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Report for Experiment #11

Single phase IM and split phase IM

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Abstract:

The Aim of experiment:

Connecting a capacitor run motor, a capacitor start motor, a capacitor start and capacitor run motor, a split phase induction motor and reversing the direction of rotation. Also, performing measurements to determine the motor's efficiency and making a comparison of this value to the value derived from the rating plate. In addition to recording and interpreting various load characteristics of the capacitor motor and investigating the influence of its starting capacitor. Moreover, measuring and interpreting the motor's load and run-up characteristics with computer aided techniques. And finally, recording and interpreting various load characteristics of split phase induction motor.

Equipment list :

1 capacitor motor F	732 06
1 bifilar-wound motor	732 05
1 machine test system	731989
1 CBM 10 computer-based analysis of electrical machines, V.5.76	728421
1 power circuit breaker module	745 561
1 RMS meters	727 10
1 power factor meter	727 12
1 motor protection switch 1 ... 1.6 A	732 14
1 isolating variable transformer, 0 ...260 V	726 85

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Theory :

Single phase motors are very widely used in home, offices, workshops..., since the power delivered to most of the houses and offices is single phase. In addition to this, single phase motors are reliable, cheap in cost, simple in construction and easy to repair.

Single phase electric motors can be classified as:

-Single phase induction motor (Split phase, Capacitor type and shaded pole) - Single phase synchronous motor -Repulsion motor.

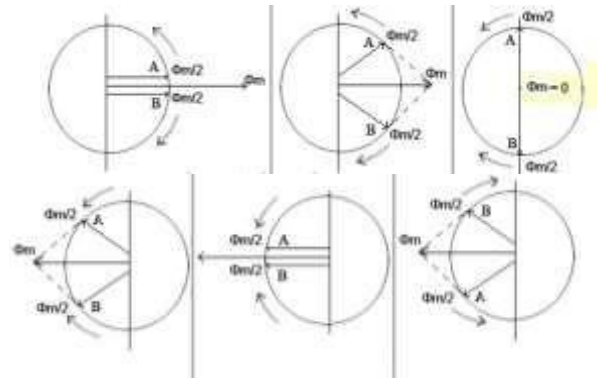
In this experiment, **single phase induction motor** is investigated and studied. The construction of a single phase induction motor is similar to the construction of three phase induction motor having squirrel cage rotor, except that the stator is wound for single phase supply; having only one winding (main winding) fed from a single phase AC source.

The Working Principle of Single Phase Induction Motor is explained as follows; when the stator of a single phase motor is fed with single phase supply, it produces alternating flux in the stator winding. The alternating current flowing through stator winding causes induced current in the rotor bars (of the squirrel cage rotor) according to Faraday's law of electromagnetic induction. This induced current in the rotor will also produce alternating flux. Even after both alternating fluxes are set up, the motor fails to start. However, if the rotor is given an initial start by external force in either direction, then motor accelerates to its final speed and keeps running with its rated speed. This behavior of a single phase motor can be explained by double-field revolving theory.

The double-field revolving theory states that, any alternating quantity (here, alternating flux) can be resolved into two components having magnitude half of the maximum magnitude of the alternating quantity, and both these components rotating in opposite direction.

.A single phase induction motor is not self-starting; the stator of a single phase induction motor is wound with single phase winding. When the stator is fed with a single phase supply, it produces alternating flux (which alternates along one space axis only). Alternating flux acting on a squirrel cage rotor can not produce rotation, only revolving flux can.

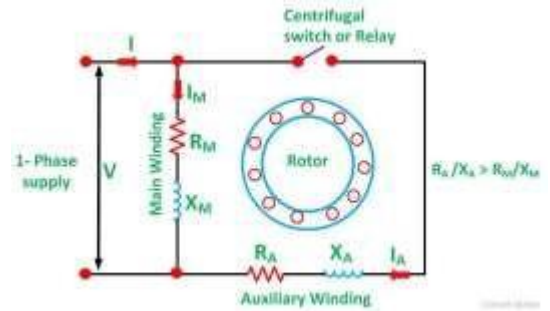
In order to **solve the starting problem** and turn this motor into self-starting motor, it can be temporarily converted into a two-phase motor while starting. This can be achieved by introducing an additional 'starting winding' also called as auxiliary winding. Hence, stator of a single phase motor has two windings; main winding and starting winding (auxiliary winding). These two windings are connected in parallel across a single phase supply and are spaced 90 electrical degrees apart. Phase difference of 90 degree can be achieved by connecting a capacitor in series with the starting winding.



Hence the motor behaves like a two-phase motor and the stator produces revolving magnetic field which causes rotor to run. Once the motor gathers speed, the starting winding gets disconnected from the circuit by means of a centrifugal switch, and the motor runs only on main winding.

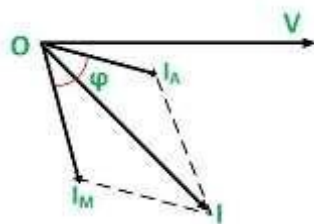
The single phase induction motors are classified as:

- Split phase induction motor.
- Capacitor start inductor motor.
- Capacitor start capacitor run induction motor.
- Permanent split capacitor (PSC) motor.
- Shaded pole induction motor.



