RESEARCH ARTICLE OPEN ACCESS

Power Factor In Electrical Networks

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I. INTRODUCTION

The power factor is the ratio between kilo-watt (KW) and kilo-volts- ampere (KVA) that producing from electrical load. The kVA is the apparent power measurement unit.The concept of power factor can be explained by the following definition: The power factor is the measure of the efficiency of energy consumption consumed. The power factor takes the value between zero and one, and the power factor equal to one is the ideal power factor that is not actually present but is used in electrical calculations as a theoretical reference. Inductive loads wherever exists lead to reduced power factor. Economically, it is not necessarily an access to an electric power factor equal to 1. A power factor of 0.9 or even 0.85, for example, leads to considerable economic feasibility. The main reason for low power factor is the inductive loads such as inductive motors and transformers that need current to generate the magnetic field in order to operate. When the power factor is less than one, the apparent power supplied to the load is greater than the actual power. When the power factor is reduced, the power supply companies have to supply the consumer with additional amounts of power, which inevitably leads to an increase in power losses in power transmission lines and that means more loss for these companies. As the power factor increases, the active power increases and the reactive powerdecrease. Active power is the useful power in the electrical network, while reactive power has no role but to generate the magnetic field necessary for the work of inductive loads.Electrical loads consist of one of the following classifications:

- Resistive loads
- Capacitive loads
- Inductive loads

II. TYPES OF POWER

The actual power used, or dissipated, is called real power measured in watt and symbolized mathematically by character P. The real power is Function of circuit dissipation elements, such as resistance (R).Interactive loads such as inductors and capacitors dissipate zero power, but the fact that it drops the voltage and draws the current giving the perception that they are wasting power this is the "dissipated power" is called the reactive power and is measured in the volt-ampere reactive (VAR).The reactive power symbolized by Q and is a function of the circuit reaction(X).The combination of real power and reactive power is called apparent power. The apparent power is product of the current and voltage, without reference to phase angle. Unitof apparent power measured in Volts- Amp (VA) and symbolized by S. The apparent power is the function of total circuit resistance (Z). There are equations for the three types of power to resistance, impedance, andReactance.

P=real power $P = I^2 * RP = \frac{V^2}{R}$

Q=reactive power $Q = I^2XQ = \frac{V^2}{X}$

S=apparent power $S = I^2ZS = \frac{V^2}{Z}$

III. POWER IN AC CIRCUITS

- **Real power in the circuits:-**

Resistance load without inductive or capacitive impedance. We suppose we have alternative current circuit single phase (see figure 1) and the source is 220v with frequency 50HZ and 110ohm resistor

Fig.1

Z_R=110ohm and I=E/Z where E=source value, Z=impedance
I=220V/110=2A
It turns out that the load current is equal to 2 amps and the power used is:
$P = I^2 * R = 4 * 110 = 440W$

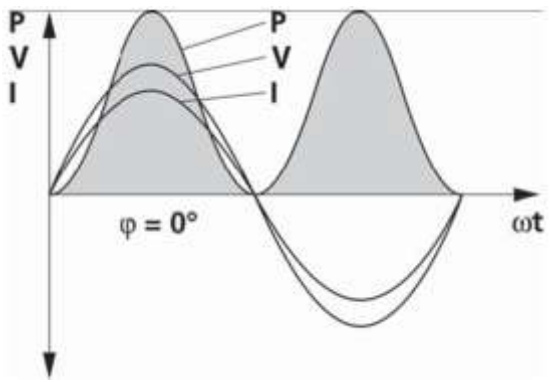

Fig.2

In this case, we note that the power value is equal to the product of both the current and voltage. The voltage and current don't take a negative value and its frequency is twice the frequency of the source, and there is no difference in phase shift between the current and the voltage (see figure 2). This type of power can switch to another type of energy (temperature, light, movement, etc.) and Active power unit (Measured by KVA).

- **Active power in the circuits:-**

In practice, you rarely find a pure circuit with resistance only butit is mixed with inductive or capacitive impedances because the consumer needs toMagnetic fields in motors and transformers ... etc.

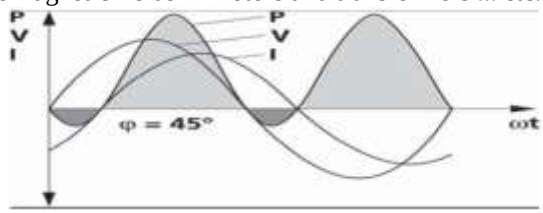

Fig.3

The current waveform shows its delay from the voltage wave at an angle (φ) and the power is not the product of multiplying current with voltage only but enters with it another factor(see figure 3)

$$P = I * V * COS\varphi$$

- **Reactive power in the circuits:-**

This Reactive power occurs within the electric currents and transformers when they are working, By ignoring copper, iron heart and friction, described as the power that flows between the no-load(Source) and the consumer at the same frequency of the voltage source in order to create the magnetic /electrical field and Fade away it.

