

Emission Control and Diagnosis

Anti-Lock Braking systems

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Contents

Introduction – Page 3

Research – Page - 4

Methodology + Data – Page 5 - 12

System comparison – Page 13

References – Page 14

Appendix – Page 15 - 17

Introduction;

The aims of this report are to define the functionality of an ABS system and the different phases experienced during braking. A test was also carried out on two separate ABS systems. These systems were the Bosch 2EH system and the Ford Teves system. During the testing phase both systems will be thoroughly tested to determine if they are working correctly and a report outlining any faults or discrepancies will be provided. Also included in the report will be a guide on how the test was carried out so that it may be replicated if needed, the procedures used, and safe working practices will also be included. Alongside the test results are the waveforms produced whilst probing the pins of the ECU. Also included in this report will be a fault diagnosis chart for an ABS warning light, this will show the steps that should be taken if this warning light should occur and how to rectify any issues regarding it. The two systems tested also use different OBD systems, these will be briefly discussed and compared.

Research;

The function of ABS;

The function of an ABS system on vehicle is to prevent wheel lock-up during braking and maintain the steerability and stability of the vehicle. A wheel sensor is used to monitor the speed of a chosen wheel and if it is noticed by the ECU that one wheel is travelling slower or not at all it will register as sliding and therefore activate a solenoid to release pressure on that wheel until it exits the slide. (Bosch, R., 2000)

An ABS system works in three different phases, pressure reduction, pressure hold and pressure increase. Pressure reduction occurs when a control signal is received by the ECU from wheel speed sensor indicating that one wheel is about to enter a slide or is locked. The solenoid that controls the wheel that is locked will shut off and pressure will be released from that wheel. Once over-braking has been corrected the pressure is re-released into the brake, this will repeat if the road surface is uneven or if the same wheel is unable to regain traction and the driver will experience pedal kick-back. The data collected for these tests are noted below. (Roll, Georg (Heusenstamm, DE), Ohm, Heinz-f (Weiterstadt, DE) 1994)

Pressure hold occurs after pressure reduction. Once the ECU recognises the wheel has come out of the slip and is rotating the same as the others the solenoid will stop the flow of fluid from that brake and hold the pressure in its current state. (Mathew Wright 2018)

Pressure increase will occur if the wheel sensor detects that a wheel is not slowing at the same rate as others. Once the ECU has registered this it will open the solenoid valve and allow fluid to flow to the selected brake and build pressure to slow the wheel at the same rate as the driver is braking. (Mathew Wright 2018)

Methodology;

The test carried out was done by using a simple replication of the ABS system used on a vehicle. To do so the ABS unit was set up on a workbench, to simulate the braking pressure, a threaded arm could be adjusted to apply / reduce pressure in the system. Once the pressure is set then, on the control panel fitted, the ignition is set the 'on' position, once in the 'on' position the ABS warning light should illuminate and stay fixed. Then the ignition is turned once more to simulate the vehicle running, at this point the ABS warning light should not be illuminated. To simulate the rotation of the wheel, the wheel sensor is aligned with a spinning gear attached to a motor. A dial on the control panel control controls the power to the motor so a constant speed can be set, therefore the test can be replicated at high or low speed. During the entire testing phase, appropriate PPE was used, this includes sensible clothing, dust coats and steel toecap boots. As well as this workshop guidelines were followed to increase safety.

During the testing phase of the Bosh system, a Multiscope was used to test voltages of all pins on the ABS module under ignition off, ignition on and running conditions. The waveforms were also recorded and will be discussed below. The same process is repeated for the Data plug and the solenoids. In comparison, the Teves system was slightly more complex therefore only the data plug was made accessible as the solenoid had to be stripped down to test and given the time slot allocated and resources this was not possible.

