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PI Controller Based Automatic Power Factor Correction (APFC) Using Capacitor Bank

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Abstract **– Power factor plays an important role in electrical industries. Low power factor results in loss of power and poor handling capacity. This factor can be overcome by using capacitors in parallel to the load. Since capacitor draws a leading while inductor draws a lagging current, hence by adjusting capacitor banks parallel to the load, it will level the power factor in the line. Earlier, the process of power factor improvement was done through manual connection of capacitor bank. Later a power factor corrector named the automated power factor corrector (APFC) was proposed. It uses a switched capacitor circuit to improve power factor. In this research, the power factor value from the load is measured and it also includes the installation of APFC unit using a PI controller. The design of this auto-adjustable power factor correction scheme is to ensure that the grid power system always operates under the specified power factor. Actual work of APFC is that it selects the capacitor bank for power factor improvement. The capacitor bank block will choose automatically to further improve the power factor. This process goes on until the required power factor is obtained. Later on, this will automatically turn off the connection between the capacitor bank and the circuit. Furthermore, power saving with power factor after improvement is also discussed in the paper. Here APFC plays a key role in order to decrease the time taken to correct the power factor, which is ultimately beneficial to increase the efficiency of the motors and all inductive loads.**

Keywords **– Closed loop systems, inductor, reactive power control, switched capacitor circuits, three phase electric power.**

I. Introduction

Electrical energy is the most wanted energy and with the passage of the time, each and every step of our life demands electricity to work. As the world has wrapped up itself to a global village, it has merged the technologies into one another [1]. For every single technology, electrical energy is required to operate it. The whole supply depends upon our generating station and its transmission [2]. For an accurate supply, we need to have a flawless transmission system, which in short means an ideal system. All the losses are not possible to cover up, but the main ones are overcome by power engineers. Looking deeply into the system, we always face a common problem of power loss during transmission [3]. This loss is sometimes gripped and is brought to low by shortening the transmission line distance to distribution. To solve this problem, it is necessary to limit the number of loads. However, this is not the permanent solution to this problem [4]–[6]. A few methods have been proposed in order to have a perfect transmission of power. Without using these methods, the industry may face a lot of issues, like burden on their generators and motors [7]. Huge amount of energy is wasted during power transfer. Therefore, a backup is required for the power to be backed out so that the desired amount can be received at the receiving end. For this backup, an extra work burden is put over the generation station. For this reason, policy makers have to inject extra money which intimately affects the consumer's pocket by the charge named surcharges. In short, it is a wastage and charge circle, which goes on and is stick to a single minor term "power factor".

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II. Types of Losses

There are many types of losses in a transmission line that can affect the transmission and can result in power services. Types of losses that we can observe in a transmission system can be viewed in Fig. 1.

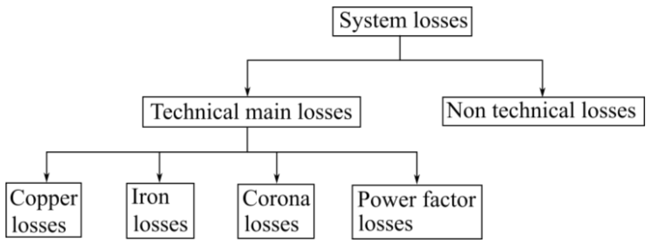

Fig. 1. Transmission line losses.

A. Technical Main Losses

Technical main losses are of four types, which are described below.

B. Iron Losses

Iron loses are defined as the combination of three losses that are the following:

Iron losses = Eddy current loss + Hysteresis loss + Anomalous loss. (1)

They can be expressed through an equation as follows:

$$W_{loss}=\Sigma(W_h+W_e+W_{corona}+W_{PF}). \quad (2)$$

C. Copper Losses

Copper losses are termed as the heat produced by electric current in a transformer winding. Although it is not fixed by name "copper", winding can be of other material like aluminum etc. Hence, a term "winding losses" is mainly used. Copper losses can be calculated by the relation given below.

$$W_{Cu}\propto I^2, \quad (3)$$

where I – current in a conductor.

D. Corona Losses

As by the name, this loss seems to be major. It is caused by the air molecule ionization near the conductor area of transmission line. The system carries current in the air along the transmission line but does not spark.

It can be indicated by the following indicators:

- fain violet glow;
- hissing sound;
- smell of ozone.

Corona loss can be calculated through a formula given below:

$$P=\frac{K_0}{K}\left(f+25\right)\sqrt{\frac{a}{b}}\left[V_0-g_0k_iak_d\ln\left(\frac{d}{a}\right)\right]\times10^{-5}\ \text{kW/km} \quad (4)$$

E. Power Factor Losses

In this research, main focus is on the base point of this whole system, which is termed as the power factor (PF). The PF is the element that is highly observed as the backbone of power supply. It is the only reason of several damages like high billing, power loss, wastage of energy and many other flaws. Power factor is set to be close to unity for the perfect power transmission in line. That is not maintained in real because of high use of induction motors in the industries.

