MDPS
(Motor Driven Power Steering)
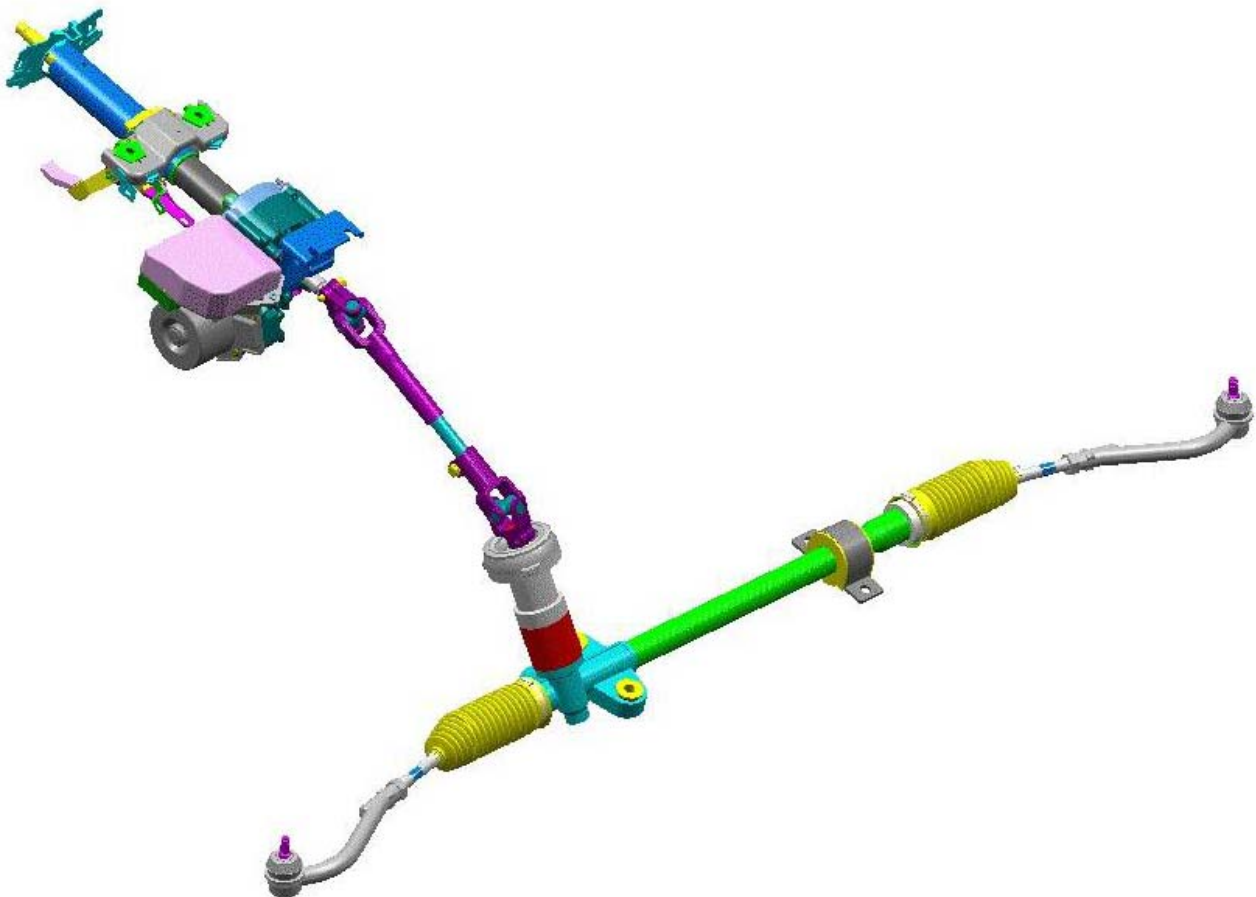
Objectives	To know the system components of MDPS system. To understand the diagnosis method of MDPS system.

The MDPS system for ED vehicle is developed by TRW and supplied by MOBIS. The MDPS system for ED car will be applied as a standard steering system

The MDPS system is second time for KMC. Though, This system is a little bit different with previous system. So, If you understand this manual, you can understand different point between previous sytem and this MDPS system.

1. System introduction

1.1 General

MDPS (Motor Driven Power Steering) has been applied from SA (Picanto) for the first time in KMC vehicle as an optional device for steering system. However, the MDPS system for ED car will be applied as a standard steering system. This means you cannot find any hydraulic type power steering system in the ED car.   As same as in the system for SA, this system is the column assist type as you can see in the right side picture.

