Palestine Polytechnic University
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COMPARISON OF DIRECT-SHIFT GEARBOX (DSG) SOFTWARES

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الإهداء

إلى من هم أكرم منا جميعا ... الشهداء

إلى من ضحوا بحريتهم من أجل حرية غيرهم .... من علمونا معنا الكرامة .... الأسرى الكرام

إلى نبع الحنان الذي ال ينضب .... أمي الغالية

إلى ينبوع العطاء الذي زرع في نفسي الطموح والمثابرة ..... والدي العزيز

إلى كل من أضاء بعلمه عقل غيره

إلى من يحملون في عيونهم ذكريات طفولتي وشبابي ... أخوتي وأخواتي

إلى مشرفي العزيز ....

إلى أصدقائي زملائي وزميلاتي في جميع المراحل الدراسية

إلى كل من ساهم في إنجاح هذا المشروع.

الشكر والعرفان

في البداية ، الشكر والحمد لله جل في علاه. فإليه ينسب الفضل كله في إكمال هذا العمل والكمال يبقى لله وحده. وبعد الحمد لله ، فأنني أتوجه إلى الدكتور ضياء عرفه بالشكر والتقدير الذي لن تفيه أي كلمات حقه فلولا مثابرته ودعمه المستمر ما تم هذا العمل. وكذلك الشكر إلى المهندس بشار قطينة على دعمه ومساعدته في إتمام هذا المشروع. وبعدها فالشكر موصول لكل أساتذتي اللذين تتلمذت على أياديهم في كل مراحل دراستي. كما نشكر كل من ساعدنا من قريب أو بعيد ولو بكلمة أو دعوة صادقة من القلب.

Abstract:

In the past, auto companies used to focus on developing mechanical design more than software development, but now they focus on developing software more than mechanical design, So The automotive world has become highly dependent on software.

In this study, the same Direct Shift Gearbox (DSG) was used in two different cars with different engine capacity and determine the strategies to follow when using a DSG from a car have a 1900cc engine and placed in a vehicle that have a 3200cc engine and vice versa.

Although the two cars use the same DSG, we have found software differences for the DSG, we will extract the MAPs from two Transmission Control Unit (TCU) and explain the differences between the two software .

في الماضي ، كانت شركات السيارات تركز على تطوير التصميم الميكانيكي أكثر من تطوير البرمجيات ، لكنها تركز الآن على تطوير البرامج أكثر من التصميم الميكانيكي ، لذلك أصبح عالم السيارات يعتمد بشكل كبير على البرمجيات.

في هذه الدراسة ، تم استخدام نفس علبة التروس ذات ناقل الحركة المباشر (DSG) في سيارتين مختلفتين بسعة محرك مختلفة وتحديد الاستراتيجيات التي يجب اتباعها عند استخدام DSG من سيارة لها محرك 1900cc ووضعها في سيارة بها محرك 3200cc والعكس صحيح.

على الرغم من أن السيارتين تستخدمان نفس DSG ، فقد وجدنا اختلافات برمجية ل علبة تروس DSG ، وسنستخرج الخرائط من وحدتي التحكم في النقل (TCU) ونوضح الاختلافات بين البرنامجين.

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Chapter one : introduction

1.Introduction

1.1. Objective

The Direct-Shift Gearbox (DSG) also called Dual Clutch Transmission (DCT) is a type of transmission used in German vehicles like Skoda and Volkswagen, it uses a close idea of manual transmission in the way of working and use automatic transmission in the way of control and driving.

In some vehicles that use DSG they use the same gearbox hardware in different vehicles, but they do some modification on the software (MAPs) to make it fit with other vehicles and for better performance, control and economy.

In this project, we will choose a specific type of DSG gear that have the same hardware and different software (MAPs) using ETKA program, and make a comparison between the two different MAPs using WinOLS program, and extract the MAPs from Transmission Control Unit (TCU) using Flex device.

1.2. Importance

This project is important to provide a knowledge to the local market about the differences in the software between same gear hardware and different software (different vehicle or different engine capacity), and knowing the differences when need to change not working gear instead other gear have the same hardware, and the need to reprogramming TCU with appropriate software or changing the TCU.

1.3. Project Methodology

In this project first we will use a program to choose two TCU for two vehicles that have the same DSG gearbox in hardware and different in software, and extract the MAPs using flex device, then compare the two MAPs by WinOLS program.

1.4. Expected Budget

The Table(1.1) show the price of all parts .

Table (1.1) : Expected Budget.

part	cost
Two TCU of DSG gearbox	300 $
Flex device	100 $
ETKA program	50 $
WinOLS program	100$
Total cost	**550 $**

1.5. Time table

Table (1.2) show the time table for this project in the first semester

Table (1. 2) : Time table for the first semester.

Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Selecting project idea	X	X														
Abstract			X													
Introduction				X	X	X										
Literature review						X	X	X	X	X						
Selecting two TCU and Reading the software										X	X	X	X	X		
Make a report			X	X	X	X	X	X	X	X	X					
prepare for presentation														X	X	X

Table (1.3) show the time table for this project in the second semester

Table (1.3) : Time table for the second semester

Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Understand DSG Control Strategy	X	X	X	X	X	X										
Extract MAPs and make comparison							X	X	X	X	X	X				
Make a report			X	X	X	X	X	X	X	X	X	X	X	X		
prepare for presentation															X	X

Chapter two : Literature review

2.Literature review

2.1.Introduction

The transmission is a very important part of the vehicle and the main function of the transmission is to transmit the power from the engine to the wheels, we can't connect the engine direct to the wheels, because that will not allow to make speed and torque conversions from the engine, so the gearbox make a ratio between engine and wheels, could be reduction or multiplication of torque.

In manual transmission the driver change the gear ratio by shift up when need more speed and shift down when need more power, but in automatic transmission the control unit determine the gear ratio needed from speed and load of the vehicle and other input (sensors).

There are many types of automatic transmission, and the most common types are traditional automatic transmission and Direct-shift gearbox (DSG) and Continuously Variable Transmission (CVT),in this chapter we will explain these three types of automatic transmission and explain the shift point in transmission and the sensors (input) in Transmission Control Unit (TCU) and their function.

2.2. Traditional Automatic Transmission

Main component of traditional automatic transmission :

1- Torque converter

Torque converter provides smooth automatic drive take-up from standstill and a torque multiplication in addition to that the normal mechanical gear provided by transmission .

The torque converter have Impeller (pump) rotates with engine fly wheel and Turbine (runner) rotates with input shaft of transmission ,and the power transfers from Impeller to Turbine and bake to Impeller by stator using a specific hydraulic fluid, and Figure (2.1) show how the power transfer.

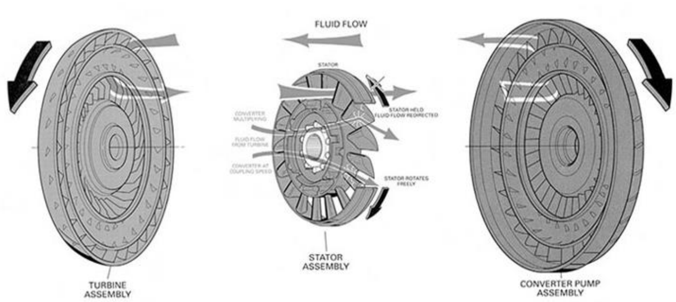

Figure (2.1) : Power transfer from Impeller to Turbine [1].

2- Planetary gear set

Planetary gear set gives the ratio of speed and torque as needed، this group contains three main elements, which are the sun gear, the carrier (planetary pinion gears), and the ring gear, the ratio depends on the installation one of the components of the group ,and which one is the input and which one is the output، and the method of fixing the group is controlled by a clutch.

3- Hydraulic valve

The main function of the hydraulic-control system is to regulate, boost, and distribute hydraulic pressures and volumetric flows. This includes generating the clutch pressures to control the planetary gear set, supplying the torque converter, and providing the lubricating pressure. The housings of the hydraulic-control system are made from die cast aluminum and contain several precision-machined slide valves and electrohydraulic actuators, Figure (2.2) show the hydraulic valve.

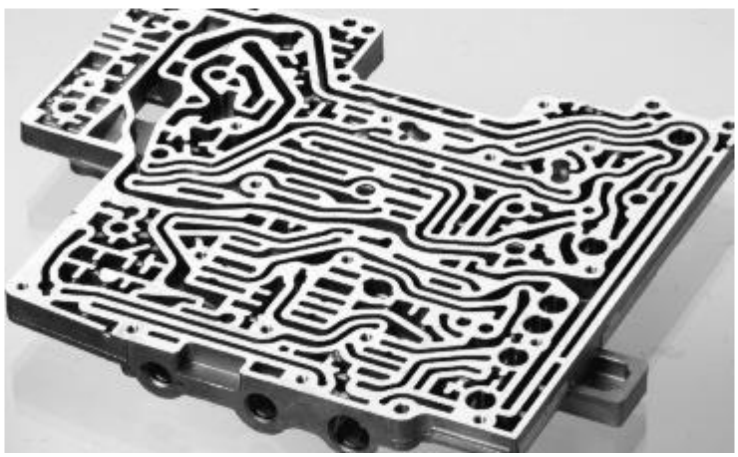

Figure (2.2) : Hydraulic valve [2].

4- Transmission Control Unit

The Transmission Control Unit use the input (sensors) such as Vehicle Speed Sensor (VSS), Throttle Position Sensor (TPS) and other sensors to do a group of commands and determine the gear ratio needed and applying the actuators on hydraulic valve, The commands inside the (TCU) is programmed to achieve optimum performance, and fuel economy.

2.3 Continuously Variable Transmission (CVT)

A Continuously Variable Transmission (CVT) doesn't use gears like a conventional transmission. Rather, it uses 2 pulleys connected by a belt Figure (2.3) show the 2 pulleys . It's a little bit like a snowmobile transmission: One pulley links to the engine, and the other one attaches to the transmission. The belt transfers the power between them. As the name proposes, this transmission changes settings constantly. This enables the vehicle's engine to run more effectively. [3]

Figure (2.3) : 2 pulleys of CVT gearbox connected by a belt.

2.4 Direct-shift gearbox (DSG)

Main component of Direct-shift gearbox :

1. Dual clutch

dual clutch includes two input primary shafts each linked to the shaft of an engine and the clutch could be operate dry or wet (in oil) [4], and one of the primary shafts contains the odd ratios and the other contains the even ratios, both shafts will be engaged with output shaft at all time but the dual clutch will engage on of the clutches as ratio needed.

2. Mechatronic unit

Mechatronic unit contain the control unit of gearbox and valve body, the valve body engaged the next gear needed and the clutch needed by actuator through the control unit. The control unit determine the clutch and gear ratio needed by analysis the information coming from sensors of the vehicle such as engine speed, vehicle speed, brake pressure, throttle position, and from the control unit of engine and ABS braking system by network connection (CAN bus).

Figure (2.4) show the DSG gear and main component.

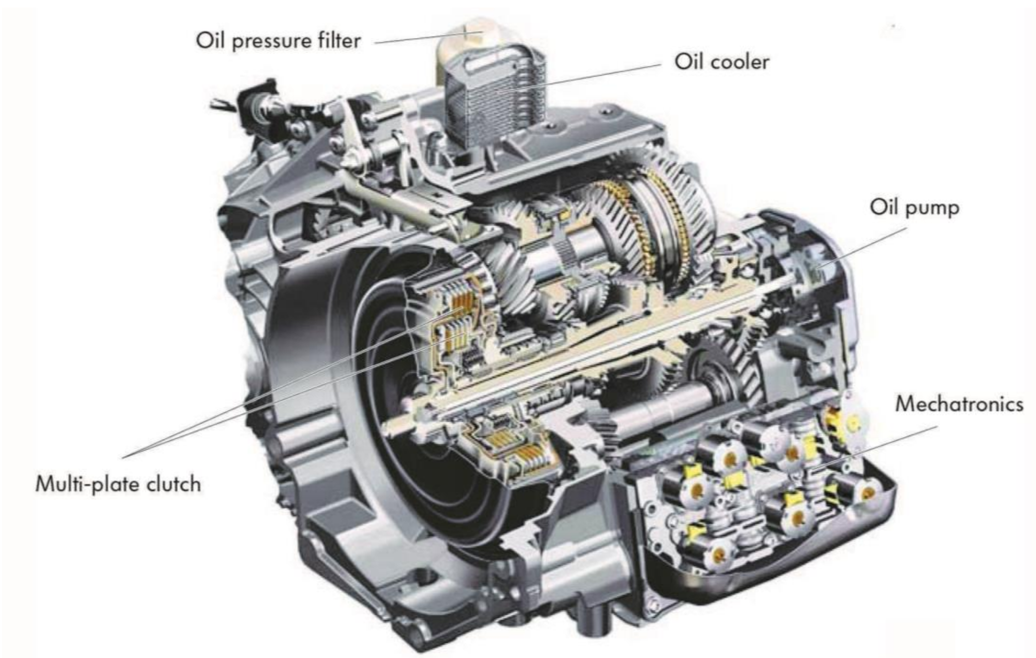

Figure (2.4) : DSG gear and main component [5].

