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Research Article

Optimization and Design of a Sustainable Industrial Grid System

Samat Iderus,[1] **Geno Peter**,[1] **K. Praghash**,[2] **and Aruna Rai Vadde**[3]

[1]*CRISD, School of Engineering and Technology, University of Technology Sarawak, Sarawak, Malaysia*
[2]*Department of Electronics and Communication Engineering, Christ University, Bengaluru, India*
[3]*Department of Electrical and Computer Engineering, Debre Tabor University, Debra Tabor, Ethiopia*

Correspondence should be addressed to Aruna Rai Vadde; dr.rai@dtu.edu.et

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Electricity is a multifaceted form of energy and is used globally, with a continuously growing demand. Electrical power grids are there for more than 150 years. The generated electrical power is delivered to different industrial, commercial, and residential sectors, thereby fulfilling the ever-growing demand. In this research paper, the design and optimization of an industrial grid for various electrical loads is discussed. The electrical grid ensures a stable power supply to the loads by providing quality power with the minimum total harmonic distortion (THD) possible. A complete study of the short circuit current has been done in two different electrical grid systems, as it is seen that the short circuit current depends on the impedance of the transformer which feeds the load. These two designs of a single diagram will be simulated by using a power system analyzer, the Electrical Transient Analyzer Program (ETAP) software. The different electrical parameters, like choosing the optimised rated generator, cables, and transformers, are done. Load flow analysis is performed on both the design to evaluate the THD, short circuit fault, as well as to choose the right protection circuit for the system.

1. Introduction

Energy use in industrial plants has long been a significant financial consideration. Due to price fluctuation related to utility deregulation and system stability, energy cost control is critical to profitability. There are plentiful opportunities to expand power usage, reliability, and quality in an industrial environment. The power system plays a vital role in a process plant. A plant's operations and production depend on a safe and reliable power system. Each plant power system design, whether new or an expansion to an existing system, must be analysed to ensure that it is safe, is reliable, meets the present objective, and permits expansion for future needs [1]. At the planning and design stage of an industrial power system, the following considerations must be made: the electrical system must be designed cost-effectively for continuous and reliable service, people and equipment safety, ease of maintenance and operation, minimal power losses, mechanical equipment protection, interchangeability, and load addition [2, 3]. A major study based on many theories and actual experiences would be required to accomplish the above goals and obtain the expected results. Loads are constantly being eliminated in modest increments in many process facilities. The net effort is also not visible until a component of the system is overloaded or has other issues. Many times, circuits are added without the required reforms to the upstream circuit breakers' usual settings. The one-line diagram serves as a road map for optimal equipment design, redundancy, and protection. The goal of this study is to come up with solutions for categorising electrical loads in the energy industry and providing stable electricity to these loads using ETAP. The aforementioned study is to come up with answers on how diverse electrical loads should be classified in the energy business as well as how to supply these loads with reliable power sources. In addition, the critical role of the transformers' short-circuit impedance in regulating the short-circuit current will be addressed. The techniques for selecting electrical equipment and accessories, such as cables, transformers, and circuit breakers, are also provided. Basic design and detailed design are the two significant stages of the analysis. The location and process of the refinery are investigated in the basic design stage, and a preliminary estimate of the types of load and demand is obtained as a result. The best option is chosen for the next stage, and basic calculations, drawings, and specifications are

Table 1: Summary of the voltage drop from IEE Wiring Regulation.

Voltage drop points	Lighting (%)	Other uses (%)
1. Public low voltage distribution system supplying LV load	3	5
2. Private low voltage distribution system supplying LV load	6	8

Table 2: Percentage of allowable voltage drop by IEC 60364 : 2001.

Voltage drop points	Lighting (%)	Other uses (%)
1. Public low voltage distribution system supplying LV distribution systems	3	5
2. Private low voltage distribution system supplying LV distribution systems	6	8

*When the main wiring systems of the installation are longer than 100 m, these voltage drops may be increased by 0.005% per meter of wiring system beyond 100 m, without this supplement being greater than 0.5%.

produced as a result. We expect to publish detailed drawings in the detailed design, which will reflect our preference for enhanced power distribution with minimal power losses. As a result, all engineering-related details should be accomplished in this step. It is essential to recognize that all of the detailed documentation must meet the specifications.

2. Literature Review

2.1. Voltage Drop. Voltage drops on an electrical power distribution system are mainly caused by cables, transformers, and motors. Voltage drop describes how the supplied energy of a voltage source is reduced as electric current moves through the passive elements (elements that do not supply voltage) of an electrical circuit. Voltage drop happens when load current (I_b) flows through a conductor or transformer having a finite impedance. Severe voltage drops will result in motor failures, dimming of lamps, and CPU shutdown [4]. Voltage drop calculation is important to the system for maintaining the nominal voltage at service sides. Tables 1 and 2 depict the summary of the voltage drop from the IEE Wiring Regulation (BS7671 : 2008) and IEC60343 : 2001.

Voltage drop is determined from the current-using equipment, applying diversity factors where applicable, or from the value of the design current of the circuits.

The voltage drop can be determined by the following formula:

(i) Approximation method

$$\%V_d \approx \frac{\sqrt{3}\left|I_b\right| \times \left[R_L \times \cos\theta - X_L \times \sin\theta\right]}{V_S}, \qquad (1)$$

where V_d is the voltage drop, V_s is the system voltage, R_L is the circuit resistance in Ohms, X_L is the circuit reactance in Ohms, I_b is the design current/line current, and θ is the phase angle of line current.

