

SECTION 5 MECHATRONICS SYSTEM

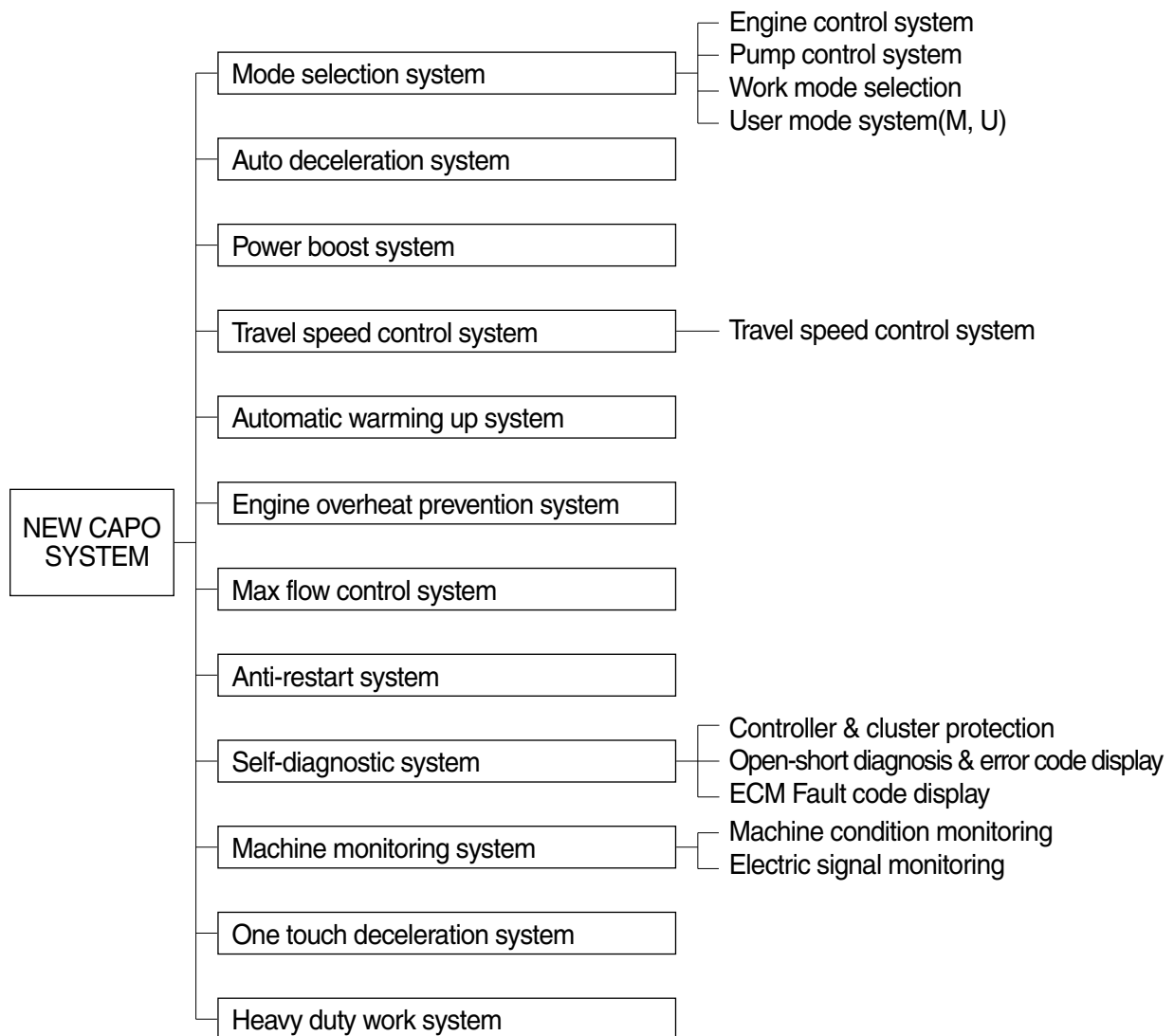
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SECTION 5 MECHATRONICS SYSTEM

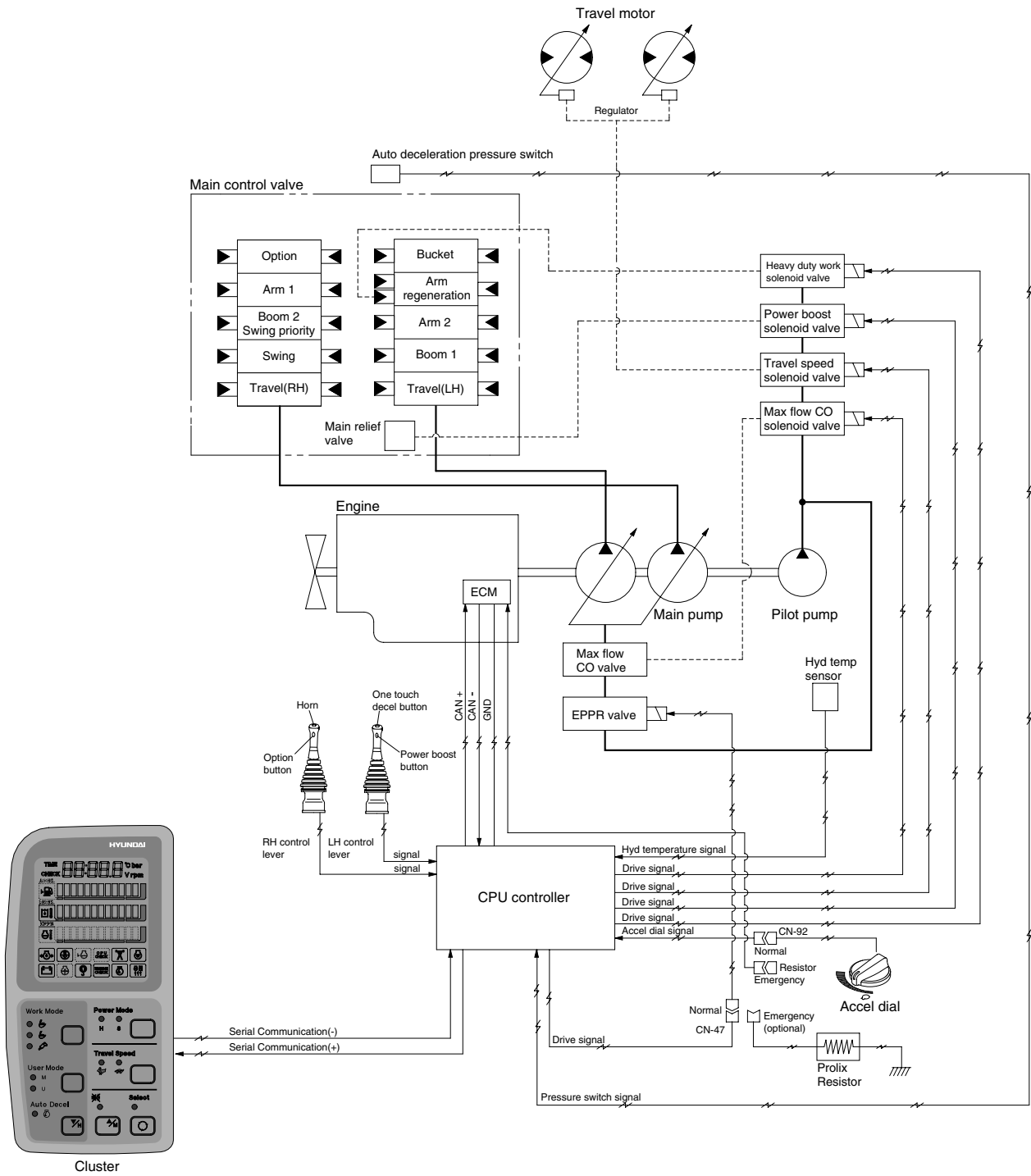
GROUP 1 OUTLINE

The NEW CAPO(Computer Aided Power Optimization) system controls engine and pump mutual power at an optimum and less fuel consuming state for the selected work by mode selection, auto-deceleration, power boost function, etc. It monitors machine conditions, for instance, engine speed, coolant temperature, hydraulic oil temperature, and hydraulic oil pressure, etc.

It consists of a CPU controller, a cluster, an accel actuator, an EPPR valve, and other components. The CPU controller and the cluster protect themselves from over-current and high voltage input, and diagnose malfunctions caused by short or open circuit in electric system, and display error codes on the cluster.



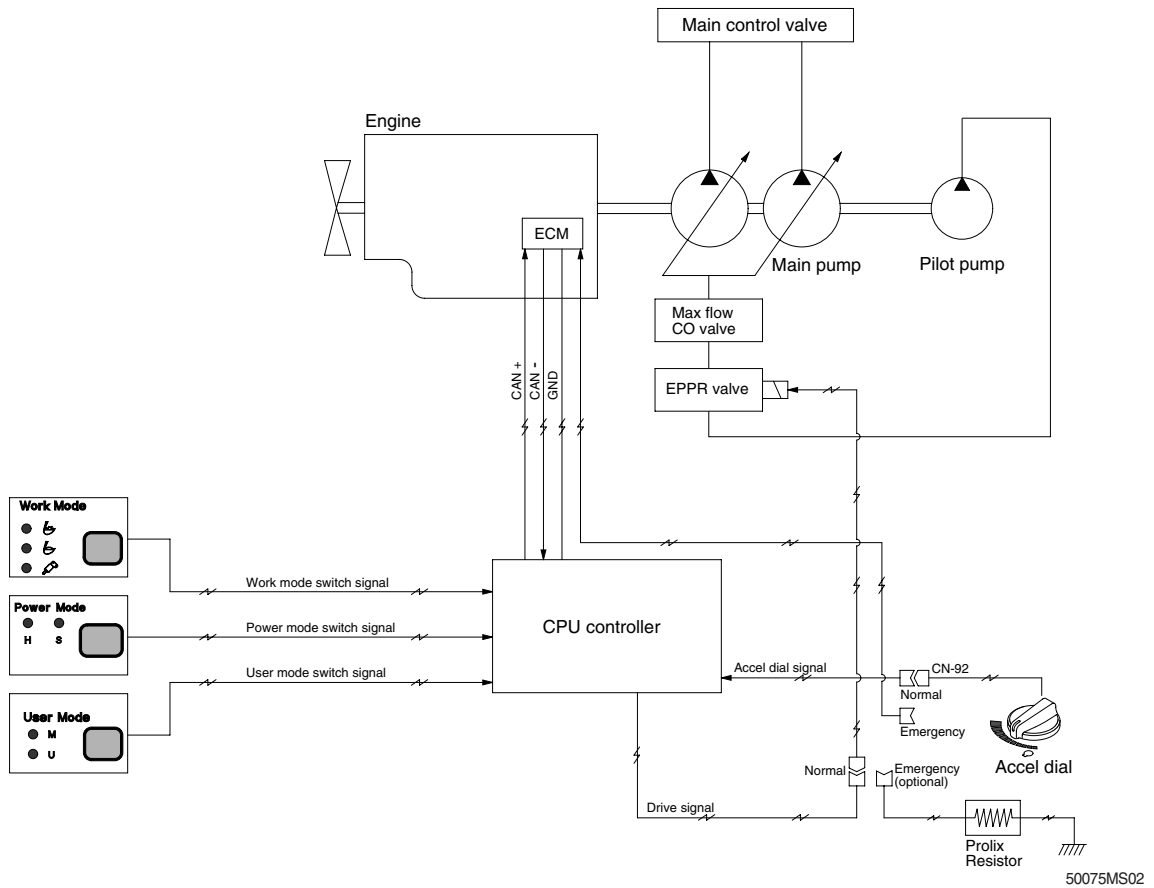
SYSTEM DIAGRAM



2907A5MS01

GROUP 2 MODE SELECTION SYSTEM

1. POWER MODE SELECTION SYSTEM



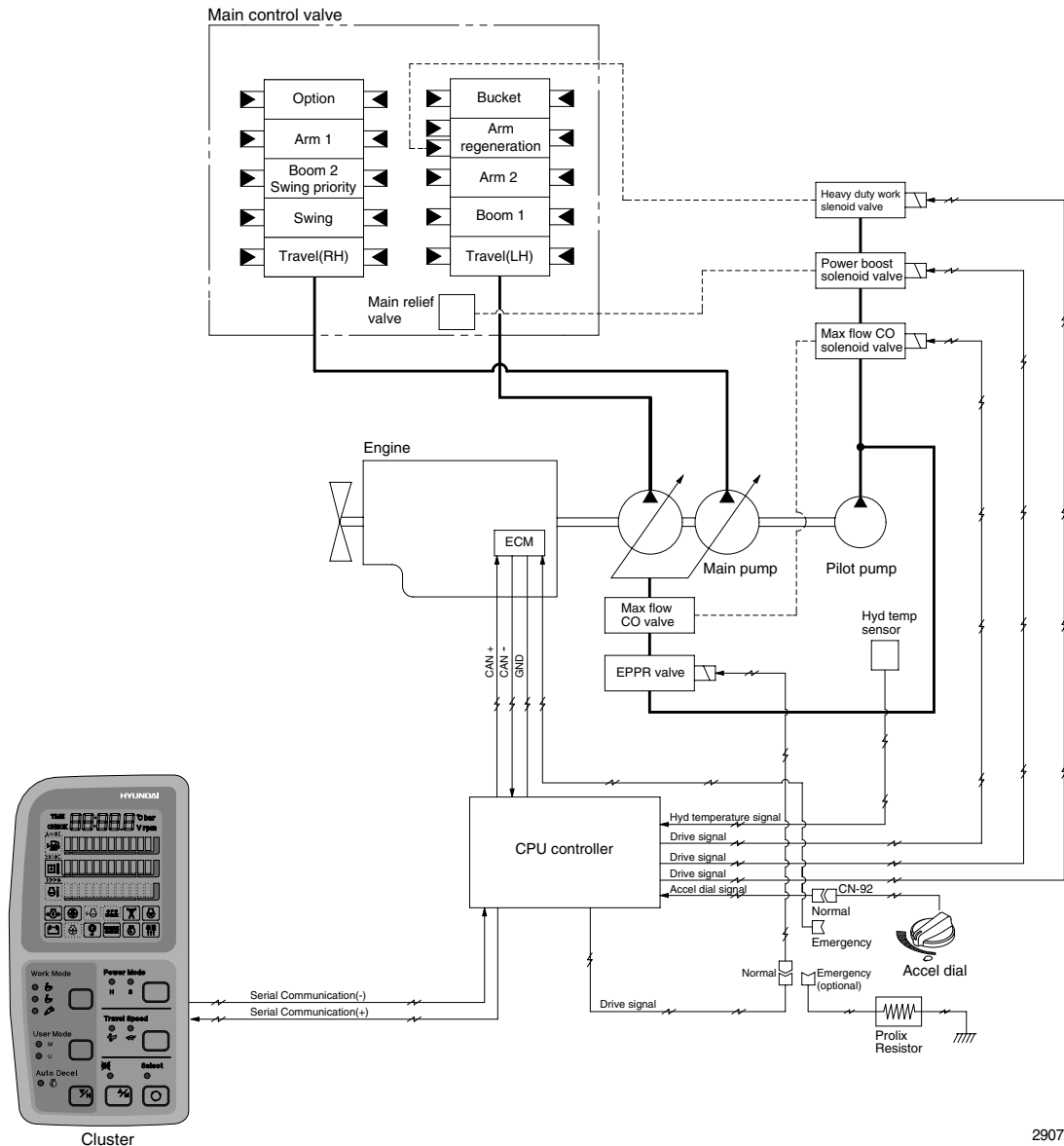
Mode selection system(Micro computer based electro-hydraulic pump and engine mutual control system) optimizes the engine and pump performance.

