DATE | SHEET NO.

INDUCTION MOTOR

OBJECTIVE :

1. To study the constructional features of a three phase induction motor
2. To plot torque - slip characteristics of the motor over the operating range.
3. To plot power factor and efficiency curves of the motor against shaft load.

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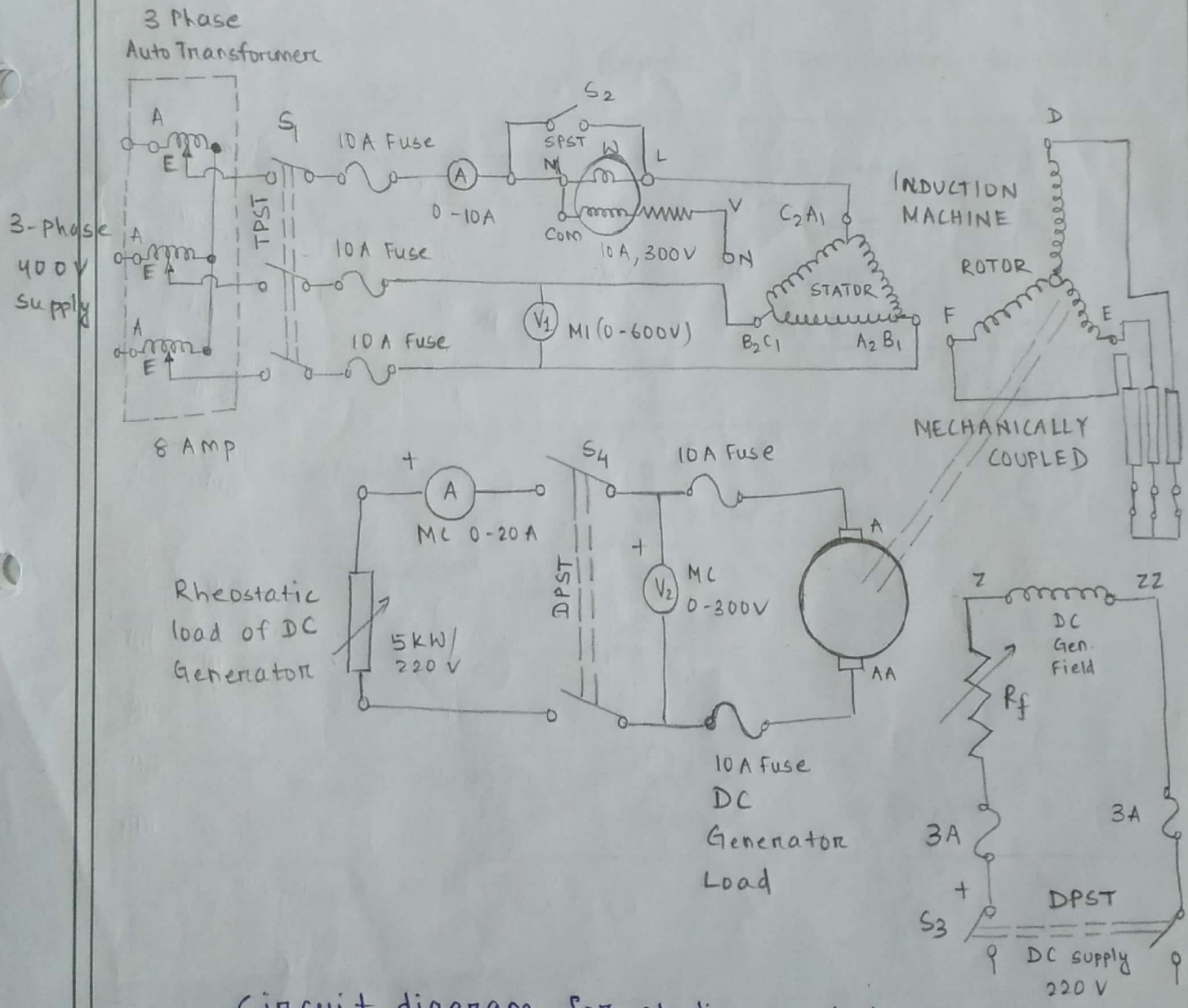
DATE | SHEET NO.

CIRCUIT DIAGRAM



Circuit diagram for studies on Induction Motor

P.R.E.

DATE | SHEET NO.

