

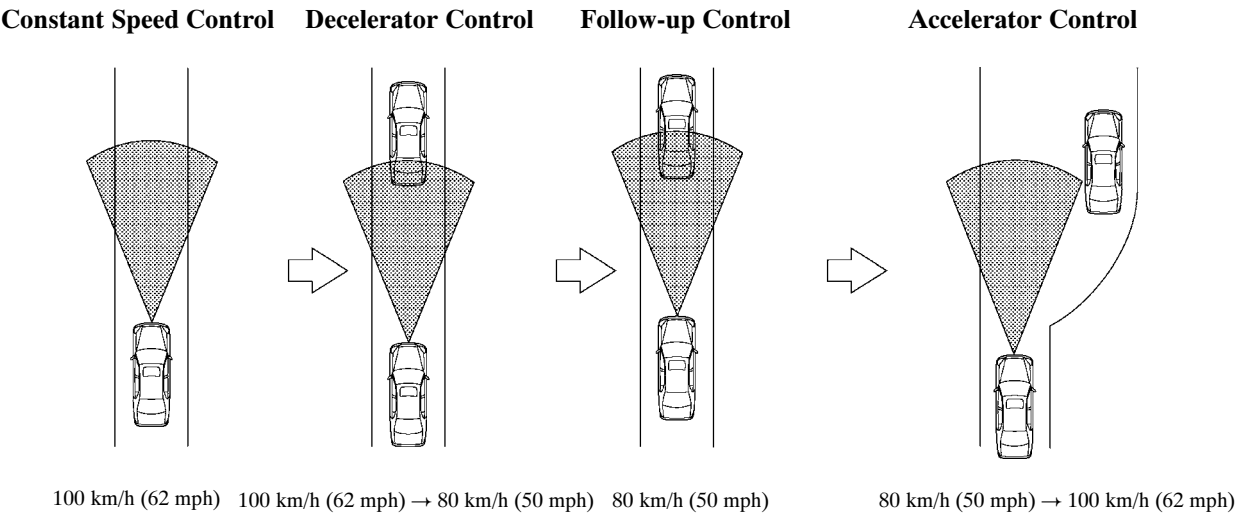
■ DYNAMIC RADAR TYPE CRUISE CONTROL SYSTEM

1. General

The Dynamic radar cruise control system has two cruise control modes: Constant Speed Control Mode, and Vehicle-to-Vehicle Distance Control Mode.

- The cruise control switch is used for switching between the two modes. The mode in which the cruise control system starts is the vehicle-to-vehicle distance control mode.
- The Distance Control ECU, millimeter wave radar sensor and Engine ECU control this system.
- The combination meter informs the driver of the control conditions.

Mode	Outline
Constant Speed Control Mode	The constant speed control mode is the same as in the conventional type cruise control system. However, differences are as follows: • Set speed: 40 km/h (25 mph) → 43 km/h (27 mph)
Vehicle-to-Vehicle Distance Control Mode	In the vehicle-to-vehicle distance control mode, the system recognizes and determines the lane in which the driver's own vehicle and the vehicle ahead are traveling. Thus, the system is able to maintain the proper vehicle-to-vehicle distance in accordance with the vehicle speed, and allows the vehicle to be driven under follow-up control. • The driver can operate the distance control switch on the steering wheel to select the vehicle-to-vehicle distance in three stages: long, middle, and short. • This mode consists mainly of four controls: constant speed control, decelerator control, follow-up control, and accelerator control. • The illustrations below show control examples while the driver's own vehicle is operating at 100 km/h (62 mph), and the vehicle ahead is operating at 80 km/h (50 mph). • Throttle control and brake control achieve smooth deceleration.

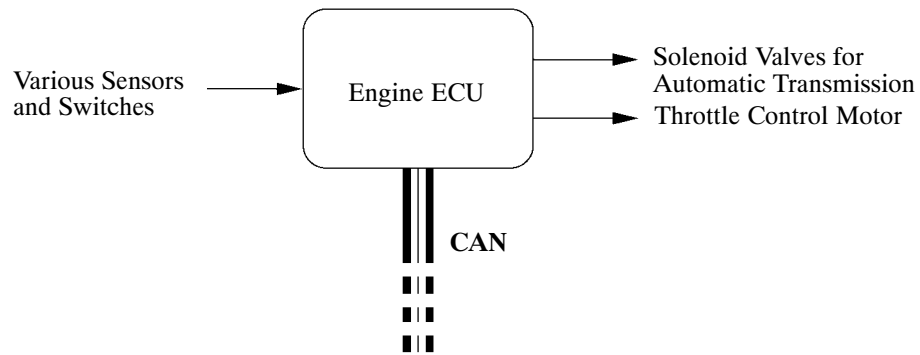


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Service Tip

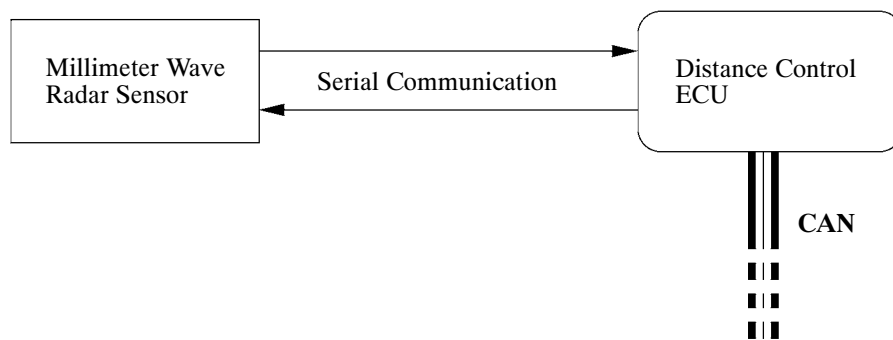
An SST is used if radar axis adjustment is needed. For details, see the LEXUS IS250 Repair Manual (Pub. No. RM0150E).

- As in the conventional type cruise control system, the constant speed control mode is controlled by the Engine ECU, which outputs signals to the actuators and the Engine ECU.



