Case study on improvement of low voltage power engineering essay

This case study provides investigations on low voltage power distribution system in terms of electrical system design at INTEC Section 17 Shah Alam. It was conducted to ensure that the system applied is viable where it could lead to reliable and economical distribution of power. Therefore, this project was focused on 415V feeder pillar where suggestion can be offered to improve the respected system design.

Distribution system is a system built to provide a means of economically and reliably distributing power from one, or occasionally more than one main location to a number of geographically dispersed load centres within a defined site boundary [1]. Low voltage power distribution system is the portion between primary feeder and utilization equipment. Therefore, the purpose of low voltage distribution is to distribute power to end user where at the same time providing safe conditions. Internatioanl Education College (INTEC) Section 17, Shah Alam is the place where this case study was carried. The low voltage distribution system applied at INTEC is conventional simple radial distribution system where the operation and expansion of the system are simple. However, problems occur as the power transformer (2000kVA 11kV/433V) is overheated and the cables insulation of secondary windings is melted due to overload. The system itself is quite old where feeder pillar used to allocate the power to specify load is quite congested where it need some upgrade. Therefore, to tackle those problems regarding on low voltage distribution system, suggestions can be offered to improve the system that meets the specifications of electrical standard and at the same time satisfy the end users. Hopefully it can be additional information for the INTEC Facility Unit to overcome the problems and upgrade the respected feeder pillar to provide safe, economical and reliable power to the end users.

OBJECTIVES

The objectives of this case study are:

To obtain a relative information regarding on the low voltage power distribution system of INTEC.

To observe the congested feeder pillar design and implementation at INTEC.

To identify problems related to the congested feeder pillar.

To propose for the improvement of congested feeder pillar.

METHODOLOGY

The case study of low voltage power distribution at INTEC was carried out based on the primer source of information such as books, journals, articles and related electrical specifications by The Institute of Electrical and Electronic Engineer (IEE), Tenaga Nasional Berhad (TNB), Suruhanjaya Tenaga (ST) and Jabatan Kerja Raya (JKR). With cooperation of local Facility Unit of INTEC, observations of respected substation and feeder pillar have been done. Some photo and reading has been taken to visualize the respected problems regarding on the overheated transformer and congested feeder pillar. Therefore, from those data, suggestions can be offered to overcome the problems and at the same time to improve the congested feeder pillar. Finally, for future study, opinions can raised for the further improvement of low voltage power distribution system.

LOW VOLTAGE POWER DISTRIBUTION SYSTEM

Distribution Feeder

Feeder is the distribution lines that carry power throughout the distribution system. Radial distribution feeders are characterized by having only single path for power to flow from the source (substation) to the consumer load. The distribution network is composed of the substations and the feeders that they supply.

Feeders are composed of sections - each serving a purpose. The mainline is the backbone of the feeder and is typically a three-phase line generally designed for 400A nominal and 600A contingency loading. From this mainline, three-phase or single-phase laterals extend. Laterals are branches that are connected to the main line to serve loads, which can have laterals of their own. To protect mainlines from faults in the laterals, these are typically fused or switched by remote reclosers.

Figure 1. Electricity Supply Specification in Malaysia

The most common configuration for feeders is a four-wire wye configuration; one conductor for each of the three phases plus a solid multi-grounded neutral conductor. Nevertheless, less common configurations are three wire wye and delta configurations. Four-wire wye configurations are extensively used for their safety and easy fault protection [4]-[7]. This circuit type permits the use of under-rated voltage equipment by using phase-to-ground voltages, and fuse protection for ground faults.

Feeder Pillar

Feeder Pillar is the electrical compartment that consists of equipment that distributes power to the respected loads. It controls the switching of load where at the same time provides protection to the distribution line. Conventional feeder pillar consists of busbar, circuit breaker, earthing protection and metering equipment.

The loads can be calculated by (1) for single phase and (2) for three phase system where it is proportional to voltage (V), current (I) and angle between voltage and current (θ):

$P= VI \cos \theta$. (1)

$P=\sqrt{3}\ VI \cos \theta$. (2)

By applying diversity factor, the load consumption should be less than the calculated value from (1) or (2) where the same load will not be used all the time. Diversity is the engineering principle that in any given installation, some of the connected loads will not be running at the same time instant as other loads [8]. Therefore the maximum demand of loads can be obtained to ensure that the cable and protection used is viable throughout the system.

