Group5_Exp5

AIM: To study the following characteristics of a synchronous motor.

1. Variation of armature current against variation in field current.
2. Variation of power factor against variation in field current.

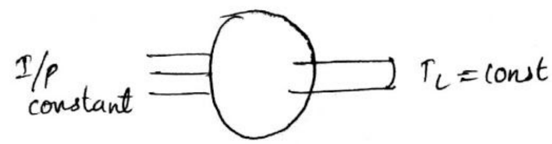
THEORY:

A synchronous motor is doubly excited machine, its armature winding is energized from an AC source and its field winding from the DC source. Total air gap flux is the resultant of the two fluxes produced by the AC and DC excitation. The DC excitation which operates the motor at unity power factor is called the nominal or normal excitation.

If the field current is made less than nominal excitation (under excitation) then the deficiency in air gap flux is made up by the armature MMF. So the armature (stator) winding draws a magnetizing current or lagging VA from the AC source and as a result the motor operates in lagging power factor. Similarly, if the field current is made more than the nominal excitation (over excited) motor operates in leading power factor.

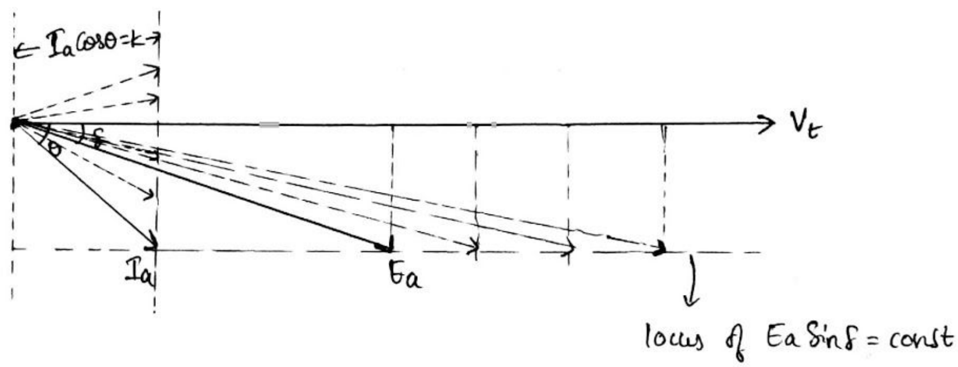
If we draw the variation of armature current and power factor vs field current the curves appear as V and inverted V respectively. The feature of synchronous motor that operates in leading power factor when over excited is utilized in power factor correction applications.Synchronous machines have parabolic type characteristics. The following figure shows the variation of armature current and power factor with field current at no load, half load and full load conditions.

