



ON-BOARD DIAGNOSTICS BOSCH GS8.87 TRANSMISSION MANAGEMENT

Vehicle Coverage:

Discovery Series II 1999 to 2004 MY

Range Rover 38A 1999 to 2002 MY



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2 Introduction

The Automatic Transmission Control Module (TCM) operates the solenoid valves in the gearbox to provide automatic control of gearshifts and Torque Converter Clutch (TCC) lock-up. Software in the TCM monitors hard wired inputs and exchanges information with the Engine Control Module (ECM) on a Controller Area Network (CAN) bus to determine gearshift and TCC lock-up requirements. Resultant control signals are then output to the gearbox solenoid valves.

2.1 Diagnostic Trouble Codes and Freeze Frames

While the ignition is on, the TCM diagnoses the system for faults. The extent of the diagnostic capability at any particular time depends on the prevailing operating conditions, e.g. it is not possible to check TCC lock-up while the vehicle is stationary, or to check for a short circuit to earth if the circuit concerned is already at a low potential.

If a fault is detected, the TCM immediately stores a fault code and the values of three operating parameters associated with the fault. Depending on the fault, there are four possible effects:

- €# The fault has little effect on gearbox operation or vehicle emissions. The driver will probably not notice any change and the warning lamps remain extinguished.
- €# The fault has little effect on gearbox operation but may effect vehicle emissions. On North American Specification (NAS) vehicles, if the fault is detected on a second consecutive drive cycle, the Malfunction Indicator Lamp (MIL) illuminates.
- €# All gears are available but kickdown does not function. The sport and manual warning lamps flash. The MIL remains extinguished. Limp home mode is selected and vehicle performance is greatly reduced. The sport and manual warning lamps flash. In all markets, if the fault is detected on a second consecutive drive cycle, the MIL illuminates.

After the detection of a fault, the effects remain active for the remainder of the drive cycle. In subsequent drive cycles, as soon as the TCM diagnoses the fault is no longer present, it resumes normal control of the gearbox. The conditions required to diagnose that the fault is no longer present depend on the fault. Some faults require the engine to be started, others require only that the ignition is switched on. After a fault has not recurred for forty warm-up cycles, the fault is deleted from the TCM fault memory. The ECM indicates via CAN that a warm up cycle has been completed. Only five different faults can be stored in the memory at any one time. If a further fault occurs, the fault with the lowest priority will be replaced by the new fault.

Mechanical limp home

In the mechanical limp home mode, the manual valve controls gear engagement. The gearbox is fixed in 4th gear if the fault occurs while the vehicle is moving, or 3rd gear if the fault occurs while the vehicle is stationary. 3rd gear is also engaged if a vehicle is brought to a stop and the selector lever is moved out of, and back into drive. Neutral and reverse gear are also available.



Inputs and Outputs

Input Signals	Monitored by OBD II?	Output Signals	Monitored by OBD II?
Engine Speed (from the ECM)	Yes	Ignition Retard Request (ECM)	Monitored by ECM
Engine Load (from the ECM)	Yes	Pressure Control Solenoid Valve	Yes
Engine Coolant Temperature (from the ECM)	Yes (no MIL)	Shift Solenoids	Yes
Engine Throttle Angle (from the ECM)	Yes	Torque Converter Clutch Solenoid	Yes
Transmission Range Switches (Gear Selector)	No	Instrument Pack (Gear Selected, Mode Information)	No
Transfer Box Range Switch	Yes	Gear Selector (Gear Indicators)	No
Transmission Mode Switch	No		
Output Shaft Speed	Via Gear Functional Checks		



3 Onboard Monitoring

3.1 Transmission Control Module

3.1.1 Description

The TCM performs six self-test integrity diagnostics on its internal hardware and software to check for faults, a fault is detected if: -

1. The ignition supply is greater than 10.5V and the voltage across the relay coil is less than the ignition supply minus 2V. The transmission controller's supply to the power output is faulty. This could be due to a problem in the harness (short circuit to 12V of a power output stage), or an internal ECU fault.
2. The ignition supply is greater than 10.5V and the voltage across the relay switch is less than the ignition supply minus 2V. The transmission controllers supply to the power outputs is faulty. This could be due to a problem in the harness (short circuit to 0V), or internal ECU fault.
3. The ignition supply is greater than 10.5V and the TCM cannot communicate with part of its internal memory. This indicates a fault with Electrically Erasable Programmable Read Only Memory (EEPROM) communication.
4. The ignition supply is greater than 10.5V and the calculated EEPROM checksum does not match the stored checksum. This indicates an EEPROM checksum fault.
5. The engine speed is greater than 992 rpm and the permanent voltage supply to the TCM is less than 10V. This indicates a permanent voltage supply fault.
6. The ignition supply is greater than 10.5V and the internal TCM voltage is less than 4.5V or greater than 5.5V.