The MDPS system for ED has been developed by TRW and it will be mass-produced and supplied by MOBIS.

The overall control system is very similar as one for SA, so it will be focused only for the difference between two models such as initial calibration and CAN communication in this training manual.
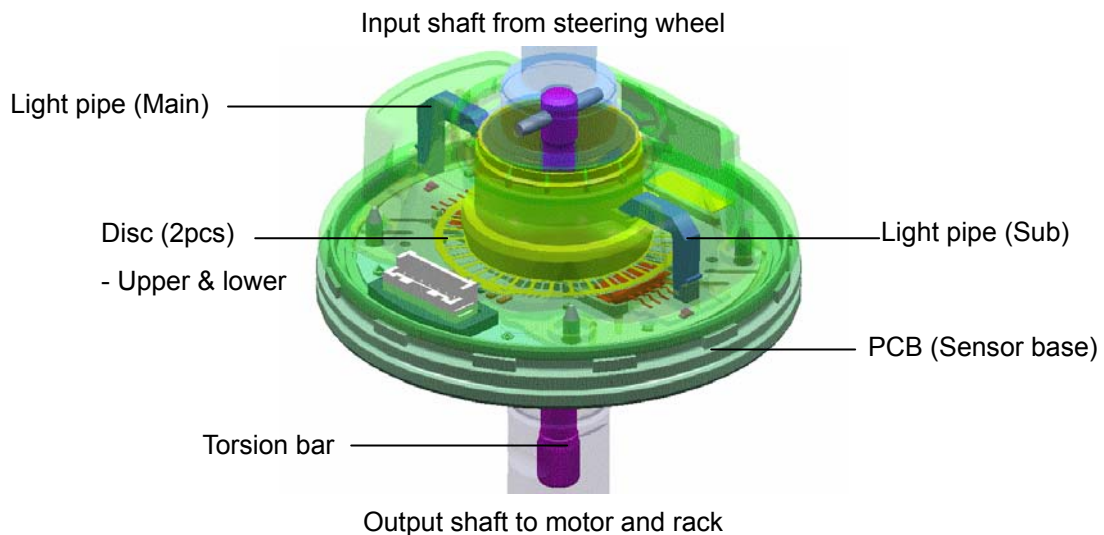
2. Control System

2.1 DTC comparison

	SA	ED
C1101		Battery voltage-high
C1102		Battery voltage-low
C1103		IG 1 voltage fail
C 1259		SAS - electrical malfunction
C1261		ASP is not calibrated
C1290		Torque sensor main signal fail
C1603		Derating (Thermal protection)
C1604		ECU hardware error
C1611		CAN time-out EMS
C1616		CAN bus off
C1617		EMS invalid engine speed
C1621	Vehicle Speed Input Malfunction	
C1622	Engine Speed Input Malfunction	
C1631	Torque Sensor Main Signal-Open/Short	
C1632	Torque Sensor Sub Signal-Open/Short	
C1633	Torque Sensor Signal Mismatch-Main $\&$ Sub	
C1634	Torque Sensor Supply voltage malfunction	
C1641	Motor circuit Short to Battery or Ground	
C1642	Motor current Overflow	
C1643	Motor current Excessive Overflow	
C1645	Motor current Insufficient flow	
C1652	EPS Module(fail safe relay stuck)Malfunction	
C1655	EPS Module(pre-charge circuit) Malfunction	
C1653	System Voltage high	
C1654	System Voltage low	
C1700		Byte coding error
C1702		Variant codign error
C1704		ECU fail-safe relay fail
C1705		ECU pre-charge circuit fail
C2101		Motor relay circuit fail
C2400		Motor fail
C2401		Motor circuit fail
C2412		Motor short or open
C2413		Motor current(Over)

∗ : ASP: Absolute Steering Position (will be explained more detail in the section of 'torque sensor')

2.2 Torque sensor

The torque sensor for MDPS in ED is a completely new encoder type sensor was applied comparing with the previous system for SA.   This sensor has a characteristic as below;

- There are two discs which have the slits and it provides the system with higher resolution.
- Through two light pipes, if the emit diode sends the light to photo diode, the light will pass two discs and the ASIC will calculate the steering angle.
- From the measured angle, MDPS ECM can calculate the torque and the steering direction.
- That is, not only the torque but also the angle can be detected.   Therefore this steering angle data can be shared for ESP system. ED has not SAS for ESP system. (Because MDPS is a standard system)
- It is not allowed to overhaul this torque sensor and also there is no external wiring from the sensor to MDPS ECM. Therefore you cannot measure the output signal for the torque sensor; you can inspect the service data in the scanner only.

