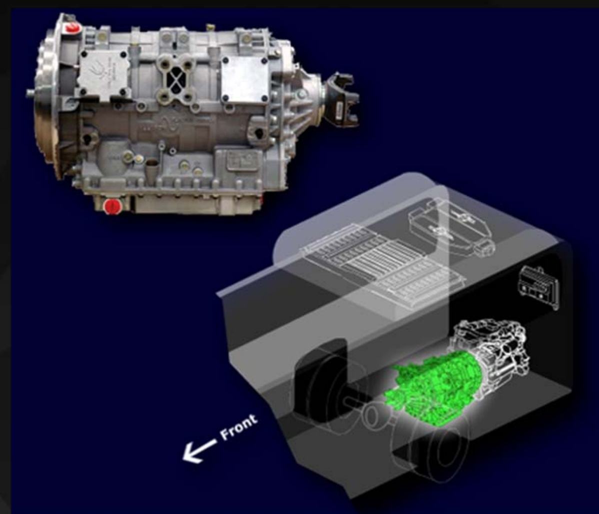
Allison Transmission | Instructor Led Training | ALLISON HYBRID H 40/50EP

Drive Unit

Overview

- **The drive unit develops propulsion using two power sources:**
  - *Electrical (from the drive motors).*
  - *Mechanical (from the engine).*
- **The drive unit produces two speed ranges, Mode 1 and Mode 2.**
  - *The shift point varies, but it is typically between 15 and 25 miles per hour.*



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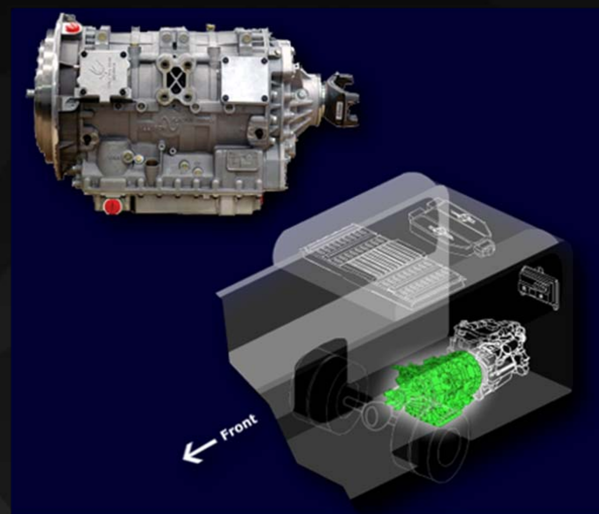
Drive Unit

Overview (cont'd)

- The two drive unit motors, three planetary gear sets and clutches can work together or independently to create torque, direction and speed.
- The drive unit connects to the engine using an input damper rather than a torque converter.



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RESOURCES: External Features

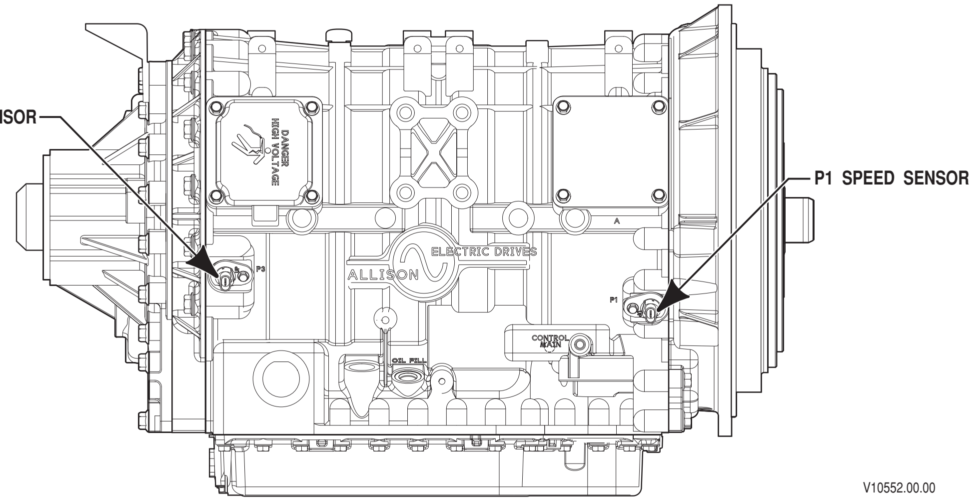


Figure 1–1. E^V Drive—Right Side

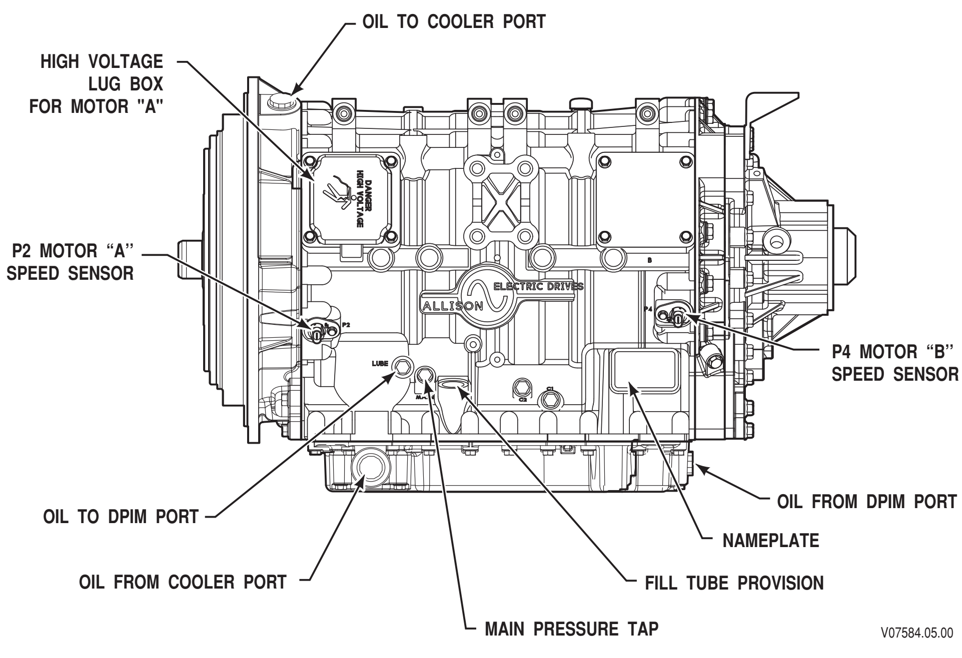
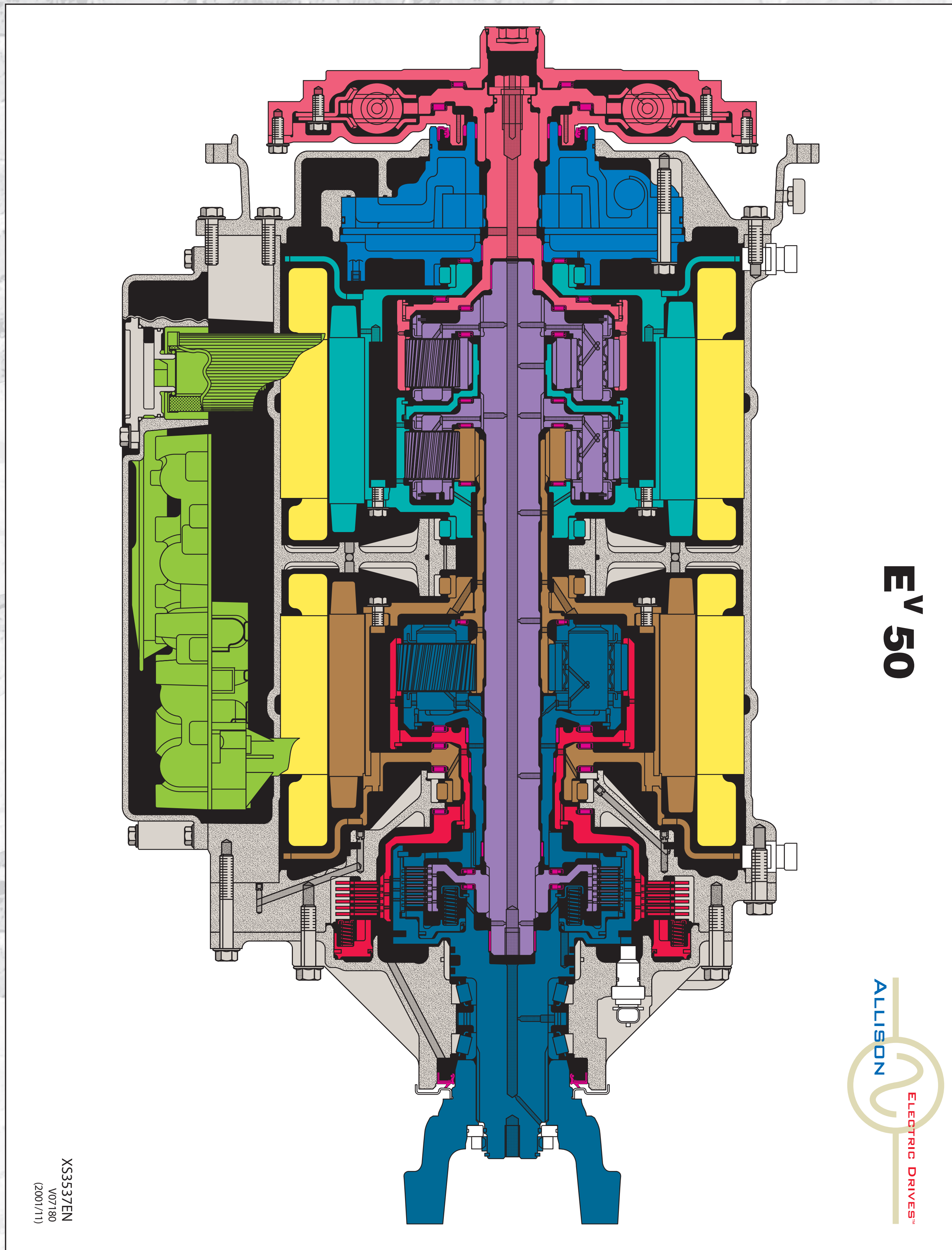