The combination of 2 power modes(H, S) and accel dial position(10 set) makes it possible to use the engine and pump power more effectively corresponding to the work conditions from a heavy and great power requesting work to a light and precise work.

Mode	Application	Power set (%)	Engine rpm		Power shift by EPPR valve			
			Unload	Load	Default		Other case	
					Current (mA)	Pressure (kgf/cm ²)	Current (mA)	Pressure (kgf/cm ²)
M	Maximum power	95	1850 ± 50	1800	250 ± 30	5	160	0
H	High power	85	1850 ± 50	1800	270 ± 30	7	200	2
S	Standard power	70	1750 ± 50	1700	330 ± 30	10	225	4
AUTO DECEL	Engine deceleration	-	1050 ± 100	-	700 ± 30	35	700 ± 30	35
One touch decel	Engine quick deceleration	-	800 ± 100	-	700 ± 30	35	700 ± 30	35
KEY START	Key switch start position	-	800 ± 100	-	700 ± 30	35	700 ± 30	35

2. WORK MODE SELECTION SYSTEM

3 work modes can be selected for the optional work speed of the machine operation.



2907A5MS02

1) HEAVY DUTY WORK MODE

The heavy duty work solenoid is activated to make the arm operation speed faster.

2) GENERAL WORK MODE

When key switch is turned ON, this mode is selected and swing operation speed is faster than heavy duty work mode.

3) BREAKER OPERATION MODE

It sets the pump flow to the optimal operation of breaker by activating the max flow cut-off solenoid.

Work mode	Heavy duty work solenoid	Max flow cut-off solenoid
Heavy duty	OFF	OFF
General	ON	OFF
Breaker	OFF	ON

3. USER MODE SELECTION SYSTEM

An operator can change the engine and pump and memorize it for his preference.

Mode	Operation
U	High idle rpm, auto decel rpm EPPR pressure can be modulated and memorized separately

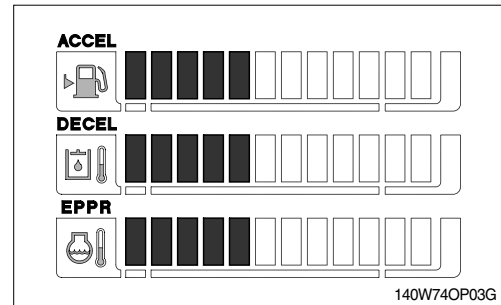
HOW TO MODULATE THE MEMORY SET

- 1) User mode has a initial set which are mid-range of max engine speed, auto decel rpm, and EPPR valve input current. When you select "U", cluster LCD displays.
- 2) To change the engine high idle speed, press the USER mode switch and SELECT switch at the same time and then ACCEL blinks at 0.5 seconds interval.
 - By pressing ▲ or ▼ switch, █ will increase or decrease.
- 3) To change DECEL rpm, press the USER mode switch and SELECT switch once more and then DECEL blinks at 0.5 seconds interval.
 - By pressing ▲ or ▼ switch, █ will increase or decrease.
- 4) To change EPPR current, press the USER mode switch and SELECT switch one more and then EPPR blinks at 0.5 seconds interval.
 - By pressing ▲ or ▼ switch, █ will increase or decrease.

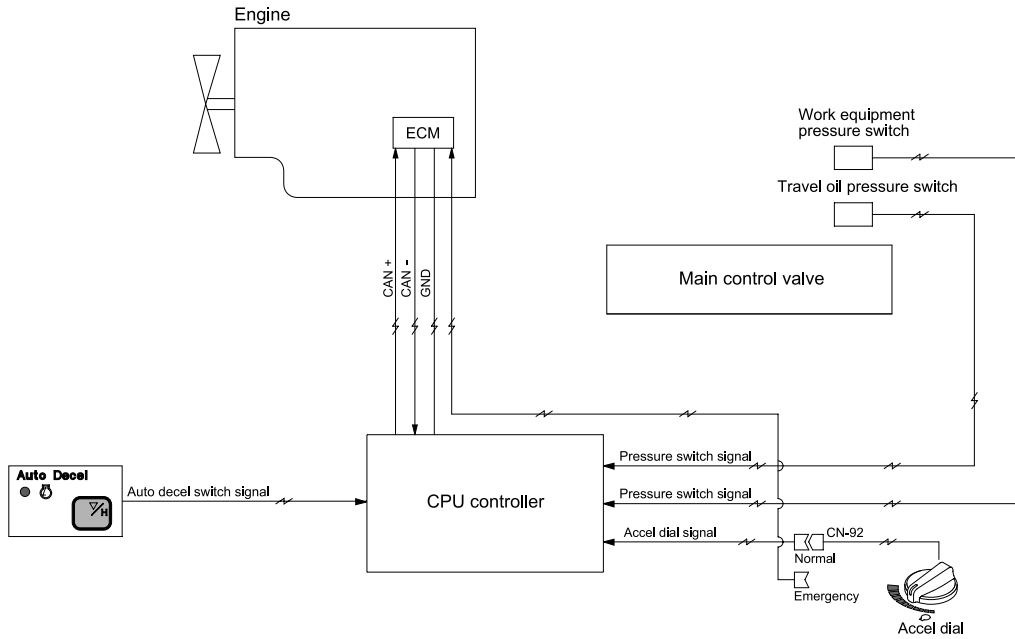
• LCD segment vs parameter setting

Segment (█)	ACCEL (rpm)	DECEL (rpm)	EPPR (mA)
1	1400	700	150
2	1450	800	200
3	1500	850	250
4	1550	900	300
5	1600	950	350
6	1650	1000	400
7	1700	Decel rpm(1050)	450
8	1750	1100	500
9	1800	1150	550
10	1850	1200	600

- 5) To memorize the final setting, press the USER mode switch and SELECT switch one more time.



GROUP 3 AUTOMATIC DECELERATION SYSTEM

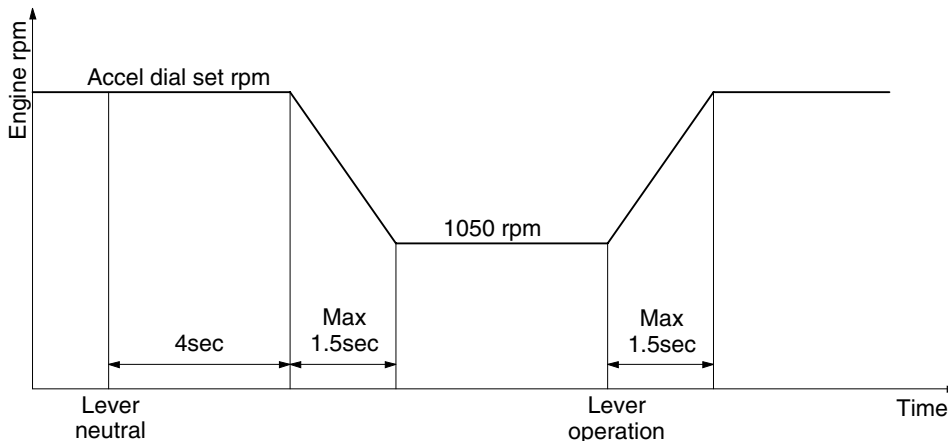


36075MS04

1. WHEN AUTO DECEL LAMP ON

If all the work equipment control levers including swing and travel levers are at neutral for at least 4 seconds, CPU controller sends throttle command to ECM to reduce the engine speed to 1050rpm. As the result of reducing the engine speed, fuel consumption and noise are effectively cut down during non-operation of the control levers.

When the Auto decel lamp is turned off by pressing the switch or any control lever is operated, the reduced engine speed rises up to the speed set before deceleration in a second.



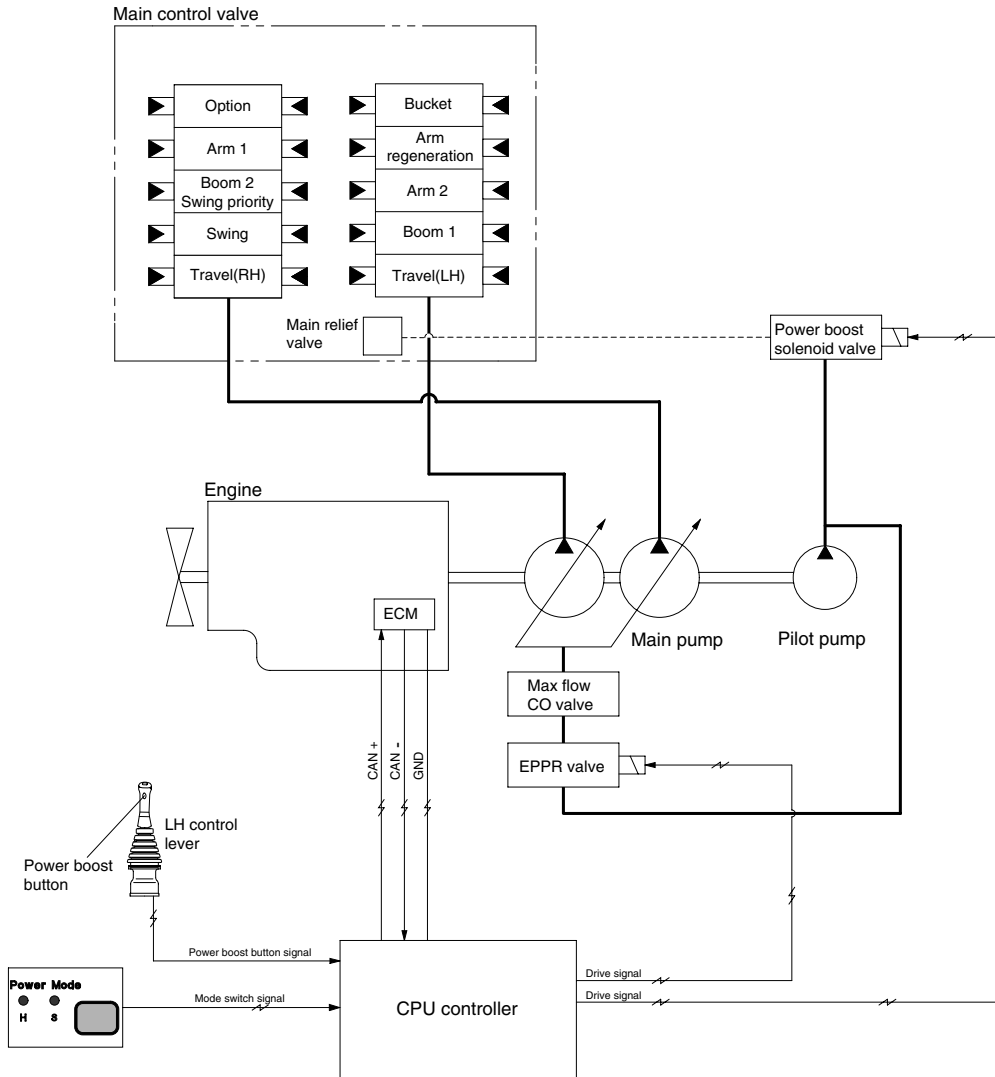
29075MS03

2. WHEN AUTO DECEL LAMP OFF

The engine speed can be set as desired using the engine speed switch, and even if the control levers are neutral, the engine speed is not reduced.

Note : Auto decel function can be activated when accel dial position is over 4.

GROUP 4 POWER BOOST SYSTEM



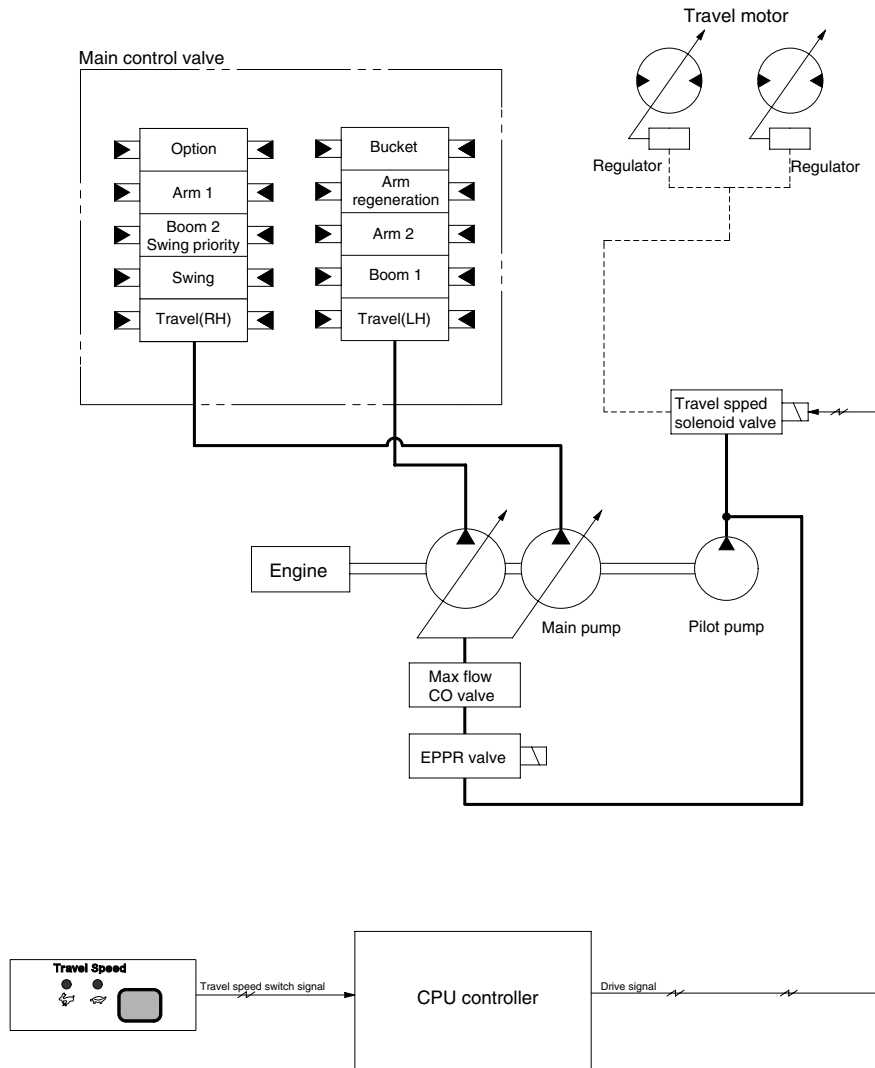
2907A5MS04

- When the power boost switch on the left control lever knob is pushed ON, the maximum digging power is increased by 10%.
- When the power set is at H or S and the power boost function is activated, the power boost solenoid valve pilot pressure raises the set pressure of the main relief valve to increase the digging power.