If Input Power is constant,



$$P = \frac{3 E_a V_t \sin\delta}{X_s} = 3 V_t I_a \cos\theta = \text{const}$$

$\boxed{E_a \sin\delta = k}$, $\boxed{I_a \cos\theta = k}$, V_t, X_s = const



Starting from

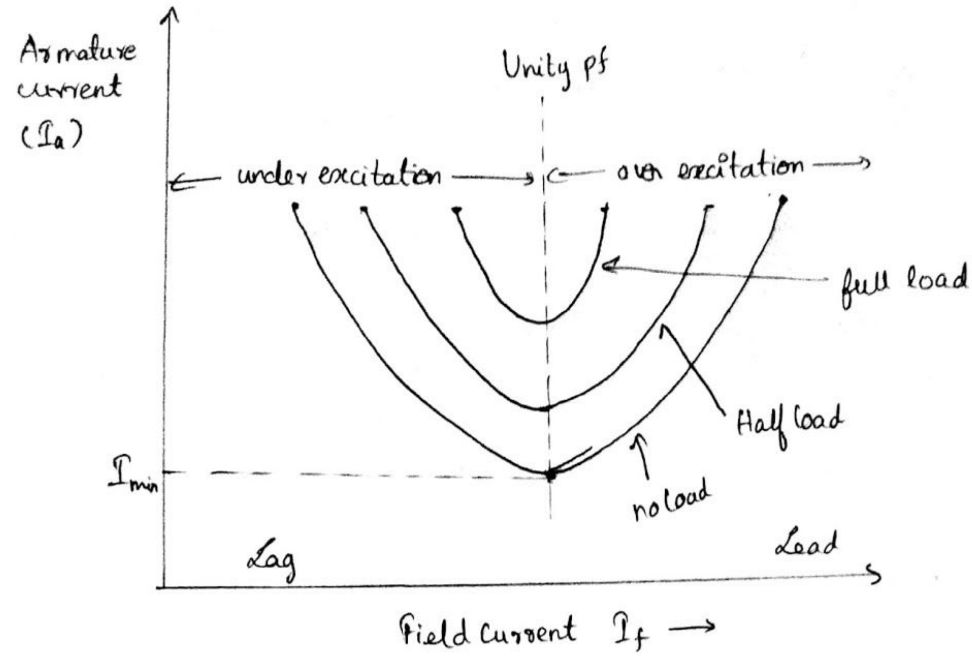
→ Lag condition

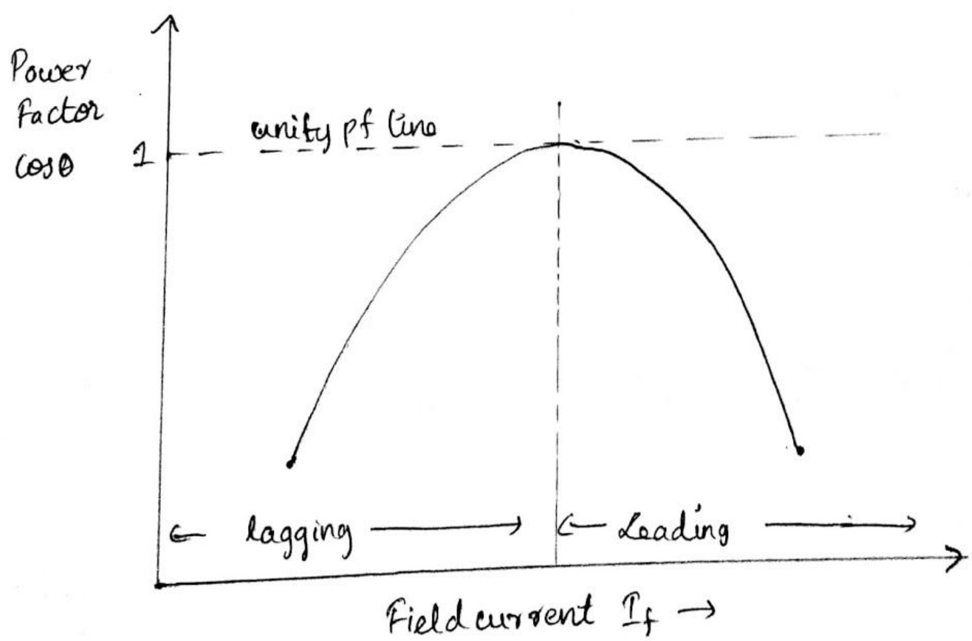
As, $I_f \uparrow$ $E_a \uparrow$ $I_a \downarrow$ pf $\uparrow$

→ Unity pf

→ Lead condition

As, $I_f \uparrow$ $E_a \uparrow$ $I_a \downarrow$ pf $\downarrow$


Armature current (I_a)
Unity pf
← under excitation → ← over excitation →
full load
Half load
no load
I_{min}
Lag
Lead
Field current I_f →


Power Factor $\cos\theta$
unity pf line
1
← lagging → ← Leading →
Field current I_f →

Under excitation	Lagging p.f	$E_b < V$
Over excitation	Leading p.f	$E_b > V$
Critical excitation	Unity p.f	$E_b \cong V$
Normal excitation	Lagging	$E_b = V$

PROCEDURE:

Our Preset model is 8.1kVA,400V,50Hz,1500rpm.

