i-stop CONTROL [SKYACTIV-G 2.0, SKYACTIV-G 2.5]

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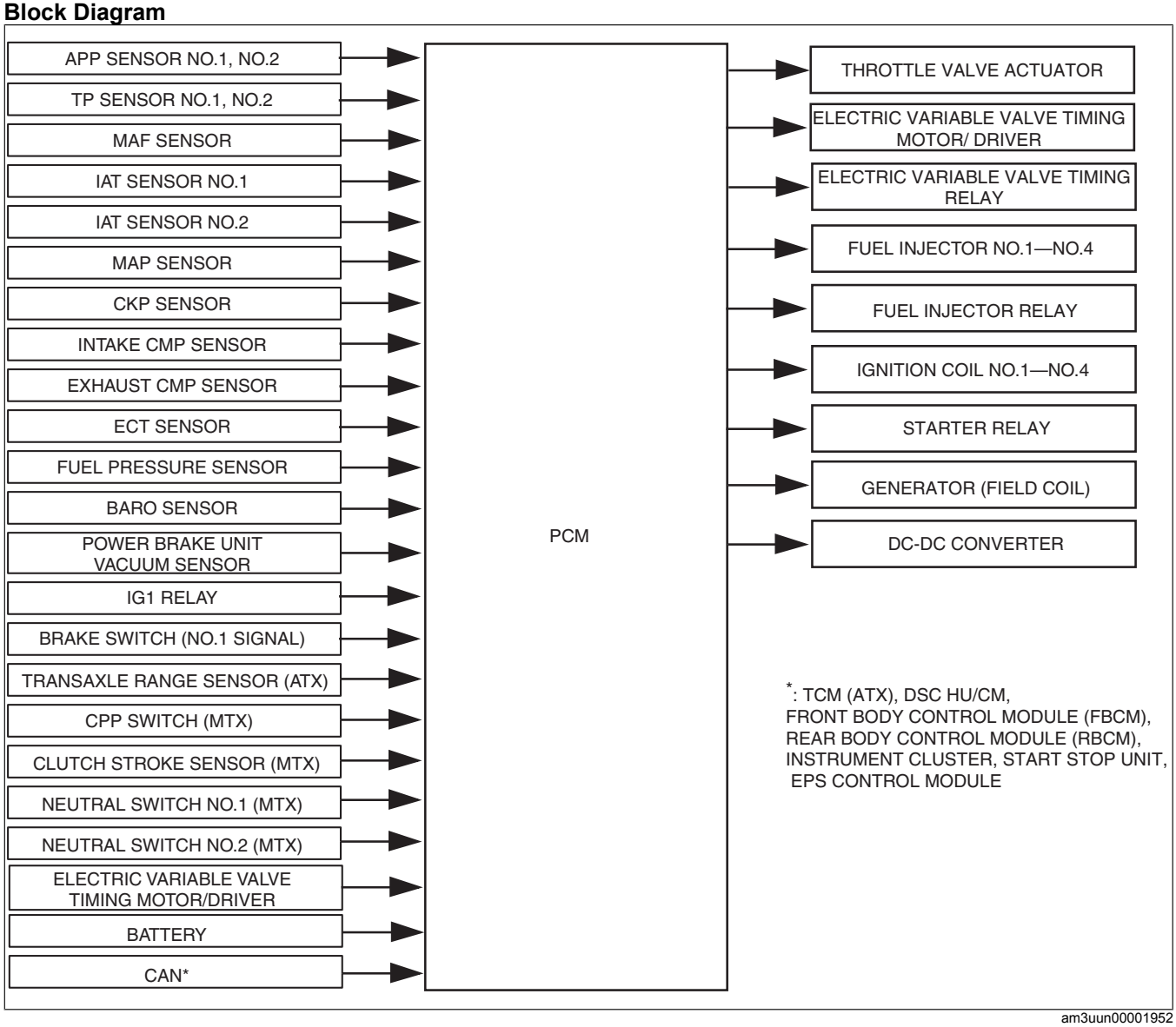
Outline

- When the vehicle is stopped such as at a stop light, the i-stop control stops/starts the engine automatically to improve fuel economy and reduce exhaust gas and idling noise.
- The PCM determines whether to permit/inhibit i-stop control based on the signal from each input part and CAN communication.
- The i-stop control includes the engine stop control, engine restart control, electric AT oil pump driver control, and hill launch assist functions.