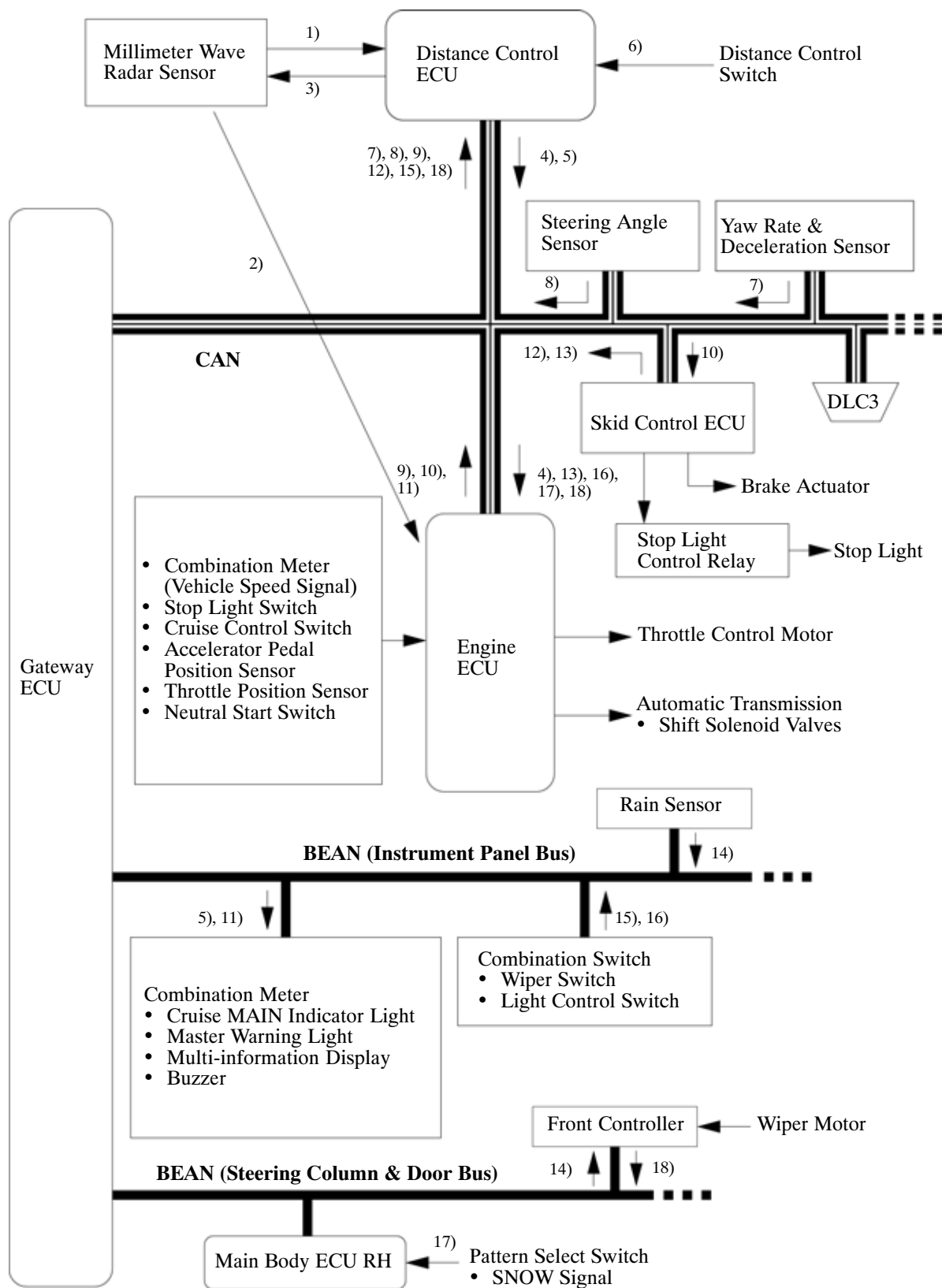
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- The vehicle-to-vehicle distance control mode is controlled by the millimeter wave radar sensor and Distance Control ECU. Thus, the signals are output to the actuators and the ECU while exchanging data as indicated below.



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2. System Diagram

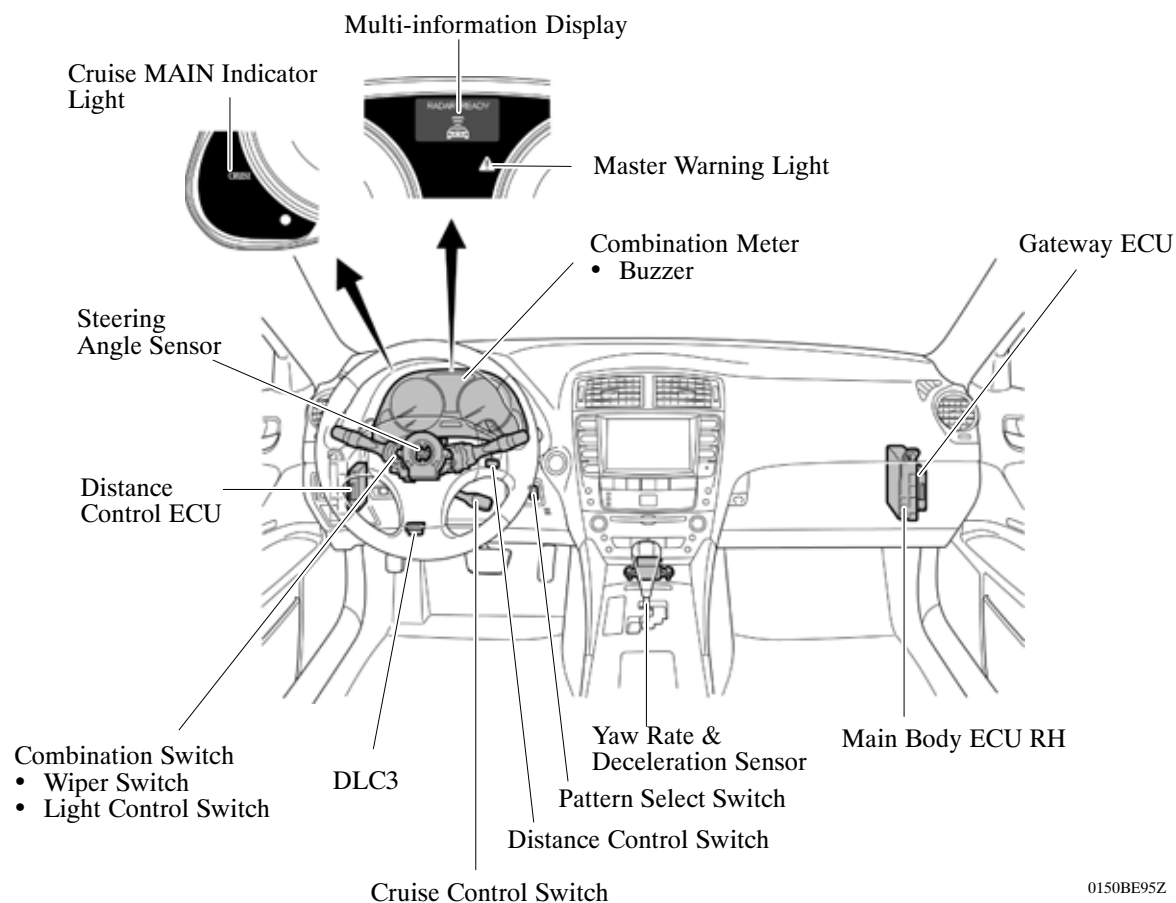


No.	Transmit	Receive	Data List	Communication
1)	Millimeter Wave Radar Sensor	Distance Control ECU	• Vehicle-to-Vehicle Distance • Presence of Vehicle Ahead • Relative Acceleration Rate • Relative Vehicle Speed • Width and Position of Object Ahead • Diagnostic Data	Serial
2)		Engine ECU	Millimeter Wave Radar Sensor Operation Signal	Wire
3)	Distance Control ECU	Millimeter Wave Radar Sensor	• Actual Vehicle Speed • Estimated Curve Radius • Wiper Condition • Light Control Switch • Set Distance • Beam Axis Adjustment Data	Serial
4)		Engine ECU	• Target Acceleration Rate • Target Deceleration Rate • Vehicle-to-Vehicle Distance • Presence of Vehicle Ahead • Brake Request • Beam Axis Deviation • Millimeter Wave Radar Sensor Dirtiness Detection • Poor Weather Detection • Proximity Warning • Gear Request • Diagnosis Data	CAN
5)		Combination Meter	• Display Data • Warning	CAN and BEAN
6)	Distance Control Switch	Distance Control ECU	Distance Control Switch	Wire
7)	Yaw Rate & Deceleration Sensor		Yaw Rate	CAN
8)	Steering Angle Sensor		Steering Angle	
9)	Engine ECU		• Set Vehicle Speed • Actual Vehicle Speed • Cruise Control Switch (MAIN Switch) • Set Distance • Brake Request Response • Accelerator Pedal Idle • Stop Light Signal • Transmission Information	
10)		Skid Control ECU	• Target Deceleration Rate • Target Deceleration Rate Gradient • Brake Request	CAN and BEAN
11)		Combination Meter	Cruise Control Switch	

