■ PRE-CRASH SAFETY SYSTEM (RADAR TYPE)

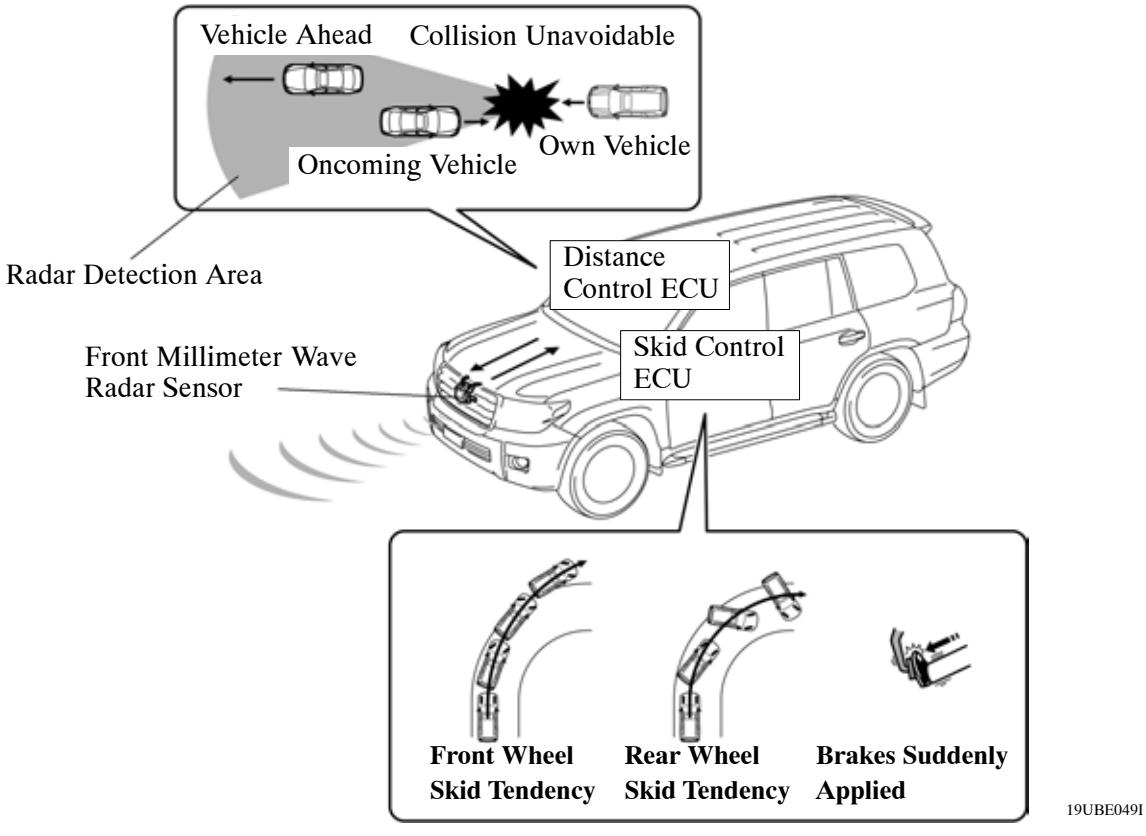
1. General

- The pre-crash safety system (radar type) retracts the slack in the front seat belts. Then, the system sets the brake control system in the brake assist standby mode below are present before a collision. This dampen the impact of a collision.

System Operation	Operating Condition
Pre-crash Safety Operation	A collision with an obstacle in front of the vehicle or a collision with the vehicle ahead is determined to be unavoidable.
Sudden Braking Operation	The sudden braking operation and serious vehicle skid operation are the same as in the pre-crash safety system.
Serious Vehicle Skid Operation	

- The millimeter wave radar sensor and distance control ECU determine whether a collision with an obstacle in front of the vehicle or a collision with the vehicle ahead is unavoidable.
- The millimeter wave radar sensor and distance control ECU make this determination based on the vehicle speed relative to the speed of an oncoming vehicle or based on the speed with which an object is being approached.
- The skid control ECU determines emergency braking, front wheel skid tendency and rear wheel skid tendency.