2.5 Shift point in gearbox

Shift point is when the gear ratio is change and it controlled by TCU, if we need the faster output the gear ratio will decrease (shift up), if we need the slower output the gear ratio will increase (shift down), Figure (2.5) shows the relation between engine speed and vehicle speed and the points at which the gear ratio change also shows the relation between engine speed and the parameter (Torque, Break Power, Specific Fuel Consumption (SFC)).

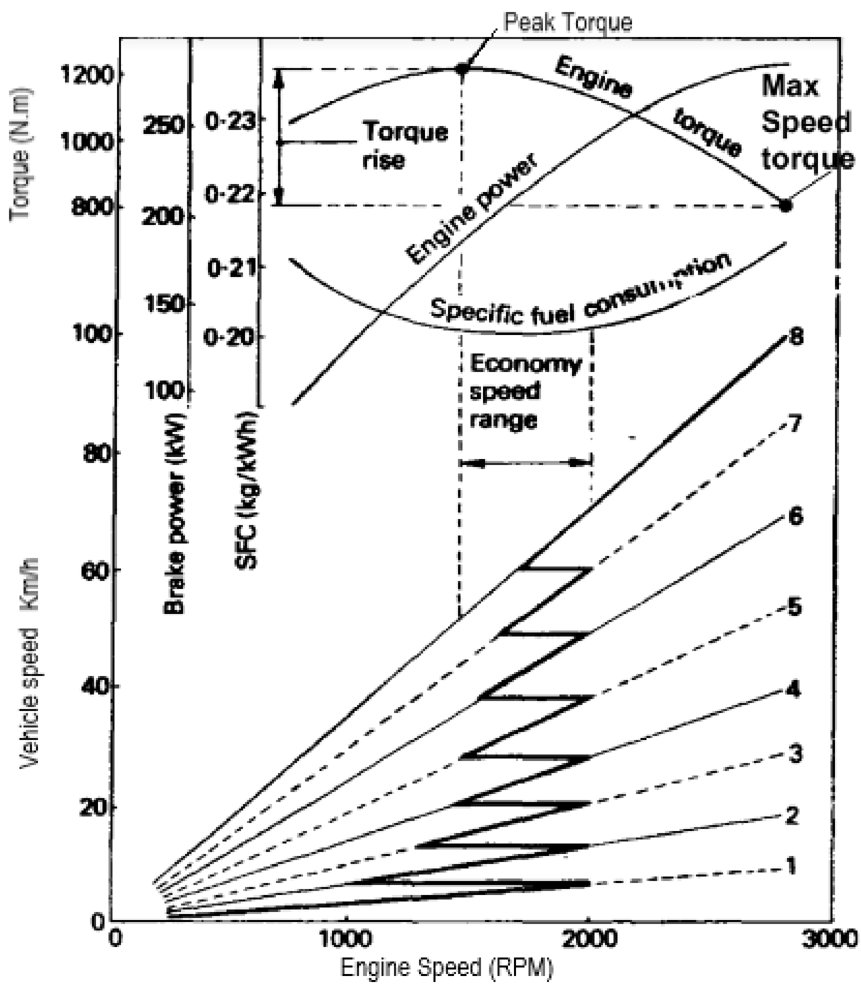

Figure (2.5) : The shift from gear ratio to another [6].

The shift point in Figure (2.5) is occur on better economy speed range and also when the drop in torque is less as possible which mean optimum shift point [7].

This is an example for calculation in drop of torque :

Figure (2.6) shows the data of engine which is a relation between engine speed (RPM) and Torque (N.m), and Table (2.10) shows the gear ratio for all gears number [7].

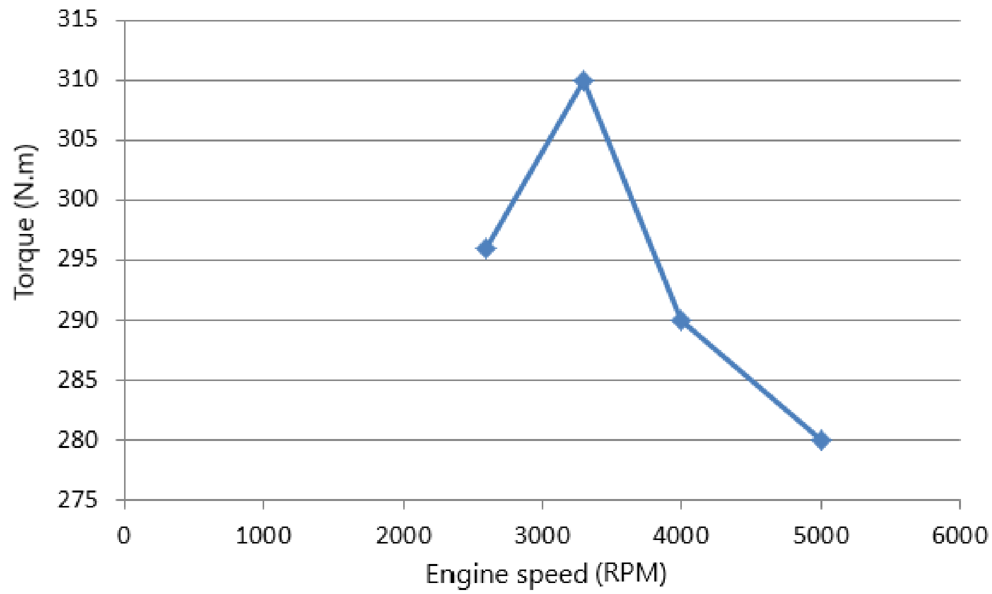

Figure (2.6) : relation between engine speed (RPM) and Torque (N.m).

Table (2.1) : gear ratio.

Gear number	1	2	3	4	5	6
Gear ratio	4	2.3	1.5	1.2	1.0	0.85

We will calculate the drop in torque from 2^{nd} to 3^{rd} at 4000 RPM and 5000 RPM.

2^{nd} gear Output Shaft Torque @ 4000 RPM = 290 * 2.3 = 667 N.m

Output Shaft Speed = 4000/2.3 = 1739 rpm.

3^{rd} gear RPM @ 1739 output shaft speed = 1739 * 1.5 = 2600 RPM.

Output shaft torque = 296 * 1.5 = 444 N.m

The drop in torque = 667 – 444 = 223 N.m @ 4000 RPM.

2^{nd} gear Output Shaft Torque @ 5000 RPM = 280 * 2.3 = 644 N.m

Output Shaft Speed = 5000/2.3 = 2174 rpm.

3^{rd} gear RPM @ 2174 output shaft speed = 2174 * 1.5 = 3300 RPM.

Output shaft torque = 310 * 1.5 = 465 N.m

The drop in torque = 644 – 465 = 179 N.m @ 5000 RPM.

Since the drop in torque is less at 5000 rpm, this is a better shift point than 4000 rpm.

2.6. Sensors in transmission and their function

The Transmission Control unit (TCU) is the most important part of the gearbox and it is fed by sensors(input) and then the TCU analyze it to give output according to sensors measurement.

These are most transmission sensors and what their purpose is :

1- Vehicle Speed Sensor(VSS) : measure the vehicle actual speed (wheel speed), the TCU use this information to control the transmission shift point [8].

2- Throttle Position Sensor : measure the throttle opening which is controlled by accelerator pedal, the throttle opening is indicated to the load and the TCU will control the shift point [8].

3- Transmission Oil temperature Sensor : monitors the temperature of the transmission fluid and provide feedback to TCU to prevent overheating the component of transmission [8].

4- Transmission Fluid Pressure Sensor : monitors the transmission fluid pressure inside the transmission and the TCU change the fluid pressure by pressure control valve to open or close the valve to raise or lower the pressure [8].

5- Turbine Speed Shaft Sensor : measure the shaft's speed rotation inside the transmission and the TCU determines the amount of clutch slipping is happening [8].

6- Airflow Sensor : measure air flow into the engine intake, the TCU use this information to control transmission shift point [8].

7- Intake Air Temperature Sensor : measure the temperature of the air going into the engine intake then the TCU will control in shift point according to the measure of the sensor [8].

8- Gear lever Position Sensor : Provides information about the position of the gear rod to the electronic control unit, which controls the gear shifting mechanism. Also used to suggest the next gear [8].

Chapter three : DSG software

3. DSG software

3.1. Introduction

In this chapter we will explain some details about the identification software of DSG gearbox and get two software of DSG with same hardware and different software with different engine capacity and get part code form ETKA program.

3.2. ETKA program

ETKA is the official spare parts catalogue for Volkswagen Group.

How we confirm that the two gearbox we need is same hardware using ETKA?

On ETKA program enter the type and model of the vehicle then open the gearbox icon to preview the gearbox type and part code that fit with the vehicle, if the number of both vehicle is the same but with different part code which mean they are same hardware but different software, Figure (3.1) shows the steps.

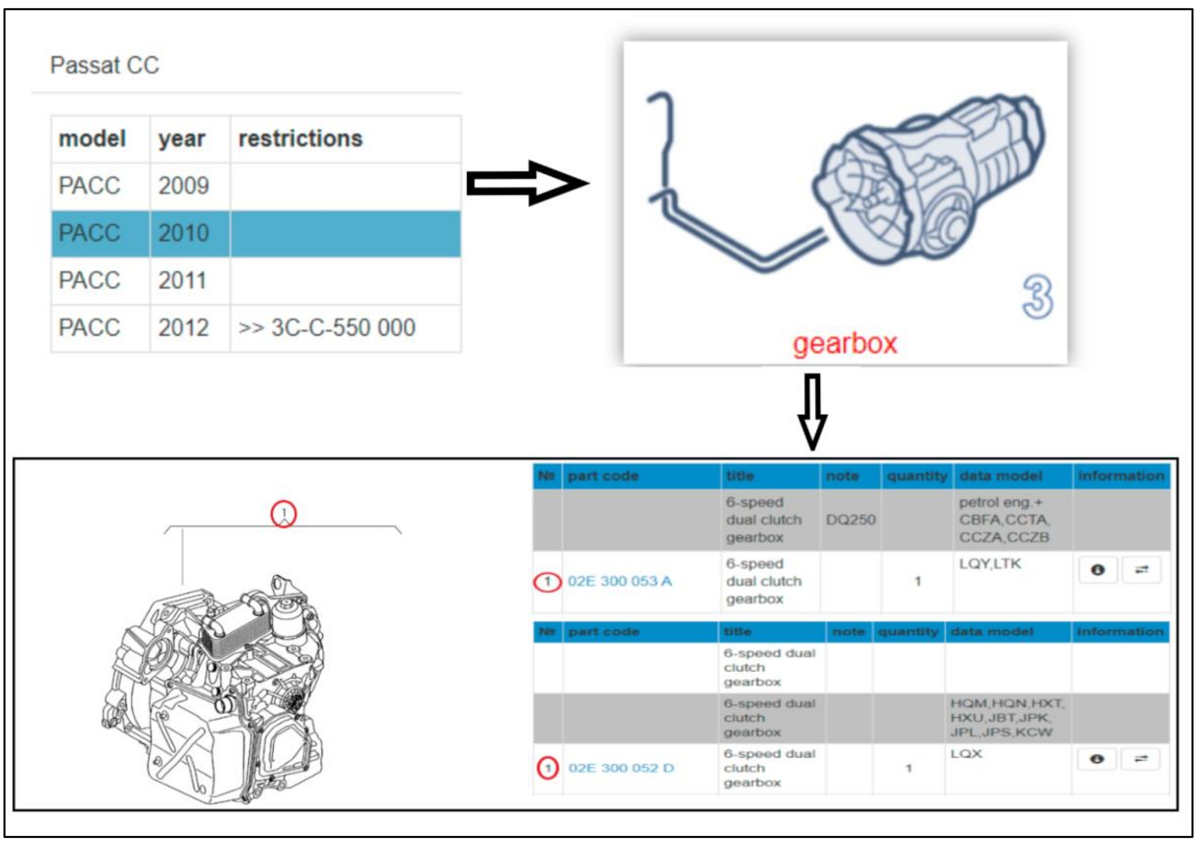

Figure (3.1) : steps of enter on ETKA gearbox type.