Control Table

Control name	Control outline
Engine stop control	• The engine is stopped when the i-stop (engine stop control) conditions are met. (See Engine stop control.)
Engine restart control	• The engine restarts when the i-stop (engine restart control) conditions are met. (See Engine restart control .)
Electric AT oil pump driver control	• Drives the electric AT oil pump to assure line pressure during an engine stop by the i-stop control.
Hill launch assist function	• Controls the traction control solenoid valve in the DSC HU/CM to maintain or decrease brake fluid pressure.

Block Diagram



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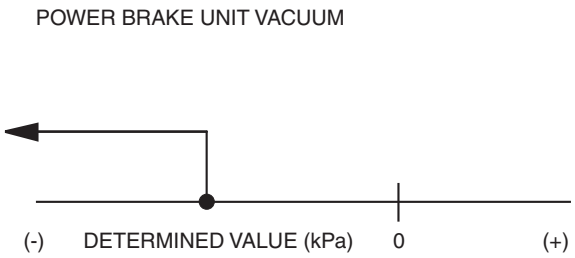
Operation
Engine stop control
i-stop (engine-stop control) permit condition

- The conditions to stop the engine by the i-stop control are as follows:

Purpose	Condition item	ATX	MTX
Driveability	Vehicle speed	0 km/h {0 mph}	3 km/h {2 mph} or less
	Brake pedal	Brake pedal depressed in D position or M position (except 2nd gear fixed mode) (If ABS operates during deceleration, i-stop operation is inhibited.)	Not applicable
	Brake fluid pressure	Brake fluid pressure is 1.25 MPa {12.7 kgf/cm^2, 181 psi} or more in D position or M position (except 2nd gear fixed mode) (pedal force sufficient to suppress vehicle lurch when engine is restarted)	Not applicable
	Accelerator pedal	Released (foot removed from accelerator pedal)	←
	Clutch pedal	Not applicable	30% or less (clutch pedal opening angle)
	Gear position	Not applicable	Neutral
	Vehicle conditions	Vehicle stopped in D position (After vehicle is stopped and shifted into N position, engine stops 0.6 s after operation. In addition, after vehicle is stopped in D position and if shifted into P position, engine stop condition continues by i-stop control	Not applicable
Marketability	Cabin temperature (With full-auto air conditioner)	Difference between target temperature in cabin and temperature in cabin is within a certain value (A/C cabin temperature control is performed)	←
	A/C temperature (With full-auto air conditioner)	Setting other than MAX/MIN	←
	Warm up condition (With manual air conditioner)	Ambient temperature is 10 °C {50 °F} or more and engine coolant temperature is 60 °C {140 °F} or more	←
	Cold condition (With manual air conditioner)	Ambient temperature is 29 °C {84 °F} or less and evaporator temperature is 9 °C {48 °F} or less	←
	Ambient temperature	-10—50 °C {14—122 °F}	←
	Steering speed	15 deg/sec or less	←
	Steering angle	-65—65 ° (Center) (After EPS control module learned center value)	Not applicable
	Steering torque	1.4 N·m {14 kgf·cm, 12 in·lbf} or less	←
	i-stop OFF switch	OFF	←
	Vehicle speed history	3 km/h {2 mph} or more	4 km/h {2.5 mph} or more

