

**Module: Emission Control &
Diagnostics
M5X02202**

Title: Anti-Lock Braking Systems

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Introduction

This report will include information around the functionality and the servicing method of an ABS system. During the report two different systems will be tested; the Bosch 2EH system, and the Ford Teves system. Between the two systems the functionality of the systems and how they are applied to the vehicles will be included. In this report there will also be a full systems operations check on the two systems. The service report will follow the systems check with any details of the procedure taken to carry out the test, the test readings found along with the signal waveforms, and also some safe working practices adopted to complete the task. Following the test procedures there will be a more in detail fault diagnostic chart when the ABS warning light 'on condition' to be investigated to determine the cause of the malfunction. There will also be a comparison of the two systems in terms of their main operational differences in this report. To conclude the report there will be a personal opinion included to state the systems strengths and weaknesses or why one is better than the other in their opinion

Function

An ABS system mainly has 3 modes of operation; it has a pressure increase, a pressure hold and also a pressure reduction. These modes of operation are determined on some longitudinal forces applied when the vehicle is moving, these are; Wheel force, brake force, rolling resistance and the drag of the vehicle. There are also some exterior factors that can determine when the ABS system activates one of the modes of operation such as the weather and the road surface/quality. The road quality and also the tyre quality will have an effect on the coefficient of friction between the two surfaces which could dramatically affect the chances of ABS activating. The lateral forces applied allow the vehicle to turn, these forces are acting sideways upon the wheel of the vehicle. (UWTSD, 2018)

The majority of the ABS systems use a wheel speed sensor and a trigger wheel to measure when the wheel is about to stop rotating and start skidding. When this occurs the wheel speed sensor sends a voltage to the ECU, which will be able to read the voltage and determine an outcome to the readings and apply one of the modes of operation by acting upon the solenoid valve or the motor controlling the return pump.

Pressure Reduction

Once the wheel speed sensor recognises that the wheel is about to enter a skid it sends the voltage through to the ECU which then, shuts the solenoid valve and activates the return pump. This will then reduce the pressure in the specific wheels brake pipes which reduces the risk of locking up and sending the excess fluid back into the reservoir. Once the pressure is reduced sufficiently the solenoid valve opens up again allowing fluid back through the pipes and applies the appropriate brake force in correlation to the force applied onto the brake pedal. This will make the driver experience the pedal pushing back and then releasing again on his/her foot several times during the operations. Some systems have a cylinder for each wheel while some have a cylinder for each wheel at the front and just the one cylinder to dictate the back axle. When one of the back wheels is about to enter a skid the cylinder dictates what is called a 'select-low' operating principle which means it applies the correct amount of pressure that is needed for the wheel with the lowest adhesion (What When How, n.d.)

Pressure Maintain

Pressure maintain occurs after the pressure decrease. When pressure decrease occurs it pushes the pedal back and forth on the drivers foot due to the solenoid opening and closing several times to stop the wheels from skidding. Pressure maintain occurs as the return pump as well as the solenoid shuts allowing the fluid in the system no return route which will lock the systems pressure. (What When How, n.d.) (Hussein, 2014)

Pressure Increase

When the ABS system is working on the wheel and the wheel speed sensor picks up that the wheel is running relatively freely, it will send this information to the ECU and it will then apply the Pressure Increase Operation. This is when the solenoid valve is re-opened allowing more fluid through the brake pipes to the desired wheel allowing more pressure to be applied onto the brakes which will slow the vehicle down in correlation with the drivers input. This will eventually return to the Pressure decrease operation and the circulation is regulated around 12 times a second, this is because at this frequency it avoids the majority of the suspension and wheel vibrations. (What When How, n.d.)

Dynamic Testing

Method of Testing

For the dynamic testing of both rigs firstly the group had a discussion on which was the most efficient way of testing the rigs. There were a few suggestions as to how to complete the testing procedures and they came across two different procedures for each system. For the Bosch system they would use a multimeter and firstly measure all the pins in the ABS plug with the ignition off. They would then turn the ignition on and check the pins again with the multimeter reading the voltage of each pin. When they turned the rig on they decided to use the diagnostics computer and monitor the waveforms as well as the voltage of each plug. They would then go on to do the same on both the Data Plug and the Solenoid.