Input shaft from steering wheel

Light pipe (Main)

Disc (2pcs)
- Upper & lower

Light pipe (Sub)

PCB (Sensor base)

Torsion bar

Output shaft to motor and rack

- As same as in the previous system, both 'Main' and 'Sub' signals are used to compensate the differences from two sensors and one is failed among two sensors, the other signal will be used for the failsafe.
- Instead of the absolute angle detection, this sensor needs to know the index position in disc. That is why we have to calibrate the neutral position whenever the related parts are replaced with new one. This is called 'ASP' and it means 'Absolute Steering Position'.
- Normally ASP calibration is done at the factory (End Of Line), but it is also necessary at the service shop if you replace the MDPS assembly or MDPS ECM(replacement for ECM only is to be determined after mass-production) or the wheel alignment was adjusted.
- How can we identify this car has been completed to do calibration or not?   If the calibration was never tried, the warning lamp will blink with the period of 1second and the motor will

operate while the engine is running. (in case of engine off and ignition on condition, the motor will assist the steering to help ASP calibration job, but the time is limited by 5 hours for battery save)   In addition, the DTC will be stored (C1261).

- What will happen if the calibration is not done properly?   Even though the ASP calibration is not done properly, for example if the steering wheel position was not neutral but the index point was found successfully while the calibration, the motor will operate depending on the vehicle speed and there is no warning lamp but DTC detected according to the condition (because ASP was done anyway).   But the problem is that the 'on-center' feeling can be poor since the MDPS ECM cannot know the exact index position in order to return back to the neutral position (on-center control).   Actually the car may not run straight ahead. (Vehicle drift problem)

How to calibrate the torque sensor (Very Important)

1) Ignition key ON (engine off) and set the steering wheel on the center (neutral) position.
2) Connect the scanner
3) Enter into the 'ASP calibration' menu on the scanner.

```
      1. KIA VEHICLE DIAGNOSIS    ▼
MODEL  : ED

   01. ENGINE(GASOLINE)
   02. ENGINE(DIESEL)
   03. AUTOMATIC TRANSAXLE
   04. ABS/ESP
   05. SRS-AIRBAG
   06. FULL AUTO AIR/CON.
   07. ELEC.POWER STEERING
   08. BODY CONTROL MODULE
```

```
          1.7. ASP CALIBRATION

*AIM
 THIS FUNCTION RESET THE ABSOLUTE
STEERING POSITION VALVE TO ZERO-
SET.

PERFORM THIS FUNCTION WHEN YOU
REPLACE EPS CONTROL MODULE


IF YOU READY, PRESS[ENTER] KEY.
```

4) Rotate the steering wheel more than ±180°(Left and right) from the center position
   - To detect the location of index point

```
          1.7. ASP CALIBRATION

           ASP CALIBRATION

              TURN STEERING WHEEL
              SLOWLY
  CONDITION   * IG.KEY  : ON
              * ENGINE  : STOP

       IF YOU STOP, PRESS [ESC] KEY!!!
```

- Rotate the steering (left and right) until the screen in the scanner becomes as below.   That is, if the index point is detected, the next procedure will be followed automatically.

```
┌─────────────────────────────────────┐
│         1.7. ASP CALIBRATION         │
├─────────────────────────────────────┤
│ ┌─────────────────────────────────┐ │
│ │          ASP CALIBRATIO         │ │
│ ├────────────┬────────────────────┤ │
│ │            │STRAIGHTEN THE FRONT,│ │
│ │            │AND ARRANGE THE      │ │
│ │ CONDITION  │STEERING WHEEL AT    │ │
│ │            │THE CENTER POSITION  │ │
│ ├────────────┴────────────────────┤ │
│ │          PRESS [ENTER]          │ │
│ └─────────────────────────────────┘ │
│                                      │
└─────────────────────────────────────┘
```

5) Set the wheel on the neutral position (±2°) and press enter key in the scanner.

