

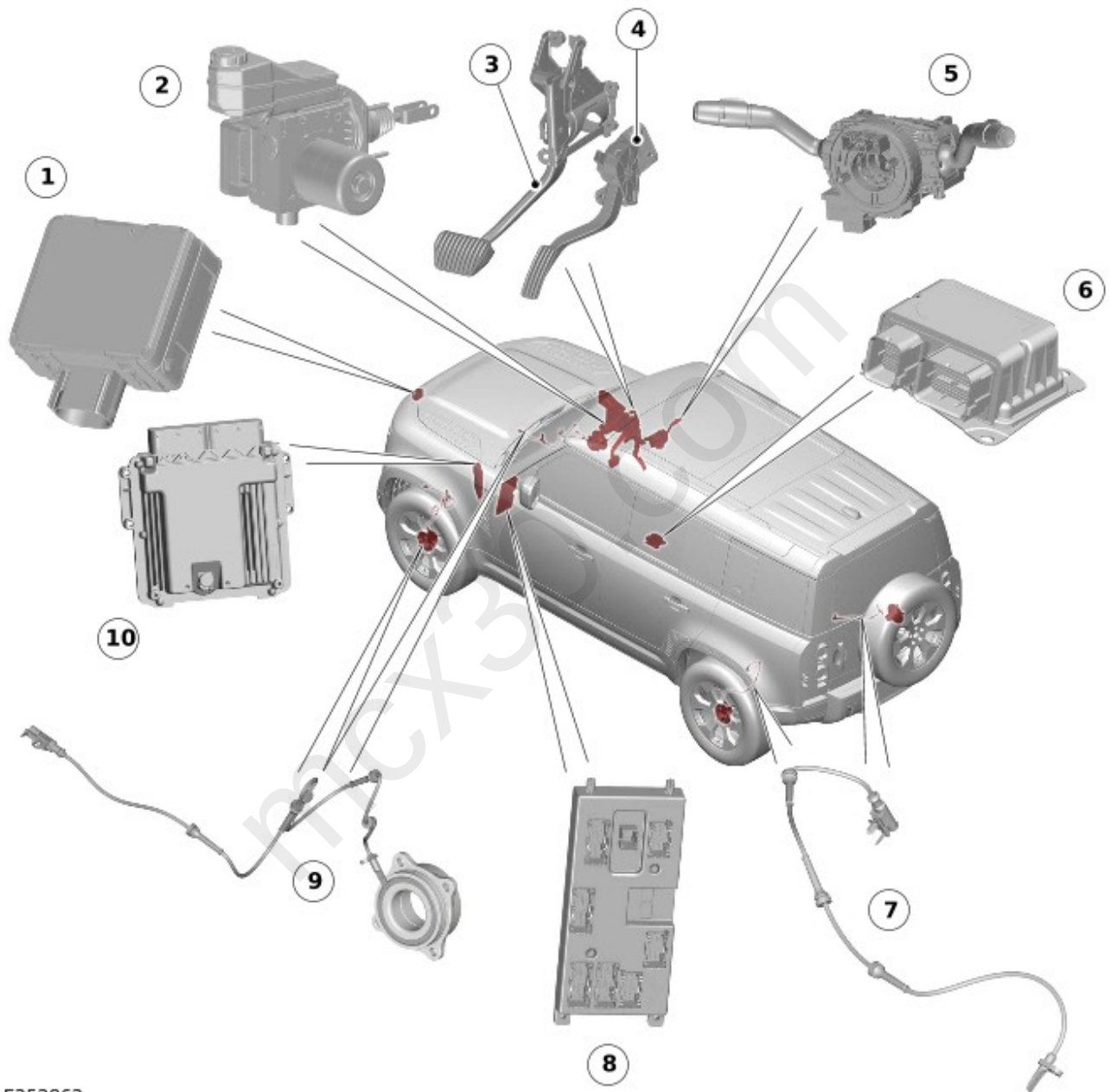
PUBLISHED: 18-FEB-2020
2020.0 DEFENDER (LE), 206-08

BRAKE CONTROLS AND ACTUATION

INTEGRATED POWER BRAKE SYSTEM (G2415754)

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COMPONENT LOCATION



E252862

ITEM	DESCRIPTION
1	Cruise Control Module (CCM)
2	Integrated Power Brake
3	Brake pedal

ITEM	DESCRIPTION
4	Accelerator Pedal Position (APP)
5	Steering Angle Sensor Control Module (SASM)
6	Restraints Control Module (RCM)
7	Rear wheel speed sensors (quantity 2)
8	Body Control Module (BCM)/ Gateway Control Module (GWM)
9	Front wheel speed sensors (quantity 2)
10	Powertrain Control Module (PCM)

OVERVIEW

The vehicle braking control is applied by the Integrated Power Brake system. The Integrated Power Brake is an electro-mechanical brake system which combines actuation and modulation.

