INFLUENCE OF GEAR RATIO PATTERN ON VEHICLE PERFORMANCE

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Report is submitted
in fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering with Honours

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

“I hereby declare that this report that title ‘Influence of Gear Ratio Pattern on Vehicle Performance’ is the result of my own work except for quotes as cited in the references.”

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SUPERVISOR DECLARATION

"I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering"

Signature	: ....
Name of supervisor	: En. Adzni bin Md Saad
Date	: ....

DEDICATION

Dedicated to my beloved family, supervisor, all the lecturer and also my friend which always be on my side

ABSTRACT

In modern vehicle design, transmission is a crucial component that functions to deliver power and torque from engine to wheel so the vehicle can move based on desired speed. In general, 5 speed manual transmission consists of 5 sets of gear ratio with one set of final drive. It multiplies the torque produced by engine for each gear ratio in each shifts. This study concentrates on the effect of power output of transmission through different specifications of gear ratio to vehicle speed and acceleration. It involves the determination of total vehicle traction force as initial step and follows by obtaining the vehicle velocity by utilizing Newton Second Law. The transmission shifting procedure by using different sets of gear ratio is modelled by using Matlab Simulink software. The testing process is only carried out by using mathematical model simulation approach without any experimental works. The study on the effect on vehicle performance is only focusing on vehicle the top speed and acceleration (0 – 110 km/h). From the simulation results, vehicle performance can be analyzed and comparison is made between the results of different sets of gear ratio. The torque produces from custom 2 specification of gear ratio is higher than the standard version because of the closer range of gear ratio compare to others parameter. This custom 2 specification also produces better acceleration of 0 to 110km/h in just 8.8 seconds, as compared to standard version which clocks 14.4 seconds. In conclusion, this study shows that gear ratio influences the vehicle performance especially in terms of acceleration and top speed.

ABSTRAK

Dalam rekaan kenderaan masakini, transmisi merupakan komponen yang penting kerana ianya berfungsi sebagai penyambung kuasa dan tork dari enjin ke roda supaya kenderaan boleh bergerak berdasarkan kelajuan yang dikehendaki. Secara umum, dalam transmisi manual 5 kelajuan ianya meliputi 5 set nisbah gear dengan satu set pemacu akhir. Ia akan mengandakan tork yang dihasilkan dari enjin dengan menggunakan perbezaan setiap gear dalam setiap peralihan. Kajian ini menumpukan kepada kesan terhadap kuasa yang dikeluarkan melalui spesifikasi nisbah gear yang berbeza kepada pecutan dan kelajuan kenderaan. Ia melibatkan penentuan jumlah daya tarikan kenderaan sebagai langkah awal dan ianya diikuti dengan mendapatkan halaju kenderaan dengan menggunakan Hukum Kedua Newton. Prosedur peralihan dalam transmisi terhadap perbezaan nisbah gear akan dimodelkan mengunakan perisian Matlab Simulink. Proses ujian hanya dijalankan dengan menggunakan pendekatan simulasi model matematik tanpa melibatkan sebarang kerja eksperiman. Corak nisbah gear baru akan diperkenalkan dan ujian menggunakan model simulasi dibuat. Kajian mengenai kesan prestasi kenderaan hanya difokuskan pada kelajuan tertinggi dan juga pecutan (0 km/h - 110 km/h) sahaja. Dari simulasi tersebut, ia akan memberikan hasil dan perbandingan akan dibuat supaya kesan pada prestasi kenderaan dapat dianalisis. Keputusan menunjukkan bahawa nisbah gear penghantaran memberi kesan kepada prestasi kenderaan. Tork yang dihasilkan daripada nisbah gear spesifikasi custom 2 adalah lebih tinggi daripada versi standard (1.5 3sz-ve) kerana nisbah gear yang lebih dekat berbanding parameter lain. Spesifikasi custom 2 juga menghasilkan daya pecutan yang lebih baik dari 0km/h hingga 110km/h kerana hanya memerlukan 8.8 saat, berbanding versi standard hanya mencatatkan 14.4 saat sahaja. Kesimpulannya, kajian ini menunjukkan bahawa nisbah gear mempengaruhi prestasi kenderaan terutamanya dari segi pecutan dan kelajuan tertinggi.

ACKNOWLEDGEMENT

In here I would like to record my grateful thank to all the support, encouragement and inspiration that engaged with me during completing my Final Year Project report.

I would like to express my gratitude to my supervisor En Adzni Bin Md Saad for giving me opportunity to do this Final Year Project under his supervision. He gives me full support and advice to complete this report. He also offered tremendous help and patiently guides me in management skill, communication and also advices that are valuable that can be use as advantages in future.

Next, I would like to express greatest thankfulness and appreciation to my father Samsuri Bin Abd Rahim and my mother Zabedah Bte Sarip that give me advice and encouragement to go through this last semester.

Also not to forget, thankful wishes to all my lecturers and staffs of Faculty of Mechanical UTeM with their unlimited support. Their advice and guidance during tough times will always be remembered.

Last but not list, to all my beloved friend that always with me through all the time in the campus. Their companion and moral support have uplifting my spirit to complete this report.

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m	-	Mass
t	-	Time
C_d	-	Drag coefficient
A	-	Frontal area of object
a	-	Acceleration on bodies
F	-	Force on body
vf	-	Final velocity
vi	-	Initial Velocity
Δv	-	Change of velocity
V	-	Relative velocity of object
R_T	-	Rolling resistance
R_G	-	Gradient resistance
R_A	-	Aerodynamic resistance
R	-	Total road load / tractive force
$\emptyset$	-	Gradient of the hill being climbed (degree)
ρ	-	Air density
C_{rf}	-	Coefficient of rolling resistances
n_t	-	Transmission efficiency
n_a	-	Efficiency of final drive
i_a	-	Final drive ratio
i_t	-	Transmission gear ratio
Tw	-	Torque at the wheel

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Background

This chapter is generally about the manual transmission and gear ratio. Transmission is a sub-system of the drive train with the exception of clutch and drive shaft. The transmission is connected to the engine through the clutch. The input shaft of the transmission therefore turns at the same rpm as the engine. There are two basic types of transmission that is manual and automatic. Manual transmission is shifted manually in each gear, while automatic transmission shifts between gears automatically, with no help from the driver. To understand the basic idea behind a standard transmission, Figure 1.1 shows a very simple five-speed transmission. The basic function of any type of automotive transmission is to transfer the engine torque to the vehicle with the desired ratio smoothly and efficiently. The most common control devices inside the transmission are clutches and hydraulic pistons. (Zongxuan.S, et al, 2005).

The choice of transmission units for a particular vehicle is usually influenced by what is in production and available in the market. The position of powertrain components within the vehicles has implications both for the engineering of the vehicle and the driveline components including transmission itself. The choice of vehicle layout is determined principally by the target market sector and brand image that the vehicle is required. The vehicle layout must also be sufficiently flexible to accommodate different engines.

From there, it is very important to appreciate the choice of gear ratio in a transmission as often dictated in practice by what is available or in mass production. This situation happens because of the large expenses involved in engineering new gear set, installing or modifying the manufacturing plant in order to make new parts. There are some cases that do necessitate a change, for example from petrol to diesel or a significant change to the weight of the vehicles in which the gearbox is to be installed. (Julian.H.S, 2002)

In this modern era, there has no need for experimental work involved in study of performance output from powertrain systems. It is a common practice to use analytical models in prediction and assessment of new types of powertrain systems in automotive industry. (M.Kulkarni, et al, 2006). Matlab Simulink software is one of the software that can produce analytical model simulation to get the results of vehicle power performance by designing and calculating the gear ratio. Matlab is a language of technical computing and Simulink is simulation and model based design.

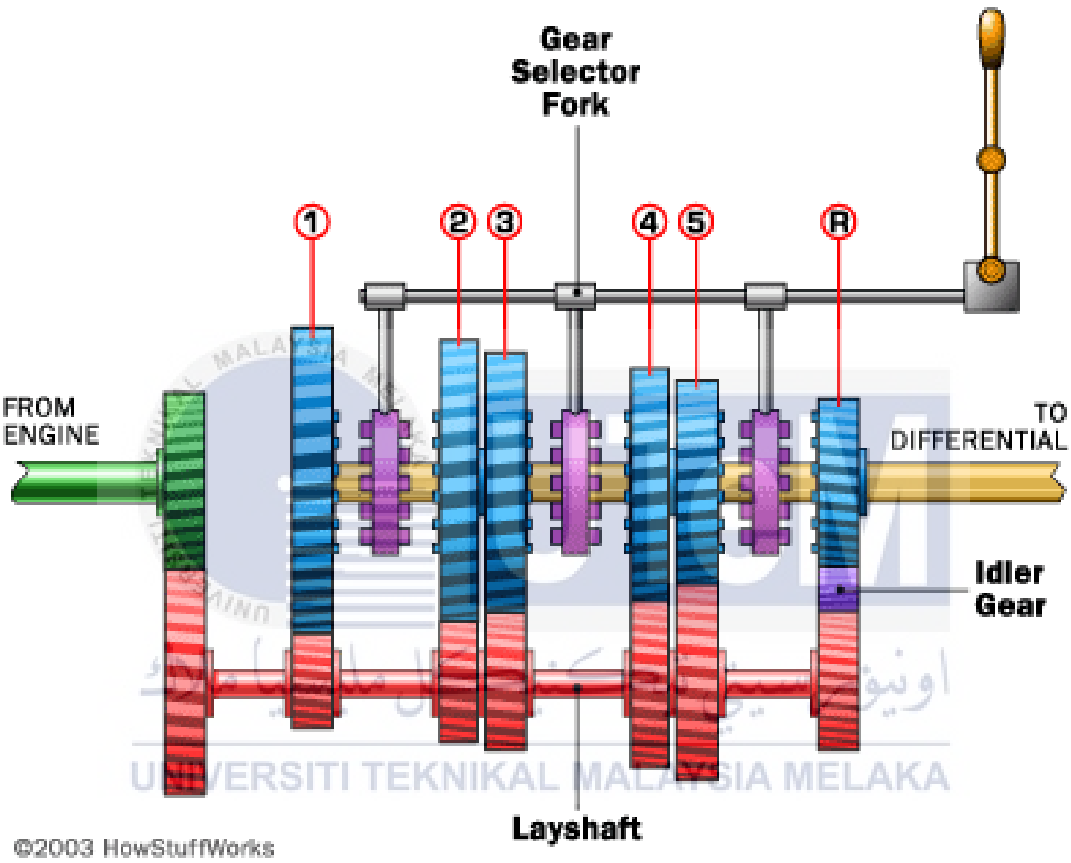

Figure 1.1: Schematic of basic 5-speed transmission (M.Brain, 2017)

1.2 Problem Statement

The aim of this project to analyze the optimum gear ratio parameters for vehicle output power. This project is focusing on the gear ratio output of manual transmission model based on the selected power input that had been chosen. In order to achieve the optimum torque and power, it needs to find the suitable gear ratio for the output performance of the vehicles by creating mathematical model simulation by using Matlab Simulink software. From the simulation process, it produces line graphs that able to simulate the effect of various gear ratio by varying the values of drive and driven gears in each gearing set of transmission.

1.3 Objective

The objectives of this project are as follows:

1. To develop mathematical simulation model of vehicle transmission
2. To investigate the effects of gear ratio on vehicle performance

1.4 Scope of Project

The scopes of this project are:

1. Investigate gear ratio based on mathematical model simulation without any experimental work involved
2. Determination of optimum gear ratio is based on required vehicle performance and engine output.

CHAPTER 2

LITERATURE REVIEW

2.1 Vehicle Transmission

In general, the function and purpose of the transmission are to provide the operator with the option of maneuvering the vehicle in either the forward or reverse direction. This is the basic requirement of all automotive vehicles. Almost all vehicles have multiple forward gear ratios, but in most cases, only one ratio is provided for reverse. Another purpose of the transmission is to provide the operator with a selection of gear ratios between engine and wheel so that the vehicle can be operated at the best efficiency under a variety of operating conditions and loads. (David.L.H, 2016)

2.1.1 Introduction of vehicle transmission system

Transmission is used to describe a unit in driveline. The driveline includes all the components from the rod wheel until the output of the engine. The engine in vehicle creates rotational power and to move the car, it needs to transfer that rotational power to the wheels. The transmission provides this function in the drivetrain (Brett, 2017). Transmission is also called a gearbox. This study is only concentrating on manual gearbox. Manual transmission means that the driver needs to change the gear ratio setting by its own that parallel to vehicle speed.

The function of transmission is to perform several functions that affecting the vehicle. First of all, it can allow the vehicle to start from rest until it reach its desired velocity. It produces high engine revolutions due to low torque and power at low engine speed. Then, the transmission can help with the climbing ability. When driving through hill which has steep gradient, the movement of vehicles becomes difficult to overcome the resistance. So, it leads to the engine slowing down and hard to reach the top of the hill. Then, the gearbox helps by increasing the output torque to move the car or to climb the steep gradient of the road. Without the presence of transmission, the vehicle is not having the neutral position and continuously moving. Gearbox can also move the vehicle backward if the reverse gear has been selected. The mechanism shows by stopping the rotating main shaft by the connection to the shift level and rotates the cam plates. Then, the vehicle moves reversely with the help of gearbox. Figure 2.1 below show the components in manual transmission.

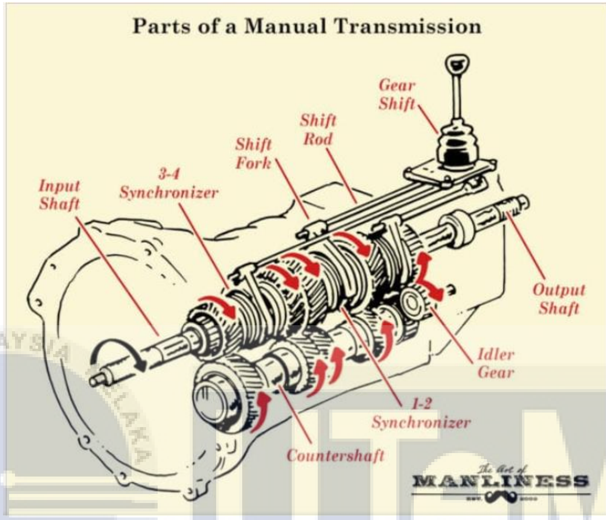

Figure 2.1: Components in manual transmission. (Brett, 2017).

2.2 Manual Transmission

The five-speed manual transmission is fairly standard on cars today.

