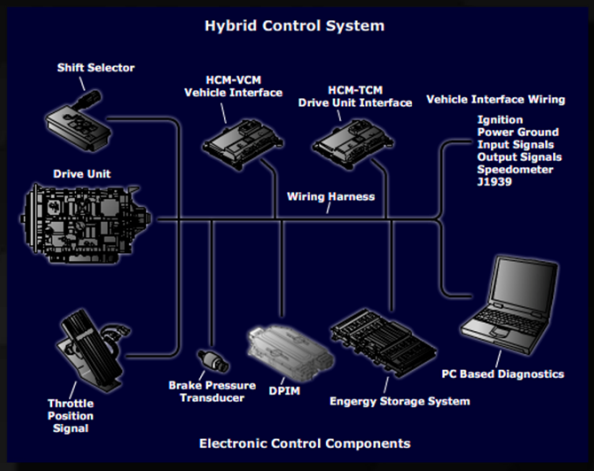
SYSTEM OVERVIEW

Allison Transmission Instructor Led Training

System Overview

Allison Hybrid E 40/50 EP System

- **Key components:**
  - *Engine.*
  - *Drive unit.*
  - *Dual Power Inverter Module (DPIM).*
  - *Energy Storage System (ESS).*
  - *Control Modules (TCM & VCM).*
- **Parallel hybrid basic operating theory:**
  - *The drive unit replaces a traditional transmission and contains planetary gear sets, clutches and electric motors.*
  - *Power from the engine and electric motors work together to create drive unit output and propulsion.*
    - *"Torque Blending" describes the engine and motors being used together to create propulsion.*



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Allison Transmission

RESOURCES: Common Acronyms

COMMON ACRONYMS

DPIM – Dual Power Inverter Module: Primarily used for AC/DC conversion and motor controls.

ESS – Energy Storage System: Uses NiMH batteries to provide high voltage energy to the E^P System™.

IGBT – Insulated Gate Bipolar Transistor: Voltage controlled power transistors used in the DPIM.

TCM – Transmission Control Module: Primary controller for the E^P System™ that interfaces with the E^V Drive™.

VCM – Vehicle Control Module: Interfaces other vehicle systems into the E^P System™.

HVIL – High Voltage Interlock Loop: Safety circuit designed to prevent access to hazardous voltage.

IDI – Inverter Disable at Idle: Disables motor torque command during engine idle to reduce electrical losses from the ESS.

PBSS – Push Button Shift Selector: Driver interface device for the E^V Drive™.

RTD – Resistance Temperature Device: Measures temperature as a voltage input.

DVOM – Digital Volt/Ohm Meter: Capable of faster sensing compared to an analog volt meter.

BCIM – Battery Control Interface Module: A component of the ESS charging system.

CAN – Controller Area Network: Device controllers used in SAE J1939 datalinks.

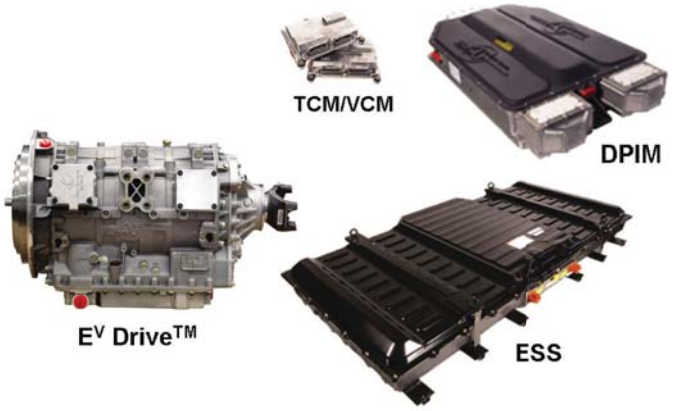
RESOURCES: System Components

E^P SYSTEM™ COMPONENTS

There are four main components that make up the E^P System™

- **The E^V Drive™ is the transmission.**
- **The Control Modules (TCM/VCM) contains control algorithms and process diagnostic information for the system.**
- **The DPIM handles AC/DC conversion and motor control.**
- **The ESS is the high voltage energy source for the E^P System.**

These four components work together along with the vehicle's engine to make up the resulting hybrid drive system.