The voltage drop of cable is affected by cable length (L), tabulated voltage drop (mV/A/m) and the design current (Ib) as shown in (3).

v. d. (V) = [(mV/A/m) - L - Ib]/1000. (3)

Protection

Moulded Case Circuit Breaker (MCCB) is used to interrupt the current path during fault occurrence. It is applicable for TPN (Three Phase and Neutral) cables while Miniature Circuit Breaker (MCB) has lower rating compared to MCCB and it is only applied for SPN (Single Phase and Neutral) line.

Earthing of the feeder pillar will provide protection from leakage current to ensure the safety to human from the danger of electric shocks during testing or maintenance.

LOW VOLTAGE POWER DISTRIBUTION SYSTEM IN INTEC

INTEC HT Distribution System

The incoming supply for INTEC from TNB is 11kV. Then it is step down to 415V by 2000KVA distribution transformer. The overall HT simplified schematic diagram of INTEC can be observed as below:

Figure 2. Simplified schematic diagram for HT electrical system in INTEC

Low Voltage Distribution System

Next, the focus will be at Pencawang Elektrik No. 1 where observation is done at Feeder Pillar No. 1. The schematic diagram of LV side from Pencawang Elektrik No. 1 can be seen from Fig. 3. INTEC used radial distribution feeder since it required lower cost, easier fault current protection, lower fault current and easier voltage control.

Figure 3. MSB schematic diagram of LV at Pencawang Elektrik No. 1

Feeder Pillar

Feeder Pillar No. 1 is located between Block B (Cafeteria) and Block A (Computer Lab). This feeder pillar was connected from MSB. The maximum current rating for the MCCB of incoming is 600A.

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Figure 4. Feeder Pillar No. 1

This respected feeder pillar distributes power to Bengkel Seni, Futsal Court, Cafeteria and Compound Feeder Pillar (Fig. 5).

Figure 5. Schematic diagram for Feeder Pillar No. 1

By applying the diversity factor, the value of protection and cable sizing shall fit the estimated load. TABLE. I shows the maximum load that the system can withstand at a time. The power at maximum demand is calculated using (2). The power factor is maintained at 0. 85.

TABLE I. LOAD AT MAXIMUM DEMAND

Load

Power (kW)

MCCB Rating (A)

Bengkel Seni

61. 098

100

Futsal Court

38. 492

63

Cafeteria

61. 098

100

Compound Feeder Pillar

48. 878

80

(Estimated value of load at maximum demand in Feeder Pillar No. 1)

From the existing load as tabulated above, the calculated nominal current is 341. 363A using (2). Therefore the rated current of MCCB for the incoming is viable where the rated current of MCCB is 600A.

The cables are connected to the busbar. Types of cables used is 4 core, 0. 6/1kV, Copper Cable with earth termination. The cables are terminated to the busbar as visualised in Fig. 6.

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Figure 6. Cables connection to the busbar.

From the above figure, it can be observed that the cables connection quite messy where it is hard to indicate which cable is connected to their respected load. It is not labelled to identify the cable. If fault occurrence, it will took a time for the technician to perform maintenance due to the congested condition of the cable.

The cable size for each line can be seen from TABLE II.

TABLE II . CABLE SIZING

Type

MCCB (A)

Cable Size (mm2)

2 x 4C XLPE

600

185

1 x 4C XLPE

100

50

1 x 4C XLPE

100

50

1 x 4C XLPE

80

35

1 x 4C XLPE

63

25

Earthing

Earthing is purposely used to protect human from electric shock due to current leakage. Therefore this feeder pillar has the same earthing mechanism for safety reason.

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Figure 7. Earthing of Feeder Pillar No. 1

From the fig. 7, all cables are terminated at the same point where it can provide easy path with a low resistance to earth and protect consumer from electric shock. However, those earth cables is not insulated which could lead to current leakage throughout the feeder pillar compartment in case the cable touch the wall of feeder pillar where it is made of steel (good conductor). Therefore, if such case happened it will cause electric shock to human who touch the feeder pillar.

PROPOSED SYSTEM

Radial Distribution System Improvement

By referring back to the type of distribution feeder system approached at INTEC, radial type of distribution feeder is applied. Even though radial circuits are simpler to operate and maintain, in order to increase the reliability and power quality of distribution feeders, networked configurations must be used [4][5][8]. However the installation cost of network system will be major obstacle where it required total modification of system. Therefore, primary loop radial distribution system can be applied to make the system more reliable.

Figure 8. Primary loop distribution system

Figure 9. Proposed MCB

Fig. 8 and 9 illustrate on how the system will look alike when improvement can be applied. The primary loop consists of two feeders which serve one or several loads. If one feeder fails, the normally open switch can be automatically (or manually) closed to feed the loads from the backup feeder, once the bad section has been sectionalized. This approach is very useful especially for underground cable system since the maintenance of underground cables is complex process that would create long interruptions if failure occurs.

