DESIGN AND IMPLEMENTATION OF POWER FACTOR CORRECTION MODEL IN HYBRID SYSTEM

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***Abstract*—** Good quality power along with efficient supply system is the need of ours in past few decades. Making power generation system more ecofriendly use of renewable sources of energy was promoted. To attain this implementation of hybrid mode (solar photovoltaic system) of power supply came forward, main issue arose was degrading power factor the main reason of this was the incapability of PV system to supply reactive power. This could however be compensated by implementing various power factor correction techniques. Out of all such methods capacitor compensation method is efficient to overcome this may it be an industry or a home.

KEYWORDS: Power quality, Solar, inverter, Power Factor.

I. INTRODUCTION

An electric power system can be outlined as variety of electrical devices interconnected to each other in order to maintain flow of power from generating station (power plant, nuclear plant, hydro power station, solar plant) to load end the transfer is done through different transmission lines and distribution system formed. Then this electricity can be used for consumption in residential areas i.e. our homes or in industrial application to operate large machines. Typical power system is a combination of generating station, responsible for conversion of power from different forms to electrical form. The transmission system acts as path of flow of power from source to load. The power transferred is utilized by loads which include small table fan at our home to large motors working in industries. Three phase AC power is standard form of power.

A. Reactive power

Typically reactive loads were considered to dissipate zero power. When observed it was found that reactive loads such as capacitor and inductor draw current & also shows drop voltage when connected in a circuit, thus it is said that these elements dissipate power. This power is also referred as imaginary power. It is measured in volt-amperes reactive (VAR). It is denoted by 'Q'.

B. True power

The real amount of power which is employed or dissipated in a circuit is termed as true power. It is measured in watts & its symbol is 'P'.

C. Apparent power

True power and apparent power when taken together is referred as apparent power. Apparent power is measured in the unit of volt-amps (VA) and it is symbolized by 'S'.

True power is a function of resistive element of circuit, reactive power is a function of reactance and apparent power is thus function of total impedance of the circuit.

D. Power triangle

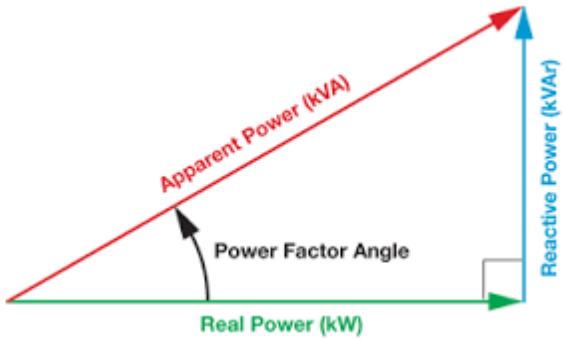

Figure 1: Power Triangle

These three types of power are associated with each other in pure trigonometric form as shown in fig 1. We call this as the power Triangle. In this right angle triangle, P = adjacent length, Q= opposite length and S= hypotenuse length. The opposite angle is equal to the circuit's impedance (Z) phase angle.

E. Power factor

Power factor cos ϕ is defined as the ratio between the Active component IR and the total value of the current I; ϕ is the phase angle between the voltage and the current. For a purely resistive load power factor is unity also for pure inductive and capacitive load power factor is zero. Value of PF varies in between 0 to 1.

F. Power factor correction

Power factor rectification is the method of adjusting the lagging current by creating main current by using capacitor as per requirement. A sufficient capacitor needs to be connected to bring power factor close to unity. This is applied to increase stability and efficiency of the system. The presence of reactive power causes the real power to be less than apparent power, thus the power factor then gets reduced. As reactive power increases losses in transmission and distribution system increases. This results in operational losses to power companies. Thus power company emphasis on increasing the power factor or keep it above 0.9.

G. Hybrid power system

Hybrid energy system brings together different generation, storage and consumption technologies in a single system, improving the overall benefit as compared to the system that depends on one supply. This system was originally designed as a mixture of conventional and non-conventional energy sources. This hybrid energy system may include grid system along with solar photovoltaic, hydro energy or wind turbines. The selection of non-renewable energy supply depends upon availability of resources. The most popular method used recently is grid system connected along with a solar power system. Renewable energy technologies are one of the fastest growing Technologies, sensors solar has its dependence on sunlight so this can produce power only during the day. Combination of this solar system along with the grid system makes our power supply unit much more reliable. Maintenance cost of hybrid solar energy system is low as compared to large diesel generator. Since no fuel is used so it does not require frequent servicing. Hybrid solar system can be connected with the technologies which adjust the energy supply according to the device they are connected whether it is an air conditioner or a fan.

