CONTENTS

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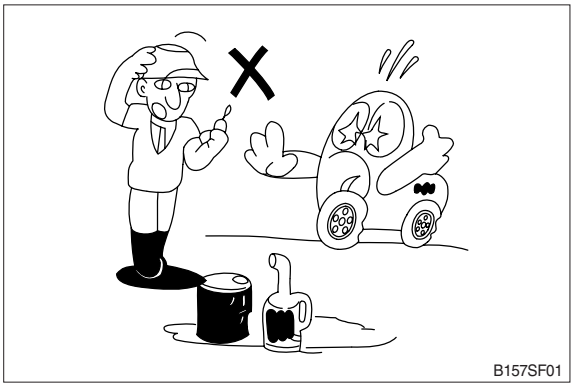
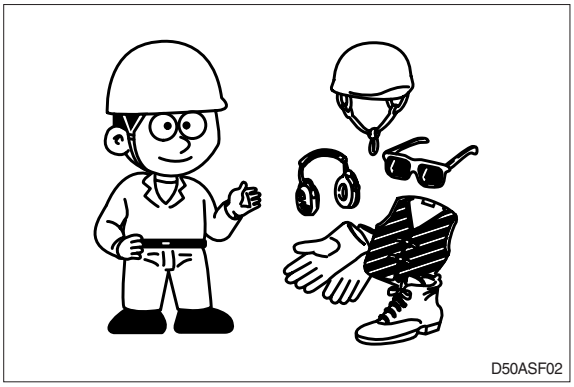
GROUP 1 SAFETY HINTS

Careless performing of the easy work may cause injuries.
Take care to always perform work safely, at least observing the following.

- Oil is a dangerous substance. Never handle oil, grease or oily clothes in places where there is any fire of flame.
  As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire fighting equipment.


B157SF01

- Wear well-fitting helmet, safety shoes and working clothes. When drilling, grinding or hammering, always wear protective goggles.
  Always do up safety clothes properly so that they do not catch on protruding parts of machines. Do not wear oily clothes.
  When checking, always release battery plug.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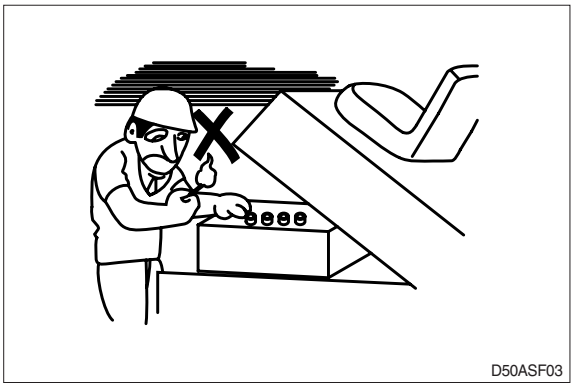
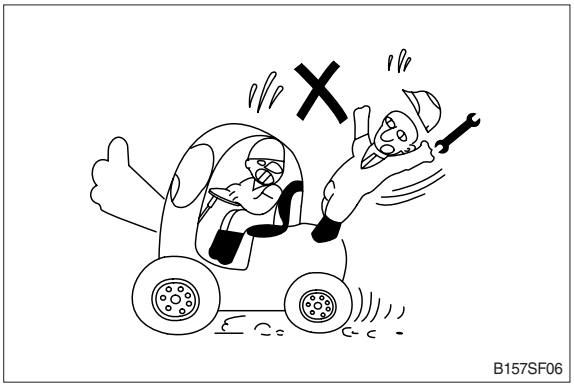

D50ASF03

- When working on top of the machine, be careful not to lose your balance and fall.


B157SF06

5. TORQUE CHART

Use following table for unspecified torque.

