Permanent Magnet Synchronous Motor Test Load

USN FRC EAST

PROBLEM STATEMENT

- Team 13's objective is to test a microcontroller using an electric load model that simulates a PMSM.
- The team will design and build the electric load model to take the place of the PMSM and be used to test the microcontroller provided by the sponsor.
- The final product will include the sponsor provided microcontroller, simulated motor model, and a circuit housing.

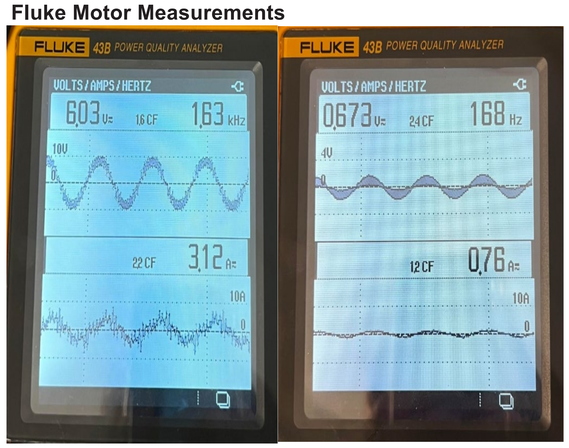
REQUIREMENTS

Req #	Requirement Description	Motivation
1	Determine if the micro controller and PMSM work under a simulated and mechanical physical load.	The sponsor wants to make sure that the controller is accurate under load conditions
2	The designed electric load model will test the controller at full range of the PMSM motor in increments.	The sponsor desires the electric load model to check the controller at every key point of start-up and operation.
3	The team will only create an initial prototype that will simulate the given permanent magnet synchronous motor with and without load.	The sponsor wants the team to concentrate on producing a working prototype for the provided controller, PMSM, and load.
4	The sponsor should be able to alter the prototype to make it applicable to varying size PMSM and loads.	The sponsor uses varying motors and loads. The team's research and prototype should be able to be applied to other PMSM motors and controllers.

CONCEPTS

- Parameterize the motor using ST software.
- Design the motor circuit in Simulink for use in D-Space simulation.
- Create a physical circuit using inductors and resistors to replace the motor.

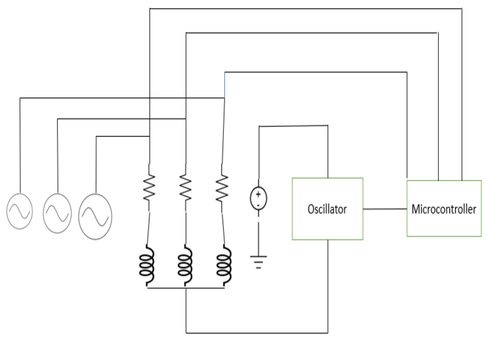
Fluke Motor Measurements



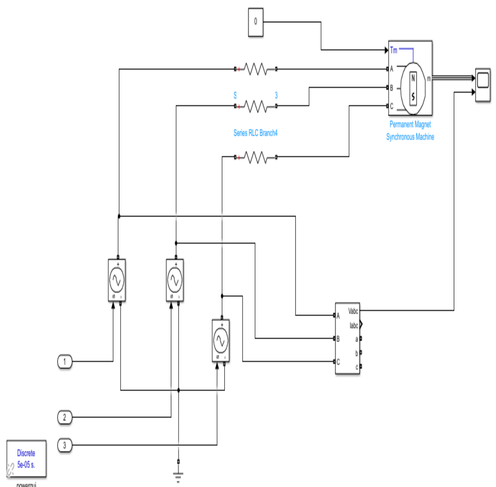
FINAL DESIGN, APPROACH, PLAN

- The team has followed two different approaches to try to create an electric load model that mimics the PMSM with and without a load.
- A physical circuit that was split into 3 phase branches, which used inductors and resistors to model the motor.
- In the physical circuit a microcontroller is used to read the frequency from the sponsor's microcontroller and synchronize the frequency of the back emf voltage.
- A Matlab Simulink model connected to the sponsor microcontroller using D-SPACE.
- The D-SPACE software sent voltages to the Matlab Simulink model

Electric Load Model Circuit



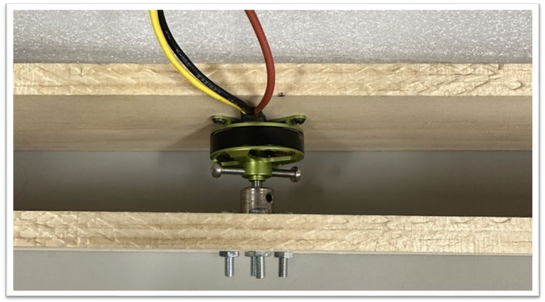
PMSM Modeled in Simulink



RESULTS

- The team successfully loaded and measured the motor's parameters.