Transmission Control Module								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Transmission Control Module	P1613	Internal relay continuity	Voltage (sticks open)	< Ignition supply – 2V	Ignition Supply	> 10.5V	0.060 sec	2 driving cycles
	P1612	Internal relay continuity	Relay (sticks closed)	< Ignition supply – 2V	Ignition Supply	> 10.5V	0.200 sec	
	P1606	EEPROM communication	No communication	No internal communications	Ignition Supply	> 10.5V	1 sec	Immediate
	P1601	EPROM checksum	Checksum value	Corrupted data	Ignition Supply	> 10.5V	60 sec	
	P1562	Permanent voltage supply	Voltage	< 10V	Engine speed	> 992 rpm	0.300 sec	no
	P1606	TCM functional check (watchdog)	Internal Voltage	< 4.5V or > 5.5V	Ignition Supply	> 10.5V	0.070 sec	2 driving cycles

If the above table does not include details of the following enabling conditions: - Intake Air Temperature (IAT), Engine Coolant Temperature (ECT), vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.



3.2 System Interfaces

3.2.1 Description

The CAN bus, introduced on 99MY petrol vehicles, provides the communication link between the ECM and the TCM. Inputs and outputs to and from each control module are transmitted via two twisted wire connections, CAN high and CAN low. The CAN bus allows more engine data to be passed to the TCM which, on earlier vehicles, would require a number of additional hardwired connections. The additional engine data is used by the TCM to give improved transmission quality and allows the TCM to operate in a greater number of default modes in the event of sensor failure. Inputs and outputs on the CAN communication bus are listed in the table that follows.

Inputs from ECM

- €# CAN version identifier
- €# Emissions (OBDII) control
- €# Engine IAT
- €# Engine speed
- €# Engine speed fault flag
- €# ECT
- €# Engine torque
- €# Engine torque fault flag
- €# Friction torque
- €# Maximum engine torque
- €# Reduced engine torque
- €# Road speed
- €# Status of engine speed torque reduction
- €# Throttle position

Outputs to ECM

- €# Calculated gear
- €# Diagnostic information
- €# Emission (OBDII) fault status
- €# Engine torque reduction request
- €# Gear position switch information
- €# Output shaft speed
- €# Mode information
- €# Shift information
- €# TCC lock-up solenoid



There are five CAN diagnostics, a fault is detected if: -

1. The ignition supply is greater than 9V and no signal or an invalid signal has been received by the TCM.
2. The ignition supply is greater than 9V, and the engine speed is greater than 460 rpm or less than 128 rpm and no CAN messages have been received by the TCM.
3. The ignition supply is greater than 9V and the throttle angle, engine speed, torque signal, ECT, road speed, IAT or altitude information is out of range, contains an error flag or incorrect flag.
4. The ignition supply is greater than 9V and there is a continuity fault with CAN low or CAN high.
5. The road speed is greater than 3.11mph and the ratio of road speed to output shaft speed exceeds a threshold ratio.

System Interfaces								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
System Interfaces	P1842	CAN level monitoring	Error flag / Timeout	invalid / no signal	Ignition Supply	> 9V	1.5 sec	2 driving cycles
	P1843	CAN timeout monitoring	No messages received	No Message	Ignition Supply Engine Speed Engine Speed	> 9V > 460 rpm < 128 rpm	0.010 sec	
	P1884	CAN message - Throttle Angle CAN message - Engine Speed CAN message - Torque Signal	Error flag / out of range Incorrect flag / out of range Error flag / out of range	Range/Performance Range/Performance Range/Performance	Ignition Supply	> 9V	0.010 sec	
	P1841	CAN bus fault	Wiring check	Continuity	Ignition Supply	> 9V	0.030 sec	immediate
	P1884	CAN message – ECT CAN message - Road Speed CAN message - IAT CAN message - Altitude	Incorrect flag / out of range Incorrect flag / out of range Incorrect flag / out of range Incorrect flag / out of range	Range/Performance Range/Performance Range/Performance Range/Performance	Ignition Supply	> 9V	0.010 sec	No
	P1705	High / Low Range plausibility	Road speed & Output shaft speed	Ratio	Road Speed	> 3.11 mph	0.010 sec	

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.