Test data;

Bosch 2EH -ABS plug;

Table 1

Pin Number	Ignition Off (V)	Ignition On (V)	Running (V)
1	0	11.88	11.75
2	0	0.2	0.25
4	0	0.29	1.25
5	0	0.2	0.25
6	0	0.2	1.25
7	0	0.2	0.25
9	0	11.88	11.75
10	0	0.2	1.25
12	0	10.68	10.51
13	0	0.2	1.25
14	0	0.2	0.25
15	0	0.2	0.25

As can be seen in the data there is no voltage whilst the ignition is turned off this is as there are no permanent live pins in this system. Pin 1 on the ABS plug relates to the ABS warning light. The battery voltage difference between ignition on and running is due to the battery not being charged as the test was being carried out.

There are some pins missing in the data sheet, this is down to the system not containing all the sensors that were available.

Pin 2, 5, 7, 14 are ground points for the wheel speed sensors, the reading of 0.2v is simply the earth return. Once under running conditions the voltage is at 0.25v but also fluctuates to 0v, this is due to the signal from the gear as it rotates, had the motor been set to a higher setting then this voltage would have increased.

Pin 4, 6, 10 and 13 are signal wires for the wheel speed sensors. This system uses a hall effect so the readings fluctuated from 1.25v to -1.25v. This due to the ecu registering the gap between each tooth of the gear which will relate to wheel speed.

Pin 9 on the ECU relates to the brake light switch. This always has voltage across it at ignition on and under running conditions due to the rig having a constant brake pressure applied. If the test were to be conducted on a vehicle then a full voltage would not be on permanently.

Data plug;

Table 2

Pin Number	Ignition Off (V)	Ignition On(V)	System Running (V)
1	0	11.79	11.75
2	0	12.04	12
3	0	0	0
4	0	11.79	11.79

Pin 1 relates to the key slot in the system. As can be seen in the table reads full battery voltage with ignition on and under running conditions. The difference in voltage is due to the battery not being recharged as the test was being conducted.

Pin 2 leads to the battery so the voltage seen is expected. The test indicates that there are no faults in the system, the only discrepancy being to the non-charging battery.

Pin 3 is an earth wire therefore sees no voltage and therefore the test confirms that there is no damage to the wire.

Pin 4 leads to pin 1 the ABS plug therefore sees battery voltage with ignition on as the light is illuminated but also sees battery voltage under running conditions. This is as both ecu's are communicating with each other. If the voltage were to be 0 then it would indicate a fault in the system.

ABS solenoid

Table 3

Solenoid	Wire colour	Ignition off (V)	Ignition On (V)	System Running (V)
1	Green	0	12.08	12.04
	Black	0	12.08	11.96
2	Yellow	0	12.08	11.96
	Black	0	12	11.96
3	Yellow	0	12	11.96
	Black	0	12	11.96

The final test was conducted on the solenoid. On this system there are only 3 solenoids, two controlling the front and one for the rear. The green and black wires are for the rear and the Black and yellow wires for the front. There is no voltage with ignition off as to be expected as there is no permanent live in the system. With ignition on and system running all show battery voltage which indicates no faults are present. The drop in voltage again is down to the charging issue.

Ford Teves System;

Because of the intricate design of the Teves system only one aspect could be tested, which was the ABS multiplug. This contained 25 pins but some were vacant again due to this system not having the full range of sensors / actuators fitted. The reason only one set of pins were able to be tested is because the solenoids were encased meaning the system would have had to be stripped down which was not possible at the time. The same test and the Bosch system was conducted with the voltages being measured at ignition off, ignition on and running.

Table 3

Pin Number	Ignition Off (V)	Ignition On (V)	Running (V)
1	0	0	0.25
2	0	0	0.25
7	12.2	12.2	12.2
8	0	0	0
9	12.2	12.2	12.2
10	0	0	0.25
11	0	0	0.25
12	0	11.9	11.9
13	9.28	9.28	9.28
16	0	11.9	11.99
17	0	0	1.25
18	0	0	1.25
20	0	0	1.25
24	0	0	0
25	12.2	12.2	12.2

As can be seen in the data, there are noticeable differences to the Bosch system. One being the 3 permanent live wires from pin 7, 9, 13 and 25. Although it is noted that only pin 7, 9 and 25 have full permanent live, whereas pin 13 only receives 9.28v. This is due to it being a data link for the OBD port of the vehicle and requires power for an external diagnostics reader. These 4 pins maintain consistent voltage through the test indicating no faults.