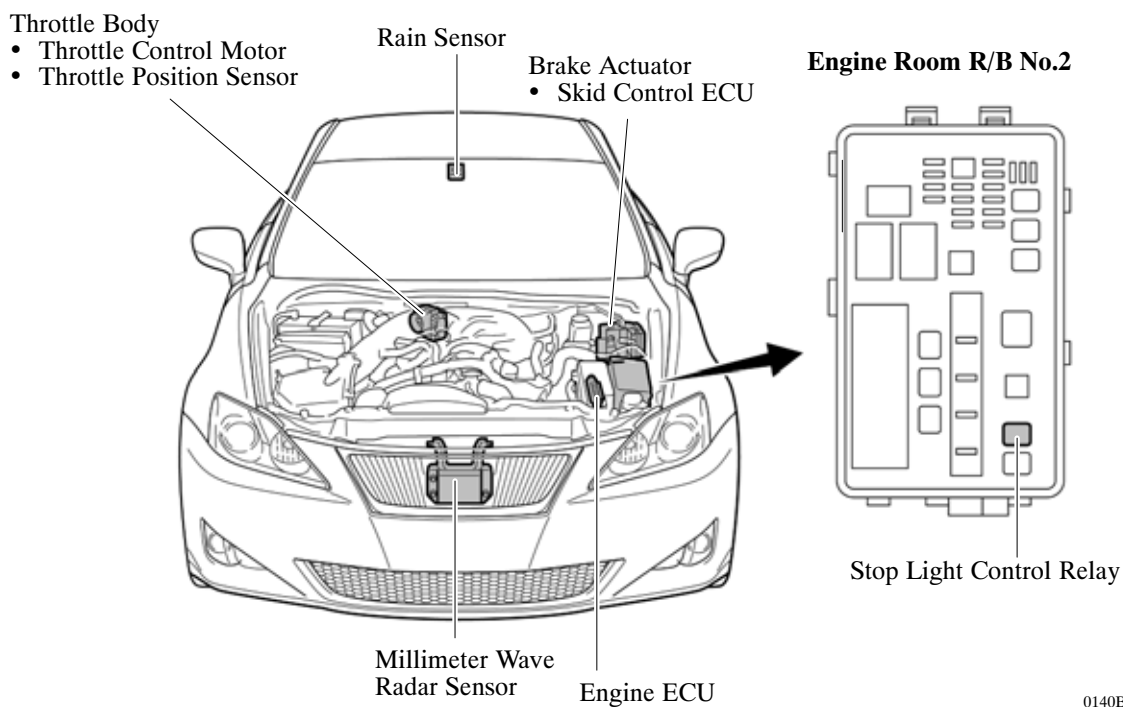
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No.	Transmit	Receive	Data List	Communication
12)	Skid Control ECU	Distance Control ECU	Zero Point Information of Yaw Rate	CAN
13)		Engine ECU	• Cruise Control Cancel Request • Brake Request Response • Brake Control Operation (VSC)	
14)	Rain Sensor	Combination Switch	Amount of Raindrops	BEAN
15)	Combination Switch	Distance Control ECU	• Wiper Switch • Light Control Switch	BEAN and CAN
16)		Engine ECU	Wiper Switch	BEAN and CAN
17)	Main Body ECU RH		Pattern Select Switch	BEAN and CAN
18)	Front Controller	Distance Control ECU	Wiper Operation	BEAN and CAN
		Engine ECU	Wiper Operation	BEAN and CAN

3. Layout of Main Component



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4. Function of Main Component

Item		Outline
Cruise Control Switch	ON-OFF Button	Turns ON/OFF the power to the cruise control system.
	MODE Switch	Switches the control mode, between the constant speed control mode and vehicle-to-vehicle distance mode.
	CANCEL Switch	A cancel signals can be output to the Engine ECU through the operation of this switch.
	RES/+ Switch	The accelerate function and resuming of a preset speed can be performed by operating this switch. A signal is output to the Engine ECU when this switch is operated.
	SET/- Switch	The decelerate function and vehicle speed setting resume signals are output to the Engine ECU due to operation of this switch.
Distance Control Switch		While the system is in the vehicle-to-vehicle distance control mode, the driver can operate the distance control switch to select the vehicle-to-vehicle distance in three stages: long, middle, and short.
Stop Light Switch		Detects the pressing of the brake pedal and transmits its signal to the Engine ECU.
Combination Switch	Wiper Switch	Transmits the wiper switch information to Distance Control ECU.
	Light Control Switch	Switches to the beam axis adjustment mode for the millimeter wave radar sensor.
Millimeter Wave Radar Sensor		Radiates radar waves forward, uses the reflected waves to detect the presence of a vehicle being driven ahead, the vehicle-to-vehicle distance, and the relative speed, and transmits this of information to the Distance Control ECU.
Distance Control ECU		While the system is in the vehicle-to-vehicle distance control mode, the Distance Control ECU detects the vehicle being followed based on signals from the millimeter wave radar sensor. Then, the Distance Control ECU calculates the acceleration or deceleration rate required in order to attain the target vehicle-to-vehicle distance, and outputs a request signal to the Engine ECU and or Skid Control ECU.
Combination Meter		Transmits the vehicle speed signal (SPD) to the Engine ECU.
	Cruise MAIN Indicator Light	• Illuminates when the ON-OFF button on the cruise control switch has been pressed to turn the system on. • If Distance Control ECU detects a malfunction, this light flashes to warn the driver.
	Master Warning Light	Illuminates when there is a malfunction in the system.
	Buzzer	If the Engine ECU or Distance Control ECU detects automatic cancel or warning signals while the vehicle is operating under cruise control, this buzzer sounds to inform the driver.
	Multi-information Display	During the dynamic radar cruise control, the multi-information display receives signals from Distance Control ECU, in order to display the system conditions.
Steering Angle Sensor		Detects the angle and direction of steering and transmits signals to the Skid Control ECU and Distance Control ECU.