▶ Unavoidable Collision Judgment ◀



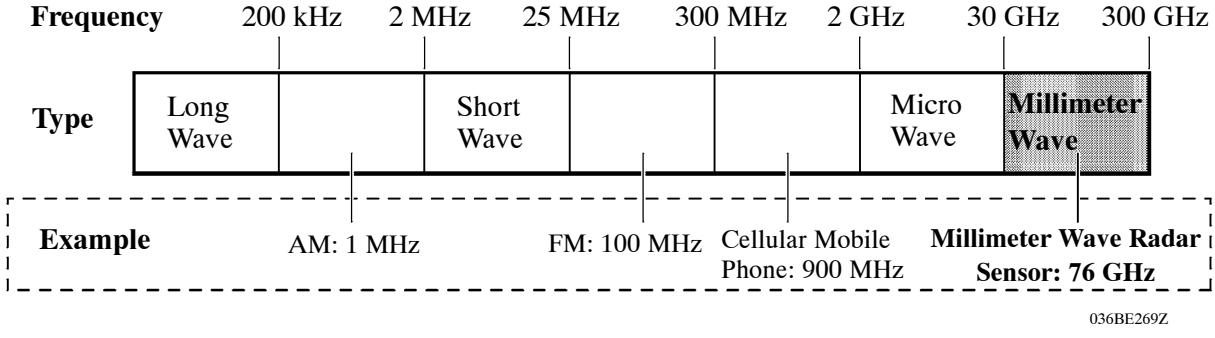
- The pre-crash safety system will not operate under the following conditions:

Non-operating Condition	1) Oncoming vehicle relative speed is approx. 30 km/h (20 mph) or less. 2) The vehicle speed is approx. 30 km/h (20 mph) or less (for a sudden braking operation and a front or rear wheel skid tendency operation). 3) The vehicle speed is approx. 5 km/h (4 mph) or less (for pre-crash safety operation). 4) The seat belt is not buckled. 5) Collision objects cannot be detected by the millimeter wave radar sensor: ● Objects that cannot be detected: plastic items (safety cones, etc.), etc. ● Objects that cannot be detected in a stable manner: people, bicycles, motorcycles, trees, animals, snow fence, etc. 6) The engine switch is off or on (ACC). 7) The multi-information display in the combination meter displays "**CHECK PCS SYSTEM**" and "**PCS TEMPORARILY NOT AVAILABLE**" warning messages. 8) The vehicle collides with an object located outside the detection area of the millimeter wave radar sensor.

