<u>Experiment-8: Determination of Voltage Regulation of a Synchronous Generator Using EMF Method</u>

Group number 22:

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Aim:-

- *The aim of this experiment is to get the value of Xs and Rs for a given synchronous generator and to find the voltage regulation of it using the EMF method.*

About Synchronous Reactance:-

The single-phase equivalent circuit of an alternator for a balanced operation is shown as follows.

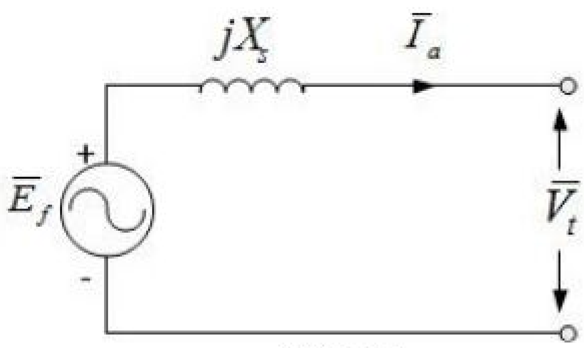


FIGURE 1

Here, E_f is the voltage that is induced in the armature winding by the field excitation and, hence, is called the excitation voltage. Apart from the excitation voltage, there will be a voltage drop in the armature circuit because of the armature current 'Ia' itself. By assuming a linear magnetization and by ignoring the armature resistance, it can be shown that the respective voltage drop is proportional to the armature current with a phase lead of 90^0. Thus, the voltage drop caused by the armature current can in effect be modeled through an inductive reactance Xs, which is finally called the synchronous reactance.

Circuit Arrangement:-

The circuits arrangement to conduct the experiment is shown in Figures 2, 3, and 4. Here, three different tests are to be performed. The first test is called the open-circuit test and is to be conducted by employing the circuit configuration shown in Figure 2. Subsequently, a short circuit test and voltmeter ammeter method is used to calculate the per phase resistance of the stator by employing the circuit configurations shown in Figures 3 and 4, respectively.