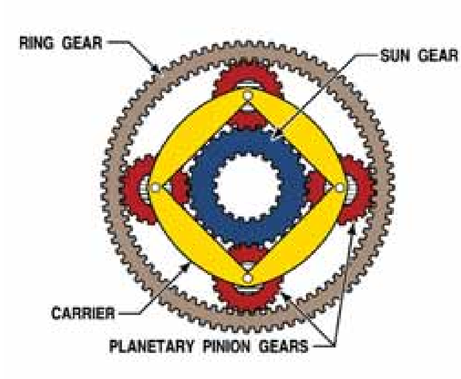
Figure 1–2. E^V Drive—Left Side

RESOURCES: E^V 50 Cross Section



PLANETARY GEAR SETS

Planetary gears are made up of three intermeshed gears, a sun gear, pinion gears held together by a carrier, and a ring gear. All three of these gear sets rotate together as a set of components. When one component is held and another is rotated, the third component becomes output. Depending on which components are held (typically with a clutch) and which are rotated, a planetary gear set can develop various output ratios including a decrease in input speed, an increase in input speed, direct 1:1 drive and reverse.



- To **decrease input speed**, the ring gear is held and the sun gear is rotated as input. This makes the carrier output rotating at a slower speed than the sun gear.
- To **increase input speed**, the ring gear is held and the carrier is rotated as input. This makes the sun gear the output rotating at a faster speed than the carrier.
- For **direct drive**, no components are held and two components rotate as input. This makes the third member output rotating at the same speed and direction as the input.
- For **reverse**, the carrier is held and either the ring gear or the sun gear is input. If the ring gear is input, the sun gear is output rotating in the opposite direction of the ring gear at a faster speed. If the sun gear is input, the ring gear is output rotating in the opposite direction of the sun gear at a slower speed.

RESOURCES: Hydraulic Clutch Operation

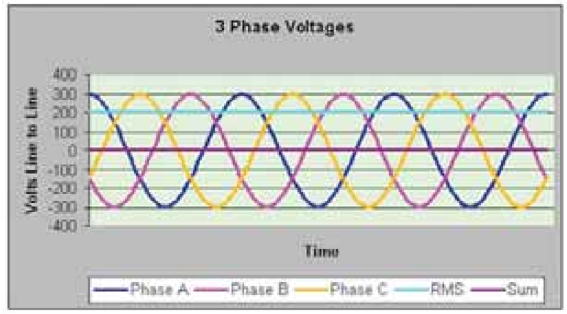
HYDRAULIC CLUTCH OPERATION

Clutches provide driving and holding forces for planetary gear sets. They are comprised of two intertwined sets of clutch plates: Fiber friction plates and steel reaction plates. Introducing pressure (via hydraulic fluid) behind a piston in the clutch clamps the two plates together. Springs inside of the clutch release the piston when hydraulic pressure is exhausted.

There are two types of clutches used in the E^V Drive™, rotating and stationary. Rotating clutches supply rotational input to planetary components. Stationary clutches act to hold planetary gear components.

E^V DRIVE™ MOTORS

The E^V Drive™ contains two internal motors, Motor A and Motor B. Both motors are three phase AC induction motors meaning that the incoming voltage to the motor is divided into three phases. These phases are 120 electrical degrees apart. Splitting the incoming current into the three phases allows increased capacity of the motor compared to operation in a single phase configuration.



Induction means that the motor rotors are not supplied current directly; they are induced with current by the stator.

NOTE: This resource link has multiple pages and information changes frequently. Reference the source document for complete, current information.

Section Two

E^V DRIVE™ DESIGN

2–1. E^V DRIVE™ OVERVIEW

A. General

The E^V Drive™ is designed to combine (torque blend) electrical machine torque with engine torque while driving in a forward direction. The E^V Drive™ does not have fixed gear ratios as does a typical automatic transmission. The gear ratios, speed ratios, and torque ratios through the E^V Drive™ are continuously variable until maximum ratings are reached (refer to Table 1–1). The E^V Drive™ has three planetary gear sets, two clutches, and two electrical machines (motor/generators).

B. Motor/Generator (Motor A, Motor B) Overview

The motor/generators operate on high voltage three-phase AC. Each motor/generator is a three-phase ten-pole asynchronous induction machine. The induction machines can each produce up to 75 kilowatts (kW) (100 hp) of continuous electrical power. They can run in either direction from 0–5000 rpm.The electrical machines (motor/generators) are located concentric to the main shaft inside the drive unit with one motor/generator in front of the other. Inside the E^V Drive™, the front motor closest to the flywheel is identified as Motor A and the rear motor is identified as Motor B.

C. E^V Drive™ Modules

The E^V Drive™ unit is comprised of five standard modules (Figure 2–1):

- Input Housing Module
- Main (Stator) Housing Module
- Control Valve Assembly/Oil Pan Module
- Clutch Housing Module
- Rear Cover Module

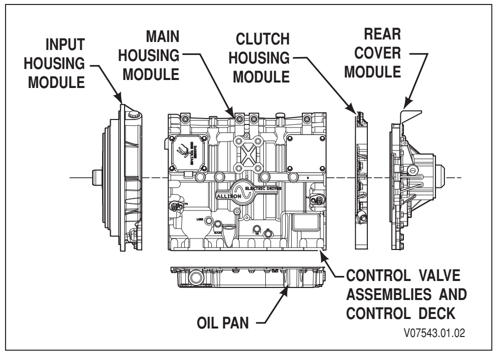


Figure 2–1. Standard Modules

2–2. INPUT HOUSING MODULE

A. Flexplate Coupling

The input housing of the E^V Drive™ mates directly to an SAE No. 2 engine flywheel housing. Flexplates bolted to the engine crank adapter and the E^V Drive™ flywheel assembly transfer engine torque to the E^V Drive™, as shown in Figure 2–2.

