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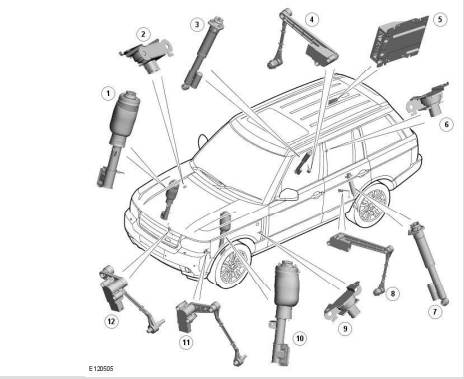
2011.0 RANGE ROVER (LM), 204-05

VEHICLE DYNAMIC SUSPENSION (G1246959)

COMPONENT LOCATION



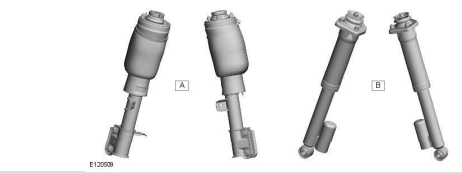
ITEM	DESCRIPTION
1	right-hand (RH) Front Shock Absorber Assembly
2	RH Front Accelerometer
3	RH Rear Shock Absorber Assembly
4	RH Rear Height Sensor
5	Adaptive Damping Module (ADM)
6	RH Rear Accelerometer
7	left-hand (LH) Rear Shock Absorber Assembly
8	LH Rear Height Sensor
9	LH Front Accelerometer
10	LH Front Shock Absorber Assembly
11	LH Front Height Sensor
12	RH Front Height Sensor

Continuously variable damping, known as Adaptive Dynamics, is available on Range Rover. Adaptive dynamics is an electronically controlled suspension system which continuously adjusts the damping characteristics of the suspension dampers in reaction to the current driving conditions.

Application of adaptive dynamics can be either a standard or option fit, dependant on vehicle variant.

The system is controlled by an Adaptive Damping Module (ADM). The ADM receives signals from three accelerometers, four suspension height sensors and from other vehicle systems to determine vehicle state, body and wheel motions and driver inputs. These signals are used by the ADM to continuously control the damping characteristics of each damper to the appropriate level resulting in optimum body control and vehicle ride.

DAMPERS



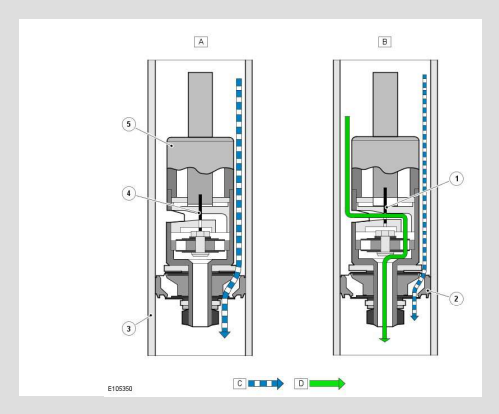
ITEM	DESCRIPTION
A	Front Dampers
B	Rear Dampers

The adaptive dynamics dampers are monotube, nitrogen gas and oil filled units. The dampers are continuously variable, which allows the damping force to be electrically adjusted when the vehicle is being driven. The dampers provide the optimum compromise between vehicle control and ride comfort. To maintain wheel travel, the rear dampers feature an additional external accumulator. This is to provide adequate rebound travel by recovering the volume through the external source. All the dampers have an electrical connector on the end of the piston rod, in the center of the top mount.

In each damper, the damping adjustment is achieved by a solenoid operated variable orifice, which opens up an alternative path for oil flow within the damper. When de-energized the bypass is closed and all the oil flows through the main (firm) piston. When energized the solenoid moves an armature and control blade, which work against a spring. The control blade incorporates an orifice which slides inside a sintered housing to open up the bypass as required. In compression, oil flows from the lower portion of the damper through a hollow piston rod, a separate soft (comfort) valve, the slider housing and orifice and into the upper portion of the damper, thereby bypassing the main (firm) valve. In rebound the oil flows in the opposite direction.

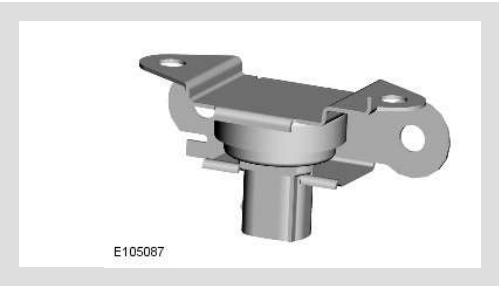
In the firm setting oil flows through the main (firm) valve only, but when the bypass is opened by any amount the oil flows through both valves in a pressure balance. When fully energized the solenoid moves the armature and therefore the slider to the maximum extension and opens the orifice completely. The damper operates continuously between these two boundary conditions.

The solenoid in each damper is operated by a 526 Hz PWM signal from the ADM. When fully energized, the ADM applies a 1.5 A current to operate the damper in the soft setting. When de-energized (0.0 A) the damper is in the firm setting. The current varies continuously as required to increase and decrease the damping individually in each of the dampers.



ITEM	DESCRIPTION
A	Firm Setting
B	Soft Setting
C	Main Oil Flow
D	Bypass oil flow
1	Bypass valve (open)
2	Main valve
3	Tube
4	Bypass valve (closed)
5	Piston and rod assembly

ACCELEROMETERS



Three accelerometers are used in the adaptive dynamics system.

Accelerometers locations are as follows

- Front left A pillar area (behind front wing)
- Front right A pillar area (behind front wing)
- Right rear luggage floor

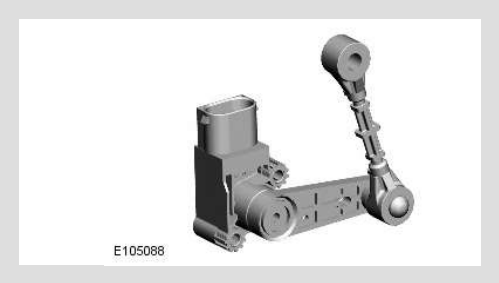
- Center front bulkhead area (below wind shield)
- Right rear luggage area (behind light unit)
- Left rear luggage area (below rear window)

The accelerometers measure acceleration in the vertical plane and output a corresponding analogue signal to the ADM. The algorithms in the ADM calculate the heave, pitch and roll motions of the vehicle, which are used by the controller to control road induced body modes.

Each accelerometer is connected to the ADM via three wires, which supply ground, 5 V supply and signal return.

The sensing element comprises a single parallel plate capacitor, one plate of which moves relative to the other dependant on the force (acceleration) applied. This causes the capacitance to change as a function of applied acceleration. This capacitance is compared with a fixed reference capacitor in a bridge circuit and the signal is processed by means of a dedicated integrated circuit to generate an output voltage that varies as a function of applied acceleration. The sensors output a signal voltage of approximately 1 V/g ± 0.05 V/g.

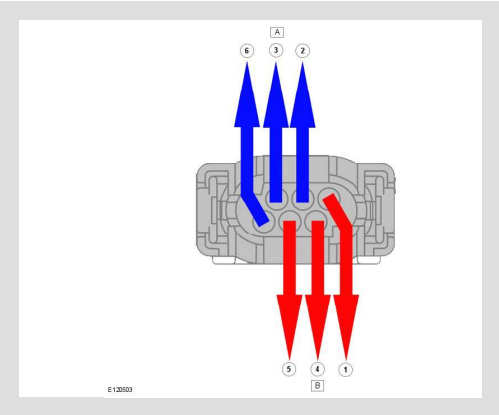
HEIGHT SENSORS



The four suspension height sensors that are used in the air suspension system also supply input to the adaptive dynamics system, two for the front suspension and two for the rear suspension. A front suspension height sensor is attached to each side of the front subframes and connected by a sensor arm and sensor link to the related lower lateral arm of the front suspension. A rear suspension height sensor is attached to each side of the rear subframe and connected by a sensor arm and sensor link to the related upper control arm of the rear suspension. On each suspension height sensor, the sensor arm and sensor link convert linear movement of the suspension into rotary movement of the sensor shaft.

