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DISTRIBUTION TRANSFORMER RATING EVALUATION BASED ON LOAD MEASUREMETNS FOR RESIDENTIAL BUILDING

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Abstract: Distribution transformers are one of the most important equipment in power network. A distribution transformer provides the final voltage transformation in the electric power distribution system, stepping down the voltage used in the distribution lines to the level used by the utilities. The case study is nine floors office building. The office building is located at the corner of Shwe Hnin Si Street, 9 mile, Mayagone Township. This paper describes about the selection of the rating of distribution transformer that installed in the office building.
Keywords: Electrical Distribution System, Nonlinear Load, Total Harmonic Distortion, Harmonic Filters

I. INTRODUCTION OF DISTRIBUTION TRANSFORMER

A transformer is a static device which transforms electrical energy from one circuit to another without any direct electrical connection and with the help of mutual induction between two windings. It transforms power from one circuit to another without changing its frequency but different voltage level. A distribution transformer provides the final voltage transformation in the electric power distribution system, stepping down the voltage used in the order to distribute the power generated from the power generation plant to remote locations, these transformers are used. It is used for the distribution of electrical energy at low voltage is less than 33kV in industrial purpose and 440V-220V in domestic purpose. It works at low efficiency at 50-70%.

- Small size
- Easy installation
- Low magnetic losses
- It is not always fully loaded

Distribution transformers normally have ratings less than 200 kVA .This type of transformer has lower ratings like 11 kV, 6.6 kV, 3.3 kV, 440 V and 230 V. They are rated less than 200 MVA and used in the distribution network to provide voltage transformation in the power system by stepping down the voltage level where the electrical energy is distributed and utilized at the consumer end. The voltage from a primary distribution circuit and “steps down” or reduces it to a secondary distribution circuit is a distribution transformer.
Distribution transformer is an electrical isolation transformer which converts high-voltage electricity to lower voltage levels acceptable for use in homes and business. A distribution transformer’s function is straight forward: to step down the voltage and provide isolation between primary and secondary. Electrical energy is passed through distribution transformers to reduce high-distribution voltage levels down to end-use levels.
The distribution transformer less than 33 kV is used in industries and 440, 220 V is used in purpose. It is smaller in size, easy to install and has low magnetic losses and is not always loaded fully. The distribution transformers are designed for maximum efficiency of 60 to 70%.

II. INTRODUCTION OF POWER TRANSFORMER

The power transformers are suitable for high voltage (greater than 33kV) power transfer applications. It used in power generation stations and Transmission substation. It has high insulation level. The Power transformer is a one kind of transformer that is used to transfer electrical energy in any part of the electrical or electronic circuit between the generator and the distribution primary circuits. These transformers are used in distribution systems to step up and step down voltages.

Power transformers are generally used in transmission network for stepping up or down the voltage level. It operates mainly during high or peak loads .The power transformers are used in the transmission networks of higher voltages. The ratings of the power transformer are as follows 400 kV, 200 kV, 110 kV, 66 kV, 33 kV. They are mainly rated above 200 MVA. They are mainly installed at the generating stations and transmission substations. They are designed for and have maximum efficiency at or near full load maximum efficiency of 100%. They are larger in size as compared to distribution transformer.

III. DIFFERENCE BETWEEN POWER AND DISRIBUTION TRANSFORMERS

The difference between power Transformer and distribution transformer are as follows:
Power transformers are used in transmission network of higher voltages for step-up and step down application (400 kV, 200 kV, 110 kV, 66 kV, 33kV) and are generally rated above 200MVA.
Distribution transformers are used for lower voltage distribution networks as a means to end user connectivity. (11kV, 6.6 kV, 3.3 kV, 440V, 230V) and are generally rated less than 200 MVA.
Power transformer is used for the transmission purpose at heavy load, high voltage greater than 33 KV & 100% efficiency. It is used in generating station and high level.
The distribution transformer is used for the distribution of electrical energy at low voltage as less than 33kV in industrial purpose and 440V-220V in domestic purpose. It work at low efficiency at 50-70%, small size, easy in installation, having low magnetic losses

IV. OPERATIONG OF DISTRIBUTION TRANSFORMER DEALS WITH GENERATORS

The distribution transformer in office building that has a nine floors RC building through a private distribution transformer (oil type). The distribution transformer provides power sources that will be used in each floor. And then they will be installed the generator with ATS (automatic transfer switch) set that will provide temporary power supply to the building in three seconds when system break down. For distribution transformer, that has included power rating calculation to select the rating of transformer.

Transformer must be sized to handle their load based on the continuous kW, kilowatt load, and kVA, kilovolt amp load. They are sized also on whether they are continuous or standby use. Total power with kVA is always larger than kW. The power factor running usually is between 0.6 and 0.85.

