Faculty of Information Technology

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ENEE 5102

Report #3

Power Factor Improvements

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Abstract:

Power factor improvement is important in many applications. Improving the power factor helps in reducing the losses in the grid. In this report, the power factor of single phase and three phase induction motor is improved by using capacitors. Results showed that the power factor increases as the value of the capacitor increases, this increases the reactive power injected from the capacitor. As a result, the apparent power consumed from the grid is reduced, which reduces the current, resulting in lower power losses.

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Theory:

Power factor of an electric system is defined as the ratio of the real power flowing to the load to the value of the apparent power in the circuit [1]. The current required by induction motors can be considered to be made up two separate kinds of currents which are: magnetizing current and power producing current. The power producing current is defined as the current which is converted by the equipment into useful work. While the magnetizing current can be defined as the current which is required to produce the flux which is important for the operation of induction devices. As mentioned previously, the power factor improvement is important in order to reduce the losses. In this experiment the power factor of single phase and three phase induction motor is improved by using capacitors. Most of the industries and power system loads are inductive that require lagging current which decreases the system power factorFor Power factor improvement purpose, Static capacitors are connected in parallel with those devices which work on low power factor[2]. Power factor improvement can be applied by connecting the correction capacitors to the motor starter. On the other hand, a disadvantage can occur when the load on the motor changes and can result in under or over correction. Static power factor correction must not be applied at the output of a variable speed drive, solid state soft starter or inverter as the capacitors can cause serious damage to the electronic components. Over-correction should not occur if the power factor correction is correctly sized. Typically the power factor correction for an individual motor is based on the no load (magnetizing) power since the reactive load of a motor is comparatively constant compared to actual kW load over compensation should be avoided[3]. Using this methods have several pros and cons in practice, some of the advantages of using this method are: it requires less maintenance since it has no moving parts (static capacitors), it doesn't require foundation for installation, and ease of installing since it has low weight. While some of the disadvantages of using this method are: the age of the capacitor bank is less than ten years, it can result in switching surges in the system when applied with a varying load and on/off operations, and once the capacitors are spoiled then repairing is costly.

Procedure:

Part A: Single-phase induction motor:

At first, the circuit of Figure 1 was connected, the voltage was adjusted to 220 V, and the torque was increased progressively in steps, the readings of the torque, speed, input power, voltage, and current were measured and tabulated in table one, then the capacitor banks were connected to the circuit as shown in Figure 2, and the previous readings were measured for different values of capacitor. Also these data were plotted (speed and power factor against torque)

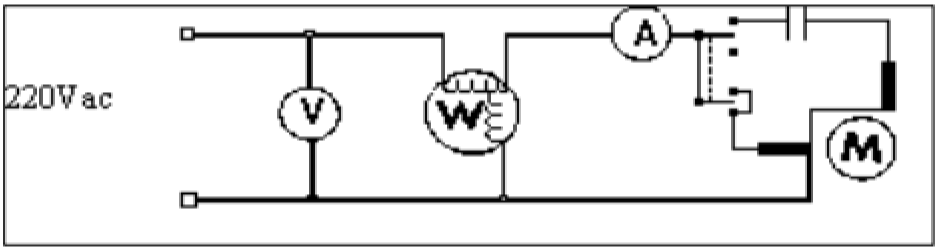

Figure 1: Capacitor start motor.