1) BOLT AND NUT

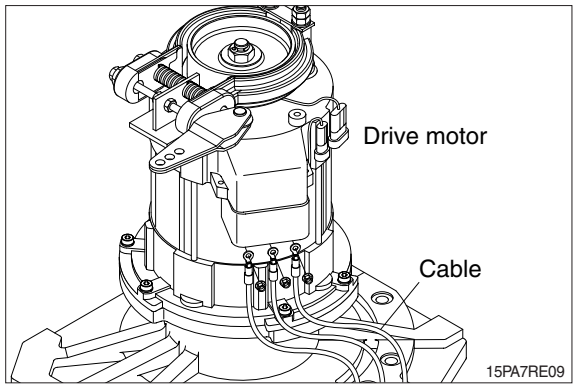
(1) Coarse thread

Bolt size	8T		10T	
	kg · m	lb · ft	kg · m	lb · ft
M 6 × 1.0	0.85 ~ 1.25	6.15 ~ 9.04	1.14 ~ 1.74	8.2 ~ 12.6
M 8 × 1.25	2.0 ~ 3.0	14.5 ~ 21.7	2.7 ~ 4.1	19.5 ~ 29.7
M10 × 1.5	4.0 ~ 6.0	28.9 ~ 43.4	5.5 ~ 8.3	39.8 ~ 60
M12 × 1.75	7.4 ~ 11.2	53.5 ~ 81.0	9.8 ~ 15.8	70.9 ~ 114
M14 × 2.0	12.2 ~ 16.6	88.2 ~ 120	16.7 ~ 22.5	121 ~ 163
M16 × 2.0	18.6 ~ 25.2	135 ~ 182	25.2 ~ 34.2	182 ~ 247
M18 × 2.5	25.8 ~ 35.0	187 ~ 253	35.1 ~ 47.5	254 ~ 344
M20 × 2.5	36.2 ~ 49.0	262 ~ 354	49.2 ~ 66.6	356 ~ 482
M22 × 2.5	48.3 ~ 63.3	349 ~ 458	65.8 ~ 98.0	476 ~ 709
M24 × 3.0	62.5 ~ 84.5	452 ~ 611	85.0 ~ 115	615 ~ 832
M30 × 3.0	124 ~ 168	898 ~ 1214	169 ~ 229	1223 ~ 1656
M36 × 4.0	174 ~ 236	1261 ~ 1704	250 ~ 310	1808 ~ 2242

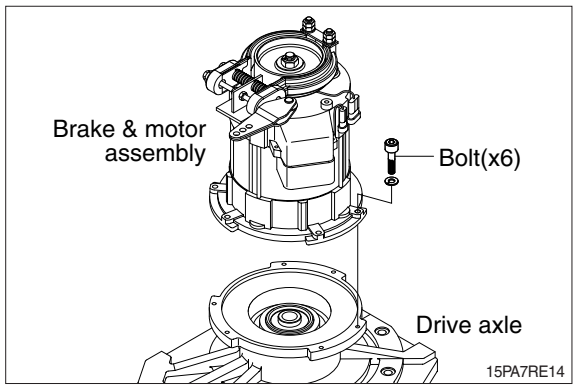
(2) Fine thread

Bolt size	8T		10T	
	kg · m	lb · ft	kg · m	lb · ft
M 8 × 1.0	2.2 ~ 3.4	15.9 ~ 24.6	3.0 ~ 4.4	21.7 ~ 31.8
M10 × 1.2	4.5 ~ 6.7	32.5 ~ 48.5	5.9 ~ 8.9	42.7 ~ 64.4
M12 × 1.25	7.8 ~ 11.6	56.4 ~ 83.9	10.6 ~ 16.0	76.7 ~ 116
M14 × 1.5	13.3 ~ 18.1	96.2 ~ 131	17.9 ~ 24.1	130 ~ 174
M16 × 1.5	19.9 ~ 26.9	144 ~ 195	26.6 ~ 36.0	192 ~ 260
M18 × 1.5	28.6 ~ 43.6	207 ~ 315	38.4 ~ 52.0	278 ~ 376
M20 × 1.5	40.0 ~ 54.0	289 ~ 391	53.4 ~ 72.2	386 ~ 522
M22 × 1.5	52.7 ~ 71.3	381 ~ 516	70.7 ~ 95.7	511 ~ 692
M24 × 2.0	67.9 ~ 91.9	491 ~ 665	90.9 ~ 123	658 ~ 890
M30 × 2.0	137 ~ 185	990 ~ 1339	182 ~ 248	1314 ~ 1796
M36 × 3.0	192 ~ 260	1390 ~ 1880	262 ~ 354	1894 ~ 2562

④ Disconnect cable from drive motor and drive axle.