The suspension height sensors measure suspension displacement at each corner of the vehicle and output a corresponding analogue signal to the ADM. The algorithms in the ADM calculate the position, velocity and frequency content of the signals and use the results for wheel control.

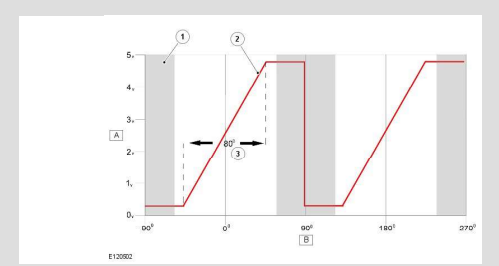
HEIGHT SENSOR WIRING



ITEM	DESCRIPTION
A	Adaptive Damping Module
B	Air Suspension Module
1	Ground
2	Ground
3	5v Supply
4	Signal Output (Air Suspension)
5	5v Supply
6	Signal Output (ADM)

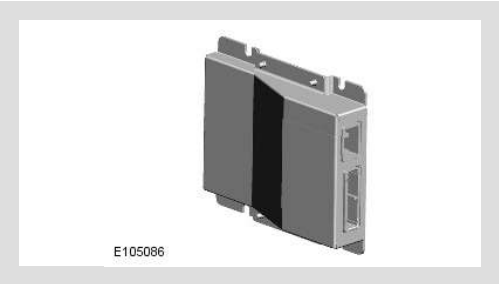
The sensing element consists of an array of hall effect devices arranged to measure the direction of the magnetic field of a small magnet attached to the end of the sensor shaft. As the sensor shaft rotates, so do the lines of magnetic flux from the magnet. The signals from the Hall effect elements are processed by means of a dedicated integrated circuit to generate an output voltage that varies as the sensor shaft is rotated. The sensor has a measurement range of ± 40° around its nominal position and the nominal sensitivity is 57 mV/° of shaft rotation. The graphic below [Fig:9] describes the repetition of the output signal as the sensor is rotated through and beyond 40°

Height Sensor Voltage



ITEM	DESCRIPTION
A	Sensor voltage
B	Angle of rotation
1	Outside measuring range
2	Voltage output
3	40 degree measuring range

ADAPTIVE DAMPING MODULE (ADM)



The adaptive damping module (ADM) is located in the RH rear quarter panel.

GENERAL

The air suspension system is a four corner system which is fitted to all models.

The system is electronically controlled by an air suspension control module which controls the air supply unit, reacts to inputs from four height sensors and distributes air around the system via valve blocks.

The main air suspension system components are:

- Air suspension control module
- Air supply unit
- Four height sensors
- Three valve block assemblies
- Reservoir
- Air harness
- Two front struts incorporating air spring damper modules
- Two rear air spring modules.
- Adaptive Damping Module (ADM)
- Air Suspension Switch

The four corner air suspension system maintains the vehicle height under all operating conditions by controlling the mass of air in the air springs. The air suspension control module uses signals from the four height sensors to maintain the correct suspension height, irrespective of vehicle load. Additionally, the system allows the driver to request ride height changes to improve off-road performance or ease access or loading. The system automatically adjusts the ride height to improve the vehicle handling and dynamics when speed increases or decreases. This is achieved by operating pneumatic control valves to increase or decrease the mass of air in the air springs.

The air suspension system has three driver selectable, pre-determined ride heights and an automated high speed ride height. A driver interface indicates the selected ride height and height change movement. Additional information is also relayed to the driver via the instrument cluster message center and by audible warnings also transmitted by the instrument cluster.

Most height changes can only be made when the engine is running and the driver's and passenger doors are closed.

The air suspension can be controlled manually by the driver using a switch on the floor console to select the required height change.

Access height can be selected using a switch on the floor console or a switch on the drivers door.

The system will temporarily inhibit height adjustments when the vehicle is subject to cornering, heavy acceleration or heavy braking. The inhibit function prevents unsettling of the vehicle by increasing the effective spring rates.

Height changes are also restricted for safety reasons, when a door is opened and the vehicle is stationary for example.

The air suspension system fitted to Range Rover is controlled by the air suspension control module which is located behind the RH rear quarter panel. The control module monitors the height of each corner of the vehicle via four height sensors, which are mounted in-board of each road wheel. The control module also performs an 'on-board diagnostic' function to perform 'health checks' on the system. If faults are detected, codes are stored in the control module and can be retrieved using the Land Rover approved diagnostic system.

The suspension geometry changes when moving from off-road to access heights. See the following table for data:

	FRONT	REAR
Toe change	30 mins	10 mins
Camber change	90 mins	90 mins

RIDE HEIGHT TOLERANCE CONTROL

The air suspension control module has two ride height tolerance bands; normal tolerance and tight tolerance.

The control module considers the vehicle to be at target height if the current height is within the appropriate tolerance band. Height adjustments are not made until the vehicle height falls outside of the tolerance band for a pre-determined time. The time period is different depending on if the vehicle is moving or stationary. The tolerance bands are as follows:

- Normal ± 10 mm
- Tight ± 3 mm.

The tight tolerance band is only used if set by the Land Rover approved diagnostic system for diagnostic purposes or when the vehicle has been stationary for more than 5 minutes.

OPERATING MODES

The driver can manually select, using the air suspension switch, one of four ride states:

- ON-ROAD - this height is the normal operating height of the vehicle
- OFF-ROAD - this height is higher than the on-road height and provides improved ground clearance, approach, departure and breakover angles
- ACCESS - this height is lower than the on-road height and makes entering and exiting the vehicle easier for the occupants
- CRAWL (Locked at access) - this mode allows the vehicle to be driven at the access height at low speeds to provide increased roof clearance in low car parks etc.

HIGH SPEED - A non-selectable, automatic high speed mode is provided which lowers the vehicle height to improve vehicle handling.

NOTE:

Vehicle height changes are restricted if the air suspension control module receives a 'Door Open' signal and the speed is less than 5 mph (8 km/h).

A complete vehicle delivery mode is available but is only selectable using the Land Rover approved diagnostic system. When this mode is active most vehicle systems, in addition to the air suspension, are inhibited or restricted to a minimal functionality. In this mode the air suspension is set to the transportation mode.

If the air suspension control module senses that the vehicle has grounded and lost traction, the control module can temporarily increase and/or redistribute the volume of air supplied to the affected air spring(s) to maximize the available traction. This is known as extended mode and will be indicated to the driver by the lamps on the air suspension switch flashing.

If the air suspension control module senses that the vehicle is prevented from moving upwards or downwards during a height change or leveling correction, the control module will adopt a safe state and further height changes will be suspended.

If a fault is detected by the air suspension control module, the control module will reduce the system functionality dependent on the type and severity of the fault. The control module will also store a fault code which can be retrieved using the Land Rover approved diagnostic system. If a severe fault occurs, the control module will attempt to put the vehicle in a safe condition. A fault is relayed to the driver by the instrument cluster message center and an audible warning emitted from the instrument cluster.

If the detected fault is minor and does not affect vehicle safety, the instrument cluster message center will display the message 'SUSPENSION FAULT' and a chime will be emitted. The fault should be investigated and rectified as soon as possible.