The **Split Phase** has a single cage rotor, and its stator has two windings known as main winding and starting winding. Both windings are displaced 90 degrees in space. The main winding has very low resistance and a high inductive reactance whereas the starting winding has high resistance and low inductive reactance. The Connection Diagram of the motor is shown next. A resistor is connected in series with the auxiliary winding. The current in the two windings is not equal as a result the rotating field is not uniform. Hence, the starting torque is small. As soon as the motor reaches the speed of about 70 to 80 % of the synchronous speed the starting winding is disconnected from the supply mains, making the motor runs on the main winding only.

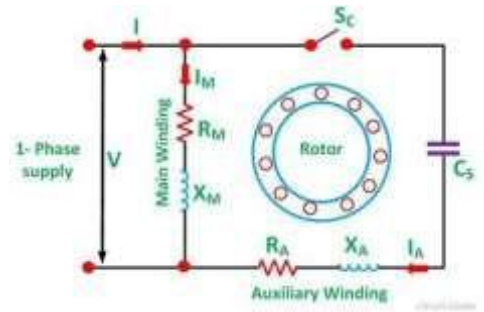
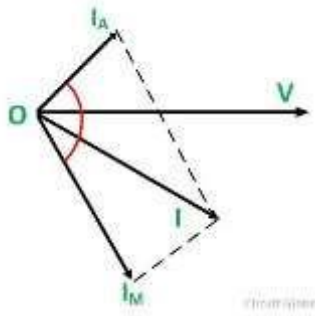
The **Torque Speed Characteristic** of the Split Phase motor is shown beside. And the **phasor diagram** of the Split Phase Induction Motor is shown below:



The current in the main winding (I_M) lag behind the supply voltage V almost by the 90-degree angle. The current in the auxiliary winding I_A is approximately in phase with the line voltage. Thus, there exists the time difference between the currents of the two windings. The time phase difference ϕ is not 90 degrees, but of the order of 30 degrees. This phase difference is enough to produce a rotating magnetic field.

A **Capacitor Start Motors** are a single phase IM that employs a capacitor in the auxiliary winding circuit to produce a greater phase difference between the current in the main and the auxiliary windings. The name capacitor starts itself shows that the motor uses a capacitor for the purpose of the starting. The figure beside shows the connection diagram of a Capacitor Start Motor.

The **Phasor Diagram** of the Capacitor Start motor is shown below.



I_M is the current in the main winding which is lagging the auxiliary current I_A by 90 degrees as shown in the phasor diagram. Thus, a single phase supply current is split into two phases. The two windings are displaced apart by 90 degrees electrical, and their MMF's are equal in magnitude but 90 degrees apart in time phase.

The motor acts as a balanced two-phase motor. As the motor approaches its rated speed, the auxiliary winding and the starting capacitor is disconnected automatically by the centrifugal switch provided on the shaft of the motor.

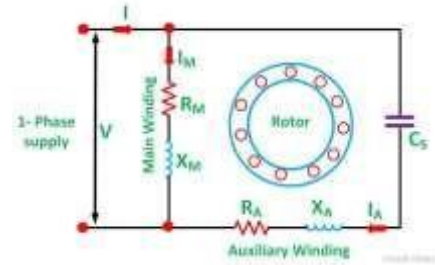
The capacitor starts motor develops a much higher starting torque of about 3 to 4.5 times of the full load torque. To obtain a high starting torque, the two conditions are essential. They are as follows: □ The Starting capacitor value must be large.

□ The value of the starting winding resistance must be low. The **Torque Speed Characteristic** of the motor is shown beside. The characteristic shows that the starting torque is high. The cost of this motor is more as compared to the split phase motor because of the additional cost of the capacitor



The **Permanent Split Capacitor** motor has only one capacitor connected in series with the starting winding. The capacitor C is permanently connected in the circuit both at the starting and the running conditions.

The connection diagram of a Permanent Split Capacitor Motor is shown beside.



The auxiliary winding is always there in the circuit. Therefore, the motor operates as the balanced two-phase motor. The motor produces a uniform torque and has noise free operation.

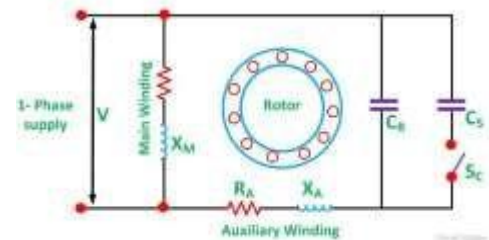
This motor has the following advantages:

- No centrifugal switch is required.
- Efficiency is high.
- As the capacitor is connected permanently in the circuit, the power factor is high. - It has a higher pullout torque.

The limitations of the motor are as follows:-

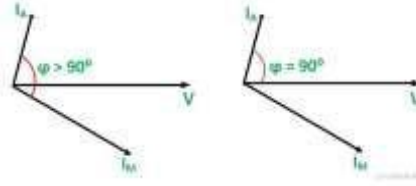
- The paper capacitor is used in the motor as an Electrolytic capacitor cannot be used for continuous running. The cost of the paper capacitor is higher, and size is also large as compared to the electrolytic capacitor of the same ratings. -It has low starting torque, less than full load torque.

