Improved Protection for Wokoma 11kv Distribution Feeder

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Abstract- This paper deals with coordination scheme for transmission lines protection against fault. Load flow is basic requirement for conducting power system analysis of any system. The load flow gives us information about voltages, real and reactive power generated and absorbed and line losses across the entire system. Short Circuit Analysis provides the information required to determine whether the interrupting capacities of the power system components are adequate enough to protect your power system. The line data from the respective feeders were taken and used in the load Flow analysis also A well simulated coordination utilizes circuit breakers at various load points as required by the network in question, ensuring proper tripping of the appropriate breaker under fault conditions. The maximum and minimum fault current are all three-phase symmetrical (30 cycle network) values and the pre-fault voltage equaled 100 percent of the nominal voltage. Furthermore, A current time interval (CTI) of $3.5\,seconds$ was used between the relays and was later increase to $4\,seconds$ base on time of operation between the relays to ensure proper coordination between the relay elements, total apparent power of $6513MVar$ and a mismatch of 0.103Mvar was obtained. it was noticed that the transformers and buses were overloaded, but with an upgrade of transformer to $2 \times 15MVA$ and implementation of $90 \times 300kar$ capacitor bank to bus 4 major improvement was actualized. The model was created using ETAP software.

Indexed Terms- Feeder, Protection, Line, Relay, Coordination, Circuit, Breaker, Overload, ETAP, Software, Capacitor, Banks.

I. INTRODUCTION

Published statistics show that an average of about 63% of system fault occurs in overhead lines and cable circuits, 14.5% transformer and reactors, 13.5% on generators generator transformers and the rest on busbars, switchgears and other equipment. A further breakdown of the fault in the overhead line and cable circuits shows that only 11.5% of such incidents occurs in cables. It is, however, generally more expensive to repair any damage in underground cable compared with a similar repaired in overhead line. Failures and interruption to supply can be reduced by the reinforcement of protection, automation. Information and control equipment. Application for accurate fault location schemes will also reduce the overall interruption time in the event of a fault occurring in the system.[1] The electrical protection coordination analysis determines the setting of protection relays and circuit breaker. Its main purpose is to obtain an optimal compromise between protection and selectivity. The analysis includes determining fault clearing time and coordination of upstream electrical protective equipment. Proper coordination and disruption clearing time can help reduce damages to electrical equipment and protect workers from harm.[2]. In power system protection relays and circuit breakers is the major instrument for large interconnected power system. We need proper protection to isolate the faulted region from healthier network [3]. Design of protection scheme for prompt clearing of fault is critical for Protection Engineers along the Transmission line such that fault clearance within the transmission line should be achieved at very minimal time interval so to avoid insulation breakdown in the substation, Fault assessment is important however to ascertain the nature and frequency at which faults occur so that a fault mitigation scheme can be implemented for effective delivery of power to end users [4].

Feeder are the power lines through which electricity is transmitted and in feeders, losses are inevitable. Thence, protection operations are introduced to minimize these losses. In power system continuity of supply is the core factor. In case of fault in the feeder system it must be detected, Analyzed and rectified. The research works considered a load flow studies using ETAP (Electrical Transient Analyzer Program) platform, load flow and simulation [5].

[7-11] extensively looked at diverse method of overcurrent relay coordination. In their separate research different meta-heuristic and conventional relay coordination algorithms were considered for optimal solution.

1.1 Relay coordination

Discrimination by time is categorized into;

CTS- Current Tap setting which can be less or equal $_{1/2}$ of the minimum fault current that is,

$CT_S < \frac{1}{2}$ or $CT \leq \frac{1}{2}$ (1)

Relay Settings CT = $\frac{IP}{IS} = \frac{I1}{I2}$ (2)

TDS = Time Dial Setting which is 0.4 or 0.5.

CDT = Coordination delay time

CDT standard ratio = America 0.4 and British 0.5

Selective coordination determines the protection equipment, characteristics setting or rated current rating that provides the correct selective coordination, equipment protection and interrupt rating for the bolted circuit of short circuit available at the point of application for each overcurrent protection device. Interrupted coordination determines the type of protection equipment, characteristics, settings and ampere rating that allows non-coordination range of the overcurrent protection device [6].