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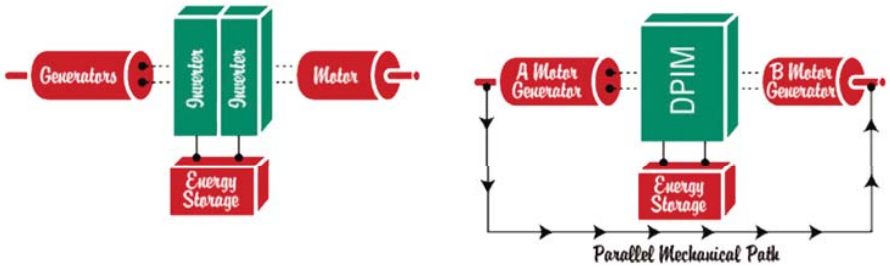
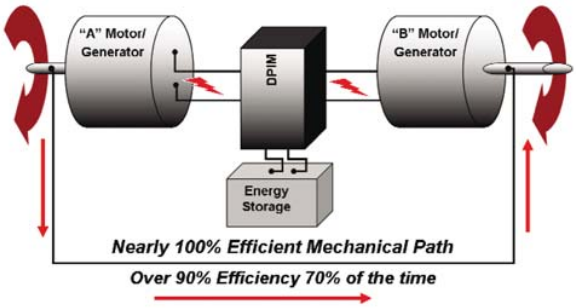
RESOURCES: Series vs. Parallel Architecture

SIMPLE SERIES HYBRID TECHNOLOGY

In a simple series hybrid system, an internal combustion engine is coupled to an electrical generator. Energy from the generator powers a traction motor. The system has an energy storage system (batteries) to store energy for the traction motor.



PARALLEL HYBRID ARCHITECTURE

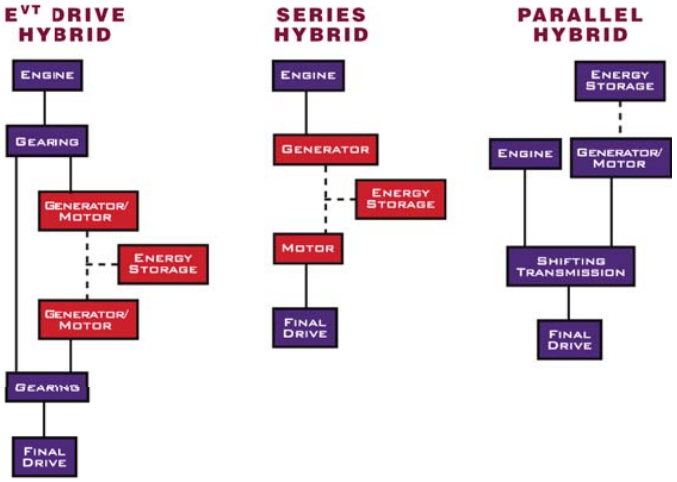


A parallel system is the best of both worlds, combining electric motors for low speed output with the capability of engine power for steady state cruising. The Two-Mode Compound Split Parallel Hybrid architecture produces over 90% efficiency 70% of the time.

SERIES vs. PARALLEL ARCHITECTURE

A series hybrid system takes engine input directly into a generator which feeds an energy storage system to power an electric motor, which outputs to the final vehicle drive.

The Allison E^{P} System uses two generator/motors integrated into the transmission gearing, which is coupled to the vehicle final drive. The engine, generator/motors and ESS operate together to optimize emissions, fuel economy, and vehicle performance.



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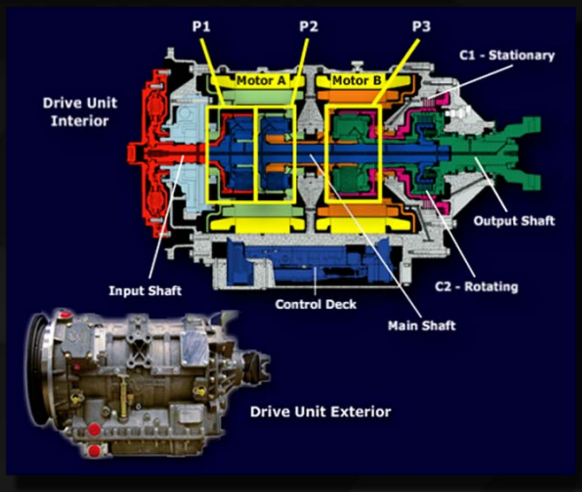
System Overview

Drive Unit

- Mounting configurations consistent with traditional Allison products.
- Similar in size to the Allison B400 transmission.
- Contains two three-phase AC induction motors.
- Contains three planetary gear sets, one rotating clutch and one stationary clutch.
- Uses a remote oil cooler and shares a hydraulic system with the DPIM.