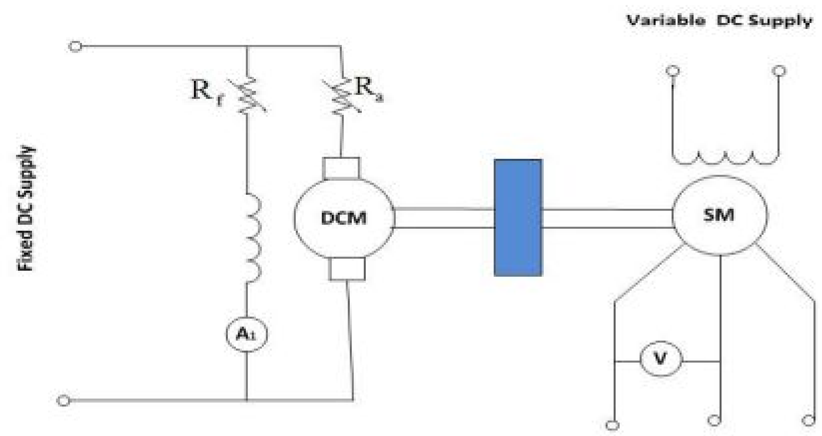


FIGURE 2

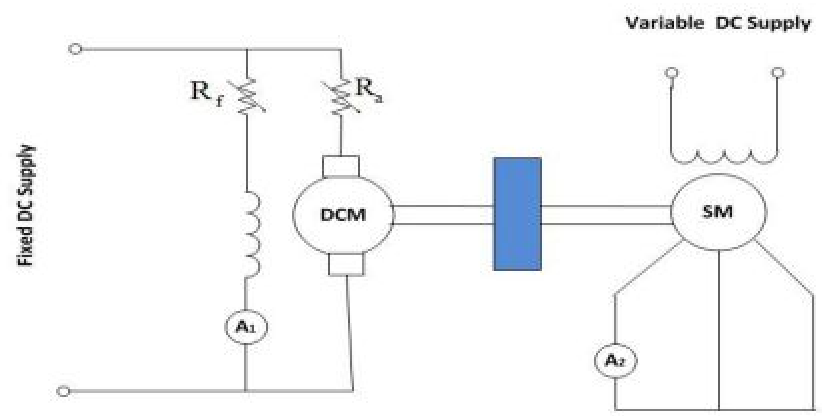


FIGURE 3

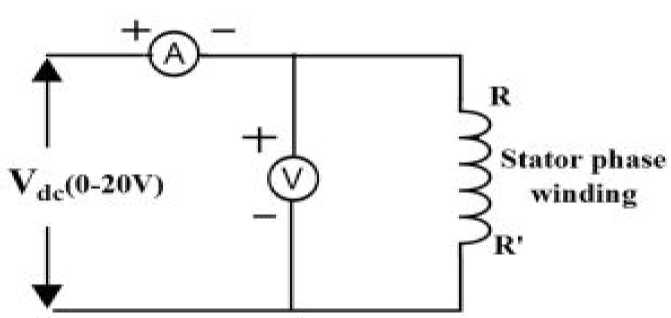


FIGURE 4

Procedure:-

1. *To perform a test, the speed of the DC shunt motor should initially be set close to 1500 r.p.m. by adjusting its armature and field resistances.*
2. *For the open circuit test, the current in the alternator field is to be gradually increased (by adjusting the variable DC voltage) and the corresponding armature voltages are to be noted down.*
3. *Similarly, for the short circuit test, the armature currents are to be noted down for different values of field currents. Although the open circuit test should be continued up to a voltage higher than the rated voltage, exceeding the armature rated current is strictly prohibited in the short circuit test.*

Based on the observations from the open circuit and short circuit tests, the *synchronous reactance of the alternator can be calculated as follows.*

$$Xs = Voc/(\sqrt{3}*Isc)$$

Here, Voc and Isc are the open circuit line-to-line voltage and short circuit line current, respectively, for the same value of field current. The value of Xs Should be calculated for all the different values of the alternator field current.

4. *Per phase stator resistance of the synchronous machine is calculated using the voltmeter and ammeter method but the value obtained here is a DC resistance of the machine winding. AC resistance should be calculated by multiplying the DC resistance with a factor of 1.1 (to account for skin effect)*

$$Rs = 1.1*R_{dc}$$

Now the voltage regulation of the machine is calculated using the values of Xs and Rs as given by the following formulae.

$$\%\ voltage\ regulation = 100*((V_{nl} - V_{fl})/V_{fl})$$

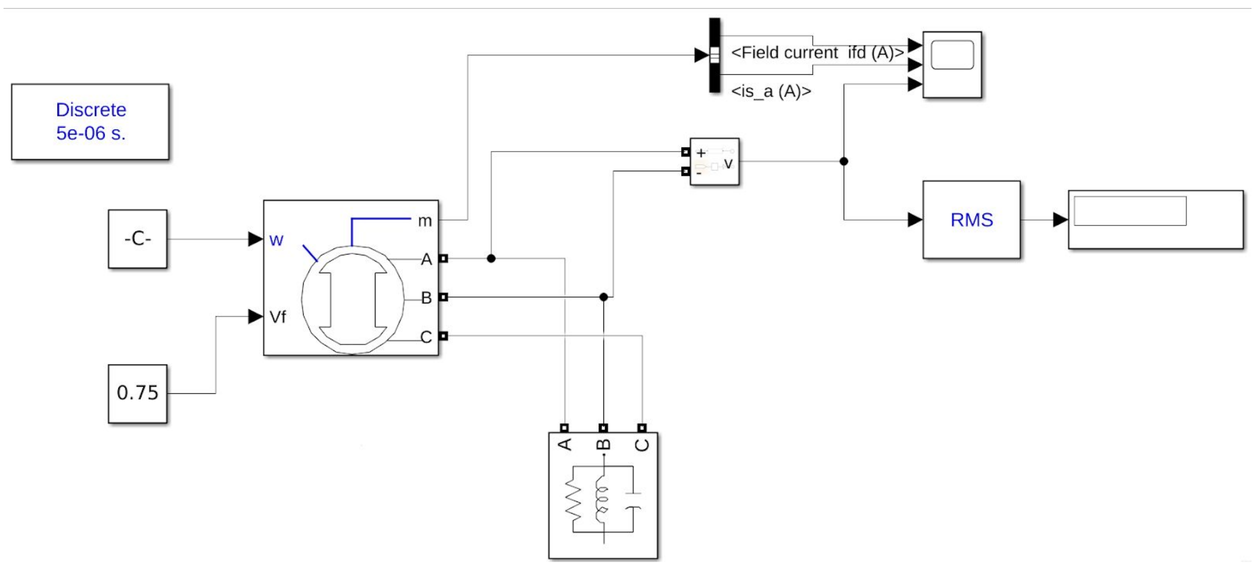
Where V_{nl} (no load) voltage is

$$V_{nl} = \sqrt{((V_{fl}*\cos\theta + I*Rs)^2 + (V_{fl}*\sin\theta + I*Xs)^2)}$$