Looking back to the National Transmission and Dispatch Company (NTDC) record, one can easily notice the power loss in the transmission line because of the poor PF. It can be seen in Fig. 2 representing the data from 1981 to 2021.

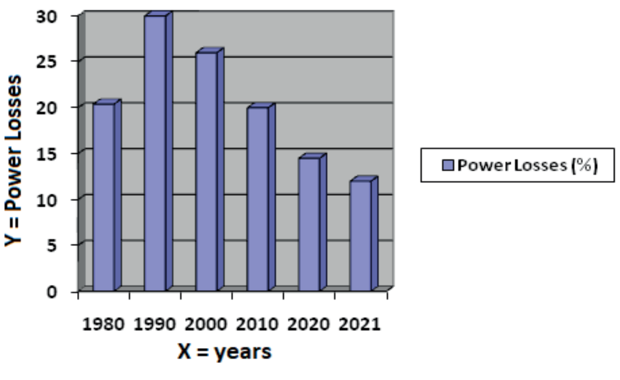

Fig. 2. Power loss data by NTDC record.

The record occupies performance of each fiscal year. As can be seen in the graph, the losses started with 1998 having about 29.5 % of power loss which was tackled by applying various techniques to control losses, such as corona loss and others. After all this, the loss graph dropped to a point of 19.4 % and by more improvement in power factor section, it stopped to almost a low point. This research provides an overview of all the mechanics that are based on power factor improvement.The main aim of this paper is to explain a new method of automatic PF improvement using capacitor banks.

III. Literature Review

Alternating current demands apparent power to operate an electrical load. Apparent power is the sum of active (kW) and reactive (kVAR) powers. Active power is the true or real power consumed by the load. On the other hand, reactive power is repeatedly demanded by the load and returned to the power source. It is the repetitive cycle that appears when AC passes through the load having a reactive element. All of these elements can be clearly examined in Fig. 3.

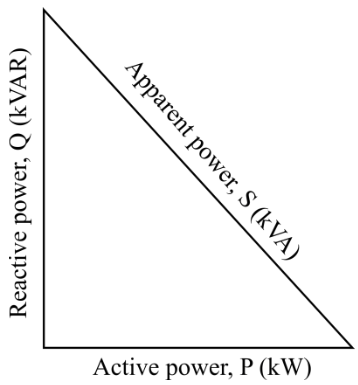

Fig. 3. Power triangle.

Figure 3 describes the true power as useful power, wasted power as the reactive and the demand power as the apparent power which we can be assumed as the desired power. However, this desired power is not the complete set, instead we receive a portion of reactive power (wasted energy), which also travels with it. This loss is due to the poor PF.

A. Power Factor

A PF is the main component to identify the system's efficiency and for that reason, it is considered to be the main element that can enhance the quality of the system by boosting the supply with minor or negligible losses.

Power factor is defined in (5):

$$\text{Power Factor}=\frac{\text{Real Power}\left(\text{kW}\right)}{\text{Apparent Power}\left(\text{kVA}\right)}, \quad (5)$$

where kW – capacity of circuit for performing work at a particular time; kVA = $V\times I$.

Hence, it is desirable to keep the PF above a specified amount (usually 0.90 or higher) or be subject to additional charges. The main reason for power factor of less than 1 can be identified through the power triangle, where the presence of reactive power causes the real power to be less than the apparent power. The reactive power is responsible for an increase in the current flow in between the source and the load. It results in a certain amount of power loss in transmission and distribution lines, leading to operational and financial losses for power companies.

PF correction can be done through many ways. Its main purpose is to adjust the knot of an AC load to unity such that PF = 1. In a majority of power systems, a poor power factor is the reason of an increasing inductive load usage, which is unnoticed most of the time. This increase in inductive load causes a lagging PF because of which the current lags behind the voltage as shown in Fig. 4, causing the PF below unity.

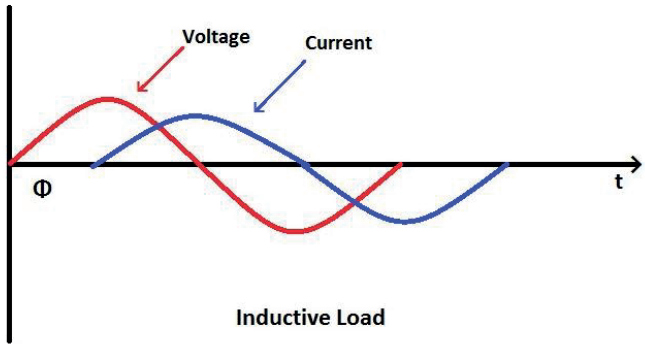

Fig. 4. Inductive load waveform.

A majority of machines we use for power production are inductive. These are the motors, altenators, transformers etc. Such loads require a magnetic field to operate. Inductive loads need two kinds of power:

- Active power that is mandatory in the operation process of a machine. It goes with the generation of heat, motion, light, output, etc;
- Reactive power to sustain the magnetic field.