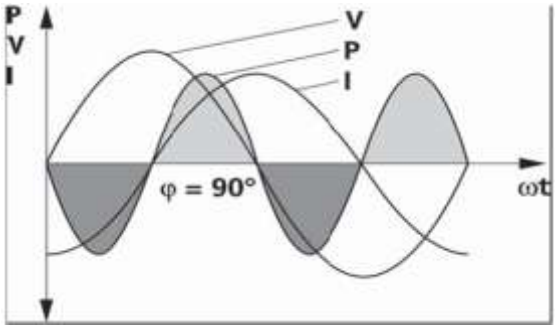

Fig.4

The phase shift between the voltages and the currents will be 90 (see figure 4), in which case the result of the Reactive power will be zero because the positive part of the power wave cancels the negative part of the wave, meaning the inductive and capacitive loads,meaning that it does not waste any energy and symbolized by (Q) and it measured (VAR) (volt ampere reactive) .

$$Q=V*I*SIN\ \varphi$$

IV. APPARENT POWER

Is the critical ability to guess within power grids when selecting generators, transformers, circuit breakers, counters and the calculation of the area of the cables of transmission and connection to any system, symbolized by (S)and its measurement unit (VA) .

$$S_{VA}=Vv*I_A$$

It is the result of multiplying the voltage and the current and not taking the phase difference between them in minds.

V. POWER TRIANGLE

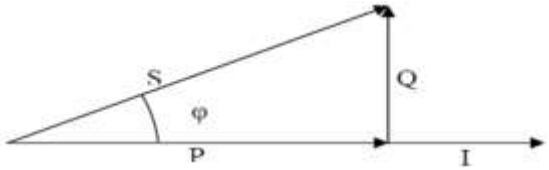

Fig.5

S is also calculated from this equation:

$$S = \sqrt{p^2 + Q^2}$$

VI. POWER FACTOR (COS Φ):-

The cosine angle of phase shift between current and voltage and is considered the most suitable factor for calculating the components of the effective and non-power Effective Of current and voltage, and in practical electrical engineering, this parameter became a symbol of power factor.

$$COS\varphi = P/S_{\ [W]/[VA]}$$

Power factor correction:-

In power transmission systems (POWER DISTRIBUTION SYSTEM)take all considerations and make the maximum effort to transmit the apparent power and make it at the lowest level, this is by making the power factor (COSφ) equal to one for the customer.It was also found that the phase shift between the current and the voltage is caused by inductive impedances and is often caused by the use of the motors. The capacitors are connected in parallel with the load after selecting them appropriately so that we can reduce the angle of phase differenceφ, if we could make the power factor equal to one, the flow current will decrease and cost less at the consumer.

Methods of connecting capacitors to correct the power factor

There are three methods to connect capacitors:

1. Direct connection (fixed)
2. Automatic connection
3. Combination connection

1. Direct connection (fixed)
In the simplest case, capacitors are connected directly to each load separately(see figure.6).

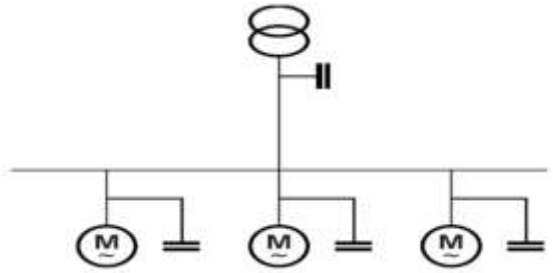

Fig.6

This method is used to

- Compensate no load reactive power of transformers.
- The motors that are working continuously

The advantage of this method:-

I. It can be linked to the shape of sets and each group must work together (see figure 7)

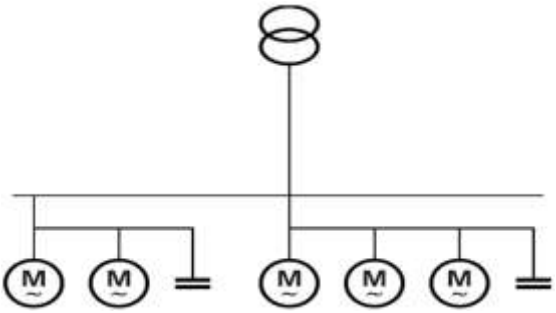

Fig.7

II. Dispose of reactive power near load
III. Low cost

2. Automatic connection
In this case, the presence of automatic reactive power control relays device is assumed. (See figure 8)

