New Discovery

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TECHNICAL ACADEMY

PART OF ROVER GROUP

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INTRODUCTION

The first Land Rover vehicle was revealed to the public at the Amsterdam Motor Show in 1948. It was designed to address the demanding and specialist needs of the utility market, which was at the time, dominated by farmers and military users.

Since then, the company has developed its model range carefully in a controlled and deliberate manner, and has influenced heavily the significant growth of the 4x4 market. Land Rover has generated a reputation for the design and production of four wheel drive vehicles that is second to none. This reputation has been built on a small but impressive range of vehicles which have earned almost icon status within their respective market niches.

Defender

The original Land Rover evolved into the Defender model range, which continues in production today (albeit with no more than a passing resemblance to the original vehicle). The Defender model range is now widely recognised as the ultimate utility vehicle.

Figure 1

Range Rover

The second vehicle designed and produced by Land Rover was introduced in 1970. This dual purpose vehicle was aimed at the luxury end of the four wheel drive market and combined impressive on road and off-road performance. The Range Rover, which subsequently evolved into the Range Rover Classic, was superseded by the New Range Rover in 1994. This model, which continues in production today, has been continuously developed since its introduction and maintains its position at the pinnacle of the luxury four wheel drive market.

Figure 2

Discovery

Figure 3

The third new Land Rover vehicle was revealed to the motoring public at the Frankfurt Motor Show in 1989. The Discovery model range was introduced to exploit the potential of the leisure segment of the four wheel drive market. It combines strength, on road and off-road capability and versatility, and continues to capture a significant proportion of the four wheel drive leisure market.

Freelander

Figure 4

In 1997 Land Rover introduced Freelander. This model range saw a significant departure from the traditional Land Rover engineering format and carried the Land Rover brand into the medium and small segments of the four wheel drive leisure market. Again, Land Rover has captured the leading position within the market segment and continues to develop its position.

LAND ROVER DISCOVERY

Each and every model range produced by Land Rover has been developed and improved continuously during its life cycle. The focus of development in all cases has been on upgrading the technical specification of the vehicle to enhance its capabilities and performance and to broaden its appeal. The Discovery model range has been exposed to this process since its introduction (detailed on following page) where it has led the market within the leisure sector.

The company has now introduced a completely new Discovery. This model is to be referred to in all communications as New Discovery, although it will be badged Series II. The concept of subjecting the Discovery model range to a major redesign follows a similar action taken on Range Rover, which saw the introduction of the New Range Rover in 1994. An overview of the design and specification of New Discovery and descriptions of its major features, are given in the following pages.

As previously mentioned, Discovery (the third major derivative produced by Land Rover), was designed to compete in the leisure segment of the 4x4 market. The Discovery was launched initially in November 1989 in three door configuration only. However, it was subsequently made available in both three and five door models.

Figure 5

Discovery utilised a Range Rover chassis. It featured coil sprung live axles at the front and rear. The front axle was located by two radius arms, which controlled fore and aft movement, and a Panhard rod, which controlled lateral movement. The rear axle was also located by two radius arms but used an A frame to control lateral movement in place of the Panhard rod.

At launch, Discovery vehicles were available in both diesel and petrol versions. The two engines used were a turbocharged four cylinder 2.5 litre, 200 Tdi diesel engine, which featured direct injection, and the tried and trusted 3.5 litre V8i petrol engine. Irrespective of the type of engine, Discovery vehicles were fitted with an LT77 5-speed manual gearbox and an LT230T transfer gearbox.

Land Rover Discovery - notable developments

Many changes were made to the specification of the Discovery model range over the period of its life cycle. Brief details of the most notable changes and developments are given below:

Year	Feature
1989	• Discovery model introduced (3 door only)
1990	• 5-door derivative • carburettors replaced by fuel injection
1991	• LT77S improved 5 -speed gearbox
1992	• deletion of the non-catalyst UK derivative • automatic transmission introduced on petrol derivatives only
1993	• 2.0 litre Mpi petrol derivative • larger capacity (3.9 litre) V8 engine
1994	• redesigned exterior (including new headlamps) • redesigned interior (including trim, fascia and switchgear) • new 300 Tdi diesel engine (developed from 200 Tdi) • anti-lock braking system ABS 4-channel • new R380 5-speed manual gearbox replaced LT77S • availability of supplementary restraint system (driver and passenger airbags) SRS • automatic transmission became available on vehicles fitted with a diesel engine
1995	• enhanced integrated security system
1996	• further enhancements made to security system • change to a single point sensed supplementary restraint system • LT230Q revised transfer gearbox replaced LT230T unit
1997	• continued development
1998	• introduction of “New Discovery”

***Note**: In access of 350,000 Discoverys have been produced by Land Rover since 1989.*

4x4 market developments

The need for Land Rover to introduce New Discovery was born out of the recent and potential developments in the 4x4 market. Its introduction will also be supported by the successful launch of the Land Rover Freelander, which gives Land Rover a presence within the Small and Medium leisure segments.

The introduction of New Discovery provides tangible evidence of the company's desire to continue the phenomenal success of Discovery and to capitalise on the significant market share it commands. Opportunity will be taken to reposition New Discovery as a premium product, soley within the Large Leisure segment using key attributes of technical innovation and breadth of capability to support this.

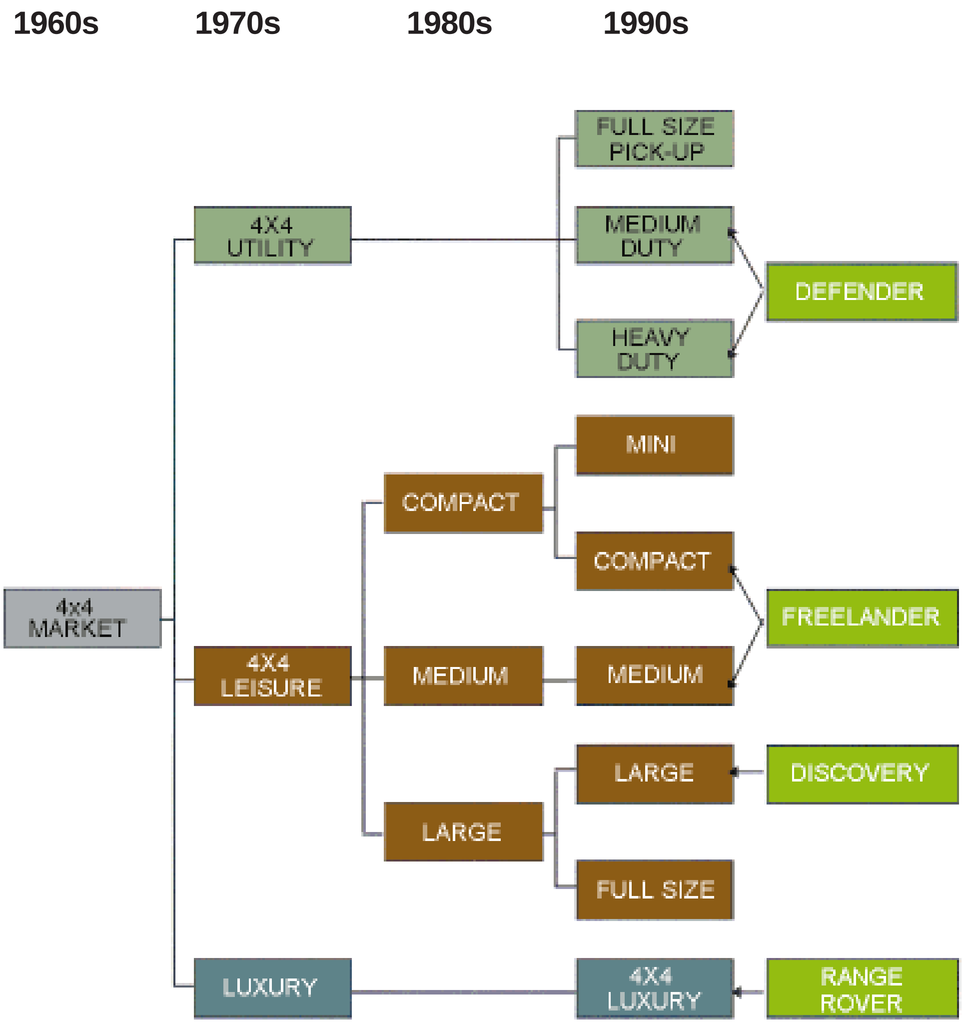


Figure 6

The diagram above illustrates the segmentation of the 4x4 market. It shows how the market, as a whole, has developed during the last four decades. It also shows the complimentary relationship of the four discrete Land Rover derivatives, i.e. Defender, Freelander, Discovery and Range Rover.

NEW DISCOVERY

A great deal of marketing research was carried out to determine the design criteria for New Discovery. The research identified the need to build upon the phenomenal success of the existing model. Particular emphasis was given, therefore, to the quality and technological properties of the new vehicle.

A number of product attributes were identified, on which the engineering team based their functional and design ideals. Quality, safety, on road behaviour and cost of ownership were all identified as fundamental requirements. Distinctive style and character is retained, versatility and capability, and an unrivalled off road ability have been further developed.

Figure 7

A great many technological advances have been incorporated into the design and specification of New Discovery. These features reflect the requirements of the customers within the large leisure segment for a more car like feel and performance. The advances also enable Land Rover to develop Discoverys reputation of providing excellent on road performance and best in class off-road performance, whilst further segmenting the Large Leisure segment.

The new Discovery will be sold in excess of 100 world markets. The precise specification of the vehicles sold in each market will vary according to the individual market requirements.

Technical Overview

The following text details the main features and outlines many of the technical and cosmetic innovations introduced on New Discovery. The features have been placed into five main groups: exterior, interior, engines & transmissions, chassis systems and body electrical.

It should be noted that this information is not intended to be an exhaustive features list. It is designed to provide the reader with an overall appreciation of the technical make-up of the model range. Further information regarding the model line-up is given later in this document.

Exterior

Figure 8

- Rounded front headlight treatment
- Raised bonnet profile
- One piece bumper moulding
- Body coloured grille surround
- Body extended (rear overhang increased by 15cm)
- Roof profile lowered
- Flush-fit glazing on all panels
- Wider shaped body side panels, more pronounced body profile
- Restyled, higher mounted rear light clusters
- Lower mounted spare wheel

Interior

Figure 9

- More substantial steering wheel
- Standard driver’s airbag
- New gear selector cover
- New interior colours
- Revised centre console incorporating relocated switches
- Redesigned front and rear seats (incorporating 3-point belts on all seats) and innovative second row armrest
- Dual purpose centre armrest/headrest
- Restyled door casings

Figure 10

- Two forward-facing occasional seats with 3 point seat belts
- Roof mounted head restraints for the two occasional seats
- Rear stowage bins fitted on all five seat models
- Retractable load space cover
- Load retention points

Engines & Transmissions

Figure 11

- New turbocharged 5-cylinder direct injection 2.5 litre diesel engine - Td5
- Electronic Unit Injectors EUIs (one per cylinder)
- MEMS electronic diesel engine management
- Revised 4.0 litre V8 petrol engine featuring completely new intake system
- Bosch Motronic 5.2.1 electronically controlled engine management system
- R380 5-speed manual gearbox
- ZF dual mode electronically controlled 4-speed automatic transmission
- LT 230Q transfer gearbox

Chassis Systems

Figure 12

- Revised steering geometry
- Revised front axle (featuring Range Rover knuckle design)
- Revised rear axle (featuring Watts linkage lateral location)
- ACE (active cornering enhancement)
- Self Levelling Rear Suspension SLS (featuring air springs)
- 4 channel Anti-lock Braking System ABS
- 4 wheel Electronic Traction Control ETC
- Hill Descent Control HDC (operative in all low range gears)
- Electronic Brake Distribution EBD

Body Electrical

- CAN bus and K-line architecture
- Body Control Unit BCU (controlling most body electrical systems)
- Comprehensive security system (CDL/remote locking/full alarm /immobiliser)
- High specification In Car Entertainment ICE system, with separate controls for occasional seat passengers

Model Line-up

The following information is designed to provide the reader with an appreciation of the model range and an overview of the specification of each derivative.

For manufacturing purposes, New Discoverys model range is effectively subdivided into four distinct trim levels (plus one other, see note below). The trim level is assigned to a vehicle prior to the start of the manufacturing process. Once assigned, it determines the basic specification of that particular vehicle, i.e. the level of standard equipment.

In addition to the basic trim level, each vehicle is issued with supplementary build information. This details the regional specification and the number and exact type of optional features to be fitted. This process allows for the required degree of flexibility and ensures the specific needs of each individual market are accommodated.

Basic Specification

The numerous markets in which New Discovery is to be sold have been grouped into a smaller and more manageable number of regions. There is currently a total of 12 regions. These are as follows:

- UK/Eire
- Northern Europe (including ROW Eastern European Countries)
- Southern Europe
- Scandinavia
- USA & Canada
- Japan
- Gulf States (including Yemen)
- ROW Africa
- ROW Asia Pacific
- ROW Americas
- South Africa
- Australia

The precise specification of the derivatives within the model line-up is determined by each region's requirements. As explained previously, the model line-up comprises four trim levels. The following table provides an overview of the differentiation between the trim levels. For full details of the specification applicable to a particular market, refer to the appropriate Land Rover sales literature:

Feature	**TL1**	**TL2**	**TL3**	**TL4**
ABS: four channel Anti-lock Brake System	✓	✓	✓	✓
ETC: Electronic Traction Control	✓	✓	✓	✓
HDC: Hill Descent Control	✓	✓	✓	✓
Cruise Control (standard on V8i + auto G/box)	-	✓	✓	✓
Coil springs & anti-roll bars (i.e. base suspension)	✓	-	-	-
Coil front springs & rear SLS Self Levelling Suspension	-	✓	-	-
ACE (Active Conering Enhancement)	-	O	-	-
ACE/ACE & SLS Active Conering Stability & Self Levelling Suspension	-	-	✓	✓
Steel wheels - (Option on TL1)	✓	-	-	-
"Tempest" 7x16/235	✓	✓	-	-
"Statos" 8x16/255	-	-	✓	-
"Mirage" 8x16/255	-	-	-	✓
Driver airbag	✓	-	-	-
Driver & passenger airbags	-	✓	✓	✓
5 cloth seats & rear stowage boxes	✓	-	-	-
7 cloth seats with rear access step	-	✓	-	-
7 leather seats (front electric) with rear access step	-	-	-	✓
7 leather & cloth seats with rear access step	-	-	✓	-
Cold climate pack 1 (heated screen only)	-	O	O	-
Cold climate pack 2 (seat heater pads & heated screen)	-	O	O	✓
Cold climate pack 3 (fuel burning heater)	O	O	O	O
Headlamp power wash	✓	✓	✓	✓
CDL/remote locking/alarm/immobiliser	✓	✓	✓	✓
Heater only	✓	✓	✓	-
Front air conditioning (with ATC)	O	O	O	✓
Front & rear air conditioning	O	O	O	O
Manual gearbox	✓	✓	✓	✓
Electronically controlled automatic gearbox	O	O	O	O

O = optional ✓= standard

Engine availability is:

- Five cylinder 2.5 litre diesel engine (TD5)
- V8 4.0 litre petrol engine

All trim levels are available as diesel or petrol. However, not all regions take all trim levels and some markets (e.g. USA), do not take diesel powered vehicles. In addition, it should be noted that the V8 petrol engine is available in two configurations, i.e. high compression and low compression, cat and non-cat.

BODY ELECTRICS

The rest of this brochure is going to look at the individual systems incorporated into New Discovery. The next section concentrates on body electrics. It is important to understand the type of electrical signals used on New Discovery, and as such the next few pages detail what these signals are and where they are likely to be found within the vehicles architecture.

Within modern motor vehicle technology there is a variety of different ways that an ECU can communicate with another ECU, diagnostic equipment, sensors within its own system and sensors outside of its own system. The following pages detail the different ways in which New Discovery achieves this communication.

Analogue signals

DC signals

This can be a voltage returned from a sensor in a range between 0 - battery volts. An example of this is the throttle position sensor or the coolant temperature sensor. The range does not necessarily have to be within the range of 0 - battery volts and in most cases, the maximum voltage supplied is 5 volts. The important factor is that the signal returned is a proportion of the supplied voltage.

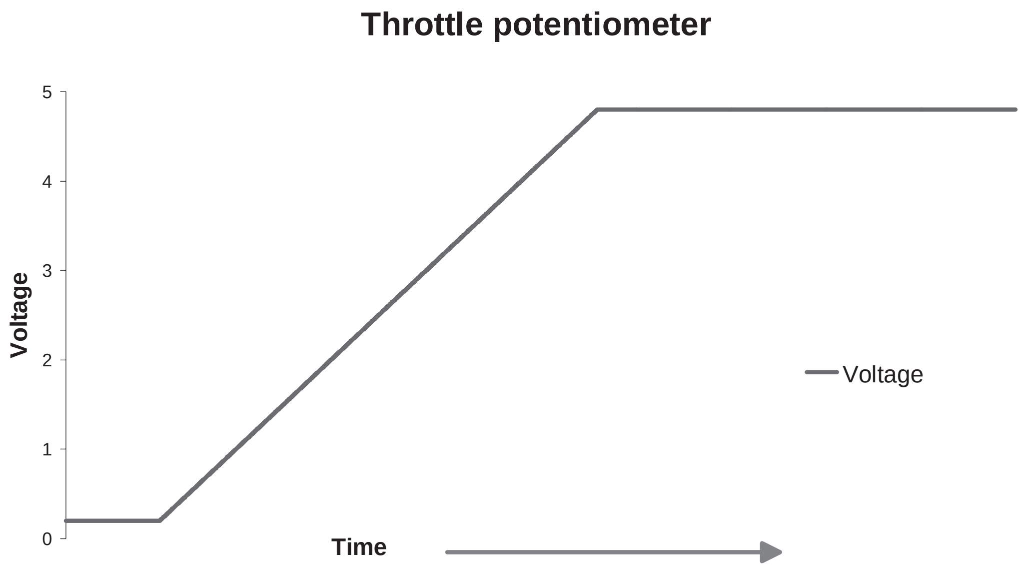


Figure 13

AC signals

An analogue signal can also be an AC signal. This means that the voltage fluctuates between a positive voltage and a negative voltage in a similar fashion to the electrical current supplied by the electricity generating companies. The signal is described as a 'sine wave'. The important factor of these signals in a motor vehicle application is not so much the voltage produced but the frequency of the wave. This is measured in waves per second (Hz). An example of this would be a crankshaft sensor. The faster the crankshaft rotates, the more quickly, and frequently the holes move past the end of the crankshaft. This can be calculated with the following equation: $Hz = \frac{Rev/\min.}{60\ (seconds)} \times number\ of\ holes$. A Td5 engine, at idle would produce a frequency of $Hz = \frac{720}{60} \times 31 = 372Hz \rightarrow 0.37kHz$. At full speed, the crankshaft sensor on a petrol engine would produce a frequency of $Hz = \frac{5400}{60} \times 58 = 5220Hz \rightarrow Or \rightarrow 5.22kHz$.

Crankshaft sensor output

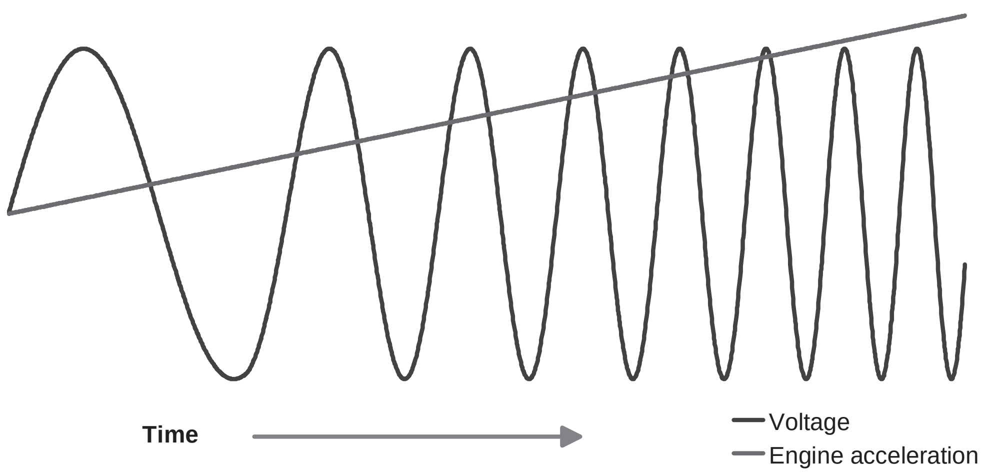


Figure 14

Logical signals

This type of signal is associated with something being switched 'on' or 'off'. An example of this is an air conditioning request. The automatic temperature control system asks the engine management system to turn on the air conditioning compressor. It does this by either supplying a voltage, or supplying a path to ground. This has implications when diagnosing electrical systems with a voltmeter. A measured voltage of 0 volts can mean that the system should be activated rather than dormant, if the controlling circuitry 'sinks' a switching voltage.

Digital signals

PWM signal

The first type of these signals is a relatively low speed pulse width modulated (PWM) signal. PWM is a digitally constructed signal with a fixed frequency. An ECU passes information to another ECU by using only one wire. The ECU constructs a signal with a different ‘period’ or ‘duty cycle’ (the amount of time the voltage is at a high level compared to a low level). This period is derived from a number (piece of information) which the sending ECU wants to send (see figure 15). The ECU receiving the signal compares the amount of time that the signal is ‘on’ with the time it is ‘off’ and assigns a value to it. This value will be the same as the first number, providing the signal has not being corrupted during transfer. Another way this signal can be used by an electrical device is for it to take an average of the signal over time. A circuit which uses this type of technology will smooth the signal, using an average of the ‘on’ time and ‘off’ time. The result of this average can be used in a similar fashion to that of an analogue signal.

Pulse width modulation

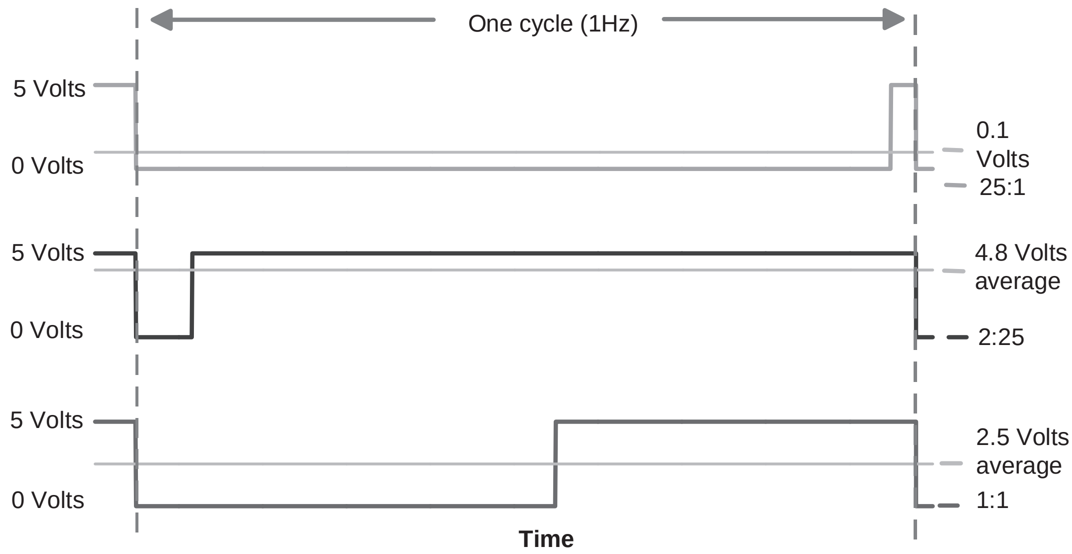


Figure 15

Pulse frequency

An ECU, or other electronic device, constructs this type of digital signal. It is then transmitted to other electronic system ECUs or devices which interpret the data rate. Figure 16 illustrates how an ABS ECU converts an analogue signal into a frequency which it then transmits to the ECM. As the road speed increases, the frequency increases. It should be noted that this type of pulsed signal does not have to correspond directly to the AC signal used to construct it. An ECU can send just a short pulse to indicate an event has occurred. In practice, this second method of sending digital frequency dependent signals is usually the preferred method.

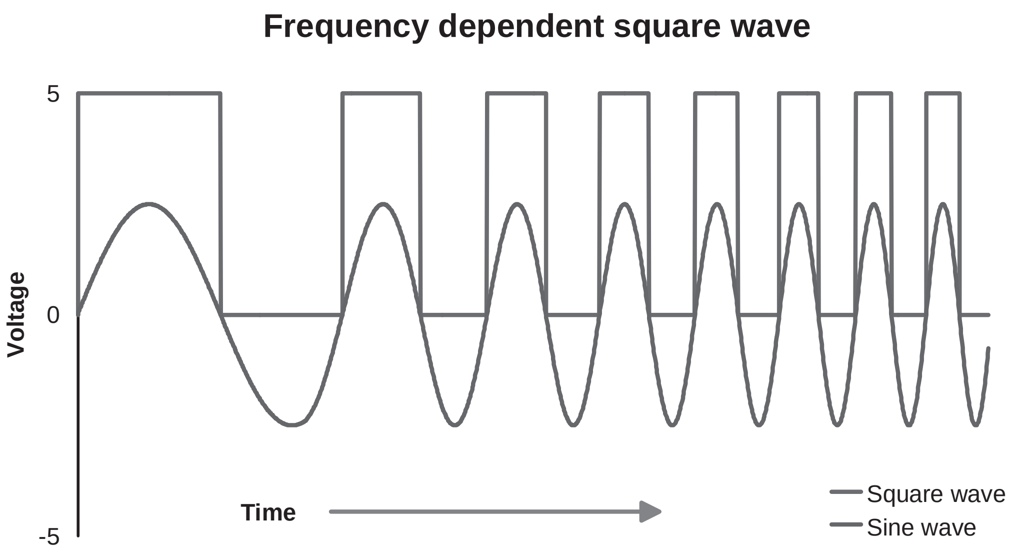


Figure 16

Bus technology

New Discovery uses three types of bus to transfer data between different ECUs:

1. Controller area network (CAN)
2. The body bus
3. Diagnostic line (K-line)

All of these technologies are used to transmit encoded messages from one source to another. In a sense, they operate in the same manner as the postal service. Information (the letter) is electronically addressed (addressed), sent (posted), decoded at the receiving end (delivered) and checked for errors (signed for). The message can be checked by the receiving ECU because, along with the original data to be transmitted, a mathematical 'check sum' is calculated and also sent. These bus signals work at a fixed frequency, all ECUs which connect to the bus are tuned to recognise the data at that frequency. Figure 17 illustrates a data word that is present on the bus.

The frequency the CAN bus operates at is, 500 kilo baud (500,000 cycles per second). Compare this with the body bus which operates at 10,400 baud (10,400 cycles per second) and the K-line, which operates at is 9,600 baud (9,600 cycles per second). This speed is why the CAN bus can transfer so much information between the engine management ECU and the automatic gearbox TCU. Both the CAN, body bus and K-line can send and receive data on the same line, but not at the same time.

CAN bus architecture

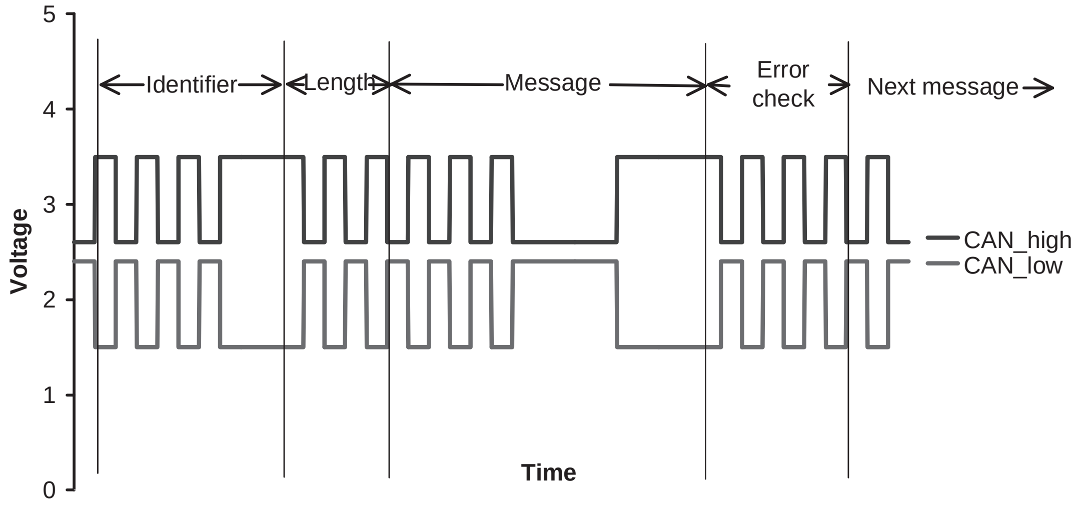


Figure 17

The CAN bus is a twisted pair of wires. The wires are matched in length and diameter. It is critical that the wires remain twisted to the correct number of turns. If not, they will produce unacceptable levels of electromagnetic radiation, adversely affecting other systems on the vehicle. The two wires carry the same signal, but are 180° out of phase. One wire is known as CAN_high, the other as CAN_low. The CAN_high wire changes from ≈2.5 volts up to 3.5 volts when the data bit changes from an '0' (off bit) to a '1' (on bit). At the same time, the CAN_low wire changes from ≈2.5 volts down to 1.5 volts. This form of signal is referred to as a differential signal, as the receiving ECU receives a voltage that varies from ≈0 volts to ≈2 volts. This, coupled with the fact the wires are twisted, reduces the electromagnetic radiation produced in any wire with a fast moving signal.

If the need arises and the harness has to be repaired, it is important that the harness is not unwound more than 3 - 4 cm. The wire should also be repaired with a crimped joint rather than a soldered one. All ECUs attached to the CAN bus have a resistor located internally on each termination of the CAN bus. These resistors stop 'electrical reflections' occurring in the wire and aid the clean delivery of the signal.

The body bus connects together the body control unit (BCU), intelligent drivers module (IDM) and the instrument pack. The K-line connects together all the ECUs on the vehicle which have the ability to communicate with TestBook. The K-line is used by TestBook to interrogate ECUs, it is not used to exchange data between the different systems. As these buses are much slower than the CAN bus, the wiring is of a more conventional design, employing a single wire to carry the signal.

Security system

New Discovery features a sophisticated security system designed to deter unauthorised entry into the vehicle and prevent the vehicle from being driven away illegitimately. The security system complies fully with all legislative requirements of all of the World Markets in which it is sold. The security system is currently being assessed against the criteria for class 1/2 approval from Thatcham (a professional organisation sponsored by insurance companies to assess the risk of vehicle theft).

The security system incorporates:

- Perimetric protection, which protects the vehicle by monitoring all of the hinged panels
- Volumetric protection, which protects the vehicle by monitoring its interior space
- Remote locking, superlocking and unlocking functions
- Passive engine immobilisation
- Friendly engine remobilisation
- Advanced mislock detection and automatic compensation
- EKA (emergency key access code) functions
- Customer configuration options
- Market configuration options

The body control unit (BCU) incorporates the security system as one of its functions. The BCU controls or accepts inputs from other electrical systems or components so that it can process the current status of the vehicle and the driver's demands with respect to the security system.

System inputs

The BCU processes information from the following:

- Door latch switches
- Driver's door key lock / unlock switches
- Bonnet activated security system switch
- Volumetric sensors
- Central door locking switches (CDL)
- Remote transmitter
- Receiver unit
- Other system inputs
- Ignition switch

Door latch switches

The BCU uses the door latch switches to indicate if a door is open or closed. There is a door latch switch within every door latch assembly, including the tail door. The only hinged panel with does not incorporate a door latch switch is the bonnet.

The BCU provides power to all of the door latch switches. The door latch switches are normally in an ‘open’ state when the door is closed. If a door is opened, the feed supplied by the BCU is allowed to go to ground. This signals to the BCU that a change of state has occurred (i.e. door has opened). These switches are connected in parallel, except for the driver’s door switch. If any door is opened, except the driver’s door, the BCU will recognise the switch input ‘change state’ but will not be able to derive from the signal which door has caused it. The driver’s door latch switch has a dedicated wire from the BCU, which enables the BCU to ‘know’ if the drivers door is open or closed.

TestBook has the ability to monitor the state of the door switches within the real time monitoring feature in the security section.

Driver’s door key lock and unlock switches

The BCU uses the driver’s door key lock and unlock switches to activate and deactivate the security system (the degree of deactivation will depend upon the programmed market). These switches are also used when the emergency key access code (EKA) is entered. Two separate switches are incorporated into the key lock assembly of the driver’s door. The BCU provides a voltage to each of the switches individually, in a similar manner to that of the door latch switches (e.g. the BCU is signalled when the supplied voltage goes to vehicle ground). This enables the BCU to determine in which direction the lock has been turned.

TestBook has the ability to monitor the operation of the door lock switches, within the real time monitoring feature in the security section.

Bonnet activated security system switch

The BCU uses a plunger type switch to determine when the bonnet is open. The switch is located under the bonnet on the right-hand side, when viewed from the front of the vehicle.

The bonnet switch is powered by the BCU. When the bonnet is closed the switch is in an open state. When the bonnet is released from its catch the switch changes state, providing a path to ground for the signal from the BCU.

TestBook has the ability to monitor the operation of the bonnet switch, within the real time monitoring feature in the security section.

Volumetric sensors

The BCU uses volumetric sensors to detect any change in air movement inside the vehicle. New Discovery incorporates two volumetric sensors located in the vehicle's headlining, one at the rear of the vehicle behind the 'D' post, the other above the 'B/C' post on the opposite side to the rear sensor (see figure 18 and 19).

Figure 18

Figure 19

TestBook has the ability to monitor the operation of the volumetric switch, within the real time monitoring feature in the security section.

Central door locking switches

New Discovery incorporates one momentary action duel direction central door locking (CDL) switch. The switch is mounted on the fascia panel to the side of the clock (see figure 20).

The switch has two inputs into the BCU, one for lock, one for unlock. TestBook has the ability to monitor the operation of the switch in both directions, within the real time monitoring feature in the security section.

Figure 20

Remote transmitter

The two remote transmitters are incorporated into the vehicle ignition/door keys (one transmitter for each key supplied). The remote transmitter uses coded radio frequency signals to lock, unlock and superlock the vehicle. The remote transmitters have two buttons. One button unlocks the vehicle (see section on security system configuration), the other locks or superlocks the vehicle. The remote transmitter will transmit successfully within a range of approximately 10 metres (33 feet) of the vehicle.

Receiver unit

The receiver unit is located above the vehicle's headlining, behind the rear sunroof aperture. The receiver receives all the signals the remote transmitter transmits, then decodes the signal and sends a 'square wave' equivalent of the received signal to the BCU for processing.

TestBook has the ability to monitor the operation of the remote transmitters and receiver unit within the real time monitoring feature in the security section.

Other switched inputs

A 'key in' signal is supplied to the BCU whenever the ignition key barrel is pressed 'in'. The ignition barrel moves slightly 'in' when the key is entered into the barrel. The presence of the key in the barrel will lock the barrel in the depressed position. The ignition barrel will move back only when the key is completely removed.

The engine inertia cut-off switch is monitored by the BCU. If the engine is running and the doors are in a locked state, the BCU will unlock all doors if it 'sees' the inertia switch trip, and will turn on the hazard lights if this feature has not been disabled within the customer configuration options.

The BCU monitors the ignition switch. The BCU will alter its operation when it detects the ignition switch change 'state' (move from one position to another). The BCU will trigger the alarm if it detects an ignition signal before it receives a valid disarm signal.

System outputs

The BCU processes the above signals. Depending upon the current operating status of the security system, the current user configuration of the security system and which market programme the vehicle is currently using, the BCU will activate the following items:

- Volumetric power supply
- Door actuators
- Passive coil
- Battery backed sounder (BBS)
- Vehicle horn
- Alarm horn
- Hazard warning lamps
- Security system light emitting diode (LED)
- Starter relay
- Fuel flap release actuator
- Courtesy lamps
- Headlamps
- Engine management system (EMS)

BCU

The BCU is located behind the passenger glovebox. One of its functions is to control the vehicle's security system. The BCU processes the information received from the various input devices, and controls various outputs in accordance with the programmed strategy.

The BCU receives its power from the under-bonnet fuse box. It also controls most of the devices through the intelligent drivers module (IDM). Between the IDM, instrument pack and BCU there is a data link. This data link is referred to as a 'low speed body bus' and is capable of transmitting messages bi-directionally at a rate of 10,400 bits per second. The bus transfers messages between all three members.

The BCU remembers the status of the security system when it powers down, or if it losses its battery supply. If the security system was in a set condition when battery voltage was lost, the BCU will trigger the alarm device and give visual warning by flashing the hazard lamps when it next receives battery voltage.

The BCU will activate the alarm devices if it detects a condition that violates any of the protection strategies currently being employed. It will activate the alarm devices for a period of 30 seconds, then reset. The BCU will do this 10 times (once if the market programme is set for Hong Kong). After this it will not respond to triggering events. When the BCU receives a valid unlock signal, the counter is reset. Even if the BCU does not respond to a triggering event, the BCU will still provide the vehicle with the security features enabled by the locking condition and the programmed market.

It is not possible to communicate with the BCU via TestBook when the security system is active (except for passive immobilisation). This ensures that no key programming or market configuration can take place if the operator is not in possession of a valid remote transmitter or the vehicle keys.

The BCU is programmed to accept two remote transmitters when it leaves the factory. A further two remote handsets can be programmed into the BCU and one optional self levelling suspension (SLS) transmitter. All remote transmitters are needed if TestBook changes the BCU programme for any one of them.

Intelligent driver's module

The IDM is located within the fuse box located under the steering column (see figure 21). The IDM, as previously mentioned, communicates with the BCU via a serial link. This link also allows the IDM to become part of the security system. If the BCU or IDM is replaced, both units will need to re-establish communications. TestBook can program this procedure or it will happen without intervention if the ignition is switched 'on' and 'left on' for 5 minutes. The vehicles immobilisation will not be removed until one of these two procedures has been followed.

Figure 21

Door lock actuators

The door lock actuators are an integral part of the door latching assembly. They all have the facility to 'superlock' (superlocking is when the inside door handles and sill buttons are disabled). The BCU controls the driver's door separately from other doors. This enables functions like single point entry and key access. All the door lock actuators are controlled by the BCU via the intelligent driver's module (IDM).

TestBook can drive all the door actuators to test their functionality. It can lock, superlock and unlock all the doors.

Passive coil

The passive coil is located around the ignition key barrel. When the BCU detects that the ignition key has moved to position III and the vehicle's immobilisation system is activated, it will supply a voltage at a frequency of 125 kHz. This voltage powers the passive coil. The coil will produce a varying magnetic field, which will radiate within close vicinity of the ignition key barrel. The magnetic field transmitted by the coil triggers the remote transmitter to transmit a remobilisation signal.

Battery backed sounder

The Battery Backed Sounder (BBS) is located inside the exterior body panel near the fuel release solenoid. The BBS is a warning device for cases where the alarm is activated or the battery is disconnected. It has a self-contained power source, allowing it to operate when the vehicle battery is disconnected, or the unit is unplugged.

The BBS will not sound if the battery is disconnected and the security system is not active. This feature negates the need for a disconnection sequence, previously needed on pre 1999MY models.

The battery backed sounder utilises a 12 volt power supply from the interior fusebox. This feed provides power for the sounder and is used to charge the internal battery.

Vehicle horn

Depending on the programmed market, the vehicle horn will either sound independently or in conjunction with the alarm horn. If the alarm is triggered, the vehicle horn operates at 250mS intervals, in phase with the hazard lamps.

Alarm horn

Depending on the build specification, New Discovery will be fitted with a BBS or alarm horn. The alarm horn will sound either independently or in conjunction with the alarm horn. If the alarm is triggered, the vehicle horn operates at 250mS intervals, in phase with the hazard lamps.

Hazard lamps

The BCU controls the operation of the hazard warning lamps by signalling the IDM to operate their relay. The hazard warning lamps are activated when:

1. The vehicle is locked and the security system is set (flashes three times if superlocked, once if not)
2. The vehicle is unlocked (flashes once for 2 seconds)
3. The alarm is triggered (flashes for the duration of audible warning, 30 seconds)
4. The driver depresses the hazard lamp switch (flashes until the driver presses the switch for a second time)
5. The inertia switch is triggered (flashes until the system is reset)
   The exact operation of the hazard lamps may alter between different market programmes and customer configuration options.

Security system status LED

A light emitting diode (LED) situated in the instrument cluster indicates the condition of the security system and acts as a warning to potential thieves that the security system is activated.

Starter relay

The starter relay on both petrol and diesel derivatives is controlled by the BCU. The BCU receives a signal from the ignition switch that the driver wishes the engine to start. If the security system has been deactivated, the BCU will operate the starter relay. The BCU cannot tell if the remobilisation signal has been accepted by the EMS. On occasions where the BCU has received a valid unlock/remobilise signal but the EMS has not, the start relay will energise, causing the engine to crank until it starts. At this point, the starter relay will disengage and the starter motor will stop cranking the engine. The ECM will then immediately stop the engine running. The BCU receives from the instrument pack an engine running signal. If the ignition key is turned to position IV when the BCU is receiving an engine running signal, it will not energise the start motor relay (see figure 22).

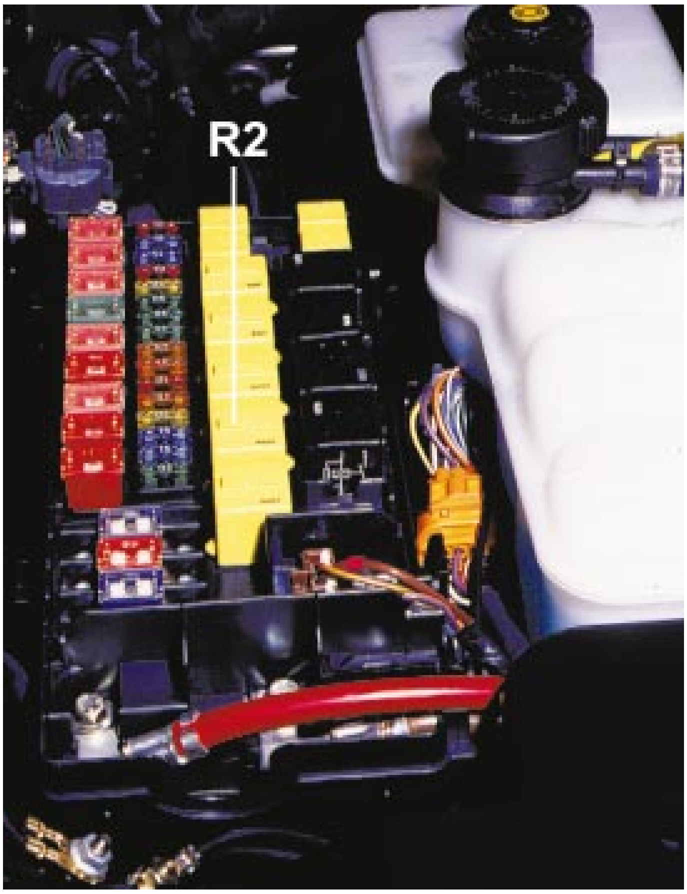


Figure 22

R2. Starter relay

Fuel flap release switch/actuator

The fuel flap release switch is located within the fascia switch pack (see figure 23). It operates only when the ignition switch is in position 0 or I and the security system is not activated (the state of engine immobilisation has no effect on the operation of the fuel flap switch).

Figure 23

The actuator circuit is inhibited or allowed to operate by the BCU. A voltage from the interior fusebox is provided to the fuel flap release switch. The switch is connected directly to the fuel flap actuator. The actuator is also connected to the BCU. When the necessary conditions have been fulfilled to allow operation of the fuel release flap, the BCU provides a path to ground.

The fuel release flap will operate only if:

1. The ignition is switched ‘off’
2. The security system is in a deactivated state
3. The driver presses the fuel flap release switch

Courtesy lamps

The BCU controls the operation of the courtesy lamps. Courtesy lamps are located in the:

1. Front headlining
2. Mid headlining
3. Rear headlining

Headlamps

New Discovery has a feature that allows the BCU to turn on the vehicle headlamps when the driver presses the remote transmitter. The BCU switches both headlamps on by signalling to IDM to switch the headlamp relay ‘on’.

System operation

The security system feature is always programmed into the BCU. Depending on the vehicle destination, some of the other security components may not be fitted to the vehicle. In markets that do not need advanced security systems, the remote transmitters will operate the CDL system, but will not activate the alarm features. Engine immobilisation always happens, even if the market programme disables the function. If this is the case, the BCU will transmit the remobilisation code when it detects the ignition change from position II to III.

The security system can be configured in many different ways, according to customer preferences and market legislative demands. The following items are available to all markets and all customer configurations:

1. Locking
2. Unlocking
3. Electric fuel flap release

Locking

The doors can be locked by any one of five methods:

1. Pressing the lock button on the remote transmitter
2. Locking the vehicle from the driver’s door with the key
3. Pressing the lower half of the CDL switch

Any of the above actions will lock all of the doors and, in some cases, the security system may also become active.

4. Pushing the sill button down (will only lock that particular door)
5. By travelling over a predetermined speed (if speed related locking is enabled)

The CDL system may not operate correctly if the vehicle is not in a suitable state to become locked. These conditions include:

1. The driver’s door is open
2. The ignition is on
3. The inertia fuel cut-off switch is tripped
4. The vehicle is superlocked

Depending on system configuration, a mislock will occur if these conditions are not met. All of the doors may or may not lock, depending on which of the above conditions is not met. If the vehicle is programmed to a market that supports mislock, the vehicle will give an audible warning and will not flash the LED or vehicle hazard lamps, this being the usual indications to the driver that the vehicle has armed the security system successfully.

Unlocking

The doors can be unlocked in any one of five ways:

1. By pressing the unlock button on the remote transmitter
2. By unlocking the vehicle from the driver’s door with the key
3. By pressing the upper half of the internal CDL switch (not operational if the vehicle is superlocked)
4. By pulling the interior door handles (not operational if the vehicle is superlocked)
5. By the inertia switch being triggered whilst the ignition is ‘on’ and the security system deactivated

The BCU may not unlock all of the doors when some of the above actions are completed. The strategy the BCU follows will depend upon the market programme and customer configuration options.

Market dependent security features

The security system (in most markets) has the ability to do most of the following items. The exact operation of each item may vary slightly between different market programmes and customer configurations. The features available are:

- Perimetric protection
- Volumetric protection
- Superlocking
- Mislock
- Passive immobilisation
- Passive remobilisation
- Emergency key access (EKA) code remobilisation
- Single point entry (SPE)
- Speed related locking
- Bathrobe related locking
- Security system LED
- Courtesy lights
- Transit mode

Perimetric protection

Perimetric protection is used to deter unauthorised entry into the vehicle by emitting audible and visual warnings on detection of an intruder. The system detects intrusion by monitoring the state of all hinged panels and the ignition circuit. If the BCU detects a change in state of any of the above it will sound an alarm and give a visual indication (the type of sound and visual indication will depend upon the build specification and some options set by the market programme and customer configuration).

The security system sounder (BBS, alarm horn, or vehicle horn) will sound for thirty seconds on detection of a triggering condition. The BCU will signal the sounder, as detailed in figure 24. The security system then resets itself in the condition it was before the security system was triggered.

Figure 24

The perimetric state also enables the engine immobilisation function, if it has not been already set by passive means. To arm the vehicle in a perimetric state, press the lock button on the remote transmitter (the exact operation may vary with different market specification) or lock the vehicle using the key in the driver's door. The following conditions must be met before the BCU will operate all of the functions of perimetric protection.

1. All of the hinged panels in a closed position
2. Ignition key not inserted in ignition switch
3. Inertia switch not tripped

If these conditions are not fulfilled, the BCU will enter a mislock condition. See section on mislock for more details.

To disarm perimetric protection press the remote transmitter's 'unlock' button, or unlock the vehicle with the key in the driver's door (this may alter according to the market specification). If the remote transmitter is needed to remove perimetric protection and is unavailable, the security system can be removed by entering the EKA code.

Volumetric protection

Volumetric protection is a function that the vehicle's security system employs to detect movement within the vehicle's interior. It enhances the perimetric function by detecting situations where personal belongings are threatened by an intruder smashing a window. Volumetric protects by using two ultrasonic sensors to produce a sound 'pressure' inside the vehicle. The sensors monitor the 'tone' of the sound being reflected from interior trim panels and seats etc. If the sensor notes a change in 'tone', it indicates that something is moving within the interior of the vehicle.

New Discovery does not operate both volumetric sensors at the same time. If it did, the sensors would give unreliable detection. As a result, the two sensors within the vehicle interior communicate with each other. Both sensors use the wire used to inform the BCU that it has detected unauthorised movement within the vehicle, as a communication bus, sending a signal to tell the other sensor that it is currently active. When the BCU provides power to both sensors, the first to operate sends a 5mS pulse along the signal wire to indicate that it has activated. After a period of 458mS the first sensor will switch off. The other sensor will, after a delay of 42mS, start to detect movement within the vehicle and also send the 5mS signal to declare that it is active along the signal wire. If one of the sensors detects movement when it is activated, it will provide a path to ground for the signal wire for a period of approximately 500mS. The BCU will interpret this lack of signal and activate the alarm components. The sensors continue to transfer operation between each other until the BCU removes their power.

The two ultrasonic sensors become active after an initial delay of fifteen seconds, providing the vehicle's security system has been set to activate volumetric sensing. This delay is incorporated into the BCU software to prevent spurious triggering events caused by air moving inside the vehicle interior. It is possible to lock the vehicle without arming the volumetric alarm by using the key.

The same three conditions apply when trying to arm the vehicle in volumetric mode. These are:

1. The ignition must not be 'on', and the key must be removed from the ignition lock (market programme dependent)
2. The inertia switch must not be active
3. All of the doors must be closed, as well as both the front windows

To unlock the vehicle and disable the security system, the 'unlock' button on the remote transmitter must be pressed. If certain market configurations are set inside the BCU, it may not be possible to disengage the volumetric protection with the key.

Superlocking

Superlocking prevents the use of the interior door handles to unlock and open the vehicle doors. This prevents an intruder gaining access to the vehicle by smashing a window to open a door.

Pressing the remote transmitter, or turning the key in the door lock activates superlocking. The market specification and customer configuration options will determine if superlocking will activate and how it can be set. There are four options:

1. No superlocking
2. Pressing the lock button on the remote transmitter, or turning the key once
3. Pressing the lock button on the remote transmitter once
4. Pressing the lock button on the remote transmitter, or turning the key twice within 1 second

The vehicle needs to be in the correct 'state' before superlocking will activate. These conditions are:

1. All doors closed
2. Ignition key not inserted in ignition switch
3. Inertia switch not tripped

Mislock function

Mislock alerts the driver to a failed attempt to lock the vehicle. This may be because one or more of the doors, bonnet or tail door is not correctly closed or the key is inserted into the ignition (any position).

A mislock condition will enable security functions only on the parts of the system that the BCU can verify as being reliable (see section on partial arming).

The audible warning of a mislock condition depends on the hardware fitted to the vehicle and on the programmed market. The BCU will trigger the BBS, alarm horn or vehicle horns for 50mS.

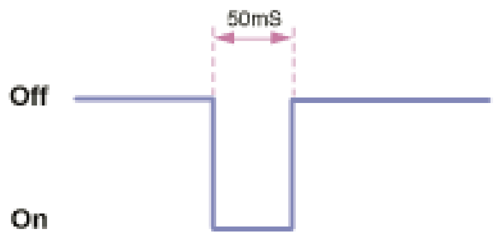


Figure 25

The BCU will not flash the hazard lights or operate the LED in a rapid flashing state when it detects a mislock condition. This is true for all market specifications, providing mislock is enabled within the vehicle configuration settings.

Partial arming

Partial arming allows as much of the vehicle to remain protected as possible. If the security system is set with one or more doors open or the bonnet open, the BCU will still monitor the rest of the system.

If the bonnet is open when the security system is armed, the BCU activates superlocking and volumetric sensing. In this condition, the security system enters a partially armed state. All other functions of the security system are active and the BCU monitors the bonnet. It the BCU detects a change in state (from an open state to a closed state), it will arm the security system fully.

If one or more of the doors are open when the vehicle is armed, the BCU will not superlock the remaining doors and will not operate the volumetric sensors. The BCU will continue to monitor the state of all the doors and, if it senses that all doors become closed, it will activate superlocking and volumetric sensing (if previously requested).

Passive immobilisation

Passive immobilisation prevents the vehicle from being started unless a correctly programmed remote transmitter key is used to start the vehicle. This system works whether or not the driver sets the security system into an active state.

The BCU immobilises the engine 5 minutes after the ignition has been switched off, providing the drivers door is not opened. The BCU will immobilise the engine 30 seconds after it detects the driver’s door opening.

Immobilisation is achieved by the BCU not transmitting the code to the EMS ECU. This code is needed to allow the engine to continue to run after the initial start-up sequence. If the BCU or ECM is replaced, this code will require synchronisation with the new unit.

Passive remobilisation

The BCU has a function that will automatically remobilise the engine when the ignition is switched ‘on’, providing the BCU receives a valid code from the remote transmitter. When the ignition is first switched ‘on’, and the vehicle is in an immobilised state, the BCU powers the passive coil located around the ignition barrel.

The passive coil produces a magnetic field, which excites the circuitry inside the remote transmitter. The transmitter then sends a remobilisation signal to the BCU. If this system fails and the BCU does not receive a valid signal it will stop energising the coil after one minute of operation. The driver of the vehicle will then need to either press the unlock button on the remote transmitter or enter the EKA code to remobilise the engine.

Both engine immobilisation and remobilisation are transparent to the driver of the vehicle providing the system is operating correctly.

Depending upon market configuration and vehicle options, the engine immobilisation features of New Discovery may be allowed to be switched off.

Emergency key access

If the remote transmitter fails to operate, the engine can be remobilised by using the key to enter a unique four digit emergency key access (EKA) code. This procedure is applicable only when the vehicle is programmed with certain market specifications.