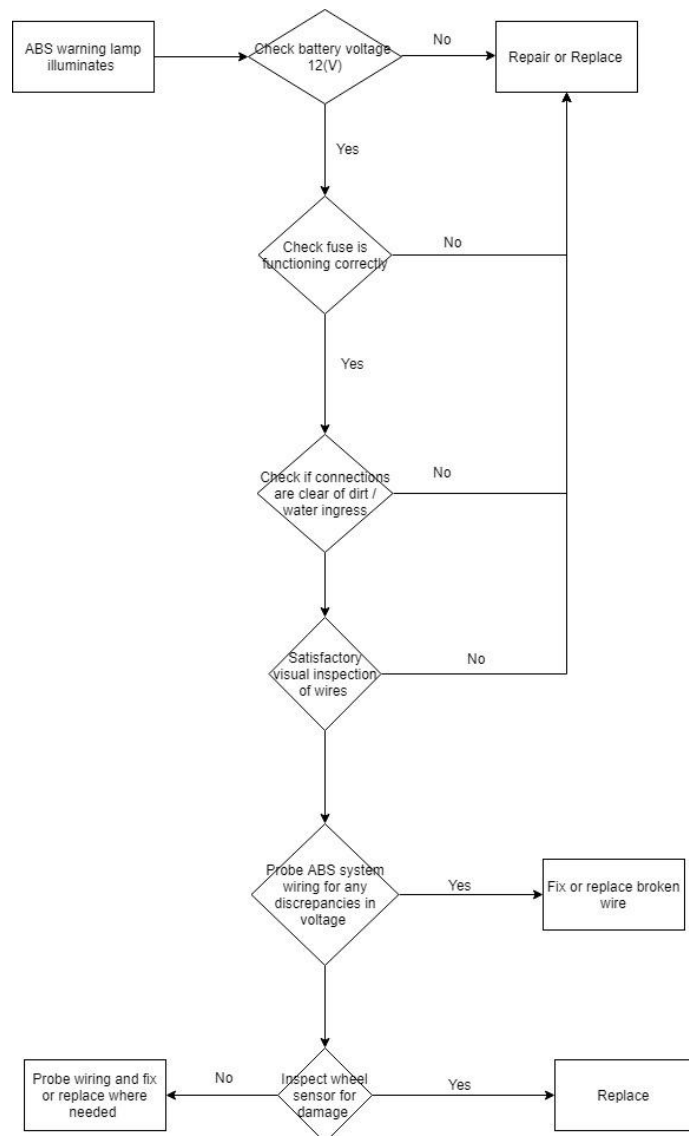
During the ignition on phase pins 12 and 16 also display battery voltage. Pin 12 is responsible for operating the brake light and due to the constant pressure applied s displaying full voltage. Pin 16 is responsible for the ABS warning lamp, the reason for the light appearing during ignition on phase is due to the system performing a self diagnostic before the vehicle is running.

During the running phase only two pins did not display a voltage which were pin 8 and 24. This is due to them being earth wires therefore it was expected that no voltage would be found otherwise there would be some fault in the system.

Pins 1, 2, 10 and 11 are earthing wires for the wheel sensors therefore averaged a voltage of 0.25v but fluctuated due to the same issue found with the Bosch setup, where the gear on the motor had imperfections in it meaning it did not provide a constant reading.

The final pins 17 to 10 are signal wires for the wheel sensor and were consistent with a voltage of 1.25v therefore not indicating any damage to the system.