The Integrated Power Brake is a mechatronic unit (combined mechanics and electronics). The Integrated Power Brake is a vacuum-free brake system that transforms the driver applied brake demand into an amplified brake pressure.

The Integrated Power Brake is a brake-by-wire system, where no effort caused by the driver at the brake pedal is passed through to the foundation brake system. The input rod travel is sensed when driver applies the brake pedal. A target brake pressure is derived from this input rod travel.

The Integrated Power Brake system does not require the brake pedal switch in the pedal box. This function is created by the Integrated Power Brake control module. The Integrated Power Brake control module outputs 2 12V signals when the pedal is pressed to replicate the outputs of the pedal switch. These outputs are sent to the PCM and the BCM/ GWM. Additionally, it sends a request to the BCM/ GWM over the FlexRay network. The PCM and BCM/ GWM then forward the brake signal toward to all related control modules through the FlexRay circuit.

On vehicles with Integrated Power Brake, the driver gear selection requests are from the Gear Shift Control Module (GSM). The gear selection request is sent:

- To the Integrated Power Brake control module through the High Speed (HS) Controller Area Network (CAN) body systems bus.
- The Integrated Power Brake forward the request to the Transmission Control Module (TCM) through the FlexRay circuit.

In the event of a vehicle electrical power net failure, the brake control system is still able to provide deceleration. This is by a mechanical push-through, based on a direct connection between the pedal and the internal master cylinder. The pedal stroke might be longer and the pedal forces higher to reach the deceleration levels compared to by-wire mode.

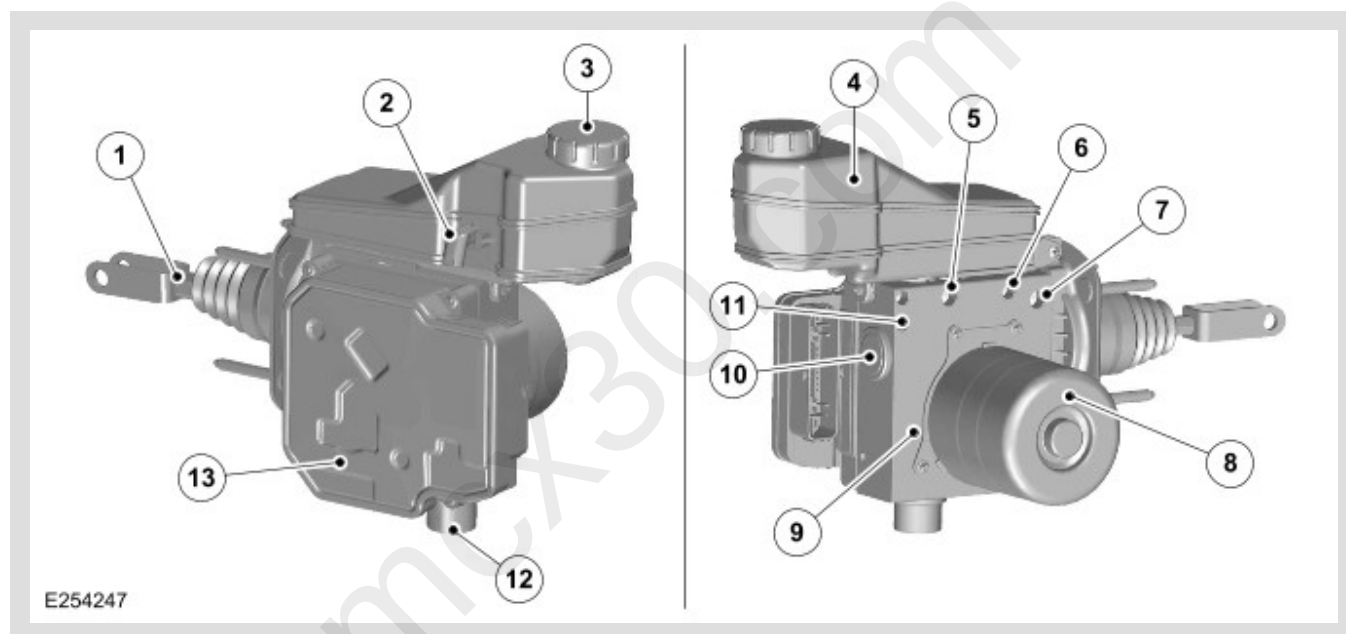
When required, the Integrated Power Brake actively intervenes and operates the Hydraulic Control Unit (HCU) during braking or vehicle maneuvers to correct the vehicle attitude, stability, traction or speed. During incidents of vehicle correction, the Integrated Power Brake control module may also request the PCM to control engine power in order to further stabilize and correct the vehicle.

The Integrated Power Brake system provides a number of brake functions that are designed to assist the vehicle or aid the driver.

For additional information, refer to: [Anti-Lock Control](#) (206-08 Brake Controls and Actuation, Description and Operation).

