Experiment-5: V and Inverted V curves of Synchronous motors

Group number 22:

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Objective:

The objective of this experiment is to study the following characteristics of the synchronous motor.

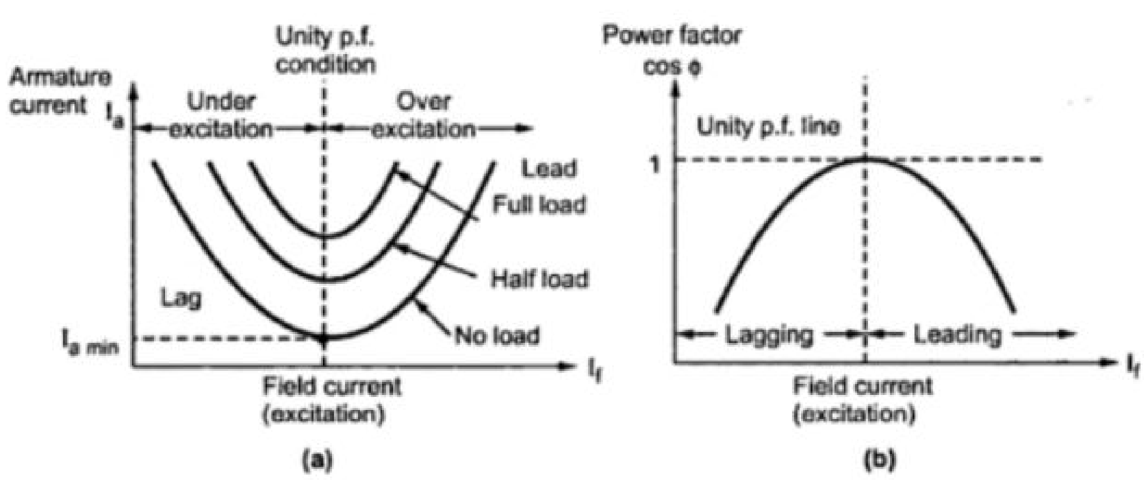
- *Variation of armature current against variation in field current.*
- *Variation of power factor against variation in field current.*

Introduction to V and Inverted V curves:

A Synchronous motor is a 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 a 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 exited) 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 the 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.

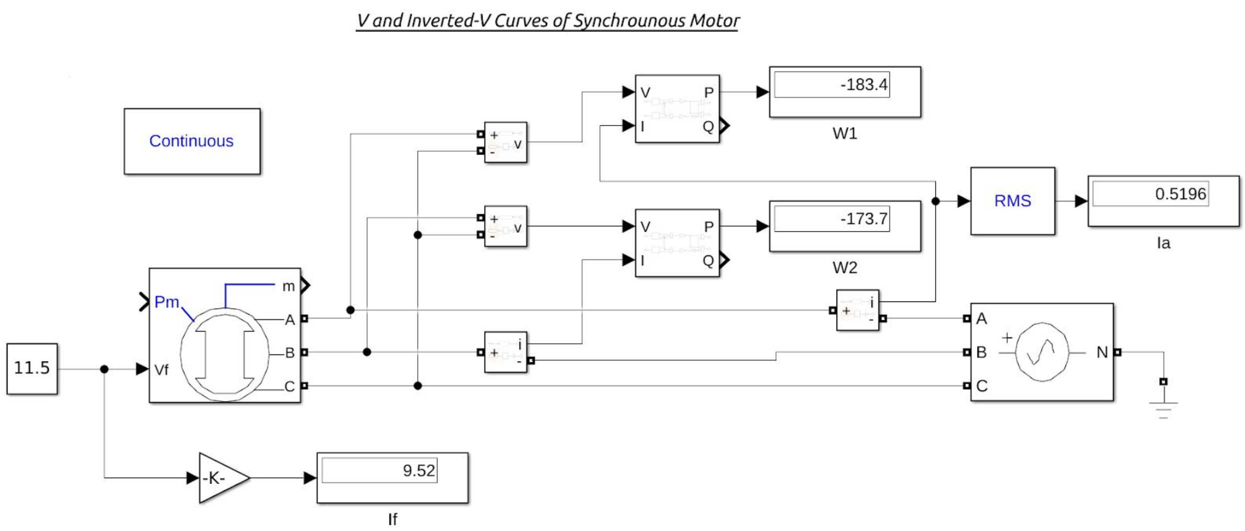


Circuit Arrangement & Experiment Procedure:

The circuit arrangement for conducting the experiment is shown as follows, where the armature current is measured by the line ammeter and power factor by the Two-wattmeter method. The field current is measured by the DC ammeter in the field circuit.