Description	Power boost switch	
	OFF	ON
Power set	H or S	H
Main relief valve set pressure	330kgf/cm ²	360kgf/cm ²
Time of operation	-	Even when pressed continuously, it is canceled after 8 sec.

※ Default - Power boost solenoid valve : OFF

GROUP 5 TRAVEL SPEED CONTROL SYSTEM



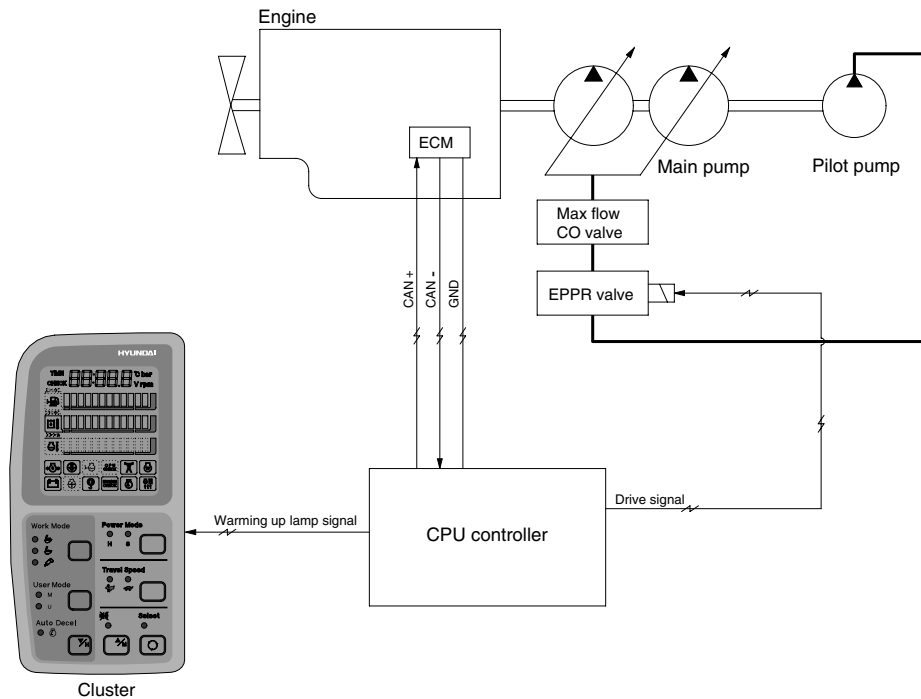
2907A5MS05

Travel speed can be switched manually by pressing the travel speed switch on the cluster.

Speed	Travel speed solenoid valve	Lamp on cluster	Operation
Lo	OFF	Turtle	Low speed, high driving torque in the travel motor
Hi	ON	Rabbit	High speed, low driving torque in the travel motor

※ Default : Turtle(Lo)

GROUP 6 AUTOMATIC WARMING UP FUNCTION



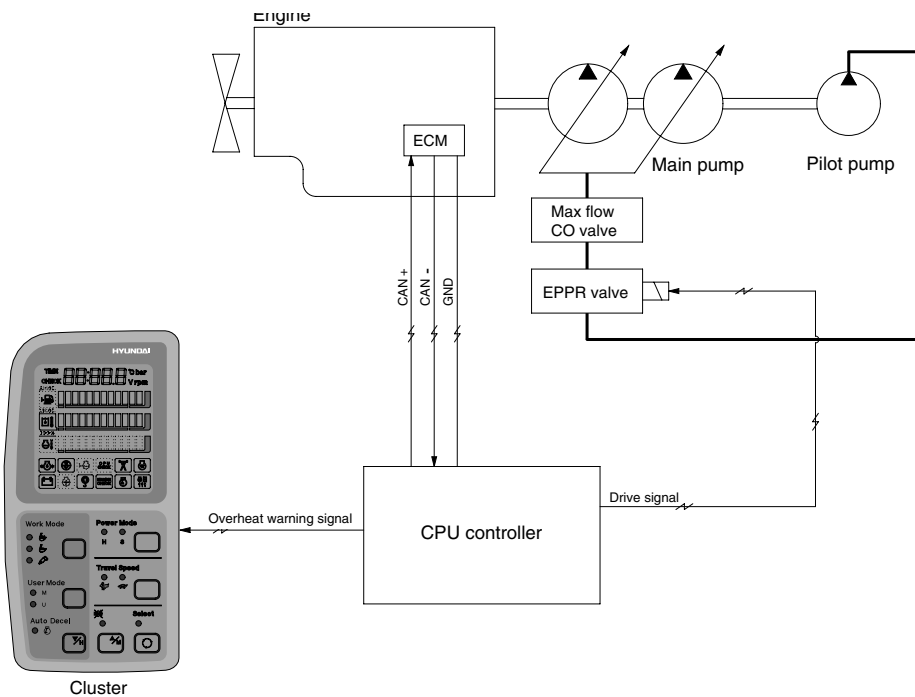
2907A5MS06

1. CPU controller receives engine coolant temperature from the ECM, and if the coolant temperature is less than 30°C, it increases the engine speed from key start rpm to 1050rpm. At this time the mode does not change.
2. In case of the coolant temperature increases up to 30°C, the engine speed is decreased to key start speed. And if an operator changes mode set during the warming up function, the CPU controller cancels the automatic warming up function.

3. LOGIC TABLE

Description	Condition	Function
Actuated	- Coolant temperature : Less than 30°C(After engine run) - Accel dial position is under 3	- Mode : Default(S mode) - Warming up time : 10 minutes(Max) - Warming up lamp : ON
Canceled	- Coolant temperature : Above 30°C - Warming up time : Above 10 minutes - Changed mode set by operator - Increase engine speed by rotating accel dial clockwise ※ If any of the above conditions is applicable, the automatic warming up function is canceled	- Default mode - Default mode - Changed mode
Warming up lamp	- Coolant temperature : Above 30°C	- Warming up lamp : OFF

GROUP 7 ENGINE OVERHEAT PREVENTION FUNCTION



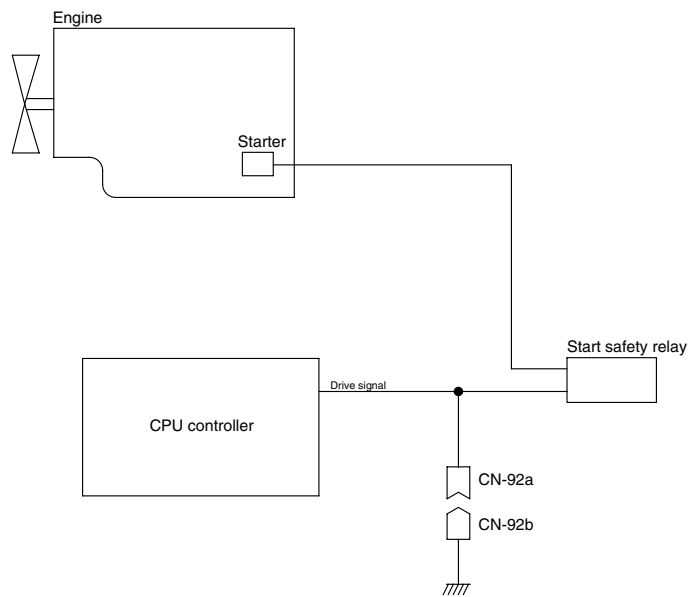
2907A5MS07

1. CPU controller receives engine coolant temperature from the ECM and when the engine coolant boils up to 110°C, it sends overheat warning signal to the cluster and decrease the engine speed same as accel dial 7 position.
2. If the coolant temperature drops less than 100°C, the CPU controller returns the mode to the mode set before. And if mode set is changed during the function, the CPU controller cancels the function. Even if the overheat prevention function is canceled by mode change, the overheat warning lamp turns OFF only when the coolant temperature is less than 100°C.

3. LOGIC TABLE

Description	Condition	Function
Actuated	- Coolant temperature : Above 110°C - Accel dial set : Above 8	- Engine rpm drop to accel dial 7 position - Overheat warning lamp & buzzer : ON
Canceled	- Coolant temperature : Less than 100°C - Changed mode set by operator ※ If any of the above conditions is applicable, engine overheat prevention function is canceled	- Return to the mode and accel dial set before - Hold on the changed set
Overheat warning lamp	- Coolant temperature : Less than 100°C	- Overheat warning lamp : OFF

GROUP 8 ANTI-RESTART SYSTEM



21075MS10

1. ANTI-RESTART FUNCTION

After 10 seconds from the engine starts to run, CPU controller turns off the start safety relay to protect the starter from inadvertent restarting.

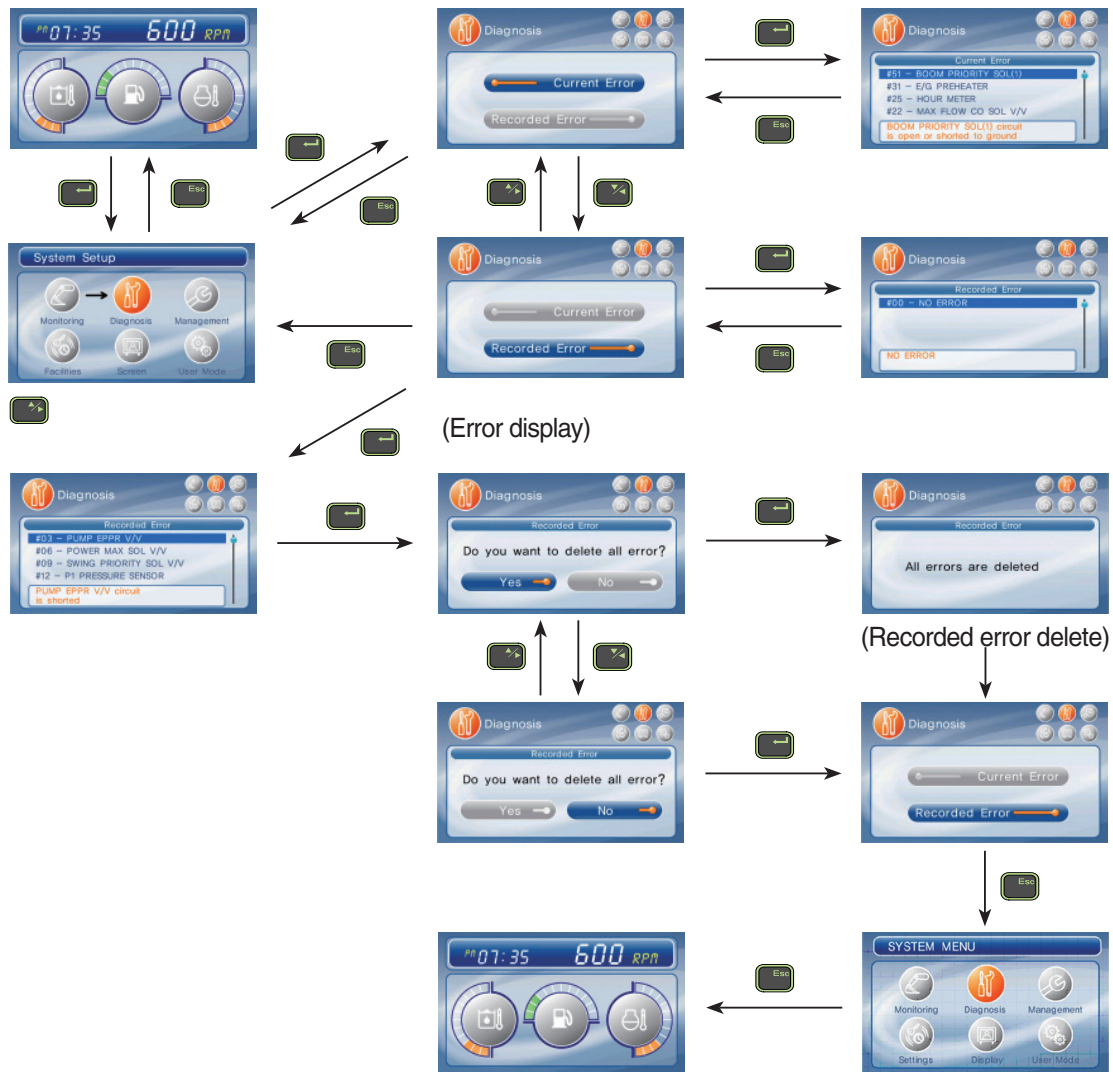
2. When a replacement or taking-off of the CPU controller is needed, connect CN-92a and CN-92b to ensure the engine start without the CPU controller.

GROUP 9 SELF-DIAGNOSTIC SYSTEM

1. OUTLINE

When any abnormality occurs in the NEW CAPO system caused by electric parts malfunction and by open or short circuit, the CPU controller diagnoses the problem and sends the error codes to the cluster and also stores them in the memory.

2. CURRENT ERROR DISPLAY



6. ECM FAULT CODES DISPLAY

If any fault code is received from ECM, cluster turns ON the “Engine check warning lamp” and sound the buzzer.