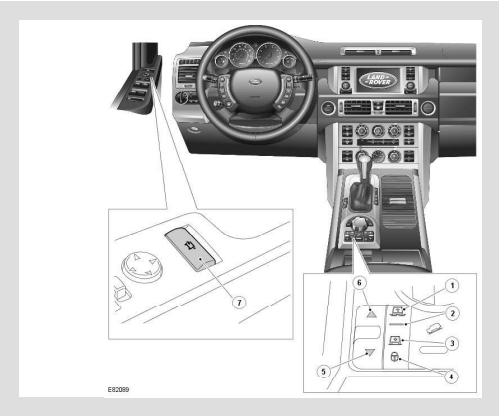
If the detected fault is more serious, the message center will display the message 'SUSPENSION FAULT NORMAL HEIGHT ONLY' and a chime will be emitted. The fault should be investigated and rectified as soon as possible.

If a fault is detected within the DSC (dynamic stability control) the message 'SUSPENSION LOWERED FOR SAFETY' and a chime will be emitted. This is not a fault with the air suspension system. The fault should be investigated and rectified as soon as possible.

If the detected fault is more severe the message center will display the message 'SUSPENSION FAULT MAX SPEED 50KPH' and two chimes will be emitted every thirty seconds if this speed is exceeded. The message will change to 'SUSPENSION FAULT' when the vehicle speed is reduced to less than 31 mph (50 km/h). The vehicle should be driven slowly until the fault is rectified.

All information messages will be displayed for four seconds.

Air Suspension Control Switch



ITEM	DESCRIPTION
1	Off-road height light emitting diode (LED)
2	On-road (normal) height LED
3	Access height LED
4	Crawl mode LED
5	Height change (lowering) switch and LED
6	Height change (raising) switch and LED
7	Drivers door module access switch

ON–ROAD MODE

This is the normal ride height for the vehicle.

OFF–ROAD MODE

Off-road mode will only be selectable if the vehicle speed is less than 25 mph (40 km/h). The vehicle will be raised 55 mm (2.2 in) higher than the on-road mode to provide additional body clearance and improved approach, departure and breakover angles. If the vehicle speed exceeds 31 mph (50 km/h), the air suspension control module will automatically lower the vehicle to the on-road mode height. At 25 to 28 mph (40 to 45 km/h) a message is displayed in the message center to warn the driver to slow down or the vehicle will lower.

ACCESS MODE

Access mode lowers the vehicle body height by 40 mm (1.6 in) and provides easier entry, exit and loading of the vehicle. Access mode can be pre-selected when the vehicle is moving. The vehicle will partly lower as the vehicle speed decreases, lowering to the full access mode height when the vehicle reaches 5 mph (8 km/h). If the required road speed is not reached within a predetermined time, the air suspension will return the vehicle to the previously selected height.

Access mode can be selected at any vehicle speed. When access mode is selected, the response of the air suspension system will depend on the vehicle speed:

- If the vehicle speed is more than 12.5 mph (20 km/h), the air suspension control module will wait for up to one minute for the vehicle speed to be reduced. The access mode LED and the lowering LED will flash while the air suspension control module waits for the vehicle speed to be reduced, the on-road mode lamp will remain illuminated. If the vehicle speed is not reduced sufficiently, the access mode request will be cancelled after 1 minute.
- If the vehicle speed is less than 12.5 mph (20 km/h), the air suspension control module will lower the suspension to a part lowered height and will remain at this height for up to one minute. The on-road mode lamp will extinguish as the air suspension control module lowers the suspension to the part lowered height. The access mode lamp and the lowering LED will illuminate. When part lowered is reached, the lowering LED will flash. If the vehicle speed is not reduced to less than 5 mph (8 km/h) in the one minute period, the access mode request will be cancelled.
- If the vehicle speed is less than 5 mph (8 km/h), the suspension will be lowered to access mode immediately. The access mode LED and the lowering LED will illuminate. When the access mode height is reached, the lowering LED will be extinguished.

Access height may be selected up to 40 seconds after the ignition is turned off, provided that the driver's door has not been opened within this time.

The suspension will automatically rise from access mode when the vehicle speed exceeds 6.2 mph (10 km/h). If access mode was selected directly from off-road mode then the system will return to off-road mode when the vehicle speed exceeds 6.2 mph (10 km/h). Otherwise the system will lift the suspension to On-road height.

Selecting Access Mode Directly from Off-Road Mode

When the suspension is in off-road mode height, pressing the 'Access' height change switch once, or pressing the lowering switch twice before the lowering LED is extinguished, the control module will lower the suspension to access mode height. The control module will remember to return the suspension to off-road height automatically if the vehicle speed increases above 6.2 mph (10 km/h).

Alternatively, pressing the drivers door module access switch once will perform the same function.

CRAWL (LOCKED AT ACCESS) MODE

Crawl mode allows the vehicle to be driven at low speeds with the suspension locked at the access mode height. This allows the vehicle to be driven in low car parks etc. with increased roof clearance.

Crawl mode can be selected up to 21.7 mph (35 km/h) with a long press of the switch in a down direction. The access mode lamp and the crawl mode lamp will be illuminated. When the control module is in crawl mode, on-road mode height will be selected automatically if the vehicle speed exceeds 24.8 mph (40 km/h). At 18.6 to 21.7 mph (30 to 35 km/h) a message is displayed in the message center to warn the driver to slow down or the vehicle will raise. Crawl mode can also be manually cancelled by moving the switch in the up direction for 1 second. The crawl mode lamp will now be extinguished.

HIGH SPEED MODE

High speed mode is a non-selectable, automatic mode which lowers the vehicle height by 20mm to improve vehicle handling. This feature is fully automated and is 'invisible' to the driver.

If the vehicle speed exceeds 100 mph (160 km/h) for more than five seconds, the air suspension control module initiates the high speed mode. When the vehicle speed reduces to less than 80 mph (130 km/h) for more than 30 seconds, the vehicle returns to the On-Road height. This function is cancelled if a trailer is connected to the trailer socket.

AUTOMATIC HEIGHT CHANGE WARNINGS

When the suspension is in off-road mode, access mode or crawl mode height, the air suspension control module will change the suspension height automatically when the vehicle speed exceeds a predetermined threshold.

When the suspension is at off-road mode or crawl mode height, the control module issues a warning to advise the driver that the vehicle is approaching the speed threshold. The instrument cluster sounder will emit a chime, a message will be displayed in the message center and the on-road mode LED and either the raising or lowering LED will flash.

The off-road mode or crawl mode height speed warning is removed when the vehicle speed is reduced.

SPECIAL MODES

DOOR OPEN FUNCTIONALITY

If one or more of the vehicle doors are opened during a height change when the vehicle is stationary, the air suspension control module will restrict further height change.

The LED on the air suspension LED display for the target mode height will remain illuminated and the raising or lowering LED will flash.

If all of the doors are closed within 90 seconds, the height change will resume. If the 90 second period is exceeded, the message 'CONFIRM REQUIRED SUSPENSION HEIGHT' will be displayed in the instrument cluster.

EXTENDED MODES

Raise Inhibit Raise inhibit is a reactive mode invoked when the following conditions are satisfied, vehicle speed below 10kph and vehicle raising very slowly. Raise inhibit is normally invoked when vehicle is lifting against an obstacle, it can also be used when the vehicle is winching or is tethered down.

JackingJacking is a reactive mode invoked when the following conditions are satisfied, vehicle stationary, system attempts to level the vehicle down and rate of vehicle lowering is below a predefined threshold for a predefined time. Jacking mode is normally invoked under the following conditions, vehicle jacking or vehicle grounded and stationary

Lower Inhibit Lower inhibit is a reactive mode invoked when the following conditions are satisfied, vehicle stationary, rate of vehicle lowering is below a predefined threshold for a predefined time. Lower inhibit is normally invoked under the following conditions, vehicle lowered onto an obstacle during a height change.