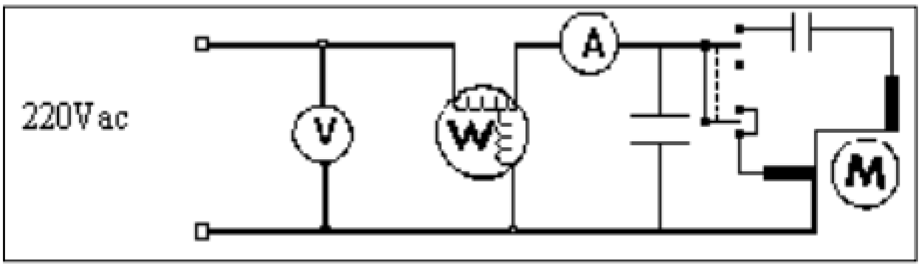

Figure 2: Capacitor start motor with parallel capacitor

Part B: Three-phase induction motor:

Using FH-90, the circuit of Figure 3 was connected, the voltage was adjusted to 220 V, and the torque was increased progressively, the readings of the torque, speed, input power, voltage, and current were measured and tabulated in Table 2, Also these data were plotted (speed and power factor against torque), then the capacitor bank of 2 uF Δ-connected were added across the terminals of the motor as illustrated in Figure 4.

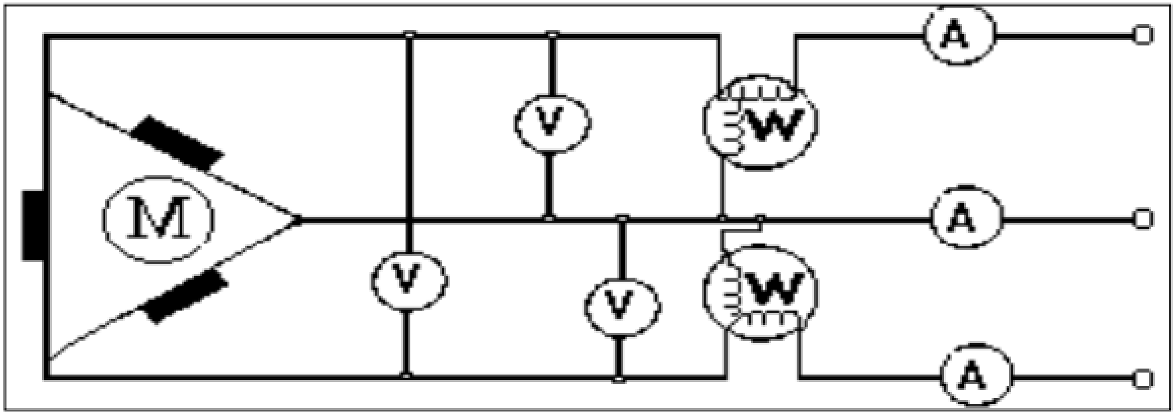

Figure 3: Three-phase induction motor Δ connected.

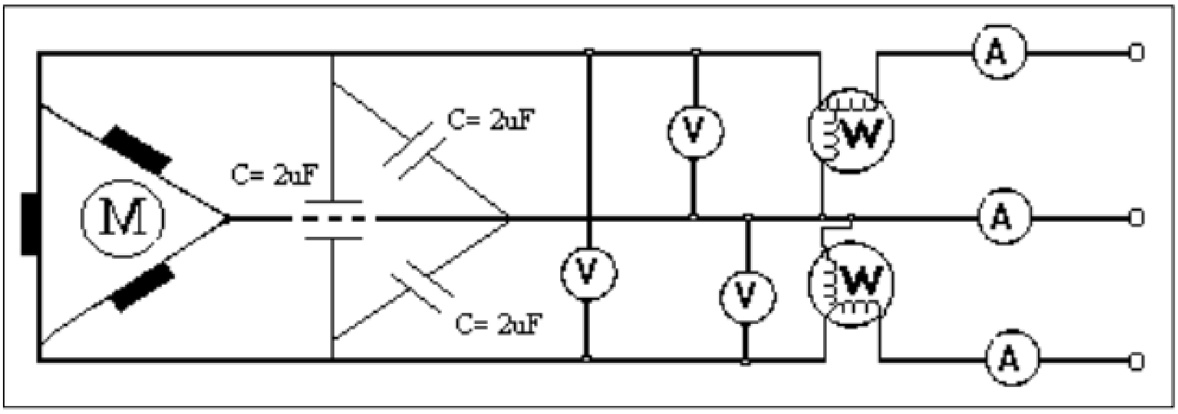

Figure 4: Three phase induction motor Δ connected with capacitors Δ connected.