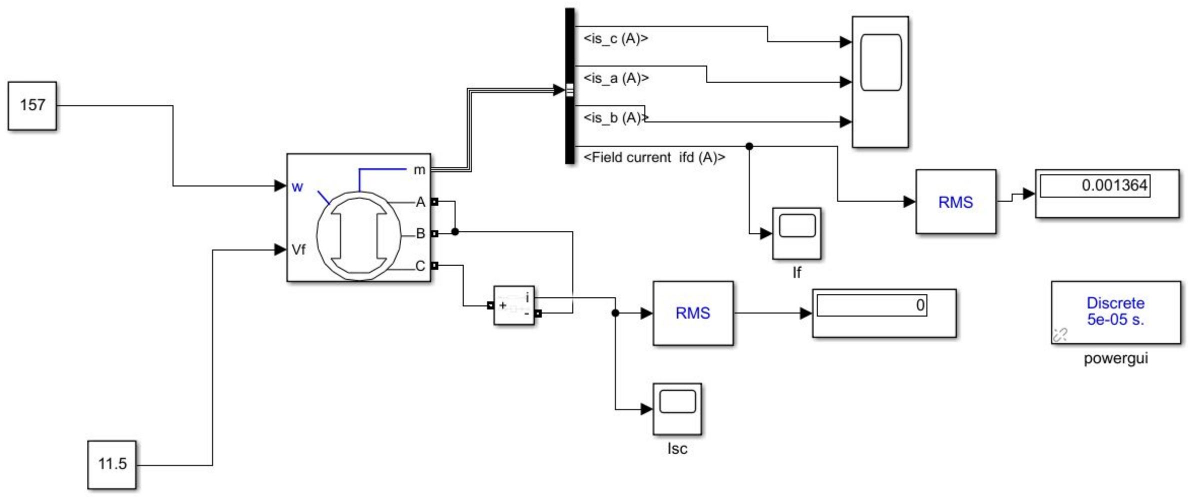
V_{fl} is full load voltage and θ is the power factor angle.