APPARATUS REQUIRED

Sl. No.	Apparatus Name	Range	Specification	Quantity
1.	Auto-Transformer	8A	3-phase	1
2.	Switch		SPST DPST TPST	1 2 1
3.	Wattmeter	10A, 300V		1
4.	Ammeter	0-10 A 0-20 A	MI MC	1 1
5.	Voltmeter	0-600 V 0-300 V	MI MC	1 1
6.	Fuse wire	3A 10 A		2 5
7.	Power Supply	220 V 400 V	DC AC (3-phase)	1 1
8.	Rotor Stator Armature			1 1 1

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RELEVANT THEORY

The induction motor consists of a stator and rotor. Stator consists of a 3-phase distributed winding, each phase winding are 120° apart. The rotor is of two types – ① squirrel cage type
② slip ring type.

Working principle of induction motor is rotating magnetic field.

The slip of an induction motor (s) is defined as

$$s = \frac{n_s - n_r}{n_s}$$, where n_s = stator rotating magnetic field

n_r = rotor speed

The shaft torque of induction meter, $T_{sh} = \frac{60\, P_{sh}}{2\pi\, n_r}$

The efficiency, $\eta = \frac{P_{sh}}{P_{input}}$

And the operating power factor of the induction motor, $\cos\theta = \frac{P_{input}}{\sqrt{3} V_1 A_1}$

OBSERVATION TABLE

Recorded values							Calculated values			
Sl. No.	V_1 (V)	A_1 (A)	V_2 (V)	A_2 (A)	W (W)	Speed (rpm)	slip %	Tsh	cosθ	η_m
1.	440	1.25	216	0	120	1480	1.33	1.16	0.38	0.5
2.	440	1.6	208	1	200	1469	2.07	2.52	0.49	0.65
3.	440	1.75	204	2	280	1456	2.93	3.86	0.63	0.7
4.	440	2	196	3	360	1448	3.47	5.06	0.71	0.71
5.	440	2.3	188	4.5	496	1432	4.53	6.84	0.85	0.69
6.	440	2.75	178	6	600	1415	5.67	8.42	0.86	0.69
7.	440	3.2	170	7.4	696	1402	6.53	9.79	0.86	0.69
8.	440	3.5	160	8.6	760	1390	7.33	10.69	0.85	0.68
9.	440	3.75	154	9.7	856	1380	8	11.58	0.90	0.65
10.	440	4	146	10.6	928	1370	8.67	11.87	0.91	0.62

P.R.E.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

Recorded values							Calculated values			
Sl. No.	V_1 (V)	A_1 (A)	V_2 (V)	A_2 (A)	W (W)	Speed (rpm)	slip %	Tsh	cosθ	η_m
1.	352	0.75	208	0	80	1474	1.73	0.78	0.52	0.5
2.	352	1	202	0.9	136	1456	2.93	1.98	0.67	0.74
3.	352	1.25	196	1.9	200	1440	4	3.26	0.79	0.82
4.	352	1.75	190	2.8	264	1426	4.93	4.37	0.74	0.82
5.	352	2	186	3.6	360	1415	5.67	5.33	0.88	0.73
6.	352	2.4	180	4.4	432	1400	6.67	6.22	0.88	0.70
7.	352	3	172	5.8	560	1374	8.4	7.77	0.92	0.66
8.	352	3.3	165	6.4	600	1360	9.33	8.26	0.89	0.65
9.	352	3.75	156	7.6	688	1340	10.67	9.30	0.90	0.63
10.	352	4.2	148	8.6	768	1315	12.33	10.11	0.94	0.60

DATE | SHEET NO.