The fault chart provided displays the process required to take if an ABS light were to occur whilst in running conditions. A number of faults can cause this to happen therefore the chart goes through each possibility that could trigger the warning light. By working through the chart, you would be able to source the fault at hand and take necessary steps to repair. The fault shown in this chart would be of an electrical failure so by following the chart it would solve that issue.



Waveforms;

Appendix 1

Referring to the signal waveforms found in the appendix, appendix 1 shows pin 9 on the Bosch system whilst in the running phase. This pin is for the ABS warning light, the spike shown in the waveform is the Abs being activated and the warning light flashing.

Appendix 2

This waveform is also for the Bosch system. At the beginning of the waveform there is a small spike, this is where the ABS is activating and preventing the wheel from locking.

Appendix 3

This wave form is also rear solenoid but runs at 5 amps instead, so it can allow more current to flow at a lower voltage.

Appendix 4

This refers to pin 2 and 4 of the Bosch system with pin 2 being the ground for the wheel sensor and pin 4 being the signal wire. The fluctuation seen is the gap between each tooth of the gear being recognised. The small fluctuation of the bottom wave is due to the low quality of the gear meaning it did not spin flat.

Appendix 5

Pin 2 and 19 are shown in this wave form, 2 being the ground and 19 being the signal, again there is inconsistency due to the quality of the gear.

Operational Differences;

One of the main differences between the two systems is the solenoids used. With the Bosch system being an older system, it only implements 3 solenoids, two for the front wheels and one for the rear. This meaning that if the system were to identify a rear wheel locking then it will either maintain or release pressure on both rear wheels rather than just the one suffering lock-up. The Teves system uses 4 solenoids and implements one for each wheel, meaning that it can accurately control a lock up by singling out a single wheel.

The two ABS systems mentioned also use different variants of OBD. The Bosch system implements OBD 1 whereas the Teves system uses the more updated OBD 2.

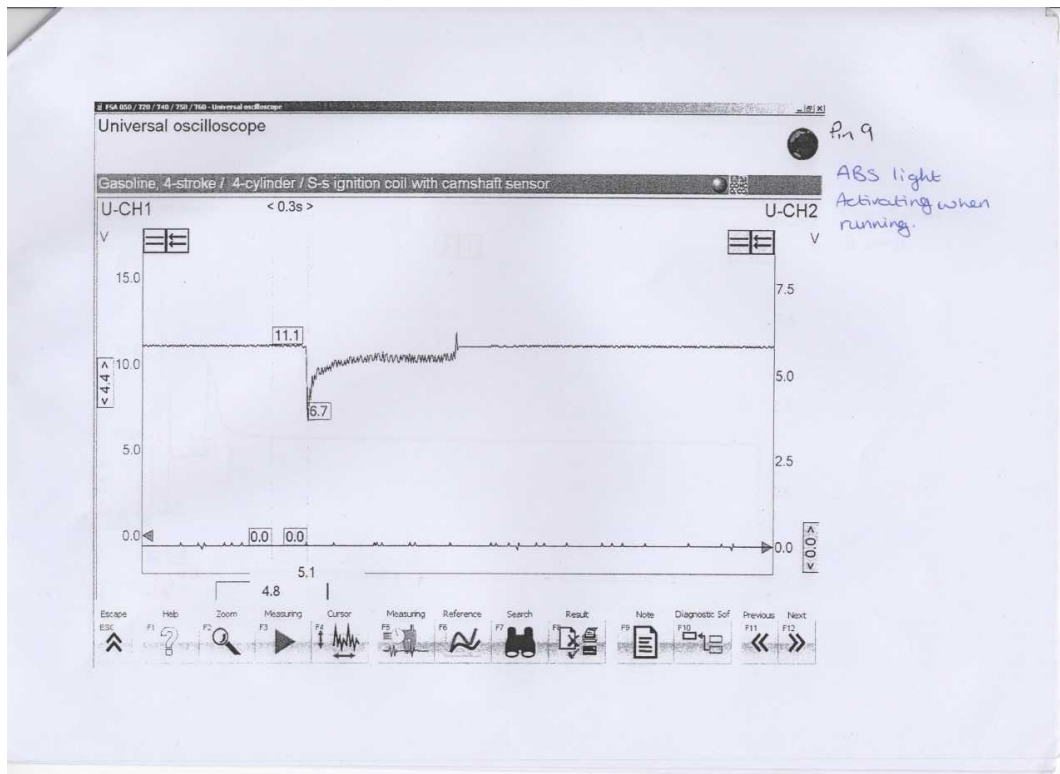
OBD 1 began use in the late 80's and was mainly used for monitoring exhaust emissions and vehicle electrical systems. Although the system was aimed to reduce vehicle emissions it wasn't as successful as predicted hence brought the introduction of the OBD 2. (OBD Advisor. 2018.) Because of the of development with OBD1 there was a demand for a better OBD system. Along with this there was also a requirement for lower emissions standards. As of 1996 it was required that all new cars had to be fitted with OBD2 to combat rise in emissions as well as ease of access for users. Because of the more updated version of the OBD it meant that newer technology for monitoring and combating emissions emerged, such as catalytic converters. (ShoutAbout. 2017.)