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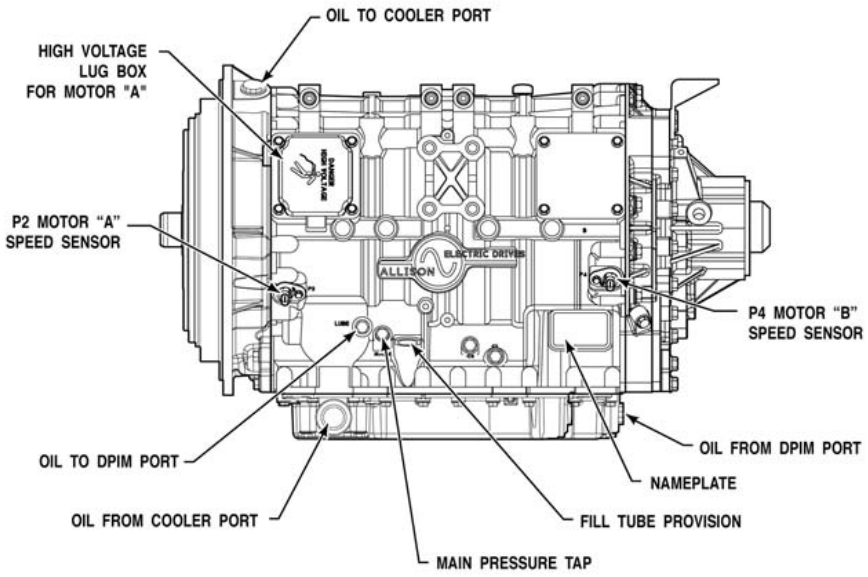
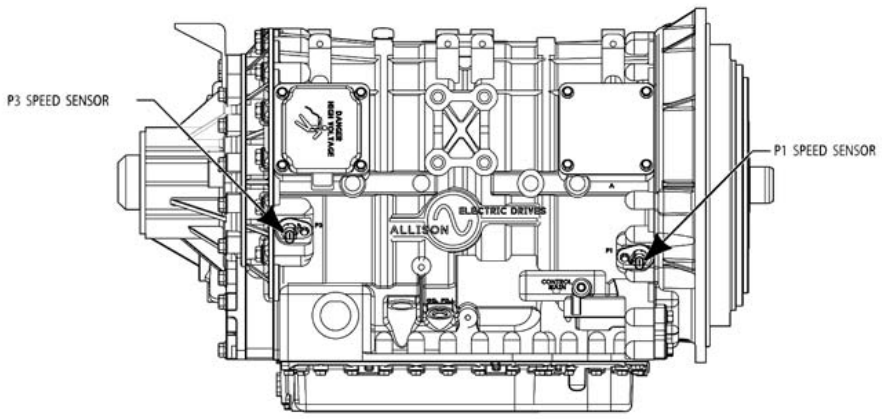
RESOURCES: External Features

