Improving Power Factor in an Estate for a Minimized Power Cost Using Intelligent Synchronous Capacitor Band

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Abstract- The consistent monetary wastage observed in power consumption in some of our estates in the country is vehemently caused by its power factor not attaining the thresh hood of 0.98 through 1 that is anchored by electrical loads that cause high current drawn from power supply. This is wittingly subdued by introducing improving power factor in an estate for a minimized power cost using intelligent synchronous capacitor band. This is done in the following procedure, characterizing estate power consumption, designing a synchronous rule base that will improve power factor, minimize cost of power consumed in an estate, training ANN in a designed synchronous rule base that will improve power factor, minimize cost of power consumed. in an estate, determining the capacitor size suitable to stabilize power factor, designing a synchronous SIMULINK model, developing an algorithm that will implement the entire process, designing a SIMULINK model for improving power factor in an estate for a minimized power cost using intelligent synchronous capacitor band and validating and justifying the percentage improvement in the power factor and minimizing power cost in the estate with and without using intelligent synchronous capacitor band. The results obtained are, The results obtained are the conventional low power factor of the electrical load that cause high current is drawn from power supply in building 1 of the estate is 0.61712 PF which cause the cost of power consumed in building 1 of the estate to be expensive. On the other hand, when an intelligent synchronous capacitor band is incorporated in the system the power factor becomes 0.9195 PF thereby reducing the cost of power consumed in building 1 of the estate, the conventional cost of power consumed in building 1 of the estate is ₦ 4500, while when an intelligent synchronous capacitor band is imbibed in the system, its cost of power consumption drastically reduced to ₦.3687 and the conventional power factor of building 4 in the estate is 0.5602 PF. On the other hand, when an intelligent synchronous capacitor band is incorporated in the system it met the thresh hood of 0.8347 PF. Finally, the conventional cost of power consumed by building 4 in the estate is ₦5100 while when an intelligent synchronous capacitor band is incorporated in the system, the cost of power consumed by building 4 in the estate reduced to ₦4178. The percentage improvement in the in the reduction of cost of power consumed in building 4 in the estate is 18.07%.

Indexed Terms- Improving, Power Factor, Estate, Minimized, Power, Cost, Intelligent, Synchronous, Capacitor, Band

I. INTRODUCTION

An increase in the cost of power consumed in an estate is as a result of low power factor that could not attain the thresh hood of 0.67 through 0.99 (Osama,2011). It is generally accepted that the lower the power factor the higher the current drawn inside the circuit that raises the cost of power consumed in the estate (Gagar, 2011).

II. METHODOLOGY

To characterize an estate power consumption

Table 1characterized data of an estate power consumption

Buildings	P(KW)	APPERANT	Power	% of high	Cost of

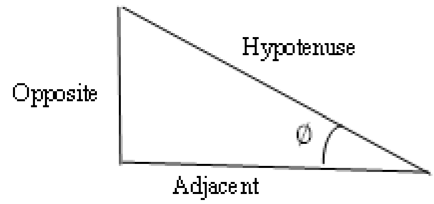
		POWER(KVA)	factor	current drawn from power supply	power used (₦)
1	52.426	84.95215	0.61712	40	4500
2	52.426	86.43746	0.6065	38	4000
3	52.426	53.97786	0.97125	35	2300
4	52.426	93.57628	0.5602	35	5100
5	52.426	53.23247	0.98485	32	2400
6	52.426	88.94860	0.5893	20	5000
7	52.426	87.72548	0.5976	21	5200
8	52.426	52.56372	0.99738	22	3100
9	52.426	52.46377	0.99928	18	2100
10	52.426	52.42652	0.99999	13	2550
11	52.426	52.42652	0.99999	13	2550

It is an axiomatic that an ideal power factor fall within the thresh hood of 0.67 through 0.99

The buildings that their power factors could not meet The power factors are calculated by with the following formulae