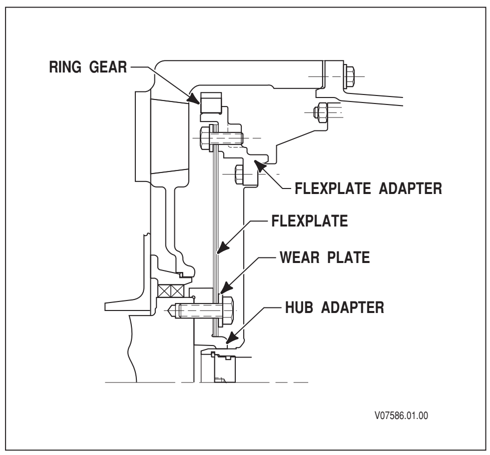


Figure 2–2 Flexplate To Engine Coupling

RESOURCES: Installation

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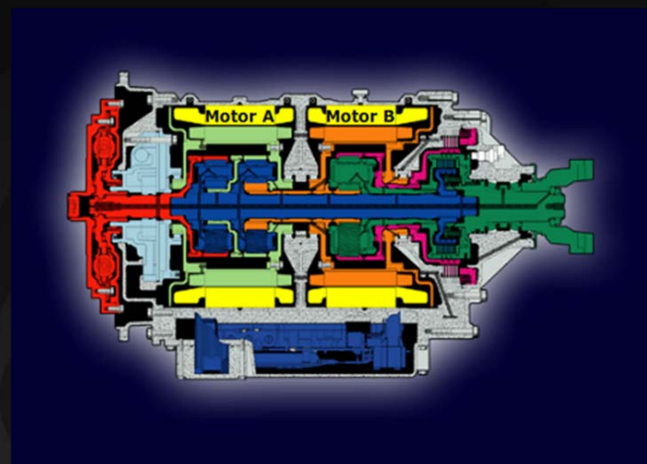
Power Flows

- **Like traditional Allison transmissions, the drive unit uses hydraulic clutches to hold rotating and stationary components.**
- **Power flows vary depending on which clutches are applied and the states of the drive unit motors.**
  - *Mode 1 is commanded at vehicle speeds below 20-25 mph.*
  - *Clutch Tie-Up is commanded to avoid shift cycling when vehicle speed is near Mode 1 and Mode 2 operation.*
  - *Mode 2 is commanded once vehicle speed reaches approximately 20-25 mph.*
  - *Reverse is created by Motor B only.*



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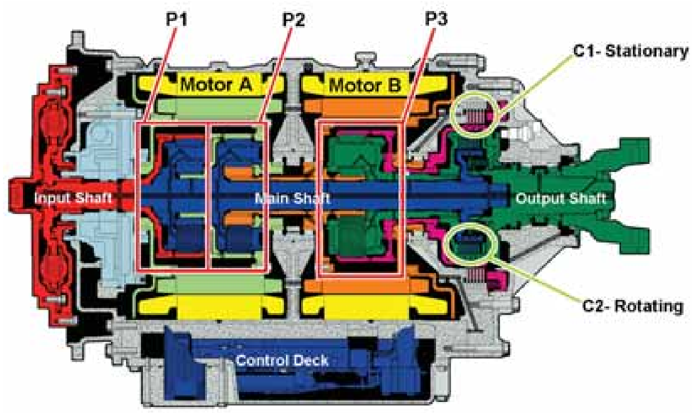
E^{V} DRIVE™ INTERNAL COMPONENTS

The input shaft is located at the front of the unit. This shaft is splined to the flywheel/input damper on one end, and the P1 ring gear on the other. The charging pump (shown as light blue) is also splined to the input shaft between the flywheel/input damper and the P1 ring gear. The windings (stator) for Motor A are located at the front of the main case, shown in yellow. The rotor for Motor A (shown in light green) is splined to the P1 sun gear and the P2 ring gear. The P1 and P2 carriers are splined to the main shaft (shown in dark blue.) At the rear if the main case are the windings (stator) for Motor B. The P2 sun gear and P3 sun gear are splined to the rotor of Motor B (shown in orange.) The P3 carrier is splined to the C2 rotating clutch hub, which is splined to the output shaft (shown in dark green.) The P3 ring gear can be held using the C1 stationary clutch (shown in pink), located at the rear of the main case.

At the bottom of the E^{V} Drive™ unit is the control deck which includes the control main valve body/solenoids, the C1/C2 valve body/solenoids and the shift relay valve body and solenoids. Other components found in this location include the internal wiring harness, Oil Level Sensor, motor temperature sensors, oil temperature sensor and the suction filter. The entire control deck is covered by the oil pan and submersed in transmission fluid.



The unique design and relationship of the internal components of the E^{V} Drive™ enable it to take the rotational input from the engine and/or Motor A/Motor B and transmit it into rotational output at varying degrees of speed and torque in both forward and reverse directions.

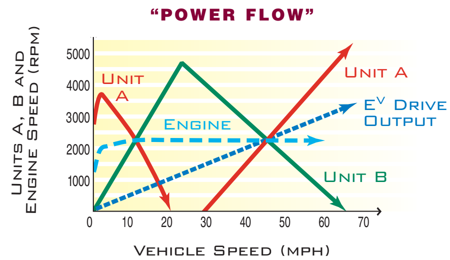
E^V DRIVE™ THEORY— MOTORS

The motors in the E^V Drive™ are capable of two operational characteristics - generating and motoring. Generating occurs when the mechanical rotation frequency of the rotor is greater than the stator field frequency (the rotor is spinning faster than the stator frequency.) Motoring occurs when the stator field frequency is greater than the mechanical rotation frequency (the rotor is spinning slower than the stator frequency).

E^V Drive™ motors can be thought of as variable clutch packs capable of producing speeds between -5000 rpm and 5000 rpm. The motors are used to control planetary gear component speeds and apply torque. In the E^P System™, electrical power from the ESS is always required to provide rotational output power from the E^V Drive™, just as hydraulic pressure is always required to apply a clutch.

E^V DRIVE™ OUTPUT

The E^V Drive™ unit takes the input variations from the vehicle engine and both onboard motors and uses internal gearing to provide a smooth, even output speed for the vehicle.



E^V DRIVE™ POWER FLOWS

	Mode 1 (1st Range)	Mode 2 (2nd Range)
Forward	C1 applied C2 un-applied	C1 un-applied C2 applied
Neutral	C1 un-applied C2 un-applied	C1 un-applied C2 un-applied
Reverse	C1 applied C2 un-applied	Reverse speed limited

There are *four primary modes* of operation that are included in this section.

- **Mode 1**
- **Clutch tie-up**
- **Mode 2**
- **Reverse**

A. MODE 1

Mode 1 is commanded at low vehicle speeds. Typically, this is going to be while the vehicle is traveling at less than 20 to 25 mph. When Mode 1 is attained, the C1 clutch applies, holding the P3 ring gear stationary. Motor B drives the P3 sun gear as the input. The output becomes the P3 carrier. Initially only Motor B is used to accelerate the vehicle from rest. However, torque from the engine and Motor A may be added to the P3 sun gear shaft through the P2 sun gear to increase output torque. The vehicle speed shift point from Mode 1 to Mode 2 or Mode 2 to Mode 1 will vary based upon specific measured parameters such as acceleration rates, throttle percentage, and vehicle speed. The clutch tie-up feature may be used to provide a seamless torque transition from Mode 1 to Mode 2.

B. CLUTCH TIE-UP

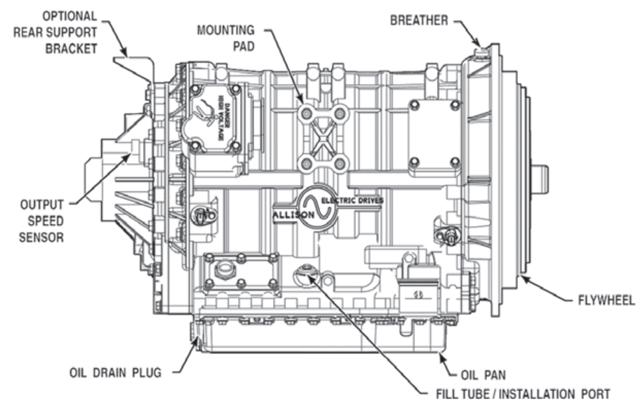
During clutch tie-up, both C1 and C2 clutches are applied. Clutch tie-up is controlled by the TCM based upon requested throttle percentage, vehicle acceleration rate, and vehicle speed. Clutch tie-up smooths torque transition during a shift. If vehicle speed remains near the Mode 1/Mode2 shift point the TCM uses clutch tie-up to avoid shift cycling. The E^V Drive™ makes a zero energy shift from Mode 1 to Mode 2 and vice versa. At clutch tie-up there is zero relative speed difference between reaction and friction plates during clutch apply.