B. Methods to Improve Power Factor

Installation of Static Capacitor

A capacitor is a device that works on generating leading power factor. A static capacitor is used in a power system in order to cancel down the lagging effect by induction machines. Capacitor is responsible for maintaining a balance between leading and lagging current which, as a result, brings up the PF near unity. That is the finest output for perfect voltage regulation. It can be attached to both star and delta connection as shown in Fig. 5.

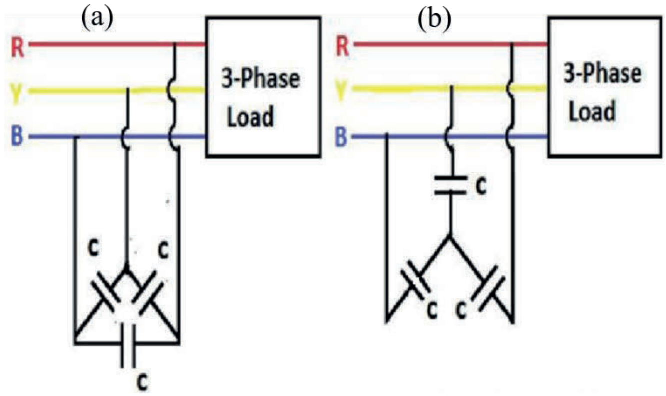

Fig. 5. Static capacitors installed parallel to the star and delta connection.

Phase Advancer Method

A phase advancer in actual is an AC exciter. It is also used for PF improvement purpose. It is set on the motor's shaft at rotor's circuit. The main working of it is to bring down the phase difference created by induction motor. Induction motor is the reason of phase shift of voltage at 90° lagging the current behind. This problem can be sorted using phase advancer technique.

Using Synchronous Condenser

A synchronous condenser method is used in PF improvement to stable it close to unity. This method uses an over-excited synchronous motor to tackle down the reactive power. It produces a large amount of leading factor that compensates the lagging component and brings the PF to a sufficient point. It is explained in Fig. 6.

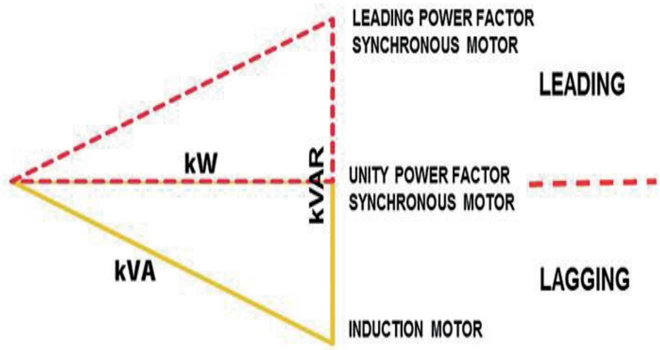

Fig. 6. Result after synchronous condenser's installation.

Installation of Capacitor Bank for Compensation of Load

For the reason to compensate the loss caused by inductive load and to restore PF close to 1, we use capacitor banks to cancel the lagging effect. Hence, at the end, it provides a fine output and a safer economic operation. As the capacitive load provides the desired leading factor, the result is now opposite and the current will lead the voltage, and the PF now is considered as leading. It is illustrated in Fig. 7.

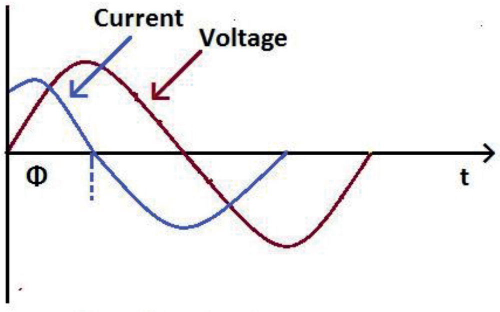

Fig. 7. Capacitive load.

Several advantages can be drained out by applying power factor correction to the system such as reduction in power system losses, increment in loads carrying capacity, improvement in voltages and many more. The aim of this research is to design a PF correction unit that is capable of monitoring the system and its energy consumption and set the power factor automatically as per need. Hence, the unit is named automatic power factor corrector (APFC) unit. However, correction of power factor is an exceptionally old practice, large numbers of the creators beneath have recommended and endorsed numerous methods of power factor correction.

