Naomi Echo

ME 476C

Analytical Analysis

Due: 4-25-25

Introduction

For my analytical analysis I used MotorCAD to calculate the effects of changing the number of turns in a coil. This analysis will inform our design by being able to categorize the effects to the voltage, current, and torque by testing different numbers of turns. From these results I will then be able to calculate the Kv rating and power output.

Equations

The Kv rating of a generator refers to the maximum power output of a generator. This is caluctated by using the equation below. The .95 term is to make the calculated results more accurate in an experimental aspect[1].

$$K_V = \omega_{rpm}/(V_p *.95)$$

$$V_p = \ Peak\ Voltage$$

$$\omega_{rpm} = RPM\ of\ the\ Motor$$

To calculate power I used this equation:

$$P = \sqrt{}(3 * V * A * PF)$$

$$V = Peak\ Voltage$$

$$PF = \ Power\ Factor$$

$$A = Current(amps)$$

I created a MATLAB function to be able to easily calculate these values, as seen below:

```
%kv and power calculator
%change r,V, and A value
r=3000;%rmp of motor
V=17.1;%peak voltage of the motor
PF=.8; %power factor
A=5; %amps
kv=(r)/(V*.95);
power=(sqrt(3)*V*A*PF); %Watts
display(kv);
display(power);
```

<u>Analysis</u>

To analyze the Kv rating and power output I used MotorCAD to model different variations of the same motor to understand how the number of turns in a coil affects the Kv. I performed three different tests on a motor with an inner stator and outer rotor with 14 magnets and 12 slots. I did a test with 12, 25, and 50 turns. These four tests all ran at 1200 rpm and a peak current of 5 amps.

12 Turn:

This simulation gave an output of a peak voltage of 1.54 and a torque of .0105. The Kv was calculated to be 2.05E3 and a power of 13.3W. In the figures below it can be seen that the sin waves in the voltage and current graphs are not completely symmetrical which is an indicator that this motor would not run well. The torque graph is also very choppy, meaning that it has small and large bumps instead of a perfectly symmetrical graph.

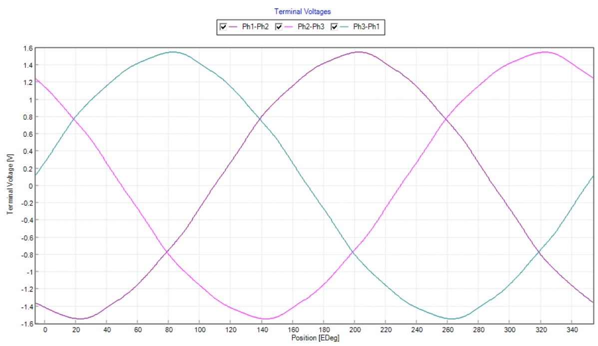


Figure 1: Voltage of 12 Turn

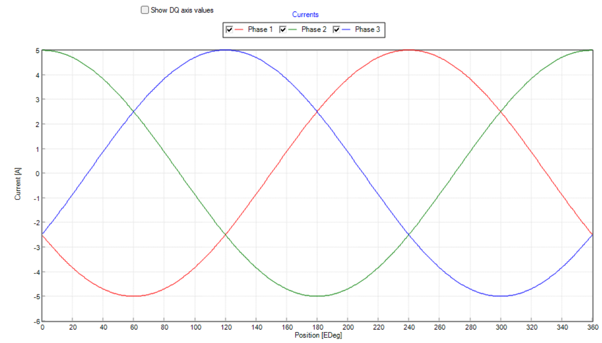


Figure 2: Current of 12 Turn

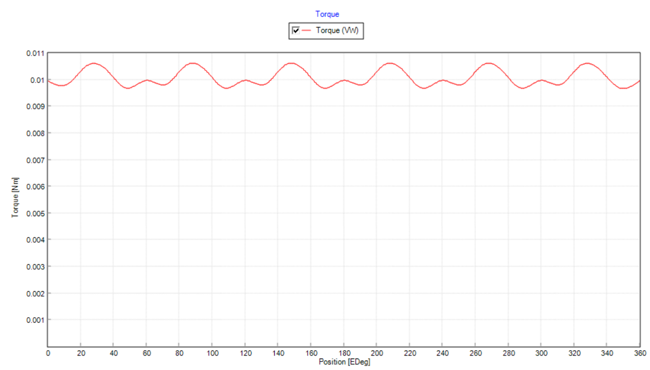


Figure 3: Torque of 12 Turn

25 Turn:

This simulation gave an output of a peak voltage of 5.04 and .0222 Nm of torque. The Kv calculated is 250 and 34.9 watts. The sin waves in the voltage and current graphs below have relatively symmetrical sin waves, although there are small ripples within the waves. The torque graph does not have bumps that are all symmetrical so this is not the best choice.

