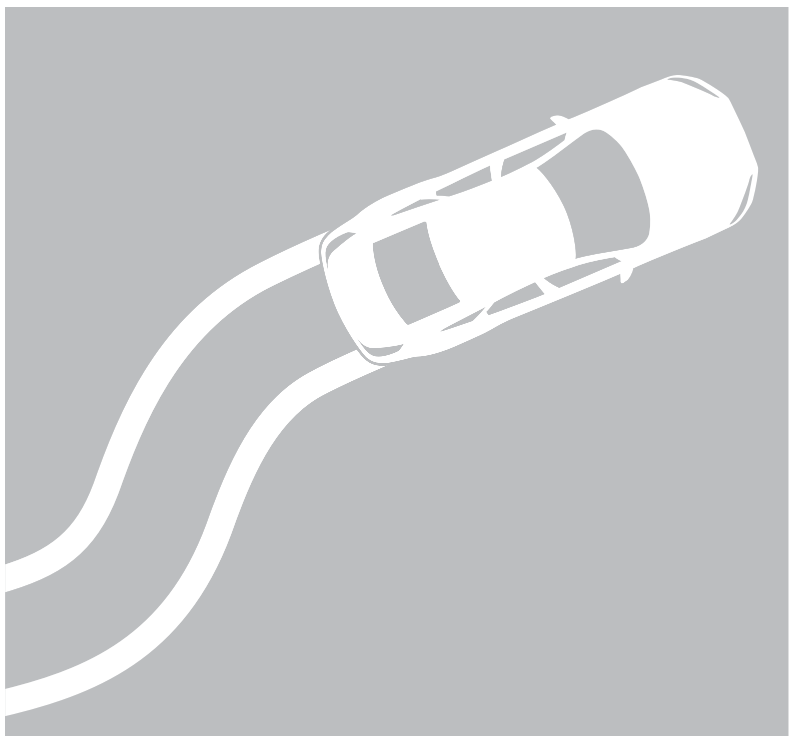
Technical Training
Chassis Systems

452-JAG: Chassis Systems



Adaptive Dynamics Systems

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Adaptive Damping System: 2007 – 2009 MY

Vehicle Dynamic Suspension: 2010 MY Onward

ADAPTIVE DAMPING SYSTEM: 2007 – 2009 MY

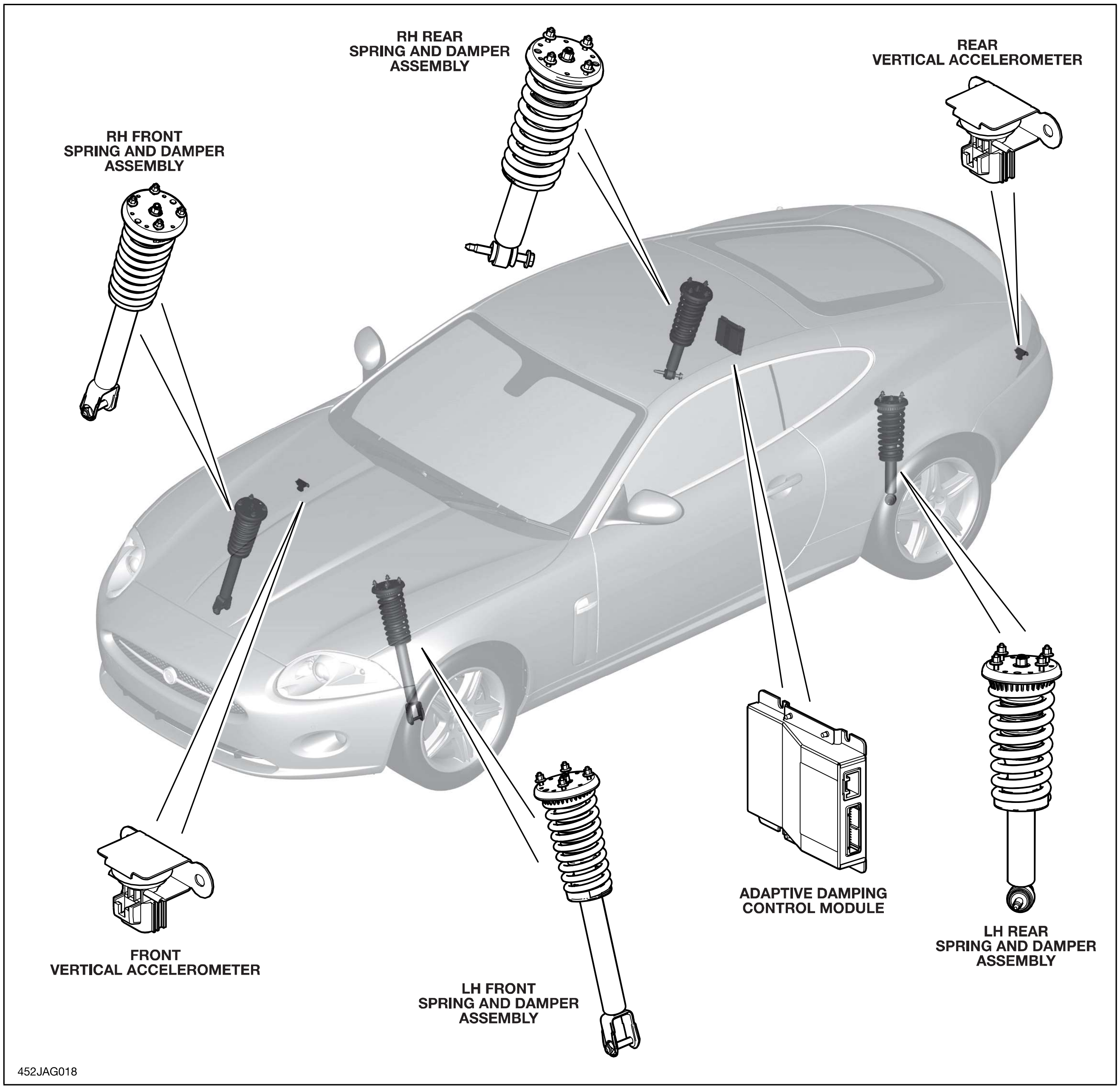
Overview

The Adaptive Damping System, also known as Computer Active Technology Suspension (CATS), is an electronically-controlled suspension system that constantly adjusts the damping characteristics of the suspension dampers in response to the existing driving conditions. The Adaptive Damping System is available on specified models.