Belly-Out Belly-Out is a pro-active mode invoked when the following conditions are satisfied, vehicle moving and speed is below 50kph, traction activity is induced on axle pairs for fixed period of time and wheel heights above a predetermined threshold on coinciding axle pairs for the same fixed period of time. Belly-Out is normally invoked under the following condition, vehicle is attempting to move and with low levels of traction and supported by an obstacle.

Additional Lift Additional lift may be beneficial for extracting a stuck vehicle or trying to negotiate obstacles requiring pure ground clearance where a loss of articulation caused by the increase in ride height is acceptable. Additional lift can be activated the vehicle must be in extended mode

If the vehicle becomes grounded and the traction control becomes operational, the air suspension control module automatically increases the mass of air in the air springs to raise the vehicle clear of the obstruction. Extended mode is activated automatically and cannot be selected manually.

When the air suspension control module has activated the extended mode, the off-road mode lamp will flash if the suspension is above off-road mode height. The off-road mode and on-road mode lamps will flash if the suspension is between off-road mode and on-road mode heights. The on-road mode and access mode lamps will flash if the suspension is between on-road mode and access mode. A message will also be displayed in the message center.

To exit the extended mode, press the air suspension switch briefly in the up or down position or alternatively drive the vehicle at a speed of more than 2 mph (3 km/h) for 45 seconds.

ADDITIONAL LIFT IN EXTENDED MODE

When extended mode has been invoked and the automatic lifting of the vehicle is complete, the driver can request an additional lift of the vehicle. This can be particularly useful when extended mode has been activated on soft surfaces.

The additional lift can be requested once the height change LED has extinguished. Press and hold the air suspension switch in the up position for 3 seconds whilst simultaneously depressing the brake pedal. A chime from the instrument cluster will sound to confirm that the request has been accepted. The raising LED will be illuminated while the vehicle is being lifted.

SUSPENSION PREVENTED FROM MOVING

If the air suspension control module is attempting to change the suspension height and it detects that the suspension is prevented from moving, the control module will stop all suspension movement. This can be caused by jacking the vehicle, attempting to lower the vehicle onto an object or raising the vehicle against an obstruction.

The air suspension switch lamps operate as described for extended mode and the same message is displayed in the message center. To re-start the air suspension system operating, press the air suspension switch briefly in the up or down position or drive the vehicle at a speed of more than 2 mph (3 km/h) for 45 seconds.

PERIODIC RE–LEVELING

When the vehicle is parked, the air suspension control module 'wakes up' two hours after the ignition was last switched off and then once every twenty four hours. The vehicle height is checked and if the vehicle is not level within a pre-set tolerance, small downwards height adjustments may be made automatically.

TRANSPORTATION MODE

Transportation mode is a factory set mode which locks the suspension to enable the vehicle to be safely lashed to a transporter. The suspension transportation mode is automatically set when the vehicle is configured for delivery mode using the Land Rover approved diagnostic system. Delivery mode also affects other vehicle systems which are inhibited or restricted to a minimal functionality.

When the ignition switch is switched off, the vehicle will be lowered onto the bump stops. This ensures that the securing straps do not become loose should air leak from the air springs.

When transportation mode is active, the air suspension switches are disabled. Periodic re-leveling is also disabled.

When the engine is started, the air suspension control module will cause the vehicle to rise to a height of –20mm to allow sufficient ground clearance for the vehicle to be loaded. While the height is changing, all the LED's in the air suspension control switch will flash and a chime will be emitted by the instrument cluster. When the height of –20mm is reached, all the LED's will illuminate continuously and the chime will stop.

When the engine is switched off, the air suspension control module will cause the vehicle to lower to a height of –60 mm to allow the vehicle to be strapped down. While the height is changing, all the LED's in the air suspension control switch will flash. When the height of –60mm is reached, all the LED's will illuminate continuously.

CALIBRATION MODE

This mode is used when the air suspension control module has been replaced or a height sensor or suspension component has been dismantled or replaced.

The following conditions apply when the vehicle is in calibration mode:

- The ride height is set to tight tolerance
- Fault reaction to vehicle identification number (VIN) mis-match with the Car Configuration File (CCF) is disabled
- The raise, lower, access and hold switches are disabled
- System is controlled to on-road height only.

- Message "Air suspension not in customer mode" is displayed in the instrument pack.

AIR SUSPENSION COMPONENTS

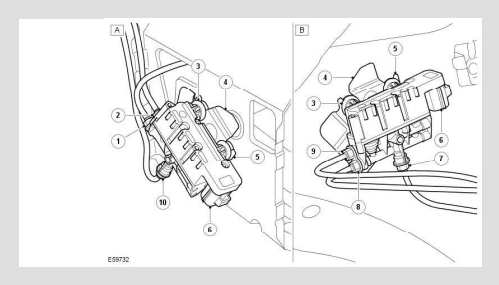
The air suspension comprises the following:

- Two front struts incorporating air springs
- Two rear air springs
- Front and rear valve blocks
- Reservoir valve block incorporating a pressure sensor
- An air reservoir
- Four height sensors
- Air supply unit
- Air suspension control module
- Air supply pipes
- Air suspension control switch.

The air suspension system is controlled by the air suspension control module. The control module is located in the RH rear quarter panel.

VALVE BLOCKS

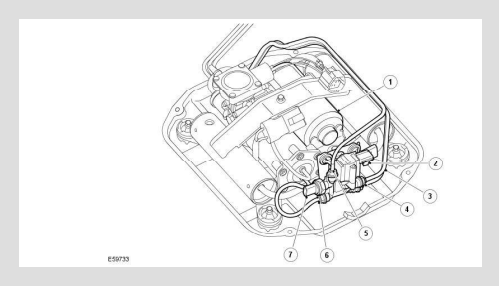
Front and Rear Valve Blocks



ITEM	DESCRIPTION
A	Front valve block
B	Rear valve block
1	Air inlet/outlet to reservoir valve block (Blue pipe)
2	RH front air spring harness connection (Yellow pipe)
3	Isolation rubber mounts
4	Mounting bracket

ITEM	DESCRIPTION
5	Location slots
6	Electrical connector
7	right-hand (RH) rear air spring harness connection (Yellow pipe)
8	Air inlet/outlet to reservoir valve block (Blue pipe)
9	left-hand (LH) rear air spring harness connection (Black pipe)
10	LH front air spring harness connection (Black pipe)

Reservoir Valve Block



ITEM	DESCRIPTION
1	Air supply unit
2	Electrical connector
3	Air harness connection to reservoir (Black pipe)
4	Air inlet/outlet to rear valve block (Blue pipe)
5	Air inlet/outlet to front valve block (Blue pipe with white tape)
6	Air harness connection to air supply unit (Black pipe)
7	Pressure sensor

Front and Rear Valve Blocks

The front and rear valve blocks are similar in their design and construction and control the air supply and distribution to the front or rear pairs of air spring damper modules respectively.

The difference between the two valves is the connections from the valve block to the left and right hand air spring damper modules and the valve size. It is important that the correct valve block is fitted to the correct axle. Fitting the incorrect valve block will not stop the air suspension system from functioning but will result in slow raise and lower times and uneven raising and lowering between the front and rear axles and may result in misleading diagnostic trouble code (DTC)'s being set.

The front valve block is attached to a bracket at the rear of the right hand front wheel arch, behind the wheel arch liner. The valve block has three attachment lugs which are fitted with isolation rubber mounts. The rubber mounts locate in 'V' shaped slots in the bracket. The valve lugs locate in the holes above the slots and are pushed downwards into positive location in the slots.

The rear valve block is attached to a bracket at the top of the right hand rear wheel arch, behind the wheel arch liner and adjacent to the fuel filler pipe. The valve block has three attachment lugs which are fitted with isolation rubber mounts which locate in the bracket in three slotted holes. The isolation rubber mounts locate in the 'V' shaped slots and are pushed downwards into positive location in the slots.

