V curves and V inverted curves of a synchronous motor

Experiment: 4 Date: 28-2-22

Aim: The aim of experiment is to draw the V and inverted V curves of three phase synchronous motor.

Apparatus Required

| S.No. | Name of the apparatus | Range | Type | Quantity |
|---|---|---|---|---|
| 1) | Ammeter | (0-10) A | MI | 1 |
| 2) | Ammeter | (0-2) A | MC | 1 |
| 3.) | Voltmeter | (0-600) A | MI | 1 |
| 4.) | Wattmeter | 600, 10 A | EDM | 2 |
| 5.) | Tachometer | (0-3000) rpm | Digital | 1 |
| 6.) | Connecting wires | 2.5 $mm^2$ | Cu/Al | few |

Name Plate Details

Rated Voltage :→ 400 V

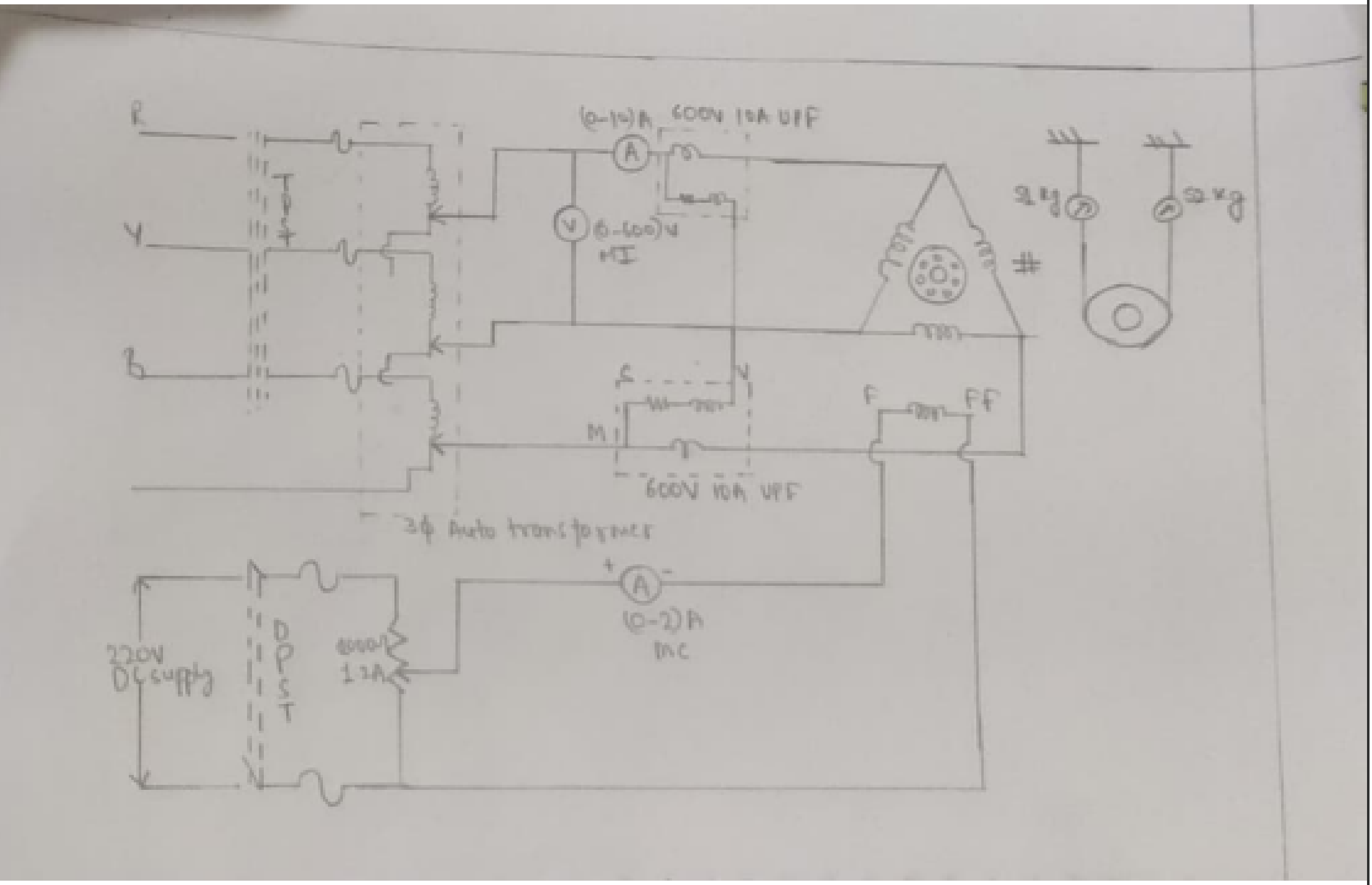
Rated current :→ 16 A

Rated power :→ 12.5 kA

Theory :→ In AC electromagnetic device magnetizing current or lagging device reactive VA, drawn from AC source is to set up the flux the magnetic circuit of device. A synchronous motor is doubly excited machine. When synchronous machine is working at a constant applied voltage, the resultant air gap flux as demanded by constant supply voltages, remains substantially constant by following equation,

