General Information

All 12-volt starting systems are equipped with a heavy-duty starter relay. See **Fig. 1**. The magnetic switch is mounted in the engine compartment on the left side of the frontwall just inboard of, and slightly below, the Bulkhead Module (BHM). When the key is turned, the Bulkhead Module sends a signal to the magnetic switch, causing it to close and to connect electrical current to the starter solenoid. This engages the starter motor pinion with the engine flywheel ring gear, then energizes the starter motor.

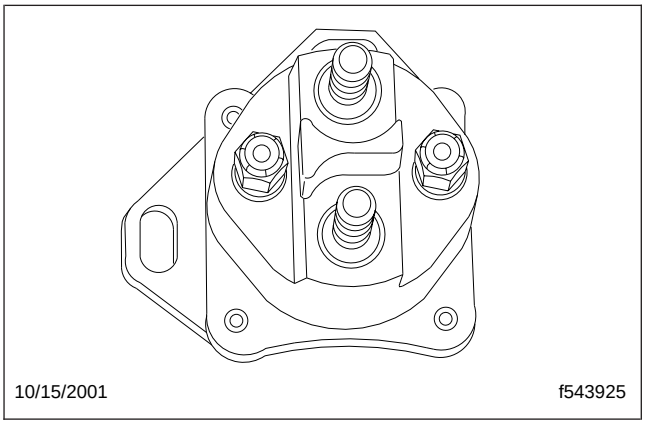


Fig. 1, Magnetic Switch

The magnetic switch consists of a winding mounted around a hollow cylinder containing a movable core or plunger with a contact disk that is assembled on the plunger.

When the winding is energized, plunger movement causes the contact disk to be held tightly against the two main switch terminals. This closes the circuit between these terminals and activates the starting motor. When the winding is de-energized, a return spring causes the plunger to return to its original position, opening the circuit to the starter motor.

The Saf-T-Liner C2 vehicle meets the Federal Motor Vehicle Safety Standards (FMVSS) requirement that the engine cannot be started unless the transmission is in neutral. The type of transmission in the vehicle dictates the condition that is used to determine whether or not the vehicle is in neutral.

When the ignition switch is turned to the start position, the Bulkhead Module verifies whether or not the neutral condition is met. If the neutral condition is met, the starter relay output from the BHM is energized. If the neutral condition is not met, the starter relay output is not energized. The neutral start condition is programmed in to the BHM.

When the BHM energizes the starter relay output, the output remains active until one of the following conditions occurs:

- The battery voltage is above 6.5 volts as measured by the BHM, and the neutral condition is no longer met.
- The battery voltage drops below 4.6 volts. This is also the voltage at which the BHM ceases to function.
- The ignition switch is returned to the run position.

See **Specifications 400** for the transmissions available on the Saf-T-Liner C2 and the neutral conditions that are checked by the BHM.

Starter Relay Signal Function

Description

The starter relay is also known as the magnetic switch or mag switch. The terms magnetic switch and starter relay are used interchangeably. When the ignition switch is in the start position, the Bulkhead Module (BHM) sends a signal to the magnetic switch, which engages the starter.

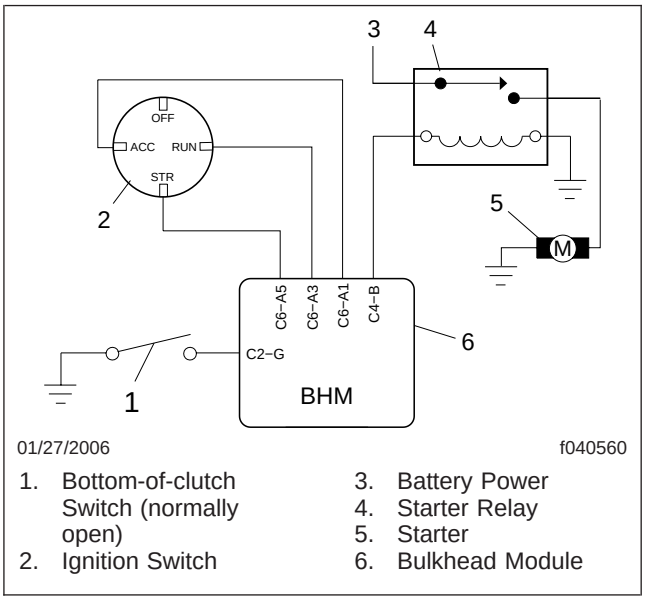
The BHM is capable of detecting short circuits in the starter relay wiring. Faults discovered by the BHM may be reported on the J1939 and/or J1708 datalinks and may be viewed through ServiceLink®.