Inductive reactance = $X_L = \omega L = 2\pi rfl$

Capacitive reactance $X_c = \frac{1}{\omega_c} = \frac{1}{2\pi rfc}$



Where,

Hypotenuse = Apparent power

Adjacent = real power

$$\text{Power factor } \cos\emptyset = \frac{Adjacent}{Hypotenuse}$$

To find power factor for building 1

$$\text{Power factor } \cos\emptyset = \frac{52.426}{84.95215} = 0.61712$$

To find power factor for building 2

$$\text{Power factor } \cos\emptyset = \frac{52.426}{86.43746} = 0.6065$$

To find power factor for building 3

$$\text{Power factor } \cos\emptyset = \frac{52.426}{53.97786} = 0.97125$$

To find power factor for building 4

$$\text{Power factor } \cos\emptyset = \frac{52.426}{93.57628} = 0.5602$$

To find power factor for building 5

$$\text{Power factor } \cos\emptyset = \frac{52.426}{53.23247} = 0.98485$$

To find power factor for building 6

$$\text{Power factor } \cos\emptyset = \frac{52.426}{88.94860} = 0.5893$$

To find power factor for building 7

$$\text{Power factor } \cos\emptyset = \frac{52.426}{87.72548} = 0.5976$$

The buildings in the estate that could not attain the thresh hood of 0.67 through 0.99 are 1, 2, 4, 6 and 7

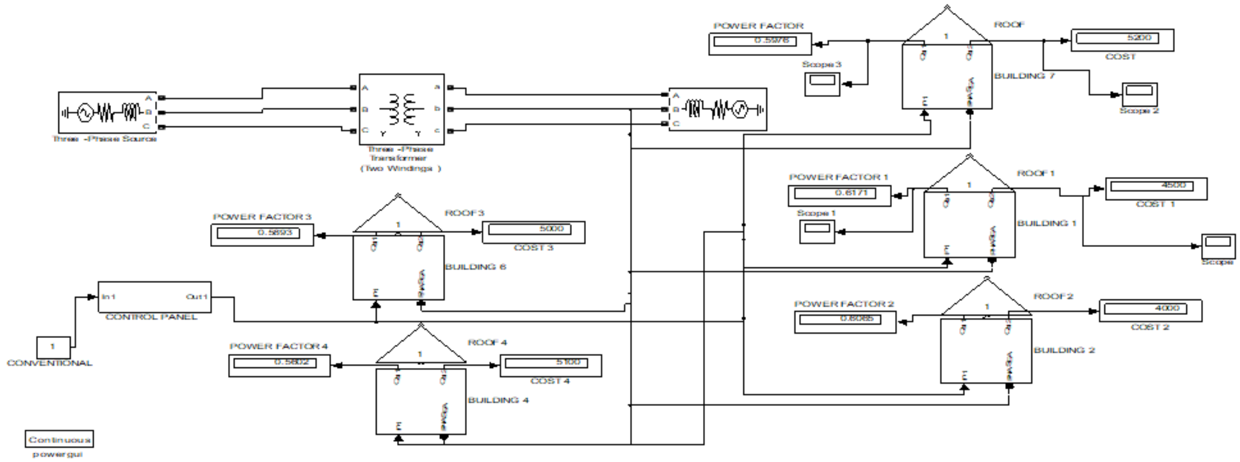


Fig 1 Conventional SIMULINK model for improving power factor in an estate for a minimized power cost

To design a synchronous rule base that will improve power factor and minimize cost of power consumed in an estate

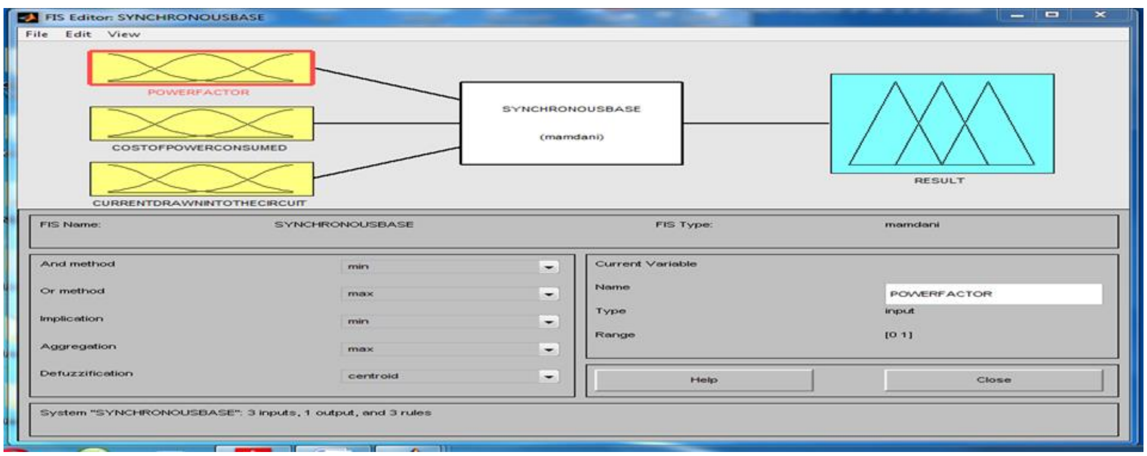


Fig 2 designed synchronous Fuzzy inference system (FIS) that will improve power factor and minimize cost of power consumed in an estate

Fig 2 it has three inputs of power factor, cost of power consumed in the estate, current drawn to the circuit used in the estate.

