

1 Experiment No. 2

2 Experiment Title

Observation of no load magnetization curve of separately excited DC generator.

3 Objective

The objectives of this lab are as follows:

- To study the relationship between field current (I_f) and induced voltage (E_g) in a DC generator.
- To observe the hysteresis loop in a DC generator by increasing and then decreasing the field current.
- To analyze the impact of residual magnetism and retentivity on the generator's performance.
- To evaluate how changes in speed affect the induced voltage in a DC generator.

4 Theory

The induced voltage in a DC generator is dependent on the magnetic flux and the speed of the machine, assuming other factors are constant. If the speed of the driving mechanism remains constant and the flux in the generator is varied, the induced voltage will change accordingly. Initially, when there is no current in the field coils, there is still a small flux due to residual magnetism in the field poles, resulting in a small induced voltage (Point 1).

As the current in the field coils increases, the flux also increases, leading to a rise in the induced voltage.

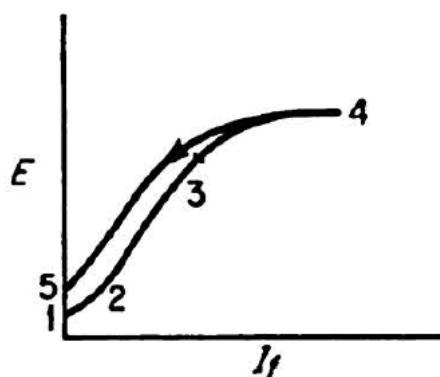


Figure 1: Induced voltage vs. Field current characteristic curve

From Figure 1, it can be observed that the induced voltage increases proportionally with the field current up to a certain point (Points 2 to 3). Beyond Point 3, further increases in the field current result in smaller increments in the induced voltage (Points 3 to 4). This behavior is due to the magnetic saturation of the circuit. In any magnetic circuit, increasing the magneto-motive force (MMF) increases the magnetic flux until saturation is reached. Beyond this point, further

increases in MMF result in only slight increases in flux. Since the induced voltage is directly related to the magnetic flux, the voltage increase also diminishes after saturation.

If the field current is now reduced, the decreasing voltage does not follow the same path as during the increase. Instead, the voltage decreases from Point 4 to Point 5, forming a hysteresis loop. This phenomenon occurs due to the retentivity of the magnetic material in the circuit. When measuring the magnetization curve in a laboratory setting, it is important to continuously increase the field current until the maximum value is reached. After that, the current should only be decreased until it reaches zero. Fluctuating the current back and forth in an attempt to achieve specific values can result in smaller hysteresis loops and inconsistent results.

Another challenge in measuring the magnetization curve is maintaining a constant speed. Since the induced voltage depends on both the flux and the speed of the machine, any speed variation will lead to corresponding variations in voltage. However, this issue can be mitigated by calculating the voltage at the desired speed, given the induced voltage at a different speed.

5 Required Apparatus:

1. Variable DC Supply (Ratings: Voltage: 0-500V, Current: 4A),
2. Three Phase Power Supply (Ratings: Voltage: 400V, Current: 10A),
3. DC Multimeter (Ratings: Voltage: 600V, Current: 20A)
4. Three Phase Asynchronous Motor (Ratings: Power: 500W, Voltage: 400V/230V, Current: 1.8A/1.3A, Speed: 1380 rpm),
5. DC Generator (Ratings: Power: 300W, Voltage: 220V, Current: 1.4A)
6. Tacho-Generator (Ratings: Current: 0.07A max, Speed: 5000 rpm max).

6 Circuit Diagram:

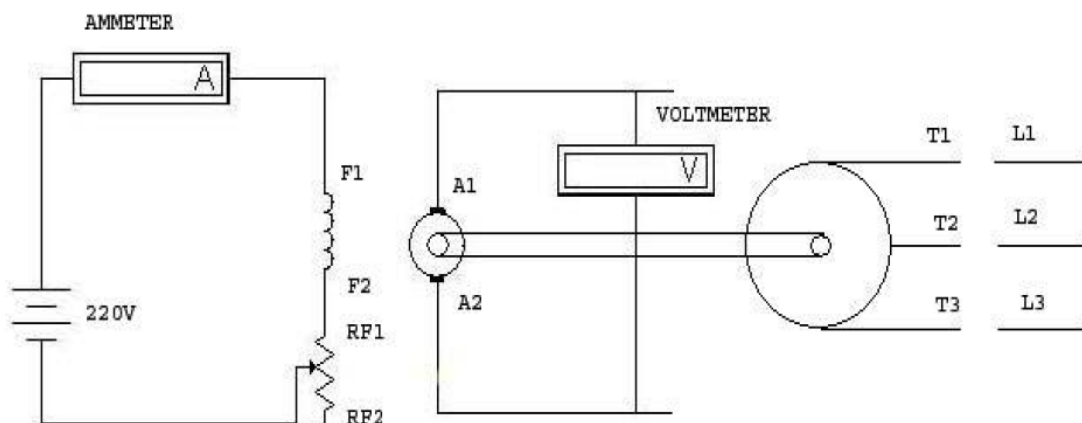


Figure 2: Circuit Diagram of the experiment

7 Data Table:

Table 1: Readings of Field Current and Induced EMF for Decreasing Current

SI No.	Increasing Current		Decreasing Current	
	Field Current I_{f_i} (A)	Induced Voltage E_{g_i} (V)	Field Current I_{f_d} (A)	Induced voltage E_{g_d} (V)
1.	0.00	63.48	0.11	211.87
2.	0.015	78.12	0.092	208.31
3.	0.021	93.63	0.084	199.83
4.	0.025	109.25	0.065	189.09
5.	0.030	120.4	0.060	184.5
6.	0.036	126.14	0.057	179.35
7.	0.048	149.88	0.046	161.97
8.	0.055	172..26	0.039	139.23
9.	0.067	186.00	0.026	120.34
10.	0.082	192.74	0.020	103.72
11.	0.096	206.22	0.016	89.21
12.	0.110	211.87	0.00	70.57