Then the circuit of Figure 5 was connected and the same manner was followed in order to complete the readings of the values of Table 2.

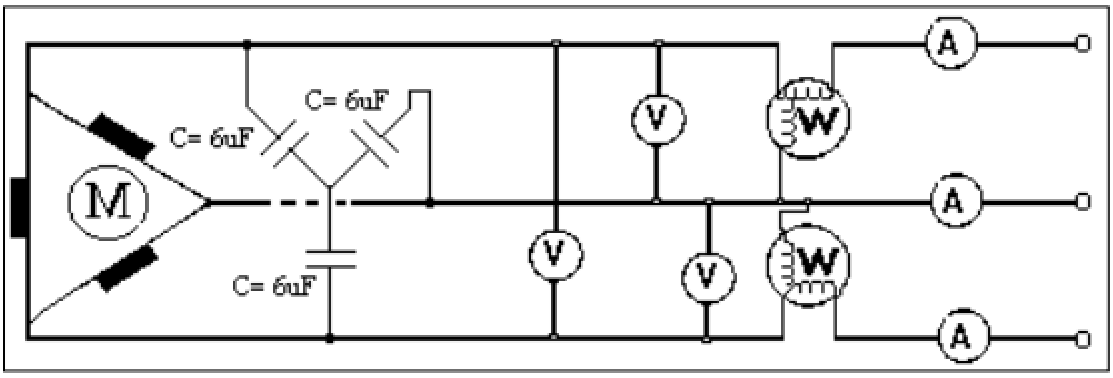

Figure 5: Three phase induction motor Δ connected with capacitors Y connected.

Results and Calculations:

PART A: Single-phase induction motor:

For C= 3 μF

Torque	Speed	I_{in}	V	P_{in}	V*I	PF	Q
0.0	14	1.16	197	75.1	228.52	0.33	215.72
0.2	13.9	1.18	195.4	95	231.35	0.41	211.01
0.4	13.8	1.26	192.2	128.2	241.21	0.531	204.4