For a wiring diagram of the starter relay signal function for a manual transmission, see **Fig. 2**. For an automatic transmission, see **Fig. 3**. For an AMT or automatic transmission, see **Fig. 4**

Input and Output Conditions

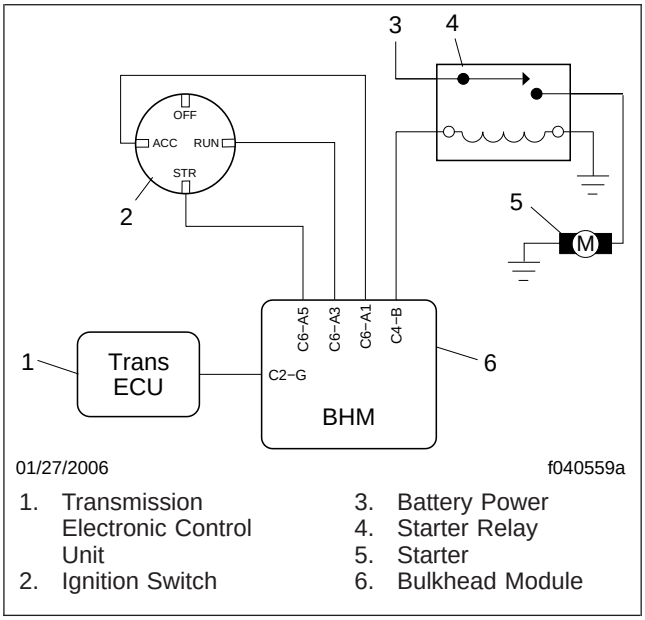
Activation of the starting system is dependent on the type of transmission. A manual transmission uses the bottom-of-clutch switch to tell the BHM when the clutch is released (pedal depressed). An automatic transmission sends a ground signal via relay to the BHM when it is in neutral or park. The Allison 3000 and 4000 Series transmissions use a J1939 message to the BHM. See **Table 1** for the inputs that are required for the BHM to allow activation of the starting system. See **Table 2** for the starting system in-

General Information



1. Bottom-of-clutch Switch (normally open)
2. Ignition Switch
3. Battery Power
4. Starter Relay
5. Starter
6. Bulkhead Module

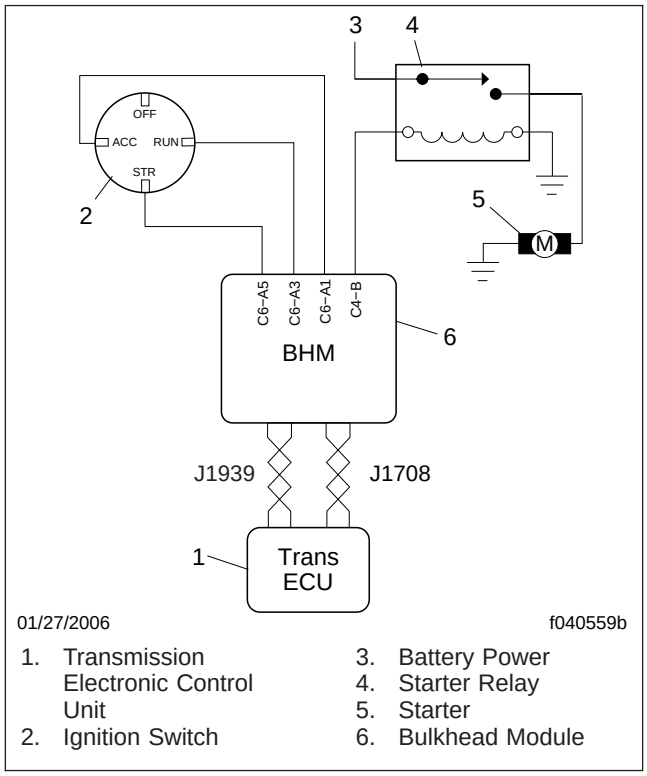
Fig. 2, Starter Relay Signal Function for a Manual Transmission



1. Transmission Electronic Control Unit
2. Ignition Switch
3. Battery Power
4. Starter Relay
5. Starter
6. Bulkhead Module

Fig. 3, Starter Relay Signal Function for an Automatic Transmission

puts to the BHM and how the system reacts to the inputs.



