



University of Wales
Trinity Saint David

Davis Gary Watkins

BSc Motorsport Engineering

Emissions Control & Diagnosis (M5X02202)

ABS System Assignment

1.0: Abstract

This report will focus on the functionality of an ABS system and the diagnostic procedures to find a certain fault in the system, it will cover the analysis and evaluation for the operation of two different types of anti-lock braking systems. The report will cover a fault in the system, the stages taken to find this fault and then the stages to correct it. There will be a comparison between two different systems and some live data recorded in groups provided for each system, followed by an analysis to compare both of the systems.

Contents

(1.0) Abstract (Page 2)

(1.1) Introduction (Page 3)

(1.2) Function of an ABS system (Page 4)

..... 1.2.1: Diagnostic Techniques (Page 5)

(1.3) Testing Procedures (Page 7)

..... 1.3.1: Teves Mk IV ABS

..... 1.3.2: Bosch ABS 2EH

(1.4) Testing Results & Graphs with Comparison (Page 8)

(1.5) Fault Diagnosis (Page 15)

(1.6) Conclusion (Page 16)

(1.7) Bibliography (Page 17)

(1.8) References

1.1: Introduction

As a group, the objectives to be carried out include the live and static testing of two different ABS system, the comparison between each system to determine the better system, a fault diagnosis including the steps to determine the fault and the rectification process for fixing the fault.

For the static and live testing, these will individually include a range of different equipment to be used. The static testing would include a Multimeter to test each voltage whilst the ignition is switched off then again with the ignition switched on. However, the live testing would include the use of a Bosch dedicated digital diagnostic centre to produce a live reading of voltages as wave forms on a graph to show a more in depth representation of what's happening in real time.

The comparison between both systems will be retrieved from the test data taken in groups, with the results comparing with each other to determine the better functioning system between the two.

The fault diagnosis would include providing a personally selected fault in the system, and the correct diagnostic procedures for finding this fault, followed by the steps to rectify this fault to fix the system. The indication of a fault is provided by the ABS warning light illuminating constantly.

1.2: Function of an ABS System

The anti-lock braking system stops the wheels of a vehicle from locking up and therefore provides the driver with steering control under harsh braking. The system allows the vehicle to maintain tractive contact with the ground and avoid going into an uncontrolled skid, which can end very badly for the driver if ABS wasn't installed on the vehicle.

Without an ABS system installed on a vehicle, under harsh braking the wheels will lock, and the car will become uncontrollable and continue forwards towards danger. The ABS system would avoid this happening to allow the driver the ability to steer away or around the danger, therefore saving any damage and also saving lives.

The ABS system allows this system to avoid locking up the brakes by controlling the brake fluid pressure applied to each wheel and bring the speed of the wheel back to the minimum slip level for optimal braking, this can decrease the stopping distance of the vehicle on dry and wet road and therefore bringing you to a complete stop sooner than a vehicle without an ABS system.

An ABS system consists of four main components, the wheel speed sensor, pressure valves, ECU, and a hydraulic control unit. The image below indicates a basic ABS setup.

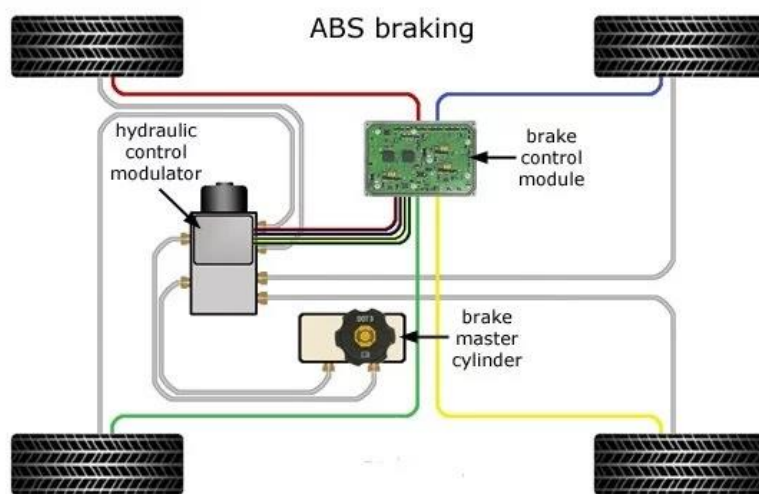


Figure 1 – ABS Layout, Ishan Daftardar (2019)

OBD (1st generation) – the diagnostic trouble codes (DTC) on this system can usually be found without an expensive scan tool, instead this system can use lights to indicate a fault by giving a certain blinking pattern. However, Cadillac is fitted with on board diagnostics which can be displayed through the climate control screen. And some Honda engines have LED's which light up in different patterns to indicate the codes.

OBD (2nd generation) – this is an improvement over the 1st generation in terms of capability, the second generation uses a diagnostic connector in order for a scan tool to be plugged in for a more in depth scan of the diagnostic trouble codes (DTC). Some manufacturers can allow this OBD system to provide certain live data if needed, which can be useful to see what is happening to the system in real time, such a voltage spikes and drops. With this OBD system there are two different male connectors that can be used, there's the basic 12v connector known as type A, and then there's a 24v connector known as type B. the type B female connector has a small section in the middle of the connector which is blocked off, this is to stop the 12v type A male connector being plugged into the 24v female connector as shown below.