— REFERENCE —

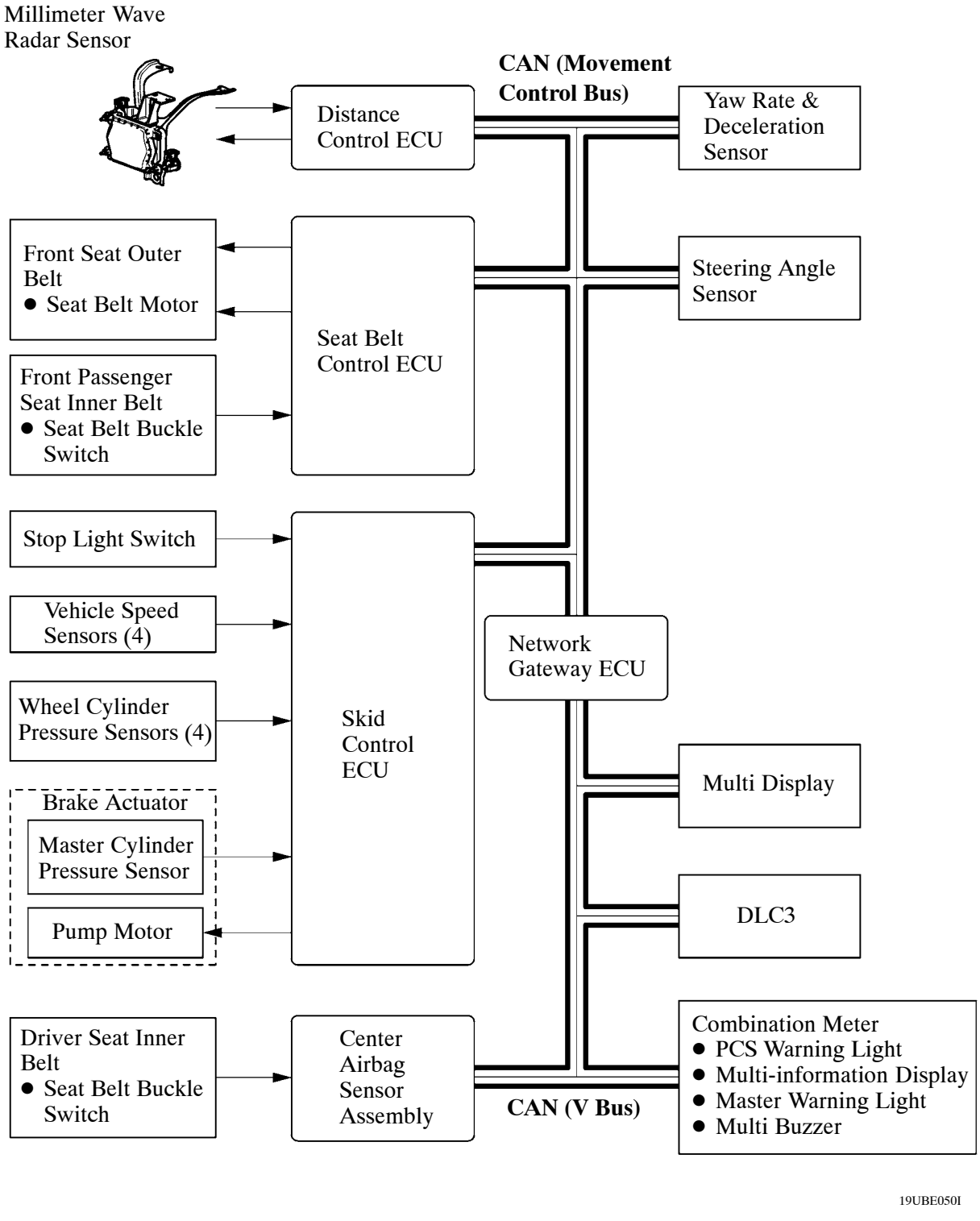
Millimeter Wave Radar:
The millimeter wave radar uses an extremely high frequency band between 30 GHz and 300 GHz, with an extremely short wavelength between 1 and 10 mm (0.04 and 0.40 in.) in a vacuum. The millimeter wave radar sensor of the pre-crash safety system uses frequencies in the 76 GHz band.
The millimeter wave radar is less affected by weather conditions such as rain, fog or snow, and provides excellent characteristics for recognizing objects. Therefore, the millimeter wave radar is well suited to the pre-crash safety system and the dynamic radar cruise control system.