Table 1

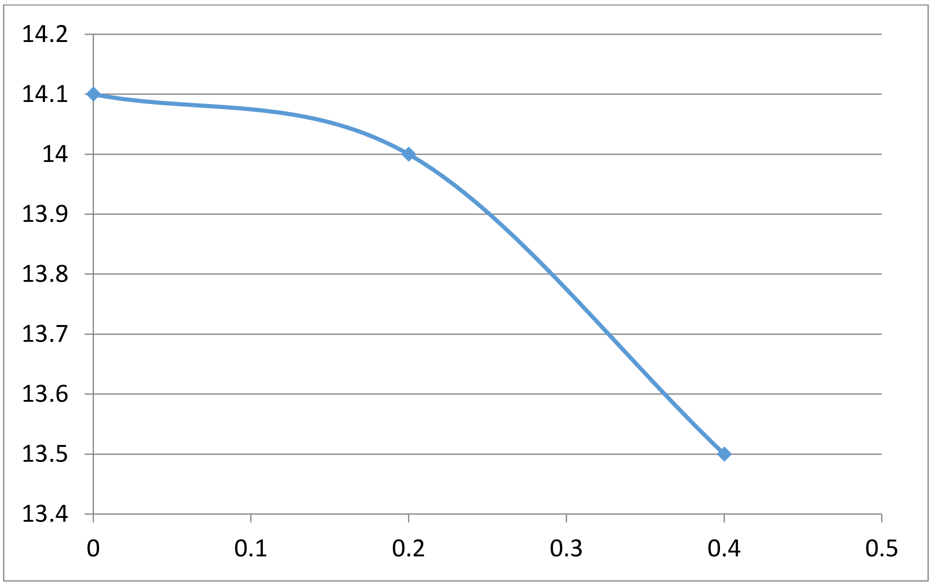

Figure 6: Torque vs. Speed for capacitor value = 3uF

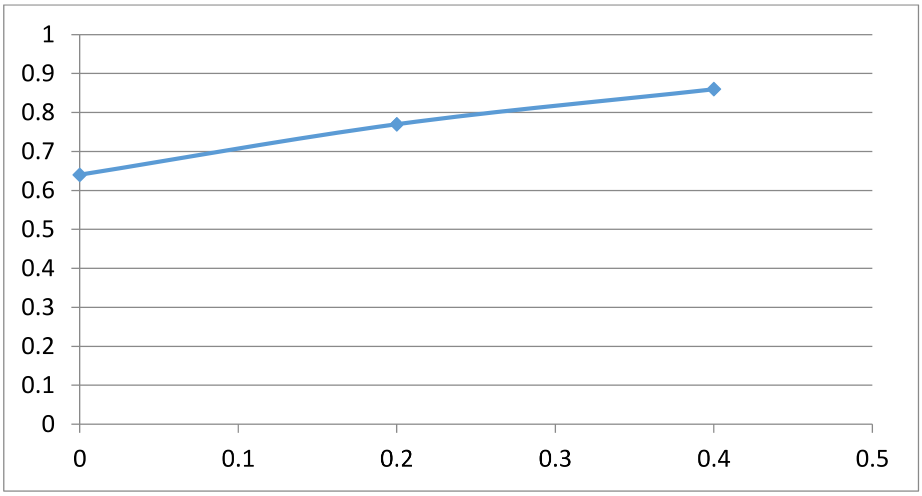

Figure 7: Torque vs. PF for capacitor value = 3uF

For C= 5 μF

Torque	Speed	I_{in}	V	P_{in}	V*I	PF	Q
0.0	14.1	0.885	202	78.4	178.77	0.46	158.73
0.2	14	0.915	199.5	109.3	182.54	0.60	146.03
0.4	13.5	1.037	195.3	144.5	202.53	0.71	142.62