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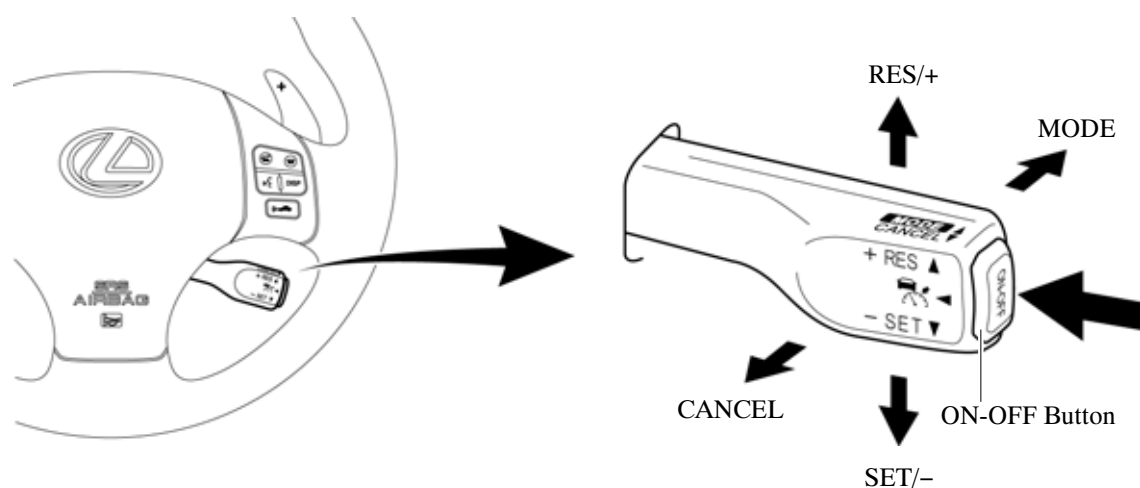
Item	Outline
Yaw Rate & Deceleration Sensor	Detects the yaw rate of the vehicle and transmits signals to Skid Control ECU and Distance Control ECU.
Rain Sensor	This sensor detects raindrops, and when the wiper operates at HI speed, it requests the Engine ECU to provide a cruise control cancel signal.
Skid Control ECU	While the system is operating in vehicle-to-vehicle distance control mode, the Skid Control ECU actuates the brake actuator in accordance with the brake request signal received from the Distance Control ECU.
Brake Actuator	Actuates the brakes in accordance with the signals from the Skid Control ECU.
Engine ECU	- Controls the cruise control system in accordance with signals from the switches, sensors, Skid Control ECU and Distance Control ECU. - If the Engine ECU detects a malfunction in the cruise control system, it will store DTCs (Diagnostic Trouble Codes).
Main Body ECU RH	Transmits the SNOW signal to the Engine ECU.

5. Construction and Operation

Cruise Control Switch

Cruise control switch consists of the ON-OFF button, RES/+, MODE, SET/- and CANCEL switches. RES/+, MODE, SET/- and CANCEL switches are lever type that operates in four directions.

- The cruise control switch is an automatic reset (normally open) type that turns ON only when the switch is being operated and turns OFF as soon as the driver releases the switch. Furthermore, the functions of the control switch are active only when the cruise control system has been turned on using the ON-OFF button on the cruise control switch.



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Distance Control Switch

While the vehicle is being driven in vehicle-to-vehicle distance control mode, the vehicle-to-vehicle distance setting can be changed each time the distance control switch is pressed, as follows; long → middle → short.

- If the power source is switched OFF and back to IG ON, the system will default to “long”.
- The vehicle-to-vehicle distance is set as follows:

Mode	Vehicle-to-Vehicle Distance*
Long	Approx. 75 m (245 ft)
Middle	Approx. 50 m (165 ft)
Short	Approx. 30 m (100 ft)

*: While driving at a vehicle speed of 90 km/h (55 mph).



Distance Control Switch

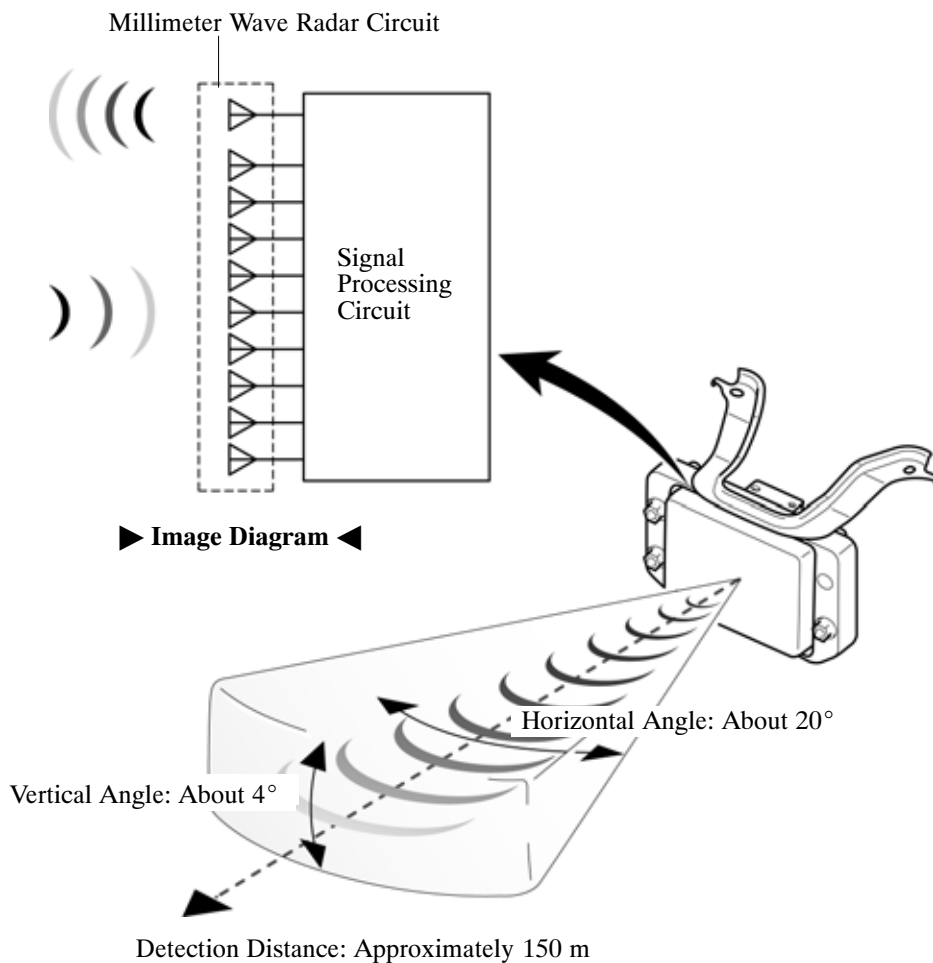
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Millimeter Wave Radar Sensor

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 one transmission antenna and nine reception antennas.
- The millimeter wave radar outputs waves when the vehicle speed is above 0, and not when the vehicle speed is at 0. The millimeter wave radar uses frequencies in the 76 GHz band.
- The reception antennas receive the millimeter wave radar waves that have been reflected.
- The signal processing circuit detects the distance, relative speed, and the direction of the object by generating millimeter wave radar waves and calculating the signals received by the reception antennas. Then, it transmits this information to the Distance Control ECU.