SAMPLE CALCULATION

For 2nd reading of 352 V –

$V_2 = 202\ V$ $A_2 = 0.9\ A$ $V_1 = 352\ V$, $A_1 = 1\ A$

$W = 136\ W$, $n_R = 1456$ rpm

$P_0 = 120\ W$ $n_s = 1500$ rpm

$$P_{sh} = 120 + 202 \times 0.9 = 301.8\ W$$

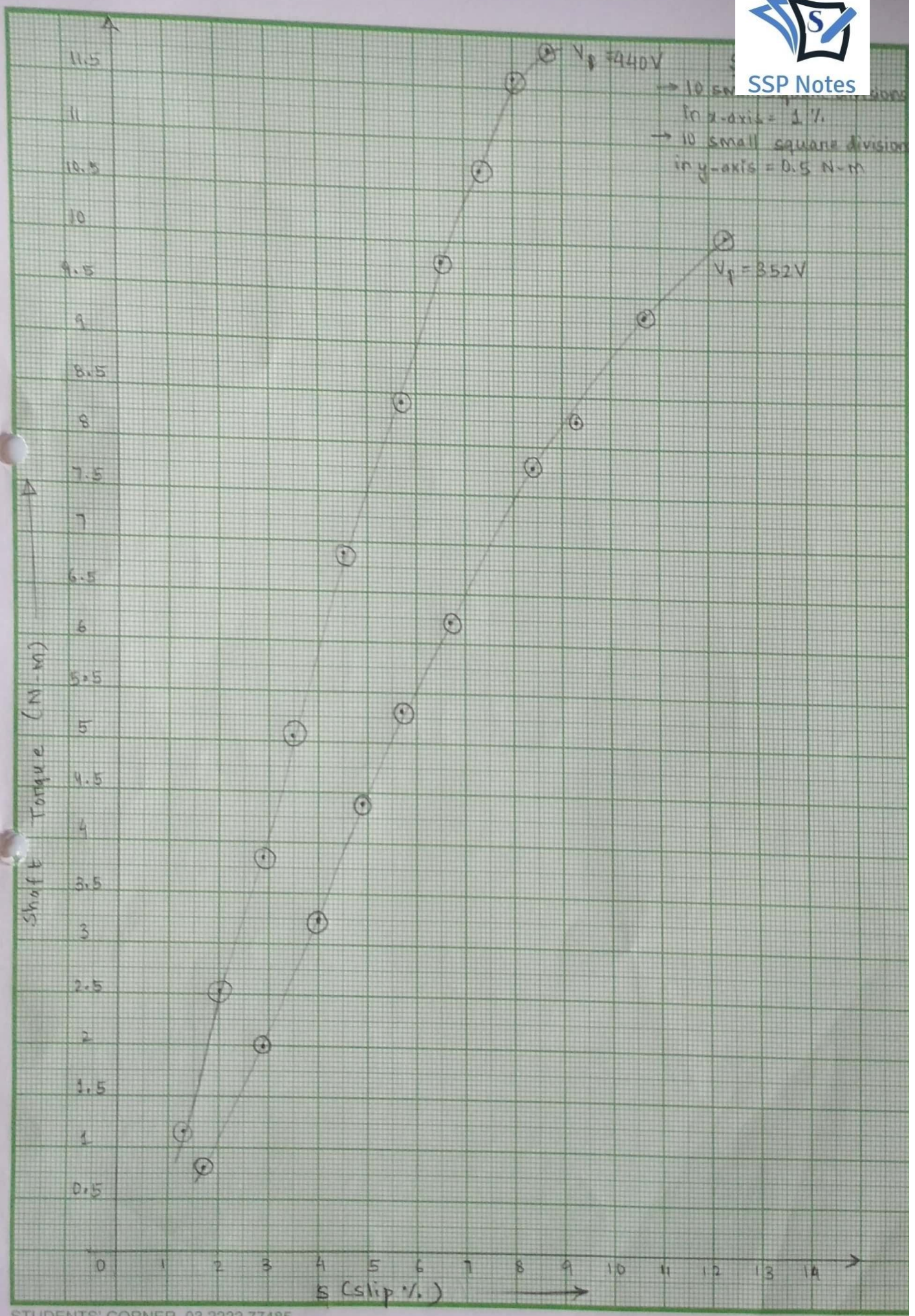
$$T_{sh} = \frac{60 \times P_{sh}}{2\pi \times n_r} = \frac{60 \times 301.8}{2\pi \times 1456} = 1.98\ N\text{-}m$$