- *Connections are made as shown in the circuit diagram.*
- *Variable three-phase supply is increased gradually to the rated value, and then the field current is increased until the unity power factor is observed.*
- *Now by varying the field current above and below the nominal excitation corresponding armature current and power factor readings are recorded.*
- *Plot these obtained armature current and power factor readings against field current to obtain V and inverted V curves.*

Circuit Arrangement in Simulink:



Results:

V Curve: If vs. Ia

S.no	***Vf***	***Field current(If)***	***Armature current (Ia)***
1.	*1*	*0.8278*	*7.063*
2.	*2.5*	*2.07*	*5.097*
3.	*5*	*4.139*	*3.695*
4.	*6.5*	*5.381*	*2.856*
5.	*8*	*6.623*	*2.021*
6.	*9.5*	*7.864*	*1.195*
7.	*11*	*9.106*	*0.447*
8.	*11.5*	*9.52*	*0.1993*
9.	*12*	*9.934*	*0.4109*
10.	*13.5*	*11.18*	*1.148*
11	*15*	*12.42*	*1.968*
12	*16.5*	*13.66*	*2.808*
13	*18*	*14.9*	*3.644*
14	*19.5*	*16.14*	*4.493*
15	*21*	*17.38*	*5.308*

Inverted V Curve: If vs. cosΦ

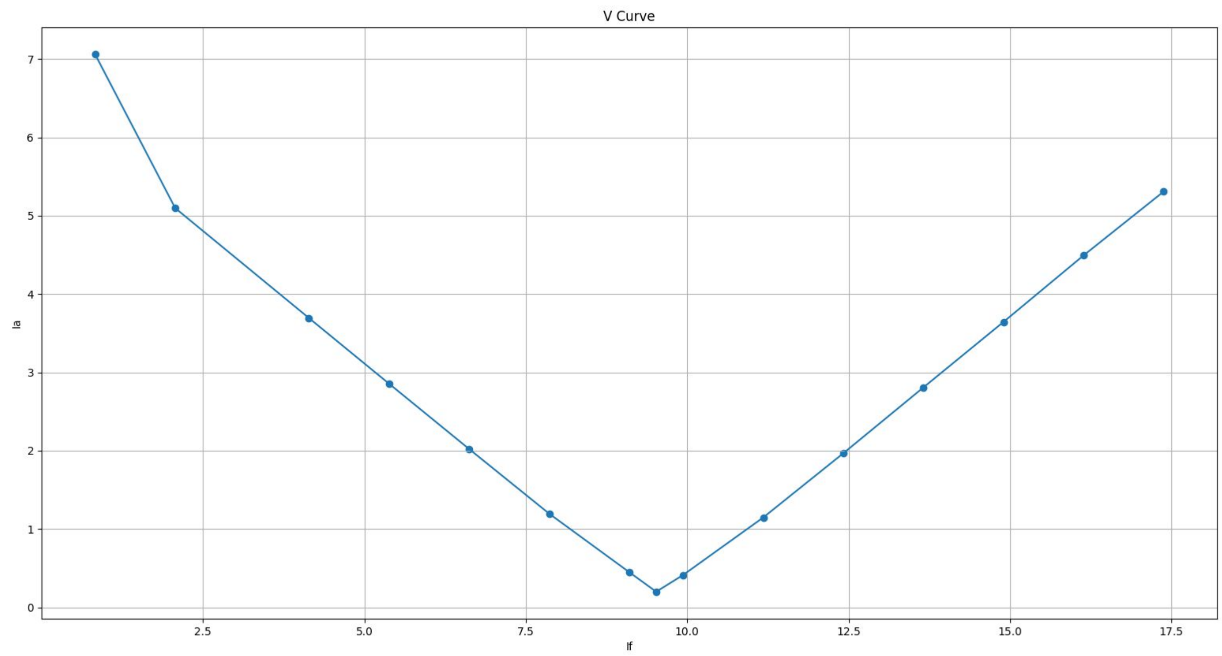
S.no	Vf	Field current(If)	W_1	W_2	Power factor(cosΦ)
1.	1	0.8278	-1640	1176	0.09
2.	2.5	2.07	-1189	841.5	0.1
3.	5	4.139	-879.1	591	0.11
4.	6.5	5.381	-697.3	436.6	0.13
5.	8	6.623	-519	278	0.17
6.	9.5	7.864	-344.3	115.6	0.28
7.	11	9.106	-173.9	-50.53	0.72
8.	11.5	9.52	-66.62	-68.22	1
9.	12	9.934	-61.54	-162.8	0.79
10.	13.5	11.18	99.32	-338.7	0.3
11	15	12.42	265.1	-509.9	0.18
12	16.5	13.66	420.6	-692.4	0.14
13	18	14.9	585.6	-864.6	0.11
14	19.5	1614	731.3	-1058	0.1
15	21	17.38	901.6	-1217	0.09

