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Exploiting the Moth–Flame Optimization Algorithm for Optimal Load Management of the University Campus: A Viable Approach in the Academia Sector

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Abstract: Unbalanced load condition is one of the major issues of all commercial, industrial and residential sectors. Unbalanced load means that, when different loads are distributed on a three-phase four-wire system, unequal currents pass through the three phases. Due to it, a heavy current flows in the neutral wire, which not only adds the losses, but also puts constraints on three phases' loads. In this paper, we have presented a practical approach for load balancing. First, we have considered the existing three-phase load system where the supply is a three-phase unbalanced supply. Before balancing the load, it is necessary to compensate the current in neutral wire. A nature-inspired moth–flame optimization (MFO) algorithm is used to propose a scheme for balancing of current in neutral wire. The information of a distributed single-phase load was used to balance the currents in a three-phase system. The feeder phase and load profiles of each single-phase load are used to reconfigure the network using an optimization process. By balancing the current of three phases, the current of the neutral conductor in substation transformers was reduced to almost zero.

Keywords: load balancing; moth–flame optimization (MFO) algorithm; neutral current reduction; optimization algorithms; practical approach of optimization

1. Introduction and Background

A very important concept of load compensation is load balancing. It is desirable to operate the three-phase system under balanced conditions because unbalanced operations result in the flow of a negative sequence current in the system and is highly dangerous, especially for rotating machines. An ideal load compensator would perform the function of providing controllable and variable reactive power almost instantaneously as required by the load. It should operate independently in all three phases. It should maintain a constant voltage at its terminal as we know that, when the amperage is split up equally, the current in neutral wire is canceled out. However, when the current is placed all on one leg, the neutral must carry the entire load. If the load is balanced, there will be no current flowing in the neutral. For that reason, a neutral wire is sometimes not connected to a balanced three-phase load. However, the unbalanced load will cause the current in neutral wire to flow. Now, if a neutral is connected, due to I^2R losses, voltage drop will occur in a neutral which is undesirable, and this will decrease voltage regulation. A four-wire system with symmetrical voltages between the phase and neutral is obtained when the neutral is connected to the "common star point" of all supply winding. In such a system, all three phases will have the same magnitude of voltage relative to the other neutral non-symmetrical systems that have been used.

In the past few decades, a lot of work has been carried out on load balancing and energy optimization. Different algorithms have been developed and deployed successfully for this purpose. In [1], authors have reconfigured the distribution network at both LTV and MTV levels with adaptation of the neural network (NN) and applied a heuristic technique (HT) for the balancing of three phases and to reduce the losses. In addition, a comparison of the NN and HT is done along with the combination of both techniques and switching mechanism. In [2–4], the authors have discussed the impacts of the unbalanced load. They have proposed new indexes compared to the old standard unbalanced standards, with the application of a discrete genetic algorithm (DGA) in a four-wire multi-grounded distribution system. In [5,6], the authors have proposed a model for minimization of the cumulative cost and improvement of the voltage profile. They have optimized re-phasing, re-configuration, and DG placement for achieving their objectives. Carvalho et al. [7,8] proposed a model for minimization of network losses. The authors examined the changes of the variations in load due to an unbalanced condition. In [9,10], the authors have proposed a model for efficient demand side management by categorizing the unbalanced load as systematic and random. In [11–13], the authors have presented a practical balancing approach for the reduction of active power losses using GA for 24 time-slots. In [14], the authors have presented an integrated method for the solution of problems like "user phase identification based on spectral clustering and three-phase unbalance mitigation using Mixed Integer Linear Programming (MILP) model". They have considered a few real scenarios for verification of their algorithm. In [15], the authors have proposed a phase balancing scheme (PBS), with the use of plug-in electric vehicles (PEV). They have used the financial incentive approach for PEV owners to charge their vehicle batteries in such a manner as to balance the three-phase distribution network using a game theoretical mechanism. They have also improved the quality of power and reliability of the power system. In [16–18], the authors have balanced the phases, for cost reduction in electric power grids in case of uncertainty with an energy storage mechanism. They have proposed distributed and centralized real-time algorithms. Similarly, if the energy provider provides an incentive to its customers in the form of real-time low prices during non-peak hours, this would be extremely beneficial and the end-users or consumers will eagerly try to balance their three-phase loads without putting a burden on the utility in terms of Max energy demands and various other types of compensation. The paper is structured as follows. Section 1 is comprised of an introduction to the current research project, related work, and existing work or literature survey. Problem Statement, Objectives of our work, and the approach of our work are being stated in Section 2. In a very brief way, Section 3 formulates the problem in a very systematical way and explained each point and block of the system in an attractive way by discussing briefly the model architecture and the portraying of real-time data and information. Section 4 explains the proposed MFO algorithm for newbies and researchers very briefly. Section 5 contains a description of our proposed system's model, whereas Section 6 compares the results for the existing and proposed systems and explains it in a very attractive way. Section 7 presents the conclusions, various research directions, and future plans.

2. Problem Statement, Objectives, and Methodology

2.1. Problem Statement

When there is unbalanced load in a three-phase four-wire system, high current flows through the neutral line of a transformer which produces heat in the core of the transformer. This is not only dangerous but undesirable, as it can cause damage to appliances. With an unbalanced load system, the following effects occur:

1. Unbalanced Line currents causing overheating of cables;

2. Circulating currents will flow in the network;
3. Damaging the proper protection and operation of protecting devices such as circuit breakers.

2.2. Objectives

The objectives of our work are as follows:

1. To efficiently utilize our resources by balancing so the maximum load can be used;
2. To reduce the blackout (i.e., load shedding on the campus);
3. To reduce the current in neutral wire.

2.3. Methodology

We have followed the following methodology to carry out our work and achieve our goals.

First, we have analyzed different network units and their appliances. Then, we have sketched existing units on the campus and electrical appliances in these units using Auto-CAD 2006 software. We then calculated the existing connected load in each unit on the campus for both the generator line and utility line. Then, we carry out the calculation of running load and made separate morning and evening schedules. We have made sketches of the existing wiring system on our campus. Based on facts and observations, we proposed a model of the balanced load on the campus. At the end, we gave the estimated cost for the implementation of the proposed balance model on the university campus.

3. Problem Formulation

3.1. Sketches of Existing Load Units and Their Respective Connected Loads

In this section, after analyzing, we made rough sketches of all load units on the campus. Then, we made those sketches in Auto-CAD. In these sketches, we showed the existing load in the form of energy saver bulbs, ceiling fans, geysers, air-conditioners, and air-coolers.

3.1.1. Sketch of the Academic Block

On the university campus, we have one academic block as shown in Figure 1. Different load units have been used with their respective symbols for ceiling fans, lights, and wall fans. All three phases are shown with three colours connecting different load units. At the bottom, the classes start from numbering 1 to 8 from left-to-right. On the right side, we have the administration block, the load of which is shown in Figure 1. The academic block also includes the main hall and four computer labs. However, on the left side of the sketch, we have the workshop, the control system lab, the environmental lab, the highway lab, the library, and one cafeteria for students. Table 1 depicts the unbalanced (existing) load data of different appliances in the academic block on the three-phase four wire system.

3.1.2. Sketch of the Allama Iqbal Hostel

Figure 2 depicts different appliances connected on the existing three-phase four wire system using different symbols for ceiling fans and energy saver lights in the Allama Iqbal Hostel. In this hostel, we have twenty-one (21) rooms, one girls hostel, and a few electrical engineering labs, having four fans and four energy saving lights. On the upper portion, there are rooms numbering 22 to 27 and also a staff hostel having three rooms and load as you can be seen in Figure 2. Table 2 depicts the existing unbalanced load units of the said hostel.

3.1.3. Sketch of the Rahman Baba Hostel

Figure 3 depicts the sketch of the Rahman Baba hostel, in which one Rahman Baba mess, one warden lodge, and the remaining twenty-four (24) rooms have almost the same load as can be seen in the sketch. Some rooms have two energy saver lights, while, in the mess, we have eight (8) fans and four (4) energy saver lights, and, in the warden lounge, we have two fans and one light, as shown in Figure 3. Table 3 gives the existing load data of three phases of the said hostel.

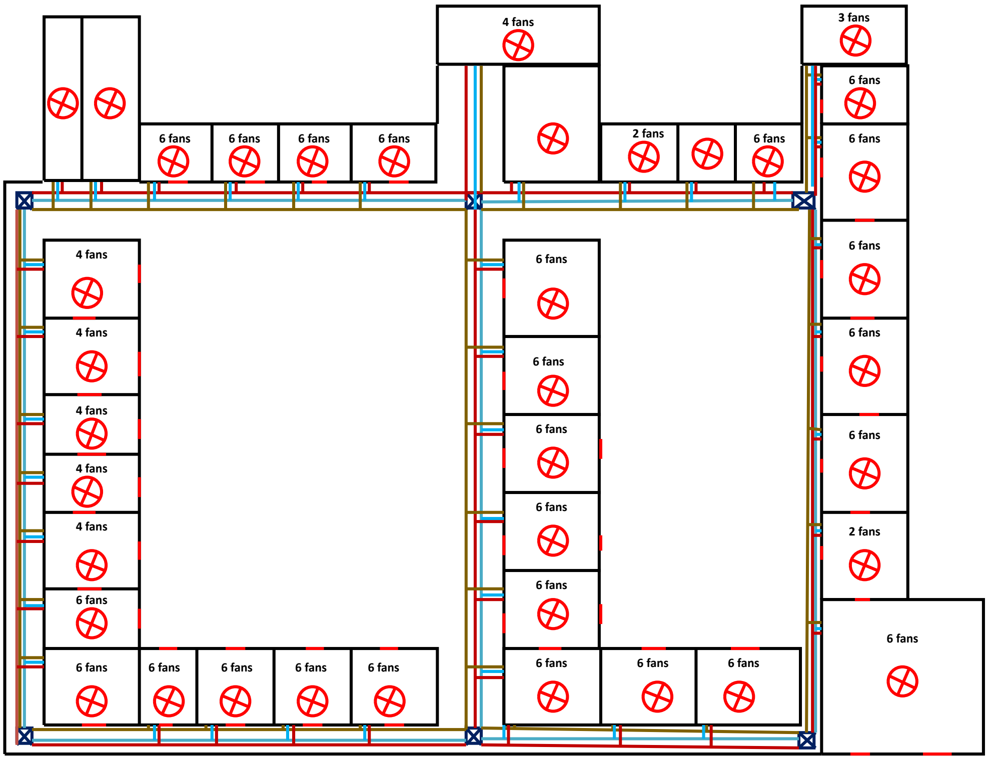

Figure 1. Sketch of the academic block.

