



EMISSION CONTROL AND DIAGNOSTICS

Abstract

This assignment consisted of an analysis of two anti-lock braking systems with a practical examination incorporated into the analysis of both systems.

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Emission Control and Diagnostics

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Contents

- 1) Introduction = 4
- 2) Fault diagnosis techniques = Page 5
- 3) Health and safety and equipment = Page 6
- 4) Operation procedure = Page 8-9
- 5) ABS test readings = Page 10-13
- 6) Comparing operational differences = Page 14
- 7) Fault Chart = Page
- 8) Waveforms = Page
- 9) References = Page 2

1) Introduction

In the automotive industry and aerospace industry Anti-lock braking systems have been developed making the processes on how the systems work being more technical. For the aerospace industry they were invented to prevent tyre lockup when landing but have been transferred in to the automotive industry. ABS has advanced over time and now integrates with many other systems that make vehicles safer under conditions other than braking. We will include some of these systems in the report. ABS is in the everyday economy vehicle to fit legislation standards set by governments with the intention to reduce road fatalities by providing road users with this the ability granted by this feature.

This assignment is an analysis and evaluation of the operation of two different types of anti-lock braking systems involving a practical examination of them using standard and dedicated test equipment, measuring voltage and what makes the systems activate. The two systems being tested are the Bosch 2EH ABS and the Teves MkIV. As a student this assignment requires research by means of practical sessions testing both systems in the university workshop and by individual reading requirements.



2) Fault diagnosis techniques

Vehicles of this era are much more complex in their engine, transmission and chassis designs makes diagnosing a fault much more difficult as 1 fault may occur on a vehicle's display but there are components to choose from where 1 or more of them could have failed to find the fault. "It is easy to assume the same problem you have seen before". (Denton. 2000). This is why having a familiarity with the modern technology being put into these vehicles will aid a technician solving and fixing these vehicles in the industry. (Denton. 2000). Modern techniques involve good diagnostic equipment, knowledge and understanding of the vehicle's system and logical thinking. Ian Doran (Buick service) said it best as "Technicians tend to just jump right in and forget the diagnostic steps when they have everything pulled apart maybe a new expensive ABS unit replaced when the problem could have simply been a loose wire or connector", low battery voltage or often a fuse or relay that has blown because of a wiring loom problem.

Vehicles ABS/TCS fault diagnosing tips

1. Visual inspection: to begin it is best to carry out a visual inspection for example when inspecting low mileage cars with an electrical fault check for stretched wiring that is too tight between connections. Ideally the harness should be long enough between connections so that it can flex when the vehicle is subject to vibrations. If you find no obvious problems with the wiring, connector in the harness. Check to see if brake fluid levels are OK and there are no leaks from the master cylinder reservoir. Check the appropriate fuses, relays in the instrument panels etc.
2. Functional checks: then following the electrical systems manual you should move onto the modern techniques of function checks. When you hook up the diagnostic computer to the OBD (onboard diagnostics) port and run a trouble shoot on the system. For example the fault that may arise relating to ABS and TCS could be the ABS/TCS warning lamp. The lamp is remained on the display after performing the trouble shoot. In this case half of the components part of the unit could contribute to this fault code occurring for the warning lamp to stay on (which makes diagnostics difficult). See the electrical systems manual to see what sensors or solenoids that could make this occur.

3) Health and Safety/Equipment

Health and safety

In undergoing testing the 2 ABS systems the class were assigned into groups and given time slots for each group to carry out the tasks instructed in the assignment brief. Before testing both ABS systems we had to take part in a health and safety briefing of the workshop test area. This was compulsory before carrying out our examination.

'Safety is not just a buzzword on a poster in the work area'. Safe work habits can reduce accidents and injuries, ease the workload and keep employees pain free'. (James. 2011). A safety brief was given to us by the university tutor with the aim to inform us of potential dangers. The university provided us with the correct PPE such as steel toe boots, lab coats, gloves and protective glasses in which were compulsory to be worn at all times in the university workshop. Our tutor showed us the steps in using the ABS test rig and introduced us to tips to accomplish the examination in a professional manner. For example one person to look over the test rig for any air leaks in the system etc.

Equipment

Undertaking these tasks we were supplied with correct professional equipment. The test rig that the Bosch 2EH and the Teves MkIV were set up on was an AGB Block automotive training rig, which allows the observation of a working anti-lock braking system via pressure gauges in the brake circuit. It includes a Bosch 2EH or a Teves MkIV complete with an ABS pump, electronic control unit, wheel sensors, master cylinder and diagnostic socket. A Bosch FSA-740 engine diagnostics system was used which is the new dimension in trouble shooting. This system gave us the ability to accurately find faults and see our readings in waveforms dynamically and pause the system in areas to see what is happening in different stages.