The **Capacitor Start Capacitor Run Motor** has two capacitors; one is used at the time of the starting and is known as starting capacitor. The other one is used for continuous running of the motor and is known as run capacitor. Connection diagram of this motor is shown beside.

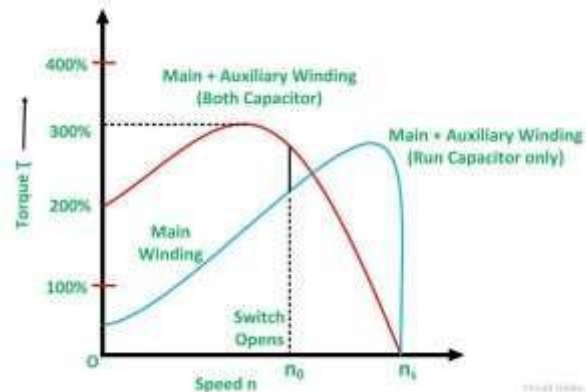


As the motor reaches the synchronous speed, the starting capacitor C_S is disconnected from the circuit by a centrifugal switch S_C . The capacitor C_R is connected permanently in the circuit and thus it is known as RUN Capacitor. The run capacitor is long time rated and is made of oil filled paper. The figure below shows the **Phasor Diagram** of the Capacitor Start Capacitor Run Motor.

The first figure shows the phasor diagram when at the starting both the capacitor are in the circuit and $\phi > 90^\circ$. The second figure shows the phasor when the starting capacitor is disconnected, and ϕ becomes equal to 90° . The **Torque Speed Characteristic** of a Capacitor Start Capacitor Run Motor is shown beside.



This type of motor is quiet and smooth running. They have higher efficiency than the motors that run on the main windings only. They are used for loads of higher inertia requiring frequent starts where the maximum pull-out torque and efficiency required are higher. The Two Value Capacitor Motors are used in pumping equipment, refrigeration, air compressors, etc.



Procedure, data and calculation

A. Capacitor Run Motor

The equipment were set as shown in Figure 11-1, and the isolating variable transformer 726 85 was set to give 230 V, then all required modules were turned on. After that, the ON button of the power circuit breaker module 745 561 was pressed to supply the motor with power, and the following measurements were taken:

- The supply voltage: 230 V
- The motor speed: 1489 rpm
- Direction of rotation looking to the motor from left to right: Clockwise

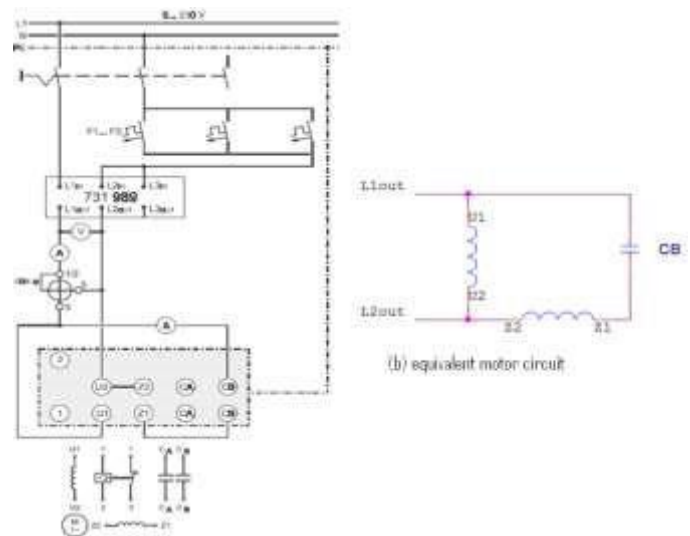


Figure 1: connection for studying the capacitor run motor

Finally, the OFF button of the power circuit breaker module 745 561 was pressed.

Q1: How do you reverse the direction of rotation?

Ans: We reverse the direction of rotation by swapping the connections of the auxiliary windings (Z1 and Z2) or the main windings (U1 and U2).

The necessary connection adjustments were made to reverse the direction of rotation, then the ON button of the power circuit breaker module 745 561 was pressed and the following measurements were taken:

-The supply voltage: 230 V

-The motor speed: 1489 rpm

-Direction of rotation looking to the motor from left to right: Counter Clockwise.

After that, the OFF button of the power circuit breaker module 745 561 was pressed and the running capacitor and the auxiliary winding was disconnected.

Then, the DUT enable connection was disconnected from the Power circuit breaker module and its Relay input was connected to its logic zero pin. Next, the shaft cover was removed, and the isolating variable transformer 726 85 was set to give 160 V, then the ON button of the Power circuit breaker module was pressed, and the motor shaft was turned clockwise by hand.

Observed result: the motor shaft continued to turn in the same direction.

Next, the OFF button of the power circuit breaker module 745 561 was pressed

Q2: Why the motor could not start until you provided it with an initial torque? Explain?