1.2 Impedance per Unit Fault Calculation

$Z_{PU} = \frac{base\ MVA}{V}$ (3)

1.3 Materials and Methods

A. Material

In this research, the collection of data was from ministry of power, materials used for the analysis are: Single line diagram of PHED injection substation RSU, ETAP software for modelling and simulation and a computer system.

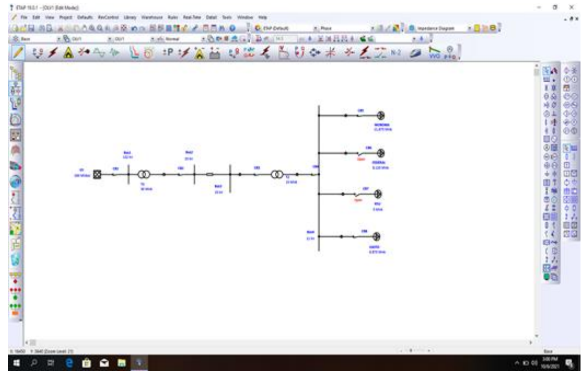

Fig-1: ETAP Representation of 11kv Feeder Network

B. The Case study of the 1×15MVA injection station

An injection sub-station located in the River State University Port Harcourt operating on 4 distribution feeders feeding different locations of the state.

The feeders are namely: Wokoma Feeder, Federal Feeder, UST Feeder, and Ojoto Feeder.

Table 1. 33/11kv Transformer Data

S/N	Name	S (MVA)	Z (%)
1	T1	30	12.27
2	T2	15	10.28
3	T3	15	10.28

C. T1 Primary Rated Current

$I_{rate\text{-}primary\ T1} = \frac{MVA}{\sqrt{3}\times KV}$ (4)

$I_{rate\text{-}primary\ T1} = \frac{30\times 10^6}{\sqrt{3}\times 33\times 10^3} = 524.86\ A$ (5)

D. T1 Secondary Rated Current

$I_{rate\text{-}secondary\ T1} = \frac{MVA}{\sqrt{3}\times KV}$ (6)

$I_{rate\text{-}primary\ T1} = \frac{30\times 10^6}{\sqrt{3}\times 11\times 10^3} = 1574.5\ A$ (7)

This is the rated current on the secondary and primary side of the *30 MVA* power transformers. The effect of the transformer and system impedances are neglected in both in the primary and secondary rated currents calculations.

II. RESULTS

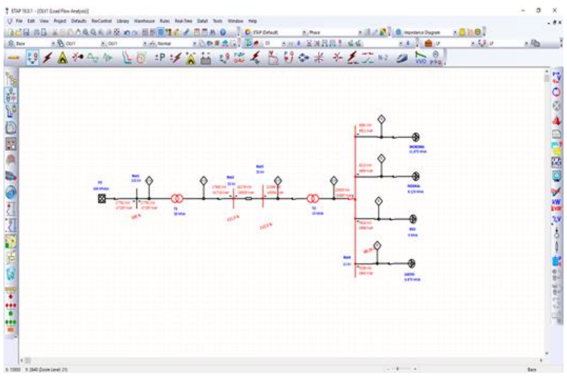

Figure-2: Simulation Result of RSU Feeders Using ETAP (A composite network)

Figure-2 shows the load flow analysis result of a radial distribution network and from the single line diagram it is observed that all buses except the swing are critical under and over loaded below and beyond the IEEE statutory voltage deviation level. Investigation report suggest the need for substation power transformer upgrade from $1 \times 15MVA\ to\ 2 \times 15MVA$ for improved power flow and effective protection.