3.3. Identification software of DSG gearbox

The software of the DSG gear has an identity DQ number relative to the number of speeds and other specifications and Table (3.1) shows the most popular DQ number.

Table (3.1) : DQ number and speeds and clutch type [9].

DQ number	Number of speeds ratio	clutch type
DQ 250	6	Wet
DQ 200	7	Dry
DQ 400	7	Dry
DQ 500	7	Wet

The DQ number have a part code Indicates to the programming method inside the control unit of gearbox, with immobilizer mean that the TCU is connected with Vehicle identification Number (VIN), if we need to deactivated the immobilizer we need to contact with company online to make the deactivation, Table (3.2) shows the main part code.

Table (3.2) : DQ Indicators and its description

DQ Indicators	Description
DQ 250 02E	without Immobilizer
DQ 250 09D	with Immobilizer
DQ 200 0AM	without Immobilizer
DQ 200 0CW	with Immobilizer and external speed sensor
DQ400 0CW	with Immobilizer and internal speed sensor
DQ500	with Immobilizer

3.4. Part Code from ETKA software

The first file we need have a part code (02E 300 011CP) (DQ250) 6-Speed Dual Clutch Gearbox fit with petrol engine 3.2Ltr with 184KW power produced, Figure (3.2) show the DSG information, Figure (3.3) show the engine information.

№	part code	title	note	quantity	data model	information
		mounting parts for engine and transmission 6-speed dual clutch gearbox with transfer box	3.2ltr. gearbox code:		quattro+ HXZ,JPZ,KDE, KNL,KQA	

Figure (3.2) : DSG information from ETKA.

№	part code	title	note	quantity	data model	information
		short engine without distribu- tor, intake manifold, exhaust manifold and alternator	3.2ltr. 184KW		6-cylinder+ petrol eng.+ BUB	

Figure (3.3) : Engine information from ETKA.

The second file we need have a part code (02E 300 052A) (DQ250) 6-Speed Dual Clutch Gearbox fit with diesel engine 1.9Ltr with 77KW power produced, Figure (3.4) show the DSG information, Figure (3.5) show the engine information.

№	part code	title	note	quantity	data model	information
		6-speed dual clutch gearbox	DQ250			
1	02E 300 052 A	6-speed dual clutch gearbox		1	KPW,LRA	

Figure (3.4) : DSG information from ETKA.

№	part code	title	note	quantity	data model	information
		base engine	1.9/2.0ltr.		diesel eng.	
1	03G 100 098 MX	base engine Detail of the restored at the factory	1.9ltr. 77KW	1	BJB	

Figure (3.5) : Engine information from ETKA.

3.5. How to get the software of TCU ?

To extract the software from TCU there are special tools and devices that can be used such as K-Tag, K-Kess and FLEX Master. In our project we use FLEX Master to extract the software.

FLEX PROGRAMER it is a device for reading and programming electronic control units (ECU) and TCU from Magic motorsport Corporation, the programmer connect with control unit without the need to fully open the electronic control unit, the programmer contain the MAP (PINs) to connect with control unit.

The programmer work on two mode to read and write the software. the first mode is On-Board Diagnostics (OBD) mode In this mode the ECUs are read Via the OBD port located inside the car without the need to remove the control unit from the car. The second mode is Bench mode In this mode the electronic control units are read ECU by using the terminals (PINs) of the control unit without the need to open the control unit and the PINs we need to connect can be found in the FLEX program.

How to connect the flex device to the electronic control unit step by step :

1- Write on the search in the program the type of the gearbox, for example DQ200 is chosen and choose the type and model of the vehicle, Figure (3.6) show this step.

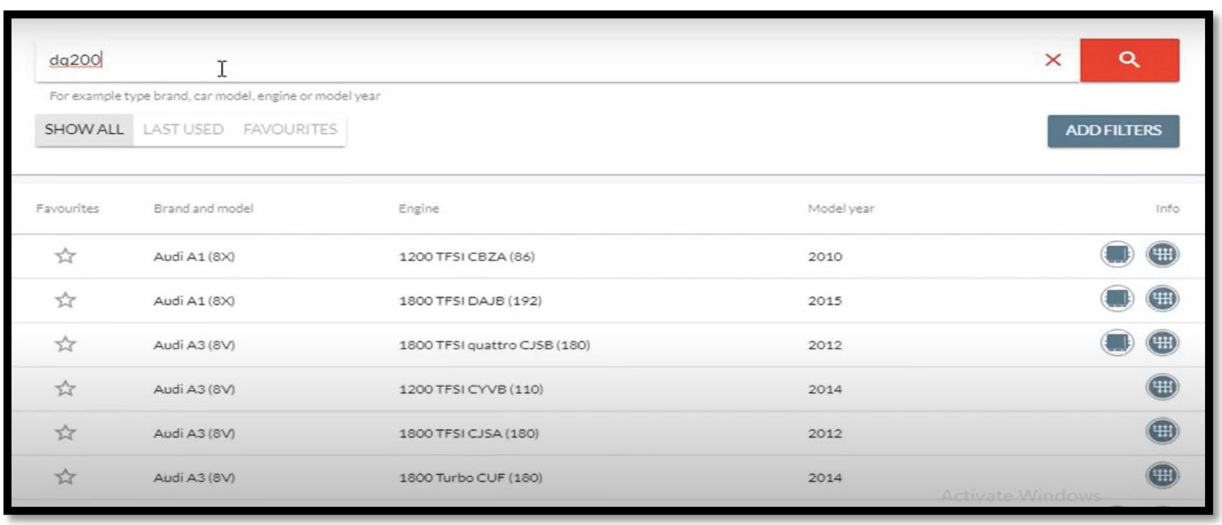

Figure (3.6) : choose the type of vehicle and gearbox.

2- click on the icon show in Figure (3.7).

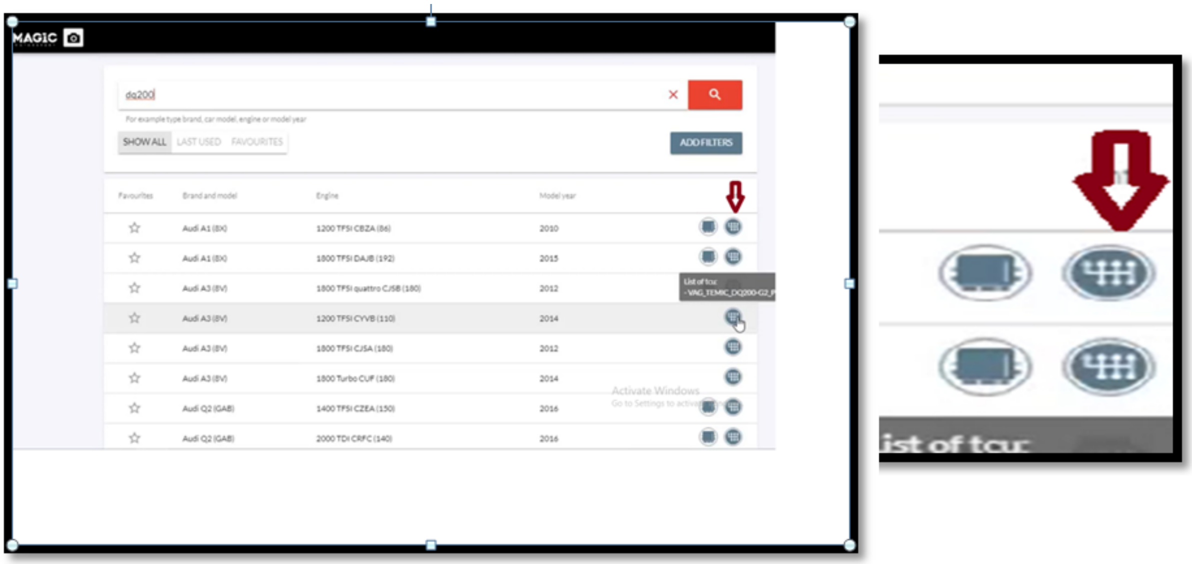

Figure (3.7) : icon to click in second step of extract software.

3- choose the communication type in TCU for example Bench mode is chosen, Figure (3.8) show this step.

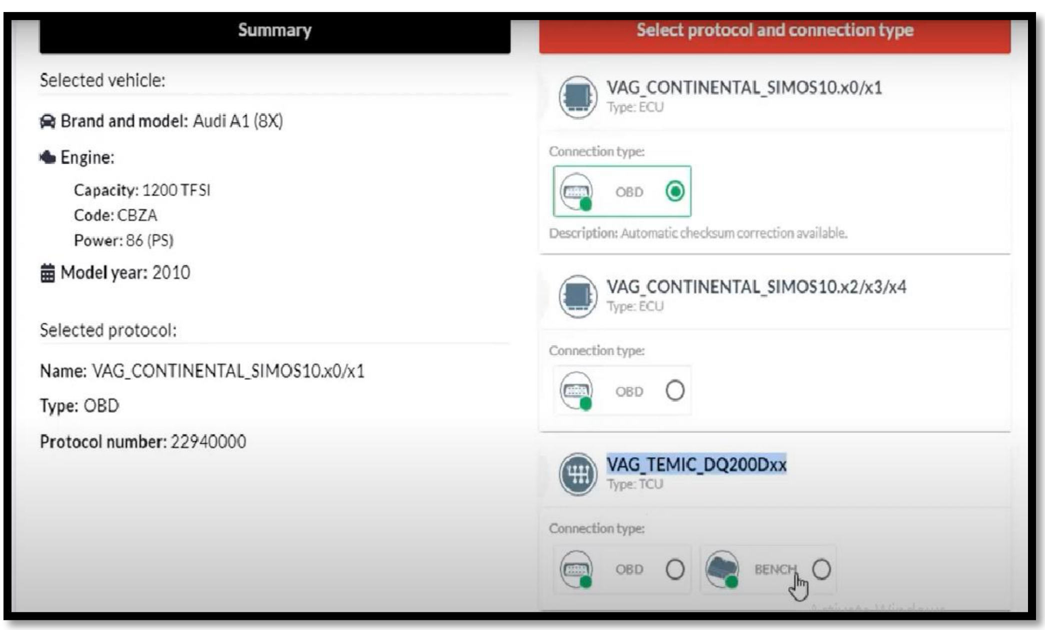

Figure (3.8) : choose the communication type.

4- the program will provide a MAP to connect TCU with FLEX PROGRAMER, Figure (3.9) is show the MAP and how to connect.

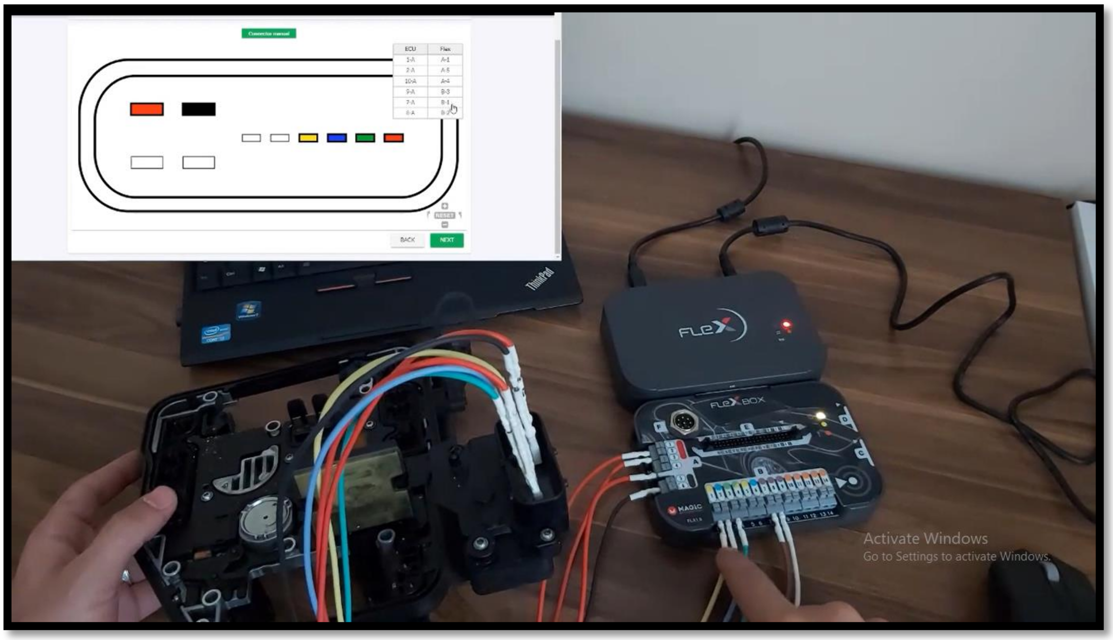

Figure (3.9) : MAP appears showing how to connect TCU with FLEX PROGRAMER.

