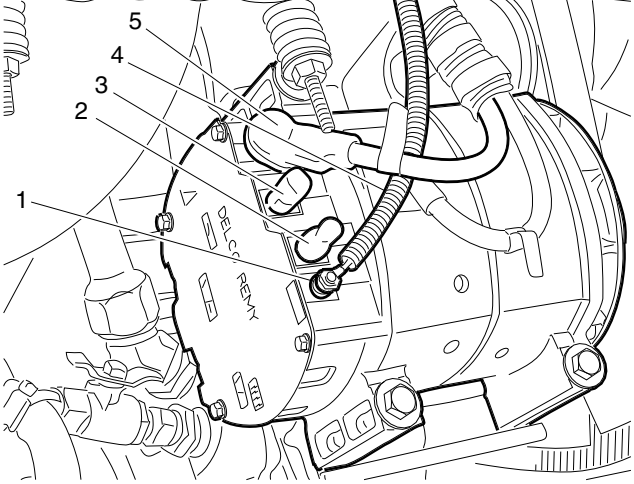
Contents

General Information

Both Leece-Neville and Delco Remy alternators are available as original equipment on Freightliner vehicles. Installation and removal are the same for all alternators on a given engine design.

Many alternators are equipped with a remote-sense terminal that connects to the batteries, and adjusts the alternator output to keep the system at full charge. See **Fig. 1** for a Delco Remy alternator with remote sense. See **Fig. 2** for a Leece-Neville alternator with remote sense.



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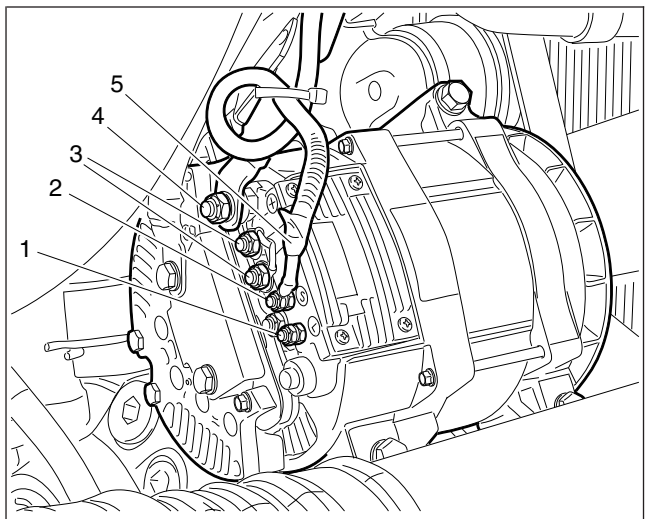
1. Remote-Sense Terminal
2. Indicator Terminal (lamp)
3. Relay Terminal 'R'
4. Remote Sense Circuit 123E
5. Positive Terminal (Battery)

Fig. 1, Delco Remy Alternator with Remote Sense



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1. Lamp Terminal 'L'
2. Remote-Sense Terminal 'S'
3. A.C. Terminals
4. Positive Terminal (Battery)
5. Remote Sense Circuit 123E

Fig. 2, Leece-Neville Alternator with Remote Sense

Removal

1. Apply the parking brake, shut down the engine, and chock the rear tires. Open the hood.
2. Disconnect the batteries.

NOTICE

Some vehicles are equipped with a cab load disconnect switch (CLDS). The CLDS does not disconnect power to the alternator and starter, so a short-circuit hazard still exists when working on the vehicle. The batteries must be disconnected to remove the short-circuit hazard when working on the charging system.

3. Remove the alternator drive belt, following the instructions in **Section 01.01** of this manual.

NOTE: Be sure the belt is working correctly before replacing the alternator. Many charging system problems originate in the drive belt. Inspect the belt for glazing, wear (frayed edges), damage (breaks or cracks), or oil contamination. Replace the belt if any of these conditions are present.

4. Note the wire connections on the terminals, then disconnect the wiring harness. Refer to **Subject 050** in this section for wiring connections.
5. Remove the alternator-mounting capscrews. Remove the alternator.
6. Remove the pulley for use on the new alternator. If the alternator is a Delco Remy, remove the pulley as follows:

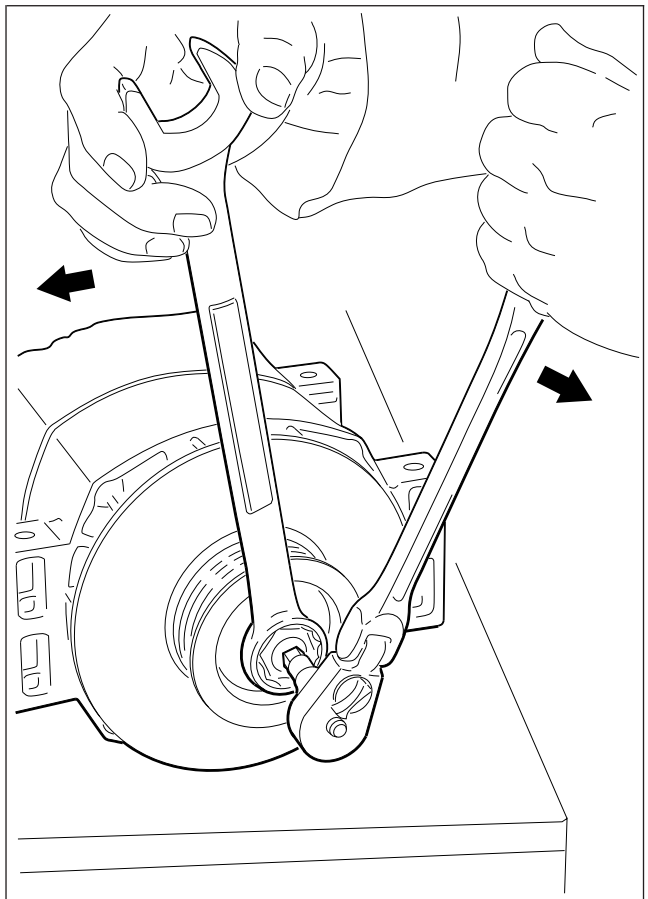
⚠ WARNING

Do not attempt to keep the pulley from turning with your hand, and do not jam a screwdriver into the cooling fins to keep it from turning, as you attempt to loosen the pulley nut. Using pulley nut removal and installation methods other than the one described below may cause personal injury, or damage the alternator and void the warranty.

6.1 Hold the alternator pulley retaining nut with a box-end wrench.

6.2 Insert a 5/16-inch Allen wrench into the Allen fitting in the rotor shaft.

6.3 Hold the rotor shaft with the Allen wrench, and turn the pulley nut counterclockwise to remove it. See **Fig. 1**. Remove the nut, washer, and pulley.



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Hold the rotor shaft with the Allen wrench, and turn the pulley nut counterclockwise to remove it. Remove the nut, washer, and the pulley.

Fig. 1, Loosening a Delco Remy Alternator Pulley Nut

Installation

1. For a Delco Remy alternator, install the pulley on the new alternator.

1.1 Hold the alternator pulley retaining nut with a box-end wrench.

1.2 Insert a 5/16-inch Allen wrench into the Allen fitting in the rotor shaft.

Removal and Installation

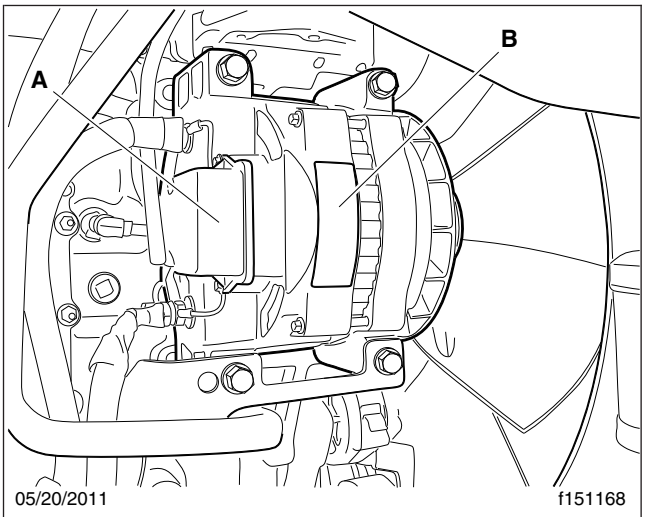
1.3 Hold the rotor shaft with the Allen wrench, and turn the pulley nut clockwise to tighten.

1.4 Tighten the pulley nut 75 lbf·ft (101 N·m).

2. Install the alternator.

2.1 Position the alternator on the engine. and start the mounting capscrews.

On Leece Neville pad-mounted alternators, belt alignment is obtained by the two mounting bolt holes closest to the alternators pulley. These holes are precision drilled so the alternator is positioned correctly on the engine bracket for proper belt alignment. When mounting a Leece-Neville alternator, it is important that the label or regulator face away from the engine block. If this is not adhered to then the belt alignment will not be correct. See **Fig. 2**.



A. Regulator must face away from the engine block.
B. Label must face away from the engine block.

Fig. 2, Leece-Neville Pad-Mounted Alternator Installation

2.2 Tighten the mounting capscrews 35 lbf·ft (48 N·m).

2.3 Install the drive belt following the instructions in **Section 01.01** of this manual.

3. As noted during removal, connect the wiring harness to the alternator terminals. Tighten the output-terminal hexnut 100 lbf·in (1140 N·cm). Tighten the ground-terminal hexnut 65 lbf·in (730 N·cm). Tighten the other terminal hexnuts 20 lbf·in (225 N·cm).

4. Protect any exposed terminal connectors with dielectric red enamel.

5. Connect the batteries.

6. Close and latch the hood, and remove the tire chocks.

Troubleshooting

IMPORTANT: Before testing, make sure:

- All belts are tensioned and are not cracked, worn, or glazed;
- The wiring and terminals are free of corrosion, properly torqued, and protected with dielectric enamel.

Pre-Test Checks

1. Shut down the engine, apply the parking brake, and chock the tires. Raise the hood.
2. If the vehicle is equipped with a remote-sense circuit, inspect as follows:
   - 2.1 Verify that the remote-sense wire (circuit # 123E) is connected to the remote sense terminal.
   - 2.2 Verify the fuse for the remote-sense circuit is not open. This fuse is located in the PTPDM on pre EPA 10 vehicles and is in the PNDB on EPA 10 vehicles. The remote sense terminal on the alternator will measure approximately 1/2 volt below battery voltage when the remote sense circuit (123E) fuse is open.
3. Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten, clean, and protect as necessary.

Using the Intelli-Check 2 Systems Analyzer

NOTE: The Intelli-Check 2 tester is recommended for alternator testing. It is capable of testing alternators with an output that is greater than the limit of the Intelli-Check (original) tester limit of 145 amps.

IMPORTANT: The batteries should be charged to at least 12.6 volts before performing the following tests. Remove the surface charge from freshly charged batteries by turning the headlights and blower fan on high for several minutes.

