GROUP 35E INDEX

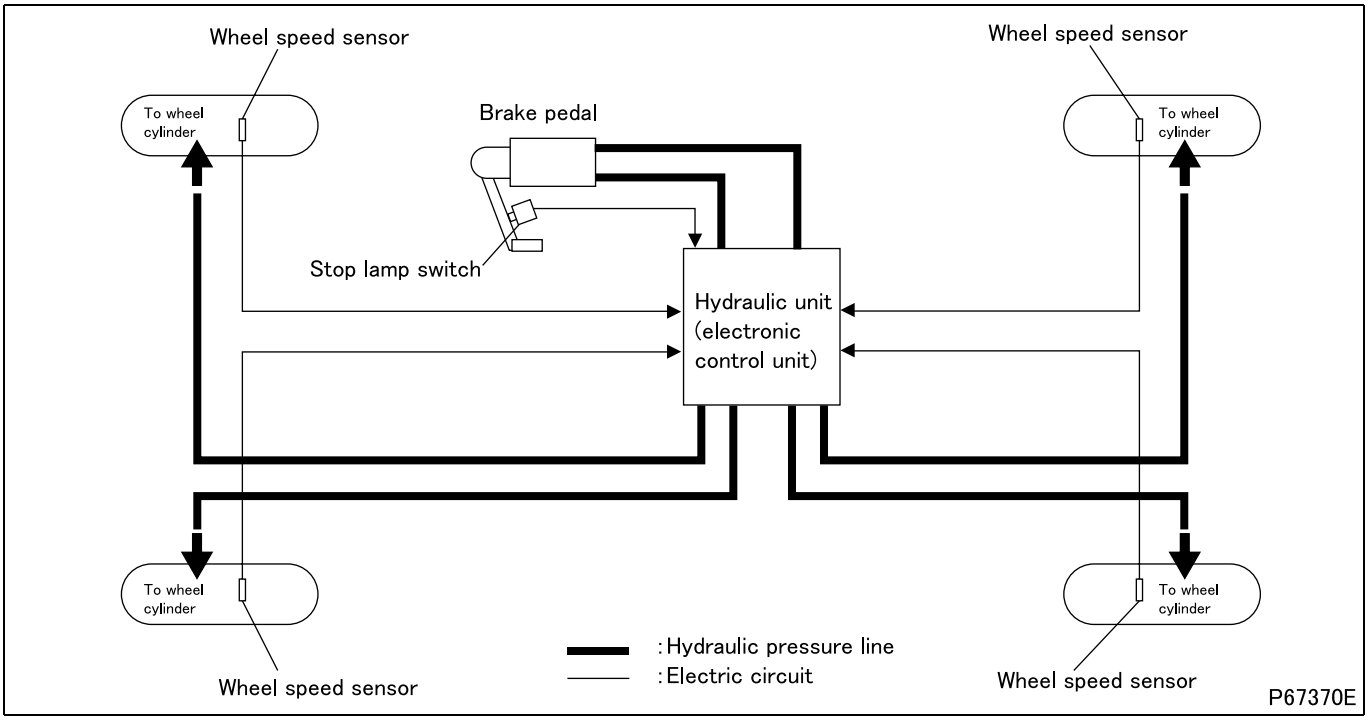
SPECIFICATIONS

Item			Specifications
Hydraulic unit (electronic control unit)	Manufacturer		ADVICS
	Rated voltage	V	DC12
	Working voltage range	V	DC10 to 18
*Wheel speed sensor	Manufacturer		SUMITOMO ELECTRIC Bosch

*Manufacturers of wheel speed sensor differ depending on the model of the brakes.

M E M O

1. Overview

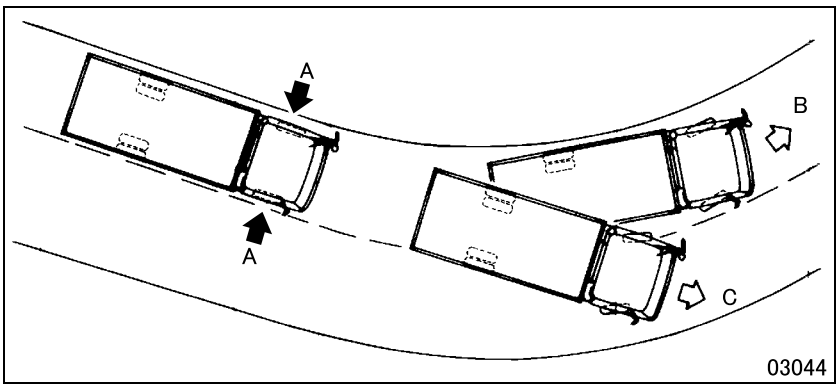


- The antilock brake system (ABS) prevents wheel lock-up and resultant skid when braking hard or on slippery roads, thus maintain vehicle stability and steerability.

1.1 Outline of antilock brake system

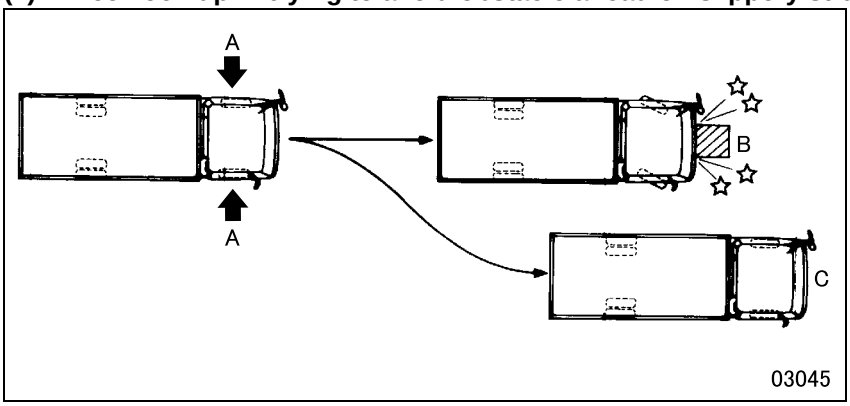
- Wheels will roll along on the road in the direction of their rotation. Therefore, the driver can steer the vehicle as he/she wishes by maneuvering the steering wheel.
  However, on vehicles not equipped with ABS, applying the brakes hard can cause wheel lock-up. Once tires are locked up, they are simply a piece of rubber in contact with the road surface and steering control will be lost. The vehicle will skid in the direction of inertia irrespective of the steering angle.
  In other words, vehicle stability and steerability are lost and the vehicle is beyond the driver's control.
- On vehicles equipped with antilock brake system, the system prevents wheel lock-up by reducing the braking power to the wheel that is about to lock up and, thereby, maintain vehicle stability and steerability.

(1) Wheel lock-up when cornering on slippery road



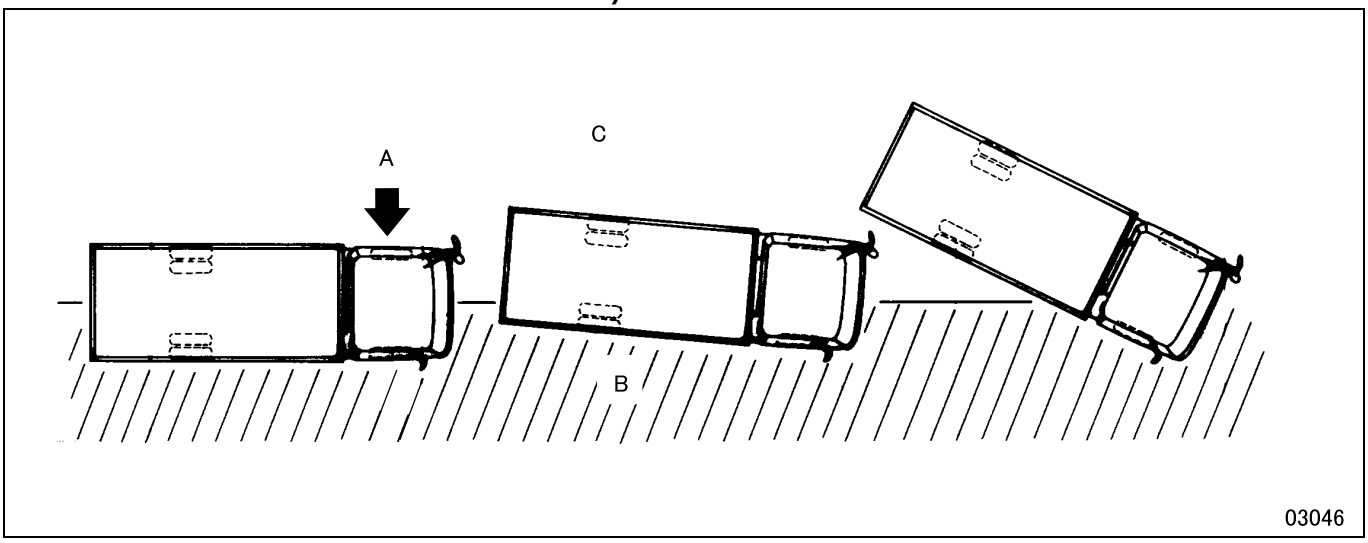
- If wheel lock-up occurs during braking on a slippery curve, steering control will be lost. If this happens, the vehicle may deviate, while skidding, from the intended course no matter how the driver maneuvers the steering wheel.
  - **A:** Application of brakes (wheel lock-up)
  - **B:** Intended course
  - **C:** Go out of course

(2) Wheel lock-up in trying to avoid obstacle ahead on slippery straight road



- If wheel lock-up occurs during hard braking on a slippery straight road in trying to avoid an obstacle ahead, steering control will be lost. If this happens, the vehicle will not be able to avoid the obstacle no matter how the driver maneuvers the steering wheel.
  - **A:** Application of brakes (wheel lock-up)
  - **B:** Obstacle
  - **C:** Intended course

(3) Split μ (Wheel lock-up on asymmetrical road surface, with higher friction of coefficient on one side and lower friction of coefficient on the other side)



- If the front and rear wheels on one side of the vehicle are on the side of the road that has a lower friction of coefficient and therefore is more slippery than the other side of the road, these wheels are more likely to lock up and slip than the wheels on the other side of the vehicle. When the brakes are applied under such conditions, the braking efficiency will be different between the right and left sides of the vehicle and the vehicle will lose stability. Braking hard under such conditions can even cause the vehicle to spin.
  - **A:** Application of brakes (wheel lock-up)
  - **B:** Less slippery road surface
  - **C:** More slippery road surface

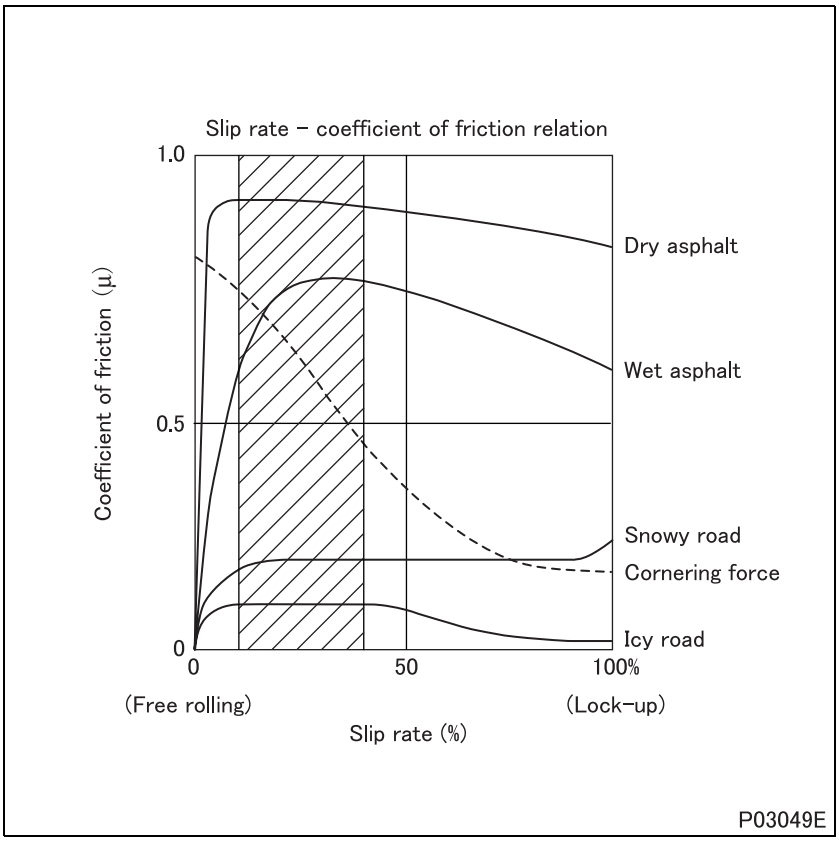
- As mentioned above, the system prevents wheel lock-up by providing controlled braking force to each wheel. This prevents wheel slip and skid and ensures steering control and vehicle stability even during hard braking.

1.2 Antilock brake system control process

- Antilock brake system ensures controlled yet optimum braking in a given road surface condition by placing the braking force within a certain range of slip rate determined by the wheel speed - vehicle speed relation.
- Stepping on the brake pedal causes the wheel speed to slow down and, as a result, the vehicle also slows down. However, the vehicle will still try to move on due to the inertia that has built up. This causes a difference between the wheel speed and the vehicle speed, or, in other words, slip. The amount of slip can be expressed as slip rate, as follows.