▶ Main Wave Types and Frequencies ◀

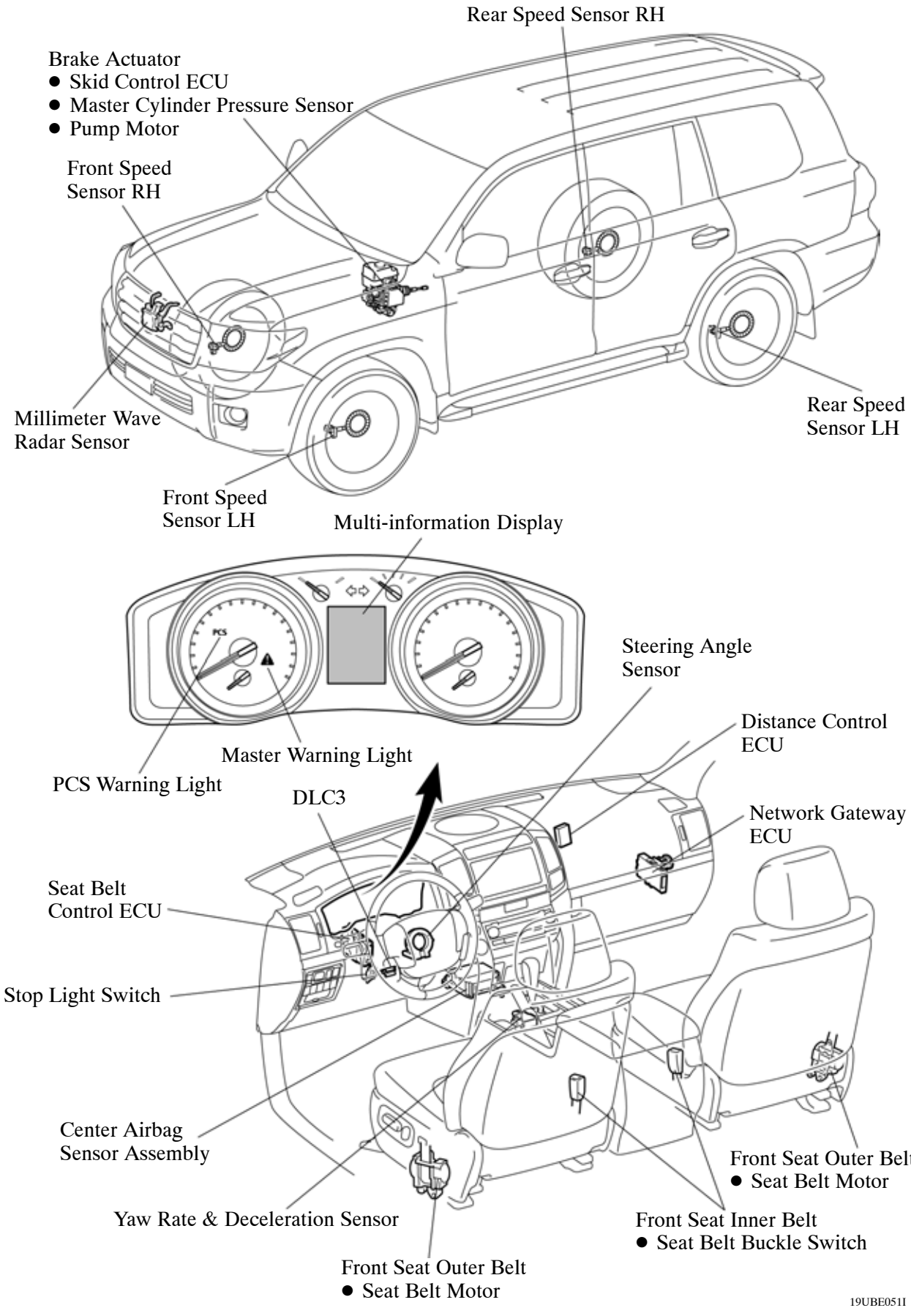


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2. System Diagram



3. Layout of Main Components



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4. Function of Main Components

General

Item		Function
Combination Meter	PCS Warning Light	Illuminates or flashes to warn the driver in accordance with signals from the seat belt control ECU.
	Multi-information Display	Displays a warning message to inform or warn the driver of the system condition in accordance with signals from the seat belt control ECU.
	Master Warning Light	Illuminates to warn the driver in accordance with signals from the seat belt control ECU.
	Multi Buzzer	Sounds to warn the driver in accordance with signals from the seat belt control ECU.
Millimeter Wave Radar Sensor		Radiates millimeter waves forward, uses the reflected millimeter waves for detecting the presence of a vehicle being driven ahead, the vehicle-to-vehicle distance and the relative speed, and transmits these pieces of information to the distance control ECU.
Front Seat Outer Belt		Retracts the seat belt in accordance with signals received from the seat belt control ECU.
	Seat Belt Motor	
Front Seat Inner Belt		● Detects the condition (verifies use of belt) of the driver seat belt and transmits a signal to the center airbag sensor assembly. ● Detects the condition (verifies use of belt) of the front passenger seat belt and transmits a signal to the seat belt control ECU.
	Seat Belt Buckle Switch	
Center Airbag Sensor Assembly		Transmits the condition (fastened or unfastened) of the driver seat belt to the seat belt control ECU.
Distance Control ECU		Makes a judgment that a collision is unavoidable based on the information received from the millimeter wave radar sensor. The ECU then outputs a seat belt operation signal and brake assist standby request signal.
Seat Belt Control ECU		● Receives a seat belt operation request signal from the distance control ECU or skid control ECU and operates the seat belts. ● If the seat belt control ECU detects a malfunction in the pre-crash safety system, it will store Diagnostic Trouble Code (DTC).
Skid Control ECU		● Receives a brake assist standby request signal from the distance control ECU and switches the brake assist to the standby mode. When a stop light switch signal is input, the ECU operates the brake assist. ● Determines that the brakes have been applied suddenly through a signal received from the master cylinder pressure sensor, and outputs a seat belt operation signal to the seat belt control ECU. ● Determines the presence of a front wheel skid tendency or rear wheel skid tendency, and outputs a seat belt operation signal to the seat belt control ECU. ● Transmits a vehicle speed signal to the distance control ECU.