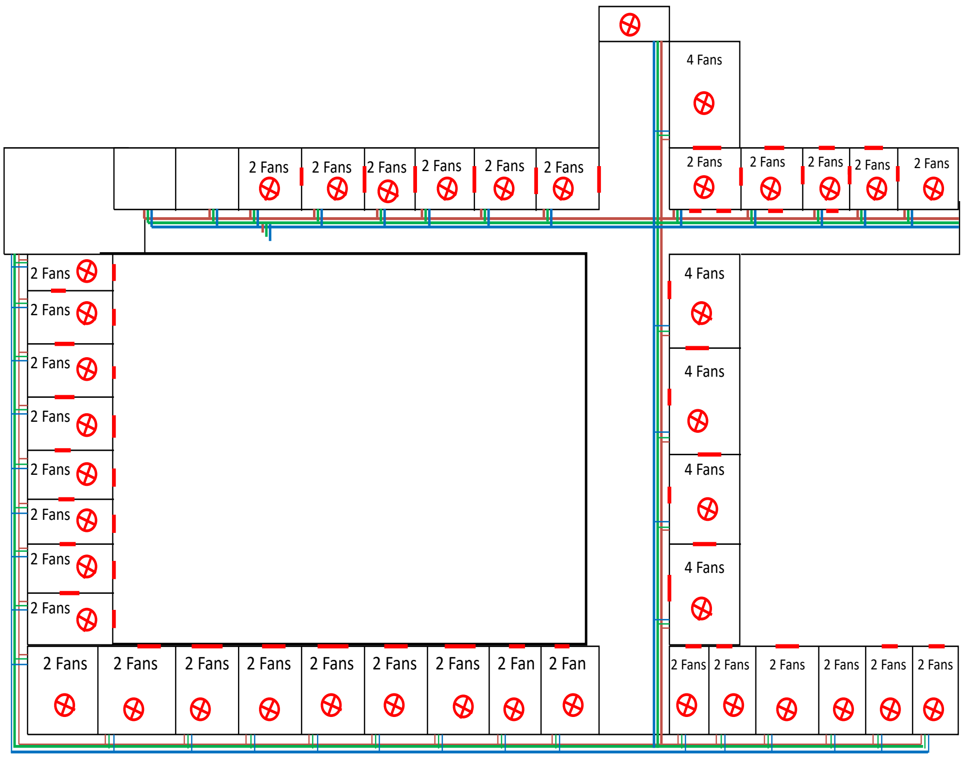

Figure 2. Sketch of the Allama Iqbal Hostel.

Table 1. Academic-block existing load data.

Class Room	Fans	Energy Savers	Tube Light	Fan Small	Extras	Fans Rating (A)	E. Saver (A)	T.L Rating (A)	Fans Rating (A)	Extras (A)	Single Room T. Load (A)
1	6		7		1	2.608695652	0	1.52173913	0	0.163043478	4.293478261
2	6		8		1	2.608695652	0	1.73913043	0	0.163043478	4.293478261
3	6		8		1	2.608695652	0	1.73913043	0	0.163043478	4.293478261
4	6		8		1	2.608695652	0	1.73913043	0	0.163043478	4.293478261
5	6		7		1	2.608695652	0	1.73913043	0	0.163043478	4.293478261
6	6		8		1	2.608695652	0	1.73913043	0	0.163043478	4.293478261
7	6		8		1	2.608695652	0	1.73913043	0	0.163043478	4.293478261
8	6		8		1	2.608695652	0	1.73913043	0	0.163043478	4.293478261
lab.1		4	2	5	1	0	0.434782609	0.43478261	1.630434783	0.163043478	2.663043478
lab.2		8	4	7	1	0	0.869565217	0.869569522	2.282608696	0.163043478	4.184782608
faculty office	5	2	2			2.608695652	0.217391304	0.434778261	0	0	2.663043478
R & D lab		5		6	3	0	0.543478261	0	1.956521739	0.489130435	2.663043478
lab.3		4		6	1	0	0.434782609	0	1.956521739	0.163043478	2.663043478
lab.4		4		6	1	0	0.434782609	0	1.956521739	0.163043478	2.663043478
confrence		2		2		0	0.217391304	0	0.652173913	0	0.869565217
Account sec.	4	9	1	1		1.739130435	0.97826087	0.2173913	0.326086958	0	3.260869565
Main Hall			17	24		0	0	3.69565217	7.826086957	0	11.52173913
office	1	2			1	0.434782609	0.217391304	0	0	0	0.652173913
Chairman CED	1	1	10	3	1	0.434782609	0.108695652	2.17391304	0.97826087	0.163043478	3.858695652
Coordinator		11		4		0	1.195652174	0	1.304347826	0	2.5
Chairman EED		4	2	4	1	0	0.434782609	0.43478261	1.304347826	0.163043478	2.336956522
Sem. Coordinator			2	2		0	0	0.43478261	0.652173913	0	1.086956522
BSI	4		2			1.739130435	0	0.43478261	0	0	2.173913043
ADS	2		6			0.869565217	0	1.30434783	0	0	2.173913043
Library		37	3	13	1	0	4.0.2173913	0.65217391	4.239130435	0.163043478	9.076086957
Matrial Lab	4	4	2			1.739130435	0.434782609	0.43478261	0	0	2.608695652
Exam Section	2	2				0.869565217	217391304	0	0	0	1.086956522
Servey lab	1	3				0.434782609	0.326086957	0	0	0	0.760869565
Lavatory	1					0.434782609	0	0	0	0	0.434782609
Hydrulaic Lab	3	2			1	1.304347826	0.217391304	0	0	0.163043478	1.684782609
Envir. Lab	3	4			1	1.304347826	0.434782609	0	0	0.163043478	1.902173913
Concrete Lab	6	6			1	2.608695652	0.652173913	0	0	0.163043478	3.423913043
Highway lab	2	4	1		1	0.869565217	0.434782609	0.2173913	0	0.163043478	1.684782609
Workshop lab	5	3			1	2.173913043	0.326086957	0	0	0.163043478	2.663043478
Control sys lab	6	6			1	2.608695652	652173913	0	0	0.163043478	3.423913043
Small room	2	2				0.869565217	0.217391304	0	0	0	1.086956522
Canteen	6	10				2.608695652	1.086956522	0	0	0	3.69562174

Table 1. *Cont.*

Class Room	Fans	Energy Savers	Tube Light	Fan Small	Extras	Fans Rating (A)	E. Saver (A)	T.L Rating (A)	Fans Rating (A)	Extras (A)	Single Room T. Load (A)
Bathroom		1	1			0	0.108695652	0.2173913	0	0	0.326086957
farooq room	2	2				0.869565217	0.217391304	0	0	0	1.086956522
Small room	2	2				0.869565217	0.217391304	0	0	0	1.086956522
Common. Lab	4	3	4		1	1.739130435	0.326086957	0.86956522	0	0.163043478	3.097822609
DLD lab	4	4				1.739130435	0.434782609	0	0	0	2.173913043
Machine Lab	4	4			1	1.739130435	0.434782609	0	0	0.163043478	2.336956522
ElectronicS Lab	4	7			2	1.739130435	0.760869565	0	0	0.326086957	2.826086957
GRAND TOTAL							17.60869565				130.326087

Table 2. Allama Iqbal Hostel existing load data.

Room No. 01	Fans	Energy Saver	Tube Light	Geyser	E. Saver Rating (A)	Fans Rating (A)	Tube Light Rating (A)	Gyser Rating (A)	Load in Single Room (A)
1	1	4			0.43478	0.43478	0	0	0.86597
2	1	2			0.21739	0.43478	0	0	0.86597
3	1	2			0.21739	0.43478	0	0	0.86597
4	1	2			0.21739	0.43478	0	0	0.86597
5	1	1			0.1087	0.43478	0	0	0.86597
6	1	2			0.21739	0.43478	0	0	0.86597
7	1	2			0.21739	0.43478	0	0	0.86597
8	1	3			0.32609	0.43478	0	0	0.86597
9	1	1			0.1087	0.43478	0	0	0.86597
10	1	2			0.21739	0.43478	0	0	0.86597
11	1	2			0.21739	0.43478	0	0	0.86597
12	1	1	1		0.1087	0.43478	0.21739	0	0.86597
13	1	3			0.32609	0.43478	0	0	0.86597
14	1	1			0.1087	0.43478	0	0	0.86597
15	1	2			0.21739	0.43478	0	0	0.86597
16	1	2			0.21739	0.43478	0	0	0.86597
17	1	2			0.21739	0.43478	0	0	0.86597
18	1	1			0.1087	0.43478	0	0	0.86597
19	1	2			0.21739	0.43478	0	0	0.86597
20	1	1			0.1087	0.43478	0	0	0.86597

Table 2. *Cont.*

Room No. 01	Fans	Energy Saver	Tube Light	Geyser	E. Saver Rating (A)	Fans Rating (A)	Tube Light Rating (A)	Gyser Rating (A)	Load in Single Room (A)
21	1	3			0.32609	0.43478	0	0	0.86597
22	1	1	1		0.1087	0.43478	0.21739	0	0.86597
23	1	1	1		0.1087	0.43478	0.21739	0	0.86597
24	1	1	2		0.1087	0.43478	0.21739	0	0.86597
25	1	1	1		0.1087	0.43478	0.21739	0	0.86597
26	1	3			0.32609	0.43478	0	0	0.86597
27	1	2			0.21739	0.43478	0	0	0.86597
Staff room. 01	2		2		0	0.86957	0.43478	0	0.86597
Staff room. 02	2	4			0.43478	0.86957	0	0	0.86597
Staff room. 03	2	4			0.43478	0.86957	0	0	0.86597
Washroom		1			0.1087	0	0	0	0.86597
Bathroom 01		1	1		0.1087	0	0.21739	0	0.86597
Bathroom 02		1			0.1087	0	0	0	0.86597
T.V Room	4	4			0.43478	1.73913	0	0	0.86597
Outside		10			1.08696	0	0	0	0.86597
G. Room 01	2	2			0.21739	0.86957	0	0	0.86597
G. Room 02	2	2			0.21739	0.86957	0	0	0.86597
G. Room 03	2	2			0.21739	0.86957	0	0	0.86597
Wash Room		2		1	0.21739	0	0	10	0.86597
Kitchen		2			0.1087	0	0	0	0.86597
OUTSIDE		15			1.63043	0	0	0	0.86597
Grand Total									35.50477

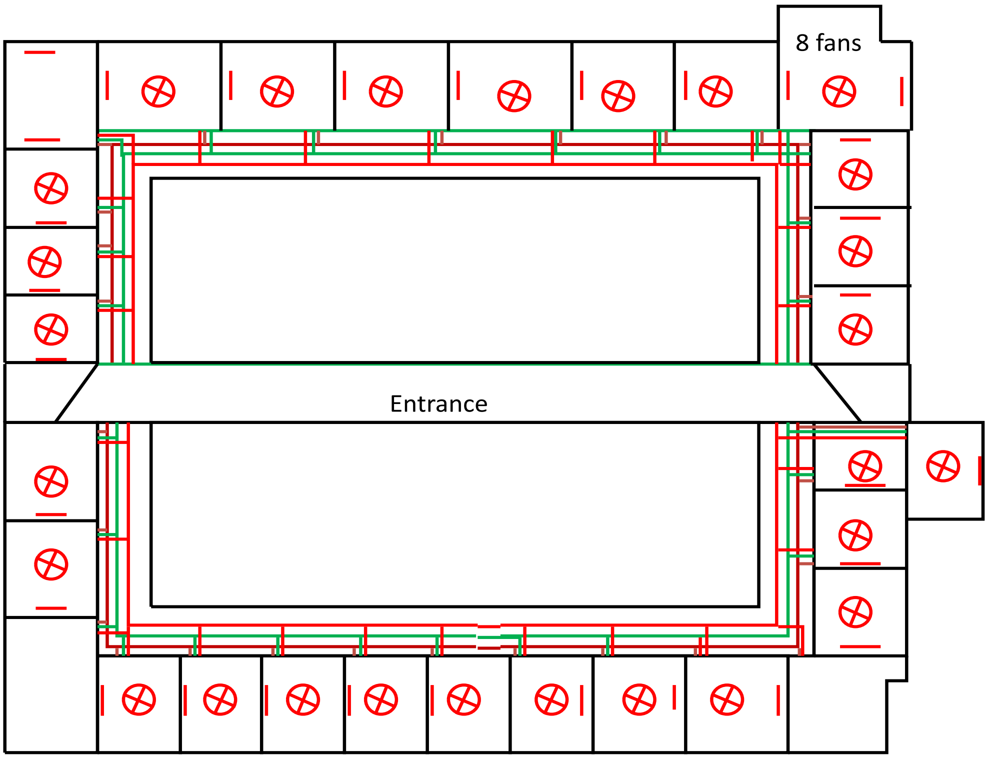

Figure 3. Sketch of the Rahman Baba Hostel.