The fault codes are displayed on the cluster as the same as current error display.

ex) CHECK Er : 143

7. ERROR CODES TABLE

Error code No.	Description
1	Short circuit in accel actuator system
2	Potentiometer circuit is shorted to Vcc(5V) or battery +
3	Short circuit in pump EPPR valve system
4	Short circuit in boom down EPPR valve system
5	Short circuit in travel speed solenoid system
6	Short circuit in power boost solenoid system
7	Short circuit in max flow solenoid system
10	Short circuit in hour-meter system
11	Accel dial circuit is shorted to Vcc(5V) or battery +
12	P1 pressure sensor circuit is shorted to power supply(24V) line
13	P2 pressure sensor circuit is shorted to power supply(24V) line
14	P3 pressure sensor circuit is shorted to power supply(24V) line
15	Boom down pressure circuit is shorted to power supply(24V) line
16	Accel actuator circuit is open or shorted to ground
17	Potentiometer circuit is open or shorted to ground
18	Pump EPPR valve circuit is open or shorted to ground
19	Boom down EPPR valve circuit is open or shorted to ground
20	Travel speed solenoid circuit is open or shorted to ground
21	Power boost solenoid circuit is open or shorted to ground
22	Max flow solenoid circuit is open or shorted to ground
25	Hour-meter circuit is open or shorted to ground
26	Accel dial circuit is open or shorted to ground
27	P1 pressure sensor circuit is open or shorted to ground
28	P2 pressure sensor circuit is open or shorted to ground
29	P3 pressure sensor circuit is open or shorted to ground
30	Boom down pressure sensor circuit is open or shorted to ground
31	Engine preheater circuit is open or shorted to ground
32	Travel alarm buzzer circuit is open or shorted to ground
33	Alternator circuit is open or shorted to ground
34	Controller input voltage is below 18V

Error code No.	Description
35	Controller input voltage is over 38V
36	Communication error with cluster
37	Engine speed sensor circuit is open or shorted to ground
38	Anti-restart relay circuit is open or shorted to ground
39	Accel actuator does not stop at a target position
40	There is more than 500rpm difference between target speed and actual speed
41	Hydraulic oil temperature sensor circuit is shorted to ground
42	Fuel level sensor circuit is shorted to ground
43	Coolant temperature sensor circuit is shorted to ground
44	Boom up pressure sensor circuit is shorted to power supply(24V) line
45	Hydraulic oil temperature sensor circuit is open or shorted to battery +
46	Fuel level sensor circuit is open or shorted to battery +
47	Coolant temperature sensor circuit is open or shorted to battery +
48	Boom up pressure sensor circuit is open or shorted to ground
49	Engine preheater circuit is shorted to battery +
51	Heavy duty work solenoid circuit is open or shorted to ground
56	Travel alarm buzzer circuit is shorted to battery +
58	Heavy duty work solenoid circuit is shorted to battery +

8. ENGINE FAULT CODE INFORMATION

Fault code J1939 SPN J1939 FMI	Reason	Effect (only when fault code is active)
111 629 12	Engine control module critical internal failure - Bad intelligent device or component. Error internal to the ECM related to memory hardware failures or internal ECM voltage supply circuits.	Possible no noticeable performance effects, engine dying, or hard starting.
115 612 2	Engine magnetic crankshaft speed/position lost both of two signals - Data erratic, intermittent, or incorrect. The ECM has detected that the primary engine speed sensor and the backup engine speed sensor signals are reversed.	Fueling to injectors is disabled and the engine can not be started.
122 102 3	Intake manifold 1 pressure sensor circuit - Voltage above normal, or shorted to high source. High signal voltage detected at the intake manifold pressure circuit.	Engine power derate.
123 102 4	Intake manifold 1 pressure sensor circuit - Voltage below normal, or shorted to low Source. Low signal voltage or open circuit detected at the intake manifold pressure circuit.	Engine power derate.
124 102 16	Intake manifold 1 pressure - Data valid but above normal operational range - Moderately severe level. Intake manifold pressure has exceeded the maximum limit for the given engine rating.	Engine power derate.
131 91 3	Accelerator pedal or lever position sensor 1 circuit - Voltage above normal, or shorted to high source. High voltage detected at accelerator pedal position circuit.	Severe derate in power output of the engine. Limp home power only.
132 91 4	Accelerator pedal or lever position sensor 1 circuit - Voltage below normal, or shorted to low source. Low voltage detected at accelerator pedal position signal circuit.	Severe derate in power output of the engine. Limp home power only.
133 974 3	Remote accelerator pedal or lever position sensor 1 circuit - Voltage above normal, or shorted to high source. High voltage detected at remote accelerator pedal position circuit.	Remote accelerator will not operate. Remote accelerator position will be set to zero percent.
134 974 4	Remote accelerator pedal or lever position sensor 1 circuit - Voltage below normal, or shorted to low source. Low voltage detected at remote accelerator pedal position signal circuit.	Remote accelerator will not operate. Remote accelerator position will be set to zero percent.
135 100 3	Engine oil rifle pressure 1 sensor circuit - Voltage above normal, or shorted to high source. High signal voltage detected at the engine oil pressure circuit.	None on performance. No engine protection for oil pressure.
141 100 4	Engine oil rifle pressure 1 sensor circuit - Voltage below normal, or shorted to low source. Low signal voltage detected at engine oil pressure circuit.	None on performance. No engine protection for oil pressure.
143 100 18	Engine oil rifle pressure - Data valid but below normal operational range - Moderately severe level.	None on performance.
144 110 3	Engine coolant temperature 1 sensor circuit - Voltage above normal, or shorted to high source. High signal voltage or open circuit detected at engine coolant temperature circuit.	Possible white smoke. Fan will stay ON if controlled by ECM. No engine protection for engine coolant temperature.

Fault code J1939 SPN J1939 FMI	Reason	Effect (only when fault code is active)
145 110 4	Engine Coolant Temperature 1 Sensor Circuit - Voltage Below Normal, or Shorted to Low Source. Low signal voltage detected at engine coolant temperature circuit.	Possible white smoke. Fan will stay ON if controlled by ECM. No engine protection for engine coolant temperature.
146 110 16	Engine Coolant Temperature - Data Valid but Above Normal Operational Range - Moderately Severe Level. Engine coolant temperature signal indicates engine coolant temperature is above engine protection warning limit.	Progressive power derate increasing in severity from time of alert.
147 91 1	Accelerator Pedal or Lever Position 1 Sensor Circuit Frequency - Data Valid but Below Normal Operational Range - Most Severe Level. A frequency of less than 100 Hz has been detected at the frequency throttle input to the ECM.	Severe derate in power output of the engine. Limp home power only.
148 91 0	Accelerator Pedal or Lever Position Sensor 1 - Data Valid but Above Normal Operational Range - Most Severe Level. A frequency of more than 1500 Hz has been detected at the frequency throttle input to the ECM.	Severe derate in power output of the engine. Limp home power only.
151 110 0	Engine Coolant Temperature - Data Valid but Above Normal Operational Range - Most Severe Level. Engine coolant temperature signal indicates engine coolant temperature above engine protection critical limit.	Progressive power derate increasing in severity from time of alert. If Engine Protection Shutdown feature is enabled, engine will shut down 30 seconds after Red Stop Lamp starts flashing.
153 105 3	Intake Manifold 1 Temperature Sensor Circuit - Voltage Above Normal, or Shorted to High Source. High signal voltage detected at intake manifold air temperature circuit.	Possible white smoke. Fan will stay ON if controlled by ECM. No engine protection for intake manifold air temperature.
154 105 4	Intake Manifold 1 Temperature Sensor Circuit - Voltage Below Normal, or Shorted to Low Source. Low signal voltage detected at intake manifold air temperature circuit.	Possible white smoke. Fan will stay ON if controlled by ECM. No engine protection for intake manifold air temperature.
155 105 0	Intake Manifold 1 Temperature - Data Valid but Above Normal Operational Range - Most Severe Level. Intake manifold air temperature signal indicates intake manifold air temperature above engine protection critical limit.	Progressive power derate increasing in severity from time of alert. If Engine Protection Shutdown feature is enabled, engine will shut down 30 seconds after Red Stop Lamp starts flashing.
187 520195 4	Sensor Supply 2 Circuit - Voltage Below Normal, or Shorted to Low Source. Low voltage detected at the sensor supply number 2 circuit.	Engine power derate.
195 111 3	Coolant Level Sensor 1 Circuit - Voltage Above Normal, or Shorted to High Source. High signal voltage detected at engine coolant level circuit.	None on performance.
196 111 4	Coolant Level Sensor 1 Circuit - Voltage Below Normal, or Shorted to Low Source. Low signal voltage detected at engine coolant level circuit.	None on performance.
197 111 18	Coolant Level - Data Valid but Below Normal Operational Range - Moderately Severe Level. Low coolant level has been detected.	None on performance.
221 108 3	Barometric Pressure Sensor Circuit - Voltage Above Normal, or Shorted to High Source. High signal voltage detected at barometric pressure circuit.	Engine power derate.

Fault code J1939 SPN J1939 FMI	Reason	Effect (only when fault code is active)
222 108 4	Barometric Pressure Sensor Circuit - Voltage Below Normal, or Shorted to Low Source. Low signal voltage detected at barometric pressure circuit.	Engine power derate.
227 520195 3	Sensor Supply 2 Circuit - Voltage Above Normal, or Shorted to High Source. High voltage detected at sensor supply number 2 circuit.	Engine power derate.
234 190 0	Engine Crankshaft Speed/Position - Data Valid but Above Normal Operational Range - Most Severe Level. Engine speed signal indicates engine speed above engine protection limit.	Fuel injection disabled until engine speed falls below the overspeed limit.
235 111 1	Coolant Level - Data Valid but Below Normal Operational Range - Most Severe Level. Low engine coolant level detected.	Progressive power derate increasing in severity from time of alert. If Engine Protection Shutdown feature is enabled, engine will shut down 30 seconds after Red Stop Lamp starts flashing.
237 644 2	External Speed Command Input (Multiple Unit Synchronization) - Data Erratic, Intermittent, or Incorrect. Communication between multiple engines may be intermittent.	
238 520196 4	Sensor Supply 3 Circuit - Voltage Below Normal, or Shorted to Low Source. Low voltage detected on the +5 volt sensor supply circuit to the engine speed sensor.	Possible hard starting and rough running.
241 84 2	Wheel-based vehicle speed - Data erratic, intermittent, or incorrect. The ECM lost the vehicle speed signal.	Engine speed limited to ,maximum engine speed without VSS parameter value. Cruise control, gear-down protection, and road speed governor will not work.
242 84 10	Wheel-based vehicle speed sensor circuit tampering has been detected - Abnormal rate of change. Signal indicates an intermittent connection or VSS tampering.	Engine speed limited to maximum engine speed without VSS parameter value. Cruise control, gear-down protection, and road speed g+H53overnor will not work.
245 647 4	Fan control circuit - Voltage below normal, or shorted to low source. Low signal voltage detected at the fan control circuit when commanded on.	The fan may stay on continuously or not run at all.
271 1347 4	Fuel pump pressurizing assembly 1 circuit - Voltage below normal, or shorted to low source. Low signal voltage detected at the fuel pump actuator circuit.	Engine will run poorly at idle. Engine will have low power. Fuel pressure will be higher than commanded.
272 1347 3	Fuel pump pressurizing assembly 1 circuit - Voltage above normal, or shorted to high source. High signal voltage or open circuit detected at the fuel pump actuator circuit.	Engine will not run or engine will run poorly.
281 1347 7	Fuel pump pressurizing assembly 1 - Mechanical system not responding properly or out of adjustment.	Engine will not run or possible low power.
285 639 9	SAE J1939 multiplexing PGN timeout error - Abnormal update rate. The ECM expected information from a multiplexed device but did not receive it soon enough or did not receive it at all.	At least one multiplexed device will not operate properly.
286 639 13	SAE J1939 multiplexing configuration error - Out of calibration. The ECM expected information from a multiplexed device but only received a portion of the necessary information.	At least one multiplexed device will not operate properly.

Fault code J1939 SPN J1939 FMI	Reason	Effect (only when fault code is active)
287 91 19	SAE J1939 multiplexed accelerator pedal or lever sensor system - received network data In error. The OEM vehicle electronic control unit (VECU) detected a fault with its accelerator pedal.	Engine may only idle or engine will not accelerate to full speed.
288 974 19	SAE J1939 Multiplexing Remote Accelerator Pedal or Lever Position Sensor Circuit - Received Network Data In Error. The OEM vehicle electronic control unit (VECU) detected a fault with the remote accelerator.	The engine will not respond to the remote throttle. Engine may only idle. The primary or cab accelerator may be able to be used.
292 441 14	Auxiliary temperature Sensor Input 1 - Special instructions.	Possible engine power derate.
293 441 3	Auxiliary temperature sensor input 1 circuit - Voltage above normal, or shorted to high source. High signal voltage or open circuit detected at the OEM auxiliary temperature circuit.	None on performance.
294 441 4	Auxiliary temperature sensor input 1 circuit - Voltage below normal, or shorted to low source. Low signal voltage detected at the OEM auxiliary temperature circuit.	None on performance.
296 1388 14	Auxiliary pressure sensor input 1 - Special instructions.	Possible engine power derate.
297 1388 3	Auxiliary pressure sensor input 1 circuit - Voltage above normal, or shorted to high source. High signal voltage detected at the OEM pressure circuit.	None on performance.
298 1388 4	Auxiliary pressure sensor input 1 circuit - Voltage below normal, or shorted to low source. Low signal voltage or open circuit detected at the OEM pressure circuit.	None on performance.
319 251 2	Real time clock power interrupt - Data erratic, intermittent, or incorrect. Real time clock lost power.	None on performance. Data in the ECM will not have accurate time and date information.
322 651 5	Injector solenoid driver cylinder 1 circuit - Current below normal, or open circuit. High resistance detected on injector number 1 circuit or no current detected at number 1 injector driver or return pin when the voltage supply at the harness is on.	Engine can possibly misfire or run rough.
323 655 5	Injector solenoid driver cylinder 5 circuit - Current below normal, or open circuit. High resistance detected on injector number 5 circuit or no current detected at number 5 injector driver or return pin when the voltage supply at the harness is on.	Engine can possibly misfire or run rough.
324 653 5	Injector solenoid driver cylinder 3 circuit - Current below normal, or open circuit. High resistance detected on injector number 3 circuit or no current detected at number 3 injector driver or return pin when the voltage supply at the harness is on.	Engine can possibly misfire or run rough.
325 656 5	Injector solenoid driver cylinder 6 circuit - Current below normal, or open circuit. High resistance detected on injector number 6 circuit or no current detected at number 6 injector driver or return pin when the voltage supply at the harness is on.	Engine can possibly misfire or run rough.

Fault code J1939 SPN J1939 FMI	Reason	Effect (only when fault code is active)
331 652 5	Injector solenoid driver cylinder 2 circuit - Current below normal, or open circuit. High resistance detected on injector number 2 circuit or no current detected at number 2 injector driver or return pin when the voltage supply at the harness is on.	Engine can possibly misfire or run rough.
332 654 5	Injector solenoid driver cylinder 4 circuit - Current below normal, or open circuit. High resistance detected on injector number 4 circuit or no current detected at number 4 injector driver or return pin when the voltage supply at the harness is on.	Engine can possibly misfire or run rough.
334 110 2	Engine coolant temperature - Data erratic, intermittent, or incorrect. The engine coolant temperature reading is not changing with engine operating conditions.	The ECM will estimate engine coolant temperature.
342 630 13	Electronic calibration code incompatibility - Out of calibration. An incompatible calibration has been detected in the ECM.	Possible no noticeable performance effects, engine dying, or hard starting.
343 620 12	Engine control module warning internal hardware failure - Bad intelligent device or component. Internal ECM failure.	No performance effects or possible severe power derate.
351 627 12	Injector power supply - Bad intelligent device or component. The ECM measured injector boost voltage is low.	Possible smoke, low power, engine misfire, and/or engine will not start.
352 1079 4	Sensor supply 1 circuit - Voltage below normal, or shorted to low source. Low voltage detected at sensor supply number 1 circuit.	Engine power derate.
386 1079 3	Sensor supply 1 circuit - Voltage above normal, or shorted to high source. High voltage detected at sensor supply number 1 circuit.	Engine power derate.
415 100 1	Engine oil rifle pressure - Data valid but below normal operational range - Most severe level. Oil pressure signal indicates oil pressure below the engine protection critical limit.	Progressive power derate increasing in severity from time of alert. If engine protection shutdown feature is enabled, engine will shut down 30 seconds after red stop lamp starts flashing.
418 97 15	Water in fuel indicator - Data valid but above normal operational range - Least severe level. water has been detected in the fuel filter.	Possible white smoke, loss of power, or hard starting.
428 97 3	Water in fuel indicator sensor circuit - Voltage above normal, or shorted to high source. High voltage detected at the water in fuel circuit.	None on performance. No water in fuel warning available.
429 97 4	Water in fuel indicator sensor circuit - Voltage below normal, or shorted to low source. Low voltage detected at the water in fuel circuit.	None on performance. No water in fuel warning available.
431 558 2	Accelerator pedal or lever idle validation switch - Data erratic, intermittent, or incorrect. Voltage detected simultaneously on both idle validation and off-idle validation switches.	Engine will only idle.
432 558 13	Accelerator pedal or lever idle validation circuit - Out of calibration. Voltage at idle validation on-idle and off-idle circuit does not match accelerator pedal position.	Engine will only idle.