(Continued)

Item		Function
Wheel Cylinder Pressure Sensor		Detects the wheel cylinder pressure and transmits a signal to the skid control ECU.
Brake Actuator	Master Cylinder Pressure Sensor	Detects the master cylinder pressure and transmits a signal to the skid control ECU.
	Pump Motor	Receives an actuation signal from the skid control ECU and generates hydraulic pressure for brake control.
Stop Light Switch		Detects if the brake pedal is pressed and transmits a signal to the skid control ECU.
Vehicle Speed Sensor		Detects the wheel speed signal and transmits a signal to the skid control ECU.
Yaw Rate & Deceleration Sensor		Detects the yaw rate and lateral/longitude deceleration of the vehicle and transmits a signal to the skid control ECU and the distance control ECU.
Steering Angle Sensor		Detects the angle and direction of steering and transmits a signal to the skid control ECU and the distance control ECU.

Service Tip

When the seat belt control ECU is replaced, an active test of the seat belt motor must be performed in accordance with the following procedure to check that the motor operates properly:

(1) Turn the engine switch on (IG).
(2) Monitor the PCS warning light for at least 3 seconds after the engine switch is turned on (IG). Make sure that the warning light does not remain on.
(3) Connect the intelligent tester II to the DLC3 and enter the select active test mode.
(4) Perform an active test of the seat belt motor and check that the motor operates properly. For details, refer to the Repair Manual.

Combination Meter

The combination meter is provided with the master warning light, PCS warning light, buzzer and multi-information display to inform the driver of a malfunction in the pre-crash safety system.

- 2 types of warning messages are used for the pre-crash safety system as described below. The pre-crash safety system will not operate when these messages appear in the combination meter.

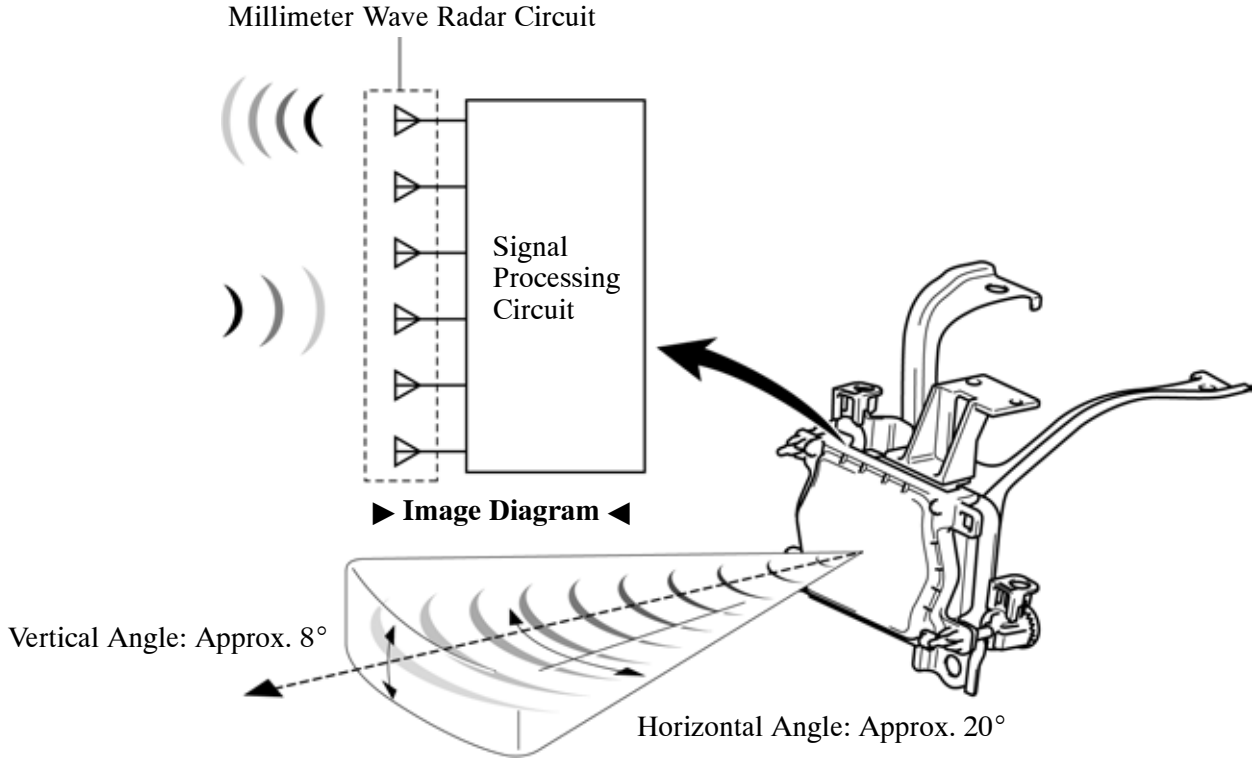
Multi-information Display	Detail	 0150BE35C	PCS 01YBE200P	Buzzer	DTC
 19UBE047I	This message appears when the seat belt control ECU detects a system malfunction.	Illuminates	Illuminates	Sounds Once	○
 19UBE048I	This message appears when the seat belt control ECU determines the following conditions: ● Dirty millimeter wave radar sensor* ● Poor weather condition ● Overheated seat belt control ECU. After these conditions have been eliminated, the system will operate normally.	—	Flashes	—	×