5- Click on full backup to extract the software, Figure (3.10) show this step.

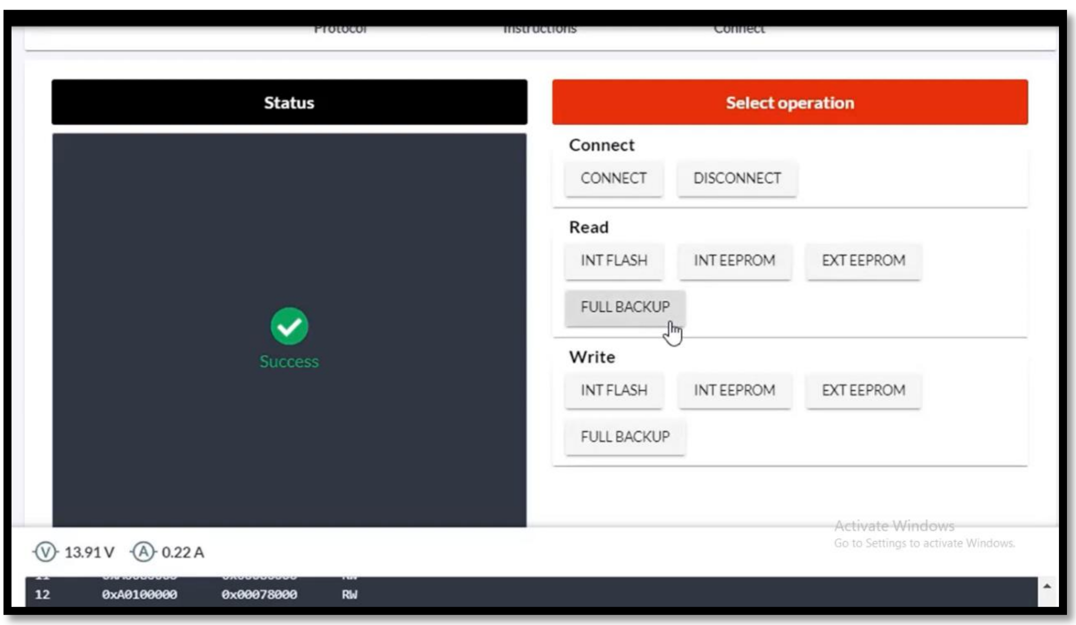

Figure (3.10) : extract the software from TCU and save it .

3.6. WinOLS program

WinOLS is an application, which is written especially to show and modify the memory contents of ECUs, the MAP on WinOLS can be viewed in text, 2D or 3D.

How to preview the MAPs of TCU on WinOLS program ?

1- Drag the file on WinOLS program as shown in Figure (3.11), then the file will open in hexadecimal number as shown in Figure (3.12).

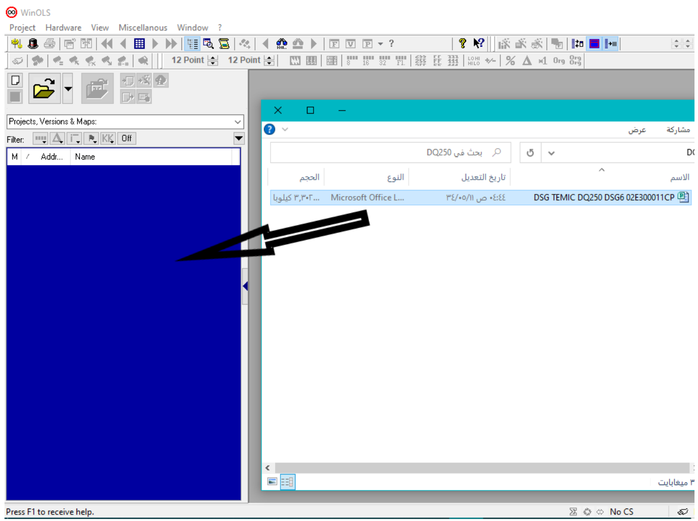

Figure (3.11) : open the software of DSG on WinOLS program.

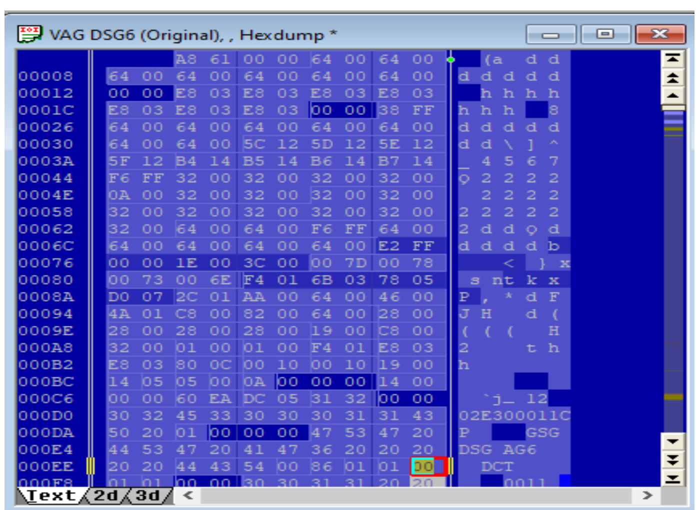

Figure (3.12) : hexadecimal number in WinOLS program.

2- To preview the MAPs of TCU we need map packs (damos) which is a file to describe the hexadecimal number to MAPs that we can understand, Figure (3.13) shows the MAPs in 2D and 3D after using damos file.

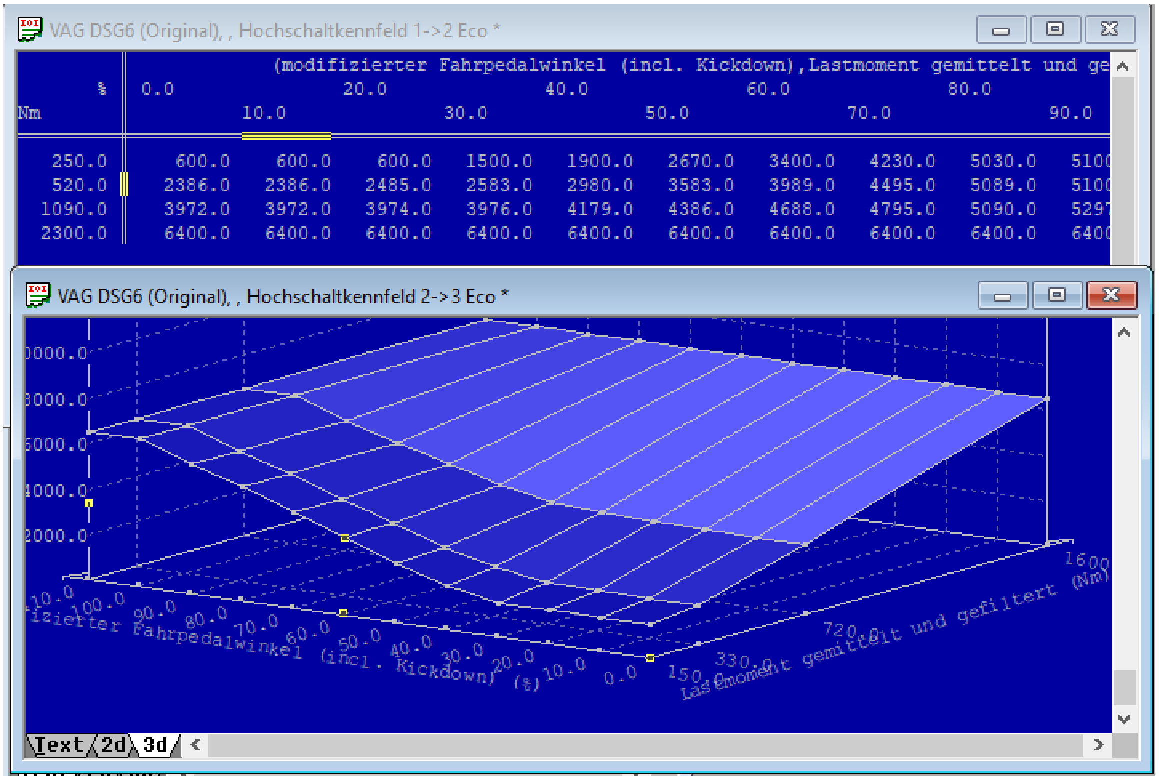

Figure (3.13) : MAPs on WinOLS in 2D and 3D.

In our project after get two different software of DSG that have same hardware we use WinOLS to preview the MAPs of DSG and in chapter 5 we will describe and compare the MAPs.

Chapter four : DSG Control Strategy

4. DSG control strategy

4.1. How does the DSG gearbox work?

The DSG gearbox are controlled electrically by TCU which produce a signal to actuator (valves) according to the input(sensors) to determine the gear ratio needed, the valves connected to selector movement to engage and disengage the gear, Figure (4.1) show the main input and output from TCU.

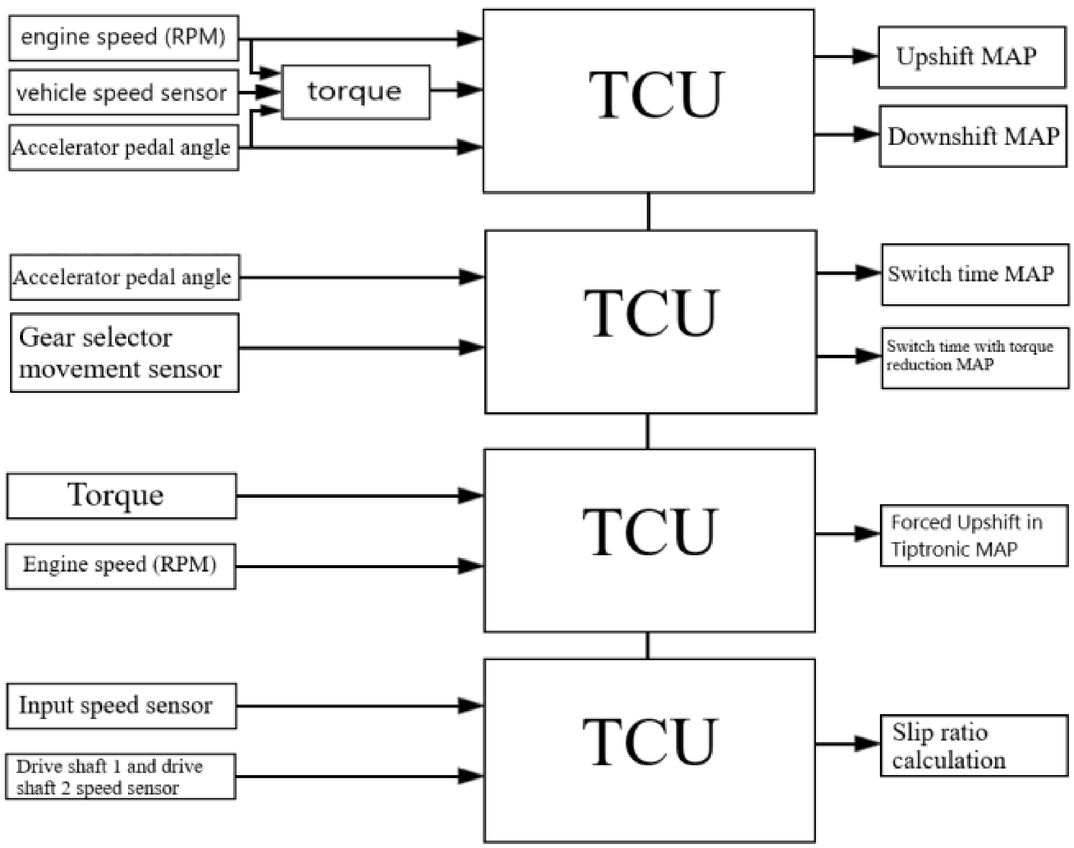

Figure (4.1) : Main input to TCU and main output

The gear use two clutches (K1) and (K2), the first clutch connected with input shaft 1 that contain the odd gears (1,3,5,7) which they connected with output shaft 1, and the second clutch connected with input shaft 2 that contain the even gears and reverse gear (2,4,6,R) which they connected with output shaft 2 and output shaft 3, Figure (4.2) show the connection of clutches with input and output shafts.

