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Study of Short Circuit and Load Flow Analysis of 132/33 KV Mawlai Nongkwar Substation

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***Abstract*: The most vital condition for conducting any system's power system analysis is load flow. The load flow shows the voltage in the branches and buses, actual and reactive power generated and absorbed, and losses in the lines of the system. The examination or evaluation of an electrical system to identify the quantity of currents that can flow during an electrical defect is known as short circuit analysis. It offers the information needed to establish whether the power system components' interrupting capacities are sufficient to secure your power system. This information is also utilised to determine the correct sizing of safety relays and sensing devices. The data used in the investigation was all collected in real time from the 132/33 kv Mawlai Nongkwar substation. The analysis is carried out using the Electrical Transient Analyzer application (ETAP), a software program which incorporates a thorough load flow and short circuit.**

***Keywords*: transient stability, load flow analysis, short circuit analysis, ETAP.**

1. Introduction

A substation is the interconnection between a transmission and distribution system, and it maintains multiple levels of voltage. The Umiam Stage -1 Power Station in Sumer supplies power to the Mawlai 132/33KV substation. After passing through several elements in the switch yard, the power is stepped down by a step-down power transformer and then transmitted to various portions of the substation. The substation is made up of three power transformers that scale down the voltage from 132 to 33 kilovolts. It provides power to a variety of feeders, including NEHU, MAWLAI, MAWPREM, and others. The most important and necessary way to investigate problems in power system operation and planning is load flow analysis. Load flow analysis solves the stable operation state with node voltages and branch power flow in the power system based on a defined generating state and transmission network configuration. A short circuit study is a procedure for examining, analyzing, and evaluating an electrical system in order to estimate the magnitude of currents that can flow during an electrical fault and comparing those values to the ratings of existing equipment and short circuit protection devices. The response of a system to disturbances like as loss of generation, line-switching operations, faults, and unexpected load changes in the initial few seconds after a disturbance is studied and analyzed in transient stability studies.

Stability is fundamentally a feature of a power system with two or more synchronous devices. When a system is subjected to one or more bounded shocks (less than infinite magnitude), the ensuing system response(s) are bounded, it is stable under a certain set of conditions. A stable system could be defined by variables that show continuous oscillations of finite magnitude (ac voltages and currents, for example), constants, or both after a disturbance. Engineers who are experienced with stability studies expect machine rotor oscillations to be damped to an acceptable level within 6 seconds after a large disruption. A transient response is the response of a system to a change from equilibrium or steady state in electrical and mechanical engineering. The transient reaction is not always associated with sudden occurrences, but rather with any event that disrupts the system's equilibrium. When there is a quick or large change in system condition, such as load, a fault at a point, or a change in mechanical input to the rotor shaft of a generator, transient state stability refers to the ability of the system to remain stable. The fundamental difference between dynamic and steady state stability is the increased rate of change of flux capability owing to regulators. This is the origin of the Power System Stabilizer (PSS), which drives the voltage regulator to alter field flux quickly in response to transients.

2. Literature Survey

According to Bhagyashri Patil et al. (2018), load flow is a necessary component of any power system study. The load flow provides data on voltages, real and reactive power generated and absorbed, and line losses across the system [1].

According to Amine Zeggai et al. (2019), electric utilities have grown up to meet load needs as they have expanded day by day. The load flow shows bus and branch voltages, active and reactive power, and losses in transformers, conductors, cables, and the entire substation. In a power system, short circuit studies are particularly important for appropriately sizing devices so that they can manage short circuit currents [2].

