Group5_Exp8

AIM: To get the values of X_s and R_s for a given synchronous generator and to find the voltage regulation of it using EMF method.

THEORY:

OPEN CIRCUIT TEST:

The alternator is run at rated synchronous speed and the load terminals are kept open. That is, all the loads are disconnected. the field current is set to zero,this condition is called open circuit test condition.

The field current is gradually increased in steps, and the terminal voltage E_t is measured at each step. The excitation current may be increased to get 25% more than rated voltage of the alternator. A graph is plotted between the open circuit test voltage E_p and field excitation current I_f.

The characteristic curve obtained is called open circuit characteristic (O.C.C.). it takes the shape of a normal magnetization curve. The extension of the linear portion of an O.C.C. is called the air gap line shown in figure.

SHORT CIRCUIT TEST:

The armature terminals are shorted through three ammeter.Care should be taken performing this test, and the field current should first decrease to zero before starting the alternator. Each ammeter should have a range greater than the full rated value. the alternator runs at synchronous speed. then the field current gradually increased in step, and the armature current is measured at each step.

The field current may be increased to get armature current upto 150% of the rated value.The field current If and the average of three ammeter reading at each step is taken.

A graph is plotted between the armature current Ia and field current If. The characteristic so obtained is called short-circuit characteristic (SCC). The characteristic is a straight line as shown in figure.

DC TEST:

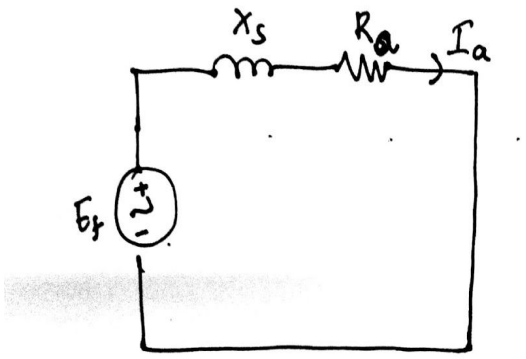
This test is done to find out the stator resistance of a synchronous machine using voltmeter and ammeter.

AC resistance should be calculated by multiplying the DC resistance with factor of 1.1 (to account for skin effect).

VOLTAGE REGULATION:

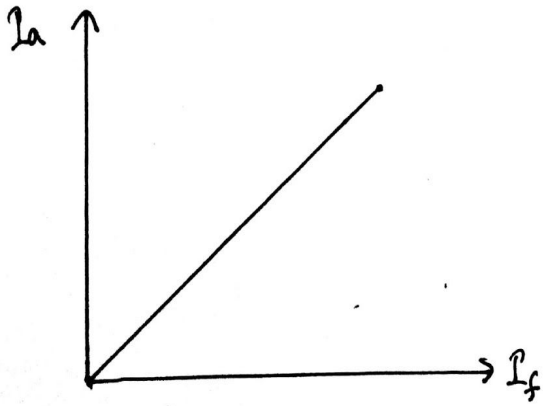
The Voltage Regulation of a Synchronous Generator is the rise in voltage at the terminals when the load is reduced from full load rated value to zero, speed and field current remaining constant. It depends upon the power factor of the load. For unity and

lagging power factors, there is always a voltage drop with the increase of load, but for a certain leading power, the full load voltage regulation is zero.