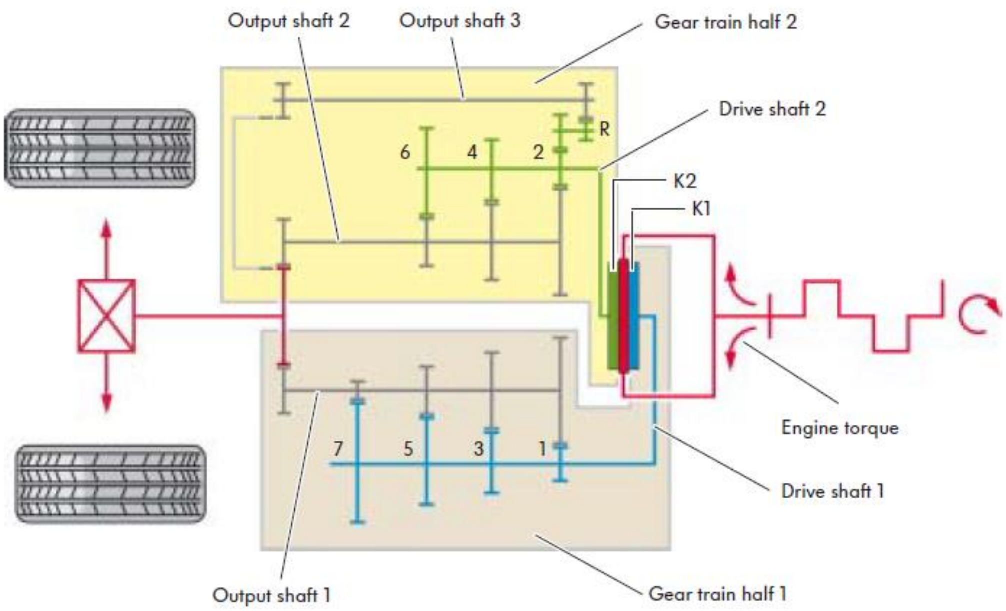

Figure (4.2) : Connection of clutches with input and output shafts [10].

4.2. the main sensors using in the DSG gearbox

1- Input speed sensor : the sensor records the gearbox input speed and it is identical to the engine speed, the TCU use the input speed signal to control the clutches and to calculate the slip ratio (indicates the percentage of wear in the clutch) using gearbox input speed sensor and drive shaft 1 and drive shaft 2 speed sensor, the sensor operates according to the hall effect principle.

2- Drive shaft 1 and drive shaft 2 speed sensor : both sensors are housed in the mechatronic unit and they measure the two shaft speeds, the TCU use the speed of drive shaft 1 and drive shaft 2 to control the clutches and to calculate the slip ratio, both sensors are hall effect principle.

- ✓ Hall effect : the hall effect sensor are used extensively for angular position and speed applications, semiconductor carrying a current in a magnetic field normal to the current flow creates a voltage potential in the semiconductor normal to the current flow in the semiconductor.

3- Clutch position sensor : the clutch position sensor located above the clutch actuators and it measure the two clutches position to control the clutch actuators to get the best starting and shifting when changing the transmission ratio, the sensor use contact-free position technology.

- ✓ contact-free position technology : the technology consists of iron core which is the primary coil is wound, two secondary evaluation coils, a permanent magnet which is located on the clutch piston and sensor electronics, the working principle for this technology :

An alternating voltage is applied to the primary coil. As a result of this, a magnetic field is built up around the iron core. If the clutch is actuated, the clutch actuator piston moves through the magnetic field with the permanent magnet. Due to the permanent magnet's movement, a voltage is induced in the secondary evaluation coils. The level of the voltage induced in the left and right evaluation coils is dependent on the position of the permanent magnet. Via the level of the voltage in the left and right evaluation coils, the sensor electronics detect the position of the permanent magnet and therefore the position of the clutch actuator piston.

4- Gear selector movement sensor : the sensor generate a signal to TCU to recognizes the position of the gear selectors to control the gear selector for changing gears, The sensor consists of an aluminum housing with an inductive force sensor and integral electronic circuitry supplied with current

5- Gearbox hydraulic pressure sensor : the sensor measure the pressure of the hydraulic oil to control the motor for the hydraulic pump, the hydraulic pressure sensor use hermetically welded thin film measuring coils with high level output circuitry. This ensures that the pressure sensor is suited to harsh environments including that of hydraulic applications as well as other industries, hydraulic pressure sensors like other sensors, will require a source of electric input. The input voltage varies but for a hydraulic pressure sensor it will usually be from 10-30V. Hydraulic pressure sensors work by producing a change in its output relative to a change in the system pressure.

6- Temperature sensor in control unit : the sensor measure the hydraulic oil temperature around the TCU to avoid high temperature of TCU that could impair the function of the electronics, so if the temperature reach more than 139 ℃ engine torque reduction can be implemented, the sensor use a Thermistors to measure the temperature, Thermistors change resistance as temperature changes. We know with ohms law that as resistance changes, the voltage signal changes as well. By increasing resistance, we lower the voltage signal sent to the TCM. Most transmission fluid temperature sensors are (NTC) or negative temperature coefficient sensors. It means that the sensor's resistance decreases as the fluid's temperature increases.

7- CAN BUS : the TCU use information from ECU by CAN BUS such as Vehicle Speed Sensor which work in hall effect method and Throttle Position Sensor which is a potentiometer.

4.3. actuator in DSG gearbox

The TCU control in DSG by controlling in the actuator, TCU mainly control in the valves to change the gear ratio and the gear have valves control in odd gear and valves control in even gear, the gear train half one valves control in clutch 1 and odd gear, the gear train half two control in clutch 2 and even gear .

The actuators that TCU control :

1- Motor for hydraulic pump : The control unit shuts the motor off when the hydraulic pressure in the system has reached 60 bar, and switches it on again when the pressure has fallen to 40 bar.

2- Valve 1 in gear train half 1 : The valve control in the first and third gear.

3- Valve 1 in gear train half 2 : The valve control in the second and fourth gear.

4- Valve 2 in gear train half 1 : The valve control in the fifth and seventh gear.

5- Valve 2 in gear train half 2 : The valve control in the sixth and reverse gear.

6- Valve 3 in gear train half 1 : The valve control in the first clutch K1.

7- Valve 3 in gear train half 2 : The valve control in the second clutch K2.

8- Valve 4 in gear train half 1 : The valve control in the first clutch K1 and in odd gear .

9- Valve 4 in gear train half 2: The valve control in the second clutch K2 and in even gear .

For example engaging first gear the valves (valve 1 half 1, valve 1 half 2, valve 3 half 1, valve 4 half 1) will be engaged and Figure (4.4) shows the fluid flow for the first gear.

Figure (4.3) show the Hydraulic control system.

Table (4.1) show which Valves is applied for all gear ratio.

Table (4.1) : Valves apply (engagement sequence).

Valve / Gear	Valve 1 half 1	Valve 1 half 2	Valve 2 half 1	Valve 2 half 2	Valve 3 half 1	Valve 3 half 2	Valve 4 half 1	Valve 4 half 2
First gear (1)	Applied	Applied			Applied		Applied	
Second gear (2)	Applied	Applied				Applied		Applied
Third gear (3)	Applied	Applied			Applied		Applied	
Forth gear (4)		Applied	Applied			Applied		Applied
Fifth gear (5)			Applied	Applied	Applied		Applied	
Sixth gear (6)			Applied	Applied		Applied		Applied
Seventh gear (7)			Applied	Applied	Applied		Applied	
Reverse gear (R)	Applied			Applied		Applied		Applied
first clutch (K1)					Applied		Applied	
second clutch (K2)						Applied		Applied

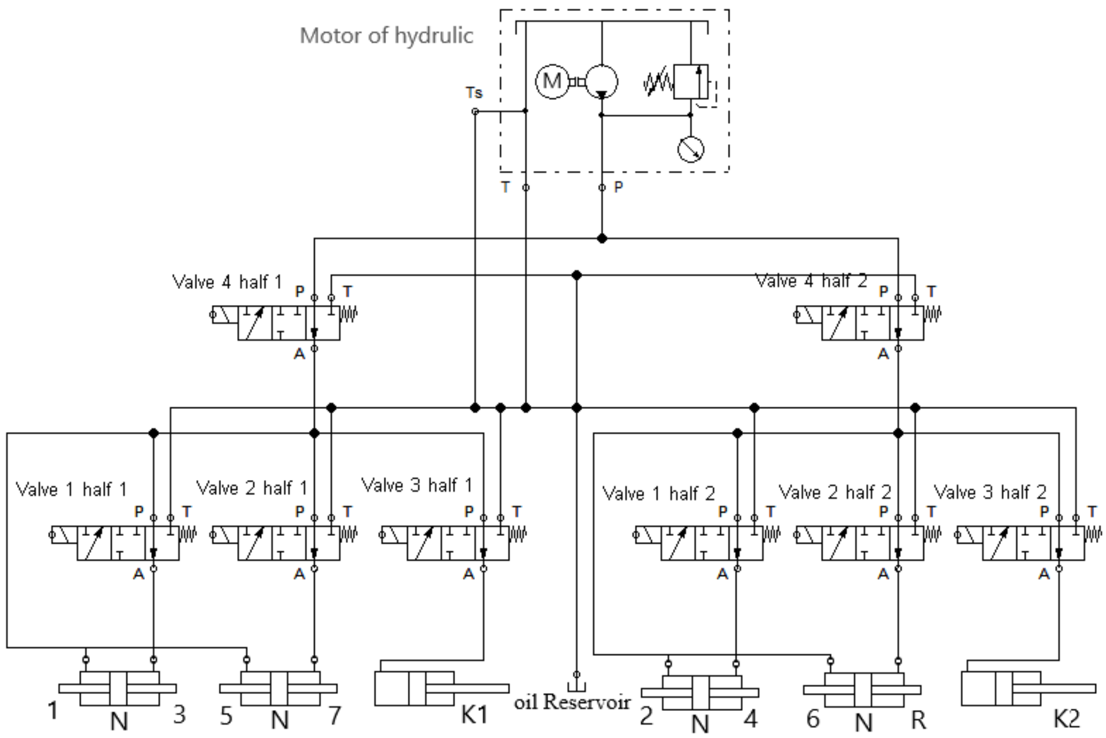

Figure (4.3) : Hydraulic control system.

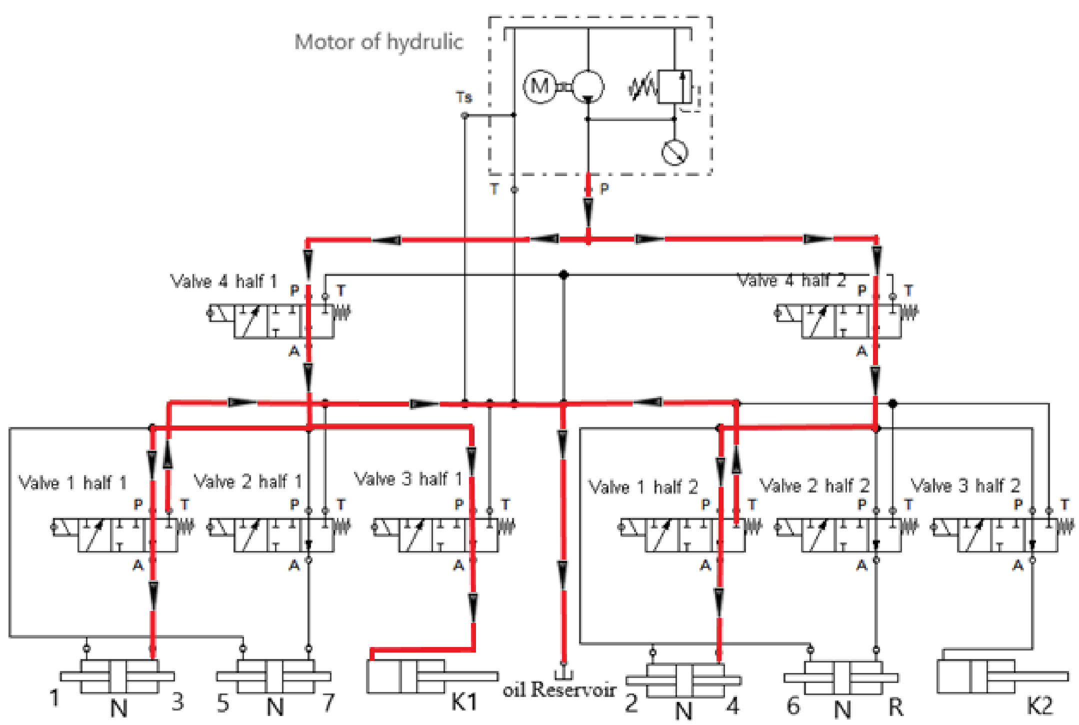

Figure (4.4) : Hydraulic fluid flow for the first gear.