6) Press the esc key and move to the current data in order to confirm the calibration status.

```
┌──────────────────────────────────┐
│    1.2 CURRENT DATA      14/16    │
├──────────────────────────────────┤
│                                ▲ │
│ MOTOR TEMPERATURE        16   °C │
│ PERCENTAGE OF DERATING   0    %  │
│ VEHICLE SPEED            0.0  Km/h│
│ FILTERED VEHICLE SPEED   0    Km/h│
│ ANGLE SNSR INDX STATUS   DETECT  │
│ ENGINE STATUS            STOPPED │
│ CALIBRATION STATUS       CAL&INDEX│
│ SUPPLY VOLTAGE           12.17V  │
│                                ▼ │
├──────────────────────────────────┤
│ FIX  SCRN  FULL  PART  GRPH  HELP │
└──────────────────────────────────┘
```

'Detect' or 'Not detect':
Every IG off & on, this value will show 'detect' or 'not detect' depending on the steering wheel position. But it will get 'detect' naturally as the steering wheel is rotated more than 180° while driving. ('not detect' does not mean the calibration fault.)

CAL&INDEX: Calibration is OK and Index
                       was found.

7) Finally check the system rotating the steering wheel and also DTC must be checked.   If you have following DTC after ASP calibration, it means that the steering wheel neutral position was *excessively* out of specification (step '1') and you have to try again from the first step.

```
┌──────────────────────────────────┐
│   1.1 DIAGNOSTIC TROUBLE CODES    │
├──────────────────────────────────┤
│ C1259 SAS-ELECTRICAL MALFUNCTION │
│                                   │
│                                   │
│                                   │
│                                   │
│                                   │
│                                   │
│                                   │
│                                   │
│                                   │
├──────────────────────────────────┤
│     NUMBER OF DTC  :  1 ITEMS     │
│ PART  ERAS  FRZE  DTAL      HELP  │
└──────────────────────────────────┘
```

* Once the calibration is done successfully, the memorized data will not be erased even though the vehicle battery is removed.

DTC & Failsafe

For the DTC of torque sensor, there are three related DTC supported.

1) C1259 (Angle sensor fault)

If the calculated angle value by ASIC and MDPS ECM is different each other, this DTC is stored.

Warning lamp ON, Motor OFF

2) C1261 (Steering angle sensor is not calibrated)

If the ASP calibration does not be done, this DTC is stored and ASP has to be calibrated for the recovery.

Warning lamp Blink, Motor ON (Just 'On-Center' control will turn off)
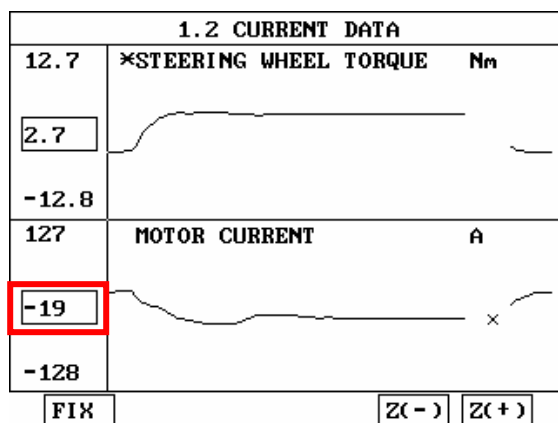
3) C1290 (Torque sensor fault)

If the received data from the sensor is invalid or the disc inside torque sensor is out of position, this DTC is stored and the data value must be normal in next ignition off and on for the recovery.

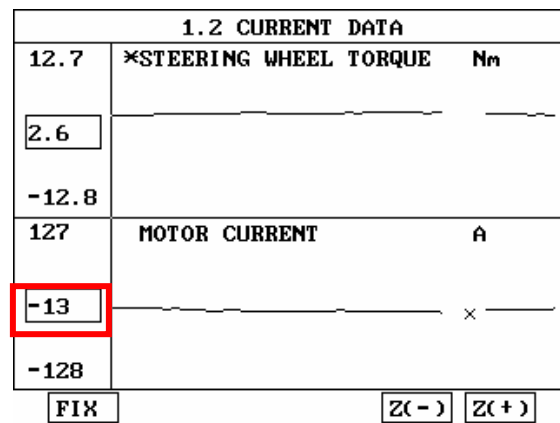Warning lamp ON, Motor OFF

2.3 Vehicle speed signal

Depending on the vehicle speed, the motor current will be controlled for the optimum steering performance.   As the vehicle speed increases, the motor current will be decreases in order to make the steering effort to be reduced.   In case of ED automatic transaxle, there is no external vehicle speed sensor and PG-B signal in A/T is used for the calculation of vehicle speed by TCM in order to upload the data on the CAN bus line.   If the vehicle speed signal is failed,

