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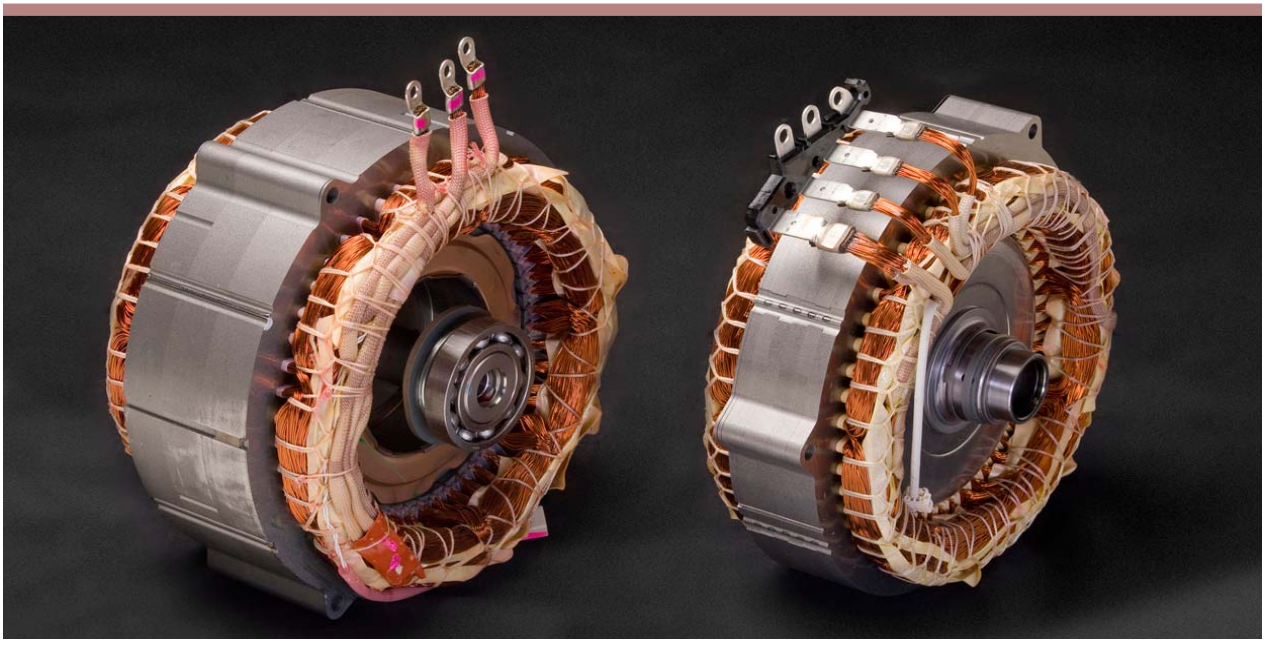
INFINITI

Infiniti HEV Technologies Technician Workbook



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INFINITI.

This book is designed for instructional use only for authorized Nissan North America, Inc. and Nissan dealer personnel. For additional information contact:

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INFINITI HEV TECHNOLOGIES
TABLE OF CONTENTS

Section 1: Text — Frame

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Section 2: Modules

INFINITI HEV TECHNOLOGIES
OBJECTIVES

Upon completion of this course, you will be able to:

- Given a service manual and owner's manual for an Infiniti Hybrid vehicle, you will be able to locate information regarding high voltage systems and safety. You will be able to describe the precautions that must be taken when working on a hybrid power train and identify the Personal Protection Equipment (PPE) that must be worn.
- Given an Infiniti QX60 Hybrid Electric Vehicle, and the appropriate personal protection equipment, you will be able to shut off the high voltage system and verify it is safe for repairs.
- Given an Infiniti QX60 HEV, you will use CONSULT and service manual information to isolate a fault in the Hybrid Control System.
- Given an Infiniti QX60 HEV, a CONSULT and the appropriate service manual you will be able to explain the operation of the cooperative regenerative brake system used in the front engine front wheel drive platform hybrid electric vehicle.
- Given an Infiniti QX60 HEV, you will be able to monitor systems and components unique to the QR25DER engine.
- Given an Infiniti QX60 HEV, the CONSULT application and the appropriate service manual you will complete the diagnostic process for a concern in the traction motor system.
- Given an Infiniti QX60 HEV, the appropriate service manual, and CONSULT you will be able to monitor and explain the operation of the clutch system used in the hybrid power train.
- Given an Infiniti HEV lithium-ion battery, you will be able to identify a fault from a trouble diagnosis scenario and follow the appropriate repair procedures.
- Given an Infiniti Q50 HEV, you will identify and repair a DTC set in the transmission control unit. You will also use CONSULT to monitor and analyze transmission data signals.
- Given an Infiniti Q50 HEV, you will be able to identify the components that control the braking system and answer questions about their functions. You will also be able to use CONSULT to retrieve and repair a DTC, and then monitor data to confirm proper system operation.

Course Procedures

Class begins promptly at 8:00 a.m. Please be in your seat and ready to begin at that time. Please silence your cell phones.

Class ends when all the modules on the sign-off page of your guidebook are initialed by the instructor. Nissan designs training so that most technicians should be able to complete all activities in the time allotted for the course. If you are unable to complete the requirements of the course in the time provided, your instructor will discuss options with you to receive course credit. You are responsible for learning the techniques and procedures featured in this course. It is important you take as much time as you need to learn the skills presented in the course material. If you cannot complete the requirements of the course in the time provided, your instructor will work with you and your dealership and help you complete the course.

Text:

The text contains information relating to the procedures, features and technology contained in the material of this course. The instructor may assign reading from the text as homework, and some of the text may help you answer questions included in the activities of this course. Read the text section for detailed information regarding the technology featured in this training. It is recommended that you save the text and use it in the future as a resource.

Course Map:

The course map indicates the order in which the modules should be completed. In the case of some training courses, certain modules must be completed before you begin other modules.

Modules:

1. Begin the module by reading the Objective, Relevance, Resources, and Skill Check on the first page. This information will present the basis for the skills included in the module.
2. Read each step carefully to determine the appropriate actions or procedures the modules are designed to impart.
3. Pay attention to the Notes, Cautions, and Service Tips included in the module. In many instances, they will help you derive the answer to questions included in the module and will help you develop the skill sets intended by the design.
4. You will probably be working with one or more technicians during this course. Follow these basic guidelines to work effectively as a team:
   - Take responsibility to understand and perform each step yourself.
   - When using diagnostic tools (CONSULT, digital multi-meters, etc.), be sure to check the on-screen results yourself and hand the tool to the other members of your group so they can confirm the results as well.
   - If you are expected to test or remove and inspect a component, perform these procedures yourself and give the same opportunity to other members of your team.

- Be patient. Everyone works at different speeds. You are responsible to be able to perform each module objective - and you are responsible to ensure that others working with you can complete the skill check.
- Complete all questions on the worksheet. In some cases, the worksheet may give you the opportunity to skip some steps, for example - you may not need to follow the instructions for booting CONSULT if you are already confident using the tool. If your co-workers wish to complete these instructions, be patient as they perform these steps.
- Treat the training center vehicles as if they were a customer's car. However if you damage a vehicle in the course of completing a module, notify the instructor immediately. Some components such as trim pieces or wire connectors may be damaged during testing. We expect these occasional problems and need to know about them as soon as they occur.
- Return the vehicle to the condition it needs to be in for the next group of technicians to complete the workstation. For example, reset the bugs if applicable, return tools to the workbench or tool box and straighten up the work area.
- Contact the instructor when you have completed the module and are confident you can perform the “Skill Check” stated on the first page. Expect the instructor to review your worksheet and confirm that you have completed the objective. Tell the instructor if you feel you need more practice. If possible, the instructor will provide you with additional information or give you the opportunity to work on the vehicle later that day.

Resources:

Resources may include ASIST, CONSULT, service manuals, digital multi-meters, hand tools, special service tools, and vehicle parts. If the ASIST terminal is not working properly or has not been updated, please notify your instructor.

Monitor the battery power for CONSULT and connect it to the charger as needed. For some courses we expect you to be comfortable using CONSULT for testing the CAN system and accessing Self Diagnosis, Data Monitor, Active Test and Work Support. Contact your instructor if you are not familiar using these applications. Contact the instructor if you have any questions about using the listed resources or, there is a problem with any of the resources you will need to complete the module.

PowerPoint Notes:

The classroom discussion highlights information you will practice during completion of the modules. Make notes and ask questions during the discussion and you will learn information that will help you complete the worksheet objectives.

Technician Creed and Code of Repair

This vehicle is the personal property of the customer.

The customer's desire is: I correctly service / repair their vehicle today.

My desire is: He / She returns to my place of business for additional service and repairs unrelated to today's visit.

It is my choice regarding the quality of repair I make today.

I will do all I can to gain the customer's trust while servicing and repairing their vehicle.

NISSAN

ATTITUDE IS EVERYTHING!

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TEXT

Welcome to Infiniti HEV Technologies

NOTES:

Introduction

Hybrid Introduction

Current Infiniti hybrids use the Direct Response Hybrid system. This is a one motor, two clutch parallel hybrid system that achieves improved fuel economy while maintaining driving performance by doing the following:

- Switching to EV mode during idle, low-speed driving, and other driving situations where the engine is not needed to conserve fuel
- Charging the high-voltage battery during braking and deceleration
- Using the combustion engine during passing, climbing, and other driving situations when the engine is needed
- Using a combination of engine and electric motor to provide optimum power and torque when required

Because the engine can be completely disengaged when needed, all motor power can be converted into driving force. This eliminates friction and provides efficient charging and discharging. The system provides a near-seamless transition from full-EV mode to varying degrees of power assist operation, and also a wide EV mode drive range. The system provides compact packaging to allow spacious passenger and cargo capacities while maintaining simplicity in design.

High-voltage Safety

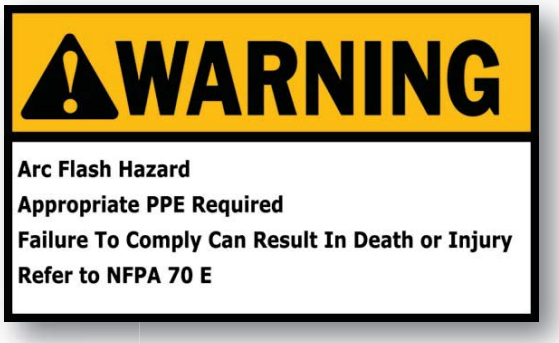
Effects of Current on the Human Body

- Voltages exceeding 60 volts DC or 25 volts (RMS) AC are considered dangerous
- Current flow between 100 and 200 milliamps through a human body are usually fatal

Safe Voltage Limits
- AC – 25V
- DC – 60V

Current		Reaction
Safe current values	1 mA or less	Causes no sensation – not felt
	1 mA to 8 mA	Sensation of shock, not painful, individual can let go at will because muscular control is not lost
Unsafe current values	8 mA to 15 mA	Painful shock, individual can let go at will because muscular control is not lost
	15 mA to 20 mA	Painful shock, control of adjacent muscles is lost, victim can not let go
	50 mA to 100 mA	Ventricular fibrillation, a heart condition that can result in death is possible at this current level
	100 mA to 200 mA	Ventricular fibrillation occurs
	200 mA and over	Severe burns, severe muscular contractions, so severe that chest muscles clamp the heart and stop it for the duration of the shock (This prevents ventricular fibrillation)

High-voltage Precautions



High-voltage Wiring Identification

All high-voltage system wiring is identified with orange insulated wrapping.

- Follow all precautions when working on or near high-voltage wiring and components

Q50 Under hood

QX60 High-voltage Battery

High-voltage Warning Labels

Q50 Battery Warning Label

QX60 Battery Warning Labels

Lithium-ion Battery Controller (LBC) Warning Label

READY to DRIVE Indicators

QX60

Q50

- If power switch is set to "READY to DRIVE", the high-voltage system is powered up and potentially hazardous
- In EV Mode, the engine could start at any time to charge the lithium-ion battery
- If possible, remove the I-key during vehicle service

HEV Unique Indicators

System READY to DRIVE Indicator

- Illuminates when the hybrid system is ready
- Vehicle may start at any time, even when in PARK
- When servicing a vehicle, make sure the indicator is OFF

System warning

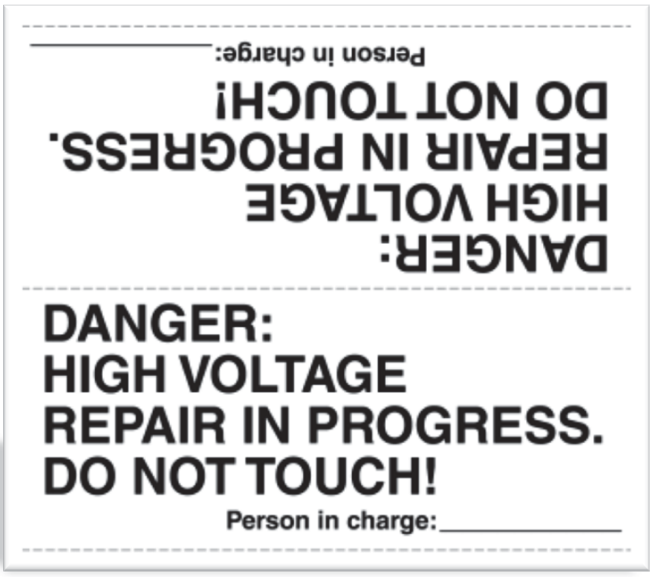
- Illuminates when the hybrid system malfunctions

High-voltage Vehicle in Service Area

When high-voltage systems are being serviced or repaired

- The work area should be clean and dry, and have high-voltage warning posted
- Warning placards may be printed from the service manual and posted on the vehicle
- Additional precautions such as a roof cone or warning tape are also recommended

- The vehicle contains parts that contain powerful magnets. If a person who is wearing a heart pacemaker or other medical device is close to these parts, the medical device may be affected by the magnets. Such persons must not perform work on the vehicle



Personal Protection Equipment (PPE)

Eye Protection

- Safety glasses or goggles
- Should be worn when working on or around high-voltage systems or components

Personal Protection Equipment (PPE)

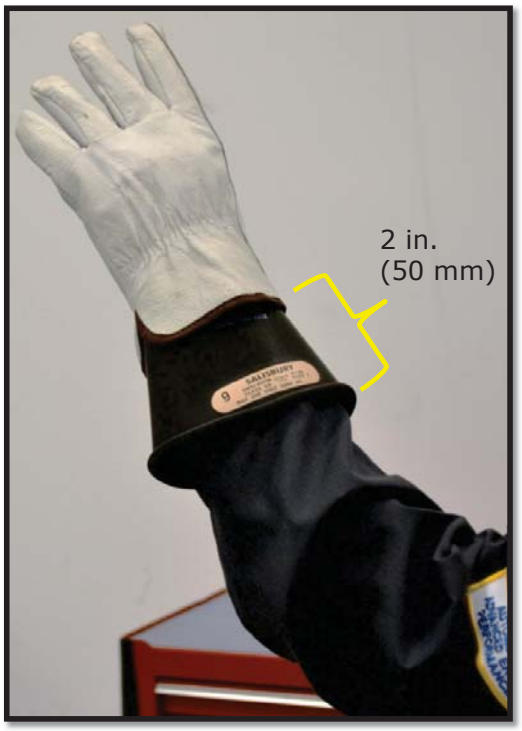
High-voltage insulated lineman's gloves and leather protectors

- Must be 1000-volt (Class 0) natural rubber (Type 1)
- Inspect gloves daily for cuts, defects, dirt, oil/grease, etc. by inflating
- Check the Certification Date printed on the gloves, and recertify every 6 months
- Wear gloves when removing the service plug, testing high-voltage system or components, or when you are not certain the high-voltage battery has been disconnected
- Remove all jewelry before working on the vehicle

Personal Protection Equipment (PPE)

Leather Protectors

- Used to prevent damage to the rubber lineman's gloves from sharp edges and corners
- Be sure the rubber lineman's glove extends at least 2 in. (50 mm) beyond the leather protector
- Arc flash clothing or 100% cotton clothing with long sleeves should be worn
- The sleeves should be tucked into the rubber insulating glove



Personal Protection Equipment (PPE)

Insulated Shoes

- Insulated shoes must be Insulated Electrical Hazard, or EH rated
- Insulated shoes are to be worn while working on or around high-voltage systems
- This includes contacting the service plug, inverter, DC/DC converter, junction box, or when dealing with a vehicle that has been in a collision
- Technicians must provide insulated shoes that are free of pin-holes, damage, nails, metal tips, worn-out soles, oil, grease or soiling

Personal Protection Equipment (PPE)

Insulated Boots

- When water, oil, or other substances cannot be cleaned off the floor, insulated boots must be worn to prevent electrical shock

Personal Protection Equipment (PPE)

Insulated Rubber Mat

- Place on the floor when exposure to high voltage is possible
- Place on workbench before placing lithium-ion battery on the workbench
- May be used when EH rated safety shoes are not available

Insulated Blanket

- Place over the battery after removal
- Place over high-voltage components to prevent accidental contact during service or repairs
- Must roll the blanket for storage
- Certified every 12 months

Personal Protection Equipment (PPE)

Arc Flash Clothing

- Arc flash clothing is highly recommended when exposure to high-voltage arcing might occur
- High-voltage arc flash can cause severe burns to the skin and eyes similar to welding flash

Personal Protection Equipment (PPE)

Fire Extinguisher

- Use only a Class C fire extinguisher
- Water must never be used for battery chemical or electrical fires

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Disabling the High-voltage System

1. Set the power switch to OFF, remove and secure the I-key
2. Disconnect the negative 12-volt battery cable and cover the exposed terminal and cable end with insulating tape

QX60

12-volt Negative Battery Cable

Q70

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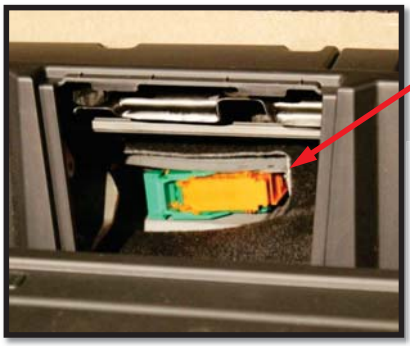
Disabling the High-voltage System

3. Remove and secure the service plug. Cover the connector with tape.
4. Wait for a minimum of 10 minutes after the service plug is removed before continuing service.
5. Perform the high-voltage shutoff confirmation procedure to insure all voltage has dissipated.



Access

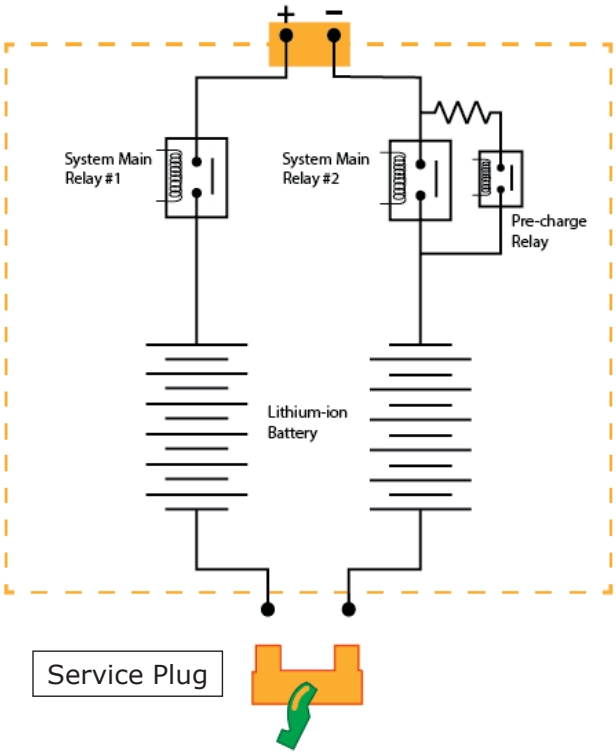
Remove

Protect

PPE must be used when working on the high-voltage system

Disabling the High-voltage System

- Removing the service plug splits the high voltage circuit in the lithium-ion battery in half
- PPE must be worn when removing the service plug



High-voltage Shutoff Confirmation (Potential Equalization)

This inspection is performed to ensure the voltage stored in the high-voltage systems has dissipated and is safe for repairs

- Personal Protection Equipment must be worn when conducting this inspection
- A voltmeter and test leads rated to at least 500 volts must be used
- After disabling the high-voltage system, measure the voltage across the terminals at the lithium-ion battery
- The specification is 5 volts or less

Insulation Resistance Test

Insulation resistance test is used to inspect the circuit insulation for decay

- Locates any weakness in the insulation of high-voltage components and circuits
- Compromised insulation can 'leak' to ground or into another circuit with lower potential
- The insulation resistance tester outputs 500 volts, so PPE is required
- The negative probe is placed on the component case
- The positive probe is placed on each terminal of the component connector
- Press and hold the TEST button until the reading stabilizes (up to 30 seconds)
- Compare results to the service manual specifications
- Use Fluke 1507, or equivalent

Equipotential Test (Ground Integrity)

- Verifies that unwanted resistance is not present between high-voltage component ground connections
- Used to test between two high-voltage components and between each high-voltage component case and ground
- Meter must be zeroed
- Resistance should be less than 0.1 ohm

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NOTES:

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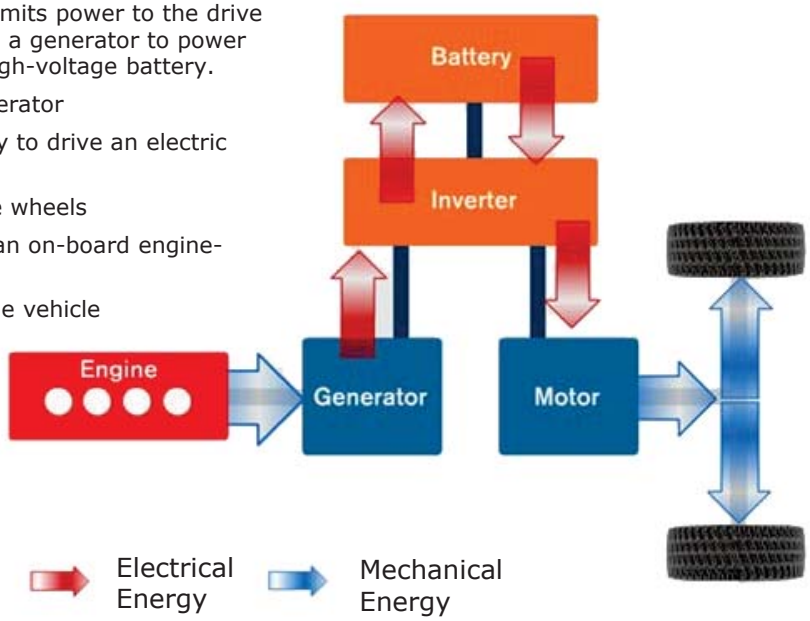
Hybrid System Overview

Series Hybrid

With a series hybrid system, only one power flow path is possible. The electric motor always transmits power to the drive wheels. The combustion engine works as a generator to power the electric motor and to recharge the high-voltage battery.

