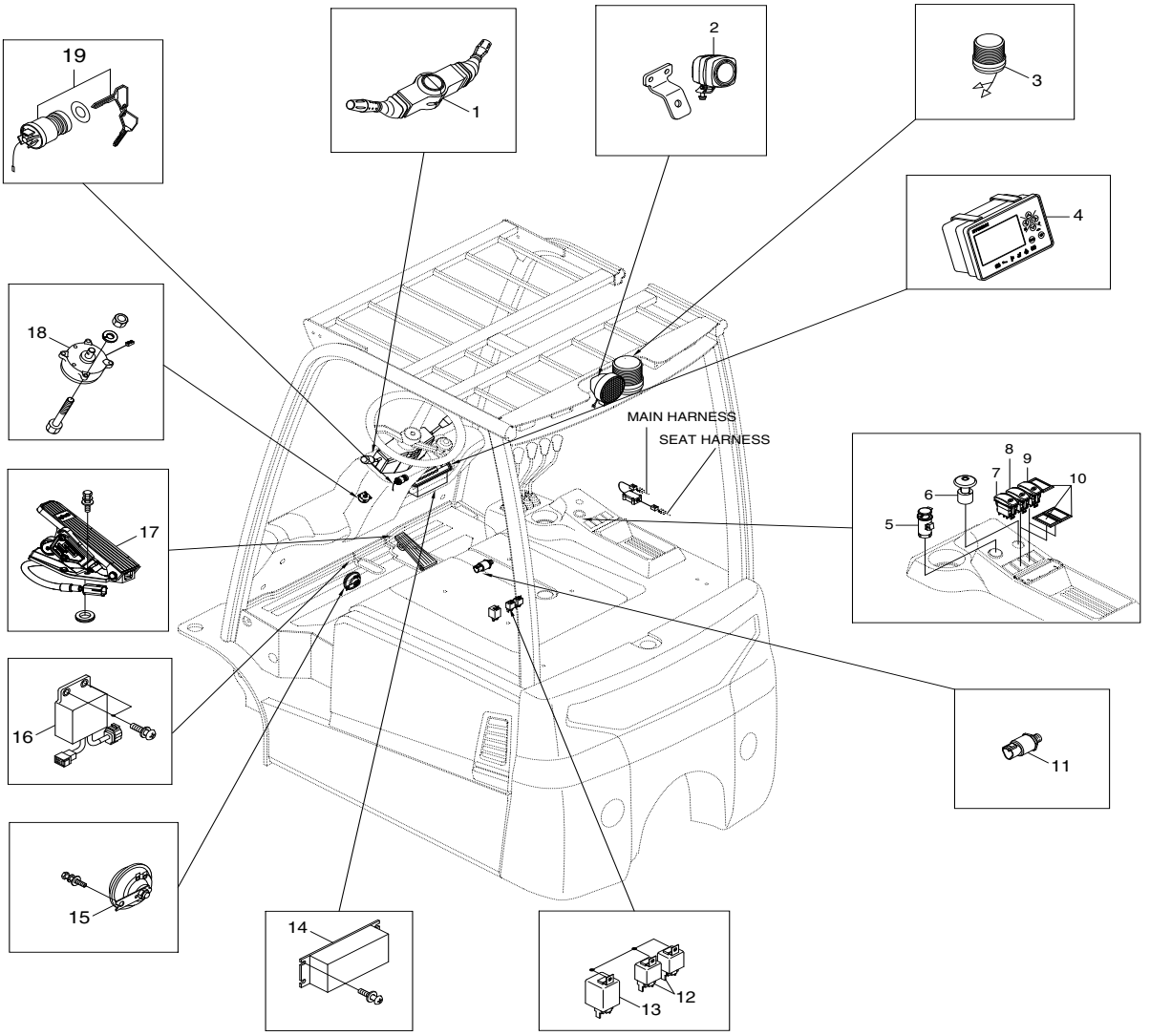
SECTION 7 ELECTRICAL SYSTEM

GROUP 1 COMPONENT LOCATION

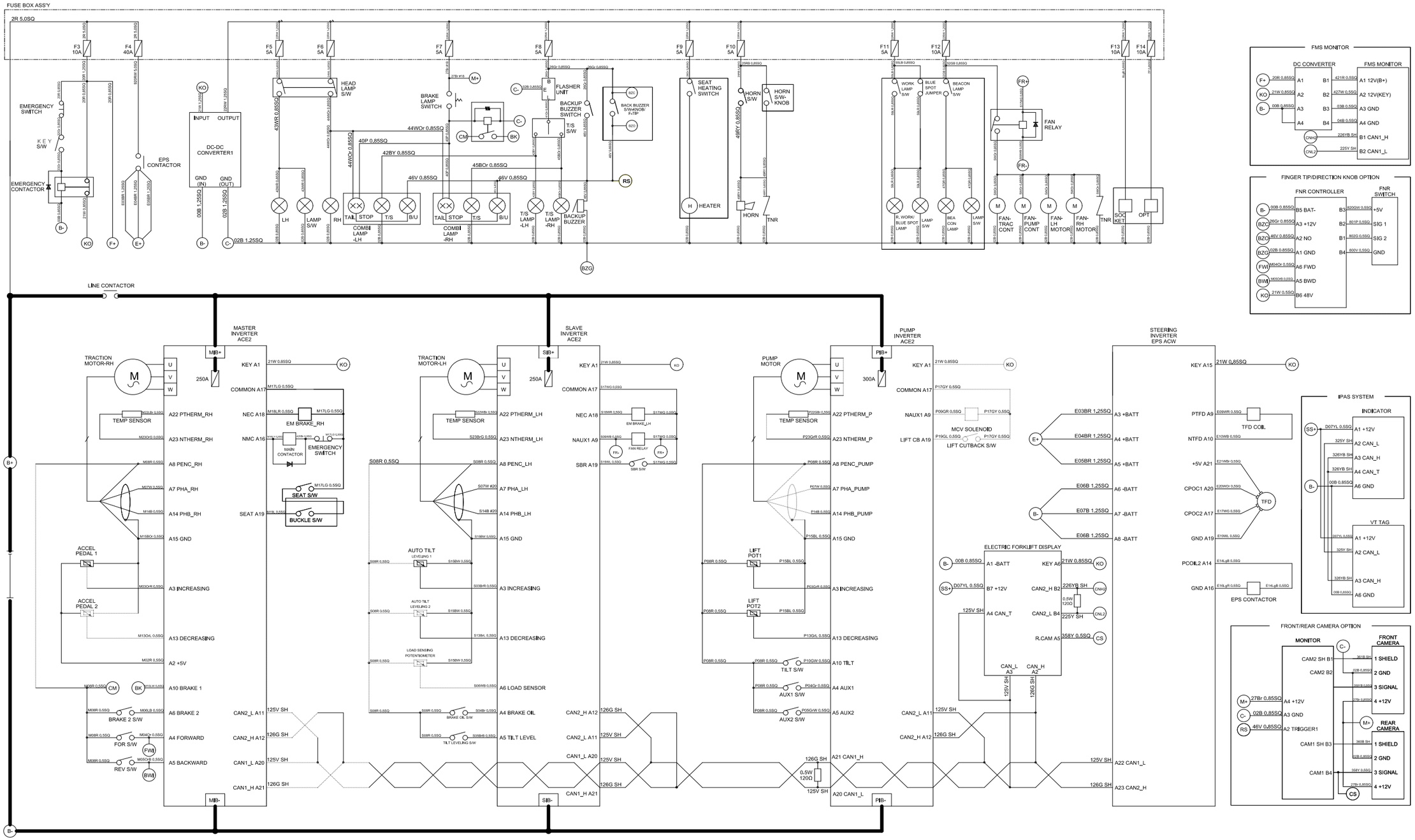


15BT9USM0701

1	Combination switch	8	Rear work lamp switch	14	Dc-Dc converter
2	Blue spot light	9	Beacon lamp switch	15	High horn
3	Beacon lamp	10	Panel plug	16	FNR controller
4	Display	11	Pressure sensor	17	Accelerator assy
5	Socket assy	12	Relay	18	TFD sensor
6	Emergency switch assy	13	Flasher unit assy	19	Key switch assy
7	Head lamp switch				

GROUP 2 ELECTRICAL CIRCUIT

·NON-UL MANUAL TYPE (15BT-9U : ~#89, 18BT-9 : ~#145, 20BT-9U : ~#179)



NOTE

1.B+ : BATTERY POSITIVE
B- : BATTERY NEGATIVE
C- : CONVERTER1 OUTPUT NEGATIVE
E+ : EPS CONTROLLER POSITIVE
KO : KEY SWITCH OUT
FR+: FAN RELAY POSITIVE

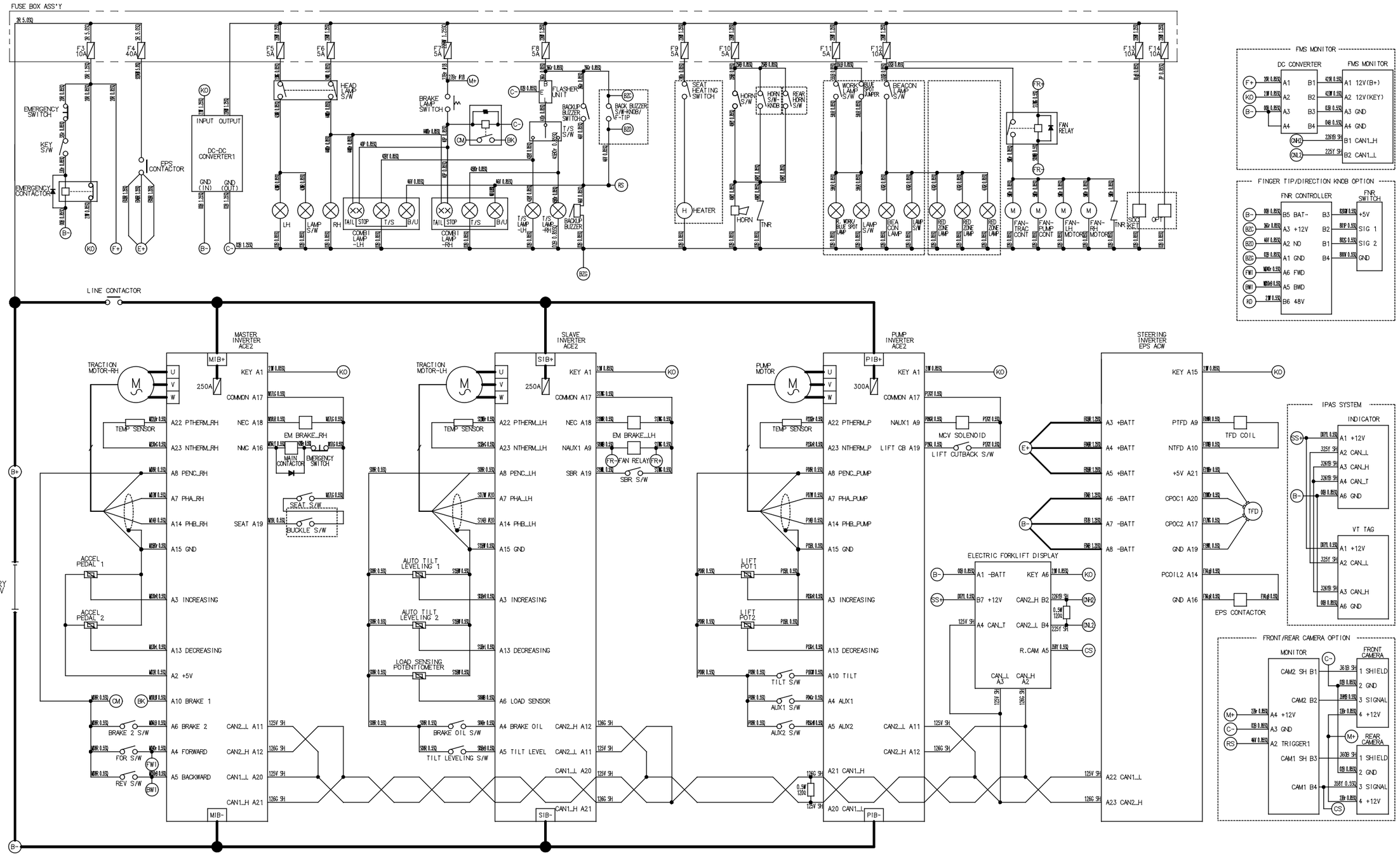
FR- : FAN RELAY NEGATIVE
M+ : MONITOR POSITIVE
F+ : FMS POSITIVE
CNH2: CAN HIGH_2
CNL2: CAN LOW_2
RS : REVERSE SIGNAL

BZC: BACK BUZZER COMMON
BZO: BACK BUZZER OUT
BZG: BACK BUZZER GROUND
FWI: FORWARD INPUT
BWI: BACKWARD INPUT
TDI: TRACTION DIGITAL INPUT COMMON

CS : CAMERA SIGNAL
SS+ : FINGERTIP SUB CONTROLLER POSITIVE
CM : CONTROLLER COMMON
BK : BRAKE SIGNAL
2. ▭ is optional item.
3. ⬭ is shield wire type.

21FY-90712

·NON-UL MANUAL TYPE (15BT-9U : #90~#227, 18BT-9 : #146~#396, 20BT-9U : #180~660)

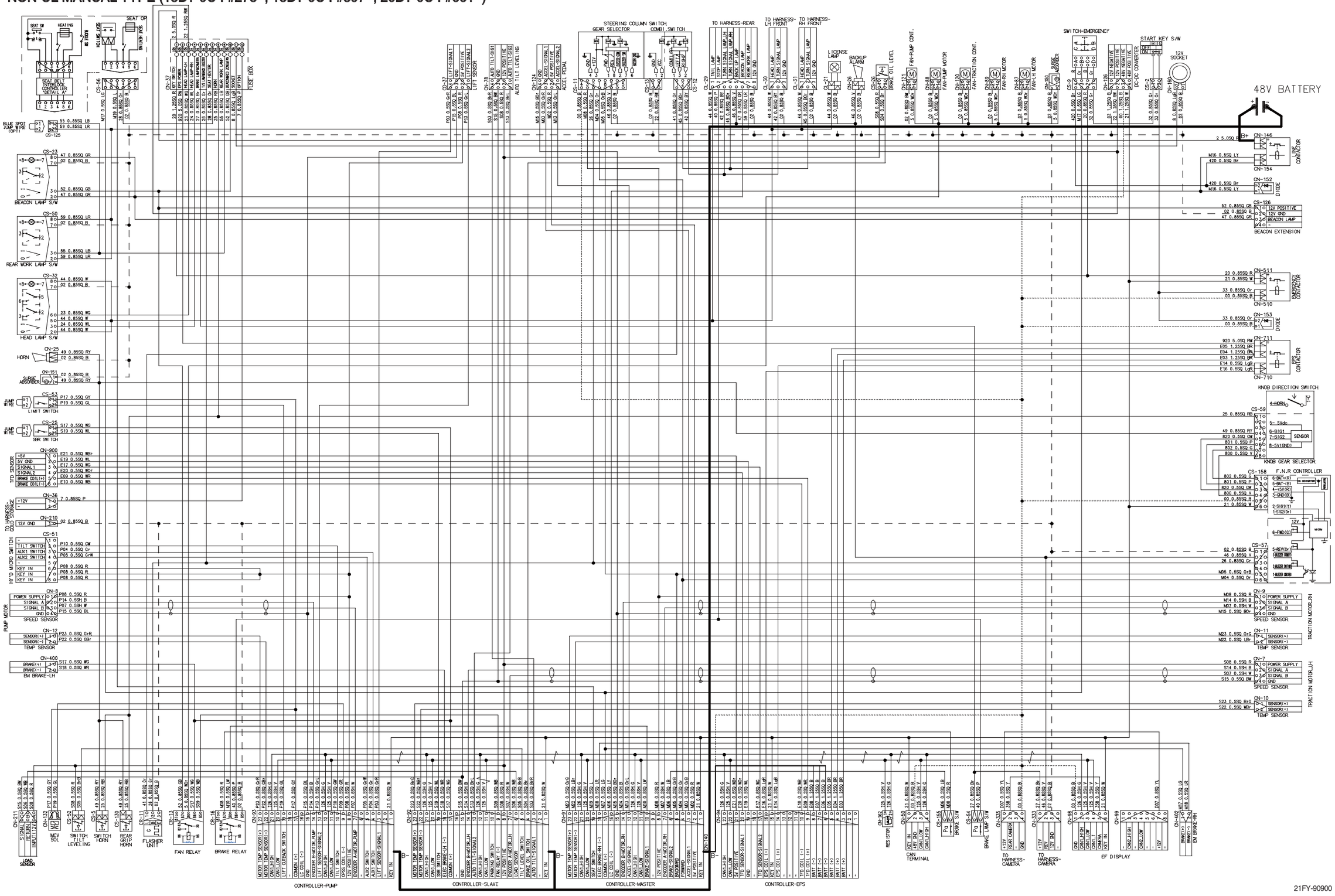


NOTE

1. B+ : BATTERY POSITIVE
   B- : BATTERY NEGATIVE
   C- : CONVERTER1 OUTPUT NEGATIVE
   E+ : EPS CONTROLLER POSITIVE
   KO : KEY SWITCH OUT
   FR+: FAN RELAY POSITIVE
   FR- : FAN RELAY NEGATIVE
   M+ : MONITOR POSITIVE
   F+ : FMS POSITIVE
   CNH2: CAN HIGH_2
   CNL2: CAN LOW_2
   RS : REVERSE SIGNAL
   BZC: BACK BUZZER COMMON
   BZO: BACK BUZZER OUT
   BZG: BACK BUZZER GROUND
   FWI: FORWARD INPUT
   BWI: BACKWARD INPUT
   TDI: TRACTION DIGITAL INPUT COMMON
   CS : CAMERA SIGNAL
   SS+ : FINGERTIP SUB CONTROLLER POSITIVE
   CM : CONTROLLER COMMON
   BK : BRAKE SIGNAL
2. [ ] is optional item.
3. <> is shield wire type.

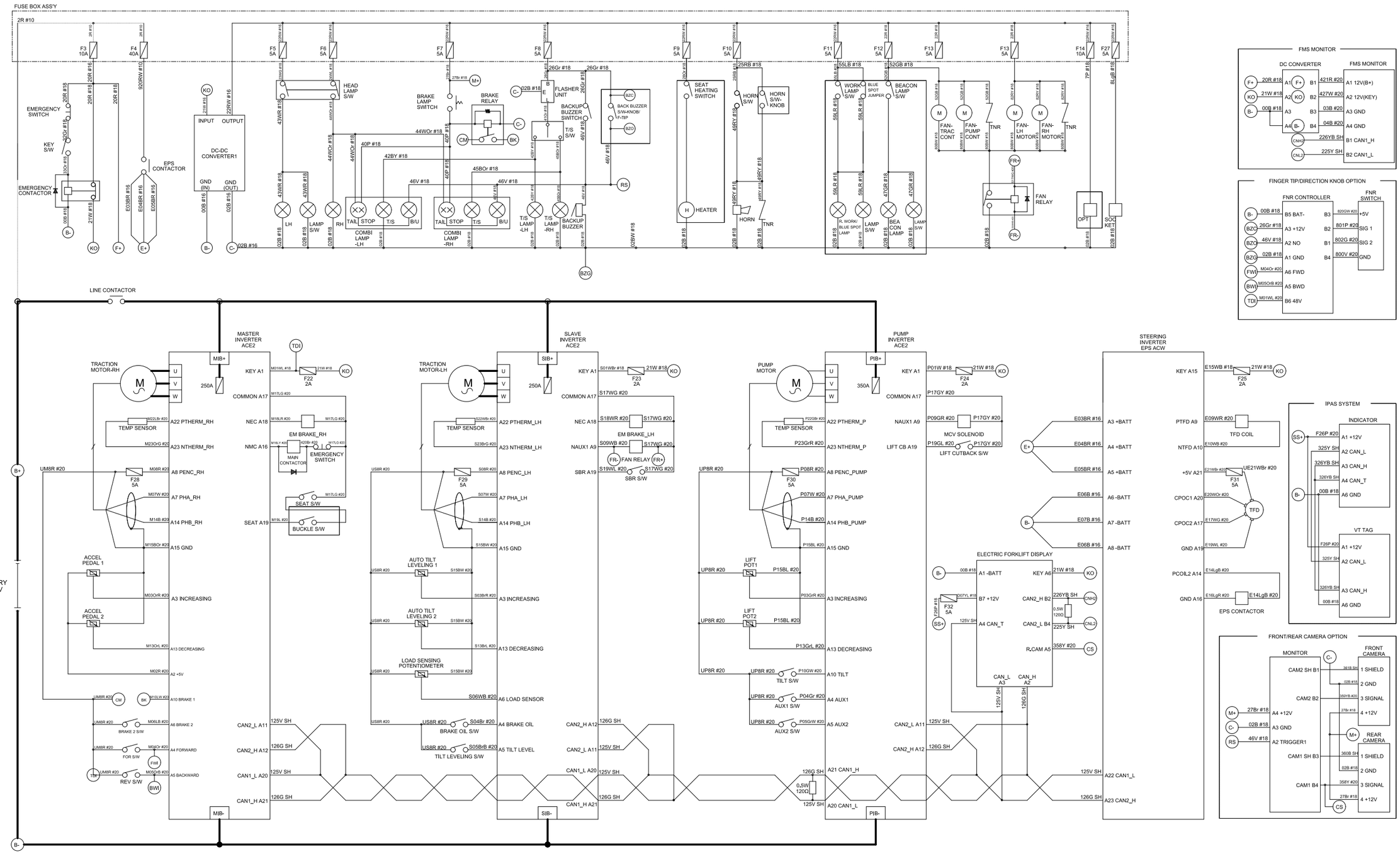
21FY-90714

·NON-UL MANUAL TYPE (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)



21FY-90900

·UL MANUAL TYPE (15BT-9U : ~#89, 18BT-9 : ~#145, 20BT-9U : ~#179)

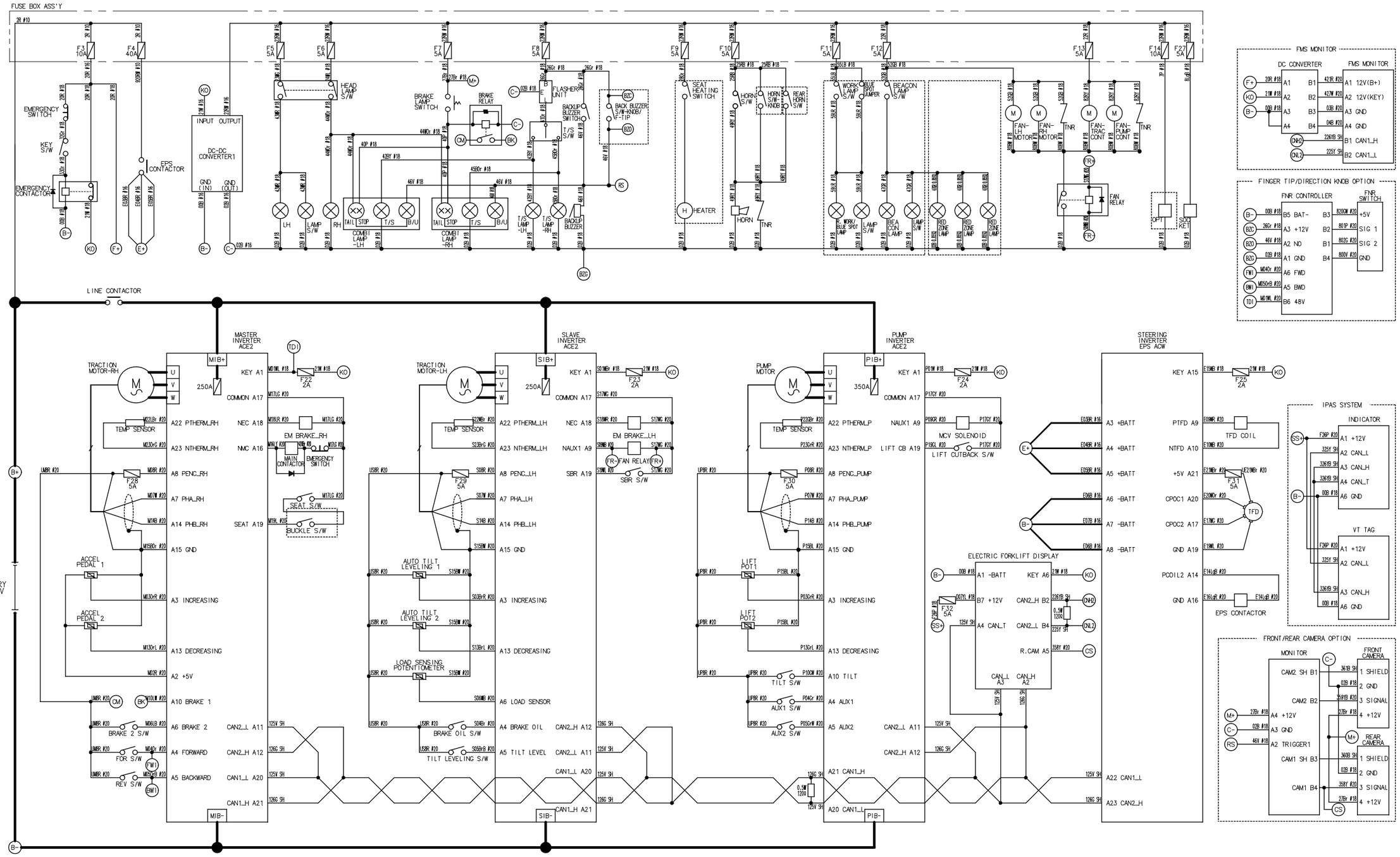


NOTE

1.B+ : BATTERY POSITIVE
B- : BATTERY NEGATIVE
C- : CONVERTER1 OUTPUT NEGATIVE
E+ : EPS CONTROLLER POSITIVE
KO : KEY SWITCH OUT
FR+: FAN RELAY POSITIVE
FR- : FAN RELAY NEGATIVE
M+ : MONITOR POSITIVE
F+ : FMS POSITIVE
CNH2: CAN HIGH_2
CNL2: CAN LOW_2
RS : REVERSE SIGNAL
BZC: BACK BUZZER COMMON
BZO: BACK BUZZER OUT
BZG: BACK BUZZER GROUND
FWI: FORWARD INPUT
BWI: BACKWARD INPUT
TDI: TRACTION DIGITAL INPUT COMMON
CS : CAMERA SIGNAL
SS+ ; FINGERTIP SUB CONTROLLER POSITIVE
CM : CONTROLLER COMMON
BK : BRAKE SIGNAL
2. ⋯ is optional item.
3. ⬭ is shield wire.

21FY-90611

·UL MANUAL TYPE (15BT-9U : #90~#227, 18BT-9 : #146~#396, 20BT-9U : #180~660)

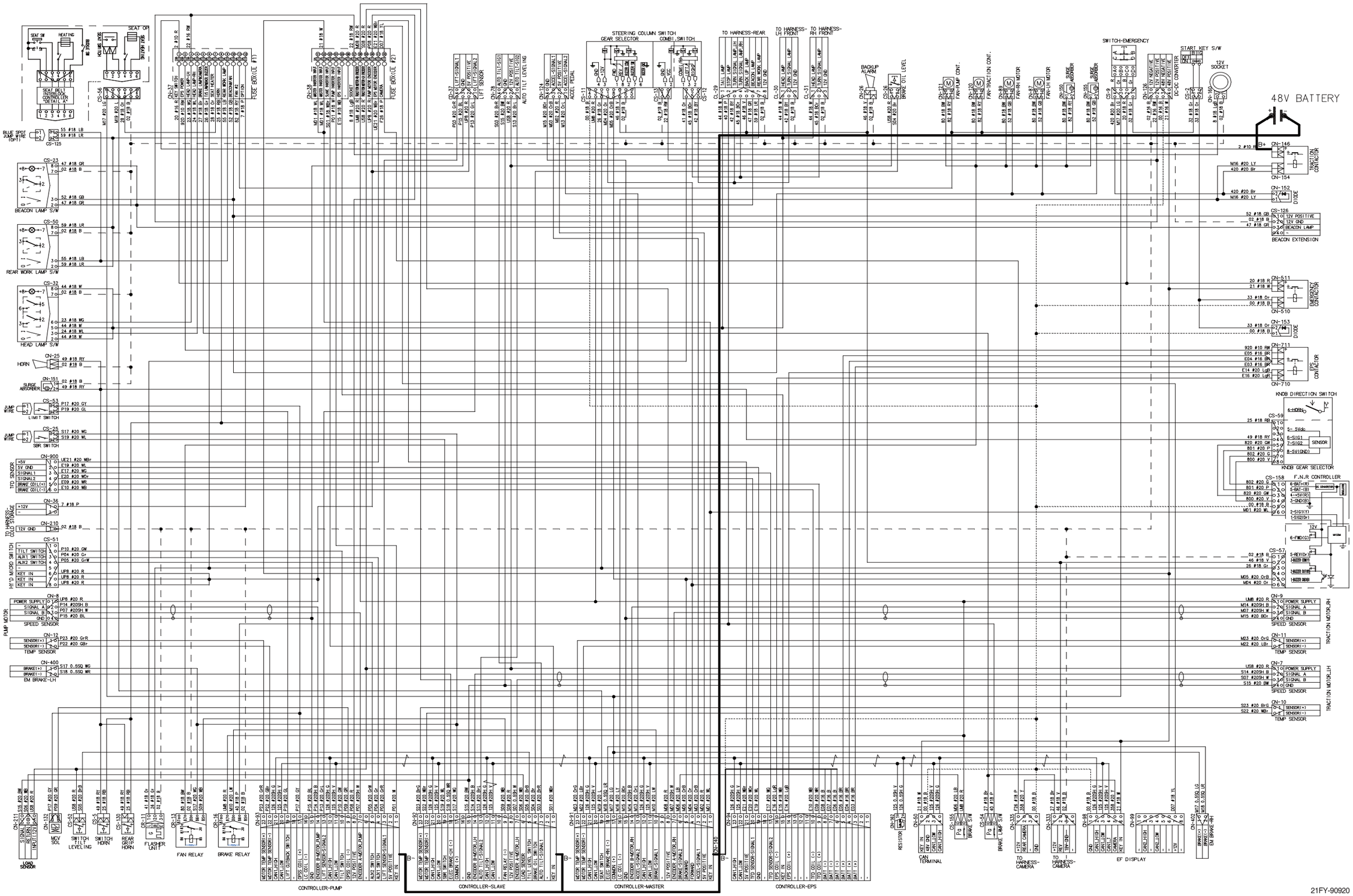


NOTE

1. B+ : BATTERY POSITIVE
   B- : BATTERY NEGATIVE
   C- : CONVERTER1 OUTPUT NEGATIVE
   E+ : EPS CONTROLLER POSITIVE
   KO : KEY SWITCH OUT
   FR+: FAN RELAY POSITIVE
   FR- : FAN RELAY NEGATIVE
   M+ : MONITOR POSITIVE
   F+ : FMS POSITIVE
   CNH2: CAN HIGH_2
   CNL2: CAN LOW_2
   RS : REVERSE SIGNAL
   BZC: BACK BUZZER COMMON
   BZO: BACK BUZZER OUT
   BZG: BACK BUZZER GROUND
   FWI: FORWARD INPUT
   BWI: BACKWARD INPUT
   TDI: TRACTION DIGITAL INPUT COMMON
   CS : CAMERA SIGNAL
   SS+ : FINGERTIP SUB CONTROLLER POSITIVE
   CM : CONTROLLER COMMON
   BK : BRAKE SIGNAL
2. [ ] is optional item.
3. <---> is shield wire type.

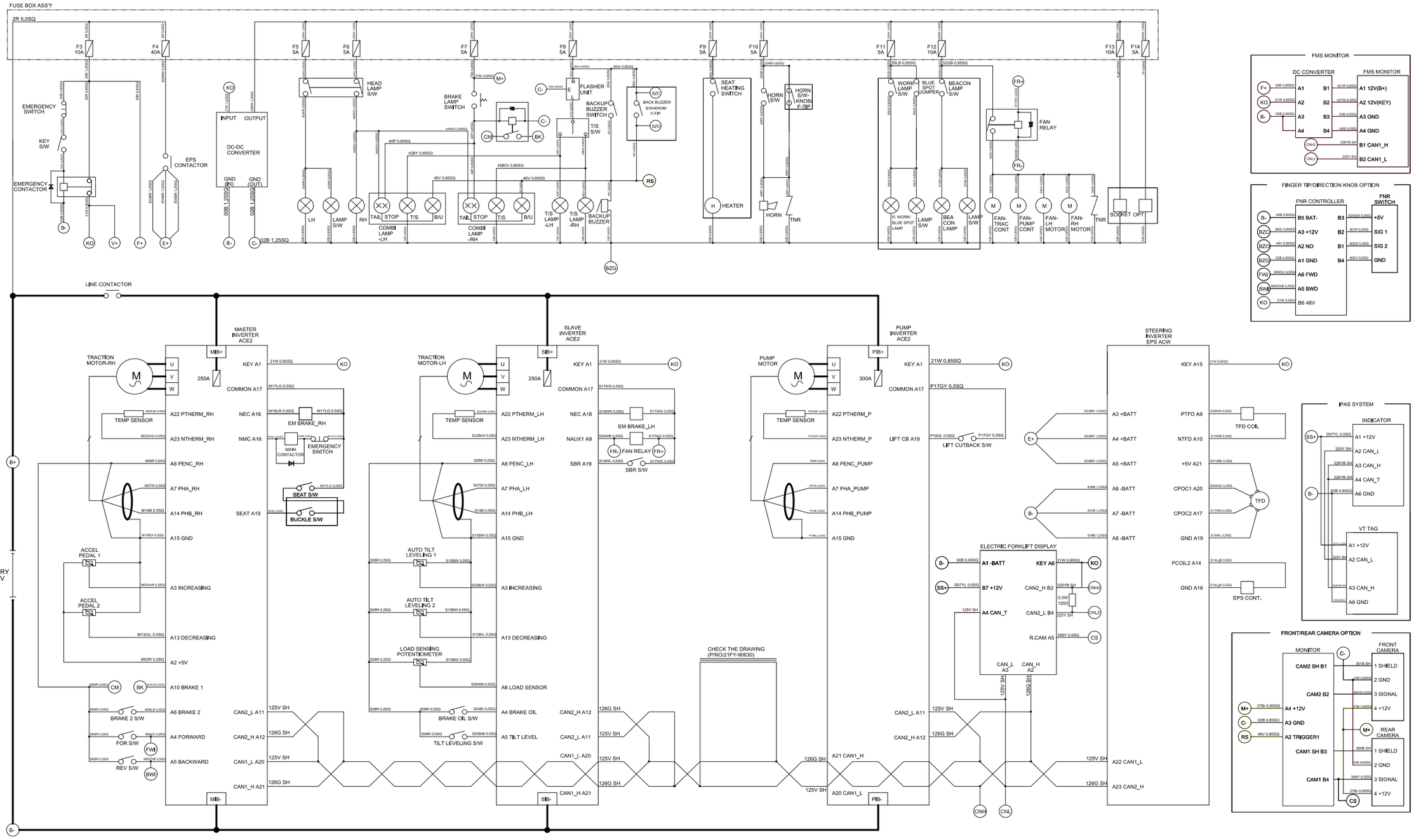
21FY-90613

·UL MANUAL TYPE (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)



21FY-90920

·NON-UL FINGERTIP TYPE (15BT-9U : ~#89, 18BT-9 : ~#145, 20BT-9U : ~#179)



NOTE

1.B+ : BATTERY POSITIVE
B- : BATTERY NEGATIVE
C- : CONVERTER1 OUTPUT NEGATIVE
E+ : EPS CONTROLLER POSITIVE
KO : KEY SWITCH OUT
FR+: FAN RELAY POSITIVE

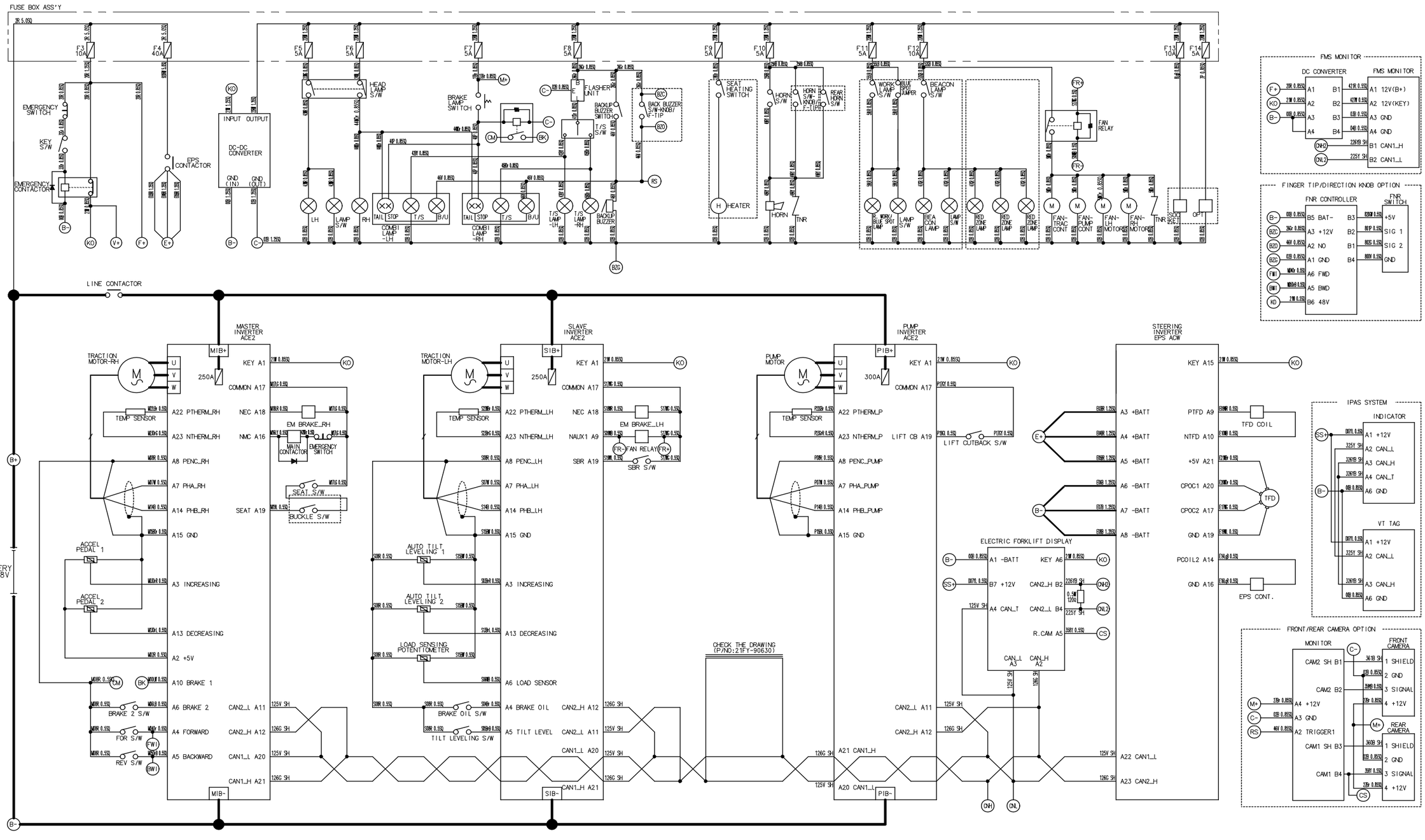
FR- : FAN RELAY NEGATIVE
M+ : MONITOR POSITIVE
F+ : FMS POSITIVE
CNH2: CAN HIGH_2
CNL2: CAN LOW_2
RS : REVERSE SIGNAL

BZC: BACK BUZZER COMMON
BZO: BACK BUZZER OUT
BZG: BACK BUZZER GROUND
FWI: FORWARD INPUT
BWI: BACKWARD INPUT
TDI: TRACTION DIGITAL INPUT COMMON

CS : CAMERA SIGNAL
SS+: FINGERTIP SUB CONTROLLER POSITIVE
V+ : VCM VALVE POSITIVE
CM : CONTROLLER COMMON
BK : BRAKE SIGNAL
2. ▭ Is optional Item.
3. ⬭ Is shield wire.

21FY-90722

·NON-UL FINGERTIP TYPE (15BT-9U : #90~#227, 18BT-9 : #146~#396, 20BT-9U : #180~660)

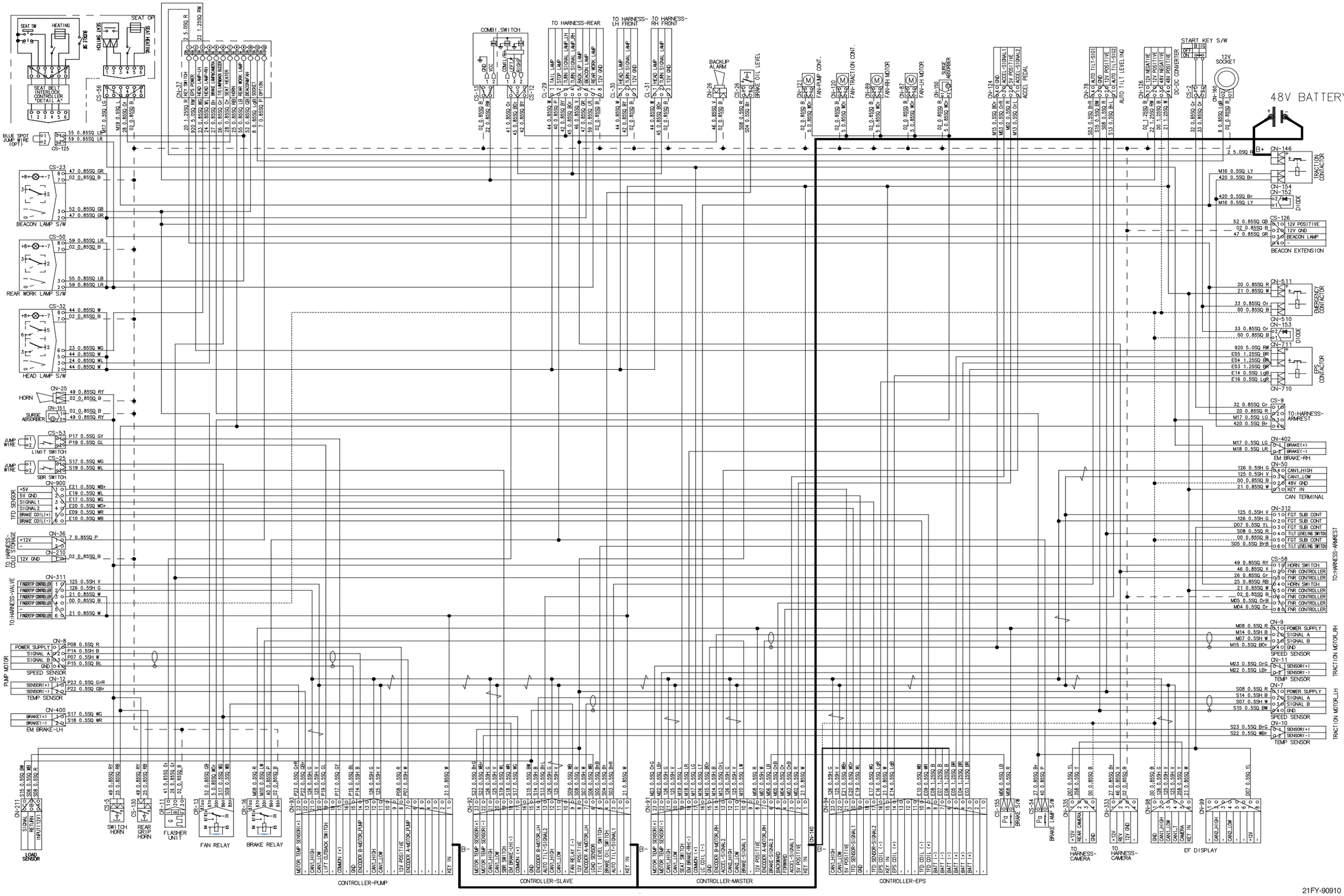


NOTE

1. B+ : BATTERY POSITIVE
   B- : BATTERY NEGATIVE
   C- : CONVERTER1 OUTPUT NEGATIVE
   E+ : EPS CONTROLLER POSITIVE
   KO : KEY SWITCH OUT
   FR+: FAN RELAY POSITIVE
   FR- : FAN RELAY NEGATIVE
   M+ : MONITOR POSITIVE
   F+ : FMS POSITIVE
   CNH2: CAN HIGH_2
   CNL2: CAN LOW_2
   RS : REVERSE SIGNAL
   BZC: BACK BUZZER COMMON
   BZO: BACK BUZZER OUT
   BZG: BACK BUZZER GROUND
   FWI: FORWARD INPUT
   BWI: BACKWARD INPUT
   TDI: TRACTION DIGITAL INPUT COMMON
   CS : CAMERA SIGNAL
   SS+: FINGERTIP SUB CONTROLLER POSITIVE
   V+ : VCM VALVE POSITIVE
   CM : CONTROLLER COMMON
   BK : BRAKE SIGNAL
2. [ ] is optional item.
3. < > is shield wire type.

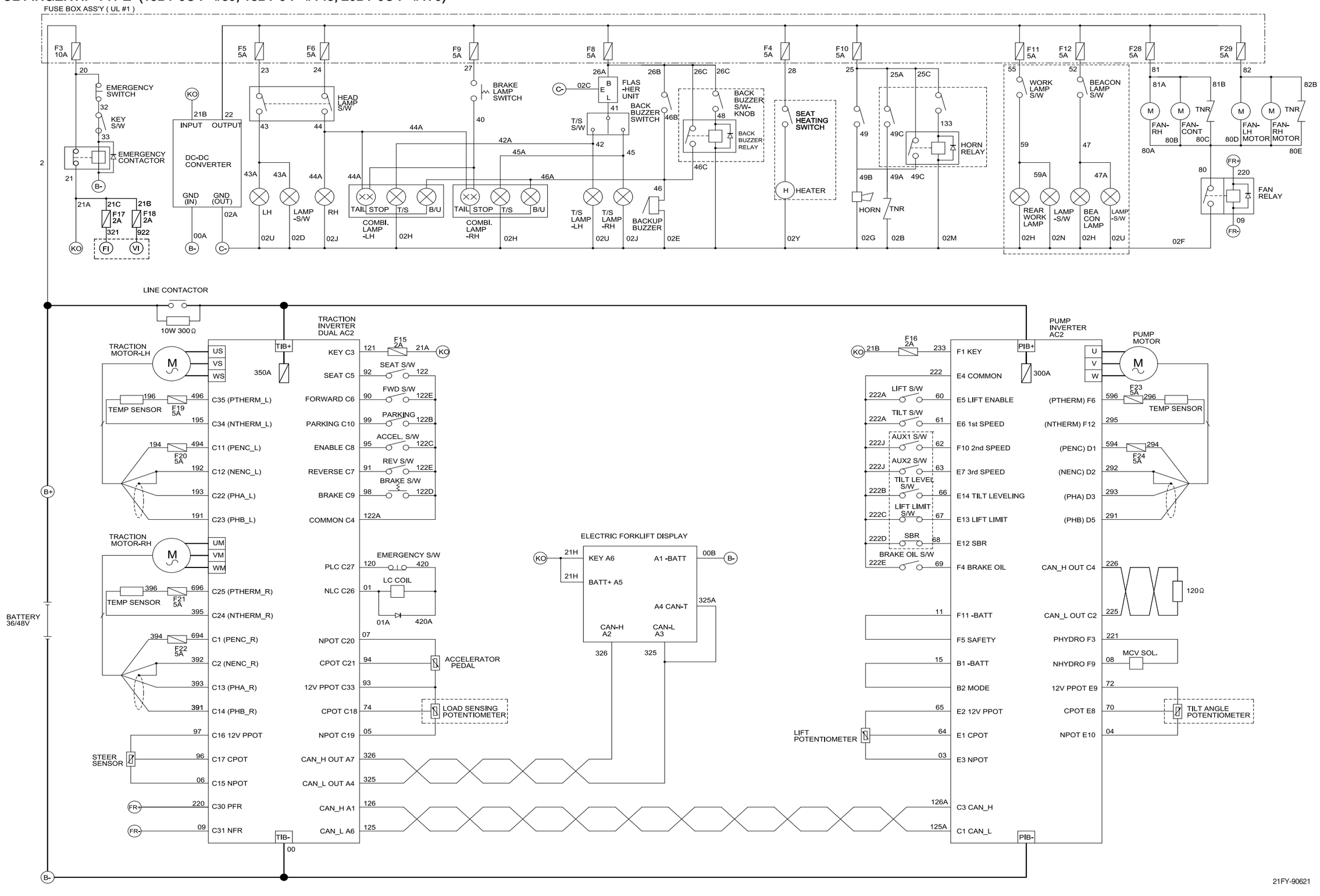
21FY-90724

·NON-UL FINGERTIP TYPE (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)

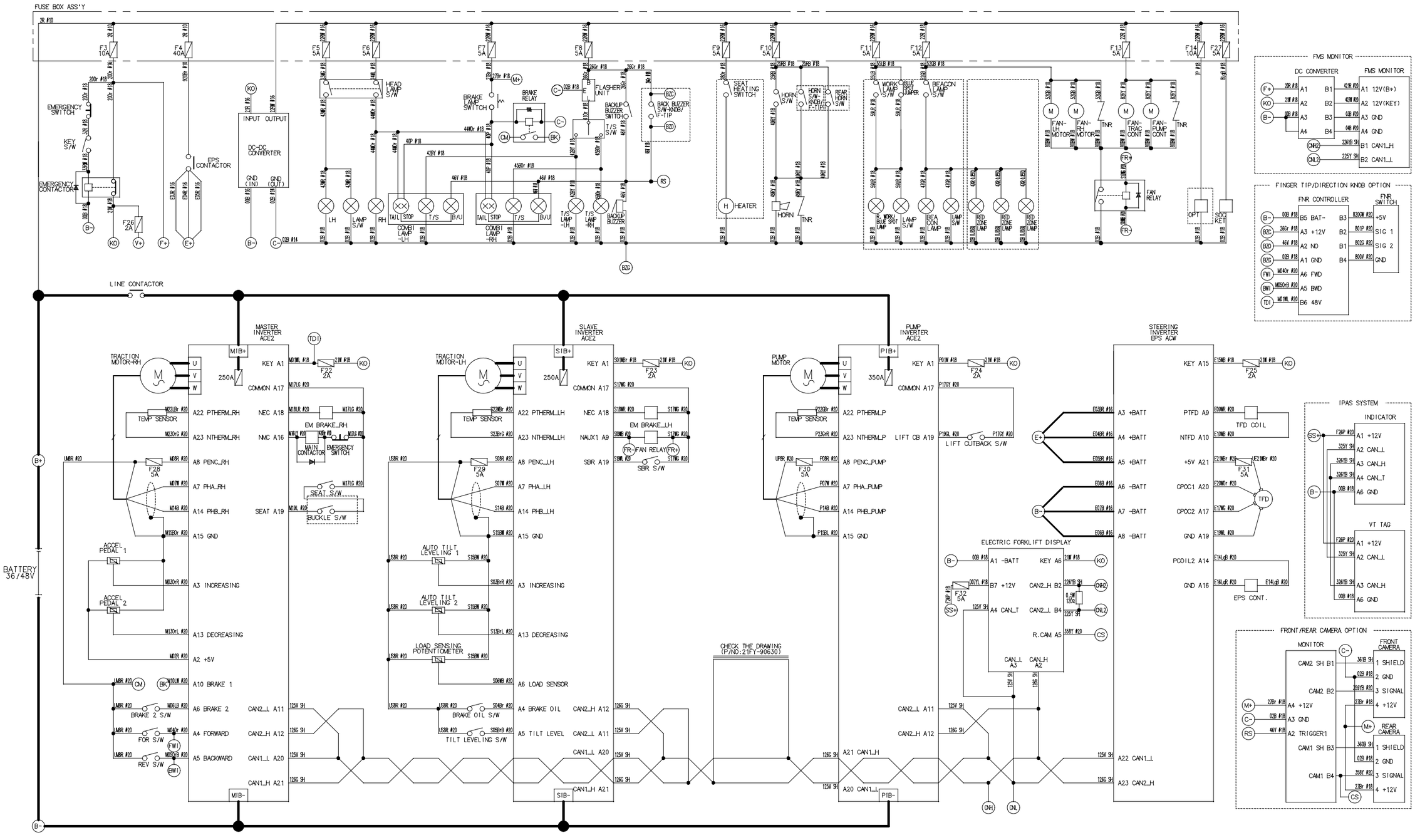


21FY-90910

·UL FINGERTIP TYPE (15BT-9U : ~#89, 18BT-9 : ~#145, 20BT-9U : ~#179)



·UL FINGERTIP TYPE (15BT-9U : #90~#227, 18BT-9 : #146~#396, 20BT-9U : #180~660)