(ii) Tabulated method

$$V_{\text{drop}} = \frac{\text{tabulated}\,(\text{mV/A/m}) \times I_b \times l}{1000}\,\text{volts}, \qquad (2)$$

where V_d is the voltage drop, mV/A/m is the tabulated cable value in milli volt per ampere per meter, I_b is the design current/line current, l is the length of the cable, large voltage drop can be caused by a variety of factors, including the following:

(i) Incorrect conductor size (undersized).

(ii) Incorrect conductor diameter and length.

(iii) Improper cable conducting material.

(iv) The actual load current exceeds the design circuit current.

2.2. Short Circuit Fault. A fault in an electrical power system is a failure which interferes with the normal flow of current. Faults occur when two or more conductors that normally operate with different potentials come into contact with each other. When fault occurs in a system, it induces a large current flow and this will cause damage to the equipment [5]. During fault occurrence in a network, it will have an effect on the generator due to the short circuit at the point of the generator. Short-circuit current exceeds locked-rotor current and can reach thousands of amperes [6]. The maximum short circuit current occurs at the time of fault occurrence only, which is when the system is at fault. Short-circuit current can also lead to arcing or flashing, which may cause severe damage to the power system. The severance effect of short circuit current is seen in a bolted fault more than in an arcing fault [7]. The short circuit current may be classified into "symmetrical" and "asymmetrical" terms, which are terms used to describe the symmetry of the short-circuit current waveform around the zero axis. A "fault" is another term for a short circuit. It is a particular type of current that injects a lot of energy into a power system. It can take the form of either heat or magnetic force. In essence, it is a low-resistance energy channel that bypasses part of a circuit and causes the bypassed circuit to stop operating. The reliability and safety of electric power distribution systems depend on accurate and thorough knowledge of short-circuit fault currents that can be present and on the ability of protective devices to satisfactorily interrupt these currents [8].

Figure 1 describes the typical short circuit current waveform. The symmetrical short circuit current contains only the pure alternating current component within its sinusoidal waveform [9]. It is applicable only to balanced three-phase power systems and can be calculated as the total line-to-neutral voltage over the total impedances of the power system. The reliability of power electronic converters

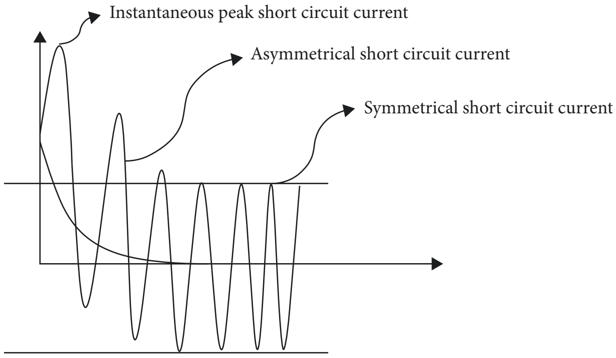

Figure 1: Short current waveform.

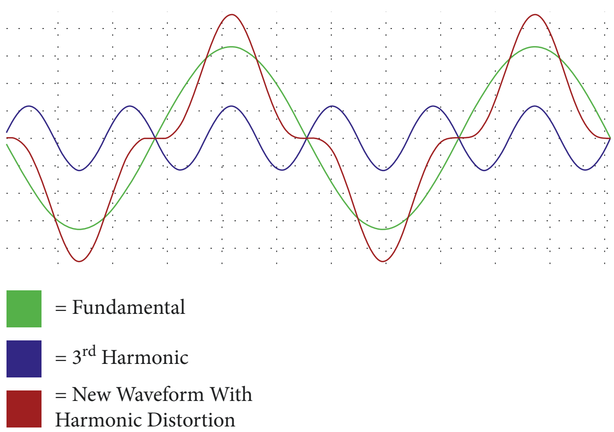

Figure 2: Harmonic distortion waveform.

used in a power system is very important for improving the overall power system design [10].

The asymmetrical short circuit current is the actual current that flows during a fault condition. It consists of direct current (DC) and alternating current (AC) components that contribute to a certain amount of "DC offset" in the waveform immediately after the initiation of the fault. The amount of "DC offset," or asymmetry, depends on the point where the fault occurs. The instantaneous peak short circuit current is the maximum peak instantaneous fault current on the asymmetrical short circuit current waveform [11].

2.3. Harmonics in Power System. A "sinusoidal component of a periodic wave or quantity with a frequency that is an integral multiple of the fundamental frequency" is how a harmonic is defined. As a result, harmonics can be defined as voltages and/or currents in an electrical system that are a multiple of the fundamental frequency as shown in Figure 2. The fifth (300 Hz), seventh (420 Hz), and eleventh harmonics are typical for a 60-Hz system (660 Hz) [12].

The direct outcome of harmonics might be power system problems such as communication disruptions, heating, and defects in the solid-state equipment. The following categorization and list of these problems are given with a short explanation or an approach to understand each of the reasons [13]. The most important issue related to power quality is harmonics [14]. The so-called "communication interference" can be caused by magnetic couplings between electric circuits and communications systems. The current flow of the power system results in the generation of a magnetic field, which induces a current in the surrounding communication connectors. The level of interference will depend on the magnetic coupling magnitude of the induced current, frequency, and efficiency [3, 7]. The other effects include the following:

(i) Induced line noise
(ii) Power line carrier system interference
(iii) Relay malfunction.
(iv) Solid-state Device Malfunctions

If the equipment is susceptible to null passages, harmonics may cause solid-state devices to fail. Resonance can cause zero crossings to occur more than once every half cycle in the current waveform [13]. This mode is usually exemplified by the diode. Since a device's operational parameters are usually defined in terms of user convenience root mean square (RMS), in the presence of harmonics, it may not function effectively since it senses a pinnacle value that does not directly match the RMS value of the wave shape [3, 4, 11]. Other defects in the stability system include the following:

(i) Mistakes in measuring equipment
(ii) Molestation in the operation of relays and breakers
(iii) Unstable interference with the engine controls of the zero voltage crossing

2.4. Previous Work. Arizaldi et al. [15] used ETAP software in conducting case studies for calculations of short circuit disturbances. The author of this paper attempts to determine the safety capacity that is capable of protecting the electrical system, and the same is functioning well in the electrical system of Lhokseumawe [15]. Riaz et al. [16] proposed a harmonic analysis in industry using a Fluke Energy Analyzer. The measured THD percent values for the voltage and current were utilised to model and analyse global harmonics in the Textile Plant's complete three-phase distribution system via simulation utilising ETAP software. Using the Fluke Energy Analyzer to take measurements, it was determined that the 5th and 7th harmonic orders are the most dominant in magnitude and are responsible for increased THD levels. ETAP utilised the Fluke Energy Analyzer results to perform a harmonic analysis of the entire plant. A resonance phenomenon was identified as a result of the conventional capacitor bank used to improve the power factor. Consequently, a single tuned filter was created, and the power factor improvement bank was replaced with a single tuned filter. The harmonic filter not only reduced the level of harmonic distortion but also improved the power factor [16]. ETAP software was used to analyse power system harmonics and discuss the full approach in detail by Azim Bhuiyan [17]. In order to inject harmonic current into the power network, a general load was simulated as a harmonic source. A harmonic load flow analysis was then performed to

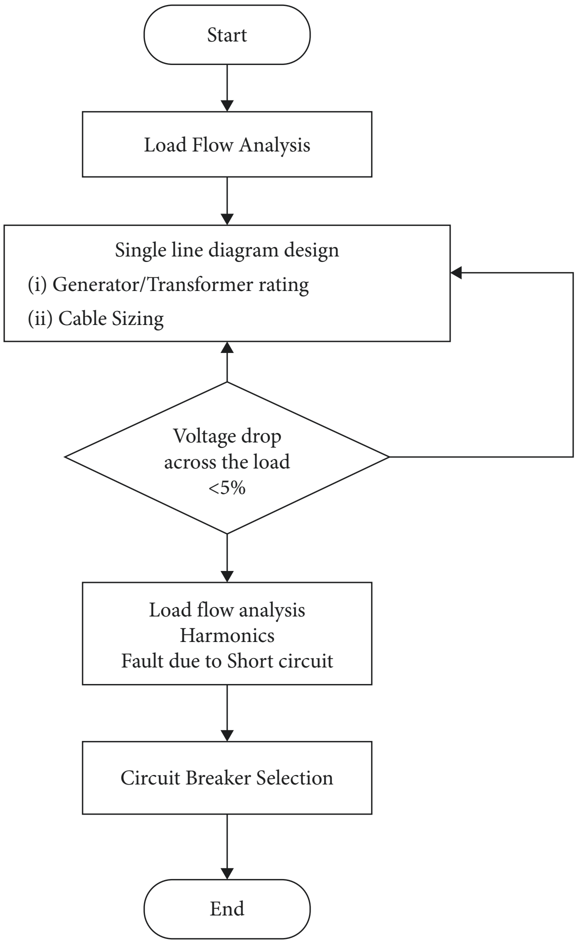

Figure 3: Flow chart of the research.

determine the impact of harmonic current, and harmonic distortion was detected [17].

3. Methodology

ETAP software is used in implementing the one-line diagram. Figure 3 describes the method used in completing the research. In this research, there are two designs for one-line diagrams proposed by using the ETAP software, which are Design A and Design B. Then, to meet the requirements of the design power system industry, analyse the technical report from ETAP software, which includes short circuit, THD, and voltage drop.

3.1. Load Analysis. Load analysis would be the first step before designing the whole distribution system. This is important in determining the incoming supply for each load and the total power that is needed for the whole system. From the analysis, two levels of incoming supply are needed for the loads, which are the 6.6 kV for process compressors A, B, and C and 415 V for the rest of the loads. The longer the transition detection time is, the more dangerous power electronic equipment operation is [18].

A feasibility study on the given industrial loads in Table 3 was performed in this power demand estimation. This study has focused on the proposal of divisions of the installation area/section, the total estimated power demand (P and Q for continuous, intermittent, and standby), and the overall power factor of the industrial installation. The estimated power demand is analysed into three categories:

(i) Operating load.
(ii) Peak load (C + I + S).
(iii) Design load (Peak load + 10% operating load).

Table 4 shows the total estimated power demand for different types of operating loads.

3.2. Cable Sizing. In designing the cable sizing of Design A and Design B, the cable sizing compiles or refers to the standards of BS 7671 : 2008, IEE Wiring Regulations 17th Edition, and IEC 60364 : 2001. In the ETAP software, the cable sizing follows the standard from the IEC. In order to select the cable size, the properties or steps are as follows:

(i) Based on the current, the size of the required cable is calculated.
(ii) Based on the Voltage drop, the size of the cable may increase.
(iii) Based on the short circuit current, the size of the cable may increase.

Both cable size and length have an impact on both current and voltage. Its impact on the voltage is much greater than that on the current. Various lengths of feeder cable were selected for this research in order to compare which design follows the limitation design from the theory. The various lengths of cable are investigated with the help of the ETAP software.

3.3. Transformer Sizing. A "transformer is the heart of an AC system." The transformer is the most important unit in an electrical distribution network. A transformer is a passive electrical device that transfers electrical energy from one electrical circuit to one or more other circuits. A transformer can be loaded up to 110% of the rated voltage, provided the cooling unit is healthy. There are many factors that need to be considered when choosing the right sizing of the transformer. The factors are as follows:

(1) Size of transformer to be powered.
(2) Machines and appliances to be installed.
(3) Location.
(4) Personnel capacity of building or structure.