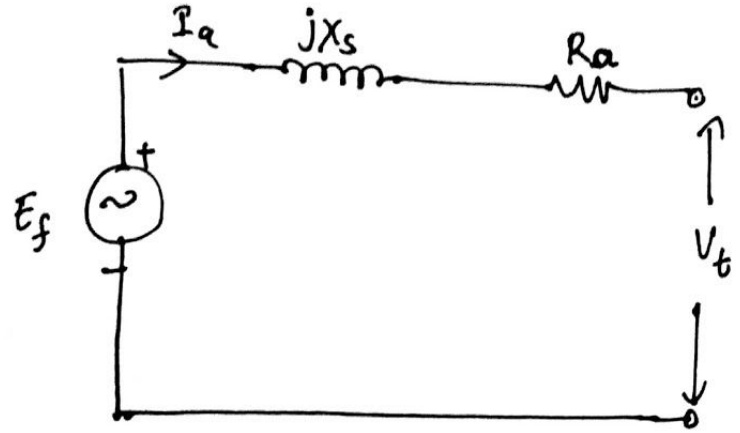


Short circuit test

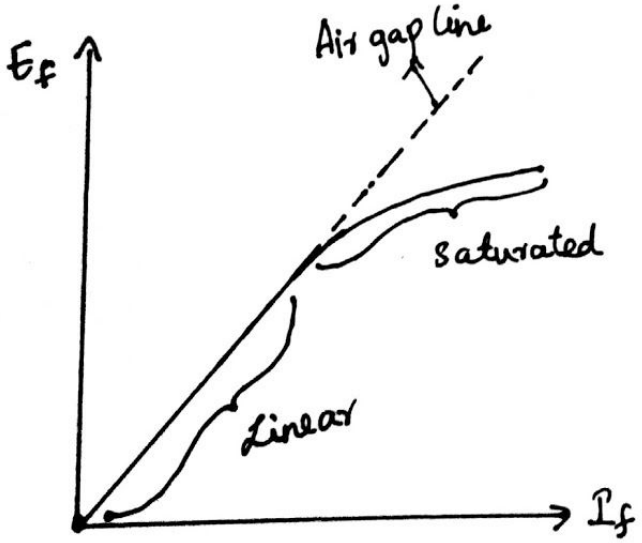
Here, $V_t = 0$.



I_a (vs) I_f plot



For open circuit test $I_a = 0 \rightarrow E_f = V_t$



Plot of E_f vs I_f

$E_f \rightarrow$ open circuit o voltage.

PROCEDURE:

Our Preset model is 8.1kVA,400V,,50Hz,1500rpm,I_{rated}= $\frac{P(KVA)}{\sqrt{3}*V}$ = $11.69A$,

OPEN CIRCUIT TEST:

1. Open a blank model in simulink.
2. Make the circuit as shown in the Circuit diagram in matlab section.
3. Observe the field current(I_f) and open circuit voltage(V_{OC}) by changing field voltage(V_f) and set speed as 1500RPM(157rad/s).
4. Note the values of I_f and V_{OC} for 15 different values of V_f.
5. The parameters of rlc parallel load are
   Real power -60W
   Capacitive power-30W
   Inductive power-30W

SHORT CIRCUIT TEST:

1. Open a blank model in simulink.
2. Make the circuit as shown in the Circuit diagram in matlab section.
3. Observe the field current(I_f) and short circuit Current(I_{SC}) by changing field voltage(V_f) and set speed as 1500RPM(157rad/s).
4. Note the values of I_f and I_{SC} for 15 different values of V_f.

DC TEST:

1. Open a blank model in simulink.
2. Make the circuit as shown in the Circuit diagram in matlab section.
3. Note the values of Voltmeter and ammeter
4. Per phase stator current can be calculated as R_s=2V/3I.

VOLTAGE REGULATION:(At 1500rpm)

We fix the value of field current by fixing the value of the field voltage,and vary the load , for a particular value of load find the phase voltage at the terminals of the armature(V_{ph}) and also find the corresponding open circuit voltage (induced voltage across the terminals)-E_{ph}.

$$\%\text{Voltage Regulation} = \frac{Eph\ (no\ load) - V\,ph(full\ load)}{V\,ph(full\ load)} * 100$$

Using the above formula , vary the load and find the load at which full load current flows(11.69A).The corresponding voltage regulation is called full load voltage regulation.