8 Graph:

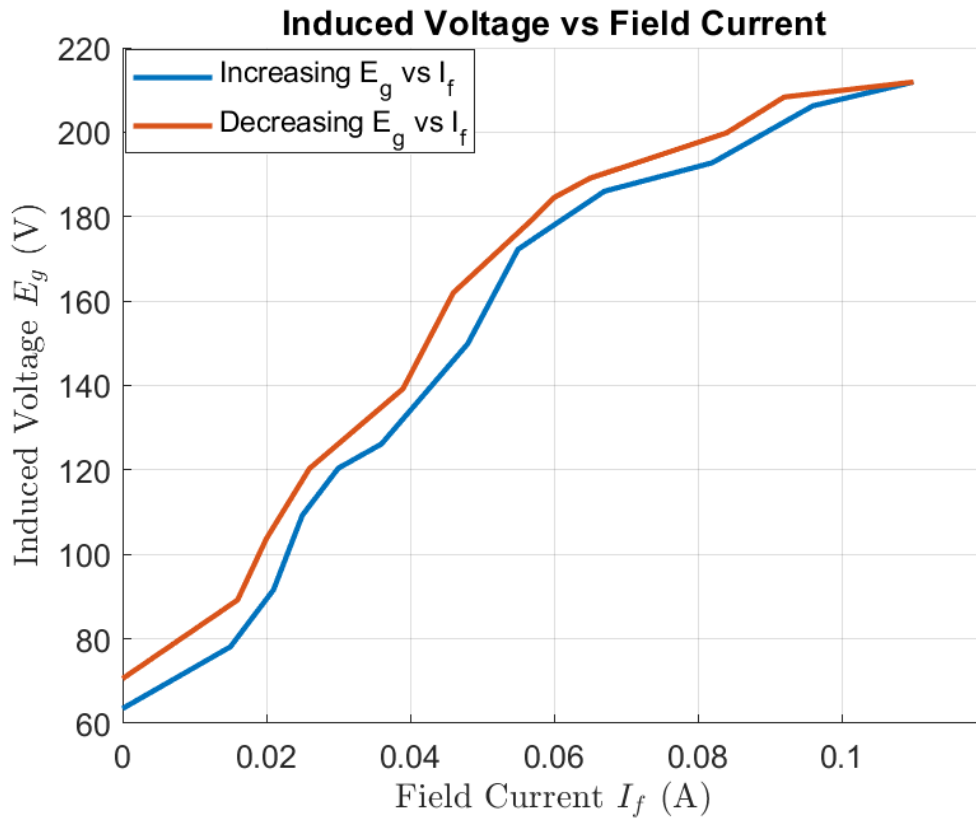


Figure 3: Induced voltage (E_g) vs. Field current (I_f) characteristic curve

8.1 Matlab Code:

```
1 % Given data
2 inc_field_current = [0.00, 0.015, 0.021, 0.025, 0.030, 0.036, 0.048,
3   0.055, 0.067, 0.082, 0.096, 0.11];
4 dec_field_current1 = [0.11, 0.092, 0.084, 0.065, 0.060, 0.057, 0.046,
5   0.039, 0.026, 0.020, 0.016, 0.00];
6 inc_generated_voltage = [63.48, 78.12, 91.63, 109.25, 120.4, 126.14,
7   149.88, 172.26, 186, 192.74, 206.22, 211.87];
8 dec_generated_voltage1 = [211.87, 208.31, 199.83, 189.09, 184.5, 179.35,
9   161.97, 139.23, 120.34, 103.72, 89.21, 70.57];
10 % Plot the data
11 figure;
12 hold on;
13 plot(inc_field_current, inc_generated_voltage, 'DisplayName', 'Increasing
14   E_g vs I_f ', 'LineWidth', 2);
15 plot(dec_field_current1, dec_generated_voltage1, 'DisplayName', 'Decreasing
16   E_g vs I_f', 'LineWidth', 2);
17 % Add labels, title, grid and legend
18 xlabel('Field Current $I_f$ (A)', 'Interpreter', 'latex', 'FontSize', 12);
19 ylabel('Induced Voltage $E_g$ (V)', 'Interpreter', 'latex', 'FontSize',
20   12);
21 title('Induced Voltage vs Field Current', 'FontSize', 16);
22 grid on;
23 legend('show', 'Location', 'Best');
24 set(gca, 'FontSize', 12);
25 hold off;
```

Listing 1: MATLAB code for plotting data

9 Discussion

This experiment examined the relationship between field current (I_f) and induced voltage (E_g) in a DC generator. The results show a nonlinear relationship, with induced voltage increasing proportionally at first and then more slowly due to magnetic saturation. The hysteresis effect was also observed, as the voltage did not follow the same path when decreasing the field current, highlighting the influence of residual magnetism.

Minor speed variations may have affected the induced voltage, but these were kept minimal. Overall, the results align with theoretical expectations, though improvements in measurement accuracy and speed control could enhance the precision of the experiment.

Overall, the results align well with theoretical expectations of magnetic saturation and hysteresis. However, the precision of the experiment could be improved by using more accurate control of the generator speed and by using a higher resolution for current and voltage measurements.