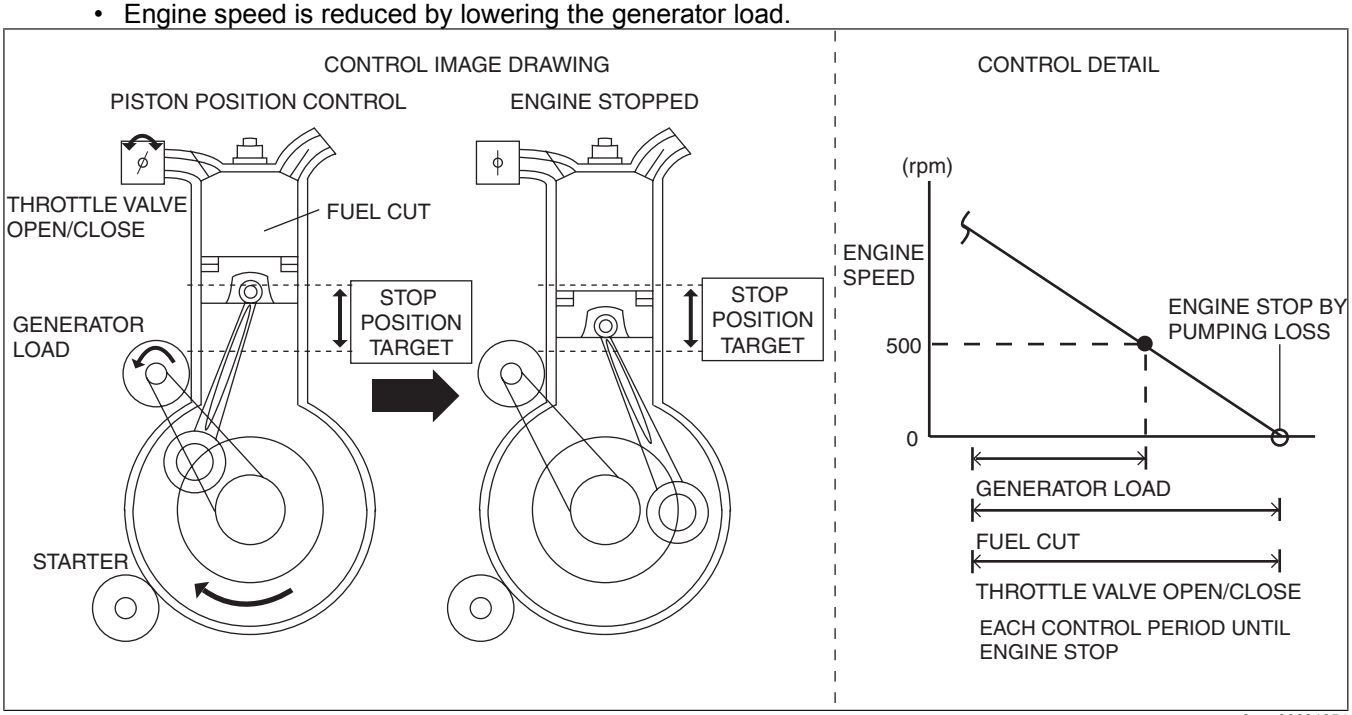
Purpose	Condition item	ATX	MTX
Safety	Battery charge condition	68.4% or more (determined from current sensor signal))	←
	Battery fluid temperature	0—70 °C {32—158 °F}	←
	Battery voltage	11.2 V or more	←
	Estimated battery voltage during engine restart	7.45 or more*1	←
	Defroster switch	OFF	←
	Power brake unit vacuum	-45 kPa {-0.46 kgf/cm2, -6.5 psi} or less 	
	Door (front, rear)	Closed	←
	Bonnet	Closed*2	←
	Liftgate	Closed	←
	Vehicle inclination angle	When level, less than ± 7%	Not applicable
	Seat belt (driver)	Fastened	←
	Push button start system	Normal	←
	System condition	i-stop related module normal	←
System restriction	Number of starter operations	Within 180,000 times	←
	Number of starter relay operations	Within 180,000 times	←
	Number of i-stop operations	Within 300,000 times	←
	ISC learning	Completed	←
	Battery condition learning setting	Completed	←
	Steering angle sensor initialization setting	Completed	Not applicable
	DSC sensor initialization	Completed	Not applicable
	Elapsed time after engine restart	Maximum 6.4 s or more (Engine stop time fluctuation by i-stop control)	Not applicable
	PCM DTC	DTC except P11A:00 and P117A:00 and P2299:00 not detected	←
Engine condition	Engine coolant temperature	55—110 °C {131—230 °F}	←
	Intake air temperature	100°C {212 °F} or less	←
	ATF temperature	20—120 °C {68—248 °F}	Not applicable
Environment condition	Altitude	**European (L.H.D. U.K.) specs.** • 1,800 m or less **Except for European (L.H.D. U.K.) specs.** • 1,500 m or less	←