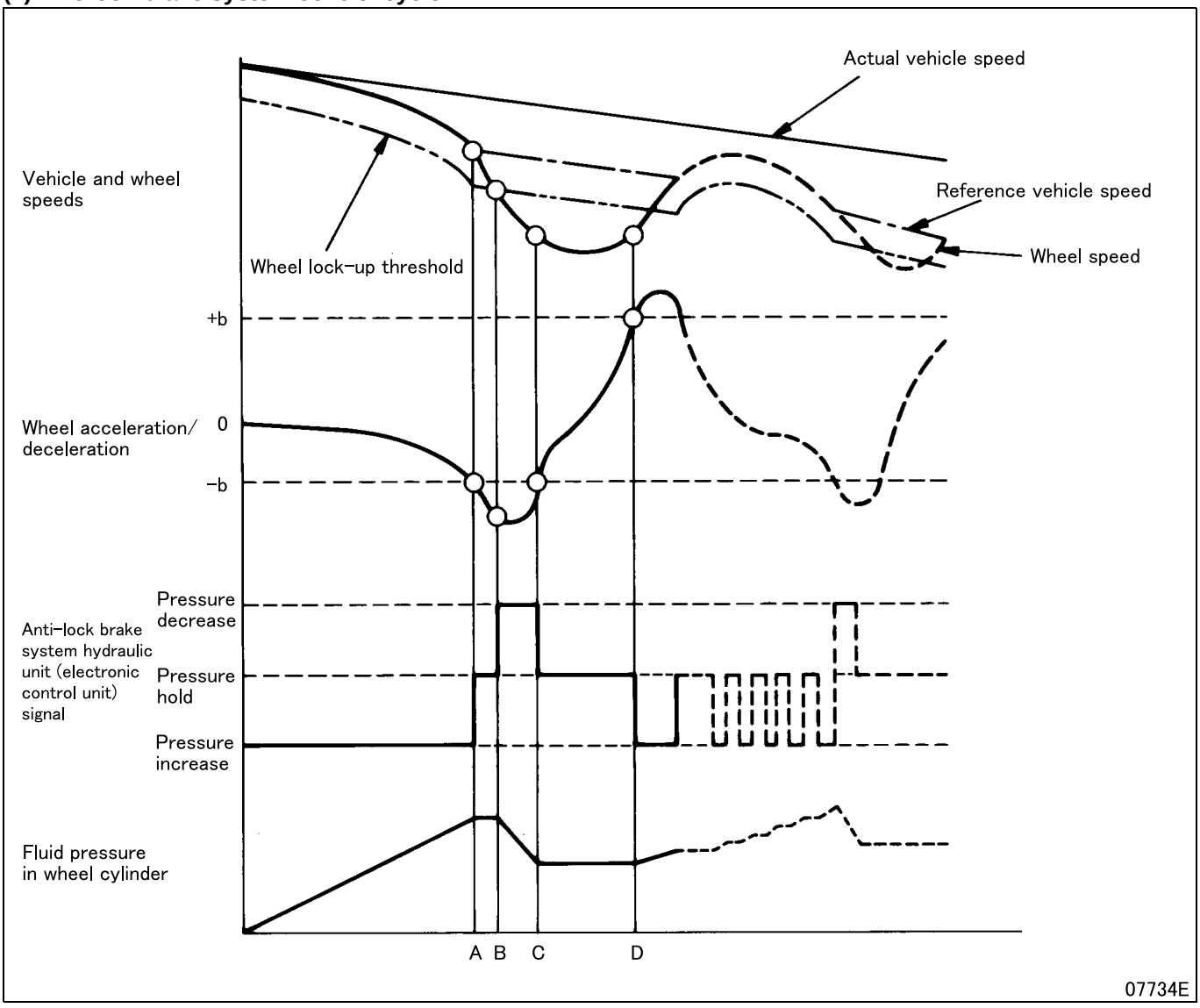
$$\text{Slip rate (\%)} = \frac{\text{Vehicle speed} - \text{Wheel speed}}{\text{Vehicle speed}} \times 100$$

- A slip ratio of 0% means that there is no slip between the wheel and the road surface. A slip rate of 100% means that the wheel is locked up.



- The graph shows the variation in the tire's coefficient of friction from free rolling to lock-up. As the brake pedal is slowly pressed, the tires continue to rotate but start slipping.
- As the stepping force on the brake pedal increases, the tires will stop rotating and the vehicle will just skid. This is wheel lock-up.
- As the graph shows, the coefficient of friction peaks within the hatched area.
- In other words, the maximum coefficient of friction can be achieved, not by stepping on the brake pedal with full force, but by doing so moderately to try to place the slip rate within the hatched area.
- On vehicles equipped with antilock brake system, the hydraulic control unit (electronic control unit) controls the braking force so that it falls within the hatched area. This will ensure that the tires do not lock up but have the maximum coefficient of friction, thus achieving efficient braking performance.

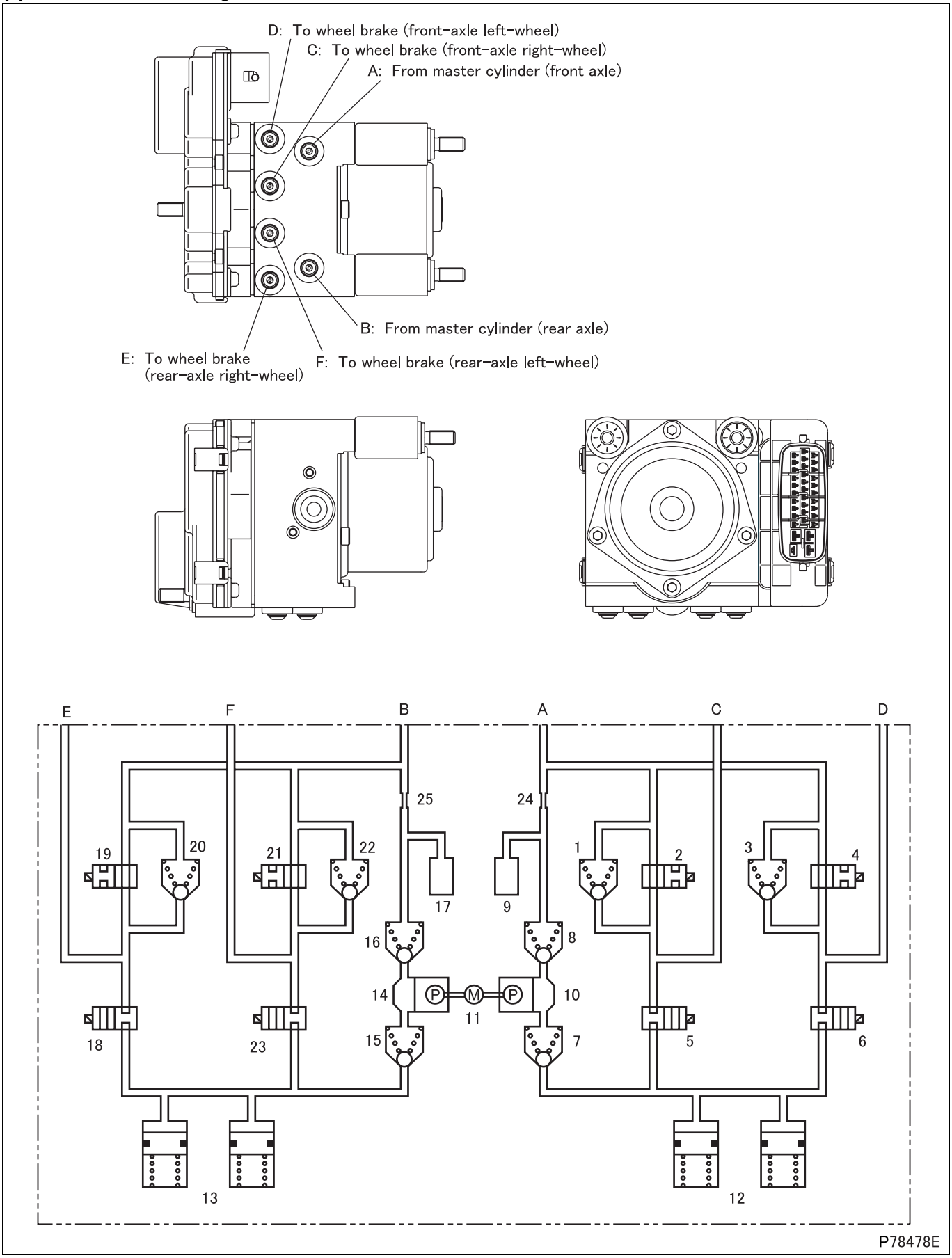
(1) Antilock brake system control cycle



- The above chart shows the typical control cycle of antilock brake system following the application of brakes, detailing in time series the variation in wheel speed, wheel speed acceleration/deceleration and fluid pressure in the wheel cylinder.
- When the wheel speed acceleration/deceleration drops to the "–b" threshold at A, the hydraulic unit (electronic control unit) sends "pressure hold" signal to maintain the fluid pressure in the wheel cylinder.
  At the same time, the hydraulic unit (electronic control unit) calculates the reference vehicle speed.
- When the vehicle decelerates to the wheel lock-up threshold at B, the hydraulic unit (electronic control unit) interprets this as imminent wheel lock-up and sends "pressure decrease" signal to reduce the fluid pressure in the wheel cylinder.
- When the wheel speed picks up and exceeds the "–b" threshold at C, the hydraulic unit (electronic control unit) sends "pressure hold" signal to maintain the fluid pressure in the wheel cylinder at the current level.
- When the wheel speed exceeds the "+b" threshold at D, the hydraulic unit (electronic control unit) determines that the imminent wheel lock-up has gone and sends "pressure increase" signal to increase the fluid pressure in the wheel cylinder.
- The pressure hold-decrease-increase cycle is repeated to keep the slip rate at optimum levels to prevent wheel lock-up.

1.3 Hydraulic unit (electronic control unit)

(1) Schematic circuit diagram



1 Check valve (front-axle right-wheel)
2 Solenoid valve (front-axle right-wheel HOLD)
3 Check valve (front-axle left-wheel)
4 Solenoid valve (front-axle left-wheel HOLD)
5 Solenoid valve (front-axle right-wheel DECREASE)
6 Solenoid valve (front-axle left-wheel DECREASE)
7 Inlet valve (front axle)
8 Outlet valve (front axle)
9 Damper (front axle)
10 Plunger pump (front axle)
11 Motor
12 Reservoir (front axle)
13 Reservoir (rear axle)
14 Plunger pump (rear axle)
15 Inlet valve (rear axle)
16 Outlet valve (rear axle)
17 Damper (rear axle)
18 Solenoid valve (rear-axle right-wheel DECREASE)
19 Solenoid valve (rear-axle left-wheel HOLD)
20 Check valve (rear-axle right-wheel)
21 Solenoid valve (rear-axle left-wheel HOLD)
22 Check valve (rear-axle left-wheel)
23 Solenoid valve (rear-axle left-wheel DECREASE)
24 Orifice (front axle)
25 Orifice (rear axle)

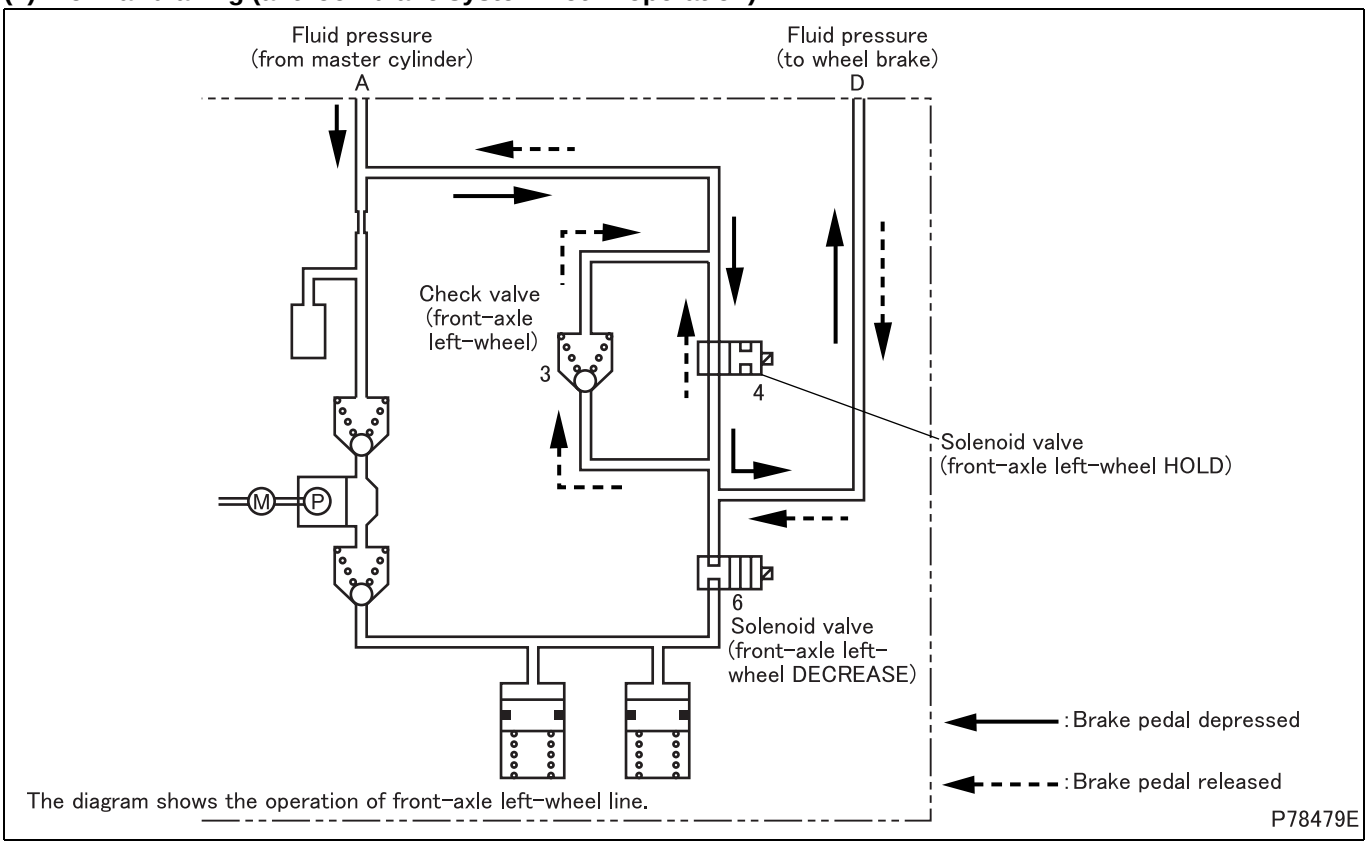
A: From master cylinder (front axle)
B: From master cylinder (rear axle)
C: To wheel brake (front-axle right-wheel)
D: To wheel brake (front-axle left-wheel)
E: To wheel brake (rear-axle right-wheel)
F: To wheel brake (rear-axle left-wheel)

- The hydraulic unit (electronic control unit) is the heart of antilock brake system control, energizing/de-energizing the solenoid valves and turning ON/OFF the motor. The table below shows how each solenoid valve and the motor are controlled in each phase.