$$\phi_{air\,gap} = \frac{V_t}{\sqrt{2}\pi f k_w T_{ph}}$$

This resultant air gap flux is established by the cooperation of both ac in armature winding and dc in field winding. If the field current is sufficient enough to set up the air gap flux, as demanded by the constant $V_t$ then magnetizing current or lagging reactive $V_A$ required from the AC source is 0 and therefore the motor operates at unity power factor. This field current is excitation or normal field current.


R
Y
B
(0-10)A 600V 10A UVF
(0-600)V MI
3φ Auto transformer
600V 10A UVF
220V DC supply
DPST
600Ω 1.7A
(0-2)A MC
F
FF
3 kg
5 kg

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→ If the field current is made less than the normal excitation i.e. the motor is under excite, then the deficiency in flux must be made up by the armature winding mmf. In order to do the need full, the armature draws an magnetizing current from the AC source and a result of it. motor operates at lagging power factor.

## Procedure

→ Note down the name plate details of motor
→ Connections are given as per diagram.
→ Close the TPST switch.
→ By adjusting the auto transformer from minimum position to maximum position the rated supply is given to the motor. The motor starts as an induction motor.
→ In order to give the excitation to the field winding, close the DPST switch
→ By varying the field current with the help of field rheostate from under excitation to over excitation, note down the armature current and input power at no load, half load and full load excitation.

## observation Table

| S.No. | Excitation current ($I_f$) | Armature Current $I_a$ | $W_1$ Reading MF = 8 | $W_2$ reading MF = 8 | Cos ϕ |
|---|---|---|---|---|---|
| 1) | 0.8 | 15.1 | 460 | -360 | 0.0711 |
| 2) | 0.9 | 14.1 | 400 | -280 | 0.1013 |
| 3) | 1.1 | 12.5 | 360 | -120 | 0.2774 |
| 4) | 1.3 | 10.1 | 330 | -10 | 0.3513 |
| 5) | 1.5 | 7.2 | 290 | -40 | 0.401 |
| 6) | 1.7 | 4.1 | 180 | 0 | 0.499 |
| 7) | 1.9 | 3 | 125 | 30 | 0.657 |
| 8) | 2.1 | 2 | 80 | 60 | 0.97 |
| 9) | 2.3 | 3.5 | 0 | 150 | 0.499 |
| 10) | 2.5 | 6.1 | -30 | 240 | 0.4099 |
| 11) | 2.7 | 9.2 | -80 | 320 | 0.3267 |
| 12) | 2.9 | 12.1 | -160 | 370 | 0.2239 |
| 13) | 3.2 | 14 | -280 | 400 | 0.1014 |

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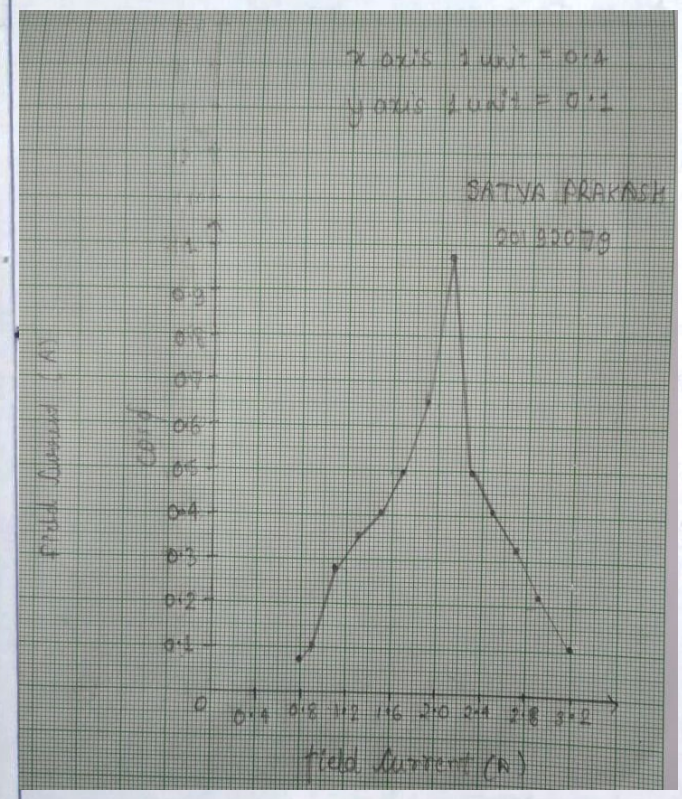
Formula Used