C. MODE 2

In Mode 2 the P1 ring gear is driven by engine speed. P1 sun gear is driven by Motor A. Both Motor A and the engine are the inputs to P1 Planetary assembly. The output member of P1 Planetary assembly is P1 carrier. The P2 Planetary assembly also has two inputs during Mode 2. The P2 ring gear is driven by Motor A, P2 sun gear is driven by Motor B. P2 carrier then becomes the output member. C1 clutch is released and C2 clutch is applied while in Mode 2. The P3 Planetary assembly is not used in Mode 2. While in Mode 2, output shaft speed is the same as main shaft speed. Inertia from Motor B's speed is maintained after the Mode 1 to Mode 2 shift.

Motor B's speed is reduced to react against Motor A and the engine through the P1 and P2 Planetary assemblies to achieve the required output torque. The E^P 40/40 System™ maintains Mode 2 operation until vehicle speed is less then 20 to 25 mph. At that point Mode 1 is commanded.

RIGHT VIEW

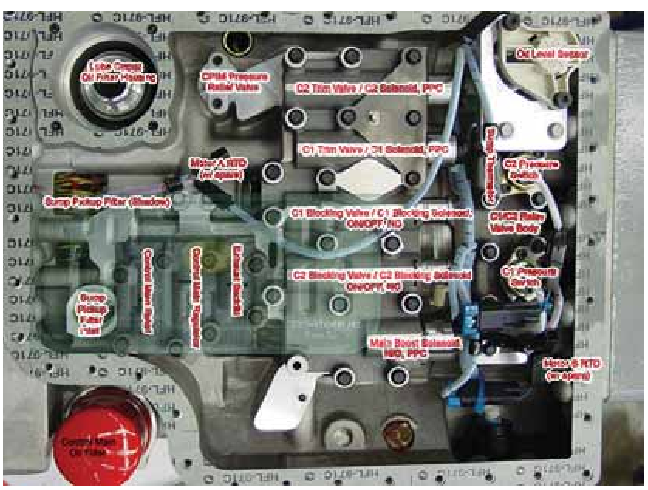


D. REVERSE

The C1 clutch is applied during reverse. Motor B rotates in the opposite direction from the direction of rotation required for forward movement. The P3 ring gear is held by C1 clutch.

The input is P3 sun gear. The carrier becomes the output in the same direction of rotation as the P3 sun gear. While in reverse mode, Motor B is the sole source of torque. Reverse is also speed limited at the output of the transmission by software.

E^V DRIVE™ CONTROL DECK



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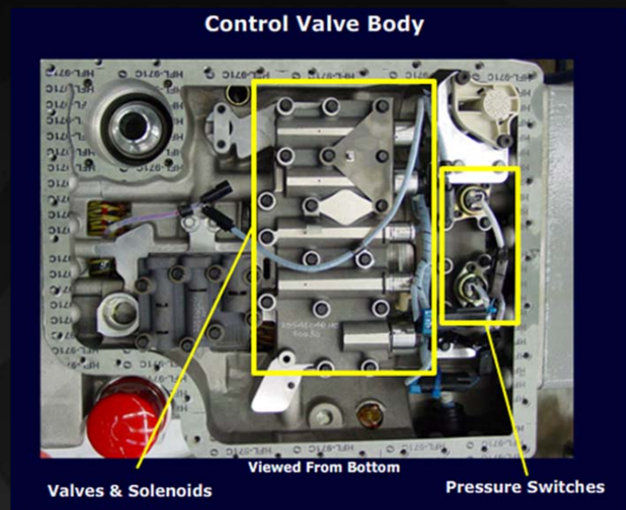
ALLISON HYBRID H40/50EP **Drive Unit**

Hydraulics

- **The drive unit hydraulic system provides clutch control, lubrication and cooling.**
- **The Control Deck houses hydraulic system solenoids, valves and circuits.**
  - *Hydraulic circuits exist throughout the Drive unit main housing.*
  - *Solenoids are energized and de-energized to control the position of valves.*
- **Based on valve position, various hydraulic pressures are routed to the appropriate circuits and components.**