When it came to the Teves system the ABS Multiplug was conducted the same way as the Bosch system and that is the only data system that the group tested as it was too complex to be able to read the solenoid pins as the system has to be stripped to be able to read and the timeslot given was not big enough to be able to complete the task.

Bosch 2EH

Test Readings

ABS Plug

When testing the Bosch system the first thing the group did was take measurements when the ignition was turned off. You will see in all of the tables, no voltage was found which is the correct as this system does not have a permanent live.

Table 1

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

As you see from *Table 1* there are some pins missing from the ABS ECU. This is because this system does not have all the sensors and actuators running the system. When the ignition was turned on there were some readings presented.

Pin 1 is simply the ABS warning lamp actuation the voltage you see here is the battery voltage running through to light up the lamp as it should at this stage. Note: Battery voltage is slightly low as testing was done on a rig and there was no alternator to recharge the battery.

you would see the brake lights come on. However, this specific test was conducted on a rig and there was already some brake force applied before turning the vehicle on hence the show of voltage before and after the rig was turned on.

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

Referring to the schematic that you will see in the Appendix you will see that there are 4 pins right in the centre in the order of 2, 3, 1 and then 4. These are the pins represented in the table above:

Pin 1 – This is the wire leading from the key slot to this control system, The data plug. As you can see from the table when the ignition is turned on battery voltage is read at Pin 1. This is because the key closes the circuit allowing the power to advance through and into the Data Plug. The voltage remains very similar when the rig system is running, the small drop is due to the fact that there is no alternator on the rig and the battery wasn't being charged while testing causing it to drain.

Pin 2 – This wire leading from pin to can be tracked back to the battery via a relay. Obviously from this information there is a level of predictability to what the results would be here. The test proved that the battery had a voltage of 12.04 running to Pin 2 when the ignition was turned on, the same was seen when the rig was up and running.

Pin 3 – This is the earth wire. As expected the tests proved the earth wire was working well with 0 volts running through the pin in all 3 variants of testing.

Pin 4 – This is the wire that leads into the ABS plug. When the ignition was on the multimeter was reading a voltage of 11.79 volts which is battery voltage, it was the same reading when the rig was running. If you look at the schematic in the appendix

you will see that pin 4 leads to pin 1 in the 15 pin ABS plug. It is expected to see battery voltage between these two pins as they are communicating with each other showing that they are functioning correctly. If hypothetically the voltage found was 0 then there would be a fault within 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 last test conducted on the Bosch 2EH system was on the solenoids. This particular system there are only three solenoids, two for the front and one to dictate the rear. The Black and yellow wired solenoids are both front solenoids and the green and black wired solenoid is the rears'.

As you can see above when the ignition is off there is no voltage running through any of the wires as expected as none of them are permanent lives according to the schematic. When the ignition is turned on as you can see from the table every pin is reading at around 12v the small decrease is once again because of the battery not being charge on the rig while tests were conducted. When the rig was turned on the voltages decreased slightly, however this is because of the battery situation mentioned above.

Ford Teves System

On the Ford Teves system the only set of pins that could've been tested freely without stripping any components was the ABS Multiplug. This system saw 25 pins however, not all the pins were being used as some of the pins were for a more recent system or for additional extras. The same test was conducted on this system where the voltage was checked in each pin when the rig was: off completely, ignition on and when the system was running.

Table 4

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

As you can see from the table above unlike the Bosch system, the Teves system does have some permanent lives. According to the schematic that you will be able to see in the appendix pins 7, 9 and 25 are permanent live wires, these wires also flow through a fuse. Both pins 9 and 25 flow through a 30A fuse, whereas pin 7 flows through a 3A fuse. These pins read the same voltage throughout under all three different modes of testing.

In the table you can also see that pin 13 was reading a voltage of 9.28 volts. If we refer to the schematic you will see that pin 13 leads back to X1. This is the data link connector (DLC) (Gibson, n.d.), or more commonly known as an OBD reader. This requires this voltage to allow the diagnostic system used into the system and to read the faults within the system. You will see in the table above the voltage did not change throughout the different modes of testing.