- Warning lamp OFF, No DTC and Motor ON (Default vehicle speed is 40km/h)

Normal condition   PG-B open circuit
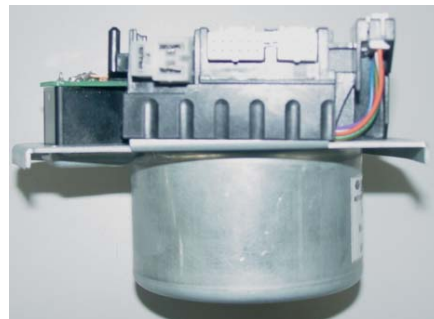
2.4 Engine speed signal

The engine must be started for the MDPS to be operated and this signal is transferred from PCM through CAN.   When the engine is running (vehicle is stationary or driving), if the engine speed signal is failed,

  - Warning lamp ON, No DTC and Motor ON for 30 seconds and turn off for the safety.


```
        1.2 CURRENT DATA        03/16

ANGLE SNSR INDX STATUS   DETECT
ENGINE STATUS            RUNNING ──────→ Stopped / Cranking / Running
CALIBRATION STATUS       CAL&INDEX
SUPPLY VOLTAGE           14.33V
STEERING WHEEL TORQUE    0.2  Nm
STEERING ANGLE SENSOR    -0.1 °
CALCULAT. ANGLE OFFSET   0    °
STEERI. WHEEL VELOCITY   0.0  deg/s

FIX   SCRN  FULL  PART  GRPH  HELP
```

2.5 Motor

To meet the required steering torque for the medium size sedan vehicle, the motor capacity of current has been increased into 75A(Maximum) comparing with the one for SA

  - SA [MANDO]

    Gasoline and Diesel (45A)

  - ED [TRW]

    Gasoline and Diesel (78A) : All models(GSL/DSL) have same motor capacity.

Items	ED
Max. Current	78A
Diameter [D]	Φ86.5mm
Length [L]	55mm
Weight	2kg
Rated torque	58N.m
Motor type	A/C

For shorter motor length and lower motor inertia, the brushless A/C type motor was applied and the D/C to A/C converter is built in motor.   Additionally, the motor position sensor also installed inside motor to know the current rotor position of A/C motor.

TC and Failsafe

For the DTC of torque sensor, there are four related DTC supported.

1) C2400 (Motor fault)

When the measured motor speed and the calculated one is different or

When the measured motor speed and the calculated torque is different.

Warning lamp ON, Motor OFF

2) C2401 (Motor circuit fault)

When the measured value from the motor position sensor inside motor is not valid.

Warning lamp ON, Motor OFF

3) C2412 (Motor short or open)

When the motor phase current is high or low under the specified self-test condition.
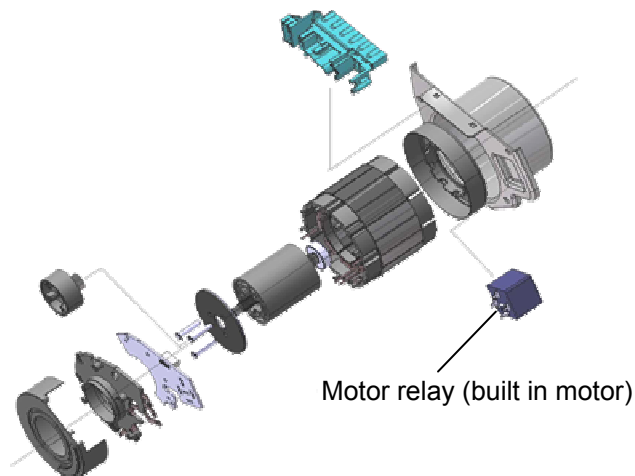
Warning lamp ON, Motor OFF

4) C2413 (Motor current fault)

When the initialization for the motor position sensor is failed.

Warning lamp ON, Motor OFF

2.6 Power supply & Relay

The system power will be monitored by MDPS control module and the specified failsafe function will be activated depending on the detected result.