H. Need for improving power factor

• Reduction in power consumption bill (electricity bill), no additional penalty amount needs to be paid.

• Reduction in copper losses improves the efficiency of transmission system.

• Voltage drop in the circuit reduces which improves the voltage regulation of power system.

• Reduction of the line current decreases the load on cables and thereby it improves our equipment's life.

• Penalties imposed due to poor power factor can be eliminated.

• Reduction in power system losses.

II. SURVEY

Efficient power generation is the true need of electrical system for efficient functioning of power unit. PF correction technique focuses on restoring

PF close to unity. Various compensation setup are made to justify this. An automatic power factor correction unit (APFC) checks the energy consumption and enhances power factor automatically to required amount. This APFC drive monitors the reactive power consumed by the system and compensates this by using capacitors from capacitor banks. APFC panel were found to be satisfactory for use in industries (Y. Lo, 2009).

Power factor in industrial plant is highly unacceptable this may cause damage to various equipment present the most inexpensive way to correct this problem in industry is by supplying reactive power with the help of a capacitor Bank. Focusing upon various considerations of capacitor new designs are built. Work power factor causes additional consumer cost when not corrected properly. Power factor penalties in utility billing method used influences the type of power factor correction method used (C. A. Heger, 2012).

Use of photovoltaic system connected to our electrical grid for various Industrial and commercial purposes are being increasing in order to create sustainable energy supply. However their efficiency is totally based on intensity of sunlight available in the daylight. The major role of converter is to inject active power to the grid irrespective of consideration of power quality capabilities in electric facilities. The scheme enabled inverter the additional function of compensating reactive power from inductive load to improve power factor by the help of solar panels. This system was verified by the help of MATLAB (M. I. Flota Banuelos, 2016).

Single phase AC-DC hybrid micro-grid contains two AC and DC zones limited by a bi-directional converter full Bridge IGBT structure which act as an inverter. This control strategy allows transfer of both reactive & active power between the hybrid micro grid and the public home supply AC grid. The complete work is depended upon combination with AC grid in order to improve power factor of the system (A. M. Iuoraş, 2020).

An Indigenous technique that is phase difference between voltage and current can be determined by using zero crossing detectors, opto-couplers, EXOR gate along with implementation with arduino microcontroller. Various voltage and current transformers are used for transforming load voltage and current to bring supply value to desired range of the microcontroller so that the system is safe to use. For rectification, rectifier was designed by the help of OPAMP. Phase difference can be measured by using gate. An algorithm was created to achieve power factor close to unity, this algorithm included functioning of capacitance automatically along with relays to improvise the lagging power factor (Owais, 2016).

There is a heavy need to promote use of renewable energy sources especially in many developing countries where there is a problem of unreliable electrical grids this is highly necessary. Solution was to use solar based single phase micro inverter feeding AC power to the grid. This method can be applied to large distributed generation network of micro inverter in weak grid areas. The problem of weak grid could thus overcome by hybrid grid. The simulation was carried out by MATLAB & was found satisfactory (N. Ramzan, 2017).

Capacitor bank method can be used in industries and in transmission procedure so as to compensate the need of reactive power. Inductive loads are the main reason of degrading power factor. Capacitor bank system develops enough amount of reactive power to improve power factor and bring it above 0.9(close to unity). Capacitor bank lifetime may be reduced due to of abrupt on and off condition and overcorrection. This method is ecofriendly since by using this method the consumption of fossil fuel as an energy source are being reduced (M Shanmugapriya1, 2021).

There is high need to eliminate harmonics by improving the power quality of the device, power quality can be improved by reducing total harmonic distortion. Three phase hybrid power filter is stated. Hybrid active filters with control algorithm were thus needed. LC power filters were used to eliminate harmonics of source when in

parallel to the load similarly series active filters help to compensate in line voltages. Combination of series and shunt active power filters were studied by MATLAB SIMULINK. This compensation reduced the risk of overload since current harmonics of nonlinear load was compensated, resonant circuits provide compensation. MATLAB platform is used to test these compensation techniques (Hameed, 2013).

The power factor acts as an important factor in efficiency of the system, the capacitors of required value are injected to the system when power factor reduces to a certain value. Under on time period of each pulse the power factor can be determined. Low power factor leads to penalty to users. The capacitance added should be of exact value calculated out using some mathematics. Micro-controller certainly decides the amount of compensation to be given so as to make system more efficient (Aditya B. Dhanke, 2020).