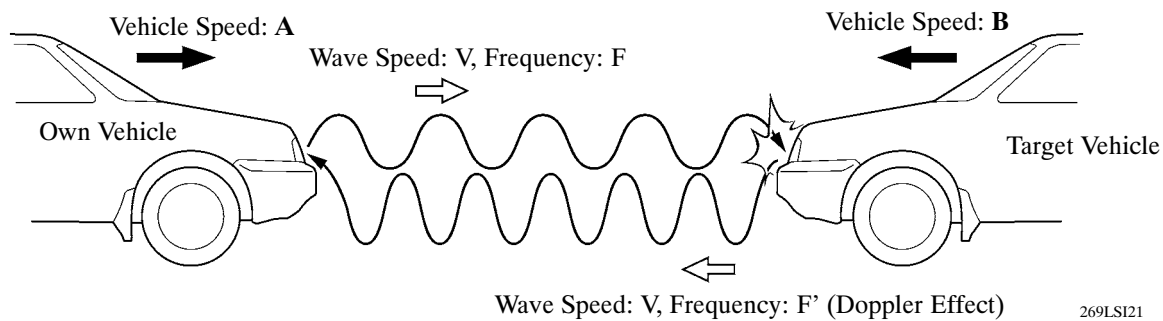


2) Calculation Method

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

Distance	Calculated from the length of time that has elapsed from the time the waves of the millimeter wave radar have been emitted, until the waves reflected by the millimeter wave radar are received.
Azimuth	Calculated from the angle of the waves reflected by the millimeter wave radar that have been received.
Relative Speed	Calculated by utilizing the changes (Doppler effect*) that occur in the frequencies of the reflected millimeter wave radar waves.

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



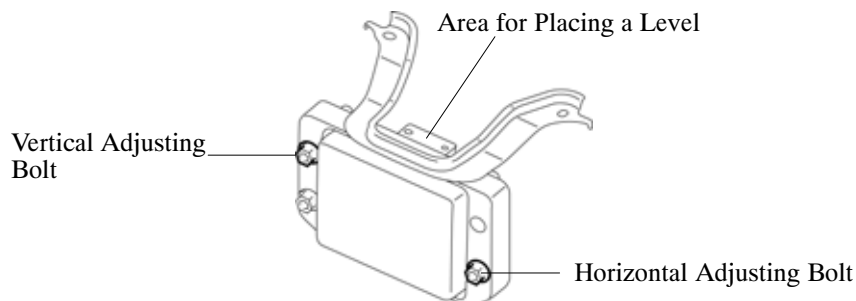
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By applying the following formula, the vehicle speed **B** of the target vehicle can be calculated.

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

Service Tip

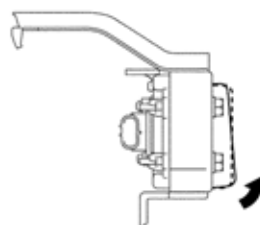
After a millimeter wave radar sensor has been replaced or removed and reinstalled, the SST (09870-60000) and a hand-held tester must be used to adjust the sensor angle. To ensure the proper precision, the sensor must be adjusted in the horizontal state. For this reason, the sensor is provided with an area for placing a level, as well as a horizontal adjusting bolt and a vertical adjusting bolt. For details, see the LEXUS IS250 Repair Manual (Pub. No. RM0150E).



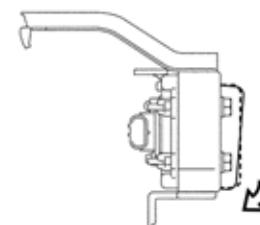
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- Turn vertical adjusting bolt to adjust the vertical direction of the millimeter wave radar sensor.
Reference: One turn of the bolt moves the sensor by approximately 1.0°.

Adjusting Bolt



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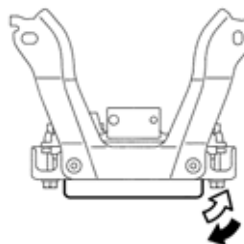


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- Turn the horizontal adjusting bolt to adjust the horizontal direction of the millimeter wave radar sensor.
Reference: One turn of the bolt moves the sensor by approximately 0.33°.



Adjusting Bolt

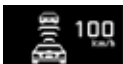


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Combination Meter

The combination meter provides a master warning light, cruise MAIN indicator light, buzzer, and multi-information display to warn and indicate in the dynamic radar cruise control system.

- The multi-information display displays the set vehicle speed, constant speed mode mark, vehicle-to-vehicle distance mark, vehicle ahead mark, and warning message.
- Examples are shown below for the illumination or display of each indicator light, warning light or multi-information display.

Mode	Condition	Multi-information Display	CRUISE 0140BE96C	 0150BE35C	Buzzer
Constant Speed Control	Being Controlled	 0150BE41C	Illuminate	—	—
Vehicle-to-Vehicle Distance Control	Set Standby	 0140BE88C	Illuminate	—	—
	Under Constant Speed Control (No Vehicle Ahead)	 Long  Middle  Short 0140BE89C	Illuminate	—	—
	Under Follow-up Control (Vehicle Ahead)	 Long  Middle  Short 0150BE42C	Illuminate	—	—
	Deceleration Control (Vehicle Ahead)	  0150BE43C The vehicles in the display are highlighted at 0.5-second intervals.	Illuminate	—	—
System Failure	Millimeter wave radar sensor is dirty.	 0140BE92C	Flash	Illuminate	Sound Once
	Poor Weather Condition	 0140BE93C	Flash	Illuminate	Sound Once
	System Check*	 0140BE94C	Flash	Illuminate	Sound Once
Beam Axis Adjustment		 0140BE95C	Flash	—	—

*: When a DTC (Diagnostic Trouble Code) is memorized.

6. System Control

General

The control of the dynamic radar cruise control system varies depending on the mode:

A: Constant Speed Control Mode

B: Vehicle-to-vehicle Distance Control Mode.

Control	Outline	Mode	
		A	B
Constant Speed Control [See page BE-250]	The Engine ECU compares the actual vehicle speed and the set speed and if the vehicle speed is lower than the set speed, it uses the throttle motor to increase throttle opening.	○	○
Deceleration Control [See page BE-251]	Effects throttle control and brake control in order to decelerate the vehicle so that the vehicle-to-vehicle distance between this vehicle and the vehicle ahead equals the set distance.	—	○
Follow-up Control [See page BE-252]	After effecting deceleration control, the vehicle follows the vehicle ahead in order to maintain the proper vehicle-to-vehicle distance in accordance with the vehicle speed.	—	○
Acceleration Control [See page BE-253]	Accelerates the vehicle in order to attain the set vehicle speed if the vehicle ahead or this vehicle has changed lanes.	—	○
Set Control	While this system fulfils the following conditions, and the cruise control switch is pressed to the SET/- side and released when the ON-OFF button on the cruise control switch has been pressed to turn the system on, the Engine ECU stores the vehicle speed and maintains the vehicle constantly at that speed. • The shift lever is in D position • The shift lever is shifted in the S mode, and shift range is 4th, 5th or 6th.	○	○
	The vehicle is running within a vehicle speed of about 43 km/h (27 mph) or more.	○	—
	The vehicle is running within a vehicle speed range [About 43 to 170 km/h (27 to 106 mph)].	—	○
Low Speed Limit Control	The low speed limit is the lowest speed that cruise control can be set and is designed as approx. “40 km/h (25 mph)”. The cruise control cannot be set below that speed. If the vehicle speed drops below that speed while running in the cruise control, the cruise control is cancelled automatically. The setting vehicle speed in the memory is kept.	○	○

(Continued)