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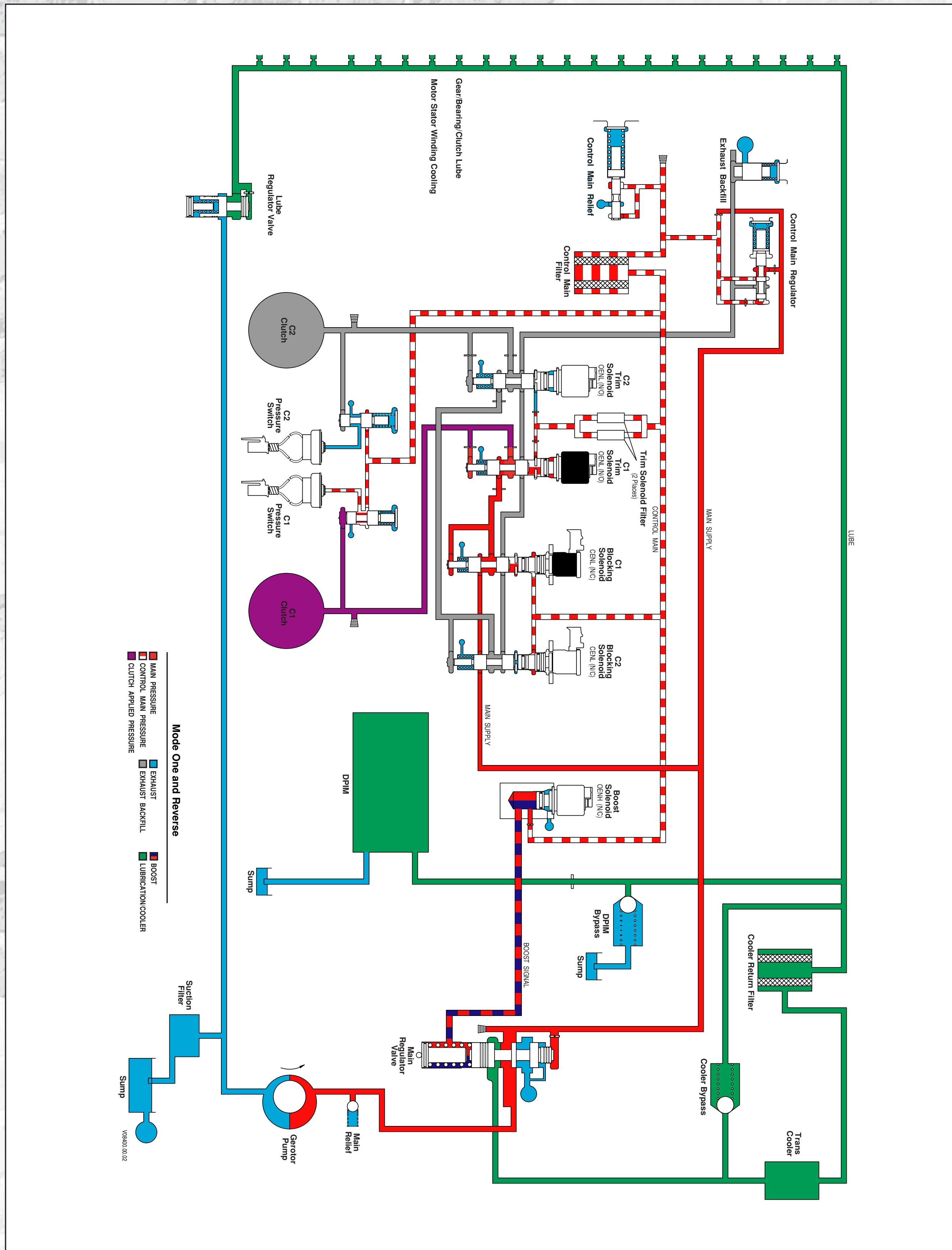
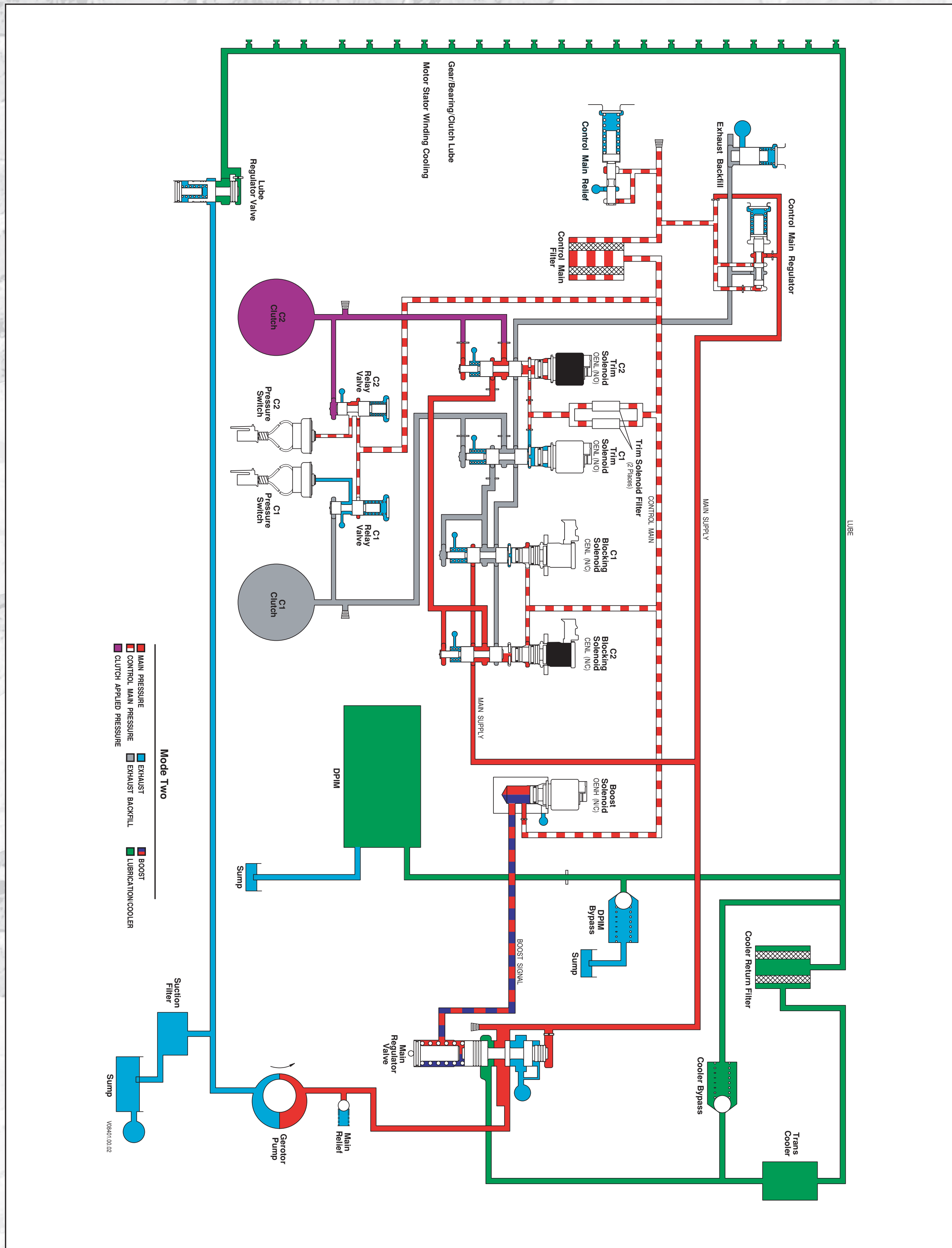
ALLISON HYBRID

RESOURCES:

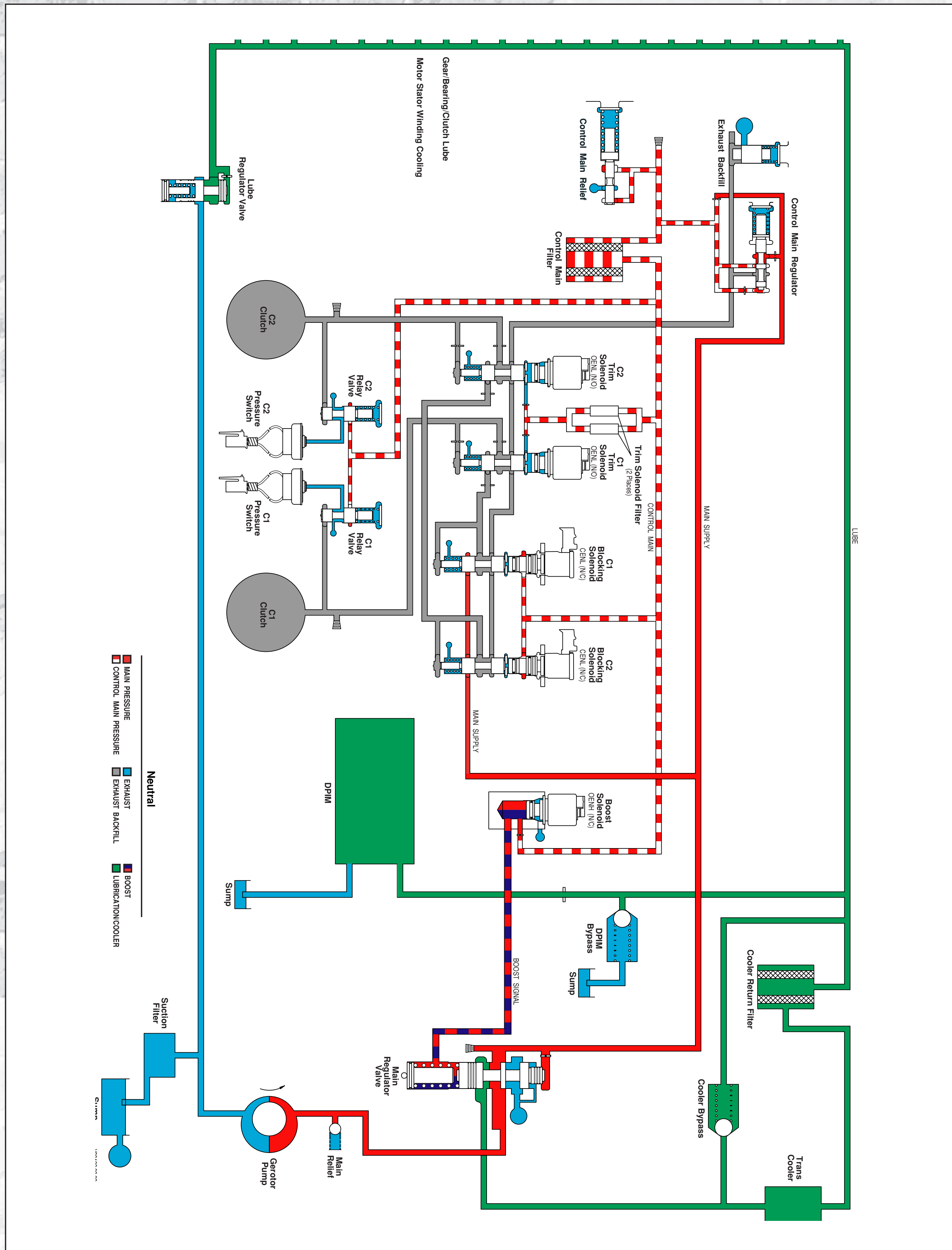
Hydraulics: Mode One & Reverse Range



Hydraulics: Mode Two Range



RESOURCES: Hydraulics: Neutral Range



RESOURCES: Hydraulic Controls Details

NOTE: This resource link has multiple pages and information changes frequently. Reference the source document for complete, current information.