1. Using the Intelli-Check 2, perform a voltage drop test on the alternator cables. See **Fig. 1**.

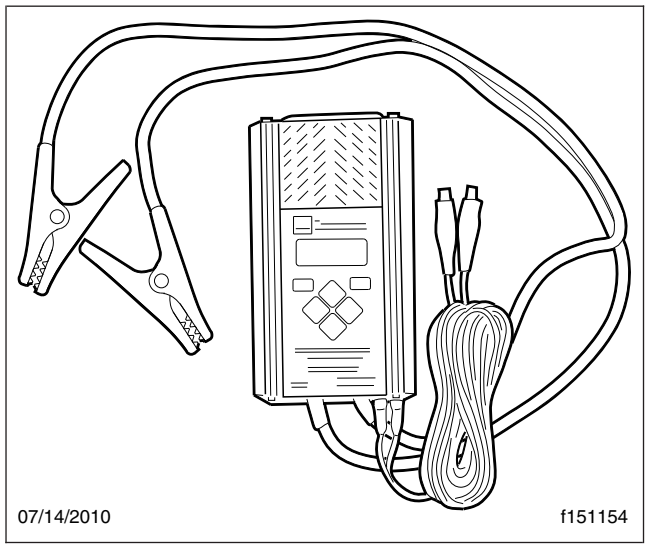


Fig. 1, Intelli-Check 2 Alternator Analyzer

   - 1.1 With the vehicle shut down, begin by turning the tester on. Select “Voltage Drop” Test and press Enter. Press ESC to bypass the vehicle ID screen.
   - 1.2 Select “Charging Cables” and press Enter. Enter the rated alternator output from the label on the alternator and press Enter.
   - 1.3 Connect the large leads to the alternator output terminal and ground and press Enter.

   NOTE: Disregard the tester summary of pass/fail. A voltage drop of 1/2 volt or less is acceptable.

   - 1.4 Connect the small leads to the battery. Press Enter to run the test. Use caution as the tester becomes warm during the test. If there is ½ volt or less voltage drop measured on each cable, the cables and connections are acceptable. If there is voltage drop in excess of ½ volt, locate and repair the cause before continuing with further testing.
2. Test the alternator using the Intelli-Check 2.
   - 2.1 With the vehicle shut down, begin by turning the tester on. Select “Alternator Test”

and press Enter. Press ESC to bypass the vehicle ID screen.

2.2 Remove the small leads from the battery, leaving the large leads connected as they were in the voltage drop test and press Enter. The alternator rated output will 'stick' from the value used in the voltage drop test. Press Enter.

2.3 Start the engine. The amount of time it takes to walk back to the tester should have given the system enough time for the voltage to stabilize. Press Enter to begin the test.

2.4 When prompted, accelerate the engine to governed speed for 10 seconds.

2.5 Turn the engine off. The results will be displayed on the Intelli-Check 2.

Using the Intelli-Check (Original) Systems Analyzer

See **Fig. 2**.

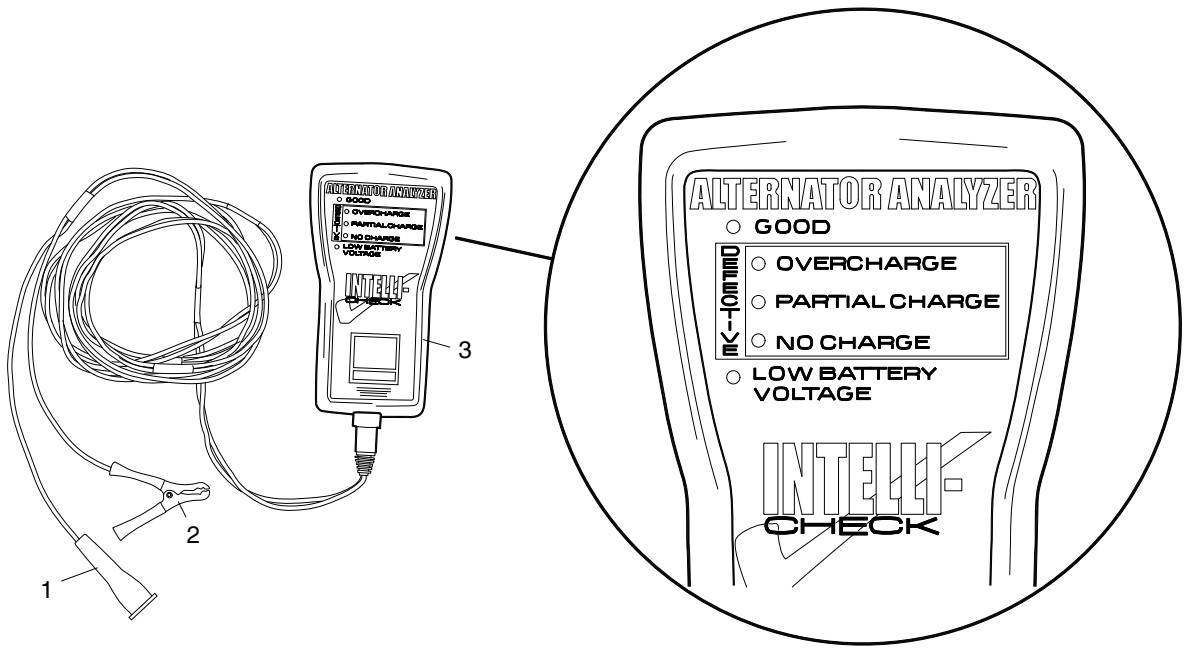
1. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
2. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:

   2.1 **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, turn on the headlights and blower fan for 2 minutes without restarting the engine. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.