1. Transmission Electronic Control Unit
2. Ignition Switch
3. Battery Power
4. Starter Relay
5. Starter
6. Bulkhead Module

Fig. 4, Starter Relay Signal Function for an Automatic Transmission

Starter Relay Signal Function Input		
Type of Transmission	**Input to BHM**	**BHM Conclusion**
Manual	Bottom-of-clutch switch is closed	Transmission is in neutral.
Automatic*	Ground signal via transmission neutral relay	Transmission is in neutral.
Allison 3000 and 4000 Series With ETC7	J1939 Transmission Engine Crank Enable = Enable	Transmission is in neutral.

* After February 2005, Allison 3000 and 4000 Series transmissions may use the J1939 transmission engine crank enable ETC7 message.

Table 1, Starter Relay Signal Function Input

Starter Relay Signal Function I/O Conditions		
Input to BHM		**Output from BHM (C4-B)**
Ignition Switch	**Starter Lockout**	**Starter Relay Signal**
OFF/ACC/ON	Neutral	Deactivated
Start	Not neutral	Deactivated
Start	Neutral	Activated
Start	Vandal Lock*	Deactivated

* Vandal lock is optional, and is not always used to disable the starter relay.

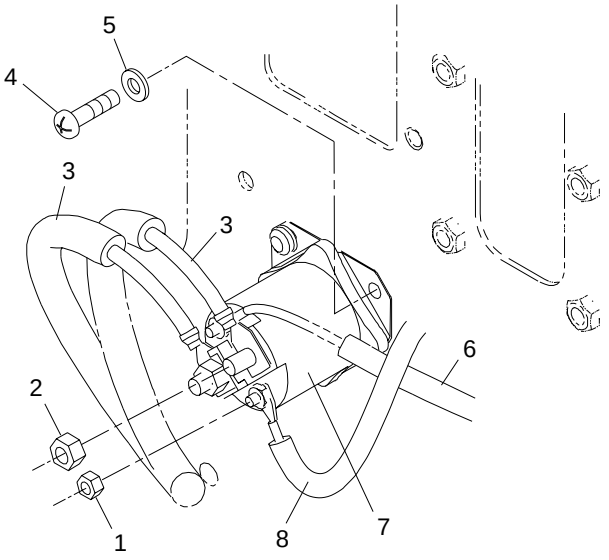
Table 2, Starter Relay Signal Function I/O Conditions

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the negative leads from the batteries or, if the vehicle is equipped with a battery disconnect switch, turn the switch to the off position.
3. The magnetic switch is mounted in the engine compartment on the left side of the frontwall just inboard of, and slightly below, the Bulkhead Module (BHM). Before removing the ring terminals from the magnetic switch, mark the ring terminals for ease of installation. See **Fig. 1**.
4. Remove the two T30 Torx® capscrews that attach the magnetic switch to the frontwall, and remove the magnetic switch.

Installation

1. Using two T30 Torx® capscrews, install the magnetic switch on the frontwall. Torque the capscrews 72 lbf·in (800 N·cm).
2. Attach and secure the ring terminals. Be sure to install the correct ring terminal to the correct mounting stud.
3. Connect the batteries or turn the battery disconnect switch to on.
4. Verify that the magnetic switch operates properly by starting the vehicle.
5. Remove the chocks from the tires.



1. 10–32 Nut
2. 5/16–18 Nut
3. Engine Harness
4. Capscrew
5. Flatwasher
6. Frontwall Harness
7. Magnetic Switch
8. Ground Harness

Fig. 1, Magnetic Switch

Before replacing the magnetic switch or repairing or replacing any of the starting and charging circuits, perform the "Preliminary Checks" and the "Magnetic Switch Circuit Test."

Preliminary Checks

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Check the condition of the batteries. Follow the battery testing procedure in **Section 54.10, Subject 140**. Be sure the batteries are fully charged.
3. Check the starting motor, ignition switch, and solenoid for damage or wear. See **Section 54.01, Subject 300**, "Ignition System, Ignition Switch Function" for instructions on how to use ServiceLink® for troubleshooting the ignition system. Repair or replace the component(s), as needed.
4. Remove the chocks from the tires.

Magnetic Switch Circuit Test

1. Apply the parking brakes, and chock the tires.
2. Check the condition of the batteries. Follow the battery testing procedure in **Section 54.10, Subject 140**. Be sure the batteries are fully charged.
3. Check the starting motor, ignition switch, and solenoid for damage or wear. Repair or replace the component(s), as needed.

⚠ WARNING

Use care when checking the cable between the magnetic switch and the starter. When the circuit is energized, it can carry starting current. If the current comes too close to a ground source, it can cause an arc and possibly damage components or cause personal injury.