Control	Outline	Mode	
		A	B
COAST Switch Control	While the cruise control switch is held to the SET/- side, the vehicle speed and the set vehicle speed change as follows, according to the mode:	○	○
	- The vehicle decelerates constantly. - The setting vehicle speed changes to the speed at which the switch is turned OFF.	○	—
	- The setting vehicle speed decreases in increments 5 km/h or 5 mph. [Example: 103 → 100 → 95 km/h (mph)] - The vehicle decelerates rapidly due to ETCS-i. The vehicle will remain at the speed that the vehicle is traveling at when the COAST switch is released.	—	○
Tap Down Control	When the cruise control switch is pushed momentarily (approx. 0.5 sec) to the SET/- side, the vehicle speed and the set vehicle speed change as follows, according to the mode: - The vehicle will decelerate in increments of approximately 1.6 km/h (1 mph) for each time the switch was pressed. - However, if the difference between the actual vehicle speed and the set vehicle speed is greater than 5 km/h or 5 mph, the set vehicle speed will change to the speed at which the vehicle was being driven at the time the switch was operated.	○	—
ACC Switch Control	When the cruise control switch is kept to push to the RES/+ side, the vehicle speed and the set vehicle speed change as follows, according to the mode:	○	○
	- The vehicle will accelerate constantly. - The set vehicle speed changes to the speed at which the switch is turned OFF.	○	—
	- The set vehicle speed increases in increments 5 km/h or 5 mph. [Example: 60 → 65 → 68 km/h (mph)] - The vehicle will accelerate to the speed that is set at the time the switch is released. However, only the set vehicle speed will change during follow-up control.	—	○
RES Switch Control	If the vehicle speed is above the low speed limit, the cruise control resumes operation (subsequently pushes the cruise control switch to the RES/+ side) to reach the vehicle speed that was set at the time the driver canceled cruise control. Even if the vehicle speed drops below the low speed limit, resume can be performed when the vehicle speed increases above the low speed limit.	○	○
Tap Up Control	When the cruise control switch is pushed momentarily (approx. 0.5 sec.) to the RES/+ side, the vehicle speed and the setting vehicle speed change as follows. - The vehicle will accelerate in increments of approx. 1.6 km/h (1 mph) for each time the switch was pressed. - However, if the difference between the actual vehicle speed and the vehicle set speed is greater than 5 km/h or 5 mph, the set vehicle speed changes to the speed as which the vehicle was being driven at the time the switch was operated.	○	○

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Control	Outline	Mode	
Automatic Transmission Control	When the vehicle is cruising uphill, there is a case where the overdrive turns off depending on the ECT (Electronic Control Transmission) control. After that, when the Engine ECU judges the end of uphill cruising based on the throttle valve opening angle, the overdrive function will turn on again.	○	○
Manual Cancel Control	If any of the following signals are sent to the Engine ECU, the cruise control is cancelled accordingly. • Shift lever is shifted from D to N. • When 1st, 2nd or 3rd range is selected in S mode position. • Stop light switch ON signal/brake pedal depressed. • CANCEL switch ON signal (cruise control switch moved to CANCEL side) • Cruise control switch (ON-OFF button) OFF signal • Pattern select switch SNOW signal • VSC operation signal	○	○
Automatic Cancel Control [See page BE-254]	When an automatic cancel signal is sent to the Engine ECU, the cruise control operation is canceled. At this time, the style of the warning to the driver and the control resumption condition varies according to the cancel signal.	○	○
Mode Switching Control	The following operations switch the modes: 1) ON-OFF button on the cruise control switch is ON. (Starts in the vehicle-to-vehicle distance control mode) 2) Cruise control switch is held to the MODE side. (Approx. one second or more) If the switch is pushed to any other side before switching modes, switch the cruise control system OFF; then, perform steps 1) and 2) again.	○	○
Diagnosis [See page BE-255]	If a malfunction occurs in the dynamic radar cruise control system during cruise control operation, the Engine ECU cancels cruise control and diagnoses and memorizes the faults related to the malfunction.	○	○

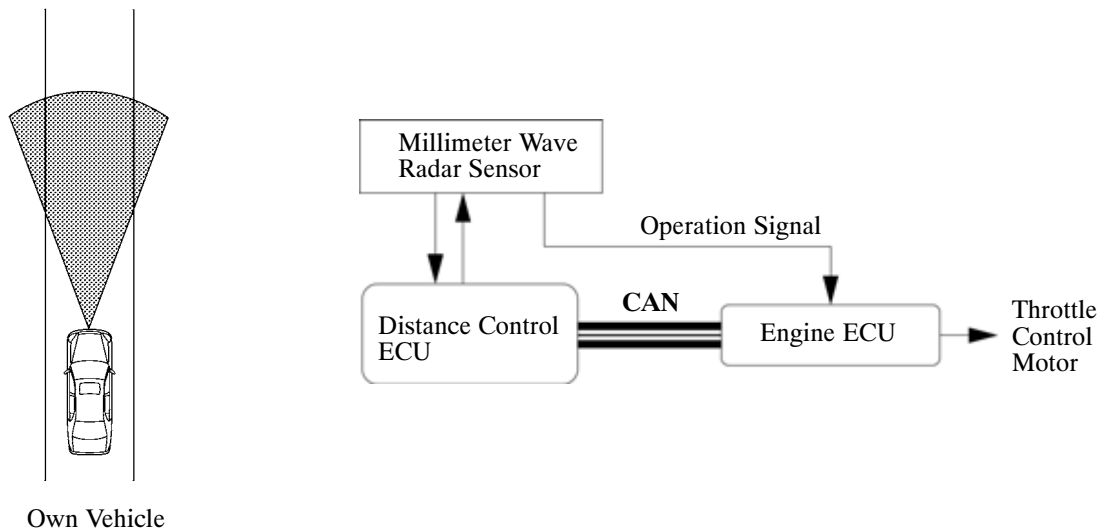
Constant Speed Control

1) General

- In the constant speed control mode, the constant speed control is effected by the Engine ECU in the same way as the conventional cruise control.
- In the vehicle-to-vehicle distance control mode, the constant speed control is effected by the Millimeter Wave Radar Sensor and Distance Control ECU.

2) Constant Speed Control in Vehicle-to-Vehicle Distance Control Mode

The millimeter wave radar sensor transmits the information about the vehicle ahead to the Distance Control ECU and also transmits a millimeter wave radar sensor operation signal to the Engine ECU. The Distance Control ECU transmits this signal to the Engine ECU. The Engine ECU compares the set vehicle speed and the actual vehicle speed, and effects constant speed control by regulating the throttle control in order to attain the set vehicle speed.