CIRCUIT DIAGRAM IN MATLAB:

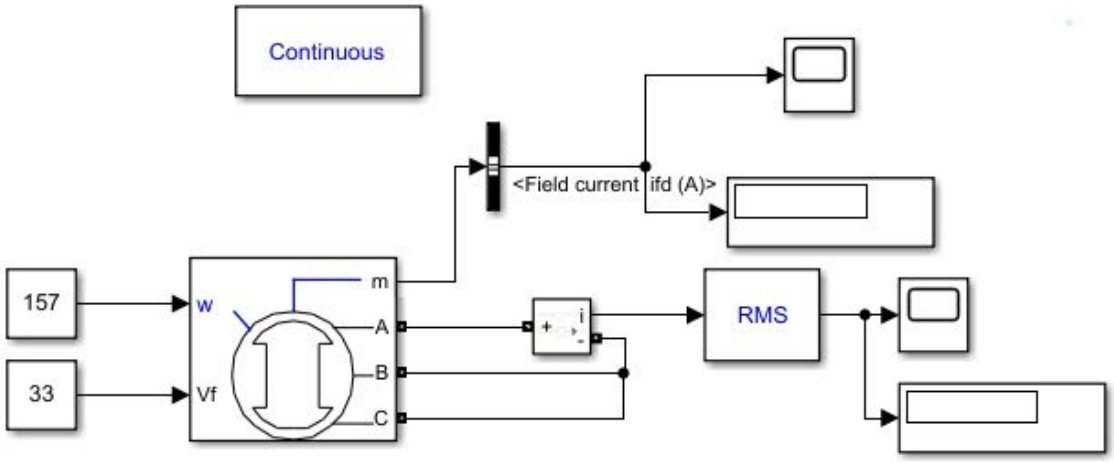


Fig1: Circuit diagram for Short Circuit Test

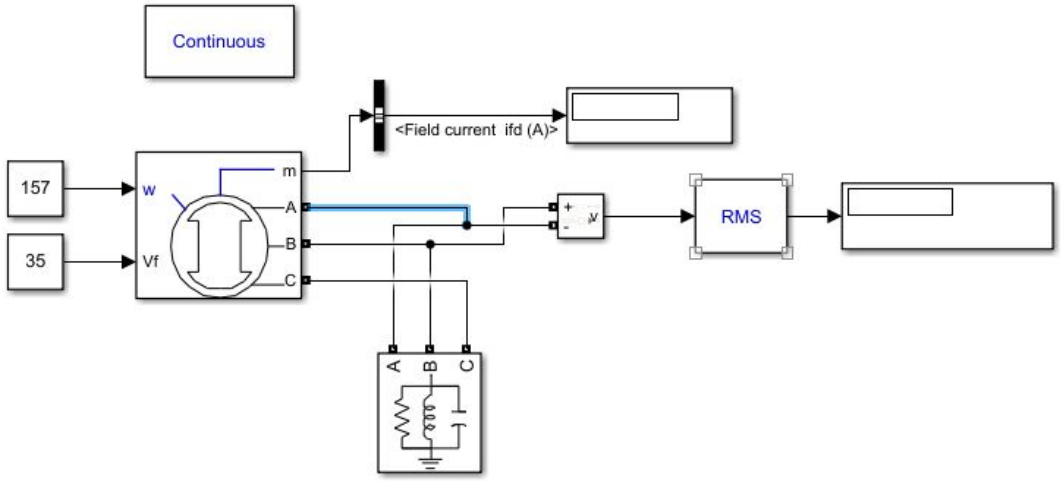


Fig2: Circuit diagram for Open Circuit test