Table 3. Rahman Baba Hostel existing load data.

Room No.	Fans	Energy Savers	Energy Saver Rating (A)	Fan Rating (A)	Load in Single Room (A)
1	1	1	0.108695652	0.434782609	0.543478261
2	1	1	0.108695652	0.434782609	0.543478261
3	1	1	0.108695652	0.434782609	0.543478261
4	1	1	0.108695652	0.434782609	0.543478261
5	1	2	0.217391304	0.434782609	0.652173913
6	1	1	0.108695652	0.434782609	0.543478261
7	1	2	0.217391304	0.434782609	0.652173913
8	1	2	0.217391304	0.434782609	0.652173913
9	1	1	0.108695652	0.434782609	0.543478261
10	1	2	0.217391304	0.434782609	0.652173913
10	1	2	0.217391304	0.434782609	0.652173913
11	1	2	0.217391304	0.434782609	0.652173913
12	1	3	0.326086956	0.434782609	0.760869565
13	1	3	0.326086956	0.434782609	0.760869565
14	1	2	0.217391304	0.434782609	0.652173913
15	1	5	0.54347826	0.434782609	0.978260869
16	1	8	0.869565216	0.434782609	1.304347825
17	1	1	0.108695652	0.434782609	0.543478261
18	1	1	0.108695652	0.434782609	0.543478261
19	1	1	0.108695652	0.434782609	0.543478261
20	1	3	0.326086956	0.434782609	0.760869565
21	1	1	0.108695652	0.434782609	0.543478261
23	1	1	0.108695652	0.434782609	0.543478261
W.Lounch	2	4	0.434782608	0.869565218	1.304347826
Mess	8	12	1.304347824	3.478260872	4.782608696
Study Room	1	1	0.108695652	0.434782609	0.543478261
Outside		0	12	1.304347824 0	1.304347824
Washroom 1	0	1	0.108695652	0	0.108695652
Washroom 2	0	1	0.108695652	0	0.108695652
GRAND TOTAL					23.26086956

3.1.4. Sketch of the Faqir-Api Hostel

Figures 4–6 depict the Faqir-Api hostel's three floors with their respective load as fans and lights. On the ground floor, one mess has 10 fans and two energy saver lights, while there are 18 rooms and all of them have almost the same load having one fan and one energy saver light, as shown in Figure 4. On the 1st floor, there is only one change TV hall, which has nine fans and two energy saver lights, while the remaining rooms have the same load as the ground floor, as shown in Figure 5. On the 2nd floor, we have only room load, having the same load as the 1st and 2nd floors, as shown in Figure 6. Tables 4–6 give the respective load data of the existing unbalanced three-phase four wire system.

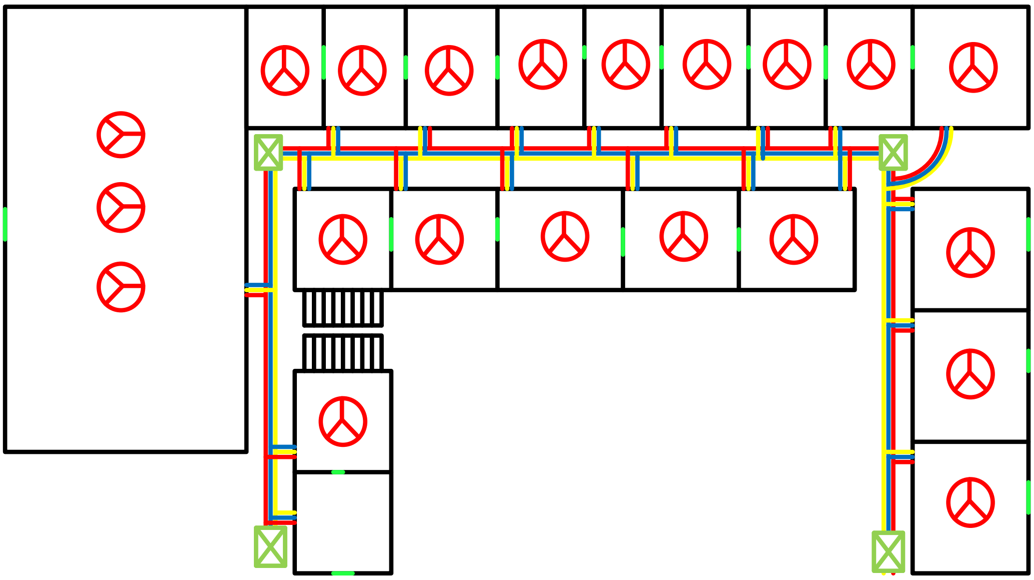

Figure 4. Sketch of the Faqir API Hostel (ground floor).

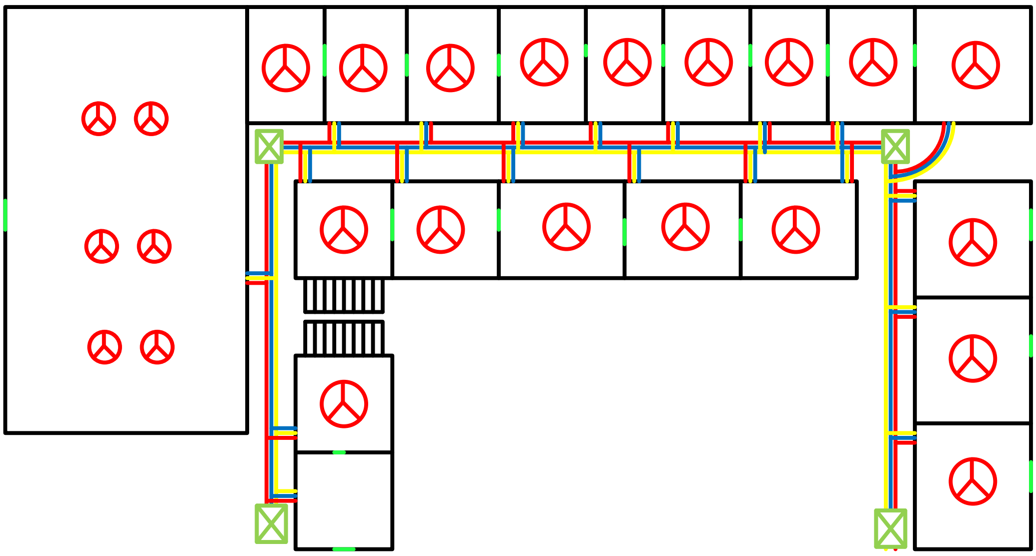

Figure 5. Sketch of the Faqir API Hostel (1st floor).

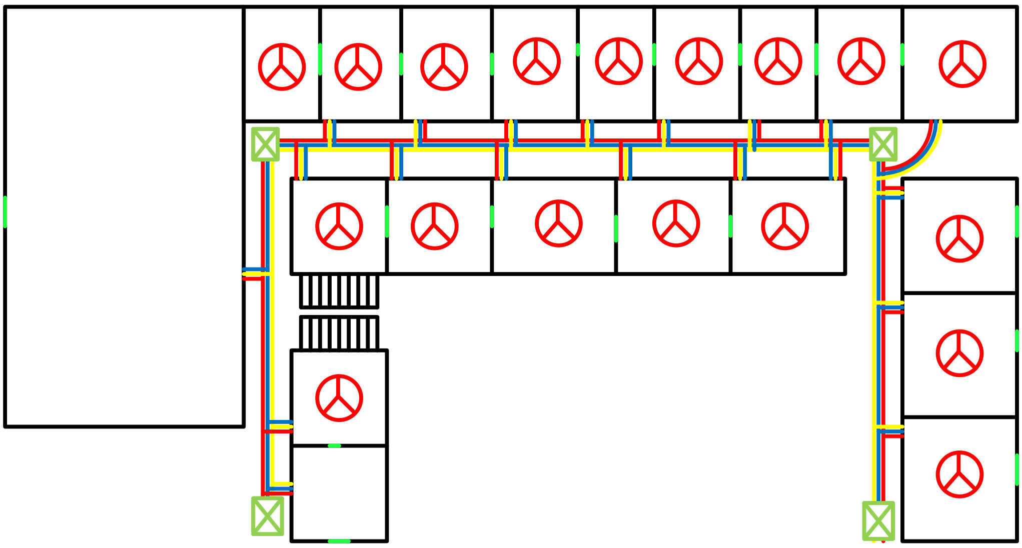

Figure 6. Sketch of the Faqir API Hostel (2nd floor).

Table 4. Faqir API Hostel (ground floor) existing load data.

Room No.	Fans	Energy Savers	Tube Lights	Energy Saver Rating (A)	Tube Lights Rating (A)	Fan Rating (A)	Load in Single Room (A)
1	1	1		0.108696	0	0.434783	0.543479
2	1	2	1	0.217392	0.21739	0.434783	0.869565
3	1	2		0.217392	0	0.434783	0.652175
4	1	2	1	0.217392	0.21739	0.434783	0.86956
5	1	1		0.108696	0	0.434783	0.543479
6	1	2		0.217392	0	0.434783	0.652175
7	1	1		0.108696	0	0.434783	0.543479
8	1	2		0.217392	0	0.434783	0.652175
9	1	1		0.108696	0	0.434783	0.543479
S 10	1	2		0.217392	0	0.434783	0.652175
11	1	2		0.217392	0	0.434783	0.652175
12	1	1		0.108696	0	0.434783	0.543479
13	1	2	1	0.217392	0.21739	0.434783	0.869565
14	1	2	1	0.217392	0.21739	0.434783	0.869565
15	1	2		0.217392	0	0.434783	0.652175
16	1	2		0.217392	0	0.434783	0.652175
17	1	1	1	0.108696	0.21739	0.434783	0.760869
W. Lounge	1	1	2	0.217392	0	0.434783	0.652175
Mess	10	5		0.54348	0	4.34783	4.89131
Washroom 1		1		0.108696	0	0	0.108696
Small Office	1	2		0.217392	0	0.434783	0.652175
GRAND TOTAL							17.8260696

Table 5. Faqir API Hostel (1st floor) existing load data.

Room No.	Fans	Energy Savers	Tube Lights	E.Saver Rating (A)	Tube Lights Rating (A)	Fan Rating (A)	Load in Single Room
18	1	1		0.108696	0	0.434783	0.543478261
19	1	1		0.108696	0	0.434783	0.543478261
20	1	2		0.217391	0	0.434783	0.653173913
21	1	1		0.108686	0	0.434783	0.543478261
22	1	2		0.217391	0	0.434783	0.652173913
23	1	1		0.108696	0	0.434783	0.543478261
24	1	2		0.217391	0	0.434783	0.673291521
25	1	2		0.217391	0	0.434783	0.673291521
26	1	1		0.108696	0	0.434783	0.543478291
27	1	2		0.217391	0	0.434783	0.673291521
28	1	2		0.217391	0	0.434783	0.673291521
29	1	1		0.108696	0	0.434783	0.543478291
30	1	1		0.108696	0	0.434783	0.543478291
31	1	2		0.217391	0	0.434783	0.673291521
32	1	2		0.217391	0	0.434783	0.673291521
33	1	1	1	0.108696	0.217391	0.434783	0.760869565
W.Lounch 2	1	2		0.217391	0	0.434783	0.652173913
Washroom 2	1	1		0.108696	0	0	0.108695652
TV Room	1	5		0.543478	0	3.913043	4.456521739
GRAND TOTAL							15

Table 6. Faqir API Hostel (2nd floor) existing load data.