The front and rear valve blocks each have three air pipe connections which use 'Voss' type air fittings. One connection is an air pressure inlet/outlet from the reservoir valve block. The remaining two connections provide the pressure connections to the left and right hand air springs.

Each valve block contains three solenoid operated valves; two corner valves and one cross-link valve. Each of the valve solenoids is individually controlled by the air suspension control module.

Reservoir Valve Block

The four way reservoir valve block is located in the air supply unit sealed housing. The valve block is attached to a bracket at the rear of the air supply unit on three attachment lugs which are fitted with isolation rubber mounts. The isolation rubber mounts locate in the 'V' shaped slots in the bracket and are pushed downwards into positive location in the slots.

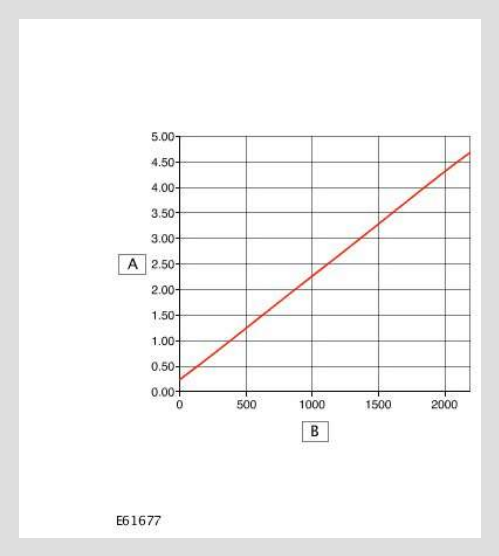
The valve block controls the storage and distribution of air from the air supply unit and the reservoir and contains an integral system pressure sensor.

The valve block has four air pipe connections which use 'Voss' type air fittings. The connections provide for air supply from the air supply unit, air supply to and from the reservoir and air supply to and from the front and rear valve blocks. The connections from the air supply unit and the front and rear control valves are all connected via a common gallery within the valve block and therefore are all subject to the same air pressures.

The valve block contains a solenoid operated valve which is controlled by the air suspension control module. The solenoid valve controls the air supply to and from the reservoir. When energized, the solenoid opens the valve allowing air to pass to or from the reservoir.

The valve block also contains a pressure sensor which can be used to measure the system air pressure in the air springs and the reservoir. The pressure sensor is connected via a harness connector to the air suspension control module. The control module provides a 5V reference voltage to the pressure sensor and monitors the return signal voltage from the sensor. Using this sensor, the control module controls the air supply unit operation and therefore limits the nominal system operating pressure to 14.5 bar gage (210 lbf/in ^{2}).

The following graph shows nominal pressure values against sensor output voltage.



ITEM	DESCRIPTION
A	Output voltage (V)
B	Pressure (kPa)

Removal of the reservoir valve block will require full depressurization of the reservoir. The valve block is a non-serviceable item and should not be disassembled other than for replacement of the pressure sensor.

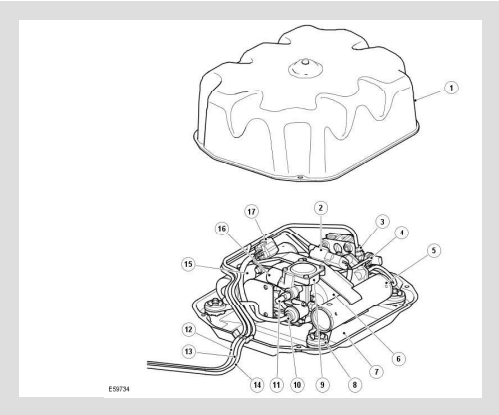
Valve Block Solenoid Specifications

DESCRIPTION	VALUE
Coil resistance at 20°C (68°F)	2.05 Ohms ± 10%

NOTE:

Resistance values will vary with coil temperature. Resistance of test leads must be measured before any readings are taken. Resistance value of the test leads must be subtracted from final solenoid resistance value.

AIR SUPPLY UNIT



ITEM	DESCRIPTION
1	Cover
2	Motor electrical connector
3	Reservoir valve block
4	Pilot air pipe
5	Secondary silencer
6	Air dryer
7	Base plate
8	Rubber mount (4 off)
9	Exhaust valve
10	Intake pipe
11	Exhaust silencer
12	Air harness to front valve block
13	Air harness to reservoir
14	Air harness to rear valve block
15	Secondary silencer
16	Pilot exhaust valve
17	Solenoid and sensors electrical connector

The air supply unit fitted from 2006MY is an improved unit providing quieter operation. Two silencer units are incorporated into the unit assembly to reduce operating noise.

The air supply unit is located in a housing which is mounted in the spare wheel well and secured with four bolts into threaded inserts to the vehicle floorpan. The unit is isolated from the vehicle body via four rubber isolation mounts.

The reservoir valve block is also located within the housing on a separate bracket at the rear of the unit.

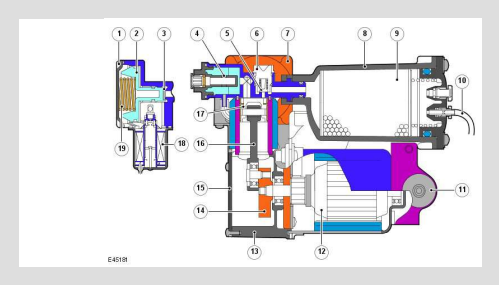
The unit is connected to the system via a single air pipe to the reservoir valve block. Three air pipes from the reservoir valve block pass through an aperture in the unit housing and through a grommet in the wheel well. It is important to ensure that this grommet is not disturbed and correctly installed. Incorrect fitment will allow water to enter the wheel well leading to possible damage to and failure of the air supply unit.

The unit comprises a piston compressor, a 12V electric motor, a solenoid operated exhaust pilot valve, a pressure relief valve, an air dryer unit and two silencers.

The electric motor, compressor, air dryer and pressure limiting and exhaust valve are mounted on a frame which in turn is mounted on flexible rubber mountings to reduce operating noise. The unit is mounted on a pressed base plate which is located on the floor of the wheel well. The unit is protected by a pressed cover which is lined with an insulating foam further limiting the operating noise.

The air supply unit can be serviced in the event of component failure, but is limited to the following components; air dryer, pilot exhaust pipe and the rubber mounts. Removal of the air supply unit does not require the whole air suspension system to be depressurized. The front and rear valve blocks and the reservoir valve block are normally closed when de-energized, preventing air pressure in the air springs and the reservoir escaping when the unit is disconnected.

There are a number of conditions that will inhibit operation of the air supply unit. It is vitally important that these system inhibits are not confused with a system malfunction. A full list of air supply unit inhibits are given in the air suspension control module section in this chapter.



ITEM	DESCRIPTION
1	Exhaust valve cap
2	Plunger
3	Valve seat
4	Intake silencer port
5	Delivery valve

ITEM	DESCRIPTION
6	Valve guide
7	Cylinder head
8	Dryer case
9	Desiccant
10	Pilot air pipe
11	Isolation rubber mount (not fitted to Range Rover)
12	Motor assembly
13	Crankcase
14	Crank
15	Crankcase cover
16	Connecting rod
17	Piston
18	Pilot exhaust valve
19	Spring - slave valve (pressure relief)

Electric Motor

The electric motor is a 12V dc motor with a nominal operating voltage of 13.5V. The motor drives a crank which has an eccentric pin to which the compressor connecting rod is attached.

The motor is fitted with a temperature sensor on the brush Printed Circuit Board (PCB) assembly. The sensor is connected to the air suspension control module which monitors the motor temperature and can suspend motor operation if the operating thresholds are exceeded.

The following table shows the control module operating parameters for the differing air supply unit functions and the allowed motor operating temperatures.

