(1/3) Specification Sheet

Li-Ion Battery Packs / LH Series

Application : AMR Robot, Motorized, Factory Automation, Industrial

7S (25V) / 14S (50V) / LG Energy Solutions 18650 High Discharge Cell (H-class) / NCM Series

< Industrial / Indoor / Stationary >

Model : LH-MOTOR-25V□□AH Series
LH-MOTOR-50V□□AH Series

⚠ Important Notes

1. user manuals and precautions for use are separate documents.
"(2/3) User Manual_ LM Li-ion Battery"
See "(3/3) Communication Protocols for LV and LM Li-ion Batteries".

2. Use: It is used indoors, in factories, for factory automation and motor drive. (It cannot be used for outdoor forklifts, golf cars, etc.)

*Please be sure to check the cad drawing uploaded to the homepage when reflecting the design.

◇ New products ship with a 30% charge. to charge and use.
◇ Documents required for export= MSDS (UN3481 , Class9) English/Chinese version and UN38.3 certificate --> Please request from us.

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0. Important Notes

[Regarding battery transportation and international shipping]

⚠ (Important) How to transport batteries domestically and internationally (measures to prevent fire during transportation and follow international shipping regulations)

< For domestic and international shipping

Do not pack batteries with automation devices.

Remove the battery from the machine (robot, etc.) on which it is mounted.

③ Check the battery voltage to make sure it is charged to 30% or less.

To check for a charge below 30%, simply discharge the battery to a level that is about 1 volt below the nominal voltage.

(Discharging too much is not good for battery life, so only discharge to a level that is 0 to 1 volt below nominal voltage.)

Charging below 30% is very important. Do not violate this rule.

This is a globally recognized rule because below 30%, no impact will cause a fire.

< For international shipping

④ Remove the batteries mounted on machines and robots, etc. as above, and transport the batteries alone. Also, the batteries must be discharged to 30% or less of their charge. Send them to a company specializing in the transportation of dangerous goods (forwarder) and ship them overseas.

* The dangerous goods transportation company repackages the battery as dangerous goods according to recognized standards.
* Documentation: MSDS provided by Tavos. Submit the UN38.3 document to the carrier.
* If you do not know the battery shipping company, please contact Tavos.

* Note: International battery-related transportation regulations : Worldwide, Air transport : IATA DGR , Worldwide, Sea ship : IMO IMDG Code , Europe, Land transport (ADR/RID /GGVSE)

⚠ UN38.3 Certification / Requirements for overseas transportation of battery packs :

In principle, a "UN38.3 test report (hereinafter referred to as certification)" is required for overseas transportation.

This certification is a safety-related testing regulation for transportation (air, ship, land).

There are 8 tests in total (T1 through T8).

Test items

Safety test under low pressure, thermal shock test, vibration test, projectile shock test, and electrical short circuit test,

Shock and compression test (battery cells), overcharge test, forced discharge test (battery cells)

As we have heard recently, it is difficult in principle to send battery packs abroad without this certification.

Tabos will be UN38.3 certified in phases, and will be available on the

Certified models are marked with "UN" in the certification notation in the product listing.

If you do not have the UN certification listed in the product list below, please contact us if you are having difficulty with overseas projects.

⚠ When using the battery, make sure it's fully charged first.

New products are shipped with a 30% charge. If the product is discharged directly from the factory without charging, the cell characteristics may vary slightly from one pack to another, which may cause the pack to be unbalanced, so it should be fully charged before use.

⚠ Do not mount the battery in an upright position. Mount it in a horizontal orientation.

[Charge/Discharge Temperature]

⚠ The allowable charge temperature is 0 to 55° C, based on the cell temperature inside the battery, The discharge allowable temperature is the temperature range of (−)20 to 55° C, based on the cell temperature inside the battery.

The temperature range above is technically the temperature of the lithium cells themselves inside the battery pack, not the temperature of the surrounding environment.

[About serial parallel connections].

⚠ Do not use them in series.

The battery contains circuit breaking semiconductor devices such as FETs. These devices are made of semiconductor devices that can respond to each voltage level, so when used in series, the voltage will be higher than the design value. The semiconductor element may be damaged, and problems such as fire may occur due to abnormalities in the safety management circuit.

⚠ Batteries can be used in parallel, provided that they have exactly the same characteristics and are grouped together,

Specifically, they must be at the same voltage when tied together.

The voltage of each battery in parallel should be managed to be within 0.5 to a maximum of 0.8 volts of each other.

[Reason for doing this]:

If you group batteries with a voltage difference, even a small one, you can destroy them because current flows rapidly from the higher-voltage battery to the lower-voltage battery.

[How to make the voltage difference smaller]:

If the batteries you want to parallel have a voltage difference between them ;

Method 1: Charge each battery to full and then connect them in parallel to each other. Make sure they have the same charge voltage and charge them with the same type of charger. This is the best method.

Method 2: Discharge the higher battery to match the voltage of the lower battery. After at least 30 seconds of discharging, the voltage should be approximately the same as the other battery (the one you want to parallel).

⚠ **Do not string new and old batteries together when stringing in parallel. This may be associated with fire accidents.**
(even if they have the same characteristics and are at the same voltage when strapped together).

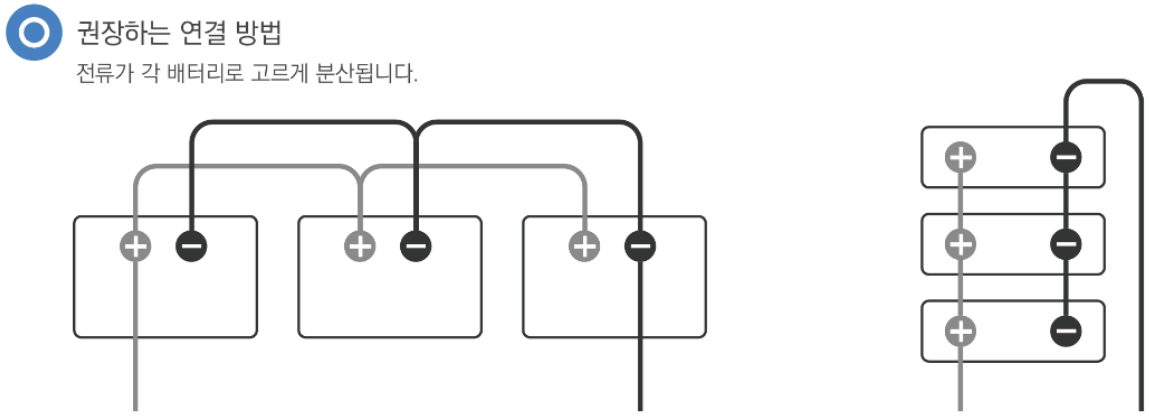
Due to the lower internal resistance of the new battery compared to the old battery, current flows primarily toward the new battery, which has a lower internal resistance, resulting in a rapidly decreasing lifespan. In addition, the chemical composition of the lithium cells inside the battery pack may be altered if left in a low-voltage disconnected state for a long period of time. Let's call such an abnormal battery (A), and if this abnormal battery (A) and a normal battery (B) are connected in parallel and charged, extremely

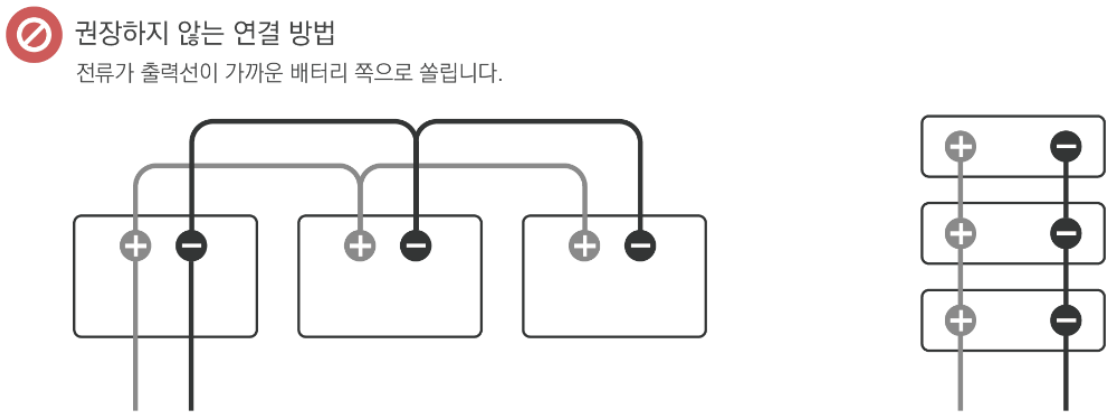
dangerous cases (such as fire) may occur.
This risk is higher for higher voltage batteries, for example, a 50V battery is more dangerous than a 25V battery.
There are certain situations where the Battery Management System (BMS) inside the battery may not be able to prevent the chemical composition of the lithium cells from changing.

⚠ When paralleling, make sure the wire path length and wire thickness are the same for each battery.

1) Check the voltage of each battery pack alone before paralleling, but if there is a voltage difference, the voltage between the battery packs should be kept within 0.5~ maximum 0.8V.
If there is a voltage difference, charge or discharge either battery to bring the voltages in line with each other.

2) Unless the battery pack is strapped in from the factory (original new condition), always leave it for at least 1 hour before using it (charging and discharging) after voltage matching and parallel connection as above.
The reason for this is that the electrochemical stabilization time inside the battery cells is necessary.
Make the connections as shown in the illustration on the next page.





[Wire Thickness Selection and Fire Prevention].

⚠ Using wires that are too thin for the current is a fire hazard.
The wire thickness is not determined by the battery capacity and size, but by the size of the current used (charging and discharging current).
In a normal temperature environment, the allowable current per 1mm2 (square millimeter) of wire is about 5A.
The formula for the allowable current per wire size in a normal temperature environment: 5A/mm2 (SQMM).
For higher temperature environments, you should use a thicker wire than the above formula.

[Selected example].

(Example 1) If you design a maximum charging current of 50A, the thickness of the charging wire is :
50A / (5A / mm2) = 10 mm2 or more

(Example 2) If you design a maximum discharge current of 80A, the thickness of the discharge wire is :
80A / (5A / mm2) = 16 mm2 or more

[Electrical fire accident mechanism].

Wires and connector contacts get hot.

→ The heated copper comes into contact with oxygen in the air and copper dioxide (copper suboxide) is produced.
→ Alternatively, the insulation may deteriorate and crack or harden due to the high temperature of the insulation sheath, causing oxygen from the air to seep into the gap between the insulation and the copper wire, creating copper oxide.
→ In particular, copper oxide is concentrated in areas that are in direct contact with air, such as connector joints.
→ Since copper oxide is a heating element, its temperature is further increased.
→ The increased heat accelerates the growth of copper oxide.
→ Above a certain threshold, the temperature can reach above the ignition point in a matter of hours and a fire will start.

Copper oxide is a material used in industry as a heating element and heater material.
Electrical fire is caused by the production of copper dioxide. High voltage electricity can cause electric shock and high current can cause electric fire. Therefore, it is recommended to reduce the current as much as possible and use thicker wires.

[Operating voltage range and charge/discharge voltage range].

⚠ The charge and discharge usage voltage zones are as follows

Operations	Automated guided vehicle (AGV) usable voltage zones				
	Disconnecting loads	Undervoltage warnings	Automated Guided Vehicle (AGV) Operating Voltage		
Battery type (nominal voltage)	Recommended on the AGV side Undervoltage shutdown Reference Voltage	When discharging Boundary of a sharp drop in voltage 0.2C or less discharge	Charging stations so that the AGV is set to Returning Reference Voltage	Recommended Chargers Charging voltage	Allow Top up Voltage
Voltage per Cell	3.15V/Cell	3.36V/Cell	3.43V/Cell	4.0V/Cell	4.14V/Cell
25V battery (7S) Estimated Balance	22V	Approx. 23.5 V	24V	28V	29.0 V
	About 3-5% of the time	About 5 to 8 percent	About 15 to 20 percent	About 80	About 90% of the time
50V battery (14S) Estimated Balance	44V	Approx. 47.0 V	48V	56 V	58.0 V
	About 3-5% of the time	About 5 to 8 percent	About 15 to 20 percent	About 88% of the time	Approximately 94

Cycle : The estimated remaining capacity varies depending on the charging and discharging current of the battery and the length and thickness of the charging wire path. The above estimated remaining capacity may vary depending on the field situation and is an estimate for your understanding.

In the table above, there is a large difference between the 'recommended load side undervoltage cutoff voltage' and the 'battery BMS undervoltage cutoff voltage', but as you can see in the graph above, the battery voltage drops rapidly as the discharge progresses, meaning that the area where the voltage drops rapidly does not have much energy available for practical use. In the area below the 'recommended load side undervoltage cutoff voltage', it is reasonable to assume that the battery has about 5% remaining (depending on the discharge current).
In other words, the area below the recommended lower limit of use is reserved for control power rather than high power.

⚠ If the battery discharge voltage frequently goes into low-voltage territory, battery life will be shortened.

⚠ When the battery is discharged, it must be disconnected at the load side before the BMS circuit inside the battery can disconnect the undervoltage.

The reason for this is that when the BMS shuts off for over-discharge (low voltage), it is a marginal cut-off just before over-discharge when the battery has very little left. To prolong battery life, it should not go to an over-discharge state very often, as this can shorten its life if repeated.
Also, the BMS should be viewed as a secondary failsafe and the load should be switched off first before the BMS over-discharge cutoff to reduce the ON/OFF burden on the BMS.