Oommen and Kohler investigated the benefits that can be achieved by legitimate execution of power factor pay [5]. A short report on the monetary examination was done to show the financial practicality of remuneration. Jiang et al. proposed a clever single-stage power factor correction plot in view of equal power factor correction idea, which was portrayed to be more proficient than the two-overflow stage plot [6]. Qureshi and Aslam framed the various techniques for power factor correction and performed an exploratory contextual investigation to investigate the regions which would be reasonable for pay [7]. After a pragmatic show to have a huge improvement in power actor was finished, they found that it would deliver the limit of circulation transformer, and the issue of over-voltage under state of low burden was avoided. Novak and Kohler drew attention to the significance of power factor improvement for mechanical development and headway in profound coal mineshaft power frameworks [8]. Unique assurance gear to check the innate electrical flaws in the mining framework was contended. The power factor correction close to loads for further developed voltage guideline was stressed inside the requirements of high voltage appropriation in underground coal mine shafts. Shwehdi and King recommended a few numerical estimations for power factor and receptive power prerequisite of the framework alongside the capacitor size assessment techniques [9]. Celtekligil examined the use of a technique for dynamic power factor correction in light rail transportation framework [10]. Central power sources have been exchanged through thyristors utilising automatic power controllers by detecting the power factor and continually checking the current and voltage, ascertaining the power factor and exchanging inductance banks as required. The proposed framework associates inductive burdens in equal with the capacitive framework to further develop the power factor correction. Choudhury gave a plan and execution of a minimal expense power factor improvement gadget for little sign low power loads [11]. The idea was to plan a little sign model burden choosing proper capacitors and proposing suitable changing circuits to choose an appropriate mix of capacitors. Shahid and Anwar offered the plan of a power factor improvement circuit utilising PIC with diminished parts to accomplish the desired productivity and minimal expense [12]. The arrangement includes guaranteeing the power factor esteem from the heap and uses a calculation to decide and trigger changing capacitors for unreasonable receptive parts to increment power factor esteem. Sharma and Haque completed a recreation and investigation study for PF correction for metal halide focused energy release lights [13]. A changed boost converter utilising dynamic gadgets was proposed alongside PI controller to balance out the control circles. R. A. Allah recommended an automatic power factor correction in view of estrangement procedure [14]. An estrangement method was developed for the computation of power factor on-line and assurance of the expected number of capacitor banks to get the ideal power factor. Distance coefficients were determined between stage voltage and current signs of power supply. Elective transient program (ETP) and MATLAB programs were utilised to execute the proposed strategy.

C. Automatic Power Factor Correction Unit

It is an automatic system that adjusts itself to control the PF at a desirable value using a bank of capacitors switched by means of connectors. Connectors are controlled by a regulator that measures PF in the network. Depending upon the load PF, the controller will adjust the PF by switching the necessary number of capacitors from the bank. A short functioning of this automatic power factor correction unit can be observed in Fig. 8.

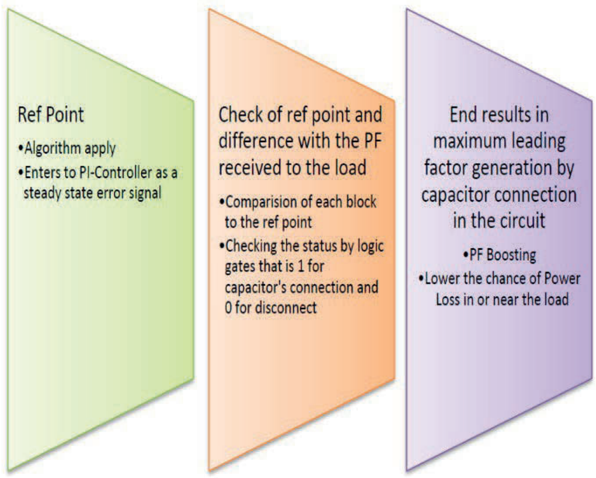

Fig. 8. Short description of APFC unit.

D. Proportional Integral Controller

PI controller stands for proportional integral controller. It is a smart controller having a closed loop system that is mainly used to detect and remove error by iterations. This device has the major role in APFC unit as it is the brain of the unit. It fixes the PF by repeating the steps, allowing different capacitors to be attached to fulfill the desired request set on it. A PI controller attaches and detaches the capacitor to boost the power factor near the reference value.

As this controller is the combination of proportional and integral controller, it means that the output of this controller must be proportional to the error signal and integral of the error signal. It can be explained using Eq. (6) and Fig. 9.

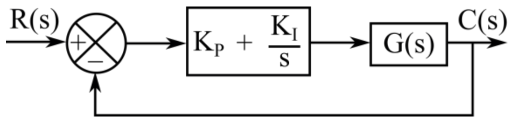

Fig. 9. PI controller.

$$G(s) = K_p\left(1+\frac{K_i}{sK_p}\right) = K_P\left(1+\frac{1}{T_i s}\right), \tag{6}$$

where

C – output of the system;
R – an error signal;
K_P – proportional gain;
K_i – integral gain.

E. Capacitor Bank

A capacitor is a component used to store electrical charge in it. Capacitor bank as indicated by its name is a bunch of capacitors attached together for better results as shown in Fig. 10. Capacitor banks are mainly used for voltage regulation purpose at many places. The reason is because of their ability to produce a leading effect that compensates the lagging current produced by an inductor causing the current to lag behind the voltage showing a disorder in voltage regulation. This in further process causes many losses and damages in power transfer. Capacitor banks are differently valued on behalf of their ratings and are attached according to the demand.