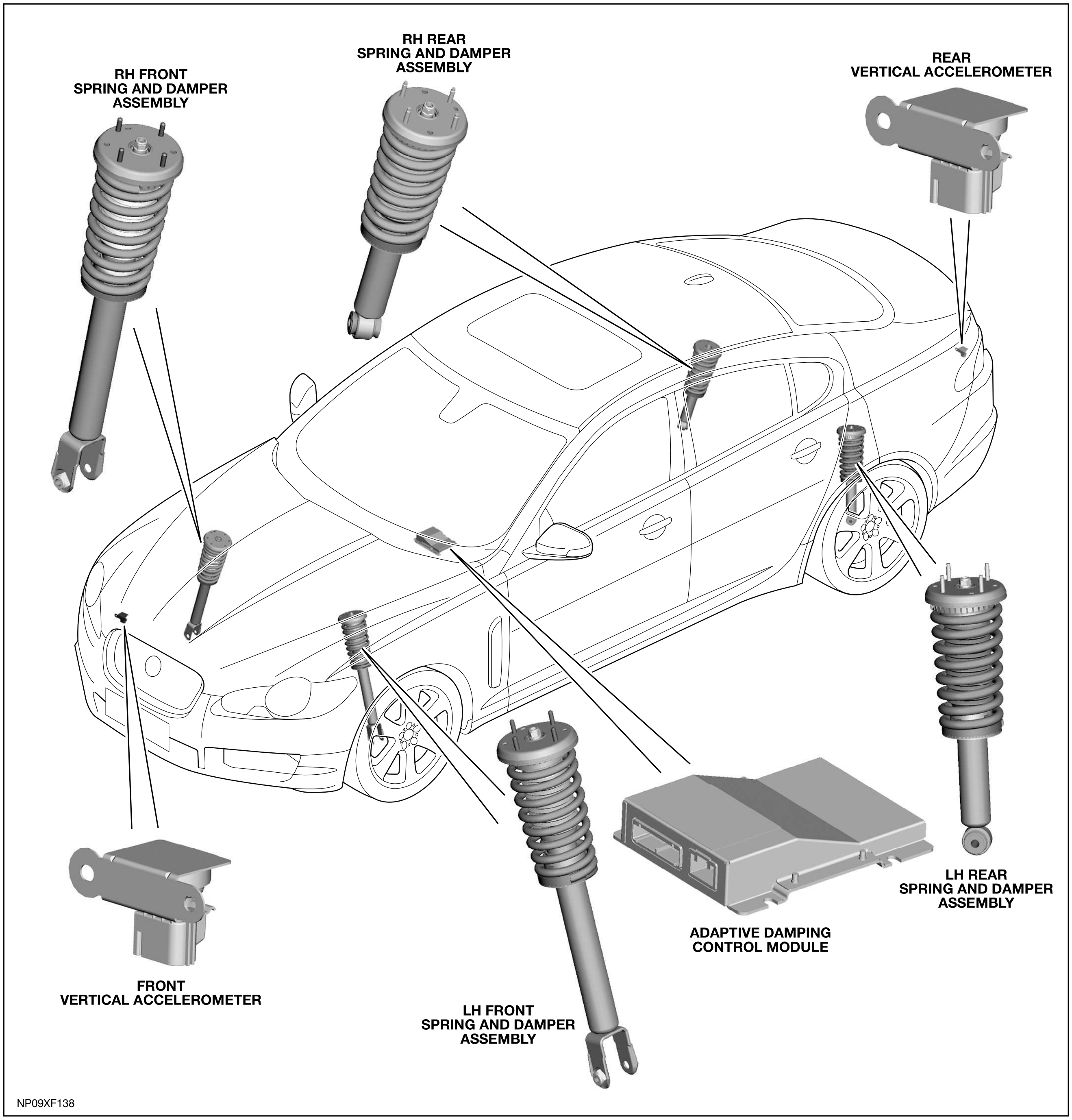
The system is controlled by an Adaptive Damping Control Module (ADCM), which receives signals from two dedicated vertical accelerometers – one at the front of the vehicle and one at the rear. The ADCM also monitors driver inputs and signals from other vehicle systems, and controls the characteristics of each damper ('firm' or 'soft' setting) to give the optimum vehicle ride for the prevailing driving conditions.

The ADCM is located behind the backrest of the RH rear passenger seat on X150 and beneath the passenger seat on X250.

X150 Adaptive Damping System Components



X250 Adaptive Damping System Components



Component Description

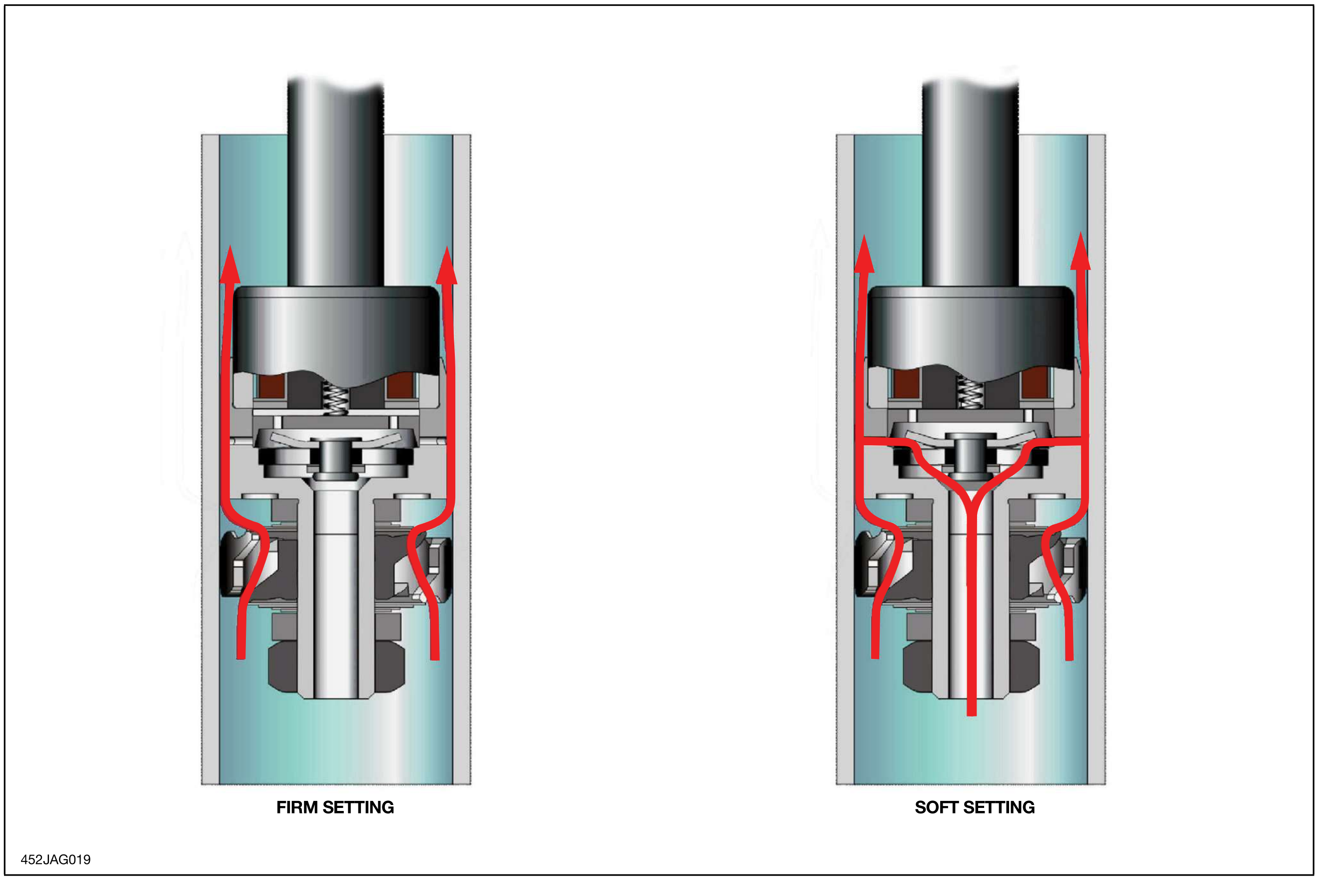
Dampers

The adaptive dampers are nitrogen-gas and oil-filled monotube units. The dampers have a two-stage adjustment that allows the damping force to be electrically adjusted while the vehicle is being driven. The two-stage dampers provide the optimum compromise between performance handling and ride comfort.

The adaptive dampers can be easily identified by an electrical connector on the end of the piston rod, in the center of the top mount.

The two-stage adjustment is achieved by a solenoid controlled valve. When the solenoid valve is de-energized, the damper is on its firm setting and oil flow is restricted to a controlled rate through orifices in the damper piston. The restricted oil flow stiffens the damper action, thereby improving handling during braking, accelerating, and cornering.

The solenoid is connected to a bypass valve that allows additional oil flow through the damper. When the solenoid is energized, the valve is lifted from its seat, allowing oil to flow through a hollow piston rod in the center of the damper piston and out through additional orifices. The increased oil flow softens the damper action, providing a more comfortable ride quality.



The solenoid is operated by a 400 Hz Pulse Width Modulated (PWM) signal from the Adaptive Damping Control Module. When energized, the module applies a 1.3 amp 'push' current for 75 milliseconds to move the valve, and then applies a 0.5 amp 'hold' current to operate the damper in the 'soft' setting.

Vertical Accelerometers

Two accelerometers are used by the Adaptive Damping System, located as follows:

- **X150**
  - The front sensor is located in the rear of the RH front wheel arch, behind the washer reservoir.
  - The rear sensor is mounted in the luggage compartment, in the rear LH corner adjacent to the rear lamp assembly.
- **X250**
  - The front accelerometer is attached to the bracket of the RH engine oil cooler
  - The rear accelerometer is mounted in the luggage compartment, in the rear LH corner next to the tail lamp assembly.