⚠ When charging the battery, the charger must first cut off the charge before the BMS circuit inside the battery can cut off the overvoltage.

The reason for this is that when the BMS shuts off for overcharge (overvoltage), it is a marginal shutdown just before the battery is in danger of overcharging. To prolong battery life, it should not frequently go to near overcharge voltages, as this can shorten its life if repeated.
Also, the BMS should be considered a secondary failsafe and the charger should be shut off first before the BMS overcharge cutoff to reduce the ON/OFF burden on the BMS.

[Cautions when applying the charger].

* Cycle: The Tabos charger comes with the following safety features as standard.

⚠ To be safe, you must use a battery charger with a Pre_Charging feature.

Charging with a charger that does not have this pre-charge function may cause damage to the MOS-FETs built into the BMS unit under certain circumstances, resulting in dangerous conditions such as overheating, burnout, or fire.
* Cycle: The pre-charge function is a safety function that charges the battery with a small current (a current of a few amperes, such as 1 to 2 amperes) while the battery is cut off due to over-discharge, so that the BMS can release the over-discharge state, and then charges it with this charging current while the battery output voltage is available.

⚠ The charger must have a charging current ripple of 5% or less of the charging current.

Larger charge current ripples can damage the lithium battery cells. If some of the Li-ion cells are damaged, the power supply to the BMS device may be limited, which can cause a power failure.

There is no prescription for the size of the flux (%), but the larger the flux, the worse it is for battery life. Tabos empirical data also shows that chargers with large reflux can cause failures between a few months~ and two years.
* Cycling: see later section 'Chargers and lithium battery life, what to look out for when choosing' for the principle and rationale.

⚠ You must use a dedicated charger for lithium batteries. It must have constant current (CC) and constant voltage (CV) capability as standard features. Charging from a regular DC power supply is not allowed and is dangerous.

[Cautions when using the inverter as a battery load (changing battery DC voltage to AC220V)].

⚠ We recommend using direct current (DC) loads (i.e., not using an inverter load) whenever possible.

If the power (W) used by the inverter is large compared to the battery size (Wh), the battery cell life will decrease dramatically. It is recommended that the battery size (Wh) is at least 10 times the power used by the inverter (W). The reason is that the battery current is applied to the battery cell in the form of a shock wave due to the presence of significant ripple, which is believed to cause damage to the coating material of the positive and negative electrodes of the lithium battery cell.

* Cycling: See "Inverter and lithium battery life, precautions for use" later in this chapter for the principle and rationale.

[Inrush Current Problem with Battery Load].

⚠ If the Inrush Current of the connected load is excessive, the battery BMS may recognize it as overcurrent and shut down the output.

* Cycle: Tavos commercializes and supplies 'inrush current protector' products to solve these problems. Contact us.

[Charge current and discharge current magnitude].

⚠ When charging and discharging the battery, use currents that are sufficiently lower than the rated charge and discharge currents.

Use at the recommended charge current and no more than 50% of the rated charge current to preserve battery life.
The recommended discharge current is for continuous use at 50% or less of the rated current, and above 100% of the rated current for instantaneous loads.

[Battery Storage].

⚠ Battery storage :

Do not leave the battery overdischarged or with a low level of charge for long periods of time. Charge and store them.
Do not leave new and quadruple batteries unattended (i.e., stored by themselves) for more than one year, even when no load is connected. Check them every year and charge them to 5-10% above average voltage before storing them.

The battery is shipped from the factory with a 30% charge. The Battery Management System (BMS) within the battery continues to consume power, albeit subtly, even in standby and unattended conditions. Therefore, there is a risk of over-discharge if left unattended for more than a year. If the over-discharge condition persists, the battery life will be shortened and in some cases even unusable. In Tabos' empirical experience, there have been cases where the battery has been left unattended for about 4 years and maintained normal voltage without over-discharging, but this cannot be said uniformly because it depends on the type of battery pack, even within Tabos products. Depending on the size of the parallel number of lithium cells in the BMS, it may last up to 4 years or only 1 year.
It varies from product to product, so it is recommended to check the maintenance every year.

1. Product lineup and individual specifications

* Models with "COM" in the model number have a battery status communication port. COM = communication
* Of the below certifications, UN38.3 certification is mandatory for international transportation.
* Case drawings for each model are uploaded on the Tavos homepage (pdf, dwg, 3D (stp, igs))
* The Wh value for each model is the same as the value recorded in the UN38.3 test report.
* Application in vertical transfer systems: Even if a hydraulic motor is used, the motor must be a speed regulated type such as BLDC and servo motor. Traditionally used hydraulic motor packs with non-speed regulated motors cannot be used. This is because when the hydraulic motor is started directly, the starting current is excessive and the battery is cut off with excessive current.
* Even if the maximum allowable discharge current value for each model is discharged for more than 30 minutes, the battery can be discharged continuously without time limit if the internal temperature of the battery remains low due to low ambient temperature.

Designed and produced by Tabos / Made in Korea / Powered by LG Li-ion battery cells (18650), cycle: Customized outside the standard specifications below

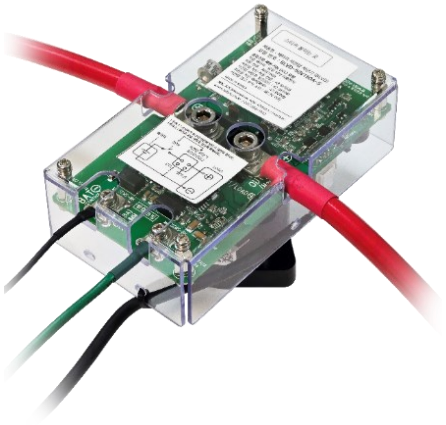
索引 Number	Product name (order number)	Authentication	Applied BLDC Motor Power (W) Soft_Start (ΔT ≥ 1.5 seconds)		Battery Energy (Wh)	Discharge current		Charging Current / Charger		Weight, size		Communication Output
			(AGV Travel Motor) Maximum Power For intermittent occurrences	(Vertical Feed, Hydraulic Motor) Maximum Power *Caution: Hydraulic Motor No direct startup		Instantaneous Max Discharge Current	Allowable discharge Max Current(A) (30 minutes)	Allowed Charges Maximum Current(A) (C_Rate)	Recommended maximum capacity for Tabos chargers (Increased low-current lifetime)	Weight (Kg)	Size type number (Case Drawing)	
Below: 25V battery / nominal voltage 25.8V (recommended usage voltage range: min. 24V ~ max. 29V) < 21V over discharge end voltage (EODV) and > 29.4V over charge end voltage (EOCV) >												
25V-101	lh-motor-25v-60ah-x2	UN38.3 CE (EMC)	3200	1920	1,512	240 (0.1 sec)	90	70 (1.2C)	1500 W (45 A)	10	X2	
25V-102	LH-MOTOR-25V-60AH-X2COM	UN38.3 CE (EMC)	3200	1920	1,512	240 (0.1 sec)	90	70 (1.2C)	1500 W (45 A)	10.5	X2COM	BMS Communication
Below: 50V battery / nominal voltage 51.7V (recommended usage voltage range: min. 48V ~ max. 58V) < 42 V over discharge end voltage (EODV) and > 58.8 V over charge end voltage (EOCV) >												
50V-101	lh-motor-50v-30ah-w2	UN38.3 CE (EMC)	3200	1920	1,512	120 (2 sec)	90	35 (1.2C)	1500W (25A)	10	W2 Thin	
50V-102	LH-MOTOR-50V-30AH-W2COM	UN38.3 CE (EMC)	3200	1920	1,512	120 (2 sec)	90	35 (1.2C)	1500W (25A)	10.5	W2COM Thin	BMS Communication
50V-103	lh-motor-50v-45ah-w3	UN38.3 CE (EMC)	3200	2800	2,268	180 (2 sec)	90	55 (1.2C)	3500 W (60 A)	15	W3 Thin	
50V-104	LH-MOTOR-50V-45AH-W3COM	UN38.3 CE (EMC)	3200	2800	2,268	180 (2 sec)	90	55 (1.2C)	3500 W (60 A)	15.5	W3COM Thin	BMS Communication
50V-105	lh-motor-50v-60ah-x4	UN38.3 CE (EMC)	4200	3800	3,024	240 (2 sec)	90	70 (1.2C)	3500 W (60 A)	20	X4	
50V-106	LH-MOTOR-50V-60AH-X4COM	UN38.3 CE (EMC)	4200	3800	3,024	240 (2 sec)	90	70 (1.2C)	3500 W (60 A)	20.5	X4COM	BMS Communication

2. Common specifications across all models

0) We strongly recommend upgrading safety features by installing additional optional items.

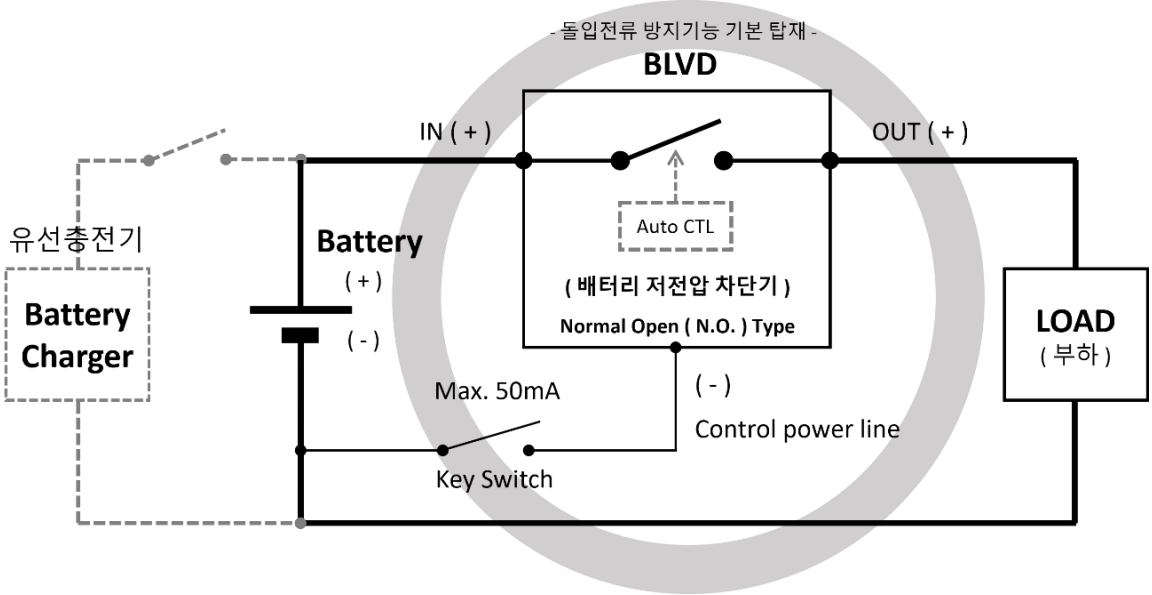
A. Necessity :

The lithium battery cells inside the battery pack have a very high risk of fire accidents due to overcharge.
However, looking at recent cases,
there have been many cases where the risk of fire accidents is high when trying to charge a battery in an over-discharge state.
So, Tabos has additionally developed a safety device that prevents over-discharge of the battery and ensures that the remaining capacity is around 5%,
and has made it available as a battery auxiliary component.

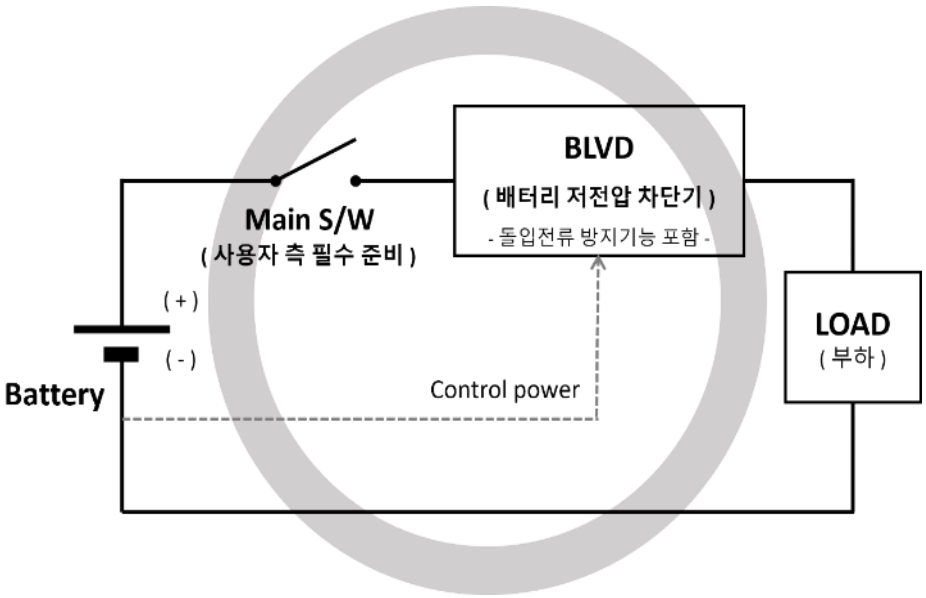


* Refer to Tabos homepage / Lithium battery accessories / Battery low voltage disconnect (BLVD)

B. Installation method



<Installation method 1> General situation / When using BLVD as a main switch



<Installation method 3> When additionally applying BLVD in a situation where the main blocking switch is used

*** Please refer to the BLVD specifications for other installation instructions.

1) Describe the safety and protection features

1) - 1. overcurrent protection (limit charge and discharge current) and auto return

The battery's protection circuit (BMS) limits the input and output currents to set values (refer to the model-specific specification sheet).