Ans: As explained in the theory, a single phase induction motor is not self-starting; the stator of a single phase induction motor is wound with single phase winding. When the stator is fed with a single phase supply, it produces alternating flux (which alternates along one space axis only). Alternating flux acting on a squirrel cage rotor can not produce rotation, only revolving flux can.

Efficiency Test and Recording load characteristics

The nominal data for the machine under test were entered in Table 1

Table 1 :Nominal Data for the machine under test

Nominal Voltage V_N	230 V
Nominal Current I_N	1.86 A
Nominal Power Factor, $\cos(\theta_N)$	0.99
Nominal Power P_N	0.25 kW
Nominal speed n_N	1400 rpm
Starting capacitor C_A	25 μ F
Running capacitor C_B	10 μ F

The machine nominal torque was determined from the data in Table 1

$$T_N = P_N / \omega_N$$

$$\omega_N = 1400 \times 2\pi / 60 = 146.61$$

$$\gg T_N = 250 / 146.61 = 1.7 \text{ N.m}$$

The running capacitor C_B and the auxiliary winding were reconnected as shown in Figure 1, also the DUT enable of the machine test system was reconnected with the power circuit breaker, and the operating mode was set to torque control. The ON button of the power circuit breaker module and the RED button of the machine test system were pressed. Next, the calculated nominal torque found above was set as a load for the motor, and the output power of the motor ($P_2 = \omega X \tau$) was calculated as follows:

The motor speed = 1415 rpm

$$\gg \text{Power} = T * \omega = 1.7 * 1415 * 2 * 3.14 / 60 = 251.7 \text{ W}$$

After that, the following measurements were taken:

-The input voltage = 230 V.

-The input current = 2 A.

-The auxiliary current $I_C = 1.4$

A. -Power Factor = 0.91 -

Motor Speed = 1415 rpm.

-Torque = 1.70 N.m

Q3: Using the values obtained, calculate the actual efficiency?

$$P_{out} = 251.7 \text{ Watt.}$$

$$P_{in} = V_L \cdot I_L \cdot \cos\theta = 230 \times 2 \times 0.91 = 418.596 \text{ Watt.}$$

$$\eta = (P_{out} / P_{in}) \times 100\% = 251.7 / 418.596 \times 100\% = 60.129\%$$

Q4: Using the data obtained in Table 11.1, calculate the theoretical efficiency?

Compare both efficiencies

$$P_{out} = 250 \text{ Watt.}$$

$$P_{in} = V_L I_L \cos\theta = 230 \times 1.86 \times 0.99 = 423.52 \text{ Watt.}$$

$$\eta = (P_{out} / P_{in}) \times 100\% = (250 / 423.52) \times 100\% = 59.028\%$$

The answer derived theoretically is almost equal to the one calculated from practical data.

In order to study the load characteristics of the motor, the load torque was set to be $(0.0X T_N)$, and the speed (n), the input current (I), the power factor (PF) and the current in

the auxiliary winding (I_c), were all measured, then the results were filled in Table 2 for various values of load. 1.732

Table 2: Measurement for Load Characteristic recording for the capacitor run motor

	$T/T_{N,act}$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
	$T/[Nm]$	$0.0XT_N$	0.171	0.342	0.513	0.684	0.85	1.02	1.19
Measure	$n/[rpm]$	1491	1485	1478	1460	1466	1461	1453	1445
	$I/[A]$	1.9	1.85	1.8	1.8	1.8	1.8	1.8	1.8
	$\cos(\theta)$	0.55	0.61	0.56	0.67	0.7	0.75	0.8	0.8
	$I_c/[A]$	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.4
calculate	n/n_N	1.065	1.06071	1.05571	1.04285	1.04714	1.04357	1.03785	1.03214
	$I/I_{N,act}$	0.95	0.925	0.9	0.9	0.9	0.9	0.9	0.9
	I_c/I_{cN}	1.07142	1.07142	1.07142	1.07142	1.07142	1.07142	1.07142	1.0
	$P_1/[W]$	240.356	259.5623	231.8464	277.3879	289.8083	310.5086	331.2095	331.2095
	P_1/P_{1N}	0.567519	0.61285	0.54741	0.65493	0.68426	0.73313	0.78201	0.78201
	$P_2/[W]$	0.0	26.5785	52.9064	78.3932	104.953	129.980	155.122	179.979
	P_2/P_{2N}	0.0	0.10631	0.21162	0.31357	0.41981	0.51992	0.62048	0.71991
	η	0.0	0.102395	0.228191	0.28261	0.362143	0.418589	0.468350	0.543397
	$T/T_{N,act}$	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
	$T/[Nm]$	1.36	1.53	1.7	1.87	2.04	2.21	2.38	2.55
Measure	$n/[rpm]$	1435	1426	1415	1405	1393	1380	1365	1348
	$I/[A]$	1.9	1.95	2	2.1	2.2	2.3	2.4	2.5
	$\cos(\theta)$	0.88	0.9	0.91	0.92	0.93	0.95	0.98	0.99
	$I_c/[A]$	1.4	1.4	1.4	1.35	1.35	1.3	1.3	1.25
calculate	n/n_N	1.025	1.01857	1.01071	1.00357	0.995	0.98571	0.975	0.96285
	$I/I_{N,act}$	0.95	0.975	1.0	1.05	1.1	1.15	1.2	1.25
	I_c/I_{cN}	1.0	1.0	1.0	0.96428	0.96428	0.92857	0.92857	0.89285
	$P_1/[W]$	384.5710	403.6616	418.6120	444.3729	470.5935	502.5646	540.9757	569.2661
	P_1/P_{1N}	0.90800	0.95308	0.98838	1.04920	1.11111	1.18659	1.27729	1.34408
	$P_2/[W]$	204.267	228.359	251.775	274.995	297.433	319.212	340.030	359.781
	P_2/P_{2N}	0.81706	0.91343	1.00710	1.09998	1.18973	1.27684	1.36012	1.43912
	η	0.530539	0.565705	0.601437	0.618826	0.632024	0.635159	0.628542	0.632006