*1 : If the i-stop is operated repeatedly with a high-capacity audio system or added electronic device connected to the DC-DC converter, engine stop by the i-stop control is inhibited at a faster timing than normal.

*2 : If the engine is started while the hood is open, i-stop is inhibited until the engine is stopped.

i-stop (engine stop control)

- When the i-stop (engine stop control) permit conditions are met, the PCM stops the engine based on the following controls:
  - — Fuel injection control (fuel cut)
    - Engine speed is reduced by the fuel cut.
  - — Drive-by-wire control (throttle valve open/closed)
    - By adjusting the throttle valve opening angle, the engine speed is reduced and the pumping loss is used to stop the engine.
  - — Electric variable valve timing control (intake valve timing retard)
    - Intake valve timing retard is performed for engine restart by i-stop control.
  - — Generator output control (generator load)
    - Engine speed is reduced by lowering the generator load.



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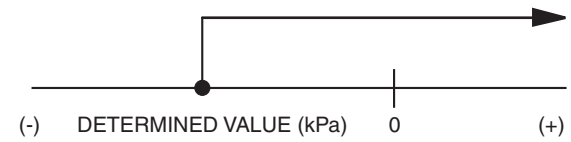
Engine restart control

i-stop (engine restart control) conditions

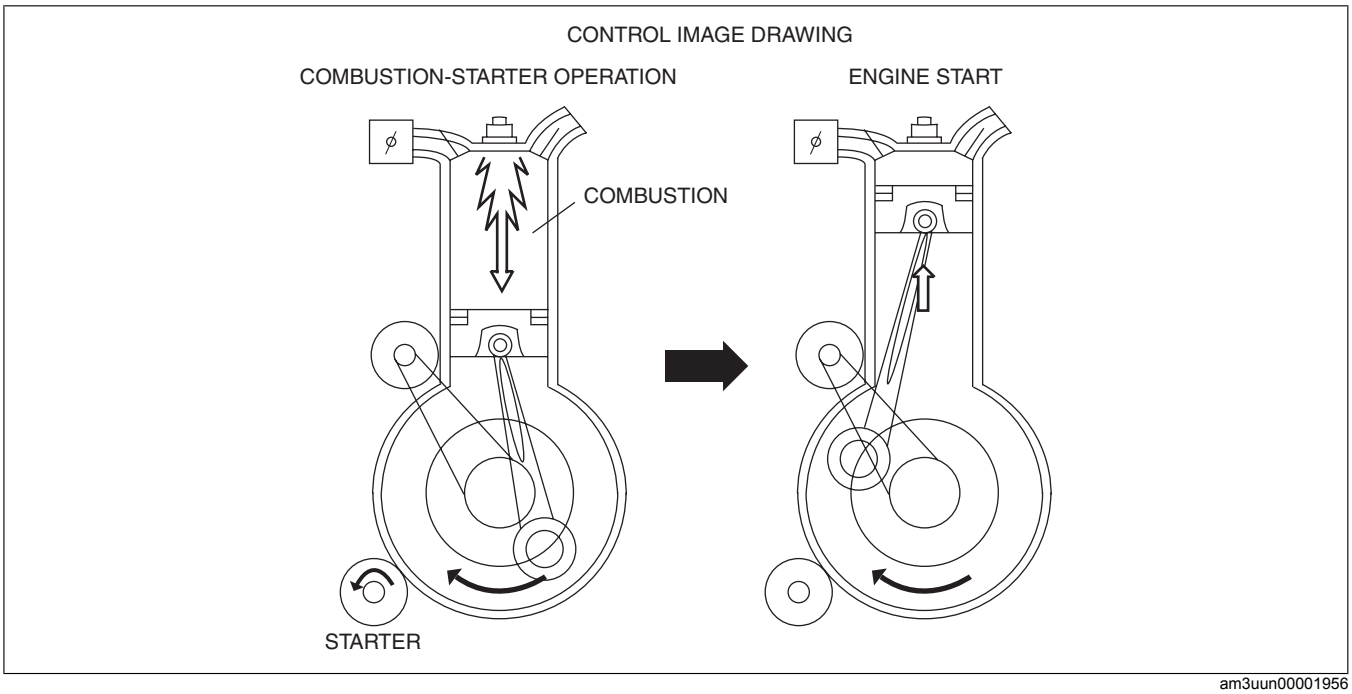
- Conditions for restarting the engine during i-stop control (engine stopped) are as follows:

Purpose	Condition item	
	ATX	**MTX**
Driver operation	Not applicable	Clutch pedal depression rate: 86% or more (If the clutch pedal depressed and then it is released while the engine is cranking to restart by the i-stop control, engine stop by the i-stop control continues. If the same operation is repeated several times, the engine will stall.)
	Brake pedal released → depressed while in P or N position	Not applicable
	Brake fluid pressure is 0.35 MPa {3.6 kgf/cm2, 51 psi} or less in D position or M position	Not applicable
	Accelerator pedal depressed while in D or M position	Not applicable
	Steering torque is 2.8 N·m {29 kgf·cm, 25 in·lbf} or more in D position or M position	Not applicable
	Steering angle (D or M position (except 2nd gear fixed mode)): -70° or less or 70° or more (after EPS control module learned center value)	Not applicable
	Engine start by key operation	←
	Shift operation • When changed to the M position (except 2nd gear fixed mode) • P or N position →D or M or R position	Not applicable

Purpose	Condition item	
	ATX	MTX
Marketability	A/C request (With full-auto air conditioner)	←
	A/C temperature MAX setting, MIN setting (With full-auto air conditioner)	←
	Warm up condition (With manual air conditioner): Ambient temperature is 9 °C {48 °F} or less and engine coolant temperature is 57 °C {135 °F} or less	←
	Cold condition (With manual air conditioner): Ambient temperature is 30 °C {86 °F} or more and evaporator temperature is 10 °C {50 °F} or more	←
	Battery charge 67.9% or less	←
	Battery charge rate is specified value or more	←
	Estimated battery voltage when engine is restarted is 7.25 V or less	←
	i-stop OFF switch on	←
	• The following conditions are met. — Seat belt (driver): Not fastened — Door or liftgate: Open	←
Safety	**Except for European (L.H.D. U.K.) specs.** • The following conditions are met while in P or N position (determined that driver is not in vehicle). — Seat belt (driver): Not fastened — Door (driver): Open	**Except for European (L.H.D. U.K.) specs.** • The following conditions are met while in neutral position (determined that driver is not in vehicle). — Seat belt (driver): Not fastened — Door (driver): Open
	Defroster switch on	←
	Power brake unit vacuum: -43 kPa {-0.44 kgf/cm^2, -6.2 psi} or more POWER BRAKE UNIT VACUUM  (-) DETERMINED VALUE (kPa) 0 (+)	←
	Vehicle speed: 1 km/h {0.6 mph} or more	Vehicle speed: 4 km/h {2.5 mph} or more
	Engine stop time by the i-stop control: 120 s or more	←

i-stop (engine restart control)

- When the i-stop (engine restart control) conditions are met, the PCM restarts the engine by the following controls:
  - — Fuel injection control (from first time, fuel injection to specific cylinders (expansion stroke)
    - Fuel is injected to cylinders which are determined to be stopped at the expansion stroke. During i-stop control (engine stop), cylinders are identified based on the signal from the crankshaft position sensor and fuel injection is enabled to those cylinders which are identified first as being stopped in the expansion stroke.
  - — DC-DC converter control
    - When the engine is restarted by the i-stop control, the battery voltage is decreased to operate the starter by supplying power from the battery. When the starter operates, the supply voltage for electronic devices is increased by the DC-DC converter.



