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Power Factor Improvement in Electric Distribution System by Using Shunt Capacitor Case Study on Samara University, Ethiopia

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ABSTRACT: Improving energy efficiency by power factor correction is all about saving your money. Conservation of resources is a fundamental objective, and increasing energy efficiency a core aim of any country. The aim of paper is to find a good solution or to improve the power factor for high energy consumption by samara university loads, through a sustainable development that corrects low power factor. Power factor correction (PFC) is a technique of counteracting the undesirable effects of electric loads that create a power factor that is less than one. Power factor correction may be applied either by an electrical power transmission utility to improve the stability and efficiency of the transmission network or correction may be installed by individual electrical customers to reduce the costs charged to them by their electricity supplier. Many control methods for the power Factor Correction (PFC) have been proposed. This work describes the design and development of a power factor corrector using shunt capacitor. Measuring of power factor from load is achieved by capacitor connected in parallel to determine and trigger sufficient switching of capacitors in order to compensate demand of excessive reactive power locally, thus bringing power factor near to unity.

KEYWORDS: Power factor correction, shunt capacitor, power world software, Reactive Power,

I. INTRODUCTION

The power factor of an AC electric power system is defined as the ratio of the real power to the apparent power, and is a number between 0 and unity. Real power is the capacity of the electric load for performing work in a particular time. Apparent power is the product of the current and voltage of the electric load. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power can be greater than the real power. Low-power-factor loads increase losses in a power distribution system and result in increased energy costs. In a purely resistive ac circuit, voltage and current waveforms are in phase, changing polarity at the same instant in each cycle. Where reactive loads are present, such as with capacitors or inductors, energy storage in the loads result in a time difference between the current and voltage waveforms. This stored energy returns to the source and is not available to do work at the load. A circuit with a low power factor will have thus higher currents to transfer a given quantity of real power than a circuit with a high power factor. Circuits containing purely resistive heating elements such as filament lamps and cooking stoves have a power factor of 1.0. Circuits containing inductive or capacitive elements such as lamp ballasts and motors, often have a power factor below 1.0.

The significance of power factor lies in the fact that utility companies supply customers with volt-amperes but bill them for watts. Power factors below 1.0 require a utility to generate more than the minimum volt-amperes necessary to

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supply the real power (watts). This increases generation and transmission costs. Alternatively all components of the system such as generators, conductors, transformers, and switchgear would be increased in size and cost to carry the extra current. Hence the need for correction of low power factor. Which results to an increment of electricity bill charge? Penalty charge is just one of the problems; however, there are more other problems occur if power factor is low. They are: 1. Extra losses in feeder cables 2. Significant voltage drop 3. Reduction of effective capacity of cables 4. Voltage drop at the secondary of the transformer 5. Losses in transformer.

Electrical power generators are design to produce quality, reliable and stable power to consumers. It came to light that most of the loads in commercial use are inductive loads that produce inductive reactance and if not immediately checked, contributes to low power factor thereby increasing the amount of electrical energy that flows through the electrical network from the generating station. Example of industrial and commercial loads are (inductive motors, furnaces, arc welding machines, etc.) and (air conditions, washing machines, deep freezers, refrigerators heaters, etc.) respectively.

In samara university there is very low powerfactors that means there is reactive power due this power loss. In case of low power factor, current will be increased, thus, to transmit this high current, we need the larger size of conductor. Also, the cost of large size of conductor will be increase.Electrical Power supply Company imposes a penalty of power factor below 0.90 lagging in Electric power bill. So we must we would improve above 0.90.

II. POWER FACTOR IMPROVEMENT METHODS

Methods for improving power factor may be classified as: 1.First in which equipment operates at unity power factor thereby improving the Overall power factor of the system, and 2.The second where auxiliary equipment is used specifically to supply the magnetizing power or the KVAR needed by the load.

