Next to the rotary control switch are mounted a series of four LED's. An illuminated LED indicates which ride height is active. If a new ride height is selected using the rotary control switch, the 'current' height LED remains illuminated and the 'requested' height LED flashes until the vehicle achieves the new ride height. If a new ride height is selected using the rotary control switch and the 'current' height LED flashes briefly, this indicates that the ride height selection is invalid and will not be performed. When the operating parameters are correct for the new ride height, the height change request must be repeated.

Standard Ride Height

Standard ride height is used during most driving conditions. This setting is used as a datum for the remaining ride heights, and is defined as 0 mm. All other ride height settings are described as above or below this setting. The standard ride height can be active at any vehicle speed.

Access or off-road ride height can be selected from standard ride height using the rotary control or the drivers door access switch.

When the vehicle is in standard ride height, the 'Hold' switch can be selected. This prevents automatic height changes from taking place and disables manual height changes until the 'Hold' switch is deselected. If a height change is selected with the hold function active, the standard height LED will flash.

When towing, the electrical connection of the trailer socket will cause the vehicle to set the air suspension to standard height. No other height setting is available whilst towing.

Off-Road Ride Height

Off-road ride height is the highest of the four settings, and raises the front of the vehicle by 60 mm, and the rear of the vehicle by 50 mm. Off-road ride height is selected by turning the rotary switch upwards when the vehicle is travelling at less than 31 mph (50 km/h). The suspension will return to the standard ride height setting if the rotary control switch is turned downwards, or vehicle speed rises above 31 mph (50 km/h).

If the vehicle is travelling too fast when off-road ride height is selected, the standard road height LED will flash, and the request will not be carried out. The driver must repeat the off-road ride height request once the vehicle speed is reduced.

When the vehicle is in the off-road ride height setting, the 'Hold' switch will not be operational. Similarly, if the vehicle is in the standard ride height setting with 'Hold' selected, the vehicle will not move into the off-road ride height setting until 'Hold' is deselected.

Motorway Ride Height

Motorway ride height lowers the vehicle by 20 mm, and improves the high speed handling of the vehicle. Motorway ride height is only active when the vehicle is travelling at more than 62 mph (100 km/h) for more than 30 seconds, and is not selectable by the driver.

If the vehicle speed falls to below 43 mph (70 km/h) for more than 60 seconds, the ECU automatically returns the vehicle to the standard ride height setting. If the vehicle stops while the motorway ride height is active, the timer is paused, stopping the vehicle rising unnecessarily.

Although motorway ride height isn't selectable by the driver, the 'Hold' switch can be used to keep the motorway ride height active, and prevent the automatic return to the standard ride height. The vehicle will return to the standard ride height once the 'Hold' switch is deselected (and vehicle speed is less than 43 mph (70 km/h).

Motorway ride height may be deselected by the driver at any speed by turning the rotary control switch upwards. The vehicle may return to motorway ride height if the vehicle speed remains greater than 62 mph (100 km/h) and the driver does not select 'Hold' when the vehicle has returned to standard ride height.

If the vehicle speed is within the required parameters, the driver can select access ride height by turning the rotary control switch downwards or pressing the access switch on the drivers door.

Access Ride Height

Access ride height lowers the vehicle by 40 mm when the vehicle is stationary or moving at very low speeds in order to improve ease of access to the vehicle. Access ride height can be selected by operating the access switch on the drivers door module when the vehicle is in standard, off-road or motorway ride heights or by turning the rotary control switch downwards when the vehicle is in standard or motorway ride heights.

Access ride height has three different modes of operation:

- Access Height
- Access Pre-Select
- Crawl Mode.

Access Height

If the vehicle is stationary or travelling at less than 15 mph (25 km/h) 'Access Height' mode can be selected. If vehicle speed increases to more than 18 mph (30 km/h) the vehicle automatically returns to the standard ride height.

Access Pre-Select

If the vehicle is travelling below 49 mph (80 km/h) and access ride height is selected, the vehicle enters the 'Access Pre-Select' mode. The ECU acknowledges this request by flashing the 'Access' LED, but the height of the vehicle does not change immediately. If the vehicle is travelling above 49 mph (80 km/h) and access ride height is selected, the 'Standard' LED will flash and the request will be denied.

When access pre-select mode is active, the vehicle will automatically lower to Access ride height if the speed drops below 15 mph (25 km/h) within 65 seconds of the request being made. If the vehicle speed rises above 49 mph (80 km/h) after 'Access Pre-Select' mode is selected, or if it takes longer than 65 seconds to come to rest, access ride height will not be activated and the vehicle will remain at its current height.

Crawl Mode

Crawl mode does not change the vehicle height, but inhibits manual height changes and allows the vehicle to be driven at a higher speed than in normal access mode.