4. Check the wiring and the magnetic switch for wear or damage. See **Specifications 400** or *EZWiring* online at AccessFreightliner.com for a circuit diagram of the magnetic switch.
5. Check the circuit between the magnetic switch and the starter "B" terminal (circuit 15B) for correct voltage, as follows.
   - 5.1 Disconnect the circuit running from the starter "S" terminal to the magnetic switch (circuit 15C).
   - 5.2 Connect a voltmeter to the magnetic switch terminal where the circuit from the starter "B" terminal is connected (circuit 15B).
   - 5.3 If the voltmeter reading is 0 volt, check for an open circuit.

     If the voltmeter reading is less than 12.0 volts, check for corroded or loose connections.

     If the voltmeter reading is 12.0 volts or more, go to the next step.
   - 5.4 Repair or replace any damaged wires.
6. Check the magnetic switch ground circuit (circuit GND), as follows.
   - 6.1 Connect an ohmmeter between the magnetic switch ground terminal and a known good ground.
   - 6.2 If the ohmmeter reading is more than 0.5 ohm, check for corroded or loose connections.
   - 6.3 Repair or replace any damaged wires.
7. Check the magnetic switch ignition wiring (circuit 15A) for correct voltage, as follows.

   NOTE: This test requires two people to perform it.
   - 7.1 Have one person turn the ignition switch to the start position.
   - 7.2 Have the other person connect a voltmeter between the magnetic switch terminal where the ignition circuit is connected (circuit 15A) and a known good ground.
   - 7.3 If the voltmeter reading is 0 volts, check for an open connection in circuit 15A.

     If circuit 15A is okay, troubleshoot the starter enable system (depending on the transmission type). See **Subject 400** for the wiring diagrams associated with each type of transmission.

     If the voltmeter reading is less than 11.0 volts, check for corroded or loose connections.

Repair or replace any damaged wires before proceeding.

7.4 If the voltmeter reading is 11.0 volts or more, go to the next step.

8. Check the circuit between the magnetic switch and the starter "S" terminal (circuit 15C) for correct voltage, as follows.

   NOTE: This test requires two people to perform it.

   8.1 Have one person hold the ignition switch in the start position.

   8.2 Have the other person connect a voltmeter between the magnetic switch terminal where the circuit from the starter "S" terminal is connected (circuit 15C) and a known good ground.

   8.3 If the voltmeter reading is less than 12.0 volts, replace the magnetic switch.

9. Connect the "S" terminal wire.
10. Remove the chocks from the tires.

Troubleshooting the Neutral Input Signal

1. Apply the parking brakes and chock the tires.
2. Turn the ignition on and connect ServiceLink® to the vehicle.
3. Open the Datalink Monitor template "C2 Starter Control System Neutral Inputs" and follow the instructions on the template.
4. Place the vehicle in the appropriate neutral condition for starting—clutch pedal depressed or neutral gear selected.
5. Determine if the appropriate neutral condition, based on transmission type, is met. If not, determine the cause and repair as necessary. See **Subject 400**.
6. Remove the chocks from the tires.

Fault Conditions for the Starter Relay Signal Function

See **Table 1** for the actions taken by the Bulkhead Module (BHM) when it encounters a fault in the starting system. The reference parameters that program the BHM determine if a fault code is broadcast. Therefore, even if the BHM detects a fault, a fault code may not be transmitted. If the BHM is programmed to transmit fault codes, they can be viewed through ServiceLink. Fault messages may be transmitted on either or both the J1939 and J1708 datalinks until the ignition is turned off.

See **Table 2** for the conditions that will cause a fault with the BHM. A fault code may be displayed or the starter motor will not start the engine along with a fault code being displayed depending on the version of the BHM.

Starter Relay Signal Function Fault Conditions	
Description of Fault	**Action Taken by BHM**
Transmission state is unavailable or in error.	BHM assumes the transmission state is not neutral.
Ignition switch is in error.	BHM assumes that the ignition switch is on, and may transmit a fault message on the J1939 and/or J1708 datalinks.
Starter relay signal wiring shorted or open.	BHM may transmit a J1939 fault message.