○: Repair is required/DTC is output
×: Repair is not required/DTC is not output
—: Not available
*: When the vehicle is driving on a road with less traffic and less objects to reflect millimeter waves, the distance control ECU may determine it as a dirty millimeter wave radar sensor condition because the millimeter wave radar sensor can not detect any reflected millimeter waves. After that, however, once the millimeter wave radar sensor detects reflected millimeter waves, the pre-crash safety system will resume automatically.

Millimeter Wave Radar Sensor

1) General

- The millimeter wave radar sensor consists of a millimeter wave radar circuit, signal processing circuit and CPU.
- The millimeter wave radar circuit consists of transmission antenna and reception antennas.
- The millimeter wave radar sensor outputs millimeter waves when the vehicle speed is above 0 km/h (0 mph), and does not when the vehicle speed is at 0 km/h (0 mph). The millimeter wave radar sensor uses frequencies in the 76 GHz band.
- The reception antennas receive the millimeter waves that have been reflected.
- The signal processing circuit detects the distance, relative speed and direction of the object by generating millimeter waves and calculating the signals received by the reception antennas. Then, it transmits this information to the distance control ECU.
- The millimeter wave radar sensor is also used by the dynamic radar cruise control system.



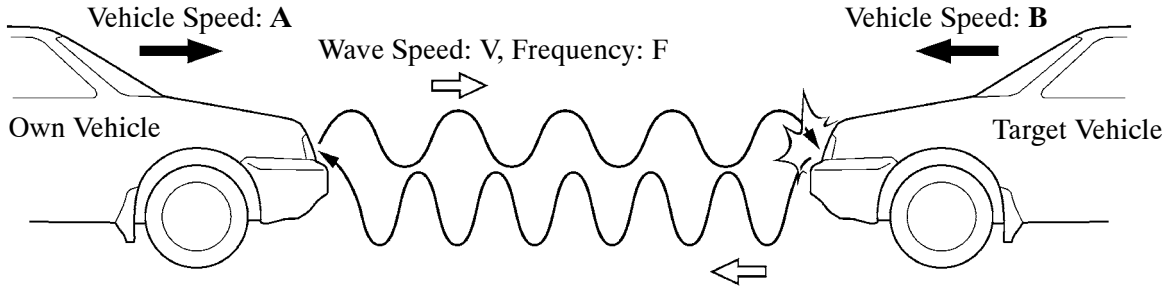
▶ **Image Diagram** ◀

2) Calculation Method

The distance to the object, azimuth (horizontal angle), and relative speed are calculated from the information that is provided by reflected millimeter waves as described below.

Distance	Calculated based on the length of time between emission and reception of millimeter waves by the millimeter wave radar sensor.
Azimuth	Calculated based on the angle of the millimeter wave reflected by an object.
Relative Speed	Calculated by utilizing the changes (Doppler effect*) that occur in the frequencies of the reflected millimeter waves.

*: The Doppler effect causes the observer to perceive the radio waves emitted by a moving object to be at higher frequencies as it approaches, and to be at lower frequencies as it recedes. This phenomenon is created because when an object is located far away, the radio waves are perceived at higher frequencies than when it is at the radio source.