   2.2 **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.

   2.3 **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test.

3. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged. Start the test again after charging the batteries and removing the surface charge.
4. Verify the engine is at idle and all electrical loads are off.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
   - If the **GOOD** (green) LED illuminates, proceed to the next step.
   - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator.
6. With the engine running, turn on all electrical loads.
7. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
8. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.
9. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator.



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1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 2, Intelli-Check Alternator Analyzer (original)

Specifications

Delco Remy Alternator, Terminal Fastener Torque		
Description	**Size**	**Torque: lbf·in (N·cm)**
Output ("BAT") Terminal Hexnut	5/16–18	100 (1140)
Ground ("GND") Terminal Hexnut	1/4–20	50 to 60 (565 to 675)
	5/16–18	60 to 90 (675 to 1016)
Terminal Hexnuts	10–24	20 (220)

Table 1, Delco Remy Alternator, Terminal Fastener Torque

Leece Neville Alternator, Terminal Fastener Torque		
Description	**Size**	**Torque: lbf·in (N·cm)**
Output ("BAT") Terminal Hexnut	5/16–24	100 (1140)
Ground ("GND") Terminal Hexnut	1/4–28	75 to 80 (850 to 900)
Remote Sense Terminal or Lamp Driver	M5 x 0.8	25 to 30 (280 to 330)

Table 2, Leece Neville Alternator, Terminal Fastener Torque

Pulley and Mounting Fastener Torque		
Description	**Size**	**Torque: lbf·ft (N·m)**
Pulley Nut Delco Remy	1/2–20	75 (102)
Pulley Nut Leece Neville	5/8–18	75 (102)
Mounting Capscrew	M10 X 1.5	35 (48)

Table 3, Pulley and Mounting Fastener Torque

Contents

General Information

The starter is mounted on the forward face of the flywheel housing. Under normal operating conditions, no maintenance will be required between engine overhaul periods. The starter has sealed bearings with lifetime lubrication. At the time of engine overhaul, replace the starter with one that has been remanufactured.

When the starter is engaged, the pinion gear extends outward to mesh with the ring gear on the engine flywheel. An overrunning clutch reduces the likelihood of the engine over driving the starter. Even with this protective feature, always release the keyswitch as soon as the engine starts to avoid overheating the overrunning clutch.

The starter is capable of drawing over 2000 amps and will quickly build up heat that could possibly cause damage. Never crank the starter continuously for more than 30 seconds, and always wait at least 2-minutes between cranking attempts. To prevent the starter from overheating, a thermal management model is incorporated in the starter control electronics. Starting is interrupted and disallowed when the software calculates the starter is too hot. If the starter does not engage after a previous crank attempt, or if cranking is only allowed for a few seconds, wait several minutes for the starter to cool down.

Principles of Operation

When battery power is applied to the magnetic switch activate terminal, cranking will begin. The magnetic switch sends power to the starter solenoid. The solenoid moves a lever which causes the pinion gear to engage with the ring gear on the flywheel. As the gears engage, battery power spins the starter motor.

When diagnosing starting problems, always begin with fully charged batteries, and perform a voltage drop test on the battery cables and magnetic-switch circuit. Once the engine is running, check that the alternator is properly charging the batteries.

A starter that cranks slowly, or just clicks when the keyswitch is turned, typically indicates a problem with supplying adequate power to the starter. Corrosion and loose connections in the battery cables will cause significant voltage drop and may prevent the starter from cranking the engine.

The bulkhead module monitors engine RPM, calculates the starter temperature, and analyzes the specific neutral conditions for the type of transmission. Cranking is not allowed if the engine is running, the transmission is engaged, or if the starter is too hot.

When the keyswitch is in the crank position, it supplies battery power to connector B6, pin A5 of the bulkhead module. This signals the bulkhead module to check for the required starter protection conditions. If these conditions pass, the BHM activates the starter output on connector B4, pin B. See **Fig. 1** for a mechanization diagram of the starter control circuitry on vehicles with an integrated magnetic switch. See **Fig. 2** for vehicles with a remote mounted magnetic switch.

NOTE: **Figure 2** is a combination diagram that shows the different starting interlock circuits that may be possible. No vehicle will have all of the circuits shown.