- Uses a gasoline engine to drive a generator
- The generator provides electric energy to drive an electric motor
- The electric motor is used to drive the wheels
- Is essentially an electric vehicle with an on-board engine-driven generator
- The engine does not directly propel the vehicle



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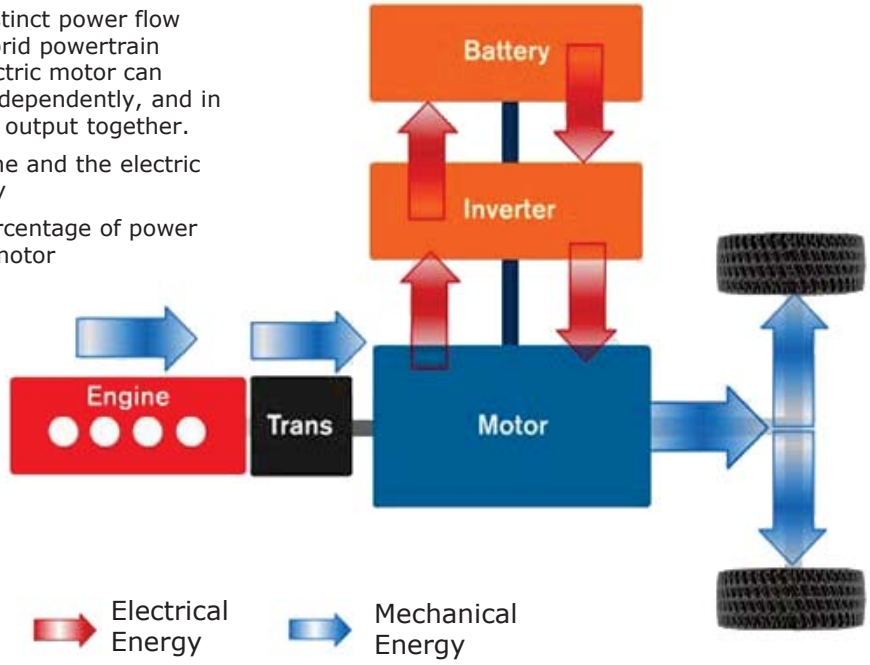
Parallel Hybrid

With a parallel hybrid system, two distinct power flow paths are possible because of the hybrid powertrain layout. The combustion engine or electric motor can transmit power to the drive wheels independently, and in many cases, can combine to transmit output together.

- Both the internal combustion engine and the electric motor can drive the wheels directly
- Control modules determine the percentage of power flow from the engine and electric motor



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Degrees of Hybridization

Hybrid Types and Configuration	Gasoline Engine Only		
	Micro Hybrid	Source of Power for Propulsion	Uses the engine for principle operation along with start/stop technology.
	Mild Hybrid		Propelled primarily by the engine, but can use the electric traction motor under certain low-load, low speed driving conditions.
	Full Hybrid		Larger and stronger electric components that propel the vehicle just with the high voltage battery/electric motor, just the engine, or a combination of both.
	Full EV		Only uses an electric motor for propulsion. Does not use a combustion engine. Plug-in charge capabilities.
	Electric Motor Only		

- **Micro Hybrid** – A micro hybrid is a vehicle with an integrated starter/generator that uses start/stop technology. When conditions are met, the engine turns off at complete stops, and re-starts instantly when the brake pedal is released. Some micro hybrids can recover limited amounts of energy through brake regeneration. Fuel economy increases from micro hybrid technology are limited.

- **Mild Hybrid** – Mild hybrids are propelled primarily by the combustion engine, but can be propelled by the electric motor alone under certain low-load, low-speed driving conditions. Mild hybrids often use a combination of power from the engine and electric motor to provide equivalent performance to gasoline-only models with larger combustion engines, with the benefit of increased fuel economy and reduced emissions.

- **Full Hybrid** – Full hybrids also include a combustion engine, a high-voltage battery, and an electric motor. The main difference between a mild and a full hybrid is the increased ability of a full hybrid to operate exclusively on electric power. Full hybrids usually include higher voltage batteries with increased storage capacity, enabling higher speed operation in electric mode.

- **Full EV** - Full EVs do not include a combustion engine and therefore, do not consume fuel or produce tailpipe emissions. Full EVs include high-voltage batteries with large storage reserves. Regenerative braking provides limited battery charging, but recharging is primarily accomplished by plugging the vehicle into an AC receptacle or recharging station.

Direct Response Hybrid Concept

The Direct Response Hybrid system adopts high performance lithium-ion battery and traction motor technologies and seamlessly blends advanced combustion engines for exhilarating performance and outstanding fuel economy.

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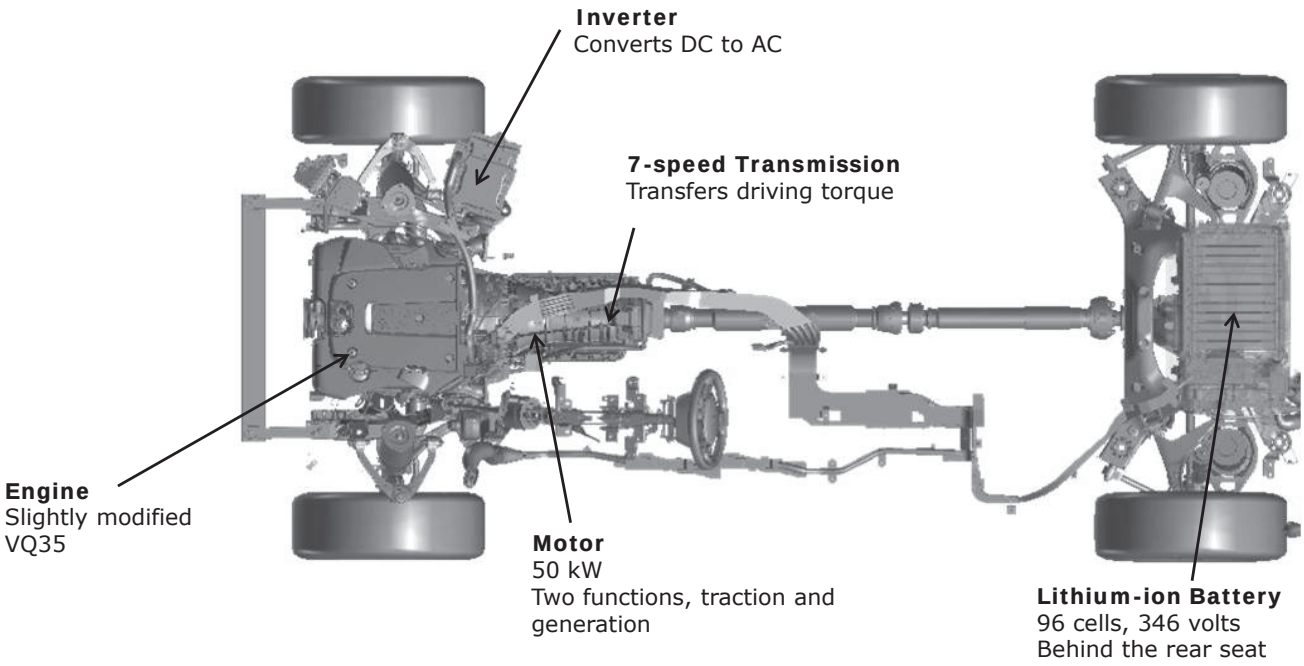
Direct Response Hybrid System – Q50 and Q70



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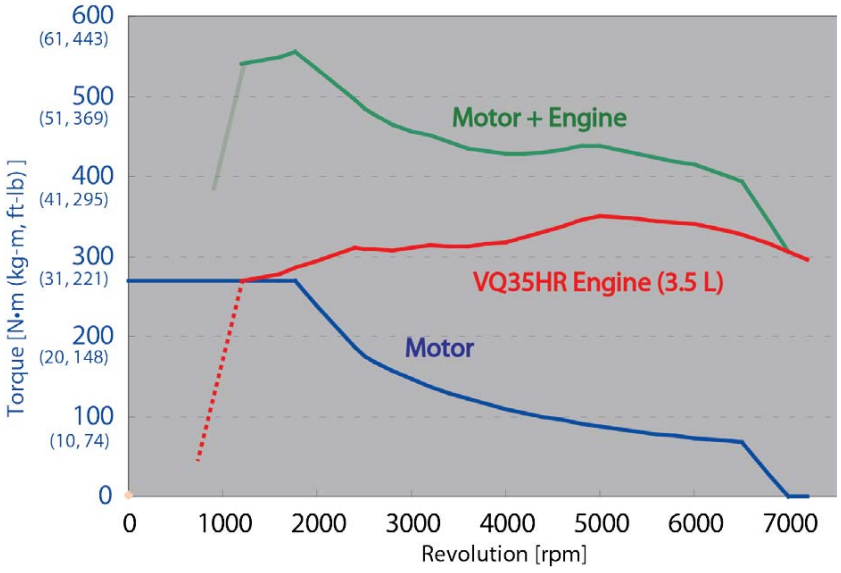
Direct Response Hybrid Operating Features – Q50 and Q70

Improves fuel economy and driving performance by:

- Switching to EV mode during idle, stop-and-go, and steady low-speed cruising when the lithium-ion battery is charged and is more efficient than the gasoline engine
- Charging the battery during braking and deceleration
- Using the V6 engine during passing, climbing, and other conditions where the gasoline engine is more efficient
- Combining the V6 engine and the electric motor to provide optimum power and torque



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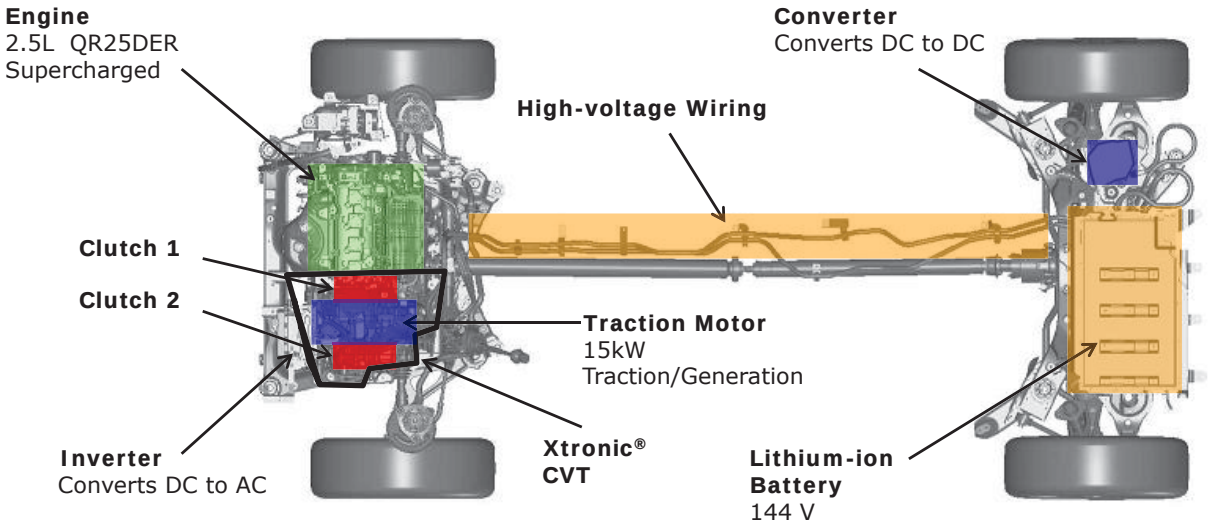
Direct Response Hybrid System – QX60

- Engine - QR25DER supercharged, variable valve timing, port fuel injection, liquid cooled intercooler
- Transmission – Next generation Xtronic Continuously Variable Transmission (CVT)
- High-voltage Battery – 144-volt lithium-ion, located under the 3rd row seat



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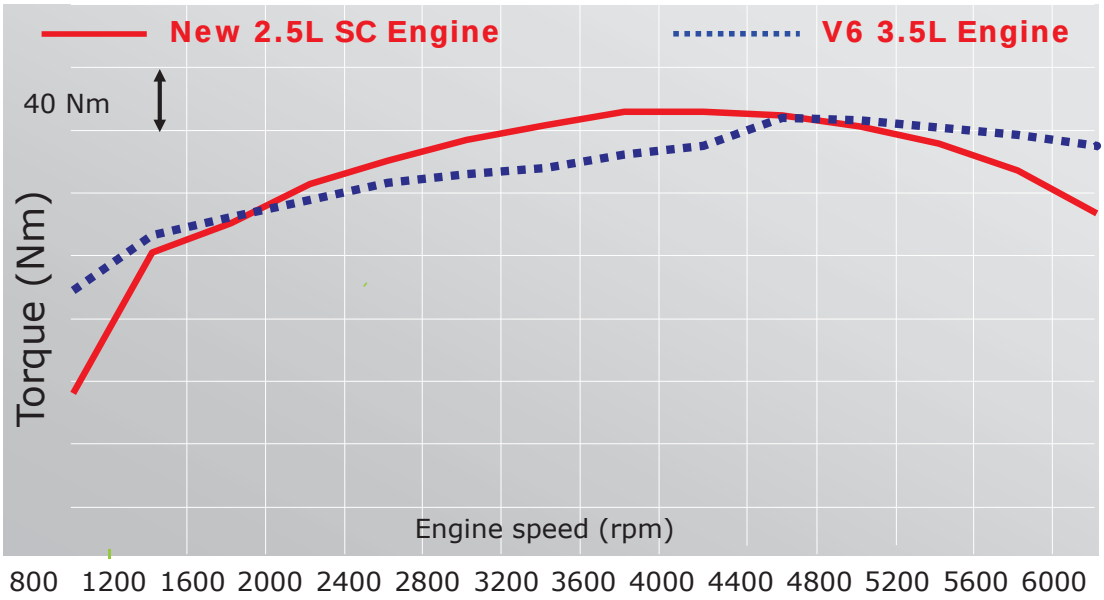
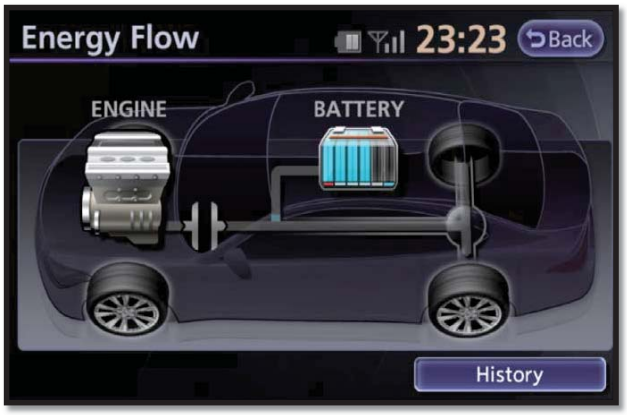
Direct Response Hybrid Operating Features – QX60

- Supercharged 2.5L engine achieves engine output equal to or greater than the 3.5L V6
- CVT allows the engine to stay at its optimum fuel economy point, providing increased fuel efficiency

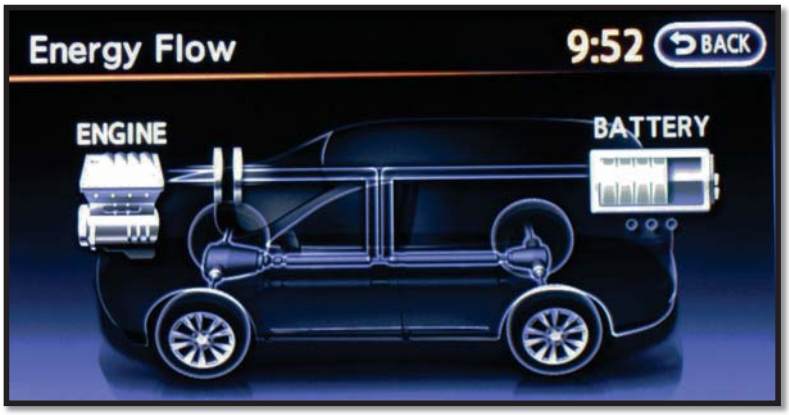


Hybrid Energy Flow – At Rest

These images show the vehicle at rest, in the READY to DRIVE mode



Q50/Q70

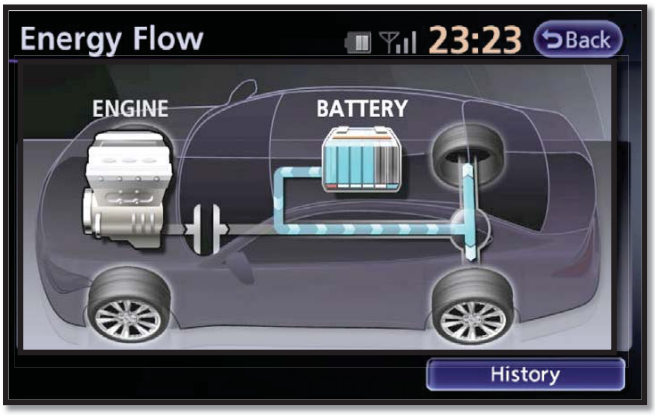


QX60

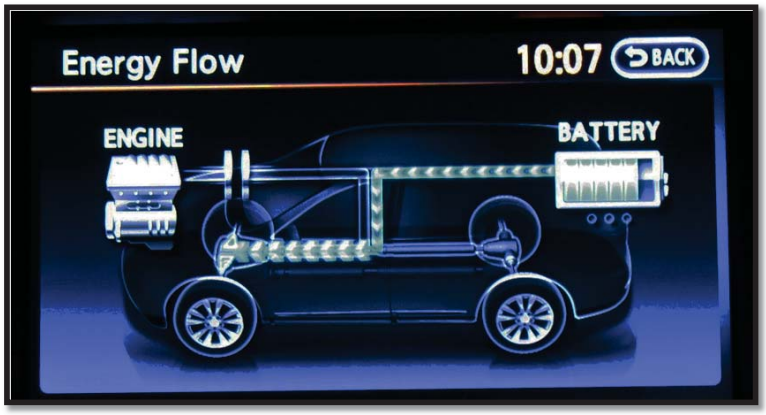
Hybrid Energy Flow – Battery / Traction Motor Only

In EV mode only the traction motor and the lithium-ion battery are used to drive the wheels.

- EV mode on the QX60 does not reach the same speed as the Q50 due to the smaller battery and traction motor



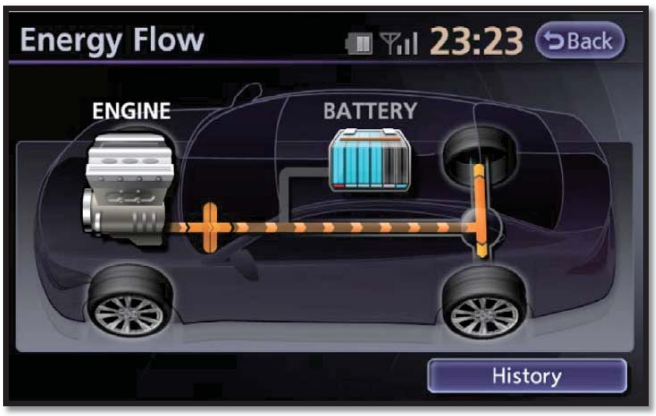
Q50/Q70



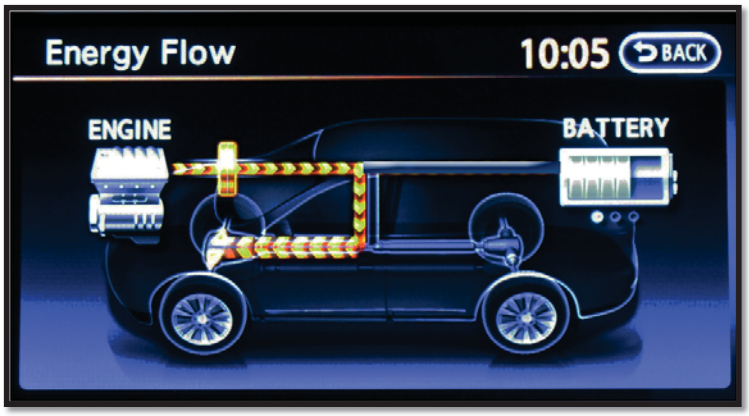
QX60

Hybrid Energy Flow – Engine Drive Only

The engine provides the power to drive the wheels when the load exceeds the traction motor's ability to provide power.