Chapter Five : DSG MAPs comparison

5. DSG MAPs comparison

5.1. Introduction

In this chapter we will extract the MAPs of the DSG gearbox using WinOLS and make a comparison between two different MAPs taking into consideration the different in engine capacity and power produced.

After using WinOLS and extract the MAPs we get 7 MAPs and the list below provide the name of MAPs from WinOLS :

1- Upshift MAP.

2- Downshift MAP.

3- Shift times in Drive (D) and Sport (S) and Tiptronic.

4- Shift times in Drive (D) and Sport (S) and Tiptronic with torque reduction.

5- The forced upshift in Tiptronic.

6-Maximum clutch pressure.

7-Warming temperature for clutch.

Note : The red color in the tables of all MAPs indicates that the value is higher for petrol 3.2Ltr, green color indicates lower value and black color means that both have the same value.

5.2. Upshift MAP

The upshift MAP is when gear ratio decrease, the upshift MAP have Accelerator pedal angle (include kickdown) in X axis, Torque in Y axis and RPM in Z axis, the upshift MAP from (1-6) gear ratio in text form is show in the Tables (5.1), (5.2), (5.3), (5.4),(5.5), the upshift MAP from (1-2) in 3D form for both software is shown in Figure (5.1), (5.2).

Table (5.1) : Upshift MAP (1->2)

Diesel 1.9Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	400	540	800	1650	1840	1840	1970	2200	2600	3000	3400	3750	4400
	660	2500	2500	2500	2550	2640	2750	3000	3200	3500	3800	4050	4400
	1110	3400	3400	3400	3450	3550	3650	3750	3850	3950	4050	4200	4400
	1850	4400	4400	4400	4400	4400	4400	4400	4400	4400	4400	4400	4400
Petrol 3.2 Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	250	600	600	600	1500	1900	2670	3400	4230	5030	5100	6200	6400
	520	2386	2386	2485	2583	2980	3583	3989	4495	5089	5100	6200	6400
	1090	3972	3972	3974	3974	4179	4386	4688	5795	5090	5297	6200	6400
	2300	6400	6400	6500	6400	6400	6400	6400	6400	6400	6400	6400	6400

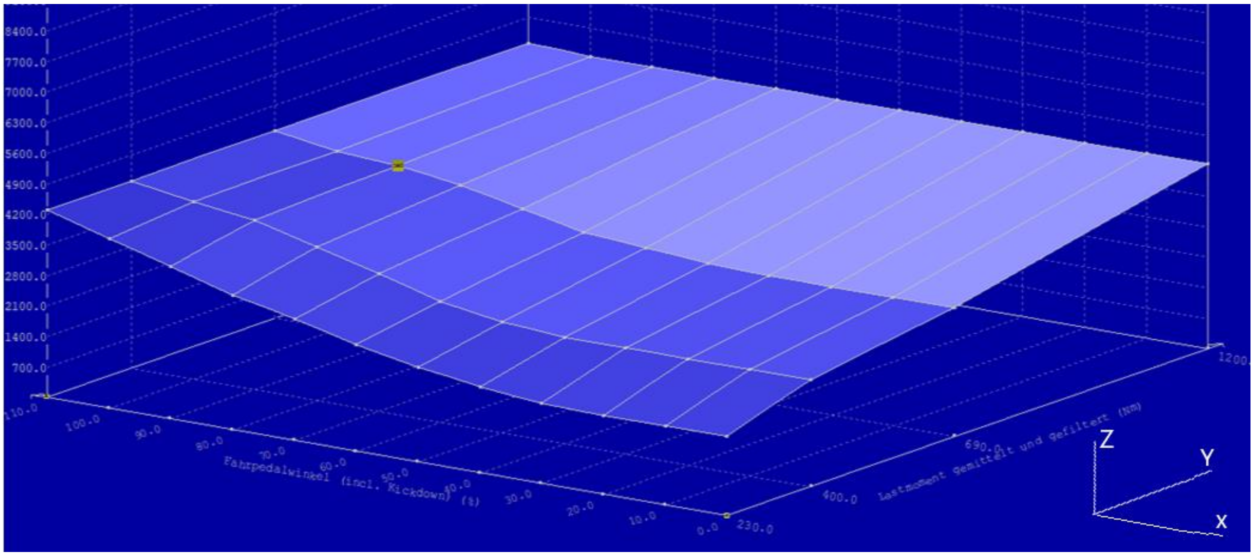

Figure (5.1) : Upshift MAP 1->2 for Diesel 1.9Ltr in 3D form.

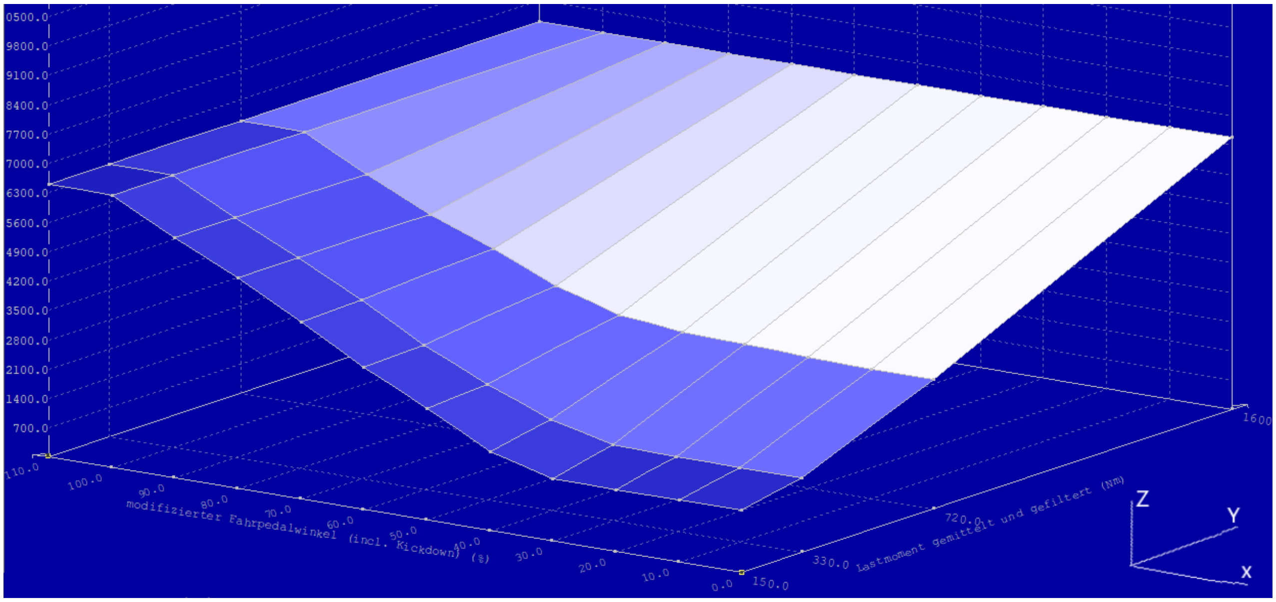

Figure (5.2) : Upshift MAP 1->2 for Petrol 3.2 Ltr in 3D form.

Table (5.2) : Upshift MAP (2->3)

Diesel 1.9Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	230	1820	1820	1820	1840	1980	2180	2470	2800	3100	3500	3900	4300
	400	2470	2470	2470	2470	2470	2550	2800	3180	3550	3900	4100	4300
	690	2950	2950	2950	2950	3000	3100	3220	3500	3810	4000	4100	4300
	1200	4250	4250	4250	4250	4250	4250	4250	4250	4250	4250	4250	4300
Petrol 3.2 Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	150	1500	1500	1500	1500	1900	2670	3400	4230	5030	5735	6500	6500
	330	1772	1772	1804	1836	2188	2776	3464	4284	5030	5735	6500	6500
	`720	3105	3105	3150	3195	3240	3385	3848	4455	5030	5735	6500	6500
	1600	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500

Table (5.3) : Upshift MAP (3->4)

Diesel 1.9Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	150	1780	1780	1780	1800	1900	2100	2400	2770	3100	3500	3880	4280
	260	2230	2230	2230	2240	2320	2470	2750	3100	3500	3800	4050	4280
	470	2700	2700	2700	2750	2800	2900	3030	3250	3650	4030	4150	4280
	850	4280	4280	4280	4280	4280	4280	4280	4280	4280	4280	4280	4280
Petrol 3.2 Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	100	1400	1400	1400	1400	1900	2670	3400	4230	5030	5735	6500	6500
	220	1632	1632	1632	1632	2140	2830	3600	4380	5120	5830	6500	6500
	520	3240	3240	3240	3240	3340	3500	3920	4610	5270	5950	6500	6500
	1200	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500

Table (5.4) : Upshift MAP (4->5)

Diesel 1.9Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	100	1800	1800	1800	1800	1850	2050	2350	2750	3100	3500	3850	4250
	180	2200	2200	2200	2230	2300	2500	2700	3000	3380	3700	4000	4250
	330	2600	2600	2600	2650	2800	3000	3190	3450	3800	4050	4150	4250
	600	4250	4250	4250	4250	4250	4250	4250	4250	4250	4250	4250	4250
Petrol 3.2 Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	80	1400	1400	1400	1400	1900	2670	3400	4250	5030	5735	6500	6500
	180	1598	1598	1598	1598	2089	2850	4570	4370	5130	5870	6500	6500
	500	2970	2970	2870	2970	3070	3357	3840	4530	5300	5980	6500	6500
	900	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500

Table (5.5) : Upshift MAP (5->6)

Diesel 1.9Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	80	820	1820	1820	1820	1860	2000	2300	2680	3100	3500	3800	4200
	140	300	2300	2300	2350	2400	2540	2800	3180	3500	3800	4000	4200
	250	420	2420	2420	2460	2680	3020	3420	3800	4000	4100	4150	4200
	450	200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
Petrol 3.2 Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	60	1400	1400	1400	1400	1900	2670	3400	4250	5030	5740	6500	6500
	130	1559	1559	1559	1559	2170	2900	3640	4470	5300	5990	6500	6500
	400	2941	2941	2941	2941	3118	3470	3847	4590	5410	6110	6500	6500
	700	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500

Upshift MAP description and comparison between Diesel 1.9Ltr and Petrol 3.2Ltr :

The TCU make the upshift according to upshift MAP stored in TCU, this is an example to explain upshift MAP : assume that the gear ratio is in the first gear and the Torque calculated is 1100 N.m in Diesel 1.9Ltr and the accelerator pedal angle is 40% then the TCU make the upshift when the RPM reach 3550 while in Petrol 3.2 Ltr at 1090 N.m and 40% of accelerator pedal angle the TCU make the upshift when the RPM reach 4179.

In upshift MAP the engine speed increases when the torque and accelerator pedal angle increase and reach to the maximum speed with maximum torque or maximum pedal angle also the torque decreases with gear ratio decrease.

The engine speed for Petrol 3.2Ltr is higher than Diesel 1.9Ltr at most of the upshift MAPs (this is due higher engine capacity and higher power produce for 3.2Ltr), the Petrol 3.2Ltr is lower than Diesel 1.9Ltr just at low accelerator pedal angle and low torque.

5.3. Downshift MAP

The downshift MAP is when gear ratio increase, the downshift MAP have Accelerator pedal angle (include kickdown) in X axis, Torque in Y axis and RPM in Z axis, the downshift MAP from (6-1) gear ratio is show in the Tables (5.6), (5.7), (5.8), (5.9),(5.10), the downshift MAP from (2-1) in 3D form for both software is shown in Figure (5.3), (5.4).