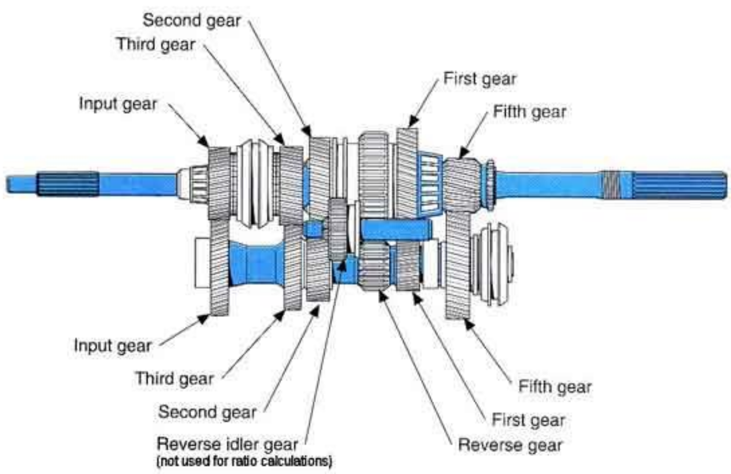

Figure 2.2: Layout of 5-speed transmission.

Based on the Figure 2.2 above, five-speed transmission applies one of five different gear ratios to the input shaft to produce a different rpm values at the output shaft. Here are some typical gear ratios. By referring to Figure 2.3, it shows a single unit that connects between green shaft and green gear. The green shaft comes from the engine through clutch. Then, the yellow shaft called splined shaft, which spins if the wheel is spinning. It is because the splined shaft is directly connected between the drive shaft and the differential of the drive wheel of the car.

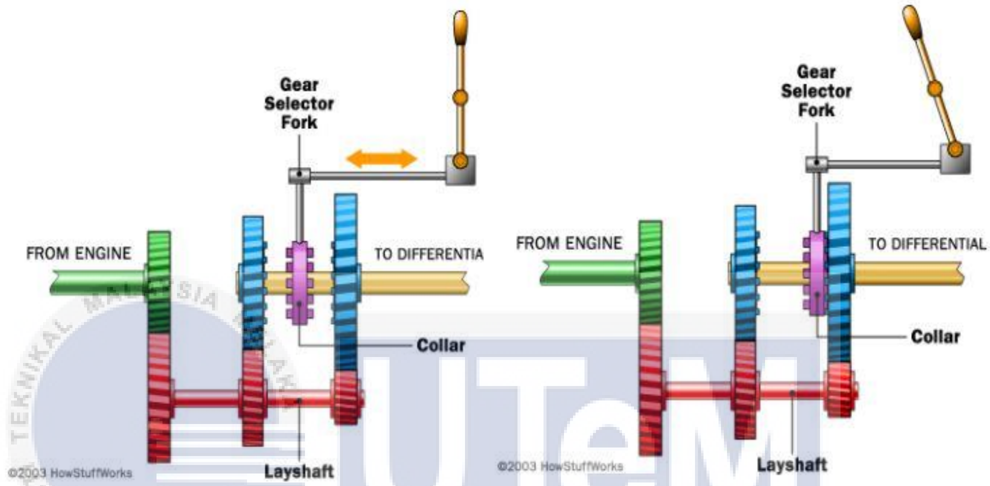

Figure 2.3: Schematic of changing for 1st gear. (M.Brain, 2017)

The red shaft is called as layshaft and all of the gears are connected as a single piece. Layshaft receives power directly from the engine when the clutch is engaged. The green and the redshaft are directly connected through their meshed gears. If the green shaft spinning, the red shaft will spin to. This is because all the gears on the layshaft and the green layshaft are spinning or moving as one unit.

The blue gears spinning on the yellow shaft because they rotate on the bearings. If the engine car is off but the car is moving, the blue and the layshaft are motionless because its movement are not directly connected to the engine. There is a collar that connects some part of the blue gear and the yellow drive shaft. The teeth on the collar are called dog teeth. The collar teeth fit into holes to engage layshaft with the blue gear. When the collar is connected, the blue gear will directly move the yellow shaft. The yellow shaft will engage either of the blue gear after the collar slide left or right along the yellow shaft. (M.Brain, 2017)

2.3 Gearing

These are the gears that are mounted on the output shaft by bearings and determine which "gear" is in the car. Each of these gears is constantly enmeshed with one of the gears on the countershaft and are constantly spinning. This constantly enmeshed arrangement is as in synchronized transmissions or constant mesh transmissions, which most modern vehicles use (Brett, 2017). The power flow from input to output of transmission for different gear ratio is shown in Figure 2.4 below.

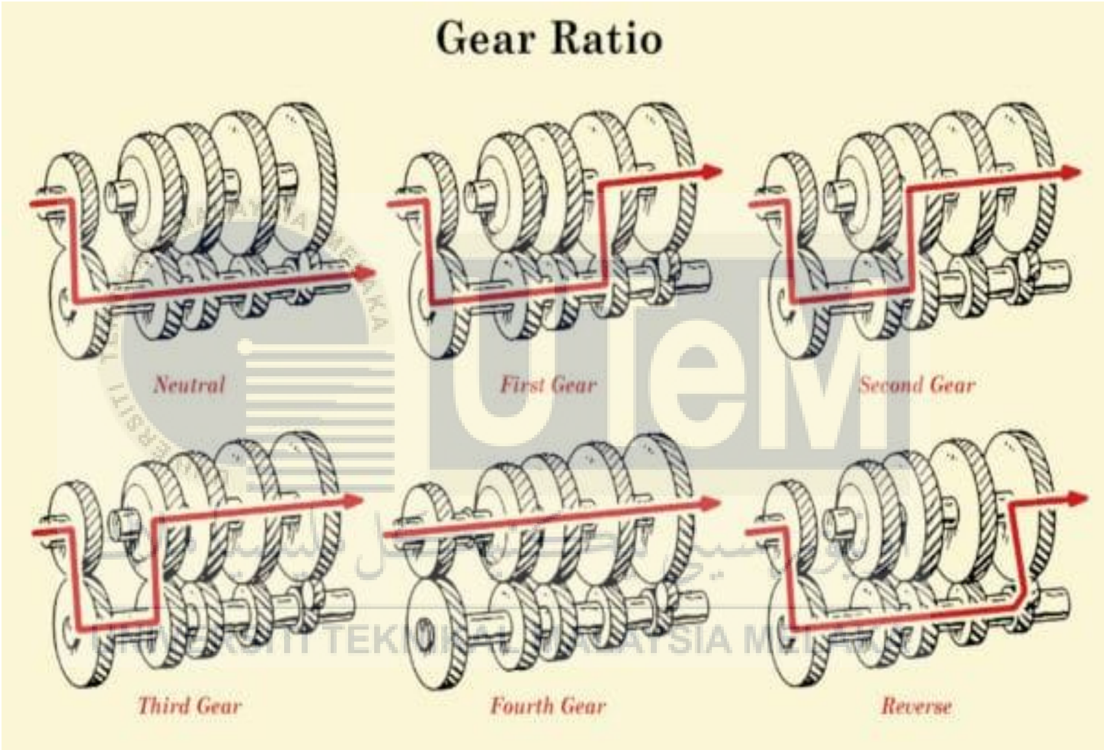

Figure 2.4 Five speed transmission power flow for all gearing

2.3.1 First gear

First gear is the largest gear, and the gears get progressively smaller as it gets to fifth gear. Because first gear is bigger than the countershaft gear that it is connected to, it can spin slower than the input shaft but deliver more power to the output shaft. When first gear is engaged, it only produces low speed, but high power is delivered. This gear ratio is great for starting the car from a standstill.

2.3.2 Second gear

The second gear is slightly smaller than the first gear, but still is enmeshed with a smaller gear. By changing to the second gears, the countershaft moves in reverse direction and leads to the same direction of rotation for output shaft as the input shaft. So, the second gear is locked to the output shaft due to the synchronizer that moves forward. Speed is increased and power decreasing slightly, which increasing the speed of the vehicle.

2.3.3 Third gear

Third gear is slightly smaller than the second, but still enmeshed with a smaller gear. The power flows are likely same with the previous gear but the synchronizer has moved to the rear and locked at the third/fourth gear.

2.3.4 Fourth gear

Fourth gear is slightly smaller than the third. In many vehicles, by the time a car is in fourth gear, the output shaft is moving at the same speed as the input shaft. This arrangement is called "direct drive". It gives maximum output speed and promotes to the maximum fuel economy.

2.3.5 Fifth gear

The vehicle with fifth gear and also called "overdrive" is connected to a gear that is significantly larger. Fifth gear or overdrive gear is a top speed gear for overdrive to increase speed. This allows the fifth gear to spin much faster than the gear that delivers the power.

2.3.6 Reverse gear

Direction of transmission spins in the opposite rotation of the engine through small idler gear. Gear from the input and output are turning in the opposite direction of each other. The output shaft and synchronizer are locked together and direct powers to the gears without affecting the gear ratio. Therefore, it is impossible to throw the transmission into reverse while the car is moving forward because the dog teeth are never engaged.

2.4 Gear Shifting

To produce maximum acceleration (torque), higher speeds (power) and good fuel economy, gear shifting is important to be taken into consideration in optimizing engine operation. It is used as an alternative way of the engine to operate at optimum efficiency by using shifting gear strategy (Kahlbau.S, et.al. 2013). Gear shifting strategy is a process that is required in order to increase the acceleration. The lower gears of the transmission are usually used for normal acceleration of the vehicle to achieve the desired cruising speed. The highest gear of the transmission is used to maintain the desired speed. The fifth gear is recommended for use in maintaining highway cruising speeds. The use of the fifth gear in city traffic is not recommended. Figure 2.5 shows the shifting pattern in normal 5-speed transmission.

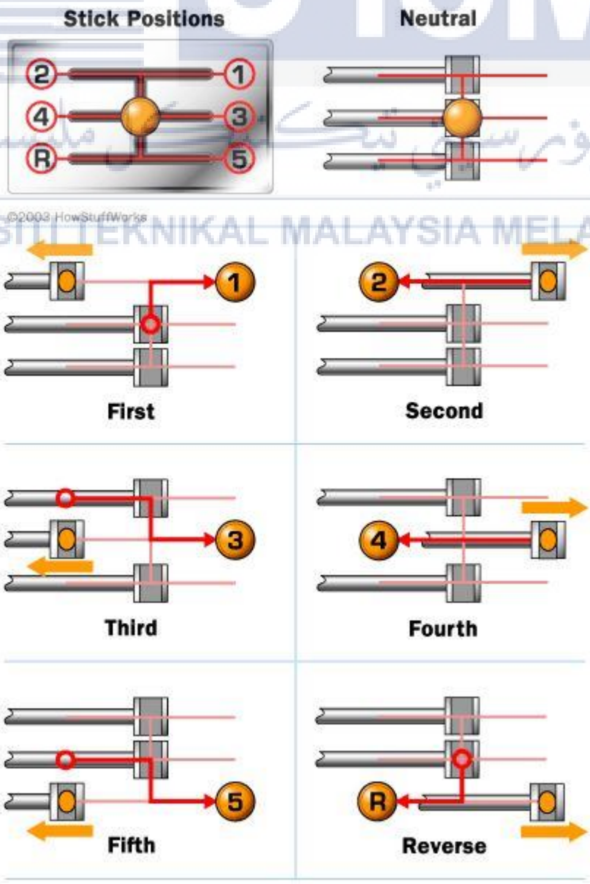

Figure 2.5: Shifting pattern in normal 5-speed transmission

In every situation, it is necessary to know the vehicle behavior in every drive. Simulation testing is conducted for each gear ratio setting to obtain gear shifting map. Vehicle performance is affected by some factors such as the available transmission ratio, required vehicle speeds, fuels consumption and other factors that can be set as datum in further testing.

2.5 Clutch

Clutch is defined as a component that connects an engine and gearbox. It connects and disconnects the engine from the transmission. Normally, standard clutch it operated by the driver. The engine and the input/green shaft are directly connected to each other when the clutch pads are released. It causes the input shaft and the gear turn at the same rpm as the engine. However, the power from engine and transmission are disconnected if the clutch pedal is pushed. Even though they are not connected, the engine can idle if the car is in standing still. This is because there is no torque or power that is transmitted to wheel from the gearbox. Figure 2.6 shows the major components of clutch system.

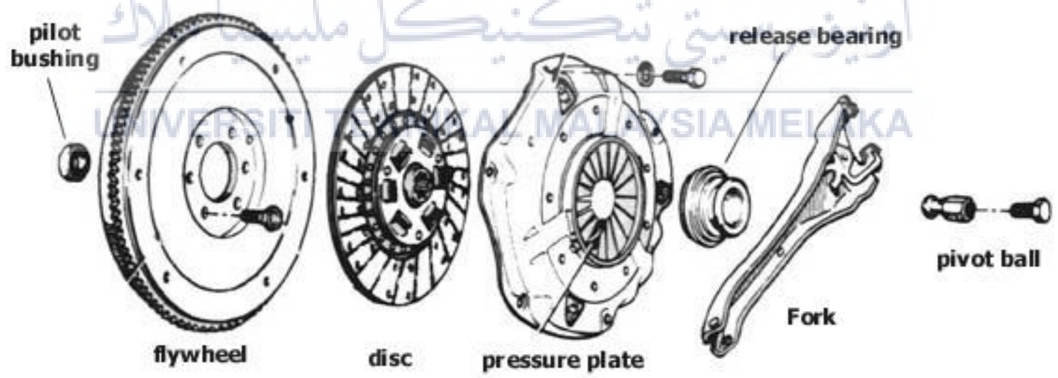

Figure 2.6: Components in clutch system

2.6 Synchronizer System

The main function of the synchronization system is to produce and generate a friction torque with the friction contact before selecting the desired gear. The synchronizer works on rotating shaft and the gear wheel. Synchromesh also allows the smooth engagement of gears especially in manual transmission when the driver is changing the gear. Then it causes the angular speed to reduce to zero. The synchronization process is also preventing gearbox from shocks that can affect the driver comfort inside the vehicle. The function characteristics of synchronizer are discussed as below.

2.6.1 Synchronizer hub

The function is to connect the input or output shaft of the rotating shaft with the spline.

2.6.2 Sliding sleeve

The function is to control the movements in axial position when engaging the position from neutral. It is a constant movement between mesh of internal splines to the synchro hub external splines.

2.6.3 Synchronizing ring

It synchronizes the input and output shafts by creating the needed friction torque. It prevents the break of the hydrodynamic oil film because of the groove pattern on the cone surfaces and also reduces the force acting in the synchronizer.

2.6.4 Gear wheel

It is mounted on the shaft with desired lubricant properties. Needle bearing normally contacts and connects the main shaft to rotate on both components.

2.6.5 Clutch gear with cone

The function is to equalize the rotation of the synchro hub with the speed of the gear.

2.6.6 Strut detent

This component acts as pre-synchronization and generates the load on synchro ring. It looks like a spring loaded ball and positions between the inner grooves in shift sleeve and the groove in the synchro hub.