Electrical power transmission and distribution systems, according to Noman Ullah et al. (2018), have high voltages and

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current ratings and cannot be tested using hit-and-miss procedures. The easiest and most efficient way to solve this problem is to first mimic the power system using contemporary software [3]. In a technical report examining the load flow conditions of transmission networks, Eze Ichebadu Wokocha et al. (2021) wrote that the primary goal of any power system is to deliver clean, reliable, and efficient power to its end users at the most favorable economic and technical optimizable standpoint [4]. Load flow studies, according to Pushp Raj et al. (2013), should be utilized to verify that electrical power transmission from consumers to the grid system is stable, reliable, and cost-effective. Iterative techniques, such as the Newton Raphson or Gauss-Seidel, are applied to solve the load flow problem. Active and reactive power travels from the generating station to the load in a three-phase ac power system via various networks, buses, and branches. Power flow, also known as load flow, is the flow of active and reactive power. Load flow analyses are based on a power system's nodal voltage analysis [5]. Short circuit analysis is carried out, according to Dr. Aung Zaw Latt (2019), to ensure the safety of the general public and to identify the ratings of protective equipment to ensure the electrical system's stability. Minimum device ratings are determined using the highest steady-state short circuit current. For relay coordination reasons, the minimal steady-state short circuit value is employed to prevent nuisance trips and loading deviations [6]. A power flow analysis, according to Muhammad Absar Uddin et al. (2022), is used to get complete voltage angle and magnitude information for each bus in a power system under defined load and generator real power and voltage conditions. Real and reactive power flow on each branch, as well as generator reactive power output, can be calculated analytically once this information is available. Because of the nonlinear character of this problem, numerical approaches are used to obtain a solution within a reasonable tolerance [7]. Deregulation of the power system, according to Sunil Malival et al. (2015), has transformed static security assessments into critical problems for which fast and accurate evaluation methodology is required. Voltage violations and power line overloading have been blamed for power system failure [8]. According to Muhammad Aman Ullah et al. (2017), load flow, voltage stability, and short circuit studies of a power system are necessary for both design and operating stage performance monitoring, as well as for ensuring reliable grid operations through appropriate protection scheme settings. Buses running at under voltage due to power grid voltage instability are identified and their voltages are improved according to prescribed voltage limits based on bus criticality with respect to loads [9] using load flow analysis that employs the Newton Raphson algorithm. Reactive power is generated when the current waveform is out of phase with the voltage waveform due to inductive or capacitive loads, according to Ankita Palod et al. (2015). With an inductive load, current lags voltage, but with a capacitive load, current leads voltage. Real or active power is produced only when the current component is in phase with the voltage [10].

3. Research Gap, Contributions and Novelty

A. *Research gap*

- The Reactor and Capacitor Bank are not employed to maintain the voltage fluctuation in the system.
- Protective system and instrumentation parameters such as Relays, PT, CT are not provided in the Single Line Diagram.

B. *Contributions*

The Contribution to this work is as follows:

- Developed a Single Line Diagram of Mawlai Nongkwar 132/33kV Substation in ETAP.
- Study of the Load Flow of Mawlai Nongkwar Substation and

Short Circuit of the substation is provided.

C. *Novelty*

Designing a Single Line Diagram of Mawlai Nongkwar 132/33kV substation in ETAP. Study of the load flow using Newton Raphson Method and Short Circuit Analysis is performed to find the fault at a particular bus using MVA method.