Tasks

1. Define the function of an ABS system and the various diagnostic techniques that can be applied.
2. Using the equipment provided carry out a full systems operation test on the test rigs provided :
 - Bosch 2EH
 - Teves MkIV
3. Produce a written service report on the outcomes of the test with particular reference to :
 - Procedure adopted when carrying out the test
 - Actual test readings and signal waveforms
 - Safe working practices adopted when carrying out the tests
4. Produce a fault diagnostic chart that enables an ABS warning light 'on condition' to be investigated to determine the cause of the malfunction.
5. Compare the main operational differences between the Bosch 2EH and the Teves MkIV ABS systems. State what you consider to be the systems strengths and weaknesses.

4) Operation procedure

Electronically sensed ABS

How these systems detect skids are provided by wheel sensors, some are electromagnetic or Hall effect. The sensors communicate by changes in wheel speed rotation at each wheel. The Bosch 2EH and Teves MkIV are ABS units are incorporated into the hydraulic brake circuit to form an 'integrated system'. Under normal braking operation brake fluid pressure is not influenced ABS (Hilliers 6th ed, 2014). ABS will only intervene when there is a wheel locked. How the ABS intervention occurs during wheel lock-up will be discussed below in 3 operational phases.

Hydraulic components

- Master cylinder
- Brake lines
- High pressure pump
- Brake calipers
- Expansion chambers

Electronic components

- ABS ecu
- ABS modulator
- Solenoid valves
- Brake switch
- Wheel speed sensors

Note: The following processes will occur many times a second and can move from different wheels very quickly.

1st Phase: pressure maintain

Under braking the ABS will detect one or more wheels slowing down faster than other wheels which is communicated by the signal from the wheel speed sensor. At this point the ecu will begin closing off the inlet solenoid to those wheels therefore stop brake pressure being applied to the wheels slowing down faster than the rest. The rest of the wheels with more traction will have increased brake pressure applied to them, 'creating a balanced braking action' (Hilliers 6th ed, 2014).

2nd Phase: pressure decrease

When a wheel sensor signals a wheel skidding the ecu closes the inlet valve then follows with opening the return valve causing a reduction in fluid pressure so wheel locking is reduced. (Hilliers 6th ed, 2014).

3rd Phase: pressure increase

When the speed of the locked starts to increase (the wheel starts to turn again) the wheel speed sensor signals free movement of the wheel. For an ABS unit to regulate itself is due to the solenoids. single solenoids for both rear wheels in the brake return line will give equal pressure reduction for both rear wheels to “unlock” them. Modern systems like the Teves MkIV and more units have solinoids independent to each wheel so pressure maintains, decreases and increases wont be equal for each wheel.

Live Testing

The investigation could only be possible in small groups so that everybody had a role to play in testing the ABS systems in the university workshop. Our tutor gave us insight into both systems in a series of lectures prior to the testing and gave us guidance into using the testing rigs while playing the role of overseeing our investigation. The examination was carried out by measuring the voltage of all the pins on both systems under a series of conditions: Ignition off, ignition on and dynamic. The voltage by connecting a probe from the Bosch FSA-740 engine diagnostic to each pin. The scribe: was the person that took notes of everything happening throughout the examination and the results received from the test. The probe operator: placed the probe into each pin of the ABS ecu so that the scope operator could receive the readings of each pin. The scope operator: was in control of the Bosch FSA-740 which created the waveforms dynamic graph for us to see.

5) ABS test readings

Bosch 2EH ABS (15 pins)

Pins	label	Ignition off	Ignition on	Dynamic	Note
1	AB warning lamp	0v	12.5v	12.25v	Not changing but grounded if a fault occurs
2	wheel speed Ground	0v	0.22v	0.23v	AC signal output
3					
4	Wheel speed signal	0v	0.35v	0.35v	looks for speed signal from wheels, causes Abs intervention if changes
5	wheel speed Ground				same as pin 2
6	Wheel speed signal				same as pin 4
7	wheel speed Ground				same as pin 2
8					
9	brake light swith	0v	12.3v (brake applied)	12.3v	under Abs intervention voltage drops to 8.9v. This is supply to brake light and system
10	Wheel speed signal				same as pin 4
11					
12	serial data wire	0v	11.13v	11.09v	data is the voltage line, draw decrease is due to sending data.
13	Wheel speed signal				same as pin 4
14	wheel speed Ground				same as pin 2
15	diagnostic lead	0v	0.25v	0.36v	Peaks on the voltage line are data.