		Antilock brake system control											
		Front-axle right-wheel			Front-axle left-wheel			Rear-axle right-wheel			Rear-axle left-wheel		
		DECREASE	HOLD	INCREASE	DECREASE	HOLD	INCREASE	DECREASE	HOLD	INCREASE	DECREASE	HOLD	INCREASE
Solenoid valve	Front-axle right-wheel DECREASE	O	×	×	–	–	–	–	–	–	–	–	–
	Front-axle right-wheel HOLD	O	O	×	–	–	–	–	–	–	–	–	–
	Front-axle left-wheel DECREASE	–	–	–	O	×	×	–	–	–	–	–	–
	Front-axle left-wheel HOLD	–	–	–	O	O	×	–	–	–	–	–	–
	Rear-axle right-wheel DECREASE	–	–	–	–	–	–	O	×	×	–	–	–
	Rear-axle right-wheel HOLD	–	–	–	–	–	–	O	O	×	–	–	–
	Rear-axle left-wheel DECREASE	–	–	–	–	–	–	–	–	–	O	×	×
	Rear-axle left-wheel HOLD	–	–	–	–	–	–	–	–	–	O	O	×
Motor		O											

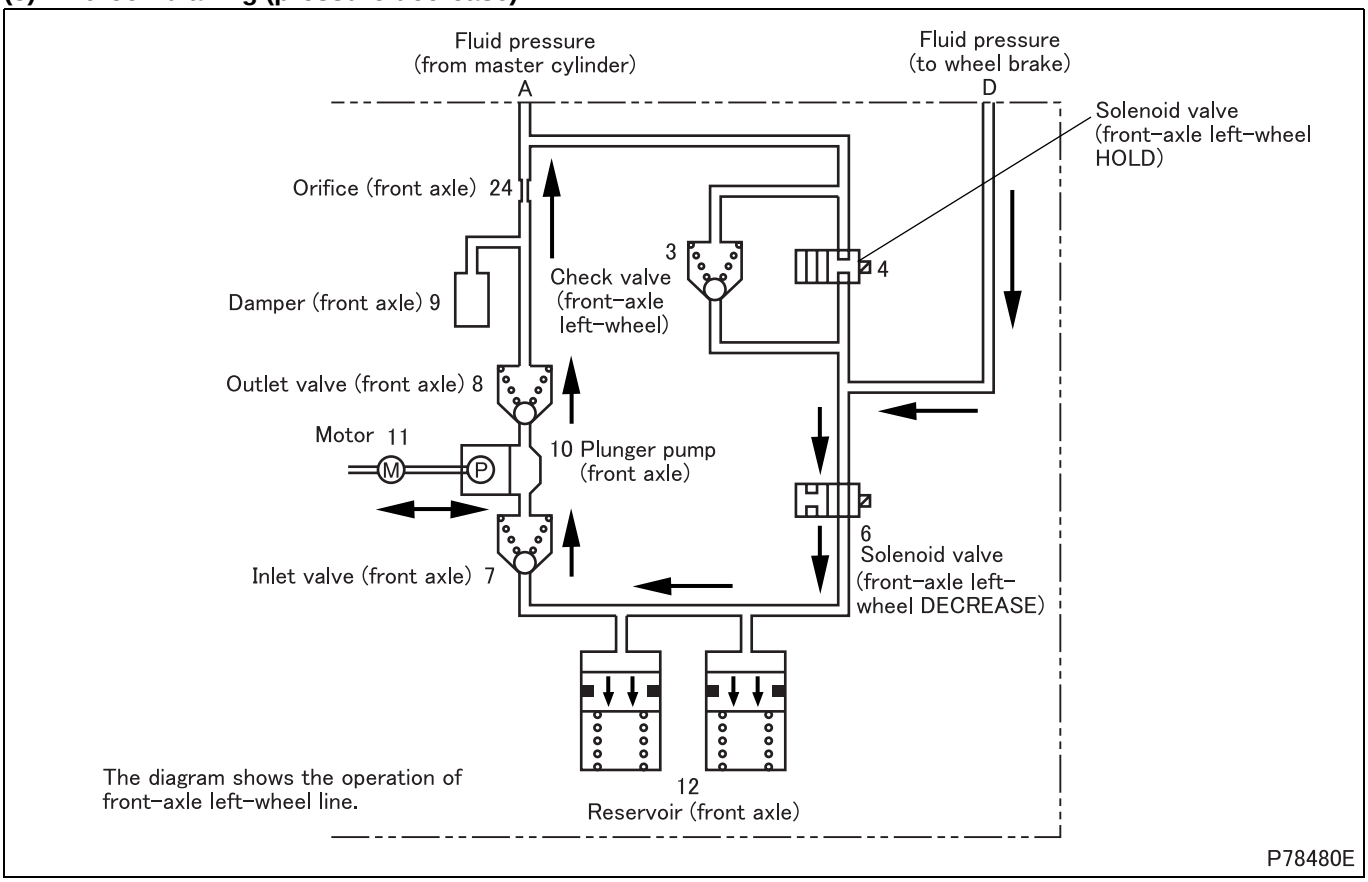
O: On
×: OFF

(2) Normal braking (antilock brake system not in operation)



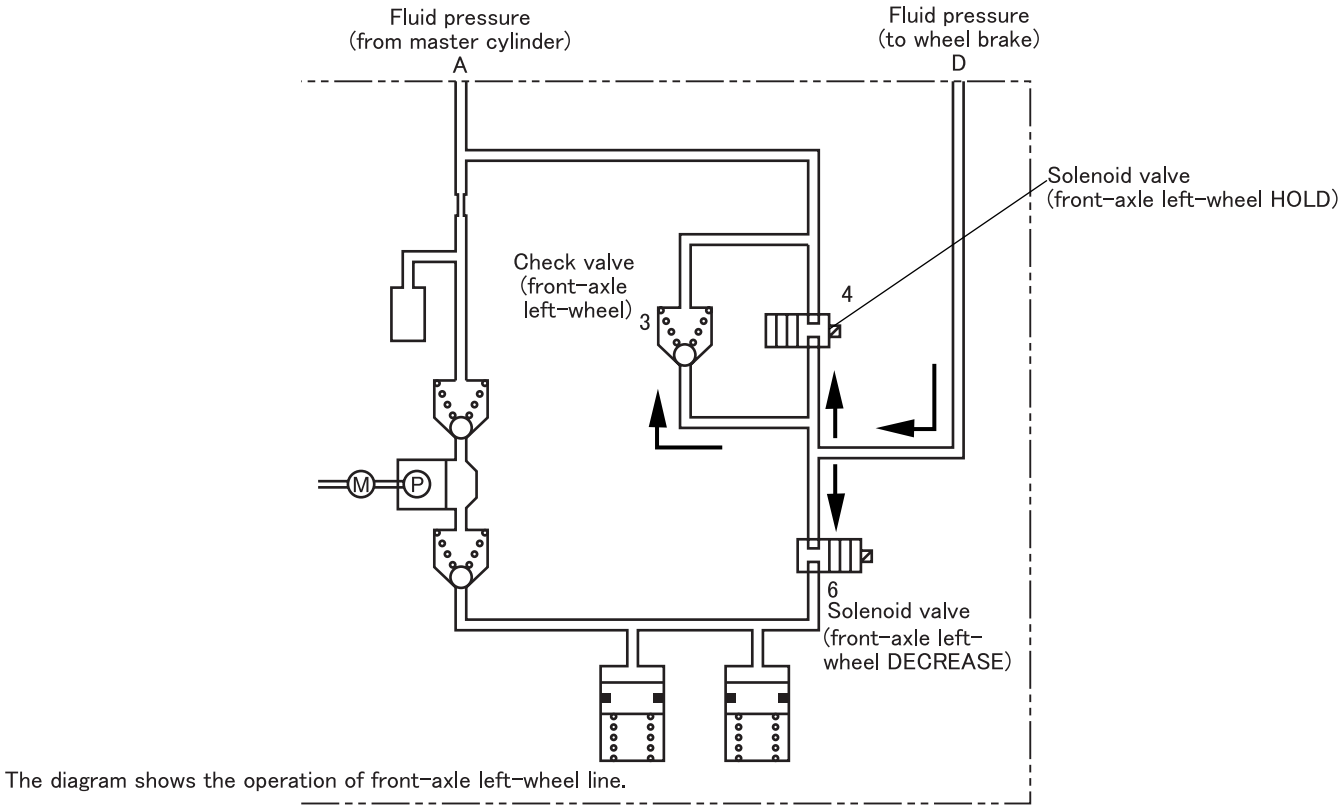
- When the brake pedal is pressed and there is no imminent wheel lock-up, the hydraulic unit (electronic control unit) will not send any control signal to the solenoid valve (front-axle left-wheel DECREASE) or to the solenoid valve (front-axle left-wheel HOLD). The former valve remains closed while the latter valve stays open.
- Pressure fluid **A** from the brake master cylinder flows past the solenoid valve (front-axle left-wheel HOLD) and to the wheel brake **D**.
- When the brake pedal is released, pressure fluid **A** from the brake master cylinder drops. Pressure fluid from the wheel brake **D** now flows past the solenoid valve (front-axle left-wheel HOLD) and the check valve (front-axle left-wheel) and returns to the brake master cylinder.

(3) Antilock braking (pressure decrease)



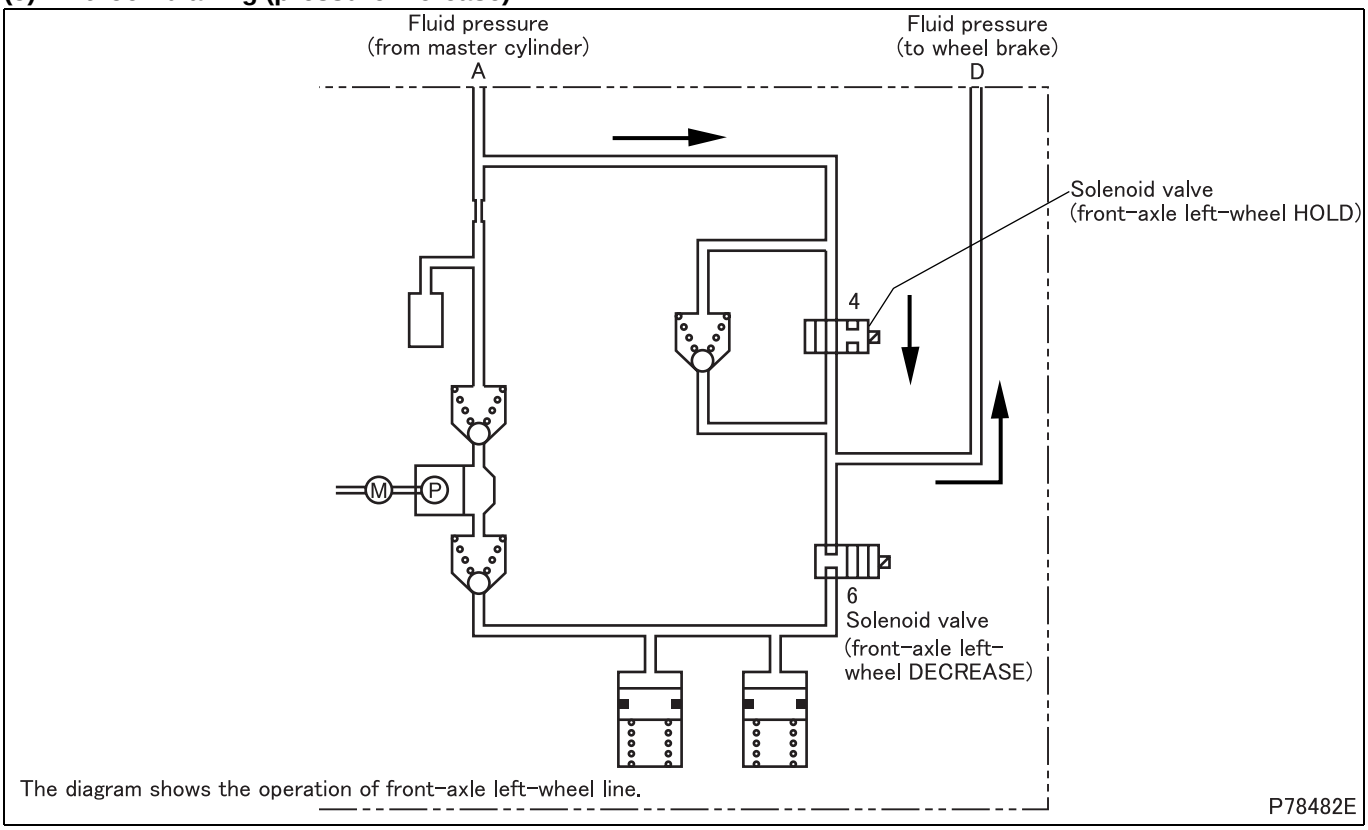
- When the brake pedal is pressed and there is imminent wheel lock-up, the hydraulic unit (electronic control unit) sends control signal to the solenoid valve (front-axle left-wheel DECREASE) and the solenoid valve (front-axle left-wheel HOLD). The former valve will open while the latter valve will close.
- Pressure fluid form the wheel brake **D** now flows past the solenoid valve (front-axle left-wheel DECREASE) and to the reservoirs. The line pressure will drop.
- When the hydraulic unit (electronic control unit) sends control signal to the solenoid valve (front-axle left-wheel DECREASE) and the solenoid valve (front-axle left-wheel HOLD), it also sends control signal to the motor at the same time, causing the plunger pump (front axle) to start pumping. Pressure fluid in the reservoirs now flows past the inlet valve (front axle), the outlet valve (front axle), the damper (front axle) and the orifice (front axle) and returns to the master cylinder.
- During this process, the check valve (front-axle left-wheel) remains closed by the fluid pressure **A** from the brake master cylinder. As a result, no pressure fluid from the master cylinder flows to the wheel brake.

(4) Antilock braking (pressure hold)



- When it becomes necessary to hold the fluid pressure **D** in the wheel brake at the same level as part of antilock brake system control, the hydraulic unit (electronic control unit) sends “HOLD” signal to the solenoid valve (front-axle left-wheel HOLD). As a result, both of the solenoid valve (front-axle left-wheel HOLD) and the solenoid valve (front-axle left-wheel DECREASE) will be closed, which holds the fluid pressure in the wheel brake at the current level.
- The check valve (front-axle left-wheel) remains closed by the fluid pressure **A** from the brake master cylinder.