Table 1, Starter Relay Signal Function Fault Conditions

Ignition Switch Fault Conditions			
Ignition Switch Accessory	**Ignition Switch**	**Ignition Switch Starter**	**Output Data**
Open	Open	Closed	Error

Ignition Switch Fault Conditions			
Ignition Switch Accessory	**Ignition Switch**	**Ignition Switch Starter**	**Output Data**
Closed	Open	Closed	Error
Open	Closed	Open	Error
Closed	Closed	Closed	Error

Table 2, Ignition Switch Fault Conditions

Specifications

Transmissions and the Corresponding Neutral Conditions			
Transmission Type or Transmission Make and Model	**Neutral Condition**	**BHM Software Level**	**Reference Figure**
All manual transmissions	Bottom-of-clutch switch input	1.2	**Fig. 1**
Allison 1000 and 2000 Series	Neutral start input	1.2	**Fig. 2**
Allison 3000 and 4000 Series	Neutral start input	1.2	**Fig. 3**
Allison 3000 and 4000 Series	J1939 ETC7 Crank Enable message	1.2	

Table 1, Transmissions and the Corresponding Neutral Conditions

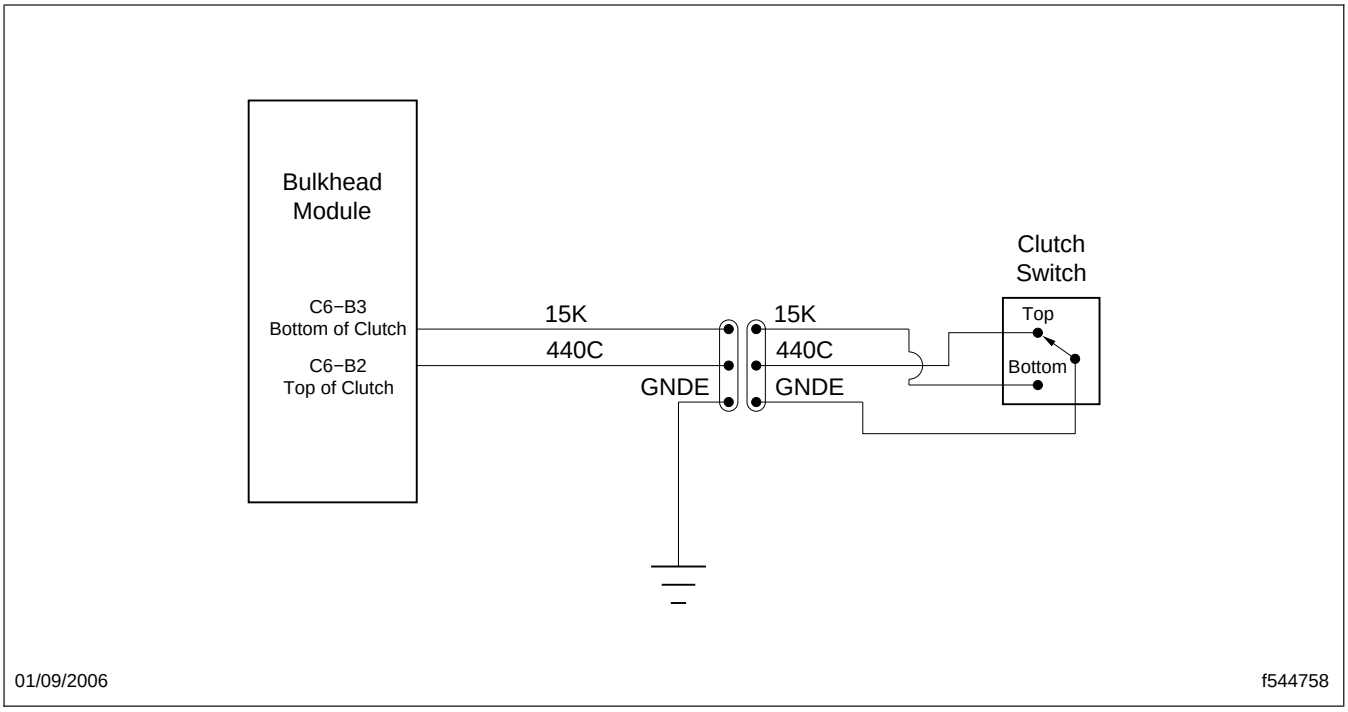
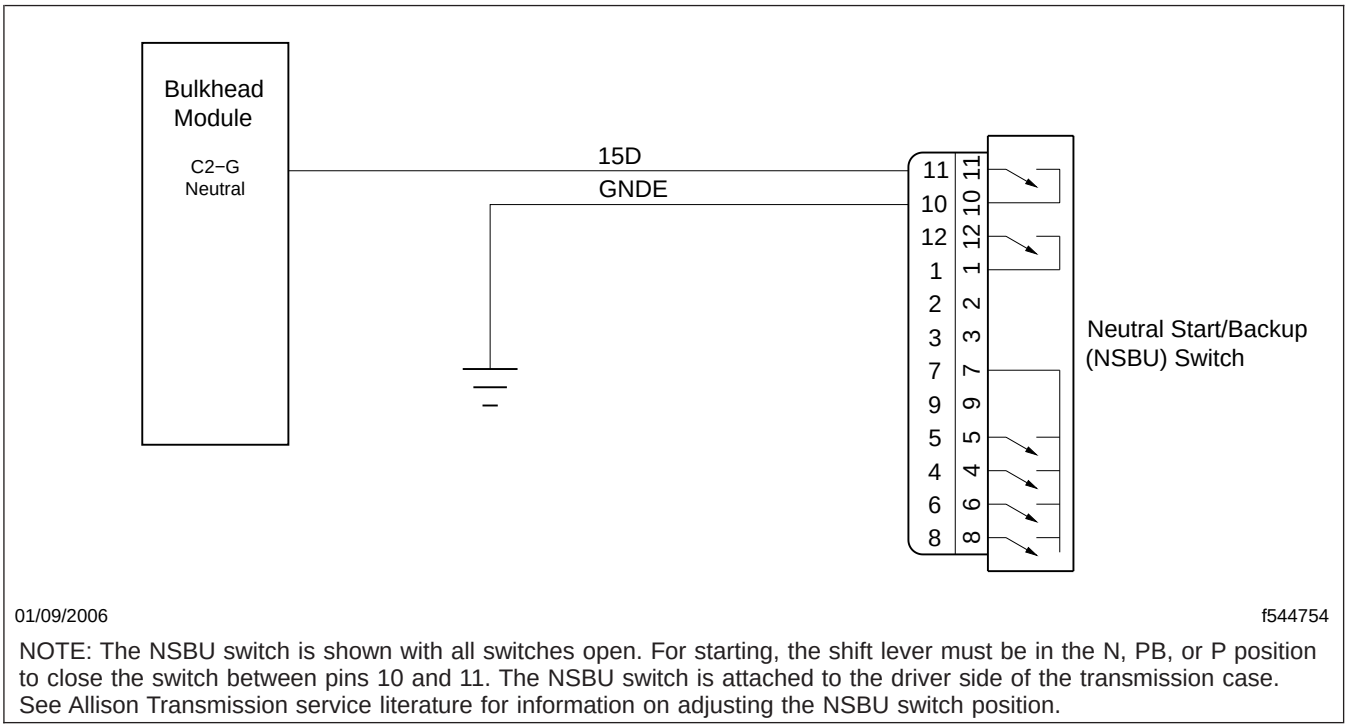