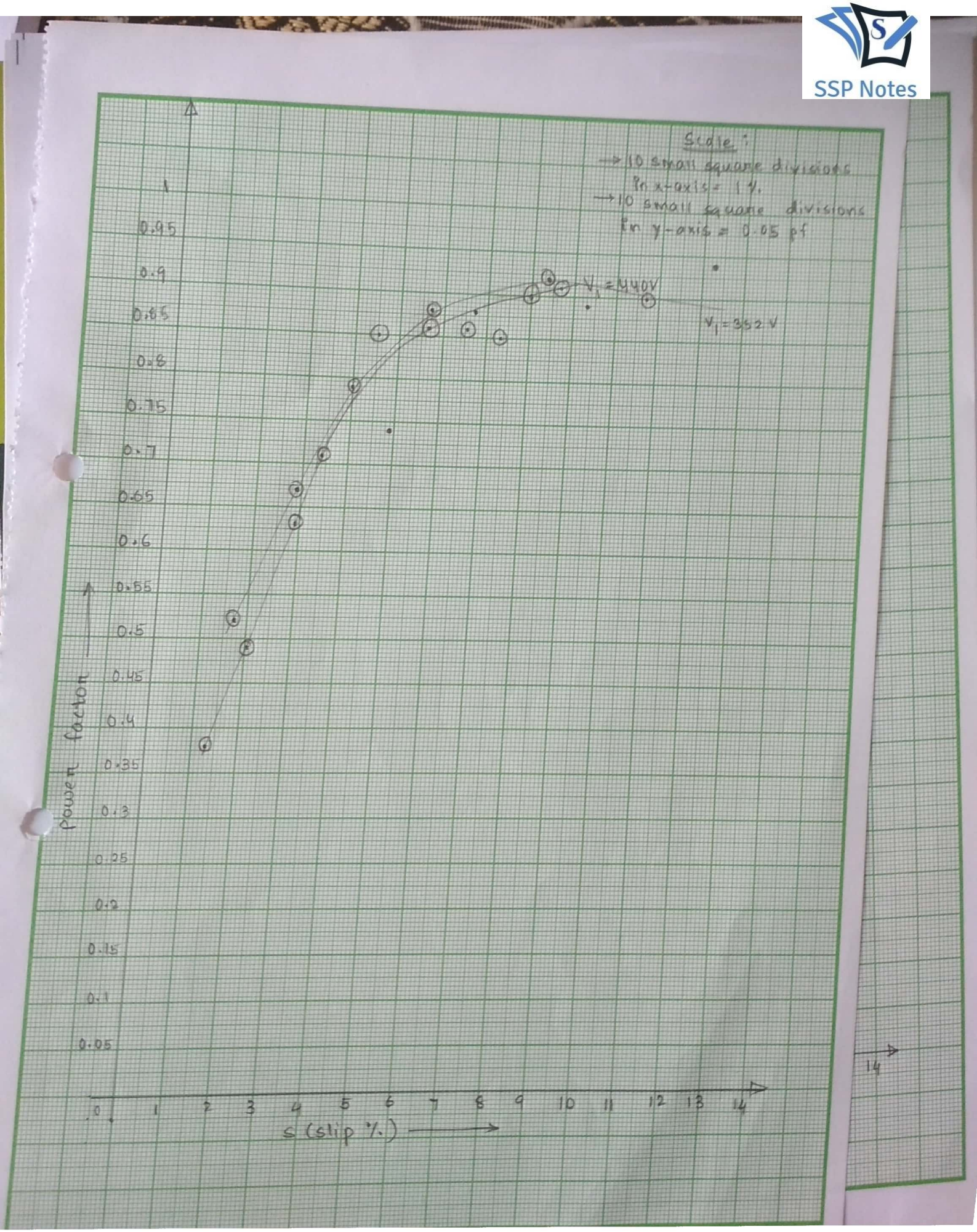
$$\text{slip \%} = \frac{1500 - 1456}{1500} = \frac{n_s - n_r}{n_s} = 2.93\%.$$

