Linear Induction Motor

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I. Introduction

Overview

Design, construct, and test a linear induction motor (LIM) that will be powered by a three-phase voltage input, rotate a simulated linear track, monitor speed, output power, input frequency and have a controllable output speed.

Objective

The project objective is to design and implement a linear induction motor to rotate a simulated linear track.

Motivation

Build off of the magnetic levitation senior project previously completed in 2013. Gaining a greater knowledge of three-phase AC induction motors and electromagnetic properties.

Significance

- Understanding how pole pitch and number of poles affect the output speed of an induction motor.
- Developing a method for the creation of a linear induction motor.
- Development of linear equations that are not necessarily available today.
- Gaining a greater understanding of magnetic flux and how induced currents can produce force.
- Working as a team to reach a common goal.

Applications

- High-Speed Magnetic Monorails
- NASA Space Ship Life Off
- Rail Guns
- Roller Coasters
- Other Magnetic Levitation Applications

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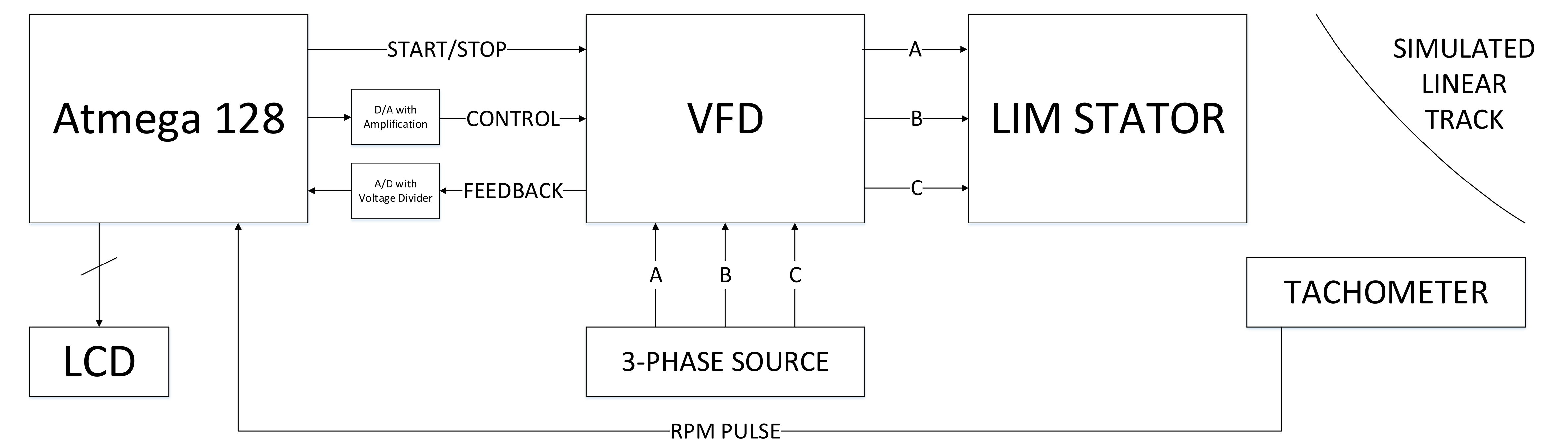
II. Methods

System Block Diagram



Turns Per Phase

$$T_{ph} = \frac{P_{out}}{6.66\{p n_{ms} B_{ag} A_p k_w I_{ph} \eta (PF)\}}$$

P_{out} = Output Power
p = Number of Poles
n_{ms} = Mechanical Cycles per Second
B_{ag} = Average Air – Gap Flux Density per Pole = 1.1 [T]
A_p = Cross – Sectional Area of Pole Faces = 0.0346 [m]
T_{ph} = Number of Turns per Phase
k_w = Coil Winding Factor = 0.86
I_{ph} = Input Phase Current = 3 [A]
η = Efficiency = 0.6
PF = Power Factor = 0.7

Air-Gap

With the mounting solution implemented the group was able to achieve an air-gap of 1/16". Originally the air-gap was assumed to be at least an 1/8". To help achieve this smaller air-gap the screws on the simulated linear track were updated with screws that have a lower head profile. A smaller air-gap will improve the efficiency of the overall system, allowing for less flux leakage losses.

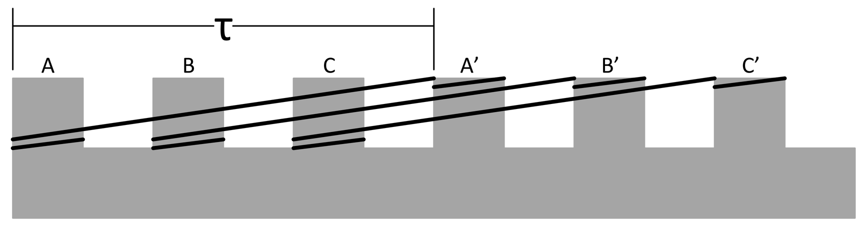
Pole Pitch

$$U_s = 2\tau f$$

U_s = Linear Synchronous Speed $[\frac{m}{s}]$
τ = Pole Pitch [m]