The RED button of the machine test system was pressed to disconnect the load torque, and the OFF button of the power circuit breaker module was also pressed.

Plots:

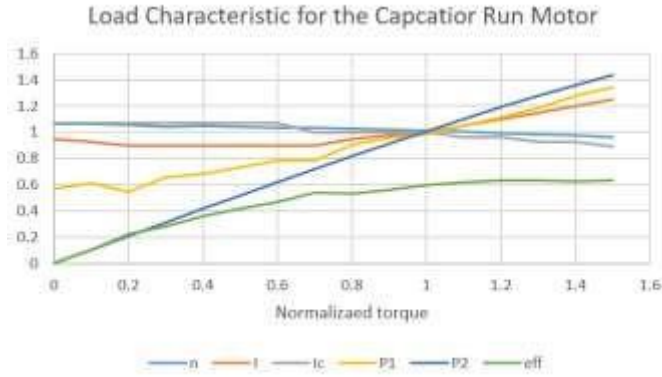


Figure 2: load characteristic of capacitor run motor

Q5: Compare the motor behavior from the plots with the expected behavior of a capacitor run motor

Ans: The plots are close to the expected behavior of the capacitor-run motor; the input power and the output power increase with the increase of the torque, also the current increases, while the speed decreases with the increase of the torque. The efficiency increases to some point then it becomes almost constant.

B. Capacitor start motor

The circuit was connected as shown in Figure 2, and the isolating variable transformer was set to 30 volts V. then, the ON button of the machine test system was pressed. The input voltage was slowly increased from 30 to 80 V, and the following was observed:

- The speed at which the centrifugal switch opens: 1120rpm
- The speed at which the switching occurs: 900rpm

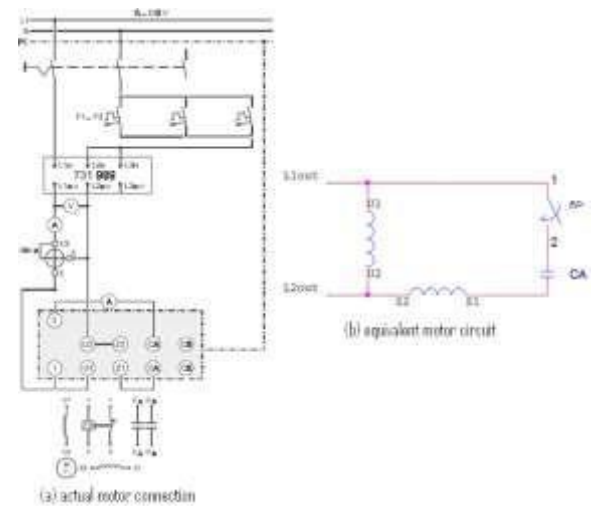


Figure 3: the circuit to study the capacitor start motor

After pressing the OFF button of the power circuit breaker module, the isolating variable transformer was set to 230 V, then, the ON button of the power circuit breaker module and the RED button of the machine test system were pressed. Next, The following table was filled:

Table 3: Measurement for Load Characteristic recording for the capacitor start motor

	$T/T_{N,act}$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
	$T/[Nm]$	$0.0XT_N$	0.71	0.342	0.513	0.684	0.85	1.02	1.19
Measure	$n/[rpm]$	1482	1470	1457	1445	1429	1413	1389	1370
	$I/[A]$	2.1	2	2	2	2	2.1	2.3	2.4
	$\text{Cos}(\theta)$	0.4	0.4	0.47	0.5	0.55	0.6	0.65	0.71
	$I_c/[A]$	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
calculate	n/n_N	1.05857	1.05	1.04071	1.03214	1.02071	1.00928	0.99214	0.97857
	$I/I_{N,act}$	1.12903	1.07526	1.07526	1.07526	1.07526	1.12903	1.23655	1.29032
	I_c/I_{CN}	0.07142	0.07142	0.07142	0.07142	0.07142	0.07142	0.07142	0.07142
	$P_1/[W]$	33193.20	184.0051	216.2061	230.0063	253.0069	289.8083	343.8596	391.9312
	P_1/P_{1N}	0.45617	0.43445	0.51048	0.54306	0.59737	0.68426	0.81188	0.92538

Plots



Figure 4:load characteristic for start motor

Q6: Compare the motor behavior with the expected behavior of a capacitor start motor

Ans: The plots behaves the expected behavior of the capacitor-start motor; the input power increases with the increase of the torque. The current first remains almost constant (because of the existence of the capacitor) then increases (after the switch opens).The speed of rotation decreases with the increase of the torque.