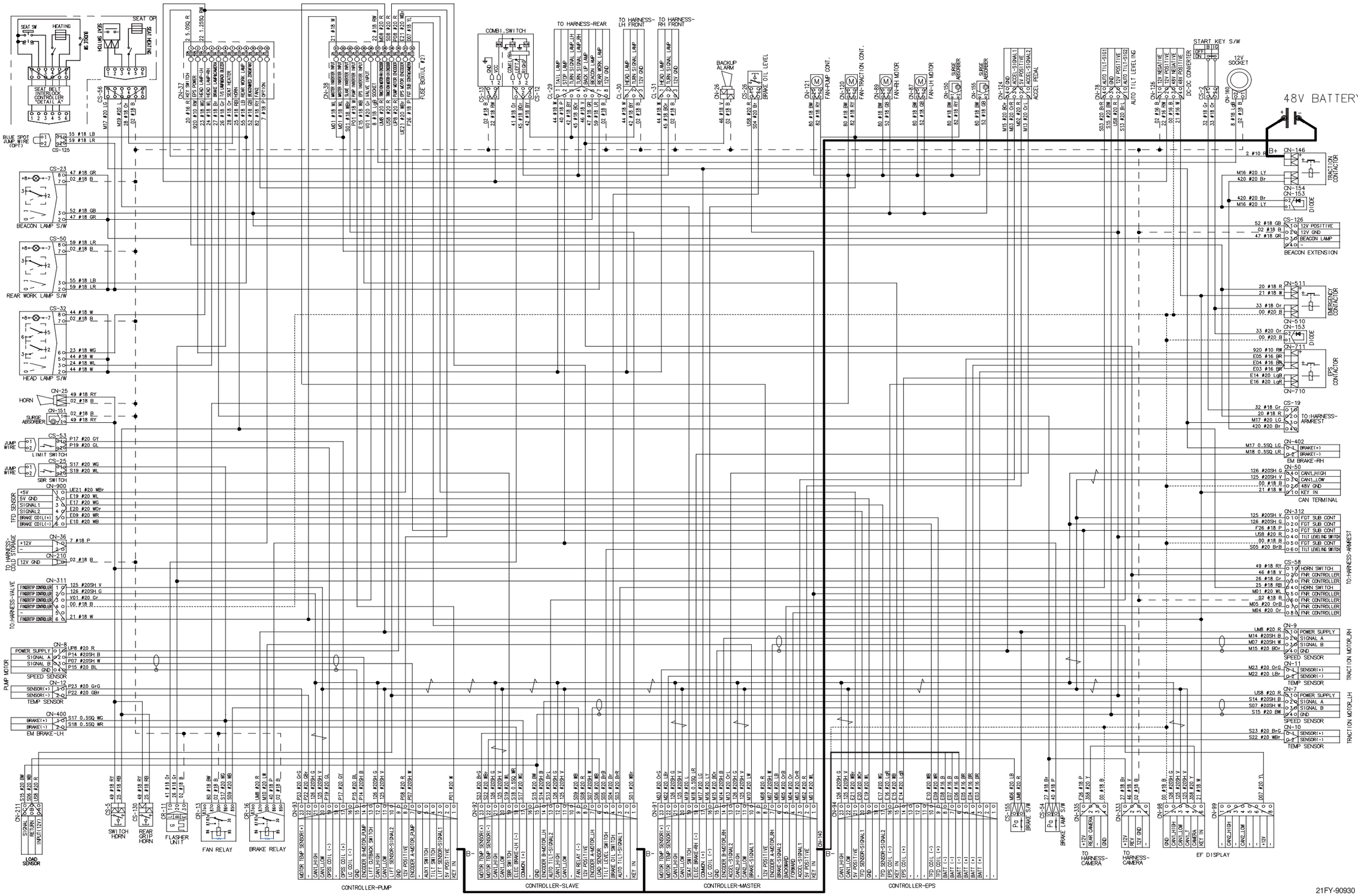


NOTE

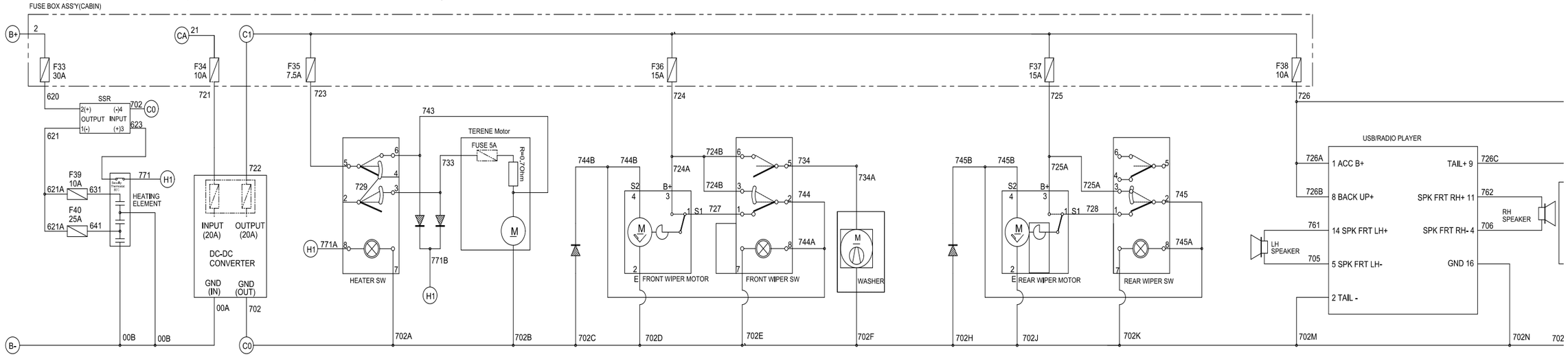
1. B+ : BATTERY POSITIVE
   B- : BATTERY NEGATIVE
   C- : CONVERTER1 OUTPUT NEGATIVE
   E+ : EPS CONTROLLER POSITIVE
   KO : KEY SWITCH OUT
   FR+: FAN RELAY POSITIVE
   FR- : FAN RELAY NEGATIVE
   M+ : MONITOR POSITIVE
   F+ : FMS POSITIVE
   CNH2: CAN HIGH_2
   CNL2: CAN LOW_2
   RS : REVERSE SIGNAL
   BZC: BACK BUZZER COMMON
   BZO: BACK BUZZER OUT
   BZG: BACK BUZZER GROUND
   FWI: FORWARD INPUT
   BWI: BACKWARD INPUT
   TDI: TRACTION DIGITAL INPUT COMMON
   CS : CAMERA SIGNAL
   SS+ : FINGERTIP SUB CONTROLLER POSITIVE
   V+ : VCM VALVE POSITIVE
   CM : CONTROLLER COMMON
   BK : BRAKE SIGNAL
2. [ ] **is optional item.**
3. <---> **is shield wire type.**

21FY-90623

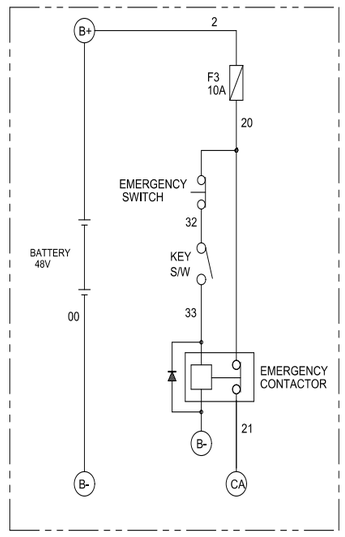
·UL FINGERTIP TYPE (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)



·CABIN (15BT-9U : ~#277, 18BT-9U : ~#396, 20BT-9U : ~#660)



* MAIN WIRING DIAGRAM *



NOTE

1.B+ : BATTERY POSITIVE

B- : BATTERY NEGATIVE

CA : CABIN ACCESSORY INPUT

C1 : CABIN CONVERTER POSITIVE

C0 : CABIN CONVERTER NEGATIVE

H1 : HEATER INPUT

2.WIRE NO. & COLOR

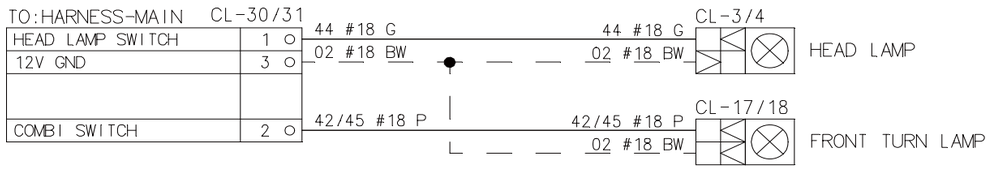
0:B 1:Br 2:R 3:Or 4:Y

5:G 6:L 7:Vi 8:Gr 9:W

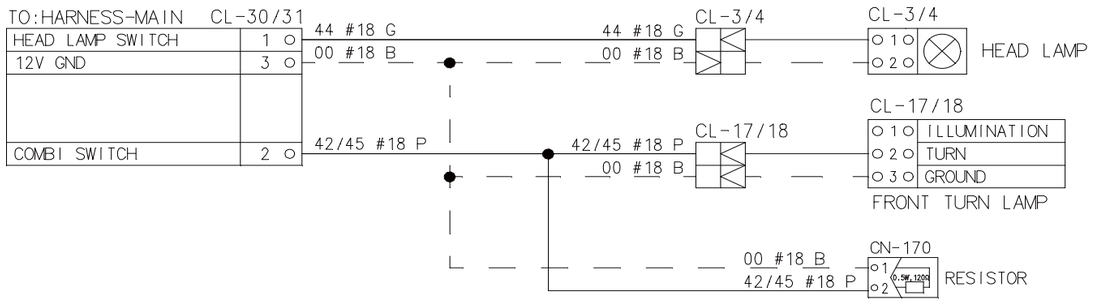
21FY-90770

·OHG (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)

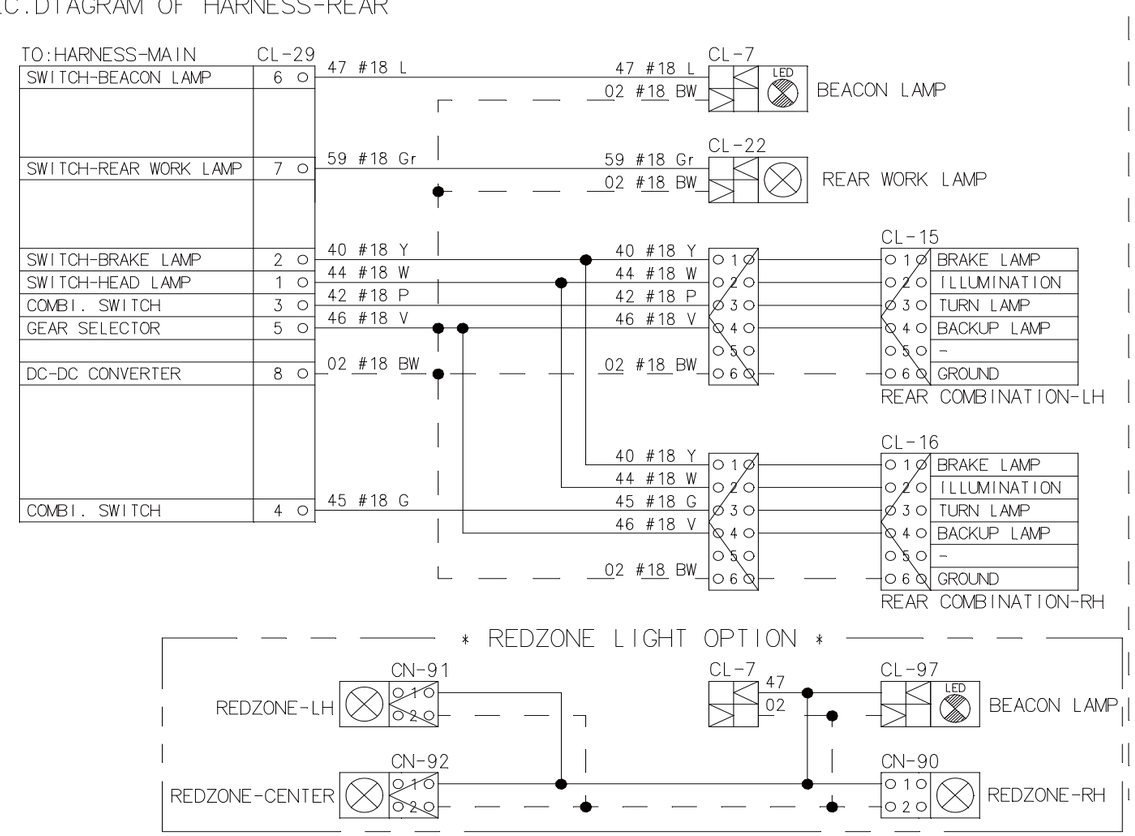
*ELEC.DIAGRAM OF HARNESS-FRONT LH/RH(HALLOGEN LAMP)



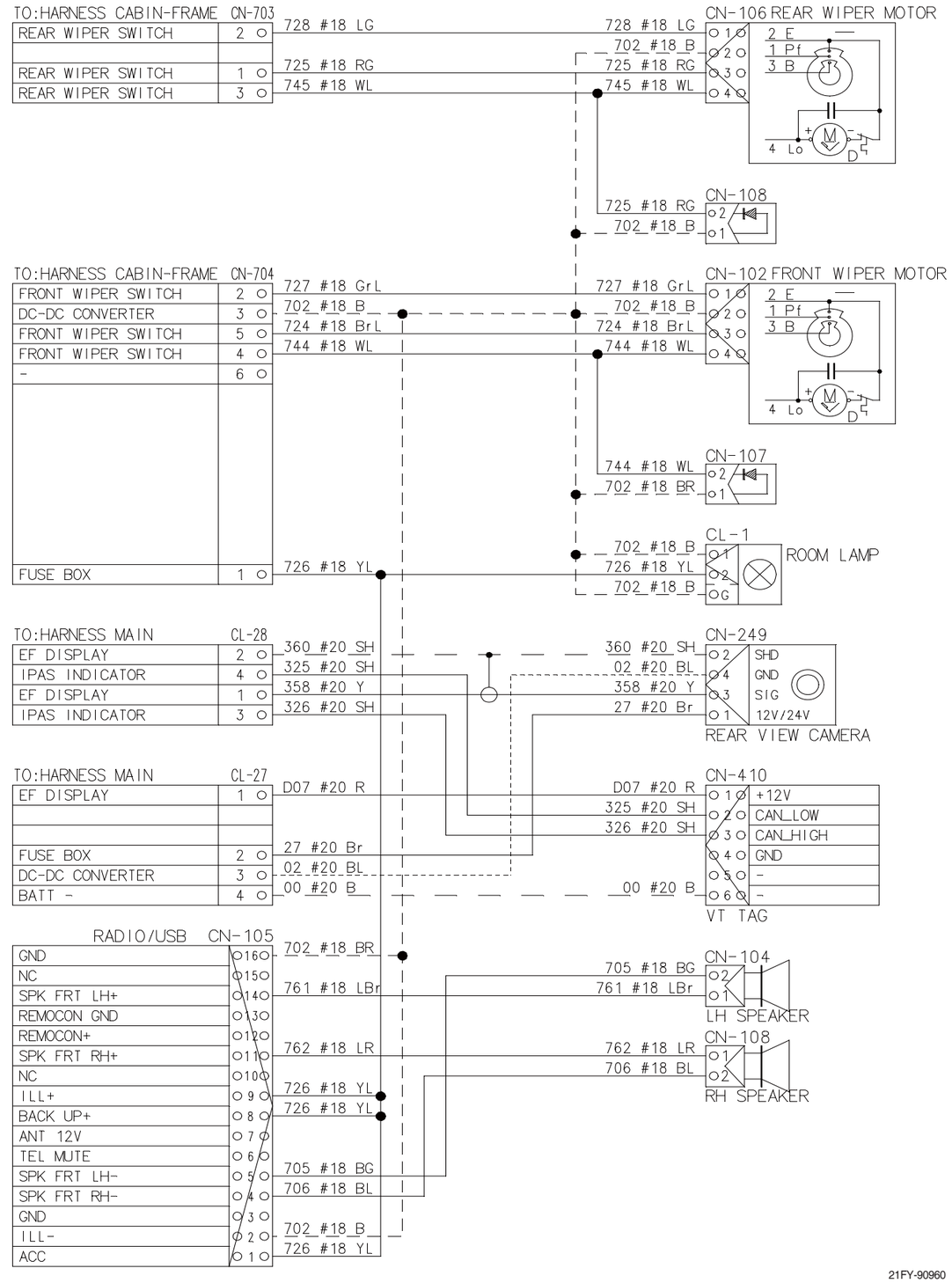
*ELEC.DIAGRAM OF HARNESS-FRONT LH/RH(LED LAMP)



*ELEC.DIAGRAM OF HARNESS-REAR

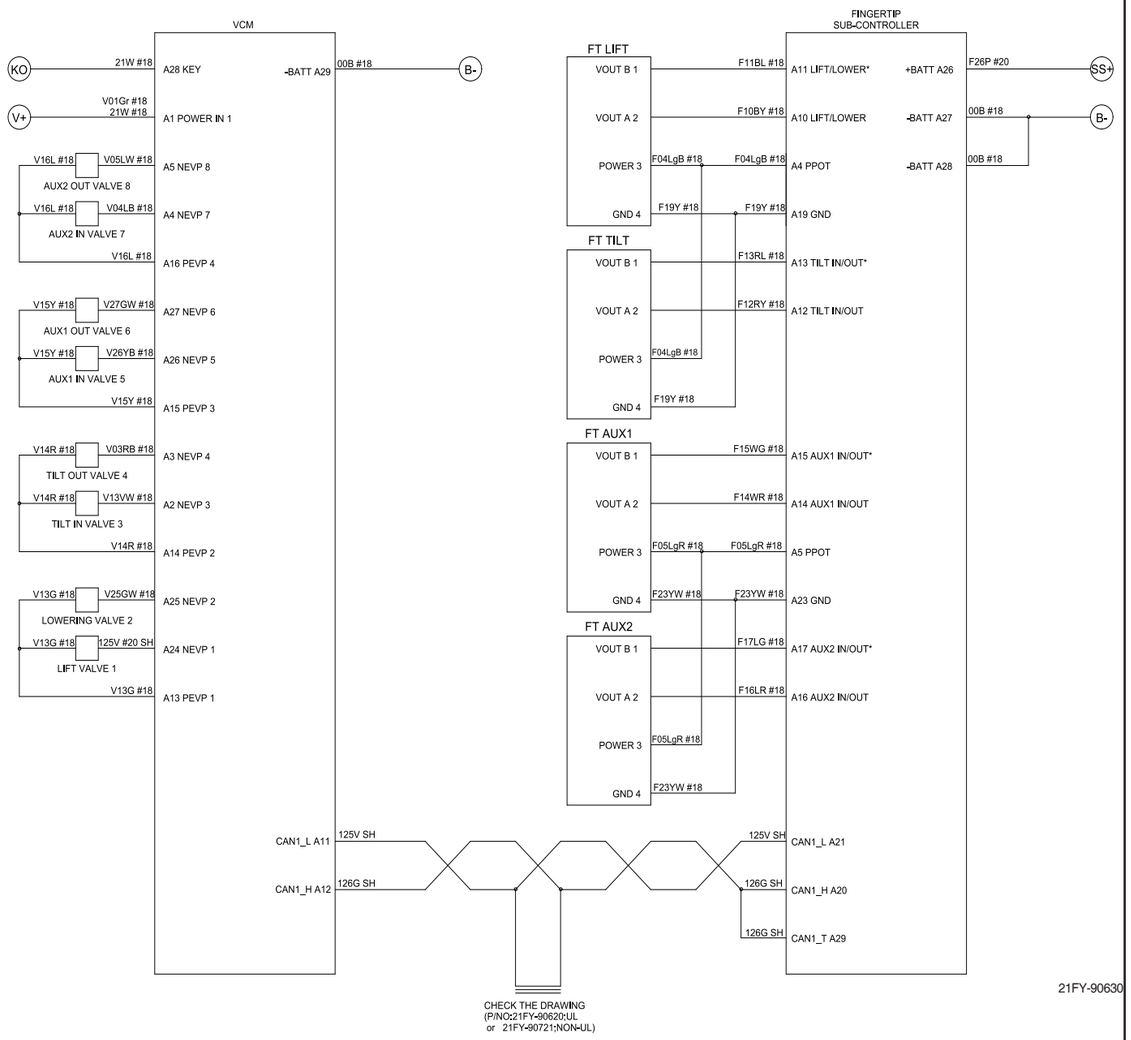


*ELEC.DIAGRAM OF HARNESS CABIN-OHG



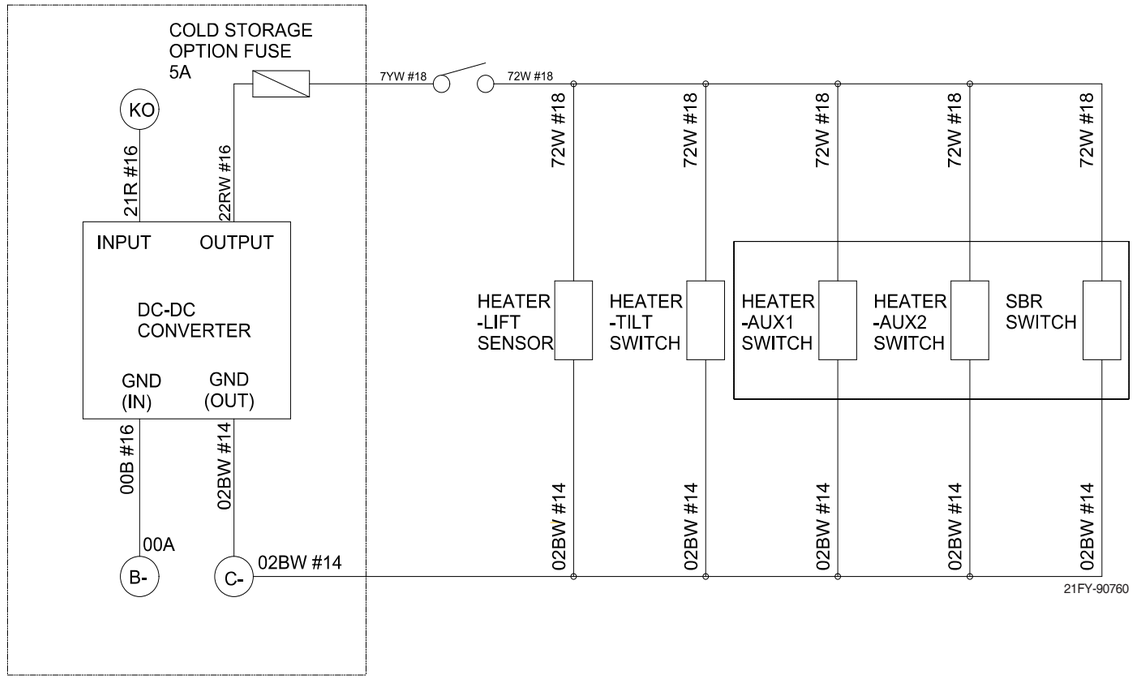
21FY-90960

·FINGERTIP (15BT-9U : ~#277, 18BT-9U : ~#396, 20BT-9U : ~#660)



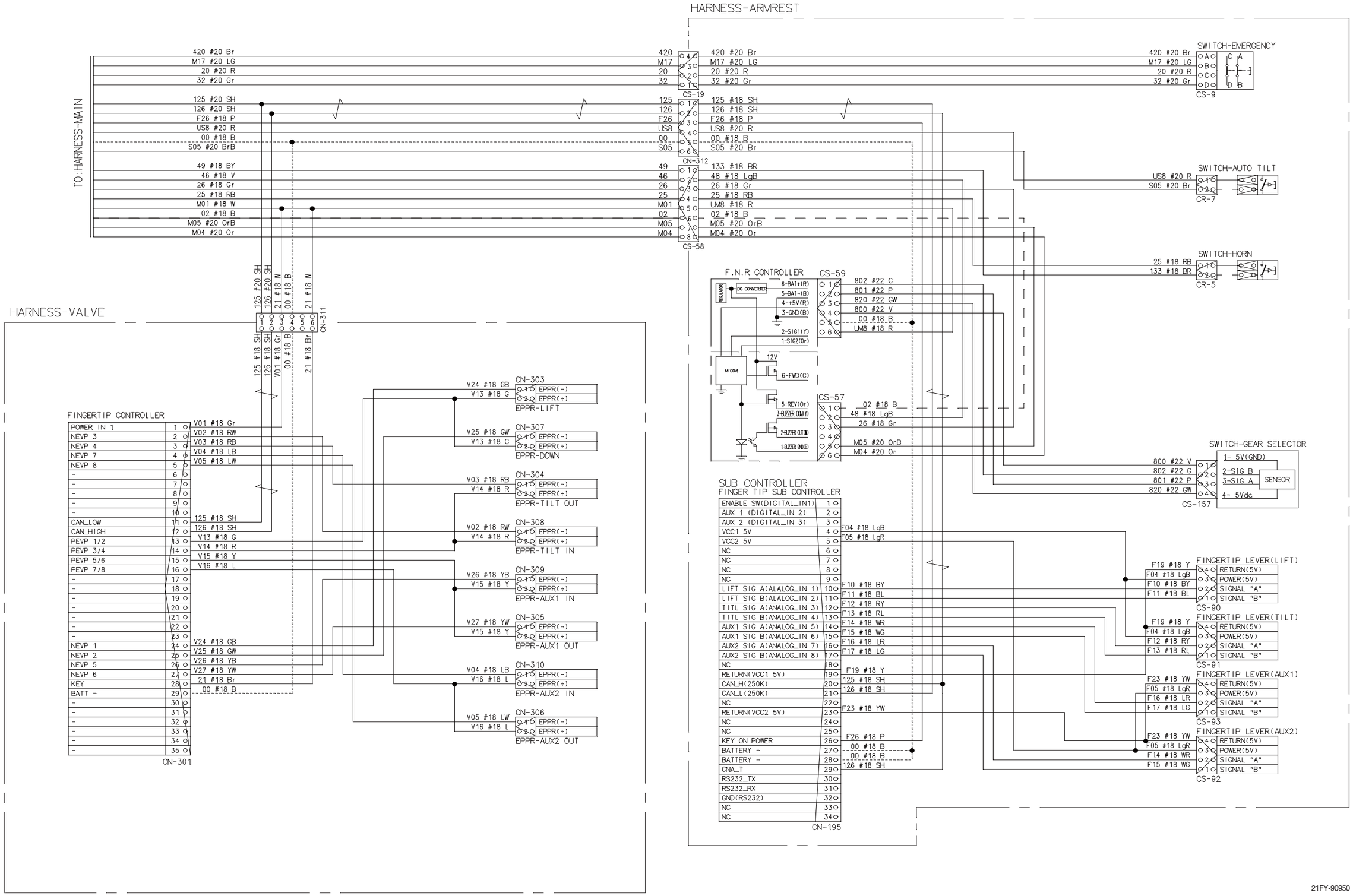
21FY-90630

·COLD STORAGE (15BT-9U : ~#277, 18BT-9U : ~#396, 20BT-9U : ~#660)



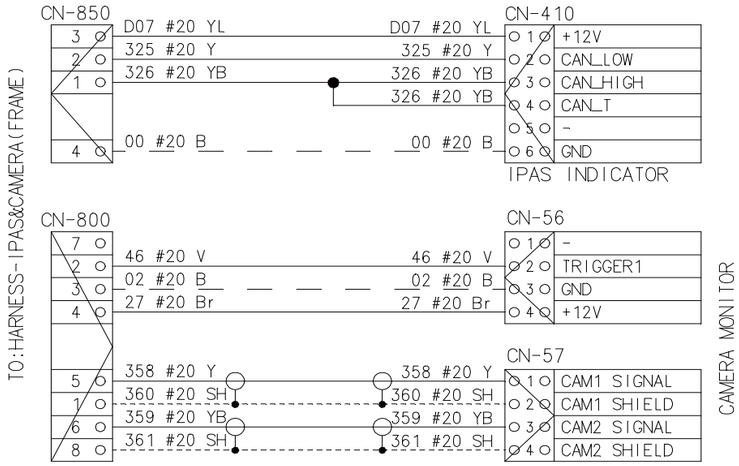
21FY-90760

·FINGERTIP GROUP (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)

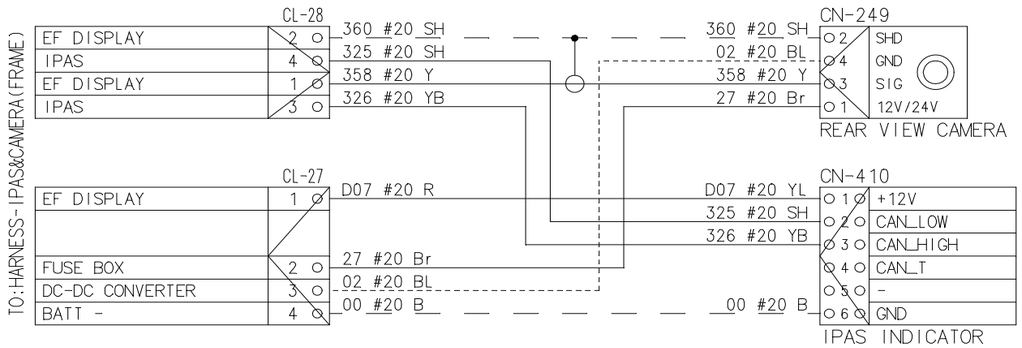


·OPTION (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)

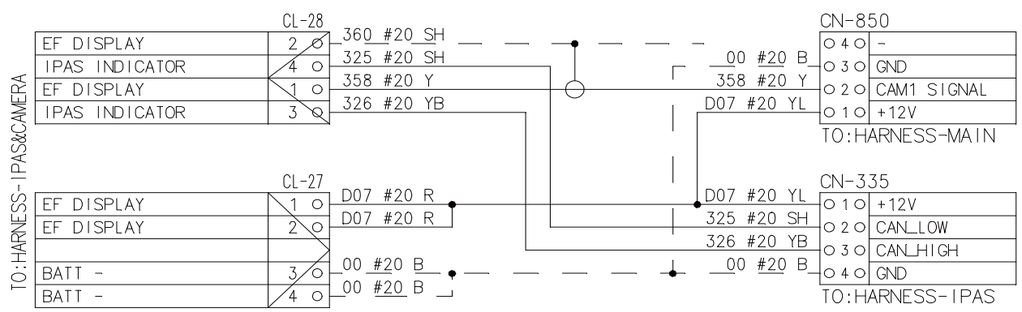
*ELEC.DIAGRAM OF HARNESS-MONITOR



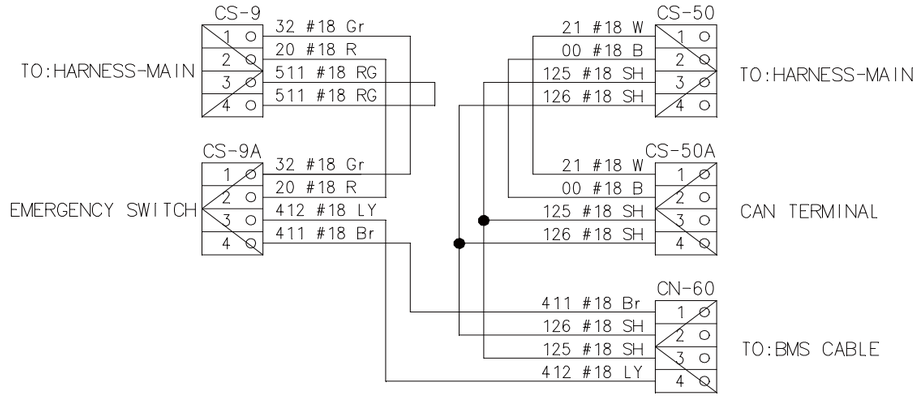
*ELEC.DIAGRAM OF HARNESS-IPAS&CAMERA



*ELEC.DIAGRAM OF HARNESS-IPAS&REAR CAMERA(FRAME)

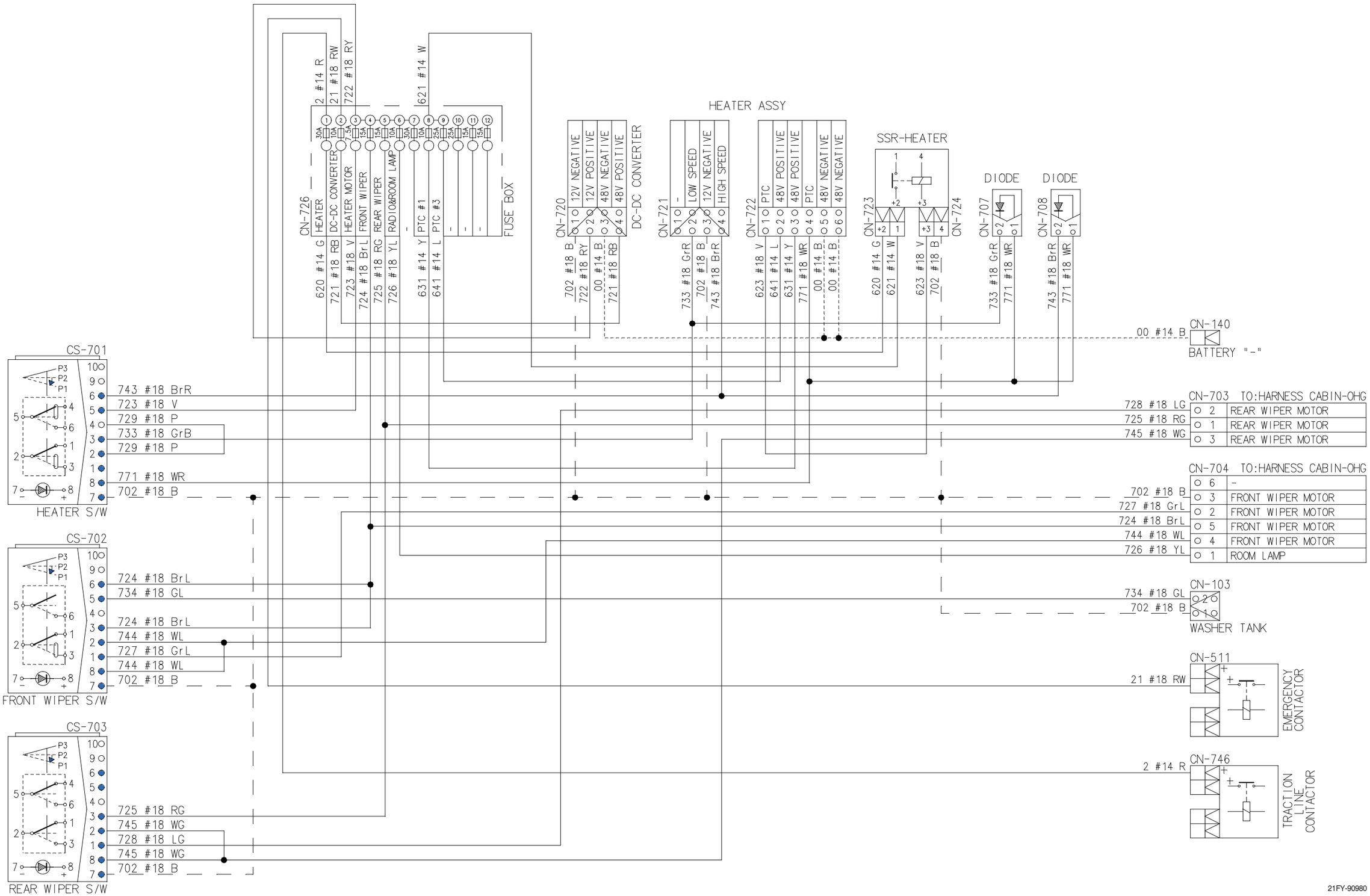


*ELEC.DIAGRAM OF HARNESS-BMS

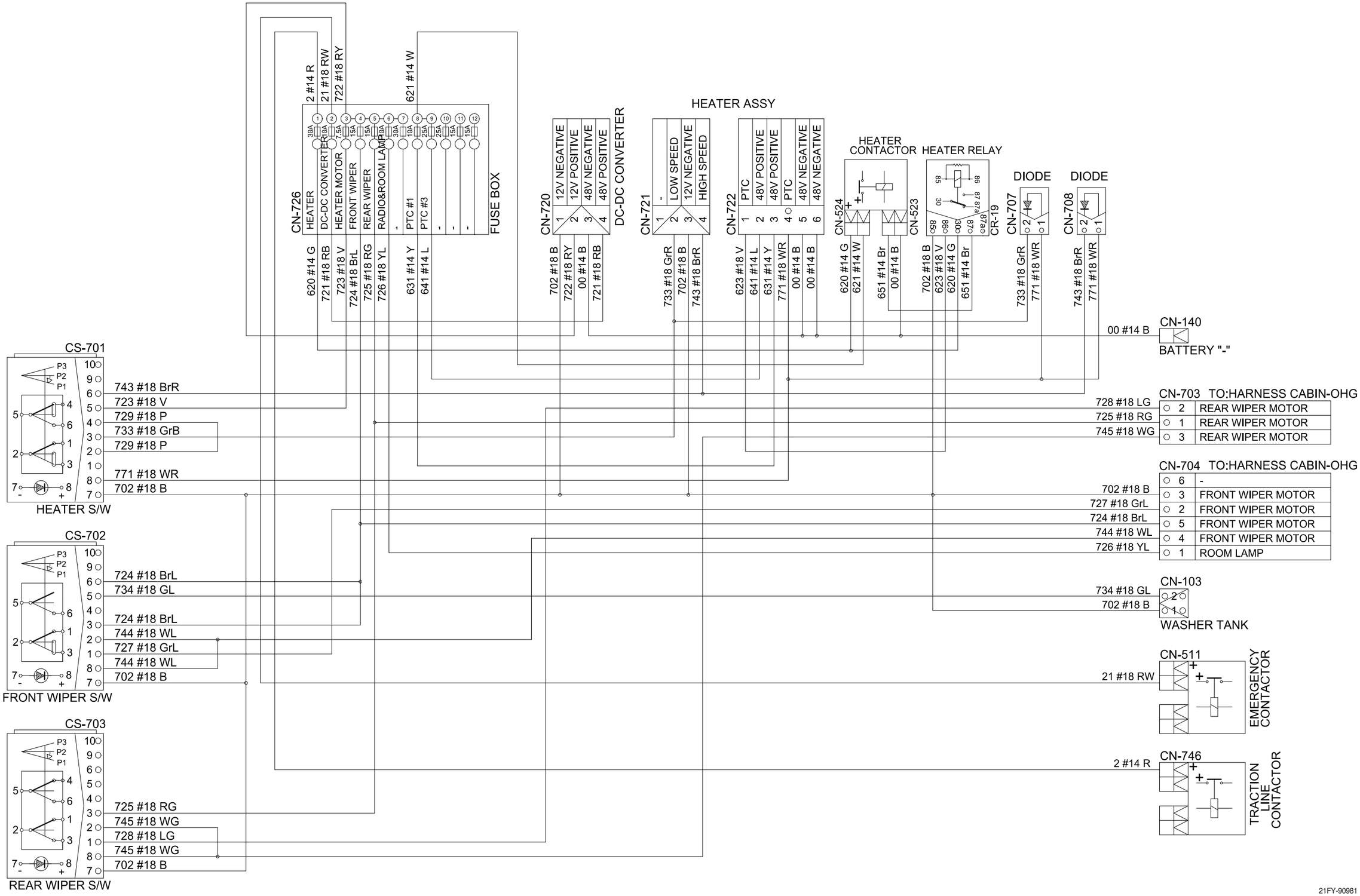


21FY-90970

·CABIN FRAME 1/2 (15BT-9U : #278~#408, 18BT-9U : #397~#602, 20BT-9U : #661~#1038)



·CABIN FRAME 2/2 (15BT-9U : #409~, 18BT-9U : #603~, 20BT-9U : #1039~)



GROUP 3 ELECTRIC COMPONENTS

1. FUNCTIONS OF BATTERY FORKLIFT TRUCK AND ELECTRIC COMPONENTS

The major functions of forklift truck can be divided into DRIVING FUNCTION and LOADING and UNLOADING FUNCTION.

All the components that work DRIVING and LOADING & UNLOADING functions are driven by AC motors. And as the BATTERY works as power source of these motors, a charging device is needed.

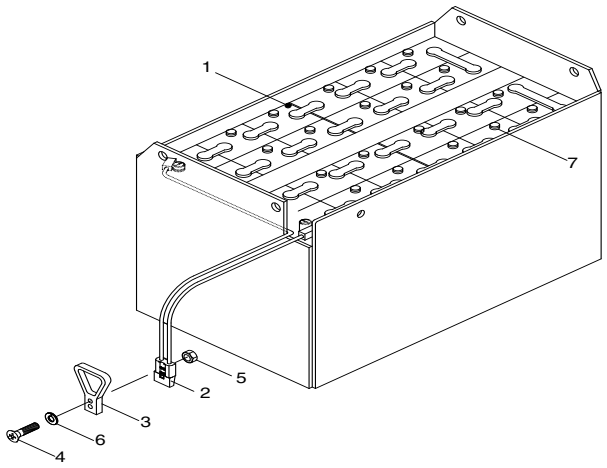
To drive the fork lift truck, a DRIVING CONTROL SYSTEM and some electric components such as direction change lever (forward/reverse section switch) and accelerator are required to select the driving direction and to control the speed of driving motor.

The CONTROL SYSTEM includes some protective circuits that protect the equipment and components from malfunctioning.

A MONITORING SYSTEM is installed in the monitor panel, which monitors the equipment and working condition, and let the operator take proper action. For the monitoring system, there are many sensors such as current sensors, potentiometer sensors, and temperature sensors. The HYUNDAI Battery forklift trucks are equipped with the most advanced DRIVING CONTROL SYSTEM currently available world-widely. The operator friendliness features enable him to set the truck conditions properly according to each working circumstance easily on his seat, and the SELF-DIAGNOSTIC function displays current status of truck in working.

2. BATTERY

1) STRUCTURE



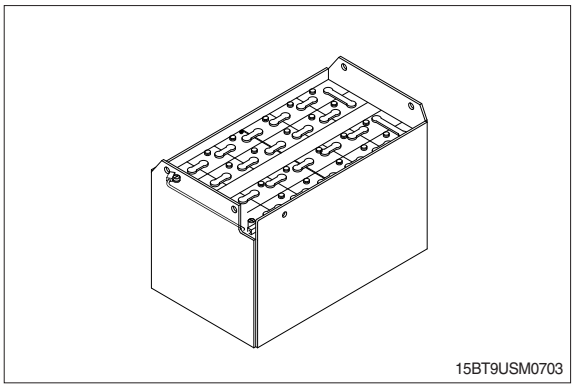
15BT9USM0702

1	Cells	4	Screw	6	Washer
2	Battery connector	5	Weld nut	7	Cap
3	Handle				

2) GENERAL

As in the battery forklift, the battery is an energy source, the handling of the battery is very important.

The life and performance of the battery greatly depend on the ordinary handling and maintenance. Therefore, be sure to check and maintain the battery so that it may be kept best.



3) SPECIFICATION AND SERVICE DATA

Item	Unit	15TB-9	18/20BT-9
Type	-	Lead Acid	
Rated voltage	V	48	
Capacity(Option)	AH/hr	440(510)	510(585)
Electrolyte	-	WET	
Dimension (W × D × H)	mm	978 × 545 × 635	978 × 630 × 635
Connector	-	SB 350 or SR 350 (SBE 320)	
Weight	kg	850(STD)	1030(STD)

Fully charged specific gravity	1.280 (25°C)
End of discharge specific gravity	1.120 (25°C)
Discharge end voltage	48V
Electrolyte	Refined dilute sulfuric
Replenishment fluid	Refined (pure) water
Insulation resistance	1MΩ

4) SAFETY PRECAUTIONS

(1) When sulfuric acid contact with skin

For acid contact with skin, eye or clothing, flush with water immediately. If swallowed, drink a large amount of water or milk. Seek medical attention immediately. When handling acid, always wear eye goggles or a face shield and rubber gloves.

(2) Strict prohibition of fire and ventilation

Since batteries generate explosive hydrogen gas, no fire should be drawn near. Before the battery charging, keep the battery cover open and check the ventilation status. Charging in an enclosed space can cause an explosion.

(3) Never place metallic articles on the batteries

If done so, it may cause "short circuit" accidents (dangerous especially while charging)
(Especially dangerous while charging).
Sparks will be generated which is equally dangerous as open fires.

(4) Handling of charger

When connecting or disconnecting a battery from a charger or attempting maintenance, make sure switches are all off. Ensure that the charger and the battery are matched. If a 300Ah battery is used with a charger designed to charge a 500Ah battery, it will severely overcharge the battery.

5) OPERATION PRECAUTIONS

(1) Avoid over-discharge

If over-discharged, it will be difficult to restore the batteries to the original state by recharge. In order to maintain the batteries in use for long period of time, it is recommended to use the batteries with discharge amount not exceeding 80% of the rated capacity. Further care should be taken for preventing the unit cell voltage from falling below 1.5V.

(2) Avoid over-charge

If overcharged, the rise in battery temperature will become excessive, resulting in deterioration of plates and other parts and markedly shortening of battery life.

(3) Avoid excessive elevation of temperature

Be sure to open the cover of battery housing tray before charging. If there is a possibility of temperature to exceed 55°C, discontinue the charge operation temporarily, or reduce the charge current.

6) CHECKING

(1) Unpacking

Electric traction storage batteries (herein after refer to as "batteries") are delivered to customers in dry-charged condition. At unpacking, check whether the batteries and accessories have been damaged. If there are observed defects, you should notify the condition to our branch office or agent. Never remove the sealing plug until the battery is put into service.

(2) Performance and maintenance of batteries

① Initial charge

Wet-charged battery gradually decreases its capacity during storage. In order to provide sufficient discharge capacity in the first discharge, the good initial charge is required. The conditions of initial charging are seen as below at room temperature.

a. By modified constant voltage charger

Connect the battery to the charger and turn on the equalizing charge "ON." The battery will be fully charged and terminated automatically.

b. By constant voltage constant current charger (standard)

Connect the battery to the charger and turn on the equalizing charge "ON." The battery will be fully charged and terminated automatically.

c. By constant current charger

Connect the charger to the battery and charge the battery by 0.1C×5 hour rate nominal capacity current for 24 hours or more. The charge shall be terminated when one of the following conditions is identified.

- When a constant value is indicated for more than 1 hour after the battery voltage has reached the maximum value.
- When more than 1 hour of charge is continued after the electrolyte specific gravity has risen fully and becomes constant.

② Discharge and capacity

The capacity of batteries is indicated at 5 hour rate capacity which means the battery can be discharged for 5 hours with the discharge current calculated by dividing the capacity value by 5 until the unit cell mean voltage reaches down to 1.7V at the electrolyte temperature of 30°C.

That is, the capacity is indicated by AH (ampere hour) being calculated as the product of ampere (A) and time (H). However, even if it is the same type of batteries, the capacity varies with the discharge conditions (discharge current, battery temperature and specific gravity of electrolyte).

Even if the batteries discharged its full capacity, if immediately charged to full, there will be no harmful effects remained. Ideal charging amount (AH) is 110-125% of the amount of previous discharge.

③ Specific gravity of electrolyte

Specific gravity of electrolyte drops at discharge and rises at charge. When the batteries are fully charged, it becomes almost constant and shows no further rise. The specific gravity value varies with the change in temperature. Therefore specific gravity measurement should be made with temperature of electrolyte at the same so the measured specific gravity value could be corrected to that at the standard temperature of 25°C by the following formula.

$$S_{25} = S_t + 0.0007\ (t-25)$$

Where, S_{25} : Specific gravity at 25°C

S_t : Actually measured specific gravity at t°C

t : Electrolyte temperature (°C)

The standard specific gravity for this type of battery is 1.280±0.01(25°C) at full charge condition. If the electrolyte is decreased naturally while using, distilled water shall be replenished up to the specified level. (Never refill sulfuric acid).

Only when large quantity of electrolyte is lost due to spillage, etc., dilute sulfuric acid specified in gravity shall be added.

④ **Normal charge**

Charge the discharged batteries as quickly as possible. The temperature of electrolyte before starting the charging operation shall preferably be below 45°C, and the temperature during the charge should be maintained at no higher than 55°C. (Under any unavoidable situations, it should never be above 55°C). Methods of charging vary in precise meaning with the types of chargers used. A standard charging method is described hereunder. (If a special method is mentioned to be adopted, follow that instruction).

a. Charging by modified constant voltage automatic charger

There is almost automatic charger today which completes the charging just only connecting the plug between battery and charger without outer operating timer. But if your charger has it, after setting the timer for 3-4 hours and turn on the charger and the charger is left as it is, then the charge will be made automatically. In principle, regardless of the amount of previous discharge, it is not required to alter the setting of timer time. The recommendable current value of this type of charger is "5 hour rate current $\times$1.0~1.5" at the start of charging, and at the final stage it is "5 hour rate current $\times$0.15~0.25". Normally the charge is terminated within 8~12 hours automatically.

b. Charging by constant current constant voltage automatic charger

After a lapse of specified charging time after the switch is turned on, the charge will be completed by turning off the switch. The charging time can be calculated by the following formula.

$$\text{Charging time} = \frac{\text{Amount of previous discharge(AH)}}{\text{Capacity of charger(A)}} + 2\sim3\text{(H)}$$

When the amount of previous discharge is not known, use the 5 hour rate rated capacity of the batteries. At immediately after charging, the charge current is allowed up to 3 times 5 hour rate current. For charger provided with a timer, the charge will terminate automatically if the timer is set at the specified time according to the operation manual.

c. Charging by constant current charger

Connect the charger to the battery and charge the battery by 0.1C$\times$5 hour rate nominal capacity current for 24 hours or more. The charge shall be terminated when one of the following condition is identified.

⑤ **Equalizing charge**

When large number of cells are used in a set of battery, the voltage and specific gravity of respective cells tend to become unequal, resulting in necessity of charging all the cells at an appropriate time in order to equalize them. This is called equalizing charge. Normally the equalizing charge should be carried out once every month. The methods are in normal type charger, extend the charge for 5 more hours after full charge at the final stage current, and in automatic charger which is in most cases provided with timer, extend the time setting for 3-6 more hours.

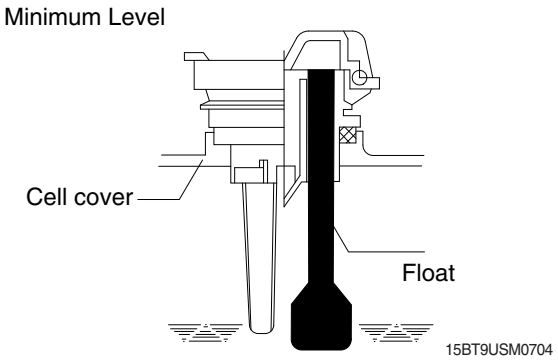
⑥ **Replenishment of distilled water**

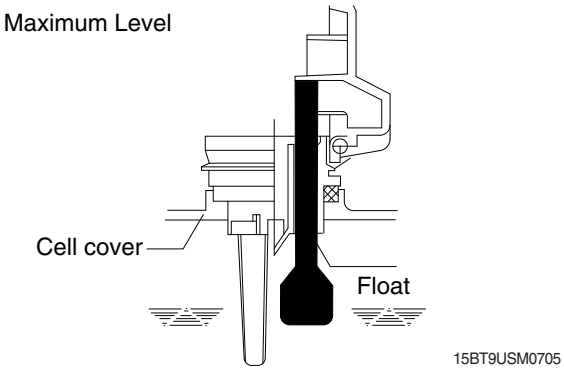
Only the water content of electrolyte is decreased due to electrolysis of distilled water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level once every week. If the electrolyte level is lowered, replenish distilled water up to the specified level. In this case, never attempt to replenish sulfuric acid or tap water. Use only distilled water for battery replenishment. If the amount of water required for weekly addition to a unit cell for 100AH of battery capacity is in excess of 45 cc, it is assumed that the cell is receiving overcharge. Accordingly, be sure to reduce slightly the daily charge amount. Under the normal conditions, the addition of water per week is 45 cc or less. Incidentally, distilled water replenishment should be made before charging to the content of minimum level. (For the purpose of uniform stirring of electrolyte by charging).

If the electrolyte level is improper after completion of charging, you may topping up the electrolyte level to the maximum level.

a. Determination of replenishment time and methods (cell with ONE TOUCH CAP)

Confirm the electrolyte level by looking at the float in the ONE TOUCH CAP. If too low as shown in figure, replenish distilled water. Replenishment shall be performed after opening the cover of the plug using syringe and jug. When refilling is completed, close each cover completely until "click" sound is heard.





⑦ **Cleaning**

If electrolyte spills or the cells are polluted with dust or stains, it will cause generation of leak current. Wipe off dust and stains with moist cloth and clean in such a manner that the cells are kept in dry condition. In the case of plastic containers or covers, never use such organic solvents as paint thinner and gasoline. If used, the plastic containers or covers may suffer cracking. If you are forced to use them, be sure to use white kerosene.

⑧ **Notice on charging**

The charging area must be well ventilated to facilitate exhaust of gas generated from the battery during charging. Charge the battery in an area free from iron working, welding, etc. Further the battery generates hydrogen, oxygen, acid mist and on rare occasions, hydrogen sulfide during charging depending on the case. Special care may be required in the case of equipment and objects near the battery that may contaminated or damaged. Do not pull out the charging plug during charging, as it will cause sparks. Since hydrogen gas generated during charging may remain in the area surrounding the battery after charging, never bring fire or flame close to this area. In case of counter-balance type vehicles, open the battery cover before charging.