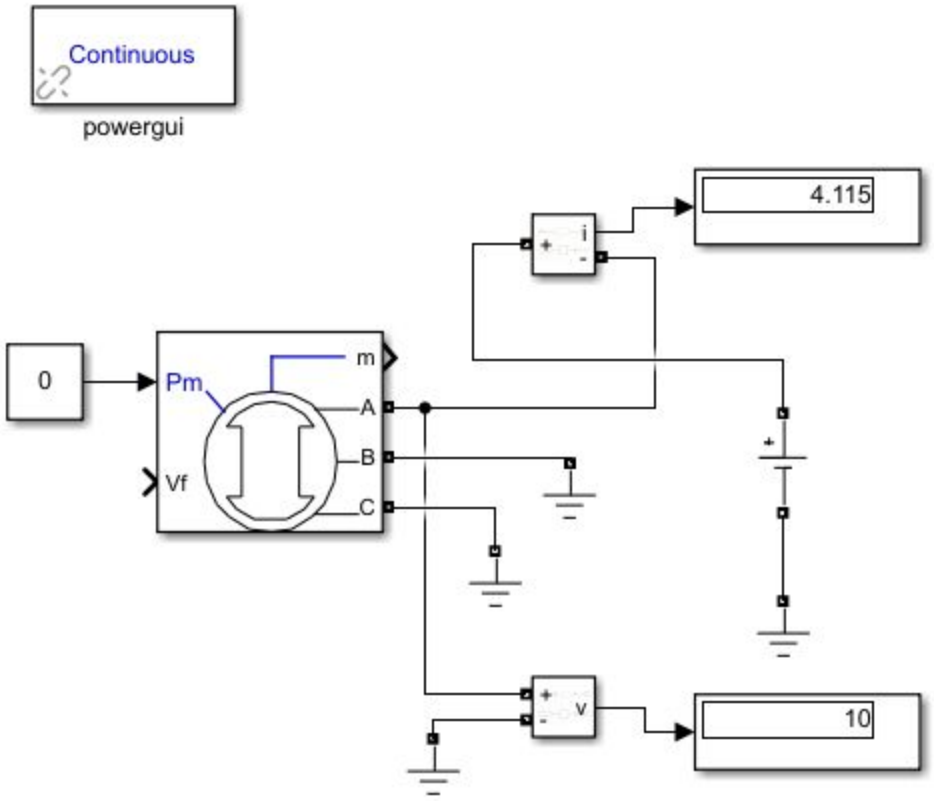


Fig 3:Circuit diagram for DC test

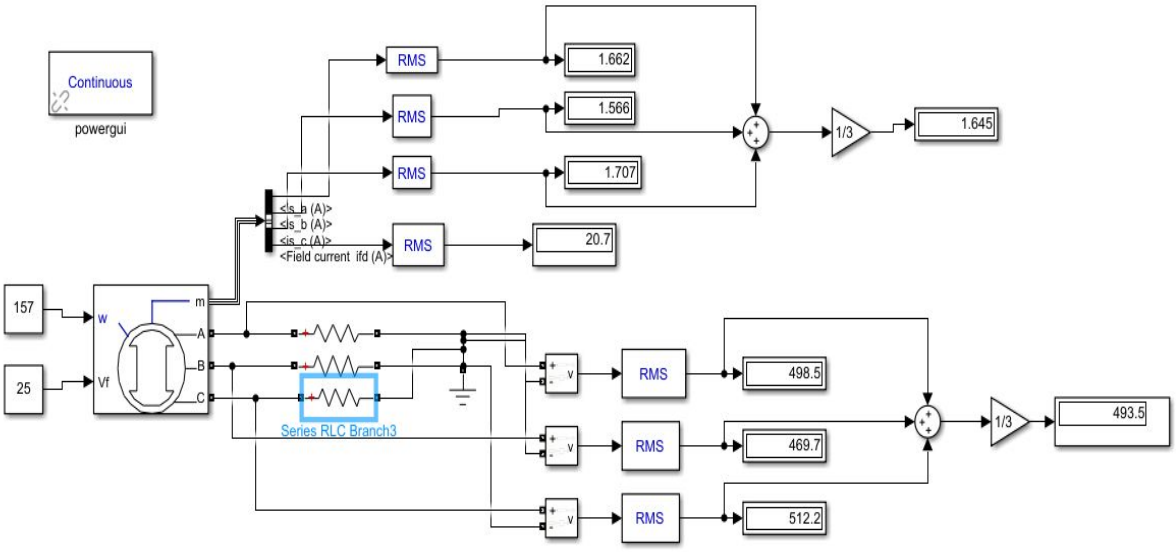


Fig 4 : Circuit for calculating voltage regulation

CALCULATIONS:

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

$$X_s = V_{oc}/(\sqrt{3}*I_{sc})$$

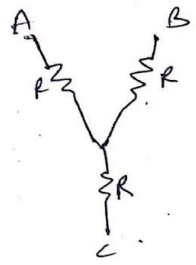
Here, V_{OC} and I_{SC} are the open circuit line-to-line voltage and short circuit line current, respectively, for the same value of field current. The value of X_S should be calculated for all the different values of the alternator field current.

2.Per phase stator resistance of the synchronous machine is calculated using voltmeter and ammeter method the value obtained here is a AC resistance of the machine winding.

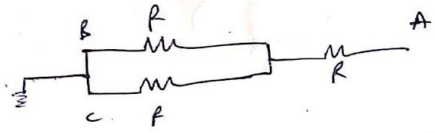
3. % voltage regulation = $(V_{nl}-V_{fl})/V_{fl}*100$

Where V_{nl} is no load voltage and V_{fl} is full load voltage.

Inside the Synchronous machine resistors are connected in star fashion.



When two terminals are grounded the equivalent circuit becomes



equivalent Resistance of the above circuit is $\frac{3R}{2}$

RESULTS:

OPEN CIRCUIT AND SHORT CIRCUIT TESTS OBSERVATIONS:

S.NO	Open Circuit Test		Short Circuit Test		Synchronous Reactance(X_s)
	Field	Open Circuit	Field	Short Circuit	

	Current(I_f)	Voltage (V_{oc})	Current(I_f)	Current (I_{SC})	
1	4.975	199.7	4.967	3.42	33.71
2	5.803	232.8	5.795	3.989	33.69
3	6.631	266.1	6.623	4.557	33.71
4	7.459	299.3	7.45	5.121	33.74
5	8.287	332.6	8.278	5.677	33.82
6	9.115	365.6	9.106	6.241	33.82
7	9.942	398.8	9.934	6.814	33.79
8	10.77	432.1	10.76	7.383	33.79
9	11.6	465.3	11.59	7.925	33.89
10	12.43	498.6	12.42	8.513	33.81
11	13.25	531.8	13.25	9.099	33.74
12	14.08	564.9	14.07	9.708	33.59
13	14.91	598.4	14.9	10.3	33.54
14	15.74	631.5	15.73	10.88	33.51
15	16.56	664.4	16.56	11.47	33.44

$X_{s(average)}=33.706\Omega$

VOLTAGE AMMETER METHOD FOR STATOR RESISTANCE MEASUREMENT:

S.NO	Current(A)	Voltage(V)	Per phase stator resistance R_s =2V/3I(Ω)
1	0.823	2	1.62
2	2.058	5	1.62
3	4.115	10	1.62
4	6.173	15	1.62

$R_{s(average)}=1.62\Omega.$

$Z_s=X_s+jR_s$

$X_s>>R_s$

$$\Rightarrow Z_s \approx X_s = 33.7\Omega.$$

VOLTAGE REGULATION VS LOAD:

Fix the value of the field voltage to 25V. While varying the load we can find that at 26.5Ω, the rated current (full load current = 11.69A)flows in the armature. So, we change the load from 26.5Ω to 300Ω ,find V_{ph} and E_{ph}.

$$E_{ph} = \sqrt{(V_{fl}*\cos\Theta + I*R_s)^2 + (V_{fl}*\sin\Theta + I*X_s)^2}$$