The equation of the power factor is as follows:

$$p.f = \frac{kW}{kVA} \quad (1)$$

The equation of transformer power rating is as follows:

$$S = \frac{kW}{kVA} \quad (2)$$

The equation of transformer power rating is as follows:

$$P = \sqrt{3}\, VI\cos\theta \quad (3)$$

$$I = \frac{P\sqrt{3}}{VI\cos\theta} \quad (4)$$

Where, P = Power (W)
I = Current(A)
V = Voltage (V)

The transformer capacity and selecting the proper rating for the design application is to obtain the calculated design load from the respective electrical schedule and add 20% spare capacity for future load growth to be shown in the equipment schedule, unless otherwise directed by the facility based on design parameter.

V. CASE STUDY

This building is the office building. It has nine floor levels including the basement floor level (car parking). The office building is located at the corner of Myamala street and Myanma Gonyi street, Thakata township. Location of transformer is beside the building after 10 meters from generator.

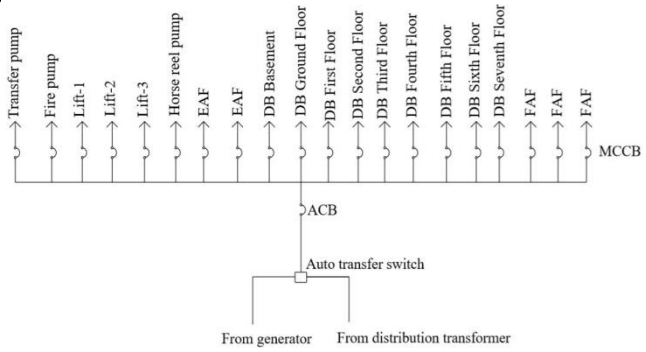

Figure1 Single Line Diagram of Main Distribution Board

Transformers, along with other power distribution apparatus, remain a fundamental component in electrical systems distribution for office building. This article presents several useful design concepts for selecting and sizing transformers in the electrical systems for office building. Transformers change voltage levels to supply electrical loads with the voltages they require. The location of transformer is beside of the building after 10 meters from generator.

VI. POWER CALCULATIONS OF LIGHTNING CIRCUITS

A. BASEMENT LEVEL

Firstly, the total power of lighting circuit located in basement level is calculated. It is shown by Table 6.1. In basement level, only 36 W fluorescent lights are used. The number of lighting load is 48 from calculation result. The total load 48 is separated to R,Y,B circuit.

Table 6.1 Power Calculation of Lighting Circuit for Basement Level

Types of room	(Maximum power in each load) x (number of loads)		
	R	Y	B
Car parking	36 x 10 = 360 36 x 9 = 324	36 x 8 = 288 36 x 9 = 324	36 x 8 = 288 36 x 4 = 144
Total (w)	684	612	432

B. GROUND FLOOR LEVEL

Firstly, the total power of lighting circuit located in ground floor level is calculated. It is shown by table. In ground floor level, 40 W LED lights are used in waiting area and portico, and 36 W fluorescent lights are used in other room. The number of lighting load is calculation result of Table 6.2. The lighting load is separated to R, Y, B circuits.

Table 6.2 Power Calculation of Lighting Circuit for Ground Floor Level

Types of room	(Maximum power in each load) x (number of loads)		
	R	Y	B
Audit area	36 x 8 = 288		
Waiting area		40 x 7 = 280	40 x 8 = 320
Lift lobby, FCC room	36 x 9 = 324		
General		36 x 8 = 288	
Female sleep			36 x 9 = 324
Male sleep	36 x 9 = 324		

(Continued)

AC common kitchen		36 x10 = 360	
Toilet			36 x 10 = 360

Canteen	36 x 5 = 180	36 x 5 = 180	36 x 5 = 180
Portico	40 x 7 = 280	40 x 6 = 240	40 x 9 = 360
General	36 x 5 = 180	36 x 9 = 324	36 x 9 = 324
Exit sign	800		
Total power	2376	1672	1868

VII. POWER CALCULATIONS OF POWER SOCKET CIRCUITS

A. GROUND FLOOR LEVEL

Firstly, the total power of power socket circuit located in ground floor level is calculated. It is shown by Table 7.1. One power socket has 300 W. The numbers of power sockets are selected data from building.

Table 7.1 Power Calculation of Power Socket Circuit for Ground Floor Level

Types of room	(Maximum power in each load) x (number of loads)		
	R	Y	B
Reception	300 x 4 = 1200		
FCC room		300 x 4 = 1200	
General	300 x 6 = 1800		300 x 4 = 1200
Sleeping room female	300 x 6 =1800	300 x 4 = 1200 300 x 6 = 1800	300 x 4 = 1200
Sleeping room male	300 x 4 = 1200	300 x 6 = 1800	300 x 6 = 1800 300 x 4 = 1200
Toilet	300 x 4 = 1200		
Canteen		300 x 2 = 600	
Kitchen	1500		1500
Total Power	9300	6600	6900

VIII. POWER CALCULATIONS OF BUILDING

A. LIGHTNING CIRCUITS

The total power of lighting circuits of building each are shown in Table 8.1

Table 8.1. Power Rating of Lighting Circuit of Building

Level	R(W)	Y(W)	B(W)
Ground	684	612	432
Basement	2376	1672	1868
1	2056	1792	1792
2	1936	1896	1944
3	2188	2220	2304
4	1792	1788	1768
5	2008	2076	2160
6	2192	2212	2064
7	1692	1540	1464
Total power (W)	16924	15808	15796