⑨ **Repair of failure cell**

a. To remove a cell from the circuit or battery from steel tray, it is first necessary that the intercell connector be removed.
b. Before performing any repairs, you must open one-touch caps for gas purging of all cells. After you have finished that, must remove connector covers and on-touch caps from failure cell including surrounding cells. All vent holes of cells removed of one-touch caps must cover by four layers of water dampened cloth and then proceed with repairs. Using an acid syringe withdraw sufficient electrolyte from failure cell to reduce the liquid levels until minimum level indicating of one touch caps.
c. The safe and most efficient method of removing a connector from failure cell as well as all surrounding cells is with hand or electric drill (25 ㎜).

⚠ You must make sure to clear of explosive hydrogen gas in the cells before repairs. Be careful not to drill to far into the cell and damage the unit. During drilling operation make sure lead curls produced do not contact opposite cell poles and cause a spark.

d. Upon completion of drilling the intercell connectors, can be lifted off.
e. Lifted off the failure cell from circuit after removing of intercell connector.
f. Installing new cell and connector.
g. With surfaces properly cleaned and neutralized, position the connectors.
h. Place damp rags around each lead head. Hold tip of the welder in center of post move welder completely around top of post and out to the area where the post meets the connector. Move welder back to center of post and add molten lead until area is filled to top of connector. Again, move welder completely around area, with tip on molten lead. If you have jig for welding connector, have easier and better welding work.
i. When replacing electrolyte in a repaired cell, use sulphuric acid of the same specific gravity that is found in the balance of the battery.
j. Finally, rejoin connector covers and one-touch caps to the cells.

⑩ Summary of daily maintenance

a. Avoid overcharge. After discharge, charge the batteries immediately. The standard frequency of equalizing charge is more than once every month.
b. Be sure to check the electrolyte level once every week. If found decreased, replenish distilled water up to the specified level.
c. The top surface of battery cells should be kept clean and dry.
d. Be sure to keep open the cover of battery housing tray during charge.
e. Never draw near open fires such as lighted cigarettes or burning matches during charge.

(3) Others

① Storage of batteries

When batteries are stored, keep them away from room heaters or other heat generating sources. Clean, cool and dry place where no direct sunlight is suited for battery storage. Before putting into storage, it is important to charge the batteries and keep the electrolyte level at the specified level.

When the temperature in storage location is higher than 20°C, check the specific gravity once a month, and when lower than 0°C, check it once every two months. If the measurements show values lower than 1.230 (20°C), it is required to charge the battery in accordance with the method described in NORMAL CHARGE.

② Maintenance record

It is recommended to keep maintenance record in order to know the operational conditions of batteries. Daily charge and discharge, equalizing charge requirements, and distilled water replenishment requirements can be clarified at a glance. Measurements of specific gravity and temperatures once every two to four months after equalizing charge and maintenance thereof will serve for battery health diagnosis.

③ Electrolyte temperature

The operating temperature range of batteries is -10~45°C (temperature of electrolyte). If the batteries are exposed to cold atmosphere in discharged condition, the electrolyte may freeze, and in extreme cases, the capacity will be decreased, but, if not frozen, no adverse effects will be exerted.

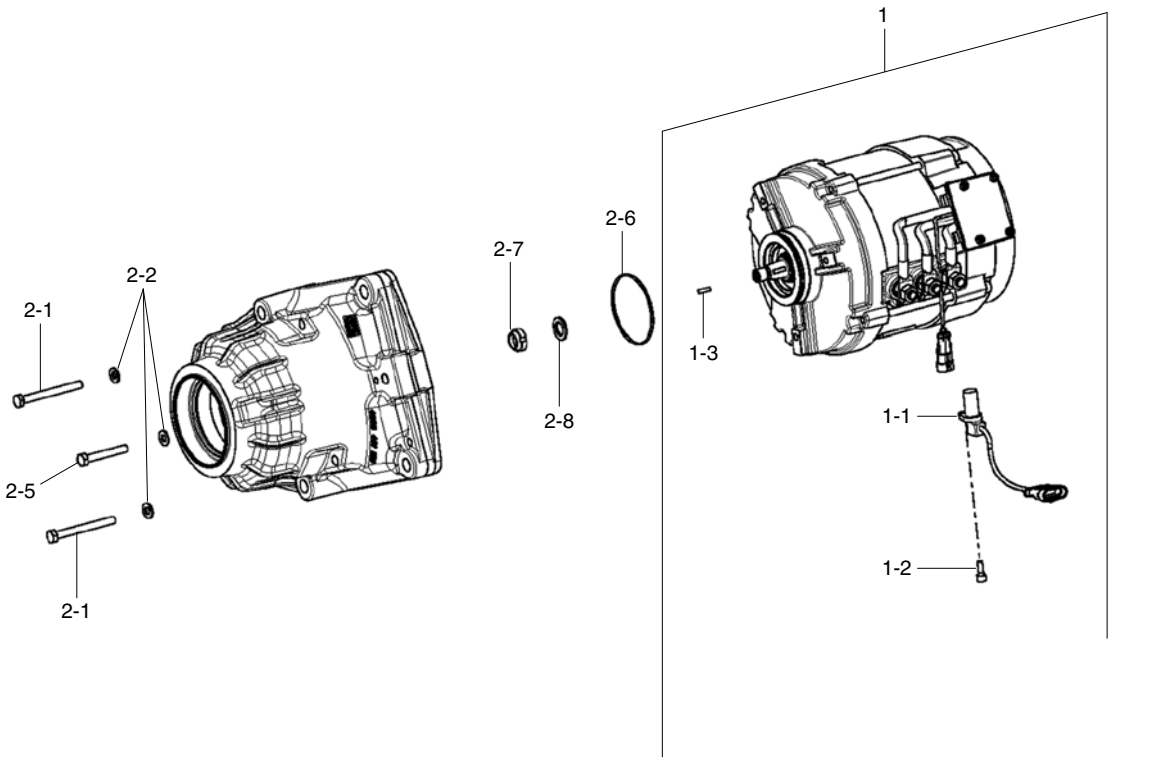
Contrarily if the temperature is high, especially if used at above 55°C, the battery life will be considerably shortened. Care must be taken so that the temperature during charge will be maintained at 55°C or lower. Even under unavoidable circumstances it should not exceed 55°C.

7) TROUBLESHOOTING

Nature of trouble	Symptoms	Causes	Corrective Action
Deformation	· Deformation of container. Lid or one touch cap	· Excessive temperature rising or external impact	· Replace
Breakage	· Electrolyte leakage according to breakage of container, lid or one touch cap · Termination of connector or pole post etc.	· External impact, improper handling, excessive vibration · Excessive temperature rising or external impact	· Replace or install a new one · Replace
Sulfate	· Specific gravity drops and capacity is decreased. · Charge voltage rises rapidly with immature gassing in earlier stage but specific gravity does not rise and charge can't be carried out.	· When left in state of discharge or left long without equalizing charge. · Insufficient charge. · When electrolyte is so decreased that plate is deposed. · When concentration of electrolyte rises. · When impurities are mixed in electrolyte.	· Need equalizing charge · Need equalizing charge · Need equalizing charge · Adjust specific gravity · Replace electrolyte
Decrease and falling of specific gravity	· May be easily detected by measurement of the specific gravity.	· Rise of temperature due to such trouble. · When left long period without refilling of water. · Short circuit.	· Replace · Refill water in regular period · Replace
Rise of specific gravity	· May be easily detected by measurement of the specific gravity.	· Diluted sulfuric acid is used in refilling. · When the electrolyte level excessively drops.	· Adjust specific gravity after full charge. · Refill distilled water.
Mixing of impurities	· Decrease of capacity. · Drop of charge and discharge voltage. · Odor of generated gas and coloring of the electrolyte.	· Metals such as iron, copper nickel and manganese. · Impurities such as sea water, chloric acid, nitric acid etc. · Filling of impure water.	· Under a fully discharged condition, pour out the electrolyte. Then pour in an acid of the specific gravity higher by 0.03~0.05 than that of the drained acid. Charge fully and adjust the specific gravity to the specified value.

3. DRIVE MOTOR

1) STRUCTURE



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1	Motor	2	Assembly parts	2-6	O-ring
1-1	Sensor	2-1	Hexagon screw	2-7	Slotted nut
1-2	Cap screw	2-2	Washer	2-8	Washer
1-3	Woodruff Key	2-5	Hexagon screw		

2) SPECIFICATION

Item	Unit	Specification
Type	-	TSA200-100-269
Rated voltage	Vac	32
Rated output	kW	5.4×2
IP Grade	-	54

3) MAINTENANCE INSTRUCTION

※ Before starting the maintenance please disconnect the power supply.

(1) Ball bearing

Both ball bearing are maintenance free. Should it be necessary to remove the bearings in case of repair, they should be replaced. In any case the sealing parts (shaft sealing ring etc.) have to be replaced.

If a bearing which is to be replaced has only one sealing lip, this should be greased with quality bearing grease.

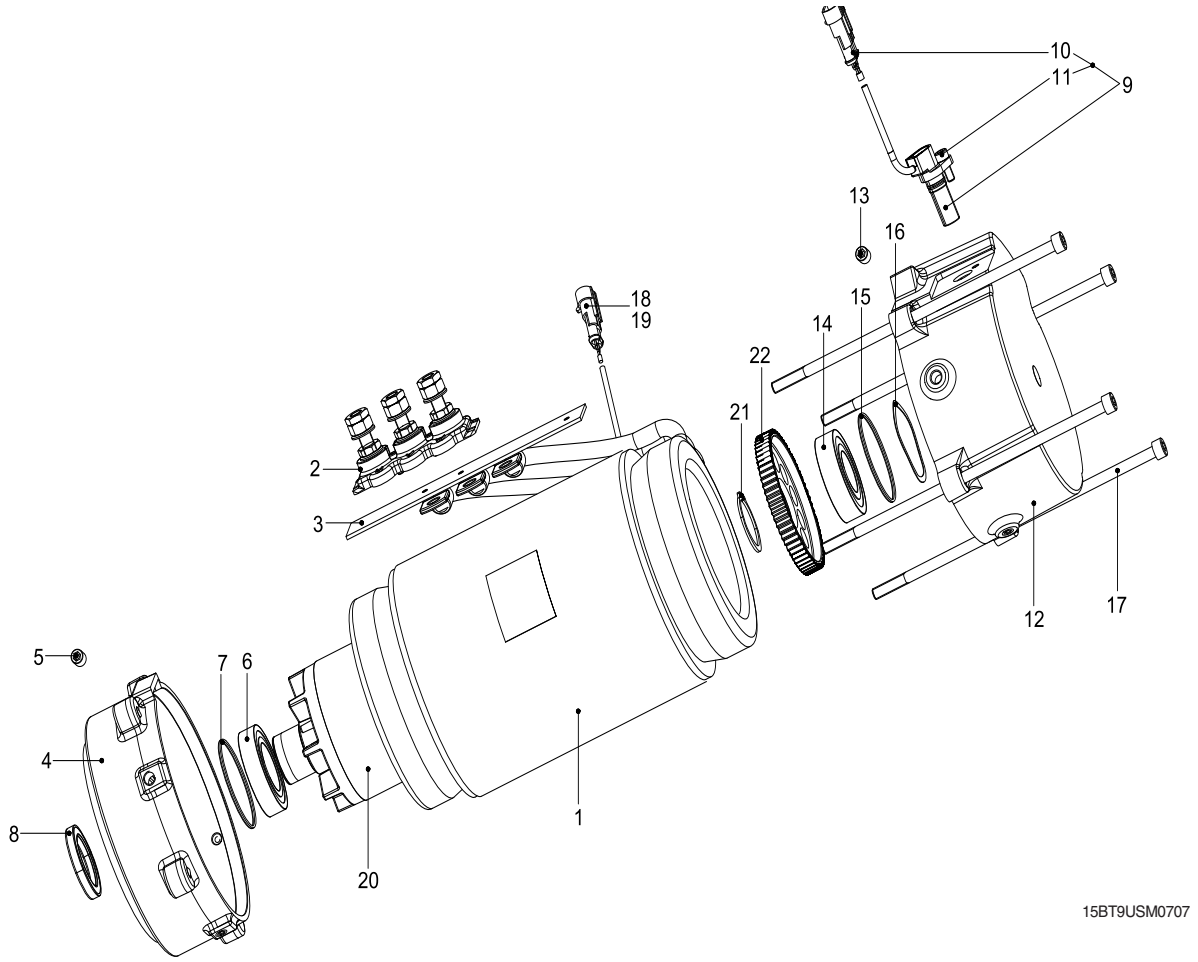
After approximately 10,000 operating hours the bearings have to be replaced.

(2) Disassembly and assembly

The motor is assembled and disassembled according to the relevant sectional drawing and part list. (See page 7-13)

4. PUMP MOTOR

1) STRUCTURE



1	Stator	9	KB sensor	16	Wavy-washer
2	Group terminal board	10	Group plug	17	Cyl. screw
3	Terminal base	11	Cyl. screw	18	Temp. sensor
4	Drive end shield	12	Commutator end plate	19	Group plug
5	Threaded pin	13	Threaded pin	20	Rotor
6	Ball bearing	14	Ball bearing	21	Circlip
7	O-ring	15	O-ring	22	Gear wheel sensor
8	Shaft seal				

2) SPECIFICATION

Item	Unit	Specification
Type	-	ABDD4002
Rated voltage	Vac	32
Rated output	kW	14.9
Insulation	-	Class F

3) INTERNAL INVOLUTE SPLINE DATA

Item	Unit	Specification
Flat root side fit	-	Class 7
No of teeth	EA	9
Spline pitch	mm	16/32
Pressure angle	Degree	30
Major diameter	mm	16.535
Form diameter	mm	15.977
Minor diameter	mm	12.9300
Pin diameter	mm	2.743

4) MAINTENANCE INSTRUCTION

※ Before starting the maintenance please disconnect the power supply.

(1) Ball bearing

Both ball bearing are maintenance free. Should it be necessary to remove the bearings in case of repair, they should be replaced. In any case the sealing parts (shaft sealing ring etc.) have to be replaced.

If a bearing which is to be replaced has only one sealing lip, this should be greased with quality bearing grease.

After approximately 10,000 operating hours the bearings have to be replaced.

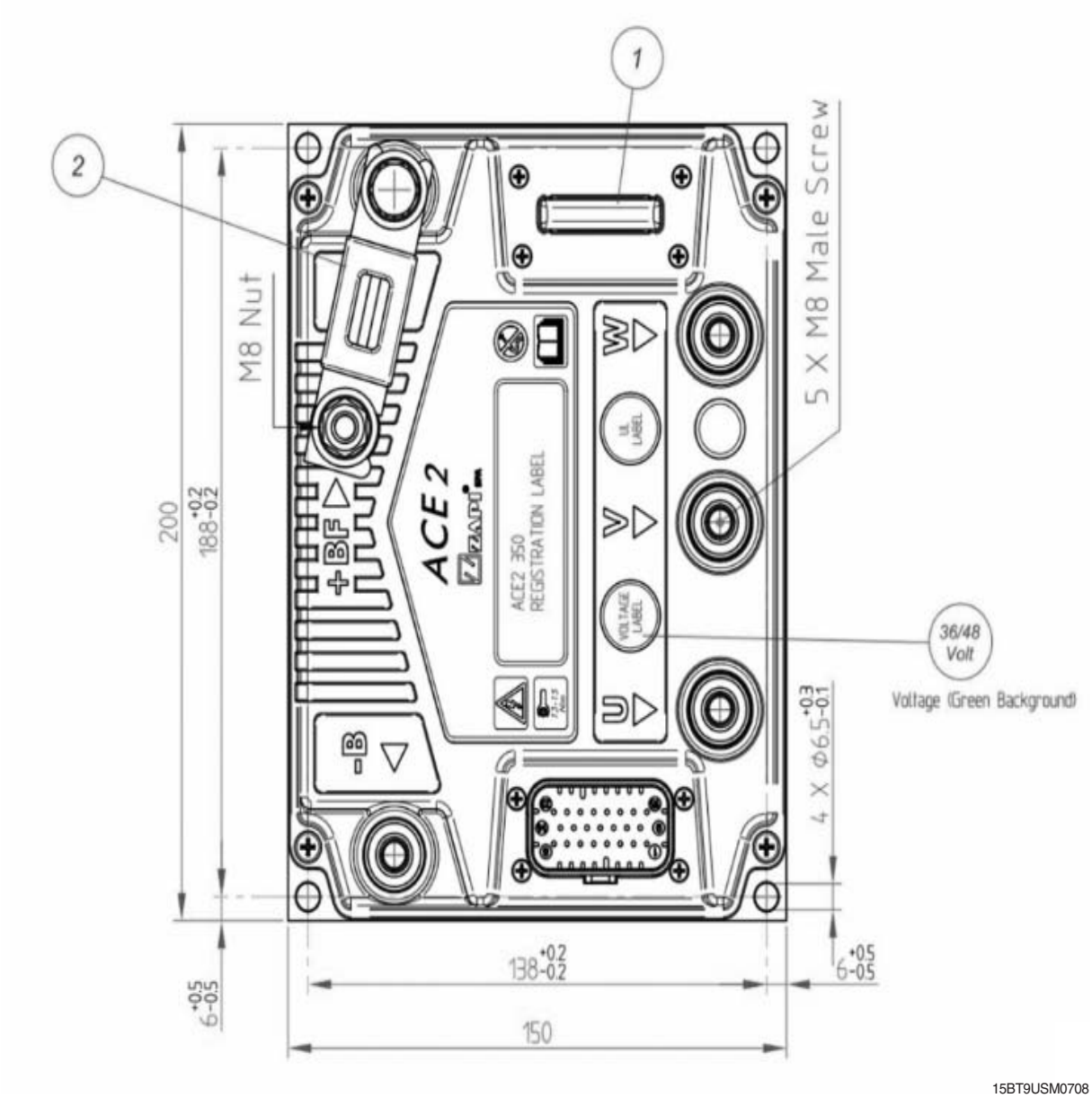
(2) Disassembly and assembly

The motor is assembled and disassembled according to the relevant sectional drawing and part list. (See page 7-15)

5. CONTROLLER SYSTEM

1) STRUCTURE

(1) Traction and Pump controller



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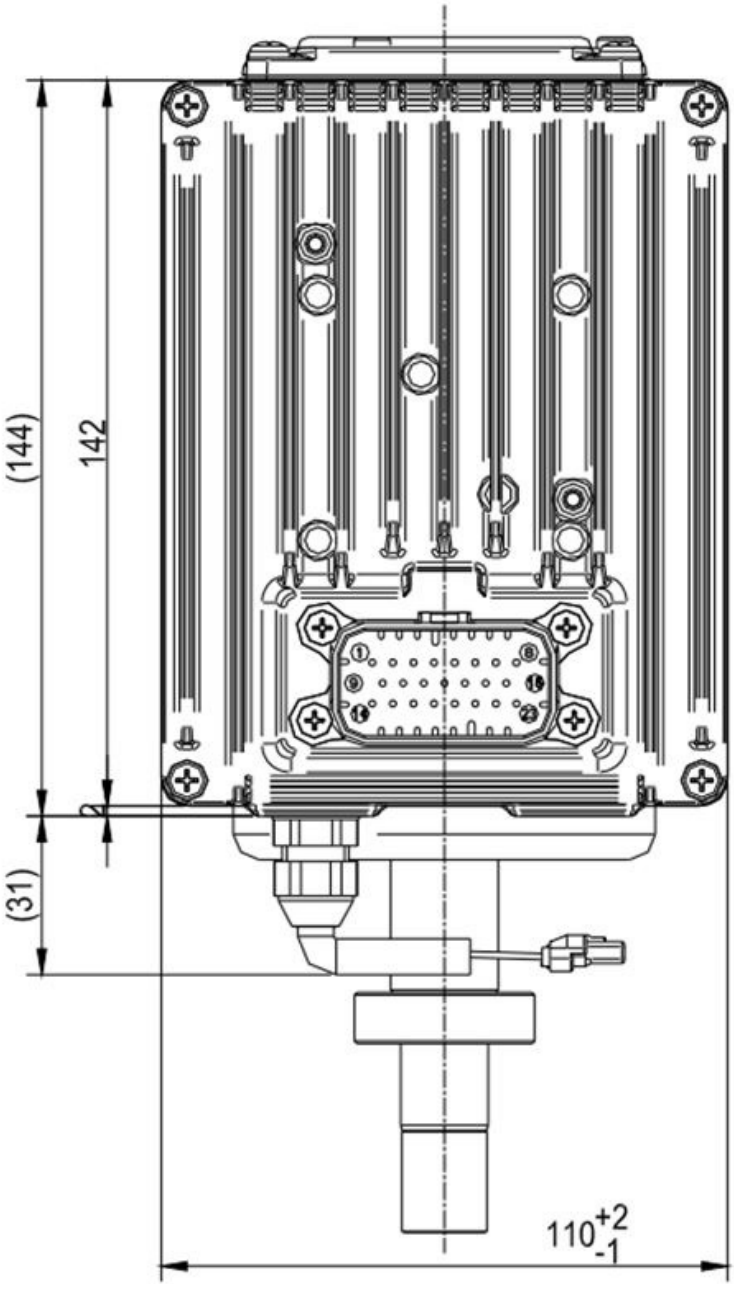
(2) EPS controller



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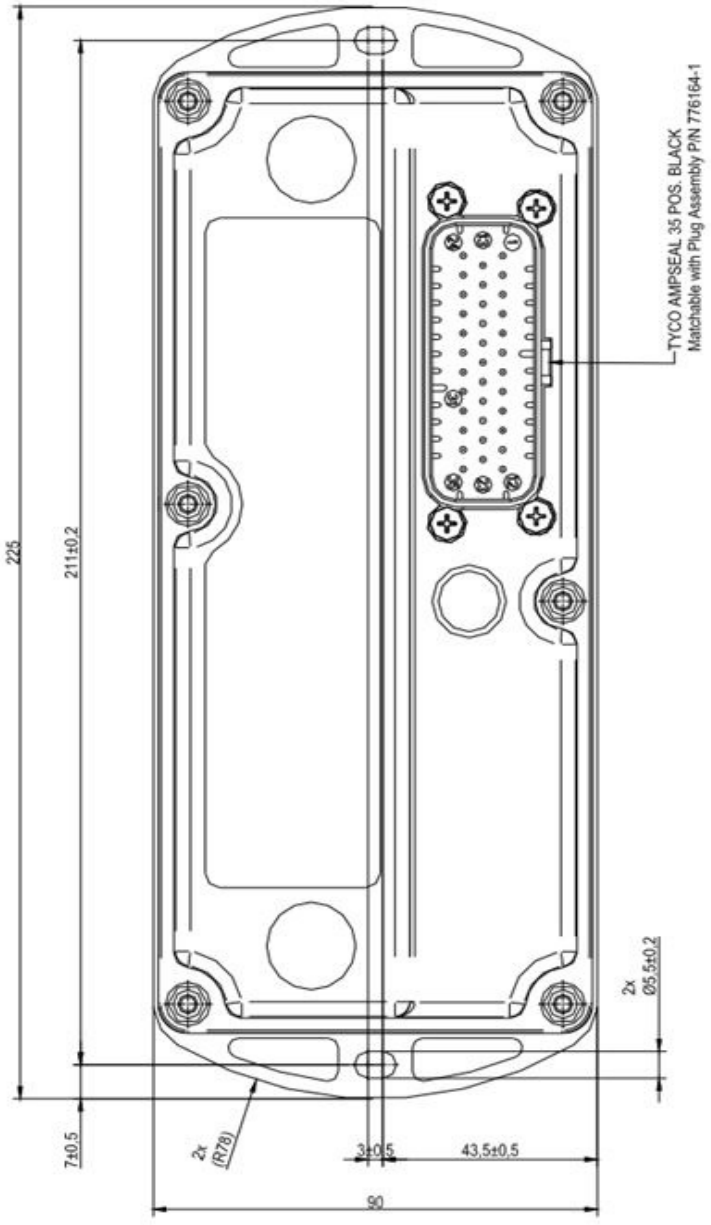
(3) VCM controller(option)



15BT9USM0710

※ Specifications

Model	Model	Application	Type	Power	Current limit
15/18/20BT-9U	ACE2 x 2	TRACTION	MOSFET	36-48V, 350A x2	350A/2min
	ACE2	PUMP	MOSFET	36-48V, 450A	450A/2min
	EPS ACW	EPS	MOSFET	36-48V, 70A	
	VCM RETAIL	FINGERTIP	MOSFET	36-48V	

2) OPERATIONAL FEATURES (Traction and Pump controller)

(1) Features

① Speed control

② Optimum behavior on a slope due to the speed feedback:
The motor speed follows the accelerator, starting a regenerative braking if the speed exceeds the set point.

③ Electrical stop on a ramp: the machine is electrically held on a slope for a programmable time.

④ Stable speed in every position of the accelerator.

⑤ Regenerative release braking based upon deceleration ramps.

⑥ Regenerative braking when the accelerator pedal is partially released (deceleration).

⑦ Direction inversion with regenerative braking based upon deceleration ramp.

⑧ Regenerative braking and direction inversion without contactors: only the main contactor is present.

⑨ The release braking ramp can be modulated by an analog input, so that a proportional brake feature is obtained.

⑩ Optimum sensitivity at low speeds.

⑪ Voltage boost at the start and with overload to obtain more torque (with current control).

⑫ The inverter settings can drive an electromechanical brake.

⑬ High efficiency of motor and battery due to high frequency commutations.

⑭ Double microcontroller for safety functions.

(2) Protection features

The ACE2 is protected against some controller injuries and malfunctions.

① Battery polarity inversion : It is necessary to fit a MAIN CONTACTOR to protect the inverter against reverse battery polarity and for safety reasons.

② Connection Errors : All inputs are protected against connection errors.

③ Voltage monitoring : Protected against battery undervoltage and overvoltage.

④ Thermal protection : If the controller temperature exceeds 85 °C, the maximum current is reduced in proportion to the thermal increase. The temperature can never exceed 105 °C.

⑤ External agents : The inverter is protected against dust and the spray of liquid to a degree of protection meeting IP65. Nevertheless, it is suggested to carefully study controller installation and position. With little simple shrewdness, the controller protection degree can be strongly increased.

⑥ Protection against uncontrolled movements :

The main contactor will not close if:

- The Power unit is not working.
- The Logic board doesn't work perfectly.
- The output voltage of the accelerator does not fall below the minimum voltage value stored, with 1 V added.
- Running microswitch in closed position.
- Low battery charge

When the battery charge is low, the maximum current is reduced to the half of the maximum current programmed.

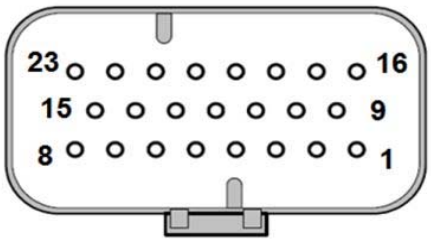
⑦ Protection against accidental start up : A precise sequence of operations are necessary before the machine will start. Operation cannot begin if these operations are not carried out correctly.

⑧ Requests for drive must be made after closing the key switch.

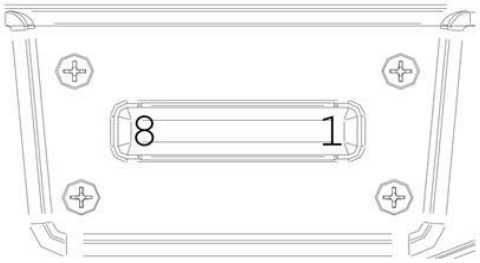
3) DESCRIPTION OF THE CONNECTORS

(1) Traction and pump controller

ACE2 is equipped with a 23-poles Ampseal connector like that of the figure. Each of the 23 pins is referred to as “A#”, where “A” denotes the connector name and “#” is the pin number, from 1 to 23.



CONN A



CONN B

15BT9USM0711

① Traction controller (Right)

Pin	Function	Description
A1	KEY	Input of the key switch signal.
A2	5V	Positive supply for the accelerator pedal. (+5V 100mA maximum).
A3	CPOT	Analog input of the accelerator pedal 1 signal. (0 – 5 V).
A4	FWD	Digital input, active when connected to +5V. The default function is as FORWARD request; closing this input the truck moves forward.
A5	BWD	Digital input, active when connected to +5V. The default function is as BACKWARD request; closing this input the truck moves backward.
A6	CPOT	Analog input. It is used for the brake pedal 2 request. (0 – 5 V).
A7	ENCA	Channel A of the incremental encoder of right traction motor.
A8	PENC	Positive supply for the encoder of right traction motor. (+5 V, 150 mA maximum)
A10	CPOT	Analog input. It is used for the brake pedal 1 request. (0 – 5 V).
A11	CANL	Low-level signal of CAN bus interface 2.
A12	CANH	High-level signal of CAN bus interface 2.
A13	CPOT	Analog input of the accelerator pedal 2 signal. (0 – 5 V).
A14	ENCB	Channel B of the incremental encoder of right traction motor.
A15	GND	Negative supply for the encoder and the accelerator pedal.
A16	NMC	Output of the main-contactor driver (driving to -B); PWM voltage controlled; 1.5A maximum continuous current.
A17	PCOM	Connect the positive supply of coils (MC, EB) to this pin.
A18	NEB	Output of the electromechanica brake driver(driving to -B). PWM voltage controlled. 1.5A maximum continuous current.

Pin	Function	Description
A19	SEAT	Digital input, active when connected to +B. It is used for SEAT input.
A20	CANL	Low-level signal of CAN bus interface 1.
A21	CANH	High-level signal of CAN bus interface 1.
A22	THMOT	Positive terminal for the right motor thermal sensor. The internal pull-up is a fixed 2 mA current source (max 5 V).
A23		Negative terminal for the right traction motor thermal sensor.
B1	PCLRXD	Positive serial reception.
B2	NCLRXD	Negative serial reception.
B3	PCLTXD	Positive serial transmission.
B4	NCLTXD	Negative serial transmission.
B5	GND	Negative console power supply.
B6	+12	Positive console power supply.
B7	FLASH	It must be connected to pin 8 for the Flash memory programming.
B8	FLASH	It must be connected to pin 7 for the Flash memory programming.

② Traction controller (Left)

Pin	Function	Description
A1	KEY	Input of the key switch signal.
A3	CPOT	Analog input of the auto tilt leveling sensor 1. (0 – 5 V).
A4	BRAKE OIL	Digital input, active when connected to +5V. The function is as BRAKE OIL request.
A5	TILT LEVEL	Digital input, active when connected to +5V. The function is as TILT LEVELING request.
A6	CPOT	Analog input of the load sensor signal. (0 – 5 V).
A7	ENCA	Channel A of the incremental encoder of left traction motor.
A8	PENC	Positive supply for the encoder of left traction motor. (+5 V, 150 mA maximum)
A9	NAUX	Output of fan relay-coil driver (driving to -B); PWM voltage controlled; 2 A maximum continuous current.
A11	CANL	Low-level signal of CAN bus interface 2.
A12	CANH	High-level signal of CAN bus interface 2.
A13	CPOT	Analog input of the auto tilt leveling sensor 2. (0 – 5 V).
A14	ENCB	Channel B of the incremental encoder of left traction motor.
A15	GND	Negative supply for the encoder and auto tilt leveling sensor.
A17	PCOM	Connect the positive supply of coils (EB, fan relay) to this pin.
A18	NEB	Output of the electromechanical-brake driver (driving to -B); PWM voltage controlled; 1.5A maximum continuous current.

Pin	Function	Description
A19	SBR	Digital input, active when connected to +B. It is used for SBR input.
A20	CANL	Low-level signal of CAN bus interface 1.
A21	CANH	High-level signal of CAN bus interface 1.
A22	THMOT	Positive terminal for the left traction motor thermal sensor. The internal pull-up is a fixed 2 mA current source (max 5 V).
A23		Negative terminal for the left traction motor thermal sensor.
B1	PCLRXD	Positive serial reception.
B2	NCLRXD	Negative serial reception.
B3	PCLTXD	Positive serial transmission.
B4	NCLTXD	Negative serial transmission.
B5	GND	Negative console power supply.
B6	+12	Positive console power supply.
B7	FLASH	It must be connected to pin 8 for the Flash memory programming.
B8	FLASH	It must be connected to pin 7 for the Flash memory programming.

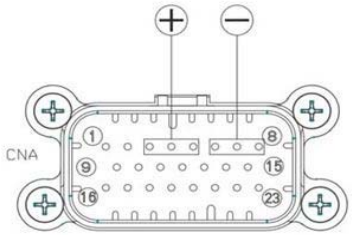
③ Pump controller

Pin	Function	Description
A1	KEY	Input of the key switch signal.
A3	CPOT	Analog input of the lift sensor. (0 – 5 V).
A4	AUX1	Digital input, active when connected to +5V. The function is as AUX1 request.
A5	AUX2	Digital input, active when connected to +5V. The function is as AUX2 request.
A7	ENCA	Channel A of the incremental encoder of pump motor.
A8	PENC	Positive supply for the encoder of pump motor. (+5 V, 150 mA maximum)
A9	NAUX	Output of MCV solenoid-coil driver (driving to -B); PWM voltage controlled; 2 A maximum continuous current.
A10	CPOT	Analog input. It is used for the tilt s/w request. (0 – 5 V).
A11	CANL	Low-level signal of CAN bus interface 2.
A12	CANH	High-level signal of CAN bus interface 2.
A14	ENCB	Channel B of the incremental encoder of pump motor.
A15	GND	Negative supply for the encoder and lift sensor.
A17	PCOM	Connect the positive supply of coils (MCV solenoid) to this pin.
A19	LIFT CB	Digital input, active when connected to +B. It is used for LIFT CBUTBACK input.
A20	CANL	Low-level signal of CAN bus interface 1.

Pin	Function	Description
A21	CANH	High-level signal of CAN bus interface 1.
A22	THMOT	Positive terminal for the right motor thermal sensor. The internal pull-up is a fixed 2 mA current source (max 5 V).
A23		Negative terminal for the right traction motor thermal sensor.
B1	PCLRXD	Positive serial reception.
B2	NCLRXD	Negative serial reception.
B3	PCLTXD	Positive serial transmission.
B4	NCLTXD	Negative serial transmission.
B5	GND	Negative console power supply.
B6	+12	Positive console power supply.
B7	FLASH	It must be connected to pin 8 for the Flash memory programming.
B8	FLASH	It must be connected to pin 7 for the Flash memory programming.

(2) EPS controller

23 poles AMPSEAL connector (CNA) assignment.



15BT9USM0712

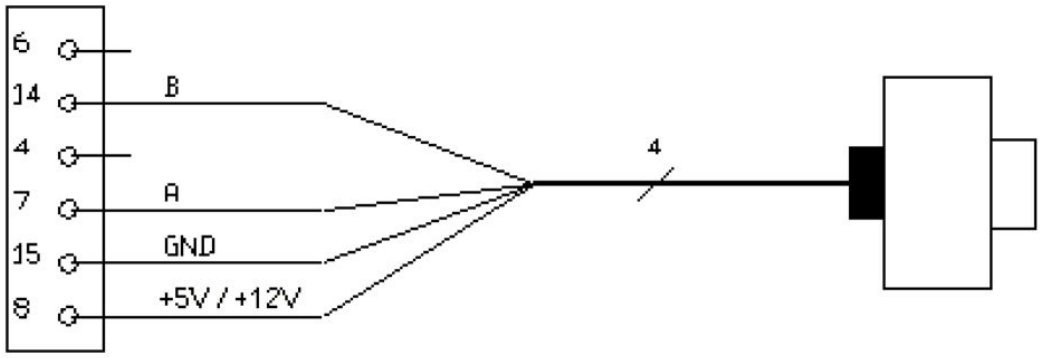
Pin	Function	Description
A3	PBATT	PBATT power connection
A4	PBATT	PBATT power connection
A5	PBATT	PBATT power connection
A6	NBATT	NBATT power connection
A7	NBATT	NBATT power connection
A8	NBATT	NBATT power connection
A9	PCOILS	Overload and short-circuit protected positive breaker for coils. A9 makes and takes Vbatt: 2Adc max @ Vbatt<=48V.
A10	NCOIL	Overload and short-circuit protected negative breaker for a proportional coil. A10 is a PWMout: 1.3Adc max @ Vbatt<=48V
A14	PCOIL2	Short-circuit protected positive breaker for a proportional coil. Cascaded with A9. A14 is a PWMout: 0.7Adc max @ Vbatt<=48V
A15	KEY IN	Key input (Logic Supply input)

Pin	Function	Description
A16	GND	GND. NBATT logic reference
A17	CPOC2	2nd triangle wave shape PWM 5% to 95% or analog signal in the range 0.5V to 4.5V
A19	GND	GND. NBATT logic reference
A20	CPOC1	1st triangle wave shape PWM 5% to 95% or analog signal in the range 0.5V to 4.5V
A21	VDD	5Vdc 50mA supply output (PPOC positive supply for CPOC1-2)
A22	CANL1	CAN Bus channel LOW (No 120 termination aboard)
A23	CANH1	CAN Bus channel HIGH (No 120 termination aboard)

(3) Connection of encoder(Traction and Pump)

ACE2 can handle different types of encoder. To control AC motor, it is necessary to install an incremental encoder with 2 phases shifted by 90°. The encoder supply can be 5 V or 12 V. For special applications it is possible to install incremental encoder with zero-position signal.

- A 8 : +5V/+12V : encoder positive power supply.
- A15 : GND : encoder negative supply.
- A 7 : ENC A : encoder phase A.
- A14 : ENC B : encoder phase B.



15BT9USM0713

4) Function configuration

Using the CONFIG MENU of the programming smart console, or using a display, the user can configure the following functions.

(1) Right traction inverter

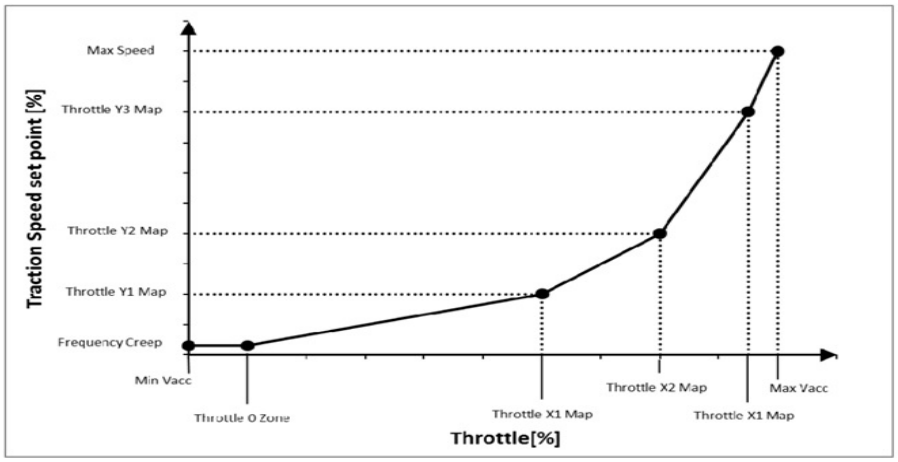
① Set option

SET OPTIONS	DESCRIPTION
HOUR COUNTER	This option specifies the hour counter mode. It can be set one of two: - RUNNING: The counter registers travel time only - KEY ON: The counter registers when the "key" switch is closed
BATTERY CHECK	This option specifies the management of the low battery charge situation. There are four levels of intervention: - 0 : nothing happens; the battery charge level is evaluated but ignored, meaning that no action is taken when the battery runs out. - 1 : The BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to 10% of the full charge. With the BATTERY LOW alarm, the control reduces the maximum speed down and it also reduces the maximum current down to 50% of the full current. - 2 : The BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to 10% of the full charge. - 3 : The BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to 10% of the full charge. With the BATTERY LOW alarm, the control reduces the maximum speed down.

SET OPTIONS	DESCRIPTION
STOP ON RAMP	- ON : The stop on ramp feature (truck electrically hold on a ramp) is managed for a fixed time (6 sec.). - OFF : The stop on ramp feature is not performed.
SET MOT.TEMPERAT	This parameter defines the type of motor temperature sensor adopted. - NONE = no motor thermal sensor is connected. - DIGITAL : A digital (ON/OFF) motor thermal sensor is connected to A23. - OPTION#1 : An analog motor thermal sensor is connected to A23. The temperature sensor is a KTY 84-130 PTC (positive thermal coefficient resistance). - OPTION#2 : An analog motor thermal sensor is connected to A23. The temperature sensor is a KTY 83-130 PTC (positive thermal coefficient resistance). - OPTION#3 : An analog motor thermal sensor is connected to A23. The temperature sensor is a PT1000 PTC (positive thermal coefficient resistance).
EM.BRAKE FUNCT.	This parameter enables or disables the output NEB A18, dedicated to the electromechanical brake: NONE = diagnoses are masked and E.B. is not driven upon a traction request. BRAKE = E.B. is driven upon a traction request if all the related diagnoses pass. The behavior on a slope depends on the STOP ON RAMP setting. Do not use this setting if the electromechanical brake is not really present.
STEER TABLE	This parameter is used to set the correct steering table. - OPTION #1 : The steering table is the one for 3 wheels truck. - OPTION #2 : The steering table is the one for 4 wheels truck.
LOAD SENSOR	- OFF : Load Sensing Function is deactivated - ON : Load Sensing Function is activated.
OVERLOAD TYPE	This option specifies how overload alarm works in overloaded situation. - NONE : There would'n be any kind of alarms or limitations. If re-configuration of V.A.S.S LOAD is required, please set this parameter as NONE, then proceedure-configuration. - Option #1 : If the weight of load filed on forks exceeds the overload weight set in overload parameter, OVERLOAD alarm will be displayed and followed by traction & pump limitation except lift down & steering function. - Option #2 : If the weight of load filed on forks exceeds the overload weight set in overload parameter, OVERLOAD alarm will be displayed.
DISPLAY	This option set the communication check between traction and display. - ON : Communication check is enable. If the traction can not detect the display communication signal, CAN BUS KO DISP is occured and travel speed cutback to turtle speed. - OFF : Communication check is disable.

SET OPTIONS	DESCRIPTION
BMS	This option set the communication check between traction and Li-ion Battery Management System. - ON : using BMS with Lithium Battery - OFF : not using BMS with Lithium Battery
RS232 CONSOLE	This parameter enables or disables the console to change settings.

② Adjustments

ADJUSTMENTS	DESCRIPTION
THROTTLE 0 ZONE	This parameter defines a dead band in the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X1 MAP	This parameter defines the acclerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y1 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X2 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y2 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X3 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y3 MAP	This parameter defines the accelerator input curve. - Accelerator input curve  The speed remains at the FREQUENCY CREEP value as long as the voltage from the accelerator potentiometer is below THROTTLE 0 ZONE. Basically this defines a dead zone close to the neutral position.
BAT. MIN ADJ. BAT. MAX ADJ.	After key on, the controller uses the following parameters to detect the BDI%. BAT. MIN ADJ. : using after key on. (discharged battery level) BAT. MAX ADJ. : using after key on. (charged battery level)
BDI ADJ STUP MIN BDI ADJ STUP MAX	At key on, the controller uses the following parameters to detect the new BDI%. BDI ADJ STUP MIN : using at key on. (discharged battery level) BDI ADJ STUP MAX : using at key on. (charged battery level)
BDI RESET BDI RESET 2	If the difference between the old BDI% and new BDI% is less than BDI RESET, the BDI% is not changed to new BDI%. BDI RESET : using the old BDI% is over 30% before key off. BDI RESET 2 : using the old BDI% is less than 30%(from 29% to 0%) before key off.

ADJUSTMENTS	DESCRIPTION
MOTOR HIGH TEMP	This parameter defines the motor temperature above which a cutback is applied. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.
MOT.SHUTDOWN TEM	This parameter defines the maximum motor temperature permitted, above which the controller stops driving the motor.
REF. LOAD WEIGHT	(This parameter is used for that LOAD SENSOR is ON) This parameter is used to show and configurate the reference load weight.
OVERLOAD WEIGHT	(This parameter is used for that LOAD SENSOR is ON) This parameter is used to show and configurate the trigger condition for OVERLOAD alarm. If the loaded weight exceeds the weight indicated in this paramter, OVERLOAD alarm and function limitation will occur according to OVERLOAD TYPE paramter.
MAX LOAD WEIGHT	(This parameter is used for that LOAD SENSOR is ON) This parameter is used to show and configurate the maximum load weight.
LOAD SPEED UPD.	(This parameter is used for that LOAD SENSOR is ON) To increase accuracy, Load Sensor only works when the traction motor speed is lower than as set in this parameter.

③ Parameter

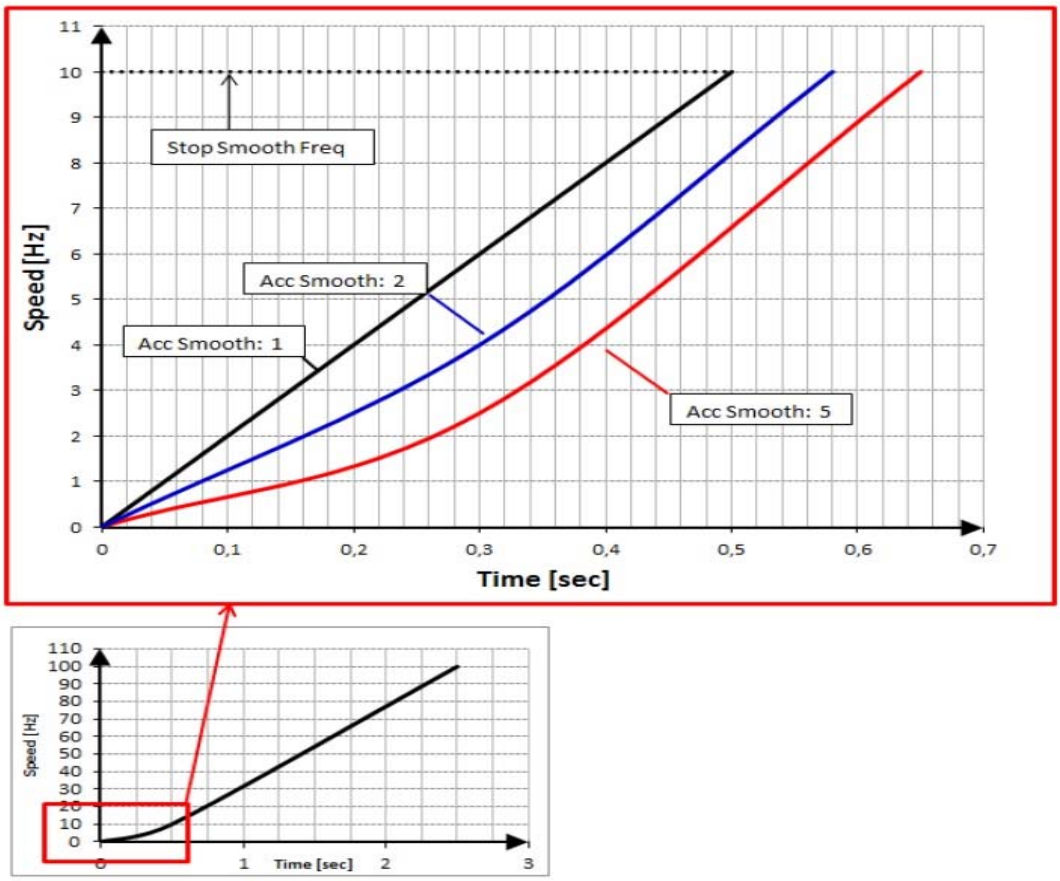
PARAMETER	DESCRIPTION
ACCELERATION 0	It specifies the motor acceleration at 0 Hz. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.
ACCELERATION 1	It specifies the motor acceleration at ACC PROF. FREQ 1[Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.
ACCELERATION 2	It specifies the motor acceleration at ACC PROF. FREQ 2[Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.
ACCELERATION 3	It specifies the motor acceleration at ACC PROF. FREQ 3[Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.
ACCELERATION 4	It specifies the motor acceleration at ACC PROF. FREQ 4[Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.
ACCELERATION 5	It specifies the motor acceleration at ACC PROF. FREQ 5[Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.
ACC PROF.FREQ 1	In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 1 parameter.

PARAMETER	DESCRIPTION
ACC PROF.FREQ 2	In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 2 parameter.
ACC PROF.FREQ 3	In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 3 parameter.
ACC PROF.FREQ 4	In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 4 parameter.
ACC PROF.FREQ 5	In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 5 parameter.
RELEASE BRAKING	This parameter defines the deceleration ramp performed after the running request is released.
INVERS. BRAKING	This parameter defines the deceleration ramp performed when the direction switch is toggled during drive.
DECEL. BRAKING	This parameter defines the deceleration ramp performed when the accelerator is released but not completely.
PEDAL BRAKING	This parameter defines the deceleration ramp performed when the braking pedal is pressed.
SPEED LIMIT BRK.	This parameter defines the deceleration ramp performed upon a speed-reduction request.
STEER BRAKING	This parameter defines the deceleration ramp related to the steering angle.
MAX SPEED FORW	This parameter defines the maximum speed in forward direction.
MAX SPEED BACK	This parameter defines the maximum speed in backward direction.
CUTBACK SPEED 1	This parameter defines the maximum speed performed when the cutback switch is active.
TURTLE SPEED	This parameter defines the maximum speed at turtle mode.
BMS WRN1 CUTBACK	This parameter defines the maximum speed performed when the BMS warning 1 is active.
MOT.HT MAX SPEED	The Maximum speed when the Motor Temperature is reached to the " MOTOR HIGH TEMP " Setting.
BATT. LOW SPEED	This parameter defines the maximum speed performed according to "BATTERY CHECK" parameter.
M.TRAC SPEED RED	Maximum speed when the MAINTENANCE is set to OPTOIN#2 or #3
CURVE SPEED 1	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 1 angle.
MAX ANGLE SPEED	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 1 angle.
OVERLOAD SPEED	This parameter defines the maximum traction speed according to the "OVERLOAD TYPE" parameter when the loaded weight exceeds the "OVERLOAD WEIGHT" parameter.
FREQUENCY CREEP	This parameter defines the minimum speed when the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
BMS WRN0 CUTBACK	This parameter defines the maximum current performed when the BMS warning 0 is active.

PARAMETER	DESCRIPTION
MOT.HT MAX CURRE	The Maximum Current when the Motor Temperature is reached to the " MOTOR HIGH TEMP " Setting
BATT. LOW CURRENT	This parameter defines the maximum current performed according to "BATTERY CHECK" parameter.
ACC. SMOOTH	This parameter defines the acceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
INV. SMOOTH	This parameter defines the acceleration profile performed when the truck changes direction: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP SMOOTH	This parameter defines the frequency at which the smoothing effect of the acceleration profile ends.
BRK SMOOTH	This parameter defines the deceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP BRK SMOOTH	This parameter defines the frequency at which the smoothing effect of the deceleration profile ends.

※ Acceleration smoothness

Smoothing-related parameters define a parabolic profile for the acceleration or deceleration ramps close to 0 rpm. Values have not a physical meaning: 1 means linear ramp, higher values (up to 5) result in smoother accelerations.



PARAMETER	DESCRIPTION
EB ENGAGE DELAY	This parameter defines the delay introduced between the traction request and the actual activation of the traction motor. This takes into account the delay occurring between the activation of the EB output (i.e. after a traction request) and the effective EB release, so to keep the motor stationary until the electromechanical brake is actually released. The releasing delay of the brake can be easured or it can be found in the datasheet.
SEAT DELAY TIME	This parameter defines the delay time after the seat switch is off.
CHAT TIME	In seconds. When truck is key on, if the operator doesn't use the truck for the time(CHAT TIME), main contactor is open to save energy.

(2) Left traction inverter

① Set option

SET OPTIONS	DESCRIPTION
EM.BRAKE FUNCT.	This parameter enables or disables the output NEB A18, dedicated to the electromechanical brake: NONE = diagnoses are masked and E.B. is not driven upon a traction request. BRAKE = E.B. is driven upon a traction request if all the related diagnoses pass. The behavior on a slope depends on the STOP ON RAMP setting. Do not use this setting if the electromechanical brake is not really present.
COOLING FAN	Cooling fans installed on nearby motors and controllers will work as follows; - None : fans don't work. - Option #1 : fans work always. - Option #2 : fans work in case a temperature of controller or motor exceeds a temperature set in FAN WORKING TEMP and FAN WORKING MOTOR. - Option #3 : fans work when motors work.
FAN RELAY COIL	- ON : Using 12V Relay for cooling fan - OFF : not Using 12V Relay for cooling fan
RS232 CONSOLE	This parameter enables or disables the console to change settings.

② Adjustments

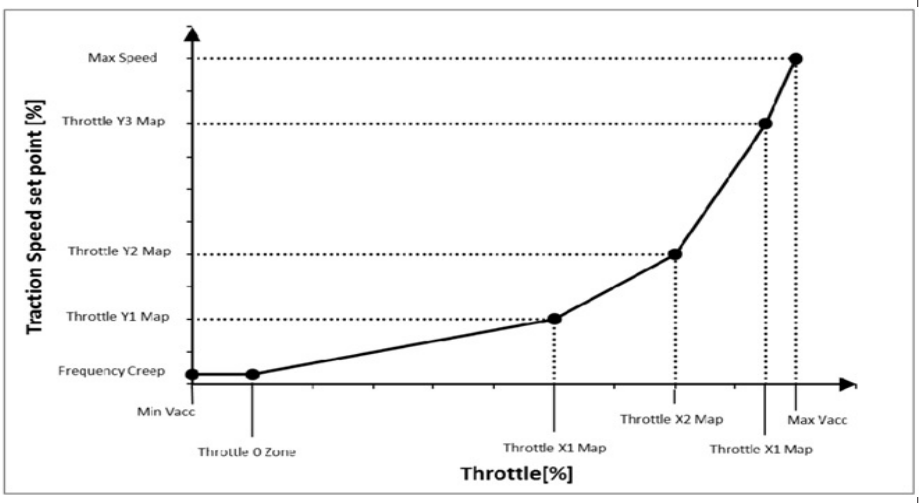
Adjustments	DESCRIPTION
FAN WORKING TEMP	(This parameter is used for that COOLING FAN is option #2) If the temperature of inverter exceeds the temperature indicated in this paramter.
FANWORKING MOTOR	(This parameter is used for that COOLING FAN is option #2) If the temperature of motor exceeds the temperature indicated in this paramter.

