Design & Analysis of control logic for automatic clutch actuation

TERM PROJECT - AUTOMOTIVE SYSTEMS (MEL 321)

Pranav Reddy
2017UME0110

ABSTRACT

Clutch actuation & gear shift control of automated manual transmissions (AMT) have many advantages in terms of improvement of driving comfort, reduction of fuel consumption and shifting quality. This paper aims to present a simulation model for clutch & gear-shift logic of an AMT by developing the control and conducting experimental tests to evaluate the performance. Vehicle speed has been used to assess the model. Though not exhaustive, the results showed great potential for a completely automated manual transmission

INTRODUCTION

Manual transmission is the best transmission available in terms of high efficiency due to transmission through gears, comparatively lower weight than its counterparts, high control, great fuel economy due to the efficiency & control, easier maintenance and an economically viable option. But driver fatigue, improper driving patterns and usage, due to the high skill set required & demanded by it, are the most important drawbacks that has kept it from being used widely and its growth rate declining recently. Automatic transmissions could be good alternatives, but they do not retain all the advantages of manual transmission. Hence there is a need for a system that can counter the disadvantages of MT but also offer its advantages

Automated manual transmission

Automated manual transmission focuses on automating the driver input process to eliminate the need for driving skill, fatigue caused and “Drive the correct way”. AMTs, with the addition of actuators (hydraulic or electric) would be able to automatically control the clutch and gear shifting. AMT systems that use actuators to automatically control MTs benefit from both the high powertrain efficiency of manual transmissions and the convenience of automatic transmissions

OBJECTIVE

To design the logic/ control of automatic clutch actuation to facilitate the following actions -

- Gear change request whenever applicable
- minimize engagement time while providing a smooth launch
- avoiding engine stall and redlining during launch

- Having minimum rollback during a hill start
- Avoid erratic clutch actuation patterns

Novelty of the idea

AMT has very recently started to prosper. Modern cars, today, have gear shift suggestors. After exhaustive literature survey, it has been found that most of the papers dealt with how the actuation should be performed. Some papers have also worked on developing algorithms for automatic clutch actuation based on several parameters. Also, No algorithm could completely automate clutch actuation

EXECUTION & RESULTS

Implementation

The system needs to be designed in such a way that it can be readily installed in an MT vehicle. An electronic actuator with high power transmission efficiency and fast control response, using an electric motor and reduction gear could be used. Design of its elements depends on the actuating pressure, torque transmitted and rotational speed

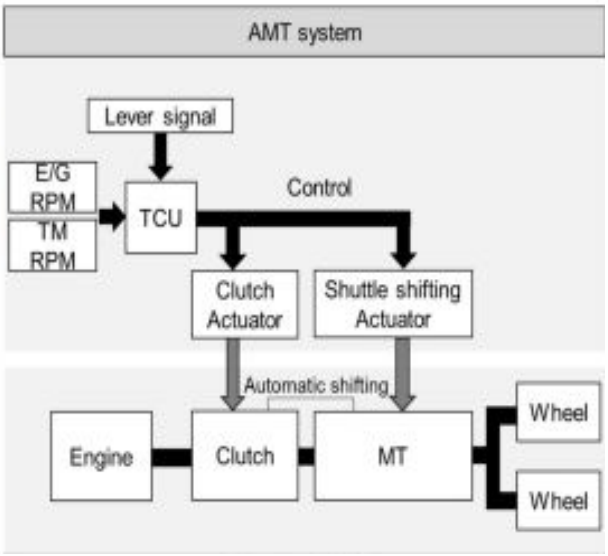

Fig 1. Schematic of AMT system

Simple gear suggestion logic

Initially, a simple logic has been written to predict the gear depending upon the vehicle speed. Logic needs to be extended to inputs from engine rpm, grade and braking requests.