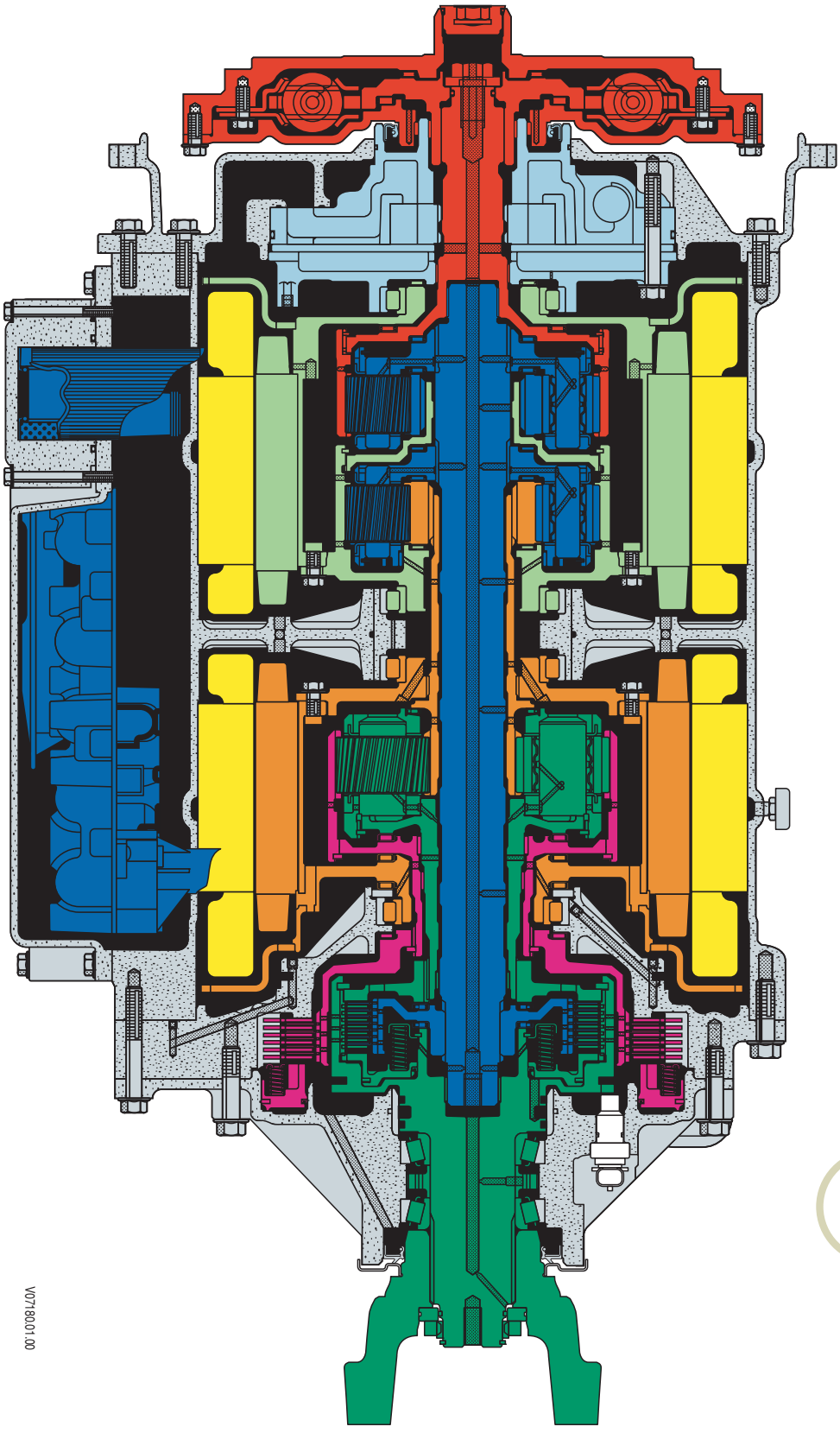
Left View



Right View



RESOURCES: Hybrid Transmission Cross Section



EP 40/50

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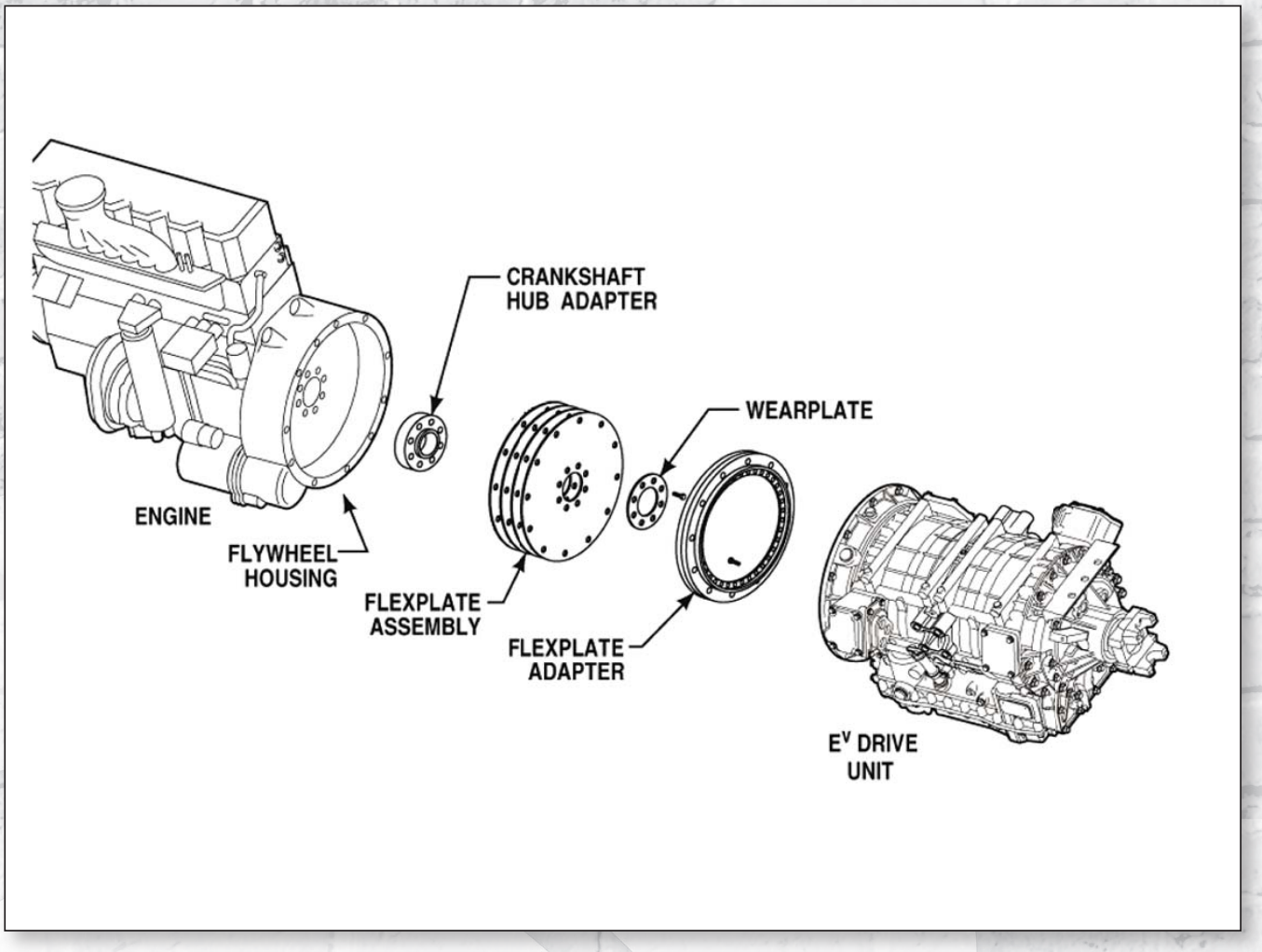
ALLISON ELECTRIC DRIVES™

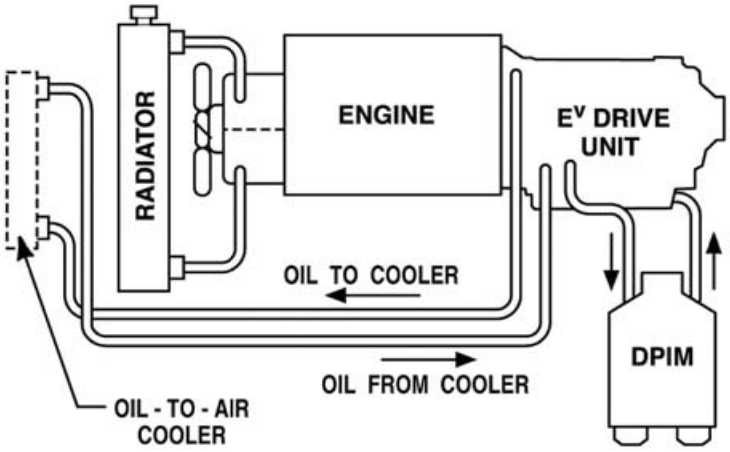
RESOURCES: Installation



RESOURCES: Drive Cooling Circuits & Role of Engine

E^{V} DRIVE™ COOLING

The E^{V} Drive™ utilizes two cooling circuits. One circuit uses a traditional oil-to-air cooler for cooling the overall system hydraulic fluid. A second circuit is routed from the E^{V} Drive™ to the DPIM to provide cooling for the IGBTs located in the DPIM.