The EKA code is entered by turning the ignition key in the driver's door lock. It is similar in operation to the EKA code sequence on pre 1999 MY Discoverys. The process is as follows:

1. Start with all vehicle doors closed and with the ignition key removed from the ignition barrel
2. Turn the ignition key in the door lock to the unlock position and hold it there until the vehicle audibly/visually indicates (there will be no audible indication on vehicles fitted with a BBS sounder) that the EKA sequence has been initiated

The BCU sounds the audible warning in the following sequence:

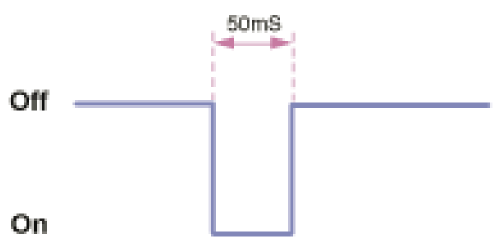


Figure 26

3. The visual warning consists of the LED being illuminated for 2 seconds
4. Unlock the vehicle the required number of times for the first digit of the code (note, this is the same direction as the step before)
5. Lock the vehicle the required number of times for the second digit
6. Unlock the vehicle the required number of times for the third digit
7. Lock the vehicle the required number of times for the fourth digit
8. Unlock the vehicle one more time to disable the security system

   The BCU will signify a successful entry of the EKA code by giving an audible warning.

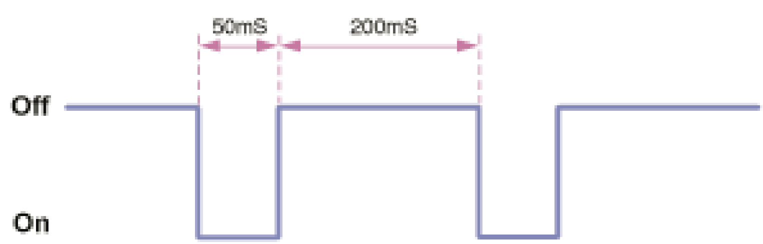


Figure 27

Whilst entering the code, it is important that the code is entered without leaving more than 10 seconds between any of the key turns or the key is not kept in the lock or unlock position for more than 5 seconds.

At the end of a successful EKA code being entered an internal timer is started. Depending on the market specification currently programmed into the BCU, the vehicle will either disarm immediately, or after 5 minutes. The market programme can also have a condition where the alarm is disarmed but engine immobilisation is still activated for a period of 5 minutes. If the engine is immobilised the security system LED will continue to flash at a rate which is equivalent to that detailed for immobilisation in the earlier section.

The EKA code can be obtained by using TestBook to interrogate the BCU. The BCU will allow the driver 10 incorrect attempts to input the EKA code before it locks out for 10 minutes. If an unsuccessful EKA code is entered, the BCU will sound an audible warning to inform the driver to re-enter the code.

Single point entry

Single point entry is a function that allows the driver to unlock just the driver's door, thus leaving all the other doors in a locked state. It is an option that can be set, if required, by TestBook. Most market configurations do not have SPE set as their default.

To use single point entry, press the 'unlock' button on the remote transmitter once. Depressing the unlock button a second time in the space of one minute unlocks the remaining doors. Single point entry is also possible by turning the key in the driver's door lock to the 'unlock' position, once. Turning the key to the 'unlock' position again within one minute unlocks the remaining doors. It is also possible to use a combination of key and remote transmitter unlock signals to unlock all of the doors.

Speed related locking

As an added option, New Discovery features speed related locking. This feature locks all the doors automatically when the vehicle speed exceeds 7 km/h (4 mph). The speed related locking function can be disabled within the customer configuration options available within the BCU. It is not set as a default setting from the factory, so the dealer will need to set it if the customer prefers his/her vehicle to behave in this manner.

The vehicle will unlock automatically when the ignition is switched off, providing the vehicle has been locked by the speed related locking function. Speed related locking only locks the vehicle once every journey/ignition cycle. If the doors are unlocked after the vehicle speed has exceeded 7 Km/h (4 mph), the vehicle will not lock under speed related locking until the ignition has been switched 'off' and then back 'on' again.

If the unlock button on the fascia (CDL switch) is pressed it will disable the operation of speed related locking for the duration of the journey.

Bathrobe locking

Bathrobe locking allows the engine to be started and then the vehicle locked with a spare key. This allows the vehicle interior to reach the desired temperature without the driver needing to be present. This option can be set by TestBook within the customer configuration options inside BCU. It should be noted that the vehicle security system is not set during this procedure, only the CDL is activated.

Courtesy headlamps

An option within the configuration of the BCU allows for courtesy headlamps to be enabled or disabled. This feature activates the headlamps for 30 seconds when the lock button on the remote transmitter is held down for longer than 1 second. The headlamps will extinguish if the BCU receives either a lock or unlock signal from the remote transmitter.

Security system LED

The LED has four different flash rates. These flash rates signal to the driver the different modes of operation or other system information. The four flash rates are:

1. Flash for 10 seconds at a rate of 10 Hz (50mS ‘on’, 50mS ‘off)
2. Flash at a rate of 10 Hz (50mS ‘on’, 50mS ‘off’)
3. Flash until the system changes state at a rate of 50mS ‘on’, 2000mS ‘off’
4. Flash ‘on’ for 50mS, ‘off’ for 50mS, ‘on’ for 50mS and ‘off’ for 2000mS

When the driver first locks the vehicle with either the key or the remote transmitter (assuming the vehicle does not mislock), the LED will follow flash rate 1 (indicating the correct setting of the security system). After 10 seconds the system will follow flash rate 3 (indication of security system being set). If the engine is immobilised but the alarm system is not set, the LED will signal the driver by following flash rate 3 (indicating the security system is set. If the vehicle is immobilised and the ignition is switch to position II, the LED will illuminate (to indicate that the engine will not start). It will extinguish only when the BCU receives a valid remobilise signal, or the ignition is switched to position 0 or I. If the alarm has triggered since the BCU received a valid ‘arm’ signal, the LED will follow flash rate 2. When the BCU receives an unlock signal (this indicates that the security system has being activated), the LED will follow flash rate 2 until the ignition is next turned to position II. The LED will flash one longer period if the EKA code sequence is stated.

The BCU will alert the driver of the vehicle if the remote transmitter battery requires replacing. The remote transmitter measures its battery voltage, and when the voltage goes below a threshold it will transmit a special code to the BCU to request that it informs the driver by flashing the LED at the rate detailed in rate 4. This is conditional upon the driver’s door being open and the ignition in an ‘off’ position, or the key removed from the ignition barrel.

Courtesy lights

The courtesy lights operate at full brightness when first switched on. The BCU will dim the brightness before it switches them off (fade-out). Fade-out always happens over a period of 2 seconds and always follows the decision to turn off the lights.

The following table details for how long the courtesy lights will operate after the BCU detects a condition that will illuminate them.

Operation	Condition	Time
Door open	-	10 minutes
Unlock signal from the remote transmitter	All doors closed & key not in position III	1 minute
Unlock signal from the driver's door lock	All doors closed & key not in position III	1 minute
Ignition key turned from position II or III to position 0	All doors closed	1 minute
Door changing from open to closed	All other doors closed & ignition not in position III	15 seconds
Ignition position III	-	Timer cancelled
BCU receives a lock command	-	Timer cancelled
Vehicle has transit mode configured to 'on'	-	15 seconds on all occasions

Transit mode

To prevent excessive battery drain during transportation of the vehicle after leaving the factory, a transit mode function has been introduced. This mode disables the following functions/ systems:

1. Volumetric sensors
2. Passive immobilisation (will remobilise the engine on a valid unlock signal from the driver's door lock, regardless of the programmed market)
3. Immobilisation of the vehicle by use of the door lock inputs
4. Ignition key interlock
5. Electric seat enable time-out with driver's door open

When TestBook communicates with the BCU for any diagnostic related to BCU diagnostics, it checks that the vehicle is not in transit mode. If it is, TestBook prompts the operator to remove the vehicle from transit mode before s/he continues. The vehicle can also be removed from transit mode by simultaneously holding down the heated rear window and the rear fog lamp switches and turning the ignition switch from position 0 to position III for 2 seconds

Market programming and customer configuration

During the previous sections within the document, reference has been made to the market programme and customer configuration options. The BCU can be programmed to 12 different markets (see introduction section for details). It also has the ability to alter some of the functionality that the market programme allows. This change in programming is referred to as ‘customer configuration’. There are two types of customer configuration:

1. CLASS (corporate locking and alarm security strategy) options
2. Non-CLASS options

TestBook can alter some of the functionality within each setting. The function of the buttons will scroll through the options available within market programme. It should be noted that, if the BCU is programmed with a different market specification, or reprogrammed with the same market specification, all customer preferences will be lost.

There are some options shown when viewing the BCU configurations from TestBook that can be changed only once. These options are set from a series of questions and information gained from the vehicle chassis number, when the BCU is first programmed to the vehicle.

Non-CLASS options

The following table lists the options available

Function	Option	Explanation
Transmission	Manual	The vehicle is fitted with manual transmission
	Automatic	The vehicle is fitted with automatic transmission
Front fog lamps	None	The vehicle is not fitted with front fog lamps
	No main	The front fog lamps will operate if the headlamps are on main beam
	Main	The front fog lamps will not operate if the headlamps are on main beam
Shift interlock	None	The vehicle is not fitted with a shift interlock solenoid
	Shift	The vehicle is fitted with both shift interlock and transfer box interlock solenoids
	No transfer	The vehicle is fitted with a shift interlock solenoid but no transfer box interlock solenoid
Daylight running lamps	None	The vehicle is not fitted with daylight running lights
	No main	The daylight running lights are on if the main beam headlights are off
	No heads	The daylight running lights are on with main and dipped beam off and the gearbox not in PARK
Programmed wash wipe	Normal	The front wipers operate if the front wash is operated
	No Wipe	The front wipers do not operate if the front wash is operated
Key-in warning	Disabled	The ignition key-in warning sound is disabled
	Enabled	The ignition key-in warning sound is generated if the ignition key is in and the driver door is open
Electric front seats	None	The vehicle is not fitted with electric front seats
	Normal	The electric seats are available if the ignition is on or the driver door is opened for a short time
	Ignition II	The electric seats are available if the ignition is on and the driver door is closed
Electric front windows	Driver cancel	The front windows will be disabled 44 seconds after the driver door is opened
	All cancel	The front windows will be disabled 44 seconds after any door is opened
	No cancel	The front windows will be disabled when the ignition is turned off
Heated front screen	None	The vehicle is fitted with heated front screens
	Fitted	The vehicle is not fitted with heated front screens

Function	Option	Explanation
Rear windows + sunroof	Driver cancel	The rear windows and sunroof will be disabled 44 seconds after the driver door is opened
	All cancel	The rear windows and sunroof will be disabled 44 seconds after any door is opened
	No cancel	The rear windows and sunroof will be disabled when the ignition is turned off
Autographics illumination	Always	The automatic gearbox selector illumination is on when the ignition is on
	Sidelights	The automatic gearbox selector illumination is on when the ignition is on and the sidelights are on
Hill descent control	None	The vehicle is not fitted with hill descent control
	Fitted	The vehicle is fitted with hill descent control
Courtesy headlamps	Disabled	The vehicle is not fitted with courtesy headlamps
	Enabled	The vehicle is fitted with courtesy headlamps
Odometer error warning	Disabled	The odometer will not flash if there is an odometer error
	Enabled	The odometer will flash if there is an odometer error
Seatbelt warning lamp	Timed	The warning lamp is on for 6 seconds after ignition is turned on
	Buckle	The warning lamp is on for 6 seconds after ignition is turned on or until the buckle is fastened
	Ignition II	If the buckle is unfastened when the ignition is turned on then the lamp is on for 6 seconds
	Disable	The warning lamp is not used
Seatbelt warning sound	Timed	The warning sound is on for 6 seconds after ignition is turned on
	Buckle	The warning sound is on for 6 seconds after ignition is turned on or until the buckle is fastened
	Ignition II	If the buckle is unfastened when the ignition is turned on then the sound is on for 6 seconds
	Disable	The warning sound is not used
Bulb failure warning	Disabled	Direction indicator bulb failure detection is disabled
	Enabled	Direction indicator bulb failure detection is enabled

CLASS options

The following table lists the options available

Function	Option	Explanation
Superlock	None	Superlocking is not available
	Double	The vehicle will superlock on a double press of the remote transmitter or double key turn
	Single	The vehicle will superlock on a single press of the remote transmitter or single key turn
	No key	The vehicle will superlock on a single press of the remote transmitter but not with the key
Unlock option	Not SPE	The SPE (single point entry) function is not used All doors unlock on a remote transmitter press
	SPE	Only the drivers door unlocks on the first remote transmitter press, others on the second
Alarm disarm option	Always	Operation of the key in the drivers door always disarms the vehicle
	Key only	Operation of the key in the drivers door only disarms the vehicle if it was locked with the key
	Key never	The security system is not disarmed by the key (except via an EKA)
Inertia switch	No Hazards	Operation of the inertia switch does not operate the hazard indicators
	Hazards	Operation of the inertia switch does operate the hazard indicators
Speed locking option	Disabled	Speed related locking is disabled
	Enabled	Speed related locking is enabled. The door locks are disabled when the vehicle is moving
Volumetric option	Disabled	Volumetric sensing is disabled
	Enabled	Volumetric sensing is enabled
Alarm option	Disabled	The vehicle is not fitted with a security system
	Enabled	The vehicle is fitted with a security system
Passive immobilisation	Disabled	Passive immobilisation is disabled
	Enabled	Passive immobilisation is enabled
Hazards option	Disabled	The hazards do not flash on security system arm, disarm or trigger
	Enabled	The hazards flash on security system trigger only
	All	The hazards flash on security system arm, disarm and trigger
Mislock option	Disabled	Mislock audible warnings are disabled
	Enabled	Mislock audible warnings are enabled

Function	Option	Explanation
Alarm sounder option	Alarm	Audible warnings are given by the security system horn only
	Both	Audible warnings are given by both the security system horn and vehicle horn
	Vehicle	Audible warnings are given by the vehicle horn only
	BBS	Audible warnings are given by the BBS only
	All	Audible warnings are given by the security system horn, vehicle horn and BBS
	Disabled	Audible warnings are not given
Bathrobe locking option	Disabled	The vehicle cannot be locked if the ignition is on
	Enabled	The vehicle can be locked if the ignition is on and the engine is running
Alarm tamper option	Disabled	The security system LED does not flash when the security system has been tampered with
	Enabled	The security system LED flashes when the security system has been tampered with
Engine immobilised option	LED off	The security system LED does not flash when the engine is immobilised
	LED flash	The security system LED flashes when the engine is immobilised
Low battery warning	Disabled	The security system LED does not flash when the remote transmitter battery is low
	Enabled	The security system LED flashes when the remote transmitter battery is low
EKA option	Disabled	EKA (emergency key access) is disabled
	Enabled	EKA (emergency key access) is enabled and the door locks operate electrically
	No unlock	EKA (emergency key access) is enabled, but the door locks do not operate electrically

Wiper system

All derivatives within New Discovery model range are fitted with front and rear wipers. Headlamp powerwash is also standard on some models and available as an option on some others. The exact specification of each model will vary according to regional requirements (see local sales literature for full details). The following provides a full description of the wiper system.

The wiper system includes the following functions:

1. Windscreen wipe function speed I
2. Windscreen wipe function speed II
3. Flick wipe (used to operate the front wipers once only)
4. Windscreen wipe intermittent
5. Windscreen wash
6. Headlamp wash
7. Rear window wipe
8. Rear window reverse operation
9. Rear window wash (ignition II only)

In all of the above conditions (except when specified), the wiper system needs the ignition switch to be in position I (auxiliary) or position II (ignition) before the system will operate

Front wiper speed I, II and flick

The front wiper motor switch is located in the end of the steering wheel stalk (right hand side). Wiper operation is achieved by turning the end of the switch. The wiper switch controls the wiper motor directly when the driver selects continuous wipe (slow or fast) and when the driver operates ‘flick’ mode (pulls the switch upwards to activate single wipe). If the driver selects intermittent wipe, or wash, the BCU controls the wiper motor via the IDM. The signal used to trigger the wiper motor from the IDM is still routed through the wiper switch, to avoid the wiper motor ever receiving simultaneous signals to operate ‘slowly’ and ‘quickly’.

Front wipers intermittent operation

The front intermittent wipe option features five pre-programmed driver-selectable delay periods. The delay periods determine how much time elapses between each single wipe operation in the intermittent mode. The shortest delay period is 3 seconds. The period is increased in 2 second increments up to a maximum of 11 seconds. The desired delay period is set by the position of the rotary switch located on the column stalk, just inboard of the wiper switch.

When the driver selects intermittent wipe (first detent), the BCU instructs the IDM to operate the wiper motor. In response, the IDM supplies power to the normal speed winding of the wiper motor for a period of time no longer than 500mS. The timed feed ensures that the wiper motor operates, but does not complete more than a single wipe of the screen. At the same time, the BCU evaluates the position of the delay switch. An internal counter, within the BCU, is set in accordance with the position of the switch. The BCU then instructs the IDM to operate the wiper motor at the frequency prescribed by the set position. This operation continues until the wiper switch is moved to the off position or to the normal or fast speed position. The delay period can be changed by altering the position of the delay switch (see description below).

It should be noted that, each time intermittent operation is selected, a delay of 500mS will be initiated before the wipers operate. This automatic delay period prevents the occurrence of a wipe action when the wiper switch is moved to the off position from the normal or fast position.

The driver can change the set delay period by moving the delay switch to a new position. If a shorter delay period is selected, the BCU will initiate a wipe action immediately and will reset the internal counter to the new value. It will then operate intermittent wipe using the new delay value. If, on the other hand, the driver moves the delay switch to a position that lengthens the delay period, the BCU initiates the revised delay period immediately.

Front and rear windscreen programmed wash

The front wash switch is located on the wiper stalk, the rear wash switch is located in the instrument pack surround (see figure 28). They are both momentary switches (do not stay in when released). The way the vehicle reacts to the driver pressing the front or rear windscreen wash switch depends upon a configurable setting programmed within the BCU. There are two options:

1. No wiper operation when the wash switch is pressed
2. Wiper action after an initial delay of 400mS

Figure 28

Assuming the vehicle is configured to operate the wipers when the washer button is pressed, the wipers will trigger 400mS (0.4 seconds) after the washer pump becomes active. If the washer switch is released before 400mS, the wipers will not operate. After the initial delay of 400mS the wipers will operate for the period that the washer switch is depressed, plus an additional 4 seconds.

Headlamp power wash

Vehicles fitted with a headlamp power wash system need to be configured by TestBook, either at the point of build or retrospectively if the system is fitted after manufacture or a new BCU is fitted.

The headlamp wash is activated by the BCU, via the IDM. It will operate the washers only if the headlamps are on (dipped beam or main beam) and then only every third time the front windscreen wash button is pressed. When the BCU operates the headlamp washers, it activates the washer pump relay for a period of 500mS (0.5 seconds).

Rear window wipe

The rear window wiper switch is located in the instrument binnacle surround. The switch is of the latching type and will operate the rear wiper via the BCU and IDM. The BCU controls the wiper operation according to a pre-programmed strategy.

The rear wiper motor is operated initially for a continuous period of 4 seconds when the switch is pressed. After this, the rear wiper will operate every other time the front wiper completes a sweep of the windscreen. The front and rear wiper motors operate at the same speed (‘normal speed’ front wiper operation). This feature enables the BCU to synchronise the front and rear wipers and control their operation, as described above.

When intermittent wipe is selected, the rear wiper continues to operate in synchronisation with the front wipers, i.e. operates every other time the front wipers complete a single sweep. Changes to the front wiper delay period will alter rear wiper operation in line with the effect on the front wipers.

Reverse gear wipe

The BCU changes the operation of the rear wiper when the front wiper is active and reverse is selected. The rate the rear wiper operates, when the above conditions are met will depend on the current front operating mode of the front wipers and the position of the rear wiper switch.

If the rear wiper is on or the front wiper is currently operating at an intermittent rate and the driver selects reverse gear, the BCU will operate the rear wiper continuously for 4 seconds via the IDM. After this initial period, the rear wiper will operate at the same rate as the front wiper, i.e. at twice its normal delay.

If the front wiper is currently operating at speed 1 or speed 2, the BCU will continuously operate the rear wiper via the IDM.

In both of the above situations the BCU will delay the operation of the rear wiper by a period of 500mS. This delay ensures the rear wiper does not operate when the gear lever is moved from ‘park’ to ‘drive’ on automatic vehicles.

Front and rear fog lamps

Front fog lamps are standard equipment on some New Discovery derivatives and are optional on most other derivatives (see local sales literature for full specification data). In cases where front fog lamps are fitted, the BCU controls their operation via the IDM. Land Rover engineers have made the operation of the front fog lamps programmable, to accommodate the legislative requirements of individual markets. The options are:

1. The vehicle is not fitted with front fog lamps
2. The front fog lamps operate when the headlamps are dipped or are on main beam
3. The front fog lamps will not operate if the headlamps are on main beam

The rear fog lamps are standard on all build specifications. Both the front and rear fog lamps switches are momentary switches. The BCU will operate the fog lamps via the IDM when the appropriate conditions are met. If those conditions are no longer current (i.e. the driver switches off the headlamps or ignition), the BCU will not operate the lamps again until the conditions needed for operation are met and the driver presses the switch again.

Daylight running lamps

Legislation in some markets requires that the headlamps illuminate whilst the vehicle is moving, or the ignition is switched on. This function is referred to as ‘daylight running lamps’. Therefore, the BCU, which controls illumination of the headlamps, must also be programmed to accommodate the legislative requirements of individual markets, with regard to daylight running lamps. The options are:

1. The vehicle does not require the daylight running lamp feature to operate in any circumstance
2. The daylight running lamps will be on if the main beam headlamps are off
3. The daylight running lamps will be on whenever the main or dipped beam headlamps are switched ‘off’ and the gear selector lever is in any position other than ‘park’

Instrument pack

New Discovery incorporates a completely new instrument pack. It is located within a binnacle on the fascia (see figure 29). Each instrument pack features the following:

1. 4 Dials (gauges and pointers)
2. 28 Driver information lamps (grouped into 4 areas)
3. LCD display (incorporating the odometer, selected gear (automatic only) and trip odometer)
4. A sounder

Figure 29

A number of different instrument packs are available to suit the wide variety of regional requirements. The precise number and function of the warning lamps and configuration of the speedometer are the main differences between the assemblies available. The precise specification of the vehicle will determine which instrument pack is fitted.

The instrument pack communicates with a variety of different ECUs on the vehicle. It is capable of processing information supplied in analogue, digital, PWM, pulse train and serial communication form. As well as communicating with other ECUs, it is connected with the body BUS, along with the BCU and the IDM.

The instrument pack also receives, and can process, information related to the regional and vehicle specification supplied by the BCU. This capability enables it to identify the engine and transmission type, the chassis systems configuration and programmed regional specification.

Dials

The instrument pack features four dials to give the driver an indication of the current vehicle status. The dials are:

1. Speedometer
2. Tachometer
3. Fuel gauge
4. Temperature gauge

The instrument pack and remote switches illuminate their displays when the driver switches on the headlamps or side lamps. The level of illumination in most markets is preset.

The speedometer registers the vehicle speed when it is in excess of 2 km/h (1.3 mph). The instrument pack receives a pulse stream from the SLABS ECU equivalent to 8,000 pulses every mile. The signal is processed into a signal which drives the speedo pointer. It should be noted that a slow frequency is always sent from the SLABS ECU when the vehicle is stationary. This instrument pack requires the signal to verify that the connection from the SLABS ECU is intact.

The instrument pack transmits the vehicle speed to the IDU and the BCU.

There are three speedometers available for derivatives of New Discovery. Each one features a different graphic display. The options are as follows:

- The major scale features miles per hour, the minor scale kilometres per hour
- The major scale features kilometres per hour, the minor scale miles per hour
- The major scale features kilometres per hour and there is no minor scale

The tachometer, which is located to the left of the speedometer in the instrument pack, displays engine speed between 228 – 6,000 rev/min. In operation, the instrument pack receives a pulse stream signal from the ECM. The signal supplies 2 pulses for every 360° of engine rotation. The signal is processed by the instrument pack and converted into an output to drive the tachometer pointer.

A signal is also supplied to the instrument pack from the ECM in circumstances where the engine is stopped but the ignition is on. This signal is supplied in the form of a pulse stream at a ‘slow’ frequency. This signal is used to ensure that the connection between the ECM and the instrument pack is intact.

The fuel level gauge, located to the right of the speedometer within the instrument pack, provides an analogue indication of the quantity of fuel present in the fuel tank. The position of the gauge is set in response to an input received from a sender unit, located within the fuel tank.

In operation, the position of a float arm, incorporated into the sender unit, is determined by the amount of fuel in the tank. In turn, the sender unit supplies a variable voltage signal to the instrument pack. The signal value is determined by the precise position of the float arm. The gauge will register fuel level as long as the resistance of the sender unit is between 8 – 550 Ohms. The instrument pack 'damps' the signal received from the fuel gauge to limit the rate of change displayed on the gauge. This feature stops the gauge moving dramatically when fuel is sloshing around the tank. It should be noted that, when the ignition is switched on, the instrument pack inhibits this damping feature, so an immediate response can be achieved.

The coolant temperature gauge is driven from the instrument pack. The ECM sends a PWM signal to indicate the temperature of the engine. This signal is processed into increments. The temperature gauge has been designed in this manner to eliminate unnecessary movement when the engine experiences normal variations, due to the position of the thermostat and the load currently being experienced by the engine. Therefore, it should be noted that there is no direct correlation between the exact engine temperature and the gauge reading.

Driver information lamps

There are 28 different driver information lamps located within the instrument pack. Although referred to as 'lamps' it should be noted that with the exception of the main beam warning lamp, all are LEDs (light emitting diodes). These are 'hard wired' into the instrument pack and cannot be serviced separately. The main beam warning lamp can be replaced in service, if required.

The exact functionality of each lamp is described within the relevant system description sections, incorporated in this document. Details of lamp functionality can also be found in the owners handbook. The following tables describe the meaning and colour of each warning lamp. In addition, they provide supplementary information not found elsewhere in this document.

Group 1

Name	Colour	Bulb check	Note
Directional indicator left	Green LED	No	Signal originates from the IDM TestBook can operate this lamp
Directional indicator right	Green LED	No	Signal originates from the IDM TestBook can operate this lamp
Main beam	Blue Light	No	Driven directly from the fuse box The instrument pack has no control over this lamp
ABS	Yellow LED	Yes, by system	See section on ABS TestBook can operate this lamp

Group 2

Name	Colour	Bulb check	Note
Oil pressure LED	Red	No	Direct input from oil pressure switch TestBook can operate this lamp
Alternator charging	Red LED	No	Direct from the alternator This lamp can be operated by TestBook
HDC	Yellow LED	Yes, by system	See section on ABS TestBook can operate this lamp
SLS	Yellow LED	Yes, by system	See section on SLS TestBook can operate this lamp
ACE	Yellow or Red LED	Yes, by system	See section on ACE TestBook can operate this lamp
Transmission manual	Green LED	Yes	See section on automatic transmissions TestBook can operate this lamp
Transmission sport	Green LED	Yes	See section on automatic transmissions TestBook can operate this lamp

Group 3

Name	Colour	Bulb check	Note
HDC	Green LED	Yes, by system	See section on ABS TestBook can operate this lamp
Brake System	Red LED	Yes, by system	See section on ABS TestBook can operate this lamp
Check engine	Yellow LED	Yes, by system	See section on petrol engine management TestBook can operate this lamp
Transfer box in Neutral	Red LED	Yes, by BCU	Japan, NAS and Canada specification only TestBook can operate this lamp
120 km/h	Yellow LED	No	Gulf specification only TestBook can operate thislamp
Centre Differential lock	Red LED	No	Direct input from the transfer box switch
TC	Yellow LED	Yes, by system	See section on ABS TestBook can operate thislamp

Group 4

Name	Colour	Bulb check	Note
SRS	Red LED	Yes, by system	See section on SRS TestBook can operate this lamp
Off road/ vehicle jacking	Yellow LED	Yes, by system	See section on SLS TestBook can operate this lamp
Trailer	Green LED	Yes, by BCU	This operates when the IDM senses that the current drawn by the indicator circuit exceeds a given threshold. TestBook can operate this lamp
Glowplug	Yellow LED	Yes, by system	See section on diesel EMS TestBook can operate this lamp
Water in oil	Yellow LED	Yes, by system	See this section TestBook can operate this lamp
Seat belt warning	Red LED	Yes	Operates for 6 seconds unless the seatbelt is successfully connected TestBook can operate this lamp
Transmission temperature	Red LED	Yes	Direct input from switch TestBook can operate this lamp

LED displays

Name	Colour	Bulb check	Note
Alarm	Red LED	No	See section on security
Low fuel	Yellow LED	Yes	Bulb check cancelled if the engine is running TestBook can operate this lamp
High temperature	Red LED	Yes	Bulb check cancelled if the engine is running TestBook can operate this lamp

LCD display

The LCD display is used to display the odometer reading, the trip reading and, on vehicles equipped with automatic transmission, the current gear position selected.

The odometer reading is calculated from the data supplied from the SLABS ECU regarding road speed. The reading is stored digitally in a non-volatile memory incorporated within the instrument pack and in a non- volatile memory incorporated within the BCU. A value up to 999999 units, (either kilometres or miles) can be stored.

Whenever the ignition is turned from position I to position II, the instrument pack and the BCU compare their stored values. If the instrument pack detects that the values are different, it will ‘flash’ the odometer. The odometer will continue to flash until the values have been synchronised. Both units continue to record any distance travelled by the vehicle, even when the display is flashing. If the need arises to change either the BCU or the instrument pack, the new unit will require synchronisation with the existing unit. The value can be synchronised only in an upward direction (the higher of the two values is stored in both units, with the one exception detailed in the next paragraph). Synchronisation of the values can be achieved using TestBook.

If necessary, the odometer readings stored by the BCU and the instrument pack can be reset to 0 kilometres (0 miles) using TestBook. This operation can be carried out only once and then only in circumstances where the current reading is below 160 kilometres (100 miles). This feature is designed to provide dealers with the opportunity of delivering New Discovery vehicles with 0 kilometres (0 miles) displayed on the odometer. This can be carried out after the pre-delivery inspection, once the delivery mileage has been recorded. It should be noted that the values stored by the BCU and the instrument pack must be reset. If only one value is reset then the odometer will flash a miss-match warning, as previously described (depending upon market specification).

The trip reading feature will record the vehicle kilometres/miles to a resolution of 0.1 unit, up to a maximum reading of 999.9 kilometres/miles. When this value is reached, it ‘rolls over’ to 0 kilometres/miles. A button is provided to reset the trip reading to 0. The driver can also change the units from kilometres to miles and vice versa, by pressing and holding the trip reset button for longer than 2 seconds (only available on certain market specifications).

The gear position display, exhibits the following:

- P Park
- N Neutral
- R Reverse
- D Drive
- 3 Gears 1-3 available
- 2 Gears 1-2 available
- 1 Only 1st gear available

The ‘sport mode’ and ‘manual mode’ functions are displayed using dedicated driver information lamps. It should be noted that, if the link between the instrument pack and the BCU fails, the gear selection display will flash, to indicate to the driver that there is a fault.

Sounder

The sounder is controlled by the instrument pack, although its operative state is determined by the BCU or IDU. For operational details, see relevant system sections in this brochure.

Fuel contamination monitoring system

The Diesel derivatives of New Discovery feature a fuel contamination sensor housed in the bottom the primary fuel filter. The sensor monitors the amount of water contamination of the diesel fuel. The sensor will supply a signal to the ECM which, in turn, signals the instrument pack to warn the driver that the fuel contamination has exceeded a predetermined level.

Windows and sunroof inputs

New Discovery window lift system and sunroof system incorporates front and rear electric windows and two optional electric sunroofs. The front windows are controlled by the BCU, while a hard-wired circuit controls the rear windows. A sunroof ECU, which is enabled by the BCU, controls sunroof operation.

The window lift system and sunroof system receives inputs from the vehicle's driver and passengers. The BCU, via the IDM, and sunroof ECU control the window and sunroof motors by processing these inputs. Figure 30 illustrates how the system inputs interconnect.

Window and sunroof system inputs:

- Ignition switch (ignition I, II)
- Front window console switches (left and right)
- Front sunroof switch
- Rear sunroof switches (front & rear)
- Rear sunroof isolator switch
- Sunroof micro-switches

There are three hard-wired parts to the window circuit. These are:

- Rear window lift on-console switches (left and right)
- Rear window disable switch
- Rear window lift on-door switches (left and right)

Electric Windows and Sunroof Block Diagram

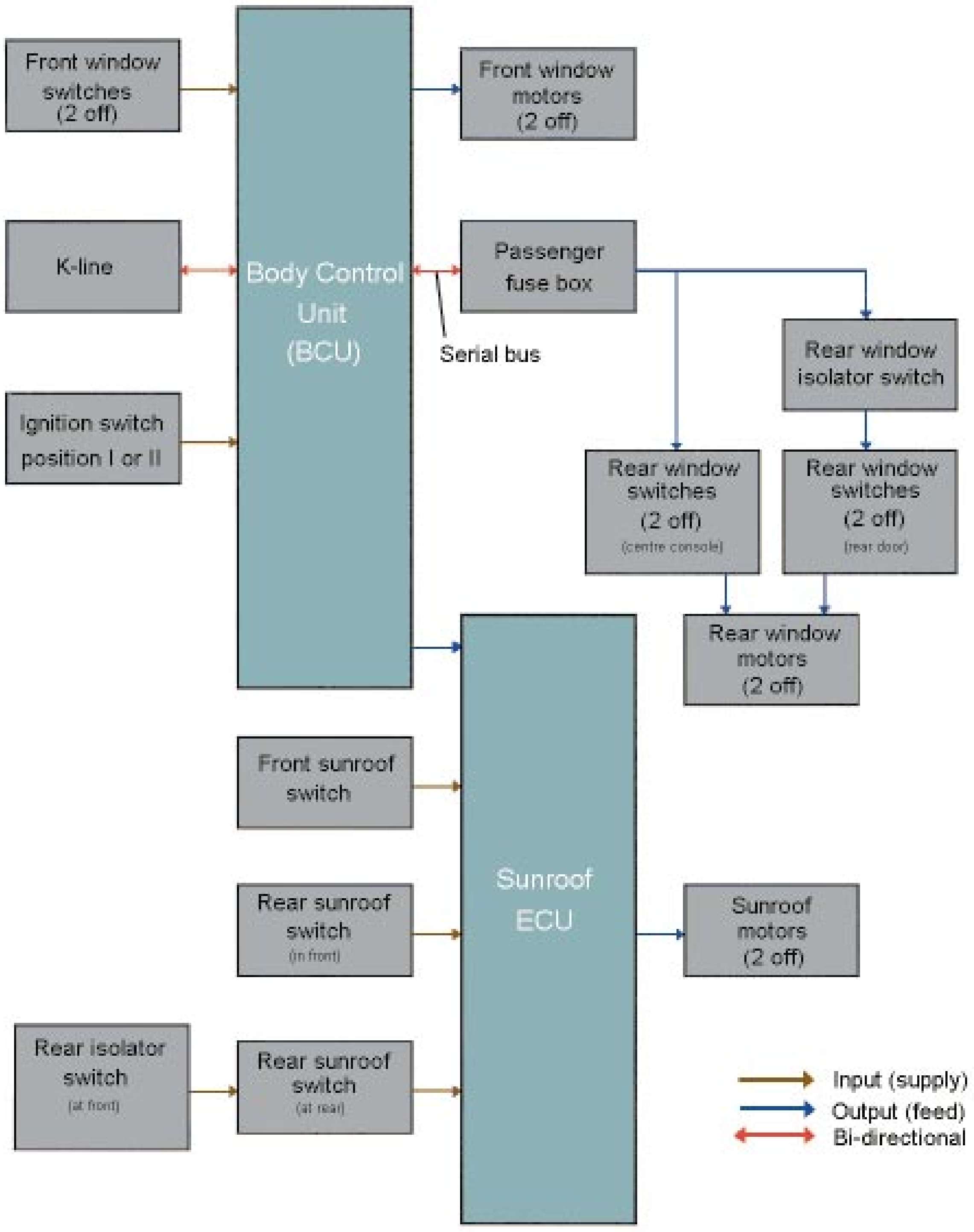


Figure 30

Ignition switch

The BCU will allow window and sunroof operation when the ignition key is in position II. The BCU also keeps the window system and sunroof system active for a period of time after the ignition has been switched off. The length of this time period, and the conditions which need to be met before the BCU will allow the windows to operate after the ignition is switched off, are described later in this section.

Front window console switches

The window lift switches are located in the centre console in front of the handbrake. The front window switches are the lower two within the switch pack. The front window switches are momentary switches (will change state when pressed and return to the neutral position when released). The switches provide a path to ground from a voltage supplied by the BCU.

TestBook can be used to monitor the operation of the front window switches. Figure 31 identifies the position of the front and rear switches within the vehicle.

Rear window console switches and rear door switches

Each of the rear windows can be operated from either one of the two switches. One switch is located in the centre console switch pack in front of the handbrake lever (top switches), the other switch is located on the rear door casing relating to that particular window. All the window switches are momentary switches. Figure 31 identifies the rear switches from the centre console switch pack.

Rear window operation is not controlled by the BCU, so the switches in the centre console and the rear doors operate the rear window motors directly. The BCU can, however, block the operation of the windows by requesting the IDM to remove the power feed to the system. This has implications when diagnosing for any failures within the rear windows system, as TestBook cannot diagnose any faults or monitor the position or operation of any of the switches, except for the inhibit signal.

Rear window disable switch

The rear window disable switch is located in the same switch pack as the front and rear window switches. It is a latching switch so remains in either the rear window enable position, or the rear window disable position. The disable switch allows rear passenger compartment window switches to operate when it is latched in. This switch has no input into the BCU so no TestBook diagnostics are available. Figure 31 identifies the position of the rear isolator switch.

Figure 31

Sunroof switches

The front and rear sunroof switches are located in the headlining above the windscreen, in front of the front sunroof. The second rear sunroof switch is located by the rear sunroof. All the sunroof switches are momentary switches and interface directly with the sunroof ECU. The BCU provides an enable/disable input into the sunroof ECU. TestBook cannot communicate directly with the sunroof ECU, so the front or rear sunroof switches status cannot be viewed within the window diagnostic features in TestBook. Figure 32 identifies the position of the sunroof switches.

Rear sunroof isolator switch

The rear sunroof isolator switch is located next to the front sunroof switch in the headlining by the front sunroof assembly. It is wired in series with the rear sunroof switch, located next to the rear sunroof. The switch toggles its outputs i.e. the switch latches in the enable position. When depressed the rear switches are enabled. Figure 32 identifies the position of this switch.

Sunroof micro-switches

The micro-switches are located within the sunroof assemblies. The sunroof assemblies incorporate two micro-switches to detect that the sunroof has reached its fully closed position. The sunroof ECU monitors both micro-switches individually. This enables it to determine the direction in which the sunroof has moved.

Figure 32

Windows and sunroof outputs

The BCU and sunroof ECU process the above system inputs and use this information to control the following items:

- Front window lift motors (left and right)
- Front sunroof motor
- Rear sunroof motor

Front window lift motors

The front window motors are located in the front door. They are connected directly to the BCU by two wires. The BCU powers one wire, whilst supplying a path to ground for the remaining wire. This configuration allows the motor to be driven in either direction by the BCU. This is achieved by the BCU reversing the wire to which it supplies a voltage and the wire to which it supplies a path to ground.

TestBook has the ability to ‘force’ the front motors to operate in either direction. This can be useful when diagnosing the failures within the window circuit.

Sunroof motors

The sunroof motors are located in the front and rear sunroof assemblies. Each sunroof motor is connected to the sunroof ECU by two wires. The sunroof ECU powers one wire, while supplying a path to ground for the other wire. This configuration allows the motor to be driven in either direction in a similar manner to that of the window motors. The BCU supplies the sunroof ECU with an ‘enable’/’disable’ signal. The enable signal is generated whenever the front windows are enabled.

Window operation

The front windows on New Discovery are controlled by the BCU. The BCU monitors the amount of current the motors are drawing during operation. The BCU can determine if the window is in a ‘stall’ condition. If the BCU determines that the window has ‘stalled’ it will immediately stop operating the window motor. The BCU will not attempt to detect a ‘stall’ condition until the window has been operated for at least 500mS (0.5 seconds). This period allows the initial current surge to pass and eliminates false window ‘stall’ detection. A ‘stall’ condition is defined as the motor current exceeding a nominal current value for a period of greater than 300mS (0.3 seconds).

If the BCU determines that it has been operating the same window motor in one direction for more than 10 seconds ± 0.2 seconds, without the BCU detecting a ‘stall’ condition or the driver releasing the switch, it will automatically stop operating the window motor.

Window operation will resume when the window switch is released and pressed again. If the window was operating in one-touch mode the window operation will resume on the next press of the window switch.

When the window switches are operated up or down, the BCU will follow a predetermined strategy. This strategy is dependent upon the market specification programmed into the BCU. Different countries have different legislation concerning automatic operation of vehicle windows. To accommodate this, New Discovery has the ability to change the way the front windows operate.

One-touch function

One-touch mode automatically lowers the window to its fully open position, without the need for the vehicle switch to be depressed for the duration of travel. One-touch mode is initialised if the window switch is operated (in the direction that will lower the window) for a period of less than 0.4 seconds ± 0.2 seconds. One-touch mode continues to lower the window until the BCU detects:

1. That a ‘stall’ condition exists (window reaches the bottom of its travel)
2. The driver or passenger has operated the window switch in either direction for more than 0.4 seconds ± 0.2 seconds, or the window switch has been operated to reverse the windows travel to an upward direction
3. The BCU has operated the motor for a period greater than 10 seconds ± 0.2 seconds

Time-out function

The time-out function enables the windows to operate after the ignition key has been removed. It is enabled for a period of 44 seconds ± 1 second, and will operate if the market specification permits its function.

The time out function will be cancelled if:

1. The driver's door switch signals the BCU that it has seen the driver's door close after the ignition is switched off (depending on market specification)
2. Any door switch signals the BCU that it has seen any door open after the ignition is switched off (depending on market specification)

Depending upon market specification, New Discovery will adopt one of the strategies detailed in the table below.

Option	Time-out on driver's door	Time-out on any door	Front windows operating
1	Yes	No	Yes
2	Yes	Yes	Yes
3	No	No	No

Rear window and sunroof operation

The use of enable lines limits the windows and sunroof to operate only when the front windows operate. The enable lines can be programmed to follow the market specification detailed above. The differences in operation are detailed in the table below .

Option	Time-out on driver's door	Time-out on any door	Rear windows operating	Sunroof operating
1	Yes	No	Yes	Yes
2	Yes	Yes	Yes	Yes
3	No	No	No	No

In car entertainment

The New Discovery model range features several different in car entertainment (ICE) system options. The exact specification of the equipment fitted to any particular vehicle is dependent upon its trim level and the regional requirements of its destination market. In all cases, the ICE system will comprise a head unit (fascia mounted control unit), speakers and antenna. Depending upon the exact specification and configuration of the vehicle, the system may also incorporate a remote control unit, a power amplifier and a CD autochanger. There are four standard ICE system configurations available:

1. Standard configuration (trim level 1)
   I. Philips head unit (radio-cassette unit)
   II. Harman 152mm (6") 30W 'full range' door speakers (one in each door, excluding the tail door)
   III. Single FM/AM antenna (mounted on right-hand rear side window)

2. EX, Fxi and FxiS specification (trim levels 2 and 3)
   I. Philips head unit (radio-cassette and CD-ready unit)
   II. Harman 152mm (6") 30W base and mid-range door speakers (one speaker in each door, excluding the tail door)
   III. Harman 25mm (1") 30W tweeter speakers located in the 'A' post finishers
   IV. Steering wheel remote control unit
   V. Single FM/AM antenna (mounted on right-hand rear side window)

3. SD and SE (trim levels 2 and 3 NAS and Japanese specification)
   I. Alpine head unit (radio-cassette and CD-ready unit)
   II. Harman 152mm (6") 30W base and mid-range door speakers (one speaker in each door, excluding the tail door)
   III. Harman 25mm (1") 30W tweeter speakers located in the 'A' post trim finishers
   IV. Steering wheel remote control unit
   V. Single FM/AM antenna (mounted on right-hand rear side window)

4. ES, FxiXS and LSE (trim level 4)
   - I. Alpine head unit (radio-cassette and CD-ready unit)
   - II. Alpine 6 CD autochanger unit (located under the right hand front seat)
   - III. Harman power amplifier 330W RMS at 1% distortion
   - IV. Harman 152mm (6”) 40W base and Harman 152mm (6”) 40W mid-range door speakers (two speakers in each front door, and one speaker in each rear door)
   - V. Two tail door mounted 40W extended-throw sub-woofer speakers
   - VI. Two Harman 33mm (1¼“) 40W tweeter speakers located in the ‘A’ post finishers and two 33mm (1¼”) tweeters mounted in the rear passenger door casings
   - VII. One FM/AM antenna (mounted on right-hand rear side window) and one FM antenna (mounted on left-hand rear side window)
   - VIII. Rear headphone modules
   - IX. Steering wheel remote control unit

New features

The premium ICE system fitted to New Discovery brings many new features to the 4x4 Market. A summarised description of the functionality of a selected number of these new features is given below. This information is provided to develop the reader’s basic understanding of the improvements and interconnection details. Full details of the functionality of all the ICE system components and features can be found in the owners handbook provided with the vehicle.

Audio power amplifier

The power amplifier is situated underneath the left-hand seat (see figure 34). Its location does not change whatever the configuration of the steering. The power amplifier provides an audio signal to each of the speakers via ‘twisted pair’ wires. These wires reduce the effect of other electrical systems on the sound quality of the audio system. The remote amplifier also powers the sub-woofers directly, so there is no rear amplifier within this system.

The amplifier receives an ‘enable’ signal from the head unit. This enable signal switches the power amplifier on, but does not provide the power feed for the unit. The amplifier receives separate audio signals from the head unit for each of the speakers incorporated into the system.

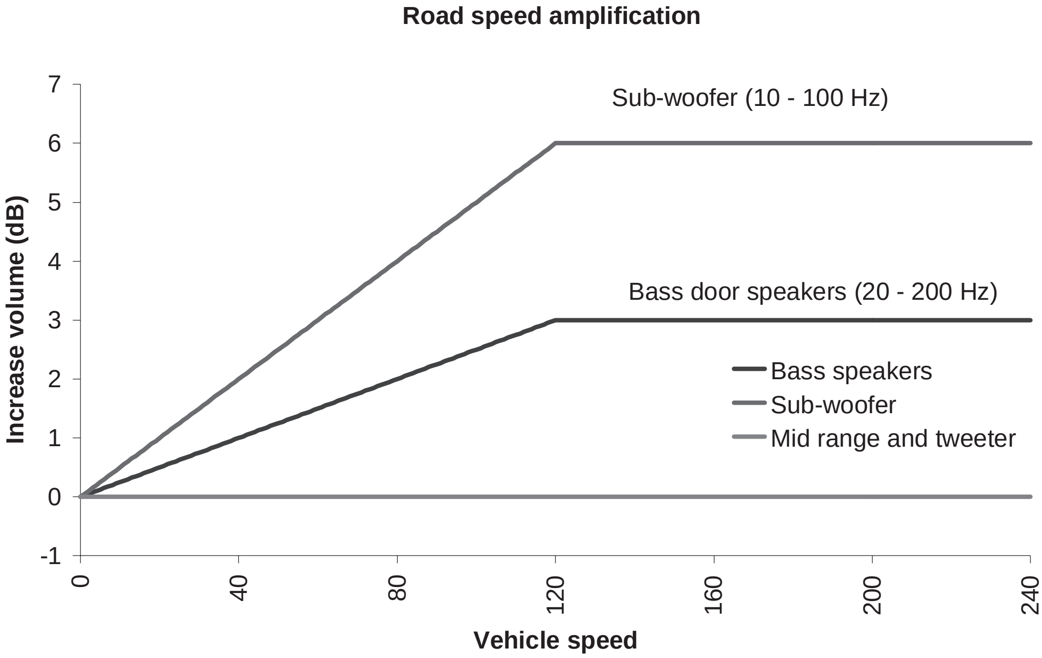


Figure 33

A road speed input signal is supplied to the amplifier from the SLABS ECU. In response to this input, the amplifier automatically adjusts the audio signal balance boosting the lower frequency notes to overcome road to tyre noise (see figure 33). This capability ensures the perceived volume of sound remains at a constant level, regardless of the predictable changes in background noise caused by increases and decreases in vehicle speed.

Figure 34

Rear headphone modules

Two rear headphone modules are incorporated into the premium ICE system. The modules are located just behind the rear seats, one on each side of the vehicle. The modules enable the rear passengers to select an audio source (i.e. tape, radio or CD), independently of the source being used by the vehicle system. The ICE system is capable of supporting independent operation of any two of the three audio sources simultaneously. An audio signal is supplied to the rear headphone modules from the head unit only if the headphones are plugged in (see figure 35). Once plugged in, the audio source and volume can be set as desired. The two rear headphone modules do not operate independently of one another, except for the ability to adjust the volume of sound delived to the headphone. Consequently, it is not possible to select a different audio source or to select a function controlling the audio source, e.g. fast forward, track skip, etc., without affecting the supply to the other module.

Figure 35

The operation and illumination of the rear modules is dependent upon the specific operating conditions, described below:

1. If the head unit is switched off, then the rear modules will not be active and will not be illuminated
2. If the head unit is switched on but the headphone jack plug is not inserted, the headphone sockets will be illuminated
3. Upon the headphone jack plug being inserted into one of the rear headphone modules, the head unit will:

   - Reduce the bass volume of the audio signal
   - Switch off the sub-woofer
   - Illuminate the headphone icon on the radio display
   - Illuminate the source icon for the rear headphone (next to the ‘headphone in’ icon on the head unit display)
   - Illuminate all the buttons of the rear headphone modules

It is not possible to override the driver's wishes using the controls on the rear modules. This remains the case even if the driver changes to the option currently being used by the rear headphone modules.

Each of the modules incorporates an internal amplifier. The amplifiers enable the head unit to supply a single audio source to both modules. The head unit also supplies an 'enable' signal to the rear modules in the same manner as it supplies an enable signal to the main amplifier.

Premium head unit

The premium head unit is manufactured and supplied by Alpine (Audio Co) (see figure 36). Many of the function/modes featured on the unit are similar to those available on other ICE systems previously used on Land Rover products. There are, however, several new functions available to the driver. These are:

1. A "dot matrix" display. The 'dot matrix' display provides an improvement over the usual LCD display in respect of brightness and clarity of symbols. Using this type of display, it is possible to display information in both numeric and more realistic alpha formats
2. The unit features a 'spatial' sound configuration. This feature provides the driver with a predetermined sound balance suited to the vehicle. This combination of sound balance, audio signal phase shifting and bass and treble amplification has been specially developed for New Discovery and is designed to increase the 'depth' and 'character' of sound
3. The system incorporates an optional third-party mobile phone installer. This utilises one of the terminal connections on the back of the head unit. This facility will automatically 'mute' the audio output for the duration of the phone call
4. The head unit is connected to two antennas. It uses the signal supplied by the right-hand antenna only for all non-FM radio stations. It monitors the signal supplied by both antennas and selects the best signal for all FM radio stations

Figure 36

Climate control system

Conventional air conditioners require the driver or passenger to perform the temperature adjustment, airflow/volume adjustment and air outlet mode selection manually each time the cabin temperature becomes higher or lower than the desired temperature.

New Discovery features an automatic temperature control (ATC) system. The ATC compensates automatically for any changes in the internal and external air temperature and the influences of sunlight. Once a desired temperature is set, the system maintains the "cabin" temperature automatically at that set temperature.

The ATC system utilises a servo motor for air distribution, moving several flaps inside the heater box to direct air to the place required. The ATC system also controls two servo motors, which control the mix of heated and cooled air. There is one servo for each side of the vehicle. A motor is used to control whether air is allowed to enter from outside the vehicle or whether it recirculates the air from the interior of the vehicle.

A new option on New Discovery diesel derivatives will be a fuel burning heater. In some markets this will be as standard.

The system comprises of the following main components:

1. Compressor
2. Condenser
3. Receiver/drier
4. Thermostatic expansion valve
5. Evaporator
6. ATC ECU
7. Heater matrix
8. Air distribution/blend unit
9. Blower motor

There is also an option of a second air conditioning unit, if required. The second unit is installed at the back of the vehicle. The rear air conditioning unit supplies cooled air to only the rear passenger seats and occasional seats (where fitted).

Automatic temperature control (ATC)

The system fitted to New Discovery has the facility to automatically control blower speed, air distribution, air temperature, fresh/recirculated air selection and the air conditioning compressor, via the engine management system. This provides a comfortable interior temperature which will mirror the drivers selected temperature.

To enable the ATC unit to control the interior compartment temperature, it needs to obtain information from the following sensors:

- Solar sensor
- Ambient temperature sensor
- Interior temperature sensor
- Coolant temperature sensor
- Evaporator thermistor sensor

Solar sensor

The solar sensor is mounted between the defrost outlets on the fascia. The sensor consists of two diodes which are sensitive to the brightness of the sun. When the sensor detects that sunlight radiation is high, it prompts the ATC unit to modify the temperature of the air entering the vehicle interior. The diodes can detect the direction of the sunlight and modify the air temperature to provide enhanced cooling to the required side.

Ambient temperature sensor

The ambient temperature sensor consists of an encapsulated thermistor which measures the external air temperature. The sensor is mounted at the front end of the vehicle, in front of the condenser. This sensor provides information to the ATC ECU so it can modify the blend of air entering the interior, in order to compensate for changes in ambient temperature.

Interior temperature sensor

The interior temperature sensor is mounted behind the fascia adjacent to the headlamp levelling switch. In order for the ATC to achieve control of interior temperature over the complete range of driver selected temperature settings, it is necessary to employ a fan aspirated sensor. This fan draws a stream of air over the sensing element. The fan operates when the ignition is switched on, even if the ATC system is switched off. This allows the ATC unit to receive an accurate reading of the passenger compartment temperature when the system is reactivated.

Coolant temperature sensor

The coolant temperature sensor is an encapsulated thermistor. It is located in a position where it contacts the heater matrix. The sensor measures the temperature of the heater matrix, not the temperature of the coolant . Information from the sensor allows the ATC unit to adjust the blend of air, and the volume of air, entering the interior. The ATC also modifies its operation during warm-up periods.

Evaporator sensor

The evaporator sensor is mounted in the heater box. It is attached to the evaporator matrix. The sensor is a thermistor which measures the evaporator temperature, not the temperature of the refrigerant. When the sensor detects that the temperature is above 4°C (39°F), it will signal the ATC unit to energise the air conditioning compressor.

Condenser cooling fans

The condenser cooling fans operate when the ambient air temperature is above 28°C (82°F), the compressor is engaged and the vehicle speed is below 100 km/h (62 mph). The engine management ECM controls the compressor clutch and condenser fans, via relays. The ECM is signalled by the ATC ECU when this operation is required. In addition, the ECM can control the condenser fans based on current engine coolant temperature, in order to provide additional engine cooling, if required. The ECM can override the ATC if extra power is needed for the engine. This is dependent upon throttle position; if the throttle is fully open, the air conditioning compressor will decouple for 8-10 seconds to allow the engine more power.