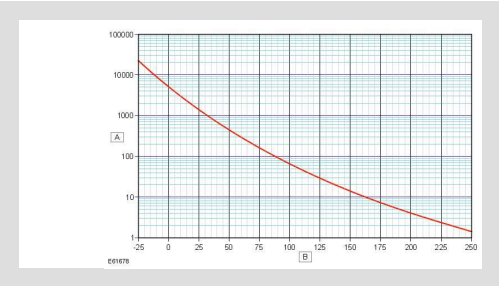
Motor Operating Temperatures

	LEVELING	RESERVOIR FILLING
OFF	140°C (284°F)	130°C (266°C)
ON	120°C (248°F)	110°C (230°F)

The following graph shows motor temperature sensor resistance values against given temperatures.

NOTE:

This graph is also applicable for the compressor cylinder head temperature sensor.

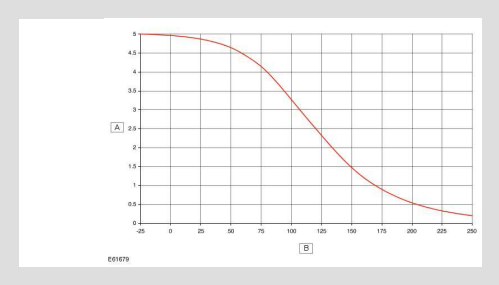


ITEM	DESCRIPTION
A	Resistance (kOhms)
B	Temperature (°C)

The following graph shows air suspension control module output voltages against motor temperature sensor temperatures.

NOTE:

This graph is also applicable for the compressor cylinder head temperature sensor.



ITEM	DESCRIPTION
A	Control module input voltage (V)
B	Temperature sensor (°C)

Compressor

The compressor is used to supply air pressure to the air suspension reservoir. The air suspension control module monitors the pressure within the reservoir and, when the engine is running, maintains a pressure of 14.5 bar gage (210 lbf/in ^{2}).

The compressor comprises a motor driven connecting rod and piston which operate in a cylinder with a separate cylinder head. The motor rotates the crank moving the piston up and down in the cylinder bore. The air in the cylinder is compressed with the up stroke and is passed via the delivery valve through the air dryer and into the system.

The cylinder head is fitted with a temperature sensor. The sensor is connected to the air suspension control module which monitors the cylinder temperature and can suspend motor and compressor operation if an overheat condition occurs.

The following table shows the control module operating parameters for the differing air supply unit functions and the allowed compressor cylinder head operating temperatures.

Compressor Cylinder Head Operating Temperatures

	LEVELING	RESERVOIR FILLING
OFF	140°C (284°F)	130°C (266°C)
ON	120°C (248°F)	110°C (230°F)

Refer to the motor temperature sensor graph for compressor cylinder head temperature sensor resistance values and the air suspension control module output voltage / temperature sensor graph.

Air Dryer

Attached to the compressor is the air dryer which contains a Desiccant for removing moisture from the compressed air. Pressurized air is passed through the air dryer which removes any moisture in the compressed air before it is passed into the reservoir and/or the system.

When the air springs are deflated, the exhaust air also passes through the air dryer, removing the moisture from the unit and regenerating the Desiccant.

The air dryer is an essential component in the system ensuring that only dry air is present in the system. If moist air is present, freezing can occur resulting in poor system operation or component malfunction or failure.

Pilot Exhaust Valve

Attached to the cylinder head is a solenoid operated exhaust pilot valve. This valve is opened when the air springs are to be deflated.

The pilot exhaust valve is connected to the air delivery gallery, downstream of the air dryer. The pilot valve, when opened, operates the compressor exhaust valve allowing the air springs to be deflated.

When the solenoid is energized, pilot air moves the exhaust valve plunger, allowing pressurized air from the air springs and/or the reservoir to pass through the air dryer to atmosphere.

Exhaust Valve

The exhaust valve operates when the pilot exhaust valve is opened, allowing air returning from the air springs and/or the reservoir to be exhausted quickly.

The pilot exhaust valve also provides the system pressure relief function which protects the air springs from over inflation. The valve is pneumatically operated, responding to air pressure applied to it to overcome pressure from its internal spring. The valve is connected into the main pressure gallery which is always subject to the system pressure available in either the air springs or the reservoir. The valve is controlled by a spring which restricts the maximum operating pressure to between 22 to 27 bar gage (319 to 391 lbf/in ^{2}).

The minimum pressure in the system is also controlled by the exhaust valve to ensure that, even when deflated, the air springs contain a positive pressure with respect to atmosphere. This protects the air spring by ensuring it can still 'roll' over the piston without creasing.

Air Supply Unit Specifications

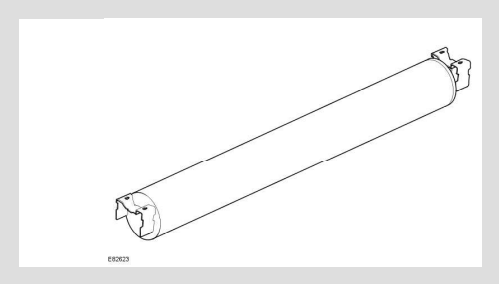
DESCRIPTION	VALUE
Working pressure	14.5 bar gage
Maximum pressure (stabilized)	22.0 to 27.0 bar gage
Operating voltage	10 to 16.5 Volts (13.5 Volts nominal)
Running current consumption	20-50 Amps depending on load
Maximum start-up current	120 Amps
Pilot Exhaust Valve - Solenoid valve resistance at 20°C (68°F)	4 Ohms ± 10%

NOTE:

Resistance values will vary with coil temperature. Resistance of test leads must be measured before any readings are taken. Resistance value of the test leads must be subtracted from final solenoid resistance value.

There are a number of conditions that will inhibit operation of the air suspension compressor. It is vitally important that these inhibits are not confused with a system malfunction. A full list of compressor inhibits is contained in the Air Suspension Control section.

RESERVOIR



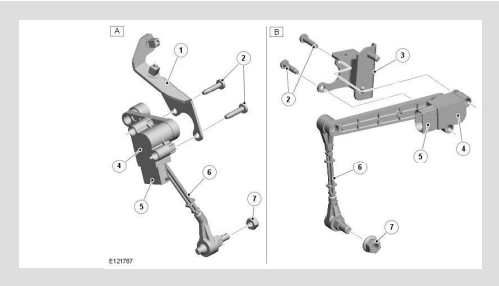
The reservoir is an air storage vessel which provides fast air suspension lift times by the immediate availability of pressurized air into the system.

The reservoir is located under the RH sill of the vehicle and is fabricated from steel and secured with four bolts to the underside of the vehicle.

The reservoir supplies pressurized air to the four air springs, via the valve blocks, to enable the air suspension system to carry out ride height changes.

The rearward end of the reservoir has a 'Voss' air fitting which provides for the connection of the air hose between the reservoir and the reservoir valve block. The reservoir has a capacity of 9.5 liters (580 in ^{3}). The nominal working pressure of the reservoir is 14.5 bar gage (210 lbf/in ^{2}), with a maximum pressure of 22 bar gage (319 lbf/in ^{2}).

HEIGHT SENSORS



ITEM	DESCRIPTION
1	Bracket - front sensor
2	Screw
3	Bracket - rear sensor
4	Sensor
5	Electrical connector
6	Lever arm and drop link
7	Nut

A height sensor is fitted in each corner of the vehicle to monitor the ride height of the vehicle. The sensors are mounted on the front and rear subframes, with a mechanical link to the suspension lower arms. There are four different types of sensor fitted.

If a height sensor is removed from its mounting position for servicing or replacement, the Land Rover approved diagnostic system must be used to recalibrate the system. Calibration will also be required if the suspension arm to which the sensor is connected is removed or replaced or if a replacement drop link is fitted.