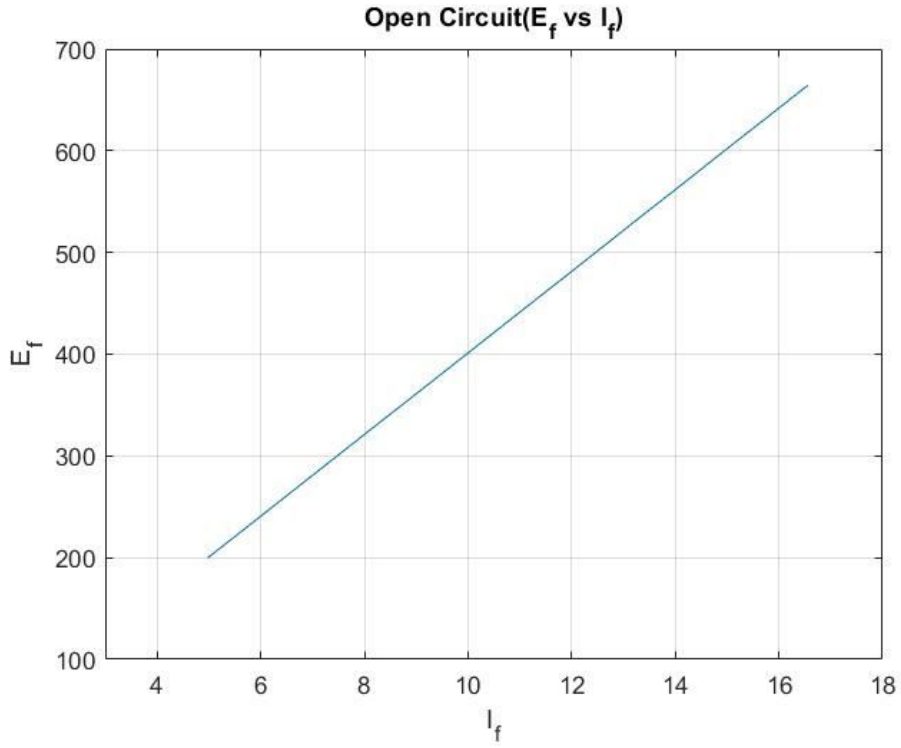
Substituting V_{fl} = 309.5V,$\cos\Theta$=1,R_s=1.62Ω,X_s=33.706Ω,I=11.69A.

We get, E_{ph}=506.38V.

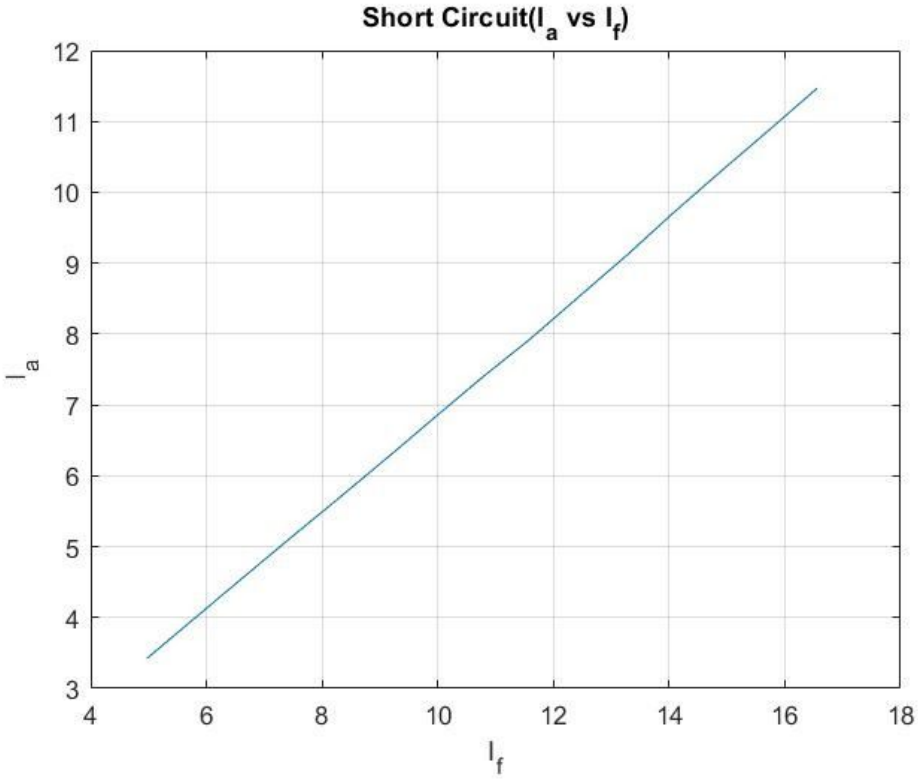
S.NO	Load(Ω)	Voltage across terminals(V_{ph})	No load voltage(E_{ph})	%Voltage Regulation
1	26.5	309.5	506.38	63.6
2	50	413.4	506.38	22.49
3	75	452.6	506.38	11.88
4	100	469.6	506.38	7.83
5	125	478.2	506.38	5.89
6	150	483.6	506.38	4.71
7	200	489.1	506.38	3.5
8	250	491.9	506.38	3.1
9	300	493.5	506.38	2.6