To conclude, the Teves system is more updated than the Bosch system in terms of capabilities regarding OBD and more reliable for diagnosing faults. Although the intricacy of the Teves system made it difficult for probing the solenoid pins so full readings could not be taken, the lack of diagnostic power and basic reading of the Bosch system means it does not keep up with the Teves. The overall design of the Teves is greater than the Bosch given it can monitor all 4 wheels simultaneously rather than monitoring just the

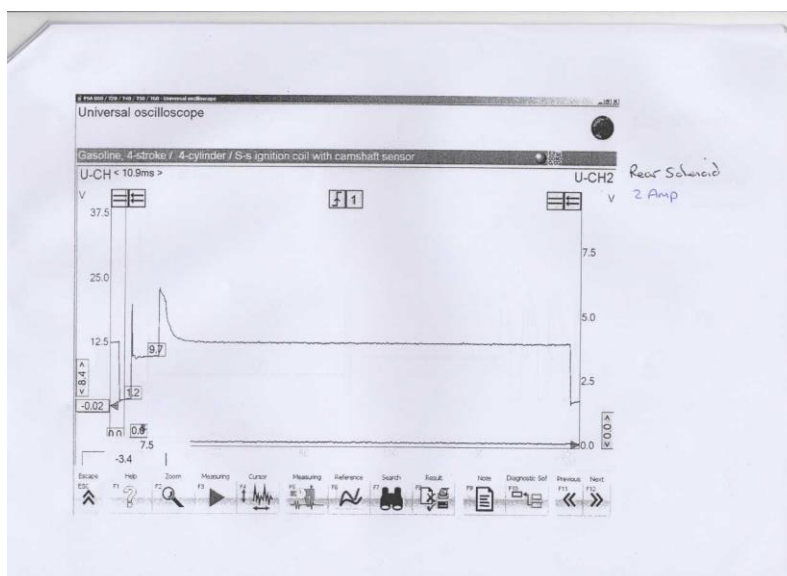
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4. OBD Advisor. 2019. *Difference Between OBD1 and OBD2 Scanners - OBD Advisor*. [ONLINE] Available at: <https://www.obdadvisor.com/difference-obd1-obd2-scanners/>. [Accessed 05 January 2018].
5. ShoutAbout. 2019. *Difference between OBD1 and OBD2*. [ONLINE] Available at: <https://www.shoutabout.org/difference-obd1-obd2/>. [Accessed 05 January 2017].