The accelerometers measure acceleration in the vertical plane and output a corresponding analog signal to the Adaptive Damping Control Module (ADCM). Each accelerometer is connected to the ADCM via three wires, which supply ground, 5V supply, and signal return.

The accelerometers are of the capacitive type. The sensing element comprises two parallel plate capacitors, which alter the peak voltage that is generated by an internal oscillator when the accelerometer is subjected to acceleration. Detection circuits within the accelerometer measure the peak voltage and pass an analog output signal to the ADCM. The accelerometers output a signal voltage of approximately 1 V/g ± 0.05 V/g.

Principles of Operation

The Adaptive Damping Control Module (ADCM) uses a combination of information from other system modules and data from the accelerometers to measure the vehicle motion and driver inputs. Using this information, the module applies algorithms to control the dampers for the existing driving conditions.

The ADCM receives signals on the high speed CAN bus from the following system components:

- **Anti-Lock Braking (ABS) module**
  - Vehicle speed
  - Brake pressure
  - Lateral acceleration
  - Steering angle sensor signals for steering wheel speed and angle
- **Engine Control Module (ECM)**
  - Brake switch status
  - Throttle pedal position
  - Engine speed
  - Engine running status
- **Transmission Control Module (TCM)**
  - Gear position
- **Central Junction Box (CJB)**
  - Power mode
- **Auxiliary Junction Box (AJB)**
  - Car Configuration File Data
  - Master configuration identification
  - Vehicle information parameters

The ADCM also outputs information for use by other systems as follows:

- **Instrument Cluster**
  - Computer Active Technology Suspension (CATS) fault
- **ECM**
  - Front left damper status
  - Front right damper status
  - Rear left damper status
  - Rear right damper status

When the vehicle is stationary with the engine running, the dampers are set to the ‘soft’ setting.

With the vehicle in motion, the ADCM monitors the input signals and operates the damper solenoids appropriately. The input signals are compared against algorithms within the ADCM and preset speed thresholds. The gear position signal is also used to determine longitudinal detection and, along with the speed signal, is compared against algorithms to select the appropriate ‘soft’ or ‘firm’ damper setting.

Because the ‘firm’ setting provides better vehicle control in all driving conditions, the ‘firm’ setting has a higher priority than the ‘soft’ setting. The dampers are set to ‘firm’ when driving at high speeds or when a system fault is detected.

The ADCM receives its power supply via a relay in the CJB. To allow the ADCM to record and store any fault codes relating to the Adaptive Damping System, the relay will remain energized for a period of time after the ignition is switched off.

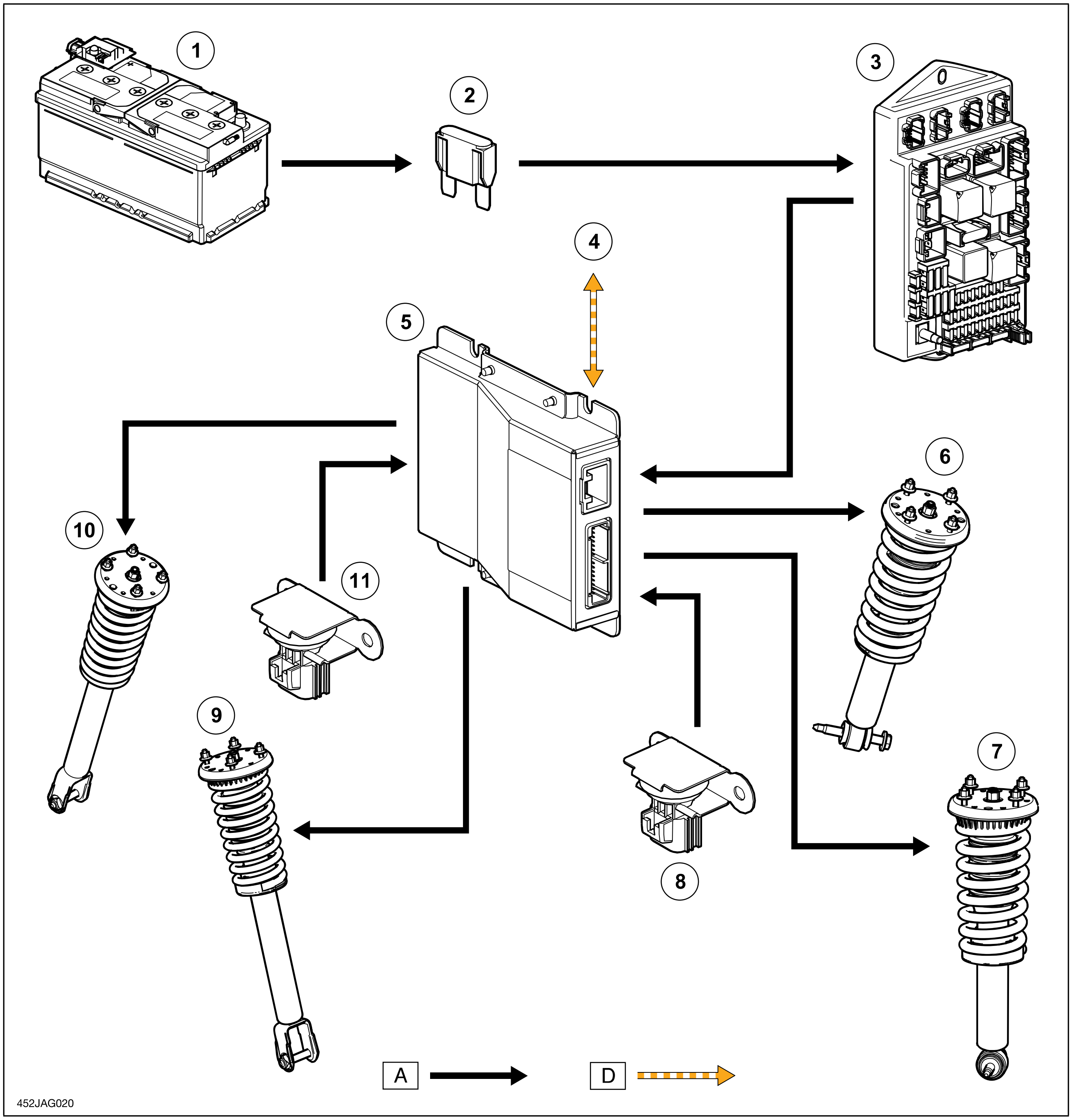
Adaptive Damping System Fault Message

The ADCM communicates with the instrument cluster on the high speed CAN bus. If a fault is detected by the ADCM, a message is sent to the instrument cluster and a ‘CATS SYSTEM FAULT’ message is displayed.

An appropriate Diagnostic Trouble Code (DTC) will be logged. DTCs can be retrieved using the Jaguar-approved diagnostic system.