When starting the vehicle, if the air conditioning compressor is switched on it will be approximately 5-8 seconds before it operates. This gives the engine time to stabilise. If the vehicle reaches speeds over 100 km/h (62 mph), the condenser fans will not operate and will not recommence working until the vehicle drops down to 80 km/h (50 mph).

Servo motors

Situated on the air distribution/blend unit are three servo motors. One servo motor controls air distribution, the other two control air mix, one for each side of the vehicle. Attached to the servo motors are their servo potentiometers. The servo motors operate the flaps on the air distribution/blend unit via a signal from the ATC ECU.

The servo motors send flap position signals (feedback signals) from their potentiometers to the ATC ECU. The ATC ECU uses these feedback signals to confirm movement of the flaps inside the heater box. It also allows the ATC ECU to calculate the exact position of the flaps so that it can determine if a change in position is required.

Automatic Temperature Control Unit

Mounted in the fascia and secured by spring clips, the unit contains the microprocessor, driver interface and servo-driver electronics needed to control the system.

Figure 37

Operation

The air conditioning system provides the means of supplying cooled and dehumidified, fresh or recirculated air to the interior of the vehicle. The cooling effect is obtained by blowing air through the matrix of an evaporator unit and, when required, mixing that air with air which has travelled over the heater matrix. The volume of conditioned air being supplied is controlled by a variable speed motor (blower motor).

Automatic temperature control modes

Button	Action
Off	Switches the ATC system off
Auto	Selects automatic control of the blower speed, temperature control and air distribution, and will override previous settings
Defrost	Fixes the air outlet mode to defrost and fixes the blower fan to the Hi mode
Recirculation/Fresh	Manual override - for selecting whether air entering the vehicle is air drawn from outside or is recirculated
Econ	Manual override - computer selected compressor operation, switches the compressor off, even if the ATC calculation would normally turn it on. Press again to return to normal operation
Blower motor	Will select one of 5 manual speeds. Fixes the blower speed each time the switch is pressed in the following sequence: Lo, M1, M2, M3. When the switch is kept depressed the blower mode is changed until manual Hi is selected
Mode/distribution	Fixes the air outlet position each time the switch is pressed in the following sequence: face, face & feet, feet, feet & screen, screen. When the switch is kept depressed it will index through the modes before stopping automatically at face/feet mode
Ext	Selects external air temperature. The temperature is displayed for 7 seconds
Left temperature setting switch	Increases or decreases the temperature setting by 1°C (2°F) each time the switch is pressed for the left side of the vehicle
Right temperature setting switch	Increases or decreases the temperature setting by 1°C (2°F) each time the switch is pressed for the right side of the vehicle

Off switch

When the off switch is pressed, the ATC system stops operating and the following functions are affected:

- All control panel indicators are extinguished
- The blower motor and compressor stop operating
- The air blend flaps are maintained at the current position
- The air inlet mode fixes forcefully to the fresh air mode if the vehicle speed is higher than 28 km/h (17 mph), or to the recirculation mode if the vehicle speed is lower than 28 km/h (17 mph)

Pressing the off switch again will signal the ATC ECU to resume the conditions existing immediately prior to the off switch being pressed the first time.

Auto switch

When the auto switch is pressed, the ATC ECU controls the functions described below automatically in order to reach the set temperature.

- Temperature adjustment via the blend servo
- Airflow volume adjustment via the air blower motor
- Air outlet adjustment via the air distribution servo
- Air inlet adjustment via the air inlet servo

Semi automatic control

If the fan speed if forced to the M1 position whilst in the automatic mode by the driver depressing the blower switch, the ATC ECU continues to control the above functions automatically minus the airflow volume.

Defroster switch

When the defrost switch is pressed, the ATC ECU sets the system to the following condition:

- Air is directed to the screen
- Air is drawn in from the exterior of the vehicle
- The compressor is switched on (via ECM control)
- The blower motor fan operates at maximum
- The front and rear heated screen is activated (if fitted)

Pressing the defrost switch again causes all the functions to resume to the conditions existing immediately prior to the defrost mode being set.

Econ switch

When the econ button is pressed this turns off the compressor by overriding the automatic control of the compressor. The ATC will not be able to control the interior temperature as the cooling ability has now been lost.

When econ is switched off, air is supplied either by ram effect (the movement of the vehicle through the air) or the internal blower motor. This air is directed to the areas selected by the controls. The air mix flap on the blend unit controls the temperature of the air being supplied. No cooled air is available.

Automatic temperature control strategies

Volume air control

When the air inlet is set to fresh air the airflow volume is controlled automatically to a value calculated by subtracting the vehicle speed compensation from the basic airflow volume. The vehicle airflow volume control is not affected when the air inlet is set to recirculation or maximum blower level.

Warm-up control

Warm-up control is activated if it is necessary to produce heated air while the engine coolant temperature remains low immediately after the engine has been started. This function prevents the heater outlet from discharging cool air whilst the engine coolant temperature is low.

When the engine coolant is below 20°C (68°F), the blower speed is set to 3 (auto blower speed). At an engine coolant temperature between 20°C (68°F) and 55°C (131°F), the ATC ECU compares the warm-up compensation value against the basic airflow volume and controls the airflow volume automatically to the lesser volume. Normal control takes over once the engine coolant temperature reaches 50°C (122°F).

Cool down control

Cool down control is initiated if it is necessary to produce cool air while the external air temperature and the vehicle internal air temperature readings are high. This function prevents hot air from blowing out of the face air outlet immediately following engine start.

The blower motor speed is fixed at 3 (auto blower speed) for 5 seconds after the fan motor begins rotating. Then for 6 seconds, the ATC ECU compares the airflow volume under cool down control against the basic airflow volume and controls the airflow automatically to the lesser value. Thereafter, normal control takes over.

Air outlet control

Air outlet selection is performed through the servo motor for the air distribution flaps. The ATC ECU selects the air outlet mode automatically to face, face/feet, and feet, according to the desired outlet air temperature.

When the temperature setting is at Hi or Lo (max setting), the air outlet becomes fixed forcefully to feet or face.

The ATC ECU determines the direction of the rotation of the flaps by comparing the present position obtained by the servo motor’s potentiometer (position detection signal) to the target opening of the air outlet mode.

Air inlet control

The selection of the air inlet mode is performed by the air inlet servo motor. The ATC ECU changes the air inlet mode automatically between the recirculation of the internal air and the introduction of fresh air, according to the obtained data, such as the desired outlet air temperature and the vehicle speed signal.

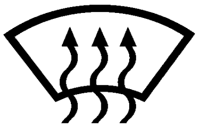
When the temperature setting is at low the air inlet becomes fixed forcefully to recirculation.

Front and rear heated window control

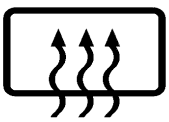
When the defrost switch is pressed, the ATC ECU controls the front and rear heated windows automatically.

If the defrost switch is pressed when the front heated screen control is manually switched off, the heated front screen is turned on by the ATC ECU for approximately 5 minutes. If the front heated screen is already switched on and the defrost switch is pressed on the ATC unit, the timer for the front heated screen will reset for approximately 5 minutes.

The process is the same for the heated rear window (HRW), but the HRW function is turned on automatically for a minimum of 6 minutes.



Heated front window switch



Heated rear window switch

Rear air conditioning

On certain models rear air conditioning is available. The rear air conditioning system cannot cool the air without the ATC system functioning (econ not active). If the rear air con is switched on whilst the ATC is off, only the rear blower motor will work.

There are four blower speeds. The on/off button selects fan speed 1, then slide settings give the other three settings. The air enters the passenger compartment through three roof vents above the rear passenger seats. The system also incorporates two vents above the occasional seat in the rear compartment.

Customer preferences

When touching any of the push buttons on the ATC unit, an audible indication will be emitted. This can be turned off by holding down the auto button and then pressing the off button for 3 seconds or more. This feature cannot be turned off during on board diagnostics mode. To turn back on the audible indication, repeat the above procedure.

To change the temperature reading from °C to °F (or vice versa), press and hold the recirculation button, then press the off button holding the switch down for 3 seconds or more until an audible "beep" is emitted. If the battery is disconnected and then reconnected, the temperature reading will revert to °C. Turning the ignition on/off will not change the customer's set preference.

During warm-up control the air outlet mode is set to full feet mode, with warm air also being discharged through the face vents for a period of up to 7 minutes. This time period is determined by the ambient temperature and the solar load. If the customer dislikes this function, then the procedure for cancelling the air from being discharged through the face vents is: the ignition must be turned from off to on whilst pressing the off and defrost buttons simultaneously. To turn this function on the ignition must be turned off to on whilst pressing the auto and defrost buttons simultaneously.

If the recirculation button is pressed for less than 1.5 seconds, it will latch into the recirculation mode. If the recirculation button is pressed for longer than 1.5 seconds, the recirculation mode will be timed for 5 minutes. If, whilst in the defrost mode the recirculation button is pressed, then the process will be reversed, i.e. if the button is pressed for less than 1.5 seconds then recirculation will occur for a timed period of 5 minutes; if pressed longer than 1.5 seconds, the recirculation will be latched.

***Note**: Pressing the auto button will override all settings.*

Diagnostics

The air temperature control unit has on board diagnostics (OBD). When the ignition is first turned on, the system performs a sensor check and a servo motor check automatically. It will check the LCD indicators and buzzer. In the event of a malfunction, the warning buzzer sounds and the auto indication on the panel flashes for 20 seconds. After 20 seconds has elapsed, the system transfers to normal control.

OBD operation

To read the fault codes, turn off the ignition, hold down the auto and mode buttons simultaneously and turn the ignition to position II. All the LCD indicators will be displayed. Shown in the left hand temperature setting are the initials for fault code FC. Any fault codes detected are then displayed where the right hand temperature selection is displayed.

There is a possibility that fault codes 21 and 22 will be displayed. These are the fault codes for the solar sensor. These codes will be shown if the ignition is switched to position II and the vehicle is subjected to reduced ambient light.

Figure 38

To eliminate these fault codes, go through the above procedure again but shine a torch or other light onto the solar sensor. This will eliminate these fault codes.

If the position of the windscreen wiper arms is incorrect, the functionality of the solar sensor will be impaired.

Service

Always refer to the vehicle workshop manual when working on the vehicle's air conditioning.

All temperature sensors must be serviced as a unit.

A service option available through Unipart (Part No JFQ 100080) is a small link lead which connects into the back of the ATC unit and keeps the temperature reading permanently in degrees Fahrenheit or centigrade, to suit customer preference.

Refer to the workshop manual for the oil and refrigerant capacities and specifications.

On board diagnostic fault codes

Display code		Fault contents	Default Value
00		Normal	-
11	In car sensor	Open circuit, short circuit short circuit to a 12v supply	25°C (77°F) 25°C
12	Ambient sensor	Open circuit, short circuit short circuit to a 12v supply	10°C (50°F) 10°C
13	Evaporator sensor	Open circuit, short circuit short circuit to a 12v supply	0°C (32°F) 0°C
14	Water temp sensor	Open circuit, short circuit short circuit to a 12v supply	70°C (158°F) 70°C
21	L/H solar sensor	Open or ground short circuit 12V short circuit	None 0 kcal/m^2, min
22	R/H solar sensor	Open or ground short circuit 12V short circuit	None 0 kcal/m^2, min
31	Air mix L/H potentiometer	Open or 12V short circuit Ground short circuit	Servo motor stopped Servo motor stopped
	Air mix L/H servo motor	Motor lock	Servo motor stopped
32	Air mix R/H potentiometer	Open or 12V short circuit Ground short circuit	Servo motor stopped Servo motor stopped
	Air mix R/H servo motor	Motor lock	Servo motor stopped
33	Mode potentiometer	Open or 12V short circuit ground short circuit	Servo motor stopped Servo motor stopped
	Mode servo motor	Motor lock	Servo motor stopped

Fuel burning heater

The diesel derivatives of New Discovery have a factory fit option (depending upon specific model) of a fuel burning heater. As engineering strives to improve the efficiency of diesel engines, the amount of waist energy the engine produces (in the form of heat into the coolant) is consistently reduced. As a result Land Rover now provides the option to customers who live in extreme cold climates of a supplementary fuel burning heater.

The fuel burning heater uses fuel to heat up the water flow into the vehicle's cooling system. This fuel burning heater can provide a maximum of 5 kW of extra heat energy to the heater matrix within the ATC system.

The Fuel Burning Heater comprises:

- In-built ECU
- Heat exchanger
- Vaporiser
- Stainless steel burner
- Flow pin
- Glow Pin/Flame detector
- Water pump
- Combustion air fan
- Temperature sensor

External components of the fuel burning heater system are:

- Ambient temperature sensor
- Stainless steel exhaust pipe
- Induction pipe (with in-built silencer)
- Dosing pump (dedicated fuel pump)
- Dedicated fuel line

Fuel burning heater

Figure 39

The fuel burning heater is located on the bulkhead panel, under-bonnet and in front of the passengers footwell. It is a self contained unit, with the vehicle's coolant pipes connected to the unit, so that the water flows in series from the cylinder head through the fuel burning heater and into the heater matrix. The coolant always flows through the heater unit, even if the fuel burning heater is not currently adding heat energy to the coolant.

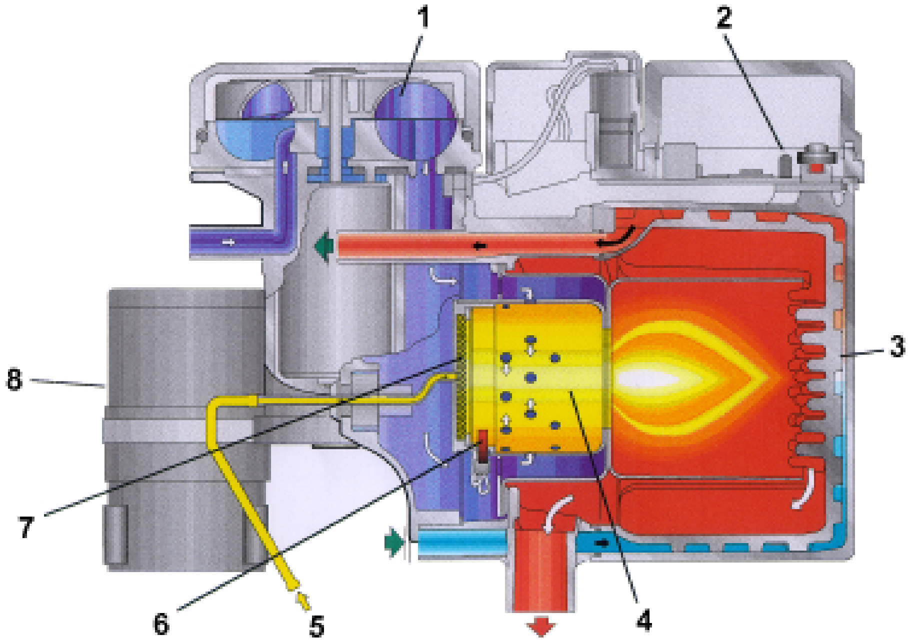


Figure 40

1. Combustion air fan
2. Electronic board
3. Heat exchanger
4. Stainless steel burner
5. Fuel supply
6. Glow pin/Flame detector
7. Evaporizer
8. Water pump

Fuel pump

The fuel pump supplying the heater unit is located in front of the rear cross member which supports the fuel tank. It is a dedicated fuel pump, supplying only the fuel burning heater. The ECU inside the fuel burning heater supplies a 12 volt supply, in the form of a frequency. This pulse of voltage powers an internal solenoid, which then delivers 0.06 ml of fuel. The pump works at one of three frequencies:

1. 0.7 Hz, used during the heater's ignition
2. 3.5 Hz, used when the heater is operating at 2.5 kW
3. 7 Hz, used when the heater is operating at 5 kW

The fuel pipe attached to the fuel burning heater incorporates a valve which seals when the fuel pipe is released from the unit. The primary fuel pump assembly incorporated inside the vehicle fuel tank (main fuel pump), has a fabricated plastic 'elbow' moulded to the upper face. The top of this elbow, when removed, allows a 'straw' to be inserted into the elbow, thus allowing a supply of fuel to the burner. This straw allows the dosing pump to draw fuel from the tank. If the main fuel pump is replaced, then the end of the 'straw' elbow must be removed to allow the existing straw to be inserted.

If the vehicle is to be run on bio-diesel, it is recommended that 1 in 3 tankfuls of fuel should be standard diesel. This will purge the fuel burning heater of the impurities that bio-diesel deposits.

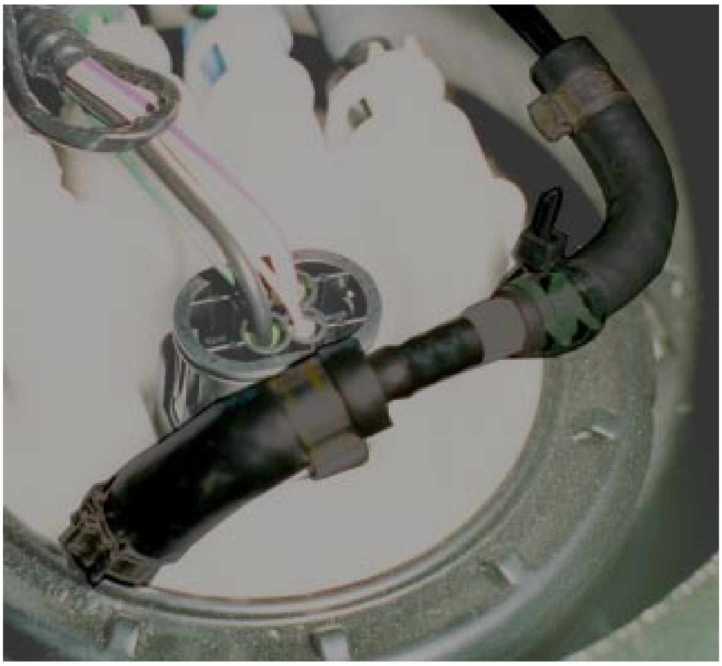


Figure 41

Ambient temperature sensor

The ambient temperature sensor is located on one of the support bars for the bonnet catch, just below the slam panel. Its location is in front of the heater radiator and air conditioning condenser. A 12 volt supply from the alternator warning lamp is supplied to the sensor. If the ambient temperature is below 5°C (41 °F), the sensor will close its internal contacts. This will allow the 12 volt feed through the sensor and to the fuel burning heater. It is this feed which signals the fuel burning heater to start to operate.

Operation

If the ambient temperature sensor measures the outside temperature to be below 5°C (41°F) and the engine is running, the ambient temperature sensor allows the voltage through to the fuel burning heater ECU. This feed enables the heater and auxiliary water pump to start operating. However, should the internal temperature sensor detect an existing coolant temperature of above 60°C (140°F) then the burner will not operate. This condition will remain unchanged until the coolant temperature drops to below 60°C (140°F). When this signal is received, the fuel burning heater ECU enters 'start-up' mode. When this mode is first initiated, the ECU powers the combustion air intake at a slow speed, drawing air in through the silenced inlet pipe. The ECU then provides power to the glowplug. This action preheats the combustion chamber for 20 seconds. After 20 seconds, the ECU starts to operate the 'dosing' pump at 0.7 Hz. The fuel entering the combustion chamber is ignited by the glowplug. The exhaust gases leave the fuel burning heater by the exhaust tube mounted on the inner wing. The ECU will then start to increase the fuel pumps rate and increase the amount of air entering the combustion chamber.

After 90 seconds of fuel has been supplied at full load, the glowplug will switch off and act as a flame detector. After the ignition sequence, if no flame is detected the fuel burning ECU will switch the fuel dosing pump off. It will continue to operate the combustion fan to purge the unit. The fuel burning ECU will then initiate the start-up sequence again. It will try to ignite the system only three times in one ignition cycle. The water jacket temperature is monitored constantly via a temperature sensor incorporated into the fuel burning heater. This sensor measures the temperature of the water jacket and not the actual coolant temperature. At 60°C (140°F) the temperature sensor signals the fuel burning heater ECU to switch to half heat (2.5kW). When this happens, the ECU will slow down the combustion air fan and reduce the frequency at which the dosing pump operates.

Once the engine has been turned off, the dosing pump will stop supplying fuel to the heater. The flame inside the fuel burning heater will continue to burn the existing fuel. To ensure that all the fuel is burnt safely, the fuel burning heater ECU continues to operate the combustion fan for 2 minutes.

The fuel burning heater is designed to shut down for approximately 2 minutes, should it be run continually for periods in excess of 72 minutes (+/- 10%). This is to allow the glowplug to re-ignite and burn off any unburnt particles.

Diagnostics

The fuel burning heater is capable of storing fault codes which are retrievable through TestBook. TestBook also has the ability to read real time inputs and outputs.

The fuel burning heater ECU will try to ignite the fuel burning heater three times within one operating cycle, (engine running and ambient temperature below 5°C (41°F)). If the heater fails to ignite, a fault is stored and the fuel burning heater will remain dormant until the conditions needed to operate are met again. If the fuel burning heater fails to ignite the fuel on three consecutive trips, (engine running, temperature below 5°C (41°F)) it will not attempt to operate again until the fault codes have been cleared.

The fuel burning heater ECU has a volatile memory. If all power is lost to the fuel burning heater, any fault code stored inside its memory will be lost. On reconnection of power the fuel burning heater will operate as if no previous faults have occurred.

No configuration is needed by TestBook. If a new fuel burning heater is ever fitted, it is a straight replacement.

PETROL ENGINE

The petrol engine fitted to New Discovery is a V8 4.0 litre unit (see figure 42). The engine is an adaptation of the existing engine used in Land Rover products. The new unit provides better power and torque characteristics than previous units of the same capacity.

Figure 42

The engine features:

- A new induction system
- A new returnless fuel system
- Bosch ignition and fuel management systems
- Modified rocker covers
- A new aluminium sump design
- A majority of new engine management sensors
- A new front cover and auxiliaries layout
- A new flywheel and reluctor ring

Some of the above changes have being developed to improve the engines NVH characteristics (noise vibration and harshness), as well as to accommodate the new induction system and the additional requirement of drive for the ACE pump.

There are two variations of engine available. The type of petrol engine New Discovery incorporates will depend upon the Market specification detailed when the vehicle was built. The two variants are a low compression engine (Gulf States and Australia):

• Compression ratio	8.23:1
• Swept volume	3950cm^3
• Maximum power @ 4750 rev/min	132 kW
• Maximum torque @ 2600 rev/min	320 Nm

And a high compression ratio engine (all other Markets):

• Compression ratio	9.38:1
• Swept volume	3950cm^3
• Maximum power @ 4750 rev/min	136 kW
• Maximum torque @ 2600 rev/min	340 Nm

Induction system

One of the most obvious differences on the engine is the new induction system (see figure 43). The changes have been made to enhance the vehicle's torque characteristics. The new design allows for longer induction tracts, and in a more confined space. The induction system is constructed from three components which are bolted together and sealed by vulcanised metal gaskets. The induction system components must be removed and refitted in the correct sequence (see workshop manual) to ensure that the gaskets will seal correctly and the units are not over-stressed when tighten together.

Figure 43

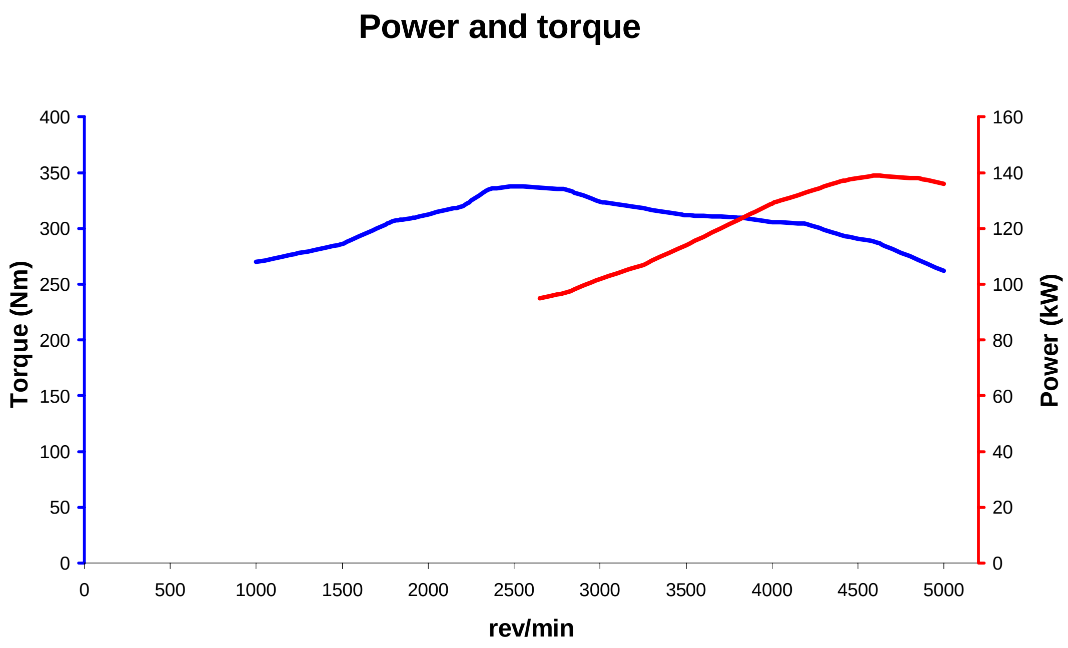


Figure 44

The induction system's extra tract length, in combination with having two plenum chambers, helps the air flow into the engine. The increased length provides a natural resonance of air at the lower engine rev/min, which increases the volumetric efficiency of the engine and increases its torque (see figure 44).

Returnless fuel system

The fuel system on the V8 engine now uses a returnless fuel rail. The pressure relief valve is now incorporated into the submerged fuel pump and regulates the fuel pressure. The fuel pressure should be 3.5 Bar (51.45 psi) across all engine rev ranges. Unlike previous petrol engine management systems, there is no pressure compensation under varying engine loads. The ECM compensates for the pressure differences within its programmed fuel maps.

The fuel rail also incorporates a connection for testing the fuel pressure. This connection is located at the rear of the engine.

Modified rocker covers

The rocker cover assemblies have been modified to accommodate the revised heater system/ coolant system. The oil filler neck has also been redesigned to accommodate the new ancillary layout.

Bosch engine management system

The engine management system (EMS) for New Discovery V8 engine derivatives is Bosch Motronic 5.2.1. This new engine design and EMS is also incorporated into the 1999 MY Range Rover.

Details of the components, strategies employed and TestBook diagnostics are explained in the section on petrol engine management.

The cylinder head houses a new design of spark plug. The spark plug is critical in the performance of the EMS and must always be replaced with the same type and make of spark plug. The spark plug used is a double platinum Champion RC11 PYPB4 plug. The quality of this spark plug allows the service interval to be greatly extended. Always check the maintenance check sheet for exact service interval relating to each component. The new spark plug should not be cleaned, as this process reduces the service life, and reliability of the spark plug. This plug also uses a socket size of 5/8 AF instead of the usual 13/16 AF. If an incorrect sized plug is fitted and the HT lead pushed onto the end, the HT lead will need to be replaced as the porcelain insulation is of a bigger diameter and will invisibly damaged the HT lead.

A new sump design

The sump is now constructed from aluminium, it is sealed using a rubber gasket. The shape and material have been changed to improve the power train rigidity and NVH characteristics.

New engine management sensors

The EMS for New Discovery V8 engine incorporates some changes in the design, make, and location of the sensors used to feedback information. The ignition system and idle control have also changed.

Details of the components, strategies employed and TestBook diagnostics are explained in the section on petrol engine management.

A new front cover

The front timing chain cover has been modified to incorporate the oil filter adapter. The ancillaries bracket has also being modified incorporating changes to repositioning of the alternator, air conditioning compressor and power steering pump. The design also incorporates provision for an ACE pump housing.

All the engine accessories are driven from one multi ‘V’ serpentine belt. An autotensioner maintains the belt tension. The fan also features a ring at the outer circumference of the fan blades (as current NAS 4.0 and 4.6 V8 engines).

The revised ancillary layout has one of four belt options according to the configuration of the vehicle these are:

Belt length (mm)	Identifying colour	Application	Figure number
1766	Blue	PAS only	45
2621	Yellow	ACE & PAS	46
2342	Green	PAS & A/C	47
2703	Red	PAS, ACE & A/C	48

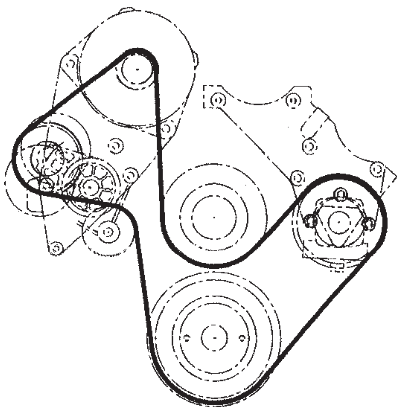


Figure 45

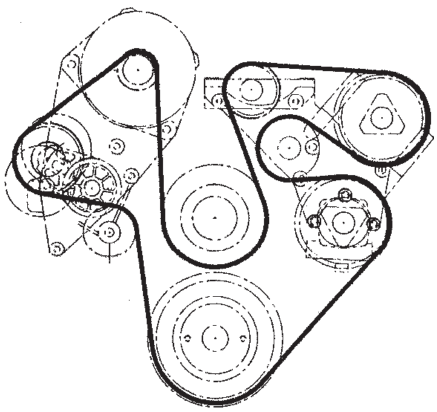


Figure 46

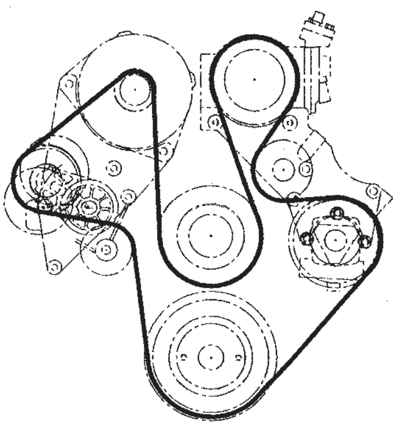


Figure 47

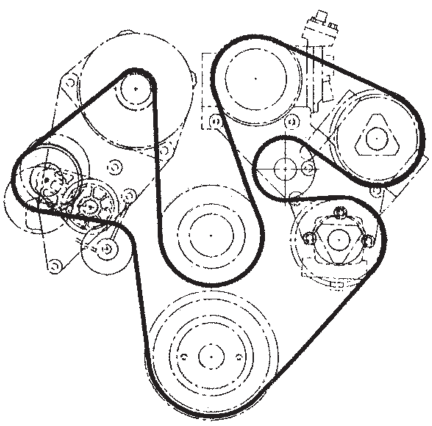


Figure 48

The alternator has an increased output. The maximum current output is now 130 amps. The power steering pump has changed, and it now has improved performance for the size. The AC compressor has changed to a swash plate design from a scroll type (used previously on the 4.0 litre and 4.6 litre engine in the Range Rover)

Flywheel

The flywheel has been changed to incorporate a new reluctor ring (see figure 49). The flywheel is now drilled at 6° intervals, with the hole dimension being equivalent to a 3° space (50% duty cycle). There are two holes which are not drilled, positioned at 60° BTDC for number 1 cylinder. All the holes are joined by a machined groove which allows the tip of the crankshaft sensor to penetrate into the holes to gain maximum response from the sensor.

Figure 49

PETROL ENGINE MANAGEMENT SYSTEM

Bosch supplies the engine management system used on petrol derivatives of New Discovery. It is referred to as the Bosch Motronic 5.2.1 system. It is a dedicated variant of the Bosch system used on the BMW 7/8 Series. The system supports sequential fuel injection and wasted spark ignition. The system is designed to optimise the performance and efficiency of the engine.

The key functions of the Bosch 5.2.1 engine management system are:

- To control the amount of fuel supplied to each cylinder
- To calculate and control the exact point of fuel injection
- To calculate and control the exact point of ignition on each cylinder
- To optimise adjustment of the injection and ignition timings to deliver the maximum engine performance throughout all engine speed and load conditions
- To calculate and maintain the desired air/fuel ratio, to ensure the 3 way catalysts operate at their maximum efficiency
- To maintain full idle speed control of the engine (ISC)
- To ensure the vehicle adheres to the emission standards (set at the time of homologation)
- To ensure the vehicle meets with the fault handling requirements, as detailed in the 'on-board diagnostic II' (OBDII) legislation
- To provide an interface with other electrical systems on the vehicle

To deliver these key functions, the Bosch 5.2.1 engine management system relies upon a number of inputs and controls a number of outputs. As with all electronic control units, the ECM needs information regarding the current operating conditions of the engine and other related systems before it can make calculations, which determine the appropriate outputs.

System Inputs

The Bosch 5.2.1 system optimises engine performance by interpreting signals from numerous vehicle sensors and other inputs. Some of these signals are produced by the actions of the driver, some are supplied by sensors located on and around the engine and some are supplied by other vehicle systems. The inputs are as follows:

- Ignition switch (position II)
- Throttle position sensor (TPS)
- Crankshaft position sensor (CKP)
- Camshaft position sensor
- Engine coolant temperature sensor (ECT)
- Knock sensors
- Air mass flow and temperature sensor (MAF)
- Oxygen sensors (O_2)
- Immobilisation signal
- Fuel level signal
- Vehicle speed sensor
- Rough road detection signal
- Automatic temperature control (ATC) system request
- Automatic gearbox information
- Fuel tank pressure sensor (NAS only)

Engine control module

The engine control module (ECM) is secured to a pressed steel bracket located at dash level on the right hand ‘A’ post. It features five separate electrical connectors. Each connector groups associated pin-outs together. The main functions of the groups of pin-outs incorporated into each connector are detailed in the following table.

Connector number	Connector colour	Main functions
1	Black	Main power supply and ground connections
2	Black	Oxygen sensor inputs and Oxygen sensor heaters, fuel pump and main relay control
3	Black	All sensor inputs and outputs
4	Black	Most related vehicle system communications. CAN bus and K-line
5	Black	Ignition coil control

The five connectors interlock when connected to the ECM. Therefore, they must be connected to the ECM in a specific order. Connector 1 must be fitted first, connector 2 second, connector 3 third, and so on. The connectors can be disconnected only in the reverse order of this. It is not possible to remove the connectors from the ECM in any other order, the way in which the connectors interlock prevents this.

The ECM is programmed during manufacture by writing the program and the engine ‘tune’ into the Flash EPROM (erasable programmable read only memory). This Flash EPROM can be reprogrammed in service, using TestBook. In certain circumstances, it is possible to alter the ‘tune’ or functionality of the ECM using this process.

The engine management system (EMS) now used on New Discovery, is an improvement over existing systems. When Land Rover first produced vehicles, all petrol engines were fuelled by carburettor. When several countries around the word started to enforce legislation concerning the amount of pollutants a vehicle was legally allowed to exhaust, Land Rover started to use fuel injection as a method of supplying the engine with the optimum amount of fuel for the current operating condition. When further legislation was introduced, it became necessary for Land Rover not only to electronically control the amount of fuel entering the engine but also to electronically control the precise time of injection and ignition. The new EMS now improves the capability with respect to the monitoring, evaluating, diagnosing and correcting of many engine mechanical irregularities. It also has improved capability for monitoring and adapting its own operation to ensure that any mechanical variations do not affect the performance or the exhaust emissions of the engine.

The ECM has advanced fault-handling capabilities. It can detect the type and severity of faults, store relevant engine operating conditions at the time a fault occurs and also store the time the fault occurred. The individual fault handling procedures the ECM completes will be explained throughout the section. The ECM stores fault codes, referred to as ‘P’ codes. It is this ‘P’ code that Land Rover has to make available to third party scanning tools. The ‘P’ codes are defined within the EOBD II legislation. Once recorded, details of a fault will stay in the ECM’s memory for 40 ‘trips’.

A ‘trip’ is defined precisely by the on board diagnostic (OBD) legislation. It is a predetermined routine through which the engine or vehicle must pass before the ECM will attempt to ‘validate’ a previously faulty signal. There are a number of OBD set routines. They are all grouped into one of several inspection/maintenance flags (IMF). These are:

- Catalytic converter efficiency (NAS)
- Purge (all markets) / evaporative loss leak detection diagnostic (NAS)
- Oxygen sensor diagnostics
- O^2 heater diagnostics

The above diagnostics all demand very strict engine conditions be met before they will run. By following the appropriate driving cycle, the IMF flags will indicate when the diagnostic completes. Most of the other diagnostics will operate within the first 30 seconds after engine starts.

TestBook can be used to view the diagnostic routines performed by the ECM, which need to be set before the relevant IMF becomes set. When a fault code is stored, it will indicate, via TestBook, the IMF required to ensure that successful repair can been verified.

When certain fault conditions prevail, the EMS stores data relating to the value of certain engine inputs. These values, when stored, are known as ‘freeze frame data’. Freeze frame data is not the same as the three environmental variables stored when a fault is detected. Environmental variables are stored along with each fault (three variable conditions for each ‘P’ code), whereas freeze frame data is stored for the highest priority fault (different faults have different priorities, according to their likely impact on exhaust gas emissions).

Freeze frame data always records:

- Engine speed
- Engine load
- ‘P’ code
- Short term fuelling trim A / B
- Long term fuelling trim A / B
- Fuelling status A / B
- Coolant temperature
- Road speed

On NAS vehicles the ECM will illuminate the malfunction indicator lamp (MIL) on detection of a fault, providing the fault has occurred on two consecutive driving cycles. This fault strategy is referred to as ‘debouncing’ the fault. There is one exception, this being the ECM detecting that a catalyst-damaging misfire is currently occurring. In this case, the ECM will flash the MIL lamp immediately the fault is detected. If the fault rectifies itself, the ECM will stop flashing the MIL lamp, changing it to continuously ‘on’.

The MIL lamp is triggered by a MIL event. In non-NAS markets the ECM merely stores a MIL event. This is treated exactly the same by the ECM, with the exception of the MIL lamp remaining extinguished. The MIL lamp is switched on only if the vehicle is of NAS specification, except for a bulb check facility when the ignition is switched to position II, or if the automatic gearbox requests it.

Ignition switch

The ignition switch supplies a signal to the ECM whenever it is turned to position II (‘ignition on’). Using this signal, the ECM is able to detect when the ignition switch is turned ‘on’ and when it is turned ‘off’. The ECM will initiate its ‘power-up’ sequence whenever the ignition is turned ‘on’. At this time it will energise the main relay (which, amongst other things, supplies the main feed to the ECM), energise the fuel pump relay and initiate a ‘self-check’ on the EMS system.

When it detects the ignition switch has been turned ‘off’, the ECM will stop the engine (if it was running) and record all the relevant information within its internal memory to enable the quick-start functions to operate correctly. It will then initiate its ‘power-down’ sequence, which involves de-energising the main relay.

Throttle position sensor

The throttle position sensor (TPS) is connected to the throttle valve shaft, located on the throttle body portion of the plenum chamber (see figure 50). It monitors the position and the rate of movement of the throttle valve, which is controlled by the driver via the throttle pedal and accelerator cable. The throttle position sensor is a potentiometer. It receives a 5 volt supply from the ECM whenever the ignition switch is turned ‘on’. It then returns a proportion of the supplied voltage to the ECM to indicate its position and rate of movement. The actual position of the throttle valve, the direction in which it is moving (if it is moving) and, if so, the rate at which it is moving will determine the value of the voltage returned. The returned voltage will be in the range of 0.1 volts (throttle fully closed) to 4.8 volts (throttle fully open). The ECM will supply 5 volts on the signal wire when the throttle potentiometer is disconnected. This voltage is used in the diagnostics of the wiring harness. The sensor has gold plated terminals to reduce the environmental impact. Care must be taken not to scratch the gold coating, particularly when using a multimeter connected directly to the sensor.

Figure 50

In addition to using the signal supplied by the throttle position sensor to determine the driver's requirements, the ECM also uses the signal to check the plausibility of the signal supplied by the air flow meter. In circumstances where the signal supplied by the air flow meter indicates that only a small quantity of air is entering the engine, and the signal supplied by the throttle position sensor indicates a large throttle angle (i.e. throttle open), the ECM will store a 'ratio fault' indicating the throttle position and airflow have not tallied.

In this application, the TPS sensor does not rely on any form of adjustment or calibration process. The Bosch 5.2.1 ECM is able to 'learn' the closed throttle position using the signal it supplies. If the ECM detects a sensor failure, or the signal supplied by the throttle position sensor is deemed implausible, then it will introduce a substitute signal. The actual value of the substitute signal will be dependent upon a variety of signals received from other sensors located on and around the engine. Engine performance will be affected in these circumstances and the driver will notice the following:

- The engine will idle poorly
- The vehicle will default to 3^{rd} / 4^{th} gear (limp home strategy automatic vehicles only)
- The engine will run poorly and respond poorly to throttle pedal movement
- The gearbox will not kickdown (automatic vehicles only)
- Altitude adaptations will be incorrect (engine performance affected even more when the vehicle is operated at high altitudes)

TestBook will retrieve the fault code (referred to as a 'P' code for OBD II regulations) and perform the necessary diagnostics. The sensor can also be probed directly, providing the care point mentioned above is adhered to. TestBook also has the capability of displaying the value of the TPS signal received by the ECM. It displays this on the 'live reading' screen. It will also display the altitude adaptive value currently being used on this screen.

Crankshaft position sensor

The crankshaft position sensor is located in the engine block, just below number 7 cylinder (see figure 51). It protrudes through the cylinder block and is positioned adjacent to the face of the flywheel or flexplate. The sensor reacts to a 'drilled reluctor' incorporated into either the flywheel or the flexplate to ascertain engine speed and position information. The sensor is located on a spacer and is secured in position by a single bolt. The spacer is 14mm thick on vehicles fitted with manual transmission and 18mm thick on vehicles fitted with automatic transmission. The thickness of the spacer determines how far the sensor protrudes through the cylinder block and, therefore, sets the position of the sensor in relation to the flywheel or flexplate. The sensor and the spacer are covered by a protective heat shield. The sensor has three wires attached to it; one signal wire, one ground wire connected to the ECM and one ground wire connected to vehicle ground. This last wire acts as a shield to earth any stray electromagnetic radiation produced from the crankshaft signal.

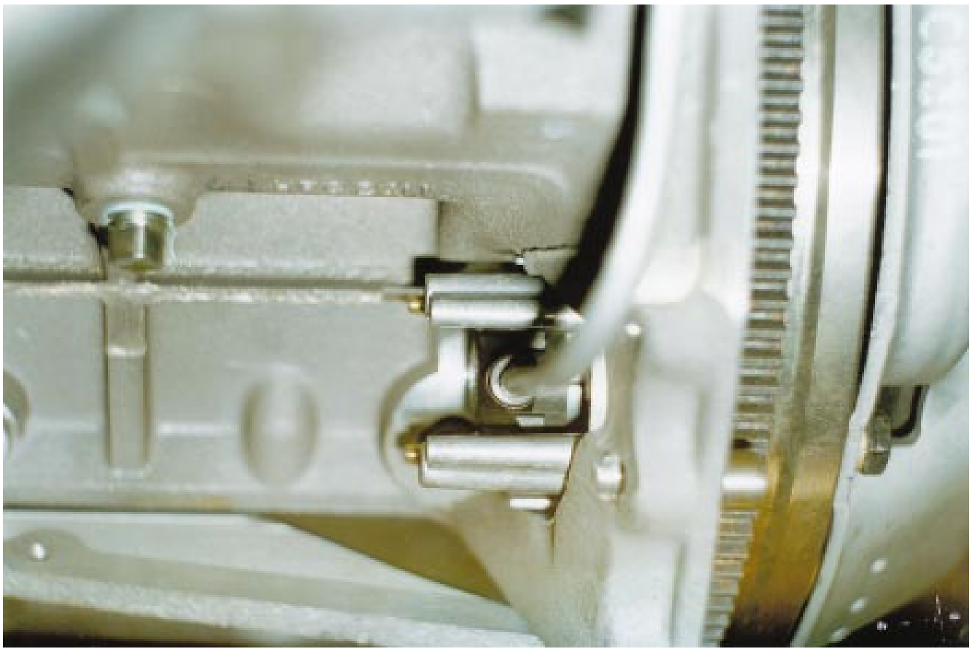


Figure 51

The crankshaft sensor is an inductive type sensor which produces a sinusoidal output voltage signal. Figure 52 illustrates a typical crankshaft signal over a 480° crankshaft revolution. This voltage is induced by the proximity of the moving toothed reluctor, which excites the magnetic flux around the tip of the sensor when each tooth passes. This output voltage will increase in magnitude and frequency as the engine rev/min rises and the speed at which the reluctor passes the sensor increases. The signal voltage will peak at approximately 6.5 volts if connected to the ECM (further increases in engine speed will not result in greater magnitude). The ECM neither specifically monitors nor reacts to the output voltage (unless it is very small or very large) but does measure the time intervals between each pulse (i.e. signal frequency). The signal is determined by the number of teeth passing the sensor, and the speed at which they pass. The teeth in this application are spaced at 6° intervals, with two teeth missing at 60° BTDC to give the ECM a hardware point of reference, so there is a total of 58 teeth.

Crankshaft sensor signal

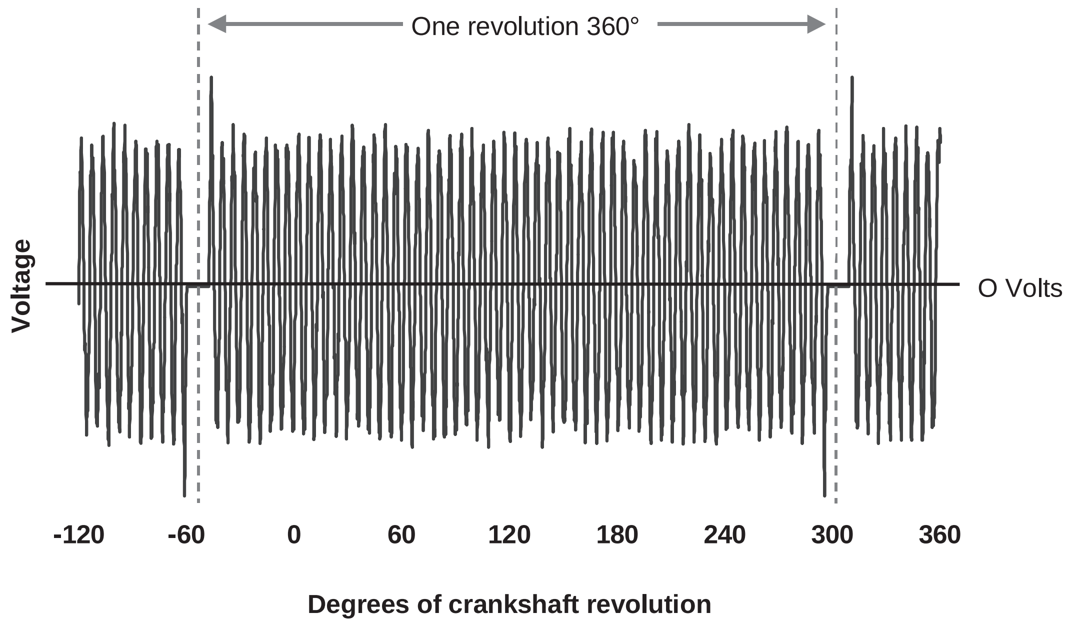


Figure 52

The ECM outputs an engine speed signal to the automatic gearbox, the SLABS ECU, the instrument pack and the ACE ECU. The signal to the automatic gearbox ECU and the SLABS ECU are supplied via the CAN link, whilst the signals to the ACE ECU and the instrument pack are carried via a frequency dependent digital signal.

The signal produced by the crankshaft position sensor is critical to engine running. There is no back-up strategy for this sensor and failure of the signal will result in the engine stalling and/or failing to start. If the sensor fails when the engine is running, then the engine will stall, a fault code will be stored and details captured, of the battery voltage, coolant temperature and air temperature at the time of the failure. If the signal fails when the engine is cranking, then the engine will not start and no fault will be stored, as the ECM will not detect that an attempt had been made to start the engine. In both cases the tachometer will also cease to function immediately and the MIL lamp will not extinguish (all market variants).

During the power-down procedure, which occurs when the ignition is switched ‘off’, the ECM stores details of the position of the crankshaft. This enables the ECM to operate the injectors appropriately to aid quick engine start, which serves to reduce emissions when the engine is cold.

Camshaft position sensor

The camshaft position sensor is located in the timing cover and the tip of the sensor is positioned in close proximity to the camshaft gear. The camshaft gear incorporates four teeth. The camshaft position sensor is a Hall-effect sensor which switches a battery fed supply 'on' and 'off'. The supply is switched when the teeth machined onto the camshaft gear pass by the tip of the sensor. The four teeth are of differing shapes, so the ECM can determine the exact position of the camshaft at any time. Using this signal in conjunction with the signal supplied by the crankshaft position sensor, the ECM is able to detect the firing position of the engine (i.e. the exact position and stroke of each piston). Care must be taken to avoid fitting an incorrect camshaft gear, as the gear fitted to engines using the GEMS EMS looks similar, but this gear is fitted in place of the correct gear a fault will be stored, as the two gears have a different tooth spacing pattern.

Crankshaft sensor signal

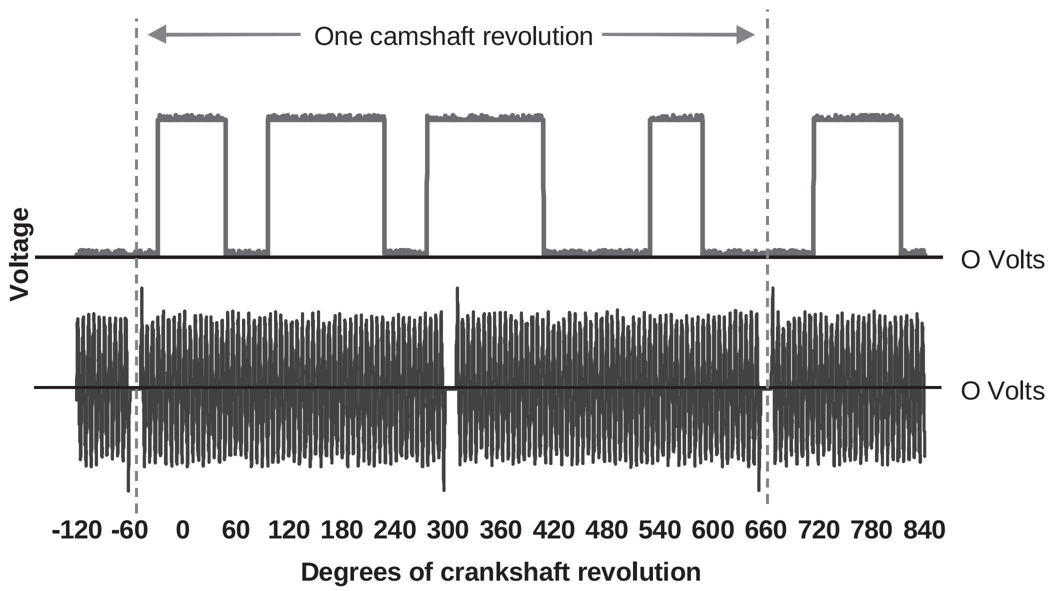


Figure 53

Unlike an inductive type sensor, a Hall-effect sensor does not produce a sinusoidal output voltage (sine wave). Instead it produces a ‘square wave’ output (see figure 53). The edges are very ‘crisp’, rising very sharply and falling very sharply, giving the ECM a defined edge on which to base its calculations. An implausible signal will result in the following:

- The MIL lamp illuminated after ‘debouncing’ the fault (NAS only; MIL event all other markets)
- Loss of performance, due to the corrective ignition strategy being disabled. A default ignition map is used which retards the timing to a safe position
- Injector operation possibly 360° out of phase, i.e. fuel injected during exhaust stroke rather than during compression stroke
- Quick crank/cam synchronisation on start-up feature disabled
- Some Oxygen sensor diagnostics disabled

In addition, the ECM will store a relevant fault code and capture the input signal supplied by the engine coolant temperature sensor, and the engine load calculation and the engine rev/min at the time of failure. TestBook will display the live readings from the camshaft sensor.

Engine coolant temperature sensor

The engine coolant temperature sensor is located near the top of the engine, adjacent to the coolant outlet pipe. The sensor features four electrical connections; two are used on New Discovery applications and all four are used in 1999 MY Range Rover applications. The sensor conforms to the conventional negative temperature coefficient (NTC) electrical characteristics.

The signal supplied by the engine coolant temperature sensor is critical to many fuel and ignition control strategies. Therefore, the Bosch 5.2.1 system incorporates a complex engine coolant temperature sensor default strategy, which it implements in the event of failure. The ECM uses several alternative inputs to determine the specific default value selected in these circumstances. The amount of time the engine has been running and the temperature of the air entering the engine are the primary inputs used to determine the default value. The software model of the temperature increasing will finish when it reaches a value of 65°C (150°F). This value is then used until the engine is switched off.

The following symptoms may be noticeable in the event of an engine coolant temperature sensor failure:

- The MIL lamp illuminated after ‘debouncing’ the fault (NAS only; MIL event all other markets)
- Poor engine hot and cold start
- Overheat warning lamp (incorporated within the Instrument pack) is illuminated
- Excessively hot or cold needle reading on the temperature gauge

The ECM will also store details of the engine speed, engine load and air temperature in its memory. This information is stored to aid diagnosis of the fault.

Knock sensors

There are two knock sensors on the V8 engine, both located directly on the cylinder block, one on each side. Figure 54 identifies their position relative to the engine block. The knock sensors produce a voltage signal in proportion to the amount of mechanical vibration generated at each ignition point. Each sensor monitors the four cylinders in one bank.

Figure 54

The knock sensors incorporate a piezoceramic crystal. This crystal produces a voltage whenever an outside force tries to deflect it, (i.e. exerts a mechanical load onto it). When the engine is running, the compression waves in the material of the cylinder block, caused by the violent combustion of the fuel/air mixture within the cylinders, deflect the crystal. As described above, these forces acting on the crystals cause them to produce an output voltage signal. These signals are supplied to the ECM and compared with sample 'mapped' signals stored within its memory. From this, the ECM can identify when the ignition is too far advanced and causing pre-ignition problems.

Care must be taken at all times to avoid damaging the knock sensors, but particularly during removal and fitting procedures. The recommendations regarding to torque and surface preparation must be adhered to. The torque applied to the sensor and the quality of the surface preparation both have an influence over the transfer of mechanical noise from the cylinder block to the crystal.