Crawl mode is activated when the vehicle is at the access ride height and 'Hold' is selected. If 'Access Height' has been selected, but the air suspension ECU has not lowered the vehicle because the road speed is too high, when 'hold' is selected the 'Access Height' request is cancelled and the vehicle remains at standard ride height. The 'Hold' button remains active so that all automatic and manual height changes are disabled.

Crawl mode allows the vehicle to be driven at speeds up to 25 mph (40 km/h) without returning to the standard ride height. If the vehicle speed reaches 22 mph (35 km/h), a chime will sound from the instrument pack sounder and the message centre will display a 'SLOW DOWN' warning message. If the vehicle speed exceeds 25 mph (40 km/h), crawl mode is cancelled and standard ride height will become active automatically.

System Inhibits

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

Compressor

The temperature sensor located within the compressor protects the compressor from overheating. If the compressor temperature rises above set limits, the ECU will inhibit compressor operation. These limits are shown in the table below:

	Filling Reservoir	Height Regulation
Stop	100 °C (212 °F)	110 °C (230 °F)
Start	80 °C (176 °F)	105 °C (221 °F)

Compressor Timeout

Compressor operation will be halted after 180 seconds of continuous operation. If the compressor was attempting to regulate vehicle height, it remains inhibited for 20 seconds. If the compressor was attempting to fill the air suspension reservoir, it remains inhibited for 180 seconds. These time out functions act as a further safe guard against over heating.

Cornering
If the air suspension ECU registers a cornering force greater than 0.2g it will inhibit all height changes and corrections. The system will remain inhibited until the cornering force falls to less than 0.15g for 0.5 seconds. The air suspension ECU receives a message from the ABS sensor on the CAN Bus for the cornering force.

Rapid Acceleration
If the air suspension ECU registers a rapid acceleration greater than 0.2g it will inhibit all height changes and corrections. The system will remain inhibited until the rapid acceleration falls to less than 0.2g for 1 second. Acceleration is calculated by the ECU from a vehicle speed signal received via the CAN bus.

Rapid Deceleration
If the air suspension ECU registers a rapid deceleration smaller than – 0.2g it will inhibit all height changes and corrections. The system will remain inhibited until the rapid deceleration rises above – 0.2g for 1 second. Deceleration is calculated by the ECU from a vehicle speed signal received via the CAN bus.

Axle Articulation
To avoid excess pressure differentials between different air springs, the air suspension ECU will inhibit all height changes and corrections if axle articulation is greater than 350 mm. The system will remain inhibited until axle articulation falls below 350 mm.

Vehicle Lift
The air suspension ECU will inhibit all height changes and corrections if it detects all four corner heights are greater than 90 mm. This is interpreted as the vehicle being on a wheels free car lift with all wheels hanging freely. In this situation, the corner heights will not change when air is released from the air springs. The system will remain inhibited until any of the following conditions exist:
- All four corner heights fall below 90 mm
- The rotary switch is moved to the 'UP' or 'DOWN' position.
- Vehicle speed rises to greater than 25 mph (40 km/h) for longer than 3 seconds.

Vehicle Jack
The air suspension ECU will inhibit all height changes and corrections if it detects a corner lowering too slowly for more than 3 seconds. This is interpreted as the corner identified as moving too slowly being supported on a jack. In this situation, the corner height will not change when air is released from the air spring because the jack acts as a mechanical prop. The system will remain inhibited until any of the following conditions exist:
- The height of the wheel identified as lowering too slowly, returns to the height where jacking was detected.
- The rotary switch is moved to the 'UP' or 'DOWN' position.
- Vehicle speed rises to greater than 25 mph (40 km/h) for longer than 3 seconds.

Door Open
The air suspension ECU will stop all height change requests while any of the doors are open. Vehicle levelling is also inhibited with a door open.

Trailer Mode
Using the electrical trailer connection will cause the air suspension to be set to standard height. If the vehicle is at any other height when the trailer is connected the air suspension will adjust to standard height and stay in that mode until the trailer is disconnected.

Diagnostics
The air suspension ECM can store fault codes which can be retrieved using TestBook/T4. The diagnostics information is obtained via the diagnostic socket which is located in the fascia, in the drivers stowage tray. The socket is secured in the fascia panel and protected by a hinged cover.

The diagnostic socket allows the exchange of information between the various ECU's on the bus systems and TestBook/T4 or a diagnostic tool. This allows the fast retrieval of diagnostic information and programming of certain functions using TestBook/T4 or a suitable diagnostic tool.

Fault Detection

The air suspension ECU performs fault detection and plausibility checks. Fault detection is limited to faults that the ECU can directly measure, as follows:

- Sensor hardware faults
- Valve hardware faults
- Sensor and actuator supply faults
- Bus failures
- ECU hardware errors.

