UNIVERSITY OF CAPE TOWN

Department of Electrical Engineering

EEE4117F – Electrical Machines and Power Electronics

DC Motor Speed Control Lab Report

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09th June 2020

Declaration

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2. I have used the IEEE convention for citation and referencing. Each contribution to, and quotation in, this report from the work(s) of other people has been attributed, and has been cited and referenced.
3. This report is my own work.
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AIM:

To exercise how to measure the armature resistance and learn how the speed of a separately exited dc motor is proportional to the armature voltage and determine the torque-speed curve of a separately exited dc motor and obtain a group of these curves for different armature voltages in the different motor control quadrants to see how the torque-speed may be controlled by armature voltage control.

EXPERIMENTATION:

A Virtual laboratory was set up to conduct the experiments of speed control on DC motor using the virtual laboratory web application: http://lvsim.labvolt.com with the access code "D132E-45BBB-B1331-D297F" to access the application.

The set up involved a DC Motor/Generator coupled to a Prime mover/Dynamometer, with a power supply and a Data Acquisition Interface module. Figure 1 depicts these modules and how they are connected to one other using the schematic shown in Figure 2. The metering icon on this web application as shown in Figure 3 was used to record the values of Armature voltage Vt [shown by M1], Armature current Ia [shown by M7] and Field current If [shown by M8]. M6, M12 and M18 represented Torque, Speed and mechanical power respectively.