(3) Pump inverter

① Set option

SET OPTIONS	DESCRIPTION
SET MOT.TEMPERAT	This parameter defines the type of motor temperature sensor adopted. - NONE = no motor thermal sensor is connected. - DIGITAL : a digital (ON/OFF) motor thermal sensor is connected to A23. - OPTION#1 : an analog motor thermal sensor is connected to A23. The temperature sensor is a KTY 84-130 PTC (positive thermal coefficient resistance). - OPTION#2 : an analog motor thermal sensor is connected to A23. The temperature sensor is a KTY 83-130 PTC (positive thermal coefficient resistance). - OPTION#3 : an analog motor thermal sensor is connected to A23. The temperature sensor is a PT1000 PTC (positive thermal coefficient resistance).
OPSS	- ON : Present (Using OPSS Coil) - OFF : Absent (Not using OPSS Coil)
FINGERTIP	- ON : The truck model includes electro-hydraulic distributor and finger tips. Can communication with VCM and Hydro CB zapi modules is enabled. - OFF : The truck model includes mechanical lever distributor.
FINGERTIP MISM	- ON : trigger the alarm if the fingertip output values are not within the admissible range; - OFF : alarm is not occurred even if the fingertip output values are not within the admissible range.
LEVER FULL	(This parameter is used for that FINGERTIP is ON.) - ON : All combinations of hydraulic function are available. - OFF : The combination of hydraulic function is not available at special condition for the safety. (Lift + tilt down)
AUX 1 FUNCTION	(This parameter is used for that FINGERTIP is ON.) - OFF : The truck doesn't have the AUX 1 function (default) - ON : The truck has the side shift function (Option)
AUX 2 FUNCTION	(This parameter is used for that FINGERTIP is ON.) - OFF : The truck doesn't have the AUX 2 function (default) - ON : The truck has the side shift function (Option)
FORK LEVELING	- OFF : Auto fork leveling function is not activated. - ON : Auto fork leveling function is activated.
CUTBACK MODE	The Traction / Pump speed cutback when the A19(P) pin is Open
RS232 CONSOLE	This parameter enables or disables the console to change settings.

② Adjustments

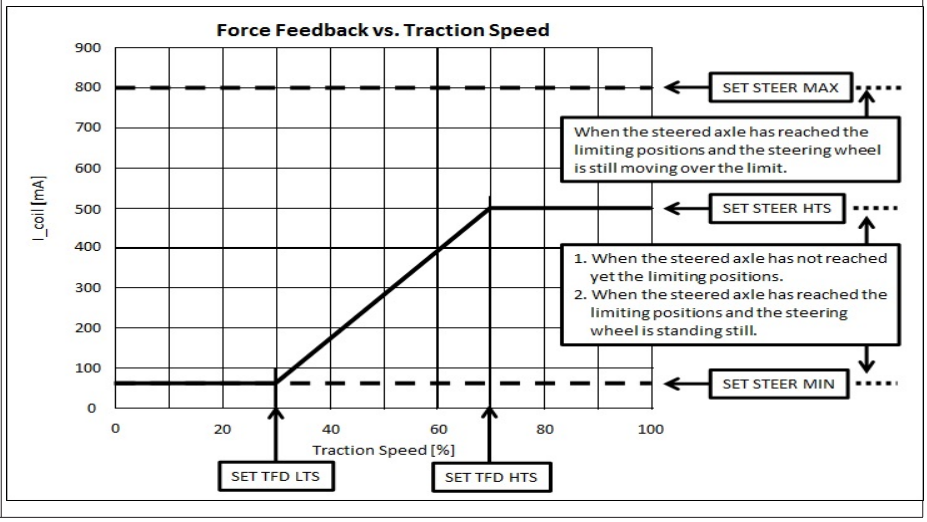
Adjustments	DESCRIPTION
THROTTLE 0 ZONE	This parameter defines a dead band in the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X1 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y1 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X2 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y2 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X3 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y3 MAP	This parameter defines the acclerator input curve. - Accelerator input curve  The speed remains at the RREQUENCY CREEP value as long as the voltage from the acclerator potentiometer is below THROTTLE 0 ZONE. Basically this defines a dead zone close to the neutral position.
MOTOR HIGH TEMP	This parameter defines the motor temperature above which a cutback is applied. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.
MOT.SHUTDOWN TEM	This parameter defines the maximum motor temperature permitted, above which the controller stops driving the motor.
FORK CENTER DEAD	(This parameter is used for that FORK LEVELING is ON) It sets the pecentage of center dead zone from the center value , when fork leveling function is doing.
FORK APPR. RANGE	(This parameter is used for that FORK LEVELING is ON) It sets the approach range from the center value , when fork leveling function is doing.
FORK VALVE MIN	(This parameter is used for that FORK LEVELING and FINGERTIP are ON) It sets the pecentage of tilt valve current , when fork leveling function is doing.

③ Parameter

Parameter	DESCRIPTION
ACCELER. DELAY	This parameter defines the acceleration ramp.
RELEASE BRAKING	This parameter defines the deceleration ramp performed after the running request is released.
DECEL. BRAKING	This parameter defines the deceleration ramp performed when the accelerator is released but not completely.
MAX SPEED LIFT	This parameter defines the maximum speed of the pump motor during lift.
TILT SPEED	This parameter defines the maximum speed of the pump motor during tilt.
AUX1 SPEED	This parameter defines the maximum speed of the pump motor during AUX1.
AUX2 SPEED	This parameter defines the maximum speed of the pump motor during AUX2.
CUTBACK SPEED 1	This parameter defines the maximum speed performed when the cutback switch is active.
BMS WRN1 CUTBACK	This parameter defines the maximum speed performed when the BMS warning 1 is active.
MOT.HT MAX SPEED	The Maximum speed when the Motor Temperature is reached to the " MOTOR HIGH TEMP " Setting.
BATT. LOW SPEED	This parameter defines the maximum speed performed according to "BATTERY CHECK" parameter.
M.PUMP SPEED RED	Maximum speed when the MAINTENANCE is set to OPTOIN#2 or #3.
FREQUENCY CREEP	This parameter defines the minimum speed when the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
BMS WRN0 CUTBACK	This parameter defines the maximum current performed when the BMS warning 0 is active.
MOT.HT MAX CURRE	The Maximum Current when the Motor Temperature is reached to the " MOTOR HIGH TEMP " Setting.
BATT. LOW CURRENT	This parameter defines the maximum current performed according to "BATTERY CHECK" parameter.
ACC. SMOOTH	This parameter defines the acceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP SMOOTH	This parameter defines the frequency at which the smoothing effect of the acceleration profile ends.
SEAT DELAY TIME	This parameter defines the delay time after the seat switch is off.
AUTO FORK SPEED	Pump speed at the Automatic Fork Leveling function is performed
FORK MIN SPEED	The maximum Tilt speed while approaching dead zone.

(4) EPS inverter

① Parameter

Parameter	DESCRIPTION
POTI REVOLUTIONS	From 30 to 90. This setting specifies the number of revolutions of the steering wheel for a side to side rotation of the steered axle.
SET STEER MIN.	0 to 1000mA. The minimum Force Feedback value is set via SET STEER MIN. (Please refer to the Force Feedback vs. Traction Speed in the description of SET TFD HTS)
SET STEER MAN.	0 to 1000mA. The maximum Force Feedback value is set via SET STEER MAX. (Please refer to the Force Feedback vs. Traction Speed in the description of SET TFD HTS)
SET STEER HTS	0 to 1000mA. This parameter is used to handle the minimum Force Feedback value at HTS (High Traction Speed). (Please refer to the Force Feedback vs. Traction Speed in the description of SET TFD HTS)
PERCUSSION DUTY	The time delay before switching off the Force Feedback when the steered axle has reached the limiting position and the steering wheel has been released is set by this parameter. - LEVEL 0: 16 msec delay. - LEVEL 1: 32 msec delay. - LEVEL 2: 48 msec delay. - LEVEL 9: 160 msec delay.
1ST ANGLE GAIN	From 30 to 180 degrees. This parameter sets the maximum steered axle angle in the steering direction with FEEDBACK POT 1 value higher than 2.5V.
2ND ANGLE GAIN	From 30 to 180 degrees. This parameter sets the maximum steered axle angle in the steering direction with FEEDBACK POT 1 value lower than 2.5V.
SET TFD LTS	This parameter is used to handle the minimum Force Feedback value at LTS(Low Traction Speed). (Please refer to the Force Feedback vs. Traction Speed in the description of SET TFD HTS)
SET TFD HTS	This parameter is used to handle the minimum Force Feedback value at HTS(High Transation Speed). 

(5) VCM INVERTER

① Set option

SET OPTIONS	DESCRIPTION
TRUCK MODEL SEL.	There are 2 options, 15/18/20BT-9U, 25/30/32/35B-9U.
HOUR COUNTER	This option specifies the hour counter mode. It can be set one of two: - RUNNING: The counter registers travel time only - KEY ON: The counter registers when the "key" switch is closed.
OUT EV2 A7 DIAG	- ON : Diagnosis is ON - OFF : Diagnosis is OFF
OUT EV1 A6 DIAG	- PRESENT : Diagnosis is Present - ABSENT : Diagnosis is absent
PROPORTIO. VALVE	- ON : using Proportional valve - OFF : Not using proportional valve

② Parameter

PARAMETER	DESCRIPTION
I MIN EVP1	This parameter adjusts the minimum current of valve 1 (Lift).
I MAX EVP1	This parameter adjusts the maximum current of valve 1 (Lift).
I MIN EVP2	This parameter adjusts the minimum current of valve 2 (Lowering).
I MAX EVP2	This parameter adjusts the maximum current of valve 2 (Lowering).
I MIN EVP3	This parameter adjusts the minimum current of valve 3 (Tilt in).
I MAX EVP3	This parameter adjusts the maximum current of valve 3 (Tilt in).
I MIN EVP4	This parameter adjusts the minimum current of valve 4 (Tilt out).
I MAX EVP4	This parameter adjusts the maximum current of valve 4 (Tilt out).
I MIN EVP5	This parameter adjusts the minimum current of valve 5 (AUX1 in).
I MAX EVP5	This parameter adjusts the maximum current of valve 5 (AUX1 in).
I MIN EVP6	This parameter adjusts the minimum current of valve 6 (AUX1 out).
I MAX EVP6	This parameter adjusts the maximum current of valve 6 (AUX1 out).
I MIN EVP7	This parameter adjusts the minimum current of valve 7 (AUX2 in).
I MAX EVP7	This parameter adjusts the maximum current of valve 7 (AUX2 in).
I MIN EVP8	This parameter adjusts the minimum current of valve 8 (AUX2 out).
I MAX EVP8	This parameter adjusts the maximum current of valve 8 (AUX2 out).
VOLTAGE EV2	Supplying Voltage for EV2.
EVP1 OPEN DELAY	It determines the acceleration ramp on EVP1.
EVP1 CLOSE DELAY	It determines the deceleration ramp on EVP1.
EVP2 OPEN DELAY	It determines the acceleration ramp on EVP2.
EVP2 CLOSE DELAY	It determines the deceleration ramp on EVP2.
EVP3 OPEN DELAY	It determines the acceleration ramp on EVP3.

PARAMETER	DESCRIPTION
EVP3 CLOSE DELAY	It determines the deceleration ramp on EVP3.
EVP4 OPEN DELAY	It determines the acceleration ramp on EVP4.
EVP4 CLOSE DELAY	It determines the deceleration ramp on EVP4.
EVP5 OPEN DELAY	It determines the acceleration ramp on EVP5.
EVP5 CLOSE DELAY	It determines the deceleration ramp on EVP5.
EVP6 OPEN DELAY	It determines the acceleration ramp on EVP6.
EVP6 CLOSE DELAY	It determines the deceleration ramp on EVP6.
EVP7 OPEN DELAY	It determines the acceleration ramp on EVP7.
EVP7 CLOSE DELAY	It determines the deceleration ramp on EVP7.
EVP8 OPEN DELAY	It determines the acceleration ramp on EVP8.
EVP8 CLOSE DELAY	It determines the deceleration ramp on EVP8.

(6) DISPLAY

① Password

If determines to set the function of user password when key on.

- OFF : No use
- ON : Activate the user password (Default password is "00000" and it can be re-set at user menu)

② Maintenance

If determines to set the function of maintenance alarm when if come to service interval.

- OFF : No use
- ON : Activate the maintenance alarm function.

③ Hour counter

It indicates the machine operating hours.

- key ON : key on time
- Pump : Pump motor operating time.
- Traction : Traction motor operating time.

(7) PROGRAMMING AND ADJUSTMENTS

There are two ways to adjust parameter via a smart console or buttons on a display.

※ Adjustments via buttons on a display, please refer to the display section. (page 7-6X)

ADJUSTMENTS VIA SMART CONSOLE(Option)

Adjustment of parameters and changes to the inverter's configuration are made using the smart console.

Connect to the MAIN HARNESS of the vehicle.

(Also need the HARNESS-EXT_SMART CONSOLE)

15BT9USM0718

※ Please connect and disconnect it from the inverter after a key switch off.

① Connected

If connection is successful, the display will show a page similar to the next one.

VMCM HY1.00
48v 0a 500H
NO CAN MSG N.05

This menu shows basic information about the controller.

- First line displays the controller firmware.
- Second line shows controller voltage, controller current and hour meter.
- Last line shows the current alarm code, if present.

Press OK to access the MAIN MENU.

MAIN MENU
PARAMETER CHANGE
TESTER
ALARMS

Use UP and DOWN keys to navigate the list: once you find the desired menu press OK to enter it.

② How to modify parameters

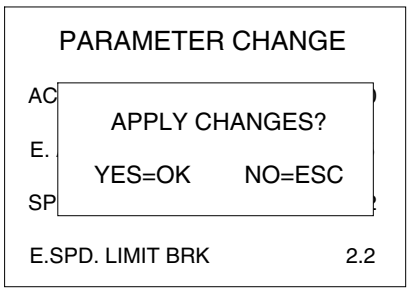
From MAIN MENU enter the desired menu (for example the PARAMETER CHANGE menu).

PARAMETER CHANGE	
ACCELER DELAY	1.0
E. ACCELER DELAY	1.5
SPEED LIMIT BRK	2.2
E.SPD. LIMIT BRK	2.2

With UP and DOWN keys you can scroll the list: once you have highlighted the parameter you want to modify, press either LEFT or RIGHT keys to decrease or increase the parameter value.

Keep LEFT/RIGHT button pressed to continuously repeat the value modification (“auto-repeat” function): this function will speed up the procedure in case many parameter values must be changed.

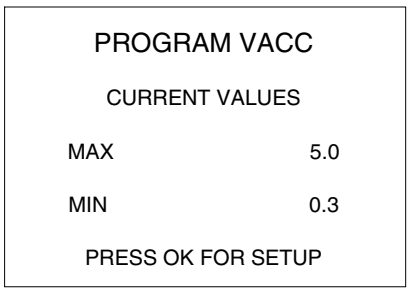
You can press ESC to exit the menu at any time. In case parameters have been modified, the console will prompt the request to confirm/discard changes.



Description above is valid for every menu which contains parameters and options like SET OPTIONS, ADJUSTMENT, HARDWARE SETTINGS, etc.

③ Program Vacc

PROGRAM VACC menu has been slightly modified from old consoles. Upon entering this menu the console shows the current programmed values.

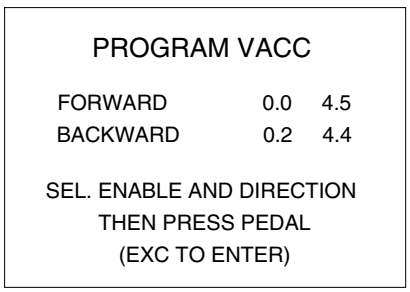


When OK is pressed, PROGRAM VACC procedure starts. Console invites you:

- To select the enable switch, if any;
- To select the direction switch (either forward or backward);
- To depress the pedal to its maximum excursion.

Displayed values vary accordingly to operator inputs.

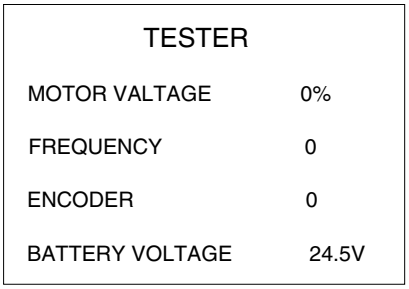
Sequence above can slightly vary depending on controller firmware. Anyway the logic remains the same: before programming the min/max values, execute any starting sequence which is necessary, then press the pedal or push the joystick.



When ESC is pressed, console asks if programmed values must be saved or discarded.

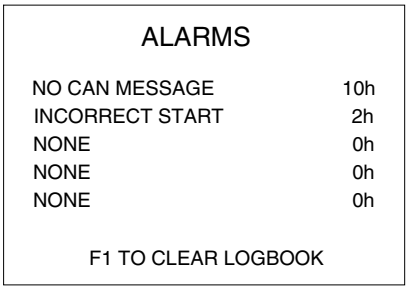
④ Tester

It shows four variables at once: use UP/DOWN keys to scroll the list.



⑤ Alarms

It shows all controller alarms at once.



Five is the maximum number of alarm codes which is stored inside the controller.

Colors are used to separate recurrent alarm codes from rare events. In order of increasing frequency, alarm names can be:

- White: up to 5 occurrences
- Yellow: up to 20,
- Orange: up to 40,
- Red: more than 40.

Use UP/DOWN to select a certain alarm in the list: if OK is pressed, additional pieces of information about that alarm are displayed. Press F1 to clear the alarm logbook of the controller: once F1 is pressed, the console asks for confirmation.

(8) MORNITORING MENU

In smart console, this menu appears as “TESTER” MENU.

① Right traction inverter - Master

Monitoring	Description
KEY VOLTAGE	Key voltage measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time (across the DC bus).
MOTOR VOLTAGE	Estimation of the DC current the inverter is drawing from the battery.
FREQUENCY	Frequency of the current sine-wave that the inverter is supplying to the motor.
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz). (measured value by master micom)
MEASURED SPD SLV	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
SLIP VALUE	Motor slip, i.e. difference between the current frequency and the motor speed (in Hz).
CURRENT RMS	Root-mean-square value of the line current supplied to the motor. (measured value by master micom)
CURRENT RMS SLV	Root-mean-square value of the line current supplied to the motor. (measured value by slave micom)
IMAX LIM. TRA	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a traction request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.).
IMAX LIM. BRK	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a braking request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.).
MOT. POWER WATT	Estimation of the power supplied to the motor.
DC BUS CURRENT	Estimation of the DC current the inverter is drawing from the battery.
STEER ANGLE	Current steering-wheel angle. When the steering is straight ahead STEER ANGLE is zero.
BATTERY CHARGE	Estimation of the battery charge based on the battery voltage.
TEMPERATURE	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT.	Motor-windings temperature. This temperature is used for the MOTOR OVERTEMP alarm.
A19 SEAT SW	Status of the Seat Input on A19.
A6 BRAKE 2 SW	Status of the Pedal-Brake SW 2 input A6.
A4 FWD SWITCH	Status of the forward input A4.
A5 BWD SWITCH	Status of the backward inch input A5.
A13 ACC1	Voltage of the Accelerator-Pedal 1 (Increasing analog signal) on A13.
A3 ACC2	Voltage of the Accelerator-Pedal 2 (Decreasing analog signal) on A13.
A10 BRAKE 1 SW	Status of the Pedal-Brake SW 1 input A10.
A16 MAIN CONT.	Voltage applied over the main contactor coil. It corresponds to the duty cycle value of PWM applied and it is expressed in percentage.

Monitoring	Description
A18 ELEC. BRAKE	Voltage applied over the electro mechanic brake coil. It corresponds to the duty cycle value of PWM applied and it is expressed in percentage.
CTRAP HW	This is a counter and it is showing the number of occurrences of hardware- overcurrent occurrences detection.
TRUCK SPEED	Speed of the truck.
ODOMETER KM	Odometer: overall distance traveled by the truck.
WEIGHT	This shows the measured load weight.

② Right traction inverter- Slave

Monitoring	Description
MEASURED SPD SLV	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
CNA4	Status of the forward input A4.
CNA5	Status of the backward inch input A5.
CNA6	Status of the Pedal-Brake SW 2 input A6.
CNA19	Status of the Seat Input on A19.
A13 ACC 1	Voltage of the Accelerator-Pedal 1 (Decreasing analog signal) on A13.

③ Left traction inverter - Master

Monitoring	Description
KEY VOLTAGE	Key voltage measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time (across the DC bus).
MOTOR VOLTAGE	Estimation of the DC current the inverter is drawing from the battery.
FREQUENCY	Frequency of the current sine-wave that the inverter is supplying to the motor.
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
SLIP VALUE	Motor slip, i.e. difference between the current frequency and the motor speed (in Hz).
CURRENT RMS	Root-mean-square value of the line current supplied to the motor.
IMAX LIM. TRA	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a traction request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.).
IMAX LIM. BRK	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a braking request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.).
MOT. POWER WATT	Estimation of the power supplied to the motor.
DC BUS CURRENT	Estimation of the DC current the inverter is drawing from the battery.
TEMPERATURE	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT.	Motor-windings temperature. This temperature is used for the MOTOR OVERTEMP alarm.
A19 SBR	Status of the SBR SW Input on A19.
A4 BRAKE OIL	Status of the Brake oil SW Input on A4.
A5 LEVELING DIG	Status of the Tilt leveling SW input A5.
A13 TILT LEV1	Status of the Auto tilt leveling 1 (Increasing analog signal) input A13.
A6 LOAD SENSOR	Status of the Load sensor potentiometer (analog signal) input A6.
A3 TILT LEV2	Status of the Auto tilt leveling 2 (Decreasing analog signal) input A6.
A18 ELEC. BRAKE	Voltage applied over the electro mechanic brake coil. It corresponds to the duty cycle value of PWM applied and it is expressed in percentage.
CTRAP HW	This is a counter and it is showing the number of occurrences of hardware- overcurrent occurrences detection.

④ Left traction slave

Monitoring	Description
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
CNA4	Status of the Brake oil SW Input on A4.
CNA5	Status of the Tilt leveling SW input A5.
CNA6	Status of the Load sensor potentiometer (analog signal) input A6.
CNA19	Status of the SBR SW Input on A19.
A13 TILT LEV 1	Status of the Auto tilt leveling 1 (Decreasing analog signal) input A13.

⑥ Pump inverter - Master

Monitoring	Description
KEY VOLTAGE	Key voltage measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time (across the DC bus).
MOTOR VOLTAGE	Estimation of the DC current the inverter is drawing from the battery.
FREQUENCY	Frequency of the current sine-wave that the inverter is supplying to the motor.
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
SLIP VALUE	Motor slip, i.e. difference between the current frequency and the motor speed (in Hz).
CURRENT RMS	Root-mean-square value of the line current supplied to the motor.
IMAX LIM. TRA	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a traction request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.)
IMAX LIM. BRK	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a braking request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.)
MOT. POWER WATT	Estimation of the power supplied to the motor.
DC BUS CURRENT	Estimation of the DC current the inverter is drawing from the battery.
BATTERY CHARGE	Estimation of the battery charge based on the battery voltage.
TEMPERATURE	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT.	Motor-windings temperature. This temperature is used for the MOTOR OVERTEMP alarm.
A4 AUX1 SWITCH	Status of the AUX1 SW Input on A4.
A5 AUX2 SWITCH	Status of the AUX2 SW Input on A5.
A19 CUTBACK SW	Status of the LIFT CUTBACK SW Input on A19.
A10 TILT SWITCH	Status of the TILT SW Input on A10.
A13 LIFT POT 1	Status of the LIFT POT 2 (Increasing analog signal) input A13.
A3 LIFT POT 2	Status of the LIFT POT 1 (Decreasing analog signal) input A3.
A9 SET EVP	This value shows the setpoint of proportional elevtrovalve (OPSS) EVP.
CTRAP HW	This is a counter and it is showing the number of occurrences of hardware overcurrent occurrences detection.

⑦ Pump Inverter - Slave

Monitoring	Description
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
CNA4	Status of the AUX1 SW Input on A4.
CNA5	Status of the AUX2 SW Input on A5.
CNA19	Status of the CUTBACK SW input A19.
A13 LIFT POT 1	Status of the LIFT POT 1 (Increasing analog signal) input A3.

⑧ EPS Inverter - Master

MONITORING	Description
FEEDBACK POT 1	Real time analog value of input CPOT1 (A1). (STEERING AXLE SENSOR)
FEEDBACK POT 2	Real time analog value of input CPOT2 (A2). (STEERING AXLE SENSOR)
FEEDBACK ENC.	Voltage 0 to 5000mV. This is the value of the encoder counting scaled in a range 2500mV +/- 2500mV corresponding to a 0+/-180 degrees in the steered axle. FEEDBACK ENC assumes 2500mV value when the encoder counting is null. A steered axle angle in the range 0+/-90degrees corresponds to a FEEDBACK ENC of 2500V+/-1250mV (i.e. from 1250mV to 3750mV). Adjustment SET STEER 0-POS must be set in order the encoder counting is null (and FEEDBACK ENC is 2500mV) when the steered axle is really straight ahead.
ENC COUNTING	Counts of the encoder vs. the straight ahead direction of the steered axle. Adjustment SET STEER 0-POS must be set in order the encoder counting is null (and FEEDBACK ENC is 2500mV) when the steered axle is really straight ahead.
ENC SPEED	This is the speed of the motor measured with the encoder on the motor shaft.
FREQUENCY	This is the frequency applied to the steering motor.
MOTOR VOLTAGE	It is a percentage. 100% means the sine waves in the motor have the maximum PWM amplitude.
MOTOR CURRENT	Root Mean Square value of the line current in the motor.
IQ RMS	Root Mean Square value of the quadrature current in the motor (torque component).
ID RMS	Root Mean Square value of the direct current in the motor (flux component).
TEMPERATURE	Temperature of the controller base plate.
MOTOR TEMPERAT.	Temperature of the motor windings measured with the thermal sensor inside the motor and connected to CNG #7.
CW LIMIT LEVEL	When the STEER ANGLE overtakes the superior limit for the steered wheel angle limitation, the steered wheel angle will be limited and CW LIMIT LEVEL turns ON (active).
ACW LIMIT LEVEL	When STEER ANGLE is lower than the inferior limit for the steered wheel angle limitation, the steered wheel angle will be limited and ACW LIMIT LEVEL turns ON (active).
TRUCK MOVING	This reading turns ON when the traction speed is not null.
I TFD	This is the real time measurement of the DC current [mA] in the load connected to CNA #10 (TFD COIL).
MOT POWER WATT	This is the real time measurement of the active power in Watts entering the motor.
STEER ANGLE	This reading supplies the angle of the steered axle in degrees with sign.
STATUS #9	STATUS #9 is used to support the embedded troubleshooting.
STATUS #8	STATUS #8 is used to support the embedded troubleshooting.
STATUS #7	STATUS #7 is used to support the embedded troubleshooting.
STATUS #6	STATUS #6 is used to support the embedded troubleshooting.
STATUS #5	STATUS #5 is used to support the embedded troubleshooting.
STATUS #2	STATUS #2 is used to support the embedded troubleshooting.
STATUS #1	STATUS #1 is used to support the embedded troubleshooting.

⑨ EPS Inverter - Slave

MONITORING	Description
FEEDBACK POT 1	Real time analog value of input CPOT 1 (A1). (STEERING AXLE SENSOR)
FEEDBACK POT 2	Real time analog value of input CPOT 2 (A2). (STEERING AXLE SENSOR)
FEEDBACK ENC.	Voltage 0 to 5000mV. This is the value of the encoder counting scaled in a range 2500mV +/- 2500mV corresponding to a 0+/-180 degrees in the steered axle. FEEDBACK ENC assumes 2500mV value when the encoder counting is null. A steered axle angle in the range 0+/-90degrees corresponds to a FEEDBACK ENC of 2500V+/-1250mV (i.e. from 1250mV to 3750mV). Adjustment SET STEER 0-POS must be set in order the encoder counting is null (and FEEDBACK ENC is 2500mV) when the steered axle is really straight ahead.
ENC COUNTING	Counts of the encoder vs. the straight ahead direction of the steered axle. Adjustment SET STEER 0-POS must be set in order the encoder counting is null (and FEEDBACK ENC is 2500mV) when the steered axle is really straight ahead.
ENC SPEED	This is the speed of the motor measured with the encoder on the motor shaft.
FREQUENCY	This is the frequency applied to the steering motor.
MOTOR CURRENT	Root Mean Square value of the line current in the motor.
IQ RMS	Root Mean Square value of the quadrature current in the motor (torque component).
ID RMS	Root Mean Square value of the direct current in the motor (flux component).
TEMPERATURE	Temperature of the controller base plate.
MOTOR TEMPERAT.	Temperature of the motor windings measured with the thermal sensor inside the motor and connected to CNG #7.
CW LIMIT LEVEL	When the STEER ANGLE overtakes the superior limit for the steered wheel angle limitation, the steered wheel angle will be limited and CW LIMIT LEVEL turns ON (active).
ACW LIMIT LEVEL	When STEER ANGLE is lower than the inferior limit for the steered wheel angle limitation, the steered wheel angle will be limited and ACW LIMIT LEVEL turns ON (active).
TRUCK MOVING	This reading turns ON when the traction speed is not null.
I TFD	This is the real time measurement of the DC current [mA] in the load connected to CNA #10 (TFD COIL).
MOT POWER WATT	This is the real time measurement of the active power in Watts entering the motor.
STEER ANGLE	This reading supplies the angle of the steered axle in degrees with sign.
STATUS #9	STATUS #9 is used to support the embedded troubleshooting.
STATUS #8	STATUS #8 is used to support the embedded troubleshooting.
STATUS #7	STATUS #7 is used to support the embedded troubleshooting.
STATUS #6	STATUS #6 is used to support the embedded troubleshooting.
STATUS #5	STATUS #5 is used to support the embedded troubleshooting.
STATUS #2	STATUS #2 is used to support the embedded troubleshooting.
STATUS #1	STATUS #1 is used to support the embedded troubleshooting.

⑩ VCM Inverter - Master

MONITORING	Description
BATTERY VOLTAGE	Battery voltage measured in real time (across the DC bus).
OUTPUT GROUP #1	% value. Percentage of the maximum current applied on the output group #1 (EVP 1 and EVP 2).
OUTPUT GROUP #2	% value. Percentage of the maximum current applied on the output group #2 (EVP 3 and EVP 4).
OUTPUT GROUP #3	% value. Percentage of the maximum current applied on the output group #3 (EVP 5 and EVP 6).
OUTPUT GROUP #4	% value. Percentage of the maximum current applied on the output group #4 (EVP 7 and EVP 8)
NEV2 OUTPUT	% value. Percentage of the battery voltage applied on the EV 2
NEV1 OUTPUT	% value. Percentage of the battery voltage applied on the EV 1

5) GENERAL SUGGESTION FOR SAFETY

(1) Before doing any operation, ensure that the battery is disconnected.

(2) For traction applications, raise up or otherwise disable driving wheels to prevent the possibility of unexpected vehicle motion or motion in the wrong direction during initial commissioning. For hydraulic applications, open the valve to prevent the possibility of excessive pressure (in the event of a malfunction of the relief valve pressure).

(3) Take necessary precautions to not compromise safety in order to prevent injuries to personnel and damages to equipment.

(4) After operation, even with the key switch open, the internal capacitors may remain charged for some time. For safe operation onto the setup, it is recommended to disconnect the battery and to discharge the capacitors by means of a resistor of about 10~100 Ohm between +B and -B terminals of the inverter.

※ The method of discharging internal capacitor.
Bofore checking controllers, motors, cables and etc., discharge the internal capacitor in controllers by following below steps ;

① Disconnect the battery cable.

② Emergency contactor on and key on.

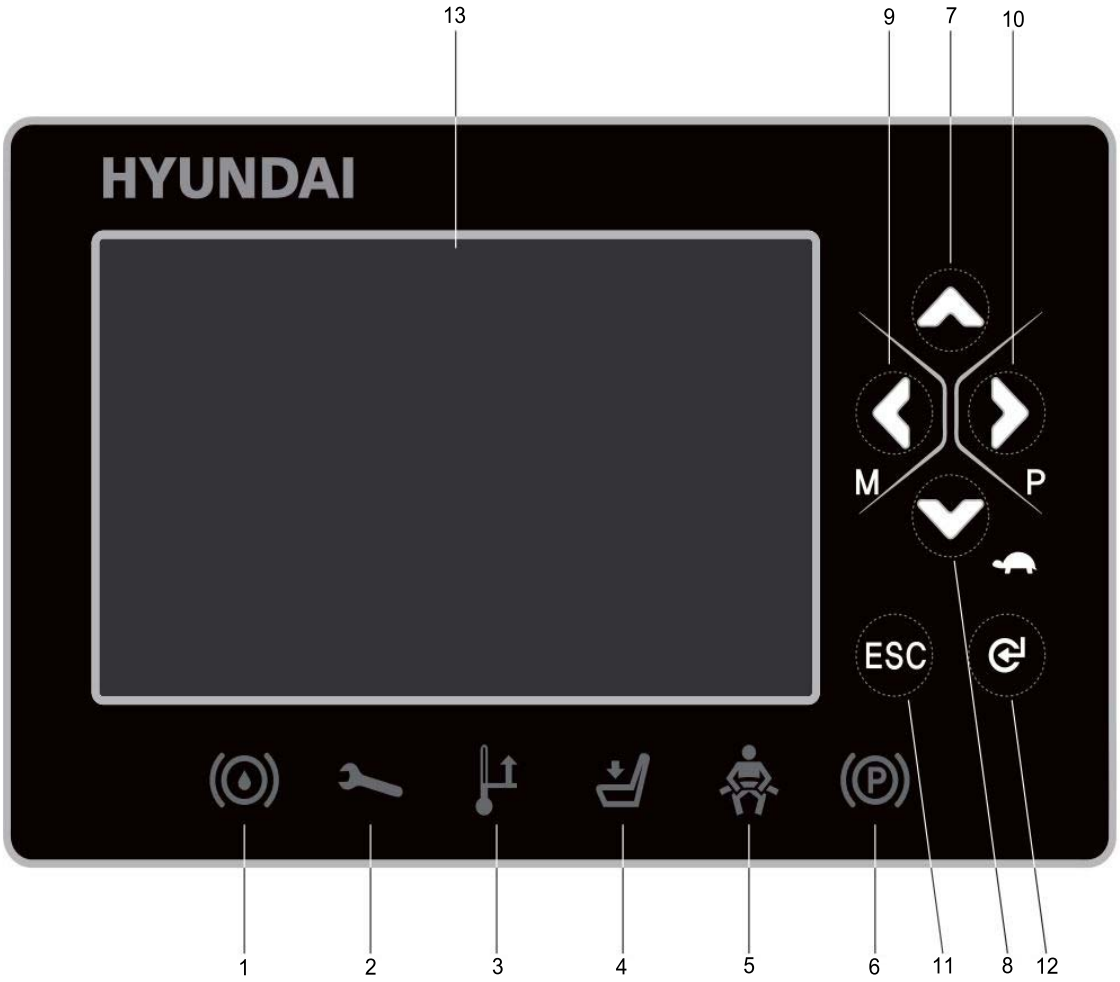
③ Wait until all warning lamps (red LED) on display become off.

④ Discharging process is finished.

6. INSTRUMENT PANEL : DISPLAY (15BT-9U : ~#303, 18BT-9U : ~#449, 20BT-9U : ~#782)

1) STRUCTURE

The instrument panel (display) has six built-in red LED, which provide the operator with an easy information about the status of some truck devices.



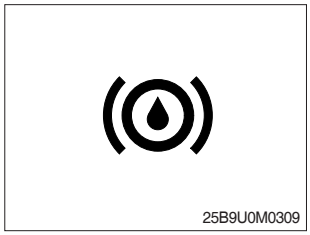
· LCD : TFT 4.3 inch IPS

25B9U0M0308

1	Oil level warning lamp	6	Parking brake warning lamp	11	ESC button
2	Wrench warning lamp	7	Up button	12	Enter button
3	Thermometer warning lamp	8	Down/turtle button	13	LCD function
4	Seat warning lamp	9	Left/menu button		
5	Seat belt warning lamp	10	Right/performance button		

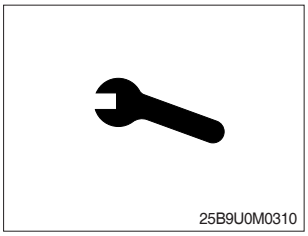
2) WARNING LAMP

(1) Brake oil level warning lamp



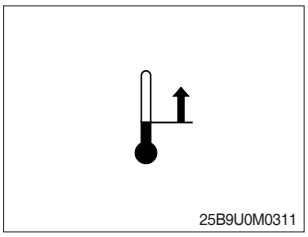
This LED lights when measured level of brake oil stored in reservoir tank is below the minimum acceptable mark.

(2) Wrench warning lamp



This LED lights when an electric device (controller, motor, cable, etc.) is in abnormal condition.

(3) Thermometer warning lamp

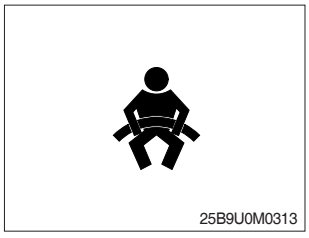


This LED lights when the controller or motor temperature is high.

(4) Seat warning lamp

This LED lights when the operator is not on the seat.

(5) Seat belt warning lamp

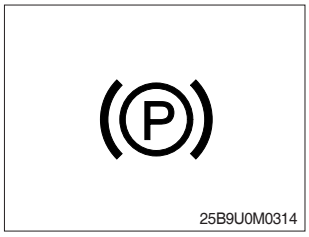


(1) This LED blinks in following 2 cases.

① When operator starts the truck, LED blinks for 5 seconds, which means initial diagnosis is on going, and buttons on display will work properely just after the diagnosis is completed.

② LED blinks when the seat belt is not correctly fastened.

(6) Parking brake warning lamp



(1) This LED lights when the parking brake is activated.

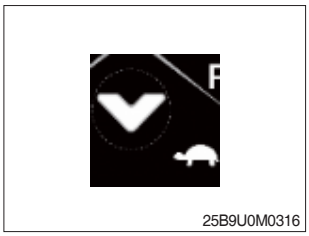
3) BUTTON

These buttons are used to select or change the menu and input value of the LCD function and display menu.

(1) Up button

Press to select upward move.

(2) DOWN/TURTLE button

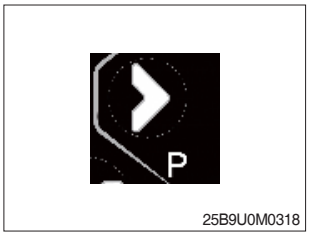


Press to select downward move.
TURTLE MODE ON/OFF

(3) LEFT/MENU button

Press to select leftward move.
Go into the menu.

(4) RIGHT/PERFORMANCE button



Press to select rightward move.
POWER MODE H/N/E

(5) Cancel (ESC) button

Press to select cancel.
Keep pressing this button shows PASSWORD entry field.

(6) ENTER button

Press to select Enter.

4) LCD FUNCTION

25B9U0M0321

1	Current time	6	Hour meter
2	Turtle mode	7	Wheel position and running direction
3	Truck speed pointer	8	Power mode
4	Speed level	9	BDI (Battery Discharge Indicator)
5	Truck speed	10	Load weight (option)

(1) Current time

The number shows the current time according to the setting, which can be changed by display setting at page 7-58.

(2) Turtle mode

The turtle symbol is normally off. When this symbol appears, the turtle mode is activated regardless of the power mode of the truck to reduce the maximum speed to the set-point. This mode can be activated by pressing the button.

(3) Truck speed pointer

The speed of the truck is indicated with a pointer.

(4) Speed level

It indicates the speed level by 2 km.

(5) Truck speed

The truck speed is shown in number. The unit can be km/h or mph according to the display setting (see 7-66 page).

(6) Hour meter

The number shows the hours worked. The letter present beside the hour meter number shows which hour meter is displayed.

– hK : the Key Hour shows the truck Key ON time;

– hT : the Traction Hour shows the Gate ON (driven) time of the traction motor.

– hP : the Pump Hour shows the Gate ON (driven) time of the pump motor.

(7) Wheel position and running direction

The arrow point is up when the truck is forward running and points down when the truck is reverse running. The arrow points the direction of the steering angle.

(8) Power mode

The letter H, N, or E, shows the power mode which is being used in the controller. The mode can be scrolled by pressing the  button sequentially. When a mode is selected, the related information will be sent via CAN-BUS to traction and pump controllers that will manage this data.

H (High) – corresponds to the highest performance

N (Normal) – corresponds to normal performance

E (Economic) – corresponds to economic performance

(9) BDI (battery's state of charge)

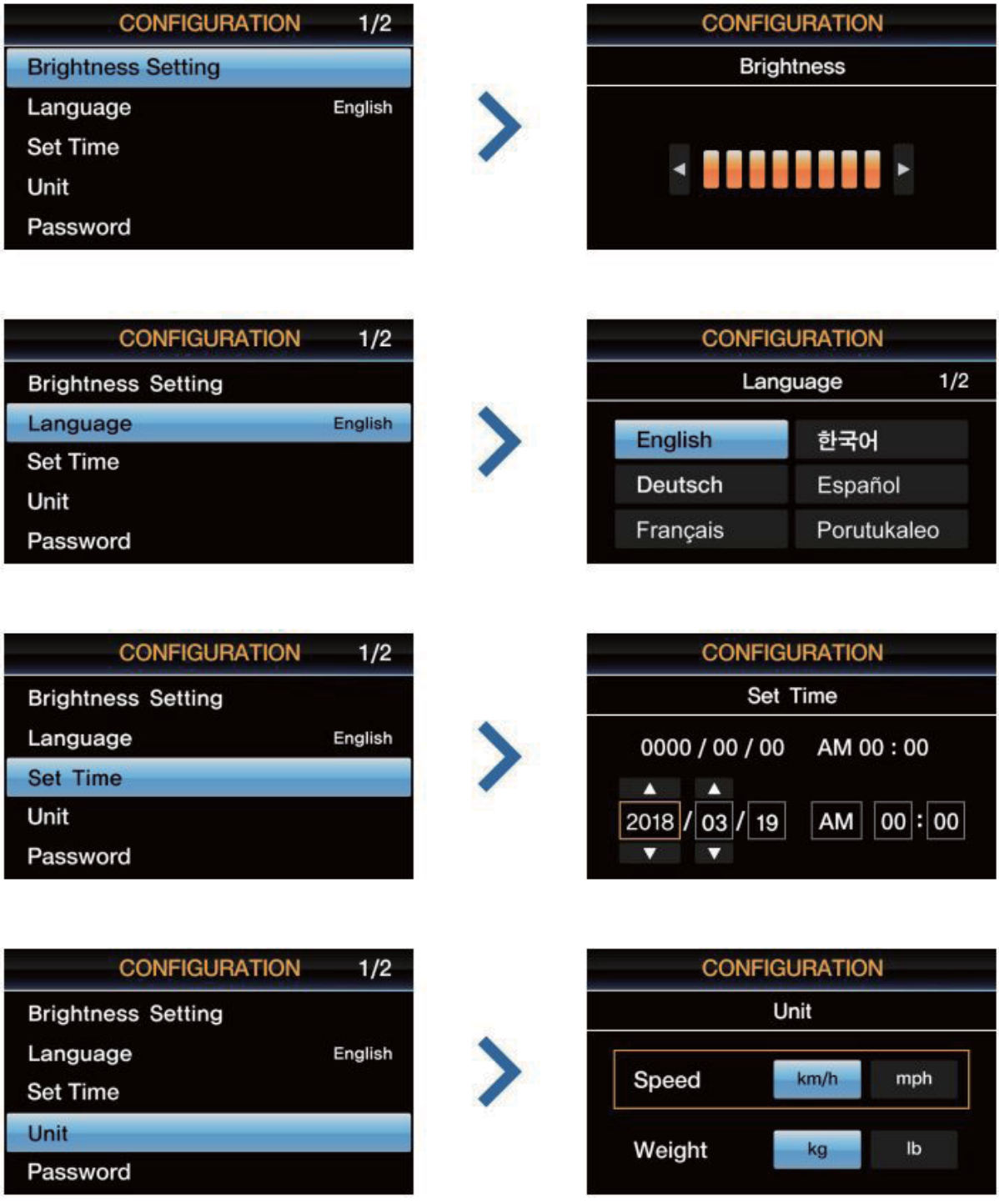
The battery's state of charge is shown by ten bars. Each bar represents the 10% of the battery charge. As the battery becomes discharged, the bars turn off progressively, one after another, in proportion to the value of the residual battery charge. When the residual battery charge is 20% or under, the bars displayed become red.

(10) Load weight (option)

The indicator shows the weight the machine carrying at load.

- Indicator range : 0~6375 kg

5) HOW TO SET THE DISPLAY MENU



25B9UOM0322


CONFIGURATION 1/2
Brightness Setting
Language English
Set Time
Unit
Password
CONFIGURATION
Password
0 * * * *
CONFIGURATION 2/2
Display Version 2,00
25B9UOM0323

6) DESCRIPTION OF THE TRUCK MENU

(1) Access to truck menu

Step	Display	Description
1		1. When the vehicle key turns on, the initial screen as shown on the left appears. 2. Press "ESC" button for more than 1 second in the initial screen.
2		1. The password input screen appears as shown on the left. 2. Enter the password using the "UP", "DOWN", "LEFT/MENU", "RIGHT/PERFORMANCE" buttons and press the "ENTER" button.
3		1. After inputting the password, the initial screen appears as shown on the left. 2. Press the "LEFT / MENU" button.
4		1. TRUCK MENU appears as shown on the left. 2. Use the "UP" and "DOWN/TURTLE" buttons to select the desired menu (HIGH-LIGHT in blue) and press the "ENTER" button to enter the menu. 3. To move to the upper menu, press "ESC" button to move.

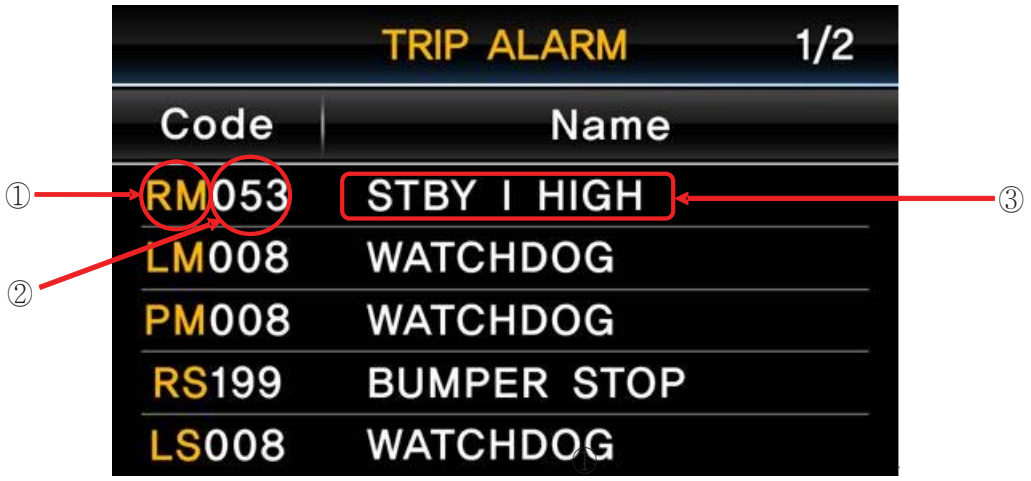
7) ALARM & ALARM HISTORY

(1) How to check alarms

Normally, ALARM SCREEN pops up if any kind of a alarm happens, but service man can switch between a MAIN SCREEN and ALARM SCREEN with ESC , ↵ buttons as follows :

15BT9USM07CL1

(2) Detail description of ALARM SCREEN



15BT9USM07CL04

①First orange capital letter shows in which controller the alarm happens as below;

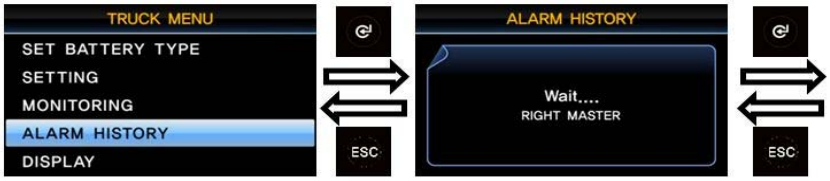
RM : Right Traction - Master	PS : Pump - Slave
RS : Right Traction - Slave	EPSM : EPS - Master
LM : Left Traction - Master	EPSS : EPS - Slave
LS : Left Traction - Slave	VCMM : VCM - Master
PM : Pump - Master	VCMS : VCM - Slave

②Following three letters or digits show alarm code. Please refer to 10. ALARM CODE (Page 7-69).

③This shows a name of ALARM. Please refer to 10. ALARM CODE (page 7-69).

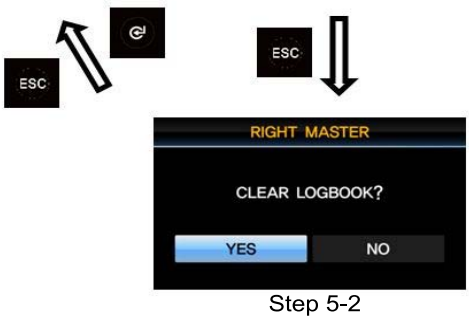
(3) Alatm history

Alarm History can be looked up as follows ;



Step 1 Step 2

Step 3 Step 4 Step 5-1



Step 5-2

15BT9USM07CL5

① Step 1 : Service man can check the alarm history on ALARM HISTORY menu
② Step 2 : When service man enter the ALARM HISTORY menu, display read entire alarm records of all controller.
③ Step 3 : When display finish to read alarm records, service man can choose each controller to read the alarm history.
④ Step 4 : When service man enters each controller's alarm history, service man can check simply up to 5 alarms and choose a specific alarm to read detail alarm information.
⑤ Step 5-1 : When service man press ↵ button at Step 4, operator can see a detail alarm information of chosen alarm. Please refer to (4) DETAIL ALARM INFORMATION (see below).
Step 5-2 : When service man press ESC button at Step 4, service man can see a alarm clear
⑥ menu. If service man press ↵ button, Recorded alarms of selected controller will be erased.
(to verify cleaned alarm records, service man should be back to Step 1 & 2 to refresh.)
If operator press ESC button, just escape to step 3 without clearing

(4) Detail alarm information

15BT9USM07CL6

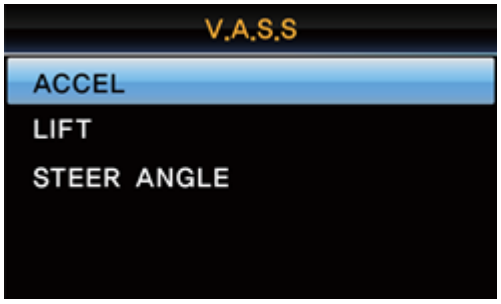
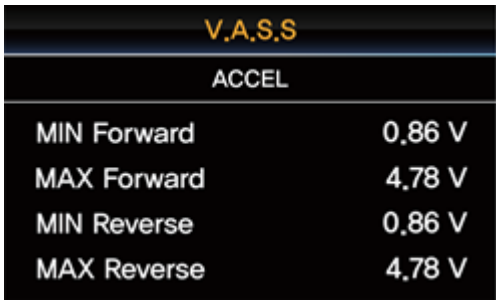
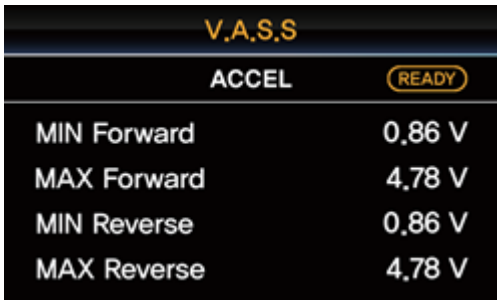
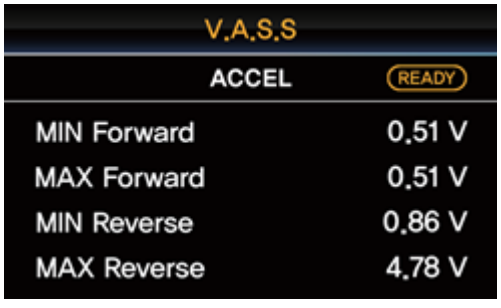
① Code of alarm
② Name of alarm
③ Count of alarm
④ Temperature of controller as alarm occurs.
⑤ Hourmeter of controller as alarm occurs.