Circuit Diagrams:-

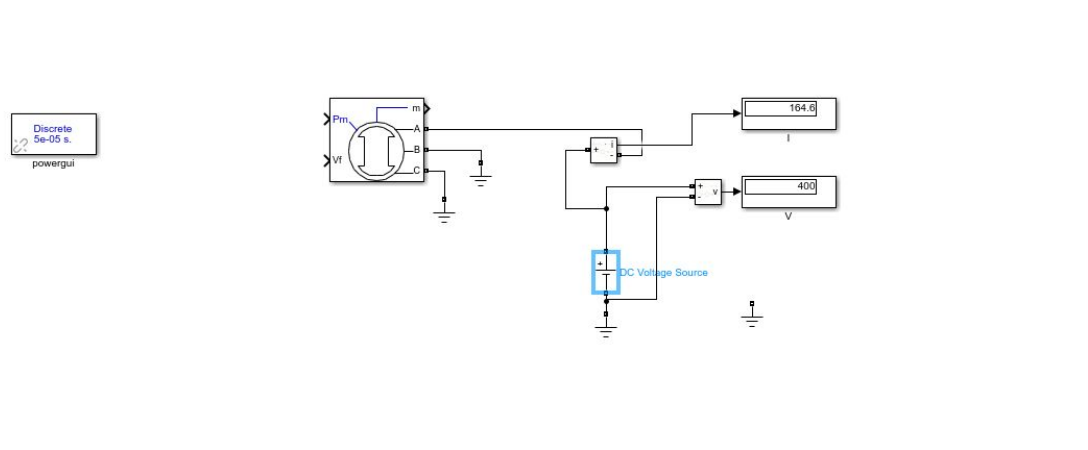
<u>Open Circuit Test:</u>



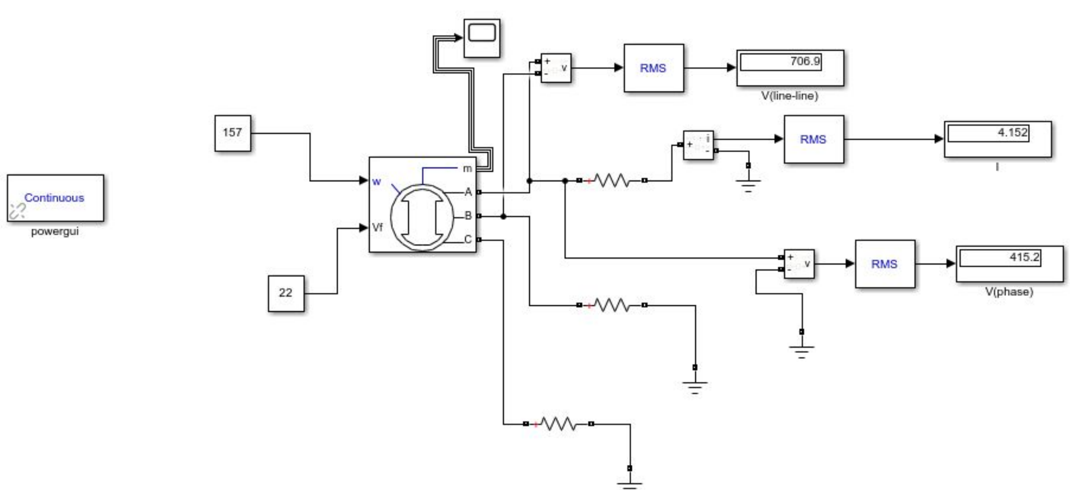
<u>Short Circuit Test:</u>



DC Test:



Voltage Regulation:



Results:-

I. OPEN CIRCUIT AND SHORT CIRCUIT TESTS' OBSERVATIONS:

S.no	*Field*	*Open*	*Open*	*Short*	*Short*	*Synchrono*

	Voltage(V_f)	Circuit Field Current(I_{fl})	Circuit Voltage(Voc)	Circuit Field Current(I_f)	Circuit Current(I_{sc})	us Reactance (Xs)
1.	0	0	0	0	0	0
2.	0.75	0.62	25.95	0.62	0.4214	35.55
3.	1.5	1.242	51.85	1.242	0.848	35.27
4.	2.25	1.8625	77.77	1.8625	1.264	35.51
5.	3	2.483	103.7	2.483	1.686	35.51
6.	3.75	3.1043	129.6	3.1043	2.107	35.50
7.	4.5	3.725	155.5	3.725	2.5286	35.50
8.	5.25	4.346	181.4	4.346	2.95	35.50
9.	6	4.9657	207.4	4.9657	3.37148	35.51
10.	6.75	5.588	233.3	5.588	3.7936	35.50
11.	7.5	6.21	259.2	6.21	4.214	35.50
12.	8.25	6.8295	285.1	6.8295	3.928	35.50
13.	9	7.45	311	7.45	5.0558	35.51
14	10	8.2782	345.6	8.2782	5.619	35.50
15.	11.5	9.52	397.5	9.52	6.463	35.50

II. VOLTMETER AMMETER METHOD FOR STATOR RESISTANCE MEASUREMENT:

S.no	Current (amps)	Voltage (volts)	DC resistance R_{dc} = (⅔)*(V/I)	Per phase stator resistance Rs =1.1*R_{dc}
1	20.58	50	1.62	1.782
2	41.5	100	1.6	1.76
3	82.3	200	1.62	1.782