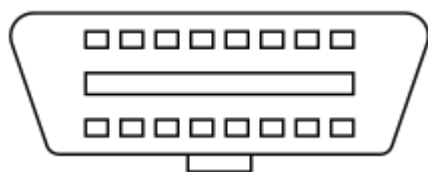


Figure 2 – Female Type A Connector, Wikipedia (2019)

12v Type
A Female
connector

24v Type
B Female
connector

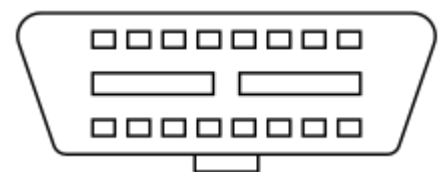


Figure 3 – Female Type B Connector, Wikipedia (2019)

EOBD (3rd generation) – this system uses regulations that are the European equivalent of the OBD 2nd generation and applies to all passenger cars of the category M1 (no more than 8 seats and maximum gross weight of 2500kg, so this follows the euro1 – euro VI emission standards. this system provides unrestricted access to the emission systems, which is based on the European emission standards compared to OBD which refers to the American emission standards. The fault codes of this system would usually be a letter followed by 4 numbers, with the letter referring to the different systems. “P” being Powertrain, “C” being Chassis, “B” being Body and “U” being User Network. Then the first number would be a “0” if it complies to the EOBD standard.

EOBD fault codes [edit]

Each of the EOBD fault codes consists of five characters: a letter, followed by four numbers. The letter refers to the system being interrogated e.g. Pxxxx would refer to the powertrain system. The next character would be a 0 if it complies to the EOBD standard. So it should look like P0xxx.

The first letter indicates the family of DTC.

- P: Powertrain, (i.e. engine and gearbox)
- C: Chassis
- B: Body
- U: User network

The first digit indicates if the code is generic or not (green digit):

- 0: Generic fault
- 1: Manufacturer fault

The next character would refer to the sub system.

- P00xx – Fuel and air metering and auxiliary emission controls.
- P01xx – Fuel and air metering.
- P02xx – Fuel and air metering (injector circuit).
- P03xx – Ignition system or misfire.
- P04xx – Auxiliary emissions controls.
- P05xx – Vehicle speed controls and idle control system.
- P06xx – Computer output circuit.
- P07xx – Transmission.
- P08xx – Transmission.

The following two characters would refer to the individual fault within each subsystem.^[23]

Figure 4 – EOBD Codes, Wikipedia (2019)

1.2.1: Diagnostic Techniques

If a problem persists with an ABS system, there are many ways to diagnose it. The areas in the system that would be tested may include; wheel speed sensors or a dirty tone ring, complete connections in the wiring (earthed), fuses, solenoids, low battery voltage, bad wheel bearing. In order to diagnose some of these components, a few methods can be applied. For example, electrical faults can be detected using a Multimeter or a Bosch dedicated digital diagnostic centre, these will provide either a reading on the Multimeter or a waveform on the diagnostic centre.

The battery charge can be tested using a battery discharge tester, this is a tool designed to provide the battery with a certain amount of current over a certain amount of time, then the resulting voltage output back from the battery will depict the condition of the battery.

A dirty connection can be cleaned with some contact cleaner, reducing the resistance because the device will be able to produce a clear reading from the component, such as a clearer reading of the wheel speed from a clean tone ring.

A faulty wheel bearing can be diagnosed by lifting the vehicle off the ground and checking for any excessive play in the wheel in any direction. Then the sensors can be connected to a diagnostic centre and tested on each wheel for any resistance.

1.3: Testing Procedures

For testing of the Bosch 2EH and the Ford Teeves Mk 4 ABS systems. The tools required include a digital Multimeter for a static test that shows the output of the electrical systems, and a Bosch diagnostic centre for live testing which shows the output of the electrical systems but as a wave form, this shows exactly what is happening in the system such as voltage spikes during cranking etc. The Bosch 2EH system uses an ECU harness of only 15 pins, with a separate component containing 4 pins which can be used to measure the front and back solenoids in the abs system. Compared to the Ford Teeves system which uses one ECU harness consisting of 25 pins. When using a digital Multimeter, a number will be displayed on the screen, but this number can sometimes not be a solid number, this can be more inaccurate than the Bosch diagnostic centre if the numbers change constantly because the diagnostic centre is able to pause the live readings to measure at certain points with an accurate value.

So, for the static testing with a Multimeter, in order to get a reading from the wires, a paper clip would be needed for reaching into the small gap and to touch the connector to pick up a clear signal. This will provide a number on the screen that may fluctuate if it is receiving some interference from the system or the connection. Then the values will need to be noted and sometimes tested for a second time for a definite final value, this avoids an inaccuracy during the testing from a loose connection or resistance. For the live testing with the Bosch diagnostic centre, in order to get a reading from the wires, an acupuncture can be applied to the tester. This will easily reach the connections, but it can also be used for piercing the wire coating if it's not possible to reach the connectors, this will also give an accurate reading. This method can be more accurate than the static testing and also provides a good representation of what's happening inside the system in real time. This is perfect for ignition timing as it shows you the sudden changes in voltage and what happens whilst it returns back to a normal voltage, but it's also great for seeing what happens during certain situations of an ABS system such as brake intervention. The Bosch diagnostic centre is capable of freezing the screen from real time readings, so it's possible to scroll through the readings to a specific point for accurate measurements, also it can screenshot the data on the screen as shown in **1.4: Testing Results**.