$$Cos\Phi = cos\{Tan^{-1}[\ (\sqrt{3} * (W_1 - W_2))/(W_1+W_2)\ ]\}$$

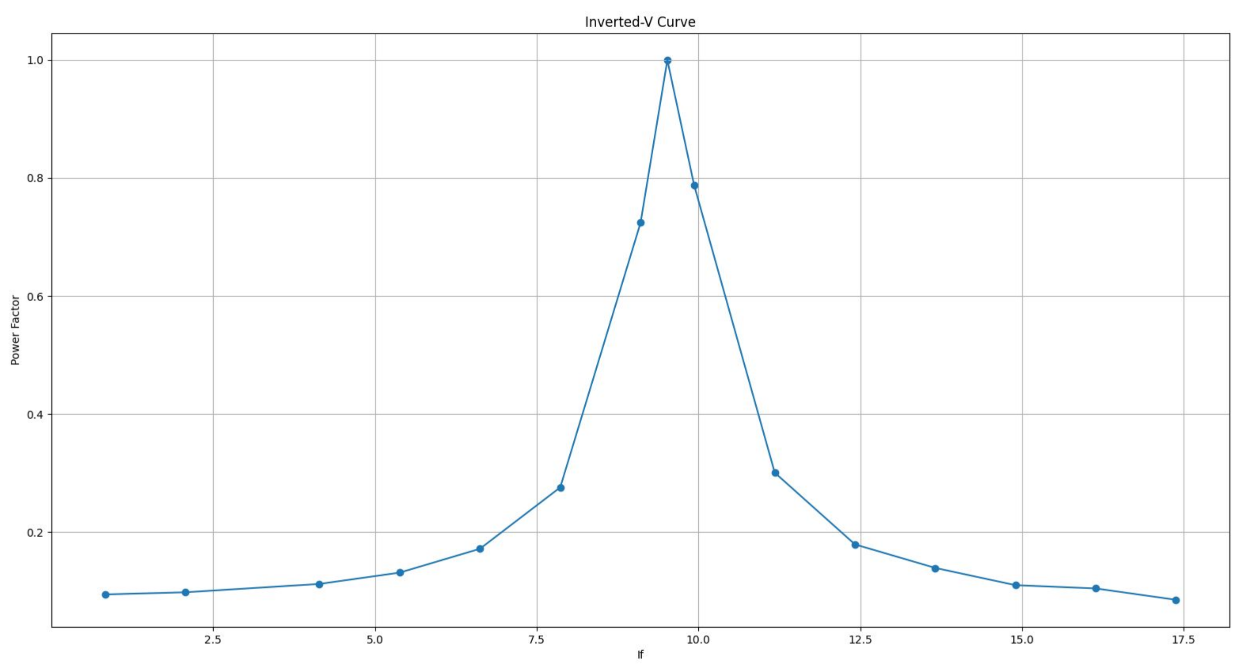
Conclusions:

Graphs:

V-Curve:



Inverted-Curve:



When the power factor of a Synchronous motor is lagging it behaves as an Inductor. When the power factor of a Synchronous motor is leading it behaves as a Capacitor.

Range of field current for which the synchronous motor behaves as an Inductor = (0,9.1A)
Range of field current for which the synchronous motor behaves as a Capacitor = (9.1A - 17.5A)

*A Synchronous motor with no load will lead the current i.e., leading power factor like a capacitor. This Synchronous motor without load(Over-excited) is **Synchronous Condenser**.*
The synchronous condenser is used in power lines to improve power factor, power factor correction by connecting it along with transmission lines.

Applications of Synchronous motor:

- *Synchronous motors are used for applications where precise and constant speed is required.*
- *They are used for efficient means of converting AC power into mechanical power.*
- *They are used for power factor correction.*