Section Four

HYDRAULIC CONTROLS

The E^V Drive™ has six hydraulic circuits that provide E^P 40/50 System™ clutch control, lubrication, and cooling. Each of these hydraulic circuits and their components are discussed below.

A. Overview of the E^V Drive™ Solenoids

The TCM controls solenoids in the C1/C2 valve body of the E^V Drive™. These solenoids control the amount of fluid flow and the resulting pressure above the valves in the C1/C2 valve body.

The E^V Drive™ uses two types of solenoids. One type is a variable bleed solenoid (VBS). Those used for the E^V Drive™ have two ports. When there are only two ports it is also called an open ended (OE) solenoid. The OE solenoids combine the supply and control port together but have a separate exhaust port. The supply/control port is physically located below the O-ring on the body of the solenoid. The exhaust port is just above the O-ring and in the side of the solenoid.

The other type of solenoid in the E^V Drive™ is an on/off solenoid. This solenoid has three ports and is called a closed end (CE) solenoid. The CE solenoids have the control port at the bottom of the solenoid. Its supply port is in the side of the solenoid located between the two O-rings. The exhaust port is located above the supply port. The on/off solenoid is designed to connect the control port to either the supply port or the exhaust port depending upon its design and whether it electrically “on” or “off”.

All of these solenoids have an armature that moves in the solenoid as electrical current is applied to the solenoid. The armature displacement in the solenoid determines whether fluid can travel a specific path between ports of the solenoid or whether a specific path is blocked.

The OE VBS solenoids have one stationary orifice between the supply/control port and the exhaust port that can be incrementally blocked or opened by the armature assembly depending upon the amount of electrical current applied to the solenoid winding.

B. C1/C2 Trim Solenoids

The trim solenoids in the C1/C2 valve body are OE VBS solenoids. The OE VBS trim solenoids in their normal state of electrically off have minimum pressure at the supply/control port. This state is called “normally low” (NL). However, it can further be described that when it is electrically off, the armature is pulled up off the orifice between control/supply and exhaust allowing orificed supply/pressure to flow through the solenoids exhaust port. This makes the solenoid a “normally open” solenoid. The trim solenoids are described as OENL VBS (N/O).

C. Boost Solenoid

The boost solenoid in the C1/C2 valve body is an OE VBS solenoid. The boost solenoid in its normal state of electrically off has maximum pressure at the supply/control port. This is called “normally high” (NH). When it is electrically off the armature is down and blocking the orifice between supply/control pressure and exhaust. The boost solenoid is considered “normally closed” (N/C) because the armature assumes a state that blocks the supply/control port when electrically off. The boost solenoid is described as OENH VBS (N/C).

D. Blocking Solenoids

The “on/off” blocking solenoids used in the E^V Drive™ are considered “normally low” (NL) because when they are electrically off they have minimum pressure at the control port. When these solenoids are electrically off, the armature is in a position that has the supply blocked and the control port open to exhaust. This makes the blocking solenoid a “normally closed” solenoid because the supply port is “closed” when electrically off. The blocking solenoids are CE NL on/off solenoids (N/C).

E. Pressure Switches

There are two normally open (N/O) pressure switches in the shift relay body fastened to the control deck of the stator housing. These switches close when hydraulic pressure is applied to them.

Allison Transmission

RESOURCES: Valve Body

NOTE: This resource link has multiple pages and information changes frequently. Reference the source document for complete, current information.

GENERAL DESCRIPTION

2. C1/C2 Valve Body

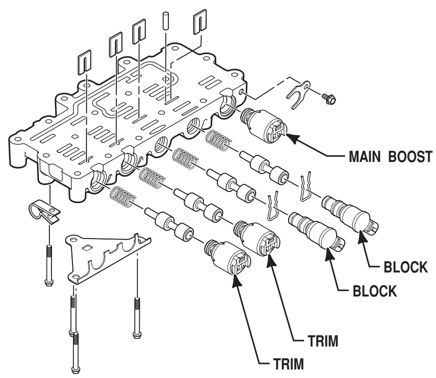


Figure 1–5. C1/C2 Valve Body

The C1/C2 valve body bolts to the stator housing control deck and contains the C1 trim valve, the C1 blocking valve, the C2 trim valve, the C2 blocking valve, the boost solenoid, C1 and C2 trim solenoids, and C1 and C2 blocking solenoids.

3. Relay Valve Body

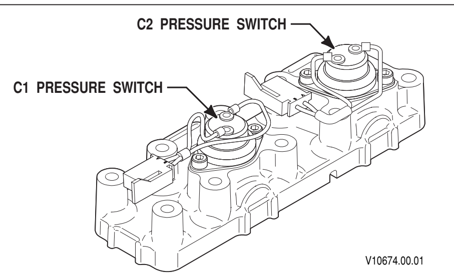


Figure 1–6. Relay Valve Body

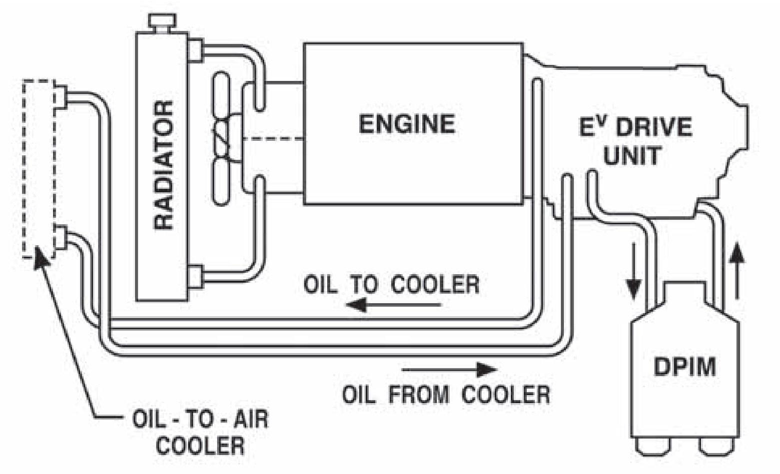
The relay valve body bolts to the stator housing control deck and contains the C1 relay valve and C1 pressure switch, the C2 relay valve and C2 pressure switch.

F. SPEED SENSORS

The E^V Drive™ has six speed sensors, two motor speed sensors for each motor (Figure 1–7) and two output speed sensors (Figure 1–8). Motor speed sensors are Hall effect devices. Output speed sensors are variable reluctance devices. Speed sensors provide rpm and direction of rotation signals to the TCM and the DPIM. Speed sensor information is also used for adaptive clutch control and in the diagnostic process.

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.



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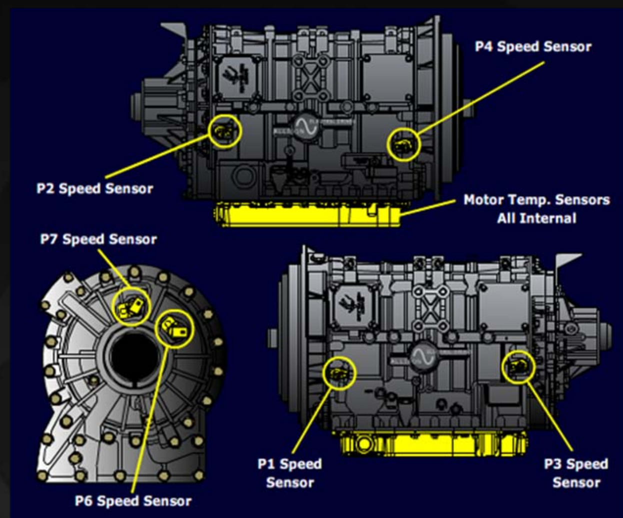
ALLISON HYBRID H40/50EP **Drive Unit**

Motor and Output Speed Sensors

- **Motor Speed Sensors.**
  - *Four sensors (two for each motor) externally located on the main housing, used to detect motor speed and direction.*
- **Output Speed Sensors.**
  - *Two sensors externally located on the rear cover, used to detect output speed and direction.*
- **Motor Temperature Sensors.**
  - *Four sensors (two for each motor) but only one is used per motor (two are spares.*
  - *Internally located and connected to the internal wiring harness.*



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E^{V} DRIVE™ MOTOR SPEED SENSORS

The E^{V} Drive™ has four motor speed sensors, two for Motor A and two for Motor B. They are Hall Effect type sensors which mean they read the magnetic flux density changes of the rotor as the motors are spinning. This magnetic flux density change is then converted into a voltage that can be translated into motor speed and direction of rotation. The output of the sensor is a square wave between 0 and 11.7 volts. This output cannot be checked with a volt-ohmmeter across the sensor leads. However, sensor output can be checked on the signal wire for the presence of an 11.7 volt signal. The four motor speed sensors are located on the left and right sides of each stator barrel.