Equipment that operates at unity power factor includes:1.Unity power factor synchronous motors 2.Unity power factor capacitor motors 3.Incandescent lamps. 4.Resistance heaters and other non-inductive loads.When this type of equipment is added to a system, the overall power factor of the system improves. This additional real power (kW) increases the demand and the energy cost, and is never done for the sole purpose of improving the power factor. However, the choice of load(Such as a synchronous motor over an induction motor) can improve power factor. For the present discussions, we would consider reducing the reactive load rather than increasing the kilowatt load to improve the power factor. Improving power factor by reducing the KVAR load requires the use of power factor equipment which operates at a leading power factor such as: 1.Synchronous motors which are either over-excited or under loaded with full excitation so they will supply KVAR to the electrical system 2.Static capacitors which are electrical devices without moving parts that have the ability to provide magnetizing current to the load. Their efficiency is high since losses are less than one-half of 1 percent of their KVAC (or KVAR) rating.

2.1 Reactive power compensation methods:

Generally speaking, undesired power factor value caused by inductive load connected to the supplying network can be corrected (compensated) by means of loads having the capacitive behavior. There are few possible configurations of compensating systems; however there are two basic methods that can be distinguished:

2.2 single power factor correction method:

Single power factor correctionput in practice by connecting power capacitor directly to terminals of a device that has to be compensated. Thanks of this solution; electric grid load is minimized, since reactive power is generated at the device terminals. This method eliminates controlling devices, since capacitor is being switched on and off by means of the same switch as the device. The main disadvantage of this method is that the capacitor is not being used when the device is not operating. Moreover, the series of type of capacitors offered by manufacturers is not always sufficient to meet the requirements.

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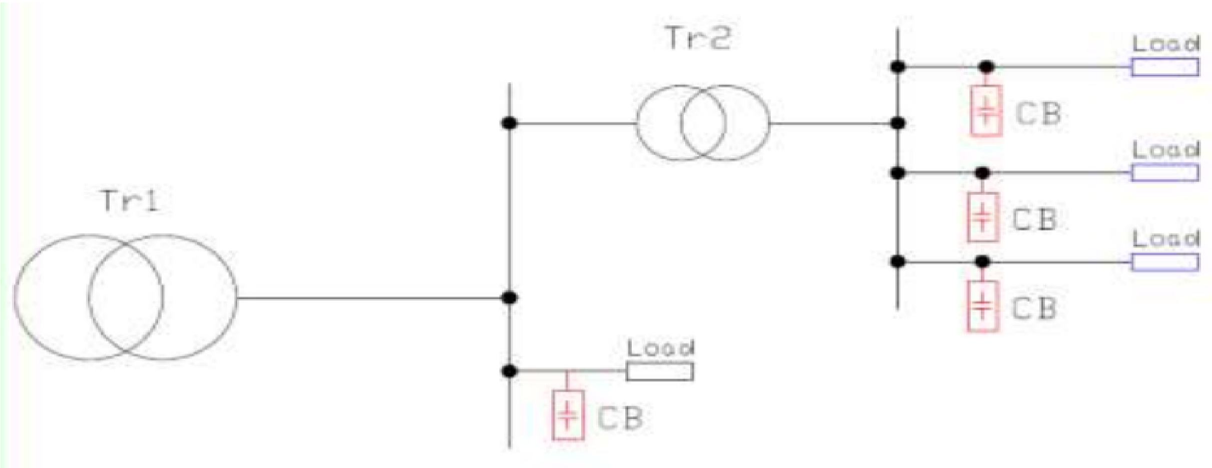

Fig 1. Illustration of fixed power factor correction

2.2.1. Group power factor correction method:
Group power factor correction method is more effective than the previous one. Group PFC assumes compensation of a group of loads supplied by the same switchgear.