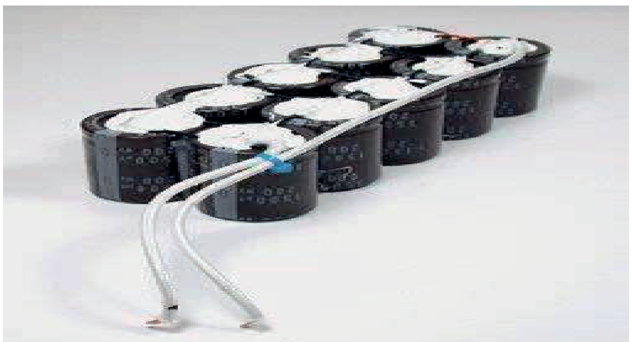

Fig. 10. Capacitor bank.

F. Power Factor Tuning

Power factor is the main reason for ups and downs of power in a transmission line. If we can grip over this figure from 0.95 to 1, we can cover up all the damages and losses we face while power transfers in transmission lines [8]. Power factor tuning needs a full fledge circuit to be implanted near an inductive load so that it can level up or down to achieve the desired point. For that reason, let us view the process of such a system through a circuit shown in Fig. 11.

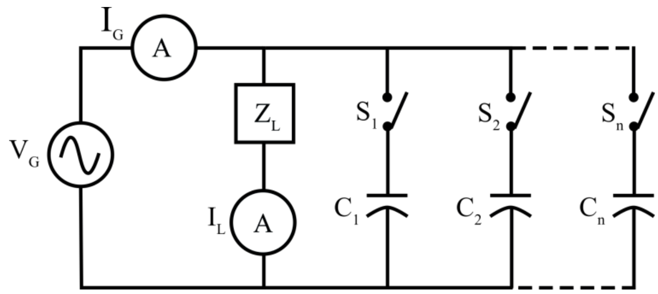

Fig. 11. Capacitor bank circuit with grid connection.

The circuit explanation is started with grid station from where the power is being transferred. At this point, we have to measure the PF so that we may know the exact measurement of PF from the supply. For this reason, an ampere meter is attached to the circuit in series for continuous measurement of current flow from the grid station. A load is attached to the grid station with an ampere meter to measure the PF we receive from the grid. Here a reference point is set for PF. For example, we set a reference of 0.75 in the correction unit. Then, according to the set algorithm, it will cross check the received value with the ref point. If it matches the desired point, the switches will freeze and no more capacitors will attach or detach with the load. The PI controller will match the PF value with the capacitor banks attached in parallel and connect the possible numbers of capacitors which can compensate the value we need. After the connection of capacitor, now the PF is boosted up to 0.75. It will be fixed for the load saving the penalty amount the consumer pays for low PF. At this point, we came to a situation where the capacitors were discrete in nature; therefore, it would not be possible to achieve the accurate output we referred [15]. For example, if we set up a value of 0.78 as a reference and connect the two capacitors with the circuit that results in an output value of 0.75, which is not the value we set. By connecting three will result in 0.79. Whereas the figure we want is 0.78. Hence, to get the accurate output, we set up an algorithm for the controller that it follows and works according to our demand. Following the rules, it will do both connection and disconnection of capacitor to achieve the reference point. To eliminate this periodic transition of switches, a termination algorithm is used before PI controller. Termination algorithm will give the closest tuning of PF.

G. Termination Algorithm

For accurate measurement and best results, the PI controller is given an algorithm that will define its output results. The algorithm is based on continuous measurement of power factor in the line near the load. We will fix a reference number of PF that will be compared to every single capacitor attached to the circuit. The process is carried out until the error is removed and it starts with the error signal as well. This sequence-wise setting of controller plays an important role in building an ideal design of APFC unit. This repetition of steps till the desired value will make a clock sequence that goes on until we reach the destination point. The terminating algorithm is set with the PI-controller for the manipulating of error, which can be viewed in the block diagram in Fig. 12.

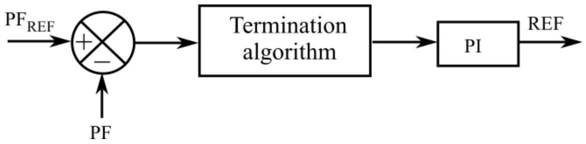

Fig. 12. Power factor termination algorithm block.

The algorithm initiates with the error signal entered in the control system. As we know, a controller operates when a steady state error is given to it. The counter is started by the value *c* = 0.

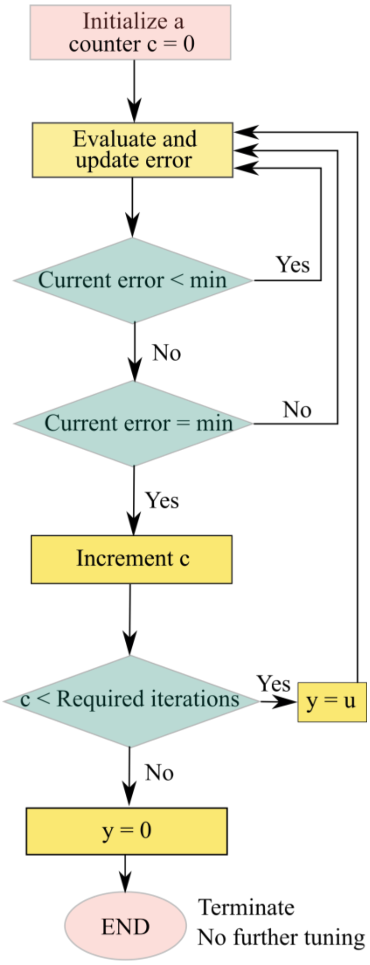

Fig. 13. Termination algorithm.