Fault code J1939 SPN J1939 FMI	Reason	Effect (only when fault code is active)
435 100 2	Engine oil rifle pressure - Data erratic, intermittent, or incorrect. An error in the engine oil pressure switch signal was detected by the ECM.	None on performance. No engine protection for oil pressure.
441 168 18	Battery 1 voltage - Data valid but below normal operational range - Moderately severe level. ECM supply voltage is below the minimum system voltage level.	Engine may stop running or be difficult to start.
442 168 16	Battery 1 Voltage - Data valid but above normal operational range - Moderately severe level. ECM supply voltage is above the maximum system voltage level.	Possible electrical damage to all electrical components.
449 157 0	Injector metering rail 1 pressure - Data valid but above normal operational range - Most severe level.	None or possible engine noise associated with higher injection pressures (especially at idle or light load). Engine power is reduced.
451 157 3	Injector metering rail 1 pressure sensor circuit - Voltage above normal, or shorted to high source. High signal voltage detected at the rail fuel pressure sensor circuit.	Power and or speed derate.
452 157 4	Injector metering rail 1 pressure sensor circuit - Voltage below normal, or shorted to low source. Low signal voltage detected at the rail fuel pressure sensor circuit.	Power and or speed derate.
488 157 16	Intake manifold 1 temperature - Data valid but above normal operational range - Moderately severe level. Intake manifold air temperature signal indicates intake manifold air temperature is above the engine protection warning limit.	Progressive power derate increasing in severity from time of alert.
497 1377 2	Multiple unit synchronization switch - Data erratic, intermittent, or incorrect.	
523 611 2	Auxiliary intermediate (PTO) speed switch validation - Data erratic, intermittent, or incorrect.	None on performance.
527 702 3	Auxiliary input/output 2 circuit - Voltage above normal, or shorted to high source. High signal voltage or open circuit has been detected at the auxiliary input/output 2 circuit.	None on performance.
528 93 2	Auxiliary alternate torque validation switch - Data erratic, intermittent, or incorrect.	None on performance.
529 703 3	Auxiliary input/output 3 circuit - Voltage above normal, or shorted to high source. Low signal voltage has been detected at the auxiliary input/output 2 circuit.	
553 157 16	Injector metering rail 1 pressure - Data valid but above normal operational range - Moderately severe level. The ECM has detected that fuel pressure is higher than commanded pressure.	The ECM will estimate fuel pressure and power is reduced.
554 157 2	Injector metering rail 1 pressure - Data erratic, Intermittent, or incorrect. The ECM has detected that the fuel pressure signal is not changing.	Possibly hard to start, low power, or engine smoke.

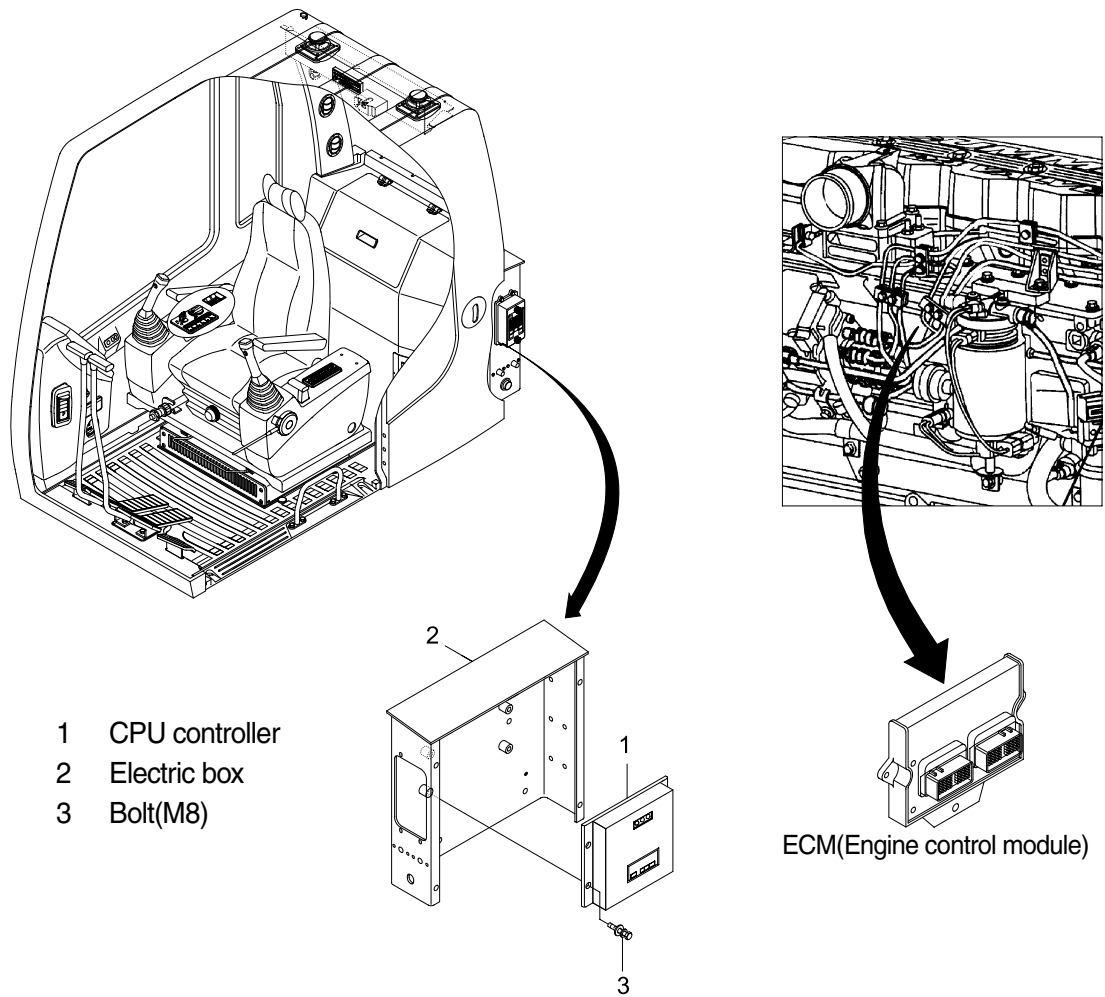
Fault code J1939 SPN J1939 FMI	Reason	Effect (only when fault code is active)
559 157 18	Injector metering rail 1 pressure - Data Valid but Below Normal Operational Range - Moderately Severe Level. The ECM has detected that fuel pressure is lower than commanded pressure.	Either the engine will not start or the engine will not have starter lockout protection.
584 677 3	Starter relay driver circuit - Voltage above normal, or shorted to high source. Open circuit or high voltage detected at starter lockout circuit.	The engine will not have starter lockout protection.
585 677 4	Starter relay driver circuit - Voltage below normal, or shorted to low source. Low voltage detected at starter lockout circuit.	Engine power derate. The ECM uses an estimated turbocharger speed.
595 103 16	Turbocharger 1 speed - Data valid but above normal operational range - Moderately severe level. High turbocharger speed has been detected.	Amber lamp will light until high battery voltage condition is corrected.
599 640 14	Auxiliary commanded dual output shutdown - Special instructions.	None or possible engine noise associated with higher injection pressures (especially at idle or light load). Engine power is reduced.
687 103 18	Turbocharger 1 speed - Data valid but below normal operational range - Moderately severe level. Low turbocharger speed detected by the ECM.	Engine can run rough. Possibly poor starting capability. Engine runs using backup speed sensor. Engine power is reduced.
689 190 2	Engine crankshaft speed/position - Data erratic, intermittent, or incorrect. Loss of signal from crankshaft sensor.	Engine power derate.
691 1172 3	Turbocharger 1 compressor inlet temperature circuit - Voltage above normal, or shorted to high source. High signal voltage detected at turbocharger compressor inlet air temperature circuit.	Engine power derate.
692 1172 4	Turbocharger 1 compressor inlet temperature circuit - Voltage below normal, or shorted to low source. Low signal voltage detected at turbocharger compressor inlet air tempera	Engine will run derated. Excessive black smoke, hard start, and rough idle possible.
731 723 7	Engine speed / position camshaft and crankshaft misalignment - Mechanical system not responding properly or out of adjustment. mechanical misalignment between the crankshaft and camshaft engine speed sensors.	Possible no noticeable performance effects, engine dying, or hard starting.
757 611 31	Electronic control module data lost - Condition exists. Severe loss of data from the ECM.	Possible poor starting. Engine power derate.
778 723 2	Engine camshaft speed / position sensor - Data erratic, intermittent, or incorrect. The ECM has detected an error in the camshaft position sensor signal.	Possible engine power derate.
779 703 11	Auxiliary equipment sensor input 3 - Root cause not known.	Possible no noticeable performance effects or engine dying or hard starting. Fault information, trip information, and maintenance monitor data may be inaccurate.

Fault code J1939 SPN J1939 FMI	Reason	Effect (only when fault code is active)
1117 627 2	Power supply lost with ignition on - Data erratic, intermittent, or incorrect. Supply voltage to the ECM fell below 6.2 volts momentarily, or the ECM was not allowed to power down correctly (retain battery voltage for 30 seconds after key OFF).	Engine will shut down.
1633 625 2	OEM datalink cannot transmit - Data erratic, intermittent, or incorrect. Communications within the OEM datalink network is intermittent.	Engine will only idle.
2185 520197 3	Sensor supply 4 circuit - Voltage above normal, or shorted to high source. High voltage detected at +5 volt sensor supply circuit to the accelerator pedal position sensor.	Engine will only idle.
2186 520197 4	Sensor supply 4 circuit - Voltage below normal, or shorted to low source. Low voltage detected at +5 volt sensor supply circuit to the accelerator pedal position sensor.	Possibly hard to start, low power, or engine smoke.
2249 157 1	Injector metering rail 1 pressure - Data valid but below normal operational range - Most severe level. The ECM has detected that fuel pressure is lower than commanded pressure.	Engine may be difficult to start.
2265 1075 3	Electric lift pump for engine fuel supply circuit - Voltage above normal, or shorted to high source. High voltage or open detected at the fuel lift pump signal circuit.	Engine may be difficult to start.
2266 1075 4	Electric lift pump for engine fuel supply circuit - Voltage below normal, or shorted to low source. Low signal voltage detected at the fuel lift pump circuit.	Possible low power.
2311 633 31	Electronic fuel injection control valve circuit - Condition exists. Fuel pump actuator circuit resistance too high or too low.	Engine may exhibit misfire as control switches from the primary to the backup speed sensor. Engine power is reduced while the engine operates on the backup speed sensor.
2321 190 2	Engine crankshaft speed/position - Data erratic, intermittent, or incorrect. crankshaft engine speed sensor intermittent synchronization.	Possible low power.
2322 723 2	Engine camshaft speed / position sensor - Data erratic, intermittent, or incorrect. Camshaft engine speed sensor intermittent synchronization.	Engine power derate.
2345 103 10	Turbocharger 1 Speed - Abnormal rate of change. The turbocharger speed sensor has detected an erroneous speed value.	Engine power derate.
2346 2789 15	Turbocharger turbine inlet temperature (Calculated) - Data valid but above normal operational range - Least severe level. Turbocharger turbine inlet temperature has exceeded the engine protection limit.	Engine power derate.
2347 2790 15	Turbocharger compressor outlet temperature (Calculated) - Data valid but above normal operational range - Least severe level.	Engine brake on cylinders 1, 2, and 3 can not be activated or exhaust brake will not operate.
2377 647 3	Fan control circuit - Voltage above normal, or shorted to high source. Open circuit or high voltage detected at the fan control circuit.	Variable geometry turbocharger will go to the open position.

Fault code J1939 SPN J1939 FMI	Reason	Effect (only when fault code is active)
2384 641 4	VGT actuator driver circuit - Voltage below normal, or shorted to low source. Low voltage detected at turbocharger control valve circuit.	Variable geometry turbocharger may be in either the open or closed position.
2385 641 3	VGT actuator driver circuit - Voltage above normal, or shorted to high source. Open circuit or high voltage detected at turbocharger control valve circuit.	The intake air heaters may be ON or OFF all the time.
2555 729 3	Intake air heater 1 circuit - Voltage above normal, or shorted to high source. High voltage detected at the intake air heater signal circuit.	The intake air heaters may be ON or OFF all the time.
2556 729 4	Intake air heater 1 circuit - Voltage below normal, or shorted to low source. Low voltage detected at the intake air heater signal circuit.	Can not control transmission.
2557 697 3	Auxiliary PWM driver 1 circuit - Voltage above normal, or shorted to high source. High signal voltage detected at the analog torque circuit.	Can not control transmission.
2558 697 4	Auxiliary PWM driver 1 circuit - Voltage below normal, or shorted to low source. Low signal voltage detected at the analog torque circuit.	Power derate and possible engine shutdown if engine protection shutdown feature is enabled.
2973 102 2	Intake manifold 1 pressure - Data erratic, intermittent, or incorrect. The ECM has detected an intake manifold pressure signal that is too high or low for current engine operating conditions.	