Plausibility checks are checks on signal behaviour, as follows:

- Average height does not change correctly
  - Height changes too slowly
  - Suspension moves in the wrong direction.
- Reservoir pressure
  - Does not increase when reservoir filling requested
  - Does not decrease when reservoir used to lift vehicle
  - Does not decrease when reservoir is vented
  - Pressure varies too much when inactive.
- Compressor temperature
  - Increases when compressor inactive
  - Does not increase when compressor active.
- 'Energy' used to change height of corner
  - Too much 'energy' used – height change takes too long or long term filtered height does not reach target.
- Sensor activity
  - Signal floating
  - Inconsistent signal characteristics – signal on one side of axle is varying but other side remains static
  - Constant articulation when moving.

When a fault is detected, the ECU will attempt to maintain a comfortable ride quality with restricted functionality of the air suspension system.

The system functionality depends on the severity of the fault. The faults are defined as minor or major faults.

Minor faults are:

- Most sensor faults (hardware faults and plausibility faults)
- Cross link valve failure
- Reservoir valve failure.

For most minor faults, height changes are inhibited except for a return to standard height. If the suspension is not in standard height, the ECU will respond to a request for manual or automatic height change to return the vehicle to standard height. The ECU will continue to level the vehicle at the 'current' ride height.

Major faults are:

- Compressor faults
- Plausibility errors – for example:
  - Average height does not increase when lifting and the vehicle is moving. This could be caused by a compressor fault or a fault in the reservoir valve.
  - Reservoir pressure decreases when filling requested. This could be caused by a leak in the common gallery in the valve block or connecting pipe.

For major faults the ECU will not level the vehicle at the 'current' ride height. The ECU freezes height changes until it receives a manual or automatic request for height change. The ECU will return to standard height and freezes once standard height is achieved.

If the air suspension ECU loses information regarding vehicle speed, the ECU cannot determine if the current ride height is suitable for the vehicle speed. The ECU immediately returns to the 'default' height, which is 20 mm below the standard height. Once at the default height, the ECU will continue to level the vehicle at this height. A loss of the speed signal could be due to a fault in the CAN Bus or a fault in the ABS ECU. It is unlikely to be a fault in the air suspension ECU. It may, for example, be caused if the battery is disconnected and the steering sensor is not recalibrated immediately after reconnection. In this case a CAN Bus fault is recorded in the error memory. If this fault is seen, other ECU's using the CAN Bus should be also be checked for faults. When the fault is repaired, the air suspension ECU will resume full functionality but the CAN error remains in the memory.

If the suspension is above the standard height and the air suspension ECU cannot lower the suspension or cannot determine the vehicle height, all height changes will be frozen. The ECU will issue a message on the CAN Bus which is received by the instrument pack which displays a maximum advisable speed in the message centre of '35MPH'. an immediate 'freeze' of the vehicle height is caused by the following:

- Failure of more than one height sensor
- Implausible articulation symptoms detected
- Valve or solenoid failure (does not include reservoir valve)
- Stuck corner or whole vehicle (diagnosed using plausibility of the sensor inputs).

If the air suspension ECU has a hardware fault, the ECU will disable all air suspension functions. Detectable hardware errors include memory error, ECU failure, calibrations errors.

Fault Messages

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

When minor faults occur and the air suspension ECU is able to level the vehicle to the 'current' ride height, the control switch LED's will display the current ride height. When the vehicle returns to the standard ride height and further height changes are disabled, the 'HOLD' LED in the control switch will be permanently illuminated.

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

If a fault occurs and the ECU can determine the ride height and the vehicle is not above standard ride height, the driver will be notified via a 'AIR SUSP. INACTIVE' message in the message centre. If the ECU cannot determine the height of the vehicle, or the vehicle is above standard ride height and cannot be lowered, the 'AIR SUSP. INACTIVE' message is accompanied with an alternating 'MAX 35MPH' message.

Operation

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

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

When the engine is not running, the 'dead band' target height tolerance is increased to +20 mm and -25 mm. During 'wake-up', the tolerance band is ±20 mm. In all cases, the ECU will bring the corner height as close as possible to the target height. The ECU monitors the rate of change of height of the corner signals to predict when to close the valve so that the target height is not overshot.