The ECM uses the signals supplied by the knock sensors, in conjunction with the signal it receives from the camshaft sensor, to determine the optimum ignition point for each cylinder. The ignition point is set according to pre-programmed ignition maps stored within the ECM. In this case, the ECM is programmed to use ignition maps for 95 RON premium specification fuel. It will also function on 91 RON regular specification fuel but without adaptations. If the only fuel available is of poor quality, or the customer switches to a lower grade of fuel after using a high grade for a period of time, the engine may suffer slight pre-ignition for a short period. This amount of pre-ignition will not damage the engine. This situation will be evident whilst the ECM learns and then modifies its internal mapping to compensate for the variation in fuel quality. This feature is called 'adaptations'. The ECM has the capability of adapting its fuel and ignition control outputs in response to several sensor inputs.

The ECM will cancel ‘closed loop’ control of the ignition system if the signal received from either knock sensor becomes implausible, or the signal from the camshaft sensor is corrupted at any time. In these circumstances, the ECM will default to a safe ignition map. This measure ensures the engine will not become damaged if low quality fuel is used. The MIL lamp will not illuminate at this time (in any market), although the driver may notice that the engine ‘pinks’ in some driving conditions and displays a slight drop in performance and smoothness.

When a knock sensor fault is stored, the ECM will also store details of the engine speed, engine load and the coolant temperature.

Air mass flow and temperature sensor

The air mass flow (AMFS) meter is located in the air intake ducting, between the air filter housing and the plenum chamber (see figure 55). The AMF meter returns a signal to the ECM to indicate how much air is entering the engine. The amount of air entering the engine is calculated from two functions:

1. The sensor incorporates a hot film element. This film is heated by the circuitry in the AMF meter. A proportion of the air flowing into the engine flows past the film and acts to cool it. The greater the air flow, the greater the cooling effect. The output voltage varies in accordance with the amount of electrical power being consumed by the mass air flow meter to keep the film at a predetermined temperature
2. The AMF meter also incorporates an air temperature sensor. This sensor is an NTC sensor. It informs the ECM of the temperature of the air entering the engine. The temperature of the air entering the engine will affect its density. The density of the air entering the engine will affect its ability to support combustion. The signal supplied by the temperature sensor is used to calculate the cooling effect on the hot film from a given mass of air, along with several other fuelling calculations

The AMF meter is sensitive to sudden shocks and changes in its orientation. It should, therefore, be handled carefully. It is also important that the intake ducting between the air filter housing and the engine plenum chamber is not altered in diameter or modified in any way. The air mass flow meter contains electronic circuitry, so never attempt to supply it directly from the battery. The terminals have a silver coating to provide a superior quality of connection over many years. If, at any time, a probe is used to measure the output directly from the sensor, then care must be taken to ensure this coating is not damaged.

Figure 55

If the AMF meter signal fails then the ECM will adopt a default strategy. This strategy will cause the ECM to assume that a certain quantity of air is entering the engine. The exact quantity will be based upon the signals received relating to throttle position, engine speed and air temperature. The following engine symptoms will be noticeable:

- The MIL lamp will be illuminated after the fault has been 'debounced' (NAS only)
- The engine speed might 'dip' before the default strategy enables continued running
- The engine may be difficult to start and prone to stalling
- The overall performance of the engine will be adversely affected (throttle response in particular)
- Exhaust emissions will be out of tolerance, because the air/fuel ratio value is now assumed, not calculated; no closed loop fuelling
- Idle speed control disabled, leading to rough idle and possible engine stall

At the time of failure, the ECM will store details of the engine speed, coolant temperature and throttle angle.

If the signal from the air temperature sensor fails, the ECM will assume a default value of 45°C (112°F). This default value is then used within all the calculations involving intake air temperature. The effect on the vehicle of a failed air temperature signal will not be so noticeable to the driver, who may notice a reduction in engine performance when operating the vehicle at high altitudes or in hot ambient temperatures. The occurrence of this fault will also disable fuelling adaptations and the catalyst monitoring function of the ECM.

The ECM will store details of the engine speed, engine load and battery voltage when this fault is first detected.

Oxygen sensors

There are four Oxygen sensors fitted to petrol derivatives of New Discovery built to NAS specification. Oxygen sensors are not fitted to ROW specification vehicles and only two Oxygen sensors are fitted to vehicles that fall outside these two categories.

If the vehicle is fitted with four sensors, two of the sensors are located in each downpipe. One sensor is fitted prior to the catalyst, i.e. between the catalyst and the engine, and one is fitted immediately downstream of the catalyst. The two sensors fitted prior to the catalyst are referred to as 'pre-catalyst' sensors, whilst the two sensors fitted after the catalysts are referred to as 'post-catalyst' sensors. It should be noted that the 'pre-catalyst' Oxygen sensors are not interchangeable with the 'post' catalyst Oxygen sensors. Only pre-catalyst sensors are fitted if the vehicle features just two sensors.

The Oxygen sensors are very sensitive devices. They must be handled carefully at all times. Failure to handle correctly will result in a very short service life, or non-operation.

Oxygen sensors are pre-coated with an anti-seize compound prior to installation. Care should be taken to avoid getting this compound on the sensor tip. If the sensor needs to be removed and refitted, a small amount of anti-seize compound should be applied (see workshop manual for details).

The Oxygen sensors use 'Zirconium technology' (see figure 56). The sensors feature a Galvanic cell, which is surrounded by a gas permeable ceramic material. This allows exhaust gas to come into contact with one side of the sensor. The other side of the sensor is exposed to the atmosphere. Due to its construction, the sensor produces a voltage. The precise value of the voltage produced is dependent upon the ratio of Oxygen in the atmosphere compared to the Oxygen in the exhaust gas. The voltage produced for an exhaust gas with Lambda 1 (i.e. stochiometric air, fuel ratio of 14.7:1) is 0.45 - 0.5 volts (450 – 500mV). The voltage will fall in value to approximately 0.1 volts (900mV), or Lambda 0.8, when the Oxygen in the exhaust gas rises (lean mixture - too much air in relation to fuel). The voltage will rise in value to approximately 0.9 volts when the Oxygen level in the exhaust gas falls to approximately Lambda 1.2 (rich mixture - too much fuel in relation to air).

The voltage from the Oxygen sensor is communicated to the ECM via the Oxygen sensor signal wires. The ECM monitors the effect of altering the injector pulse widths using the information supplied by the Oxygen sensors. Injector pulse width is the length of time the injector is energised, which determines how much fuel is injected. The response time is such that under certain driving conditions, the ECM can assess individual cylinder contributions to the total exhaust emissions. This enables the ECM to adapt the fuelling strategy on a cylinder by cylinder basis, i.e. inject the precise amount of fuel required by each individual cylinder at any given time.

Figure 56

The ECM continuously checks the signals supplied by the Oxygen sensors for plausibility. If it detects an implausible signal, then it will store a relevant fault code. On the second concurrent ‘journey’ that a fault is recognised, the ECM will illuminate the MIL lamp (NAS only) and store details of engine speed, engine load and the Oxygen sensor voltage (all markets other than ROW). The ECM requires the Oxygen sensor signals to set most of its adaptations. Failure of an Oxygen sensor will result in most of these adaptations resetting to their default values. This, in turn, will result in the engine losing its ‘finesse’. The engine may exhibit poor idle characteristics and emit a strong smell of rotten eggs from the exhaust (H^2S).

The efficiency of the Oxygen sensors slowly deteriorates over many kilometres/miles (unless contamination such as excessive oil or lead has occurred causing sudden damage/ failure). The ECM is able to detect this steady deterioration using the feedback signals. When a signal from a sensor deteriorates beyond a predetermined threshold, the ECM will illuminate the MIL lamp (NAS only) and store a fault code (NAS and non-ROW markets). At the same time, the ECM will capture details of the engine speed, engine load and battery voltage. This feature eliminates the need for a ‘service engine’ lamp (NAS only). As the sensor response time will deteriorate over its life, the sensor must be replaced every 200,000 km (120,000 miles). Always refer to the maintenance schedules for the exact service replacement periods.

On NAS vehicles the ECM also monitors the efficiency of the catalysts. The ECM uses the signal received from the two post-catalyst Oxygen sensors to do this. The state of each catalyst is assessed in line with its ability to ‘hold’ Oxygen. In a serviceable unit the ‘excess’ Oxygen in the exhaust gas is held on the surface of the precious metal coating of the ceramic blocks within the catalyst. This Oxygen is used to convert the harmful elements produced by incomplete combustion (particularly during acceleration and conditions where the engine requires a rich air/fuel ratio) into Carbon Dioxide, Nitrogen and water. By comparing the signals received from the pre-catalyst sensors with those received from the post-catalyst sensors, the ECM can calculate how much Oxygen is retained by each catalyst and can, therefore, determine their condition. If the ECM determines that one or both catalysts require replacement, then it will illuminate the MIL lamp (after debouncing the fault) and store the relevant fault code. At the same time, the ECM will record details of the engine speed, engine load and air temperature.

Zirconium Oxygen sensors need high operating temperatures to work effectively. To ensure a suitable operating temperature is reached as soon as possible, each sensor incorporates a heating element inside the ceramic tip. This element heats the Oxygen sensor to a temperature greater than 350°C (670°F). The heating rate (the speed at which the temperature rises) is carefully controlled by the ECM to prevent thermal shock to the ceramic material. By way of a PWM voltage supply to the heater elements, the ECM controls the rate at which the element temperature is increased. The sensors are heated during engine warm-up and again after a period of engine idle.

The ECM monitors the state of the heating elements by calculating the amount of current supplied to each sensor during operation. If the ECM identifies that the resistance of either heating element is too high or too low, it will store a fault code, the engine speed, coolant temperature and the battery voltage. When the fault is logged twice on consecutive ‘journeys’, the MIL lamp will illuminate (NAS only).

Immobilisation signal

The BCU sends a coded signal to the ECM before it activates the starter motor. If the ECM accepts the immobilisation signal (i.e. the code is correct), the engine will be permitted to start and will continue to run normally. If the immobilisation signal is corrupted (i.e. not sent, or incorrect), then the ECM may allow the engine to start, but will then stop it immediately.

If either the BCU or the ECM is replaced during the service life of the vehicle, the immobilisation code will need to be relearned. If an attempt to start the engine is made with a ‘new-born’ ECM fitted to the vehicle (an ECM not yet programmed with any immobilisation code), the ECM will not allow the engine to start and will store a fault code. This fault code must be cleared and the immobilisation code learned before the ECM will allow the engine to run.

The immobilisation code must also be relearned in cases where an ECM from one vehicle is fitted to another. The only circumstance where this action is not necessary is where an ECM is replaced on a NAS vehicle. To prevent this condition being misused, engineers have ensured that NAS ECMs cannot be fitted to any other market derivative, unless the immobilisation code is reset.

If the ECM detects an incorrect immobilisation code it will store a fault code. Simultaneously, the ECM will record the engine speed, battery voltage and the number of occurrences (the number of times the incorrect code has been detected).

Fuel level signal

This signal is supplied to the ECM by the instrument pack. It is used to alter the fault code strategy adopted by the ECM when a misfire is detected (see misfire detection) or if the ECM detects that the Oxygen signal is unexpectedly recording a weak air/fuel ratio (Lambda < 0.8). It will not stop a fault being logged but will modify the fault code to indicate the likely cause of the misfire.

Vehicle speed sensor signal

The ECM uses this signal within its calculations for idle control. The ECM also forwards the vehicle speed signal to the automatic gearbox TCU via the CAN link. The vehicle speed signal is produced by the SLABS ECU. The signal represents the 'average' of the road speed signals received from all four wheel speed sensors.

Rough road signal

This signal is also produced by the SLABS ECU. It is derived from the variations between each signal received from the four wheel speed sensors (see section on ABS for full description).

The ECM alters its misfire detection strategy whenever a rough road signal is received. The ECM will not store details of a misfire fault at this time (see misfire detection strategy).

Automatic temperature control system request

A signal is supplied to the ECM whenever the ATC system requires the compressor clutch and/or condenser fans to function. The ECM integrates the control of these components with the engine management system. This ensures effective engine preparation for any sudden increase in the engine load.

The ECM will turn off the ATC compressor clutch if the engine coolant temperature exceeds 124°C (255°F). The ECM will turn on the condenser fans if the engine coolant temperature exceeds 100°C (212°F). See section on ATC for more details on the exact operation of the compressor clutch and condenser fans.

The ECM will store engine speed, battery voltage and engine load details whenever it detects a fault originating from the ATC circuit. It will store engine speed, intake air temperature and details of the battery voltage if the fault relates to the compressor clutch or condenser fan operation.

Automatic gearbox information

Information sent to and from the automatic gearbox TCU is transmitted on the CAN bus. Full details of this information are in the section on automatic gearbox.

The ECM requires information on gear position to calculate the likely engine load during acceleration and deceleration conditions. The ECM also disables the misfire detection function whenever low range is selected. Information regarding range selection is supplied by the TCU.

There are several possible fault codes associated with the CAN bus and the validity of information sent to and from the ECM from the TCU. In most cases, the ECM will store engine speed, engine coolant temperature and details of the battery voltage at the time when the fault is detected.

The automatic transmission TCU is able to request the illumination of the MIL lamp (NAS only; MIL event stored non-NAS markets) if it detects a fault within its systems that might lead to the vehicle emitting excessive levels of pollutants. It is good practise to check both ECM and the automatic gearbox TCU for faults when the MIL lamp is illuminated, or a MIL event is logged in the ECM.

Fuel tank pressure sensor (NAS only)

The fuel tank pressure sender is located in the fuel tank. This unit supplies a signal to the ECM related to the amount of fuel vapour pressure within the fuel tank. It is used as a feed-back device within the ECM’s evaporative loss control (ELC) leak test. This test is detailed later in the section.

If a fault is present, the ECM will store a relevant fault code and the engine speed value, battery voltage and details of the engine coolant temperature. If the fault happen on the next ‘journey’, the ECM will illuminate the MIL lamp.

System Outputs

The ECM receives and processes the input information previously described and modifies the fuelling and the ignition points for each cylinder accordingly. The ECM will also supply output information to other vehicle system ECUs.

The ECM drives the following components:

- Fuel injectors
- Ignition coils
- Idle speed actuator
- Main relay and fuel pump relay
- Purge valve

The ECM provides other systems with information regarding the -

- Engine speed
- Driver demand
- Grant signals ATC
- Grant signals Automatic Transmission

Ignition coils

The V8 petrol engine installed in New Discovery is fitted with two twin-ignition coils (total of four coils). The two coils are located behind the plenum chamber at the rear of the engine (see figure 57). Each coil contains two primary windings and two secondary windings. There is a three-pin connector on each coil. Pin two connects both primary windings to an ignition supply. There is one suppression capacitor connected to each supply. This helps eliminate the effect of the magnetic radiation created by the sudden demands for power as each coil recharges.

The system employs wasted spark technology to produce a powerful and precise spark. The cylinders are paired according to the table below.

	Coil 1	Coil 2	Coil 3	Coil 4
Cylinders	1 & 6	7 & 4	5 & 8	3 & 2

The ECM provides a path to ground whenever a spark is required. To ensure a sustained magnetic field collapse, the ECM carefully controls the rate of discharge from each coil at this time. This control also limits the amount of heat created during this process and reduces the total power consumed by each coil. Any faults detected within the primary and HT circuits will result in the ECM storing an appropriate misfire fault but not a fault directly related to the spark creation and delivery.

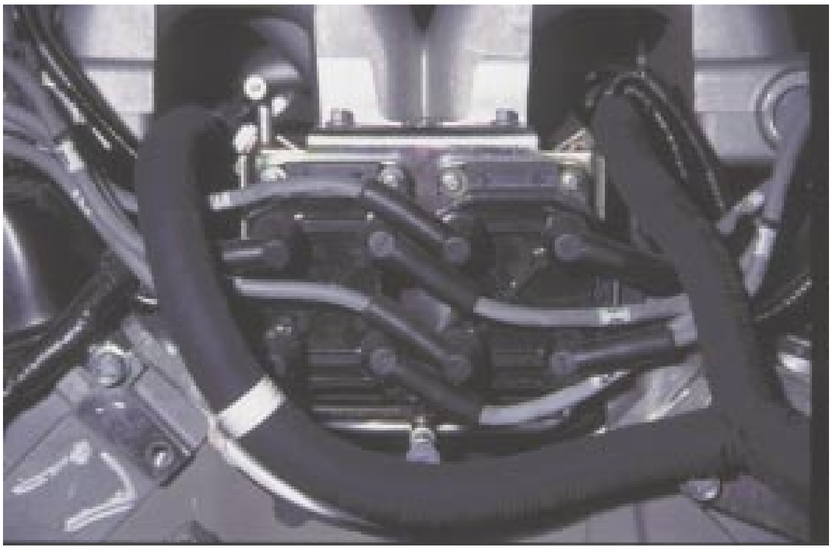


Figure 57

Fuel injectors

There are eight injectors (one per cylinder) fitted to the V8 petrol engine. The ECM controls the injectors directly, and individually. It opens an injector by providing a path to ground for a voltage supplied by a common fuse. The injectors are fed fuel under pressure from a common fuel rail. A fuel pressure relief valve, incorporated into the lift pump assembly located inside the fuel tank, controls the pressure in the fuel rail. In this case, the pressure is controlled to a fixed value of 3.5 Bar. As indicated, the fuel pressure is fixed and the relief valve provides no compensation for increases or decreases in manifold depression. The ECM alters injector duration to accommodate such changes.

Connecting an appropriate gauge to the Schrader valve on the fuel rail provides a method of checking the fuel pressure. The valve is located to the rear of injector no. 7.

Considerable care must be taken whenever making this connection.

Each injector is sealed with two ‘O’ rings. These ‘O’ rings should be renewed whenever an injector is refitted to an engine. A small amount of engine oil can be applied to the ‘O’ rings to aid installation. No other form of lubrication should be used.

Measuring the electrical resistance of the injectors internal coil enables an assessment to be made of the serviceability of an injector. An injector in a serviceable condition should possess a resistance of 14.5 ohms at 20°C (68°F) with a tolerance of ± 0.7 ohms.

The ECM can detect electrical inconsistencies within each injector. It can also detect, via feedback from the Oxygen sensors, mechanical faults such as blockage or leakage. The ECM will store a relevant fault code in these circumstances. The ECM will also store the engine speed, engine load and details of one of the following: battery voltage, engine coolant temperature or intake air temperature. The precise details stored depend on the exact nature of the fault detected.

TestBook will also display data regarding injector operation via its live readings. Care must be taken when analysing this data, as the precise timings will vary considerably. Individual timings will be affected by any current engine load.

Idle speed actuator

The idle speed control actuator is located behind the throttle body on the intake manifold. It is connected to the intake manifold by two hoses. One hose connects upstream and the other connects downstream of the throttle valve (see figure 58). Therefore, the idle speed actuator effectively provides an air bypass for the throttle valve.

The ECM controls the engine idle speed via the idle speed actuator. It does this by allowing a measured quantity of air into the engine when the throttle valve is closed. The idle speed actuator comprises a rotary valve and two electrical coil windings. The ECM alters the position of the idle speed actuator and, therefore, the amount of air bypassing the closed throttle valve by providing a PWM voltage to the two opposing coils inside the actuator. These coils control the position of the rotary valve by producing opposing magnetic fields. When the ECM identifies a need for a higher idle speed it enables a greater quantity of air to bypass the throttle valve. It does this by altering the PWM voltage supplied to both coils. This provides an imbalance in magnetic fields inside the actuator and, in turn, alters the amount of air bypassing the throttle valve.

Figure 58

The ECM controls the position of the rotary valve within the idle speed actuator to maintain a stable idle speed in all conditions. It will alter the position to obtain a pre-set target speed. The precise pre-set idle speed will vary according to the precise model specification and the operating conditions of the engine. These pre-set speeds are detailed in the table below.

Transmission/Gearbox	Air conditioning status	Target idle speed (rev/min) high range	Target idle speed (rev/min) low range
Manual (first 20 seconds after a cold start)	N/A	1200	1200
Automatic (first 20 seconds after a cold start)	N/A	1200	1200
Low battery voltage detected	N/A	850	850
Manual	On	740	740
Manual	Off	660	660
Automatic drive selected	On	740	580
Automatic park/ neutral selected	On	740	580
Automatic drive selected	Off	660	580
Automatic park/ neutral selected	Off	660	580

The market specification programmed into the vehicle can have an effect upon the idle speed. In some markets the idle speed is raised slightly to aid engine cooling.

For 20 seconds immediately following cold start, the idle speed will be raised to 1200 rev/min. At the same time the ECM will retard the ignition timing. These actions ensure the engine and the catalysts reach their operating temperatures as quickly as possible.

The ECM can identify faults with the circuitry used to control the position of the idle speed actuator. In circumstances where it detects a fault with one coil it will de-energise the other coil. This action prevents the idle speed control valve being driven to a fully open or fully closed position. The idle speed control actuator contains two permanent magnets inside the body. These magnets will determine the position of the valve at this time. In this position the engine will idle at approximately 1200 rev/min. This state should not be confused with the target idle speed initiated by the ECM for the first 20 seconds immediately following cold engine start.

The ECM will store fault codes relating to the electrical properties of the idle speed actuator and to associated failures, such as poor engine response to movement of the rotary valve. The associated data stored will depend upon which fault is detected, such as battery voltage, engine coolant temperature and throttle angle for faults related to the circuitry; or engine speed, engine coolant temperature and intake air temperature for ‘poor response’ fault codes.

If ECM control of the idle speed actuator is suspended, (i.e. fault stored), then the driver may notice the following symptoms relating to engine performance:

- The engine will exhibit poor idle stability
- The engine will exhibit a high idle speed
- The engine will be prone to stalling
- The engine will be difficult to start

Main relay and fuel pump relay

The ECM controls the main relay and the fuel pump relay. They are both located in the under-bonnet fuse box (see figure 59).

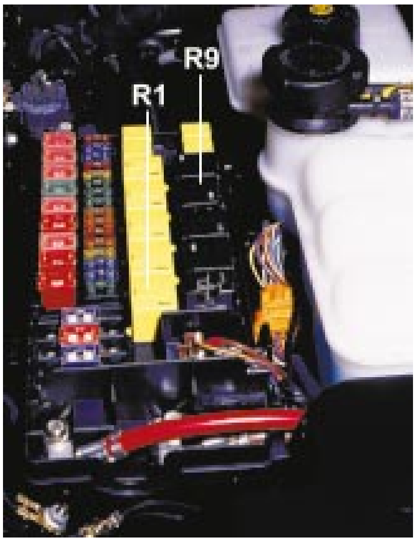


Figure 59

R1. Fuel pump relay R9. Main relay

The ECM energises the fuel pump relay when the ignition is first turned to position II. It also energises it during engine cranking and when the engine is running.

The ECM controls its own power supply, via the main relay. When the ignition is turned to position II, the ECM provides a ground to the relay coil winding. This, in turn, connects the main power feed to the ECM. The ECM controls the main relay and therefore its own power, so that when the ignition is turned off it can follow the previously described power-down sequence, during which it records values from various sensors and writes adaptations into its memory, etc. The last action the ECM carries out before completing its power-down sequence is to turn off the main relay. This will occur approximately 15 seconds after the ignition has been switched off, as long as the coolant temperature is not rising.

The ECM monitors the state of the wiring to the coil winding within the fuel pump relay. The ECM will store relevant fault codes if the ECM detects a problem. The ECM is not able to assess the state of the fuel pump circuit because it is isolated by the function of the relay. However, if the fuel pump circuit fails, or the pump fails to deliver sufficient fuel (whilst the fuel level is above its minimum), the ECM will store adaptive faults as it tries to increase the air/fuel ratio by increasing the duration (pulse width) of the injectors.
Failure of the main relay will result in engine non-start. The engine will cease to operate if the main relay fails whilst the engine is running.

Failure of the fuel pump relay will result in engine non-start. If the fuel pump fails whilst the engine is running, the symptoms will be engine hesitation and engine misfire. These symptoms will worsen progressively until the engine stops. The ECM will store several fault codes under this condition.

Purge valve

The purge valve is located on the right hand side of the engine (when viewed from the front of the vehicle). It forms part of the evaporative loss control system (ELC) and is situated in the line between the charcoal canister and the manifold. The purge valve controls the amount of air/fuel vapour drawn from the canister into the engine. The other components incorporated into the ELC system are:

- The charcoal canister, which is located on the right hand inner chassis rail by the hand-brake drum
- The fuel tank pressure sensor (NAS only), located in the fuel sender unit
- The intake manifold

The ECM controls the amount of vapour drawn from the charcoal canister by controlling the length of time the purge valve is open. It controls the length of time it is open by supplying the purge valve with a PWM voltage. Control is used to maintain the required level of emissions, as a hydrocarbon vapour level of 1% can affect the air/fuel ratio by as much as 20%.

The ECM can diagnose faults with the purge valve and the rest of the ELC system. The ECM will store the relative fault codes, along with details of the engine speed, battery voltage and air temperature. The driver may notice the following effects in circumstances where the ELC system has failed:

- The engine may stall periodically when returning to idle
- The engine may suffer from poor idle quality

Engine speed

The engine speed signal is supplied from the ECM to the automatic gearbox TCU via the CAN bus. All other systems requiring the engine speed input receive a frequency dependent square wave supplied by the ECM.

Driver demand

The ECM receives and processes the signal supplied by the throttle position sensor. It then digitises this information, which enables it to supply a driver demand signal, via the CAN bus, to the automatic gearbox TCU or, by a PWM signal, to any other system requiring this information.

ATC grant signal

The ECM supplies a signal to the ATC Compressor relay to activate the compressor.

Torque reduction grant signal

The ECM also informs the automatic gearbox ECU if its torque reduction request has been granted.

ECM Adaptations

The ECM, as previously mentioned, has the ability to adapt the values it uses to control certain outputs. This capability ensures the EMS can meet emissions legislation and improve the refinement of the engine throughout its operating range.

The components which have adaptations associated with them are:

- The idle speed control valve
- The throttle position sensor (TPS)
- The Oxygen sensors
- The airflow meter (MAFS)
- The crankshaft sensor (CKP)

Idle speed control valve

Over a period of time, the ECM adapts the position it sets the idle speed control valve.The adaptations are made relative to engine coolant temperature and engine load. When a new idle speed control valve or a replacement ECM is fitted, this adaptation should be reset. Subsequently, the ECM will make further adaptations to suit the particular characteristics of the new or replacement components. Failure to reset the original adaptation may result in a prolonged period of poor idling. During this time the ECM slowly adapts the original, 'incorrect' value stored in its memory.

TestBook will display the adaptation currently being applied against the model programmed into its memory. This can be used to indicate the possible cause of problems relating to the amount of air entering the engine, such as air blockages or air leaks within the induction system.

Throttle position sensor

The ECM 'learns' the closed position of the throttle position sensor. The closed voltage value supplied by the sensor is stored by the ECM and can be read using TestBook (see TPS sensor for information regarding the likely readings and signal tolerance band).

If the sensor is replaced, the new closed throttle position will be learned by the ECM during the IMF cycle for the TPS.

The signal from the TPS sensor is used in conjunction with the air mass flow meter to calculate the altitude adaptations. This adaptation affects the amount of fuel entering the engine and the ignition timing. Details of the value of this adaptation are supplied to the automatic gearbox TCU. Using this information, it will adapt its gear change control maps. The altitude adaptation is continuously changing and indicates current driving conditions. Details of the altitude adaptation are stored within the ECM's memory when the ignition is switched off. This enables the ECM to provide correct fuelling on the next engine start.

Oxygen sensors & air flow meter

There are several adaptive maps associated with the fuelling strategy. Within the fuelling strategy the ECM calculates short-term adaptations and long term adaptations. The ECM will monitor the deterioration of the Oxygen sensors over a period of time. It will also monitor the current correction associated with the sensors.

The ECM will store a fault code in circumstances where an adaptation is forced to exceed its operating parameters. At the same time, the ECM will record the engine speed, engine load and intake air temperature.

Crankshaft position sensor

The characteristics of the signal supplied by the crankshaft position sensor are learned by the ECM. This enables the ECM to set an adaptation and support the engine misfire detection function. Due to the small variation between different flywheels and different crankshaft sensors, the adaptation must be reset if either component is renewed, or removed and refitted. It is also necessary to reset the flywheel adaptation if the ECM is renewed or replaced.

The ECM supports four flywheel adaptations for the crankshaft position sensor. Each adaptation relates to a specific engine speed range. The engine speed ranges are detailed in the table below.

Engine speed range	Adaptation
1800 – 3000	1
3001 – 3800	2
3801 – 4600	3
4601 - 5400	4

To set the flywheel adaptations, follow the procedure detailed below. This procedure should be carried out in an appropriate area off the public highway. TestBook must be connected throughout this procedure. The adaptive speed settings must be read from TestBook whilst the vehicle is moving at speed.

1. Use TestBook to clear any adaptations currently set.
2. With the engine warm >86°C (187°F) select 2nd gear high range
3. Accelerate the vehicle until the engine speed reaches the limiter
4. Release the throttle and allow the vehicle to decelerate until the engine idle speed is reached
5. Check that one of the speed range adaptations has been set (read this from TestBook)
6. Repeat the above procedure until all four adaptations are set

When all four adaptations have been set, check that the ECM has not recorded any misfire detection faults. If it has, then clear the memory of the fault codes.

It may not be possible to reset adaptation number 4 if the ECM has already been programmed with a value. Due to the nature of the procedure and the self learn capacity of the ECM, if adaptation number 4 does not reset, it is permissible to leave this adaptation and let the ECM learn it.

Misfire detection

Legislation requires that the ECM must be able to detect the presence of an engine misfire. It must be able to detect misfires at two separate levels. The first level is a misfire that could lead to the vehicle emissions exceeding 1.5 times the FTP requirements for this engine. The second level is a misfire that may cause catalyst damage.

The ECM monitors the number of misfire occurrences within two engine speed ranges. If the ECM detects more than a predetermined number of misfire occurrences within either of these two ranges, over two consecutive ‘journeys’, the ECM will illuminate the MIL lamp (NAS only). The ECM will also record details of the engine speed, engine load and engine coolant temperature. In addition, the ECM monitors the number of misfire occurrences that happen in a ‘window’ of 200 engine revolutions. The misfire occurrences are assigned a ‘weighting’ of the likely impact to the catalysts. If the number of misfires exceeds a certain value, the ECM stores catalyst-damaging fault codes, along with the engine rev/min, engine load and engine coolant temperature. It will also flash the MIL lamp (NAS only) until the misfires no longer exceed the predetermined number. After the flashing stops, the ECM will continue to illuminate the MIL lamp until the fault is rectified.

The signal from the crankshaft position sensor indicates how fast the poles on the flywheel are passing the sensor tip. A sine wave is generated each time a pole passes the sensor tip. The ECM can detect variations in flywheel speed by monitoring the sine wave signal supplied by the crankshaft position sensor.

By assessing this signal, the ECM can detect the presence of an engine misfire. At this time, the ECM will assess the amount of ‘variation’ in the signal received from the crankshaft position sensor and assigns a ‘roughness’ value to it. This roughness value can be viewed within the real time monitoring feature, using TestBook. The ECM will evaluate the signal against a number of factors and will decide whether to count the occurrence or ignore it. The ECM can assign a roughness and misfire signal for each cylinder, (i.e. identify which cylinder is misfiring).

Evaporative loss control system (NAS derivatives only)

The evaporative loss control (ELC) system serves to control the amount of hydrocarbon vapour emitted from the vehicle. It does this by controlling the amount of vapour purged from the charcoal canister and by monitoring the state of the fuel tank and fuel system.

It detects any mechanical failure in the sealing of the fuel system. Legislation dictates that the ECM must indicate the occurrence of a fault to the driver, if a leak in the fuel system allows hydrocarbons to escape to atmosphere. It will do this whenever it detects leakage greater than a predetermined rate, (figure based upon the amount permitted to escape through a 1mm (0. 04”) hole). The ECM uses the purge system and the fuel tank pressure gauge to assess the integrity of the fuel system.

The ECM completes this test only if the vehicle is stationary and at idle. The test compensates for the natural evaporation of petrol, which occurs when it is exposed to a slight vacuum. If any condition is detected that would produce an excessive level of natural evaporation levels (e.g. excessive air temperatures or a large degree of movement of fuel within the fuel tank), the diagnostic is cancelled.

The ECM purges the charcoal canister of vapour and then closes the charcoal canister vent valve. This action produces a depression within the fuel tank. At a predetermined depression, the purge valve is closed. This action seals the fuel system. The ECM then monitors the rate at which the pressure within the fuel tank climbs to atmospheric pressure. The rate at which the pressure equalises is assessed against a ‘model’ (i.e. a pre-programmed map) of fuel evaporation. If a leak exists, then the pressure will equalise rapidly. If the ECM detects a leak in the fuel system (i.e. it has an air leak greater than 1 mm (0. 04”) in it), it will record a fault code. A loose fuel filler cap can cause the ECM to incorrectly diagnose an excessive air leak, so always ensure that the fuel filler cap is tight if the ECM has logged a present fault with the ELC system. If the ECM records a fault code, the engine speed, engine coolant temperature and battery voltage is also recorded when the fault is first recognised. If the ECM detects a fault within the ELC system on two consecutive ‘journeys’, then it will illuminate the MIL lamp.

Setting the CO (ROW derivatives only)

The Carbon Monoxide (CO) emissions can be set manually on non-catalyst vehicles. On these vehicles, the CO is adjusted by reprogramming the ECM’s software using TestBook. TestBook has three specific functions relating to the setting of the CO. These are:

- Read the current CO value
- Adjust the current CO value
- Programme the required CO value into the ECM

The ECM stores the base CO setting as a number in a range between 0 and 255. The nominal setting is 128. TestBook can be used to adjust this value in increments of 1 or 10 units.

It is important that the CO adjustment is made following the procedure detailed below.

Preparation:

1. Disconnect the electrical connector from the purge valve
2. Warm up the exhaust gas analyser and position it appropriately
3. Connect TestBook to the vehicle (TestBook must be connected to the vehicle via the vehicle battery supply lead)

Procedure:

1. Drive the vehicle until the engine coolant temperature stabilises, indicating that the thermostat is open fully. This signal can be monitored via the live reading display on TestBook. The temperature must stay above 86°C (187°F) for the duration of this procedure
2. Drive the vehicle to the exhaust gas analyser, and, without delay, measure the CO. Adjust the setting to obtain the correct CO

   Care Point:
   I. The exhaust gas reading must be allowed to stabilise between adjustments
   II. Do not allow the engine to idle for than 30 seconds during the procedure (the engine speed should be raised to 2000 rev/min, with the vehicle in neutral gear if this occurs)
   III. If the total adjustment process takes longer than 2 minutes, then the vehicle must be driven (as described in Procedure 1) again
3. When the correct CO setting has been achieved, the reading must be programmed into the ECM memory. TestBook must be used to do this. Once completed, the ignition should be switched off for at least 15 seconds
4. The purge valve must be reconnected and the purge valve fault code cleared from the ECM's memory

TestBook diagnostics

The ECM will, as explained earlier, store fault codes and environmental data. The ECM also records additional data in connection with each fault. The additional data recorded is as follows:

1. The number of occurrences
2. If the fault is currently present
3. If the fault is historic, the number of 'journeys' that have elapsed since the fault last occurred
4. The 'current time' stored when the fault occurred. (The time is incremented in hours, hour 0 being the first time the ECM is powered-up, hour 1 being 60 minutes of ignition 'on' time, etc.)

This information is displayed for each fault, along with an explanation of the fault code and the stored environmental data. All the above information is stored and displayed to assist with effective fault diagnosis and rectification.

TestBook can also read real time data from each sensor, the adaptive values currently being employed and the current engine fuelling, ignition and idle settings. The live readings are displayed first as a page of readings. To gain more detail press and highlight the reading for which you require more information.

DIESEL ENGINE

New Discovery is fitted with a diesel engine known as the Td5. This engine is all new and introduces innovative technology to the 4x4 utility vehicle marketplace. Land Rover engineers have developed a quiet, responsive engine which considerably reduces exhaust emissions. The Td5 engine complies with ECD2 (European Commission Directive) legislative requirements, without employing an oxidising catalyst.

Key features of the engine include:

- Five cylinder engine configuration
- Cast iron block with aluminium cylinder head and structural aluminium engine sump
- Overhead camshaft with a single rocker shaft
- Hydraulic lash adjusters with independent finger followers
- Electronic unit injectors
- Timing chain and chain-driven oil pump
- An aluminium lower ladder frame, incorporating the oil pump
- Centrifugal oil filter
- Fuel cooler
- Integrated oil cooler
- A new engine management system
- Sequential cyclone engine breathing system
- An integrated vacuum pump with the alternator

Figure 60

Engine specification figures

• Cubic capacity		2498cc
• Piston stroke		88.95mm
• Piston bore		84.45mm
• Compression ratio		19.5:1 ± 0.5
• Maximum Governed rev/min.		4850
• Maximum rev/min (e.g. overrun)		5460
• Target idle speed >0°C		740 rev/min.
• Target idle speed <0°C		1000 rev/min.
• Maximum torque (manual gearbox fitted)		300 Nm
• Maximum torque (automatic gearbox fitted)		315 Nm
• Maximum power	New Discovery	101.5 kW @ 4,200 rev/min
	Defender 1999 MY	90.0kW @ 4,200 rev/min

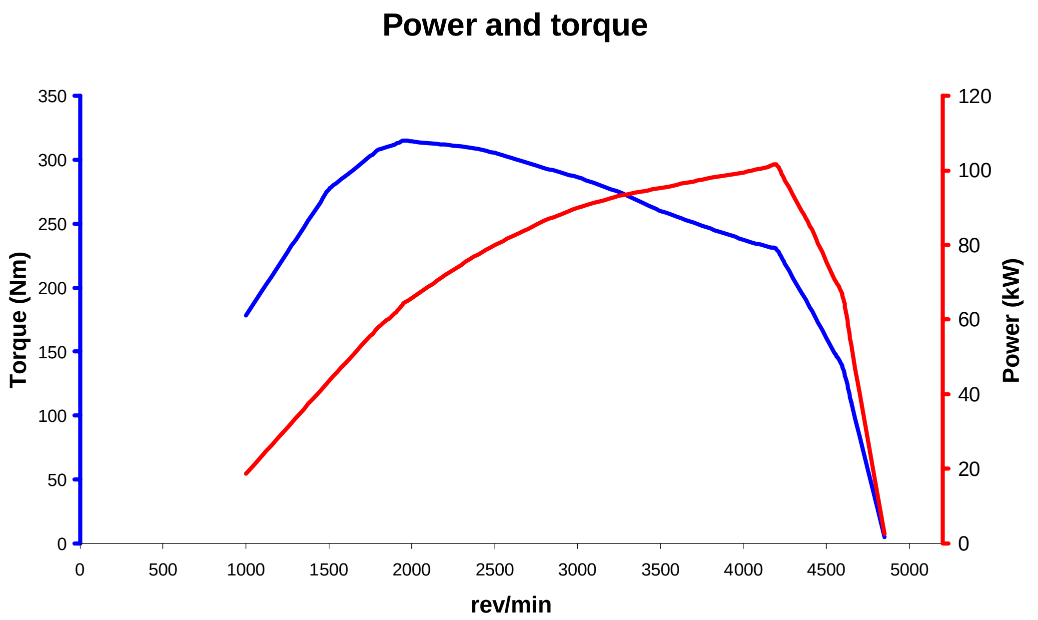


Figure 61

Engine construction

The engine is an in-line five cylinder, turbocharged direct injection compression ignition unit. The block is of cast iron construction with an aluminium cylinder head. The engine uses 'through bolt' technology. This provides excellent structural support and rigidity. An aluminium ladder frame secures to the bottom of the cylinder block to enhance the lower block rigidity. The ladder frame also incorporates a rotary oil pump. This oil pump passes pressurised oil through the aluminium ladder frame into the cylinder block. A gasket seals the ladder frame oil gallery and the cylinder block oil gallery. This gasket must be replaced whenever the ladder frame is removed.

Cylinder block

The cylinder block incorporates oil squirt jets which are used to cool the pistons. Each squirt jet incorporates a pressure valve which shuts off whenever the oil pressure falls below 1.5 Bar. The engine does not feature a conventional adaptor plate, instead, the gearbox bolts directly to the engine block. The gearbox casing itself houses the starter motor and provides access for the TDC positioning tool, which engages directly into the flywheel.

The engine has an aluminium structural sump sealed to the cylinder block with a rubber gasket. This gasket features integrated metal sleeves (compression limiters) at the points where the sump bolts pass through the gasket. This prevents the gasket from distorting as the sump bolts are tightened. The sump gasket should be fitted dry to cleaned and dry surfaces.

The crankshaft is constructed of iron and incorporates journals with rolled fillet radii to increase the crankshaft's ability to withstand 'bending' fatigue. It is not possible to regrind the crankshaft, due to its design and the techniques used in its construction. The crankshaft main bearings feature a grooved shell, which locates in the cylinder block and with a smooth shell in the cap. The number 3 main bearing includes provision for the two thrust washers; these washers are only available in a standard size. It should be noted that all the main bearing caps have a slight interference-fit with the cylinder block. This feature negates the need for main bearing locating dowels.

The pistons feature a graphite coated skirt and incorporate an integral combustion chamber. The pistons have three piston ring grooves, housing two compression rings and one oil-control ring. An internal oil gallery, fed by the oil squirt jet, cools the piston. The piston design eliminates the need for additional strengthening rings using its shape to transfer the combustion forces through to the con-rod.

Fracture split con-rods

The con-rod is identical in design to the con-rod fitted to the Freelander L series engine. It is a fracture split con-rod. This meens that the big end bearing cap has no machined surface in contact with the con-rod. In manufacture, the con-rod is bored to a nominal diameter as a one-piece unit. Two grooves are then machined into the inner land and then the cap is forced apart. This causes the metal to fracture, leaving a unique mating surface. Once this process is completed, the cap is refitted and tightened using two retaining bolts and the final internal diameter is machined. Utilising the fractured state of the cap ensures that the two pieces of the con-rod fit perfectly and possess a strong resistance to lateral movement (side-ways movement).

The bolts are located off-centre. This serves to ensure that the cap is fitted to the rod in the correct orientation. If, when the con-rod is out of the engine, the cap is fitted incorrectly (the wrong way round) and the bolts are tightened then the con-rod must be replaced. This is necessary because the unique profile of the mating surfaces will have been damaged when the cap was tightened. The cap will no longer locate correctly, even if it is turned back to the correct position.

The small end of the con-rod is machined to a taper. This allows for clearance between the piston head and the con-rod and provides increased load capability by increasing the surface area on both load sides of the gudgeon pin. The small end is lubricated by a splash-feed, facilitated by the squirt jets. The big end bearings have no featherway to locate them laterally. They rely solely on ‘bearing nip’ to control their position and to eliminate rotational and lateral movement. The bearing shell located in the con-rod is different to the bearing shell fitted in the con-rod cap. The con-rod bearing goes through a manufacturing process called ‘sputtering’. This process is used to form very pure materials. In this case, the sputtering process is used to increase the con-rod bearing shell resistance to wear and is used to offset the greater wearing loads experienced by the top bearing shell. The sputter bearing can be identified by having a shiny surface (bearing shell to con-rod side), a dedicated part number and a different appearance when viewed from the working side of the bearing as compared to the back of the bearing.

Flywheel

The flywheel is a ‘dual-mass’ flywheel. This means it has a proportion of its mass mounted by an internal spring. A dual-mass flywheel helps to dampen the unavoidable variations in crankshaft rotational speed which occur at the point of combustion for each cylinder. This damping action helps to reduce drive train vibration particularly when the engine is at low speed and at idle. The flywheel also incorporates a series of holes drilled into the circumference. These holes work in conjunction with the crankshaft sensor to feed back information on the crankshaft speed and the crankshaft phase.

There are 31 drilled holes, spaced at 10° intervals, around the flywheel. At five 10° intervals the crankshaft has not been drilled. This acts in the same manner as having a ‘missing pole’ (i.e. as used on the V8 engine fitted to the Range Rover pre-1999 MY). The missing holes are placed unevenly around the circumference of the flywheel. By having the crankshaft drilled in a unique sequence, the ECM is able to determine its position in the engine’s cycle within a maximum of 130° of crankshaft rotation.

Cylinder head

The cylinder head face is heat treated to increase its durability, so it cannot be re-faced. The head houses four glow plugs (number 5 cylinder does not have one) and two valves per cylinder. It also features the machining for the camshaft, hydraulic lash adjusters, the electronic unit injectors and the low pressure fuel rail.

The camshaft locates between the head and the cam carrier. These two components are line bored, so form a matched pair. It is important to note that the head is subjected to a force equivalent to that of clamping the cylinder head to the surface block when it is line bored. This ensures that the camshaft bearing surfaces match the profile of the camshaft journals perfectly when the engine is in an operating condition. If the need arises to replace the cylinder head or the cam carrier, the other component must also be replaced. The cam carrier is sealed to the cylinder head by liquid sealer, in this case Hydrogrip 2000. It is important to apply the correct amount of sealer. Always follow the procedure detailed in the workshop manual to ensure that the correct amount of sealer is applied.

The rocker shaft sits above the camshaft in the cam carrier and has on it five rockers. These rockers are used to generate fuel pressure inside the EUI injectors.

The valves use finger followers to transfer the camshaft lobe movement into vertical valve movement. The finger followers locate over the hydraulic lash adjusters and the tops of the valves (see figure 62). The finger followers are not held rigidly into position, they hold their position by locating on top of the valve and locating over the hydraulic lash adjusters pivoting ball. The valve is activated by the lobe of the camshaft pressing down on the roller of the finger follower.

Figure 62

When the hydraulic lash adjusters are removed from the engine, they must be stored upright and in clean conditions. Failure to follow this procedure can result in serious engine damage when they are reinstalled.

The cylinder head incorporates the fuel gallery, as previously mentioned. Supply and return connections are located at the rear of the cylinder head. All the fuel pipes are connected by means of quick-fit connectors. A fuel cooler is mounted on the side of the inlet manifold (see figure 63). The fuel cooler cools the hot fuel from the cylinder head before it returns to the fuel filter. The fuel cooler has two coolant connections to the radiator. The radiator incorporates a small diameter tube dedicated to supplying coolant for the fuel cooler. The small diameter of the tube slows the coolant flow, which ‘super cools’ the coolant before it is supplied to the fuel cooler. The fuel cooler has a thermostat which opens when the coolant inside the fuel cooler reaches approximately 70°C (160 °F). It is important to cool the fuel returning to the fuel filter, as this ensures that the fuel within the fuel circuit is kept at a predetermined temperature for optimum performance and emissions.

Figure 63

Fuel supply system

The fuel supply system on New Discovery diesel derivative uses an electric two-stage pump. The pump is submerged in the fuel tank. Fuel passes through the pump twice before it flows to the engine. In the first stage, the fuel is drawn from the swirl pot and flows out of the fuel tank to the fuel filter (line A). The fuel filter is located on the outside of the chassis on the right hand side of the vehicle, forward of the rear wheel. This fuel filter is of a canister design and should be replaced at scheduled intervals, according to the service maintenance service sheet. Once the fuel has passed through the filter, it returns to the fuel tank (line B) where it enters the fuel pump for the second time. The fuel pump then boosts the pressure to 4.0 Bar. The boosted fuel pressure is controlled by a pressure relief valve located in the aluminium fuel connector block, which is situated on the rear of the cylinder head. The pressure relief valve controls the fuel pressure by regulating the amount of fuel returning to the fuel filter. The fuel connector block also retains an additional ‘fit for life’ fuel filter. This filter should not be replaced under normal circumstances. However, if a blockage does occur, then the housing can be removed and the filter replaced.

It is extremely important that no dirt enters the fuel rail as this could lead to engine misfire by blocking an injector or making it stick open. It can also lead to combustion gases mixing with the fuel in the fuel rail, causing the engine to stop running.

The fuel is supplied to the engine (line C) and into the gallery within the cylinder head. The injectors then use a proportion of the fuel. The return pipe allows the excess fuel from the head (line D) to flow into the fuel cooler. Finally, fuel flows to the fuel filter (line E) and back into the fuel pump, ready for the next cycle.

Care should be taken when disconnecting any part of the fuel system as it can contain hot pressurised fuel. In cases where an EUI needs to be removed, follow the procedure detailed in the workshop manual. Failure to disassemble the engine correctly, or to not take heed of the warning associated with allowing fuel to drain into the combustion chambers, can lead to engine damage.

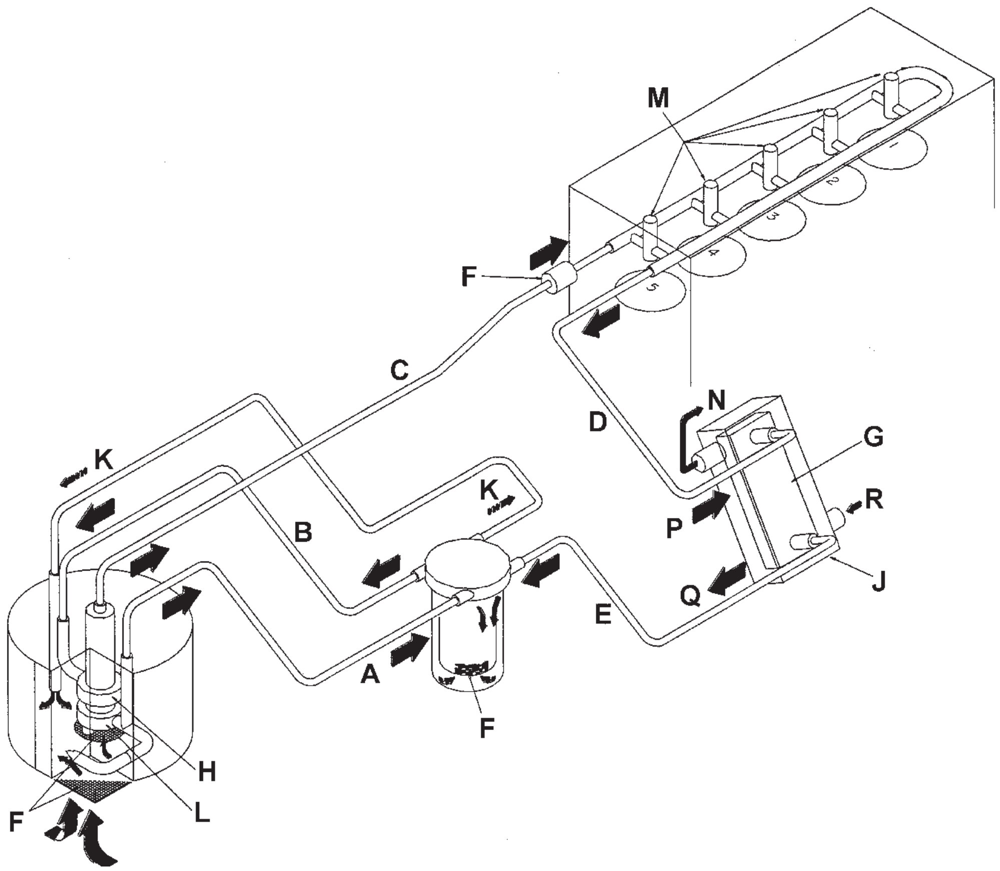


Figure 64

A. LP out
B. LP in
C. HP out
D. Return pipe
E. Spill return
F. Filters
G. Fuel cooler
H. HP stage
J. Water jacket
K. Air bleed
L. LP stage
M. Electonic unit injectors
N. Water out
P. Hot fuel in
Q. Cool fuel out
R. Cool water in

Oil pump

The oil pump, as previously mentioned, is located in the stiffener plate. A chain drives it from the crankshaft. The oil pump contains no serviceable parts except for the pressure relief valve spring. The free length measurement of this spring is detailed in the workshop manual. It is the free length of the oil pressure spring which determines whether the pump is suitable for refitting into the engine. Before the oil pump or crankshaft drive sprocket can be removed, the oil pump drive sprocket must first be removed.

Electronic unit injector (EUI)

The injectors used by the Td5 engine are located in the cylinder head. A copper washer and an 'O' ring are used to seal the injector nozzle and injector body to the cylinder head. If, at any time, an injector is removed then this washer and the injector 'O' ring must be replaced. Extreme care must be taken when removing an injector from the cylinder head as the tip of the injector can be damaged if it is handled incorrectly. If the copper washer fails to seal the injector to the cylinder head, combustion gases will contaminate the fuel in the fuel gallery. This results in the fuel becoming aerated. If this happens, the engine will suffer poor starting and poor performance. Even with relatively small amounts of combustion gas in the fuel, the engine performance will suffer noticeably. The injectors 'O' ring prevents the fuel in the fuel gallery from entering the engine oil supply.

The EUI injectors are very susceptible to foreign matter in the fuel rail or any dirt or particles around or in injector body between the 'O' ring and the copper washer. No attempt to clean this part of the injector should be made. Always follow the procedure detailed in the workshop manual when removing the EUI injectors.

Figure 65

The injectors are electronically operated units in which the fuel injected is pressurised mechanically. Each EUI consists of a hydraulic plunger, a conventional injector nozzle and an electric solenoid. The hydraulic plunger is driven mechanically by the camshaft and rocker assembly. The injector operates in four stages:

1. The camshaft lobe turns and transfers mechanical force and motion to the rocker, which is in contact with the injector hydraulic plunger. This transfer of mechanical force starts to move the plunger down inside the injector. At this point, the injector has fuel flowing through it because of the action of the pump located in the fuel tank. N.B. Fuel exits the injector via the spill hole back into the fuel rail
2. As the plunger travels down, it closes the inlet port and prevents more fuel entering the injector. The fuel already in the injector can still exit the injector at this stage because the EUI solenoid has not shut off the spill port
3. At a calculated time, the ECM will supply a voltage to the injector solenoid, causing it to activate. This will close the injector spill port and cause the pressure within the injector to rise very rapidly. At this point, the injector will spray fuel into the combustion chamber at very high pressure (up to 1500 Bar. As a comparison, the current 300 Tdi engine injects fuel at approximately 600 Bar)
4. At the calculated time, the ECM will remove the voltage to the EUI injector solenoid. By doing so, the spill port will open and fuel will now flow through the injector, rather than out through the nozzle. The hydraulic plunger will return to its rest position by means of a powerful spring. The EUI is now ready for the next injection sequence

It is critical that each injector delivers the desired quantity of fuel at the required time. To do this, its opening and closing times must be controlled precisely. Despite the fact that the injectors are manufactured to extremely close tolerances, an amount of variation may exist between them. This is due to slight differences in spring tension and nozzle bore dimensions. As a result of this variation, the ECM must be informed of the precise specification of each injector. This enables the ECM to adjust its opening and closing injection points to gain the maximum fuel efficiency. This procedure is called the calibration process.