3.3 End of Line Programming

3.3.1 Description

The TCM contains two calibrations for 4.0 and 4.6 litre engines. When a replacement TCM is fitted, the correct calibration must be selected or the control module will store a gearbox fault and 'GEARBOX FAULT' will be displayed in the message centre. The vehicle can still be driven and is not in 'limp home mode'.

End of Line Programming								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
End of Line Programming	P1602	Incorrect / invalid calibration	Error flag / out of range	invalid selection	Ignition Supply Tune Flag	> 9V <> 0 or 1	0.300 sec	2 driving cycles

If the above table does not include details of the following enabling conditions: - IAT, ECT, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.



3.4 Shift Solenoids

3.4.1 Description

To provide the different driving characteristics for each mode of operation, the TCM incorporates different shift maps of throttle position/road speed. Base shift points are derived from the appropriate shift map. When a shift is required, the TCM sends a request to the ECM for a reduction in engine torque, in order to produce a smoother shift. The percentage of torque reduction requested varies according to the operating conditions at the time of the request. When the TCM receives confirmation of the torque reduction from the ECM, it then signals the shift solenoid valves in the gearbox to produce the shift. To further improve shift quality, the TCM also signals the pressure regulating solenoid valve to modulate the hydraulic pressure and so control the rate of engagement and disengagement of the brake clutches.

There are two diagnostic checks for each shift solenoid, an error is detected if: -

1. The ignition supply is greater than 9V and the solenoid voltage is greater than 2.5V with the driver off. This indicates a short circuit to battery positive.
2. The ignition supply is greater than 9V and the solenoid voltage is less than 3.5V with the driver on. This indicates an open circuit or a short circuit to ground.

Shift Solenoids								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Shift Solenoid 1	P0753	Solenoid valve - Electrical	Voltage (short circuit to battery positive)	> 2.5V	Ignition Supply	> 9V	0.010 sec	2 driving cycles
		Solenoid valve - Electrical	Voltage (open circuit or short circuit to ground)	< 3.5V	Output Voltage Ignition Supply Output Voltage	= Low > 9V = High	0.020 sec	
Shift Solenoid 2	P0758	Solenoid valve - Electrical	Voltage (short circuit to battery positive)	> 2.5V	Ignition Supply	> 9V	0.010 sec	2 driving cycles
		Solenoid valve - Electrical	Voltage (open circuit or short circuit to ground)	< 3.5V	Output Voltage Ignition Supply Output Voltage	= Low > 9V = High	0.020 sec	

If the above table does not include details of the following enabling conditions: - IAT, ECT, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.



3.5 Torque Converter Clutch Solenoid

3.5.1 Description

The TCM energises the lock-up solenoid valve to engage the lock-up clutch. Lock-up clutch operation is dependent on throttle position, engine speed, operating mode and the range selected on the transfer box. Unique lock-up maps, similar to the shift maps, are incorporated in the economy and sport modes for all forward gears. Engagement and disengagement of the lock-up clutch is dependent on throttle position and engine speed.

There are four TCC solenoid diagnostics, an error is detected if: -

1. The ignition supply is greater than 9V and the solenoid voltage is greater than 2.5V with the driver off. This indicates a short circuit to battery positive.
2. The ignition supply is greater than 9V and the solenoid voltage is less than 3.5V with the driver on. This indicates an open circuit or a short circuit to ground.
3. Warm up is complete, the transfer box is in high range, engine torque is greater than 100Nm, the TCC is closed and the TCC performance is out of range.
4. The ignition supply is greater than 9V, there is no gear ratio fault and the TCC performance is out of range.