Q50/Q70

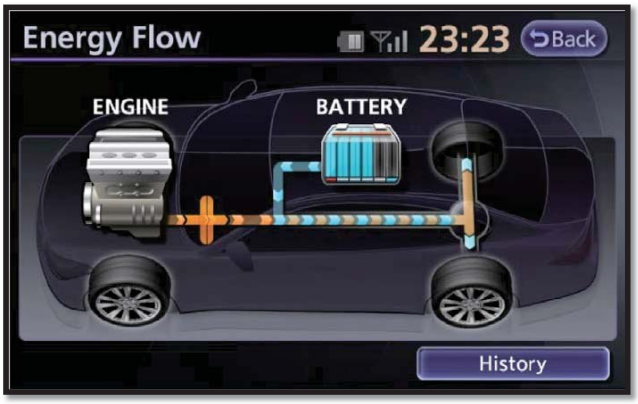


QX60

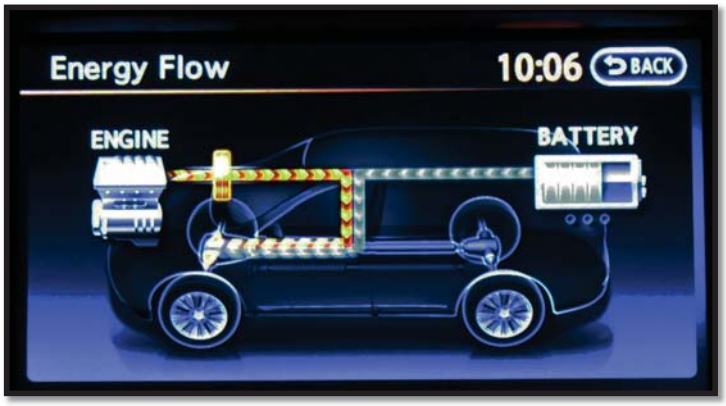
Hybrid Energy Flow – Combined Engine / Traction Motor (Power Assist)

Combined engine/traction motor drive

- The engine and motor generator provide torque to the driven wheels when the HPCM sees a demand for full power, typically during moderate to heavy load conditions



Q50/Q70

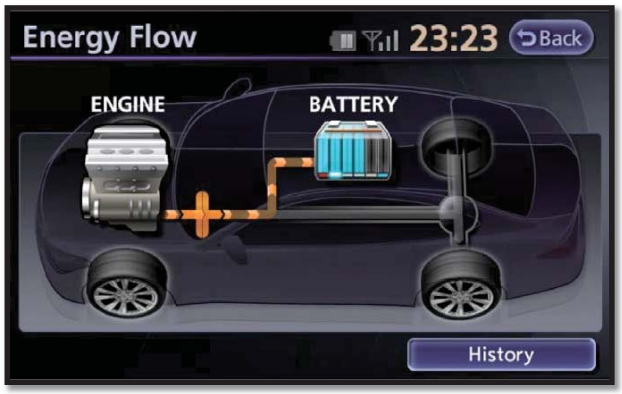


QX60

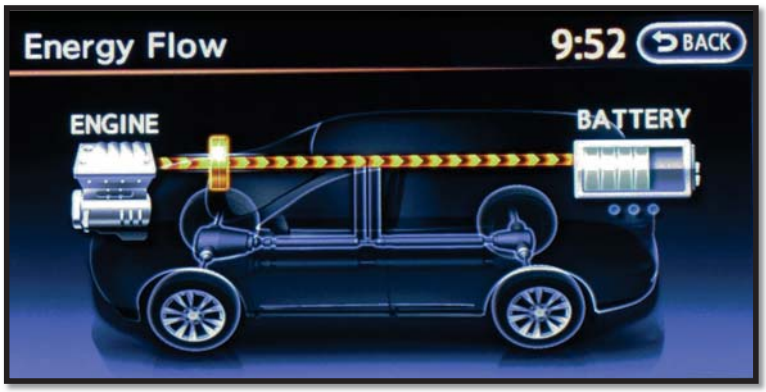
Hybrid Energy Flow – Engine Running, Charging Battery

Combustion engine running, battery charging

- Clutch 1 is engaged and the vehicle is stationary
- The combustion engine is being used to charge the lithium-ion battery
- If the battery state of charge is below about 40% and the Power switch is ON, the engine may start to charge the battery



Q50/Q70

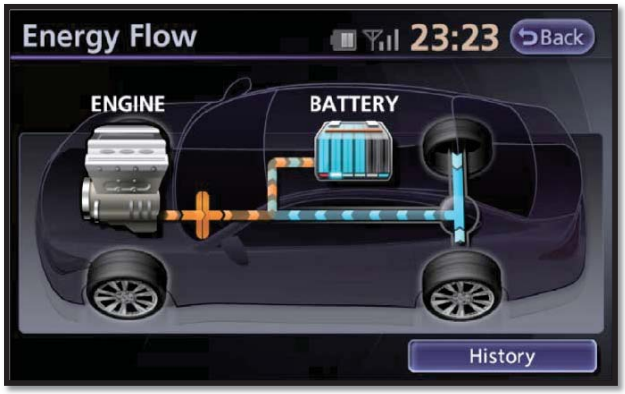


QX60

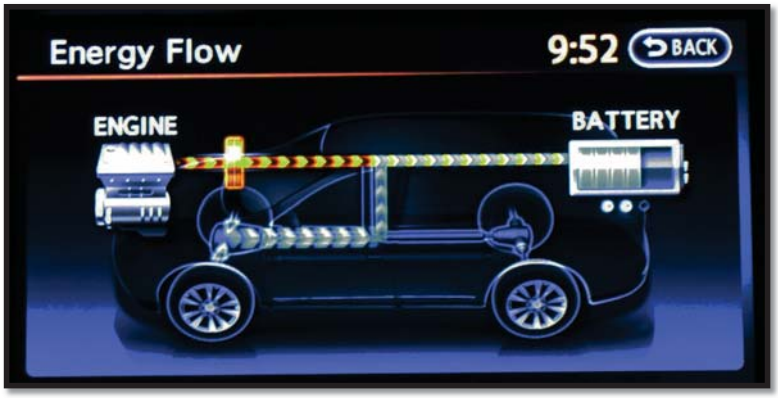
Hybrid Energy Flow – Deceleration and Brake Regeneration

Engine and regenerative brake charging

- When the accelerator is lifted and the vehicle slows down, the rear wheels will spin the traction motor (through the transmission) and the traction motor will charge the battery



Q50/Q70

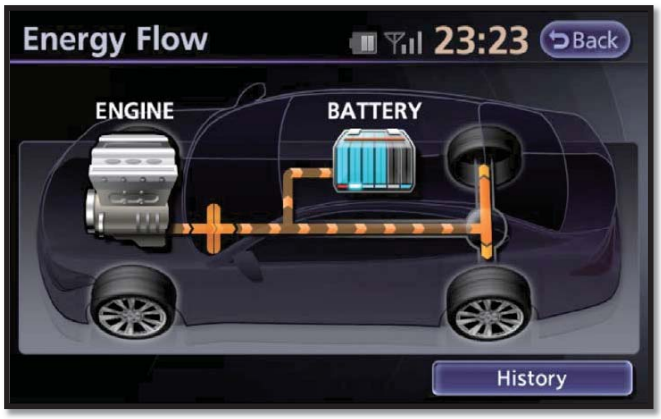


QX60

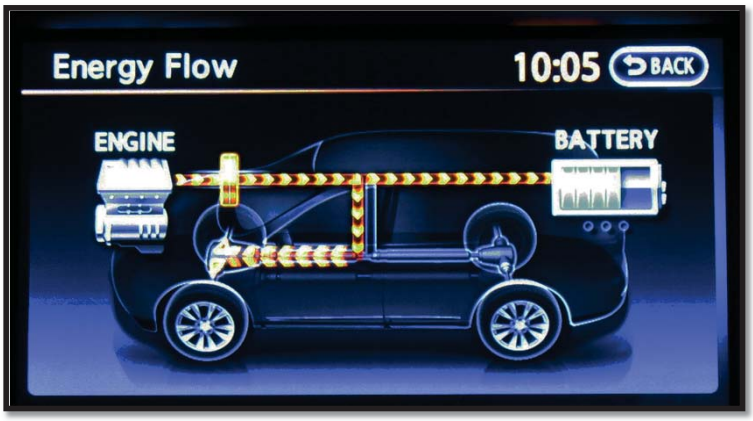
Hybrid Energy Flow – Engine Driving, Battery Charging

Engine driving and recharging the battery

- During low to moderate acceleration the engine provides both drive power and battery charging
- Some of the power from the engine charges the lithium-ion battery while some powers the wheels



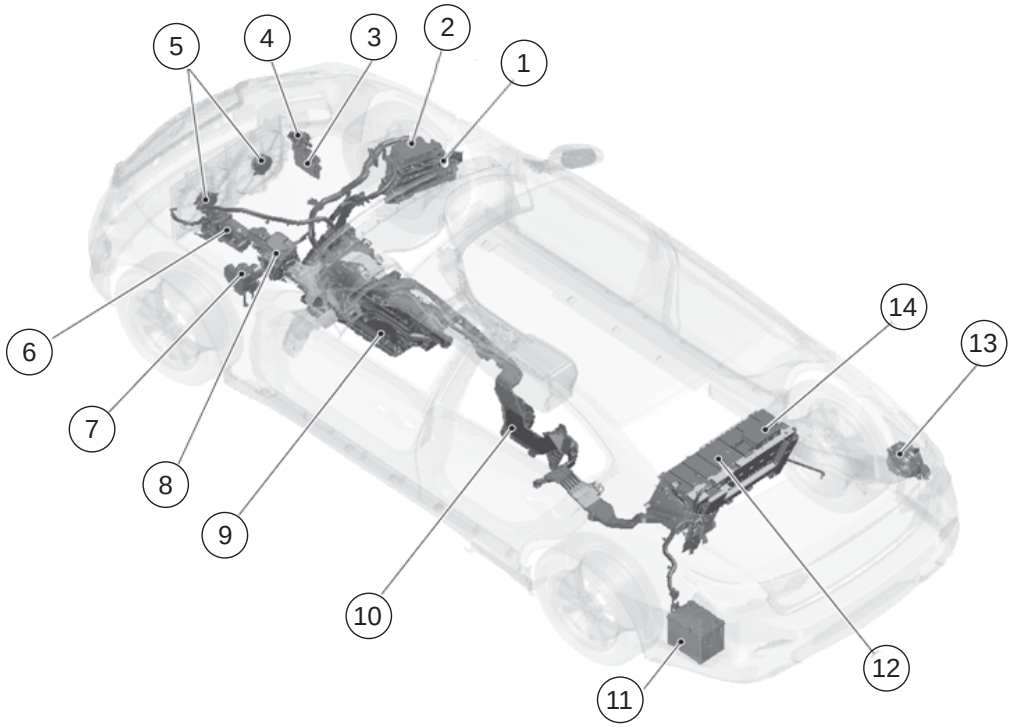
Q50/Q70



QX60

Q50 Hybrid Component Locations

1. Traction Motor Inverter
2. IPDM/ER
3. ECM
4. Electric Water Pump
5. Engine Cooling Fans
6. Electric Compressor
7. ABS Actuator and Control Unit
8. Electrically-driven Intelligent Brake Unit
9. Transmission Assembly
10. High-voltage Harness
11. 12-volt Battery
12. Lithium-ion Battery Assembly
13. Battery cooling fan
14. HPCM



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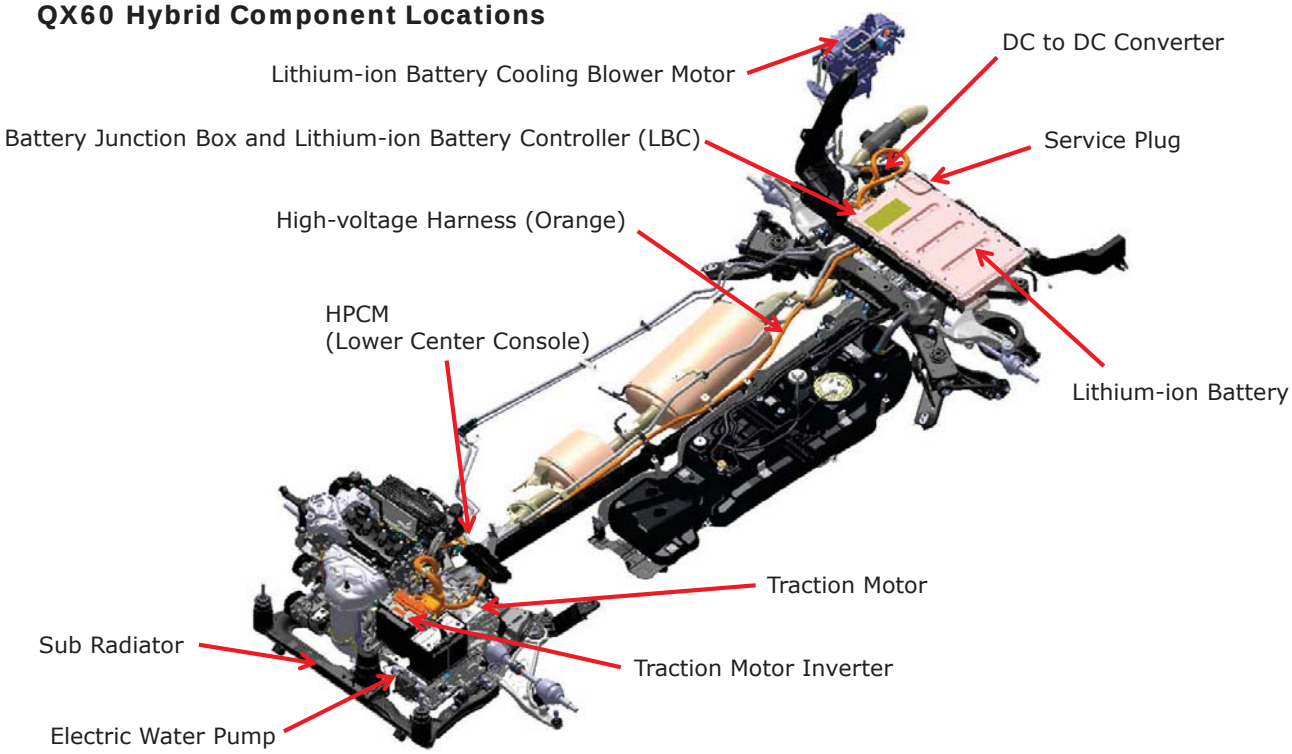
QX60 Hybrid Component Locations



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NOTES:

Hybrid-specific Engine Systems

Q50 / Q70 Engine

Q50 and Q70 Hybrids use the VQ35HR, 3.5-liter V6 engine

- No conventional starter motor; the traction motor starts the combustion engine
- Electric A/C compressor used instead of conventional belt-driven compressor

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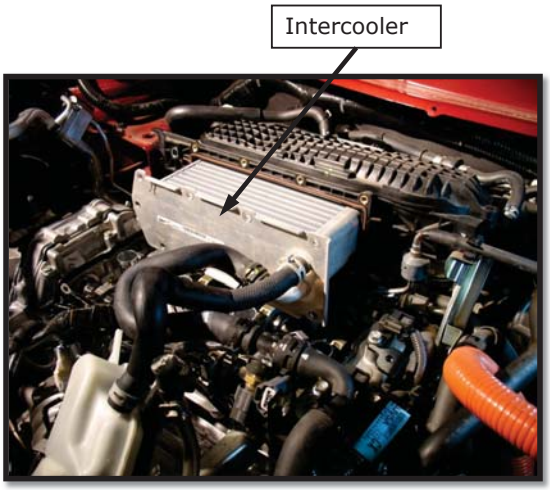
QX60 Engine

The QX60 uses a QR25DER 2.5-liter, inline 4-cylinder engine

- Uses a Roots-type supercharger with intercooler for increased output
- Intercooler shares coolant with traction motor and inverter cooling system
- Engine normally started by the traction motor
- Includes a conventional 12-volt starter motor that starts the engine during extreme cold weather conditions or low state of charge of the lithium-ion battery



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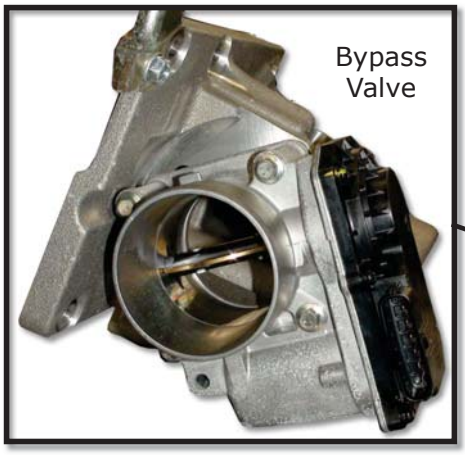
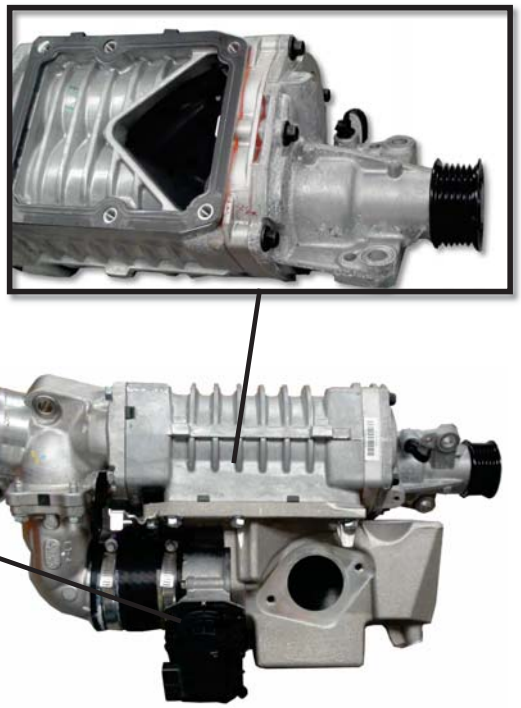
QX60 Engine - Supercharger

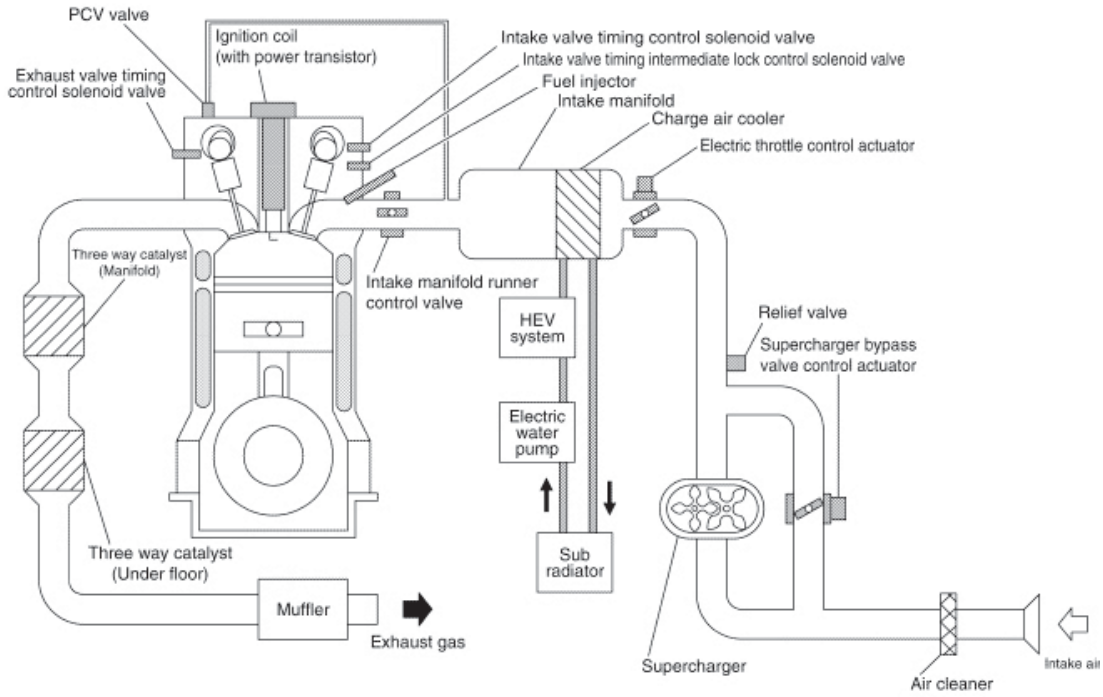
The QX60 uses a QR25DER 2.5-liter, inline 4-cylinder engine

- Roots-type multi-rotor supercharger driven off crankshaft pulley
- Includes a bypass valve that is controlled by the ECM to regulate boost pressure in the air intake system





QX60



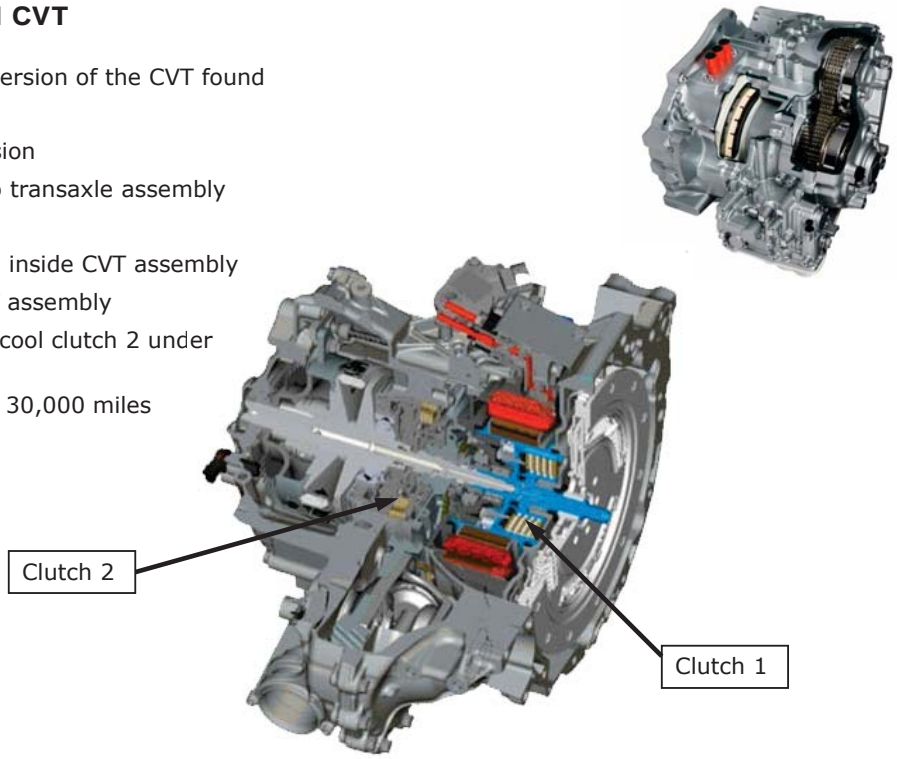
53

Hybrid-specific Transmissions

QX60 Transaxle – RE0F02H CVT

The QX60 Hybrid uses a modified version of the CVT found in the conventional QX60

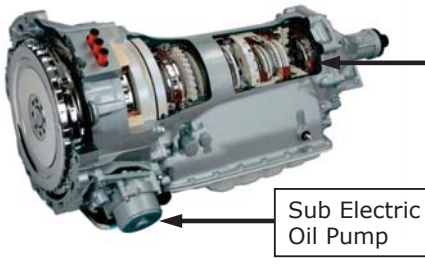
- Continuously Variable Transmission
- Traction motor incorporated into transaxle assembly
- No torque converter
- Clutch 1 – multi-plate dry clutch inside CVT assembly
- Clutch 2 – wet clutch inside CVT assembly
- Sub Electric Oil Pump – used to cool clutch 2 under certain conditions
- Change transmission fluid every 30,000 miles
- Uses NS-3 fluid



Q50 / Q70 Transmission – RE7R01H

The Q50 and Q70 Hybrids use a modified version of the 7-speed automatic transmission.