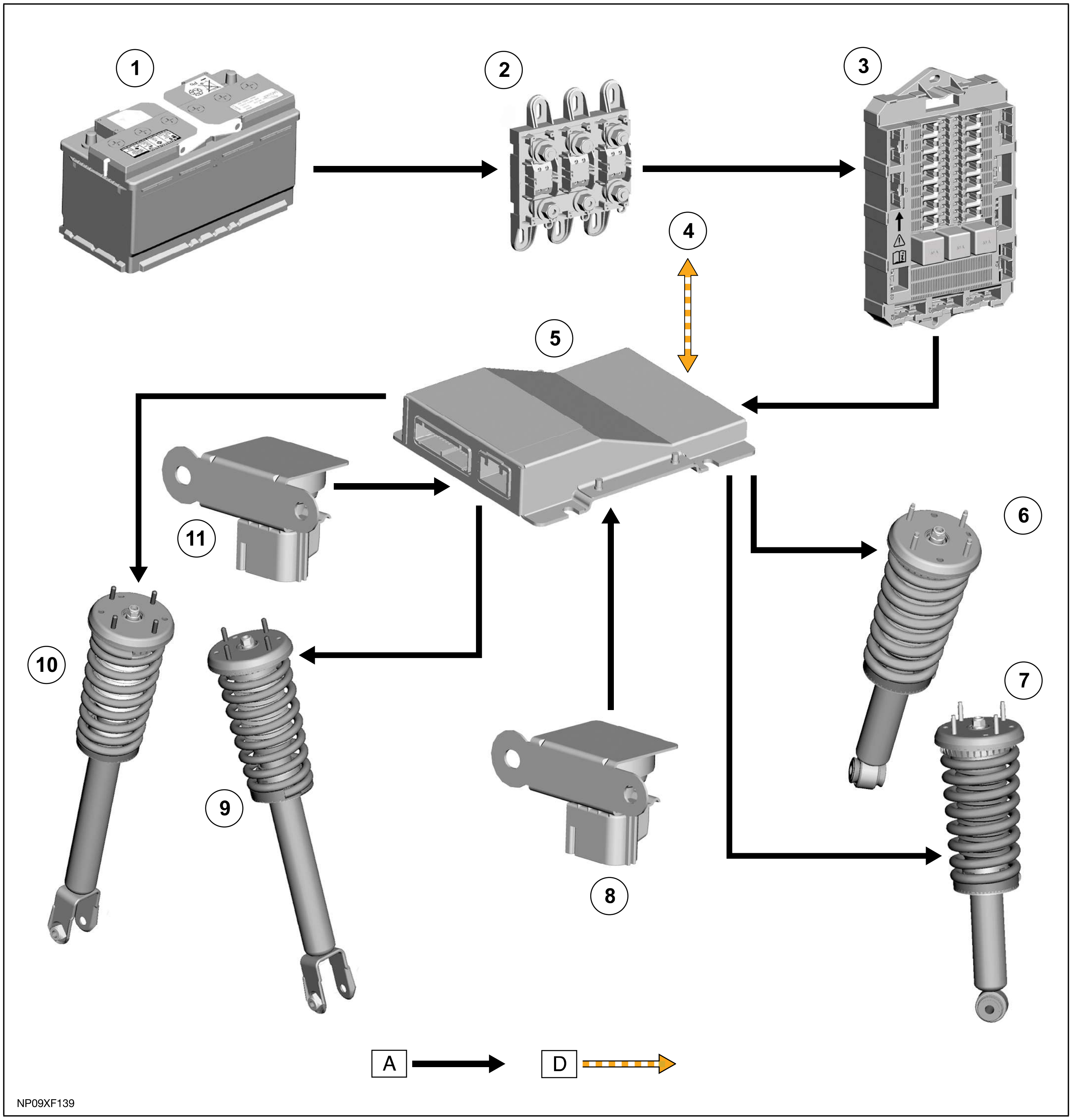
When a fault is detected, the ADCM stops outputs to the dampers; the dampers will operate continually on their default ‘firm’ setting until the fault is corrected.

X150 Control Diagram



A	Hardwired	4	HS CAN to other vehicle systems	8	Rear vertical accelerometer
D	High Speed CAN bus	5	Adaptive damping control module	9	LH front active damper
1	Battery	6	RH rear active damper	10	RH front active damper
2	Megafuse (175 A)	7	LH rear active damper	11	Front vertical accelerometer
3	CJB				

X250 Control Diagram



A	Hardwired	4	HS CAN to other vehicle systems	8	Rear vertical accelerometer
D	High Speed CAN bus	5	Adaptive damping control module	9	LH front active damper
1	Battery	6	RH rear active damper	10	RH front active damper
2	Megafuse (250 A)	7	LH rear active damper	11	Front vertical accelerometer
3	CJB				

VEHICLE DYNAMIC SUSPENSION: 2010 MY ONWARD

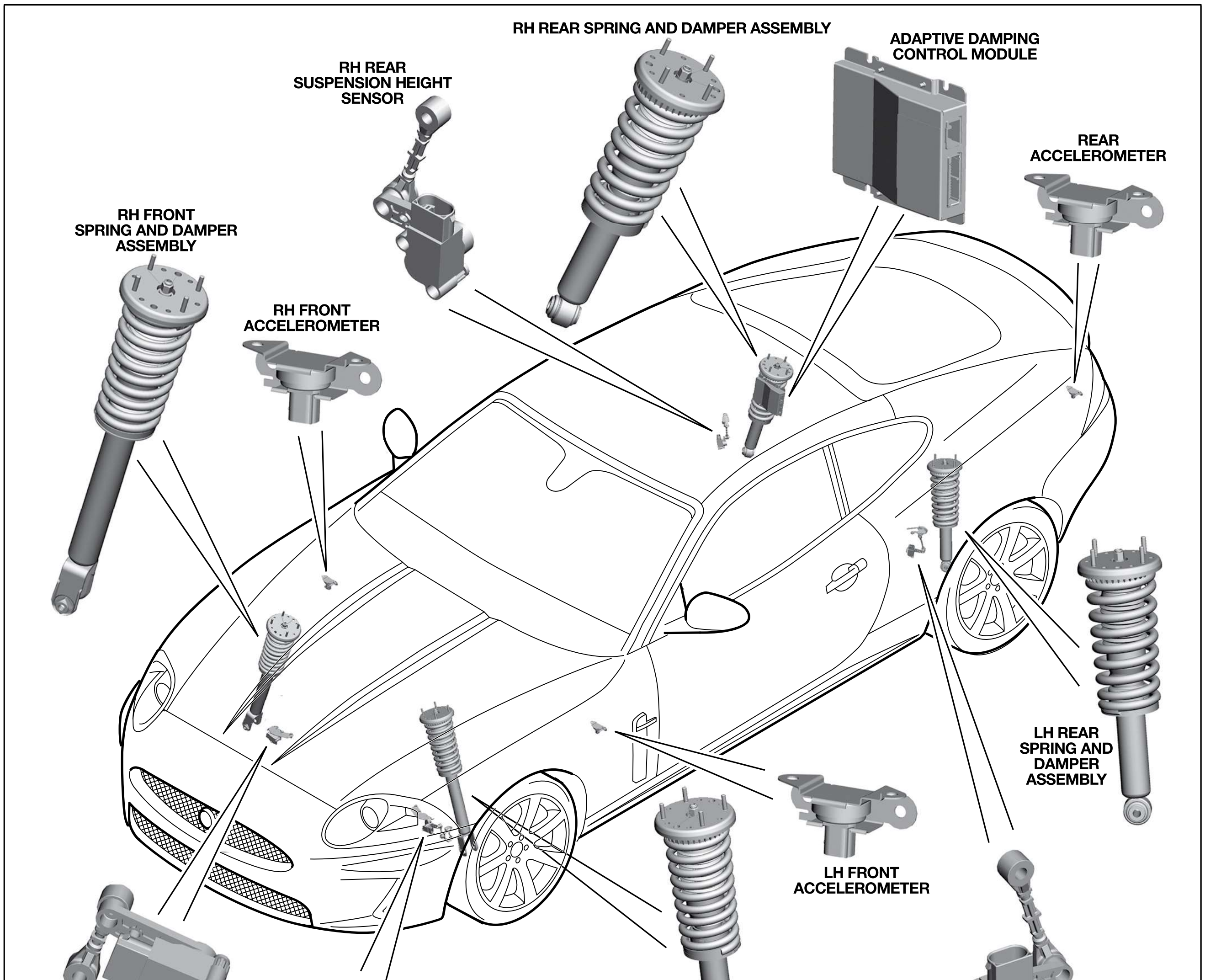
Overview

The Adaptive Dynamics System is an electronically-controlled suspension system that constantly adjusts the damping characteristics of the suspension dampers in reaction to the existing driving conditions. The adaptive dynamics system is available on specified models.