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Indicator illumination request

- The PCM sends an i-stop indicator light (green)/i-stop warning light (amber) illumination or flash request to the instrument cluster according to the vehicle conditions.
- The i-stop indicator light (green)/i-stop warning light (amber) illumination/flash request conditions are as follows:

European (L.H.D. U.K.) specs.

IS: Engine stop by i-stop control
IR: Engine restart by i-stop control
×: Applicable

Vehicle condition		Vehicle condition	i-stop indicator light (green)/i-stop warning light (amber) display			Indicator (other)	Buzzer
			Illumination on	Flash (0.5 s)	Illumination off	Illumination on/ Flash	
Driving	IS conditions not met	—	—	—	×	—	—
	IS conditions met*7	—	—	—	×	—	—
Vehicle parked	IS conditions not met*7	Idle	—	—	×	—	—
	IS conditions met*7	IS	Green	—	—	—	—

Vehicle condition			Vehicle condition	i-stop indicator light (green)/i-stop warning light (amber) display			Indicator (other)	Buzzer
				Illumination on	Flash (0.5 s)	Illumination off	Illumination on/ Flash	
During IS	IS conditions met*7		IS	Green	—	—	—	—
	IS continues normally	**ATX** When the following conditions are met: • Brake depressed • D or M position (except 2nd gear fixed mode) • Steering angle less than 70° When the following conditions are met: • Brake released • D or M position (except 2nd gear fixed mode) →N position • D or M position (except 2nd gear fixed mode) →N position →P position • Steering angle less than 70°	IS continues	Green	—	—	—	—
		MTX Clutch pedal depressed→ Clutch pedal is released while engine is cranking to restart by i-stop control	IS continues/Engine stall*11					
	IR request (driver's operation)	When changed to the M position (except 2nd gear fixed mode)	IR	—	—	×*2	—	—
		Engine start by key operation						
		A/C temperature MAX setting, MIN setting						
		ATX • Brake pedal released → depressed while in P or N position • Brake fluid pressure is 0.35 MPa {3.6 kgf/cm2, 51 psi} or less in D position or M position • Accelerator pedal depressed while in D or M position • Steering torque is 2.8 N·m {29 kgf·cm, 25 in·lbf} or more in D position or M position • Steering angle (D or M position (except 2nd gear fixed mode)): -70° or less or 70° or more • Shift operation — When changed to the M position (except 2nd gear fixed mode) — P or N position →D or M or R position						
		MTX • Clutch pedal opening angle is 86% or more						

Vehicle condition			Vehicle condition	i-stop indicator light (green)/i-stop warning light (amber) display			Indicator (other)	Buzzer
				Illumination on	Flash (0.5 s)	Illumination off	Illumination on/ Flash	
During IS	IR request (driver's operation)	When the following conditions are met: • Seat belt (driver): Not fastened • Door (driver): Open • P or N position (ATX) • Neutral position (MTX)	Engine stall	Amber	—	—	Same illumination as normal engine stall condition	0.25 s intervals for 3 s
	Switches to unsafe condition (driver's operation)	Door (driver) open	IS continues	—	Green	—	—	0.25 s intervals
		When the following conditions are met: • Seat belt (driver): Not fastened • Door (driver): Open • D or M position (except 2nd gear fixed mode) (ATX) • In gear (MTX)	Engine stall	Amber	—	—	Same illumination as normal engine stall condition	0.25 s intervals for 3 s
		Bonnet open	Engine stall	Amber	—	—	Same illumination as normal engine stall condition	0.25 s intervals for 3 s
		MTX In gear	IS continues	—	Green	—	—	—
	IR request (vehicle request)	Any of the following conditions are met: • A/C request • Battery charge 67.9% or less • Battery charge rate is specified value or more • Estimated battery voltage when engine is restarted is 7.25 V or less • Defroster switch on • Engine stop time by the i-stop control: 120 s or more	IR	—	Green*9	×*2	—	—
		Any of the following conditions are met: • Vehicle speed: 1 km/h {0.6 mph} or more (ATX) • Vehicle speed: 4 km/h {2.5 mph} or more (MTX) • Power brake unit vacuum reduced	IR	—	—	×*2	—	—
		• Advanced key is carried outside of vehicle	IR*6	—	—	×*2	Keyless warning light (red) flash	Keyless control module normal buzzer
	IR not functional	• Cranking for 3 s or more when engine is restarted	Engine stall	Amber	—	—	Same illumination as normal engine stall condition	—