4. Proposed Single Line Diagram using ETAP Software

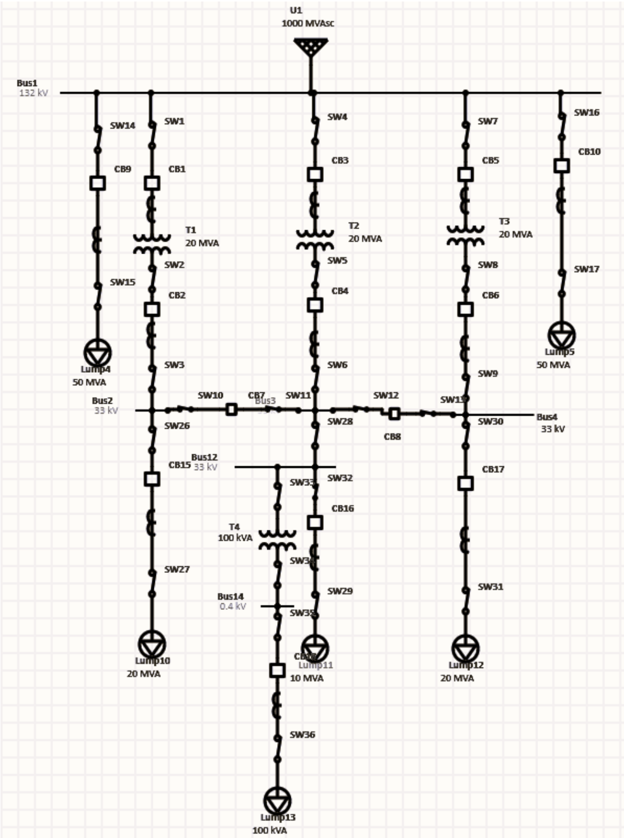

Fig. 1. Complete single line diagram of 132/33kV Mawlai Nongkwar substation

It is designed a 132/33kV substation with 6 buses, 27 isolators, 14 circuit breakers, 12 current transformers, 4 power transformers, and 6 lump loads, Bus1-132kV, Bus2,3,4,5-33kV, Bus 6- 0.4kV. CB-SF6, transformer 1,2,3- 132/33 KV,

Table 1
Load flow analysis result

From Bus	To Buses	MW	Mvar	Amp	%PF
Bus 1 (132 KV)	Bus2	11.790	8.988	68.4	79.5
	Bus3	15.043	10.822	81.1	81.2
	Bus4	15.043	10.822	81.1	81.2
Bus 2 (33KV)	Bus1	-11.759	-7.615	259.4	83.9
	Bus3	-4.877	-2.695	103.2	87.5
Bus 3 (33KV)	Bus1	-14.958	-9.107	324.2	85.4
	Bus2	4.877	2.695	103.2	87.5
	Bus4	1.678	1.203	38.2	81.3
	Bus12	8.403	5.210	183.0	85.0
Bus 4 (33KV)	Bus1	-14.958	-9.107	324.2	85.4
	Bus3	-1.678	-1.203	38.2	81.3
Bus 12 (33KV)	Bus14	0.084	0.055	1.9	84.0
	Bus3	-8.403	-5.210	183.0	85.0
Bus 14 (0.4 KV) substation service purpose	Bus12	-0.082	-0.051	153.6	85.0

20 MVA, transformer 4- 33/0.4 KV, lump load 1,2- 50 MVA, lump load 3,4,5 – 50 MVA, lump load 6- 100 KVA. It is shown in fig. 1.

5. Load Flow Analysis using ETAP

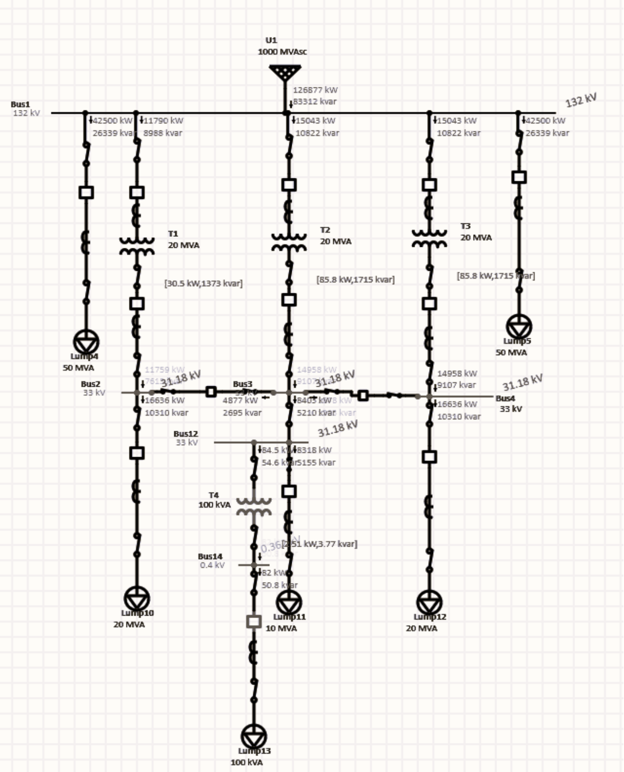

Fig. 2. Circuit diagram of load flow analysis in ETAP

The most critical and needed way to investigate problems in power system operation and planning is load flow analysis. Load flow analysis solves the stable operation state with node voltages and branch power flow in the power system based on a defined generating state and transmission network configuration. Following the load flow analysis, it was discovered that Bus 2 has a voltage drop, and that by examining this, we will cause Bus 2 to be at fault. The load flow report below shows the data for actual and reactive power, as well as current and power factor. In this simulation, it can compute currents, power factor, actual power, and reactive power flows across the substation's system, providing us with a full model of our system. Figure 2 depicts it. Table 1 shows the load flow analysis report generated by ETAP software.

