Power quality problems

INTRODUCTION

Power quality problems have become serious and common issues that are being discussed due to its effect on power system networks. Any variation in voltage, current, or frequency which may lead to an equipment failure or malfunctions is potentially a power quality problem. According to IEEE standard 1159-1995, a voltage sag is defined as a decrease to between 0. 1 and 0. 9 p. u. in root mean square (rms) voltage at the power frequency for durations of 0. 5 cycle to 1 min.

A power system fault is a typical cause of voltage sag and have been the vast contribution of power quality problems. Other typical causes of voltage sag includes of starting of large induction motor, transformer energizing and load changes. When a system is faulted, the voltage on the particular phase will drop to certain amount and sometimes drop to zero. When certain voltage drops to zero, particularly it will become an interruption. Interruption can't be tolerated as it gives a very bad impact to the utilities. Thus it is important to ensure that the consumer side will not experience any problems related to the power quality problems. Voltage sags can generally be characterized by sag magnitude, duration and frequency. Voltage sag is a common power quality problem that always occurred in power system network. Voltage sag problems is one of the most serious problems that affecting process industry consumers. Due to the awareness developed from time to time, consumers and utilities have become concerned with the inconvenience caused by voltage sag.

It is important to distinguish between interruptions and voltage sags. Both is a power quality problems but are different in terms of occurrence. Interruptions (zero voltage) are mainly occur when a fault occur at the particular bus. Whilst the feeder in parallel that share the same bus will particularly experienced voltage sag during the period of a fault for faults in any area of the power system network. The travelling and the propagation of the faulted voltages may change it to sagged voltage depending on the transformer connections. Voltage sag does not cause any interruption but in the case of sensitive equipment it tends to resulting in shut down of a certain process.

This paper is written to describe the propagation of the faulted voltage to other busbar depending on the transformer connections, system grounding and the effect of line length impedances to the faulted voltages. The purpose of these research is also to extract the features of the travelling and the propagation of sgged voltage. Thus it is hope that the purpose and objectives of this project, an empirical formula can be developed in monitoring the propagation of voltage sag in every level of distribution network on the consumer side. Futhermore, this research is intended to contribute to the utilities in improving the existing power quality monitoring system, and to develop a better understanding on voltage sag propagations.

Several studies shows that from all types of power quality disturbances known, voltage sags have the most significant severity to consumer equipment. In specified that almost 80% of the disoperation in distribution systems cause the failure and interruptions of power system. The behaviour of voltage sag in embedded generation in distribution networks is discussed in. The study of faults that occurring in transmission (EHV), subtransmission (HV) medium-voltage (MV), low-voltage (LV) systems and the voltage sags propagate through out the power system can be seen in and is being concentrated as the frequency of voltage sag occurrences. Focuses on studying the propagation characteristics of sag and harmonics in medium voltage distribution systems by using EMTP simulation, analysing the effects of fault locations on sag levels, nature of sag produced by different types of faults, effects of line length on sag/swell propagation, transformer connection effects on the nature of sag and swells effects, swell propagation characteristics and the total harmonic distortion in different parts of the systems. Discussed in detailed the sag propagation characteristics in medium voltage busbar.

Voltage sag is a serious power quality problem such that it can propagates through transformer to all distribution networks and travel to the consumers voltage level.

Voltage sags that are caused by symmetrical three-phase faults propagate without changes through transformers but in the case of unsymmetrical faults, however, the transformer connections have a strong effect. Moreover the propagation of voltage sag through transformer that is caused by transmission fault is dependent on the location of voltage source of the transmission system.

METHODOLOGY

Before any voltage is being sent to consumer it is generated in power station. Not all feeders are being installed monitoring equipments. The monitoring equipments are being installed at strategic places where utilities think that have the worst severity at 33/11kV bus feeders only. Thus the data that are being recorded only at the respective feeder that are being install monitoring equipment i. e. 33/11KV busbar. In this situation, it creates several questions on how to acquire the data at different level of voltage busbar. As installing metering equipment and waveform recorders would lead to huge increased costs, alternative method to monitor the propagation of voltage sag should be establish. This paper can be divided into several phases. The methodology of this project can be simplified by the flowchart in figure 2. The simulation package that will be used is PSS/ADEPT.

