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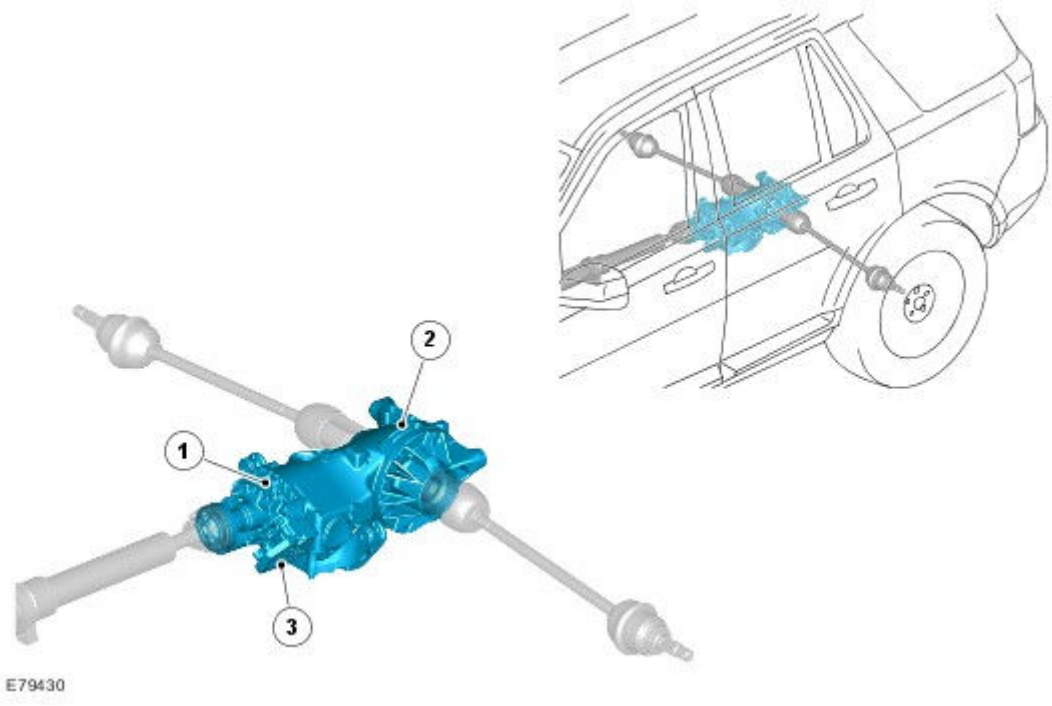
Rear Drive Axle and Differential

COMPONENT LOCATION



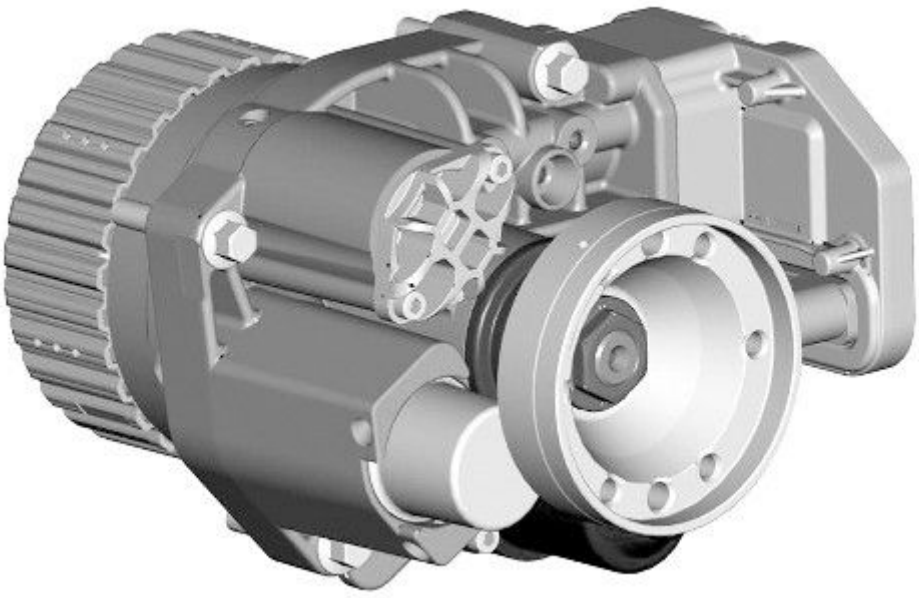
Item	Part Number	Description
1		Active on-demand coupling
2		Differential
3		Active on-demand coupling module

OVERVIEW

The differential operates in conjunction with the active on-demand coupling to provide drive to the rear axle.