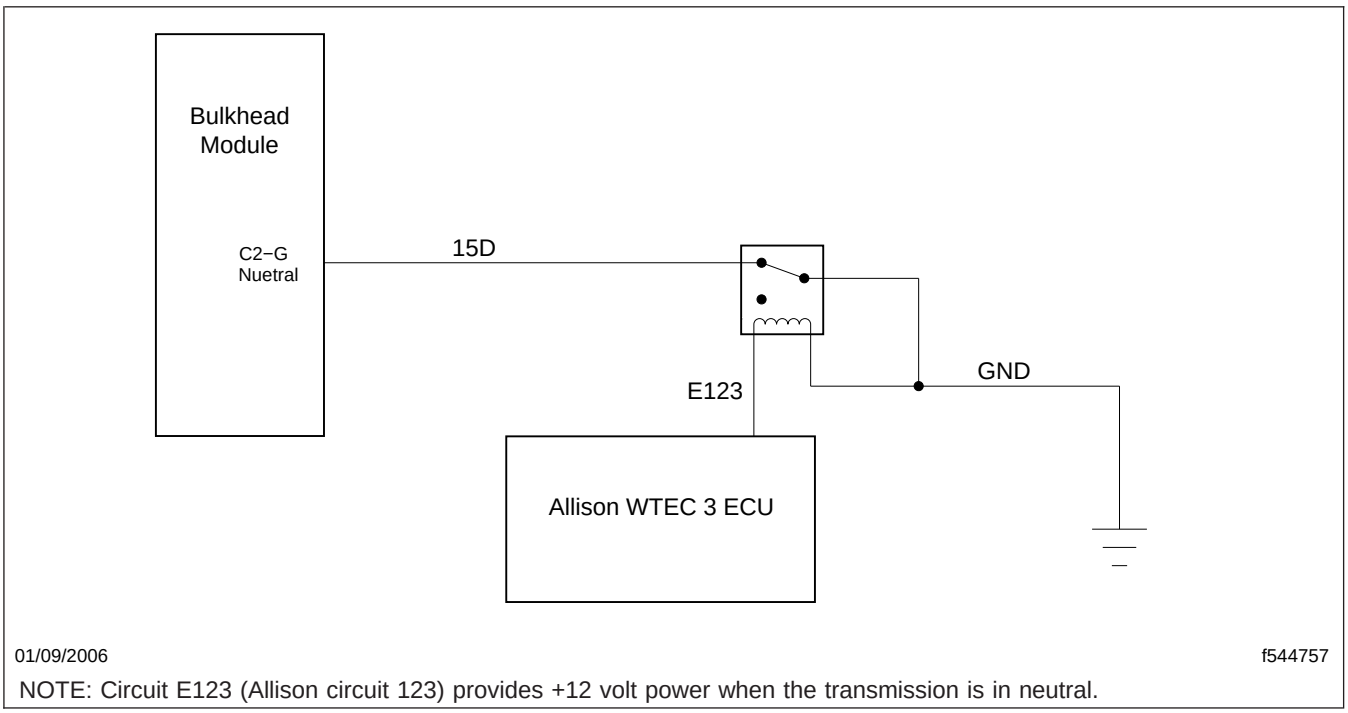
Fig. 1, Clutch Switch Wiring Diagram for All Manual Transmissions