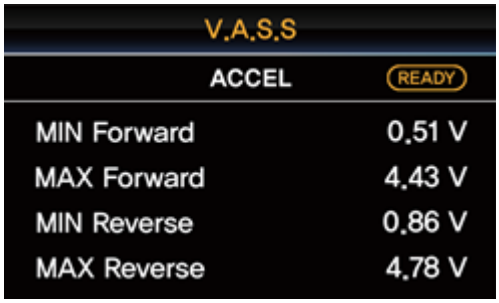
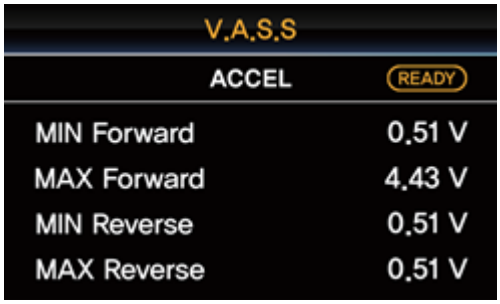
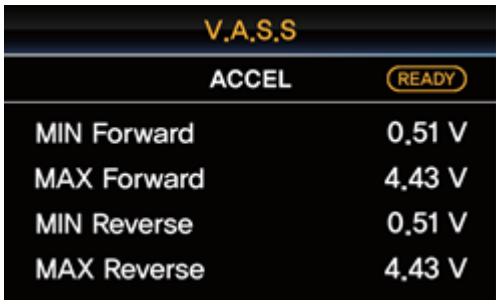
8) VASS SETUP USING DISPLAY MENU

This function searches and memorizes the minimum and maximum potentiometer wiper voltage of the accelerator pedal, lift lever, and steering sensor which use potentiometer sensors. The belows show how to use the VASS function of DISPLAY. (All figures in belows are just example.)

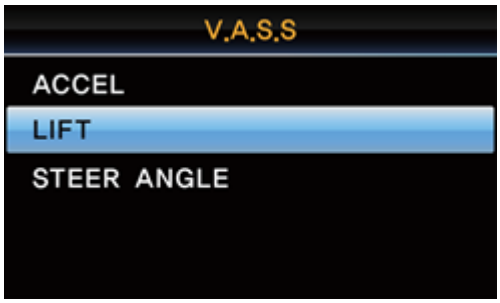
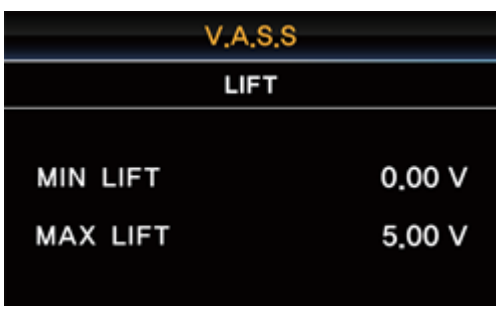
While even a motor is running, VASS can not be configurated properly, so please be sure that all motors are not running before entering configuration process & saving.

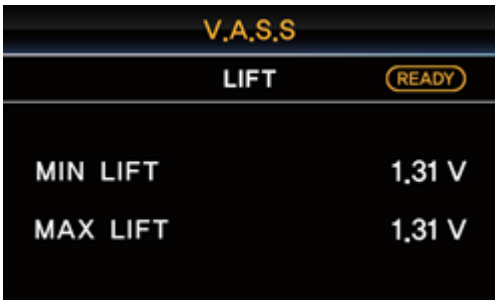
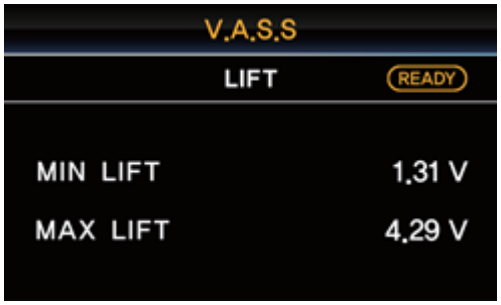
(1) ACCEL VASS setting method

Step	Display	Description
1		1. Access the accelerator pedal setup screen via "TRUCK MENU → SETTING → V .A.S.S → ACCEL".
2		1. As shown on the left screen, the accelerator pedal setting screen appears. ※ Confirm that the forward / reverse gear is neutral and both the traveling and hydraulic motor are stopped. 2. Press the "ENTER" button to start the setting.
3		1. When the ready indicator appears in the upper right corner of the screen, start setting. 2. Place the forward / reverse gear in forward position.
4		1. Press the accelerator pedal all the way down and release it again

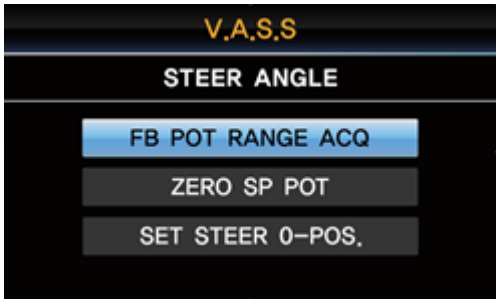
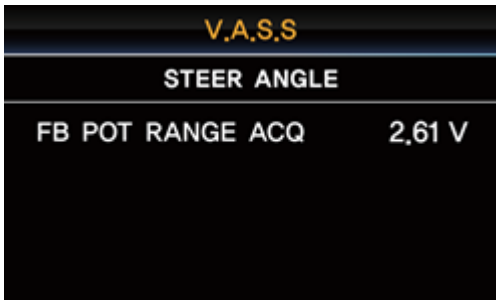
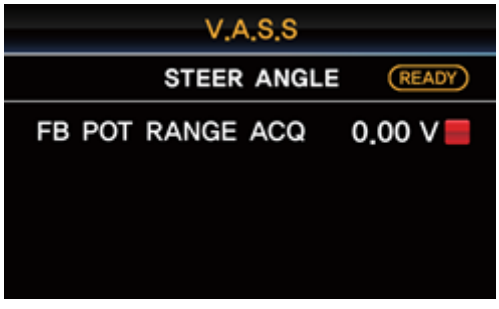
Step	Display	Description
5		1. You can see that MAX FORWARD has been changed. 2. Change the forward / reverse gear from forward to reverse.
6		1. MIN REVERSE (minimum value at backward) and MAX REVERSE (maximum value at backward) are changed to 0V ~ 0.9V state. 2. Place the forward / reverse gear in forward position.
7		1. You can see that MAX REVERSE has been changed. ※ Set the forward / reverse gear to neutral and check that all motors are stopped. 2. Press the "ENTER" button to save.

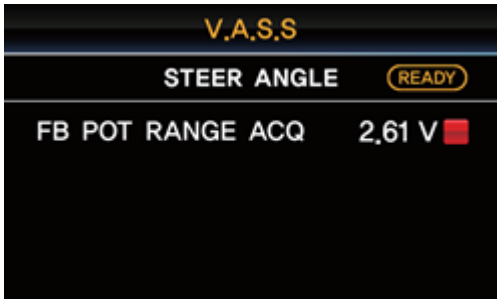
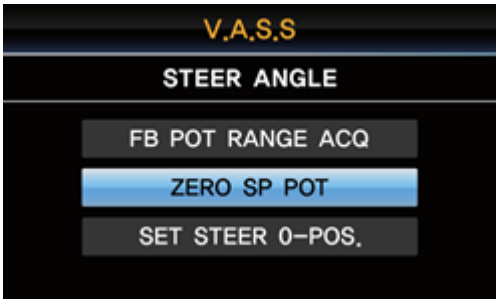
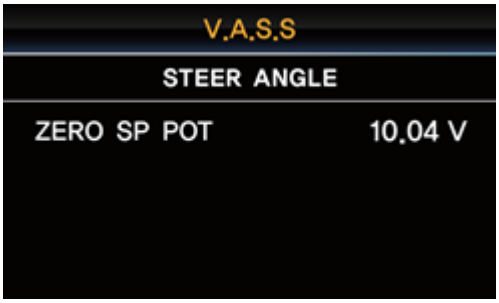
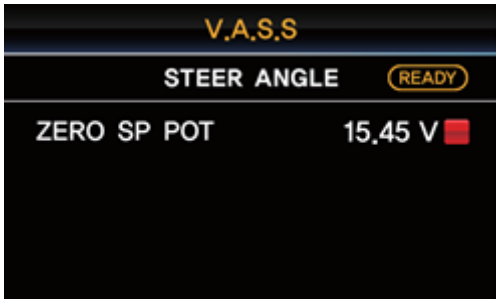
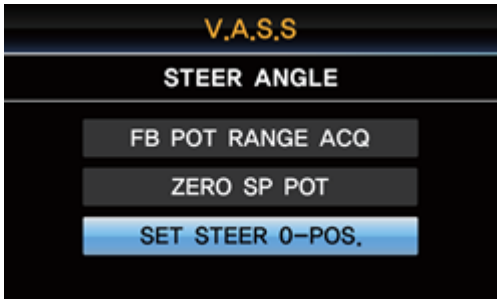
(2) LIFT VASS setting method

Step	Display	Description
1		1. Access the lift sensor setting screen via "TRUCK MENU → SETTING → V.A.S.S. → LIFT".
2		1. As shown on the left screen, the accelerator setting screen appears. ※ Confirm that the forward / reverse gear is neutral and both the traveling / hydraulic motor is stopped. 2. Press the "ENTER" button to start the setting.

Step	Display	Description
3		1. The READY indicator appears in the upper right corner of the screen, and the MIN LIFT and MAX LIFT values are aligned to the current minimum value. 2. Pull up the lift lever until it stops.
4		1. Pulling the LIFT LEVER all the way down will change the value when the MAX LIFT value is pulled to its maximum. ※ Set the forward / reverse gear to neutral and check that all motors are stopped. 2. Press the "ENTER" button to save.

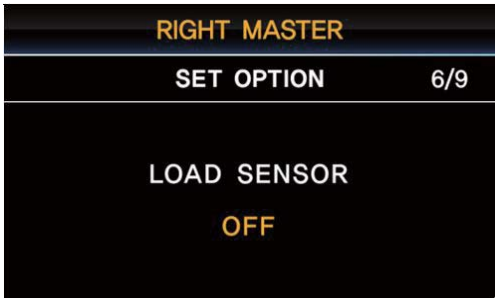
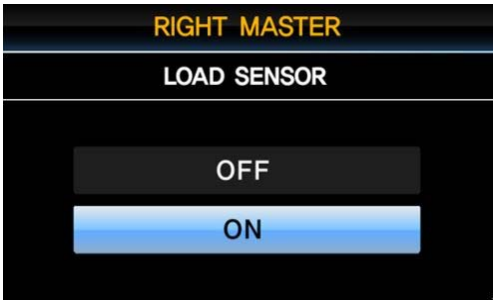
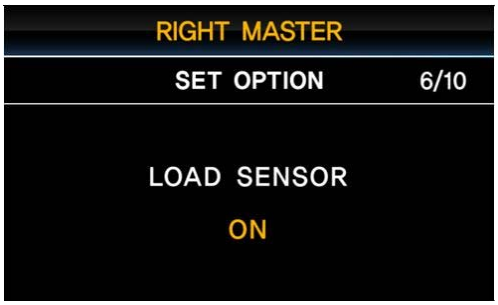
(3) STEER ANGLE VASS setting method

Step	Display	Description
1		1. Access the lift sensor setting screen via "TRUCK M ENU → S ETTING → V.A.S.S. → STEER ANGLE". 2. Enter the "FB POT RANGE ACQ" menu.
2		1. Press the "ENTER" button on the left screen to start the setting.
3		1. Turn the steering wheel repeatedly 3 to 4 times to the left and right. (Repeat as close as possible to the left / right maximum steering angle.)

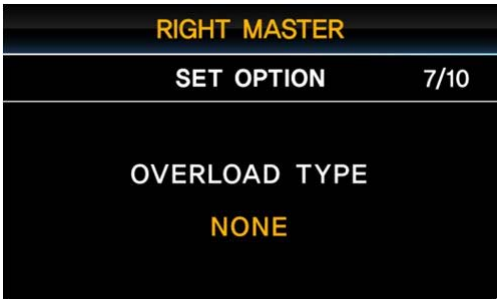
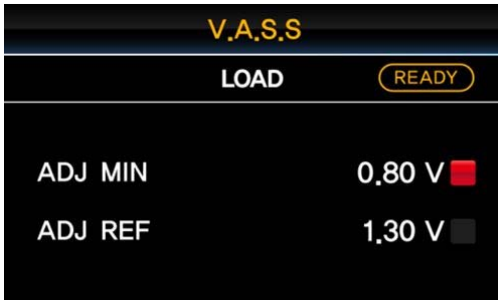
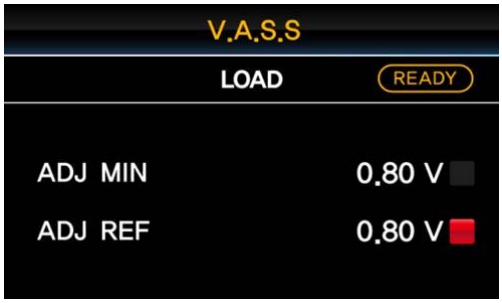
Step	Display	Description
4		1. If the voltage change no longer appears, press "ENTER" to save.
5		1. Access the lift sensor setting screen via "TRUCK M ENU → SETTING → V.A.S.S. → STEER ANGLE". 2. Enter the "ZERO SP POT" menu.
6		1. Press the "ENTER" button on the left screen to start the setting.
7		1. Position the steering wheel in the forward direction (steering knob at 8 o'clock) and press "ENTER" to save. 
8		1. Access the lift sensor setting screen via "TRUCK M ENU → S ETTING → V.A.S.S. → STEER ANGLE". 2. Enter the "SET STEER 0-POS." menu.

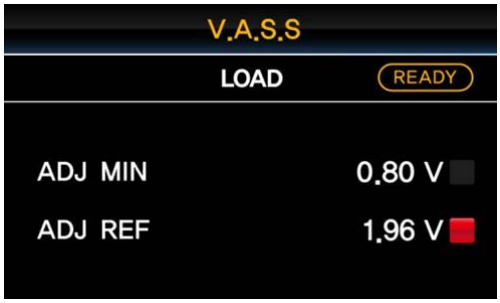
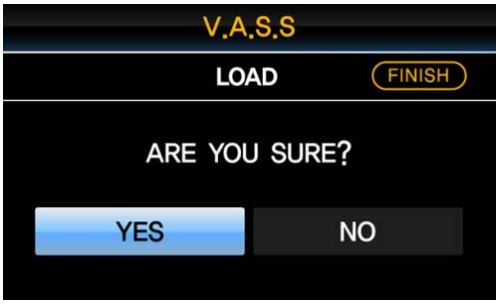
Step	Display	Description
9		※ Make sure that the angle of the steering wheel (rear wheel) is in the complete forward direction (0.) before starting the setting. 1. Press the "ENTER" button on the left screen to start the setting.
10		1. Press the "UP" and "DOWN / TURTLE" buttons to adjust the value to match the "FEEDBACK POT 1" value at the bottom of the screen and press "ENTER" to save.

(4) LOAD SENSOR setting method(Option)

Step	Display	Description
1		1. In the TRUCK MENU, find the LOAD SENSOR parameter via “SETTING RIGHT MASTER SET OPTION”
2		1. Change it to “ON” by using "UP" button and "DOWN / TURTLE" button and press "ENTER" button to save.
3		1. You can see that LOAD SENSOR has been changed to “ON”.

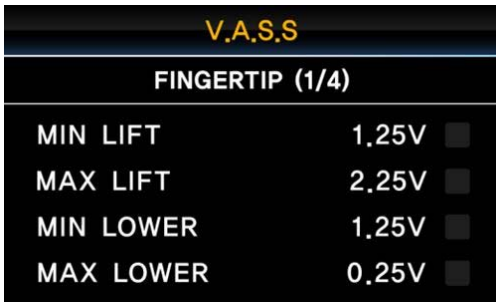
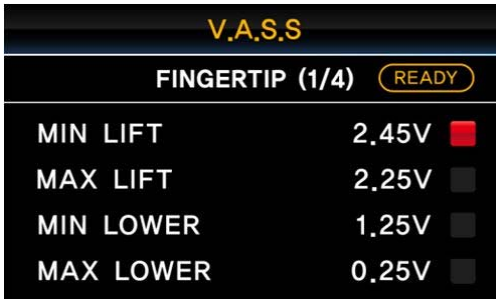
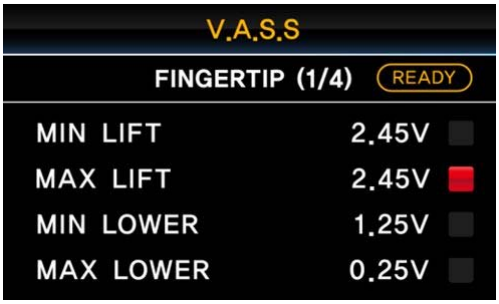
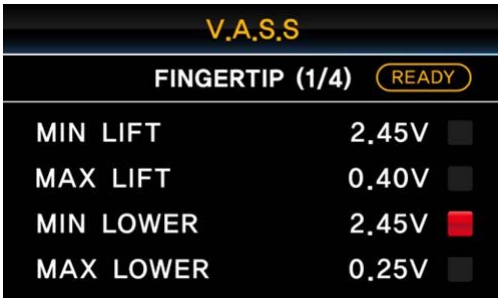
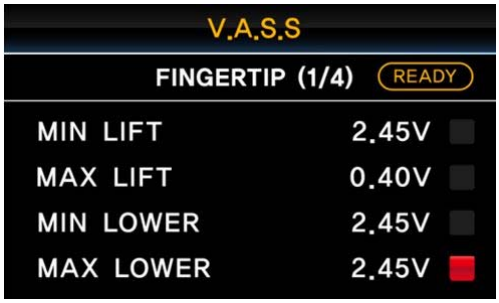
Step	Display	Description
4		1. In the TRUCK MENU, find the REF.LOAD WEIGHT parameter via “TRUCK MENU RIGHT MASTER ADJUSTMENTS” 2. REF LOAD WEIGHT is a parameter that adjusts the weight of the setting load. Press the "ENTER" button to set.
5		1. Use the "UP" button and the "DOWN / TURTLE" button to set the load weight for the setup (assuming 2800KG) and press the "ENTER" button.
6		1. Press the "ENTER" button to save.
7		1. You can see that the REF LOAD WEIGHT parameter value has changed. 2. Use the "UP" and "DOWN / TURTLE" buttons to find the OVER LOAD WEIGHT parameter.
8		1. The OVER LOAD WEIGHT parameter sets the weight at which the overload warning occurs, and the value differs for each model / mast. Refer to "OVERLOAD WEIGHT” for each model / mast. 2. Refer to steps 5 and 6 to set the specified weight. 3. Open TRUCK MENU RIGHT MASTER SET OPTION OVERLOAD TYPE setting screen.

Step	Display	Description
9		1. The OVER LOAD TYPE parameter has three options as shown below. 1) NONE: No warning even if the load weight exceeds the OVER LOAD WEIGHT setting. 2) OPTION # 1: OVER LOAD WEARING occurs when the load weight exceeds the OVER LOAD WEIGHT setting value, and stops the vehicle operation except LIFT DOWN and steering function. 3) OPTION # 2: OVER LOAD WARNING occurs only when the load weight exceeds the OVER LOAD WEIGHT setting. 2. OVER LOAD TYPE must be set to NONE for LOAD SENSOR setting. If set to OPTION # 1 or OPTION # 2, change to "NONE" using "ENTER" button and "UP" or "DOWN / TURTLE" After that, LOAD SENSOR must be set.
10		1. Access the LOAD SENSOR setting screen via “TRUCK MENU SETTING V.A.S.S LOAD SENSOR”. (Only when the LOAD SENSOR parameter in step 1 is set to ON.) 2. After confirming that the forward / reverse gear is neutral and both the drive and hydraulic motor are stopped, press the "ENTER" button in no-load state to start the setting.
11		1. At the top right of the screen, "READY" appears, "ADJ MIN" displays a red mark, and the "ADJ MIN LOAD" setting starts. The value of "ADJ MIN" indicates the no-load LOAD SENSOR input, and the setup proceeds. 2. Press Enter button to move on to the "ADJ REF".
12		1. "ADF REF" displays a red mark and the "ADJ REF" setting starts. 2. "ADJ REF" is the input value of the load sensor when the load for setting is lifted. When setting, lift the load to a height of about 50 cm from the ground. ※Before lifting the load, slightly lower and lift the load to operate normally. 3. You can see that the "ADF REF" value changes every time you lift the load.

Step	Display	Description
13		1. After waiting for 5 ~ 10 seconds after lifting the load(REF. LOAD WEIGHT), make sure that the ADJ REF value stabilizes, then press the ENTER button.
14		1. Press the "ENTER" button to save and exit. 2. Set the OVERLOAD TYPE in Step 9 as desired. (Default value is NONE) ※ Note: For accuracy of LOAD SENSOR, the reference load for setting should be as large as possible within the range of not exceeding OVERLOAD WEIGHT.

(5) FINGERTIP setting method(OPTION)

Step	Display	Description
1		1. In the TRUCK MENU, find the TRUCK MODEL SEL. parameter via “TRUCK MENU → SETTING → PUMP MASTER → SET OPTION”
2		1. Use the "UP" button and the "DOWN / TURTLE" button to find each of the following parameters and change them to the corresponding settings. 1) EVP TYPE: NONE (Not applicable for 15/18/20BT-9U) 2) OPSS: OFF 3) FINGERTIP: ON 4) FINGERTIP MISM: ON 5) AUX 1 FUNCTION: ON (when the lever specification is 3-spool or more) 6) AUX 2 FUNCTION: ON (when the lever specification is 4-spool or more)

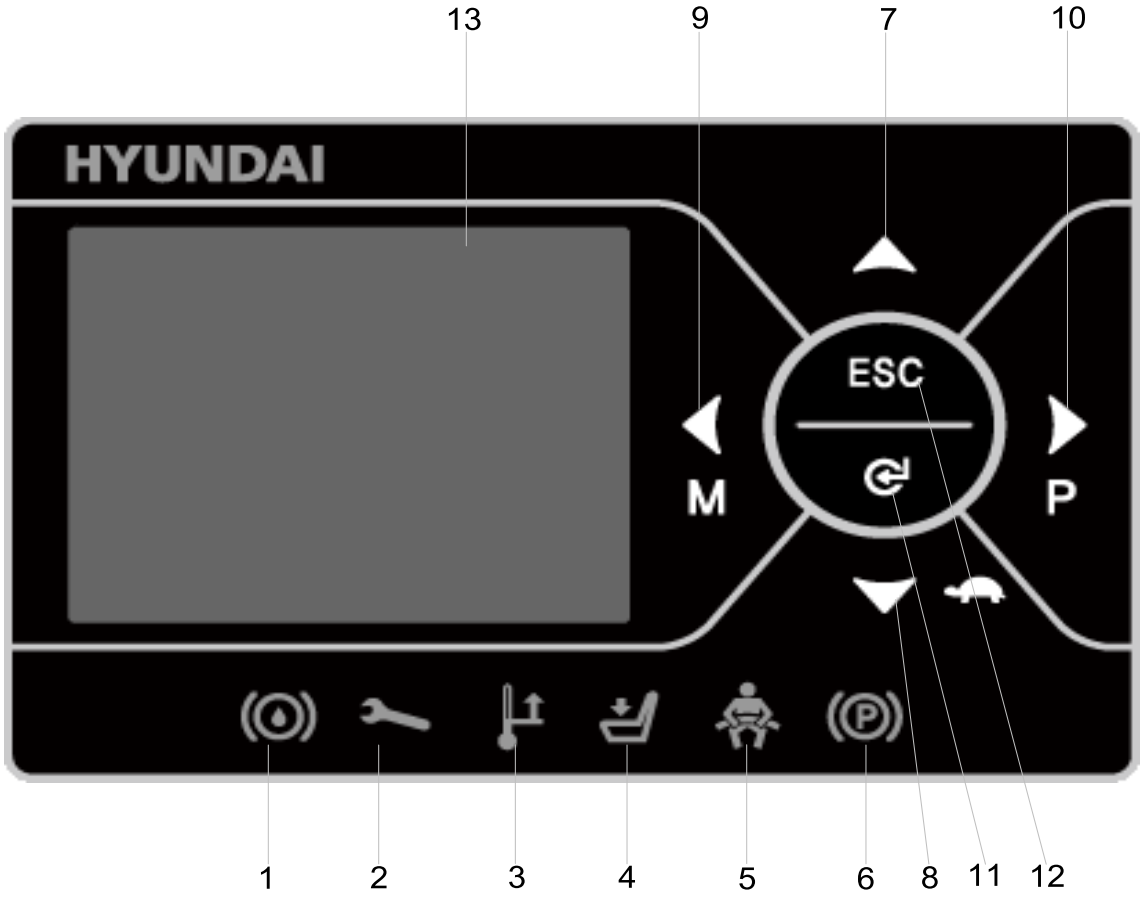
Step	Display	Description
3		1. Access the FINGERTIP setting screen via “TRUCK MENU SETTING V.A.S.S FINGERTIP”. (Only when the FINGERTIP parameter in step 1 is set to ON.) 2. Press the ENTER button to set the LEVER as shown below. 1) 2-SPOOL : LIFT, TILT 2) 3-SPOOL : LIFT, TILT, AUX1 3) 4-SPOOL : LIFT, TILT, AUX1, AUX2 3. For illustrative purposes, Below will set the LIFT LEVER by pressing the "ENTER" button.
4		1. The READY indicator appears in the upper right corner of the screen, a red indicator appears on the right of the MIN LIFT and MIN LIFT (LIFT UP MIN value) setting starts. 2. Set MIN LIFT (LIFT UP MIN value). While pulling the LEVER a little bit (about 10˚) from the center, press the "ENTER" button to set the MIN LIFT value.
5		1. It switches to MAX LIFT (LIFT UP MAX value) setting and displays real time LEVER voltage value. 2. Set MAX LIFT (LIFT UP MAX value). While pulling the lever all the way down, press the "ENTER" button to set the MIN LOWER value.
6		1. It switches to MIN LOWER (LOWER MIN value) setting and displays real time LEVER voltage value. 2. Set MIN LOWER (LOWER MIN value). While pushing the LEVER a little bit (about 10˚) from the center, press the "ENTER" button to set the MAX LOWER value.
7		1. It switches to MAX LOWER (LOWER MAX value) setting and displays real time LEVER voltage value. 2. Set MAX LOWER (LOWER MAX value). While pulling the lever all the way down, press the "ENTER" button.

Step	Display	Description
8		1. After completing all lever settings, press "ENTER" button. 2. Press the "ENTER" button to exit.

6. INSTRUMENT PANEL : DISPLAY (15BT-9U : #304~, 18BT-9U : #450~, 20BT-9U : #783~)

1) STRUCTURE

The instrument panel (display) has six built-in red LED, which provide the operator with an easy information about the status of some truck devices.



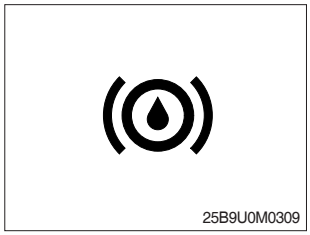
25B9U0M0308-1

· LCD : TFT 3.5 inch IPS

1	Oil level warning lamp	6	Parking brake warning lamp	11	Enterbutton
2	Wrench warning lamp	7	Up button	12	ESC button
3	Thermometer warning lamp	8	Down/turtle button	13	LCD function
4	Seat warning lamp	9	Left/menu button		
5	Seat belt warning lamp	10	Right/performance button		

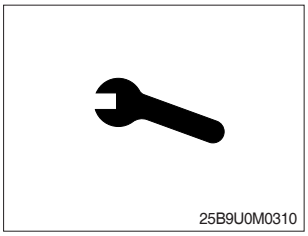
2) WARNING LAMP

(1) Brake oil level warning lamp



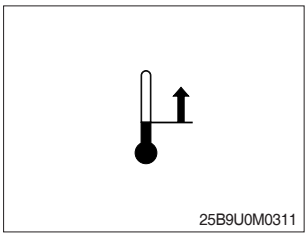
This LED lights when measured level of brake oil stored in reservoir tank is below the minimum acceptable mark.

(2) Wrench warning lamp



This LED lights when an electric device (controller, motor, cable, etc.) is in abnormal condition.

(3) Thermometer warning lamp

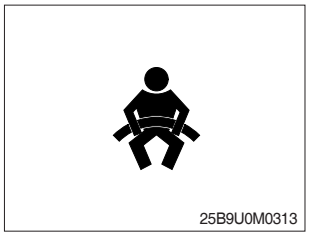


This LED lights when the controller or motor temperature is high.

(4) Seat warning lamp

This LED lights when the operator is not on the seat.

(5) Seat belt warning lamp

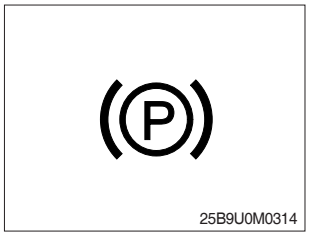


(1) This LED blinks in following 2 cases.

① When operator starts the truck, LED blinks for 5 seconds, which means initial diagnosis is on going, and buttons on display will work properely just after the diagnosis is completed.

② LED blinks when the seat belt is not correctly fastened.

(6) Parking brake warning lamp



(1) This LED lights when the parking brake is activated.

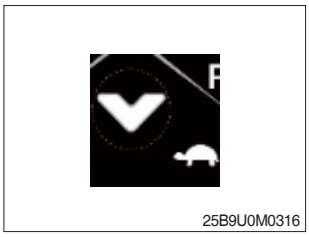
3) BUTTON

These buttons are used to select or change the menu and input value of the LCD function and display menu.

(1) Up button

Press to select upward move.

(2) DOWN/TURTLE button

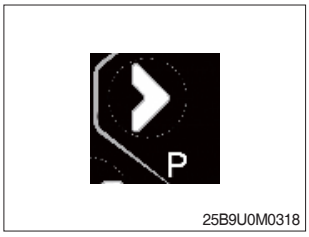


Press to select downward move.
TURTLE MODE ON/OFF

(3) LEFT/MENU button

Press to select leftward move.
Go into the menu.

(4) RIGHT/PERFORMANCE button



Press to select rightward move.
POWER MODE H/N/E

(5) Cancel (ESC) button

Press to select cancel.
Keep pressing this button shows PASSWORD entry field.

(6) ENTER button

Press to select Enter.

4) LCD FUNCTION

1	Current time	6	BDI (Battery Discharge Indicator)
2	Turtle mode	7	Hour meter
3	Truck speed pointer	8	Load weight (option)
4	Speed level	9	Wheel position and running direction
5	Truck speed	10	Power mode

(1) Current time

The number shows the current time according to the setting, which can be changed by display setting at page 7-58.

(2) Turtle mode

The turtle symbol is normally off. When this symbol appears, the turtle mode is activated regardless of the power mode of the truck to reduce the maximum speed to the set-point. This mode can be activated by pressing the button.

(3) Truck speed pointer

The speed of the truck is indicated with a pointer.

(4) Speed level

It indicates the speed level by 2 km.

(5) Truck speed

The truck speed is shown in number. The unit can be km/h or mph according to the display setting (see 7-66 page).

(6) Hour meter

The number shows the hours worked. The letter present beside the hour meter number shows which hour meter is displayed.

– hK : the Key Hour shows the truck Key ON time;

– hT : the Traction Hour shows the Gate ON (driven) time of the traction motor.

– hP : the Pump Hour shows the Gate ON (driven) time of the pump motor.

(7) Wheel position and running direction

The arrow point is up when the truck is forward running and points down when the truck is reverse running. The arrow points the direction of the steering angle.

(8) Power mode

The letter H, N, or E, shows the power mode which is being used in the controller. The mode can be scrolled by pressing the  button sequentially. When a mode is selected, the related information will be sent via CAN-BUS to traction and pump controllers that will manage this data.

H (High) – corresponds to the highest performance

N (Normal) – corresponds to normal performance

E (Economic) – corresponds to economic performance

(9) BDI (battery's state of charge)

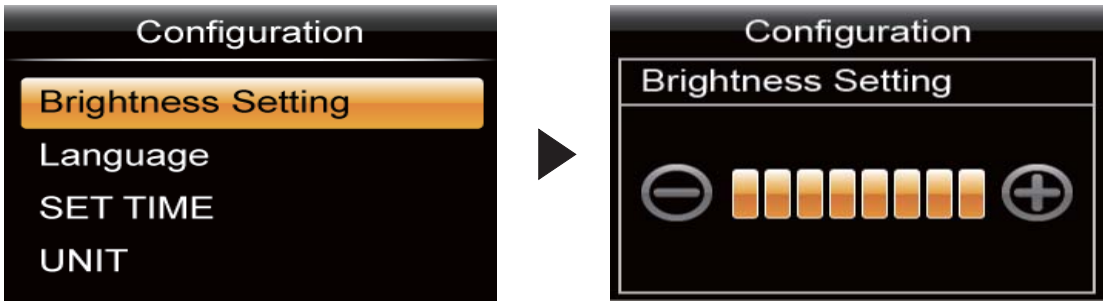
The battery's state of charge is shown by ten bars. Each bar represents the 10% of the battery charge. As the battery becomes discharged, the bars turn off progressively, one after another, in proportion to the value of the residual battery charge. When the residual battery charge is 20% or under, the bars displayed become red.

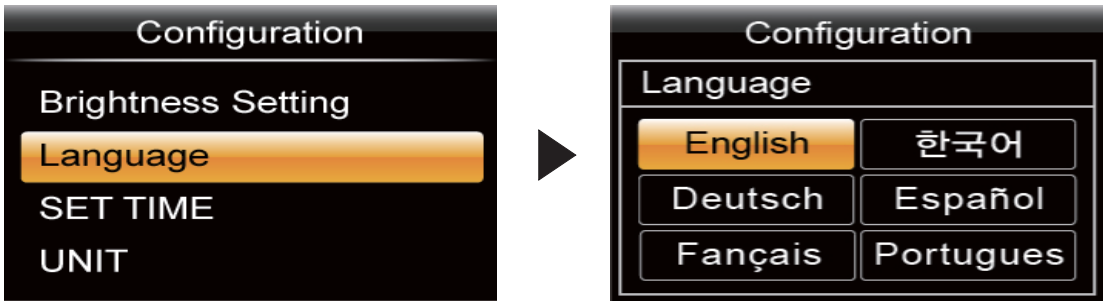
(10) Load weight (option)

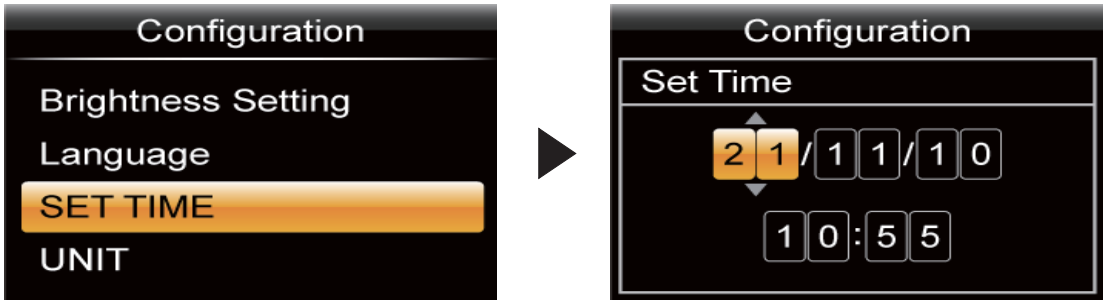
The indicator shows the weight the machine carrying at load.

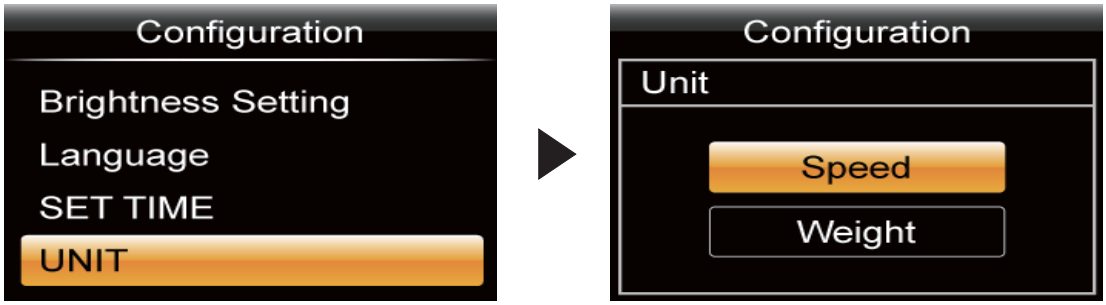
- Indicator range : 0~6375 kg

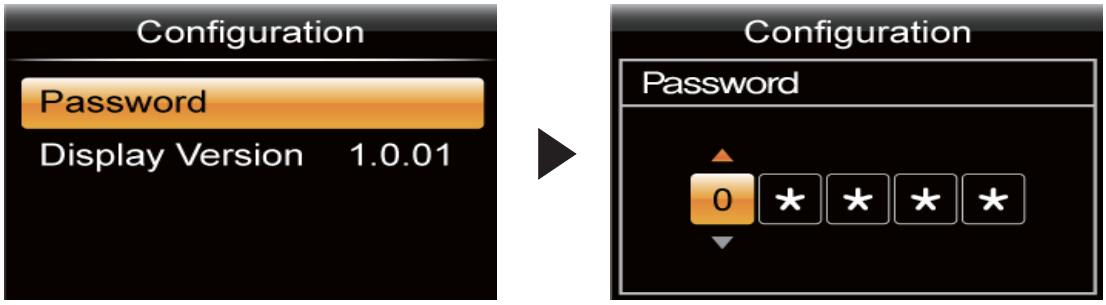
5) HOW TO SET THE DISPLAY MENU





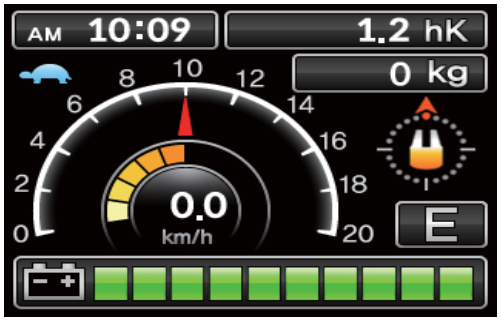
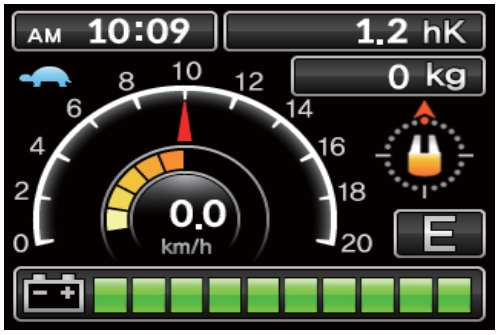
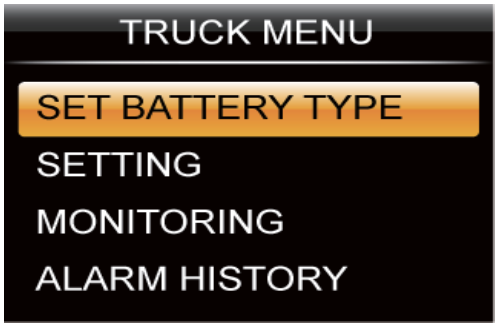






6) DESCRIPTION OF THE TRUCK MENU

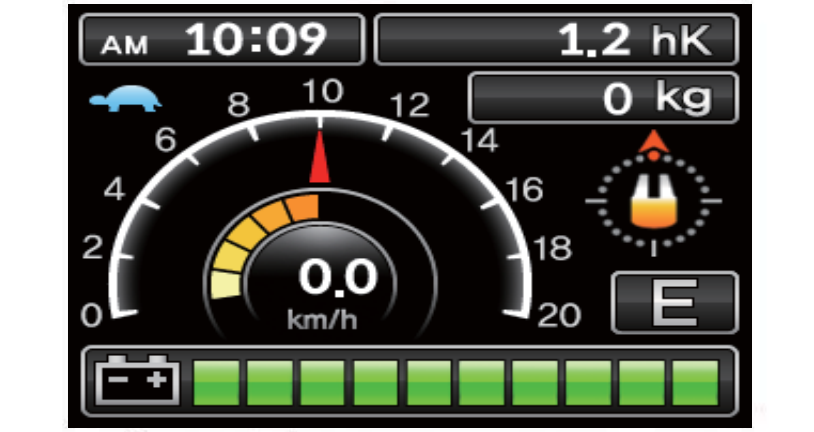
(1) Access to truck menu

Step	Display	Description
1		1. When the vehicle key turns on, the initial screen as shown on the left appears. 2. Press "ESC" button for more than 1 second in the initial screen.
2		1. The password input screen appears as shown on the left. 2. Enter the password using the "UP", "DOWN", "LEFT/MENU", "RIGHT/PERFORMANCE" buttons and press the "ENTER" button.
3		1. After inputting the password, the initial screen appears as shown on the left. 2. Press the "LEFT / MENU" button.
4		1. TRUCK MENU appears as shown on the left. 2. Use the "UP" and "DOWN/TURTLE" buttons to select the desired menu (HIGH-LIGHT in orange) and press the "ENTER" button to enter the menu. 3. To move to the upper menu, press "ESC" button to move.

7) ALARM & ALARM HISTORY

(1) How to check alarms

Normally, ALARM SCREEN pops up if any kind of a alarm happens, but service man can switch between a MAIN SCREEN and ALARM SCREEN with ESC , ↵ buttons as follows :



RIGHT MASTER

Code	Name
RM053	Stby I High
LM008	Watchdog
PM008	Watchdog
RS199	Bumper Stop
LS008	Watchdog

(2) Detail description of ALARM SCREEN

①First orange capital letter shows in which controller the alarm happens as below;

RM : Right Traction - Master	PS : Pump - Slave
RS : Right Traction - Slave	EPSM : EPS - Master
LM : Left Traction - Master	EPSS : EPS - Slave
LS : Left Traction - Slave	VCMM : VCM - Master
PM : Pump - Master	VCMS : VCM - Slave

②Following three letters or digits show alarm code. Please refer to 10. ALARM CODE (Page 7-69).

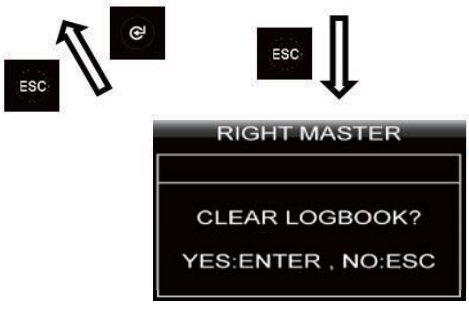
③This shows a name of ALARM. Please refer to 10. ALARM CODE (page 7-69).

(3) Alatm history

Alarm History can be looked up as follows ;

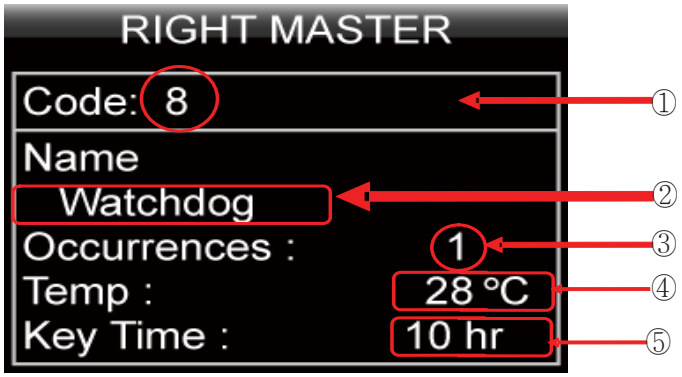
Step 1 Step 2

Step 3 Step 4 Step 5-1



① Step 1 : Service man can check the alarm history on ALARM HISTORY menu
② Step 2 : When service man enter the ALARM HISTORY menu, display read entire alarm records of all controller.
③ Step 3 : When display finish to read alarm records, service man can choose each controller to read the alarm history.
④ Step 4 : When service man enters each controller's alarm history, service man can check simply up to 5 alarms and choose a specific alarm to read detail alarm information.
⑤ Step 5-1 : When service man press button at Step 4, operator can see a detail alarm information of chosen alarm. Please refer to (4) DETAIL ALARM INFORMATION (see below).
Step 5-2 : When service man press ESC button at Step 4, service man can see a alarm clear
⑥ menu. If service man press button, Recorded alarms of selected controller will be erased.
(to verify cleaned alarm records, service man should be back to Step 1 & 2 to refresh.)
If operator press ESC button, just escape to step 3 without clearing

(4) Detail alarm information



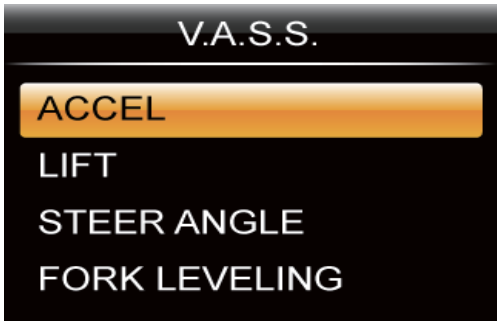
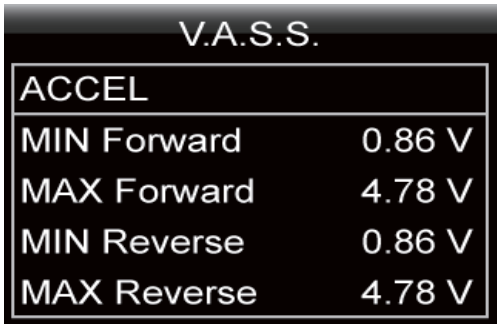
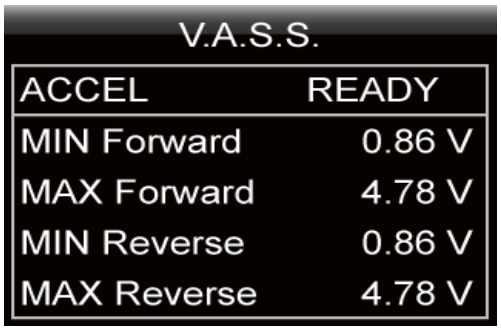
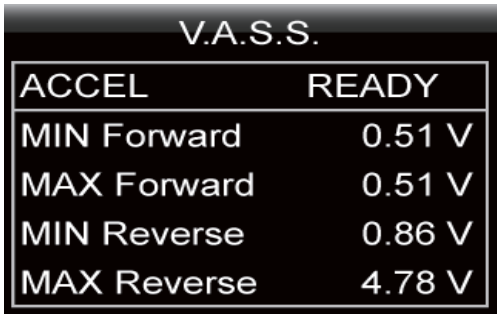
① Code of alarm
② Name of alarm
③ Count of alarm
④ Temperature of controller as alarm occurs.
⑤ Hourmeter of controller as alarm occurs.

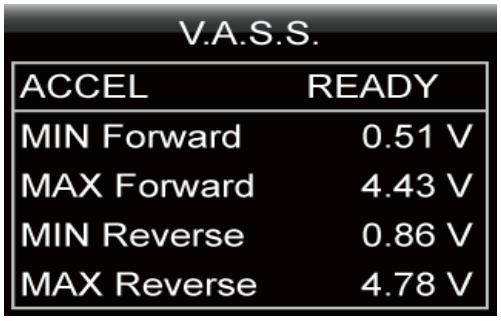
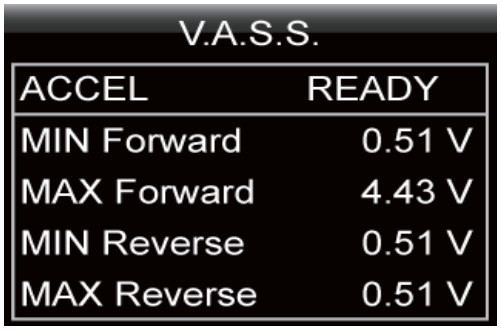
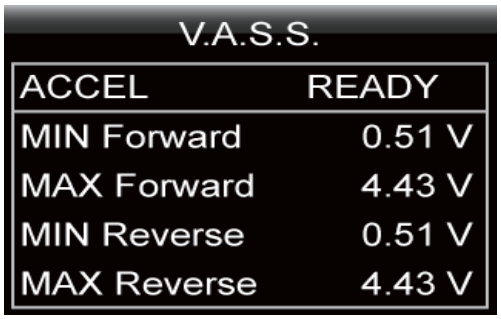
8) VASS SETUP USING DISPLAY MENU

This function searches and memorizes the minimum and maximum potentiometer wiper voltage of the accelerator pedal, lift lever, and steering sensor which use potentiometer sensors. The belows show how to use the VASS function of DISPLAY. (All figures in belows are just example.)

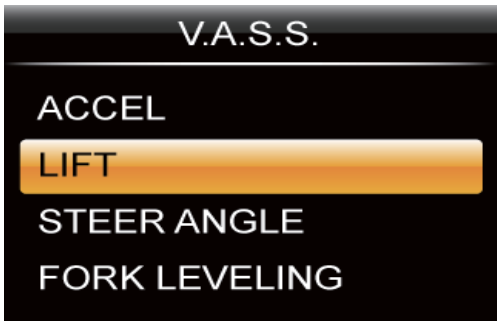
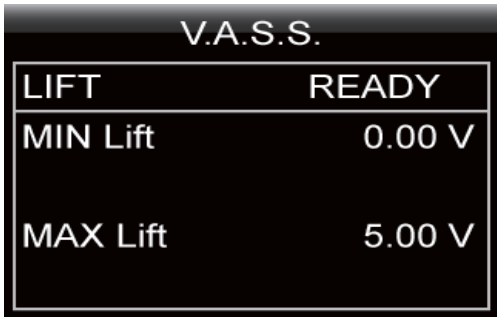
While even a motor is running, VASS can not be configurated properly, so please be sure that all motors are not running before entering configuration process & saving.

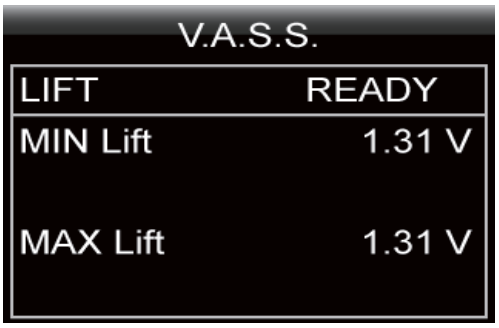
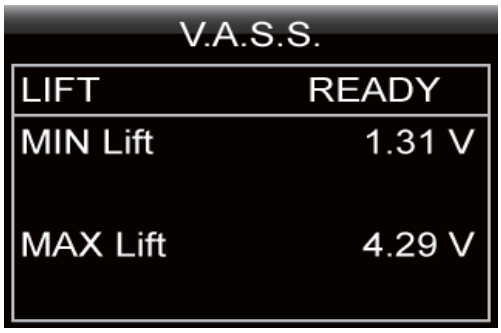
(1) ACCEL VASS setting method

Step	Display	Description
1		1. Access the accelerator pedal setup screen via "TRUCK MENU → SETTING → V .A.S.S → ACCEL".
2		1. As shown on the left screen, the accelerator pedal setting screen appears. ※ Confirm that the forward / reverse gear is neutral and both the traveling and hydraulic motor are stopped. 2. Press the "ENTER" button to start the setting.
3		1. When the ready indicator appears in the upper right corner of the screen, start setting. 2. Place the forward / reverse gear in forward position.
4		1. Press the accelerator pedal all the way down and release it again

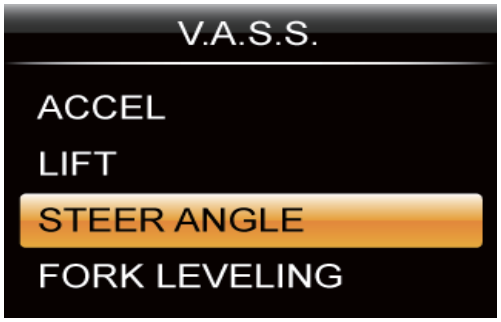
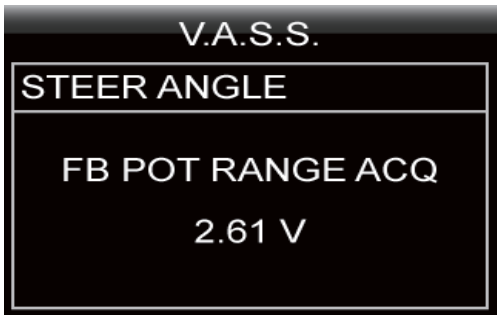
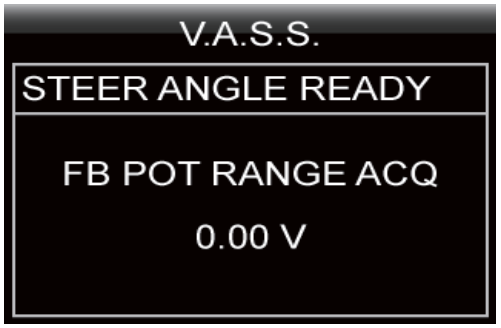
Step	Display	Description
5		1. You can see that MAX FORWARD has been changed. 2. Change the forward / reverse gear from forward to reverse.
6		1. MIN REVERSE (minimum value at backward) and MAX REVERSE (maximum value at backward) are changed to 0V ~ 0.9V state. 2. Place the forward / reverse gear in forward position.
7		1. You can see that MAX REVERSE has been changed. ※ Set the forward / reverse gear to neutral and check that all motors are stopped. 2. Press the "ENTER" button to save.