1.4: Testing Results & Graphs with Comparison

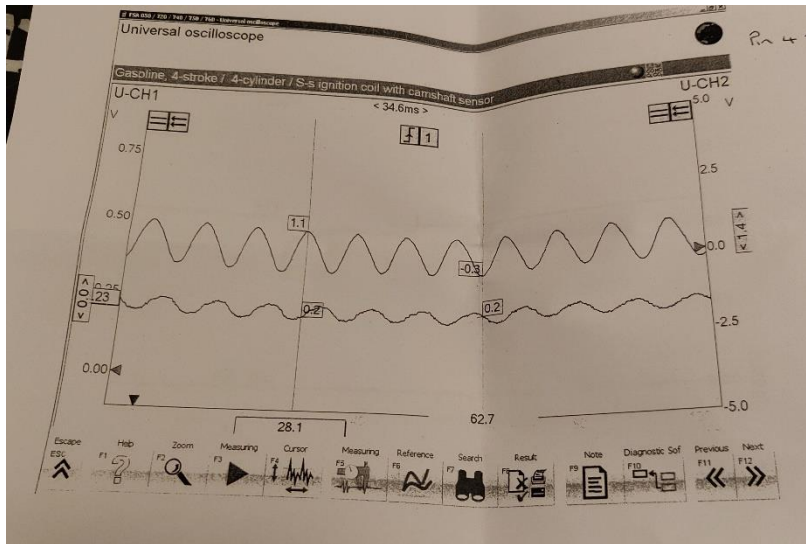


Figure 5 – Wheel Speed Sensor, Andrew Gibson, Davis Watkins (2019)

[Bosch] The image to the right shows the brake light switch feed. The drop in voltage shown in the image indicates the moment that the brake pedal is applied and then the short rise after is the brake light being applied, with the voltage then returning to normal after the brake pedal has been released.

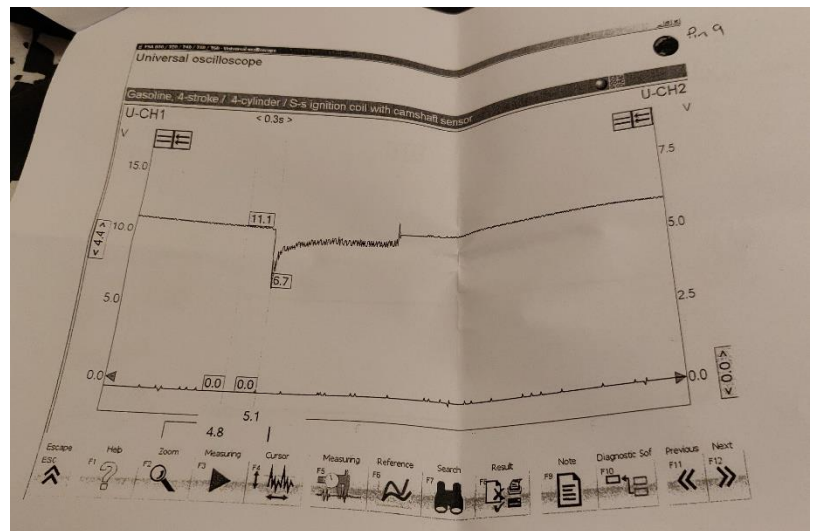


Figure 7 – Brake Light Switch, Andrew Gibson, Davis Watkins (2019)

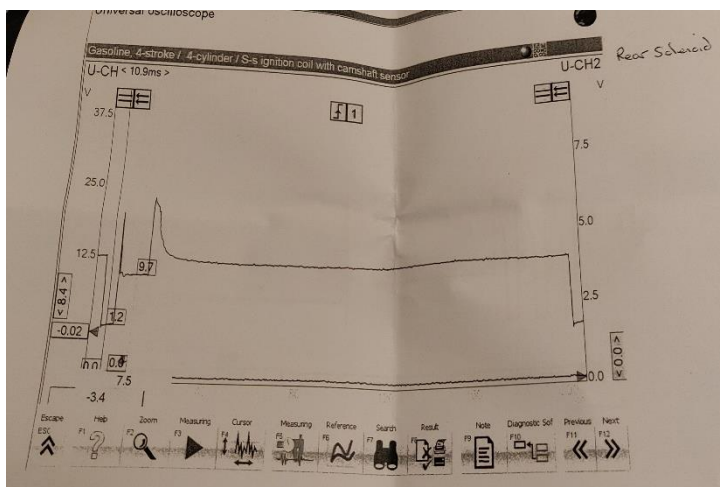
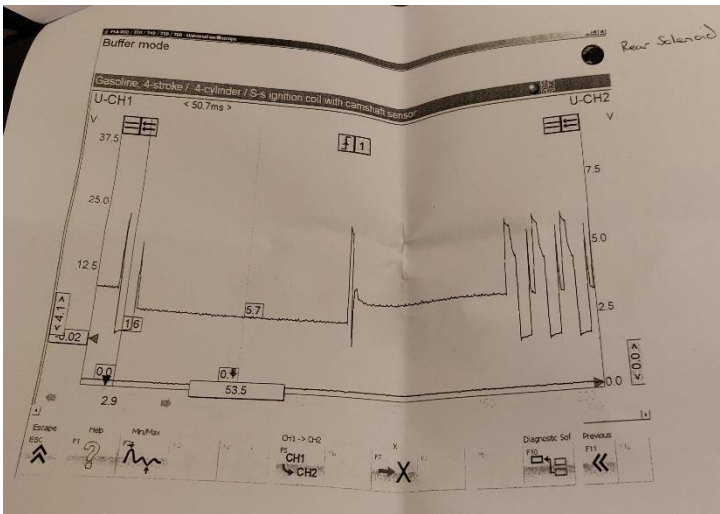


Figure 6 – Brake Light Switch, Andrew Gibson, Davis Watkins (2019)

[Bosch] The image to the left shows the rear solenoid of the ABS system when the wheel goes through a phase called "ABS Intervention".