E^{V} DRIVE™ OUTPUT SPEED SENSORS

The E^{V} Drive™ has two output speed sensors located on the rear cover of the unit. The sensors are reluctance-type devices that are the same as the output speed sensors used in other Allison Transmissions.

The signals can be checked with a volt-ohmmeter across the leads. A good sensor will provide a reading of approximately 300 ohms. The output of the sensor is an AC wave form that is used by the TCM to determine the speed and direction of the output shaft. The output signal from the sensor is not used by the TCM until the output speed of the E^{V} Drive™ exceeds 100 rpm.

E^{V} DRIVE™ MOTOR TEMPERATURE SENSORS

There are four motor temperature sensors on the E^{V} Drive™ unit, two for each motor. The type of sensor used is a Resistance Temperature Device, or RTD, and they are not serviceable. Therefore, one sensor per motor is active, and the other is a spare. The sensors operate on the principle that resistance varies linearly with temperature. The sensors can be checked with a volt-ohmmeter. The temperature signal output from the sensors is provided to the DPIM where it is measured as a voltage input.

ALLISON HYBRID

RESOURCES: Speed Sensors

NOTE: This resource link has multiple pages and information changes frequently. Reference the source document for complete, current information.

RAL DESCRIPTION

1–13. SPEED SENSORS

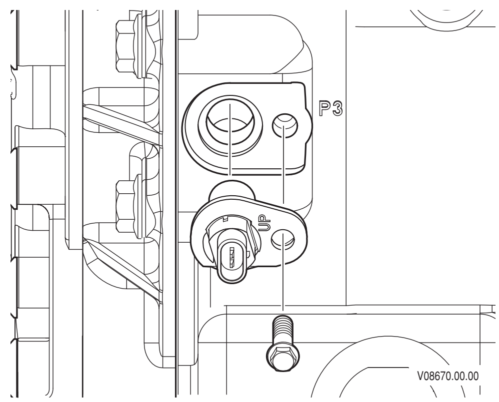


Figure 1–6. Typical Speed Sensor

NOTE: ***Do not rotate the speed sensor in the retaining bracket. Orientation is fixed, and if changed, may cause improper operation.***

A. Motor Speed Sensor

The motor speed sensors are hall effect devices that provide a digital signal to the TCM. The motor speed sensors are externally mounted on the stator housing (Figure 1–7).

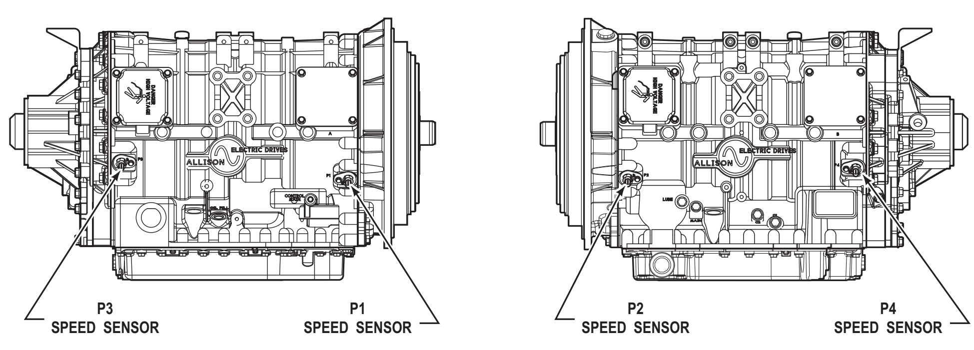


Figure 1–7. Motor Speed Sensors

B. Output Speed Sensor

The speed sensors are variable reluctance devices which convert mechanical motion to an AC voltage. Each sensor consists of a wire coil wrapped around a pole piece that is adjacent to a permanent magnet. These elements are contained in a housing which is mounted adjacent to a rotating ferrous member (such as a gear tooth). Two signal wires extend from one end of the housing and an exposed end of the pole piece is at the opposite end of the housing. The

GENERAL DESCRIPTION

G. WIRING HARNESSES

1. External Wiring Harness

The external wiring harness requirements are typically met through the use of nine (9) separate harnesses.

- There are two harnesses connecting the TCM to system components.
- There are two harnesses connecting the VCM to system components.
- There are three harnesses connecting the DPIM to system components.
- There is one harness connecting the ESS to system components.
- One harness connecting the E^{V} Drive™ to system components.

Each harness may be a single piece or may be divided into two segments joined by bulkhead connectors. All wiring harnesses and mating connectors are customer-supplied.

NOTE: ***Allison Transmission is providing for service of wiring harnesses and wiring harness components as follows:***

- ***Repair parts for the internal wiring harness will be available through the Allison Transmission Parts Distribution Center (PDC). Use the P/N from your appropriate parts catalog or from Appendix E in this manual. Allison Transmission is responsible for warranty on these parts.***
- ***Repair parts for the external harnesses and external harness components must be obtained through the vehicle OEM. The OEM is responsible for warranty on these parts.***

2. Internal Wiring Harness *(Figure 1–9)*

The internal wiring harness, located in the sump, connects the various sensors and solenoids to the TCM. The harness exits the stator housing through a 31-pin connector.

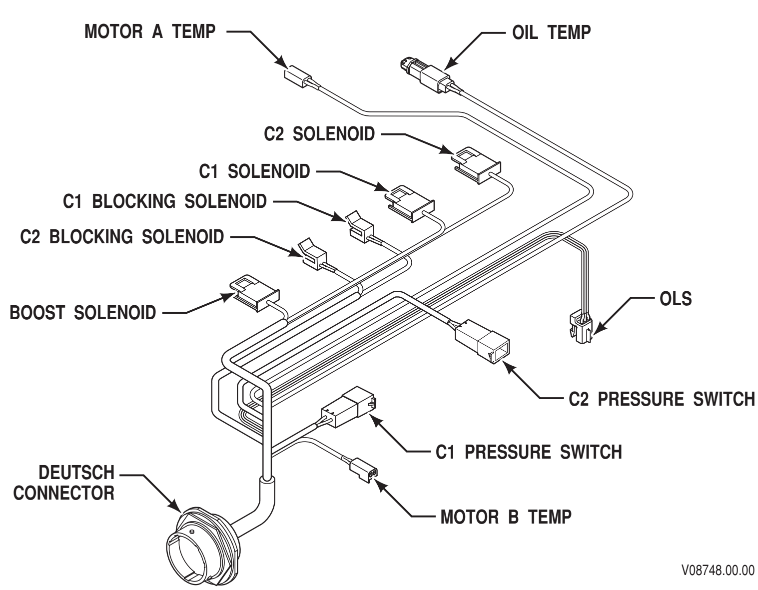
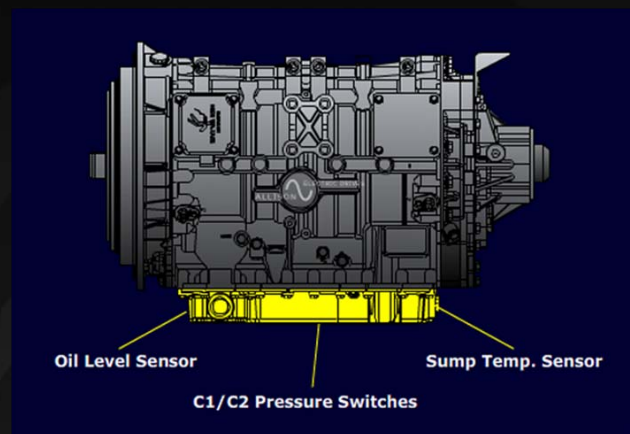