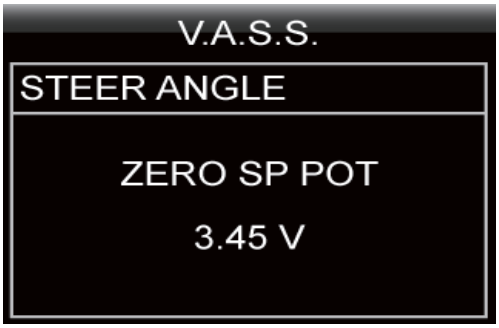
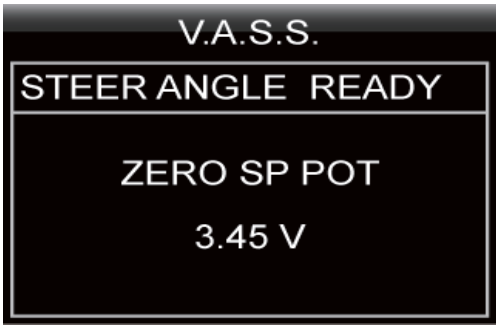
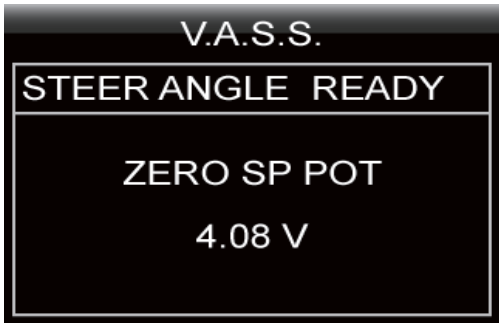
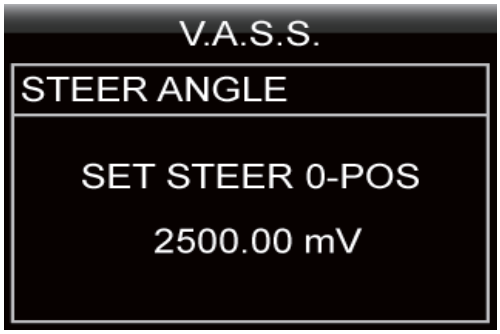
(2) LIFT VASS setting method

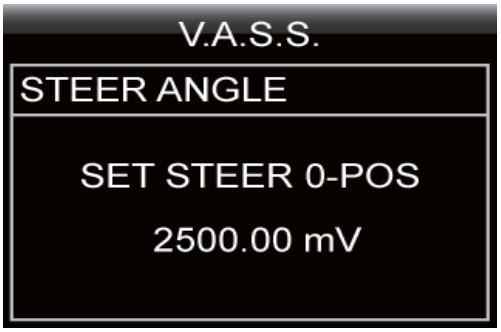
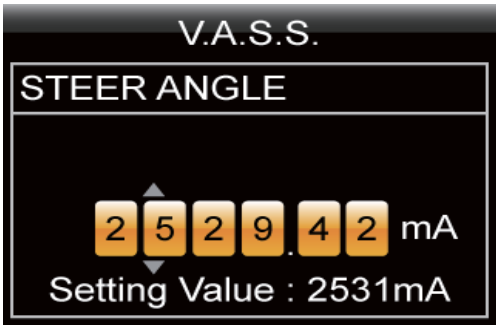
Step	Display	Description
1		1. Access the lift sensor setting screen via "TRUCK MENU → SETTING → V.A.S.S. → LIFT".
2		1. As shown on the left screen, the accelerator setting screen appears. ※ Confirm that the forward / reverse gear is neutral and both the traveling / hydraulic motor is stopped. 2. Press the "ENTER" button to start the setting.

Step	Display	Description
3		1. The READY indicator appears in the upper right corner of the screen, and the MIN LIFT and MAX LIFT values are aligned to the current minimum value. 2. Pull up the lift lever until it stops.
4		1. Pulling the LIFT LEVER all the way down will change the value when the MAX LIFT value is pulled to its maximum. ※ Set the forward / reverse gear to neutral and check that all motors are stopped. 2. Press the "ENTER" button to save.

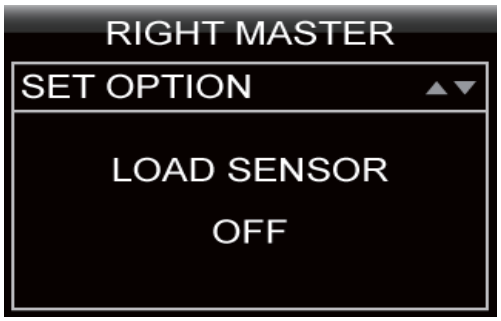
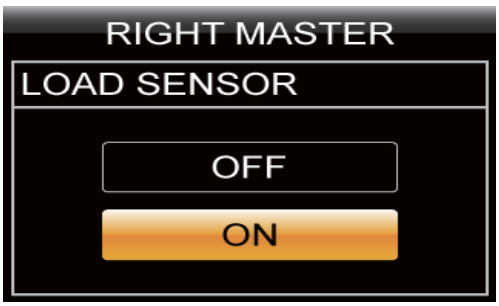
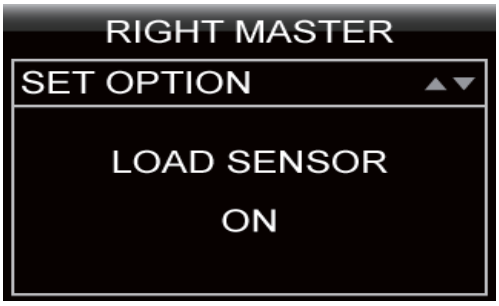
(3) STEER ANGLE VASS setting method

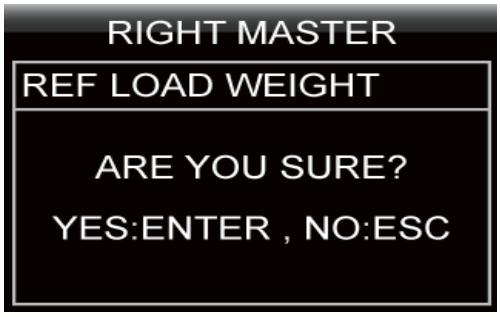
Step	Display	Description
1		1. Access the steer angle sensor setting screen via "TRUCK M ENU → S ETTING → V.A.S.S. → STEER ANGLE".
2		1. You can see the "FB POT RANGE ACQ" screen. 2. Press the "Enter" button on the left screen to start the setting.
3		1. Turn the steering wheel repeatedly 3 to 4 times to the left and right. (Repeat as close as possible to the left / right maximum steering angle.)

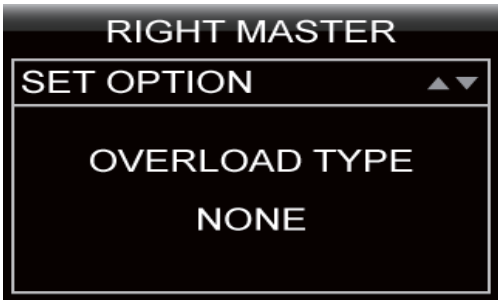
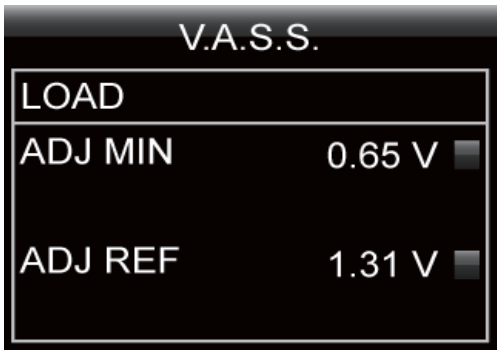
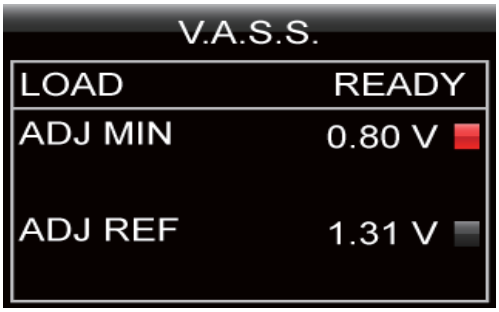
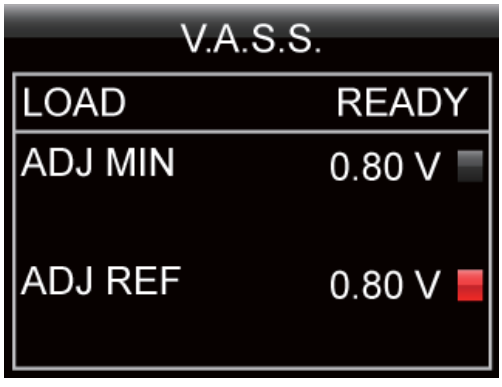
Step	Display	Description
4		1. If the voltage change no longer appears, press "ENTER" to save. 2. You have to key-off and key-on the forklift after the save.
5		1. Access the steer angle sensor setting screen via "TRUCK M ENU → SETTING → V.A.S.S. → STEER ANGLE". 2. Press the "▼" DOWN button. 3. You can see the "ZERO SP POT" screen.
6		1. Press the "ENTER" button on the left screen to start the setting.
7		1. Position the steering wheel in the forward direction (steering knob at 8 o'clock) and press "ENTER" to save.  2. You have to key-off and key-on the forklift after the save.
8		1. Access the lsteer angle sensor setting screen via "TRUCK M ENU → S ETTING → V.A.S.S. → STEER ANGLE". 2. Press the "▼" DOWN button twice. 3. You can see the "SET STEER 0-POS" screen.

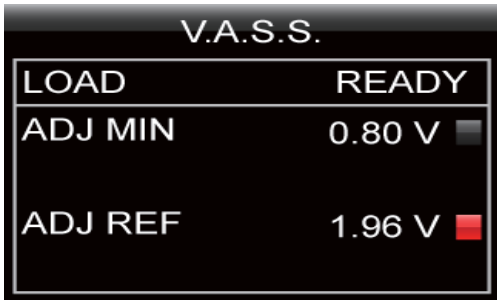
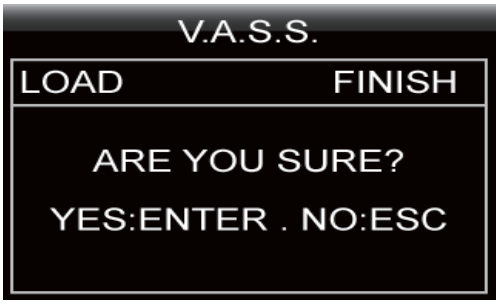
Step	Display	Description
9		※ Make sure that the angle of the steering wheel (rear wheel) is in the complete forward direction (0.) before starting the setting. 1. Press the "ENTER" button on the left screen to start the setting.
10		1. Press the "UP" and "DOWN / TURTLE" buttons to adjust the value to match the "Setting value" at the bottom of the screen and press "ENTER" to save.

(4) LOAD SENSOR setting method(Option)

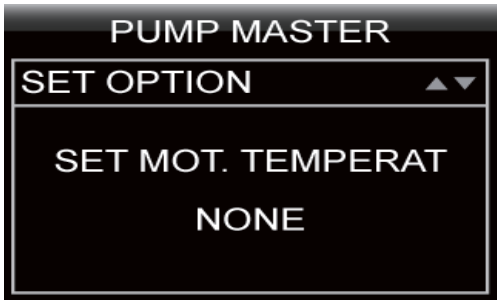
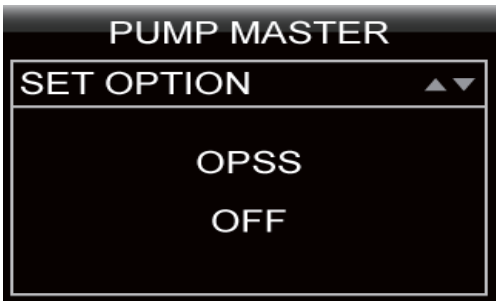
Step	Display	Description
1		1. In the TRUCK MENU, find the LOAD SENSOR parameter via “SETTING → RIGHT MASTER → SET OPTION”
2		1. Change it to “ON” by using "UP" button and "DOWN / TURTLE" button and press "ENTER" button to save.
3		1. You can see that LOAD SENSOR has been changed to “ON”.

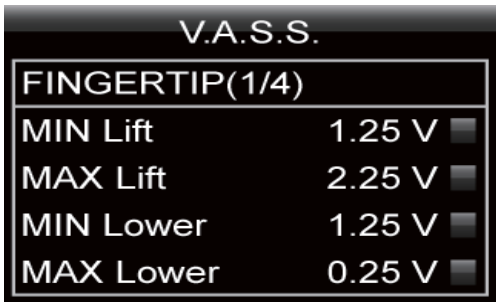
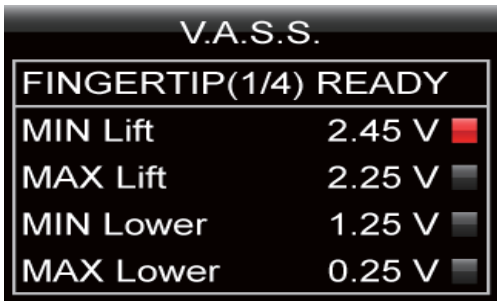
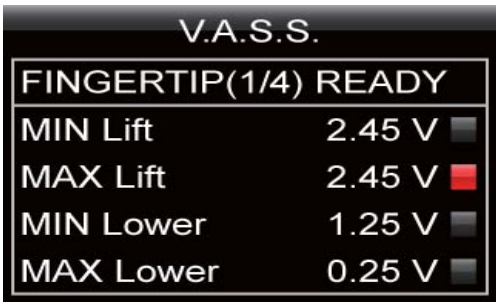
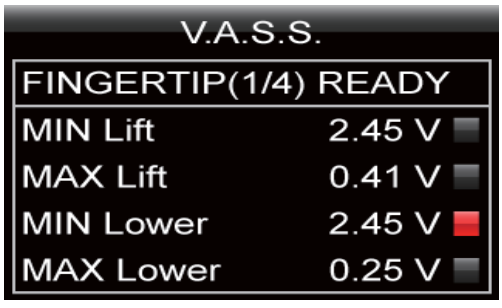
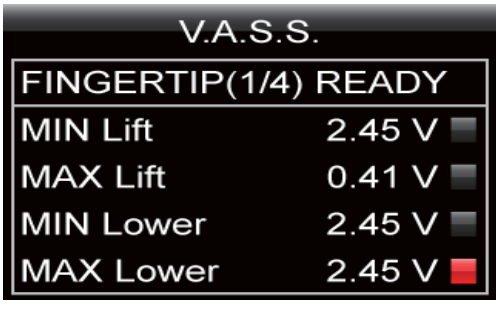
Step	Display	Description
4		1. In the TRUCK MENU, find the REF.LOAD WEIGHT parameter via “TRUCK MENU → RIGHT MASTER → ADJUSTMENTS” 2. REF LOAD WEIGHT is a parameter that adjusts the weight of the setting load. Press the "ENTER" button to set.
5		1. Use the "UP" button and the "DOWN / TURTLE" button to set the load weight for the setup (assuming 2800KG) and press the "ENTER" button.
6		1. Press the "ENTER" button to save.
7		1. You can see that the REF LOAD WEIGHT parameter value has changed. 2. Use the "UP" and "DOWN / TURTLE" buttons to find the OVER LOAD WEIGHT parameter.
8		1. The OVER LOAD WEIGHT parameter sets the weight at which the overload warning occurs, and the value differs for each model / mast. Refer to "OVERLOAD WEIGHT” for each model / mast. 2. Refer to steps 5 and 6 to set the specified weight. 3. Open TRUCK MENU → RIGHT MASTER → SET OPTION → OVERLOAD TYPE setting screen.

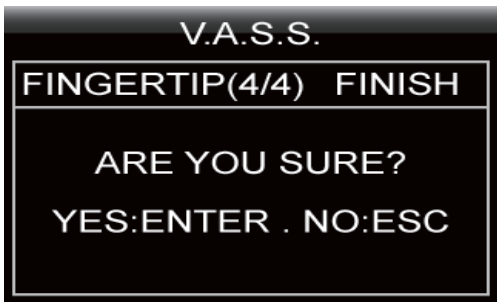
Step	Display	Description
9		1. The OVER LOAD TYPE parameter has three options as shown below. 1) NONE: No warning even if the load weight exceeds the OVER LOAD WEIGHT setting. 2) OPTION # 1: OVER LOAD WEARING occurs when the load weight exceeds the OVER LOAD WEIGHT setting value, and stops the vehicle operation except LIFT DOWN and steering function. 3) OPTION # 2: OVER LOAD WARNING occurs only when the load weight exceeds the OVER LOAD WEIGHT setting. 2. OVER LOAD TYPE must be set to NONE for LOAD SENSOR setting. If set to OPTION # 1 or OPTION # 2, change to "NONE" using "ENTER" button and "UP" or "DOWN / TURTLE" After that, LOAD SENSOR must be set.
10		1. Access the LOAD SENSOR setting screen via “TRUCK MENU → SETTING → V.A.S.S → LOAD SENSOR”. (Only when the LOAD SENSOR parameter in step 1 is set to ON.) 2. After confirming that the forward / reverse gear is neutral and both the drive and hydraulic motor are stopped, press the "ENTER" button in no-load state to start the setting.
11		1. At the top right of the screen, "READY" appears, "ADJ MIN" displays a red mark, and the "ADJ MIN LOAD" setting starts. The value of "ADJ MIN" indicates the no-load LOAD SENSOR input, and the setup proceeds. 2. Press Enter button to move on to the "ADJ REF".
12		1. "ADF REF" displays a red mark and the "ADJ REF" setting starts. 2. "ADJ REF" is the input value of the load sensor when the load for setting is lifted. When setting, lift the load to a height of about 50 cm from the ground. ※Before lifting the load, slightly lower and lift the load to operate normally. 3. You can see that the "ADF REF" value changes every time you lift the load.

Step	Display	Description
13		1. After waiting for 5 ~ 10 seconds after lifting the load(REF. LOAD WEIGHT), make sure that the ADJ REF value stabilizes, then press the ENTER button.
14		1. Press the "ENTER" button to save and exit. 2. Set the OVERLOAD TYPE in Step 9 as desired. (Default value is NONE) Note: For accuracy of LOAD SENSOR, the reference load for setting should be as large as possible within the range of not exceeding OVERLOAD WEIGHT.

(5) FINGERTIP setting method(OPTION)

Step	Display	Description
1		1.Acess the PUMP SET OPTION setting screen via "TRUCK MENU → SETTING → PUMP MASTER → SET OPTION
2		1. Use the "UP" button and the "DOWN / TURTLE" button to find each of the following parameters and change them to the corresponding settings. 1) EVP TYPE: NONE (Not applicable for 15/18/20BT-9U) 2) OPSS: OFF 3) FINGERTIP: ON 4) FINGERTIP MISM: ON 5) AUX 1 FUNCTION: ON (when the lever specification is 3-spool or more) 6) AUX 2 FUNCTION: ON (when the lever specification is 4-spool or more)

Step	Display	Description
3		1. Access the FINGERTIP setting screen via “TRUCK MENU → SETTING → V.A.S.S → FINGERTIP”. (Only when the FINGERTIP parameter in step 1 is set to ON.) 2. Press the ENTER button to set the LEVER as shown below. 1) 2-SPOOL : LIFT, TILT 2) 3-SPOOL : LIFT, TILT, AUX1 3) 4-SPOOL : LIFT, TILT, AUX1, AUX2 3. For illustrative purposes, Below will set the LIFT LEVER by pressing the "ENTER" button.
4		1. The READY indicator appears in the upper right corner of the screen, a red indicator appears on the right of the MIN LIFT and MIN LIFT (LIFT UP MIN value) setting starts. 2. Set MIN LIFT (LIFT UP MIN value). While pulling the LEVER a little bit (about 10˚) from the center, press the "ENTER" button to set the MIN LIFT value.
5		1. It switches to MAX LIFT (LIFT UP MAX value) setting and displays real time LEVER voltage value. 2. Set MAX LIFT (LIFT UP MAX value). While pulling the lever all the way down, press the "ENTER" button to set the MIN LOWER value.
6		1. It switches to MIN LOWER (LOWER MIN value) setting and displays real time LEVER voltage value. 2. Set MIN LOWER (LOWER MIN value). While pushing the LEVER a little bit (about 10˚) from the center, press the "ENTER" button to set the MAX LOWER value.
7		1. It switches to MAX LOWER (LOWER MAX value) setting and displays real time LEVER voltage value. 2. Set MAX LOWER (LOWER MAX value). While pulling the lever all the way down, press the "ENTER" button.

Step	Display	Description
8		1. After completing all lever settings, press "ENTER" button. 2. Press the "ENTER" button to exit.

7. ALARM CODE

1) TRACTION AND PUMP CONTROLLER

Code	Alarm	Master	Slave	Description
8	WATCHDOG	O	O	Cause: This is a safety related test. It is a self-diagnosis test that involves the logic between master and supervisor microcontrollers. Troubleshooting: This alarm could be caused by a CANbus malfunctioning, which blinds master-supervisor communication.
17	LOGIC FAILURE #3	O	O	Cause: A hardware problem in the logic board due to high currents (overload). An overcurrent condition is triggered even if the power bridge is not driven. Troubleshooting: The failure lies in the controller hardware. Replace the controller.
18	LOGIC FAILURE #2	O		Cause: Fault in the hardware section of the logic board which deals with voltage feedbacks of motor phases. Troubleshooting: The failure lies in the controller hardware. Replace the controller.
19	LOGIC FAILURE #1	O	O	Cause: This fault is displayed when the controller detects an undervoltage condition at the KEY input (A1). Undervoltage threshold depends on the nominal voltage of the controller. - Nominal voltage : 36/48V - Undervoltage threshold : 10V Troubleshooting (fault at startup or in standby): - Fault can be caused by a key input signal characterized by pulses below the undervoltage threshold, possibly due to external loads like DC/DC converters starting-up, relays or contactors during switching periods, solenoids energizing or de-energizing. Consider to remove such loads. - If no voltage transient is detected on the supply line and the alarm is present every time the key switches on, the failure probably lies in the controller hardware. Replace the logic board. Troubleshooting (fault displayed during motor driving): - If the alarm occurs during motor acceleration or when there is a hydraulic-related request, check the battery charge, the battery health and power-cable connections.

Code	Alarm	Master	Slave	Description
30	VMN LOW	O		Cause 1: Start-up test. Before switching the LC on, the software checks the power bridge: it turns on alternatively the high-side power MOSFETs and expects the phase voltages increase toward the positive rail value. If one phase voltage is lower than a certain percentage of the rail voltage, this alarm occurs. Cause 2: Motor running test. When the motor is running, the power bridge is on and the motor voltage feedback tested; if it is lower than expected value (a range of values is considered), the controller enters in fault state. Troubleshooting: - If the problem occurs at start up (the LC does not close at all), check: - Motor internal connections (ohmic continuity); - Motor power-cables connections; - If the motor connections are OK, the problem is inside the controller; Replace it. - If the alarm occurs while the motor is running, check: - Motor connections; - That the LC power contact closes properly, with a good contact; - If no problem is found, the problem is inside the controller. Replace it.

Code	Alarm	Master	Slave	Description
31	VMN HIGH	O		Cause 1: Before switching the LC on, the software checks the power bridge: it turns on alternatively the low-side power MOSFETs and expects the phase voltages decrease down to -B. If the phase voltages are higher than a certain percentage of the nominal battery voltage, this alarm occurs. Cause 2: This alarm may also occur when the start-up diagnosis has succeeded and so the LC has been closed. In this condition, the phase voltages are expected to be lower than half the battery voltage. If one of them is higher than that value, this alarm occurs. Troubleshooting: - If the problem occurs at start-up (the LC does not close), check: - Motor internal connections (ohmic continuity); - Motor power cables connections; - If the motor connections are OK, the problem is inside the controller. Replace it. - If the alarm occurs while the motor is running, check: - Motor connections; - That the LC power contact closes properly, with a good contact; - If no problem is found, the problem is inside the controller. Replace it.
37	CONTACTOR CLOSED	O		Cause: Before driving the LC coil, the controller checks if the contactor is stuck. The controller drives the power bridge for several dozens of milliseconds, trying to discharge the capacitors bank. If the capacitor voltage does not decrease by more than a certain percentage of the key voltage, the alarm is raised. Troubleshooting: It is suggested to verify the power contacts of LC; if they are stuck, is necessary to replace the LC.
38	CONTACTOR OPEN	O		Cause: The LC coil is driven by the controller, but it seems that the power contacts do not close. In order to detect this condition the controller injects a DC current into the motor and checks the voltage on power capacitor. If the power capacitors get discharged it means that the main contactor is open. Troubleshooting: - LC contacts are not working. Replace the LC. - If LC contacts are working correctly, contact a Hyundai dealer.

Code	Alarm	Master	Slave	Description
52	PUMP I=0 EVER	O		Cause: While truck is running, current value is 0 for more than 1 sec. Remedy: - Check the Main contactor - Check the controller
53	STBY I HIGH	O		Cause: In standby, the sensor detects a current value different from zero. Troubleshooting: The current sensor or the current feedback circuit is damaged. Replace the controller.
60	CAPACITOR CHARGE	O		Cause: When the key is switched on, the inverter tries to charge the power capacitors through the series of a PTC and a power resistance, checking if the capacitors are charged within a certain timeout. If the capacitor voltage results less than a certain percentage of the nominal battery voltage, the alarm is raised and the main contactor is not closed. Troubleshooting: - Check if an external load in parallel to the capacitor bank, which sinks current from the capacitors-charging circuit, thus preventing the caps from charging well. Check if a lamp or a dc/dc converter or an auxiliary load is placed in parallel to the capacitor bank. - The charging resistance or PTC may be broken. Insert a power resistance across line-contactor power terminals; if the alarm disappears, it means that the charging resistance is damaged. - The charging circuit has a failure or there is a problem in the power section. Replace the controller.
62	TH. PROTECTION	O		Cause: The temperature of the controller base plate is above 85 °C. The maximum current is proportionally decreased with the temperature excess from 85 °C up to 105 °C. At 105 °C the current is limited to 0 A. Troubleshooting: It is necessary to improve the controller cooling. To realize an adequate cooling in case of finned heat sink important factors are the air flux and the cooling-air temperature. If the thermal dissipation is realized by applying the controller base plate onto the truck frame, the important factors are the thickness of the frame and the planarity and roughness of its surface. If the alarm occurs when the controller is cold, the possible reasons are a thermal-sensor failure or a failure in the logic board. In the last case, it is necessary to replace the controller.

Code	Alarm	Master	Slave	Description
66	BATTERY LOW	O		Cause: Parameter BATTERY CHECK is other than 0 (SET OPTION list, at page 7-34) and battery charge is evaluated to be lower than BATT.LOW TRESHLD. Troubleshooting: - Check the battery charge and charge it if necessary. - If the battery is actually charged, measure the battery voltage through a voltmeter and compare it with the BATTERY VOLTAGE reading in the TESTER function. If they are different, adjust the ADJUST BATTERY parameter with the value measured through the voltmeter. - If the problem is not solved, replace the logic board.
74	DRIVER SHORTED	O		Cause: The driver of the LC coil is shorted. Troubleshooting: - Check if there is a short or a low impedance pull-down between NLC (A16) and -B. - The driver circuit is damaged; replace the logic board.
75	CONTACTOR DRIVER	O		Cause: The LC coil driver is not able to drive the load. The device itself or its driver circuit is damaged. Troubleshooting: This type of fault is not related to external components; replace the logic board.
78	VACC NOT OK	O		Cause: At key-on and immediately after that, the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading (in TESTER function) is above the minimum value acquired during the PROGRAM VACC procedure. Troubleshooting: - Check the wirings. - Check the mechanical calibration and the functionality of the accelerator potentiometer. - Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function. - If the problem is not solved, replace the logic board.

Code	Alarm	Master	Slave	Description
79	INCORRECT START	O		Cause: Incorrect starting sequence. Possible reasons for this alarm are: - A travel demand active at key-on. - Man-presence sensor active at key on. Troubleshooting: - Check wirings. - Check microswitches for failures. - Through the TESTER function, check the states of the inputs are coherent with microswitches states. - If the problem is not solved, replace the logic board.
80	FORW + BACK	O		Cause: This alarm occurs when both the travel requests (FW and BW) are active at the same time. Troubleshooting: - Check that travel requests are not active at the same time. - Check the FW and BW input states through the TESTER function. - Check the wirings relative to the FW and BW inputs. - Check if there are failures in the microswitches. - If the problem is not solved, replace the logic board.
82	ENCODER ERROR	O		Cause: This fault occurs when the frequency supplied to the motor is higher than 30 Hz and the signal feedback from the encoder has a too high jump in few tens of milliseconds. This condition is related to an encoder failure. Troubleshooting: - Check the electrical and the mechanical functionality of the encoder and the wires crimping. - Check the mechanical installation of the encoder, if the encoder slips inside its housing it will raise this alarm. - Also the electromagnetic noise on the sensor can be the cause for the alarm. In these cases try to replace the encoder. - If the problem is still present after replacing the encoder, the failure is in the controller.
86	PEDAL WIRE KO	O		Cause: Fault in accelerator negative (NPOT) input circuit Troubleshooting: -
134	PEDAL BRAKE MISM	O		Cause: BRAKE 1 and BRAKE 2 inputs have a different value. Troubleshooting: - Check the wirings.

Code	Alarm	Master	Slave	Description
135	DISPLAY ENABLE	O		Cause: The display enable signal has not been received to operate the truck. Troubleshooting: -
136	FORK POT MISM.	O		Cause: The sum of TILT LEVELING 1 and TILT LEVELING 2 input voltages do not match the supply voltage of the sensor. Troubleshooting: - Check the wirings. - Check the tilt leveling sensor output voltages.
137	FORK S.WRONG DIR	O		Cause: Direction of “AUTO TILT LEVELING” movement is not correct. Troubleshooting: - Check if operator operates truck correctly. - Check the Tilt Sensor of Fork leveling Option. - Re-configurate Tilt Sensor of Fork leveling Option.
138	FORK S. OUT RNG.	O		Cause: Value of tilt sensor (AUTO TILT LEVELING) is out of range. Troubleshooting: - Check the Tilt Sensor of AUTO TILT LEVELING Option. - Re-configurate Tilt Sensor of AUTO TILT LEVELING Option
139	FORK SENS LOCK	O		Cause: Value of tilt sensor (AUTO TILT LEVELING) is fixed even tilt request is activated. Troubleshooting: - Check the Tilt Sensor of AUTO TILT LEVELING Option. - Re-configurate Tilt Sensor of AUTO TILT LEVELING Option.
140	FINGERTIPS ACQ	O		Cause: Fingertip calibration is not correct. Troubleshooting: - Acquire the correct value of parameters LIFT MAX, LIFT MIN, LOWER MAX, LOWER MIN, TILT UP MAX, TILT UP MIN, TILT DOWN MAX, TILT DOWN MIN, AUX1 UP MAX, AUX1 UP MIN, AUX1 DOWN MAX, AUX1 DOWN MIN, AUX2 UP MAX, AUX2 UP MIN, AUX2 DOWN MAX, AUX2 DOWN MIN
141	LOAD SENS. ERROR	O		Cause: The signal of LOAD SENSOR input is not valid. Troubleshooting: - Acquire the correct value of parameters ADJ MIN LOAD, ADJ REF LOAD - Check the wirings.

Code	Alarm	Master	Slave	Description
142	OVERLOADED	O		Cause: The signal of LOAD SENSOR indicates a weight greater than parameter OVER LOAD WEIGHT. Troubleshooting: - Check if the operator operates truck correctly. - Acquire the correct value of parameters ADJ MIN LOAD, ADJ REF LOAD. - Verify the value of parameter OVERLOAD WEIGHT. - Check the wirings.
143	FINGERTIP MISM	O		Cause: The sum of input voltages from one of the fingertip sensors do not match the supply voltage of the sensor. Troubleshooting: - Check the wirings. - Check the fingertip sensor output voltages.
144	CAN REC VMC ERR	O		Cause: CAN communication problem with the VCM. Troubleshooting: - Check the CAN wirings. - Verify if the VCM is off or damaged.
145	SBR S/W OPEN	O		Cause: SBR (Side Battery Removal) sensor is open. Troubleshooting: - To remove warning cause. - Check the sensor.
146	BRAKE OIL	O		Cause: Lack of brake oil. Troubleshooting: Check the brake oil tank & sensor.
147	MAINT PRE WARN	O		Cause: The truck hours reached MAINT PRE WARN parameter value. Troubleshooting: Perform the truck maintainance and reset the alarm using MAINTEN. RESET parameter.
148	MOTOR HIGH TEMP	O		Cause: The temperature of left or right or both motors is high. Troubleshooting: - To remove warning cause. - Check the motor temp-sensor.
150	BMS WARNING 1	O		Cause: The battery monitoring system is in WARNING 1 status.

Code	Alarm	Master	Slave	Description
151	BMS WARNING 0	O		Cause: The battery monitoring system is in WARNING 0 status.
152	BMS FAULT	O		Cause: The battery monitoring system is in FAULT status.
153	BMS NOT READY	O		Cause: The battery monitoring system is in BMS NOT READY status.
154	POT MISMATCH	O		Cause: The sum of LIFT POT 1 and LIFT POT 2 input voltages do not match the supply voltage of the sensor. Troubleshooting: - Check the wirings. - Check the lift sensor output voltages.
155	WAIT MOTOR STILL	O		Cause: The controller is waiting for the motor to stop rotating. This warning can only appear in ACE 2 for brushless motors.
161	RPM HIGH	O		Cause: This alarm occurs in Gen. Set versions when the speed exceeds the threshold speed.
162	BUMPER STOP	O		Cause: The two digital inputs dedicated to the bumper functionality are high at the same time. The alarm can occur only if parameter BUMPER STOP = ON and only if ACE 2 is in CAN OPEN configuration. Troubleshooting: - Turn off one or both inputs dedicated to the bumper functionality. - If the alarm occurs even if the inputs are in the rest position, check if the microswitches are stuck. - In case the problem is not solved, replace the logic board.
163	ED SLIP MISMATCH	O		Cause: The control detects a mismatch between the expected slip and the evaluated one. This diagnostic occurs only if ED COMPENSATION = TRUE.
164	PWM ACQ. ERROR	O		Cause: This alarm occurs only when the controller is configured to drive a PMSM and the feedback sensor selected in the HARDWARE SETTINGS list is ENCODER ABI + PWM. The controller does not detect correct information on PWM input at start-up. Troubleshooting: - Re-cycle the key. - Check the sensor in order to verify that it works properly. - Check the wiring. - If the problem occurs permanently it is necessary to substitute logic board.

Code	Alarm	Master	Slave	Description
168	SIN/COS D.ERR XX	O		Cause: This alarm occurs only when the controller is configured as PMSM and the feedback sensor selected is sin/cos. The signal coming from sin/cos sensor has a wrong direction. The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: - Check the wirings. - If the motor direction is correct, swap the sin and cos signals. - If the motor direction is not correct, swap two of the motor cables. - If the problem is not solved, contact a Hyundai dealer.
169	ENCODER D.ERR XX	O		Cause: This alarm occurs only when the controller is configured as PMSM and the feedback sensor selected is the encoder. The A and B pulse sequence is not correct. The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: - Check the wirings. - If the motor direction is correct, swap A and B signals. - If the motor direction is not correct, swap two of the motor cables. - If the problem is not solved, contact a Hyundai dealer.
170	WRONG KEY VOLT.	O		Cause: The measured key voltage is not the right one for the inverter. Troubleshooting: - Check if the SET KEY VOLTAGE parameter in the ADJUSTMENTS list is set in accordance with the key voltage. - Check if the key voltage is ok using a voltmeter, if not check the wiring. - In case the problem is not solved, replace the logic board.
171	ACQUIRING A.S.	O		Cause: Controller is acquiring data from the absolute feedback sensor. Troubleshooting: The alarm ends when the acquisition is done.
172	ACQUIRE ABORT	O		Cause: The acquiring procedure relative to the absolute feedback sensor aborted.
173	ACQUIRE END	O		Cause: Absolute feedback sensor acquired.

Code	Alarm	Master	Slave	Description
175	SPEED FB. ERROR	O		Cause: This alarm occurs if the absolute position sensor is used also for speed estimation. If signaled, it means that the controller measured that the motor was moving too quick. Troubleshooting: - Check that the sensor used is compatible with the software release. - Check the sensor mechanical installation and if it works properly. - Also the electromagnetic noise on the sensor can be a cause for the alarm. - If no problem is found on the motor or on the speed sensor, the problem is inside the controller, it is necessary to replace the logic board.
176	HOME SENS.ERR XX	O		Cause: The controller detected a difference between the estimated absolute orientation of the rotor and the position of the index signal (ABI encoder). It is caused by a wrong acquisition of the angle offset between the orientation of the rotor and the index signal. The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: Repeat the auto-teaching procedure.
177	COIL SHOR. EB.	O		Cause: This alarm occurs when an overload of the EB driver (output NEB A18) occurs. Troubleshooting: - Check the connections between the controller outputs and the loads. - Collect information about characteristics of the coil connected to the driver and ask for assistance to a Hyundai dealer in order to verify that the maximum current that can be supplied by the hardware is not exceeded. - In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

Code	Alarm	Master	Slave	Description
178	MOTOR SHUTDOWN	O		Cause: The temperature sensor has overtaken the threshold defined by MOT.SHUTDOWN TEM. Troubleshooting: - Check the temperature read by the thermal sensor inside the motor through the MOTOR TEMPERATURE reading in the TESTER function. - Check the sensor ohmic value and the sensor wiring. - If the sensor is OK, improve the cooling of the motor. - If the warning is present when the motor is cool, replace the controller.
179	STEER SENSOR KO	O		Cause: The voltage read by the microcontroller at the steering-sensor input is not within the STEER RIGHT VOLT ÷ STEER LEFT VOLT range, programmed through the STEER ACQUIRING function. Troubleshooting: - Acquire the maximum and minimum values coming from the steering potentiometer through the STEER ACQUIRING function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. - If the problem is not solved, replace the logic board.
180	OVERLOAD	O		Cause: The motor current has overcome the limit fixed by hardware. Troubleshooting: If the alarm condition occurs again, ask for assistance to a Hyundai dealer. The fault condition could be affected by wrong adjustments of motor parameters.
181	WRONG ENC SET	O		Cause: Mismatch between “ENCODER PULSES 1” parameter and “ENCODER PULSES 2” parameter. Troubleshooting: Set the two parameters with the same value, according to the adopted encoder.
186	WAIT MOT.P STILL	O		The controller is waiting for the motor to stop rotating. This warning can only appear in ACE 2 or ACE 3 for brushless motors.

Code	Alarm	Master	Slave	Description
187	LIFT+LOWER	O		Cause: Both the pump requests (LIFT and LOWER) are active at the same time. Troubleshooting: - Check that LIFT and LOWER requests are not active at the same time. - Check the LIFT and LOWER input states through the TESTER function. - Check the wirings.
188	PUMP VACC NOT OK	O		Cause: At key-on and immediately after that, the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading (in TESTER function) is above the minimum value acquired during the PROGRAM VACC procedure. Troubleshooting: - Check the wirings. - Check the mechanical calibration and the functionality of the accelerator potentiometer. - Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function. - If the problem is not solved, replace the logic board.
189	PUMP INC START	O		Cause: Man-presence switch is not enabled at pump request. Troubleshooting: - Check wirings. - Check microswitches for failures. - Through the TESTER function, check the states of the inputs are coherent with microswitches states. - If the problem is not solved, replace the logic board.
192	FORK S.WRONG DIR		O	Cause: TILT LEVELING input is ON and the TILT LEVELING analog sensor output is not moving to the center values direction. Troubleshooting: - Release TILT LEVEL command. - Check wirings and TILT LEVELING sensor.
193	FORK S. OUT RNG.		O	Cause: TILT LEVELING input is outside admitted range. Troubleshooting: - Acquire the correct value of parameters FORK LEVEL MIN, FORK LVL CENTER, FORK LEVEL MAX. - Check wirings and TILT LEVELING sensor.

Code	Alarm	Master	Slave	Description
194	FORK SENS LOCK		O	Cause: TILT LEVELING sensor is frozen (stuck) more than 1.5sec at the correct direction movement. Troubleshooting: - Release the tilt leveling command. - Check if the tilt function is working correctly or if it is mechanically locked. - Check wirings and TILT LEVELING sensor.
195	FINGERTIPS ACQ		O	Cause: Fingertip calibration is not correct. Troubleshooting: - Acquire the correct value of parameters LIFT MAX, LIFT MIN, LOWER MAX, LOWER MIN, TILT UP MAX, TILT UP MIN, TILT DOWN MAX, TILT DOWN MIN, AUX1 UP MAX, AUX1 UP MIN, AUX1 DOWN MAX, AUX1 DOWN MIN, AUX2 UP MAX, AUX2 UP MIN, AUX2 DOWN MAX, AUX2 DOWN MIN
196	MOT.PHASE SH.	O		Cause: Short circuit between two motor phases. The hexadecimal value "XX" identifies the shorted phases: 36: U – V short circuit 37: U – W short circuit 38: V – W short circuit Troubleshooting: - Verify the motor phases connection on the motor side. - Verify the motor phases connection on the inverter side. - Check the motor power cables. - Replace the controller. - If the alarm does not disappear, the problem is in the motor. Replace it.
	LOAD SENS. ERROR		O	Cause: The signal of LOAD SENSOR input is not valid. Troubleshooting: - Acquire the correct value of parameters ADJ MIN LOAD, ADJ REF LOAD - Check the wirings.

Code	Alarm	Master	Slave	Description
197	WRONG SLAVE VER.	O		Cause: Wrong software version on supervisor uC. Troubleshooting: Upload the correct software version or ask for assistance to a Hyundai dealer.
	OVERLOADED		O	Cause: The signal of LOAD SENSOR indicates a weight greater than parameter OVER LOAD WEIGHT. Troubleshooting: - Check if the operator operates truck correctly. - Acquire the correct value of parameters ADJ MIN LOAD, ADJ REF LOAD. - Verify the value of parameter OVERLOAD WEIGHT. - Check the wirings.
198	M/S PAR CHK MISM	O		Cause: At start-up there is a mismatch in the parameter checksum between the master and the supervisor microcontrollers. Troubleshooting: Restore and save again the parameters list.
199	PARAM TRANSFER	O		Cause: Master uC is transferring parameters to the supervisor. Troubleshooting: Wait until the end of the procedure. If the alarm remains longer, re-cycle the key.
	BUMPER STOP		O	Cause The two digital inputs dedicated to the bumper functionality are high at the same time. The alarm can occur only if parameter BUMPER STOP = ON and only if ACE 2 is in CAN OPEN configuration. Troubleshooting - Turn off one or both inputs dedicated to the bumper functionality. - If the alarm occurs even if the inputs are in the rest position, check if the microswitches are stuck. - In case the problem is not solved, replace the logic board.

Code	Alarm	Master	Slave	Description
200	VDC OFF SHORTED	O		Cause: The logic board measures a voltage value across the DC-link that is constantly out of range, above the maximum allowed value. Troubleshooting: - Check that the battery has the same nominal voltage of the inverter. - Check the battery voltage, if it is out of range replace the battery. - If the battery voltage is ok, replace the logic board.
	STEER SENSOR KO		O	Cause: The voltage read by the microcontroller at the steering-sensor input is not within the STEER RIGHT VOLT ÷ STEER LEFT VOLT range, programmed through the STEER ACQUIRING function. Troubleshooting: - Acquire the maximum and minimum values coming from the steering potentiometer through the STEER ACQUIRING function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. - If the problem is not solved, replace the logic board.
201	TORQUE PROFILE	O		Cause: There is an error in the choice of the torque profile parameters. Troubleshooting: Check in the HARDWARE SETTINGS list the value of those parameters.
	WRONG ENC SET		O	Cause: Mismatch between “ENCODER PULSES 1” parameter and “ENCODER PULSES 2” parameter. Troubleshooting: Set the two parameters with the same value, according to the adopted encoder.

<table>
<tr><th>Code</th><th>Alarm</th><th>Master</th><th>Slave</th><th>Description</th></tr>
<tr><td>202</td><td>VDC LINK OVERV.</td><td>O</td><td>O</td><td>Cause:
This fault is displayed when the controller detects an overvoltage condition.
Overvoltage threshold depends on the nominal voltage of the controller.
<table><tr><th>Nominal voltage</th><th>24V</th><th>36/48V</th><th>72/80V</th><th>96V</th></tr><tr><td>Overvoltage threshold</td><td>35V</td><td>65V</td><td>115V</td><td>130V</td></tr></table>
As soon as the fault occurs, power bridge and MC are opened.
The condition is triggered using the same HW interrupt used for undervoltage detection, uC discerns between the two evaluating the voltage present across DC-link capacitors:
- High voltage Overvoltage condition
- Low/normal voltage Undervoltage condition

Troubleshooting:
If the alarm happens during the brake release, check the line contactor contact and the battery power-cable connection.</td></tr>
<tr><td>204</td><td>BRAKE RUN OUT</td><td>O</td><td></td><td>Cause:
The CPOT BRAKE input read by the microcontroller is out of the range defined by parameters SET PBRK. MIN and SET PBRK. MAX.

Troubleshooting:
- Check the mechanical calibration and the functionality of the brake potentiometer.
- Acquire the minimum and maximum potentiometer values.
- If the alarm is still present, replace the logic board.</td></tr>
<tr><td>205</td><td>EPS RELAY OPEN</td><td>O</td><td></td><td>Cause:
The controller receives from EPS information about the safety contacts being open.

Troubleshooting:
Verify the EPS functionality.</td></tr>
</table>

Code	Alarm	Master	Slave	Description
206	INIT VMN HIGH	O		Cause: Before closing the LC, the software checks the power-bridge voltage without driving it. The software expects the voltage to be in a “steady state” value. If it is too high, this alarm occurs. The hexadecimal value “XX” identifies the faulty phase: 81: phase U 82: phase V 83: phase W Troubleshooting: - Check the motor power cables. - Check the impedance between U, V and W terminals and -B terminal of the controller. - Check the motor leakage to truck frame. - If the motor connections are OK and there are no external low impedance paths, the problem is inside the controller. Replace it.
207	INIT VMN LOW	O		Cause: Before closing the LC, the software checks the power-bridge voltage without driving it. The software expects the voltage to be in a “steady state” value. If it is too low, this alarm occurs. The hexadecimal value “XX” identifies the faulty phase: 01: phase U 02: phase V 03: phase W Troubleshooting: - Check the motor power cables. - Check the impedance between U, V and W terminals and -B terminal of the controller. - Check the motor leakage to truck frame. - If the motor connections are OK and there are no external low impedance paths, the problem is inside the controller. Replace it.
208	EEPROM KO	O	O	Cause: A HW or SW defect of the non-volatile embedded memory storing the controller parameters. This alarm does not inhibit the machine operations, but it makes the truck to work with the default values. Troubleshooting: Execute a CLEAR EEPROM procedure (refer to the Console manual). Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will be replaced by the default parameters.

Code	Alarm	Master	Slave	Description
209	PARAM RESTORE	O	O	Cause: This is a confirmation that a clear eeprom parameter was correctly performed. Troubleshooting: Recycle the key.
210	WRONG RAM MEM.	O	O	Cause: Deterministic Finite Automaton (DFA) is characterized by state transitions. As a protective measure any state transition is commanded by assigning two variables (state label and its complement). These two variables identify the new state (redundancy in the state label). This redundancy has been thought in order to avoid that a failure in the RAM memory leads to a wrong destination state for the DFAs. In case the two state labels are inconsistent or not complemented in between, this alarm occurs. Troubleshooting: If it is repetitive, it reports a problem in the controller.
211	STALL ROTOR	O		Cause: The traction rotor is stuck or the encoder signal is not correctly received by the controller. Troubleshooting: - Check the encoder condition. - Check the wiring. - Through the TESTER function, check if the sign of REQUENCY and ENCODER are the same and if they are different from zero during a traction request. - If the problem is not solved, replace the logic board.
	BMS NOT READY		O	Cause: The battery monitoring system is in BMS NOT READY status.
212	POWER MISMATCH	O		Cause : The error between the power setpoint and the estimated power is out of range. Troubleshooting : Ask for assistance to a Hyundai dealer about the correct adjustment of the motor parameters.
	W.SET. TG-EB XX		O	Cause: Supervisor microcontroller has detected that the master microcontroller has imposed a wrong setpoint for TG or EB output. Troubleshooting: - Check the matching of the parameters between master and supervisor. - Ask for the assistance of a Hyundai dealer. - If the problem is not solved, replace the logic board.

Code	Alarm	Master	Slave	Description
213	POSITIVE LC OPEN	O		Cause The positive voltage of LC is different from expected. Troubleshooting - Verify LC coil is properly connected. - Verify CONF. POSITIVE LC parameter is set in accordance with the actual coil positive supply. Software, depending on the parameter value, makes a proper diagnosis; a mismatch between the hardware and the parameter configuration could generate a false fault. - In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
	INPUT MISMATCH		O	Cause: The supervisor microcontroller records different input values with respect to the master microcontroller. Troubleshooting: - Compare the values read by master and slave through the TESTER function. - Ask for the assistance to a Hyundai dealer. - If the problem is not solved, replace the logic board.
214	EVP COIL OPEN	O		Cause: No load is connected between the NEVP output (A19) and the electrovalve positive terminal. Troubleshooting: - Check the EVP condition. - Check the EVP wiring. - If the problem is not solved, replace the logic board.
215	EVP DRIV. SHORT.	O		Cause: - The EVP driver (output A19) is shorted. - The microcontroller detects a mismatch between the valve set-point and the feedback of the EVP output. Troubleshooting: - Check if there is a short circuit or a low-impedance conduction path between the negative of the coil and -B. - Collect information about: · The voltage applied across the EVP coil. · The current in the coil. · Features of the coil. Ask for assistance to Zapi in order to verify that the software diagnoses are in accordance with the type of coil employed. - If the problem is not solved, it could be necessary to replace the controller.

Code	Alarm	Master	Slave	Description
216	EB. COIL OPEN	O		Cause: This fault appears when no load is connected between the NEB output (A18) and the EB positive terminal PCOM (A17). Troubleshooting: - Check the EB coil. - Check the wiring. - If the problem is not solved, replace the logic board.
217	PEV NOT OK	O		Cause: Terminal PCOM is not connected to the battery or the voltage is different from that defined by parameter SET POSITIVE PEB. This alarm can occur if output NAUX 1 is present (and the related setting is active) or the AUX OUT function is active. Troubleshooting: - Check PCOM terminal: it must be connected to the battery voltage (after the main contactor). - Set the nominal PCOM voltage in parameter SET POSITIVE PEB in ADJUSTMENTS list.
	BMS FAULT		O	Cause: The battery monitoring system is in FAULT status.
218	SENS MOT TEMP KO	O		Cause: The output of the motor thermal sensor is out of range. Troubleshooting: - Check if the resistance of the sensor is what expected measuring its resistance. - Check the wiring. - If the problem is not solved, replace the logic board.
220	VKEY OFF SHORTED	O		Cause: At key-on, the logic board measures a voltage value of the KEY input that is constantly out of range, above the maximum allowed value. Troubleshooting: - Check that the battery has the same nominal voltage of the inverter. - Check the battery voltage, if it is out of range replace the battery. - In case the problem is not solved, replace the logic board.
221	EPS OPEN		O	Cause: The EPS is in alarm state.

Code	Alarm	Master	Slave	Description
222	SEAT MISMATCH	O		Cause: This alarm can appear only in a Traction + Pump configuration or in a multi-motor one. There is an input mismatch between the traction controller and the pump controller relatively to the TILLER/SEAT input (A6): the two values recorded by the two controllers are different. Troubleshooting: - Check if there are wrong connections in the external wiring. - Using the TESTER function, verify that the seat inputs are in accordance with the actual state of the external switch. - In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
223	COIL SHOR. MC	O		Cause: This alarm occurs when an overload of the MC driver (output NMC A16) occurs. Troubleshooting: - Check the connections between the controller outputs and the loads. - Collect information about characteristics of the coil connected to the driver and ask for assistance to a Hyundai dealer in order to verify that the maximum current that can be supplied by the hardware is not exceeded. - In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
224	WAITING FOR NODE	O		Cause: The controller receives from the CANbus the message that another controller in the net is in fault condition; as a consequence the controller itself cannot enter into an operative status, but it has to wait until the other node comes out from the fault status. Troubleshooting: Check if any other device on the CANbus is in fault condition.