We began With Bosch 2EH ABS system which had 15 pins and a First generation onboard diagnostics port. We checked the system by measuring the voltage of the input coming from the ecu to the sensors in the circuit. Pin 1. As you can see in the above chart is the warning lamp. (12.5v) is the supply voltage is really a potential voltage which represents nothing, the light will only come on if the ecu detects a fault. If the ecu detects a fault it will ground the voltage to inform the driver. Pin 2. (0.2v) Is only a residual voltage. Pin 2. Which is the speed sensor shows the system sending a residual voltage to the line and then its going to come back on the line signifying a complete circuit and the light will stay off. These ABS systems do a preliminary check by priming the system with one phase to check the system for faults. This happens when you turn the ignition on of your car that has ABS. Pin 2. (Under dynamic conditions) our tutor showed us the frequency and magnitude changes of the speed sensor because it showed blips which may have been from the ABS rigs teeth may have been worn or due to the thin luctor rings. The voltage was still within the voltage value of the manual so we carried on. These blips wouldn't show up in the abs unit of a car unless there was a little wear and tear of components. (Hillers. 2014).

Pin 4. (0.37v) wheel speed signal showed we were looking for any jumps into a phase but it stayed the same meaning all wheels would stay at the same speed. We didn't test Pin 5 Because it's the same as Pin 2, didn't test Pin 6 because it's the same as Pin 4, didn't test Pin7 because it's the same as Pin 2 as stated in the chart above.

Pin 9. (brake light switch) which on the test rig was always on showing battery voltage therefore no abs intervention but the brake is applied. Under abs intervention the voltage dropped to 8.9v because the pump is brought in. this shows that bringing abs in with that substantial voltage has a huge impact on the whole supply throughout the whole car. Since the rig is not equipped with an alternator to step up and maintain a standard this is why the unit has such a draw. (Hilliers. 2012). Modern cars are equipped with other methods of withstanding this draw for example by fitting cars with bulbs with their own battery packs so that the lights don't dim from these substantial draws and therefore improve timing.

Pin 12. (Data Wire) as stated in the chart above the voltage decrease to 11.09v is due to sending data. We didn't check Pin 13 because it's the same as Pin 4 and we didn't check Pin 14 because it's the same as Pin 2.

Pin 15 (diagnostic lead) which is a residual voltage. 0.2v indicates the completion of the circuit. Eg for the information to go through it has to come back.

Bosch 2EH ABS (4 pins)

Pins	label	Ignition off	Ignition on	Dynamic	Note
1	Ignition key	0v	12.37v	12.37v	
2	Over arch Relay	0v	12.6v	12.6v	
3	EARTH	0v	0.04v	0.04v	
4	Light	0v	12.33v	12.3v	

The Bosch 2EH had a 4 pin element which goes throughout the circuit. For Pin 1 (ignition key) 12.37v supply to the fuse box then to the key. Pin 2. (over arch relay) 12.8v comes from the battery powering the ecu. (Modern ecus have better protections from extra voltage that may burn out this relay). Pin 3 (Earth) 0.04v shows it grounding. Pin 4 (light) same as pin 1 on the ecu.

Bosch 2EH solenoid

Pins		Ignition off	Ignition on	Dynamic	Note
black	Front	0v	12.5v	12.5v	At stage 1 Abs intervention 9.5v @stage 2 Abs intervention 5.5v
Yellow		0v	12.5v	12.5v	At stage 1 Abs intervention 9.5v @stage 2 Abs intervention 5.5v
black	Front	0v	12.5v	12.5v	At stage 1 Abs intervention 9.5v @stage 2 Abs intervention 5.5v
Yellow		0v	12.5v	12.5v	At stage 1 Abs intervention 9.5v @stage 2 Abs intervention 5.5v
Black	Rear	0v	12.5v	12.5v	At stage 1 Abs intervention 9.5v @stage 2 Abs intervention 5.5v
Green		0v	12.5v	12.5v	At stage 1 Abs intervention 9.5v @stage 2 Abs intervention 5.5v

These Bosch solenoids are dual control solenoids which are only 2 amp hour and 5 amp hour phase. If the system is recognizing one of the wheels slowing down a lot more than the others it will energise the 2 amp hour phase and move the solenoid up ever so much no longer allowing go to that wheel maintaining pressure at that wheel. If during this pressure maintain the vehicle goes into lockup, it would energise the 5 amp hour phase that further releases the pressure on that one line but sending that pressure to all the others because the pump is turned on. (Bosch. Handbook 2014).