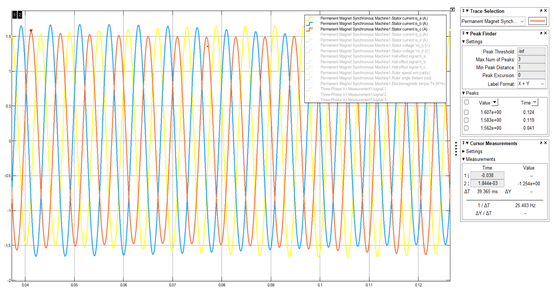
Load Testing Setup



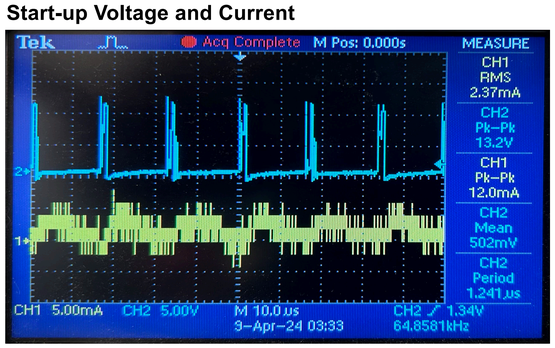
PMSM No Load Measurements

Measurement	Speed	Voltage	Amps	Power
	1400	0.673	0.76	0.51148
	2800	1.29	0.98	1.2642
	4200	1.9	1.21	2.299
	5600	2.493	1.41	3.51513
	7000	3.088	1.62	5.00256
	8400	3.671	1.87	6.86477
	9800	4.31	2.16	9.3096
	11200	4.85	2.47	11.9795
	12600	5.48	2.78	15.2344
	14000	6.03	3.12	18.8136
Unit	RPM	V	A	W

Simulink Peak Current Measurement



Start-up Voltage and Current



SUMMARY AND CONCLUSIONS

- The team aimed to test a provided controller by designing an electric load model resembling a Permanent Magnet Synchronous Motor (PMSM).
- The team pursued two main approaches:
  - Creating a Matlab Simulink model integrated with D-SPACE.
  - Constructing a physical circuit to replicate PMSM's current and frequency behaviors at different voltage levels.
- The team encountered several challenges:
  - Integrating the controller with D-SPACE and Simulink proved unsuccessful due to the controller's need for current feedback, while D-SPACE could only sense voltage.
  - Despite attempts to design a physical circuit, it couldn't accurately reproduce the intricate current feedback characteristics of the PMSM.
  - Unable to develop a design meeting the controller's feedback requirements.

FUTURE WORK

This project is unattainable for students at the bachelor level with the given time frame. The team believes that this project does not have a feasible working outcome, and that it should not be continued as it is. The team has conversed with two professors in the power industry, and both have explained that the goal of this project is impossible.

TEAM & ACKNOWLEDGEMENTS

- Andrew Holcombe Electrical Engineering
- Peyton Johnson Electrical Engineering
- Hernan Ramirez Electrical Engineering Concentration in Power
- Andrew Edney Mechanical Engineering

Project Mentors
- Richard Lawrence
- Jared Tucker
- Tarek Kandil
- Hayrettin Karayaka
- Martin Tanaka.

References

1. Carey, K. (2009). *Hybrid sensor less field oriented and direct torque control ...* Hybrid Sensor less Field Oriented and Direct Torque Control for Variable Speed Brushless DC Motors .
2. Krause, P. C., & Wasynczuk, O. (1989). Electromechanical Motion Devices (S. W., Ed.). MccGraw-Hill.