Code	Alarm	Master	Slave	Description
226	VACC OUT RANGE	O		Cause: - The CPOT input read by the microcontroller is not within the MIN VACC ÷ MAX VACC range, programmed through the PROGRAMM VACC function. - The acquired values MIN VACC and MAX VACC are inconsistent. Troubleshooting: - Acquire the maximum and minimum potentiometer values through the PROGRAM VACC function. If the alarm is still present, check the mechanical calibration and the functionality of the accelerator potentiometer. - If the problem is not solved, replace the logic board.
227	HW FAULT	O		Cause: At start-up, some hardware circuit intended to enable and disable the power bridge or the LC driver (output A16) is found to be faulty. The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: This type of fault is related to internal components. Replace the logic board.
	OUT MISMATCH XX		O	Cause: This is a safety related test. Supervisor µC has detected that master µC is driving traction motor in a wrong way (not corresponding to the operator request). The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: - Checks the matching of the parameters between Master and Supervisor. - Ask for assistance to a Hyundai dealer. - If the problem is not solved, replace the logic board.
228	CHAT TIME	O		Cause: The chat time has expired. Troubleshooting: To activate traction or pump request

Code	Alarm	Master	Slave	Description
229	HW FAULT EB.	O		Cause: At start-up, the hardware circuit dedicated to enable and disable the EB driver (output A18) is found to be faulty. The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
	NO CAN WR MSG. XX		O	Cause CANbus communication does not work properly. The hexadecimal value “XX” identifies the faulty node. Troubleshooting - Verify the CANbus network (external issue). - Replace the logic board (internal issue).
230	LC COIL OPEN	O		Cause: This fault appears when no load is connected between the NLC output A16 and the positive voltage (for example +KEY). Troubleshooting: - Check the wiring, in order to verify if LC coil is connected to the right connector pin and if it is not interrupted. - If the alarm is still present, than the problem is inside the logic board; replace it.
	SOFTWARE ERROR		O	Cause: A software issue has been detected. This alarm code is reserved for factory tests during the development of the application.
232	CONT. DRV. EV	O		Cause: AUX valve driver is not able to drive the load. Troubleshooting: The device or its driving circuit is damaged. Replace the controller.
233	POWERMOS SHORTED	O		Cause: The DC-link voltage drops to zero when a high-side or low-side MOSFET is turned on. Troubleshooting: - Check that motor phases are correctly connected. - Check that there is no dispersion to ground for every motor phases. - In case the problem is not solved, replace the controller.
234	DRV. SHOR. EV	O		Cause: AUX valve driver is shorted. Troubleshooting: Check if there is a short circuit or a low impedance path between the negative terminal of the coils and -B.

Code	Alarm	Master	Slave	Description
236	CURRENT GAIN	O		Cause: The maximum current gain parameters are at the default values, which means that the maximum current adjustment procedure has not been carried out yet. Troubleshooting: Ask for assistance to a Hyundai dealer in order to do the adjustment procedure of the current gain parameters.
237	ANALOG INPUT	O	O	Cause: This alarm occurs when the A/D conversion of the analog inputs returns frozen values, on all the converted signals, for more than 400 ms. The goal of this diagnosis is to detect a failure in the A/D converter or a problem in the code flow that skips the refresh of the analog signal conversion. Troubleshooting If the problem occurs permanently it is necessary to replace the logic board.
238	HW FAULT EV.	O		Cause: At start-up, the hardware circuit dedicated to enable and disable the EV driver (output A9) is found to be faulty. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
239	CONTROLLER MISM.	O	O	Cause: The software is not compatible with the hardware. Each controller produced is “signed” at the end of line test with a specific code mark saved in EEPROM according to the customized Part Number. According with this “sign”, only the customized firmware can be uploaded. Troubleshooting: - Upload the correct firmware. - Ask for assistance to a Hyundai dealer in order to verify that the firmware is correct.

Code	Alarm	Master	Slave	Description
240	EVP DRIVER OPEN	O		Cause: The EVP driver (output NEVP) is not able to drive the EVP coil. The device itself or its driving circuit is damaged. Troubleshooting: This fault is not related to external components. Replace the logic board.
	OUT MISMATCH PU		O	Cause: This is a safety related test. Supervisor µC has detected that master µC is driving traction motor in a wrong way (not corresponding to the operator request). The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: - Checks the matching of the parameters between Master and Supervisor. - Ask for assistance to a Hyundai dealer. - If the problem is not solved, replace the logic board.
241	SP MISMATCH PUMP		O	Cause: This is a safety related test. The master µC has detected a supervisor µC wrong set point. The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: - Check the matching of the parameters between master and supervisor. - Ask for assistance to a Hyundai dealer. - If the problem is not solved, replace the logic board.

Code	Alarm	Master	Slave	Description
242	OPEN COIL EV.	O		Cause: This fault appears when no load is connected between the NAUX 1 output (A9) and the positive terminal PCOM (A17). Troubleshooting: - Check the EB coil. - Check the wiring. - If the problem is not solved, replace the logic board.
	SP MISMATCH XX		O	Cause: This is a safety related test. The master µC has detected a supervisor µC wrong set point. The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: - Check the matching of the parameters between master and supervisor. - Ask for assistance to a Hyundai dealer. - If the problem is not solved, replace the logic board.
243	THROTTLE PROG.	O		Cause: A wrong profile has been set in the throttle profile. Troubleshooting: Set properly the throttle-related parameters.
244	WARNING SLAVE	O		Cause: Warning on supervisor uC. Troubleshooting: Connect the Console to the supervisor uC and check which alarm is present.
245	IQ MISMATCHED	O		Cause: The error between the Iq (q-axis current) setpoint and the estimated Iq is out of range. Troubleshooting: Ask for assistance to a Hyundai dealer in order to do the correct adjustment of the motor parameters.
246	EB. DRIV.OPEN	O		Cause: The EB coil driver is not able to drive the load. The device itself or its driving circuit is damaged. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
247	DATA ACQUISITION	O		Cause: Controller in calibration state. Troubleshooting: The alarm ends when the acquisition is done.

Code	Alarm	Master	Slave	Description
248	NO CAN MSG.	O	O	Cause CANbus communication does not work properly. The hexadecimal value “XX” identifies the faulty node. Troubleshooting - Verify the CANbus network (external issue). - Replace the logic board (internal issue).
249	MAINTENANCE HOUR	O		Cause: The truck hours reached MAINTEINANCE HOUR parameter value. Troubleshooting: Perform the truck maintainance and reset the alarm using MAINTEN. RESET parameter.
250	THERMIC SENS. KO	O		Cause: The output of the controller thermal sensor is out of range. Troubleshooting: This kind of fault is not related to external components. Replace the controller.
251	WRONG SET BAT.	O		Cause: At start-up, the controller checks the battery voltage (measured at key input) and it verifies that it is within a range of ±20% around the nominal value. Troubleshooting: - Check that the SET BATTERY parameter inside the ADJUSTMENTS list matches with the battery nominal voltage. - If the battery nominal voltage is not available for the SET BATTERY parameter inside the ADJUSTMENTS list, record the value stored as HARDWARE BATTERY RANGE parameter in the SPECIAL ADJUST. list and contact a Hyundai dealer. - Through the TESTER function, check that the KEY VOLTAGE reading shows the same value as the key voltage measured with a voltmeter on pin A1. If it does not match, then modify the ADJUST BATTERY parameter according to the value read by the voltmeter. - Replace the battery.
252	WRONG ZERO	O		Cause: At start-up, the amplifiers used to measure the motor voltage sense voltages outside a fixed range. Troubleshooting: This fault is related to internal components. Replace the logic board.

Code	Alarm	Master	Slave	Description
253	FIELD ORIENT. KO	O		Cause: The error between the Id (d-axis current) setpoint and the estimated Id is out of range. Troubleshooting: Ask for assistance to a Hyundai dealer in order to do the correct adjustment of the motor parameters.
254	EB. DRIV.SHRT.	O		Cause: - The EB driver is shorted. - The microcontroller detects a mismatch between the valve setpoint and the feedback at the EB output. Troubleshooting: - Check if there is a short or a low impedance path between the negative coil terminal and -B. - Check if the voltage applied is in accordance with the parameters settings. - If the problem is not solved, replace the controller.

2) EPS CONTROLLER

Code	Alarm	Master	Slave	Description
8	WATCHDOG	O	O	Cause: MuC and SuC communicate on a local CANbus communication system. Communication between them requires a stuffing bit (stuffing bit must be reversed at any new frame). In case the stuffing bit is frozen longer than 100msec this alarm occurs. Troubleshooting: If it is repetitive, it reports a problem in the controller.
13	EEPROM KO	O	O	Cause: Every microcontroller has its own Eeprom with two parameters lists (to have a local back up copy). Each list has its own checksum. When both checksums are wrong, this alarm occurs. In case a parameter list has a wrong checksum it will be repaired using the second list (back up copy with a correct checksum). Troubleshooting: Make a Clear EEPROM. If the problem persists replace controller.
16	LOGIC FAILURE #4	O	O	Cause: This alarm occurs in the rest state if the output of the voltage amplifier on the linked voltage Vu-Vw have a drift larger than +/- 0.25V (vs. the rest value it had at key-on). Troubleshooting: It is necessary to replace the controller.
17	LOGIC FAILURE #3	O	O	Cause: This alarm occurs in the rest state if the output of the voltage amplifier on the linked voltage Vv-Vu have a drift larger than +/- 0.25V (vs. the rest value it had at key-on). Troubleshooting: It is necessary to replace the controller.
32	VMN NOT OK	O	O	Cause: This alarm occurs at key on, in case at least one amplifiers on linked voltage Vv-Vu and Vu-Vw is not in a narrow window of +/- 300mV around 2.4Vdc 10msec long (sampling time 2msec for 5 consecutive samples). (Admitted outputs at rest are from 2.1V to 2.7V). Troubleshooting: If it is repetitive, it is necessary to replace the controller.

Code	Alarm	Master	Slave	Description
48	MAIN CONT. OPEN	O	O	Cause: This warning is active when the steering controller is receiving via CANbus the information that the power line contactor is open. Troubleshooting: This is not a problem in the E-steering motor controller. When this warning is raised up it means the VCM has open (or not closed yet) the line contactor.
53	STBY I HIGH	O	O	Cause: This alarm occurs when the eps E-steering motor controller is at rest, in case at least one current amplifiers on phases U and W is not in a narrow window of +/- 300mV around 2.5Vdc 10msec long (sampling time 2msec for 5 consecutive samples). (Admitted outputs at rest are from 2.2V to 2.8V). Troubleshooting: If it is repetitive, it is necessary to replace the controller.
60	CAPACITOR CHARGE	O	O	Cause: This alarm occurs at key on in case the DC Bus (rail capacitors) doesn't reach a minimum value of 14Vdc within 3.2secs despite it is expected to do. STATUS #5 supplies the real time value of the battery link (+B) in its short duration instance. Troubleshooting: Some cases: - if this alarm is only reported in the steering controller, check the continuity of cables to CNA#3-4-5 from battery source and E-steering motor controller. - if the cables to CNA #3-4-5 are OK, measure the voltage between CNA#3-4-5 and –B within 3 sec after key-on. Only in case the voltage measured is higher than 14Vdc (and short duration instance on STATUS#5 is lower instead) replace the controller. - In case the voltage measured between CNA#3-4-5 and –B is close to 0 there are two possibilities: · Short circuit on the DC rail and –B inside the E-steering motor controller (disconnect CNA#3-4-5 and measure the voltage in the traction controller DC bus (+B to –B posts): replace E-steering motor controller in case DC bus voltage of the traction controller raises up to higher than 14Vdc. · Short circuit on the DC rail and –B on another unit in the truck.

Code	Alarm	Master	Slave	Description
61	HIGH TEMPERATURE	O	O	Cause: This alarm occurs when the temperature in the power mosfets is higher than 80 degrees. Troubleshooting: Improve the cooling of the controller; otherwise it is necessary to replace the controller.
65	MOTOR TEMPERAT.	O	O	Cause: This alarm occurs only when DIAG MOTOR TEMP is analog and the thermal sensor inside the motor measures a temperature higher than 120 degrees. It occurs also when trying to acquire the motor resistance with a temperature in the motor higher than 120 degrees. Troubleshooting: Check the thermal sensor in the motor is right working. If it is, improve the cooling of the motor.
70	HIGH CURRENT	O	O	Cause: This alarm occurs two ways: - At key on, in case the circuit for limiting the max current via Hardware is always active (can be due to a failure of a current amplifier). - After key on, in case the circuit for limiting the max current via Hardware acts frequently. Troubleshooting: If it is repetitive, it is necessary to replace the controller.
71	POWER FAILURE #3	O	O	Cause: Current in phase W of the motor very low 100msec long even if it is commanded higher than 14% Imax. Troubleshooting: If it is repetitive, check if the battery is connected to the controller. Otherwise the problem can be a failure in the power three phase bridge or in the motor.

Code	Alarm	Master	Slave	Description
72	POWER FAILURE #2	O	O	Cause: This alarm is raised by the MuC when the current in phase V of the motor very low 100msec long even if it is commanded higher than 14% Imax. Zapi Universal 2.0: this alarm is raised by the SuC at key on, in case the contactor on the DC-rail to the E-steering controller is welded in its closed position (MAIN CONTACTOR to OPTION #1 only). Troubleshooting: MuC: If it is repetitive, check if the battery is connected to the controller. Otherwise the problem can be a failure in the power three phase bridge or in the motor. SuC: if the contactor on the DC-rail to the E-steering controller is welded in its closed position, replace it.
73	POWER FAILURE #1	O	O	Cause: This alarm is raised by the MuC when the current in phase U of the motor is very low 100msec long even if it is commanded higher than 14% Imax. Zapi Standard 1ST Gen and Universal 2.0: this alarm is raised by the SuC in case the I^2t of the current in the battery overtakes the admitted limit of 22000A^2s (i.e. overload protection of the battery connections). Troubleshooting: MuC: if it is repetitive, check if the battery is connected to the controller. Otherwise the problem can be a failure in the power three phase bridge or in terminal U motor connection. SuC: an overload is occurred in the steering controller. One possibility is too much friction in the transmission. Launch selfcheck #2 with the steered wheel lifted up (and then on the floor) to measure the current in the motor when turning the steered axle. Check the diagnostic response (STATUS #2 and alarm message).
91	DRIVER 2 KO	O	O	Cause: This alarm occurs in case the safety switch between CNA #9 and CNA #14 is detected short circuited at key-on and option AUX OUTPUT #1 is set to PRESENT. Troubleshooting: It reports either a short circuit to GND of the load connected to CNA #14 or a problem in the controller.

Code	Alarm	Master	Slave	Description
98	INPUT ERROR #2	O	O	Cause: The revolution of the sensor at the steering wheel is split in 4 quadrants: 1ST: 0 to 90 degrees 2ND: 90 to 180 degrees 3RD: 180 to 270 degrees 4TH: 270 to 360 degrees This alarm occurs in case the configuration of the two outputs jumps to a NOT ADIACENT quadrant. In practice, when the configuration of the two outputs: - Is in the 1ST quadrant, shift to 3RD quadrant is not admitted - Is in the 2ND quadrant, shift to 4TH quadrant is not admitted - Is in the 3RD quadrant, shift to 1ST quadrant is not admitted - Is in the 4TH quadrant, shift to 2ND quadrant is not admitted Single event raises the alarm. Troubleshooting: Check the connections of the analog sensor at the steering wheel (CNA #20 and CNA #17). Disturb or interference on the sensor.
205	SELF CHECK #2	O	O	Cause: This warning occurs when the SELFCHECKING routine #2 is in progress and the check result has not been determined yet. This selfchecking routine carries out an embedded monitoring of the encoder and of the current in the motor when commanded to move at a fixed speed of 25Hz. We suggest to launch SELFCHECK #2 with the steered wheel lifted up. The goal of this selftest is to check the functionality of encoder and mechanical components (transmission, sensor bearings, gears, pinion). After the gathered data have been processed and an unexpected result occurred, this warning message will turn in an alarm information. Troubleshooting: Recycle the key to exit the SELFCHECK #2 warning.
206	SELF CHECK #1	O	O	Cause: This warning occurs when the SELFCHECKING routine #1 is in progress and the check result has not been determined yet. This selfchecking routine carries out a voltammeter measure of the motor resistances between phase V and W (Rvw) and between phase W and U (Rwu) by injecting a fixed 14.7Adc current (sqrt(3/2) * ID RMS MAX). The goal of this selftest is to check the functionality of motor and three phase power bridge. After the gathered data have been processed and an unexpected result occurred, this warning message will turn in an alarm information. Troubleshooting: Recycle the key to exit the SELFCHECK #1 warning.

Code	Alarm	Master	Slave	Description
207	WRONG HW SET	O		Cause: A Zapi adjusted hardware setting, called HW TYPE, specifies the hardware characteristics of the controller where the SW has been downloaded (absolute max current and battery voltage). In case HW TYPE has an inconsistent value (i.e. specifies a not foreseen pair, battery voltage and absolute max current) this alarm occurs. Troubleshooting: Call Hyundai dealer or replace the controller.
	SP MISMATCH		O	Cause: MuC and SuC calculate independently each other the set point for speed in the motor and position at the wheel. This alarm is raised by the SuC in case it calculates different set points than the MuC. Troubleshooting: If it is repetitive, it reports a problem in the controller.
208	OUTPUT MISMATCH		O	Cause: SuC compares the set points of motor current, motor speed and position at the wheel with the actual values. If there is a mismatch SuC raises this alarm. Imax in the motor with the correct sign is an exception: no alarm in this case. Troubleshooting: If it is repetitive, it it reports a problem in the controller.
209	W.D. SYNCRO	O	O	Cause: SuC doesn't receive synchronization signal frpm MuC longer than 90msec. Troubleshooting: Recycle the key. If the problem remains replace the controller.
210	WRONG SLAVE VER.	O	O	Cause: This alarm is raised by MuC in case the Software release in MuC and SuC are not matched (different release). Troubleshooting: Download the same software release (same number) on both microcontrollers.
211	TFD FEEDB. ERROR	O	O	Cause: MuC raises this alarm in case the actual current and the set point current in the TFD (to friction the steering wheel) stays unmatched more than 150mA 120msec long. Troubleshooting: Problem can be the resistance of the TFD coil is too high (coil broken) or the wires to the TFD coil broken or a problem in the controller.

Code	Alarm	Master	Slave	Description
212	WRONG RAM MEM.	O	O	Cause: Deterministic Finite Automaton (DFA) is characterized by state transitions. As a protective measure any state transition is commanded by assigning two variables (state label and its complement). These two variables identify the new state (redundancy in the state label). This redundancy has been thought in order to avoid that a failure in the RAM memory leads to a wrong destination state for the DFAs. In case the two state labels are inconsistent or not complemented in between, this alarm occurs. Troubleshooting: If it is repetitive, it reports a problem in the controller.
213	PARAM RESTORE	O	O	Cause: This is a confirmation that a clear eeprom parameter was correctly performed. Troubleshooting: Recycle the key.
214	SP JERK	O	O	Cause: This alarm occurs if an output of the sensor at the steering wheel has a step wider than 586mV between two consecutive samples and confirmed for further ten samples (all the samples are picked up with a sampling delay is 4msec). Troubleshooting: Read STATUS #9 when the alarm occurs to find the output between CNA #20 and CNA #17 had the widest step. Check the continuity of the cables from sensor to controller. Check for a disturb, noise, interference between sensor in the steering wheel and controller. Check the cable between steering wheel and controller is shorter than 2meters.
215	CAN BUS KO M/S	O	O	Cause: MuC and SuC communicate via a local (embedded) CanBus communication system. If a node does not receive any response from the other node longer than 100msec, this alarm occurs. Troubleshooting: If it is repetitive, it is a problem in the steering controller.

Code	Alarm	Master	Slave	Description
216	TFD WRONG RESIST	O	O	Cause: Parameter TFD OHM IMPED. sets the expected resistance of the TFD coil @ 25°C. This parameter is used for a coarse check of the integrity of the TFD coil. E-steering motor controller measures the TFD coil resistance with a voltammeter test (V_in_the_coil/ Current_in_the_coil). When the measured resistance is outside the range from 1/3 to 3 times TFD OHM IMPED 180msec long, MuC raises this alarm. V_in_the_coil is calculate using VCNA#9 –VCNA#10, if V in_the_ coil expected is lower than 2.3V diagnosis is not done due to a too low precision in value V_in_the_coil. Troubleshooting: Problem can be the resistance of the TFD coil is too high (coil broken) or too low (a short circuit inside the TFD) or the wires to the TFD are broken or the parameter called TFD OHM IMPED has been wrong set or a problem in the controller.
218	CONTROLLER MISM.	O	O	Cause: This alarm occurs when the embedded SW is not compatible with Hardware. Troubleshooting: Update the embedded SW.
220	MOTOR LOCKED	O	O	Cause: This alarm occurs when the current in the motor stays higher than 90% Imax longer than 1 secs when the traction speed is higher than 15% (delay becomes 5 secs when the traction speed is lower than 5%). Troubleshooting: Too much torque required to steer or problem in the encoder (launch selfcheck #2).
221	M/S PAR CHK MISM	O	O	Cause: MuC compares its checksum for the parameters list with the checksum of the parameters list in the SuC. In case they are mismatched, MuC raises this alarm. Troubleshooting: Check which parameter(s) is different between MuC and SuC and update (write) the unmatched parameter(s). To easily fix the problem make a Clear Eeprom.

Code	Alarm	Master	Slave	Description
223	FB JERK	O	O	Cause: This alarm occurs if the encoder counting has a step wider than 21° between two consecutive samples and confirmed for further thirteen samples (all the samples are picked up with a sampling delay is 16msec). The diagnostic routine uses an encoder counting scaled in the range 2048ud+/-2048ud (corresponding to a steered axle angle of 0+/-180°) and the threshold for the alarm is +/-244ud corresponding to an angle of 244/2048*180° =21° . Troubleshooting: See reading SLOPE PEAK of the tester menu (with DEBUG OUTPUT temporary set to Level 13) to have a real time monitoring of the max step detected by the diagnostic routine. Check the encoder is right working. Use also STATUS # 2 to have a feedback on the encoder functionality (see topic 16: TROUBLESHOOTING).
225	CURRENT GAIN	O	O	Cause: This alarm occurs when the gains of the current amplifiers (ADJUSTMENT #03 and ADJUSTMENT #04) are set to their default values (Imax has not been regulated yet). Troubleshooting: Call Hyundai dealer.
226	STOP TRAC WR.	O	O	Cause: The eps is inhibiting the traction movement due to a wrong parameter configuration or calibration of the eps controller.
227	OUTRNG-TURN ST01	O	O	Cause: The wheel performed a rotation of 180 degrees.
228	POSITION ERR	O	O	Cause: This alarm occurs when the displacement between position of the steered wheel measured with the encoder (FEEDBACK ENC) and with the first output of the analog sensor (FBPOT1 AT ENC) is wider than 173mV (for six subsequent samples picked up with a sampling delay is 16msec). STATUS #7 can be used to detect real time the peak value of the displacement (to be compared with the alarm threshold of 175mV) and the values of the variables involved when that peak of the displacement has been recorded. Troubleshooting: Check STATUS #7 when alarm occurred. Check the analog value of the sensor on CND #2 (FEEDBACK POT 1). Verify also the encoder works correctly.

Code	Alarm	Master	Slave	Description
230	PARAM CONFIGURAT	O	O	Cause: 1 SYSYEM CONFIG not admitted or not available in this software 2 Not possible for this hardware has 2 feedback encoder and analog setpoints 3 EPS SYNC TYPE not admitted for this software 4 Command input not admitted for this software 5 Torque assist not available for this software 6 software end limit are not setted (360°) in position control 8 FEEDBACK DEVICE not admitted or not available in this software 9 key-on 0 alignement request without feedback switch (sw version <=7.01) 0A analog feedback without feedback switch and key-on syncronization not manual (sw version <=7.01) 0B In a single feedback encoder , parameter 1ST ENCODER RES 1= 2ND ENCODER RES 0C Analog feedback with no end limit setted 0D FEEDBACK DEVICE set to 7 (only encoder) in position control is not admitted 0E position or speed can command with no caniopen protocoll 0F 2nd home switch activated with AUX FUNCTION#11 set to 2 or 3 or4 or5 10 analog setpoint parallel trace not jet available 11 manaul startup syncronization in position control with feedback switch 12 2 encoder and analog feedback not possible 13 zero_sp1 + zero_sp2 out of range 20 Wrong teaching in potentiometer analog command (for example maximul lower then 0) 22 reserved for input_analog && sp_sawtooth
235	TFD SHRT/VOLT KO	O	O	Cause: This diagnosis is processed only at key on the Circuit in. Two tests: Q3 is initially off: CNA #9 is expected to be lower than 5Vdc. In case it isn't this alarm occurs; otherwise Q3 is switched on. Q3 is on: CNA #9 is expected to be higher than 60% of the DC bus. In case it isn't this alarm occurs. This alarm (with alarm number 40h) is raised also by the SuC in case the key input stays lower than 12.5V longer than 200msec. Troubleshooting: It reports either a short circuit to GND of the load connected to CNA #9 or a problem in the controller (on safety switch Q3).

Code	Alarm	Master	Slave	Description
236	TFD STB I HIGH	O	O	Cause: If the output of the amplifier to measure the current in the TFD is not Zero at rest, this alarm occurs. Zero for MuC is 0.5V (alarm when it is higher than 1V). (For MuC output increases when the current is not null). Zero for SuC is 4.5V (alarm when it is lower than 4V). For SuC output decreases when the current is not null. Troubleshooting: It reports a problem in the controller.
237	SLAVE ALARM	O		Cause: When SuC raises an alarm, steering motor cannot be actuated and the MuC informs the SuC has cut off the power stage by raising this warning. In the Zapi console, MuC specifies the LSByte of the SuC alarm code. For instance, in case of SuC alarm code FFD0 (OUTPUT MISMATCH), MuC raises SLAVE ALARM D0. (i.e. XX assumes the two last nibbles of the SuC alarm code.) Troubleshooting: If it is repetitive, it reports a problem in the controller.
	WAITING MASTER		O	Cause: When MuC raises an alarm, steering motor cannot be actuated and the SuC informs the MuC has cut off the power stage by raising this warning. In the Zapi console, SuC specifies the LSByte of the MuC alarm code. (i.e. XX assumes the two last nibbles of the MuC alarm code.) Troubleshooting: If it is repetitive, it reports a problem in the controller.
240	LOGIC SUPPLY ERR	O	O	Cause: This alarm occurs in case the 13.5V logic supply voltage to drive the three phase power bridge is detected lower than 11Vdc. Troubleshooting: Recycle the key. If it is repetitive, it reports a problem in the controller.

Code	Alarm	Master	Slave	Description
241	FB SENSOR LOCKED	O	O	Cause: This alarm occurs if the actual position (steered wheel angle measured via the encoder counting) does not pursuit the commanded position (steering wheel) longer than 500msec @ traction speed higher than 15% (at lower traction speed, time delay increases up to 2.5secs when traction speed is lower than 5%). If the displacement between commanded position and the encoder counting (i.e. steered wheel angle) is higher than 10degrees and the encoder counting increases less than 2degrees within the time delay of 500msec, this alarm occurs. Troubleshooting: STATUS #2 Selfchecking routine helps to found the root of the problem. This alarm can be due to: - At least one encoder channel broken. - Too much friction in the transmission/gears. - A failure in the power controller. - A failure in the motor (e.g. a sensor bearing locked or a motor phase broken).
244	PARAM TRANSFER	O	O	Cause: Master uC and Slave uC has its own parameter list (with its local back up copy). Change of a parameter is handled by the MuC only. MuC writes its own parameter and commands the SuC to do the same for its parameter list. Execution of the write command in the SuC is protected by a password. This alarm is raised up by the MuC in case SuC refuses to do the write command. Troubleshooting: Try to change one more time a parameter. If problem persists replace controller.
245	DATA ACQUISITION	O	O	Cause: This alarm occurs during max current regulation (factory adjusted) and when a procedure to acquire the motor resistance is launched. Troubleshooting: Recycle the key.
247	CAN BUS KO	O	O	Cause: If a node does not receive its dedicated CANbus message longer than 100msec, this alarm occurs. Troubleshooting: Problem can be in the CANbus wires, or in the CANbus transceiver inside VCM, E-steering motor controller or another unit in the truck. Identification of the root of the problem needs a CANbus analyzer.

Code	Alarm	Master	Slave	Description
248	S.P OUT OF RANGE	O	O	Cause: If occurs when the displacement between actual and expected conditions of the analog sensor at the steering wheel is wider than a threshold (16 subsequent samples picked up with a sampling delay is 4msec). PWM sensor: this threshold is a displacement of +/-5.5% of duty cycle when the speed of the steering wheel is null; linearly increasing up to 11% when the speed of the steering wheel is 5rev/sec. Analog sensor: this threshold is +/-250mV for the SuC and +/-400mV for the MuC. In case it gets higher than 250mVdc (or 400mVdc) or lower than -250mVdc (or 400mVdc) this alarm occurs. Diagnosis is split into 4 quadrants (0 to 90, 90 to 180, 180 to 270, 270 to 360 degrees). STATUS #8 can be used to detect real time the peak value of the displacement (to be compared with the alarm threshold of 250mV) and the values of the outputs when that peak of the displacement has been recorded). Troubleshooting: Check STATUS #8 when alarm occurred. Check the connections of the analog sensor at the steering wheel (CNA #20 and CNA #17). Disturb or interference on the sensor.
250	INPUT MISMATCH		O	Cause: MuC and SuC read the inputs independently each other. SuC takes care the values that it is reading are matched real time with the values the MuC is reading. The inputs are: - Steering Wheel sensor (CNA #20 and CNA #17) - Steered Wheel analog sensor - Encoder in the motor SuC raises this alarm in case they are mismatched Troubleshooting: If it is repetitive, it reports a problem in the controller.

Code	Alarm	Master	Slave	Description
251	INIT VMN NOT OK	O	O	Cause: After key-on, with the three phase power bridge off, the DC bus voltage is expected to raises up to 14Vdc within 3.2secs (alarm CAPACITOR CHARGE below if it isn't). In the same time, steering controller monitors the common voltage at the motor terminals (see STATUS #5 (MONITORING list)) and raises this alarm when the 3.2secs time-out is expired and: - The common voltage is lower than 7Vdc (bottom power mosfet shortcircuited to –B). OR - The common voltage is stuck to the DC Bus (top power mosfet shorcircuited to +B). (It is considered stuck in case it is in a window of +/- 1Vdc around the DC Bus). STATUS #5 in the TESTER menu, supplies the real time value of this common voltage on its long duration instance. Troubleshooting: Try to disconnect all the motor terminals from the controller, recycle the key and read STATUS #5. If the long duration instance (i.e. 1ST value) is in a window 8 to 13.5Vdc, the problem is a dispersion (lost of insulation of the motor). Otherwise replace the controller.
252	TWIN POT MISMAT.	O	O	Cause: it occurs when the displacement between actual and expected conditions (FEEBACK POT 1 + FEEDBACK POT 2=5Vdc) of the analog sensor at the steered wheel (tire) is wider than 490mVdc six subsequent samples picked up with a sampling delay is 16msec. STATUS #6 can be used to detect real time the peak value of the displacement (to be compared with the alarm threshold of 490mV) and the values of the outputs when the peak of the displacement has been recorded. Troubleshooting: Check STATUS #6 when alarm occurred. Check the connections (mechanical and electrical) of the analog sensor at the steered axle. Replace the sensor if nothing is found.
253	ANALOG	O	O	Cause: At key on, the A/D converter is switched on and it is expected to complete a conversion of the analog inputs within 16msec. In case it isn't, this alarm occurs. Troubleshooting: Recycle the key. If problem persists replace the controller.

Code	Alarm	Master	Slave	Description
254	NO SP REFRESH	O	O	Cause: This alarm is alive only when the sensor at the steering wheel is of PWM type (not analog). Then, in case at least one output between CPOC 1 and CPOC 2 (CNA #20 and CNA #17) has a PWM period shorter than 4msec or longer than 6msec confirmed for 92msec long, this alarm occurs (NO SP REFRES 02 and NO SP REFRES 04). It occurs also when at least one between CPOC 1 and CPOC 2 does not switch longer than 12msec (2 period lost) with alarm NO SP REFRES20 (i.e. 20h=32dec). Troubleshooting: Check the sensor at the steering wheel and the wiring from the steering wheel to the controller.

3) VCM CONTROLLER

Code	Alarm	Master	Slave	Description
8	WATCHDOG	O	O	Cause: A software watchdog is programmed inside each microcontroller. Its role is to check the correct operation of the software. All functions are blocked. Troubleshooting: it is an internal error, the module must be replaced.
19	LOGIC FAILURE #1	O	O	This alarm signals that an undervoltage at the key input has been detected. All functions are blocked. Troubleshooting depends on which is the reason of the alarm: - A real undervoltage situation happened. The alarm should disappear by simply switching off and on again the key. The cause of the undervoltage event has to be found on the application. For example: a truck function requesting a very large battery current may decrease too much the battery voltage. - Fault in the circuit which detects the undervoltage condition. The board must be replaced.
199	OUT1/2 COIL SH.		O	Cause: This alarm occurs when there is a short circuit of the EVP 1 or EVP 2 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. - In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
200	WRONG PARAMETER	O		Cause: This is an alarm related to the throttle configuration. Troubleshooting: Check the parameters.
	OUT3/4 COIL SH.		O	Cause: This alarm occurs when there is a short circuit of the EVP 3 or EVP 4 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. - In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.

Code	Alarm	Master	Slave	Description
201	WRONG SLAVE VER.	O		Cause: Wrong software version on supervisor uC. Troubleshooting: Install the correct software version in the supervisor uC.
	OUT5/6 COIL SH.		O	Cause: This alarm occurs when there is a short circuit of the EVP 5 or EVP 6 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. - In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
202	HM MISMATCH	O		Cause: Mismatch between VCM and traction regarding the Hour Meter. Troubleshooting: Check the parameter setting concerning the HM.
	OUT7/8 COIL SH.		O	Cause: This alarm occurs when there is a short circuit of the EVP7 or EVP8 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. - In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
203	TILLER MISMATCH	O		-
	LASER COIL SH.		O	-

Code	Alarm	Master	Slave	Description
204	BATTERY LOW	O		Cause: It occurs when the battery charge is calculated being less than or equal to 10% of the full charge and the BATTERY CHECK setting is other than 0 (refer to SET OPTION menu). Troubleshooting: Get the battery charged. If it doesn't work, measure with a voltmeter the battery voltage and compare it with the value in the BATTERY VOLTAGE parameter. If they are different adjust the value of the ADJUST BATTERY function.
	BAT OUT COIL SH.		O	Cause: This alarm occurs when there is a short circuit of the EV 1 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. - In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
205	LOAD BRK COIL SH		O	Cause: This alarm occurs when there is a short circuit of the EVP 9 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. - In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
206	ALARM COIL SH.		O	Cause: This alarm occurs when there is a short circuit of the EV 2 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. - In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
207	WATCH DOG MASTER		O	Cause: An Hardware watchdog is present inside to synchronize the microcontrollers. All functions are blocked. Troubleshooting: It is an internal error, the module must be replaced.

Code	Alarm	Master	Slave	Description
208	EEPROM KO	O	O	Cause: Fault in the area of memory where the parameters are stored or problems during the read/write operations of this memory. This alarm does not inhibit machine operation but default parameters are used. Troubleshooting: If the fault continues when the key switch is re-cycled, replace the board. If the fault disappears, the previously stored parameters will have been replaced by the default parameters.
209	PARAM RESTORE	O	O	Cause: This warning appears when the controller restored the default values. Troubleshooting: If a CLEAR EEPROM was mode before the last keyon-recycle, this warning just means that the EEPROM was correctly cleared. A travel demand or a pump request cancel the alarm. If this alarm appears at keyon without any CLEAR EEPROM request by the operator, there could be a problem inside.
210	WRONG RAM MEM.	O	O	Cause: The algorithm implemented to check the main RAM registers finds a wrong contents: the register is “dirty”. This alarm inhibit the machine operations. Troubleshooting: Try to switch the key off and then on, if the alarm is still present replace the logic board.
211	PUMP INC. START	O		Cause: This is a warning for an incorrect starting sequence. Troubleshooting: The possible reasons for this alarm is (use the readings in the TESTER to facilitate the troubleshooting) pump demand active at key on or a pump demand is present without the seat input active. Check the wirings. Check the micro-switches. It could be also an error sequence made by the operator. A failure in the logic is possible too; so when all of the above conditions were checked and nothing was found, replace the controller.
	PEV DRV. OPEN		O	Cause: VCM is not able to drive the high side driver of output PEVP 1. Troubleshooting: This type of fault is not related to external components; replace the logic board.
212	PEV DRV. SHORT.		O	Cause: The high side driver of output PEVP 1 is shorted. Troubleshooting: - Check if there is a short or a low impedance pull-up between pin A13 and +BATT. - The driver circuit is damaged in the logic board, which has to be replaced.

Code	Alarm	Master	Slave	Description
213	ENCODER LOCKED 1	O		Cause: The encoder n°1 is stuck or the encoder signals are not correctly received by the controller. Troubleshooting: Please check if the ENCODER 1 on the tester menu is different than zero during a lifting request. Check the wirings and check that the sensor works correctly. A failure in the logic is possible too; so when all of the above conditions were checked and nothing was found, replace the controller.
	VALVE MISM. OUT		O	Cause: Mismatch between uC Master and uC slave for output set point calculation. Troubleshooting: The logic board has to be replaced.
214	ENCODER LOCKED 2	O		Cause: The encoder n°2 is stuck or the encoder signals are not correctly received by the controller. Troubleshooting: Please check if the ENCODER 2 on the tester menu is different than zero during a lifting request. Check the wirings and check that the sensor works correctly. A failure in the logic is possible too; so when all of the above conditions were checked and nothing was found, replace the controller.
215	OUT PORT PULL-UP	O	O	Cause: This is an alarm related to the hardware configuration. Troubleshooting: The problem is on the logic board, which must be replaced.
217	ANALOG INPUT	O	O	Cause: There is a problem in the analog-to-digital module of the microcontroller. All functions are stopped. Troubleshooting: This a failure internal to the microcontroller, replace the
218	IN. MISM. D		O	Cause: Mismatch on digital input between Master and Slave. Troubleshooting: Compare the values read by Master and Slave by tester menu of console. Ask the assistance of a Hyundai dealer.

Code	Alarm	Master	Slave	Description
219	VALVE ENABLE	O		Cause: It occurs when the uC master try to activate an output but the supervisor uC doesn't activate the enable. Troubleshooting: Check if some alarm is present on supervisor uC. Otherwise a fault in the hardware is present, the board must be replaced.
	IN. MISM. A/E		O	Cause: Mismatch on analog inputs or encoder inputs between Master and Slave. Troubleshooting: Compare the values read by Master and Slave by tester menu of console. Ask the assistance of a Hyundai dealer.
223	NO CAN MSG. 5	O		Cause: Timeout on the local CANbus. Troubleshooting: Switch OFF and ON. If the alarm is still present replace the board.
	NO CAN MSG. C		O	Cause: No CAN message from traction controller. Troubleshooting: Check the CAN connection on traction controller side. Verify that the traction communicates on CANbus.
224	WAITING FOR NODE	O		Cause: The controller receives from the CAN the message that another controller in the net is in fault condition; as a consequence the VCM controller itself cannot enter an operative status, but has to WAIT for the other controller coming out from the fault status.
	NO CAN MSG. 4		O	Cause: Timeout on the local CANbus. Troubleshooting: Switch OFF and ON. If the alarm is still present replace the board.
225	CONTROLLER MISM.	O	O	Cause: Wrong customer ID code found in the protected area of memory where this parameter are stored. Troubleshooting: Replaced the controller.
226	PUMP IN ALARM	O		Cause: Alarm on pump controller. Troubleshooting: Check the alarm on pump controller.
227	NO CAN MSG. 14	O	O	Cause: No CAN message from pump controller. Troubleshooting: Check the CAN connection on pump controller side. Verify that the pump communicates on CANbus.

Code	Alarm	Master	Slave	Description
228	NO CAN MSG. A	O	O	Cause: No CAN message from the Mini Lever or Joystick. Troubleshooting: Check the CAN connection on Mini Lever or Joystick side. Verify that the Mini Lever or Joystick communicate on CAN bus.
229	SDO TRAC.	O		Cause: There is a problem in the communication of HM between VCM and traction. Troubleshooting: Verify the communication between the two controllers. If all is ok try to replace the board.
231	DRV. SHRT A		O	Cause: VCM is not able to drive one of the first eight outputs. Troubleshooting: - Check if there is a short or a low impedance pull-down between one of the output and –BATT. - The driver circuit is damaged in the logic board, which has to be replaced.
232	DRV. OPEN A		O	Cause: The driver of one of the first eight outputs is shorted. Troubleshooting: This type of fault is not related to external components; replace the logic board.
233	DRV. SHRT B		O	Cause: The driver of one of the outputs NEV 1,.., NEV 3 is shorted. Troubleshooting: - Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. - The driver circuit is damaged in the logic board, which has to be replaced.
234	DRV. OPEN B		O	Cause: VCM is not able to drive one of the outputs NEV 1,.., NEV 3. Troubleshooting: This type of fault is not related to external components; replace the logic board.
241	M/S PAR CHK MISM	O		Cause: Parameters are saved both in the master Eeprom and in the slave Eeprom. The two non-volatile memories must contains the same parameter values and they are compared periodically. If a difference is found, this alarm is raised. This alarm does not inhibit machine operation but default parameters are used. Troubleshooting: Try to save again the parameters. If the fault continues when the key switch is re-cycled, replace the board.

Code	Alarm	Master	Slave	Description
242	PARAM TRANSFER	O		Cause: Parameters are saved both in the master Eeprom and in the slave Eeprom. The two non-volatile memories must contains the same parameter values and they are compared periodically. If the master is not able to transfer the parameters to the slave, this alarm is raised. Troubleshooting: Try to save again the parameters. If the fault continues when the key switch is re-cycled, replace the board.
243	COIL OPEN A		O	Cause: This fault appears when the no load is connected between one of the outputs NEVP 1, NEVP 2….NEVP 8 and the positive terminal. Troubleshooting: - It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. - If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.
244	CHECK UP	O		Cause: This is just a warning to call for the time programmed maintenance. Troubleshooting: It is just enough to turn the CHECK UP DONE option to level ON after the maintenance is executed.
	COIL OPEN B		O	Cause: This fault appears when no load is connected between one of the outputs NEV 1….NEV 3 and the positive terminal. Troubleshooting: - It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. - If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.
245	COIL OPEN BRAKE		O	Cause: This fault appears when no load is connected between the output NEVP9 and the positive terminal. Troubleshooting: - It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. - If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.
246	NO CAN MSG. C	O		Cause: No CAN message from traction controller. Troubleshooting: Check the CAN connection on traction controller side. Verify that the traction communicates on CANbus.

Code	Alarm	Master	Slave	Description
247	NO CAN MSG. 6	O		Cause: No CAN message from EPS. Troubleshooting: Check the CAN connection on steering controller side. Verify that the steering module communicates on CANbus.
248	NO CAN MSG. 10	O		Cause: No CAN message from DISPLAY. Troubleshooting: Check the CAN connection on display side. Verify that the display communicates on CANbus.
249	CAN BUS DISPLAY	O		Cause: The key relay driven by display is open. Troubleshooting: Check the relay.

8. BATTERY CHARGER

This explains basic information related to charger to help you easily understand and use it. This includes the contents from the way to install a charger to tips for emergency situations. This is focused on practices aiming to be usefully utilized in the field.

1) BASIC INFORMATION

(1) What is charger

Charger is a device which makes a battery accept D.C electricity under optimal condition as it transforms A.C provided from external source of electricity.

The charger is a constant-current and constant-voltage way, SCR type charger that it has advantages as follows

① Even though A.C input voltage fluctuates within 10% of rated voltage (220/380/410/440V), the current and voltage provided to the battery are stable.

② As minimizing the increase of temperature while charging a battery, it minimizes the stress on the battery.

③ The noisy of charger is minimal but the charging efficiency is very high.

④ It prevents from under charging and overcharging.

Therefore, it helps the battery to maintain its performance for longer time and to prolong the life of the battery.

(2) Notice on caring chargers

① If any abnormal status is found while using a charger, immediately stop using and check the charger. If it is impossible to take an appropriate measure for yourself, please apply for A/S.

② While charging, hydrogen and oxygen gas is produced. Use or approach of fire should be strictly prohibited.

③ Keep clean to prevent from sneak current and attack on the interface and surroundings of the battery.

④ Check the electrolyte of the battery every week and provide distilled water immediately if it is required. (Electrolyte has to be provided between 10~12 ㎜ level on the positive plate inside storage battery)

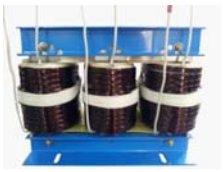
⑤ If battery liquid temperature becomes over 55°C, charging should be stopped.
If it is continued,
- the appearance is transformed
- and metal area can be attacked as electrolyte overflows

⑥ Electric forklift truck using battery should be charged as soon as the charging lamp is on while driving. As batteries are internally discharged naturally if they are deposed for a long time, charge them once or twice a month to prevent from reducing the lives of batteries.

⑦ When a green sign is on among charging status indication lamps, please notify that it is not converted as equalized charge for stabilization of charging status.

(3) Names of each part (independent items)

① 

② 

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1	Main PCB board	5	Monitor PCB	9	Resistance (RD)
2	Main trans (Class H)	6	Overload	10	Resistance (DR)
3	Cooling fan	7	MG S/W		
4	SCR module	8	Assistant trans		

2) CHARGER INSTALLATION METHOD

(1) Location for charger installation

① Dry and well ventilated place.
② No inflammable and B7 fire are near by.
③ Safe place where no collision possibility with people or equipment is.

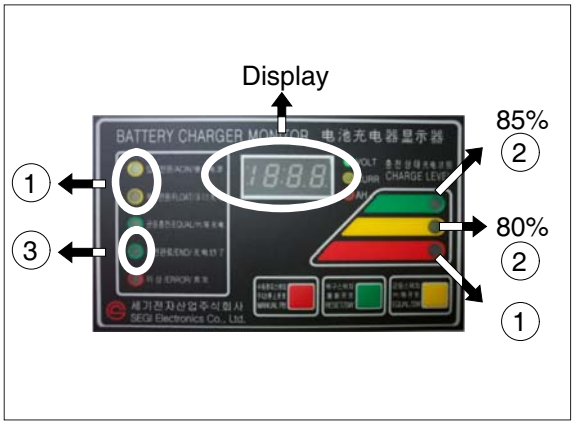
(2) Check points before installing charger

① Enough capacity of AC input power source to operate charger.
② Standard electric wire for power source by capacity.

(3) Table for capacity of charger input cable

48 V battery	Capacity of cable	Input voltage	Remarks
200-365 AH	4P - 2.5 mm^2	Based on 3Ø380 V 3Ø440 V	For 3Ø220V, one step higher capacity cable should be used. (2.5 mm^2 → 4mm^2)
400-80 AH	4P - 4 mm^2		
600-800 AH	4P - 6 mm^2		
850-1000 AH	4P - 10 mm^2		
24 V battery	-		
200-600 AH	4P - 2.5 mm^2		
700-1000 AH	4P - 4 mm^2		
80V battery	-		
500-600 AH	4P - 6 mm^2		
700-800 AH	4P - 10 mm^2		

3) HOW TO USE A CHARGER



(1) General charging method (Floating charging)

① Charging by this method supplies electric power to the charger as operating external AC power switch of the charger.

② Connect battery connecter and charger connecter.

· **According to charging condition**

① If there is no abnormality found when the charger checks itself for 3-4 seconds after inputting AC input power source, the charger slowly increases the electric flow for charging and the charging condition lamp in the lower part of the front panel for floating charging of "input" is on.

② A charging voltage, current, amount and time are displayed in order on a monitor display window.

③ When charging is processed about 80%, yellow lamp in the middle of the front panel, which shows that the charging condition is in the middle, is on and then green lamp is on when charging is processed over 85% until charging is completed.

④ When charging is completed, "charging is completed" lamp is on in the monitor and other lamps of all monitors become off.

(2) Equalized charging

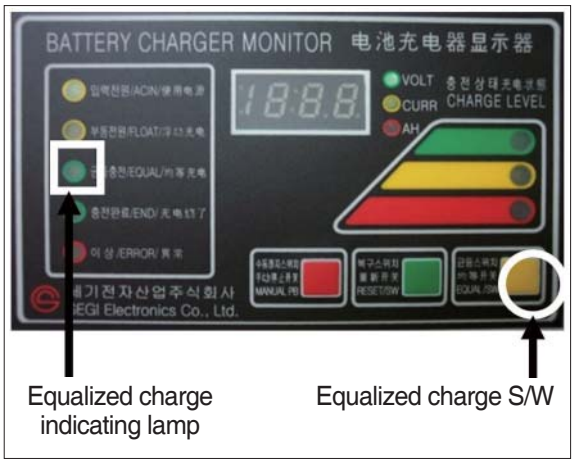
① Equalized charging is

Equalized charging is to correct the battery when it does not normally perform its functions as the voltage differences are too big between cells of a battery.

- **When equalized charging is required?**
- When re-operates the battery after having left the battery for a long time.
- When a battery is over-discharged.
- When there is large deviation of voltage and specific gravity between battery cells.
- When change or supply electrolyte of battery.

② Tips for equalized charging
If once push the equalized charging button on the monitor in the beginning of charging, the equalized charging lamp becomes on and starts charging.

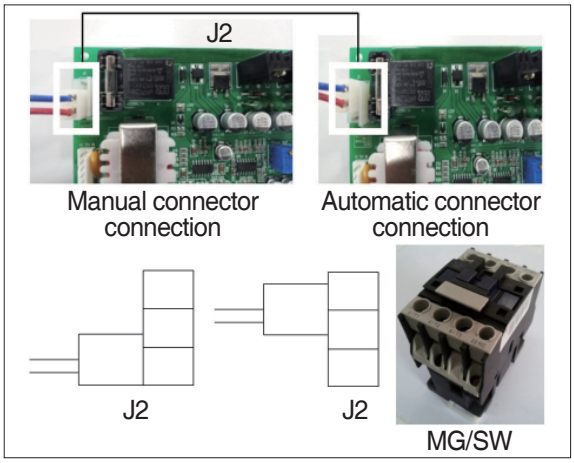
※ **When the green charging condition lamp is on (over 85% charged), the equalized charging switch is locked that it does not operate even pushing the button.**



(3) Automatic/Manual switching method
Automatic connector. Manual switching connector (J2) is located on a left top corner of PCB.

※ **In case of manual switching for charger checking, make sure that the battery connector is separated beforehand.**

⊙ MG/SW operation
(Refer to the charger trouble SHEET components manual)



(4) Checking charging voltage soft start function (Refer to the monitor)

① Plug it into a manual connector and input after 5 sec., a floating charge, charging status red LED lights up.
② After 15 sec., charging status yellow LED lights up.
③ After a green LED lights up, if measured voltage comes out as Iulua63V ~ Iula64V by measuring output voltage of battery connector side with multi-meter, then it is normal.
④ After 30 sec. of switching to a manual connector, if a buzzer sound rings continuously for 10 sec. and completion LED lights up, then it is normal.
⑤ If you confirm that the charger operates in normal after checking manual switching of the charger, make sure that the charger is switched to automatic.

⑥ If charger's out voltage is under 60 V, it is abnormal.
Please refer to the error sheet.

⑦ When the charging voltage is indicated as normal condition (64 V), convert automatic / manual switch to automatic and start charging.

※ Display error code on the front cover as following table.

No	Code	Description of error
1	E.F	EPROM fail
2	O.V	Over voltage - Refer to page 7-86
3	O.C	Over current - Refer to page 7-85, 7-87.
4	F.B	Battery error (After starting charging, the voltage doesn't go over 52V for 2 hours.) Check the battery.
5	O.T	Transformer over heat (Stop charging when it is over 160°C). - If input voltage is high, output current is over normal value and there is heat in the trans because of SCR control part fault. - Check the output current and PCB control board
6	O.H	Heatsink over heat (Stop charging when it is over 100°C). - Check the cooling fan, SCR connection cable contact point and control part.
7	A.O	Power supply error (input power 220/380V wrong wiring). - Refer to page 7-84.
8	A.F	Power supply error (absent phase) - Check if input cable is open.
9	A.C	AC fail (black out) - Check if input voltage is right.
10	L.C	Low current (If this sign is on for setting value (60 sec), charging is over).
11	F	Manual stop.

4) CHECK POINTS BEFORE APPLYING A/S

(1) AC input power source switch is input.

(2) Check if the battery connector of the order picker truck and charger's connector are connected.

(3) Check points when "Error" lamp is on in the front monitor of the charger.

(4) Check the front cover indicator.

① A.F : Input three phase power source continuity check = Check if input three phase power source is normal with AC voltage meter.

② A.O : Error on selection of input power source of 220V or 380V - Check it appropriately with full three phases.

③ A.C : Check if the input power source (220V or 380V) is normal.

④ O.C : Check the electric current, as charging current of the battery is over-standards condition.

⑤ O.V : Check the voltage, as charging voltage of the battery is over-voltage condition (66V).
Normally it is 64V±1.0V.

(5) Check other abnormalities as well. Then apply for A/S when on-site measurements are not applicable.

Error indication

5) ERROR DETECTION

(1) Error list

① Only floating charge lamp is on in the monitor but it is not charged.
② ON and OFF is repeated with a few minutes intervals even after starting charging.
③ Charger TRIP is occurred after abnormality lamp is on. In case error code is "O.V"
④ Charger TRIP is occurred after abnormality lamp is on. In case error code is "O.C"
⑤ Charger TRIP is occurred after it started charging and charging completion lamp is on.
⑥ Charger has no response even the battery connector is connected.
⑦ SCR module checking method

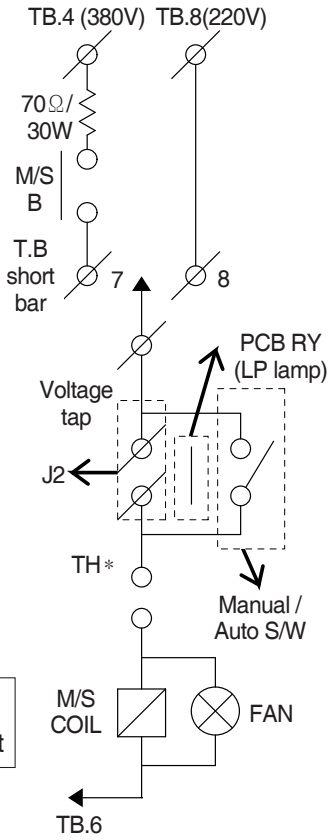
(2) Troubleshooting

① Only floating charge lamp is on after indicating "A.O", It's not charged.