Room No.	Fans	Energy Savers	Tube Lights	E.Saver Rating (A)	Tube Lights Rating (A)	Fan Rating (A)	Load in Single Room
34	1	1		0.108696	0	0.434783	0.543478261
35	1	2		0.217391	0	0.434783	0.652173913
36	1	2		0.217391	0	0.434783	0.652173913
37	1	2		0.217391	0	0.434783	0.652173913
38	1	1		0.108696	0	0.434783	0.543478261
39	1	2		0.217391	0	0.434783	0.652173913
40	1	2		0.217391	0	0.434783	0.652173913
41	1	1		0.108696	0	0.434783	0.543478261
42	1	1		0.108696	0	0.434783	0.543478261
43	1	1		0.108696	0	0.434783	0.543478261
44	1	1		0.108696	0	0.434783	0.543478261
45	1	1		0.108696	0	0.434783	0.543478261
56	1	2		0.2173 91	0	0.434783	0.652173913
57	1	1		0.108696	0	0.434783	0.543478261
48	1	2		0.217391	0	0.434783	0.652173913
49	1	2		0.217391	0	0.434783	0.652173913
50	1	2		0.217391	0	0.434783	0.652173913
Washroom 3		1		0.108696	0	0	0.108695652
outside		12		1.304348	0	0	1.304347826
GRAND TOTAL							11.63043478

3.1.5. Sketch of the Coordinator's House

Figure 7 depicts the coordinator's house. There are four air conditioners (ACs), one refrigerator, thirty-eight (38) energy saver lights, five fans, and two geysers. All appliances have been shown with their respective symbols for fans, lights, ACs, and geysers. Table 7 gives details of the existing unbalanced load units in the said house.

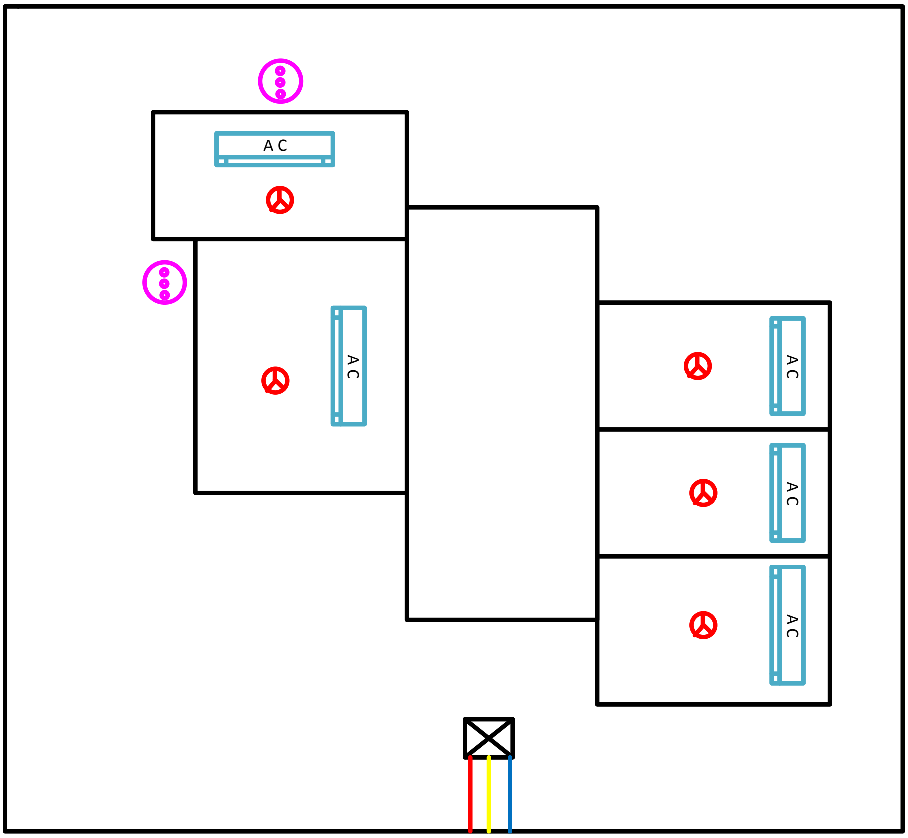

Figure 7. Sketch of the coordinator house.

3.1.6. Sketch of the Staff Hostel

Figure 8 depicts the sketch of the staff hostel in which we have five (5) rooms, and all of them have the same load having one fan and four energy saver lights. Only one room has three energy savers, while in the corridor two fans and four energy savers and two air cooler fans. One room at the bottom right has four energy savers only, while, outside, we have only two energy savers. Table 8 gives the details of the existing unbalanced load units in the said hostel.

3.2. Sketches of the Existing Wiring System in Each Unit

Balancing of the load means to distribute all load units of the campus equally in three phases so that the current in neutral wire can be minimized. However, for doing this, we need to know how much old is the existing wiring system?. Then, according to the load conditions, we have to distribute the load in three phases in such a way so that the current in neutral wire can be minimized.

Table 7. Coordinator house existing load data.

Room No.	Fans	Energy Severs	A.C (Split)	A.C (General)	Geyser	Refrigerator	E. Saver Rating (A)	Fan Rating (A)	A.C (S) Rating (A)	A.C (G) Rating	Geyser Rating	Ref.Rating	Load In Single room (A)
1	1	4	1		1		0.434782609	0.434782609	6.25	0	9	0	16.11956522
2	1	4	1		1		0.434782610	0.434782610	6.26	0	9	0	16.11956522
3	1	4	1				0.434782611	0.434782611	6.27	0	0	0	7.119565217
4	2	4		2			0.434782612	0.869565217	0	16	0	0	17.30434783
corridor		6				1	0.652173913	0	0	0	0 2.173913043	2.826086957	
washroom		3					0.326086957	0	0	0	0	0	0.326086957
kitchen + store		2					0.217391304	0	0	0	0	0	0.217391304
outside		9					0.97826087	0	0	0	0	0	0.97826087
search light		2					0.217391304	0	0	0	0	0	217391304
GRAND TOTAL													61.22826087

Table 8. Staff Hostel existing load data.

Room No.	Fans	Energy Saver	Cooler	Refrigrator	Fan Rating (A)	E. Saver Rating (A)	Cooler Rating (A)	Ref.Rating (A)	Load in Single Room (A)
1	1	4	1		0.434782609	0.434782609	1.793478261	0	0.663043478
2	1	4	1		0.434782610	0.434782610	1.793478262	0	0.663043479
3	1	4			0.434782611	0.434782611	0	0	0.869565217
4	1	4			0.434782612	0.434782612	0	0	0.869565218
5	1	4			0.434782613	0.434782613	0	0	0.869565219
Kitchen		2			0	217391304	0	0	0.217391304
outside		4			0	0.434782609	0	0	0.434782609
inside		9			0	0.97826087	0	2.173913043	3.152173913
Grand TOTAL									11.73913043

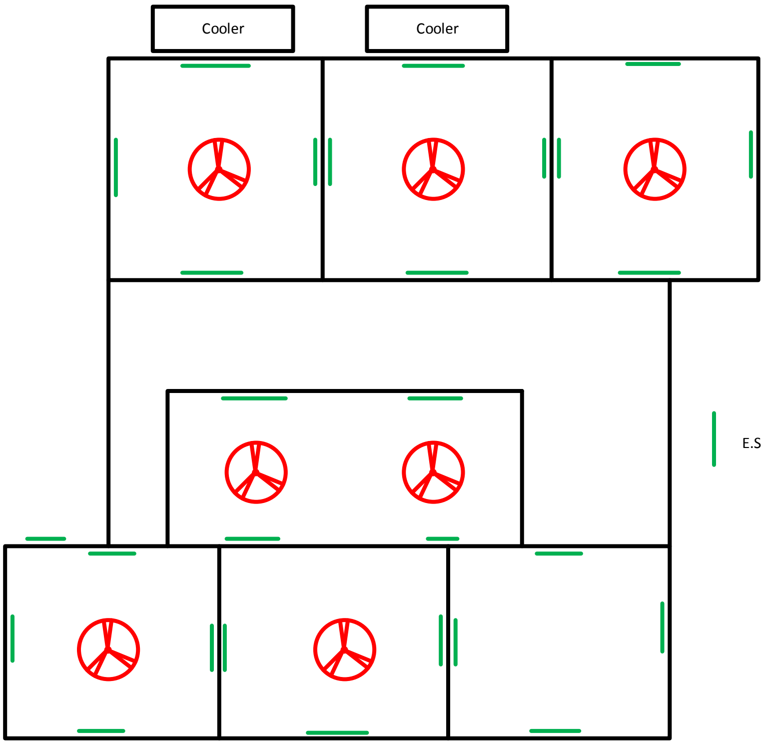

Figure 8. Sketch of the Staff Hostel.

3.2.1. Sketch of Academic Block

In the academic block, as you can see in the diagram, all symbols are the same, but the only symbol with color that we used is just for the wall fan. First, we examine every unit in the academic floor and then examine every real load in units and then sketched them with the help of Auto CAD. At the bottom, classes started from numbering 1 to 8 to the right side of this load unit whereas, at the right side of administration block, the loads points could also be seen easily. In the academic block, there is a hall and also computer labs numbering from 1 to 4. However, on the left side of the sketch, we have the workshop, the control system lab, the environmental lab, the highway lab, the library, and one cafeteria for students. The name of the unit does not really mean but finding the actual load in these units matters. We just made hand sketches in which we have given names to all units, as shown in Figure 9.

3.2.2. Sketch of the Allama Iqbal Hostel

In this hostel, the load is unequally distributed on the three phases among different units, which have room no. 1 to 21, and four rooms of staff hostel drawing current of 1.1 A are in the yellow phase, while drawing current of 23.3 A. In the blue phase, we have three rooms of the girls-hostel, as can be seen in the sketch and room no. 22 to 27 is also on the blue phase, drawing current of 18.7 A. In the red phase, we have five labs, including drawing, microwave, DLD, machine, electronics, and BEE labs, drawing current of 22 A, as can be seen in Figure 10.