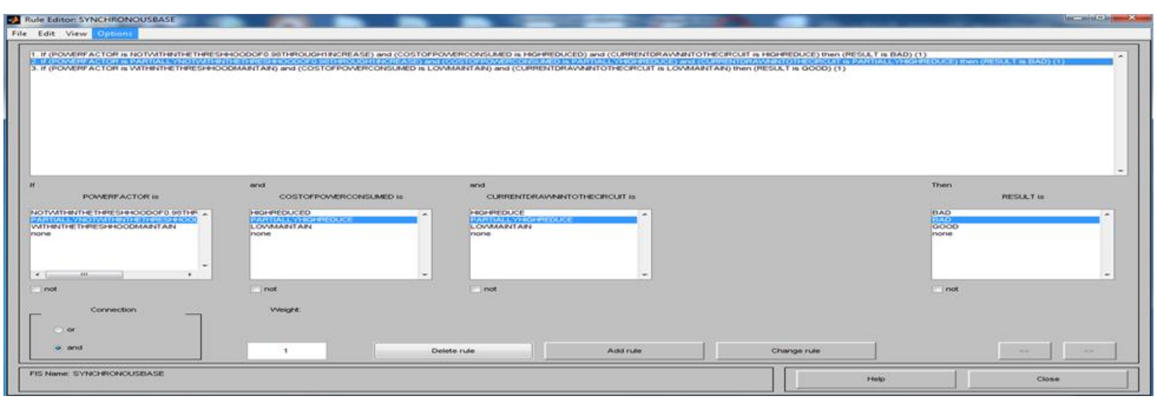


Fig 3 designed synchronous rule base that will improve power factor and minimize cost of power consumed in an estate

The comprehensive detail of the rules is as shown in table 2

Table 2 comprehensive detail of synchronous rule base that will improve power factor and minimize cost of power consumed in an estate

If power factor is not within the thresh hood of 0.67 through 0.99 increase	And cost of power consumed is high reduce	And current drawn from the circuit is high reduce	Then result is bad
If power factor is partially not within the thresh hood of 0.67 through 0.99 increase	And cost of power consumed is partially high reduce	And current drawn from the circuit is partially high reduce	Then result is bad
If power factor is within the thresh hood maintain	And cost of power consumed is low maintain	And current drawn from the circuit is low maintain	Then result is good

To train ANN in a designed synchronous rule base that will improve power factor, minimize cost of power consumed. in an estate

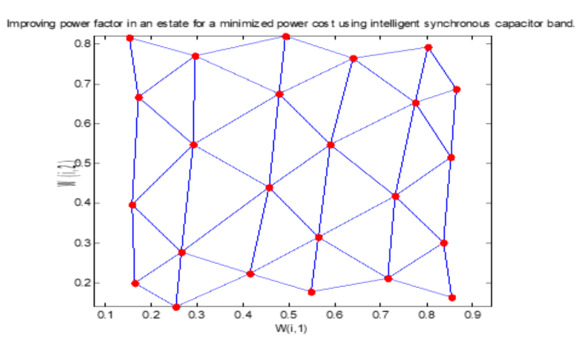


Fig 4 trained ANN in a designed synchronous rule base that will improve power factor, minimize cost of power consumed in an estate

The three rules were train ten times 3 x 10 = 30 to give thirty neurons that looks like a human brain. This training makes it to effectively make the power factor to attain thresh hood of 0.67 through 0.99.it equally minimizes the cost of power consume in the estate. The result obtained during the training is as shown in figure 5.

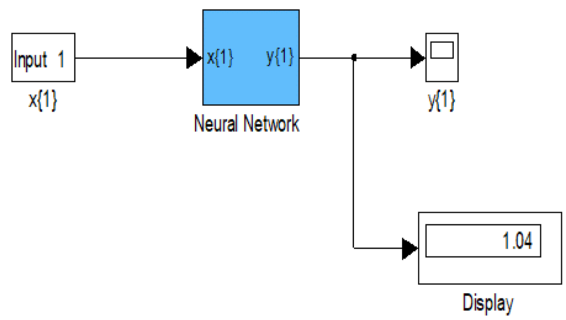


Fig 5 result obtained during the training.