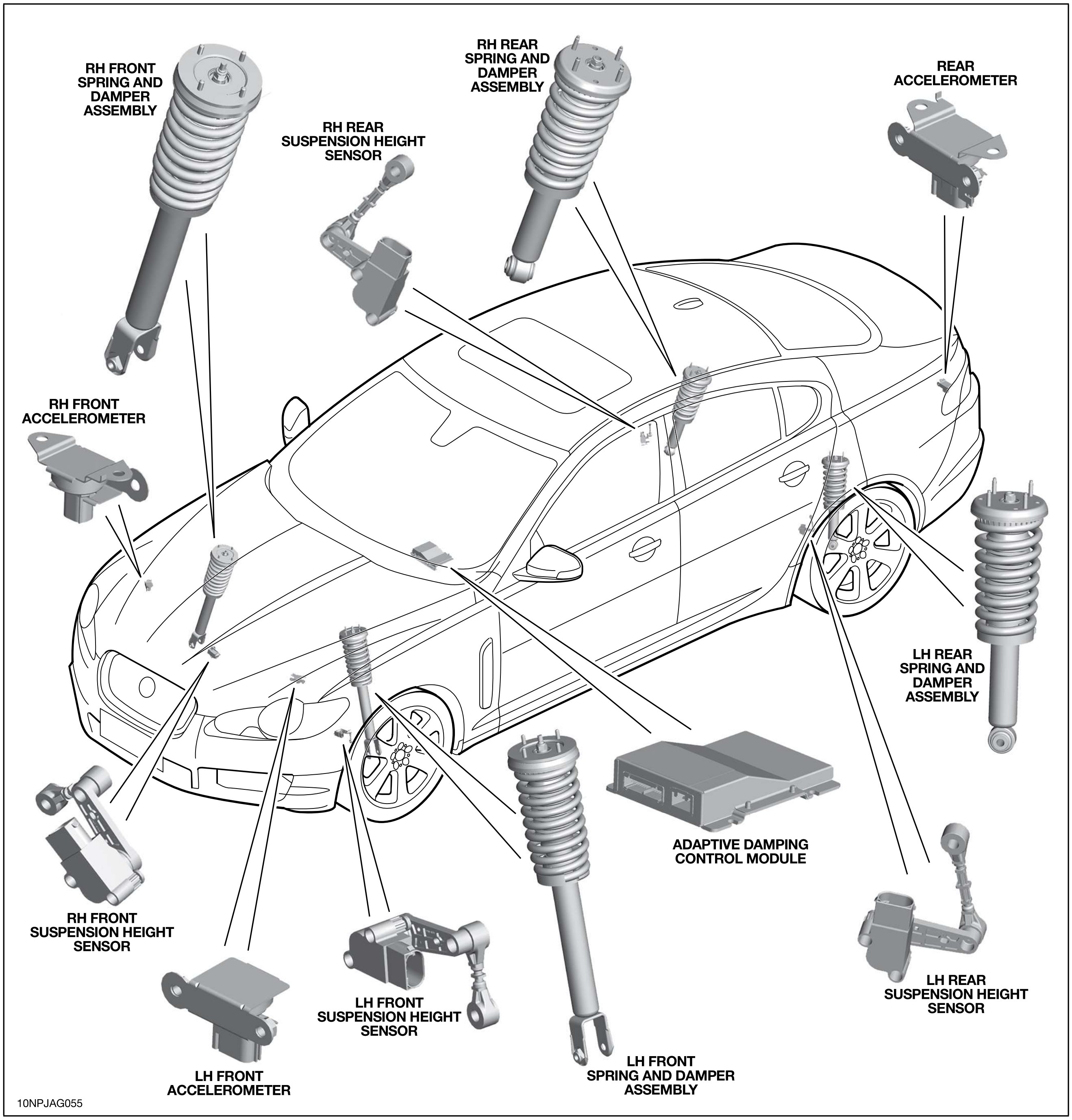
The system is controlled by an Adaptive Damping Control Module (ADCM), or suspension module 'B' (SUMB). The module receives signals from three dedicated vertical accelerometers – two at the front of the vehicle and one at the rear – which, together with four suspension height sensors, determine the state of the vehicle body and wheel motions. The ADCM also monitors driver inputs and signals from other vehicle systems, and controls the characteristics of each damper to give the optimum vehicle ride for the prevailing driving conditions.

The ADCM also contains the controller for the electronic differential, if equipped.

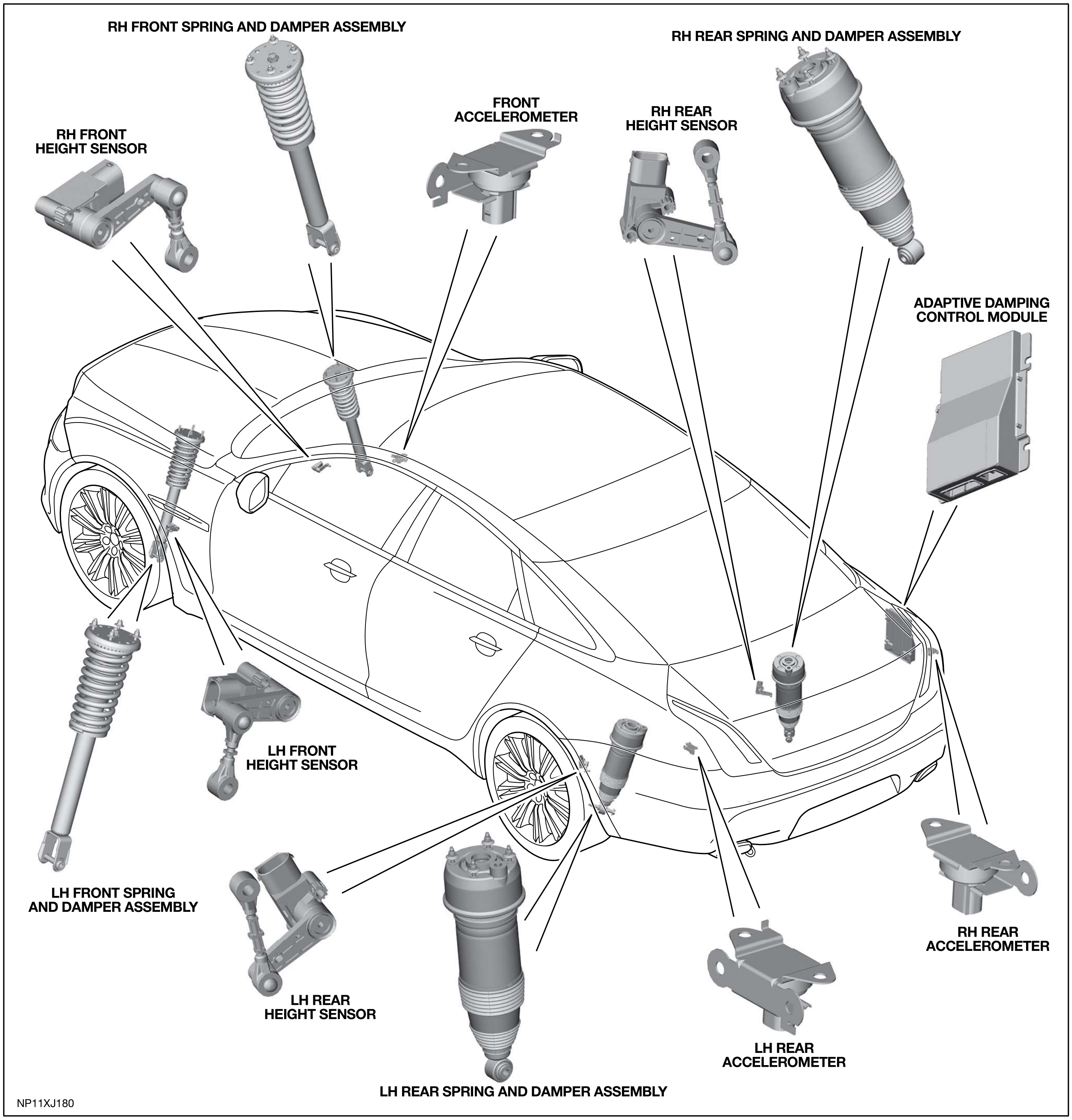
X150 Component Location (2010 MY Onward)