ROLE OF THE ENGINE

The engine's involvement in the hybrid system is limited to providing power at tuned torque and speed points. Engine speed varies depending on the torque needs being requested by the hybrid system.

The engine has two typical operational modes, torque mode and speed mode. In torque mode, the E^{P} System™ TCM provides the engine with a torque and speed request. Speed mode is used during startup, shutdown, IDI (inverter disable at idle), and limp mode. In speed mode, the hybrid system commands a desired speed to the engine.

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System Overview

Energy Storage System (ESS)

- Uses NiMH (Nickel Metal Hydride) battery technology.
- Acts as the high voltage energy source for the system.
- Stores energy generated by the drive unit and regenerative braking.
- Provides energy to the drive unit “on demand”.
- Does not require off-board charging.
- Regenerative braking slows the vehicle like a retarder and recharges the ESS.
  - *This occurs when the drive unit motors are driven and act as generators.*

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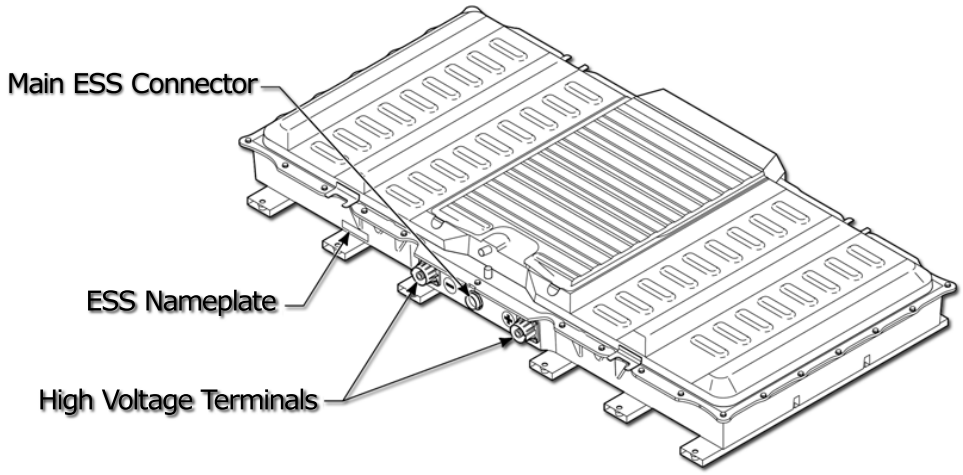
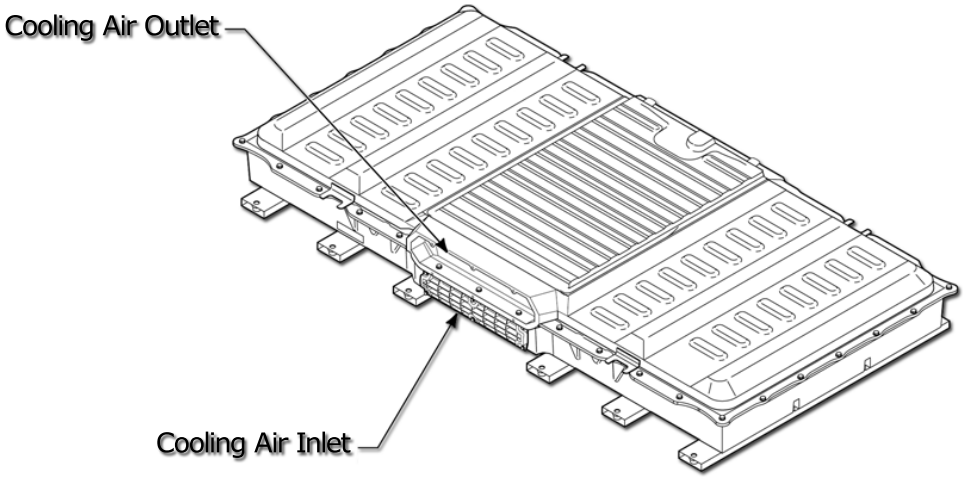
RESOURCES: ESS External Features

Left Front View



Left Rear View



RESOURCES: Regenerative Braking

REGENERATIVE BRAKING

The key to hybrid technology is regenerative braking. When stopping the vehicle, the E^{V} Drive™ automatically converts the vehicle's moving energy into electrical energy. This electrical energy is stored in the ESS for future use. The effect of regenerative braking is similar to that of a hydraulic retarder which assists in slowing the vehicle and reduces the need for use of the service brakes.