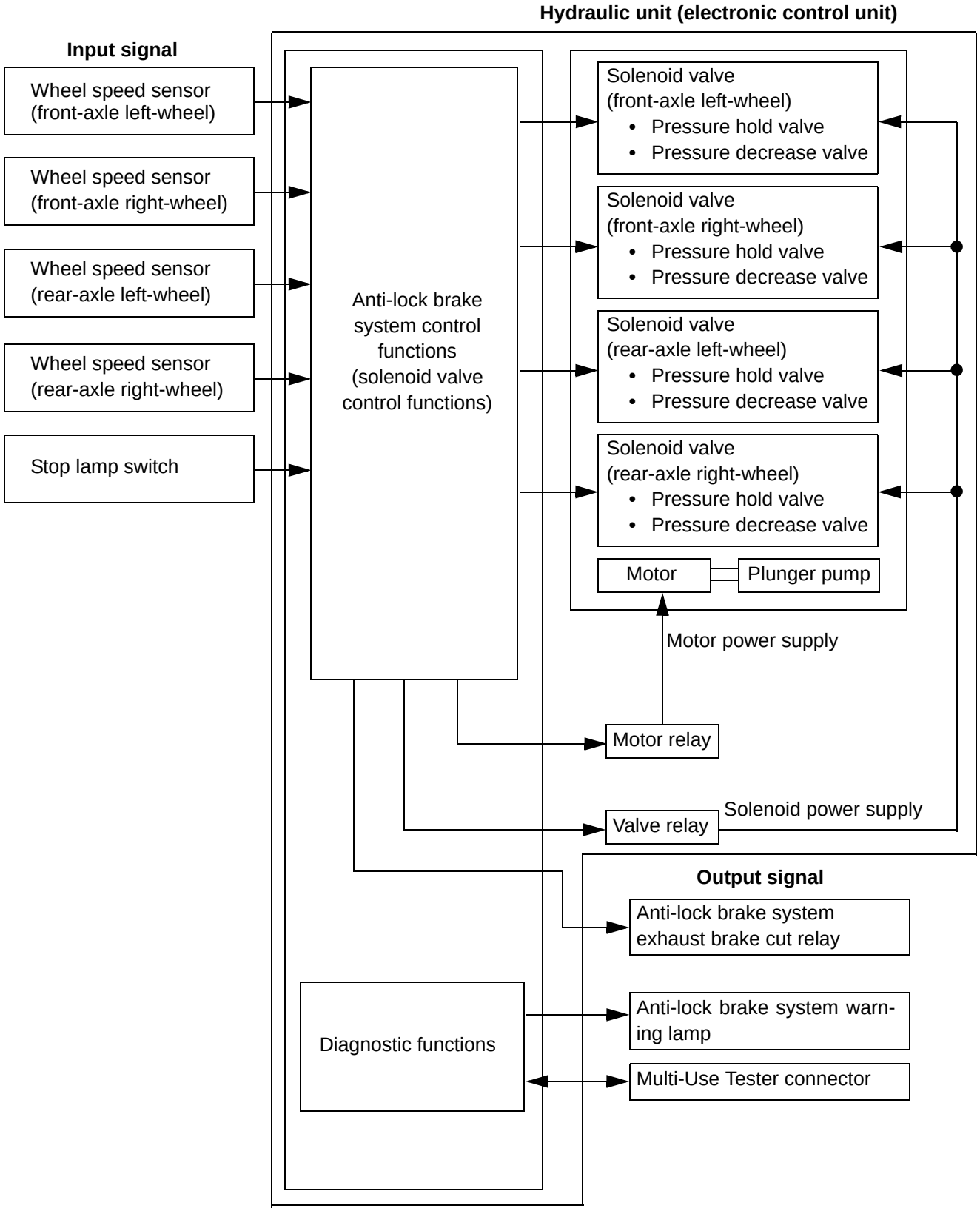
(5) Antilock braking (pressure increase)



- When it becomes necessary to increase the fluid pressure **D** in the wheel brake, control signal from the hydraulic unit (electronic control unit) to the solenoid valve (front-axle left-wheel HOLD) and to the solenoid valve (front-axle left-wheel DECREASE) will be cut off.
- As a result, the solenoid valve (front-axle left-wheel HOLD) will open while the solenoid valve (front-axle left-wheel DECREASE) will close. Both valves are now in their normal-braking positions. Fluid pressure **A** being generated by the depression of the brake pedal is now applied to the wheel brake to increase the braking force.

2. Electronic Control System

2.1 Block diagram



Part	Primary function or operation
Wheel speed sensor	Senses wheel speed
Brake light switch	Senses the depression of brake pedal
Antilock brake system exhaust brake cut relay	Cuts off exhaust brake in antilock braking mode
ABS warning (diagnostic light)	Displays antilock brake system faults; Performs system check
Multi-Use Tester connector	Communicates with Multi-Use Tester; Displays/Clears diagnosis codes

2.2 Antilock brake system control functions

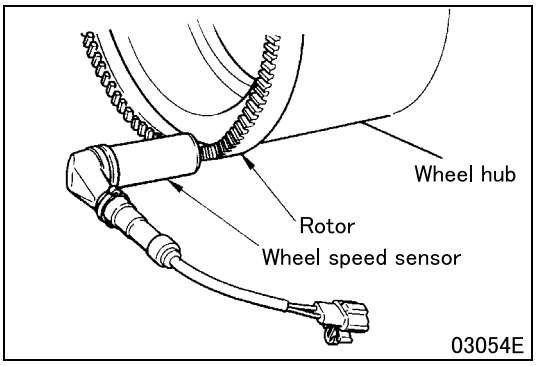
- The hydraulic unit (electronic control unit) continuously monitors signals from the wheel speed sensors. The unit sends signal to solenoid valves.

(1) Antilock brake system fail-safe

- If any fault occurs in the antilock brake system, the warning light comes on to warn the driver of the fault and the normal braking will resume in place of the antilock braking which will be disabled.

(2) Antilock brake system and exhaust brake

- On slippery roads, wheel lock-up can result even from application of the exhaust brake. In the antilock braking mode, activation of the exhaust brake makes it difficult for antilock brake system to perform controlled braking.
  To avoid this, the exhaust brake will be disabled upon activation of antilock brake system even when the exhaust brake switch is in the “ON” position.
  The exhaust brake will automatically be enabled upon deactivation of antilock brake system.



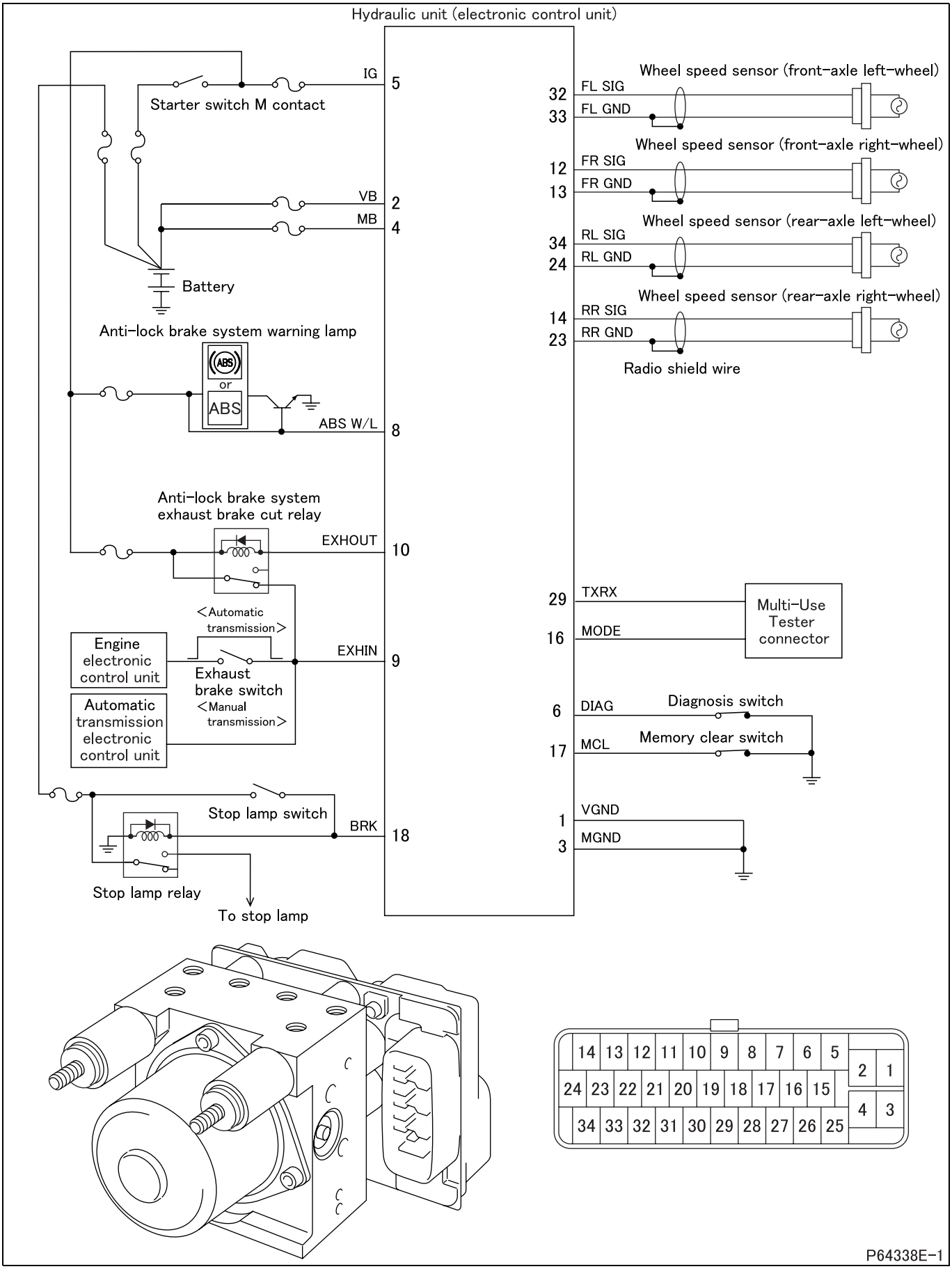
(3) Wheel speed sensor

- Each wheel speed sensor detects wheel speed and sends this as a signal to the hydraulic unit (electronic control unit). The sensor is essentially a magnetic pickup unit, consisting of a permanent magnet core and a coil of wire wound around the core.
- A rotor is fitted onto the wheel hub. This rotor, like a ring gear, has a set of evenly-spaced teeth directly facing the sensor. As the wheel rotates, these teeth pass through the magnetic flux of the sensor, inducing potential difference in the coil which is then sent as a signal (alternating voltage proportional to the wheel speed) to the hydraulic unit (electronic control unit).

2.3 Diagnostic functions

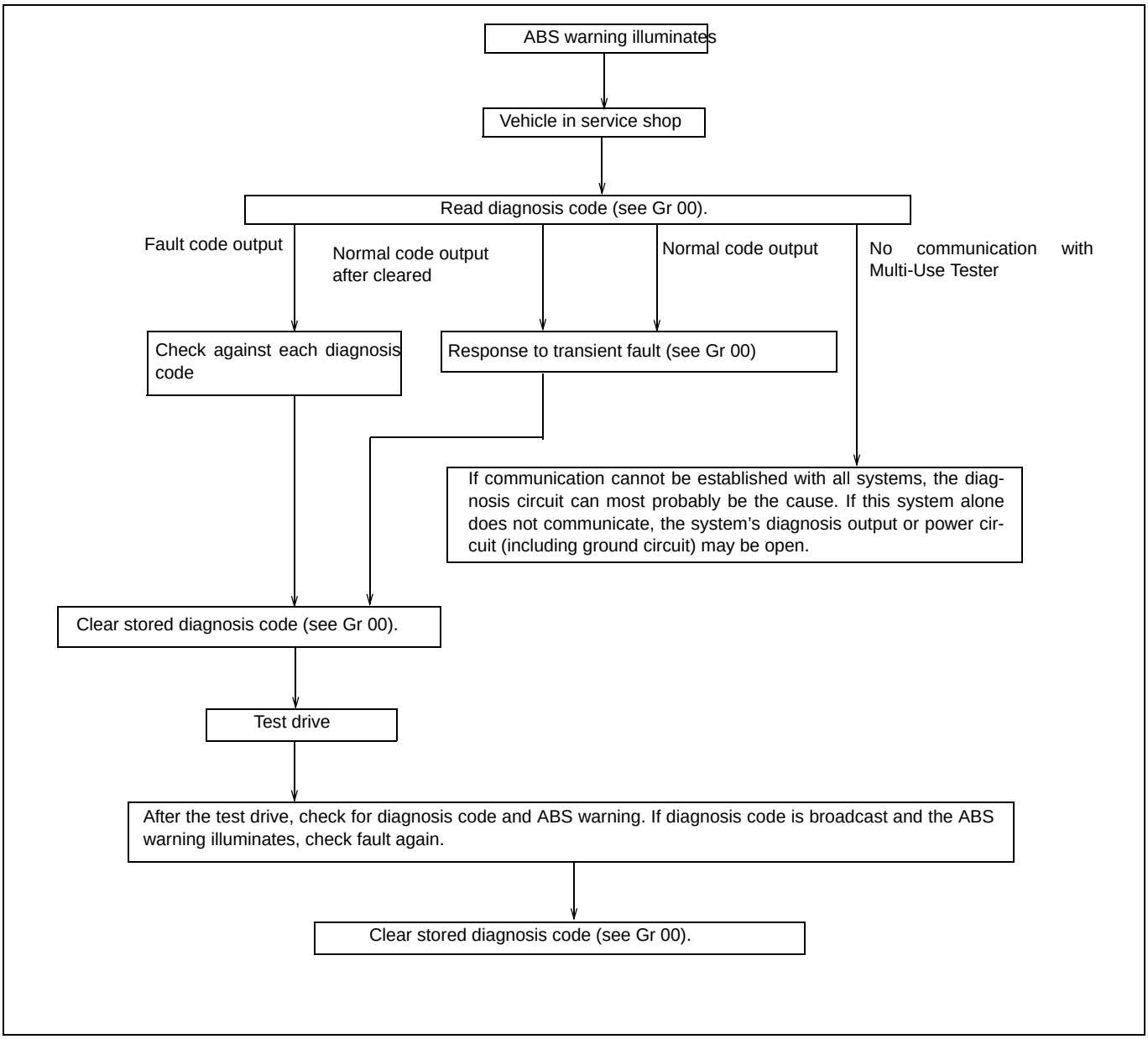
- When the ignition switch is in the ON position, the system continuously monitors the sensors and other system components. If any fault is detected, the system warns the driver of this by displaying the relevant fault information on the meter cluster. At the same time, the system also stores a relevant diagnosis code in the memory and starts operation in the fault mode.
- In the fault-mode operation, the system functions are limited to ensure safety for the driver and the vehicle. Stored diagnosis codes can be accessed using Multi-Use Tester or can be read by observing the flashing of the diagnostic light.

3. Electronic Control Unit Schematic Diagram



1. Diagnosis Procedure

- The system can be efficiently inspected for faults using a Multi-Use Tester.
  System inspection can be accomplished basically in two ways according to trouble symptom and diagnosis code as shown below.
  - Check against each diagnosis code stored in memory by the electronic control unit
  - Response to transient fault



2. Diagnostic Precautions

- Before measuring voltage, check the battery for charged condition and specific gravity. If system inspection is performed with the battery uncharged or reduced in specific gravity, accurate measurements cannot be achieved.
- To avoid having electrical parts damaged, set the ignition switch and headlight switch to LOCK or OFF before disconnecting and reconnecting battery cables.
- Before disconnecting connectors, set the ignition switch to LOCK or OFF, then allow at least 20 seconds. Voltage may remain in electric parts or connected circuit.
- When performing measurement with the tester, handle the test bar carefully so that it does not damage internal circuit and other electrical parts of the electronic control unit to result in a short-circuit failure between terminals in connector or between connector and car body.
- Resistance is affected by temperature. Determine the necessity of resistance measurement following given temperature specification as a guide. Otherwise, use normal temperature (10 to 35°C {50 to 95°F}) as the measuring condition.

