

Anti-Lock Braking Systems



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Introduction

Within this report, the definition of the function of an Anti-Locking Brake system will be discussed, from here a service report for the outcomes of the full operation test using test rigs will be discussed along with the procedures adopted to complete the tests. The actual readings will be shown and the safe working practices that were adopted during the testing will be discussed. From here, a fault diagnostics chart will be produced that enables for the determination of a cause of a malfunction when an ABS warning lamp is on. A comparison between the operational differences of the Bosch ABS 2EH system and the Ford TEVES Mk IV system will be made. Finally, the strengths and weaknesses of both systems will be discussed.

Task 1

The function of an anti-lock braking system is, as the name states, to prevent the brakes from locking up and causing the vehicle to skid, the system does this by modulating the braking pressure, this is done with the three operational processes, pressure build-up, pressure hold and pressure reduction (Bosch, 2000). The wheel speed sensors monitor the wheel speed of the vehicle, when the vehicle is braking, the sensors send a signal to the ABS ECU, this allows for ABS to engage if one of the wheels begins to slip, if one or all wheels begin to slip the system will reduce the braking pressure to allow for the wheels to regain traction, the system will continuously do this if the wheels continue to slip, thus allowing for steerability and stability (Bosch, 2000) over the vehicle under harsh braking. Pressure hold occurs after pressure reduction, once the wheel regains traction, the wheel speed sensor sends the signal to the ABS ECU, the solenoid for the wheel will hold the pressure of the brakes. Pressure build-up will occur if the wheel speed sensor detects that a wheel is not slowing at the same rate as the other wheels and will increase the pressure in the brakes of that wheel.

Task 3a

In order to test the Anti-Lock Braking Systems, testing rigs were used along with multi-meters and Bosch Diagnostics Computers. The first ABS system to be tested was the Ford TEVES Mk IV ABS system, prior to conducting the testing, the pressure in the ABS system was set to the correct pressure, once this had been done the pins in the data module were tested for voltage when the ignition was off, this was done using the multi-meter, the voltages of the pins were then measured with the ignition on. Once the voltages for each pin with the ignition on were measured, the voltages were measured with the system running, this was measured using the Bosch Diagnostics computer.

The Bosch ABS 2EH system was then tested, the testing process for this system was completed in the same way as the TEVES system initially, the voltages of the ABS ECU were measured, with the ignition off, then with the ignition on, these were measured using a multi-meter and finally the voltage of the pins when system was running was measured, this was done using the Bosch Diagnostics Computer. From here voltages on the pins of the data plug were measured. The voltages of these pins were measured using the multi-meter, the voltages were measured when the ignition was off and when the ignition was on. The voltages in these pins were then measured using the Bosch Diagnostics Computer, whilst the system was running. The voltages in the ABS solenoids were then measured when the ignition was off and on using the multi-meter and the voltages of the solenoids were measured using the Bosch Diagnostics Computer when the system was running.

Task 3b

Bosch 2EH

Pin Number	Ignition Off (v)	Ignition On (v)	System 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

Table 1 – ABS ECU

From the test results in table 1, it is evident that there are some pins missing from the ABS ECU, this is due to the testing rig not having all the sensor and actuators running of the testing rig. When testing the ABS ECU, the voltage with the ignition off was measured, from the results, it is made clear that the system does not have a permanent live, this is evident as the voltage reading throughout the pins was 0 volts. The ABS ECU was then tested with the ignition on, the results can be found in table 1.

Pin 1 is the pin for the ABS warning lamp, when there is voltage the ABS warning lamp turns on, in this case the readings show that battery voltage is running through the pin, the voltage was 11.88 volts, the battery voltage is lower than expected as the testing was conducted on a rig, thus meaning that there was no alternator to recharge the battery. Pins 2, 5, 7 and 14 are the ground signal pins running from the ABS ECU to the wheel speed sensors on each wheel, from the results in table 1, the ground voltage on each pin was 0.25 volts when measured using the Bosch

