

## Principles of Operation

### Transfer Case — Electronic Shift

The four-wheel drive, electronic shift-on-the-fly feature electrically shifts the vehicle transfer case between 2WD, 4X4 HIGH, and 4X4 LOW. The system mode is selected by the operator through the mode select switch (MSS) on the instrument panel. The operator is informed which mode the system is in by two instrument cluster indicators, one for 4X4 HIGH which is 4X4, and one for 4X4 LOW which is LOW RANGE (in 4X4 LOW both the lamps are on). Shifts into 4X4 HIGH can be made at any speed. When shifting into 4X4 HIGH with the vehicle stationary, tooth blockage may occur, preventing shift completion. When the vehicle is driven above 8 km/h (5mph) the shift will complete. When shifting in or out of 4X4 LOW, the generic electronic module (GEM) requires that the vehicle speed be less than 5 km/h (3 mph), the brake pedal be applied, and the transmission in NEUTRAL (automatic transmission) or the clutch pedal be depressed (manual transmission). (The digital transmission range [TR] sensor informs the GEM when the automatic transmission is in the NEUTRAL range position.)

The gearmotor encoder assembly is mounted externally on the transfer case. It drives a rotary cam which moves the mode fork and the range fork within the transfer case between the 4X4 HIGH, 4X4 LOW, and 2WD range positions.

The GEM uses two relays to control the gearmotor encoder assembly shift between 4X4 HIGH, 4X4 LOW, and 2WD modes. The GEM controls the pulse vacuum hublock (PVH) solenoid which supplies engagement and disengagement vacuum to control the hublocks.

The GEM accomplishes shifts by interpreting inputs from:

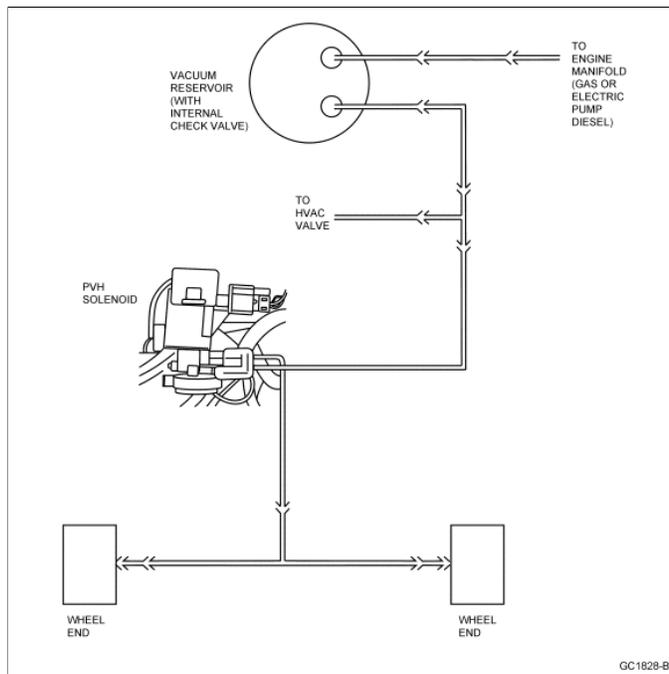
- mode select switch (MSS)
- vehicle speed signal (transmitted from the ABS system)
- gearmotor encoder plate position
- brake pedal switch
- digital transmission range (TR) sensor (automatic transmission)
- clutch pedal position (CPP) switch (manual transmission)
- ignition switch

Based on these inputs, the GEM controls the shifts into 2WD, 4X4 HIGH, or 4X4 LOW with the following outputs:

- low to high relay (clockwise)
- high to low relay (counterclockwise)
- pulse vacuum hublock (PVH) solenoid
- gearmotor encoder assembly

The electronic shift-on-the-fly (ESOF) system has a feature which allows the driver to override the vacuum operated hublocks. When the front hublocks are manually turned to the LOCK position, the hublocks are locked at all times, overriding the vacuum operated system. If the front hublocks are manually turned to the AUTO position, the hublocks can only be locked by turning the MSS to 4X4 HIGH or 4X4 LOW position.

### Electronic Shift Vacuum Schematic



### Hublock Operation

The Super Duty and Excursion 4X4 ESOF system uses timed vacuum sequences to lock and unlock the wheel ends. A high vacuum level is used to engage the hublocks, and a lower vacuum level is used to disengage the hublocks, after which the vacuum is released and the hublock holds itself in the proper mode. The vacuum signals are supplied to the hublocks by system components, including the GEM, wiring harness, solenoid, vacuum harness and vacuum seals. As the first step in service, eliminate such obvious items as loose wiring connections, loose vacuum connections, or damaged vacuum lines.

### Disengage Time

"Slow" release of the hublocks is not considered abnormal for this system. Anytime vacuum is applied to the hubs, whether for 4X4 or 4X2, the hublocks will initially engage. If 4X4 was requested, the hublocks will remain engaged, but if 4X2 was selected, the internal mechanism will release only after the GEM timers expire and vacuum is vented from the hub. This normally takes 15 seconds, but can take up to two minutes, depending on how the 4X4 mode select switch was operated. After the hub mechanism releases, internal springs must work the hublock gears to the disengaged position. Road bumps, vehicle speed, acceleration cycles, or momentary reversal of direction can assist this process, varying the length of time the hublocks remain engaged in each situation.

### Manual Override

The hublocks have manual override selector dials, which, when rotated to the "LOCK" position, will keep the mechanism locked regardless of the instrument panel 4X4 mode select switch position. Verify that both dials are in "AUTO" before evaluating ESOF operation.

#### Hublock Replacement

Left and right side hublocks are not connected, other than by the common vacuum supply line. If a malfunction in either hublock is diagnosed, it should be installed as an individual unit; there is no need to "balance" an axle with new hublocks on both sides. If both sides appear to be malfunctioning, be sure to verify upstream integrity before installing new hublocks on both sides.

Many system components are involved in the proper operation of the ESOF hubs on 1999 and newer Super Duty and Excursion 4X4 vehicles. Before diagnosing the hublocks themselves as the cause of 4X4 concerns, be sure to verify all related system components.

After removing the hublock retaining ring be sure not to use tools other than the hands or "grip" gloves to remove the hublock, as damage may occur to either the paint or the function of the hublock. Pliers or locking Channel-Locks® should be considered as a last resort, and will usually damage the hublock, making it necessary to install a new hublock.

#### Inspection and Verification — Electronic Shift

1. Visually inspect for the following obvious signs of mechanical and electrical damage.

#### Visual Inspection Chart

Mechanical	Electrical
<ul style="list-style-type: none"> <li>• Hublocks               <ul style="list-style-type: none"> <li>▪ installed</li> <li>▪ correct type</li> </ul> </li> <li>• Axle shafts and universal joints</li> <li>• Driveshaft and universal joints</li> <li>• Shift linkage</li> <li>• Fluid leaks</li> <li>• Matching tire size</li> <li>• Vacuum harness</li> </ul>	<ul style="list-style-type: none"> <li>• Battery junction box (BJB) fuse 17 (30A), F-Super Duty or fuse 104 (30A), Excursion</li> <li>• Central junction box (CJB) fuse 6 (15A)</li> <li>• Generic electronic module (GEM)</li> <li>• Pulse vacuum hublock (PVH) solenoid</li> <li>• Wiring harness</li> <li>• Mode select switch (MSS)</li> <li>• gearmotor encoder assembly</li> <li>• Connector(s)</li> <li>• Shift relays</li> <li>• Circuitry</li> </ul>