When the ignition is turned on the results show that pins 12 and 16 also show a reading of battery voltage at 11.99 volts. If you look at the schematic pin 12 runs from the ignition live (no.15) down through a 15A fuse into S13 which is the brake pedal position switch. This switch is activated when some force is applied to the brake pedal, it allows for the brake lights to turn on and in more modern vehicles it disables the cruise control system (Gibson, n.d.) (Standex Electronics, n.d.). Pin 16 is also connected to the same fuse and wire as pin 12. However, the wire also leads through the ABS warning lamp as well as the traction control warning lamp. This is why we see the battery voltage, as when the ignition is turned on these two lights light up because the whole system is tested before the engine is actually running (Gibson, n.d.).

When the rig was turned on every pin had a reading apart from pins 8 and 24. These two pins are earth wires for the system. Seeing 0 volts at these pins shows that they are working as they should be.

Pins 1, 2, 10 and 11 are the earth wires for the wheel speed sensor. On average they read 0.25v but it did fluctuate. You will be able to see the waveforms in the appendix, where it shows pin 2 and 19 running side by side that the earth wire fluctuates as the trigger wheel pulses a signal to the wheel speed sensor similarly to the Bosch system.

Pins 17 to 20 are the signal wires for the wheel speed sensor. Similarly to the earth leads there was a pulse reading running through these pins however, the average reading was 1.25 volts rather than the 0.25 running through the earth. . You will be able to see this in the appendix alongside the waveform for pin 2.

Safe Working Practices

When working on any vehicle or a rig you must adhere to a health and safety risk assessment and the laws around safety in a workshop. Most of these rules and regulations comply with the (HSG129) 1995/1999 (HSE, 1999). The test was also conducted adhering to The Control of Noise at Work Regulations 2005 (HSE, 2005).