This result will be integrated in the synchronous SIMULINK model to boost the efficacy of making the buildings in the estate to reach the thresh hood of 0.67 through 0.99

To determine the capacitor size suitable to stabilize power factor
Ultra capacitor sizing procedure

Original P.F = $\cos\theta_1 = 0.75$
Final P.F = $\cos\theta_2 = 0.90$
$\theta_1 = \cos^{-1} = (0.75) = 41°.41$; $\tan\theta_1 = \tan(41°.41) = 0.8819$
$\theta_2 = \cos^{-1} = (0.90) = 25°.84$; $\tan\theta_2 = \tan(25°.50) = 0.4843$
Required Capacitor kVAR to improve P.F from 0.75 to 0.90
Required Capacitor kVAR = P ($\tan\theta_1 - \tan\theta_2$)
= 52.426 (0.8819 – 0.4843)
= 52.426 x 0.3976
= 20.845 kVAR
And Rating of Capacitors connected in each Phase
20.845 kVAR / 3 = 6.948 kVAR
The ideal sizing capacitor that will stabilize power factor is 20.845 kVAR

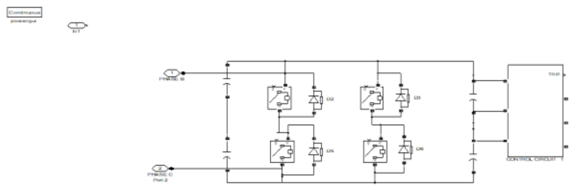


Fig 6 designed synchronous SIMULINK model

To develop an algorithm that will implement the process

1. Characterize estate power consumption.
2. Identify the buildings in the estate that their power factors could not attain the thresh hood of 0.67 through 0.99.
3. Design a conventional SIMULINK and integrate 1 and 2.
4. Design a synchronous rule base that will improve power factor, minimize cost of power consumed in an estate.
5. Train ANN in a designed synchronous rule base that will improve power factor, minimize cost of power consumed. in an estate
6. determine the capacitor size suitable to stabilize power factor
7. Design a synchronous SIMULINK model
8. Integrate 4, 5 and 6 and 7
9. Integrate 8 in 3
10. Does power factor improve and cost of power consumed in the estate reduce when 8 is integrated in 3?
11. If No go to 9
12. If yes go to 13.
13. Improved power factor and minimized power cost in an estate.
14. Stop.
15. End.

To design SIMULINK model for improving power factor in an estate for a minimized power cost using intelligent synchronous capacitor band

