

**MIDDLE EAST TECHNICAL UNIVERSITY**

ELECTRICAL AND ELECTRONICS ENGINEERING DEPARTMENT

EE 462-EE 464 COMMON PROJECT

Design of a SM-PMSM Variable Frequency Drive with MATLAB/Simulink

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# 1.Introduction

# 2. Part A: Pre-design Stage

## 1.

We can calculate the base speed of the PMSM from the calculation of voltage on MTPA. The base speed equation in d-q coordinates is written as follows:

In addition, Sinusoidal-PWM modulation is applied to the system. This means that the output voltage is half of the DC voltage.

Also, inductances in the d and q axes are equal to each other in SM-PMSM.

Another situation is that in case of MTPA there is only current on the q axis. The current value on the d axis is zero.

Moreover, flux linkage is given as shown below:

So:

The base speed we found above is electrical. A pole pair is required to find the mechanical base speed. The pole pair is found as follows:

The mechanical base speed is found by the equation given below:

There is a gearbox in the system, with a ratio of 8.5. With the help of the following formula, the mechanical shaft speed which is referred to as the vehicle speed is found.

In the project definition, vehicle speed is expected in km/h. Therefore, we must first multiply the velocity we found in rad/s by the radius. Then we have to multiply by 3600/1000.

## 2.

The maximum speed of the motor is given in the project description.

In order to find the maximum electrical frequency applied, we first need to find the mechanical frequency. So we need to find the maximum speed in rad/s.

Now that we have found the maximum speed in rad/s, we can calculate its frequency as shown below:

As is known, the electrical frequency is greater than the mechanical frequency. The ratio between them depends on the pole pair. The electrical frequency is found as shown below:

The frequency modulation ratio should be chosen as an odd value that is not too high to reduce harmonic effects. In electric vehicles, this ratio is usually chosen between 8 and 12.

As a result, choosing this ratio as 11 would be a good choice.

# 3. Part B: Sinusoidal PWM

In this part, we are expected to implement a motor drive using sinusoidal PWM (Sine-PWM), and implement a cascaded speed and current controller using parameters

## 1.

In this section , firstly , we need to calculate the equivalent inertia and the load seen at the electric machine shaft. Also, there is a single speed gear box connected between electric motor and wheels with 8.5 gear ratio.

The equivalent inertia is found as follows :

We know the inertia on the wheel. But this inertia is on the load side. Therefore, we need to transfer this to the electric machine side with the gear ratio. We can do this as follows:

Now we need to calculate the inertia of the vehicle. Since the result we found will be on the load side, we need to transfer it to the electric machine side with the gear ratio.

Since all inertia values are found and transferred to the electric machine side, the equivalent inertia is as follows:

The load characteristics of the vehicle are given in the project description. Here is given as shown below.

However, we need to calculate the load torque seen at the electric machine shaft. So, to obtain load torque expression, we should multiply the expression of the load force by radius.

# 4. Part C: Component Selection

# 5. Part D: About the Project