- 7-speed automatic transmission
- Traction motor incorporated into transmission assembly
- No torque converter
- Clutch 1 – single disc dry clutch
- CSC – for Clutch 1 application and release
- Clutch 2 – wet clutch inside transmission
- Sub Electric Oil Pump – produces line pressure when combustion engine is OFF
- In EV mode, as traction motor speed increases, the sub electric oil pump contribution decreases



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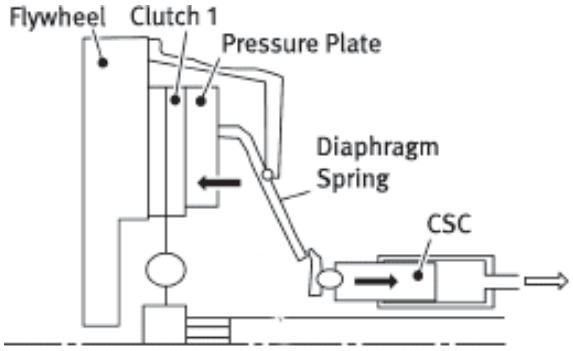
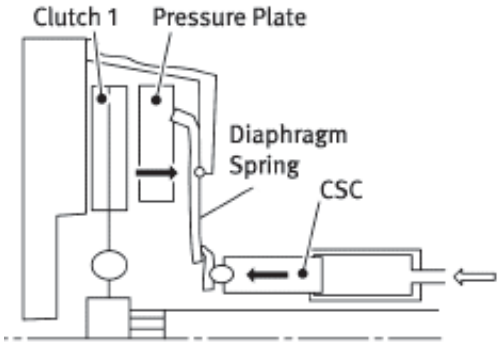
Q50/Q70 - Clutch 1 Operation

Clutch 1 modulation

- When the CSC is commanded to release Clutch 1 the line pressure is directed to operate the CSC via a solenoid
- The solenoid is part of the control valve assembly
- Clutch 1 can be replaced separately from the transmission assembly
- There is a learning procedure for Clutch 1



Clutch 1 Engaged



Clutch 1 Disengaged

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High-voltage Battery System

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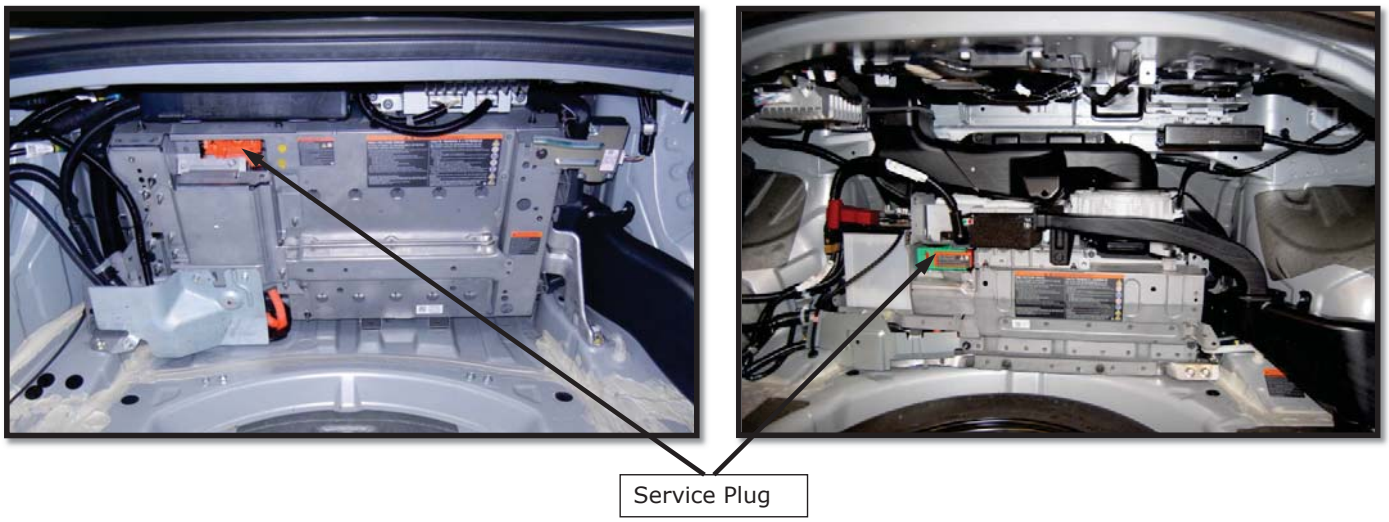
Q50/Q70 - High-voltage Battery Locations

- Battery assemblies are shown with trim panels removed
- Q70 battery is mounted horizontally
- Q50 battery is mounted vertically to conserve space

Q50 Battery Location

Q70 Battery Location



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Q50/Q70 – Lithium-ion Battery Structure

High-voltage battery specifications:

- 96 cells (3.6 volts per cell)
- 12 Modules (8 cells per module)
- 1 Battery Pack (12 modules)
- Combined voltage is approximately 346 volts
- Individual modules may be serviced

96 Cells (3.6V Each)

12 Modules (8 Cells Per Module)

Battery Pack

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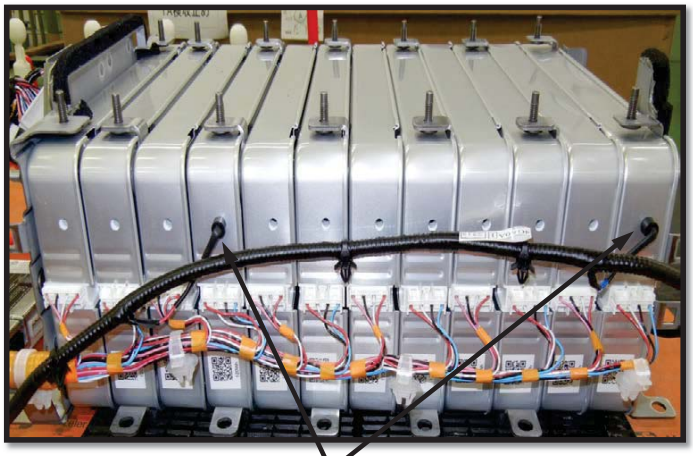
Q50/Q70 - Battery Temperature Sensors

- Temperature sensors are mounted within the high-voltage battery assembly
- Temperature readings are taken from inside the battery pack and cooling duct
- The Lithium-ion Battery Controller (LBC) monitors the battery and DC to DC converter temperatures and adjusts the cooling fan speed accordingly



Battery Pack Temperature Sensors

Battery Cooling Intake Temp Sensor (Q50 only)

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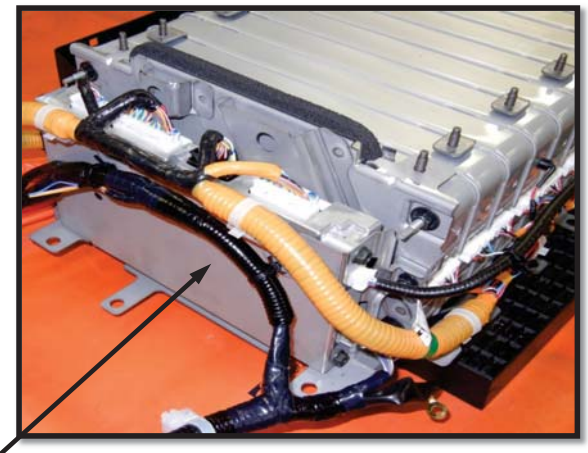
Q50/Q70 - Lithium-ion Battery Controller (LBC)

- Detects battery pack voltage, current, battery temperature, and voltage of each cell
- If cell voltage varies by more than approximately 200mV battery life is reduced
- Calculates input/output values and sends data to the HPCM
- Helps optimize cell voltage deviation
- Prevents over-voltage, over-current, and overheat conditions
- Detects decreased insulation resistance of the high-voltage circuit



Q50 LBC (shown)

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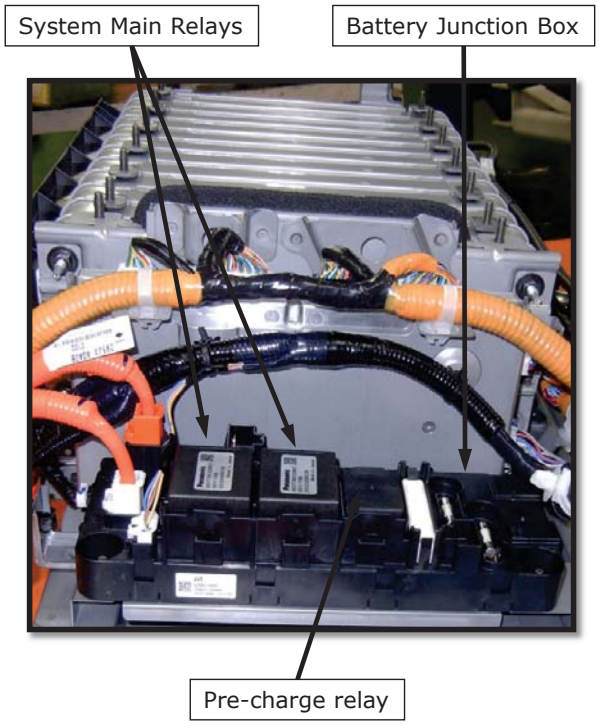
Q50 / Q70 - Battery Junction Box

- Located on the battery pack assembly
- Houses the system main relays
- Contains the pre-charge relay and resistor
- Houses a current sensor
- Also houses fuses for the electric A/C compressor and DC/DC converter circuits
- The fuses are not serviceable



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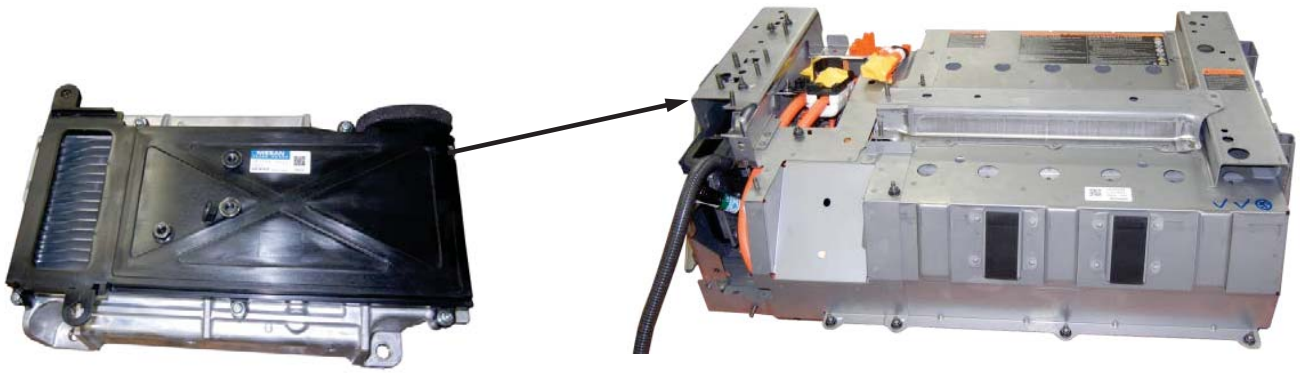
Q50 / Q70 - DC / DC Converter

- Located on the battery pack near the LBC
- Converts the high-voltage from the lithium-ion battery to low voltage to power electrical components
- Changes the output voltage according to the HPCM signals to supply the correct voltage
- Recharges the 12-volt battery



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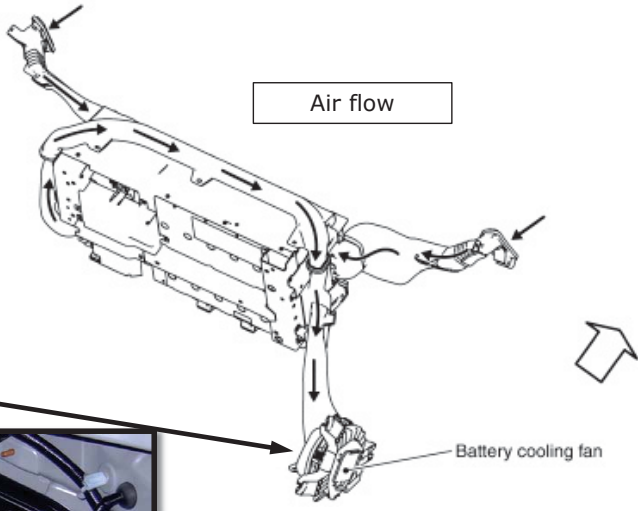
Q50 High-voltage Battery Cooling System

- Located in right rear truck area
- Provides cooling for the lithium-ion battery pack and DC/DC converter
- Consists of intake/exhaust ducts and a blower motor delivering cooled air from the passenger compartment into the trunk area
- Blower motor speed is controlled by the HPCM based on signals lithium-ion battery controller



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QX60 - High-voltage Battery Location

- Photo shows the high-voltage battery assembly with the 3rd row seat and trim removed for clarity
- Cooling fan and ducts are located at the right-rear corner of the battery assembly
- The service plug is located on the right side of the battery pack

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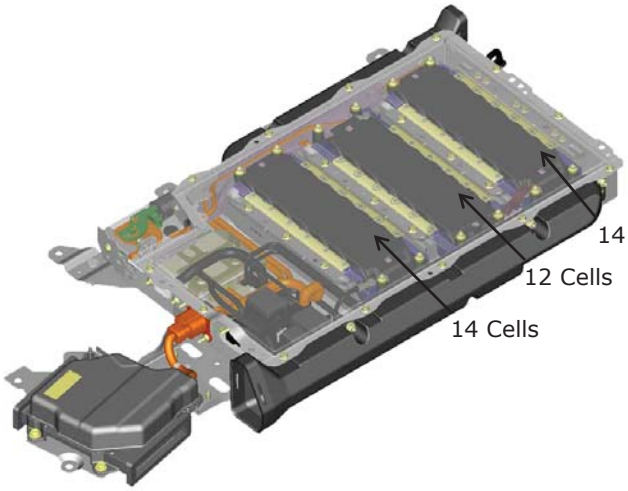
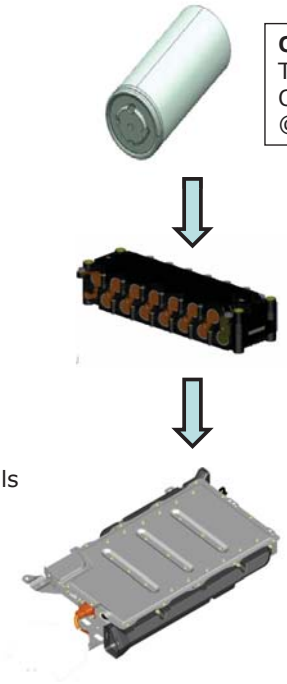
QX60 - Lithium-ion Battery Structure

- 40 cells (3.6 volts per cell)
- 3 Modules
- 1 Battery Pack (3 modules)
- Combined voltage is approximately 144 volts
- Individual modules are NOT serviceable





Cell
Two modules of 14 cells
One module of12 cells
@3.6 volts-each

Module
3 modules in a pack

Battery Pack
1 pack per vehicle
144 volts
4.4 Ah
62 lbs. (28kg)

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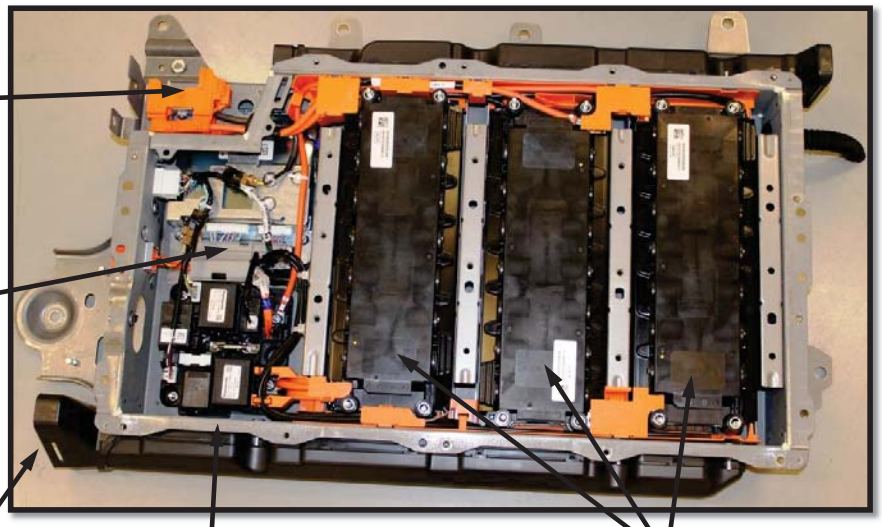
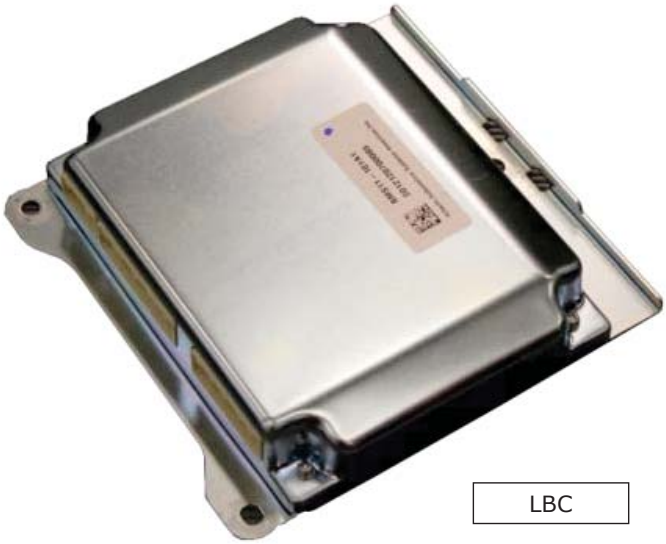
QX60 - High-voltage Battery Components

- HV battery temperature sensors are integral to the battery modules and are not serviceable



QX60 - Lithium-ion Battery Controller (LBC)

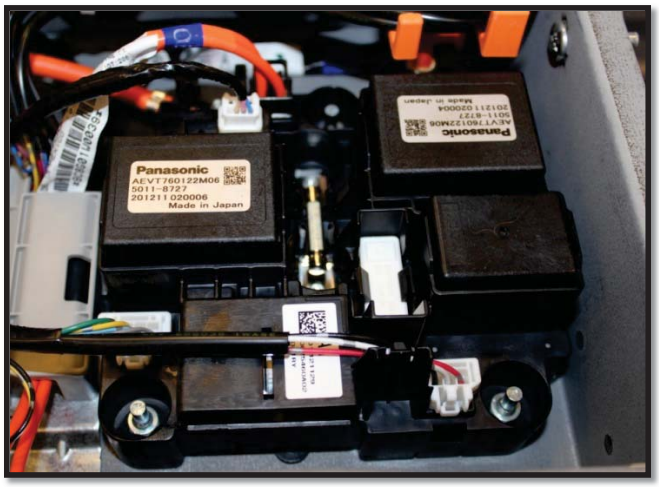
- Detects battery pack voltage, current, battery temperature, and voltage of each cell
- If cell voltage varies by more than approximately 200mV battery life is reduced
- Calculates input/output values and sends data to the HPCM
- Helps optimize cell voltage deviation
- Prevents over-voltage, over-current, and overheat conditions
- Detects decreased insulation resistance of the high-voltage circuit



LBC

QX60 - Battery Junction Box

- Located on the battery pack
- Contains the system main and pre-charge relays
- Houses a current sensor



Installed

Removed

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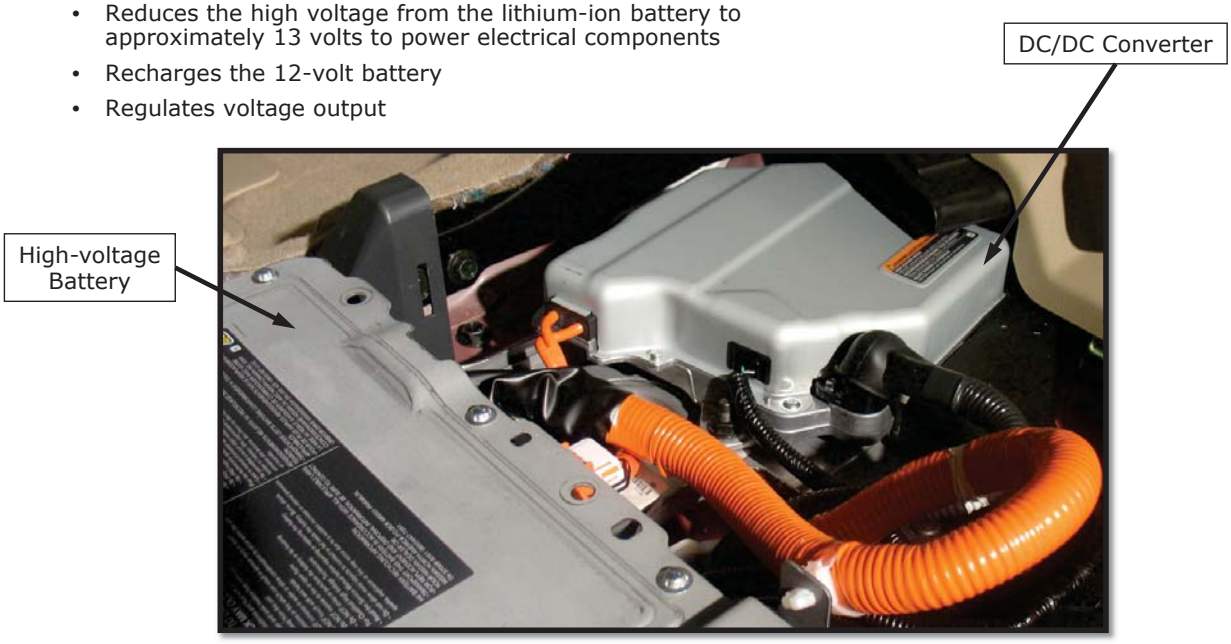
QX60 - DC/DC Converter

- Located next to high-voltage battery
- Reduces the high voltage from the lithium-ion battery to approximately 13 volts to power electrical components
- Recharges the 12-volt battery
- Regulates voltage output



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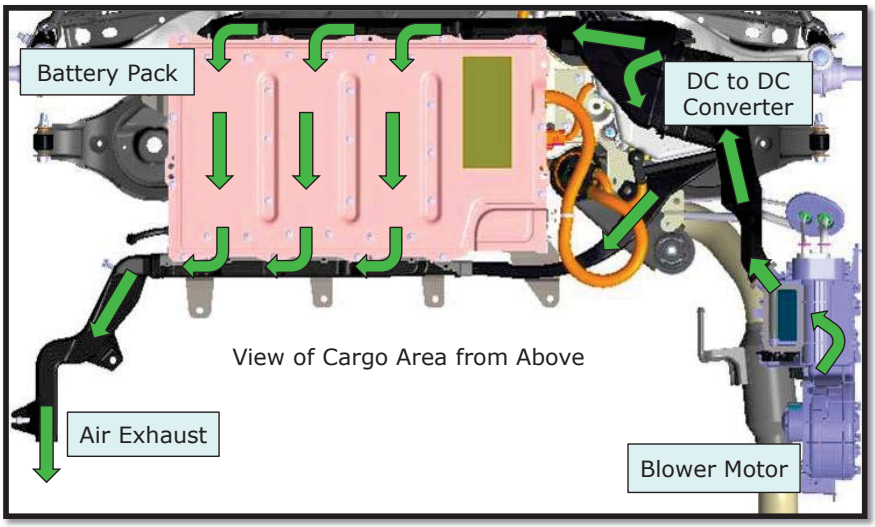
QX60 - High-voltage Battery Cooling System