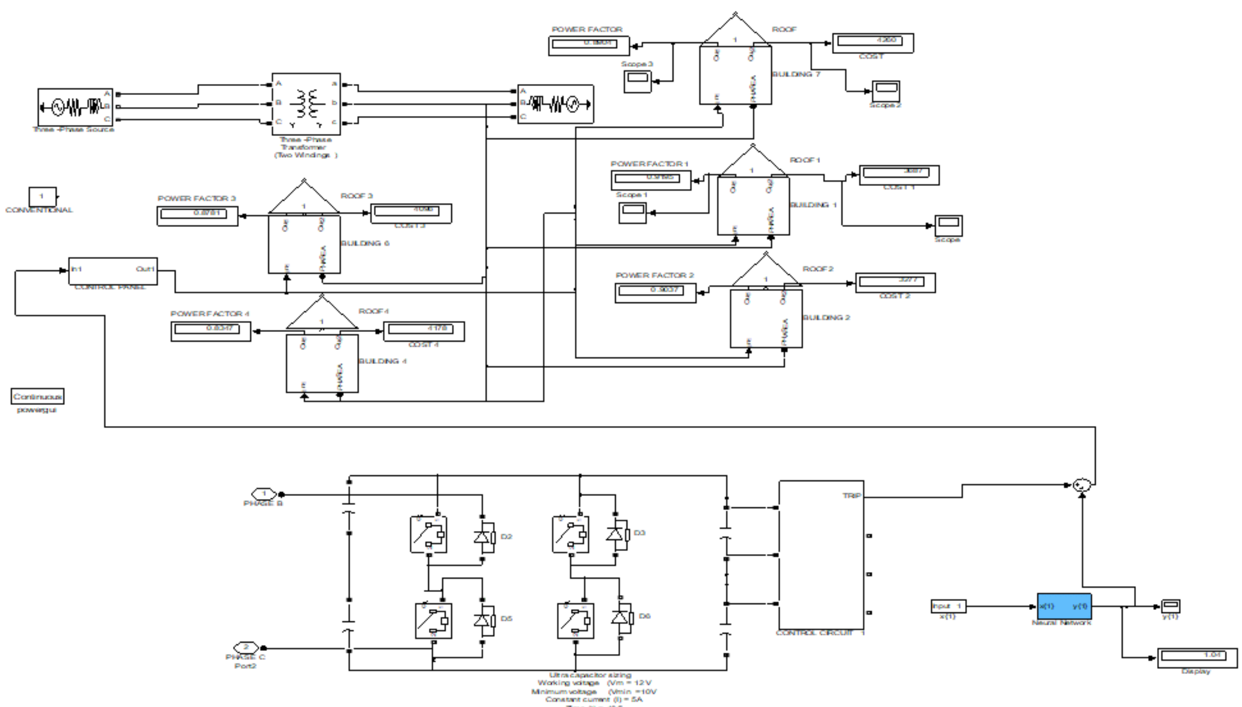


Fig 7 designed SIMULINK model for improving power factor in an estate for a minimized power cost using intelligent synchronous capacitor band.

III. DISCUSSION OF RESULT

The results obtained are as shown in figs 8 through 11

Table 3 comparison of conventional and intelligent synchronous capacitor band. Power factor of building 1 in improving power factor in an estate for a minimized power cost

Time (Months)	Conventional power factor of building 1 in improving power factor in an estate for a minimized power cost(PF)	Intelligent synchronous capacitor band. power factor of building 1 in improving power factor in an estate for a minimized power cost (PF)
1	0.61712	0.9195
2	0.61712	0.9195
3	0.61712	0.9195
4	0.61712	0.9195
10	0.61712	0.9195

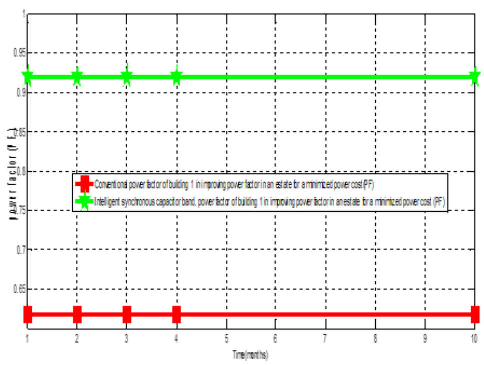


Fig 8 comparison of conventional and intelligent synchronous capacitor band. power factor of building 1 in improving power factor in an estate for a minimized power cost

The conventional low power factor of the electrical load that cause high current is drawn from power supply in building 1 of the estate is 0.61712PF which cause the cost of power consumed in building 1 of the estate to be expensive. On the other hand, when an intelligent synchronous capacitor band is incorporated in the system the power factor becomes0.9195 PF thereby reducing the cost of power consumed in building 1 of the estate.

Table 4 comparison of conventional and intelligent synchronous capacitor band Cost of power used in building 1 in improving power factor in an estate for a minimized power cost

Time (Months)	Conventional Cost of power used in building 1 in improving power factor in an estate for a minimized power cost(₦)	Intelligent synchronous capacitor band Cost of power used in building 1 in improving power factor in an estate for a minimized power cost (₦)
1	4500	3687
2	4500	3687
3	4500	3687
4	4500	3687
10	4500	3687

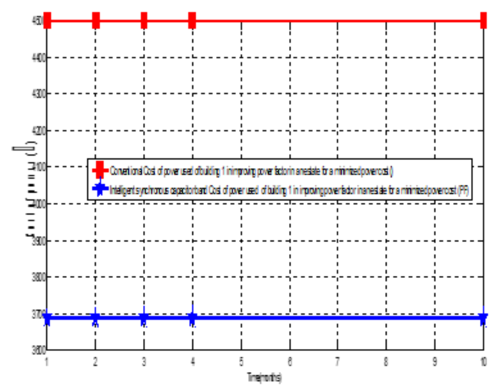


Fig 9 comparison of conventional and intelligent synchronous capacitor band Cost of power used in building 1 in improving power factor in an estate for a minimized power cost

In Fig 9 the conventional cost of power consumed in building 1 of the estate is ₦ 4500while when an intelligent synchronous capacitor band is imbibed in the system, its cost of power consumption drastically reduced to ₦.3687

Table 5 comparison of conventional and intelligent synchronous capacitor band. power factor of building 4 in improving power factor in an estate for a minimized power cost