This feature helps keep the battery safe by preventing the battery from outputting excessive current.

1) - 2. Output blocking control in case of short circuit (short) : Restore normal when the short circuit is eliminated

In the event of a short circuit (short) between the output terminals due to mishandling, the BMS immediately disconnects the output.

When the short-circuit is cleared, it will revert back to normal and output normally.

1) - 3. Over Voltage Protection and Auto-Return

The voltage of each group of Li-ion cells is monitored by the battery's protection circuit (BMS).

When charging, if the voltage of each group of cells exceeds the prescribed voltage level, charging is stopped and resumes when the voltage returns to the prescribed level.

1)-4. Under Voltage Protection and Auto-Return

The voltage of each group of Li-ion cells is monitored by the battery's protection circuit (BMS), which stops discharging when each group of cells falls below a specified voltage level and resumes discharging when the voltage returns to the specified level.

1)-5. Over Temperature Protection and Auto-Return

It detects the temperature of the battery cell and the control circuit elements themselves and automatically shuts off charging and discharging when the temperature is above the allowable

temperature. If the temperature drops below the allowable temperature after a certain period of time, it will automatically shut down and the battery will be available for use.

The cooling system (FAN) automatically kicks in when the battery temperature rises above a certain level.

1)-6. Cell Balancing monitoring function

Measure the voltage of each of the cells in series with each other in the battery pack to ensure that if any reach a voltage above the allowable range, the charge is immediately cut off to prevent overcharging.

2) List of Battery Management Systems (BMS) protection behaviors

(Note1): All Tabos batteries have a built-in BMS.

(Note2) : The following safety-related figures are subject to change without notice to improve product performance.

	Large categories	Protection operating conditions, characteristic values	Conditions for unlocking/reverting protection, or other
λ	Overvoltage protection (OVP) -------- = Overcharge protection	* 25V battery : EOCV = 29.4V or higher * 50V battery : EOCV = 58.8V or higher * EOCV = End of Charge Voltage=End of Charge Voltage	**< Overvoltage protection (OVP) release condition: >** Discharged (AND) * 25V Battery : Battery voltage≤ 29.2V * 50V Battery : Battery voltage≤ 58.4V Auto-revert when conditions are met. * If the overvoltage protection (OVP) function is triggered, it will only prevent charging, but discharging will be normal.
Charging Manage	Manage users Maximum allowable charging voltage	* 25V Battery: ~ Max. 29V * 50V Battery: ~ Max. 58V	To prevent the BMS from using OVP as a protection behavior Charge at or below the voltage shown on the left.
B	Undervoltage protection (UVP) -------- = Over discharge protection	* 25V battery: EODV = 19.6V or less * 50V battery: EODV = 39.2V or less *EODV= End of Discharge Voltage) = Discharge Cutoff Voltage	**< Undervoltage protection (UVP) release condition: >** is charged (AND) * 25V Battery : Battery voltage≥ 21.0V * 50V Battery : Battery voltage≤ 42.0V Auto-revert when conditions are met. * When the under voltage protection (UVP) function is activated, discharging is not allowed, but charging is normal.
Discharge Manage	Battery Before the BMS blocks output with UVP The voltage at which the load should be disconnected (or a voltage that needs to be charged immediately)	Consider using a device that automatically disconnects the load before it drops below the voltage below, or a voltage that needs to be charged immediately. * 25V Battery : Min. Does not fall below 23.5~24V Don't. * 50V Battery : Min. Does not fall below 47~48V Don't. This ensures a safe, long-lasting battery.	**Before the battery BMS shuts off due to over-discharge,** **Battery Low Voltage Disconnect (BLVD) should be used to disconnect the load first to extend battery life and prevent safety incidents.** **→ Sold separately as a sister product to Tabos BLVD.** **If the battery frequently drops below the low voltage protection voltage, the chemical composition inside the battery changes, increasing the risk of fire.**
③ â -1	Overcurrent protection when charging (OCP)	The maximum charging current values for each battery model can be found in the "Product lineup and individual specifications" table. It will cut off charging if it draws more current than the maximum current for that model. * OCP = Over Current Protection	**< Charge overcurrent protection (OCP) release conditions :> <** Auto return when the charger is disconnected from the battery

	Large categories	Protection operating conditions, characteristic values	Conditions for unlocking/reverting protection, or other
③ â -2	Overcurrent protection during discharge (OCP)	For the maximum discharge current values for each battery model, see the "Product Lineup and Individual Specifications" table. If a current greater than the maximum current for that model is drawn, it will cut off the discharge. * OCP = Over Current Protection	**< Discharge overcurrent protection (OCP) release conditions :> <** Automatic return when the load circuit is disconnected from the battery. ⚠Caution; models with a Tavos BMU, i.e, Models with battery status communicator (COM type) the Enable S/W must be OFF, as the communication device is recognized as a load from the battery perspective.
④ â	Short-circuit protection (SCP)	Protects the battery and load by automatically shutting off discharge in the event of a short circuit. This is a self-recursive eFUSE method.	**< Conditions for releasing short-circuit protection (SCP) :> <** When the load circuit is disconnected from the battery, it automatically reverts back to normal use of the battery. ⚠Caution; models with a Tavos BMU, i.e, Models with battery status communicator (COM type) the Enable S/W must be OFF, as the communication device is recognized as a load from the battery perspective.
⑤ â	Cell balancing Surveillance features	If the voltage of each group of cells connected in series is higher or lower than the average voltage level by a certain amount, the Block charging or discharging.	Auto-revert when the blocking condition is lifted.
⑥ ⑥	Overheat protection (OTP)	(Condition 1). When the battery cell surface temperature rises above 50℃ . (Condition 2). When the FET (battery charge/discharge ON/OFF switching element) temperature rises above 80℃ . Charging and discharging are automatically shut off.	**< Conditions for disabling overtemperature protection (OTP):> >.** Overheat protection is automatically turned off when the temperature drops more than 10 degrees below the corresponding temperature in (Condition 1) and (Condition 2).
⑦ â -1	Automatic cooling system ------ General (Products without battery communication)	* Auto ON/OFF cooling fan Runs when the internal temperature of the battery is above 40 degrees, Fans stop running after a period of time when the temperature drops.	
⑦ â -2	Automatic cooling system ------ COM-type :	* FAN operation (ON) condition (Condition 1). When the temperature is above 40 degrees	* Conditions under which the FAN is turned off again (OFF) (Condition A). When the temperature is 35 degrees or lower.

	Large categories	Protection operating conditions, characteristic values	Conditions for unlocking/reverting protection, or other
	Add 'COM' to the battery type number Products containing text (BMU-equipped products, i.e., products with a communication function for transmitting battery status)	(Condition 2). When the charge/discharge current is 10A or higher If either of the above two conditions occur, the fan is activated (ON). ⚠Caution: The communication device must be powered on for the FAN to run.	(Condition B). When the charging current is 5A or less. (Condition C). When the battery voltage drops 0.2V in an overvoltage condition. The FAN stops (OFF) when all three of the above conditions are met.

3) List of other common specifications / Cell→ Lifetime→ Temperature→ Transportation→ Storage→Disposal→Connect→Load→Charge→BMU

Large categories	Attribute values	内容
<0> Cell & Producer information	Cylindrical 21700, NCM (Nickel, Cobalt, Manganese) series	This product uses the LG Li-ion battery cells are used, Made in Korea by Tabos, where everything including the BMS is designed and built by Tabos.
<1> Click Nominal Wh, Ah Definition of	(Definition)	The charge capacity (Ah) and nominal energy (Wh) listed on this product are idealized capacities when charged at full charge voltage and 0.1C while maintaining a cell temperature of 20℃ . Charging faster or at higher temperatures will reduce the charging energy.
<2> Life expectancy	LV Series : 5,000 Cycles LM Series : 4,000 Cycles (estimate, usage dependent)	Life expectancy condition : 1) When used at a battery cell temperature of approximately 20°C. 2) Charge and discharge must be at 0.2C Rate. 3) When charging and discharging between 30% remaining ↔ 90% remaining, Life expectancy depends on usage conditions. The closer the battery temperature is to room temperature, and the smaller the charge and discharge currents are relative to the battery capacity, the longer the lifespan. 4) Avoid discharging it completely. The closer the level is to zero, the more rapidly the life will decrease.
<3-1> Temperature conditions / charge,discharge	Charging: 0°C to 45°C (Charging in subzero temperatures is not allowed) At discharge : -20°C to 60°C	* Cycle : The temperature here is not the ambient temperature, but the temperature of the lithium cell itself. The temperature. * Glass closer to room temperature, shorter life at lower temperatures and higher temperatures.
<3-2> Temperature conditions / Transportation and storage (outside temperature,humidity)	1) Transportation or storage conditions * Condition: State of Charge (SOC) 30% and below / Humidity 50% and below For 1 month : -20 to 55℃ 3 months : -20 to 45℃ More than 1 year : -20 to 25℃ * Note : Transportation is only possible with SOC 30% or less. / International transportation specifications Storage above 30% SOC is not a problem. If stored at 80% charge, the Can be stored for a long time. 2) Storage of products in a fully charged state (almost 100% SOC) / humidity below 50%. For 1 month : -20 to 45℃ 6 months or more: -20 to 25℃	
<3-3> Temperature conditions	Do not allow charging in subzero temperatures	
	When charging from 0 to 20℃ degrees	(Ideal Charge Temperature) The charge temperature that will provide the longest life.

Large categories	Attribute values	内容
/charge cell Changes in life expectancy with temperature	30 When charging at℃ degrees	There is some lifetime reduction.
	40 When charging at ℃	This is considered high temperature and will reduce battery life.
	50 When charging at ℃	Increases the risk of battery damage.
<3-4> Temperature conditions /Cell Temperature By bin Available energy (Wh) Change	minus (-) 20℃ when discharging from	At 0.2C discharge, the energy (Wh) is around 60%.
	minus (-) 10℃ when discharging from	At 0.2C discharge, the energy (Wh) is around 70%.
	0 When discharging from℃	At 0.2C discharge, the energy (Wh) is around 80%.
	Video 10 At℃ , you can watch the discharge	At 0.2C discharge, the energy (Wh) is around 90%.
	Video 20 At℃ , when discharging	At 0.2C discharge, the energy (Wh) is on the order of 1000%.
	Video 40 At℃ , click Discharge	0.2C At discharge, the energy (Wh) is about 95%.
	Video50 From℃ on discharge	At 0.2C discharge, the energy (Wh) is around 90%.
	When applying the above data Common things to use when calibrating and judging	*If the discharge rate is higher at the same temperature (i.e., the C rate is higher), then the More available energy (Wh) is reduced, A lower discharge rate reduces the amount of available energy less.
<4-1> Transportation methods	(Important) How to ship batteries domestically and internationally (This is a measure to prevent fire during transportation and follows international shipping regulations.) < For domestic and international transportation Do not pack batteries with automation devices. Remove the battery from the machine (robot, etc.) on which it is mounted. ③ Check the battery voltage to make sure it is charged to 30% or less. To check for a charge below 30%, simply discharge the battery to a level that is about 1 volt below the nominal voltage. (Discharging too much is not good for battery life, so only discharge to a level that is 0 to 1 volt below nominal voltage.) Charging below 30% is very important. Do not violate this rule. This is a globally recognized rule because below 30%, no impact will cause a fire. < For international shipping ④ Remove the batteries mounted on machines and robots, etc. as above, and transport the batteries alone. Also, the batteries must be discharged to	

Large categories	Attribute values	内容
	30% or less of their charge. Send them to a company specializing in the transportation of dangerous goods (forwarder) and ship them overseas. * The dangerous goods transportation company repackages the battery as dangerous goods according to recognized standards. * Documentation: MSDS provided by Tavos. Submit the UN38.3 document to the carrier. * If you do not know the battery shipping company, please contact Tavos. * Note: International battery shipping regulations : Worldwide, Air transport : IATA DGR , Worldwide, Sea ship : IMO IMDG Code , Europe, Land transport (ADR/RID /GGVSE)	
<4-2> Storage methods	The key to long-term battery storage is to keep them from discharging. Make sure the battery is disconnected from all loads. 1) Disconnect the output terminals (Main S/W OFF, etc.) 2) Disconnecting the self load (Communication board power contact OFF for COM model products) - Keep the green light on the front of the battery OFF. 3) Store with at least 30% state of charge (SOC).	
<4-3> Disposal methods	1) Connect a load (or electronic load) to the battery to discharge it sufficiently (or completely). You can then send them to a lithium battery recycler. 2) Go ahead and add salt to the water and let it soak for at least 4 hours. This is called electrolyzed water. Electrolyzed water is the kind of water used in Korea to marinate cabbage for kimchi. Electrolyte (salt water) for battery discharge should have a concentration of 8% to 10%. → -is 8 to 10 kg of salt dissolved in 100 liters (100 kg) of water. You don't have to stick to this ratio. 3) Immersing the battery in electrolyzed water will completely discharge the remaining electrical energy in the battery. 4) Research lithium battery recycling companies and arrange for them to pick up your dead batteries.	
<5-1> Connections /Enable battery parallel connection	Batteries of the same type can be connected in parallel, i.e. (+ to+ , (-) to (-))	< Condition > However, when connected in parallel, they must be within 0.5V of each other, have the same age, and the same internal resistance. This means that it's common to link them together when they're new, and you shouldn't link used ones together.
<5-2> Connections /Use series connection between batteries	←- Never.	It is absolutely prohibited to double the voltage by connecting batteries in series. The reason is that the BMS may not operate because the voltage withstand of the protective circuit elements exceeds the allowable value, causing a fire or other hazard.
<5-3> Connections /power terminal block Screw specifications		SEMS Hex Wrench Bolt : M6-15 Tightening torque : 25 (kgf*cm)