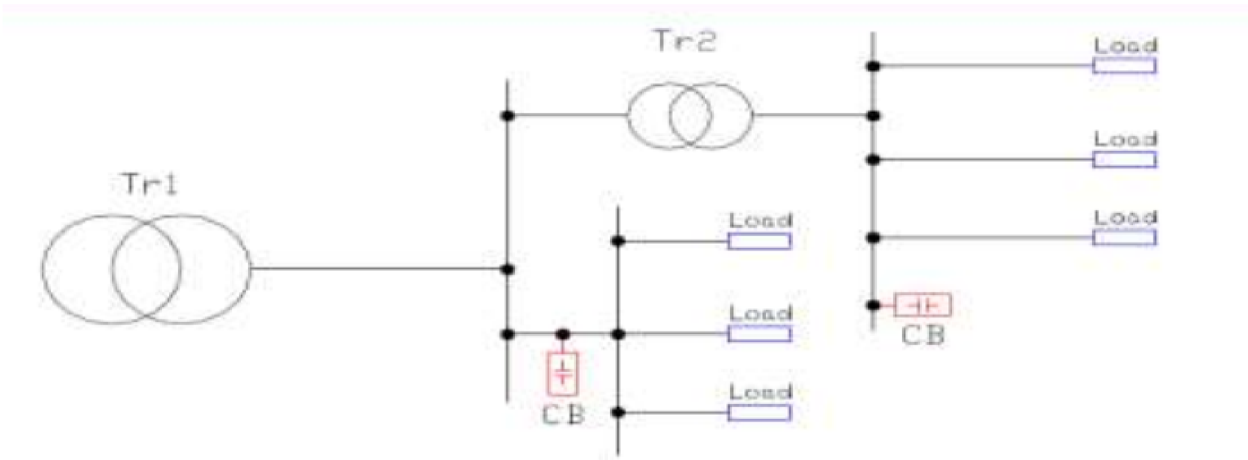

Fig 2.Illustration of group power factor correction

III. CASE STUDY ON POWER FACTOR IMPROVEMENT IN SAMARA UNIVERSITY

In Samara University there are six transformers found in now:

a) Transformer one **(T1)**, was supplied to all department of load that use to water treatment
b) Transformer two (**T2**) was supplied to also fed all social class room building, IT and computer lab, laboratory building and PHO, Medicine class room
c) Transformer three (T3) was supplied to all load that used to waste power treatment
d) Transformer four(T4) was supplied to all student dormitories, libraries, student cafeteria, register building, collage of technology and engineering, lab class of such as electrical and computer, mechanical, chemical, statics and some offices found these building and street light system.

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e) Transformer five (T5) was supplied to lecturer residence, street light system that are found around lecturer residence and technology class room also supplied to all technology class room buildings rounding street light
f) Transformer six (T6) was supplied to administrative building, cisco building, store building, student DSTV room, launch and shops

Now the rating power each transformer and their need of capacitor for improving of power factor to around 0.90 to 0.95 shown below

Table 1. Power factor improvement for various transformer exist in Samara University

No	Type of Transformer	S in KVA	P in KW	Q in KVAR	Need of C in KVAR	PF before connected C	Pf after connected capacitor
1	T1	315	252	193	76	0.8	0.93
2	T2	315	236	208	90	0.76	0.92
3	T3	200	160	120	60	0.8	0.95
4	T4	1250	925	839	379.6	0.74	0.93
5	T5	800	640	480	130	0.8	0.90
6	T6	315	252	205	70	0.76	0.9

From this table we get billing of the campus and sending ending of reactive and active power supplied to it.
Power consumption=327060kwh x 140x 0.6946birr/kwh=31,790.88birr
Penalty billing =228751 x 140x 0.608birr=22,161birrr
The real and reactive power would be: For one transformer that is found near student cafeteria Q=603,360kvarh/720h=839.34kvar P=666,003kwh/720h=925kw is supplied power. The campus must install power factor correction schemes at their load to cut down on these higher costs. In addition to the increased operating costs, reactive power can require the use of wiring, switches, circuit breakers, transformers and transmission lines with higher current capacities. Power world simulator is very important to analysis reactive and active power flow of the power system. As we show in below power flow diagram line which is supplied by sub-district of samara EEU, so we would take as generators on simulation which connected to bus one. In practical bus one is the common bus to transformer of primary supply; three phases are shunted on bus one then takes to transformer with their arrangements of R-S-T.