[Bosch] The image to the left shows the rear solenoid of the ABS system when the wheel begins to lock up, then the ABS system needs to step in and stop the wheel from locking up and causing an uncontrolled skid, this is where the voltage drops and remains at a constant whilst the solenoid is controlling the pressure.

Figure 8 – Rear Solenoid, Andrew Gibson, Davis Watkins (2019)

[Ford] The image to the right shows the wheel speed sensor picking up a signal from the tone ring on the wheel whilst the wheel speed has been increased, this causes the wave patterns to become a smaller diameter because the tone ring is passing much quicker.

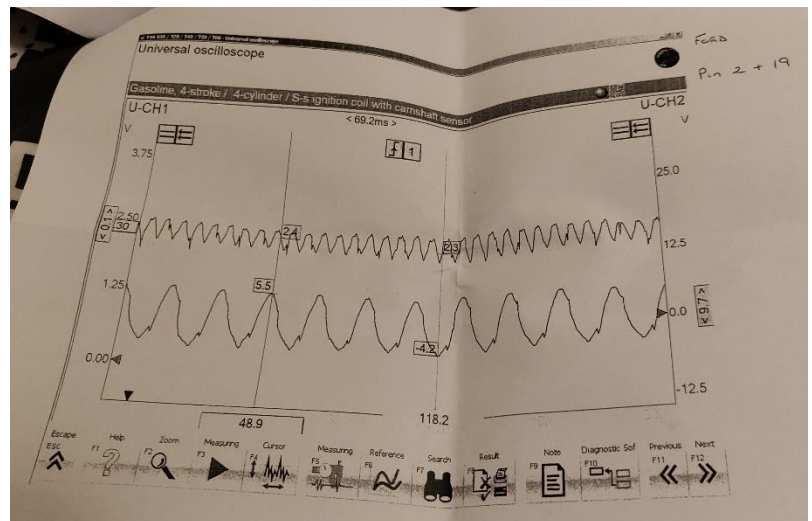


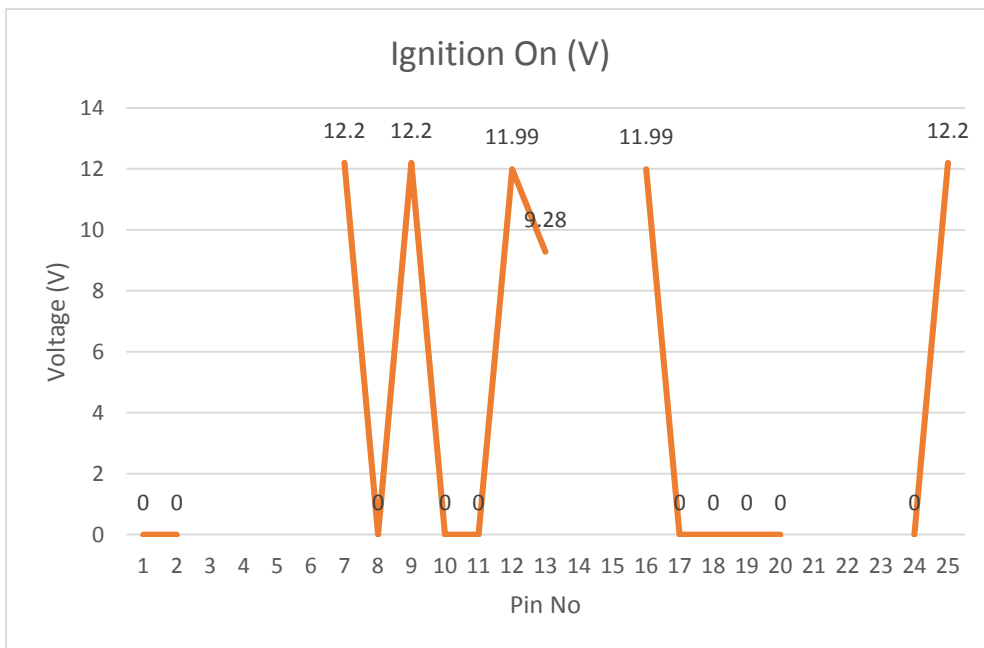
Figure 9 – Wheel Speed Sensor, Andrew Gibson, Davis Watkins (2019)

Recorded Data

	A	B	C	D	E	F	G	H
1								
2		Ford Teves	ABS Multiplug					
3								
4		Pin No	Ign On (V)	Ign Off (V)	Running (V)			
5		1	0	0	0.25			
6		2	0	0	0.25			
7		3						
8		4						
9		5						
10		6						
11	P Live	7	12.2	12.2	12.2			
12	Ground	8	0	0	0			
13	P Live	9	12.2	12.2	12.2			
14		10	0	0	0.25			
15		11	0	0	0.25			
16		12	11.99	0	11.99			
17		13	9.28	9.28	9.28			
18		14						
19		15						
20		16	11.99	0	11.99			
21		17	0	0	1.25			
22		18	0	0	1.25			
23		19	0	0	1.25			
24		20	0	0	1.25			
25		21						
26		22						
27		23						
28	Ground	24	0	0	0			
29	P Live	25	12.2	12.2	12.2			
30								
31		Pin 17 to 20	Signal wheel sensors					
32								
33		Pin 12,10,11	ground wheel sensors					
34								
35								
36								
37								
38								

[Ford] To the left is an excel spreadsheet of all the recorded data from the Ford Teeves system taken in the workshop by our provided groups. These are the static test results taken by a digital Multimeter whilst the ignition was switched off, switched on, and then when the system was running.