Detent face is the contact of synchro spring face by axially moving the sleeve to neutral position, which indicates the start of synchronization phase. This step starts with the disengagement from free travel of neutral position which has no torque transfer. It continues by contacting the strut and synchronization ring. It causes the initial of indexing process of pre-synchronization. The contact of synchronization ring with the sleeve cone initiates the synchronization phase and begins to turn the ring gear. Then, the second gear is free travel with tip contact of the sleeve against the gear clutch washer. It is easy to detect the possibly of double bump phenomena from this stage and after the end of gear angular movement and finally reach the fully engagement. (Savaresi, et al 2016)

2.7 Vehicle Performance

Vehicle performance is the study of motion on the vehicle. Force and moment rely on the vehicle bodies are always affecting the performance of a vehicle. The surrounding environment such as earth or tarmac surface, air or water, gravitational forces and others factors can also affect the vehicle performance. Through this research, acceleration and top speed on vehicle will be studied.

2.7.1 Acceleration

Automobile that able to accelerate very quickly is usually reserved for high performance car and it can achieve high speed in short amount of time. Actual acceleration can be calculated theoretically. Acceleration performance can also influences consumer in the decision of purchasing for vehicle. It also proves to be very important for driver to avoid collision or accident. A slower acceleration rate means that the car is weak and takes longer to respond to the driver's controls. Table 2.1 shows previous researches on acceleration from different manufactures (Elert,G, 2016)

Table 2.1: Previous researches on acceleration from different manufactures (Elert,G, 2016)

Bibliographic Entry	Result	Bibliographic Entry
Zitzewitz, Paul. Merrill Physics Principles and Problems. New York: Glencoe, 1995: 91.	"A drag racer tries to obtain maximum acceleration over a quarter mile course. The fastest time on record for the quarter mile is 4.801 seconds. The highest final speed on record is 301.70 miles per hour."	28.1 m/s2
2000 Acura Integra GS Coupe. Edmunds.	"Acceleration (0-60 mph): 7.9 sec."	3.4 m/s2
Jaguar XK8 (2001). The Auto Channel.	"0-60 mph 7.0 seconds"	3.8 m/s2
Taruffi, Piero. The Technique of Motor Racing. Cambridge, Massachusetts: Robert Bently, 1958: 58.	"exceed an acceleration of 6 mph/sec"	2.7 m/s2
2000 Mitsubishi Eclipse GT. Edmunds.	"Acceleration (0-60 mph): 7.0 sec."	3.8 m/s2

Acceleration is important especially in climbing hill and gaining speed in a short distance especially when overtaking other vehicles. Driving behavior can be determined and acceleration profile is an important indicator to discover the level of driver aggression and skill. (A.Chowdhury et al, 2015)

$$F=ma \tag{2.1}$$

Where:

F = Applied force on body

m = Vehicle mass

a = Acceleration on bodies

According to Eq. (2.1) of Newton's Second Law has stated that an object subjected to an external force will accelerate and that the amount of the acceleration is proportional to the size of the force. The amount of acceleration is also inversely proportional to the mass of the object. (Nancy.H 2015). The integration result from the formula can be used in characterization for the vehicle performance. Study on the vehicle acceleration is calculated based on time taken from zero motion (0 km/hour) until it reaches the velocity of 100 km/hour. So, the test will be conducted with initial velocity of zero to achieve final velocity of 100 km/hour. In order to calculate the actual acceleration, the formula below is used.

$$a = \frac{\Delta v}{t} = (vf - vi)/t \tag{2.2}$$

Where:

a = acceleration

vf = the final velocity

vi = the initial velocity

t = the time in which the change occurs

Δv = change in velocity

2.7.2 Top Speed

Top speed is one of parameter that works as indicator for road safety and also fuel consumption. Top speed is probably the most important statistic for a car manufacturer. It is because, if the car can achieve 55mph and the rival manufacturer can only achieve 45mph, that means car that cruises at 50mph can easily overtake others at 40mph. (Andrew.F, 2013). In Malaysia, standard top speed that can be driven on the road or highway usually is around 80 to 110 km. But on the road that has no speed limit such as Autobahn in German, it is an advantage for a car that has high top speed performance (Johan.D.M, et.al, 2009).

By increasing the top speed, it reduces the travel times and often critically important for many essential services e.g. for emergency vehicles. Ambulances and fire vehicles can arrive faster at the scene of an emergency. High speed is also an important advantage for public transport vehicles, such as inter-urban coaches and intra-city bus services (OCD, 2006).

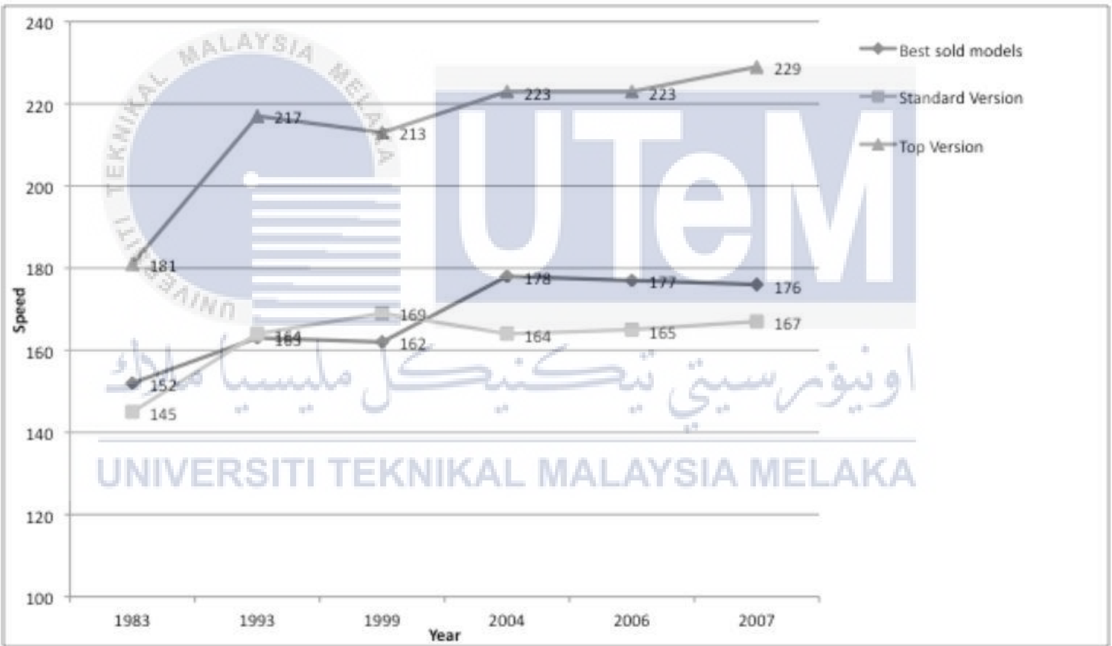

Figure 2.7: Type of version vehicles that been sold. (Johan.D.M, et.al, 2009).

From the Figure 2.7 above show that the different version car that been sell in the Belgium for the last twenty years. The top version car that has better top speed lead the selling at the country as the higher model to be sold. From that figure, it shows that top speed is also affecting the criteria for customer in buying a car. Nowadays driver prefers to buy high top speed car rather that either standard version or premium version.

2.7.3 Fuel Consumption

Fuel consumption of vehicle can affect the market value. Customer becomes more interested to buy lower fuel consumption vehicle. By increasing the value of consumed fuel and the competition market of automobiles, automotive market is affected by this two main factors including both unit price and supplied facilities. If the internal combustion engine works with lower ratios, it notices that the consumption of specific fuel increases (R.G.Ahangar, 2010).

Table 2.2: Table for fuel consumption vs different overdrive gear (R.G.Ahangar, 2010).

N_t	1	0.84	0.81	0.8	0.79	0.76	0.7	0.64
Velocity	Specific fuel consumption							
80	0.272	0.268	0.270	0.272	0.273	0.276	0.285	0.293
90	0.270	0.270	0.267	0.267	0.268	0.268	0.273	0.282
100	0.268	0.272	0.272	0.272	0.271	0.270	0.267	0.272
110	0.268	0.269	0.270	0.271	0.271	0.272	0.270	0.268
120	0.273	0.267	0.271	0.269	0.269	0.270	0.272	0.270
Max. Velocity	131	124	123	122	120	118	112	102
rpm of the Engine	4900	3850	3700	3600	3500	3350	2900	2450
Min. Velocity	75.97	90.45	93.80	94.97	96.17	99.97	108.5	118.7

From the Table 2.2, if the engine works with lower ratios or 0.79, the consumption of specific fuel increases as compared to 0.8 to 0.84. According to the above mentioned results, the appropriate gear ratio must between 0.8 until 0.84. Based on the minimum engine rpm, 0.8 is the appropriate gear ratio. Number of 0.8 (0.64-1) gear ratios and appropriate pair gears are studied according to Table 2.2 with trial and error procedure. The general effect of fuel economy parameters is evaluated. Minimum engine velocity, the difference of maximum and minimum effective velocity of the engine are studied to specify 0.81 as the most appropriate engine ratio.

From other previous researches also show that 20% fuel consumption can be increased due to a difference in the manner of gear shifting with the same average driving speed. Volkswagen has investigated by using passenger car segment as medium for experiment. Figure 2.8 shows that the higher consumption of fuel occurs through third, fourth and fifth gear at speed of 50 km/h and 90 km/h. The fuel consumption increases when driving in the third and the fourth gear. In the fifth gear, the relative higher fuel consumption on the 50 and 90 km/h. From the test, conclusion can be made that the vehicle has different fuel consumption in each different gear at the same specifications of car. (I.Blagojević, et.al 2012)

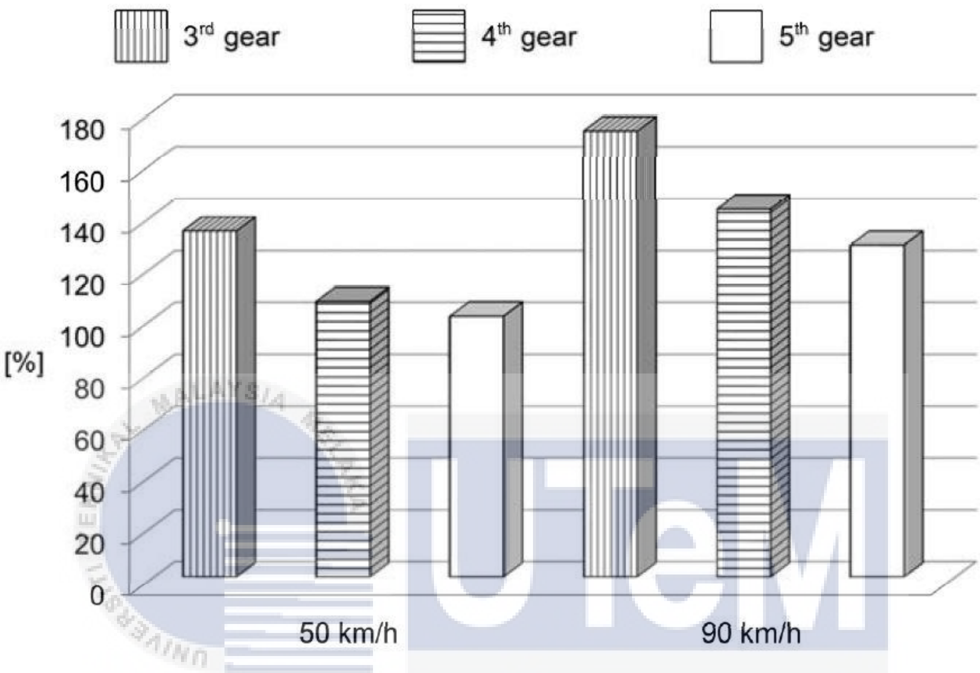

Figure 2.8: Fuel consumption related to 50 km/h in 5th gear (I.Blagojević, et.al 2012)

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter explains the methodology used in this project about the influence of gear ratio pattern on vehicle performance in obtaining data and parameters that can be used. By referring journal and others reliable sources, all the related equation and parameter are listed to be discussed later with appropriate data. After that, the study of how to use Matlab Simulink software is carried out by experimenting of running some exercise in Simulink. Then, equations are created in Simulink environment and the results are analyzed. By using different parameter to obtain data will give various results in gear shifting pattern. Conclusion for each obtained data can be made. If the results show some errors, the current equation is revised and others source are used for simulation data.

3.2 Analyze the Problem

The problem of the current manual transmission regarding the effect of gear ratio pattern on the vehicle performance is studied. All the parameters are listed out and compared for each setting of gear ratio of the same vehicle. Based on the results, some analyses are conducted at the end of simulation. Research on previous journal and other sources are included in literature review for the major topic in this project.

The methodology of this study is summarized in the flow chart as shown in Figure 3.1

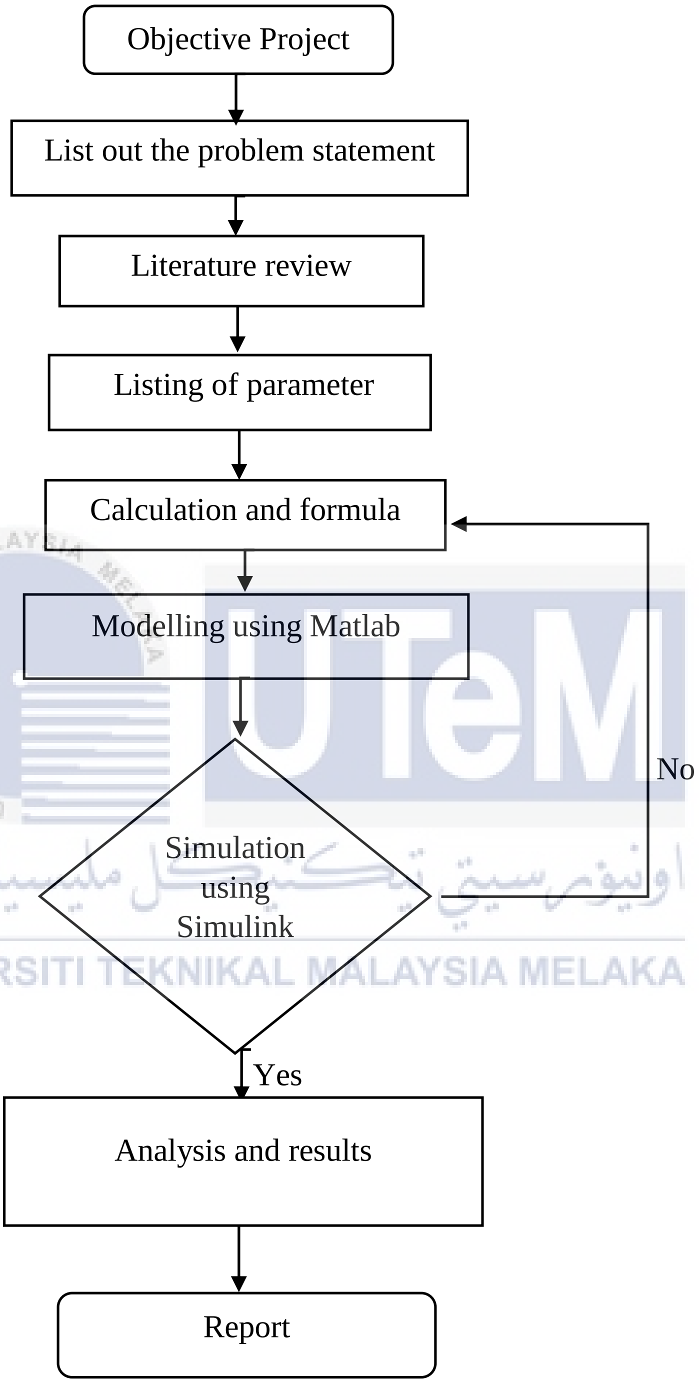

Figure 3.1: Flow chart of the methodology.