- Located in right rear cargo area
- Provides cooling for the lithium-ion battery pack and DC to DC converter
- Consists of intake/exhaust ducts and a blower motor
- Blower motor speed is controlled by the LBC based on signals from current and temperature sensors, vehicle noise state, and other signals from the HPCM

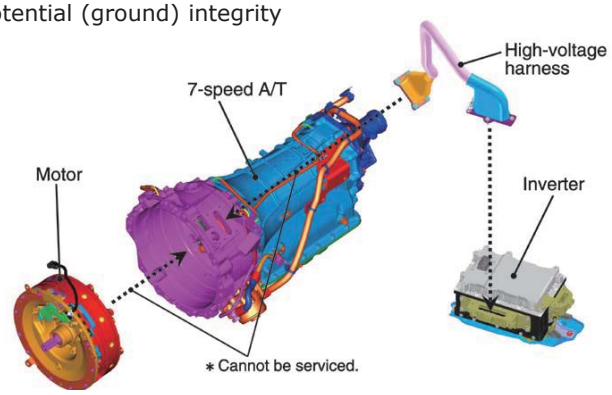


Traction Motor System

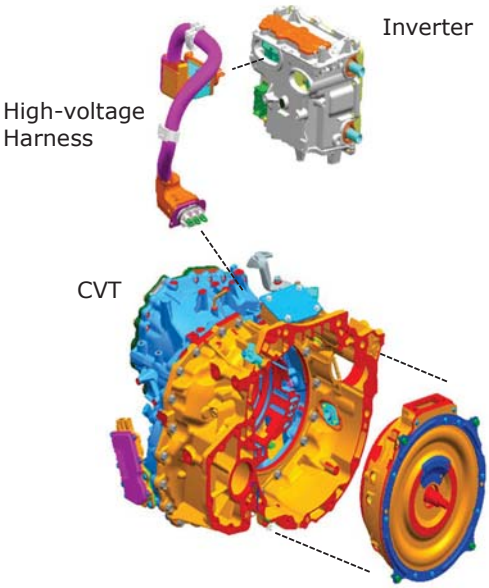
Traction Motor System

- Traction motor system allows vehicle propulsion by electric power, or a combination of gasoline engine and electric power
- Traction motor can also function as a generator to recharge the lithium-ion battery
- System includes the traction motor, DC to AC inverter (traction motor inverter), and a liquid cooling system
- The traction motor and transmission are serviced as an assembly
- If any components are removed or replaced, the harness and motor must be checked for insulation resistance and equipotential (ground) integrity

Q50



QX60



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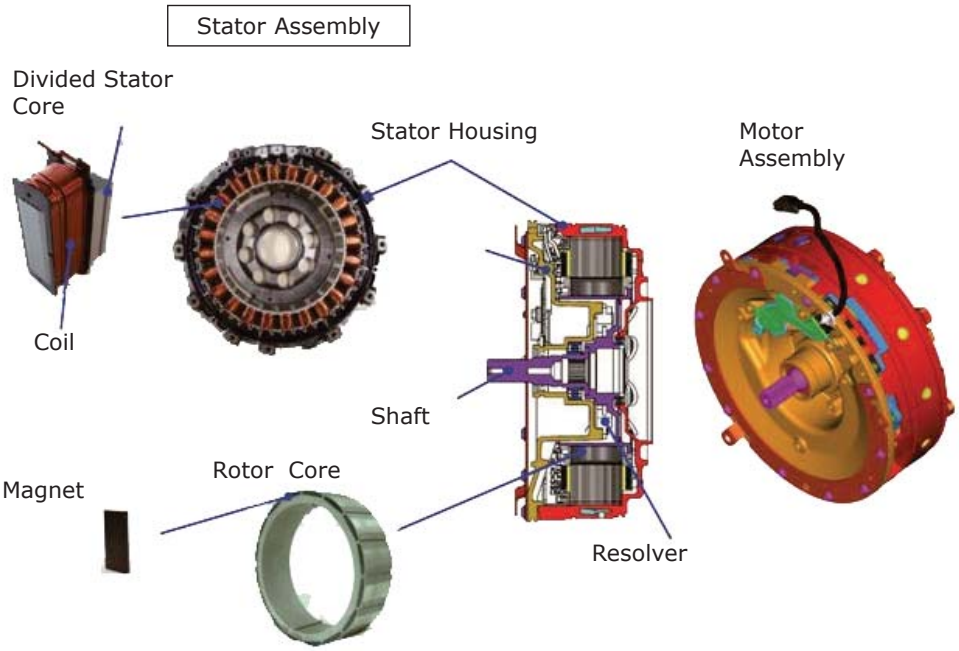
Traction Motor Components

- Synchronous, 3-phase, permanent magnet motor
- 50kW (68 hp) – Q50/Q70
- 15kW (20 hp) – QX60
- Located inside the transmission



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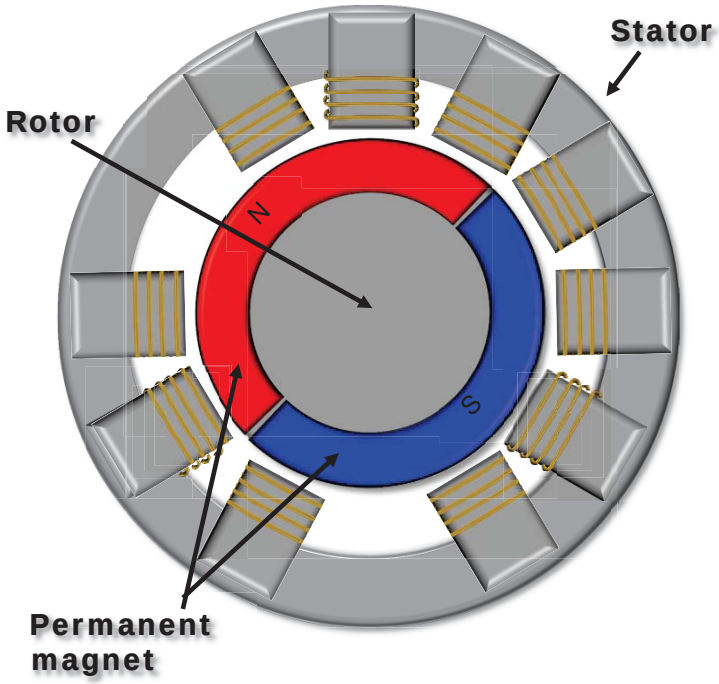
Rotation of Permanent Magnet Synchronous Motor



Motor is constructed of:

- Permanent magnet rotor
- Multi coil stator

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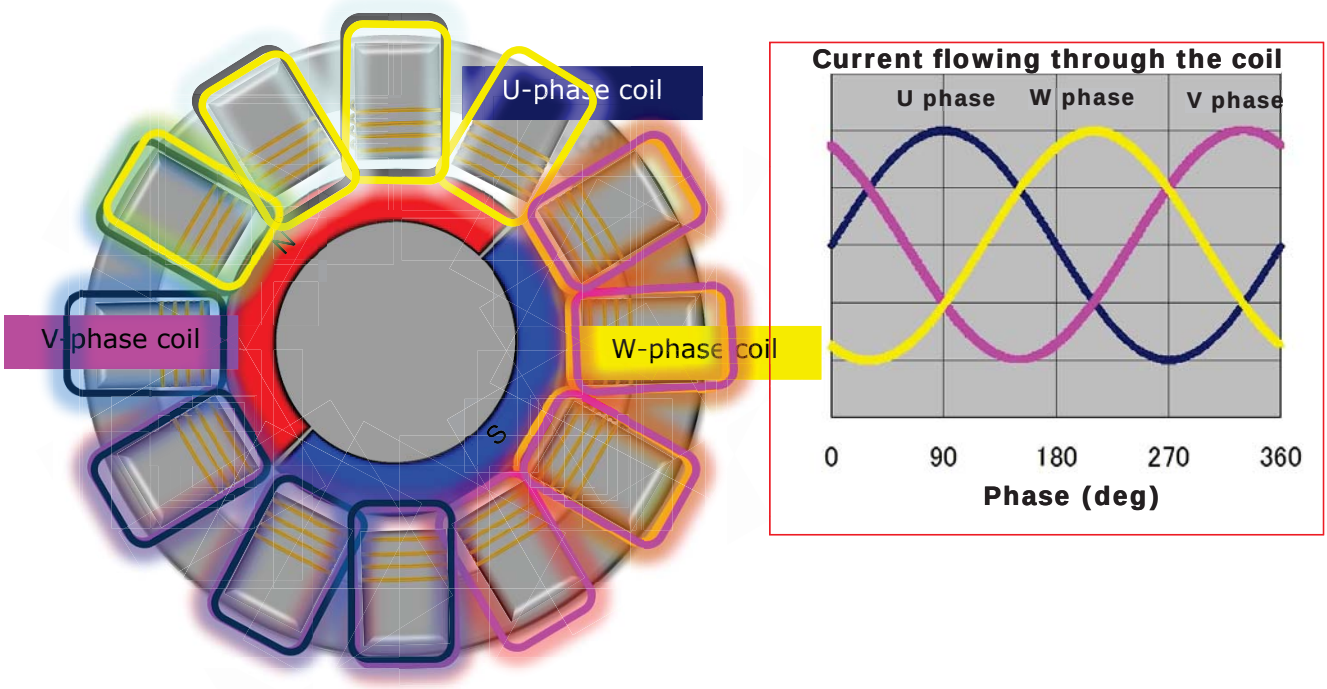
Rotation of Permanent Magnet Synchronous Motor



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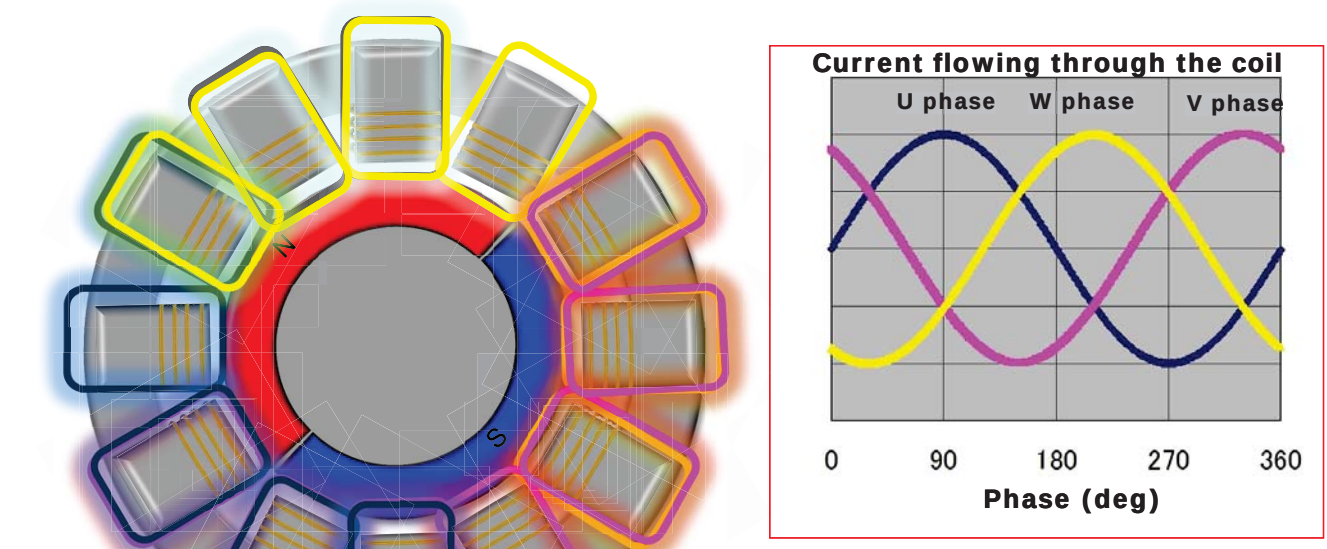
Rotation of Permanent Magnet Synchronous Motor



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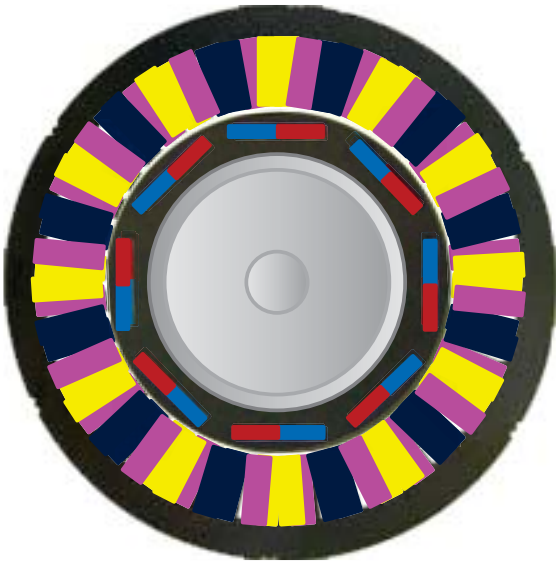
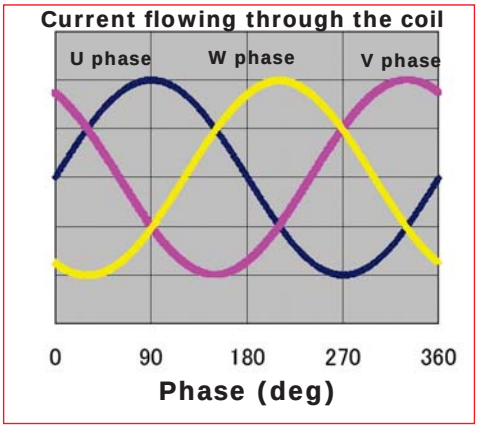
Motor Structure





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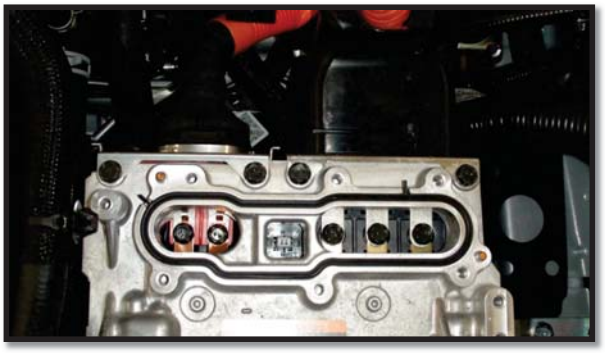
QX60 Motor Revolution Sensor

- The hybrid control system must detect the exact position of the traction motor as it rotates
- A revolution sensor or resolver is mounted on the transmission case, and is used by the traction motor inverter and Hybrid Powertrain Control Module (HPCM) to precisely monitor motor speed and position

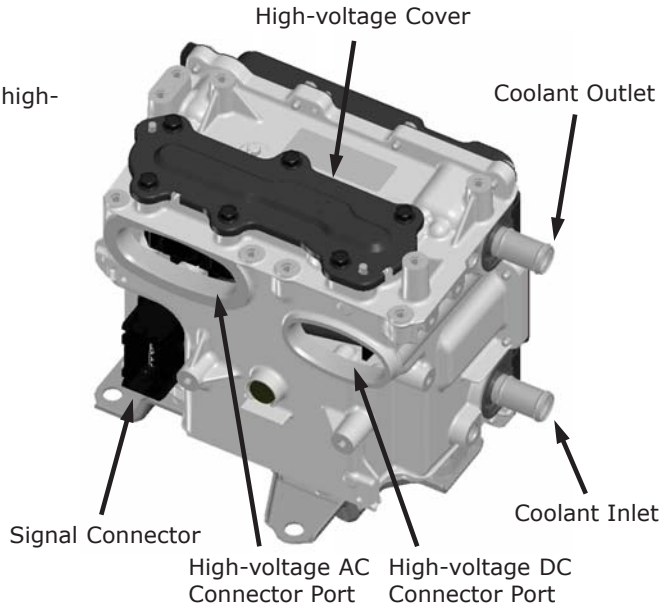
DC to AC Inverter (Traction Motor Inverter)

- QX60 – Located in front left portion of engine compartment near 12-volt battery
- Q50/Q70 – Located in back right corner of engine compartment
- Inverter cover includes a safety interlock that disables high-voltage when cover is removed
- Includes inlet and outlet coolant ports for high-voltage cooling system



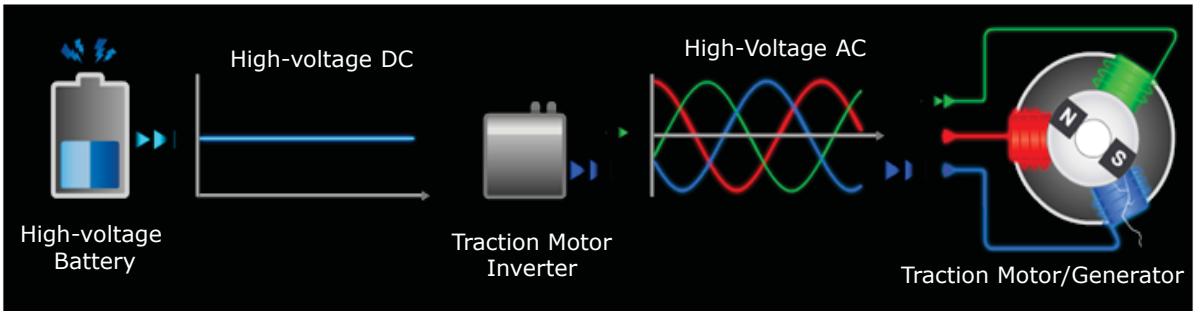
High-voltage Cover Removed

QX60 Inverter



DC to AC Inverter

- The traction motor inverter converts high-voltage DC from the lithium-ion battery to 3-phase AC voltage to drive the traction motor

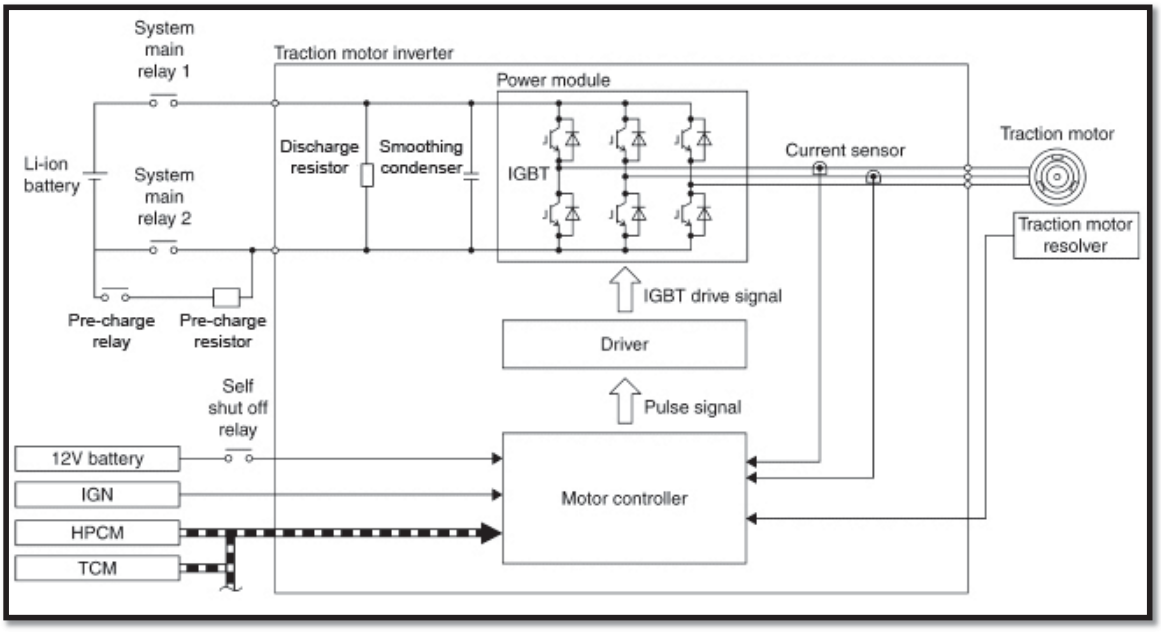


DC to AC Inverter

- Drives the traction motor by converting high-voltage DC from the Li-ion battery into 3-phase AC power
- Provides precise control of motor operation by varying the AC frequency when converting DC power to AC
- Allows the traction motor to function as a propulsion device and as a generator

Component	Function
Motor Controller	Receives signals and creates the pulse for driving the Insulated Gate Bipolar Transistors (IGBTs)
Driver	Converts the pulse signal (12 volts) from the motor controller to high voltage to drive the IGBTs
Power Module	Contains six IBGTs that perform switching, conversion of high-voltage DC to AC power, and supply AC power to the traction motor
Smoothing Condenser	Controls the voltage ripple that occurs as a result of IGBT switching
Current Sensors	Detects current supplied to traction motor and transmits current value feedback to the motor controller
Coolant Temperature Sensor	Detects the coolant temperature in the DC to AC inverter
Discharge Resistor	Discharges high voltage in case the DC to AC inverter cannot discharge the remaining voltage due to malfunction

DC To AC Inverter Circuit Diagram



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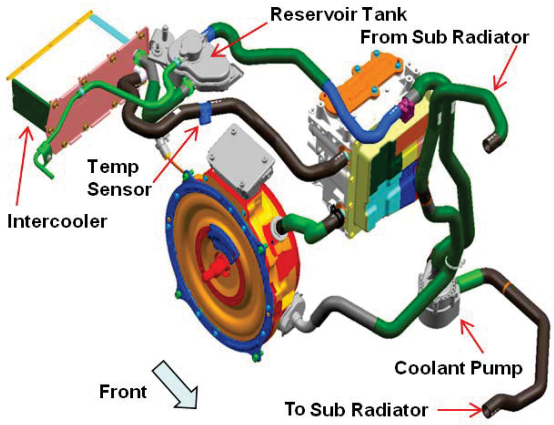
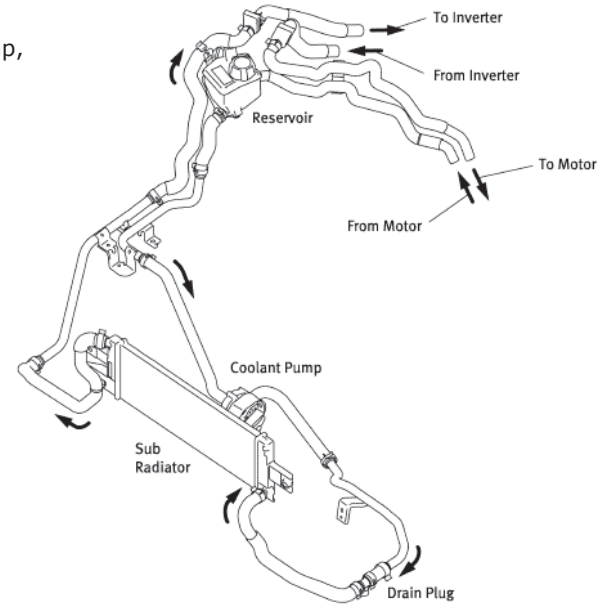
Traction Motor / Inverter Cooling System