C. Computer based Recording of Run-up Characteristics of capacitor motor

In this part, the computer was used to plot curves that represent the behavior of the capacitor start motor, capacitor run motor and capacitor start and capacitor run motor at two values of voltage (230V and 125 V).

Capacitor start and capacitor run motor was connected as the following figure.

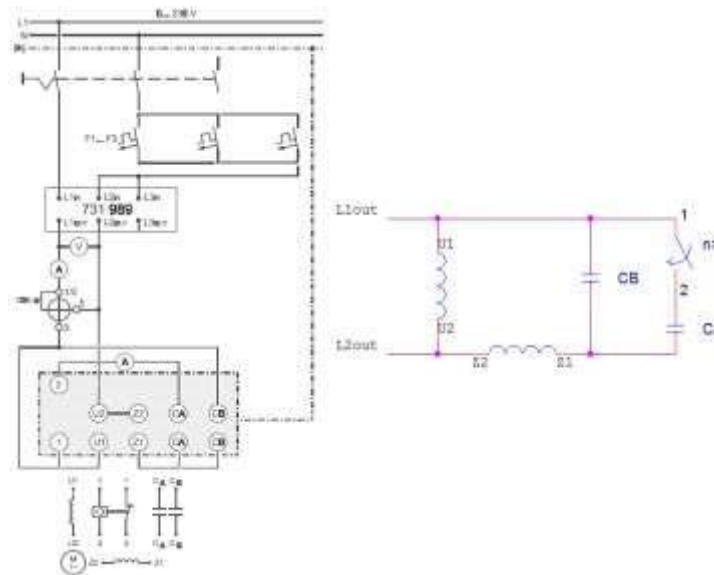


Figure 5: Circuit connection for capacitor start capacitor run motor

The starting torque of the Capacitor-Start motor is very high, here it exceeds 150% of its rated value. The Capacitor-Run motor has a smooth torque, but it has less starting torque than the previous motor, because the capacitor is sized to balance the currents in the main and the auxiliary windings at normal conditions only. While in the Capacitor-Start, Capacitor-Run motor, a large capacitance ($C_{start} + C_{run}$) is present in the circuit during starting, which balances the currents in the main and the auxiliary windings during starting, yielding a very high starting torque. In both, Capacitor-Start, Capacitor-Run motor and Capacitor-Start motor, a centrifugal switch disconnects the starting capacitor when the motor speeds up, while in the Capacitor-Run motor, no centrifugal switch is required. Moreover, it has a higher pullout torque.