GROUP 10 ENGINE CONTROL SYSTEM

1. CPU CONTROLLER AND ECM

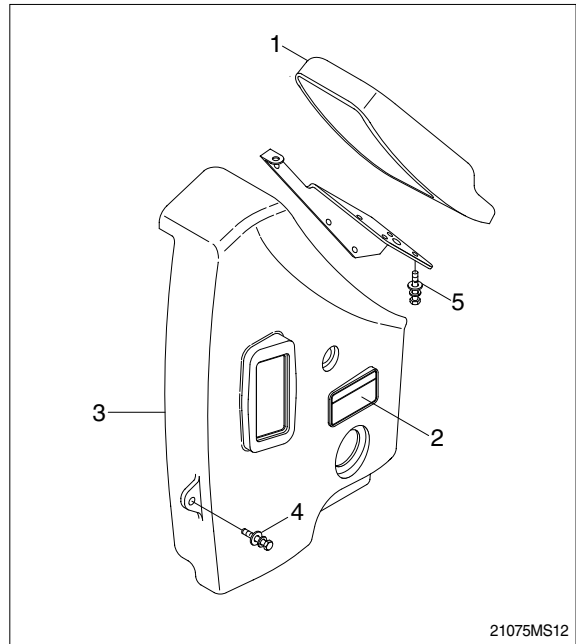


2. CPU CONTROLLER ASSEMBLY

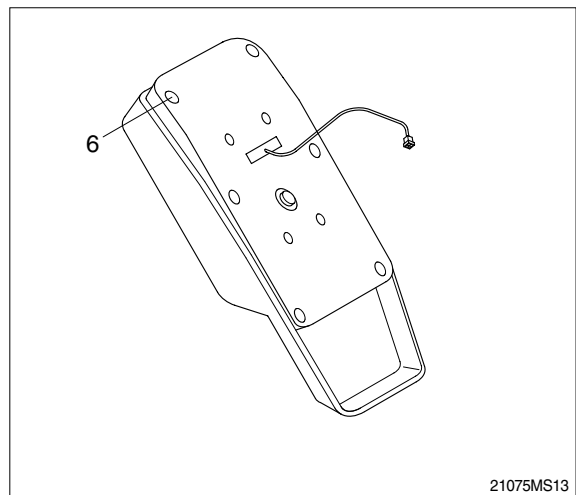
- 1) Remove four pieces of bolt(3) of electric box(2).
- 2) Disconnect 2 connectors from CPU controller.
- 3) Remove 6 pieces of screw and open the cover of CPU controller.
- 4) Inspection : Check PCB(Printed Circuit Board)
 - (1) If any damage is found, replace CPU controller assembly.
 - (2) If not, but CAPO system does not work please report it to HHI dealer or A/S department.

3. EXCHANGE METHOD OF THE ROM IN THE CLUSTER

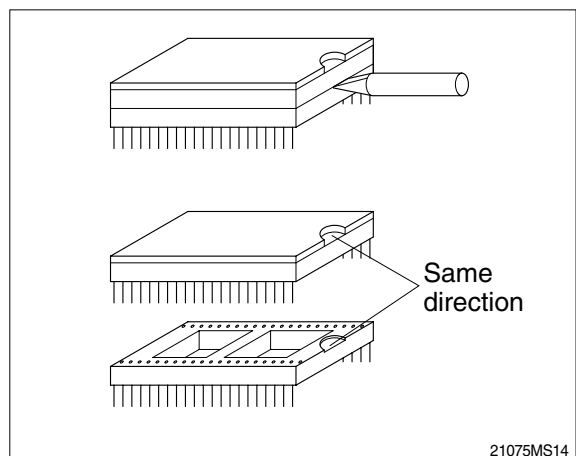
- 1) Disassemble the ash tray(2).
- 2) Disassemble the wiper motor cover(3).
- 3) Disassemble the cluster(1).



- 4) Loosen the screws(6EA) located back of the cluster.
- 5) Then you can open the upper case of the cluster easily.



- 6) Install the new ROM.(Be careful of direction and assmelbe the cluster in the reverse order to removal).



GROUP 11 EPPR VALVE

1. COMPOSITION OF EPPR VALVE

EPPR(Electro Proportional Pressure Reducing) valve consists of electro magnet and spool valve installed at main hydraulic pump.

1) ELECTRO MAGNET VALVE

Receive electric current from CPU controller and move the spool proportionally according to the specific amount of electric current value.

2) SPOOL VALVE

Is the two way direction control valve for pilot pressure to reduce hydraulic pump flow.

When the electro magnet valve is activated, pilot pressure enters into flow regulator of hydraulic pump. So, pump flow decreases to prevent engine stall.

3) PRESSURE AND ELECTRIC CURRENT VALUE FOR EACH MODE

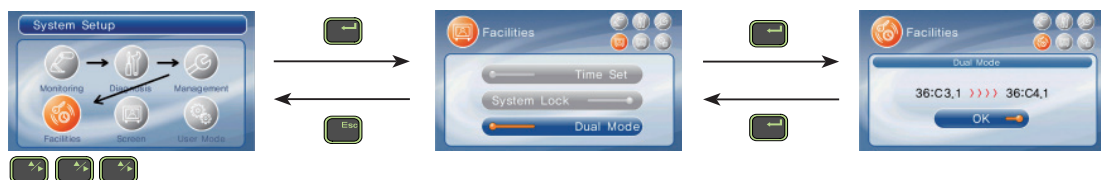
Mode		Pressure		Electric current (mA)	Engine rpm (At accel dial 10)
		kgf/cm ²	psi		
Standard (Ver : 3.1)	M	5 ± 3	71 ± 40	250 ± 30	1850 ± 50
	H	7 ± 3	100 ± 40	270 ± 30	1850 ± 50
	S	10 ± 3	142 ± 40	330 ± 30	1750 ± 50
Option (Ver : 4.1)	M	0 ± 3	0 ± 40	160 ± 30	1850 ± 50
	H	2 ± 3	28 ± 40	200 ± 30	1850 ± 50
	S	4 ± 3	57 ± 40	225 ± 30	1750 ± 50
★		20 ± 3	284 ± 40	453 ± 30	-

★ Manually operated condition when prolix switch is selected emergency position.

2. HOW TO SWITCH THE VERSION(3.1↔4.1) ON THE CLUSTER

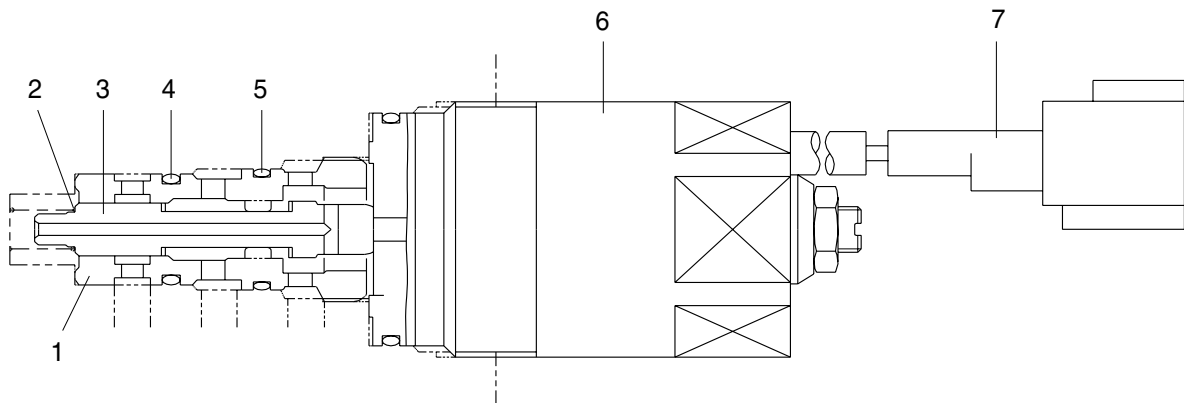
You can switch the EPPR valve pressure set by selecting the version(3.1 ↔ 4.1).

- Dual mode
 - Changing the MCU mode



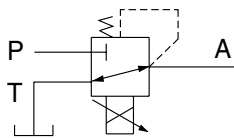
2. OPERATING PRINCIPLE

1) STRUCTURE



5-22(1)

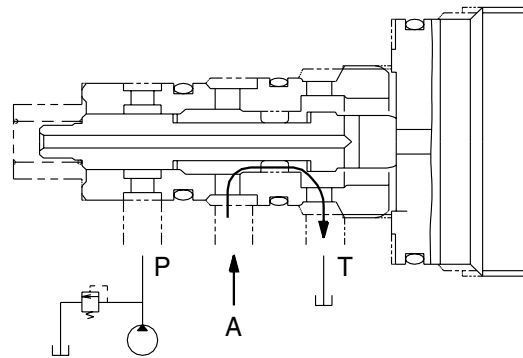
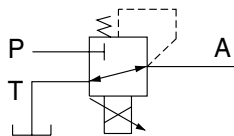
- | | | |
|----------|----------|------------------|
| 1 Sleeve | 4 O-ring | 6 Solenoid valve |
| 2 Spring | 5 O-ring | 7 Connector |
| 3 Spool | | |



- | | |
|---|--|
| P | Pilot oil supply line(Pilot pressure) |
| T | Return to tank |
| A | Secondary pressure to flow regulator at hydraulic pump |

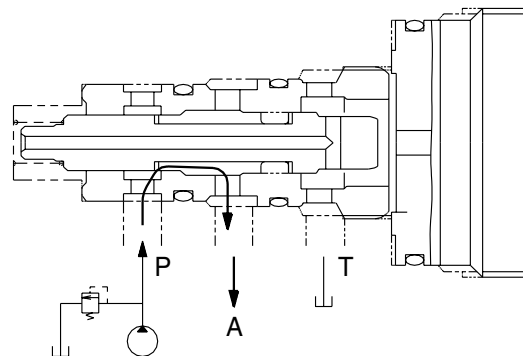
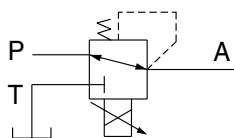
2) AT H MODE

Pressure line is blocked and A oil returns to tank.



3) AT S MODE

Secondary pressure enters into A.

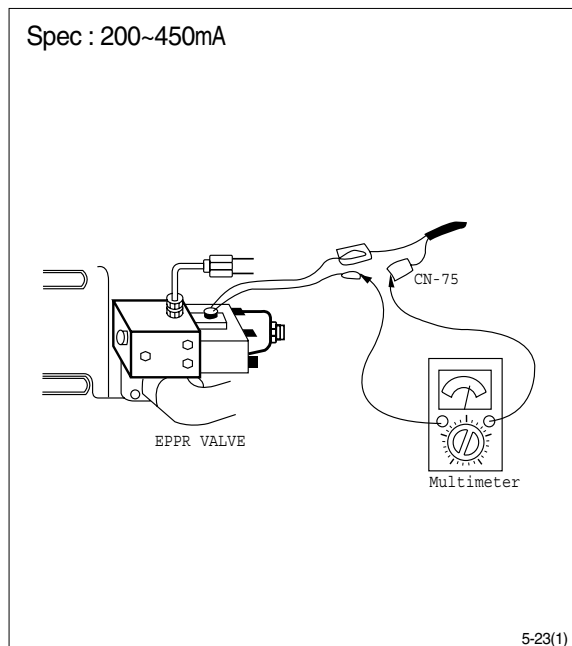


5-22(2)

3. EPPR VALVE CHECK PROCEDURE

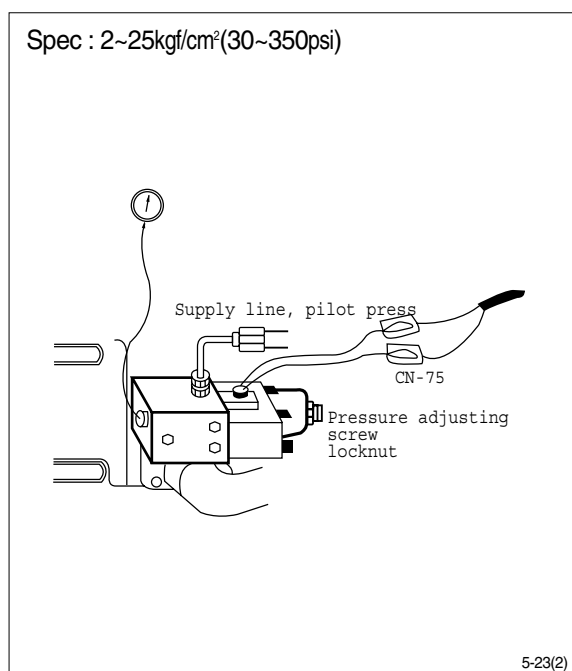
1) CHECK ELECTRIC VALUE AT EPPR VALVE

- (1) Start engine.
- (2) Set S-mode and cancel auto decel mode.
- (3) Position the accel dial at 10.
- (4) If tachometer show approx 1750 ± 50 rpm disconnect one wire harness from EPPR valve.
- (5) Install multimeter as figure.
- (6) Check electric current at bucket circuit relief position.



2) CHECK PRESSURE AT EPPR VALVE

- (1) Remove plug and connect pressure gauge as figure.
 - Gauge capacity : 0 to 40-50kgf/cm²
(0 to 580-725psi)
- (2) Start engine.
- (3) Set S-mode and cancel auto decel mode.
- (4) Position the accel dial at 10.
- (5) If tachometer show approx 1750 ± 50 rpm check pressure at relief position of bucket circuit by operating bucket control lever.
- (6) If pressure is not correct, adjust it.
- (7) After adjust, test the machine.



GROUP 12 MONITORING SYSTEM

1. OUTLINE

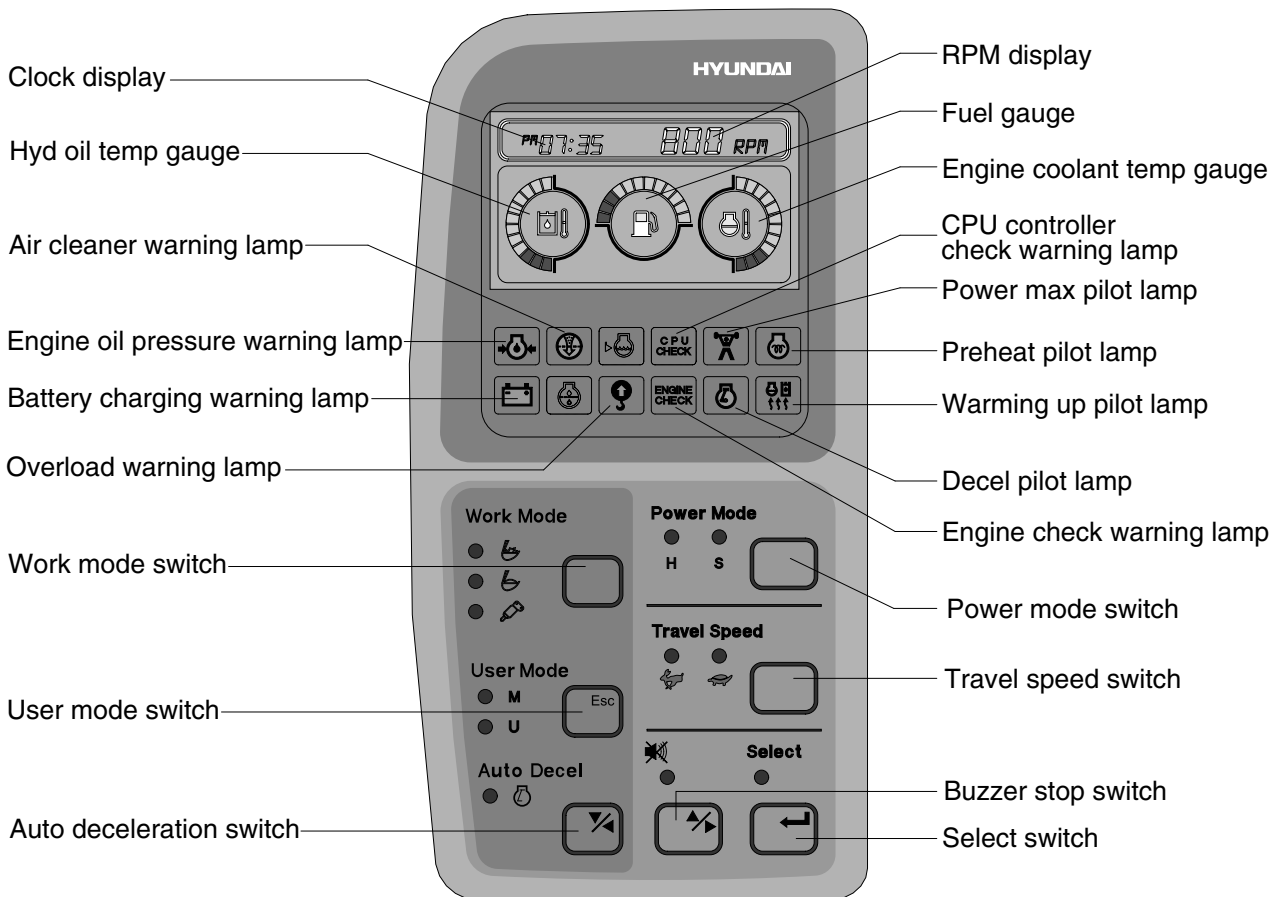
Monitoring system consists of the monitor part and switch part.