Large categories	Attribute values	内容
<6> Connecting loads	1) Check the charge level before connecting the battery to the load: First, measure the battery voltage: if it's near the nominal voltage, it's roughly 30% charged. First, connect the charger to charge it before use. Using it with a low level will cause over-discharge, which will significantly reduce battery life and is not safe. 2) Inserting a battery low voltage disconnect (BLVD) between the load and the battery before the BMS shuts off the output due to low battery voltage will ensure that the battery is safe to use. 3) If the load has a large capacitor on the input side (inverter, DCDC converter, motor driver, etc.) Inrush currents of hundreds of amperes (A) may be drawn when the battery is connected to the load, causing the battery's BMS to shut down the battery output. In this case, reduce the inrush current or use an additional inrush current limiter.	
<7-1> How to charge /What to look for when choosing a charger	1) Use a charger with simultaneous constant voltage (CV) + constant current (CC) capability. 2) Setting of charging voltage, current in the charger : * Charger's charge voltage ≤ battery's maximum allowable charge voltage * Charger's charge current ≤ battery's maximum allowable charge current 3) We recommend using an isolated charger. *Explanation: Isolated charger refers to a method in which the primary side (AC220V power supply) and the secondary side (DC battery charging side) are combined with a transformer that converts electricity into a magnetic field and transmits it to the secondary side. This prevents the AC220V high voltage from being applied directly to the battery when the charger burns out. 4) We recommend using a charger with an output current ripple of 5% or less. *Clarification: 0% ripple is fully direct current, while 5% ripple means that it contains 5% alternating current. The closer you charge a lithium battery to direct current, the better. 5) Charge at a moderate value below the rated charging current, as charging at the lowest possible current can extend battery life.	
<7-2> How to charge / When the battery is overdischarged and battery voltage is not available	1) Use a charger that has the ability to charge the battery even if it is over-discharged. (The Tabos charger has such a feature.) When charging, disconnect the load connected to the battery and connect the charger and battery 1:1 to charge. For batteries with a BMU (optional: /COM models), also turn off the BMU power switch. 2) There have been cases of people trying to force a dead battery to charge and catching fire.	

Large categories	Attribute values	内容
<8> Battery status Communication Port_BMU (/COM: Optional)	Communication content : Battery voltage, level, and temperature, Estimated charge time, estimated discharge time, Information about battery usage, including error status	1) When multiple batteries are connected in series or parallel, it is implemented as a master-slave method, which collects the capacity and status of multiple batteries and finally transmits battery status information from the master battery. 2) Provide pin map and protocol of communication port connector 3) RS232C / RS422 / RS485 / CAN User-selectable available. --- For more information, see the next chapter on BMUs

4) Battery Monitoring Unit (BMU) and ON/OFF Remote (Enable) Switch

4) - 1. Limited to models with the letters 'COM' in the configuration / battery model name.

* Example model name: LV-50V75AH-VX3COM or LM-MOTOR-25V-70AH-X2COM

◇ Removable threaded plug, Pluggable Type: PHOENIX / Order no. 177798

* Notes: Series: MSTB 2,5/2-STF-5,08), (2P plug, 5.08 mm pitch)

* Caution: This threaded removable plug is shipped with the mating piece in

You don't need to prepare a counterpart connector.

4) - 2. This remote switch does not turn battery power ON/OFF.

Only turn on/off the battery status communicator.

When this switch is off, the communication device is turned off, but the battery mains power is not turned off.

The battery's main power is always output, just like a car's lead-acid battery.

Shorting pins 1 and 2 of the green terminal will power the communication unit (BMU) and illuminate the green LED.

4) - 3. Communication device power consumption = 5W (Condition: When the remote ON/OFF switch is turned ON, and the fan is not running)

Keep the remote switch OFF when the battery is not in use.

4) - 4. Brief description of communication device functions

◇ Displays battery status values (estimated time to discharge, estimated time to charge, battery temperature, etc.
◇ Communication type: CAN / RS485 / RS422 / RS232C

* For other details, please refer to the separate 'Communication protocol manual'.

4)-5. Features of SOC calculation of Guage IC and measures in case of problems

A) How to calculate the SOC of the Guage IC:

- The SOC (%) figure exported by the BMU is the one calculated by Gauge IC's own algorithm,
- The variables in the calculation are voltage, current, temperature, and cell (Chemistry Values on Calibration).

B) Guage IC's battery charge/discharge current related features.

- Conservatively calculates SOC rise proportional to current magnitude when charging.
- Conservatively calculates SOC drop proportional to current magnitude at discharge.

::: After charging (more than 3 minutes), it has the ability to recalculate itself if the discharge conditions are right,
You can see the SOC numbers recalculate (recalculated based on calibration values) :::

C) Causes and actions for SOC exceeding tolerance.

< Cause

- Some modules inside the pack are blocked by protective behavior, reducing Ah. - To be checked separately.
- Guage IC malfunctions (stops calculating) due to environmental noise, etc.

< What you can do in the field

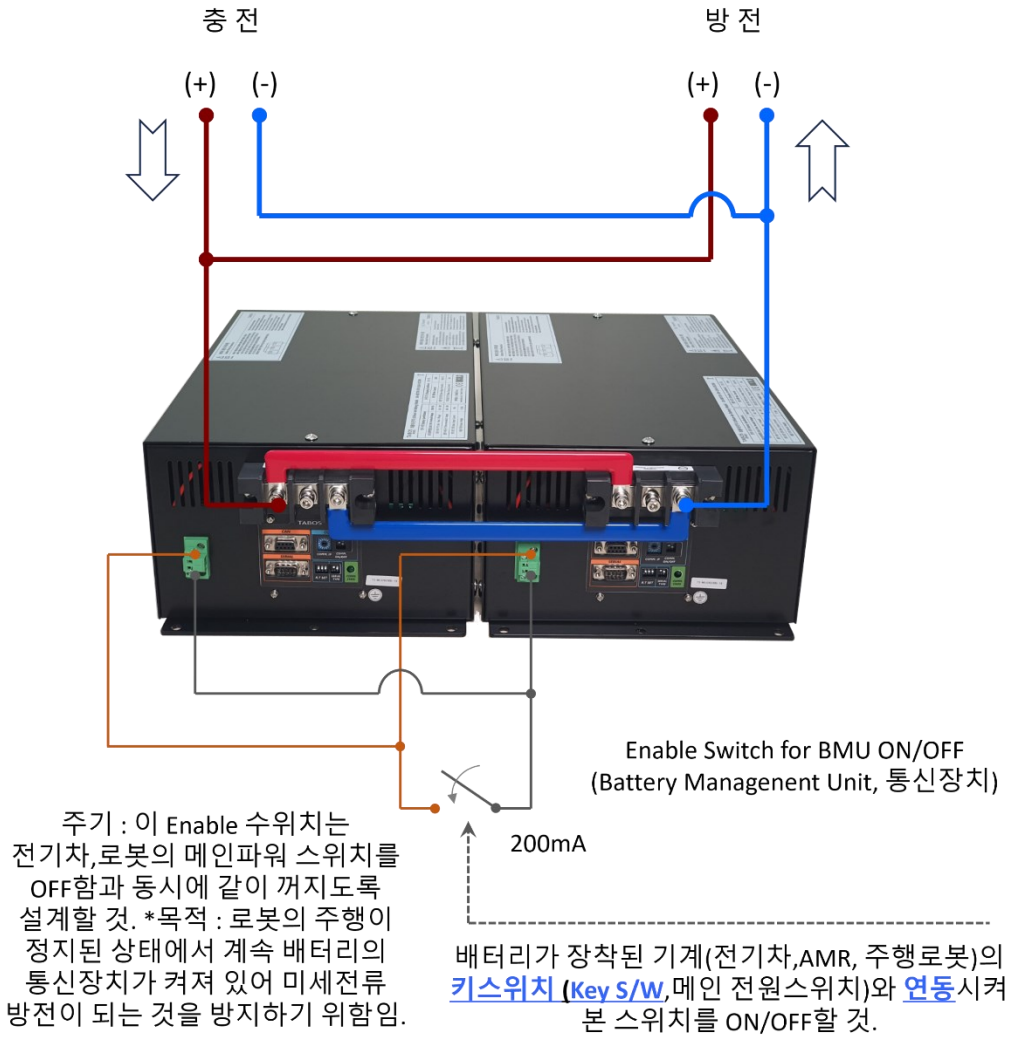
- Reset the board power using the green contact (BMU power switch) (current should be minimal)
- Recalculates itself after more than 3 minutes of charging and 2 minutes of discharge standby under 5A.
- If the above two actions don't work, it's time for a consultation.

4)-6. Use the remote switch contacts in conjunction with the AGV and system power.

In other words, work with the system (+) line switch to ensure that the communication unit (BMU) is powered off when the system is turned off.

To prevent battery over-discharge due to communication unit (BMU) standby current.

* For other details, please refer to the separate 'Communication protocol manual'.



4)-7. Caution⚠ : If the above Enable Switch is OFF, the battery cooling FAN is not activated, so the battery cooling FAN is not activated.

I'm having a problem.

*Continuing to charge or discharge the battery without the cooling fan running will cause the battery to heat up.

The battery will automatically stop charging or discharging when it overheats, i.e. when the battery cell temperature goes above 50 degrees.

After that, it will cool down naturally and become chargeable again when it drops below a certain temperature.

5) List of battery status data

/ COM model, i.e., only for models equipped with a BMU (Battery Monitoring Unit).

5) - 1. Battery information

Order	Type	Unit	Scale	Range	Description
1	Voltage	V	0.01	0 to 655.35	
2	Current	A	0.01	(-) 327.68 to (+) 327.67 (-): Discharge, (+): Charge Declare the variable→ signed	
3	SOC (remaining) (State Of Charge)	B	1	0 to 100	
4	Battery status information (See next chapter☞ for details)			If no data is output, the battery is healthy. *Nonstandard data contents : Overvoltage, undervoltage, overcurrent, high temperature, low temperature, BMU communication error	*Abnormal condition data types (contents): overvoltage, undervoltage, overcurrent, high temperature, low temperature, BMU communication error
5	Charging time	min	1	0 to 65535	Calculation formula: Charging completion time (H) = Ah to be charged / charging current A, This value is weighted and averaged to compensate.
6	Discharge completion time	min	1	0 to 65535	Calculation formula: Discharge completion time (H) = Residual Ah / Discharge current A, This value is weighted and averaged to correct it.
7	Temperature	℃	0.1	(-) 3276.8 to (+) 3276.7 (-): Above freezing, (+): Video Declare the variable→ signed	
8	SOH (Soundness of Health) (State Of Health)	B	1	0 to 100 (Reference value) :New: 95 ~100 Used,Aged: 80% or less	If the value is below 80%, it is inspected or discarded. This phenomenon may occur when some modules in the battery pack are connected in parallel and the charging or discharging function is restricted by BMS.

9	Residual capacity	Ah	0.01	0 to 655.35	
10	Residual Energy	Wh	0.1	0 to 6553.5	

5) – 2. Battery status information

Bit	Description.	Bit
0	Battery overvoltage	8
1	Low battery voltage	9
2	Excessive charging current	10
3	Excessive discharge current	11
4	High temperature	12
5	Low temperature	13
6	BMU Errors	14

[Note 1]

The communication protocol is subject to change due to our circumstances. Please check the latest version.

The protocol specification is available for download on the home page.

[Note 2]

✧ State Of Charge (SOC) :

1) Unit: 0~100%, full charge 100%, full discharge 0%.
2) State of charge (SOC) measurement method: The battery level is not calculated by simply using the battery voltage alone. SOC data is generated using a statistical method by using multiple information including the internal resistance of the battery, the battery voltage, and the cumulative current charged or discharged by the battery.
This means that even if the battery voltage fluctuates rapidly when charging and discharging the battery, the SOC value will fluctuate slowly instead of rapidly.
2) Fully Charged: Normally, this data value may not go to 99-100% when fully charged. To get to 100%, you'll need to charge very slowly, and you'll need to charge to full pressure. If you see a reading of 95% or higher, you're usually good to go.
3) Discharged state: Normally, this data value may not go to 0% when discharged.
No, you need to charge it very slowly to get to 100%, and it needs to be charged to a full charge pressure, usually 95% or higher to be considered full.

*Note: The battery must occasionally be in a full state for accurate calculations.
However, we typically don't charge the battery to a full charge for battery safety reasons, which makes the data a bit less precise.

[Note 3]

✧ State Of Health (SOH) :

1) Unit: 0~100

A value closer to 100% means the battery is at full capacity and a value closer to 0% means the battery is degraded.