The designs mostly follow the voltage distribution levels (33 kV, 22 kV, 6.6 kV, and 0.415 kV) and the classification of load types. Two designs are being prepared for comparison purposes. For the designs, the loading section will have the same topology and the only part that differs is the head (transformer and voltage distribution) for investigation purposes. Figures 4 and 5 show the one-line diagram for both designs. For this research, a standard frequency of 50 Hz was chosen, and the IEC standard is used in doing ETAP work.

Table 3: List of industrial loading.

Load description	Real power (P) KW	Reactive power (Q) KVAR	Power factor	Apparent power (S) KVA	Voltage (V)	Current (I) KA	Duty (%)	Estimate power demand (PD) KW
Split unit air conditional	50.00	30.99	0.85	58.82	415.00	0.08	100	50.00
General lighting distribution board (DB)	5.56	2.69	0.90	6.17	415.00	0.01	100	5.55
General power sockets	33.33	20.66	0.85	39.22	415.00	0.05	100	33.33
Fire water pump A	85.23	50.57	0.86	99.10	415.00	0.14	10	8.52
Fire water pump B	85.23	50.57	0.86	99.10	415.00	0.14	10	8.52
Fire water pump C	85.23	50.57	0.86	99.10	415.00	0.14	10	8.52
UPS system	88.89	55.09	0.85	104.58	415.00	0.15	100	88.88
Process compressor A	842.11	477.24	0.87	967.94	6600.00	0.08	100	842.10
Process compressor B	842.11	477.24	0.87	967.94	6600.00	0.08	10	84.21
Process compressor C	842.11	477.24	0.87	967.94	6600.00	0.08	100	842.10
Recirculation pump A	46.51	31.26	0.83	56.04	415.00	0.08	100	46.51
Recirculation pump B	46.51	31.26	0.83	56.04	415.00	0.08	10	4.65
Recirculation pump C	46.51	31.26	0.83	56.04	415.00	0.08	100	46.51
Conveyor motor A	33.33	25.00	0.80	41.67	415.00	0.06	100	33.33
Conveyor motor B	33.33	25.00	0.80	41.67	415.00	0.06	100	33.33
Conveyor motor C	33.33	25.00	0.80	41.67	415.00	0.06	100	33.33
Welding system A	13.64	6.60	0.90	15.15	415.00	0.02	50	6.82
Welding system B	13.64	6.60	0.90	15.15	415.00	0.02	50	6.82
Welding system C	13.64	6.60	0.90	15.15	415.00	0.02	50	6.82
HVAC	100.00	61.97	0.85	117.65	415.00	0.16	100	100.00
Lighting DB A	22.22	13.19	0.86	25.84	415.00	0.04	100	22.22
Lighting DB B	22.22	13.19	0.86	25.84	415.00	0.04	10	2.22
Lighting DB C	22.22	13.19	0.86	25.84	415.00	0.04	100	22.22
Lift	11.76	8.21	0.82	14.35	415.00	0.02	50	5.88
Total (P, Q, S, I & PD)	3418.65	1991.19		3957.99		1.72		2342.41

Table 4: Total analysed estimation power demand.

Types of load	Total power (kW)
i. Operating load	2166.12
ii. Peak load	2342.44
iii. Peak load + 10% of (i)	2559.06

4. Result and Analysis

Using ETAP the optimization analysis is done between the two simulated one-line diagram designed and the best out of it chosen. The analysis is based on the below mentioned:

(i) Design of one-line diagram

(ii) Voltage drop

(iii) Short circuit analysis

(iv) Harmonics

4.1. Design of One-Line Diagram (Design A and Design B). Figures 4 and 5 illustrates the one-line diagram for Design A and Design B, respectively. Figure 4 illustrates Design A; a 33 kV (100 MVAsc) of incoming power supply from the utility is stepped down to 6.6 kV by a 33 kV/6.6 kV (20 MVA) step down transformer. The voltage is then further stepped down to 415 V by a 6.6 kV/415 V (5 MVA) step down transformer. In Design B as shown in Figure 5, the incoming 33 kV of power supply is stepped down to 6.6 k by a 33 kV/6.6 kV (10 MVA) step down transformer at one end and is stepped down to 11 kV by a 33 kV/11 kV (4 MVA) transformer at the other end. A 11 kV/415 V (1 MVA) is used to reduce the voltage from 11 kV to 415 V. From incoming voltage for both designs, six groups of load are divided each consisting of the following loads:

(i) Process Compressor

(ii) Conveyer motor and lift

(iii) Welding system

(iv) Firewater pumps

(v) General lightings

(vi) Air conditioner, UPS, HVAC, and sockets

The comprehensive load modelling is performed in the ETAP based upon original system data. Different design between Design A and Design B are summarised as in Table 5 below.

In Design B, instead of using a single 33 kV/415 step down transformer, a 33 kV/11 kV step down transformer and a 11 kV/415 V transformer is used to step down the voltage from 33 kV to 415 V. It is not advisable to step down directly for following reasons. The transmission of electrical energy will experience losses if the system is directly stepped down from 33 kV to 415 V.