The monitor part gives warnings when any abnormality occurs in the machine and informs the condition of the machine.

Various select switches are built into the monitor panel, which act as the control portion of the machine control system.

2. CLUSTER

1) MONITOR PANEL



2507A5MS10

2) CLUSTER CHECK PROCEDURE

(1) Start key : ON

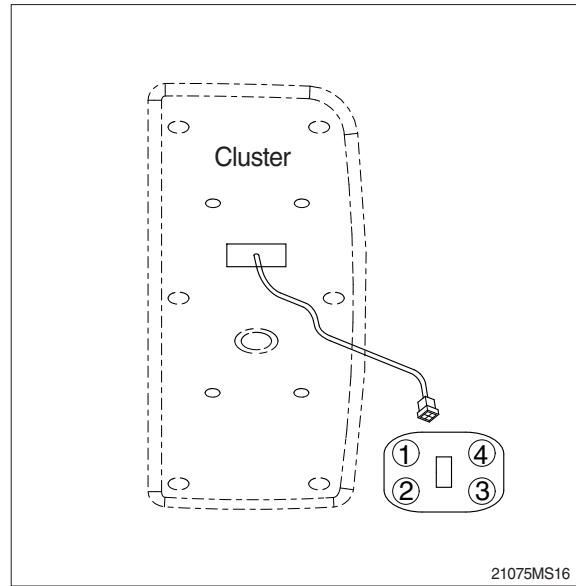
- ① Check monitor initial 5 seconds
 - a. All lamps light up.
 - b. Buzzer sound.
- ② Check monitor after 5 seconds : Indicate cluster version and machine condition
 - a. Cluster program version : 「1.00」 ← Indicates program version 「1.00」 for 5 seconds.
 - b. Tachometer : 0rpm
 - c. Fuel gauge : All light up below appropriate level
 - d. Hydraulic temperature : All light up below appropriate level
 - e. Engine coolant temperature gauge : All light up below appropriate level
 - f. Warning lamp
 - ※ During start key **ON** the engine oil pressure lamp and battery charging lamp go on, but it is not abnormal.
 - ※ When engine coolant temperature below 30℃, the warming up lamp lights up.
- ③ Indicating lamp state
 - a. Work mode selection : General work
 - b. Power mode selection : S mode
 - c. User mode selection : No LED ON
 - d. Auto decel LED : ON
 - e. Travel speed pilot lamp : Low(Turtle)

(2) Start of engine

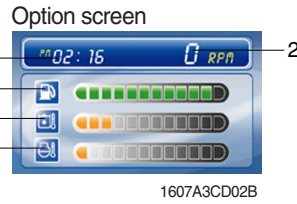
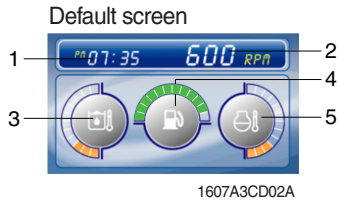
- ① Check machine condition
 - a. Tachometer indicates at present rpm
 - b. Gauge and warning lamp : Indicate at present condition.
 - ※ When normal condition : All warning lamp OFF
 - c. Work mode selection : General work
 - d. Power mode selection : S mode
 - e. User mode selection : No LED ON
 - f. Auto decel LED : ON
 - g. Travel speed pilot lamp : Low(Turtle)
- ② When warming up operation
 - a. Warming up lamp : ON
 - b. 10 seconds after engine started, engine speed increases to 1200rpm(Auto decel LED : ON)
 - ※ Others same as above ①.
- ③ When abnormal condition
 - a. The lamp lights up and the buzzer sounds.
 - b. If **BUZZER STOP** switch is pressed, buzzer sound is canceled but the lamp light up until normal condition.

3. CLUSTER CONNECTOR

No.	Signal	Input / Output
1	Power IG(24V)	Input(20~32V)
2	GND	Input(0V)
3	Serial-(RX)	Input(Vpp=12V)
4	Serial+(TX)	Output(Vpp=4V)



2) LCD main operation display



- 1 Time display
- 2 RPM display
- 3 Hydraulic oil temperature gauge
- 4 Fuel level gauge
- 5 Engine coolant temperature gauge

(1) Time display



- ① This displays the current time.

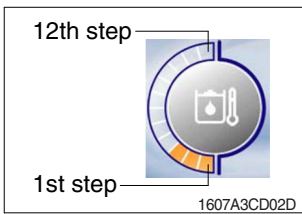
※ Refer to page 5-36 to set time for details.

(2) RPM display



- ① This displays the engine rpm.

(3) Hydraulic oil temperature gauge



- ① This gauge indicates the temperature of hydraulic oil in 12 step gauge.

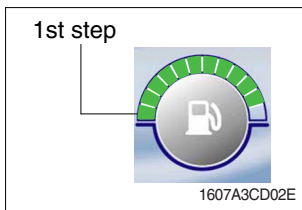
- 1st step : Below 30°C (86°F)
- 2nd~10th step : 30-105°C (86-221°F)
- 11th~12th step : Above 105°C (221°F)

- ② The gauge between 2nd and 10th steps illuminates when operating.

- ③ Keep idling engine at low speed until the gauge between 2nd and 10th steps illuminates, before operation of machine.

- ④ When the gauge of 11th and 12th steps illuminates, reduce the load on the system. If the gauge stays in the 11th~12th steps, stop the machine and check the cause of the problem.

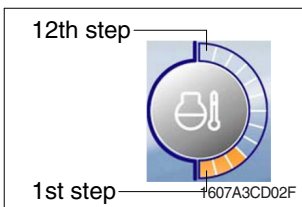
(4) Fuel level gauge



- ① This gauge indicates the amount of fuel in the fuel tank.
- ② Fill the fuel when the 1st step or fuel icon blinks in red.

※ If the gauge illuminates the 1st step or fuel icon blinks in red even though the machine is on the normal condition, check the electric device as that can be caused by the poor connection of electricity or sensor.

(5) Engine coolant temperature gauge



- ① This gauge indicates the temperature of coolant in 12 step gauge.

- 1st step : Below 30°C (86°F)
- 2nd~10th step : 30-105°C (86-221°F)
- 11th~12th step : Above 105°C (221°F)

- ② The gauge between 2nd and 10th steps illuminates when operating.

- ③ Keep idling engine at low speed until the gauge between 2nd and 10th steps illuminates, before operation of machine.

- ④ When the gauge of 11th and 12th steps illuminates, turn OFF the engine, check the radiator and engine.

3) Warning of main operation screen

(1) Warning display

① Engine coolant temperature



- This lamp blinks and the buzzer sounds when the temperature of coolant is over the normal temperature 105°C (221°F).
- Check the cooling system when the lamp blinks.

② Fuel level



- This lamp blinks and the buzzer sounds when the level of fuel is below 40 l (10.6U.S. gal).
- Fill the fuel immediately when the lamp blinks.

③ Hydraulic oil temperature



- This warning lamp operates and the buzzer sounds when the temperature of hydraulic oil is over 105 °C (221 °F).
- Check the hydraulic oil level when the lamp blinks.
- Check for debris between oil cooler and radiator.

④ All gauge



- This lamp blinks and the buzzer sounds when the all gauge is abnormal.
- Check the each system when the lamp blinks.

⑤ Communication error



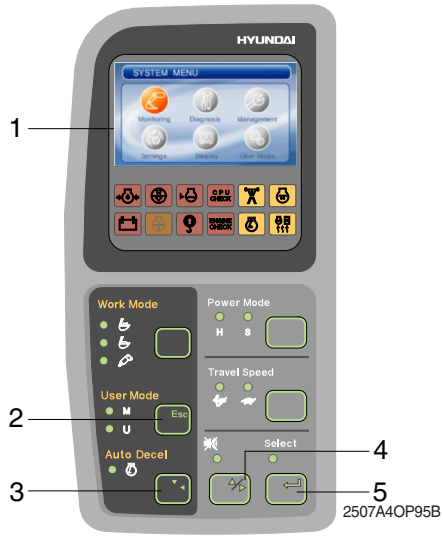
- Communication problem between CPU controller and cluster makes the lamp blinks and the buzzer sounds.
- Check if any fuse for CPU burnt off.
If not check the communication line between them.






(2) Pop-up icon display

No	Switch	Selected mode	Display
1	Work mode switch	General work mode	
		Heavy duty work mode	
		Breaker operation mode	
2	Power mode switch	High power work mode	
		Standard power work mode	

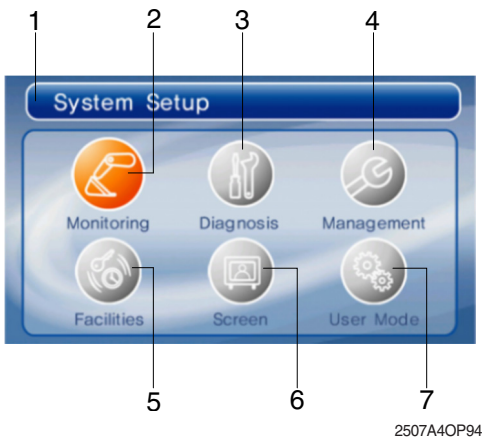
No	Switch	Selected mode	Display
3	Auto deceleration switch	Light ON	
		Light OFF	
4	Travel speed control switch	Low speed	
		High speed	




4) LCD



- 1  : LCD
- 2  : Escape, Return to the previous menu
- 3  : Down/Left Direction
- 4  : Up/Right Direction
- 5  : Select(Enter) Activate the currently chosen item

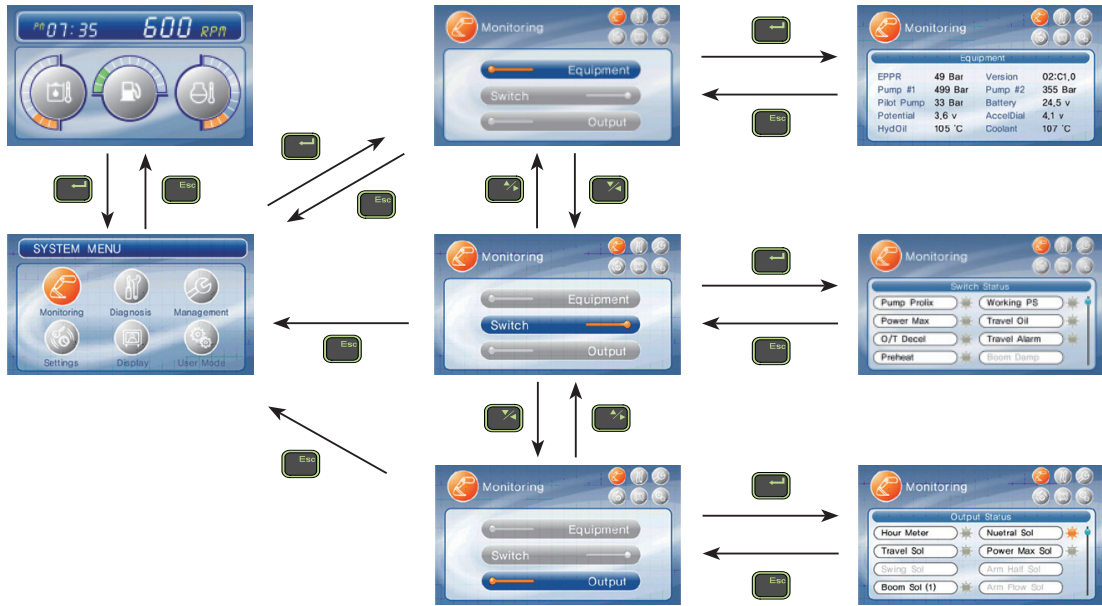
(1) Main menu



- 1  : Menu information
- 2  : Monitoring
– Equipment, Switch, Output
- 3  : Diagnosis
– Current error, Recorded error
- 4  : Maintenance
- 5  : Settings
– Time set, Dual mode
– System lock(Reserved)
- 6  : Display
– Operation skin, Brightness, Language
- 7  : User mode