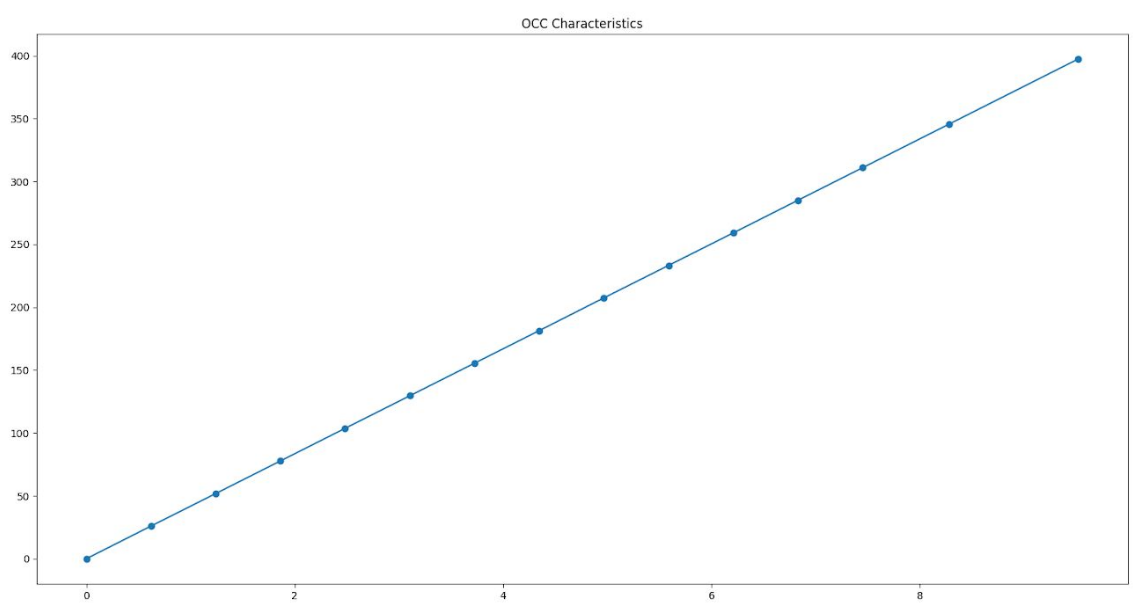
4	*164.6*	*400*	*1.619*	*1.7809*

III. Voltage Regulation:

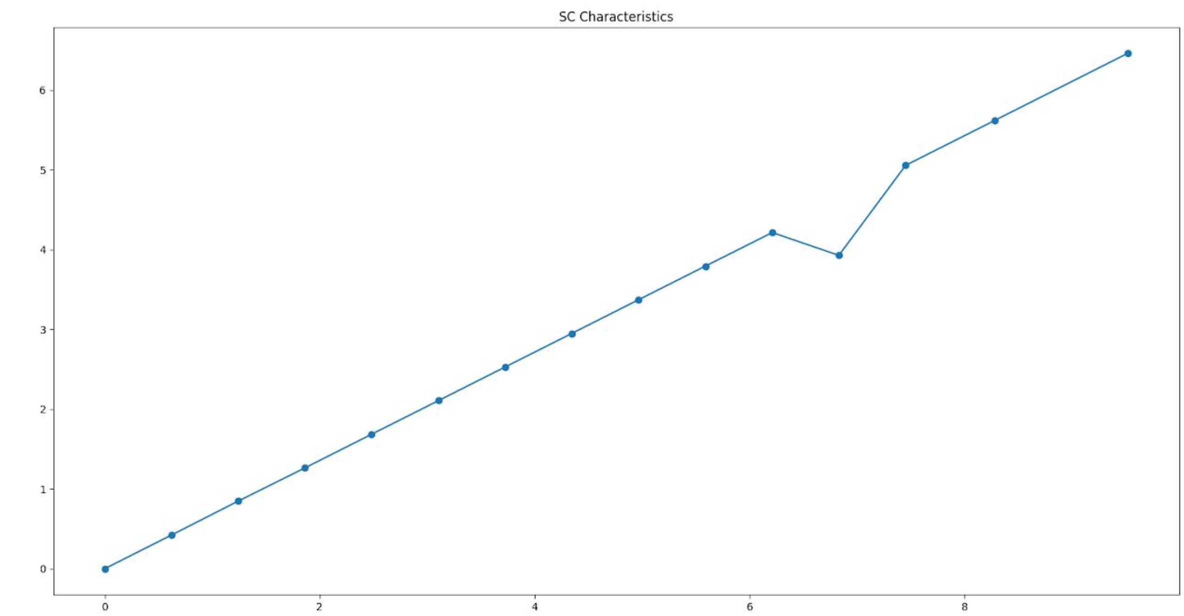
S.no	*Resistance*	$V_{no\text{-}load}$	V_T	*% Regulation*
1.	*20*	*723.9*	*395.8*	*82.9*
2.	*50*	*723.9*	*629.8*	*14.94*
3.	*100*	*723.9*	*706.9*	*2.4*
4.	*150*	*723.9*	*698.1*	*3.69*
5.	*200*	*723.9*	*715.9*	*1.117*