A calibration routine is performed using the Land Rover approved diagnostic system to read the position of each corner of the vehicle and record the settings in the control module memory. Once set, the calibration is not required to

be performed unless the air suspension control module is removed or replaced, a height sensor is removed or replaced or a suspension arm to which the sensor is connected is removed or replaced. If the removed height sensor is subsequently refitted, the calibration procedure will have to be performed to ensure the integrity of the system.

The height sensors are attached to brackets on the subframes and are connected to the lower arms by links. The links allow articulation of the arm to allow for suspension travel. Each sensor is connected by a six pin multiplug.

The front and rear sensor drop links are serviceable items.

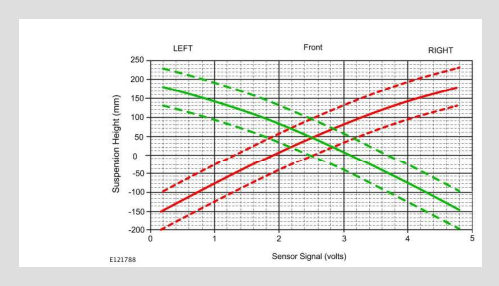
The four suspension height sensors that are used in the air suspension system also supply input to the adaptive dynamics system, two for the front suspension and two for the rear suspension. A front suspension height sensor is attached to each side of the front subframes and connected by a sensor arm and sensor link to the related lower lateral arm of the front suspension. A rear suspension height sensor is attached to each side of the rear subframe and connected by a sensor arm and sensor link to the related upper control arm of the rear suspension. On each suspension height sensor, the sensor arm and sensor link convert linear movement of the suspension into rotary movement of the sensor shaft.

The suspension height sensors measure suspension displacement at each corner of the vehicle and output a corresponding analogue signal to the air suspension module. The algorithms in the air suspension module calculate the position, velocity and frequency content of the signals and use the results for wheel control.

The sensors can be checked by applying 5V across the positive and negative terminals and measuring output signal which should be a nominal 57mV ± 3% per degree of sensor arm movement.

The following graph shows the vehicle height displacement from normal against output voltage for the front height sensors. The center line represents the "nominal" condition but depending on tolerances, the actual line may lie anywhere between the upper and lower lines.

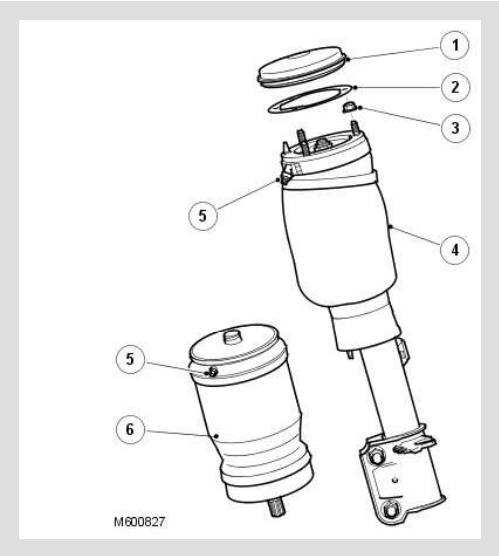
Front Height Sensor



The following graph shows the vehicle height displacement from normal against output voltage for the rear height sensors. The center line represents the "nominal" condition but depending on tolerances, the actual line may lie anywhere between the upper and lower lines.

Rear Height Sensor

AIR SPRINGS



ITEM	DESCRIPTION
1	Cover
2	Seal plate
3	Nut
4	Front air spring
5	Air hose connector
6	Rear air spring

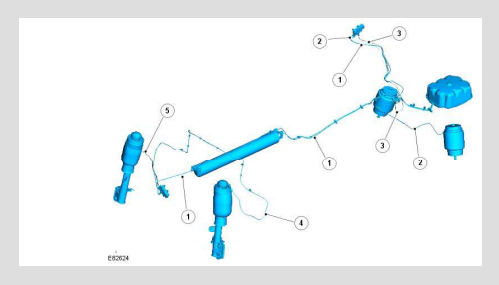
The air springs on the front and rear suspension are similar in construction. The air springs are manufactured from a flexible rubber and each air spring forms an air tight cavity which provides the required spring rate for each corner of the vehicle.

As the air spring is compressed, the rubber material compresses and rolls down the side of the vertical housing (piston) below the spring. An air connection port is located on the top of each spring and allows air to be added or removed from each spring. The port is connected via a Voss connector and a plastic tube to the axle valve block.

Replacement of an individual air spring does not require a full depressurization of the air suspension system. Only the corner concerned need be depressurized. This is achieved using a routine in the Land Rover approved diagnostic system.

When servicing of an air spring or a full system depressurization is required, the weight of the vehicle must be supported before the system is depressurized. On reassembly, the air spring must be fully pressurized before the weight of the vehicle is applied to it.

AIR HARNESS



ITEM	DESCRIPTION
1	Pipe - Main harness
2	Pipe - Rear valve block to rear left hand air spring
3	Pipe - Rear valve block to rear right hand spring
4	Pipe - Front valve block to front left hand air spring
5	Pipe - Front valve block to front right hand air spring

The system is interconnected via 6 mm diameter blue, yellow and black colored nylon pipes. The yellow pipes denote the right hand side and the black pipes denote the left hand side. Blue colored pipes are used to show the pipes which connect the front and rear valve blocks to the reservoir valve.

The air harness comprises a main harness which is located along the full length of the vehicle and connects the reservoir valve block to the front and rear valve blocks and the reservoir and four separate harnesses which are used to connect each valve block to the air springs.

The pipes are attached to the subframes and vehicle body with clips. To ensure that the correct routing is maintained, the pipes have timing marks which align with various clip positions. The timing marks are in the form of a white band around the pipe, indicating the clip position. If the correct routing is not achieved, unnecessary tension at the pipe joints will occur resulting in possible early failure.

If a pipe becomes damaged, an in-line connector is available for repair purposes. The pipes are secured to the body and the chassis with a number of plastic clips.

LEAK DETECTION

Leak detection can be carried out using a Land Rover approved leak detection spray.

If the vehicle appears to be leaking, perform a leak check on all aspects of the system, i.e.; air spring hose fittings and the associated connections on the valve blocks, air springs and reservoir. Failure to correctly diagnose leakage will result in unnecessary exchange of serviceable components and recurrence of original problem.

AIR SUSPENSION CONTROL MODULE

The air suspension system fitted to Range Rover is controlled by the air suspension control module which is located in the RH rear quarter panel.

The control module monitors the height of each corner of the vehicle via four height sensors, which are mounted in-board of each road wheel.

The control module has the following modes of operation:

- Calibration
- Normal
- Periodic Wake-Up.

When a new air suspension control module is fitted, the air suspension system will not function until the air suspension software is loaded and the system calibrated using the Land Rover approved diagnostic system.

CALIBRATION

A calibration routine is performed using the Land Rover approved diagnostic system to access the position of each corner of the vehicle and record the settings in the control module memory. Once set, the calibration is not required to be performed unless the air suspension control module is removed or replaced, a height sensor or bracket is removed, replaced or disturbed or a suspension arm to which the sensor is connected is removed or replaced. If the removed height sensor is subsequently refitted, the calibration procedure will have to be performed to ensure the integrity of the system.

If the air supply unit, the reservoir, a valve block, a damper module or the air harness is removed or replaced, the system will not require recalibration.

PERIODIC WAKE–UP MODE

When the vehicle is parked, the air suspension control module 'wakes up' two hours after the ignition was last switched off and once every twenty four hours thereafter. The vehicle height is checked and if the vehicle is not level within a pre-set tolerance, small downwards height adjustments may be made automatically.