3. Diagnosis Based on Diagnosis Codes

3.1 List of diagnosis codes

Code	Message	Warning lamp indication
11	FR SENSOR	O
12	FL SENSOR	O
13	RR SENSOR	O
14	RL SENSOR	O
21	FR SENSOR SIG	O
22	FL SENSOR SIG	O
23	RR SENSOR SIG	O
24	RL SENSOR SIG	O
31	BATT VOLT ERR	O
35	EXB CUT RLY	O
41	FR VALVE	O
42	FL VALVE	O
43	RR VALVE	O
44	RL VALVE	O
51	VALVE RLY	O
52	MOTOR RLY	O
53	MOTOR ERR	O
61	ECU ID ERR	O
63	ECU ERR	O
64	ILLEGAL WHEEL	O
65	LONG ABS	O

3.2 Code generation criteria and inspection items

11: FR SENSOR

Code generation criteria		Wheel speed sensor resistance out of range
Resettability		System resets when normal resistance is detected after ignition switch OFF → ON.
Electronic control unit control		Antilock brake system disabled
Inspection item	Service data	11: FR SPEED
	Electronic control unit connector	01: Wheel speed sensor
	Electrical part	#329: Wheel speed sensor
	Wiring diagram	Wheel speed sensor circuit

12: FL SENSOR

Code generation criteria		Wheel speed sensor resistance out of range
Resettability		System resets when normal resistance is detected after ignition switch OFF → ON.
Electronic control unit control		Antilock brake system disabled
Inspection item	Service data	12: FL SPEED
	Electronic control unit connector	01: Wheel speed sensor
	Electrical part	#329: Wheel speed sensor
	Wiring diagram	Wheel speed sensor circuit

13: RR SENSOR

Code generation criteria		Wheel speed sensor resistance out of range
Resettability		System resets when normal resistance is detected after ignition switch OFF → ON.
Electronic control unit control		Antilock brake system disabled
Inspection item	Service data	13: RR SPEED
	Electronic control unit connector	01: Wheel speed sensor
	Electrical part	#329: Wheel speed sensor
	Wiring diagram	Wheel speed sensor circuit

14: RL SENSOR

Code generation criteria		Wheel speed sensor resistance out of range
Resettability		System resets when normal resistance is detected after ignition switch OFF → ON.
Electronic control unit control		Antilock brake system disabled
Inspection item	Service data	14: RL SPEED
	Electronic control unit connector	01: Wheel speed sensor
	Electrical part	#329: Wheel speed sensor
	Wiring diagram	Wheel speed sensor circuit

21: FR SENSOR SIG

Code generation criteria		When driving off, no wheel speed sensor output or abrupt change in wheel speed sensor output
Resettability		System resets upon normal signal input after ignition switch OFF → ON
Electronic control unit control		Antilock brake system disabled
Inspection item	Service data	11: FR SPEED
	Electrical part	#329: Wheel speed sensor
	Wiring diagram	Wheel speed sensor circuit
	Other	• Inspect rotor (See Gr26.) • Incorrectly installed wheel speed sensor

22: FL SENSOR SIG

Code generation criteria		When driving off, no wheel speed sensor output or abrupt change in wheel speed sensor output
Resettability		System resets upon normal signal input after ignition switch OFF → ON
Electronic control unit control		Antilock brake system disabled
Inspection item	Service data	12: FL SPEED
	Electrical part	#329: Wheel speed sensor
	Wiring diagram	Wheel speed sensor circuit
	Other	• Inspect rotor (See Gr26.) • Incorrectly installed wheel speed sensor

23: RR SENSOR SIG

Code generation criteria		When driving off, no wheel speed sensor output or abrupt change in wheel speed sensor output
Resettability		System resets upon normal signal input after ignition switch OFF → ON
Electronic control unit control		Antilock brake system disabled
Inspection item	Service data	13: RR SPEED
	Electrical part	#329: Wheel speed sensor
	Wiring diagram	Wheel speed sensor circuit
	Other	• Inspect rotor (See Gr27.) • Incorrectly installed wheel speed sensor

24: RL SENSOR SIG

Code generation criteria		When driving off, no wheel speed sensor output or abrupt change in wheel speed sensor output
Resettability		System resets upon normal signal input after ignition switch OFF → ON
Electronic control unit control		Antilock brake system disabled
Inspection item	Service data	14: RL SPEED
	Electrical part	#329: Wheel speed sensor
	Wiring diagram	Wheel speed sensor circuit
	Other	• Inspect rotor (See Gr27.) • Incorrectly installed wheel speed sensor

31: BATT VOLT ERR

Code generation criteria		Electronic control unit power-supply terminal voltage out of range
Resettability		Normal signal with ignition switch in the ON position
Electronic control unit control		Antilock brake system enabled
Inspection item	Service data	15: BATT VOLTAGE
	Electronic control unit connector	02: Electronic control unit power-supply voltage
	Wiring diagram	Electronic control unit power supply circuit

35: EXB CUT RLY

Code generation criteria		Antilock brake system exhaust brake cut relay monitor terminal voltage out of range
Resettability		Normal signal after ignition switch OFF → ON (re-energize electronic control unit)
Electronic control unit control		Exhaust brake control disabled (no exhaust brake cut while antilock brake system is operating)
Inspection item	Service data	22: EXB CUT RLY, 23: EXB MONITOR
	Actuator test	22: EXB RLY ON
	Electronic control unit connector	03: Antilock brake system exhaust brake cut relay
	Electrical part	#201: Antilock brake system exhaust brake cut relay
	Wiring diagram	Antilock brake system exhaust brake cut relay circuit

41: FR VALVE

Code generation criteria		Solenoid valve terminal voltage out of range
Resettability		Normal signal after ignition switch OFF → ON (re-energize electronic control unit)
Electronic control unit control		Antilock brake system enabled
Inspection item	Service data	15: BATT VOLTAGE
	Electronic control unit connector	02: Electronic control unit power-supply voltage
	Wiring diagram	Electronic control unit power-supply circuit
	Other	Clear memory and re-energize. If system still does not reset when driving at 10km/h or above, replace hydraulic unit (electronic control unit).

42: FL VALVE

Code generation criteria		Solenoid valve terminal voltage out of range
Resettability		Normal signal after ignition switch OFF → ON (re-energize electronic control unit)
Electronic control unit control		Antilock brake system enabled
Inspection item	Service data	15: BATT VOLTAGE
	Electronic control unit connector	02: Electronic control unit power-supply voltage
	Wiring diagram	Electronic control unit power-supply circuit
	Other	Clear memory and re-energize. If system still does not reset when driving at 10km/h or above, replace hydraulic unit (electronic control unit).

43: RR VALVE

Code generation criteria		Solenoid valve terminal voltage out of range
Resettability		Normal signal after ignition switch OFF → ON (re-energize electronic control unit)
Electronic control unit control		Antilock brake system enabled
Inspection item	Service data	15: BATT VOLTAGE
	Electronic control unit connector	02: Electronic control unit power-supply voltage
	Wiring diagram	Electronic control unit power-supply circuit
	Other	Clear memory and re-energize. If system still does not reset when driving at 10km/h or above, replace hydraulic unit (electronic control unit).

44: RL VALVE

Code generation criteria		Solenoid valve terminal voltage out of range
Resettability		Normal signal after ignition switch OFF → ON (re-energize electronic control unit)
Electronic control unit control		Antilock brake system enabled
Inspection item	Service data	15: BATT VOLTAGE
	Electronic control unit connector	02: Electronic control unit power-supply voltage
	Wiring diagram	Electronic control unit power-supply circuit
	Other	Clear memory and re-energize. If system still does not reset when driving at 10km/h or above, replace hydraulic unit (electronic control unit).

51: VALVE RLY

Code generation criteria		Terminal voltage of valve relay in electronic control unit out of range
Resettability		Normal signal after ignition switch OFF → ON (re-energize electronic control unit)
Electronic control unit control		Antilock brake system enabled
Inspection item	Service data	15: BATT VOLTAGE
	Electronic control unit connector	02: Electronic control unit power-supply voltage
	Wiring diagram	Electronic control unit power-supply circuit
	Other	Clear memory and re-energize. If system still does not reset when driving at 10km/h or above, replace hydraulic unit (electronic control unit).

52: MOTOR RLY

Code generation criteria		Terminal voltage of motor relay in electronic control unit out of range
Resettability		Normal signal after ignition switch OFF → ON (re-energize electronic control unit)
Electronic control unit control		Antilock brake system enabled
Inspection item	Service data	32: MOTOR RLY
	Actuator test	21: ABS MOTOR ON
	Electronic control unit connector	02: Electronic control unit power-supply voltage
	Wiring diagram	Electronic control unit power-supply circuit

53: MOTOR ERR

Code generation criteria		Motor terminal voltage out of range
Resettability		Normal signal after ignition switch OFF → ON (re-energize electronic control unit)
Electronic control unit control		Antilock brake system enabled
Inspection item	Wiring diagram	Electronic control unit power-supply circuit
	Other	Clear memory and re-energize. If system still does not reset when driving at 10km/h or above, replace hydraulic unit (electronic control unit).

61: ECU ID ERR

Code generation criteria		Wiring incorrect for vehicle system
Resettability		Normal signal after ignition switch OFF → ON (re-energize electronic control unit)
Electronic control unit control		Antilock brake system enabled
Inspection item	Electronic control unit connector	04: Configuration check
	Wiring diagram	Antilock brake system EXB cut relay circuit

63: ECU ERR

Code generation criteria		Electronic control unit internal fault
Resettability		Normal signal after ignition switch OFF → ON (re-energize electronic control unit)
Electronic control unit control		Antilock brake system enabled
Other		Clear memory and re-energize. If system still does not reset, replace hydraulic unit (electronic control unit).

64: ILLEGAL WHEEL

Code generation criteria		At 30 km/h {18.6 mph} or above, difference in output signal between wheel speed sensors exceeds the limit. (The difference should be less than 20% between front and rear wheel speed sensors and less than 10% between left and right wheel speed sensors.)
Resettability		Normal signal after ignition switch OFF → ON (re-energize electronic control unit)
Electronic control unit control		Antilock brake system disabled
Inspection item	Service data	11: FR SPEED, 12: FL SPEED, 13: RR SPEED, 14: RL SPEED * Min. speed displayed = 2 km/h {1.2 mph}
	Electrical part	#329: Wheel speed sensor
	Wiring diagram	Wheel speed sensor circuit

65: LONG ABS

Code generation criteria		Antilock brake system operates longer than the specified time duration.
Resettability		Normal signal after ignition switch OFF → ON (re-energize electronic control unit)
Electronic control unit control		Antilock brake system disabled
Inspection item	Service data	11: FR SPEED, 12: FL SPEED, 13: RR SPEED, 14: RL SPEED
	Electrical part	#329: Wheel speed sensor
	Wiring diagram	Wheel speed sensor circuit
	Other	• Inspect rotor (See Gr26, Gr27.) • Incorrectly installed wheel speed sensor

4. Multi-Use Tester Service Data

NOTE

- **Service data can be accessed while actuator test is being performed, and vice versa.**

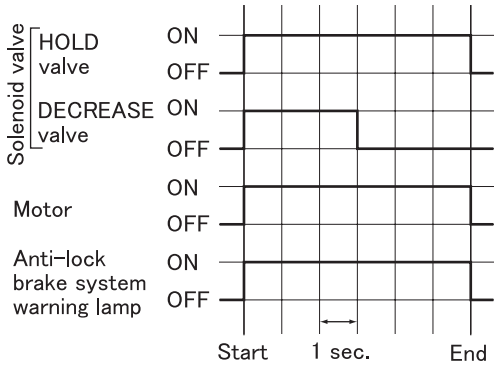
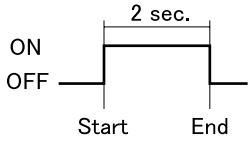
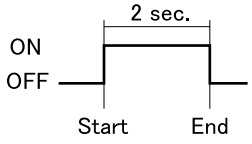
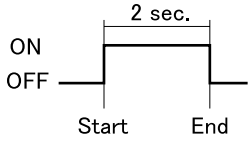
No.	Item	Data	Diagnosis condition	Pass criteria
11	FR SPEED	■■■. ■km/h	Drive at a constant speed	Synchronized with speedometer
12	FL SPEED	■■■. ■km/h		
13	RR SPEED	■■■. ■km/h		
14	RL SPEED	■■■. ■km/h		
15	BATT VOLTAGE	■■. ■■V	Ignition switch ON	Correspond with battery voltage
21	BRAKE SW	ON/OFF	Brake pedal depressed	ON
			Brake pedal released	OFF
22	EXB CUT RLY	ON/OFF	When antilock brake system exhaust brake cut relay activated	ON
			When antilock brake system exhaust brake cut relay not activated	OFF
			[Actuator test] 22: EXB RLY ON	
23	EXB MONITOR	ON/OFF	When antilock brake system exhaust brake cut relay activated	ON
			When antilock brake system exhaust brake cut relay not activated	OFF
			[Actuator test] 22: EXB RLY ON	
24	ABS LAMP	ON/OFF	ABS warning ON	ON
			ABS warning OFF	OFF
			[Actuator test] 23: ABS LAMP ON	
25	DIAGNOSIS SW	OPEN/CLOSE	Diagnosis switch fuse removed	OPEN
			Diagnosis switch fuse plugged in	CLOSE
26	DIAG.RESET SW	OPEN/CLOSE	Memory clear switch fuse removed	OPEN
			Memory clear switch fuse plugged in	CLOSE
31	VALVE RLY	ON/OFF	When valve relay activated	ON
			When valve relay not activated	OFF
32	MOTOR RLY	ON/OFF	Motor in operation	ON
			Motor stationary	OFF
			[Actuator test] 11: FR ABS MV ON 12: FL ABS MV ON 13: RR ABS MV ON 14: RL ABS MV ON 21: ABS MOTOR ON	
41	FR-DV	ON/OFF	Solenoid valve energized (front-axle right-wheel DECREASE)	ON
			Solenoid valve de-energized (front-axle right-wheel DECREASE)	OFF
			[Actuator test] 11: FR ABS MV ON	

No.	Item	Data	Diagnosis condition	Pass criteria
42	FR-HV	ON/OFF	Solenoid valve energized (front-axle right-wheel HOLD)	ON
			Solenoid valve de-energized (front-axle right-wheel HOLD)	OFF
			[Actuator test] 11: FR ABS MV ON	
43	FL-DV	ON/OFF	Solenoid valve energized (front-axle left-wheel DECREASE)	ON
			Solenoid valve de-energized (front-axle left-wheel DECREASE)	OFF
			[Actuator test] 12: FL ABS MV ON	
44	FL-HV	ON/OFF	Solenoid valve energized (front-axle left-wheel HOLD)	ON
			Solenoid valve de-energized (front-axle left-wheel HOLD)	OFF
			[Actuator test] 12: FL ABS MV ON	
45	RR-DV	ON/OFF	Solenoid valve energized (rear-axle right-wheel DECREASE)	ON
			Solenoid valve de-energized (rear-axle right-wheel DE-CREASE)	OFF
			[Actuator test] 13: RR ABS MV ON	
46	RR-HV	ON/OFF	Solenoid valve energized (rear-axle right-wheel HOLD)	ON
			Solenoid valve de-energized (rear-axle right-wheel HOLD)	OFF
			[Actuator test] 13: RR ABS MV ON	
47	RL-DV	ON/OFF	Solenoid valve energized (rear-axle left-wheel DECREASE)	ON
			Solenoid valve de-energized (rear-axle left-wheel DECREASE)	OFF
			[Actuator test] 14: RL ABS MV ON	
48	RL-HV	ON/OFF	Solenoid valve energized (rear-axle left-wheel HOLD)	ON
			Solenoid valve de-energized (rear-axle left-wheel HOLD)	OFF
			[Actuator test] 14: RL ABS MV ON	