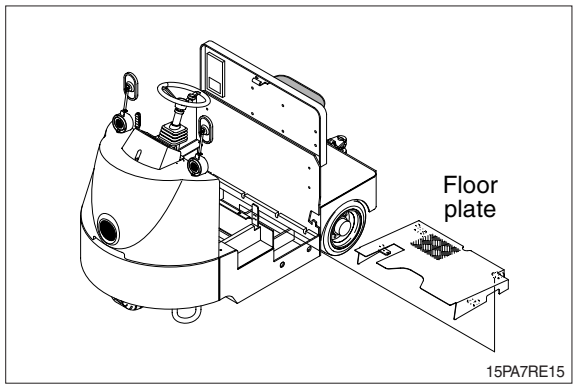


⑤ Remove drive motor and brake assembly by loosening the mounting bolts.

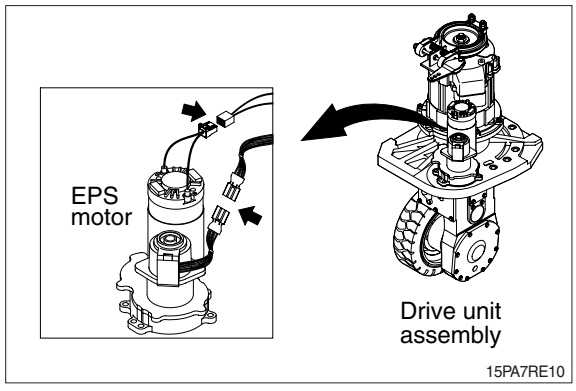


(2) EPS-actuator assembly

① Remove floor plate



② Disconnect cable from power EPS-actuator assy.

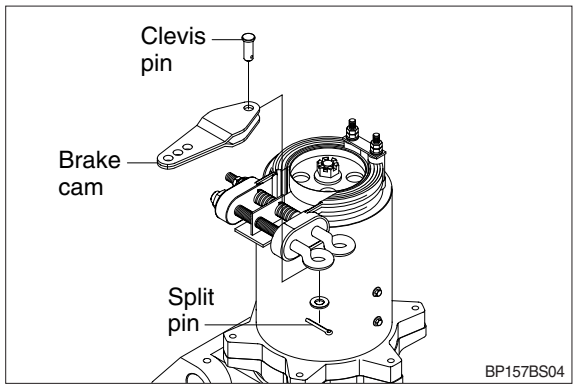


Problem	Probable cause	Remedy
Oil leakage on oil filler or oil drain plug	· Dirt between sealing ring and housing. · Old sealing ring was used. · Bolts not tightened according to the specified tightening torque.	· Cleaning required. · Use new sealing ring · Tighten bolts with the specified tightening torque.
Oil leakage between housing and top section	· Seal faces not sealed or uneven. · Burrs on cylinder pin. · Bolts not tightened according to the specified tightening torque.	· Apply LOCTITE 574 onto seal faces. · Touch up seal faces with oil · rubber. · Use a new cylinder pin. Tighten bolts with the specified tightening torque.
Oil leakage on top section within gear stage / input	· Too much oil in drive unit. · O-ring on cover defective. · Breather valve defective.	· Check oil level. · Install new O-ring. · Replace breather valve.
Beating noise at gear stage	· Teeth on input pinion and/or gear damaged by false installation.	· Check tooth flanks for damage and touch up damaged spots with oil rubber.
Ringing noise	· Gear stage running without oil.	· Check oil level. Refill oil.
Grinding noise	· Bearing preload or backlash not correctly adjusted.	· Checking and new adjustment.
Bearing damage on input pinion	· No axial play.	· Install new bearing and adjust axial play.
Pivoting bearing is difficult to rotate or backlash recognizable	· Cover disc loosened and dirt enter-ed into the bearing. · Cage segments are damaged. · Plastic deformation of balls or ball race. · Bearing not relubricated. · Grease not distributed.	· Replace pivoting bearing. · Replace pivoting bearing. · Replace pivoting bearing. · Relubricate pivoting bearing. · Rotate pivoting bearing several times by hand.

