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Nuisance Tripping of 11kv HV Switchgear Protection Relay

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ABSTRACT

A protective relay is a device that gives instructions to disconnect a faulty part of the system. This action ensures that the remaining system is still fed with power, and protects the system from further damage because of the fault. A protection apparatus has three main functions/duties—to safeguard the entire system to maintain continuity of supply, minimize damage and repair costs where it senses fault, and ensure safety of personnel. Protection of any distribution system is a function of many elements, and this dissertation gives a brief outline of various components that go in protecting a system and to eliminate Nuisance tripping of the HV Switchgear Protection relay. In other words, to reduce and eliminate unnecessary faults on the power system configuration. A power system is capable of meeting the present load and has the flexibility to meet the future demands. A power system is designed to generate electric power in sufficient quantity to meet the present and estimated future demands of the users in a particular area, to transmit it to the areas where it will be used, and then distribute it within that area on a continuous basis. The effective and continuous supply of electricity ensures that Factory Equipment, and home appliances last longer, which invariably improves businesses and social and economic lives of the people connected on the network.

Keywords: Nuisance Tripping of 11kv, HV Switchgear Protection Relay, Nigeria Liquefied Natural Gas (NLNG)

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Nuisance tripping of an 11kV MV Switchgear protection Relay occurs frequently due to faults at the source or load end of power distribution. The basic parameters of the three-phase electrical system are voltage, current, frequency, and power. All these have predetermined values and/or sequences under healthy conditions. Any shift from this normal behavior could be the result of a fault condition either at the source end or at the load end. The 11kV MV Switchgear Protection Relays are devices that monitor various parameters in various ways, and this chapter gives a brief outline of their principles of operation. The function of the relay is to measure the input and assess its condition. A digital relay comprises sensitive devices and hence it is necessary that they do not fail because of the input changes. This is taken care by the isolating transformer and the limiter used in the relay. Earth Fault protection in MV Switchboards One very important protection in MV Switchboards is Earth Fault Protection. Earth Fault or Ground fault is the most common cause for electrical hazards like Arc Flash. Hence, special attention is necessary while designing earth fault protection system. Earth Faults are generally classified into: Sensitive earth fault, restricted earth fault and earth leakage

1.2 Problem Statement

There have been cases of Nuisance Tripping of Protection Relay in our Electricity system distribution networks in Nigeria.This is one of the causes of Power Outages in our distribution network. The Nuisance Tripping of 11kV system leads to Power outages and unbalanced Power distribution system. This as a result leads to frequent damages to Electronics equipment within our homes and industries.

1.3 Research Aim and Objectives

This research work is aimed to study the causes and proffer solution to Nuisance Tripping of 11kV HV Switchgear Protection Relay.

The objectives of this research work are:

- Identify Various protection Relay Trip Functions
- Causes of Nuisance Tripping of 11kVProtection Relay.
- Method to Eliminate / reduce Nuisance Tripping of 11kV Protection Relay.

1.4 Significance of Study

Over the years within the country, there have been irregular power disruptions, sometimes during thunderstorms and at other times just earth fault.

The significance of this study would be to provide correct Protection component installation and Relay Setting that will guarantee healthy 11kV system operation without the Nuisance Tripping thereby causing unnecessary outage which causes damages to electronics equipment and industrial equipment and machineries

1.5 Scope of Work

The scope of this research work shall be restricted to:

a. Causes of Nuisance Tripping of 11kV HV Switchgear Protection Relay
b. Trip Functions Of a Protection Relay
c. Various Types of Protection Relay
d. Solutions to Nuisance Tripping of an 11kV Protection Relay

1.6 Work Outline

This work shall be targeted at providing Nuisance Tripping of Protection relay solution to solve the problem of damage to equipment and incessant power outage in Nigerian power distribution network.

- Chapter two of this work shall review the literature with keywords; general overview of Protection relay, Types of Protection Relays, Protection Relay Tripping Functions, Protection Relay Setting
- Chapter three will present the case study of Nigeria Liquefied Natural Gas (NLNG) Substation 29 Nuisance Tripping of 11kV HV Switchgear Protection Relay
- Chapter four will present data analysis on ABB Protection Relay software environment, results, summary and discussion.
- Chapter five will present a summary of the conclusion and recommendation for further work.

However, this project work shall be made of great practical relevance to the society and Nigeria in particular. Meanwhile actual data will be collected from the Nigeria Liquefied Natural Gas (NLNG) Substation 2911kv Substation distributing Power to the Bonny Airstrip.

CHAPTER 2

LITERATURE REVIEW

2.1 General Overview of 11kV HV Switchgear Protection Relay

A protective relay is a relay device designed to trip a circuit breaker when a fault is detected. Protection Relay are used for the detection of abnormal operating conditions such as over-current, over-voltage, reverse power flow, over-frequency, and under-frequency. Microprocessor-based digital protection relays now emulate the original devices, as well as providing types of protection and supervision impractical with electromechanical relays.

In many cases a single microprocessor relay provides functions that would take two or more electromechanical devices. However, due to their very long-life span, tens of thousands of these "silent sentinels" are still protecting transmission lines and electrical apparatus all over the world. Important transmission lines and generators have cubicles dedicated to protection, with many individual electromechanical devices, or one or two microprocessor relays. The need to act quickly to protect circuits and equipment often requires protective relays to respond and trip a breaker within a few thousandths of a second. In some instances, these clearance times are prescribed in legislation or operating rules. A maintenance or testing program is used to determine the performance and availability of protection systems. Based on the end application and applicable legislation, various standards such as ANSI C37.90, IEC255-4, IEC60255-3, and IAC govern the response time of the relay to the fault conditions that may occur.

2.1.1. RELAY TECHNOLOGY

The last thirty years have seen enormous changes in relay technology. The electromechanical relay in all of its different forms has been replaced successively by static, digital and numerical relays, each change bringing with it reductions and size and improvements in functionality. At the same time, reliability levels have been maintained or even improved and availability significantly increased due to techniques not available with older relay types. This represents a tremendous achievement for all those involved in relay design and manufacture. This chapter charts the course of relay technology through the years. As the purpose of the book is to describe modern protection relay practice, it is natural therefore to concentrate on digital and numerical relay technology.

2.1.1.1. ELECTROMECHANICAL RELAYS

These relays were the earliest forms of relay used for the protection of power systems, and they date back nearly100 years. They work on the principle of a mechanical force causing operation of a relay contact in response to a stimulus. The mechanical force is generated through current flow in one or more windings on a magnetic core or cores, hence the term electromechanical relay. The principle advantage of such relays is that they provide galvanic isolation between the inputs and outputs in a simple, cheap and reliable form – therefore for simple, on/off switching functions where the output contact shave to carry substantial currents, they are still used. Electromechanical relays can be classified into several different types as follows:

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a. attracted armature

b. moving coil

c. induction

d. thermal

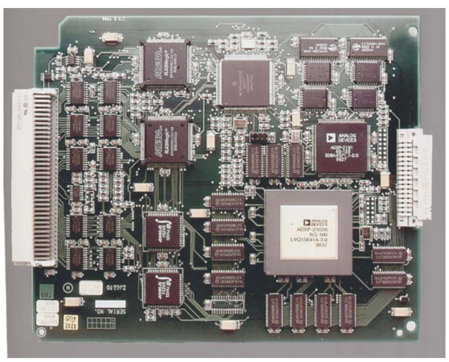
e. motor operated

f. mechanical

However, only attracted armature types have significant

2.1.1.2. STATIC RELAY

Fig 2.1.1.2 STATIC RELAY



The term ‘static’ implies that the relay has no moving parts. This is not strictly the case for a static relay, as the output contacts are still generally attracted armature relays. In a protection relay, the term ‘static’ refers to the absence of moving parts to create the relay characteristic. Introduction of static relays began in the early 1960’s.Their design is based on the use of analogue electronic devices instead of coils and magnets to create the relay characteristic. Early versions used discrete devices such as transistors and diodes in conjunction with resistors, capacitors, inductors, etc., but advances in electronics enabled the use of linear and digital integrated circuits in later versions for signal processing and implementation of logic functions. While basic circuits may be common to a number of relays, the packaging was still essentially restricted to a single protection function per case, while complex functions required several cases of hardware suitably interconnected. User programming was restricted to the basic functions of adjustment of relay characteristic curves. They therefore can be viewed in simple terms as an analogue electronic replacement for electromechanical relays, with some additional flexibility in settings and some saving in space

requirements. In some cases, relay burden is reduced,making for reduced CT/VT output requirements.

2.1.1.3. **DIGI TAL RELAY S**

FIG2.1.1.3 DIGITAL RELAYS

Digital protection relays introduced a step change in technology. Microprocessors and microcontrollers replaced analogue circuits used in static relays to implement relay functions. Early examples began to be introduced into service around 1980, and, with improvements in processing capacity, can still be regarded as current technology for many relay applications.

However, such technology will be completely superseded within the next five years by numerical relays. Compared to static relays, digital relays introduce A/D conversion of all measured analogue quantities and use a microprocessor to implement the protection algorithm. The microprocessor may use some kind of counting technique, or use the Discrete Fourier Transform (DFT) to implement the algorithm. However, the typical microprocessors used have limited processing capacity and memory compared to that provided in numerical relays. The functionality tends therefore to be limited and restricted largely to the protection function itself. Additional functionality compared to that provided by an electromechanical or static relay is usually available, typically taking the form of a wider range of settings ,and greater accuracy. A communications link to a remote computer may also be provided. The limited power of the microprocessors used in digital relays restricts the number of samples of the wave form that can be measured per cycle. This, in turn, limits the speed of operation of the relay in certain applications. Therefore, a digital relay for a particular protection function may have a longer operation time than the static relay equivalent. However, the extra time is not significant in terms of overall tripping time and possible effects of power system stability.

2.1.1.4. **NUMERICAL RELAY S**

FIG 2.1.1.4. **NUMERICAL RELAY S**

The distinction between digital and numerical relay rests on points of fine technical detail, and is rarely found in areas other than Protection. They can be viewed as natural developments of digital relays as a result of advances in technology. Typically, they use a specialized digital signal processor (DSP) as the computational hardware, together with the associated software tools.