Diagnostics Computer. Pins 4, 6, 10 and 13 are the pins for the signal pulse wires, these wires go from the ECU to the wheel speed sensors, when being measured using the Bosch Diagnostics Computer, the results would fluctuate between 1.25 volts and -1.25 volts, this is due to the Bosch 2EH system utilising a Hall Effect system to send the voltage back to the ECU to regulate the wheel speed when the ABS is being applied. Like pin 1, pin 9 also has a reading of 11.88 volts when the ignition is on, this is due to pin 9 being the brake light switch feed, the battery voltage was measured due to the rig having a constant brake pressure in order to show a voltage when testing, if the testing was conducted on a vehicle, the voltage would have read 0 volts if the brakes weren't being applied. The waveform for pin 9 can be seen in Appendix 1. The Waveforms for pins 4 and 2 can be seen in Appendix 4.

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

Table 2 – Data Plug

The results from the testing of the data plug can be seen in table 2, the results show that when the ignition was off there was a voltage reading of 0 volts, this is due to the system not having a permanent live. Pin 1 is the wire running from the ignition switch to the data plug, when the ignition switch is off, the voltage reads 0 volts, when the ignition is switched on the voltage reads 11.79 volts, thus meaning that the reading is battery voltage. When the system is running the voltage should read the same, however, due to this test being done on a rig, the battery voltage had dropped slightly due to the lack of alternator to recharge the battery. Pin 2 is a wire that can be traced back to the battery via a relay, due to this an assumption can be made that when the ignition is on and when the system is running, the pin would have a reading of the battery voltage, which in this case is 12.04 volts. Pin 3 is the earth wire, this is evident in the results, as all three readings were 0 volts. Pin 4 is the wire that connects the Data plug to the ABS ECU (Pin 1), when measured the voltage reading for this pin was 11.79 volts when the ignition was on and when the system was running, this is battery voltage. When looking at Pin 1 on table 1, the voltage reading,

as expected, was also battery voltage, thus meaning that there is communication between both the data plug and the ABS ECU and that the system is functioning as it should.

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

Table 3 – ABS Solenoid

The final testing conducted on the Bosch 2EH system was to test the voltages on the ABS solenoids, in this case, there are only three solenoids. Pin 2 and 3 are the solenoids for the front and pin 1 is the rear solenoid, the waveform for this solenoid can be seen in Appendix 2 and 3. From the results in table 3, it is shown that when the ignition is off the voltage reading is 0 volts. When the ignition is turned on, the voltage of the pins all read around 12 volts. The voltages were then tested when the system was running, the results show that the voltages all dropped slightly, this is due to battery not being charged as it would be in a vehicle.

Ford TEVES MK IV

Pin Number	Ignition Off (v)	Ignition On (v)	System 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	11.99	11.99
13	9.28	9.28	9.28
16	0	11.99	11.99
17	0	0	1.25
18	0	0	1.25
19	0	0	1.25
20	0	0	1.25
24	0	0	0
25	12.2	12.2	12.2