X250 Component Location (Supercharged Vehicles 2010 MY Onward)



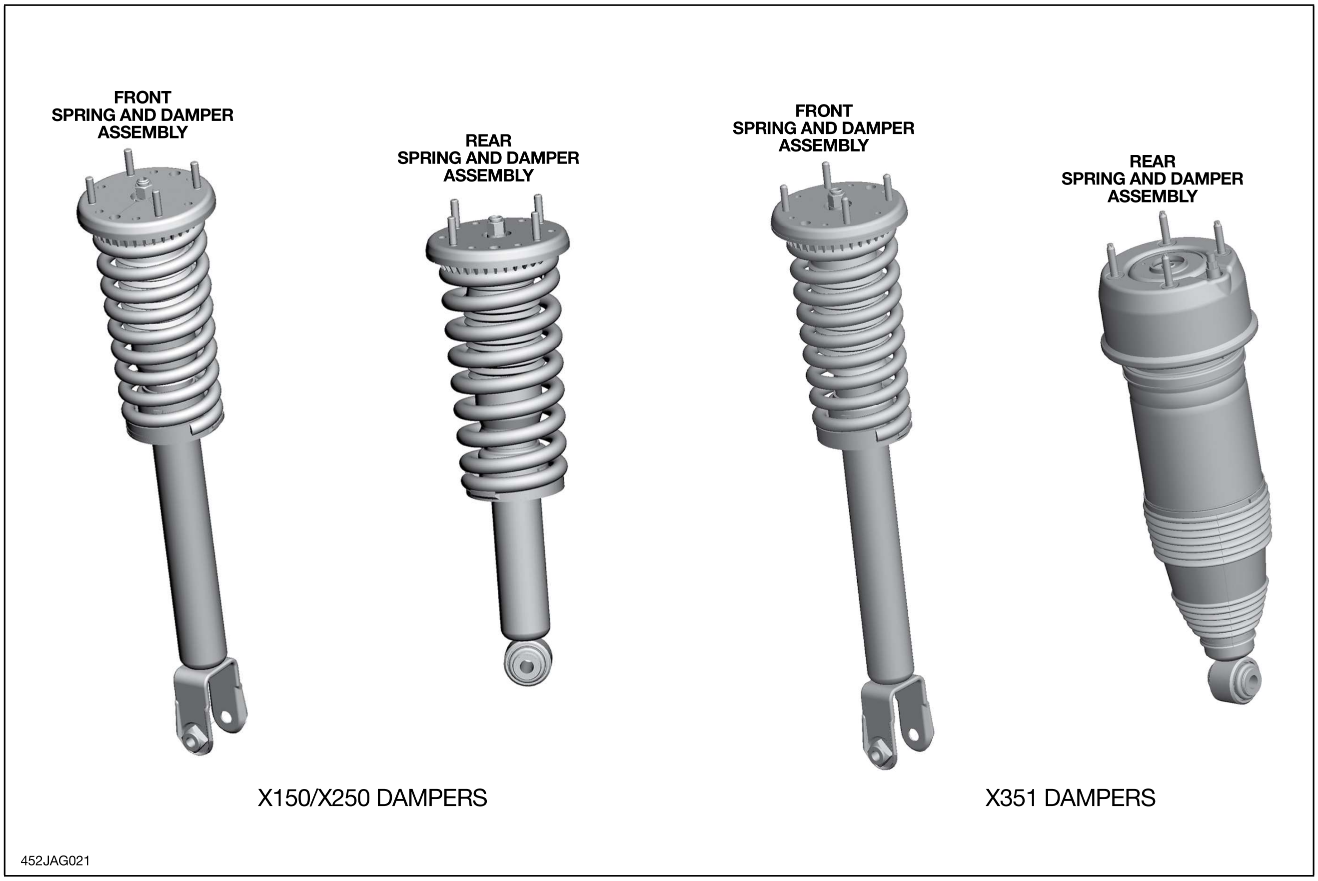
X351 Component Location



Component Description

Dampers

The ‘Adaptive Dynamics’ dampers are monotube, nitrogen gas and oil filled units, manufactured by Bilstein. The dampers are continuously variable, which allows the damping force to be electrically adjusted while the vehicle is being driven. The variable dampers provide the optimum compromise between vehicle control and ride comfort.

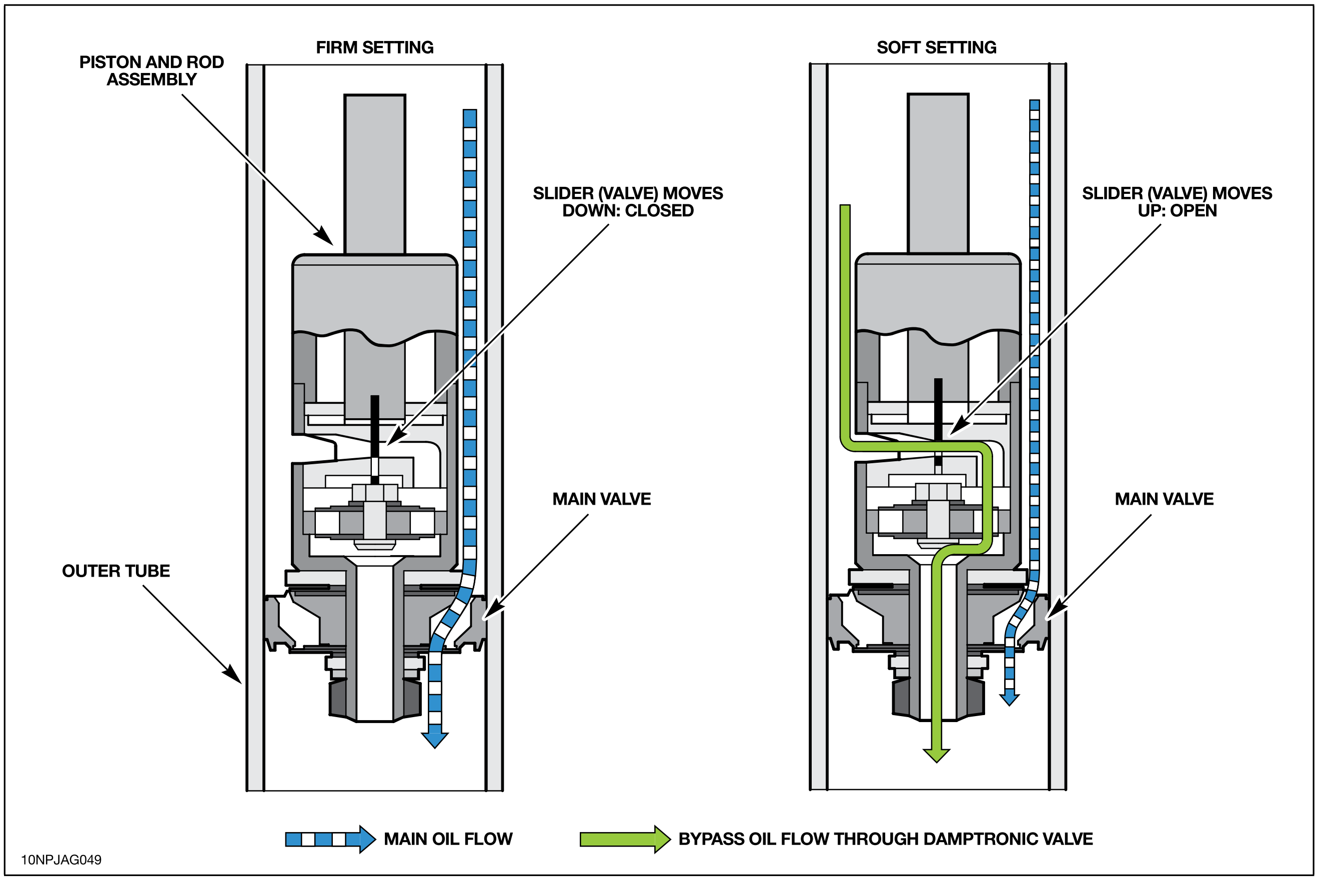


The dampers have an electrical connector on the end of the piston rod, in the center of the top mount (the dampers look identical to those on the Computer Active Technology Suspension (CATS) system of 4.2L SC vehicles, but have a different part number).