Figure 10 – Ford Test Result Spreadsheet, Davis Watkins (2019)



[Ford] To the left is an excel graph created to show the results of the Ford ABS system recorded in the workshop. As shown in the graph, when the ignition is switched on this means that most of the pins are provided with a battery voltage, usually 11V-12V. any values at 0 means they are not given a feed from the battery.

Figure 11 – Ford Ignition On Results Graph, Davis Watkins (2019)

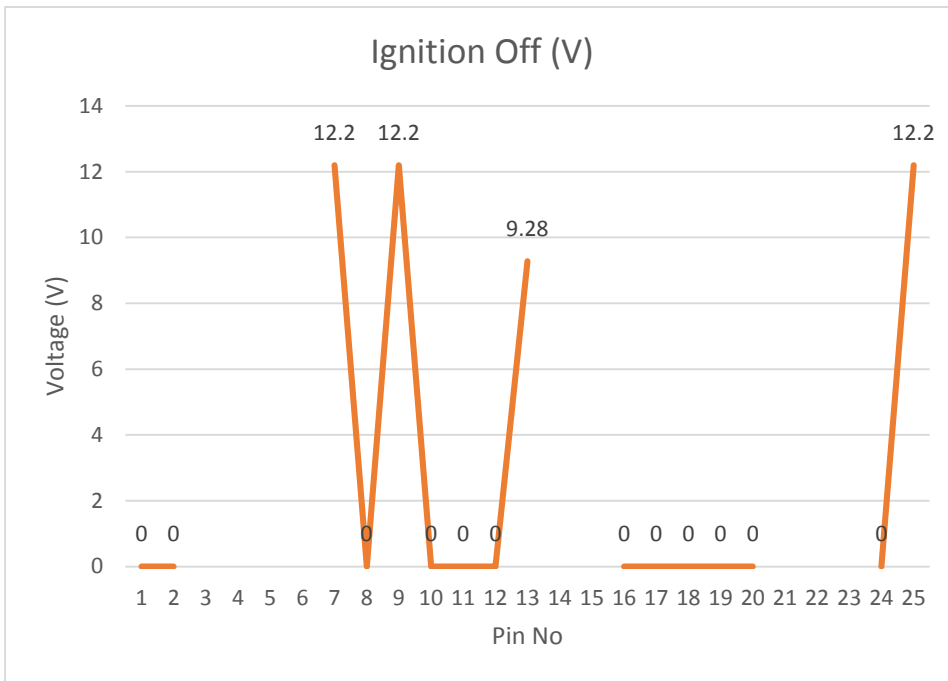


Figure 12 – Ford Ignition Off Results Graph, Davis Watkins (2019)

[Ford] To the left is an excel graph created to show the results of the Ford ABS system recorded in the workshop. As shown in the graph, when the ignition is switched off this means that some of the pins are still provided with a battery voltage, these can be sensors that need to test before the car is running, maybe to check faults. Some of the pins have lost the battery voltage whilst the ignition is switched off.

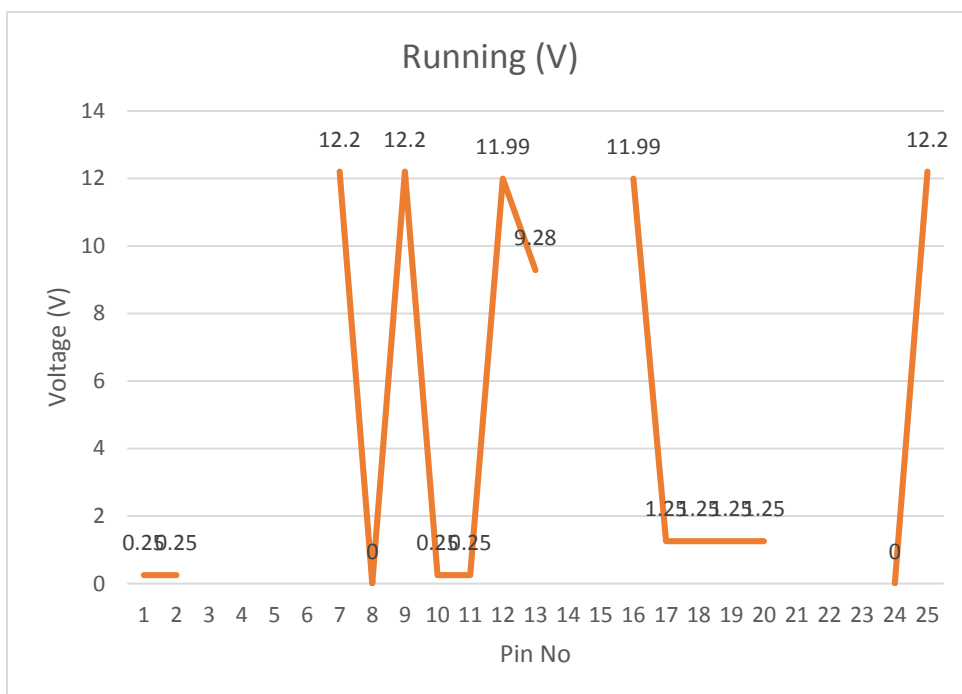


Figure 13 – Ford System Running Results Graph, Davis Watkins (2019)

[Ford] To the left is an excel graph created to show the results of the Ford ABS system recorded in the workshop. As shown in the graph, when the system is running this means that some of the pins are still provided with a battery voltage, but many have now started drawing a small amount of voltage. These can be the wheel speed sensors that are now picking up a signal whilst the wheels are rotating.