5. Actuator Test Using Multi-Use Tester

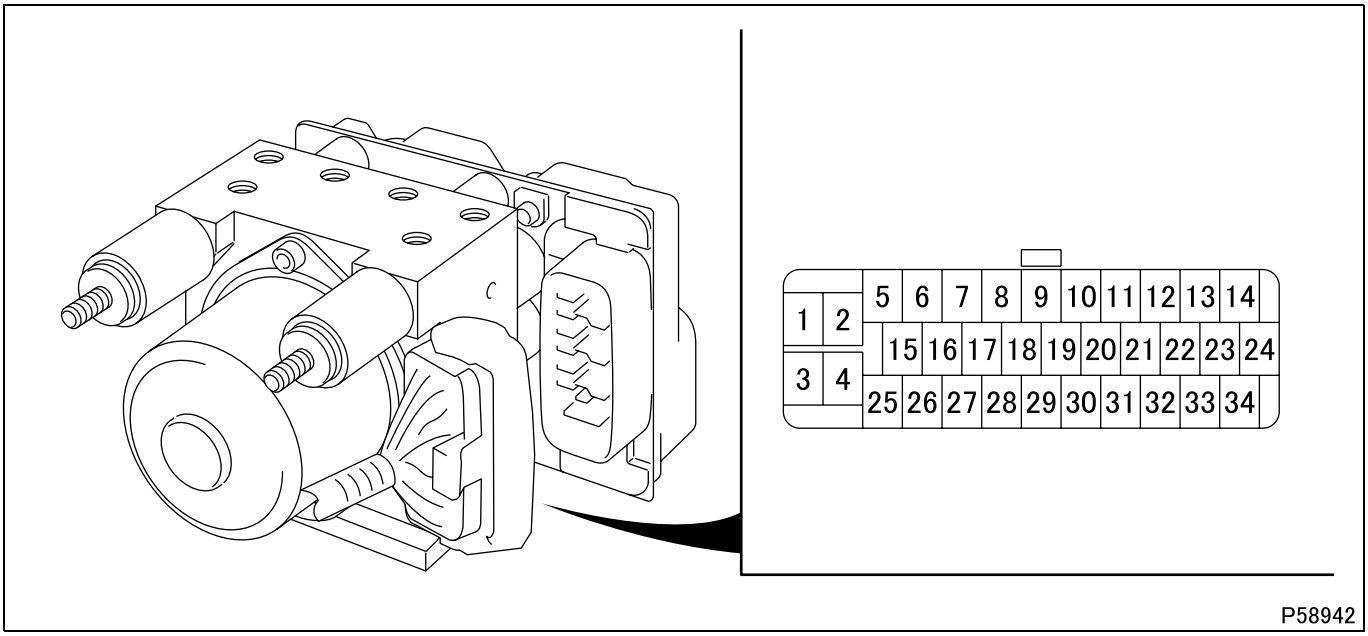
NOTE

- **Service data can be accessed while actuator test is being performed, and vice versa.**

No.	Item	Description	Verification method
11	FR ABS MV ON	 P49621E	Hydraulic unit (electronic control unit) functional check [Service data] 32: MOTOR RLY 41: FR-DV 42: FR-HV 43: FL-DV 44: FL-HV 45: RR-DV 46: RR-HV 47: RL-DV 48: RL-HV Use the data when bleeding the system (See Gr 35A.)
12	FL ABS MV ON		
13	RR ABS MV ON		
14	RL ABS MV ON		
21	ABS MOTOR ON	Motor  P49620E	Motor noise [Service data] 32: MOTOR RLY
22	EXB RLY ON	Exhaust brake cut relay  P49620E	Relay noise [Service data] 22: EXB CUT RLY 23: EXB MONITOR
23	ABS LAMP ON	ABS warning  P49620E	ABS warning ON [Service data] 24: ABS LAMP

6. Inspection at Hydraulic Unit (Electronic Control Unit) Connector

- This inspection is intended to aid troubleshooting by verifying whether or not hydraulic unit (electronic control unit) signals are correctly transmitted via the vehicle harness and connector.
  The ⓫, ⓬ ··· in the table below is a cross reference to the electronic control unit connector inspection items listed in the table in "**3. Diagnosis Based on Diagnosis Codes**" of this manual.



- The inspection requires the connector with a locking feature to be uncoupled. Before carrying out the inspection, read the "Hydraulic Unit Connector Uncoupling and Coupling" in this manual.

CAUTION ⚠

- **Do not touch terminals that are not part of the inspection being performed. When using a tester, be careful not to cause a short circuit across the terminals being measured.**

Check item	Measurement
⓫ Wheel speed sensor resistance	[Condition] • Ignition switch OFF • With the connector uncoupled, inspect at vehicle harness connector half [Pass criteria] Between terminals: 12 and 13 (FR) Between terminals: 32 and 33 (FL) Between terminals: 14 and 23 (RR) Between terminals: 34 and 24 (RL) • The resistance measured should be 1 to 2 kΩ
⓬ Electronic control unit power-supply voltage	[Condition] • Ignition switch ON • With the connector uncoupled, inspect at vehicle harness connector half [Pass criteria] Between terminals (+) - (–): 2 - 1 (VB) 4 - 3 (MB) 5 - 1 (IG) • 10 to 18 V

Check item	Measurement
⓪③ Antilock brake system exhaust brake cut relay voltage	[Condition] • Ignition switch ON • With the connector uncoupled, inspect at vehicle harness connector half [Pass criteria] Between terminals (+) - (–): 10 - 1 (EXHOUT) 9 - 1 (EXHIN) • 10 to 18 V
⓪④ Configuration check	[Pass criteria] Terminals 11, 22 and 30 should be free (no wiring connected). **NOTE** • **If wires are connected to these terminals, disconnect the wires and insulate the exposed portions.**

M E M O

1. Functional Check

1.1 Inspection with vehicle stationary

- While pressing the brake pedal, check the hydraulic unit (electronic control unit) and the brake lines and connections for fluid leakage.
- If fluid is leaking from the hydraulic unit (electronic control unit), replace the unit. If fluid is leaking from the brake lines or connections, retighten the hardware.

1.2 Inspection using brake tester

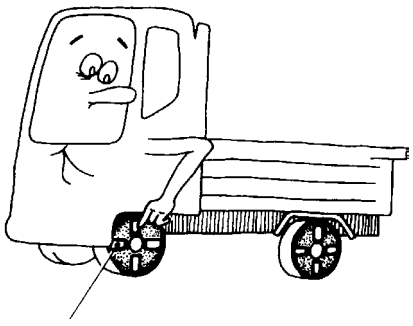
- Using the brake tester, check each wheel for braking force following the normal procedures.
- If faulty, check the wheel brake in question, the service brake system and the hydraulic unit (electronic control unit).

1.3 Inspection of antilock brake system operation while driving the vehicle

WARNING ⚠

- **To prevent personal injury, do not allow any other vehicle or any persons onto the test course during this inspection.**

- The vehicle being tested should be unloaded.
- Apply white tape to the sidewalls of both front and rear tires to aid observation of wheel rotation.
- Turn the ignition switch from LOCK to ON. The ABS warning should illuminate and, in several seconds, go out.
- Drive the vehicle at 20 to 30 km/h {12 to 19 mph} and apply the brakes hard. The wheels should not lock up.



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2. Inspection of Hydraulic Unit (Electronic Control Unit) Operation

2.1 Inspection using Multi-Use Tester

- Raise the vehicle with a jack and support it on safety stands, or place the vehicle on the rollers of a brake tester.

WARNING ⚠

- **Apply the parking brake when testing the front brakes. Chock the front wheels when testing the rear brakes.**

NOTE

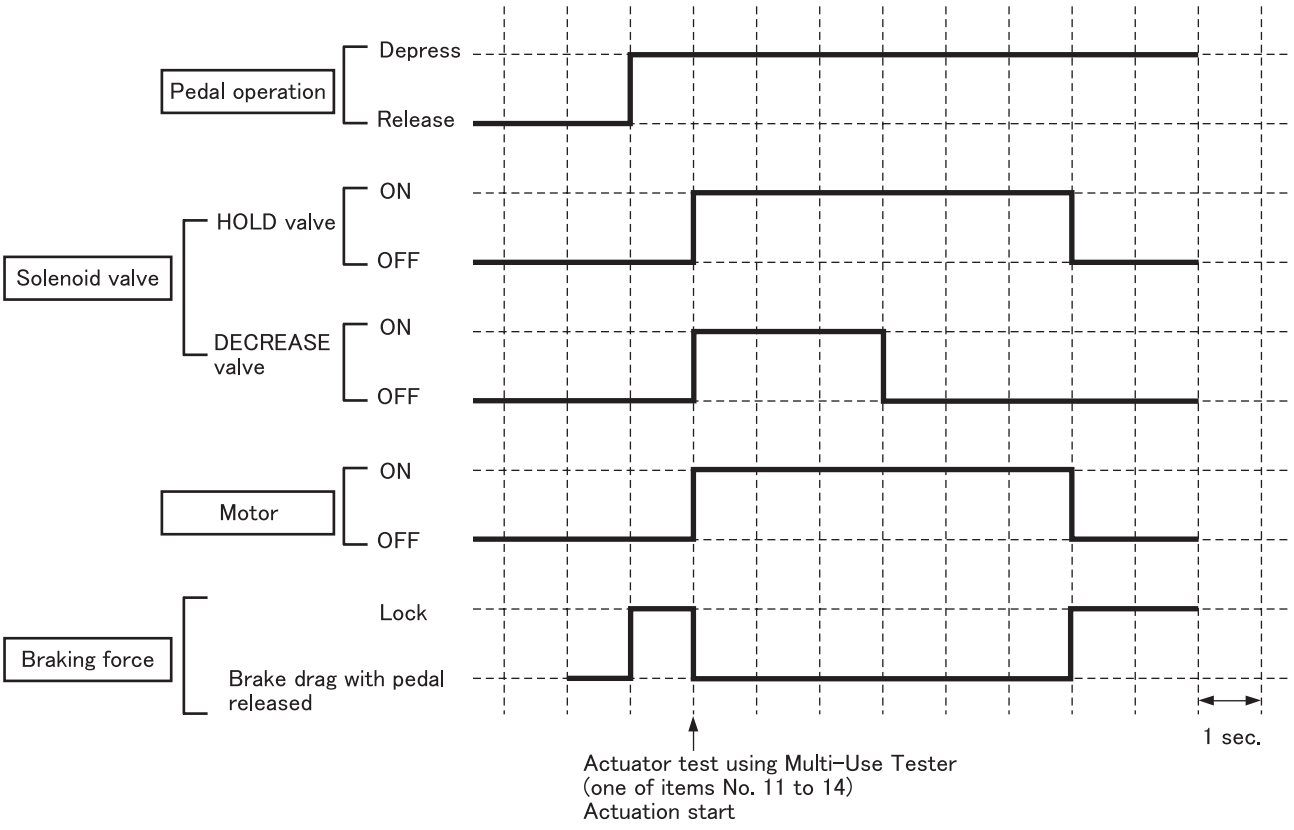
- **During the inspection, keep the brake tester rollers and the tires dry.**

- With the parking brake released, feel the brake drag of each wheel. When using a brake tester, note the brake drag reading.
- Connect the Multi-Use Tester (see Gr00).
- With the transmission in neutral, start the engine.
- Using the Multi-Use Tester, move the actuator.

NOTE

- **It is not possible to test the actuator using the Multi-Use Tester when the hydraulic unit (electronic control unit) is inoperative in fail-safe mode.**

- While rotating the wheel by hand, feel the variation in brake drag/force as the brake pedal is pressed and released. This can be expressed as follows.



- Determine whether the system is faulty or not by referring to the diagnosis table on the next page. If faulty, take the actions indicated.

Diagnosis table (actuator test using Multi-Use Tester)

No.	Multi-Use Tester display	Operation	Diagnosis		Cause	Remedial action
			Normal	Faulty		
11	FR ABS MV ON	(1) Press the brake pedal to lock up the wheel. (2) Using Multi-Use Tester, select the wheel being tested and move the corresponding actuator. (3) Rotate the wheel being tested using the brake tester or by hand, and check the variation in braking force.	Braking force drops for 6 seconds following wheel lock-up.	Wheel will not lock up when brake pedal is pressed.	Clogged brake line outside hydraulic unit (electronic control unit)	Inspect and clean brake line
12	FL ABS MV ON				Clogged line inside hydraulic unit (electronic control unit)	Replace hydraulic unit (electronic control unit)
13	FR ABS MV ON			Braking force will not drop.	Incorrectly connected hydraulic unit (electronic control unit) brake piping	Connect piping correctly
14	RL ABS MV ON				Faulty hydraulic unit (electronic control unit) magnetic valve	Replace hydraulic unit (electronic control unit)

- With the inspection completed, turn the ignition switch to LOCK before removing the Multi-Use Tester.

3. Inspection after Replacing or Removing/Installing Hydraulic Unit (Electronic Control Unit)

- Check the hydraulic unit (electronic control unit) for normal operation.
- After replacing or removing/installing the hydraulic unit (electronic control unit), always check the system for normal operation. Controlled braking will not be available if the piping is incorrect.
- After replacement or reinstallation of the hydraulic unit (electronic control unit), be sure to bleed the brake system. (See Gr35A.)
- The vehicle harness connector is equipped with a locking device. For correct use of the device, see "**HYDRAULIC UNIT CONNECTOR COUPLING AND UNCOUPLING**" in this manual.

4. Oscilloscopic Inspection through Wheel Speed Sensor Signal Waveform

- The tester is inappropriate to inspection for dented rotor or missing rotor tooth. Instead, use the oscilloscope function of the Multi-Use Tester or an oscilloscope capable of waveform recording.
- In many cases, dented rotor or missing rotor tooth results from the contact of the rotor press-fitted in the hub tip with the axle or elsewhere that can occur in the process of the hub and brake drum being assembled to the axle. Therefore, care should be taken so that the rotor does not touch other parts when the hub and brake drum are assembled to the axle.

4.1 Inspection

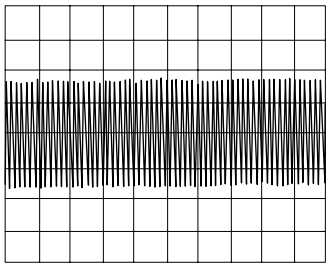
- Jack up the wheel under inspection. Disconnect the wheel speed sensor connector.
- Connect the oscilloscope terminals to the disconnected connector. Rotate the wheel at a certain speed and check oscilloscopic waveform for dented rotor or missing rotor tooth.
- If any wave is evidently smaller in width than others, there should be a dented rotor or missing rotor tooth. The standard wave width is as calculated below.

$$\frac{\text{Vmean} - \text{Vmin}}{\text{Vmean}} \times 100 \leq 20\%$$

where
Vmin: Minimum wave width
Vmean: Average of maximum wave widths

- If there is a wave more than 20% smaller in width than others, visually examine the rotor for the defect and replace if necessary. (See Gr26, 27).