In this case the 2 front wheels increase in pressure and the others decrease if the rear is locking up on one side then the others will do the same in the case of this Bosch unit. This is because the unit has 3 solenoids which is 2 for each front wheel and 1 for the rear which is different to the Teves MkIV unit which has Independent solenoids. This is a major flaw in the system by having pressure maintained, increases or decreases non-independently.

AS shown in the chart above the Black and yellow pins are the 2 front solenoids and the black green is the singular rear. The black pins are all 12.5v because here we are sending a supply into the coil windings in and out of the system. The green pin is the only pin in which you can see intervention because that's one of the rears that is connected to the 1st and 2nd phases. (Hilliers. 2014). The 1st phase is asking the solenoid to move slightly therefore no more pressure to be let through. It reads 9.5v as it's a 2 amp hour draw. The 2nd phase when its brought in it will drop to 5.5v as shown in the chart above. It is no using no more voltage as the pump is going from on to off to on to off to on trying to get the wheel to speed up again. In a real life scenario this could be a simulation if the wheels are locked up while there is debris on the road continuing this action.

Teves MkIV ABS (25 pins)

Pins	label	Ignition off	Ignition on	Dynamic	Note
1	wheel speed ground				same as pin 2
2	wheel speed ground	0v	2.3v	2.6v	AC output
3					
4					
5					
6					
7		12.6v	12.6v	12.57v	Memory Perminant live
8	EARTH	0v	0v	0v	EARTH
9		0v	12.6v	12.6v	Ignition live
10	wheel speed ground				same as pin 2
11	wheel speed ground				same as pin 2
12		0v	12.6v	12.6v	Ignition live
13		9.86v	9.86v	9.7v	Data link
14					
15					
16		0v	12.6v	12.6v	Lamp
17	wheel speed signal				same as pin 19
18	wheel speed signal				same as pin 19
19	wheel speed signal	0v	2.3v	2.6v	Speed reading changes up and down voltage in dynamic
20	wheel speed signal				same as pin 19
21					
22					Not included in this system
23					
24	EARTH	0v	0v	0v	EARTH
25		12.6v	12.6v	12.6v	perminant live

Note: With the ford Teves system the pins are internal because the solenoid is internal. For the live testing of the teves it is very similar to the Bosch system in describing what is happening at each pin even though the Teves is more advanced. As you can see above the warning lamp is left on when the ignition stays through running the system which shows there is a fault. When the abs system is switched on the abs control module receives battery voltage (12.5v). This signals the controller to pull in the main abs relay to perform a diagnostic function check that lasts a few seconds. As stated by Ian Doran (Buick service engineer) "During this check the controller looks for about 9 volts from the main relay" as you can see at Pin 13 (9.86v).

At Pin.7 (Memory permanent live), Pin.13 (Data Link) and Pin.25 (Permanent live) you can see above that when the ignition is off there is still battery voltage, this is because the Teves system Electronic brake control modulator (EBCM) stores trouble codes in memory. Fault codes can only be erased by a sequence or procedure through the OBD2.

6) Compare the operational differences

The Teves MkIV system that we tested has 10 solenoids whereas the Bosch system has only 3. The Teves system that we tested has 10 for the addition of electronic traction control, the electronic braking traction control modulator uses the anti-lock brake pressure modulator valve to control braking to the slipped drive wheels. The system has 2 isolation valves and a pressure switch. (these valves are so named as they isolate the front brakes from the master cylinder and the driven wheels circuits. This is a strength to that it has over the Bosch 2EH system as it only has 3 solenoids, two for the front wheels and 1 for regulating the rear in which was mentioned above.

The Teves MkIV system was further developed to improve traction by signalling the powertrain ecu to reduce torque, the signal comes direct from the traction control modulator. This is accomplished by retarding spark and cutting fuel to the engines cylinders. This is another trait that the Teves system has over the Bosch as traction control is available at all speeds. The Bosch system would have to add components to have traction control whereas the Teves has it already.

The Bosch 2EH system has an OBD1 port which was designed to allow a car to monitor itself and transfer useful data to the driver and servicing crew. OBD1 is an interface to retrieve diagnostic information and inform the driver of any problems. A problem with the interface with these was their interface was designed for the manufacturers spec so diagnostic equipment for them are specific to the vehicle whereas the Teves MkIV had OBD2 (2nd generation) which is still used to this day and its interface is universal. The OBD2 port on the Teves has more features and takes into account different calculations and codes to solve the problems that are faced.