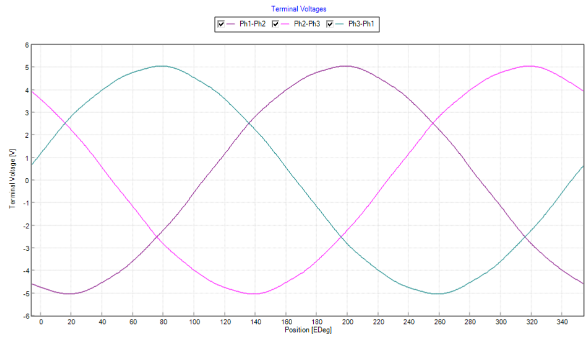


Figure 4: Voltage of 25 Turn

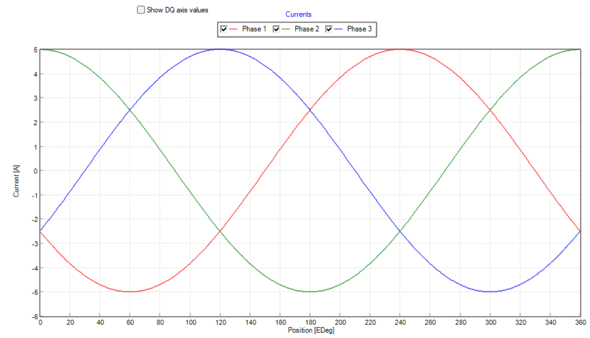


Figure 5: Current of 25 Turn

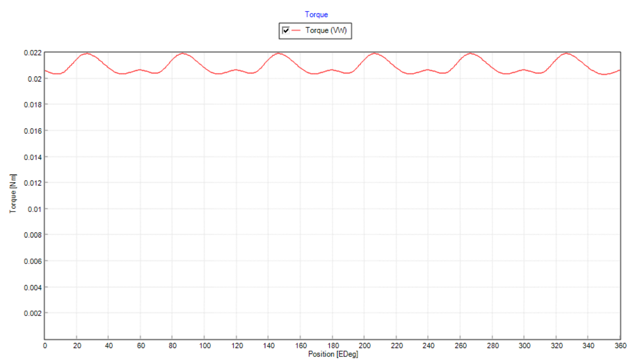
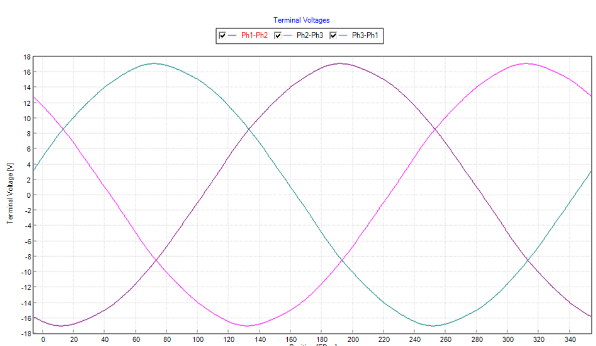


Figure 6: Torque of 25 Turn

50 Turn:

This simulation produced a peak voltage of 17.1 and .043 Nm of torque. The Kv calculated 184.67 and 118.47 watts. The sin waves in the voltage and current graphs below are very symmetrical and do not have any major ripples within the waves. The torque graph has symmetrical waves as well, this is a good indicator that this number of turns is a good choice.



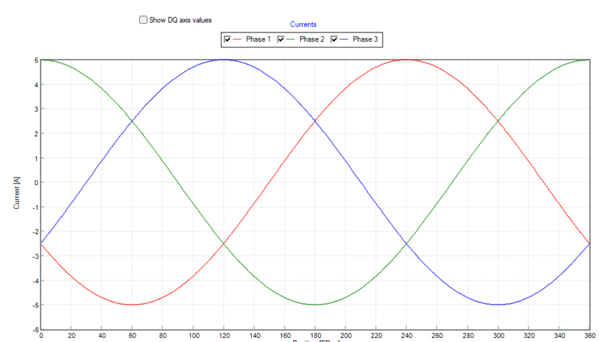


Figure 7: Voltage of 50 Turn

Figure 8: Current of 50 Turn

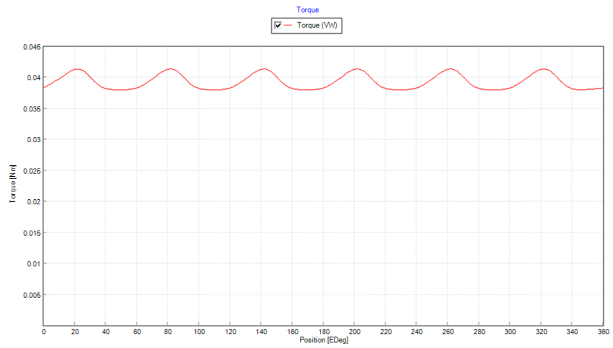


Figure 9: Torque of 50 Turn

Conclusion

From this analytical modeling it is safe to conclude that a high number of turns in a generator will reduce the Kv and increase the power output. There is a direct correlation to the torque and voltage, the higher torque produces a higher voltage is produced which as a result the Kv gets lower and the power output gets higher. MotorCAD has been a great tool to model this correlation and help me understand how it is all connected.

References

[1] Staff, General. “How to Calculate Motor KV & Motor Poles.” *Tyto Robotics*, Tyto Robotics, 11 Oct. 2023, www.tytorobotics.com/blogs/articles/how-to-calculate-motor-poles-and-brushless-motor-kv#:~:text=Motor%20Kv%20provides%20a%20way,motor%20with%20the%20applied%20voltage.