Figure 1–9. Typical Internal Wiring Harness

Additional Sensors and Switches

- **Oil Level Sensor.**
  - *Located in drive unit sump and can be read via the pushbutton shift selector and/or Allison DOC™ for PC (H 40/50 EP).*
- **Sump Temperature Sensor.**
  - *Located in the drive unit sump, provides sump temperature readings to the TCM.*
- **C1 and C2 Pressure Switches.**
  - *Located on the relay valve body near the rear of the drive unit.*
  - *Provides clutch apply circuit pressure information to the TCM.*



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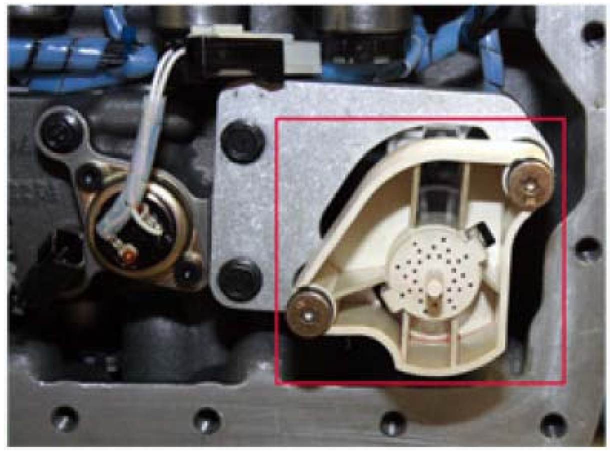
RESOURCES: Additional Sensor & Switches Detail

E^V DRIVE™ OIL LEVEL SENSOR

The Oil Level Sensor for the E^V Drive™ is located in the sump. It is mounted on the relay valve body at the rear of the transmission. This sensor is also a Hall Effect device and cannot be checked with a volt-ohmmeter. The output of the sensor can be read via the push button shift selector or by using Allison DOC™ for PC (AED). The transmission fluid temperature in the sump must be at least 20 degrees Celsius (68 degrees Fahrenheit) for an accurate fluid level reading. The sensor is capable of reading a fluid level range between five quarts low and five quarts high.

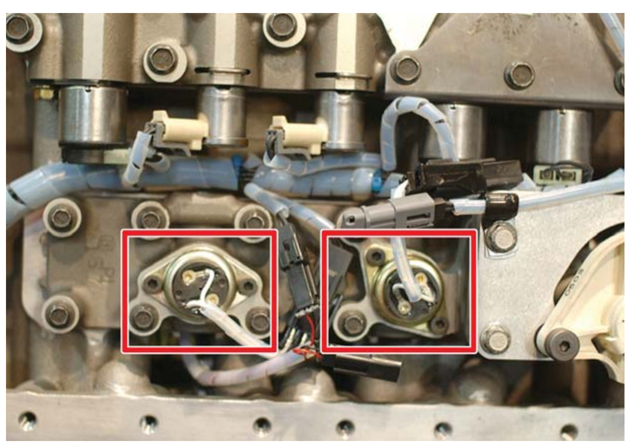


E^V DRIVE™ SUMP TEMPERATURE SENSOR

The sump temperature sensor is located in the sump of the E^V Drive™. It is a thermistor device that is used to provide a transmission fluid temperature reading to the TCM.

E^V DRIVE™ C1/C2 PRESSURE SWITCHES

The C1 and C2 pressure switches for the E^V Drive™ provide a ground signal to the TCM when hydraulic clutch pressure is sensed. Main pressure strokes the relay valve to provide the pressure switch with a control main pressure signal of 80 psi. The C1 and C2 pressure switches are located on the relay valve body near the rear of the transmission.



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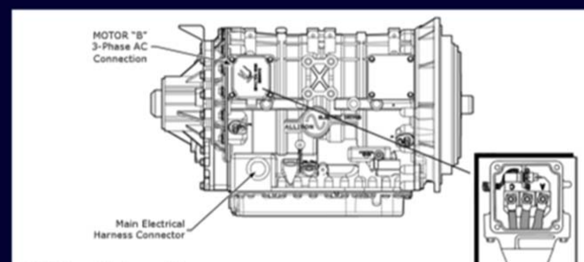
Drive Unit

Electrical Connections

- The control system harness connects at the lower right side of the drive unit.
- 3-Phase AC connections are under the lug box covers on the right rear and left front of the drive unit.
  - *Lug box configuration includes High Voltage Interlock (HVIL) switches designed to minimize technician exposure to high voltage when covers are removed.*



E^V Drive High and Low Voltage Connections

NOTE: Always follow the Electrical Disconnect Verification Procedure in Troubleshooting Manual TS3715 when performing any work on the H 40/50 EP System.

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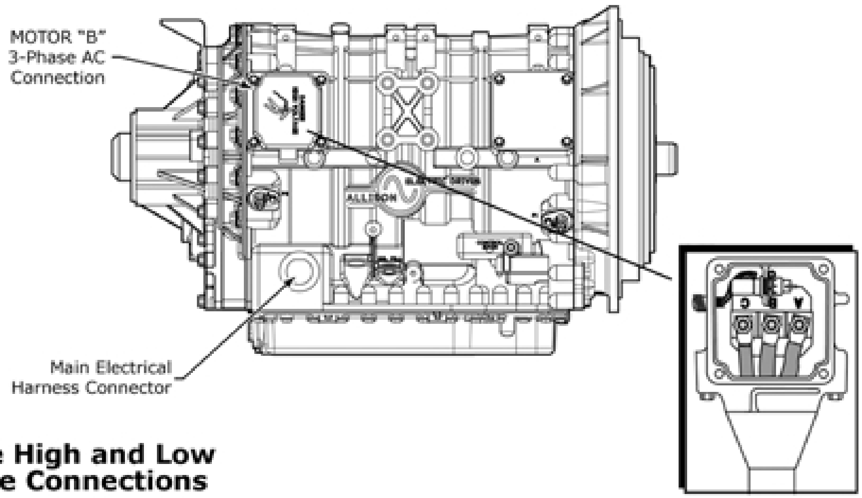
E^V DRIVE™ 3-PHASE AC CONNECTIONS



E^V Drive High and Low Voltage Connections

E^V DRIVE™ HVIL SWITCHES

There are two high voltage lug boxes on the side of the E^V Drive™ main case that are used for the 3-phase AC connections between Motor A,
Motor B, and the DPIM. Under the cover of each of these lug boxes is an HVIL interrupt lid switch. The HVIL circuit is designed to prevent access to hazardous voltages inside of an energized lug box. Removing a cover opens the HVIL circuit and prevents ESS pre-charge and engine startup. If a cover removal (or similar event such as a broken wire on a lid switch) is detected during operation of the vehicle, the system will be shut down the next time Neutral is attained. A system restart will be denied until the HVIL circuit is closed. HVIL switches are located in other places throughout the E^P System™ including the DPIM DC lug box, DPIM AC lug boxes and ESS high voltage plug connections.

RESOURCES: Electrical Disconnect Verification

NOTE: This resource link has multiple pages and information changes frequently. Reference the source document for complete, current information.

ELECTRICAL SAFETY

WARNING!

The Allison Electric Drive E^P 40/50 System™ uses potentially hazardous electrical energy. All E^P 40/50 System™ components are identified with warning labels or symbols (see Figure 1, Figure 2, and Figure 3). DO NOT attempt to service components containing potentially hazardous electrical energy if you are not trained to do so.

All persons working with potentially hazardous electric energy should familiarize themselves with safe electrical work practices. Paragraph f in Electrical Safety section contains references to publicly available documentation that can assist a technician in developing the safe electrical work practices required to service the E^P 40/50 System™ electrical system.

E^P 40/50 System™ Normal Operating Conditions

ESS Voltage Range: 432–780VDC
DPIM Voltage Range: –350 to +350A

Figure 1. DPIM Warning Label

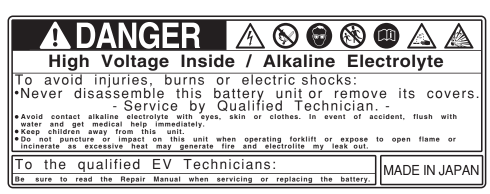


Figure 2. ESS Warning Label