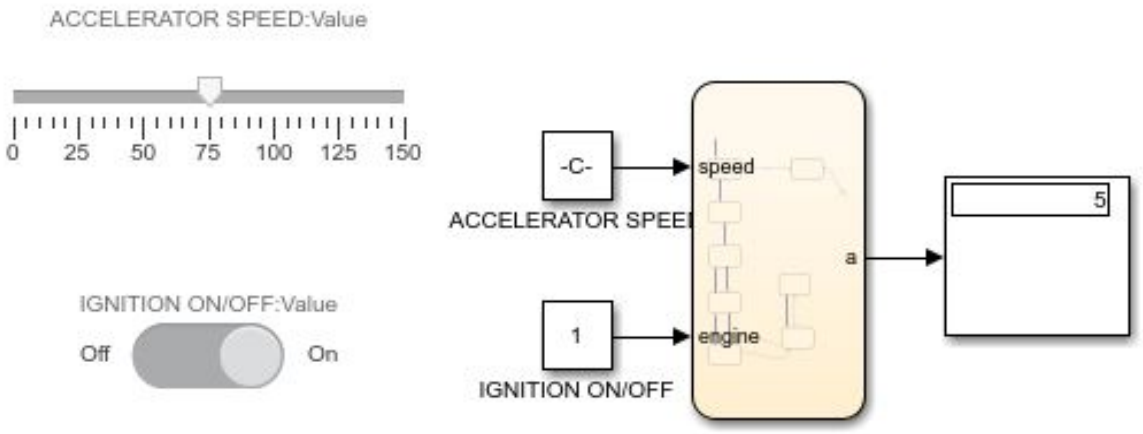

Fig 2 - Simulink block diagram for gear suggestion

Vehicle Model

A simulink model has been designed to capture the dynamics of the system and whether it can produce the desired results. Simulink's vehicle dynamics block has been used for the same. It provides blocks for the engine, transmission, and vehicle body. Vehicle speed can be observed for certain driving patterns as input