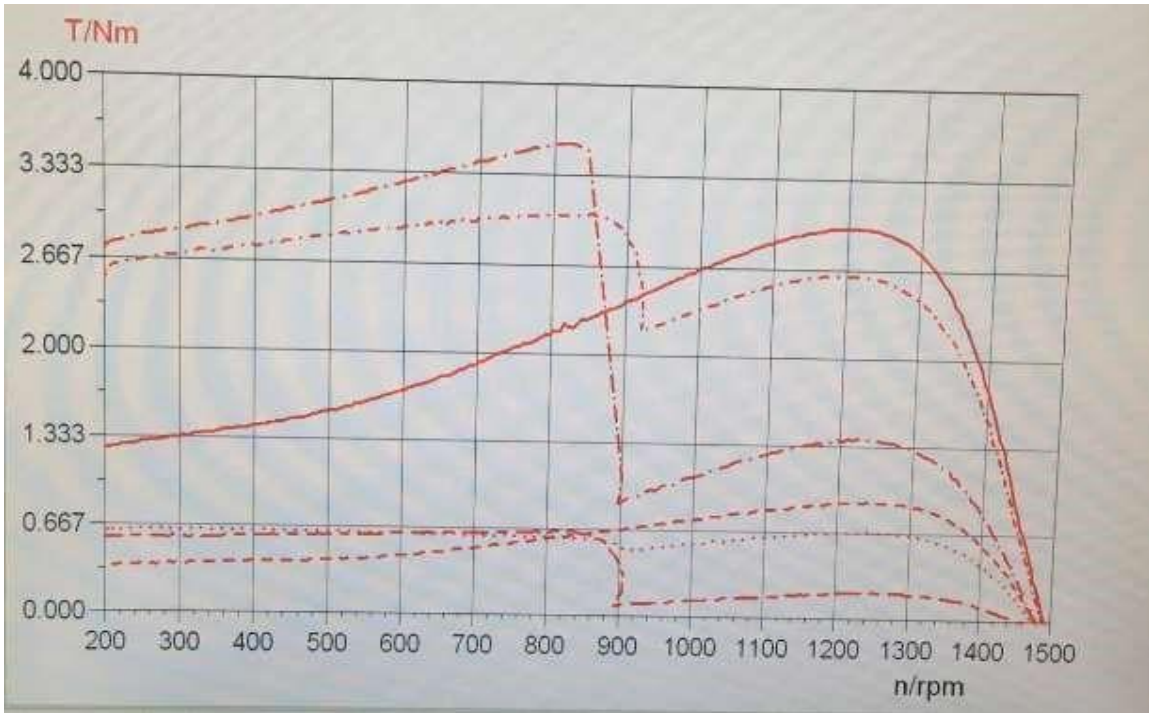


Figure 6: Torque-speed characteristic for IM

D. Separate winding induction motor (bifilar wound motor)

The circuit was connected as shown in Figure 7

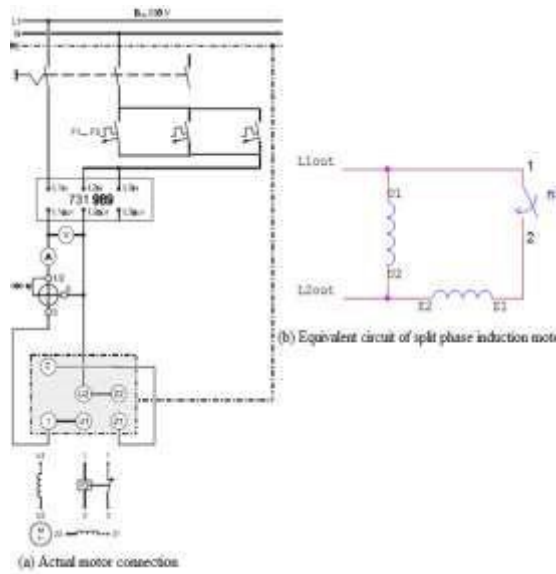


Figure 7: Circuit for studying separate winding induction motor

The nominal data for the machine under test were entered in Table 4

Table 4: Nominal Data for the machine under test

Nominal Voltage V_N	230
Nominal Current I_N	3 A
Nominal Power P_N	0.2 kW
Nominal speed n_N	1420 rpm

Based on the data obtained previously, the machine's nominal torque was calculated as follows: $T_N = P_N / \omega_N = 200 / 148.6 = 1.34 \text{ N.m}$

After setting the operating mode to torque regulation, the ON button of the power circuit breaker module and the RED button of the machine test system were pressed, then, the nominal torque was set as a load for the motor and the output power was calculated.

$$P_2 = T_N * \omega$$

-The torque=1.34 N.m -

The speed=1418 rpm

$$\gg P_2 = 198.879 \text{ Watt}$$

The following measurements were taken:

-The input voltage=230 V.

-The input current= 3.25

-The power factor =0.6

-The speed= 1418 rpm.

-The torque= 1.34 N.m

Q7: Using the values obtained in step 8 calculate the actual efficiency?

$$P_{OUT} = T \omega = 1.34 \times 1418 \times (2\pi/60) = 198.879 \text{ watt.}$$

$$P_{IN} = V_1 I_1 \cos\theta = 230 \times 3.25 \times 0.6 = 448.49 \text{ watt.}$$

$$\eta = P_{OUT} / P_{IN} \times 100\% = 44.34\%$$

Q8: Using the data obtained in Table 4, calculate the theoretical efficiency? Compare both values of efficiencies

$$P_{OUT} = 200 \text{ watt.}$$

$$P_{IN} = V_{IN} I_{IN} \cos(\theta_N) = 230 \times 3 \times 0.6 = 414.012 \text{ watt}$$

The nominal power factor was considered to be 0.6, as measured practically.

$$\eta = P_{OUT} / P_{IN} \times 100\% = 48.307\%$$

As noticed, this value is close to the value calculated in the previous question.

In order to study the load characteristics of the motor, the load torque was set to be (0.0XT_N), the speed (n), the input current (I) and the power factor (PF) were measured, then Table 5 was filled for various values of the torque.

Table5::Measurement for Load Characteristic recording for the split phase Induction motor