- Function is to dissipate heat generated by the traction motor and DC to AC inverter via the sub radiator
- System is self-contained using long-life coolant
- Includes a sub-radiator, coolant reservoir, electric coolant pump, intercooler (QX60 only), and hoses connected to and from the motor and inverter

QX60



Q50/Q70



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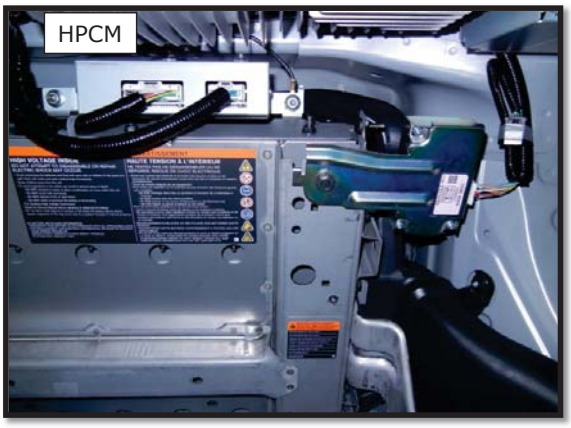
Hybrid Control System

Hybrid Powertrain Control Module (HPCM)

- The HPCM is the main control unit for powertrain functions and hybrid control
- Uses inputs like throttle position, vehicle speed, gear range, high-voltage battery SOC, and temperature to determine the required output of the engine and traction motor
- Monitors high-voltage circuits and reports malfunctions
- Assists in the control of cooperative regenerative braking



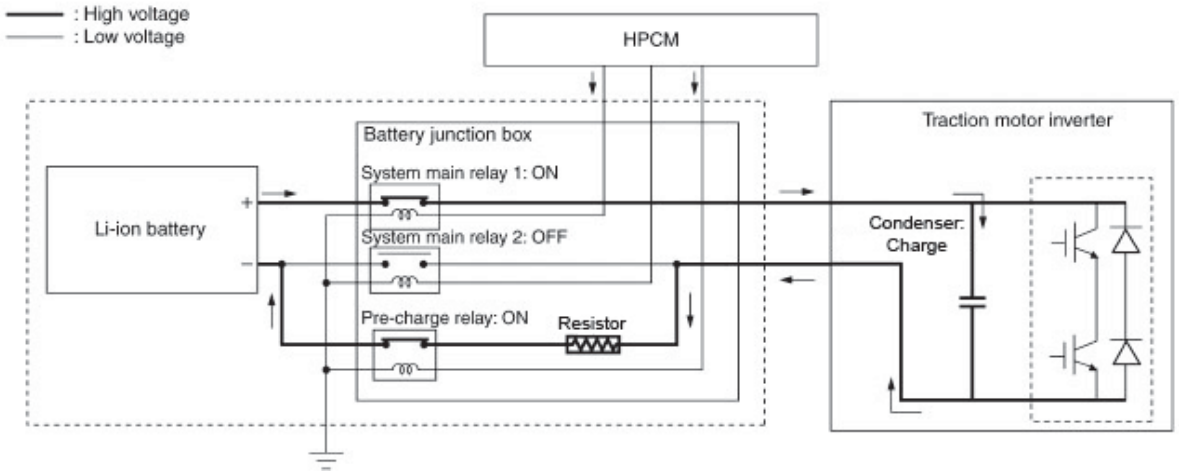
HPCM Location – Q50

HPCM Location – QX60

High-voltage Start-up Sequence

When the ignition is moved from OFF to the READY position, the high-voltage system undergoes a start-up sequence to prepare the system for operation.

- HPCM energizes the pre-charge relay and system main relay 1
- This charges the capacitors in the traction motor inverter
- Then, the HPCM energizes system relay 2 and de-energizes the pre-charge relay, completing the high-voltage circuit
- This sequence prevents current surges and spikes in the system

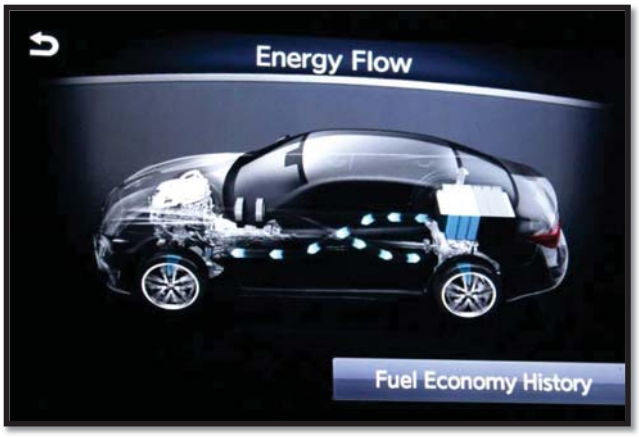


Click here to continue the presentation

Hybrid Modes of Operation

The hybrid powertrain can operate in various combinations of engine and traction motor modes.

- In many cases, the HPCM determines the appropriate mix of engine and traction motor drive based on driving conditions and maximizing fuel economy
- Engine temperature, high-voltage battery SOC, electrical load, and other factors also help determine the appropriate hybrid drive mode



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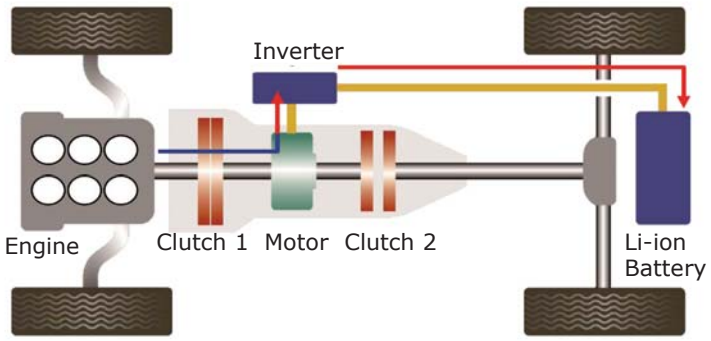
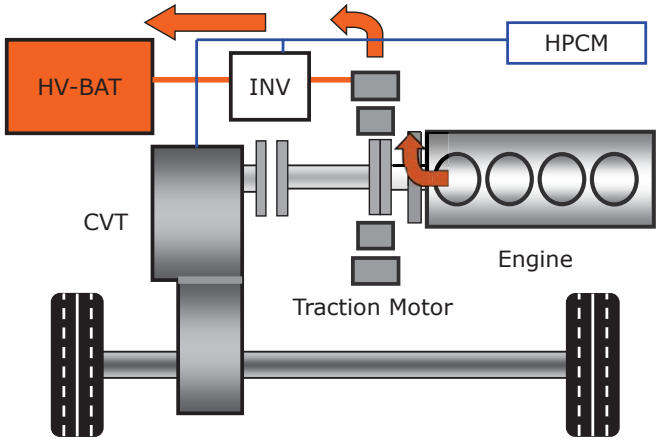
Engine Idle / Battery Charging Mode

- When the lithium-ion battery state of charge is low, engine output is used to generate power from the traction motor to charge the lithium-ion battery
- HPCM detects the lithium-ion battery status from the LBC and transmits a signal to the traction motor to charge the lithium-ion battery
- Clutch 1 is engaged, Clutch 2 is disengaged

Q50/Q70



QX60



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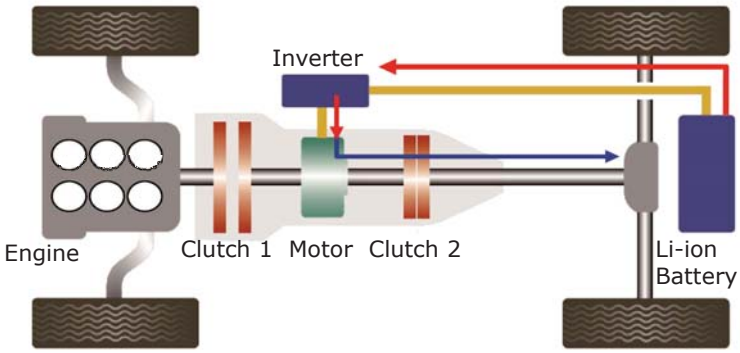
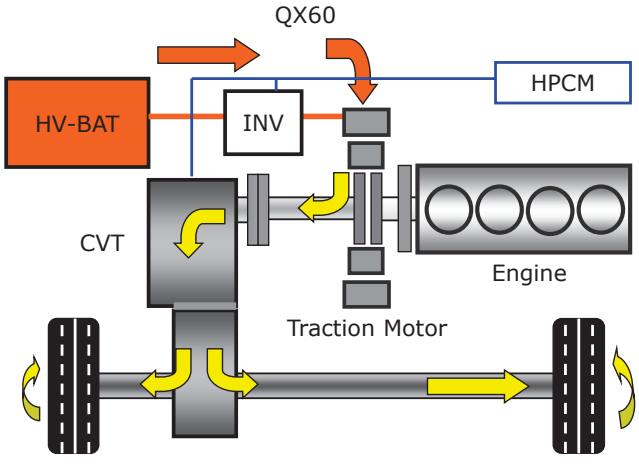
Battery / Traction Motor Only

- Electrical power from the lithium-ion battery is used to drive the vehicle (low speed) using traction motor rotational torque only
- Clutch 1 is disengaged and the engine is OFF
- Clutch 2 is engaged, allowing the traction motor to drive the wheels

Q50/Q70



QX60



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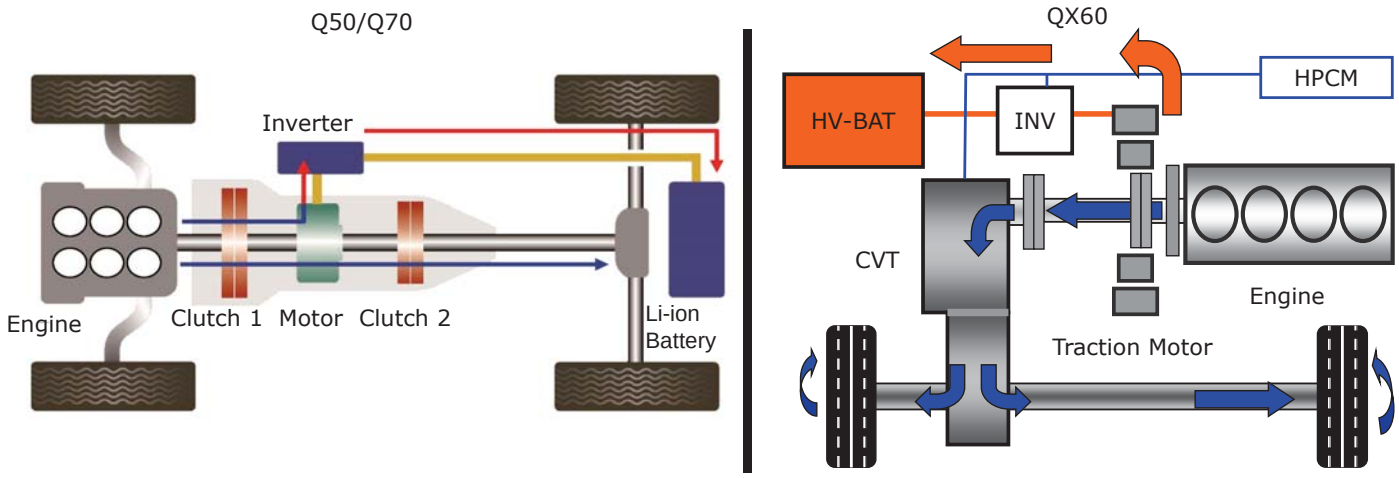
Engine Drive / Charging High-voltage Battery

- The vehicle is driven by the combustion engine only
- If the battery state of charge is sufficient, the engine may also drive the wheels without driving the traction motor as a generator
- Clutch 1 and 2 are engaged



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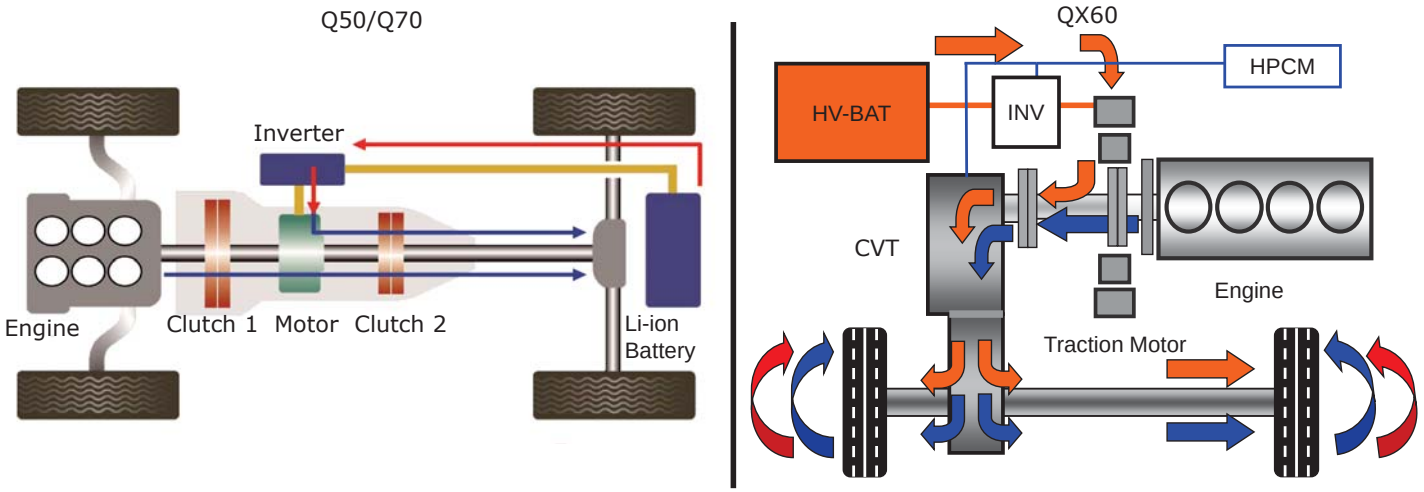
Power Assist Mode

- When the accelerator pedal is fully depressed, the engine assists the output torque from the traction motor providing maximum power to drive the vehicle
- HPCM engages Clutch 1 and Clutch 2, and transmits the output torque signal to the ECM and drive command signal to the inverter thus synchronizing the engine and traction motor output



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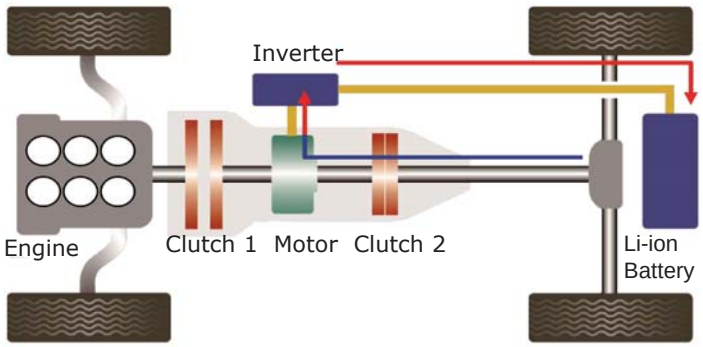
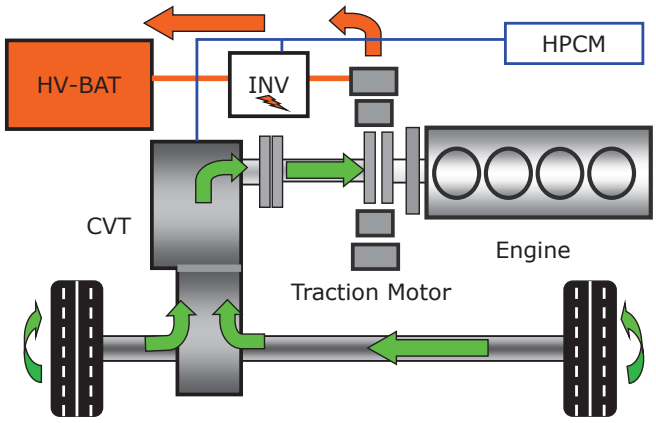
Deceleration / Regeneration Mode

- When decelerating, regenerative braking uses the motion of the drive wheels to generate power from the traction motor and charge the lithium-ion battery
- The regenerative torque that is generated when the traction motor is driven as a generator is used as braking force, acting similar to engine braking and reducing the load on the service brakes
- On sufficiently long deceleration, the engine may be shut off to conserve fuel
- Clutch 1 is disengaged, Clutch 2 is engaged

Q50/Q70



QX60



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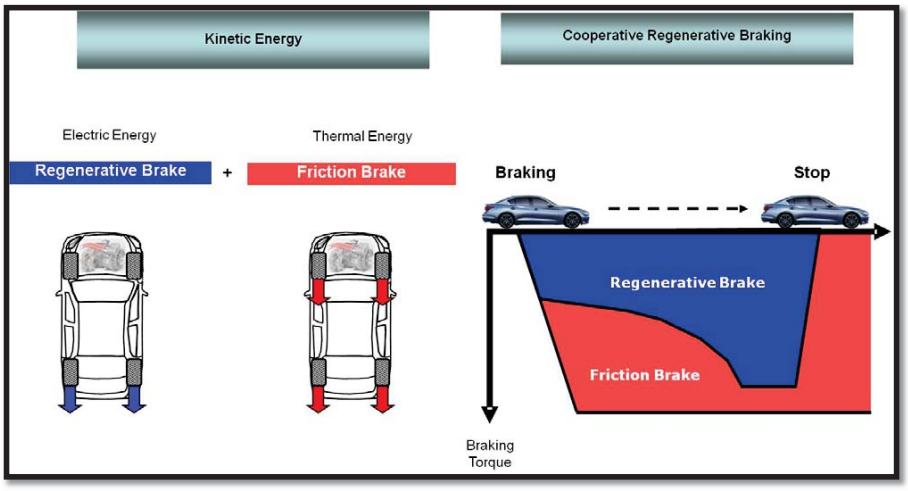
NOTES:

Hybrid-specific Brake Systems

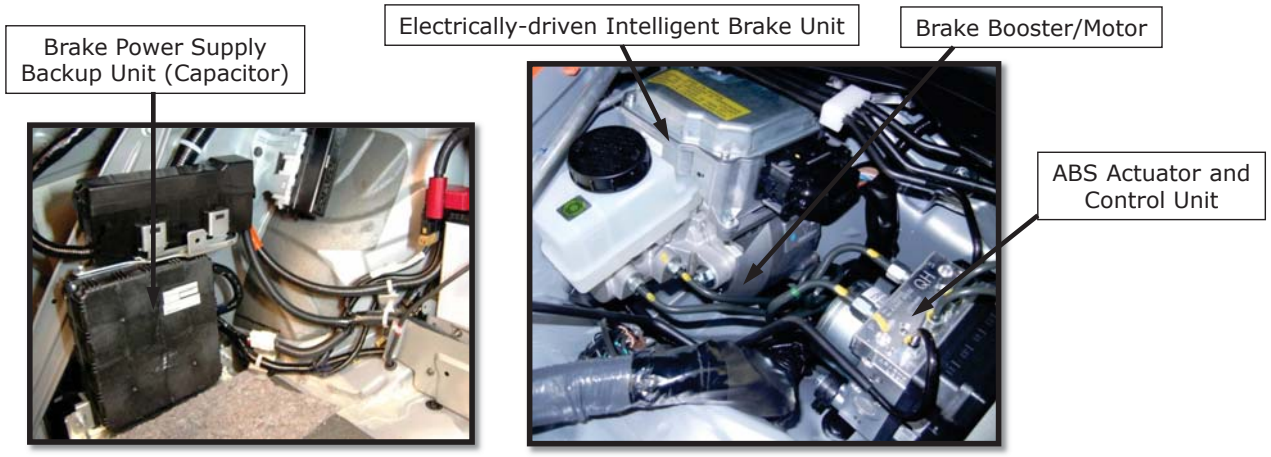
Hybrid Brake Systems

- Acceleration decreases the amount of stored energy in the battery. However, when the vehicle travels downhill or the driver decelerates, the electric motor is not needed to move the vehicle forward.
- During deceleration, the drivetrain spins the traction motor, generating current to recharge the high-voltage battery.
- This electrical load slows the vehicle, creating what is known as regenerative braking.
- The concept of using the conventional hydraulic brake system and the traction motor for combined braking is referred to as cooperative regenerative braking.



Electrically Driven Intelligent Braking System – Q50 / Q70

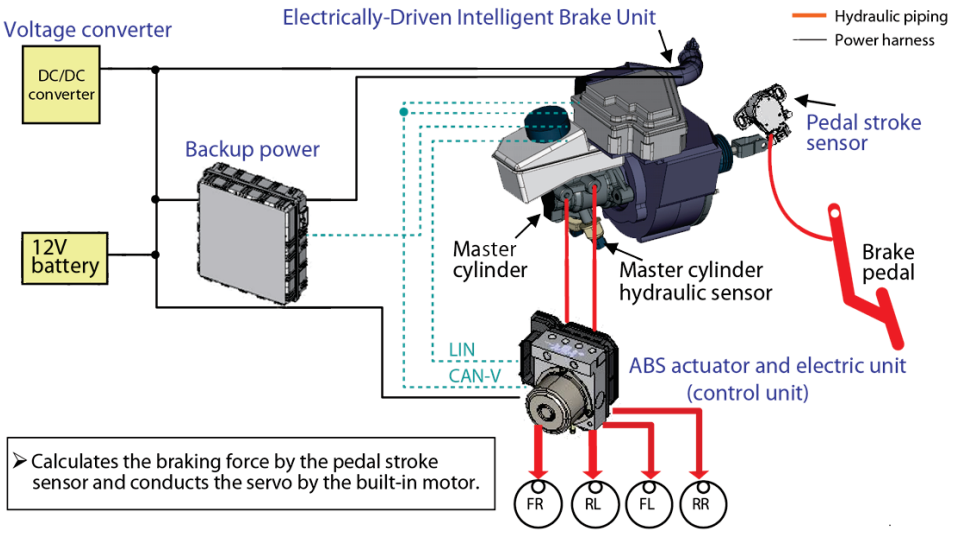
- Electrically-driven intelligent brake unit allows brake assist without the need for engine vacuum (can function with engine off)
- System provides friction braking as well as cooperative regenerative braking
- Sensors and control units are used to determine the appropriate blend of friction and regenerative braking
- Communication is via the HEV-CAN bus
- Includes a backup power supply to allow temporary operation if a malfunction occurs in the 12-volt battery or DC/DC converter



Normal Operation – Q50 / Q70

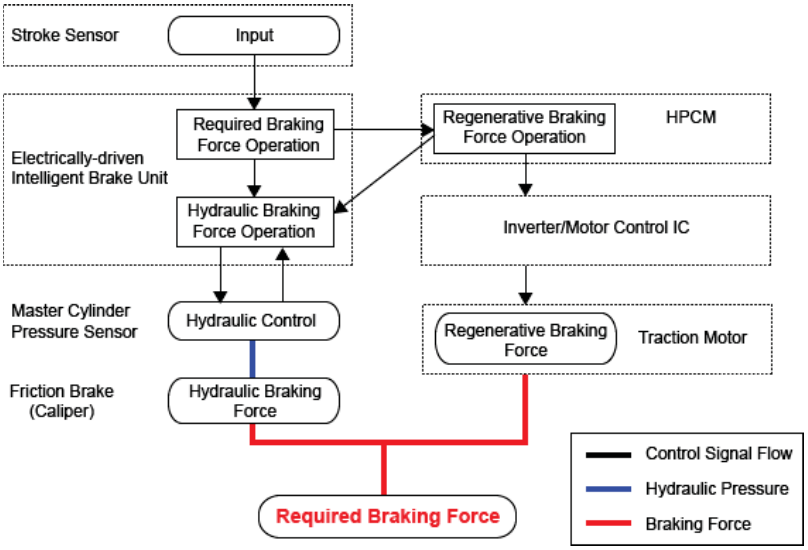
When the brake pedal is pressed, the pedal stroke sensor monitors the speed and force of the pedal application and sends the signal to the intelligent brake unit.