General Information

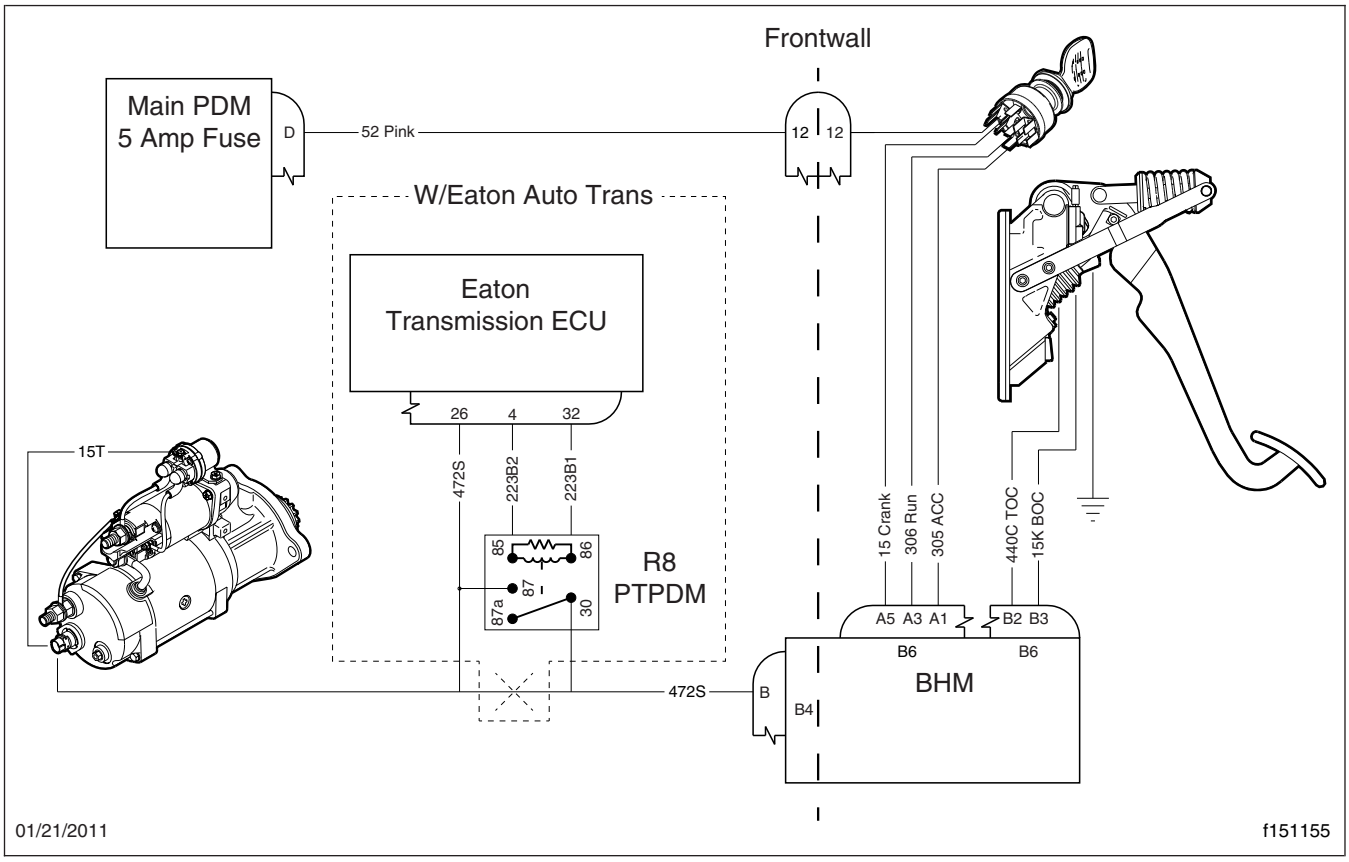


Fig. 1, Starter Control Circuitry with Integrated Magnetic Switch

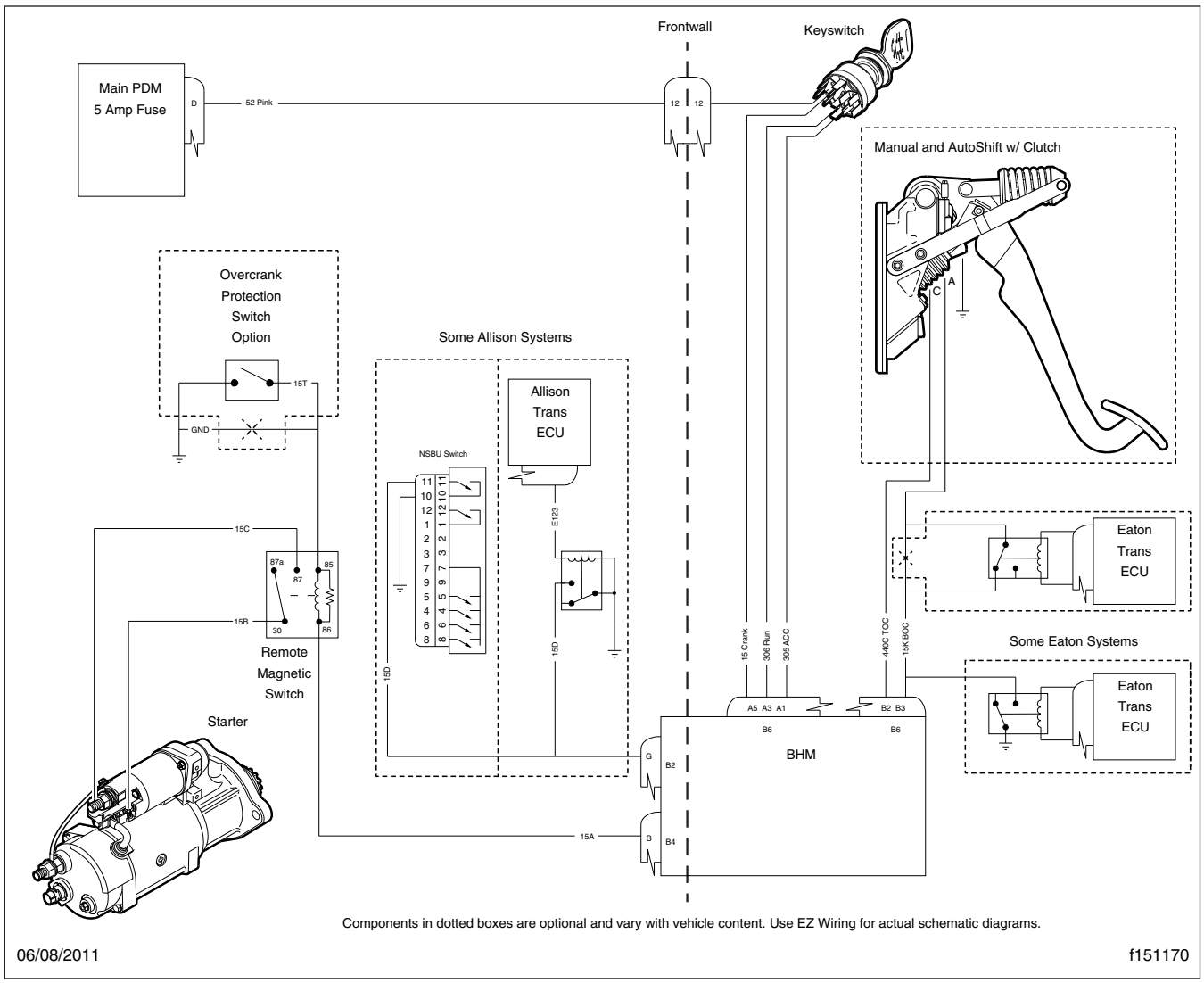
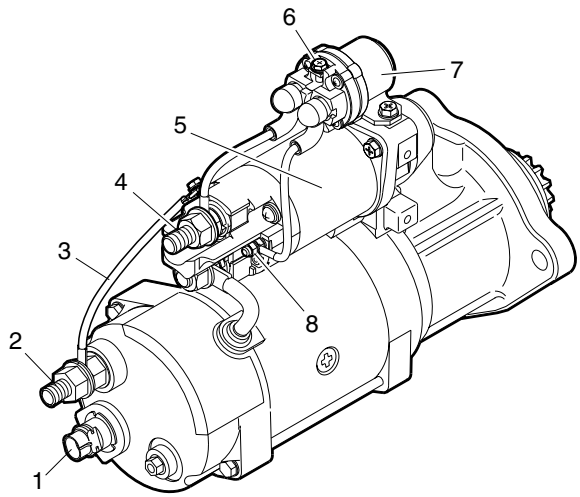