Table 4

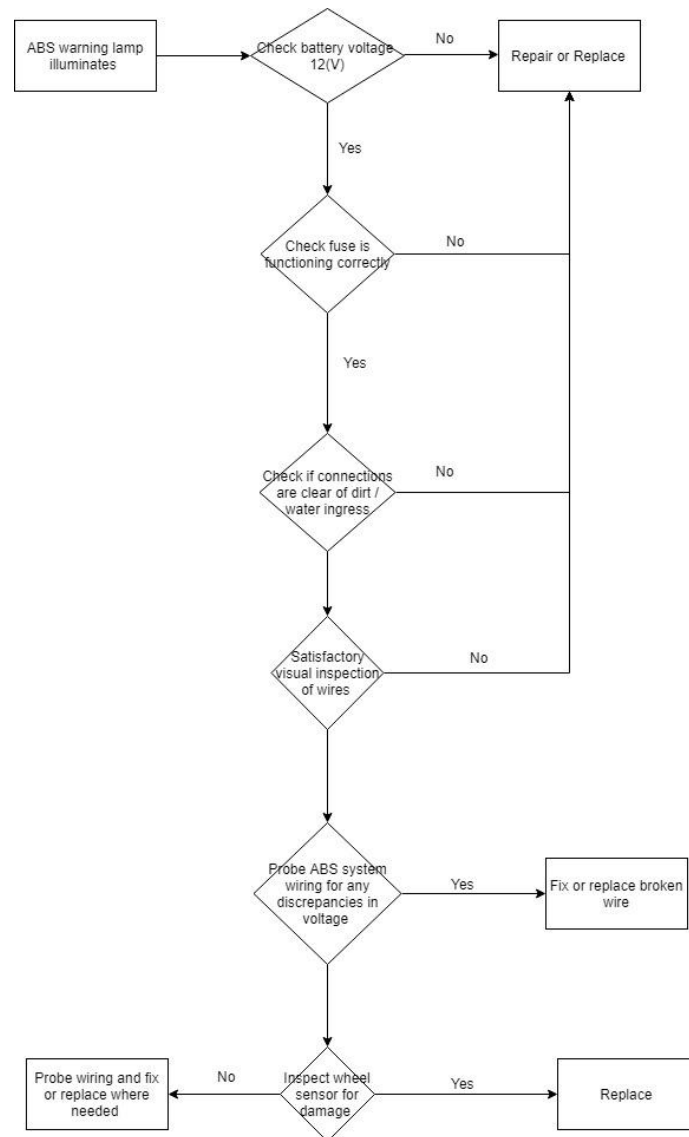
From the testing of the Ford TEVES MK IV system, the only pins that could be tested were the 25 pins on the ABS multiplug, however not all 25 pins were being used within the plug. The results from the readings can be found in table 4. From the results, it is evident that, unlike the Bosch 2EH system, the TEVES system has some permanent lives, pins 7, 9 and 25. The wires for these pins also go through fuses, pins 9 and 25 go through a 30A fuse and pin 7 goes through a 7A fuse. All three pins read a voltage of 12.2 volts, which is a continuous voltage throughout all three tests. Pins 1, 2, 10 and 11 are the earth wires for the wheel speed sensor, as expected of an earth wire, they all read 0 volts when the ignition was both on and off, however, when the system was running, they read 0.25 volts when measured with the Bosch Diagnostics Computer, there is a fluctuation within this reading, the fluctuations can be seen in Appendix 5. Pins 8 and 24 are the earth wires for the TEVES system, due

to this the readings are 0 volts for both pins throughout the testing of the system. Pins 12 for the brake pedal position switch, when the ignition is off the voltage is measured as being 0 volts, when the ignition is turned on, the voltage is measured as being 11.99 volts, which is battery voltage. When the system is running, the voltage is also measured as being 11.99 volts, this is due to there being a constant brake pressure, like when testing the Bosch 2EH system. Pin 16 is also connected to pin 12 through a 15A fuse, due to this both pins have the same readings when the ignition is on and when the system is running. Pin 16 is the wire for the ABS warning lamp and the traction control warning lamp. Pin 13 is the wire for the OBD2 port, the voltage for this pin was measured as being 9.28 volts when the ignition was off, thus meaning that it has a permanent live. The voltage remained the same for all three tests. Pins 17, 18, 19 and 20 are the signal wires for the wheel speed sensors, the voltage for each pin was 0 volts when the ignition was both on and off, however, when the system was running, the voltage in the pins was 1.25 volts. The waveform for this can be seen in Appendix 5.

Task 3c

When carrying out practical testing, whether using a rig or testing a vehicle, the correct Health and Safety regulations and legislations must be adhered to, in this case, the correct PPE (HSE, 2015) must be worn i.e. lab coats and steel toe capped boots, under the Health and Safety at Work Act 1974 (HSE, 1974) and the Control of Noise at Work Regulations (HSE, 2005). Health and Safety risk assessments must also be completed prior to testing. The correct Health and Safety regs and legislations must be adhered to, to ensure that when carrying out practical tests, neither you nor any others person are at risk.

Task 4



The fault chart above illustrates the correct process in which to check for faults if the ABS warning lamp was lit. The initial step would be to check the voltage of the battery, if the battery voltage is low, then it should be recharged or replaced. From here you would check the fuse for the ABS warning lamp, as it may have blown, if so, then you would replace the fuse. If the fuse is functioning correctly, then you would go onto check the connections for any water ingress or dirt and replace or repair if need be. The next step would be to check the wires, and replace or repair any that are damaged, if this does not solve the issue, then you would go onto probing the ABS system wiring for any discrepancies in the voltages. If the voltages are all okay, then you would inspect the wheel speed sensors for damage and repair

or replace if it required, if this does not solve the issue then you would re-check the wiring and replace where needed.