On top of the injector there is a five letter code. This code is used in the EUI calibration process. It details the exact performance or ‘profile’ of the injector. Each injector is tested after manufacture and is measured against a nominal start of injection point, end of injection point and an idle quality factor. The graph in figure 66 below demonstrates how this alpha code is used to tighten the tolerance of the EUI.

Injection profile

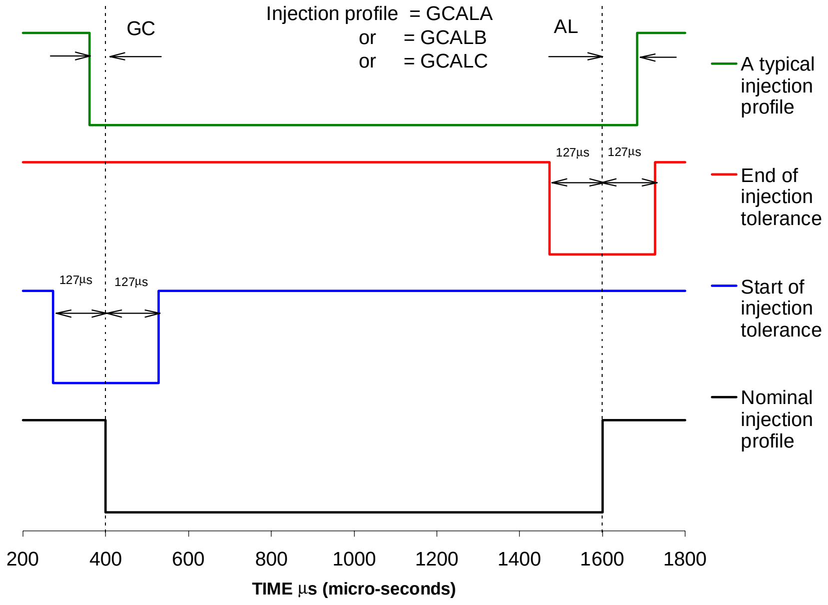


Figure 66

The first two letters of the alpha code refer to the degree of variance from a nominal injector to the measured injectors start point. The second two letters in the alpha code refer to the end of the injectors tolerance. The tolerance band for the start and end of injection is ± 127µS (0.000127 seconds). The last letter in the alpha code is a measured variance in idle performance. The injector is given one of three idle letters: A, B or C.

The alpha codes used for both the start point and the end point are not sequential, i.e. not AA through to ZZ. The codes have been picked at random to stop the possibility of deliberately over-fuelling the engine in the search for greater performance.

The letters do not denote that one injector is better than another injector. The letters give the ECM the mapping adjustment needed for that particular injector, to enable very precise fuelling and smooth idle performance.

It is important that the injector code is programmed into the ECM if an injector is replaced, or if the order of the injectors is mixed up. This procedure is completed with the aid of TestBook.

The injectors are operated electrically by the ECM, which is able to produce a voltage of approximately 80 volts at 8 amps to shut the injector spill port. This is a considerable amount of electrical energy. Appropriate care should be taken while working with a running engine.

The rockers which transfer the downward force on the EUI must be adjusted correctly at all times. The process used to set the adjustment is dissimilar to conventional tappet adjustment procedures. The procedure is as follows :

1. Loosen the lock nuts on all the adjusting screws (this should have been completed before the rocker shaft was removed)
2. Set the engine to a position where the EUI to be adjusted is fully compressed, i.e. the cam lobe is at its highest point. There is a timing mark on the front of the camshaft for each of the injector's lobes. This mark will align with the edge of the cam carrier housing to signify that the relevant injector lobe is at its maximum point
3. Screw the adjuster 'in' to further compress the EUI hydraulic plunger spring (this will feel quite stiff). Stop when the plunger contacts the base of the injector (at this point it will not be possible to screw the adjuster in further)
4. Turn the adjusting screw back 1 turn and tighten the lock nut
5. Repeat steps 2 – 4 for the other four injectors

This adjustment procedure should be carried out whenever the rocker shaft has been removed. When adjusted correctly, the injector plunger travels the correct distance. If not adjusted correctly the plunger could either travel too far and make contact with the base of the chamber or may not travel far enough. In both cases, damage and a reduction in engine performance could result.

Timing chain

The timing chain is a duplex link chain driven by the crankshaft. It has 56 links, three of which are of a bronze colour. The significance of these links will be described when the engine timing procedure is explained. The timing chain runs over two plastic guides. One of the guides is fixed rigidly to the cylinder block, whilst the other is kept tight against the chain by a spring-tensioned and oil damped chain tensioner. The timing chain tensioner locates through the side of the head. The tensioner has a direct oil feed, which provides additional tension to the chain as well as dampening transient vibrations in the timing chain when the engine load changes.

To fit the timing chain correctly the crankshaft and the camshaft must be in set positions. The crankshaft should be locked at TDC using the correct special tool. The camshaft can then be located by inserting special tool LRT 12 058 through the cam carrier into a locating slot machined into the camshaft flange (see figure 67).

Figure 67

The bolts securing the camshaft sprocket should remain loose at this stage to allow the sprocket to move independently of the camshaft. The bronze coloured links in the timing chain are used to position the chain correctly on both sprockets. The two adjoining bronze links should be placed either side of the machined mark on the camshaft sprocket. The single bronze link should be placed in-line with the machined mark on the crankshaft sprocket. At this point, both chain guides should be fitted and the chain adjuster inserted to tension the timing chain. The camshaft sprocket bolts should then be tightened to the specified torque. Both special tools should be removed and the crankshaft rotated twice. The crankshaft timing pin should then be reinserted. It should now be possible to insert the camshaft tool LRT 12 058 without resistance. If not, the procedure should be repeated.

Figure 68

Oil filter

The Td5 engine features two oil filters. The primary oil filter is a conventional canister type. The primary oil filter filters all the oil entering the oil gallery and the oil entering the secondary oil filter. The primary filter features a paper element which is used to trap particles as small as 15 microns (0.015 mm) in diameter. But diesel engine produces many particulate impurities smaller than this and these particles are removed efficiently by the secondary centrifugal filter. Therefore, the service life of the primary oil filter canister can be greatly extended. Always refer to the maintenance check sheet for the correct service interval for both the primary and secondary oil filters.

The secondary oil filter is a centrifugal oil filter which is housed in a 'pot' located by the exhaust manifold. The pot lid is sealed to the pot by an 'O' ring. This 'O' ring should be replaced when the centre canister is replaced. The oil filter works by the replaceable centre unit spinning very rapidly. The unit has two very fine holes drilled at an obtuse angle so that when oil flows through them under pressure it spins the centre filter unit. The centre of the centrifugal filter can rotate at speeds up to 15,000 rev/min. The inner surface of the spinning canister gets coated in a gel of old engine oil and carbon particles. The centrifugal filter is capable of retaining much finer carbon particles than a traditional canister type oil filter.

The oil pressure warning switch is located in the housing under the turbocharger. The oil pressure switch will go to an open circuit state (light off) when the oil pressure rises above 0.5 – 0.68 Bar .

Figure 69

The housing between the two oil filters and the cylinder block incorporates an oil cooler (see figure 70). The oil is passed through the oil cooler via a thermostat in the oil filter housing, which has a 72 °C (160°F) opening temperature. The oil is then cooled by the cylinder block water jacket.

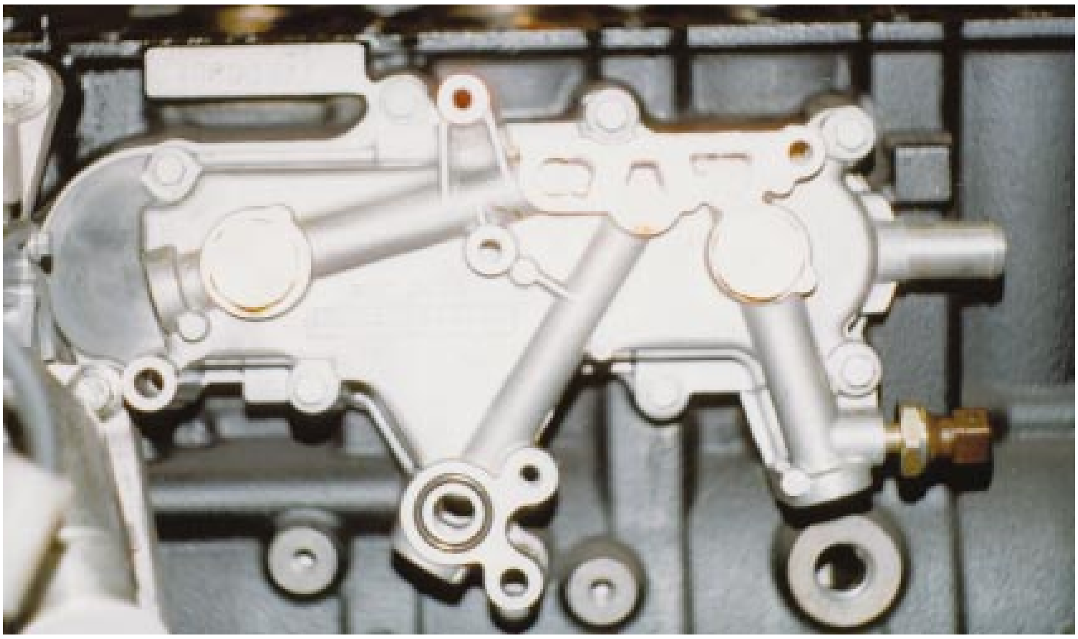


Figure 70

Turbocharger

The turbocharger used on the Td5 engine is a Garrett GT20. This unit features an electronic modulating wastegate. This enables the ECM to control accurately the amount of boost pressure the engine receives. The conventional care points should be observed when starting and stopping the Td5, i.e. allow the engine to idle for 15 seconds immediately following start-up and before the engine is switched off.

Cooling system

The cooling system uses a 50/50 antifreeze/water mix. The specified antifreeze to be used in this application is Texaco XLC. The capacity of the system is approximately 10 litres. The workshop manual details the procedure to drain and refill the cooling system.

The cooling system hoses have been fabricated to incorporate a thermostat housing. This thermostat housing has three hose connections. The coolant is drawn into the water pump via hose (F) from either the heater matrix circuit (D) or from the thermostat housing (A). When the thermostat (B) is closed, the water pump will draw fluid from the bypass hose (E). Before it is able to do this, it will need to overcome a spring-loaded valve (C) inside the thermostat housing (A). This spring is rated so that, when the engine speed is below approximately 1500 rev/min, all the coolant will circulate around the heater circuit (D). This serves to aid fast ‘warm-up’ when the vehicle is operated in cold climate conditions. If the engine speed exceeds approximately 1500 rev/min, the suction the water pump creates will be sufficently strong to lift the spring-loaded valve (C) off its seat. This will allow coolant to circulate through the bypass hose (E), as well as through the heater circuit (D). When the coolant temperature exceeds 82°C (180°F), the thermostat (B) will open, allowing the coolant to flow through the top hose (E), through the radiator and into the thermostat housing, via hose (G). Finally, it will be drawn into the water pump via hose (F).

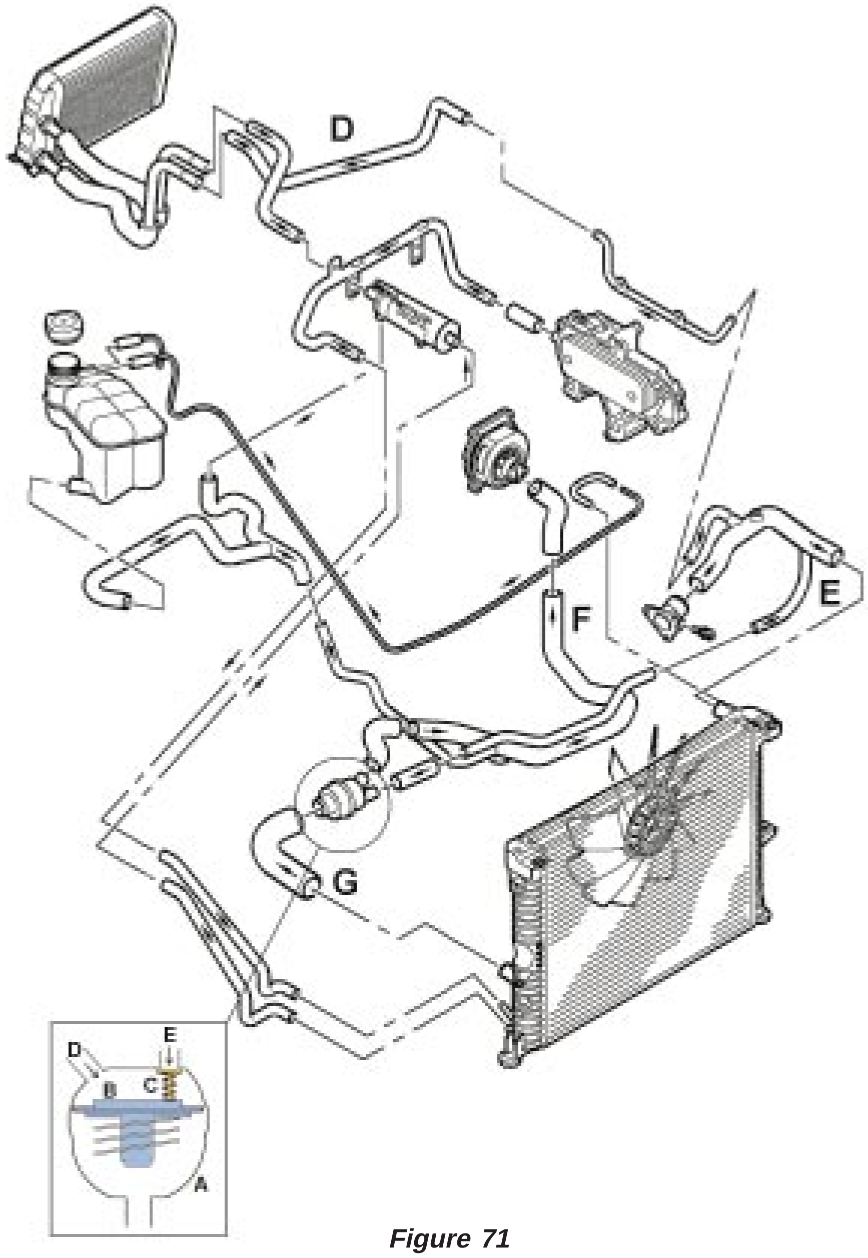


Figure 71

Auxiliary drive belt

The auxiliary drive belt is used to drive the following items (depending upon the vehicle specification):

1. The viscous fan
2. The water pump
3. The alternator
4. The vacuum pump (via the same pulley as the alternator)
5. The power steering pump
6. The air conditioning compressor
7. The active cornering enhancement control pump

The auxiliary drive belt is tensioned with an auto-tensioner. The auto-tensioner has an uprated spring to provide the belt with greater tension than the 300 TDI. This is needed because of the extra power transfer required to drive the above components.

The Td5 engine features an integrated 120 amp alternator and vacuum pump. It is driven directly by the auxiliary belt and supplies vacuum for the servo assisted brakes, and for the EGR modulating valve.

There are four auxiliary drive belts, each of differing length. The drive belt fitted is determined by the specific components fitted to the vehicle. Each drive belt is colour coded to assist with identification. The table below identifies which belt is used for each vehicle derivative and provides a key to the colour coding.

Colour	Length mm	ACE	A/C	Configuration	Figure No.
White	1716	No	No	No ACE or A/C	72
Yellow	1820	Yes	No	ACE only	73
Green	1801	No	Yes	A/C only	74
Red	1867	Yes	Yes	ACE and A/C	75

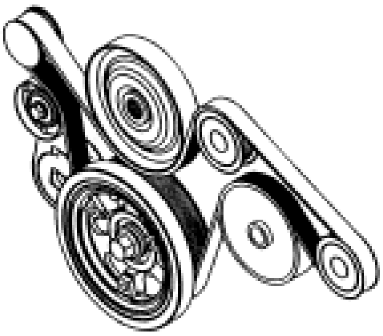


Figure 72

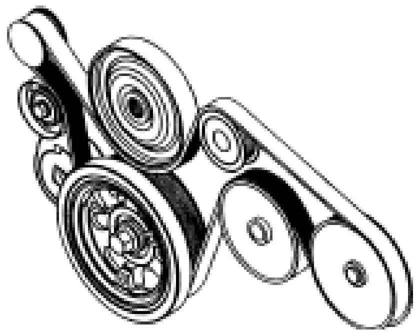


Figure 73

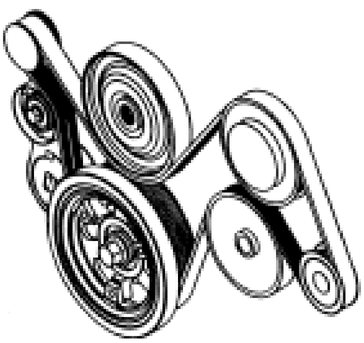


Figure 74

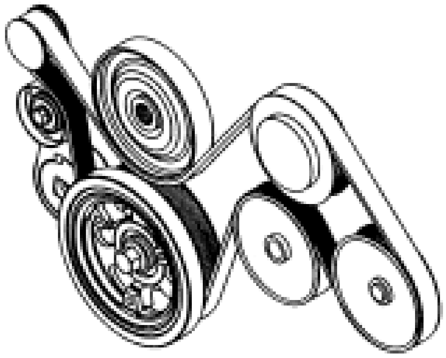


Figure 75

Crankcase ventilation

The Td5 engine features an innovative solution in the control of crankcase emissions. The new system ensure that very low levels of oil mist enters the combustion process or escapes to the atmosphere. The new rocker cover has cast into it five circular, sequentially positioned chambers (see figure 76). These chambers force the oil mist into a cyclononic movement from one chamber to the next. As the mist races around each chamber, any oil particles are flung to the chamber walls where it then collects and falls back into the cylinder head via the two air inlet holes located at each end of the rocker cover.

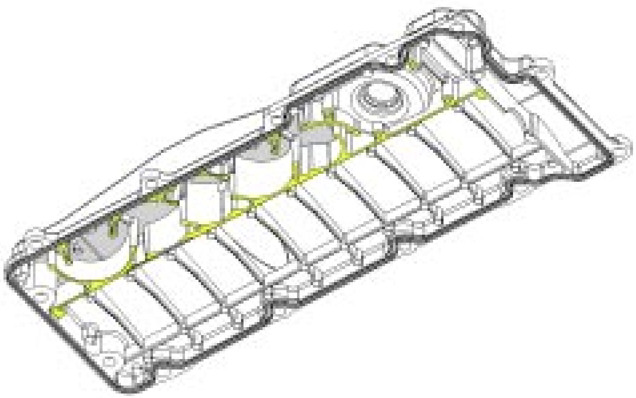


Figure 76

DIESEL ENGINE MANAGEMENT SYSTEMS

The diesel electronic engine management system fitted to derivatives of New Discovery equipped with the Td5 diesel engine is referred to as the diesel modular engine management system (diesel MEMS). The system features a single engine control module located next to battery and vehicle jack.

Within the diesel MEMS system, all inputs are converted into electrical signals and processed by the ECM. Inputs are received from the driver, various sensors located strategically on and around the engine, and from other vehicle systems. The unit exercises full control over the fuel injection system and supports a sequential injection strategy by way of the EUI injectors. The system utilises ‘drive by wire’ technology and, therefore, does not incorporate a direct mechanical connection between the throttle pedal and the engine.

Driver inputs

The system receives several inputs from the driver. The ECM processes the information received and controls the outputs accordingly. The driver inputs are:

- Ignition switch
- Driver demand sensor (throttle position sensor - TPS)
- Brake pedal switch
- Clutch pedal switch (manual only)
- Cruise control switch (if fitted)
- Cruise set/acceleration switch (if fitted)
- Cruise resume/suspend switch (if fitted)

Ignition switch

The ignition switch does not supply the ECM with a signal when the ignition switch is in position 0 or 1 (off or auxiliary). When the ECM ‘wakes-up’ it will complete various self-test functions and security functions in preparation for engine start. The ECM does not receive a starting signal, it only knows the engine is cranking by monitoring the crankshaft sensor.

Driver demand sensor

The driver demand sensor (TPS) is integrated into the throttle pedal housing and performs the function of the throttle position sensor. The sensor cannot be replaced separately from the throttle pedal housing and requires no adjustment in service.

The sensor comprises two opposing potentiometers housed within its body. Its body is located precisely on the throttle pedal housing and ‘timed’ with the position of the throttle pedal. The potentiometers are referred to as the high potentiometer and the low potentiometer. The ECM provides a 5 volt supply to both potentiometers. The ECM receives two input signals back, one from each potentiometer.

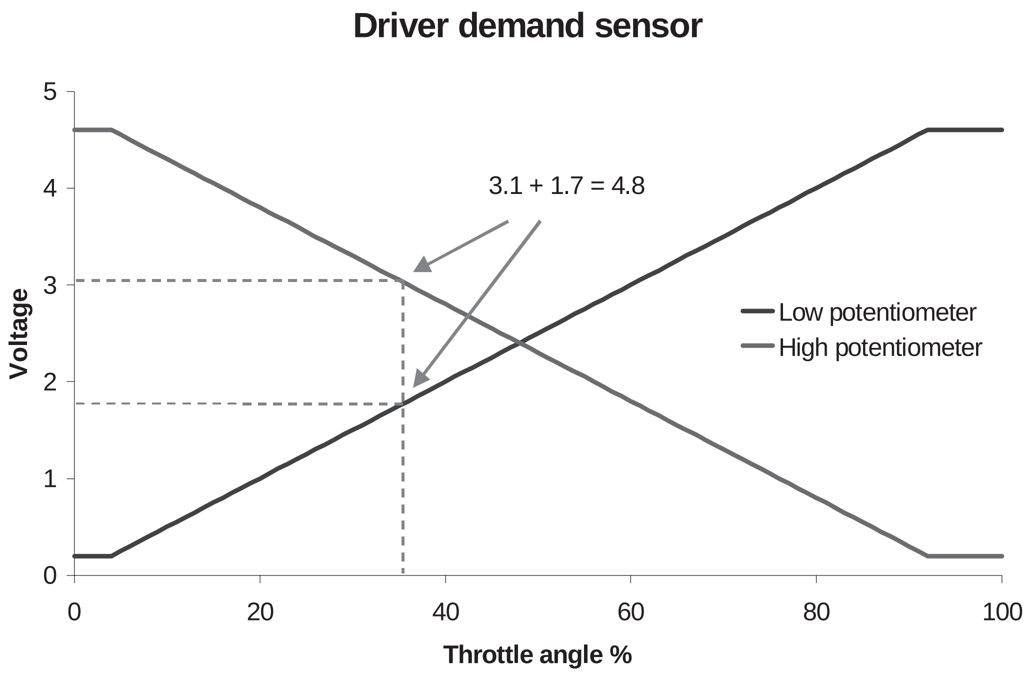


Figure 77

The above graph (figure 77) illustrates the signal returned to the ECM by the drivers demand sensor, over its complete throttle range. At idle, i.e. throttle released (0° throttle angle), the high potentiometer will return 4.6 volts, whilst the low potentiometer will return 0.2 volts. The sum of these two figures adds up to 4.8 Volts. At a 75% throttle angle (3/4 fully open), the high potentiometer will return 1.4 volts, whilst the low potentiometer will return 3.4 volts. Again the sum of these two figures adds up to 4.8 volts. The ECM uses this strategy so it can error-check the throttle signal.

Brake pedal switch

The brake pedal switch monitors the position of the brake pedal. This switch is located on the pedal housing. It comprises a main body, plunger and two internal switches. The two switches are designed to operate simultaneously in response to plunger movement. The ECM receives an input from each individual switch.

When the brake pedal is released, i.e. brakes off, one switch is normally open and one is normally closed. In this state, the open switch will not allow current to flow, whilst the closed switch will allow current to flow. When the brake pedal is pushed, i.e. brakes applied, the switches will change state. At this time the previously open switch will change state to closed and the previously closed switch will change state to open. The use of two switches increases the systems fail-safe capability.

The brake switch inputs are used by the ECM to cancel cruise control operation, if it is set at the time.

Clutch switch

The clutch switch is fitted only to vehicles equipped with a manual gearbox. The switch is an hydraulic pressure switch and is located next to the clutch master cylinder. When the clutch is engaged, i.e. pedal released, the switch will be in the open state. When the pedal is pushed and the clutch is disengaged, the switch will change to the closed state. The ECM will suspend cruise control operation in response to this change of state. The ECM will also reduce fuelling in response to this signal, to reduce engine surging (dampens the effects of fast throttle transitions to eliminate jerky vehicle movements). If the clutch switch fails at any time then the ECM will not support cruise control operation. In addition, the engine will be more susceptible to surging at times when the engine is decelerating quickly.

Cruise control switch

The cruise control switch is located in the binnacle surrounding the instrument pack The switch is pressed by the vehicle user whenever cruise control operation is required. It is a latching switch which changes state when pressed. In response to this change of state, the ECM will enable cruise control functions.

Cruise control suspend/resume switch

This switch is located on the steering wheel (figure 78). It is a ‘momentary’ switch, i.e. it is normally open but will change state to closed when pushed and held, immediately changing back to open when released. The switch has two functions. It is used to inform the ECM that the driver wants to either suspend the operation of cruise control, or requires the cruise control system to resume operation to the same target speed as previously set.

Cruise control set/accelerate switch

This switch is also located on the steering wheel. Like the suspend/resume switch, it is a momentary switch. The switch has two functions. It is used to inform the ECM that the driver wants to either set a target speed for the cruise control system, or increase its present target speed. The precise increase in speed will depend upon the length of time the switch is held for. It is important not to depress the switch for more than 60 seconds, as this action will cause a ‘stuck switch’ fault within the ECM memory and will disable cruise control operation. The driver can also increment the target speed by ‘tapping’ the switch. This operation will raise the speed in 1.6 km/h (1 mph) increments.

The set/acceleration switch and the suspend/resume switch require the following conditions to operate:

1. The vehicle speed must be in excess of 50 km/h (32 mph)
2. The cruise control master switch must be active
3. The brake pedal must not be depressed
4. The clutch pedal must not be depressed
5. The vehicle must be in drive (automatic vehicles only); the ECM performs a ‘valid gear’ ratio calculation if the vehicle has manual transmission. The calculation is derived from the road speed and engine rev/min

Figure 78

Engine state inputs

The engine management system requires information on the current operating conditions of the engine. It uses several electrical devices to feed back this information. It uses the information received to calculate the precise opening time and duration of the EUI’s which, in turn, determines the quantity of fuel injected into the engine.

The engine state inputs are supplied to the ECM by the following:

- Mass air flow sensor (MAF)
- Ambient air pressure sensor
- Engine coolant temperature sensor (ECT)
- Crankshaft position sensor (CKP)
- Fuel temperature sensor
- Manifold absolute pressure sensor
- Inlet air temperature sensor

Air flow meter

The air flow meter is located in the ‘air out’ tube of the air intake box (figure number 79). The specification and dimensions of the air out tube are critical and determine precisely the air flow. It is, therefore, important that the air tube is not altered or modified in any way and that the air flow meter is not moved or fitted incorrectly. Any of these actions will adversely effect air flow and the performance of the air flow meter in correctly determining the quantity of air entering the engine.

Figure 79

The air flow meter uses “thick film” technology to produce an accurate reading of the amount of air entering the engine. It operates by monitoring the amount of electrical current required to keep the film inside the meter at a predetermined temperature. The amount of current required to do this will vary in response to the amount of air entering the engine. The airflow meter modifies a voltage and returns it to the ECM in proportion to the amount of current being consumed (the amount of air entering the engine).

To help control EGR operation (see EGR description below) the ECM uses the signal supplied by the air flow meter. If the ECM detects that the air flow meter has failed, it will log a fault code. The ECM will not attempt to operate EGR while an air flow meter fault is present.

Atmospheric air pressure sensor

The ambient pressure sensor is located in the air filter housing. The unit receives a 5 volt supply from the ECM. It returns a proportion of this supply to the ECM. The value of the signal returned to the ECM enables the ECM to calculate the current atmospheric air pressure. Using this information, the ECM alters its fuelling characteristics and EGR operation. This input is particularly significant when the vehicle is travelling at high altitudes.

If the ambient pressure sensor fails, the vehicle may experience excessive exhaust emissions (smoke) when operating at altitudes above 2,000 meters (6,500 feet).

Engine coolant temperature sensor

The engine coolant temperature sensor is located in the water outlet elbow. It is in direct contact with the engine coolant. It supplies a non-linear (NTC) analogue output voltage to the ECM, which it uses to determine the temperature of the engine coolant. The ECM uses this information to modify its basic fuelling calculations. The ECM sends the engine coolant signal to the instrument pack to drive the temperature gauge. The ECM also uses the signal supplied by the coolant temperature sensor to alter the condenser fan and compressor clutch operation, whenever the engine coolant temperature exceeds a predetermined value.

If the signal from the engine coolant temperature sensor is interrupted or corrupted at any time, a back-up signal will be implemented. The ECM calculates the value of this signal. The calculation is based on the amount of time for which the engine has been operating, at the point the sensor failed and other temperature related information such as the fuel temperature and air temperature values. The ECM is not able to display the engine coolant temperature via the temperature gauge, or give excess temperature warnings at times when a back-up signal is implemented.

Crankshaft speed and position sensor

The crankshaft position sensor is an inductive sensor. It is located in the gearbox bell housing (see figure 80). It provides a signal to the ECM which enables it to calculate the exact speed and position of the crankshaft. The signal is supplied to the ECM in the form of an analogue sine wave. This signal is generated by the sensor in response to holes drilled into the circumference of the flywheel or drive plate. These holes are in close proximity to the end of the crankshaft position sensor. As the flywheel rotates, the holes alter the magnetic flux formed around the end of the sensor. The change in magnetic flux caused by this movement generates the voltage signal.

Figure 80

As previously mentioned, the crankshaft is drilled at 10° intervals and features 5 missing holes. (Figure 81 identifies the location of the holes, the position of the missing holes and shows the relative position of the crankshaft position sensor). Because the missing holes are positioned at uneven intervals around the circumference of the flywheel, the ECM is able to calculate the exact position of the crankshaft within each 360° of rotation.

In addition to detecting the crankshaft position, the ECM is able to assess relative acceleration and deceleration of the crankshaft, caused by a pistons compression cycle and firing strokes. This function is explained in the section on diesel engine strategies.

The signal supplied to the ECM by the crankshaft position sensor is used to support its fuelling strategy. The ECM also uses this signal to calculate engine speed and supplies this information to a number of other vehicle systems. The ECM is also able to calculate the exact position of the crankshaft relative to the firing position of the engine. This information is used to calculate the exact point of injection.

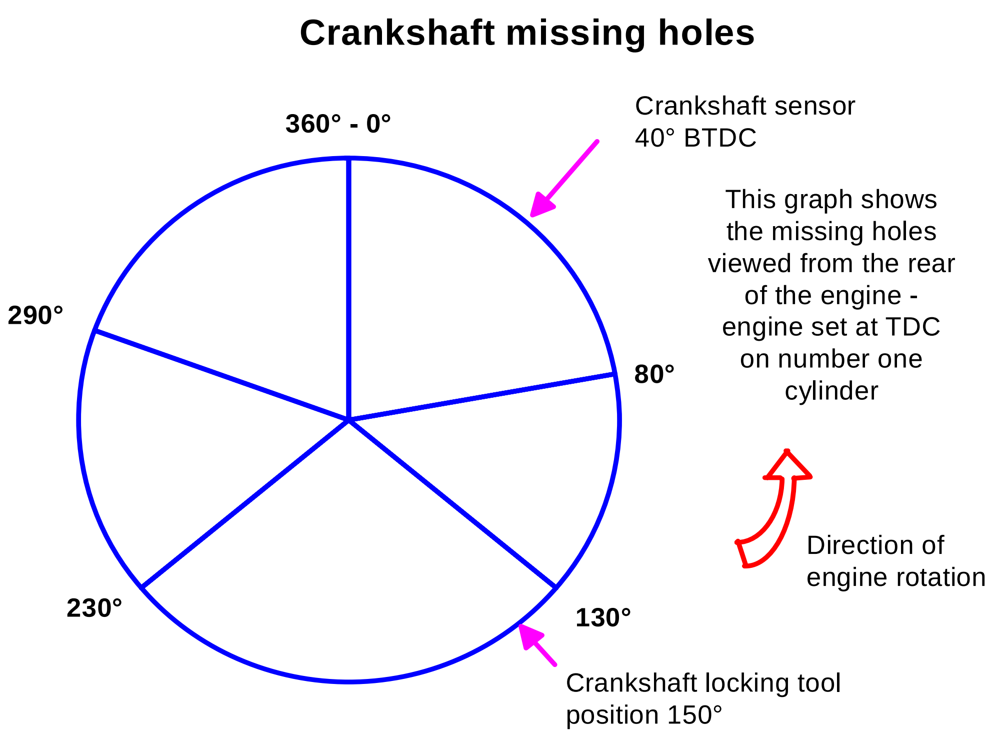


Figure 81

If the signal from the crankshaft position sensor fails or is corrupted the engine will cease to run and will not start again until the problem has been rectified. The MIL lamp will also be illuminated in these circumstances.

Fuel temperature sensor

The fuel temperature sensor is located in the fuel connector block at the rear of the engine (figure 82). It is in direct contact with the fuel and measures its temperature continuously between a range of -40°C to 140°C (-40°F to 285°F). The ECM uses this information within its fuelling strategy. It ensures the appropriate quantity of fuel is injected into the engine to compensate for any change in density caused by a change in the fuel's temperature.

If the signal from the fuel temperature sensor is interrupted or corrupted at any time then the ECM will implement a predetermined default value of 60°C (140°F).

Absolute manifold pressure sensor and air temperature sensor

The manifold absolute pressure sensor and intake air temperature sensor are both located within a single unit. The unit is located on the inlet manifold (figure 82). It supplies two dedicated signals to the ECM relating to the pressure within the manifold and the temperature of the air entering the engine. This information is used by the ECM within its fuelling strategy. It is also used to control the amount of turbocharger boost pressure.

Figure 82

If the manifold pressure signal is interrupted or corrupted at any time the ECM will use a predetermined default value of 100 kPa in its place. The use of the default value will always result in a reduction in engine performance, as the ECM will assume a 'safe' fuelling/boost map in these circumstances. If the intake air temperature signal fails then a fixed default value of 60°C (140°F) will be assumed.

Digital inputs from other vehicle systems

The following additional vehicle systems communicate with the EMS ECM:

- The air conditioning system
- The automatic gearbox
- The SLABS ECU
- BCU
- Inertia switch

Air conditioning

The air conditioning (ATC) ECU communicates requests for the compressor clutch and cooling fan operation to the EMS ECM. The ECM will enable operation as requested at all times, other than when the driver requires full engine torque or the engine coolant exceeds certain parameters.

Operation of the cooling fans is required whenever the compressor clutch is engaged to aid condenser cooling. It is also activated when the coolant temperature exceeds a predetermined value.

The automatic gearbox

The automatic gearbox TCU communicates with the ECM via the CAN bus. The precise nature of the information transmitted and received is described in detail in the section entitled Automatic gearbox.

The automatic gearbox TCU cannot illuminate the MIL lamp on diesel engine applications.

If the CAN bus fails, then the EMS ECM and the gearbox TCU will both register the fault, providing both ECUs receive a power and an ignition feed. The automatic gearbox will also default into 3rd or 4th gear depending upon the current operating conditions

SLABS interface

The EMS ECM communicates directly with the SLABS ECU. It provides information related to the driver demand, engine torque and engine type. The SLABS ECU sends information to the EMS ECM related to a rough road signal, a vehicle speed signal and a fault signal.

The two units use pulse width modulation (PWM) to transfer this information between each other through a single wire. If the communication link between the two units fails at any time, then the HDC and cruise control features are suspended. Details of any fault detected at this time will be stored in both systems fault memories.

BCU

The EMS ECM and the BCU communicate with one another regarding the status of the security system (specifically engine immobilisation). In service, the ECM must receive a coded signal from the BCU before each engine start. If this signal is not received, or not recognised, then the ECM will disable the engine management system, which will cause the engine to stall immediately after initially starting. If either the BCU or the ECM is replaced in service, then this code will need to be reset using TestBook. The engine immobilisation signal is transmitted in a PWM form. This ensures the minimum wiring is required.

Inertia switch

The inertia switch is located on the bulkhead under-bonnet, behind the exhaust turbocharger (see figure 83). It is wired in series with the main relay. Whenever the inertia switch is tripped by a sudden deceleration of the vehicle (over and above the capacity of the braking system), the main power feed to the ECM will be interrupted. This action will stop the fuel pump and the engine by means of the ECM no longer operating the EUI's. The vehicle will not restart until the inertia switch has been reset.

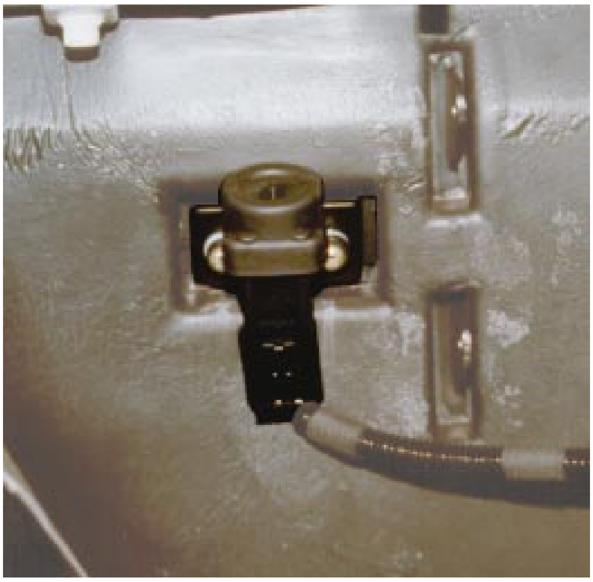


Figure 83

ECM outputs

Like all electronic control units the EMS ECM collects information, processes it and then sends signals back out. On New Discovery the ECM controls the following systems:

- Electronic unit injectors (EUI)
- Electronic EGR vacuum modulator (Japanese specification has two)
- Turbocharger wastegate modulator
- Malfunction indicator lamp (MIL)
- Glowplug lamp
- Glowplug relay
- Air conditioning compressor clutch
- Air conditioning condenser fans
- Main ECM supply relay
- Fuel pump relay
- Tachometer
- Temperature gauge

Electronic unit injectors

There are five EUI's located in the cylinder head (one per cylinder). The ECM controls the operation of each EUI by supplying a voltage to activate its solenoid. The exact timing of this voltage and the calibration coding associated with the EUI's is explained in the section on the Td5 diesel engine.

The ECM does not simply switch the voltage 'on' and 'off' to operate the injectors. Instead, it controls the amount of current supplied to each EUI solenoid. It calculates the current requirement using a current/time relationship map stored within the ECM.

The ECM uses a strategy of 'hit and hold' when operating the EUI's. This strategy will initially allow a very large current to flow to the solenoid 'hit'. This ensures the injector opens very quickly. After approximately 20% of the injection period, the ECM will start to pulse the current supplied to the solenoid 'hold'. By doing this the overall current consumption of each injector can be reduced and the amount of heat energy generated inside the ECM can be reduced.

Electronic exhaust gas recirculation vacuum modulator

The electronic vacuum regulator is located in the engine compartment, on the left-hand side under the coolant expansion tank when viewed from the front of the vehicle (figure 84). It is secured on a rubber mounting, which is designed to reduce the level of operating noise transferred though to the vehicles passenger compartment. If the vehicle is to Japanese specification, the additional modulator is located next to it.

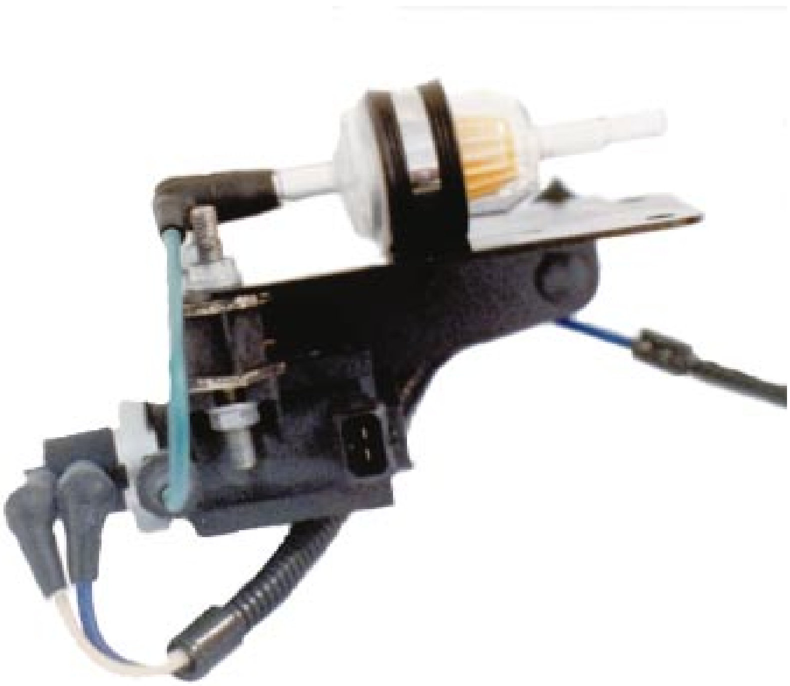


Figure 84

The modulator connects to three vacuum pipes:

1. The first pipe connects the modulator to the vacuum source (i.e. the vacuum pump located on the engine)
2. The second pipe connects the regulator to the EGR valve
3. The third pipe is connected to a filter mounted on the rear of the plate. The other side of the filter is unconnected and allows the air to fill the vacuum previously generated to increase the amount of exhaust gas entering the engine via the EGR modulator valve

The ECM controls the modulator using a PWM signal (Japanese specification additional modulator is controlled in the same manner).

Vehicles built to a Japanese specification incorporate an additional EGR exhaust modulator. This additional modulator controls an inlet manifold butterfly which creates an additional vacuum in the inlet manifold, so increasing the quantity of exhaust gas draw into the manifold under certain engine operating conditions.

Turbocharger wastegate modulator

The turbocharger wastegate modulator is located on the engine, by the air conditioning compressor mounting platform. The modulator enables the ECM to control the quantity of exhaust gas passing the turbocharger turbine and, therefore, the pressure of the air entering the engine. The ECM monitors the pressure and temperature of the intake air continuously. Using this information, it calculates the maximum boost pressure the inlet manifold should be experiencing and controls the turbocharger wastegate modulator by supplying a PWM signal to ensure that this maximum is not exceeded. The ECU cannot increase the boost pressure, it can only reduce it.

Malfunction indicator lamp

The malfunction indicator lamp (MIL) is located in the instrument pack. The ECM will illuminate the lamp for 2 seconds whenever the ignition is switched on. This will allow the driver to check the operation of the bulb. In certain circumstances, the ECM will illuminate the MIL lamp to inform the driver that a fault with the EMS has been detected. However, most engine/EMS faults will not illuminate the MIL lamp. See description of inputs for full details.

Glowplug lamp

The glowplug lamp is located in the instrument pack. The ECM will illuminate the lamp whenever the driver switches the ignition switch from position I to postion II, as long as it detects the need to operate the glowplugs. No attempt to start the engine should be made before the ECM extinguishes the glowplug lamp.

It should be noted that the operation of the warning lamp does not necessarily coincide with the operation of the glow plugs. The ECM will supply a voltage to the glowplugs whenever it identifies a need, regardless of the status of the glowplug lamp in the instrument pack.

Glow plugs

There are only four glowplugs fitted to the engine (number five cylinder is not fitted with one). The ECM activates the glowplugs via a relay. When activated the glowplugs heat to approximately 1000°C (1800°F). The heat generated by the glowplugs helps the atomised fuel injected into the engine to vaporise and combust.

The ECM activates the glowplugs by energising the glowplug relay. It does this to provide the engine with both preheat and post-heat, (i.e. before the engine is started and when the engine is running but still cold). The amount of preheat provided is determined by battery voltage and engine coolant temperature. The amount of post-heat provided is determined by engine coolant temperature only.

Post-heat is provided to reduce emissions created by slower combustion of the fuel at times when the engine is still cold, and to give the engine greater stability when idling. If the coolant temperature sensor fails at any time, then the ECM will implement default preheat and post-heat times.

Air conditioning compressor clutch relay & condenser relay

The ECM has full control over the operation of the condenser fans and the compressor clutch. If the engine coolant temperature rises and/or the air conditioning ECU indicates the refrigerant pressure is high, the ECM will supply a path to ground, thus energising the condenser fan relay. If the ECM receives a request from the air conditioning ECU to run the compressor, then the ECM will supply a path to ground, and so energise the compressor clutch relay. The ECM has final control because of the need to protect engine performance and to prepare the engine for the extra load if the engine is idling.

Main relay and fuel pump relay

The main relay and the fuel pump relay are located in the engine compartment fusebox (figure number 85).

The ECM controls the operation of the main relay (which supplies the ECM) and the fuel pump relay. The ECM needs to control its own power so that it can operate its ‘power down’ strategy. This strategy operates as follows: When the driver switches the ignition off, the ECM is signalled to start the power down sequence. The precise duration of the power down sequence will vary according to the status of the engine at the time when the ignition is switched off. At the end of the sequence the ECM will allow the main relay to switch off. At this time, the main power source to the ECM is switched off. A time period of at least 15 seconds should be allowed for this process to complete. If the ECM detects that it is likely the engine temperature will exceed a given value, the ECM will remain active until the coolant temperature starts to decline. In this condition it may take several minutes before the ECM finally powers down.

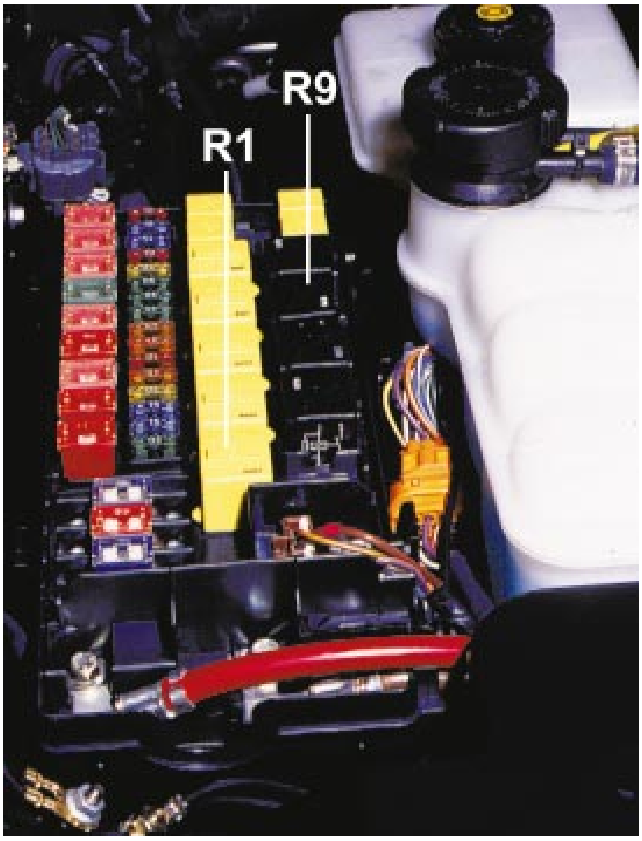


Figure 85

R1. Fuel pump relay R9. Main relay

Tachometer and coolant temperature signal

The ECM receives an engine speed signal from the crankshaft position sensor. It uses this information within its fuelling strategies, as previously described. It also forwards an engine speed signal to the instrument pack. The frequency of the signal reflects the current engine speed. The tachometer then converts this frequency signal into a pulse width modulated (PWM) signal which it uses to drive the needle.

The ECM also supplies the instrument pack with a signal relating to the current engine coolant temperature. The signal is supplied by the ECM in PWM form. The instrument pack will drive the engine temperature gauge needle to the appropriate position to indicate engine temperature. If the instrument pack does not receive the signal at any time, it will assume the engine temperature is cool. In these circumstances, the instrument pack will illuminate the engine overheat warning lamp.

ECM strategies

The ECM uses the system input signals to calculate the precise injection timings and quantity of fuel required by the engine during all running conditions. The ECM supports a sequential fuel injection strategy, i.e. it times the injection of fuel to each individual cylinder's requirements.

Engine position calculations

To ensure the ECM injects fuel at the correct time, it must know the exact position of the crankshaft and the firing point of each cylinder. In a sequential conventional EMS system (where this information is required), a camshaft sensor is used to provide the ECM with the firing point information. The Td5 engine is not fitted with a camshaft position sensor. Therefore, the ECM used on the Td5 engine employs a different strategy to identify the firing position of each cylinder.

In this application, the signal provided by the crankshaft position sensor identifies the exact position of the crankshaft within each revolution. This information enables the ECM to determine which one of the five pistons is approaching TDC at any given time.

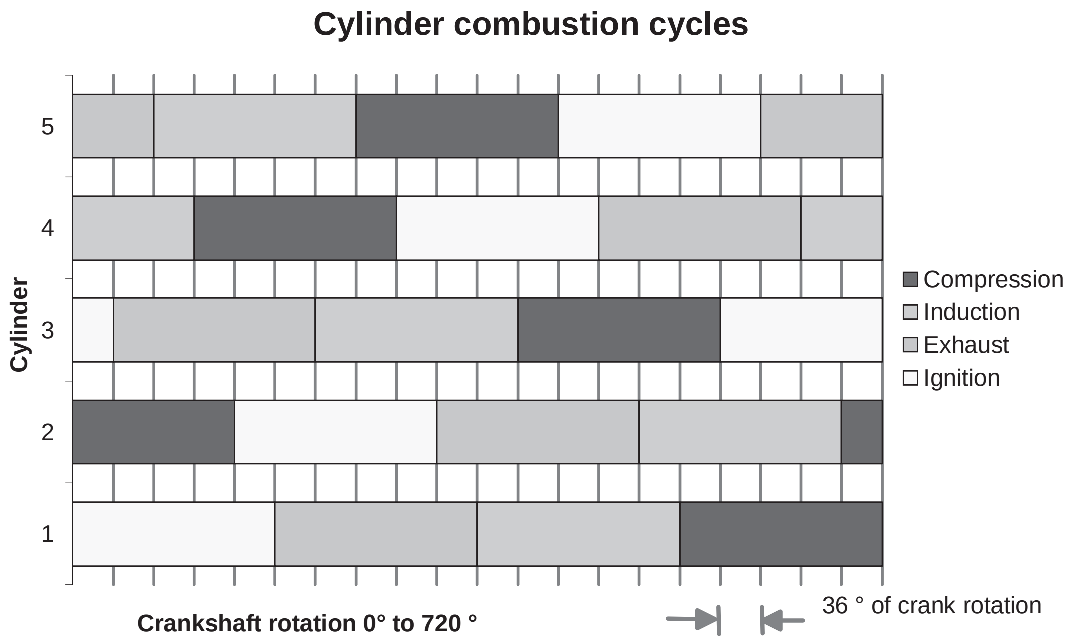


Figure 86

In the Td5 diesel engine, the crankshaft speed 'slows' as each piston travels up the bore on its compression stroke. Figure 86 identifies the compression cycle over 720 ° of crankshaft rotation. This characteristic allows the ECM to determine the firing position of the engine using the relative acceleration and deceleration of the pulses within the engine speed signal provided by the crankshaft sensor.

Engine idle strategy

The ECM uses a different fuelling strategy when idling than when not idling. The use of these two different strategies ensures the ECM maximises the efficiency of the engine.

As previously mentioned, the EUI's inject fuel when the camshaft lobe, via the rocker shaft assembly, forces the plunger down inside the injector. The ECM decides when to close off the spill port during the plungers descent to control the injector opening time. When the engine is accelerating or under load, the ECM will shut off the spill port earlier and leave it closed for longer. This has the effect of advancing the ignition point and injecting more fuel into the engine.

When the driver requires the engine to idle, the ECM injects a small quantity of fuel twice within each firing cycle (at two different points within the downward stroke of the injector plunger). It does this to support a pre-burn cycle inside the combustion chamber, which occurs prior to the main combustion cycle. Engine noise is reduced using this strategy and the engine idle characteristics are improved still further.

Starting strategy

The ECM implements an excess fuel strategy to initiate combustion when starting. When the engine is cranking, the ECM ignores the driver's demand sensor (TPS) and fuels the engine according to its starting strategy. This strategy is dependent on the temperatures of the fuel, engine coolant and intake air.

Anti-surge strategies

The ECM incorporates software to control the rate of engine acceleration and deceleration. This feature, referred to as the anti-surge strategy, “damps” the engines response when changing gear (engine does not flare). It also improves the vehicles driving characteristics in circumstances when the driver's demand is lower than the current engine speed (i.e. lifting off). The software inside the ECM alters the rate at which the engine decelerates to suit the conditions. This rate will alter according to the current engine rev/min, the target rev/min and the duration of engine deceleration. The rate of deceleration will also increase if the driver depresses the clutch (activating the clutch switch).

The anti-surge strategy is cancelled if the driver selects low range. This improves the engine braking performance when the vehicle is travelling at low speeds.

Fuel purging strategy

If the vehicle runs out of fuel, or the fuel level is so low that the fuel system draws air into the fuel rail, the fuel rail will need to be purged before the engine will start. This can be achieved by following a set procedure. The process does not require the use of any specialist equipment and can be performed by the driver of the vehicle. The process is as follows:

1. Turn off the ignition
2. Wait 15 seconds
3. Turn the ignition 'on' (position II)
4. Wait 3 minutes (this ensures that the fuel system purges all the air from the fuel rail within the cylinder head)
5. Depress the throttle pedal to more than 90% of its total travel (to the throttle stop)
6. Crank the engine keeping the throttle pedal depressed

The ECM will then enter fuel purging mode. This mode will initiate after 10 engine rotations. Once initiated, the ECM will inject approximately 4 times the maximum quantity of fuel into the engine. This excess fuel delivery will help purge any air from the EUI's. It is important that this purging sequence is not initiated on a vehicle that has not run out of fuel. If it is carried out unnecessarily it can lead to the engine flooding and failing to start.

This mode of operation will be cancelled:

1. As soon as the engine speed exceeds 600 rev/min.
2. The driver allows the throttle pedal to close to a position less than 90% of its travel.
3. The key is released from position III (start). There is no direct electrical connection between the ECM and position III of the ignition switch, the ECM detects the engine has stopped cranking by the lack of signal from the crankshaft sensor.

It should also be noted that the engine must not be cranked for more than 30 seconds in any one period.

If the engine does not start during this initial period of purging, the driver of the vehicle will need to repeat the sequence.