By applying the following formula, the vehicle speed **B** of the target vehicle can be calculated.

$$\text{Doppler Effect: } F' = \frac{V + \mathbf{B}}{V - \mathbf{A}} F$$

5. System Operation

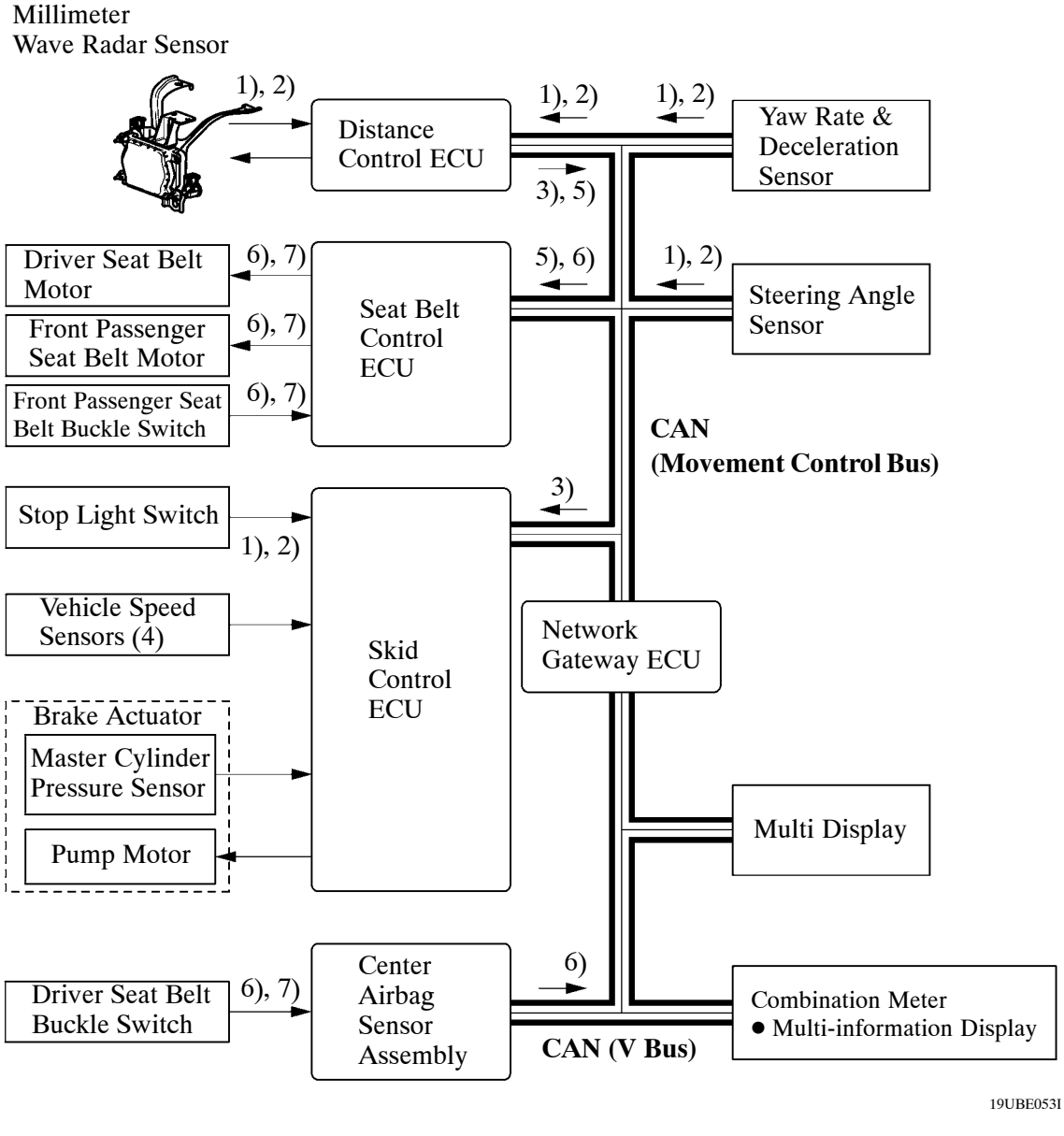
Operating Condition

Controls on the pre-crash safety system are performed under the following conditions:

Operation Condition	Impact Dampening Component
Seat Belt Retracting Operation (Sudden Braking Operation/Front or Rear Wheel Skid Tendency Operation)	● Front seat belt is buckled. ● Vehicle speed is approx. 30 km/h (20 mph) or above. ● Brakes are suddenly applied, or front or rear wheel skid tendency is detected.
Seat Belt Retracting Operation (Pre-crash Safety Operation)	● Front seat belt is buckled. ● Vehicle speed is approx. 5 km/h (4 mph) or above. ● Oncoming vehicle or an obstacle relative speed is approx. 30 km/h (20 mph) or above.
Brake Assist Standby Condition	● Vehicle speed is approx. 30 km/h (20 mph) or above. ● Oncoming vehicle or an obstacle relative speed is approx. 30 km/h (20 mph) or above. ● Brake pedal is depressed.