Simulation Test System

A single line diagram test system was modeled as in figure 3. Transformers connections in the test system are being modeled as accurate as possible with the transformer connections that are being used by the utilities. G1 is a generator producing 11. 5kV. The voltage level at B2 and B3, B4 and B5, B6 and B7, B8 and B9 are 275kV or 132kV, 33kV, 11kV and 0. 415kV respectively. The transformers connections are being described in table 1. Transformer and transmission lines parameters for different types of impedances are being described in table II and III respectively. In the vector group of the transformer configurations, capital letter represents the high voltage winding and small letter represents the low voltage winding. 1 and 11 represents the phase shift in between high voltage and low voltage angle where 1 is -300 and 11 is +300.

In the test system single line diagram, the system grounding is being implemented in all of the transformer connection. System grounding is referring to the method of how the entire system or network is being grounded. The grounding in electrical distribution system is being at the Y-connected side of the transformers. The resistor that is being used grounding at TX3 and TX4 is called Neutral Earthing Resistor (NER). The basic purpose of the NER is to protect the transformer from from damaging fault currents fault current by limiting the fault current to be equaled to the transformer's capacity or the transformer's full load current. Fault event will be simulated at B5. The propagated voltage through TX3 will be characterized. Different types of transformer and transmission lines parameters will be used to analyze the vulnebarality of the fault event at the neigbouring busbar B4.

RESULTS AND DISCUSSIONS

1. *Propagated Fault Event*

The simulation faulted results that were being presented was single line to ground fault and double line to ground fault using type 1 parameters for transformer and transmission lines. The results of the simulations are being represented by phasor diagram shown in figure 5, 6 and 7. For all figure the bold line represent the primary voltage of TX3 i. e voltage at B5 and for dashed line represents the voltage at the secondary side of TX3 i. e. voltage at B6. Figure 6 depicts the situation of a single line to ground fault is being applied at B5 (33kV). The red phase at B5 experiencing an interruption due to the fault but the other two phases experiencing increase in voltage and phase angle jumps. From due to solid grounding stated that sag that is caused by single phase fault is given by the equation in table IV and is classified as type B and after traveling to Dyn11 transformer transform into type C but in this scenario the situation is different because the presence of

NER restore the voltage to a normal voltage level at B6 (11kV). Figure 7 depicts the situation when there line to line fault is simulated at B5. The voltage at B5 during this type of fault follows the explanation in but after propagated to TX3 the red phase blue phase at B6 disappears due to the presence of NER. The voltage during fault may not necessarily drop to zero but the value of the voltage is very minuscule that it can be assumed it reached to zero during fault.

2. Vulnerability of fault event

The neighbouring bus B4 is of concern when there is a fault. In order to test the vulnerability of the propagation of sagged voltage at the neighbouring busbar B4, the length pf the transmission lines is being increased. The transformer and transmission lines parameters is being changed by the data given in table II and III respectively. In figure 8, 9, 10, 11 and 12 are being presented by two graph where bold line is the voltage at B4 without any fault as the length is being increased where as the dashed line is the voltage at B4 during fault event occurs. the fault that is being simulated is single line to ground fault. In shows that the theoretical calculation of the vulnerability of fault event increase to a constant value. But in this research simulation as the length of the transmission lines is being increased when fault is simulated, the voltage at the neighbouring bus is decreasing due to the voltage drop of the cable length it self. Up to a certain point as the length of the transmission lines is being increased, the voltage during fault and the voltage when there is no fault is moving towards the same value.

CONCLUSIONS

The transformer connection and configuration as well as transformer and transmission lines have a crucial role where it gave an impact to the propagation of sagged voltage. It can be seen that when a single line to ground fault event occurs, one phase may not necessary drop to zero but will be sagged and two phases will swelled and the transformer connection Dyn11 NER grounding can automatically mitigates the problems. But Dyn11 transformer might not necessarily mitigates any fault because it s shown that line to line fault that propagates through it does not mitigates the problems. Consumers that are connected to 0. 415 kV may or may not be affected by the fault event as the transformer connections have mitigated the disturbances since the severity of the sag voltage is presence eventhough NER grounding transformer connections is being used. The vulnerability may overcome the severity of sagged voltage but up to a certain point the voltage drop due to cable length may provides under voltage to the power system network. Through transformer connections, the voltage sag propagation can be predicted with empirical formula through continuous observations. As installing monitoring equipment could dramatically increase cost, alternative approach such as developing empirical formula can overcome this hassle. By having a proper monitoring method, voltage sag propagation that can cause variety of problems can be apprehended. It is hope through this study and investigation, future development in predicting to develop an empirical formula can be establish.

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