	A	B	C	D	E	F	G	H	I	J	K	L
1		Bosch	2EH									
2								Key				
3								No Wire				
4		Pin No	Ign On (V)	Ign Off (V)	Running (V)			Permanent				
5		1	11.88	0	11.75			11V to 13V	Battery V			
6		2	0.2	0	0.25			0	Ground			
7		3										
8		4	0.29	0	1.25							
9		5	0.2	0	0.25							
10		6	0.2	0	1.25							
11		7	0.2	0	0.25							
12		8										
13		9	11.88	0	11.75							
14		10	0.2	0	1.25							
15		11										
16		12	10.68	0	10.51							
17		13	0.2	0	1.25							
18		14	0.2	0	0.25							
19		15	0.2	0	0.25							
20												
21		Pin 2	earth return pulse									
22			generator +0.25V									
23		Pin 4	Signal Pulse 1.25 to -									
24			1.25									
25		Pin 15	data signals spike V									
26												
27												
28												
29												
30												
31												
32												
33												
34												
35												
36												
37												
38												

Figure 14 – Bosch Results Graph, Davis Watkins (2019)

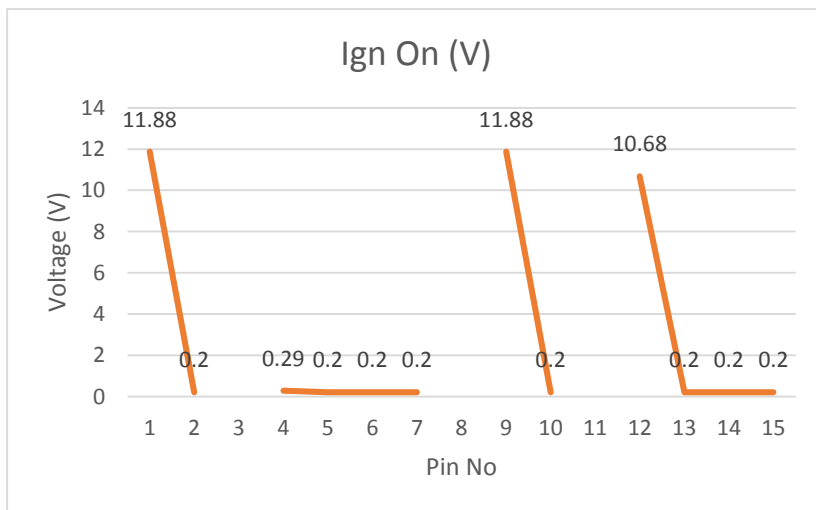


Figure 15 – Bosch Ignition On Results Graph, Davis Watkins (2019)

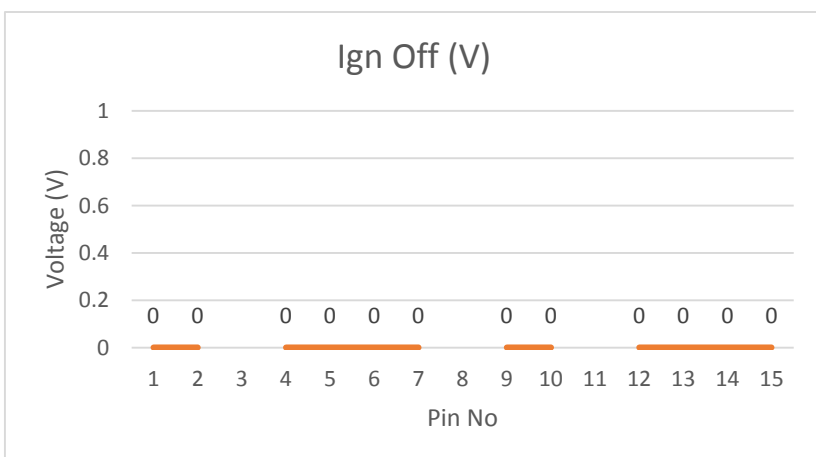


Figure 16 – Bosch Ignition Off Results Graph, Davis Watkins (2019)

[Bosch] To the left is an excel spreadsheet of all the recorded data on the Bosch 2EH system taken in the workshop by our provided groups. These are the static test results taken by a digital Multimeter whilst the ignition was switched off, switched on, and then when the system was running.

[Bosch] To the left is the recorded data whilst the ignition was switched on, as shown there are 3 different pins using a battery voltage whereas the rest of the pins are only using around 0.2v. the pins using battery voltage could be sensors, which would check the system for any faults.

[Bosch] To the left is all the recorded data whilst the ignition was switched off. compared to the Ford Teeves system which has pins drawing a voltage, the Bosch system doesn't have any pins drawing a voltage whilst the ignition is off.