Time (Months)	Conventional power factor of building 4 in improving	Intelligent synchronous capacitor band. power factor of

	power factor in an estate for a minimized power cost(PF)	building 4 in improving power factor in an estate for a minimized power cost (PF)
1	0.5602	0.8347
2	0.5602	0.8347
3	0.5602	0.8347
4	0.5602	0.8347
10	0.5602	0.8347

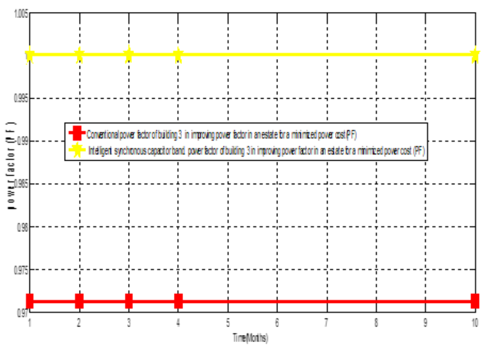


Fig 10 comparison of conventional and intelligent synchronous capacitor band. power factor of building 4 in improving power factor in an estate for a minimized power cost

The conventional power factor of building 4 in the estate is 0.5602PF. On the other hand, when an and intelligent synchronous capacitor band is incorporated in the system it met the thresh hood of 0.8347PF.

Table 6 comparison of conventional and intelligent synchronous capacitor band Cost of power used in building 4 in improving power factor in an estate for a minimized power cost

Time (Months)	Conventional Cost of power used in building 4 in improving power factor in an estate for a minimized power cost(₦)	Intelligent synchronous capacitor band Cost of power used in building 4 in improving power factor in an estate for a minimized power cost (₦)
1	5100	4178
2	5100	4178
3	5100	4178
4	5100	4178
10	5100	4178

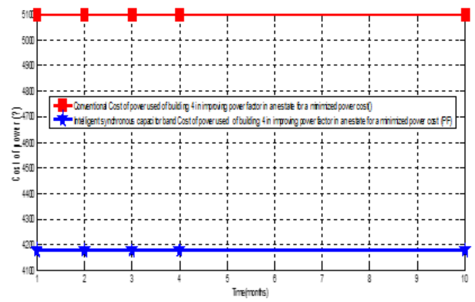


Fig 11 comparison of conventional and intelligent synchronous capacitor band Cost of power used in building 4 in improving power factor in an estate for a minimized power cost

Meanwhile, the conventional cost of power consumed by building 4 in the estate is ₦5100 while when an intelligent synchronous capacitor band is incorporated in the system, the cost of power consumed by building 4 in the estate reduced to ₦4178. The percentage improvement in the in the reduction of cost of power consumed in building 4 in the estate is 18.07%.

CONCLUSION

The cost of power consumed in the estate arises as a result of power factor of electrical loads that caused high current drawn from power supply. This is surmounted by introducing improving power factor in an estate for a minimized power cost using intelligent synchronous capacitor band. This is done in the following procedure, characterizing estate power consumption, designing a synchronous rule base that will improve power factor, minimize cost of power consumed in an estate, training ANN in a designed synchronous rule base that will improve power factor, minimize cost of power consumed. in an estate, determining the capacitor size suitable to stabilize power factor, designing a synchronous SIMULINK model, developing an algorithm that will implement the process, designing a SIMULINK model for improving power factor in an estate for a minimized power cost using intelligent synchronous capacitor band and validating and justifying the percentage improvement in improving power factor and minimizing power cost in estate with and without using intelligent synchronous capacitor band. The results obtained are the conventional low power factor of the electrical load that cause high current is drawn from power supply in building 1 of the estate is 0.61712PF which cause the cost of power consumed in building 1 of the estate to be expensive. On the other hand, when an intelligent synchronous capacitor band is incorporated in the system the power factor becomes0.9195 PF thereby reducing the cost of power consumed in building 1 of the estate, the conventional cost of power consumed in building 1 of the estate is ₦ 4500while when an intelligent synchronous capacitor band is imbibed in the system, its cost of power consumption drastically reduced to ₦.3687 and the conventional power factor of building 4 in the estate is 0.5602PF. On the other hand, when an and intelligent synchronous capacitor band is incorporated in the system it met the thresh hood of 0.8347PF.Finally, the conventional cost of power consumed by building 4 in the estate is ₦5100 while when an intelligent synchronous capacitor band is incorporated in the system, the cost of power consumed by building 4 in the estate reduced to ₦4178. The percentage improvement in the in the reduction of cost of power consumed in building 4 in the estate is 18.07%.

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