Vehicle condition		Vehicle condition	i-stop indicator light (green)/i-stop warning light (amber) display			Indicator (other)	Buzzer
			Illumination on	Flash (0.5 s)	Illumination off	Illumination on/ Flash	
IS permit/inhibit implement	• i-stop OFF switch on (long pressed for 0.5 s or more)	IS not authorized*8	Amber*3	—	—	—	Beep sound 1 time
	• i-stop OFF switch off (long pressed for 0.5 s or more)	IS authorized	—	—	×*4	—	Beep sound 1 time
System malfunction		IS not authorized	—	Amber*5	—	×*10	—

*1 : Changes illumination to IS when the conditions are met for driver operation (brake pedal force).
*2 : No flashing, turns off when the engine restarts.
*3 : Illuminates according to the i-stop OFF switch operation (long-press for 0.5 s or longer).
*4 : Turns off according to the i-stop OFF switch operation (long-press for 0.5 s or longer).
*5 : It may illuminate in amber when communication between PCM is cut.
*6 : Only when the advanced key is outside of the vehicle with the doors other than driver's door open.
*7 : The i-stop (engine-stop control) permit conditions differ depending on the driving condition. (See i-stop INDICATOR LIGHT (GREEN) [SKYACTIV-G 2.0, SKYACTIV-G 2.5].)
*8 : If during engine stop by i-stop control, engine restarted by i-stop control.
*9 : IR is performed after the i-stop indicator light (green) flashes for 3 s.
*10 : If there is a battery related malfunction, the master warning light illuminates.
*11 : If the clutch pedal depressed and then it is released while the engine is cranking to restart by the i-stop control, engine stop by the i-stop control continues. If the same operation is repeated several times, the engine will stall.

Except for European (L.H.D. U.K.) specs.

IS: Engine stop by i-stop control
IR: Engine restart by i-stop control
×: Applicable

Vehicle condition		Vehicle condition	i-stop indicator light (green)/i-stop warning light (amber) display			Indicator (other)	Buzzer
			Illumination on	Flash (0.5 s)	Illumination off	Illumination on/ Flash	
Driving	IS conditions not met	—	—	—	×	—	—
	IS conditions met*7	—	Green	—	—	—	—
Vehicle parked	IS conditions not met*7	Idle	—	Green*1	—	—	—
			—	—	×	—	—
	IS conditions met*7	IS	Green	—	—	—	—

Vehicle condition			Vehicle condition	i-stop indicator light (green)/i-stop warning light (amber) display			Indicator (other)	Buzzer
				Illumination on	Flash (0.5 s)	Illumination off	Illumination on/ Flash	
During IS	IS conditions met*7		IS	Green	—	—	—	—
	IS continues normally	**ATX** When the following conditions are met: • Brake depressed • D or M position (except 2nd gear fixed mode) • Steering angle less than 70° When the following conditions are met: • Brake released • D or M position (except 2nd gear fixed mode) →N position • D or M position (except 2nd gear fixed mode) →N position →P position • Steering angle less than 70°	IS continues	Green	—	—	—	—
		MTX Clutch pedal depressed→ Clutch pedal is released while engine is cranking to restart by i-stop control	IS continues/Engine stall*10					
	IR request (driver's operation)	When changed to the M position (except 2nd gear fixed mode)	IR	—	—	×*2	—	—
		Engine start by key operation						
		A/C temperature MAX setting, MIN setting						
		ATX • Brake pedal released → depressed while in P or N position • Brake fluid pressure is 0.35 MPa {3.6 kgf/cm2, 51 psi} or less in D position or M position • Accelerator pedal depressed while in D or M position • Steering torque is 2.8 N·m {29 kgf·cm, 25 in·lbf} or more in D position or M position • Steering angle (D or M position (except 2nd gear fixed mode)): -70° or less or 70° or more • Shift operation — When changed to the M position (except 2nd gear fixed mode) — P or N position →D or M or R position						
		MTX • Clutch pedal opening angle is 86% or more						