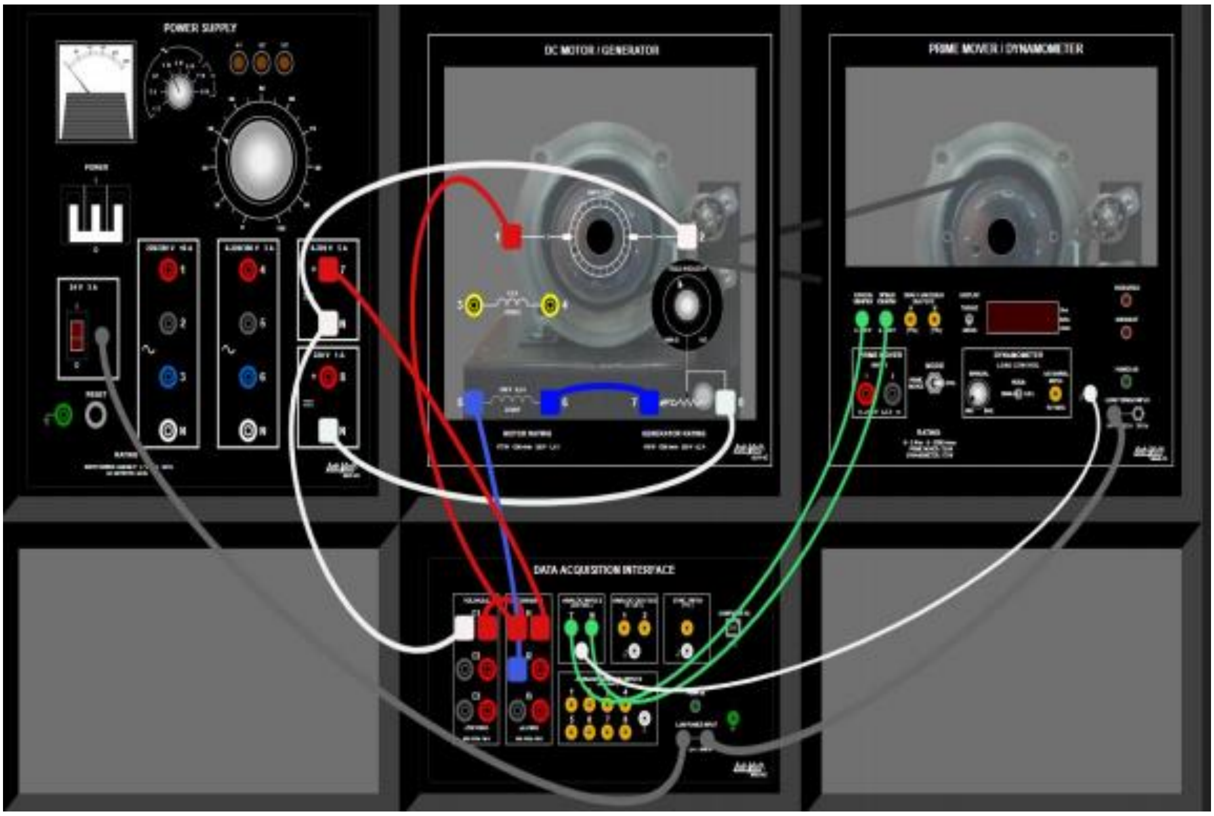


Figure 1: Shows the modules and their connections

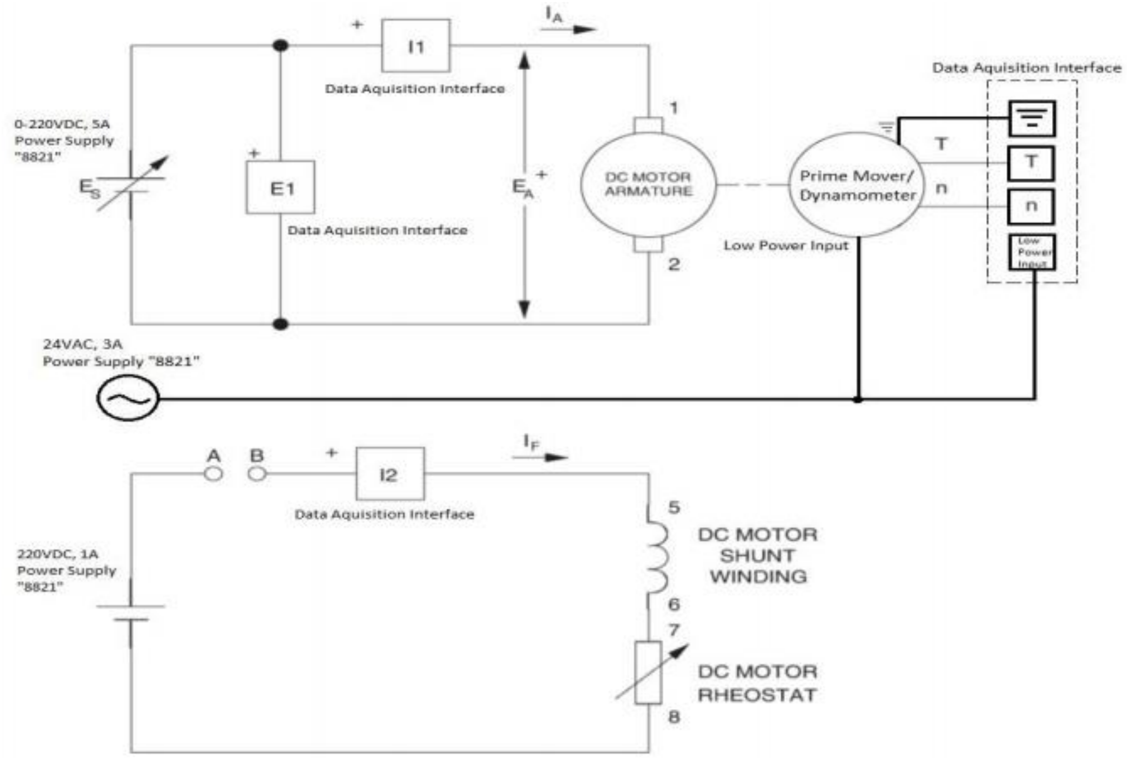


Figure 2: Schematic of the Circuit Diagram

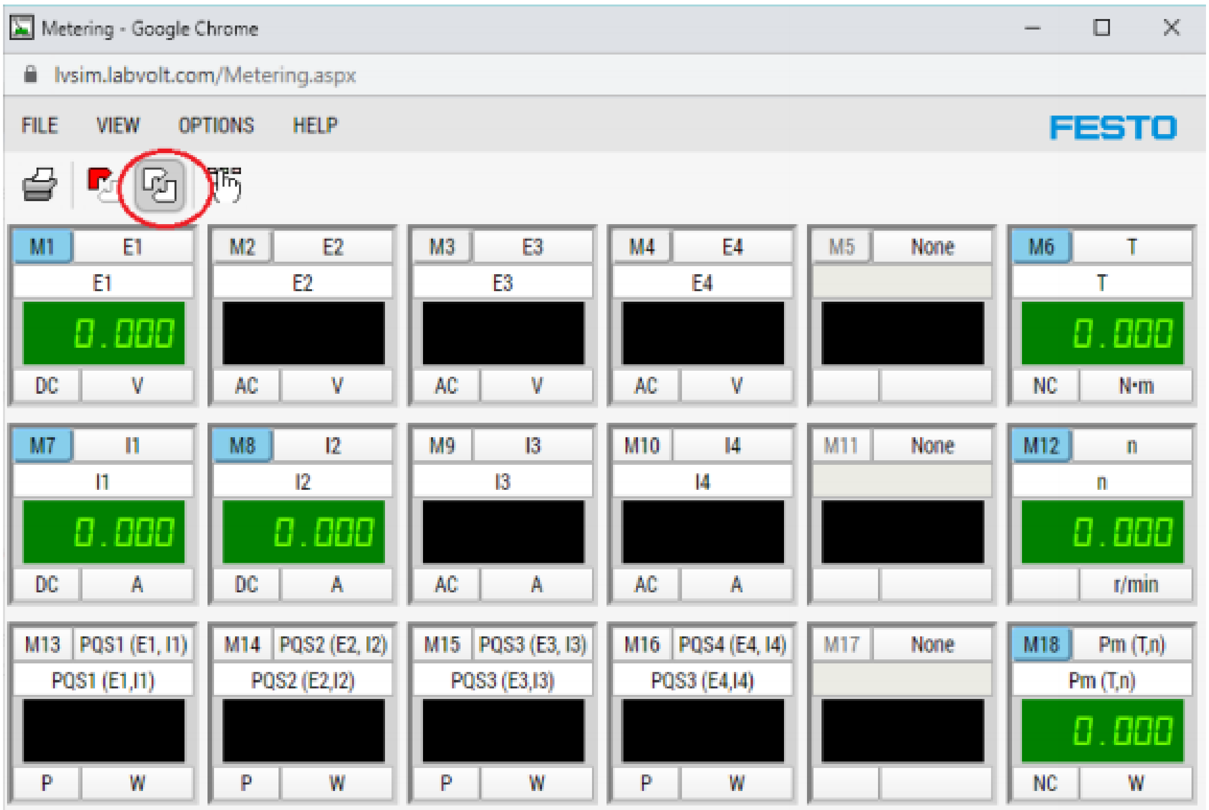


Figure 3: Metering tool used to record values

The main breaker of the power supply was now turned ON and while monitoring meters, the "voltage control knob" was increased until the armature current Ia reached to the rated current value of 1.5A. The following measurements were obtained:

Vt [V]	42.73 V
Ia [A]	1.5 A
Ra [ohms]	28.5 Ω

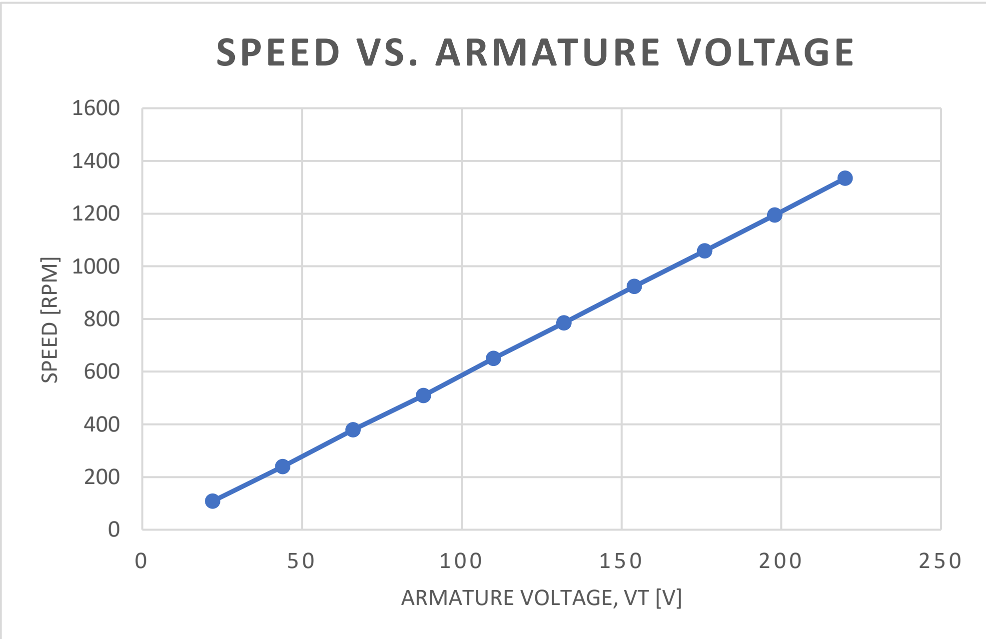
Motor Speed versus the Armature voltage:

Now the 24VAC switch and the main breaker of the power supply were turned ON and while monitoring the meters, a field rheostat was adjusted using the "field rheostat control knob" so that the filed current If, was equal to 190mA. The Armature voltage Vt was then increased by the "voltage control knob" of power supply to rated armature voltage in steps and the following table was filled:

Step	**Vt [V]**	**Ia [A]**	**Speed, n [rpm]**	**If [A]**	
1	22	0.18	108.2	0.19	
2	44	0.198	240.2	0.19	
3	66	0.213	379.5	0.19	
4	88	0.228	509.8	0.19	
5	110	0.237	650.5	0.19	
6	132	0.248	785.3	0.19	
7	154	0.255	923.7	0.19	
8	176	0.264	1058	0.19	
9	198	0.27	1195	0.19	K1 = [n10 - n9] / [Vt10 - Vt9]
10	220	0.276	1334	0.19	K1 = **6.318182**

Table 1:Values obtained from Motor Speed vs Vt variations

Question 1:



Graph 1: Plot of Motor speed as a function of Armature Voltage

Question 2:

Vt = Ea + IaRa;   Vt = k*w + IaRa

w = [1/k]*Vt – [1/k]*[IaRa]; where: k = 6.32, Vt = 42.73V, Ra = 28.5Ω

w = 0.158*42.73 – 0.158*28.5*Ia

w = 6.75 – 4.503*Ia

@Ia = 0.5A; w = 4.5 rpm

@Ia = 1.0A; w = 2.247 rpm

@Ia = 1.5A; w = 0.0045 rpm

Thus, the DC motor speed decreases when the armature current increases stating that the motor speed is inversely proportional to the armature current.

<u>Motor Torque versus Armature current and speed in different armature voltages in the 1st motor control quadrant (forward driving):</u>

24VAC switch and the main breaker of the power supply were turned ON with an adjusted field current of "190mA". While monitoring the meters, the armature voltage was adjusted so the speed was equal to 1500 rpm and following table was filled:

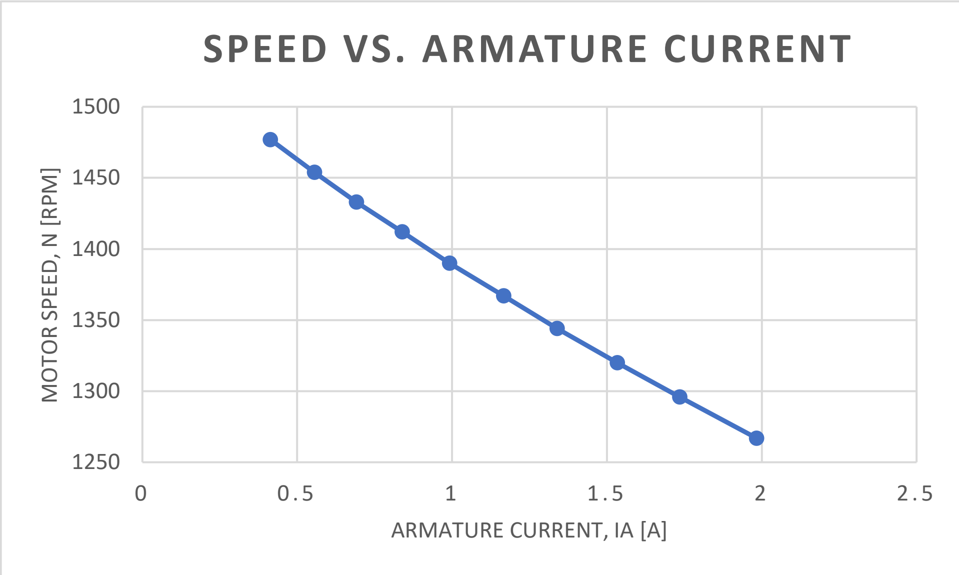
Speed [rpm]	**Vt [V]**
1500	250.1 V

The load was now increased by turning the "manual load control knob" of the dynamometer in steps. For each torque setting, the armature voltage was readjusted so that the armature voltage remained equal to the value recorded in the table above of 250.1V.

step	**Torque [Nm]**	**Vt [V]**	**Ia [A]**	**Speed, n [rpm]**	**If [A]**
1	0.2	249.4	0.413	1477	0.19
2	0.4	248.6	0.555	1454	0.19
3	0.6	248	0.691	1433	0.19
4	0.8	247.2	0.839	1412	0.19
5	1	246.5	0.992	1390	0.19
6	1.2	245.6	1.166	1367	0.19
7	1.4	244.7	1.339	1344	0.19
8	1.6	243.8	1.533	1320	0.19
9	1.8	242.7	1.735	1296	0.19
10	2	241.5	1.983	1267	0.19

Table 2: Values at n = 1500 rpm

Question 3:



Graph 2: Plot of Motor speed as a function of Armature Current

Yes, this graph does confirm the prediction made in Question 2 above, that the variation of the DC motor speed is inversely proportional to the armature current, Ia.

The armature voltage was adjusted so the speed was now equal to 1250 rpm and the values obtained using this configuration were tabulated below:

Speed [rpm]	Vt [V]
1250	209.5 V

step	Torque [Nm]	Vt [V]	Ia [A]	Speed, n [rpm]	If [A]
1	0.2	208.9	0.407	1226	0.19
2	0.4	208.2	0.547	1202	0.19
3	0.6	207.5	0.682	1180	0.19
4	0.8	206.8	0.828	1157	0.19
5	1	206	0.99	1132	0.19
6	1.2	205.1	1.15	1108	0.19
7	1.4	204.3	1.322	1083	0.19
8	1.6	203.4	1.509	1056	0.19
9	1.8	202.4	1.705	1028	0.19
10	2	200.9	1.995	988.4	0.19

Table 3: Values at n = 1250 rpm

The armature voltage was adjusted so the speed was now equal to 1000 rpm and the values obtained using this configuration were tabulated below:

Speed [rpm]	Vt [V]
1000	169.4 V

step	Torque [Nm]	Vt [V]	Ia [A]	Speed, n [rpm]	If [A]
1	0.2	168.8	0.388	979.8	0.19
2	0.4	168	0.531	954.6	0.19
3	0.6	167.3	0.676	929.4	0.19
4	0.8	166.6	0.814	906.1	0.19
5	1	165.8	0.98	878.2	0.19
6	1.2	165.1	1.127	854	0.19
7	1.4	164.2	1.296	826.4	0.19
8	1.6	163.3	1.49	794.8	0.19
9	1.8	162.2	1.691	762.4	0.19
10	2	161	1.941	721.6	0.19

Table 4: Values at n = 1000 rpm

<u>Motor Torque versus Armature current and speed in different armature voltages in the 3rd motor control quadrant (reverse driving):</u>

The armature connection was now reversed by reversing the connection of the leads at terminals 7 and N of the power supply. 24VAC switch and the main breaker of the power supply were then turned ON with an adjusted field current of "190mA". While monitoring the meters, the armature voltage was adjusted so the speed was equal to -1500 rpm and following table was filled:

Speed [rpm]	Vt [V]
-1500	-250 V

The load was now increased by turning the "manual load control knob" of the dynamometer in steps. For each torque setting, the armature voltage was readjusted so that the armature voltage remained equal to the value recorded in the table above of -250 V.

step	Torque [Nm]	Vt [V]	Ia [A]	Speed, n [rpm]	If [A]
1	-0.2	-249.4	-0.413	-1477	0.19
2	-0.4	-248.5	-0.557	-1455	0.19
3	-0.6	-248.1	-0.691	-1433	0.19
4	-0.8	-247.2	-0.84	-1411	0.19
5	-1	-246.5	-0.992	-1391	0.19
6	-1.2	-245.6	-1.168	-1367	0.19
7	-1.4	-244.6	-1.34	-1344	0.19
8	-1.6	-243.8	-1.533	-1323	0.19
9	-1.8	-242.7	-1.736	-1296	0.19
10	-2	-241.6	-1.983	-1265	0.19

Table 5: Values at n = -1500 rpm

The armature voltage was adjusted so the speed was now equal to -1250 rpm and the values obtained using this configuration were tabulated below:

Speed [rpm]	Vt [V]
-1250	-209.4 V

step	Torque [Nm]	Vt [V]	Ia [A]	Speed, n [rpm]	If [A]
1	-0.2	-208.9	-0.407	-1226	0.19
2	-0.4	-208.1	-0.546	-1201	0.19
3	-0.6	-207.5	-0.682	-1180	0.19
4	-0.8	-206.8	-0.827	-1157	0.19
5	-1	-206.1	-0.98	-1134	0.19
6	-1.2	-205.2	-1.15	-1108	0.19
7	-1.4	-204.3	-1.322	-1082	0.19
8	-1.6	-203.4	-1.51	-1056	0.19
9	-1.8	-202.3	-1.705	-1028	0.19
10	-2	-200.8	-1.994	-988	0.19

Table 6: Values at n = -1250 rpm

The armature voltage was adjusted so the speed was now equal to -1000 rpm and the values obtained using this configuration were tabulated below:

Speed [rpm]	Vt [V]
-1000	-169.6 V

step	Torque [Nm]	Vt [V]	Ia [A]	Speed, n [rpm]	If [A]
1	-0.2	-168.8	-0.388	-979.8	0.19
2	-0.4	-167.9	-0.531	-954.8	0.19
3	-0.6	-167.3	-0.675	-929.4	0.19
4	-0.8	-166.7	-0.814	-906.3	0.19
5	-1	-165.8	-0.982	-878.4	0.19
6	-1.2	-165.1	-1.127	-854.2	0.19
7	-1.4	-164.3	-1.296	-826.4	0.19
8	-1.6	-163.4	-1.488	-795.1	0.19
9	-1.8	-162.2	-1.691	-762.4	0.19
10	-2	-161.2	-1.943	-722.1	0.19

Table 7: Values at n = -1000 rpm

Question 4: Family of Speed Vs. Torque curves in the 4-quadrant diagram.