6. Short Circuit Analysis using ETAP

It is observed a drop in voltage in Bus 2 after performing the load flow analysis, so we believe Bus 2 is the source of the problem. It will analyze that the short circuit current flowing in Bus 2 and generate a short circuit report for it if Bus 2 is found to be at fault. After running a short circuit analysis on the above system, it can see that the short circuit current of three phase, line to line, line to ground and line-line to ground fault through Bus 2. as indicated in the table 2. Figure 3 depicts it.

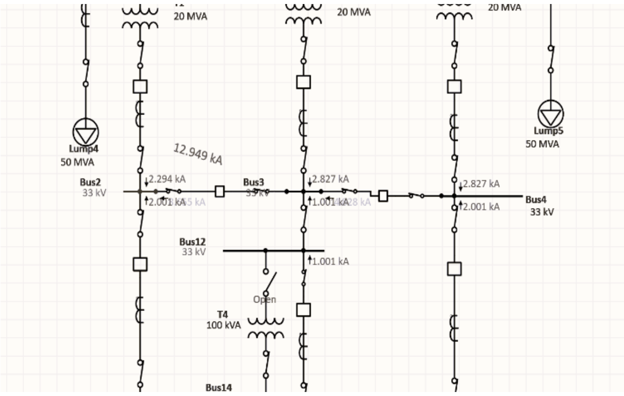

Fig. 3. A single line diagram of short circuit analysis

Table 2
Short circuit analysis result

Bus		3-Phase Fault		
ID	kV	I″ (Amp)	I′ (Amp)	I (Amp)
Bus2	33.00	32.962	12.956	6.750
Bus		Line-to-Ground Fault		
ID	kV	I″ (Amp)	I′ (Amp)	I (Amp)
Bus2	33.00	31.095	12.222	12.222
Bus		Line-to-Line Fault		
ID	kV	I″ (Amp)	I′ (Amp)	I (Amp)
Bus2	33.00	28.546	11.220	11.220

Bus		*Line-To-Line-To-Ground		
ID	kV	I″ (Amp)	I′ (Amp)	I (Amp)
Bus2	33.00	32.432	12.748	12.748

½ Cycle – 3-Phase, LG, LL, & LLG Fault Currents
Prefault Voltage = 100% of the Bus Nominal Voltage
All fault currents are symmetrical (1/2 Cycle network) values in rms kV.
* LLG fault current is the larger of the two faulted line currents.

7. Transient Stability Analysis

To examine the system's transient stability, we assumed Bus 2 was malfunctioning, and the time it took for the fault to occur and clear is indicated in table 3 below.

Table 3
Setting time for transient stability analysis

Time before fault (Pre-fault)	Time during fault	Time to clear the fault (Post fault)
T = 0sec	T = 1sec	T = 1.1sec

A. Pre-fault condition (T=0s)

The figure below shows the condition of the system when the system is at pre-fault condition, i.e. when the time is at 0 sec.

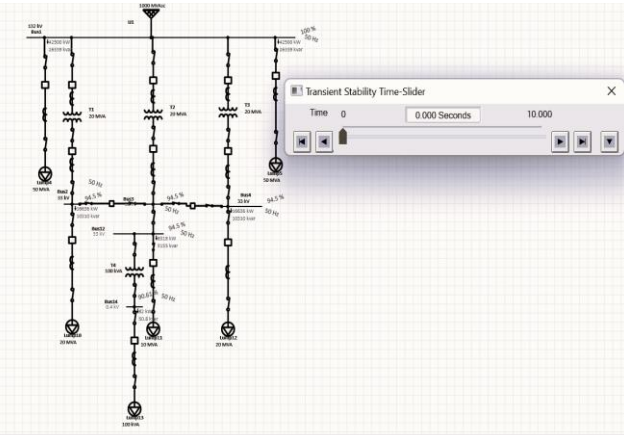

Fig. 4. Simulation of substation under pre-fault condition

B. During fault condition (T=1s)

The figure below shows the condition of the system when the system is at fault condition, i.e. when the time is at 1 sec.

