Advanced Induction Machine Topics

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Performed: February 27th 2020
Written: March 5th 2020

1 INTRODUCTION

The objective of this lab was to continue our interaction with induction motors and learn more about them. We again used a machine with a dynamometer connected to it to set specific speeds and torques. We learned about speed control of induction motors using varying frequencies and also how the torque-speed curve is generated.

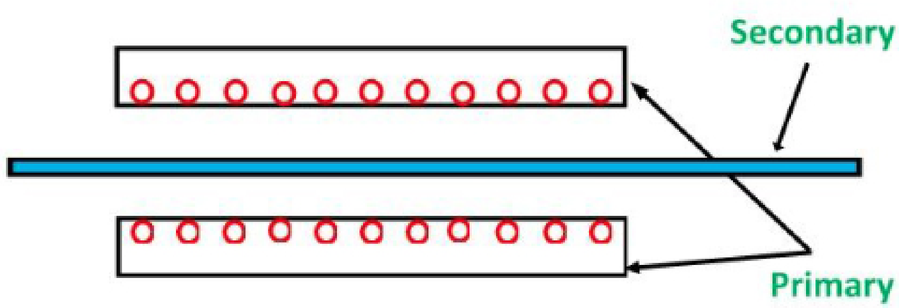
All data/measurements taken are provided in the appendix at the bottom of the document.

2 RESULTS

2.1 *Linear Induction Machine*

The first part of this lab was viewing a demonstration of a linear induction motor, specifically one that was double sided. A diagram can seen below:

Fig.1 Linear Induction Machine



The secondary is an aluminium plate and the primary is a metal with coils in it. The machine we used was a 3 phase machine. The way the machine moves the secondary is by using magnetic fields similar to a reluctance machine (motor) however instead of a rotating field it is a linearly translating field. The coils are excited in a sequence that pulls the secondary in the direction the coils are being excited in.

2.2 *Speed Control*

In this part of the lab we varied the frequency at no load to see a difference in the speed while observing current and voltage. Below are screenshots of oscilloscope from 2 different frequencies, 60Hz and 70Hz respectively.