In each damper, the continuous damping adjustment is achieved by a solenoid-operated variable orifice, which opens up an alternative path for oil flow within the damper. When de-energized the bypass is closed and all the oil flows through the main (firm) piston. When energized, the solenoid moves an armature and control blade, which work against a spring.

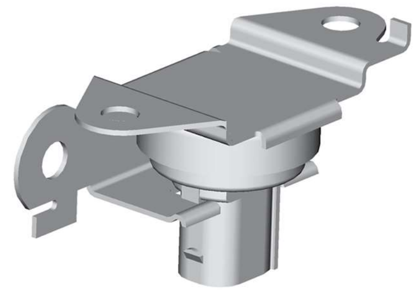
The control blade incorporates an orifice that slides inside a sintered housing to open up the bypass as required. In compression, oil flows from the lower portion of the damper through a hollow piston rod, a separate soft (comfort) valve, the slider housing and orifice and into the upper portion of the damper, thereby bypassing the main (firm) valve. In rebound, the oil flows in the opposite direction.

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



The solenoid in each damper is operated by a 526 Hz Pulse Width Modulated (PWM) signal from the Adaptive Damping Control Module (ADCM). When fully energized, the ADCM applies a 1.5 amp current to operate the damper in the soft setting. When de-energized (no current) the damper is in the firm setting. The current varies continuously as required to increase and decrease the damping individually in each of the dampers.

Accelerometers



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Three accelerometers are used in the Adaptive Dynamics System. The accelerometers are located as follows:

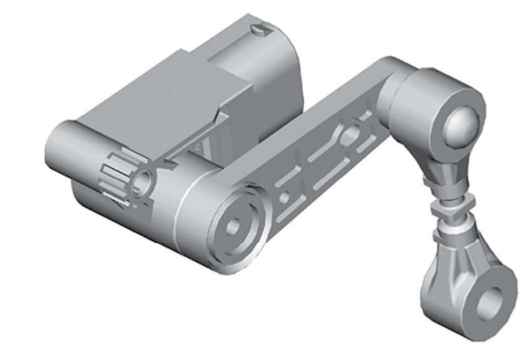
- **X150**
  - One each on the front edge of the LH and RH ‘A’ pillars
  - One in the trunk, in the rear LH corner adjacent to the tail lamp assembly
- **X250**
  - One each on the rear edge of the radiator support panel
  - One in the trunk, in the rear LH corner adjacent to the tail lamp assembly
- **X351**
  - One attached to the body behind the right front wheel, on the front sidemember to dash gusset
  - One on each side of the trunk, attached to the related rear quarter panel.

The accelerometers measure acceleration in the vertical plane and output a corresponding analog signal to the Adaptive Damping Control Module (ADCM). The algorithms in the ADCM calculate the heave, pitch, and roll motions of the vehicle, which are used by the module to control road-induced body modes.

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

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

Suspension Height Sensors



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Four suspension height sensors are used in the Adaptive Dynamics System, two for the front suspension and two for the rear suspension. A front suspension height sensor is attached to each side of the front subframe and connected by a sensor arm and sensor link to the related lower lateral arm of the front suspension. A rear suspension height sensor is attached to each side of the rear subframe and connected by a sensor arm and sensor link to the related upper control arm of the rear suspension. On each suspension height sensor, the sensor arm and sensor link convert linear movement of the suspension into rotary movement of the sensor shaft.

The sensors are also used for the static dynamic headlight leveling system on vehicles fitted with Xenon headlights.

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

Each suspension height sensor is connected to the ADCM via three wires, which supply ground, 5V supply, and signal return.

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

Adaptive Damping Control Module

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The Adaptive Damping Control Module (ADCM) receives its power supply via a relay and fuse in the CJB. To allow the ADCM to record and store DTCs relating to Adaptive Dynamics System faults, the relay remains energized for a period of time after the ignition is switched off.

System Fault Message

The ADCM communicates with the instrument cluster on the high speed CAN bus. If a fault is detected by the ADCM, a message is sent to the instrument cluster and the 'ADAPTIVE DYNAMICS FAULT ' message is displayed.

An appropriate Diagnostic Trouble Code (DTC) will be logged. DTCs can be retrieved using the Jaguar-approved diagnostic system.

When a fault is detected, the ADCM implements a strategy based on the type of fault. If there is an electrical power fault, or the ADCM cannot control the dampers, they default to the firm condition. If a sensor fails that only affects one or more control modes, then an intermediate damper setting is used as the lower threshold and the remaining working modes can demand higher damping as required.

Principles of Operation

The Adaptive Damping Control Module (ADCM) uses a combination of information from other system modules and data from the accelerometers and suspension height sensors to measure the vehicle and suspension states and driver inputs. Using this information, the adaptive damping control module applies algorithms to control the dampers for the current driving conditions.

The ADCM receives signals on the high speed CAN bus from the following system components:

- **ABS module**
  - Brake Pressure
  - Lateral Acceleration
  - Roll Stability Control Mode
  - Steering Wheel signals for speed, angle, and status
  - Individual Wheel Speed signals
  - Vehicle Speed
- **ECM**
  - Engine Speed
  - Engine Torque Flywheel Actual
- **TCM**
  - Gear Position Target
  - Torque Converter Slip
- JaguarDrive Selector
  - Terrain Mode Requested
- **CJB**
  - Power Mode (Ignition Signal)
  - Vehicle Information Parameters
- **AJB**
  - Car Configuration Parameters
  - Vehicle Information Parameters

The ADCM also outputs information on the high speed CAN bus for use by other systems as follows:

- **Instrument Cluster**
  - Fault Message
- **JaguarDrive Selector**
  - Mode (Winter Mode, Trac DSC, Dynamic Mode)
  - Mode Status LED
- **Other systems as required**
  - Individual Suspension Height signals

Control Modes

The ADCM monitors the input signals to operate the damper solenoids. The input signals are used in control modes, with the required force for that mode calculated for each damper. An arbitration mode monitors the force requirements from each mode and apportions a force to a damper. The force is converted to the appropriate current and sent to the damper.

The Control Modes are as follows:

Body Control
Uses body vertical accelerometer and CAN inputs. Calculates road induced body motions 100 times per second and sets each damper to the appropriate level to maintain a flat and level body attitude. Provides improved body control without loss of ride quality.

Roll Rate Control
Uses CAN inputs. Predicts vehicle roll rate due to driver steering inputs 100 times per second and increases damping to reduce roll rate. Provides improved control and driver confidence.