3.3 List of Parameter

Equations are going to be modelled for the simulation in this experiments. So the vehicle parameter with suggested gear ratio are required for the purpose of this study. Perodua Alza specifications are used as parameter guidelines. Figure 3.2 show the specification of Perodua Alza

Identification data

Perodua Alza 1.5 SXi
as offered for the year 2012 for Asia

Production/sales period of this car without major change in specs:	mid-year 2009 -
Modelyears:	-
Country of origin:	MAL Malaysia
Make:	Perodua
Model:	Alza 2009-
Submodel:	Alza 2009-2012
Optional equipment:	
EEC segmentation:	M (C) (multi purpose cars - segment C - medium, compact)
Class:	compact minivan / MPV (multi purpose vehicle)
Body style:	multi-purpose
Doors:	5
Traction:	FWD (front-wheel drive)
Curb weight (without a driver):	1130 kg / 2491 lbs
Dry weight:	
Shipping weight:	
Curb weight estimated:	
Engine type:	spark-ignition 4-stroke
Fuel type:	petrol (gasoline)
Cylinders alignment:	Line 4
Displacement:	1495 cm3 / 90.8 cui
Horsepower net:	76.5 kW / 104 PS / 103 hp (JIS net) / 6000
Horsepower gross:	
Redline rpm:	
Transmission type:	manual
Number of gears:	5
Car power to weight ratio net:	67.7 watt/kg / 30.7 watt/lb
Car weight to power ratio net:	14.8 kg/kW / 10.9 kg/PS / 24.2 lbs/hp

Figure 3.2 Specification of Perodua Alza (Pawel.Z 2011)

Table 3.1 Parameters of vehicle.

Parameters	Vehicle
Sprung mass (kg)	1130
Unsprung mass(kg)	1120
Front tyre – C.G Distance (m)	1.1
Rear tyre – C.G Distance (m)	1.65
Wheels radius (N/m)	0.292
Height of C.G (m)	0.54
Air resistance	1.2-1.3
Rolling resistance on front (N)	98.88
Rolling resistance on rear (N)	65.92
A (m/s^2)	3.33
V (m/s)	16.67
Grade angle (°)	0
Dynamic axle load (front/rear)	6043.15/5526.42
Frontal area (m^2)	2.75

Table 3.2: Parameters of gear ratio

Gear	Gear ratios	Final reduction	Top speed (km/h)
1st	3.091	4.643	49.9
2nd	1.842	4.643	83.7
3rd	1.250	4.643	123.39
4th	0.865	4.643	178.31
5th	0.75	4.643	205.15

From the Table 3.1 and 3.2 above, these specifications are used to simulate different gear ratio pattern. Comparison can be made in Simulink by changing different vehicle parameters.

3.4 Formula / Calculation

In order to get the actual output from the engine, there are resistance or traction force that can reduce the power generated from the engine to the road surface. So the calculation for this project is very important because it easier to get the actual result or close to it.

Input power
- Torque, T_e
- Power , bhp

−

Traction force

$T_e - Inertia$

−

Resistance
- Grade slope,
- Aerodynamic force
- Rolling resistances

=

Output Power
- Vehicle speed, km/h
- Torque, T_w

In the drive wheels which were generate by motor vehicle, there has term that is called as the pull force that can function to determine the torque at the transmission output (output torque) or by the transmission output power. The output torque is essentially dependent upon the two variables “transmission ratio” and “motor torque”. (Luh et al.2007)

3.4.1 Work and load

Based on the Eq (3.1), work is definition of force vector that applied on the same travelled distance. Unit for work is joule. So the formula for work is:

$$w = F * d \tag{3.1}$$

Power can be defined by work done divided with time taken. The unit for power is Watt. We can use this formula to calculate power

$$power = work\ done \times\ time\ taken$$

Besides that, we can use others formula using to find power:

$$power = force \times speed$$

$$= Fv$$

3.4.2 Resistance load

There are also resistances that acting on the body of vehicle. These resistances need to be calculated because it can affect the engine performance. There are 3 types of resistance that usually should be considered.

- Rolling resistance.
- Air resistance
- Grade load (Resistance when climbing slope road)

i. Rolling resistance

Rolling resistance is the force per unit vehicle weight required to drive the vehicle on ground at a fixed slow speed. Aerodynamic drag is not being considered and also where no grip power or brake is used. Vehicles tires produce resistance from the power that being used by the car from 20% to 50%. The gas mileage can increase by 3% and engineers can improve to only 10% of the rolling resistance in passenger-car tires. (Stephen.M, 2015). Figure 3.3 show the rolling resistance coefficient.

Tire Type	Coefficient of Rolling Friction
Low rolling resistance car tire	0.006 - 0.01
Ordinary car tire	0.015
Truck tire	0.006 - 0.01
Train wheel	0.001

Figure 3.3: Rolling resistance coefficient. (Karim.N, 2000)

According to Eq. (3.2), the rolling resistances in front and rear wheels are:

$$R_f\, , R_r \;= C_{rf} \times\; N \qquad (3.2)$$

Where

C_{rf} : Coefficient of rolling resistances

N : weight of the vehicle

R_f , R_r : rolling resistance force (front, rear)

Total Rolling Resistance, $R_T = R_r + R_f$

ii. Air Resistances

Drag force happens by the interaction and contact of solid bodies which are opposite to the relative motion of the object. If there is no motion, no drag occurs on the body. Equation (3.3) show the general equation of drag force:

$$R_A = \frac{1}{2} C_D \rho V^2 A \tag{3.3}$$

Where

C_D drag coefficient

A frontal area of object

ρ air density

V^2 relative velocity of object

iii. Grade Load

Grade load or gradient resistance is determined by the steepness of the hill and the weight of the vehicle. Equation (3.4) show the rolling resistance formula.

$$R_G = W sin\emptyset \tag{3.4}$$

So, the drag force increases when density of fluid, frontal area or speed increase. Other than that, different shape profile is also affecting the coefficient of the drag. This can be prooved through the equation. By considering these forces occur on the steady state conditions, so according Eq. (3.5) show the total road load

$$Total\ Road\ Load, R = R_T + R_A + R_G \qquad (3.5)$$

Where:

R_T = Rolling Resistance

R_A = Air Resistance

R_G = Grade Load Resistance

Comparison can be made on different types of car. From the graph above show the drag coefficient provides influence as the speed increases. The heavier and large vehicle has higher rolling resistance. Large vehicle has disadvantages when driving at high speed. Heavier vehicle are also easy to roll over at the higher speed.

3.4.3 Axle Load

In order to overcome the total resistance, a sufficient amount of motive force has to be applied to the driven wheels. The greater the engine torque, the higher the transmission ratio between the engine and the driven wheels and the smaller the power loss through the drivetrain. (Reif.K, 2014). Axle load of a wheeled vehicle is the total weight felt by the roadway for all wheels connected to a given axle. It can be viewed in different way as the fraction of total vehicle weight resting on a given axle. Axle load is an important design consideration in the engineering of roadways and railways, as both are designed to tolerate a maximum weight-per-axle (axle load). Figure 3.4 show the example of free body diagram for vehicle accelerating on a slope

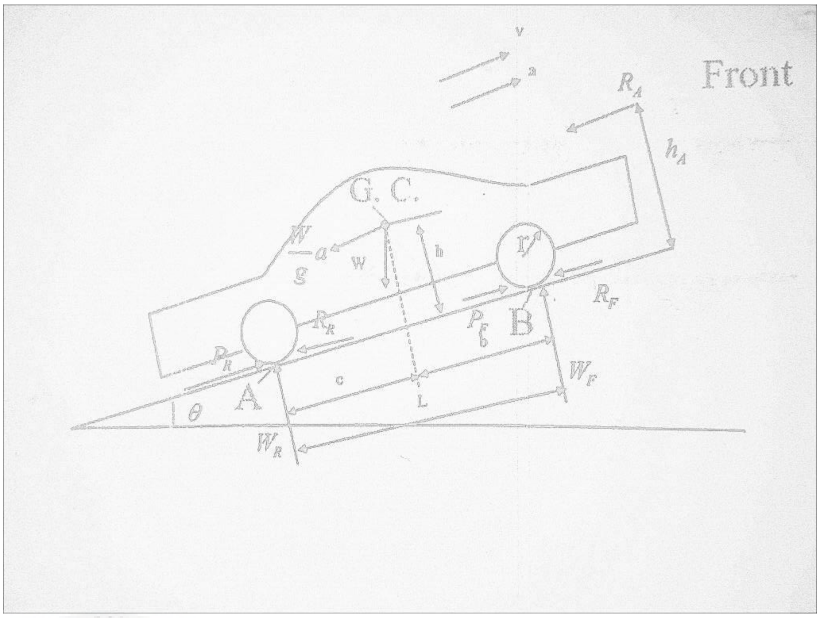

Figure 3.4: Example of free body diagram for vehicle accelerating on a slope

Based on the condition of equilibrium:

$$\sum M_A = 0$$

$$\sum M_B = 0$$

From there, find the dynamic axle load in both front and rear axles

$$W_F = \frac{1}{L}(W.c.cos\emptyset - R_A.h_A - \frac{W}{g}a.h - W.h.sin\emptyset)$$

$$W_R = \frac{1}{L}(W.b.cos\emptyset - R_A.h_A - \frac{W}{g}a.h - W.h.sin\emptyset)$$

$$P_F + P_R - R_F - R_R - R_A - Wsin\emptyset = \frac{W}{g}a$$

Total traction: $$P = P_F + P_R \quad (3.6)$$

3.4.4 Kinematical Relations of Powertrains

In the vehicle engine, it produces the power that can be calculated as engine torque and angular velocity

Engine torque = T_e

Angular velocity = ω_e

Transmission output torque and angular velocity

$$T_t = n_t i_t T_e$$

$$\omega_t = \frac{\omega_e}{i_t}$$

Where,

n_t= transmission effieciency

i_t= transmission gear ratio (stepped variable)

Then torque and angular velocity on driving wheels are based on Eq.(3.7) and Eq. (3.8)

$$T_W = n_a i_a T_t = n_a n_t i_a i_t T_e \tag{3.7}$$

$$\omega_w = \frac{\omega_e}{i_a i_t} \tag{3.8}$$

Where,

n_a=efficiency of final drive

i_a=final drive ratio

So from here we can get the engine output at wheel

$$T_W = n_a n_t i_a i_t T_e = n_a i_t T_e$$

$$\omega_w = i_t i_a \frac{V}{r}$$

Where *n* is total power efficiency

$$\text{Driving force } P = P_R = \frac{T_w}{r} = {n i_a i_t T_e}/{r} \tag{3.8}$$

The engine output torque at a fixed throttle position is a function of engine RPM. These data are obtained by measurement on testing rig and may be plotted or tabulated. The engine performance capacity is achieved at wide-open throttle position (WOT). By interpolating, the engine torque may be represented as function of RPM:

$$T_e = T_e(\omega_e) \tag{3.9}$$

$$\omega_e = {\pi(RPM)}/{30}\, rad/s \tag{3.10}$$

3.5 Modelling and Simulation

Simulink is a software that assists to produce simulation, automatic code generation, and continuous test and verification of embedded systems. It works by using block diagram environment that combine for multi-domain simulation and Model-Based Design. It can be created base on the formula of calculation that involves. By building Matlab Algorithm, further analysis can be done in the Simulink and simulation result can be produced by running the software. In vehicle dynamic, it can be modelled and simulated for the purpose of study and analysis. This method of analysis and study the dynamic performances of vehicles via simulation is carried out due to the constraints (cost, time and safety) especially in other approach such as actual vehicle experiment (M.Azman et.al 2016).

Modelling steps start by understanding the system function. Then, the developers can enter the parameter that has been studied. If there has some integer overflow, division by zero or dead logic, the Simulink can detect, and the developer can back trace their equation. Correction can be made by using Constant and Signal general Block Simulink that related in the MathWorks. As the efficiency and quick real time result from the simulation, it has widely used in production system. It has 25 modelling style checking that enables trace verification and validations of the input logic. Development phase in Simulink library provides the simulation that also include common block in the equation.

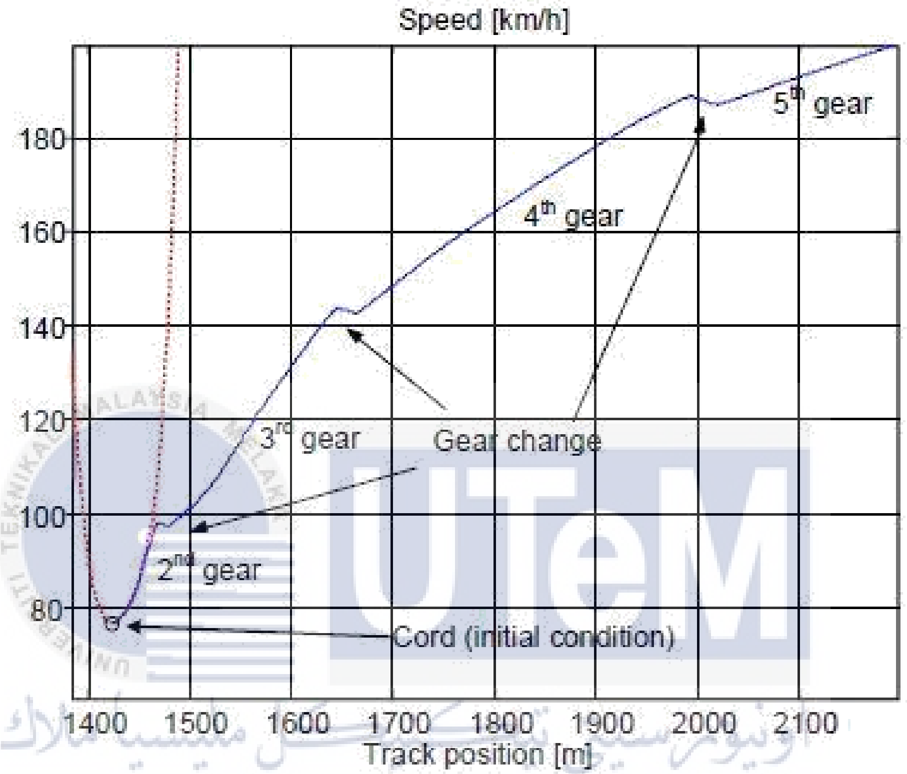

Figure 3.5 Expected graph with each gear ratio (S.M.Ciotti 2016).