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

If an upwards height change request is made when the engine is not running, air pressure within the reservoir is used to lift the vehicle. If the pressure within the reservoir has dropped below 9 bar (130 lbf/in^2) when an upwards height change request is made, the lift procedure is performed by the compressor. When the engine is started, the ECU runs the compressor to increase reservoir pressure to:

- 13.7 bar (199 lbf/in^2), in systems without an external pressure relief valve
- 11.8 bar (171 lbf/in^2), in systems with an external pressure relief valve

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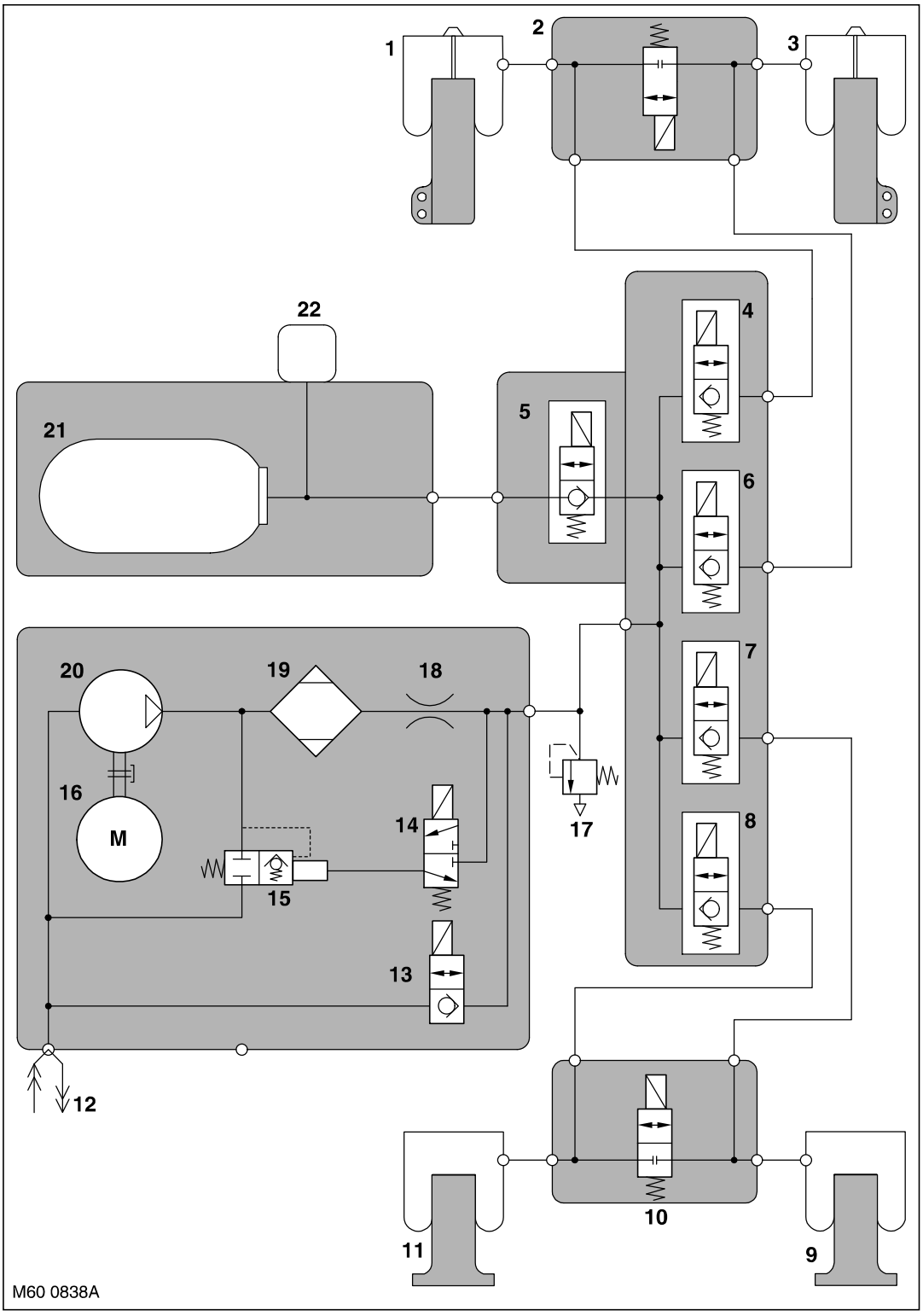
System Pneumatic Circuit

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

System Schematic Circuit Diagram



1 Front LH damper air spring
2 Front cross link valve
3 Front RH damper air spring
4 Front LH corner valve
5 Reservoir valve
6 Front RH corner valve
7 Rear RH corner valve
8 Rear LH corner valve
9 Rear RH air spring
10 Rear cross link valve
11 Rear LH air spring
12 Compressor inlet/exhaust port
13 HP pressure exhaust valve
14 Exhaust pilot valve
15 Pressure limiting valve
16 Electric motor
17 External pressure relief valve (where fitted)
18 Restrictor
19 Drier
20 Compressor
21 Reservoir
22 Pressure sensor