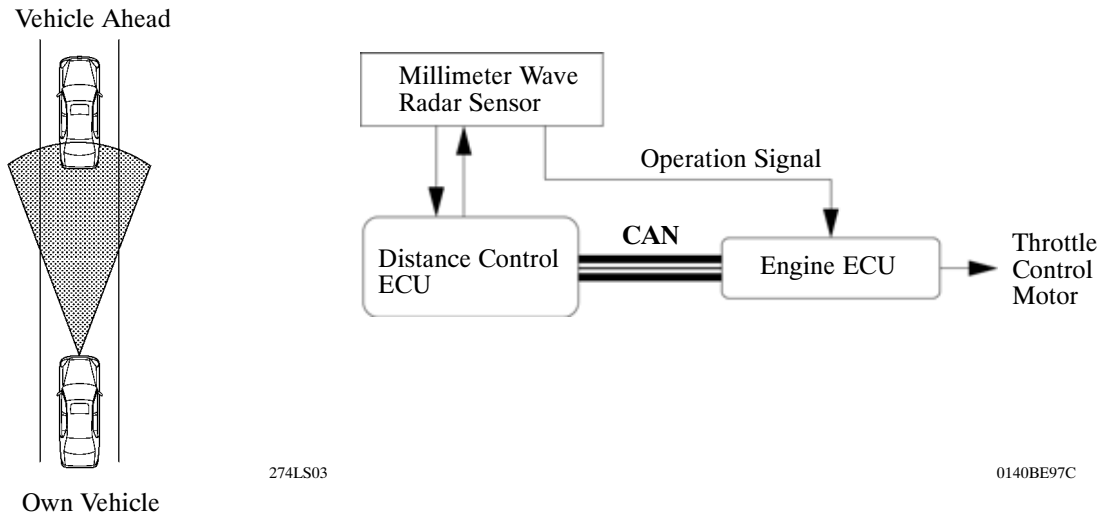


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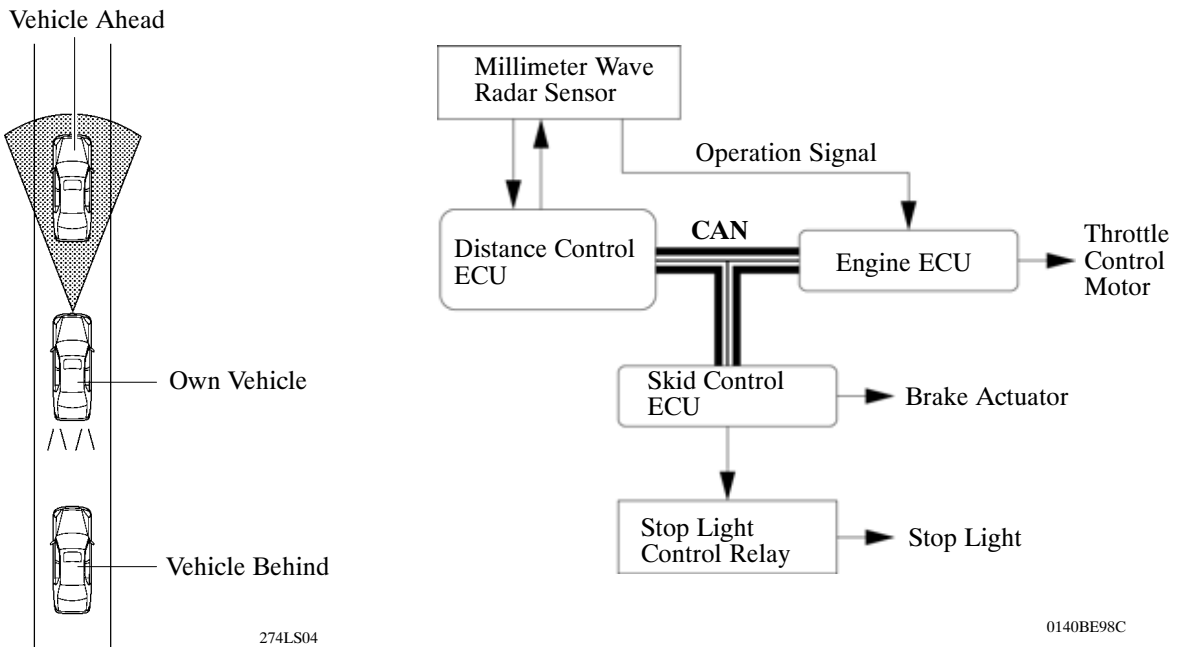
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Deceleration Control

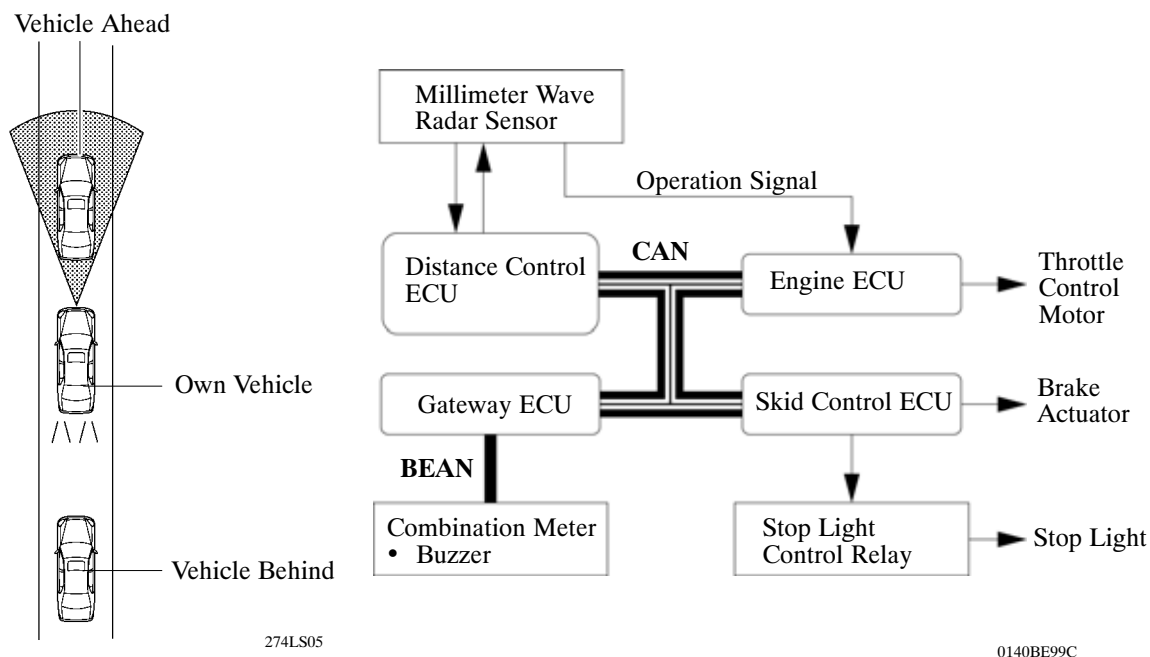
- The Distance Control ECU calculates the target deceleration rate in accordance with signals from the millimeter wave radar sensor, and transmits a deceleration request signal to the Engine ECU. Upon receiving this signal, the Engine ECU closes the throttle valve in order to cause the vehicle to decelerate.
- This control is not effected in the presence of a parked vehicle or object, or below the settable vehicle speed range.



- If Distance Control ECU determines that further deceleration is necessary, it transmits a brake request signal to the Engine ECU. Upon receiving this signal, the Engine ECU transmits a brake request signal to Skid Control ECU. Skid Control ECU then controls the brake actuator to apply the brakes.
- At this time, if the deceleration rate is higher than a predetermined value, The Skid Control ECU outputs a stop light illumination request signal to the stop light control relay, in order to inform anyone who might be following the vehicle.