3.1 Design simulation based on study

Using power world simulation software we analyzed power flow for reactive and real power in the campus and selected suitable value of capacitors to compensate it.We take the load side the real power 253MW and reactive power 129MVAR. Because the power world software limitation it cannot show the flow path as well as the value of loss or the value loss less than 2MW now in order to show the loss in inductive load and power factor in power world software we take the above value.

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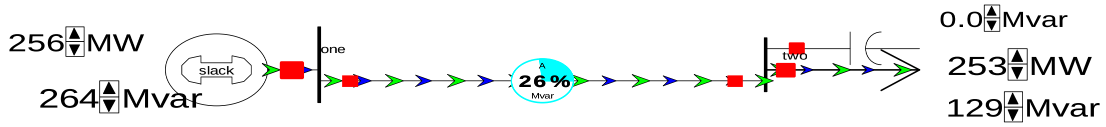

Fig 3.power flow diagram without shunt capacitor connected

From the the above figure we observed the apparent power 37%, the real power 26%, the reactive power 26% ,the magnitude of load bus voltage in per unit 0.7725Pu and the line current is 37% .When small amount of shunt capacitor or 81.3MVAR connected in parallel to the load as shown figure below

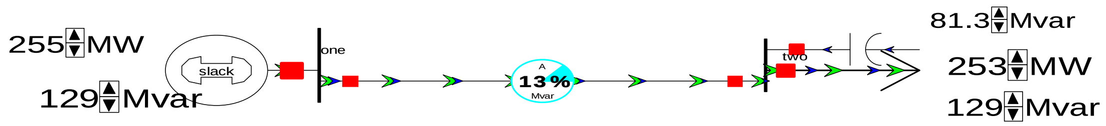

Fig 4. Power flow diagram with 81.3MVAR connected in parallel

From the above diagram of power flow we observed the apparent power 29%, the reactive power 13%, real power 25%, the magnitude of load bus voltage in per unit 0.9015Pu and the line current is 29% so there is some reduction of reactive power and line current. When the shunt capacitor connected rated value 142.3MVAR as shown figure below

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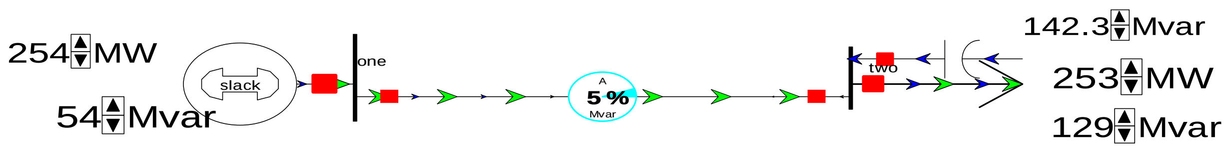

Fig 5.power flow diagram with 142.3MVAR connected in parallel

From the above diagram of power flow we observed the apparent power 26%, the reactive power 5%, real power 25%, the magnitude of load bus voltage in per unit 0.9740Pu and the line current is 26% so there is some reduction of reactive power and line current. When the shunt capacitor connected rated value 222.1MVAR as shown figure below:

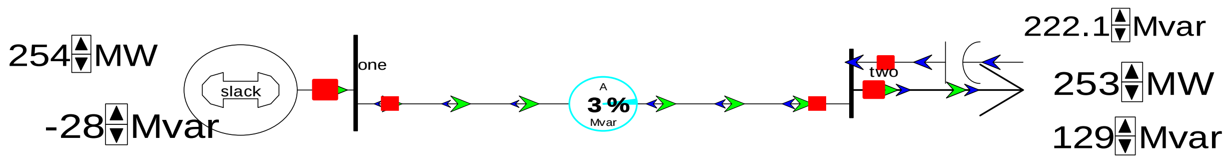

Fig 6.Power flow diagram with 222.1MVAR connected in parallel

From the above diagram of power flow we observed the apparent power 26%, the reactive power 3%, real power 25%, the magnitude of load bus voltage in per unit 1.0538Pu and the line current is 26% so there is reduction of reactive power and minimum line current is reduced.