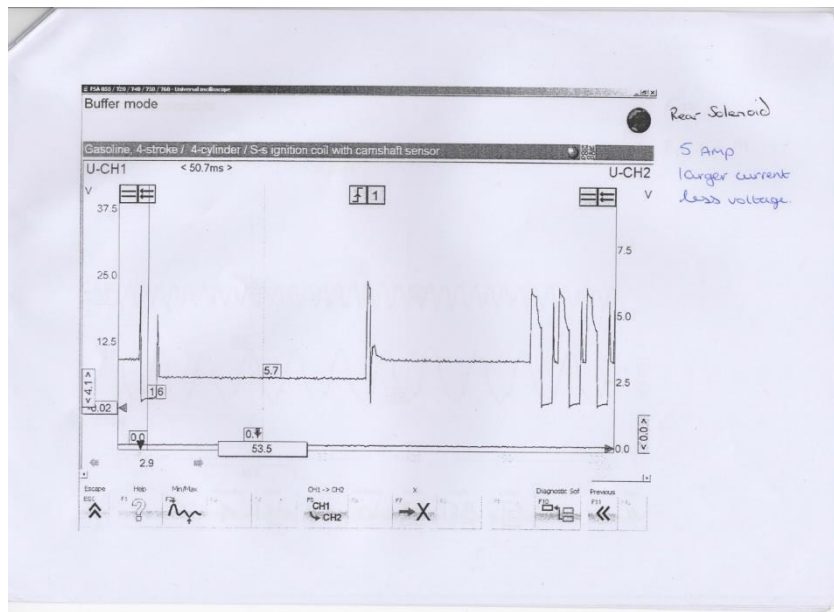
Appendix 1



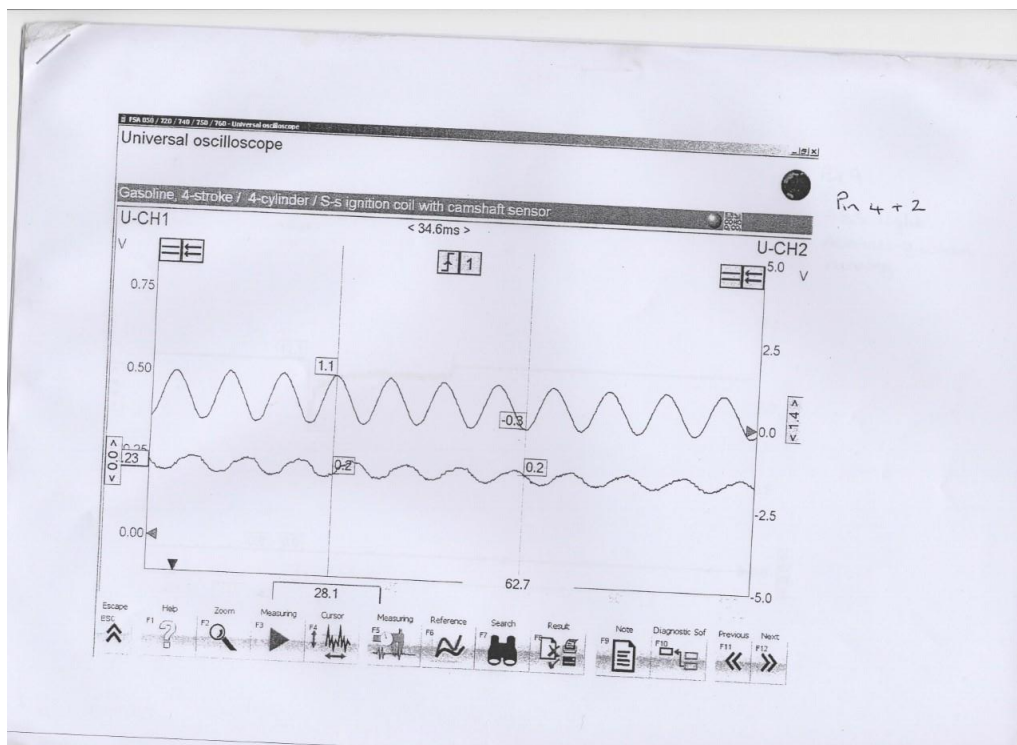
Appendix 2



Appendix 3



Appendix 4



Appendix 5