DESCRIPTION

INTEGRATED POWER BRAKE



ITEM	DESCRIPTION
1	Input rod and pedal interface
2	Brake fluid level sensor electrical connector
3	Brake fluid reservoir cap
4	Brake fluid reservoir
5	Front left brake outlet port
6	Front right brake outlet port
7	Rear left brake outlet port
8	Electric motor

ITEM	DESCRIPTION
9	HCU
10	Internal brake master cylinder
11	Rear right brake outlet port
12	Pedal feel simulator
13	Integrated Power Brake control module

The Integrated Power Brake comprises:

- HCU which integrates a tandem master cylinder with its input rod, a pedal feel simulator, valves and sensors.
- An electric motor, rotor position sensor, gear set and the plunger.
- The Integrated Power Brake control module.
- A pedal interface.
- The brake fluid reservoir.
- The hydraulic ports for the wheel brake calipers.

The Integrated Power Brake uses the HCU to modulate hydraulic pressure to the individual wheel brakes to control the brake functions.

The Integrated Power Brake is installed onto the firewall on the driver side. A multi-pin electrical connector provides the electrical interface between the Integrated Power Brake control module and the vehicle wiring. A separate 2 pin connector provides the interface between the brake fluid level switch and the Integrated Power Brake control module through the vehicle wiring. Hydraulic pipes and hoses connect the hydraulic module to the brake calipers.

The master cylinder is integrated into the HCU.

The internal master cylinder has 3 circuits within the HCU:

- The primary circuit has separate outlet ports to the front right and rear left brakes.
- A secondary circuit has separate outlet ports to the front left and rear right brakes.
 - Each of these circuits have a circuit separation valve which separates the hydraulic circuits from the master cylinder.
- The third circuit is for a Pedal Feel Simulator which supplies the pedal feedback to the driver. This circuit provides a varying (increasing) level of resistance based on fluid volume and pedal travel. The Pedal Feel Simulator circuit is independent of the brake pressure at the wheel brakes.

The HCU also contains an electric motor which moves a plunger through a gear set.

The plunger builds pressure to the main brake circuits through the 2 pressure solenoid valves.

When the Integrated Power Brake is active, the Integrated Power Brake controls the supplied brake pressure by opening and closing the appropriate solenoid valves in the HCU.

The Integrated Power Brake also provides the brake boost functionality. The pressure generated at the wheels may typically be more than the input pressure from the driver in the simulator circuit.

The Integrated Power Brake can operate to control each wheel individually.

For additional information, refer to: [Anti-Lock Control](#) (206-08 Brake Controls and Actuation, Description and Operation).

STANDSTILL MANAGEMENT

Power management and duty

The driver may keep a vehicle stationary by pressing the brake pedal connected to the Integrated Power Brake as done with a traditional brake system. However, a driver often demands more brake pressure than actually required to hold the vehicle stationary. The Integrated Power Brake current consumption is dependent on the brake pressure required. When the vehicle is standstill the Integrated Power Brake may reduce the brake pressure to a lower level than requested by the driver. The Integrated Power Brake maintains vehicle standstill, but reduces the amount of electrical power the Integrated Power Brake consumes.

The Integrated Power Brake reduces power consumption and reduce load on the component during longer periods held at stationary. The Integrated Power Brake employs this strategy by using the hydraulic brakes above approximately 25 bar pressure. The duty on the motor may be reduced by intermittently increasing pressure by a small amount (approximately 3 bar). The motor load is then reduced, allowing the pressure to gradually decrease to its original level before boosting again to the previous value. This is not expected to be perceptible to the driver. If the car is held using brake pressure while stationary for more than 3 minutes, the pressure may be held in by the (PSV) valves. At this point the motor is retracted to a no-load position. An increased pressure demand redeploys the motor and opens the valves. While stationary, the sound of the valve actuation may be noticeable by sensitive customers as there is little background noise to mask it.

Reaction to Air and Leakage detected

Some faults that set Diagnostic Trouble Code(s) (DTC) and warning lamps react by isolating the suspected brake circuit. In order to confirm if the fault has been cleared, after starting a new power cycle the system retests itself. Pressing and holding the brake pedal with high pressure (>78 bar) may be accompanied by valve clicking while the system retests each circuit in turn. This will also be part of the service check to verify DTC clearance for these fault codes.

If the driver demands a higher brake pressure than that requested from a driver assistance system or from the stability control algorithm, then the Integrated Power Brake supports the driver braking request. The Integrated Power Brake is able to build pressure without driver input upon an external request. The Integrated Power Brake, for example may have to support adaptive cruise control or Autonomous Emergency Braking (AEB) functions. The Integrated Power Brake is also able to build pressure without driver input upon an internal request, for example: Dynamic Stability Control (DSC) function support.

SERVICE INFORMATION

The Integrated Power Brake control module and the HCU form a single component and must not be separated. The brake fluid reservoir and its seals are separate service parts only.