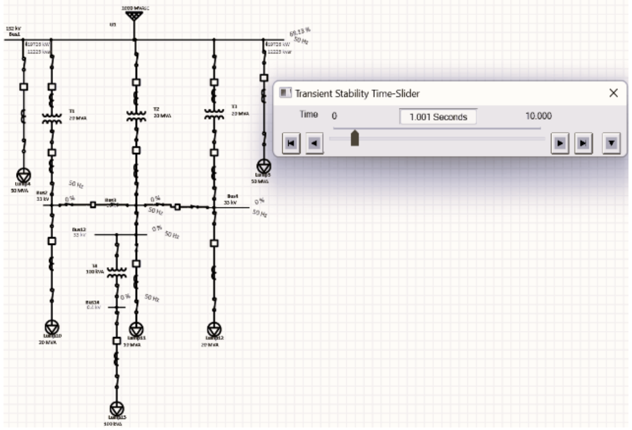

Fig. 5. Simulation of substation under during fault condition

C. Post fault condition (T=1.1s)

The fig. 6 shows the condition of the system when the system is at post fault condition, i.e. when the time is at 1.1 sec.

8. Results and Discussion

The graph is plotted between the bus voltage angle which is in degrees and the time in seconds. When the T=0s, the pre-fault condition, the voltage angle is -10.4 deg, as shown in the figure 7, but when the T=1s, which is during fault condition, the voltage angle is 0 deg and when the T=1.1s, which is at post-fault condition or when the fault has been cleared, the voltage angle becomes -10.4 deg, which is back to normal condition or pre-fault condition.