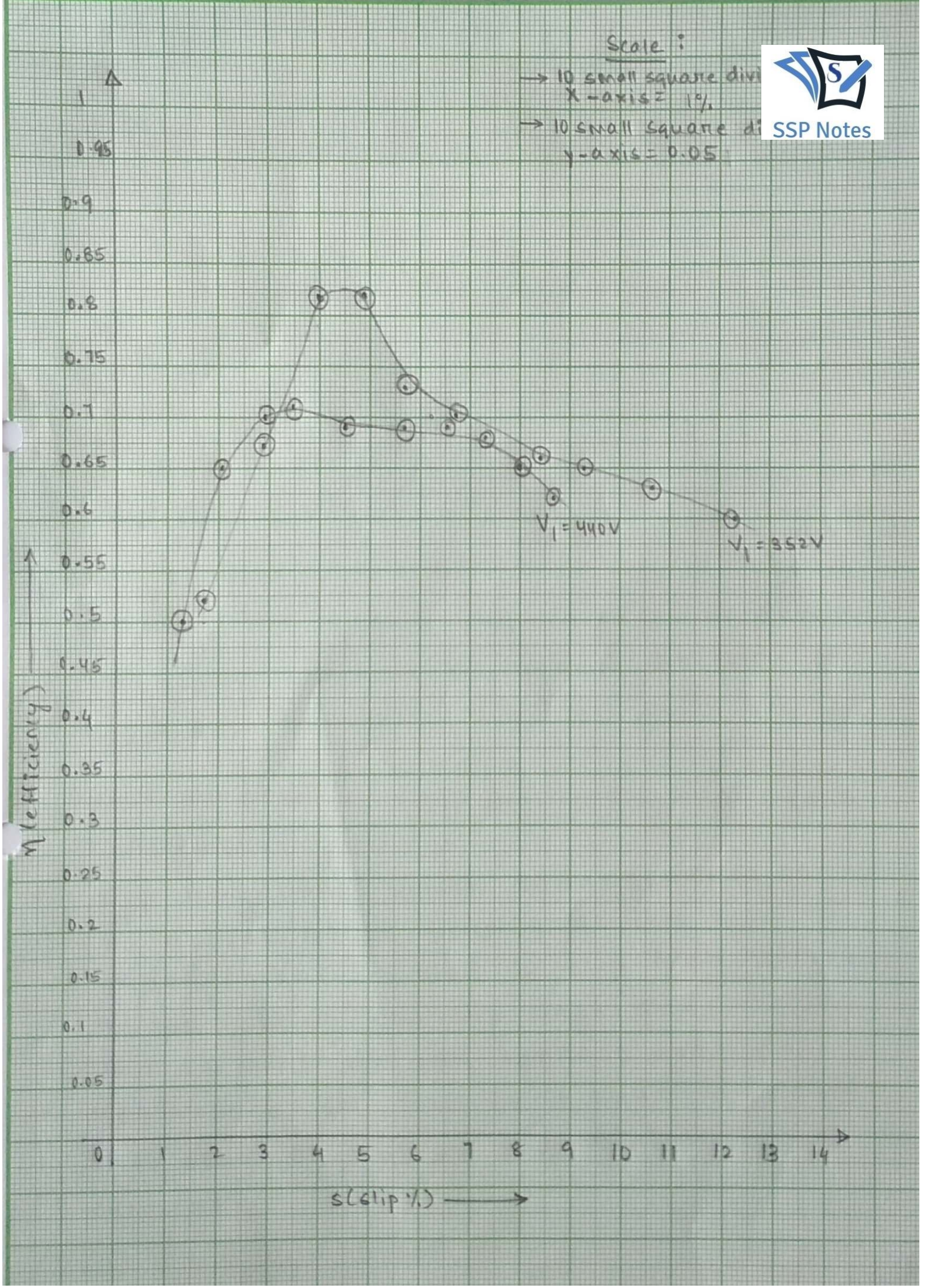
P_{in} = 3-ϕ input power $= 3 \times W = 408\ W$

$$\eta = \text{efficiency} = \frac{P_{sh}}{P_{in}} = \frac{301.8}{408} = 0.74$$

$$\text{Operating power factor} = \cos\theta = \frac{P_{in}}{\sqrt{3}\, V_1 A_1} = 0.67$$







DATE | SHEET NO.

DISCUSSIONS :

Q1. How can the direction of rotation of a 3-phase induction motor be reversed ?

Ans - The direction of rotation of magnetic field of stator can be reversed by changing any two of the phase sequence or all the three phases. The a-b-c sequence can be reversed to b-a-c sequence to reverse direction of rotation.

Q2. What purpose do the slip rings and brush arrangement serve ?

Ans - Slip rings and brush arrangements are used to access rotor terminals. This type of arrangement is found in slip ring induction motor. Using the slip rings and brush arrangement we can connect external resistance or load to it thus increasing the starting torque and minimising starting current.

Q3. Explain how the induction motor gets loaded when DC motor is loaded?

Ans- Since the motor is mechanically coupled with shaft of induction motor, the DC motor provides the load torque, which is in opposition to the electromagnetic torque of induction motor. As the load torque if increased the speed of induction motor is decreased.

Q4. What is the effect of reduction in voltage supply on torque and speed of motor?

Ans- The electromagnetic torque is given by-

$$T_e = \frac{3V_1^2}{2\pi n_s} \cdot \frac{r_2' s}{r_2'^2 + (x's)^2}$$

i.e. $T_e \propto V^2$

∴ if stator voltage decreases by 10%, the torque decreases by 20%..

of V decreases, then T decreases

so to maintain same torque the slip increases i.e. speed decreases.

DATE

SHEET NO.

Q5. What happens to the running motor when fuse of one of the phases blows off?

Ans- The consequence of blown outs is that the motor becomes single phased. An open circuit in one leg kills two other phase and there will be only one phase working even if both the wires are intact. If already running on half load or less the motor will continue running but will not run at high speeds but rather low speeds.

Q6. Will the motor start, if fuse of one of the phases is not present?

Ans- When one line gets broken or opened, it is called 'single phasing' and motor will not start in such a condition until external force is provided to it.