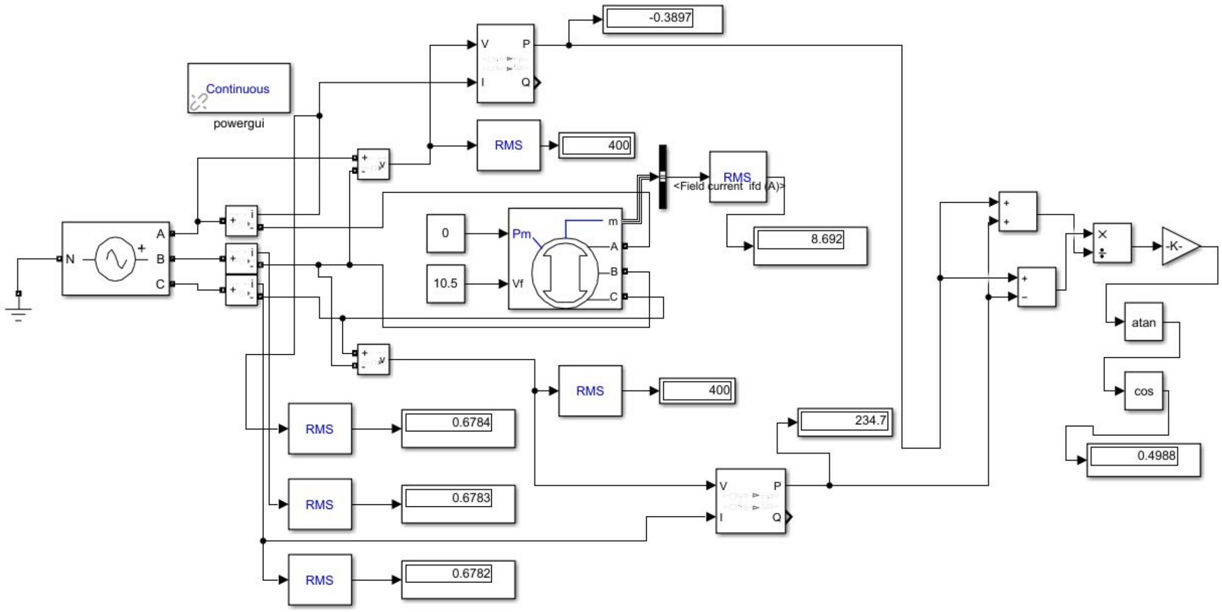
V Curve of Synchronous Motor:

1. Open a blank model in simulink
2. Connect the Circuit as shown in Circuit Diagram in matlab section.
3. Note the reading of Field current(I_f) and Armature current(I_a) by changing Field Voltage(V_f).
4. Tabulate V_f ,I_f and I_a and plot I_a vs I_f to observe the V curve of synchronous motor.

Inverted V Curve of Synchronous Motor:

1. Open a blank model in simulink
2. Connect the Circuit as shown in Circuit Diagram in matlab section.
3. Note the reading of Field current(I_f) and Power factor(cosΘ) by changing Field Voltage(V_f).
4. Tabulate V_f ,I_f and Power factor and plot power factor(cosΘ) vs I_f to observe the Inverted V curve of synchronous motor.

CIRCUIT DIAGRAM IN MATLAB:



RESULTS:

V Curve : I_f vs I_a

Case(i): No load

S.NO	V_f(Field Voltage)	Field Current(I_f)	Armature Current(I_a)
1.	7	5.795	2.577
2.	8	6.623	2.02
3.	9.1	7.533	1.414
4.	10	8.278	0.928
5.	11	9.106	0.4453
6.	12	9.934	0.4095
7.	13	10.76	0.8772
8.	14	11.59	1.416
9.	15	12.42	1.968
10.	16	13.25	2.524