The Integrated Power Brake brake fluid reservoir functions differently from conventional tandem master cylinder. Based on the Integrated Power Brake functionality the brake fluid is cycled back into the reservoir and consequently a slight pressure increase during modulation is possible. Therefore this function is incorporated to the cap for Integrated Power Brake reservoir.

CAUTION:

The Integrated Power Brake must not be used after being accidentally dropped. Invisible and/or internal damages can impact the Integrated Power Brake proper operation.

The Integrated Power Brake is supplied in a pre-filled state. After installation, the hydraulic brake system only requires a conventional bleed of the system.

After installation, the hydraulic brake system requires use of the Jaguar Land Rover (JLR) Diagnostic equipment to:

- Check the brake system for presence of air
- Calibrate
- And clear its Assembly Mode.

Unlike previous systems, the Integrated Power Brake monitors for the presence of air in the brake circuits, either in the driver simulator circuit or the wheel circuits. If a fault is detected, this must be cleared after bleeding by using the diagnostic tester Leakage and Air Test routine.

INCORRECT USAGE OF THE INTEGRATED POWER BRAKE SYSTEM

Typical misuse by the driver or workshop person:

- Activation of test bench detection under normal driving condition.
- Use without sufficient cooling-air supply and over temperature.
- Excessive pedal oscillation caused by the driver.
- Permanent pedal application with high forces.
- Installation of an Integrated Power Brake which was dropped.
- Operation of the supplied Integrated Power Brake without brake fluid in the system or while any hydraulic circuit is opened.

The Integrated Power Brake control module controls the electric motor depending on the driver brake request, detected by the pedal travel sensor and the pressure sensor. The motor transmits the torque with the help of the gear set to the plunger, which creates an output hydraulic pressure.

The Integrated Power Brake control module actively interacts with other vehicle system control modules and associated sensors to receive and transmit current vehicle operating information.

The Integrated Power Brake control module is connected to the FlexRay and HS CAN Underbody Systems Bus.

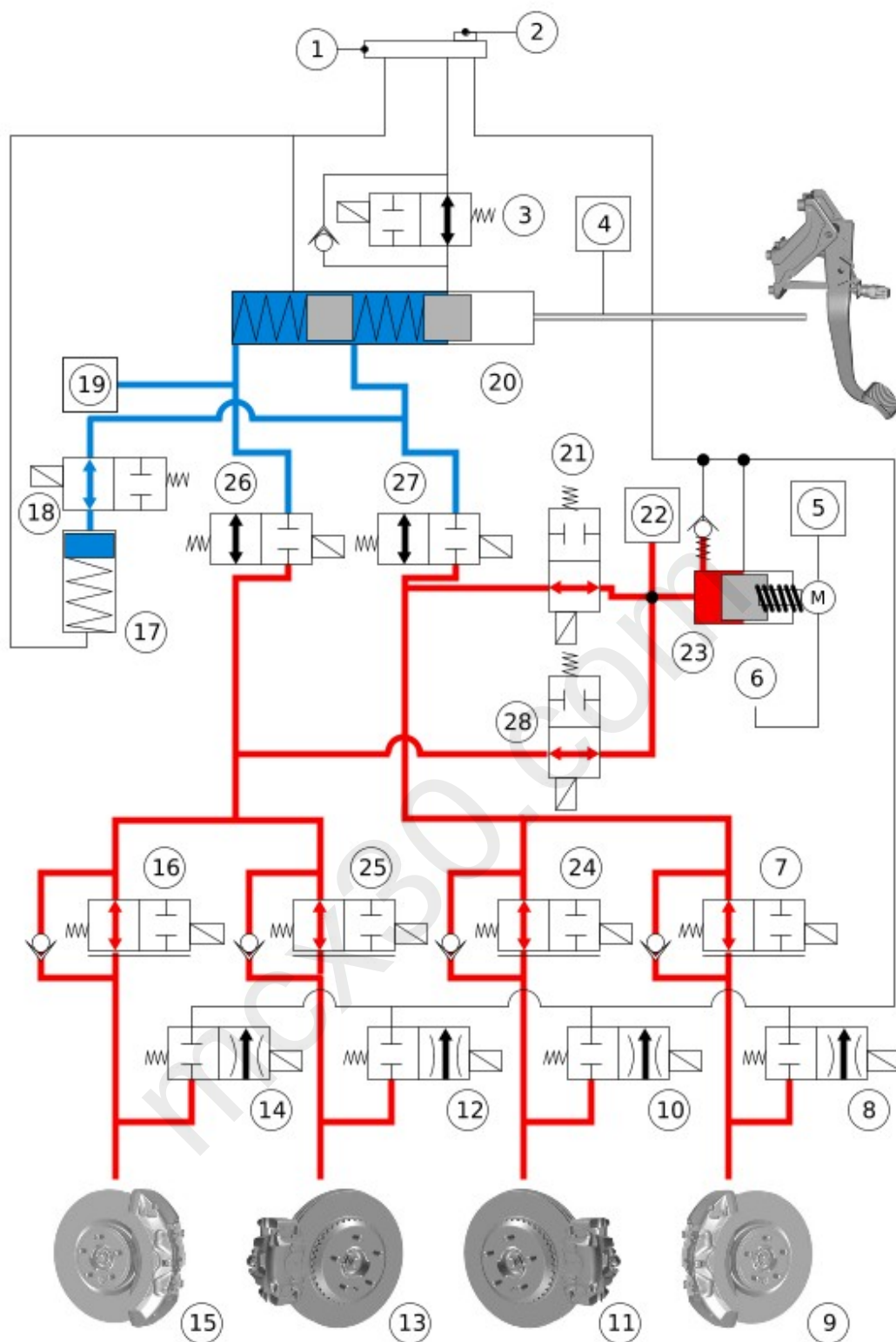
The Integrated Power Brake control module processes the information received from the sensors according to defined mathematical procedures (control algorithms). The results of these calculations form the basis for the control signals sent to the HCU. The HCU increases and decreases the pressure in the brakes of the vehicle according to the functional requirements.