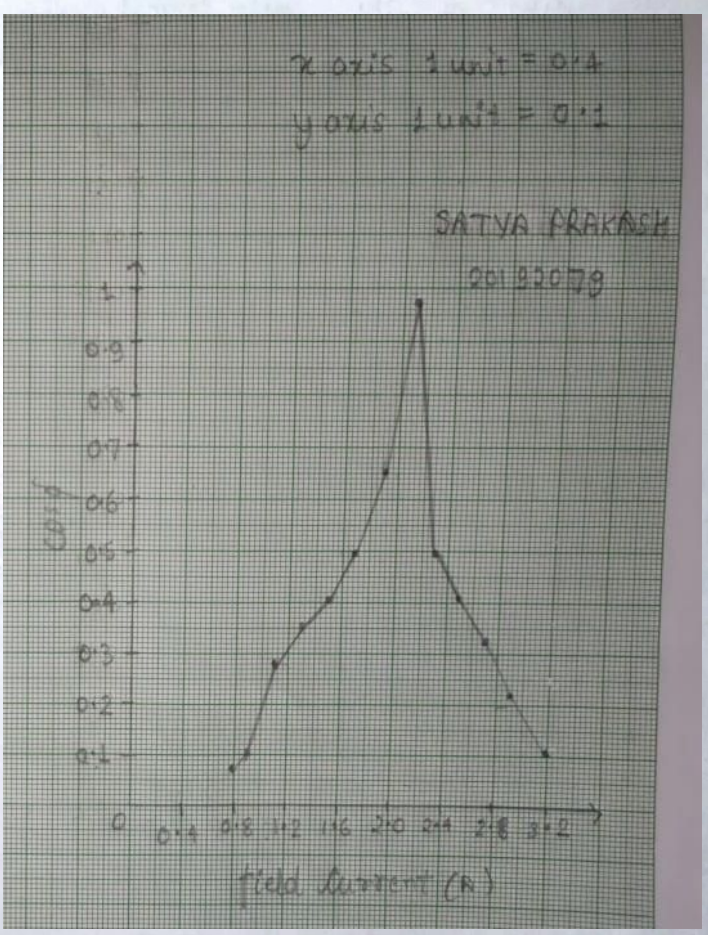
$\cos\phi = P_i / \sqrt{3} V_L I_L$ where $\phi$ = phase angle b/w voltage and current.

$P_i$ = Input power, $V_L$ = line voltage $I_L$ = line current.

$\cos\phi = \cos\left(\tan^{-1}\left(\sqrt{3}\ \frac{\omega_1 - \omega_2}{\omega_1 + \omega_2}\right)\right)$.

Graph



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Calculation

| S.No | $W_1$ | $W_2$ | $\frac{W_1-W_2}{W_1+W_2}$ | $\sqrt{3}\tan^{-1}\left(\frac{W_1-W_2}{W_1+W_2}\right)$ | $\tan^{-1}\frac{\sqrt{3}W_1W_2}{W_1+W_2}$ | $\cos\left(\tan^{-1}\left(\frac{W_1-W_2}{W_1+W_2}\right)\right)$ |
|---|---|---|---|---|---|---|
| 1.) | 460 | -360 | 8.2 | 14.2028 | 1.4996 | 0.0711 |
| 2.) | 400 | -280 | 5.67 | 9.82072 | 1.46932 | 0.1013 |
| 3.) | 360 | -120 | 2 | 3.464 | 1.28975 | 0.2774 |
| 4.) | 330 | -70 | 1.5385 | 2.665 | 1.21182 | 0.3513 |
| 5.) | 290 | -40 | 1.32 | 2.286 | 1.1584 | 0.401 |
| 6.) | 180 | 0 | 1 | 1.7321 | 1.0472 | 0.499 |
| 7.) | 125 | 30 | 0.6129 | 1.0616 | 0.8536 | 0.657 |
| 8.) | 80 | 60 | 0.14285 | 0.2474 | 0.2425 | 0.97 |
| 9.) | 0 | 150 | -1 | -1.7321 | -1.0472 | 0.499 |
| 10.) | -30 | 240 | -1.2857 | -2.2269 | -1.1487 | 0.4099 |
| 11.) | -80 | 320 | -1.67 | -2.893 | -1.238 | 0.3267 |
| 12.) | -160 | 380 | -2.524 | -4.37169 | -1.348 | 0.2238 |
| 13.) | -280 | 400 | -5.667 | -9.8155 | -1.4692 | -0.1014 |

Result

With the help of the experimental value, we have calculated power factor and plotted graph for V curve and inverted V curve repectively.

Precautions

- The potential divider should be in maximum position.
- The motor should not be started without load.
- Initially TPST switch switch is in open position.