Fig.2 60Hz Waveform

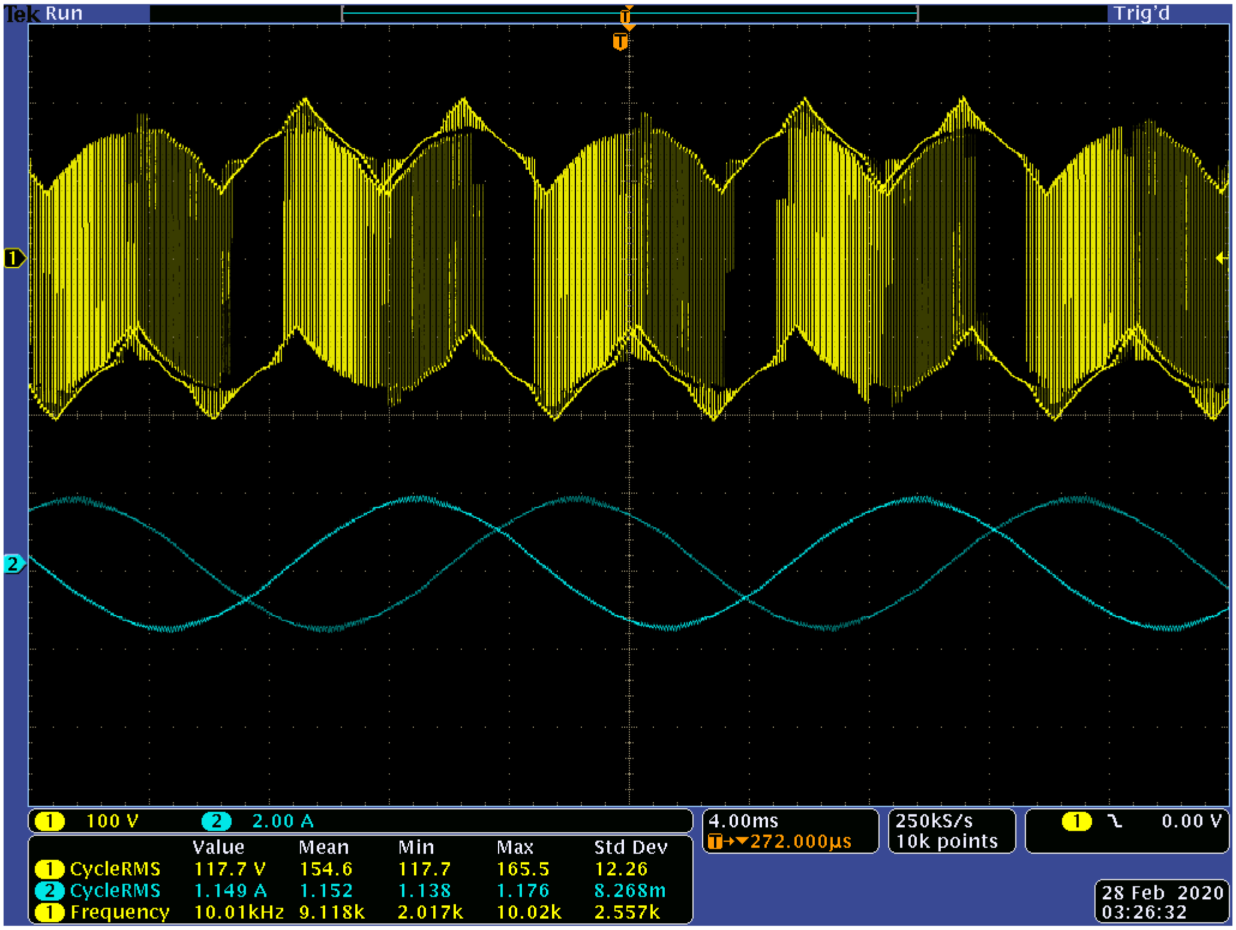
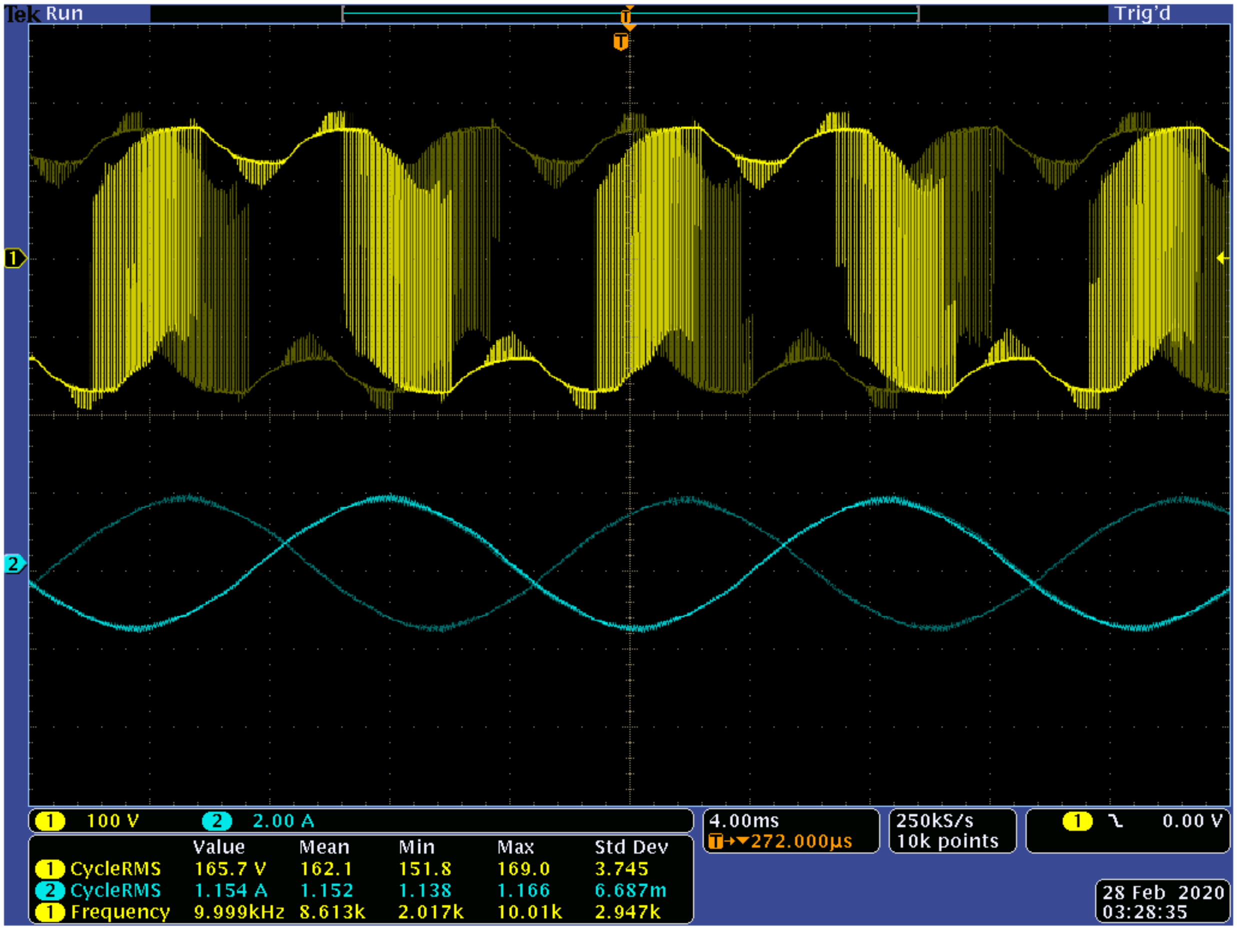