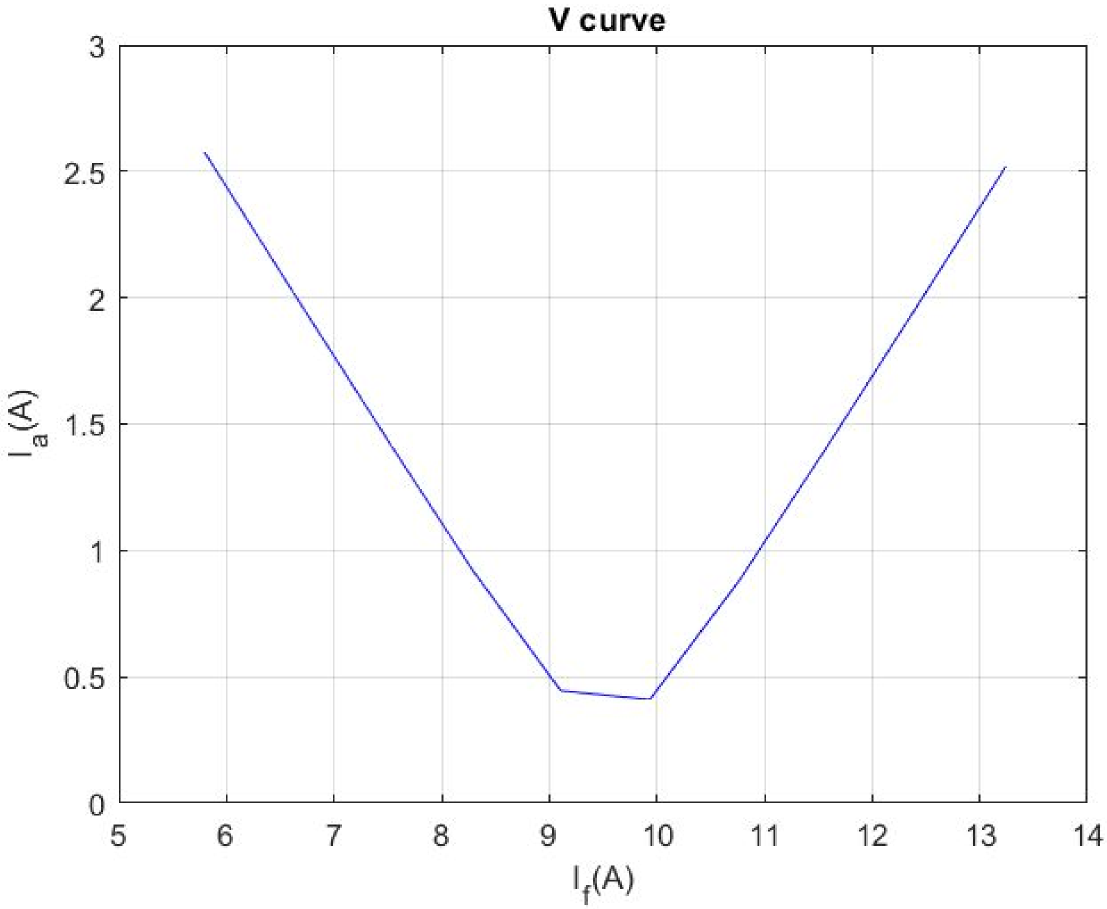
Inverted V Curve: I_f vs cosΘ.

S.NO	V_f(Field Current)	Field Current(I_f)	W_1	W_2	Power factor (cosΘ)
1.	7	5.795	-382.6	636.9	0.1426
2.	8	6.623	-276.8	518.7	0.1729
3.	9.1	7.533	-158.6	390.4	0.2368
4.	10	8.278	-60.48	286.7	0.3521
5.	11	9.106	50	173	0.723
6.	11.546	9.558	111	111.6	1
7.	12	9.934	162	60.85	0.7861
8.	13	10.76	275.6	-49.81	0.3719
9.	14	11.59	390.7	-158.9	0.2366
10.	15	12.42	507.4	-266.5	0.1769