Table 2

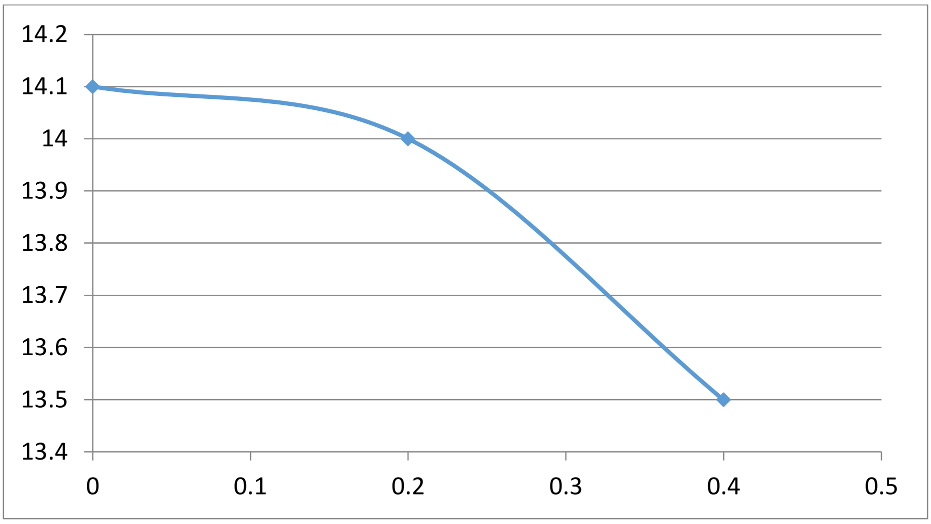

Figure 8: Torque vs. Speed for capacitor value = 5uF

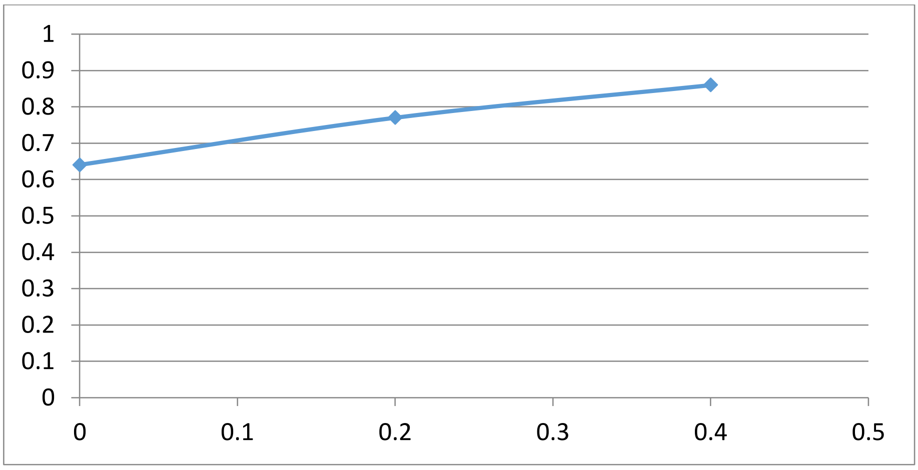

Figure 9: Torque vs. PF for capacitor value = 5uF

For C= 10 μF

Torque	Speed	I_{in}	V	P_{in}	V*I	PF	Q
0.0	14	0.616	203.1	78.8	125.11	0.64	96.13
0.2	13.9	0.706	200.6	109.6	141.62	0.77	90.36
0.4	13.5	0.867	197.1	146.6	170.89	0.86	87.21