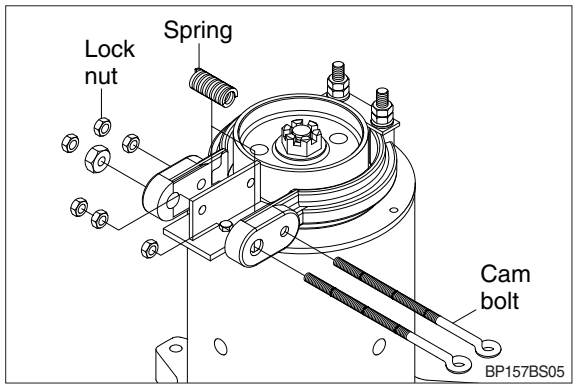
2) DISASSEMBLY AND ASSEMBLY

(1) Disassembly

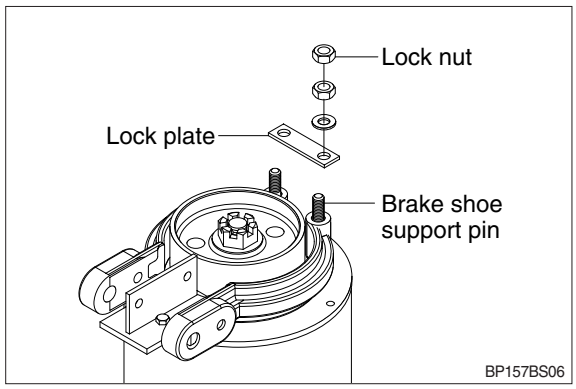
① Remove the brake cam carefully from bolt head.



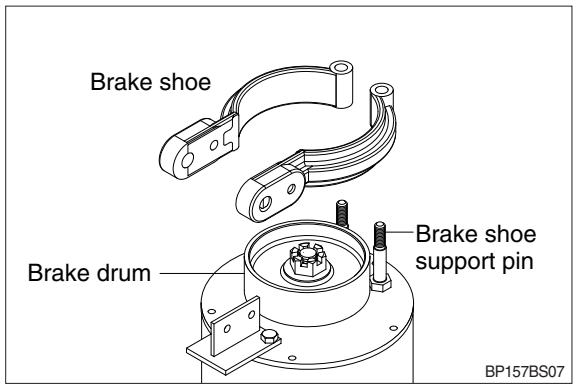
② Remove spring and cam bolts after removing lock nut.



③ Remove lock nut of brake shoe support pin and take off lock plate.



④ Take off brake shoe by lifting up straightly.



2. SPECIFICATIONS AND SERVICE STANDARD

Type		1st stage	Chain
		2st stage	Gear
Steering wheel diameter (mm)		ø 320	
Steering wheel free play (mm)		25~50	
Steering chain slack (mm)		3~5	
Steering angle	Right turn	90°	
	Left turn	90°	
Minimum turning radius (mm)	15PA	2065	
	40TA	1565	

3. TROUBLE SHOOTING

Problem		Cause	Remedy
Heavy steering	At traveling	· Damage of bearing at steering pinion · Damage of bearing of steering shaft of drive unit · Lack of grease of bearing	· Replace bearing · Replace bearing · Lubricate grease
	At releasing joint at spline	· Damage of bearing in steering bracket · Over tension of roller chain	· Replace bearing · Adjust the tension
Steering play is large (STD : 25~50 mm)		· Looseness of roller chain · Extention of roller chain · Looseness of rubber coupling is large · Looseness of spline and joint is large · Backlash of steering pinion and gear is large	· Ajust the tension · Adjust the tension or replace the chain · Replace coupling · Replace · Replace
Steering wheel is robbed in one way during traveling		· Eccentric wear of tire · Transformation of drive unit-rear axle · Transformation of frame	· Replace · Repair or replace · Repair or replace

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(3) Performance and maintenance of batteries

① Initial charge

Dry-charged battery gradually decrease 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
   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 condition 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 in 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.

6) INSPECTION

(1) Rotor assembly inspection


15PASM20

① Rotor should always be cleaned with compressed air.
If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline.