*Note: The battery must occasionally be in a full state for accurate calculations.
However, we typically don't charge the battery to a full charge for battery safety reasons, which makes the data a bit less precise.
*Side note 2: To illustrate the usefulness of SOH values, consider the following example.
I've had the battery for 7 years and it's working fine, with SOH values of 80-90% or higher.
This value makes it ambiguous to determine if the battery is nearing the end of its life.
Then, as you use it more and more, the battery suddenly fails (usually because it has been used for a long time and the cell balancing is naturally out of order, making it completely unusable, etc.
Rather than a gradual decline with age, SOH values often work fine at values above 80% and then suddenly become unusable.
There are not many empirical statistics available yet.
Therefore, it is recommended to view this SOH value as a reference value.

---

6) How to charge the battery when it's fully discharged (when the output is cut off and the voltage is not working properly)

Models with the letters 'COM' in the battery model name / models described above you must use
Charging must be done with the remote (Enable) switch OFF.

This is because the battery BMS has shut down its own output due to over-discharge.
The charger does not detect the battery output voltage and charges with a small current pulse wave, because if the above communication device is turned on, the communication device consumes the small pulse wave current from the charger, and no current reaches the battery.

3. Model name and order code descriptions and options

Number	λ	B	③ â	④ â	⑤ â	⑥ ⑥
Model name examples	LH –	MOTOR –	50V –	45AH –	W3COM / Handle	

* Apply a battery with as high a voltage as possible. This is advantageous as it reduces the current magnitude.
* Battery performance, charge rate, discharge rate, price in order: LH > LM

No	Item	内容
λ	Lithium-ion batteries Cell Type	LH: Fast charge, fast discharge (High rate) Applicable lithium battery cells: up to 4~ 8C dischargeable, 1.5C rechargeable 2.5Ah cylindrical cells. Charging: 1.2C or less, (up to 50 minutes to 1 hour charge) Discharge: 2-3C or less discharge, (depending on battery pack type) [Cycle 1] 1C discharge (rechargeable) means that the battery has a current capacity of 10Ah. This means that it can discharge (charge) up to 10A, which is one times as much. [Cycle 2] Higher C values are more expensive and can be charged and discharged at higher currents.
B	Battery type	Products made for high-power, high-load applications such as motors
③ â	Nominal voltage V	Battery nominal voltage abbreviations
④ â	Current capacity Ah	Current capacity abbreviated . (Nominal Ah capacity rounded to the nearest decimal) [Example] Nominal 52.2Ah→ written as 52AH, Nominal 43.5Ah→ written as 44AH
⑤ â	External case types	◊ Capital C: Aluminum profiled case CV(COM) : C-type Vertical installation type CH(COM): C-type Horizontal installation type ◊ x2(com), x3(com), x4(com), w2(com), w3(com) : Iron painted finish case ◊ Model with COM appended : BMS communication port optional
In the COM-attached models Notes	BMS Battery status Communication devices	Ability to pass battery status through the communication port. Status display: remaining charge (SOC), health (SOH), battery capacity (Ah, Wh), temperature, Estimated charge time, estimated discharge time, etc. Supports all 4 communication methods (user selects port, switch)

		1) Serial communication : RS232C / RS485 / RS422 → Battery-mounted communication output connector specification: Dsub 9-pin male. 2) Parallel Communication : CAN → Battery-mounted communication output connector specification: Dsub 9-pin female. [Cycle 1] : CAN is recommended as noise-resistant as possible, with RS485/ RS422 communication as a secondary consideration. [Cycle 2] : The battery with the communication device attached will be longer than the battery without. [Cycle 3] : Download and use the communication protocol from the Tabos homepage.
⑥ ⑥	(Optional) Handle	Add "/Handle" to the end of the battery name

4. Model selection caveats

By applying a high voltage battery (50V), you can reduce battery heat generation and charge/discharge current, reduce wire thickness, and drive a motor with a larger output.

1) For 25V battery: The terminal block has an allowable current capacity of 100A, and the allowable current is limited to 90A for safety margin, so there is a limit to increase the battery charging and discharging current.
For this reason, 50V batteries are often advantageous for large capacity batteries.
2) For a 50V battery: Since the current is reduced by 1/2 compared to a 25V battery of the same capacity, there is room to increase the charging and discharging currents, so you can drive a larger power motor per battery.

◇ If one battery cannot handle the full power of the motor, use two or three batteries in parallel.

◇ The maximum charge voltage magnitude of the applicable charger determines the actual usable charge capacity. Caution when selecting battery capacity

1) For 25V battery: 28V charge will charge to about 80% SOC, 29V charge will charge to about 95% SOC
2) For 50V batteries: 56V charge to approximately 88% SOC; 58V charge to approximately 94% SOC
* SOC (State Of Charge): The amount of charge.

If you need more than the battery's maximum allowable charge and discharge current, connect multiple batteries in parallel.

5. Product drawings and photos

* Refer to the accompanying drawings for a drawing of each model name. The last number in the model name is the instrument case type number.

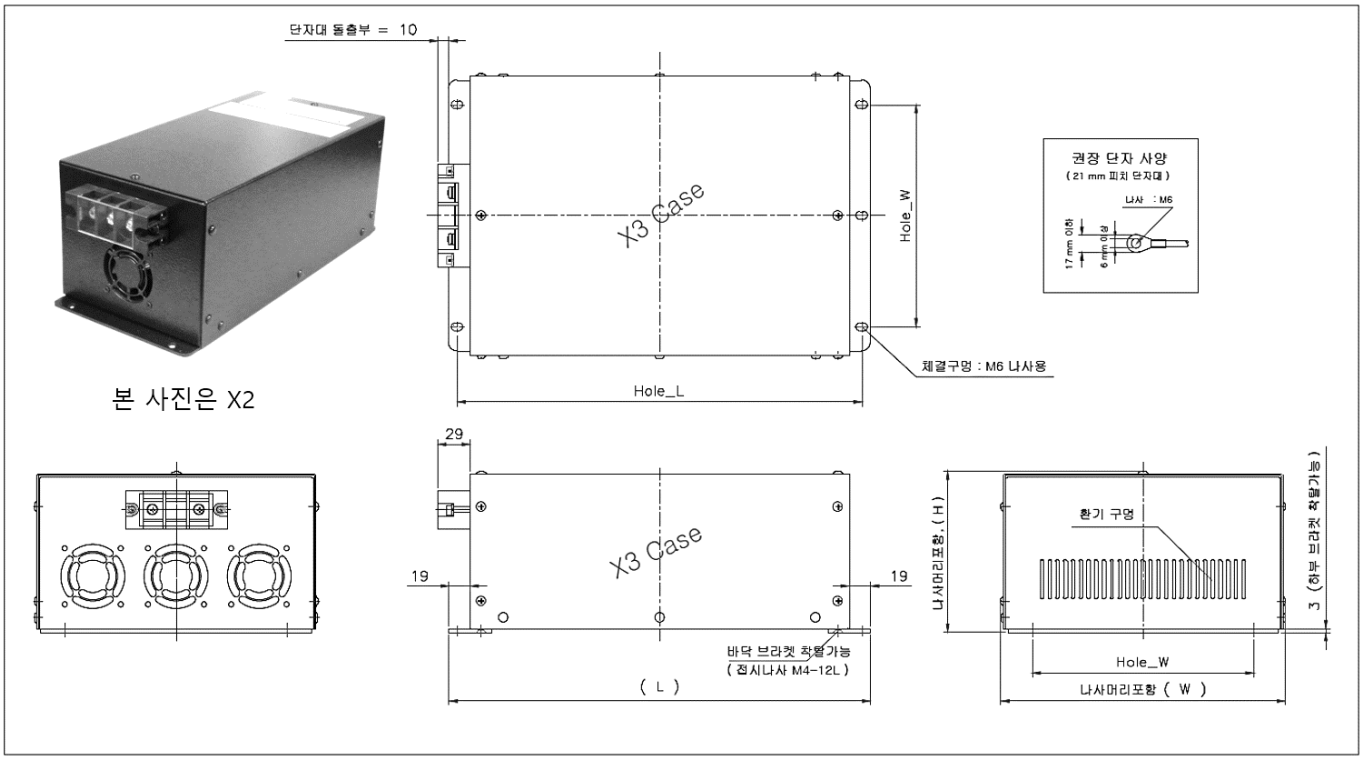
Example 1: LM-MOTOR-50V-35AH-X2COM → See 'X2COM' for the mechanical drawing.

Example 2: LV-50V75AH-VX3COM/V → See 'VX3COM/V' for the mechanical drawing.

* Drawings can be downloaded from our homepage / dwg, pdf, 3D (stp, igs)

* The diagram below is simplified and for reference only.

[X2, X4 type cases].



Unit: mm, For detailed drawings, please download the latest version of the drawings from the homepage.

Case names	W	H	L	Hole_W	Hole_L	Remarks
X2	174	145	380	120	365	
X4	306	145	380	250	365	

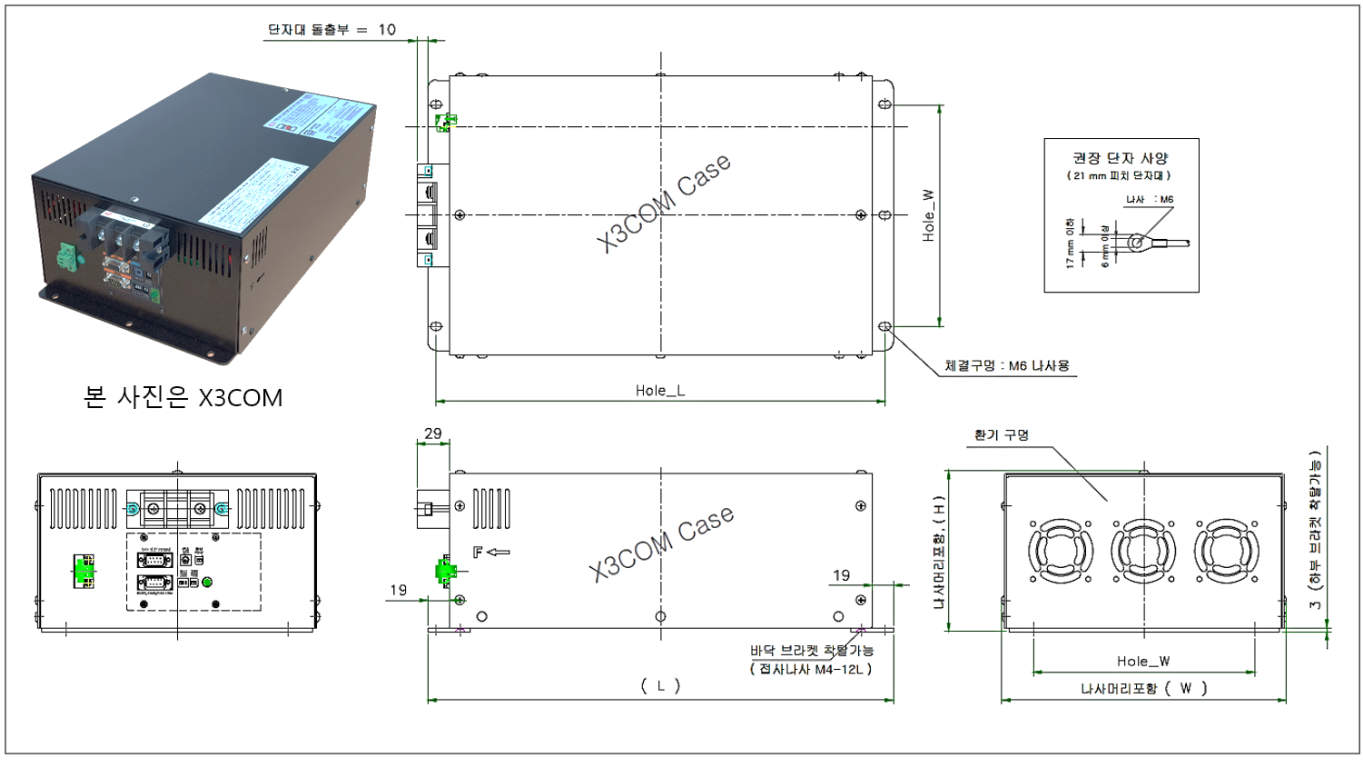
Unit: mm

* See attached drawing for homepage

[X2COM, X4COM cases].

(BMS communication device equipped)

For detailed drawings, download the latest version of the drawings from the homepage.



Unit: mm, For detailed drawings, please download the latest version of the drawings from the homepage.