The value, for example, given to the system is 1, which is an error signal in regards to the PI controller, which will be the difference with the reference point we set for the controller. The difference value will be the missing figure to be filled by capacitor bank connections. The minimum error value will be stored in the algorithm variable "*y*" till the next minimum value appears. The next minimum value will replace the former one like 1 is the first minimum value we have and a value of 1.5 appears next, then the variable y will be fixed on the value of 1, till a value below 1 appears as shown in Fig. 13.

IV. Simulation

Starting with the transmission line we are using without a correction unit, alternators are used to generate power in power sectors. The extensive use of motors, alternators and generators results in a burden over the line and generating machines. The inductive current is produced by the motor causing a lag of current behind the voltage and that is how the PF drops. Let us view the value given below in Table I [13].

TABLE I

Power Transmission without PF Correction

Type of Load	Supply Voltage	Power Factor	Remarks
Inductive Load 3 phase	230 V	0.53 (lag)	Correction required

As we have analysed the whole power statement without the correction unit, there seems to be a need of plantation of a section that will be responsible for the improvement in PF in the line. For this reason, APFC unit is installed with induction motor or at the start of the consumer point by the consumer to receive the desired value for their use. This process is all dependent on the programming we have done before the controller. The PI controller is chosen for this purpose because it is a closed loop controller; therefore, it will give the fine output. The algorithm will be followed, which drags the received power to all the capacitor banks and matches the results with the reference value. The process will go on until the value matches and the program terminates. In the whole process, capacitor banks will play the lead role in compensating the lagging current with their leading ability. Although the capacitor is dynamic in nature, a continuous monitoring algorithm is followed up that connects and disconnects the capacitor banks simultaneously and we obtain the fine result.

The capacitors are connected via a switch and a reference block is set for each switch. This reference block is designed for the PI controller that matches the required percentage to compensate the load. Each reference point is checked by the controller if it is adding the minimum amount the switch closes and the capacitor connects as shown in Fig. 14. Otherwise, it will move to the next reference point. Let us take a value and calculate its results. With the set algorithm locked, we can see the value of PF that is fixed in the output as 0.7612. While removing this block will result in oscillation in output because of continuously on/off of capacitors. The value fixed in the reference is 0.75. The algorithmic block (fnc) will lock the reference point in its algorithm and will check the PF received from the grid. It will measure the difference between both as given in (7).

$$\text{Corrected PF or Fixed Ref Point} = \text{ref point} - \text{PF grid} \quad (7)$$

Setting the reference point to 0.75, we will monitor the response of PI controller. After settlement of the value, the difference can be seen with the receiving PF of 0.0249. The obtained difference will work as an error signal for the controller and it will decide the number of capacitors to be activated. The output response for a set PF reference of 0.75 is shown in Fig. 15.

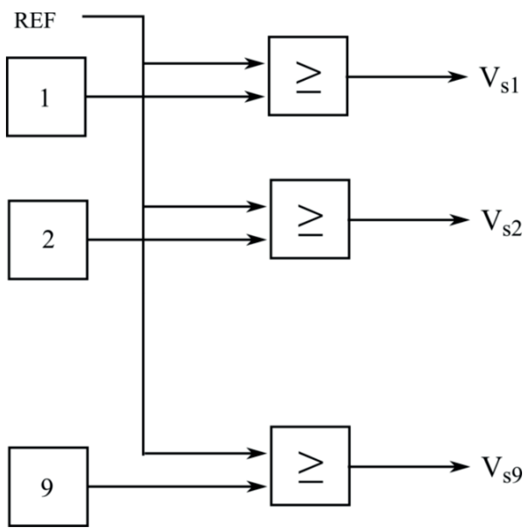

Fig. 14. Logic operation for operating the capacitor switches.

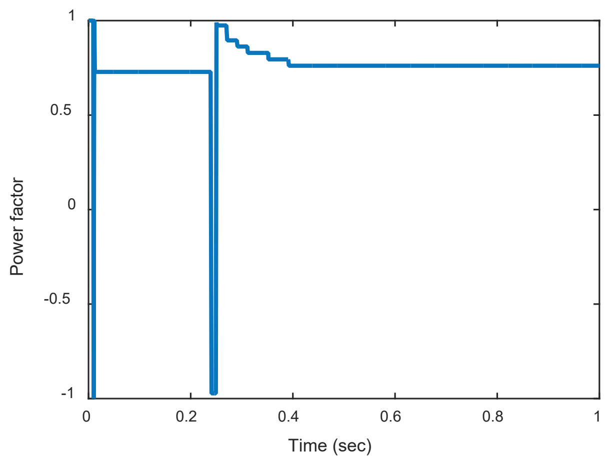

Fig. 15. Output scope result for reference point of 0.75.