Flow Chart

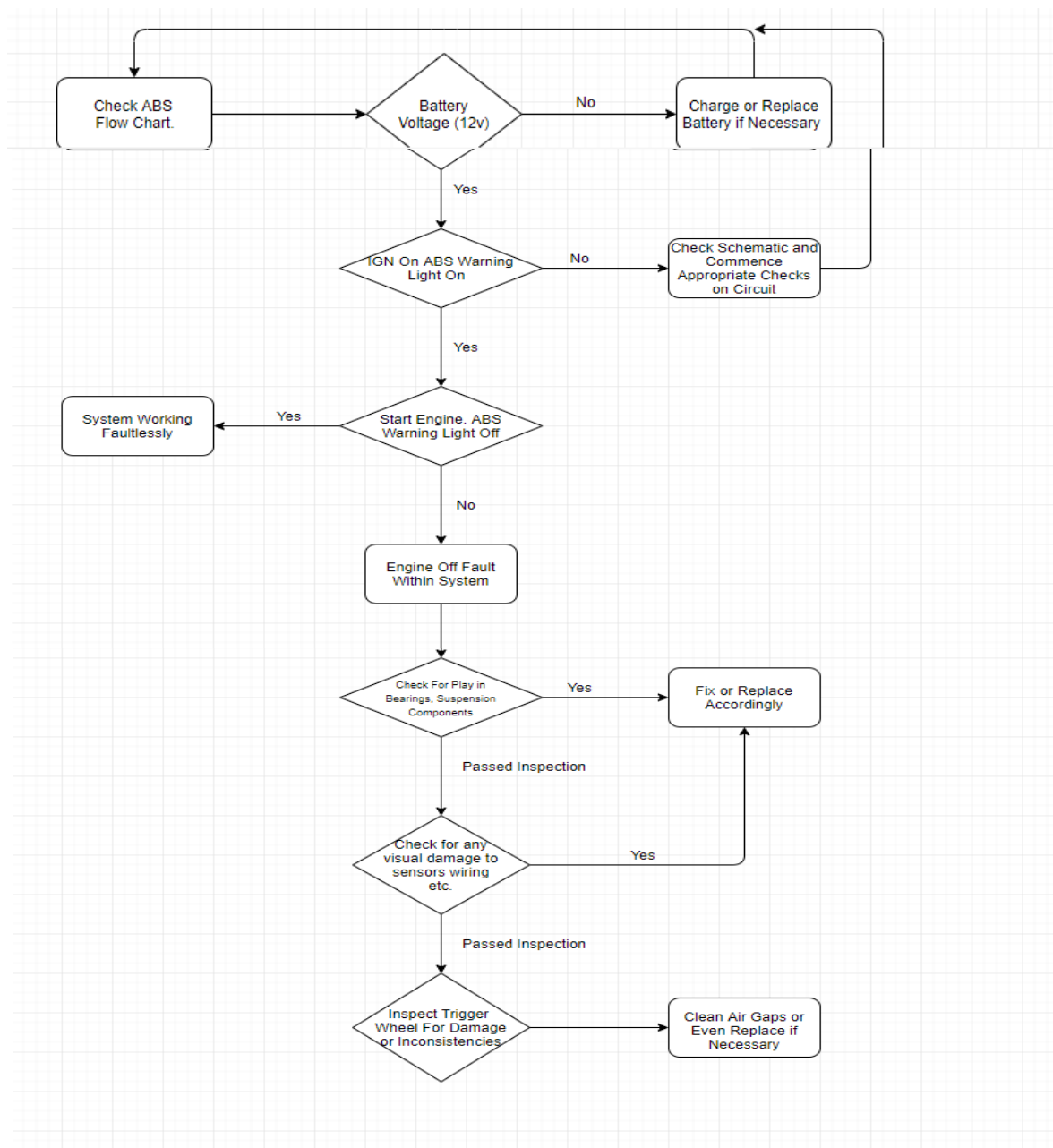


Figure 2 (Billing, 2018)

The flow chart above shows the correct process to take if there is a fault with the trigger wheel in terms of its consistency with the airgaps or damage to the wheel itself. The process starts right at the beginning of any electrical diagnostic process which is the battery. You work your way down the circuit up until you find the fault. In this flow chart and problem with the system the fault is a mechanical one which you would still follow the electrical process just in case there is also an electrical fault.

Operational Differences/Pros and Cons

There are some differences between the way the Bosch 2 EH operates compared to the Teves system. The main one being the amount of solenoids used to control the ABS pressure. In the earlier Bosch system when testing there were only 3 solenoids. As stated in *ABS Solenoid* there is one solenoid dictating the front two wheels with just the one dictating the rear axle. The rear solenoid will take the lowest wheel speed and detect when that wheel will lock and then it will activate one of the modes of operation (Pressure Maintain or Pressure Reduction in this case) on both wheels. Compare this to the Teves system which has 4 solenoids, one for each wheel this system is a much better system in terms of accuracy as it can select that singular wheel rather than locking both rear wheels up.

Another operational difference is the OBD systems within each vehicle. The Bosch system had the first generation of OBD or OBD-I, whereas the Teves system used the second generation OBD or OBD-II system.

The first generation OBD system was developed before the 1990s, however according to Digital Trends the California Air Resources Board (CARB) made a push to standardise the OBD system in all cars to make the vehicle more economically friendly in 1991 (Digital Trends, 2018). The first version of the OBD was forced upon many manufactures with the change in the emission regulations and mainly the change in fuel injection. In the 1980s many European manufacturers started to use electronic fuel injectors rather than carburettors which improved fuel burn quality better the fuel economy and in turn the emissions of the vehicle. Stated in the Automotive News (Armstrong, 2004) that Bosch Introduced their Jetronic and was common in vehicles in the 80s. due to all these electronic components to make it easier and quicker to fix they added an OBD system to most vehicles too, this was to detect the issue within the electronic system. The basic operation of the OBD system is to read what information the ECU is gathering from the sensors and actuators and the re feeding them back into the technicians OBD reader so they can solve the issue. OBD-I was very basic and most vehicles had different slots located in different areas in the dashboard of the vehicles. Some of the OBD I scanners can actually clear the codes themselves, while others require a particular procedure to get rid of them. This procedure usually entails disconnecting the battery, removing and ECM fuse, or turning the engine on and off for a couple of intervals. (Coleman, 2018)

The Teves OBD-II system was an improved version of the first generation as expected. As of 1st of January 1996 every car manufactured had OBD-II system in including the Teves system that was tested (The OBDII Homepage, n.d.). All OBD-II cars have a connector located in the passenger compartment easily accessible from the driver's seat. Which is a pro against the OBD-I as it is easier to locate. The scanning equipment are also an improvement. There were code readers and scan tools available for the OBD-II whereas the OBD-I used a Morse code type system where there would be a flashing light or an alarm type noise that gave a code that would transfer into a code. Overall the OBD system in the Teves is better in terms of reading the codes as well as delivering the codes to the driver/technician working on the vehicle.