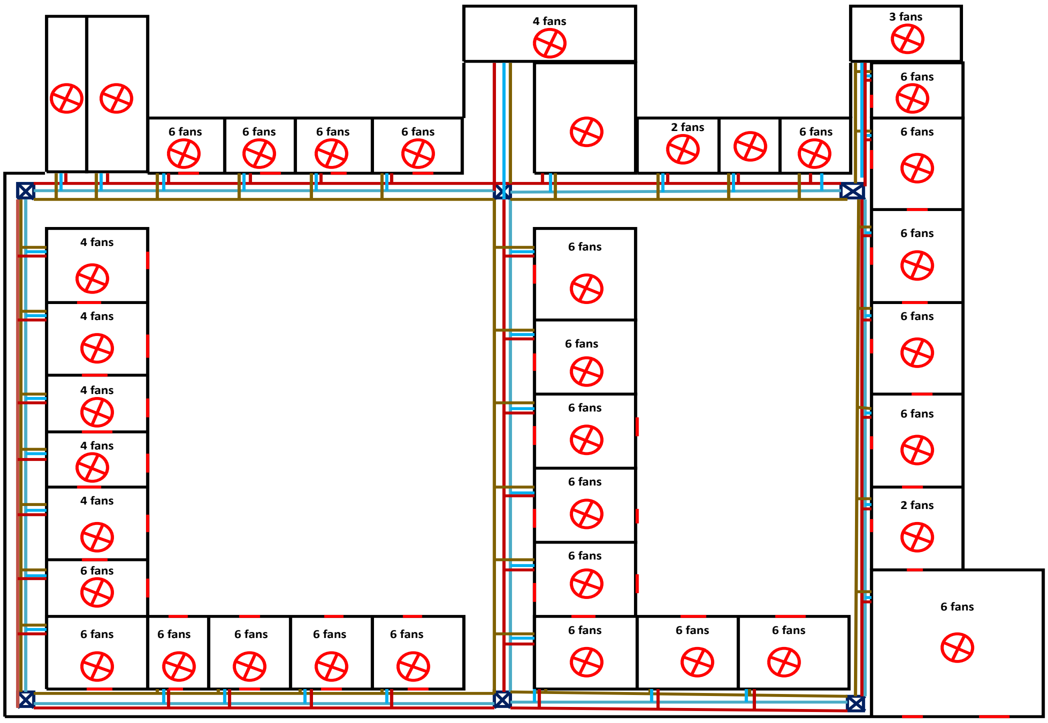

Figure 9. Sketch of academic block.

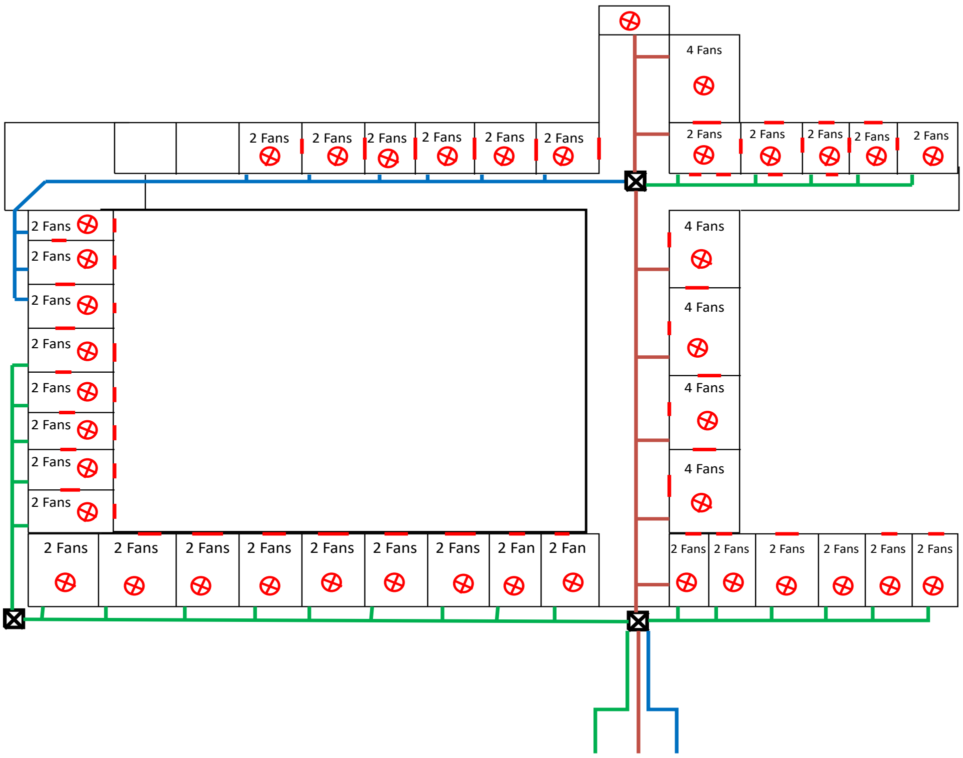

Figure 10. Allama Iqbal Hostel wiring.

3.2.3. Sketch of the Rahman Baba Hostel

In the Rahman Baba Hostel from room no. 1 to 9 and study room, warden lounge, and room number 24 is on the blue phase drawing current of 5A, while room numbers 10 to 23 is on yellow phase drawing, as shown in Figure 11.

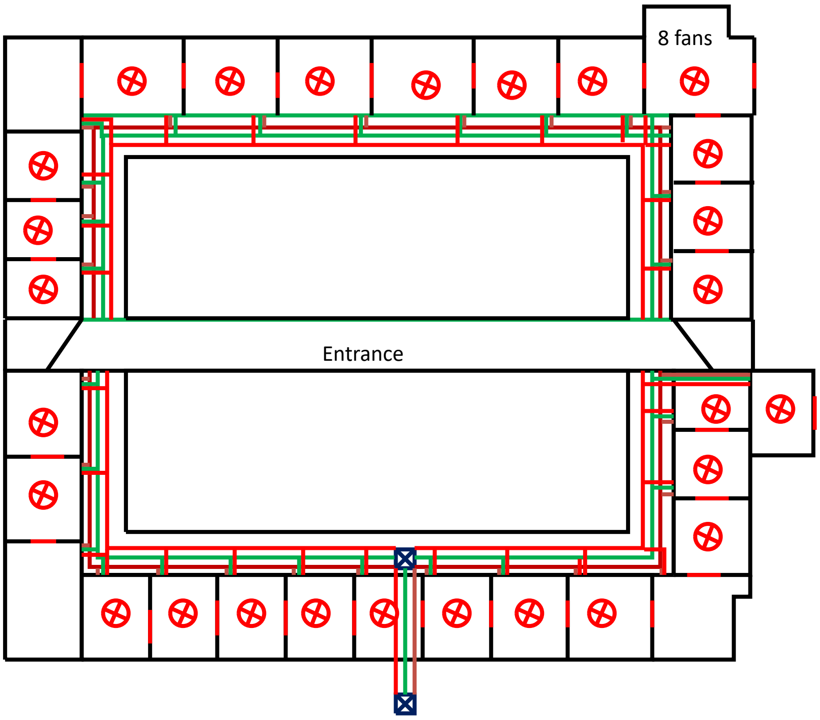

Figure 11. Rahman Baba Hostel wiring.

3.2.4. Sketch of the Faqir API Hostel

There are three floors in the Faqir API hostel. The first one is the ground floor. This floor is in the red phase drawing current of 15.3 A, as shown in Figure 12. The 1st floor is on the blue phase drawing current of 15.4 A, as shown in Figure 13, while the 2nd floor is in the yellow phase drawing current of 14.7 A, as shown in Figure 14.

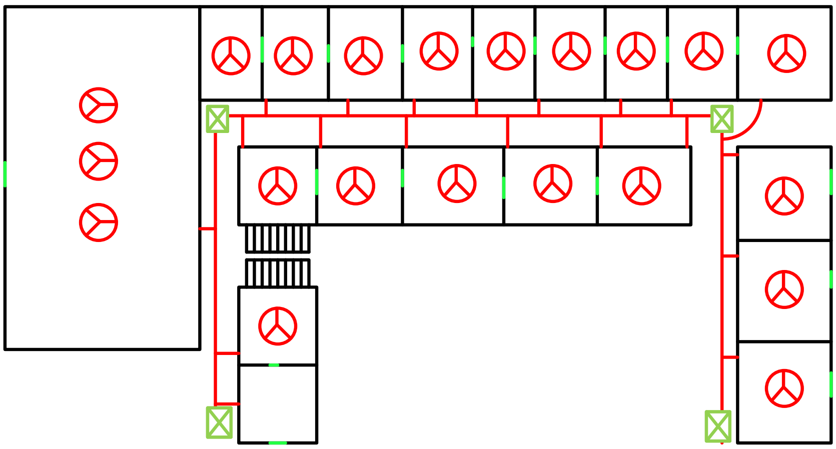

Figure 12. Faqir API Hostel (ground floor) wiring.

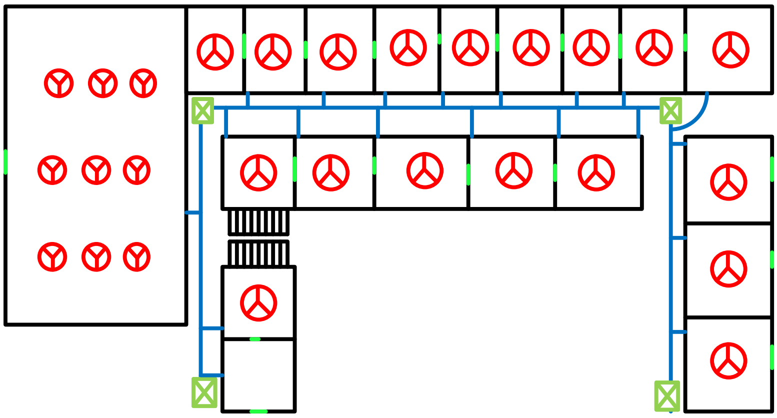

Figure 13. Faqir API Hostel (1st floor) wiring.

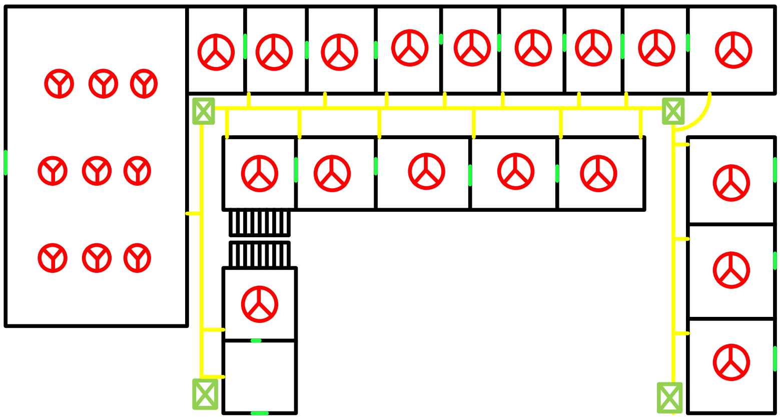

Figure 14. Faqir API Hostel (2nd floor) wiring.

3.2.5. Coordinator House Wiring

The coordinator house connection is in single-phase only, which is on the yellow phase drawing current of 17.1 A, as shown in Figure 15.

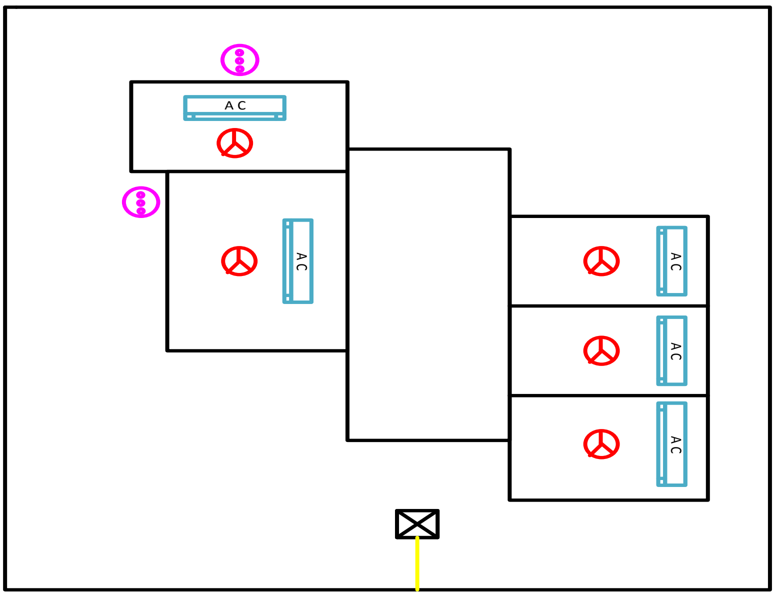

Figure 15. Coordinator house wiring.