For equation in Simulink is constructed based on the formulae that were used in the calculation especially Eq. (3.7) of torque and Eq. (3.5) of force with the traction force. Different values of gear ratio are included in every testing with it specific parameter. For each different gear ratio, it gives different result. Figure above shows the shifting on different gear ratio. Analysis is conducted to study the top speed and acceleration for the vehicle performance.

CHAPTER 4

RESULT & DISCUSSION

4.1 Simulation Model

Figure 4.1 shows the simulation model of the gear ratio inside the transmission for this project. The vehicle performance is focused on the speed of vehicle. This model is combined with the actual full body model to test out the simulation and analyze the result. Several tests with different setup of gear ratios are conducted to get the performance graph. The simulation is based on calculated input power and the outcome of different gear ratio are obtained.

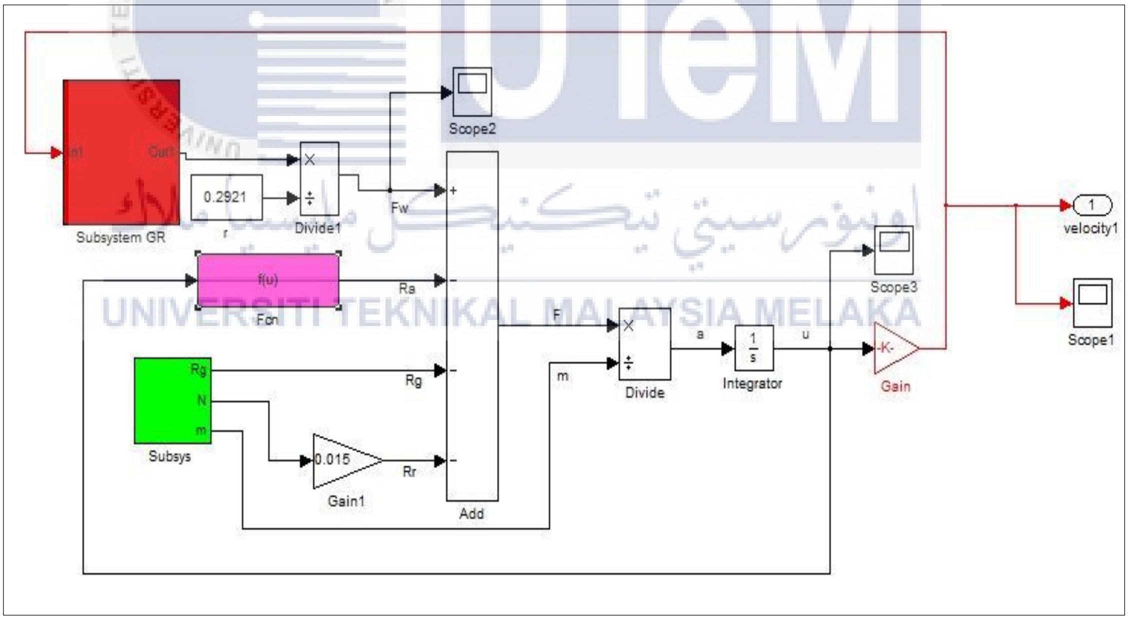

Figure 4.1: The full system of simulation of gear ratio

Simulation is tested with actual vehicle parameter data. Some improvement and modification are added through this simulation to get results and outcome. All the parameters are listed out through this report as references.

Transmission selection simulation is needed to be used in the full model of the conventional car body to get the graph of the shifting map. The transmission model needs to be compatible with the full body simulation in order to simplify the running the simulation.

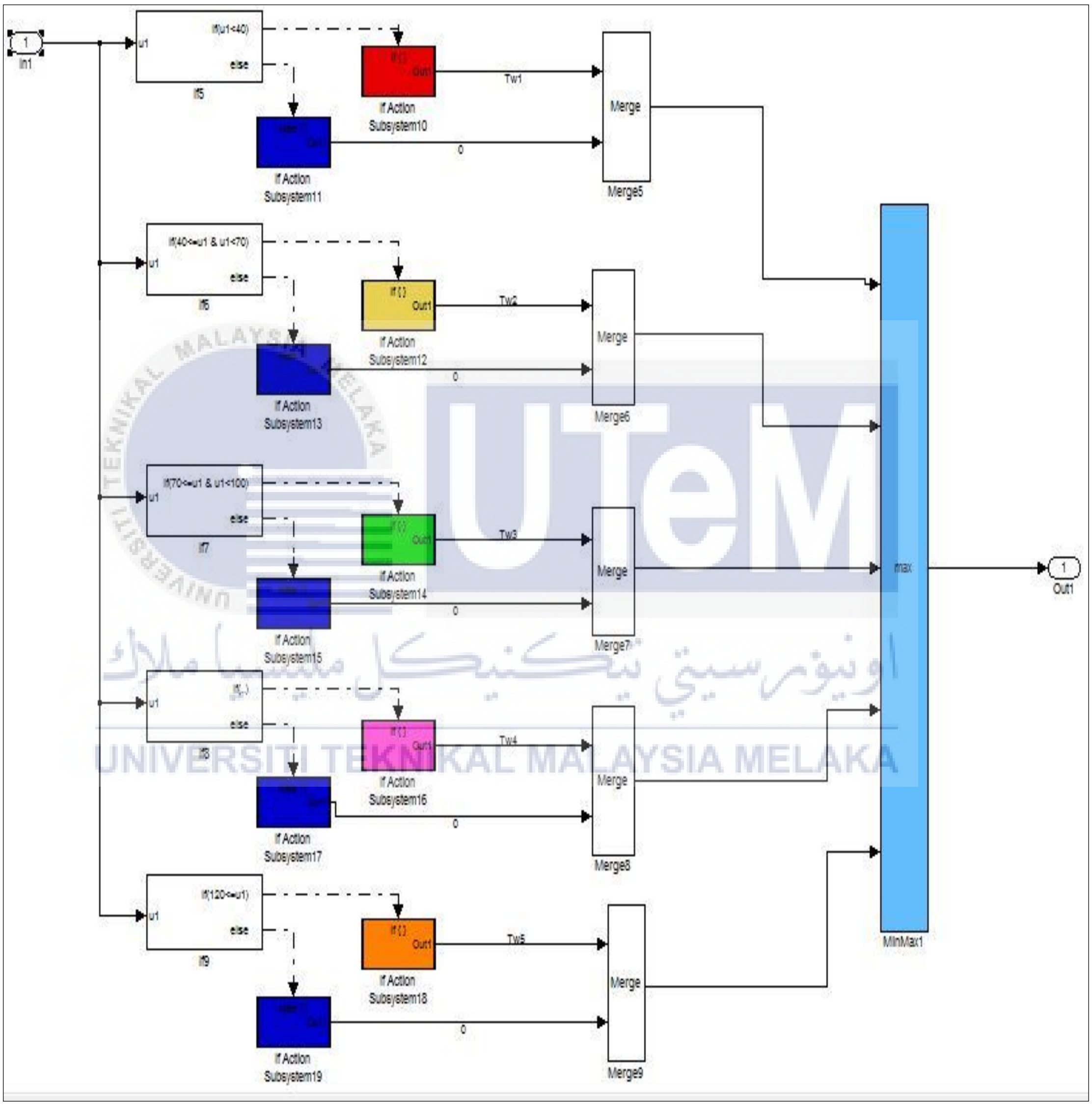

Figure 4.2 Gear ratio selection model

4.2 Specification of Vehicle

Table 4.1 below shows the parameters of vehicle specification that are used as references. These parameters were used as the input for the simulation model that in Matlab Simulink software. Information from the parameter are needed for the outcomes of actual result that is acceleration (0kmh-110km/h) and the top speed (5th gear) of vehicle.

Table 4.1 Specification of vehicle

Component	Parameter	SI Units
Vehicle	Mass	1200 kg
	Frontal area	2.75m^2
	Drag coefficient	1.23
	Tire rolling radius	0.292m
	Wheelbase	M
Engine	Type	3sz-ve ,DOHC
	Maximum Torque	136Nm/100ftlb/13.9kgm@ 4400rpm
	Maximum Power	76kW(104hp)@6000rpm
	Cylinders	4 inline,16valve with DVVT

4.3 Gear Ratio Determination

For the determination of gear ratio, the model of standard (1.5 3s-ve) were use as standardized data or datum. All the data from the manufacturer were used and the others data for customization were developed and modified from the original data. For the 1.3 k3-ve data, standard gear ratio and final drive of Perodua Myvi 1.3 parameters are used.

Table 4.2 show the specification of gear ratio selection that were used in this project. For the parameter of custom 1, custom 2 and custom 3 were still using the same gear ratio for 1st gear, 5th gear and final drive gear based on the standard (1.5 3sz-ve) gear ratio parameters. The parameters that were changed were between 2nd gears until 4th gear by changing the percentage distribution for each gear. As an example for setup of standard gear ratio by manufacturer, the range between 1st gears until 5th gear was 2.341. These data then distributed in three types of setup; custom 1 had equal distribution (25%) for range of each gear, custom 2 increased the gear by 10%, 20%, 30% and 40% of increment and custom 3 that decreased by 40%, 30%, 20% and 10% for each increment of gear.

Table 4.2 Specification of gear ratio selection

Gear Ratio \ Model	1.5 3s-ve	Custom 1	Custom 2	Custom 3	1.3 k3-ve
First	3.091	3.091	3.091	3.091	3.182
Second	1.892	2.5058	2.8569	2.1546	1.842
Third	1.25	1.921	1.9205	1.4523	1.25
Fourth	0.865	1.335	1.6864	0.9841	0.865
Fifth	0.75	0.75	0.75	0.75	0.75
Final Drive	4.643	4.643	4.643	4.643	4.267

4.4 Result of Parameter

4.4.1 Test 1 for standard spec (1.5l 3sz-ve)

Figure 4.3 show the standard (1.5 3sz-ve) data of speed map by using simulation of actual parameters. There actual data and parameters from the manufacturer being used straight away in the simulation.

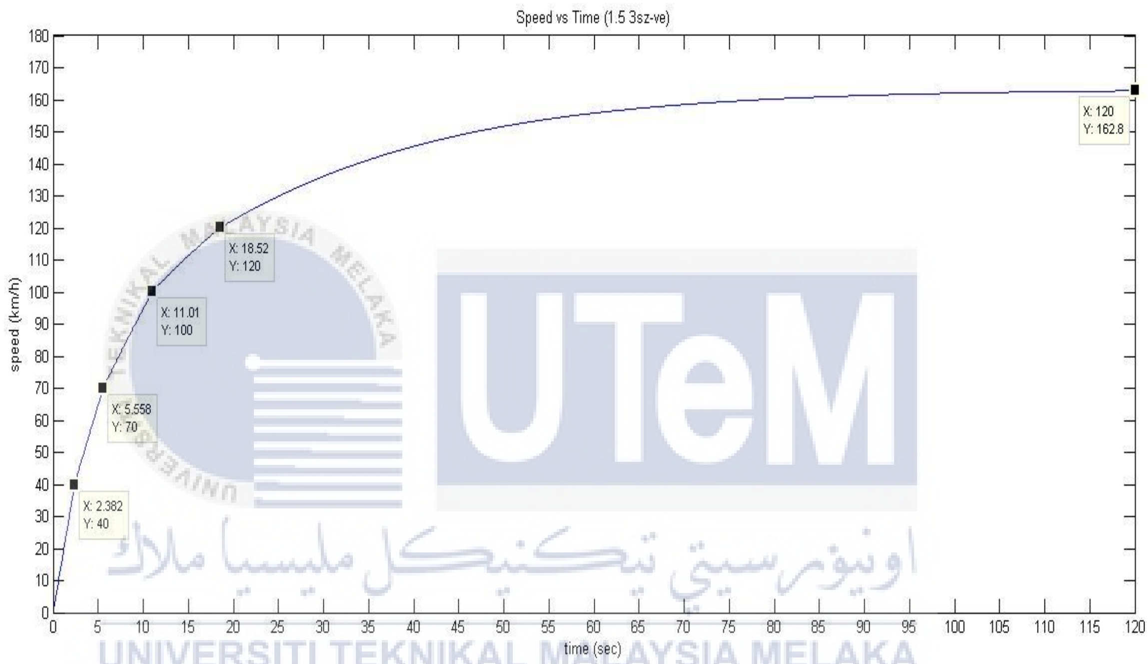

Figure 4.3 Data of speed map for datum gear ratio

For the standard (1.5 3sz-ve), of speed vs time graph shows that the top speed at 120 seconds is 162.8 km/h. The initial graph shows that 1st gear only needed 2.382 seconds to achieve speed of 40 km/h. Then it changes to the 2nd gear and it reaches 70 km/h for only 5.558 seconds from initial and 3.176 second for the range of 1st gear to 2nd gear. Next, by changing to the 3rd gear it only needs 11.01 seconds to reach 100 km/h with the range of 5.452 seconds from the 2nd gear to the 3rd gear. At 120 km/h, it needs 18.52 seconds of acceleration time by using 4th gear sequence and needed 7.51 seconds from 3rd gear up to 4th gear. Lastly, for the 5th gear, it then produces top speed of 162.8km/h at 120 seconds.

4.4.2 Test 2 for custom 1 specification

For the second test, a new setup of gear ratio specification has been constructed by adjusting the percentage of range between 1st gears until 5th gear. This gear ratio pattern is constructed by distributing equal ratio so the percentage is equal to 25% range between each gear. Figure 4.4 show the data of speed map for custom 1 gear ratio.