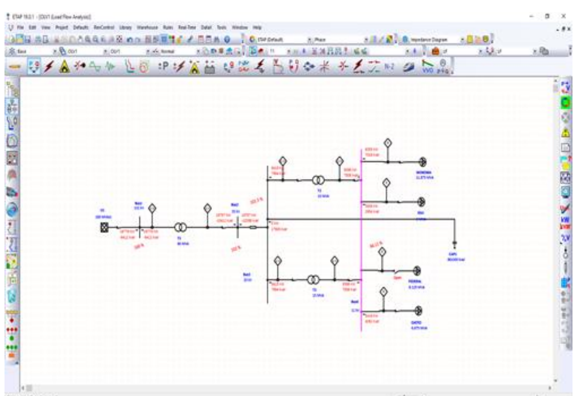

Figure-3: Result of load flow after improvement Network of RSU

Capacitor banks of appropriate size in the tune of $90 \times 300KVAR$ as contained in Figure 3 alongside substation reconfiguration through introduction of another $15MVA$ transformer. Evidently after implementation of the proposed correctional measures, all buses were declared healthy with a minimum voltage profile level of 96.1% at bus 4.

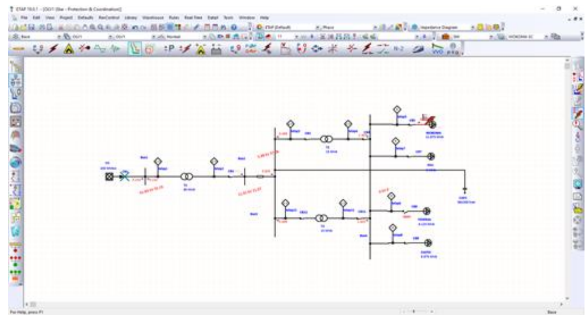

Figure-4: Existing Relay Coordination Scheme in RSU

In figure 4, the present state of the network was tested under fault condition to ascertain the quality of protection. Upon application of a sequential 3 phase fault between Wokoma feeder and circuit breaker 5 adjacent to bus 4. Due to poor relay coordination fault signals meant to be sensed by relay5 is rather sensed by relay1, with a tripping command issued to circuit breaker 1 resulting to faulting and damaging the system equipment and total isolation of all network users.

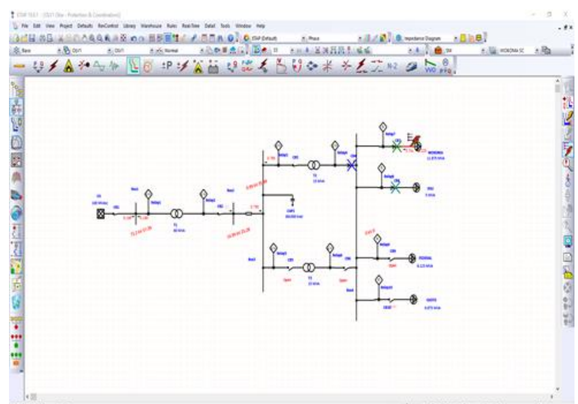

Figure-5: Improved Coordination Result

It is evident that all feeders are connected to bus 4 and a fault current incurred by any would be emitted to the buses damaging all equipment connected to it, therefore in order to avoid crucial damage proper feeder co-ordination is suggested and implemented in Figure 5. In Figure 5, with breakers close to Ojoto and Federal in open state, Wokoma feeder was faulted and breaker 7, 8 and 4 responded swiftly in line with their configuration. CB 7 acted as the primary while CB 8 and 4 acted as backup for the feeder under consideration.

CONCLUSION

The design analysis has vividly illustrated that the implementation of distance protection scheme goes a long way to protect the system against the spread of fault, also upgrade of the network equipment can greatly improve the efficiency eradicating unnecessary interruption of supply due to overcurrent excitation and its spread in the system. It was noted that there was an over-load and under-load on the transformers and buses, but with the upgrades on the transformer and introduction of capacitor bank major improvement was achieved in the system as regards voltage profile and power loss. Also, well simulated coordination scheme anchored on overcurrent relays and circuit breakers at various load points as required in the network in question, ensured proper tripping of the appropriate breaker under fault conditions.

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