3.2.6. Staff Hostel Wiring

The staff hostel is also in the yellow phase drawing current of 8.7A, as shown in Figure 16.

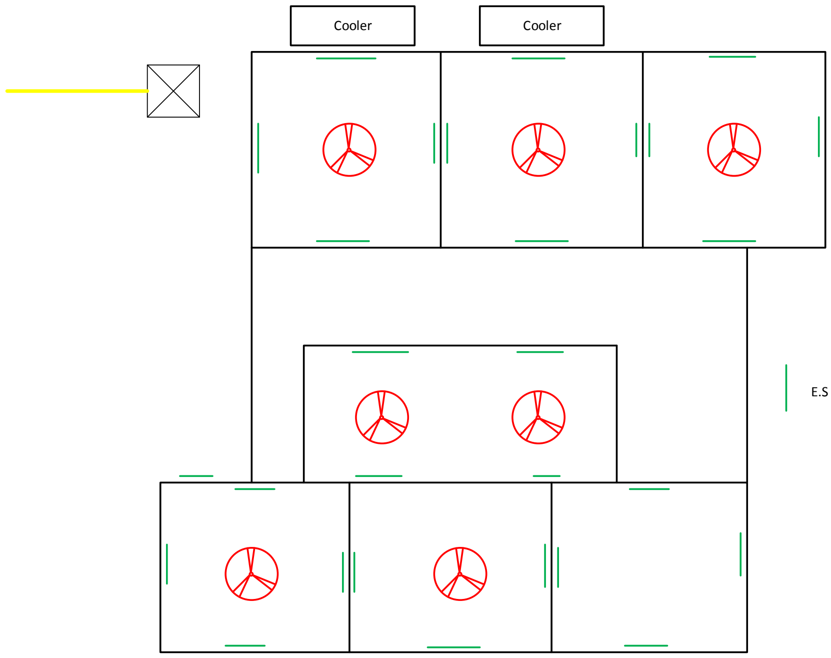

Figure 16. Staff hostel wiring.

4. Proposed Nature-Inspired Moth–Flame Optimization (MFO) Algorithm

The nature-inspired algorithm MFO was proposed by Seyedali Mirjalili in 2015 [12,19]. Moths are butterfly-like insects, having 160,000 plus different species in nature. They have their unique navigation mechanism known as transverse orientation when flying in the moonlight. When they fly in a spiral, they maintain a constant angle related to the moon, ultimately converging in the direction of light. The spiral articulates the searching region, and it assures the exploitation of the optimum solution.

Since MFO is a population-based algorithm, the movement of m moths in n dimensions (variables) is given in the position matrix form as follows:

$$Q = \begin{bmatrix} q_{1,1} & \cdots & q_{1,n} \\ \cdots & \cdots & \cdots \\ q_{m,1} & \cdots & q_{m,n} \end{bmatrix} \quad (1)$$

The resultant fitness values, for "m" number of moths, are stored in an array. The fitness function (objective) evaluates each moth's fitness value. Each moth's position vector, i.e., matrix Q's first row, is evaluated on the fitness function, and its output is then allocated to its respective moth.

Similarly, a matrix U_F is assigned to the corresponding flames as follows:

$$U_f = \begin{bmatrix} u_{1,1} & \cdots & u_{1,n} \\ \cdots & \cdots & \cdots \\ u_{m,1} & \cdots & u_{m,n} \end{bmatrix} \quad (2)$$

Now, in mapping our problem of the optimal load balancing in the three-phase system of university campus, moths act as searching agents for each connected load, and flames are the optimum phase for that appliance. In each iteration, a moth searches for an optimum flame, with updates in the next iteration for the best solution by comparing with the previous one. Moths follow the logarithmic spiral for their update positions, where moths start from some initial position, following some limited fluctuating search space, and reach their destination flames. In MFO, the logarithmic spiral is:

$$S(X_i, P_j) = d_i.e^{bt}.cos(2\pi t) + P_j \tag{3}$$

where $d_i = |P_j - X_i|$ is the ith moth distance from the jth flame, b is the spiral shape defining the constant and the random number t lies between -1 and one. When $t = -1$, this means that the moth is closest to its destination flame, while $t = 1$ indicates its farthest position from the flame. Therefore, the moth is always assumed to be in a hyper-ellipse space, which guarantees the exploitation and exploration of search space. Table 9 depicts the MFO parameters.

Table 9. Moth–flame optimization (MFO) algorithm parameters.

S. No.	Parameter	Value
1	Number of moths and flames	12
2	Max. No. of Iterations	1000
3	Lower bound L_b	-100
4	Upper bound U_b	100

5. Proposed Model for Balance Load

On the basis of the proposed model, we have to make some compulsory changes in the electrical wiring system. We have proposed that there must be a connection from all the three phases in every hostel, academic block, and coordinator's house, so, for this purpose, we have to make a new installation of wiring cables in the network and replace some damaged pieces of equipment with new ones. The proposed model for each unit is given below.

5.1. The Proposed Model for an Academic Block

In the academic block, we have distributed all the load equally on the three phases. From room 1 to room 5, the ADC office, BSI office, Semester coordinator, and chairman office of the electrical engineering department and Lab2, faculty office, R and D Lab, the examination section, CDC office, and the lavatory close to it, all the load of these rooms are in the Red phase. From room 6 to room 8, the Canteen, Warden Lodge, Lab1 lavatory along with the Coordinator and Chairman Office of the Civil Engineering Department and the main hall load are in the yellow phase. The account section, the conference room, Lab3, Lab4, the library, material testing lab, hydraulic lab, concrete lab, environmental lab, highway lab, workshop, and the control system lab load are in the green phase, as shown in Figure 17.

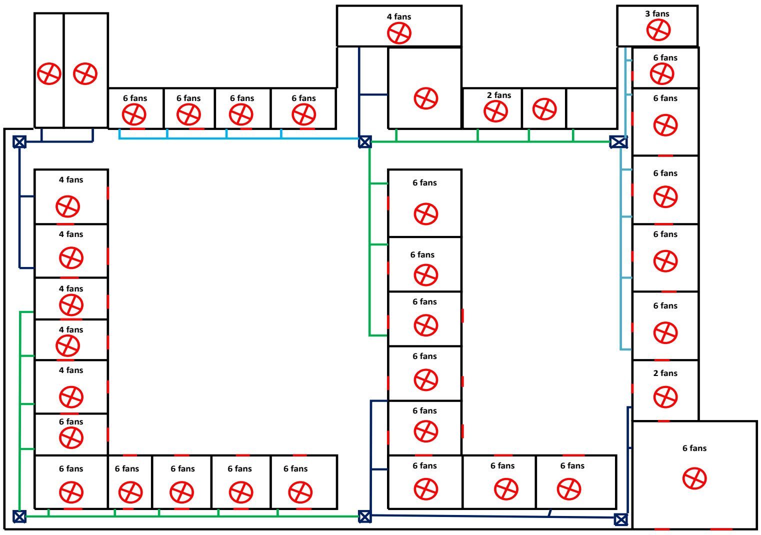

Figure 17. Proposed model for the Academic Block.

5.2. The Proposed Model for the Rahman Baba Hostel

Here, all the load of the rooms is distributed among the three phases equally. Room 1 to room 9 and lavatory1 are in the yellow phase. Room 10 to room 20 and lavatory 2 are in the green phase. Warden Lodge, study room Mess, from room 21 to room 24, and one room attached to this hostel are in the red phase, as shown in Figure 18.

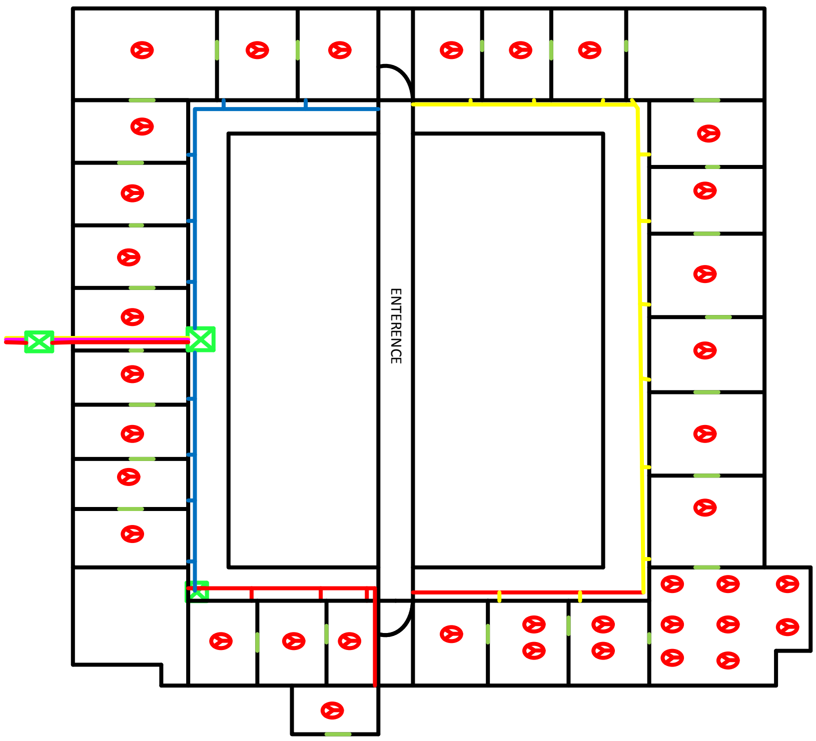

Figure 18. The proposed model for the Rahman Baba Hostel.

5.3. The Proposed Model for the Faqir API Hostel

The load of the Faqir API hostel is already distributed equally among the three phases such as the ground floor taking connection from the red phase, the first floor from the blue phase and the second floor from the yellow phase. Thus, there is no need to change the configuration of the phases. The load in the Faqir API hostel is almost balanced, but we have to change the cable size from 3/0.29 to 7/0.29.

5.4. The Proposed Model for the Coordinator House

The load of the coordinator is also distributed in three phases. The load of room-1 is in the yellow phase. Room 2 is in the red phase, and room-3, room-4, and room-5 are in the blue phase, as shown in Figure 19.

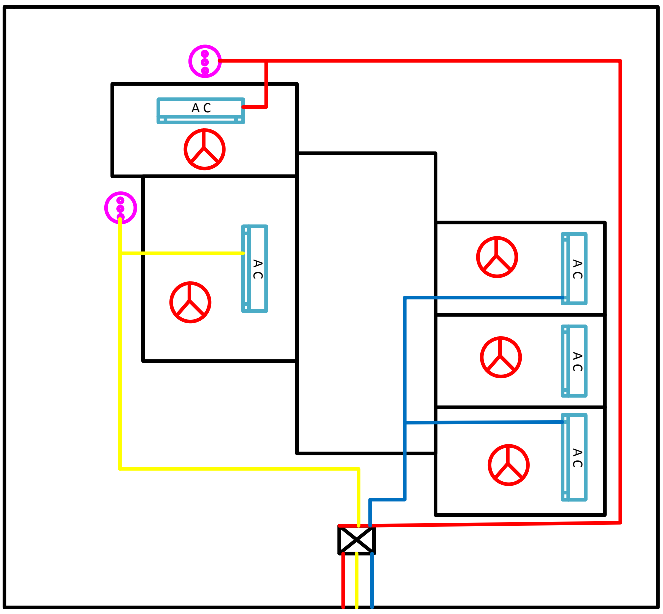

Figure 19. Proposed model for the coordinator house.