As the results, power rating of lighting is16924W for R, 15808W for Y and 15796W for B are shown in Table 8.1. And then, Total power of lighting circuit P_T is calculated as follows:

Total power of lighting P_T :

$$P_T = P_R + P_Y + P_B$$
$$= 16924 + 15808 + 15796$$
$$= 48528 \text{ W}$$
$$= 48.58 \text{ kW}$$

The apparent power rating is calculated as follows: power factor is 0.8.

$$S = \frac{P_T}{p.f}$$

$$S = \frac{48.53\text{kW}}{0.8}$$

$$S = 60.663 \text{ kVA}$$

According to International Standard, Maximum demand power is 80% of the total power of the lighting load. Therefore, the maximum demand power is calculated as follows:

Maximum demand power = 80% of the total power of lighting load

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= 0.8 × 60.663 kVA

= 48.5304 kVA

Therefore, the calculation result of maximum demand power in lighting circuits is 48.5304 kVA.

B. POWER SOCKET CIRCUITS

The Total Power rating of power socket circuit is 49200W, 48300W for Y and 42600W for B. And then, Total power of power sockets circuit PT is calculated as follows:

Total

Total power of power sockets circuit

$$P_T = P_R + P_Y + P_B$$
$$= 49200 + 48300 + 42600$$
$$= 140100 \text{ W}$$
$$= 140 \text{ kW}$$

The apparent power rating is calculated is S, Take power factor is 0.8.

$$S = \frac{140 kW}{0.8}$$

S = 175 kVA

According to International Standard ,

Assume, Maximum demand power in = 50% of total power of power socket

= 175 ×0.5

= 87.5k VA

Therefore, the calculation result of maximum demand power in power socket circuits is 87.5kVA.

C. AIR CONDITIONER

Power rating of AC circuit 118614W. And then, Total power of AC circuit P_T is calculated as follows: Total power of AC circuit = 118614 W

= 118.614 k W

The calculation result of maximum demand power in AC circuits is 148.268 kVA.

D. LIFT

Number of lift = 3 lifts

Total power of lift = 3 × 7.5 kVA

= 22.5 kVA

Therefore, the calculation result of maximum demand power in lift is 22.5 kVA.

E. PUMP AND FAN

Power rating of pump and fan 113.3k W is calculated. The apparent power rating is calculated is S, Take power factor is 0.8.

S= 141.63 k VA

Therefore, the calculation result of maximum demand power in pump and fan is 141.63 kVA.

F. COMPUTER

Power rating of computer is calculated as follows:

Total power of computer = 89200W

= 89.2 kW

The apparent power rating is 111.5 k VA

Therefore, the calculation result of maximum demand power in computer is 111.5 kVA.

G.HEATER

Power rating of heater is 6.3 k W.

The apparent power rating is 7.875 kVA.

Therefore, the calculation result of Total power of office building is as follows;

The Total Power = 87.5+ 48.53 +148.27+ 22.5+ 141.63+ 111.5+ 7.875

= 568 k VA

IX. SELECTION OF THE RATING OF TRANSFORMER APPLIED IN BUILDING

Transformer cannot produce 100% , the most they can do is 80% .

Therefore, The capacity of transformer = 20% × 568

= 114 k VA

The total power rating of transformer = 568 + 114 = 682 kVA

The real capacity of transformer is 682 kVA but there is no transformer with that total power. Therefore, we choose 750 k VA transformer is applied in this building.

X. SPECIFICATION OF CURRENT RATING OF TRANSFORMER

At the Primary Voltage (single phase) , current is calculated as follows;

V=400 V, P = 750kVA, I =?

$$P = \sqrt{3} VI\cos\theta$$

$$I = \frac{P}{\sqrt{3}\ V\cos\theta}$$

$$= \frac{750}{\sqrt{3} \times 400 \times \cos 0.8}$$

=1083A

At the Secondary Voltage, current is calculated as follows;

P= 750kVA, V = 231V, I =?

$$P = \sqrt{3} VI\cos\theta$$

I = 2.59 A

In this paper, the capacity of single phase distribution transformer 750kVA is applied in office building. At the primary voltage, the current rating of transformer is 1083A and at the secondary voltage, the current rating of transformer is 2.59A.

XI. CONCLUSIONS

The paper describes about the rating of transformer depends on the total power of office building. Among the different rating of transformer, 750 kVA transformer is applied in this thesis. Transformer cannot generate 100% of power rating , the most they can do is 80% .The real capacity of transformer is 682 kVA but there is no transformer with that total power in markert. Therefore, select 750 k VA transformer is applied in this case study. The distribution transformer provides power sources that will be used in each floor. And will be install the generator with ATS (automatic transfer switch) set that will provide temporary power supply to the building in 3 seconds when system break down. For distribution transformer, that has included power rating calculation to select the rating of transformer

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