DC Machine Equivalent Circuit

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1 INTRODUCTION

The objective of this lab was to understand the parameters and equivalent circuit of a DC Machine. This is somewhat similar to the last lab of a brushless DC motor, however the control of the machine is different. The lab also goes through speed control of the machine and how resistances can be varied to do so.

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

2 RESULTS

2.1 *Machine Characterization*

In this section we go through and measure different parameters of the machine to develop our equivalent circuit.

By taking measurements using an ohmmeter we can get the resistances:

R_f = 118 ohms

R_a = 5 ohms

R_s = 0.75 ohms

After getting these parameters we turn the DC machine with a dyno and measure the outputs:

When the field line is open and at a speed of 1150RPM, we get a residual voltage of -5.2V.

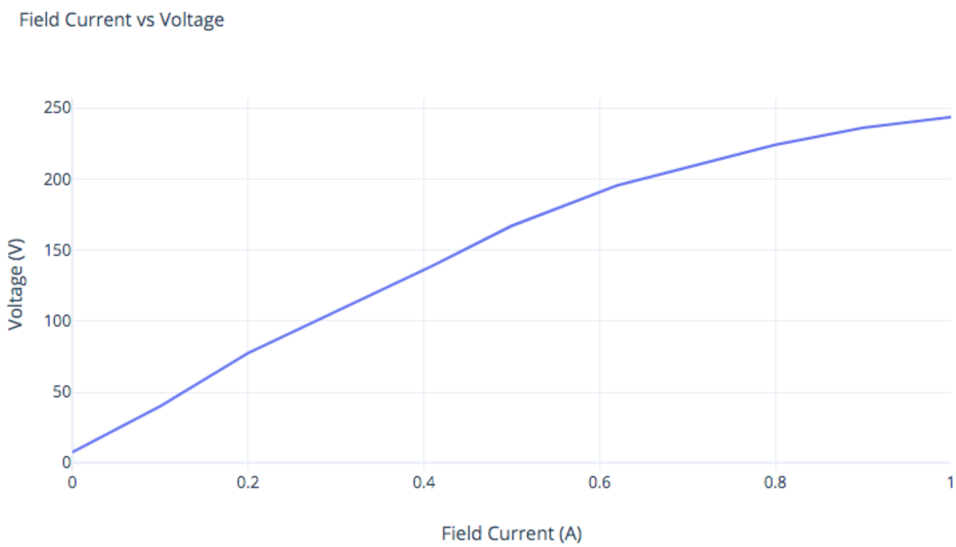
We can then close the twich on field line and manipulate field resistance to increase field current and see the change in voltages:

Table 1: Field Current and Terminal Voltage

If (A)	Voltage (V)
0	7.75
.1	40
.2	77.35
.32	113
.41	139
.5	167
.62	195.5
.8	224
.9	236
1	243.6

We can plot the above data and get this result:

Figure 1: Field Current vs Terminal Voltage



From this data we can find λ_R and $K^{SH}{}_f$ with this equation:

For a shunt machine:

$$E_{as} = K^{SH}{}_f \cdot \omega \cdot I_f + \lambda_R \cdot \omega \qquad \textbf{Equation 1.}$$

So λ_R = **0.064** and $\mathbf{K^{SH}{}_f = 2.05}$

After this we can run the machine with a load at rated voltage and take more measurements:

Table 2: Running Machine as Generator with Load

Rl (ohms)	If (A)	Voltage (V)	It (A)	Speed (RPM)	Torque (Nm)
open	.944	240V	0	1150	2.6
500	.92	234.7	.453	1150	3.4
250	.895	229.94	.89	1150	4.2
166.67	.875	225	1.3	1150	4.95
125	.85	220	1.7	1150	5.64
100	.83	214.9	2.1	1150	6.24
83.3	.81	209.4	2.43	1150	6.8

Then we can reverse the field connections and repeat the above measurements so that we can determine which series field connection results in a cumulative-compound machine (connection that provides highest terminal voltage):

Table 3: Running Machine as Generator with Load [Reversed]

Rl (ohms)	If (A)	Voltage (V)	It (A)	Speed (RPM)	Torque (Nm)
open	.92	239	0	1150	2.55
500	.91	236	.45	1150	3.4
250	.9	233	.9	1150	4.3
166.67	.89	231	1.33	1150	5.15
125	.88	228	1.75	1150	6
100	.87	225	2.16	1150	6.8

With this data and what we got from Part A we can calculate $\mathbf{K^{SE}{}_f}$.

Taking the average value of the readings from part B we get a value of $\mathbf{K^{SE}{}_f}$ = 0.12

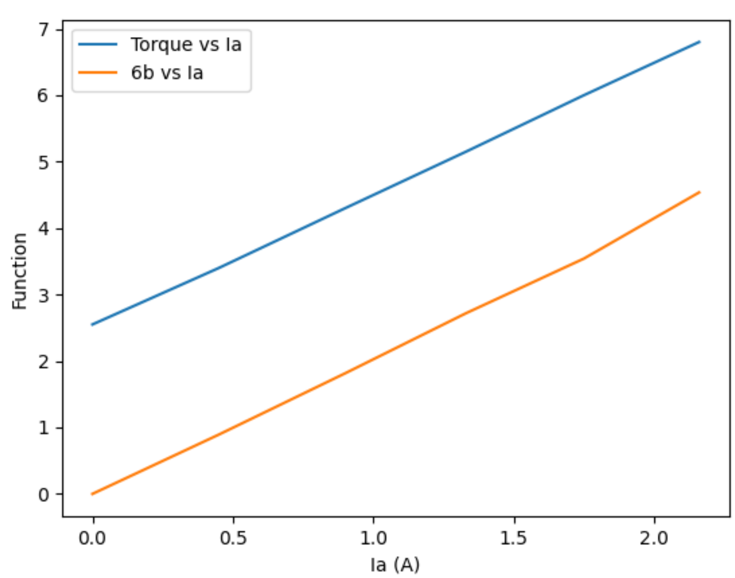
With this we get the following parameters:

Table 4: Circuit Parameters

Ra	5 Ohms
Rs	.75 Ohms
Rf	118 Ohms
$K^{SH}{}_f$	2.05
$K^{SE}{}_f$	0.061
λ_R	0.12

Next we can plot what is asked in question 6:

Figure 2: Functions vs Ia



We can see that both the plots are relatively the same and have the same slope. This is because the quantity in 6b is actually just the torque equation as it is $P_{FROM_{Shaft}}/\omega$

3 CONCLUSION

This lab gave us a good look into DC machines and how they are operated to work like we want. The experiments we did showed us how to measure the different characteristics of the machine. This lab was short yet very interesting. The questions in the remote were easy to understand and made sense to what we were actually calculating. Very fun and insightful lab overall.

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: All the data used is presented in the tables.