Pre-crash Safety Operation

1) The distance control ECU determines that the possibility of a frontal collision is high based on the signals received from the millimeter wave radar sensor, steering angle sensor, vehicle speed sensor and yaw rate & deceleration sensor.
2) The distance control ECU determines that an unavoidable collision condition exists based on the signals received from the millimeter wave radar sensor, vehicle speed sensor, steering angle sensor and yaw rate & deceleration sensor.
3) The distance control ECU outputs a brake assist standby request signal to the skid control ECU.
4) Upon receiving this signal, the skid control ECU switches the brake assist to the standby mode.
5) The distance control ECU outputs a seat belt operation request signal to the seat belt control ECU.
6) The seat belt control ECU determines the seat belt motor operation condition based on this signal and the seat belt buckle switch signal, and retracts the slack in the seat belts by operating the seat belt motors.
7) If no collision occurs, the seat belts and the brake assist will return to their normal states.



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6. Precaution for Pre-crash Safety System (Radar Type) Operation

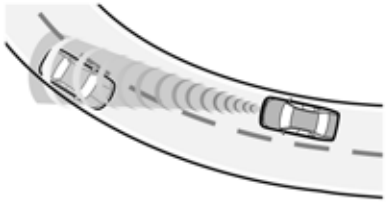
Millimeter Wave Radar Sensor

When the millimeter wave radar sensor detects an object ahead under the conditions described below, the distance control ECU may determine that a collision is unavoidable, and operate the pre-crash safety system (radar type). However, this is not abnormal.

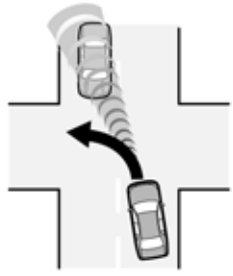
Object on Road Surface at Corner Entrance (Guard Rail, Street Light, Sign, Signboard)



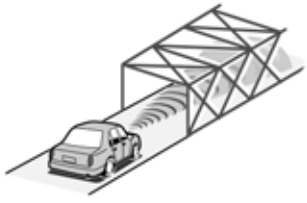
Opposing Traffic Vehicle during Cornering



Opposing Traffic at Intersection



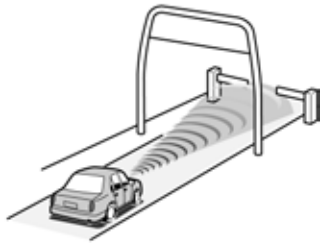
Narrow Iron Bridge



Metal Object, Steel Plate, or Bump on Road Surface



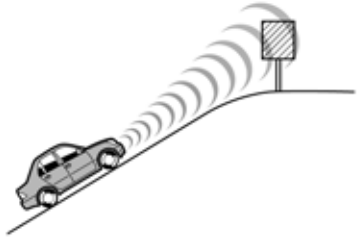
Toll Gate



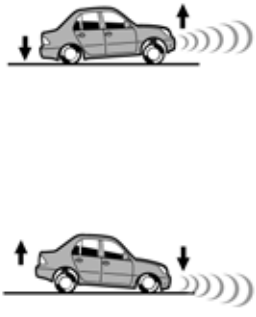
Metal Object or Steel Plate in the Ground at the Base of a Downhill Place



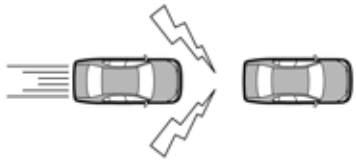
Metal Object such as a Sign in Front of the Vehicle on Uphill Slope



Vehicle Height Change Significantly (Front of Vehicle Inclined Either Upward or Downward)



Rapid Approach to a Preceding Vehicle



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The millimeter wave radar sensor might not be able to detect the following objects as collision objects:

Objects that cannot be detected	Plastic items (e.g. safety cones), etc.
Objects that cannot be detected in a stable manner	People, bicycles, motorcycles, trees, animals, snow fence, etc.

NF