Electrical power is essential part for manufacturing cost in various areas. Various reasons for power factor reduction maybe because of use of various induction motors, coiled loads, choke coils etc. Less power factor implies large amount of losses, improvement in the power factor can be done by the use of capacitor banks in industries. Improvement in power factor implies better economic management in a plant. Thus low power factor implies greater losses in active power in various parts of power station. Thus efforts must be made to maintain power factor close to unity, this can be achieved by using various compensation techniques (Samarjit Bhattacharyya, 2011).

Hybrid grid system consisting of various alternative energy sources (solar PV cell, wind turbines, fuel cells). Various technologies are developed with variety of improvement features so as to compensate the need of renewable energy. Implementation of BJT and MOSFET to design highly efficient DC/DC converter. The results showed the output taken by 3 Phase diode rectifier was satisfactory. Boost converters along with PV cells were used to get desired DC bus voltages (R.Karthick, 2016).

III. PROBLEM IDENTIFICATION

In hybrid system the power is intermittent and unpredictable in nature several factors affect the system which includes harmonics, lowering power factor, voltage fluctuations and frequency fluctuation. The solar photovoltaic system mainly produces active power for the load. When this system is used along with grid supply the complete hybrid system is incapable to supply reactive power resulting in poor performance of system. Where loss in power factor is major issue for which different method is used which are effective to improve power factor such as automatic power factor controller, capacitor banks microcontroller& IOT based device.