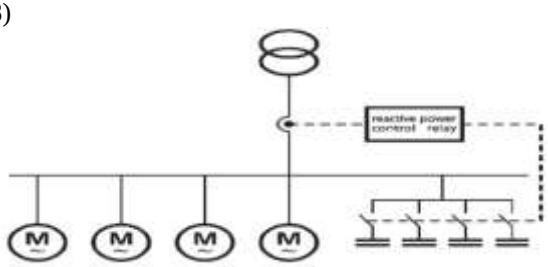

Fig.8

The capacitors are connected centrally to the main distribution panel, which covers the main requirement of the reactive power. This method is the most common and used as it is easy to control. This method enters into system and is separated by contactors. The total used capacitors are usually less than necessary by calculating total loads in design.

3. **Combination connection (direct with Automatic):**
The combination of the three methods is economical and combines the advantages of each (see figure 9)

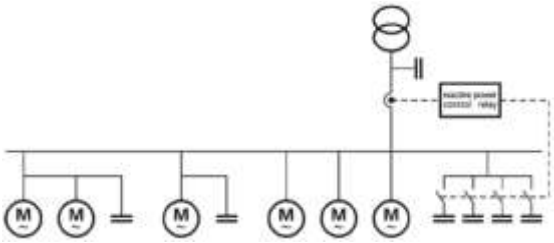

Fig.9

VII. Methods of calculating capacitors values

Loads that need to be improved are their power factors are transformers and motors with usually high capacities**.**The values of the capacitors can be calculated from the tables or through the calculations and unit of measurement of these capacitors are kvar. As written on it (see figure 10)

Fig.10

VIII. HOW TO CONNECT CAPACITORS BY CONNECTION MOTOR AND ITS USES

- When connected to the motor, the capacitors are connected directly to the motor poles (see figure 11)

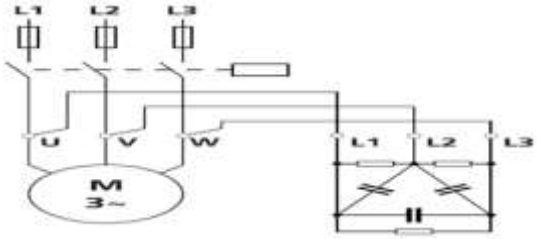

Fig.11

- In the case of connection star-delta: the capacitors are connected directly to the beginning of the three coils of the motor(see figure 12)

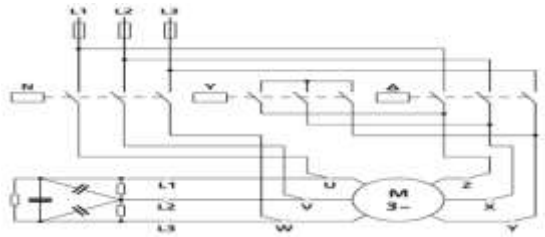

Fig.12

Capacitors are charged when the motors are in operation, if it stopped may cause damage, but often have internal capacitors are resistors connected in parallel with it. To make it safe when it is not directly connected to the terminals and preferably to connect the external discharger, such as stifling coils orResistors

- In the case of the use of motors in cranes and elevators, which are constantly changing direction

It is known that the motors in this case do not rotate in a constant direction and speed, so connect the capacitors by separate contactors and before the controller (Controller) and must be connected to thestifling coils in parallel to accelerate the process of unloadingWhen the motors stop and before it rotates backwards.(see figure 13)

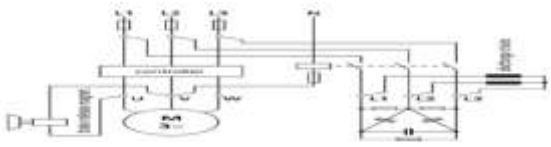

Fig.13

IX. CONCLUSIONS:

As we have seen, the power factor comes from the ratio between the real power in kilowatt and the apparent power in kVA, where the real benefit comes from the network or the machine when the power factor is closer to oneThis is due to the following reason That is due to the reason that the higher the value of this power factor, the lower the value of the current power and this also leads to another benefit is that we can use electric circuit breakers with less capacity and less space is also less and this is the desired benefit of the improvement of power factor reduction of currentTherefore, the electricity network always requires its customers to improve the power factor by putting capacitors in a certain way to improve the power factorand when we make the improvement to the power factor this leads to improve the efficiency of electrical generating plants, reduce consumption and cost of kVA, reduce overload on cables and devices and reduce the fuel required to generate power as a result of reduced losses.

X. REFERENCES

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