Table (5.6) : Downshift MAP (2->1)

Diesel 1.9Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	400	70	230	450	480	520	550	620	820	1000	1160	1360	1600
	660	1200	1200	1200	1200	1200	1250	1320	1420	1540	1660	1730	1800
	1110	1480	1480	1480	1500	1540	1580	1680	1750	1820	1880	1950	2000
	1850	1500	1500	1500	1500	1500	1500	1780	2050	2380	2380	2380	2380
Petrol 3.2 Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	250	150	150	150	450	450	450	450	450	450	450	1510	1510
	520	1088	1088	1088	1186	1186	1186	1186	1186	1285	1363	1700	1700
	1090	1493	1493	1493	1593	1593	1691	1790	1790	2000	2000	2000	2000
	2300	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

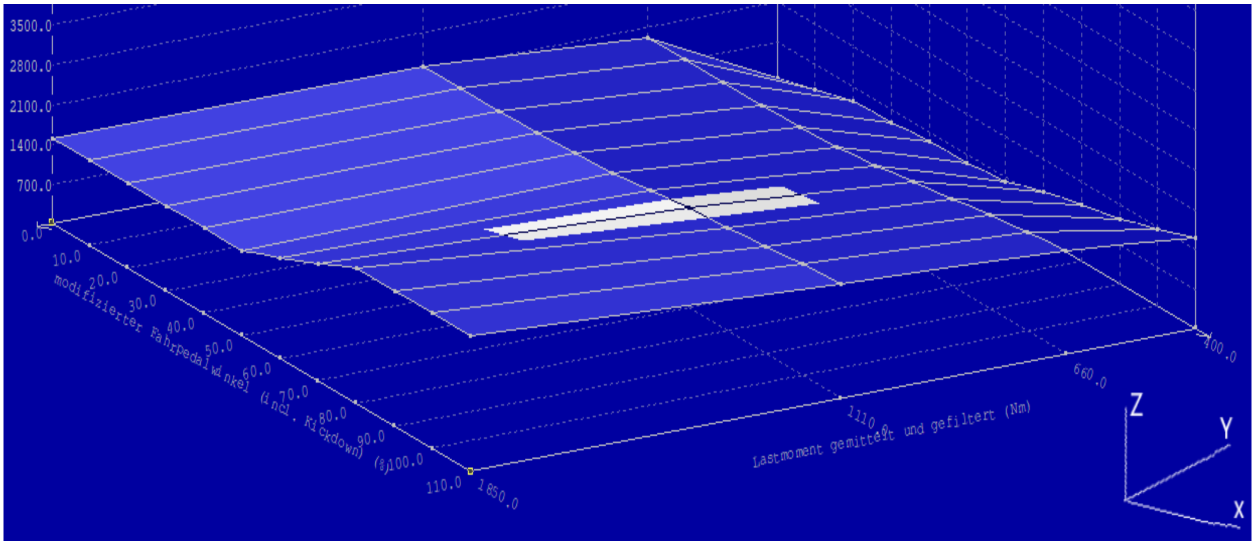

Figure (5.3) : downshift MAP 2->1 for Diesel 1.9Ltr in 3D form.

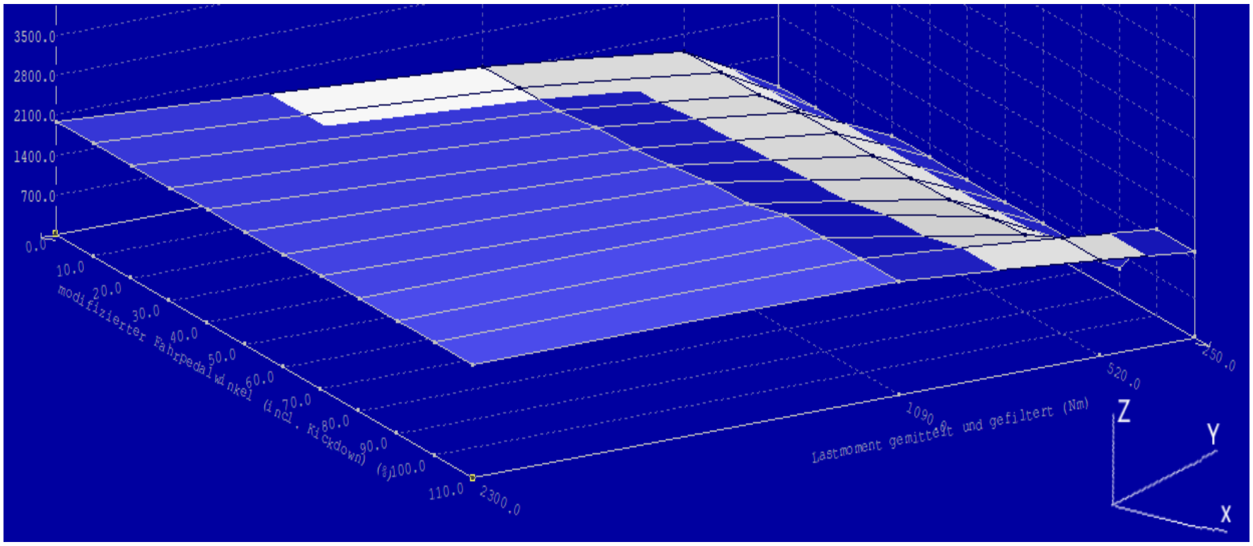

Figure (5.4) : downshift MAP 2->1 for Petrol 3.2 Ltr in 3D form.

Table (5.7) : Downshift MAP (3->2)

Diesel 1.9Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	230	900	900	900	941	1006	1100	1220	1375	1530	1700	1925	2300
	400	1230	1230	1230	1230	1230	1300	1400	1500	1650	1850	2100	2470
	690	1520	1520	1520	1520	1600	1720	1850	2000	2150	2350	2450	2540
	1200	1700	1700	1700	1700	1770	1900	2100	2380	2575	2600	2600	2600
Petrol 3.2 Ltr		**Accelerator pedal angle (include kickdown)**											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	150	900	900	900	900	900	1060	1380	1790	2240	2890	3600	3600
	330	1010	1010	1014	1014	1040	1250	1520	1920	2420	3030	3600	3690
	720	1398	1398	1398	1453	1544	1644	1871	2193	2520	3052	3600	3833
	1600	1800	1800	1800	2000	2300	2600	3000	3200	3400	3600	3800	3950

Table (5.8) : Downshift MAP (4->3)

Diesel 1.9Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	150	1100	1100	1100	1100	1130	1220	1330	1500	1680	1900	2190	2650
	260	1350	1350	1350	1350	1350	1420	1550	1680	1850	2050	2350	2710
	470	1640	1640	1640	1640	1720	1800	1900	2050	2250	2450	2600	2780
	850	1720	1720	1720	1760	1840	2000	2330	2640	2765	2780	2780	2780
Petrol 3.2 Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	100	900	900	900	900	900	1220	1670	2170	2710	3320	4450	4450
	220	978	978	993	1015	1026	1390	1840	2330	2860	3440	4450	4461
	520	1330	1330	1350	1470	1580	1792	2100	2520	3010	3600	4450	4520
	1200	1900	1900	1900	2000	2300	2600	3100	3500	3900	4100	4450	4600

Table (5.9) : Downshift MAP (5->4)

Diesel 1.9Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	15	1300	1300	1300	1300	1300	1350	1440	1550	1720	1930	2300	2950
	27	1450	1450	1450	1480	1520	1600	1700	1830	2000	2250	2600	2950
	49	1700	1700	1700	1700	1780	1880	1980	2150	2350	2550	2750	3000
	90	1900	1900	1900	1950	2050	2255	2560	2875	3000	3000	3000	3000
Petrol 3.2 Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	12	950	950	950	950	950	1380	1870	2420	3020	3644	4700	4700
	27	1040	1050	1030	1040	1030	1540	2080	2610	3200	3780	4700	4700
	75	1259	1259	1259	1275	1355	1790	2270	2760	3320	3940	4700	4716
	135	2000	2000	2000	2000	2300	2600	3100	3600	4000	4200	4700	4800

Table (5.10) : Downshift MAP (6->5)

Diesel 1.9Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	80	1400	1400	1400	1400	1420	1450	1570	1720	1900	2150	2550	3150
	140	1500	1500	1500	1500	1560	1700	1850	2000	2200	2520	2850	3250
	250	1750	1750	1750	1750	1850	1950	2050	2200	2400	2700	3000	3300
	450	2000	2000	2000	2050	2180	2435	2810	3150	3310	3310	3310	3310

Petrol 3.2 Ltr		Accelerator pedal angle (include kickdown)											
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	110%
Torque N.m	60	1000	1000	1000	1000	1000	1460	2010	2610	3220	3930	5000	5000
	130	1025	1025	1067	1067	1067	1640	2210	2810	3420	4110	5000	5000
	400	1203	1203	1203	1215	1238	1988	2582	3152	3542	4208	5000	5000
	700	2200	2200	2200	2200	2500	2800	3100	3400	3630	4208	5000	5000

Downshift MAP description and comparison between Diesel 1.9Ltr and Petrol 3.2Ltr :

The TCU make the downshift according to downshift MAP stored in TCU, this is an example to explain the downshift MAP : assume that the gear ratio is in the second gear and the Torque calculated is 1100 N.m in Diesel 1.9Ltr and the accelerator pedal angle is 40% then the TCU make the upshift when the RPM reach 1540 while in Petrol 3.2 Ltr at 1090 N.m and 40% of accelerator pedal angle the TCU make the upshift when the RPM reach 1593.

In downshift MAP the engine speed increases when the torque and accelerator pedal angle increase and reach to the maximum speed with maximum torque or maximum pedal angle also the torque decreases with gear ratio decrease.

The engine speed for Petrol 3.2Ltr is higher than Diesel 1.9Ltr at most of the downshift MAPs (this is due higher engine capacity and higher power produce for 3.2Ltr), the Petrol 3.2Ltr is lower than Diesel 1.9Ltr just at low accelerator pedal angle and low torque.

5.4. Switch times in Drive (D) and Sport (S) and Tiptronic

The Switch times MAP have Accelerator pedal angle in X axis, last gear ratio in Y axis and the time (Milliseconds) in Z axis, the Switch times in D and S and Tiptronic MAPs is show in the Tables (5.11), (5.12), (5.13), the downshift MAP from (2-1) in 3D form for both software is shown in Figure (5.5), (5.6).

Table (5.11) : Switch times in Drive (D).

Diesel 1.9Ltr		Accelerator pedal angle				
		0%	25%	50%	75%	100%
Last gear	1	1000	900	1000	1000	1000
	2	1000	950	950	950	950
	3	1000	950	950	950	950
	4	1000	950	950	950	950
	5	1000	950	950	950	950
Petrol 3.2 Ltr		**Accelerator pedal angle**				
		0%	25%	50%	75%	100%
Last gear	1	1200	900	600	500	500
	2	1100	900	600	500	500
	3	1100	900	600	500	500
	4	1100	900	600	500	500
	5	1100	900	600	500	500

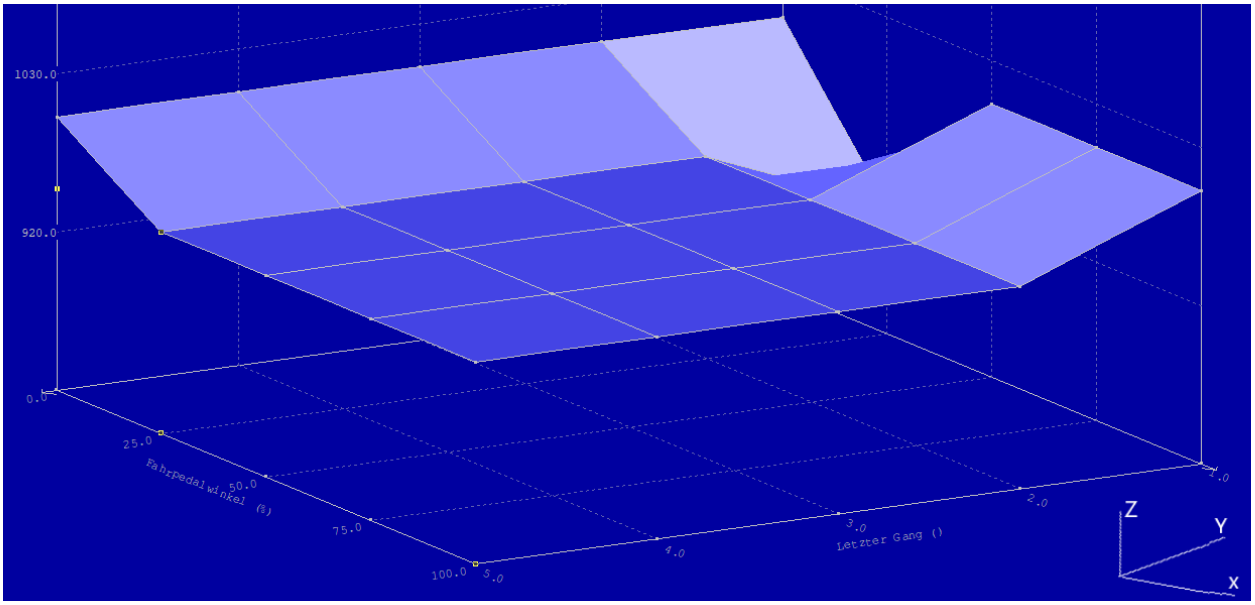

Figure (5.5) : Switch times in Drive for Diesel 1.9Ltr in 3D form.