8) Waveforms

Appendix 1: this waveform is screenshot of the wheel speed sensor on the bosch 2EH. The waveform shows the signal and the grounding. A voltage is recorded on the upper signal of 1.1v and a lower signal of -0.3 volts. The variation of the signal is because of the magnet is the wheels speed sensor. The just shows that as the wheels gains speed the frequency does.

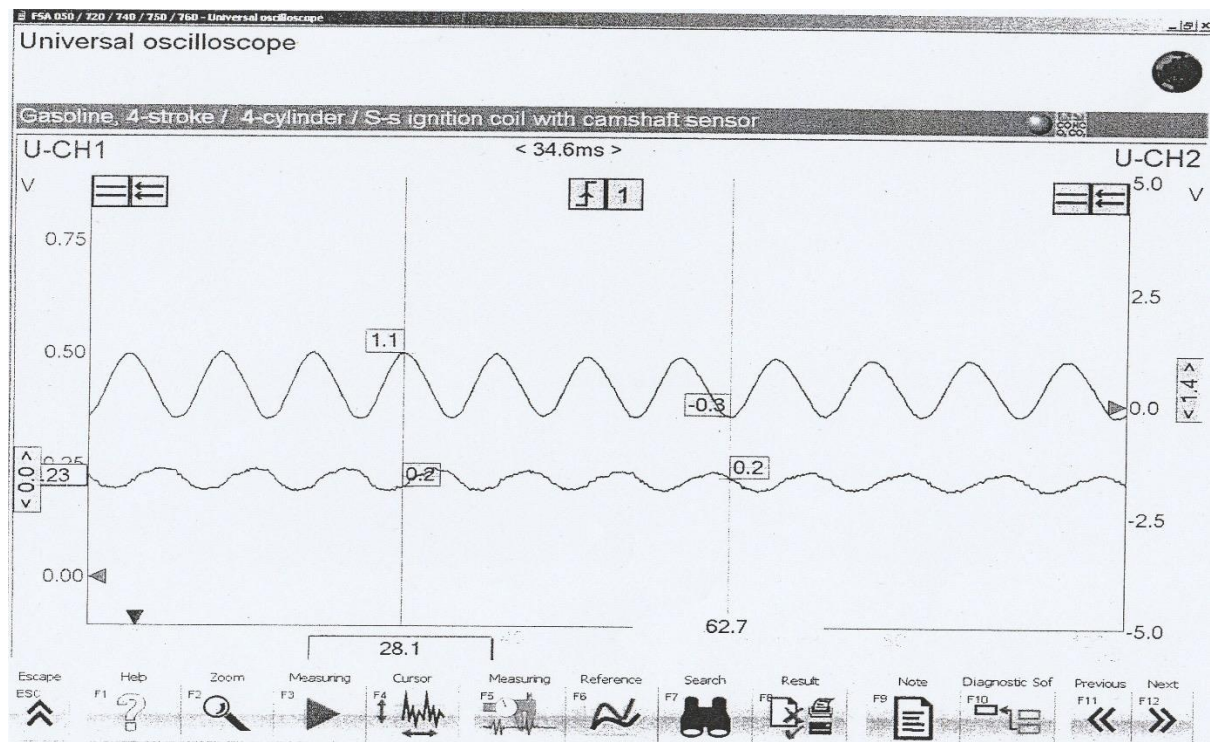
Appendix 2: this waveform is the brake light switch. Which we measured at 11.1v and then drops to 6.7v this drop is because the brakes are applied and then under abs intervention the pump takes the energy from the battery. The significant drop is because the rig has no alternator.

8) References

1. (Hillier's, fundamentals of motor vehicle technology.2014, 6th edition, by Oxford)
2. (Hillier's, Fundamentals of automotive electronics.2012, 6th edition, by Oxford)
3. (Allan W.M. Bonnick, Automotive computer controlled systems: Diagnostic Tools and Techniques.2000 by Routledge)
4. (Ian Doran, Buick Service engineer, diagnosing Teves MkIV system 1994 video footage.) Link: <https://www.youtube.com/watch?v=hnoP2HHhi8I>
5. (Tom Dentons, Advanced Automotive Fault Diagnosis.2000 , 4th editon, by Routledge)
6. (Robert Bosch.2014 Automotive handbook,(9th Edition), Sussex, Robert Bosch GmbH.)

9) Appendix

Appendix 1.



Appendix 2.