Vehicles from 2009MY

Generation 4 Active On-Demand Coupling from 2009MY



E103421

Vehicles from 2009MY are fitted with a modified design of the active on-demand coupling, known as the generation 4 unit. The new active on-demand coupling has design improvement changes over the previous generation 3 coupling which give the following advantages:

- Reduced base torque at high differential speed
- Torque activation independent of differential speed
- Accurate torque limiter
- Energy stored in accumulator
- Lower max current consumption
- Faster response.

DIFFERENTIAL

The differential unit is a low-offset-hypoid spiral-bevel design, based on a 167mm crown wheel geared to deliver a ratio of 2.58:1. The design of the differential gears and the 4 mountings that control the torque reaction of the unit within the rear subframe, provide a differential unit of excellent efficiency and refinement.

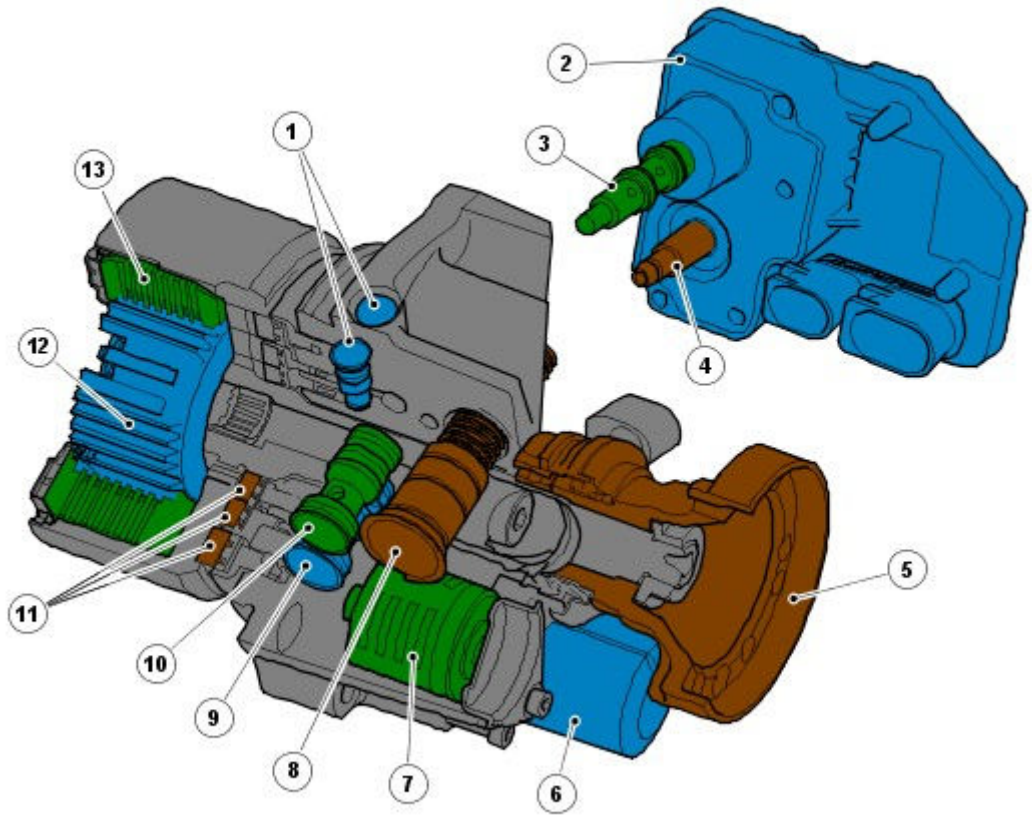
The torque delivered to the differential is controlled by the active on-demand coupling, mounted into the void at the front of the differential's cast-aluminum casing, which also provides the oil reservoir for the coupling.

ACTIVE ON-DEMAND COUPLING

Active On-demand Coupling

NOTE:

Generation 3 coupling shown.



E79431

Item	Part Number	Description
1		Check valves - exhaust side
2		Active on-demand coupling module
3		Control valve / axial solenoid
4		Oil pressure and temperature sensor
5		Input shaft
6		Electric hydraulic pump
7		Oil filter
8		Accumulator
9		Check valve - intake side
10		Combined check and by-pass valve
11		Ring shaped annular piston
12		Inner connection hub with splines for outer hub.
13		Inner and outer wet clutch plates

The active on-demand coupling provides the benefits of a permanent 4x4 system with the efficiency and economical benefits of a part-time system. Located between the differential and driveshaft, the coupling is a self-contained unit combining mechanical, hydraulic and electronic functions to distribute drive between the front and rear axles with transparent automatic control.

The active on-demand coupling provides the following functions:

- Electronic management of torque transfer.
- Rapid engagement in response to traction demands.
- Rapid disengagement to ensure its operation cannot corrupt wheel speed signals and compromise stability

control system operation; this is especially important on very low friction surfaces.
- Pre-engagement from rest to minimize the risk of wheel-spin.
- No opposing forces when maneuvring or parking the vehicle.
- Not sensitive to brake testing on a chassis dynamometer.