1. When stopping the vehicle, Allison Electric Drive automatically becomes an energy generator by converting vehicle energy into electrical energy.

2. The electrical energy is then saved, by storing it in the Allison Energy Storage System for future use.

3. When accelerating the vehicle, the stored electrical energy is used to accelerate the vehicle, *saving fuel and reducing harmful emissions and noise, while improving comfort.*

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System Overview

Dual Power Inverter Module (DPIM)

- Responsible for AC/DC current conversion and drive unit motor control.
- The drive unit motors use Alternating Current and create Direct Current.
- The DPIM facilitates AC/DC conversion for energy storage and use.
- Uses a remote oil cooler and shares a hydraulic system with the drive unit.

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System Overview

Control Modules (TCM & VCM)

- The system uses two control modules.
- Transmission Control Module (TCM) is primarily responsible for transmission controls.
- Vehicle Control Module (VCM) is primarily responsible for vehicle level input and output interfaces.
- Both work together to control different portions of the hybrid system.

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RESOURCES: TCM Inputs/Outputs

C. TCM Inputs

In addition to J1939 messages that are used as inputs for the TCM, there are hardwired inputs as well. Some of the inputs listed may have an equivalent J1939 message from another controller. One or the other is used in that situation, not both.

- Ignition sense—detects key switch state
- Drive Unit ID—identifies EV Drive™ hardware level (similar to TID in other products)
- ECU ID (TCM/VCM)
- C1/C2 Pressure Sense
- Sump Oil Temperature
- EV Drive™ Output Speed
- ESS Relay Closed
- Accelerator interlock—disables engine response to throttle when active
- Fast Idle—commands higher idle speed when active
- Engine Brake Enable—notifies TCM of the engine brake state
- Auxiliary Function Range Inhibit—inhibits selection to range when auxiliary equipment enabled
- Front Operation—allows vehicle start-up and operation from the driver's compartment
- Remote Shutdown—requests system shutdown
- Oil Level Sensor

D. TCM Outputs

- C1 and C2 Trim Solenoid Drivers
- C1 and C2 Blocking Solenoid Drivers
- DPIM Wake-up Signal
- ESS Wake-up Signal
- Engine Controller Wake-up Signal
- Speedometer Signal (optional)
- Engine Brake Enable (optional)
- Auxiliary Brake Enable Indicator Lamp
- PTO Enable
- Output Speed Indicator—provides an output at a programmed vehicle speed
- Propulsion Inhibits—based upon system diagnostics and operating parameters

E. VCM Functions

The VCM controls vehicle functions related to the EP 40/50 System™. The VCM also communicates with various vehicle auxiliary systems to limit vehicle movement when an auxiliary system is functioning or to limit auxiliary system operation such as rear door open when vehicle speed inhibits door opening. The VCM can control relays, solenoids, or lamps and can request, via the J1939, another controller to perform an action.

i. VCM Inputs

- Engine Start Request
- Idle Verification
- Shift Selector Inputs
- System Override Requests
- Auxiliary Brake Enable Request
- Electric Mode Request (a special calibration)
- Auxiliary Brake Analog Input

ii. VCM Outputs

- Accelerator Pedal Sensor Supply
- Shift Selector Serial Data Link
- Dash Indicator Lamp Control
- Main Pressure Boost Solenoid Commands
- Reverse Warning
- Propulsion Inhibits Based Upon Diagnostics or Operating Parameters

RESOURCES: TCM/VCM

TCM / VCM

There are two control modules used in the E^{P} System™, the Transmission Control Module (TCM) and the Vehicle Control Module (VCM). Both of them work together to control different portions of the hybrid system. The TCM is primarily responsible for transmission controls:

- **Range selection.**
- **Shift management (solenoid controls).**
- **Wakeup signals.**
- **Input/Output functions.**
- **Diagnostic capabilities.**

The VCM is primarily responsible for vehicle level I/O interface.