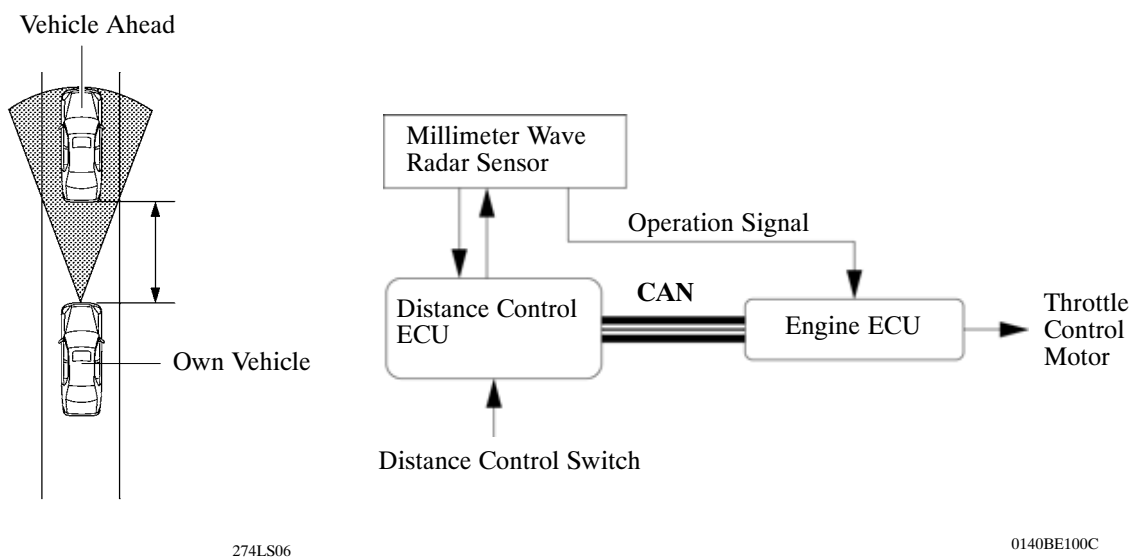


- If the vehicle is not decelerating adequately, Distance Control ECU sounds a buzzer to prompt the driver to apply the brakes.



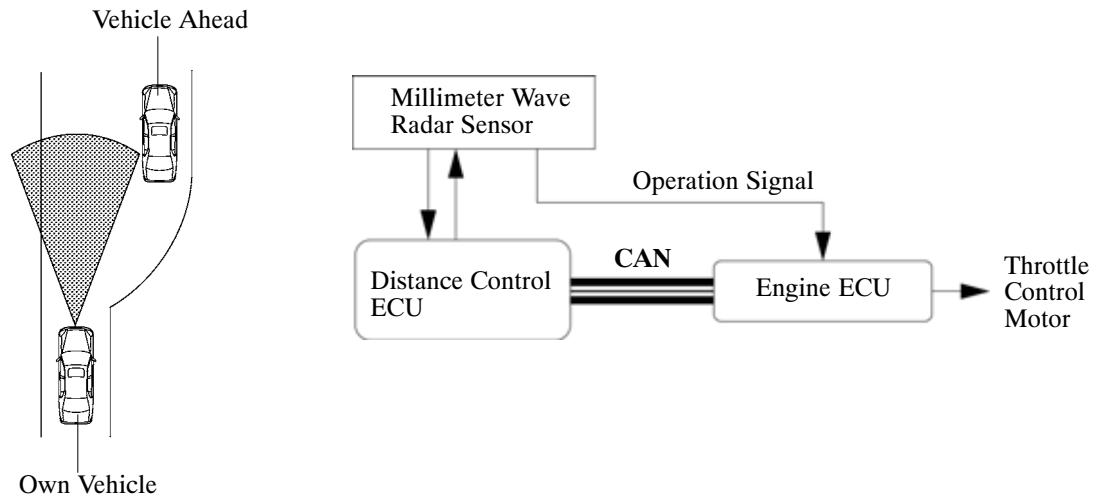
Follow-up Control

- After effecting deceleration control, Distance Control ECU transmits a request signal to the Engine ECU so that the vehicle can follow the vehicle ahead while maintaining the proper vehicle-to-vehicle distance according to the vehicle speed. Upon receiving this signal, the Engine ECU regulates the throttle in order to effect follow-up control.
- Three stages (long, middle, and short) of vehicle-to-vehicle distance can be selected by operating the distance control switch.



Acceleration Control

If Distance Control ECU detects (based on the millimeter wave radar sensor) that either the vehicle ahead or own vehicle has changed lanes, an acceleration request signal is transmitted to the Engine ECU in order to attain the set vehicle speed. Upon receiving this signal, the Engine ECU regulates the throttle in order to effect acceleration control.



Automatic Cancel Control

If any of the conditions listed below occur while the vehicle is in cruise control (A: constant speed control mode; B: vehicle-to-vehicle distance control mode), the cruise control will be canceled. Then, the following warning items will appear for the driver.

- 1) Warning message is displayed on the multi-information display.
- 2) Master warning light illuminates.
- 3) Buzzer sounds.
- 4) Cruise MAIN indicator light flashes.

Mode	Description of Malfunction	Warning
A and B	If any of the conditions listed below occur, the Engine ECU clears the set vehicle speed and cancels the cruise control. • Malfunction of the vehicle speed signal (SPD). • Malfunction in the ETCS-i. • An open or short circuit in the stop light switch. The cruise control is prohibited until the conditions are remedied or the cruise control system is turned off and back on again using the ON-OFF button on the cruise control switch.	1) “CHECK CRUISE SYSTEM” 2) Illuminate 3) Sound Once 4) Flash
	If any of the conditions listed below occur, the Engine ECU cancels the cruise control while retaining the setting vehicle speed in its memory. • The vehicle speed drops below low speed limit [approx. 40 km/h (25 mph)].	1) — 2) — 3) — 4) —
A	If any of the conditions listed below occur, the Engine ECU cancels the cruise control. • The vehicle speed drops more than 16 km/h (10 mph) below the set vehicle speed.	1) — 2) — 3) — 4) —
B	If any of the conditions listed below occur, the Engine ECU clears the set vehicle speed and cancels the cruise control. • Malfunction of the millimeter wave radar sensor. • Displacement of the axis of the millimeter wave radar sensor. • Malfunction in the dynamic radar cruise control system other than those given above. The cruise control is prohibited until the conditions are remedied or the cruise control system is turned off and back on again using the ON-OFF button on the cruise control switch.	1) “CHECK CRUISE SYSTEM” 2) Illuminate 3) Sound Once 4) Flash
	If any of the conditions listed below occur, the Engine ECU cancels the cruise control while retaining the setting vehicle speed in its memory. • The millimeter wave radar sensor is dirty. The cruise control is prohibited until the conditions are remedied or the ON-OFF button on the cruise control switch is turned on again.	1) “CLEAN RADAR SENSOR” 2) Illuminate 3) Sound Once 4) —
	If any of the conditions listed below occur, the Engine ECU cancels the cruise control while retaining the set vehicle speed in its memory. • The wipers operate at HI speed (including AUTO mode). • The pattern select switch is SNOW mode. • The measurement becomes extremely unstable due to poor weather conditions. The cruise control is prohibited until the conditions are remedied or the cruise control system is turned off and back on again using the ON-OFF button on the cruise control switch.	1) “CRUISE NOT AVAILABLE” 2) Illuminate 3) Sound Once 4) —

Diagnosis

If a malfunction occurs in the dynamic radar cruise control system, during cruise control, the Engine ECU cancels the cruise control and flashes the cruise MAIN indicator light to inform the driver of the malfunction. At the same time, the malfunction is stored in memory as a DTC (Diagnostic Trouble Code).

- When an intelligent tester II connects to DLC3 or SST (09843-18040) is connected between the Tc and CG terminals of DLC3, DTCs can be read.
- An intelligent tester II can be used to read the 5-digit codes. If the SST is used, 2-digit codes can be read based on the number of blinks of the cruise MAIN indicator light.