Normal waveform
(no dent or chipped tooth on the rotor)



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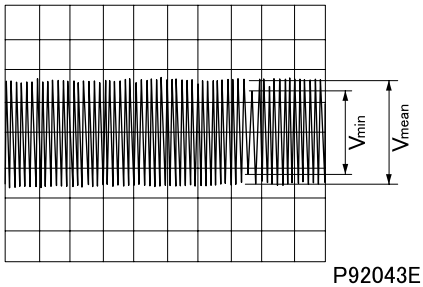
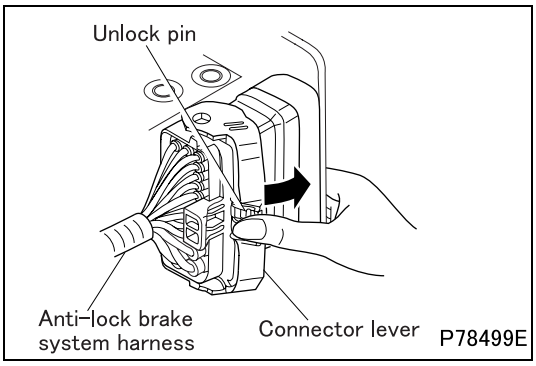
Abnormal waveform
(with dented rotor or missing rotor tooth)



P92043E

1. Uncoupling the Connector



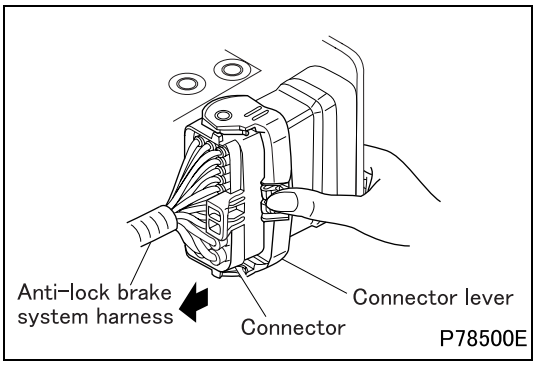
- While holding the connector, push the unlock pin on the connector lever.
- With the connector unlocked, push the connector lever in the direction of the arrow.

CAUTION ⚠

- **Do not force the connector lever. It may break.**

NOTE

- **If the connector lever will not move, return the connector lever to the locked position and try again.**

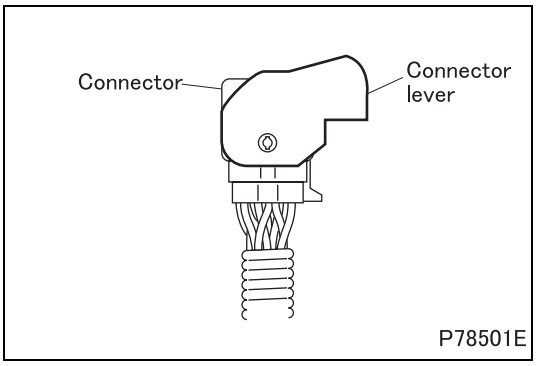


- With the connector lever fully pushed back, remove it, together with the antilock brake system harness, while continuing to hold the connector.

CAUTION ⚠

- **If the locking device is not completely unlocked, do not attempt to remove the connector by force. This may damage the connector. Push the connector lever all the way back and try again.**

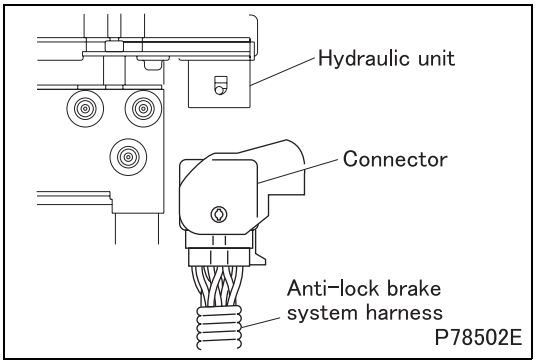
2. Coupling the Connector



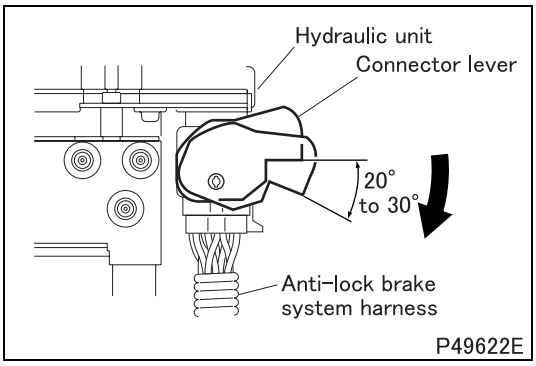
- Ensure that the connector terminals are clean and free from dirt or debris.
- Set the connector lever to the position shown in the illustration.

CAUTION ⚠

- **If the connector lever is not properly positioned, trying to plug in the connector may damage the connector lever.**



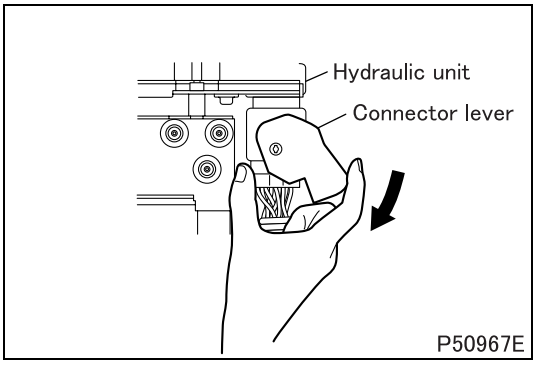
- Insert the antilock brake system harness connector straight into the other connector half on the hydraulic unit.



- Gently turn the connector lever to the specified angle in the direction of the arrow.

CAUTION ⚠

- **If the connector lever fails to turn to the specified angle, start the connector installation procedure again from the beginning. If this is not done, the connector lever could be broken when it is turned in the next step.**

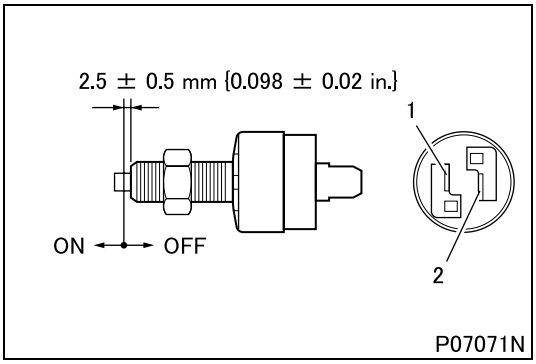


- In order to lock the connector lever, turn the lever in the direction of the arrow until it clicks. Apply force to the central part of the lever while holding the connector body.

NOTE

- **If the connector is not completely connected, the antilock brake system (ABS) warning may be illuminated. If the light is illuminated, start the connector installation procedure again.**

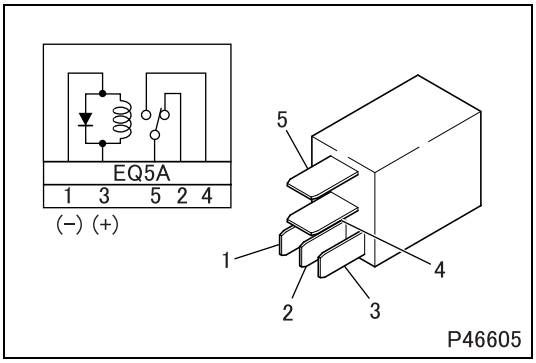
INSPECTION OF ELECTRICAL COMPONENTS



#042 Inspection of brake light switch

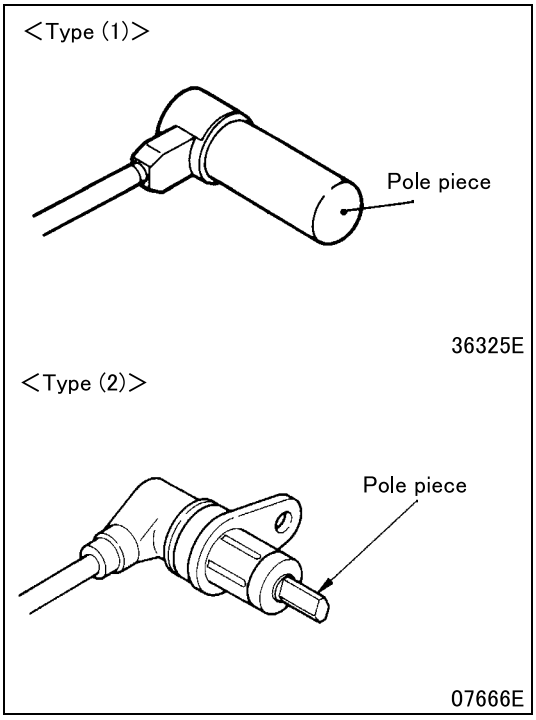
Switch position	Continuity between the terminals
OFF	–
ON	1 – 2

- If faulty, replace the brake light switch.



#201 Inspection of relay (normally open 5-pin relay)

- Check the relay for continuity and normal operation. If faulty, replace the relay.



#329 Inspection of wheel speed sensor

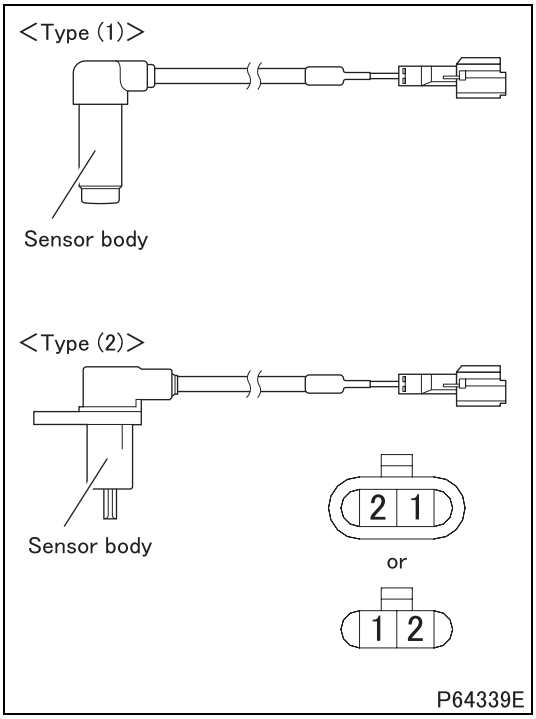
- Manufacturer of wheel speed sensor.

Type	Manufacturer
(1)	Sumitomo Electric
(2)	Bosch

- Carry out the following checks. If faulty, replace the wheel speed sensor.

CAUTION ⚠

- **The pole piece is magnetized by the magnet housed in the wheel speed sensor. Be careful not to allow metal parts to stick onto the pole piece.**



(1) Resistance between terminals

Standard value	Type (1)	1.4 ± 0.2 kΩ
	Type (2)	1.6 ± 0.16 kΩ

(2) Insulation resistance (between the sensor body and each terminal)

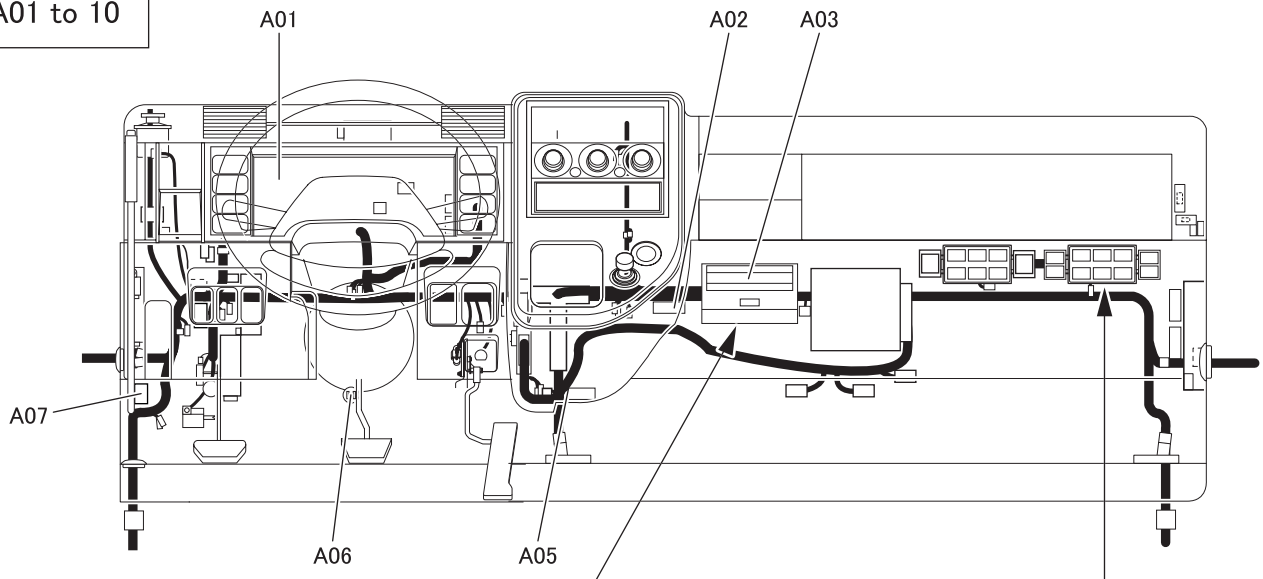
Standard value	Type (1)	1000 kΩ or above
	Type (2)	100 kΩ or above

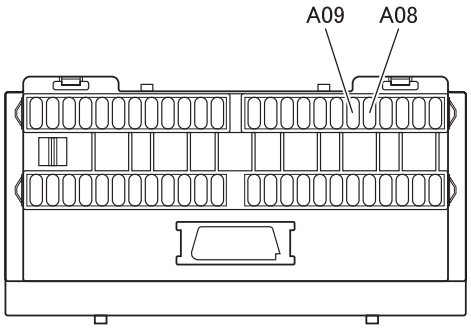
(3) Open circuit

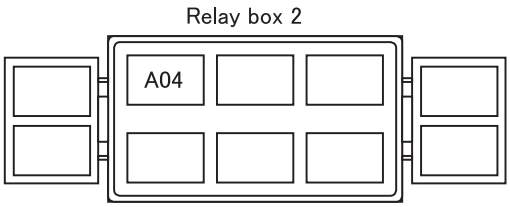
- If open circuit is suspected, remove the harness clamps and wiggle the harness to determine whether it is an intermittent fault or not. Check also the connector terminals for proper connection.