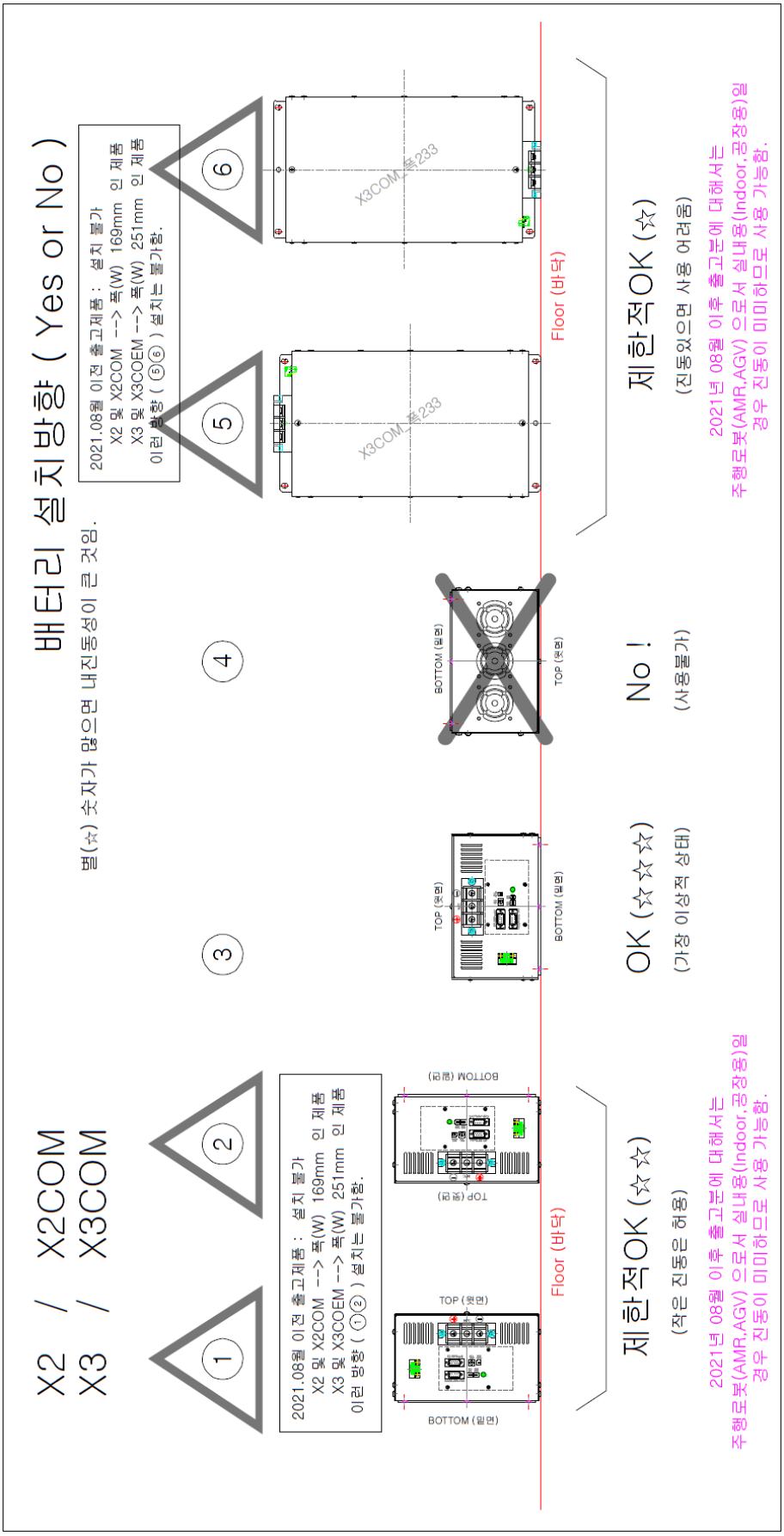
Cycle: In the case of COM model, the communication port operation switch is changed to the terminal block for Remote.

Case names	W	H	L	Hole_W	Hole_L	Remarks
X2COM	174	145	420	120	405	
X4COM	306	145	420	250	405	

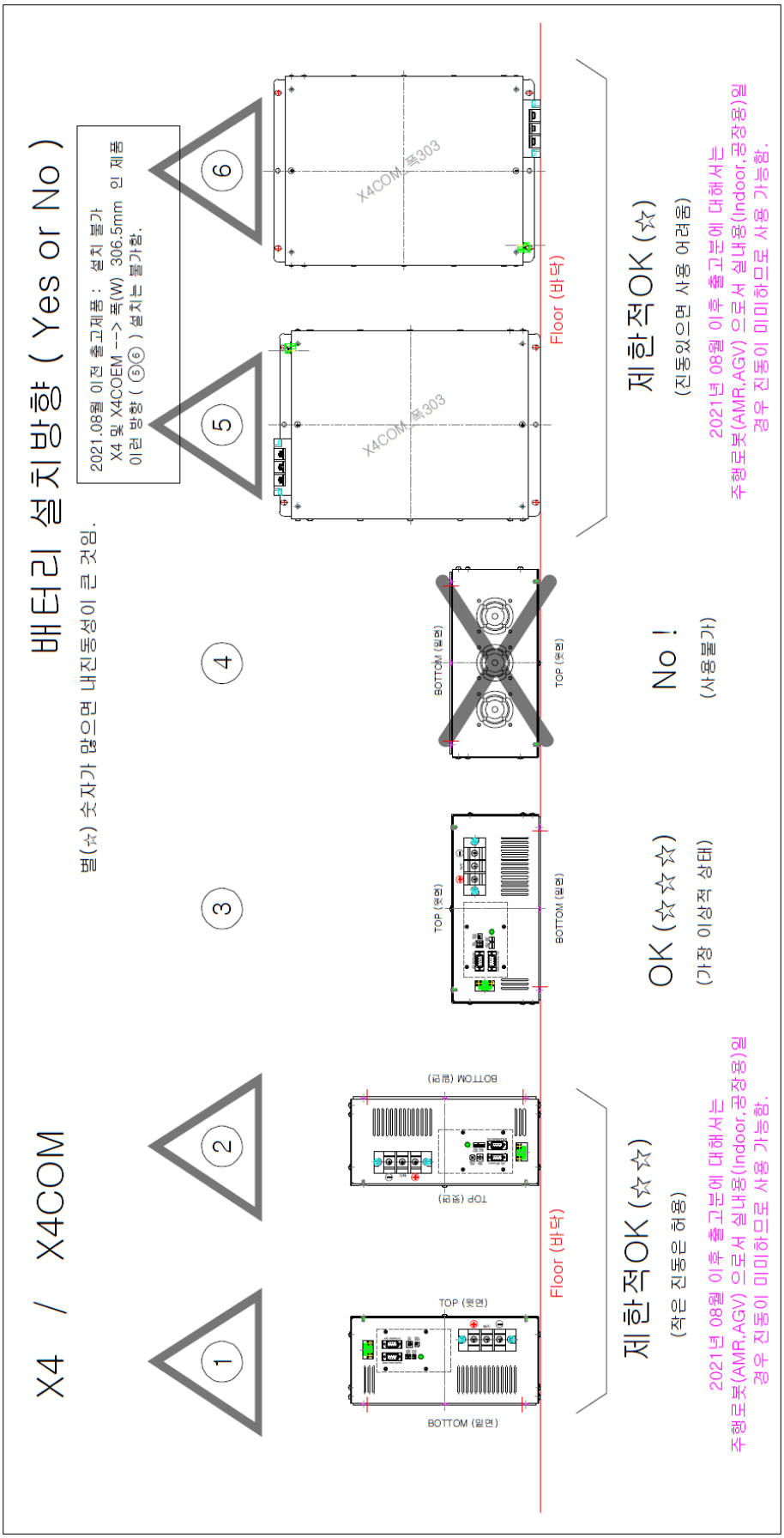
Unit: mm

* See attached drawing for homepage

< Battery Installation Orientation / X2, X2COM Cases >

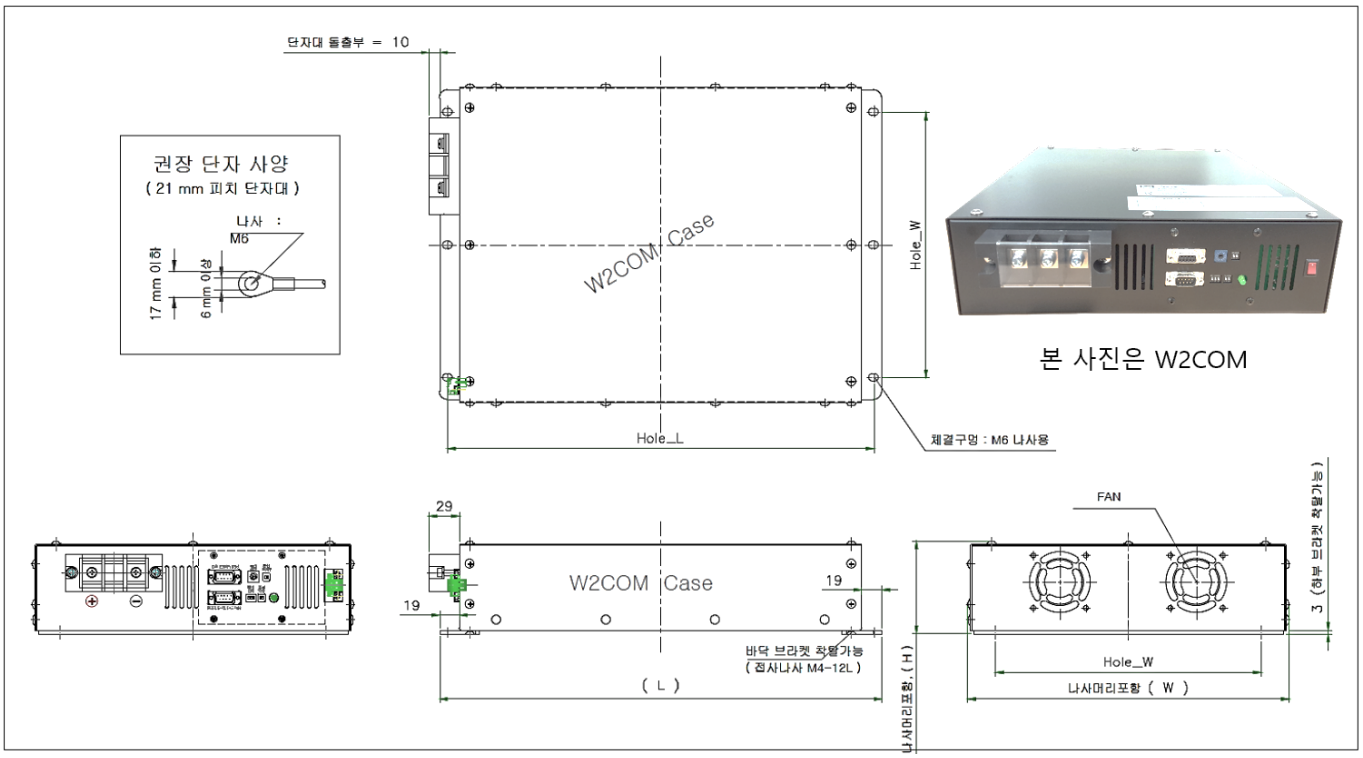


< Battery Installation Direction / X4, X4COM Case



[W2, W2COM, W3, W3COM case]

(Standard and with BMS communicator)



Unit: mm, For detailed drawings, please download the latest version of the drawings from the homepage.

Cycle: In the case of COM model, the communication port operation switch is changed to the terminal block for Remote.

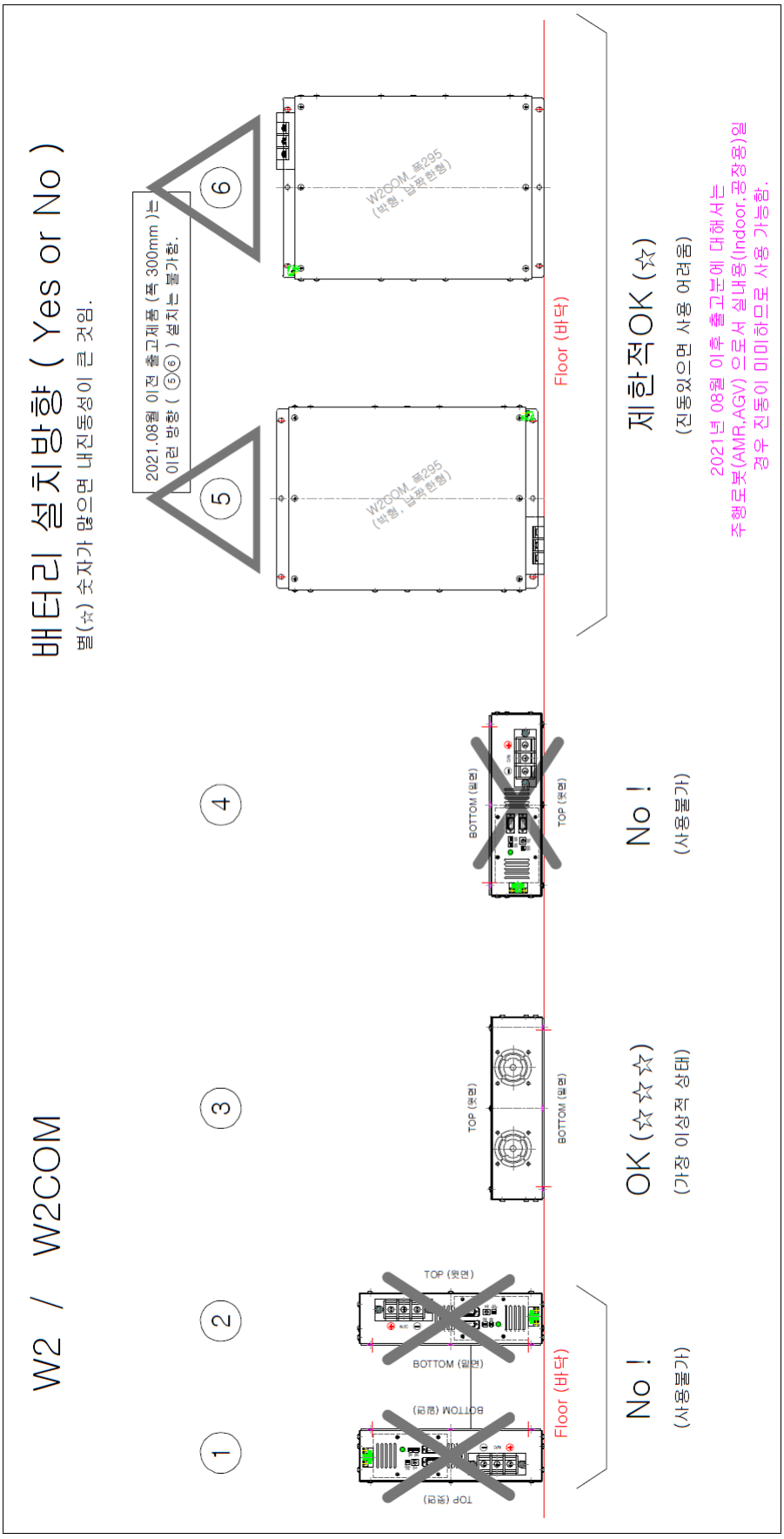
If it is not a COM model, there is no communication port on the drawing.