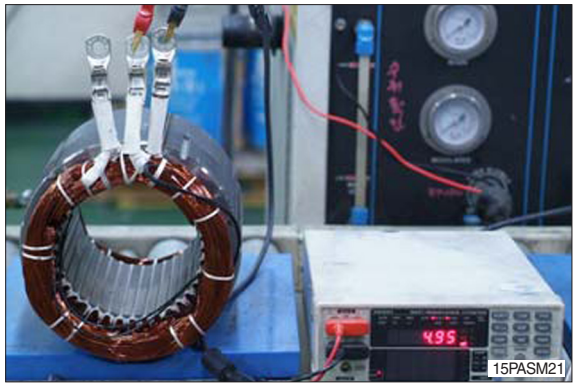
② Rotor out diameter : ø 123.1±0.05

③ Tool : Vernier calipers and standard tool

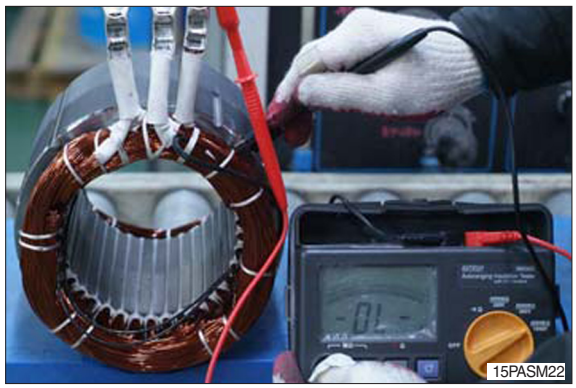
(2) Stator assembly inspection

① Stator should always be cleaned with compressed air.
If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline, using care not to damage the coil insulation.

② Use mmΩ tester and check for two power line of stator repeatedly (U-V, V-W, W-U).
At that time resistance is around 6.85 mmΩ .


15PASM21

③ **Insulation test**
Use insulation tester (1000 Vac, min. 10MΩ) and measure as a picture.
If the insulation is defective, replace with new parts.


15PASM22

(2) High current connections

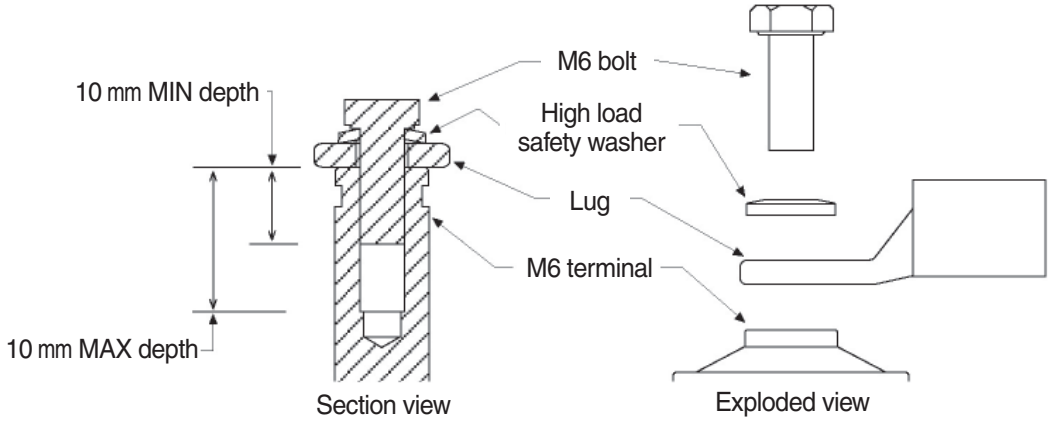
There are five high-current terminals, identified on the controller housing as B+, B-, U, V, and W.

High current connections	
Terminal	Function
B+	Positive battery to controller.
B-	Negative battery to controller.
U	Motor phase U.
V	Motor phase V.
W	Motor phase W.

① Lug assembly

Five aluminum M6 terminals are provided. Lugs should be installed as follows, using M6 bolts sized to provide proper engagement (see diagram):

- Place the lug on top of the aluminum terminal, followed by a high-load safety washer with its convex side on top. The washer should be a SCHNORR 416320, or equivalent.
- If two lugs are used on the same terminal, stack them so the lug carrying the least current is on top.
- Tighten the assembly to 10.2±1.1 Nm (90±10 in-lbs).