IV. DESIGN AND IMPLEMENTATION

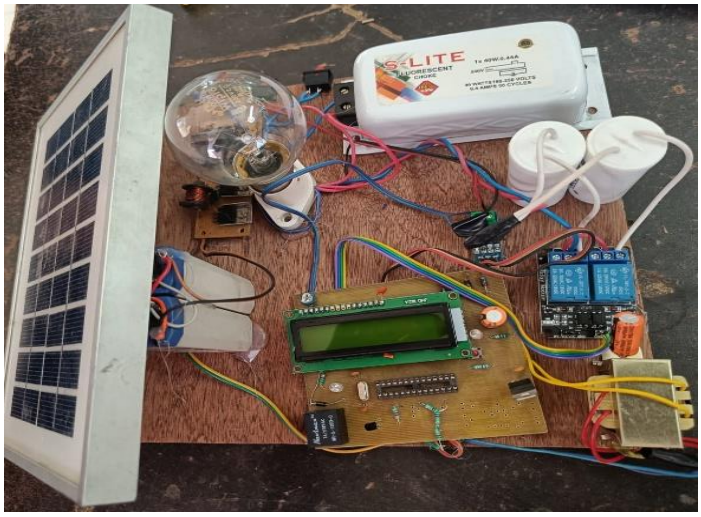

Figure 2: Model Setup

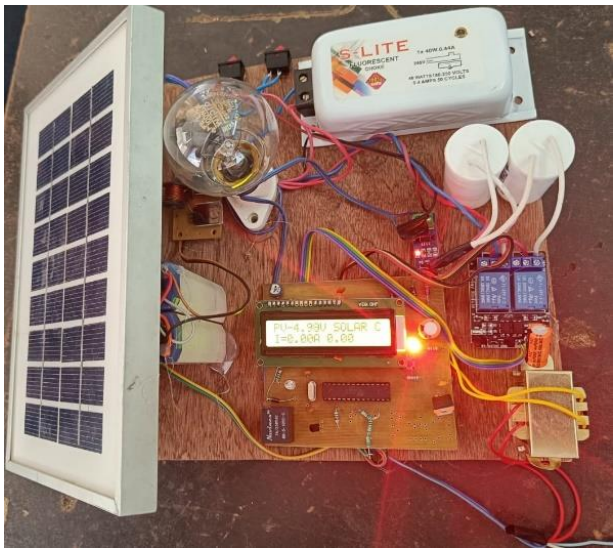

Figure 3: Operating mode 1

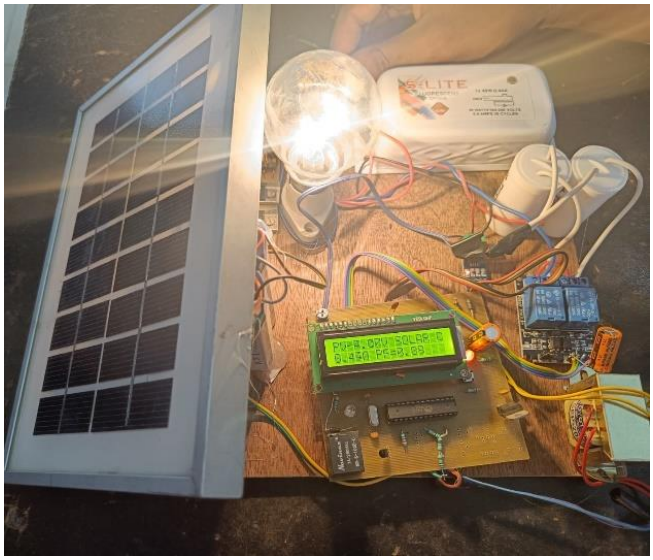

Figure 4: Operating mode 2

Figure 2 represents the Model setup for the power factor improvement with capacitor device

Figure 3 shows the setup when the power is switched on, currently the readings on LCD screen is zero

Figure 4 shows the working mode of setup initially the power factor is 0.65 when load was connected. Later when capacitor bank was connected via relay to the system in parallel power factor of the system improves Power Factor and the reading on LCD screen changes to 0.89. Hence the Power Factor Improves.

V. CONCLUSIONS

During the study of power factor improvement in hybrid system we conclude that during grid supply only active and reactive power is supplied as per load but in hybrid system the grid supplies less active power and same amount of reactive power which results in lowering of power factor. Harmonics present in hybrid system also results in the increase of reactive power and overall loss in power factor. Low power factor results in reducing of performance appliances and it results in loss of power in grid. Various methods are used to prevent the loss of power and to increase the power factor rating like automatic power factor correction (APFC) panels, capacitor banks, IOT devices, microcontroller etc. The capacitor Bank method is proposed to improve the power factor in industrial areas. Physical implementation of capacitor Bank in hybrid system is entertained and results were studied.

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REFERENCES

[1]. A. M. Iuoraş, S. I. (2020). Power factor compensation for a single-phase AC-DC Hybrid Micro-Grid. *IEEE 11th International Symposium on Power Electronics for Distributed Generation Systems (PEDG),*, pp. 455-458,.

[2]. Aditya B. Dhanke, M. B. (2020, january). Microcontroller Based Automatic Power Factor Improvement. *International Journal of Research in engineering, science and management, vol. 3*(no.1), 2581-5792.
[3]. C. A. Heger, P. K. (2012). Power factor correction — A fresh look into today's electrical systems. *IEEE-IAS/PCA 54th Cement Industry Technical Conference*, pp. 1-13.
[4]. Cadere, C. A., Barbuta, M., Rosca, B., Serbanoiu, A. A., Burlacu, A., & Oancea, I. (n.d.).
[5]. Cadere, C. A., Barbuta, M., Rosca, B., Serbanoiu, A. A., Burlacu, A., & Oancea, I. (2018). Engineering properties of concrete with polystyrene granules. *Procedia Manufacturing*, 288-293.
[6]. Hameed, M. M. (2013, november). Enhancement of Electric Power Quality by Using Hybrid Power Filters. *International Journal of Engineering Research & Technology (IJERT), vol. 2*(no. 11).
[7]. M Shanmugapriya1, A. C. (2021). Inductive Load power factor Correction using Capacitor Bank. *Journal of Physics: Conference Series 1916(2021)012140*.
[8]. M. I. Flota Banuelos, B. A. (2016). Passivity-Based Control for a Photovoltaic Inverter with Power Factor Correction and Night Operation. *IEEE Latin America Transactions, vol. 14*(no. 8), pp. 3569-3574.
[9]. N. Ramzan, Z. J. (2017). Grid tied solar micro-converter with optimizer-mode operation for weak-grid operation. *IEEE Applied Power Electronics Conference and Exposition (APEC)*, pp. 2068-2075.
[10]. Owais, M. B. (2016). Automatic power factor correction unit. *nternational Conference on Computing, Electronic and Electrical Engineering (ICE Cube)*, pp. 283-288.
[11]. R.Karthick, S. (2016). GRID INTERCONNECTION OF HYBRID POWER SYSTEM. *International Journal of Advanced Engineering Technology, vol. 7*(no. 1).
[12]. Samarjit Bhattacharyya, D. A. (2011, december). Case Study On Power Factor Improvement. *International Journal of Engineering Science and Technology (IJEST), vol. 3*(no. 12), 8372 - 8378.
[13]. Y. Lo, H. C. (2009, november). Analysis and Design of a Photovoltaic System DC Connected to the Utility With a Power Factor Corrector. *IEEE Transactions on Industrial Electronics, vol, 56*(no. 11), pp. 4354-4362.