CONCLUSIONS:

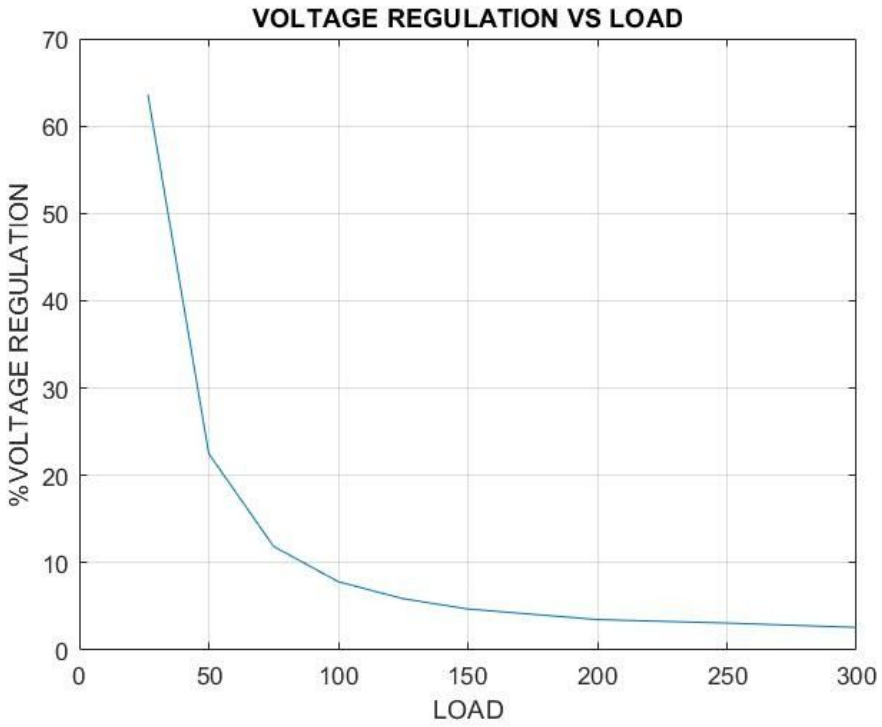
OPEN CIRCUIT CHARACTERISTICS:



SHORT CIRCUIT CHARACTERISTICS:



VOLTAGE REGULATION VS LOAD:



COMMENTS:

1. The Open Circuit Characteristics curve is linear but in practical machines the curve is linear only upto some extent and gets saturated after a particular value due to the Air gap line.
2. The Short Circuit Characteristics curve is linear.
3. As the load increases the voltage regulation decreases.

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