Fig. 2, Starter Control Circuitry with Remote Mounted Magnetic Switch

Removal

Before replacing the starter, perform the checks in **Troubleshooting 300**.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the negative battery cables at the batteries. Open the hood.
3. Disconnect and label the wiring that connects to the starter. See **Fig. 1**.



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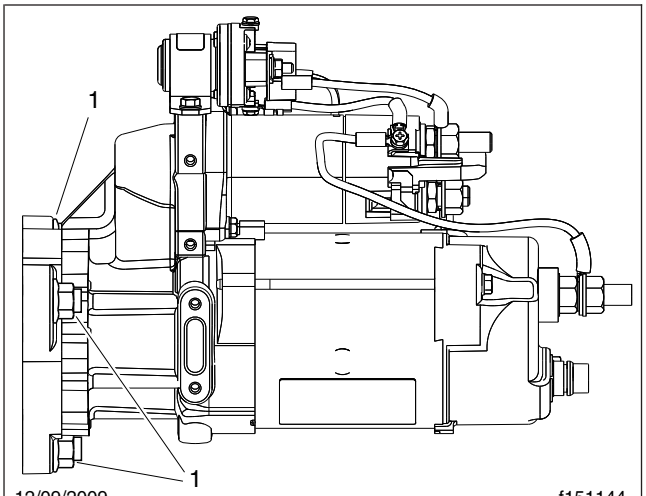
1. Over-Crank Protection Switch Terminal
2. Battery Ground Terminal
3. Ground Circuit to Starter Solenoid
4. Battery Positive Terminal
5. Solenoid
6. Magnetic Switch Activate Terminal
7. Magnetic Switch
8. Solenoid Activate Terminal

Fig. 1, Starter with Integrated Magnetic Switch (IMS)

4. Support the starter, then remove the bolts that mount it to the flywheel housing. See **Fig. 2**.

Installation

1. Place the starter into the mounting hole in the flywheel housing.
2. Hand start the three mounting bolts, then hand tighten them until snug. Using a torque wrench,



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1. Mounting Bolts

Fig. 2, Starter Mounting

tighten them to the values shown in **Specifications 400**.

3. Connect the wiring to the solenoid and starter as previously marked. Tighten the terminals to the torque values shown in **Specifications 400**.
4. Protect all exposed terminal connectors with dielectric red enamel.
5. Connect the batteries.

Starter System Troubleshooting

Use troubleshooting tables 1 through 5 for system diagnosis to reduce the likelihood of replacing a starter that is not defective, and to insure the complete starting system is tested.

Check for fault codes from Source Address 33 (BHM) and the transmission. Perform the recommended action in **Table 1** if fault codes from the BHM are shown. Use the applicable transmission manufacturers troubleshooting material if fault codes from the transmission control system are shown.

Vehicles with automated manual or automatic transmissions may have electrical hardware to interrupt or enable starting. Newer designs use serial data messaging to broadcast neutral status. Use EZ-Wiring to access the schematics for the vehicle and Service-Link to analyze which neutral and starter interlock conditions are being broadcast by the transmission controller.

If the vehicle has an Allison transmission and a NSBU, the shift lever must be in the N, PB, or P position to close the switch between pins 10 and 11. The NSBU is located on the drivers side of the transmission case. If the NSBU requires adjustment, use the procedure in the Allison service manual.

If the vehicle is equipped with an automated or automatic transmission, also check for any fault codes with gear position selection and control. If the transmission is not confirmed to be in neutral, the transmission controller will not allow the engine to be started.