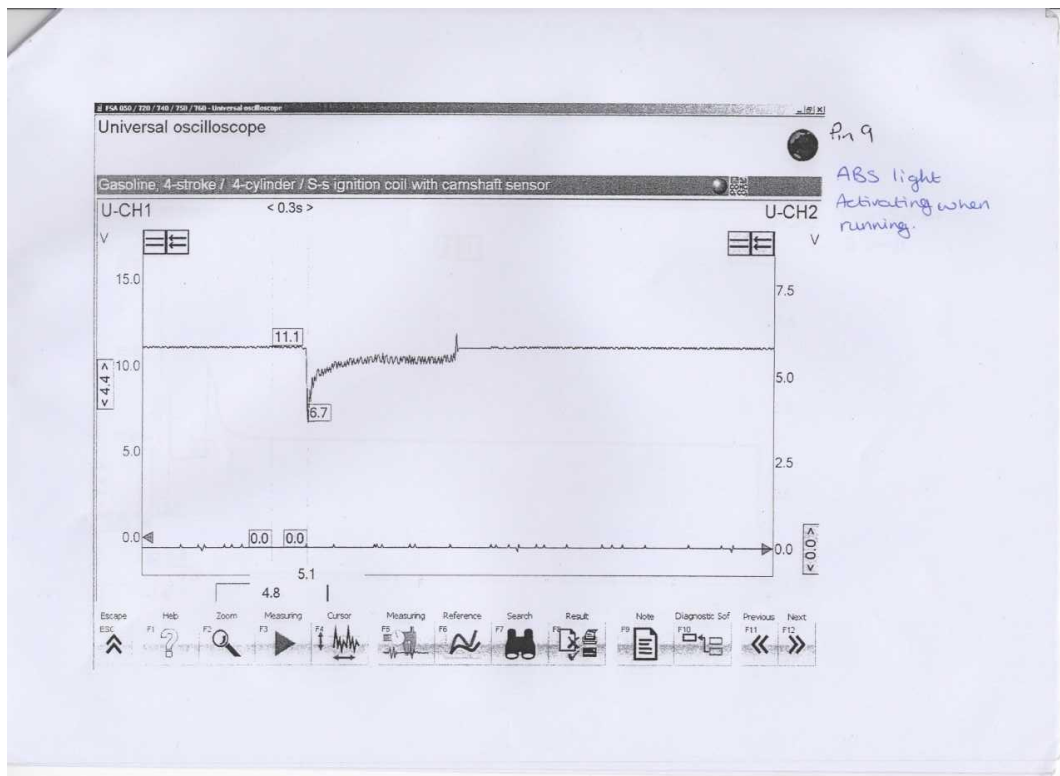
Overall the Teves system is a more updated version of the Bosh 2-EH system. There is always the argument of there's more electrical components that could go wrong and the expense of those faults would be greater. However the overall accuracy of the more modern system and the contribution it has towards improving emission control and fuel economy is a lot more beneficial in the long run of upkeeping the vehicle.