Case names	W	L	Hole_W	Hole_L	Remarks
W2	305	380	252	365	
W2COM	305	420	252	405	
W3	446	380	390	365	
W3COM	446	420	390	405	

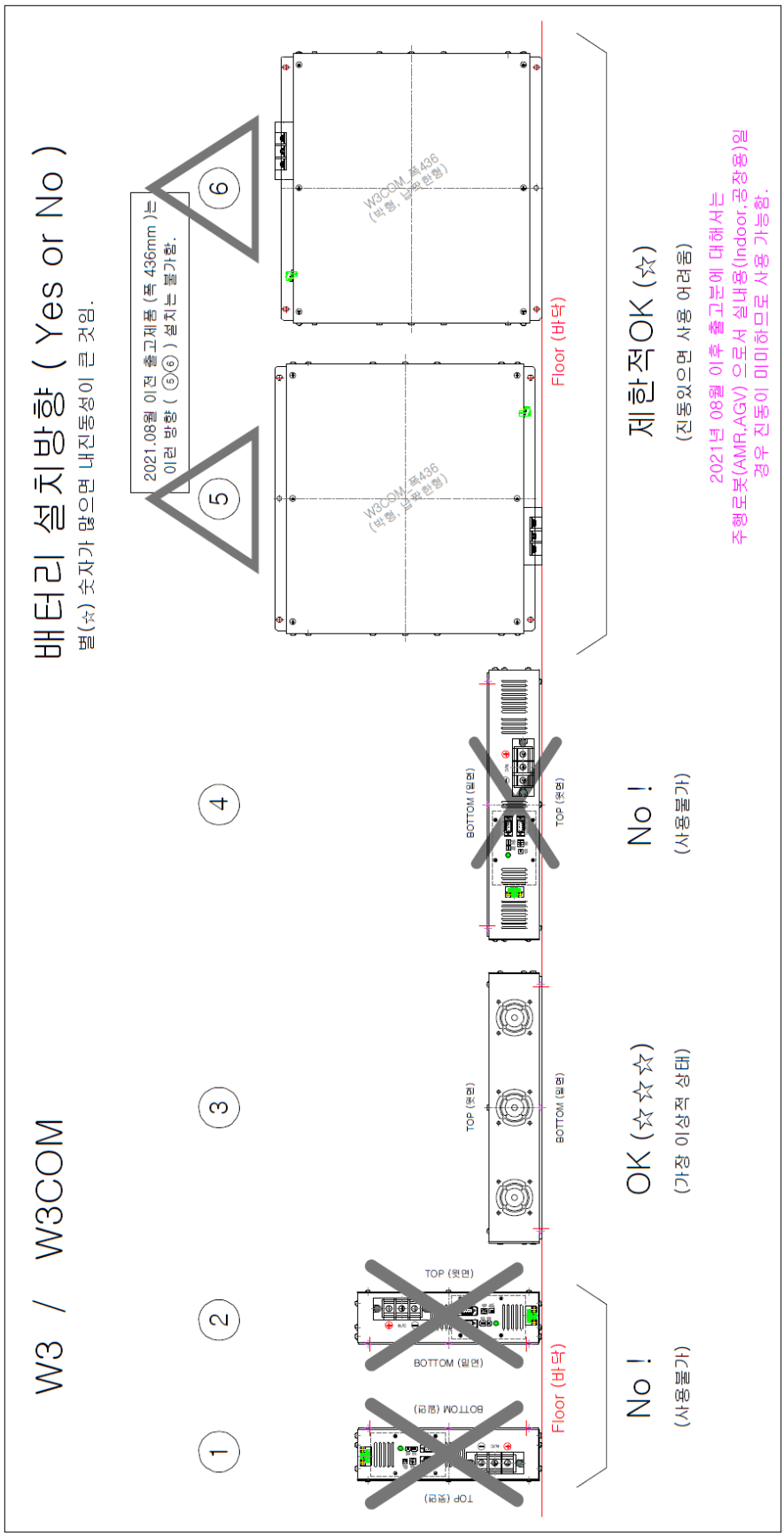
Unit: mm

* See attached drawing for homepage

< Battery Installation Direction / W2, W2COM Case

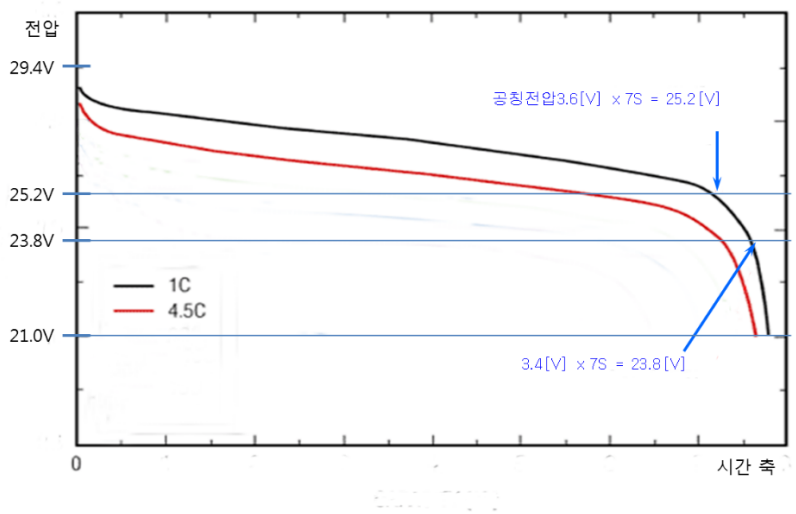


< Battery Installation Direction / W3, W3COM Case



6. Residual State Of Charge (SOC) and Voltage Relationships

It is difficult to know the exact battery level from the battery voltage. This is because there are areas where the relationship between voltage and level is not proportional, as shown in the figure below, and the battery voltage drops depending on the magnitude of the discharge and charge currents.
For example, if you look at a discharge graph around 1C, there is some linearity to it, so you can infer battery level from the voltage until the level is above 30%. (See Graph cycles below for a definition of 1C.)
However, if you further increase the discharge current (for example, to a 4.5C discharge as shown in the graph below), the battery voltage will suddenly drop, but this does not mean that the battery level has decreased, only that the voltage drop is caused by the resistance inside the battery.
Also, if you discharge a 25V battery by 1C or so, if you continue to discharge it and it drops below 24V, you will only have about 20% remaining (experimental). Further discharge will cause the voltage to drop rapidly.



[Graph] 25V (7S type) lithium battery discharge current and its relationship with voltage

** Cycle: Graph description
When we say 1C, we are referring to a discharge of 1x the total amount, say 35AH, regardless of the battery voltage.
When we say 4.5C, we are talking about discharging at 157A, which is 4.5 times the total amount of 35AH, regardless of battery voltage.
For this product, you can see the top black graph in the graph above because it discharges no more than 1C or 2C at most.
The graph above shows the discharge characteristic curve of Li-ion, which is characterized by the fact that as the discharge current increases, the voltage drops further from the original voltage of the battery. For a 25V battery, the fluctuations are particularly sharp in the region below 24[V].

7. Battery capacity changes with battery temperature and discharge current Lifespan and cautions

Cycle: The temperature below is the temperature of the Li-ion cells inside the battery pack, not the ambient temperature.

	Terms of Use	Charge and discharge status, Change in capacity (Wh)	内容
[Charge].	0 to 45°C		◇ Shortened lifetime outside this temperature range. No out-of-range usage data.
[Discharge].	Above 60°C	Unavailable	◇ The battery BMS automatically shuts off if the temperature rises above this.
	40°C to 60°C	Chargeable/dischargeable, (custom temperature)	◇ Temperatures that should be avoided, ◇ Temperature ranges where lifespan decreases rapidly
	0 to 20 to 40 °C	Chargeable/dischargeable Capacity:100 to 90	◇ Closer to room temperature (20°C) is the ideal temperature range for use. ◇ The higher the temperature relative to room temperature, the shorter the lifespan. ◇ The higher the charge/discharge current, the lower the available (chargeable and dischargeable) battery capacity, regardless of temperature.
	0°C ~ 10 °C	Dischargeable (In principle, charging is prohibited, but microcurrent charging may be possible in some cases). Discharge rate: 80	◇ LM-MOTOR series products: When discharged at a current of 40% or less of the nominal Ah capacity (e.g. 10Ah battery is 10A x 40% = 4A) ◇ The lower the temperature relative to room temperature, the shorter the lifespan. ◇ The higher the charge/discharge current, the lower the available (chargeable and dischargeable) battery capacity, regardless of
	-10°C ~ -20°C	Can discharge microcurrents (not rechargeable) Discharge rate: 50 to 70	◇ LM-MOTOR series products: When discharged with a current of 20% or less of the nominal Ah capacity (e.g., 10A x 20% = 2A for a 10Ah battery) ◇ Lifespan decreases dramatically at lower temperatures relative to room temperature. ◇ The higher the charge/discharge current, the lower the available (chargeable and dischargeable) battery capacity, regardless of temperature.
Discharge	Heavy	85 to 90	◇ LM-MOTOR series products: When

Current	Duty Discharge		discharging with a current of 100% or less of the nominal Ah capacity (e.g., 10A x 100% = 10A for a 10Ah battery)
	High load Discharge	70 to 80	◇ LM-MOTOR series products: When discharged with a current of 200% or less of the nominal Ah capacity (e.g., 10A x 200% = 20A for a 10Ah battery)

Cycle :

1. The "battery temperature" is the temperature of the Li-ion cells inside the battery pack, not the ambient temperature.
2. There is a cooling fan in the battery tray, but high battery ambient temperatures limit cooling.
3. The above material is based on our own testing over time at Tabos and is for reference only.

8. Charger and lithium battery life, what to look for when choosing

1) Choose a charger

Be sure to use a charger with built-in, proven constant voltage and constant current circuitry.
Although the battery has built-in overvoltage and undervoltage protection, you should use a product with built-in overvoltage charge protection in the charge/discharge controller to ensure the battery is safe for long-term use.
Please contact Tabos first as they have developed products specifically for this Li-ion battery.

2) Quick Charge / Slow Charge

Rapid charging reduces battery life. We recommend slow charging whenever possible.
Charging current should be within the limit current values listed in the specification for each battery model, but it is recommended that the charging current be lowered to 0.5C or less.
When we say 0.5C, we are referring to charging the battery at 100A x 0.5 = 50A if the battery has a capacity of 100Ah.
To ensure longevity, a slow charge is recommended, which means charging at 0.2C or less.
For [cycle] solar charging, this is a slow charge.

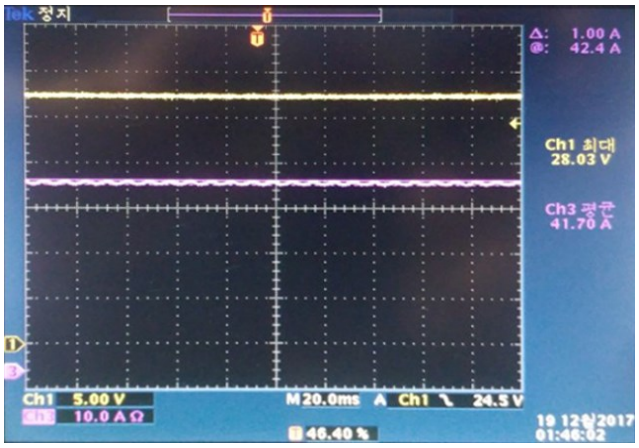
3) What to look out for when choosing a charger

The charging current ripple in the charger and the pulsatile voltage [V(t)=L*di/dt] induced by this ripple is It can damage the coating materials (Ni-Mn-Co-Li oxide and graphite particles) on the anode and cathode of a lithium-ion battery, shortening its lifespan and causing an imbalance in the characteristics of the battery cell, and can also degrade the performance of the battery management system (BMS) of a lithium-ion battery, causing safety issues.
This is something we've noticed over the eight years we've been collecting data on lithium battery and charger lifetimes.
Chargers with high reflux have been known to fail within months~ to two years.

This is being reported in empirical research papers.
Reference paper : 'The effects of high frequency current ripple on electric vehicle battery Performance' by 'Kotub Uddin' , 'Andrew D. Moore' in UK.