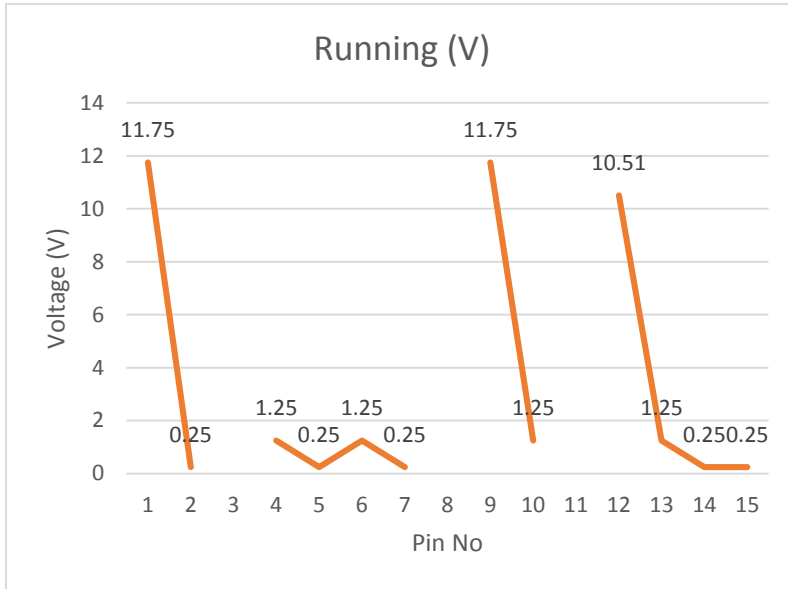


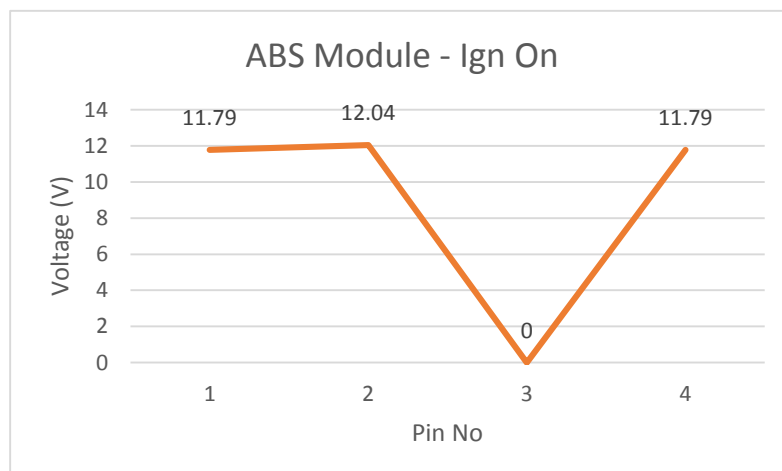
Figure 17 – Bosch System Running Results Graph, Davis Watkins (2019)

[Bosch] To the left is all the recorded data whilst the system is running. The 3 pins using battery voltage are still the same, however some of the pins are now using slightly more voltage, which means that these could be taking live measurements of the system.



Figure 18 – Bosch ABS Module Off Results Graph, Davis Watkins (2019)

[Bosch] To the left is all the recorded data of the ABS module whilst the ignition is switched off. As shown there are no voltage being drawn by any of the pins.



[Bosch] To the left is all the recorded data of the ABS module whilst the ignition is switched on. As shown there are 3 pins of 4 that are drawing a battery voltage to check and prepare the system, whereas pin 3 is being earthed so has no voltage draw.

Figure 19 – Bosch ABS Module On Results Graph, Davis Watkins (2019) 13

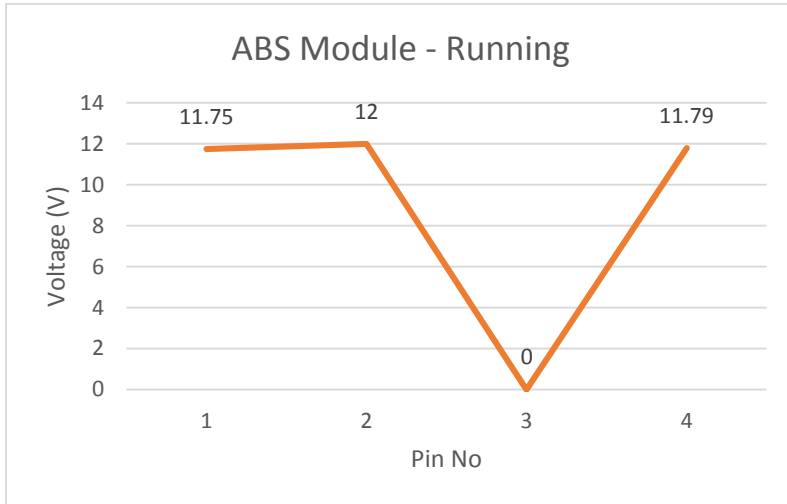


Figure 20 – Bosch ABS system running Results Graph, Davis Watkins

[Bosch] To the left is all the recorded data of the ABS module whilst the system is running. As shown the 3 pins are still using a battery voltage and pin 3 is still being earthed so not drawing a voltage.

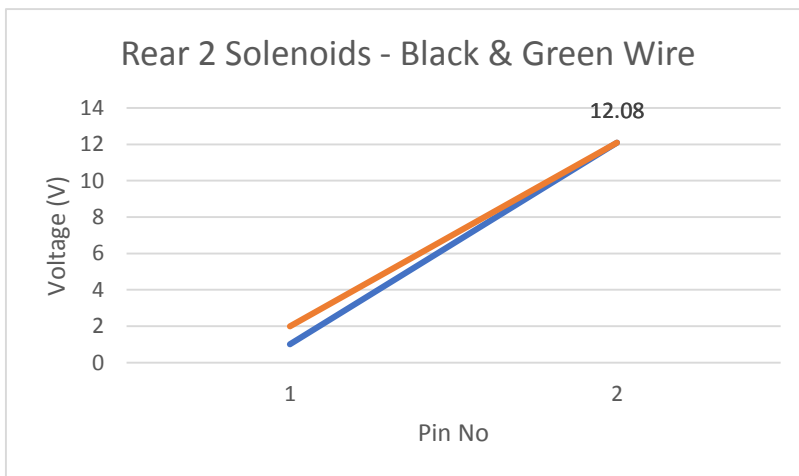


Figure 21 – Bosch ABS Rear Solenoids Results Graph, Davis Watkins (2019)

[Bosch] To the left is all the recorded data of the rear ABS solenoids. As shown on the graph, both pins are using a battery voltage while the system is running. This is to control the brake pressure in the system, which needs to be constantly checked so it can be adjusted correctly depending on how much pressure is needed.