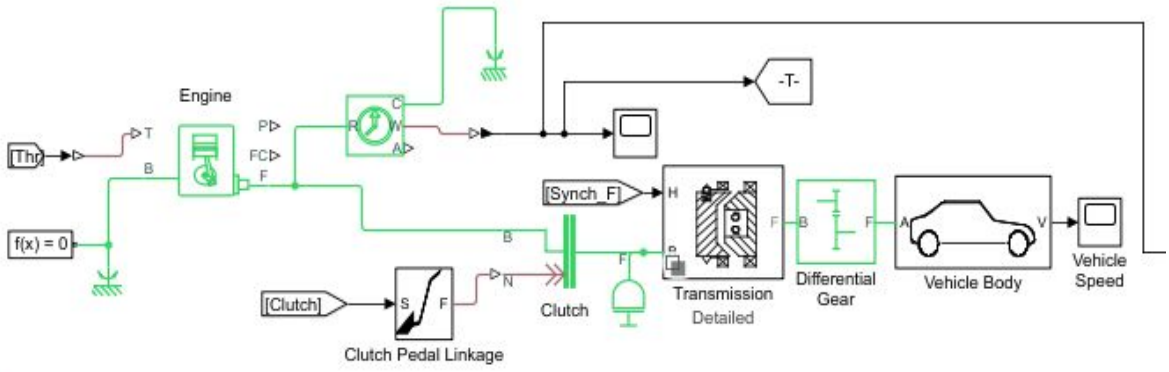

Fig 3 - Vehicle dynamics model - Simulink

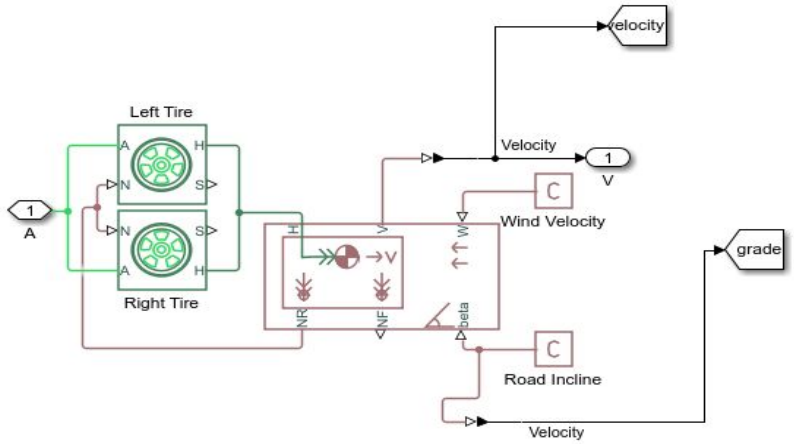

Fig 5 - Simulink block for vehicle body

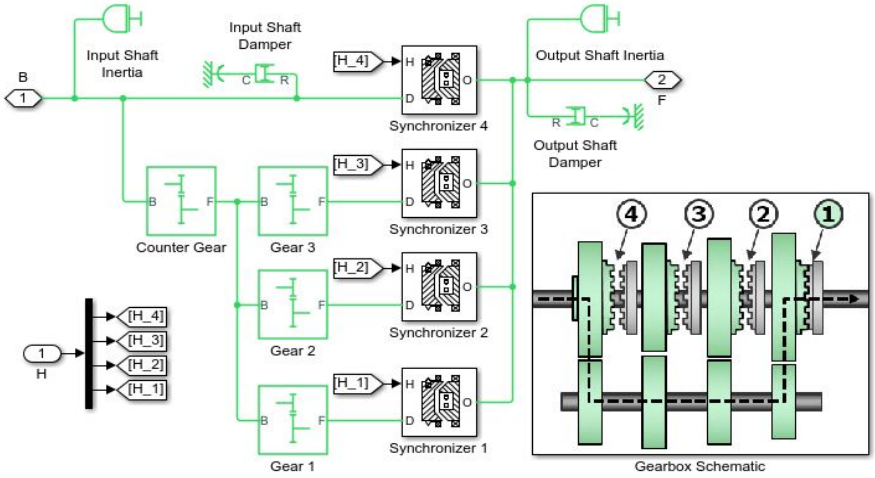

Fig 4 - Simulink block (detailed) for gear box

SYSTEM INPUTS (TEST CASE)

- Positive force/ pressure denotes actuation and negative - disengagement of gear/ clutch/ throttle
- The vehicle starts with clutch engaged
- Gear has been changed once from 1-2
- Throttle % age is increased after the gear is changed and clutch disengaged