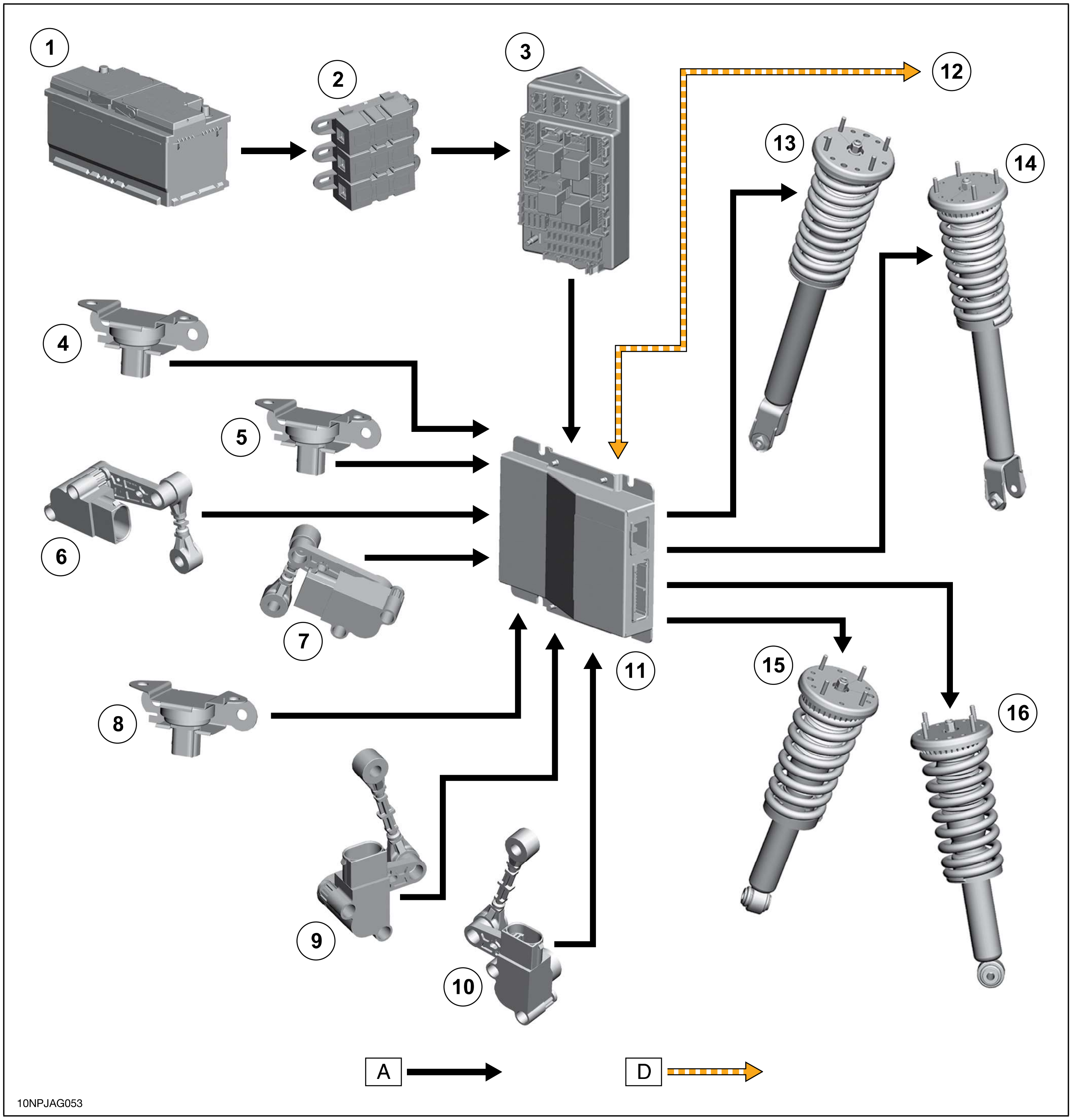
Pitch Rate Control
Uses CAN inputs. Predicts vehicle pitch rate due to driver throttle and braking inputs 100 times per second and increases damping to reduce pitch rate. Provides improved control and driver confidence.

Bump Rebound Control
Uses suspension height sensor and CAN inputs. Monitors the position of the wheel 500 times per second and increases the damping rate as the damper approaches the end of its travel. Provides improved ride quality.

Wheel Hop Control
Uses suspension height sensor and CAN inputs. Monitors the position of the wheel 500 times per second and detects when the wheel is at its natural frequency and increases the damping. Provides improved ride quality.

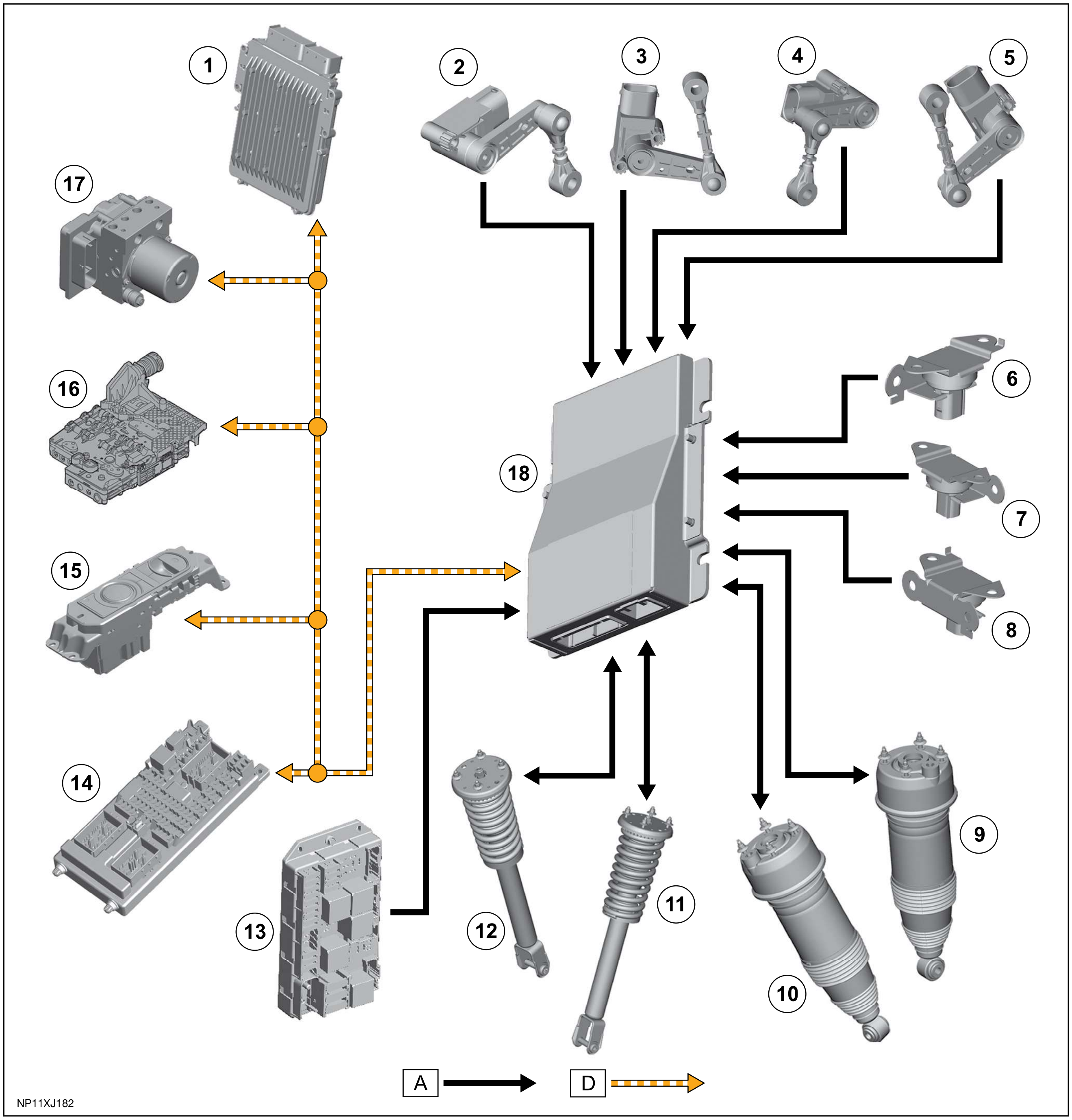
Under normal road conditions when the vehicle is stationary with the engine running, the dampers are set to the firm condition to reduce power consumption.

X150 / X250 Control Diagram



A Hardwired
D HS CAN
1 Battery
2 BJB – Megafuse (175A)
3 CJB – Fuse 14 (15A) from relay
4 LH front accelerometer
5 RH front accelerometer
6 LH front suspension height sensor
7 RH front suspension height sensor
8 Rear accelerometer
9 LH rear suspension height sensor
10 RH rear suspension height sensor
11 ADCM
12 HS CAN to other systems
13 LH front damper
14 RH front damper
15 LH rear damper
16 RH rear damper

X351 Control Diagram



A	Hardwired	6	Front Accelerometer	13	RJB
D	HS CAN Bus	7	RH Rear Accelerometer	14	CJB
1	ECM	8	LH Rear Accelerometer	15	JaguarDrive Selector Module
2	RH Front Height Sensor	9	LH Rear Damper	16	TCM
3	RH Rear Height Sensor	10	RH Rear Damper	17	ABS Module
4	LH Front Height Sensor	11	LH Front Damper	18	ADCM
5	LH Rear Height Sensor	12	RH Front Damper		