SYSTEM OPERATION

Under normal operating conditions, the air suspension control module keeps the vehicle level at the 'current' ride height. The incoming height signals from the sensors are passed through filters to remove irregular signals produced by road noise or other irregularities. When the vehicle is stationary or a height change is in progress, the signals are passed through a 'fast' filter, which tracks the true rate of change of height. When the vehicle is moving, the signals are passed through a 'slow' filter. The 'slow' filtered signals remove almost all road noise from the signals and output a true long term average for each corner height. The 'slow' filtered signals cannot be used to respond quickly during height changes.

The air suspension control module monitors each corner height signal using the fast filtered signals if the vehicle is stationary or the slow filtered signals if the vehicle is moving. If the height remains in a 'dead band' which is ±10 mm from the target height, the control module does not implement any height adjustment changes. When the control module detects that a corner has moved outside of the 'dead band', the control module operates the compressor and /or the valves to raise or lower the corresponding corner(s) back into the target height.

SYSTEM INHIBITS

A number of conditions exist where a change in ride height is undesirable. To counter this, the air suspension control module is programmed with a number of system inhibits. If any of the conditions detailed below exist, the air suspension control module will suspend height changes and height corrections.

COMPRESSOR

Compressor Temperature

Two temperature sensors are located within the compressor to prevent overheating. If the temperature of the motor brush assembly or the compressor cylinder head rise above pre-set limits, the air suspension control module will inhibit the compressor operation. The limits are detailed in tables in the Air Supply Unit section of this manual.

CORNERING

If the air suspension control module registers a cornering force greater than 0.2g it will inhibit all height changes and corrections. The system will remain inhibited until the cornering force falls to less than 0.15g. The air suspension control module receives a message from the lateral acceleration sensor (which is an integral part of the anti-lock brake system (ABS) yaw rate sensor) on the high speed controller area network (CAN) bus for the cornering force.

RAPID ACCELERATION

If the air suspension control module registers a rapid acceleration greater than 0.2g it will inhibit all height changes and corrections. The system will remain inhibited until the rapid acceleration falls to less than 0.15g. Acceleration is calculated by the control module from a vehicle speed signal received via the high speed CAN bus.

RAPID DECELERATION

If the air suspension control module registers a rapid deceleration smaller than - 0.2g it will inhibit all height changes and corrections. The system will remain inhibited until the rapid deceleration rises above - 0.15g. Deceleration is calculated by the control module from a vehicle speed signal received via the high speed CAN bus.

VEHICLE JACK

The air suspension control module will inhibit all height changes and corrections if it detects a corner lowering too slowly for more than 1.2 seconds. This is interpreted as the corner identified as moving too slowly being supported on a jack. In this situation, the corner height will not change when air is released from the air spring because the jack acts as a mechanical prop.

The system will remain inhibited until any of the following conditions exist:

- The air suspension rotary switch is moved to the up or down position
- The vehicle speed rises to more than 2 mph (3 km/h) for more than 45 seconds.

DOOR OPEN

The air suspension control module will stop all height change requests while any of the doors are open. Vehicle leveling continues with a door open by keeping the vehicle at the height when the door was opened if the vehicle load changes. Door open status is ignored when the vehicle speed is above 5 km/h.

DIAGNOSTICS

The air suspension control module can store fault codes which can be retrieved using the Land Rover approved diagnostic system. The diagnostics information is obtained via the diagnostic socket which is located below the instrument panel, above the drivers foot pedals. The socket is protected by a hinged cover.

The diagnostic socket allows the exchange of information between the various control modules on the bus systems and the Land Rover approved diagnostic system. This allows the fast retrieval of diagnostic information and programming of certain functions using the Land Rover approved diagnostic system.

FAULT MESSAGES

The air suspension has two methods which it can use to inform the driver of a fault in the air suspension system; the air suspension control switch LED's and the instrument cluster message center.

If the air suspension control module suffers a major failure and there is no air suspension control, all the control switch LED's will remain unlit.

If a fault occurs and the control module can determine the ride height and the vehicle is not above on-road height, the driver will be notified via a message in the message center. If the control module cannot determine the height of the vehicle, or the vehicle is above on-road height and cannot be lowered, a message is displayed and accompanied with a maximum speed message.

For additional information, refer to: Information and Message Center (413-08 Information and Message Center, Description and Operation).

RESERVOIR

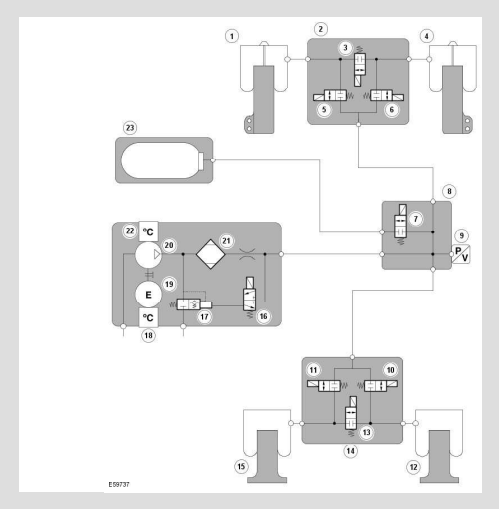
The reservoir supplies pressurized air to the four air springs, via the reservoir valve block, to enable the air suspension system to raise the vehicle more quickly.

The air suspension control module assumes the reservoir has sufficient pressure, which is measured before a vehicle raise is started. The control module then uses a software model to operate the compressor as required.

SYSTEM PNEUMATIC CIRCUIT

The following schematic diagram shows the connection relationship between the air supply unit, the reservoir, the reservoir valve block, the cross-link valves and the air springs.

System Schematic Circuit Diagram



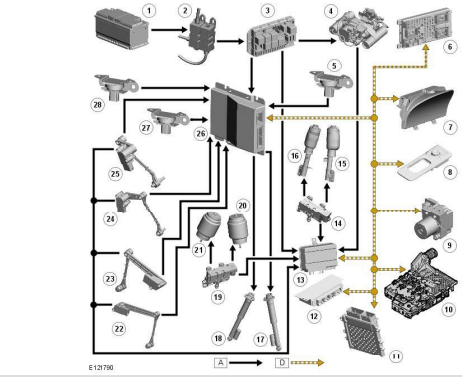
ITEM	DESCRIPTION
1	Front left hand air spring
2	Front valve block
3	Cross link valve
4	Front right hand air spring
5	Front left hand corner valve
6	Front right hand corner valve
7	Reservoir valve
8	Reservoir valve block

ITEM	DESCRIPTION
9	Pressure sensor
10	Rear right hand corner valve
11	Rear left hand corner valve
12	Rear right hand air spring
13	Cross link valve
14	Rear valve block
15	Rear left hand air spring
16	Pilot exhaust valve
17	Pressure relief and exhaust valve
18	Motor temperature sensor
19	Electric motor
20	Compressor
21	Air dryer
22	Compressor temperature sensor
23	Reservoir

AIR SUSPENSION CONTROL DIAGRAM

NOTE:

A = Hardwired; **D** = High speed CAN bus



ITEM	DESCRIPTION
1	Battery

ITEM	DESCRIPTION
2	Battery Junction Box 2
3	Rear Fuse Box
4	Compressor
5	Accelerometer
6	Central Junction Box
7	Instrument Cluster
8	Terrain Response Selector/Air Suspension Control Switch
9	anti-lock brake system (ABS) Module
10	Automatic Transmission Control Module
11	engine control module (ECM)
12	Rear Differential Control Module
13	Air Suspension Control Module
14	Front Cross Link Valve
15	RH Front Spring and Shock Absorber Assembly
16	LH Front Spring and Shock Absorber Assembly
17	RH Rear Shock Absorber Assembly
18	LH Rear Shock Absorber Assembly
19	Rear Cross Link Valve
20	RH Rear Air Spring
21	LH Rear Air Spring
22	Height Sensor
23	Height Sensor
24	Height Sensor
25	Height Sensor
26	Active Damping Module
27	Accelerometer
28	Accelerometer