See **Table 2** for troubleshooting related to the starter cranking slowly, or making repeated clicking sounds.

See **Table 3** for troubleshooting problems relating to the starter doing nothing, or making only a single click for vehicles with an integrated magnetic switch.

See **Table 4** for troubleshooting problems relating to the starter doing nothing, or making only a single click for vehicles with an remote mounted magnetic switch.

See **Table 5** for troubleshooting relating to the starter making spinning or grinding sounds.

Starting System Faults from SA 33					
SPN	**FMI**	**Conn/Pin**	**Description**	**Behavior**	**Action**
598	7	B6, pins B2 & B3	Clutch switch fault	The bottom of clutch switch and the top of clutch switch are both closed at the same time.	Check the clutch switch for an open or short in circuits 15K and 440C, between the BHM and the clutch switch.
6983	6	B4, pin B	Starter relay output circuit	Current too high when cranking is attempted.	Check for a short to ground on circuits 472S and 15T, between the BHM and the magnetic switch on the starter.
6986	7	B6, pins A1, A3, & A5	Ignition switch inputs fault	The ignition switch input circuits are in a combination of states that is not expected. E.G: • Pin A5 is at battery voltage but pin A3 is not. • Pin A3 is at battery voltage but pin A1 is not. • Pin A5 and A1 are at battery voltage.	Check for open circuit or short in circuits 305, 306, and 15, between the ignition switch and the BHM. Also check the ignition switch.

Table 1, Starting System Faults from SA 33

Troubleshooting

Slow Cranking or Repeated Clicking Sound but the Engine Does Not Start			
This symptom often indicates low voltage at the starter, or worn and binding starter components.			
Step	**Test Procedure**	**Test Result**	**Action**
1.	Check the ambient temperature. Is the temperature extremely cold?	Yes	Slow cranking due to extreme cold is a normal condition. Do not mistake slow cranking due to cold for slow cranking due to equipment malfunction. Go to step 2.
		No	Go to step 2.
2.	With the keyswitch in the ON position, and the engine not running, measure the voltage at the batteries. Is the voltage below 12 volts?	Yes	Charge the batteries then go to step 3. Perform an alternator test when the vehicle is able to start.
		No	Go to step 3.
3.	Test the batteries individually with the battery tester. Are any batteries defective?	Yes	Replace any batteries that tested defective.
		No	Go to step 4.
4.	Perform a voltage drop test on the starter cables. Is excessive voltage drop present?	Excessive voltage drop	Inspect for corroded and loose connections. Clean, tighten and repair all connections, then protect all exposed terminal connectors with dielectric red enamel.
		Ok	Go to step 5.
5.	Turning the keyswitch to START (cranking), measure the voltage at the magnetic switch activate terminal. Is battery voltage present?	No voltage, or intermittent voltage	Use the troubleshooting procedures in the table titled Starter Does Nothing, or Makes Only a Single Click.
		Yes	Replace the starter.

Table 2, Slow Cranking or Repeated Clicking Sound but the Engine Does Not Start

Starter Does Nothing or Makes Only a Single Click—Vehicles with an Integrated Magnetic Switch			
This symptom often indicates a problem with the magnetic switch or starter solenoid circuit. Worn components in the starter or engine can also create binding and result in this symptom.			
Step	**Test Procedure**	**Test Result**	**Action**
1.	With the keyswitch in the START (crank) position, measure the voltage at the magnetic switch activate terminal. Is battery voltage present?	Yes	Go to step 2.
		No	Go to step 3.
2.	Perform a voltage drop test on the starter cables. Is excessive voltage drop present?	Excessive voltage drop	Inspect for corroded and loose connections. Clean, tighten and repair all connections, then protect all exposed terminal connectors with dielectric red enamel.
		No	Replace the starter.
3.	With the keyswitch in the START (crank) position, measure the voltage on connector 6, pin A5 of the bulkhead module Is battery voltage present?	Yes	Go to step 5.
		No	Go to step 4.

Starter Does Nothing or Makes Only a Single Click—Vehicles with an Integrated Magnetic Switch			
This symptom often indicates a problem with the magnetic switch or starter solenoid circuit. Worn components in the starter or engine can also create binding and result in this symptom.			
Step	**Test Procedure**	**Test Result**	**Action**
4.	Measure the voltage on circuit 52 at the keyswitch. Is battery voltage present?	Yes	Troubleshoot for an open in circuit 15 between the keyswitch and the BHM, and for an open keyswitch.
		No	Check for an open 5 amp fuse (F5) in the main PDM. Test for a wiring fault in circuit 52 between the PDM and the keyswitch and in circuits 15, 305, and 306 between the keyswitch and the BHM.
5.	With the keyswitch in the START (crank) position, measure the voltage on connector 4, pin B of the bulkhead module. Is battery voltage present?	Yes	Go to step 6.
		No	Allow time for the starter protection temperature model to calculate that the starter has cooled off. Troubleshoot for a wiring fault in the bottom of the clutch switch circuit on connector 6, pin B3. If the vehicle has an automated transmission, troubleshoot for faults with gear position and control circuits, otherwise replace the bulkhead module.
6.	Does the vehicle have an Eaton automated transmission?	Yes	Ensure the transmission is in neutral. Test for a wiring fault in circuit 472S between the bulkhead module and relay R8 in the PTPDM. Test for a fault with the transmission control of R8 and repair if necessary. If R8 testing passes, test circuit 472S to the overcrank protection switch in the starter, and circuit 15T to the magnetic switch.
		No	Test for a wiring fault in circuit 472S between the bulkhead module and the starter. If the starter uses the internal overcrank protection switch, test circuit 15T from the overcrank protection switch to the magnetic switch.

