A Study on Distribution Substation (1) in Kyaing Tong

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**Abstract**—This paper is intended to study of distribution substation in Kyaing Tong. The three generation station of Nam Wop (1), Nam Wop (2) and Nam Soo are produced the large power source. Generation sources are incoming voltage as 0.4/11 kV, 6.6/33 kV, 0.4/33 kV and 6.6/33 kV and then transmitted to Kyaing Tong substation (1) and substation (2). Kyaing Tong substation (1) and (2) are distribution substations and distributed 11 kV to the load sides as outgoing feeders. Moreover, the performance is the choice of conductor size, transformer incoming and outgoing conductor size, insulation level of lightning arrester and circuit breaker. This paper presents a case study on substation load 33 kV receiving station.

**Index Terms**—Cable size, circuit breaker, distribution substation, feeders, lightning arrester

**INTRODUCTION**

Power Station System in Kyaing Tong is not interconnected to National Grid of Myanmar. Kyaing Tong Energy Company Limited is mainly vested with the functions of Transmission and Distribution of power in the entire of Kyaing Tong. It operates under a license issued by Myanmar Electric Power Enterprise (MEPE). There are four Generation Stations that are namely Nam Lup, Nam Wop (1), Nam Wop (2) and Nam So which generate and operate major power generating projects in Kyaing Tong including of Hydro Electric Power.

A generating station which utilizes the potential energy of water at a high level for the generation of electrical energy is known as a hydro-electric power station. In a hydro-electric power station, water head is created by constructing a dam across a river or lake. From the dam, water is led to a water turbine. The water turbine captures the energy in the falling water and changes the hydraulic energy (i.e., product of head and flow of water) into mechanical energy at the turbine shaft. Hydro-electric power stations are becoming very popular because the reserves of fuels (i.e., coal and oil) are depleting day by day.

The generating capacity of the Nam Wop (1), Nam Wop (2) and Nam So Power station are totally 7.3 MW. The power demand was increased, for industries and rural electrification, and additions to generating became imperative. Several classifications related to the dimension of hydropower plants are:

- Large hydropower > 100 MW
- Medium hydropower 5 MW ~ 100 MW
- Small hydropower 1 MW ~ 10 MW
- Mini hydropower 100 kW ~ 1 MW

**POWER TRANSMISSION AND DISTRIBUTION**

An electrical power system supplies energy to our homes and industrial buildings. Fig.1 shows a sketch of a simple electrical power system. The source of energy may be derived from coal, oil, natural gas, atomic fuel, or moving water. This type of energy is needed to produce mechanical energy, which in turn develops the rotary motion of a turbine. Three-phase alternators are then rotated by the turbine to produce alternating-current electrical energy. Power transmission and distribution systems are used to interconnect electrical power production systems.

**Electrical Substations**

Electrical substations are essential parts of the electrical distribution system. Moreover complex power distribution systems are used, however, to transfer electrical power from the power plant to industries, homes, and commercial buildings. The link between high-voltage transmission lines and low-voltage power distribution systems is the substation. The function of electrical distribution substation as shown in Fig. 1 is to receive electrical power from a high-voltage transmission system and convert it to voltage levels suitable for industrial, commercial, or residential use.

The major component of an electrical substation is the transformer. However, there are many other types of specialized equipment required for the operation of a substation. The distribution substation is composed of many electrical and mechanical components. Distribution system is usually employed as transformers, circuit breakers, and protective devices.

**Fig. 1:** Representative portion of a typical power system configuration [2]
TYPE OF DISTRIBUTION SYSTEMS

Electrical power distribution systems are classified which are the radial, ring, and network systems.

Radial System

The simplest type since the power comes from one power source is radial distribution systems. A generating system supplies power from the substation through radial lines which are extended to the various areas of a community as shown in Fig. 2. Radial systems are used the least reliable in terms of continuous service since there is no back-up distribution system connected to the single power source. If any power line opens, one or more loads are interrupted. There is more likelihood of power outages. However, the radial system is the least expensive. This system is used in remote areas where other distribution systems are not economically feasible.

Ring System

Ring distribution systems are used in heavily populated areas as shown in Fig. 3. The distribution lines encircle the service area. Power is delivered from one or more power sources into substations near the service area. The power is then distributed from the substations through the radial power lines. When a power line is opened, no interruption to other loads occurs. The ring system provides a more continuous service than the radial system. Due to additional power lines and a greater circuit complexity, the ring system is more expensive.

Network System

Network distribution systems are a combination of the radial and ring systems as shown in Fig. 4. Most of the distribution systems are network systems. This system is more complex but it provides very reliable service to consumers. With a network system, each load is fed by two or more circuits.

STUDY ON DISTRIBUTION SUBSTATION

In a distribution substation, breaking capacity and making capacity of components are very important. One Line Diagram of Generation, Transmission and Distribution Substation of Kyaing Tong is shown in Figure 5.

Choice of Conductor Size

System voltage = 33 kV

Rated power = \( \sqrt{3} V_L I_L \)  

Rated current= 201.19 A

Insulation Level of Lighting Arrestor

The minimum insulation level is needed to calculate. Require equations to calculate the minimum insulation levels are as below.