Conclusions:-

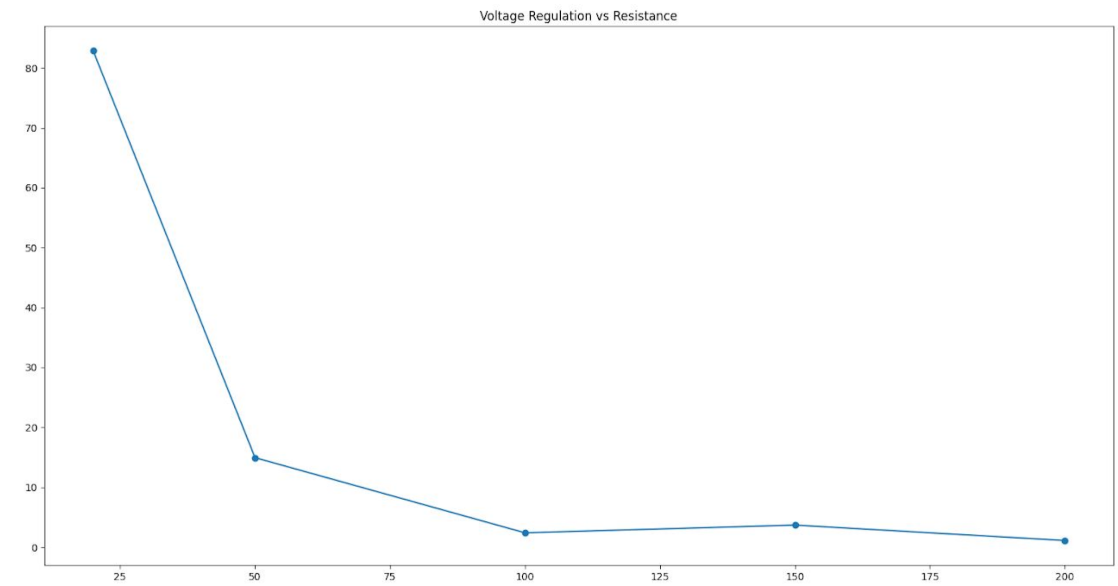
OCC Characteristics:

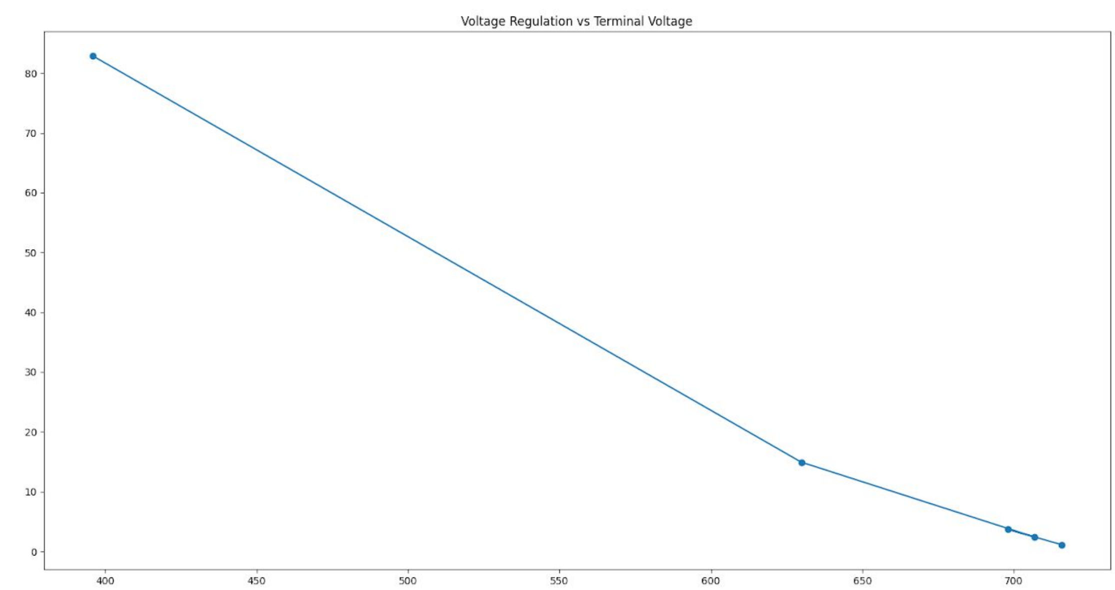


SC Characteristics:



Voltage Regulation:


Voltage Regulation vs Resistance
80
70
60
50
40
30
20
10
0
25
50
75
100
125
150
175
200


Voltage Regulation vs Terminal Voltage
80
70
60
50
40
30
20
10
0
400
450
500
550
600
650
700