· 220/380V Model : Measure the voltage between input voltage change over tabs 2-4 2-6 4-6
· 220,380,410,440V Model : Measure the voltage in front of AC INPUT MS S/W

MS electric socket

Manual/Auto TAP (J2)



M/S electrical circuit

Check the rated voltage → YES → Insert automatic/ manual connector (J2) at the upper part of PCB to manual, after separating battery connector.

AC INPUT MS switch ON → YES → PCB LP lamp lights up → YES → CN4 contact fault / PCB RY contact fault

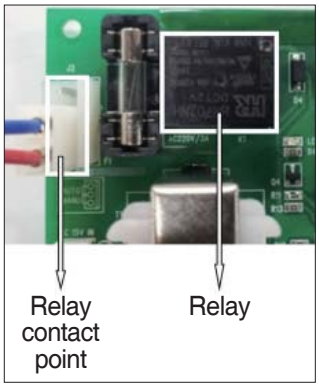
AC INPUT MS switch ON → NO → Put a black lead of multi-tester to input voltage switch No. 6 and measure voltage between tab No.8,PCB CN4,TH contact points with a red lead.

PCB LP lamp lights up → NO → Change PCB

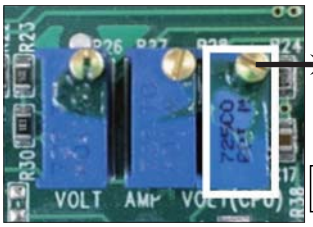
Check the rated voltage → NO → Input power supply is not supplied.
· Check external lead cable.
· Check the connection of external input connecter
· Check external NFB TRIP

Put a black lead of multi-tester to input voltage switch No. 6 and measure voltage between tab No.8,PCB CN4,TH contact points with a red lead. → Voltage 220V → NO → TH contact fault / CN4 contact fault / PCB RELAY fault / TH manual restoration release

Voltage 220V → YES → MS COIL fault



② ON and OFF is repeated with a few minutes intervals after starting charging.
Indicate "O.C" on the monitor.
- TH is operated (AC input over-current TRIP).



OUTPUT CURRENT

DE-CREASE

IN-CREASE

Trans noise is severe at MS ON status

NO

Measure output current using DC current measure

Current value : 10~16A /100AH

NO

Exceed Standard current

Adjust output current AMP, VR within PCB Re-adjust to VR

YES

· TH Setting fault
· Re-adjust TH setting value

TH. TRIP

YES

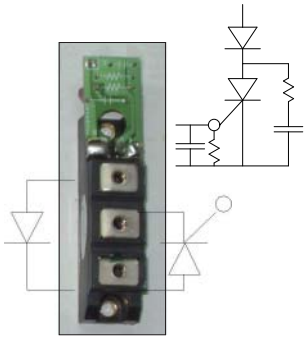
Change TH

NO

Complete

YES

* Refer to SCR Module checking method



Rated Current SETTING

YES

NO

Complete

Change PCB

Separate the battery connector and tune the charger off

Check SCR Module

NO

Change SCR MODULE

YES

Check MAIN TRANS VOLT

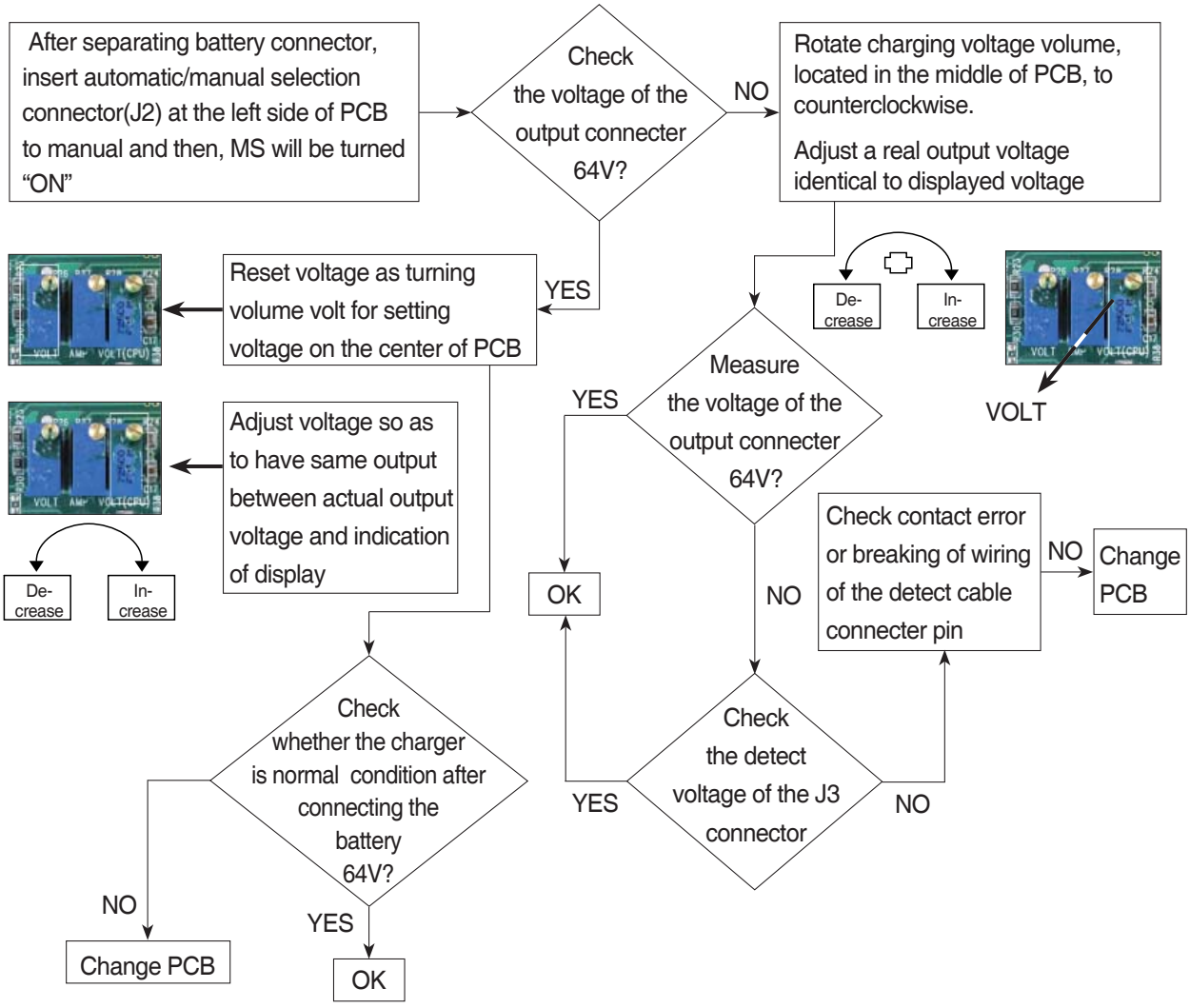
NO

Change PCB

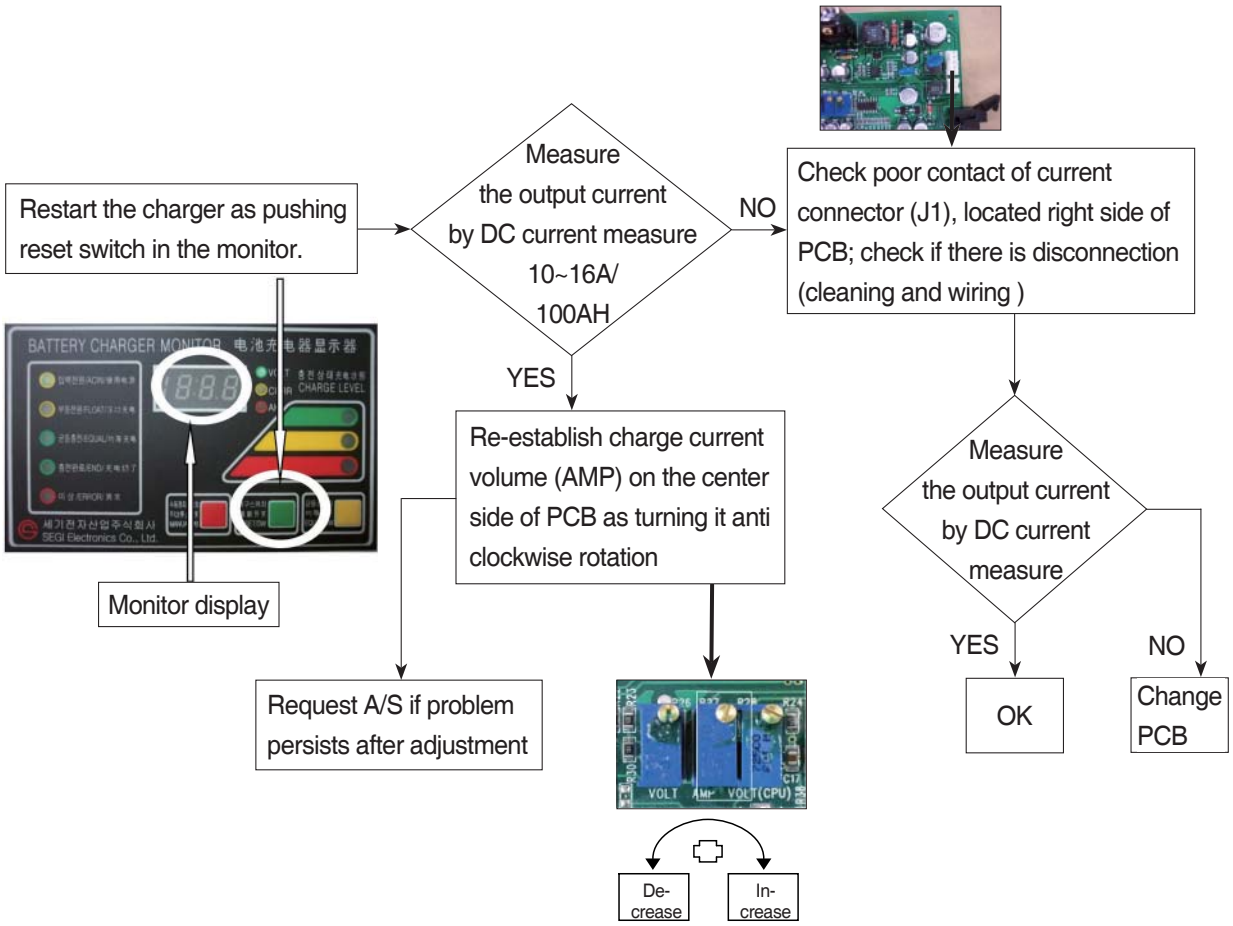
YES

Check the normal operating condition of the charger

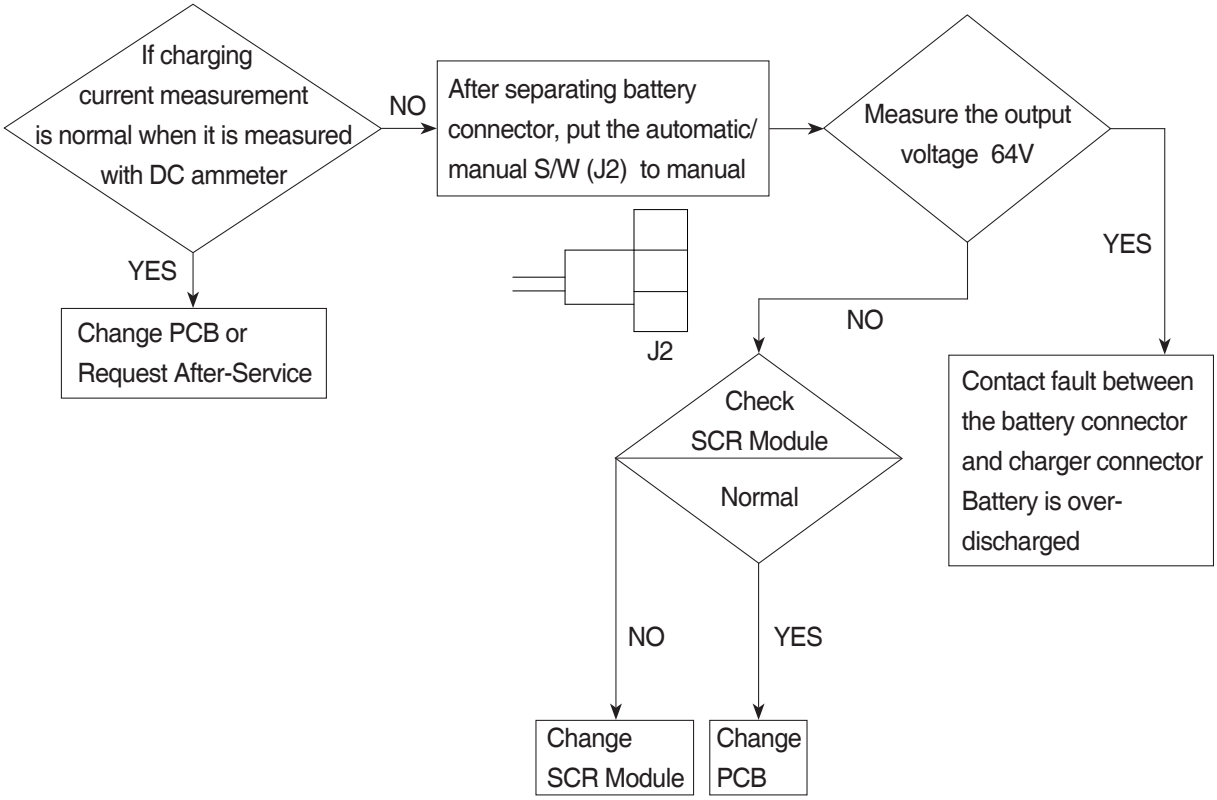
③ Charger TRIP is occurred after abnormality lamp is on.
In case error code is "O.V" → Over-voltage output / Set at 66V (In case of BATT 48V)
34V (In case of BATT 24V)
108V (In case of BATT 80V)



④ Charger TRIP is occurred after abnormality lamp is on.
After opening the cover which is located on the front bottom side of the charger.
In case error code is "O.C" → Output over current, established as 110~120% of the rated current.

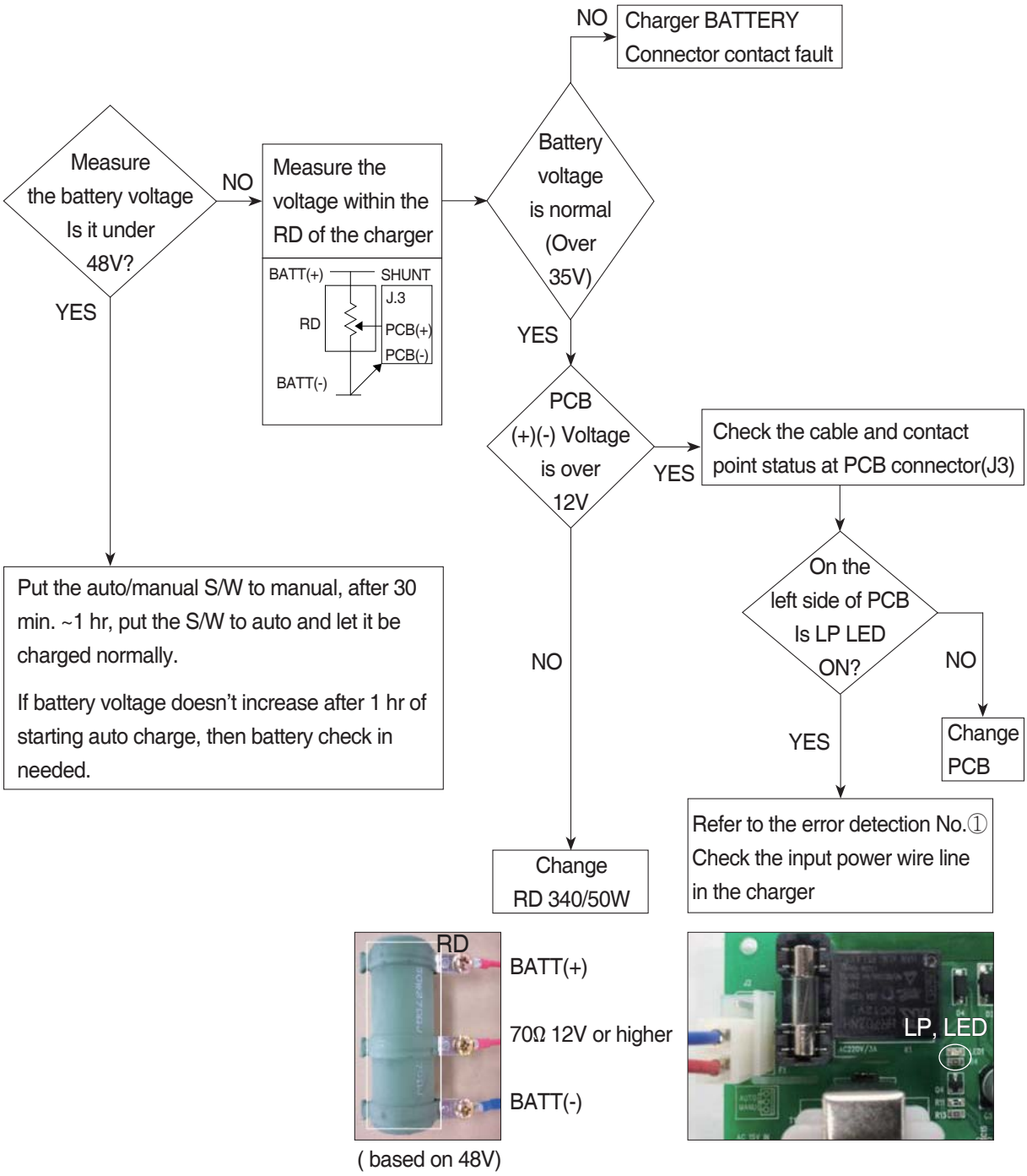


⑤ Charger TRIP is occurred after it started charging and charging completion lamp is on.
(In case input voltage is normal - Refer to the error detection No. 1)
Restore the charger as pushing reset switch.



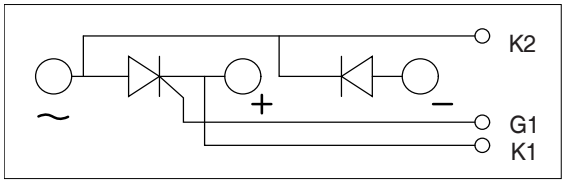
⑥ Charger has no response even if the battery connector is connected.

- In case only floating LED is on, charger input power is cut off or doesn't connect. (In case the input voltage is normal - Refer to the error detection No. ①)

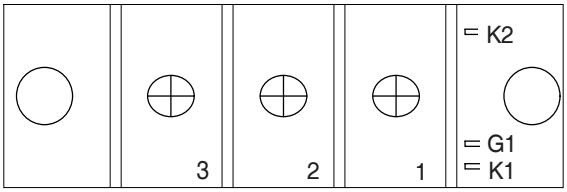


7) HOW TO CHECK THE SCR MODULE

Circuit

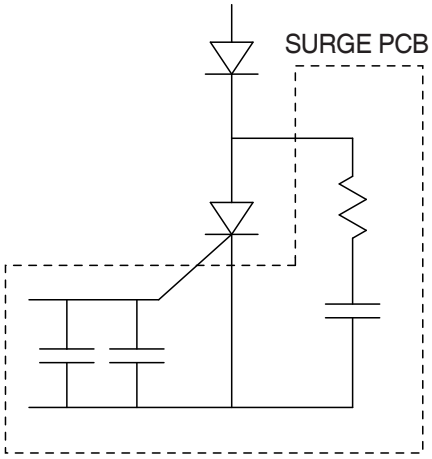


Real diagram

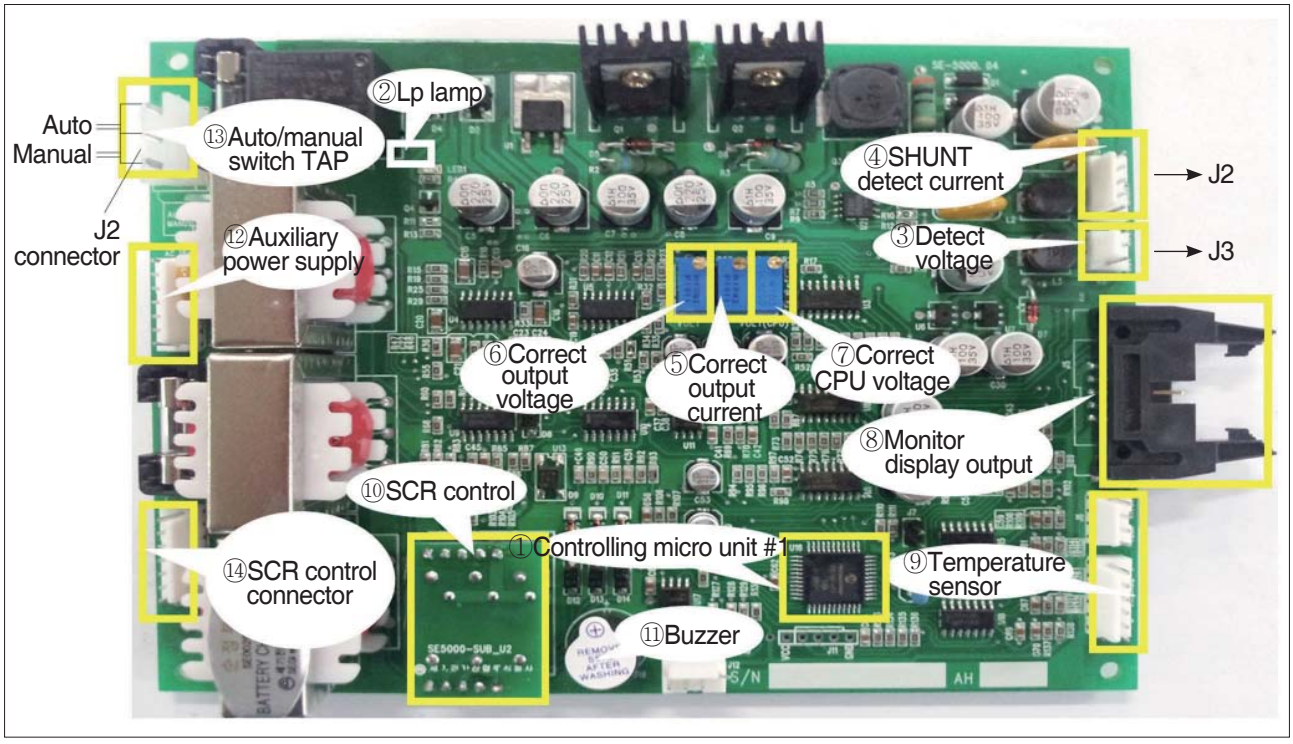


* Before checking SCR MODULE, be sure to disconnect bus bar and wire on the terminal.

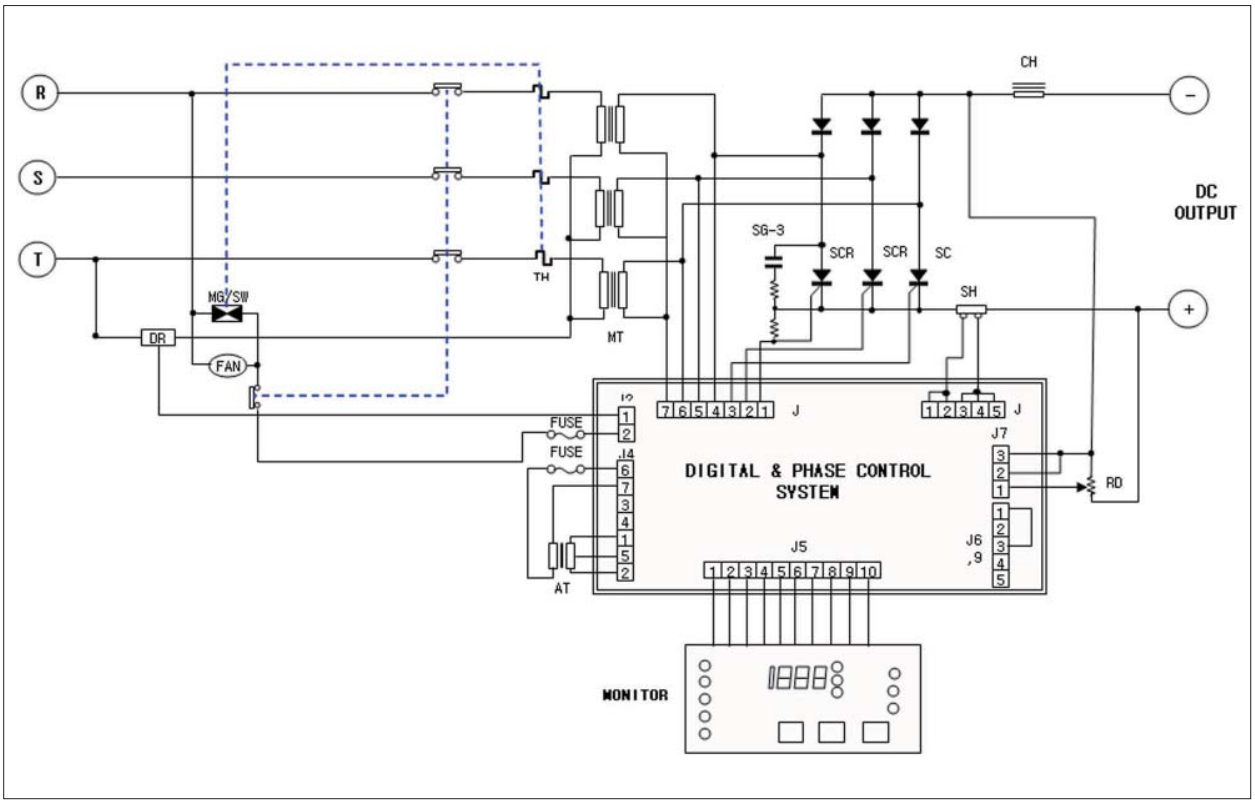
No.	Measuring point (Real diagram)	Measure value (Measurement of digital tester)
1	No.1 ~ No.3	Forward : Under 100 k ohm Reverse : Infinity (∞)
2	No.2 ~ No.3	Forward : Infinity (∞) Reverse : Infinity (∞)
3	G1 ~ K1	Forward : Under 100 ohm Reverse : Under 100 ohm But It depends on the module. If it is not 0 ohm, It is Ok.
4	G1 ~ K2	Forward : Infinity (∞) Reverse : Infinity (∞)



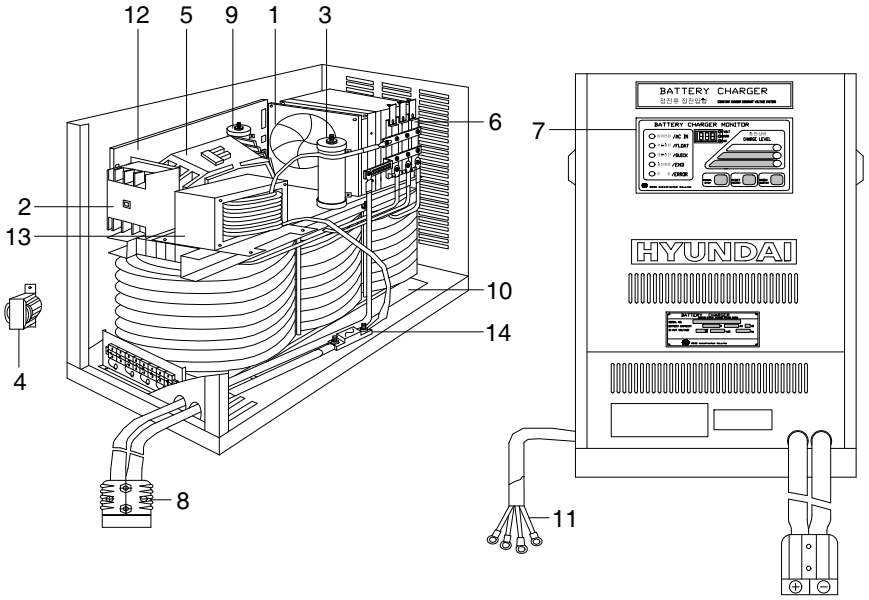
8) PCB MAJOR PARTS (NAME AND LOCATION)



1	Controlling MICOM #1	6	Correct output voltage	11	Buzzer
2	Lp lamp	7	Correct CPU voltage	12	Auxiliary power supply
3	Detect voltage	8	Monitor display output	13	Auto/manual switch TAP
4	SHUNT detect current	9	Temperature sensor	14	SCR control connector
5	Correct output current	10	SCR control		


R
S
T
MG/SW
DR
FAN
TH
MT
CH
SG-3
SCR
SCR
SC
SH
DC
OUTPUT
FUSE
FUSE
AT
DIGITAL & PHASE CONTROL
SYSTEM
J
J7
RD
J5
J6
MONITOR

CHARGER INTERIOR PARTS



1	AC fan	6	SCR module	11	AC input cable
2	Over load	7	Monitor board assy	12	Main board assy
3	Resistor assy - RD	8	DC output cable	13	Choke filter
4	Auxiliary trans	9	DR resistor	14	Fuse
5	Magnet switch	10	Main transformer		

※ LITHIUM ION BATTERY (OPTION)

1) Characteristics and Information

(1) This Lithium-Ion battery is a designed for the power supply of electric forklifts.

(2) It can be used on the charger or forklift when the battery pack is active.

(3) For recharging batteries, proper management may have a long useful life, but not in use for long periods of time may reduce capacity.

(4) Do not expose the battery to extremely high or low temperatures above 55°C and below -25°C. Use within -25 ~ 55°C to maintain maximum capacity.

(5) When the battery is used at low temperatures, the battery capacity is reduced.

(6) Battery charger is used at temperatures between 0 and 45°C.

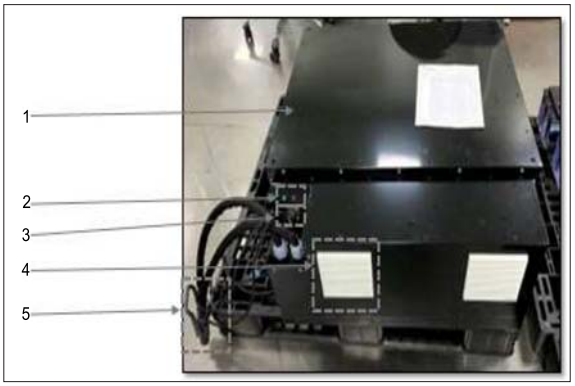
(7) Battery Management System(BMS) within the battery pack maintains a constant voltage difference between cell voltages and safely controls current and voltage.

(8) If the temperature rises above 60°C, the charging/discharge function will automatically stop.

(9) When Battery pack voltage falls below 37.8v, the protection function is activated and automatically shuts down the discharge.

※ The explanation of lithium batteries described in this manual, read carefully and understand . Refer to this manual at all times properly.

※ If you have any questions or technical problems, contact HYUNDAI dealer.

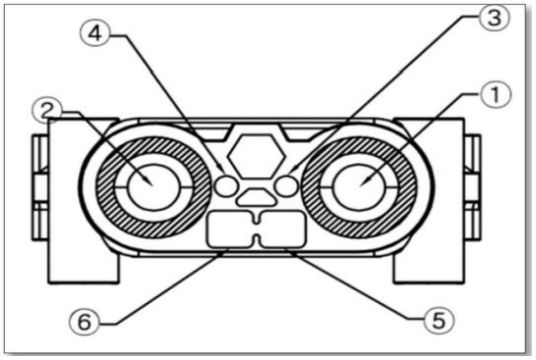


① Battery pack ② Status indicator
③ Monitoring connector ④ Cooling fan
⑤ Battery pack connector

COLOR	FUNCTION	OFF	FLICKERING	ON
GREEN	CHARGING/ DISCHARGING STATUS	STANDBY	CHARGING	DISCHARGING
RED	BATTERY STATUS	NORMAL	CAUTION	PROTECTION MODE

* Meaning of status indicator *

PIN No	Pin Name
1	Battery +
2	Battery -
3	CAN H
4	CAN L
5	Wake-Up
6	Wake-Up



* Structure & function
of battery pack connector*

2) Lithium Ion Battery Safety Matters

※ Proper handling and inspection are required for safe use of lithium-ion batteries.

※ Follow the instrustions to avoid accident. The explanations are in threee steps as below.

◈ Danger, ◆ Warning, ◇ Caution. Read the contents carefully and check the risk factors to prevent safety accidents.

(1) Electric shock caused by contact with conducting agent (◈ Danger - Electric shock)

① The lithium battery pack has high voltage, so if the body contacts the conducting agent during installation, repair, and inspection, it will be electrocuted.

② Maintenance and inspection shall be carried out by qualified professional personnel.

③ Wear protective gear such as rubber gloves and rubber boots for inspection and use insulated tools.

(2) Damage caused by organic solvent electrolyte (◈ Danger - electrolyte)

① Damages or incorrect use of the battery pack may result in excessive pressure in the internal cells.

② Each cell in the battery pack has a Vent that can't be reset. When the increases pressure of the battery cell, it is dangerous as the Vent may release flammable electrolytes.

③ Avoid smoking and stay away from sources of ignition, such as sparks.

④ Do not incinerate the battery pack. Do not drill or shock.

⑤ Do not solder or weld the battery pack..

(3) Safe handling of lithium battery packs (◈ Danger - Explosion, Electric shock)

① Do not throw the cell into fire. Do not heat the cell. It causes leakage, fever and rupture.

② If the battery smells strange, temperature is high, connection with the wire is damaged, terminals of the part are corroded, plug is deformed and finds trace of heating, Do not use it as it is due to may cause ignition, heat and flammable explosions. Ask your dealer or specialist for diagnosis.

③ Do not attach contaminants and foreign substances to the surface and connections of the battery. It may cause explosions and fires.

④ Clean contaminants and foreign substances with a wet cloth and keep them dry.

⑤ Be careful not to touch the battery by children.

⑥ The battery packs that has been in use for a long time are exchanged with new battery packs according to inspection result. If the exchange is delayed, internal aging can cause the explosion.

⑦ Do not arbitrarily disassemble or repair battery packs. It causes fever and ignition.

⑧ Do not overcharge or discharge when charging.

⑨ Do not allow lithium battery pack temperature to exceed 55℃.

⑩ Keep the lithium battery pack surface clean and dry always.

(4) Precautions prior to commencement of use (◆ Warning - Unpackage, Check / ◇ Caution - Installation, Connection)

① Check that the battery is free from leakage, heat, etc. when receiving. This will result in corrosion, fire and short circuit.

② Check the plug, cable for damage. This causes the fire.

③ Ensure that the actual battery type matches the specified battery in the forklift.
If the unsuitable battery is used, it can cause poor performance or damage to the truck during operation.

④ The battery pack is shipped with a charge of 30% to 50%, so charge it fully before use.

⑤ Do not install or connect except for professional technicians who have been sufficiently trained in handling methods and risks.

⑥ Please contact your dealer for battery module replacement. Incorrect replacement operation may cause battery damage.

⑦ Do not reverse or drop the battery pack.

⑸ **Maintenance (◆ Warning - Discharge, Charge)**

① Do not use the battery current that exceeds twice the rated capacity.
The battery Internal damage caused by abnormal use may cause an explosion.

② Charge the battery pack with a charger dedicated to the lithium-ion battery. If use different type charger will not charge enough, Battery may leak, short circuit.

③ Make sure that the lithium battery pack temperature is not above 55℃during charging. A rise in temperature causes fire and explosion. Take extra care when charging during the summer and under the direct sunlight.

④ Do not change the maximum voltage of the charger without consulting the battery manufacturer. An excessive high input voltage will overcharge the battery, increasing the temperature and shortening battery life.

⑤ Don't charge in areas with poor ventilation, high temperature and high humidity, rainy areas, and corrosive gases.

⑥ Do not use firearm (lighter, cigarette, grinder, welding flame, etc.) during charging. It causes an explosion.

⑦ Do not overcharge. The battery can overheat. It can be dangerous and shorten its life.

⑧ Keep the battery below 55℃. It will shorten the life cycle when used at high temperatures. If the battery exceeds 55℃ during charging, the charge must be stopped.

⑨ Make sure that there is sufficient ventilation when charging indoors. Even if Battery is stored indoors, enough ventilation is needed.

⑩ Do not charge the battery below -25℃. Because it can be increased battery internal resistance at low temperature. Low temperature will reduce the efficiency of the charge and require adjustment of the charge volume. Therefore, a charging room with a temperature of 5 to 10℃ required at low temperatures.

⑹ **Environment of use (◇ Caution - Cleaning, ◆ Warning - Organic solvent)**

① Contaminants and debris on the top or connections of the battery may cause a short circuit and fire. Clean with a wet cloth and keep the area clean and dry.

② Do not use organic solvents or chemicals such as benzene, thinner and gasoline for battery cleaning. It may cause damage to the battery.

③ Do not flush the battery. It may causes damage.

④ If it is not used for a long time, keep it in a well ventilated and fire-free place to prevent explosion.

⑤ To prevent deformation and damage caused by freezing and overheating, the recommended use temperature is -25 ~ 55℃. Avoid contact with rainwater or sea water to prevent damage and fire.

(7) **Handling method (◈ Danger - Explosion, ◇ Caution - Others)**

① Turn off both key switch and charger switch when unplugging. When the key is removed from the ON state, sparks are generated and cause fire and explosion.

② Check + and - thoroughly when connecting cables. Causes damage to electronic parts. If cables and plugs are open due to corrosion or heat, contact your HYUNDAI dealer to replace them.

③ Do not modify the plug or connector arbitrarily. It may cause heat and explosion.

④ When connecting the plug, make sure it is in full contact and remove any foreign substances to prevent heating.

⑤ To prevent short circuit, do not place tools, such as spanners, on top of the battery.
Secure cables and battery terminals properly to prevent short circuit and performance degradation.

⑥ Do not use it for purposes other than forklift power sources. It may cause damage to the battery.

⑦ Do not spray water in case of fire. It may cause an explosion. Use a special powder fire extinguisher.

⑧ Follow the battery manufacturer's instructions on how to dispose of the battery at the end of its life.

3) Battery pack replacement

※ This guide explains how to repair when a problem occurs for lithium battery pack.

① Before replacing, read this instruction carefully .

② Use insulated tools and suitable clothing.

③ Before replacing the parts, remove the main plugs.

④ Check whether the contactor is disconnected. (Measured Voltage : 0V)

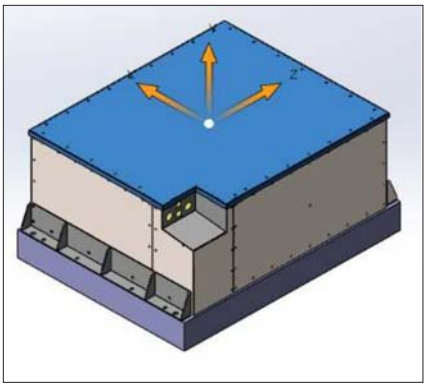
⑤ Electrical shock hazard. Do not touch uninsulated wires when the parts are repaired.

(1) Master BMS & Electronic parts replcement

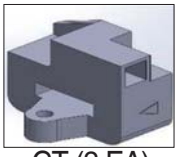
① Remove the cover

- Disassemble the 15 screw on cover.
- Remove the cover.

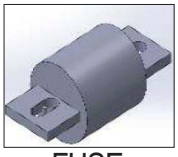
* Tool : Screwdriver



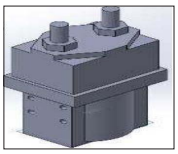
② Check the parts.



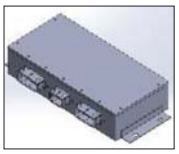
CT (2 EA)



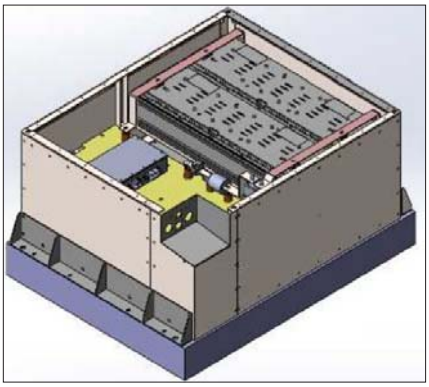
FUSE



CONTACTOR



MASTER BMS



③ CT Replacement

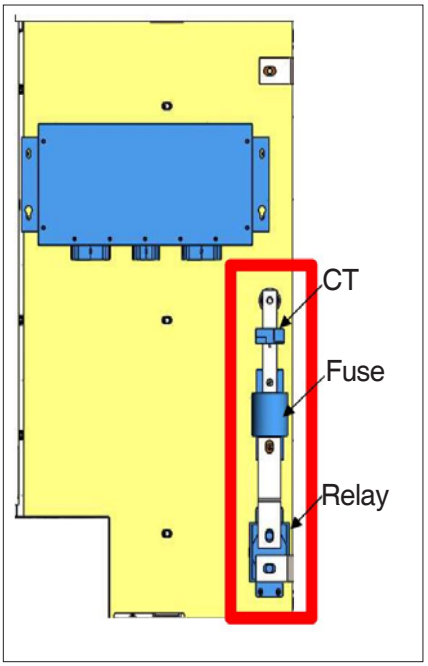
- Disassemble 2 M8 screws.
- Remove the CT.
- Set the new CT.
- Fasten the 2 M8 screws to fit it.

④ Fuse Replacement

- Disassemble M8 screws.
- Remove the Fuse.
- Set the new Fuse.
- Fasten the M8 screws to fit it.

⑤ Relay Replacement

- Disassemble 2 M10 screws.
- Remove the Relay.
- Set the new Relay.
- Fasten the 2 M10 screws to fit it.

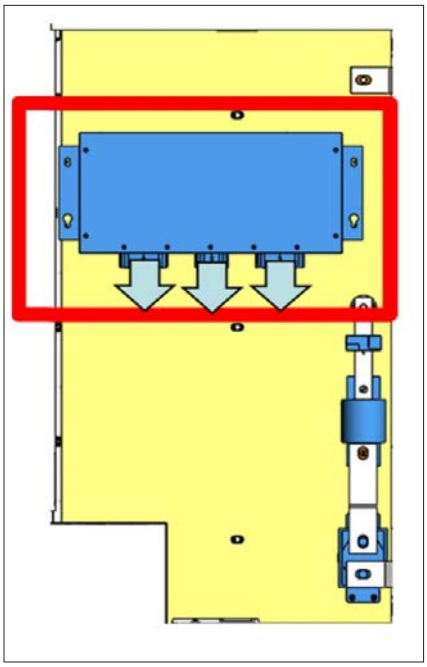


* Tool : Torque wrench 13mm & 17mm. Torque pressure when reassembling - M8 : above 122kgf·cm, M10 : 136 ~ 143kgf·cm.

⑥ Master BMS Replacement

- Disassemble cables that connect the slave BMS.
- Disassemble 4-point screw.
- Remove the Master BMS.
- Set the new Master BMS.
- Fasten the 4-point screw to fit it.

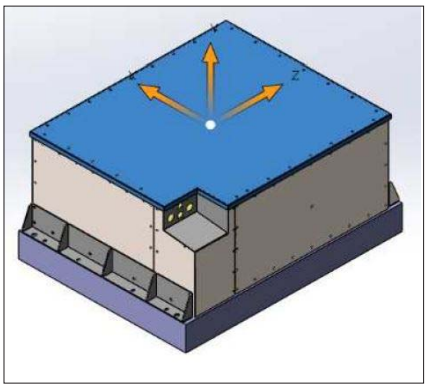
* Tool : Screwdriver. Torque pressure when reassembling
  - M4 : 14kgf·cm.



⑦ Assemble the cover

- Fasten the 15 screws on cover.
- Fit the cover.

* Tool : Screwdriver.

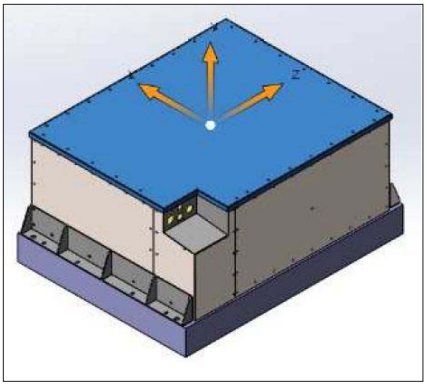


(2) Module & Slave BMS replcement.

① Remove the top cover

- Disassemble the 15 screw on cover.
- Remove the cover.

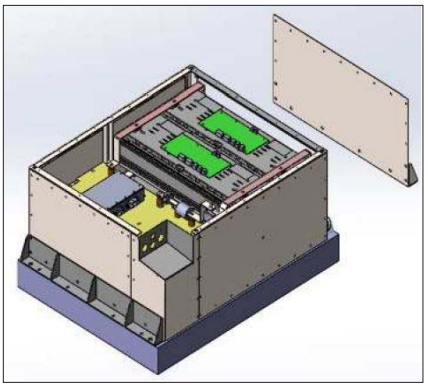
* Tool : Screwdriver



② Remove the right cover

- Disassemble the 18 screw on the right cover.
- Remove the right cover.

  * Tool : Screwdriver

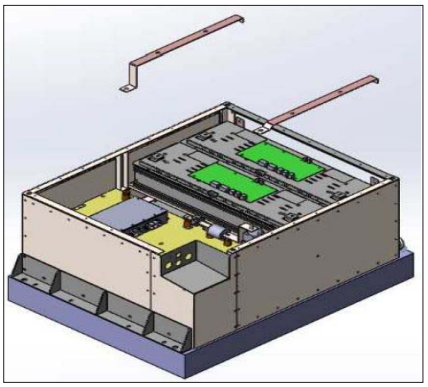


③ Remove +/- bus bars.

- Disassemble the 5 M8 screws & 1 M10 nut on the module.
- Remove the +/- bus bars.

  * Tool : Torque wrench 13mm & 17mm

※ When removing bus-bars, make sure not to touch other component. Electrical shock hazard.

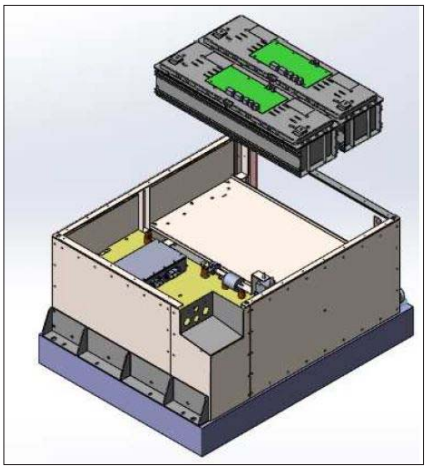


④ Module replacement

- Disassemble 4 screws on the floor.
- Remove the module.
- Set the new module.
- Fasten 4 screws to fit it.

  * Tool : Torque wrench 13mm

※ The entire weight amounts over 38kg by unit. Serious injury may occur due to the heavy weight of the product. Therefore, special care must be taken when handling. Make sure to have at least two people to deliver and remove the package. There is a risk of electric shock. So do not remove the cover.

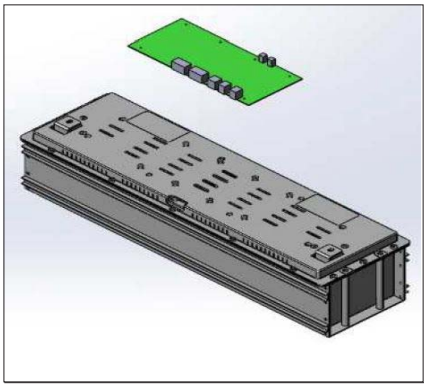


⑤ Slave BMS replacement

- Disassemble sensor cable that connects the lithium cell.
- Disassemble the M3 screws on the module.
- Remove the slave BMS
- Set the new slave BMS
- Fasten the M3 screws to fit it

  * Tool : Screwdriver, Wear rubber gloves.

※ There is a risk of electric shock. So do not remove the cover.

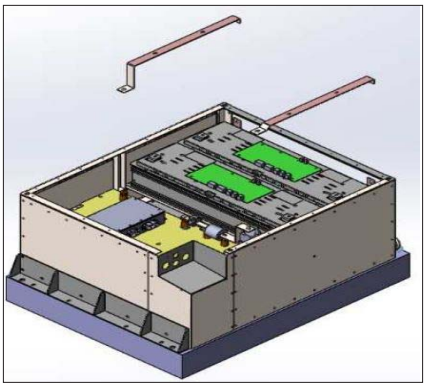


⑥ Assemble +/- bus-bars

- Fasten 5 M8 screws & 1 M10 nut on the module.
- Fit + / - bus-bars.

  * Tool : Torque wrench 13mm & 17m

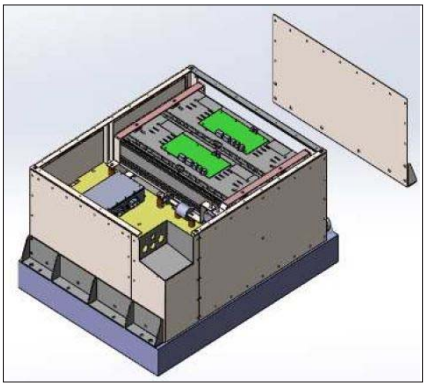
※ **When removing bus-bars, make sure not to touch other component. Electrical shock hazard.**



⑦ Assemble the right cover

- Fasten 18 screws on the right cover.
- Fit the right cover .

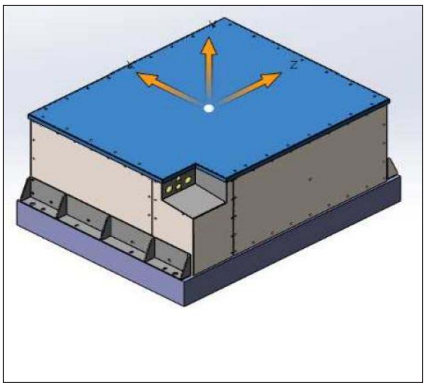
  * Tool : Screwdriver



⑧ Assemble the cover

- Fasten 15 screws on the cover.
- Fit the cover.

  * Tool : Screwdriver



※ LITHIUM ION BATTERY CHARGER (OPTION)

※ Before connecting the battery charger to the power supply and the battery, carefully read the instructions below.

1) Use and Operation

(1) To use this battery charger you must comply with safety requirements contained in laws and regulations and in the provisions set out by the local authorities.

(2) The user should make sure that the use of charging equipment complies with current regulations and that any action that may endanger the life and health of the user or any third party is avoided, as well as avoiding any damage to property.

2) Installation and Safety warnings

(1) Before connecting the battery charger to the power supply and the battery, carefully read the instructions below.

① For correct functioning and improved yield, the battery charger must be positioned on the wall in the correct direction and fixed with plugs through the relative slots; Pay attention not to obstruct the ventilation slots holes.

② Only specialised and authorised staff can carry out jobs that require the battery charger to be opened.

③ Before operating the battery charger, the insulation of mains connection cables and of the battery connectors must be verified

④ It is necessary to intervene on electrical equipment, thoroughly trained personnel only.

⑤ Disconnect the mains connection before connecting or disconnecting the battery.

⑥ The battery being charged generates explosive gases, therefore it is prohibited to smoke in proximity of the machinery; avoid naked flames and or sparks and proximity with other machinery that lead to hazardous circumstances for people or property.

⑦ This battery charger contains electrical components which can generate electric arcs and sparks, so if used in enclosed areas it must be positioned in a site suitable to its function; anyhow the standard battery charger must be used in enclosed and well ventilated areas and not exposed to rain and/or splashing water, placed on sound, levels floors. Dusty areas or areas with water sources, sources of heat and humidity should be particularly avoided. DO NOT place the battery charger on surfaces and/or shelves made with wood or other flammable materials or accumulate various materials near the battery charger and place any items or containers with liquids on the lid.

⑧ To prevent dangers of electrocution, the battery charger must be connected to a current socket connected to earth. Moreover, the current socket to which the battery charger will be connected must be proportionate to the power of the same and must be protected by appropriate electric equipment in compliance with Standards (fuses automatic switch). For sufficient selectivity, the protection must have calibration of at least 10 % over the equipment current absorption.

⑨ Always use special bipolar connectors (DIN 320 REMA).

⑩ DO NOT use additional cables to extend the existing electrical connections.

⑪ The charging appliance is maintenance-free, except for routine cleaning that must be performed regularly and periodically according to the type of work environment. Before starting to clean the appliance, disconnect the power supply cable from the mains and the connection cables to the battery.

3) Connection to power supply

It is essential to connect to a current socket proportioned to the power of the installed battery charger. Ensure to also correctly connect the earth conductor. It is good practice during installation (or successively if the battery charger is moved), to check the mains voltage and the presence of all 3 phases present on the position where the battery charger works.

Battery Voltage	Charger Current	Module Power	Active Input Power	INPUT Iac Nom	FuseAC	DC Fuse
V	A	KW	kW	A	A	Code
48	250	16	15, 32	24, 97	32	LMT315

4) Battery connection

It is recommended to use relevant bi-polar connectors in compliance with Standards without the possibility of inversion of the polarity on the battery. Also check the current connection of the cables in the connector contacts. This operation has to be performed by skilled personnel only.

※ The USB port is a service port to be used only for programming the charging parameters and downloading of historical data and graphs. You must disconnect the charger from USB cable during charging, to prevent EMI noise from interference with the charging process with unpredictable consequences for the battery charger and battery.