4.2. Voltage Drop Analysis (Design A and Design B). The ETAP software calculates the voltage drop for each bus as shown below in Figures 6 and 7. The voltage drop (V_d) is

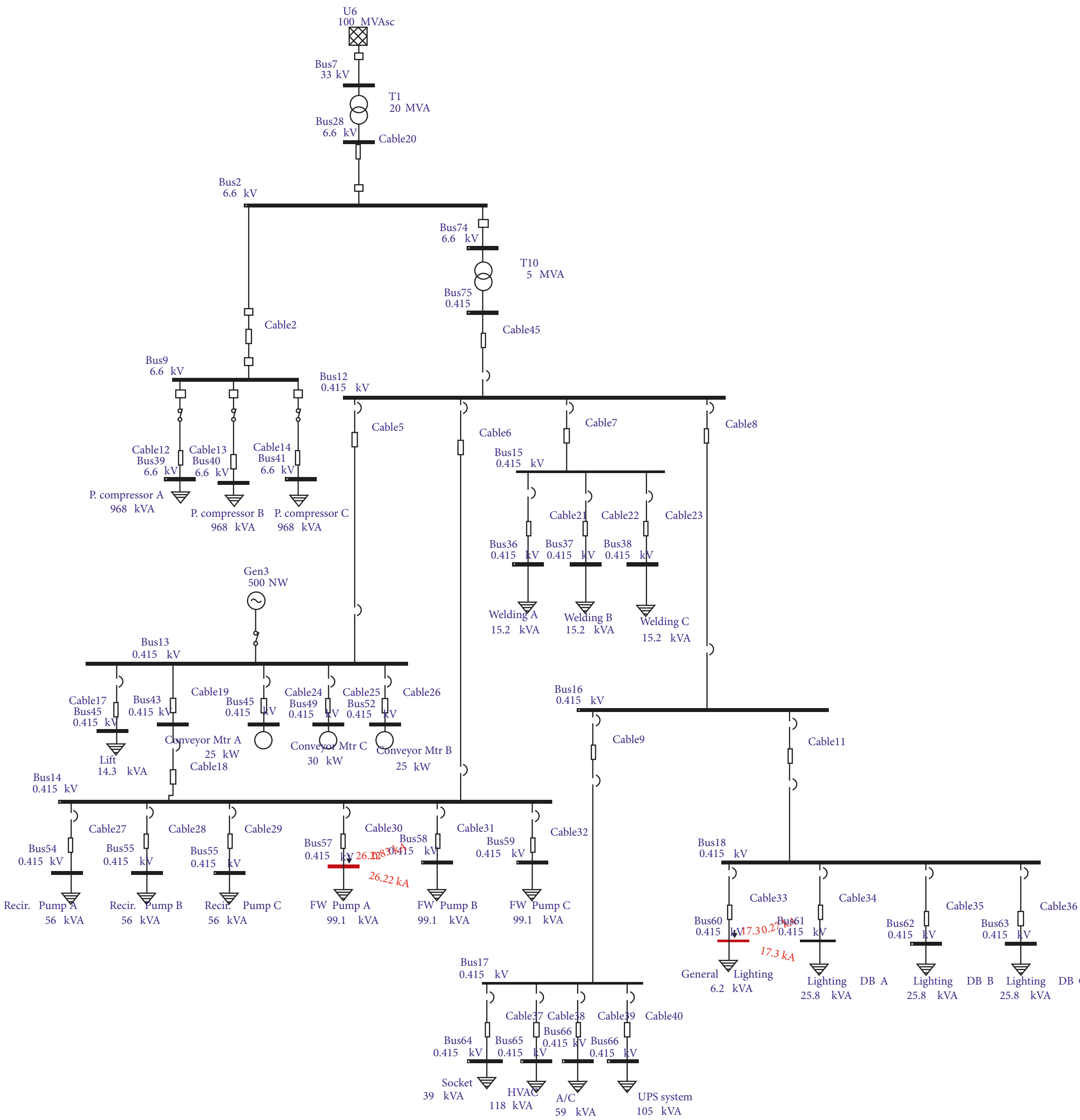

Figure 4: Single Line diagram-Design A.

measured after voltage has flowed through the bus line as well as the loading on the bus, such as transformer, cable, and other loads. Then the voltage loss is computed and displayed. According to the results achieved in Design A, the highest voltage drop is observed at cable 8 with a V_d value of 0.64 percent, while the lowest voltage drop is observed with a Vd value of 0 percent. Because the percentage of voltage drop is less than the allowable voltage drop, which is less than 5%, this design may be considered acceptable. In Design B, it demonstrates that the highest voltage drop is measured at transformer 10, which has a 0.34% V_d. The lowest voltage drop is measured to be 0.0%.

The difference in reading the voltage drop is due to the distance between the cable and the impedance of the cable. Also, the voltage drop in the transformer is due to the sizing of the transformer. The arrangement of the transformer also plays a main role in the voltage drop. In Design B, the number of transformers used is three, and there is utilisation of the tap changer transformer. The purpose of the tap changer transformer is to supply a desired voltage to the load, to counter the voltage drops due to loads, and to counter the input supply voltage changes on load. The voltage control is done by changing the turn ratio. This is done by the provision of taps in the winding. Design B can

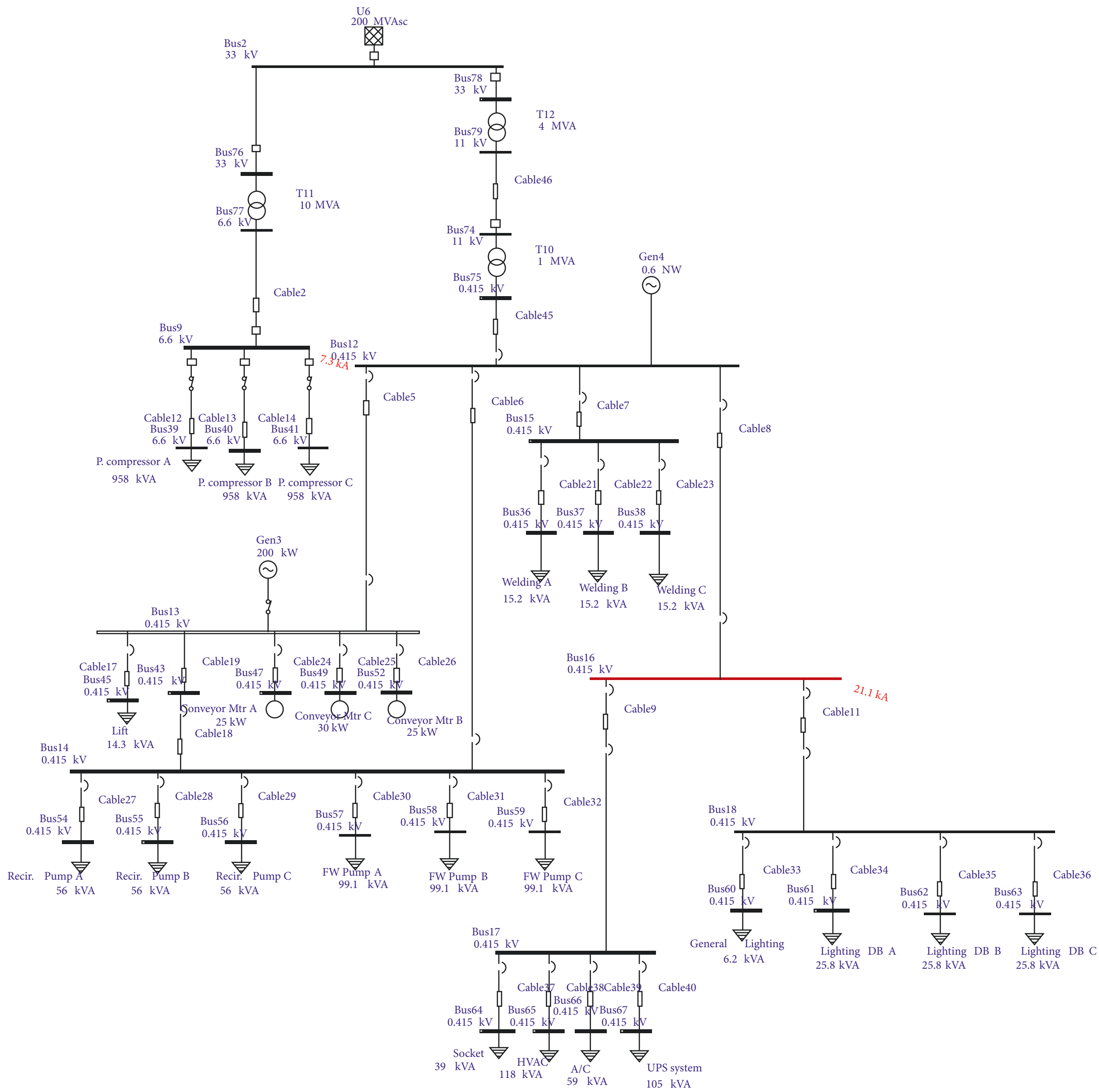

Figure 5: Single Line diagram-Design B.

Table 5: Comparison load modelling for Design A and B.

No	Design A	Design B
1	Step down voltage rating 33 kV ⟶ 6.6 kV ⟶ 415 V	Step down voltage rating 33 kV ⟶ 11 kV ⟶ 415 V
2	Two transformers	Three transformers
3	One emergency generator set	Two emergency generator set
4	Same sub load	Same sub load
5	Different design in supplying power	Different design in supplying power
6	100 MVA supplying power	200 MVA supplying power

also be said to be a good design because the percentage of the voltage drop is less than the acceptable voltage drop, which is 5%. The report generated by ETAP for the voltage drop is shown in Figures 6–8 from the branch losses summary report.

Table 6 summarises the report's findings for both case studies in relation to the IEE Wiring Regulation (BS7671 : 2008) and IEC60343 : 2001. According to the data, Design B is a better design to Design A in terms of voltage drop percent.

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop in Vmag
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	
Cable 2	1.752	0.993	-1.752	-0.993	0.1	0.1	99.6	99.5	0.01
Cable 20	-2.288	-1.344	2.288	1.344	0.3	0.4	99.6	99.6	0.02
Cable 7	0.020	0.010	-0.020	-0.010	0.0	0.0	98.4	98.4	0.02
Cable 8	0.311	0.192	-0.310	-0.191	1.6	2.0	98.4	97.8	0.64

FIGURE 6: Report list for voltage drop percent at cable 8 in Design A.

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop in Vmag
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	
T10	0.083	0.395	-0.082	-0.387	1.4	8.0	100.0	100.3	0.34
T11	1.766	1.033	-1.764	-1.000	2.2	33.4	100.0	99.9	0.11
T12	0.084	0.398	-0.083	-0.395	0.3	2.9	100.0	100.0	0.01
					6.7	48.0			

FIGURE 7: Report list for voltage drop percent at transformer 10 in Design B.

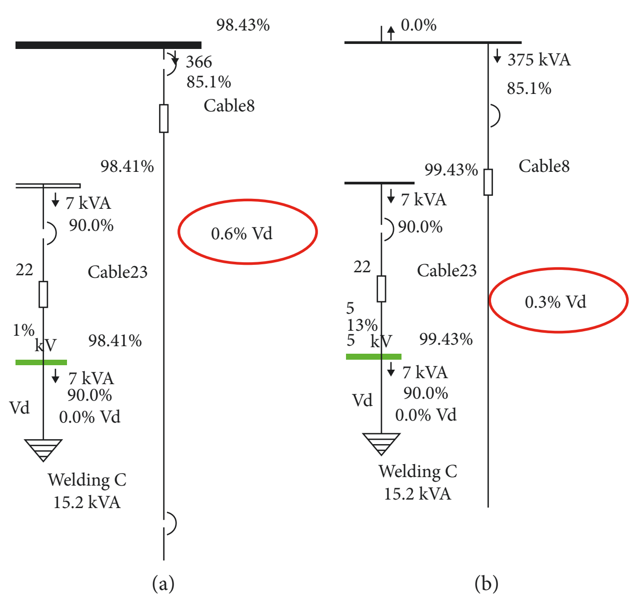

FIGURE 8: Branch summary report. (a) Design A–V_d at cable 8. (b) Design B–V_d at transformer 10.