The brake unit generates hydraulic assist force by using the electric motor within the intelligent brake unit to operate the piston in the master cylinder.



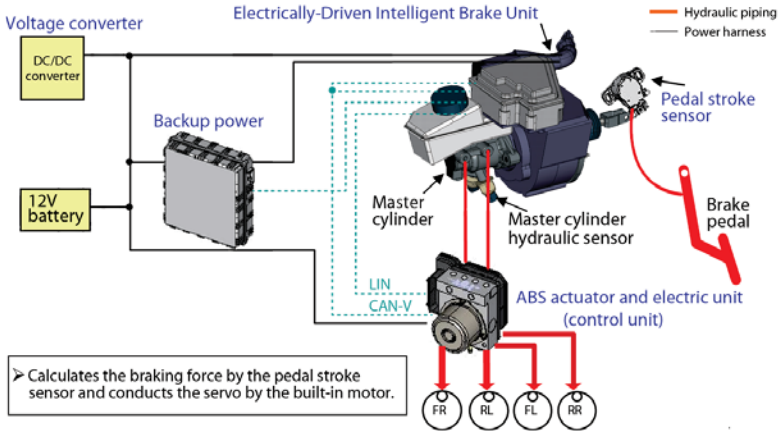
Cooperative Regenerative Braking– Q50 / Q70

When the brakes are operated (during driving), the electrically-driven intelligent brake unit calculates the required hydraulic braking force based on the input value from the stroke sensor, and sends the result to the traction motor inverter. The traction motor inverter determines the amount of regenerative breaking that is available and communicates the value back to the brake control unit. The brake control unit then adjusts the amount of hydraulic pressure to produce the combined braking force between friction and regenerative braking.



Cooperative Regenerative Braking – Q50 / Q70

- During deceleration the charging system is driven by the transmission, spinning the electric motor, recharging the lithium-ion battery
- Communication between the HPCM and the brake unit dictate the amount of brake boost
- The electric booster will reduce brake pressure to compensate for the braking effect of the regenerative braking
- The brake booster pulls the push-rod away from the master cylinder piston to prevent over-braking
- As the vehicle slows and regenerative braking is reduced the brake booster allows progressively more brake pressure from the brake push-rod
- If 12-volt power is lost the brake pedal supplies unboosted brake pressure.



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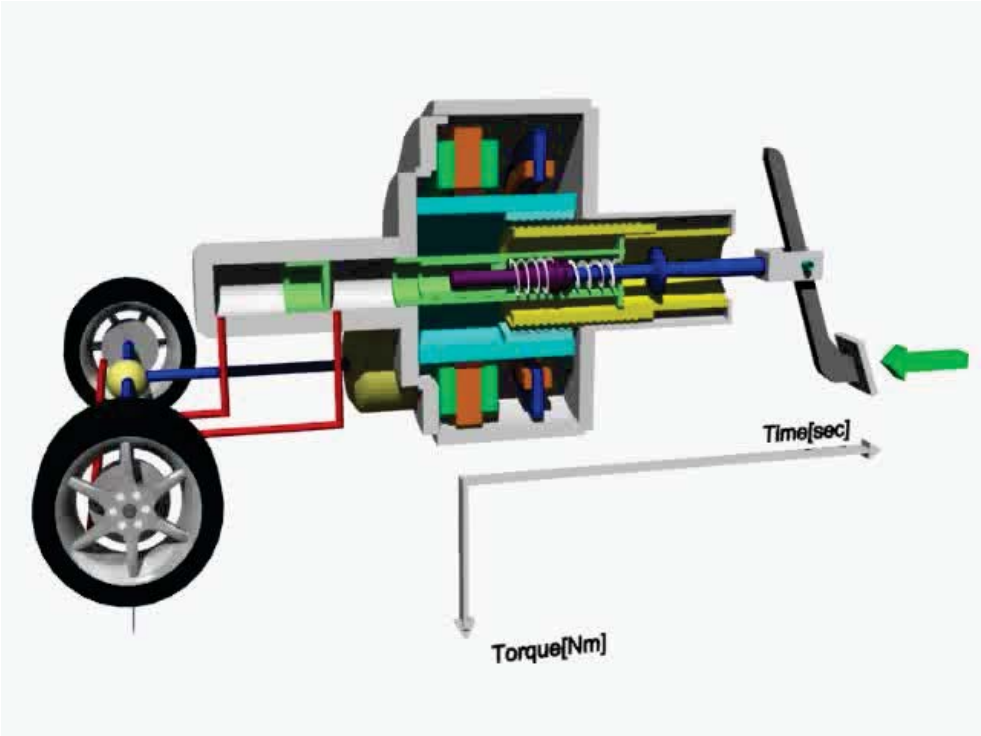
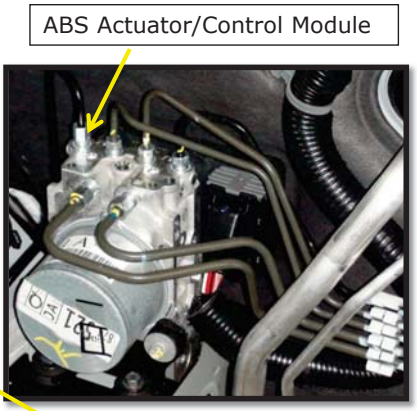
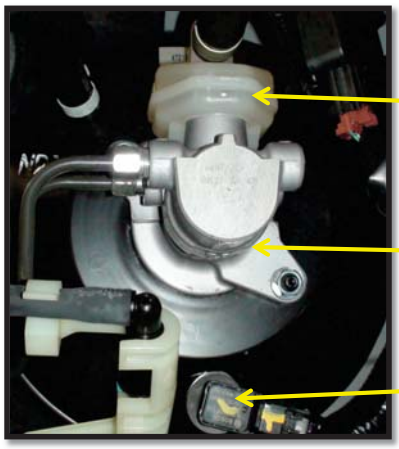


QX60 Brake System Components

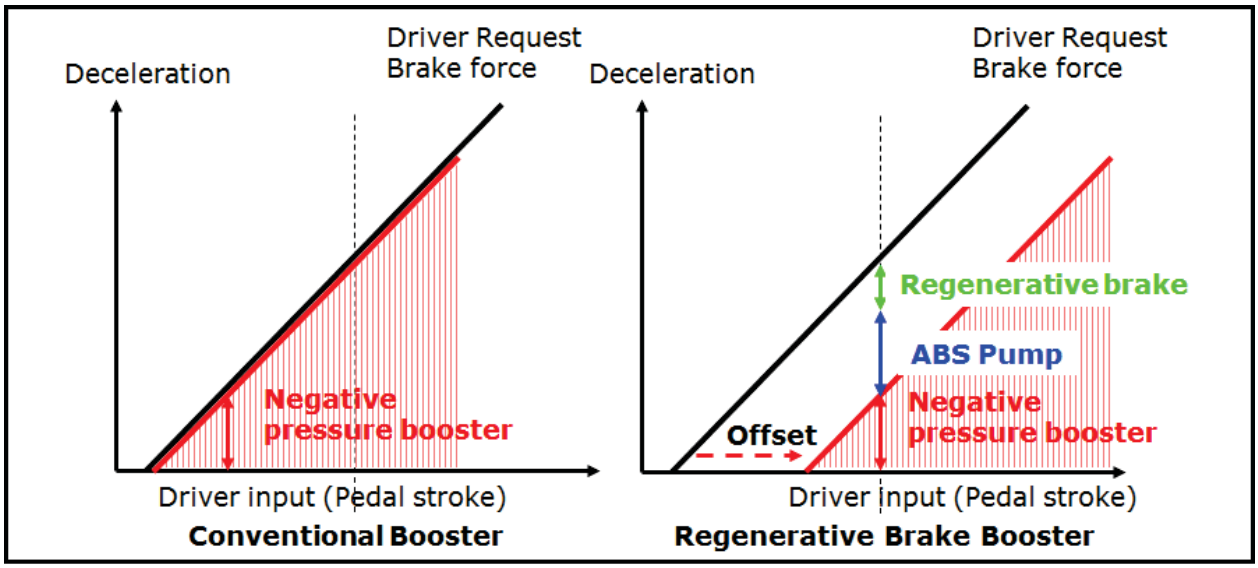
- The QX60 uses a more conventional braking system with a vacuum booster
- A vacuum reserve tank stores vacuum for engine-off assist applications





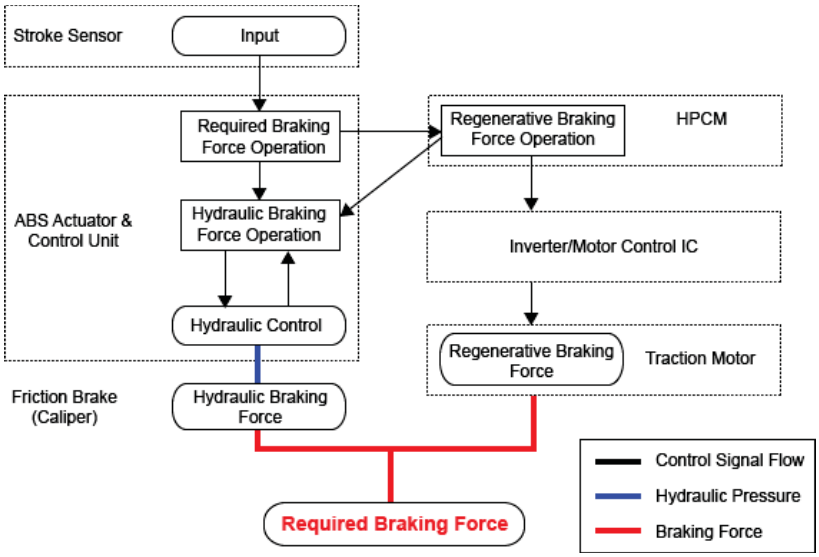
QX60 Cooperative Regenerative Braking

- When the brake pedal is applied, hydraulic pressure is initially provided by the ABS actuator and the traction motor
- After this initial phase, the brake booster starts to contribute to hydraulic braking pressure
- During emergency brake applications, the brake booster will provide immediate hydraulic pressure with full assist



Cooperative Regenerative Braking – QX60

The cooperative regenerative braking functions for the QX60 are similar to those used for the Q50 and Q70 hybrids. Because the QX60 does not incorporate an electrically-driven intelligent brake unit, the control calculations are performed in the ABS actuator and control unit.

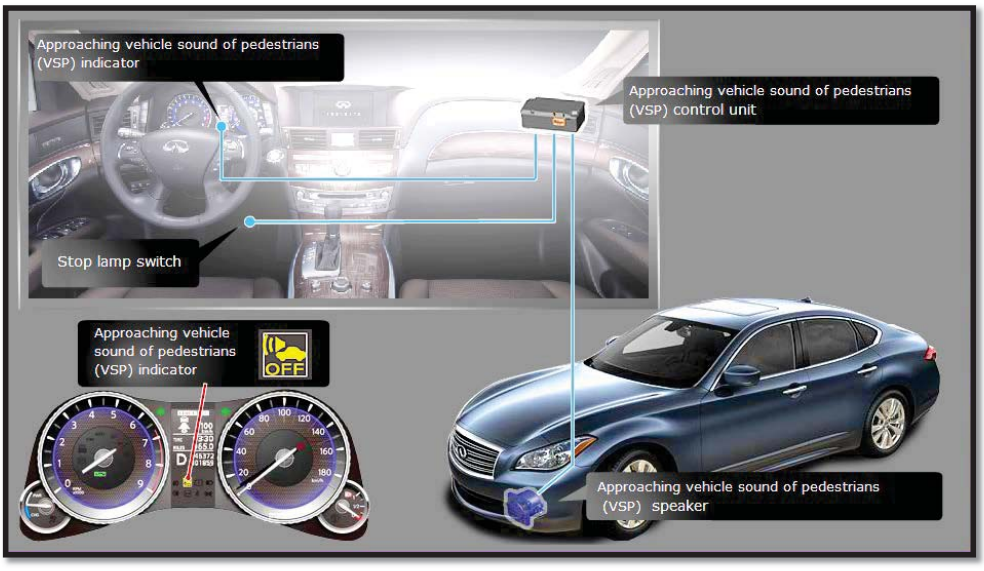


Approaching Vehicle Sound for Pedestrians (VSP)

Approaching Vehicle Sound for Pedestrians (VSP)

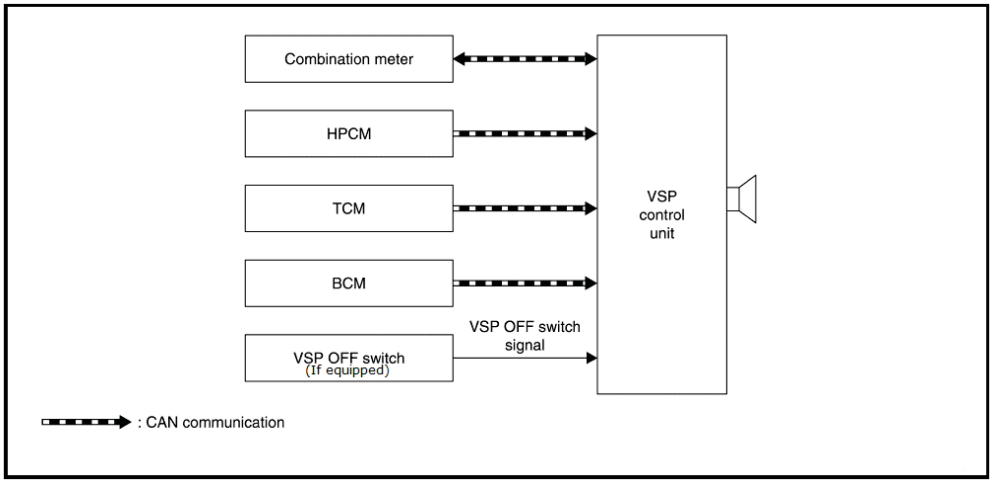
All Infiniti hybrid vehicles feature an audible pedestrian warning system to alert pedestrians when the vehicle is operating in EV mode. The system uses a control unit and a speaker to emit a warning sound. The VSP system operates in three modes:

- Driving Start Sound
- Driving Sound
- Reverse Sound



VSP Components And Operation

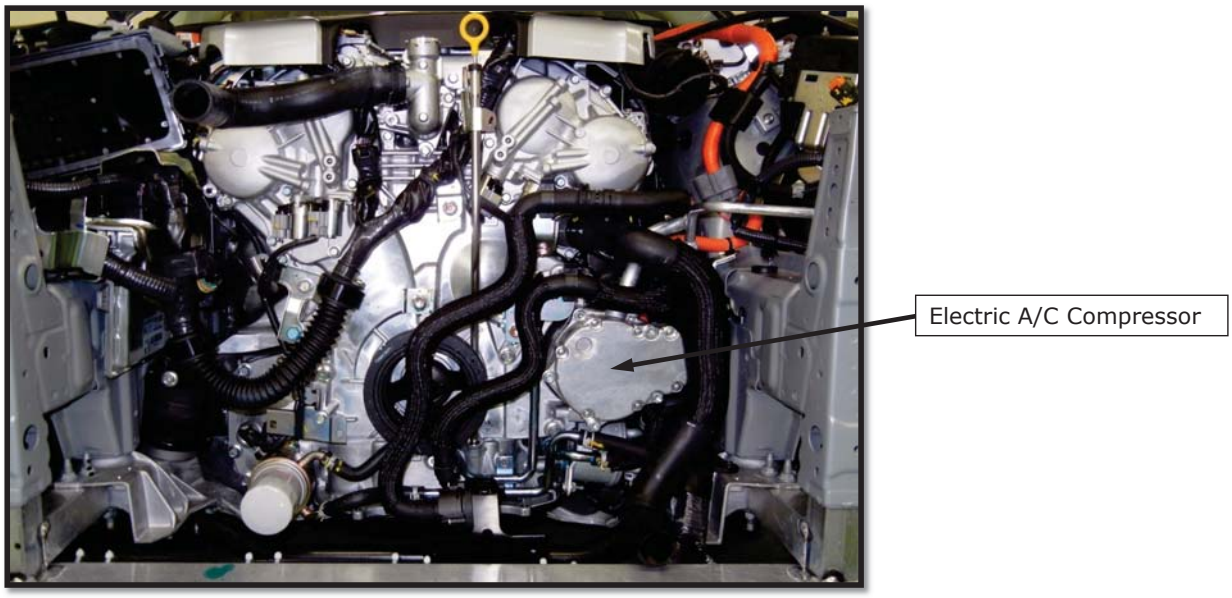
- Controlled by the HPCM, and receives signals from the TCM, BCM, and combination meter
- VSP system activates the speaker only during EV mode with the engine off
- The VSP control unit is attached to the VSP speaker
- The VSP control unit operates the VSP speaker according to driving conditions



Hybrid-specific HVAC Components

Electric A/C Compressor – Q50/Q70

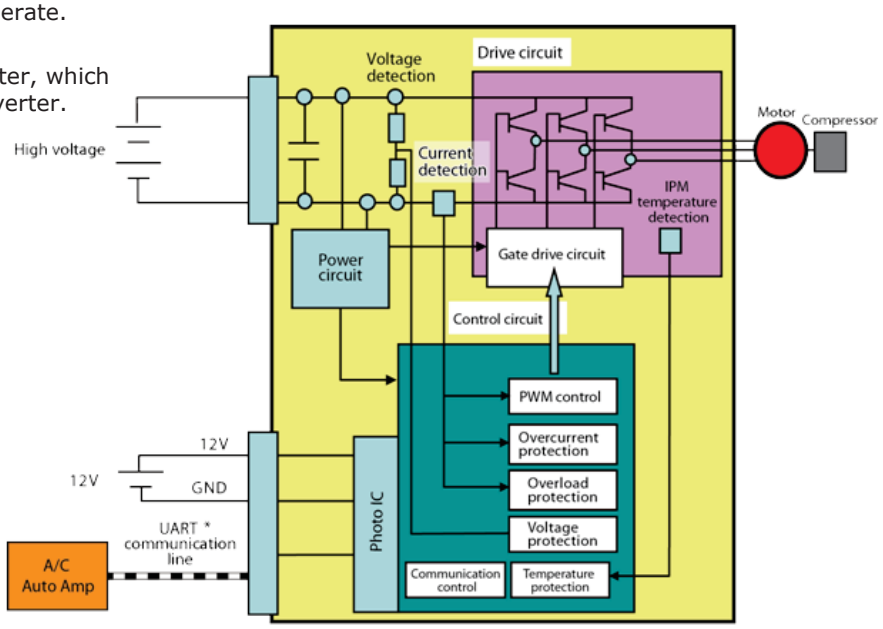
The Q50 and Q70 hybrids use a high-voltage electric A/C Compressor. This allows the A/C system to operate, even when the combustion engine is off in EV modes.



Electric Compressor Operation – Q50/Q70

The electric A/C compressor is not driven by an engine drive belt. As a result, significant electrical power is required for the electric compressor to operate.

The electric compressor includes an inverter, which functions much like the traction motor inverter. The compressor inverter receives 346 volts DC from the high-voltage battery and converts it to 3-phase AC to drive the compressor motor.