Configuration

The ECM needs to be configured before it will operate correctly (see figure 87). There are two levels of configuration. If the ECM or the BCU is replaced in service, the immobilisation code will need to be reconfigured. The engine will not run unless this operation has been completed. The ECM will also need to be configured with the vehicle details. This process must be carried out when the ECM is first fitted to the vehicle, or whenever a new ECM is fitted in service.

Figure 87

The ECM also needs to be programmed with the 5 sets of injector alpha codes. These codes relate to the EUI calibration (see diesel engine section). A new ECM is programmed with blank codes. If EUI codes are not entered at this stage, the ECM will allow the engine to rev up to a maximum of only 3,000 rev/min.

The ECM cannot verify the EUI alpha codes. If incorrect codes are entered, engine performance will be significantly impaired. This process must also be carried out when one or more injectors are replaced, or the order of injectors in the cylinder head is unknown.

TestBook diagnostics

The ECM supports on board diagnostics (OBD). To do this it monitors its inputs and the effects of its outputs. If it detects that an implausible signal (a signal of a value which significantly differs from the expected value), it assumes a fault exists. It will store a fault code in its memory and initiate the appropriate strategy.

TestBook incorporates software designed to interrogate the ECM's memory. It can be used in service to retrieve fault codes and assist with diagnostics. The faults stored by the ECM are categorised into two states.

1. Historical - This flag will be set if the fault has previously happened once in the vehicles past, or until the last time TestBook cleared the fault code memory
2. Present - This flag is set if the fault currently exist within the system

This additional information on the status of a fault code is included in the majority of the TestBook diagnostics. It can aid with diagnosing a fault within the system.

Fault codes remain inside the ECM memory until they are removed using TestBook.

Real time data

TestBook can retrieve and display input data received by the ECM. This information can be used to analyse system performance in cases where a fault condition is suspected. TestBook can display single or multiple readings.

When a single reading is displayed, TestBook displays the current value of the signal being examined, the plausible value of the signal (minimum/maximum) and an explanation of the reading.

If multiple readings are displayed, no written information on the acceptable parameters will be displayed.

TestBook can also drive many of the ECM outputs via the ECM. This feature can be used to test systems which are currently outside their normal operating parameters (e.g. the ECM can be made to drive an injector solenoid without the engine running).

THE ACTIVE CORNERING ENHANCEMENT (ACE) SYSTEM

The philosophy behind the system

Active Cornering Enhancement is a system designed by Rover Group engineers to enhance the dynamic handling and suspension characteristics of New Discovery. In essence, it is a system which monitors the lateral forces acting on a vehicle during cornering and makes adjustments to the suspension to compensate for these forces.

When cornering, the lateral acceleration acting on the vehicle body results in the body pivoting about the suspension roll axis (which, on New Discovery is determined by the Panhard rod and the Watts linkage). The lateral acceleration acting on the centre of gravity of the sprung mass results in a torque about the roll axis. This torque on a 'normal' passive suspension vehicle is opposed by the road springs and the anti-roll bars (see figure 88).

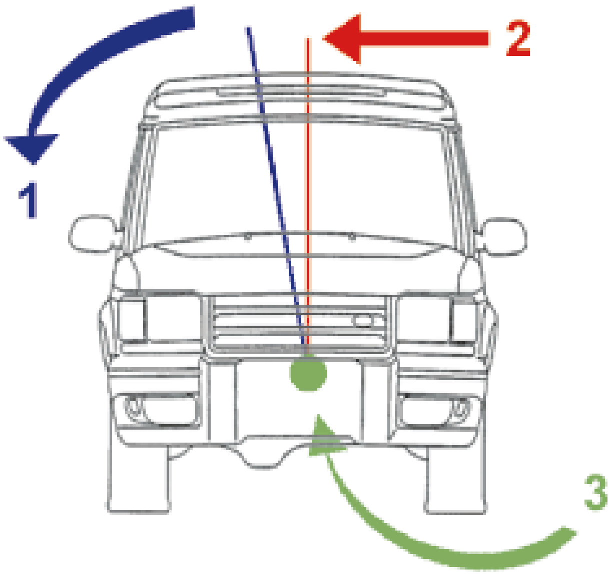


Figure 88

1. Body reaction
2. Lateral force due to the centrifugal effect of cornering
3. Centre of gravity

The anti-roll bars (on a conventionally sprung vehicle) are springs which resist any differential movement of the wheels on an axle. This effects the single wheel bump rate but has no effect on parallel movement of the axle.

The Active Cornering Enhancement (ACE) system replaces the standard anti-roll bars with roll control modules. These modules can be considered to be rigid, apart from the hydraulic actuator which connects one end of the bar to the other. The ACE system uses accelerometers to monitor the lateral acceleration of the vehicle (how hard it is cornering) and applies a predetermined amount of hydraulic pressure to the actuators. This pressure is then translated, first, into a force in the actuator and, subsequently, into a torque, which acts between the axle and the vehicle body. This force counters the torque produced by the lateral acceleration of the vehicle when cornering.

The roll control modules are controlled by pressure. If one wheel hits a bump during cornering, no further pressure (force) is applied to that wheel. In this circumstance, it is only the road spring which opposes the bump, unlike passive suspension where the anti-roll bar also opposes the movement of a wheel when encountering a bump. This feature enhances the ‘ride’ quality of the vehicle when cornering.

This principle enables the ACE system to reduce body roll significantly in all circumstances and to eliminate it altogether in certain circumstances. It also enables the vehicle to be fitted with relatively low rate springs, improving ride comfort and optimising axle articulation for superb off road ability.

Lateral acceleration is measured in m/s^2. Acceleration due to the earth’s gravity measures approximately $10m/s^2$ (1g) and is referred to as 1(g). The greater the mass, the bigger the effect (or force) of gravity, though the ‘g’ level does not change. When cornering in extreme circumstances, lateral acceleration of up to 1(g) can be felt. The ACE system is designed to virtually eliminate the movement of the vehicle body up to a lateral acceleration of 0.4(g) (unladen) and then to allow a progressively higher amount of body roll as lateral accelerations increases. The graph in figure 89 shows this relationship. The benefit to the driver is that the vehicle feels very stable and responsive under these conditions, while passenger comfort is improved due to significantly reduced body movement. A second benefit is improved steering characteristics. The steering is less susceptible to the normal variations that are felt when the body and chassis move relative to the steered axle.

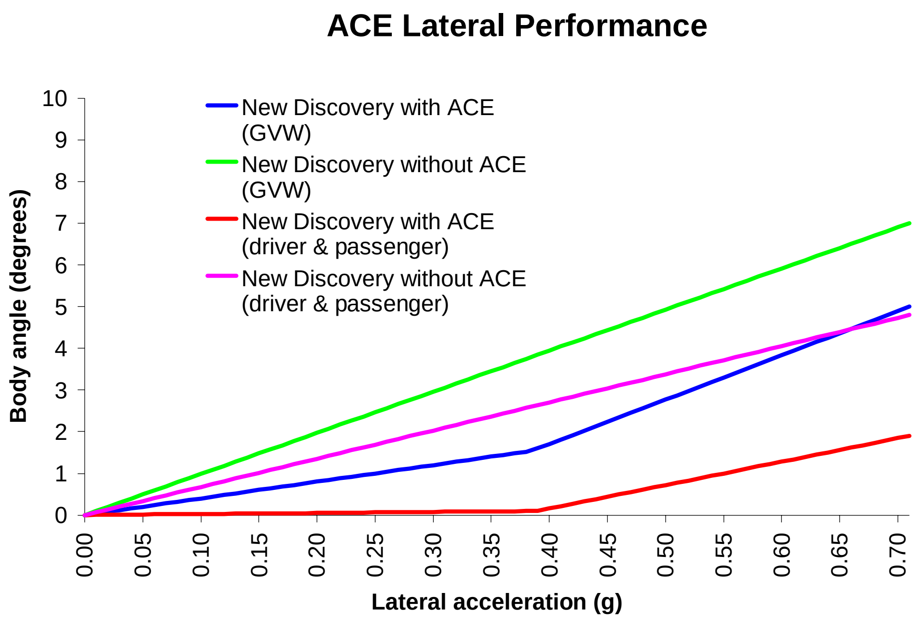


Figure 89

System components

ACE employs an hydraulic system comprising a reservoir, pipe-work, pump, valve block and two actuators, one on each of the two roll control modules. These actuators apply the required torque to the suspension. To control the hydraulic system, two accelerometers are used which supply the ACE ECU with information on the lateral acceleration of the vehicle. A pressure transducer is incorporated to monitor the hydraulic pressure in the system; its inputted signal is used by the ACE ECU to monitor the effect of applying a controlling electrical current to the proportional pressure control valve. The ACE ECU also uses inputs from other vehicle system's ECU's to determine:

- If the engine is running
- The vehicle speed
- If the driver has selected reverse gear
- The above information is required for system control calculations.

It should be understood that the ACE system works independently of the air suspension self-levelling system, although it does use the road speed input from the Self-Levelling Anti-lock Braking System (SLABS) ECU.

Hydraulic pump

The hydraulic pump is located on the engine and is driven by the auxiliary drive belt. The belt is self-tensioned and must be replaced in accordance with the vehicle maintenance schedule. It is a radial piston pump which differs from a conventional power steering pump because of the unique requirements of the ACE system. Where as a power steering pump requires its greatest pressure at low engine rev/min (due to the need for the greatest assistance when the vehicle is completing parking type manoeuvres). The ACE system works across the complete engine range, and so requires the pump to deliver a constant flow from relatively low engine rev/min through to high engine rev/min. The ACE system also requires the pump to deliver high pressures across the complete engine range. If a power steering type pump were used, it would require up to six times the amount of engine power to drive it.

The ACE pump flow characteristic is a result of 'suction control', which is regulated by the size and position of the fluid inlet holes in the piston (see figure 90). If the suction hose between the reservoir and the ACE pump becomes kinked or restricted, it will reduce the pumps output flow characteristic.

Figure 90

This condition is difficult to diagnose because there are no obvious changes in noise levels and/or performance. The driver may, however, be aware that the response time of the ACE system increases when completing extreme vehicle manoeuvres. Flow/engine rev/min characteristics of a typical radial pumps are detailed in figure 91.

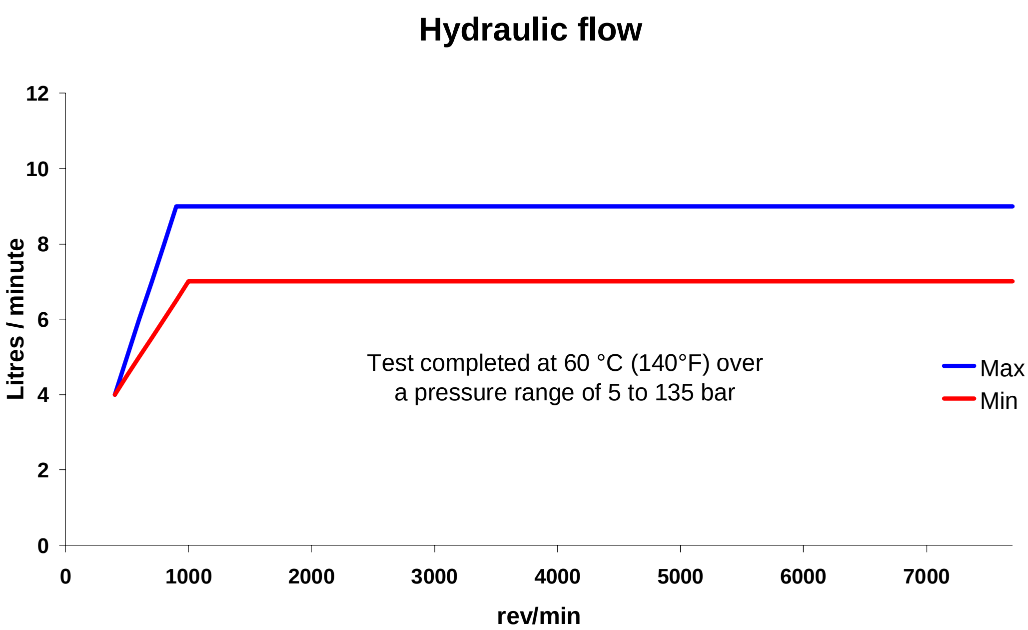


Figure 91

Hydraulic pipes

The flow from the pump goes to the valve block located on the outside of the right hand chassis rail, via a high-pressure hose and pipe assembly. The hose is particularly important as it contains two attenuator springs and a restrictor, which have been tuned in their lengths, positions and diameters in order to minimise the system's noise level and vibration. A multi piston pump generates pulses of flow as each piston forces fluid out of its outlet port. These pulses have been minimised by careful design of the pump, but the pump still produces some pulsations over the complete engine speed range. The pulsation frequency changes with engine speed but the overall flow remains constant. It is, therefore, necessary to have the above devices incorporated into the hose to dampen out these pulsations. The hose specification is also extremely important, as a hose which dilated significantly would result in very poor hydraulic response to system pressure changes, impacting on total system performance. The hose has, therefore, been selected to give the required system response whilst also giving some attenuation to the pulsations.

It is vital that this pipe is serviced as a unit and that no attempt is made to repair it. Both the front and rear pipe assemblies follow a defined route and are secured by several brackets that clamp them to the chassis. The positioning of these brackets is extremely important. The pipes have location features to ensure that both the front and rear pipe assemblies can be located easily on the chassis frame without either 'loading' the isolators and isolator brackets or allowing the pipes to foul other vehicle components. If the pipe or brackets are removed, care must be taken to ensure that the pipe is reattached in the original position.

There are two isolating blocks located on the pipework. These blocks are used to keep a distance between the different ACE pipes and to ensure there is no contact with other vehicle components. These isolation blocks must not be fixed to the chassis, nor should any other fixing be placed onto the pipes, otherwise the noise refinement of the system can be destroyed.

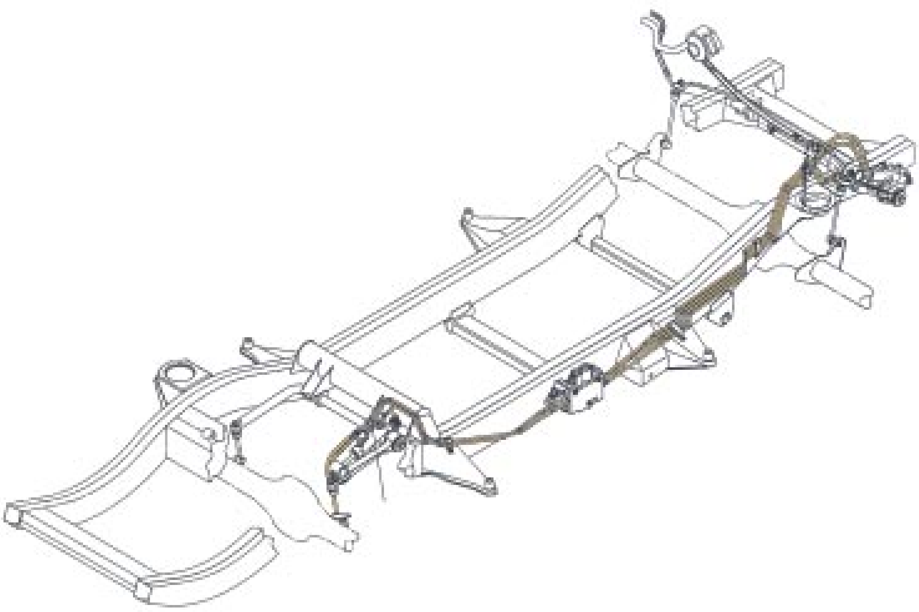


Figure 92

The hydraulic pipes incorporated within the ACE system from the pump to the valve block and from the valve block to the reservoir differ as service replacements from those fitted when the vehicle is manufactured. This is because these two pipes are fitted to the vehicle before the body of New Discovery is attached to the chassis. This allows the use of ‘one piece’ pipes. In service it is not possible to remove the pipes without cutting them. To facilitate an acceptable repair policy, the service pipe from the pump to the valve block, and the pipe from the valve block to the reservoir, will be sold in two parts with a connector to seal the joint. The pipe route along the chassis has a strategically placed enlarged gap to allow for these connection joints.

At no time may the pipes be joined or cut, other than to replace a manufactured pipe with the two pipes supplied for after sales use. It is important that if the pipes are removed from the valve block they are re-fitted to the correct ports. If the pipes are ‘crossed’ the system will be damaged. To facilitate correct fitment, all ports are marked on the connector plate and the pipes are tagged with identifying letters. The letter on the pipe must match the letter stamped on the valve block connector plate. These are:

- ‘A’. There are two ‘A’s - one for the front pipe and one for the rear. It is not possible to fix the pipes incorrectly from front to rear
- ‘B’. There are two ports marked with the letter B again one front and one rear
- ‘P’. This pipe is the pressure pipe from the ACE pump
- ‘T’. This pipe is the return and goes back to the reservoir (tank)

The hydraulic pipes that supply pressure to the actuators from the valve block must also never be cut or joined. Each actuator has two pipes which are routed along the chassis with short, flexible hoses (jump hoses) to the actuators. These jump hoses are stainless steel braided and then covered for increased abrasion resistance. This design combines minimum pipe dilation with robust service life. Like the hydraulic pipes from the pump and reservoir, the routing and fixing points of the pipes are critical in assuring quiet and effective operation of the ACE system.

Reservoir

The ACE system reservoir is combined with the power steering fluid reservoir but can be thought of as a separate reservoir, as it has its own filling neck and there is no provision for the fluids to mix. A characteristic of a radial piston pump and the ACE system is that, in the case of fluid loss, no discernible noise will be heard from the system, so the driver will have no audible indication that there may be a problem. The ACE ECU has an onboard diagnostics capability to determine if the system is low on fluid. If the ECU does detect this, it will alert the driver by flashing the warning lamp red and sounding an audible warning.

It is important that the oil level is maintained correctly and that any leak in the system be investigated immediately. The ACE system requires clean uncontaminated oil. The oil used to top-up the reservoir must be taken from a new container of oil or, if the oil is held in bulk, it must be filtered before it is dispensed into the reservoir. The oil used in the ACE system can be obtained through Unipart. It is a green semi synthetic oil (Texaco 14315), which provides consistent performance throughout the temperature range that will be experienced by vehicles in all world markets. The oil capacity of the ACE system is 1.62 litres.

Valve block

The valve block is located on the chassis, under the right hand seat. It is fixed to the chassis by three bolts that pass through bushes in the valve block. These bushes have been designed to isolate the chassis frame from the vibration frequencies of the valve block whilst firmly locating the valve block to the chassis rail. The valve block has six pipes connected to it. As previously described, these pipes must not deviate from the designed route and must not be altered in size or shape. The valve block pipe fittings each have a double 'O' ring system that has support rings and a plastic retainer (see figure 93). If the seals need to be replaced, the retainer rings are removed by using a new clean 10mm bolt. A smooth plastic hook should then be used to remove the 'O' rings and support rings (this could be a crochet hook). A plastic sleeve supplied with the new seal set is used to refit the new seals and supporting rings into their correct position. If any of the 'O' rings or support rings are removed, then all the parts must be replaced. The diagram in figure 93 illustrates the seal position and the clamping system used to locate the pipe in the correct position. The pipes are retained in the valve block seal packs by a cast aluminium connector plate and plastic collet arrangement.

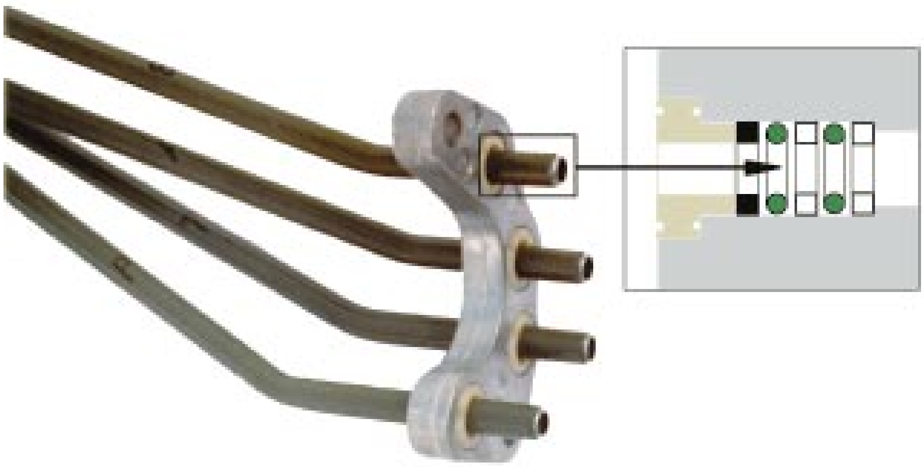


Figure 93

To assemble the pipe retainer assembly, the pipe is passed through the aluminium connector plate, and then a plastic 'split' collet is clipped around the flare of the pipe. The pipe/collet assembly can then be pulled back into the connector plate where it again clips in position ready for assembly into the valve block. When a pipe is removed and you are preparing to refit it, make sure that there are no score marks in the direction of the long axis of the pipe. This is especially important around the area sealed by the 'O' rings. The cleanliness of all units before removal, whilst the system is open and during reassembly cannot be overstated. The valve block has small orifices and the valves are machined to exacting tolerances. If foreign material is allowed to enter the system, it can adversely affect the operation of the valve block.

The valve block incorporates an ultra fine filter. This should be replaced in accordance with the maintenance schedule. It should also be replaced if the fluid has any foreign material in it, or if any hydraulic components are replaced in the system. When the filter is replaced, the cleanliness of the working area, new filter and any tools used is paramount. It is important that any pipe disconnected from any part of the system is suitably protected from the ingress of dirt particles. Use suitable cleaned ‘pipe-plugs’ in both the removed pipe end and the opened port. Care must be taken not to damage any internal surface when fitting or removing the pipe plugs.

There are three solenoid valves incorporated into the valve block. The first is a proportional pressure control valve. This valve is fitted in the back face of the valve block assembly and has a blue coil fitted. This valve is ‘normally open’, such that, with the engine running and the vehicle stationary, the oil is free to flow from the pump, through the valve and back to the reservoir with the minimum amount of resistance.

In this case, the system is operating at ‘residual pressure’. Residual pressure occurs as a result of pipe lengths and diameters, as well as the ‘porting’ in the valve block and a very light spring in the proportional pressure control valve. When the vehicle is cornering, the ACE ECU controls the current in the valve with a 200Hz pulse width modulated (PWM) signal to regulate the pressure drop across the valve to the required level. This pressure can be infinitely varied over the operating pressure range to ensure refined operation of the system. It is important to remember that this valve does not stop the fluid flowing through the valve block but internally balances forces to create a ‘back pressure’.

The other two solenoid valves are directional spool valves located on the top of the valve block assembly. These solenoids are black in colour, these are both ‘normally closed’ so that they will open only when the ACE ECU determines that the vehicle is cornering and assistance is required. Only one of the valves is operated to ensure that the correct side of the front and rear actuators are exposed to the controlling pressure, whilst the opposite side is opened to the reservoir. For control of the system, only one of these valves will be opened at once.

The valve coils are serviceable, though the valves themselves are not. Care must be taken when refitting the electrical coils that there is no dirt or other contamination between the hydraulic valve and the inner surface of the electrical coil. The coil, retaining nut, ‘O’ ring seals and the valve must be clean prior to being fitted. The retaining nut ‘O’ ring should be checked to ensure that it is in good condition. The retaining nuts on the solenoids form part of the magnetic field and, therefore, it is important that only the correct nuts are used to hold the electrical coils on to the valves.

All fixings, retaining bolts and pipes must be tightened to the specified torque. If items are over torqued or under torqued, system operation can be adversely effected.

The diagram in figure 94 shows the positions of the three solenoids.

Figure 94

The ACE ECU powers the two directional spool valves with a 200Hz PWM 'hit' and 'hold' current control feed. This feed is similar to the feed sent to the proportional pressure control valve, except that this feed is not continuously variable. The ECU controls the pulse width to one of two levels, either the 'hit' current or the 'hold' current. The current supplied to all solenoids is independent of battery voltage. The 'hit' current is a minimum of 3.75 amps for 250mS at which point the current is dropped to a 'hold' current of 1.65 amps ± 0.3 amps. Figure 95 demonstrates the current/time characteristics of the directional spool valves.

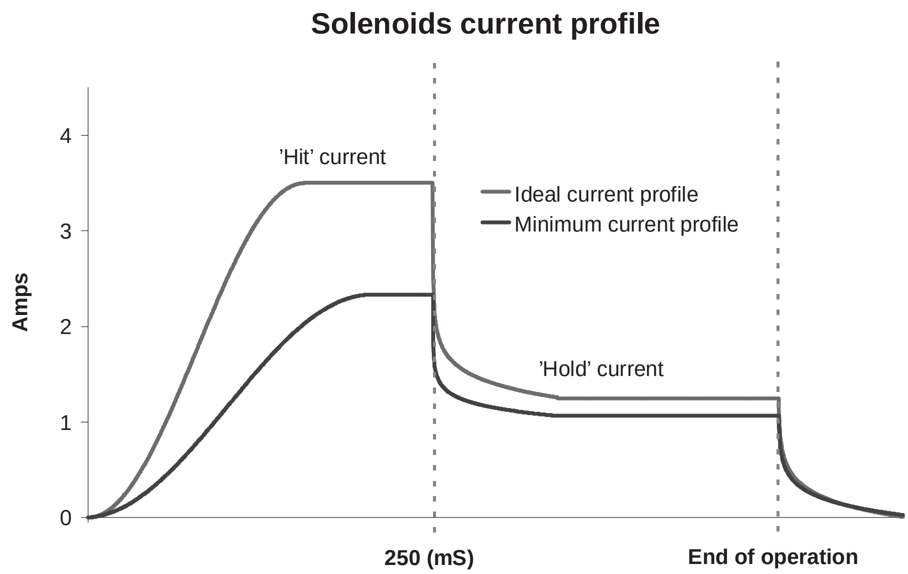


Figure 95

The ACE ECU senses the pressure in the valve block with a pressure transducer, to enable closed loop control of the system. The ECU uses this signal to tune the operation of the proportional pressure control valve. The ECU maps the amount of current needed to produce the required pressure in the system and then fine tunes the proportional pressure control valve to deliver the appropriate pressure. The pressure transducer unit screws into the valve block assembly and measures the fluid pressure directly after the high-pressure filter. The transducer alters a voltage in proportion to the pressure acting on it and sends this information to the ACE ECU via a dedicated wire.

Actuators

There are two actuators in the ACE system. Their position is indicated in figures 96 and 97 below.

Figure 96
Front actuator

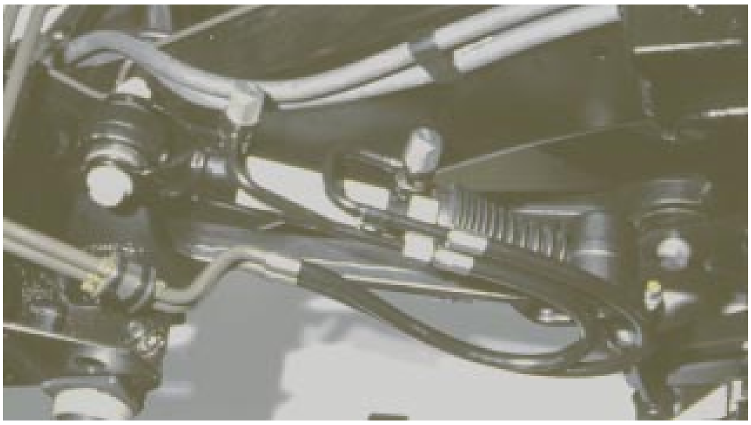


Figure 97
Rear actuator

The actuator is the unit in the ACE system which transfers hydraulic pressure supplied by the valve block into a force and, hence into mechanical movement. The actuator is constructed in a similar manner to a standard hydraulic cylinder, with a 40mm diameter piston connected to the end of a 14mm rod. As the force applied by the actuator is determined by the pressure multiplied by the effective area (force = pressure x area). In order to apply a similar force to the roll control module, it is necessary for the system to apply a higher pressure to the rod side of the cylinder (area of piston – area of rod) than the piston side (area of piston only). Due to the installation of the hydraulic actuators within the roll control modules, a higher pressure is used in the system when cornering to the right. The configuration of the valve block assembly and the pipework ensures that both the front and rear actuators are always supplied with the same pressure on the same side of the cylinder. When one side of the actuators is being pressurised the other is vented to the reservoir.

It should be remembered that it is the force applied by the actuator that resists the vehicle body movement and not the actuator displacement i.e. the ACE system is pressure controlled, not displacement controlled.

The actuator has no replaceable seals within it and if a leak is evident the actuator must be replaced. The ‘jump’ hoses are sealed by ‘Dowty’ self centring banjo sealing washers. It is important that only self-centring washers are used, as standard ‘Dowty’ seals will result in serious system leaks. Such leaks may happen when the pipes are first fitted, but are more likely to occur during the service life of the vehicle. To avoid confusion, it is strongly recommended that the washers are obtained by ordering the correct Land Rover part number as a replacement. The washers should be replaced every time the connection is loosened.

There is no fluid path through the actuator, so the system cannot self-bleed. The bleeding procedure will be explained later in this section.

Anti-roll bar

Conventional anti-roll bars are, effectively, torsion bar springs which resist the relative movement of one wheel on an axle with respect to the other wheel on the same axle. Hence they resist the vehicle body rolling relative to the axle.

The greater (stiffer) the spring rate of the anti-roll bar, the greater the resistance to body movement from the axle line. A road vehicle or a heavy goods vehicle can have comparatively stiff anti-roll bars because there is a reduced need to supply the vehicle with a large wheel articulation. An off-road vehicle requires large wheel articulation to overcome obstacles that effect only one wheel. This gives the suspension designers of off road utility vehicles a problem: achieving the correct balance between the capability of the body to remain composed whilst allowing axle articulation for overcoming an obstacle. This need is offset with the need to keep the body from rolling excessively from the line of the axle when the vehicle is cornering at speed.

The roll control module is quite different in construction to a conventional anti-roll bar. Referring to figure 98, it is constructed from one piece of very high rate spring steel torsion bar (1), a long arm (2) which locates one end of the actuator (3) and pivots on a bush located on the torsion bar. Also, a short arm (4) which locates the other end of the actuator, is clamped rigidly to the torsion bar. All of the components are made from substantially stiffer/thicker steel than in a conventional anti-roll bar to minimise deflections/compliance in the system.

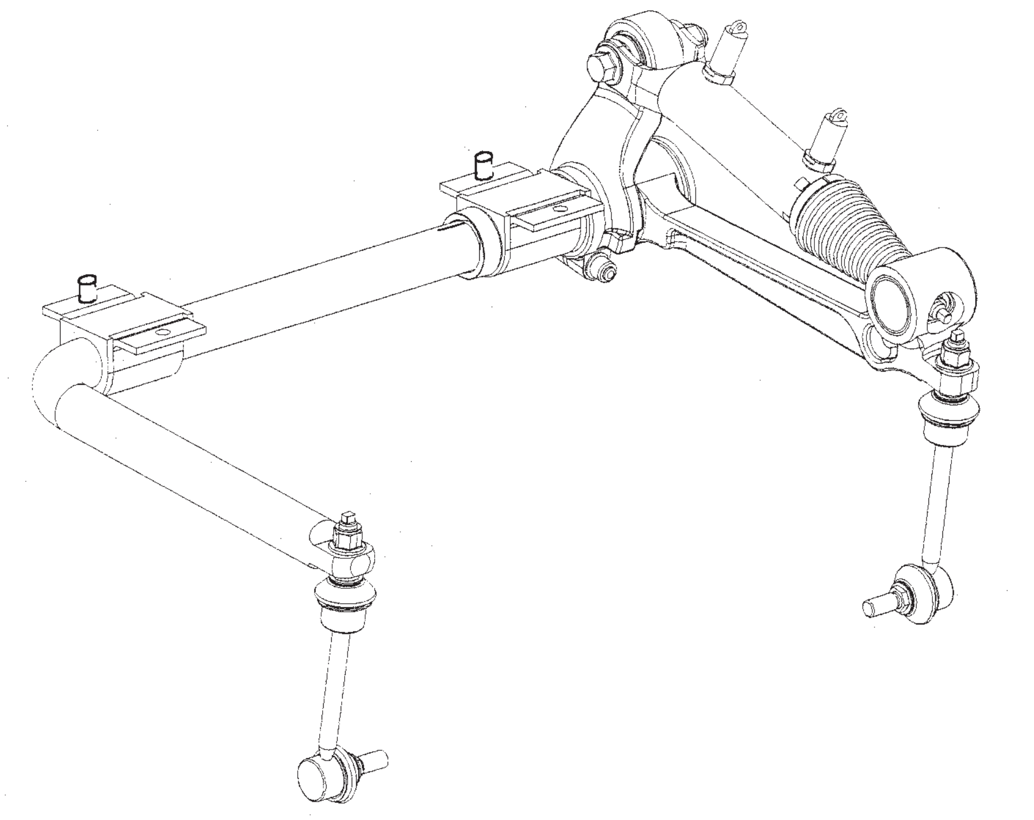


Figure 98

1 Cross bar	3 Actuator
2 Long arm	4 Short arm

The response time of the ACE system is very important as, during avoidance type manoeuvres, the lateral acceleration of the vehicle can build up at a rate of up to 2.0g/s. The ACE system has the ability to build up a system pressure equivalent to 1.0g within the primary circuit (both direction valves closed) in less than 130mS. When cornering, the system has to take up compliance due to bar twist, bush deflections, 'jump' hose dilation, chassis frame deflections etc. This results in a system that is matched to the vehicle response. The system response time is determined by the following key items:

- ECU control algorithm
- Valve response times
- Pump flow
- Hydraulic bleed condition
- Suspension component condition (bushes, links, dampers etc)

If the actuator is removed, there will be no resistance to body roll as the long arm would rotate freely on the torsion bar. Conversely, if the actuator always remained in the same position, the anti-roll bars characteristics would simulate a very stiff conventional anti-roll bar. There are also stabilising links which can pivot on the end of the anti-roll bar and on the axle. These are needed to allow for correct operation over a large axle travel range.

The long arm is constructed from forged steel and, as previously mentioned, is free to rotate around the torsion bar on a ‘slipper’ bush. This bush is a two piece design, with locations preventing relative movement of the outer housing to the long arm. The second bush in the long arm locates the rod of the actuator. The location of this bush in the long arm is extremely important and changes between the front and rear roll control modules.

The roll control modules are different from front to rear; the relative lengths and widths of the component parts have been designed to give the required front/rear suspension balance. This is similar to the way a conventional passive suspension balances the forces using different spring rated material. The ACE system is a force balance system, as opposed to a roll stiffness balance for a passive suspension system.

Accelerometers

There are two accelerometers used in the ACE system. These are electronic devices which measure acceleration along one axis (the ‘Y’ axis). This is achieved by changes within the internal capacitance. The accelerometers have a 5 volt supply; the output from the sensor will fall into a range between 0.25 - 4.75 volts, depending on the lateral acceleration currently being experienced. The accelerometers are located on the body of the vehicle, one behind the headlining above the front interior lamp, the second by the bottom of the ‘A’ post, under the vehicle near the body-to-chassis fixing point on the right hand inner sill. The orientation of these devices is very important for correct operation. They are attached to the vehicle by brackets and must only be removed from the brackets using a special tool LRT-76-002.

Figure 99

Care must be taken when relocating each sensor in its bracket to ensure that it has slotted into the correct position. The bracket must be in a good condition, (not bent or loose) as this will result in the system becoming unrefined and, possibly, inoperable. Mislocating a sensor will either disable the system completely or at the very least greatly reduce its performance. Figure 100 illustrates the position of the accelerometer within its bracket.

Figure 100

The position of the brackets on the vehicle is also very important. As you can see, both the sensors are positioned so that they fall on the same 90° plane, taken from a line drawn from the front of the vehicle to the rear. The sensors are positioned in this manner so that during cornering they each see the same accelerations. If the sensors are moved, the calibration in the system will be lost and, again, the system will function with a reduced finesse, or may be disabled.

Both accelerometer assemblies are mechanically and electrically identical, but the system uses the information each one supplies in a different manner. The system can operate on the lower accelerometer if the upper accelerometer fails, but will not operate if this condition is reversed. If the upper accelerometer does fail, the system will function with a reduced level of finesse and the driver will be alerted by means of a warning light, details of which will be covered later in this section.

Accelerometers are very sensitive electronic devices**. Do not drop or 'shock' them in any way**. If the device does experience a shock it will need to be replaced. The device has no serviceable parts and must not be tampered with in any way. There is no way to check that the accelerometer is in a serviceable condition apart from when it is fitted to the vehicle and assessed for correct operation using TestBook. If a new accelerometer is fitted or if an accelerometer is removed and refitted, TestBook must be used to recalibrate the system. This procedure must also be followed if a new ECU is fitted.

The accelerometers, as previously mentioned, supply a voltage signal to the ACE ECU when they are subjected to an acceleration force in the correct direction. It must be understood that these sensors do not measure the amount of body roll that the vehicle is experiencing, but the vehicle's lateral acceleration due to cornering. This statement might be seem to be 'splitting hairs', but there is a fundamental difference. If the accelerometers did measure the amount of vehicle body roll, the system would act only as a consequence of movement, so the driver would experience body roll before any action took place to correct it. By having accelerometers that return a signal when the vehicle is experiencing cornering forces, the system can act before the vehicles body starts to roll. This makes the system an active system, rather than a reactive or adaptive system.

Two accelerometers are used so that the ECU can detect the level of road roughness and modify the system control appropriately. The accelerometer locations have been selected carefully so that, by monitoring the upper and lower acceleration signals, the ECU can detect the level of body roll and rock due to the road condition. Both accelerometers are subjected to the lateral acceleration generated when the vehicle corners, but only the upper accelerometer will see inputs as the body rocks. The difference in signal can be used for road roughness detection by the ACE ECU. On detection of a 'rough road', the ECU will modify the level of assistance the system provides, as long as the vehicle speed is below 40 Km/h (25 mph). Above 40 Km/h (25 mph), the system gives full assistance, regardless of the 'roughness' of the road surface. If the assistance currently being provided to the vehicle is reduced by the ACE ECU sensing a 'rough road' and the vehicle speed increases to above 40 Km/h (25 mph), full assistance will quickly return.

Below 40 Km/h (25 mph), the accelerometer signals are used to detect if the vehicle is on a side slope. A side slope with a lateral acceleration of greater than +/-0.2g will result in both direction valves being closed and no ACE assistance is given (locked bars). This enables the vehicle to maintain a consistent attitude, which is parallel to the ground.

ACE ECU

The ACE ECU is situated behind the passenger glove box on a metal bracket. To gain access to it, lift the two sprung glove box stays and release the glove box to hang towards the vehicle floor. There are three ECU's on the bracket, the ACE ECU, the body control unit (BCU) and the self levelling anti-lock brake ECU (SLABS). The ACE ECU can be identified because it is the only ECU with a single 36-way connector. On a vehicle with left hand drive (LHD), the position of the ECU's on the bracket is still behind the passenger-side glove box and remains in the same order, (looking from left to right: SLABS, BCU, ACE). The system is supplied current via a fuse in the engine compartment fusebox. This fuse feeds the ACE relay, which is also located inside the engine compartment fusebox. The ACE ECU supplies the ACE relay with an earth signal, thus energising the relay. This, in turn, supplies the ACE ECU with its main power feed. An ignition on signal is supplied to the ACE ECU by a fuse located in the intelligent drivers module.

Warning indicators

There is one ACE system warning light, located in the instrument pack. The warning lamp can display either a red or amber light. Both colours inform the driver of the status of the system. In certain fault conditions, the red lamp will flash and the vehicle's internal sounder will be activated, indicating to the driver that the vehicle must be stopped to prevent serious damage to the ACE system and, potentially, the auxiliary drive belt.

In the event of a new ECU being fitted to a vehicle, the amber warning light will be illuminated continuously and the system will be in a 'locked bars' condition. The ACE ECU needs to be programmed using TestBook and the accelerometer calibration entered into the ECU before the lamp will extinguish.

Under most circumstances, when the ECU detects a system fault the amber light will be illuminated and the system will default to a 'locked bars' condition. The primary hydraulic circuit is allowed to run at a residual pressure i.e. only the restriction of the pipes dimension and internal valve block components. This condition minimises body roll, by allowing the roll control modules to act like very stiff passive anti-roll bars whilst cornering. However with a front to rear interconnection, axle articulation and vehicle ride are not impaired significantly.

If the system detects a loss of fluid in the primary circuit (which would result in the pump running dry and subsequently causing serious damage to itself and other system components) the red lamp will flash and the audible warning will sound. This combination warning will last for approximately 30 seconds, at which point the red light remains on permanently. The red lamp indicates to the driver that s/he must stop to prevent serious damage. The system will close both direction valves, causing a 'locked bars' condition. If the system has detected a fault of this nature, it is likely that a significant amount of oil will have been lost from the secondary circuit. This loss of oil will result in the driver experiencing greater body roll. Safe handling characteristics are always maintained in all fault conditions.

System operation

Hydraulic operation

Within the section describing the system components, a brief description of the hydraulic fluid flow through each components was introduced. This section will describe the flow of fluid in more detail and how different pressures within the system allow the Active Cornering Enhancement system to operate.

Figure 101 shows an ACE system that is currently not detecting the need to operate.

The fluid travels from the reservoir (1) and is drawn into the radial piston hydraulic pump (2). The fluid travels from the pump, through the damping hose and metal pipe to the valve block. Here the fluid is filtered by the high-pressure filter (3) and, because both spool valves (4)(5) are shut, it then flows through the pressure control valve (6) and back through the return pipe to the reservoir. At this point, there is a small pressure difference between the two sides of the pressure control valve due to a spring acting on the spool valves, as described in the earlier section. The pressure transducer (7) monitors the pressure of the fluid in the system and feeds back this information to the ACE ECU.

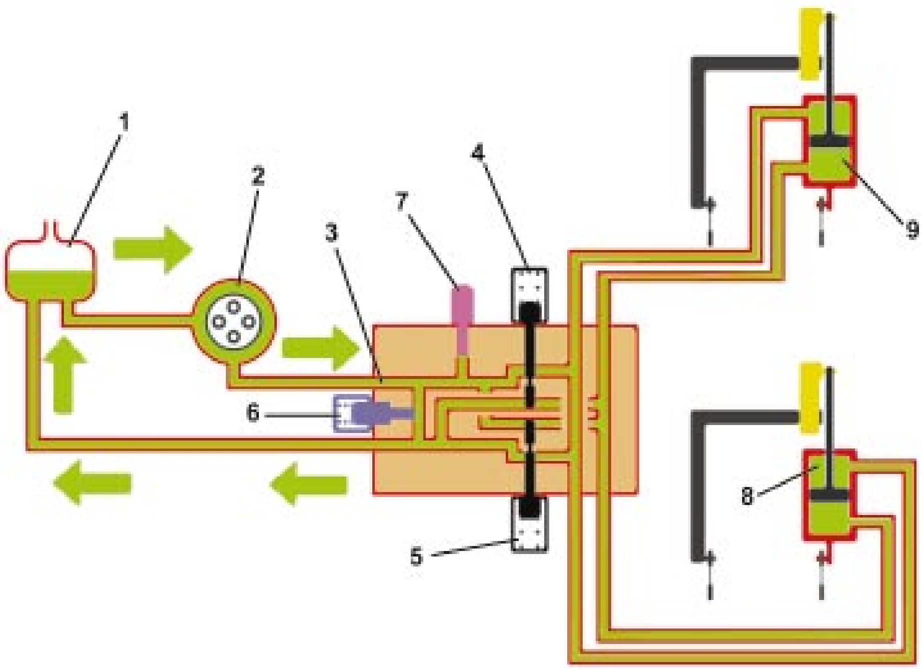


Figure 101

1. Reservoir
2. Hydraulic pump
3. High pressure filter
4. Spool valve
5. Spool valve
6. Pressure control valve
7. Pressure transducer
8. Actuator (front)
9. Actuator (rear)

When the ACE ECU detects the need for the system to operate, it energises the required directional spool valve (4) or (5) and the pressure control valve (6). This pressure control valve then starts to restrict the flow through the valve, so building pressure in the system to the required level due to the hydraulic and solenoid forces being balanced within the valve. The fluid will travel into one side of both hydraulic actuators (8)(9) as the pressure builds, the increased forces take up compliance within the mechanical system. As the actuators move against the incoming pressure, so the fluid from the other side of the actuator is displaced back into the valve block. This fluid is returned to the reservoir through a separate gallery in the same opened spool valve, which is currently open to allow the pressurised fluid into the actuators.

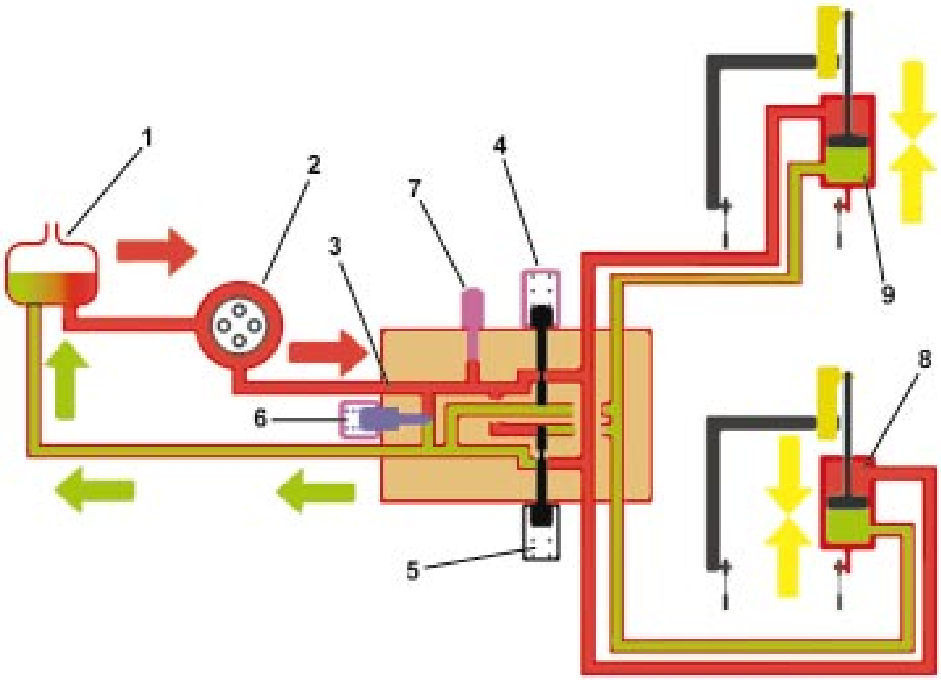


Figure 102

1. Reservoir
2. Hydraulic pump
3. High pressure filter
4. Direction spool valve
5. Direction spool valve
6. Pressure control valve
7. Pressure transducer
8. Actuator (front)
9. Actuator (rear)

It is only when the vehicle experiences extreme manoeuvres that all the pump flow is required to take up the compliance within the complete ACE system, at a rate deemed necessary for the particular manoeuvre. Under most circumstances, as the vehicle enters a corner, most of the pump flow will still pass through the proportional pressure control valve and back to the reservoir. If the vehicle then maintains a constant speed and radius (i.e. constant lateral acceleration), the pressure is maintained within the actuators and all the pump flow passes through the proportional pressure control valve. Under most cornering situations, the lateral acceleration will vary and, hence, the ACE ECU will adjust the demanded pressure accordingly. This will result in hydraulic oil flowing in and out of both sides of the actuators to maintain the force equilibrium needed at that particular moment in time.

As the vehicle comes out of the corner the ACE ECU decreases the pressure in the system at the required rate. This then allows fluid to flow back from the pressurised side of the actuators due to the mechanical forces in the suspension pushing the actuator rams back into a neutral position. Only once the vehicle has stopped cornering completely will the ACE ECU turn off the spool valve.

The valve block cannot restrict or direct fluid pressure to just one of the actuators. Inside the valve block there is a drilling through from one side to the other. Even when the valve block has both valves closed, fluid can flow freely from one actuator to another on the same side of each ram; i.e. if the piston of one actuator were forced in it would force the piston out on the other actuator. This feature is used at very low speeds to allow minimal resistance to axle cross articulation when off road, yet give a high resistance to body roll or body rock motions. When the valve block is not operating, or has been locked electronically from operating with both valves closed, the ACE system is said to be in a ‘locked bars’ condition.

The system can act very quickly to assist the vehicle’s suspension in stopping body roll. As an indication, the system can produce enough assistance to contain body roll of a magnitude from 0g to 0.5g within 250mS (0.25 seconds). Because the system operates so quickly, it is impossible to gain any useful readings from usual electrical measuring equipment. The ACE ECU has on board diagnostic capability of capturing implausible sensor signals and storing relevant system faults. It is also capable of communicating with TestBook to relay these faults and to display relevant system information.

Mechanical operation

When the ACE ECU demands a system response, the valves in the valve block respond and the actuators have a pressure fed through to one side of the ram as previously described. The pressure of the fluid now changes into mechanical force. Depending upon which side of the ram the pressure is applied, the ram will either move together (reducing its overall length), or apart (increasing its overall length). It should be remembered that both the front and the rear actuators have the same high pressure acting upon them, hence the actuators are applying the same force. These forces that are then applied to the front and rear axles are different due to the roll control modules having different short lever lengths and torsion bar widths. As previously stated, the system requires different pressures to apply the same force for left and right hand corners, due to the effective area of the rod in the actuator.

The forces of the roll control modules are transferred to the chassis by the roll control modules chassis brackets and by the stabiliser links to the vehicle axles.

Figure 103
Anti-roll bar in extended position

During the repair of the suspension system, there is no necessity to release any hydraulic pipe connections or complete a de-energising process, as the system has no reservoir of stored energy like the ABS or air suspension systems on a Range Rover.

Figure 104
Anti-roll bar in compressed position

Electrical operation

The sensors on the vehicle supply information on the vehicle status and the pressure in the system. The pressure signal, as previously discussed, provides a feedback mechanism to the ACE ECU so it can fine tune the control of the pressure control valve in the valve block. The accelerometers supply information about the lateral forces acting on the vehicle. The ACE ECU uses this information, in conjunction with a road speed signal supplied by the SLABS ECU, to calculate the amount of assistance needed. The accelerometer signals go through a conditioning process inside the ACE ECU to modify them according to the learned base value of that particular sensor.

Vehicle communications

The ACE takes and gives information to other systems in the vehicle. The type of interface is listed below:

Communication	System	Signal	Used For
From ACE	Instrument pack	Digital	Illumination of the warning indicators and sounder.
From ACE	Diagnostic socket	Digital	Used diagnostics in conjunction with TestBook.
From ACE	Under bonnet fuse box	On/Off	Turning the ACE ECU power line 'On'.
To ACE	Reverse signal switch/Park switch	On/Off	To inhibiting operation when in reverse.
To ACE	SLABS road speed	Digital	Operational calculations, for determining the required assistance.
To ACE	ECM engine speed	Digital	Engine running reference.
To ACE	In-car fuse box 29	On/Off	Ignition status information.
To ACE	Under bonnet fuse box	On/Off	Supplying power to the ACE ECU.

Fault code strategy

The ACE ECU diagnostic system follows a strategy when handling fault diagnostics. Like many of today's vehicle systems, the ECU performs a self-check when it powers-up, along with a complete system check. Assuming the system check reports no faults on power-up, the driver warning indicators will be extinguished and the system will be fully functional. This will happen even if, on a previous journey, there was a recorded fault.

A journey is defined as the vehicle travelling at over 32 Km/h (20 mph) for a minimum continuous period of 5 minutes.

If the ACE ECU detects a fault on power-up or when it is in operation, it will give the driver an indication of the fault. It does this in one of two ways:

1. It will turn on the 'amber' LED in the instrument pack. The system will default to a 'locked bars' condition. No hydraulic functions will take place and the pump will circulate the fluid round the primary circuit with all flow going through the pressure control valve
2. It will flash the 'red' LED and will activate the audible warning system for a period of 30 seconds and then leave the 'red' LED on. The system will default to a 'locked bars' condition

The ACE system will keep only the recorded faults encountered within the last 50 journeys. After this period, it will not be possible to read or analyse the fault with TestBook.

TestBook diagnostics

TestBook can supply live information of various system parameters, including pressure demands and actual readings, solenoid demands and operation and sensor inputs. The live data also incorporates signals from other vehicle systems that the ACE ECU uses to modify its operation.

Real time monitoring

Data is supplied via the ACE ECU to TestBook. This can be displayed in one screen, showing all the system inputs and outputs, or in individual screens that detail the sensors individually. The advantage of looking at the individual sensors is that TestBook details the plausible reading for that particular sensor and states the value or tolerance which applies to that particular sensor.

The ACE system has three routines which it uses to ensure that the mechanical system is operating correctly and giving optimum performance. It is possible to view them whilst in real time monitoring.

On engine start up, the ACE ECU controls the system pressure to approximately 20 bar. This pressure is set at a level which the ACE ECU knows will not be exceeded due to temperature and viscosity variations. With both the direction valves closed, the system reads the valve block pressure and quickly reduces the PCV current to the minimum controllable residual pressure in the system. In the case of both direction valves being opened at the same time, this PCV current is still maintained. During vehicle running, the residual pressure will change slightly due to fluid temperature and system operating conditions.

The second routine that the ACE ECU completes is to instruct the system to increase the pressure in the primary circuit by applying 0.5 amps to the pressure conscious valve for 200mS. It does this every 10 seconds whilst the system is not actively controlling the vehicles body roll. The information returned by the pressure transducer provides the ACE ECU with a 'virtual' system temperature measurement. The measurement is based on coil resistance and is used to compensate for temperature drift in the pressure transducer, as well as to detect if the system is overheating.

The third routine is a self-diagnostic routine, which the ACE ECU performs to check for stuck directional spool valves. It does this by opening both direction valves simultaneously and monitoring the effect on residual pressure. If both direction valves open there will be a small drop in residual pressure. The ECU performs this test only if the vehicle speed exceeds 25 Km/h (15 mph), and the vehicle has not tried actively to control the vehicles body movement for more than 5 seconds.

System response checks

TestBook has the facility to enable a system test within the ACE ECU. This test operates the hydraulic system and measures the response time of the hydraulics/mechanics to achieve the demanded pressure in both primary and secondary circuits. Care should be taken when undertaking this test as the engine will need to be running at a minimum of 1200rev/min, and the vehicle body will move quickly. This has implications if rigid equipment is attached to the vehicle.

Diagnostic procedures

As explained, the ACE ECU completes a power-up self test and then continues to monitor the system whilst operational. Fault codes can be retrieved from the ECU and their meanings displayed on TestBook. An indication is then given to the possible causes and any necessary checks and measurements that need to be made. Also incorporated within TestBook is a mechanical diagnostics help, for instances where there is a problem that does not result in a fault being recorded by the ECU, such as mechanical noise or mechanical knocks etc.