3.2 Simulation Result& Discussion:

Power flow analysis has been done on the power world simulator software. Figures above illustrate the major power system components represented in Power World. In our case one Generator, transmission line and one load are

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represented to analysis simple power system of the samara university. We selected the appropriate value of the capacitors to compensate the reactive power.

To see an animated view of the above power flow diagram, open Power Word Simulator case campus. On the main menu, select Simulation, Solve, and Animate to begin the simulation. The speed and size of the green arrows are proportional to the real power supplied to the load bus, and the blue arrows are proportional to the reactive power. Here reactive power compensation can be supplied in discrete 39KVAR steps by clicking on the arrows in the capacitor's KVAR field, (which means manual operation in practical cause to switch ON and OFF capacitor units by step by step) and the load can be varied by clicking on the arrows in the load field. Notice that increasing the reactive compensation decreases both the reactive power flow on the supply line and the KVA power supplied by the generator; the real power flow is unchanged.

The primary benefit of power factor correction is the elimination of charges related to reactive power-consumption. If the utility is adding a power factor penalty or billing for apparent power (KVA), reduction in reactive power will net savings. The amount of savings seen will depend on the size, configuration, and operation of the power system. Typically, the costs for correction are paid back inside of one year, and after that, the savings will reduce operating costs. In addition, power factor correction will improve the overall performance of the power system which can increase switchgear, starter, transformer, bus bars and transmission line life. The bottom line is protection, efficiency, and savings.

IV. CONCLUSION

It can be concluded that power factor correction techniques can be applied to the campus, power systems and also households to make them stable and due to that the system becomes stable and efficiency of the system as well as the apparatus increases. The use of shunt capacitor reduces the costs. Care should be taken for overcorrection otherwise the voltage and current becomes more due to which the power system or loads becomes unstable and the life of capacitor banks reduces.

This paper shows an efficient technique to improve the power factor of a power system by an economical way. Static capacitors are invariably used for power factor improvement in factories or distribution line. But this paper presents a system that uses capacitors only when power factor is low otherwise they are cut off from line. Thus it not only improves the power factor but also increases the life time of static capacitors. The power factor of any distribution line can also be improved easily by low cost small rating capacitor. This system with static capacitor can improve the power factor of any distribution line from load side. As, if this static capacitor will apply in the high voltage transmission line then its rating will be unexpectedly large which will be uneconomical & inefficient. So a variable speed synchronous condenser can be used in any high voltage transmission line to improve power factor.

Generally before capacitor connected the power factor is 0.76 and 264MVAR no the generation side but after capacitor connected an improved power factor is 0.98 and reactive power is 28MVAR therefore much reduction of power loss, reactive current, voltage drop in long transmission line and extra equipment life.

REFERENCES

1. P. N. Enjeti and R martinez, "A high performance single phase rectifier with input power factor correction,"IEEE Trans. Power Electron..vol.11,No.2,Mar.2003.pp 311-317.
2. J.G. Cho,J.W. Won,H.S. Lee , "Reduced conduction loss zero-voltage-transition power factor correction converter with low cost,"IEEETrans.Industrial Electron..vol.45, no 3,Jun. 2000,pp395-400
3. J. E. Miller (1982). "Reactive Power Control in Electric System" New York: Wiley.
4. Stephen, J. C. (1999). "Electric Machinery and Power System Fundamentals." 3rdedition. United State of America: McGraw-Hill Companies, Inc.
5. John J. Grainger, William D. Stevenson (1994). "Power System Analysis" New York: McGraw-Hill.
6. JosArrillaga, Neville R. Watson (2003). "Power System harmonic"2nd edition chichester:johnwiley.