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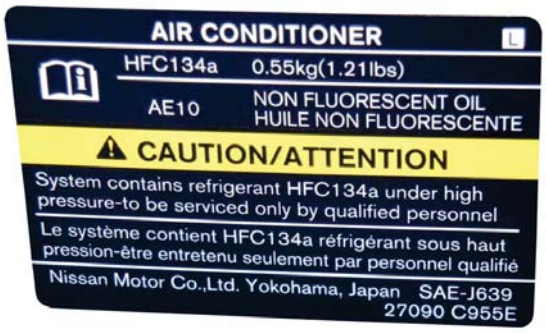
Electric A/C Compressor Special Service Requirements – Q50/Q70

- The high-voltage system must be disabled before servicing the electric A/C compressor
- EV-specific Ester oil must be used with the electric A/C compressor
- AE10 refrigerant oil is used for the factory fill; ND-Oil 11 is used during service. These oils are compatible
- PAG oil cannot be used; it will degrade the lubricant's insulation resistance
- Fluorescent dye cannot be used in systems with an electric A/C compressor



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Air Conditioning Compressor 2.5L QR25DER – QX60

- Serpentine belt driven
- Uses conventional R134a refrigerant, PAG oil and leak detection dye
- Uses conventional recycling/recharging station

Belt Driven A/C Compressor

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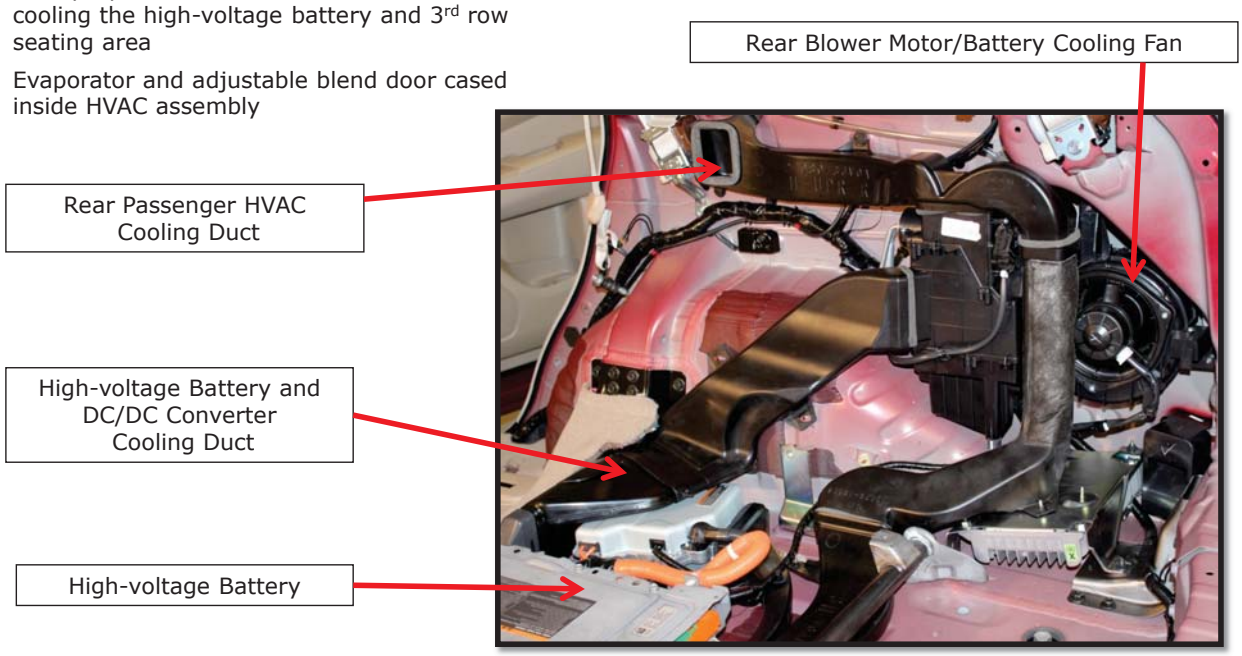
Rear HVAC and High-voltage Battery Cooling System– QX60

- Dual purpose HVAC blower motor, used for cooling the high-voltage battery and 3rd row seating area
- Evaporator and adjustable blend door cased inside HVAC assembly



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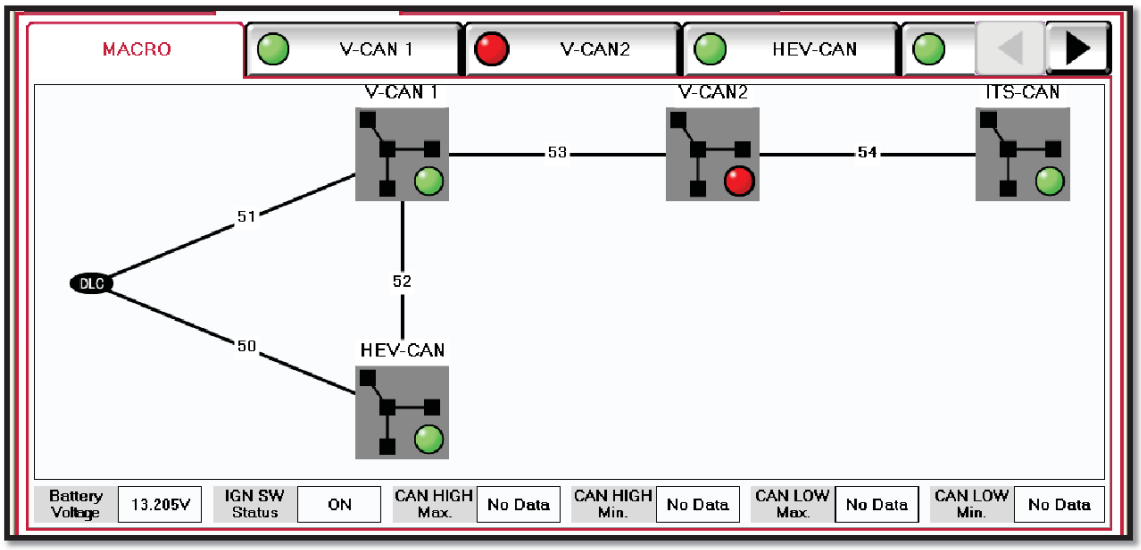
CAN Communication

CAN Communication – Q50 / Q70

The CAN on the Q50 and Q70 includes four communication circuits:

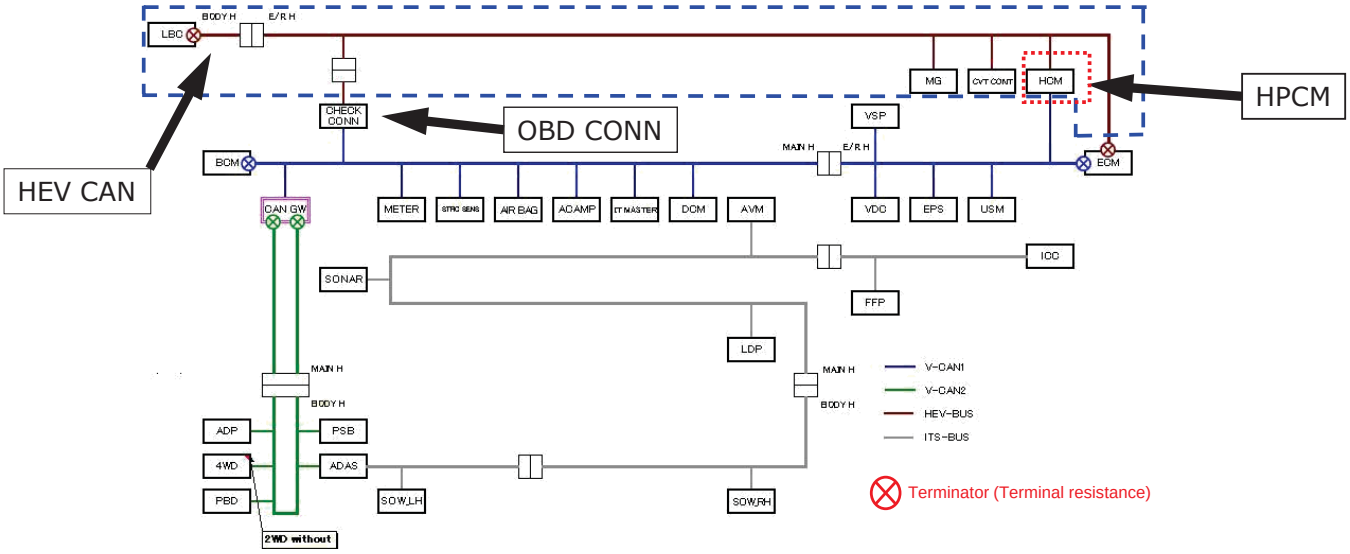
- V-CAN-1
- V-CAN-2
- HEV-CAN
- ITS-CAN



CAN Communication – QX60

The CAN network on the QX60 is comprised of three systems: V-CAN, HEV-CAN, and ITS-CAN

- V-CAN is the conventional CAN system which is developed around the ECM
- HEV-CAN is a CAN system which deals specifically with the HEV system
- ITS-CAN system is used for driver assistance systems



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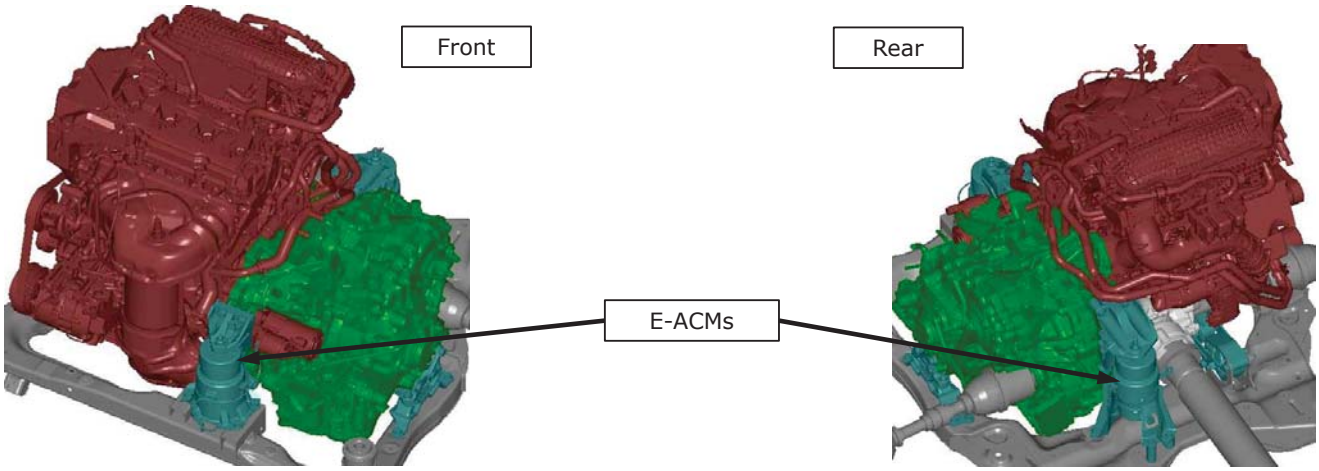
Noise and Vibration Control

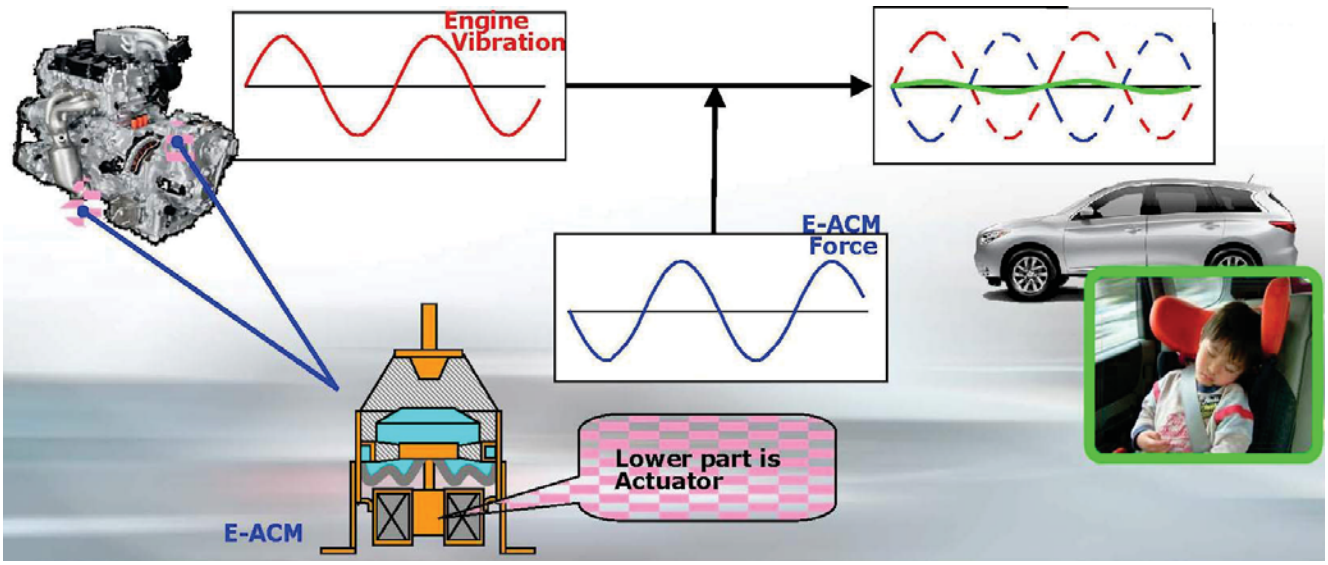
Electric Active Control Mount (E-ACM) – QX60

- E-ACM generates reverse-phase cancellation force from the engine mounts against engine vibration during start-up, idle and low speed operation
- E-ACM control module



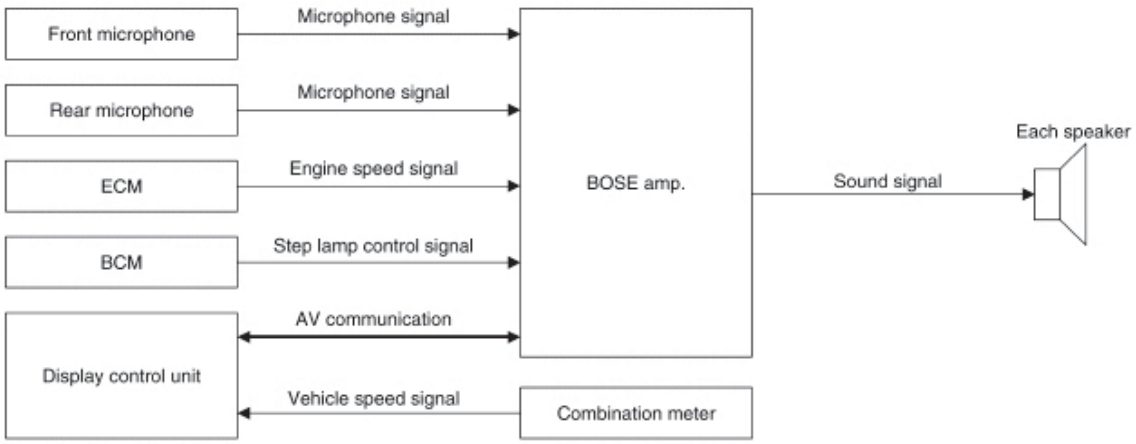
E-ACM – QX60

- Normal engine vibration is calculated and a reverse-phase cancelling force is applied to the engine mount



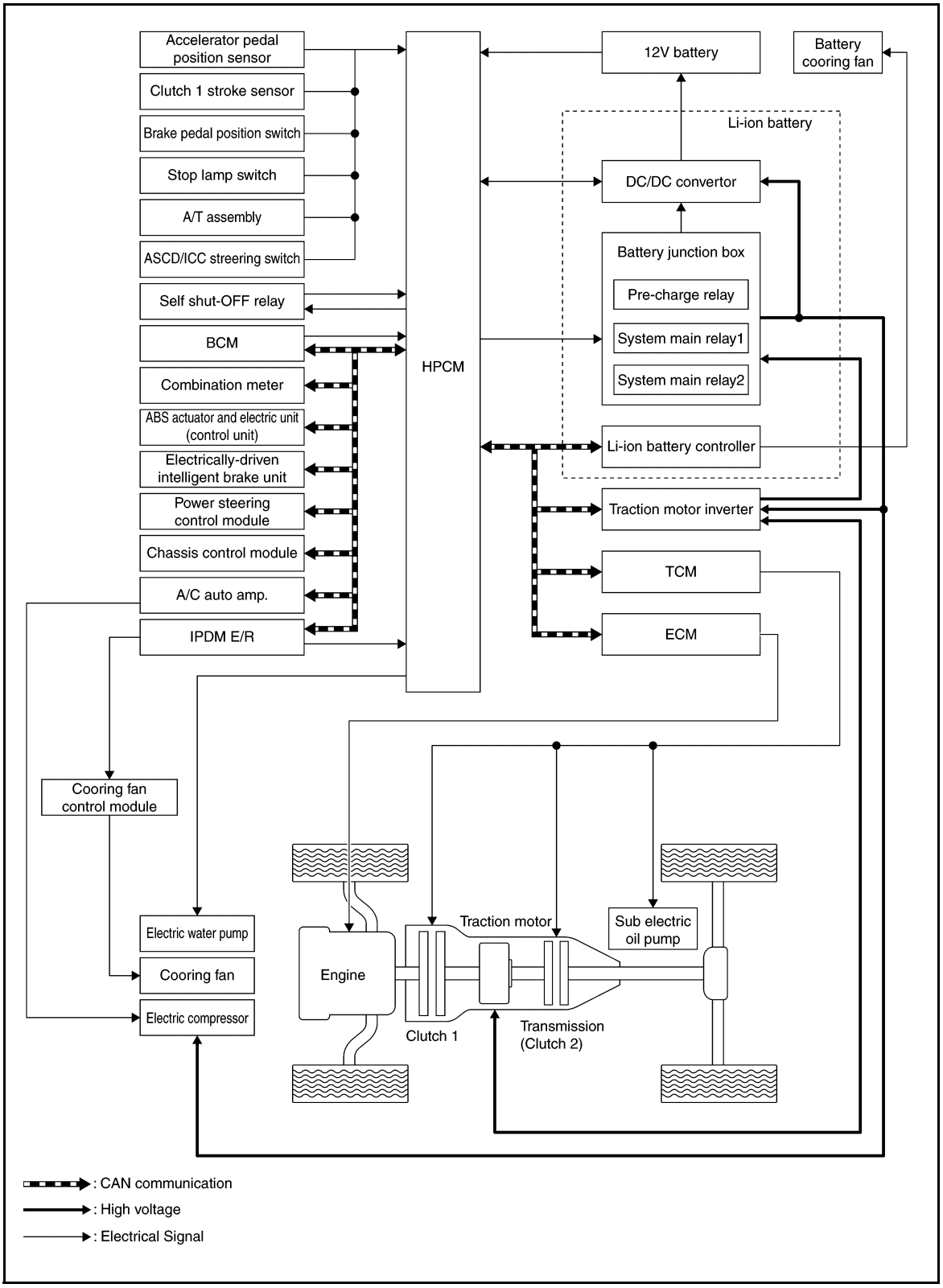
Active Noise Control (ANC)

- ANC incorporates interior microphones to monitor cabin noise
- The cabin noise signal is sent to the Bose amplifier where it is analyzed to determine the noise characteristics
- The Bose amplifier outputs a reverse-phase sound through the audio system speakers to cancel the engine noise and reduce interior sound levels

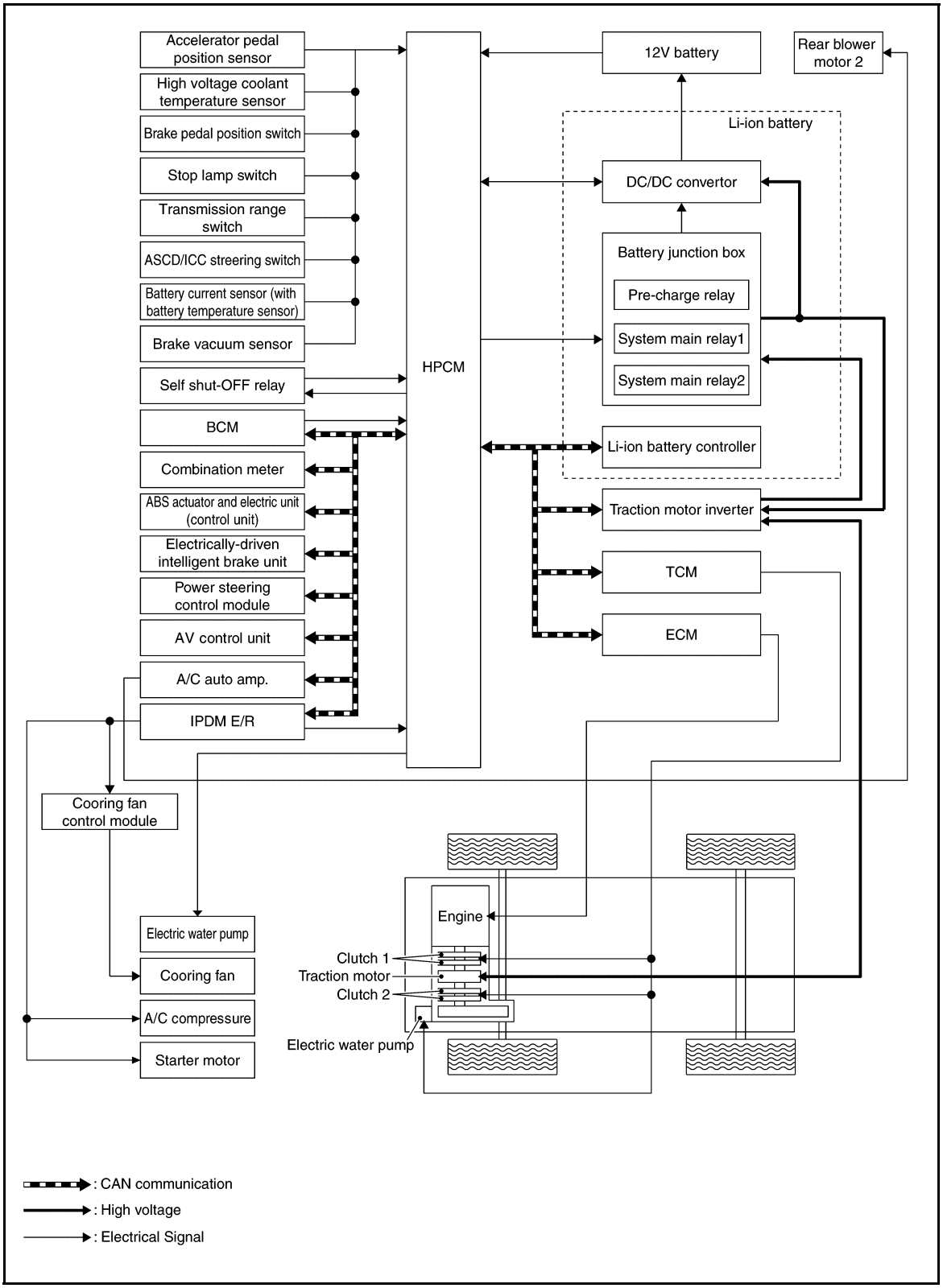


Appendix

Hybrid Control System Diagram - Q50/Q70



Hybrid Control System Diagram - QX60



GLOSSARY

AC	Alternating Current
A/C	Air Conditioning
CAN	Controller Area Network
CHG	Charge relay
DC	Direct Current
EPS	Electric Power Steering
EV	Electric Vehicle
F/S	Fail Safe relay
GDC	Global Data Center
HEV	Hybrid Electric Vehicle
HPCM	Hybrid Powertrain Control Module
HVAC	Heating Ventilation and Cooling
ICE	Internal Combustion Engine
IGBT	Insulated Gate Bipolar Transistors
INV	Inverter
IT	Information Technology
kg-m	Kilogram meter
kW	Kilowatt
LAN	Local Area Network
LB C	Lithium-ion Battery Controller
lb.-ft.	pound feet
LiB	Lithium-ion battery
li-ion	lithium-ion
LIN	Local Interconnect Network

LLC	Long Life Coolant
mA	Milliamp
M/C	Master Control relay
NAVI	Navigation system
Ni-MH	Nickel-Metal Hydride batteries
PC	Personal Computer
PPE	Personal Protection Equipment
PTC	Positive Thermal Coefficient heater
RPM	Revolutions Per Minute
SOC	State Of Charge
SOH	State of Health
UART	Universal Asynchronous Receiver Transmitter
V	Volt
VCM	Vehicle Control Module
VDC	Vehicle Dynamic Control
VSP	Vehicle Sound for Pedestrian