Motor relay (built in motor)

MDPS Fuse (80A)

For the motor assist in normal condition, ignition ON signal and the engine starting (500rpm or more) signal are required. If the CAN failure is resident in the system, the motor will assist forever under the just ignition on without engine running because the system cannot identify the engine status due to the CAN failure. Under the normal system condition, whenever ignition off after engine stop you can hear the relay off sound after 2~3 seconds. However, if you choose ignition on immediately before the relays are off (before 2~3 seconds from ignition off), the motor assist will

be available even though the engine is not running, because the relays are still on condition.

There are some kinds of diagnostic trouble code for the system power supply failure. However, it will be restored when the system power is restored into battery voltage.

1) C1101 (Battery voltage high)

This failure is detected if the system voltage is higher than 18V for 400ms or more.

Warning lamp OFF, Motor OFF

It will be restored when the system power is lower than 17V for 400ms or more.

2) C1102 (Battery voltage low)

This failure is detected if the system voltage is lower than 9V for 10 seconds or more while the engine speed is higher than 500rpm.

Warning lamp OFF, Motor OFF

It will be restored when the system power is higher than 10V for 10 seconds or more.

3) C1705 (ECM Pre-charge circuit fault)

This failure is detected if the MDPS ECM pre-charge voltage does not drop under the discharging condition. Too much high pre-charge voltage will make the relay contact point damaged.

Warning lamp ON, Motor OFF

4) C2101 (Motor Relay fault)

This failure is detected if the motor relay does not open normally.

Warning lamp ON, Motor OFF

2.7 Ignition signal

IG1 signal is used to detect the engine status (running or not) together with the engine speed signal through CAN. Be sure that this signal is not for the power supply of MDPS system.

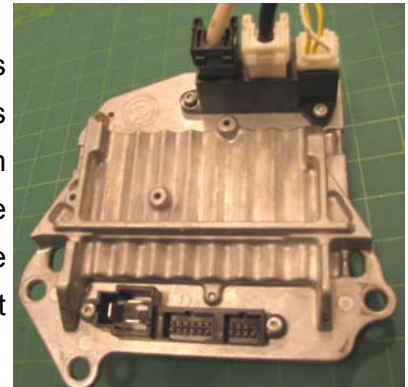1) C1103 (Ignition voltage fault)

- When the vehicle speed through CAN is higher than 3km/h, and ignition off OR

- When the engine speed through CAN is higher than 500rpm for 4 seconds or more after and ignition off OR

- When the CAN communications stop and ignition off.

If the above problem is detected while driving, the motor assist will not stop immediately and the warning lamp is not illuminated until the next power cycle for the safety. Following is the table for the symptom and failsafe depending on the failure situation.

Items	While engine running	Before engine start
Failure	Ignition signal open circuit	
Warning lamp	X	O
Motor Assist (while engine run)	O	X
DTC	C1103	C1103

2.8 MDPS Control module

There are only three external wirings for the input and output signals except the motor.   One is for ignition on signal and other two signals are CAN high and low.   As it is already mentioned, the system power supply for MDPS ECM comes from the motor '+' line and the ignition on signal is not for the power but for the identification of the engine and vehicle status.   MDPS ECM only cannot be replaced but it will be determined after mass production.

Several diagnostic trouble codes are supported for the failure of control module.

1) C1704 (ECM Failsafe relay fault)

   This failure is detected if the ECM link relay does not be closed circuit under the normal condition.

   Warning lamp ON, Motor OFF

2) C1604 (MDPS ECM hardware error)

   MCU functional failure, ASIC communication error, Drive stage FET short or Checksum test fail.

   Warning lamp ON, Motor OFF

3) C1603 (Derating): Overheat protection

   This failure is detected if the internal ECM temperature (not motor temperature) is higher than 85°. Before this DTC is detected (before the temperature reaches 85°), as soon as the steering torque reaches to maximum value, the motor current will decrease by 40% - maximum value can be inspected in the service data of scanner. (78A X 40% = 31A)

   Warning lamp OFF, Motor ON (Derating)

   As the temperature reaches lower than 85°, this will be recovered.

```
        1.2 CURRENT DATA        10/16

  ✳ MOTOR CURRENT           31    A
  ✳ ECU TEMPERATURE SENSOR  31    °C
  ✳ MOTOR TEMPERATURE       96    °C
  ✳ PERCENTAGE OF DERATING  40    %
    SUPPLY VOLTAGE           14.27V
    STEERING WHEEL TORQUE    -8.9 Nm
    STEERING ANGLE SENSOR    -570.°
    CALCULAT. ANGLE OFFSET   0    °

   FIX   SCRN  FULL  PART  GRPH  HELP
```

4) C1700 (Byte coding error)

   When the calibration and tuning data in EEPROM has error while the self-test, this DTC is detected.