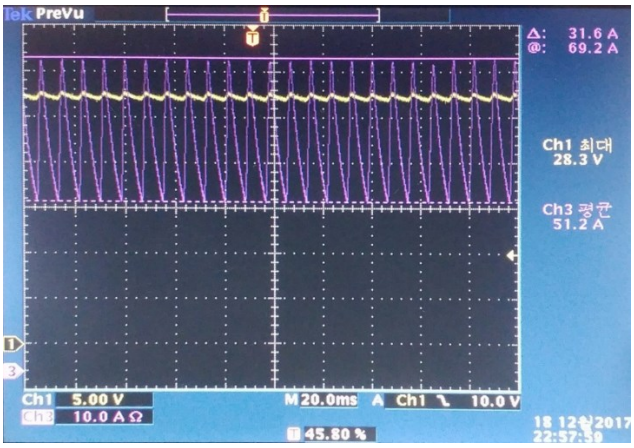
[Measured data comparing the "charging current ripple" of Tabos products to other companies' products]

Measurement Equipment : Tektronics / TCP303 with TCPA300



[Tabos charger: TC-1500W-25V45A].

Charge current reflow (△A) = 1A



[Other company (OOOO) charger : 50A charger for 25V].

Charge current reflow (△A) = 31.6A

◇ As you can see in the photo above, the charging current ripple of Tabos lithium battery charger is about 3% smaller than other companies (tested), which makes the lithium battery more stable.
It also has several features to protect the lithium battery, such as micro-charging at low voltage intervals and multi-stage current boosting.

◇ In particular, we recommend using Tabos lithium batteries in pairs with Tabos chargers.

4) Tabos charger instructions

Purpose	Model Name	Contents	Features	Authentication/Remarks
300W Class For normal AC power (AC220V)	TC-7S10A-S	For 7S / 10A, For 25V batteries	Low charge current ripple, Charging current stage low high frequency noise, Short circuit/reverse short circuit protection ,Precharging, Monitoring Current output when unconnectedX.	CE, KC
700W Class For normal AC power (AC220V)	TC-700W-25V24A TC-700W-50V12A	25V, 50V For batteries	(Hire by default for above functions) [Optional]: Equip two-way communication for automation systems	Authentication In Progress

1,500W Class For normal AC power (AC220V)	TC-1500W-25V45A	For 25V batteries	(Hire by default for above functions) Voltage and current indicators, Charge Current Control Switch ---------- [Optional]: Equip two-way communication for automation systems	Authentication In Progress
	TC-1500W-50V25A	For 50V batteries		Authentication In Progress
3,000W Class For normal AC power (AC220V)	TC-3000W-25V90A TC-3000W-50V50A	25V, 50V For batteries	(Hire by default for above functions) But no display. Charge Current Control Switch ---------- for automated systems Built-in two-way communication device, (external input charge control, monitoring)	

Two-way radio functionality :

External control and RS232C, 485, and CAN communication with external control devices

Transmit externally commanded charge control (charge ON/OFF, current control) and status monitoring

9. Inverter and lithium battery lifespan, precautions for use

[Cautions when using the inverter as a battery load (changing battery DC voltage to AC220V)].

⚠ We recommend using direct current (DC) loads (i.e., not using an inverter load) whenever possible.

If the power (W) used by the inverter is large compared to the battery size (Wh), the battery cell life will decrease dramatically. It is recommended that the battery size (Wh) is at least 10 times the inverter power (W).

We recommend using a direct current (DC) load without using an inverter load (i.e., without using an AC load) whenever possible.

The reason is that the battery current is applied to the battery cell in the form of a shock wave due to the presence of significant ripple, which is believed to cause damage to the coating material on the positive and negative electrodes of the lithium battery cell.

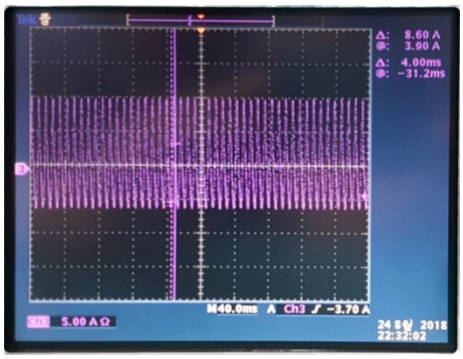
The shockwave ripple of the battery load current and the accompanying pulsatile voltage [V(t)=L*di/dt] can damage the coating materials (Ni-Mn-Co-Li oxide and graphite particles) of the anode and cathode of a Li-ion battery, shortening its lifetime and causing an imbalance in the characteristics of the battery cell, and can also degrade the performance of the battery management system (BMS) of a Li-ion battery, causing safety issues.

This is something we've noticed over the eight years we've been collecting data on the lifetime of lithium batteries and inverters.

With inverter loads that have a large load power relative to the battery size, there are cases of failures in months~ to two years.

Commercially available inverters, whether sinusoidal or quasi-sinusoidal, have a significant amount of ripple in the DC current supplied from the battery side (see measurements below). This means that if your inverter draws 200W of power, your battery will last about 2,000Wh.

However, even under the above conditions, most inverters on the market have a shockwave-like ripple in the current supplied by the battery, which reduces their lifespan compared to using a direct current load.



[Example photo at left: inverter battery current measurement].
* Test machine: 1000VA sinusoidal inverter / input 48VDC
* Test condition: 500W load-side power pull on the inverter
* Measure current: Battery→ Measure inverter supply DC current waveforms

*** Analyze：**
When the supply current from the battery is 8 A, the ripple current

10. Other cautions for use

⚠ This lithium battery is not waterproof. Do not allow moisture to enter. Moisture will cause failure.

⚠ Cautions for using the battery status communication port (BMS communication port)

The Tabos BMS communication device has a certain degree of noise resistance by applying filters and photocouplers to reduce the noise level entering the battery from the charger and load stage, but if the noise generated by the charger and load stage exceeds a certain level, BMS communication failure due to noise may occur. In such a case, you must take measures against noise at the charger and load stage. For reference, there is no noise generation at the charging stage when applying the Tabos charger.

⚠ Be Careful When Sizing Battery Output Wires

The commonly used method of sizing the wire between the battery and the end load by the wire thickness versus the allowable current value is not reasonable.
If the wire is insufficiently thick or the length of the wire is long, the current flowing will cause a voltage drop.
If this voltage drop is large, the voltage supplied to the load connected to the wire will be low, even if the battery is sufficient.
Especially during maneuvers that require a lot of instantaneous peak current, a small wire thickness can result in a large voltage drop that prevents the vehicle from even starting.
Make sure that the battery output wires (charging or discharging) are thick enough. Thin wires can cause the wire temperature to rise and cause a fire. (High current can cause overheating and fire.)

⚠ Recommended battery cell self temperature range when charging: 0 to 45℃ / The closer to room temperature, the longer the lifespan.
Cycling: As a rule of thumb, charging in sub-zero weather is possible if the charge C-rate is 0.05C or less.

⚠ Recommended battery cell self-temperature range at discharge: -20 to 60℃ / The closer to room temperature, the longer the lifespan.

⚠ Ideal recommended storage temperature range: -20 to 60℃ / For long-term storage, the closer you keep it to room temperature, the longer it will last.

⚠ Elevated temperatures can reduce battery life and are dangerous, so be sure to keep the device well ventilated.

⚠ Do not utilize and wire in any form other than the uses/methods described in the user manual.

⚠ Flame and high temperature caution, do not place in fire.

⚠ Do not disassemble, do not shock, and do not punch.

11. Efficient use of chargers and charging characteristics

Why it takes longer to charge than calculated and how to avoid it.
Or the battery's state of charge (SOC) value after charging is lower than expected.
Why and how to prevent it

(1) Understand the behavior of charging stages :

**(Charge_step_1) / CC (Constant Current) mode charging:

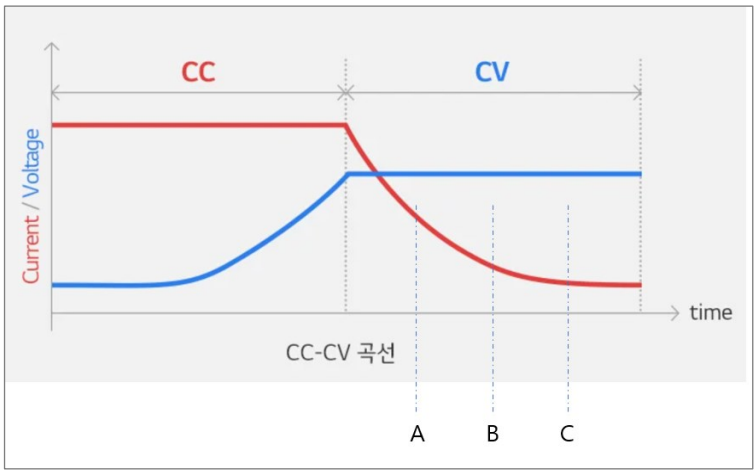
The Li-ion charger will charge to the set maximum charge current value as it starts charging.

**(Charge_step 2) / CV (Constant Voltage) mode charging:

As charging continues in CC mode, at some point the battery voltage will approach the set maximum charge voltage. The charger automatically reduces the charging current to avoid exceeding the set maximum charge voltage.

**(Charge_step 3) / Ends charging at a suitable point during CV mode:

CV mode charging will continue to reduce the charging current and stop charging when it drops to the charger's programmed shutdown current value. Alternatively, the user can force the charger to stop charging at any of the above stages.



Note :
If you stop charging while charging, the :

The voltage after stopping will be lower compared to the voltage during charging (voltage drop). The higher the resistance of the charging circuit and the higher the charging current, the more severe this voltage drop is.
Therefore, terminating the charge at point A will cause more voltage drop than terminating the charge at point C. A large voltage drop indicates that there is not much charge left.

(2) Reasons and solutions for not fast charging :

◇ In "Charge_step 3" above, the size of the charged energy (SOC) is different depending on whether the end point of the charge is point A, B, or C.

In the graph, the area under the red (current) color affects the SOC value 1:1.
This means that disconnecting the charge quickly will result in a lower SOC value. Different charger manufacturers have different cutoff points.

◇ Theoretical charge time

For example, if you have a 100Ah battery and your charger has a charge current of 50A, you can use the

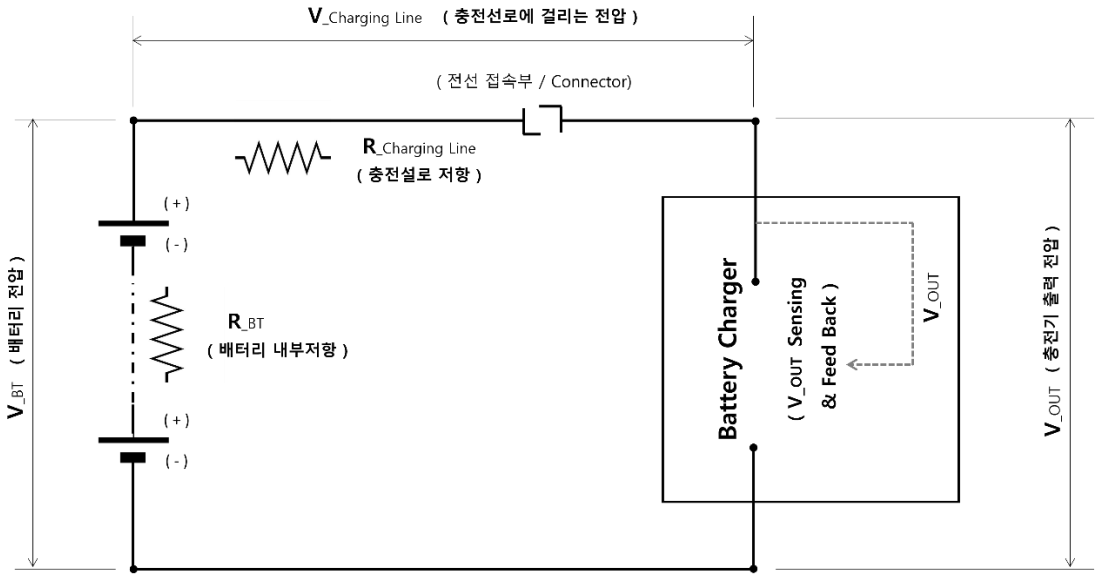
The theoretical charging time (full discharge→ full charge) is

= Lithium battery current capacity (Ah) / charger charging current (A) x correction factor (1.2)

= 100Ah / 50A * 1.2 = 2.4 hours

◇ Why it takes longer than the theoretical charging time :

The larger the resistance of the charging line between 'Charger <--> Battery' (R_Charging Line), the higher the voltage rise on the line (V_Charging Line) and consequently the higher the charger output voltage V_OUT.



$$V\_OUT = (V\_Charging\ Line) + (V\_BT)$$

The charger senses the voltage just before the charger output connector and recognizes it as the battery voltage.

The voltage rise on the track itself is added to the battery voltage and becomes the voltage at the charger output. In this case, the charger will think that the battery voltage is high even if the battery voltage is low and charge in CV mode, which reduces the current. As a result, the charging time will be longer.

Let's analyze the case where the line resistance is large and the charging current is also large, resulting in a voltage rise of 3V on the charging line.

For example, let's say your charger has a full charge pressure setting of 58V.

V_OUT = (V_Charging Line) + (V_BT) = 58V = 3V + 55V

The charger sees the battery voltage as 58V, even though it is at 55V, and reduces the charging current.
(In the Charge_stage_3 graph above, the CC interval is shortened, resulting in longer charging time.)
For this reason, it takes longer to charge.

◇ Bottom line: use as thick a wire as possible for the charging wire, and use a large enough capacity for the connection connector –→ to reduce the resistance across the line.