TABLE 6: Summarised report of Voltage drop between Design A and Design B.

Type of supply	BS7671 : 2008 (%)	IEC60343 : 2001 (%)	Design A	Design B
Public low voltage distribution system supplying LV load	5	5	Cable 6 = 0.65% Cable 8 = 0.64% Cable 9 = 0.27% Cable 38 = 0.10% Cable 45 = 0.56% Transformer 1 = 0.43%	Cable 6 = 0.12% Cable 8 = 0.33% Cable 9 = 0.28% Cable 45 = 0.32% Transformer 10 = 0.34%

Table 7: Summaries of fault current between Design A and B.

No	Design A	Design B
1	Fault current at bus 57 = 26.44 kA	Fault current at bus 9 = 7.3 kA
2	Fault current at bus 60 = 17.3 kA	Fault current at bus 16 = 21.1 kA

Table 8: Comparison of %THD for Design A and Design B.

No	Industrial load	%THD	
		Design A	Design B
1	Process compressor	1.92	1.40
2	Conveyer motor	2.11	1.50
3	Lift	2.11	1.51
4	Welding system	2.12	1.51
5	Firewater Pumps	2.13	1.53
6	General lightings	2.25	1.59
7	UPS and HVAC	2.31	1.65
8	Air cond and sockets	2.30	1.64

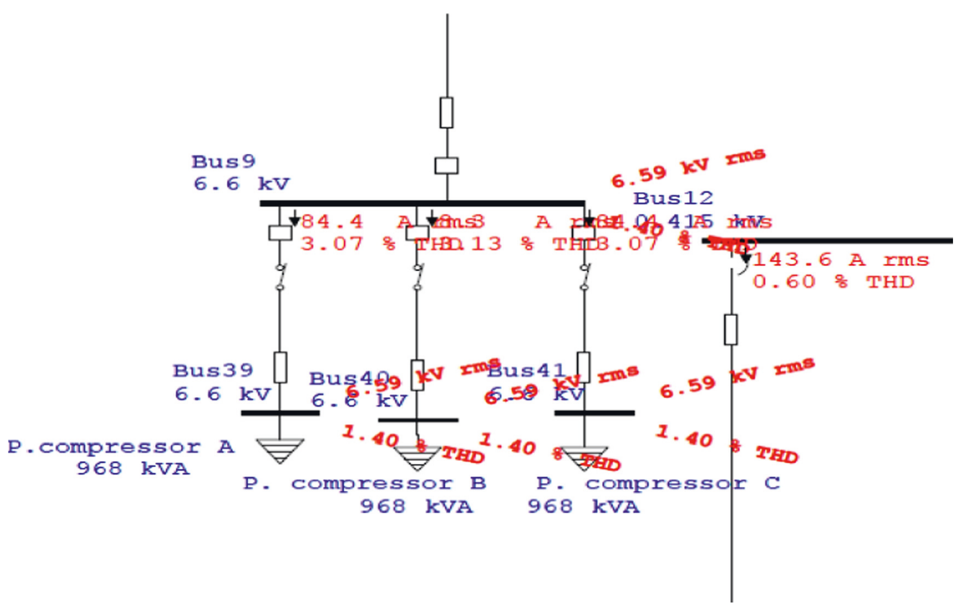

Figure 9: Value of %THD for load process compressor.

4.3. Short Circuit Analysis (Design A and B). In Design A the fault is located at the bus 57 and bus 60. When the fault occurs, the current value at the bus 57 increased up until 26.44 kA and the current value at bus 60 rise to 17.3 kA. While for the Design B, the fault is located at the bus 9 and bus 16. Table 6 summarises the fault current for both of design.

The current on bus 9 climbed to 7.3 kA during the fault, whereas the current on bus 16 jumped to 21.1 kA as shown in Table 7. The current value becomes extremely high because the impedance to current flow is extremely low. The fault current generated during a short circuit has a tendency to take the small impedance path and always reaches the ground. The evaluation of the earth faults and localization is very important for an industrial grid [10]. The closer the power sources are, the more they contribute to the fault current. Currents from the separate power sources concentrate near the fault, resulting in a total fault current that can be hundreds of times larger than usual. Design B is determined to be better than Design A in terms of fault current since the magnitude of the fault current is substantially reduced compared to Design A.

4.4. Harmonics. Total harmonic distortion is measured in percentage. From Table 8, all loads in Design B shows the lower value of THD compared to Design A which indicates the higher value of THD.