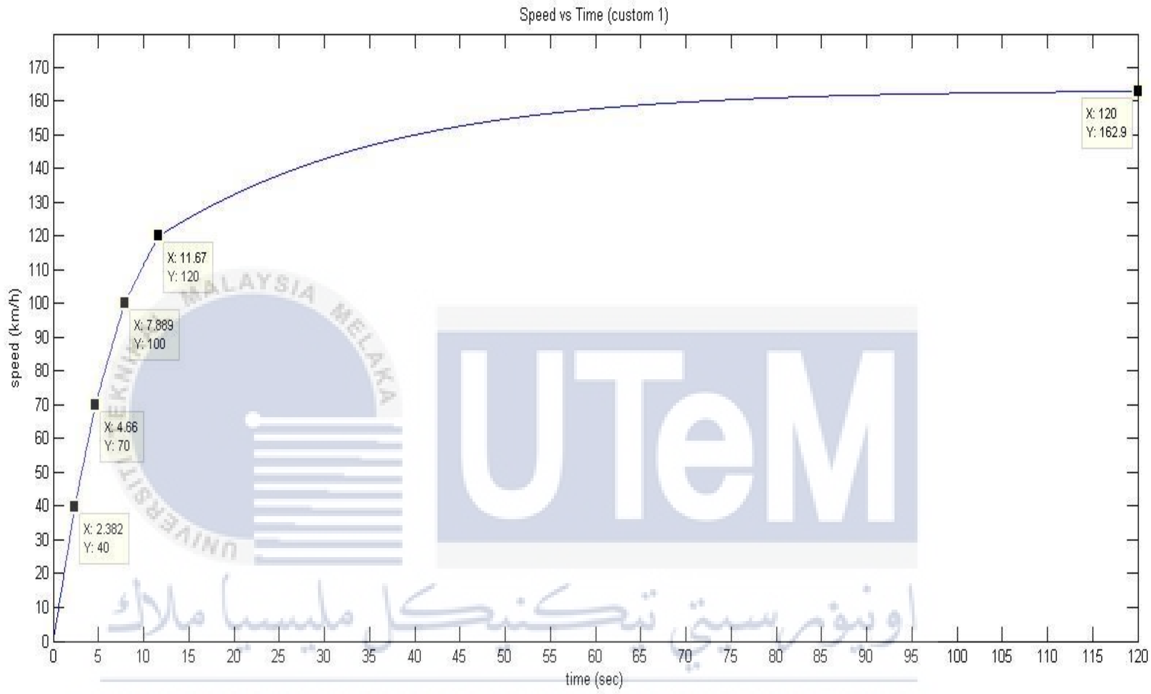

Figure 4.4 Data of speed map for Custom 1 gear ratio

For the custom 1 specification of parameter, the speed vs time graph shows that the top speed of 162.9 km/h is achieved in 120 seconds. The initial graph show that 1st gear only needs 2.382 seconds to achieve speed of 40 km/h. Then it changes to the 2nd gear and it reaches 70 km/h in only 4.66 seconds from initial and 2.278 seconds of range from 1st gear to 2nd gear. Next, by changing to the 3rd gear, it only needs 7.889 seconds to reach 100 km/h and produces range of 3.229 seconds from the 2nd gear to the 3rd gear. At 120 km/h, it needs 11.67 seconds of acceleration time by using 4th gear sequence and needs 3.781 seconds from 3rd gear up to 4th gear. Lastly, for the 5th gear, it produces top speed of 162.9km/h in 120 seconds.

4.4.3 Test 3 for custom 2 specification

For the third test, a new setup of gear ratio specification has been constructed by adjusting the percentage of range between 1st gears until 5th gear. This gear ratio pattern is constructed by distributing ratio so the percentage increases by 10% of increment for each gear. It then produces 10%, 20%, 30% and 40% of ratio increment in the gear. Figure 4.5 show the data of speed map for custom 2 gear ratio.

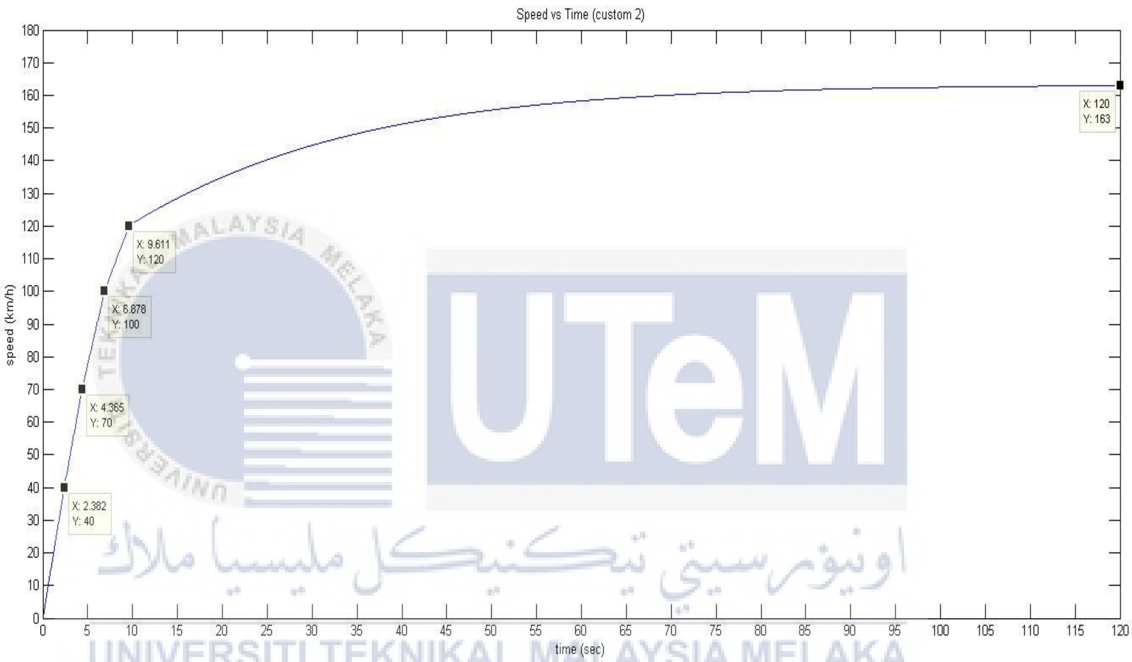

Figure 4.5 Data of speed map for Custom 2 gear ratio

For the custom 2 specification of parameter, the speed vs time graph shows that the top speed of 163.0 km/h is achieved in 120 seconds. The initial graph shows that 1st gear only needs 2.382 seconds to achieve speed of 40 km/h. Then it changes to the 2nd gear and it reaches 70 km/h for only 4.365 seconds from initial and 1.983 second range from 1st gear to 2nd gear. Next, by changing to the 3rd gear it only needs 6.878 seconds to reach 100 km/h and takes range of 2.513 seconds from the 2nd gear to the 3rd gear. At 120 km/h, it needs 9.611 seconds of acceleration time by using 4th gear sequence and needs 2.733 seconds from 3rd gear up to 4th gear. Lastly, for the 5th gear, it then produces top speed of 163.0 km/h in 120 seconds.

4.4.4 Test 4 for custom 3 specification

For the fourth test, a new setup of gear ratio specification has been constructed by adjusting the percentage of range between 1st gears until 5th gear. This gear ratio pattern is constructed by distributing ratio so the percentage decreases by 10% of increment for each gear. It then produces 40%, 30%, 20% and 10% of ratio increment in the gear. Figure 4.6 show the data of speed map for custom 3 gear ratio.

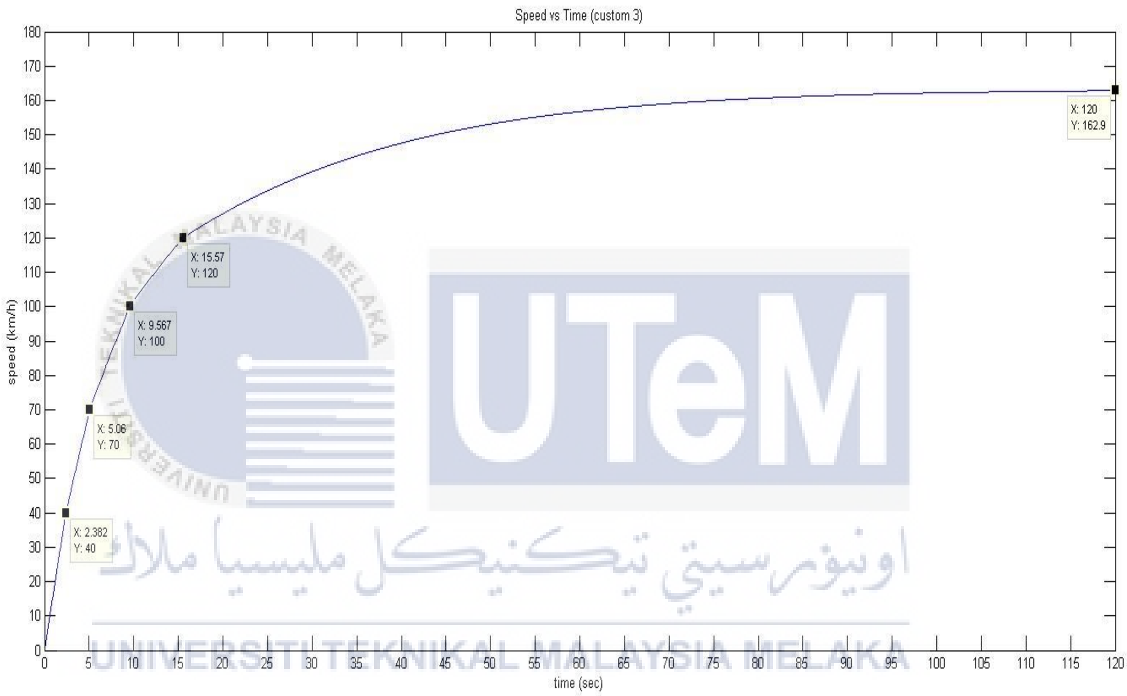

Figure 4.6 Data of speed map for Custom 3 gear ratio

For the custom 3 specification of parameter, the speed vs time graph shows that the top speed of 162.9 km/h is achieved in 120 seconds. The initial graph shows that 1st gear only needs 2.382 seconds to achieve speed of 40 km/h. Then it changes to the 2nd gear and it reaches 70 km/h for only 5.06 seconds from initial and 2.678 second range from 1st gear to 2nd gear. Next, by changing to the 3rd gear it only needs 9.567 seconds to reach 100 km/h and takes range of 4.507 seconds from the 2nd gear to the 3rd gear. At 120 km/h, it needs 15.57 seconds of acceleration time by using 4th gear sequence and needs 6.003 seconds from 3rd gear up to 4th gear. Lastly, for the 5th gear, it then produces top speed of 162.9km/h in 120 seconds.

4.4.5 <u>Test 5 for 1.3 k3-ve specification</u>

Figure 4.7 shows the 1.3 k3-ve specification data of speed map by using simulation. There actual data and parameter from the manufacturer being used straight away in the simulation.

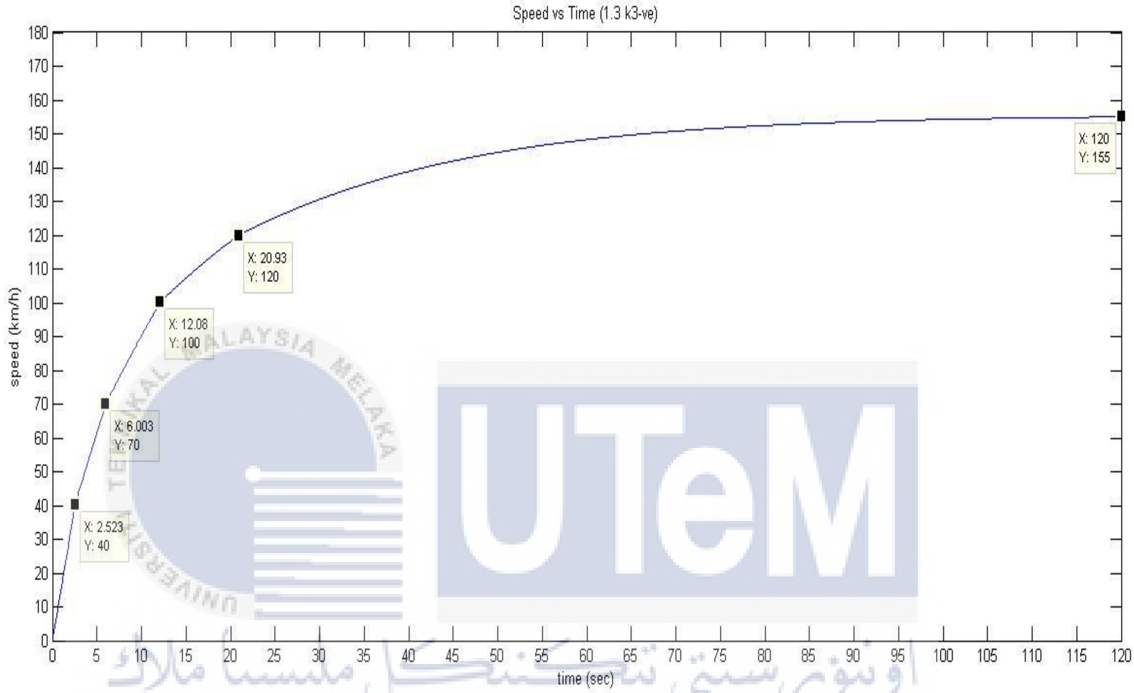

Figure 4.7 Data of speed map for 1.3 k3-ve gear ratio

For the 1.3 k3-ve specification, the parameter of speed vs time graph shows that the top speed of 155 km/h is achieved in 120 seconds. The initial graph shows that 1st gear only needs 2.523 seconds to achieve speed of 40 km/h. Then it changes to the 2nd gear and it reach 70 km/h in 6.003 seconds from initial and produces 3.48 seconds range from 1st gear to 2nd gear. Next, by changing to the 3rd gear it only needs 12.08 seconds to reach 100 km/h and produces 6.077 seconds range of time from the 2nd gear to the 3rd gear. At 120 km/h, it needs 20.93 second of acceleration time by using 4th gear sequence and needs 8.85 second from 3rd gear up to 4th gear. Lastly, for the 5th gear, it then produces top speed of 155.0km/h in 120 seconds.

4.4.6 Comparison of Data

Figure 4.8 show the comparison of data between each gear and specification are plotted and the result of each specification are compared.

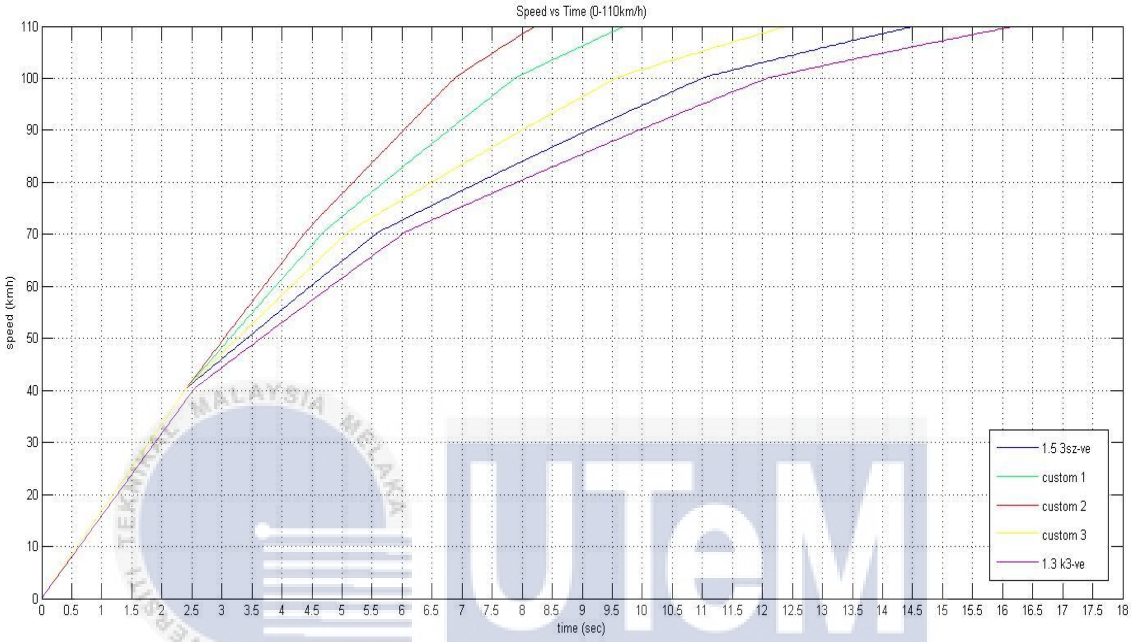

Figure 4.8 Comparison between each gear ratio for acceleration (0-110km/h)

From the graph, it shows the comparison between the specifications for 1st gear performance produces the same amount of speed vs time from 0-40km/h. This is because it still uses the same setting of gear ratio, only 1.3 k3-ve produce slightly slower than others. Standard (1.5 3sz-ve), custom 1, custom 2 and custom 3 only need 2.382 seconds to achieve 40km/h but 1.3 k3-ve needs 2.523 seconds to reach the same amount of speed. From there, it has more significant differences of result between each specification.