Feeder Pillar Proposed Design

From the Feeder Pillar No. 1, suggestion can be offered to improve the system is upgrading the feeder pillar to MSB. By referring back to fig. 5, there were two loads that have circuit breaker rating of 100A TPN MCCB while in the MSB as in fig. 3 there were spare load that can be used. Therefore those two loads from Cafeteria and Bengkel Seni can be directly connected to MSB. By this action, the congested condition of feeder pillar can be solved.

Figure 10. Upgrade of feeder pillar to MSB

Some benefits can be obtained if the load of Bengkel Seni and Cafeteria is transferred to MSB:

If fault occur at Feeder Pillar No. 1, those loads will not being interrupted. Therefore it promises the continuity of power supply to the load.

The voltage drop of each cable is shown in TABLE III.

TABLE III. CABLE VOLTAGE DROP

Size (mm2)

mV/A/m

Length (m)

Ib

Voltage Drop (V)

185

0. 22

100

278. 241

6. 12

50

0. 86

10

81. 84

0. 70

80

81. 84

5. 63

35

1. 15

10

65. 47

0. 753

25

1. 60

150

49. 10

11. 784

(Voltage drop of respected cable in the Feeder Pillar No. 1)

From TABLE III, it shows that the incoming cables itself occupy high voltage drop which is 6. 12V for each cable. Then, if load of Bengkel Seni and Cafeteria is upgraded to MSB, the voltage drop can be observed from TABLE IV.

TABLE IV. LOAD VOLTAGE DROP

Load

Calculated Voltage Drop (V)

Future Length (m)

Future Voltage Drop (V)

Percentage (%)

Bengkel Seni

11. 75

180

12. 67

3. 05

Cafeteria

6. 82

110

7. 742

1. 87

(Future voltage drop if load of Bengkel Seni and Cafeteria is upgraded into MSB)

Although the voltage drop risen up since the length of occupied cable is increased, the voltage can be reduce by replacing higher cross sectional area of the cable. However, the value of voltage drop is still within the specified value of allowed voltage drop [8].

By connecting those loads to MSB, the existed feeder pillar will not be congested anymore. Those two loads that were directly connected to MSB will became spare and it can be used for future expansion of nearest building located near to the respected feeder pillar (refer fig. 11).

Figure 11. Empty slot of loads acted as spare

Therefore the future load will be based on TABLE V.

Load	Power (kW)	MCCB Rating (A)
Futsal Court	38. 492	63
Compound Feeder Pillar	48. 878	80
Spare	-	-
Spare	-	-

The total load at Feeder Pillar No. 1 will be about only 70kW where the nominal current value from the incoming will be only 114. 57V that could lead to only 2. 52V of voltage drop.

Earthing

For earthing cable, it is wise to insulate those cables with PVC insulator to avoid any electric shock due to current leakage. It must meet the electrical standard where earth cable must be insulated with green or green/yellow insulation based on fig. 12 [6].

http://www. china-wire-cable. com/photo/6654ca80a2286ebde6efb52e3ffbab88/Earth-Cable. jpg

Figure 12. Proper insulation of earth cable

Comments and Suggestion

The project will become a wise step to ensure that the respected Feeder Pillar No. 1 will become a reliable where it can provide a continuity of supply to a certain loads. However this project could not be implemented immediately since it will took period of time where maintenance underground cables is a complex task where it require skills and occupy more human power. In addition, the substation (PE No. 1) need to be shutdown to perform the upgrade process where ironically the substation itself must distribute power to important places such as administration office where it operates 24 hours a day and 7 days per week.

Therefore it is recommended that this project must be implemented during the holiday where the total shutdown of PE No. 1 can be done and the task of upgrade of the system can be performed by the respected party.

CONCLUSION

From the case study that was carried out, it is necessary for Facility Unit of INTEC to consider those suggestions in order to overcome any problems related to low voltage power distribution system.

FUTURE STUDY

Surge protection was integrated within the low voltage distribution system to protect the system from lightning strikes. For future study, the recommendation that can be offered to further the respected case study is to perform research on surge protection system in low voltage power distribution system in INTEC.

ACKNOWLEDGEMENT

The author would like to express appreciation to his supervisor Ir. Harizan Che Mat Haris due to wise guidance and advices. For INTEC Facility Unit, the author felt pleasured to carry out this case study where he can affix his knowledge and gather more experience. Finally the author wants to offer his gratitude to people who was contributed toward the completion of this case study.