Torque Converter Clutch Solenoid								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Torque Converter Clutch Solenoid	P0743	TCC - Electrical	Voltage (short circuit to battery positive)	> 2.5V	Ignition Supply	> 9V	0.010 sec	2 driving cycles
		TCC - Electrical	Voltage (open circuit or short circuit to ground)	< 3.5V	Output Voltage Ignition Supply Output Voltage	= Low > 9V = High		
	P0741	TCC - Performance	Out of range	Ratio	Warm-up Transfer Gears Engine Torque TCC	Complete High Range > 100 Nm Closed	2.5 sec	2 driving cycles
	P0722	TCC - Performance (stall speed)	Out of range	Ratio	Ignition Supply Gear Ratio Fault	> 9V False		

If the above table does not include details of the following enabling conditions: - IAT, ECT, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.



3.6 Pressure Regulator Solenoid

3.6.1 Description

The lock-up and brake clutches are operated by pressurised transmission fluid from the valve block in the sump. The pressure regulator solenoid valve modulates the pressure of the supplies to the brake clutches, to control shift quality.

There are two diagnostic checks of the pressure regulator solenoid, an error is detected if: -

1. The ignition supply is greater than 9V and edge detection has indicated a short circuit to battery positive.
2. The ignition supply is greater than 9V and edge detection has indicated an open circuit or a short circuit to ground.

Pressure Regulator Solenoid								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Pressure Regulator Solenoid	P0748	Pressure regulator - Electrical Pressure regulator - Electrical	Voltage (short circuit to battery positive) Voltage (open circuit or short circuit to ground)	Edge Detection (0.004 sec)	Ignition Supply	> 9V	0.150 sec	2 driving cycles

If the above table does not include details of the following enabling conditions: - IAT, ECT, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.



3.7 Transmission Range Switch (Park, Reverse, Neutral, Drive) – Range Rover Only

3.7.1 Description

The transmission range switch on the transmission passes gear selection signals to the TCM. The signals are interpreted by the TCM for the correct gear selection and the appropriate control signals are output to an electro-hydraulic valve block in the transmission.

There are two diagnostic checks of the transmission range switch, an error is detected if: -

1. The ignition supply is greater than 9V and an incorrect position code has been received.
2. The ignition supply is greater than 9V, the engine is cranking and the position code does not indicate a park or neutral state.

Transmission Range Switch – Range Rover only								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Transmission Range Switch	P0705	Position switch input (permanent)	Incorrect code	Coded input	Ignition Supply	> 9V	0.100 sec	2 driving cycles
		Position switch input (cranking)	Must be Neutral or Park	Coded input	Ignition Supply	> 9V	0.010 sec	

If the above table does not include details of the following enabling conditions: - IAT, ECT, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.



3.8 Gear Ratio Functional Check

3.8.1 Description

There are five gear ratio function diagnostic checks, an error is detected if: -

1. All enabling conditions are satisfied and the ratio of engine speed to output shaft speed whilst 1st gear is engaged is out of range.
2. All enabling conditions are satisfied and the ratio of engine speed to output shaft speed whilst 2nd gear is engaged is out of range.
3. All enabling conditions are satisfied and the ratio of engine speed to output shaft speed whilst 3rd gear is engaged is out of range.
4. All enabling conditions are satisfied and the ratio of engine speed to output shaft speed whilst 4th gear is engaged is out of range.
5. All enabling conditions are satisfied and the transmission control unit has prevented a gearshift, which would have caused an engine over speed.

Gear Ratio Functional check								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Gear Ratio Functional Check					Ignition Supply Engine Torque Warm up Transfer Gears Engine Speed Throttle Angle Throttle Change Engine State Selector Position TCC	> 9V > 80 Nm Complete High Range > 0 rpm < 90 % < 20 %/sec Not Overrun Drive, 3, 2 or 1 No change	3.5 sec	2 driving cycles
	P0731	Gear ratio - 1st	Ratio out of range	Ratio	Gear Selected	1 st		
	P0732	Gear ratio - 2nd			Gear Selected	2 nd		
	P0733	Gear ratio - 3rd			Gear Selected	3 rd		
	P0734	Gear ratio - 4th			Gear Selected	4 th		
	P0721	Downshift safety monitoring	Incorrect gear selection	Engine overspeed	Engine Speed	3680 rpm	0.010 sec	