The input analogue signals are converted into a digital representation and processed according to the appropriate mathematical algorithm. Processing is carried out using a specialized microprocessor that is optimized for signal processing applications, known as a digital signal processor or DSP for short. Digital processing of signals in real time requires a very high-power microprocessor. In addition, the continuing reduction in the cost of microprocessors and related digital devices (memory, I/O, etc.) naturally leads to an approach where a single item of hardware is used to provide a range of functions('one-box solution' approach). By using multiple microprocessors to provide the necessary computational performance, a large number of functions previously implemented in separate items of hardware can now be included within a single item.

Numerical distance relay features

- Distance Protection- several schemes including user definable)
- Overcurrent Protection (directional/non-directional)
- Several Setting Groups for protection values
- Switch-on-to-Fault Protection
- Power Swing Blocking
- Voltage Transformer Supervision
- Negative Sequence Current Protection
- Undervoltage Protection
- Overvoltage Protection
- CB Fail Protection
- Fault Location

- CT Supervision
- VT Supervision
- Check Synchronization
- Auto reclose
- CB Condition Monitoring
- CB State Monitoring
- User-Definable Logic
- Broken Conductor Detection
- Measurement of Power System Quantities (Current, Voltage, etc.)
- Fault/Event/Disturbance recorder

Relay Software

The software provided is commonly organized into a series of tasks, operating in real time. An essential component is the Real Time Operating System (RTOS),whose function is to ensure that the other tasks are executed as and when required, on a priority basis. Other task software provided will naturally vary according to the function of the specific relay, but can be generalized as follows:

a. system services software – this is akin to the BIOS of an ordinary PC, and controls the low-level I/O for the relay (i.e. drivers for the relay hardware, boot-up sequence, etc.)

b. HMI interface software – the high level software for communicating with a user, via the front panel controls or through a data link to another computer running suitable software, storage of setting data, etc.

c. application software – this is the software that defines the protection function of the relay

d. auxiliary functions – software to implement other features offered in the relay – often structured as a series of modules to reflect the options offered to a user by the manufacturer

Application Software**.** The relevant software algorithm is then applied. Firstly, the values of the quantities of interest have to be determined from the available information contained in the data samples. This is conveniently done by the application of the Discrete Fourier Transform (DFT), and the result is magnitude and phase information for the selected quantity. This calculation is repeated for all of the quantities of interest. The quantities can then be compared with the relay characteristic, and a decision made in terms of the following:

a. value above setting – start timers, etc.

b. timer expired – action alarm/trip

c. value returned below setting – reset timers, etc.

d. value below setting – do nothing

e. value still above setting – increment timer, etc.

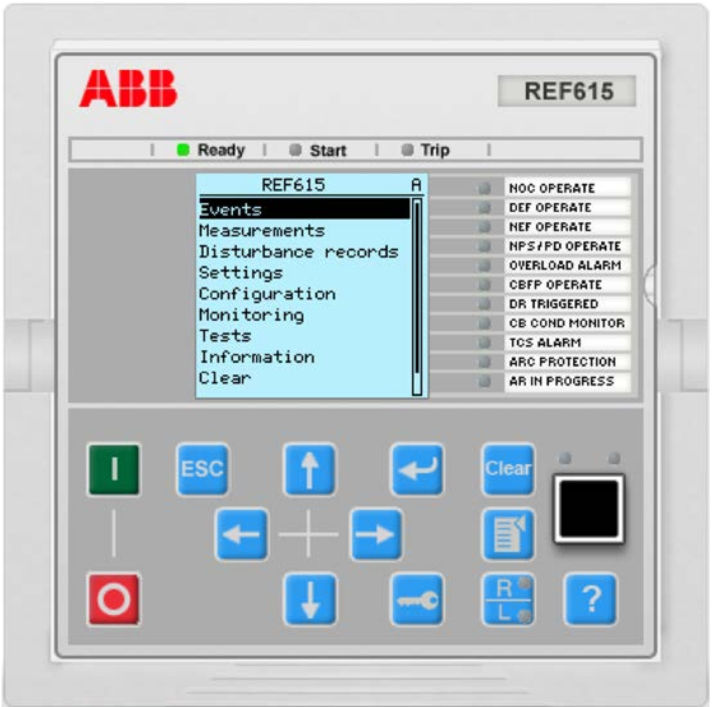
f. Since the overall cycle time for the software is known,

a. timers are generally implemented as counters.

2.2 VARIOUS TYPES OF PROTECTION RELAY AND THEIR TRIP FUNCTIONS

- **SPAJ140 non-directional overcurrent and earth fault protection.**
- **SPAJ110 earth fault protection.**
- **SPAM150 motor protection**
- **REF 615- Combination of SPAJ140 and SPAJ110**

Fig 2.2 REF 615



- **Siemens SIPROTEC 7SJ62** line protection of high and medium voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point

2.3. TYPICAL 11kV HV SWITCHGEAR PROTECTION RELAY TRIP FUNCTIONS

Table 2.3. Protection Relay Trip Functions

Function	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC1	3I> (1)	51P-1 (1)
	PHLPTOC2	3I> (2)	51P-1 (2)
Three-phase non-directional overcurrent protection, high stage	PHHPTOC1	3I>> (1)	51P-2 (1)
	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I>>> (1)	50P/51P (1)
	PHIPTOC2	3I>>> (2)	50P/51P (2)
Three-phase directional overcurrent protection, low stage	DPHLPDOC1	3I>→ (1)	67-1 (1)
	DPHLPDOC2	3I>→ (2)	67-1 (2)

Three-phase directional overcurrent protection, high stage	DPHHPDOC1	3I>>→	67-2
Non-directional earth-fault protection, low stage	EFLPTOC1	I0> (1)	51N-1 (1)
	EFLPTOC2	I0> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage	EFHPTOC1	I0>> (1)	51N-2 (1)
	EFHPTOC2	I0>> (2)	51N-2 (2)
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	I0>>>	50N/51N
Directional earth-fault protection, low stage	DEFLPDEF1	I0>→ (1)	67N-1 (1)
	DEFLPDEF2	I0>→ (2)	67N-1 (2)

Table continues on next page

Directional earth-fault protection, high stage	DEFHPDEF1	I0>>→	67N-2
Transient / intermittent earth-fault protection	INTRPTEF1	I0>→ IEF	67NIEF
Non-directional (cross-country) earth fault protection,	EFHPTOC1	I0>>	51N-2
Negative-sequence overcurrent protection	NSPTOC1	I2> (1)	46 (1)
	NSPTOC2	I2> (2)	46 (2)
Phase discontinuity protection	PDNSPTOC1	I2/I1>	46PD
Residual overvoltage protection	ROVPTOV1	U0> (1)	59G (1)
	ROVPTOV2	U0> (2)	59G (2)
	ROVPTOV3	U0> (3)	59G (3)
Three-phase undervoltage protection	PHPTUV1	3U< (1)	27 (1)
	PHPTUV2	3U< (2)	27 (2)
	PHPTUV3	3U< (3)	27 (3)
Three-phase overvoltage protection	PHPTOV1	3U> (1)	59 (1)
	PHPTOV2	3U> (2)	59 (2)
	PHPTOV3	3U> (3)	59 (3)
Positive-sequence undervoltage protection	PSPTUV1	U1<	47U+
Negative-sequence overvoltage protection	NSPTOV1	U2>	47O-
Three-phase thermal protection for feeders, cables and	T1PTTR1	3Ith>F	49F
Three-phase thermal overload protection for power	T2PTTR1	3Ith>T	49T
Negative-sequence overcurrent protection for motors	MNSPTOC1	I2>M (1)	46M (1)
	MNSPTOC2	I2>M (2)	46M (2)
Loss of load supervision	LOFLPTUC1	3I<	37
Motor load jam protection	JAMPTOC1	Ist>	51LR
Motor start-up supervision	STTPMSU1	Is2t n<	49,66,48,51LR
Phase reversal protection	PREVPTOC	I2>>	46R
Thermal overload protection for motors	MPTTR1	3Ith>M	49M
Binary signal transfer	BSTGGIO1	BST	BST

Stabilized and instantaneous differential protection for	TR2PTDF1	3dI>T	87T
Line differential protection and related measurements, stabilized and instantaneous stages	LNPLDF1	3dI>L	87L
Numerical stabilized low impedance restricted earth-fault	LREFPNDF1	dI0Lo>	87NL
High impedance based restricted earth-fault protection	HREFPDIF1	dI0Hi>	87NH
Circuit breaker failure protection	CCBRBRF1	3I>/I0>BF	51BF/51NBF
Three-phase inrush detector	INRPHAR1	3I2f>	68

CHAPTER 3

MATERIALS AND METHODS

3.1 RESEARCH MATERIALS

Data required for the purpose of analysis and investigation of the study area was collected from Nigeria Liquefied Natural Gas (NLNG) Substation 37 and Substation 29 11kV installation. The method and procedure adopted in this research are described accordingly.

3.1.1. The Purpose of this test is to define and describe the method, tests and test sequence of connections required to investigate the root cause of the tripping at the HV switchgear SB37D1 SIEMEN multifunction protection relay (7SJ8031-5EB00-3FB0).

In order to investigate the cause of the tripping two (2) separate analyses shall be carried out:

1. To determine, if the Emergency Diesel Generator G-0001 is a factor in the tripping of the SB29C1-3, Siemens multifunction protection relay (7SJ8031-5EB00-3FB0), the related static load test will be executed again, but in different sequences
2. 2nd investigation will analyze the whole electrical system of the Bonny River airstrip powered through the HV switchgear SB29C1

To support both investigations, three phase power quality analyzer (C.A 8332B) shall be installed to verify the current conditions, positioned as follow;

a. Three phase power quality analyzer (C.A 8332B) connected to the EDG G-0001 to verify the output parameters from the EDG (positioned at the bus bar on EDG power part.

b. Three phase power quality analyzer (C.A 8332B) connected to the airstrip electrical system to verify the general output parameters (positioned at the LV switchgear SB29N1/2.H)

Note:

i. **Circuits to be de-isolated:**

a) Rack in SB29N1/1.H.- Incoming Emergency Diesel Generator G-0001 feeder on LV switchgear SB29N1

b) SB29N1/4.M – Spare Breaker on LV Switchgear SB29N1.

ii. **Circuits to be Isolated**

a) SB29N1/3.H – SB29N12 MDB Terminal Building Ground Floor

b) SB29N1/3.M – SB29N13 SDB Terminal HVAC GF

c) SB29N1/5.M – SB29N15 SDB Gate house 2

d) SB29N1/5.L – SB29N14 SDB Fire Rescue

e) Partial isolation of SB29N11 SDB Substation

This distribution board SB29N11 shall be partially isolated- lighting circuits (SB29N11/02) and small power outlets (SB29N11/09, 10, & 11) shall be energised for test purpose within the electrical room

f) SB29N1/5.N-5.P- UP29V2 30kVA AC UPS System

g) SB29N1/4.D-4.H – UP29V1 160kVA AC UPS System

3. Energization of above mentioned circuit after test,- By NLNG Authorised Personnel

4. Return all electrical installation to Normal running mode (pre-test status) after tests - By NLNG Authorized personnel.

3.1.2. TEST METHOD STATEMENT

Preliminaries

- All necessary permits (isolation permit/clearance certificate) shall be obtained before the test starts
- Appropriate equipments / tools shall be used
- Pre check of materials / equipments to be used for the test shall be carried out
- Advance notice to the consumers connected to SB29N1 (BRTA)

3.1.3. Three Phase Power Quality Analyzer: C.A 8332B

The measurements and connections shall be made strictly according to manufacturer user manual and instructions.

The principal measurements made are:

- Measurement of AC rms voltages up to 480V (phase –to-phase) and of AC rms current for four wire networks.
- Measurement of the frequency of 50Hz network

Calculation of the power,

- Calculation of active, reactive and apparent power per phase and their aggregate.
- Calculation of neutral current by vector summing of phase current for star configurations.
- Calculation of the peak factors for current and voltages
- Calculation of the phase unbalance for voltages and current (three-phase network only).

3.2.0. TESTS TO BE CARRIED OUT

To determine/verify, if the Emergency Diesel Generator (EDG) (G-0001) is a factor in the tripping of the SB29C1-3, Siemens multifunction protection relay (7SJ8031-5EB00-3FB0) the following tests shall be executed:

1. Emergency Diesel Generator G-0001 synchronization to grid/ static load test with transformer only (gradually increase the load from 10% to 100%).
2. Checking the entire BRTA electrical system without the EDG G-0001 by:

a) Connecting the three phase power quality analyzer: C.A 8332B to the LV switchgear terminal SB29N1/2.H, and taking the parameters on the analyzer at 1s interval for 20 minutes, with the Terminal building HVAC panel SB29N13 (SB29N1/3.M) energized while other circuits remain in off position

b) Connecting the three phase power quality analyzer: C.A 8332B to the LV switchgear terminal SB29N1/2.H, and taking the parameters on the analyzer at 1s interval for 20 minutes, with the substation panel SB29N11 HVAC circuits (18, 19, 20, 21, 22, 23 & 24) energized while other circuits remain in off position.

c) Connecting the three phase power quality analyzer: C.A 8332B to the LV switchgear terminal SB29N1/2.H, and taking the parameters on the analyzer at 1s interval for 20 minutes, with all other circuits:

SB29N1/5.M – SB29N15 SDB Gate house 2

SB29N1/5.L – SB29N14 SDB Fire Rescue

SB29N1/5.K - SB29N11 SDB Substation

This distribution board SB29N11 shall be partially isolated- HVAC circuits (SB29N11/18, 19, 20, 21, 22, 23 & 24) shall be in off position – Reference Attachment 6.3

SB29N1/5.N-5.P- UP29V2 30kVA AC UPS System

SB29N1/4.D-4.H – UP29V1 160kVA AC UPS System energized.

The terminal building HVAC panel SB29N13 shall remain in off position

3.2.1. TEST SEQUENCE

Before any test shall be carried out, three phase power quality analyser (C.A 8332B) will be installed:

Phase 1: Connection of three phase power quality analyser C.A 8332B

i. Three phase power quality analyser (C.A 8332B) installed on the EDG output on the LV Switchgear (SB29N1/1.H)

ii. Three phase power quality analyzer (C.A 8332B) installed on the transformer output on the LV switchgear (SB29N1/2.H)

Phase 2: Emergency Diesel Generator Static load test to Grid with transformer TR29CN1 only

In order to investigate the tripping of the HV Switchgear SB29C1-3 Siemens multifunction protection relay (7SJ8031-5EB00-3FB0), the tests on the Emergency Diesel Generator shall be carried out (as mentioned in section 4 - Test to be carried out):

Emergency Diesel Generator G-0001 synchronization to grid/ static load test with transformer only (gradually increase the load from 10% to 100%).

Phase 3: BRTA electrical system check without the EDG G-0001

.Checking the entire BRTA electrical system without the EDG G-0001.

Phase 1: Connection of three phase power quality analyzer C.A 8332B-Generator Panel

Fig3.2.1a: Typical Three Phase Power Quality Analyzer Connection

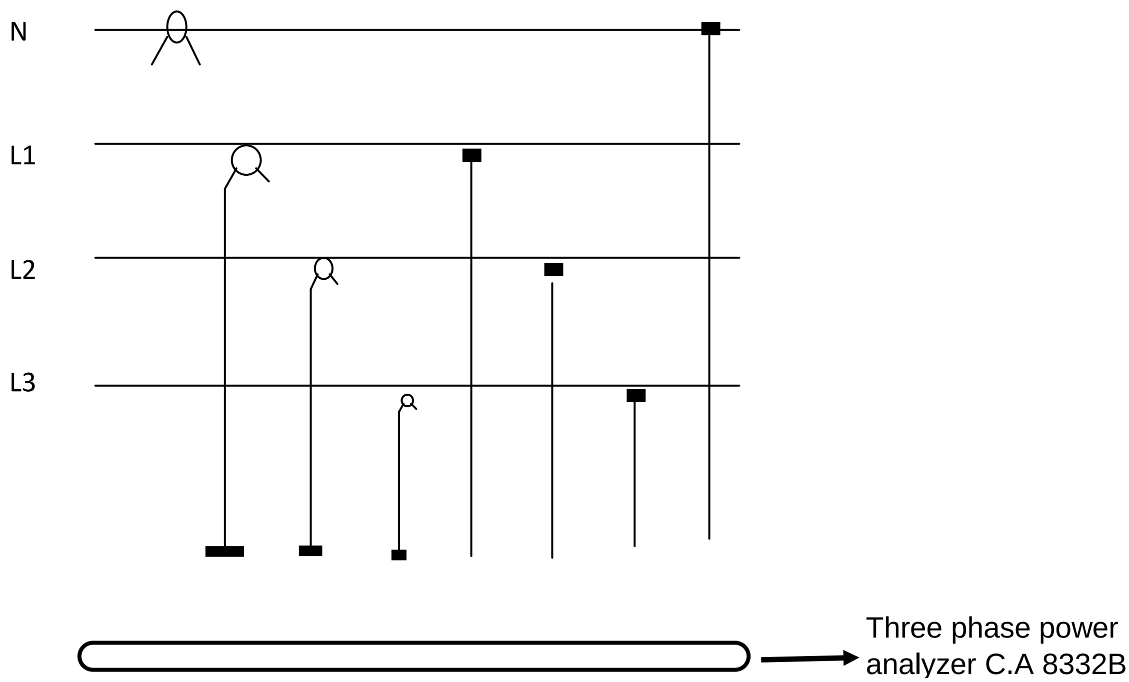


Fig3.2.1b: Typical Three Phase Power Quality Analyzer Connection

3.2.2. **Step 1**.

Connection of Thethree (3) phase power quality analyzer (C.A 8332B) to bus bar on emergency diesel generator G-0001 power part terminal

The three (3) phase power quality analyzer (C.A 8332B) current measurement probe (Ampflex) is clamped round the bus bar on EDG power part terminal.

- Green Ampflex cable clamped around L1 bus bar on EDG power part terminal
- Yellow Ampflex cable clamped around L2 bus bar on EDG power part terminal
- Red Ampflex cable clamped around L3 bus bar on EDG power part terminal

The neutral current shall be calculated by the three phase power quality analyzer (C.A 8332B).

3.2.3. **Step 2**:

The three (3) phase power quality analyzer (C.A 8332B) voltage measuring leads are clamped to the bus bar on the EDG Q201 control panel terminal

- Clamp green voltage lead to L1 bus bar on EDG power part terminal
- Clamp yellow voltage lead to L2 bus bar on EDG power part terminal
- Clamp red voltage lead to L3 bus bar on EDG power part terminal
- Clamp blue voltage lead to N bus bar on EDG power part terminal

CHAPTER 4

RESULTS AND DISCUSSION

4.1 RESULT ANALYSIS

Table.4.1: Relay protection Functions

RELAY - PROTECTION FUNCTIONS

2 Non-Directional overcurrent protection Low – I>

2.1 Settings:
Curve – IEC NORMAL INVERSE
Primary setting = 262.5 A
Secondary value = 1.31A

	Main Setting	Second Setting
Start Value :	1.31	1.31
Time (TMS) :	0.8	0.8

2.2 Measurements (OMICRON)

	Injected Current A)	Triping time on Test Set (sec)	Tripping Time (sec) to open Vacuum Contactor
L1	1.32	91.2 Secs	86.04 Secs
L2	1.32	91.2 Secs	86.04 Secs
L3 :	1.32	91.2 Secs	86.04 Secs

	Injected Current A)	Triping time on Test Set (sec)	Tripping Time (sec) to open Vacuum Contactor
L1	1.5	14.31 Secs	13.8 Secs
L2	1.5	14.31Secs	13.8 Secs
L3 :	1.5	14.31 Secs	13.8 Secs

	Injected Current A)	Triping time on Test Set (sec)	Tripping Time (sec) to open Vacuum Contactor
L1	2.0	9.10 Secs	8.05 Secs
L2	2.0	9.10 Secs	8.05 Secs
L3 :	2.0	9.10 Secs	8.05 Secs

Omicron was used to check the time before the vacuum contactor opens.

It is capable of analyzing the system.

4.2 Analysis from Sequence of Operation Result.

The result obtained from the tripping test carried out showed that the tripping time from the Omicron for test 1 on L1 is 91.2 Sec while the actual tripping of the Vacuum Contactor tripped at 82.4 Sec:

Table 4.2: Transformer Neutral Earth Fault

3 TRANSFORMER NEUTRAL EARTH FAULT (ELEMENT USED PHPTOC2) – I>>

3.1 Settings:
Time delay: DEFINITE TIME
Primary setting = 593.78A
Secondary value = 3.97A

Case)

	Main Setting	Second Setting
Start Value :	3	3
Time (Secs) :	0.5	0.5

3.2 Measurements

ew

	Injected Current (A)	Triping time onTest Set (sec)	Tripping Time (sec) to open Vacuum Contactor
TRANSFORMER NEUTRAL	3.1	0.545	0.525

4.3. NON-DIRECTIONAL EARTH FAULT

Table 4.3. Relay Protection Functions

RELAY - PROTECTION FUNCTIONS

4 Non directionall Earth Fault (I_o>1).

4.1 Settings:
Time Delay – DEFINITE TIME
Primary setting = 12.425A
Secondary value = 0.124A

	Main Setting	Second Setting
Start Value :	0.2	0.2
Time (Secs) :	0.5	0.5

4.2 Measurements (OMICRON)

	Injected Current (A)	Triping time onTest Set (sec)	Tripping Time (sec) to open Vacuum Contactor
Earth Fault CT I_o	0.2	0.524	0.485

FIG 4.3- SLD- 11kV HV SWITCHGEAR

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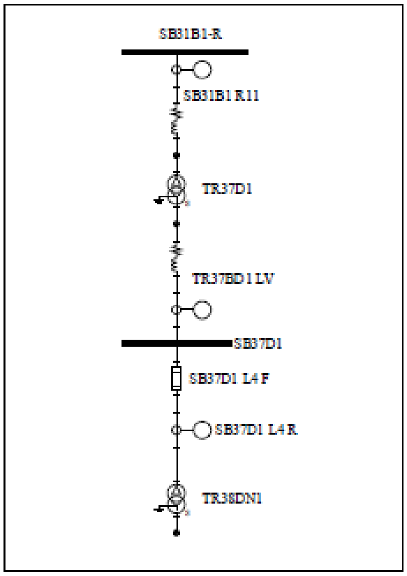
FIG 4.4. SS37 SB37BD1 RELAY PROTECTION SETTING AND GRAPH

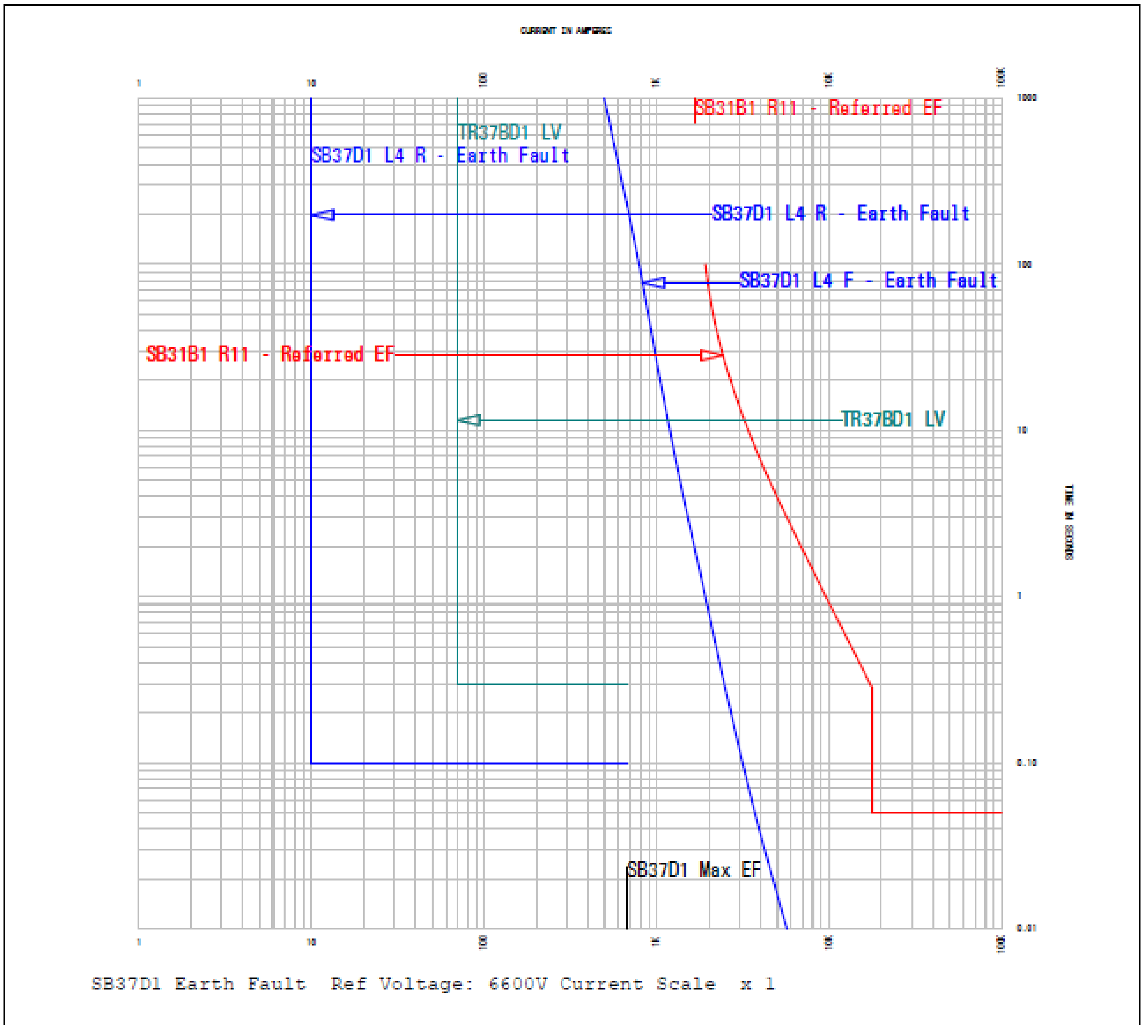
Relays

Name/Type	Description	CT Ratio (A)	Settings
SB37D1 L4 R Electronic	ABB SPAJ140C 1A Phase & Neutral O/C	100 / 1	Earth Fault Io> 0.1 (10A) To> 0.1
TR37BD1 LV Electronic	ABB SPAJ110C 1A Phase and Neutral O/C	700 / 1	Earth Fault Io> 0.1 (70A) To> 0.3
SB31B1 R11 Electronic	ABB REF542+, 1A OC & EF	416 / 1	Referred EF I> 0.8 (332.8A) EI 30xDT 0.4 I>> 8.5 (3536A) T>> 0.05

Fuses

Name/Type	Description	Cartridge/Trip	Settings
SB37D1 L4 F High Voltage	BUSSMANN WFN/WKN/WFM/WKM 7.2kV	200.0A 200.0A	Earth Fault 200.0 Amps





CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This research work has highlighted the benefits of improved protection relay Setting in 11kv HV Switchgear in Substation 37, within the NLNG power installation.

Nuisance tripping is eliminated with Proper Protection relay Setting, and utilizing OEM ABB RET 615 multipurpose protection relay. All the primary data and data derived from the different trip function analysis served as input data to model and evaluate the functionality of the ABB RET 615 Protection relay.

5.1.1 Non Directional Overcurrent protection low: for the Overcurrent protection, the pickup setting for the fault current is set higher than the maximum expected Normal or emergency load flow condition. The pickup value of the time element is set to prevent tripping for the maximum load current that can flow in either direction on the line. It is set to produce the fastest operating time that will not result in mis coordination with other protection downstream or upstream.

5.1.2 Transformer Neutral Earth fault: this has the advantage that both the primary and secondary windings are protected from both earth and phase to phase faults. The relay will only operate for faults appearing within the protection Zone.Under normal load conditions the CT secondary currents are equal and no current flows in the relay operating coil. If these currents become unequal because of a fault current being sensed in the transformer windings, the resulting current energises the operating coil.

The Aim of this project is to reduce fault currents causing nuisance tripping of contactors in the 11kV switchgear and this has been achieved through the introduction of ABB RET 615 protection relay and configuring to proper set values.

5.2 Recommendations

- The Electrical Engineering Team should incorporate OEM such as ABB or Siemens Protection Relay into The High Voltage Switchgear operation to reduce Nuisance Tripping.
- Protection Relay setting to be optimized for each Switchgear, from downstream to upstream.
- Further research should be done on relay technologies which fundamentally affect sensitivity and reliability of the protection system. The use of Multifunction relays other than electromechanical relays should be encouraged for higher security in our local networks as operating times of relay are more reduced.
- Government should put in place effective policies for effective relay coordination between various voltage levels without restriction by any power supply provider. This has to do with Generation, Transmission and Distribution systems inter link protective systems.

5.3 Contribution to Knowledge

This research work has contributed to knowledge in the following areas:

i. This research has proof the efficacy of OEM (ABB RET 615) High voltage Protection Relay to be effective against Nuisance tripping of 11kV HV Switchgear contactors.
ii. This research has shown that Proper setting of the Protection relay enhances coordination function in different voltage levels of power distribution and eliminate Nuisance tripping.
iii. Tripping sequence violation has been eliminated resulting in improved relay coordination.

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