HYDRAULIC FUNCTIONS

Integrated Power Brake has 2 initial hydraulic functions.

The Brake By-Wire mode

The Brake By-Wire mode (power assisted), is the default operation when the vehicle is in Power Mode 6 (Ignition ON) or above.



E252865

ITEM	DESCRIPTION
1	Brake fluid reservoir
2	Brake fluid reservoir cap
3	Test Separation Valve

ITEM	DESCRIPTION
4	Pedal travel sensor
5	Motor position sensor
6	Electric motor
7	Front right brake caliper inlet valve
8	Front right brake caliper outlet valve
9	Front right brake caliper
10	Rear left brake caliper outlet valve
11	Rear left brake caliper
12	Rear right brake caliper outlet valve
13	Rear right brake caliper
14	Front left brake caliper outlet valve
15	Front left brake caliper
16	Front left brake caliper inlet valve
17	Pedal feel simulator
18	Simulator Separation Valve
19	Pedal pressure sensor
20	Master cylinder
21	Plunger Separation Valve
22	Pressure sensor
23	Plunger
24	Rear left brake caliper inlet valve
25	Rear right brake caliper inlet valve
26	Circuit Separation Valve
27	Circuit Separation Valve
28	Plunger Separation Valve

In Brake By-Wire mode:

- The Circuit Separation Valves are closed (the driver is decoupled from the main brake circuit).
- The Simulator Separation Valve is opened (feedback to provide connection to the pedal feel simulator and therefore an associated pedal force).

- When the driver is decoupled from the wheel brakes - The Plunger Separation Valves are opened to allow fluid /pressure into the base brake circuit for pressure build-up.
- The plunger provides fluid and pressure towards to the base brake circuit (wheel brakes). During normal base braking, fluid passes through the inlet valves to each wheel, and the outlet valves remain closed.