$$\tau = \frac{L}{p}$$

L = Arc Length
p = number of poles



Rotary to Linear

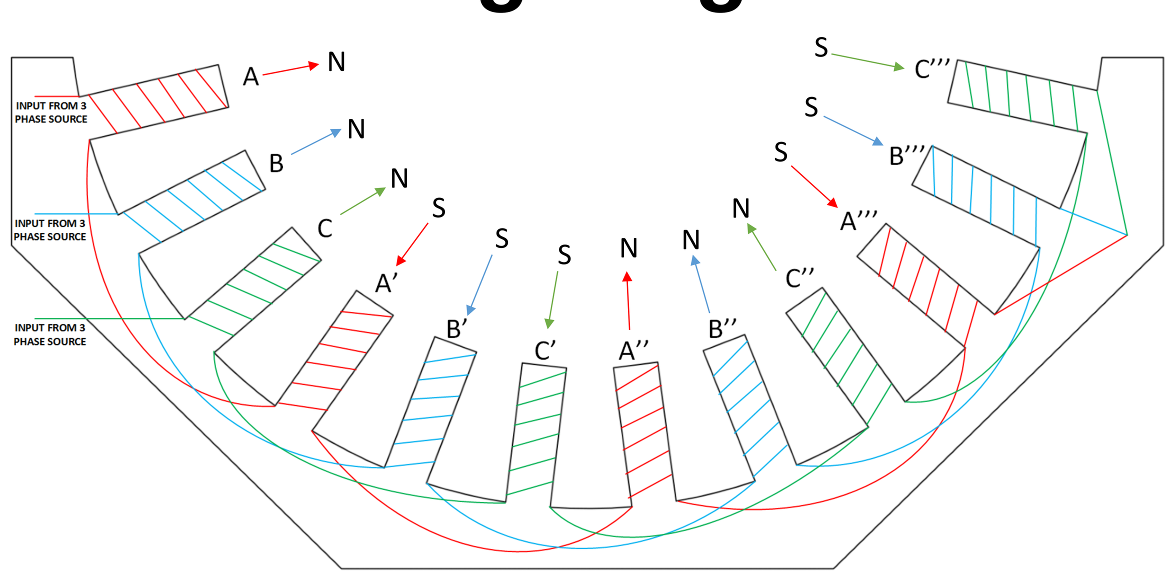
$$v = r\omega\left(\frac{2\pi}{60}\right)$$

v = Linear Velocity $\left[\frac{m}{s}\right]$
r = Radius of Rotor [m]

$$\omega = \frac{120f}{p}$$

ω = Rotational Speed of Rotor [rpm]
p = Number of Poles
f = Input Frequency [Hz]

Wiring Diagram



III. Results

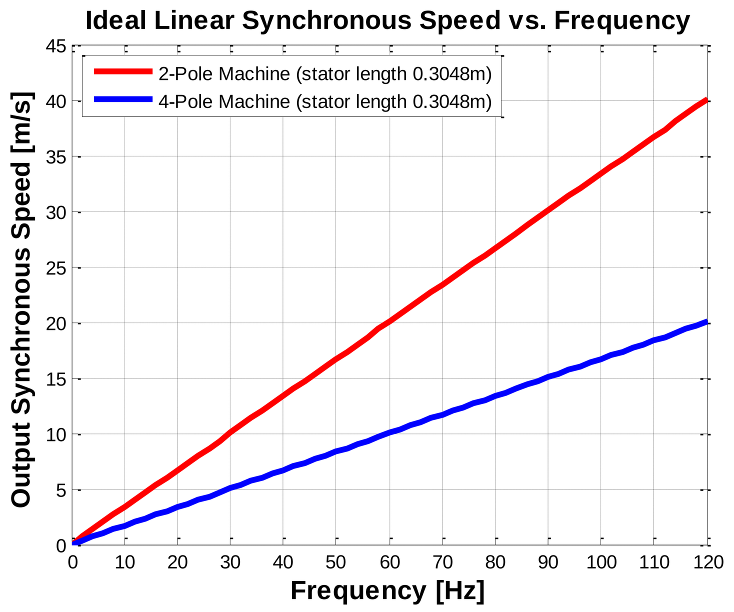
- Currently Stator is not rotating wheel
- Higher current flowing through coils than expected
- Assuming it is due to lack of balanced load

Coils

Issues associated with the coil construction were the time to wind a coil and the structural integrity of the coils. The theoretical turns needed per stator tooth to rotate the wheel at a maximum speed of 1,200 rpm is 213 turns per tooth. The final result was 4 layers of windings with 235 wraps per stator tooth.

Variable Frequency Drive

- 0-120 Hz frequency range.
- Achieved up to 30 Hz on a 208 volt input with the current draw being 5 amps.



Acknowledgements

Special thanks to Illinois Switchboard and Laser Laminations for providing the materials to create this linear induction motor.

IV. Conclusion

The Linear Induction Motor provides a base for future work to be done.

- Reinstall magnetic levitation system.
- Update wheel and mounting solution for a more balanced wheel and smaller air-gap.