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Appendix

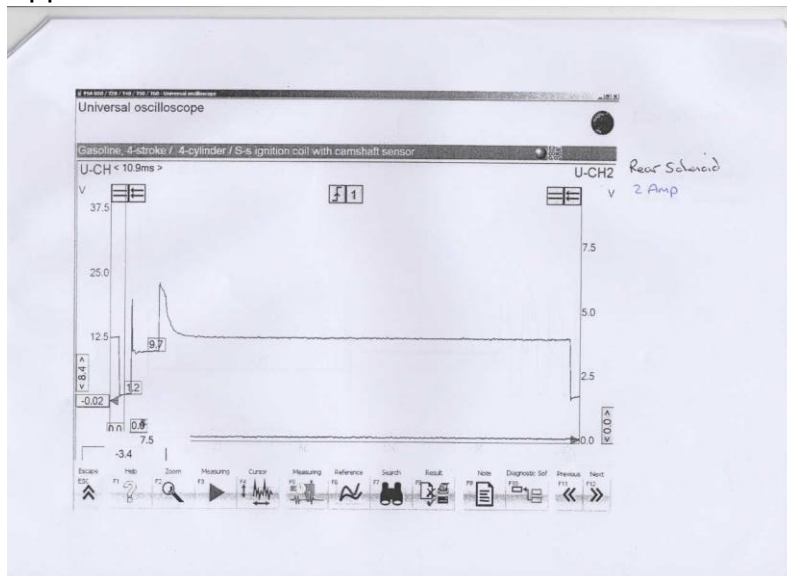
Appendix 1



(Gibson, 2018)

As you can see above this is the waveform seen at Pin 9 on the Bosch 2EH when the engine is running. The little spike you see in the middle is when the ABS system is being activated.

Appendix 2

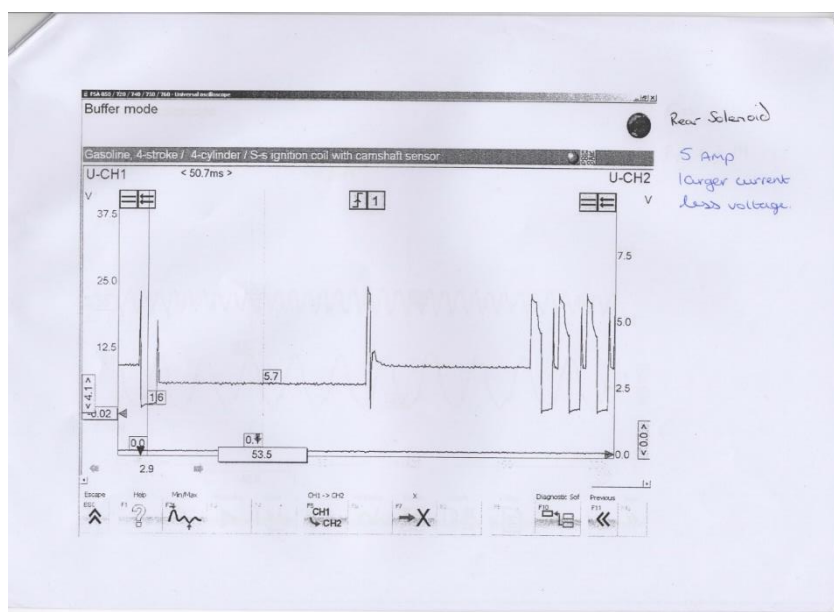


(Gibson, 2018)