Hydraulic bleeding procedures

The hydraulic system does not have a constant flow of fluid through the secondary circuit (actuator lines). Although moved by pressure changes in the hydraulic fluid the actuators do not normally allow fluid or air to flow through them. Because of this, there is a procedure that must be followed when an actuator pipe, valve block or an actuator is replaced. This procedure removes air from the secondary hydraulic circuit. If this procedure is not used to remove all the air from the circuit, it is possible that the vehicle behaves normally to start with, or normally when the system is not working at 100% capacity, but, in conditions of maximum demand, the system may store a fault code because the air in the system reduces the response time. It is, therefore, imperative that, if any one of the above components is changed, the system is bled using the procedure detailed in TestBook. If the pump or ACE high pressure oil filter are changed, bleeding the secondary system is not required. If the hydraulic pump is changed, it is necessary to prime the pump to prevent damage; refer to the relevant section within the workshop manual for the exact procedure.

BRAKING SYSTEM

Introduction to anti-lock braking

All derivatives of New Discovery feature an Anti-lock Braking System (ABS). This is a Wabco system, with similar hardware to the system currently used on Freelander. It is a four-channel system, allowing independent braking control for each wheel. The software inside the self levelling anti-lock braking system (SLABS) ECU includes many new features. These features are:

1. The ABS system can control the braking effort applied to each wheel depending upon the amount of adhesion the tyre has with the surface. This function is known as ABS (anti-lock braking system)
2. The ABS system can control the braking balance of the vehicle. This function is an improvement over the PCRV (pressure conscious reducing valve) usually incorporated into a vehicle braking system. This function is referred to as EBD (electronic brake distribution)
3. The ABS system can control the rate of descent of the vehicle when negotiating steep gradients 'off-road'. This function is known as HDC (hill descent control). It is an enhanced version of the HDC system already fitted to some Freelander derivatives
4. The ABS system can influence the amount of torque delivered to each wheel. The ABS can apply a braking force to a slipping wheel, allowing the engine torque to be applied to wheels that have good traction. This function is known as four wheel traction control

System components

Brake master cylinder

New Discovery uses a diagonally split brake circuit configuration. A dual diaphragm vacuum servo is attached onto the tandem brake master cylinder (referred to as a traction control traction control (TCTC) type) to provide assistance in the amount of braking effort produced when the driver depresses the brake pedal. The master cylinder also incorporates the brake fluid reservoir. DOT 4 brake fluid must always be used when topping up the reservoir. The Brake fluid capacity of the manual derivatives is 950 ml, the automatic brake fluid capacity is 850 ml.

Brake calipers

The front and rear brake calipers are Lucas Colette calipers. The front calipers house two pistons on one side of the caliper and use a sliding body assembly to distribute half of the braking effort to the other side. The rear caliper housing has one piston to produce the braking effort for both sides of the brake disc.

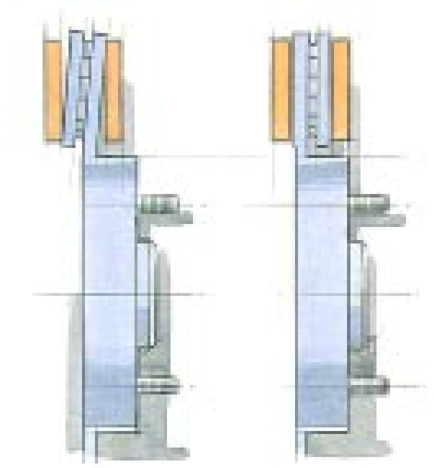


Figure 105

The brake discs on the front of the vehicle are reverse vented to aid the dispersion of heat generated by the friction material (see figure 105). By having the outboard friction surface detached from the mounting bell, the disk has greater performance when subjected to sustained high temperatures. The front discs have a 148.6mm (5.85 in) radius and a thickness of 25mm (1 in). The minimum thickness for the front discs is 22.00mm (0.87 in). The rear discs are of a standard construction with a radius of 152mm (6 in), and a thickness of 12.6 mm (0.5 in). The minimum thickness for the rear discs is 11.7mm (0.46 in). Both discs have a maximum run-out of 0.15mm (0.006 in). On the previous Discovery and Range Rover models, each rear brake disc incorporates a reluctor ring used in conjunction with a wheel speed sensor. New Discovery does not use this type of wheel speed sensor, so this reluctor ring has been deleted.

The handbrake is mounted on the rear of the transfer box. It is of a drum design and includes a cable-operated expander to apply the braking effort. The same care points must be observed when operating the handbrake. These are:

1. Never apply the handbrake when the vehicle is moving
2. Follow the procedure detailed in the workshop manual to adjust the handbrake shoes running clearance
3. Always replace the handbrake back plate retaining bolts with the correct new bolts, as these bolts are of a specially hardened material

ABS modulator

The Wabco system incorporates a combined modulator and return pump assembly located on the left-hand front inner wing panel (see figure 106). This assembly looks similar to the unit used on the Freelander. However, it is important that these two units are not interchanged, as neither system will work correctly on the other model. The fixing points are different to prevent the incorrect brake modulator being fitted to New Discovery. If difficulty is experienced when fitting a unit, check the part number on the unit.

Figure 106

The modulator houses two shuttle valves, which are moved when brake pressure is supplied via the brake master cylinder's dual channels. The shuttle valves have a switch attached to them, along with a set of resistors located between them. The resistance of the circuit controlled by these shuttle valve switches will change depending upon the position of the shuttle valve. With no brake pressure supplied, the current flows through the three resistors. With one switch open, the current flows through two of the resistors, and when both are open it will flow through only one. The switches can switch at slightly different times because of the internal workings of the master cylinder. The signal from the shuttle valve is used by the SLABS ECU to detect the correct operation of the brake master cylinder and the integrity of the braking circuit, and is used to supply a 'brake on' signal. The vehicle still has a brake light switch. This switch is used to control the brake lamp operation and the cruise control inhibitor.

The modulator also encases the four inlet and four outlet solenoids which control the pressure flow to individual brake calipers. These solenoids, as will be explained later, can be controlled as individual units or in banks. The modulator also incorporates the brake pump. This pump can be used to return fluid expelled from the brake calipers and stored in the expansion chamber. Alternatively, the pump can be used to generate braking pressure for use in HDC (hill descent control) and TC (traction control). No parts in the modulator are serviceable and any fault identified within the modulator will require the complete replacement of the unit.

If a new modulator unit is required, it will be dispatched from Land Rover Parts in a vacuum-sealed,date stamped packet. If the packet has lost its vacuum, or the date stamp is older than 3 years, the unit must not be fitted to the vehicle.

It is this modulator which provides the capability of controlling each of the wheel brakes independently. The software programmed into the SLABS ECU can control this modulator unit to supply New Discovery with all the functions previously described.

Wheel speed sensors

The wheel speed sensors are different to the conventional wheel speed sensors used on other Land Rover products. Conventionally, wheel speed sensors have an interference fit with the hub or back plate. This positions the sensor close to a reluctor ring.

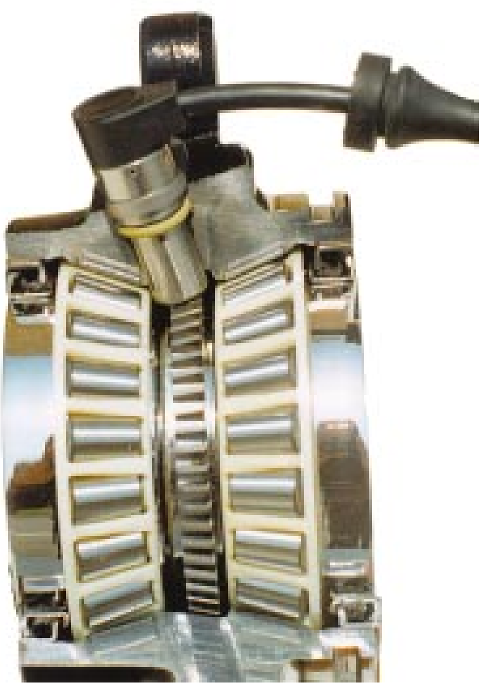


Figure 107

The sensors used on New Discovery are incorporated into the inboard wheel bearing, on both front and rear hubs (see figure 107). This bearing assembly is a sealed unit and has no replaceable parts. Also different is the wire from the wheel speed sensor. Land Rover has, historically used a wheel speed sensor employing a signal wire inside a shielded earth wire. The New Discovery wheel speed sensors have a twisted pair of wires. A twisted pair of wires offers electrical advantages over two straight wires:

- The signal is less susceptible to electrical noise or interference
- The voltage signal generates less electrical noise
- The wires can be balanced together (similar electrical properties) to ensure voltage losses are minimised

Like a conventional wheel speed sensor, the signal created is an AC sine wave. This wave is generated in the inductive sensor by a sixty-tooth reluctor, machined into the wheel bearing inner race. The frequency of this signal supplies the SLABS ECU with the information it needs to determine the speed of the individual wheels and is used in the calculation of vehicle speed or vehicle reference speed.

SLABS ECU

The self levelling anti-lock braking system (SLABS) electronic control unit (ECU) is located behind the glovebox on a mounting bracket, along with the ACE (active cornering enhancement) ECU and body control unit (BCU) (see figure 108). It is accessible by lifting the spring clips to the side of the glove box and allowing the glovebox to hang towards the floor of the vehicle. The SLABS ECU is in the centre of the three.

Figure 108

The SLABS ECU is a combined ECU with ABS and self levelling suspension (SLS), both sharing the same case. Although these two functions are housed in the same ECU, they can be thought of as completely separate systems. A vehicle that does not have SLS as an option still has the same ECU, but without the harness connections for the SLS. Otherwise, the hardware inside the ECU is identical.

Warning lamps

The SLABS ECU communicates with the instrument pack to inform it of the system's operational modes and its status. It does this via five lamps, which illuminate symbols on the instrument pack:

An amber lamp which illuminates a symbol with the letters ABS inside a circle.

A red lamp which illuminates a graphic with an explanation mark inside a circle.

A green lamp which illuminates a vehicle in descent, indicating HDC.

An amber lamp which illuminates the same type of graphic as the green HDC lamp, but with an added exclamation mark.

A dotted symbol with the letters TC, indicating traction control.

The strategy the SLABS ECU adopts when a fault is present, or when operating some of its functions, will be described later in this section.

Driver controls

The driver controls the operation of hill descent control by depressing a latching switch located in the 'switch pack' in the fascia. Low range must also be selected before HDC will become active.

Braking system functions

Anti-lock brake system (ABS)

The SLABS ECU monitors the wheel speed of all of the wheels. It produces an average of these wheel speeds, which it uses to formulate the vehicle road speed. It is this signal that is then used as an output to various other vehicle systems which will be discussed later in this section.

The SLABS ECU monitors the individual wheel speeds relative to the calculated road speed. When a signal from a wheel speed sensor reduces at a faster rate than within a predetermined margin from the calculated road speed, the SLABS ECU will energise the inlet solenoid, thereby reducing the pressure to that wheel. The SLABS ECU continues to monitor the wheel speed and, if it still sees a diminishing frequency from the wheel speed sensor, the SLABS ECU will then open the outlet valve. This removes the pressure from the brake caliper and will allow the wheel to accelerate to the vehicle speed. At the same time, the SLABS ECU will start the pump to recirculate the expelled fluid. It is the pump noise that the driver notices, along with the feel of the brake pedal.

This ABS function allows the driver to apply more braking effort than the vehicle can transfer onto the road surface without the risk of the driver losing control of the direction of the vehicle. The system is designed to minimise the stopping distance, with maximum stability, by using the ‘brake point’ of the tyre on the road surface (see figure 109). This brake point can be explained by degrees of slip. When a vehicle wheel rotates at a rate such that the wheel circumference multiplied by the wheel rotation rate equals the vehicle speed, it is said to have ‘zero slip’. If a wheel is in a locked condition (e.g. not rotating) and the vehicle is moving, the wheel is said to have ‘100% slip’. The maximum frictional adhesion happens when the wheel is experiencing between 10-20% slip. Achieving this amount of slip is the aim of the ABS system when it intervenes when the driver brakes. The operation of the ABS is automatic and requires no driver intervention.

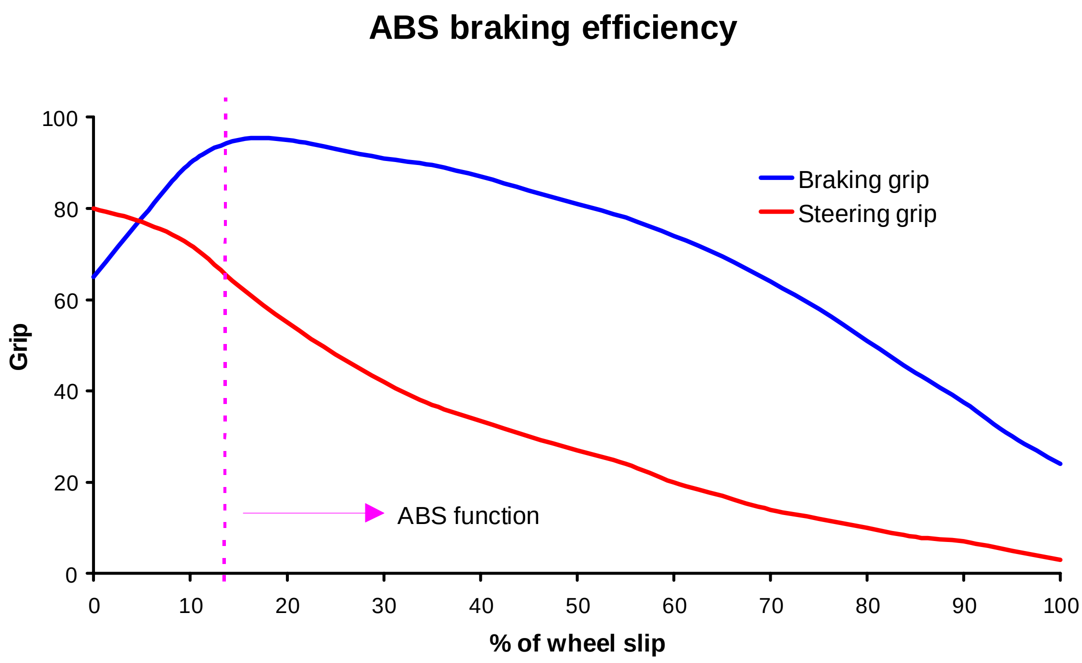


Figure 109

Electronic brake distribution

Electronic brake distribution (EBD) is a function of the ABS system. Historically, Land Rover has fitted a mechanical reducing valve to limit the brake pressure applied to the rear wheels. It is important to limit the pressure to the rear wheels because of the weight distribution change in the vehicle when the brakes are applied. On the application of the brakes, the weight transfers to the front of the vehicle. This reduces the ability of the rear wheels to transfer braking effort onto the road surface. If the rear brakes lock, the vehicle becomes unstable and the rear of the vehicle will try to overtake the front, causing a spin. If the front brakes lock, the vehicle does not become unstable, but will continue in a straight line from the point of the wheels locking (this may be a tangent to the corner the vehicle is negotiating).

There are several different methods manufactures have devised to overcome the problem of brake distribution. Some manufactures have a fixed percentage reducing valve. A disadvantage of this system is that the rear wheels cannot receive full braking effort when appropriate, typically when the vehicle is laden. A method of introducing some variance in the degree of braking effort is to have a mechanical reducing valve, with an arm attached to the rear suspension. A laden vehicle with compressed rear suspension will direct a greater proportion of the braking effort to the rear brakes than an empty vehicle.

On New Discovery, Land Rover engineers have designed a system which can overcome the problem of varying weight distribution. The EBD system uses the modulator unit to optimise the brake distribution electronically. The system has the capability of maximising the braking effort on both front and rear axles, even if the rear axle requires more braking effort than the front.

The SLABS ECU constantly compares the wheel speeds with the vehicle reference speed. If it detects a slight variation in speed of both wheels on one axle when the brakes have been applied, it operates the inlet valve solenoids in the modulator unit related to that axle. This has the effect of preventing any more pressure through to the brakes on the axle with the slipping wheels. The amount of wheel slip allowed is greatly reduced. An ABS system will typically allow approximately 10-20% wheel slip before it intervenes. This function of the ABS system starts to cap the pressure at significantly less than 10% slip, one axle relative to the other axle (see figure 109). When the signal from the wheel in the slip condition normalises with the road speed, the SLABS ECU opens the inlet valves to allow more pressure through to the axle. The SLABS ECU cannot close the inlet valves to both axles at the same time. The pump is not run when the SLABS ECU is in EBD mode and, as the operation of solenoids is very quiet, the driver will not usually notice when the brake distribution feature is active. As the SLABS ECU can monitor both the front axle and the rear axle against the vehicle road speed, it can adjust the brake balance of either axle to maximise the braking effort supplied by the driver. This keeps the vehicle under maximum control. The software can identify the current driving conditions, such as when the vehicle is cornering, or travelling at high speed. This ability enables the SLABS ECU to vary its sensitivity. The operation of EBD is automatic and requires no driver intervention.

Electronic traction control (ETC)

All New Discovery's are equipped with a 230Q transfer gearbox. The most noticeable change is that the driver has no means of manually selecting the centre differential lock. The second gear lever is similar to the Classic Range Rover (post 1988 MY), in allowing the driver to select only high range gears or low range gears. Unlike the Range Rover Classic, the transfer gearbox does not include a viscous drive coupling. This viscous drive coupling provides the transfer gearbox with the ability to limit the speed differential between the front and rear axles. It is unacceptable on an off-road four wheel drive vehicle to have a condition where loss of traction on one wheel can allow the vehicle to become, and remain, stuck. Land Rover engineers have designed a feature into the ABS system that eliminates the need for driver intervention or expensive components to distribute the drive evenly to both axles, when needed.

The SLABS ECU monitors the individual road speed signals relative to the calculated road speed signal. If it monitors that one wheel on one axle increases in speed, or that both wheels on one axle increase in speed relative to the other axle (and the driver has not applied the brakes), the SLABS ECU will operate the pump to create brake pressure. It then diverts this pressure, as appropriate, to either one wheel or both wheels on the axle which has lost traction. The effect on the vehicle is to simulate a viscous drive coupling, or a limited slip differential. The amount of slip between individual wheels and axles can be controlled to a predetermined amount. This system will operate fully up to a speed of 50 km/h (31.25 mph) and some functions are active up to speeds of 100 km/h (62.5 mph). All ETC functions are suspended when the vehicle's brakes are applied. The ETC can be active for an indefinite period. The operation will not be suspended unless the vehicle speed is greater than 100 km/h (62.5 mph). The ETC system uses the same hardware as the ABS system, and its operation is automatic, requiring no driver intervention.

Hill descent control (HDC)

The purpose of the HDC system is to provide improved control when descending steep gradients. The system applies the brakes automatically to supplement the engine braking. The amount of assistance will depend upon the gear selected to descend a slope and the amount of throttle applied.

The HDC feature, introduced for the first time on the Freelander, has been adopted and added to for New Discovery. HDC is an integral part of the ABS system. The HDC system uses the ABS hardware, contained within the ABS system, to supply this feature.

The system also gives extra security in circumstances where the wrong gear, or no gear is selected. As mentioned previously, New Discovery has no centre differential lock. Without this feature, the effect of engine braking, when navigating a steep decline, can be reduced. This can happen even if only one wheel starts to lose traction with the surface.

Engine braking can apply only the same amount of braking to each wheel. It is usually better, for stability reasons, to distribute the applied braking effort predominately to the downhill axle. The SLABS ECU can accomplish this by distributing the braking balance predominately to the downhill axle using HDC and ABS. The HDC system also compensates automatically for wheels that lose grip. It does this by employing some of the ABS type strategies, if the SLABS ECU deems it necessary.

Figure 110

The HDC system is functional in low range gears only. The driver activates the system by selecting low range on the transfer gearbox and depressing the hill descent control switch (see figure 110). It is important that the foot brake is not depressed as HDC will be over-ridden. HDC operates in all gears when in low range and can also function in neutral. However, when it detects neutral has been selected, it will give a warning to the driver and be functional for only a limited period of time. There is no direct signal from the manual gearbox or the automatic gearbox to indicate to the SLABS ECU which gear has been selected. The ECU calculates this by using signals from the engine management system, engine speed signal and its own calculated road speed. If the ECU detects no gear is selected, or that the clutch is depressed, then a fixed target speed is selected. This target speed will be detailed later in this section. The system will operate for 60 seconds with neutral selected before 'fade-out' begins.

Fade-out refers to the system continuing to operate, but increasing the target speed automatically at a predetermined rate. When the fade-out speed increases to above 50 km/h (31.25 mph), or if the throttle angle raises the target speed to above its current threshold, fade-out will be cancelled (see figure 111).

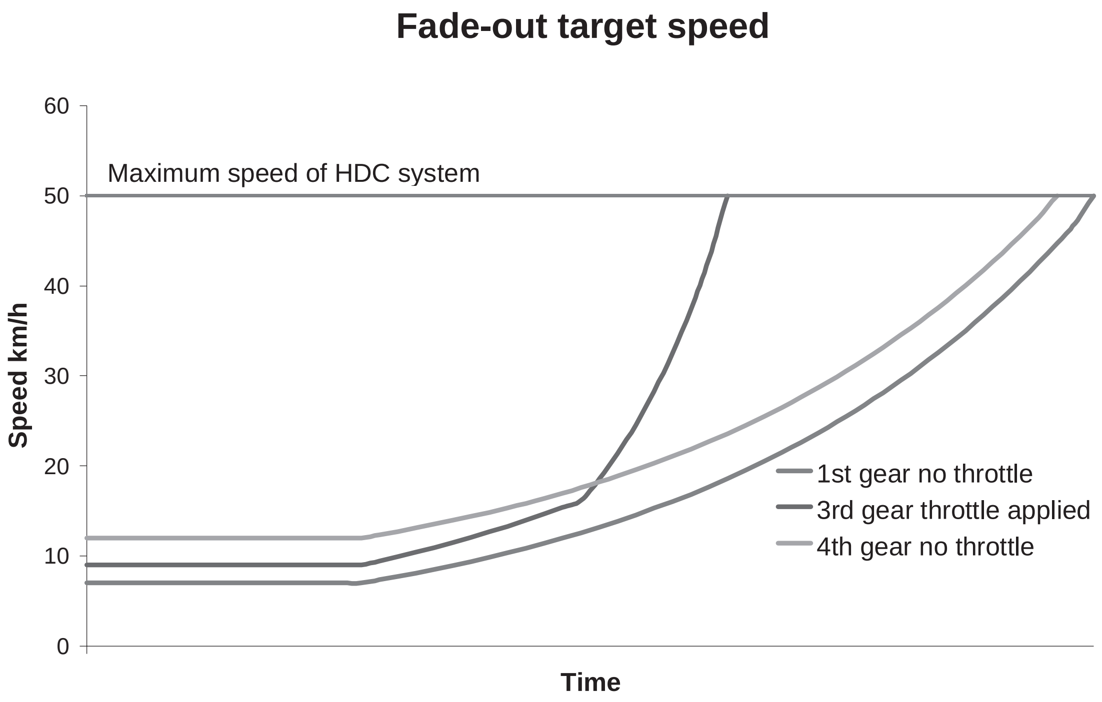


Figure 111

The target speed for descending hills depends on the gear selected, and whether the vehicle has an automatic or a manual gearbox. These figures are detailed in the table below. In the higher gears, the SLABS ECU can automatically reduce the speed from the normal descent target speed to a lower speed. This function will be triggered mainly on very rough or very slippery terrain, or in tight corners. This feature aids control of the vehicle in difficult situations. These conditions are determined by the SLABS ECU detecting a higher degree of variation in the individual wheel speeds. Additionally, a signal is produced that is used by the engine management system for calculations involving misfire detection.

The HDC descent speeds in Km/h (mph) for New Discovery are:

	Manual		Automatic	
Gear Selected	Normal	Reduced	Normal	Reduced
1	7.0 (4.38)	7.0 (4.38)	7.0 (4.38)	7.0 (4.38)
2	8.3 (5.19)	7.0 (4.38)	7.0 (4.38)	7.0 (4.38)
3	9.6 (6.00)	7.0 (4.38)	12.0 (7.50)	9.6 (6.00)
4	12.0 (7.50)	9.6 (6.00)	12.0 (7.50)	9.6 (6.00)
5	14.0 (8.75)	11.2 (7.00)	-	-
Reverse	5.6 (3.50)	5.6 (3.50)	5.6 (3.50)	5.6 (3.50)
Neutral detected	14.0 (8.75)	Reduced speed last used	7.0 (4.38)	7.0 (4.38)

These vehicle target speeds will depend on the throttle; the speeds above assume that the throttle angle is 0%, e.g. foot off the throttle. The SLABS ECU will increase the target speed when the throttle is applied. The amount the target speed increases will depend upon how far the throttle is pressed and will range from the target speed associated with the gear selected to 50 km/h (31.25 mph). This feature enables the vehicle to be driven normally when HDC is selected and allows the vehicle to be driven down shallow hills under full HDC control, at speed greater than the minimum target speed. When the throttle pedal is released, the vehicle will gradually reduce the target speed back to the target for the particular gear selected.

When the HDC system is in operation, the brake lights are illuminated automatically by the ABS ECU, regardless of the foot brake position. This serves to warn following vehicles that the brakes have been applied.

The HDC feature will not operate continuously like traction control does, but will work as long as required under correct operation. The SLABS ECU monitors the HDC activity and can act to curb this amount if it deems that the system is being over used. This is more likely to happen if the HDC feature is abused by the selection of neutral or too high a gear for the decline. The SLABS ECU will start to warn the driver by flashing the warning light and then will eventually fade-out the HDC function.

Hydraulic circuit operation

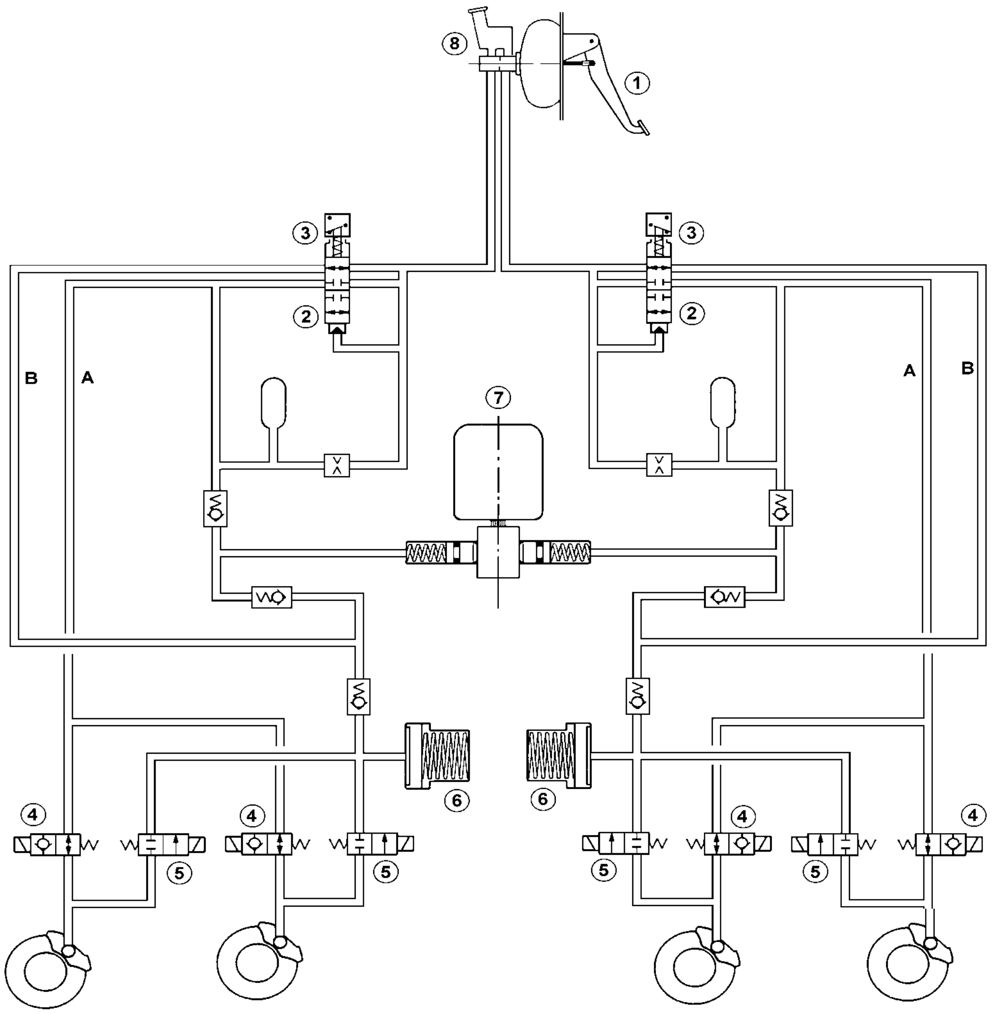


Figure 112

1. Brake pedal
2. Shuttle valve
3. Shuttle valve switch
4. Inlet solenoid valve
5. Outlet solenoid valve
6. Expansion chambers
7. Recirculation pump
8. Master cylinder

Non-ABS braking

When the brake pedal (1) is pressed, the shuttle valve (2) is moved by hydraulic pressure and opens line (A). As the shuttle valve moves, it triggers the shuttle valve switches (3). This informs the ECU that the brake pedal has been pressed. Pressure will be fed down line (A) to the front and rear brake calipers.

During ‘normal’ non-ABS braking situations, the inlet valves (4) are in the open position and the outlet valves (5) are in the closed position. This allows hydraulic pressure to act on the front calipers and the rear brake cylinders and applies the brakes. The inlet valves are in the open position by default, i.e. they will allow pressure through to the calipers, with no power supplied to the solenoid valves. The outlet solenoid valves, when de-energised, are in a closed state. This is a fail safe condition. If a complete loss of power is experienced, the vehicle will have full braking, although none of the ABS functions will operate.

Anti-lock braking system

If the ECU detects, via any of the wheel speed sensors, that a wheel is close to the point of locking, the system will initiate the ABS function. The inlet valve (4) of the slowing wheel will be closed and the outlet valve (5) will also remain in the closed position. At this point, no increased pedal pressure is allowed to the caliper. At the same time, pressure between the closed inlet and outlet valves is stable. Therefore, the pressure acting at the wheel caliper will remain constant. The SLABS ECU will continue to monitor the wheel speed and calculate whether the wheel is still at the point of locking. If the SLABS ECU decides that the wheel is no longer in danger of locking, the inlet valve (4) will be opened, thus allowing pedal pressure to increase at the caliper. If the SLABS ECU detects that the wheel is still in danger of locking, the inlet valve will remain closed and outlet valve will be opened.

The brake fluid will then travel into the expansion chambers (6), enabling pressure to be released from the brakes. At the same time, the recirculation pump (7) is activated and fluid is drawn into the pump circuit through the one way valves. Pressure is then recirculated in and out of the brakes by controlled modulation of the inlet and outlet valves.

Electronic brake distribution

When the SLABS ECU identifies the need to intervene in the brake balance of the vehicle, the ECU shuts the inlet valves (4) to both wheel calipers on the axle that the ECU has identified as needing limited fluid pressure to prevent wheel locking. It then continues to monitor the axle speed in relation to the other axle. If the SLABS ECU detects the axle speed equalising, it will open the inlet valve to allow the braking effort supplied by the brake pedal through to the caliper. If the SLABS ECU detects a continuing axle speed reduction, it will open the outlet valves (5). This is, effectively, the same as the functionality of ABS, except that ABS operates on one wheel only and EBD operates axle by axle.

Electronic traction control

When the SLABS ECU detects that one wheel is spinning faster than the other wheels, it will initialise TC. To start TC, the system activates the pump (7). The shuttle valve (2) is in its rest position and line (B) is open to the master cylinder (8). Fluid is drawn from the reservoir through line (B) and via a one way valve into the pump; it then leaves the pump through the other one way valve and travels to the inlet valves (4). The SLABS ECU at the same time as starting the pump (7), closes the inlet valves (4) to wheels that are not in a slip condition. This allows pressure to be generated by the pump through to the calipers on the wheel in slip. The outlet valves (5) remain closed during this phase. The SLABS ECU will continue to monitor the wheel speeds until it can determine it is appropriate to remove the braking force. At this point, it will stop the operation of the pump and open the outlet valve (5) on the braking circuit that has had the pressure applied. The fluid will return to the reservoir by line (B).

Hill descent control

If HDC has been selected and low range is engaged, the system will be ready to provide HDC functionality. When HDC is required to maintain the minimum target speed, the pump (7) is activated. The shuttle valve (2) is in its rest position and line B is open to the master cylinder (8). Fluid is drawn from the reservoir into the pump circuit and subsequently into the brakes. The inlet (4) and outlet (5) valves, in response to ECU inputs, control the pressure to the front and rear brakes. Pressure is applied to both front brakes or both rear brakes at the same time.

If the brake pedal (1) is pressed whilst in active braking mode (HDC), the shuttle valve switch (3) will be triggered. This informs the ECU that the brakes have been applied and HDC functionality will be disabled. Normal braking will be reinstated immediately.

TestBook ABS operations

The SLABS ECU can be interrogated via TestBook to:

1. Diagnose faults stored in current or previous journeys
2. Display ABS system components in operation
3. Test individual parts of the system
4. Initialise a new SLABS ECU for operation and configuration of functionality

The SLABS ECU can store faults in a non-volatile memory. This is to say that on removal from the vehicle, or after battery removal, the faults previously stored will remain until they have been diagnosed using TestBook.

TestBook can also display values received from the Engine Management System (EMS), automatic gearbox and other input signals.

All individual components and functions can be tested using TestBook.

TestBook must be used if the SLABS ECU is replaced. The process is important even if the vehicle is not equipped with self levelling suspension. The ABS system will not operate correctly if the SLABS ECU has not been initialised.

Driver information lamp operation

Figure 113

The ABS warning, as previously described, is an amber light with the letters ABS inside a circle (see figure 113). The operation of this light differs from other Land Rover products. On Range Rover, Freelander and Discovery pre 1999 MY, the lamp comes on for 1.3 - 2.0 seconds, off for 0.5 - 0.625 seconds and then back on until the ABS ECU detects a vehicle speed over 7km/h (4.375 mph). It did this in an ignition 'on' situation, provided there were no faults stored in the system.

New Discovery operates the warning lamp for 3 seconds when the ignition is switched on. This serves as a bulb check. It will then extinguish the ABS warning lamp, assuming that there are no current faults within the system. If there is a fault the ABS warning lamp will remain illuminated until the ignition is switched off. The moment the system detects a fault, the warning lamp will illuminate and there will be a pulsed audible warning, which will be 'on' for ¼ of a second and then 'off' for ¼ for a second, for three cycles. If it is an intermittent fault, the ABS light will act in the same manner as when the system experiences a hard fault, except that when the ignition is turned back on, the warning lamp will remain illuminated until the system can verify whether the fault still exists. An example of this could be a wheel speed sensor fault. The warning lamp will stay illuminated even if the signal from the sensor returns to a plausible state. The SLABS ECU will keep the warning lamp illuminated during the next 'ignition on' sequence, until the vehicle speed exceeds a maximum of 15km/h (8.75 mph). It can take up to reaching this speed for the SLABS ECU to determine whether or not the fault has cleared.

The ABS and TC warning lamp will also be illuminated if the vehicle has the differential lock engaged by turning the linkage on the transfer box. The differential lock warning lamp switch still exists on New Discovery and is used to inform different electronic systems that the transfer box has the differential lock engaged. The action of engaging the differential lock will also illuminate a warning lamp in the instrument pack.

ABS functionality will be impaired if differential lock is engaged.

The ABS warning lamp will also be illuminated if the SLABS ECU is in 'new-born' mode. This mode will be discussed later in this section.

The warning lamp will be illuminated, and the audible warning device will sound and cycle three times, when the system is being interrogated via TestBook.

This warning lamp is described as a 'normally on' light. This means the SLABS ECU needs to supply a voltage to turn off the light.

Summary table for the operation of the ABS warning lamp

ABS	Audible	Parameters
–	-	ABS/TC/HDC systems OK
On	-	Ignition on (bulb check for 3 seconds)
On	3 cycles	SLABS ECU being interrogated via TestBook
On	-	No power to SLABS ECU
On	-	SLABS ECU supply voltage much too high or much too low
On	-	'New-born' SLABS ECU fitted, ABS not checked
On	-	Centre differential lock engaged manually on transfer box
On	-	Wheel speed sensor fault on previous journey, and the vehicle speed has not exceeded 15 Km/h (8.75 mph)
On	3 cycles	ABS has detected a sensor/pump or valve fault
On	-	ABS has a sensor/pump or valve fault logged for this journey

Electronic balance distribution lamp operation

The EBD lamp is a combined warning lamp with the low brake fluid warning and the handbrake warning lamp. The lamp is a red light with an exclamation mark inside a brake symbol. The SLABS ECU will illuminate this light if it senses a fault that will affect its ability to control the braking balance of the vehicle.

The vehicle must not be driven when this lamp is illuminated.

The EBD lamp will be illuminated for 3 seconds when the ignition is switched on, as a bulb check function. It will then extinguish as long as no fault currently exists that may effect the operation of the EBD.

The EBD warning lamp will remain illuminated if the SLABS ECU is in ‘new-born’ mode.

Unlike the ABS warning lamp, the SLABS ECU supplies a voltage to illuminate the light, not turn it off.

Summary table for the operation of the EBD warning lamp

EBD	Audible	Parameters
-	-	ABS/EBD/TC and HDC systems OK
On	-	Ignition on (Bulb check for 3 seconds)
On	3 cycles	SLABS ECU being interrogated via TestBook
On	-	Handbrake on or low brake fluid level
On	-	SLABS ECU supplied voltage much too high or much too low
On	-	‘New born’ SLABS ECU fitted, ABS not checked
On	3 cycles	ABS has detected a sensor/pump or valve fault
On	-	ABS has a sensor/pump or valve fault logged for this journey

Traction control lamp operation

The system employs one amber lamp, which has the letters TC in a dotted circle. The lamp will illuminate during the ‘ignition on’ lamp check. The system will indicate TC operation by illuminating the amber TC lamp for a minimum of 2 seconds.

It is possible for the ABS modulator pump to operate in preparation for traction control operation without the warning lamp being illuminated. The warning lamp will illuminate only when enough pressure has built up in the system to apply braking effort to the brake discs. It will then illuminate for a minimum period of 2 seconds, or as long as the SLABS ECU is applying brake pressure to one or two wheels.

The lamp will also illuminate when a fault is detected in any of the ETC components. The traction control fault lamp strategy works in the same way as the ABS warning lamp. If the fault was rectified in the previous driving cycle, the TC lamp will remain illuminated until the vehicle has accelerated to approximately 15 km/h. This enables a more in-depth check to be performed by the SLABS ECU, ensuring the wheel speed sensors are functioning correctly.

Traction control will be disabled if the centre differential lock has been engaged.

The bulb is extinguished by the SLABS ECU supplying a voltage to the instrument pack, similar to the process used to control the ABS warning lamp.

Summary table for the operation of the ETC warning lamp

TC	Audible	Parameters
-	-	ABS/EBD/TC and HDC systems OK.
On	-	Ignition on (Bulb check for 3 seconds).
On	3 cycles	SLABS ECU being interrogated via TestBook.
On	-	No power to the SLABS ECU.
On	-	SLABS ECU supply voltage much too high or much too low.
On	-	Centre differential lock engaged manually on transfer box.
On	3 cycles	ABS has detected a sensor/pump or valve fault.
On	-	ABS has a sensor/pump or valve fault logged for this journey.
On	-	Traction control is active (minimum period of 2 seconds).

Hill descent control lamp operation

To indicate that the system is switched on and ready to assist with descents, when necessary, a green HDC information light is illuminated.

The HDC amber lamp is used to indicate a fault with the system. The graphic is the same as the green HDC light, but has an additional exclamation mark next to it. The moment a fault appears that will affect the operation of the HDC function, a audible warning is sounded, similar to the ABS fault warning, and the amber light will be illuminated.

Green lamp functionality

The lamp will illuminate for 3 seconds when the ignition is switched on (as a bulb check function).

If the driver is operating the HDC system incorrectly, the lamp will flash at a frequency of 2Hz (twice a second) and will sound the audible warning buzzer, cycling it continuously. This includes the selection of HDC in high range, depressing the clutch pedal or turning off the system when it is currently controlling the vehicle speed. This flashing lamp and audible warning can also be the indication of ‘fade-out’. Audible and visual warning will stop when fade-out finishes.

If the system is over-used in a given period and the SLABS ECU detects the need to cool the brakes, it will illuminate the green lamp and flash the amber warning lamp. As well as these two functions, the audible warning system will be activated until the SLABS ECU determines the brakes no long require cooling and that there is no reduction in their capability, at which time the audible warning will cease. The HDC system remains fully functional during this process.

If neutral is selected, the green lamp fade-out will start after one minute. Unlike the conditions above, the green lamp will be extinguished and the amber lamp flashed along with an audible warning. As soon as a gear is selected, normal operation will resume.

Summary table for the operation of the HDC function lamp

HDC!	Audible	Parameters
-	-	ABS/EBD/TC and HDC systems OK
On	-	Ignition on (Bulb check for 3 seconds)
On	Cycles 3 times	SLABS ECU being interrogated via TestBook
Flashes once	Cycles once	A fault with the link between EMS and the SLABS ECU. This triggers fade-out
Flashes once	Cycles once	A gear plausibility problem, e.g. clutch depressed. This A triggers fade-out
On	-	HDC conditions met for correct functionality
Flashes continually	Cycles continually	HDC conditions NOT met for correct functionality
Flashes until fade out is complete	Cycles until fade out complete	HDC system is in fade-out
On	Cycles 3 times	A minor fault has occurred, the HDC system is still fully functional
Flashes continually	Cycles continually	The SLABS ECU has detected the vehicle is in a neutral gear
On	-	The SLABS ECU has detected over-use, but is still fully functional

Amber lamp functionality

The amber lamp will illuminate for 3 seconds as a bulb check function when the ignition is switched on.

The amber lamp will flash at a frequency of 2Hz and the audible warning will activate when a fault occurs that will affect the operation of HDC. If the HDC system is actively controlling the speed of the vehicle, the green lamp will flash and fade-out will begin. If the HDC system is not currently controlling the vehicle speed, the green lamp will be extinguished and the HDC function will be cancelled. If HDC is not selected and a fault occurs that would inhibit operation, the SLABS ECU inhibits the selection of the function by not illuminating the green lamp when the driver operates the switch.

Both bulbs are extinguished by the SLABS ECU supplying a voltage to the instrument pack, similar to the process used to control the ABS and TC warning lamps.

Summary table for the operation of the HDC warning lamp

HDC!	Audible	Parameters
-	-	ABS/EBD/TC and HDC systems OK
On	-	Ignition on (Bulb check for 3 seconds)
On	Cycles 3 times	SLABS ECU being interrogated via TestBook
On	-	No power to the SLABS ECU
On	-	SLABS ECU supply voltage much too high or much too low
Flashes once	Cycles once	A fault with the link between EMS and the SLABS ECU. This triggers fade-out
Flashes once	Cycles once	A gear plausibility problem, e.g. clutch depressed. This triggers fade-out
On	Cycles 3 times	Brake light relay fault
On	Cycles 3 times	ABS has detected a sensor/pump or valve fault
On	-	ABS has a sensor/pump or valve fault logged for this journey
Flashes continually	Cycles continually	HDC conditions NOT met, for correct functionality
Flashes until fade-out is complete	Cycles until fade-out complete	HDC system is in fade-out
On	Cycles 3 times	A fault has occurred that affects HDC operation. The system is switched on but is not currently controlling the vehicle speed
On	Cycles 3 times	A minor fault has occurred, the HDC system is still fully functional
Flashes continually	Cycles continually	The SLABS ECU has detected over-use, but is still fully functional
Flashes continually	Cycles continually	The SLABS ECU has detected over use, and is in fade-out
Flashes continually	-	HDC system is disabled after fade-out has occurred due to over use. The system activation switch is still on, ready to resume after cool down

Fault code strategy

The SLABS ECU controls all of its ABS functions in a fault condition with a 'best as can' strategy. This is to say that the SLABS ECU will use substitute values when possible and only disable the bare minimum of operations to overcome the particular faulty component. An alternative to using substitute signals is the use of predetermined 'safe' operational maps for critical operations, e.g. fade-out and EBD.

SLABS interface with other vehicle systems

Information regarding engine status is transmitted from the ECM to the SLABS ECU, whenever the engine is running. The information is received via a pulse width modulated (PWM) multiplexed signal from the ECM to SLABS ECU. In total, four areas of information are transmitted:

- *Engine identification signal* - This provides the SLABS ECU with details on engine type, e.g. petrol or diesel, and transmission type
- *Throttle position signal* - This is received by the ECM from the throttle position sensor. It enables the SLABS ECU to determine the exact throttle position
- *Engine torque signal* - The ECM calculates this signal using information received from a number of sensors within the engine management system. It enables the SLABS ECU to make any necessary changes to the operation of the HDC and ETC function when the engine torque output changes

Engine speed signal – This is transmitted on another wire from the ECM. The signal is a frequency that represents the engine speed. The SLABS ECU uses this information in some of its internal operational calculations.

The SLABS ECU also sends information to the ECM. This information, sent in a pulse width modulated (PWM) multiplex line, consists of a rough road signal. As explained earlier, the rough road signal is generated from sudden acceleration and deceleration variances on individual wheels, relative to the calculated average wheel speed. The signal can indicate smooth road, rough road or fault. See the section on EMS (engine management systems) to understand how this signal is used.

The SLABS ECU also supplies the vehicle speed information to all the systems that require it. These include:

1. The instrument pack
2. The engine control module (ECM)
3. The body control module (BCM)
4. The active cornering enhancement system (ACE)
5. The self levelling system (SLS)
6. The automatic gearbox
7. Cruise control system
8. Central door locking and alarm functions

In the above cases the signal is sent as a square wave. The frequency of the signal equates to approximately 5,000 pulses per kilometre (8,000 pulses per mile) <u>*times*</u> by the vehicle speed in Km/h (mph) and <u>*divided*</u> by 3,600.

SUSPENSION

The suspension fitted to New Discovery has been enhanced to improve handling, stability and ride characteristics.

With the addition of the optional Active Cornering Enhancement (ACE) system, the road ride is improved as the suspension stiffness to single wheel inputs is reduced, leading to a more supple suspension. The front and rear suspensions have been designed to allow maximum wheel travel and large axle articulation angles, vital for off-road performance.

Front suspension

Radius arms

The front two radius arms fitted to the front axle are longer than those fitted to pre 99 MY Discovery. They provide longitudinal axle location and allow large axle articulation. The geometry has been designed to give the driver greater feedback under braking by tuning the level of dive. Too much dive and the driver thinks the vehicle is braking harshly. Land Rover engineers have designed the suspension so that the amount the vehicle dives is kept to a minimum, whilst still giving the driver feedback as to the level of braking. Dive is noticeable when the vehicle brakes are applied and the front suspension compresses as a result of weight transfer. The driver notices this movement by viewing the front edge of the bonnet relative to the horizon. 100% 'anti- dive' is when the vehicle brakes are applied but the driver does not see the vehicle lower at the front edge of the bonnet due to the force within the front suspension acting against the weight transfer forces associated with braking.

The chosen geometry provides good ride comfort, with the axle moving in the vertical direction on inputs from the road surface. The forged steel radius arms are fitted with two ferrule rubber bushes, the characteristics of which improve the vehicle handling. The bushes are used to fix the radius arms to the front axle via mounting brackets fabricated on to the axles. To fix the end of the radius arm to the chassis frame, a third ferrule bush is used.

A Panhard rod is fitted to ensure that the axle remains centrally located to the chassis and resists cornering forces. It is fitted transversely between the axle and chassis and also utilises ferrule bushes at both axle and chassis locations.

Front and rear anti-roll bars

Vehicles not fitted with Active Cornering Enhancement (ACE) are fitted with front and rear anti-roll bars to control body roll and directional stability. They are attached to the chassis via two bushes and retaining brackets, with the connection to the axle being made by ball jointed links. The front and rear anti-roll bars are not interchangeable.

Front and rear dampers

Conventional telescopic dampers are used to assist with control of the body and axle movement. The fronts are secured to the chassis frame by bolt on damper towers. The front upper fixing utilises a ferrule rubber bush with a single bolt fixing to the damper tower. The front lower end is fixed to the axle by another ferrule bush, which has a cross pin and is secured by two bolts. The upper and lower fixings of the rear dampers use a ferrule rubber bush with single bolt fixings to the chassis and axle.

Bush rate characteristics have been designed to provide reduced noise, vibration and harshness (NVH) and improved axle control. The dampers are tuned to each of the suspension options offered to the customer, to ensure optimum comfort and control. Therefore, dampers are not interchangeable.

Progressive rate rubber bump stops are fitted under the chassis, adjacent to the front springs, to prevent possible damage which could occur should there be excessive axle to chassis travel, whilst maintaining ride comfort when large road wheel inputs are encountered.

Front road springs

Single rate coil springs are fitted to the front axle. These differ between diesel and petrol derivatives as the weight difference has to be counterbalanced to maintain the correct ride height.

Tuned isolators are fitted between the spring and chassis frame. Isolators are fitted to improve NVH and ride performance.

Rear suspension

Radius arms

The rear suspension fitted to New Discovery has long radius arms which provide longitudinal axle location and allow large axle articulation. The front and rear radius arms are not interchangeable.

The geometry has been designed to provide a level of anti-jacking. This reduces the amount of rear end lift when the vehicle brakes, thereby improving braking stability. The radius arm comprises a forged steel link with two ferrule rubber bushes used to attach the arm to the rear axle mounting brackets. The radius arm is attached to the chassis frame by means of a third ferrule bush.

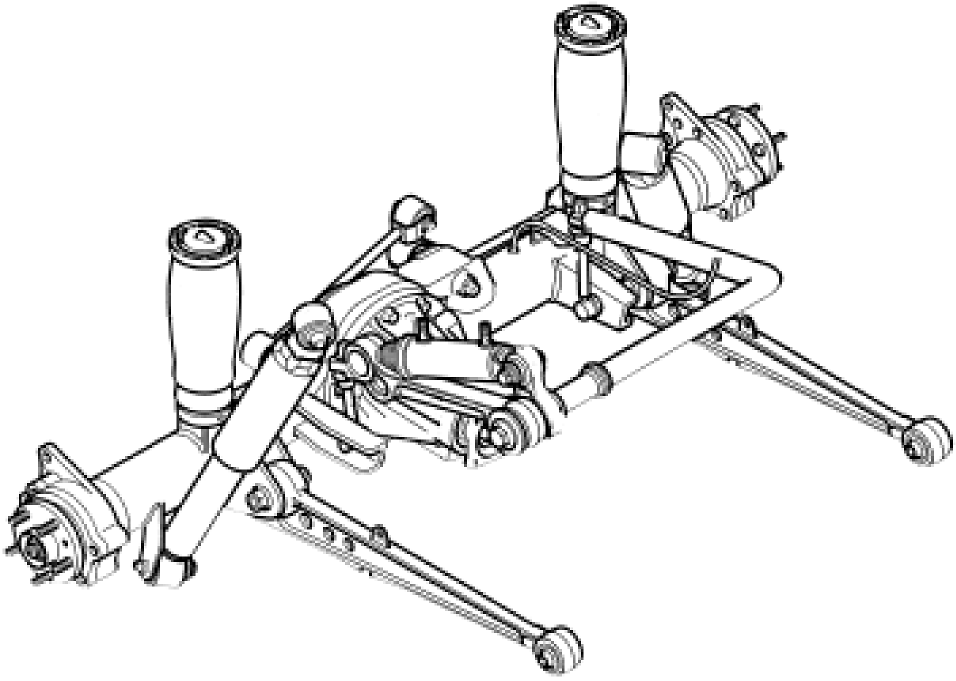


Figure 114

Rear road springs

Standard derivative vehicles are fitted with multi-rate rear coil springs designed for good ride comfort over a wide loading range and, as with the front springs, tuned isolators are fitted between the spring and chassis frame to improve the NVH and ride performance.

Watts linkage

Figure 115

Fitted to all derivatives of New Discovery rear suspension is the Watts linkage, which provides lateral location of the rear axle. This gives near vertical travel of the axle, and provides good body roll control via a high roll centre. The linkage offers good ride and NVH performance as the two chassis mounting bushes are relatively soft, needing only to provide lateral location of the axle as the radius arms provide longitudinal location and brake reaction.

The Watts linkage comprises two links, fitted with chassis mounting bushes, and a centre pivot assembly. The centre pivot has two spherical ball bushes and a centre bearing (all sealed for life) fitted into a machined casting. The linkage is fitted to the centre of the axle utilising a nut and bolt. A further two nuts and bolts secure it to either side of the chassis frame.

Self levelling suspension

A optional new feature for New Discovery is self levelling suspension (SLS). This incorporates air springs for the rear axle and conventional springs fitted to the front of the vehicle. It is similar visually to the air suspension fitted to Range Rover but it is different physically. There is no air reservoir fitted to New Discovery and no air springs are fitted to the front of the vehicle.

The system comprises:

- Air distribution unit
- Silencer
- Two height sensors
- Two air springs
- Air suspension height switch
- Air suspension warning lamp
- Off-road mode warning lamp

The function of the rear self levelling suspension is to keep the vehicle level under all loading conditions. It is not designed to give rapid height adjustment. The suspension system keeps the vehicle level even if there is an unevenly distributed load in the rear of the vehicle, or the vehicle is towing.

Air distribution unit

The Air distribution unit is the box which contains the:

- Compressor
- Air drier
- Air valves

It is mounted on the left hand chassis rail, beneath the left hand floor panel. No routine maintenance is required.

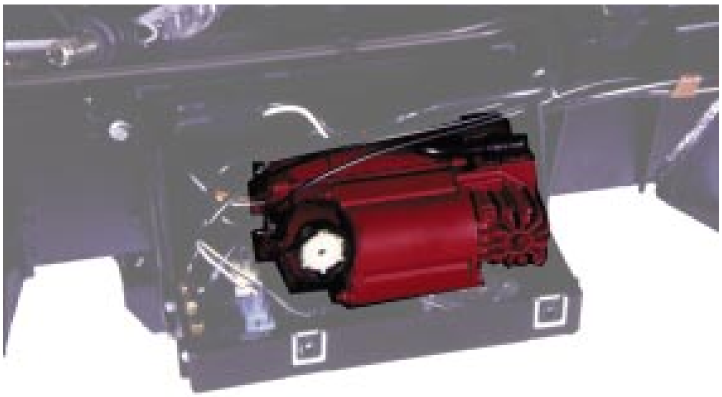


Figure 116

Compressor

The compressor provides compressed air to pressurise the rear springs. The compressor receives its power from a relay in the under bonnet fuse box, which is controlled by the self levelling anti-lock brake system (SLABS) ECU. The air intake for the compressor is located behind the LH rear light cluster in the 'E' post. It contains a felt and foam air filter and is replaceable (refer to workshop manual). For the correct service intervals refer to the service maintenance check sheet. Built into the compressor is the air drier and the exhaust valve. The compressor also has a pressure relief valve to limit the maximum air pressure in the system.