Similary, at reference point 0.85, the control system will then come in contact with the control switches in the circuit attached with the capacitors. It will match every single capacitor value with the difference it gained as an input value when matching the desired capacitor numbers. PI controller will close that number of switches and the capacitors will be connected. However, at this time, the value is not a fixed number. The reason is because of the discrete nature of capacitor. Hence, the *fcn* block will fix the value as a minimum error case and the output value stops oscillation resulting in the connection of fixed number of capacitors. Figure 16 shows the tuning of PF at a reference value of 0.85.

The number of capacitors required for the compensation is 3. The process goes on like the ref value is compared to every single constant block 0→9. If the value is larger than 1, then the capacitor 1 will receive a value of 1, i.e., its connection is ON and if the difference is more than 1, it will compare the constant block 1 making its connection and check for the amount left. If the remaining value is less than 1, for example, 0.5, which is less than the constant block 2, it will perform the discrete function until the value is fixed in the algorithmic block. After that, a maximum number of capacitors are connected and the value will not oscillate. In this case the no. of capacitors is 3 because it is the required possible value needed to buck up the PF value.

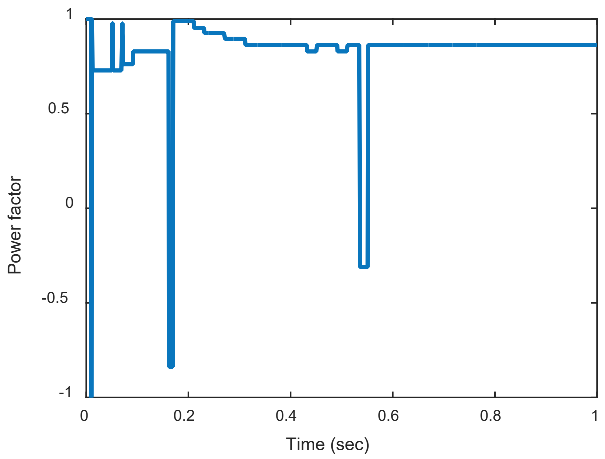

Fig. 16. Output scope result for reference point of 0.85.

Changing the ref value from 0.85 to 0.95, let us check the compensation of PF using algorithm. The same loop goes on starting from the difference between the two points: the PF we are receiving and the ref point we have set to achieve. The difference is 0.0128, which is less than 1. Let us see how the circuit will boost up the value to a PF fix up. The PI controller is receiving the error at an input terminal. It will pick up the reference point and will check the reference block connecting the minimum no. of capacitors to compensate the PF value. A reference block is also connected to each capacitor in parallel, which is responsible to check the value. If satisfied, then it will allow for the capacitor connection. The reference point is compared to every reference block in the circuit. The tuning of PF to 0.95 is shown in Fig. 17.

The ref value will be compared to every single constant block in the circuit following the algorithm. The logic operators are used with the screen that decides the signal should be either 0 or 1. If the value is greater than 1, the logic operator will have the status of 1 on the screen and move to the next constant block for comparison. In the case of 0.95, it can be clearly observed that more than one capacitor is connected because the reference point is compared to many and is fixed at the closure of 7 capacitors in parallel.

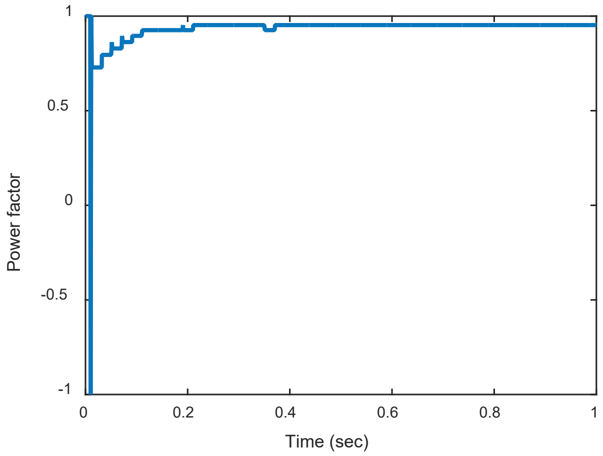

Fig. 17. Output scope result for reference point of 0.95.

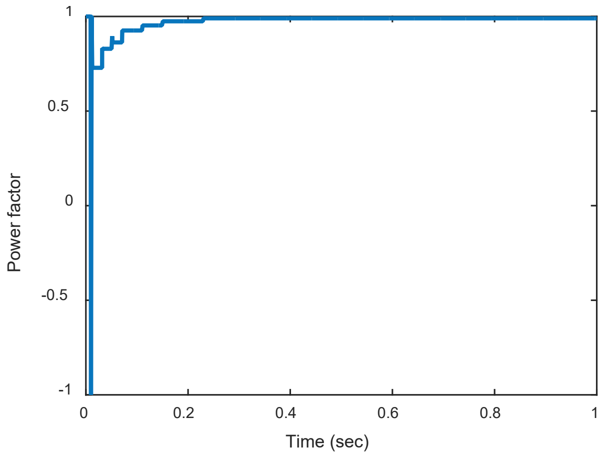

Fig. 18. Output scope result for reference point of 1.