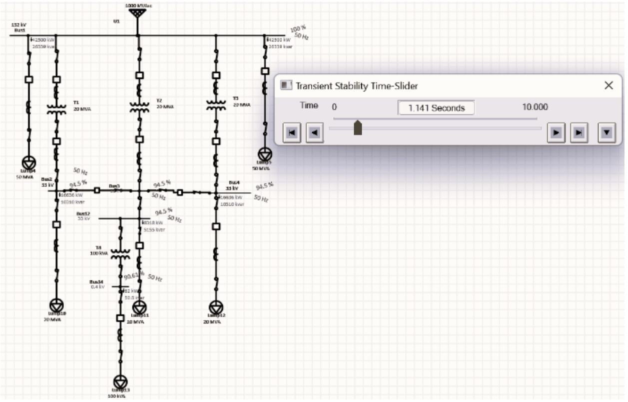

Fig. 6. Simulation of substation under post-fault condition

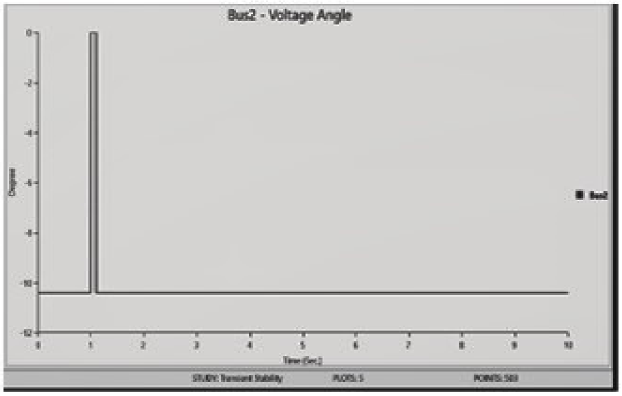

Fig. 7. Voltage angle vs. Time graph

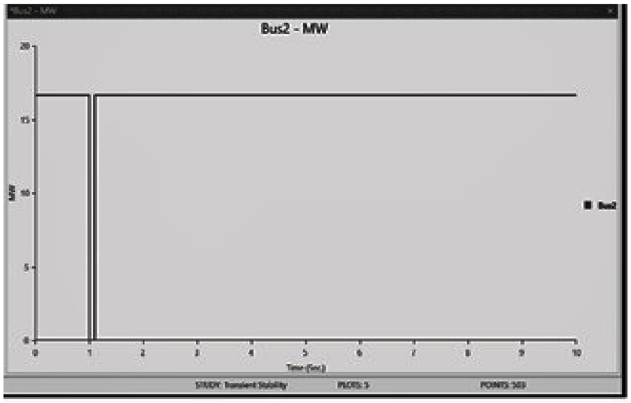

Fig. 8. MW vs. Time graph

The graph is plotted between the real power (MW) and the time in seconds. When the T=0s, which is no fault or pre-fault condition, the power is 16.636 MW, as shown in the figure 8, but when the T=1s, which is during fault condition, the power is 0 MW and when the T=1.1s, which is at post-fault condition or when the fault has been cleared, the power becomes 16.636 MW, which is back to normal condition or pre-fault condition. It is shown in fig. 8.

The graph is plotted between the reactive power (MVAR) and the time in seconds. When the T=0s, which is no fault or pre-fault condition, the power is10.31 MVAR, as shown in the figure 9, but when the T=1s, which is during fault condition, the power is 0 MVAR and when the T=1.1s, which is at post-fault condition or when the fault has been cleared, the power becomes 10.31 MVAR, which is back to normal condition or pre-fault condition. It is shown in fig. 9.

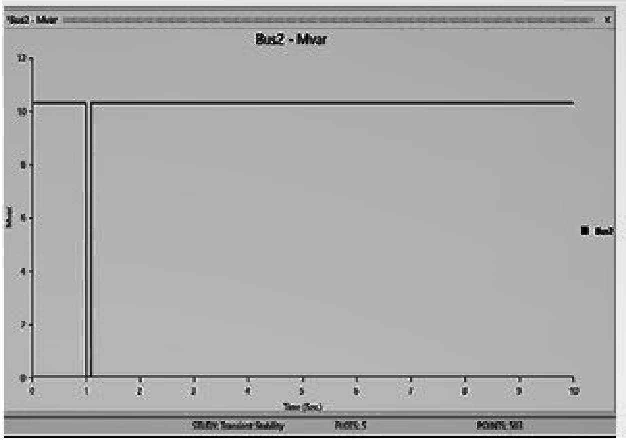

Fig. 9. Mvar vs. Time graph

The graph is plotted between the bus voltage which is in kV and the time in seconds. When the T=0s, which is no fault or pre-fault condition, the voltage is 33kV, as shown in the figure 10, but when the T=1s, which is during fault condition, the voltage is 0 kV and when the T=1.1s, which is at post-fault condition or when the fault has been cleared, the voltage angle becomes 33kV, which is back to normal condition or pre-fault condition. It is shown in fig. 10.

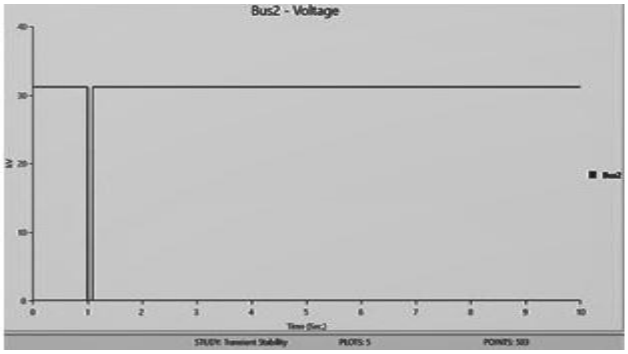

Fig. 10. Post fault condition of voltage vs. time graph

9. Conclusion

In this study, an analysis of a 132/33kV substation is carried out using ETAP software with the goal of overcoming the problems of undervoltage, line losses, and voltage dips. ETAP was used to conduct load-flow evaluations. ETAP load-flow studies are a great tool for planning future power system expansion as well as evaluating the best performance of existing systems. The most significant studies in a power system are short circuit studies, which are used to appropriately design devices so that they can handle short circuit currents. Furthermore, these investigations give data on the severity of the short circuit as well as the possible harm it might produce. This study also contributes to the right design of the security system.

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