Design B demonstrates that lower percentages indicate significantly smaller THD. The difference between these two designs can be seen in the waveforms and spectrums. The overall harmonic current and voltage restrictions for this

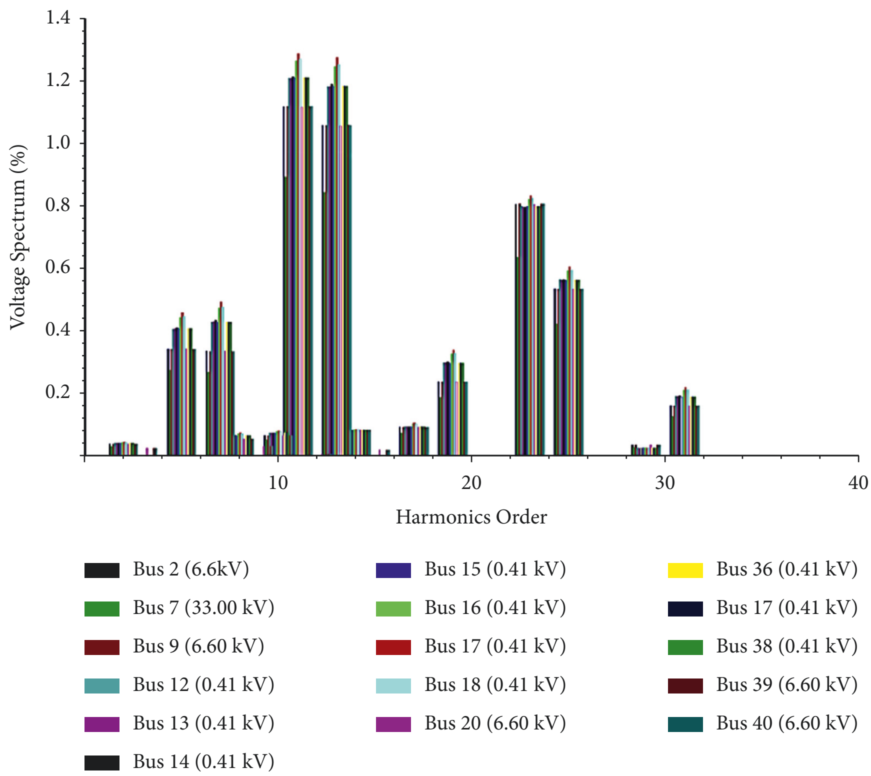

Figure 10: Harmonic diagram bus Design A–Spectrum.

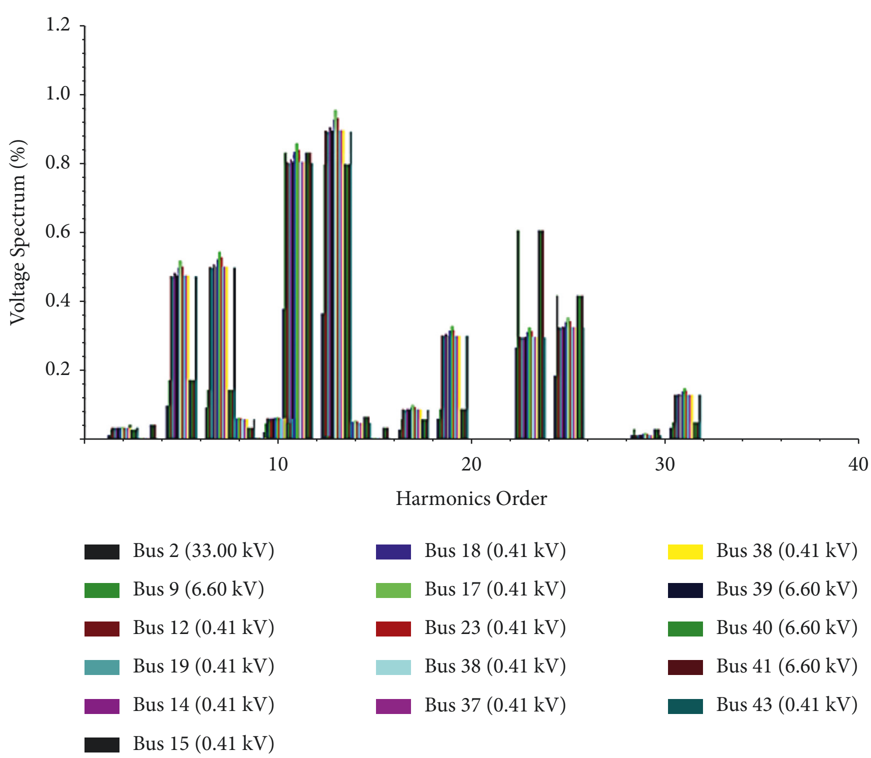

Figure 11: Harmonic diagram bus Design B–Spectrum.

power system will be set at 8% and 5%, respectively, by the IEEE519-92 standard. The objectives of the current limits are to limit the maximum individual frequency voltage harmonics to 3% of the fundamental and the voltage THD to 5% for systems. The results obtained show the circuit succeeds in achieving THD of less than 5%. Figure 9 shows the

THD for the process compressor under design B. Figures 10 and 11 show the harmonic spectrum for designs A and B, respectively.

5. Conclusion

The goal of this research is to design a long-term industrial power system in a practical situation. Two separate power systems of one-line diagram have been built with both systems in reference to the environment and sustainability issues, safety of personnel and equipment, minimum power losses, harmonic analysis, and addition of the load using the ETAP software. Before designing the one-line diagram, effective load planning and total power demand estimation must be established, and the loads must also be classified according to their rating and powered by a reliable power source. The precise load list in terms of required power, load factors, load types, and relevant feeding types assures a reliable system. During the designing of the one-line diagram, selection procedures of the electrical equipment and accessories, including cables, transformers, and circuit breakers, are presented with the following factors: the size of equipment, voltage drops, losses, and THD will be checked by the load flow study and according to the standards.

Cable sizing, for example, is vital in many aspects, such as cost, voltage drop, and reactive power losses. Improper cable sizing could have a severe impact on the system, resulting in faulty conditions. After finalising the power system design, the two designs are analysed by applying energy efficiency considerations to specific loadings such as voltage drop analysis, fault current analysis, and THD analysis. According to the results of the analysis, Design B is significantly better than Design A. Upon completing this research, it is evident that designing an electrical system is not a straightforward process, and there are numerous factors that should be carefully examined, either on the estimating or analysis side.

Data Availability

The data can be obtained from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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