	T/T_{N,act}	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
	T/[Nm]	0.0XT _N	0.134	0.268	0.402	0.54	0.67	0.8	0.99
Measure	n/[rpm]	1487	1480	1475	1470	1464	1458	1452	1441
	I/[A]	3.3	3.3	3.3	3.2	3.1	3.1	3.15	3.15
	Cos (θ)	0.3	0.35	0.4	0.41	0.42	0.45	0.49	0.51
	n/n_N	1.04718	1.04225	1.03873	1.03521	1.03098	1.02676	1.02253	1.01478
calculate	I/I_{N,act}	1.01538	1.01538	1.01538	0.98461	0.95384	0.95384	0.96923	0.96923
	P₁/[W]	227.7061	265.6576	303.6085	301.7684	299.4682	320.8591	355.0150	369.5057
	P₁/P_{1N}	0.55	0.64166	0.73333	0.72888	0.72333	0.77500	0.85750	0.89250
	P₂/[W]	0.0	20.7574	41.3747	61.8517	82.7452	102.244	121.580	149.316
	P₂/P_{2N}	0.0	0.10378	0.20687	0.30925	0.41372	0.51122	0.60790	0.74658
	η	0.0	0.078130	0.136273	0.204947	0.276305	0.318653	0.342451	0.404092
	T/T_{N,act}	0.8	0.9	1.0	1.1	1.2	1.3	1.4	
	T/[Nm]	1.07	1.21	1.34	1.47	1.61	1.74	1.88	
	n/[rpm]	1436	1427	1418	1406	1393	1379	1360	
Measure	I/[A]	3.15	3.2	3.25	3.3	3.5	3.5	3.7	
	Cos (θ)	0.54	0.57	0.6	0.62	0.65	0.67	0.7	
	n/n_N	1.01126	1.00492	0.99859	0.99014	0.98098	0.97112	0.95774	
	I/I_{N,act}	0.96923	0.98461	1.0	1.01538	1.07692	1.07692	1.13846	
calculate	P₁/[W]	391.2413	419.5317	448.5127	470.5935	523.2650	539.3654	595.7159	
	P₁/P_{1N}	0.94500	1.01333	1.08333	1.13666	1.26388	1.30277	1.43888	
	P₂/[W]	160.822	180.724	198.879	216.327	234.739	251.143	267.611	
	P₂/P_{2N}	0.80411	0.90362	0.99439	1.08163	1.17369	1.25571	1.33805	
	η	0.411055	0.430765	0.443409	0.459672	0.448588	0.465613	0.449211	

The RED button of the machine test system and the OFF button of the power circuit breaker module were pressed.

Plots:



Figure 8:load characteristic for split phase IM

Starting torque is low, typically 100 to 175% of rated load, while the maximum running torque ranges from 250 to 350% of normal. Also, the motor develops high starting current, approximately 700 to 1,000% of rated. Consequently, prolonged starting times cause the start winding to overheat and fail.

The computer was used to plot curves that represent the behavior of the separate winding induction motor at 230V and 130V.

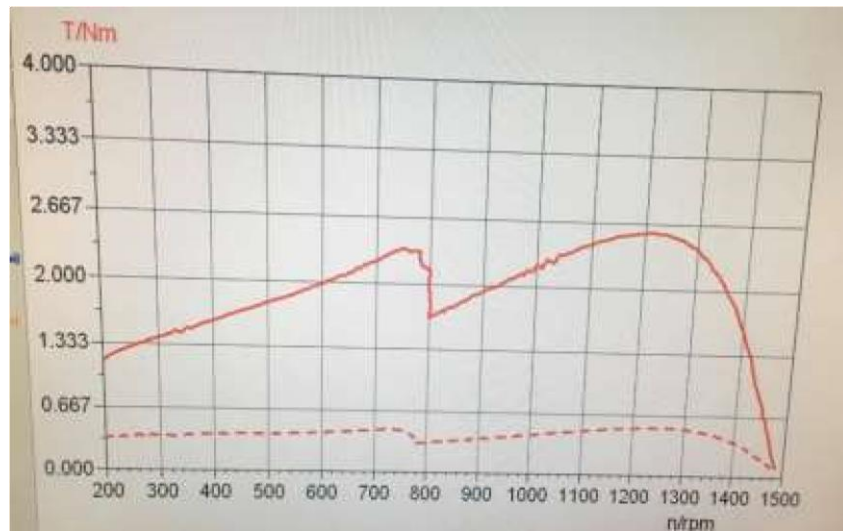


Figure 9:Computerized curve that represent the torque speed characteristic for split-phase IM

The split-phase motor has a moderate starting torque, because the angle between the auxiliary current and the main current is small, with a fairly low starting current, as noticed, as the motor speeds up, the centrifugal switch disconnects the auxiliary windings.

Conclusion:

By the end of this experiment, all the objectives were achieved; starting with how to connect, start, and reverse the direction of each investigated motor. And finishing with getting to know each motor load characteristic.

A single phase Induction motor is not self-starting, hence, four methods of starting this motor were carried out; first, the capacitor-run motor, which is also called a permanent splitcapacitor motor. This method is more efficient, has a higher power factor, and has a smoother torque than an ordinary single phase IM at normal loads, on the other hand, it has less starting torque and a starting current that is much greater than the rated current, but higher pullout torque. Moreover, no centrifugal switch is required.

The second method that was executed is the capacitor-start motor, this motor develops a much higher starting torque of about 3 to 4.5 times of the full load torque. But in order to obtain a high starting torque, two conditions are essential; the starting capacitor value must be large and the value of the starting winding resistance must be low. In this method a centrifugal switch is needed.

The third method is the capacitor-start, capacitor-run motor, it has two capacitors. This motor has the largest possible starting torque and the best running conditions amongst other single phase motors. Its permanent capacitor is large enough to balance the currents at normal conditions.

The last method is the split-phase (separate) winding IM, in all the motors mentioned previously, the phase shift between the main current and the auxiliary current is typically 90 degrees, but in this type of motor it is in the range: 30-45 degrees. It has a moderate starting torque, with a fairly starting current.

Systematic errors existence may be referred to several reasons; such as estimating the reading of the Ammeter and the power factor meter.

References:

[1] lab manual

[2] Electrical Machinery Fundamental "fifth edition"