15PASM02

② High current wiring recommendations

- Battery cables (B+, B-)

  These two cables should be run close to each other between the controller and the battery. Use high quality copper lugs and observe the recommended torque ratings. For best noise immunity the cables should not run across the center section of the controller. With multiple high current controllers, use a star ground from the battery B- terminal.

- Motor wiring (U, V, W)

  The three phase wires should be close to the same length and bundled together as they run between the controller and the motor. The cable lengths should be kept as short as possible. Use high quality copper lugs and observe the recommended torque ratings. For best noise immunity the motor cables should not run across the center section of the controller. In applications that seek the lowest possible emissions, a shield can be placed around the bundled motor cables and connected to the B- terminal at the controller. Typical installations will readily pass the emissions standards without a shield. Low current signal wires should not be run next to the motor cables. When necessary they should cross the motor cables at a right angle to minimize noise coupling.

CONTROL MODE SELECT		
Parameter	Allowable range	Description
Control mode select	0-2	This parameter determines which control method will be in effect when programming motor response : 0 = Speed mode express 1 = Speed mode 2 = Torque mode Contact to Hyundai if you are interested in a custom control method. Do not change this parameter while the controller is powering the motor. Any time this parameter is changed a parameter change fault (fault code 49) is set and must be cleared by cycling power; this protects the controller and the operator.

⚠We use O (speed mode express) as the default value. Please don't change this setting to the other things.

※ Motor speed constraints

The maximum motor speed is a programmable parameter in each control mode.
Regardless of which control mode is used, the maximum motor speed the controller will allow is constrained by the number of motor poles, the number of encoder pulses per motor revolution, and the maximum speed constraint imposed by the firmware.

Electrical frequency constraint

The maximum electrical frequency the controller will output is 300 Hz.
To determine how fast this constraint will allow your motor to spin, use the equation

Max motor RPM = 36000 / number of motor poles
(e.g., a 6-pole motor can run up to 6000 rpm).

Encoder pulses / revolution constraint

The maximum encoder frequency the controller will accept is 10 kHz.
To determine how fast this constraint will allow your motor to spin, use the equation

Max motor RPM = 600000 / encoder size
(e.g., a motor with a 128-pulse encoder can run up to 4687 rpm).

※ Firmware max speed constraint

The maximum motor speed the controller will allow is 8000 rpm.

The overall maximum motor speed allowed is the least of these three constraints.

MAIN CONTACTOR MENU		
Parameter	Allowable range	Description
Main enable Main_enable OptionBits1 [Bit 0]	ON/OFF ON/OFF	When programmed On, the controller's native software controls the main contactor when the interlock is enabled; when programmed Off, the contactor is controlled by VCL. Note: With Main Enable programmed Off, the controller will not be able to open the main contactor in serious fault conditions and the system will therefore not meet EEC safety requirements.
Pull In voltage Main_pull_in_voltage	0–100 % 0–32767	The main contactor pull-in voltage parameter allows a high initial voltage when the main contactor driver first turns on, to ensure contactor closure. After 1 second, this peak voltage drops to the contactor holding voltage. Note: The Battery Voltage Compensated parameter (below) controls whether the pull-in and holding voltages are battery voltage compensated.
Holding voltage Main_holding_voltage	0–100 % 0–32767	The main contactor holding voltage parameter allows a reduced average voltage to be applied to the contactor coil once it has closed. This parameter must be set high enough to hold the contactor closed under all shock and vibration conditions the vehicle will be subjected to. Note: The Battery Voltage Compensated parameter (below) controls whether the pull-in and holding voltages are battery voltage compensated.
Battery voltage compensated Main_driver_battery_voltage_compensated Main_driver_battery_voltage_compensated_Bit0 [Bit 0]	ON/OFF ON/OFF	This parameter determines whether the main pull-in and holding voltages are battery voltage compensated. When set On, the pull-in and holding voltages are set relative to the set Nominal Voltage (see battery menu, page 6-52). In other words, the output voltage is adjusted to compensate for swings in battery voltage, so the percentage is relative to the set nominal voltage—not to the actual voltage. For example, suppose Nominal Voltage is set to 48V and Holding Voltage is set to 75% (36V) to the output driver. Now suppose the bus voltage dips to 40V. If battery voltage compensated = On, the output will still be 36V (nominal voltage × holding voltage) to the coil. If battery voltage compensated = Off, the output will be 30V (actual voltage × holding voltage) to the coil.
Interlock type Interlock_type	0-2 0-2	Three interlock options are available: 0 = interlock turns on with switch 3. 1 = interlock controlled by VCL functions. 2 = interlock turns on with KSI.
Open delay Open_delay	0-40 sec 0–2500	Applicable only when Interlock type = 0 or 1. The delay can be set to allow the contactor to remain closed for a period of time (the delay) after the interlock switch is opened. The delay is useful for preventing unnecessary cycling of the contactor and for maintaining power to auxiliary functions that may be used for a short time after the interlock switch has opened.
Checks enable Checks_enable OptionBits1 [Bit 2]	ON/OFF ON/OFF	When programmed On, the controller performs ongoing checks to ensure that the main contactor has closed properly each time it is commanded to do so, and that it has not welded closed. These checks (main contactor welded and main contactor did not close) are not performed if this parameter is Off. The main contactor driver, however, is always protected from short circuits.