2.9 Warning lamp

There is no serial wiring between MDPS ECM and the warning lamp in the cluster, that is, all the DTC or failure information will be sent to the cluster through CAN from MDPS ECM. 'CAN cluster' will illuminate the warning lamp even though both CAN high and low line is open condition.

2.10 CAN communication

CAN line is the most important factor in this system because all the vehicle status such as the engine and vehicle speed will input through CAN. *For the safety in the system while driving, the motor assist must be possible always even though any electrical CAN fault is detected.*
There are three DTC for the CAN system failure detection.

1) C1611 (CAN timeout fault)

When the MDPS ECM cannot receive the CAN message signal for 1.12 seconds or more, this DTC will be detected.

Warning lamp ON (except while driving), Motor ON

2) C1616 (CAN Bus off)

When the communication error is detected for 800ms or more, this DTC is stored.

Warning lamp ON (except while driving), Motor ON

3) C1617 (CAN invalid value fault)

When the invalid CAN data is detected, this DTC is stored.

Warning lamp ON (except while driving), Motor ON

Following is the symptom and failsafe when the CAN has a designated fault.

One or two CAN lines (High or Low) are open/short to ground circuit OR
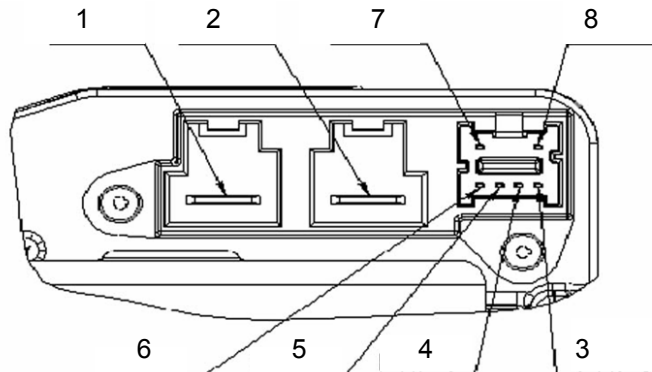**Both CAN lines (High & Low) are shorted circuit each other**

- Warning lamp turns on immediately. (while driving or IG on before engine starting)
- Motor assists the steering under the ignition on condition. (engine running <u>or not</u>)
- Motor assists the steering for about <u>1 minute under the ignition off</u> condition.
  (Because cannot identify the engine is running or not)
- Relevant DTC for CAN is stored. (C1611 CAN Timeout EMS)
- Not possible to communicate with the scanner.

2.11 Idle up

There is no engine idle speed up device or logic between MDPS ECM and PCM.   Instead of that, PCM will monitor the charging status in the alternator and its compensation will be done between PCM and alternator.

2.12 Connector layout

Symbol	Description	Pin No.	Reference
Vbatt	Battery (+)	1	
GND	Battery (-)	2	
CAN_BUS	CAN High	3	CAN 2.0B, 500kbps
CAN_BUS	CAN Low	6	CAN 2.0B, 500kbps
CAN_BUS_2	CAN High	7	Not used
CAN_BUS_2	CAN Low	4	Not used
IGN	Ignition switch input	5	
NC	Spare	8	Not used

2.13 Current map selection

The 'General' area is default from the factory. Therefore it is not necessary to change this option when you replace the MDPS assembly or ECM except the area of 'Europe'.   When the current map selection (General/Europe) is not done, DTC C1702 (Variant Coding Error) may be detected.

Also, 17 inch wheel is applied for ED.

If 17 inch wheel is applied, should choose 17-Gasoline or 17-Diesel.


```
1.6. EPS TYPE RECOGNITION

01. GASOLINE
02. DIESEL
03. 17-GASOLINE
04. 17-DIESEL


THIS SERVICE IS USED FOR LOADING
ACCURATE EPS TYPE INTO THE EPS
CONTROL MODULE.
 TO SAVE ANYWAY, PRESS [ENTER]
```