Task 5

The main difference between the Bosch ABS 2EH system and the Ford TEVES MK IV system is the number of solenoids that are used to regulate the ABS pressure. The Bosch ABS 2EH system has three solenoids, two for the front wheels and one for the rear, the rear solenoid takes the lowest speed of the rear wheels and detects when that wheel will lock up, it will then activate one of the modes of operation, which in this case would be to reduce the braking pressure on both wheels. The TEVES system has four solenoids, one for each wheel, thus allowing for a more precise braking system. Another difference between the systems is the OBD's that are used. In the Bosch system the first generation OBD (OBD1) is used and the second generation OBD (OBD2) is used in the TEVES system, thus meaning that the TEVES system is more updated.

Task 6

The Bosch 2EH system has its strength and weaknesses, its strengths are that the system can be checked for discrepancies in voltage throughout the plugs and solenoids easily, however, the system is outdated as it uses the OBD1, and was developed in the 80s, another weakness is that it only has one solenoid for both rear wheels, this could result in both rear wheels locking if the solenoid was to fail. The TEVES system is more updated than the Bosch system and allows for a higher accuracy in the braking as it has a solenoid for each wheel, however, there are more electrical components that could be faulty, and the design of the system makes for the probing of the solenoid pins to be difficult. The TEVES system allows for the use of standard vacuum boosters and a conventional master cylinder (dii.unimo.it. 2006)

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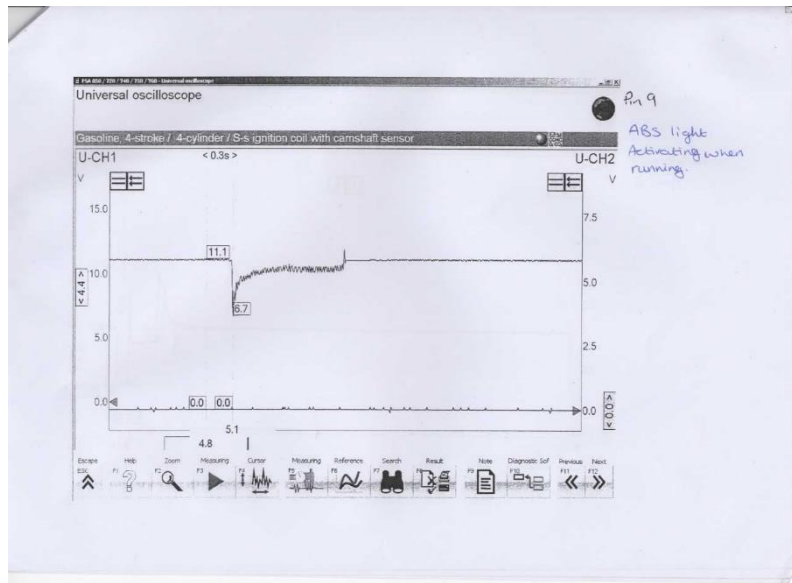
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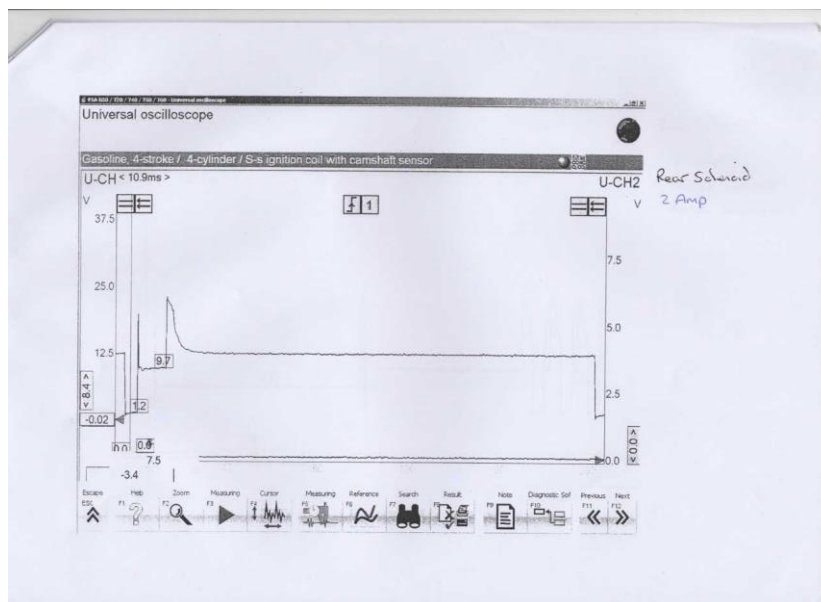
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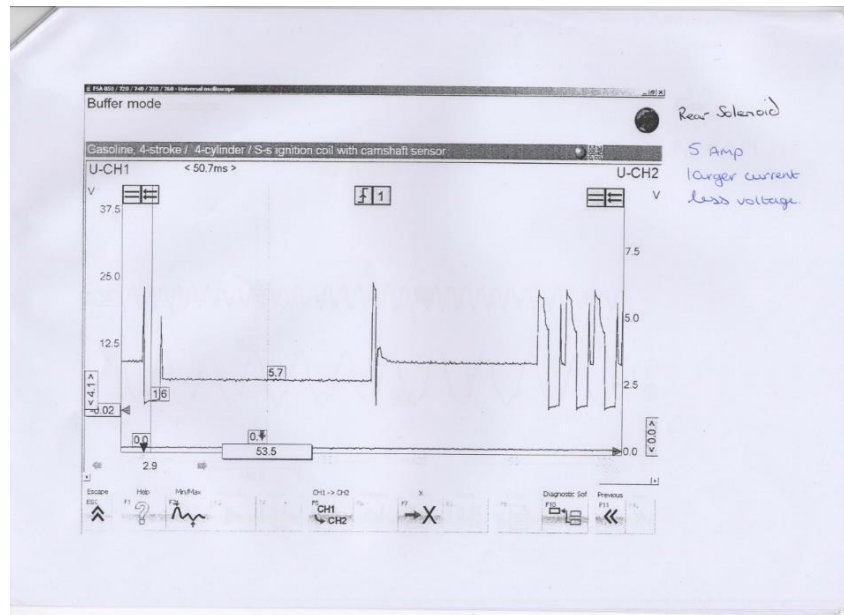
Appendix 1.