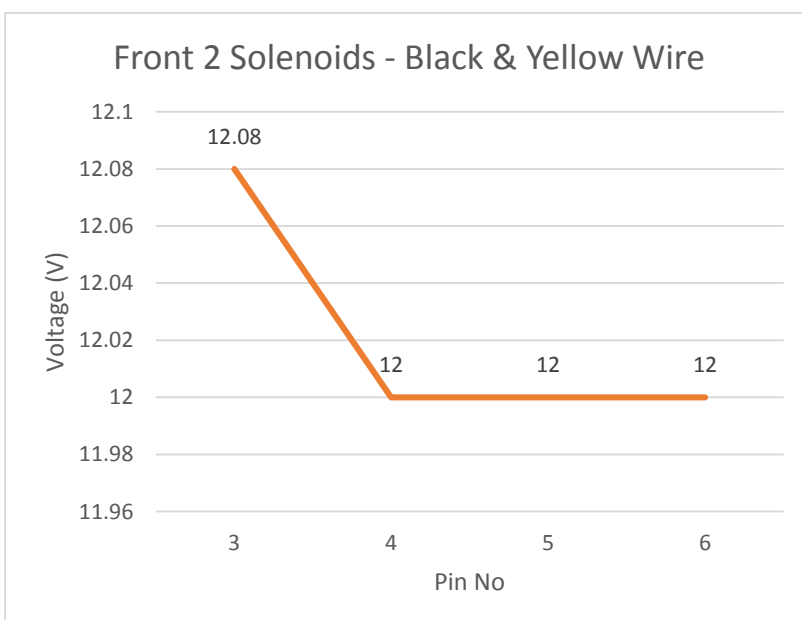


Figure 22 – Bosch ABS Front Solenoids Results Graph, Davis Watkins (2019)

[Bosch] To the left is all the recorded data of the front ABS solenoids. As shown on the graph, all 4 pins are using a battery voltage while the system is running. This is to control the brake pressure in the system, which needs to be constantly checked so it can be adjusted correctly depending on how much pressure is needed.

1.5: Fault Diagnosis

A vehicle comes into the workshop with an ABS warning light on, which of course indicates to the driver that there is a fault somewhere in the ABS system. So, the first step to take could include turning the vehicle off and then back on for the system to check over and refresh. After this removing any sensors that could cause this issue, spray the contacts with some contact cleaner, then take the vehicle for a road test to check if the fault would have been fixed. However, if the problem persists then plug in an OBD reader to scan the ABS system for any faults, or some vehicles are fitted with on board diagnostics that flash in a sequence on the dashboard depending on the fault.

The OBD reader has provided a fault in the ABS system, which was indicated to be a leaking brake fluid reservoir. This means that the brake fluid would run low, dropping the brake pressure and making it harder to stop, So a further investigation of the brake fluid level would confirm this to be the case. So, to replace the brake fluid reservoir, first the remaining brake fluid would need to be drained from the system to ensure there's no leaks while removing the reservoir. Then remove the brake pipes connecting to the reservoir and then detach the faulty reservoir.

To fit the new reservoir, attach the brake pipes to the new brake fluid reservoir and then fill the reservoir with new brake fluid until the fluid level is at MAX on the side of the reservoir. From here the brakes need to be bled to ensure that all the air is removed from the brake system as this would cause a soft spot in the brake pedal, which would cause a drop in brake pressure and increase the stopping distance. So, raise the car off of the floor and remove all of the wheels, then with someone to assist and press the brakes, continue to bleed the brakes starting furthest from the reservoir until a constant stream of brake fluid is passing through each of the pipes, and then reinstall the wheels and take the vehicle for a road test to check if the ABS warning light has gone out. The warning light has now turned off meaning the problem is fixed.

1.6: Conclusion

There are many different ECU's that are fitted to vehicles, but there isn't a big difference between them as indicated in the recorded data shown in **Section 4**.

The main difference between an OBD system and an EOBD system is the fact that the OBD systems follow the U.S standards for emissions, whereas the EOBD systems follow the European standards for emissions. So, the EOBD system would be fitted to the European vehicles designed to follow these emissions, and the OBD system would be fitted to U.S vehicles designed to follow these emissions.

Comparing a static test with a live test shows that the live testing can prove more accurate, but also produces real time measurements of the system with a visual representation of what happens in the system, such as voltage spikes and drops. This is great for finding the duration of a fuel injection, or to find a damaged tooth on a gear, or the ignition timing under certain circumstances.

1.7 Bibliography:

- Figure 1, <https://www.scienceabc.com/innovation/abs-sensors-anti-lock-breaking-system-technology-cars-work.html>
- Figure 2 + 3, https://en.wikipedia.org/wiki/On-board_diagnostics#OBD-II
- Figure 4, https://en.wikipedia.org/wiki/On-board_diagnostics
- Figure 5 to 9, Handouts from Andrew Gibson, Photographed by Davis Watkins
- Figures 10 to 22, Excel spreadsheet created by Davis Watkins

1.8 References:

- ABS System Research – Daftardar, I. (2019). How Does Anti-lock Braking System (ABS) Technology In Cars Work? [Online]. Science ABC: <https://www.scienceabc.com/innovation/abs-sensors-anti-lock-breaking-system-technology-cars-work.html> [accessed 03/01/19].
- OBD Research – No Author (2019). Onboard Diagnostics [Online]. Wikipedia: https://en.wikipedia.org/wiki/On-board_diagnostics [accessed 03/01/19].
- EOBD Research – Broughton, I. (2019). OBD and EOBD Systems Explained. [Online] Part Info: <http://www.partinfo.co.uk/articles/123>