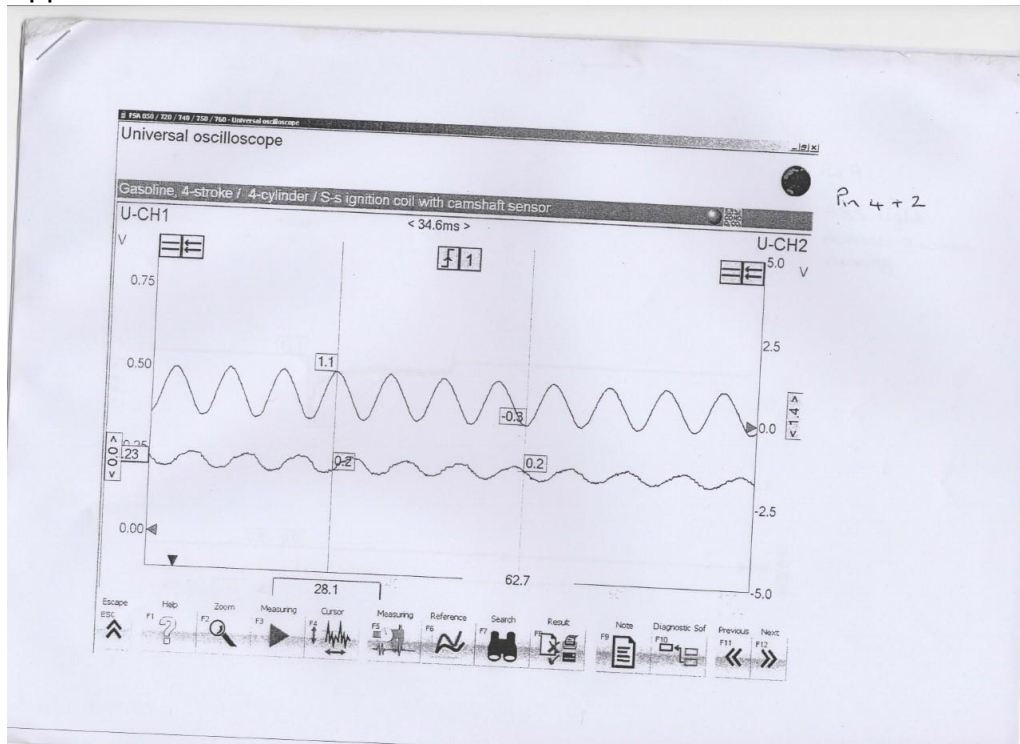
This waveform is the rear solenoid on the 2EH system. This particular solenoid is a 2 amp solenoid, as you can see right at the start of the waveform there is a small spike this is the solenoid activating and in turn preventing the rear wheels from locking up. As you can see below there is the waveform for the rear solenoid at 5Amps which allows the current to be larger however the voltage is lower.

Appendix 3

(Gibson, 2018)



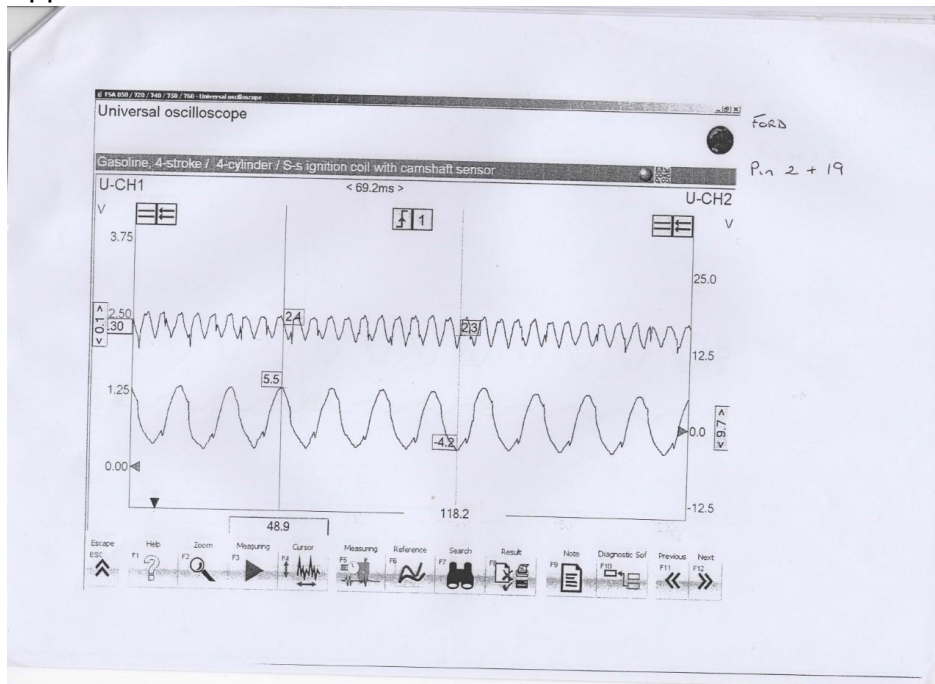
Appendix 4



(Gibson, 2018)

Above is the waveforms for pin 2 and 4 on the 2EH system. Pin 4 being the signal for the wheel speed sensor and 2 being the ground for the sensor. The fluctuation in the top wave is expected and is the signal when the trigger wheel gap passes the sensor. The bottom wave fluctuation is down to the inconsistency in the trigger wheel.

Appendix 5



(Gibson, 2018)

Pin 2 in the picture above is the ground wheel sensor on the ford and pin 19 is the signal for the wheel speed sensor.