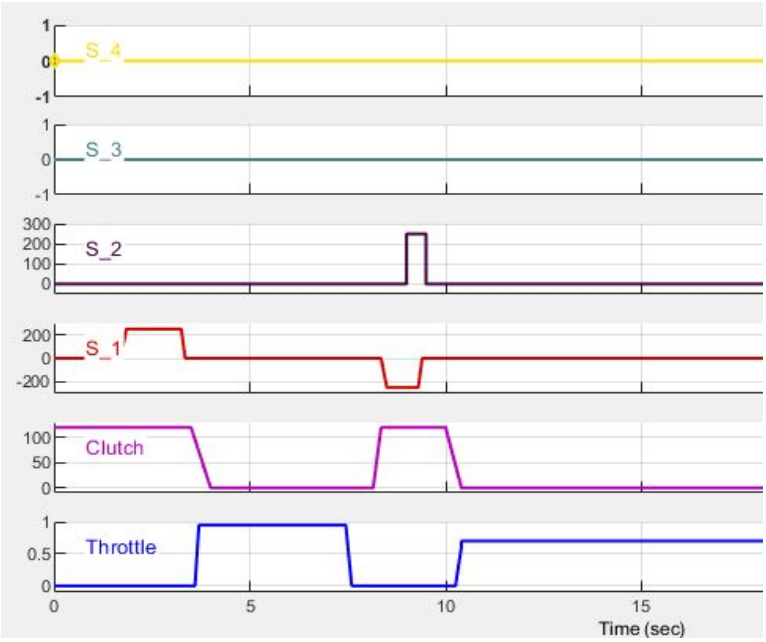

Fig 6 - System inputs to simulink model

RESULTS

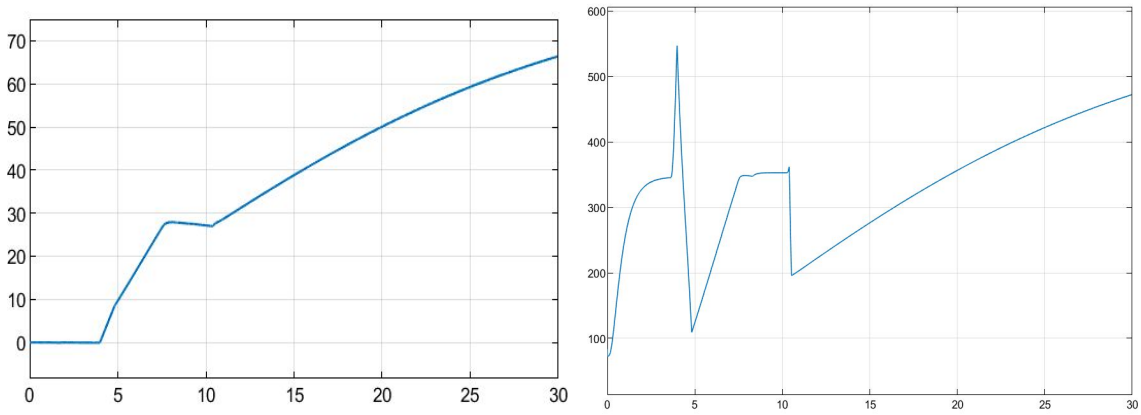

Fig 7 - performance of vehicle on standard given inputs

a) Vehicle speed b) Engine RPM

Integrating shift logic with vehicle Model

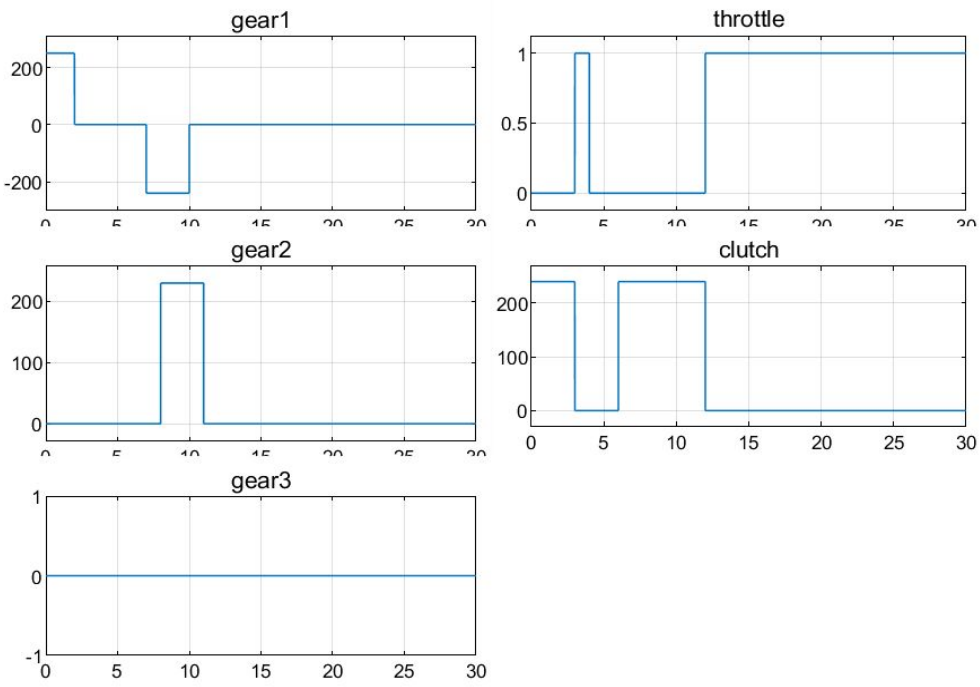

Fig 8 - Vehicle performance on automatic clutch actuation & gear shift

Simple logic which accepts a gear change request based on engine rpm has been written. The pedal force instantaneously has increased/ decreased which doesn't happen in reality. Ramp function needs to used other than sudden change of values.