MONITOR MENU : INPUTS		
Variable	Display range	Description
Emer Rev EMR_state System_Flags1 [Bit 1]	ON/OFF ON/OFF	Emergency reverse input ON or OFF. The source of the emergency reverse input is determined by the EMR type parameter: from switch 1 (pin 24) if EMR type = 0 from VCL function if EMR type = 1.
Analog 1 Analog 1_input	0–10.0 V 0–1023	Voltage at analog 1 (pin 24).
Analog 2 Analog 2_input	0–10.0 V 0–1023	Voltage at analog 2 (pin 8).
Switch 1 Sw_1 Switches [Bit 0]	ON/OFF ON/OFF	Switch 1 ON or OFF (pin 24).
Switch 2 Sw_2 Switches [Bit 1]	ON/OFF ON/OFF	Switch 2 ON or OFF (pin 8).
Switch 3 Sw_3 Switches [Bit 2]	ON/OFF ON/OFF	Switch 3 ON or OFF (pin 9).
Switch 4 Sw_4 Switches [Bit 3]	ON/OFF ON/OFF	Switch 4 ON or OFF (pin 10).
Switch 5 Sw_5 Switches [Bit 4]	ON/OFF ON/OFF	Switch 5 ON or OFF (pin 11).
Switch 6 Sw_6 Switches [Bit 5]	ON/OFF ON/OFF	Switch 6 ON or OFF (pin 12).
Switch 7 Sw_7 Switches [Bit 6]	ON/OFF ON/OFF	Switch 7 ON or OFF (pin 22).
Switch 8 Sw_8 Switches [Bit 7]	ON/OFF ON/OFF	Switch 8 ON or OFF (pin 33).
Driver 1 input Sw_9 Switches [Bit 8]	ON/OFF ON/OFF	Driver 1 input ON or OFF (pin 6).
Driver 2 input Sw_10 Switches [Bit 9]	ON/OFF ON/OFF	Driver 2 input ON or OFF (pin 5).

① Summary of LED display formats

The two LEDs have four different display modes, indicating the type of information they are providing.

Display	Status
Neither LED illuminated	Controller is not powered on; or vehicle has dead battery; or severe damage.
Yellow LED flashing	Controller is operating normally.
Yellow and red LEDs both on solid	Controller is in Flash program mode.
Red LED on solid	Watchdog failure or no software loaded. Cycle KSI to restart, and if necessary load software.
Red LED and yellow LED flashing alternately	Controller has detected a fault. 2-digit code flashed by yellow LED identifies the specific fault; one or two flashes by red LED indicate whether first or second code digit will follow.

(2) Troubleshooting

The troubleshooting chart, following page, provides the following information on all the controller faults:

- Fault code
- Fault name as displayed on the programmer's LCD
- The effect of the fault
- Possible causes of the fault
- Fault set conditions
- Fault clear conditions.

Whenever a fault is encountered and no wiring or vehicle fault can be found, shut off KSI and turn it back on to see if the fault clears. If it does not, shut off KSI and remove the 35-pin connector. Check the connector for corrosion or damage, clean it if necessary, and re-insert it.

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