Fig.3 70Hz Waveform



It is visible that the current has a sinusoidal waveform for both the frequencies however voltage is higher on the 70Hz one because it means that the motor sees more pulses.

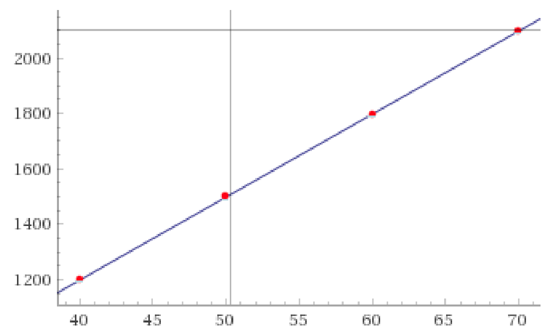
Data collected from the this test is in the table below:

Table 1: Speed Control Data

Frequency (Hz)	Voltage (V)	Current (A)	Speed (RPM)
40	121	1.29	1198.8
50	133	1.23	1498.5
60	141	1.15	1797.9
70	147	.968	2097.7

It can be seen that voltage increases for higher frequencies by current actually drops. This makes sense because since there is no extra load being applied the current does not need to rise too. If we plot this data we can see a nice relationship:

Fig.3 Speed vs. Frequency Graph



The line is very linear and a good fit to the data collected. The speeds match what we expect because 60Hz has close to 1800RPM speed and 40Hz has exactly 2/3 of that which is 1200RPM.