Generation 4 Active On-Demand Coupling - Vehicles from 2009MY

- The generation 4 coupling does not have the differential speed driven pump used on the previous generation 3 coupling, but is fitted with a bigger capacity electrically operated axial pump and a high pressure accumulator.
- The proportional throttle valve and pressure sensor on the generation 3 coupling is replaced with a proportional pressure reducing valve.
- The torque limiter pressure reducing valve on the generation 3 coupling is replaced by an electronic control valve and controlling software.

The generation 4 active on-demand coupling gives the following improvements over the previous generation 3 coupling:

- Reduced base torque at high differential speeds
- Torque activation is now independent of differential speed
- Accurate torque limiter control
- Energy stored in high pressure accumulator giving a low maximum current consumption of the electric pump and faster response.

Control Module - Generation 3 and 4 Couplings

The control module, attached to the casing of the active on-demand coupling, forms a single unit with the control valve/axial solenoid. By analyzing information from other vehicle modules and sensors the control module regulates the axial solenoid to control the hydraulic fluid pressure supplied to the clutch plates. Some of the modules and sensors the control module communicates with are listed below:

- Hardwired: Control valve / axial solenoid Electric hydraulic pump Oil pressure and temperature sensor
    - Control valve / axial solenoid
    - Electric hydraulic pump
    - Oil pressure and temperature sensor
- High speed CAN (controller area network): Engine control module Anti-lock brake system / traction control module Traction response switch Yaw rate sensor Steering wheel rotation sensor
    - Engine control module
    - Anti-lock brake system / traction control module
    - Traction response switch
    - Yaw rate sensor
    - Steering wheel rotation sensor

The axial solenoid constantly adjusts the control valve output using a Pulse Width Modulation (PWM) signal. The fluid pressure delivered to the clutch plates determines the amount of torque that is delivered to the rear axle.

The active on-demand coupling has integrated oil pressure and temperature sensors to enable the control module to accurately manage the torque transfer under all environmental and operating conditions. Using these signals the control module will use strategies to protect the coupling from overheating; in extreme cases to protect the coupling from damage the coupling will disengage if the temperature of the hydraulic fluid exceeds 105°C. The coupling will return to normal functionality when the temperature falls below 101°C.

The control module has an integrated diagnostics system, which constantly monitors the active on-demand coupling system as well as its input and output signals. If the control module detects a fault a Diagnostic Trouble Code (DTC) is stored. The DTC is accessed using the Land Rover approved diagnostic system.

Electric Hydraulic Pump

When negotiating very low friction surfaces such as wet grass, snow or ice; initial wheel-spin can cut into the surface and reduce grip. With a re-active on-demand coupling, almost 60 degrees of wheel rotation would occur before torque could be transmitted through the coupling.

On Generation 3 couplings, to counteract this Land Rover developed a unique high-pressure pre-charge facility which energizes the hydraulic circuit as soon as the engine is started. Essentially an electrically operated hydraulic pump was designed to maintain a potential of 500 Nm (369 lb ft) of torque pressure within the coupling. (This pre-charge

torque capacity has been increased to 1500Nm (1106 lb ft) for the Generation 4 coupling.)

Vehicles fitted with Terrain Response also add further benefits by varying the level of pre-charge to deliver optimum traction over a range of different terrain surfaces. The level of pre-charge is varied depending on the particular terrain response mode, for example:

- Terrain response in 'Special Programs Off' mode as common with vehicles without terrain response, the coupling is programmed to transmit 500 Nm 369 lb ft of torque on Generation 3 couplings and 1500 Nm (1106 lb ft) of torque on Generation 4 couplings to the rear axle when the vehicle moves from rest in a straight line. This strategy minimizes traction loss from a standing-start regardless of the terrain. When the vehicle accelerates the pressure in the coupling is decreased to improve fuel economy.
- The ability to sense the steering angle allows the coupling to be programmed to provide no torque transfer through the coupling. This prevents the coupling locking when the vehicle is maneuvring at low speeds and acute steering angles.
- In 'Grass / Gravel / Snow' mode the coupling is programmed to maintain its pre-charge state until much higher speeds are obtained. The same applies even if the vehicle is traveling at low speeds and acute steering angles, as traction takes precedence over coupling lock-up on low-friction surfaces.

For additional information, refer to Ride and Handling Optimization (204-06 Ride and Handling Optimization)

Mechanical Hydraulic Pump - Generation 3 Couplings - Vehicles up to 2009MY

The driveshaft is attached to the coupling's front clutch plate assembly (input), with the rear clutch plate assembly connected to the differential pinion (output). A swash-plate with 6 hydraulic rollers is also attached to the differential pinion. When there is no speed difference between the coupling's input and output, the rollers do not function.

However, when the front and rear axles start to rotate at different speeds, the swash-plate rotates relative to the rollers which generates the hydraulic pressure. This pressure is used to force the opposing clutch plates together, increasing the transmission of torque to the rear axle. As the difference in axle speed increases the hydraulic pressure pushes the clutch plates further together to increase the torque to the rear axle.

A control valve/axial solenoid controls the amount of pressure applied to the clutch plates, and hence the amount of torque transmitted to the rear wheels. Close manufacturing tolerances and exceptionally low component wear ensure torque control remains accurate throughout the vehicle's life.

Mechanical Hydraulic Pump - Generation 4 Couplings - Vehicles from 2009MY

The Generation 4 coupling does not use the swash plate to mechanically raise hydraulic pressure; instead, a new hydraulic pump is used to generate hydraulic pressure and force the clutch plates together. The removal of the swash plate allows a larger overall clutch plate surface area, which in turn reduces the hydraulic pressure requirement. The pressure required to achieve 1500Nm (1106 lb ft) has been reduced from 100 Bar for Generation 3 couplings to 40 Bar for Generation 4 couplings.

The positioning of the Generation 4 coupling's input and output remains the same as the Generation 3 coupling, as described above.

By-pass Valve

On very low friction surfaces, driveline drag torque can occur, for example:

- reverse torque from engine braking, or
- forced movement of the driveshaft by the front wheels.

This can influence rear wheel speed, making it impossible to determine the true friction capability of the rear wheels, by distorting the wheel speed signal. To prevent this, the active on-demand coupling is designed to open immediately in response to a stability control event. This is achieved by a by-pass valve instantly reducing system pressure to nominal.

To balance the 4 bar base pressure (see below for details), the Generation 3 coupling uses a large Belleville spring to force the clutch plates clear of each other to prevent torque transmission through the coupling. Even at 0°C, torque transmission is reduced from 300 Nm to Zero within 10 ms. The Generation 4 coupling however, does not require a Bellville spring to separate the plates as the coupling does not have a significant base pressure pushing the plates together.

Accumulator

The further the clutch plates have to move in order to contact each other, the longer it takes to displace the hydraulic fluid necessary to build pressure and transmit torque. To counter this, the Generation 3 coupling incorporates an accumulator. This retains a nominal 4 bar pressure within the hydraulic circuit. Although this is not enough pressure to cause significant torque transmission through the coupling, it forces the plates very close together so that very little fluid displacement is required to achieve full engagement and maximum torque transfer. Full torque transmission can be achieved in 150 ms.

On Generation 4 couplings, the 150ms activation time is achieved through the use of a Bellville spring that acts to push the plates together (without causing significant torque transmission through the coupling). As the pump is not continuously used to create this base pressure (as it was with Generation 3 coupling), improvements in fuel economy have been achieved.

Wet Clutch Pack

The clutch pack is made up of 7 pairs of plates; the inner discs are produced from hardened steel with the outer discs manufactured from steel with a sintered face. The clutch plates operate in transmission fluid.

Torque transmission across the clutch pack is limited to 1500 Nm (1106 lb ft). This ensures the lower gears retain an element of front-wheel-drive for traction stability. Within the higher gears the coupling is theoretically capable of transmitting all the drive to the rear axle; although conditions would have to be extreme for this to occur.

PRINCIPLES OF OPERATION

Generation 3 Couplings - up to 2009MY

An internal electronically-controlled pump provides hydraulic pre-charge pressure within the coupling. The pre-charge pressure supplies the required operating pressure to the clutch plates to eliminate initial wheel-spin as the vehicle accelerates from standstill.

In conjunction with the pre-charge pressure a mechanical hydraulic pump operates within the clutch plates to supply the coupling's main hydraulic operating pressure. The mechanical pump is functioned by the 'input' and 'output' of the coupling:

- input - driveshaft connection from the front axle,
- output - differential connection to the rear axle.

Any speed difference between the front and rear axles will start the operation of the mechanical hydraulic pump. The amount of hydraulic pressure applied to the clutch pack by the pump determines the gap between the clutch plates. For example, the greater the hydraulic pressure, the smaller the gap between the plates and subsequently the greater the torque transmitted through the coupling from the front axle to the rear axle.

This main hydraulic pressure is designed to transmit the torque for traction demands of off-road driving, and to provide lock-up as required.

Generation 4 Couplings - from 2009MY

The Generation 4 coupling still uses an electrically-controlled pump to provide hydraulic pre-charge to eliminate wheel-spin from standstill; however, the same pump is also used to provide the coupling's main hydraulic operating pressure.

The principles of transmitting torque through the clutch plates remains the same, as described above for the Generation 3 coupling.