Based on the Figure 4.8 and 4.9, the custom 2 specification leads as compared to others by accelerating from 0-110km/h in only 8.8 seconds. Then it follows by custom 1 specification that 9.7 seconds to reach 110km/h. Third position that reaches 110km/h from the list is the custom 3 specification that clocks 12.2 seconds. The standard specification that acts as datum clocks 14.4 seconds and lastly is the 1.3 k3-ve that requires 16.0 seconds to achieve 110km/h.

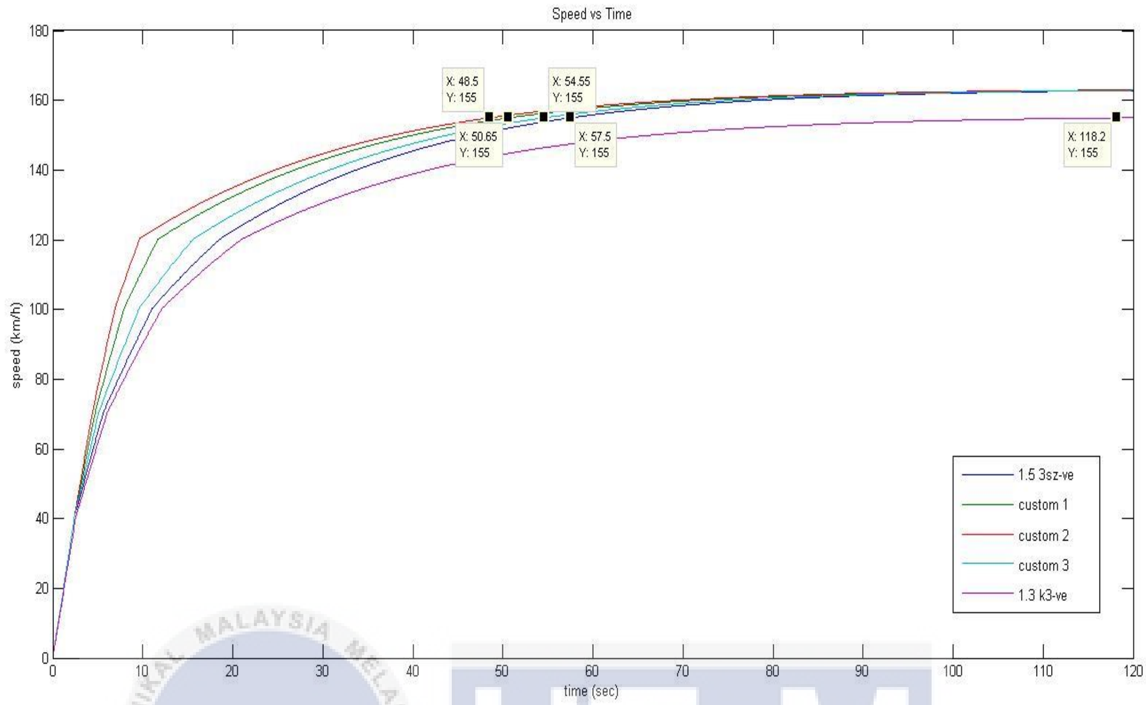

Figure 4.9 Comparison between each gear ratio specification

Figure 4.9 shows the results of speed for different gear ratio specifications to reach 120 seconds. Based from the figure, it shows the 1.3 k3-ve produces the lowest top speed, at only 155km/h. The standard specification produces 162.8 km/h, then follows by custom 1 and custom 3 that produce the same amount of top speed that is 162.9km/h. The highest recorded top speed is 163km/h is performed by specification of custom 2. While 1.3 k3-ve only gets 155 km/h at 120 seconds, custom 2 155 km/h at 48.5 seconds, follows by custom 1 that reaches time of 50.65 second. Third and fourth are custom 3 and standard (1.5 3sz-ve) that get at 54.55 seconds and 57.5 seconds.

4.5 Discussion

1. Standard specification (1.5 3sz-ve) of gear ratio have been construct through the analysis in term of the changing gear with the speed produce against time. From the given result, the performance pattern shows that maximum top speed can be achieved based on the targeted time.
2. The shifting pattern of gear ratio is based on the speed that is controlled on each gear. The speed from 0 km/h – 40km/h is using torque from 1st gear and if exceeds the maximum speed of shifting point, it returns back and does not affect other torque or speed in the simulation.
3. The construction of new specification parameter for gear ratio must be logical to be used in this system. Each system in the simulation is depended on other systems to obtain the actual results.
4. The result for the standard specification by using original parameter from manufacturer that acts as datum are compared with other parameters.

Table 4.3 Acceleration time and top speed for all gear ratio specifications

Specification	0-100km/h (s)	Top speed (km/h)
1.5 3sz-ve	14.4	162.8
Custom 1	9.7	162.9
Custom 2	8.8	163.0
Custom 3	12.2	162.9
1.3 k3-ve	16.0	155.0

5. The comparison of each data shows the acceleration from 0 km/h – 110km/h. It is based on the optimum and fixed data according to its system and parameter of the vehicle. The equation (4.1) for percent error formula is given by

$$\frac{theoretical\ value - experimantal\ value}{theoretical\ value} \times 100 \qquad (4.1)$$

For first comparison (custom 2)

$$\frac{(14.4sec - 8.8sec)}{(14.4sec)} \times 100 = 38.89\%$$

For second comparison (custom 3)

$$\frac{(14.4sec - 9.7sec)}{(14.4sec)} \times 100 = 32.64\%$$

For third comparison (custom 1)

$$\frac{(14.4sec - 12.2sec)}{(14.4sec)} \times 100 = 15.27\%$$

For fourth comparison (1.3 k3-ve)

$$\frac{(14.4sec - 16.0sec)}{(14.4sec)} \times 100 = -11.11\%$$

6. From the analysis that had been done and based on the graph, if the vehicle that uses greater or higher ratio from the standard version, it able to increase the acceleration and torque but in terms of top speed there has no significant difference between each of the specification. This shows that by using the setup of custom 2 has the highest acceleration. Then it follows by custom 3, custom 1, standard (1.5 3sz-ve) and 1.3 k3-ve.
7. All the graph for torque and force maps that generated for different setup of gear ratios are included in the appendix.

If the vehicle uses closer ratio of gear, it produces more torque shifting pattern than standard specification, as in custom 2 had 2.8569 more close to 1st gear ratio than the standard that only had 1.892. The basic calculation of torque shows that the different results of maximum force and torque affect the performance outcome. The different setup of the gear ratio is one of the major factor for its performance. The simulation model proves the theory that vehicle can accelerate higher but in the term of top speed it still producing the equal outcomes. Table 4.4 show the torque for all gear that were produce using different specification.

Although the torque and power is higher than the standard version that were produce by manufacturer, but in the real-life, drivers need vehicle with smoother and more comfortable driving styles. It can be achieved by practice but driver requires understanding, knowledge and also practice to change gear in smooth manner. When operating the manual vehicle with higher torque, it produces more mileage per liter because it rotates higher than normal. But by using suitable shifting pattern in each gear, it produces more torque with low mileage for driver.

Table 4.4: Torque for all gear ratios

Specification / Gear	Standard 1.5 3sz-ve (Nm)	Custom 1 (Nm)	Custom 2 (Nm)	Custom 3 (Nm)	1.3 k3-ve (Nm)
1st	1580.96	1580.96	1580.96	1580.96	1495.708
2nd	942.13	1281.65	1461.227	1102.02	865.837
3rd	639.341	982.539	1221.755	742.812	587.566
4th	442.42	682.816	862.548	503.34	406.596
5th	383.6	383.6	383.6	383.6	352.54

The standard operation when shifting gear especially with optimum torque in each gear can be achieved by finding suitable pattern before shifting to the next gear. Vehicle transmission can be shifted with parallel to engine power to utilize its true performances. By choosing the suitable gear ratio that, it can match with the power output to give better performance of the vehicle

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The objective for this experiment is to analyze the optimum gear ratio parameters that can produce more vehicle output power. This project is focusing on gear ratio output in the manual transmission model based on the selected power input that had been chosen. A set of parameter from 5-speed manual transmission (Perodua Alza 1.5 3sz-ve) was chosen to be investigated and calculated. In order to achieve the optimum torque and top speed without any experimental works involve, while finding the suitable and optimum gear ratio for the output performance of the vehicles, a mathematical model simulation by using Matlab Simulink software was created.

Mathematical model of transmission was constructed and tested by to show the vehicle performance when changing the gear. It can also provide the comparison between each setup and vehicle performance specifications in terms of top speed or torque. The top speed of vehicle can be increased by combining the optimum gears ratio with the complete calculation on the strategy through analysis. The results of simulation can be used to obtain the most effective gear ratio in investigating the top speed in vehicle. From this study, it proves that gear shifting pattern can be adjusted by using closer ratio between gears and produces great effect on vehicle performance.

5.2 Recommendation

In any type of research, they are many parameters that are investigated in their work. Additional information can surely be beneficial in any research activities. This study can be continued by including the comparison of different selection gear ratio with the consumption of petrol. Nowadays, consumers are always demanding high performance vehicle that also has better fuel consumption especially when world oil price is increasing. So by doing this research, the fuel consumption can be determined whether it can be much lower if it has much more torque curve in performance map or it uses higher consumption as compared to standard specification.

Other than that, the execution of this research by using simulation is an approach that can be done by anyone and becomes the focus point in automotive industry. The use of basic simulation and several functions need to be understand especially in a mathematical modelling. It can greatly reduce the time of research and experiment. This study can also be improved by having the experimental set up in lab environment. The actual data which includes the environment and any other external factors will surely produce different results. Instead of using simulation to get the result, an actual model is more reliable and easy to understand the flow of the system.

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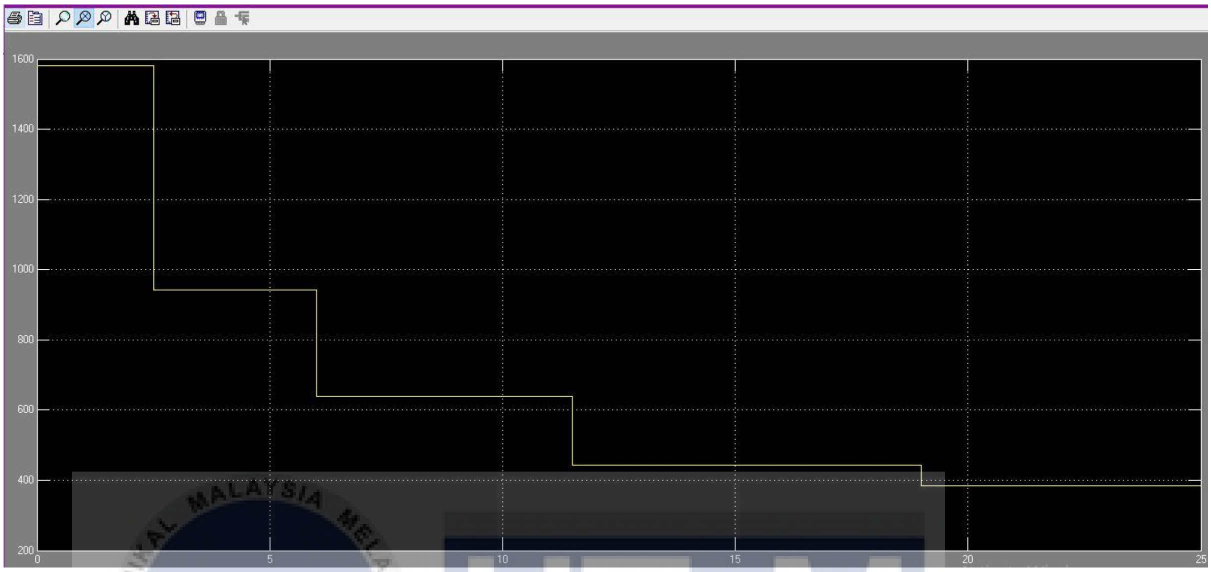
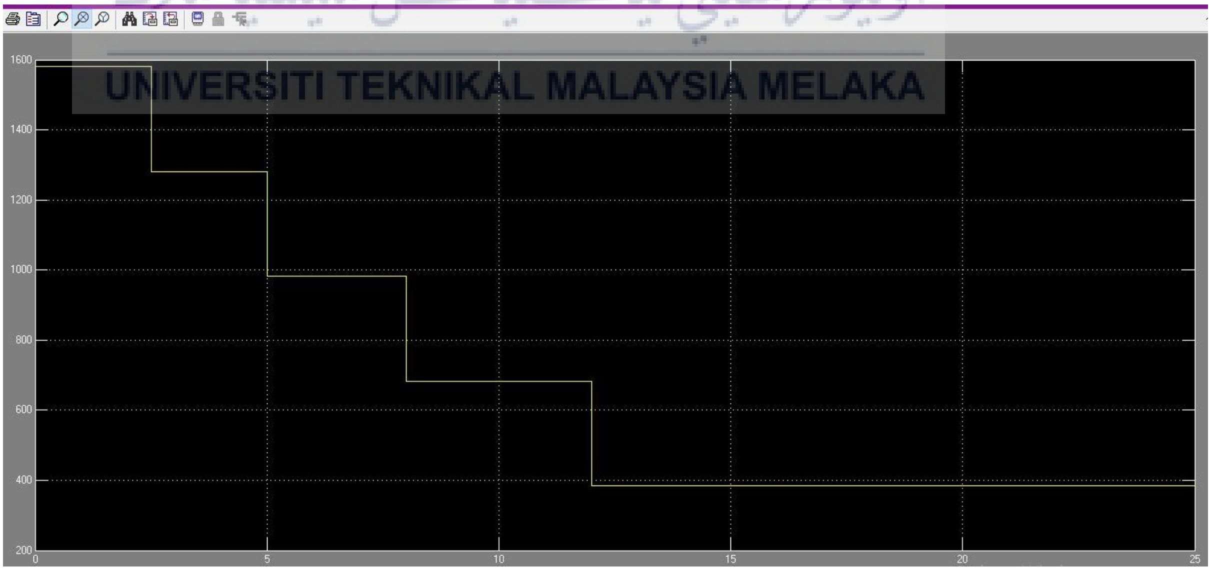
APPENDIX