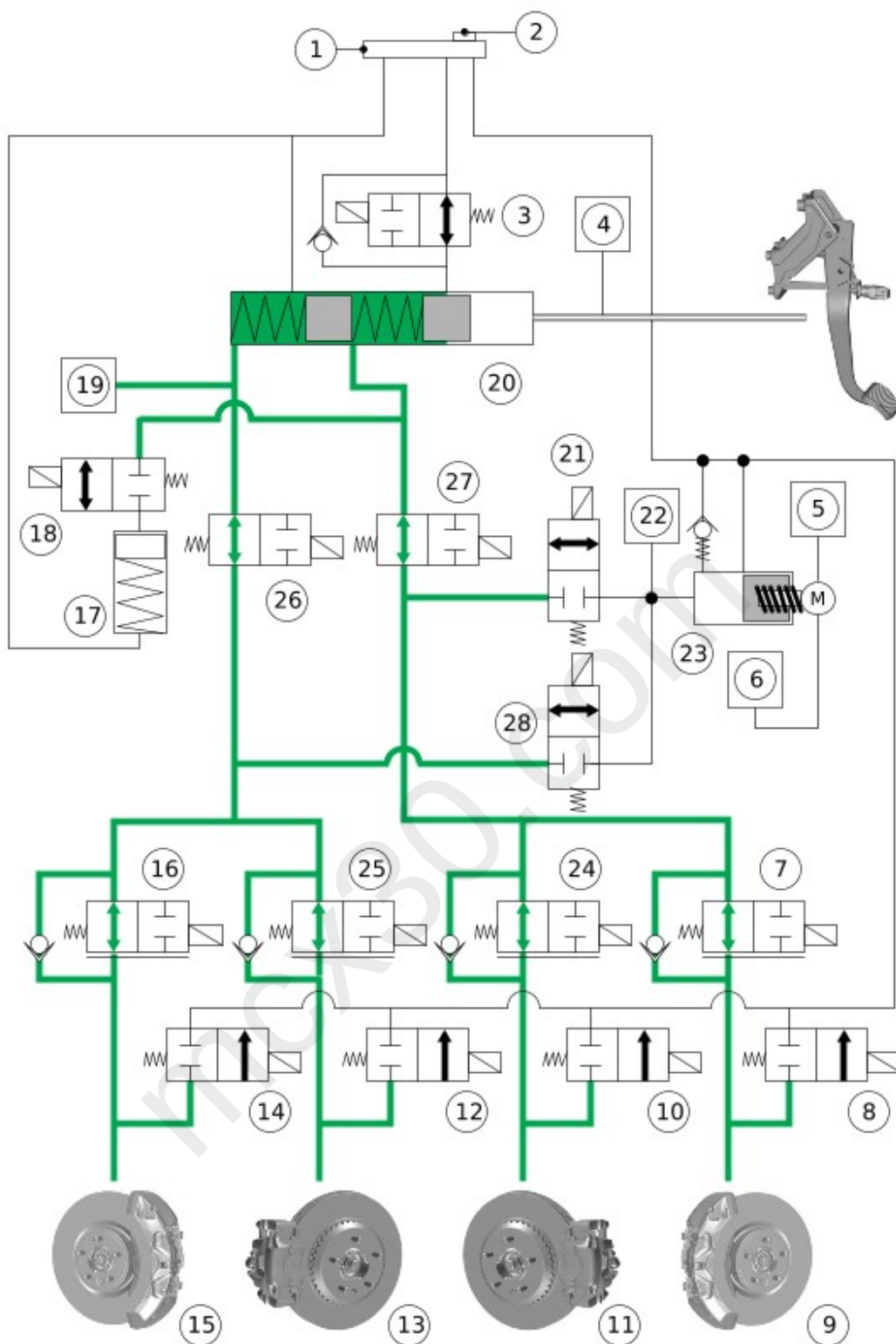
The Integrated Power Brake provides Anti-Lock Brake System Control Module (ABS) operating modes depending on signal inputs:

- Increase or decrease hydraulic pressure
 - To increase pressure, the inlet valve is open, the outlet valves are closed.
 - To decrease the pressure at all the wheels for reduced braking demand the inlet valves remain open, but the plunger moves backward, the outlet valves still closed.
 - To decrease pressure at a specific wheel, such as in the case of ABS function, the inlet valves closed, the outlet valves can partially open to release fluid back to the reservoir.
- Prevent brake pressure increase, such as in the case of Electronic Brake Distribution (EBD) function
 - The inlet and outlet valves are closed.
- Release hydraulic pressure.
 - This is when all the pressure released by fluid channel opened (outlet valves) towards the reservoir.

With this 2 valve design the appropriate brake pressure can be precisely set to each individual brake calipers.

A mechanical backup mode

In the event of a vehicle power net failure, the Integrated Power Brake is still able to provide deceleration through a mechanical push-through. The mechanical push-through is based on a direct connection between the pedal and the master cylinder. The pedal stroke might be longer and the pedal forces higher to reach the deceleration levels compared to Brake By-Wire mode.



E252864

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12	Rear right brake caliper outlet valve
13	Rear right brake caliper
14	Front left brake caliper outlet valve
15	Front left brake caliper
16	Front left brake caliper inlet valve
17	Pedal feel simulator
18	Simulator Separation Valve
19	Pedal pressure sensor
20	Master cylinder
21	Plunger Separation Valve
22	Pressure sensor
23	Plunger
24	Rear left brake caliper inlet valve
25	Rear right brake caliper inlet valve
26	Circuit Separation Valve
27	Circuit Separation Valve
28	Plunger Separation Valve

CAUTION:

The deceleration capability in mechanical backup at the same pedal force is lower than in Brake By-Wire mode and no stabilization functions are available. In addition to this the required pedal stroke to achieve the requested deceleration is higher than in Brake By-Wire mode.

In mechanical backup mode the plunger separation valves, simulator separation valve and outlet valves are normally closed as no electrical power available. The inlet valves and Circuit Separation Valves are normally open to allow the fluid to be pressurized by pedal stroke manually.

When the pedal is released, the brake fluid can return to the reservoir through the internal master cylinder.

SYSTEM SELF TEST

The Integrated Power Brake system performs several self-tests. These can be separated into 3 areas:

Upon Integrated Power Brake control module wake-up, for example: unlocking the car:

- The Integrated Power Brake system briefly activates the motor and the plunger then both return to the start position.
 - Test duration typically 1-2 seconds under normal conditions.
 - Small Noise, Vibration and Harshness (NVH) influence is expected from the valve and the motor.

