism. These two protection mechanisms shall be able to be interchanged and shall not affect the protection function.

A.3.2.2 Execution requirements for standard protection mechanism

The standard protection mechanism shall comply with the following requirement:

a) Without MOS in battery pack.

b) When discharge MOS is placed on the machine; during discharge, the machine determines whether to turn on or off the discharge MOS based on the data packet sent by the battery pack.

c) When charge MOS is placed on the charger; during charging, the charger determines whether to turn on or off the charge MOS based on the data packet sent by the battery pack.

A.3.2.3 Execution requirements for dual protection mechanism

A.3.2.3.1 The dual protection mechanism shall comply with the following requirements:

a) When discharge MOS and charge MOS are placed on the battery pack; the battery pack determines whether to turn on or off the charge and discharge MOS based on its own program, realizing the function of enabling or stopping charging and discharging.

b) When discharge MOS is placed on the machine; during discharge, the machine determines whether to turn on or off the discharge MOS based on its own program or the data packet sent by the battery pack, realizing the function of enabling or stopping discharge.

c) When charge MOS is placed on the charger; during charging, the charger determines whether to turn on or off the charge MOS based on its own program or the data packet sent by the battery pack, realizing the function of enabling or stopping charging.

A.3.2.3.2 Under the dual protection mechanism, when the machine is used in conjunction with the battery pack, the condition for stopping discharge shall be determined by the protection value of the machine and the battery pack, whichever triggers the protection value first, and the action of stopping discharging shall be completed by the discharge MOS of the battery pack or the machine.

A.3.2.3.3 Under the dual protection mechanism, when the charger is used in conjunction with the battery pack, the condition for stopping charging shall be determined by the protection values of the charger and the battery pack, whichever triggers the protection value first, and the action of stopping charging shall be completed by the charge MOS of the charger or the battery pack.

A.3.3 Protection functions in the protection mechanism

A.3.3.1 Overcurrent protection during discharge

When the battery pack receives the current and duration in the response data packet from the machine greater than or equal to the set upper limit value, the battery pack shall send an overcurrent data packet to the machine, and the machine shall turn off the discharge MOS and stop discharging.

According to the definition of A.3.2.2, the battery pack is allowed to perform dual protection for overcurrent during discharge.

A.3.3.2 Overcurrent protection during charging

When the battery pack receives the current and duration in the response data packet from the charger greater than or equal to the set upper limit value, the battery pack shall send an overcurrent data packet to the charger, and the charger shall turn off the charge MOS and stop charging.

According to the definition of A.3.2.2, the battery pack is allowed to perform dual protection for overcurrent during charging.

A.3.3.3 Under-voltage protection during discharge

During discharge, when the battery pack detects its own voltage lower than the undervoltage set value, the battery pack shall send an undervoltage data packet to the machine, and the machine shall turn off the discharge MOS and stop discharging.

According to the definition of A.3.2.2, the battery pack is allowed to perform dual protection for undervoltage during discharge.

A.3.3.4 Overvoltage protection during charging

During charging, when the battery pack detects its own voltage greater than or equal to the overvoltage set value, the battery pack shall send an overvoltage data packet to the charger, and the charger shall turn off the charge MOS and stop charging.

According to the definition of A.3.2.2, the battery pack is allowed to perform dual protection for overvoltage during charging.

A.3.3.5 Temperature protection during discharge

During discharge, when the battery pack detects its own temperature lower than the low-temperature set value or higher than the high-temperature set value, the battery pack shall send a temperature data packet to the machine, and the machine shall turn off the discharge MOS and stop discharging.

A.3.3.6 Temperature protection during charging

During charging, when the battery pack detects its own temperature lower than the low-temperature set value or higher than the high-temperature set value, the battery pack shall send a temperature data packet to the charger, and the charger shall turn off the charge MOS and stop charging.

Annex B
(normative)
The "Universal · Shared" symbol

The "Universal · Shared" symbol for battery packs is shown in Figure B.1.

Figure B.1—"Universal · Shared" symbol

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