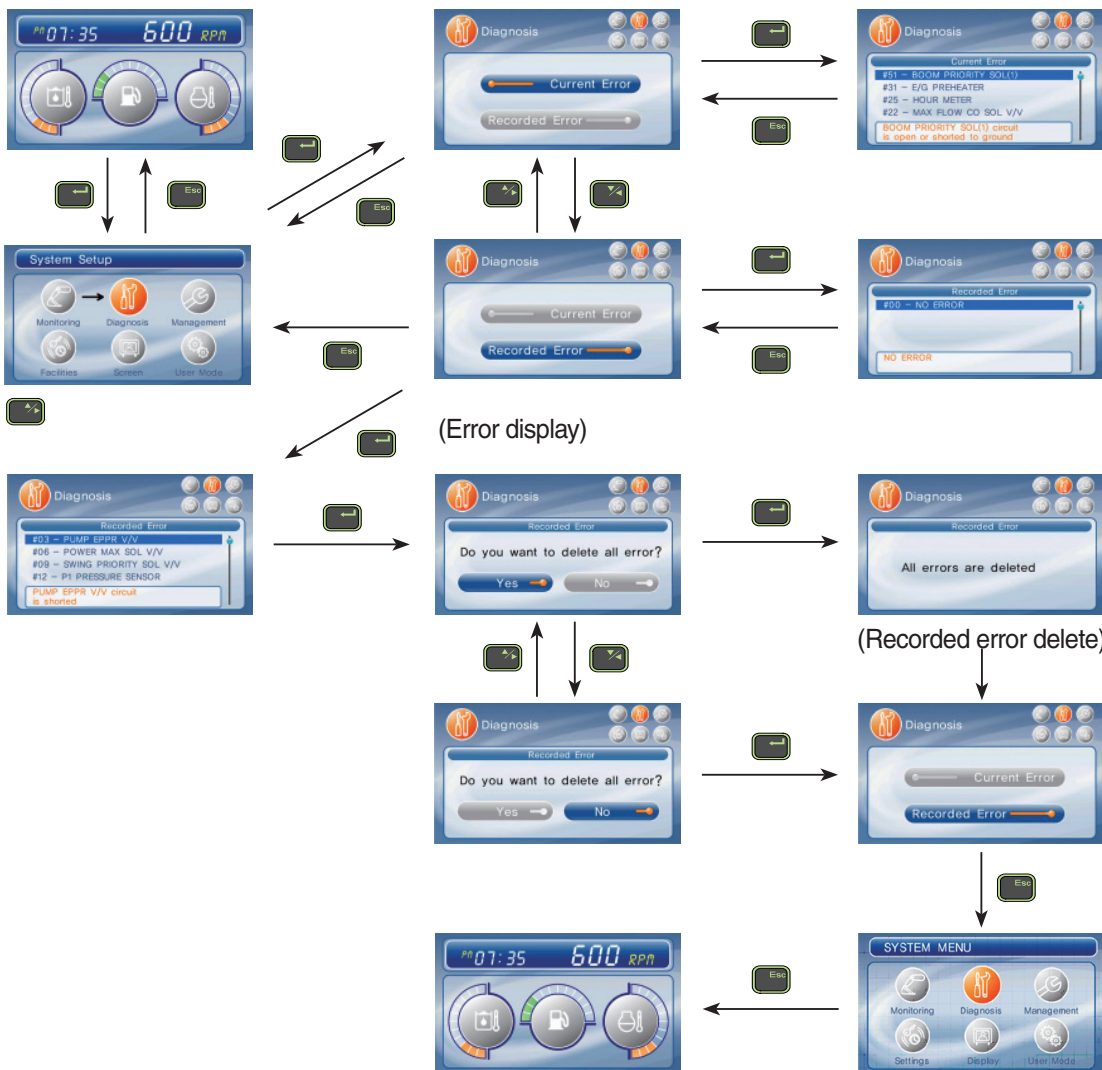
(2) Display map

① Monitoring



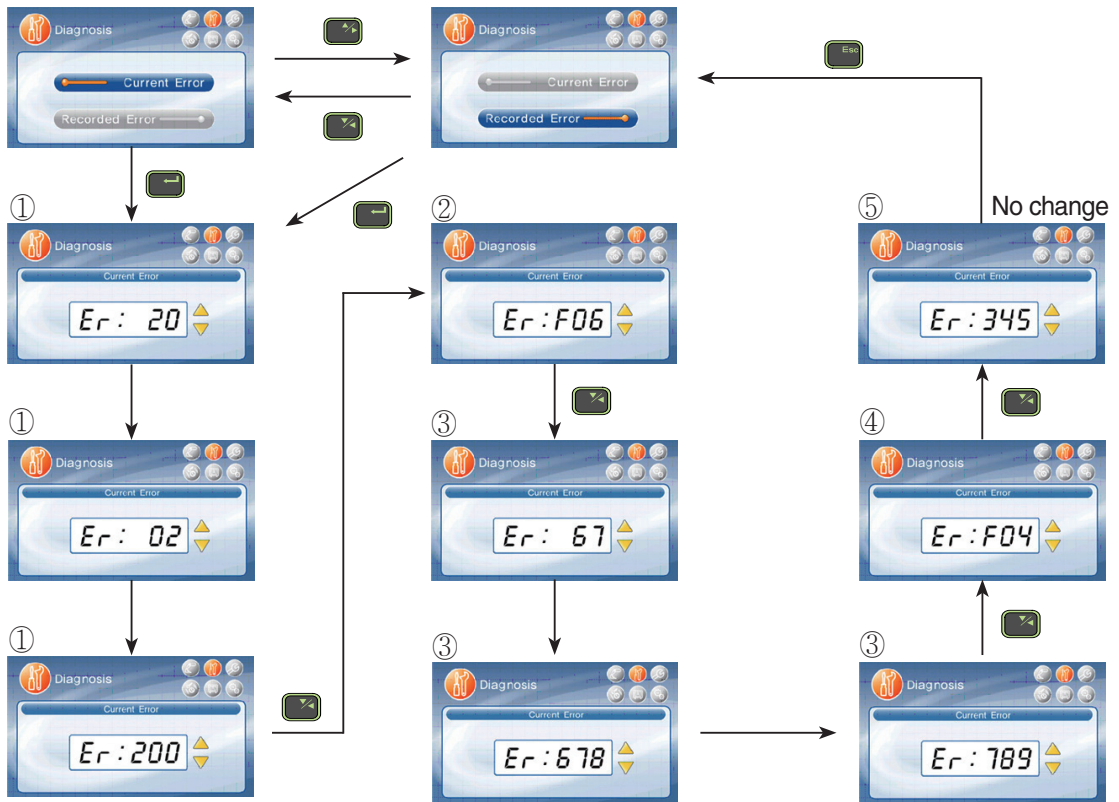
② Diagnosis

a. Protocol type 1

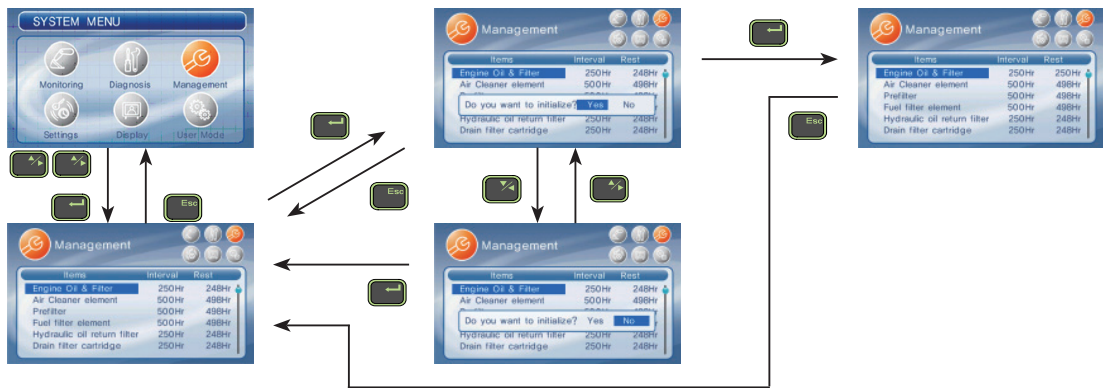


b. Protocol type 2

- If there are more than 2 error codes, each one can be displayed by pressing or switch respectively.
- 3 error codes (①SPN200200, ②FMI06, ③SPN6789, ④FMI04, ⑤345) display.

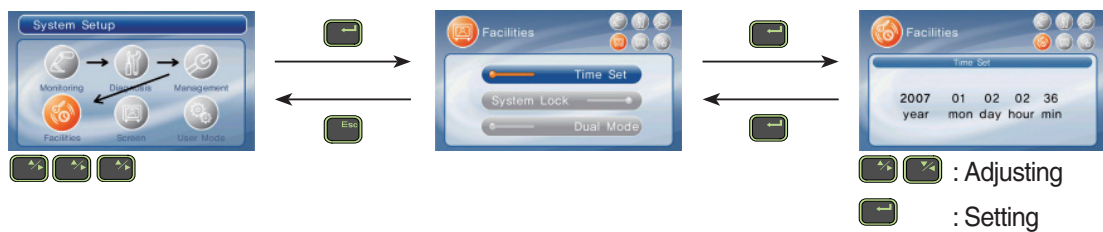


③ Maintenance



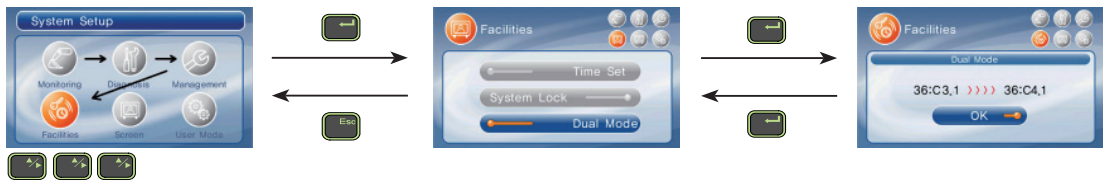
④ Setting

a. Time set



b. System lock - Reserved

c. Dual mode
- Changing the MCU mode

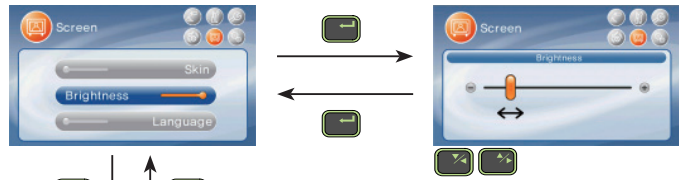


⑤ Display

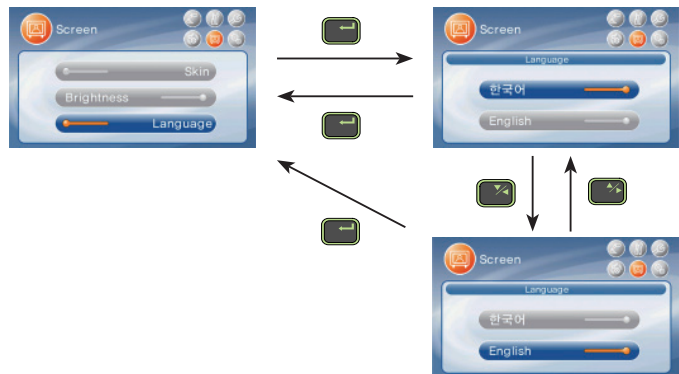
a. Operation skin



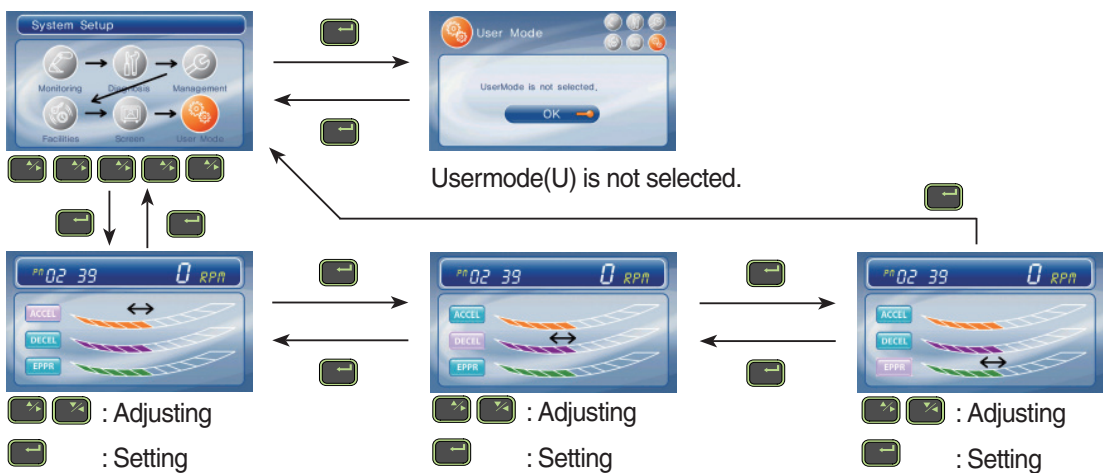
b. Brightness



c. Language

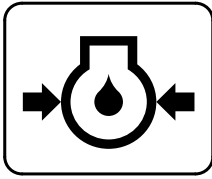


⑥ User mode



5) Warning and pilot lamp

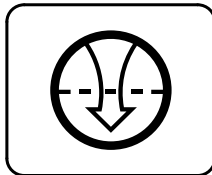
(1) Engine oil pressure warning lamp



21073CD07

- ① This lamp blinks and the buzzer sounds after starting the engine because of the low oil pressure.
- ② If the lamp blinks during engine operation, shut OFF engine immediately. Check oil level.

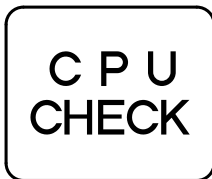
(2) Air cleaner warning lamp



21073CD08

- ① This lamp blinks and the buzzer sounds when the filter of air cleaner is clogged.
- ② Check the filter and clean or replace it.

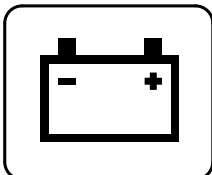
(3) CPU controller check warning lamp



21073CD10

- ① If any fault code is received from CPU controller, this lamp blinks and the buzzer sounds.
- ② Check the communication line between CPU controller and cluster.

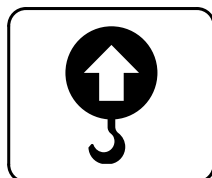
(4) Battery charging warning lamp



21073CD13

- ① This lamp blinks and the buzzer sounds when the starting switch is ON, it is turned OFF after starting the engine.
- ② Check the battery charging circuit when this lamp blinks during engine operation.

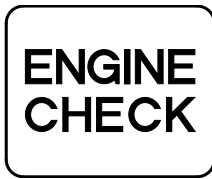
(5) Overload warning lamp



21073CD15

- ① When the machine is overload, the overload warning lamp blinks during the overload switch is ON.

(6) Engine check warning lamp



29073CD10

- ① This lamp blinks and the buzzer sounds when the communication between CPU controller and ECU on the engine is abnormal, or if any fault code received from ECU.
- ② Check the communication line between them.
If the communication line is OK, then check the fault code on the cluster

(7) Power max pilot lamp



21073CD11

- ① The lamp will be ON when pushing power max switch on the LH RCV lever.

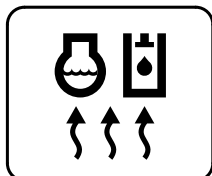
(8) Decel pilot lamp



21073CD17

- ① Operating auto decel or one touch decel makes the lamp ON.
- ② The lamp will be ON when pushing one touch decel switch on the LH RCV lever.

(9) Warming up pilot lamp



21073CD18

- ① This lamp is turned ON when the coolant temperature is below 30°C (86 °F).
- ② The automatic warming up is cancelled when the engine coolant temperature is above 30 °C, or when 10 minutes have passed since starting.

(10) Preheat pilot lamp



21073CD12

- ① Turning the start key switch ON position starts preheating in cold weather.
- ② Start the engine as this lamp is OFF.