Figure 117

Air drier

The air drier is built into the compressor. The drier removes moisture from the compressed air entering the system. All air exhausted from the system passes through the drier in the opposite direction. The air drier is regenerative in that exhaust air absorbs moisture in the drier and expels it into the atmosphere.

The air drier is designed to last the life of the vehicle and is non-serviceable.

Air valves

The self levelling suspension air valves control the operation of the air springs at the rear of the vehicle. There are three solenoid actuated valves incorporated within the air distribution unit. These are the:

- Left spring valve
- Right spring valve
- Exhaust valve

The exhaust valve is integrated into the compressor. The left and right spring valves are in a separate block within the air distribution unit.

For the left hand side of the vehicle to rise, the left spring valve is opened and the compressor run. The same operation with the right spring valve raises the right hand side.

To lower the left hand side of the vehicle, the left hand valve is opened along with the exhaust valve. The same operation with the right hand valve lowers the right hand side.

Silencer

The silencer is connected into the air lines behind the air distribution unit. It has two chambers, one to reduce compressor pulsing noises at the intake filter, the other to minimise exhaust noise.

Height sensors

The height sensors are located on the chassis, with the sensor arms attached to the rear radius arms. They incorporate Hall-effect sensors and feed information relating to the height between the axle and chassis to the SLABS ECU.

If, for any reason, the sensors are replaced, or removed and refitted, a calibration process must be completed to ensure that the SLABS ECU knows the correct height of the vehicle. This process involves using TestBook and a set of special setting blocks (LRT 64-003). The blocks differ from those used on Range Rover.

Figure 118

Air Springs

The air springs located on the rear axle differ from those fitted to the Range Rover. They have a new construction and are made from new lighter materials. This gives the vehicle an improved secondary ride. Secondary ride is the term used to describe vibrations/oscillations caused by the vehicle reacting to minor road surface imperfections.

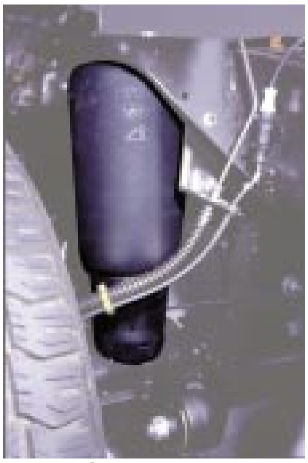


Figure 119

System operation

Basics

Self levelling is accomplished automatically when the engine is running (the engine ECM sends an engine speed signal to the SLABS ECU to indicate when the engine is running). The height sensors inform the SLABS ECU at what height the vehicle is currently set. If the rear suspension is too low, the SLABS ECU switches on the compressor by actuating the compressor relay. The left hand and right hand spring valves will open simultaneously (providing the vehicle is on flat ground), allowing compressed air to the air springs. The exhaust valve will remain closed. The height sensors then inform the ECU that the target height has been reached, the compressor stops and the spring valves are closed. If the air suspension is too high, the left and right hand spring valves will open, along with the exhaust valve, purging air until the height sensors inform the ECU that the target height has been reached.

If the LH and RH rear corners of the vehicle are at different heights, then the height sensors will inform the SLABS ECU that the distance between the axle and chassis is uneven. The SLABS ECU can then actuate the individual spring valves, along with the compressor or the exhaust, to level the rear suspension.

Other operation features

The levelling system is capable of lowering the rear suspension to within 20mm of the target height for up to 30 minutes after a door has been opened. This allows the suspension to be levelled as the vehicle is unloaded. With the exception of this unloading function, all other levelling functions are disabled if the doors are open while the vehicle is stationary.

The SLABS ECU will disable all levelling activities if the height sensors indicate that the rear suspension is articulated more on one side than the other by more than 100mm above its target ride height.

The SLABS ECU monitors the signals from the height sensors while it is changing the rear ride height. If the rear ride height is not changing as the SLABS ECU expects it to, then all valve (and compressor) activity is halted. If the vehicle is moving at greater than 5km/h (3 mph) when this happens, a fault will be logged in the ECU. Full functionality will be re-enabled when the expected movement is seen, or when the target ride height is changed e.g. by selection of off-road mode or by use of the remote handset function.

The SLABS ECU monitors use of the compressor and the valves. If these components are being over-used then they are disabled to allow them to cool down, and an event code is stored in the ECU for interrogation by TestBook. If the SLABS ECU decides that the compressor or the valves are being over- used, the levelling behaviour of the system may become erratic.

Information lamps

The SLS system has two information lamps in the instrument pack. Situated in the bottom left of the instrument pack is the first amber warning lamp. If it is continuously illuminated, this indicates that a malfunction has been detected or that the transit function is set. If it flashes, then the remote handset function is being used or the transit function is raising the rear suspension.

Figure 120

Malfunction / remote function lamp

The second amber warning lamp is situated in the top right of the instrument pack. This is the off-road warning lamp. The warning lamp, if continuously illuminated indicates that the self levelling suspension is in off-road mode. If the lamp flashes, this indicates that the SLS is between the standard ride height and the off-road mode, or that the vehicle is in its extended mode.

Figure 121

The off-road warning lamp

Modes of operation

- Off road mode
- Extended mode

Off road mode

To give the vehicle extra height off-road, there is an off-road mode. To activate the off-road mode, press the self levelling switch on the fascia for a minimum of 0.5 second. A single audible warning will be given and on release of the switch the off-road warning lamp on the instrument pack will flash, indicating a change of ride height. When the vehicle is at the off-road mode target height, the lamp will stop flashing and remain illuminated. To exit the off-road mode, press the self levelling switch for a minimum of 0.5 second. The audible warning will sound once. On release of the fascia switch, the warning lamp will flash and the system returns the rear suspension back to the standard height.

Figure 121

Off-road mode can only be selected if the vehicle speed is lower than 30 km/h (19 mph), all doors are closed (if the vehicle is stationary), the engine is running and the rear axle has less than 100mm of articulation. If any of these conditions are not satisfied, the audible warning will sound three times and the off-road warning lamp will extinguish when the switch is released.

The off-road height setting is 100mm from the bump stops on the chassis to the axle. The vehicle will return automatically to the standard setting (60mm from the axle to the bump stops) if the vehicle speed exceeds 30 km/h (19 mph). Again, this height transition will be accompanied by an audible warning and lamp flashing.

Off-road mode can only be deselected if all doors are closed (if the vehicle is stationary) and the rear axle has less than 100mm of articulation. If either of these conditions are not satisfied, the audible warning will sound three times and the off-road warning lamp will remain illuminated when the switch is released.

Extended mode

The extended mode operates only under the SLABS ECU control and is not selected by the driver. This will happen only when the ECU senses a grounded chassis, the rear wheels are spinning and the vehicle speed is lower than 10 km/h (6 mph). This function is intended to increase the rear suspension height to clear an obstacle. Under these conditions, the compressor will operate for 25 seconds. The self levelling warning lamp will flash at a different rate, 75% on, 25% off. This function is cancelled if the vehicle exceeds speeds of more than 13 km/h (8 mph) or if the fascia switch is pressed for a minimum of 0.5 second.

Headlamp adjuster

All New Discovery derivatives feature a headlamp levelling switch situated on the vehicle fascia. The switch adjusts the headlamp setting to the driver preference. When the system has levelled the rear suspension, the driver can then set the headlamps to suit. This is especially useful when towing, as the vehicle's pivot point will cause the headlamps to rise at the front due to the weight pulling down on the rear of the vehicle.

Figure 122

Remote function

An additional option available as an accessory, is a dedicated air suspension remote transmitter which allows the driver to stand outside the vehicle and adjust the height to match that of a trailer hitch for hitching/disconnecting. This enables the rear vehicle height to be controlled between standard ride height and bump stop height. This option is purchased from the dealer and has to be configured by TestBook.

Operation

To operate the remote transmitter the ignition must be in position II and all doors must be closed. The vehicle must be stationary and the self levelling suspension should be at the standard ride height.

Pressing the lower button on the remote handset will allow the suspension to be lowered by up to 60mm below standard ride height. Pressing the raise button on the remote transmitter will allow the suspension to rise up to the standard ride height. If either button on the remote transmitter is released during the remote operation then the suspension height will freeze in whatever position it is positioned currently.

Figure 123

Whilst undertaking the operation of modifying the suspension height in response to the remote transmitter signal, the fascia warning lamp flashes and the audible warning is activated.

The rear suspension height will return automatically to standard ride height if the vehicle speed exceeds 5 km/h (3 mph) for longer than 5 seconds, or instantly if it exceeds 12km/h (7 mph).

Transportation function

The self levelling suspension has a transportation function. This function should be used whenever the vehicle is to be transported on a trailer and is to be lashed down by its chassis frame. The transportation function can only be enabled and disabled using TestBook. The transportation function lowers the rear suspension onto the bump stops, when the engine is not running. In this condition, the malfunction warning lamp will be illuminated continuously if the ignition is in position II. When the engine is running, the transportation function raises the rear suspension until the gap between the chassis mounted bump stops and the axle is 25mm. In this condition, the malfunction warning lamp will flash while the suspension is rising, then it will be illuminated continuously when the 25mm bump stop gap has been achieved.

Door switches

The driver, passenger and rear entry door switches are important in the operation of the self levelling system. The levelling system will not operate if the SLABS ECU, detects that the vehicle is stationary and a door is open. Within the SLABS ECU, the driver's door switch and the passenger door switches are connected together. Therefore, the SLABS ECU cannot determine which door is open, or if more than one door is open.

Diagnostics

The SLABS ECU can be interrogated via TestBook to:

- Diagnose faults stored in the ECU memory, current or historic
- Test individual parts of the system
- Initialise a new SLABS ECU for operation and configuration of functionality

TestBook will also be required to calibrate the settings of new height sensors and to configure the remote transmitter (if applicable).

TRANSMISSION

Manual gearbox

The R380 five speed manual gearbox is fitted to New Discovery. This gearbox was introduced across the Land Rover model range in March 1994.

Transfer gearbox

The transfer gearbox fitted to New Discovery is the LT 230Q, but with some significant changes. The speedo drive has been deleted from the transfer box, with the vehicle speed signal now being supplied by the self levelling anti-lock brake system (SLABS) electronic control unit (ECU). The speedo drive casing is therefore blanked off. High-Low shift is now cable operated. The ABS simulates the centre differential lock, so no driver operation is available or required. The handbrake drum is mounted on the rear of the transfer box, as on Discovery, Range Rover and Defender.

Propshafts

A redesigned front propshaft has been fitted to New Discovery. The new propshaft utilises a double hooks type joint at the transfer box drive flange. This is best described as a double universal joint. The double hooks type joint provides the propshaft with increased articulation and reduces noise, vibration and harshness (NVH) levels. The increased degree of articulation was necessitated by a change to the front axle pinion angle. The service level applicable to the front propshaft is limited to replacement of the universal joint at the front end (axle end) only. Should the universal joints fail at the hooks joint, then the complete propshaft will need to be replaced. The rear propshaft is identical to pre 99 model year Discovery vehicles.

Figure 124

Automatic transmission

All derivatives of New Discovery are available with the option of automatic transmission. The automatic gearbox used in New Discovery is similar in design mechanically to the automatic transmission used in the pre 1999 model year Range Rover.

The automatic transmission fitted to New Discovery is the ZF4HP22EH electronically/ hydraulically controlled 4 speed gearbox.

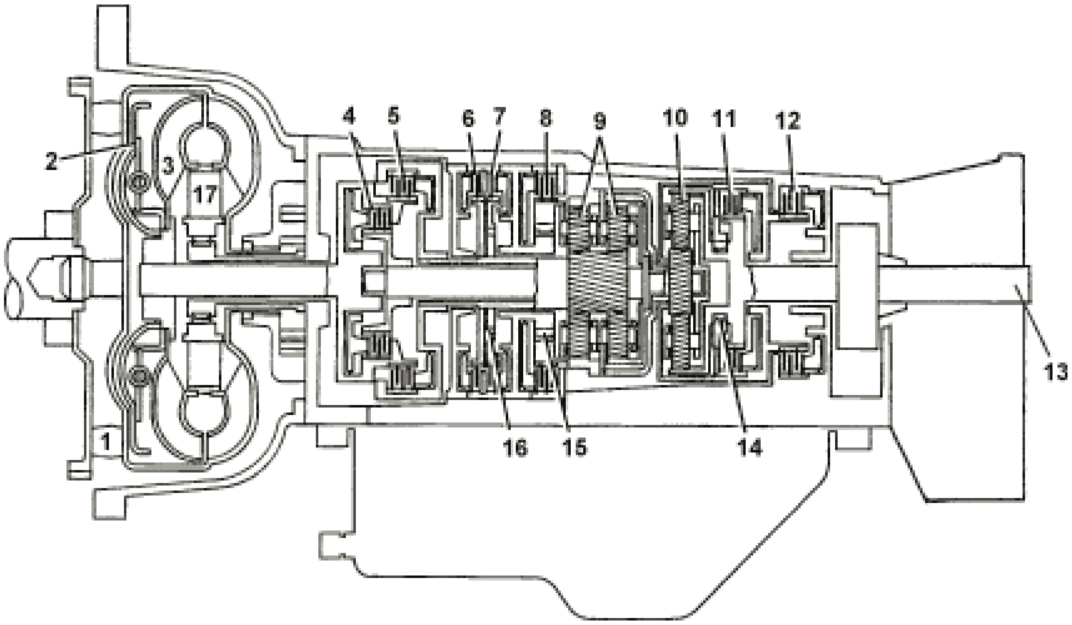


Figure 125

1. Input/impeller
2. Converter lock-up clutch
3. Turbine
4. Clutch forward drive
5. Clutch reverse drive
6. Clutch brake
7. Clutch brake
8. Clutch brake
9. Epicyclic gear set
10. Epicyclic gear set
11. Clutch
12. Clutch brake
13. Input to transfer gearbox
14. Freewheel (one way clutch)
15. Freewheel (one way clutch)
16. Freewheel (one way clutch)
17. Stator and one way clutch)

The most significant difference between the automatic transmissions used in pre 1999 model year Discoverys and the automatic transmission used in New Discovery is the addition of electronic transmission control. In New Discovery, gear selection, gear change speeds and torque converter lock up are now controlled electronically/hydraulically, rather than being controlled by mechanical/hydraulic means.

There are a number of significant advantages provided by an automatic transmission equipped with an electronically/hydraulically control system compared to an automatic transmission featuring a more conventional mechanically governed system. The main advantages are:

- The gear change points of an electronically/hydraulically controlled transmission are more precise and consistent. With mechanical/hydraulic control there is a greater tolerance band regarding the gear change points because of the nature of mechanical components, which are influenced by conditions such as temperature and component wear
- The automatic transmission system incorporates an output shaft speed sensor which is an input to the transmission ECU (TCU). The TCU selects the gears electronically using solenoid valves. The TCU determines which gear to select by monitoring the signals received regarding road speed, throttle angle, engine torque and engine speed
- The load on the transmission can be reduced by introducing engine intervention when the automatic gearbox changes gear. Rather than operating independently of the engine management system, the transmission ECU (TCU) is capable of communicating with the engine control module (ECM). In the case of New Discovery the ECM requests a percentage reduction of engine torque. This reduction results in an improvement in gear shift quality

Gear position switch

The gear position switch is mounted on the side of the transmission and contains internal switches. This switch has four input lines known as the W, X, Y, and Z lines. The gear position switch provides the TCU with the current driver-selected gear position. By analysing the status of these inputs, the TCU calculates which gear is most suitable for the current conditions.

Range Rover has only three input lines from the position switch: X, Y, and Z. New Discovery uses the fourth line for improved electrical diagnostics and better lever position information (intermediate gear lever positions, i.e. to detect when the gear lever is moving between positions). This helps to align mechanical and electrical tolerances.

Figure 126

Electronic control

The TCU is located under the left hand front seat (on both RHD and LHD models). Using information from the engine management ECU, together with its own sensors, the TCU selects the most suitable gear.

The gear is selected depends on certain variables, including:

- Road speed (from output shaft sensor)
- Throttle angle (from engine management)
- Engine torque (from engine management)
- Altitude (from engine management)
- Selector position (from position switch)

Other factors such as vehicle acceleration are also taken into account when the optimum gear is calculated.

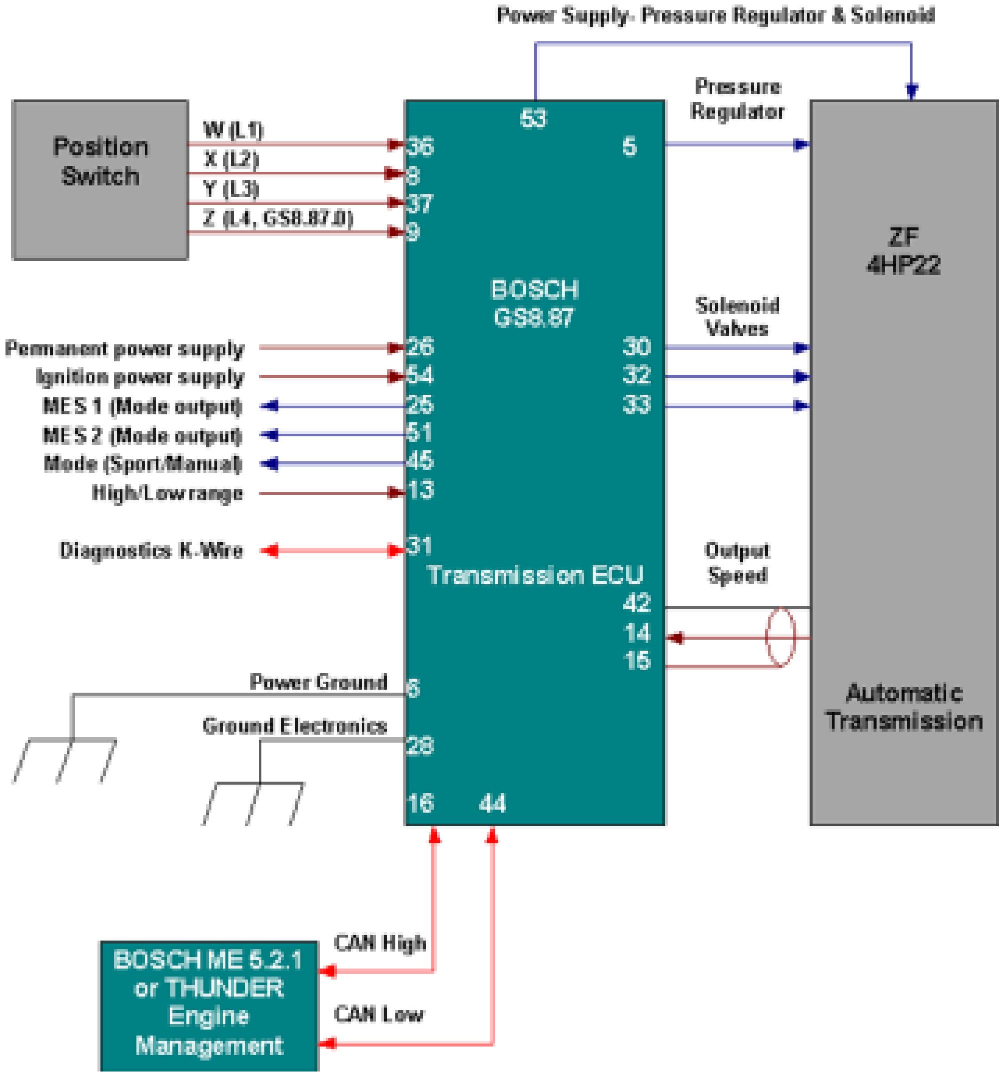


Figure 127

The TCU controls gear selection by directing pressurised transmission fluid to the required clutch assembly. This is achieved by controlling the operation of two shift solenoids incorporated within the valve block.

The TCU controls the gear shift quality by modulating the pressure regulator solenoid. This solenoid is incorporated into the automatic gearbox valve block.

To enhance the quality of the gear changes, the TCU sends a torque reduction signal to the ECM during gear changes. Responding to this signal, the engine management ECM will reduce engine torque to improve shift quality.

The third solenoid valve incorporated into the valve block is the torque converter lock-up solenoid. This solenoid is energised by the TCU when torque converter lock-up is required.

High Range

The high range gears should be used for all normal driving, including off-road driving across dry level terrain.

Selector lever position	Characteristics
'P' (park)	In the park position, the transmission is locked mechanically and the vehicle is prevented from moving. Park should be selected only when the vehicle is stationary. Engine cranking is permitted.
'R' (reverse)	In this position, drive is supplied by the transmission output shaft, in the reverse direction. Reverse should be selected only when the vehicle is stationary.
'N' (neutral)	In the neutral position no drive is supplied. Neutral should be selected when the vehicle is stationary and the engine is at idle for a short time, before resuming drive. Engine start is permitted.
'D' (drive)	In this position, forward drive will be supplied. It should be selected for all normal driving. All forward gears will be supplied with fully automatic gear changes, determined by vehicle speed and throttle position.
'3'	Forward drive will be supplied with the selector lever in this position. Automatic gear changes are provided in this position, although changes will be limited to 1st, 2nd and 3rd gears only.
'2'	Forward drive will be supplied with the selector lever in this position. Automatic gear changes are provided in this position, although changes will be limited to 1st and 2nd gears only. Moderate engine braking will be provided.
'1'	Forward drive will be supplied in the forward direction in 1st gear only with the selector lever in this position. No automatic gear changes will be provided in this position and maximum engine braking will be provided.

Note: *If the gear lever is moved from drive to a lower gear whilst the vehicle is moving at speed, the selected gear will be engaged only when the road speed is reduced to an acceptable level. This prevents the possibility of the engine over-revving.*

(see figure 128 below for High range-normal mode-diesel gear map).

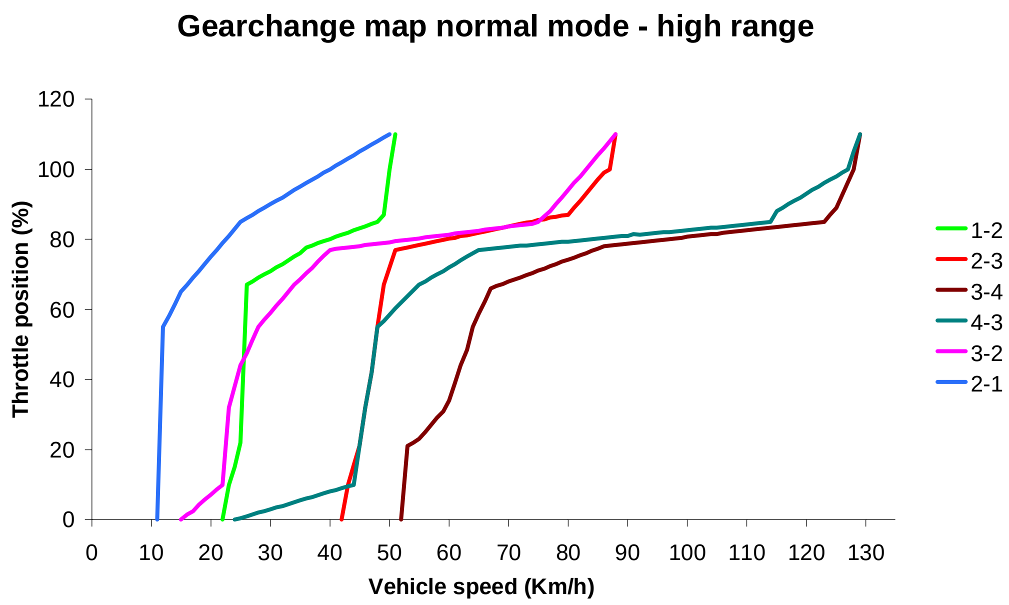


Figure 128

Low range

Low range gears should be selected in any situation where low speed manoeuvring is necessary, extreme off-road condition driving is required or hill descent control (HDC) is required. Selection is made via the hi/lo lever situated on the vehicle's centre console.

Torque converter lock-up

At vehicle pull away and during gear changes, the torque converter will allow a certain amount of slip to occur between the crankshaft drive plate and the input shaft of the gearbox. Incorporated into the design of the automatic transmission system used on New Discovery is a lock-up feature, where the ECM will activate the torque converter lock-up solenoid. The New Discovery will lock the torque converter in all gears (see figure 129 Lock-up Engagement-Normal Mode-High Range V8), whereas on pre 1999 Range Rover this can only be activated in third and fourth gears. When activated, the torque converter lock-up clutch will be engaged and no slip will be allowed. Direct drive through the torque converter will be provided in this condition.

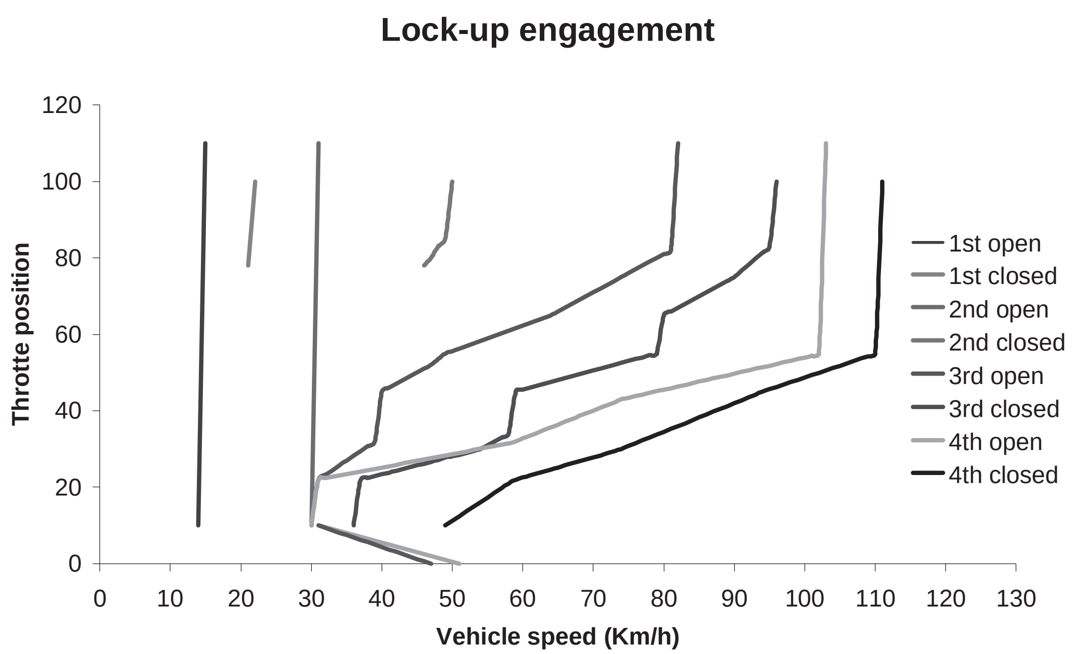


Figure 129

The torque converter can be locked and unlocked during driving to improve driveability, fuel consumption and gear changing. The torque converter will not be locked until the transmission has calculated that the oil temperature has reached a predetermined temperature. This is calculated from the engine coolant temperature via a software timer within the TCU, as the transmission itself has no temperature sensor. The length of this timer depends on several variables, including the engine coolant temperature during cranking, but is approximately :

Engine ambient temperature	*Time taken for oil to warm up*
25°C	0 minutes
0°C	7 minutes
-25°C	12 minutes

When low range is engaged, the torque converter is used to improve the vehicle's off-road capabilities. One example of this is locking the torque converter at 0% throttle. This improves engine braking whilst negotiating steep gradients. This feature will be active only whilst there is no danger of stalling the engine.

Mode select

In addition to providing drive, and electronically controlling the gear changes throughout the conventional gear selection range in both high and low ranges, the automatic transmission system featured on New Discovery also incorporates a mode select facility. This feature enables the driver to select the gear change strategy that most suits the current driving conditions. The mode switch, situated adjacent to the rear of the automatic selector gate, can be used to select a Sport mode when in high range, and Manual mode when low range is selected.

Figure 130

Sport mode

Sport mode can be selected by pressing the mode button whenever high range is engaged. Once sport mode has been selected, a dash board lamp will illuminate the letter 'S'. Although automatic gear shifts continue to be controlled by the ECM, they will be made using a different strategy, i.e. remaining in a given gear longer when accelerating, and changing down to a lower gear earlier when decelerating (see figure 132 for sports mode-diesel gear map). The characteristics of the transmission whilst in sport mode help make optimum use of the engine's power. Pressing the mode button for a second time returns the transmission system to its normal operation within the high range.

Figure 131

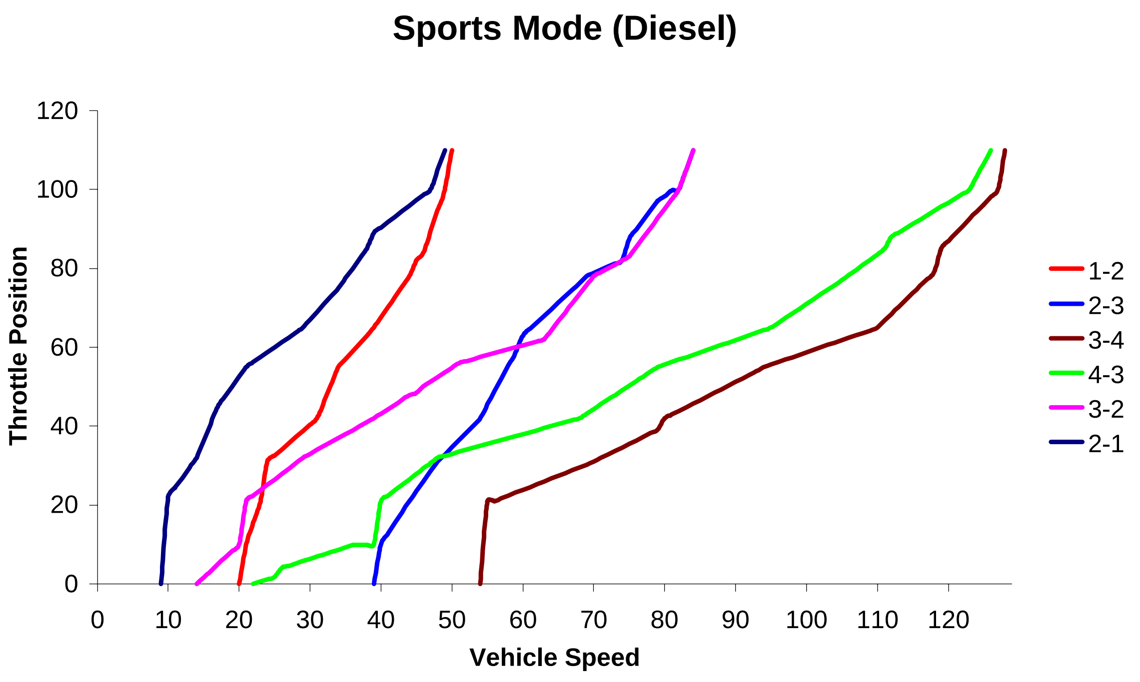


Figure 132

Manual mode

Figure 133

Manual mode can be selected by pressing the mode button whenever low range is selected. With manual mode selected a dashboard lamp will illuminate the letter 'M'. The transmission will function in a similar way to a manual gearbox. In this condition the transmission will change into the selected gear as soon as possible, and then remain in that gear at all speeds, changing down only to prevent engine stall. The characteristics of the transmission in manual mode make it ideal for use in extreme off-road conditions.

Towing/steep gradients

When the vehicle is normal mode (i.e. high range with sport not selected) the automatic gearbox will select a shift pattern appropriate to the current conditions. If a heavy load is being pulled, a steep gradient is being climbed or both, then the automatic gearbox will use a more aggressive shift pattern, compensating for the load by using higher engine speeds for any given throttle angle.

Fault finding diagnostics

If there is a fault, the automatic transmission will attempt to drive as normally as possible. However, if it is not safe to continue changing gear, a limp home mode will be selected.

Limp home mode differs depending upon the vehicle conditions when the fault is diagnosed. If high range is selected, then the default condition is third, if stationary when the fault occurred and fourth, (if moving) when the fault occurred. If low range is selected, then the system will attempt to maintain the current gear until the ignition supply is removed. This is in case the fault occurs whilst negotiating a steep gradient.

If there is a fault which either prevents all gears being used or disables the kick-down facility, the sport and manual lights will flash at the same time. This indicates to the driver that the vehicle has entered limp home mode. This mode will continue until the ignition is turned off. When the ignition is turned back on and the engine has been cranked, the TCU will complete a self-test. If the fault has rectified itself the automatic gearbox will resume normal operation and the sport and manual lights will no longer flash. If the fault is still evident, then the vehicle should be taken to the nearest Land Rover dealer as soon as possible for the fault to be investigated and rectified. It is important to appreciate that if a fault has been rectified or is no longer present but the fault code has not been deleted, the sport and manual lights will continue to flash until the TCU has diagnosed the fault is no longer present.

If a fault exists that will not damage the transmission or cause inconvenience to the driver, no warning lights will illuminate but a fault code will be stored. If a driver does notice a slight change with the behaviour of the gearbox, this could be due to a fault of this type.

If a transmission fault exists that will increase the emissions of the vehicle, the malfunction indicator lamp (MIL) will illuminate (NAS models only).

If any of the above conditions are true, the software within the transmission ECM will have stored a fault code. After a fault code has been stored and the car has completed 40 warm-ups, (warm-up is defined as the engine coolant rising by at least 16°C and exceeding 70°C), then the vehicle fault code will be deleted from memory providing the fault does not reappear during this time. If the fault codes re-appear, this counter is reset and requires another 40 warm-ups before the fault is deleted automatically.

If the automatic transmission ECM is found to have been disconnected, the vehicle will have selected an hydraulic limp home mode. Reconnection must occur when the ignition is switched off. If the ECM was disconnected whilst the ignition was turned on, fault codes will have been stored within the ECM and TCU. These fault codes must be deleted using TestBook.

Engine management faults

Faults can occur with the engine management system which affect the transmissions performance. After the fault has been diagnosed through interrogating the ECM, and has been rectified successfully, the fault must be cleared from the ECM and TCU using TestBook. On petrol derivatives, if a fault has been stored in the TCU, it will illuminate the MIL (check engine) lamp (NAS models only). This will happen only if the fault is emissions-related i.e. torque converter not functioning or 3rd/ 4th gear permanently selected.

On board diagnostic (OBD) system

The TCU communicates with the ECM via a CAN interface. This is used by the transmission for the gearshift torque interface and as a means for transmitting OBD information between the TCU and ECM. The automatic transmission requests the ECM that ‘freeze frame’ data is stored, and requests MIL activation. If the MIL is illuminated without any fault codes being stored in the ECM, then the automatic transmission is requesting MIL activation. The automatic transmission MIL activation request can be checked with TestBook.

CAN System

The controller area network (CAN) is a high speed serial interface for transmitting information between ECU’s. CAN communications are ‘self checked’ for errors and if an error is detected, the message is ignored by the receiving ECU. Due to the high rate of information exchange, the system has a high degree of latency. This allows for an error to be present without reducing the overall data transfer rate.

Service maintenance

The automatic transmission identification number can be found stamped on a plate riveted to the bottom left hand side of the auto transmission casing.

There is no filler/dipstick tube fitted to the automatic transmission. New Discovery utilises a filler plug and a drain plug for service maintenance of the transmission fluid.

The procedure for the automatic gearbox drain and refill is as follows:

Drain

1. Position vehicle on ramp
2. Apply handbrake and position chocks under front and rear wheels
3. Position container under gearbox
4. Remove gearbox drain plug and allow oil to drain, discard sealing washer
5. Refit drain plug using new sealing washer and tighten to 15Nm (11lbf. ft)

Refill

1. Remove filler/level plug and discard sealing washer
2. Refill gearbox to bottom of filler/level plug hole with correct grade of fluid
3. Ensure gear lever is in the ‘P’ position, start engine and move selector lever through all gear positions and back to ‘P’ position
4. With the engine idling, continue filling gearbox until a small thread of fluid runs from filler/ level orifice
5. Refit filler / level plug using a new sealing washer and tighten to 30 Nm (22lbs/ft)

The scheduled service requirement for the automatic gearbox, relates to the maintenance of the transmission oil and automatic gearbox oil filter. The oil specified for use is ATF Dexron IID or III from the approved list. The fluid capacity is 9.7 litres dry fill, refill quantity being dependent upon oil temperature at time of draining and length of time allowed to drain.

Always refer to the current maintenance sheet whenever servicing New Discovery, to ensure the correct schedule is always followed.

SUPPLEMENTARY RESTRAINT SYSTEM (SRS)

In recent years, technical advances in occupant safety have reduced significantly the risk of injury to occupants in road accidents. Land Rover's commitment to continually enhance vehicle safety has led to an increase in the level of protection offered by the vehicle restraint systems fitted to its products.

Features designed to complement the 3 point diagonal seat belt provided for front occupants are known as supplementary restraint systems (SRS). In most instances, the term SRS refers to the use of components such as airbags to restrain the front seat occupants.

During frontal impacts, the occupants move forward under the deceleration forces until the seat belt retractor locks up. The amount of forward travel may vary depending upon the webbing slack prior to impact, i.e. wearing thick winter clothing. The fitment of frontal airbags complements the seat belt restraint system by providing further occupant protection.

All derivatives of New Discovery feature a driver airbag as standard. A passenger airbag is a standard feature on certain vehicles, and can be specified as an option on others.

For the first time Land Rover is introducing front seat belt buckle pretensioners on all derivatives of New Discovery vehicles to complement the restraint system. Pretensioners are fitted to all New Discovery derivatives. On impact, the seat belt buckle pretensioners reduce the amount of slack in the seat belt. This is achieved by retracting the seat belt buckle when the system detects a need to deploy the airbags.

Safety precautions

Before commencing work on the SRS or any of its associated components, it is vital to adhere to certain safety precautions. The first two items in the following list must be performed in sequence:

1. Switch off the ignition and remove the ignition key from the switch
2. Disconnect the battery terminals. The negative terminal should be disconnected first, followed by the positive terminal. Wait 10 minutes before proceeding. This allows the reserve energy capacitors incorporated in the system to discharge fully, thereby preventing the possibility of accidental airbag or pretensioner deployment
3. Never substitute components from another vehicle
4. Never cut, splice or make any attempt to repair any wiring or associated SRS components
5. Never dismantle or incinerate any of the airbag components or pyrotechnic seat belt buckle pretensioners
6. When an airbag module is removed from the vehicle, it must be stored temporarily in the boot of the vehicle, with the trim facing upwards (always ensure that the boot is secured). If no boot is available, storage must be in an approved store
7. When carrying an airbag module always ensure that the metal base is facing away from your body (i.e. the cover towards you). Never wrap your arms around the module
8. Always ensure that airbag components are kept in a cool and dry environment
9. Always disconnect the battery before carrying out any electric welding on the vehicle
10. Never probe into any electrical connectors associated with the SRS with multimeters or any other general purpose test equipment
11. A fault with the SRS should be diagnosed using TestBook only
12. Always ensure that the DCU is secured correctly in accordance with the repair manual instructions, and that fixings are secured to the correct torque
13. Always use new fixings on replacement of any SRS component
14. If an airbag module has been deployed, be aware that it will be hot for up to 30 minutes

__Important__: Improper handling or storage can result in internal damage to the SRS components, rendering them inoperative. In circumstances where you suspect a component has been dropped or damaged, always install a new unit.

In the event of a crash severe enough to deploy the airbags and seatbelts, then the whole electrical SRS system must be replaced (including the harness).

System functionality

The SRS on New Discovery derivatives is controlled by an electronic control unit known as a Diagnostic Control Unit (DCU). The DCU has the following functions:

1. The unit must monitor continually for possible crash conditions severe enough to warrant airbag deployment. In such circumstances, the DCU will deploy the airbags and the seat belt pretensioners simultaneously
2. The unit features full self diagnostic capabilities to ensure correct performance and functionality. The diagnostic capabilities require constant assessment, as opposed to the one-off deployment function. Therefore, the control unit will always be referred to as a diagnostic control unit (DCU)

In common with the diagnostic control units fitted to post 97 MY Discovery and Range Rover vehicles, the DCU on New Discovery models is of the single point sensing (SPS) variety. This means that the crash sensing and the mechanical safing sensor are both housed within the DCU.

In the event of a severe frontal collision, the crash sensor measures the deceleration of the vehicle through the use of an accelerometer. This is an electronic device which has the capability of processing deceleration data. In circumstances where the accelerometer measures deceleration forces of a predicted value and characteristic, deployment will be initiated through the DCU electronics.

The mechanical safing sensor is a device which is monitored by the DCU electronics. In conjunction with the information provided by the crash sensor regarding deceleration, the safing sensor must also be in a closed position, thus completing the electrical circuit. When all these conditions are met, deployment of the airbags and seat belt pretensioners will occur.

Also contained within the DCU are energy reserve capacitors. These are installed to ensure an adequate supply of electrical energy is available for deployment after the loss of battery voltage supply. This feature enables the deployment of the airbags, even if the battery supply is lost during impact.

The DCU contains an additional capacitor which is capable of supporting microprocessor activity for 150mS after loss of battery voltage. This enables the DCU to store data related to the crash event. With the inclusion of this feature, by using the appropriate equipment the DCU memory can be read after an accident. This provides a means of analysing the functionality of certain parameters within the SRS unit following a crash. TestBook will not be able to read the DCU memory after a decision to deploy has occurred. The DCU will need to be returned to Land Rover to access this data.

Crash lock mode

When a crash deployment decision has been taken and crash recording completed by the DCU, the DCU will illuminate the SRS warning lamp permanently whenever the ignition is switched to position II. At this stage the DCU enters a mode referred to as crash locked mode. Once the DCU has entered the crash locked mode no further deployment of the SRS components is possible, thus rendering the DCU inoperative.

SRS warning lamp functionality

- As part of the SRS start-up procedure, the lamp will illuminate when the ignition is switched on. The lamp will illuminate for approximately 5 seconds. If no faults in the system are detected the lamp will extinguish. If a fault is detected during the SRS start-up procedure, the warning lamp will be illuminated for approximately 5 seconds, and then extinguish briefly. The lamp will then re-illuminate, and will stay illuminated for the entire ignition-on cycle. In circumstances where the warning lamp fails to illuminate during the start-up procedure, the existence of a fault should be assumed in either the lamp or power supply to the DCU
- If the warning lamp illuminates when the ignition is switched on, and remains illuminated without extinguishing briefly, the existence of a system fault should be assumed. In this scenario, the cause of the fault is likely to be the connection to the DCU, the ground or the associated SRS wiring
- If the DCU detects that a fault has occurred whilst the ignition is on, the warning lamp will be illuminated for the entire ignition-on cycle. If the fault is no longer present during the next ignition-on cycle the warning lamp will be extinguished. However a fault code will be logged in the DCU memory. If the fault code is still present during the next ignition-on cycle, the warning lamp will illuminate when the ignition is switched on and remain illuminated

To enable accurate measurement of the inputs to the DCU, the supply voltage must be maintained within defined parameters. These voltage parameters are as follows:

Limit	Voltage
Voltage low	9.0, tolerance +0 -1
Voltage high	16.5, tolerance +3 -0

- If the voltage supply exceeds these parameters the warning lamp will be illuminated for the duration of the error, and a fault will be logged into the DCU memory
- During periods where the DCU has identified a voltage value outside the given parameters, all diagnostics will be suspended. This measure is invoked as the accuracy of the diagnostic measurements cannot be guaranteed when the voltage supply is outside the defined levels. However, in the event of an impact, the DCU will still attempt to deploy the airbag and seatbelt buckle pretensioners until the voltage drops to below approximately 7.0 volts

Rotary coupler

The rotary coupler is a rotating link harness encapsulated in a cassette. The cassette is positioned on the steering column assembly between the steering wheel and the column switch assembly.

The function of the rotary coupler is to pass the required electrical signals for the functions built into the steering wheel area, i.e. in car entertainment, cruise control, horn and airbag. The cassette contains a flat ribbon type flexible cable (FFC) although not all of the seven electrical circuits are utilised on all vehicle derivatives. The length of flat flexible cable (FFC) gives a minimum of 4.2 turns of flexible cable within the cassette.

Figure 134

Always refer to the workshop manual before removal of the rotary coupler and follow the safety precautions outlined earlier in this section. It is **important** that the battery is disconnected before attempting to carry out any work involving the removal of the rotary coupler.

Precautions

- Do not install any rotary coupler if you suspect it has been dropped or mishandled in any way
- Do not fit the rotary coupler if the tamper tape is broken
- Do not attempt to modify or repair a rotary coupler in any way or form
- Do not cut or tamper in any way with the rotary coupler’s driver’s airbag connector or flying leads

Wiring harness

Land Rover vehicles, such as Range Rover, have employed previously a separate SRS wiring harness independent of the vehicle's main interior wiring harness. In this application, the SRS wiring harness could be identified easily by a yellow plastic shroud which covered the complete SRS wiring harness.

A new feature for New Discovery vehicles is the integration of the SRS wiring harness into the vehicle's main interior wiring harness. As a result of this inclusion, part of the SRS harness is no longer covered with the yellow plastic shroud. However, the SRS harness integrated in the main interior harness can be identified by yellow tape wrapped around the SRS wiring at regular intervals.

It should be noted, however, that the wiring leading from the main interior harness to SRS components can still be identified by a short yellow plastic shroud.

In circumstances where the deployment of the airbags and seat belt pretensioners has taken place, all SRS components should be replaced. This should include the replacement of the SRS wiring harness, i.e. the main interior harness.

Seat belt pretensioners

As referred to earlier in this document, all derivatives of the Land Rover New Discovery are equipped with pyrotechnic seat belt buckle pretensioners. They are secured directly to the seat frames, and are fitted to both front seats.

In modern motor vehicle applications, essentially two types of seat belt buckle pretensioner are available. These are the mechanical type and the pyrotechnic type. Most mechanical pretensioners operate independently of the control of the DCU. Often, these components have their own inertia sensing device incorporated into the unit. In New Discovery application, pyrotechnic seat belt buckle pretensioners are used. In this application, the seat belt buckle pretensioners are controlled by the DCU. In circumstances where the DCU has taken a deployment decision, seat belt buckle pretensioners and frontal airbags will be deployed simultaneously.

Location of pretensioner

The pretensioner is located along the side of the front seats and is orientated in a horizontal position.

Figure 135

A pyrotechnic device is located in a piston, which is retained in a cylinder. A cable is attached to the piston and seat belt buckle. Activation occurs when the relevant electrical signals are transmitted to the pretensioner by the DCU, and the chemical propellant starts to burn. As the chemical propellant burns, a large quantity of high pressure gas is created in the cylinder. This forces the piston and cable along the cylinder, which, in turn, retracts the seat belt buckle assembly, thus reducing the slack in the belt.

Pretensioner retraction events

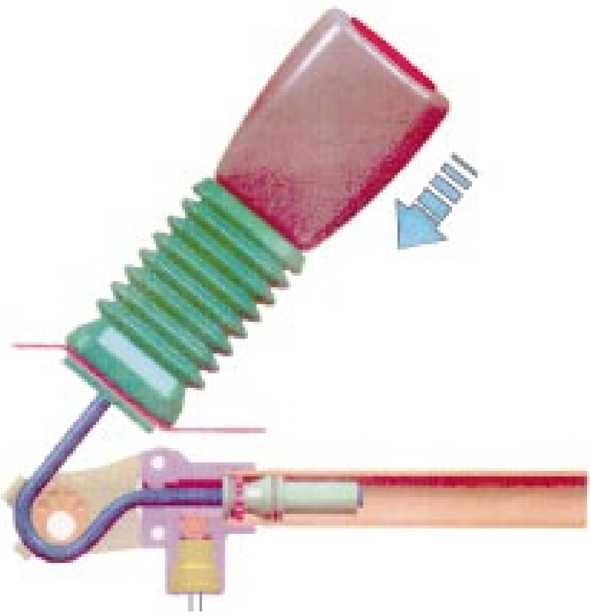


Figure 136
Pre-deployment

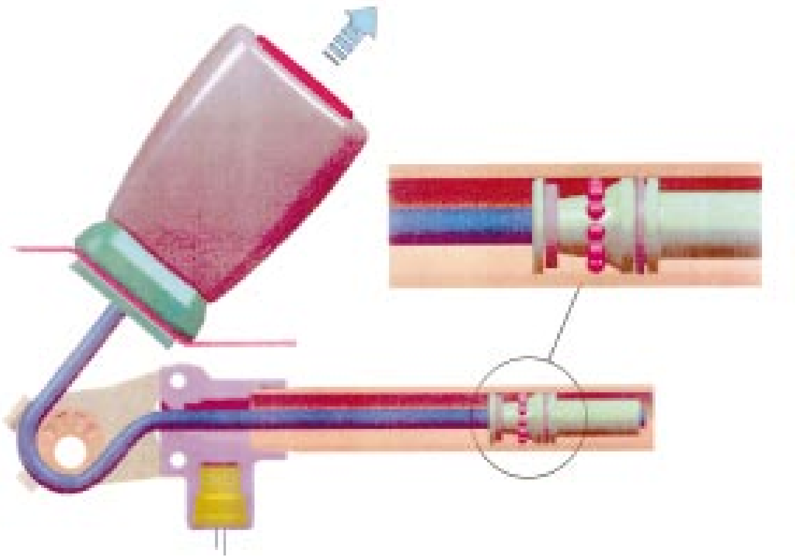


Figure 137
Post-deployment

Driver's airbag

As stated previously, all New Discovery derivatives are supplied with a driver's airbag as standard equipment. The airbag module is secured to the steering wheel by means of two 6mm internal Torx head screws. The screws should be replaced whenever the airbag module is removed.

Contained within the airbag module assembly is an airbag, which, when inflated, has a capacity of approximately 55 litres. Also contained within the module assembly is a gas generator and the chemical propellants sodium azide and cupric oxide. When the relevant electrical signals are transmitted from the DCU to the igniter in the gas generator, combustion occurs and the rapidly expanding gas causes the airbag to inflate. As the pressure rises, the airbag expands and appears through designed tear lines in the module cover. The airbag deflates after maximum pressure occurs, causing no obstruction to driver visibility.

Passenger airbag

The airbag module is secured to the fascia by means of four fixings. Two fixings secure the airbag module to a bracket, which, in turn, is secured to the body by the other two fixings. The bracket is excluded from vehicles not equipped with a passenger airbag.

Contained within the airbag module assembly is an airbag, which, when inflated, has a capacity of approximately 123 litres. Also contained within the module assembly is a gas generator and various chemical propellants. When the relevant electrical signals are transmitted from the DCU to the igniter in the gas generator, combustion occurs, creating stored heat which rapidly expands the stored gas causing the airbag to inflate. As the pressure rises, the airbag expands and appears through a designed tear seam in the module cover.

Important: *When working with SRS components, always refer to the repair manual for information regarding fixing torque.*

Diagnostics

The SRS system is operational from the moment the ignition is turned to position II. When the system is initially powered-up, the warning lamp situated in the instrument panel should illuminate, as described previously. This serves as a warning lamp functionality check. In normal circumstances, the lamp should extinguish after approximately 5 seconds. In the event of an SRS system fault being detected (internal or external to the DCU), the warning lamp will remain illuminated. Or, if a fault is detected after the lamp has extinguished, the lamp will be illuminated in both cases, and a fault code will be stored in the DCU memory. Fault codes can be accessed using TestBook via the 16 pin diagnostic connector situated on a bracket in the driver’s footwell above the pedals.

In the event of a total loss of power to the SRS DCU or failure of the warning lamp bulb, the warning lamp in the instrument panel will not illuminate during the preliminary ignition-on lamp check. Such faults should be investigated immediately. The electrical circuits used to transmit electrical signals within the SRS system are monitored continuously by the DCU.

The number of deployment circuits for the various gas generators (e.g. airbag and pyrotechnic seat belt pretensioners) monitored by the DCU, will be determined by the information stored in its memory. During production, New Discovery SRS DCU’s are configured to suit the vehicle’s specification i.e. to be compatible for driver’s only, or driver’s and passenger applications, always with seat belt pretensioners.

A diagnostic test is carried out by the DCU to determine the condition of the component and the wiring integrity on each of the output circuits.

During the start-up sequence, the DCU measures the resistance across each of the output lines. This check determines whether the relevant gas generators are adequately connected to the SRS wiring harness. In conditions where poor connections exist between the wiring harness and a component, a high circuit resistance would result. By comparison, short circuits between the supply and ground connection would result in a low circuit resistance. Both faults would be detected by the DCU, which would store details of the fault and illuminate the warning lamp, as previously described.

Service life

After a period of ten years from the date of registration (or the date of installation of a replacement airbag SRS component), some components in the SRS will need to be replaced. **(See the airbag modules replacement date shown in the service record book).**

To ensure absolute safety, this work must be carried out only by an authorised Land Rover Dealer, who should stamp and sign the appropriate page in the service record book.

GLOSSARY

ABS - anti-lock braking system
ACE - active cornering enhancement
AMFS - air mass flow sensor
ATC - automatic temperature control
BBS - battery backed sounder
BCU - body control unit
CAN - controller area network
CDL - central door locking
CKP - crankshaft position sensor
CO - carbon monoxide
DCU - diagnostic control unit
EBD - electronic brake distribution
ECM - engine control module
ECT - engine coolant temperature sensor
ECU - electronic control unit
EKA - emergency key access
ELC - evaporative loss control
EMS - engine management system
ETC - electronic traction control
EUI - electronic unit injector
FFC - flat flexible cable
HDC - hill descent control
HRW - heated rear window
ICE - in car entertainment
IDM - intelligent driver's module
IMF - inspection/maintenance flags
ISC - idle speed control
LED - light emitting diode
LHD - left hand drive
MAF - mass air flow
MIL - malfunction indicator lamp
NAS - North American specification
NTC - negative temperature coefficient
NVH - noise, vibration and harshness
OBD - on board diagnostics
OBDII - on-board diagnostic II
PWM - pulse width modulated
SLABS - self levelling anti lock brake system
SLS - self levelling suspension
SPE - single point entry
SPS - single point sensing
SRS - supplementary restraint system
TCTC - traction control traction control
TCU - transmission ecu
TPS - throttle position sensor