5.5. The Proposed Model for the Staff Hostel

In this model, the load of the staff hostel is equally distributed among the three phases, which was in the single phase before this model. Room 1and Room 2 is in the yellow phase. Room 3, the kitchen, and the corridor are in the blue phase. Room 4 and Room 5 are in the red phase, as shown in Figure 20.

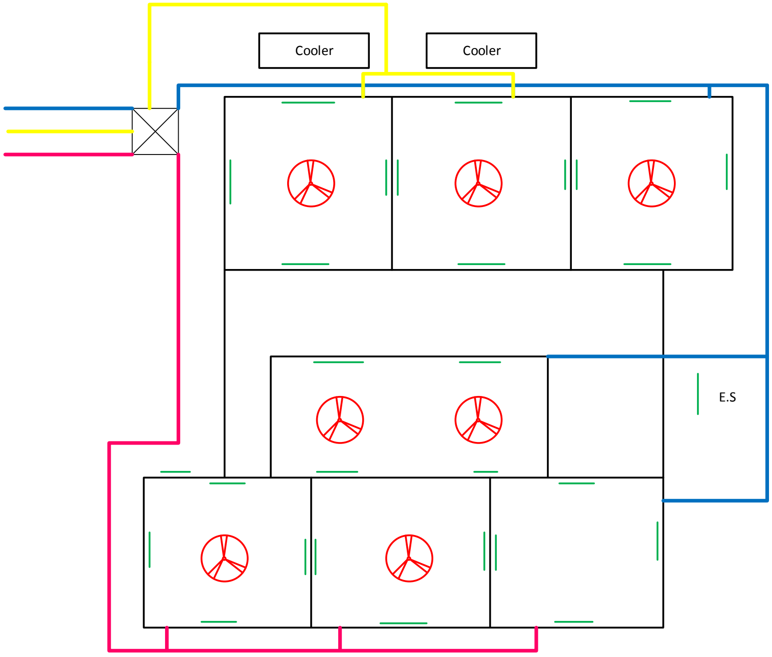

Figure 20. Proposed model for the Staff Hostel.

6. Results and Discussion

In this paper, we follow a practical approach for balancing of the load on the university campus to minimize the flow of current through the neutral wire, which is the main cause of the overheating of cables and the cause of the load shedding on the campus. Following the above methodology and based on the facts, observations and calculation, we proposed a balance model for the campus. This model will be practically implemented on the campus and after the installation of new cables and required equipment, the unbalanced load condition will be minimized to very large extent. There will be approximately only 5 to 6 percent unbalanced load condition in the three phases in the three-phase four-wire system, which is the acceptable limit according to the standard rules of wiring.

In this paper, we have also calculated the total connected load as well as the total running load on the campus and used a bio-inspired moth–flame optimization (MFO) algorithm for proper distribution and configuration of load on the three-phase four wire system to achieve the balanced load condition. Then, on the basis of these results, we have proposed a balance model for UET Peshawar Bannu Campus. Results are given below:

6.1. Allama Iqbal Hostel

Table 10 gives the Allama-Iqbal-Hostel proposed load data on all three phases of the system. In comparison of Table 2, it is clear that all three phases have approximately equal load (i.e., 18.8 A, 18.9 A, and 18.8 A, respectively), along with almost zero current (0.1 A) in the neutral wire.

Table 10. Allama-Iqbal-Hostel proposed load data.

Device Name	Watt	Volt	Amp	Pf	Phase	Amp XN	Amp YN	Amp ZN	Amp N
fan	80 W	231	0.43 A	−8	Z-N			0.4 A	0.4 A
fan	80 W	231	0.43 A	−8	Y-N		0.4 A		0.4 A
fan	80 W	231	0.43 A	−8	X-N	0.4 A			0.4 A
tube light	40 W	231	0.22 A	−8	Z-N			0.2A	0.2 A
tube light	40 W	231	0.22 A	−8	Y-N		0.2 A		0.2 A
tube light	40 W	231	0.22 A	−8	Z-N			0.2 A	0.2 A
tube light	40 W	231	0.22 A	−8	Y-N		0.2 A		0.2 A
tube light	40 W	231	0.22 A	−8	X-N	0.2 A			0.2 A
tube light	40 W	231	0.22 A	−8	Z-N			0.2 A	0.2 A
tube light	40 W	231	0.22 A	−8	Y-N		0.2 A		0.2 A
tube light	40 W	231	0.22 A	−8	X-N	0.2 A			0.2 A
tube light	40 W	231	0.22 A	−8	Z-N			0.2 A	0.2 A
tube light	40 W	231	0.22 A	−8	Y-N		0.2 A		0.2 A
tube light	40 W	231	0.22 A	−8	X-N	0.2 A			0.2 A
tube light	40 W	231	0.22 A	−8	Z-N			0.2 A	0.2 A
e saver	25 W	231	0.14 A	−8	Y-N		0.1 A		0.1 A
e saver	25 W	231	0.14 A	−8	Y-N		0.1 A		0.1 A
e saver	25 W	231	0.14 A	−8	X-N	0.1 A			0.1 A
e saver	25 W	231	0.14 A	−8	Z-N			0.1 A	0.1 A
e saver	25 W	231	0.14 A	−8	Y-N		0.1 A		0.1 A
e saver	25 W	231	0.14 A	−8	X-N	0.1 A			0.1 A
e saver	25 W	231	0.14 A	−8	Z-N			0.1 A	0.1 A
Qty of Devices = 204	10,450 W	231/400 V	56.6 A		3-Ph	18.8 A	18.9 A	18.8 A	0.1 A

Total Amps X-N: 18.8 A; Total Amps Y-N: 18.9 A; Total Amps Z-N: 18.8 A.

6.2. Rahman Baba Hostel

Table 11 gives the proposed balanced load data on all three phases of the three-phase four-wire system of Rahman Baba Hostel. In comparison with Table 3, it is clear that all three phases have almost equal load (i.e., 8.4 A, 8.0 A and 8.0 A), along with nearly zero current (0.1 A) in the neutral wire.

Table 11. Rahman Baba Hostel proposed load data.

Device Name	Watt	Volt	Amp	Pf	Phase	Amp XN	Amp YN	Amp ZN	Amp N
fan	40 W	231	0.43 A	−8	X-N	0.4 A			0.4 A
fan	40 W	231	0.43 A	−8	Z-N			0.4 A	0.4 A
fan	40 W	231	0.43 A	−8	Y-N		0.4 A		0.4 A
fan	40 W	231	0.43 A	−8	X-N	0.4 A			0.4 A
fan	40 W	231	0.43 A	−8	Z-N			0.4 A	0.4 A
fan	40 W	231	0.43 A	−8	Y-N	0.4 A	0.4 A		0.4 A
fan	40 W	231	0.43 A	−8	X-N				0.4 A
fan	40 W	231	0.43 A	−8	Z-N			0.4 A	0.4 A
fan	40 W	231	0.43 A	−8	Y-N	0.4 A	0.4 A		0.4 A
fan	40 W	231	0.43 A	−8	X-N				0.4 A
fan	40 W	231	0.43 A	−8	Z-N			0.4 A	0.4 A
fan	40 W	231	0.43 A	−8	Y-N	0.4 A	0.4 A		0.4 A
fan	40 W	231	0.43 A	−8	X-N				0.4 A
e saver	25 W	231	0.14 A	−8	Z-N			0.1 A	0.1 A
e saver	25 W	231	0.14 A	−8	Y-N		0.1 A		0.1 A
e saver	25 W	231	0.14 A	−8	Z-N			0.1 A	0.1 A
e saver	25 W	231	0.14 A	−8	Y-N		0.1 A		0.1 A
e saver	25 W	231	0.14 A	−8	Z-N			0.1 A	0.1 A
e saver	25 W	231	0.14 A	−8	Y-N		0.1 A		0.1 A
e saver	25 W	231	0.14 A	−8	Z-N			0.1 A	0.1 A
e saver	25 W	231	0.14 A	−8	Y-N		0.1 A		0.1 A
e saver	25 W	231	0.14 A	−8	X-N	0.1 A			0.1 A
e saver	25 W	231	0.14 A	−8	Z-N			0.1 A	0.1 A
QtY-N of Devices = 114	4720 W	120/208 V	25.5A		3-Ph	8.4 A	8.6 A	8.6 A	0.1 A

Total Amps X-N: 8.4 A; Total Amps Y-N: 8.6 A; Total Amps Z-N: 8.6 A.

Academic Block

Tables 12–14 depict the Academic Block's proposed balanced load data on all three phases of the three-phase four-wire system. In comparison with Table 1, it is clear that all three phases have almost equal load (i.e., 47.4 A, 47.3 A and 47 A), along with almost zero current (i.e., 0.4 A) in the neutral wire.

Table 12. Academic Block proposed load data.

Device Name	Watt	Volt	Amp	pf	Phase	Amp XN	Amp YN	Amp ZN	Amp N
Fan	80	231	0.43 A	−8	Y-N		0.4		0.4 A
Fan	80	232	0.43 A	−8	Z-N			0.4	0.4 A
Fan	80	233	0.43 A	−8	X-N	0.4			0.4 A
Fan	80	234	0.43 A	−8	Y-N		0.4		0.4 A
Fan	80	235	0.43 A	−8	Z-N			0.4	0.4 A
Fan	80	236	0.43 A	−8	X-N	0.4			0.4 A
Fan	80	237	0.43 A	−8	Y-N		0.4		0.4 A
Fan	80	238	0.43 A	−8	Z-N			0.4	0.4 A
Fan	80	239	0.43 A	−8	X-N	0.4			0.4 A
Fan	80	240	0.43 A	−8	Y-N		0.4		0.4 A
Fan	80	240	0.43 A	−8	Z-N			0.4	0.4 A
Wall Fan	73	241	0.4 A	−8	X-N	0.4			0.4 A
Wall Fan	73	242	0.4 A	−8	Y-N		0.4		0.4 A
Wall Fan	73	243	0.4 A	−8	Z-N			0.4	0.4 A
Wall Fan	73	244	0.4 A	−8	X-N	0.4			0.4 A
Wall Fan	73	245	0.4 A	−8	Y-N		0.4		0.4 A
Wall Fan	73	246	0.4 A	−8	Z-N			0.4	0.4 A
Wall Fan	73	247	0.4 A	−8	X-N	0.4			0.4 A
Wall Fan	73	248	0.4 A	−8	Y-N		0.4		0.4 A
Wall Fan	73	249	0.4 A	−8	Z-N			0.4	0.4 A
Wall Fan	73	250	0.4 A	−8	X-N	0.4			0.4 A
Wall Fan	73	251	0.4 A	−8	Y-N		0.4		0.4 A
Wall Fan	73	252	0.4 A	−8	Z-N			0.4	0.4 A
Qty. of Device 524	26,174 W	231/400 V	141.6 A		3-Ph	47.4 A	47.3 A	47 A	0.4 A

Total Amps X: 47.4 A; Total Amps Y: 47.3 Al Total Amps Z: 47 A.

Table 13. Academic Block proposed load data (1).