Table 3, Starter Does Nothing or Makes Only a Single Click—Vehicles with an Integrated Magnetic Switch

Starter Does Nothing or Makes Only a Single Click—Vehicles with a Remote Mounted Magnetic Switch			
This symptom often indicates a problem with the magnetic switch or starter solenoid circuit. Worn components in the starter or engine can also create binding and result in this symptom.			
Step	**Test Procedure**	**Test Result**	**Action**
1.	With the keyswitch in the START (crank) position, measure the voltage at the starter solenoid (circuit 15C) activate terminal. Is battery voltage present?	Yes	Go to step 2.
		No	Go to step 3.

Troubleshooting

Starter Does Nothing or Makes Only a Single Click—Vehicles with a Remote Mounted Magnetic Switch			
This symptom often indicates a problem with the magnetic switch or starter solenoid circuit. Worn components in the starter or engine can also create binding and result in this symptom.			
Step	**Test Procedure**	**Test Result**	**Action**
2.	Perform a voltage drop test on the starter cables. Is excessive voltage drop present?	Excessive voltage drop	Inspect for corroded and loose connections. Clean, tighten and repair all connections, then protect all exposed terminal connectors with dielectric red enamel.
		No	Replace the starter.
3.	With the keyswitch in the START (crank) position, measure the voltage on connector 6, pin A5 of the bulkhead module Is battery voltage present?	Yes	Go to step 5.
		No	Go to step 4.
4.	Measure the voltage on circuit 52 at the keyswitch. Is battery voltage present?	Yes	Troubleshoot for an open in circuit 15 between the keyswitch and the BHM, and for an open keyswitch.
		No	Check for an open 5 amp fuse (F5) in the main PDM. Test for a wiring fault in circuit 52 between the PDM and the keyswitch and in circuits 15, 305, and 306 between the keyswitch and the BHM.
5.	With the keyswitch in the START (crank) position, measure the voltage on connector 4, pin B of the bulkhead module. Is battery voltage present?	Yes	Go to step 6.
		No	Allow time for the starter protection temperature model to calculate that the starter has cooled off. Use EZ wiring to access the vehicle wiring schematic and determine if the vehicle uses the clutch switch input on BHM connector B6, pin 3 or the neutral input on connector B2 pin G. If none of these hardwire inputs are used, connect ServiceLink to determine if the transmission controller is detecting neutral gear. If either of these hardwire neutral/ clutch inputs are used, use the vehicle schematic to determine where the ground signal is interrupted. This circuit must be at ground to enable starting. If the circuit is at ground replace the bulkhead module.
6.	Allow time for the starter protection model to calculate that the starter has cooled. Then with the keyswitch in the START position, measure for battery voltage across the 15A circuit and the ground circuit at the magnetic switch on the two small terminals. Is battery voltage present?	Yes	Troubleshoot and repair for an open magnetic switch or a wiring fault in circuit 15B or 15C between the starter and the magnetic switch.
		No	Troubleshoot and repair for an open magnetic switch, an open overcrank protection switch, or for a wiring fault in circuit 15A between the BHM and the magnetic switch or for an open ground circuit at magnetic switch or overcrank protection switch.

Table 4, Starter Does Nothing or Makes Only a Single Click—Vehicles with a Remote Mounted Magnetic Switch

Starter Makes Spinning or Grinding Sounds but the Engine Does Not Crank.			
This symptom often indicates a mechanical problem with the starter or the ring gear.			
Step	**Test Procedure**	**Test Result**	**Action**
1.	With the keyswitch in the START (crank) position, test the voltage at the starter battery cable connections. Is battery voltage present?	Low or No	Go to step 2.
		Yes	Go to step 3.
2.	Perform a voltage drop test on the starter cables. Is excessive voltage drop present?	No	Go to step 3.
		Excessive voltage drop	Inspect for corroded and loose connections. Clean, tighten and repair all connections, then protect all exposed terminal connectors with dielectric red enamel
3.	Remove the starter and inspect the starter pinion gear for milling. Attempt to spin the pinion gear in both directions. The overrunning clutch will allow the gear to be turned in the clockwise direction, but it should be extremely difficult or impossible to turn in the counter clockwise direction.	Ok	Go to step 4.
		Defective	Replace the starter.
4.	Bar the engine over to inspect the 3 positions on the ring gear where the starter engages.	Damaged	Replace the ring gear.

Table 5, Starter Makes Spinning or Grinding Sounds but the Engine Does Not Crank

Specifications

Torque Values, Starter-Motor to Flywheel-Housing Bolts		
Fastener Description	**Size**	**Torque Value: lbf·ft (N·m)**
MBE 400, DD 13/15/16	M10 x 1.5	38±5 (51±7)
Cummins ISB	M10 x 1.5	38±5 (51±7)
Cummins ISC/ISL	M12 x 1.5	58±5 (78±7)
CAT 3176, 3406, 10/12, Cummins ISX	5/8–11	100±48/-0 (+65)

Table 1, Torque Values, Starter-Motor to Flywheel-Housing Bolts

Torque Values, Starter Connections		
Magnetic Switch (+)	**Solenoid Battery (+)**	**Starter Ground (–)**
18 to 21 lbf·in (200 to 250 N·cm)	18 to 20 lbf·ft (24 to 28 N·m)	18 to 20 lbf·ft (24 to 28 N·m)

Table 2, Torque Values, Starter Connections