Vehicle condition			Vehicle condition	i-stop indicator light (green)/i-stop warning light (amber) display			Indicator (other)	Buzzer
				Illumination on	Flash (0.5 s)	Illumination off	Illumination on/ Flash	
During IS	IR request (driver's operation)	When the following conditions are met: • Seat belt (driver): Not fastened • Door (driver): Open • P or N position (ATX) • Neutral position (MTX)	IR	—	—	×*2	—	—
	Switches to unsafe condition (driver's operation)	Door (driver) open	IS continues	Green	—	—	—	0.25 s intervals
		When the following conditions are met: • Seat belt (driver): Not fastened • Door (driver): Open • D or M position (except 2nd gear fixed mode) (ATX) • In gear (MTX)	Engine stall	Amber	—	—	Same illumination as normal engine stall condition	0.25 s intervals for 3 s
		Bonnet open	Engine stall	Amber	—	—	Same illumination as normal engine stall condition	0.25 s intervals for 3 s
		MTX In gear	IS continues	—	Green	—	—	—
	IR request (vehicle request)	Any of the following conditions are met: • A/C request • Battery charge 67.9% or less • Battery charge rate is specified value or more • Estimated battery voltage when engine is restarted is 7.25 V or less • Defroster switch on • Engine stop time by the i-stop control: 120 s or more	IR	—	—	×*2	—	—
		Any of the following conditions are met: • Vehicle speed: 1 km/h {0.6 mph} or more (ATX) • Vehicle speed: 4 km/h {2.5 mph} or more (MTX) • Power brake unit vacuum reduced	IR	—	—	×*2	—	—
		• Advanced key is carried outside of vehicle	IR*6	—	—	×*2	Keyless warning light (red) flash	Keyless control module normal buzzer
	IR not functional	• Cranking for 3 s or more when engine is restarted	Engine stall	Amber	—	—	Same illumination as normal engine stall condition	—

Vehicle condition		Vehicle condition	i-stop indicator light (green)/i-stop warning light (amber) display			Indicator (other)	Buzzer
			Illumination on	Flash (0.5 s)	Illumination off	Illumination on/ Flash	
IS permit/inhibit implement	• i-stop OFF switch on (long pressed for 0.5 s or more)	IS not authorized*8	Amber*3	—	—	—	Beep sound 1 time
	• i-stop OFF switch off (long pressed for 0.5 s or more)	IS authorized	—	—	×*4	—	Beep sound 1 time
System malfunction		IS not authorized	—	Amber*5	—	×*9	—

*1 : Changes illumination to IS when the conditions are met for driver operation (brake pedal force).

*2 : No flashing, turns off when the engine restarts.

*3 : Illuminates according to the i-stop OFF switch operation (long-press for 0.5 s or longer).

*4 : Turns off according to the i-stop OFF switch operation (long-press for 0.5 s or longer).

*5 : It may illuminate in amber when communication between PCM is cut.

*6 : Only when the advanced key is outside of the vehicle with the doors other than driver's door open.

*7 : The i-stop (engine-stop control) permit conditions differ depending on the driving condition. (See i-stop INDICATOR LIGHT (GREEN) [SKYACTIV-G 2.0, SKYACTIV-G 2.5].)

*8 : If during engine stop by i-stop control, engine restarted by i-stop control.

*9 : If there is a battery related malfunction, the master warning light illuminates.

*10 : If the clutch pedal depressed and then it is released while the engine is cranking to restart by the i-stop control, engine stop by the i-stop control continues. If the same operation is repeated several times, the engine will stall.