During Running:

- Plunger check:
 - Executed one time per ignition cycle, at vehicle speed not below 15km/h and while brake pedal is not pressed.
 - The test has small effect on the brake pedal feel.
 - The test is interrupted, if brake pedal is pressed after the test has started.
 - The test duration is typically 4-5 seconds, but can be extended at low ambient temperatures (especially below 0°C), if necessary.
 - NVH influence is not expected to be perceptible.
- Motor check:
 - If the motor has not been recently activated (20-30 seconds) test is run cyclically during driving.
 - Test duration is typically 0.5s.
 - NVH is not expected to be perceptible.



NOTE:

Tests upon wake-up and during running do not apply brake pressure to the brake calipers.

After the vehicle is switched off (Integrated Power Brake control module in Post-Run):

- The Integrated Power Brake system performs a plunger check and a system test to check presence of air and brake system leaks.
 - The tests commence within 5 seconds of entering post-run when the brake pedal is not pressed.
 - The test duration varies, typically 15-30s.
 - Some NVH influence from the motor and the valves may be perceptible when the vehicle is switched OFF.

- If the brake pedal is pressed after test start, the tests interrupt, but the pedal feel may be different from normal use.

SYSTEM SELF PROTECTION

The Integrated Power Brake uses internal programming to protect itself against cases which can cause damage to the system.

In these cases the power assisting performance of the Integrated Power Brake may be reduced or unavailable.

Overheating

The Integrated Power Brake features a thermal degradation strategy to protect the Integrated Power Brake motor and control module against damage from high temperature.

If the Integrated Power Brake internal temperature sensor detects a temperature between 120°C and 135°C (248°F - 275°F), the operating current is gradually reduced leading to reduced dynamics.

If the Integrated Power Brake temperature sensor detects a temperature between 135°C and 138°C (275°F - 280°F) the allowed current is further gradually reduced. The operating current is reduced until the minimum operation current needed to maintain legal requirements is reached at 138°C (280°F).

For Integrated Power Brake temperatures between 138°C and 142°C (280°F - 288°F) the allowed current is constantly the minimum value to maintain legal requirements.

For Integrated Power Brake temperatures higher than 142°C (288°F) the Integrated Power Brake switches to mechanical back-up mode.

Under- and overvoltage

In case of under- and overvoltage, the Integrated Power Brake control module performs a power assist degradation strategy. Pressure degradation is according to the available Integrated Power Brake supply voltage level.

The normal operating voltage is between 10V to 16V.

The minimum operating voltage is 6.5V.

The maximum operating voltage is 27V.

Undervoltage degradation is between 10V to 6.5V.

Overvoltage degradation is between 16V to 27V.

Outside this threshold (below 6.5V and over 27V) the Integrated Power Brake switches in to the mechanical back-up mode.

	MINIMUM VOLTAGE	NORMAL OPERATION VOLTAGE		MAXIMUM VOLTAGE
Voltage Threshold	6.5V	10V	16V	27V
Hydraulic Pressure	≥ 78 bar (1131 psi)	180 bar (2611 psi)	180 bar (2611 psi)	≥ 78 bar (1131 psi)

ROLLER TEST BENCH DETECTION

The Integrated Power Brake has a test bench detection function and consequently result in a behavior deviating from normal operation while being operated on a roller test bench.

Under normal driving condition this mode is inactive.

The activation of the roller test bench mode is through a network signal from the JLR approved diagnostic equipment.

The roller test bench mode is deactivated by:

- Reset of activation signal from the diagnosis tester
- Closed ignition cycle (without diagnosis tester)
- By a “misuse detection” that detects road driving with roller bench mode active.

When the roller test bench mode is active the red brake warning lamp and yellow ABS warning lamp are activated and all vehicle stability control functions are deactivated for safety reasons.

POWER ASSIST DEGRADATION STRATEGY

The Integrated Power Brake system is able to operate even if a system failure is already detected.

Operation of the Integrated Power Brake in these circumstances are according to the level of the failure.

The Integrated Power Brake has 6 power assist degradation levels:

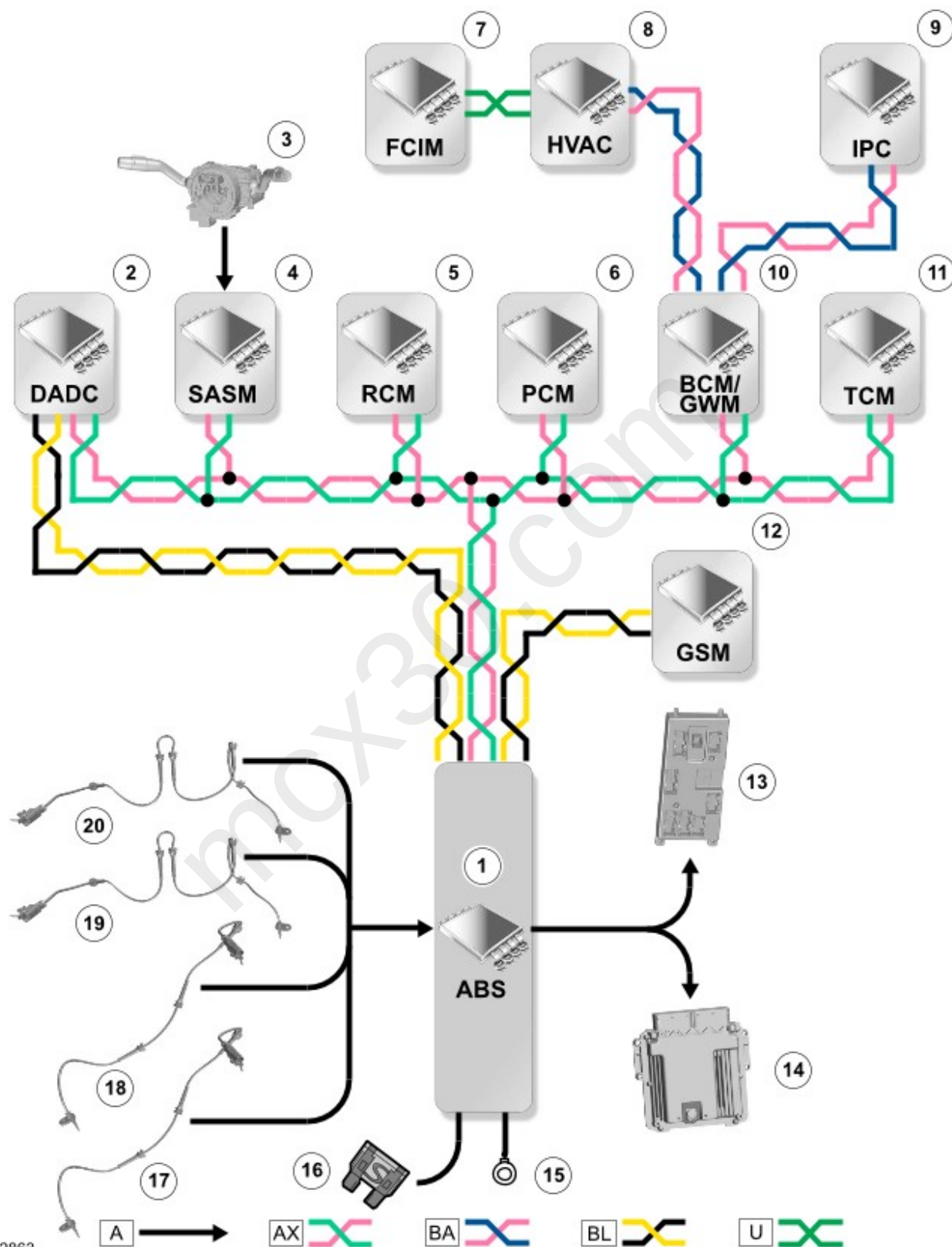
- 1 Normal function - no failure
- 2 Degraded pedal feel - pedal stroke based failure
- 3 Power assist available with circuit degradation
 - Integrated Power Brake identifies the defect circuit by alternating pressure build up in both circuits.
 - Power assist is reduced but still available.
 - Potential further degradation step to level 4 in case of brake circuit failure.
- 4 Brake circuit separation - identified circuit failure
 - Power assist for brake circuit 1 only - in case of failure in brake circuit 2.
 - Power assist for brake circuit 2 only - in case of failure in brake circuit 1.
- 5 Mechanical backup mode with monitoring and reduced EBD function
- 6 Mechanical backup mode with no Integrated Power Brake control.

DEGRADATION LEVEL	POWER ASSIST	WARNING LAMP
Level 1	YES	NO
Level 2	YES	RED

DEGRADATION LEVEL	POWER ASSIST	WARNING LAMP
Level 3	REDUCED	RED
Level 4	REDUCED	RED
Level 5	NO	RED
Level 6	NO	RED

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CONTROL DIAGRAM



E252863

A = HARDWIRED: AX = FLEXRAY: BL = HS CAN UNDERBODY SYSTEMS BUS: BA = HS CAN HUMAN MACHINE INTERFACE (HMI) SYSTEMS BUS: U = HS CAN PRIVATE BUS.

ITEM	DESCRIPTION
1	Integrated Power Brake control module (ABS)
2	Driver Assistance Domain Controller (DADC)
3	Steering Wheel Module (SWM)
4	SASM
5	RCM
6	PCM
7	Integrated Control Panel (FCIM)
8	Heating, ventilation, and air conditioning (HVAC)
9	Instrument Panel Cluster (IPC)
10	BCM/ GWM
11	TCM
12	GSM
13	Brake pedal activation signal - BCM/ GWM
14	Brake pedal activation signal - PCM
15	Ground
16	Power supply
17	Rear left wheel speed sensor
18	Rear right wheel speed sensor
19	Front left wheel speed sensor
20	Front right wheel speed sensor