Table 3

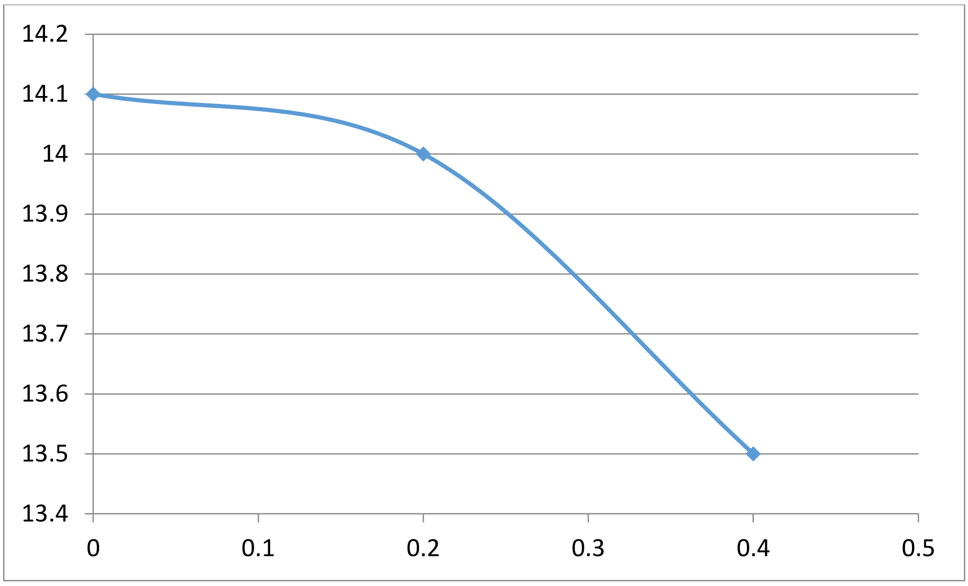

Figure 10: Torque vs. Speed for capacitor value = 10uF

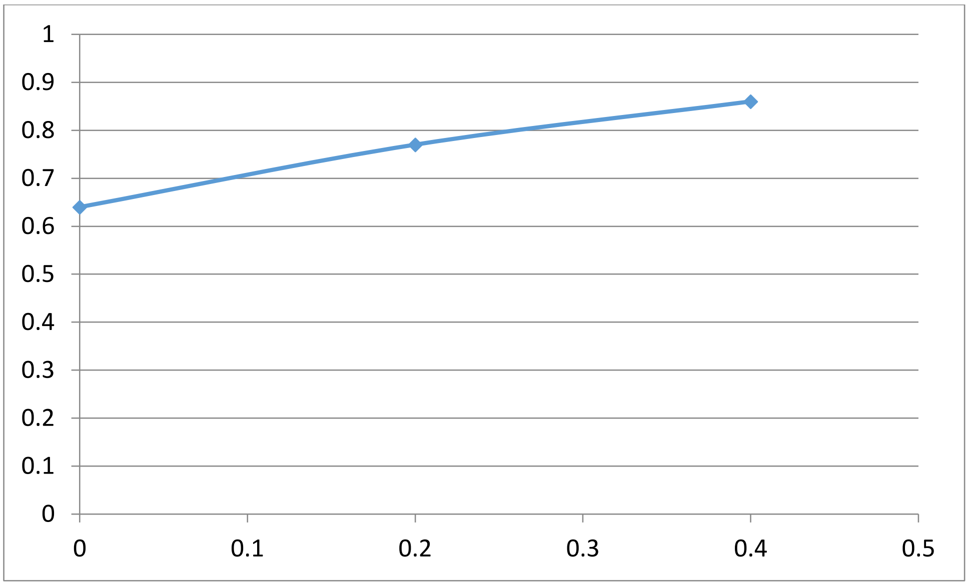

Figure 11: Torque vs. PF for capacitor value = 10uF

PART B: Three-phase induction motor:
Without capacitor

Torque	Speed	P_{in}
0.0	14	70
0.2	13.7	104
0.4	13	156

Table 4

For C= 2 μF (Delta connection)

Torque	Speed	P_{in}
0.0	14	71
0.2	13.5	120
0.4	13.4	170

Table 5

For C= 2 μF (Star connection)

Torque	Speed	P_{in}
0.0	14	76
0.2	13.7	86
0.4	13	120

Table 6

Discussion:

In this report the characteristic of the single phase and three phase induction motor were studied during power factor correction process. Results showed that a capacitor should be connected to the single phase induction motor during starting operation. Moreover, it showed that the motor current increasing in order to remained the desired motor speed with higher load torque as shown in tables (1) and (2) also, it can improve the motor power factor as shown in figure (7). Also, It showed that the starting capacitor can be used for power factor improvement purpose because increasing the capacitance of the capacitor can be used in order to increase the power factor of the motor as shown in tables (1), (2) and (3).

In 3-phase induction motor no need for the starting capacitor. Results showed that increasing the motor load torque needs a higher input power. The capacitor is used to efficiency improvement because it can produce the needed reactive power to the motor. Also, from tables (5) and (6) it clearly that a star connection need less input power than the delta connection for the same load torque and motor speed in other word for the same output power. This describe why the star connection is widely used because it more efficient compared with the delta connection.

Conclusion:

In this report power factor and efficiency improvement were studied for the single and three phase induction motor. It showed that the single phase need a starting capacitor to operate this capacitor can be used also to improve the power factor. In some applications a running capacitor is added for more power factor improvement. However, in the three phase induction motor the capacitor used only for efficiency improvement. In 3 phase motor star connection is more preferred to running the motor because it more efficient while, The delta connection is used at the starting to decrease the starting current.

References:

[1]: https://en.wikipedia.org/wiki/Power_factor

[2]: http://www.electricaltechnology.org/2013/10/power-factor-improvement-methods-with-their-advantages-disadvantages.html

[3]: https://www.iee.org/spring_2006/John_Ware/power_factor_correction_PCF