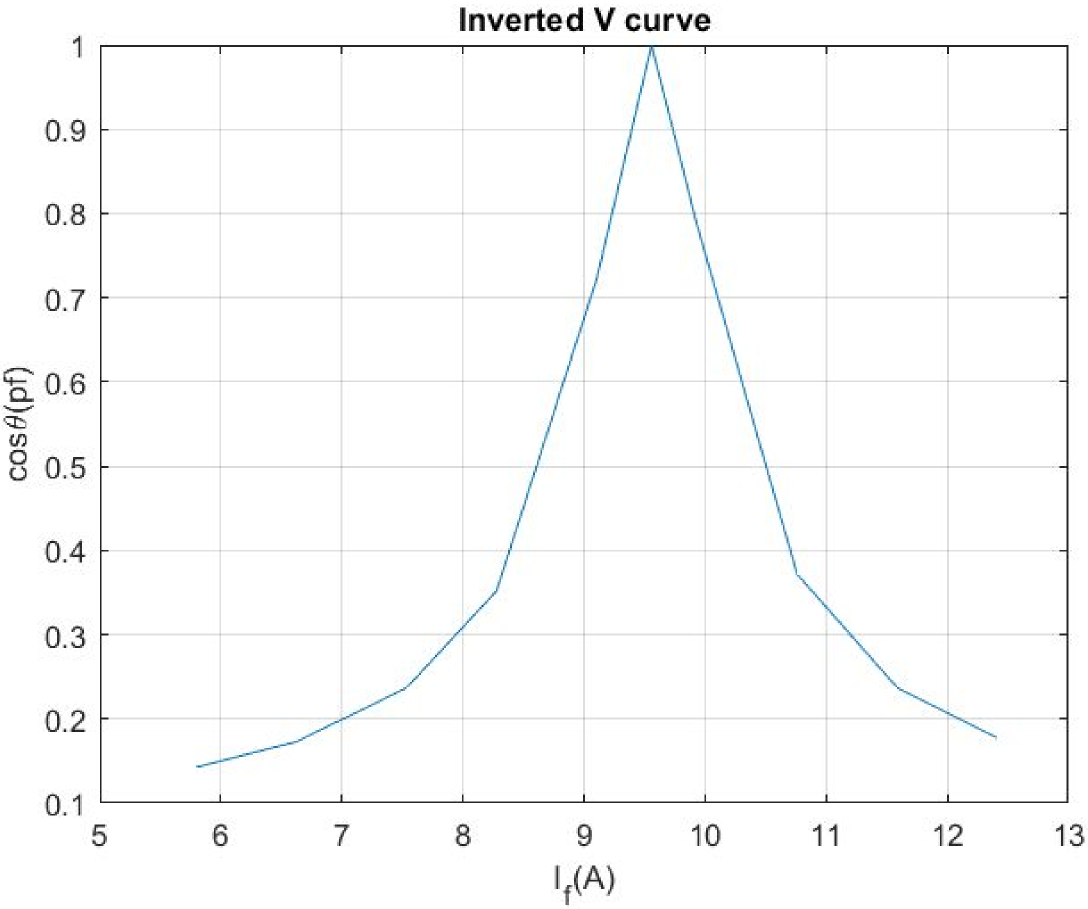
$$\cos\phi = \cos\left\{\tan^{-1}\left[\frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2}\right]\right\}$$

CONCLUSION:

PLOT OF V CURVE:



PLOT OF INVERTED CURVE:



COMMENTS:

When synchronous motor is over excited then it has leading power factor means synchronous motor behaves as a capacitor from V curve it is shown when I_f is in 9.558A-11.59A, similarly when the synchronous motor is under excited then it has lagging power factor means it behaves as a inductor from V curve it is shown when I_f is in 7.45A-9.558A.

Operation of synchronous motor as a synchronous condenser:

When a synchronous motor runs with over-excitation, it draws leading current from the source. Thus a synchronous motor at no-load behaves as a variable condenser or inductor by simply varying its excitation.The machine operated under such a condition(no load or light load) is known as synchronous condenser and finds its application in large integrated power systems for improving the power factor under heavy-load conditions and for deproving the power factor under light-load conditions ,thereby controlling the voltage profile of the power system within reasonable limits.

Applications of synchronous motor based on the observations:

The V curve of a synchronous machine shows armature current as a function of field current. With increasing field current armature current at first decreases, then reaches a minimum, then increases.The minimum point is also the point at which the power factor is unity. This ability to selectively control power factor can be exploited for power factor correction of the power system to which the motor is connected. Since most power systems of bigger size have a net lagging power factor, the presence of over excited synchronous motors moves the system's net power factor closer to unity, improving efficiency.

Synchronous motors are mostly used in applications requiring precise speed and position control.

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