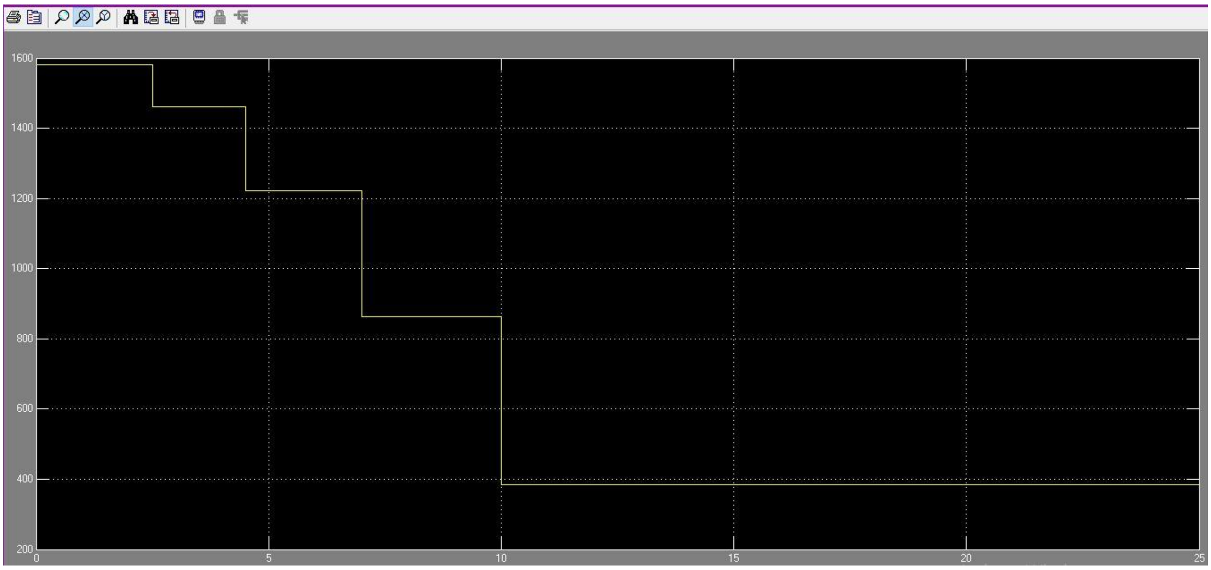
A. Torque Parameter



Appendix A1: 1.5 3sz-ve (standard)

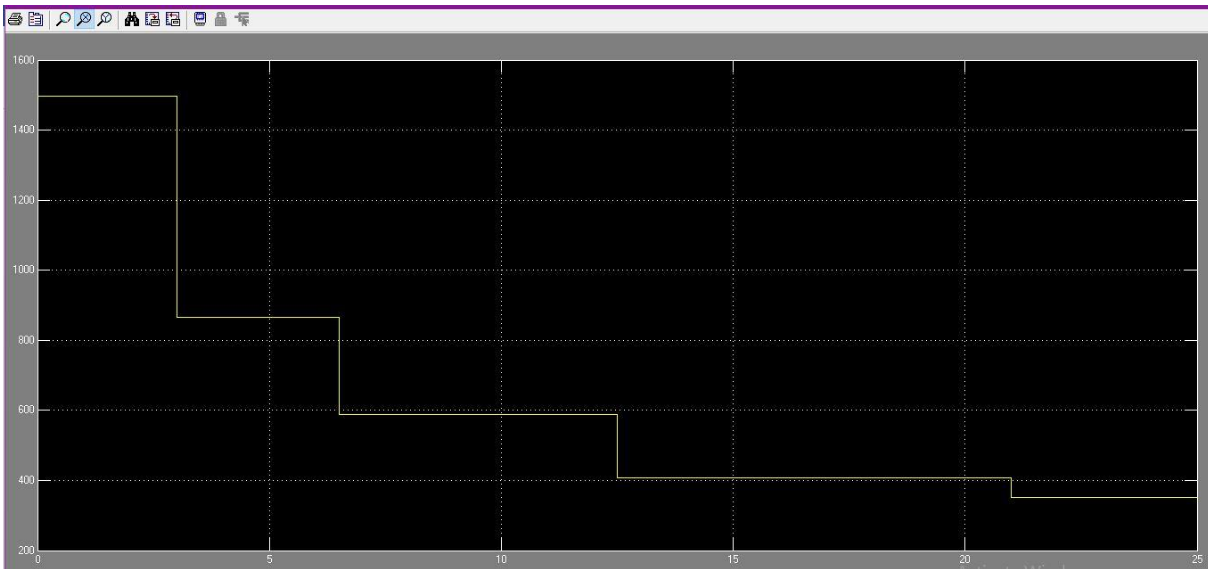


Appendix A2: custom 1



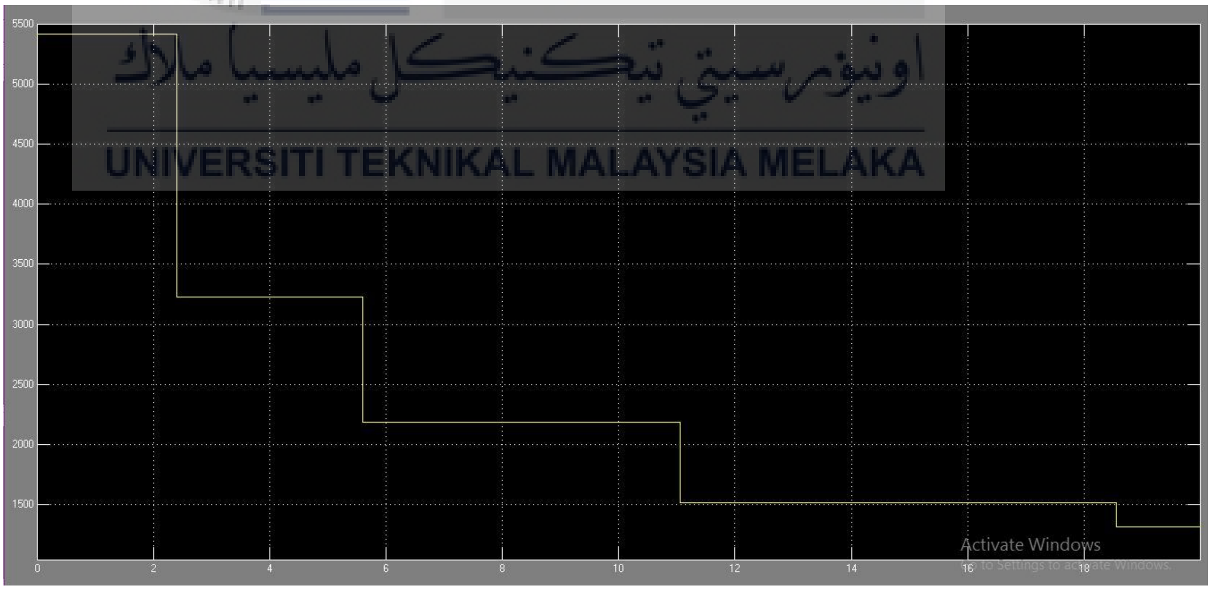
Appendix A3: custom2

Appendix A4: custom 3

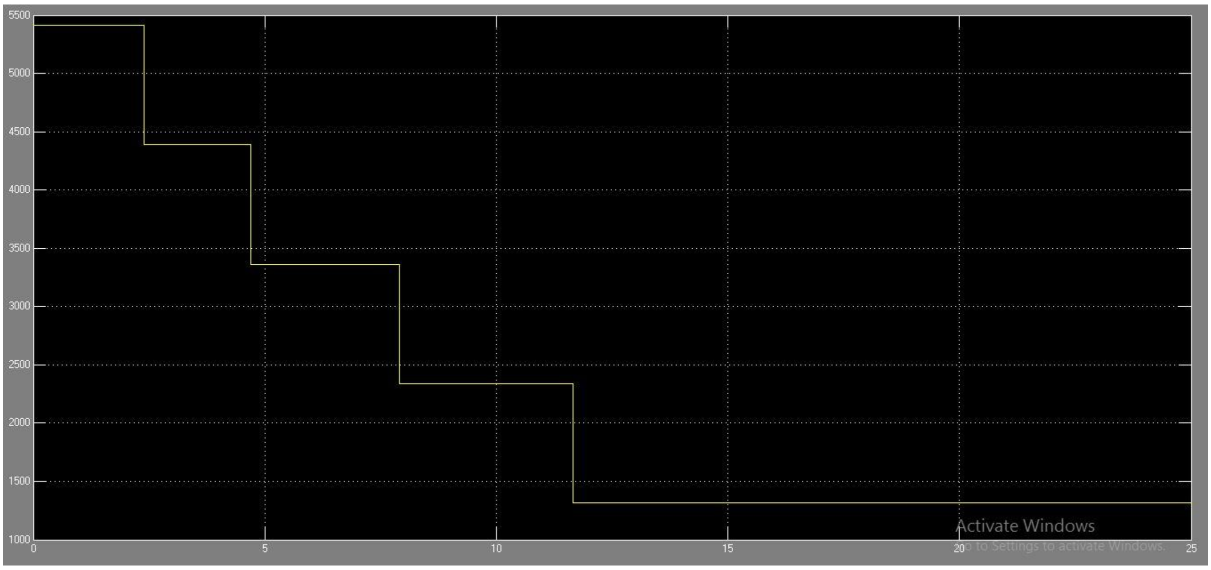


Appendix A5: 1.3 k3-ve

B. Force Parameter

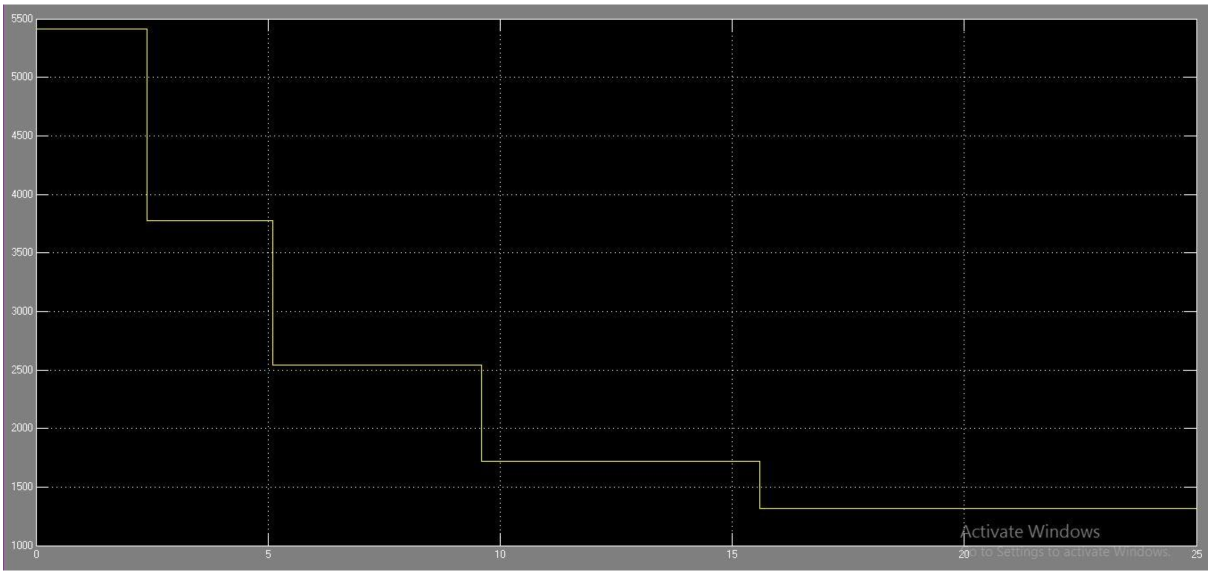


Appendix B1: 1.5 3sz-ve

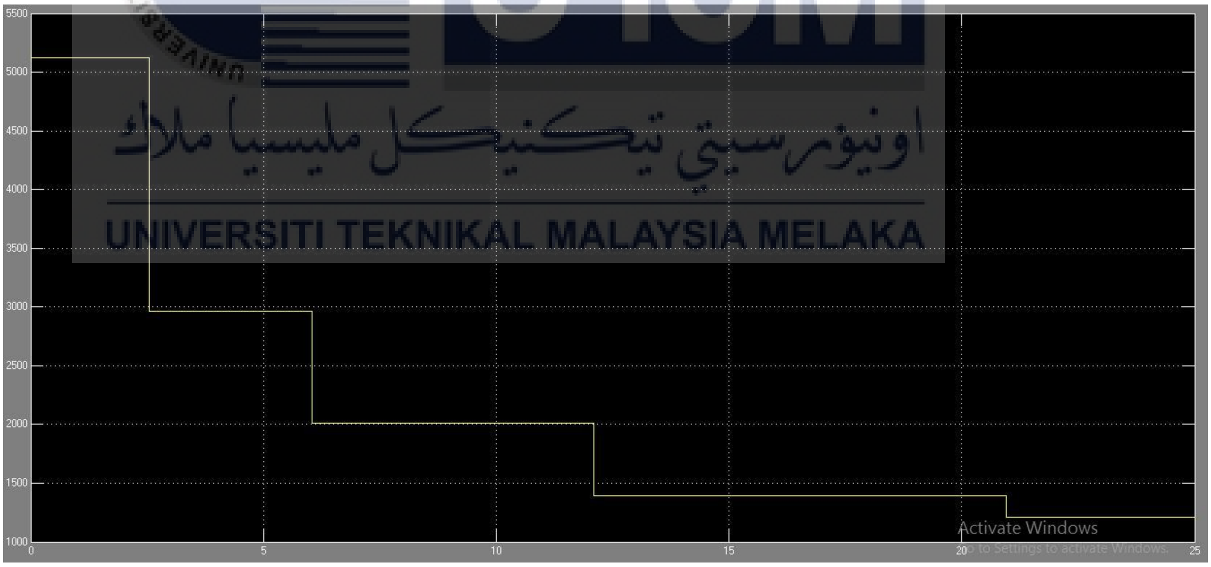


Appendix B2: custom 1

Appendix B3: custom 2



Appendix B4: custom 3



Appendix B5: 1.3 k3-ve