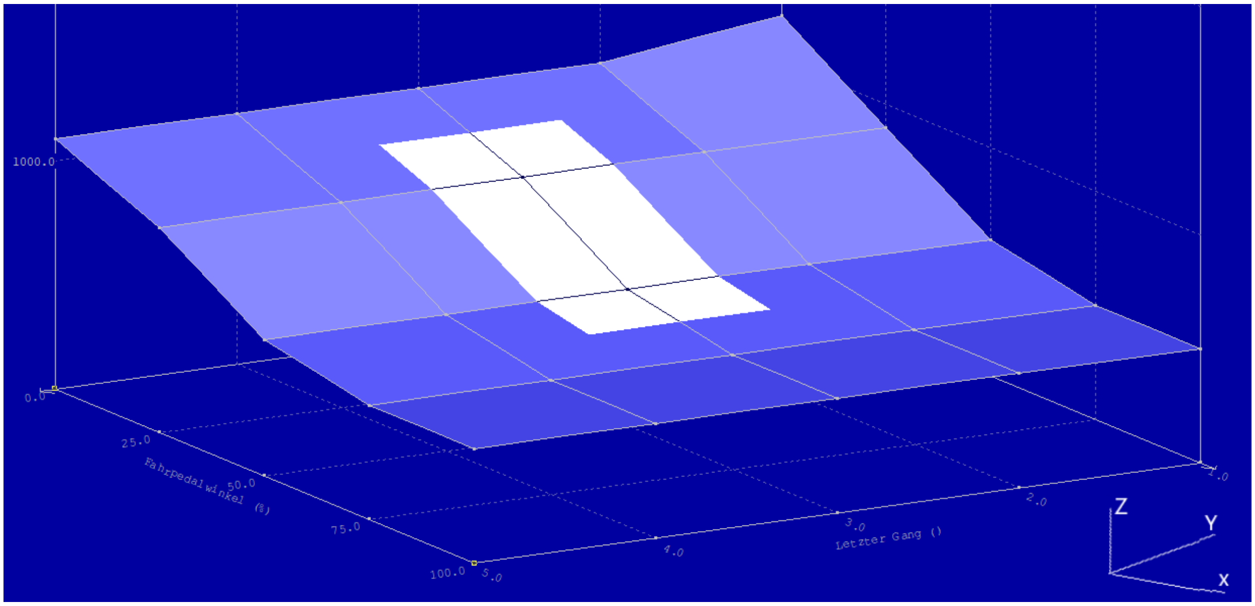

Figure (5.6) : Switch times in Drive for Petrol 3.2 Ltr in 3D form.

Table (5.12) : Switch times in Sport (S).

Diesel 1.9Ltr		Accelerator pedal angle				
		0%	25%	50%	75%	100%
Last gear	1	1500	1000	1000	1000	1000
	2	1000	950	950	950	950
	3	1000	950	950	950	950
	4	1000	950	950	950	950
	5	1000	950	950	950	950
Petrol 3.2 Ltr		**Accelerator pedal angle**				
		0%	25%	50%	75%	100%
Last gear	1	1200	900	600	500	500
	2	1100	900	600	500	500
	3	1100	900	600	500	500
	4	1100	900	600	500	500
	5	1100	900	600	500	500

Table (5.13) : Switch times in Tiptronic.

Diesel 1.9Ltr		Accelerator pedal angle				
		0%	25%	50%	75%	100%
Last gear	1	1500	1000	1000	1000	1000
	2	1000	950	950	950	950
	3	1000	950	950	950	950
	4	1000	950	950	950	950
	5	1000	950	950	950	950
Petrol 3.2 Ltr		Accelerator pedal angle				
		0%	25%	50%	75%	100%
Last gear	1	1200	900	600	500	500
	2	1100	900	600	500	500
	3	1100	900	600	500	500
	4	1100	900	600	500	500
	5	1100	900	600	500	500

5.5. Switch times in Drive (D) and Sport (S) and Tiptronic with torque reduction

The Switch times with torque reduction MAPs have Accelerator pedal angle in X axis, last gear ratio in Y axis and the time (Milliseconds) in Z axis, the Switch times in D and S and Tiptronic MAPs is show in the Tables (5.14), (5.15), (5.16).

Table (5.14) : Switch times in Drive (D) with torque reduction.

Diesel 1.9Ltr		Accelerator pedal angle				
		0%	25%	50%	75%	100%
Last gear	1	1024	715	398	300	270
	2	725	486	300	270	250
	3	540	376	275	250	225
	4	455	352	250	220	200
	5	450	332	225	200	200
Petrol 3.2 Ltr		Accelerator pedal angle				
		0%	25%	50%	75%	100%
Last gear	1	850	500	270	200	100
	2	700	490	260	190	100
	3	650	480	250	180	100
	4	600	450	250	170	100
	5	550	300	240	170	100

Table (5.15) : Switch times in Sport (S) with torque reduction.

Diesel 1.9Ltr		Accelerator pedal angle				
		0%	25%	50%	75%	100%
Last gear	1	450	440	525	305	220
	2	425	390	275	245	210
	3	400	375	250	225	205
	4	375	350	225	195	195
	5	350	330	200	195	190
Petrol 3.2 Ltr		**Accelerator pedal angle**				
		0%	25%	50%	75%	100%
Last gear	1	600	400	300	200	100
	2	550	340	290	190	100
	3	500	340	250	180	100
	4	400	340	250	170	100
	5	370	340	240	170	100

Table (5.16) : Switch times in Tiptronic with torque reduction.

Diesel 1.9Ltr		Accelerator pedal angle				
		0%	25%	50%	75%	100%
Last gear	1	1000	900	525	305	220
	2	610	570	275	245	210
	3	590	550	250	225	205
	4	550	490	225	195	195
	5	490	470	200	195	190
Petrol 3.2 Ltr		**Accelerator pedal angle**				
		0%	25%	50%	75%	100%
Last gear	1	600	400	300	250	150
	2	550	340	290	230	150
	3	500	340	280	220	150
	4	400	340	250	200	150
	5	370	340	230	200	150

5.6. Forced upshift in Tiptronic MAP

The forced upshift in Tiptronic MAP has torque in X axis and the data is RPM, the forced upshift in Tiptronic MAP from (1-6) gear ratio is show in the Table (5.17), the forced upshift in Tiptronic MAP in 3D form for both software is shown in Figure (5.7), (5.8).

Table (5.17) : Forced upshift in Tiptronic MAP.

Diesel 1.9Ltr					
1->2	Torque	400	660	1110	1850
	RPM	4400	4400	4400	4400
2->3	Torque	230	400	690	1200
	RPM	4300	4300	4300	4300
3->4	Torque	150	260	470	850
	RPM	4280	4280	4280	4280
4->5	Torque	100	180	330	600
	RPM	4250	4250	4250	4250
5->6	Torque	80	140	250	450
	RPM	4200	4200	4200	4200
Petrol 3.2 Ltr					
1->2	Torque	250	520	1090	2300
	RPM	4600	4600	4600	4600
2->3	Torque	150	330	720	1600
	RPM	6500	6500	6500	6500
3->4	Torque	100	220	520	1200
	RPM	6500	6500	6500	6500
4->5	Torque	80	180	500	900
	RPM	6500	6500	6500	6500
5->6	Torque	60	130	400	700
	RPM	6500	6500	6500	6500

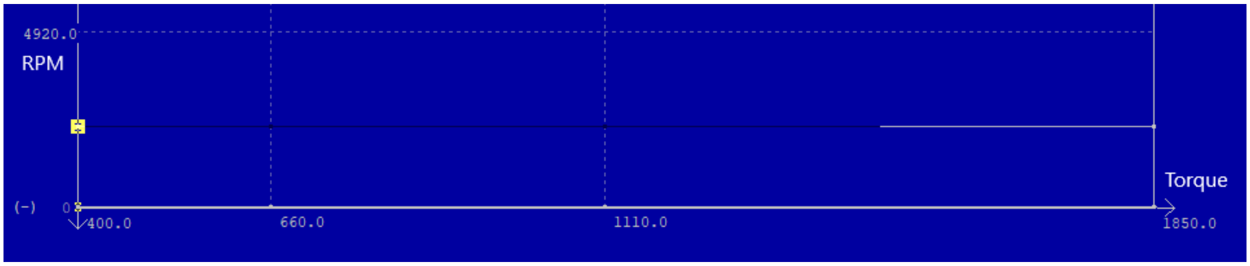

Figure (5.7) : Forced upshift in Tiptronic MAP for Diesel 1.9Ltr in 2D form.

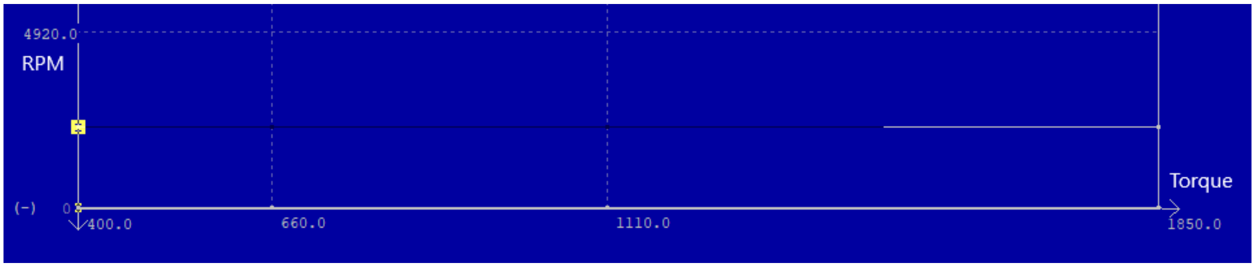

Figure (5.8) : Forced upshift in Tiptronic MAP for Petrol 3.2 Ltr in 2D form.

Forced upshift in Tiptronic MAP description and comparison between Diesel 1.9Ltr and Petrol 3.2Ltr :

The forced upshift in Tiptronic MAP is when the vehicle in Tiptronic mode which is allow to the driver to change the gear ratio, but if the driver did not change the gear ratio in the right time the TCU change the gear ratio according to forced upshift in Tiptronic MAP.

The torque using in forced upshift MAP is the same as torque in upshift MAP and the RPM is the same as maximum RPM in upshift MAP.

5.7. Maximum clutch pressure

The maximum clutch pressure MAP has the pressure in Z axis, Table (5.18) show the maximum clutch pressure for both clutches (K1,K2).

Table (5.18) : Maximum clutch pressure

Diesel 1.9Ltr	Maximum clutch pressure	
	K1	K2
Clutch pressure (bar)	5	5
Petrol 3.2 Ltr	Maximum clutch pressure	
	K1	K2
Clutch pressure (bar)	5	5

5.8. Warming temperature for clutch

The Warming temperature MAP has the temperature in Z axis, Table (5.19) show the warming temperature for both clutches (K1,K2).

Table (5.19) : Warming temperature for clutch

Diesel 1.9Ltr	Warming temperature for clutch	
	K1	K2
Warming temperature (°C)	150	150
Petrol 3.2 Ltr	Maximum clutch pressure	
	K1	K2
Warming temperature (°C)	150	150

- The Clutch pressure and Warming temperature for clutch use have the same value for Diesel 1.9Ltr and Petrol 3.2Ltr since they have the same hardware.

Chapter six : Conclusion and Recommendations

6. Conclusion and Recommendations

6.1. Conclusion

In the modern vehicle the TCU is the basis to control in transmission and the most development in transmission occur in TCU and all orders depend on the software inside TCU, the development occur to keeping the fuel consumption as low as possible by intelligent shifting strategy, low weight, low losses also make gear changes smooth and comfortable.

In this study we describe the DSG MAPs and identified the differences between two software of DSG gear box, the first software fit with Petrol engine 3.2Ltr with 184KW power produced and 250 N.m @1900 RPM and the second software fit with diesel engine 1.9Ltr with 77KW power produced and 320 N.m @ 2500 RPM.

We extract DSG MAPs then describe and compare them as follow :

- ✓ The upshift and downshift MAPs is to change the gear ratio and it depend on Torque and accelerator pedal angle and RPM.
- ✓ The switch time MAPs is the time that gear ratio will take to make the change and its depend on the current gear ratio and accelerator pedal angle.
- ✓ The forced upshift in Tiptronic MAP is when the driver control in gear ratio changing and its depend on current gear ratio and torque and RPM.

6.1. Recommendations

The working in the local market is done by not professional people which they could make some mistakes in changing or remapping the TCU or ECU, so we recommend the following points:

1- The remapping of TCU and ECU must done by professionals people because if the remapping done by wrong way or incompatible software could damage the gearbox.

2- Provide workshop at the university related to changing and modifying the software.

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