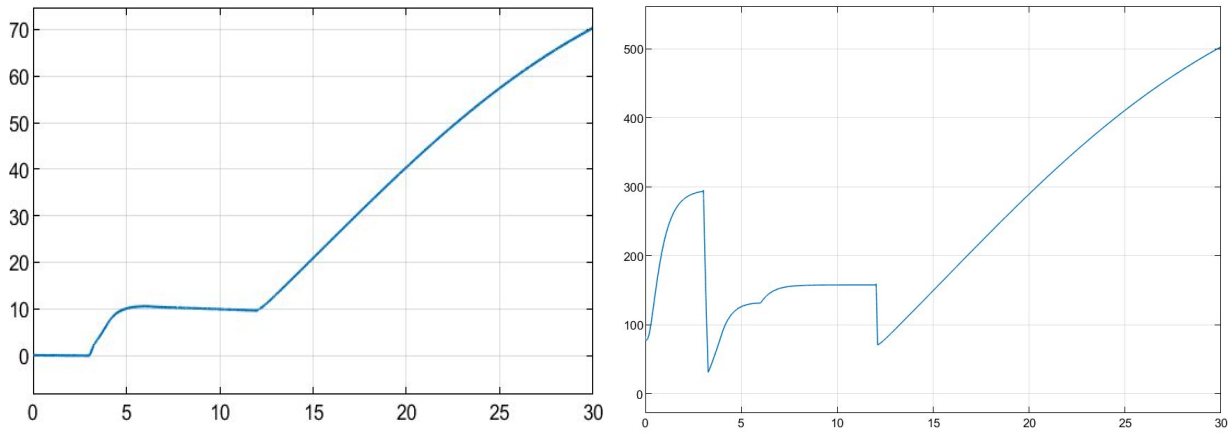

Fig 9 - performance of vehicle on automated logic

b) Vehicle speed b) Engine RPM

CONCLUSION & FUTURE SCOPE

A simple gear shift logic with engine rpm as input has been designed. Clutch actuation

has been performed appropriately engaging slightly before gear actuation starts and disengaging after it stops. Though AMTs provide many advantages, the sudden transition of torque delivered, slight jerk while shifting gears would still remain a problem unlike in the automatic transmission.

Primary goal would be to incorporate grade and design a much robust logic. Other alternatives which eliminate vision/ LIDAR based inputs are by using machine learning algorithms with appropriate feature vectors that capture the performance of the vehicle. They are the speed, acceleration, gear change frequency, etc vectors as inputs and corresponding clutch actuation, gear state vectors as their corresponding outputs. Such data set doesn't exist as of now, and needs to be created by using information from OBD2 port. Parameters like fuel efficiency can be used to evaluate the result

FUTURE SCOPE - VISION TECHNIQUES

Computer vision techniques to be used to obtain Traffic scenario and road conditions as input for gear shift logic. Either video with very low frame rate is continuously taken using a camera and using optical flow techniques, object detection is performed to state what percent of road is occupied.
The model could be trained using Siamese CNN. This gives the advantage of one shot detection - only one image of a new scenario is needed for it to be classified.

REFERENCES

1. The Analysis of Gear Shift Indicator Test Results - **Ivan A.Blagojević, Dragan D. Stamenković, Branislav B. Rakićević** - 2016
2. Development of Control System for Automated Manual Transmission of 45-kW Agricultural Tractor - 2020
3. Modeling and Simulation of Gear-Shift Controller for Automated Manual Gearbox Based on Neuro Fuzzy Control Logic - 2014
4. https://in.mathworks.com/help/stateflow/ug/implement-an-automatic-transmission-gear-system-by-using-the-duration-operator.html
5. Development of automatic clutch actuator for automated manual transmissions - 2005
6. http://automateindia.in/products/auto-clutch/
7. Controlled gearshift with automatic clutch actuator for vehicles with manual gearboxes