Let us choose a reference point as 1 and check the output process. The difference between the PF received and the ref point is drained out as 0.002104. The reference value is given to the controller as an error signal and the comparison starts. The reference point is dragged to every door of constant block and is compared. The logic signal after comparison if it is satisfactorily generates a status signal 1. For example, moving with 1 as a reference, the constant block 1 will be checked. If the value is more than 1, the comparator will have the status of 1 on the screen and the signal will move to the next door until an error-free state 0 appears on the screen. It requires 9 kVAR to compensate the PF value; hence, 9 capacitors will connect in parallel to compensate the lagging of current by a leading effect as summarized in Table II. The overall response of the system is shown in Fig. 18.

The results show the improvement of PF in every step. The connection of capacitor 1 will give an increment in the reference unit but that would not be enough for the perfect status; therefore, according to the programmed algorithm, it will go again in the flow and match the value and connect another capacitor resulting the PF of 0.75, which is just ok. Again for the reference number of 0.95 we set on the controller, the program will move and connect another capacitor and achieve the perfect status of 0.95 and the program will terminate until another error signal enters the loop.

TABLE II

POWER FACTOR AFTER CORRECTION

Type of Load	Supply Voltage	Capacitor Banks	Power Factor	Remarks
Inductive Load 3 phase	230 V	0 kVAR	0.65	Correction required
		1 kVAR	0.75	Correction required
		3 kVAR	0.85	PF improved
		7 kVAR	0.95	PF improved

V. CALCULATION OF PF AFTER IMPROVEMENT

Noticing all the factors involved in the PF's up and down movements, let us make an assumption to calculate the margin we saved after implantation of this correction unit and what was the extra budget we faced before the correction unit. Let us assume the unit we used for a month be 36 868 units/month. The PF before correction is 0.70. Now, let us calculate the total amount we paid for one month plus penalty. For the PF of 70 %, we assume the penalty to be 0.5 % in amount. 0.5 % will be on the behalf of every 1 % fall from 95 % PF.

$$\text{Energy Cost} = 36\,868 \times 7.80 \text{ Rs} = 287\,570 \text{ Rs} \tag{8}$$

Whereas, penalty is 0.5% of every 1 fall by 95 %; therefore,

$$\text{Penalty} = 43\,135.56 \text{ Rs} \tag{9}$$

Calculation of the total amount one pays with the addition of penalty:

$$\text{Total amount} = \text{Energy Cost} + \text{Penalty}; \tag{10}$$

$$\text{Total amount} = 287\,570 + 4135.56 = 330\,705.56 \text{ Rs} \tag{11}$$

It can be seen with the addition of PF penalty in the billing amount, we have to pay a huge amount of penalty which we are not even aware of. Therefore, to pay for what we use, we need time that should be tackled. By observing these values, let us calculate the value of total amount after the installation of APFC unit near the load. We when use the APFC unit near the load, it boosts up the PF from 0.75 to 0.95 and further to 1.

$$\text{Total Charges} = \text{Energy Cost} + \text{Penatly} = 287\,570 \text{ Rs} \tag{12}$$

For the 0 % penalty as savage, let us check the amount we save after installation of APFC unit.

$$\text{Saving amount} = 330\,705.56 - 287\,570 = 43\,135.56 \text{ Rs} \tag{13}$$

Hence, the difference is clear before and after the use of correction unit. One can clearly assume that it is almost of 13 % of the monthly electric charges that we were paying for non-useable energy.

VI. Conclusion

We have designed and researched thoroughly over the power factor loss in transmission lines and its hazards in return, which cause the third party to suffer. We, in accordance with the situation, have analysed an APFC unit keeping in mind the extra surcharge one pays to the power sector for the unused energy. This unit will enable the organisations to pay for the units used by fixing the power factor close to the unity before reaching. The whole unit design and feasibility have been calculated in this research paper. All the components have been explained in detail with their advantages and their usage.

Improving the PF results in less current being drawn, thus causing less electricity costs, less heat and greater longevity of the electrical system and the installation, reducing the maximum demand tariff and power costs [16]. The proposed project and its prototype seem to be the fine solution. As we know, power is the main component of electrical energy and it should be dealt sensitively. Hence, for the accuracy in power transmission, there is a strong need of modification, which can be gained through the installation of APFC unit [17], [18].

The APFC unit will be helpful in future in the following aspects:

- The system designed will be favourable for high rating, i.e., overcoming the PF loss and boosting the transmission to a satisfactory level;
- The system will eradicate harmonic hurdles found in the network and leave a smooth path for power transmission;
- The system will put on a low rate of burden over the generating station, which will result in good health of generators and their efficient operation;
- The system will help reduce network losses;
- The system will reduce equipment overloading and stress on insulation;
- The system will reduce costs, unplanned outages and increase power availability.

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