Specifications



NOTE: The NSBU switch is shown with all switches open. For starting, the shift lever must be in the N, PB, or P position to close the switch between pins 10 and 11. The NSBU switch is attached to the driver side of the transmission case. See Allison Transmission service literature for information on adjusting the NSBU switch position.

Fig. 2, Neutral Input Wiring Diagram for Allison 1000 and 2000 Series Transmissions



NOTE: Circuit E123 (Allison circuit 123) provides +12 volt power when the transmission is in neutral.

Fig. 3, Neutral Input Wiring Diagram for Allison 3000 and 4000 Series Transmissions

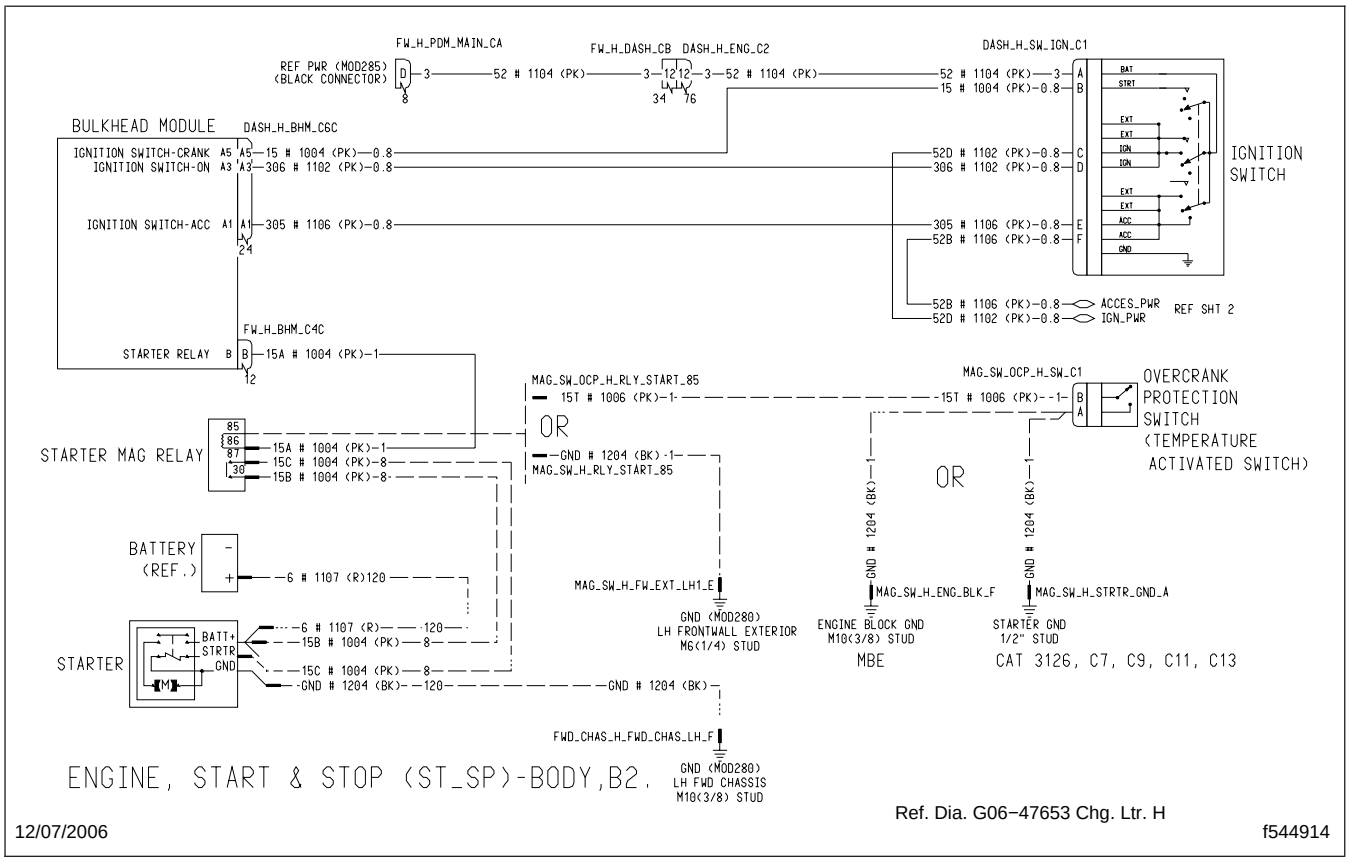


Fig. 4, Magnetic Switch Wiring Diagram

Specifications

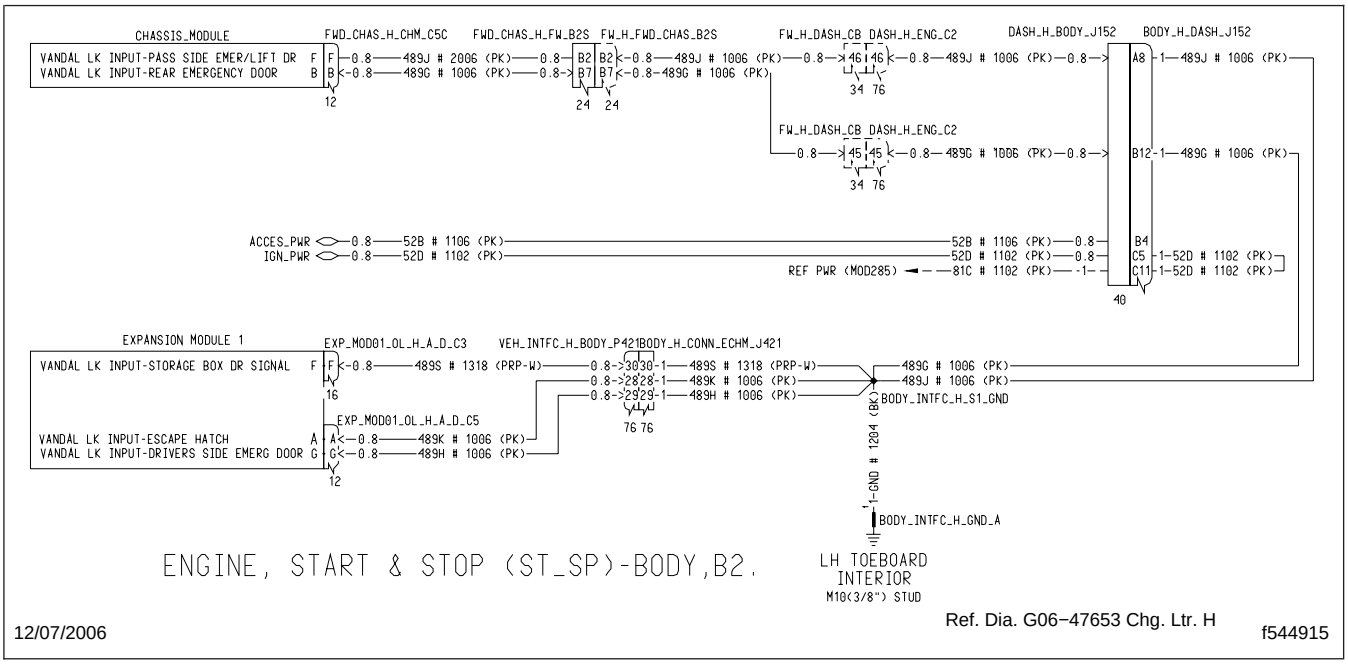


Fig. 5, Vandal Lock Wiring Diagram