Device Name	Watt	Volt	Amp	pf	Phase	Amp XN	Amp YN	Amp ZN	Amp N
Tube light	40	231	0.22 A	−8	X-N	0.2			0.2 A
Tube light	40	232	0.22 A	−8	Y-N		0.2		0.2 A
Tube light	40	233	0.22 A	−8	Z-N			0.2	0.2 A
Tube light	40	234	0.22 A	−8	X-N	0.2			0.2 A
Tube light	40	235	0.22 A	−8	Y-N		0.2		0.2 A
Tube light	40	236	0.22 A	−8	Z-N			0.2	0.2 A
Tube light	40	237	0.22 A	−8	X-N	0.2			0.2 A
Tube light	40	238	0.22 A	−8	Y-N		0.2		0.2 A
Tube light	40	239	0.22 A	−8	Z-N			0.2	0.2 A
Tube light	40	240	0.22 A	−8	X-N	0.2			0.2 A
Tube light	40	241	0.22 A	−8	Y-N		0.2		0.2 A
Tube light	40	242	0.22 A	−8	Z-N			0.2	0.2 A
Tube light	40	243	0.22 A	−8	X-N	0.2			0.2 A
Exaust	36	244	0.22 A	−8	Y-N		0.2		0.2 A
Exaust	36	245	0.22 A	−8	Z-N			0.2	0.2 A
Exaust	36	246	0.22 A	−8	X-N	0.2			0.2 A
Exaust	36	247	0.22 A	−8	Y-N		0.2		0.2 A
Exaust	36	248	0.22 A	−8	Z-N			0.2	0.2 A
Exaust	36	249	0.22 A	−8	X-N	0.2			0.2 A
Exaust	36	250	0.22 A	−8	Y-N		0.2		0.2 A
Exaust	36	251	0.22 A	−8	Z-N			0.2	0.2 A
Exaust	36	252	0.22 A	−8	X-N	0.2			0.2 A
Exaust	36	253	0.22 A	−8	Y-N		0.2		0.2 A
Qty. of Device: 524	26174	231/400V	141.6 A		3-Ph	47.4	47.3	47	0.4 A

Total Amps X: 47.4 A; Total Amps Y: 47.3 A; Total Amps Z: 47 A.

Table 14. Academic Block proposed load data (2).

Device Name	Watt	Volt	Amp	pf	Phase	Amp XN	Amp YN	Amp ZN	Amp N
E. Saver	25	231	0.14 A	−8	X-N	0.1			0.1 A
E. Saver	25	232	0.14 A	−8	Y-N		0.1		0.1 A
E. Saver	25	233	0.14 A	−8	Z-N			0.1	0.1 A
E. Saver	25	234	0.14 A	−8	X-N	0.1			0.1 A
E. Saver	25	235	0.14 A	−8	Y-N		0.1		0.1 A
E. Saver	25	236	0.14 A	−8	Z-N			0.1	0.1 A
E. Saver	25	237	0.14 A	−8	X-N	0.21			0.1 A
E. Saver	25	238	0.14 A	−8	Y-N		0.1		0.1 A
E. Saver	25	239	0.14 A	−8	Z-N			0.1	0.1 A
E. Saver	25	240	0.14 A	−8	X-N	0.1			0.1 A
E. Saver	25	241	0.14 A	−8	Y-N		0.1		0.1 A
E. Saver	25	242	0.14 A	−8	Z-N			0.1	0.1 A
E. Saver	25	243	0.14 A	−8	X-N	0.1			0.1 A
E. Saver	25	244	0.14 A	−8	Y-N		0.1		0.1 A
E. Saver	25	245	0.14 A	−8	Z-N			0.1	0.1 A
E. Saver	25	246	0.14 A	−8	X-N	0.1			0.1 A
E. Saver	25	247	0.14 A	−8	Y-N		0.1		0.1 A
E. Saver	25	248	0.14 A	−8	Z-N			0.1	0.1 A
E. Saver	25	249	0.14 A	−8	X-N	0.1			0.1 A
E. Saver	25	250	0.14 A	−8	Y-N		0.1		0.1 A
E. Saver	25	251	0.14 A	−8	Z-N			0.1	0.1 A
E. Saver	25	252	0.14 A	−8	X-N	0.1			0.1 A
E. Saver	25	253	0.14 A	−8	Y-N		0.1		0.1 A
Qty. of Device: 524	26174	231/400V	141.6 A		3-Ph	47.4	47.3	47	0.4 A

Total Amps X: 47.4 A; Total Amps Y: 47.3 A; Total Amps Z: 47 A.

6.3. Coordinator House

Table 15 depicts the Coordinator Houses proposed balanced load data on all three phases of the three-phase four-wire system. In comparison with Table 7, it is clear that all three phases have exactly equal loads (i.e., 26.9 A on each phase), along with zero current (i.e., 0.0A) in the neutral wire.

Table 15. Coordinator House proposed load data.

Device Name	Watt	Volt	Amp	pf	Phase	Amp XN	Amp YN	Amp ZN	Amp N
Geyser	3000	231	16.23 A	−8	X-N	16.2			16.2 A
Geyser	3000	232	16.23 A	−8	Y-N			16.2	16.2 A
AC general	1500	233	8.12 A	−8	Z-N		8.1 A		8.1 A
AC general	1500	234	8.12 A	−8	X-N	6.5	8.1 A		8.1 A
A.C Split	1200	235	6.49 A	−8	Y-N				6.5 A
A.C Split	1200	236	6.49 A	−8	Z-N			6.5	6.5 A
A.C Split	1200	237	6.49 A	−8	X-N	2.7	6.5 A		6.5 A
Refrigerator	500	238	2.71 A	−8	Y-N				2.7 A
Fan	80	239	0.43 A	−8	Z-N			0.4	0.4 A
Fan	80	240	0.43 A	−8	X-N		0.4 A		0.4 A
Fan	80	241	0.43 A	−8	Y-N			0.4	0.4 A
Fan	80	242	0.43 A	−8	Z-N		0.4 A		0.4 A
Fan	80	243	0.43 A	−8	X-N			0.4	0.4 A
E. Saver	38	244	0.21 A	−8	Y-N		0.2 A		0.2 A
E. Saver	38	245	0.21 A	−8	Z-N		0.2 A		0.2 A
E. Saver	38	246	0.21 A	−8	X-N		0.2 A		0.2 A
E. Saver	38	247	0.21 A	−8	Y-N			0.2	0.2 A
E. Saver	38	248	0.21 A	−8	Z-N		0.2 A		0.2 A
E. Saver	38	249	0.21 A	−8	X-N			0.2	0.2 A
E. Saver	38	250	0.21 A	−8	Y-N		0.2 A		0.2 A
E. Saver	38	251	0.21 A	−8	Z-N			0.2	0.2 A
E. Saver	38	252	0.21 A	−8	X-N		0.2 A		0.2 A
E. Saver	38	253	0.21 A	−8	Y-N			0.2	0.2 A
Qty. of Device: 50	14906	120/208V	80.7 A		3-Ph	26.9	26.9 A	26.9 A	0.0 A

Total Amps X: 26.9 A; Total Amps Y: 26.9 A; Total Amps Z: 26.9 A.

6.4. *Staff Hostel*

Table 16 depicts the proposed balanced load data on all three phases of the three-phase four-wire system of the Staff Hostel. In comparison with Table 8, it is clear that all three phases have almost equal load (i.e., 4.6 A, 4.7 A and 4.7 A), along with almost zero current (i.e., 0.1 A) in the neutral wire.

Table 16. Staff Hostel proposed load data.

Device Name	Watt	Volt	Amp	pf	Phase	Amp XN	Amp YN	Amp ZN	Amp N
Refrigerator	500	231	2.71 A	−8	X-N				2.7 A
Cooler	410	232	2.22 A	−8	Y-N			2.2 A	2.2 A
Cooler	410	233	2.22 A	−8	Z-N		2.2 A		2.2 A
Fan	80	234	0.43 A	−8	X-N			0.4 A	0.4 A
Fan	80	235	0.43 A	−8	Y-N		0.4 A		0.4 A
Fan	80	236	0.43 A	−8	Z-N			0.4	0.4 A
Fan	80	237	0.43 A	−8	X-N		0.4 A		0.4 A
Fan	80	238	0.43 A	−8	Y-N	0.4			0.4 A
Saver	25	239	0.14 A	−8	Z-N			0.1	0.1 A
Saver	25	240	0.14 A	−8	X-N		0.1 A		0.1 A
Saver	25	241	0.14 A	−8	Y-N	0.1			0.1 A
Saver	25	242	0.14 A	−8	Z-N			0.1	0.1 A
Saver	25	243	0.14 A	−8	X-N		0.1 A		0.1 A
Saver	25	244	0.14 A	−8	Y-N	0.1			0.1 A
Saver	25	245	0.14 A	−8	Z-N			0.1	0.1 A
Saver	25	246	0.14 A	−8	X-N		0.1 A		0.1 A
Saver	25	247	0.14 A	−8	Y-N	0.1			0.1 A
Saver	25	248	0.14 A	−8	Z-N			0.1	0.1 A
Saver	25	249	0.14 A	−8	X-N		0.1 A		0.1 A
Saver	25	250	0.14 A	−8	Y-N	0.1			0.1 A
Saver	25	251	0.14 A	−8	Z-N			0.1	0.1 A
Saver	25	252	0.14 A	−8	X-N		0.1 A		0.1 A
Saver	25	253	0.14 A	−8	Y-N	0.1			0.1 A
Qty. of Device: 47	2596	120/208V	14 A		3-Ph	4.6	4.7 A	4.7 A	0.1 A

Total Amps X: 4.6 A; Total Amps Y: 4.7 A; Total Amps Z: 4.7 A.

6.5. Cost Estimation

For balancing of the load, new cables were needed in the network and the installation of some equipment such as changeover switches and circuit breakers for extra protection. For this purpose, we estimated the cost of individual units and then we have estimated the total cost [20,21] of new installation, which is given below in Table 17.

Table 17. Estimated cost of wires and extra equipment used in the proposed balanced load system.

	Description	Size of the Cable	Length (m)	Quantity	Price/Meter (Cents)	Estimated Cost ($)
1	**Wiring Cable from the Faqir API Hostel to Staff Hostel (Generator Line)**	LT line 7/0.122	165	2 2 × 165 = 330	115	379.5
2	**Wiring Cable for Faqir API Hostel**	7/0.29	210	3 3 × 210 = 630	48	302.4
3	**Wiring Cable for the Rahman Baba Hostel**	7/0.29	406	1	48	195
4	**Wiring Cable for the Allama Iqbal Hostel**	7/0.29	383	1	48	184
5	**Wiring Cable for Academic Block**	7/0.36	640	1	55	352
6	**Change over Switch and Circuit breakers for the Allama Iqbal Hostel**			4 4 × 2500		100
	Grand Total					**1512.9**

7. Conclusions and Future Work

We have demonstrated a viable method for load balancing on a university campus in this article. We began by sketching all load units and then determining the linked load in each unit. Following that, we sketched the load unit's existing wiring system. Finally, we advocated balanced load units, balanced wiring, and the use of a bio-inspired moth–flame optimization (MFO) algorithm to ensure optimal load unit distribution. Additionally, we provided an estimate for the installation of the entire system. This not only ensures the system's reliability, but also eliminates the generation of a significant amount of current in neutral wire.

Different sorts of software may be employed in the future to balance three-phase load units more optimally on a large scale. Furthermore, a combination of new algorithms may increase the efficacy of the proposed model. In the future, the integration of renewable energy resource can enhance the system's performance much better through Distributed Generation (DG). The green IoT, Smart water management system and Electric Vehicle projects may add an enhanced level of credibility to the existing project and may enhance the level of the existing project of the campus to a challenging, smart and secure system.

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