Impulse surge voltage = 1.15 (1.1E_A + 40) kV  

Switching surge voltage = 3.88E kV

Power frequency over voltage, (75%) = 2.37 E_L

Power frequency over voltage (80%) = 2.53 E_L

Power frequency over voltage (100%) = 2.3 E_L

E_L is system voltage discharge = \( \frac{\text{Discharge Voltage}}{\text{Rated Voltage}} \)

Fig. 2: Simple form of Radial-Type Distribution System [3].

Fig. 3: Simple form of Ring-Type Distribution System [2].

Fig. 4: Simple form of Network Distribution System [2].

Fig. 5: One Line Diagram of Kyaing Tong Substation (1) and (2).
MVA METHOD SHORT CIRCUIT CALCULATION

A short circuit calculation is an important tool in determining the ratings of electrical equipment to be installed in a project. It is also used as a basis in setting protection devices. Computer software simplifies this process however, in cases where it is not available, alternative methods should be used. The easy way to do hand calculation is the MVA method [4].

It is needed to be calculating the short circuit current when there is transformer in the circuit. Every transformer has present impedance value stamped on the nameplate. It is stamped because it is a tested value after the transformer has been manufactured [5].

In the event of a short circuit, the sources of short circuit current are following as:
1. Utility
2. Generators
3. Motors

The "Equivalent MVA" are:
Transmitters and Motors
\[
MVA_{sc} = \frac{MVA}{\%Z}
\]

For Distribution Substation (1)
33/11 kV Bus (X’mer 1&2, 2MVA, %Z=6.49%)
\[MVA_{sc} = 2MVA/0.0649=30816.64 kVA = 30MVA\]

Selection of Circuit Breaker

<table>
<thead>
<tr>
<th>Base Impedance</th>
<th>Base MVA</th>
<th>Base impedance</th>
<th>Base Current</th>
<th>Base current = \sqrt{3}\times Base kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.89 \Omega</td>
<td>Base kV</td>
<td>3.34 pu</td>
<td>rated current = \sqrt{3}\times Base kV</td>
<td></td>
</tr>
<tr>
<td>1749.546 A</td>
<td>Base kV</td>
<td>3.34 pu</td>
<td>Actual Fault Current = \sqrt{3}\times Base kV</td>
<td></td>
</tr>
<tr>
<td>524.863 A</td>
<td>3.34 pu</td>
<td>Actual fault current = 524.863 A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5 pu</td>
<td>3.33 pu</td>
<td>per unit current = 0.3 pu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.33 pu</td>
<td>3.33 pu</td>
<td>per unit impedance = per unit voltage / per unit impedance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rated current of transformer = \( \frac{MVA}{\sqrt{3}\times kV} \times 100\% \) impedance x kV = 34.99 A
Transformer’s impedance = 35.34 \Omega

Rated Current = 201.19 A
Rated Current = 209.945 A
Rated Current = 70 A
Rated Current = 43.738 A
Rated Current = 150 mm²
Rated Current = 150 mm²

Table 2: Design Values of Component for 33/11 kV Distribution Substation

<table>
<thead>
<tr>
<th>Nominal Voltage</th>
<th>(Incoming Voltage) 33kV</th>
<th>(Outgoing Voltage) 11kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Current (11.5 MVA)</td>
<td>201.19A</td>
<td>341.16 A</td>
</tr>
<tr>
<td>System Installed Capacity (6.5 MVA)</td>
<td>34.99</td>
<td>74.177 kV</td>
</tr>
<tr>
<td>System Installed Capacity (5 MVA)</td>
<td>76.654 kV</td>
<td></td>
</tr>
<tr>
<td>Transformer capacity (4MVA)</td>
<td>262.43 A</td>
<td></td>
</tr>
<tr>
<td>Transformer capacity (2.5 MVA)</td>
<td>262.43 A</td>
<td></td>
</tr>
<tr>
<td>Transformer capacity (5MVA)</td>
<td>262.43 A</td>
<td></td>
</tr>
</tbody>
</table>

Insulation Level of Lightning Arrestor

Impulse Surge Voltage of 75% Arrestor = 130.53kV
Impulse Surge Voltage of 80% Arrestor = 136.1692 kV
Impulse Surge Voltage of 100% Arrestor = 158.711 kV
Switching Surge Voltage of 75% Arrestor = 96.03 kV
Switching Surge Voltage of 80% Arrestor = 102.432 kV
Switching Surge Voltage of 100% Arrestor = 128.04 kV
Power Frequency Over Voltage of 75% Arrestor = 78.21 kV
Power Frequency Over Voltage of 80% Arrestor = 83.49 kV
Power Frequency Over Voltage of 100% Arrestor = 75.9 kV

Selection of Circuit Breaker

Breaking Capacity = 38.87 MVA
Installed Capacity = 50 MVA

CONCLUSION

In this paper, the main study is distribution substation in Kyaing Tong with design calculations. Most of components in distribution substation are protection devices. Some components, design, calculation and choice of some equipment have been described. Therefore the design values in table (1) are summarized with the overhead cable size, transformer capacity, and insulation level of lightning arrester and selection of circuit breaker. In this paper, the design value data can provide to survey the distribution substation in Kyaing Tong.

Acknowledgment

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REFERENCES