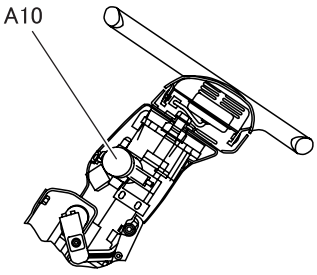
COMPONENT LOCATIONS

A01 to 10





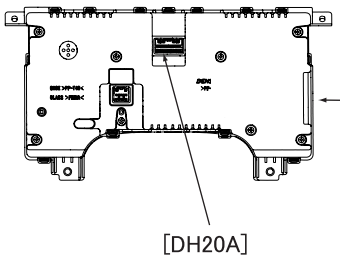


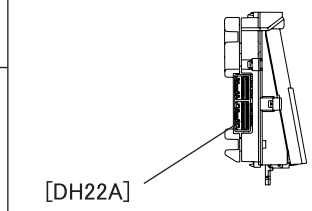


A01 Meter cluster
A02 Joint connector (J/C-1)
A03 Fuse box
A04 ABS exhaust brake cut relay
A05 Joint connector (J/C-M1)
A06 Stop lamp switch
A07 Multi-use tester connector
A08 Memory clear switch
A09 Diagnosis switch
A10 Starter switch

ABS : Anti-lock brake system
J/C : Joint connector

(Meter cluster backward view)





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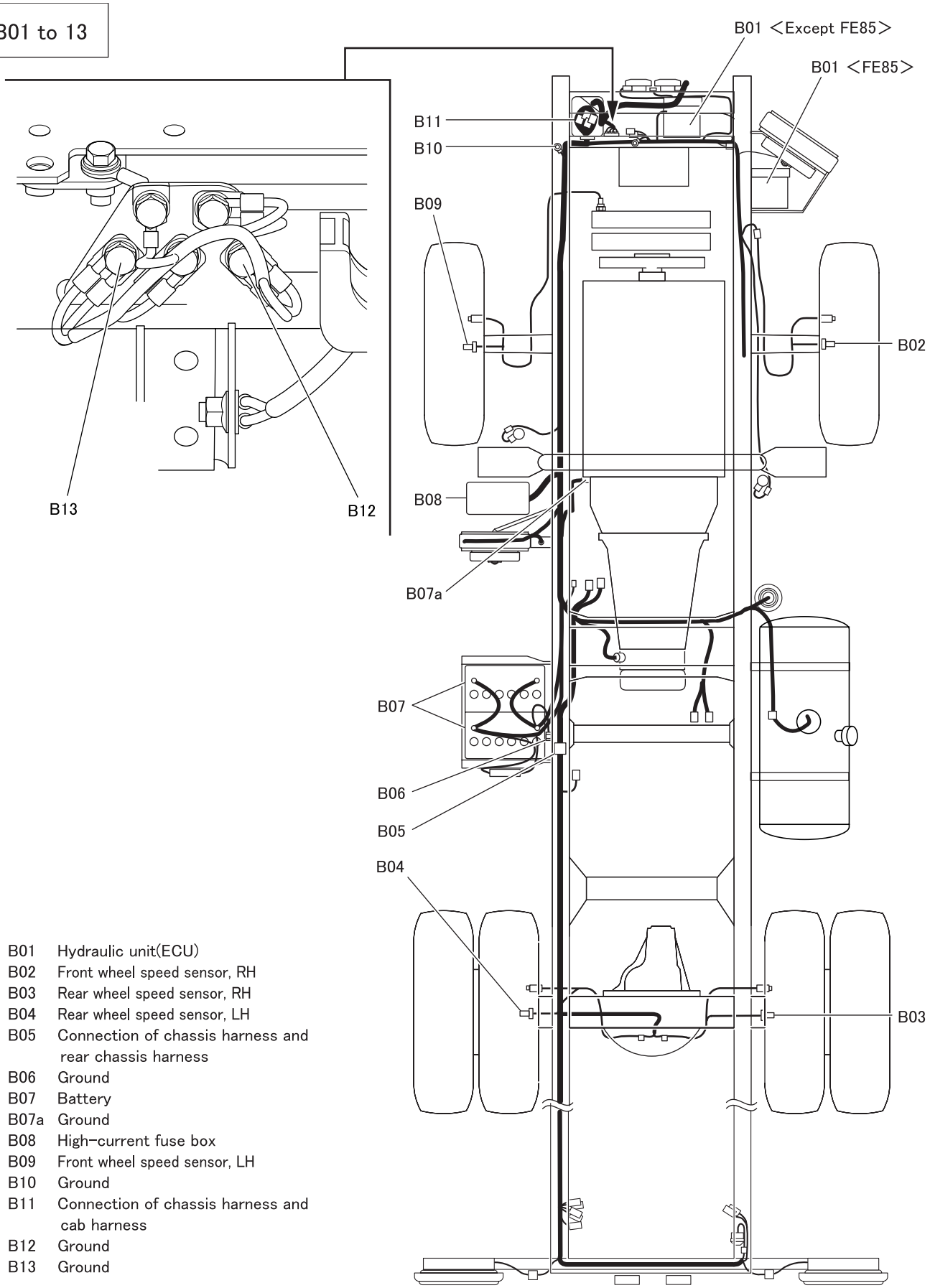
B01 to 13



B01 Hydraulic unit(ECU)
B02 Front wheel speed sensor, RH
B03 Rear wheel speed sensor, RH
B04 Rear wheel speed sensor, LH
B05 Connection of chassis harness and rear chassis harness
B06 Ground
B07 Battery
B07a Ground
B08 High-current fuse box
B09 Front wheel speed sensor, LH
B10 Ground
B11 Connection of chassis harness and cab harness
B12 Ground
B13 Ground

ABS : Anti-lock brake system
ECU : Electronic control unit

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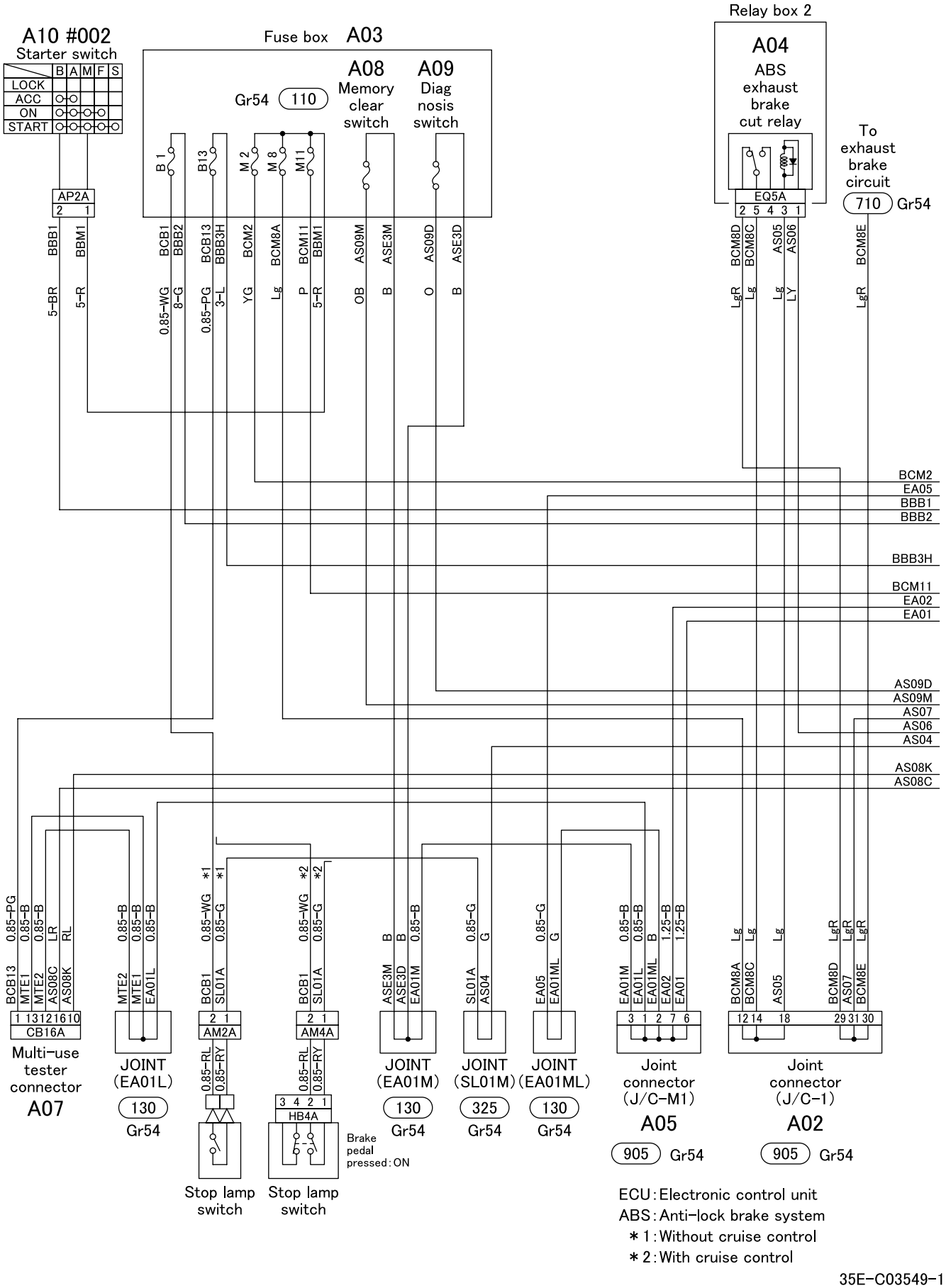
ELECTRICAL WIRING DIAGRAM



ECU : Electronic control unit
ABS : Anti-lock brake system
＊1 : Without cruise control
＊2 : With cruise control

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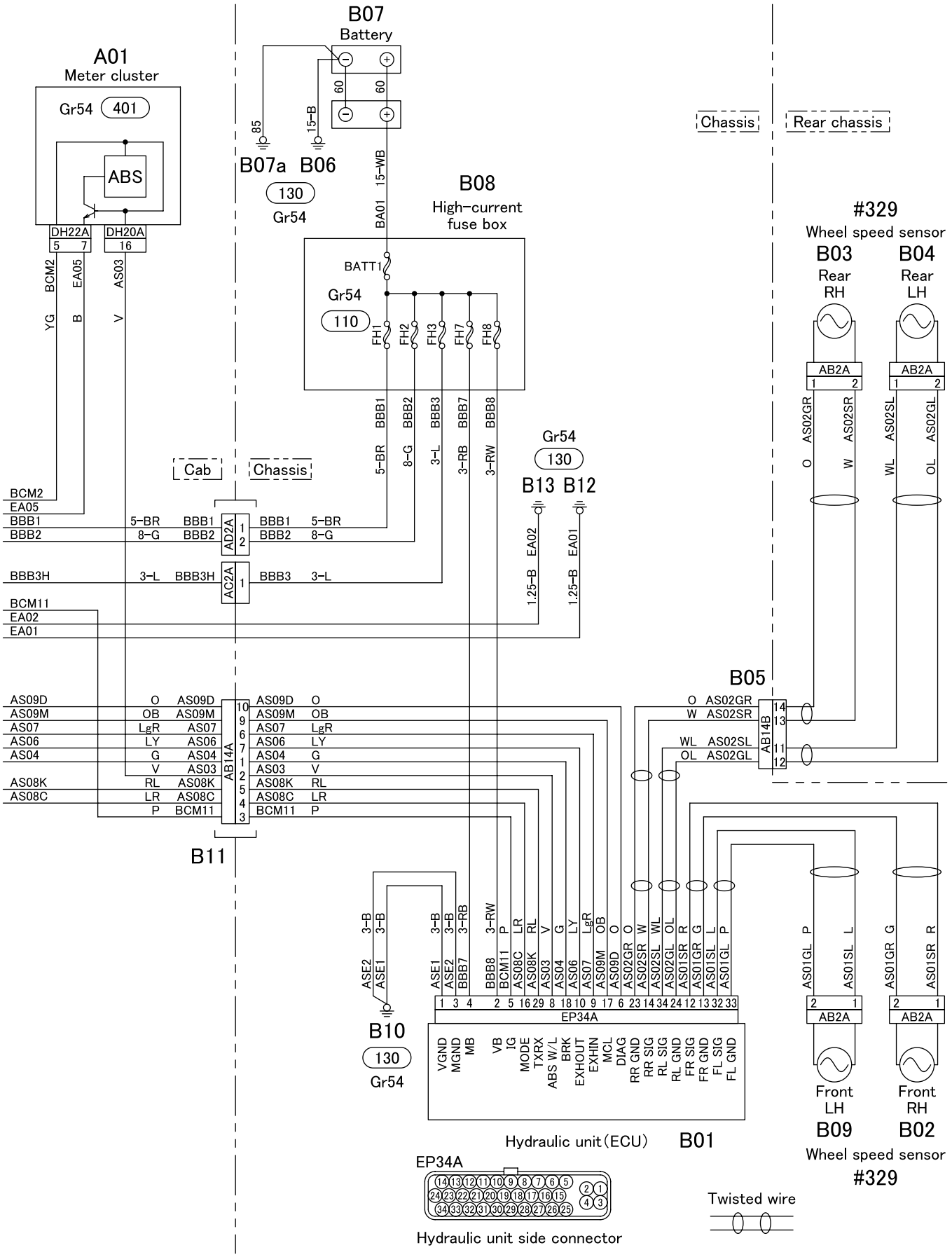
B07
Battery
A01
Meter cluster
Gr54 401
ABS
DH22A
DH20A
BCM2
EA05
AS03
YG
B
V
85
15-B
60
60
B07a B06
130
Gr54
15-WB
BA01
B08
High-current fuse box
BATT1
Gr54
110
FH1
FH2
FH3
FH7
FH8
BBB1
BBB2
BBB3
BBB7
BBB8
5-BR
8-G
3-L
3-RB
3-RW
Chassis
Rear chassis
#329
Wheel speed sensor
B03
Rear RH
B04
Rear LH
AB2A
AS02GR
AS02SR
AS02SL
AS02GL
O
W
WL
OL
Cab
Chassis
Gr54
130
B13 B12
EA02
EA01
1.25-B
BCM2
EA05
BBB1
BBB2
BBB3H
AD2A
AC2A
BCM11
EA02
EA01
B05
AB14B
AS09D
AS09M
AS07
AS06
AS04
AS08K
AS08C
AB14A
B11
LgR
LY
G
V
RL
LR
P
BCM11
B10
130
Gr54
ASE2
ASE1
3-B
3-RB
BBB7
BBB8
3-RW
EP34A
VGND
MGND
MB
VB
IG
MODE
TXRX
ABS W/L
BRK
EXHOUT
EXHIN
MCL
DIAG
RR GND
RR SIG
RL SIG
RL GND
FR SIG
FR GND
FL SIG
FL GND
Hydraulic unit(ECU)
B01
AS01GL
AS01SL
AS01GR
AS01SR
Front LH
Front RH
B09
B02
Wheel speed sensor
#329
EP34A
Hydraulic unit side connector
Twisted wire

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