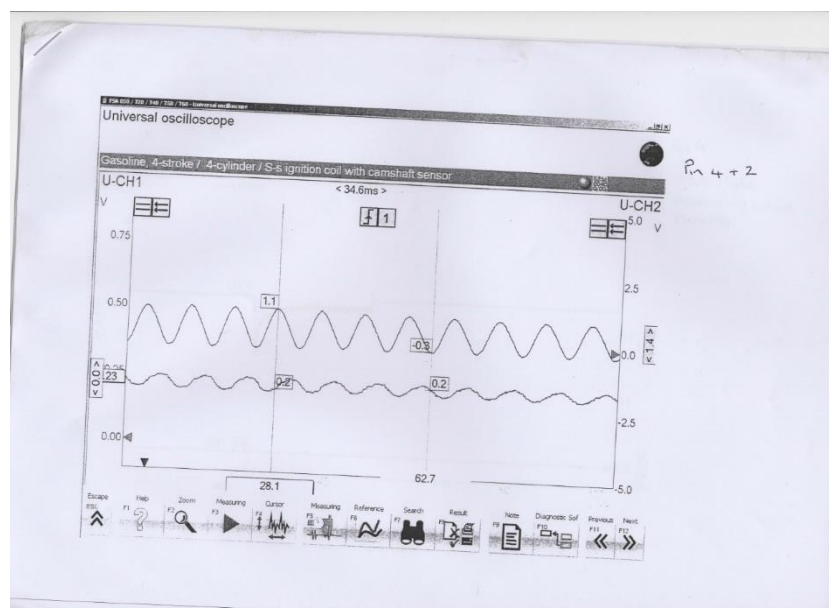
Appendix 2.



Appendix 3.



Appendix 4.



Appendix 5.