2.3 *Torque-speed Curve*

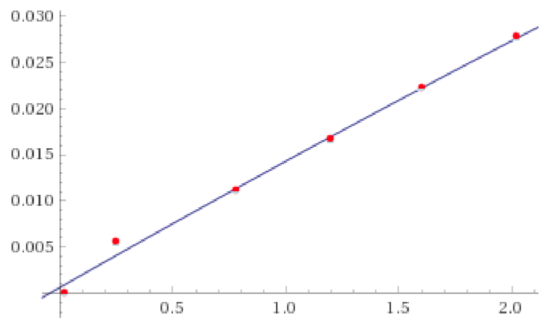
In this part of the lab we used the dynamometer to set the speed close to synchronous (3600RPM) and drove the induction motor with it. We proceeded to take measurements between 3500-3700 speeds to see how it affects slip, torque, current draw and voltage.

Table 2: Speed-Torque Curve Data

Speed (RPM)	Torque (Nm)	Vab (V)	Vcb (V)	Ia (A)	Ic (A)	Slip
3500	2.02	202.5	202.7	3.5	3.6	0.0277
3520	1.6	203	203	3.1	3.1	0.0222
3540	1.2	203	203.4	2.69	2.73	0.0166
3560	.78	203.5	203.9	2.33	2.38	0.0111
3580	.25	204	204.5	2.07	2.10	0.0055
3600	.02	204.3	204.8	1.98	1.96	0
3620	.5	205	205.7	2.05	2.06	-0.0055
3640	1.2	205.6	206	2.33	2.31	-0.0111
3660	2.27	206	207	2.7	2.62	-0.0166
3680	3.00	206.7	207.1	3.2	3.1	-.0222
3700	3.65	207	207.5	3.66	3.57	-.0277

Again it is visible that as speed increases voltage constantly increases, however current actually decreases until synchronous speed is reached because that is what the motor want to run at, over that speed current increases again because it has to provide extra torque to spin.

Fig.4 Slip vs. Torque Graph (Slip > 0)



The slope of this line is .0139 which makes sense as it is close to the value we expected. Usually we plot Torque on the Y axis so that would give us a slope of 71.9, which again makes sense because if we have a very small slip then we would get a small torque as expected. From experiment 4 we know that if we were holding voltage around 205V then our slope would be:

$$Torque_{\text{small slip}} = \frac{3 \cdot V^2}{\omega_e(r_2 + R_{\text{ext}}} \frac{P}{2} = \frac{3 \cdot 118.4^2}{120\pi(1.25)} \frac{2}{2} = 89.17$$

Equation 1.

This is relatively close to our measurement value, the error occurs because the speed recorded is not exactly correct and the slip value is actually different. However, we know that our measured value is close enough to acceptable.

For the last part of the lab we had to vary speed from 3000-3900 to get rated current to flow (5.2A) however we never got rated current to flow because at 3000RPM we had the following data and increasing speed decreased current:

Table 3: Speed-Torque Curve Data Part 2

Speed (RPM)	Torque (Nm)	Vab (V)	Vcb (V)	Ia (A)	Ic (A)	Power (W)
3000	.970	77	76.9	4.89	4.86	570.8

The TA told us since we did not reach rated current to not go below the 3000RPM limit. I do not know how I can plot Torque vs Speed for this part. However computing max torque from equation (4.19) is still possible:

$$MaxTorque = \frac{3 \cdot V^2}{2\omega_e(r_1 + \sqrt{r_1{}^2 + (x_1 + x_2)^2})} \frac{P}{2} = \frac{3 \cdot 132.8^2}{240\pi(1.32 + \sqrt{1.32^2 + (3.58)^2})} \frac{2}{2} = 4.58Nm$$

Equation 2.

3 CONCLUSION

This lab gave us a good look into speed control of induction motors. The experiments we did showed the benefits of using induction motors and their ease to control using frequency modulation. Further we also inspected torque vs speed, and saw how voltage and current were affected when they changed. It made a lot of sense and was well connected to what we learned in lecture and tied it in well.

4 REFERENCES

[1] P.W. Sauer, P.T. Krein, P.L. Chapman, *ECE 431 Electric Machinery Course Guide and Laboratory Information*, University of Illinois at Urbana-Champaign, 2005.

5 APPENDIX

Raw Data: