CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Electricity is a fundamental asset to the world economy, in that certainty, stability indices are used to express a country's standing (consumption or production of electricity per capital) and the standard of living enjoyed by the people (Anyaka, 2014; Attigah and Mayer-Tasch, 2013).

Electric power system comprises mainly of the generation, transmission, and distribution systems (Abanihi, Ikheloa, and Okodede, 2018). These components were also listed as one of the most significant elements of both national and global infrastructure such that when power system collapses, it leads to major direct/indirect impacts on the economy. That is, the economic growth/development of a country depends heavily on the reliability and quality of electric power supply (Ritula and Puneet, 2015; Robert, 2003).

The basic aim of an electric power system and its operators is to deliver electrical energy efficiently, safely and at a cheap rate to consumers (Heussen, Saleem, and Lind, 2009; NERC, 2012). This implies that all aspects or components of the power system; the generating stations, the transmission network, and distribution network must work together to ensure that power is delivered to consumers safely, efficiently and at cheap rate.

Some researches including the one done by Morad, Abdellah, and Ahmed, (2014), show that the performance of a distribution network can be measured or determined by the following key indicators;

i. Reliability of the network.
ii. Availability of power on demand by consumers.
iii. Rated/Proper/Satisfactory voltage level.
iv. Affordability of power.

Electric power distribution network being the most visible part of the power supply chain and the one with direct effect on the consumers, should be a system with high reliability, efficiency, high quality of service and proper voltage level.

In recent years, the demand on electricity has dramatically grown due to substantial increase in environmental infrastructural development and different human activities without the corresponding upgrade and improvement in power infrastructural development, resulting in overloaded grids. This leads to low reliability of the distribution network, poor availability of power on demand by the consumers and poor quality of power from the distribution network.

Most electric power distribution networks are designed as radial distribution systems. This radial distribution network has a unique feature that bus voltage reduces, moving away from the substation, which is as a result of increasing number of inductive loads along the distribution line and this leads to greater demand for reactive power in the system (Bhongade and Sachin, 2016; Teja, Murty, and Kumar, 2016). It is observed that Power distribution network has greater number of inductive loads in electric power system network and as this number of inductive load increases, reactive power demand increases such that the load voltage drops to the extent that the value often violates the acceptable standard limit set by American National Standards Institute - ANSI C84.1 ($90\% \leq V \leq 106\%$ of the nominal voltage value). This frequent low voltage level in the network is caused by the inability of radial system of electric power distribution network in supporting all consumers connected to its injection substation to receive the same and standard acceptable voltage level as stated by ANSI C84.1. This low voltage could affect the proper functioning of power consumer's equipment/appliances and can reduce the service life of such equipment.

Mobile communication is tremendously enlarging day by day, that it becomes easy to monitor and control equipment or appliances over a large distance through GSM modem or cellular phone. Global System for Mobile Communication network (GSM) is almost everywhere.

Sometimes in critical situations, the need to take real-time decision is possible using this system of remote monitoring. Also the need of human presence in the vicinity of the monitored appliance is reduced and in a similar way systems can be controlled and monitored from anywhere, at any point and without worrying about geographical locations (Sonika and Wadhawe, 2016). The absence of automated transformer phase monitoring device that monitors and reports blown low voltage fuse to the Distribution System Operator shows that often blown low voltage fuse or the affected phase remains open for a long period of time, thus affecting the reliability of the network, availability of power on demand by the consumers and supply of rated or proper voltage value to three (3) phase consumers. (*See Appendix 1, picture of a distribution transformer feeder pillar or fuse panel in New Bussa network showing blown J&P fuses*).

Also the absence of automated remote monitoring system that monitors and reports over-voltage supply caused by the transformer's low voltage neutral failure leads to greater damage to power consumers' equipment without the knowledge of the power provider's Distribution System Operator (DSO) so as to isolate the affected transformer for the maintenance team to repair and restore good quality power supply from the affected transformer.

The absence of automated remote monitoring system that monitors and reports individual transformer trip to the Distribution system operator despite that the transformer's service feeder is still energized leads to power providers applying incorrect energy bill calculations approach in determining the energy bill for non-prepaid electricity customers (estimation billing approach). In this approach, power providers use the number of hours the feeder circuit breaker is closed (feeder supplying power) to calculate the amount of energy for customers on that feeder notwithstanding that some customers on that feeder may have their service transformer trip on fault during that period the feeder is supplying power and calculating the energy bill with that number of hours for all the non-prepaid customers supplied by that feeder is wrong.

The recent development in wireless communication and digital technology, especially in mobile phone networks offers new and cheaper possibilities for remote monitoring of complex electric power distribution system.

Thus the need to improve the performance of electric power distribution network, by developing an automated voltage compensating switching system with a GSM-based monitoring and reporting system leads to the development of this research work.

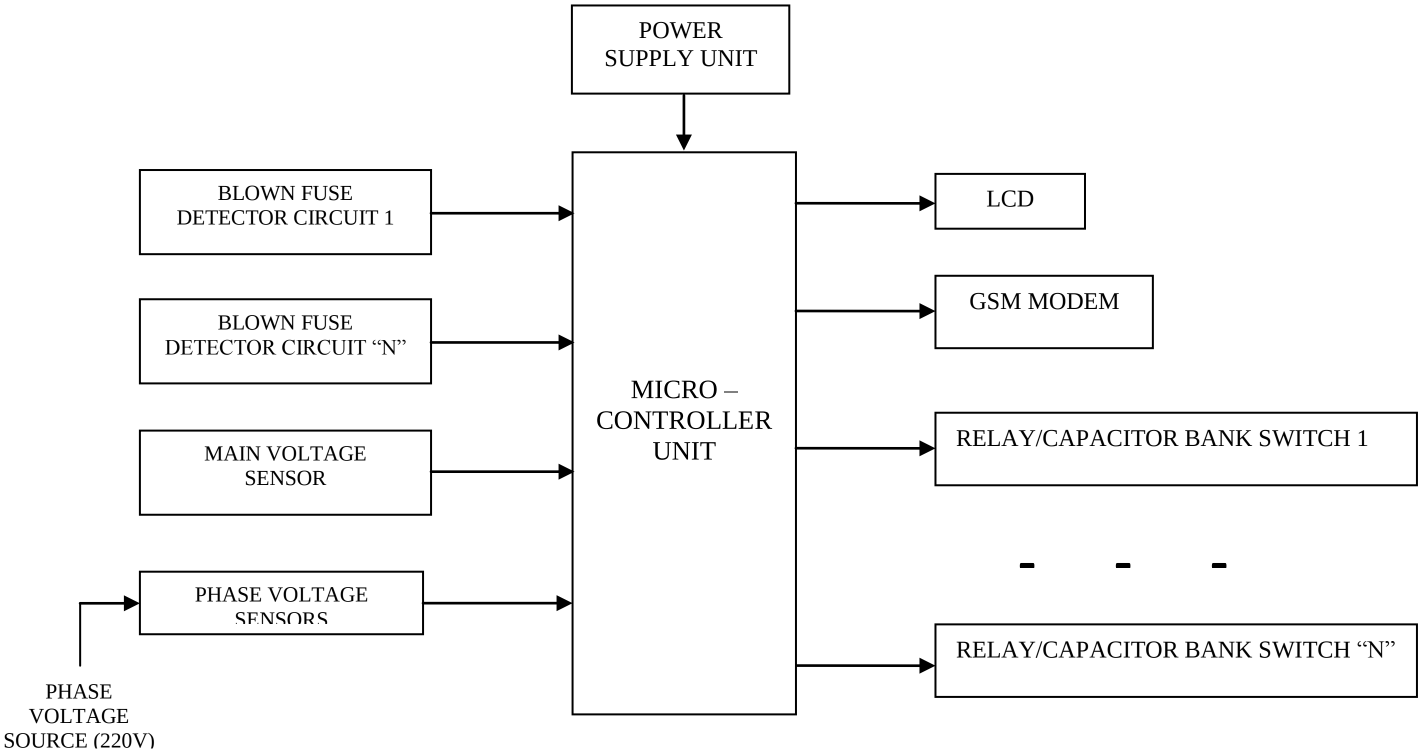

Figure 1.1: Block diagram of the Microcontroller-based switching system and GSM-based monitoring system

1.2 Statement of the Problem

The incessant low voltage supply to power consumers, complain by power consumers due to slow response to faults by power providers and improper energy billing systems by power providers to customers without prepaid meters have necessitated the development of a microcontroller based system, remotely monitored by GSM module to facilitate proper attention of distribution system operators to faults like blown low voltage fuse, transformer neutral failure and transformer trip within a given notice.

1.3 Aim of the Study

The aim of this research work is to enhance the performance of electric power distribution network using microcontroller and GSM based system.

1.4 Research Objectives

The aim of this study was achieved using the following specific objectives:

1. To determine the reliability of New Bussa Injection station in supplying quality power to all the distribution transformers in the network by conducting a power flow analysis of the network.
2. To develop voltage compensating system that reduces the voltage violations in the network using the optimal capacitor placement (OCP) module in ETAP 12.6 software and a mathematical model so as to ensure that ANSI C84.1 standard acceptable voltage levels are met at load buses.
3. To develop a microcontroller based switching system with remote adaptability that automatically switches the voltage compensators (capacitor banks) and reports sensed faults using GSM.
4. To carry out performance evaluation of the proposed technique and validate the functionality with respect to ANSI C84.1 acceptable voltage limit.

1.5 Significance of the Study

This research work assists in the development of an automated power distribution network that reduces the downtime associated with system maintenance, ensures prompt monitoring of the network, faster means of restoration of lost transformer phase and failed transformer neutral thus creating a more reliable distribution network system with its service voltage being within the ANSI acceptable limit.

The research work also added in its design work, a technical feature which when enforced by the Power regulatory body (NERC) for power providers to implement, produces a system that indicates to power providers when a particular distribution transformer is out of service (not active), irrespective of the fact that its service feeder is still active.

1.6 Scope of the Study

This research work focused on enhancing the performance of electric power distribution network using microcontroller and GSM based system. The test bed or the study environment for the research work is 15MVA, 33/11KV Injection Substation at New Bussa in Niger State, together with its feeders and their associated 11/0.415KV distribution transformers. The work covers the following: development and performance evaluation of a microcontroller-based capacitor switching system that automatically switches on/off capacitor bank for voltage compensation, development and performance evaluation of a GSM-based monitoring and reporting of transformer lost phase caused by blown low voltage fuse, over-voltage supply caused by transformer neutral failure and no voltage supply caused by transformer trip despite that the transformer's service feeder is still active or energized.

1.7 Arrangement of the Dissertation

Chapter one is basically the introduction of the research work. This includes research background, problem statement, aim and objectives of the research, scope of the work, and arrangement of thesis.

Chapter two deals with literature review, which include overview and theory of work on electric power distribution system, power quality in a distribution network, voltage control in distribution system, load flow studies, summary of reviewed related works and various research gaps.

Chapter three deals with research methodology and experiment. This include the research methods, brief description of New Bussa Injection substation that serves as the study environment, data collection and design of automated switching, monitoring and reporting system.

Chapter four deals with the presentation of the data collected from the field measurement (New Bussa distribution network) and simulation in Electrical Transient and Analysis Program (ETAP 12.6) computer software, analysis of generated reports from load flow study, summary of observation, findings and contribution to knowledge.

Chapter five contains conclusion and recommendation for future study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Review of Literature on GSM-based monitoring system

With the wide spread use of cellular networks, this application is popular when small amount of data is to be transferred through the network. Extensive work has been carried out by researchers using this GSM-based application.

Kadam, Baikar, Kote, and Shah (2016) developed a GSM based LAN monitoring system that monitors all the physical devices, that is, PC's from handheld device called mobile. The system has shut down, process list, broadcasting message and net view modules to trace and keep track of various client activities. The targeted users are labs in colleges and various other organizations. The most required module in the field of IT industries is the efficient computer network management. There are many requests related to such networks which network manager needs to solve immediately for avoiding the any kind of interruptions.

Madan and Reddy (2012) developed a GSM-Bluetooth based Remote Monitoring and Control System with Automatic Light Controller. The authors gave a review of home automation & remote control and monitoring systems based on existing technologies and also proposed a GSM-Bluetooth based light controller and remote monitoring system. This system has simple features designed with the objective of minimum power consumption using infrared sensor for controlling lights, fans and other appliances which are controlled through SMS using a GSM module. A Bluetooth module is also interfaced with the main microcontroller chip. This Bluetooth module eliminates the usage charges by communicating with the appliances through Bluetooth when the application is in a limited range of few meters. The system informs user about any abnormal conditions like intrusion detection and temperature rise through SMS from the GSM module or by Bluetooth module to the user’s mobile and actions are taken accordingly by the user.

Purnima (2012) developed a design of remote monitoring and control system with automatic Irrigation system using GSM-Bluetooth. This paper gives a review of these systems based on existing technologies and also proposes an economical and generic automatic irrigation system based on wireless sensors with GSM-Bluetooth for irrigation system controller and remote monitoring system. This system has simpler features designed with the objective of low cost and effective with less power consumption using sensors for remote monitoring and controlling devices which are controlled through SMS using a GSM module. A Bluetooth module is also interfaced with the main microcontroller chip. This Bluetooth module eliminates the usage charges by communicating with the appliances through Bluetooth when the application is in a limited range of few meters. The system informs user about any abnormal conditions like less moisture content and temperature rise, even concentration of CO2 through SMS from the GSM module or by Bluetooth module to the farmer’s mobile and actions are taken accordingly by the farmer.

Chen Peijiang and Jiang Xuehua, (2008) describe a remote monitoring system based on SMS of GSM. The system includes two parts which are the monitoring center and the remote monitoring station. The monitoring center consists of a computer and a TC35 GSM communication module. The computer and TC35 are connected by RS232. The remote monitoring station includes a TC35 GSM communication module, a MSP430F149 MCU, a display unit, various sensors, data gathering and processing unit.

Jagdeep (2014) developed GSM-Microcontroller based remote control of sprinkler irrigation. This system is a new concept in the field of the irrigation for doing irrigation work remotely without any risk of accident due to electric shock, hard work and working in difficult environment condition. This system discards the conventional methods of irrigation work. The author designed and developed an automatic sprinkler irrigation system which is controlled and monitored by a microcontroller interfaced with display device, current flow sensor, solenoid valves and GSM modems. The operating principle of the system involves a given command to stop, start, interrupt and parameters under monitoring are stored in a memory based upon which microcontroller takes decision to run the system. Provision of protection against dry run and overload of motor coupled with centrifugal pump is also incorporated. Options using selector switches make this system compatible with single phase motor and three phase motor. This system makes obsoletes the mechanical work of farmers by automatically changing over sprinkler water lines in sequence after running for a period of set time decided by farmer and switch off the water pump house motor upon completion of irrigation work using GSM modems interfaced with microcontrollers.

Scanaill, Ahearne, and Lyons (2006) developed a telemonitoring system, based on short message service (SMS), to remotely monitor the long-term mobility levels of elderly people in their natural environment. Mobility is measured by an accelerometer-based portable unit, worn by each monitored subject. The portable unit houses the Analog Devices ADuC812S microcontroller board, Falcon A2D-1 GSM modem, and a battery-based power supply. Two integrated accelerometers are connected to the portable unit through the analog inputs of the microcontroller. Mobility level summaries are transmitted hourly, as an SMS message, directly from the portable unit to a remote server for long-term analysis. Each subject's mobility levels are monitored using custom-designed mobility alert software, and the appropriate medical personnel are alerted by SMS if the subject's mobility levels decrease.

Jiang, Yan, Shi, Kandachar, and Freudenthal (2010) proposed a system for early diagnosis of hypertension and other chronic diseases. The proposed design consists of three main parts: a wrist Blood Pressure (BP) measurement unit, a server unit and a terminal unit. Blood Pressure is detected using data acquired by sensors intelligently using DSP microchip. The data is then transmitted to the remote server unit located at Community Healthcare Centers/Points (CHC/P) by using Short Messaging Service (SMS), and notification information is sent to the terminal unit to inform users if patient's BP is abnormal.

Alheraish (2004) implemented home security system by means of GSM cellular communication network using microcontroller 89X52 and Sony Ericsson GM-47 GSM module. This system enables far end user through SMS facility to monitor the state of home door, provide password facility for key based door lock and control home lighting system.

Abdullah and Ali (2014) developed GSM Based Water level and Temperature Monitoring System. The system that the authors produced is an extended approach to monitor a control industrial system. The system monitor the industrial system from any location, due to this it will save lots of time in this busy era. In this project, authors designed GSM based water level and temperature monitoring system (WLTMS), which detect the water level of the tank which is connected to the industry. The system also monitored the temperature of the tank. For this purpose, LM35 sensor was used which defines the parameters of the temperature sensor. Analogue output of LM35 is amplified through a process of signal conditioning, where OP-741 is used to amplify the signal. Amplified signal is fed into an ADC for the sake of digital data.

This digital data is transferred to an LCD for displaying result. PIC microcontroller is used for this procedure. Modem is also connected to this controller for the wireless communication of the data through GSM technology through SMS.

Khiyal, Khan, and Shehzadi (2009) developed SMS based system for controlling of home appliances remotely and providing security when the user is away from the place. Home appliance control system (HACS) consists of PC which contains the software components through which the appliances are controlled and home security is monitored and GSM Modem that allow the capability to send and receive SMS to and from the system. The communication with the system takes place via RS232 serial port.

Van Der Werff, Gui and Xu, (2005) presented a mobile-based home automation system that consists of a mobile phone with Java capabilities, a cellular modem, and a home server. The home appliances are controlled by the home server, which operates according to the user commands received from the mobile phone via the cellular modem. In the proposed system the home server is built upon an SMS/GPRS (Short Message Service/General Packet Radio Service) mobile cell module Sony Ericsson GT48 and a microcontroller Atmel AVR 169, allowing a user to control and monitor any variables related to the home by using any java capable cell phone.

Hongwei and Hongxia (2009) investigated the design and implementation of a remote data collection and monitoring system. The system communication is based on GSM short messages from cell phones using Siemens cell phone module TC35. The serial interface of TC35 is directly connected to the serial interface of PC computer. The system hardware includes remote client monitoring hardware, central monitoring module, and 0809 A/D converter. The central monitoring module sends commands via channel 1. Data collection commands are sent out through TC35 to collect all sorts of data. After data are collected they are processed by remote clients and sent back to the central monitoring module by GSM short messages via channel 2. Each monitoring module can connect up to 128 sensors and equipment within the range of 1000 meters via RS485 interface. The server hardware consists of 8031 microprocessor, 74LS373, one 8kB 2764 E2PROM, one 2kB 6116 extended memory, and one 8155 programmable serial interface chip. One 4×4 keyboard is connected to the PI port and 8 LED displays are connected to PA and PB ports of 8155.

2.2 Review of Literature on Systems for Remote Monitoring Using Wireless Sensor Networks (WSN), Bluetooth, Wi-Fi, Zigbee Technologies

Many wireless technologies like RF, Wi-Fi, bluetooth and zigbee have been developed and remote monitoring systems using these technologies are popular due to flexibility, low operating charges, etc. Today Wireless Sensor Network are used in an increasing number of commercial solutions, aimed at implementing distributed monitoring and control system in a great number of different application areas**.**

Zhang (2011) developed Design and Optimization of Wireless Remote Monitoring and Control System using the ZigBee Protocol. From the system architecture point of view as presented by author, the remote wireless monitoring and control system is mainly combined by three parts; the wireless sensor network, the message gateway and the web service. In order to increase the system flexibility and the reconfigurability, each part communicates with each other by using the standard communication protocols.

Zhang, Liu, Su, Jiang and Wei (2015) developed a remote mobile health monitoring system with mobile phone and web service capabilities. This system provides an end-to-end solution in physiologic parameters. This include respiration rate and heart rate, which were measured by wearable sensors and recorded by a mobile phone that presented the graphical interface for the user to observe his/her health status more easily. It also provided doctors and family members with necessary data through a web interface and enabled authorized personnel to monitor the patient's condition and to facilitate remote diagnosis. This developed system supports real-time alarming and positioning services during an urgent situation, such as a tumble or a heart attack, so that unexpected events can be handled in a timely manner.

Wijetunge, Peiris, Aluthgedara and Wijetunge (2008) developed a general purpose controlling module which has the capability of controlling and sensing up to five devices simultaneously. The communication between the controlling module and the remote server is done using Bluetooth technology. The server can communicate with many such modules simultaneously. The controller is based on ATMega64 microcontroller and Bluetooth communication TDK Blu2i (Class 1) module which provides a serial interface for data communication. The designed controller was deployed in a home automation application for a selected set of electrical appliances.

Alhasnawi and Jasim (2018) developed a work using Different Network Technologies and Wireless Sensor Networks to Design and Implement a Fully Smart Home System. The author presented a thorough explanation of diverse, smart homes systems and technologies from the viewpoint of control and safety. This work highlights numerous faults with regard to safety in current smart home systems. Various smart homes machineries are considered in this project, including Internet-based, Short Messaging Service-based, mobile Global System for Mobile communications-based, Bluetooth-based, and Email-based smart home systems. The proposed system is made up of two parts: the hardware and software. The hardware consists of a base station unit (BSU) and several terminal nodes (TNs). The BSU is comprised of the main unit, represented by a Raspberry Pi3, while the TN represented by a Wemos-D1 board, the required sensors and appliances. The software is made up of the programming of the Wi-Fi network and the system protocol. In this paper, an MQTT (Message Queue Telemetry Transportation) broker was built on the Raspberry Pi3 and Wemos-D1. The MQTT broker was utilized as a platform to provide the Internet of Things (IoT) services, which control and monitor smart home appliances

Kanma, Kanazawa, Wakabayashi and Ito (2003) presented a home appliance control system over Bluetooth with a cellular phone, which enables remote-control, fault-diagnosis and software-update for home appliances through Java applications on a cellular phone. The system consists of home appliances, a cellular phone and Bluetooth communication adapters for the appliances. The communication adapter hardware consists of a 20MHz 16bit CPU, SRAM and a Bluetooth module. The communication adapter board is connected to the home appliance and to the cellular phone through serial ports. The appliances can communicate with the cellular phone control terminal via Bluetooth SPP.

Yu and Cheng (2005) proposed a wireless patient monitoring system which integrates Bluetooth and Wi-Fi wireless technologies. The system consists of the mobile unit, which is set up on the patient’s side to acquire the patient’s physiological signals, and the monitor units, which enable the medical personnel to monitor the patient’s status remotely. The mobile unit is based on AT89C51 microprocessor. The digitized vital-sign signals are transmitted to the local monitor unit using a Bluetooth dongle. Four kinds of monitor units, namely, local monitor unit, a control center, mobile devices (personal digital assistant; PDA), and a web page were designed to communicate via the Wi-Fi wireless technology.

Flammini, Marioli, Sisinni and Taroni, (2007) suggested a novel architecture for environmental tele-monitoring that relies on GSM for sampling point delocalization, while on-field nodes implement local subnets based on the DECT technology. Local subnets contain two major blocks; Acquisition Station (AS) where sensors and actuators are located and Transmitting Module (TM), i.e., the module that handles several measurement stations and sends data to the control center (CC). Each AS acts as a data logger, storing in its internal memory device field data; communications between AS and TM are cyclic (round robin), with a cycle time of about 1–10 min. On the contrary, communications between TM and CC occur once a day for data-logging purposes, while alarms or threshold crossings are communicated asynchronously by means of Short Message Service (SMS). Prototypes have been realized to interface with temperature (*T*, AD590 from analog devices), humidity (RH, HumirelHM1500), and carbon monoxide (CO, Figaro TGS2442) sensors. DECT Siemens module MD32 and GSM module MC35 were used. AS was based on Microchip's PIC18F452 microcontroller and TM was designed using 32-bit ARM-based microcontroller from Samsung (S3F441FX).

Yunseop, Evans, Iversen (2008) described details of the design and instrumentation of variable rate irrigation, a wireless sensor network, and software for real-time in-field sensing and control of a site-specific precision linear-move irrigation system. Field conditions were site-specifically monitored by six in-field sensor stations distributed across the field based on a soil property map, and periodically sampled and wirelessly transmitted to a base station. An irrigation machine was converted to be electronically controlled by a programming logic controller (Siemens S7-226 with three relay expansion modules activated electric over air solenoids to control 30 banks of sprinklers) that updates geo-referenced location of sprinklers from a differential Global Positioning System (GPS) (17HVS, Garmin) and wirelessly communicates with a computer at the base station. Communication signals from the sensor network and irrigation controller to the base station were successfully interfaced using low-cost Bluetooth wireless radio communication through Bluetooth RS-232 serial adaptor (SD202, Initium Company).

Bencini et al., (2009) developed state of the art WSN based system for monitoring a series of physiological parameters in the vineyard to prevent plant vine diseases. The different soil moistures in the same field is used to decide the correct amount of water for irrigation; sandy soils have very different behavior to irrigation in respect to clayey ones; water retention capacity is completely different and measuring it exactly where it is needed can help in controlling the irrigation system and saving water. Monitoring air temperature and humidity in different parts of a vine can help in preventing and fighting plants diseases, reducing the amount of pesticides only when and where they are necessary. Each node consists of MIDRA mote is equipped with 868 MHz radio transceiver, Chipcon CC1000TM. The master node of the Wireless Sensor Network is connected to a GPRS gateway board, forwarding data to a remote server, using the TCP-IP standard protocol. It included 11 nodes with a total of 35 sensors distributed on 1 hectare area; monitor common parameter using simple, unobtrusive, commercial and cheap sensors, forwarding their measurements by the means of a heterogeneous infrastructure, consisting of WSN technology, GPRS communication and ordinary Internet data transfer (TCP-IP protocol). Data coming from sensors are stored in a database that can be queried by users everywhere in world, only using a laptop or a PDA: the Smart User Interface also allows to read and to analyze data in an easy way.

2.3 Review of Related Works

Researches have shown that the efficiency and quality of power delivered by the distribution network to the consumers depend mostly on the intelligent nature and effective performance of the distribution grid network. Many researchers did their research work on improving the performance of power distribution network by improving the voltage level of the system, monitoring some of the power distribution system's parameter variables using sensor network. This work reviewed some of those related works, identified the research gaps and the need for further improved research work.

Hemant and Sujata (2016) did a research on improving the power quality in distribution system using Dynamic Voltage Restorer (DVR). This type of custom power devices used can eliminate or mitigate power quality problems like voltage sag, swell and restores the system to the pre-fault condition/status.
Drawbacks of this research work are that authors did not state clearly the best position for installation of Dynamic Voltage Restorer (DVR) for optimal performance in cases where there are many load buses that violate voltage standard threshold rule and reason in choice of capacitor size used in Voltage Source Converter (VSC) which is a component of DVR.

Suhas, Nikhil, and Lilachand (2015) presented a review on the Unified Power Quality Conditioner (UPQC) to enhance the electric power quality on distribution networks. They also discussed several other custom power device configurations that can be used for power quality improvement.
The drawbacks of this research work are that authors did not state the measure taken to avoid over-compensation of the line and also installation of Unified Power Quality Conditioner device industrially will not be economical.

Rohit and Sandip (2015) proposed the use of Shunt Active Power Filter (SAPF) for eliminating precisely the voltage and load current harmonic in their quest to improve the quality of power in distribution network. The SAPF installed injects a suitable compensating current with 180^0 phase opposition such that current harmonics introduced by non-linear loads are cancelled out and sinusoidal nature of current and voltage waveform restored, thus maintaining the harmonic content in power lines within the permissible limit of IEEE standards.

The drawback of this work is that there is no explanation concerning the optimal point of connection of the device within the network.

Ritula and Puneet (2015) presented methods of reduction of distribution losses in 11KV urban distribution feeder so as to improve the voltage profile by looking into voltage drop calculations and design of urban distribution feeders. Effects of under-sizing of conductors, poor jointing and termination of conductors were checked and recommendations were made. Also location, proper placement and sizing of capacitor banks for improving power factor and harmonics in 11KV feeders were investigated for improvement but the detailed criteria on the capacitor bank optimized placement, method on the choice of capacitor sizes were not stated and also other voltage profile improvement recommendations can be manually achieved.

Mian (2015) developed a system capable of detecting the blown fuse at distribution transformer and informing the station operator. In distribution transformer, fuses are connected in each phase to protect the system from overloading. When load (current) in any of the three phases exceeds a safety limit, the respective fuse is blown and electricity supply of that particular phase is cut off. The detection circuitry will detect it and microcontroller will process that signal received from detection circuitry. Microcontroller will access the GSM module and will send sms alert to the station operator. The drawback is that in a case where the fuses at the three phases are affected at the same time, the author did not include a design that will differentiate through the SMS sent to the System Operator, a blown fuse from a no voltage supply.

Osahenvemwen (2015) presented the evaluation of voltage drop in power distribution networks by investigating two injection substations in Benin Electricity Distribution Company (BEDC), both in Ekpoma and Benin City. Authors developed the mathematical modeling for voltage drop by considering the major parameters of voltage drop which include; size or surface area or diameter of the conductor, the materials resistivity, the applied load, and thus produced a mathematical model that the total voltage in a distribution line is the summation of all these parameters.

$$V = \sum I\left(\frac{\rho L}{SA}\right) + \frac{P}{I} \tag{2.24}$$

Where,

I is current

ρ is resistivity of the conductor

L is the length of the conductor

SA is the surface area of the conductor

P is applied load

The major drawback of this study is that the recommended proposals in reducing the voltage drop in the investigated distribution networks are meant to be done manually which is bound to have limits.

Kunal *et al.* (2015) proposed an innovative design to develop microcontroller based system used for monitoring voltage, current and temperature of distribution substation and sends GSM sms alerts to authorized person whenever these parameters exceed the pre-defined limits. The drawback includes that authors did not state the optimal position of the relay/circuit breaker which does the controlling.

Pragati and Titare (2014) proposed ways of minimizing overall losses of distribution system based mostly on network reconfiguration and capacitor addition on an inter-connected ring main distribution network. The drawback of the work is that authors did not state the rationale on the choice of the capacitor size and correct placement in their explanation.

Izuegbunam *et al.* (2014) evaluated the reliability of Onitsha power distribution network and also when a photovoltaic/inverter system is connected at the 11KV busbar of the feeder as alternative or complementary supply source using ETAP simulation software to analyze the various data obtained from the injection substations. The investigation revealed that before installation of photovoltaic/inverter system, that there was greater revenue loss due to outages in the investigated years than after installation of photovoltaic/inverter system. The drawback of this research work is that authors did not explain in details how/where the photovoltaic/inverter system was connected and why it was connected at that position along the feeder.

Ohajianya (2014) produced a work that dealt on erratic power supply in Nigeria; causes and solutions which affects the availability and reliability of distribution network. The author listed the factors responsible for this erratic power supply and proffered recommendations towards solving these erratic power supply problems which will in turn improve the performance of distribution network in Nigeria.

Egwaile and Bello (2014) proposed a design of transformer monitoring system in distribution network. The drawback of this research work is that authors did not include in their design the feature that confirms that the affected transformer is still active (transforming and supplying voltage) before sending SMS and also did not include in the design the part that will always indicate when the distribution transformer is not active through SMS despite its service feeder still active.

Jyotishi and Deeparamchandani (2013) proposed a technique for reducing power quality problems in distribution network using Distribution Static Synchronous Compensator (D-STATCOM). This custom power device, during transient conditions provides leading or lagging reactive power to activate the system voltage stability, power factor correction and generally, improve the power quality delivered to consumers.
The drawback of this research work is that the custom power device D-STATCOM is too sophisticated and will not be economical to be industrially implemented.

Karthik (2013) proposed transformer oil temperature monitoring electronic device together with automatic circuit breaker. Authors designed the system using PIC Microcontroller to monitor the transformer’s oil temperature continuously throughout its operation. If the Microcontroller recognizes oil temperature that violates the limit, then the entire unit is shut down by the designed controlling unit, with the display unit displaying values throughout the process to inform the current status of the transformer. The drawback is that authors did not state clearly the connection between the sensor and the ADC (if it is directly or indirectly connected) through Contactor or Relay and also did not state the calibrated limits for the temperature (for instance, oil temperature alarm limit and oil temperature trip limit).

Guneet, Brar, and Jaswanti, (2012) presented a research work where they used Static Var Compensator (SVC) in power distribution system for enhancing the distribution bus voltages, improve power flow and reduce branch losses. Simulations were carried out with ETAP software to validate their proposal but they did not state what inform their choice of two (2nos.) of SVCs for compensation and their placement on bus numbers 9 and 10.

Amit (2012) proposed a system that sends real-time acquired values of electrical parameters like voltage, current and frequency through GSM network using GSM modem/phone. This system sends sms alerts whenever the parameters exceed the pre-defined limits to an electromagnetic relays which operates the circuit breakers to switch off the main supply. The drawback is that the authors only presented how to protect the electrical facility from damage but did not explain how to improve the power or voltage supplied by the transformer.

Nunoo (2012) analyzed causes and effects of voltage drop on 11KV GMC sub-transmission feeder in Tarkwa Ghana. The outcome of the study shows that voltage drop, total impedance, percentage efficiency, and percentage regulation are all beyond the acceptable limits. They proposed a number of solutions to these facts but they could not technically proffer solution to the effects caused by increased load/current along the line which as well leads to increased voltage drop.

Thiyagarajan and Palanivel (2010) presented a design of system based on AVR microcontroller that is used to monitor and control the voltage, current and temperature of a distribution transformer and protect the system from rise in these parameters. The drawback is that authors did not state how to compensate the voltage supply to the consumers when the distribution transformer receives low voltage, stepping it down and thus supplying low voltage as well to end users.

Ramesh *et al.* (2009) presented minimization of power loss in distribution system by considering the feeder restructuring, incorporation of distributed generators (DG) and placement of capacitors. The drawback is that authors did not state in details how the distribution feeder structure should be re-structured, what size of capacitor should be used for compensation and how the capacitor bank should be placed, how the distribution generators (DG) should be placed and what location along the feeder.

Kishor, Thakre, and Bodhe (2009) developed a power flow analysis of 33/11 kV distribution substation and its feeder so as to know the status of voltage and power flow at each bus. The rated voltage at load end is maintained by installing low rated static VAR compensators (SVC). With the insertion of SVC, there is improvement in voltage level at various buses, reduction in system power loss, improvement in power factor and power flow but authors did not explain vividly the automated principle utilized in achieving their aim and reason supporting the size of the VAR compensators to be installed and their optimal positioning.

Okundamiya, Udeozor, and Imade (2009) presented a study that looked into investigation and evaluation of voltage drops taking into consideration Guiness and Ikpoba Dam Injection Substations in Benin. Authors performed an in-depth analysis and evaluation of the amount of voltage drops in houses along selected streets in Benin City by getting the readings of the transformer supplied voltage, house-to-house received voltage, currents, power consumption in each house and they observed that the longer the cable distance, the higher the voltage drop, which entails that for efficient supply of voltage to consumer, the distance of the consumer's service cable from the transformer should not exceed 400m. They are also recommended that proper monitoring of load connected to transformers, use of standard sizes and qualities of conductor to distribute power from the transformer will reduce voltage drop but the drawback of this study is that the all the recommended monitoring of the transformer were done manually and not automated.

2.4 Summary of Reviewed Works

- A good number of researchers have produced or developed works on improving the performance of power distribution networks using various techniques.
- Results from most of these research works gave room for further research activities on achieving a robust power distribution network.
- Some of the authors of these research works were not explicit in the explanation of the technique they applied in enhancing the performance of the power distribution network.
- Some of these applied techniques by authors in improving the performance of the distribution network and quality were observed to be costly when implemented.

2.5 Research Gaps on Reviewed Related Works

i. Reviewed work that dealt on enhancing the availability of power to consumers did not include a design that monitors and reports distribution transformers when they tripped on fault (not active) despite their service feeder still active.

ii. Reviewed work that dealt on enhancing the availability of power to consumers through monitoring and reporting lost transformer phases or blown low voltage fuse did not show how the design confirms that the affected transformer is still active (still energized) before sending SMS of lost phase (blown fuse) to the DSO mostly when the three fuses were affected.

iii. Reviewed work that dealt on enhancing the availability of power to consumers through monitoring and reporting of its parameter variables to System Operator did not state clearly how the System Operator can identify the actual distribution transformer being reported faulty from the GSM SMS message.

iv. Reviewed works that dealt on enhancing the voltage delivered to the consumers could not state clearly their applied criteria and conditions in choosing capacitor size, optimal positioning of these compensators.

v. Reviewed work that dealt on improving the voltage delivered to the consumers using Custom Power Devices could not state how the work can avert issue of over-compensation of the line. Also, the use of devices like UPQC, D-STATCOM is costly and not economical to be implemented industrially.

vi. Reviewed work that dealt on improving the voltage delivered to the consumers recommended an electromechanical or manual way of reducing the voltage drop in the investigated distribution networks.

2.6 Review of Related Key Terms and Concept

This entails brief review and explanation of key terms and words that are related to the research work itself. They include but not limited to:

2.6.1 Voltage control using switched shunt capacitors

A shunt capacitor generates reactive power to compensate the reactive power demand and thereby boosts the voltage. Shunt capacitors can be installed in the substation and are referred to as substation capacitors or along the feeder and as well are referred to as feeder capacitors (Hemasekhar and Chevireddy, 2014).

In order to properly compensate the reactive power demand that changes from minimum to maximum, the shunt capacitor may need to be switched during the maximum loading of the network and to be switched off during the minimum of the network. When the load varies during the day, the switched capacitors should be properly controlled. Some control variables can be used to control switched capacitors, such as time, voltage and reactive power. Time controlled capacitors are especially applicable on feeders with typical daily load profiles in a long term, where the time of the switching-on and off of the shunt capacitor can be predicted. The main disadvantage of this control is that the control has no flexibility to respond to load fluctuation caused by weather, holidays, etc. Voltage controlled capacitors are used when the major role of the capacitor is for voltage support and regulation. Reactive power controlled capacitors are more effective when the capacitor is mearnt to minimize the reactive power flow.

2.6.2 Voltage control using custom power devices

Custom power devices are power electronic devices used in distribution systems to improve the reliability and power quality of the system. They are flexible alternating current transmission system (FACTS) devices used in distribution systems with different application and strategy to improve the power quality in the network. Custom power devices are classified based on their applications in the distribution system (Zakaria, Chen, Hassan, Yuan, 2008).

They are classified as follows: (Desale, Dhawale, and Bandgar, 2014)

i. Series custom power device. Example, Dynamic Voltage Restorer (DVR).

ii. Shunt custom power device. Example, Distribution Static Synchronous Compensator (D-STATCOM).

iii. Series-shunt custom power device. Example Unified Power Quality Conditioner (UPQC).

Dynamic Voltage Restorer (DVR) can be used to compensate for voltage sag and swell, voltage balancing and voltage harmonic distortions (Kumar, Susanna, Manjusha, Suneel, 2016).

Distribution Static Synchronous Compensator (D-STATCOM) can be used in distribution networks to compensate for power quality problems such as unbalanced load, voltage drop, voltage fluctuation, unbalanced voltage and harmonic distortions.

Unified Power Quality Conditioner (UPQC) can as well be used to compensate for load current harmonic, reactive power compensation, power factor correction, correcting non-load current and regulating DC circuit voltage.

2.6.3 Optimal selection of capacitors in distribution system

Development and complex distribution system result in several problems such as loss increase and voltage drop. Past research works show that 13% of total power generated is wasted in the form of losses at the distribution level. To reduce these losses, shunt capacitor banks are installed on distribution primary feeders or by the side of load bus. The advantages of the installation of shunt capacitors banks are to improve the power factor, improve feeder voltage profile; Power loss reduction and feeder capacity release or upgrade (Bhongade and Sachin, 2016). Thus it is necessary to determine the optimal location and sizes of capacitors in the system so as to achieve the above mentioned objectives. For optimal capacitor placement, many different optimization techniques and algorithms have been proposed in the past. Neagle and Samson (1956), developed a fact that optimal capacitor size is a 2/3 of VAR requirement of the circuit and optimal capacitor placement is 2/3 of the distance from the substation to the end of the line. Grainger and Lee (1981) developed a principle that place the capacitor at the point of circuit where reactive power equals one half the capacitor rating. Baran and Wu (1989) presented a method with mixed integer programming technique for capacitor placement problem. Sundharajan and Pahwa (1994), proposed a design methodology for determining the size, location, type and number of capacitors to be placed on radial distribution system.

2.6.4 Capacitor placement and sizing

The objective of capacitor placement and sizing in the distribution system is to minimize the total annual cost of the system, which involves minimizing the annual cost of power losses and annual cost of capacitor installed in the system when subjected to certain operating constraints. This is given by;

$$K^P P_{Loss} + \sum_{n=1}^{M} K_n^{\ c} Q_n^{\ c} \tag{2.8}$$

Where, P_{Loss} is the total power losses

K^P - The annual cost per unit of power losses (₦/KW)

$K_n^{\ c}$ - The capacitor annual cost (₦/KVAR)

$Q_n^{\ c}$ - The capacitor size placed at bus ‘n’ and ‘M’ is the number of candidate buses for capacitor placement.

To ensure optimal placement, these constraints need to be satisfied:

a. Shunt capacitors limits

$$Q^c_{max} \leq Q_{total} \tag{2.9}$$

Where, Q^c_{max} is the largest capacitor size allowed and Q_{total} is the total reactive load demand.

b. Busbar voltage limits

$$V_{min} < V_n < V_{max} \tag{2.10}$$

In radial distribution system, $V_{min} = 0.9$ and $V_{max} = 1.06$

c. Line power flow limits

$$Flow_m < Flow_m^{max} \tag{2.11}$$

Where, $Flow_m$ is the power flow in the mth-line and $Flow_m^{max}$ is the maximum allowable power flow.

No matter how carefully the system is designed, losses still exist in the power system. The losses in the network are reduced and the voltage profile of buses improved using optimal capacitor placement. This is achieved through optimal sizing and placement of capacitors on the network.

The problem of optimal capacitor placement involves determining the sizes, locations and the number of capacitors to be installed on a power system. This is aimed at maximizing the benefits to be achieved while satisfying the constraints at certain loading level. In this research work, capacitor size is assumed as known discrete values. The optimum location for these capacitors is determined in such a way that it minimizes the power losses thereby reducing the overall cost of the power system. The problem is formulated as a constrained optimization problem.

2.6.4.1 Methods of determining optimal capacitor placement

i. Loss Sensitivity Factor calculation method
ii. Use of Optimal Capacitor Placement Module in ETAP 12.6 software

Loss sensitivity factors: The candidate buses for the capacitor placement are determined using the loss sensitivity factors and it shows the bus with the biggest power loss reduction when capacitor is placed in the network (Dinakara, 2013)

Consider a distribution line with an impedance R+jX and a load of $P_{eff} + jQ_{eff}$ connected between "p" and "q" buses as shown in the diagram below.

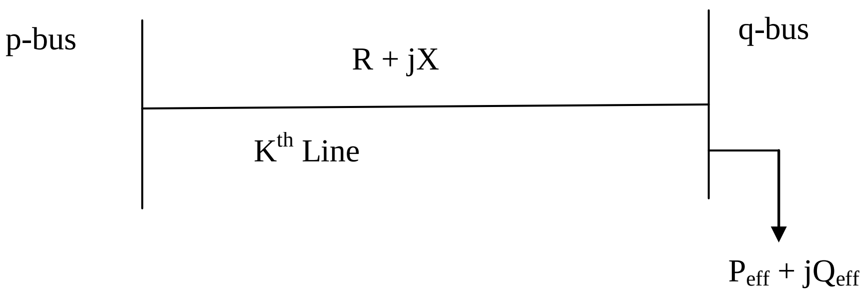

Figure 2.1: Single diagram of a distribution line

Real or Active power loss in the kth line is given by;

$P_{loss[q]} = I_{pq}^2 \times R_{pq}$ (2.16)

But Apparent power $S_{pq} = I_{pq} \times V_q$ (2.17)

$$I_{pq} = \frac{S_{pq}}{V_q} \quad (2.18)$$

Substitute equation (2.18) into equation (2.16)

$$P_{Loss(q)} = \frac{S_{pq}^{\ 2}}{V_q^{\ 2}} x R_{pq} \tag{2.19}$$

But $S_{pq}^{2} = P_{pq}^{2} + Q_{pq}^{2}$ (2.20)

Substitute equation (2.20) into equation (2.19)

$$P_{Loss(q)} = \frac{P_{pq}^{\ 2} + Q_{pq}^{\ 2}}{V_q^{\ 2}} x R_{pq}$$

$$P_{Loss(q)} = \frac{P_{pq}^{\ 2} R_{pq}}{V_q^{\ 2}} + \frac{Q_{pq}^{\ 2} R_{pq}}{V_q^{\ 2}} \tag{2.21}$$

Differentiating Power loss $P_{Loss[q]}$ in equation (2.21) with respect to Q;

$$\frac{\partial P_{Loss}}{\partial Q} = \frac{2xQ_{pq} R_{pq}}{V_q^{\ 2}} \tag{2.22}$$

The Loss Sensitivity Factors (∂P_{loss} / ∂Q) parameter variables are obtained from the generated load flow reports of the base (initial) case status of the network and the calculated values are arranged in descending order. The sequence in which buses are arranged decides the sequence in which buses are to be considered for capacitor placement.

Optimal capacitor placement module in ETAP 12.6 software: Optimal positioning of the capacitor bank can be confirmed by the use of the optimal capacitor placement (OCP) module in ETAP 12.6 software. This helps to confirm the earlier determined candidate buses by the loss sensitivity factor calculation.

2.6.5 Load/Power Flow Study

Load flow study is used to show that electrical power transmission from generating plants to consumers through the power grid is stable, reliable and economic. In a three phase ac power system active and reactive power flows from the generating plants to consumer loads through different buses and branches in the network. Load flow is the flow of active and reactive power in the network. Load flow studies are used to determine bus voltages, their phase angle, active and reactive power flows through different branches, generators and loads under steady state condition in the network. In order to obtain a reliable power system operation under normal balanced three phase steady state conditions, it is required to have the followings:

- Generation supplies the load demand and losses.
- Bus voltage magnitudes should have values close to rated values.
- Generating plants should operate within particular active and reactive power limits.
- Transmission lines and needed transformers should not be overloaded.

Power flow study/analysis is widely used by power professionals during power planning and operation of power distribution system.

2.6.5.1 Reasons for power flow analysis

The various needs for Power flow analysis are as follows:

- Power flow analysis is used to calculate the voltage drop on each feeder, the voltage at each bus, and the power flow in all branch and feeder circuits.
- Power flow studies are used to determine if the service voltages or system voltages are still within standard limits under various conditions, and whether equipment such as transformers and conductors are overloaded.
- Power flow studies indicate the need for capacitive, or inductive VAR compensation, or the placement of capacitors and/or reactors to maintain system voltages within standard limits.
- With Power flow analysis, losses in each branch and total system power losses are also calculated.

- It is necessary for planning, economic scheduling, and control of an existing system as well as planning its future expansion.

2.6.6 Bus classification in power flow studies

Each bus in a power system can be classified as follows:

i. Load bus (P-Q bus)

ii. Generator bus (P-V bus)

iii. Slack bus (Swing bus)

2.6.6.1 Load bus (P-Q bus)

This is a bus at which the real and reactive power are specified, and for which the bus voltage will be calculated. All busses having no generators are load busses. In this type, V and δ are unknown parameters and should be determined.

2.6.6.2 Generator bus (P-V bus)

This is a bus at which the magnitude of the voltage is defined and is kept constant by adjusting the field current of a synchronous generator. In this type, Q and δ are unknown parameters and should be determined.

2.6.6.3 Slack bus (swing bus)

This is a special generator bus serving as the reference bus. The voltage value in the bus is assumed to be fixed in both magnitude and phase. In this type, P and Q are unknown parameters and should be determined.

These parameters listed above are:

P – Real or Active Power

Q – Reactive Power

V – Voltage magnitude

δ – Phase angle

2.6.7 Methods of solving power flow equations

The numerical study that produces results of algebraic simultaneous equations also forms the basis for solution of the performance equations in computer aided electrical power system analyses e.g. for power flow analysis.

There are several methods of solving nonlinear algebraic equations like power flow analysis equations, they include:

i. Gauss – Seidel method
ii. Newton – Raphson method
iii. Fast decoupled method

2.6.7.1 **G***auss – Seidel method*

This method basically rely more on the Gauss method. It involves an iterative process of solving set of nonlinear algebraic equations. The method bases on an initial guess for the voltage value, so as to obtain a calculated value of a specific variable which in turn has the initial guess voltage value being replaced by a calculated value. The process is then repeated until the iteration solution converges. The convergence is quite sensitive to the starting values assumed. This method suffers from poor convergence characteristics.

2.6.7.2 Newton – Raphson method

This method was developed by Isaac Newton and Joseph Raphson and was subsequently named after them. The origin of this method was late 1960s. It is an iterative method which approximates a set of non-linear simultaneous equations to a set of linear simultaneous equations using Taylor's series expansion and the terms are limited to the first approximation. It is the most frequently used for the load flow analysis because of its convergence characteristics are relatively more powerful compared to other alternative methods. If the value assumed is close to the solution, then the result yields very quickly, but if the value assumed is not close to the solution then the method may take longer time to converge. This method is also widely used for solving nonlinear equation.

2.6.7.2 Fast decoupled method

The Fast Decoupled Power Flow Method is a method that bases on a simplification of the Newton-Raphson method and was reported by Stott and Alsac in 1974. This method offers calculation simplifications, fast convergence and reliable results and became a widely used method in power flow analysis like the Newton-Raphson method.

This method is a modification of Newton-Raphson, which takes the advantage of the weak coupling between $P - \delta$ and $Q - V$ due to the high X:R ratios.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Methodology

This research study employed empirical method, quantitative analysis and simulation processes in achieving the research objectives.

The empirical determination and values involved the collection of data from the test bed (New Bussa 15MVA 33/11KV injection substation).

Quantitative analysis involved the analysis of the quantities of values in the generated reports obtained from the simulation processes in ETAP 12.6 software.

Simulative processes entails the evaluation of the collected empirical data and measured real-time data using Electrical Transient & Analysis Program (ETAP 12.6) computer software to model the test bed (that is, develop the single line diagram of New Bussa distribution network) and run the network model in the software so as to generate reports for further evaluation and analysis.

3.2 Description of Environment Test bed

The research study for this dissertation was carried out in 15MVA, 33/11KV injection substation at New Bussa in Niger State of Nigeria. It is the new site of Bussa around the Kainji Lake dam. New Bussa is the headquarters of the Borgu Emirate and also the headquarters of Borgu Local Government Area. New Bussa sits at 9°53′N 4°31′ and the original town of Bussa was located about 40 km North of New Bussa at 10°13′51″N 4°28′31″E.

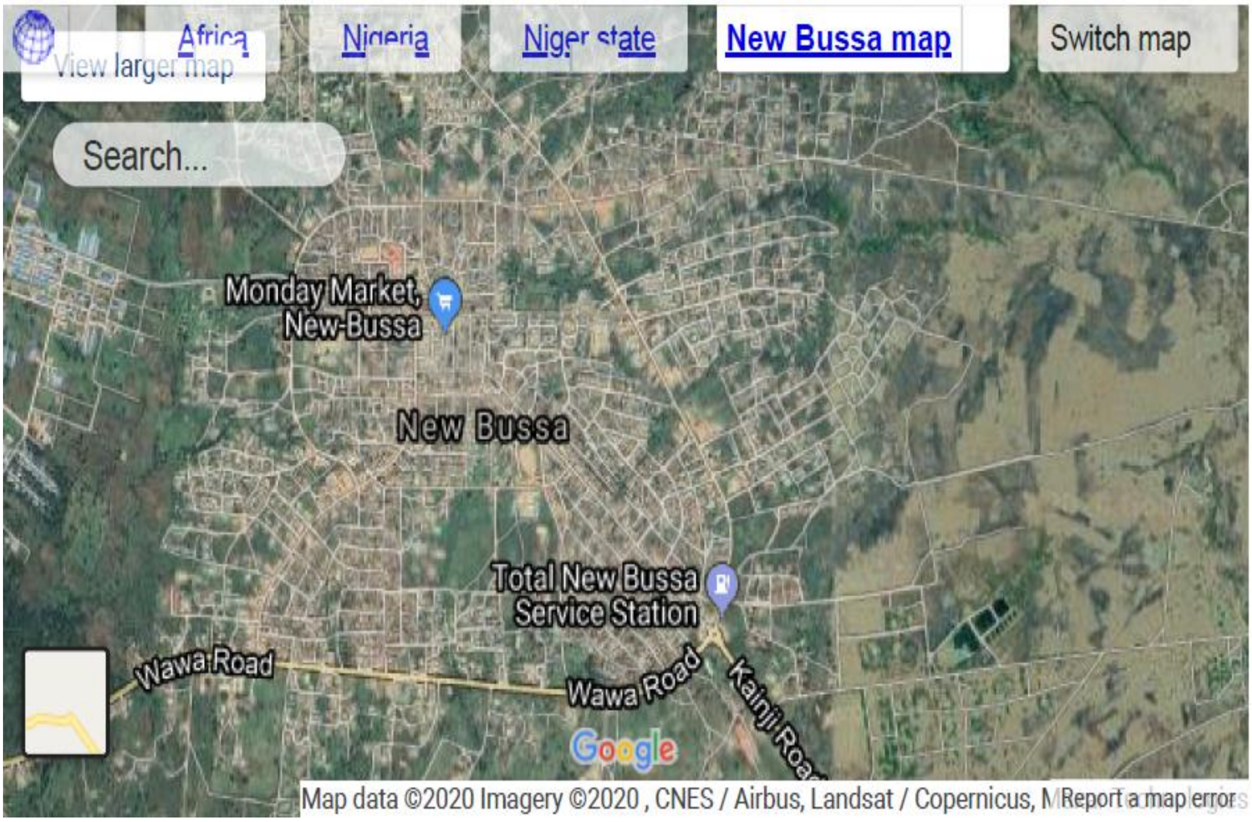

Figure 3.1: Map of Environment under Study (New Bussa Town - 9°53′N 4°31′)

New Bussa injection substation receives power through one bay of 33KV feeder emanating from 132/33KV transmission substation at Dogongeri in New Bussa town. It supplies power to the New Bussa town through three 11KV feeders, namely: Sabo feeder, Senior Camp feeder and Township feeder.

The single line diagram, the switchyard layout drawing and the switchyard cross-sectional drawing of New Bussa injection substation are shown in figures 3.1, 3.2 and 3.3 respectively.

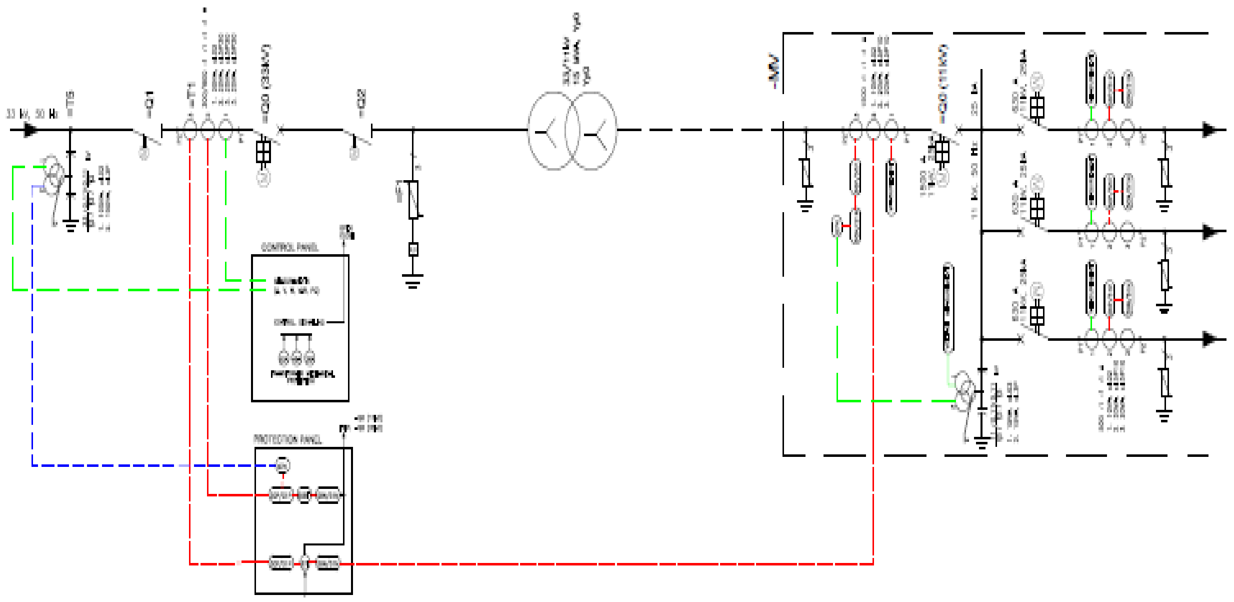

Figure 3.2: Single line diagram (SLD) of New Bussa injection substation (See attached, Appendix 2, the SLD of the station printed in A3 paper for clarity)

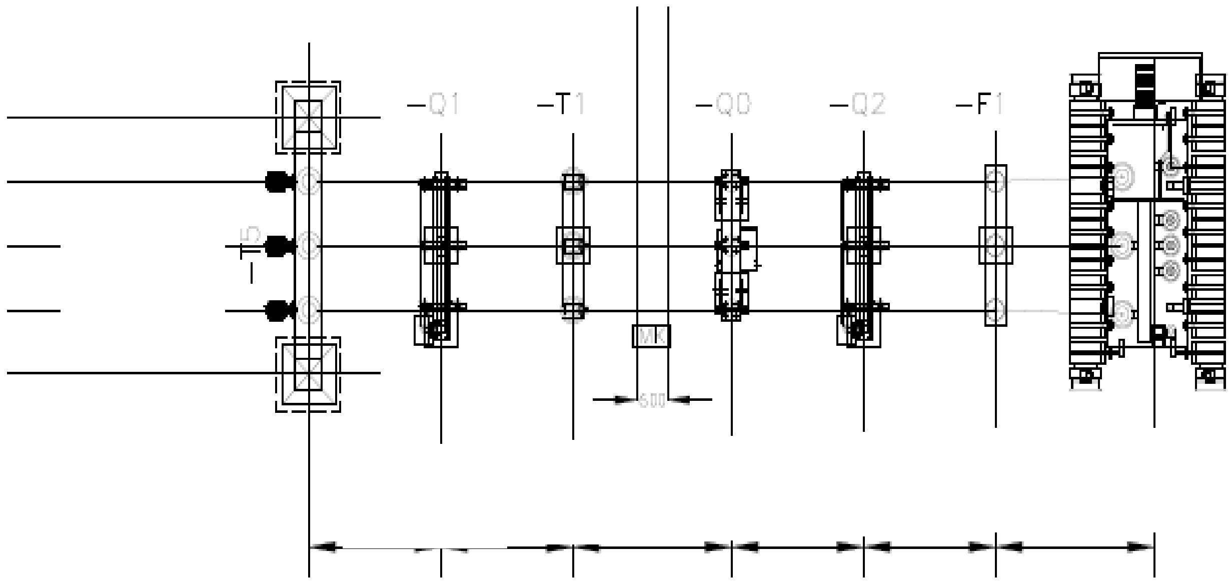

Figure 3.3: Switchyard equipment layout drawing of New Bussa injection station (See attached, Appendix 3, Switchyard equipment layout drawing printed in A3 paper for clarity)

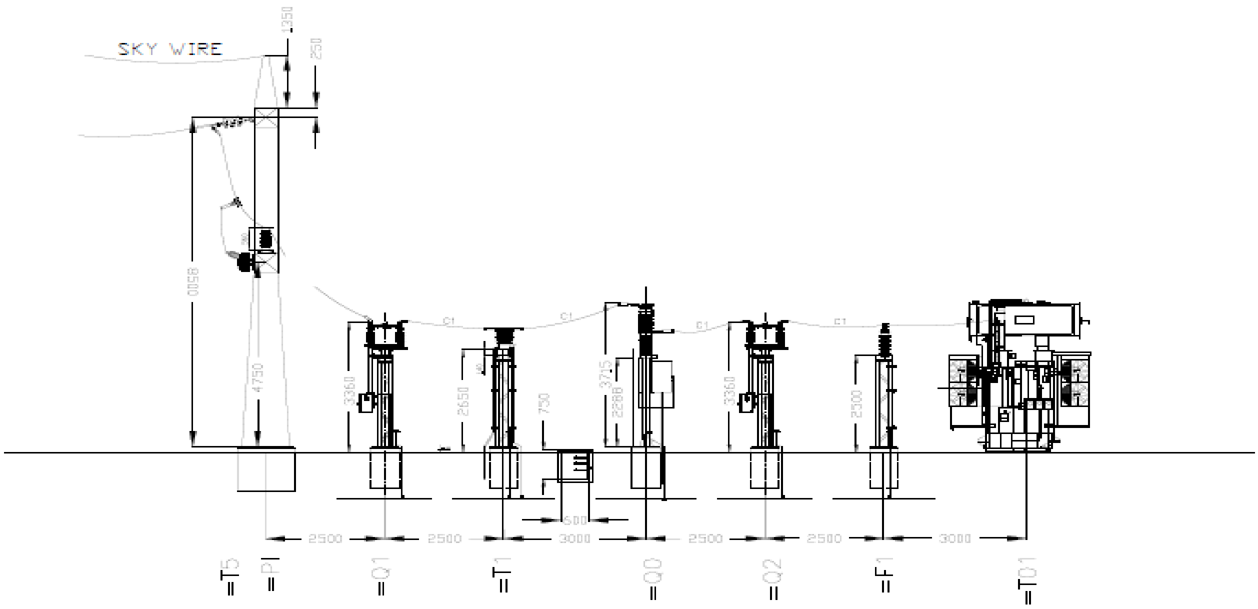

Figure 3.4: Cross-sectional drawing of Switchyard equipment of New Bussa injection station

(See attached, Appendix 4, Cross-sectional drawing printed in A3 paper for clarity)

Equipment designation as shown in drawings of figures 3.1, 3.2 and 3.3 are:

Q0 - 33KV Circuit breaker.

Q1, Q2 - 33KV Disconnect switches.

T1 - 33KV Current transformer.

T5 - 33KV Voltage transformer.

F1 - 33KV Surge arrester.

P1 - 33KV Post insulator

MK - Marshaling Kiosk

New Bussa Injection substation as earlier stated has three 11KV feeders that emanates from the station, they are;

i. Sabo feeder

ii. Senior camp feeder

iii. Township feeder.

Sabo feeder has sixteen (16) numbers of 11/0.415KV distribution transformers of different power ratings connected at various points along the feeder.

Senior camp feeder has sixty-three (63) numbers of 11/0.415KV distribution transformers of different power ratings connected at various points along the feeder.

Township feeder has twenty-four (24) numbers of 11/0.415KV distribution transformers of different power ratings connected at various points along the feeder.

3.3 Design Materials

Microcontroller (ATmega328P type), GSM Modem (SIM900D), LCD, 415/12V step down transformers, 220/12V step down transformer, bridge rectifier, voltage regulator (7805), 12VDC rechargeable battery back-up, paper capacitor, potentiometer, Digital Power Meter (Fluke 345), Measuring Tape, GPS, Digital Multimeter, ETAP 12.6 Software.

3.4 Data Collection

The data collection involved collection of empirical data from field measurements in New Bussa distribution network during peak and off-peak loading periods. These empirical values include data obtained from the injection station about its three feeders, the ones obtained from all the 11/0.415KV distribution transformers within the network and the ones obtained from the distribution lines within the network.

The collection of data needed for this research work involved visiting New Bussa injection substation. This was done on many occasions as we interacted with the Network Manager, Service Engineers and System Operators of the station about the detailed information of the injection station, its feeders and the associated distribution transformers within the network.

Various data collected from the Injection substation that were needed for New Bussa distribution network assessment, were as follows:

i. Single line diagram of New Bussa 15MVA 33/11KV injection substation showing its feeders.
ii. Switchyard equipment layout drawing of New Bussa 15MVA 33/11KV injection substation.
iii. Switchyard equipment cross-sectional drawing of New Bussa 15MVA 33/11KV injection substation.
iv. List of all the 11/0.415KV distribution transformers connected to each feeder of the substation and their ratings.
v. Sample copies of feeders hourly load readings from the injection station's daily log book.
vi. The route length of each 11/0.415KV distribution transformer from the injection substation.
vii. Impedance per unit length of aluminium conductors used for the 11KV feeders.

3.5 Evaluation of Collected Data

This involves studying and technical evaluation of empirical data obtained from New Bussa injection station.

3.5.1 Conducting the power flow analysis of New Bussa distribution network

To determine the reliability of New Bussa Injection Substation network in supplying power to the entire 11/0.415KV distribution transformers connected to its three feeders, one had to conduct power flow study of the distribution network. But before conducting the power flow study for the network, there was need to determine the peak and off-peak loading periods of New Bussa distribution network.

From 8th August to 31st August 2017, empirical data showing the hourly load readings in Amperes for the three feeders for twelve months period (between July1, 2016 to July 1, 2017) were collected. The copies of these hourly load readings were studied, such that for each particular feeder, and for each day of the week (Sunday through Saturday) between July1, 2016 to July 1, 2017 twelve (12) sample copies of feeder's hourly load readings for that particular day were tabulated and their average load readings calculated by adding the twelve samples hourly load readings in Amperes divided by 12. This process was repeated for the remaining six days of the week and their average load readings were also calculated. *(See attached Appendices 5, 6, 7, 8 and 9, showing samples of hourly load readings for each feeder collected from New Bussa Injection Substation and also see below Tables 3.1 to 3.21 showing the selected twelve samples of hourly load readings for each day of the week obtained from the samples of hourly load readings and their corresponding average load readings for each feeder).*

Therefore, to actually determine the peak and off-peak loading periods of New Bussa distribution network, with the tabulated hourly load readings in Amperes, the average hourly load values in Amperes were calculated by adding the twelve samples hourly load readings in Amperes divided by 12. Bar charts were generated for further evaluation and analysis by plotting average hourly load readings in Amperes with their corresponding times in hours (*See the bar charts as they are presented in Figures 3.5 to 3.11*).

A critical study of these bar charts and tabulated hourly load readings in Amperes were performed to determine the load profile.

The tabulated hourly load readings for each day of the week as obtained from the samples of hourly load readings and for each feeder were shown in Tables 3.1 to 3.21 and their corresponding bar charts used for further analysis were shown in Figures 3.5 to 3.11.

Table 3.1: Sabo Feeder Hourly Load Readings for twelve Sundays

	TIME (HOURS)	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	56	54	48	52	59	61	53	51	51	50	47	47	47	45	45	44	43	54	66	71	70	69	66	61
	2	62	60	58	61	62	65	58	55	53	52	49	49	48	44	44	42	42	57	68	79	75	71	69	65
	3	61	57	50	58	64	67	60	54	53	50	50	50	46	45	42	41	41	60	71	78	74	72	68	63
	4	56	53	47	50	60	63	57	56	56	56	53	51	50	50	50	48	47	62	74	77	76	73	61	60
	5	54	50	45	48	49	58	50	47	44	43	42	42	40	40	37	37	36	56	68	80	79	69	65	56
	6	65	52	50	57	66	68	59	54	52	51	50	48	45	44	41	40	40	58	65	75	72	71	64	69
	7	62	56	53	55	57	59	51	47	45	45	45	46	44	42	42	42	41	55	64	74	65	60	58	62
	8	62	60	59	62	65	68	59	55	53	52	50	50	50	46	44	43	41	59	62	75	74	73	68	63
	9	63	60	51	62	63	65	61	58	56	55	55	52	53	50	48	45	42	61	64	69	65	62	59	68
	10	60	53	49	57	60	66	59	57	55	52	51	48	46	45	43	42	40	56	67	78	73	68	61	64
	11	61	56	54	58	64	67	60	52	51	50	50	50	44	41	40	40	38	58	69	77	67	65	57	63
	12	56	56	50	53	56	61	52	51	51	51	50	45	42	38	38	35	34	53	61	73	70	65	64	58
	Av. Load	**60**	**56**	**51**	**56**	**60**	**64**	**57**	**53**	**52**	**51**	**49**	**48**	**46**	**44**	**43**	**42**	**40**	**57**	**67**	**76**	**71.7**	**68**	**63**	**63**

Table 3.2: Sabo Feeder Hourly Load Readings for twelve Mondays

	TIME (HOURS)	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	60	58	53	57	58	62	51	49	46	45	43	40	39	39	39	37	36	54	63	73	71	69	68	62
	2	62	60	56	58	60	64	60	58	57	55	54	53	51	48	44	43	42	61	67	77	71	68	63	66
	3	60	58	50	53	58	60	58	56	54	53	50	50	47	47	47	43	40	56	68	79	75	73	71	64
	4	58	55	49	51	56	60	55	54	50	49	47	45	44	42	41	40	37	52	65	73	72	69	65	61
	5	56	50	50	51	57	63	57	56	55	55	55	53	52	48	47	45	41	62	71	76	75	73	68	60
	6	60	57	55	55	54	59	56	55	52	51	48	47	44	42	41	40	40	58	67	72	72	68	65	64
	7	65	60	57	59	63	65	60	54	54	54	54	51	48	44	43	41	37	54	69	77	66	63	61	68
	8	54	53	51	54	56	59	52	50	49	47	46	45	42	40	37	36	34	52	61	69	67	66	65	58
	9	67	65	61	62	62	65	61	60	57	55	54	52	51	50	48	47	43	59	67	79	70	68	63	68
	10	48	47	43	46	47	49	48	47	44	44	42	40	40	37	35	33	32	49	51	56	52	43	40	51
	11	56	54	50	53	54	58	56	55	53	52	51	48	46	45	42	40	38	51	62	67	63	61	60	59
	12	61	60	57	59	59	62	60	59	59	58	54	53	51	49	48	45	44	59	67	78	72	67	56	61
	Av. Load	**59**	**56**	**53**	**55**	**57**	**61**	**56**	**54**	**53**	**52**	**50**	**48**	**46**	**44**	**43**	**41**	**39**	**56**	**65**	**73**	**68.8**	**66**	**62**	**62**

Table 3.3: Sabo Feeder Hourly Load Readings for twelve Tuesdays

	TIME (HOURS)	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	61	56	52	53	60	63	55	54	52	51	50	47	44	43	42	41	40	59	69	78	74	72	70	62
	2	60	54	49	54	56	62	58	55	54	52	51	50	48	47	45	44	42	61	70	79	74	69	64	60
	3	62	59	63	64	55	60	52	49	48	46	45	43	42	40	40	37	37	57	71	80	76	70	63	65
	4	61	60	58	59	61	64	60	58	57	55	52	51	49	48	45	44	42	58	73	75	74	72	67	62
	5	64	60	53	57	60	61	56	56	54	51	51	51	50	44	44	43	40	60	75	79	73	70	65	66
	6	61	56	54	58	64	67	60	52	51	50	50	50	44	41	40	40	38	58	69	77	67	65	57	63
	7	59	59	51	55	57	61	57	55	53	52	50	49	47	46	43	42	39	59	67	76	76	68	61	60
	8	60	58	55	57	58	62	59	54	52	49	45	44	43	41	39	36	33	57	64	73	70	65	57	61
	9	62	60	58	61	62	65	58	55	53	52	49	49	48	44	44	42	42	57	68	79	75	71	69	64
	10	42	42	40	41	45	47	43	41	40	38	37	37	37	34	33	31	30	44	48	49	47	45	45	45
	11	59	55	53	54	58	59	55	52	50	49	47	44	43	41	40	40	40	55	58	67	64	60	59	60
	12	54	50	45	48	49	58	50	47	44	43	42	42	40	40	37	37	36	56	68	80	79	69	65	56
	Av. Load	**59**	**56**	**53**	**55**	**57**	**61**	**55**	**52**	**51**	**49**	**47**	**46**	**45**	**42**	**41**	**40**	**38**	**57**	**67**	**74**	**70.8**	**66**	**62**	**60**

Table 3.4: Sabo Feeder Hourly Load Readings for twelve Wednesdays

TIME (HOURS)		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	60	56	54	60	64	67	62	60	57	56	54	53	51	50	47	45	44	60	69	75	72	70	67	63
	2	59	59	51	58	61	62	60	55	54	52	51	50	48	48	49	43	41	56	67	73	69	64	57	62
	3	53	50	48	51	55	59	56	54	52	51	50	47	45	42	41	40	40	51	57	68	62	61	57	56
	4	61	60	57	59	60	62	57	55	54	52	51	50	48	47	45	44	42	57	64	74	68	65	63	63
	5	67	65	61	62	62	65	61	60	57	55	54	52	51	50	48	47	43	59	67	79	70	68	63	68
	6	56	56	50	53	56	61	52	51	51	51	50	45	42	38	38	35	34	53	61	73	70	65	64	58
	7	57	54	53	58	59	60	59	58	55	53	52	50	49	45	44	41	38	54	63	71	70	66	61	59
	8	58	55	49	51	56	60	55	54	50	49	47	45	44	42	41	40	37	52	65	73	72	69	65	61
	9	61	60	57	59	59	62	60	59	59	58	54	53	51	49	48	45	44	59	67	78	72	67	56	61
	10	43	40	40	48	50	52	48	46	47	46	44	41	38	37	33	32	32	49	52	62	60	58	56	46
	11	58	57	56	56	57	59	55	55	53	50	47	45	44	42	40	38	38	54	61	70	69	68	53	59
	12	65	61	58	59	63	66	62	60	61	56	55	52	50	50	48	47	45	64	69	81	76	72	68	67
	Av. Load	**58**	**56**	**53**	**56**	**59**	**61**	**57**	**56**	**54**	**52**	**51**	**49**	**47**	**45**	**44**	**41**	**40**	**56**	**64**	**73**	**69.2**	**66**	**61**	**60**

Table 3.5: Sabo Feeder Hourly Load Readings for twelve Thursdays

TIME (HOURS)		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	62	60	59	59	61	66	64	60	58	57	53	52	51	47	46	43	42	62	71	79	74	66	64	65
	2	59	55	53	54	58	59	55	52	50	49	47	44	43	41	40	40	40	55	58	67	64	60	59	60
	3	63	60	54	57	57	63	62	60	57	52	50	46	45	44	42	40	37	56	65	71	68	68	61	63
	4	61	60	57	59	59	62	60	59	59	58	54	53	51	49	48	45	44	59	67	78	72	67	56	61
	5	62	60	58	61	62	68	58	55	53	52	49	49	48	44	44	42	42	57	68	79	75	71	69	64
	6	64	61	59	59	60	64	59	58	54	53	51	50	47	46	45	43	41	60	70	80	78	77	68	67
	7	66	61	60	62	62	67	63	61	60	57	56	55	52	51	47	46	45	63	74	82	70	66	65	68
	8	59	55	53	56	57	60	56	52	51	50	46	45	45	43	41	39	38	51	64	70	67	63	60	59
	9	62	60	58	61	62	67	58	55	53	52	49	49	48	44	44	42	42	57	68	79	75	71	69	64
	10	52	51	51	51	54	59	51	47	46	43	43	43	41	41	37	36	35	42	54	67	56	54	53	54
	11	55	53	50	55	57	63	53	53	52	50	47	46	44	43	41	40	39	47	54	69	63	61	58	56
	12	61	60	58	59	61	64	60	58	57	55	52	51	49	48	45	44	42	58	73	75	74	72	67	62
	Av. Load	**61**	**58**	**56**	**58**	**59**	**64**	**58**	**56**	**54**	**52**	**50**	**49**	**47**	**45**	**43**	**42**	**41**	**56**	**66**	**75**	**69.7**	**66**	**62**	**62**

Table 3.6: Sabo Feeder Hourly Load Readings for twelve Fridays

TIME (HOURS)		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	54	54	49	52	53	58	53	52	50	47	46	44	41	40	36	35	33	52	68	72	70	64	59	57
	2	62	59	59	59	61	64	58	56	55	51	50	47	46	44	43	41	40	59	65	78	76	75	64	65
	3	64	62	59	60	60	63	61	58	56	55	53	52	49	47	46	44	43	58	69	80	75	64	63	65
	4	60	58	57	59	59	62	60	59	59	58	54	53	51	49	48	45	44	59	67	78	72	67	56	61
	5	50	50	50	53	54	59	56	55	53	52	50	47	46	42	42	38	36	54	65	74	69	62	58	54
	6	60	59	59	60	62	67	60	59	57	56	52	51	50	45	42	41	40	56	67	79	76	73	69	63
	7	65	65	62	62	64	68	63	60	59	56	55	53	50	49	47	46	45	59	69	82	76	70	67	68
	8	65	61	60	61	65	68	61	61	58	57	53	54	51	50	45	42	40	56	63	76	76	72	69	67
	9	59	59	51	58	61	65	60	55	54	52	51	50	48	48	49	43	41	56	67	73	69	64	57	62
	10	48	45	40	43	43	49	47	45	45	45	41	40	37	36	34	33	30	52	54	61	56	53	50	48
	11	56	53	52	56	56	62	58	56	55	51	50	46	45	43	42	40	39	55	61	76	67	65	62	58
	12	69	69	65	65	67	69	62	60	57	58	53	52	51	49	48	46	45	60	73	83	78	74	71	70
	Av. Load	**59**	**58**	**55**	**57**	**59**	**63**	**58**	**56**	**55**	**53**	**51**	**49**	**47**	**45**	**44**	**41**	**40**	**56**	**66**	**76**	**71.7**	**67**	**62**	**62**

Table 3.7: Sabo Feeder Hourly Load Readings for twelve Saturdays

	TIME (HOURS)	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	62	58	60	61	64	59	57	54	54	52	51	49	46	45	43	40	58	66	71	65	61	59	57	65
	2	62	56	53	55	57	59	51	47	45	45	45	46	44	42	42	42	41	55	64	74	65	60	58	62
	3	65	61	60	61	65	68	61	61	58	57	53	54	51	50	45	42	40	56	63	76	76	72	69	67
	4	56	50	50	51	57	63	57	56	55	55	55	53	52	48	47	45	41	62	71	76	75	73	68	60
	5	62	60	58	61	62	67	58	55	53	52	49	49	48	44	44	42	42	57	68	79	75	71	69	64
	6	61	56	54	58	64	67	60	52	51	50	50	50	44	41	40	40	38	58	69	77	67	65	57	63
	7	52	51	51	51	54	59	51	47	46	43	43	43	41	41	37	36	35	42	54	67	56	54	53	54
	8	57	54	53	58	59	60	59	58	55	53	52	50	49	45	44	41	38	54	63	71	70	66	61	59
	9	52	51	51	51	54	59	51	47	46	43	43	43	41	41	37	36	35	42	54	67	56	54	53	54
	10	61	56	54	58	64	67	60	52	51	50	50	50	44	41	40	40	38	58	69	77	67	65	57	63
	11	60	58	50	53	58	60	58	56	54	53	50	50	47	47	47	43	40	56	68	79	75	73	71	64
	12	63	60	54	57	57	63	62	60	57	52	50	46	45	44	42	40	37	56	65	71	68	68	61	63
	Av. Load	**59**	**56**	**54**	**56**	**60**	**63**	**57**	**54**	**52**	**50**	**49**	**49**	**46**	**44**	**42**	**41**	**40**	**55**	**65**	**73**	**67.6**	**65**	**61**	**62**

Table 3.8: Senior Camp Feeder Hourly Load Readings for twelve Sundays

	TIME (HOURS)	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	277	268	263	265	269	274	316	283	252	254	257	260	270	272	275	276	291	307	311	328	319	310	299	286
	2	187	180	175	178	183	188	218	215	211	222	256	282	287	290	293	294	295	296	296	316	306	304	283	213
	3	250	234	221	228	231	239	241	243	246	250	254	260	272	275	278	280	283	283	296	300	290	288	277	261
	4	265	250	245	253	259	265	290	270	239	240	248	259	263	266	268	270	280	287	290	308	306	302	226	267
	5	238	233	220	225	228	235	260	239	211	222	224	239	247	252	258	259	263	269	294	303	291	270	266	242
	6	189	182	177	181	185	190	220	203	192	194	199	220	232	241	244	248	252	270	283	303	298	263	259	215
	7	248	235	219	221	228	251	270	240	218	222	224	245	256	258	263	265	269	270	275	284	277	248	237	252
	8	242	225	209	228	234	254	266	236	215	225	230	247	250	254	256	258	260	270	282	304	296	286	270	265
	9	253	247	232	240	241	244	248	221	200	213	227	228	231	240	251	260	263	271	298	307	289	287	273	258
	10	220	210	199	200	201	210	214	189	179	180	187	190	200	217	227	239	272	274	275	294	279	244	230	247
	11	240	236	221	227	230	235	237	217	211	220	228	245	255	259	266	285	289	300	303	312	269	260	235	243
	12	193	188	184	191	195	197	213	192	179	186	203	214	221	236	241	252	283	285	289	296	278	264	240	196
	Av. Load	**234**	**224**	**214**	**220**	**224**	**232**	**249**	**229**	**213**	**219**	**228**	**241**	**249**	**255**	**260**	**266**	**275**	**282**	**291**	**305**	**292**	**277**	**258**	**245**

Table 3.9: Senior Camp Feeder Hourly Load Readings for twelve Mondays

	TIME (HOURS)	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	276	270	266	262	271	321	308	259	246	240	242	247	264	271	257	250	256	263	225	300	307	290	286	283
	2	268	263	258	258	248	262	305	290	280	270	242	247	264	296	303	300	295	263	294	315	317	315	287	272
	3	251	247	242	242	242	253	277	261	250	247	249	242	258	264	241	261	271	298	325	320	318	312	293	264
	4	255	255	240	241	239	254	269	254	248	244	247	253	252	261	256	260	268	273	324	325	319	301	280	271
	5	232	227	226	226	229	236	256	256	244	221	226	228	228	231	235	235	243	255	295	305	302	290	272	251
	6	226	213	205	207	221	276	268	227	214	207	214	224	232	232	234	216	279	284	291	303	323	310	301	241
	7	214	208	206	208	222	277	269	228	215	208	199	206	192	213	232	240	254	250	171	293	294	296	291	222
	8	213	181	177	180	202	247	250	200	190	191	208	207	211	226	223	237	233	260	279	302	299	292	277	215
	9	242	242	243	263	250	248	255	252	257	231	251	242	243	264	268	271	299	307	301	316	325	308	275	254
	10	243	243	244	264	251	249	256	253	258	203	216	219	235	242	270	291	294	306	311	314	309	299	181	255
	11	187	188	198	220	232	247	233	207	203	200	207	210	216	220	262	292	295	307	322	326	319	306	300	211
	12	206	204	202	245	251	258	261	211	206	199	204	206	217	225	246	258	286	303	291	305	241	276	261	210
	Av. Load	**234**	**228**	**226**	**235**	**238**	**261**	**267**	**242**	**234**	**222**	**225**	**228**	**234**	**245**	**252**	**259**	**273**	**281**	**286**	**310**	**306**	**300**	**275**	**246**

Table 3.10: Senior Camp Feeder Hourly Load Readings for twelve Tuesdays

TIME (HOURS)		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	258	250	241	239	271	299	212	195	190	192	220	266	283	283	285	286	289	290	311	325	310	308	300	269
	2	266	262	247	224	250	265	301	288	288	282	279	279	282	275	270	272	264	255	298	322	324	324	311	272
	3	274	266	265	270	282	308	308	304	301	266	281	272	275	270	285	280	281	289	309	311	298	300	290	282
	4	226	258	254	254	255	275	289	278	269	269	271	273	274	276	279	280	280	283	286	300	292	290	274	261
	5	250	236	234	230	247	270	275	242	243	224	230	240	239	249	252	258	259	273	307	311	304	264	243	263
	6	223	215	213	216	231	256	272	215	214	225	231	235	237	238	239	242	249	253	310	321	307	284	260	214
	7	222	214	212	215	230	255	271	215	215	207	209	218	223	227	248	248	257	255	270	300	296	271	253	240
	8	241	234	227	234	258	267	314	236	229	229	232	236	237	256	262	262	260	264	287	321	313	283	267	258
	9	213	211	194	216	219	222	231	224	209	210	217	220	221	225	225	226	228	229	229	238	232	228	217	223
	10	245	232	227	209	261	239	229	204	212	200	212	222	226	245	265	268	289	296	301	309	301	290	286	258
	11	235	226	218	220	223	227	235	231	219	220	223	226	235	243	249	261	265	272	292	302	297	276	268	260
	12	234	225	217	218	221	225	234	230	217	219	222	224	232	240	245	259	260	270	290	298	273	244	238	259
	Av. Load	**241**	**236**	**229**	**229**	**246**	**259**	**264**	**239**	**234**	**229**	**236**	**243**	**247**	**252**	**259**	**262**	**265**	**269**	**291**	**305**	**296**	**280**	**267**	**255**

Table 3.11: Senior Camp Feeder Hourly Load Readings for twelve Wednesdays

TIME (HOURS)		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	274	261	261	287	291	292	319	287	248	250	252	263	272	273	275	275	276	277	321	325	320	320	290	277
	2	294	271	244	256	272	276	277	268	249	256	257	271	272	265	261	260	254	268	310	316	318	320	304	296
	3	262	258	252	243	247	262	278	270	261	273	276	279	283	293	268	263	273	281	301	317	315	306	288	277
	4	272	269	264	258	252	256	257	260	242	241	244	252	258	259	268	265	264	271	282	315	314	307	301	278
	5	292	269	242	254	270	274	280	266	247	254	255	269	270	271	274	275	278	280	289	295	293	283	275	296
	6	229	225	222	219	231	298	299	213	200	191	216	218	241	236	233	244	244	255	296	296	293	284	264	236
	7	230	211	214	216	231	248	250	215	207	206	209	208	216	221	222	226	229	258	292	295	278	282	273	248
	8	241	239	238	240	245	247	250	221	200	204	209	222	223	247	252	257	254	258	278	303	304	304	284	259
	9	187	185	184	199	200	210	213	177	174	175	179	179	182	196	197	212	240	256	257	260	241	233	200	200
	10	243	239	237	260	259	277	279	215	204	201	205	206	214	230	246	271	294	283	285	295	288	264	260	251
	11	240	240	239	240	240	251	253	212	202	200	200	199	217	220	238	247	270	290	300	306	285	274	283	252
	12	203	199	190	226	227	230	231	206	196	195	215	223	233	239	246	254	289	290	272	281	272	239	203	212
	Av. Load	**247**	**239**	**232**	**242**	**247**	**260**	**266**	**234**	**219**	**221**	**226**	**232**	**240**	**246**	**248**	**254**	**264**	**272**	**290**	**300**	**293**	**285**	**269**	**257**

Table 3.12: Senior Camp Feeder Hourly Load Readings for twelve Thursdays

TIME (HOURS)		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	276	268	265	267	267	288	290	275	250	253	255	255	258	260	264	273	276	291	298	314	279	279	260	286
	2	272	260	259	263	264	278	286	277	230	234	236	239	241	249	259	260	266	268	289	313	312	300	285	275
	3	274	268	240	242	244	295	305	283	260	265	268	270	270	272	282	284	286	299	306	315	309	305	295	277
	4	292	269	242	254	270	274	280	266	247	254	255	269	270	271	274	275	278	280	289	295	293	283	275	296
	5	241	234	227	234	258	267	314	236	229	229	232	236	237	256	262	262	260	264	287	321	313	283	267	258
	6	235	228	208	220	221	237	239	220	207	210	213	220	226	229	230	238	247	265	283	312	299	292	253	247
	7	161	159	158	200	225	239	255	213	184	188	190	192	193	199	204	209	223	237	280	295	270	267	261	215
	8	247	242	239	240	242	253	269	226	200	201	204	207	210	212	235	244	250	260	266	290	263	245	240	256
	9	173	168	163	192	200	206	209	171	161	170	174	184	189	210	233	254	268	272	276	299	284	266	254	185
	10	233	229	222	236	250	252	266	231	216	218	220	227	237	246	252	261	268	269	273	286	264	262	257	241
	11	240	239	229	239	246	253	257	232	216	219	223	225	230	234	253	258	266	273	279	296	285	273	268	258
	12	181	178	172	188	205	215	229	213	182	199	200	205	215	229	242	249	275	279	288	293	289	267	249	190
	Av. Load	**235**	**229**	**219**	**231**	**241**	**255**	**267**	**237**	**215**	**220**	**223**	**227**	**231**	**239**	**249**	**256**	**264**	**271**	**285**	**302**	**288**	**277**	**264**	**249**

Table 3.13: Senior Camp Feeder Hourly Load Readings for twelve Fridays

TIME (HOURS)		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	238	231	219	227	229	258	263	245	224	230	233	247	249	253	257	275	286	295	301	317	310	289	270	255
	2	219	213	211	212	224	234	280	265	244	250	253	259	260	265	269	271	276	278	291	300	285	280	265	236
	3	270	251	231	247	249	283	298	270	238	240	244	245	246	249	253	257	260	270	280	289	276	265	243	282
	4	248	235	219	221	228	251	270	240	218	222	224	245	256	258	263	265	269	270	275	284	277	248	237	252
	5	216	205	204	209	216	236	258	234	207	210	222	231	233	235	236	239	241	241	269	308	281	298	270	220
	6	247	231	219	221	229	236	256	222	201	203	204	215	226	230	240	242	245	246	277	292	289	281	273	252
	7	232	227	226	226	229	236	256	256	244	221	226	228	228	231	235	235	243	255	295	305	302	290	272	251
	8	235	227	220	203	221	270	275	228	209	213	217	228	230	233	237	240	241	245	253	287	284	280	265	240
	9	231	229	228	259	263	271	276	256	218	220	225	229	232	237	250	254	255	260	274	296	289	273	270	242
	10	243	238	237	248	260	278	280	240	212	214	224	236	240	243	262	281	287	297	298	302	290	276	265	255
	11	249	244	240	243	247	250	260	238	211	220	225	230	234	239	260	272	285	293	300	306	301	287	263	252
	12	233	228	211	228	235	252	262	234	201	204	207	213	216	221	230	246	248	253	261	266	247	209	197	245
	Av. Load	**238**	**230**	**222**	**229**	**236**	**255**	**270**	**244**	**219**	**221**	**225**	**234**	**238**	**241**	**249**	**256**	**261**	**267**	**281**	**296**	**286**	**273**	**258**	**249**

Table 3.14: Senior Camp Feeder Hourly Load Readings for twelve Saturdays

TIME (HOURS)		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	250	234	221	228	231	239	241	243	246	250	254	260	272	275	278	280	283	283	296	300	290	288	277	261
	2	248	235	219	221	228	251	270	240	218	222	224	245	256	258	263	265	269	270	275	284	277	248	237	252
	3	232	227	226	226	229	236	256	256	244	221	226	228	228	231	235	235	243	255	295	305	302	290	272	251
	4	235	228	208	220	221	237	239	220	207	210	213	220	226	229	230	238	247	265	283	312	299	292	253	247
	5	229	224	220	216	205	215	198	225	163	202	157	206	214	214	197	204	187	216	250	288	288	261	246	234
	6	222	214	212	215	230	255	271	215	215	207	209	218	223	227	248	248	257	255	270	300	296	271	253	240
	7	243	239	237	260	259	277	279	215	204	201	205	206	214	230	246	271	294	283	285	295	288	264	260	251
	8	219	213	211	212	224	234	280	265	244	250	253	259	260	265	269	271	276	278	291	300	285	280	265	236
	9	240	239	229	239	246	253	257	232	216	219	223	225	230	234	253	258	266	273	279	296	285	273	268	258
	10	272	269	264	258	252	256	257	260	242	241	244	252	258	259	268	265	264	271	282	315	314	307	301	278
	11	253	247	232	240	241	244	248	221	200	213	227	228	231	240	251	260	263	271	298	307	289	287	273	258
	12	270	251	231	247	249	283	298	270	238	240	244	245	246	249	253	257	260	270	280	289	276	265	243	282
	Av. Load	**243**	**235**	**226**	**232**	**235**	**248**	**258**	**239**	**220**	**223**	**223**	**233**	**238**	**243**	**249**	**254**	**259**	**266**	**282**	**299**	**291**	**277**	**262**	**254**

Table 3.15: Township Feeder Hourly Load Readings for twelve Sundays

TIME (HOURS)		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	139	134	132	134	136	144	157	143	132	119	118	114	110	123	137	141	145	146	167	170	168	160	158	145
	2	140	136	124	127	129	136	148	140	130	128	126	125	121	134	140	140	141	145	161	174	167	163	152	147
	3	143	138	130	132	134	140	150	144	137	126	125	123	119	126	134	143	145	147	150	177	172	167	151	144
	4	145	140	135	138	140	146	162	148	130	125	121	120	114	130	141	145	147	150	166	174	171	161	154	153
	5	118	118	118	123	125	131	146	135	132	130	127	123	117	124	127	135	140	144	168	180	164	158	151	120
	6	151	142	120	125	127	130	140	138	133	126	123	119	109	123	131	133	137	146	160	170	163	152	140	157
	7	137	136	133	137	140	144	159	153	150	143	138	137	131	144	158	161	164	166	167	169	164	153	141	140
	8	138	130	123	128	131	151	160	149	140	137	134	130	125	132	139	141	143	145	167	186	183	178	168	139
	9	139	131	122	127	136	140	147	141	136	132	128	125	110	121	134	137	153	176	181	189	134	120	114	141
	10	109	108	100	102	103	106	109	108	104	95	94	90	89	90	91	92	129	148	150	152	143	135	127	110
	11	124	122	121	126	129	131	137	132	130	126	125	124	120	139	148	157	166	170	173	176	173	170	156	126
	12	126	122	119	125	127	128	148	140	132	120	118	117	112	120	138	145	149	152	164	168	164	161	151	131
	Av. Load	**134**	**130**	**123**	**127**	**130**	**136**	**147**	**139**	**132**	**126**	**123**	**121**	**115**	**126**	**135**	**139**	**147**	**153**	**165**	**174**	**164**	**157**	**147**	**138**

Table 3.16: Township Feeder Hourly Load Readings for twelve Mondays

TIME (HOURS)		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	146	140	134	140	144	154	163	135	130	125	123	122	120	133	136	140	139	153	160	183	177	171	159	152
	2	144	139	127	130	131	140	144	141	135	131	130	126	123	134	141	144	145	161	169	179	174	172	160	146
	3	139	129	121	126	128	136	157	155	143	135	126	123	119	122	128	131	136	159	161	178	173	161	157	147
	4	147	136	123	130	131	140	150	139	136	132	129	124	121	140	142	145	150	174	181	183	181	170	155	154
	5	130	128	116	125	128	134	145	144	142	138	136	132	127	130	144	146	147	161	171	173	167	146	141	139
	6	126	118	115	116	124	148	158	140	136	132	126	121	117	128	135	143	146	148	156	158	150	148	139	131
	7	125	114	105	110	119	134	143	139	131	120	118	115	111	124	134	137	145	163	171	183	172	167	163	129
	8	124	118	106	109	115	131	147	142	140	131	126	122	115	126	128	130	139	151	174	184	172	170	162	138
	9	101	100	95	104	107	111	137	132	130	126	123	120	106	119	135	141	163	178	181	186	180	178	157	114
	10	118	113	110	123	126	143	151	147	132	131	125	123	120	127	131	141	147	150	153	162	159	157	142	135
	11	137	114	106	123	126	140	149	145	136	134	120	112	100	124	142	152	158	171	179	189	183	179	165	148
	12	124	117	106	118	131	145	155	150	136	132	125	122	118	131	142	149	154	169	170	179	158	151	144	128
	Av. Load	**130**	**122**	**114**	**121**	**126**	**138**	**150**	**142**	**136**	**131**	**126**	**122**	**116**	**128**	**137**	**142**	**147**	**162**	**169**	**178**	**171**	**164**	**154**	**138**

Table 3.17: Township Feeder Hourly Load Readings for twelve Tuesdays

TIME (HOURS)		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	141	140	131	135	146	150	155	145	139	137	129	126	122	131	136	137	142	150	170	181	176	171	159	148
	2	139	134	122	129	134	143	159	155	149	137	135	133	132	133	137	140	147	152	156	179	176	161	152	144
	3	147	133	132	134	137	147	158	150	148	145	141	139	130	133	134	137	139	143	162	174	168	167	160	154
	4	139	135	129	131	133	149	162	154	146	136	135	134	128	129	132	137	144	150	155	178	173	169	163	147
	5	131	124	120	125	128	134	139	135	132	129	125	123	119	120	124	128	135	144	167	172	165	151	148	140
	6	140	136	124	127	129	136	148	140	130	128	126	125	121	134	140	140	141	145	161	174	167	163	152	147
	7	128	126	122	127	135	145	171	134	129	126	124	123	120	135	139	140	146	150	173	190	180	164	147	136
	8	140	136	129	132	152	159	166	137	128	125	124	122	118	140	144	148	151	153	172	198	191	176	143	150
	9	147	136	123	130	131	140	150	139	136	132	129	124	121	140	142	145	150	174	181	183	181	170	155	154
	10	133	131	128	135	140	146	149	134	131	123	121	118	115	131	137	148	165	170	174	176	170	167	162	135
	11	142	139	130	133	137	149	156	142	137	136	126	124	121	137	140	151	158	160	173	184	175	161	152	149
	12	139	129	121	126	128	136	157	155	143	135	126	123	119	122	128	131	136	159	161	178	173	161	157	147
	Av. Load	**139**	**133**	**126**	**130**	**136**	**145**	**156**	**143**	**137**	**132**	**128**	**126**	**122**	**132**	**136**	**140**	**146**	**154**	**167**	**181**	**175**	**165**	**154**	**146**

Table 3.18: Township Feeder Hourly Load Readings for twelve Wednesdays

TIME (HOURS)		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	141	136	133	139	144	167	168	147	132	129	127	123	122	139	139	141	143	155	178	189	182	170	156	147
	2	142	139	131	135	140	146	158	151	139	138	133	125	116	134	137	138	145	146	173	179	166	167	161	146
	3	139	137	132	136	137	143	159	154	147	139	136	135	128	132	137	139	141	151	158	170	164	149	146	155
	4	150	148	146	148	149	152	159	152	145	140	137	132	131	140	143	145	147	149	166	179	177	163	156	154
	5	137	114	106	123	126	140	149	145	136	134	120	112	100	124	142	152	158	171	179	189	183	179	165	148
	6	139	131	122	127	136	140	147	141	136	132	128	125	110	121	134	137	153	176	181	189	134	120	114	141
	7	130	126	121	123	131	143	161	134	128	124	122	119	112	136	139	139	145	151	178	191	184	178	164	139
	8	131	124	120	125	128	134	139	135	132	129	125	123	119	120	124	128	135	144	167	172	165	151	148	140
	9	124	118	106	109	115	131	147	142	140	131	126	122	115	126	128	130	139	151	174	184	172	170	162	138
	10	145	141	133	145	147	160	164	146	134	131	130	125	121	136	149	156	158	163	167	176	171	159	152	148
	11	153	146	141	143	146	158	160	127	125	122	122	118	109	133	143	155	158	164	175	177	167	160	150	155
	12	123	116	111	122	126	137	148	131	126	125	122	121	118	120	121	124	153	156	160	172	164	143	125	135
	Av. Load	**138**	**131**	**125**	**131**	**135**	**146**	**155**	**142**	**135**	**131**	**127**	**123**	**117**	**130**	**136**	**140**	**148**	**156**	**171**	**181**	**169**	**159**	**150**	**146**

Table 3.19: Township Feeder Hourly Load Readings for twelve Thursdays

	TIME (HOURS)	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	149	145	132	142	145	168	173	151	137	134	131	125	122	134	137	138	142	151	178	180	161	158	130	153
	2	140	131	126	132	137	138	155	149	138	135	135	131	127	139	140	148	150	164	167	180	169	143	135	141
	3	135	132	122	130	134	135	145	136	133	132	130	129	124	131	136	140	143	160	163	173	165	160	152	136
	4	139	129	121	126	128	136	157	155	143	135	126	123	119	122	128	131	136	159	161	178	173	161	157	147
	5	118	113	110	123	126	143	151	147	132	131	125	123	120	127	131	141	147	150	153	162	159	157	142	135
	6	139	131	122	127	136	140	147	141	136	132	128	125	110	121	134	137	153	176	181	189	134	120	114	141
	7	137	128	123	139	146	148	167	137	131	128	127	122	114	133	141	144	151	154	184	193	181	164	155	142
	8	136	128	128	131	143	147	151	139	132	125	119	111	106	129	137	148	152	164	166	183	158	147	140	142
	9	140	136	129	132	152	159	166	137	128	125	124	122	118	140	144	148	151	153	172	198	191	176	143	150
	10	137	133	131	137	143	143	156	127	124	121	120	119	111	140	147	157	172	175	178	187	181	162	156	143
	11	152	146	137	140	147	147	159	130	128	127	126	131	124	139	142	145	149	165	170	176	173	157	150	155
	12	109	105	100	121	127	134	136	123	122	122	118	114	101	133	135	137	157	169	177	179	178	161	154	120
	Av. Load	**136**	**130**	**123**	**132**	**139**	**145**	**155**	**139**	**132**	**129**	**126**	**123**	**116**	**132**	**138**	**143**	**150**	**162**	**171**	**182**	**169**	**156**	**144**	**142**

Table 3.20: Township Feeder Hourly Load Readings for twelve Fridays

	TIME (HOURS)	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	124	122	118	120	122	141	146	134	127	122	115	106	100	127	137	140	142	150	176	179	172	165	164	132
	2	126	120	113	117	120	132	142	137	135	127	124	120	115	130	134	139	140	144	176	178	168	172	160	129
	3	141	131	120	124	128	136	152	146	140	138	134	130	120	132	140	142	142	157	163	169	166	147	143	146
	4	147	136	123	130	131	140	150	139	136	132	129	124	121	140	142	145	150	174	181	183	181	170	155	154
	5	112	110	101	107	115	148	152	131	124	121	113	111	104	112	123	125	126	139	147	168	167	164	151	119
	6	130	124	120	134	142	153	160	130	117	114	112	106	101	123	126	126	131	135	139	166	159	154	142	141
	7	136	134	130	133	134	141	155	137	126	118	117	110	107	127	136	136	138	150	156	178	174	171	149	140
	8	132	120	118	124	138	156	165	139	134	131	129	123	122	130	138	146	149	150	167	191	172	169	151	136
	9	145	141	133	145	147	160	164	146	134	131	130	125	121	136	149	156	158	163	167	176	171	159	152	148
	10	145	141	140	151	153	155	161	138	135	130	126	124	123	132	148	161	165	172	180	185	183	174	163	151
	11	128	128	112	137	141	142	153	140	134	133	130	121	118	134	150	156	157	169	170	180	161	154	138	130
	12	135	125	120	141	145	155	159	133	129	127	124	122	115	120	132	132	140	144	156	168	162	109	100	138
	Av. Load	**133**	**128**	**121**	**130**	**135**	**147**	**155**	**138**	**131**	**127**	**124**	**119**	**114**	**129**	**138**	**142**	**145**	**154**	**165**	**177**	**170**	**159**	**147**	**139**

Table 3.21: Township Feeder Hourly Load Readings for twelve Saturdays

	TIME (HOURS)	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
HOURLY LOAD (AMPERES)	1	151	142	120	125	127	130	140	138	133	126	123	119	109	123	131	133	137	146	160	170	163	152	140	157
	2	124	117	106	118	131	145	155	150	136	132	125	122	118	131	142	149	154	169	170	179	158	151	144	128
	3	128	126	122	127	135	145	171	134	129	126	124	123	120	135	139	140	146	150	173	190	180	164	147	136
	4	150	148	146	148	149	152	159	152	145	140	137	132	131	140	143	145	147	149	166	179	177	163	156	154
	5	147	136	123	130	131	140	150	139	136	132	129	124	121	140	142	145	150	174	181	183	181	170	155	154
	6	153	146	141	143	146	158	160	127	125	122	122	118	109	133	143	155	158	164	175	177	167	160	150	155
	7	146	140	134	140	144	154	163	135	130	125	123	122	120	133	136	140	139	153	160	183	177	171	159	152
	8	152	146	137	140	147	147	159	130	128	127	126	131	124	139	142	145	149	165	170	176	173	157	150	155
	9	139	131	122	127	136	140	147	141	136	132	128	125	110	121	134	137	153	176	181	189	134	120	114	141
	10	126	122	119	125	127	128	148	140	132	120	118	117	112	120	138	145	149	152	164	168	164	161	151	131
	11	133	131	128	135	140	146	149	134	131	123	121	118	115	131	137	148	165	170	174	176	170	167	162	135
	12	135	132	122	130	134	135	145	136	133	132	130	129	124	131	136	140	143	160	163	173	165	160	152	136
	Av. Load	**140**	**135**	**127**	**132**	**137**	**143**	**154**	**138**	**133**	**128**	**126**	**123**	**118**	**131**	**139**	**144**	**149**	**161**	**170**	**179**	**167**	**158**	**148**	**145**

With reference to Tables 3.1 through 3.21, which were the empirical values obtained from New Bussa injection substation, showing the daily hourly load readings in Amperes for the three feeders in the network, bar charts were plotted for further evaluation and analysis of load profile for the three feeders in the network.

The bar charts are shown in Figures 3.5 to 3.11;

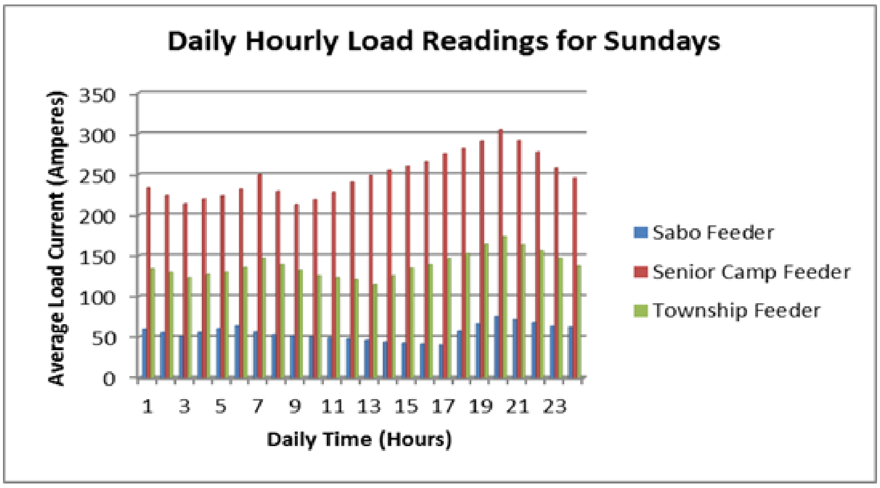

Figure 3.5: Chart showing Hourly Load Profile for Sundays

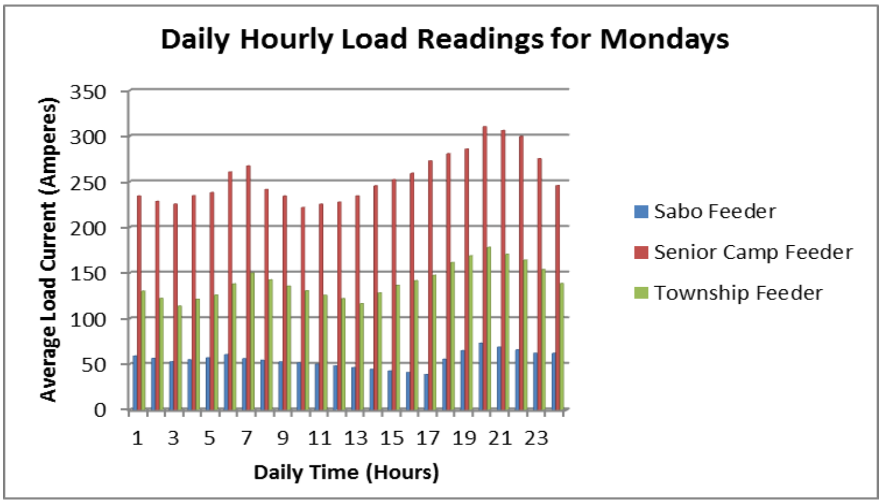

Figure 3.6: Chart showing Hourly Load Profile for Mondays

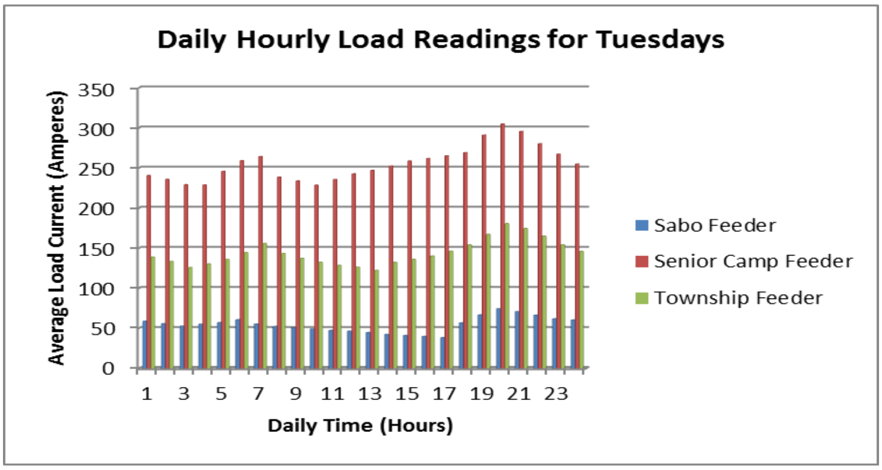

Figure 3.7: Chart showing Hourly Load Profile for Tuesdays

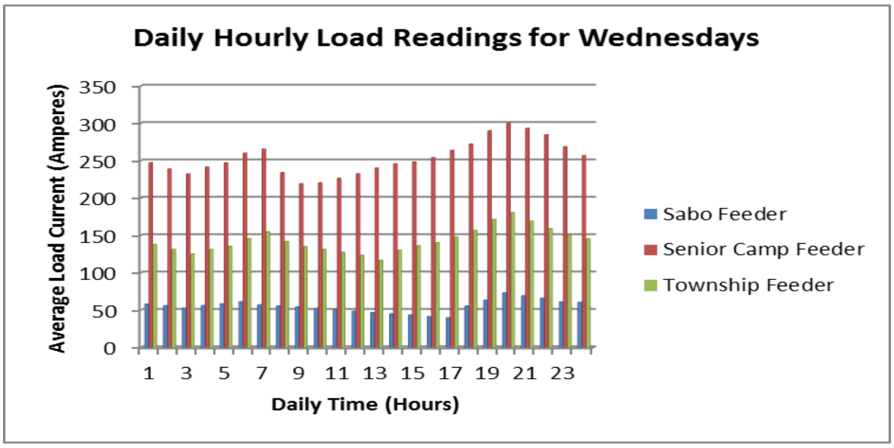

Figure 3.8: Chart showing Hourly Load Profile for Wednesdays

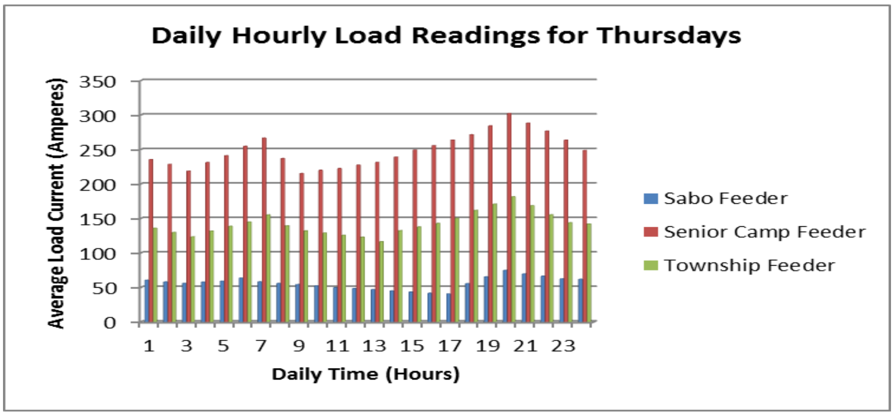

Figure 3.9: Chart showing Hourly Load Profile for Thursdays

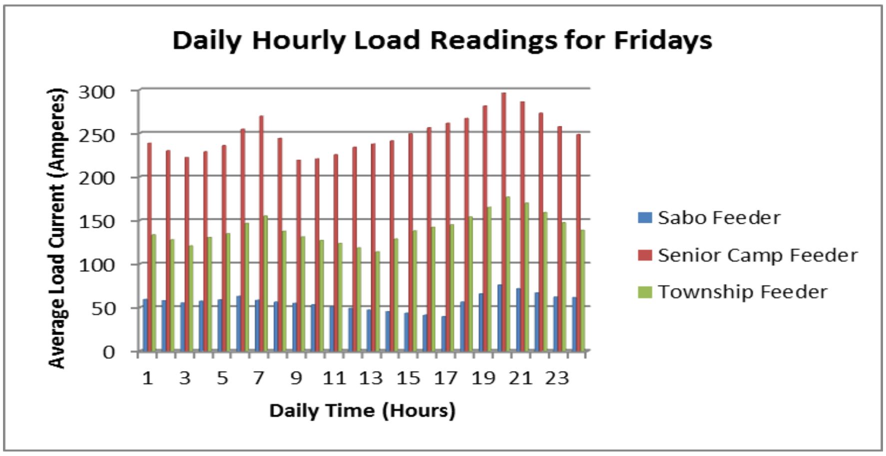

Figure 3.10: Chart showing Hourly Load Profile for Fridays

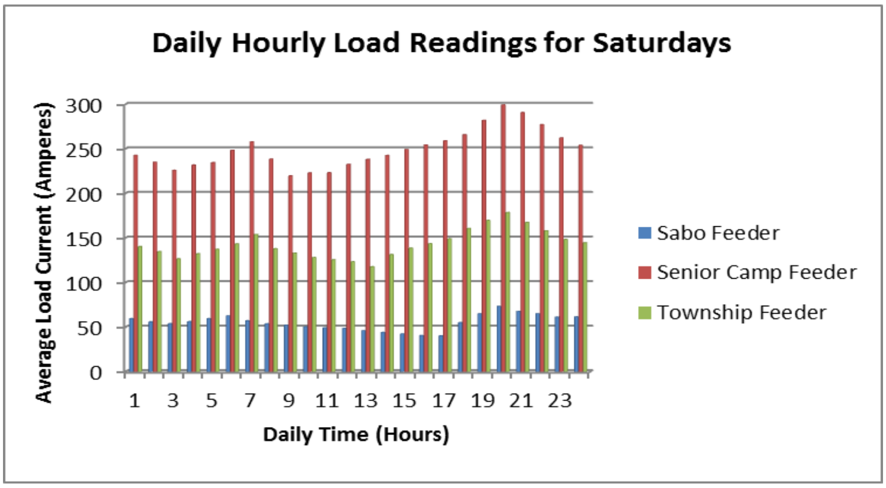

Figure 3.11: Chart showing Hourly Load Profile for Saturdays

To conduct the load flow study of New Bussa distribution network, certain real-time data obtained from the network were entered into power simulation software called Electrical Transient and Analysis Program (ETAP 12.6). This was to carry out the computer aided power flow analysis of New Bussa distribution network. Power flow model of New Bussa distribution network was generated and was used to characterize the performance status of the network. These real-time data include;

i. Names and ratings of all distribution transformers (11/0.415KV) in the network.

ii. Load readings (Apparent power) for each transformer.
iii. Power factor of each load.
iv. Impedance (resistance and reactance) per unit length of the bare aluminium conductors and cables used for distribution line.
v. Route length of each distribution transformer.
vi. Swing bus (33KV bus)

These real-time transformer data for New Bussa network were obtained from 1st September, 2017 to 30th September, 2017 from all the 11/0.415KV transformers in each feeder. They are tabulated as shown in Tables 3.22, 3.23 and 3.24;

Table 3.22: New Bussa Distribution Empirical Data for Sabo Feeder								
					PEAK PERIOD		OFF-PEAK PERIOD	
S/N	TRANSFORMER DESIGNATION	RATING	ROUTE LENGTH (km)	POWER FACTOR PF	ACTIVE POWER KW	APPARENT POWER KVA	ACTIVE POWER KW	APPARENT POWER KVA
1	Awuru S/S 1	200KVA	28.1	0.73	28.62	39.15	14.88	20.36
2	Awuru S/S 2	200KVA	28.9	0.66	27.59	41.87	11.86	18.00
3	Fukun S/S	200KVA	10.1	0.80	31.03	38.68	12.10	15.09
4	NAPTIN School	500KVA	12.5	0.74	19.14	25.86	25.84	34.92
5	Nassarawa Grinder	200KVA	15.5	0.59	27.73	46.77	15.81	26.66
6	GDSS Nassarawa	100KVA	15.1	0.76	29.43	38.82	22.07	29.12
7	Nassarawa 1	500KVA	14.5	0.59	31.74	53.98	20.63	35.09
8	Nassarawa 2	315KVA	14	0.83	33.00	39.96	22.11	26.77
9	Manyara S/S	300KVA	10	0.63	31.28	49.88	15.33	24.44
10	Sabo 1	315KVA	18	0.75	28.80	38.46	10.95	14.61
11	Sabo 2	200KVA	18.5	0.61	34.34	56.20	10.30	16.86
12	Sabo Grinder	200KVA	17.5	0.77	32.85	42.83	12.15	15.85
13	National Park HQ	200KVA	9.1	0.84	34.57	41.40	26.97	32.29
14	Federal College of Wildlife	300KVA	12	0.79	30.38	38.40	39.49	49.92
15	MTN Wildlife	100KVA	11.5	0.66	32.05	48.85	28.84	43.97
16	MTN Nassarawa	100KVA	12.1	0.59	24.75	41.74	23.27	39.23

Table 3.23: New Bussa Distribution Empirical Data for Township Feeder								
					PEAK PERIOD		OFF-PEAK PERIOD	
S/N	**TRANSFORMER DESIGNATION**	**RATING**	**ROUTE LENGTH (km)**	**POWER FACTOR PF**	**ACTIVE POWER KW**	**APPARENT POWER KVA**	**ACTIVE POWER KW**	**APPARENT POWER KVA**
1	SS 40 Roundabout	300KVA	4	0.68	58.38	85.72	26.27	38.57
2	Old Dogondari	300KVA	4	0.81	66.92	82.42	36.81	45.33
3	Koro 1	500KVA	4.2	0.75	53.59	71.16	25.19	33.45
4	Koro Grinder	200KVA	4.15	0.81	54.16	66.95	27.08	33.48
5	Koro Radio	200KVA	4.05	0.84	41.06	48.83	55.44	65.92
6	Emirs Guest House	330KVA	5.1	0.68	52.51	77.33	39.38	58.00
7	SS 13 Manchester	500KVA	6.1	0.74	63.52	86.07	41.29	55.94
8	Army Engineer	300KVA	5.8	0.79	71.00	89.54	60.35	76.11
9	New Quarters	500KVA	5.4	0.70	62.48	89.64	46.24	66.34
10	Jobice	200KVA	6.4	0.86	46.12	53.88	36.89	43.10
11	Jevohah Witness	500KVA	7.1	0.86	69.83	81.10	30.03	34.87
12	Lafia Spot	100KVA	7	0.76	43.21	56.55	25.92	33.93
13	Agip	500KVA	7.5	0.86	71.74	83.41	55.95	65.06
14	Niger Water Booster	200KVA	7.1	0.60	46.10	77.49	33.66	56.56
15	General Hospital	300KVA	7.5	0.81	67.62	83.59	60.86	75.23
16	Dantoro Road	500KVA	6.8	0.66	54.84	82.59	29.07	43.77
17	FGGC	500KVA	6	0.75	39.88	52.96	57.82	76.79
18	Hydro	300KVA	6.1	0.80	56.54	70.41	22.61	28.16
19	Old Market	500KVA	5.8	0.69	54.77	79.61	31.22	45.38
20	Fisheries School	300KVA	8.2	0.74	50.68	68.30	60.82	81.97
21	Fisheries Quarters	300KVA	8	0.79	59.22	74.59	22.50	28.34
22	NIFFR Sec. Quarters	500KVA	6.2	0.84	49.03	58.58	19.61	23.43
23	NIFFR Senior Quarters 1	300KVA	7.2	0.87	52.69	60.49	27.92	32.06
24	NIFFR Senior Quarters 2	300KVA	6.8	0.71	41.43	58.76	25.68	36.43

Table 3.24: New Bussa Distribution Empirical Data for Senior Camp Feeder								
					PEAK PERIOD		OFF-PEAK PERIOD	
S/N	TRANSFORMER DESIGNATION	RATING	ROUTE LENGTH (km)	POWER FACTOR PF	ACTIVE POWER KW	APPARENT POWER KVA	ACTIVE POWER KW	APPARENT POWER KVA
1	Govt. Sec. School	300KVA	1.5	0.82	51.14	62.60	24.55	30.05
2	Technical Junction	300KVA	1	0.59	102.16	172.57	41.89	70.75
3	Dantoro Lodge	500KVA	1.9	0.66	101.74	154.62	38.66	58.76
4	Niger River Basin	300KVA	3.1	0.79	94.18	119.07	32.02	40.48
5	Local Govt. Quarters	200KVA	2.5	0.54	51.73	96.70	18.11	33.84
6	NIFFR HQS	500KVA	2.9	0.60	94.75	157.39	27.48	45.64
7	Nedudu Estate	300KVA	2.8	0.84	159.50	190.34	55.83	66.62
8	NIFFR Junior Quarters	300KVA	3.9	0.69	97.89	141.88	28.39	41.14
9	Tudun Wali	500KVA	4.9	0.56	98.28	176.44	33.41	59.99
10	Kwarin Wali	200KVA	5	0.87	83.67	95.74	23.43	26.81
11	Anglican Church 1	300KVA	5.2	0.76	124.38	163.22	28.61	37.54
12	Anglican Church 2	500KVA	5.6	0.59	112.00	190.47	29.12	49.52
13	Mil Quarters 1	500KVA	5.9	0.74	123.42	166.55	34.56	46.64
14	Mil Quarters 2	150KVA	5.7	0.69	87.58	126.93	20.14	29.19
15	Baba Ilorin Farm	100KVA	6.1	0.80	56.37	70.37	27.62	34.48
16	Monai	100KVA	12.1	0.76	49.17	64.79	11.31	14.90
17	Yuna	300KVA	15.2	0.61	106.84	174.58	26.71	43.64
18	MESL Water Treatment	150KVA	11	0.71	73.49	103.07	17.64	24.74
19	Niger Water Plant	1MVA	16.2	0.87	278.53	318.69	130.91	149.78
20	MESL Water Intake	500KVA	12.1	0.90	110.20	122.04	68.33	75.67
21	MESL Water Reserviour	500KVA	8.1	0.76	107.12	141.31	40.70	53.70
22	Old Army Baracks	250KVA	8	0.71	95.36	133.75	22.89	32.10
23	Baba Ilorin House	100KVA	7	0.79	33.00	41.82	7.59	9.62
24	Waziri Primary School	500KVA	8	0.55	171.37	312.14	37.70	68.67
25	Bussa Town Hall	500KVA	6.5	0.64	114.53	179.79	21.76	34.16
26	Aligani	500KVA	8.9	0.62	122.53	197.95	35.53	57.41
27	Kidagba	500KVA	9	0.74	91.77	124.36	16.52	22.38
28	MTN	200KVA	8.5	0.88	47.44	53.72	13.76	15.58
29	UBA	200KVA	8.2	0.89	39.79	44.66	23.48	26.35
30	KEYSTONE	200KVA	7.9	0.59	30.31	51.46	18.19	30.88
31	Borgu Community Bank	100KVA	8	0.66	21.98	33.10	10.33	15.56
32	Luma Road	500KVA	9.5	0.76	187.52	246.74	50.63	66.62
33	Ngaski	500KVA	9	0.84	94.55	112.83	19.86	23.69
34	Elshadai	150KVA	9.9	0.76	74.12	97.39	18.53	24.35
35	Niger Crescent	150KVA	10.5	0.74	63.67	86.63	19.10	25.99
36	Kaduna Drive	300KVA	11.1	0.60	93.24	155.66	29.84	49.81
37	NAPTIN Guest House 1	300KVA	12	0.91	65.74	72.16	26.30	28.86
38	NAPTIN Guest House 2	300KVA	12.5	0.91	69.42	76.62	33.32	36.78
39	Zaria Way	150KVA	12.9	0.65	77.83	120.30	13.23	20.45
40	Kadariko	150KVA	13.6	0.58	81.04	140.20	21.07	36.45
41	Kuruwasa	300KVA	17	0.85	98.53	115.65	21.68	25.44
42	Corpra Below S/S	300KVA	10.1	0.76	121.58	159.13	40.12	52.51
43	BF 1 S/S	100KVA	9.4	0.52	48.74	93.38	16.57	31.75
44	Hanger S/S	500KVA	8.9	0.64	86.69	134.83	30.34	47.19
45	MT Yard S/S	200KVA	8.7	0.78	86.46	110.99	17.29	22.20
46	TFT S/S	300KVA	9.1	0.72	105.47	147.51	18.98	26.55
47	Clinic S/S	300KVA	10.4	0.77	79.92	104.20	31.17	40.64
48	Water Treatment	300KVA	9.9	0.69	96.77	140.45	34.84	50.56
49	BSW S/S	315KVA	10.2	0.84	82.83	99.08	15.74	18.83
50	Mammy Market	300KVA	8.6	0.91	146.64	161.67	41.06	45.27
51	Officers' Mess	750KVA	10	0.86	177.62	205.58	30.20	34.95
52	Rader S/S	300KVA	11.1	0.78	108.38	138.24	20.59	26.27
53	SNCO S/S	500KVA	11.2	0.79	113.56	143.21	17.03	21.48
54	SOQ S/S	500KVA	12.2	0.74	95.39	129.61	13.35	18.15
55	Donia Camp	500KVA	13	0.85	96.12	112.81	20.18	23.69
56	Chinese Quarters	200KVA	12.2	0.87	92.37	106.53	29.56	34.09
57	Motel Annex	500KVA	12.1	0.59	88.53	149.55	53.12	89.73
58	Ilorin Road	500KVA	11.9	0.75	123.65	165.52	38.33	51.31
59	Senior Camp C/T	150KVA	10.9	0.80	67.33	84.69	21.55	27.10
60	D4 S/S	500KVA	10	0.87	121.43	139.89	31.57	36.37
61	GRA S/S	300KVA	11.2	0.84	116.74	138.48	44.36	52.62
62	Catholic Church	150KVA	11	0.80	47.35	59.04	10.42	12.99
63	Katamaya Hospital	250KVA	12	0.77	74.95	97.85	27.73	36.20

Where; PF – Power Factor; KW – Kilowatt; KVA – Kilovolt-ampere

To generate a load flow model of New Bussa distribution network, the various real-time empirical data listed in Tables 3.22, 3.23 and 3.24 obtained from the network were entered into the ETAP 12.6 simulation software for peak and off-peak loading period respectively. The New Bussa distribution network model (Single line diagram of the network) is shown as Figure 4.1 in chapter 4. The generated load flow reports for the network under review, for both peak & off-peak loading periods are shown in Tables 4.1 & 4.2 while the branch power losses summary reports for both peak and off-peak period are shown Tables 4.3 & 4.4. These generated reports were analyzed in chapter four to determine the performance status of the New Bussa distribution network (characterize New Bussa distribution network).

3.5.2 Developing the voltage compensating system using the optimal capacitor placement (OCP) module of ETAP 12.6 software and a mathematical model.

For optimum functioning of the voltage compensator (capacitor bank), it must be optimally sized and positioned in the network.

To optimally position capacitor bank in the network, one adopted the method in research work by Harisha and Lakshmi (2015). This research work used an improved format for capacitor placement in a radial distribution system by applying loss sensitivity factors to select the candidate locations (buses) for capacitor optimal placement.

In as much as the manual/mathematical approach of loss sensitivity factor calculations was considered in this research work for determining the optimal locations for capacitors, the Optimal Capacitor Placement (OCP) module in ETAP 12.6 software was also used as faster and easier way to confirm those candidate buses. Also, the Optimal Capacitor Placement (OCP) module and its power flow simulation determine the optimal capacitor sizes based on the earlier selected candidate buses.

3.5.2.1 Calculation of loss sensitivity factor

Loss sensitivity factor calculation determines the bus that will have the biggest power loss reduction when a capacitor is installed on that particular bus.

Mathematically, Loss sensitivity factor is given as:

$$\varphi = \frac{\partial P_{Loss}}{\partial Q} = \frac{2QR}{V^2} \quad \text{(Dinakara, 2013)} \qquad (3.39)$$

Taking a critical look at New Bussa distribution network model shown in Figure 4.1 and the generated load flow reports of Tables 4.1 and 4.2; nine buses were selected and confirmed by OCP module of ETAP 12.6 as candidate buses due to their voltage magnitudes, their locations in the network, and distances from the injection station. The selected candidate buses were 04, 05, 07, 08, 09, 10, 57, 020 and 0012.

To determine the order in which they were considered as candidate buses, loss sensitivity factors calculation was done using equation 3.39 and the bus with the biggest value of loss sensitivity factor was considered first as the candidate bus and in that order. The parameter variables in equation 3.39 were obtained from the generated load flow report in Table 4.1.

Bus 04:

$$\varphi = \frac{2QR}{V^2}$$

Q = 3.276MVar, R = 1.11325Ω, V = 0.81167

$$\varphi = \frac{2x3.276x1.11325}{(0.81167)^2} = 11.072$$

Bus 05:

Q = 2.556MVar, R = 1.47825Ω, V = 0.75

$$\varphi = \frac{2x2.556x1.47825}{(0.75)^2} = 13.434$$

Bus 07:

Q = 1.887MVar, R = 1.6425Ω, V = 0.7

$$\varphi = \frac{2x1.887x1.6425}{(0.7)^2} = 12.651$$

Bus 08:

Q = 1.309MVar, R = 1.825Ω, V = 0.65

$$\varphi = \frac{2x1.309x1.825}{(0.65)^2} = 11.309$$

Bus 09:

Q = 0.933MVar, R = 2.0075Ω, V = 0.62

$$\varphi = \frac{2x0.933x2.0075}{(0.62)^2} = 9.745$$

Bus 10:

Q = 0.582MVar, R = 2.19Ω, V = 0.6

$$\varphi = \frac{2x0.582x2.19}{(0.6)^2} = 7.081$$

Bus 57:

Q = 0.34MVar, R = 2.28125Ω, V = 0.58

$$\varphi = \frac{2x0.34x2.28125}{(0.58)^2} = 4.611$$

Bus 020:

Q = 0.291MVar, R = 1.314Ω, V = 0.89

$$\varphi = \frac{2x0.291x1.314}{(0.89)^2} = 0.966$$

Bus 0012:

Q = 0.171MVar, R = 3.19375Ω, V = 0.89

$$\varphi = \frac{2x0.171x3.19375}{(0.89)^2} = 1.379$$

To determine the order at which these buses were chosen as candidate buses, the values of loss sensitivity factors for the nine buses were arranged and tabulated in descending order as shown in Table 3.25.

Table 3.25: Loss Sensitivity Factors of selected buses

S/N	BUS No.	ROUTE LENGTH (Km)	TOTAL ROUTE RESISTANCE (Ohms)	Q_{drawn} (Mvar)	VOLTAGE MAGNITUDE	LOSS SENSITIVITY FACTOR
1	05	8.1	1.47825	2.556	0.75	13.434
2	07	9.0	1.64250	1.887	0.70	12.651
3	08	10.0	1.82500	1.309	0.65	11.309
4	04	6.1	1.11325	3.276	0.81	11.072
5	09	11.0	2.00750	0.933	0.62	9.945
6	10	12.0	2.19000	0.582	0.60	7.081
7	57	12.5	2.28125	0.340	0.58	4.611
8	0012	17.5	3.19375	0.171	0.89	1.379
9	020	7.2	1.31400	0.291	0.89	0.966

3.5.2.2 Determining the optimal capacitor sizing using OCP module of ETAP 12.6 and mathematical calculation of determining the capacitance value of the capacitor.

Optimal Capacitor Placement (OCP) module in ETAP 12.6 was used to determine the optimal capacitor sizes (capacitor bank sizes) based on the earlier selected candidate buses. OCP module used during the design stage in sizing and positioning of the capacitor banks ensured that key objective function requirements like capacitor bank size, capacitor cost consideration in terms of actual capacitor cost/installation cost and capacitor position/location were satisfied during selection of the capacitors needed for compensation. This OCP module approach of capacitor placement ensured that voltage magnitudes and power factor of the load buses were improved while considering the load levels and cost of capacitor installation.

The Optimal Capacitor Placement results as presented in Tables 4.7 and 4.8 shows that for voltage improvement and power loss minimization in the network, the following capacitor bank sizes will be installed:

For Peak Period:

i. 1800KVar at bus 04.

ii. 300KVar at bus 05.

iii. 600KVar at buses 07, 08, 0012 and 020 respectively.

iv. 900KVar at buses 09 and 10 respectively.

v. 1500KVar at bus 57.

For Off-Peak Period:

i. 900KVar at bus 07.

ii. 300KVar at buses 08, 09 and 10 respectively.

The capacitance value of the capacitor used per phase for 1800KVar bank;

Line voltage (V_L) = 11KV

Phase voltage $V_{ph} = \frac{V_L}{\sqrt{3}}$ (Theraja B.L and Theraja A.K, 1994) (3.40)

$$V_{ph} = \frac{11}{\sqrt{3}}$$

$$= 6.35KV$$

The capacitive reactive power for the 3-lines or bus Q_c = 1800KVar

The capacitive reactive power per phase Q_{cph} = 1800/3 = 600Kvar

The relationship between capacitive reactance, reactive power and voltage is shown as:

$$Q_{cph} = \frac{(V_{ph})^2}{X_{cph}} \tag{3.41}$$

$$X_{cph} = \frac{(V_{ph})^2}{Q_{cph}}$$

$$X_{cph} = \frac{(6.35x10^3)^2}{600x10^3}$$

$$= 67.2\Omega$$

But, $C = \frac{1}{2\Pi f X_{cph}}$

$$C = \frac{1}{2\Pi x50x67.2}$$

$$= 0.0000474F = 47.4\mu F$$

Using the same approach, we calculate the capacitance value for 300KVar, 600KVar, 900KVar and 1500KVar capacitor banks.

For 300KVar bank, we have C = 7.9μF

For 600KVar bank, we have C = 15.8μF

For 900KVar bank, we have C = 23.7μF

For 1500KVar bank, we have C = 39.5μF

Power flow simulation in ETAP 12.6 for the New Bussa compensated network was also carried out for both peak and off-peak loading periods with the capacitor banks installed at their appropriate buses so as to determine the performance status of New Bussa distribution network after the compensation process. The power flow reports for the compensated network for both peak and off-peak periods were shown in Tables 4.9 and 4.10 while the summary of voltage magnitudes for load buses obtained from the compensated network for both peak and off-peak periods were shown in Tables 4.13 and 4.14. These power flow reports and generated data or summary of voltage magnitudes for load buses obtained from the compensated network for both peak and off-peak periods were presented and analyzed in chapter four to ascertain if the performance status (load bus voltage) of the compensated New Bussa network still violates the ANSI C84.1 acceptable voltage standard.

3.5.2.3 Mathematical model for an optimally placed and sized capacitor bank

The objective of optimal capacitor placement and sizing in the distribution system is to minimize the total annual cost of the system when subjected to certain operating constraints and load pattern. This minimization of the total annual cost of the system involves;

i. Minimizing the annual cost of power losses in the system.

ii. Minimizing the annual cost of capacitor bank installed in the system.

New Bussa network optimal capacitor placement and sizing cost can be modeled mathematically based on standard mathematical equation for optimal capacitor placement and sizing;

$$K_s = K^p P_{loss} + \sum_{n=1}^{M} (K_n^c Q_n^c + K_{fn}^c) \quad (3.42)$$

Where,

P_{loss} is the total power losses

K^{p} is the annual cost per unit of power losses (₦/KW)

K_{n}^{c} is the capacitor annual installation cost (₦/KVAR)

Q_{n}^{c} is the capacitor reactive power size placed at bus 'n'.

'M' is the number of candidate buses selected for capacitor placement.

K_{fn}^{c} is the fixed cost for the capacitor bank at bus 'n'.

To ensure that there is optimal capacitor placement in the New Bussa distribution network model; these operating constraints were ascertained to be satisfied:

i. Busbar voltage limits: Voltage magnitude at each bus was checked to ensure that its value is maintained within the standard voltage limits as shown below;

$$V_{min} < /V/ < V_{max} \qquad (3.43)$$

In radial distribution system, Vmin = 0.9 and Vmax = 1.06.

ii. Shunt capacitors limit

$$Q_{\max}^{c} \leq Q_{total} \qquad (3.44)$$

Where, $Q_{\max}^{c}$ is the largest capacitor size allowed and Q_{total} is the total reactive load demand.

iii. Line power flow limit

$$Flow_{m} < Flow_{m}^{max} \qquad (3.45)$$

Where $Flow_{m}$ is the power flow in the mth-line and $Flow_{m}^{max}$ is the maximum allowable power flow.

From the loss sensitivity factor calculation and optimal capacitor placement module (OCP module) in ETAP 12.6 software, nine (9) buses were determined and chosen as candidate buses for peak loading period and four (4) buses were chosen as candidate buses for off-peak loading period.

The New Bussa Distribution System optimal capacitor placement and sizing cost during peak loading period:

$$K_s = K^p P_{loss} + \sum_{n=1}^{M} (K_n^c Q_n^c + K_{fn}^c)$$

During peak loading period, the determined and chosen candidate buses are buses 4, 5, 7, 8, 9, 10, 0012, 020, 57;

$$Ks = K^p P_{loss} + [(K^c_4 Q^c_4 + K^c_5 Q^c_5 + K^c_7 Q^c_7 + K^c_8 Q^c_8 + K^c_9 Q^c_9 + K^c_{10} Q^c_{10} + K^c_{0012} Q^c_{0012} + K^c_{020} Q^c_{020} + K^c_{57} Q^c_{57}) + (K^c_{f4} + K^c_{f5} + K^c_{f7} + K^c_{f8} + K^c_{f9} + K^c_{f10} + K^c_{f0012} + K^c_{f020} + K^c_{f57}) \qquad (3.46)$$

Taking, Q^c_x = 300KVAR

Taking capacitor sizes from the generated values from power flow report (see Table 4.7);

Q^c_4 = 6 x 300KVAR = 6 x Q^c_x = 6 Q^c_x

Q^c_5 = 1 x 300VAR = Q^c_x

Q^c_7 = 2 x 300VAR = 2 x Q^c_x = 2 Q^c_x

Q^c_8 = 2 x 300KVAR = 2 x Q^c_x = 2 Q^c_x

Q^c_9 = 3 x 300KVAR = 3 x Q^c_x = 3 Q^c_x

$Q^{c}_{10} = 3 \text{ x } 300KVAR = 3 \text{ x } Q^{c}_{x} = 3\, Q^{c}_{x}$

$Q^{c}_{0012} = 2 \text{ x } 300KVAR = 2 \text{ x } Q^{c}_{x} = 2\, Q^{c}_{x}$

$Q^{c}_{020} = 2 \text{ x } 300KVAR = 2 \text{ x } Q^{c}_{x} = 2\, Q^{c}_{x}$

$Q^{c}_{57} = 5 \text{ x } 300KVAR = 5 \text{ x } Q^{c}_{x} = 5\, Q^{c}_{x}$

$$Ks = K^{p} P_{loss} + K^{c}_{4} (6\, Q^{c}_{x}) + K^{c}_{5} Q^{c}_{x} + K^{c}_{7} (2\, Q^{c}_{x}) + K^{c}_{8} (2\, Q^{c}_{x}) + K^{c}_{9} (3\, Q^{c}_{x}) + K^{c}_{10} (3\, Q^{c}_{x}) + K^{c}_{0012} (2\, Q^{c}_{x}) + K^{c}_{020} (2\, Q^{c}_{x}) + K^{c}_{57} (5\, Q^{c}_{x}) + (K^{c}_{f4} + K^{c}_{f5} + K^{c}_{f7} + K^{c}_{f8} + K^{c}_{f9} + K^{c}_{f10} + K^{c}_{f0012} + K^{c}_{f020} + K^{c}_{f57})$$

$$Ks = K^{p} P_{loss} + Q^{c}_{x}[(6\, K^{c}_{4}) + (K^{c}_{5}) + (2\, K^{c}_{7}) + (2\, K^{c}_{8}) + (3\, K^{c}_{9}) + (3\, K^{c}_{10}) + (2\, K^{c}_{0012}) + (2\, K^{c}_{020}) + (5\, K^{c}_{57}) + (K^{c}_{f4} + K^{c}_{f5} + K^{c}_{f7} + K^{c}_{f8} + K^{c}_{f9} + K^{c}_{f10} + K^{c}_{f0012} + K^{c}_{f020} + K^{c}_{f57})] \qquad (3.47)$$

$$Ks = K^{p} P_{loss} + 300[(6\, K^{c}_{4}) + (K^{c}_{5}) + (2\, K^{c}_{7}) + (2\, K^{c}_{8}) + (3\, K^{c}_{9}) + (3\, K^{c}_{10}) + (2\, K^{c}_{0012}) + (2\, K^{c}_{020}) + (5\, K^{c}_{57}) + (K^{c}_{f4} + K^{c}_{f5} + K^{c}_{f7} + K^{c}_{f8} + K^{c}_{f9} + K^{c}_{f10} + K^{c}_{f0012} + K^{c}_{f020} + K^{c}_{f57})]$$

The following constant values when determined assist in calculating the cost of the system optimal capacitor placement and sizing:

K^{c}_{4} is the annual installation cost of capacitor bank on bus 4

K^{c}_{5} is the annual installation cost of capacitor bank on bus 5

K^{c}_{7} is the annual installation cost of capacitor bank on bus 7

K^{c}_{8} is the annual installation cost of capacitor bank on bus 8

K^{c}_{9} is the annual installation cost of capacitor bank on bus 9

K^c_{10} is the annual installation cost of capacitor bank on bus 10

K^c_{0012} is the annual installation cost of capacitor bank on bus 0012

K^c_{020} is the annual installation cost of capacitor bank on bus 020

K^c_{57} is the annual installation cost of capacitor bank on bus 57

K^c_{f4} is the actual cost of capacitor bank installed on bus 4.

K^c_{f5} is the actual cost of capacitor bank installed on bus 5.

K^c_{f7} is the actual cost of capacitor bank installed on bus 7.

K^c_{f8} is the actual cost of capacitor bank installed on bus 8.

K^c_{f9} is the actual cost of capacitor bank installed on bus 9.

K^c_{f10} is the actual cost of capacitor bank installed on bus 10.

K^c_{f0012} is the actual cost of capacitor bank installed on bus 0012.

K^c_{f020} is the actual cost of capacitor bank installed on bus 020.

K^c_{f57} is the actual cost of capacitor bank installed on bus 57.

K^p is the cost of power loss.

P_{loss} is the total power loss.

$$Ks = K^pP_{loss} + 300[(6\ K^c_4) + (K^c_5) + (2\ K^c_7) + (2\ K^c_8) + (3\ K^c_9) + (3\ K^c_{10}) + (2\ K^c_{0012}) + (2\ K^c_{020}) + (5\ K^c_{57}) + (K^c_{f4} + K^c_{f5} + K^c_{f7} + K^c_{f8} + K^c_{f9} + K^c_{f10} + K^c_{f0012} + K^c_{f020} + K^c_{f57})] \quad (3.48)$$

3.6 Microcontroller-based Switching System

The switching of the compensators (capacitor banks) was developed to be an automated switching system so as to avoid over-compensation of the distribution line by the capacitor when compensation is not needed especially during the off-peak loading period of the network. This entails the need for a microcontroller-based switching system to switch on the capacitor banks only when they are needed to compensate the voltage on the distribution line.

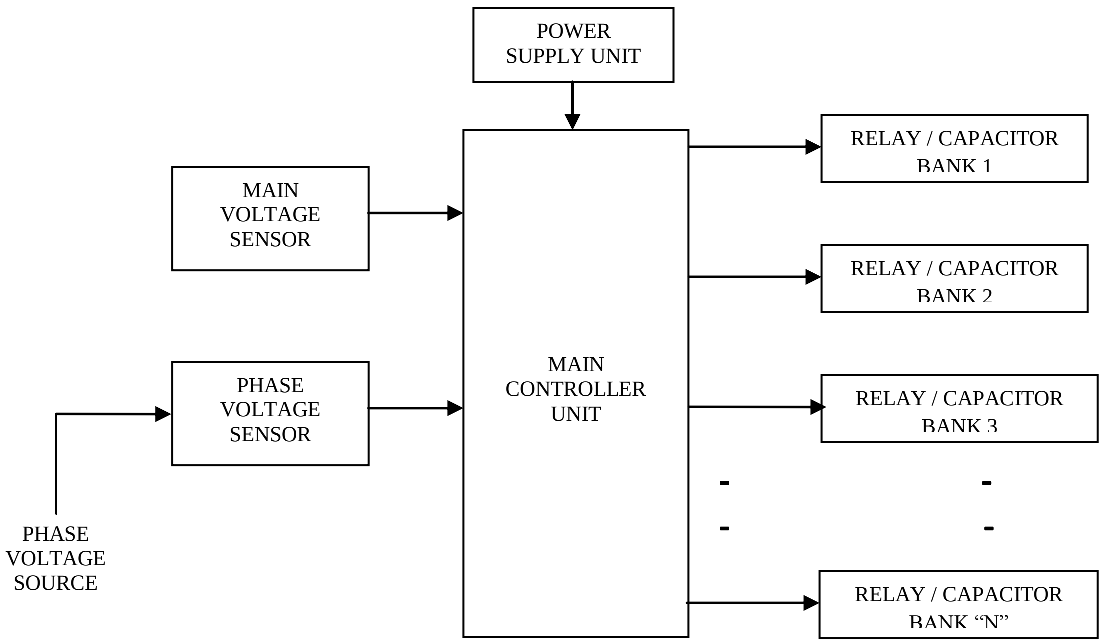

Figure 3.12: Block diagram of Microcontroller-based switching system

The Microcontroller-based switching system consists of:

i. Power supply unit

ii. Main controller unit (ATmega328P microcontroller)

iii. Voltage monitoring units that comprises of:

- Main voltage sensor
- Phase voltage sensors.

For simplicity, 3-phase voltages supplied to consumers were monitored by voltage monitoring units in the research work.

From the block diagram, the phase voltage sensors monitoring the voltage values of each of the three phases continuously samples the phase voltages and sends analog signals proportional to the phase voltage values to main controller unit through its inbuilt analog-to-digital converter (ADC) input ports. The main controller unit compares the individual phase voltage from the three phases with a reference voltage value so as to determine when to switch on the capacitor banks for voltage compensation. The microcontroller must first confirm the presence of real phase voltage through the analog signal it received from the main voltage sensor which signifies that the transformer is active/energized (transforming from high to low voltage) before considering switching for compensation process.

Again, as the voltage value increases due to the compensation action of the capacitor or during the off-peak period, and goes above the standard acceptable limit, the main controller unit switches off the capacitor banks in turn to prevent the capacitor banks from over-compensating the distribution line thus leading to over-voltage supply that will cause damage to power consumers' appliances.

3.6.1 Power supply unit

The 5VDC power supply used by the system is supplied by the 12VDC rechargeable battery, which is recharged by the rectifier circuit whenever the voltage goes down. The circuit diagram for the power supply unit is shown in Figure 3.13.

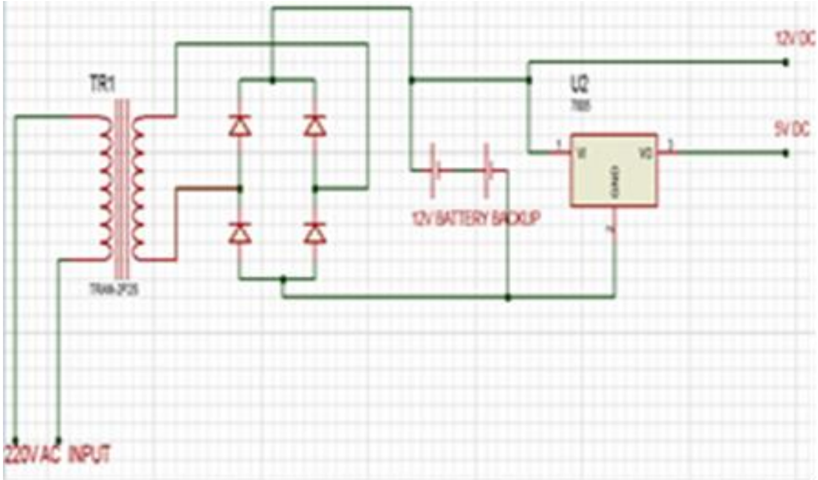

Figure 3.13: Power supply circuit diagram

3.6.1.1 Mathematical details in 5VDC power supply circuit

The power supply circuit comprises 220/12V, 300mA step down transformer, a bridge rectifier, 12VDC rechargeable battery, voltage regulator (7805). The 12VAC output of the transformer is rectified by a bridge arrangement of IN4007 diode to give and approximate DC voltage value;

12VDC – 1.2VDC = 10.8VDC.

1.2VDC drop is due to the conduction of the two sections of the diodes (silicon PN junction drops approximate 0.6V), since the two sections of diodes conducts at same time in bridge arrangement. The 7805 voltage regulator was used to regulate the voltage to 5VDC since the maximum input voltage required by the analog-to-digital converter (ADC) of the microcontroller is 5VDC.

3.6.2 Voltage monitoring circuit

The voltage monitoring unit is designed as a phase voltage sensor. In this research work, we used same type of voltage sensor, but they served different functions;

- Main Voltage Sensor: This voltage sensor always sends analog signal to the main controller unit indicating the presence of real or desired voltage value from the transformer (that is, if the transformer is active or energized). Its voltage input source is directly from the transformer 415/220volts side (voltage source point that connects to the low voltage fuse).

- Phase Voltage Sensor: This voltage sensor monitors the voltage values for each of the three phases. Its voltage input source is directly from the transformer low voltage fuse point.

These voltage sensors send analog signals proportional to the sensed phase voltage values to the main controller unit through its inbuilt analog-to-digital converter (ADC) input ports.

For simplicity in the research work, the loads at the three phases of the distribution lines were assumed to be balanced (equal voltage values in the three phases).

The voltage monitoring circuit is as shown in figure 3.14. It consists of a 415/12V step-down transformer, a bridge rectifier, a filter circuit formed by the combination of resistance and capacitor.

The output voltage of the rectifier and filter circuit served as input to a voltage divider network of resistors R1 and R2 as shown in signal conditioning circuit. The output of the voltage divider network which varied in proportion with the input phase voltage served as input to the ATmega328 microcontroller unit.

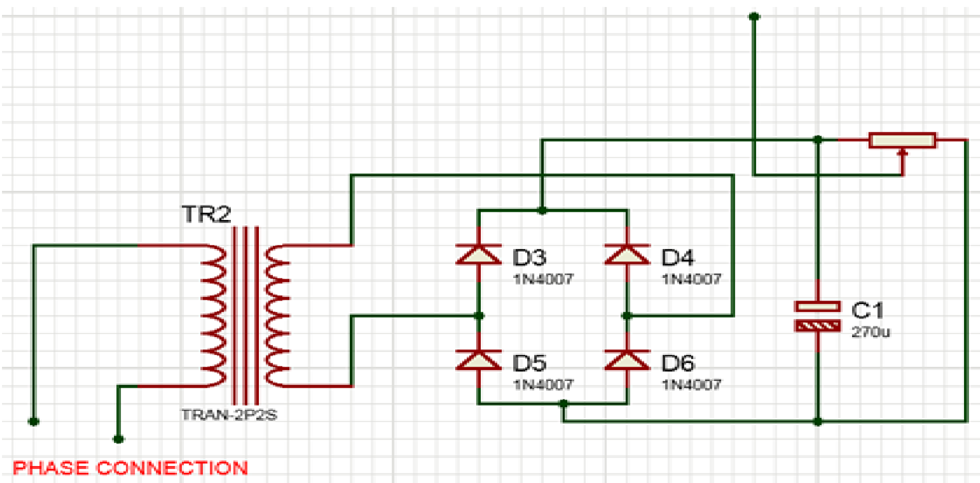

Figure 3.14: Voltage monitoring circuit diagram

3.6.2.1 Mathematical details in voltage monitoring circuit

The circuit diagram for the voltage monitoring unit was developed as a voltage sensor that senses voltages and sends an analog signal indicating the voltage value to the microcontroller. The transformer used is a centre tap 415/12V step down transformer. The transformer brings down the 415V to 12V when we use any of the secondary taps with respect to the centre tap. The 12VAC output of the transformer is rectified by a bridge arrangement of IN4007 diode to give and approximate DC voltage value;

12VDC – 1.2VDC = 10.8VDC.

1.2VDC drop is due to the conduction of the two sections of the diodes (silicon PN junction drops approximate 0.6V), since the two sections of diodes conducts at same time in bridge arrangement.

A filter capacitor is introduced to filter off the ripples. The size of the capacitor is given by;

$$C_x = \frac{I_{load}}{f * V_{ripples}} \quad \text{for full wave bridge rectification.}$$

The practice is to try and keep $V_{ripples}$ to 100mV and below.

$$I_{load} = \frac{V}{R_L} = \frac{10.8}{10*10^3} = 1.08 \text{ x } 10^{-3}\text{A}$$

$$C_x = \frac{1.08x10^{-3}}{50x100x10^{-3}} = 0.000216\text{F}$$

$$= 216\mu\text{F}$$

This is the minimum capacitance of the capacitor required.

To get better performance, 1000µF was used which was experimentally selected.

But the sensed voltage (V_{sensor}) must be kept at 5VDC maximum, thus, there was need for a simple signal conditioning circuit as shown in the figure 3.15.

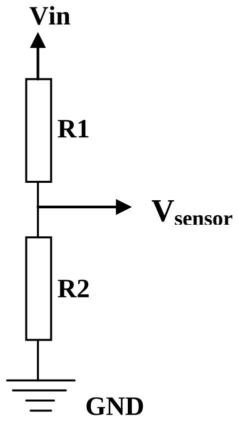

Figure 3.15: Signal conditioning circuit (Voltage divider network)

Note;

- V_{in} - The output voltage of the voltage sensor circuitry.
- V_{sensor} - The conditioned signal.
- R_1 and R_2 are conditioning resistances.

In this research work, a variable resistor of 10kΩ was used instead of the above signal conditioning circuitry.

From voltage division principle;

$$V_{sensor} = \frac{(R_2 x V_{in})}{(R_1 + R_2)} \qquad (3.49)$$

But R_1+R_2 =10kΩ, since we are using a 10kΩ variable resistor.

Then,

V_{in} = 12VDC

V_{sensor} = 5VDC

We calculated the value of R_2, which was the resistance value the variable resistor was tuned to and it gave the maximum voltage of 5VDC.

$$R_2 = \frac{(R_1 + R_2) x V_{sensor}}{V_{in}} \qquad (3.50)$$

$$R_2 = \frac{10x10^3 x5}{12}$$

R_2 =50000/12 = 4.167kΩ

Practically, we had two considerations that we made, it was either we use a 10kΩ variable resistor and tune it to get 4.167kΩ or we use two fixed resistors of 5.833kΩ and 4.167kΩ to condition the V_{sensor} to 5VDC, which is the maximum the microcontroller ADC could take.

Ideally, the variable resistor should not be tuned to the maximum and to be on the safe side, we used 4VDC and calibrated to get exactly that value.

3.6.2.2 Mathematical details used for the centre tap 415/12V Transformer

Applying simple transformer formular,

$$\frac{E_s}{E_p} = \frac{N_s}{N_p} \tag{3.51}$$

Where;

E_s - Secondary voltage

E_p - Primary voltage

N_s - Number of turns in secondary winding

N_p - Number of turns in primary winding

E_s = 415V

E_p = 24V

N_p = 22.5 turns

$$N_S = \frac{E_S x N_P}{E_P}$$

$$N_S = \frac{415x22.5}{24} = 389 \text{ turns}$$

The cross sectional area of the copper coil used was determined by the ratio of primary to secondary current.

Primary current $I_P = \frac{VA}{Eff * V_P}$ (3.52)

Where,

VA = Apparent power rating of the transformer

Eff = Efficiency

V_p = Primary voltage

$$I_P = \frac{1000VA}{0.95 * 415V} = 2.536\text{A}$$

Secondary current $I_S = \frac{VA}{V_S} = \frac{1000VA}{24V} = 41.66\text{A}$

The ratio of primary and secondary current is given as;

$$\frac{I_S}{I_P} = \frac{41.66}{2.536} = 16.42$$

This is called the copper current density. This value corresponds to 3.31mm^2 gauge copper wire cross sectional area required for the winding.

3.6.3 Main controller unit

The main controller unit used was ATmega328 microcontroller. The operating principle of the research work has it that the microcontroller must first confirm that the monitored transformer is energized, through the signal the controller received from the main voltage sensor before considering switching process for voltage compensation. The microcontroller then compares signals from the three phase voltage sensors (which is proportional to the voltage value on each of the phases) with reference voltage and then sends a control signal to the required relay to either switch on or switch off the capacitor bank depending on the voltage values received from the phase voltage sensors. The ATmega328 microcontroller pin-out diagram is shown in Figure 3.16. As shown in the research work, the microcontroller switches on the capacitor bank when the input voltage value received from the phase voltage sensors goes below the lower limit in the standard service voltage range stated by ANSI C84.1 which is 90% $\leq$ V $\leq$ 106% of the nominal voltage value (that is when the percentage voltage drop on the line is more than 10% of the nominal voltage value). The microcontroller sends signal to the LCD which displays the actual phase voltage value on the line before and after voltage compensation process.

The instruction set for the ATmega328 microcontroller was written in C++ language and shown in Appendix 10.

Figure 3.16: The Pin-out of ATmega328P microcontroller (Nasir, 2017)

3.6.4 Liquid crystal display (LCD)

The LCD displays the actual voltage values on the monitored lines. It displays phase voltage values before and after the voltage compensation process.

These displayed data avail the maintenance team with prompt, quick information about the quality of power that is always supplied to consumers and presents the performance status of the network. These facts assist maintenance team in their regular routine and maintenance checks in the network.

3.6.5 The developed microcontroller-based switching system

The operating principle of microcontroller-based switching system as developed in Figure 3.17 has it that the phase voltage sensors continuously monitor the phase voltages on the three phases of the distribution line and each of them sends analog signal which is proportional to the sensed phase voltage to the microcontroller. The main voltage sensor continuously monitors the presence of desired or real voltage supply from the transformer and sends the analog signal which is proportional to the sensed voltage to the microcontroller. The microcontroller, ATmega328P type continuously receives analog signals from the main voltage and phase voltage sensors. The controller at first confirms that the transformer that supplies power to consumers is active (energized) through the signal received from the main voltage sensor. It also compares the phase voltage values received from the three phase voltage sensors with a reference voltage and then sends a control signal to the required relay to either switch on or switch off the capacitor bank depending on the voltage value received from the phase voltage sensors. The system was developed in a way that before the microcontroller sends a switching signal to the relay for switching of the capacitor bank, it must first confirm that the distribution transformer is active (energized). The microcontroller switches on the capacitor bank when the voltage value received from the phase voltage sensors goes below the lower limit in the standard service voltage range as stated by ANSI C84.1 which is $90\% \leq V \leq 106\%$ of the nominal voltage value (that is when the percentage voltage drop on the line is more than 10% of the nominal value). Considering the ETAP 12.6 load flow report for the load buses in New Bussa distribution network, the capacitor bank is switched on when the bus phase voltage value drops below 216V. Thus the standard acceptable phase voltage range with reference to ANSI C84.1 is between 216V and 255V.

The instruction set for the ATmega328P microcontroller is written in C++ language and shown in Appendix 10.

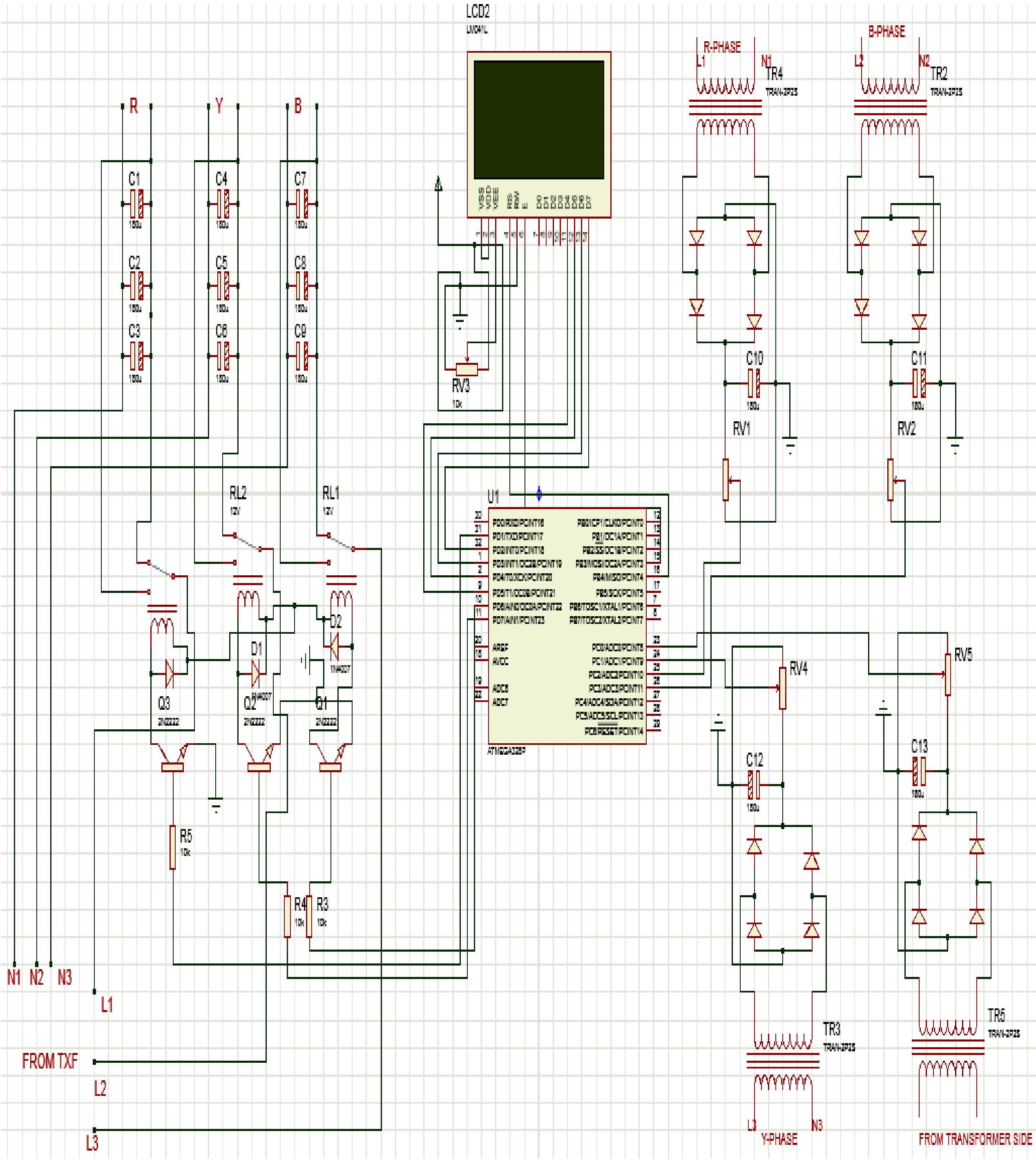

Figure 3.17: Circuit diagram of microcontroller-based switching system

3.6.5.1 *Mathematical details in capacitor switching system*

$I_e = I_b + I_c$ (Kirchhoff's current law – KCL)

Also, $I_c = hfe * I_b$

Where, hfe = Transistor gain

$I_c = 150mA$ (From transistor datasheet)

hfe = 200

Therefore, $I_b = \frac{I_c}{hfe} = \frac{150x10^{-3}}{200}$ = 0.75 x 10^{-3}A

$I_b = 0.75mA$

But from Kirchhoff's voltage law (KVL),

$V_{in} = I_b R_b + V_{be}$

$R_b = \frac{V_{in} - V_{be}}{I_b}$

Where,

V_{be} = 0.7V (For Silicon)

V_{in} = 5V (Output of the Controller pin)

$R_b = \frac{5 - 0.7}{0.75x10^{-3}}$ = 5.733 x $10^3\Omega$

$R_b = 5.733k\Omega$

Thus, $R_b = 5.6k\Omega$ is readily available.

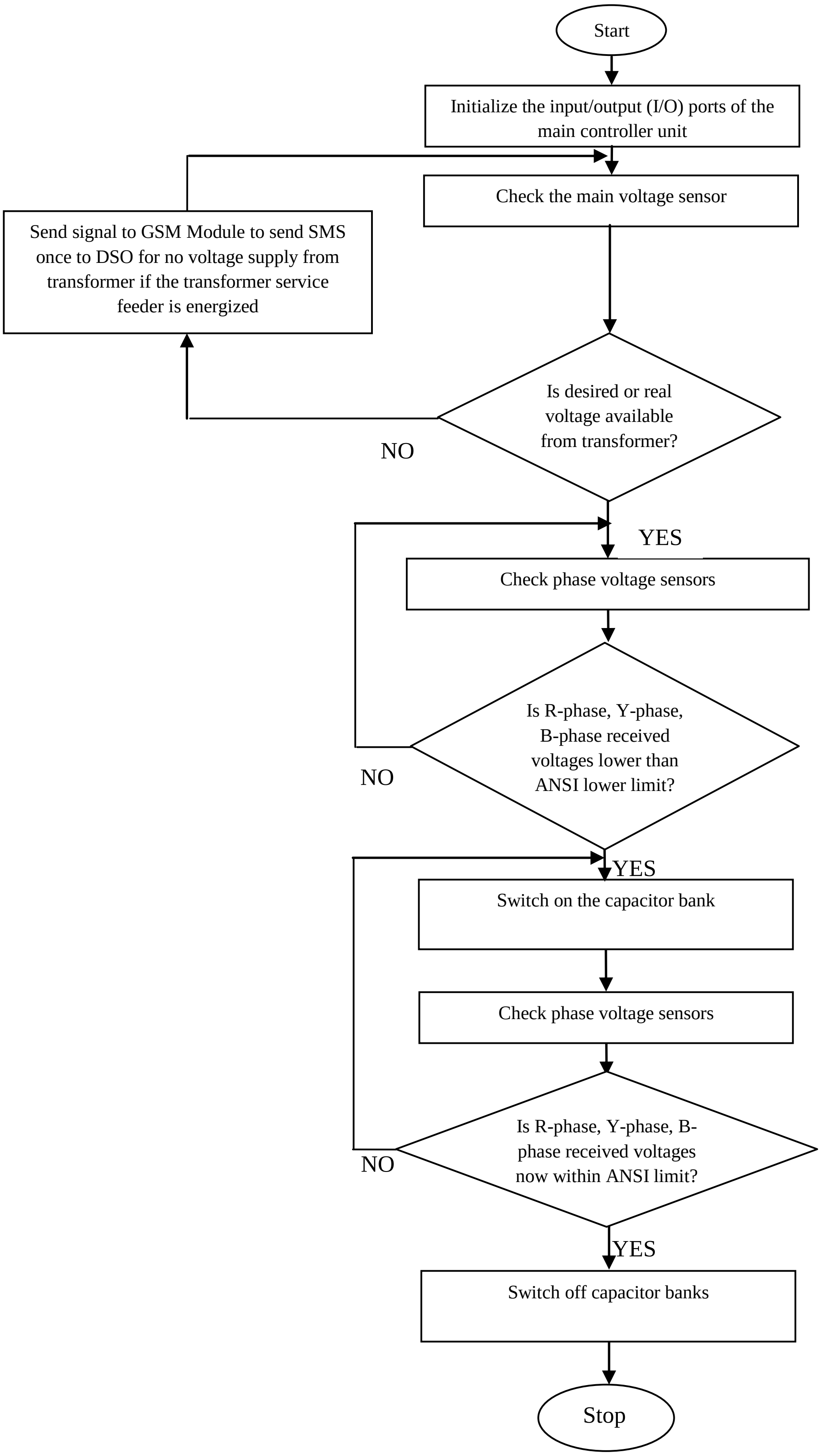

Figure 3.18: Flow chat for Microcontroller-based switching system

3.7 GSM-based Monitoring and Reporting System

This system involves development of an automated monitoring and reporting device that reports the following issues about distribution transformers within the network to the Distribution System Operator (DSO):

- Loss of transformer phase as a result of blown low voltage fuse of that particular phase.
- Over-voltage supply from the transformer caused by the transformer low voltage neutral failure.
- No voltage supply from the transformer as a result of the transformer's trip on fault despite the transformer's service feeder still active or energized.

The absence of this automated transformer phase monitoring device in Nigeria, which monitors and reports blown low voltage fuse to the system operator entails that often distribution transformers in rural or remote areas have their blown low voltage fuses or the particular phases remain open for a long period of time without the prompt knowledge of the power providers, thereby affecting the availability of power to consumers and also quality of voltage supplied to the three (3) phase power consumers in the network. Since availability of power to consumers and quality voltage supply are part of key performance indicators that determine the performance of distribution network, development and installation of this GSM-based transformer monitoring device in the network, leads to a quicker means of restoring power whenever there is issue of blown fuse, transformer neutral failure and transformer trip thus improving the number of hours power is available to consumers and quality of voltage supply to consumers, thus enhancing the performance of power distribution network.

This transformer phase monitoring system consists of the following:

i. Power supply unit
ii. Blown fuse detector units
iii. Main phase voltage sensor
iv. Main controller unit
v. GSM modem
vi. LCD unit

For simplicity, the block diagram shown is for system that can only monitor one distribution transformer.

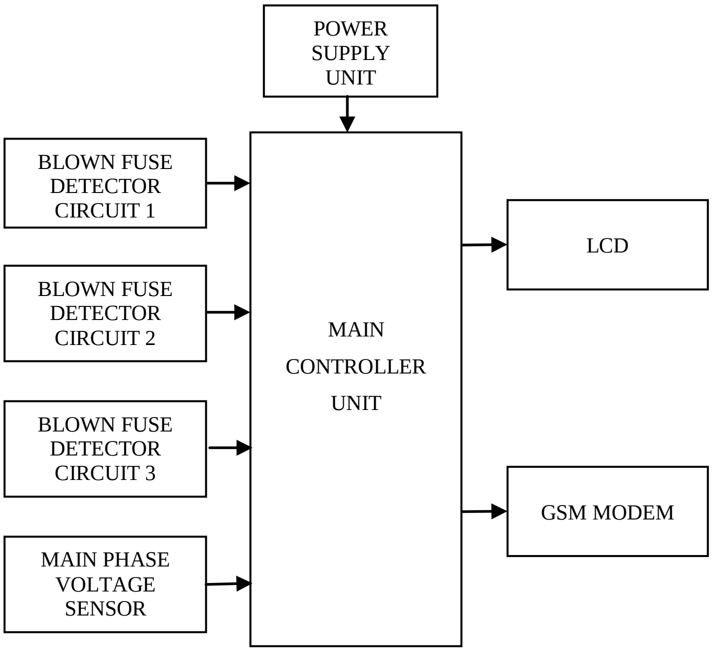

Figure 3.19: Block diagram of a GSM-based monitoring system

3.7.1 Power supply unit

The 5VDC power supply used by the system is supplied by the 12VDC rechargeable battery, which is recharged by the rectifier circuit whenever the voltage goes down. The circuit diagram for the power supply unit is shown in Figure 3.20.

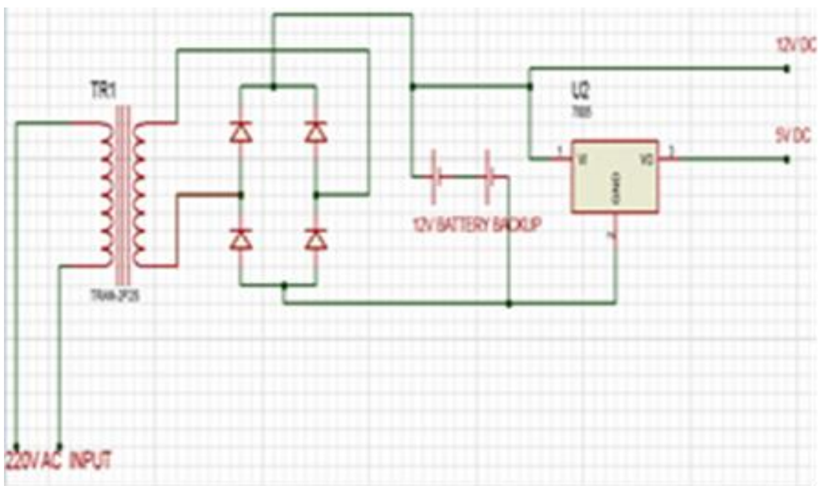

Figure 3.20: Power supply circuit diagram

3.7.1.1 Mathematical details in 5VDC power supply circuit

The power supply circuit comprises 220/12V, 300mA step down transformer, a bridge rectifier, 12VDC rechargeable battery, voltage regulator (7805). The 12VAC output of the transformer is rectified by a bridge arrangement of IN4007 diode to give and approximate DC voltage value;

12VDC – 1.2VDC = 10.8VDC.

1.2VDC drop is due to the conduction of the two sections of the diodes (silicon PN junction drops approximate 0.6V), since the two sections of diodes conducts at same time in bridge arrangement. The 7805 voltage regulator was used to regulate the voltage to 5VDC since the maximum input voltage required by the analog-to-digital converter (ADC) of the microcontroller is 5VDC.

3.7.2 Blown fuse detector unit

The blown fuse detector unit in this system is a voltage sensor that monitors the status of the transformer low voltage fuses. Its input terminals are connected across the low voltage fuse at each of the three phases of the low voltage side of the distribution transformer. The blown fuse detector unit monitors the phase voltage value and when it senses a normal phase voltage value across the fuse; it sends an analog voltage signal (5V) or digital signal (HIGH) to the microcontroller, indicating that the fuse is still intact. When it senses a no voltage value (no voltage) across the fuse, it sends an analog voltage signal (0V) or digital signal (LOW) to the microcontroller, indicating that the fuse is blown. The blown fuse detector unit is shown in figure 3.21. It comprises a 415/12V transformer, bridge rectifier, paper capacitor, and a potentiometer.

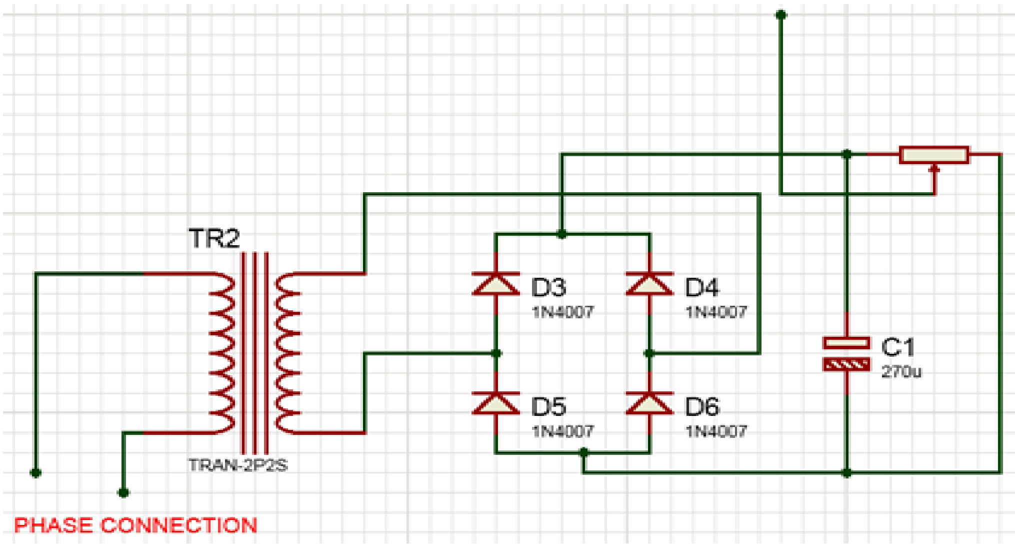

Figure 3.21: Blown Fuse Detector circuit diagram

3.7.2.1 Mathematical details in voltage monitoring circuit

The circuit diagram for the voltage monitoring unit was developed as a voltage sensor that senses voltages and sends an analog signal indicating the voltage value to the microcontroller. The transformer used is a centre tap 415/12V step down transformer. The design transformer brings down the 415V to 12V when we use any of the secondary taps with respect to the centre tap. The 12VAC output of the transformer is rectified by a bridge arrangement of IN4007 diode to give and approximate DC voltage value;

12VDC – 1.2VDC = 10.8VDC.

1.2VDC drop is due to the conduction of the two sections of the diodes (silicon PN junction drops approximate 0.6V), since the two sections of diodes conducts at same time in bridge arrangement.

A filter capacitor is introduced to filter off the ripples. The size of the capacitor is given by;

$$C_x = \frac{I_{load}}{f * V_{ripples}} \quad \text{for full wave bridge rectification.} \qquad (3.53)$$

The practice is to try and keep $V_{ripples}$ to 100mV and below.

$$I_{load} = \frac{V}{R_L} = \frac{10.8}{10*10^3} = 1.08 \text{ x } 10^{-3}\text{A}$$

$$C_x = \frac{1.08x10^{-3}}{50x100x10^{-3}} = 0.000216\text{F}$$

$$= 216\mu\text{F}$$

This is the minimum capacitance of the capacitor required.

To get better performance, 1000µF was used which was experimentally selected.

But the sensed voltage (V_{sensor}) must be kept at 5VDC maximum, thus, there was need for a simple signal conditioning circuit as shown in the figure 3.5a.

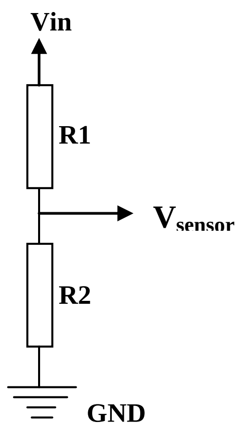

Figure 3.22: Signal conditioning circuit (Voltage divider network)

Note;

- V_{in} - The output voltage of the voltage sensor circuitry.
- V_{sensor} - The conditioned signal.
- R_1 and R_2 are conditioning resistances.

In this research work, a variable resistor of 10kΩ was used instead of the above signal conditioning circuitry.

From voltage division principle;

$$V_{sensor} = \frac{(R_2 x V_{in})}{(R_1 + R_2)} \quad (3.54)$$

But R_1+R_2 =10kΩ, since we are using a 10kΩ variable resistor.

Then,

V_{in} = 12VDC

V_{sensor} = 5VDC

We calculated the value of R_2, which was the resistance value the variable resistor was tuned to and it gave the maximum voltage of 5VDC.

$$R_2 = \frac{(R_1 + R_2) x V_{sensor}}{V_{in}} \quad (3.55)$$

$$R_2 = \frac{10x10^3 x5}{12}$$

R_2 =50000/12 = 4.167kΩ

Practically, we had two considerations that we made, it was either we use a 10kΩ variable resistor and tune it to get 4.167kΩ or we use two fixed resistors of 5.833kΩ and 4.167kΩ to condition the V_{sensor} to 5VDC, which is the maximum the microcontroller ADC could take.

Ideally, the variable resistor should not be tuned to the maximum and to be on the safe side, we used 4VDC and calibrated to get exactly that value.

3.7.2.2 Mathematical details used for the centre tap 415/12V Transformer

Applying simple transformer formular,

$$\frac{E_s}{E_p} = \frac{N_s}{N_p} \quad (3.56)$$

Where;

E_s - Secondary voltage

E_p - Primary voltage

N_s - Number of turns in secondary winding

N_p - Number of turns in primary winding

E_s = 415V

E_p = 24V

N_p = 22.5 turns

$$N_S = \frac{E_S x N_P}{E_P}$$

$$N_S = \frac{415x22.5}{24} = 389 \text{ turns}$$

The cross sectional area of the copper coil used was determined by the ratio of primary to secondary current.

Primary current $I_P = \frac{VA}{Eff * V_P}$ (3.57)

Where,

VA = Apparent power rating of the transformer

Eff = Efficiency

V_p = Primary voltage

$$I_P = \frac{1000VA}{0.95 * 415V} = 2.536\text{A}$$

Secondary current $I_S = \frac{VA}{V_S} = \frac{1000VA}{24V} = 41.66\text{A}$

The ratio of primary and secondary current is given as;

$$\frac{I_S}{I_P} = \frac{41.66}{2.536} = 16.42$$

This is called the copper current density. This value corresponds to 3.31mm^2 gauge copper wire cross sectional area required for the winding.

3.7.3 Main controller unit

The main controller unit is the ATmega328P microcontroller. It receives and analyzes analog signals from blown fuse detector units and main phase voltage sensor connected at transformer low voltage side through its analog-to-digital converter (ADC) input ports. When the microcontroller receives a no voltage analog signal (0V) or digital signal (LOW) from both the blown fuse detector unit and main phase voltage sensor, it sends two signals simultaneously to the LCD and GSM module. LCD displays “Black out”, signifying that there is no voltage supply from the transformer and the one to the GSM module prompted the module to further send an SMS to the Distribution System Operator (DSO) that reads “Black out detected at transformer A” indicating that the transformer A is not energized. In a case when the microcontroller receives a normal voltage (5V) analog signal from both the blown fuse detector unit and main phase voltage sensor, it sends a signal to the LCD that displays “FUSE ACTIVE” on the LCD, signifying that the fuse is still intact. In another case when the microcontroller receives normal voltage (5V) analog signal from the main phase voltage sensor and a no voltage (0V) analog signal from the blown fuse detector unit, it sends two signals simultaneously; the first one to the LCD that displays “FUSE BLOWN” on the LCD, signifying that the fuse is blown while there is real voltage supply from the transformer and the second signal, to the GSM module for onward sending of SMS to the Distribution System Operator (DSO) indicating that the fuse is blown.

Also, the microcontroller continuously compares the voltage values received from the fuse detector units for the three phases with the standard maximum voltage limit as stated by ANSI

C84.1 and whenever the received voltage value exceeds the maximum voltage limit due to transformer neutral failure, the microcontroller sends signal to both GSM Module and LCD unit for onward transmission of SMS to the DSO and display of over-voltage value on the LCD unit. The ATmega328P is a microcontroller chip that is used on Arduino Uno boards.

Table 3.26: Digital Explanation of the role of microcontroller using logic table.

Blown Fuse Detector	Main Phase Voltage Sensor	Result	Comment
0	0	0	Transformer is OFF
0	1	0	Fuse blown
1	0	0	Practically does not exist
1	1	1	Fuse is ACTIVE

3.7.4 GSM module (SIM900D)

The GSM module used is SIM900D component and it receives three signals from the main controller unit. The particular signal that signifies that the monitored transformer is not energized prompts the module to send a pre-programmed SMS to Distribution System Operator that reads “Black out”. The second signal signifying a blown fuse, prompts the GSM module to send a pre-programmed SMS to the Distribution System Operator that reads “fuse blown detected at red phase (Rph) of transformer A, urgent attention needed”. The third signal indicating over-voltage supply due to transformer neutral failure, prompts the GSM Modem to send a pre-programmed SMS to DSO that reads “High voltage fault detected in red phase (Rph) of transformer A, urgent attention needed; Possible neutral failure”. This over-voltage SMS alert prompts the DSO to immediately isolate the affected transformer for quick repair and restoration of quality power supply to consumers from that transformer.

3.7.6 The developed GSM-based distribution transformer phase monitoring and reporting system

The operating principle of distribution transformer phase monitoring and reporting system as shown in circuit diagram of Figure 3.23 and explained using a flow chart in Figure 3.24 involves an automated mode of informing the Distribution System Operator (DSO) about some issues that affect the efficient performance of distribution network through SMS from GSM. The reported issues are lost phase of transformer resulting from blown low voltage fuse, over-voltage supply from the transformer due to the transformer low voltage neutral failure, and no voltage supply from the transformer as a result of the transformer trip on fault despite the affected transformer's service feeder still active or energized. The blown fuse detector unit monitors the low voltage fuses in each of the phases. When a fuse is blown, the detector circuit sends a no voltage (0V) analog signal to the microcontroller, who also analyzes the analog signal received from the main phase voltage sensor to ascertain if there is a real voltage supply from the transformer (if the transformer is active). Whenever the microcontroller receives a normal voltage (5V) analog signal from the main phase voltage sensor and a no voltage (0V) analog signal from the blown fuse detector unit, it sends two signals simultaneously; the first one to the LCD that displays "FUSE BLOWN" on the LCD, signifying that the fuse is blown while there is voltage supply from the transformer and the second signal, to the GSM modem for onward SMS to the Distribution system operator indicating that the fuse is blown. Also, when the microcontroller receives a no voltage (0V) analog signal from both the blown fuse detector unit and main phase voltage sensor, it sends two signals simultaneously; the first signal that goes to the LCD displays "Black out" on the LCD, signifying that the transformer is not energized and the second signal, goes to the GSM modem for onward SMS to the Distribution system operator indicating that the transformer is not energized or tripped on fault.

The microcontroller continuously compares the voltage values received from the fuse detector units for the three phases with the standard maximum voltage limit as stated by ANSI C84.1 and whenever the received voltage value exceeds the maximum voltage limit due to transformer neutral failure, the microcontroller sends signal to both GSM Modem and LCD unit for onward transmission of SMS to the DSO alerting him about the over-voltage supply and display of the over-voltage value on the LCD unit.

The LCD displays “FUSE BLOWN” at the monitored and affected transformer that had blown fuse. It displays “Black out” at the monitored transformer side, when the transformer trips on fault and is not supplying power. It also displays the over-voltage value at the transformer side whenever the transformer had low voltage neutral failure as explained using the flow chart in Figure 3.25.

The circuit diagram that explained the combine operation of the microcontroller-based switching system and GSM-based monitoring system is shown in Figure 3.26.

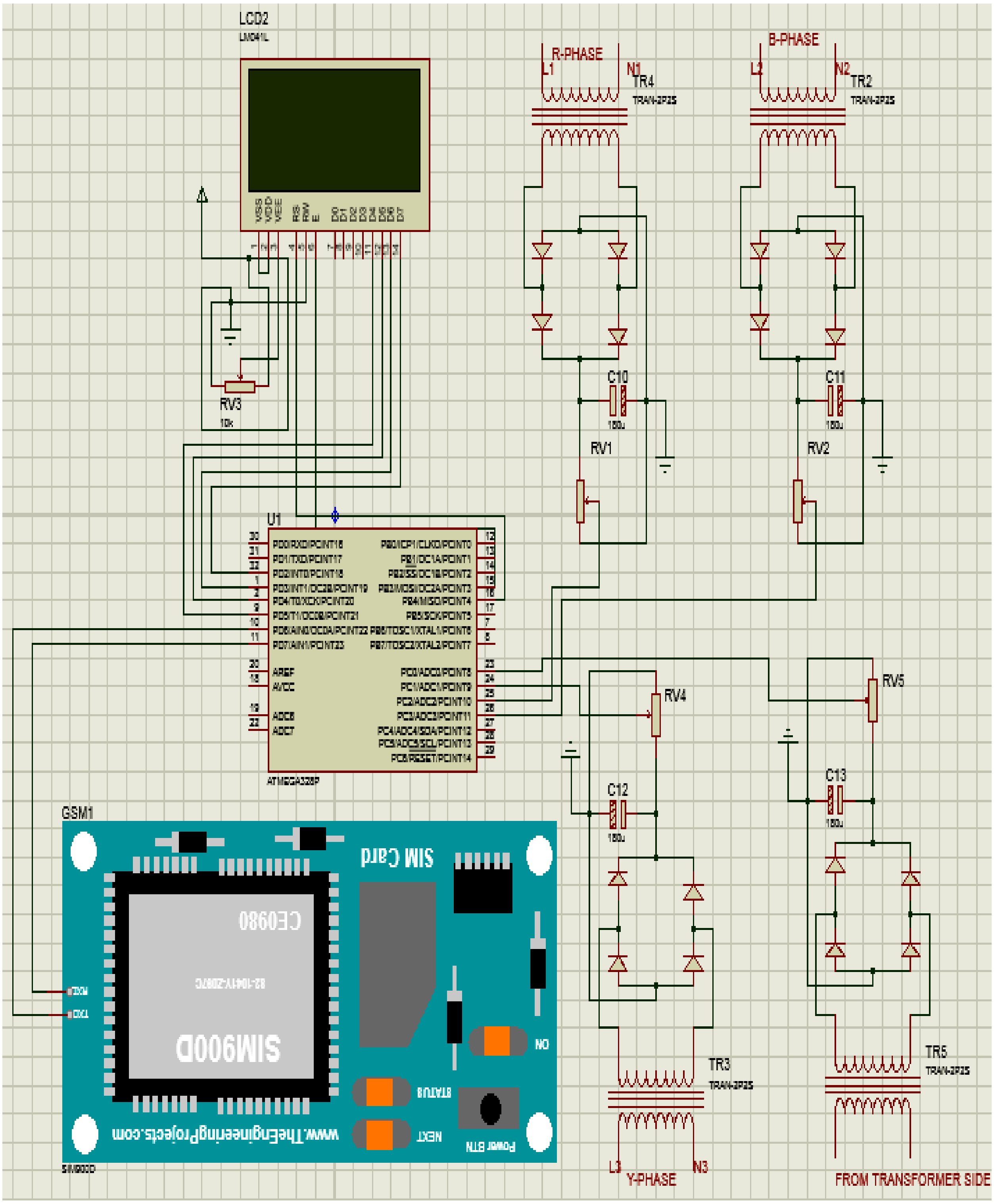

Figure 3.23: Circuit diagram of a GSM-based monitoring system

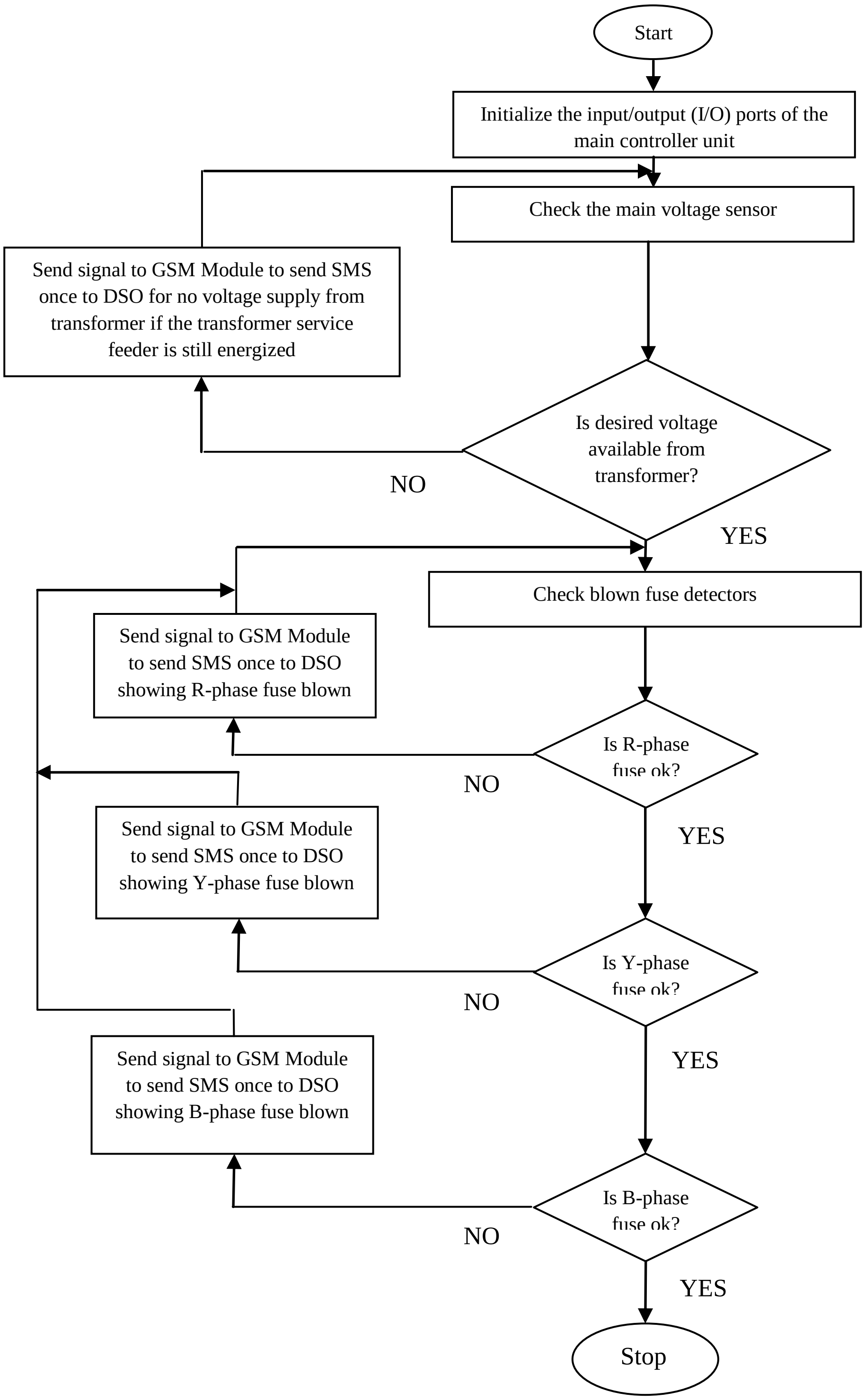

Figure 3.24: Flowchart of Distribution transformer blown low voltage fuse/phase monitoring system using GSM technology

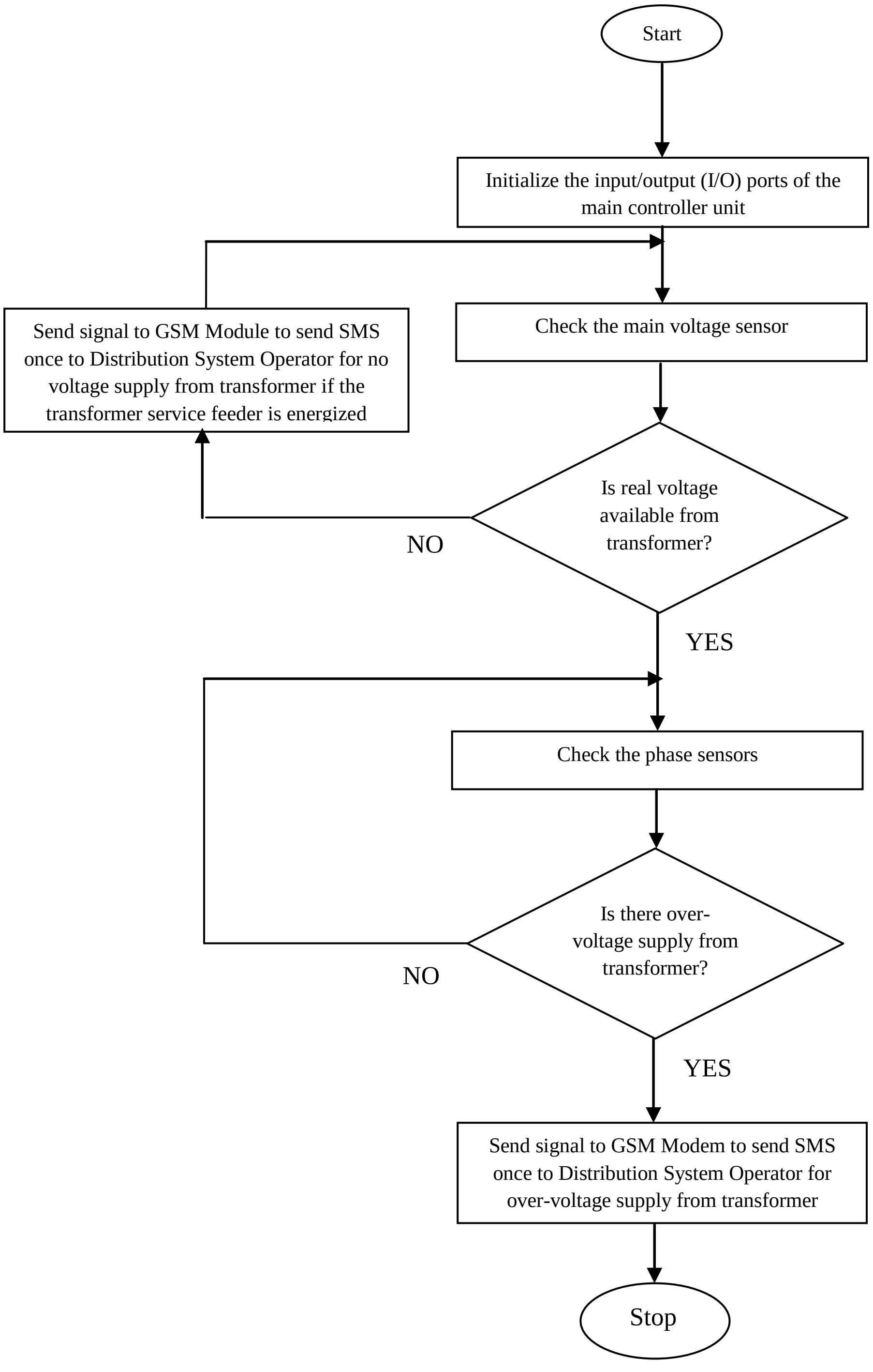

Figure 3.25: Flowchart of Distribution transformer low voltage neutral failure monitoring system using GSM technology

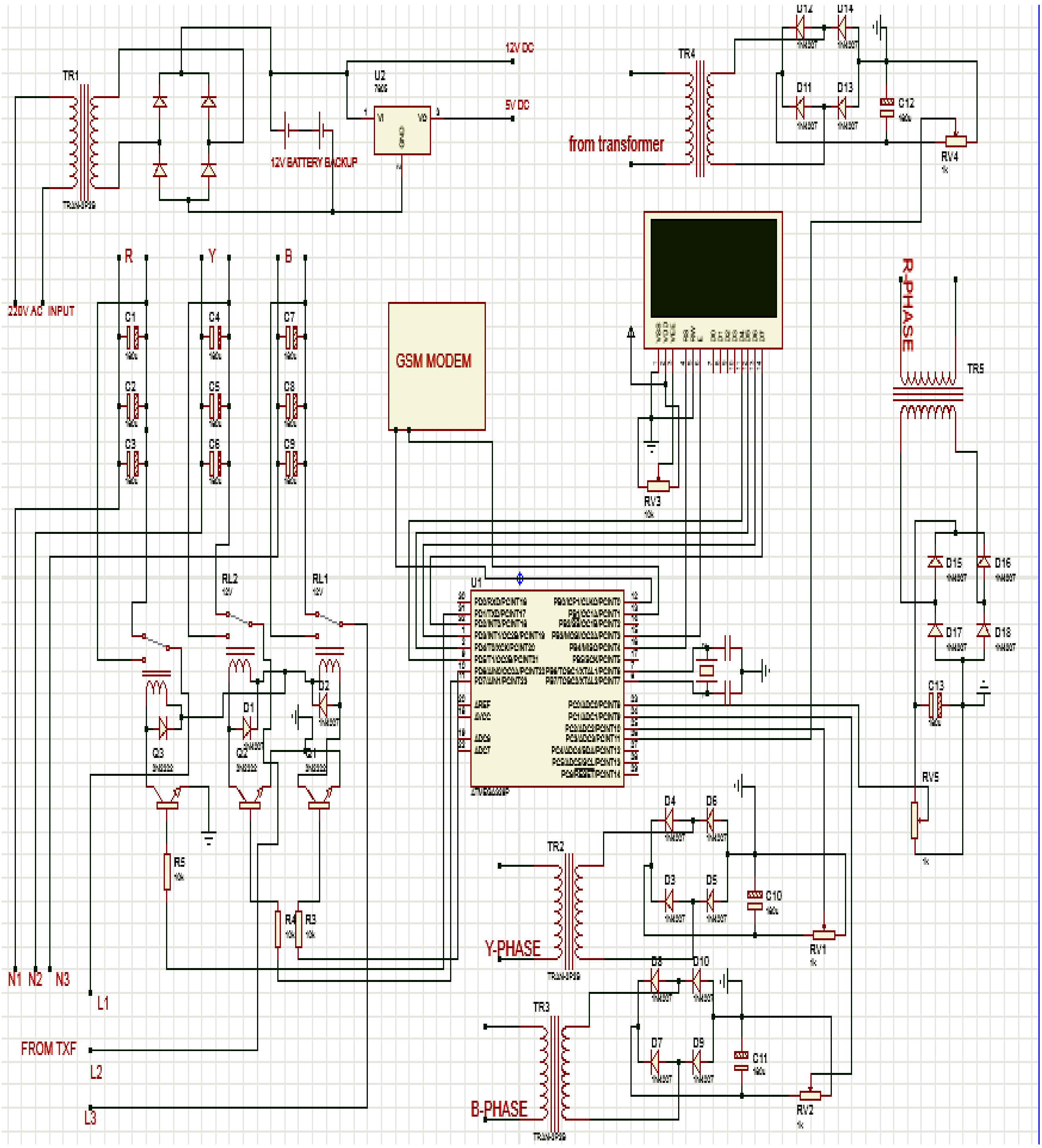

Figure 3.26: Circuit diagram of Microcontroller-based Switching System and GSM-based Monitoring System

CHAPTER FOUR

DATA PRESENTATION AND RESULT ANALYSIS

4.1 Analyzing Hourly Load Profile of New Bussa Distribution Network

Critical study carried out on Tables 3.1 through 3.21 and bar charts of Figures 3.5 through 3.11 in chapter 3 for daily hourly load readings from the three feeders shows the following:

i. Load profiles for the three feeders (Sabo, Senior Camp and Township feeders) have similar shapes irrespective of the day of the week thereby leading to an assertion that loading of the feeder is a function of time of the day and not a function of day of the week.

ii. Senior Camp feeder had the greatest load on the network, followed by the Township feeder and finally the Sabo feeder with the least load.

iii. The peak loading period occurred within same period of time for the three feeders and for each day of the week. The peak period is between 5:00 (5:00a.m) to 8:00 (8:00a.m) and between 18:00 (6:00p.m) to 21:00 (9:00p.m), with the greatest load occurring at 20.00 (8:00p.m) every day while other times within the following ranges of time; 1:00 (1:00a.m) to 4:59 (4:59a.m), 8:01 (8:01a.m) to 17.59 (5:59p.m), 21:01 (9:01p.m) to 24.59 (12:59a.m) are referred to as off-peak periods.

4.2 Load Flow Reports for New Bussa Base (Initial) Distribution Network

As earlier mentioned in chapter 3, New Bussa distribution network was modeled using the empirical data listed in Tables 3.22, 3.23 and 3.24, imputed and simulated in ETAP 12.6 software so as to generate the load flow reports for New Bussa network during both peak and off-peak loading periods and thus characterize New Bussa distribution network. Looking at the New Bussa network model (the single line diagram of New Bussa distribution network) as shown below in Figure 4.1, we have one hundred and three (103) load buses (buses that have loads directly connected to them), one hundred and four non-load buses (buses with no load directly connected to them) and the 33KV bus that serves as the swing bus.

The load flow reports generated from the evaluation of the New Bussa network model are shown in Tables 4.1, 4.2 and the branch power losses summary reports, are also shown in Tables 4.3 and 4.4 for peak and off-peak periods of the network respectively. These reports show the real-time bus voltage values (percentage voltage magnitude of each of the load buses), branch power losses, and power flow in the New Bussa base (initial) distribution network.

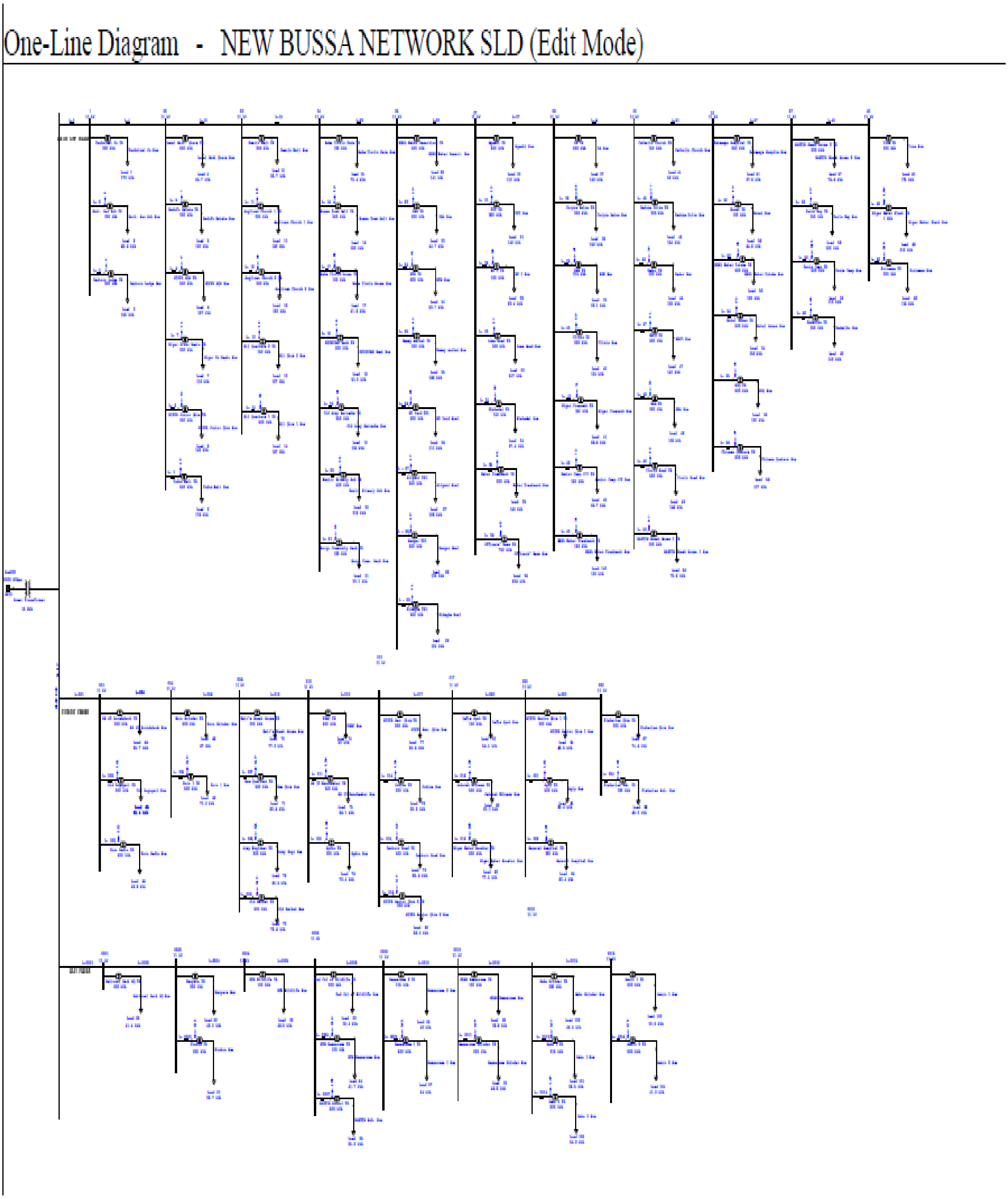

Figure 4.1: New Bussa distribution network model (See attached in Appendix 11, New Bussa distribution model printed in a bigger paper for clarity)

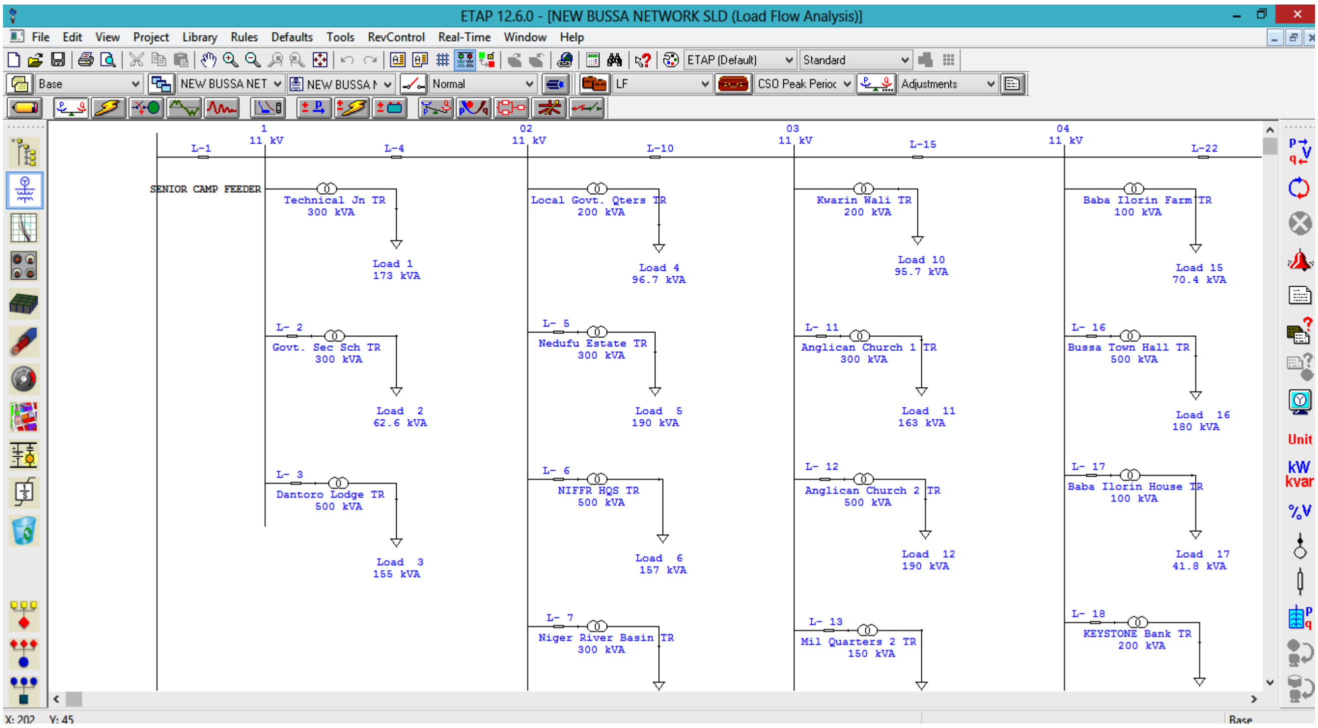

Figure 4.2: Sample view of part of the modeled New Bussa distribution Network shown in ETAP 12.6 Environment

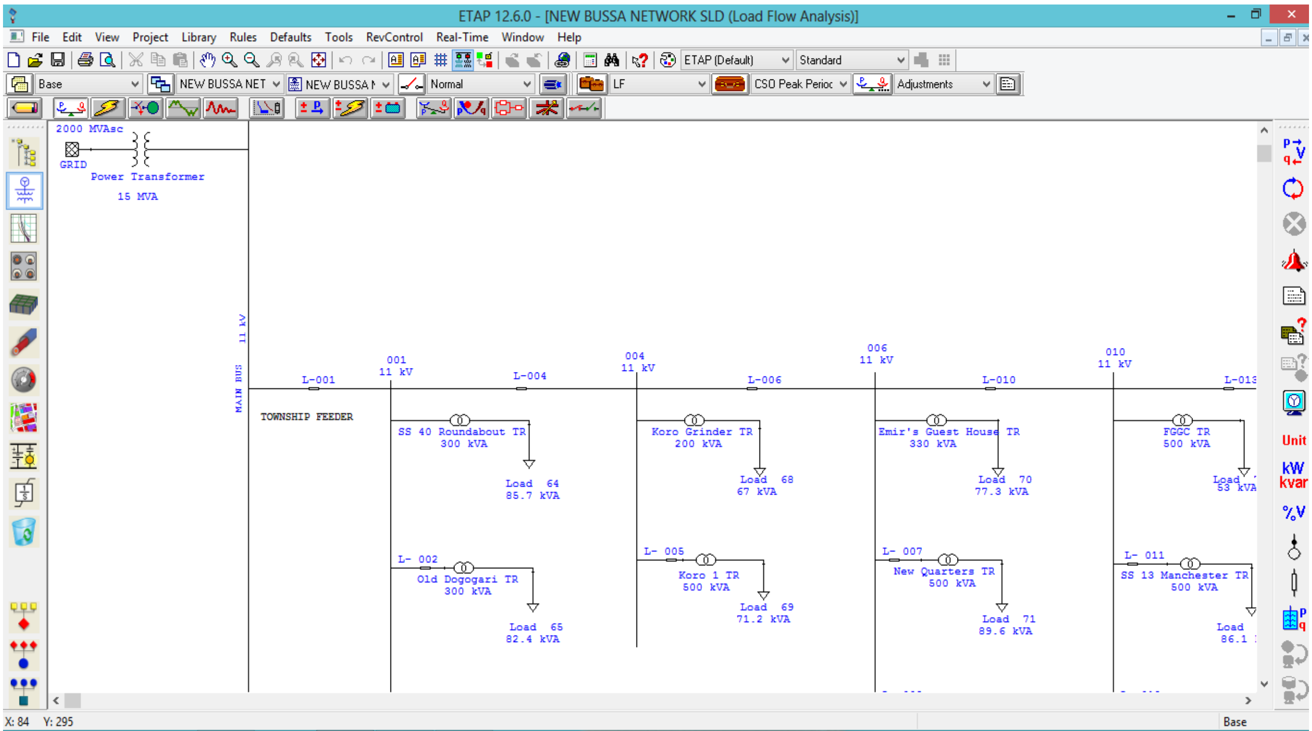

Figure 4.3: Sample view of part of the modeled New Bussa distribution Network shown in ETAP 12.6 Environment

Table 4.1: Load flow report for New Bussa distribution network during peak period

Project:	PhD. PROJECT	ETAP		Page:	1
Location:	NEW BUSSA - NIGER STATE	12.6.0H		Date:	12-10-2017
Contract:				SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case:	LOAD FLOW	Revision:	Base
Filename:	save			Config.:	Normal

LOAD FLOW REPORT(PEAK PERIOD)

LOAD FLOW REPORT

Bus	Voltage			Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
1	11.000	94.970	0.2	0	0	0	0	MAIN BUS	-0.863	-5.470	306.0	15.6	
								Bus 2	0.001	0.056	3.1	1.1	
								Bus 4	0.002	0.138	7.6	1.2	
								02	0.858	5.125	287.2	16.5	
								Technical Jn Bus	0.002	0.152	8.4	1.4	
001	11.000	94.965	0.4	0	0	0	0	MAIN BUS	-0.057	-1.490	82.4	3.8	
								Bus 111	0.001	0.073	4.0	1.2	
								Bus 113	0.000	0.043	2.4	1.1	
								004	0.055	1.297	71.7	4.2	
								SS 40 Roundabout Bus	0.001	0.076	4.2	1.2	
0001	11.000	95.106	0.3	0	0	0	0	MAIN BUS	-0.025	-0.583	32.2	4.2	
								0002	0.024	0.546	30.2	4.4	
								National Park HQ Bus	0.000	0.037	2.0	1.0	
02	11.000	91.911	1.2	0	0	0	0	1	-0.746	-4.973	287.2	14.8	
								Bus 7	0.002	0.155	8.9	1.6	
								Bus 9	0.002	0.130	7.4	1.2	
								Bus 11	0.001	0.098	5.6	1.3	
								Bus 13	0.002	0.117	6.7	1.4	
								Bus 15	0.002	0.146	8.3	1.3	
								03	0.736	4.247	246.1	17.1	
								Local Govt Qters Bus	0.001	0.080	4.6	1.2	
0002	11.000	93.908	0.8	0	0	0	0	0001	-0.019	-0.540	30.2	3.6	
								Bus 152	0.000	0.034	1.9	1.1	
								0004	0.018	0.462	25.9	4.0	
								Manyara Bus	0.000	0.044	2.4	1.0	
03	11.000	86.671	3.0	0	0	0	0	02	-0.570	-4.024	246.1	14.0	
								Bus 18	0.002	0.119	7.2	1.4	
								Bus 20	0.002	0.140	8.5	1.4	
								Bus 22	0.002	0.091	5.5	1.7	
								Bus 24	0.002	0.124	7.5	1.3	
								04	0.562	3.480	213.5	15.9	
								Kwarin Wali Bus	0.001	0.070	4.3	1.3	
04	11.000	81.167	5.0	0	0	0	0	03	-0.410	-3.276	213.5	12.4	
								Bus 26	0.002	0.117	7.6	1.5	
								Bus 28	0.000	0.027	1.7	1.4	
								Bus 30	0.000	0.034	2.2	1.1	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Bus 32	0.001	0.085	5.5	1.5	
								Bus 34	0.004	0.198	12.8	1.8	
								Bus 36	0.000	0.021	1.4	1.2	
								05	0.402	2.748	179.6	14.5	
								Baba Ilorin Farm Bus	0.001	0.045	2.9	1.6	
004	11.000	93.785	0.9	0	0	0	0	001	-0.043	-1.281	71.7	3.3	
								Bus 116	0.001	0.062	3.5	1.0	
								006	0.042	1.161	65.0	3.6	
								Koro Grinder Bus	0.001	0.058	3.2	1.2	
0004	11.000	92.731	1.3	0	0	0	0	0002	-0.014	-0.457	25.9	3.1	
								0005	0.014	0.416	23.5	3.3	
								MTN Wildlife Bus	0.001	0.041	2.3	1.4	
05	11.000	75.083	7.6	0	0	0	0	04	-0.258	-2.556	179.6	10.1	
								Bus 39	0.000	0.025	1.7	1.1	
								Bus 41	0.000	0.030	2.1	1.2	
								Bus 43	0.001	0.089	6.2	1.6	
								Bus 45	0.001	0.061	4.2	1.4	
								Bus 47	0.002	0.109	7.6	1.4	
								Bus 49	0.001	0.075	5.2	1.3	
								Bus 51	0.001	0.069	4.8	1.3	
								07	0.251	2.021	142.4	12.3	
								MESL Water Reserv. Bus	0.001	0.078	5.5	1.0	
0005	11.000	91.618	1.8	0	0	0	0	0004	-0.010	-0.411	23.5	2.4	
								Bus 156	0.000	0.034	2.0	1.4	
								Bus 158	0.000	0.022	1.2	0.9	
								0008	0.009	0.323	18.5	2.8	
								Fed Col of Wildlife Bus	0.000	0.032	1.8	1.0	
006	11.000	92.476	1.4	0	0	0	0	004	-0.030	-1.145	65.0	2.6	
								Bus 119	0.001	0.076	4.3	1.1	
								Bus 121	0.001	0.075	4.3	1.2	
								Bus 123	0.001	0.067	3.8	1.0	
								010	0.027	0.861	48.9	3.1	
								Emir's Guest House Bus	0.001	0.065	3.7	1.0	
07	11.000	69.784	10.1	0	0	0	0	05	-0.151	-1.887	142.4	8.0	
								Bus 53	0.001	0.071	5.3	1.6	
								Bus 55	0.001	0.043	3.3	1.8	
								Bus 57	0.002	0.117	8.8	1.6	
								Bus 59	0.001	0.046	3.5	1.6	
								Bus 61	0.001	0.067	5.0	1.4	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Bus 62	0.001	0.099	7.4	1.4	
								08	0.144	1.390	105.1	10.3	
								Ngaski Bus	0.001	0.054	4.1	1.1	
08	11.000	65.488	12.3	0	0	0	0	07	-0.083	-1.309	105.1	6.4	
								Bus 65	0.001	0.066	5.3	1.6	
								Bus 67	0.001	0.042	3.4	1.3	
								Bus 69	0.001	0.044	3.5	1.4	
								Bus 71	0.001	0.036	2.9	1.5	
								Bus 73	0.001	0.035	2.8	1.4	
								Bus 75	0.001	0.043	3.4	1.7	
								09	0.079	0.983	79.0	8.0	
								D4 Bus	0.001	0.059	4.7	1.2	
0008	11.000	90.602	2.2	0	0	0	0	0005	-0.006	-0.319	18.5	2.0	
								Bus 161	0.000	0.044	2.5	1.0	
								0010	0.006	0.243	14.1	2.3	
								Nassarawa 2 Bus	0.000	0.033	1.9	0.9	
09	11.000	61.978	14.4	0	0	0	0	08	-0.041	-0.933	79.0	4.4	
								Bus 77	0.001	0.058	4.9	1.7	
								Bus 79	0.001	0.052	4.4	1.5	
								Bus 81	0.001	0.054	4.6	1.4	
								Bus 83	0.001	0.052	4.4	1.5	
								Bus 85	0.001	0.062	5.3	1.5	
								Bus 87	0.000	0.027	2.3	1.1	
								10	0.036	0.605	51.3	6.0	
								Catholic Church Bus	0.000	0.022	1.9	1.2	
10	11.000	59.520	16.0	0	0	0	0	09	-0.019	-0.582	51.3	3.2	
								Bus 89	0.000	0.022	2.0	1.5	
								Bus 91	0.001	0.043	3.8	1.3	
								Bus 93	0.001	0.052	4.6	1.4	
								Bus 95	0.001	0.045	4.0	1.3	
								Bus 97	0.001	0.037	3.2	1.6	
								57	0.016	0.349	30.8	4.5	
								Katamaya Hospita Bus	0.000	0.034	3.0	1.4	
010	11.000	91.322	1.9	0	0	0	0	006	-0.019	-0.851	48.9	2.2	
								Bus 126	0.001	0.071	4.1	1.1	
								Bus 128	0.001	0.058	3.3	1.1	
								013	0.017	0.678	39.0	2.5	
								FGGC Bus	0.000	0.044	2.5	1.0	
0010	11.000	89.771	2.6	0	0	0	0	0008	-0.004	-0.240	14.1	1.7	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Bus 164	0.000	0.037	2.2	1.2	
								0012	0.003	0.173	10.1	1.8	
								GDSS Nassarawa Bus	0.000	0.031	1.8	1.3	
0012	11.000	89.082	2.9	0	0	0	0	0010	-0.002	-0.171	10.1	1.3	
								Bus 167	0.000	0.030	1.8	1.1	
								Bus 169	0.001	0.044	2.6	1.2	
								0015	0.001	0.063	3.7	1.5	
								Sabo Grinder Bus	0.000	0.034	2.0	1.1	
013	11.000	90.376	2.4	0	0	0	0	010	-0.012	-0.671	39.0	1.8	
								Bus 131	0.001	0.043	2.5	1.2	
								Bus 133	0.001	0.067	3.9	1.0	
								Bus 135	0.001	0.047	2.8	1.1	
								017	0.010	0.466	27.0	2.1	
								NIFFR Sec. Qtrs Bus	0.000	0.048	2.8	1.0	
0015	11.000	88.673	3.1	0	0	0	0	0012	-0.001	-0.063	3.7	1.2	
								Bus 172	0.000	0.033	1.9	1.4	
								Awuru 1 Bus	0.000	0.031	1.8	1.0	
017	11.000	89.636	2.7	0	0	0	0	013	-0.007	-0.462	27.0	1.5	
								Bus 138	0.001	0.065	3.8	1.0	
								Bus 140	0.001	0.061	3.6	1.3	
								020	0.005	0.292	17.1	1.6	
								Lafia Spot Bus	0.001	0.044	2.6	1.3	
020	11.000	89.156	2.9	0	0	0	0	017	-0.004	-0.291	17.1	1.2	
								Bus 143	0.001	0.066	3.9	1.1	
								Bus 145	0.001	0.065	3.9	1.3	
								023	0.001	0.112	6.6	1.3	
								NIFFR Senior Qtrs 1 Bus	0.001	0.048	2.8	1.1	
023	11.000	88.951	3.0	0	0	0	0	020	-0.001	-0.112	6.6	1.2	
								Bus 148	0.001	0.053	3.1	1.2	
								Fisheries Qtrs Bus	0.001	0.058	3.4	1.1	
57	11.000	57.996	17.0	0	0	0	0	10	-0.009	-0.340	30.8	2.7	
								Bus 99	0.001	0.039	3.5	1.7	
								Bus 101	0.000	0.038	3.4	1.3	
								Bus 103	0.001	0.045	4.1	1.9	
								61	0.007	0.194	17.6	3.5	
								NAPTIN Guest House 2 Bus	0.000	0.025	2.3	1.1	
61	11.000	56.945	17.7	0	0	0	0	57	-0.004	-0.190	17.6	2.2	
								Bus 106	0.002	0.101	9.3	2.0	
								Bus 108	0.001	0.037	3.4	1.5	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Yuna Bus	0.002	0.052	4.8	3.2	
Agip Bus	0.415	88.290	3.1	0	0	0.001	0.065	Bus 143	-0.001	-0.065	102.5	0.8	
Aligani Bus1	0.415	73.334	7.9	0	0	0.001	0.106	Bus 47	-0.001	-0.106	202.0	0.8	
Anglican Church 1 Bus	0.415	84.187	3.4	0	0	0.001	0.116	Bus 18	-0.001	-0.116	190.9	0.8	
Anglican Church 2 Bus	0.415	84.838	3.3	0	0	0.001	0.137	Bus 20	-0.001	-0.137	224.3	0.9	
Army Engr Bus	0.415	90.991	1.6	0	0	0.001	0.074	Bus 121	-0.001	-0.074	113.3	0.8	
Awuru 1 Bus	0.415	88.067	3.3	0	0	0.000	0.030	0015	0.000	-0.030	48.0	0.8	
Awuru 2 Bus	0.415	87.810	3.4	0	0	0.000	0.032	Bus 172	0.000	-0.032	51.1	0.9	
Baba Ilorin Farm Bus	0.415	79.208	5.5	0	0	0.000	0.044	04	0.000	-0.044	77.5	0.8	
Baba Ilorin House Bus	0.415	79.421	5.3	0	0	0.000	0.026	Bus 28	0.000	-0.026	46.2	0.9	
BF 1 Bus	0.415	66.489	10.6	0	0	0.000	0.041	Bus 55	0.000	-0.041	86.4	0.8	
Borgu Comm. Bank Bus	0.415	79.774	5.2	0	0	0.000	0.021	Bus 36	0.000	-0.021	36.7	0.8	
BSW Bus	0.415	64.627	12.6	0	0	0.000	0.041	Bus 67	0.000	-0.041	89.1	0.8	
Bus 2	11.000	94.952	0.2	0	0	0	0	1	-0.001	-0.056	3.1	1.1	
								Govt. Sec Sch Bus	0.001	0.056	3.1	1.1	
Bus 4	11.000	94.914	0.3	0	0	0	0	1	-0.002	-0.137	7.6	1.1	
								Dantoro Lodge Bus	0.002	0.137	7.6	1.1	
Bus 7	11.000	91.814	1.3	0	0	0	0	02	-0.002	-0.155	8.9	1.5	
								Nedufu Estate Bus	0.002	0.155	8.9	1.5	
Bus 9	11.000	91.827	1.3	0	0	0	0	02	-0.002	-0.130	7.4	1.2	
								NIFFR HQS Bus	0.002	0.130	7.4	1.2	
Bus 11	11.000	91.844	1.3	0	0	0	0	02	-0.001	-0.098	5.6	1.2	
								Niger Rv Basin Bus	0.001	0.098	5.6	1.2	
Bus 13	11.000	91.810	1.3	0	0	0	0	02	-0.002	-0.117	6.7	1.3	
								NIFFR Junior Qtrs Bus	0.002	0.117	6.7	1.3	
Bus 15	11.000	91.753	1.3	0	0	0	0	02	-0.002	-0.146	8.3	1.1	
								Tudun Wali Bus	0.002	0.146	8.3	1.1	
Bus 18	11.000	86.525	3.1	0	0	0	0	03	-0.002	-0.119	7.2	1.3	
								Anglican Church 1 Bus	0.002	0.119	7.2	1.3	
Bus 20	11.000	86.487	3.1	0	0	0	0	03	-0.002	-0.139	8.5	1.3	
								Anglican Church 2 Bus	0.002	0.139	8.5	1.3	
Bus 22	11.000	86.548	3.0	0	0	0	0	03	-0.001	-0.091	5.5	1.6	
								Mil Qtrs 2 Bus	0.001	0.091	5.5	1.6	
Bus 24	11.000	86.499	3.1	0	0	0	0	03	-0.001	-0.123	7.5	1.2	
								Mil Qtrs 1 Bus	0.001	0.123	7.5	1.2	
Bus 26	11.000	80.975	5.1	0	0	0	0	04	-0.002	-0.117	7.6	1.3	
								Bussa Town Hall Bus	0.002	0.117	7.6	1.3	
Bus 28	11.000	81.119	5.1	0	0	0	0	04	0.000	-0.027	1.7	1.3	
								Baba Ilorin House Bus	0.000	0.027	1.7	1.3	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus 30	11.000	81.100	5.1	0	0	0	0	04	0.000	-0.034	2.2	1.1	
								KEYSTONE Bank Bus	0.000	0.034	2.2	1.1	
Bus 32	11.000	80.994	5.1	0	0	0	0	04	-0.001	-0.085	5.5	1.4	
								Old Army Barracks Bus	0.001	0.085	5.5	1.4	
Bus 34	11.000	80.766	5.2	0	0	0	0	04	-0.003	-0.197	12.8	1.5	
								Waziri Primary Sch Bus	0.003	0.197	12.8	1.5	
Bus 36	11.000	81.123	5.1	0	0	0	0	04	0.000	-0.021	1.4	1.1	
								Borgu Comm. Bank Bus	0.000	0.021	1.4	1.1	
Bus 39	11.000	75.027	7.6	0	0	0	0	05	0.000	-0.025	1.7	1.0	
								UBA Bus	0.000	0.025	1.7	1.0	
Bus 41	11.000	75.014	7.6	0	0	0	0	05	0.000	-0.030	2.1	1.1	
								MTN Bus	0.000	0.030	2.1	1.1	
Bus 43	11.000	74.875	7.7	0	0	0	0	05	-0.001	-0.088	6.2	1.4	
								Mammy market Bus	0.001	0.088	6.2	1.4	
Bus 45	11.000	74.939	7.7	0	0	0	0	05	-0.001	-0.061	4.2	1.3	
								MT Yard Bus1	0.001	0.061	4.2	1.3	
Bus 47	11.000	74.819	7.7	0	0	0	0	05	-0.001	-0.109	7.6	1.2	
								Aligani Bus1	0.001	0.109	7.6	1.2	
Bus 49	11.000	74.901	7.7	0	0	0	0	05	-0.001	-0.075	5.2	1.1	
								Hangar Bus1	0.001	0.075	5.2	1.1	
Bus 51	11.000	74.914	7.7	0	0	0	0	05	-0.001	-0.069	4.8	1.1	
								Kidagba Bus1	0.001	0.069	4.8	1.1	
Bus 53	11.000	69.596	10.2	0	0	0	0	07	-0.001	-0.070	5.3	1.4	
								TFT Bus	0.001	0.070	5.3	1.4	
Bus 55	11.000	69.665	10.1	0	0	0	0	07	-0.001	-0.043	3.3	1.7	
								BF 1 Bus	0.001	0.043	3.3	1.7	
Bus 57	11.000	69.459	10.3	0	0	0	0	07	-0.002	-0.116	8.8	1.3	
								Luma Road Bus	0.002	0.116	8.8	1.3	
Bus 59	11.000	69.650	10.2	0	0	0	0	07	-0.001	-0.046	3.5	1.5	
								Elshadai Bus	0.001	0.046	3.5	1.5	
Bus 61	11.000	69.590	10.2	0	0	0	0	07	-0.001	-0.067	5.0	1.2	
								Water Treatment Bus	0.001	0.067	5.0	1.2	
Bus 62	11.000	69.496	10.2	0	0	0	0	07	-0.001	-0.098	7.4	1.1	
								Officers' Mess Bus	0.001	0.098	7.4	1.1	
Bus 65	11.000	65.279	12.5	0	0	0	0	08	-0.001	-0.066	5.3	1.4	
								Corpra Below Bus	0.001	0.066	5.3	1.4	
Bus 67	11.000	65.354	12.4	0	0	0	0	08	0.000	-0.042	3.4	1.1	
								BSW Bus	0.000	0.042	3.4	1.1	
Bus 69	11.000	65.345	12.4	0	0	0	0	08	-0.001	-0.044	3.5	1.2	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Clinic Bus	0.001	0.044	3.5	1.2	
Bus 71	11.000	65.369	12.4	0	0	0	0	08	0.000	-0.036	2.9	1.3	
								Niger Crescent Bus	0.000	0.036	2.9	1.3	
Bus 73	11.000	65.368	12.4	0	0	0	0	08	0.000	-0.035	2.8	1.3	
								Senior Camp C/T Bus	0.000	0.035	2.8	1.3	
Bus 75	11.000	65.339	12.4	0	0	0	0	08	-0.001	-0.043	3.4	1.5	
								MESL Water Treatment Bus	0.001	0.043	3.4	1.5	
Bus 77	11.000	61.765	14.5	0	0	0	0	09	-0.001	-0.058	4.9	1.4	
								Kaduna Drive Bus	0.001	0.058	4.9	1.4	
Bus 79	11.000	61.789	14.5	0	0	0	0	09	-0.001	-0.051	4.4	1.3	
								Rader Bus	0.001	0.051	4.4	1.3	
Bus 81	11.000	61.779	14.5	0	0	0	0	09	-0.001	-0.054	4.6	1.2	
								SNCO Bus	0.001	0.054	4.6	1.2	
Bus 83	11.000	61.787	14.5	0	0	0	0	09	-0.001	-0.051	4.4	1.3	
								GRA Bus	0.001	0.051	4.4	1.3	
Bus 85	11.000	61.733	14.6	0	0	0	0	09	-0.001	-0.062	5.3	1.2	
								Ilorin Road Bus	0.001	0.062	5.3	1.2	
Bus 87	11.000	61.870	14.5	0	0	0	0	09	0.000	-0.027	2.3	1.0	
								NAPTIN Guest House 1 Bus	0.000	0.027	2.3	1.0	
Bus 89	11.000	59.428	16.0	0	0	0	0	10	0.000	-0.022	2.0	1.3	
								Monai Bus	0.000	0.022	2.0	1.4	
Bus 91	11.000	59.344	16.1	0	0	0	0	10	0.000	-0.042	3.8	1.1	
								MESL Water Intake Bus	0.000	0.042	3.8	1.1	
Bus 93	11.000	59.304	16.1	0	0	0	0	10	-0.001	-0.052	4.6	1.1	
								Motel Annex Bus	0.001	0.052	4.6	1.1	
Bus 95	11.000	59.331	16.1	0	0	0	0	10	0.000	-0.045	4.0	1.0	
								SOQ Bus	0.000	0.045	4.0	1.0	
Bus 97	11.000	59.366	16.1	0	0	0	0	10	-0.001	-0.037	3.2	1.4	
								Chinese Quaters Bus	0.001	0.037	3.2	1.4	
Bus 99	11.000	57.820	17.1	0	0	0	0	57	-0.001	-0.039	3.5	1.5	
								Zaria Way Bus	0.001	0.039	3.5	1.5	
Bus 101	11.000	57.824	17.1	0	0	0	0	57	0.000	-0.037	3.4	1.1	
								Donia Camp Bus	0.000	0.037	3.4	1.1	
Bus 103	11.000	57.781	17.1	0	0	0	0	57	-0.001	-0.045	4.1	1.7	
								Kadariko Bus	0.001	0.045	4.1	1.7	
Bus 106	11.000	56.356	18.2	0	0	0	0	61	-0.001	-0.100	9.3	1.2	
								Niger Water Plant Bus	0.001	0.100	9.3	1.2	
Bus 108	11.000	56.721	17.9	0	0	0	0	61	0.000	-0.037	3.4	1.2	
								Kurmwasa Bus	0.000	0.037	3.4	1.2	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus 111	11.000	94.902	0.4	0	0	0	0	001	-0.001	-0.073	4.0	1.1	
								Old Dogogari Bus	0.001	0.073	4.0	1.1	
Bus 113	11.000	94.927	0.4	0	0	0	0	001	0.000	-0.043	2.4	1.1	
								Koro Radio Bus	0.000	0.043	2.4	1.1	
Bus 116	11.000	93.728	0.9	0	0	0	0	004	-0.001	-0.062	3.5	0.9	
								Koro 1 Bus	0.001	0.062	3.5	0.9	
Bus 119	11.000	92.386	1.5	0	0	0	0	006	-0.001	-0.076	4.3	1.1	
								New Qtrs Bus	0.001	0.076	4.3	1.1	
Bus 121	11.000	92.380	1.5	0	0	0	0	006	-0.001	-0.075	4.3	1.1	
								Army Engr Bus	0.001	0.075	4.3	1.1	
Bus 123	11.000	92.390	1.5	0	0	0	0	006	-0.001	-0.067	3.8	0.9	
								Old Market Bus	0.001	0.067	3.8	0.9	
Bus 126	11.000	91.225	2.0	0	0	0	0	010	-0.001	-0.071	4.1	1.0	
								SS 13 Manchester Bus	0.001	0.071	4.1	1.0	
Bus 128	11.000	91.243	2.0	0	0	0	0	010	-0.001	-0.058	3.3	1.1	
								Hydro Bus	0.001	0.058	3.3	1.1	
Bus 131	11.000	90.313	2.4	0	0	0	0	013	-0.001	-0.043	2.5	1.2	
								Jobice Bus	0.001	0.043	2.5	1.2	
Bus 133	11.000	90.273	2.4	0	0	0	0	013	-0.001	-0.067	3.9	1.0	
								Dantoro Road Bus	0.001	0.067	3.9	1.0	
Bus 135	11.000	90.303	2.4	0	0	0	0	013	0.000	-0.047	2.8	1.0	
								NIFFR Senior Qtrs 2 Bus	0.000	0.047	2.8	1.0	
Bus 138	11.000	89.532	2.7	0	0	0	0	017	-0.001	-0.064	3.8	1.0	
								Jehovah Witness Bus	0.001	0.064	3.8	1.0	
Bus 140	11.000	89.537	2.7	0	0	0	0	017	-0.001	-0.061	3.6	1.3	
								Niger Water Booster Bus	0.001	0.061	3.6	1.3	
Bus 143	11.000	89.043	3.0	0	0	0	0	020	-0.001	-0.066	3.9	1.0	
								Agip Bus	0.001	0.066	3.9	1.0	
Bus 145	11.000	89.043	3.0	0	0	0	0	020	-0.001	-0.065	3.9	1.2	
								General Hospital Bus	0.001	0.065	3.9	1.2	
Bus 148	11.000	88.850	3.1	0	0	0	0	023	-0.001	-0.053	3.1	1.1	
								Fisheries Sch. Bus	0.001	0.053	3.1	1.1	
Bus 152	11.000	93.834	0.8	0	0	0	0	0002	0.000	-0.034	1.9	1.1	
								Funkum Bus	0.000	0.034	1.9	1.1	
Bus 156	11.000	91.525	1.8	0	0	0	0	0005	0.000	-0.034	2.0	1.3	
								MTN Nassarawa Bus	0.000	0.034	2.0	1.3	
Bus 158	11.000	91.558	1.8	0	0	0	0	0005	0.000	-0.022	1.2	0.8	
								NAPTIN Sch. Bus	0.000	0.022	1.2	0.8	
Bus 161	11.000	90.458	2.3	0	0	0	0	0008	0.000	-0.044	2.5	0.9	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Nassarawa 1 Bus	0.000	0.044	2.5	0.9	
Bus 164	11.000	89.640	2.7	0	0	0	0	0010	0.000	-0.037	2.2	1.1	
								Nassarawa Grinder Bus	0.000	0.037	2.2	1.1	
Bus 167	11.000	88.957	3.0	0	0	0	0	0012	0.000	-0.030	1.8	1.0	
								Sabo 1 Bus	0.000	0.030	1.8	1.0	
Bus 169	11.000	88.896	3.0	0	0	0	0	0012	0.000	-0.044	2.6	1.1	
								Sabo 2 Bus	0.000	0.044	2.6	1.1	
Bus 172	11.000	88.455	3.2	0	0	0	0	0015	0.000	-0.033	1.9	1.2	
								Awuru 2 Bus	0.000	0.033	1.9	1.2	
* Bus230	33.000	100.000	0.0	1.032	7.937	0	0	MAIN BUS	1.032	7.937	140.0	12.9	
Bussa Town Hall Bus	0.415	79.964	5.4	0	0	0.001	0.115	Bus 26	-0.001	-0.115	200.2	0.9	
Catholic Church Bus	0.415	60.756	14.6	0	0	0.000	0.022	09	0.000	-0.022	49.9	0.8	
Chinese Quters Bus	0.415	57.785	16.4	0	0	0.000	0.036	Bus 97	0.000	-0.036	86.0	0.9	
Clinic Bus	0.415	64.545	12.6	0	0	0.000	0.043	Bus 69	0.000	-0.043	93.4	0.9	
Corpra Below Bus	0.415	63.556	12.8	0	0	0.001	0.064	Bus 65	-0.001	-0.064	140.6	0.9	
D4 Bus	0.415	64.563	12.5	0	0	0.001	0.058	08	-0.001	-0.058	125.7	0.9	
Dantoro Lodge Bus	0.415	93.433	0.4	0	0	0.001	0.135	Bus 4	-0.001	-0.135	201.5	0.9	
Dantoro Road Bus	0.415	89.517	2.5	0	0	0.001	0.066	Bus 133	-0.001	-0.066	102.9	0.8	
Donia Camp Bus	0.415	57.361	17.2	0	0	0.000	0.037	Bus 101	0.000	-0.037	90.2	0.8	
Elshadai Bus	0.415	68.069	10.5	0	0	0.000	0.045	Bus 59	0.000	-0.045	92.2	0.8	
Emir's Guest House Bus	0.415	91.382	1.5	0	0	0.001	0.065	006	-0.001	-0.065	98.3	0.8	
Fed Col of Wildlife Bus	0.415	91.023	1.9	0	0	0.000	0.032	0005	0.000	-0.032	48.6	0.9	
FGGC Bus	0.415	90.830	2.0	0	0	0.000	0.044	010	0.000	-0.044	66.9	0.9	
Fisheries Qtrs Bus	0.415	87.834	3.1	0	0	0.001	0.058	023	-0.001	-0.058	91.1	0.9	
Fisheries Sch. Bus	0.415	87.828	3.2	0	0	0.000	0.053	Bus 148	0.000	-0.053	83.5	0.9	
Fumkun Bus	0.415	92.915	0.9	0	0	0.000	0.033	Bus 152	0.000	-0.033	50.0	0.9	
GDSS Nassarawa Bus	0.415	88.024	2.8	0	0	0.000	0.030	0010	0.000	-0.030	47.5	0.9	
General Hospital Bus	0.415	87.792	3.1	0	0	0.001	0.064	Bus 145	-0.001	-0.064	102.1	0.9	
Govt. Sec Sch Bus	0.415	93.950	0.4	0	0	0.000	0.055	Bus 2	0.000	-0.055	81.8	0.9	
GRA Bus	0.415	60.367	14.8	0	0	0.000	0.050	Bus 83	0.000	-0.050	115.9	0.8	
Hanger Bus1	0.415	73.882	7.8	0	0	0.001	0.074	Bus 49	-0.001	-0.074	138.8	0.9	
Hydro Bus	0.415	90.497	2.1	0	0	0.000	0.058	Bus 128	0.000	-0.058	88.6	0.8	
Ilorin Road Bus	0.415	60.703	14.7	0	0	0.001	0.061	Bus 85	-0.001	-0.061	140.2	0.9	
Jehovah Witness Bus	0.415	88.795	2.8	0	0	0.001	0.064	Bus 138	-0.001	-0.064	100.2	0.8	
Jobice Bus	0.415	89.086	2.5	0	0	0.000	0.043	Bus 131	0.000	-0.043	66.8	0.9	
Kadariko Bus	0.415	55.148	17.6	0	0	0.000	0.043	Bus 103	0.000	-0.043	107.4	0.8	
Kaduna Drive Bus	0.415	60.165	14.8	0	0	0.001	0.056	Bus 77	-0.001	-0.056	130.6	0.9	
Katamaya Hospita Bus	0.415	58.246	16.3	0	0	0.000	0.033	10	0.000	-0.033	79.3	0.9	
KEYSTONE Bank Bus	0.415	80.361	5.2	0	0	0.000	0.033	Bus 30	0.000	-0.033	57.5	0.8	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Kidagba Bus1	0.415	73.976	7.8	0	0	0.001	0.068	Bus 51	-0.001	-0.068	127.6	0.9	
Koro 1 Bus	0.415	93.051	1.0	0	0	0.000	0.062	Bus 116	0.000	-0.062	92.1	0.8	
Koro Grinder Bus	0.415	92.206	1.0	0	0	0.001	0.057	004	-0.001	-0.057	85.9	0.9	
Koro Radio Bus	0.415	93.757	0.5	0	0	0.000	0.043	Bus 113	0.000	-0.043	63.7	0.8	
Kuruwasa Bus	0.415	55.622	18.1	0	0	0.000	0.036	Bus 108	0.000	-0.036	89.8	0.8	
Kwarin Wali Bus	0.415	84.601	3.2	0	0	0.001	0.069	03	-0.001	-0.069	112.7	0.9	
Lafia Spot Bus	0.415	87.117	3.0	0	0	0.000	0.043	017	0.000	-0.043	68.5	0.8	
Local Govt Qters Bus	0.415	89.694	1.5	0	0	0.001	0.078	02	-0.001	-0.078	120.7	0.8	
Luma Road Bus	0.415	67.748	10.5	0	0	0.001	0.113	Bus 57	-0.001	-0.113	232.8	0.8	
MAIN BUS	11.000	96.276	-0.2	0	0	0	0	1	0.914	5.539	306.0	16.3	
								001	0.072	1.510	82.4	4.7	
								0001	0.030	0.590	32.2	5.0	
								Bus230	-1.016	-7.639	420.1	13.2	
Mammy market Bus	0.415	72.863	8.0	0	0	0.001	0.086	Bus 43	-0.001	-0.086	164.2	0.9	
Manyara Bus	0.415	93.117	0.9	0	0	0.000	0.043	0002	0.000	-0.043	64.6	0.9	
MESL Water Intake Bus	0.415	58.612	16.2	0	0	0.000	0.042	Bus 91	0.000	-0.042	99.5	0.9	
MESL Water Reserv. Bus	0.415	74.016	7.7	0	0	0.001	0.077	05	-0.001	-0.077	145.2	0.8	
MESL Water Treatment Bus	0.415	63.800	12.9	0	0	0.000	0.042	Bus 75	0.000	-0.042	91.4	0.8	
Mil Qtrs 1 Bus	0.415	85.479	3.3	0	0	0.001	0.122	Bus 24	-0.001	-0.122	198.6	0.9	
Mil Qtrs 2 Bus	0.415	82.956	3.5	0	0	0.001	0.087	Bus 22	-0.001	-0.087	146.6	0.8	
Monai Bus	0.415	57.523	16.4	0	0	0.000	0.021	Bus 89	0.000	-0.021	51.8	0.7	
Motel Annex Bus	0.415	58.408	16.3	0	0	0.000	0.051	Bus 93	0.000	-0.051	121.9	0.8	
MT Yard Bus1	0.415	72.871	7.9	0	0	0.000	0.059	Bus 45	0.000	-0.059	112.5	0.8	
MTN Bus	0.415	73.998	7.8	0	0	0.000	0.029	Bus 41	0.000	-0.029	55.3	0.9	
MTN Nassarawa Bus	0.415	90.203	2.1	0	0	0.000	0.034	Bus 156	0.000	-0.034	52.4	0.8	
MTN Wildlife Bus	0.415	90.471	1.6	0	0	0.000	0.040	0004	0.000	-0.040	61.5	0.9	
NAPTIN Guest House 1 Bus	0.415	61.119	14.6	0	0	0.000	0.027	Bus 87	0.000	-0.027	61.4	0.8	
NAPTIN Guest House 2 Bus	0.415	57.249	17.1	0	0	0.000	0.025	57	0.000	-0.025	61.0	0.9	
NAPTIN Sch. Bus	0.415	91.317	1.8	0	0	0.000	0.022	Bus 158	0.000	-0.022	32.9	0.8	
Nassarawa 1 Bus	0.415	89.962	2.4	0	0	0.000	0.044	Bus 161	0.000	-0.044	67.6	0.8	
Nassarawa 2 Bus	0.415	90.018	2.3	0	0	0.000	0.032	0008	0.000	-0.032	50.0	0.8	
Nassarawa Grinder Bus	0.415	88.581	2.8	0	0	0.000	0.037	Bus 164	0.000	-0.037	57.6	0.9	
National Park HQ Bus	0.415	94.111	0.4	0	0	0.000	0.037	0001	0.000	-0.037	54.2	0.8	
Nedufu Estate Bus	0.415	88.934	1.6	0	0	0.001	0.150	Bus 7	-0.001	-0.150	235.1	0.9	
New Qtrs Bus	0.415	91.547	1.6	0	0	0.001	0.075	Bus 119	-0.001	-0.075	114.2	0.9	
Ngaski Bus	0.415	68.987	10.2	0	0	0.000	0.054	07	0.000	-0.054	108.5	0.9	
NIFFR HQS Bus	0.415	90.376	1.4	0	0	0.001	0.128	Bus 9	-0.001	-0.128	197.4	0.9	
NIFFR Junior Qtrs Bus	0.415	89.640	1.5	0	0	0.001	0.114	Bus 13	-0.001	-0.114	177.1	0.9	
NIFFR Sec. Qtrs Bus	0.415	89.838	2.4	0	0	0.000	0.047	013	0.000	-0.047	73.2	0.9	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
NIFFR Senior Qtrs 1 Bus	0.415	88.246	3.0	0	0	0.000	0.047	020	0.000	-0.047	74.3	0.9	
NIFFR Senior Qtrs 2 Bus	0.415	89.407	2.5	0	0	0.000	0.047	Bus 135	0.000	-0.047	73.1	0.8	
Niger Crescent Bus	0.415	63.494	12.7	0	0	0.000	0.035	Bus 71	0.000	-0.035	76.5	0.8	
Niger Rv Basin Bus	0.415	90.018	1.5	0	0	0.001	0.096	Bus 11	-0.001	-0.096	149.0	0.8	
Niger Water Booster Bus	0.415	87.798	2.9	0	0	0.001	0.060	Bus 140	-0.001	-0.060	94.6	0.9	
Niger Water Plant Bus	0.415	55.720	18.3	0	0	0.001	0.099	Bus 106	-0.001	-0.099	247.3	0.9	
Officers' Mess Bus	0.415	68.533	10.4	0	0	0.001	0.097	Bus 62	-0.001	-0.097	196.4	0.9	
Old Amry Barracks Bus	0.415	78.603	5.4	0	0	0.001	0.083	Bus 32	-0.001	-0.083	146.5	0.9	
Old Dogogari Bus	0.415	93.587	0.5	0	0	0.001	0.072	Bus 111	-0.001	-0.072	107.3	0.9	
Old Market Bus	0.415	91.644	1.5	0	0	0.001	0.067	Bus 123	-0.001	-0.067	101.5	0.8	
Radar Bus	0.415	60.369	14.8	0	0	0.000	0.050	Bus 79	0.000	-0.050	115.9	0.9	
Sabo 1 Bus	0.415	88.405	3.1	0	0	0.000	0.030	Bus 167	0.000	-0.030	47.3	0.9	
Sabo 2 Bus	0.415	87.637	3.2	0	0	0.000	0.043	Bus 169	0.000	-0.043	68.5	0.8	
Sabo Grinder Bus	0.415	88.117	3.1	0	0	0.000	0.033	0012	0.000	-0.033	52.5	0.9	
Senior Camp C/T Bus	0.415	63.533	12.7	0	0	0.000	0.034	Bus 73	0.000	-0.034	74.9	0.8	
SNCO Bus	0.415	60.889	14.7	0	0	0.000	0.053	Bus 81	0.000	-0.053	121.1	0.9	
SOQ Bus	0.415	58.553	16.2	0	0	0.000	0.045	Bus 95	0.000	-0.045	105.9	0.8	
SS 13 Manchester Bus	0.415	90.429	2.1	0	0	0.001	0.070	Bus 126	-0.001	-0.070	108.3	0.9	
SS 40 Roundabout Bus	0.415	93.597	0.5	0	0	0.001	0.075	001	-0.001	-0.075	111.6	0.9	
Technical Jn Bus	0.415	92.250	0.5	0	0	0.001	0.147	1	-0.001	-0.147	222.0	0.8	
TFT Bus	0.415	68.410	10.5	0	0	0.001	0.069	Bus 53	-0.001	-0.069	140.9	0.8	
Tudun Wali Bus	0.415	90.131	1.5	0	0	0.001	0.143	Bus 15	-0.001	-0.143	220.7	0.8	
UBA Bus	0.415	74.444	7.8	0	0	0.000	0.025	Bus 39	0.000	-0.025	46.3	0.8	
Water Treatment Bus	0.415	68.448	10.4	0	0	0.001	0.066	Bus 61	-0.001	-0.066	133.3	0.8	
Waziri Primary Sch Bus	0.415	78.268	5.6	0	0	0.002	0.191	Bus 34	-0.002	-0.191	339.7	0.9	
Yuna Bus	0.415	52.679	19.1	0	0	0.000	0.049	61	0.000	-0.049	128.3	0.8	
Zaria Way Bus	0.415	55.548	17.5	0	0	0.000	0.037	Bus 99	0.000	-0.037	92.7	0.7	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

Table 4.2: Load flow report for New Bussa distribution network during off-peak period

Project: PhD. PROJECT	ETAP 12.6.0H	Page:	1
Location: NEW BUSSA - NIGER STATE		Date:	12-10-2017
Contract:		SN:	
Engineer: OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename: save 2		Config.:	Normal

LOAD FLOW REPORT (OFF-PEAK PERIOD)

LOAD FLOW REPORT

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
1	11.000	97.853	0.2	0	0	0	0	MAIN BUS	-0.153	-2.166	116.4	7.1	
								Bus 2	0.000	0.029	1.5	1.0	
								Bus 4	0.001	0.056	3.0	1.0	
								02	0.152	2.014	108.3	7.5	
								Technical Jn Bus	0.001	0.067	3.6	1.0	
001	11.000	97.503	0.3	0	0	0	0	MAIN BUS	-0.027	-0.969	52.2	2.8	
								Bus 111	0.000	0.043	2.3	1.0	
								Bus 113	0.000	0.030	1.6	1.0	
								004	0.026	0.859	46.3	3.0	
								SS 40 Roundabout Bus	0.000	0.036	2.0	1.0	
0001	11.000	97.616	0.3	0	0	0	0	MAIN BUS	-0.010	-0.368	19.8	2.7	
								0002	0.010	0.337	18.1	2.9	
								National Park HQ Bus	0.000	0.031	1.6	1.0	
02	11.000	96.755	0.6	0	0	0	0	1	-0.136	-1.993	108.3	6.8	
								Bus 7	0.001	0.062	3.3	1.1	
								Bus 9	0.000	0.043	2.3	1.0	
								Bus 11	0.000	0.038	2.0	1.0	
								Bus 13	0.000	0.038	2.1	1.1	
								Bus 15	0.001	0.056	3.0	1.0	
								03	0.133	1.725	93.9	7.7	
								Local Govt Qters Bus	0.000	0.031	1.7	1.0	
0002	11.000	96.904	0.6	0	0	0	0	0001	-0.008	-0.335	18.1	2.3	
								Bus 152	0.000	0.014	0.8	1.0	
								0004	0.007	0.298	16.1	2.5	
								Manyara Bus	0.000	0.023	1.2	1.0	
03	11.000	94.854	1.3	0	0	0	0	02	-0.109	-1.693	93.9	6.4	
								Bus 18	0.000	0.034	1.9	0.9	
								Bus 20	0.000	0.044	2.5	1.1	
								Bus 22	0.000	0.026	1.4	1.0	
								Bus 24	0.000	0.042	2.3	1.0	
								04	0.107	1.523	84.5	7.0	
								Kwarin Wali Bus	0.000	0.024	1.3	1.0	
04	11.000	92.776	2.1	0	0	0	0	03	-0.083	-1.491	84.5	5.6	
								Bus 26	0.000	0.029	1.7	1.0	
								Bus 28	0.000	0.008	0.5	1.0	
								Bus 30	0.000	0.026	1.5	1.0	

LOAD FLOW REPORT (OFF-PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Bus 32	0.000	0.027	1.6	1.0	
								Bus 34	0.001	0.059	3.3	1.1	
								Bus 36	0.000	0.013	0.8	1.0	
								05	0.081	1.299	73.6	6.2	
								Baba Ilorin Farm Bus	0.000	0.029	1.7	1.2	
004	11.000	96.747	0.6	0	0	0	0	001	-0.021	-0.853	46.3	2.5	
								Bus 116	0.000	0.031	1.7	0.9	
								006	0.020	0.791	42.9	2.6	
								Koro Grinder Bus	0.000	0.031	1.7	1.1	
0004	11.000	96.177	0.9	0	0	0	0	0002	-0.006	-0.295	16.1	2.0	
								0005	0.005	0.256	14.0	2.1	
								MTN Wildlife Bus	0.001	0.040	2.2	1.3	
05	11.000	90.387	3.1	0	0	0	0	04	-0.057	-1.266	73.6	4.5	
								Bus 39	0.000	0.021	1.2	1.0	
								Bus 41	0.000	0.030	1.8	1.1	
								Bus 43	0.000	0.037	2.1	1.1	
								Bus 45	0.000	0.018	1.0	0.9	
								Bus 47	0.000	0.047	2.7	1.0	
								Bus 49	0.000	0.038	2.2	1.0	
								Bus 51	0.000	0.018	1.1	1.0	
								07	0.055	1.013	58.9	5.4	
								MESL Water Reserv. Bus	0.000	0.044	2.5	0.9	
0005	11.000	95.522	1.2	0	0	0	0	0004	-0.004	-0.254	14.0	1.6	
								Bus 156	0.000	0.035	1.9	1.4	
								Bus 158	0.000	0.015	0.8	0.9	
								0008	0.003	0.182	10.0	1.8	
								Fed Col of Wildlife Bus	0.000	0.021	1.2	1.0	
006	11.000	95.888	1.0	0	0	0	0	004	-0.015	-0.784	42.9	1.9	
								Bus 119	0.001	0.061	3.3	1.1	
								Bus 121	0.001	0.069	3.8	1.1	
								Bus 123	0.000	0.042	2.3	0.9	
								010	0.013	0.560	30.7	2.3	
								Emir's Guest House Bus	0.001	0.053	2.9	0.9	
07	11.000	88.271	4.1	0	0	0	0	05	-0.037	-0.990	58.9	3.8	
								Bus 53	0.000	0.021	1.2	1.0	
								Bus 55	0.000	0.024	1.4	1.1	
								Bus 57	0.001	0.051	3.1	1.1	
								Bus 59	0.000	0.019	1.1	1.0	
								Bus 61	0.000	0.039	2.3	1.0	

LOAD FLOW REPORT (OFF-PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Bus 62	0.000	0.027	1.6	1.0	
								08	0.035	0.790	47.0	4.5	
								Ngaski Bus	0.000	0.018	1.1	0.9	
08	11.000	86.406	4.9	0	0	0	0	07	-0.023	-0.774	47.0	3.0	
								Bus 65	0.000	0.039	2.4	1.2	
								Bus 67	0.000	0.014	0.9	0.9	
								Bus 69	0.000	0.030	1.8	1.1	
								Bus 71	0.000	0.019	1.2	1.0	
								Bus 73	0.000	0.020	1.2	1.0	
								Bus 75	0.000	0.018	1.1	1.0	
								09	0.022	0.606	36.9	3.6	
								D4 Bus	0.000	0.027	1.6	1.0	
0008	11.000	94.974	1.4	0	0	0	0	0005	-0.002	-0.181	10.0	1.3	
								Bus 161	0.000	0.032	1.7	0.9	
								0010	0.002	0.126	7.0	1.5	
								Nassarawa 2 Bus	0.000	0.024	1.3	0.9	
09	11.000	84.806	5.6	0	0	0	0	08	-0.013	-0.595	36.9	2.2	
								Bus 77	0.000	0.035	2.2	1.2	
								Bus 79	0.000	0.019	1.2	1.0	
								Bus 81	0.000	0.015	1.0	1.0	
								Bus 83	0.000	0.037	2.3	1.1	
								Bus 85	0.000	0.037	2.3	1.1	
								Bus 87	0.000	0.021	1.3	0.9	
								10	0.012	0.422	26.1	2.7	
								Catholic Church Bus	0.000	0.009	0.6	0.9	
10	11.000	83.577	6.2	0	0	0	0	09	-0.007	-0.416	26.1	1.7	
								Bus 89	0.000	0.010	0.6	0.9	
								Bus 91	0.001	0.052	3.3	1.2	
								Bus 93	0.001	0.062	3.9	1.1	
								Bus 95	0.000	0.013	0.8	0.9	
								Bus 97	0.000	0.024	1.5	1.1	
								57	0.005	0.230	14.4	2.2	
								Katamaya Hospita Bus	0.000	0.025	1.6	1.1	
010	11.000	95.168	1.3	0	0	0	0	006	-0.010	-0.556	30.7	1.8	
								Bus 126	0.001	0.050	2.8	1.0	
								Bus 128	0.000	0.025	1.4	0.9	
								013	0.009	0.458	25.3	1.9	
								FGGC Bus	0.000	0.022	1.2	0.9	
0010	11.000	94.565	1.6	0	0	0	0	0008	-0.002	-0.125	7.0	1.2	

LOAD FLOW REPORT (OFF-PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Bus 164	0.000	0.024	1.3	1.1	
								0012	0.001	0.076	4.2	1.3	
								GDSS Nassarawa Bus	0.000	0.026	1.4	1.2	
0012	11.000	94.278	1.7	0	0	0	0	0010	-0.001	-0.076	4.2	1.1	
								Bus 167	0.000	0.013	0.7	1.0	
								Bus 169	0.000	0.015	0.8	0.9	
								0015	0.000	0.034	1.9	1.2	
								Sabo Grinder Bus	0.000	0.014	0.8	1.0	
013	11.000	94.556	1.6	0	0	0	0	010	-0.007	-0.456	25.3	1.5	
								Bus 131	0.000	0.038	2.1	1.2	
								Bus 133	0.000	0.039	2.2	0.9	
								Bus 135	0.000	0.032	1.8	1.0	
								017	0.005	0.325	18.1	1.7	
								NIFFR Sec. Qtrs Bus	0.000	0.021	1.2	0.9	
0015	11.000	94.071	1.8	0	0	0	0	0012	0.000	-0.034	1.9	1.0	
								Bus 172	0.000	0.016	0.9	1.1	
								Awuru 1 Bus	0.000	0.018	1.0	0.9	
017	11.000	94.063	1.8	0	0	0	0	013	-0.004	-0.324	18.1	1.3	
								Bus 138	0.000	0.031	1.7	0.9	
								Bus 140	0.001	0.049	2.8	1.2	
								020	0.003	0.214	11.9	1.4	
								Lafia Spot Bus	0.000	0.030	1.6	1.1	
020	11.000	93.728	1.9	0	0	0	0	017	-0.002	-0.213	11.9	1.1	
								Bus 143	0.001	0.057	3.2	1.0	
								Bus 145	0.001	0.065	3.6	1.2	
								023	0.001	0.063	3.5	1.1	
								NIFFR Senior Qtrs 1 Bus	0.000	0.028	1.6	1.0	
023	11.000	93.618	2.0	0	0	0	0	020	-0.001	-0.063	3.5	1.1	
								Bus 148	0.000	0.039	2.2	1.1	
								Fisheries Qtrs Bus	0.000	0.025	1.4	1.0	
57	11.000	82.872	6.6	0	0	0	0	10	-0.004	-0.228	14.4	1.6	
								Bus 99	0.000	0.014	0.9	0.9	
								Bus 101	0.000	0.016	1.0	0.9	
								Bus 103	0.000	0.025	1.6	1.1	
								61	0.003	0.148	9.4	1.9	
								NAPTIN Guest House 2 Bus	0.000	0.025	1.6	1.0	
61	11.000	82.317	6.9	0	0	0	0	57	-0.002	-0.147	9.4	1.4	
								Bus 106	0.001	0.101	6.4	1.4	
								Bus 108	0.000	0.017	1.1	1.0	

LOAD FLOW REPORT (OFF-PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Yuma Bus	0.000	0.029	1.8	1.5	
Agip Bus	0.415	93.017	2.1	0	0	0.000	0.056	Bus 143	0.000	-0.056	84.2	0.8	
Aliguni Bus1	0.415	89.767	3.2	0	0	0.000	0.046	Bus 47	0.000	-0.046	71.7	0.8	
Anglican Church 1 Bus	0.415	94.214	1.4	0	0	0.000	0.033	Bus 18	0.000	-0.033	49.2	0.8	
Anglican Church 2 Bus	0.415	94.323	1.4	0	0	0.000	0.044	Bus 20	0.000	-0.044	65.0	0.9	
Army Engr Bus	0.415	94.577	1.2	0	0	0.001	0.068	Bus 121	-0.001	-0.068	100.1	0.8	
Awuru 1 Bus	0.415	93.736	1.9	0	0	0.000	0.018	0015	0.000	-0.018	26.6	0.8	
Awuru 2 Bus	0.415	93.676	1.9	0	0	0.000	0.016	Bus 172	0.000	-0.016	23.5	0.9	
Baba Ilorin Farm Bus	0.415	91.666	2.4	0	0	0.000	0.029	04	0.000	-0.029	44.0	0.8	
Baba Ilorin House Bus	0.415	92.310	2.2	0	0	0.000	0.008	Bus 28	0.000	-0.008	12.4	0.9	
BF 1 Bus	0.415	86.809	4.2	0	0	0.000	0.024	Bus 55	0.000	-0.024	38.3	0.8	
Borgu Comm. Bank Bus	0.415	92.021	2.2	0	0	0.000	0.013	Bus 36	0.000	-0.013	19.9	0.8	
BSW Bus	0.415	86.188	4.9	0	0	0.000	0.014	Bus 67	0.000	-0.014	22.6	0.8	
Bus 2	11.000	97.844	0.2	0	0	0	0	1	0.000	-0.029	1.5	1.0	
								Govt. Sec Sch Bus	0.000	0.029	1.5	1.0	
Bus 4	11.000	97.831	0.2	0	0	0	0	1	-0.001	-0.056	3.0	1.0	
								Dantoro Lodge Bus	0.001	0.056	3.0	1.0	
Bus 7	11.000	96.719	0.6	0	0	0	0	02	-0.001	-0.062	3.3	1.1	
								Nedufu Estate Bus	0.001	0.062	3.3	1.1	
Bus 9	11.000	96.729	0.6	0	0	0	0	02	0.000	-0.043	2.3	1.0	
								NIFFR HQS Bus	0.000	0.043	2.3	1.0	
Bus 11	11.000	96.731	0.6	0	0	0	0	02	0.000	-0.038	2.0	1.0	
								Niger Rv Basin Bus	0.000	0.038	2.0	1.0	
Bus 13	11.000	96.724	0.6	0	0	0	0	02	0.000	-0.038	2.1	1.0	
								NIFFR Junior Qtrs Bus	0.000	0.038	2.1	1.0	
Bus 15	11.000	96.698	0.6	0	0	0	0	02	-0.001	-0.056	3.0	0.9	
								Tudun Wali Bus	0.001	0.056	3.0	0.9	
Bus 18	11.000	94.817	1.3	0	0	0	0	03	0.000	-0.034	1.9	0.9	
								Anglican Church 1 Bus	0.000	0.034	1.9	0.9	
Bus 20	11.000	94.801	1.3	0	0	0	0	03	0.000	-0.044	2.5	1.0	
								Anglican Church 2 Bus	0.000	0.044	2.5	1.0	
Bus 22	11.000	94.822	1.3	0	0	0	0	03	0.000	-0.026	1.4	1.0	
								Mil Qtrs 2 Bus	0.000	0.026	1.4	1.0	
Bus 24	11.000	94.801	1.3	0	0	0	0	03	0.000	-0.042	2.3	0.9	
								Mil Qtrs 1 Bus	0.000	0.042	2.3	0.9	
Bus 26	11.000	92.734	2.2	0	0	0	0	04	0.000	-0.029	1.7	1.0	
								Bussa Town Hall Bus	0.000	0.029	1.7	1.0	
Bus 28	11.000	92.764	2.1	0	0	0	0	04	0.000	-0.008	0.5	1.0	
								Baba Ilorin House Bus	0.000	0.008	0.5	1.0	

LOAD FLOW REPORT (OFF-PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus 30	11.000	92.730	2.2	0	0	0	0	04	0.000	-0.026	1.5	1.0	
								KEYSTONE Bank Bus	0.000	0.026	1.5	1.0	
Bus 32	11.000	92.728	2.2	0	0	0	0	04	0.000	-0.027	1.6	1.0	
								Old Army Barracks Bus	0.000	0.027	1.6	1.0	
Bus 34	11.000	92.673	2.2	0	0	0	0	04	-0.001	-0.059	3.3	1.0	
								Waziri Primary Sch Bus	0.001	0.059	3.3	1.0	
Bus 36	11.000	92.753	2.2	0	0	0	0	04	0.000	-0.013	0.8	1.0	
								Borgu Comm. Bank Bus	0.000	0.013	0.8	1.0	
Bus 39	11.000	90.347	3.2	0	0	0	0	05	0.000	-0.021	1.2	0.9	
								UBA Bus	0.000	0.021	1.2	0.9	
Bus 41	11.000	90.329	3.2	0	0	0	0	05	0.000	-0.030	1.8	1.1	
								MTN Bus	0.000	0.030	1.8	1.1	
Bus 43	11.000	90.316	3.2	0	0	0	0	05	0.000	-0.037	2.1	1.1	
								Mammy market Bus	0.000	0.037	2.1	1.1	
Bus 45	11.000	90.352	3.1	0	0	0	0	05	0.000	-0.018	1.0	0.9	
								MT Yard Bus1	0.000	0.018	1.0	0.9	
Bus 47	11.000	90.294	3.2	0	0	0	0	05	0.000	-0.047	2.7	0.9	
								Aliyu Bus1	0.000	0.047	2.7	0.9	
Bus 49	11.000	90.310	3.2	0	0	0	0	05	0.000	-0.038	2.2	1.0	
								Hangar Bus1	0.000	0.038	2.2	1.0	
Bus 51	11.000	90.350	3.1	0	0	0	0	05	0.000	-0.018	1.1	0.9	
								Kidagba Bus1	0.000	0.018	1.1	0.9	
Bus 53	11.000	88.228	4.1	0	0	0	0	07	0.000	-0.021	1.2	0.9	
								TFT Bus	0.000	0.021	1.2	0.9	
Bus 55	11.000	88.218	4.1	0	0	0	0	07	0.000	-0.024	1.4	1.1	
								BF 1 Bus	0.000	0.024	1.4	1.1	
Bus 57	11.000	88.158	4.1	0	0	0	0	07	0.000	-0.051	3.1	1.0	
								Luma Road Bus	0.000	0.051	3.1	1.0	
Bus 59	11.000	88.228	4.1	0	0	0	0	07	0.000	-0.019	1.1	1.0	
								Elshadai Bus	0.000	0.019	1.1	1.0	
Bus 61	11.000	88.182	4.1	0	0	0	0	07	0.000	-0.039	2.3	1.0	
								Water Treatment Bus	0.000	0.039	2.3	1.0	
Bus 62	11.000	88.209	4.1	0	0	0	0	07	0.000	-0.027	1.6	0.9	
								Officers' Mess Bus	0.000	0.027	1.6	0.9	
Bus 65	11.000	86.313	4.9	0	0	0	0	08	0.000	-0.039	2.4	1.1	
								Corpra Below Bus	0.000	0.039	2.4	1.1	
Bus 67	11.000	86.372	4.9	0	0	0	0	08	0.000	-0.014	0.9	0.9	
								BSW Bus	0.000	0.014	0.9	0.9	
Bus 69	11.000	86.331	4.9	0	0	0	0	08	0.000	-0.030	1.8	1.0	

LOAD FLOW REPORT (OFF-PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Clinic Bus	0.000	0.030	1.8	1.0	
Bus 71	11.000	86.358	4.9	0	0	0	0	08	0.000	-0.019	1.2	1.0	
								Niger Crescent Bus	0.000	0.019	1.2	1.0	
Bus 73	11.000	86.354	4.9	0	0	0	0	08	0.000	-0.020	1.2	1.0	
								Senior Camp C/T Bus	0.000	0.020	1.2	1.0	
Bus 75	11.000	86.358	4.9	0	0	0	0	08	0.000	-0.018	1.1	1.0	
								MESL Water Treatment Bus	0.000	0.018	1.1	1.0	
Bus 77	11.000	84.711	5.7	0	0	0	0	09	0.000	-0.035	2.2	1.1	
								Kaduna Drive Bus	0.000	0.035	2.2	1.1	
Bus 79	11.000	84.755	5.7	0	0	0	0	09	0.000	-0.019	1.2	1.0	
								Rader Bus	0.000	0.019	1.2	1.0	
Bus 81	11.000	84.764	5.7	0	0	0	0	09	0.000	-0.015	1.0	0.9	
								SNCO Bus	0.000	0.015	1.0	0.9	
Bus 83	11.000	84.705	5.7	0	0	0	0	09	0.000	-0.037	2.3	1.0	
								GRA Bus	0.000	0.037	2.3	1.0	
Bus 85	11.000	84.701	5.7	0	0	0	0	09	0.000	-0.037	2.3	1.0	
								Ilorin Road Bus	0.000	0.037	2.3	1.0	
Bus 87	11.000	84.746	5.7	0	0	0	0	09	0.000	-0.021	1.3	0.9	
								NAPTIN Guest House 1 Bus	0.000	0.021	1.3	0.9	
Bus 89	11.000	83.546	6.3	0	0	0	0	10	0.000	-0.010	0.6	0.9	
								Monai Bus	0.000	0.010	0.6	0.9	
Bus 91	11.000	83.422	6.3	0	0	0	0	10	-0.001	-0.052	3.3	1.0	
								MESL Water Intake Bus	0.001	0.052	3.3	1.0	
Bus 93	11.000	83.393	6.3	0	0	0	0	10	-0.001	-0.062	3.9	1.0	
								Motel Annex Bus	0.001	0.062	3.9	1.0	
Bus 95	11.000	83.539	6.3	0	0	0	0	10	0.000	-0.013	0.8	0.8	
								SOQ Bus	0.000	0.013	0.8	0.8	
Bus 97	11.000	83.506	6.3	0	0	0	0	10	0.000	-0.024	1.5	1.0	
								Chinese Quaters Bus	0.000	0.024	1.5	1.0	
Bus 99	11.000	82.828	6.6	0	0	0	0	57	0.000	-0.014	0.9	0.9	
								Zaria Way Bus	0.000	0.014	0.9	0.9	
Bus 101	11.000	82.820	6.6	0	0	0	0	57	0.000	-0.016	1.0	0.9	
								Donia Camp Bus	0.000	0.016	1.0	0.9	
Bus 103	11.000	82.789	6.6	0	0	0	0	57	0.000	-0.025	1.6	1.0	
								Kadariko Bus	0.000	0.025	1.6	1.0	
Bus 106	11.000	81.912	7.1	0	0	0	0	61	-0.001	-0.100	6.4	1.1	
								Niger Water Plant Bus	0.001	0.100	6.4	1.1	
Bus 108	11.000	82.244	6.9	0	0	0	0	61	0.000	-0.017	1.1	0.9	
								Kuruwasa Bus	0.000	0.017	1.1	0.9	

LOAD FLOW REPORT (OFF-PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus 111	11.000	97.467	0.3	0	0	0	0	001	0.000	-0.043	2.3	1.0	
								Old Dogogari Bus	0.000	0.043	2.3	1.0	
Bus 113	11.000	97.477	0.3	0	0	0	0	001	0.000	-0.030	1.6	1.0	
								Koro Radio Bus	0.000	0.030	1.6	1.0	
Bus 116	11.000	96.719	0.7	0	0	0	0	004	0.000	-0.031	1.7	0.9	
								Koro 1 Bus	0.000	0.031	1.7	0.9	
Bus 119	11.000	95.819	1.0	0	0	0	0	006	-0.001	-0.060	3.3	1.0	
								New Qtrs Bus	0.001	0.060	3.3	1.0	
Bus 121	11.000	95.803	1.0	0	0	0	0	006	-0.001	-0.069	3.8	1.1	
								Army Engr Bus	0.001	0.069	3.8	1.1	
Bus 123	11.000	95.837	1.0	0	0	0	0	006	0.000	-0.041	2.3	0.9	
								Old Market Bus	0.000	0.041	2.3	0.9	
Bus 126	11.000	95.102	1.3	0	0	0	0	010	0.000	-0.050	2.8	1.0	
								SS 13 Manchester Bus	0.000	0.050	2.8	1.0	
Bus 128	11.000	95.135	1.3	0	0	0	0	010	0.000	-0.025	1.4	0.9	
								Hydro Bus	0.000	0.025	1.4	0.9	
Bus 131	11.000	94.503	1.6	0	0	0	0	013	0.000	-0.038	2.1	1.1	
								Jobice Bus	0.000	0.038	2.1	1.1	
Bus 133	11.000	94.499	1.6	0	0	0	0	013	0.000	-0.039	2.2	0.9	
								Dantoro Road Bus	0.000	0.039	2.2	0.9	
Bus 135	11.000	94.508	1.6	0	0	0	0	013	0.000	-0.032	1.8	1.0	
								NIFFR Senior Qtrs 2 Bus	0.000	0.032	1.8	1.0	
Bus 138	11.000	94.016	1.8	0	0	0	0	017	0.000	-0.031	1.7	0.9	
								Jehovah Witness Bus	0.000	0.031	1.7	0.9	
Bus 140	11.000	93.987	1.8	0	0	0	0	017	-0.001	-0.049	2.8	1.2	
								Niger Water Booster Bus	0.001	0.049	2.8	1.2	
Bus 143	11.000	93.635	2.0	0	0	0	0	020	-0.001	-0.057	3.2	1.0	
								Agip Bus	0.001	0.057	3.2	1.0	
Bus 145	11.000	93.621	2.0	0	0	0	0	020	-0.001	-0.065	3.6	1.2	
								General Hospital Bus	0.001	0.065	3.6	1.2	
Bus 148	11.000	93.549	2.0	0	0	0	0	023	0.000	-0.039	2.2	1.1	
								Fisheries Sch. Bus	0.000	0.039	2.2	1.1	
Bus 152	11.000	96.874	0.6	0	0	0	0	0002	0.000	-0.014	0.8	1.0	
								Funkun Bus	0.000	0.014	0.8	1.0	
Bus 156	11.000	95.431	1.2	0	0	0	0	0005	0.000	-0.035	1.9	1.3	
								MTN Nassarawa Bus	0.000	0.035	1.9	1.3	
Bus 158	11.000	95.481	1.2	0	0	0	0	0005	0.000	-0.015	0.8	0.8	
								NAPTIN Sch. Bus	0.000	0.015	0.8	0.8	
Bus 161	11.000	94.876	1.5	0	0	0	0	0008	0.000	-0.031	1.7	0.8	

LOAD FLOW REPORT (OFF-PEAK PERIOD)

Bus	Voltage			Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Nassarawa 1 Bus	0.000	0.031	1.7	0.8	
Bus 164	11.000	94.486	1.6	0	0	0	0	0010	0.000	-0.024	1.3	1.0	
								Nassarawa Grinder Bus	0.000	0.024	1.3	1.0	
Bus 167	11.000	94.227	1.7	0	0	0	0	0012	0.000	-0.013	0.7	0.9	
								Sabo 1 Bus	0.000	0.013	0.7	0.9	
Bus 169	11.000	94.218	1.7	0	0	0	0	0012	0.000	-0.015	0.8	0.9	
								Sabo 2 Bus	0.000	0.015	0.8	0.9	
Bus 172	11.000	93.972	1.8	0	0	0	0	0015	0.000	-0.016	0.9	1.0	
								Awuru 2 Bus	0.000	0.016	0.9	1.0	
* Bus230	33.000	100.000	0.0	0.209	3.582	0	0	MAIN BUS	0.209	3.582	62.8	5.8	
Bussa Town Hall Bus	0.415	92.512	2.2	0	0	0.000	0.029	Bus 26	0.000	-0.029	44.0	0.9	
Catholic Church Bus	0.415	84.432	5.7	0	0	0.000	0.009	09	0.000	-0.009	15.3	0.8	
Chinese Quaters Bus	0.415	82.785	6.4	0	0	0.000	0.023	Bus 97	0.000	-0.023	39.3	0.9	
Clinic Bus	0.415	85.916	5.0	0	0	0.000	0.030	Bus 69	0.000	-0.030	48.6	0.9	
Corpra Below Bus	0.415	85.547	5.0	0	0	0.000	0.038	Bus 65	0.000	-0.038	62.5	0.9	
D4 Bus	0.415	86.085	4.9	0	0	0.000	0.027	08	0.000	-0.027	43.6	0.9	
Dantoro Lodge Bus	0.415	97.247	0.2	0	0	0.000	0.056	Bus 4	0.000	-0.056	79.5	0.9	
Dantoro Road Bus	0.415	94.078	1.7	0	0	0.000	0.039	Bus 133	0.000	-0.039	57.3	0.8	
Donia Camp Bus	0.415	82.680	6.6	0	0	0.000	0.016	Bus 101	0.000	-0.016	27.2	0.8	
Elshadai Bus	0.415	87.719	4.2	0	0	0.000	0.019	Bus 59	0.000	-0.019	29.7	0.8	
Emir's Guest House Bus	0.415	95.035	1.1	0	0	0.000	0.052	006	0.000	-0.052	76.7	0.8	
Fed Col of Wildlife Bus	0.415	95.148	1.2	0	0	0.000	0.021	0005	0.000	-0.021	30.5	0.9	
FGGC Bus	0.415	94.937	1.3	0	0	0.000	0.021	010	0.000	-0.021	31.5	0.9	
Fisheries Qtrs Bus	0.415	93.168	2.0	0	0	0.000	0.025	023	0.000	-0.025	36.7	0.9	
Fisheries Sch. Bus	0.415	92.846	2.1	0	0	0.000	0.038	Bus 148	0.000	-0.038	57.4	0.9	
Funkun Bus	0.415	96.502	0.6	0	0	0.000	0.014	Bus 152	0.000	-0.014	20.3	0.9	
GDSS Nassarawa Bus	0.415	93.178	1.7	0	0	0.000	0.025	0010	0.000	-0.025	37.7	0.9	
General Hospital Bus	0.415	92.436	2.1	0	0	0.001	0.064	Bus 145	-0.001	-0.064	96.7	0.9	
Govt. Sec Sch Bus	0.415	97.346	0.2	0	0	0.000	0.028	Bus 2	0.000	-0.028	40.7	0.9	
GRA Bus	0.415	83.952	5.8	0	0	0.000	0.037	Bus 83	0.000	-0.037	61.5	0.8	
Hangar Bus1	0.415	89.876	3.2	0	0	0.000	0.038	Bus 49	0.000	-0.038	59.0	0.9	
Hydro Bus	0.415	94.823	1.4	0	0	0.000	0.025	Bus 128	0.000	-0.025	37.1	0.8	
Ilorin Road Bus	0.415	84.259	5.8	0	0	0.000	0.036	Bus 85	0.000	-0.036	60.1	0.9	
Jehovah Witness Bus	0.415	93.682	1.9	0	0	0.000	0.031	Bus 138	0.000	-0.031	45.4	0.8	
Jobica Bus	0.415	93.473	1.7	0	0	0.000	0.038	Bus 131	0.000	-0.038	56.0	0.9	
Kadariko Bus	0.415	81.773	6.8	0	0	0.000	0.024	Bus 103	0.000	-0.024	41.5	0.8	
Kaduna Drive Bus	0.415	83.998	5.8	0	0	0.000	0.035	Bus 77	0.000	-0.035	58.2	0.9	
Katamaya Hospita Bus	0.415	82.906	6.3	0	0	0.000	0.025	10	0.000	-0.025	41.8	0.9	
KEYSTONE Bank Bus	0.415	92.222	2.2	0	0	0.000	0.026	Bus 30	0.000	-0.026	39.6	0.8	

LOAD FLOW REPORT (OFF-PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Kidagba Bus1	0.415	90.144	3.2	0	0	0.000	0.018	Bus 51	0.000	-0.018	28.1	0.9	
Koro 1 Bus	0.415	96.389	0.7	0	0	0.000	0.031	Bus 116	0.000	-0.031	44.9	0.8	
Koro Grinder Bus	0.415	95.926	0.7	0	0	0.000	0.031	004	0.000	-0.031	44.7	0.9	
Koro Radio Bus	0.415	96.693	0.4	0	0	0.000	0.030	Bus 113	0.000	-0.030	42.7	0.8	
Kuruwasa Bus	0.415	81.889	6.9	0	0	0.000	0.017	Bus 108	0.000	-0.017	29.0	0.8	
Kwarin Wali Bus	0.415	94.209	1.4	0	0	0.000	0.024	03	0.000	-0.024	35.1	0.9	
Lafia Spot Bus	0.415	92.459	2.0	0	0	0.000	0.029	017	0.000	-0.029	43.6	0.8	
Local Govt Qters Bus	0.415	95.926	0.7	0	0	0.000	0.031	02	0.000	-0.031	45.2	0.8	
Luma Road Bus	0.415	87.562	4.2	0	0	0.000	0.051	Bus 57	0.000	-0.051	81.2	0.8	
MAIN BUS	11.000	98.325	0.0	0	0	0	0	1	0.161	2.176	116.4	7.4	
								001	0.033	0.977	52.2	3.4	
								0001	0.012	0.370	19.8	3.2	
								Bus230	-0.205	-3.522	188.3	5.8	
Mammy market Bus	0.415	89.624	3.2	0	0	0.000	0.036	Bus 43	0.000	-0.036	56.4	0.9	
Manyara Bus	0.415	96.502	0.6	0	0	0.000	0.023	0002	0.000	-0.023	32.8	0.9	
MESL Water Intake Bus	0.415	82.781	6.4	0	0	0.000	0.052	Bus 91	0.000	-0.052	87.1	0.9	
MESL Water Reserv. Bus	0.415	89.894	3.2	0	0	0.000	0.043	05	0.000	-0.043	67.2	0.8	
MESL Water Treatment Bus	0.415	85.861	5.0	0	0	0.000	0.018	Bus 75	0.000	-0.018	29.6	0.8	
Mil Qtrs 1 Bus	0.415	94.486	1.4	0	0	0.000	0.042	Bus 24	0.000	-0.042	61.3	0.9	
Mil Qtrs 2 Bus	0.415	93.888	1.4	0	0	0.000	0.026	Bus 22	0.000	-0.026	38.1	0.8	
Monai Bus	0.415	82.915	6.3	0	0	0.000	0.010	Bus 89	0.000	-0.010	17.2	0.7	
Motel Annex Bus	0.415	82.635	6.4	0	0	0.000	0.061	Bus 93	0.000	-0.061	103.2	0.8	
MT Yard Bus1	0.415	89.842	3.2	0	0	0.000	0.018	Bus 45	0.000	-0.018	27.7	0.8	
MTN Bus	0.415	89.469	3.3	0	0	0.000	0.030	Bus 41	0.000	-0.030	46.8	0.9	
MTN Nassarawa Bus	0.415	94.133	1.5	0	0	0.000	0.035	Bus 156	0.000	-0.035	51.4	0.8	
MTN Wildlife Bus	0.415	94.062	1.1	0	0	0.000	0.039	0004	0.000	-0.039	57.5	0.9	
NAPTIN Guest House 1 Bus	0.415	84.332	5.7	0	0	0.000	0.021	Bus 87	0.000	-0.021	33.9	0.8	
NAPTIN Guest House 2 Bus	0.415	82.356	6.7	0	0	0.000	0.025	57	0.000	-0.025	42.1	0.9	
NAPTIN Sch. Bus	0.415	95.317	1.2	0	0	0.000	0.015	Bus 158	0.000	-0.015	22.3	0.8	
Nassarawa 1 Bus	0.415	94.537	1.5	0	0	0.000	0.031	Bus 161	0.000	-0.031	46.2	0.8	
Nassarawa 2 Bus	0.415	94.563	1.5	0	0	0.000	0.024	0008	0.000	-0.024	35.2	0.8	
Nassarawa Grinder Bus	0.415	93.846	1.7	0	0	0.000	0.023	Bus 164	0.000	-0.023	34.8	0.9	
National Park HQ Bus	0.415	96.817	0.4	0	0	0.000	0.030	0001	0.000	-0.030	43.5	0.8	
Nedufu Estate Bus	0.415	95.633	0.7	0	0	0.001	0.061	Bus 7	-0.001	-0.061	88.6	0.9	
New Qtrs Bus	0.415	95.173	1.1	0	0	0.001	0.060	Bus 119	-0.001	-0.060	87.8	0.9	
Ngaski Bus	0.415	88.058	4.1	0	0	0.000	0.018	07	0.000	-0.018	29.0	0.9	
NIFFR HQS Bus	0.415	96.280	0.6	0	0	0.000	0.042	Bus 9	0.000	-0.042	61.1	0.9	
NIFFR Junior Qtrs Bus	0.415	96.051	0.7	0	0	0.000	0.038	Bus 13	0.000	-0.038	55.0	0.9	
NIFFR Sec. Qtrs Bus	0.415	94.330	1.6	0	0	0.000	0.021	013	0.000	-0.021	30.7	0.9	

LOAD FLOW REPORT (OFF-PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
NIFFR Senior Qtrs 1 Bus	0.415	93.219	2.0	0	0	0.000	0.028	020	0.000	-0.028	41.6	0.9	
NIFFR Senior Qtrs 2 Bus	0.415	93.925	1.7	0	0	0.000	0.032	Bus 135	0.000	-0.032	47.6	0.8	
Niger Crescent Bus	0.415	85.600	5.0	0	0	0.000	0.019	Bus 71	0.000	-0.019	31.0	0.8	
Niger Rv Basin Bus	0.415	96.068	0.7	0	0	0.000	0.037	Bus 11	0.000	-0.037	54.1	0.8	
Niger Water Booster Bus	0.415	92.647	2.0	0	0	0.000	0.049	Bus 140	0.000	-0.049	72.9	0.9	
Niger Water Plant Bus	0.415	81.475	7.1	0	0	0.001	0.100	Bus 106	-0.001	-0.100	170.0	0.9	
Officers' Mess Bus	0.415	87.999	4.1	0	0	0.000	0.027	Bus 62	0.000	-0.027	42.8	0.9	
Old Army Barracks Bus	0.415	92.057	2.2	0	0	0.000	0.027	Bus 32	0.000	-0.027	41.1	0.9	
Old Dogogari Bus	0.415	96.720	0.4	0	0	0.000	0.042	Bus 111	0.000	-0.042	61.0	0.9	
Old Market Bus	0.415	95.395	1.1	0	0	0.000	0.041	Bus 123	0.000	-0.041	60.2	0.8	
Radar Bus	0.415	84.378	5.7	0	0	0.000	0.019	Bus 79	0.000	-0.019	30.8	0.9	
Sabo 1 Bus	0.415	94.004	1.8	0	0	0.000	0.013	Bus 167	0.000	-0.013	19.1	0.9	
Sabo 2 Bus	0.415	93.814	1.8	0	0	0.000	0.015	Bus 169	0.000	-0.015	22.0	0.8	
Sabo Grinder Bus	0.415	93.897	1.8	0	0	0.000	0.014	0012	0.000	-0.014	20.7	0.9	
Senior Camp C/T Bus	0.415	85.564	5.0	0	0	0.000	0.020	Bus 73	0.000	-0.020	32.3	0.8	
SNCO Bus	0.415	84.578	5.7	0	0	0.000	0.015	Bus 81	0.000	-0.015	25.3	0.9	
SOQ Bus	0.415	83.385	6.3	0	0	0.000	0.013	Bus 95	0.000	-0.013	21.1	0.8	
SS 13 Manchester Bus	0.415	94.562	1.4	0	0	0.000	0.050	Bus 126	0.000	-0.050	73.6	0.9	
SS 40 Roundabout Bus	0.415	96.866	0.4	0	0	0.000	0.036	001	0.000	-0.036	52.0	0.9	
Technical Jn Bus	0.415	96.688	0.3	0	0	0.001	0.066	1	-0.001	-0.066	95.2	0.8	
TFT Bus	0.415	87.955	4.1	0	0	0.000	0.021	Bus 53	0.000	-0.021	32.5	0.8	
Tudun Wali Bus	0.415	96.108	0.7	0	0	0.000	0.055	Bus 15	0.000	-0.055	80.2	0.8	
UBA Bus	0.415	89.931	3.2	0	0	0.000	0.021	Bus 39	0.000	-0.021	33.0	0.8	
Water Treatment Bus	0.415	87.654	4.2	0	0	0.000	0.039	Bus 61	0.000	-0.039	61.7	0.8	
Waziri Primary Sch Bus	0.415	92.027	2.3	0	0	0.001	0.058	Bus 34	-0.001	-0.058	87.9	0.9	
Yuna Bus	0.415	80.691	7.2	0	0	0.000	0.028	61	0.000	-0.028	49.0	0.8	
Zaria Way Bus	0.415	82.254	6.7	0	0	0.000	0.014	Bus 99	0.000	-0.014	23.4	0.7	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

Table 4.3: Branch Losses Report for New Bussa distribution network during Peak Period

Project:	PhD. PROJECT	ETAP 12.6.0H	Page:	1
Location:	NEW BUSSA - NIGER STATE		Date:	15-12-2019
Contract:			SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename:	NEW BUSSA SUBSTATION		Config.:	Normal

LOAD FLOW REPORT(PEAK PERIOD)

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
L-1	-0.863	-5.470	0.914	5.539	51.3	68.8	95.0	96.3	1.31
L- 2	0.001	0.056	-0.001	-0.056	0.0	0.0	95.0	95.0	0.02
L- 3	0.002	0.138	-0.002	-0.137	0.1	0.1	95.0	94.9	0.06
L-4	0.858	5.125	-0.746	-4.973	112.9	151.5	95.0	91.9	3.06
Technical Jn TR	0.002	0.152	-0.001	-0.147	0.8	4.3	95.0	92.2	2.72
L-001	-0.057	-1.490	0.072	1.510	14.9	20.0	95.0	96.3	1.31
L- 002	0.001	0.073	-0.001	-0.073	0.0	0.0	95.0	94.9	0.06
L- 003	0.000	0.043	0.000	-0.043	0.0	0.0	95.0	94.9	0.04
L-004	0.055	1.297	-0.043	-1.281	11.7	15.7	95.0	93.8	1.18
SS 40 Roundabout TR	0.001	0.076	-0.001	-0.075	0.2	1.1	95.0	93.6	1.37
L-0001	-0.025	-0.583	0.030	0.590	5.2	6.9	95.1	96.3	1.17
L-0002	0.024	0.546	-0.019	-0.540	5.0	6.7	95.1	93.9	1.20
National Park HQ TR	0.000	0.037	0.000	-0.037	0.1	0.4	95.1	94.1	1.00
L- 5	0.002	0.155	-0.002	-0.155	0.1	0.2	91.9	91.8	0.10
L- 6	0.002	0.130	-0.002	-0.130	0.1	0.1	91.9	91.8	0.08
L- 7	0.001	0.098	-0.001	-0.098	0.1	0.1	91.9	91.8	0.07
L- 8	0.002	0.117	-0.002	-0.117	0.1	0.1	91.9	91.8	0.10
L- 9	0.002	0.146	-0.002	-0.146	0.2	0.2	91.9	91.8	0.16
L-10	0.736	4.247	-0.570	-4.024	165.8	222.6	91.9	86.7	5.24
Local Govt. Qtars TR	0.001	0.080	-0.001	-0.078	0.4	1.9	91.9	89.7	2.22
L- 0003	0.000	0.034	0.000	-0.034	0.0	0.0	93.9	93.8	0.07
L-0004	0.018	0.462	-0.014	-0.457	4.2	5.7	93.9	92.7	1.18
Manyara TR	0.000	0.044	0.000	-0.043	0.1	0.4	93.9	93.1	0.79
L- 11	0.002	0.119	-0.002	-0.119	0.1	0.2	86.7	86.5	0.15
L- 12	0.002	0.140	-0.002	-0.139	0.2	0.3	86.7	86.5	0.18
L- 13	0.002	0.091	-0.001	-0.091	0.1	0.1	86.7	86.5	0.12
L- 14	0.002	0.124	-0.001	-0.123	0.2	0.2	86.7	86.5	0.17
L-15	0.562	3.480	-0.410	-3.276	152.2	204.3	86.7	81.2	5.50
Kwarin Wali TR	0.001	0.070	-0.001	-0.069	0.3	1.7	86.7	84.6	2.07
L- 16	0.002	0.117	-0.002	-0.117	0.2	0.3	81.2	81.0	0.19
L- 17	0.000	0.027	0.000	-0.027	0.0	0.0	81.2	81.1	0.05
L- 18	0.000	0.034	0.000	-0.034	0.0	0.0	81.2	81.1	0.07
L- 19	0.001	0.085	-0.001	-0.085	0.1	0.2	81.2	81.0	0.17
L- 20	0.004	0.198	-0.003	-0.197	0.7	1.0	81.2	80.8	0.40
L- 21	0.000	0.021	0.000	-0.021	0.0	0.0	81.2	81.1	0.04

LOAD FLOW REPORT(PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	% Drop in Vmag
L-22	0.402	2.748	-0.258	-2.556	143.0	192.0	81.2	75.1	6.08
Baba Ilorin Farm TR	0.001	0.045	0.000	-0.044	0.4	1.1	81.2	79.2	1.96
L- 005	0.001	0.062	-0.001	-0.062	0.0	0.0	93.8	93.7	0.06
L-006	0.042	1.161	-0.030	-1.145	11.8	15.9	93.8	92.5	1.31
Koro Grinder TR	0.001	0.058	-0.001	-0.057	0.2	1.0	93.8	92.2	1.58
L-0005	0.014	0.416	-0.010	-0.411	3.6	4.9	92.7	91.6	1.11
MTN Wildlife TR	0.001	0.041	0.000	-0.040	0.2	1.0	92.7	90.5	2.26
L- 23	0.000	0.025	0.000	-0.025	0.0	0.0	75.1	75.0	0.06
L- 24	0.000	0.030	0.000	-0.030	0.0	0.0	75.1	75.0	0.07
L- 25	0.001	0.089	-0.001	-0.088	0.2	0.2	75.1	74.9	0.21
L- 26	0.001	0.061	-0.001	-0.061	0.1	0.1	75.1	74.9	0.14
L - 27	0.002	0.109	-0.001	-0.109	0.3	0.4	75.1	74.8	0.26
L - 28	0.001	0.075	-0.001	-0.075	0.1	0.2	75.1	74.9	0.18
L - 29	0.001	0.069	-0.001	-0.069	0.1	0.2	75.1	74.9	0.17
L-30	0.251	2.021	-0.151	-1.887	100.0	134.2	75.1	69.8	5.30
MESL Water Reserviour TR	0.001	0.078	-0.001	-0.077	0.2	1.1	75.1	74.0	1.07
L- 0006	0.000	0.034	0.000	-0.034	0.0	0.0	91.6	91.5	0.09
L- 0007	0.000	0.022	0.000	-0.022	0.0	0.0	91.6	91.6	0.06
L-0008	0.009	0.323	-0.006	-0.319	2.6	3.5	91.6	90.6	1.02
Fed Col of Wildlife TR	0.000	0.032	0.000	-0.032	0.0	0.2	91.6	91.0	0.60
L- 007	0.001	0.076	-0.001	-0.076	0.1	0.1	92.5	92.4	0.09
L- 008	0.001	0.075	-0.001	-0.075	0.1	0.1	92.5	92.4	0.10
L- 009	0.001	0.067	-0.001	-0.067	0.0	0.1	92.5	92.4	0.09
L-010	0.027	0.861	-0.019	-0.851	7.9	10.6	92.5	91.3	1.15
Emir's Guest House TR	0.001	0.065	-0.001	-0.065	0.2	0.8	92.5	91.4	1.09
L- 31	0.001	0.071	-0.001	-0.070	0.1	0.2	69.8	69.6	0.19
L- 32	0.001	0.043	-0.001	-0.043	0.1	0.1	69.8	69.7	0.12
L- 33	0.002	0.117	-0.002	-0.116	0.4	0.5	69.8	69.5	0.33
L- 34	0.001	0.046	-0.001	-0.046	0.1	0.1	69.8	69.7	0.13
L- 35	0.001	0.067	-0.001	-0.067	0.1	0.2	69.8	69.6	0.19
L- 36	0.001	0.099	-0.001	-0.098	0.3	0.4	69.8	69.5	0.29
L-37	0.144	1.390	-0.083	-1.309	60.5	81.3	69.8	65.5	4.30
Ngaski TR	0.001	0.054	0.000	-0.054	0.1	0.6	69.8	69.0	0.80
L- 38	0.001	0.066	-0.001	-0.066	0.2	0.2	65.5	65.3	0.21
L- 39	0.001	0.042	0.000	-0.042	0.1	0.1	65.5	65.4	0.13
L- 40	0.001	0.044	-0.001	-0.044	0.1	0.1	65.5	65.3	0.14
L- 41	0.001	0.036	0.000	-0.036	0.0	0.1	65.5	65.4	0.12

LOAD FLOW REPORT(PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
L- 42	0.001	0.035	0.000	-0.035	0.0	0.1	65.5	65.4	0.12
L- 43	0.001	0.043	-0.001	-0.043	0.1	0.1	65.5	65.3	0.15
L-44	0.079	0.983	-0.041	-0.933	37.7	50.6	65.5	62.0	3.51
D4 TR	0.001	0.059	-0.001	-0.058	0.2	0.8	65.5	64.6	0.92
L- 0009	0.000	0.044	0.000	-0.044	0.1	0.1	90.6	90.5	0.14
L-0010	0.006	0.243	-0.004	-0.240	1.6	2.2	90.6	89.8	0.83
Nassarawa 2 TR	0.000	0.033	0.000	-0.032	0.0	0.2	90.6	90.0	0.58
L- 45	0.001	0.058	-0.001	-0.058	0.1	0.2	62.0	61.8	0.21
L- 46	0.001	0.052	-0.001	-0.051	0.1	0.2	62.0	61.8	0.19
L- 47	0.001	0.054	-0.001	-0.054	0.1	0.2	62.0	61.8	0.20
L- 48	0.001	0.052	-0.001	-0.051	0.1	0.2	62.0	61.8	0.19
L- 49	0.001	0.062	-0.001	-0.062	0.2	0.2	62.0	61.7	0.25
L- 50	0.000	0.027	0.000	-0.027	0.0	0.0	62.0	61.9	0.11
L-51	0.036	0.605	-0.019	-0.582	17.3	23.3	62.0	59.5	2.46
Catholic Church TR	0.000	0.022	0.000	-0.022	0.1	0.4	62.0	60.8	1.22
L- 52	0.000	0.022	0.000	-0.022	0.0	0.0	59.5	59.4	0.09
L- 53	0.001	0.043	0.000	-0.042	0.1	0.1	59.5	59.3	0.18
L- 54	0.001	0.052	-0.001	-0.052	0.1	0.2	59.5	59.3	0.22
L- 55	0.001	0.045	0.000	-0.045	0.1	0.1	59.5	59.3	0.19
L- 56	0.001	0.037	-0.001	-0.037	0.1	0.1	59.5	59.4	0.15
L-57	0.016	0.349	-0.009	-0.340	6.5	8.7	59.5	58.0	1.52
Katamaya Hospital TR	0.000	0.034	0.000	-0.033	0.2	0.7	59.5	58.2	1.27
L- 011	0.001	0.071	-0.001	-0.071	0.1	0.1	91.3	91.2	0.10
L- 012	0.001	0.058	-0.001	-0.058	0.0	0.1	91.3	91.2	0.08
L-013	0.017	0.678	-0.012	-0.671	5.2	6.9	91.3	90.4	0.95
FGGC TR	0.000	0.044	0.000	-0.044	0.0	0.2	91.3	90.8	0.49
L- 0011	0.000	0.037	0.000	-0.037	0.0	0.1	89.8	89.6	0.13
L-0012	0.003	0.173	-0.002	-0.171	1.0	1.3	89.8	89.1	0.69
GDSS Nassarawa TR	0.000	0.031	0.000	-0.030	0.1	0.6	89.8	88.0	1.75
L- 0013	0.000	0.030	0.000	-0.030	0.0	0.0	89.1	89.0	0.12
L- 0014	0.001	0.044	0.000	-0.044	0.1	0.1	89.1	88.9	0.19
L-0015	0.001	0.063	-0.001	-0.063	0.2	0.3	89.1	88.7	0.41
Sabo Grinder TR	0.000	0.034	0.000	-0.033	0.1	0.4	89.1	88.1	0.96
L- 014	0.001	0.043	-0.001	-0.043	0.0	0.0	90.4	90.3	0.06
L- 015	0.001	0.067	-0.001	-0.067	0.1	0.1	90.4	90.3	0.10
L- 016	0.001	0.047	0.000	-0.047	0.0	0.0	90.4	90.3	0.07
L-017	0.010	0.466	-0.007	-0.462	2.8	3.8	90.4	89.6	0.74

LOAD FLOW REPORT(PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
NIFFR Sec. Qtrs TR	0.000	0.048	0.000	-0.047	0.1	0.3	90.4	89.8	0.54
L- 0016	0.000	0.033	0.000	-0.033	0.1	0.1	88.7	88.5	0.22
Awuru 1 TR	0.000	0.031	0.000	-0.030	0.1	0.2	88.7	88.1	0.61
L- 018	0.001	0.065	-0.001	-0.064	0.1	0.1	89.6	89.5	0.10
L- 019	0.001	0.061	-0.001	-0.061	0.0	0.1	89.6	89.5	0.10
L-020	0.005	0.292	-0.004	-0.291	1.2	1.5	89.6	89.2	0.48
Lafia Spot TR	0.001	0.044	0.000	-0.043	0.2	1.2	89.6	87.1	2.52
L- 021	0.001	0.066	-0.001	-0.066	0.1	0.1	89.2	89.0	0.11
L- 022	0.001	0.065	-0.001	-0.065	0.1	0.1	89.2	89.0	0.11
L-023	0.001	0.112	-0.001	-0.112	0.2	0.3	89.2	89.0	0.21
NIFFR Senior Qtrs 1 TR	0.001	0.048	0.000	-0.047	0.1	0.5	89.2	88.2	0.91
L- 024	0.001	0.053	-0.001	-0.053	0.0	0.1	89.0	88.9	0.10
Fisheries Qtrs TR	0.001	0.058	-0.001	-0.058	0.1	0.7	89.0	87.8	1.12
L- 58	0.001	0.039	-0.001	-0.039	0.1	0.1	58.0	57.8	0.18
L- 59	0.000	0.038	0.000	-0.037	0.1	0.1	58.0	57.8	0.17
L- 60	0.001	0.045	-0.001	-0.045	0.1	0.2	58.0	57.8	0.22
L-61	0.007	0.194	-0.004	-0.190	2.6	3.4	58.0	56.9	1.05
NAPTIN Guest House 2 TR	0.000	0.025	0.000	-0.025	0.1	0.3	58.0	57.2	0.75
L- 62	0.002	0.101	-0.001	-0.100	0.8	1.0	56.9	56.4	0.59
L- 63	0.001	0.037	0.000	-0.037	0.1	0.1	56.9	56.7	0.22
Yuna TR	0.002	0.052	0.000	-0.049	1.3	3.9	56.9	52.7	4.27
Agip TR	-0.001	-0.065	0.001	0.066	0.1	0.6	88.3	89.0	0.75
Aligani TR1	-0.001	-0.106	0.001	0.109	0.4	2.2	73.3	74.8	1.48
Anglican Church 1 TR	-0.001	-0.116	0.002	0.119	0.6	3.2	84.2	86.5	2.34
Anglican Church 2 TR	-0.001	-0.137	0.002	0.139	0.5	2.7	84.8	86.5	1.65
Army Engineer TR	-0.001	-0.074	0.001	0.075	0.2	1.1	91.0	92.4	1.39
Awuru 2 TR	0.000	-0.032	0.000	0.033	0.1	0.2	87.8	88.5	0.65
Baba Ilorin House TR	0.000	-0.026	0.000	0.027	0.1	0.6	79.4	81.1	1.70
BF 1 TR	0.000	-0.041	0.001	0.043	0.4	2.0	66.5	69.7	3.18
Borgu Community Bank TR	0.000	-0.021	0.000	0.021	0.1	0.4	79.8	81.1	1.35
BSW TR	0.000	-0.041	0.000	0.042	0.1	0.5	64.6	65.4	0.73
Govt. Sec Sch TR	0.001	0.056	0.000	-0.055	0.1	0.6	95.0	93.9	1.00
Dantoro Lodge TR	0.002	0.137	-0.001	-0.135	0.4	2.1	94.9	93.4	1.48
Nedufu Estate TR	0.002	0.155	-0.001	-0.150	1.0	4.9	91.8	88.9	2.88
NIFFR HQS TR	0.002	0.130	-0.001	-0.128	0.4	2.1	91.8	90.4	1.45
Niger River Basin TR	0.001	0.098	-0.001	-0.096	0.4	2.0	91.8	90.0	1.83
NIFFR Junior Qtrs TR	0.002	0.117	-0.001	-0.114	0.5	2.8	91.8	89.6	2.17

LOAD FLOW REPORT(PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Tudun Wali TR	0.002	0.146	-0.001	-0.143	0.5	2.6	91.8	90.1	1.62
Mil Quarters 2 TR	0.001	0.091	-0.001	-0.087	0.7	3.8	86.5	83.0	3.59
Mil Quarters 1 TR	0.001	0.123	-0.001	-0.122	0.4	1.5	86.5	85.5	1.02
Bussa Town Hall TR	0.002	0.117	-0.001	-0.115	0.5	1.5	81.0	80.0	1.01
KEYSTONE Bank TR	0.000	0.034	0.000	-0.033	0.1	0.3	81.1	80.4	0.74
Old Army Barracks TR	0.001	0.085	-0.001	-0.083	0.4	2.5	81.0	78.6	2.39
Waziri Primary Sch TR	0.003	0.197	-0.002	-0.191	1.2	6.1	80.8	78.3	2.50
UBA TR	0.000	0.025	0.000	-0.025	0.1	0.2	75.0	74.4	0.58
MTN TR	0.000	0.030	0.000	-0.029	0.1	0.4	75.0	74.0	1.02
Mammy market TR	0.001	0.088	-0.001	-0.086	0.5	2.4	74.9	72.9	2.01
MT Yard TR1	0.001	0.061	0.000	-0.059	0.3	1.7	74.9	72.9	2.07
Hanger TR1	0.001	0.075	-0.001	-0.074	0.2	1.0	74.9	73.9	1.02
Kidagba TR1	0.001	0.069	-0.001	-0.068	0.2	0.9	74.9	74.0	0.94
TFT TR	0.001	0.070	-0.001	-0.069	0.4	1.2	69.6	68.4	1.19
Luma Road TR	0.002	0.116	-0.001	-0.113	0.6	2.9	69.5	67.7	1.71
Elshadai TR	0.001	0.046	0.000	-0.045	0.3	1.0	69.7	68.1	1.58
Water Treatment TR	0.001	0.067	-0.001	-0.066	0.3	1.1	69.6	68.4	1.14
Officers' Mess TR	0.001	0.098	-0.001	-0.097	0.3	1.4	69.5	68.5	0.96
Corpra Below TR	0.001	0.066	-0.001	-0.064	0.3	1.7	65.3	63.6	1.72
Clinic TR	0.001	0.044	0.000	-0.043	0.1	0.5	65.3	64.5	0.80
Niger Crescent TR	0.000	0.036	0.000	-0.035	0.2	1.0	65.4	63.5	1.88
Senior Camp C/T TR	0.000	0.035	0.000	-0.034	0.2	1.0	65.4	63.5	1.83
MESL Water Treatment TR	0.001	0.043	0.000	-0.042	0.3	1.0	65.3	63.8	1.54
Kaduna Drive TR	0.001	0.058	-0.001	-0.056	0.3	1.5	61.8	60.2	1.60
Rader TR	0.001	0.051	0.000	-0.050	0.2	1.2	61.8	60.4	1.42
SNCO TR	0.001	0.054	0.000	-0.053	0.2	0.8	61.8	60.9	0.89
GRA TR	0.001	0.051	0.000	-0.050	0.2	1.2	61.8	60.4	1.42
Ilorin Road TR	0.001	0.062	-0.001	-0.061	0.2	1.0	61.7	60.7	1.03
NAPTIN Guest House 1 TR	0.000	0.027	0.000	-0.027	0.1	0.3	61.9	61.1	0.75
Monai TR	0.000	0.022	0.000	-0.021	0.1	0.7	59.4	57.5	1.91
MESL Water Intake TR	0.000	0.042	0.000	-0.042	0.1	0.5	59.3	58.6	0.73
Motel Annex TR	0.001	0.052	0.000	-0.051	0.2	0.8	59.3	58.4	0.90
SOQ TR	0.000	0.045	0.000	-0.045	0.1	0.6	59.3	58.6	0.78
Chinese Quters TR	0.001	0.037	0.000	-0.036	0.2	1.0	59.4	57.8	1.58
Zaria Way TR	0.001	0.039	0.000	-0.037	0.3	1.5	57.8	55.5	2.27
Donia Camp TR	0.000	0.037	0.000	-0.037	0.1	0.3	57.8	57.4	0.46
Kadariko TR	0.001	0.045	0.000	-0.043	0.4	2.0	57.8	55.1	2.63

LOAD FLOW REPORT(PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Niger Water Plant TR	0.001	0.100	-0.001	-0.099	0.3	1.1	56.4	55.7	0.64
Kuruwasa TR	0.000	0.037	0.000	-0.036	0.1	0.7	56.7	55.6	1.10
Old Dogogari TR	0.001	0.073	-0.001	-0.072	0.2	1.0	94.9	93.6	1.31
Koro Radio TR	0.000	0.043	0.000	-0.043	0.1	0.5	94.9	93.8	1.17
Koro 1 TR	0.001	0.062	0.000	-0.062	0.1	0.4	93.7	93.1	0.68
New Quarters TR	0.001	0.076	-0.001	-0.075	0.1	0.7	92.4	91.5	0.84
Old Market TR	0.001	0.067	-0.001	-0.067	0.1	0.5	92.4	91.6	0.75
SS 13 Manchester TR	0.001	0.071	-0.001	-0.070	0.1	0.6	91.2	90.4	0.80
Hydro TR	0.001	0.058	0.000	-0.058	0.2	0.5	91.2	90.5	0.75
Jobice TR	0.001	0.043	0.000	-0.043	0.1	0.6	90.3	89.1	1.23
Dantoro Road TR	0.001	0.067	-0.001	-0.066	0.1	0.6	90.3	89.5	0.76
NIFFR Senior Qtrs 2 TR	0.000	0.047	0.000	-0.047	0.1	0.5	90.3	89.4	0.90
Jehovah Witness TR	0.001	0.064	-0.001	-0.064	0.1	0.5	89.5	88.8	0.74
Niger Water Booster TR	0.001	0.061	-0.001	-0.060	0.2	1.2	89.5	87.8	1.74
General Hospital TR	0.001	0.065	-0.001	-0.064	0.2	0.9	89.0	87.8	1.25
Fisheries Sch. TR	0.001	0.053	0.000	-0.053	0.1	0.6	88.9	87.8	1.02
Funkun TR	0.000	0.034	0.000	-0.033	0.1	0.3	93.8	92.9	0.92
MTN Nassarawa TR	0.000	0.034	0.000	-0.034	0.2	0.5	91.5	90.2	1.32
NAPTIN School TR	0.000	0.022	0.000	-0.022	0.0	0.1	91.6	91.3	0.24
Nassarawa 1 TR	0.000	0.044	0.000	-0.044	0.0	0.2	90.5	90.0	0.50
Nassarawa Grinder TR	0.000	0.037	0.000	-0.037	0.1	0.4	89.6	88.6	1.06
Sabo 1 TR	0.000	0.030	0.000	-0.030	0.0	0.2	89.0	88.4	0.55
Sabo 2 TR	0.000	0.044	0.000	-0.043	0.1	0.6	88.9	87.6	1.26
Power Transformer	1.032	7.937	-1.016	-7.639	16.1	298.5	100.0	96.3	3.72
					978.0	1674.3			

Table 4.4: Branch Losses Report for New Bussa distribution network during Off-Peak Period

Project:	PhD. PROJECT	ETAP	Page:	1
Location:	NEW BUSSA - NIGER STATE	12.6.0H	Date:	15-12-2019
Contract:			SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename:	NEW BUSSA SUBSTATION 2		Config.:	Normal

LOAD FLOW REPORT (OFF-PEAK PERIOD)

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
L-1	-0.153	-2.166	0.161	2.176	7.4	10.0	97.9	98.3	0.47
L- 2	0.000	0.029	0.000	-0.029	0.0	0.0	97.9	97.8	0.01
L- 3	0.001	0.056	-0.001	-0.056	0.0	0.0	97.9	97.8	0.02
L-4	0.152	2.014	-0.136	-1.993	16.1	21.6	97.9	96.8	1.10
Technical Jn TR	0.001	0.067	-0.001	-0.066	0.2	0.8	97.9	96.7	1.17
L-001	-0.027	-0.969	0.033	0.977	6.0	8.0	97.5	98.3	0.82
L- 002	0.000	0.043	0.000	-0.043	0.0	0.0	97.5	97.5	0.04
L- 003	0.000	0.030	0.000	-0.030	0.0	0.0	97.5	97.5	0.03
L-004	0.026	0.859	-0.021	-0.853	4.9	6.5	97.5	96.7	0.76
SS 40 Roundabout TR	0.000	0.036	0.000	-0.036	0.0	0.2	97.5	96.9	0.64
L-0001	-0.010	-0.368	0.012	0.370	1.9	2.6	97.6	98.3	0.71
L-0002	0.010	0.337	-0.008	-0.335	1.8	2.4	97.6	96.9	0.71
National Park HQ TR	0.000	0.031	0.000	-0.030	0.0	0.2	97.6	96.8	0.80
L- 5	0.001	0.062	-0.001	-0.062	0.0	0.0	96.8	96.7	0.04
L- 6	0.000	0.043	0.000	-0.043	0.0	0.0	96.8	96.7	0.03
L- 7	0.000	0.038	0.000	-0.038	0.0	0.0	96.8	96.7	0.02
L- 8	0.000	0.038	0.000	-0.038	0.0	0.0	96.8	96.7	0.03
L- 9	0.001	0.056	-0.001	-0.056	0.0	0.0	96.8	96.7	0.06
L-10	0.133	1.725	-0.109	-1.693	24.1	32.4	96.8	94.9	1.90
Local Govt. Qters TR	0.000	0.031	0.000	-0.031	0.1	0.3	96.8	95.9	0.83
L- 0003	0.000	0.014	0.000	-0.014	0.0	0.0	96.9	96.9	0.03
L-0004	0.007	0.298	-0.006	-0.295	1.6	2.2	96.9	96.2	0.73
Manyara TR	0.000	0.023	0.000	-0.023	0.0	0.1	96.9	96.5	0.40
L- 11	0.000	0.034	0.000	-0.034	0.0	0.0	94.9	94.8	0.04
L- 12	0.000	0.044	0.000	-0.044	0.0	0.0	94.9	94.8	0.05
L- 13	0.000	0.026	0.000	-0.026	0.0	0.0	94.9	94.8	0.03
L- 14	0.000	0.042	0.000	-0.042	0.0	0.0	94.9	94.8	0.05
L-15	0.107	1.523	-0.083	-1.491	23.8	32.0	94.9	92.8	2.08
Kwarin Wali TR	0.000	0.024	0.000	-0.024	0.0	0.2	94.9	94.2	0.65
L- 16	0.000	0.029	0.000	-0.029	0.0	0.0	92.8	92.7	0.04
L- 17	0.000	0.008	0.000	-0.008	0.0	0.0	92.8	92.8	0.01
L- 18	0.000	0.026	0.000	-0.026	0.0	0.0	92.8	92.7	0.05
L- 19	0.000	0.027	0.000	-0.027	0.0	0.0	92.8	92.7	0.05
L- 20	0.001	0.059	-0.001	-0.059	0.0	0.1	92.8	92.7	0.10
L- 21	0.000	0.013	0.000	-0.013	0.0	0.0	92.8	92.8	0.02

LOAD FLOW REPORT (OFF-PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
L-22	0.081	1.299	-0.057	-1.266	24.0	32.3	92.8	90.4	2.39
Baba Ilorin Farm TR	0.000	0.029	0.000	-0.029	0.1	0.3	92.8	91.7	1.11
L- 005	0.000	0.031	0.000	-0.031	0.0	0.0	96.7	96.7	0.03
L-006	0.020	0.791	-0.015	-0.784	5.1	6.9	96.7	95.9	0.86
Koro Grinder TR	0.000	0.031	0.000	-0.031	0.1	0.3	96.7	95.9	0.82
L-0005	0.005	0.256	-0.004	-0.254	1.3	1.7	96.2	95.5	0.65
MTN Wildlife TR	0.001	0.040	0.000	-0.039	0.2	0.9	96.2	94.1	2.12
L- 23	0.000	0.021	0.000	-0.021	0.0	0.0	90.4	90.3	0.04
L- 24	0.000	0.030	0.000	-0.030	0.0	0.0	90.4	90.3	0.06
L- 25	0.000	0.037	0.000	-0.037	0.0	0.0	90.4	90.3	0.07
L- 26	0.000	0.018	0.000	-0.018	0.0	0.0	90.4	90.4	0.04
L - 27	0.000	0.047	0.000	-0.047	0.0	0.0	90.4	90.3	0.09
L - 28	0.000	0.038	0.000	-0.038	0.0	0.0	90.4	90.3	0.08
L - 29	0.000	0.018	0.000	-0.018	0.0	0.0	90.4	90.4	0.04
L-30	0.055	1.013	-0.037	-0.990	17.1	23.0	90.4	88.3	2.12
MESL Water Reserviour TR	0.000	0.044	0.000	-0.043	0.0	0.2	90.4	89.9	0.49
L- 0006	0.000	0.035	0.000	-0.035	0.0	0.0	95.5	95.4	0.09
L- 0007	0.000	0.015	0.000	-0.015	0.0	0.0	95.5	95.5	0.04
L-0008	0.003	0.182	-0.002	-0.181	0.8	1.0	95.5	95.0	0.55
Fed Col of Wildlife TR	0.000	0.021	0.000	-0.021	0.0	0.1	95.5	95.1	0.37
L- 007	0.001	0.061	-0.001	-0.060	0.0	0.0	95.9	95.8	0.07
L- 008	0.001	0.069	-0.001	-0.069	0.0	0.1	95.9	95.8	0.09
L- 009	0.000	0.042	0.000	-0.041	0.0	0.0	95.9	95.8	0.05
L-010	0.013	0.560	-0.010	-0.556	3.1	4.1	95.9	95.2	0.72
Emir's Guest House TR	0.001	0.053	0.000	-0.052	0.1	0.5	95.9	95.0	0.85
L- 31	0.000	0.021	0.000	-0.021	0.0	0.0	88.3	88.2	0.04
L- 32	0.000	0.024	0.000	-0.024	0.0	0.0	88.3	88.2	0.05
L- 33	0.001	0.051	0.000	-0.051	0.0	0.1	88.3	88.2	0.11
L- 34	0.000	0.019	0.000	-0.019	0.0	0.0	88.3	88.2	0.04
L- 35	0.000	0.039	0.000	-0.039	0.0	0.0	88.3	88.2	0.09
L- 36	0.000	0.027	0.000	-0.027	0.0	0.0	88.3	88.2	0.06
L-37	0.035	0.790	-0.023	-0.774	12.1	16.3	88.3	86.4	1.87
Ngaski TR	0.000	0.018	0.000	-0.018	0.0	0.0	88.3	88.1	0.21
L- 38	0.000	0.039	0.000	-0.039	0.0	0.0	86.4	86.3	0.09
L- 39	0.000	0.014	0.000	-0.014	0.0	0.0	86.4	86.4	0.03
L- 40	0.000	0.030	0.000	-0.030	0.0	0.0	86.4	86.3	0.07
L- 41	0.000	0.019	0.000	-0.019	0.0	0.0	86.4	86.4	0.05

LOAD FLOW REPORT (OFF-PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
L- 42	0.000	0.020	0.000	-0.020	0.0	0.0	86.4	86.4	0.05
L- 43	0.000	0.018	0.000	-0.018	0.0	0.0	86.4	86.4	0.05
L-44	0.022	0.606	-0.013	-0.595	8.2	11.0	86.4	84.8	1.60
D4 TR	0.000	0.027	0.000	-0.027	0.0	0.1	86.4	86.1	0.32
L- 0009	0.000	0.032	0.000	-0.031	0.0	0.0	95.0	94.9	0.10
L-0010	0.002	0.126	-0.002	-0.125	0.4	0.5	95.0	94.6	0.41
Nassarawa 2 TR	0.000	0.024	0.000	-0.024	0.0	0.1	95.0	94.6	0.41
L- 45	0.000	0.035	0.000	-0.035	0.0	0.0	84.8	84.7	0.09
L- 46	0.000	0.019	0.000	-0.019	0.0	0.0	84.8	84.8	0.05
L- 47	0.000	0.015	0.000	-0.015	0.0	0.0	84.8	84.8	0.04
L- 48	0.000	0.037	0.000	-0.037	0.0	0.0	84.8	84.7	0.10
L- 49	0.000	0.037	0.000	-0.037	0.0	0.0	84.8	84.7	0.10
L- 50	0.000	0.021	0.000	-0.021	0.0	0.0	84.8	84.7	0.06
L-51	0.012	0.422	-0.007	-0.416	4.5	6.0	84.8	83.6	1.23
Catholic Church TR	0.000	0.009	0.000	-0.009	0.0	0.0	84.8	84.4	0.37
L- 52	0.000	0.010	0.000	-0.010	0.0	0.0	83.6	83.5	0.03
L- 53	0.001	0.052	-0.001	-0.052	0.1	0.1	83.6	83.4	0.15
L- 54	0.001	0.062	-0.001	-0.062	0.1	0.1	83.6	83.4	0.18
L- 55	0.000	0.013	0.000	-0.013	0.0	0.0	83.6	83.5	0.04
L- 56	0.000	0.024	0.000	-0.024	0.0	0.0	83.6	83.5	0.07
L-57	0.005	0.230	-0.004	-0.228	1.4	1.9	83.6	82.9	0.70
Katamaya Hospital TR	0.000	0.025	0.000	-0.025	0.1	0.2	83.6	82.9	0.67
L- 011	0.001	0.050	0.000	-0.050	0.0	0.0	95.2	95.1	0.07
L- 012	0.000	0.025	0.000	-0.025	0.0	0.0	95.2	95.1	0.03
L-013	0.009	0.458	-0.007	-0.456	2.2	2.9	95.2	94.6	0.61
FGGC TR	0.000	0.022	0.000	-0.021	0.0	0.1	95.2	94.9	0.23
L- 0011	0.000	0.024	0.000	-0.024	0.0	0.0	94.6	94.5	0.08
L-0012	0.001	0.076	-0.001	-0.076	0.2	0.2	94.6	94.3	0.29
GDSS Nassarawa TR	0.000	0.026	0.000	-0.025	0.1	0.4	94.6	93.2	1.39
L- 0013	0.000	0.013	0.000	-0.013	0.0	0.0	94.3	94.2	0.05
L- 0014	0.000	0.015	0.000	-0.015	0.0	0.0	94.3	94.2	0.06
L-0015	0.000	0.034	0.000	-0.034	0.1	0.1	94.3	94.1	0.21
Sabo Grinder TR	0.000	0.014	0.000	-0.014	0.0	0.1	94.3	93.9	0.38
L- 014	0.000	0.038	0.000	-0.038	0.0	0.0	94.6	94.5	0.05
L- 015	0.000	0.039	0.000	-0.039	0.0	0.0	94.6	94.5	0.06
L- 016	0.000	0.032	0.000	-0.032	0.0	0.0	94.6	94.5	0.05
L-017	0.005	0.325	-0.004	-0.324	1.2	1.7	94.6	94.1	0.49

LOAD FLOW REPORT (OFF-PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
NIFFR Sec. Qtrs TR	0.000	0.021	0.000	-0.021	0.0	0.0	94.6	94.3	0.23
L- 0016	0.000	0.016	0.000	-0.016	0.0	0.0	94.1	94.0	0.10
Awuru 1 TR	0.000	0.018	0.000	-0.018	0.0	0.1	94.1	93.7	0.33
L- 018	0.000	0.031	0.000	-0.031	0.0	0.0	94.1	94.0	0.05
L- 019	0.001	0.049	-0.001	-0.049	0.0	0.0	94.1	94.0	0.08
L-020	0.003	0.214	-0.002	-0.213	0.6	0.8	94.1	93.7	0.33
Lafia Spot TR	0.000	0.030	0.000	-0.029	0.1	0.5	94.1	92.5	1.60
L- 021	0.001	0.057	-0.001	-0.057	0.0	0.1	93.7	93.6	0.09
L- 022	0.001	0.065	-0.001	-0.065	0.1	0.1	93.7	93.6	0.11
L-023	0.001	0.063	-0.001	-0.063	0.1	0.1	93.7	93.6	0.11
NIFFR Senior Qtrs 1 TR	0.000	0.028	0.000	-0.028	0.0	0.2	93.7	93.2	0.51
L- 024	0.000	0.039	0.000	-0.039	0.0	0.0	93.6	93.5	0.07
Fisheries Qtrs TR	0.000	0.025	0.000	-0.025	0.0	0.1	93.6	93.2	0.45
L- 58	0.000	0.014	0.000	-0.014	0.0	0.0	82.9	82.8	0.04
L- 59	0.000	0.016	0.000	-0.016	0.0	0.0	82.9	82.8	0.05
L- 60	0.000	0.025	0.000	-0.025	0.0	0.0	82.9	82.8	0.08
L-61	0.003	0.148	-0.002	-0.147	0.7	1.0	82.9	82.3	0.56
NAPTIN Guest House 2 TR	0.000	0.025	0.000	-0.025	0.0	0.2	82.9	82.4	0.52
L- 62	0.001	0.101	-0.001	-0.100	0.4	0.5	82.3	81.9	0.40
L- 63	0.000	0.017	0.000	-0.017	0.0	0.0	82.3	82.2	0.07
Yuna TR	0.000	0.029	0.000	-0.028	0.2	0.6	82.3	80.7	1.63
Agip TR	0.000	-0.056	0.001	0.057	0.1	0.4	93.0	93.6	0.62
Aligani TR1	0.000	-0.046	0.000	0.047	0.1	0.3	89.8	90.3	0.53
Anglican Church 1 TR	0.000	-0.033	0.000	0.034	0.0	0.2	94.2	94.8	0.60
Anglican Church 2 TR	0.000	-0.044	0.000	0.044	0.0	0.2	94.3	94.8	0.48
Army Engineer TR	-0.001	-0.068	0.001	0.069	0.2	0.9	94.6	95.8	1.23
Awuru 2 TR	0.000	-0.016	0.000	0.016	0.0	0.0	93.7	94.0	0.30
Baba Ilorin House TR	0.000	-0.008	0.000	0.008	0.0	0.0	92.3	92.8	0.45
BF 1 TR	0.000	-0.024	0.000	0.024	0.1	0.4	86.8	88.2	1.41
Borgu Community Bank TR	0.000	-0.013	0.000	0.013	0.0	0.1	92.0	92.8	0.73
BSW TR	0.000	-0.014	0.000	0.014	0.0	0.0	86.2	86.4	0.18
Govt. Sec Sch TR	0.000	0.029	0.000	-0.028	0.0	0.1	97.8	97.3	0.50
Dantoro Lodge TR	0.001	0.056	0.000	-0.056	0.1	0.3	97.8	97.2	0.58
Nedufu Estate TR	0.001	0.062	-0.001	-0.061	0.1	0.7	96.7	95.6	1.09
NIFFR HQS TR	0.000	0.043	0.000	-0.042	0.0	0.2	96.7	96.3	0.45
Niger River Basin TR	0.000	0.038	0.000	-0.037	0.1	0.3	96.7	96.1	0.66
NIFFR Junior Qtrs TR	0.000	0.038	0.000	-0.038	0.1	0.3	96.7	96.1	0.67

LOAD FLOW REPORT (OFF-PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Tudun Wali TR	0.001	0.056	0.000	-0.055	0.1	0.3	96.7	96.1	0.59
Mil Quarters 2 TR	0.000	0.026	0.000	-0.026	0.1	0.3	94.8	93.9	0.93
Mil Quarters 1 TR	0.000	0.042	0.000	-0.042	0.0	0.1	94.8	94.5	0.31
Bussa Town Hall TR	0.000	0.029	0.000	-0.029	0.0	0.1	92.7	92.5	0.22
KEYSTONE Bank TR	0.000	0.026	0.000	-0.026	0.0	0.1	92.7	92.2	0.51
Old Army Barracks TR	0.000	0.027	0.000	-0.027	0.0	0.2	92.7	92.1	0.67
Waziri Primary Sch TR	0.001	0.059	-0.001	-0.058	0.1	0.4	92.7	92.0	0.65
UBA TR	0.000	0.021	0.000	-0.021	0.0	0.1	90.3	89.9	0.42
MTN TR	0.000	0.030	0.000	-0.030	0.1	0.3	90.3	89.5	0.86
Mammy market TR	0.000	0.037	0.000	-0.036	0.1	0.3	90.3	89.6	0.69
MT Yard TR1	0.000	0.018	0.000	-0.018	0.0	0.1	90.4	89.8	0.51
Hanger TR1	0.000	0.038	0.000	-0.038	0.0	0.2	90.3	89.9	0.43
Kidagba TR1	0.000	0.018	0.000	-0.018	0.0	0.0	90.4	90.1	0.21
TFT TR	0.000	0.021	0.000	-0.021	0.0	0.1	88.2	88.0	0.27
Luma Road TR	0.000	0.051	0.000	-0.051	0.1	0.3	88.2	87.6	0.60
Elshadai TR	0.000	0.019	0.000	-0.019	0.0	0.1	88.2	87.7	0.51
Water Treatment TR	0.000	0.039	0.000	-0.039	0.1	0.2	88.2	87.7	0.53
Officers' Mess TR	0.000	0.027	0.000	-0.027	0.0	0.1	88.2	88.0	0.21
Corpra Below TR	0.000	0.039	0.000	-0.038	0.1	0.3	86.3	85.5	0.77
Clinic TR	0.000	0.030	0.000	-0.030	0.0	0.1	86.3	85.9	0.42
Niger Crescent TR	0.000	0.019	0.000	-0.019	0.0	0.2	86.4	85.6	0.76
Senior Camp C/T TR	0.000	0.020	0.000	-0.020	0.0	0.2	86.4	85.6	0.79
MESL Water Treatment TR	0.000	0.018	0.000	-0.018	0.0	0.1	86.4	85.9	0.50
Kaduna Drive TR	0.000	0.035	0.000	-0.035	0.1	0.3	84.7	84.0	0.71
Rader TR	0.000	0.019	0.000	-0.019	0.0	0.1	84.8	84.4	0.38
SNCO TR	0.000	0.015	0.000	-0.015	0.0	0.0	84.8	84.6	0.19
GRA TR	0.000	0.037	0.000	-0.037	0.1	0.3	84.7	84.0	0.75
Ilorin Road TR	0.000	0.037	0.000	-0.036	0.0	0.2	84.7	84.3	0.44
NAPTIN Guest House 1 TR	0.000	0.021	0.000	-0.021	0.0	0.1	84.7	84.3	0.41
Monai TR	0.000	0.010	0.000	-0.010	0.0	0.1	83.5	82.9	0.63
MESL Water Intake TR	0.001	0.052	0.000	-0.052	0.1	0.4	83.4	82.8	0.64
Motel Annex TR	0.001	0.062	0.000	-0.061	0.1	0.6	83.4	82.6	0.76
SOQ TR	0.000	0.013	0.000	-0.013	0.0	0.0	83.5	83.4	0.15
Chinese Quaters TR	0.000	0.024	0.000	-0.023	0.0	0.2	83.5	82.8	0.72
Zaria Way TR	0.000	0.014	0.000	-0.014	0.0	0.1	82.8	82.3	0.57
Donia Camp TR	0.000	0.016	0.000	-0.016	0.0	0.0	82.8	82.7	0.14
Kadariko TR	0.000	0.025	0.000	-0.024	0.1	0.3	82.8	81.8	1.02

LOAD FLOW REPORT (OFF-PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Niger Water Plant TR	0.001	0.100	-0.001	-0.100	0.1	0.5	81.9	81.5	0.44
Kuruwasa TR	0.000	0.017	0.000	-0.017	0.0	0.1	82.2	81.9	0.35
Old Dogogari TR	0.000	0.043	0.000	-0.042	0.1	0.3	97.5	96.7	0.75
Koro Radio TR	0.000	0.030	0.000	-0.030	0.0	0.2	97.5	96.7	0.78
Koro 1 TR	0.000	0.031	0.000	-0.031	0.0	0.1	96.7	96.4	0.33
New Quarters TR	0.001	0.060	-0.001	-0.060	0.1	0.4	95.8	95.2	0.65
Old Market TR	0.000	0.041	0.000	-0.041	0.0	0.2	95.8	95.4	0.44
SS 13 Manchester TR	0.000	0.050	0.000	-0.050	0.1	0.3	95.1	94.6	0.54
Hydro TR	0.000	0.025	0.000	-0.025	0.0	0.1	95.1	94.8	0.31
Jobice TR	0.000	0.038	0.000	-0.038	0.1	0.4	94.5	93.5	1.03
Dantoro Road TR	0.000	0.039	0.000	-0.039	0.0	0.2	94.5	94.1	0.42
NIFFR Senior Qtrs 2 TR	0.000	0.032	0.000	-0.032	0.0	0.2	94.5	93.9	0.58
Jehovah Witness TR	0.000	0.031	0.000	-0.031	0.0	0.1	94.0	93.7	0.33
Niger Water Booster TR	0.001	0.049	0.000	-0.049	0.1	0.7	94.0	92.6	1.34
General Hospital TR	0.001	0.065	-0.001	-0.064	0.2	0.8	93.6	92.4	1.19
Fisheries Sch. TR	0.000	0.039	0.000	-0.038	0.1	0.3	93.5	92.8	0.70
Funkun TR	0.000	0.014	0.000	-0.014	0.0	0.1	96.9	96.5	0.37
MTN Nassarawa TR	0.000	0.035	0.000	-0.035	0.2	0.5	95.4	94.1	1.30
NAPTIN School TR	0.000	0.015	0.000	-0.015	0.0	0.0	95.5	95.3	0.16
Nassarawa 1 TR	0.000	0.031	0.000	-0.031	0.0	0.1	94.9	94.5	0.34
Nassarawa Grinder TR	0.000	0.024	0.000	-0.023	0.0	0.2	94.5	93.8	0.64
Sabo 1 TR	0.000	0.013	0.000	-0.013	0.0	0.0	94.2	94.0	0.22
Sabo 2 TR	0.000	0.015	0.000	-0.015	0.0	0.1	94.2	93.8	0.40
Power Transformer	0.209	3.582	-0.205	-3.522	3.2	60.0	100.0	98.3	1.67
					180.7	315.5			

4.2.1 Analyzing load flow reports for New Bussa base (initial) distribution network

This involves taking critical look or observation on the voltage profile (percentage voltage magnitude) for all the load buses in New Bussa network, since those bus voltage values determine the value of voltage delivered to or received at consumers' premises.

Various percentage voltage magnitudes for load buses obtained from the Load Flow reports for peak and off-peak periods of New Bussa network were analyzed using bar charts of figures 4.4 through 4.13.

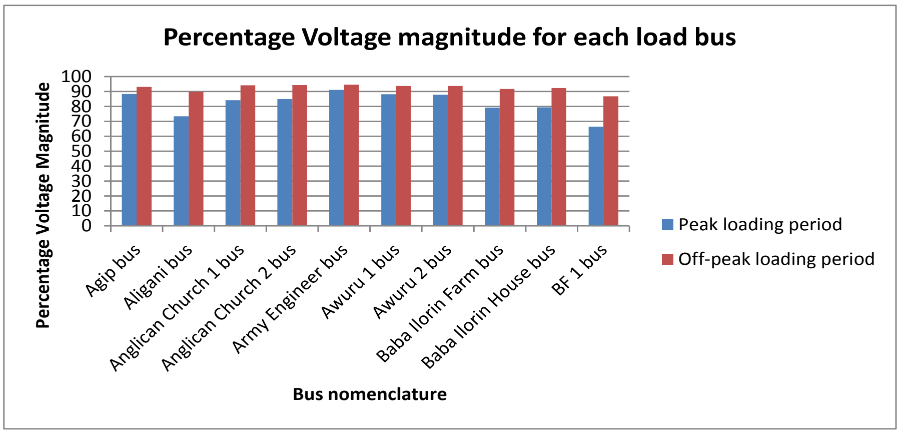

Figure 4.4: Voltage profile for first set of ten load buses

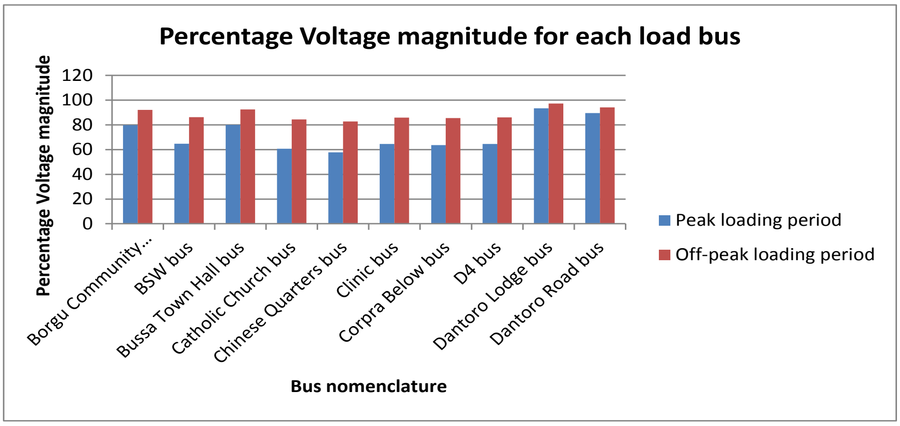

Figure 4.5: Voltage profile for second set of ten load buses

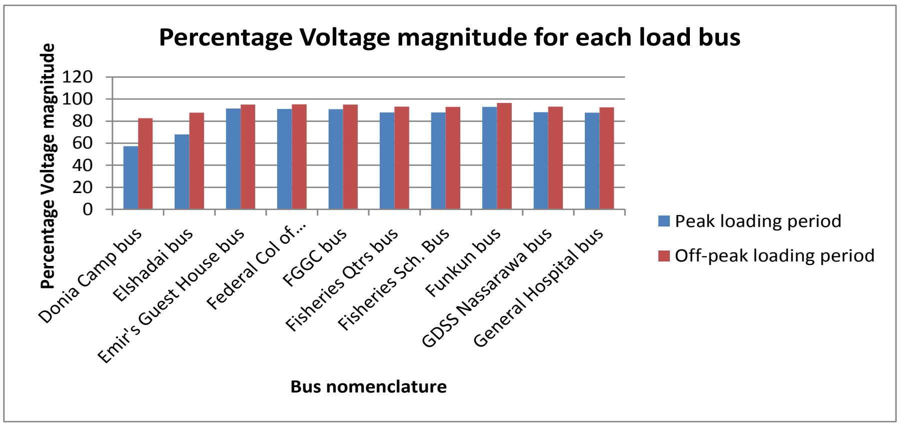

Figure 4.6: Voltage profile for third set of ten load buses

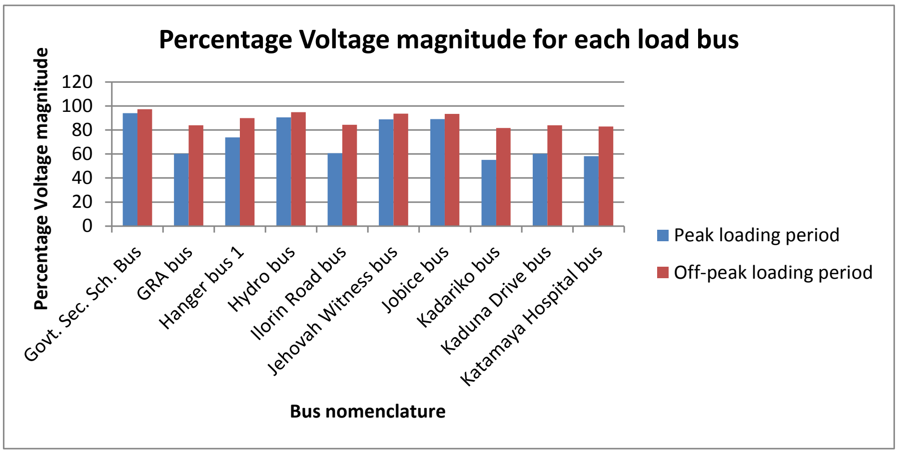

Figure 4.7: Voltage profile for fourth set of ten load buses

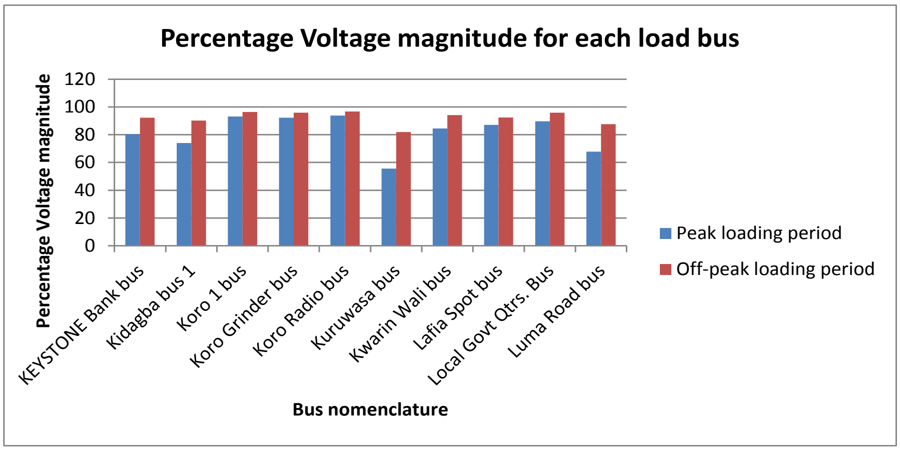

Figure 4.8: Voltage profile for fifth set of ten load buses

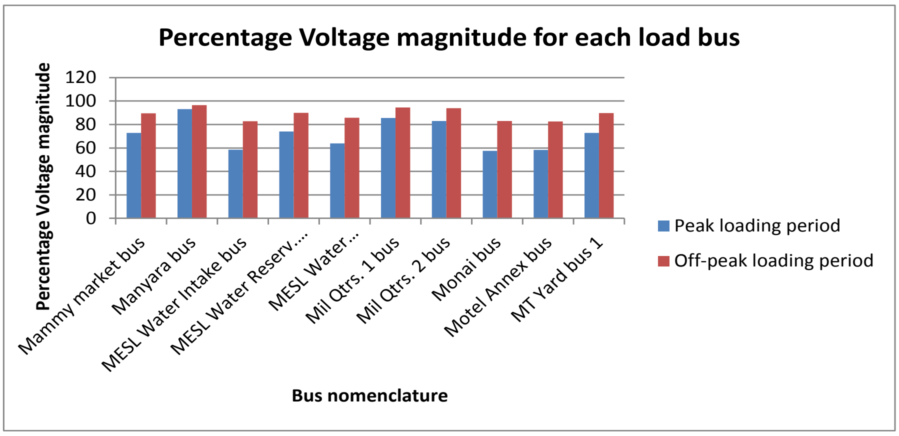

Figure 4.9: Voltage profile for sixth set of ten load buses

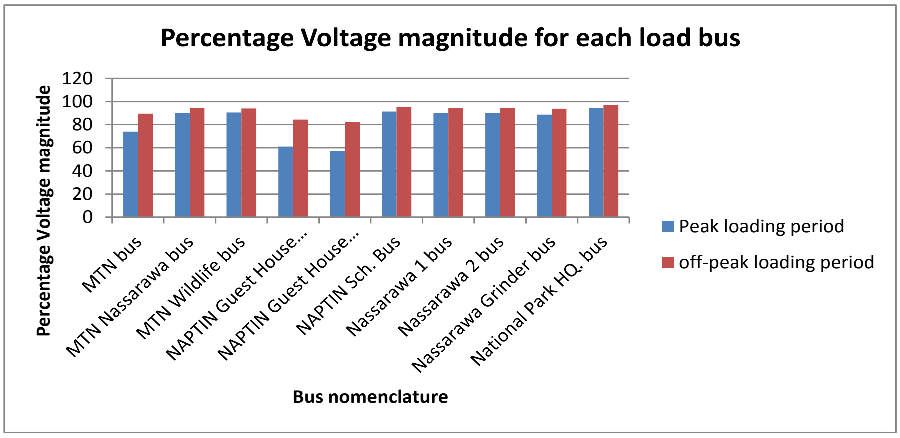

Figure 4.10: Voltage profile for seventh set of ten load buses

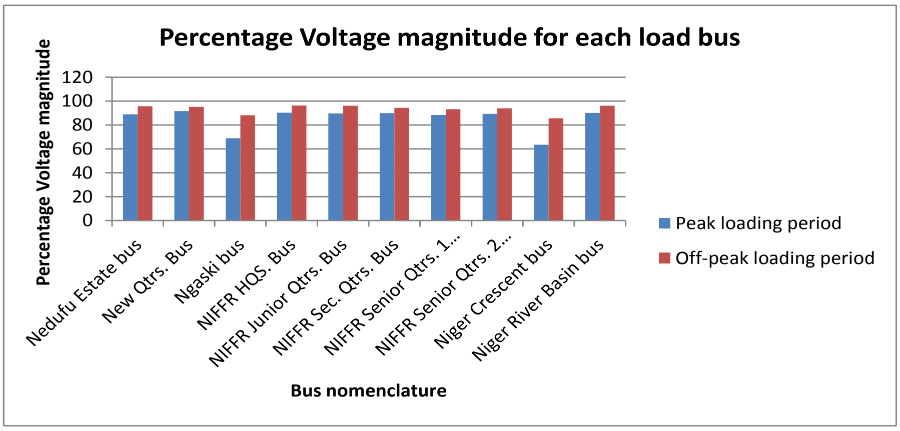

Figure 4.11: Voltage profile for eighth set of ten load buses

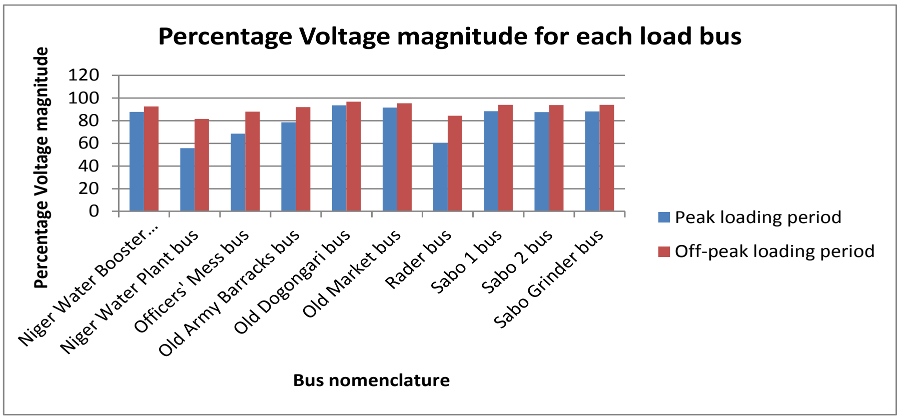

Figure 4.12: Voltage profile for nineth set of ten load buses

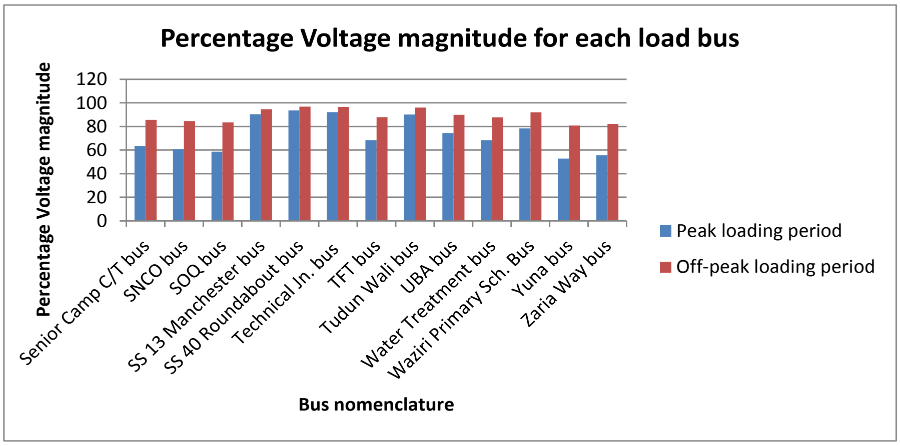

Figure 4.13: Voltage profile for tenth set of ten load buses

Analyzing the percentage voltage magnitude (voltage profile) of the load buses using the bar charts in figures 4.4 to 4.13 helps us to ascertain the present performance status of the New Bussa base (initial) distribution network(characterize the network), since these percentage voltage magnitudes of the load buses determine the voltage supplied to consumers' premises.

4.2.2 Validation of generated voltage values

These various load bus voltages can be validated by comparing them to the acceptable standard voltage value for distribution network set by the American National Standard Institution in ANSI C84.1.

ANSI C84.1 states the following:

For distribution system with service voltage less than 600V, the minimum acceptable service voltage for distribution network is about 90% of nominal voltage while the maximum acceptable service voltage for distribution network is about 106% of nominal voltage.

This indicates that maximum allowable voltage drop for distribution network is 10% of the nominal voltage value.

Thus, concerning the New Bussa base distribution network, with emphasis on the load bus voltages that determines the voltage level supplied to consumers' equipment, the category of the voltage to be considered as the standard limit is the one that accepts 10% of the nominal voltage as the maximum allowable voltage drop since each load bus in the network has 415V as its maximum or nominal voltage value.

Analyzing the various load bus voltages obtained from the load flow reports for peak and off-peak loading periods as shown in Tables 4.1 and 4.2 with bar charts of Figures 4.4 through 4.13 shows that load bus voltage values with percentage voltage magnitude less than 90% of nominal voltage value violate the ANSI C84.1 standard voltage limit.

Tabulating the load buses as shown in Table 4.5 and Table 4.6 with their percentage voltage magnitude, indicate buses that violate the acceptable standard voltage limit for both peak and off-peak periods.

Table 4.5: Shows percentage voltage magnitude at load buses during peak period

S/N	Bus Name	Percentage Voltage Magnitude	Comment
1	Agip bus	88.29	Voltage not within acceptable limit
2	Aligani bus	73.334	Voltage not within acceptable limit
3	Anglican Church 1 bus	84.187	Voltage not within acceptable limit
4	Anglican Church 2 bus	84.838	Voltage not within acceptable limit
5	Army Engr bus	90.991	Voltage within acceptable limit
6	Awuru 1 bus	88.067	Voltage not within acceptable limit
7	Awuru 2 bus	87.81	Voltage not within acceptable limit
8	Baba Ilorin Farm bus	79.208	Voltage not within acceptable limit
9	Baba Ilorin House bus	79.427	Voltage not within acceptable limit
10	BF 1 bus	66.489	Voltage not within acceptable limit
11	Borgu Community Bank bus	79.774	Voltage not within acceptable limit
12	BSW bus	64.627	Voltage not within acceptable limit
13	Bussa Town Hall bus	79.964	Voltage not within acceptable limit
14	Catholic Church bus	60.756	Voltage not within acceptable limit
15	Chinese Quarters bus	57.785	Voltage not within acceptable limit
16	Clinic bus	64.545	Voltage not within acceptable limit
17	Copra Below bus	63.556	Voltage not within acceptable limit
18	D4 bus	64.563	Voltage not within acceptable limit
19	Dantoro Lodge bus	93.433	Voltage within acceptable limit
20	Dantoro Road bus	89.517	Voltage not within acceptable limit
21	Donia Camp bus	57.361	Voltage not within acceptable limit
22	Elshadai bus	68.069	Voltage not within acceptable limit
23	Emir's Guest House bus	91.382	Voltage within acceptable limit
24	Federal College of Wildlife bus	91.023	Voltage within acceptable limit
25	FGGC bus	90.83	Voltage within acceptable limit
26	Fisheries Quarters bus	87.834	Voltage not within acceptable limit
27	Fisheries School bus	87.828	Voltage not within acceptable limit
28	Funkun bus	92.915	Voltage within acceptable limit
29	GDSS Nassarawa bus	88.024	Voltage not within acceptable limit
30	General Hospital bus	87.792	Voltage not within acceptable limit
31	Govt. Secondary School bus	93.95	Voltage within acceptable limit
32	GRA bus	60.367	Voltage not within acceptable limit
33	Hanger bus	73.882	Voltage not within acceptable limit
34	Hydro bus	90.497	Voltage within acceptable limit
35	Ilorin Road bus	60.703	Voltage not within acceptable limit

36	Jehoval Witness bus	88.795	Voltage not within acceptable limit
37	Jobice bus	89.086	Voltage not within acceptable limit
38	Kadariko bus	55.148	Voltage not within acceptable limit
39	Kaduna Drive bus	60.165	Voltage not within acceptable limit
40	Katamaya Hospital bus	58.246	Voltage not within acceptable limit
41	KEYSTONE Bank bus	80.361	Voltage not within acceptable limit
42	Kidagba bus	73.976	Voltage not within acceptable limit
43	Koro 1 bus	93.051	Voltage within acceptable limit
44	Koro Grinder bus	92.206	Voltage within acceptable limit
45	Koro Radio bus	93.757	Voltage within acceptable limit
46	Kurwasa bus	55.622	Voltage not within acceptable limit
47	Kwarin Wali bus	84.601	Voltage not within acceptable limit
48	Lafia Sort bus	87.117	Voltage not within acceptable limit
49	Local Govt Quarters bus	89.694	Voltage not within acceptable limit
50	Luma Road bus	67.748	Voltage not within acceptable limit
51	Mammy market bus	72.863	Voltage not within acceptable limit
52	Manyara bus	93.117	Voltage within acceptable limit
53	MESL Water Intake bus	58.612	Voltage not within acceptable limit
54	MESL Water Reserve bus	74.016	Voltage not within acceptable limit
55	MESL Water Treatment bus	63.8	Voltage not within acceptable limit
56	Mil Quarters 1 bus	85.479	Voltage not within acceptable limit
57	Mil Quarters 2 bus	82.956	Voltage not within acceptable limit
58	Monai bus	57.523	Voltage not within acceptable limit
59	Motel Annex bus	58.408	Voltage not within acceptable limit
60	MT Yard bus	72.871	Voltage not within acceptable limit
61	MTN bus	73.998	Voltage not within acceptable limit
62	MTN Nassarawa bus	90.203	Voltage within acceptable limit
63	MTN Wildlife bus	90.471	Voltage within acceptable limit
64	NAPTIN Guest House 1 bus	61.119	Voltage not within acceptable limit
65	NAPTIN Guest House 2 bus	57.249	Voltage not within acceptable limit
66	NAPTIN School bus	91.317	Voltage within acceptable limit
67	Nassarawa 1 bus	89.962	Voltage not within acceptable limit
68	Nassarawa 2 bus	90.018	Voltage within acceptable limit
69	Nassarawa Grinder bus	88.581	Voltage not within acceptable limit
70	National Park Headquarter bus	94.111	Voltage within acceptable limit
71	Nedufu Estate bus	88.934	Voltage not within acceptable limit
72	New Quarters bus	91.547	Voltage within acceptable limit
73	Ngaski bus	68.987	Voltage not within acceptable limit
74	NIFFR Headquarters bus	90.376	Voltage within acceptable limit
75	NIFFR Junior Quarters bus	89.64	Voltage not within acceptable limit

76	NIFFR Secondary Quarters bus	89.838	Voltage not within acceptable limit
77	NIFFR Senior Quarters 1 bus	88.246	Voltage not within acceptable limit
78	NIFFR Senior Quarters 2 bus	89.407	Voltage not within acceptable limit
79	Niger Crescent bus	63.494	Voltage not within acceptable limit
80	Niger River Basin bus	90.018	Voltage within acceptable limit
81	Niger Water Booster bus	87.798	Voltage not within acceptable limit
82	Niger Water Plant bus	55.72	Voltage not within acceptable limit
83	Officers' Mess bus	68.533	Voltage not within acceptable limit
84	Old Army Barracks bus	78.603	Voltage not within acceptable limit
85	Old Dogongeri bus	93.587	Voltage within acceptable limit
86	Old Market bus	91.644	Voltage within acceptable limit
87	Rader bus	60.369	Voltage not within acceptable limit
88	Sabo 1 bus	88.405	Voltage not within acceptable limit
89	Sabo 2 bus	87.637	Voltage not within acceptable limit
90	Sabo Grinder bus	88.117	Voltage not within acceptable limit
91	Senior Camp C/T bus	63.533	Voltage not within acceptable limit
92	SNCO bus	60.889	Voltage not within acceptable limit
93	SOQ bus	58.553	Voltage not within acceptable limit
94	SS 13 Manchester bus	90.429	Voltage within acceptable limit
95	SS 40 Roundabout bus	93.597	Voltage within acceptable limit
96	Technical Junction bus	92.25	Voltage within acceptable limit
97	TFT bus	68.41	Voltage not within acceptable limit
98	Tudun Wali bus	90.131	Voltage within acceptable limit
99	UBA bus	74.444	Voltage not within acceptable limit
100	Water Treatment bus	68.448	Voltage not within acceptable limit
101	Waziri Primary School bus	78.268	Voltage not within acceptable limit
102	Yuna bus	52.679	Voltage not within acceptable limit
103	Zaria Way bus	55.548	Voltage not within acceptable limit

Table 4.6: Shows percentage voltage magnitude at load buses during off-peak period

S/N	Bus Name	Percentage Voltage Magnitude	Comment
1	Agip bus	93.017	Voltage within acceptable limit
2	Aligani bus	89.767	Voltage not within acceptable limit
3	Anglican Church 1 bus	94.214	Voltage within acceptable limit
4	Anglican Church 2 bus	94.323	Voltage within acceptable limit
5	Army Engr bus	94.577	Voltage within acceptable limit
6	Awuru 1 bus	93.736	Voltage within acceptable limit
7	Awuru 2 bus	93.676	Voltage within acceptable limit
8	Baba Ilorin Farm bus	91.666	Voltage within acceptable limit
9	Baba Ilorin House bus	92.31	Voltage within acceptable limit
10	BF 1 bus	86.809	Voltage not within acceptable limit
11	Borgu Community Bank bus	92.021	Voltage within acceptable limit
12	BSW bus	86.188	Voltage not within acceptable limit
13	Bussa Town Hall bus	92.512	Voltage within acceptable limit
14	Catholic Church bus	84.432	Voltage not within acceptable limit
15	Chinese Quarters bus	82.785	Voltage not within acceptable limit
16	Clinic bus	85.916	Voltage not within acceptable limit
17	Copra Below bus	85.547	Voltage not within acceptable limit
18	D4 bus	86.085	Voltage not within acceptable limit
19	Dantoro Lodge bus	97.247	Voltage within acceptable limit
20	Dantoro Road bus	94.078	Voltage within acceptable limit
21	Donia Camp bus	82.68	Voltage not within acceptable limit
22	Elshadai bus	87.719	Voltage not within acceptable limit
23	Emir's Guest House bus	95.035	Voltage within acceptable limit
24	Federal College of Wildlife bus	95.148	Voltage within acceptable limit
25	FGGC bus	94.937	Voltage within acceptable limit
26	Fisheries Quarters bus	93.168	Voltage within acceptable limit
27	Fisheries School bus	92.846	Voltage within acceptable limit
28	Funkun bus	96.502	Voltage within acceptable limit
29	GDSS Nassarawa bus	93.178	Voltage within acceptable limit
30	General Hospital bus	92.436	Voltage within acceptable limit
31	Govt. Secondary School bus	97.346	Voltage within acceptable limit
32	GRA bus	83.952	Voltage not within acceptable limit
33	Hanger bus	89.876	Voltage not within acceptable limit
34	Hydro bus	94.823	Voltage within acceptable limit
35	Ilorin Road bus	84.259	Voltage not within acceptable limit

36	Jehoval Witness bus	93.682	Voltage within acceptable limit
37	Jobice bus	93.473	Voltage within acceptable limit
38	Kadariko bus	81.773	Voltage not within acceptable limit
39	Kaduna Drive bus	83.998	Voltage not within acceptable limit
40	Katamaya Hospital bus	82.906	Voltage not within acceptable limit
41	KEYSTONE Bank bus	92.222	Voltage within acceptable limit
42	Kidagba bus	90.144	Voltage within acceptable limit
43	Koro 1 bus	96.389	Voltage within acceptable limit
44	Koro Grinder bus	95.926	Voltage within acceptable limit
45	Koro Radio bus	96.693	Voltage within acceptable limit
46	Kurwasa bus	81.889	Voltage not within acceptable limit
47	Kwarin Wali bus	94.209	Voltage within acceptable limit
48	Lafia Sort bus	92.459	Voltage within acceptable limit
49	Local Govt Quarters bus	95.926	Voltage within acceptable limit
50	Luma Road bus	87.562	Voltage not within acceptable limit
51	Mammy market bus	89.624	Voltage not within acceptable limit
52	Manyara bus	96.502	Voltage within acceptable limit
53	MESL Water Intake bus	82.781	Voltage not within acceptable limit
54	MESL Water Reserve bus	89.894	Voltage not within acceptable limit
55	MESL Water Treatment bus	85.861	Voltage not within acceptable limit
56	Mil Quarters 1 bus	94.486	Voltage within acceptable limit
57	Mil Quarters 2 bus	93.888	Voltage within acceptable limit
58	Monai bus	82.915	Voltage not within acceptable limit
59	Motel Annex bus	82.635	Voltage not within acceptable limit
60	MT Yard bus	89.842	Voltage not within acceptable limit
61	MTN bus	89.469	Voltage not within acceptable limit
62	MTN Nassarawa bus	94.133	Voltage within acceptable limit
63	MTN Wildlife bus	94.062	Voltage within acceptable limit
64	NAPTIN Guest House 1 bus	84.332	Voltage not within acceptable limit
65	NAPTIN Guest House 2 bus	82.356	Voltage not within acceptable limit
66	NAPTIN School bus	95.317	Voltage within acceptable limit
67	Nassarawa 1 bus	94.537	Voltage within acceptable limit
68	Nassarawa 2 bus	94.563	Voltage within acceptable limit
69	Nassarawa Grinder bus	93.846	Voltage within acceptable limit
70	National Park Headquarter bus	96.817	Voltage within acceptable limit
71	Nedufu Estate bus	95.633	Voltage within acceptable limit
72	New Quarters bus	95.173	Voltage within acceptable limit
73	Ngaski bus	88.058	Voltage not within acceptable limit
74	NIFFR Headquarters bus	96.28	Voltage within acceptable limit
75	NIFFR Junior Quarters bus	96.051	Voltage within acceptable limit

76	NIFFR Secondary Quarters bus	94.33	Voltage within acceptable limit
77	NIFFR Senior Quarters 1 bus	93.219	Voltage within acceptable limit
78	NIFFR Senior Quarters 2 bus	93.925	Voltage within acceptable limit
79	Niger Crescent bus	85.6	Voltage not within acceptable limit
80	Niger River Basin bus	96.068	Voltage within acceptable limit
81	Niger Water Booster bus	92.647	Voltage within acceptable limit
82	Niger Water Plant bus	81.475	Voltage not within acceptable limit
83	Officers' Mess bus	87.999	Voltage not within acceptable limit
84	Old Army Barracks bus	92.057	Voltage within acceptable limit
85	Old Dogongeri bus	96.72	Voltage within acceptable limit
86	Old Market bus	95.395	Voltage within acceptable limit
87	Rader bus	84.378	Voltage not within acceptable limit
88	Sabo 1 bus	94.004	Voltage within acceptable limit
89	Sabo 2 bus	93.814	Voltage within acceptable limit
90	Sabo Grinder bus	93.897	Voltage within acceptable limit
91	Senior Camp C/T bus	85.564	Voltage not within acceptable limit
92	SNCO bus	84.578	Voltage not within acceptable limit
93	SOQ bus	83.385	Voltage not within acceptable limit
94	SS 13 Manchester bus	94.562	Voltage within acceptable limit
95	SS 40 Roundabout bus	96.866	Voltage within acceptable limit
96	Technical Junction bus	96.688	Voltage within acceptable limit
97	TFT bus	87.955	Voltage not within acceptable limit
98	Tudun Wali bus	96.108	Voltage within acceptable limit
99	UBA bus	89.931	Voltage not within acceptable limit
100	Water Treatment bus	87.654	Voltage not within acceptable limit
101	Waziri Primary School bus	92.027	Voltage within acceptable limit
102	Yuna bus	80.691	Voltage not within acceptable limit
103	Zaria Way bus	82.254	Voltage not within acceptable limit

4.2.3 Deductions from load flow analysis of New Bussa base (initial) distribution network

After the load flow study and analysis of New Bussa distribution network, it was observed that out of a total of one hundred and three (103) load buses, voltage violations occurred in seventy-eight (78) load buses during peak loading period (75% of entire network) and forty-one (41) load buses during off-peak loading period (39% of entire network).

It was also observed from the branch power losses summary report for New Bussa distribution network that the active and reactive power losses are 978KW & 1674.30KVAR during the peak period and are 180.70KW & 315.50KVAR during the off-peak loading period.

4.3 Improving Voltage Level in New Bussa Distribution Network using Microcontroller-based Capacitor Bank Switching Technique

Looking at percentage voltage magnitudes of all the load buses in the network, it was observed that 75% of the entire load buses in the network do not supply proper voltage level to consumers during peak and 39% of the entire load buses in the network also do not supply proper voltage level to consumers during off-peak loading periods, thus the need for voltage improvement or compensation and regulation on the network.

The voltage compensation or improvement in this research work involved the use of microcontroller-based capacitor bank switching technique. The components of this compensation system were applied as follows:

- The shunt capacitor was used to compensate the reactive power demand in the network which in turns improved the voltage level in the network.
- Microcontroller-based switching system. This electronic switching system is an automated system that mainly used microcontroller to switch on the needed candidate capacitor banks for compensation, only when there is need for compensation (when the monitored phase voltage drops below 216V, which is the lower standard phase voltage limit as stipulated in ANSI C84.1 standard). The microcontroller switches off the capacitor bank when the load bus voltage value improves and falls back within the standard acceptable phase voltage limit (216V – 255V). This automated switching on & off of the system ensured that the chosen capacitor banks did not over-compensate the distribution line in the network.

For better way of determining the optimal capacitor placement and sizing, the Optimal Capacitor Placement (OCP) module in ETAP 12.6 software was used and the power flow analysis of New Bussa compensated network was carried out for both peak and off-peak loading periods.

From the ETAP 12.6 OCP module study, the Optimal Capacitor Placement Results showing the optimal capacitor bank sizes and the selected candidate buses for both peak and off-peak periods were shown in Tables 4.7 and 4.8.

Table 4.7: Optimal Capacitor Placement Results during Peak Period

Project:	PhD. PROJECT	ETAP	Page:	1
Location:	NEW BUSSA - NIGER STATE	12.6.0H	Date:	12-01-2018
Contract:			SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case: OCP	Revision:	Base
Filename:	PEAK 1		Config.:	Normal

OPTIMAL CAPACITOR PLACEMENT REPORT (PEAK PERIOD)

Optimal Capacitor Placement Results

Candidate Buses					Capacitor Information			
		Operating Voltage			Rated	Rated		
ID	Nominal kV	% Mag.	Angle	% PF	kvar/Bank	kV	# of Banks	Total kvar
04	11.000	96.614	0.12	100.0	300.000	12.470	6	1800.000
05	11.000	95.671	0.25	100.0	300.000	12.470	1	300.000
07	11.000	96.186	-0.28	100.0	300.000	12.470	2	600.000
08	11.000	98.113	-1.39	100.0	300.000	12.470	2	600.000
09	11.000	100.396	-2.59	100.0	300.000	12.470	3	900.000
10	11.000	102.613	-3.66	100.0	300.000	12.470	3	900.000
0012	11.000	105.106	-3.28	100.0	300.000	12.470	2	600.000
020	11.000	93.758	1.86	100.0	300.000	12.470	2	600.000
57	11.000	103.977	-4.32	100.0	300.000	12.470	5	1500.000
Total							26	7800.000

Table 4.8: Optimal Capacitor Placement Results during Off-Peak Period

Project:	PhD. PROJECT	ETAP		Page:	1
Location:	NEW BUSSA - NIGER STATE	12.6.0H		Date:	11-20-2017
Contract:				SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case:	OCP	Revision:	Base
Filename:	NEW BUSSA SUBSTATION			Config.:	Normal

OPTIMAL CAPACITOR PLACEMENT REPORT (OFF-PEAK PERIOD)

Optimal Capacitor Placement Results

Candidate Buses					Capacitor Information			
		Operating Voltage			Rated	Rated		
ID	Nominal kV	% Mag.	Angle	% PF	kvar/Bank	kV	# of Banks	Total kvar
07	11.000	98.974	-0.24	100.0	300.000	12.470	3	900.000
08	11.000	98.843	-0.21	100.0	300.000	12.470	1	300.000
09	11.000	98.661	-0.16	100.0	300.000	12.470	1	300.000
10	11.000	98.472	-0.10	100.0	300.000	12.470	1	300.000
57	11.000	98.361	-0.06	100.0				
61	11.000	98.671	-0.21	100.0				
Total							6	1800.000

These capacitor banks were installed on the appropriate load buses 04, 05, 07, 08, 09, 10, 57, 020, 0012 and the compensated network simulated in the ETAP 12.6 version of the software for both peak and off-peak periods.

The load flow reports generated from the simulation of the compensated network model are shown in Tables 4.9 and 4.10 and the branch power losses summary reports also generated are shown in Tables 4.11 and 4.12 for peak and off-peak periods of the network respectively, while the summary of percentage voltage magnitudes for load buses generated from the load flow reports for the compensated network during both peak and off-peak periods are also shown in Tables 4.13 and 4.14.

Table 4.9: Load Flow Report of New Bussa Compensated Network during Peak period

Project:	PhD. PROJECT	ETAP	Page:	1
Location:	NEW BUSSA - NIGER STATE	12.6.0H	Date:	13-01-2018
Contract:			SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename:	NEW BUSSA SUBSTATION		Config.:	Normal

LOAD FLOW REPORT(PEAK PERIOD)

LOAD FLOW REPORT

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
1	11.000	98.535	0.1	0	0	0	0	MAIN BUS	-0.169	-1.328	71.3	12.6	
								Bus 2	0.001	0.060	3.2	1.1	
								Bus 4	0.002	0.148	7.9	1.2	
								02	0.165	0.957	51.7	16.9	
								Technical Jn Bus	0.002	0.163	8.7	1.4	
001	11.000	97.940	0.3	0	0	0	0	MAIN BUS	-0.030	-1.056	56.6	2.8	
								Bus 111	0.001	0.078	4.2	1.2	
								Bus 113	0.001	0.046	2.5	1.1	
								004	0.027	0.851	45.6	3.2	
								SS 40 Roundabout Bus	0.001	0.081	4.3	1.2	
0001	11.000	98.694	0.0	0	0	0	0	MAIN BUS	-0.015	-0.063	3.5	23.7	
								0002	0.015	0.024	1.5	53.8	
								National Park HQ Bus	0.000	0.040	2.1	1.0	
02	11.000	97.981	0.2	0	0	0	0	1	-0.161	-0.952	51.7	16.7	
								Bus 7	0.003	0.176	9.5	1.6	
								Bus 9	0.002	0.148	7.9	1.2	
								Bus 11	0.001	0.112	6.0	1.3	
								Bus 13	0.002	0.133	7.1	1.4	
								Bus 15	0.002	0.166	8.9	1.3	
								03	0.150	0.126	10.5	76.4	
								Local Govt Qters Bus	0.001	0.091	4.9	1.2	
0002	11.000	98.622	0.0	0	0	0	0	0001	-0.015	-0.024	1.5	53.8	
								Bus 152	0.000	0.037	2.0	1.1	
								0004	0.014	-0.062	3.4	-22.3	
								Manyam Bus	0.001	0.048	2.6	1.0	
03	11.000	97.735	0.2	0	0	0	0	02	-0.150	-0.126	10.5	76.5	
								Bus 18	0.002	0.151	8.1	1.4	
								Bus 20	0.003	0.178	9.5	1.4	
								Bus 22	0.002	0.116	6.2	1.7	
								Bus 24	0.002	0.157	8.4	1.3	
								04	0.140	-0.565	31.3	-24.0	
								Kwarin Wali Bus	0.001	0.089	4.8	1.3	
04	11.000	98.320	-0.2	0	0	0.000	-1.740	03	-0.136	0.570	31.3	-23.3	
								Bus 26	0.003	0.171	9.2	1.5	
								Bus 28	0.001	0.040	2.1	1.4	
								Bus 30	0.001	0.049	2.6	1.1	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Bus 32	0.002	0.125	6.7	1.5	
								Bus 34	0.005	0.291	15.5	1.8	
								Bus 36	0.000	0.031	1.7	1.2	
								05	0.124	0.396	22.1	29.9	
								Baba Ilorin Farm Bus	0.001	0.066	3.5	1.6	
004	11.000	97.194	0.6	0	0	0	0	001	-0.023	-0.845	45.6	2.7	
								Bus 116	0.001	0.067	3.6	1.0	
								006	0.021	0.716	38.7	2.9	
								Koro Grinder Bus	0.001	0.062	3.4	1.2	
0004	11.000	98.743	-0.1	0	0	0	0	0002	-0.014	0.062	3.4	-22.1	
								0005	0.013	-0.108	5.8	-12.3	
								MTN Wildlife Bus	0.001	0.046	2.5	1.4	
05	11.000	97.506	0.0	0	0	0.000	-0.285	04	-0.122	-0.393	22.1	29.6	
								Bus 39	0.000	0.042	2.3	1.1	
								Bus 41	0.001	0.050	2.7	1.2	
								Bus 43	0.002	0.149	8.0	1.6	
								Bus 45	0.001	0.102	5.5	1.4	
								Bus 47	0.003	0.184	9.9	1.4	
								Bus 49	0.002	0.126	6.8	1.3	
								Bus 51	0.001	0.116	6.3	1.3	
								07	0.110	-0.224	13.4	-43.9	
								MESL Water Reserv. Bus	0.001	0.132	7.1	1.0	
0005	11.000	98.986	-0.2	0	0	0	0	0004	-0.013	0.109	5.8	-12.0	
								Bus 156	0.001	0.040	2.1	1.4	
								Bus 158	0.000	0.025	1.3	0.9	
								0008	0.012	-0.212	11.2	-5.7	
								Fed Col of Wildlife Bus	0.000	0.037	2.0	1.0	
006	11.000	96.418	1.0	0	0	0	0	004	-0.017	-0.710	38.7	2.4	
								Bus 119	0.001	0.082	4.5	1.1	
								Bus 121	0.001	0.082	4.5	1.2	
								Bus 123	0.001	0.073	4.0	1.0	
								010	0.014	0.401	21.9	3.4	
								Emir's Guest House Bus	0.001	0.071	3.9	1.0	
07	11.000	97.775	-0.3	0	0	0.000	-0.574	05	-0.109	0.226	13.4	-43.4	
								Bus 53	0.002	0.139	7.4	1.6	
								Bus 55	0.002	0.085	4.6	1.8	
								Bus 57	0.004	0.229	12.3	1.6	
								Bus 59	0.001	0.091	4.9	1.6	
								Bus 61	0.002	0.131	7.0	1.4	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Bus 62	0.003	0.193	10.4	1.4	
								08	0.094	-0.627	34.0	-14.8	
								Ngaski Bus	0.001	0.107	5.7	1.1	
08	11.000	98.936	-1.0	0	0	0.000	-0.587	07	-0.088	0.636	34.0	-13.7	
								Bus 65	0.002	0.151	8.0	1.6	
								Bus 67	0.001	0.096	5.1	1.3	
								Bus 69	0.001	0.100	5.3	1.4	
								Bus 71	0.001	0.082	4.4	1.5	
								Bus 73	0.001	0.080	4.3	1.4	
								Bus 75	0.002	0.098	5.2	1.7	
								09	0.077	-0.791	42.2	-9.7	
								D4 Bus	0.002	0.135	7.2	1.2	
0008	11.000	99.567	-0.5	0	0	0	0	0005	-0.011	0.213	11.2	-5.2	
								Bus 161	0.001	0.053	2.8	1.0	
								0010	0.010	-0.305	16.1	-3.3	
								Nassarawa 2 Bus	0.000	0.039	2.1	0.9	
09	11.000	100.603	-1.9	0	0	0.000	-0.911	08	-0.066	0.806	42.2	-8.2	
								Bus 77	0.003	0.153	8.0	1.7	
								Bus 79	0.002	0.136	7.1	1.5	
								Bus 81	0.002	0.142	7.4	1.4	
								Bus 83	0.002	0.136	7.1	1.5	
								Bus 85	0.002	0.165	8.6	1.5	
								Bus 87	0.001	0.072	3.8	1.1	
								10	0.054	-0.758	39.6	-7.1	
								Catholic Church Bus	0.001	0.059	3.1	1.2	
10	11.000	102.349	-2.7	0	0	0.000	-0.943	09	-0.043	0.771	39.6	-5.6	
								Bus 89	0.001	0.066	3.4	1.5	
								Bus 91	0.002	0.126	6.5	1.3	
								Bus 93	0.002	0.154	7.9	1.4	
								Bus 95	0.002	0.134	6.9	1.3	
								Bus 97	0.002	0.109	5.6	1.6	
								57	0.034	-0.517	26.6	-6.5	
								Katamaya Hospita Bus	0.001	0.100	5.1	1.4	
010	11.000	95.901	1.2	0	0	0	0	006	-0.012	-0.399	21.9	3.0	
								Bus 126	0.001	0.078	4.3	1.1	
								Bus 128	0.001	0.064	3.5	1.1	
								013	0.010	0.208	11.4	4.8	
								FGGC Bus	0.000	0.048	2.7	1.0	
0010	11.000	100.484	-0.9	0	0	0	0	0008	-0.008	0.308	16.1	-2.6	

Project:	PhD. PROJECT	ETAP	Page:	4
Location:	NEW BUSSA - NIGER STATE	12.6.0H	Date:	13-01-2018
Contract:			SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename:	NEW BUSSA SUBSTATION		Config.:	Normal

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Bus 164	0.001	0.047	2.4	1.2	
								0012	0.007	-0.393	20.5	-1.8	
								GDSS Nassarawa Bus	0.000	0.038	2.0	1.3	
0012	11.000	101.858	-1.5	0	0	0.000	-0.623	0010	-0.003	0.399	20.5	-0.7	
								Bus 167	0.000	0.040	2.0	1.1	
								Bus 169	0.001	0.057	3.0	1.2	
								0015	0.001	0.083	4.3	1.5	
								Sabo Grinder Bus	0.000	0.044	2.3	1.1	
013	11.000	95.618	1.3	0	0	0	0	010	-0.010	-0.208	11.4	4.6	
								Bus 131	0.001	0.049	2.7	1.2	
								Bus 133	0.001	0.075	4.1	1.0	
								Bus 135	0.001	0.053	2.9	1.1	
								017	0.007	-0.022	1.3	-30.4	
								NIFFR Sec. Qtrs Bus	0.001	0.053	2.9	1.0	
0015	11.000	101.390	-1.3	0	0	0	0	0012	-0.001	-0.083	4.3	1.2	
								Bus 172	0.001	0.043	2.2	1.4	
								Awuru 1 Bus	0.000	0.040	2.1	1.0	
017	11.000	95.643	1.3	0	0	0	0	013	-0.007	0.022	1.3	-30.4	
								Bus 138	0.001	0.073	4.0	1.0	
								Bus 140	0.001	0.069	3.8	1.3	
								020	0.005	-0.215	11.8	-2.2	
								Lafia Spot Bus	0.001	0.050	2.8	1.3	
020	11.000	95.966	1.1	0	0	0.000	-0.553	017	-0.004	0.216	11.8	-1.9	
								Bus 143	0.001	0.076	4.2	1.1	
								Bus 145	0.001	0.076	4.1	1.3	
								023	0.002	0.130	7.1	1.3	
								NIFFR Senior Qtrs 1 Bus	0.001	0.055	3.0	1.1	
023	11.000	95.746	1.2	0	0	0	0	020	-0.001	-0.129	7.1	1.2	
								Bus 148	0.001	0.062	3.4	1.2	
								Fisheries Qtrs Bus	0.001	0.068	3.7	1.1	
57	11.000	103.571	-3.3	0	0	0.000	-1.609	10	-0.029	0.524	26.6	-5.5	
								Bus 99	0.002	0.123	6.2	1.7	
								Bus 101	0.002	0.120	6.1	1.3	
								Bus 103	0.003	0.143	7.2	1.9	
								61	0.022	0.618	31.3	3.5	
								NAPTIN Guest House 2 Bus	0.001	0.081	4.1	1.2	
61	11.000	101.694	-2.5	0	0	0	0	57	-0.013	-0.607	31.3	2.2	
								Bus 106	0.006	0.323	16.7	2.0	
								Bus 108	0.002	0.117	6.0	1.5	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Yuru Bus	0.005	0.167	8.6	3.2	
Agip Bus	0.415	95.035	1.3	0	0	0.001	0.075	Bus 143	-0.001	-0.075	110.3	0.8	
Aligani Bus1	0.415	95.235	0.3	0	0	0.001	0.180	Bus 47	-0.001	-0.180	262.3	0.8	
Anglican Church 1 Bus	0.415	94.933	0.6	0	0	0.001	0.147	Bus 18	-0.001	-0.147	215.3	0.8	
Anglican Church 2 Bus	0.415	95.667	0.5	0	0	0.002	0.174	Bus 20	-0.002	-0.174	252.9	0.9	
Army Engr Bus	0.415	94.870	1.2	0	0	0.001	0.081	Bus 121	-0.001	-0.081	118.2	0.8	
Awuru 1 Bus	0.415	100.698	-1.2	0	0	0.000	0.040	0015	0.000	-0.040	54.8	0.8	
Awuru 2 Bus	0.415	100.403	-1.1	0	0	0.000	0.042	Bus 172	0.000	-0.042	58.5	0.9	
Baba Ilorin Farm Bus	0.415	95.947	0.3	0	0	0.001	0.065	04	-0.001	-0.065	93.9	0.8	
Baba Ilorin House Bus	0.415	96.205	0.0	0	0	0.000	0.039	Bus 28	0.000	-0.039	56.0	0.9	
BF 1 Bus	0.415	93.158	0.2	0	0	0.001	0.081	Bus 55	-0.001	-0.081	121.0	0.8	
Borgu Comm. Bank Bus	0.415	96.633	0.0	0	0	0.000	0.031	Bus 36	0.000	-0.031	44.5	0.8	
BSW Bus	0.415	97.637	-0.8	0	0	0.001	0.094	Bus 67	-0.001	-0.094	134.6	0.8	
Bus 2	11.000	98.516	0.1	0	0	0	0	1	-0.001	-0.060	3.2	1.1	
								Govt. Sec Sch Bus	0.001	0.060	3.2	1.1	
Bus 4	11.000	98.476	0.1	0	0	0	0	1	-0.002	-0.148	7.9	1.1	
								Dantoro Lodge Bus	0.002	0.148	7.9	1.1	
Bus 7	11.000	97.877	0.3	0	0	0	0	02	-0.003	-0.176	9.5	1.5	
								Nedufu Estate Bus	0.003	0.176	9.5	1.5	
Bus 9	11.000	97.891	0.3	0	0	0	0	02	-0.002	-0.148	7.9	1.2	
								NIFFR HQS Bus	0.002	0.148	7.9	1.2	
Bus 11	11.000	97.908	0.3	0	0	0	0	02	-0.001	-0.112	6.0	1.2	
								Niger Rv Basin Bus	0.001	0.112	6.0	1.2	
Bus 13	11.000	97.872	0.3	0	0	0	0	02	-0.002	-0.133	7.1	1.3	
								NIFFR Junior Qtrs Bus	0.002	0.133	7.1	1.3	
Bus 15	11.000	97.811	0.3	0	0	0	0	02	-0.002	-0.165	8.9	1.1	
								Tudun Wali Bus	0.002	0.165	8.9	1.1	
Bus 18	11.000	97.570	0.3	0	0	0	0	03	-0.002	-0.151	8.1	1.3	
								Anglican Church 1 Bus	0.002	0.151	8.1	1.3	
Bus 20	11.000	97.526	0.3	0	0	0	0	03	-0.002	-0.177	9.5	1.3	
								Anglican Church 2 Bus	0.002	0.177	9.5	1.3	
Bus 22	11.000	97.596	0.3	0	0	0	0	03	-0.002	-0.116	6.2	1.6	
								Mil Qtrs 2 Bus	0.002	0.116	6.2	1.6	
Bus 24	11.000	97.540	0.3	0	0	0	0	03	-0.002	-0.157	8.4	1.2	
								Mil Qtrs 1 Bus	0.002	0.157	8.4	1.2	
Bus 26	11.000	98.089	-0.1	0	0	0	0	04	-0.002	-0.171	9.2	1.3	
								Bussa Town Hall Bus	0.002	0.171	9.2	1.3	
Bus 28	11.000	98.263	-0.2	0	0	0	0	04	-0.001	-0.040	2.1	1.3	
								Baba Ilorin House Bus	0.001	0.040	2.1	1.3	

Project:	PhD. PROJECT	ETAP	Page:	6
Location:	NEW BUSSA - NIGER STATE	12.6.0H	Date:	13-01-2018
Contract:			SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename:	NEW BUSSA SUBSTATION		Config.:	Normal

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus 30	11.000	98.240	-0.2	0	0	0	0	04	-0.001	-0.049	2.6	1.1	
								KEYSTONE Bank Bus	0.001	0.049	2.6	1.1	
Bus 32	11.000	98.112	-0.1	0	0	0	0	04	-0.002	-0.125	6.7	1.4	
								Old Army Barracks Bus	0.002	0.125	6.7	1.4	
Bus 34	11.000	97.835	0.0	0	0	0	0	04	-0.004	-0.289	15.5	1.5	
								Waziri Primary Sch Bus	0.004	0.289	15.5	1.5	
Bus 36	11.000	98.268	-0.2	0	0	0	0	04	0.000	-0.031	1.7	1.1	
								Borgu Comm. Bank Bus	0.000	0.031	1.7	1.1	
Bus 39	11.000	97.434	0.0	0	0	0	0	05	0.000	-0.042	2.3	1.0	
								UBA Bus	0.000	0.042	2.3	1.0	
Bus 41	11.000	97.417	0.0	0	0	0	0	05	-0.001	-0.050	2.7	1.1	
								MTN Bus	0.001	0.050	2.7	1.1	
Bus 43	11.000	97.236	0.1	0	0	0	0	05	-0.002	-0.149	8.0	1.4	
								Mammy market Bus	0.002	0.149	8.0	1.4	
Bus 45	11.000	97.319	0.0	0	0	0	0	05	-0.001	-0.102	5.5	1.3	
								MT Yard Bus1	0.001	0.102	5.5	1.3	
Bus 47	11.000	97.163	0.1	0	0	0	0	05	-0.002	-0.183	9.9	1.2	
								Aliguri Bus1	0.002	0.183	9.9	1.2	
Bus 49	11.000	97.270	0.1	0	0	0	0	05	-0.001	-0.126	6.8	1.1	
								Hanger Bus1	0.001	0.126	6.8	1.1	
Bus 51	11.000	97.287	0.1	0	0	0	0	05	-0.001	-0.116	6.3	1.1	
								Kidagba Bus1	0.001	0.116	6.3	1.1	
Bus 53	11.000	97.510	-0.2	0	0	0	0	07	-0.002	-0.138	7.4	1.4	
								TFT Bus	0.002	0.138	7.4	1.4	
Bus 55	11.000	97.607	-0.3	0	0	0	0	07	-0.001	-0.085	4.6	1.7	
								BF 1 Bus	0.001	0.085	4.6	1.7	
Bus 57	11.000	97.319	-0.2	0	0	0	0	07	-0.003	-0.228	12.3	1.3	
								Luma Road Bus	0.003	0.228	12.3	1.3	
Bus 59	11.000	97.586	-0.3	0	0	0	0	07	-0.001	-0.091	4.9	1.5	
								Elshadai Bus	0.001	0.091	4.9	1.5	
Bus 61	11.000	97.503	-0.2	0	0	0	0	07	-0.002	-0.131	7.0	1.2	
								Water Treatment Bus	0.002	0.131	7.0	1.2	
Bus 62	11.000	97.370	-0.2	0	0	0	0	07	-0.002	-0.193	10.4	1.1	
								Officers' Mess Bus	0.002	0.193	10.4	1.1	
Bus 65	11.000	98.621	-0.9	0	0	0	0	08	-0.002	-0.151	8.0	1.4	
								Corpra Below Bus	0.002	0.151	8.0	1.4	
Bus 67	11.000	98.735	-0.9	0	0	0	0	08	-0.001	-0.096	5.1	1.1	
								BSW Bus	0.001	0.096	5.1	1.1	
Bus 69	11.000	98.721	-0.9	0	0	0	0	08	-0.001	-0.100	5.3	1.2	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Clinic Bus	0.001	0.100	5.3	1.2	
Bus 71	11.000	98.758	-0.9	0	0	0	0	08	-0.001	-0.082	4.4	1.3	
								Niger Crescent Bus	0.001	0.082	4.4	1.3	
Bus 73	11.000	98.755	-0.9	0	0	0	0	08	-0.001	-0.080	4.3	1.3	
								Senior Camp C/T Bus	0.001	0.080	4.3	1.3	
Bus 75	11.000	98.713	-0.9	0	0	0	0	08	-0.002	-0.098	5.2	1.5	
								MESL Water Treatment Bus	0.002	0.098	5.2	1.5	
Bus 77	11.000	100.257	-1.7	0	0	0	0	09	-0.002	-0.153	8.0	1.4	
								Kaduna Drive Bus	0.002	0.153	8.0	1.4	
Bus 79	11.000	100.296	-1.7	0	0	0	0	09	-0.002	-0.136	7.1	1.3	
								Rader Bus	0.002	0.136	7.1	1.3	
Bus 81	11.000	100.280	-1.7	0	0	0	0	09	-0.002	-0.142	7.4	1.2	
								SNCO Bus	0.002	0.142	7.4	1.2	
Bus 83	11.000	100.293	-1.7	0	0	0	0	09	-0.002	-0.136	7.1	1.3	
								GRA Bus	0.002	0.136	7.1	1.3	
Bus 85	11.000	100.205	-1.7	0	0	0	0	09	-0.002	-0.164	8.6	1.2	
								Ilorin Road Bus	0.002	0.164	8.6	1.2	
Bus 87	11.000	100.428	-1.8	0	0	0	0	09	-0.001	-0.072	3.8	1.0	
								NAPTIN Guest House 1 Bus	0.001	0.072	3.8	1.0	
Bus 89	11.000	102.190	-2.6	0	0	0	0	10	-0.001	-0.065	3.4	1.4	
								Monai Bus	0.001	0.065	3.4	1.4	
Bus 91	11.000	102.044	-2.6	0	0	0	0	10	-0.001	-0.125	6.5	1.1	
								MESL Water Intake Bus	0.001	0.125	6.5	1.1	
Bus 93	11.000	101.976	-2.6	0	0	0	0	10	-0.002	-0.154	7.9	1.1	
								Motel Annex Bus	0.002	0.154	7.9	1.1	
Bus 95	11.000	102.023	-2.6	0	0	0	0	10	-0.001	-0.134	6.9	1.0	
								SOQ Bus	0.001	0.134	6.9	1.0	
Bus 97	11.000	102.083	-2.6	0	0	0	0	10	-0.001	-0.109	5.6	1.4	
								Chinese Quaters Bus	0.001	0.109	5.6	1.4	
Bus 99	11.000	103.256	-3.2	0	0	0	0	57	-0.002	-0.123	6.2	1.5	
								Zaria Way Bus	0.002	0.123	6.2	1.5	
Bus 101	11.000	103.263	-3.2	0	0	0	0	57	-0.001	-0.120	6.1	1.1	
								Donia Camp Bus	0.001	0.120	6.1	1.1	
Bus 103	11.000	103.186	-3.1	0	0	0	0	57	-0.002	-0.142	7.2	1.7	
								Kadariko Bus	0.002	0.142	7.2	1.7	
Bus 106	11.000	100.640	-2.1	0	0	0	0	61	-0.004	-0.319	16.7	1.2	
								Niger Water Plant Bus	0.004	0.319	16.7	1.2	
Bus 108	11.000	101.294	-2.4	0	0	0	0	61	-0.001	-0.117	6.0	1.2	
								Kuruwasa Bus	0.001	0.117	6.0	1.2	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus 111	11.000	97.875	0.4	0	0	0	0	001	-0.001	-0.078	4.2	1.1	
								Old Dogogari Bus	0.001	0.078	4.2	1.1	
Bus 113	11.000	97.901	0.4	0	0	0	0	001	0.000	-0.046	2.5	1.1	
								Koro Radio Bus	0.000	0.046	2.5	1.1	
Bus 116	11.000	97.135	0.7	0	0	0	0	004	-0.001	-0.067	3.6	0.9	
								Koro 1 Bus	0.001	0.067	3.6	0.9	
Bus 119	11.000	96.324	1.0	0	0	0	0	006	-0.001	-0.082	4.5	1.1	
								New Qtrs Bus	0.001	0.082	4.5	1.1	
Bus 121	11.000	96.318	1.0	0	0	0	0	006	-0.001	-0.082	4.5	1.1	
								Army Engr Bus	0.001	0.082	4.5	1.1	
Bus 123	11.000	96.328	1.0	0	0	0	0	006	-0.001	-0.073	4.0	0.9	
								Old Market Bus	0.001	0.073	4.0	0.9	
Bus 126	11.000	95.799	1.2	0	0	0	0	010	-0.001	-0.078	4.3	1.0	
								SS 13 Manchester Bus	0.001	0.078	4.3	1.0	
Bus 128	11.000	95.817	1.2	0	0	0	0	010	-0.001	-0.064	3.5	1.1	
								Hydro Bus	0.001	0.064	3.5	1.1	
Bus 131	11.000	95.552	1.3	0	0	0	0	013	-0.001	-0.049	2.7	1.2	
								Jobice Bus	0.001	0.049	2.7	1.2	
Bus 133	11.000	95.510	1.3	0	0	0	0	013	-0.001	-0.075	4.1	1.0	
								Dantoro Road Bus	0.001	0.075	4.1	1.0	
Bus 135	11.000	95.541	1.3	0	0	0	0	013	-0.001	-0.053	2.9	1.0	
								NIFFR Senior Qtrs 2 Bus	0.001	0.053	2.9	1.0	
Bus 138	11.000	95.532	1.3	0	0	0	0	017	-0.001	-0.073	4.0	1.0	
								Jehovah Witness Bus	0.001	0.073	4.0	1.0	
Bus 140	11.000	95.538	1.3	0	0	0	0	017	-0.001	-0.069	3.8	1.3	
								Niger Water Booster Bus	0.001	0.069	3.8	1.3	
Bus 143	11.000	95.845	1.2	0	0	0	0	020	-0.001	-0.076	4.2	1.0	
								Agip Bus	0.001	0.076	4.2	1.0	
Bus 145	11.000	95.845	1.2	0	0	0	0	020	-0.001	-0.076	4.1	1.2	
								General Hospital Bus	0.001	0.076	4.1	1.2	
Bus 148	11.000	95.637	1.3	0	0	0	0	023	-0.001	-0.062	3.4	1.1	
								Fisheries Sch. Bus	0.001	0.062	3.4	1.1	
Bus 152	11.000	98.545	0.0	0	0	0	0	0002	0.000	-0.037	2.0	1.1	
								Funkun Bus	0.000	0.037	2.0	1.1	
Bus 156	11.000	98.885	-0.2	0	0	0	0	0005	-0.001	-0.040	2.1	1.3	
								MTN Nassarawa Bus	0.001	0.040	2.1	1.3	
Bus 158	11.000	98.921	-0.2	0	0	0	0	0005	0.000	-0.025	1.3	0.8	
								NAPTIN Sch. Bus	0.000	0.025	1.3	0.8	
Bus 161	11.000	99.409	-0.4	0	0	0	0	0008	0.000	-0.053	2.8	0.9	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Nassarawa 1 Bus	0.000	0.053	2.8	0.9	
Bus 164	11.000	100.337	-0.8	0	0	0	0	0010	-0.001	-0.047	2.4	1.1	
								Nassarawa Grinder Bus	0.001	0.047	2.4	1.1	
Bus 167	11.000	101.715	-1.4	0	0	0	0	0012	0.000	-0.040	2.0	1.0	
								Sabo 1 Bus	0.000	0.040	2.0	1.0	
Bus 169	11.000	101.645	-1.4	0	0	0	0	0012	-0.001	-0.057	3.0	1.1	
								Sabo 2 Bus	0.001	0.057	3.0	1.1	
Bus 172	11.000	101.141	-1.2	0	0	0	0	0015	0.000	-0.043	2.2	1.2	
								Awuru 2 Bus	0.000	0.043	2.2	1.2	
* Bus230	33.000	100.000	0.0	0.226	2.490	0	0	MAIN BUS	0.226	2.490	43.8	9.0	
Bussa Town Hall Bus	0.415	96.863	0.1	0	0	0.002	0.169	Bus 26	-0.002	-0.169	242.6	0.9	
Catholic Church Bus	0.415	98.619	-1.7	0	0	0.000	0.057	09	0.000	-0.057	81.0	0.8	
Chinese Quaters Bus	0.415	99.365	-2.3	0	0	0.001	0.106	Bus 97	-0.001	-0.106	147.9	0.9	
Clinic Bus	0.415	97.512	-0.7	0	0	0.001	0.099	Bus 69	-0.001	-0.099	141.1	0.9	
Corpra Below Bus	0.415	96.018	-0.6	0	0	0.001	0.147	Bus 65	-0.001	-0.147	212.4	0.9	
D4 Bus	0.415	97.540	-0.9	0	0	0.001	0.133	08	-0.001	-0.133	190.0	0.9	
Dantoro Lodge Bus	0.415	96.940	0.3	0	0	0.001	0.146	Bus 4	-0.001	-0.146	209.0	0.8	
Dantoro Road Bus	0.415	94.710	1.4	0	0	0.001	0.074	Bus 133	-0.001	-0.074	108.8	0.8	
Donia Camp Bus	0.415	102.436	-3.0	0	0	0.001	0.119	Bus 101	-0.001	-0.119	161.0	0.9	
Elshadai Bus	0.415	95.372	0.1	0	0	0.001	0.089	Bus 59	-0.001	-0.089	129.2	0.8	
Emir's Guest House Bus	0.415	95.277	1.1	0	0	0.001	0.070	006	-0.001	-0.070	102.5	0.8	
Fed Col of Wildlife Bus	0.415	98.342	-0.1	0	0	0.000	0.037	0005	0.000	-0.037	52.5	0.9	
FGGC Bus	0.415	95.384	1.2	0	0	0.000	0.048	010	0.000	-0.048	70.3	0.9	
Fisheries Qtrs Bus	0.415	94.544	1.4	0	0	0.001	0.067	023	-0.001	-0.067	98.1	0.9	
Fisheries Sch. Bus	0.415	94.537	1.4	0	0	0.001	0.061	Bus 148	-0.001	-0.061	89.8	0.9	
Funkun Bus	0.415	97.580	0.2	0	0	0.000	0.037	Bus 152	0.000	-0.037	52.5	0.9	
GDSS Nassarawa Bus	0.415	98.528	-0.7	0	0	0.000	0.038	0010	0.000	-0.038	53.2	0.9	
General Hospital Bus	0.415	94.499	1.3	0	0	0.001	0.075	Bus 145	-0.001	-0.075	109.9	0.9	
Govt. Sec Sch Bus	0.415	97.476	0.2	0	0	0.001	0.059	Bus 2	-0.001	-0.059	84.9	0.9	
GRA Bus	0.415	97.988	-1.5	0	0	0.001	0.132	Bus 83	-0.001	-0.132	188.1	0.8	
Hanger Bus1	0.415	95.946	0.2	0	0	0.001	0.124	Bus 49	-0.001	-0.124	180.2	0.9	
Hydro Bus	0.415	95.034	1.4	0	0	0.001	0.064	Bus 128	-0.001	-0.064	93.1	0.8	
Ilorin Road Bus	0.415	98.533	-1.5	0	0	0.001	0.161	Bus 85	-0.001	-0.161	227.6	0.9	
Jehovah Witness Bus	0.415	94.746	1.4	0	0	0.001	0.073	Bus 138	-0.001	-0.073	106.9	0.8	
Jobice Bus	0.415	94.254	1.5	0	0	0.000	0.048	Bus 131	0.000	-0.048	70.7	0.9	
Kadariko Bus	0.415	98.485	-2.6	0	0	0.001	0.136	Bus 103	-0.001	-0.136	191.8	0.8	
Kaduna Drive Bus	0.415	97.660	-1.5	0	0	0.001	0.149	Bus 77	-0.001	-0.149	211.9	0.9	
Katamaya Hospita Bus	0.415	100.157	-2.4	0	0	0.001	0.098	10	-0.001	-0.098	136.3	0.9	
KEYSTONE Bank Bus	0.415	97.344	0.0	0	0	0.000	0.049	Bus 30	0.000	-0.049	69.7	0.8	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Kidagba Bus1	0.415	96.069	0.2	0	0	0.001	0.114	Bus 51	-0.001	-0.114	165.7	0.9	
Koro 1 Bus	0.415	96.434	0.7	0	0	0.001	0.066	Bus 116	-0.001	-0.066	95.5	0.8	
Koro Grinder Bus	0.415	95.558	0.8	0	0	0.001	0.061	004	-0.001	-0.061	89.0	0.9	
Koro Radio Bus	0.415	96.694	0.5	0	0	0.000	0.046	Bus 113	0.000	-0.046	65.7	0.8	
Kurawasa Bus	0.415	99.330	-2.2	0	0	0.001	0.114	Bus 108	-0.001	-0.114	160.3	0.9	
Kwarin Wali Bus	0.415	95.399	0.5	0	0	0.001	0.087	03	-0.001	-0.087	127.1	0.9	
Lafia Spot Bus	0.415	92.956	1.6	0	0	0.000	0.049	017	0.000	-0.049	73.1	0.8	
Local Govt Qters Bus	0.415	95.617	0.5	0	0	0.001	0.088	02	-0.001	-0.088	128.6	0.8	
Luma Road Bus	0.415	94.921	0.1	0	0	0.002	0.223	Bus 57	-0.002	-0.223	326.2	0.8	
MAIN BUS	11.000	98.834	0.0	0	0	0	0	1	0.172	1.332	71.3	12.8	
								001	0.037	1.066	56.6	3.4	
								0001	0.016	0.064	3.5	23.7	
								Bus230	-0.224	-2.461	131.3	9.1	
Mammy market Bus	0.415	94.623	0.4	0	0	0.001	0.145	Bus 43	-0.001	-0.145	213.3	0.9	
Manyara Bus	0.415	97.791	0.1	0	0	0.000	0.048	0002	0.000	-0.048	67.9	0.9	
MESL Water Intake Bus	0.415	100.787	-2.5	0	0	0.001	0.124	Bus 91	-0.001	-0.124	171.1	0.9	
MESL Water Reserv. Bus	0.415	96.121	0.1	0	0	0.001	0.130	05	-0.001	-0.130	188.6	0.8	
MESL Water Treatment Bus	0.415	96.387	-0.5	0	0	0.001	0.096	Bus 75	-0.001	-0.096	138.1	0.8	
Mil Qtrs 1 Bus	0.415	96.390	0.5	0	0	0.001	0.155	Bus 24	-0.001	-0.155	223.9	0.9	
Mil Qtrs 2 Bus	0.415	93.545	0.7	0	0	0.001	0.111	Bus 22	-0.001	-0.111	165.3	0.8	
Monai Bus	0.415	98.913	-2.3	0	0	0.000	0.063	Bus 89	0.000	-0.063	89.2	0.8	
Motel Annex Bus	0.415	100.435	-2.4	0	0	0.001	0.151	Bus 93	-0.001	-0.151	209.6	0.8	
MT Yard Bus1	0.415	94.634	0.3	0	0	0.001	0.099	Bus 45	-0.001	-0.099	146.1	0.8	
MTN Bus	0.415	96.097	0.1	0	0	0.000	0.050	Bus 41	0.000	-0.050	71.8	0.9	
MTN Nassanwa Bus	0.415	97.456	0.1	0	0	0.000	0.040	Bus 156	0.000	-0.040	56.6	0.8	
MTN Wildlife Bus	0.415	96.337	0.2	0	0	0.000	0.045	0004	0.000	-0.045	65.5	0.9	
NAPTIN Guest House 1 Bus	0.415	99.208	-1.7	0	0	0.001	0.071	Bus 87	-0.001	-0.071	99.6	0.8	
NAPTIN Guest House 2 Bus	0.415	102.236	-3.1	0	0	0.001	0.080	57	-0.001	-0.080	109.0	0.9	
NAPTIN Sch. Bus	0.415	98.660	-0.1	0	0	0.000	0.025	Bus 158	0.000	-0.025	35.5	0.8	
Nassanwa 1 Bus	0.415	98.864	-0.4	0	0	0.000	0.053	Bus 161	0.000	-0.053	74.2	0.8	
Nassanwa 2 Bus	0.415	98.926	-0.4	0	0	0.000	0.039	0008	0.000	-0.039	55.0	0.8	
Nassanwa Grinder Bus	0.415	99.152	-0.7	0	0	0.000	0.046	Bus 164	0.000	-0.046	64.5	0.9	
National Park HQ Bus	0.415	97.660	0.1	0	0	0.000	0.039	0001	0.000	-0.039	56.2	0.8	
Nedufu Estate Bus	0.415	94.806	0.6	0	0	0.002	0.171	Bus 7	-0.002	-0.171	250.6	0.9	
New Qtrs Bus	0.415	95.449	1.1	0	0	0.001	0.082	Bus 119	-0.001	-0.082	119.0	0.9	
Ngaski Bus	0.415	96.658	-0.2	0	0	0.001	0.106	07	-0.001	-0.106	152.0	0.9	
NIFFR HQS Bus	0.415	96.344	0.4	0	0	0.001	0.146	Bus 9	-0.001	-0.146	210.4	0.9	
NIFFR Junior Qtrs Bus	0.415	95.559	0.5	0	0	0.001	0.130	Bus 13	-0.001	-0.130	188.8	0.9	
NIFFR Sec. Qtrs Bus	0.415	95.049	1.4	0	0	0.000	0.053	013	0.000	-0.053	77.5	0.9	

LOAD FLOW REPORT(PEAK PERIOD)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
NIFFR Senior Qtrs 1 Bus	0.415	94.987	1.2	0	0	0.000	0.055	020	0.000	-0.055	79.9	0.9	
NIFFR Senior Qtrs 2 Bus	0.415	94.594	1.4	0	0	0.000	0.053	Bus 135	0.000	-0.053	77.3	0.8	
Niger Crescent Bus	0.415	95.925	-0.6	0	0	0.001	0.080	Bus 71	-0.001	-0.080	115.6	0.8	
Niger Rv Basin Bus	0.415	95.962	0.5	0	0	0.001	0.110	Bus 11	-0.001	-0.110	158.9	0.8	
Niger Water Booster Bus	0.415	93.682	1.5	0	0	0.001	0.068	Bus 140	-0.001	-0.068	101.0	0.9	
Niger Water Plant Bus	0.415	99.506	-1.9	0	0	0.003	0.316	Bus 106	-0.003	-0.316	441.6	0.9	
Officers' Mess Bus	0.415	96.022	0.0	0	0	0.002	0.190	Bus 62	-0.002	-0.190	275.2	0.9	
Old Army Barracks Bus	0.415	95.214	0.2	0	0	0.001	0.121	Bus 32	-0.001	-0.121	177.5	0.9	
Old Dogogari Bus	0.415	96.519	0.5	0	0	0.001	0.077	Bus 111	-0.001	-0.077	110.7	0.9	
Old Market Bus	0.415	95.551	1.1	0	0	0.001	0.073	Bus 123	-0.001	-0.073	105.8	0.8	
Rader Bus	0.415	97.991	-1.5	0	0	0.001	0.133	Bus 79	-0.001	-0.133	188.1	0.9	
Sabo 1 Bus	0.415	101.084	-1.4	0	0	0.000	0.039	Bus 167	0.000	-0.039	54.1	0.9	
Sabo 2 Bus	0.415	100.206	-1.3	0	0	0.000	0.056	Bus 169	0.000	-0.056	78.3	0.8	
Sabo Grinder Bus	0.415	100.755	-1.4	0	0	0.000	0.043	0012	0.000	-0.043	60.0	0.9	
Senior Camp C/T Bus	0.415	95.984	-0.6	0	0	0.001	0.078	Bus 73	-0.001	-0.078	113.1	0.8	
SNCO Bus	0.415	98.834	-1.6	0	0	0.001	0.140	Bus 81	-0.001	-0.140	196.6	0.9	
SOQ Bus	0.415	100.684	-2.4	0	0	0.001	0.132	Bus 95	-0.001	-0.132	182.1	0.8	
SS 13 Manchester Bus	0.415	94.963	1.3	0	0	0.001	0.078	Bus 126	-0.001	-0.078	113.7	0.9	
SS 40 Roundabout Bus	0.415	96.530	0.5	0	0	0.001	0.080	001	-0.001	-0.080	115.1	0.9	
Technical Jn Bus	0.415	95.712	0.4	0	0	0.001	0.158	1	-0.001	-0.158	230.4	0.8	
TFT Bus	0.415	95.849	0.1	0	0	0.001	0.136	Bus 53	-0.001	-0.136	197.4	0.8	
Tudun Wali Bus	0.415	96.082	0.5	0	0	0.001	0.162	Bus 15	-0.001	-0.162	235.3	0.8	
UBA Bus	0.415	96.676	0.1	0	0	0.000	0.042	Bus 39	0.000	-0.042	60.1	0.8	
Water Treatment Bus	0.415	95.903	0.0	0	0	0.001	0.129	Bus 61	-0.001	-0.129	186.8	0.8	
Waziri Primary Sch Bus	0.415	94.809	0.3	0	0	0.003	0.280	Bus 34	-0.003	-0.280	411.5	0.9	
Yuna Bus	0.415	94.075	-1.2	0	0	0.001	0.155	61	-0.001	-0.155	229.0	0.8	
Zaria Way Bus	0.415	99.198	-2.7	0	0	0.001	0.118	Bus 99	-0.001	-0.118	165.6	0.8	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

\# Indicates a bus with a load mismatch of more than 0.1 MVA

Table 4.10: Load Flow Report of New Bussa Compensated Network during Off-peak period

Project:	PhD. PROJECT	ETAP 12.6.0H		Page:	1
Location:	NEW BUSSA - NIGER STATE			Date:	11-20-2017
Contract:				SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case:	LOAD FLOW	Revision:	Base
Filename:	NEW BUSSA SUBSTATION			Config.:	Normal

LOAD FLOW REPORT (OFF - PEAK)

LOAD FLOW REPORT

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
1	11.000	99.119	0.0	0	0	0	0	MAIN BUS	-0.040	-0.339	18.1	11.8	
								Bus 2	0.000	0.029	1.6	1.0	
								Bus 4	0.001	0.057	3.0	1.0	
								02	0.039	0.184	10.0	20.7	
								Technical Jn Bus	0.001	0.069	3.6	1.0	
001	11.000	98.364	0.3	0	0	0	0	MAIN BUS	-0.027	-0.986	52.6	2.8	
								Bus 111	0.000	0.044	2.3	1.0	
								Bus 113	0.000	0.030	1.6	1.0	
								004	0.026	0.875	46.7	3.0	
								SS 40 Roundabout Bus	0.000	0.037	2.0	1.0	
0001	11.000	98.479	0.3	0	0	0	0	MAIN BUS	-0.010	-0.374	19.9	2.7	
								0002	0.010	0.343	18.3	2.9	
								National Park HQ Bus	0.000	0.031	1.7	1.0	
02	11.000	99.010	0.1	0	0	0	0	1	-0.039	-0.184	10.0	20.6	
								Bus 7	0.001	0.065	3.4	1.1	
								Bus 9	0.000	0.045	2.4	1.0	
								Bus 11	0.000	0.039	2.1	1.0	
								Bus 13	0.000	0.040	2.1	1.1	
								Bus 15	0.001	0.058	3.1	1.0	
								03	0.036	-0.096	5.4	-34.9	
								Local Govt Qters Bus	0.000	0.033	1.7	1.0	
0002	11.000	97.760	0.6	0	0	0	0	0001	-0.008	-0.341	18.3	2.3	
								Bus 152	0.000	0.014	0.8	1.0	
								0004	0.008	0.303	16.3	2.5	
								Manyara Bus	0.000	0.023	1.2	1.0	
03	11.000	99.081	0.0	0	0	0	0	02	-0.036	0.096	5.4	-34.8	
								Bus 18	0.000	0.037	1.9	0.9	
								Bus 20	0.001	0.048	2.6	1.1	
								Bus 22	0.000	0.028	1.5	1.0	
								Bus 24	0.000	0.046	2.4	1.0	
								04	0.034	-0.281	15.0	-12.0	
								Kwarin Wali Bus	0.000	0.026	1.4	1.0	
04	11.000	99.401	-0.2	0	0	0	0	03	-0.033	0.282	15.0	-11.7	
								Bus 26	0.000	0.034	1.8	1.0	
								Bus 28	0.000	0.009	0.5	1.0	
								Bus 30	0.000	0.030	1.6	1.0	

LOAD FLOW REPORT (OFF - PEAK)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Bus 32	0.000	0.031	1.7	1.0	
								Bus 34	0.001	0.067	3.6	1.1	
								Bus 36	0.000	0.015	0.8	1.0	
								05	0.031	-0.503	26.6	-6.1	
								Baba Ilorin Farm Bus	0.000	0.034	1.8	1.2	
004	11.000	97.602	0.7	0	0	0	0	001	-0.021	-0.868	46.7	2.5	
								Bus 116	0.000	0.032	1.7	0.9	
								006	0.021	0.805	43.3	2.6	
								Koro Grinder Bus	0.000	0.032	1.7	1.1	
0004	11.000	97.027	0.9	0	0	0	0	0002	-0.006	-0.301	16.3	2.0	
								0005	0.005	0.260	14.1	2.1	
								MTN Wildlife Bus	0.001	0.040	2.2	1.3	
05	11.000	100.196	-0.6	0	0	0	0	04	-0.028	0.508	26.6	-5.4	
								Bus 39	0.000	0.026	1.4	1.0	
								Bus 41	0.000	0.037	2.0	1.1	
								Bus 43	0.001	0.045	2.4	1.1	
								Bus 45	0.000	0.022	1.2	0.9	
								Bus 47	0.001	0.057	3.0	1.0	
								Bus 49	0.000	0.047	2.5	1.0	
								Bus 51	0.000	0.022	1.2	1.0	
								07	0.025	-0.819	42.9	-3.0	
								MESL Water Reserv. Bus	0.000	0.054	2.8	0.9	
0005	11.000	96.366	1.2	0	0	0	0	0004	-0.004	-0.258	14.1	1.6	
								Bus 156	0.000	0.036	2.0	1.4	
								Bus 158	0.000	0.016	0.8	0.9	
								0008	0.003	0.186	10.1	1.8	
								Fed Col of Wildlife Bus	0.000	0.021	1.2	1.0	
006	11.000	96.736	1.0	0	0	0	0	004	-0.016	-0.798	43.3	1.9	
								Bus 119	0.001	0.062	3.3	1.1	
								Bus 121	0.001	0.070	3.8	1.1	
								Bus 123	0.000	0.042	2.3	0.9	
								010	0.013	0.570	30.9	2.3	
								Emir's Guest House Bus	0.001	0.054	2.9	0.9	
07	11.000	101.660	-1.2	0	0	0.000	-0.930	05	-0.015	0.831	42.9	-1.9	
								Bus 53	0.000	0.027	1.4	1.0	
								Bus 55	0.000	0.032	1.7	1.1	
								Bus 57	0.001	0.068	3.5	1.1	
								Bus 59	0.000	0.025	1.3	1.0	
								Bus 61	0.000	0.025	1.3	0.9	

LOAD FLOW REPORT (OFF - PEAK)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Bus 62	0.000	0.036	1.9	1.0	
								08	0.013	-0.140	7.2	-9.3	
								Ngaski Bus	0.000	0.024	1.3	0.9	
08	11.000	101.920	-1.3	0	0	0.000	-0.312	07	-0.013	0.140	7.2	-9.1	
								Bus 65	0.001	0.054	2.8	1.2	
								Bus 67	0.000	0.020	1.0	0.9	
								Bus 69	0.000	0.042	2.2	1.1	
								Bus 71	0.000	0.027	1.4	1.0	
								Bus 73	0.000	0.028	1.4	1.0	
								Bus 75	0.000	0.026	1.3	1.0	
								09	0.010	-0.062	3.2	-16.4	
								D4 Bus	0.000	0.038	1.9	1.0	
0008	11.000	95.814	1.4	0	0	0	0	0005	-0.002	-0.185	10.1	1.3	
								Bus 161	0.000	0.032	1.8	0.9	
								0010	0.002	0.128	7.0	1.5	
								Nassarawa 2 Bus	0.000	0.024	1.3	0.9	
09	11.000	102.039	-1.4	0	0	0.000	-0.312	08	-0.010	0.062	3.2	-16.3	
								Bus 77	0.001	0.051	2.6	1.2	
								Bus 79	0.000	0.027	1.4	1.0	
								Bus 81	0.000	0.022	1.1	1.0	
								Bus 83	0.001	0.054	2.8	1.1	
								Bus 85	0.001	0.053	2.7	1.1	
								Bus 87	0.000	0.030	1.5	0.9	
								10	0.008	-0.001	0.4	-99.0	
								Catholic Church Bus	0.000	0.013	0.7	0.9	
10	11.000	102.028	-1.4	0	0	0.000	-0.312	09	-0.008	0.001	0.4	-99.0	
								Bus 89	0.000	0.015	0.8	0.9	
								Bus 91	0.001	0.078	4.0	1.2	
								Bus 93	0.001	0.092	4.8	1.1	
								Bus 95	0.000	0.019	1.0	0.9	
								Bus 97	0.000	0.035	1.8	1.1	
								57	0.005	0.034	1.8	13.2	
								Katamaya Hospita Bus	0.000	0.037	1.9	1.1	
010	11.000	96.009	1.3	0	0	0	0	006	-0.010	-0.566	30.9	1.8	
								Bus 126	0.001	0.051	2.8	1.0	
								Bus 128	0.000	0.026	1.4	0.9	
								013	0.009	0.467	25.5	1.9	
								FGGC Bus	0.000	0.022	1.2	0.9	
0010	11.000	95.401	1.6	0	0	0	0	0008	-0.002	-0.128	7.0	1.2	

LOAD FLOW REPORT (OFF - PEAK)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Bus 164	0.000	0.024	1.3	1.1	
								0012	0.001	0.077	4.3	1.3	
								GDSS Nassarawa Bus	0.000	0.026	1.4	1.2	
0012	11.000	95.111	1.7	0	0	0	0	0010	-0.001	-0.077	4.3	1.1	
								Bus 167	0.000	0.013	0.7	1.0	
								Bus 169	0.000	0.015	0.8	0.9	
								0015	0.000	0.034	1.9	1.2	
								Sabo Grinder Bus	0.000	0.014	0.8	1.0	
013	11.000	95.392	1.6	0	0	0	0	010	-0.007	-0.464	25.5	1.5	
								Bus 131	0.000	0.039	2.1	1.2	
								Bus 133	0.000	0.040	2.2	0.9	
								Bus 135	0.000	0.033	1.8	1.0	
								017	0.006	0.331	18.2	1.7	
								NIFFR Sec. Qtrs Bus	0.000	0.021	1.2	0.9	
0015	11.000	94.903	1.8	0	0	0	0	0012	0.000	-0.034	1.9	1.0	
								Bus 172	0.000	0.016	0.9	1.1	
								Awuru 1 Bus	0.000	0.018	1.0	0.9	
017	11.000	94.894	1.8	0	0	0	0	013	-0.004	-0.329	18.2	1.3	
								Bus 138	0.000	0.031	1.7	0.9	
								Bus 140	0.001	0.050	2.8	1.2	
								020	0.003	0.218	12.0	1.4	
								Lafia Spot Bus	0.000	0.030	1.7	1.1	
020	11.000	94.557	2.0	0	0	0	0	017	-0.002	-0.217	12.0	1.1	
								Bus 143	0.001	0.058	3.2	1.0	
								Bus 145	0.001	0.066	3.7	1.2	
								023	0.001	0.065	3.6	1.1	
								NIFFR Senior Qtrs 1 Bus	0.000	0.029	1.6	1.0	
023	11.000	94.445	2.0	0	0	0	0	020	-0.001	-0.064	3.6	1.1	
								Bus 148	0.000	0.039	2.2	1.1	
								Fisheries Qtrs Bus	0.000	0.025	1.4	1.0	
57	11.000	101.935	-1.4	0	0	0	0	10	-0.005	-0.034	1.8	13.2	
								Bus 99	0.000	0.021	1.1	0.9	
								Bus 101	0.000	0.025	1.3	0.9	
								Bus 103	0.000	0.037	1.9	1.1	
								61	0.003	-0.087	4.5	-3.8	
								NAPTIN Guest House 2 Bus	0.000	0.038	2.0	1.0	
61	11.000	102.190	-1.5	0	0	0.000	-0.313	57	-0.003	0.087	4.5	-3.6	
								Bus 106	0.002	0.155	8.0	1.4	
								Bus 108	0.000	0.026	1.4	1.0	

LOAD FLOW REPORT (OFF - PEAK)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Yuna Bus	0.001	0.045	2.3	1.5	
Agip Bus	0.415	93.839	2.1	0	0	0.000	0.057	Bus 143	0.000	-0.057	84.9	0.8	
Aligani Bus1	0.415	99.508	-0.5	0	0	0.000	0.057	Bus 47	0.000	-0.057	79.5	0.8	
Anglican Church 1 Bus	0.415	98.413	0.1	0	0	0.000	0.036	Bus 18	0.000	-0.036	51.4	0.8	
Anglican Church 2 Bus	0.415	98.527	0.1	0	0	0.000	0.048	Bus 20	0.000	-0.048	67.9	0.9	
Army Engr Bus	0.415	95.413	1.2	0	0	0.001	0.069	Bus 121	-0.001	-0.069	101.0	0.8	
Awuru 1 Bus	0.415	94.565	1.9	0	0	0.000	0.018	0015	0.000	-0.018	26.8	0.8	
Awuru 2 Bus	0.415	94.504	1.9	0	0	0.000	0.016	Bus 172	0.000	-0.016	23.7	0.9	
Baba Ilorin Farm Bus	0.415	98.212	0.0	0	0	0.000	0.033	04	0.000	-0.033	47.1	0.8	
Baba Ilorin House Bus	0.415	98.901	-0.1	0	0	0.000	0.009	Bus 28	0.000	-0.009	13.2	0.9	
BF 1 Bus	0.415	99.977	-1.0	0	0	0.000	0.032	Bus 55	0.000	-0.032	44.2	0.8	
Borgu Comm. Bank Bus	0.415	98.592	-0.1	0	0	0.000	0.015	Bus 36	0.000	-0.015	21.3	0.8	
BSW Bus	0.415	101.663	-1.3	0	0	0.000	0.019	Bus 67	0.000	-0.019	26.6	0.8	
Bus 2	11.000	99.110	0.0	0	0	0	0	1	0.000	-0.029	1.6	1.0	
								Govt. Sec Sch Bus	0.000	0.029	1.6	1.0	
Bus 4	11.000	99.097	0.0	0	0	0	0	1	-0.001	-0.057	3.0	1.0	
								Dantoro Lodge Bus	0.001	0.057	3.0	1.0	
Bus 7	11.000	98.973	0.1	0	0	0	0	02	-0.001	-0.065	3.4	1.1	
								Nedufu Estate Bus	0.001	0.065	3.4	1.1	
Bus 9	11.000	98.984	0.1	0	0	0	0	02	0.000	-0.045	2.4	1.0	
								NIFFR HQS Bus	0.000	0.045	2.4	1.0	
Bus 11	11.000	98.985	0.1	0	0	0	0	02	0.000	-0.039	2.1	1.0	
								Niger Rv Basin Bus	0.000	0.039	2.1	1.0	
Bus 13	11.000	98.978	0.1	0	0	0	0	02	0.000	-0.040	2.1	1.0	
								NIFFR Junior Qtrs Bus	0.000	0.040	2.1	1.0	
Bus 15	11.000	98.951	0.1	0	0	0	0	02	-0.001	-0.058	3.1	0.9	
								Tudun Wali Bus	0.001	0.058	3.1	0.9	
Bus 18	11.000	99.042	0.0	0	0	0	0	03	0.000	-0.037	1.9	0.9	
								Anglican Church 1 Bus	0.000	0.037	1.9	0.9	
Bus 20	11.000	99.026	0.0	0	0	0	0	03	0.000	-0.048	2.6	1.0	
								Anglican Church 2 Bus	0.000	0.048	2.6	1.0	
Bus 22	11.000	99.048	0.0	0	0	0	0	03	0.000	-0.028	1.5	1.0	
								Mil Qtrs 2 Bus	0.000	0.028	1.5	1.0	
Bus 24	11.000	99.026	0.0	0	0	0	0	03	0.000	-0.046	2.4	0.9	
								Mil Qtrs 1 Bus	0.000	0.046	2.4	0.9	
Bus 26	11.000	99.356	-0.2	0	0	0	0	04	0.000	-0.034	1.8	1.0	
								Bussa Town Hall Bus	0.000	0.034	1.8	1.0	
Bus 28	11.000	99.387	-0.2	0	0	0	0	04	0.000	-0.009	0.5	1.0	
								Baba Ilorin House Bus	0.000	0.009	0.5	1.0	

Project:	PhD. PROJECT	ETAP		Page:	6
Location:	NEW BUSSA - NIGER STATE	12.6.0H		Date:	11-20-2017
Contract:				SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case:	LOAD FLOW	Revision:	Base
Filename:	NEW BUSSA SUBSTATION			Config.:	Normal

LOAD FLOW REPORT (OFF - PEAK)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus 30	11.000	99.352	-0.2	0	0	0	0	04	0.000	-0.030	1.6	1.0	
								KEYSTONE Bank Bus	0.000	0.030	1.6	1.0	
Bus 32	11.000	99.349	-0.2	0	0	0	0	04	0.000	-0.031	1.7	1.0	
								Old Army Barracks Bus	0.000	0.031	1.7	1.0	
Bus 34	11.000	99.290	-0.1	0	0	0	0	04	-0.001	-0.067	3.6	1.0	
								Waziri Primary Sch Bus	0.001	0.067	3.6	1.0	
Bus 36	11.000	99.376	-0.2	0	0	0	0	04	0.000	-0.015	0.8	1.0	
								Borgu Comm. Bank Bus	0.000	0.015	0.8	1.0	
Bus 39	11.000	100.152	-0.5	0	0	0	0	05	0.000	-0.026	1.4	0.9	
								UBA Bus	0.000	0.026	1.4	0.9	
Bus 41	11.000	100.131	-0.5	0	0	0	0	05	0.000	-0.037	2.0	1.1	
								MTN Bus	0.000	0.037	2.0	1.1	
Bus 43	11.000	100.117	-0.5	0	0	0	0	05	0.000	-0.045	2.4	1.1	
								Mammy market Bus	0.000	0.045	2.4	1.1	
Bus 45	11.000	100.157	-0.5	0	0	0	0	05	0.000	-0.022	1.2	0.9	
								MT Yard Bus1	0.000	0.022	1.2	0.9	
Bus 47	11.000	100.092	-0.5	0	0	0	0	05	-0.001	-0.057	3.0	0.9	
								Aligani Bus1	0.001	0.057	3.0	0.9	
Bus 49	11.000	100.111	-0.5	0	0	0	0	05	0.000	-0.047	2.5	1.0	
								Hanger Bus1	0.000	0.047	2.5	1.0	
Bus 51	11.000	100.155	-0.5	0	0	0	0	05	0.000	-0.022	1.2	0.9	
								Kidagba Bus1	0.000	0.022	1.2	0.9	
Bus 53	11.000	101.610	-1.2	0	0	0	0	07	0.000	-0.027	1.4	0.9	
								TFT Bus	0.000	0.027	1.4	0.9	
Bus 55	11.000	101.600	-1.2	0	0	0	0	07	0.000	-0.032	1.7	1.1	
								BF 1 Bus	0.000	0.032	1.7	1.1	
Bus 57	11.000	101.530	-1.2	0	0	0	0	07	-0.001	-0.068	3.5	1.0	
								Luma Road Bus	0.001	0.068	3.5	1.0	
Bus 59	11.000	101.611	-1.2	0	0	0	0	07	0.000	-0.025	1.3	1.0	
								Elshadai Bus	0.000	0.025	1.3	1.0	
Bus 61	11.000	101.610	-1.2	0	0	0	0	07	0.000	-0.025	1.3	0.9	
								Water Treatment Bus	0.000	0.025	1.3	0.9	
Bus 62	11.000	101.588	-1.2	0	0	0	0	07	0.000	-0.036	1.9	0.9	
								Officers' Mess Bus	0.000	0.036	1.9	0.9	
Bus 65	11.000	101.811	-1.3	0	0	0	0	08	-0.001	-0.054	2.8	1.1	
								Corpra Below Bus	0.001	0.054	2.8	1.1	
Bus 67	11.000	101.880	-1.3	0	0	0	0	08	0.000	-0.019	1.0	0.9	
								BSW Bus	0.000	0.019	1.0	0.9	
Bus 69	11.000	101.833	-1.3	0	0	0	0	08	0.000	-0.042	2.2	1.0	

LOAD FLOW REPORT (OFF - PEAK)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Clinic Bus	0.000	0.042	2.2	1.0	
Bus 71	11.000	101.864	-1.3	0	0	0	0	08	0.000	-0.027	1.4	1.0	
								Niger Crescent Bus	0.000	0.027	1.4	1.0	
Bus 73	11.000	101.859	-1.3	0	0	0	0	08	0.000	-0.028	1.4	1.0	
								Senior Camp C/T Bus	0.000	0.028	1.4	1.0	
Bus 75	11.000	101.864	-1.3	0	0	0	0	08	0.000	-0.026	1.3	1.0	
								MESL Water Treatment Bus	0.000	0.026	1.3	1.0	
Bus 77	11.000	101.925	-1.4	0	0	0	0	09	-0.001	-0.051	2.6	1.1	
								Kaduna Drive Bus	0.001	0.051	2.6	1.1	
Bus 79	11.000	101.978	-1.4	0	0	0	0	09	0.000	-0.027	1.4	1.0	
								Rader Bus	0.000	0.027	1.4	1.0	
Bus 81	11.000	101.989	-1.4	0	0	0	0	09	0.000	-0.022	1.1	0.9	
								SNCO Bus	0.000	0.022	1.1	0.9	
Bus 83	11.000	101.917	-1.4	0	0	0	0	09	-0.001	-0.054	2.8	1.0	
								GRA Bus	0.001	0.054	2.8	1.0	
Bus 85	11.000	101.912	-1.4	0	0	0	0	09	-0.001	-0.053	2.7	1.0	
								Ilorin Road Bus	0.001	0.053	2.7	1.0	
Bus 87	11.000	101.967	-1.4	0	0	0	0	09	0.000	-0.030	1.5	0.9	
								NAPTIN Guest House 1 Bus	0.000	0.030	1.5	0.9	
Bus 89	11.000	101.990	-1.4	0	0	0	0	10	0.000	-0.015	0.8	0.9	
								Monai Bus	0.000	0.015	0.8	0.9	
Bus 91	11.000	101.839	-1.4	0	0	0	0	10	-0.001	-0.078	4.0	1.0	
								MESL Water Intake Bus	0.001	0.078	4.0	1.0	
Bus 93	11.000	101.804	-1.3	0	0	0	0	10	-0.001	-0.092	4.8	1.0	
								Motel Annex Bus	0.001	0.092	4.8	1.0	
Bus 95	11.000	101.982	-1.4	0	0	0	0	10	0.000	-0.019	1.0	0.8	
								SOQ Bus	0.000	0.019	1.0	0.8	
Bus 97	11.000	101.942	-1.4	0	0	0	0	10	0.000	-0.035	1.8	1.0	
								Chinese Quaters Bus	0.000	0.035	1.8	1.0	
Bus 99	11.000	101.880	-1.4	0	0	0	0	57	0.000	-0.021	1.1	0.9	
								Zaria Way Bus	0.000	0.021	1.1	0.9	
Bus 101	11.000	101.871	-1.4	0	0	0	0	57	0.000	-0.025	1.3	0.9	
								Donia Camp Bus	0.000	0.025	1.3	0.9	
Bus 103	11.000	101.833	-1.4	0	0	0	0	57	0.000	-0.037	1.9	1.0	
								Kadariko Bus	0.000	0.037	1.9	1.0	
Bus 106	11.000	101.688	-1.3	0	0	0	0	61	-0.002	-0.154	8.0	1.1	
								Niger Water Plant Bus	0.002	0.154	8.0	1.1	
Bus 108	11.000	102.100	-1.5	0	0	0	0	61	0.000	-0.026	1.4	0.9	
								Kuruwasa Bus	0.000	0.026	1.4	0.9	

Project:	PhD. PROJECT	ETAP		Page:	8
Location:	NEW BUSSA - NIGER STATE	12.6.0H		Date:	11-20-2017
Contract:				SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case:	LOAD FLOW	Revision:	Base
Filename:	NEW BUSSA SUBSTATION			Config.:	Normal

LOAD FLOW REPORT (OFF - PEAK)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus 111	11.000	98.328	0.4	0	0	0	0	001	0.000	-0.043	2.3	1.0	
								Old Dogogari Bus	0.000	0.043	2.3	1.0	
Bus 113	11.000	98.339	0.3	0	0	0	0	001	0.000	-0.030	1.6	1.0	
								Koro Radio Bus	0.000	0.030	1.6	1.0	
Bus 116	11.000	97.574	0.7	0	0	0	0	004	0.000	-0.032	1.7	0.9	
								Koro 1 Bus	0.000	0.032	1.7	0.9	
Bus 119	11.000	96.666	1.0	0	0	0	0	006	-0.001	-0.062	3.3	1.0	
								New Qtrs Bus	0.001	0.062	3.3	1.0	
Bus 121	11.000	96.650	1.1	0	0	0	0	006	-0.001	-0.070	3.8	1.1	
								Army Engr Bus	0.001	0.070	3.8	1.1	
Bus 123	11.000	96.684	1.0	0	0	0	0	006	0.000	-0.042	2.3	0.9	
								Old Market Bus	0.000	0.042	2.3	0.9	
Bus 126	11.000	95.943	1.4	0	0	0	0	010	-0.001	-0.051	2.8	1.0	
								SS 13 Manchester Bus	0.001	0.051	2.8	1.0	
Bus 128	11.000	95.976	1.3	0	0	0	0	010	0.000	-0.026	1.4	0.9	
								Hydro Bus	0.000	0.026	1.4	0.9	
Bus 131	11.000	95.338	1.6	0	0	0	0	013	0.000	-0.039	2.1	1.1	
								Jobice Bus	0.000	0.039	2.1	1.1	
Bus 133	11.000	95.334	1.6	0	0	0	0	013	0.000	-0.040	2.2	0.9	
								Dantoro Road Bus	0.000	0.040	2.2	0.9	
Bus 135	11.000	95.344	1.6	0	0	0	0	013	0.000	-0.033	1.8	1.0	
								NIFFR Senior Qtrs 2 Bus	0.000	0.033	1.8	1.0	
Bus 138	11.000	94.847	1.8	0	0	0	0	017	0.000	-0.031	1.7	0.9	
								Jehovah Witness Bus	0.000	0.031	1.7	0.9	
Bus 140	11.000	94.818	1.8	0	0	0	0	017	-0.001	-0.050	2.8	1.2	
								Niger Water Booster Bus	0.001	0.050	2.8	1.2	
Bus 143	11.000	94.463	2.0	0	0	0	0	020	-0.001	-0.058	3.2	1.0	
								Agip Bus	0.001	0.058	3.2	1.0	
Bus 145	11.000	94.449	2.0	0	0	0	0	020	-0.001	-0.066	3.7	1.2	
								General Hospital Bus	0.001	0.066	3.7	1.2	
Bus 148	11.000	94.376	2.0	0	0	0	0	023	0.000	-0.039	2.2	1.1	
								Fisheries Sch. Bus	0.000	0.039	2.2	1.1	
Bus 152	11.000	97.730	0.6	0	0	0	0	0002	0.000	-0.014	0.8	1.0	
								Funkun Bus	0.000	0.014	0.8	1.0	
Bus 156	11.000	96.274	1.2	0	0	0	0	0005	0.000	-0.036	2.0	1.3	
								MTN Nassarawa Bus	0.000	0.036	2.0	1.3	
Bus 158	11.000	96.325	1.2	0	0	0	0	0005	0.000	-0.016	0.8	0.8	
								NAPTIN Sch. Bus	0.000	0.016	0.8	0.8	
Bus 161	11.000	95.715	1.5	0	0	0	0	0008	0.000	-0.032	1.8	0.8	

Project:	PhD. PROJECT	ETAP	Page:	9
Location:	NEW BUSSA - NIGER STATE	12.6.0H	Date:	11-20-2017
Contract:			SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename:	NEW BUSSA SUBSTATION		Config.:	Normal

LOAD FLOW REPORT (OFF - PEAK)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Nassarawa 1 Bus	0.000	0.032	1.8	0.8	
Bus 164	11.000	95.321	1.6	0	0	0	0	0010	0.000	-0.024	1.3	1.0	
								Nassarawa Grinder Bus	0.000	0.024	1.3	1.0	
Bus 167	11.000	95.060	1.7	0	0	0	0	0012	0.000	-0.013	0.7	0.9	
								Sabo 1 Bus	0.000	0.013	0.7	0.9	
Bus 169	11.000	95.051	1.7	0	0	0	0	0012	0.000	-0.015	0.8	0.9	
								Sabo 2 Bus	0.000	0.015	0.8	0.9	
Bus 172	11.000	94.803	1.9	0	0	0	0	0015	0.000	-0.016	0.9	1.0	
								Awuru 2 Bus	0.000	0.016	0.9	1.0	
*Bus230	33.000	100.000	0.0	0.087	1.724	0	0	MAIN BUS	0.087	1.724	30.2	5.0	
Bussa Town Hall Bus	0.415	99.118	-0.1	0	0	0.000	0.034	Bus 26	0.000	-0.034	47.1	0.9	
Catholic Church Bus	0.415	101.589	-1.4	0	0	0.000	0.013	09	0.000	-0.013	18.4	0.8	
Chinese Quaters Bus	0.415	101.061	-1.3	0	0	0.000	0.035	Bus 97	0.000	-0.035	47.9	0.9	
Clinic Bus	0.415	101.342	-1.2	0	0	0.000	0.042	Bus 69	0.000	-0.042	57.3	0.9	
Corpra Below Bus	0.415	100.908	-1.2	0	0	0.000	0.053	Bus 65	0.000	-0.053	73.7	0.9	
D4 Bus	0.415	101.542	-1.3	0	0	0.000	0.038	08	0.000	-0.038	51.4	0.9	
Dantoro Lodge Bus	0.415	98.505	0.1	0	0	0.000	0.057	Bus 4	0.000	-0.057	80.5	0.8	
Dantoro Road Bus	0.415	94.909	1.7	0	0	0.000	0.039	Bus 133	0.000	-0.039	57.8	0.8	
Donia Camp Bus	0.415	101.699	-1.3	0	0	0.000	0.025	Bus 101	0.000	-0.025	33.5	0.8	
Elshadai Bus	0.415	101.025	-1.1	0	0	0.000	0.025	Bus 59	0.000	-0.025	34.2	0.8	
Emir's Guest House Bus	0.415	95.875	1.1	0	0	0.000	0.053	006	0.000	-0.053	77.4	0.8	
Fed Col of Wildlife Bus	0.415	95.989	1.2	0	0	0.000	0.021	0005	0.000	-0.021	30.8	0.9	
FGGC Bus	0.415	95.776	1.3	0	0	0.000	0.022	010	0.000	-0.022	31.8	0.9	
Fisheries Qtrs Bus	0.415	93.991	2.1	0	0	0.000	0.025	023	0.000	-0.025	37.1	0.9	
Fisheries Sch. Bus	0.415	93.667	2.1	0	0	0.000	0.039	Bus 148	0.000	-0.039	57.9	0.9	
Funkun Bus	0.415	97.355	0.6	0	0	0.000	0.014	Bus 152	0.000	-0.014	20.4	0.9	
GDSS Nassarawa Bus	0.415	94.001	1.7	0	0	0.000	0.026	0010	0.000	-0.026	38.1	0.9	
General Hospital Bus	0.415	93.253	2.1	0	0	0.001	0.065	Bus 145	-0.001	-0.065	97.6	0.9	
Govt. Sec Sch Bus	0.415	98.605	0.1	0	0	0.000	0.029	Bus 2	0.000	-0.029	41.2	0.9	
GRA Bus	0.415	101.011	-1.3	0	0	0.000	0.054	Bus 83	0.000	-0.054	73.9	0.8	
Hanger Bus1	0.415	99.630	-0.5	0	0	0.000	0.047	Bus 49	0.000	-0.047	65.4	0.9	
Hydro Bus	0.415	95.661	1.4	0	0	0.000	0.026	Bus 128	0.000	-0.026	37.5	0.8	
Ilorin Road Bus	0.415	101.380	-1.3	0	0	0.000	0.053	Bus 85	0.000	-0.053	72.4	0.9	
Jehovah Witness Bus	0.415	94.510	1.9	0	0	0.000	0.031	Bus 138	0.000	-0.031	45.9	0.8	
Jobice Bus	0.415	94.299	1.7	0	0	0.000	0.038	Bus 131	0.000	-0.038	56.5	0.9	
Kadariko Bus	0.415	100.584	-1.2	0	0	0.000	0.037	Bus 103	0.000	-0.037	51.0	0.8	
Kaduna Drive Bus	0.415	101.066	-1.3	0	0	0.000	0.051	Bus 77	0.000	-0.051	70.0	0.9	
Katamaya Hospita Bus	0.415	101.209	-1.3	0	0	0.000	0.037	10	0.000	-0.037	51.0	0.9	
KEYSTONE Bank Bus	0.415	98.807	-0.1	0	0	0.000	0.030	Bus 30	0.000	-0.030	42.4	0.8	

LOAD FLOW REPORT (OFF - PEAK)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Kidagba Bus1	0.415	99.926	-0.5	0	0	0.000	0.022	Bus 51	0.000	-0.022	31.1	0.9	
Koro 1 Bus	0.415	97.241	0.7	0	0	0.000	0.032	Bus 116	0.000	-0.032	45.2	0.8	
Koro Grinder Bus	0.415	96.774	0.7	0	0	0.000	0.031	004	0.000	-0.031	45.1	0.9	
Koro Radio Bus	0.415	97.547	0.4	0	0	0.000	0.030	Bus 113	0.000	-0.030	43.1	0.8	
Kuruwasa Bus	0.415	101.660	-1.4	0	0	0.000	0.026	Bus 108	0.000	-0.026	36.0	0.8	
Kwarin Wali Bus	0.415	98.407	0.1	0	0	0.000	0.026	03	0.000	-0.026	36.7	0.9	
Lafia Spot Bus	0.415	93.276	2.0	0	0	0.000	0.030	017	0.000	-0.030	44.0	0.8	
Local Govt Qters Bus	0.415	98.161	0.1	0	0	0.000	0.033	02	0.000	-0.033	46.2	0.8	
Luma Road Bus	0.415	100.843	-1.1	0	0	0.001	0.068	Bus 57	-0.001	-0.068	93.5	0.8	
MAIN BUS	11.000	99.194	0.0	0	0	0	0	1	0.041	0.339	18.1	11.9	
								001	0.034	0.994	52.6	3.4	
								0001	0.012	0.377	19.9	3.2	
								Bus230	-0.086	-1.710	90.6	5.0	
Mammy market Bus	0.415	99.351	-0.5	0	0	0.000	0.045	Bus 43	0.000	-0.045	62.6	0.9	
Manyara Bus	0.415	97.355	0.6	0	0	0.000	0.023	0002	0.000	-0.023	33.1	0.9	
MESL Water Intake Bus	0.415	101.057	-1.3	0	0	0.001	0.077	Bus 91	-0.001	-0.077	106.4	0.9	
MESL Water Reserv. Bus	0.415	99.649	-0.5	0	0	0.000	0.053	05	0.000	-0.053	74.4	0.8	
MESL Water Treatment Bus	0.415	101.278	-1.2	0	0	0.000	0.025	Bus 75	0.000	-0.025	34.9	0.8	
Mil Qtrs 1 Bus	0.415	98.697	0.1	0	0	0.000	0.045	Bus 24	0.000	-0.045	64.0	0.9	
Mil Qtrs 2 Bus	0.415	98.072	0.1	0	0	0.000	0.028	Bus 22	0.000	-0.028	39.8	0.8	
Monai Bus	0.415	101.220	-1.3	0	0	0.000	0.015	Bus 89	0.000	-0.015	21.0	0.7	
Motel Annex Bus	0.415	100.878	-1.2	0	0	0.001	0.091	Bus 93	-0.001	-0.091	125.9	0.8	
MT Yard Bus1	0.415	99.592	-0.5	0	0	0.000	0.022	Bus 45	0.000	-0.022	30.8	0.8	
MTN Bus	0.415	99.178	-0.4	0	0	0.000	0.037	Bus 41	0.000	-0.037	51.9	0.9	
MTN Nassarawa Bus	0.415	94.965	1.5	0	0	0.000	0.035	Bus 156	0.000	-0.035	51.8	0.8	
MTN Wildlife Bus	0.415	94.893	1.1	0	0	0.000	0.040	0004	0.000	-0.040	58.0	0.9	
NAPTIN Guest House 1 Bus	0.415	101.468	-1.3	0	0	0.000	0.030	Bus 87	0.000	-0.030	40.7	0.8	
NAPTIN Guest House 2 Bus	0.415	101.300	-1.3	0	0	0.000	0.038	57	0.000	-0.038	51.8	0.9	
NAPTIN Sch. Bus	0.415	96.160	1.2	0	0	0.000	0.016	Bus 158	0.000	-0.016	22.5	0.8	
Nassarawa 1 Bus	0.415	95.373	1.5	0	0	0.000	0.032	Bus 161	0.000	-0.032	46.6	0.8	
Nassarawa 2 Bus	0.415	95.399	1.5	0	0	0.000	0.024	0008	0.000	-0.024	35.5	0.8	
Nassarawa Grinder Bus	0.415	94.676	1.7	0	0	0.000	0.024	Bus 164	0.000	-0.024	35.1	0.9	
National Park HQ Bus	0.415	97.673	0.4	0	0	0.000	0.031	0001	0.000	-0.031	43.9	0.8	
Nedufu Estate Bus	0.415	97.862	0.2	0	0	0.001	0.064	Bus 7	-0.001	-0.064	90.7	0.9	
New Qtrs Bus	0.415	96.015	1.1	0	0	0.001	0.061	Bus 119	-0.001	-0.061	88.6	0.9	
Ngaski Bus	0.415	101.415	-1.2	0	0	0.000	0.024	07	0.000	-0.024	33.4	0.9	
NIFFR HQS Bus	0.415	98.524	0.1	0	0	0.000	0.044	Bus 9	0.000	-0.044	62.6	0.9	
NIFFR Junior Qtrs Bus	0.415	98.289	0.1	0	0	0.000	0.040	Bus 13	0.000	-0.040	56.3	0.9	
NIFFR Sec. Qtrs Bus	0.415	95.164	1.6	0	0	0.000	0.021	013	0.000	-0.021	31.0	0.9	

LOAD FLOW REPORT (OFF - PEAK)

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
NIFFR Senior Qtrs 1 Bus	0.415	94.043	2.0	0	0	0.000	0.028	020	0.000	-0.028	41.9	0.9	
NIFFR Senior Qtrs 2 Bus	0.415	94.755	1.7	0	0	0.000	0.033	Bus 135	0.000	-0.033	48.0	0.8	
Niger Crescent Bus	0.415	100.970	-1.2	0	0	0.000	0.026	Bus 71	0.000	-0.026	36.5	0.8	
Niger Rv Basin Bus	0.415	98.307	0.1	0	0	0.000	0.039	Bus 11	0.000	-0.039	55.4	0.8	
Niger Water Booster Bus	0.415	93.466	2.0	0	0	0.000	0.049	Bus 140	0.000	-0.049	73.6	0.9	
Niger Water Plant Bus	0.415	101.145	-1.2	0	0	0.001	0.153	Bus 106	-0.001	-0.153	211.1	0.9	
Officers' Mess Bus	0.415	101.347	-1.2	0	0	0.000	0.036	Bus 62	0.000	-0.036	49.3	0.9	
Old Army Barracks Bus	0.415	98.631	-0.1	0	0	0.000	0.031	Bus 32	0.000	-0.031	44.0	0.9	
Old Dogogari Bus	0.415	97.574	0.4	0	0	0.000	0.043	Bus 111	0.000	-0.043	61.5	0.9	
Old Market Bus	0.415	96.238	1.1	0	0	0.000	0.042	Bus 123	0.000	-0.042	60.8	0.8	
Rader Bus	0.415	101.524	-1.3	0	0	0.000	0.027	Bus 79	0.000	-0.027	37.1	0.9	
Sabo 1 Bus	0.415	94.835	1.8	0	0	0.000	0.013	Bus 167	0.000	-0.013	19.3	0.9	
Sabo 2 Bus	0.415	94.643	1.8	0	0	0.000	0.015	Bus 169	0.000	-0.015	22.2	0.8	
Sabo Grinder Bus	0.415	94.727	1.8	0	0	0.000	0.014	0012	0.000	-0.014	20.9	0.9	
Senior Camp C/T Bus	0.415	100.927	-1.2	0	0	0.000	0.028	Bus 73	0.000	-0.028	38.1	0.8	
SNCO Bus	0.415	101.765	-1.4	0	0	0.000	0.022	Bus 81	0.000	-0.022	30.4	0.9	
SOQ Bus	0.415	101.793	-1.4	0	0	0.000	0.019	Bus 95	0.000	-0.019	25.7	0.8	
SS 13 Manchester Bus	0.415	95.397	1.4	0	0	0.000	0.051	Bus 126	0.000	-0.051	74.2	0.9	
SS 40 Roundabout Bus	0.415	97.722	0.4	0	0	0.000	0.037	001	0.000	-0.037	52.4	0.9	
Technical Jn Bus	0.415	97.938	0.2	0	0	0.001	0.068	1	-0.001	-0.068	96.4	0.8	
TFT Bus	0.415	101.296	-1.1	0	0	0.000	0.027	Bus 53	0.000	-0.027	37.4	0.8	
Tudun Wali Bus	0.415	98.348	0.1	0	0	0.000	0.058	Bus 15	0.000	-0.058	82.1	0.8	
UBA Bus	0.415	99.691	-0.5	0	0	0.000	0.026	Bus 39	0.000	-0.026	36.5	0.8	
Water Treatment Bus	0.415	101.311	-1.2	0	0	0.000	0.025	Bus 61	0.000	-0.025	34.9	0.8	
Waziri Primary Sch Bus	0.415	98.598	-0.1	0	0	0.001	0.067	Bus 34	-0.001	-0.067	94.2	0.9	
Yuna Bus	0.415	100.172	-1.2	0	0	0.000	0.044	61	0.000	-0.044	60.8	0.8	
Zaria Way Bus	0.415	101.175	-1.3	0	0	0.000	0.021	Bus 99	0.000	-0.021	28.8	0.7	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

Table 4.11: Branch Losses Report for New Bussa Compensated Distribution Network during Peak Period

Project:	PhD. PROJECT	ETAP	Page:	1
Location:	NEW BUSSA - NIGER STATE	12.6.0H	Date:	15-12-2019
Contract:			SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename:	save		Config.:	Normal

LOAD FLOW REPORT(PEAK PERIOD)

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
L-1	-0.145	-1.913	0.151	1.921	5.7	7.7	98.3	98.7	0.42
L- 2	0.001	0.060	-0.001	-0.060	0.0	0.0	98.3	98.3	0.02
L- 3	0.002	0.147	-0.002	-0.147	0.1	0.1	98.3	98.2	0.06
L-4	0.141	1.544	-0.132	-1.531	9.4	12.6	98.3	97.4	0.85
Technical Jn TR	0.002	0.162	-0.001	-0.158	0.9	4.6	98.3	95.5	2.81
L-001	-0.033	-0.482	0.035	0.484	1.5	2.0	98.3	98.7	0.42
L- 002	0.001	0.078	-0.001	-0.078	0.0	0.1	98.3	98.2	0.07
L- 003	0.001	0.047	0.000	-0.047	0.0	0.0	98.3	98.2	0.04
L-004	0.031	0.276	-0.030	-0.275	0.5	0.7	98.3	98.0	0.26
SS 40 Roundabout TR	0.001	0.082	-0.001	-0.080	0.2	1.2	98.3	96.9	1.42
L-0001	-0.011	-0.355	0.013	0.357	1.8	2.4	98.0	98.7	0.68
L-0002	0.011	0.315	-0.009	-0.313	1.6	2.1	98.0	97.3	0.67
National Park HQ TR	0.000	0.039	0.000	-0.039	0.1	0.4	98.0	97.0	1.03
L- 5	0.003	0.174	-0.003	-0.174	0.1	0.2	97.4	97.3	0.10
L- 6	0.002	0.147	-0.002	-0.146	0.1	0.1	97.4	97.3	0.09
L- 7	0.001	0.111	-0.001	-0.111	0.1	0.1	97.4	97.4	0.07
L- 8	0.002	0.131	-0.002	-0.131	0.1	0.1	97.4	97.3	0.11
L- 9	0.002	0.164	-0.002	-0.164	0.2	0.3	97.4	97.3	0.17
L-10	0.121	0.715	-0.116	-0.709	4.2	5.6	97.4	96.6	0.83
Local Govt. Qters TR	0.001	0.090	-0.001	-0.087	0.4	2.2	97.4	95.1	2.35
L- 0003	0.000	0.036	0.000	-0.036	0.0	0.0	97.3	97.3	0.08
L-0004	0.008	0.230	-0.007	-0.229	1.0	1.3	97.3	96.8	0.56
Manyara TR	0.000	0.047	0.000	-0.046	0.1	0.4	97.3	96.5	0.82
L- 11	0.002	0.148	-0.002	-0.147	0.2	0.2	96.6	96.4	0.16
L- 12	0.002	0.174	-0.002	-0.173	0.3	0.4	96.6	96.4	0.21
L- 13	0.002	0.113	-0.002	-0.113	0.1	0.2	96.6	96.5	0.14
L- 14	0.002	0.154	-0.002	-0.153	0.2	0.3	96.6	96.4	0.19
L-15	0.107	0.034	-0.106	-0.033	0.1	0.2	96.6	96.4	0.14
Kwarin Wali TR	0.001	0.087	-0.001	-0.085	0.4	2.1	96.6	94.3	2.31
L- 16	0.002	0.165	-0.002	-0.165	0.3	0.4	96.4	96.2	0.23
L- 17	0.001	0.038	0.000	-0.038	0.0	0.0	96.4	96.4	0.06
L- 18	0.001	0.047	0.000	-0.047	0.0	0.0	96.4	96.4	0.08
L- 19	0.002	0.121	-0.002	-0.120	0.2	0.3	96.4	96.2	0.20
L- 20	0.005	0.280	-0.004	-0.278	1.0	1.4	96.4	96.0	0.48
L- 21	0.000	0.030	0.000	-0.030	0.0	0.0	96.4	96.4	0.05

LOAD FLOW REPORT(PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
L-22	0.095	-0.154	-0.094	0.154	0.4	0.6	96.4	96.6	0.14
Baba Ilorin Farm TR	0.001	0.064	0.000	-0.062	0.5	1.5	96.4	94.1	2.33
L- 005	0.001	0.068	-0.001	-0.068	0.0	0.0	98.0	98.0	0.06
L-006	0.029	0.144	-0.029	-0.144	0.2	0.2	98.0	97.8	0.17
Koro Grinder TR	0.001	0.063	-0.001	-0.062	0.2	1.1	98.0	96.4	1.65
L-0005	0.006	0.184	-0.006	-0.183	0.7	0.9	96.8	96.3	0.47
MTN Wildlife TR	0.001	0.045	0.000	-0.044	0.2	1.1	96.8	94.4	2.36
L- 23	0.000	0.041	0.000	-0.041	0.0	0.0	96.6	96.5	0.07
L- 24	0.001	0.049	-0.001	-0.049	0.0	0.0	96.6	96.5	0.09
L- 25	0.002	0.147	-0.002	-0.146	0.3	0.4	96.6	96.3	0.27
L- 26	0.001	0.100	-0.001	-0.100	0.1	0.2	96.6	96.4	0.19
L - 27	0.003	0.180	-0.002	-0.180	0.5	0.6	96.6	96.2	0.34
L - 28	0.002	0.124	-0.001	-0.124	0.2	0.3	96.6	96.4	0.23
L - 29	0.001	0.114	-0.001	-0.114	0.2	0.3	96.6	96.4	0.22
L-30	0.082	0.359	-0.080	-0.357	2.0	2.7	96.6	95.8	0.79
MESL Water Reserviour TR	0.001	0.130	-0.001	-0.128	0.4	1.8	96.6	95.2	1.37
L- 0006	0.001	0.038	-0.001	-0.038	0.0	0.0	96.3	96.2	0.10
L- 0007	0.000	0.024	0.000	-0.024	0.0	0.0	96.3	96.2	0.06
L-0008	0.005	0.086	-0.005	-0.086	0.2	0.2	96.3	96.0	0.26
Fed Col of Wildlife TR	0.000	0.035	0.000	-0.035	0.0	0.2	96.3	95.7	0.63
L- 007	0.001	0.085	-0.001	-0.085	0.1	0.1	97.8	97.7	0.10
L- 008	0.001	0.084	-0.001	-0.084	0.1	0.1	97.8	97.7	0.10
L- 009	0.001	0.076	-0.001	-0.075	0.1	0.1	97.8	97.8	0.09
L-010	0.025	-0.174	-0.025	0.175	0.3	0.4	97.8	98.0	0.19
Emir's Guest House TR	0.001	0.073	-0.001	-0.072	0.2	0.9	97.8	96.7	1.16
L- 31	0.002	0.133	-0.002	-0.133	0.3	0.4	95.8	95.5	0.26
L- 32	0.001	0.082	-0.001	-0.081	0.1	0.1	95.8	95.6	0.16
L- 33	0.004	0.220	-0.003	-0.219	0.8	1.0	95.8	95.3	0.45
L- 34	0.001	0.087	-0.001	-0.087	0.1	0.2	95.8	95.6	0.18
L- 35	0.002	0.126	-0.002	-0.126	0.3	0.3	95.8	95.5	0.27
L- 36	0.003	0.186	-0.002	-0.185	0.6	0.8	95.8	95.4	0.40
L-37	0.066	-0.579	-0.061	0.587	5.6	7.5	95.8	96.9	1.13
Ngaski TR	0.001	0.103	-0.001	-0.101	0.2	1.2	95.8	94.7	1.09
L- 38	0.002	0.145	-0.002	-0.144	0.3	0.5	96.9	96.6	0.31
L- 39	0.001	0.092	-0.001	-0.092	0.1	0.2	96.9	96.7	0.20
L- 40	0.001	0.096	-0.001	-0.096	0.2	0.2	96.9	96.7	0.21
L- 41	0.001	0.079	-0.001	-0.079	0.1	0.1	96.9	96.7	0.17

Project:	PhD. PROJECT	ETAP	Page:	3
Location:	NEW BUSSA - NIGER STATE	12.6.0H	Date:	15-12-2019
Contract:			SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename:	save		Config.:	Normal

LOAD FLOW REPORT(PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
L- 42	0.001	0.077	-0.001	-0.077	0.1	0.1	96.9	96.7	0.18
L- 43	0.002	0.094	-0.001	-0.094	0.2	0.2	96.9	96.7	0.22
L-44	0.050	0.109	-0.050	-0.109	0.3	0.3	96.9	96.6	0.34
D4 TR	0.002	0.130	-0.001	-0.128	0.4	1.8	96.9	95.6	1.37
L- 0009	0.000	0.049	0.000	-0.049	0.1	0.1	96.0	95.9	0.15
L-0010	0.004	0.000	-0.004	0.000	0.0	0.0	96.0	96.0	0.01
Nassarawa 2 TR	0.000	0.037	0.000	-0.036	0.0	0.2	96.0	95.4	0.62
L- 45	0.002	0.141	-0.002	-0.141	0.4	0.5	96.6	96.3	0.33
L- 46	0.002	0.125	-0.002	-0.125	0.3	0.4	96.6	96.3	0.30
L- 47	0.002	0.131	-0.002	-0.131	0.3	0.4	96.6	96.3	0.31
L- 48	0.002	0.125	-0.002	-0.125	0.3	0.4	96.6	96.3	0.30
L- 49	0.002	0.152	-0.002	-0.151	0.4	0.6	96.6	96.2	0.38
L- 50	0.001	0.066	-0.001	-0.066	0.1	0.1	96.6	96.4	0.17
L-51	0.038	-0.406	-0.035	0.411	3.2	4.3	96.6	97.5	0.95
Catholic Church TR	0.001	0.054	0.000	-0.053	0.2	1.1	96.6	94.7	1.91
L- 52	0.001	0.060	-0.001	-0.059	0.1	0.1	97.5	97.4	0.15
L- 53	0.002	0.114	-0.001	-0.114	0.3	0.3	97.5	97.2	0.29
L- 54	0.002	0.140	-0.002	-0.140	0.4	0.5	97.5	97.2	0.36
L- 55	0.002	0.122	-0.001	-0.121	0.3	0.4	97.5	97.2	0.31
L- 56	0.002	0.099	-0.001	-0.099	0.2	0.3	97.5	97.3	0.25
L-57	0.027	-0.180	-0.026	0.181	0.7	0.9	97.5	98.0	0.42
Katamaya Hospital TR	0.001	0.091	-0.001	-0.089	0.5	1.9	97.5	95.4	2.09
L- 011	0.001	0.082	-0.001	-0.082	0.1	0.1	98.0	97.9	0.10
L- 012	0.001	0.067	-0.001	-0.067	0.0	0.1	98.0	98.0	0.09
L-013	0.023	-0.374	-0.022	0.376	1.4	1.8	98.0	98.5	0.46
FGGC TR	0.000	0.051	0.000	-0.050	0.1	0.3	98.0	97.5	0.53
L- 0011	0.001	0.043	0.000	-0.042	0.0	0.1	96.0	95.9	0.14
L-0012	0.003	-0.078	-0.003	0.078	0.2	0.2	96.0	96.3	0.28
GDSS Nassarawa TR	0.000	0.035	0.000	-0.034	0.1	0.7	96.0	94.2	1.87
L- 0013	0.000	0.035	0.000	-0.035	0.0	0.0	96.3	96.2	0.14
L- 0014	0.001	0.051	-0.001	-0.051	0.1	0.1	96.3	96.1	0.20
L-0015	0.001	0.074	-0.001	-0.074	0.3	0.3	96.3	95.9	0.44
Sabo Grinder TR	0.000	0.039	0.000	-0.039	0.1	0.4	96.3	95.3	1.04
L- 014	0.001	0.052	-0.001	-0.051	0.0	0.0	98.5	98.4	0.07
L- 015	0.001	0.079	-0.001	-0.079	0.1	0.1	98.5	98.4	0.11
L- 016	0.001	0.056	-0.001	-0.056	0.0	0.0	98.5	98.4	0.08
L-017	0.019	-0.620	-0.015	0.625	4.2	5.6	98.5	99.4	0.87

LOAD FLOW REPORT(PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
NIFFR Sec. Qtrs TR	0.001	0.056	-0.001	-0.056	0.1	0.3	98.5	97.9	0.59
L- 0016	0.001	0.038	0.000	-0.038	0.1	0.1	95.9	95.6	0.23
Awuru 1 TR	0.000	0.036	0.000	-0.035	0.1	0.2	95.9	95.2	0.65
L- 018	0.001	0.079	-0.001	-0.079	0.1	0.1	99.4	99.3	0.12
L- 019	0.001	0.075	-0.001	-0.075	0.1	0.1	99.4	99.3	0.11
L-020	0.012	-0.834	-0.005	0.844	7.7	10.3	99.4	100.6	1.21
Lafia Spot TR	0.001	0.054	0.000	-0.053	0.3	1.5	99.4	96.6	2.79
L- 021	0.001	0.084	-0.001	-0.083	0.1	0.1	100.6	100.5	0.13
L- 022	0.001	0.083	-0.001	-0.083	0.1	0.1	100.6	100.5	0.13
L-023	0.002	0.142	-0.002	-0.142	0.2	0.3	100.6	100.4	0.23
NIFFR Senior Qtrs 1 TR	0.001	0.061	-0.001	-0.060	0.1	0.6	100.6	99.6	1.03
L- 024	0.001	0.068	-0.001	-0.068	0.1	0.1	100.4	100.2	0.11
Fisheries Qtrs TR	0.001	0.074	-0.001	-0.073	0.2	0.9	100.4	99.1	1.26
L- 58	0.002	0.110	-0.002	-0.110	0.2	0.3	98.0	97.7	0.30
L- 59	0.001	0.107	-0.001	-0.107	0.2	0.3	98.0	97.7	0.29
L- 60	0.002	0.128	-0.002	-0.127	0.3	0.5	98.0	97.6	0.36
L-61	0.019	0.553	-0.012	-0.543	7.3	9.8	98.0	96.2	1.77
NAPTIN Guest House 2 TR	0.001	0.073	-0.001	-0.072	0.2	0.9	98.0	96.7	1.26
L- 62	0.006	0.289	-0.004	-0.286	2.2	3.0	96.2	95.2	1.00
L- 63	0.002	0.105	-0.001	-0.104	0.3	0.4	96.2	95.8	0.38
Yuna TR	0.005	0.150	-0.001	-0.139	3.6	11.1	96.2	89.0	7.21
Agip TR	-0.001	-0.083	0.001	0.083	0.1	0.7	99.6	100.5	0.85
Aligani TR1	-0.001	-0.176	0.002	0.180	0.7	3.6	94.3	96.2	1.91
Anglican Church 1 TR	-0.001	-0.143	0.002	0.147	0.8	4.0	93.8	96.4	2.61
Anglican Church 2 TR	-0.002	-0.170	0.002	0.173	0.6	3.3	94.5	96.4	1.84
Army Engineer TR	-0.001	-0.083	0.001	0.084	0.2	1.3	96.3	97.7	1.47
Awuru 2 TR	0.000	-0.038	0.000	0.038	0.1	0.3	94.9	95.6	0.70
Baba Ilorin House TR	0.000	-0.037	0.000	0.038	0.2	0.8	94.4	96.4	2.02
BF 1 TR	-0.001	-0.078	0.001	0.081	0.7	3.7	91.3	95.6	4.36
Borgu Community Bank TR	0.000	-0.030	0.000	0.030	0.1	0.5	94.8	96.4	1.60
BSW TR	-0.001	-0.091	0.001	0.092	0.3	1.0	95.6	96.7	1.08
Govt. Sec Sch TR	0.001	0.060	-0.001	-0.059	0.1	0.6	98.3	97.2	1.04
Dantoro Lodge TR	0.002	0.147	-0.001	-0.145	0.4	2.3	98.2	96.7	1.53
Nedufu Estate TR	0.003	0.174	-0.002	-0.169	1.1	5.5	97.3	94.3	3.05
NIFFR HQS TR	0.002	0.146	-0.001	-0.144	0.5	2.3	97.3	95.8	1.54
Niger River Basin TR	0.001	0.111	-0.001	-0.108	0.4	2.2	97.4	95.4	1.94
NIFFR Junior Qtrs TR	0.002	0.131	-0.001	-0.128	0.6	3.1	97.3	95.0	2.30

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ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Tudun Wali TR	0.002	0.164	-0.001	-0.161	0.6	2.9	97.3	95.5	1.72
Mil Quarters 2 TR	0.002	0.113	-0.001	-0.109	0.9	4.7	96.5	92.5	4.00
Mil Quarters 1 TR	0.002	0.153	-0.001	-0.152	0.5	1.8	96.4	95.3	1.14
Bussa Town Hall TR	0.002	0.165	-0.001	-0.163	0.7	2.0	96.2	95.0	1.20
KEYSTONE Bank TR	0.000	0.047	0.000	-0.047	0.1	0.4	96.4	95.5	0.88
Old Army Barracks TR	0.002	0.120	-0.001	-0.117	0.6	3.6	96.2	93.4	2.84
Waziri Primary Sch TR	0.004	0.278	-0.002	-0.270	1.7	8.6	96.0	93.0	2.97
UBA TR	0.000	0.041	0.000	-0.041	0.1	0.3	96.5	95.8	0.75
MTN TR	0.001	0.049	0.000	-0.049	0.1	0.7	96.5	95.2	1.31
Mammy market TR	0.002	0.146	-0.001	-0.142	0.8	3.9	96.3	93.7	2.59
MT Yard TR1	0.001	0.100	-0.001	-0.098	0.5	2.8	96.4	93.7	2.66
Hanger TR1	0.001	0.124	-0.001	-0.122	0.3	1.7	96.4	95.0	1.31
Kidagba TR1	0.001	0.114	-0.001	-0.112	0.3	1.4	96.4	95.2	1.21
TFT TR	0.002	0.133	-0.001	-0.131	0.8	2.3	95.5	93.9	1.63
Luma Road TR	0.003	0.219	-0.002	-0.214	1.1	5.4	95.3	93.0	2.35
Elshadai TR	0.001	0.087	-0.001	-0.085	0.5	2.0	95.6	93.4	2.17
Water Treatment TR	0.002	0.126	-0.001	-0.124	0.6	2.1	95.5	94.0	1.57
Officers' Mess TR	0.002	0.185	-0.002	-0.182	0.5	2.6	95.4	94.1	1.32
Corpra Below TR	0.002	0.144	-0.001	-0.141	0.7	3.8	96.6	94.1	2.55
Clinic TR	0.001	0.096	-0.001	-0.095	0.3	1.2	96.7	95.5	1.18
Niger Crescent TR	0.001	0.079	-0.001	-0.076	0.4	2.3	96.7	94.0	2.78
Senior Camp C/T TR	0.001	0.077	-0.001	-0.075	0.4	2.2	96.7	94.0	2.71
MESL Water Treatment TR	0.001	0.094	-0.001	-0.092	0.8	2.2	96.7	94.4	2.28
Kaduna Drive TR	0.002	0.141	-0.001	-0.137	0.7	3.6	96.3	93.8	2.49
Rader TR	0.002	0.125	-0.001	-0.122	0.6	2.9	96.3	94.1	2.21
SNCO TR	0.002	0.131	-0.001	-0.129	0.4	1.9	96.3	94.9	1.39
GRA TR	0.002	0.125	-0.001	-0.122	0.6	2.9	96.3	94.1	2.21
Ilorin Road TR	0.002	0.151	-0.001	-0.149	0.5	2.5	96.2	94.6	1.61
NAPTIN Guest House 1 TR	0.001	0.066	0.000	-0.065	0.2	0.8	96.4	95.2	1.17
Monai TR	0.001	0.059	0.000	-0.058	0.4	1.9	97.4	94.3	3.12
MESL Water Intake TR	0.001	0.114	-0.001	-0.113	0.3	1.4	97.2	96.0	1.20
Motel Annex TR	0.002	0.140	-0.001	-0.137	0.4	2.1	97.2	95.7	1.47
SOQ TR	0.001	0.121	-0.001	-0.120	0.3	1.6	97.2	96.0	1.28
Chinese Quaters TR	0.001	0.099	-0.001	-0.096	0.5	2.6	97.3	94.7	2.59
Zaria Way TR	0.002	0.110	-0.001	-0.106	0.8	4.3	97.7	93.8	3.84
Donia Camp TR	0.001	0.107	-0.001	-0.106	0.2	0.9	97.7	96.9	0.78
Kadariko TR	0.002	0.127	-0.001	-0.121	1.1	5.8	97.6	93.1	4.45

Project:	PhD. PROJECT	ETAP	Page:	6
Location:	NEW BUSSA - NIGER STATE	12.6.0H	Date:	15-12-2019
Contract:			SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename:	save		Config.:	Normal

LOAD FLOW REPORT(PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Niger Water Plant TR	0.004	0.286	-0.003	-0.283	0.9	3.2	95.2	94.1	1.07
Kuruwasa TR	0.001	0.104	-0.001	-0.102	0.4	2.0	95.8	93.9	1.86
Old Dogogari TR	0.001	0.078	-0.001	-0.077	0.2	1.1	98.2	96.8	1.36
Koro Radio TR	0.000	0.047	0.000	-0.046	0.1	0.6	98.2	97.0	1.21
Koro 1 TR	0.001	0.068	-0.001	-0.067	0.1	0.5	98.0	97.3	0.71
New Quarters TR	0.001	0.085	-0.001	-0.084	0.2	0.8	97.7	96.9	0.89
Old Market TR	0.001	0.075	-0.001	-0.075	0.1	0.6	97.8	97.0	0.79
SS 13 Manchester TR	0.001	0.082	-0.001	-0.081	0.1	0.7	97.9	97.1	0.85
Hydro TR	0.001	0.067	-0.001	-0.066	0.2	0.5	98.0	97.1	0.80
Jobice TR	0.001	0.051	0.000	-0.051	0.1	0.7	98.4	97.1	1.34
Dantoro Road TR	0.001	0.079	-0.001	-0.079	0.1	0.7	98.4	97.6	0.82
NIFFR Senior Qtrs 2 TR	0.001	0.056	0.000	-0.056	0.1	0.6	98.4	97.4	0.98
Jehovah Witness TR	0.001	0.079	-0.001	-0.079	0.1	0.7	99.3	98.4	0.82
Niger Water Booster TR	0.001	0.075	-0.001	-0.073	0.3	1.5	99.3	97.3	1.93
General Hospital TR	0.001	0.083	-0.001	-0.082	0.2	1.2	100.5	99.0	1.41
Fisheries Sch. TR	0.001	0.068	-0.001	-0.067	0.2	0.8	100.2	99.1	1.15
Funkun TR	0.000	0.036	0.000	-0.036	0.1	0.4	97.3	96.3	0.95
MTN Nassarawa TR	0.001	0.038	0.000	-0.038	0.2	0.5	96.2	94.8	1.39
NAPTIN School TR	0.000	0.024	0.000	-0.024	0.0	0.1	96.2	96.0	0.25
Nassarawa 1 TR	0.000	0.049	0.000	-0.049	0.1	0.3	95.9	95.4	0.53
Nassarawa Grinder TR	0.000	0.042	0.000	-0.042	0.1	0.5	95.9	94.8	1.13
Sabo 1 TR	0.000	0.035	0.000	-0.035	0.0	0.2	96.2	95.6	0.60
Sabo 2 TR	0.001	0.051	0.000	-0.050	0.1	0.7	96.1	94.7	1.36
Power Transformer	0.201	2.799	-0.199	-2.762	2.0	36.7	100.0	98.7	1.31
					118.5	328.0			

Table 4.12: Branch Losses Report for New Bussa Compensated Distribution Network during Off-Peak Period

Project: PhD. PROJECT	ETAP	Page:	1
Location: NEW BUSSA - NIGER STATE	12.6.0H	Date:	15-12-2019
Contract:		SN:	
Engineer: OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename: save 2		Config.:	Normal

LOAD FLOW REPORT (OFF-PEAK PERIOD)

Branch Losses Summary Report

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
L-1	-0.039	-0.440	0.039	0.441	0.3	0.4	99.1	99.1	0.10
L- 2	0.000	0.029	0.000	-0.029	0.0	0.0	99.1	99.0	0.01
L- 3	0.001	0.057	-0.001	-0.057	0.0	0.0	99.1	99.0	0.02
L-4	0.037	0.285	-0.037	-0.285	0.3	0.4	99.1	98.9	0.16
Technical Jn TR	0.001	0.069	-0.001	-0.068	0.2	0.8	99.1	97.9	1.18
L-001	-0.027	-0.985	0.033	0.993	6.1	8.1	98.3	99.1	0.83
L- 002	0.000	0.043	0.000	-0.043	0.0	0.0	98.3	98.3	0.04
L- 003	0.000	0.030	0.000	-0.030	0.0	0.0	98.3	98.3	0.03
L-004	0.026	0.874	-0.021	-0.867	4.9	6.6	98.3	97.6	0.76
SS 40 Roundabout TR	0.000	0.037	0.000	-0.037	0.0	0.2	98.3	97.7	0.64
L-0001	-0.010	-0.374	0.012	0.376	2.0	2.7	98.4	99.1	0.71
L-0002	0.010	0.343	-0.008	-0.340	1.8	2.5	98.4	97.7	0.72
National Park HQ TR	0.000	0.031	0.000	-0.031	0.0	0.3	98.4	97.6	0.81
L- 5	0.001	0.064	-0.001	-0.064	0.0	0.0	98.9	98.9	0.04
L- 6	0.000	0.044	0.000	-0.044	0.0	0.0	98.9	98.9	0.03
L- 7	0.000	0.039	0.000	-0.039	0.0	0.0	98.9	98.9	0.03
L- 8	0.000	0.040	0.000	-0.040	0.0	0.0	98.9	98.9	0.03
L- 9	0.001	0.058	-0.001	-0.058	0.0	0.0	98.9	98.8	0.06
L-10	0.034	0.006	-0.034	-0.006	0.0	0.0	98.9	98.9	0.03
Local Govt. Qters TR	0.000	0.033	0.000	-0.033	0.1	0.3	98.9	98.0	0.85
L- 0003	0.000	0.014	0.000	-0.014	0.0	0.0	97.7	97.7	0.03
L-0004	0.008	0.303	-0.006	-0.300	1.7	2.2	97.7	97.0	0.73
Manyara TR	0.000	0.023	0.000	-0.023	0.0	0.1	97.7	97.3	0.41
L- 11	0.000	0.036	0.000	-0.036	0.0	0.0	98.9	98.8	0.04
L- 12	0.001	0.048	0.000	-0.048	0.0	0.0	98.9	98.8	0.06
L- 13	0.000	0.028	0.000	-0.028	0.0	0.0	98.9	98.8	0.03
L- 14	0.000	0.045	0.000	-0.045	0.0	0.0	98.9	98.8	0.06
L-15	0.032	-0.179	-0.032	0.179	0.3	0.4	98.9	99.1	0.19
Kwarin Wali TR	0.000	0.026	0.000	-0.026	0.0	0.2	98.9	98.2	0.67
L- 16	0.000	0.033	0.000	-0.033	0.0	0.0	99.1	99.0	0.04
L- 17	0.000	0.009	0.000	-0.009	0.0	0.0	99.1	99.0	0.01
L- 18	0.000	0.030	0.000	-0.030	0.0	0.0	99.1	99.0	0.05
L- 19	0.000	0.031	0.000	-0.031	0.0	0.0	99.1	99.0	0.05
L- 20	0.001	0.067	-0.001	-0.067	0.1	0.1	99.1	98.9	0.11
L- 21	0.000	0.015	0.000	-0.015	0.0	0.0	99.1	99.0	0.03

LOAD FLOW REPORT (OFF-PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
L-22	0.029	-0.398	-0.027	0.401	2.0	2.7	99.1	99.7	0.62
Baba Ilorin Farm TR	0.000	0.033	0.000	-0.033	0.1	0.4	99.1	97.9	1.19
L- 005	0.000	0.032	0.000	-0.032	0.0	0.0	97.6	97.5	0.03
L-006	0.021	0.804	-0.016	-0.797	5.2	7.0	97.6	96.7	0.87
Koro Grinder TR	0.000	0.032	0.000	-0.031	0.1	0.3	97.6	96.7	0.83
L-0005	0.005	0.260	-0.004	-0.258	1.3	1.7	97.0	96.3	0.66
MTN Wildlife TR	0.001	0.040	0.000	-0.040	0.2	0.9	97.0	94.8	2.13
L- 23	0.000	0.026	0.000	-0.026	0.0	0.0	99.7	99.6	0.04
L- 24	0.000	0.037	0.000	-0.037	0.0	0.0	99.7	99.6	0.06
L- 25	0.000	0.045	0.000	-0.045	0.0	0.0	99.7	99.6	0.08
L- 26	0.000	0.022	0.000	-0.022	0.0	0.0	99.7	99.6	0.04
L - 27	0.001	0.057	-0.001	-0.057	0.0	0.1	99.7	99.6	0.10
L - 28	0.000	0.047	0.000	-0.047	0.0	0.0	99.7	99.6	0.09
L - 29	0.000	0.022	0.000	-0.022	0.0	0.0	99.7	99.6	0.04
L-30	0.024	-0.709	-0.018	0.718	6.9	9.2	99.7	100.9	1.27
MESL Water Reserviour TR	0.000	0.053	0.000	-0.053	0.1	0.3	99.7	99.1	0.54
L- 0006	0.000	0.036	0.000	-0.036	0.0	0.0	96.3	96.2	0.09
L- 0007	0.000	0.016	0.000	-0.016	0.0	0.0	96.3	96.3	0.04
L-0008	0.003	0.185	-0.002	-0.184	0.8	1.1	96.3	95.8	0.55
Fed Col of Wildlife TR	0.000	0.021	0.000	-0.021	0.0	0.1	96.3	95.9	0.38
L- 007	0.001	0.062	-0.001	-0.062	0.0	0.0	96.7	96.6	0.07
L- 008	0.001	0.070	-0.001	-0.070	0.0	0.1	96.7	96.6	0.09
L- 009	0.000	0.042	0.000	-0.042	0.0	0.0	96.7	96.6	0.05
L-010	0.013	0.569	-0.010	-0.565	3.1	4.2	96.7	96.0	0.73
Emir's Guest House TR	0.001	0.054	0.000	-0.053	0.1	0.5	96.7	95.8	0.86
L- 31	0.000	0.027	0.000	-0.027	0.0	0.0	100.9	100.9	0.05
L- 32	0.000	0.032	0.000	-0.032	0.0	0.0	100.9	100.9	0.06
L- 33	0.001	0.067	-0.001	-0.067	0.1	0.1	100.9	100.8	0.13
L- 34	0.000	0.025	0.000	-0.025	0.0	0.0	100.9	100.9	0.05
L- 35	0.001	0.051	0.000	-0.051	0.0	0.1	100.9	100.8	0.10
L- 36	0.000	0.036	0.000	-0.035	0.0	0.0	100.9	100.9	0.07
L-37	0.015	-0.390	-0.013	0.393	2.3	3.0	100.9	101.7	0.76
Ngaski TR	0.000	0.024	0.000	-0.024	0.0	0.1	100.9	100.7	0.24
L- 38	0.001	0.054	-0.001	-0.054	0.0	0.1	101.7	101.6	0.11
L- 39	0.000	0.019	0.000	-0.019	0.0	0.0	101.7	101.7	0.04
L- 40	0.000	0.042	0.000	-0.042	0.0	0.0	101.7	101.6	0.09
L- 41	0.000	0.027	0.000	-0.027	0.0	0.0	101.7	101.7	0.06

Project:	PhD. PROJECT	ETAP	Page:	3
Location:	NEW BUSSA - NIGER STATE	12.6.0H	Date:	15-12-2019
Contract:			SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename:	save 2		Config.:	Normal

LOAD FLOW REPORT (OFF-PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
L- 42	0.000	0.028	0.000	-0.028	0.0	0.0	101.7	101.6	0.06
L- 43	0.000	0.025	0.000	-0.025	0.0	0.0	101.7	101.7	0.06
L-44	0.010	-0.022	-0.010	0.022	0.0	0.0	101.7	101.7	0.03
D4 TR	0.000	0.037	0.000	-0.037	0.0	0.1	101.7	101.3	0.38
L- 0009	0.000	0.032	0.000	-0.032	0.0	0.0	95.8	95.7	0.10
L-0010	0.002	0.128	-0.002	-0.127	0.4	0.5	95.8	95.4	0.41
Nassarawa 2 TR	0.000	0.024	0.000	-0.024	0.0	0.1	95.8	95.4	0.41
L- 45	0.001	0.051	-0.001	-0.051	0.0	0.1	101.7	101.6	0.11
L- 46	0.000	0.027	0.000	-0.027	0.0	0.0	101.7	101.7	0.06
L- 47	0.000	0.022	0.000	-0.022	0.0	0.0	101.7	101.7	0.05
L- 48	0.001	0.054	-0.001	-0.054	0.0	0.1	101.7	101.6	0.12
L- 49	0.001	0.053	-0.001	-0.053	0.0	0.1	101.7	101.6	0.13
L- 50	0.000	0.030	0.000	-0.030	0.0	0.0	101.7	101.7	0.07
L-51	0.008	0.027	-0.008	-0.027	0.0	0.0	101.7	101.7	0.08
Catholic Church TR	0.000	0.013	0.000	-0.013	0.0	0.1	101.7	101.3	0.45
L- 52	0.000	0.015	0.000	-0.015	0.0	0.0	101.7	101.6	0.04
L- 53	0.001	0.077	-0.001	-0.077	0.1	0.1	101.7	101.5	0.19
L- 54	0.001	0.092	-0.001	-0.091	0.1	0.2	101.7	101.4	0.22
L- 55	0.000	0.019	0.000	-0.019	0.0	0.0	101.7	101.6	0.05
L- 56	0.000	0.035	0.000	-0.035	0.0	0.0	101.7	101.6	0.09
L-57	0.004	0.048	-0.004	-0.048	0.0	0.1	101.7	101.5	0.13
Katamaya Hospital TR	0.000	0.037	0.000	-0.037	0.1	0.3	101.7	100.8	0.82
L- 011	0.001	0.051	-0.001	-0.051	0.0	0.0	96.0	95.9	0.07
L- 012	0.000	0.026	0.000	-0.026	0.0	0.0	96.0	95.9	0.03
L-013	0.009	0.466	-0.007	-0.463	2.2	3.0	96.0	95.3	0.62
FGGC TR	0.000	0.022	0.000	-0.022	0.0	0.1	96.0	95.7	0.23
L- 0011	0.000	0.024	0.000	-0.024	0.0	0.0	95.4	95.3	0.08
L-0012	0.001	0.077	-0.001	-0.077	0.2	0.2	95.4	95.1	0.29
GDSS Nassarawa TR	0.000	0.026	0.000	-0.026	0.1	0.4	95.4	94.0	1.40
L- 0013	0.000	0.013	0.000	-0.013	0.0	0.0	95.1	95.0	0.05
L- 0014	0.000	0.015	0.000	-0.015	0.0	0.0	95.1	95.0	0.06
L-0015	0.000	0.034	0.000	-0.034	0.1	0.1	95.1	94.9	0.21
Sabo Grinder TR	0.000	0.014	0.000	-0.014	0.0	0.1	95.1	94.7	0.38
L- 014	0.000	0.039	0.000	-0.039	0.0	0.0	95.3	95.3	0.05
L- 015	0.000	0.040	0.000	-0.040	0.0	0.0	95.3	95.3	0.06
L- 016	0.000	0.033	0.000	-0.033	0.0	0.0	95.3	95.3	0.05
L-017	0.006	0.331	-0.004	-0.329	1.3	1.7	95.3	94.8	0.50

LOAD FLOW REPORT (OFF-PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
NIFFR Sec. Qtrs TR	0.000	0.021	0.000	-0.021	0.0	0.1	95.3	95.1	0.23
L- 0016	0.000	0.016	0.000	-0.016	0.0	0.0	94.9	94.8	0.10
Awuru 1 TR	0.000	0.018	0.000	-0.018	0.0	0.1	94.9	94.5	0.34
L- 018	0.000	0.031	0.000	-0.031	0.0	0.0	94.8	94.8	0.05
L- 019	0.001	0.050	-0.001	-0.050	0.0	0.0	94.8	94.8	0.08
L-020	0.003	0.218	-0.002	-0.217	0.6	0.8	94.8	94.5	0.34
Lafia Spot TR	0.000	0.030	0.000	-0.029	0.1	0.5	94.8	93.2	1.62
L- 021	0.001	0.058	-0.001	-0.058	0.0	0.1	94.5	94.4	0.09
L- 022	0.001	0.066	-0.001	-0.066	0.1	0.1	94.5	94.4	0.11
L-023	0.001	0.064	-0.001	-0.064	0.1	0.1	94.5	94.4	0.11
NIFFR Senior Qtrs 1 TR	0.000	0.028	0.000	-0.028	0.0	0.2	94.5	94.0	0.51
L- 024	0.000	0.039	0.000	-0.039	0.0	0.0	94.4	94.3	0.07
Fisheries Qtrs TR	0.000	0.025	0.000	-0.025	0.0	0.1	94.4	93.9	0.45
L- 58	0.000	0.021	0.000	-0.021	0.0	0.0	101.5	101.5	0.05
L- 59	0.000	0.024	0.000	-0.024	0.0	0.0	101.5	101.5	0.06
L- 60	0.000	0.037	0.000	-0.037	0.0	0.0	101.5	101.4	0.10
L-61	0.003	-0.072	-0.003	0.072	0.1	0.2	101.5	101.7	0.21
NAPTIN Guest House 2 TR	0.000	0.038	0.000	-0.037	0.0	0.2	101.5	100.9	0.63
L- 62	0.002	0.154	-0.002	-0.153	0.6	0.7	101.7	101.2	0.50
L- 63	0.000	0.026	0.000	-0.026	0.0	0.0	101.7	101.7	0.09
Yuna TR	0.001	0.044	0.000	-0.043	0.3	0.9	101.7	99.7	2.01
Agip TR	0.000	-0.057	0.001	0.058	0.1	0.4	93.8	94.4	0.62
Aliganı TR1	0.000	-0.056	0.001	0.057	0.1	0.3	99.0	99.6	0.58
Anglican Church 1 TR	0.000	-0.036	0.000	0.036	0.0	0.2	98.2	98.8	0.63
Anglican Church 2 TR	0.000	-0.048	0.000	0.048	0.0	0.2	98.3	98.8	0.50
Army Engineer TR	-0.001	-0.069	0.001	0.070	0.2	0.9	95.4	96.6	1.24
Awuru 2 TR	0.000	-0.016	0.000	0.016	0.0	0.1	94.5	94.8	0.30
Baba Ilorin House TR	0.000	-0.009	0.000	0.009	0.0	0.0	98.6	99.0	0.48
BF 1 TR	0.000	-0.031	0.000	0.032	0.1	0.5	99.3	100.9	1.61
Borgu Community Bank TR	0.000	-0.015	0.000	0.015	0.0	0.1	98.2	99.0	0.78
BSW TR	0.000	-0.019	0.000	0.019	0.0	0.0	101.5	101.7	0.22
Govt. Sec Sch TR	0.000	0.029	0.000	-0.029	0.0	0.1	99.0	98.5	0.50
Dantoro Lodge TR	0.001	0.057	0.000	-0.057	0.1	0.3	99.0	98.4	0.59
Nedufu Estate TR	0.001	0.064	-0.001	-0.064	0.1	0.7	98.9	97.7	1.11
NIFFR HQS TR	0.000	0.044	0.000	-0.044	0.0	0.2	98.9	98.4	0.46
Niger River Basin TR	0.000	0.039	0.000	-0.039	0.1	0.3	98.9	98.2	0.68
NIFFR Junior Qtrs TR	0.000	0.040	0.000	-0.040	0.1	0.3	98.9	98.2	0.69

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Contract:			SN:	
Engineer:	OKAFOR CHUKWUNENYE .S.	Study Case: LOAD FLOW	Revision:	Base
Filename:	save 2		Config.:	Normal

LOAD FLOW REPORT (OFF-PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Tudun Wali TR	0.001	0.058	0.000	-0.058	0.1	0.4	98.8	98.2	0.60
Mil Quarters 2 TR	0.000	0.028	0.000	-0.028	0.1	0.3	98.8	97.9	0.97
Mil Quarters 1 TR	0.000	0.045	0.000	-0.045	0.0	0.2	98.8	98.5	0.33
Bussa Town Hall TR	0.000	0.033	0.000	-0.033	0.0	0.1	99.0	98.8	0.24
KEYSTONE Bank TR	0.000	0.030	0.000	-0.030	0.0	0.2	99.0	98.5	0.54
Old Army Barracks TR	0.000	0.031	0.000	-0.031	0.0	0.2	99.0	98.3	0.72
Waziri Primary Sch TR	0.001	0.067	-0.001	-0.066	0.1	0.5	98.9	98.3	0.69
UBA TR	0.000	0.026	0.000	-0.026	0.0	0.1	99.6	99.2	0.46
MTN TR	0.000	0.037	0.000	-0.037	0.1	0.4	99.6	98.7	0.95
Mammy market TR	0.000	0.045	0.000	-0.044	0.1	0.3	99.6	98.8	0.76
MT Yard TR1	0.000	0.022	0.000	-0.022	0.0	0.1	99.6	99.1	0.56
Hanger TR1	0.000	0.047	0.000	-0.046	0.0	0.2	99.6	99.1	0.48
Kidagba TR1	0.000	0.022	0.000	-0.022	0.0	0.1	99.6	99.4	0.23
TFT TR	0.000	0.027	0.000	-0.027	0.0	0.1	100.9	100.6	0.31
Luma Road TR	0.001	0.067	-0.001	-0.067	0.1	0.5	100.8	100.1	0.68
Elshadai TR	0.000	0.025	0.000	-0.025	0.0	0.1	100.9	100.3	0.58
Water Treatment TR	0.000	0.051	0.000	-0.051	0.1	0.3	100.8	100.2	0.60
Officers' Mess TR	0.000	0.035	0.000	-0.035	0.0	0.1	100.9	100.6	0.24
Corpra Below TR	0.001	0.054	0.000	-0.053	0.1	0.5	101.6	100.7	0.90
Clinic TR	0.000	0.042	0.000	-0.042	0.1	0.2	101.6	101.1	0.49
Niger Crescent TR	0.000	0.027	0.000	-0.026	0.0	0.2	101.7	100.8	0.89
Senior Camp C/T TR	0.000	0.028	0.000	-0.027	0.0	0.3	101.6	100.7	0.93
MESL Water Treatment TR	0.000	0.025	0.000	-0.025	0.0	0.1	101.7	101.1	0.59
Kaduna Drive TR	0.001	0.051	0.000	-0.051	0.1	0.4	101.6	100.8	0.86
Rader TR	0.000	0.027	0.000	-0.027	0.0	0.1	101.7	101.2	0.45
SNCO TR	0.000	0.022	0.000	-0.022	0.0	0.0	101.7	101.5	0.22
GRA TR	0.001	0.054	0.000	-0.053	0.1	0.5	101.6	100.7	0.90
Ilorin Road TR	0.001	0.053	0.000	-0.052	0.1	0.3	101.6	101.1	0.53
NAPTIN Guest House 1 TR	0.000	0.030	0.000	-0.030	0.0	0.1	101.7	101.2	0.50
Monai TR	0.000	0.015	0.000	-0.015	0.0	0.1	101.6	100.9	0.77
MESL Water Intake TR	0.001	0.077	-0.001	-0.077	0.1	0.6	101.5	100.7	0.78
Motel Annex TR	0.001	0.091	-0.001	-0.091	0.2	0.8	101.4	100.5	0.92
SOQ TR	0.000	0.019	0.000	-0.019	0.0	0.0	101.6	101.4	0.19
Chinese Quaters TR	0.000	0.035	0.000	-0.035	0.1	0.3	101.6	100.7	0.88
Zaria Way TR	0.000	0.021	0.000	-0.021	0.0	0.1	101.5	100.8	0.70
Donia Camp TR	0.000	0.024	0.000	-0.024	0.0	0.0	101.5	101.3	0.17
Kadariko TR	0.000	0.037	0.000	-0.037	0.1	0.5	101.4	100.2	1.24

LOAD FLOW REPORT (OFF-PEAK PERIOD)

CKT / Branch	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Niger Water Plant TR	0.002	0.153	-0.001	-0.152	0.2	0.8	101.2	100.7	0.54
Kuruwasa TR	0.000	0.026	0.000	-0.026	0.0	0.1	101.7	101.2	0.44
Old Dogogari TR	0.000	0.043	0.000	-0.043	0.1	0.3	98.3	97.5	0.75
Koro Radio TR	0.000	0.030	0.000	-0.030	0.0	0.2	98.3	97.5	0.79
Koro 1 TR	0.000	0.032	0.000	-0.032	0.0	0.1	97.5	97.2	0.33
New Quarters TR	0.001	0.062	-0.001	-0.061	0.1	0.4	96.6	96.0	0.65
Old Market TR	0.000	0.042	0.000	-0.042	0.0	0.2	96.6	96.2	0.45
SS 13 Manchester TR	0.001	0.051	0.000	-0.051	0.1	0.3	95.9	95.4	0.55
Hydro TR	0.000	0.026	0.000	-0.026	0.0	0.1	95.9	95.6	0.32
Jobice TR	0.000	0.039	0.000	-0.038	0.1	0.4	95.3	94.3	1.04
Dantoro Road TR	0.000	0.040	0.000	-0.039	0.0	0.2	95.3	94.9	0.42
NIFFR Senior Qtrs 2 TR	0.000	0.033	0.000	-0.033	0.0	0.2	95.3	94.7	0.59
Jehovah Witness TR	0.000	0.031	0.000	-0.031	0.0	0.1	94.8	94.5	0.34
Niger Water Booster TR	0.001	0.050	0.000	-0.049	0.1	0.7	94.8	93.4	1.35
General Hospital TR	0.001	0.066	-0.001	-0.065	0.2	0.8	94.4	93.2	1.20
Fisheries Sch. TR	0.000	0.039	0.000	-0.039	0.1	0.3	94.3	93.6	0.71
Funkun TR	0.000	0.014	0.000	-0.014	0.0	0.1	97.7	97.3	0.38
MTN Nassarawa TR	0.000	0.036	0.000	-0.035	0.2	0.5	96.2	94.9	1.31
NAPTIN School TR	0.000	0.016	0.000	-0.016	0.0	0.0	96.3	96.1	0.17
Nassarawa 1 TR	0.000	0.032	0.000	-0.032	0.0	0.1	95.7	95.3	0.34
Nassarawa Grinder TR	0.000	0.024	0.000	-0.024	0.0	0.2	95.3	94.6	0.64
Sabo 1 TR	0.000	0.013	0.000	-0.013	0.0	0.0	95.0	94.8	0.22
Sabo 2 TR	0.000	0.015	0.000	-0.015	0.0	0.1	95.0	94.6	0.41
Power Transformer	0.085	1.826	-0.085	-1.810	0.8	15.6	100.0	99.1	0.85
					52.9	105.3			

4.3.1 Analyzing load flow reports for New Bussa compensated distribution network

Analyzing the load flow reports of New Bussa compensated distribution network from Tables 4.9 and 4.10 for peak and off-peak period, showed the percentage voltage magnitude for all the load buses in the network. The values of percentage voltage magnitudes for all the load buses in New Bussa compensated distribution network were tabulated in Tables 4.13 & 4.14 for peak and off-peak period respectively.

Table 4.13: Voltage magnitude for load buses in compensated network during Peak period

S/N	Bus Name	Voltage Magnitude	Comment
1	Agip bus	95.035	Voltage within acceptable limit
2	Aligani bus	95.235	Voltage within acceptable limit
3	Anglican Church 1 bus	94.933	Voltage within acceptable limit
4	Anglican Church 2 bus	95.667	Voltage within acceptable limit
5	Army Engr bus	94.87	Voltage within acceptable limit
6	Awuru 1 bus	100.698	Voltage within acceptable limit
7	Awuru 2 bus	100.403	Voltage within acceptable limit
8	Baba Ilorin Farm bus	95.947	Voltage within acceptable limit
9	Baba Ilorin House bus	96.205	Voltage within acceptable limit
10	BF 1 bus	93.158	Voltage within acceptable limit
11	Borgu Community Bank bus	96.633	Voltage within acceptable limit
12	BSW bus	97.637	Voltage within acceptable limit
13	Bussa Town Hall bus	96.863	Voltage within acceptable limit
14	Catholic Church bus	98.619	Voltage within acceptable limit
15	Chinese Quarters bus	99.365	Voltage within acceptable limit
16	Clinic bus	97.512	Voltage within acceptable limit
17	Copra Below bus	96.018	Voltage within acceptable limit
18	D4 bus	97.54	Voltage within acceptable limit
19	Dantoro Lodge bus	96.94	Voltage within acceptable limit
20	Dantoro Road bus	94.71	Voltage within acceptable limit
21	Donia Camp bus	102.436	Voltage within acceptable limit
22	Elshadai bus	95.372	Voltage within acceptable limit
23	Emir's Guest House bus	95.277	Voltage within acceptable limit
24	Federal College of Wildlife bus	98.342	Voltage within acceptable limit
25	FGGC bus	95.384	Voltage within acceptable limit

26	Fisheries Quarters bus	94.544	Voltage within acceptable limit
27	Fisheries School bus	94.537	Voltage within acceptable limit
28	Funkun bus	97.58	Voltage within acceptable limit
29	GDSS Nassarawa bus	98.528	Voltage within acceptable limit
30	General Hospital bus	94.499	Voltage within acceptable limit
31	Govt. Secondary School bus	97.476	Voltage within acceptable limit
32	GRA bus	97.988	Voltage within acceptable limit
33	Hanger bus	95.946	Voltage within acceptable limit
34	Hydro bus	95.034	Voltage within acceptable limit
35	Ilorin Road bus	98.533	Voltage within acceptable limit
36	Jehovah Witness bus	94.746	Voltage within acceptable limit
37	Jobice bus	94.254	Voltage within acceptable limit
38	Kadariko bus	98.485	Voltage within acceptable limit
39	Kaduna Drive bus	97.66	Voltage within acceptable limit
40	Katamaya Hospital bus	100.157	Voltage within acceptable limit
41	KEYSTONE Bank bus	97.344	Voltage within acceptable limit
42	Kidagba bus	96.069	Voltage within acceptable limit
43	Koro 1 bus	96.434	Voltage within acceptable limit
44	Koro Grinder bus	95.558	Voltage within acceptable limit
45	Koro Radio bus	96.694	Voltage within acceptable limit
46	Kurwasa bus	99.33	Voltage within acceptable limit
47	Kwarin Wali bus	95.399	Voltage within acceptable limit
48	Lafia Sport bus	92.956	Voltage within acceptable limit
49	Local Govt Quarters bus	95.617	Voltage within acceptable limit
50	Luma Road bus	94.921	Voltage within acceptable limit
51	Mammy market bus	94.623	Voltage within acceptable limit
52	Manyara bus	97.791	Voltage within acceptable limit
53	MESL Water Intake bus	100.787	Voltage within acceptable limit
54	MESL Water Reserve bus	96.121	Voltage within acceptable limit
55	MESL Water Treatment bus	96.387	Voltage within acceptable limit
56	Mil Quarters 1 bus	96.39	Voltage within acceptable limit
57	Mil Quarters 2 bus	93.545	Voltage within acceptable limit
58	Monai bus	98.913	Voltage within acceptable limit
59	Motel Annex bus	100.435	Voltage within acceptable limit
60	MT Yard bus	94.634	Voltage within acceptable limit
61	MTN bus	96.097	Voltage within acceptable limit
62	MTN Nassarawa bus	97.456	Voltage within acceptable limit
63	MTN Wildlife bus	96.337	Voltage within acceptable limit
64	NAPTIN Guest House 1 bus	99.208	Voltage within acceptable limit
65	NAPTIN Guest House 2 bus	102.236	Voltage within acceptable limit

66	NAPTIN School bus	98.66	Voltage within acceptable limit
67	Nassarawa 1 bus	98.864	Voltage within acceptable limit
68	Nassarawa 2 bus	98.926	Voltage within acceptable limit
69	Nassarawa Grinder bus	99.152	Voltage within acceptable limit
70	National Park Headquarter bus	97.66	Voltage within acceptable limit
71	Nedufu Estate bus	94.806	Voltage within acceptable limit
72	New Quarters bus	95.449	Voltage within acceptable limit
73	Ngaski bus	96.658	Voltage within acceptable limit
74	NIFFR Headquarters bus	96.344	Voltage within acceptable limit
75	NIFFR Junior Quarters bus	95.559	Voltage within acceptable limit
76	NIFFR Secondary Quarters bus	95.049	Voltage within acceptable limit
77	NIFFR Senior Quarters 1 bus	94.987	Voltage within acceptable limit
78	NIFFR Senior Quarters 2 bus	94.594	Voltage within acceptable limit
79	Niger Crescent bus	95.925	Voltage within acceptable limit
80	Niger River Basin bus	95.962	Voltage within acceptable limit
81	Niger Water Booster bus	93.682	Voltage within acceptable limit
82	Niger Water Plant bus	99.506	Voltage within acceptable limit
83	Officers' Mess bus	96.022	Voltage within acceptable limit
84	Old Army Barracks bus	95.214	Voltage within acceptable limit
85	Old Dogongeri bus	96.519	Voltage within acceptable limit
86	Old Market bus	95.551	Voltage within acceptable limit
87	Rader bus	97.991	Voltage within acceptable limit
88	Sabo 1 bus	101.084	Voltage within acceptable limit
89	Sabo 2 bus	100.206	Voltage within acceptable limit
90	Sabo Grinder bus	100.755	Voltage within acceptable limit
91	Senior Camp C/T bus	95.984	Voltage within acceptable limit
92	SNCO bus	98.834	Voltage within acceptable limit
93	SOQ bus	100.684	Voltage within acceptable limit
94	SS 13 Manchester bus	94.963	Voltage within acceptable limit
95	SS 40 Roundabout bus	96.53	Voltage within acceptable limit
96	Technical Junction bus	95.712	Voltage within acceptable limit
97	TFT bus	95.849	Voltage within acceptable limit
98	Tudun Wali bus	96.082	Voltage within acceptable limit
99	UBA bus	96.676	Voltage within acceptable limit
100	Water Treatment bus	95.903	Voltage within acceptable limit
101	Waziri Primary School bus	94.809	Voltage within acceptable limit
102	Yuna bus	94.075	Voltage within acceptable limit
103	Zaria Way bus	99.198	Voltage within acceptable limit

Table 4.14: Voltage Magnitude for Load Buses in Compensated Network during Off-Peak Period

S/N	Bus Name	Voltage Magnitude	Comment
1	Agip bus	93.839	Voltage within acceptable limit
2	Aligani bus	99.508	Voltage within acceptable limit
3	Anglican Church 1 bus	98.413	Voltage within acceptable limit
4	Anglican Church 2 bus	98.527	Voltage within acceptable limit
5	Army Engr bus	95.413	Voltage within acceptable limit
6	Awuru 1 bus	94.565	Voltage within acceptable limit
7	Awuru 2 bus	94.504	Voltage within acceptable limit
8	Baba Ilorin Farm bus	98.212	Voltage within acceptable limit
9	Baba Ilorin House bus	98.901	Voltage within acceptable limit
10	BF 1 bus	99.977	Voltage within acceptable limit
11	Borgu Community Bank bus	98.592	Voltage within acceptable limit
12	BSW bus	101.663	Voltage within acceptable limit
13	Bussa Town Hall bus	99.118	Voltage within acceptable limit
14	Catholic Church bus	101.589	Voltage within acceptable limit
15	Chinese Quarters bus	101.061	Voltage within acceptable limit
16	Clinic bus	101.342	Voltage within acceptable limit
17	Copra Below bus	100.908	Voltage within acceptable limit
18	D4 bus	101.542	Voltage within acceptable limit
19	Dantoro Lodge bus	98.505	Voltage within acceptable limit
20	Dantoro Road bus	94.909	Voltage within acceptable limit
21	Donia Camp bus	101.699	Voltage within acceptable limit
22	Elshadai bus	101.025	Voltage within acceptable limit
23	Emir's Guest House bus	95.875	Voltage within acceptable limit
24	Federal College of Wildlife bus	95.989	Voltage within acceptable limit
25	FGGC bus	95.776	Voltage within acceptable limit
26	Fisheries Quarters bus	93.991	Voltage within acceptable limit
27	Fisheries School bus	93.667	Voltage within acceptable limit
28	Funkun bus	97.355	Voltage within acceptable limit
29	GDSS Nassarawa bus	94.001	Voltage within acceptable limit
30	General Hospital bus	93.253	Voltage within acceptable limit
31	Govt. Secondary School bus	98.605	Voltage within acceptable limit
32	GRA bus	101.011	Voltage within acceptable limit
33	Hanger bus	99.63	Voltage within acceptable limit
34	Hydro bus	95.661	Voltage within acceptable limit

35	Ilorin Road bus	101.38	Voltage within acceptable limit
36	Jehoval Witness bus	94.51	Voltage within acceptable limit
37	Jobice bus	94.299	Voltage within acceptable limit
38	Kadariko bus	100.584	Voltage within acceptable limit
39	Kaduna Drive bus	101.066	Voltage within acceptable limit
40	Katamaya Hospital bus	101.209	Voltage within acceptable limit
41	KEYSTONE Bank bus	98.807	Voltage within acceptable limit
42	Kidagba bus	99.926	Voltage within acceptable limit
43	Koro 1 bus	97.241	Voltage within acceptable limit
44	Koro Grinder bus	96.774	Voltage within acceptable limit
45	Koro Radio bus	97.547	Voltage within acceptable limit
46	Kurwasa bus	101.66	Voltage within acceptable limit
47	Kwarin Wali bus	98.407	Voltage within acceptable limit
48	Lafia Sport bus	93.276	Voltage within acceptable limit
49	Local Govt Quarters bus	98.161	Voltage within acceptable limit
50	Luma Road bus	100.843	Voltage within acceptable limit
51	Mammy market bus	99.351	Voltage within acceptable limit
52	Manyara bus	97.355	Voltage within acceptable limit
53	MESL Water Intake bus	101.057	Voltage within acceptable limit
54	MESL Water Reserve bus	99.649	Voltage within acceptable limit
55	MESL Water Treatment bus	101.278	Voltage within acceptable limit
56	Mil Quarters 1 bus	98.697	Voltage within acceptable limit
57	Mil Quarters 2 bus	98.072	Voltage within acceptable limit
58	Monai bus	101.22	Voltage within acceptable limit
59	Motel Annex bus	100.878	Voltage within acceptable limit
60	MT Yard bus	99.592	Voltage within acceptable limit
61	MTN bus	99.178	Voltage within acceptable limit
62	MTN Nassarawa bus	94.965	Voltage within acceptable limit
63	MTN Wildlife bus	94.893	Voltage within acceptable limit
64	NAPTIN Guest House 1 bus	101.468	Voltage within acceptable limit
65	NAPTIN Guest House 2 bus	101.3	Voltage within acceptable limit
66	NAPTIN School bus	96.16	Voltage within acceptable limit
67	Nassarawa 1 bus	95.373	Voltage within acceptable limit
68	Nassarawa 2 bus	95.399	Voltage within acceptable limit
69	Nassarawa Grinder bus	94.676	Voltage within acceptable limit
70	National Park Headquarter bus	97.673	Voltage within acceptable limit
71	Nedufu Estate bus	97.862	Voltage within acceptable limit
72	New Quarters bus	96.015	Voltage within acceptable limit
73	Ngaski bus	101.415	Voltage within acceptable limit
74	NIFFR Headquarters bus	98.524	Voltage within acceptable limit

75	NIFFR Junior Quarters bus	98.289	Voltage within acceptable limit
76	NIFFR Secondary Quarters bus	95.164	Voltage within acceptable limit
77	NIFFR Senior Quarters 1 bus	94.043	Voltage within acceptable limit
78	NIFFR Senior Quarters 2 bus	94.755	Voltage within acceptable limit
79	Niger Crescent bus	100.97	Voltage within acceptable limit
80	Niger River Basin bus	98.305	Voltage within acceptable limit
81	Niger Water Booster bus	93.466	Voltage within acceptable limit
82	Niger Water Plant bus	101.145	Voltage within acceptable limit
83	Officers' Mess bus	101.347	Voltage within acceptable limit
84	Old Army Barracks bus	98.631	Voltage within acceptable limit
85	Old Dogongeri bus	97.574	Voltage within acceptable limit
86	Old Market bus	96.238	Voltage within acceptable limit
87	Rader bus	101.524	Voltage within acceptable limit
88	Sabo 1 bus	94.835	Voltage within acceptable limit
89	Sabo 2 bus	94.643	Voltage within acceptable limit
90	Sabo Grinder bus	94.727	Voltage within acceptable limit
91	Senior Camp C/T bus	100.927	Voltage within acceptable limit
92	SNCO bus	101.765	Voltage within acceptable limit
93	SOQ bus	101.793	Voltage within acceptable limit
94	SS 13 Manchester bus	95.397	Voltage within acceptable limit
95	SS 40 Roundabout bus	97.722	Voltage within acceptable limit
96	Technical Junction bus	97.938	Voltage within acceptable limit
97	TFT bus	101.296	Voltage within acceptable limit
98	Tudun Wali bus	98.348	Voltage within acceptable limit
99	UBA bus	99.691	Voltage within acceptable limit
100	Water Treatment bus	101.311	Voltage within acceptable limit
101	Waziri Primary School bus	98.598	Voltage within acceptable limit
102	Yuna bus	100.172	Voltage within acceptable limit
103	Zaria Way bus	101.175	Voltage within acceptable limit

4.3.2 Deductions from load flow analysis of New Bussa compensated distribution network

Tables 4.7, 4.8, 4.9, 4.10, 4.11, 4.12, 4.13 and 4.14 showed the following: the optimal capacitor placement results indicating the optimal capacitor sizes & the selected candidate buses for both peak & off-peak periods, load flow reports of New Bussa compensated distribution network, Branch losses report for New Bussa compensated distribution network during peak & off-peak periods and summary of the percentage voltage magnitude for load buses in compensated network for peak & off-peak periods. These various results when analyzed showed that:

i. The candidate buses were 04, 05, 07, 08, 09, 10, 57, 020, 0012; the order for best position and bus with greater voltage improvement and power losses as determined from loss sensitivity factor calculations were buses 05, 07, 08, 04, 09, 10, 57, 0012, 020 as arranged.
ii. Percentage voltage magnitudes for all the load buses were within the ANSI acceptable voltage standard limit after voltage compensation process. Thus, none of the load buses has its percentage voltage magnitude violating the standard since the percentage voltage magnitudes for all the load buses fall within the ANSI acceptable standard range (90% < V < 106%).
iii. After voltage compensation, Donia Camp bus and SOQ bus have the highest percentage voltage magnitudes of 102.436% and 101.793% for both peak and off-peak periods respectively.
iv. After voltage compensation, Lafia Sport bus and General Hospital bus have the lowest percentage voltage magnitudes of 92.956% and 93.253% for both peak and off-peak periods respectively.
v. After voltage compensation of New Bussa distribution network, Branch power losses for both active and reactive power were reduced from 978.00KW & 1674.30KVAR to 118.50KW & 328.00KVAR during peak loading period and were also reduced from 180.70KW & 315.50KVAR to 52.9KW & 105.30KVAR during off-peak loading period.

4.4 Enhanced/Improved Voltage Value for New Bussa Distribution Network after Voltage Compensation

This shows the quantity of voltage value that was added at each of the load buses in the network by the Capacitor banks during the voltage compensation for both the peak and off-peak period. This compensated voltage value directly improved the quality of voltage value received by power consumers within New Bussa distribution network.

Table 4.15: Enhanced Voltage Magnitude for Load Buses in New Bussa Network during Peak Period

S/N	Bus Name	Voltage Magnitude Before Voltage Compensation	Voltage Magnitude After Voltage Compensation	Enhanced Voltage Magnitude
1	Agip bus	88.29	95.035	6.745
2	Aligani bus	73.334	95.235	21.901
3	Anglican Church 1 bus	84.187	94.933	10.746
4	Anglican Church 2 bus	84.838	95.667	10.829
5	Army Engr bus	90.991	94.87	3.879
6	Awuru 1 bus	88.067	100.698	12.631
7	Awuru 2 bus	87.81	100.403	12.593
8	Baba Ilorin Farm bus	79.208	95.947	16.739
9	Baba Ilorin House bus	79.427	96.205	16.778
10	BF 1 bus	66.489	93.158	26.669
11	Borgu Community Bank bus	79.774	96.633	16.859
12	BSW bus	64.627	97.637	33.01
13	Bussa Town Hall bus	79.964	96.863	16.899

14	Catholic Church bus	60.756	98.619	37.863
15	Chinese Quarters bus	57.785	99.365	41.58
16	Clinic bus	64.545	97.512	32.967
17	Copra Below bus	63.556	96.018	32.462
18	D4 bus	64.563	97.54	32.977
19	Dantoro Lodge bus	93.433	96.94	3.507
20	Dantoro Road bus	89.517	94.71	5.193
21	Donia Camp bus	57.361	102.436	45.075
22	Elshadai bus	68.069	95.372	27.303
23	Emir's Guest House bus	91.382	95.277	3.895
24	Federal College of Wildlife bus	91.023	98.342	7.319
25	FGGC bus	90.83	95.384	4.554
26	Fisheries Quarters bus	87.834	94.544	6.71
27	Fisheries School bus	87.828	94.537	6.709
28	Funkun bus	92.915	97.58	4.665
29	GDSS Nassarawa bus	88.024	98.528	10.504
30	General Hospital bus	87.792	94.499	6.707
31	Govt. Secondary School bus	93.95	97.476	3.526
32	GRA bus	60.367	97.988	37.621
33	Hanger bus	73.882	95.946	22.064
34	Hydro bus	90.497	95.034	4.537
35	Ilorin Road bus	60.703	98.533	37.83
36	Jehovah Witness bus	88.795	94.746	5.951
37	Jobice bus	89.086	94.254	5.168

38	Kadariko bus	55.148	98.485	43.337
39	Kaduna Drive bus	60.165	97.66	37.495
40	Katamaya Hospital bus	58.246	100.157	41.911
41	KEYSTONE Bank bus	80.361	97.344	16.983
42	Kidagba bus	73.976	96.069	22.093
43	Koro 1 bus	93.051	96.434	3.383
44	Koro Grinder bus	92.206	95.558	3.352
45	Koro Radio bus	93.757	96.694	2.937
46	Kurwasa bus	55.622	99.33	43.708
47	Kwarin Wali bus	84.601	95.399	10.798
48	Lafia Sport bus	87.117	92.956	5.839
49	Local Govt Quarters bus	89.694	95.617	5.923
50	Luma Road bus	67.748	94.921	27.173
51	Mammy market bus	72.863	94.623	21.76
52	Manyara bus	93.117	97.791	4.674
53	MESL Water Intake bus	58.612	100.787	42.175
54	MESL Water Reserve bus	74.016	96.121	22.105
55	MESL Water Treatment bus	63.80	96.387	32.587
56	Mil Quarters 1 bus	85.479	96.39	10.911
57	Mil Quarters 2 bus	82.956	93.545	10.589
58	Monai bus	57.523	98.913	41.39
59	Motel Annex bus	58.408	100.435	42.027
60	MT Yard bus	72.871	94.634	21.763

61	MTN bus	73.998	96.097	22.099
62	MTN Nassarawa bus	90.203	97.456	7.253
63	MTN Wildlife bus	90.471	96.337	5.866
64	NAPTIN Guest House 1 bus	61.119	99.208	38.089
65	NAPTIN Guest House 2 bus	57.249	102.236	44.987
66	NAPTIN School bus	91.317	98.66	7.343
67	Nassarawa 1 bus	89.962	98.864	8.902
68	Nassarawa 2 bus	90.018	98.926	8.908
69	Nassarawa Grinder bus	88.581	99.152	10.571
70	National Park Headquarter bus	94.111	97.66	3.549
71	Nedufu Estate bus	88.934	94.806	5.872
72	New Quarters bus	91.547	95.449	3.902
73	Ngaski bus	68.987	96.658	27.671
74	NIFFR Headquarters bus	90.376	96.344	5.968
75	NIFFR Junior Quarters bus	89.640	95.559	5.919
76	NIFFR Secondary Quarters bus	89.838	95.049	5.211
77	NIFFR Senior Quarters 1 bus	88.246	94.987	6.741
78	NIFFR Senior Quarters 2 bus	89.407	94.594	5.187
79	Niger Crescent bus	63.494	95.925	32.431
80	Niger River Basin bus	90.018	95.962	5.944
81	Niger Water Booster bus	87.798	93.682	5.884
82	Niger Water Plant bus	55.72	99.506	43.786
83	Officers' Mess bus	68.533	96.022	27.489
84	Old Army Barracks bus	78.603	95.214	16.611

85	Old Dogongeri bus	93.587	96.519	2.932
86	Old Market bus	91.644	95.551	3.907
87	Rader bus	60.369	97.991	37.622
88	Sabo 1 bus	88.405	101.084	12.679
89	Sabo 2 bus	87.637	100.206	12.569
90	Sabo Grinder bus	88.117	100.755	12.638
91	Senior Camp C/T bus	63.533	95.984	32.451
92	SNCO bus	60.889	98.834	37.945
93	SOQ bus	58.553	100.684	42.131
94	SS 13 Manchester bus	90.429	94.963	4.534
95	SS 40 Roundabout bus	93.597	96.53	2.933
96	Technical Junction bus	92.25	95.712	3.462
97	TFT bus	68.41	95.849	27.439
98	Tudun Wali bus	90.131	96.082	5.951
99	UBA bus	74.444	96.676	22.232
100	Water Treatment bus	68.448	95.903	27.455
101	Waziri Primary School bus	78.268	94.809	16.541
102	Yuna bus	52.679	94.075	41.396
103	Zaria Way bus	55.548	99.198	43.65

Table 4.16: Enhanced Voltage Magnitude for Load Buses in New Bussa Network during Off-Peak Period

S/N	Bus Name	Voltage Magnitude Before Voltage Compensation	Voltage Magnitude After Voltage Compensation	Enhanced Voltage Magnitude
1	Agip bus	93.017	93.839	0.822
2	Aligani bus	89.767	99.508	9.741
3	Anglican Church 1 bus	94.214	98.413	4.199
4	Anglican Church 2 bus	94.323	98.527	4.204
5	Army Engr bus	94.577	95.413	0.836
6	Awuru 1 bus	93.736	94.565	0.829
7	Awuru 2 bus	93.676	94.504	0.828
8	Baba Ilorin Farm bus	91.666	98.212	6.546
9	Baba Ilorin House bus	92.31	98.901	6.591
10	BF 1 bus	86.809	99.977	13.168
11	Borgu Community Bank bus	92.021	98.592	6.571
12	BSW bus	86.188	101.663	15.475
13	Bussa Town Hall bus	92.512	99.118	6.606
14	Catholic Church bus	84.432	101.589	17.157
15	Chinese Quarters bus	82.785	101.061	18.276
16	Clinic bus	85.916	101.342	15.426
17	Copra Below bus	85.547	100.908	15.361
18	D4 bus	86.085	101.542	15.457
19	Dantoro Lodge bus	97.247	98.505	1.258
20	Dantoro Road bus	94.078	94.909	0.831

21	Donia Camp bus	82.68	101.699	19.019
22	Elshadai bus	87.719	101.025	13.306
23	Emir's Guest House bus	95.035	95.875	0.84
24	Federal College of Wildlife bus	95.148	95.989	0.841
25	FGGC bus	94.937	95.776	0.839
26	Fisheries Quarters bus	93.168	93.991	0.823
27	Fisheries School bus	92.846	93.667	0.821
28	Funkun bus	96.502	97.355	0.853
29	GDSS Nassarawa bus	93.178	94.001	0.823
30	General Hospital bus	92.436	93.253	0.817
31	Govt. Secondary School bus	97.346	98.605	1.259
32	GRA bus	83.952	101.011	17.059
33	Hanger bus	89.876	99.63	9.754
34	Hydro bus	94.823	95.661	0.838
35	Ilorin Road bus	84.259	101.38	17.121
36	Jehoval Witness bus	93.682	94.51	0.828
37	Jobice bus	93.473	94.299	0.826
38	Kadariko bus	81.773	100.584	18.811
39	Kaduna Drive bus	83.998	101.066	17.068
40	Katamaya Hospital bus	82.906	101.209	18.303
41	KEYSTONE Bank bus	92.222	98.807	6.585
42	Kidagba bus	90.144	99.926	9.782
43	Koro 1 bus	96.389	97.241	0.852
44	Koro Grinder bus	95.926	96.774	0.848

45	Koro Radio bus	96.693	97.547	0.854
46	Kurwasa bus	81.889	101.66	19.771
47	Kwarin Wali bus	94.209	98.407	4.198
48	Lafia Sport bus	92.459	93.276	0.817
49	Local Govt Quarters bus	95.926	98.161	2.235
50	Luma Road bus	87.562	100.843	13.281
51	Mammy market bus	89.624	99.351	9.727
52	Manyara bus	96.502	97.355	0.853
53	MESL Water Intake bus	82.781	101.057	18.276
54	MESL Water Reserve bus	89.894	99.649	9.755
55	MESL Water Treatment bus	85.861	101.278	15.417
56	Mil Quarters 1 bus	94.486	98.697	4.211
57	Mil Quarters 2 bus	93.888	98.072	4.184
58	Monai bus	82.915	101.22	18.305
59	Motel Annex bus	82.635	100.878	18.243
60	MT Yard bus	89.842	99.592	9.75
61	MTN bus	89.469	99.178	9.709
62	MTN Nassarawa bus	94.133	94.965	0.832
63	MTN Wildlife bus	94.062	94.893	0.831
64	NAPTIN Guest House 1 bus	84.332	101.468	17.136
65	NAPTIN Guest House 2 bus	82.356	101.3	18.944
66	NAPTIN School bus	95.317	96.16	0.843
67	Nassarawa 1 bus	94.537	95.373	0.836
68	Nassarawa 2 bus	94.563	95.399	0.836

69	Nassarawa Grinder bus	93.846	94.676	0.83
70	National Park Headquarter bus	96.817	97.673	0.856
71	Nedufu Estate bus	95.633	97.862	2.229
72	New Quarters bus	95.173	96.015	0.842
73	Ngaski bus	88.058	101.415	13.357
74	NIFFR Headquarters bus	96.28	98.524	2.244
75	NIFFR Junior Quarters bus	96.051	98.289	2.238
76	NIFFR Secondary Quarters bus	94.33	95.164	0.834
77	NIFFR Senior Quarters 1 bus	93.219	94.043	0.824
78	NIFFR Senior Quarters 2 bus	93.925	94.755	0.83
79	Niger Crescent bus	85.6	100.97	15.37
80	Niger River Basin bus	96.068	98.305	2.237
81	Niger Water Booster bus	92.647	93.466	0.819
82	Niger Water Plant bus	81.475	101.145	19.67
83	Officers' Mess bus	87.999	101.347	13.348
84	Old Army Barracks bus	92.057	98.631	6.574
85	Old Dogongeri bus	96.72	97.574	0.854
86	Old Market bus	95.395	96.238	0.843
87	Rader bus	84.378	101.524	17.146
88	Sabo 1 bus	94.004	94.835	0.831
89	Sabo 2 bus	93.814	94.643	0.829
90	Sabo Grinder bus	93.897	94.727	0.83
91	Senior Camp C/T bus	85.564	100.927	15.363
92	SNCO bus	84.578	101.765	17.187

93	SOQ bus	83.385	101.793	18.408
94	SS 13 Manchester bus	94.562	95.397	0.835
95	SS 40 Roundabout bus	96.866	97.722	0.856
96	Technical Junction bus	96.688	97.938	1.25
97	TFT bus	87.955	101.296	13.341
98	Tudun Wali bus	96.108	98.348	2.24
99	UBA bus	89.931	99.691	9.76
100	Water Treatment bus	87.654	101.311	13.657
101	Waziri Primary School bus	92.027	98.598	6.571
102	Yuna bus	80.691	100.172	19.481
103	Zaria Way bus	82.254	101.175	18.921

4.5 Performance Evaluation

The performance of this developed system, Microcontroller-based capacitor switching and GSM based monitoring system was ascertained by its ability to carry out the following functions successfully; voltage compensation, automatic switching of capacitor, automated transformer phase monitoring and reporting of blown low voltage fuse, transformer neutral failure and transformer trip on fault.

4.5.1 Voltage compensation

Having discovered that New Bussa distribution network was not reliable in supplying quality power to all consumers in the network after conducting the load flow study/analysis of the New Bussa base (initial) network whereby 75% of entire load buses during peak period and 39% of entire load buses in the network during off-peak loading period violated the ANSI C84.1 standard as shown in Tables 4.1 and 4.2, Load flow simulation of New Bussa network was also carried out in ETAP 12.6 software for both peak and off-peak loading periods with the optimally selected capacitor banks installed at their appropriate buses so as to improve the voltage profile of the network and ascertain if there were still load buses that violate the ANSI voltage standard. The load flow reports generated for the compensated New Bussa network as shown in Tables 4.9 & 4.10 and the summarized percentage voltage magnitudes for all the load buses in the network as presented in Tables 4.13 & 4.14 indicate that the voltage compensation process was successful and that no load bus voltage in the network still violates the ANSI C84.1 voltage standard.

4.5.2 Microcontroller switching system

The automated switching aspect of the research work is needed to switch the compensators (capacitors) when the bus voltages violate the ANSI C84.1 standard (90% ≤ V ≤ 106% of the nominal voltage value). It was developed to switch on the capacitor bank when the monitored phase voltage falls below 216V being the minimum ANSI C84.1 acceptable phase voltage limit or switch off the capacitor bank when the voltage goes back to a value within the standard phase voltage limit (216V – 255V) after the voltage compensation process, so as to avoid over-compensation of the line, thus avoiding damage to consumers' electronic appliances with high voltage. For simplicity and explanation of the switching aspect, the research work was tested by injecting a voltage value of 220V to the constructed work through red phase (Rph) voltage sensor of the device. The red phase sensor senses the 220V value and sends the analog signal to the ATmega328 microcontroller that controls the switching itself. The microcontroller compares the received signal with the reference value. Since the injected 220V is within the ANSI standard phase voltage limit of 216 – 255V; the system did not see any need for voltage compensation, hence, the microcontroller did not send any signal to the relay for switching on of the capacitor bank. But when 190V was injected through the red phase voltage sensor, the microcontroller receives the analog voltage signal through its analog to digital converter ports, it then compares the received signal with the reference voltage value and due to the fact that sensed 190V is less than the minimum standard phase voltage value (216V), the microcontroller immediately responds by sending a closing signal to the open contact of the relay so as to switch on the capacitor bank for voltage compensation of the distribution line.

4.5.3 Blown fuse detection

This aspect of the objective was tested by connecting the red phase blown fuse detector input terminals of the constructed research work across a low voltage fuse link of 200A connected in the fuse holder and in a low voltage fuse panel in New Bussa injection station. When the fuse holder is closed and the fuse link is energized, the blown fuse detector senses a normal phase voltage across the fuse link and sends an analog voltage signal (5V) or a digital signal (HIGH) to the ATmega328 microcontroller indicating that the fuse is still intact. But when the fuse was de-energized by opening the fuse holder (depicting practical cut of fuse link or fuse blown), with the blown fuse detector input terminals still connected across the fuse link, the blown fuse detector senses a no voltage value across the fuse link, it sends an analog voltage signal (0V) or a digital signal (LOW) to the microcontroller. The microcontroller activates the GSM Modem which in turns sends a pre-programmed SMS message that reads "RED-Phase Fuse had blown at Transformer (T01), please check urgently" to the System Operator. The LCD as well displayed "FUSE BLOWN".

4.5.4 Transformer low voltage neutral failure

Practically whenever there is a low voltage neutral failure of distribution transformer, the supplied phase voltage from the transformer to consumers becomes line-to-line voltage value of about 400V, which is high and greater than the maximum ANSI C84.1 phase voltage standard of

255V. This high voltage value supply from the transformer causes a lot of damages to consumers' appliances when the transformer is not quickly isolated from the network. This GSM-based monitoring and reporting aspect of the research work was tested by supplying 220V to the red phase sensor input terminals of the research work. When a voltage of 220V was injected into the system through the red phase voltage sensor, the system did not respond to the injected 220V value because the injected voltage is within the ANSI standard phase voltage limit. But when a voltage of 400V was injected into the system, the microcontroller received the signal, compared it with the reference voltage and sends a control signal to the LCD and GSM modem. The GSM modem also sends a pre-programmed SMS to the Distribution system operator (DSO) informing him about the over-voltage problem so that he can quickly isolate that particular transformer to avoid further damage to consumers' equipment and ensure quicker process of restoring quality power to consumers. The pre-programmed SMS received by the DSO reads, "High Voltage fault Detected in Red Phase (Rph) Distribution Transformer at Location A (T01), Urgent attention needed; Possible Neutral Failure". The LCD as well displayed "High Voltage".

4.5.5 Transformer trip

The automated monitoring and reporting of transformer trip (no voltage supply) by the research work was done by injecting a voltage of 220V through the research work main voltage sensor's input terminals of the research work. The system did not respond to the injected 220V voltage value which signifies in practical reality that the transformer is energized because of the fact that energized distribution transformers by standard, supplies phase voltage values between 216V – 255V. But immediately a very low voltage value (less than 30V) was injected into the system, which is not a real voltage, the main phase voltage sensor sends the signal to the microcontroller which compares it with the reference voltage value and sends a control signal to the LCD and the GSM modem. The GSM modem as well sends a pre-programmed SMS to distribution system operator (DSO) indicating transformer trip and that there is no voltage supply from the transformer. The pre-programmed SMS reads, "Black out Detected at transformer (T01) Location A, please check urgently", despite the transformer service feeder being active.

Having concluded these performance evaluations and tests successfully, it can be affirmed that the developed constructed work, Microcontroller-based switching and GSM based monitoring system is satisfactorily ok.

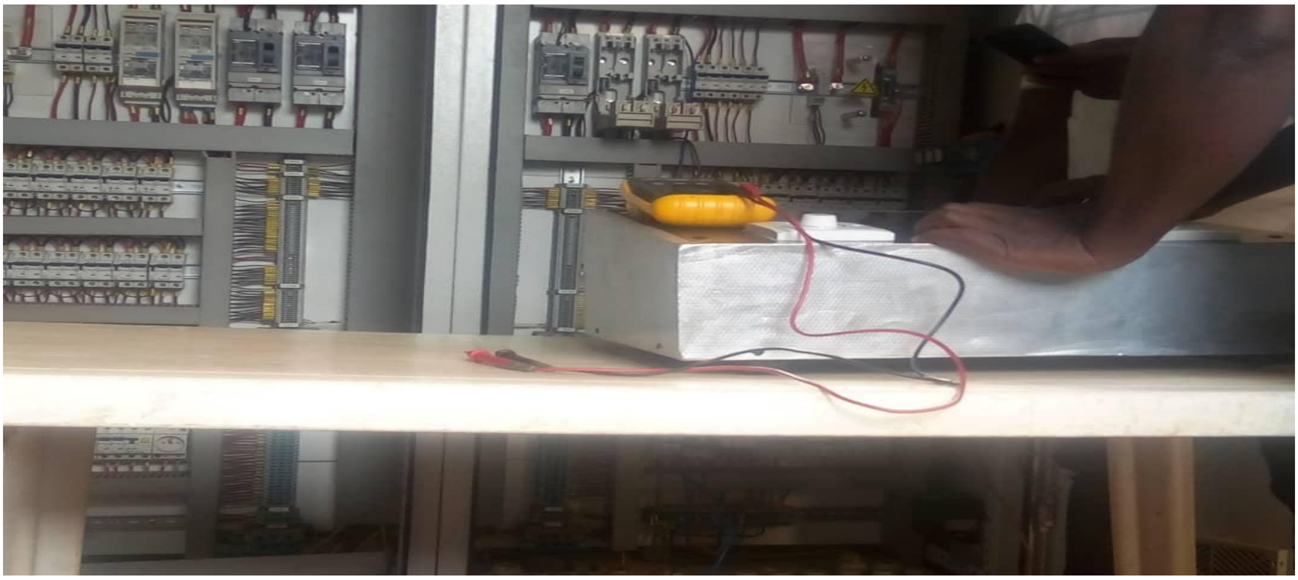
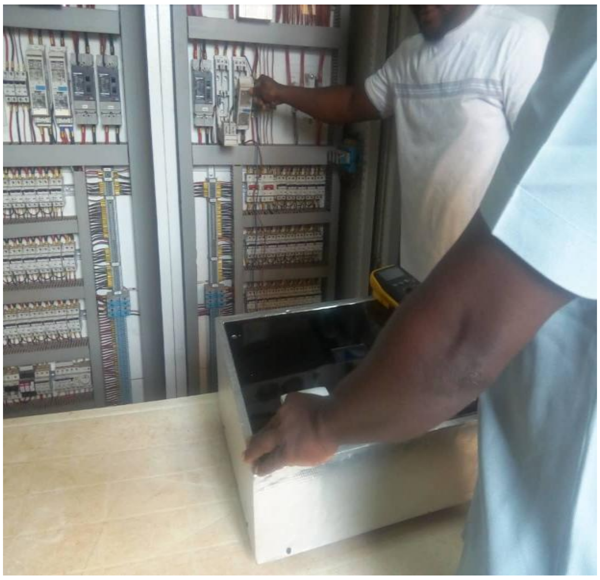


Figure 4.14: Section A of the performance evaluation using the constructed research work



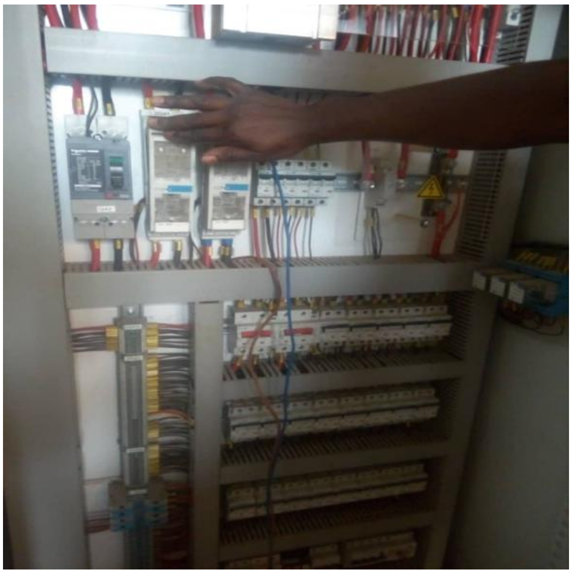


Figure 4.15: Section B of performance evaluation using the constructed research work

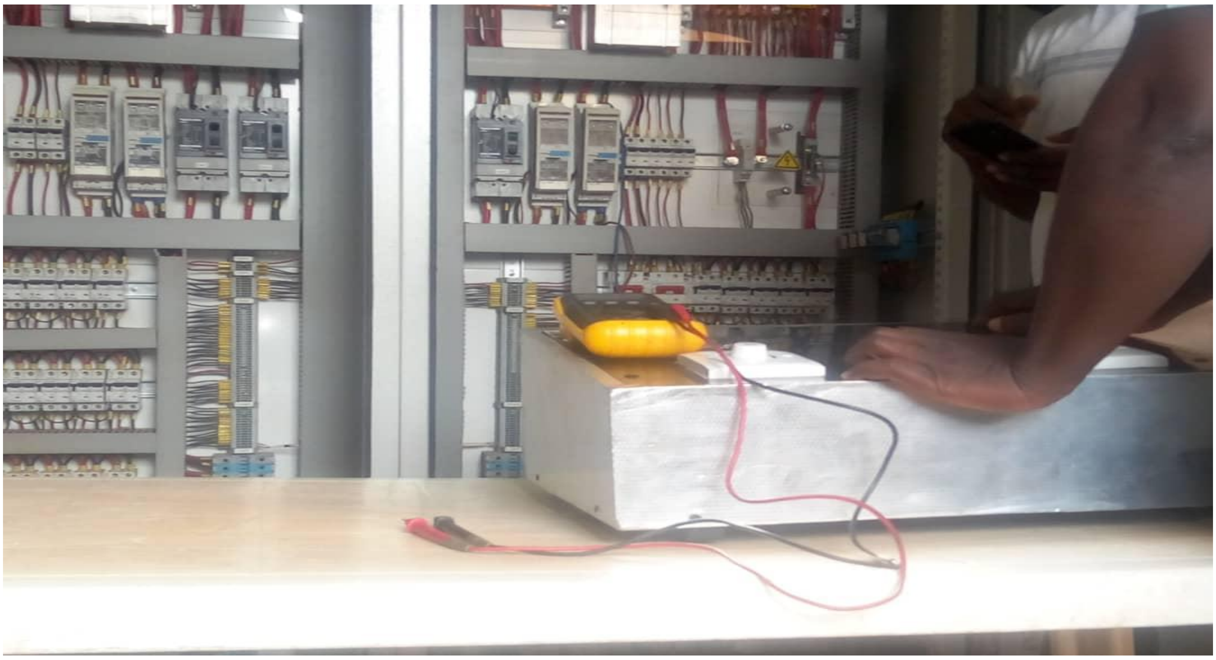


Figure 4.16: Section C of performance evaluation using the constructed research work

Figure 4.17: Section D of performance evaluation using the constructed research work

4.6 Bill of Engineering Measurement and Evaluation (BEME as at September, 2019)

Table 4.17: Bill of Engineering Measurement and Evaluation as at September, 2019

S/N	COMPONENTS	QTY	UNIT PRICE (Naira)	AMOUNT (Naira)
1	ATmega328P	1	2000	2000
2	GSM Modem - SIM900D	1	10,000	10,000
3	LCD	1	1500	1500
4	415/12V Step-down transformer	4	20,000	80,000
5	220/12V Step-down transformer	1	4000	4000
6	1N5400	5	120	600
7	Voltage regulator – 7805	1	100	100
8	12VDC Rechargeable battery	1	7000	7000
9	Capacitor	13	150	1,950
10	Potentiometer	5	50	250
11	Transistor	3	50	150
12	Diode	3	20	60
13	Relay	3	250	750
14	Resistor	3	10	30
15	Light dimmer switch	3	500	1500
16	Packaging	1	20000	20,000
17	Miscellaneous	1	30000	30,000
18	Total			159,890

4.7 Findings and Discussions

During the period of developing this research work, a lot of things were observed and discovered at some points in the course of producing the work. Various findings were made during the following periods;

- Period of collection of empirical data from New Bussa 15MVA, 33/11KV injection substation.
- Period after the load flow study of New Bussa base (initial) distribution network and analysis of the generated load flow reports.
- Period after the load flow study of New Bussa base compensated distribution network and analysis of the generated load flow reports.

4.7.1 Findings observed during period of empirical data collection from New Bussa 15MVA 33/11KV injection substation

i. The New Bussa distribution network's record of number of 11/0.415KV distribution transformer in the network was not updated.

ii. The New Bussa network's record of the route lengths of all distribution transformers from the injection substation also was not updated.

iii. The absence of transformer phase monitoring device that monitors and reports blown low voltage fuse to Distribution System Operator (DSO) in the network, leads to delayed time in restoration of lost transformer phase whenever there is blown fuse of a particular transformer phase. This also results to consumers in that particular phase having no power supply thereby switching over to other phases with available power, thus overloading those phases and resulting to greater drop in voltage supplied to them and as well increases the risk of breakdown of the transformer.

iv. The absence of phase monitoring device that monitors and reports over-voltage supply caused by transformer neutral failure leads to continued existence of over-voltage supply without the knowledge of the power provider's maintenance team in restoring the rated or proper voltage supply thus causing more damage to consumers' appliances.

v. The absence of transformer monitoring system that monitors and reports no voltage supply caused by transformer trip on fault despite the transformer's service feeder still active leads to the power provider having wrong transformer performance status thus resulting to incorrect estimated energy bill calculation given to non-prepaid electricity consumers supplied by that transformer.

4.7.2 Findings observed after Load flow analysis of New Bussa base (initial) network

i. The peak loading period for the three feeders (Sabo, Senior Camp and Township feeders) was between 5:00 (5:00a.m) to 8:00 (8:00a.m) and between 18:00 (6:00p.m) to 21:00 (9:00p.m), with the greatest load occurring at 20.00 (8:00p.m) every day as shown in Tables 3.1 through 3.21 and Figures 3.5 through 3.11 in chapter 3.

ii. The power flow study performed on New Bussa base (initial) distribution network showed that voltage violations occurred in seventy-eight (78) load buses and forty-one (41) load buses for peak and off-peak period respectively, out of a total of one hundred and three (103) load buses in the network as shown in Tables 4.1 and 4.2. This implies that 75% and 39% of entire power consumers in New Bussa network experienced low voltages during peak and off-peak periods respectively.

iii. Yuna bus had the lowest percentage voltage magnitude of 52.679% for peak period and 80.691% for off-peak period. This implies that Yuna bus had the largest voltage drop of 47.321% and 19.309% for peak and off-peak periods respectively. This voltage drop values were very high when compared to the ANSI maximum standard voltage drop value of 10%.

iv. It was also observed from the branch power losses summary report for New Bussa distribution network that the active and reactive power losses are 978KW & 1674.30KVAR during the peak period and are 180.70KW & 315.50KVAR during the off-peak loading period.

4.7.3 Findings observed after load flow study of New Bussa compensated network

i. The selected switching order for candidate locations for capacitor placement are at buses 05, 07, 08, 04, 09, 10, 57, 0012, 020 as determined by loss sensitivity factor calculations in chapter 3.

ii. The percentage voltage magnitudes for all buses were within the ANSI acceptable standard limit of 90% < V < 106% for both peak and off-peak periods after the compensation.

iii. The voltage drop for Yuna bus which had the highest and the worst voltage drop in the network was reduced from 47.321% to 5.925% during the peak period, and the voltage drop was eliminated entirely from the initial 19.309% during off-peak period after the compensation.

iv. After voltage compensation of New Bussa distribution network, Branch power losses for both active and reactive power were reduced from 978.00KW & 1674.30KVAR to 118.50KW & 328.00KVAR during peak loading period and were also reduced from 180.70KW & 315.50KVAR to 52.9KW & 105.30KVAR during off-peak loading period.

v. The use of microcontroller in switching the capacitor in the network ensured that only the needed amount of reactive power was injected into the network at any point in time, to avoid over-compensating the lines during the off-peak period when some loads have dropped from the network.

vi. The use of GSM-based phase monitoring system automatically monitors and reports blown low voltage fuse, over-voltage supply and transformer trip to Distribution system operator for prompt and proactive resolution and restoration of quality power supply from the affected transformer.

CHAPTER FIVE

CONTRIBUTION TO KNOWLEDGE, CONCLUSION AND RECOMMENDATIONS

5.1 Contribution to Knowledge

This research work contributed to knowledge in the following areas:

i. It helped New Bussa injection substation being a sub division of Ibadan Electricity Distribution Company (IBEDC) to update their data resources in terms of the accurate number of transformers and various route lengths to the injection station for New Bussa distribution network.

ii. It developed a system that reduces voltage violations and minimizes power losses at all loading periods for New Bussa distribution network.

iii. The developed system was able to monitor and report blown low voltage fuse to system operator so as to ensure prompt action and quick restoration of quality power supply to consumers by the maintenance team in the network.

iv. The developed automated reporting system can as well report over-voltage issue of a particular transformer in the network caused by the transformer low voltage neutral failure to the Distribution System Operator.

v. The developed automated reporting system that reports transformer trip can serve as a power regulatory system which when enforced by the Power regulatory body (NERC) ensures a better and accurate calculation of energy consumption hours by non-prepaid electricity consumers. This system indicates to power providers when a particular distribution transformer is not energized (trips on fault), though there is voltage on the 11KV feeder supplying it. The automated regulatory approach by the research work discourages wrong energy bill calculation pattern done by power providers when they calculate for non-prepaid electricity customers' energy bill where they use the actual number of hours the 11KV service feeder supplies power to the transformer instead of the actual number of hours the distribution transformer is energized to calculate for non-prepaid electricity customers' energy bill.

5.2 Conclusion

This research work applied microcontroller-based switching system, GSM-based monitoring and reporting system in enhancing the performance of power distribution network. ETAP 12.6 computer simulation software was used to conduct a load flow study of New Bussa distribution network using the empirical data collected from New Bussa injection station for peak and off-peak loading periods. It was observed from the generated load flow reports that New Bussa distribution network was not reliable in supplying quality power to the consumers in the network and the performance status of New Bussa network was not satisfactory; there are voltage violations in 75% of load buses in the network during peak loading period and 39% of load buses in the network during off-peak loading period, meaning that 75% of power consumers within the network received low voltage supply during peak period while 39% of power consumers within the network received low voltage supply during off-peak period.

This issue led to the development of a system with an automated way of voltage compensation and also automated way of transformer phase monitoring and reporting to Distribution system operator (DSO).

Load flow study was also conducted on the network with the capacitor banks connected on the optimal positions using ETAP 12.6 software and load flow reports were generated for both the peak and off-peak periods. Analysis carried out on the generated reports for the compensated network showed that there were no longer buses with voltage violations, thus all load bus voltages have been improved and were within the ANSI C84.1 accepted standard limit after the compensation process *(See Tables 4.15 and 4.16)*.

Therefore, the use of microcontroller-based switching system and GSM-based transformer phase monitoring system successfully improved the performance of New Bussa distribution network.

5.3 Recommendations

The following facts are recommended to enhance particularly the performance of New Bussa distribution network and generally the entire power system in Nigeria.

1. There should be regular update of data and information in the network, at least twice a year by Network Engineers since these data/information help in proper network planning.

2. Power providers should adopt this method of an automated reporting of blown low voltage fuses as this would ensure quicker time of restoring lost transformer phase and will as well reduce downtime associated with location of the fault.

3. There should be construction of a new 7.5MVA 33/11KV Injection Substation around Wawa community so as to reduce the load on Senior Camp feeder and as well reduce the losses and voltage drop, as consumers will be closer to source of power.
4. Power regulatory body (NERC) should enforce that power providers apply and implement this design since it indicates to power providers when a particular distribution transformer is not active, notwithstanding that there is voltage on the 11KV feeder supplying it. This indication of transformer being off “Black out” shown both as a display on LCD and as SMS sent to the Distribution system operator (DSO) discourages incorrect energy bill calculation pattern done by power providers when they calculate for non-prepaid electricity customers’ energy bill using the number of hours the 11KV service feeder is energized and supplies power irrespective of the fact that the service distribution transformer is not active due to other faults.

REFERENCES

Abanihi, V.K., Ikheloa S.O., Okodede F. (2018). Overview of the Nigerian Power Sector. American Journal of Engineering Research (AJER) Volume-7, Issue-5, pp-253-263.

Abdullah, U., Ali, A. (2014). GSM Based Water level and Temperature Monitoring System. International Journal of Recent Development in Engineering and Technology. Volume 3, Issue 2.

Alhasnaw, B.N., Jasim, B.H. (2018). Using Different Network Technologies and Wireless Sensor Networks to Design and Implement a Fully Smart Home System. International Journal of Computer Applications. Volume 179, No.16.

Alexander, K., Marc, T.T. (2007). Power Quality in Electrical Systems. McGraw Hills Company.

Amit, S. (2012). Microcontroller Based Substation Monitoring and Control System with GSM Modem. Journal of Electrical and Electronics Engineering, Volume 1, Issue 6, pp.13-21.

Anyaka, O. B. (2014). Challenges of Deregulation of Electric Power Sector in a Third World Economy. IOSR Journal of Electrical and Electronics Engineering, Volume 9, Issue 3 Ver. III, pp.19-22.

Attigah, B., Mayer-Tasch, L. (2013). The Impact of Electricity Access on Economic Development.

Balasubramaniam, P.M., Prabha, S.U. (2015). Power Quality Issues, Solutions and Standards: A Technology Review. Journal of Applied Science and Engineering, Vol. 18, No.4, pp.371 – 380.

Baran, M.E., Wu, F.F. (1989). Network Reconfiguration in Distribution Systems for Loss Reduction and Load Balancing. IEEE Transactions on Power Delivery, Vol. 4, No. 2, pp.1401-1414.

Bencini, L., Chiti, F., Collodi, G., Di Palma, D., Fantacci, R., Manes, A., Manes, G. (2009). Agricultural Monitoring Based on Wireless Sensor Network Technology: Real Long Life Deployments for Physiology and Pathogens Control. Sensor Technologies and Applications.

Bhongade, S., Sachin, A. (2016). Optimal Capacitors in Radial Distribution System for Loss Reduction and Voltage Enhancement. Indonesian Journal of Electrical Engineering and Computer Science, Vol. 2, No. 3, pp. 566 -582.

Chen, P., Jiang, X. (2008). Design and Implementation of Remote Monitoring System Based on GSM. Pacific-Asia Workshop on Computational Intelligence and Industrial Application. pp. 678 – 681.

Desale, P.A., Dhawale, V.J., Bandgar, R.M. (2014). Brief Review Paper on the Custom Power Devices for Power Quality Improvement. International Journal of Electronic and Electrical Engineering. Vol. 7, Number 7, pp. 723-733.

Dinakara, P.R.P. (2013). Application of Loss Sensitivity Factor and Genetic Algorithm for Capacitor Placement for Minimum Loss in radial Distribution System. International Journal of Engineering Sciences & Research Technology, pp. 2400 – 2403.

Dugan, R.C., McGranaghan, M.F., Santoso, S., Beaty, H.W. (2004). Electrical Power Systems Quality. McGraw-Hill Companies, Second Edition.

Egwaile, J.O., Bello, N. (2014). Design and Implementation of GSM Based Transformer Phase Monitoring System. Nigerian Journal of Technology, Vol. 33. No. 3, July 2014, pp.331-336.

Flammini, A., Marioli, D., Sisinni, E., Taroni, A. (2007). Environmental Telemonitoring: A Flexible GSM-DECT-Based Solution, Instrumentation and Measurement. IEEE Transactions.

Grainger, J.J., Lee, S.H. (1981). Optimum Size and Location of Shunt Capacitors for Reduction of Losses on Distribution Feeders. AIEE Transactions, Vol. 100, Issue: 3, pp. 1105 – 1118.

Hemant, S., Arora, S. (2016). Improvement of Power Quality in Distribution System using DVR. International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169, Volume: 4 Issue: 3 pp. 383 – 386.

Hemasekhar, A., Harika, C. (2014). Voltage Profile Improvement by Capacitor Placement and Control in Unbalanced Distribution Systems Using Differential Evolution Algorithm. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3, Issue 8, pp. 11210 – 11217.

Heussen, K., Saleem, A., Lind, M. (2009). Control architecture of power systems: Modeling of purpose and function. IEEE Power & Energy Society General Meeting, PES '09. pp. 1-8.

Hongwei, Y., Hongxia, P. (2009). Remote Data Monitoring System Design Based on GSM Short Message Service. IEEE International Symposium on Industrial Electronics, Seoul Olympic Parktel, Seoul, Korea.

Izuegbunam, F.I., Uba, I.S., Akwukwaegbu, I.O., Dike, D.O. (2014). Reliability Evaluation of Onitsha Power Distribution Network via Analytical Technique and the Impact of PV System. Journal of Electrical and Electronics Engineering, Volume 9, Issue 3 pp. 15-22.

Jagdeep (2014). GSM-Microcontroller Based Remote Control of Sprinkler Irrigation. International Journal of Modern Engineering Research. Vol. 4, Iss.11.

Jiang, J., Yan, Z., Shi, J., Kandachar, P., Freudenthal, A. (2010). A Mobile Monitoring System of Blood Pressure for Underserved in China by Information and Communication Technology Service. IEEE Transactions on Information Technology in Biomedicine. Vol. 14, No. 3.

Jyotishi, P., Deeparamchandani, P. (2013). Mitigate Voltage Sag/Swell Condition and Power Quality Improvement in Distribution Line using D-STATCOM. International Journal of Engineering Research and Applications, Vol. 3, Issue 6, pp.667-674.

Kadam, A., Baikar, S., Kote, A., Shah, A.P.T., (2016). GSM based LAN Monitoring System. National Conference on Technological Advancement and Automatization in Engineering. ISSN: 2321-0613

Kanma, H., Kanazawa, H., Wakabayashi, N., Ito, H. (2003). Home appliance control system over Bluetooth with a cellular phone. IEEE Transactions on Consumer Electronics 49(4):1049 – 1053.

Khadkikar, V. (2012). Enhancing Electric Power Quality Using UPQC: A Comprehensive Overview. IEEE Transactions on Power Electronics, Vol. 27, No. 5, pp. 2284-2297.

Khiyal, M.S.H., Khan, A., Shehzadi, E. (2009). SMS Based Wireless Home Appliance Control System (HACS) for Automating Appliances and Security. Issues in Informing Science and Information Technology. Volume 6.

Kour, G., Brar, G.S., Dhiman, J. (2012). Improvement by Voltage Profile by Static Var Compensators in Distribution Substation. International Journal of Instrumentation Science, 1(2): 21-24

Kumar, K.S.P., Susanna, M.M., Manjusha, P., Suneel, N. (2016). Improving Voltage Profile in Distribution Systems using Custom Power Devices (CPD). International Research Journal of Engineering and Technology, Vol. 03 Issue: 04, pp. 646 – 652.

Madan, V., Reddy, S.R.N. (2012). GSM-Bluetooth based Remote Monitoring and Control System with Automatic Light Controller. International Journal of Computer Applications, Volume 46 – No.1.

Mian, M.K., (2015). GSM Based Link Monitoring of Distribution Transformer. International Journal of Recent Research Aspects ISSN: 2349- 7688, Vol. 2, Issue 4, December 2015, pp.56-59.

Morad, M., Abdellah, E., Ahmed, E. (2014). A Maintenance Optimization Policy for an Electric Power Distribution System: Case of the HV/MV Substations. Scientific Research Publishing Inc. pp. 236-253.

Neagle, N.M., Samson, D.R. (1956). Loss Reduction from Capacitors Installed on Primary Feeders. AIEE Transactions, part III, Vol. 75, pp.950-959.

Nunoo, S., Attachie, J.C., Duah, F.N. (2012). An Investigation into the Causes and Effects of Voltage Drops on an 11 kV Feeder. Canadian Journal on Electrical and Electronics Engineering Vol. 3, No. 1.

Ohajianya, A.C., Abumere, O.E., Owate, I.O. Osarolube, E. (2014). Erratic Power Supply in Nigeria: Causes and Solutions. International Journal of Engineering Science Invention Volume 3, Issue 7, pp.51-55.

Okundamiya, M.S., Udeozor, O.S., Imade, O.J. (2009). Investigation and Evaluation of Voltage Drops: A case study of Guiness and Ikpoba Dam Injection Substations. International Journal of Electrical Engineering and Power Engineering, Medwell Publishing, 3(2), 105-111.

Osahenvemwen, O.A., Omorogiuwa, O. (2015). Parametric Modeling of Voltage Drop in Power Distribution Networks. International Journal of Technical Research and Applications e-ISSN: 2320-8163, Volume 3, Issue 3, pp. 356-359.

Parihar, K., Pangtey, D.S., Rana, B.S. (2013). Transformer Oil Temperature Monitoring with Automatic Circuit Breaker. International Journal of Research in IT & Management, Volume 3, Issue 4.

Porate, K., Thakre, K.L., Bodhe, G.L. (2009). Voltage Stability Enhancement of Low Voltage Radial Distribution Network Using Static VAR Compensator: A Case Study. WSEAS Transactions on Power Systems, Issue 1, Volume 4.

Pragati, P., Titare, L.S. (2014). Minimization of Overall Losses of a Distribution System under Contingency Conditions. International Journal of Recent Research in Electrical and Electronics Engineering Vol. 1, Issue 3, pp. 17-25.

Purnima, S.R.N. R. (2012). Design of Remote Monitoring and Control System with Automatic Irrigation System using GSM-Bluetooth. International Journal of Computer Applications. Volume 47, No.12.

Rainer, B. (1993). Power System Models, Objectives and Constraints in Optimal Power Flow Calculations - Optimization in Planning and Operation of Electric Power Systems". Physica-Verlag (Springer), pp. 217-264.

Ramesh, L., Chowdhury, S.P., Chowdhury, S., Natarajan, A.A., Gaunt, C.T. (2009). Minimization of Power Loss in Distribution Networks by Different Techniques. International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering Vol.3, No.4.

Ranvir, K.V., Solanke, M.A., Ratnaparkhi, R.P., Sable, A.N. (2015). Substation Monitoring System. International Journal of Engineering and Technical Research, ISSN: 2321-0869, Volume-3, Issue-2.

Ravi., Radha, R. (2016). Coordination between SVC and OLTC for voltage control in Wind Energy Conversion System. International Research Journal of Engineering and Technology, Vol. 03 Issue: 10, pp. 482 – 485.

Ritula, T., Puneet C. (2015). Calculative Analysis of 11KV Urban Distribution Feeder. International Journal on Recent Technologies in Mechanical and Electrical Engineering Vol. 2 pp. 74-84.

Rohit, G. R., Sandip, S.J. (2015). Performance Analysis of Power Quality Improvement in Distribution Network Using Shunt Active Power Filter. International Journal on Recent and Innovation Trends in Computing and Communication, Vol. 3, Issue: 2, pp. 5-9.

Rojin, R.K. (2013). A Review of Power Quality Problems and Solutions in Electrical Power System. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 2, Issue 11.

Sabin, D., McGranaghan, M., Sundaram, A. (1998). A Systems Approach to Power Quality Monitoring for Performance Assessment. Electric Power Research Institute (EPRI).

Sankaran, C. (2002). Power Quality. CRC Press LLC.

Scanaill, C.N., Ahearne, B., and Lyons, G.M. (2006). Long-Term Telemonitoring of Mobility Trends of Elderly People Using SMS Messaging. IEEE Transactions on Information Technology in Biomedicine, Vol. 10, No. 2.

Shembekar, S.M., Borse, N.S., Patil, L.P (2015). A Comparative Analysis of UPQC for Power Quality Improvement. International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163, Issue 4, Volume 2.

Sujitkumarsingh., Sumankumar, S. (2014). A Review of Voltage Control Technique of Grid Connected Distributed Generation. International Journal of Innovative Research in Science, Engineering and Technology, Volume 3, Special Issue 1.

Sundharajan, S., Pahwa, A. (1994). Optimal selection of capacitors for radial distribution systems using a genetic algorithm. IEEE Transactions on Power Systems, 9(3): 1499-1507.

Teja, B.R., Murty, V.V.S.N., Kumar, A. (2016). An Efficient and Simple Load Flow Approach for Radial and Meshed Distribution Networks. International Journal of Grid and Distributed Computing, Vol. 9, No. 2, pp.85-102.

Thiyagarajan, V., Palanivel, T.G. (2010). An Efficient Monitoring of Substations using Microcontroller Based Monitoring System. IJRRAS 4 (1).

Thongkeaw, S., Boonthienthong, M. (2013). Technique for Voltage Control in Distribution System. International Journal of Electrical and Computer Engineering Vol.7, No.10, pp. 1313 – 1316.

Van Der Werff, M., Gui, X., Xu, W.L. (2005). A Mobile-Based Home Automation System. IEEE conference on Mobile Technology, Applications and Systems. pp 1-5.

Wijetunge, S.P., Peiris, G.R.V., Aluthgedara, C.S., Wijetunge, U.S., Samarasinghe, A.T.L.K. (2008). Design and Implementation of a Bluetooth based General Purpose Controlling Module. International Conference on Information and Automation for Sustainability.

Xu, T., Taylor, P.C. (2008). Voltage Control Techniques for Electrical Distribution Networks including Distributed Generation. The International Federation of Automatic Control Seoul, Korea, pp. 11967 – 11971.

Yu, S., Cheng, J. (2005). A Wireless Physiological Signal Monitoring System with Integrated Bluetooth and WiFi Technologies. International Conference of the IEEE Engineering in Medicine and Biology Society. Volume 3.

Yunseop, K., Evans, R.G., Iversen, W.M. (2008). Remote Sensing and Control of an Irrigation System using a Distributed Wireless Sensor Network; Instrumentation and Measurement. IEEE Transactions. Volume 57, Issue 7

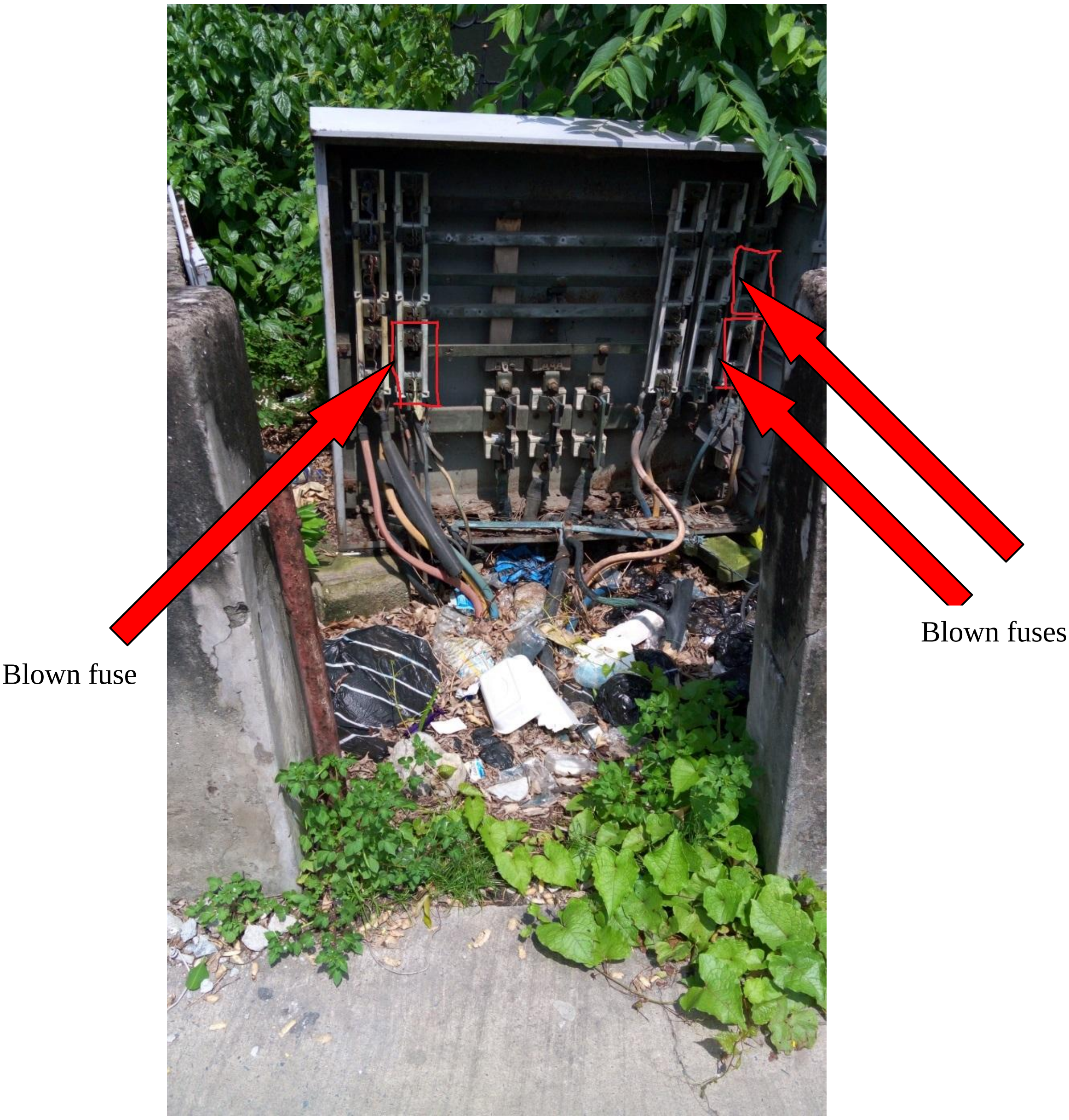
Zakaria, Z.A., Chen, B.C., Hassan, M.O., Yuan, J.X. (2008). Distribution Static Compensator used as Custom Power Equipment and its Simulation Using PSCAD. Information Technology Journal, pp. 1141 – 1148.

Zhang, J. (2011). Design and Optimization of Wireless Remote Monitoring and Control System using the ZigBee Protocol. Linköping Studies in Science and Technology Licentiate. Thesis No. 1508.

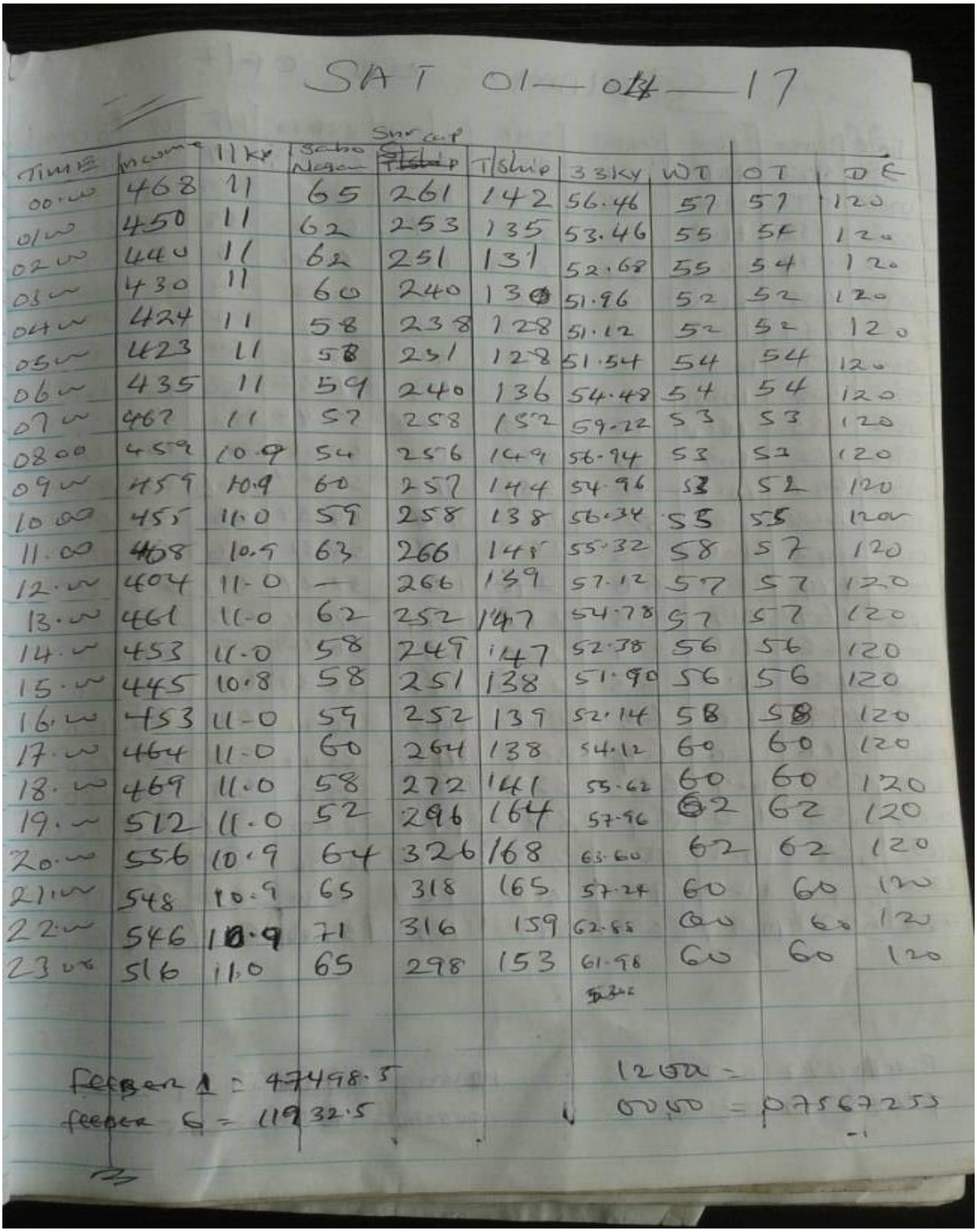
Zhang, Y., Liu, H., Su, X., Jiang, P., Wei, D. (2015). Remote Mobile Health Monitoring System Based on Smart Phone and Browser/Server Structure. Journal of Healthcare Engineering. Vol. 6, No. 4, pp. 717–738.

APPENDICES

Appendix 1: A picture showing fuse box or low voltage feeder pillar with blown/faulty low voltage fuses



Appendix 5: Sample 1 of daily hourly load readings for New Bussa Injection Substation



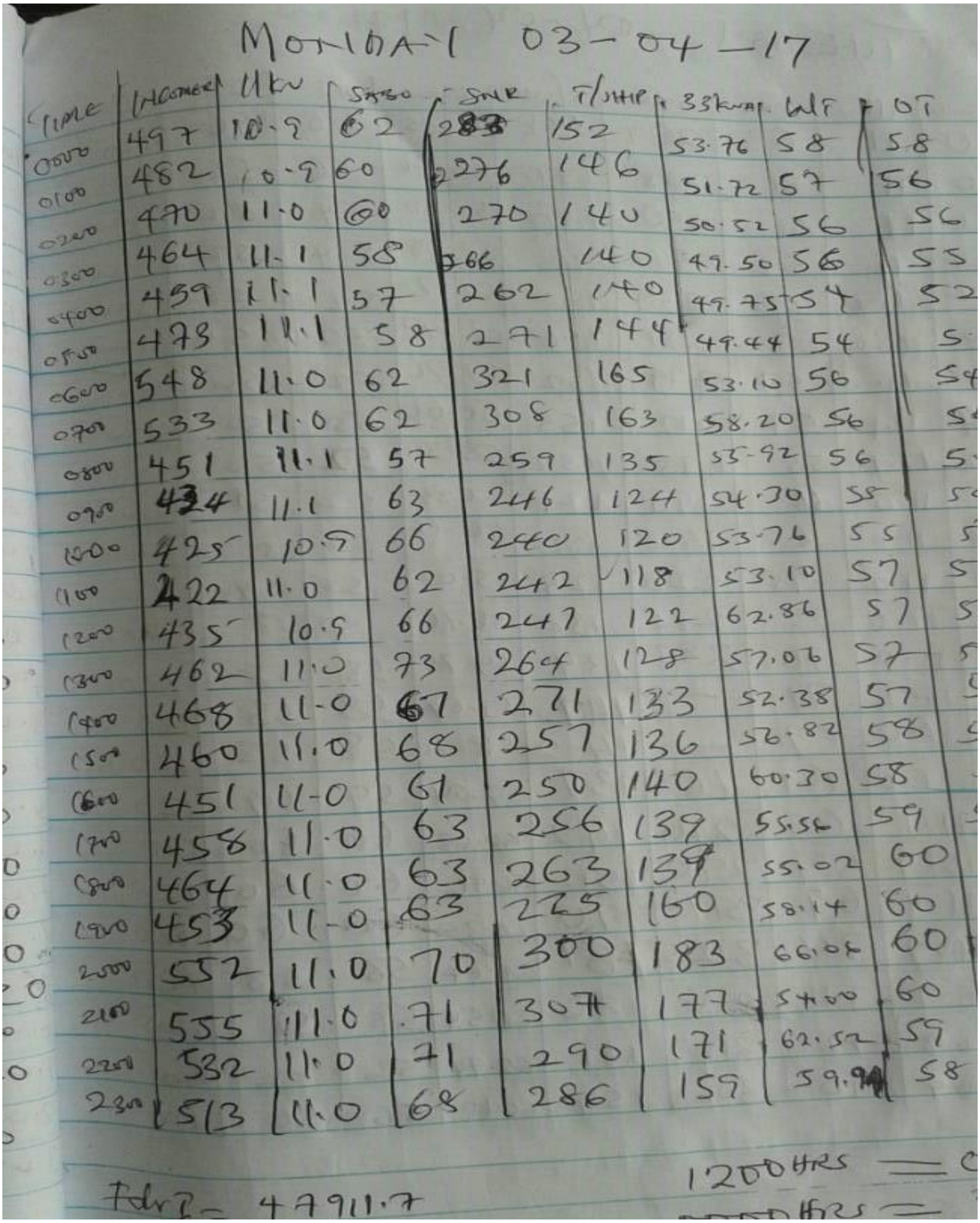
SAT 01—04—17

Time	Mcom	11kV	Sabo Nagari	Shr cut	T/ship	33kV	WT	OT	DE
00.00	468	11	65	261	142	56.46	57	57	120
01.00	450	11	62	253	135	53.46	55	54	120
02.00	440	11	62	251	131	52.68	55	54	120
03.00	430	11	60	240	130	51.96	52	52	120
04.00	424	11	58	238	128	51.12	52	52	120
05.00	423	11	58	231	128	51.54	54	54	120
06.00	435	11	59	240	136	54.48	54	54	120
07.00	467	11	57	258	152	59.22	53	53	120
08.00	459	10.9	54	256	149	56.94	53	52	120
09.00	459	10.9	60	257	144	54.96	53	52	120
10.00	455	11.0	59	258	138	56.34	55	55	120
11.00	468	10.9	63	266	145	55.32	58	57	120
12.00	404	11.0	—	266	159	57.12	57	57	120
13.00	461	11.0	62	252	147	54.78	57	57	120
14.00	453	11.0	58	249	147	52.38	56	56	120
15.00	445	10.8	58	251	138	51.90	56	56	120
16.00	453	11.0	59	252	139	52.14	58	58	120
17.00	464	11.0	60	264	138	54.12	60	60	120
18.00	469	11.0	58	272	141	55.62	60	60	120
19.00	512	11.0	52	296	164	57.96	62	62	120
20.00	556	10.9	64	326	168	63.60	62	62	120
21.00	548	10.9	65	318	165	57.24	60	60	120
22.00	546	10.9	71	316	159	62.88	60	60	120
23.00	516	11.0	65	298	153	61.98	60	60	120

Feeder 1 = 47498.5
Feeder 6 = 11932.5

1200 =
0000 = 07567253

Appendix 6: Sample 2 of daily hourly load readings for New Bussa Injection Substation



MONDAY 03-04-17

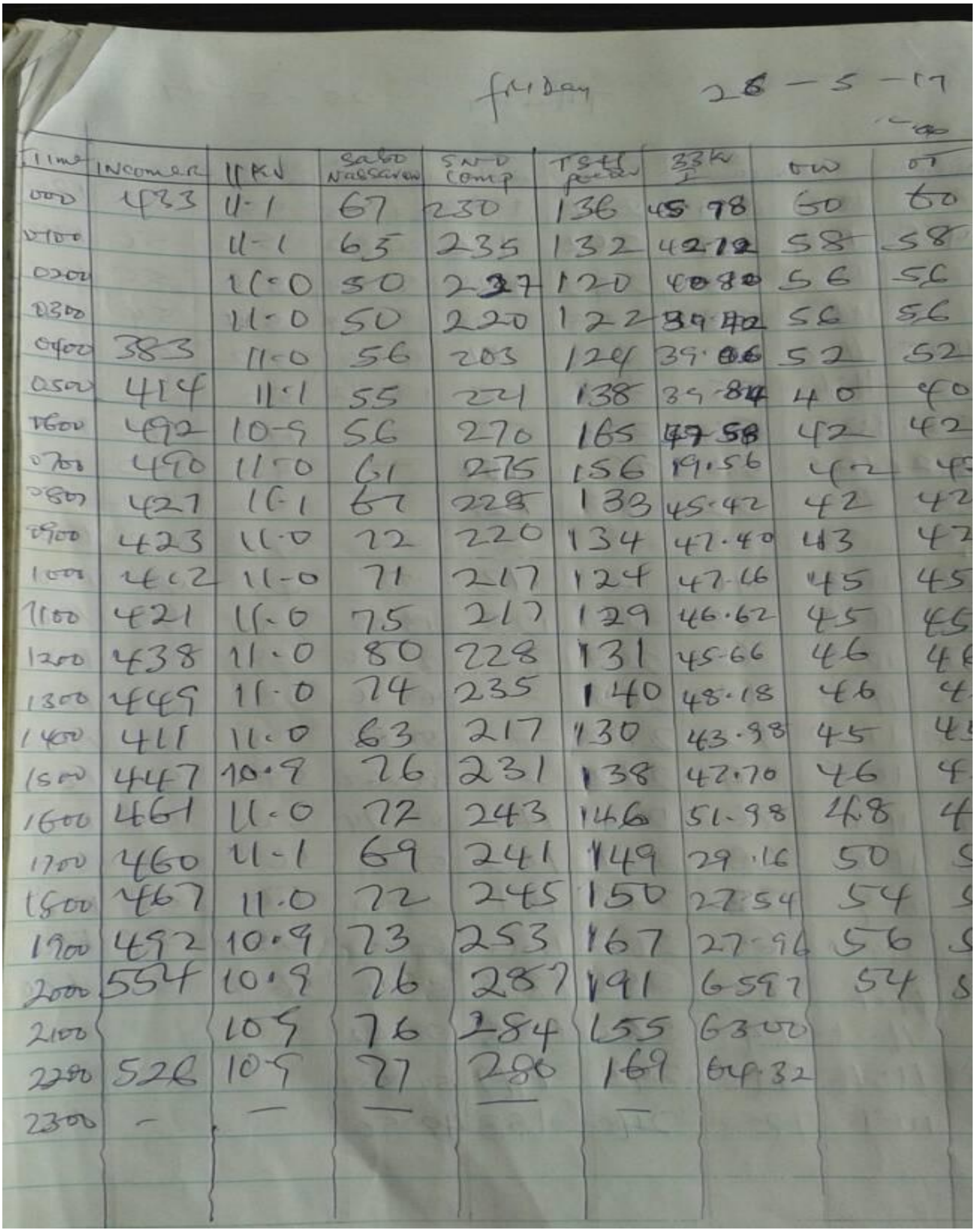
TIME	INCOMER	11KV	SASSO	SNR	T/SHIP	33KV WAP	WF	OT
0000	497	10.9	62	283	152	53.76	58	58
0100	482	10.9	60	276	146	51.72	57	56
0200	470	11.0	60	270	140	50.52	56	56
0300	464	11.1	58	266	140	49.50	56	55
0400	459	11.1	57	262	140	49.75	54	52
0500	473	11.1	58	271	144	49.44	54	5
0600	548	11.0	62	321	165	53.10	56	54
0700	533	11.0	62	308	163	58.20	56	5
0800	451	11.1	57	259	135	55.92	56	5
0900	434	11.1	63	246	124	54.30	55	5
1000	425	10.9	66	240	120	53.76	55	5
1100	422	11.0	62	242	118	53.10	57	5
1200	435	10.9	66	247	122	62.86	57	5
1300	462	11.0	73	264	128	57.06	57	5
1400	468	11.0	67	271	133	52.38	57	
1500	460	11.0	68	257	136	56.82	58	
1600	451	11.0	61	250	140	60.30	58	
1700	458	11.0	63	256	139	55.56	59	
1800	464	11.0	63	263	139	55.02	60	
1900	453	11.0	63	225	160	58.14	60	
2000	552	11.0	70	300	183	66.08	60	
2100	555	11.0	71	307	177	54.00	60	
2200	532	11.0	71	290	171	62.52	59	
2300	513	11.0	68	286	159	59.94	58	

1200HRS = C

Fdr 2 = 47911.7

HRS =

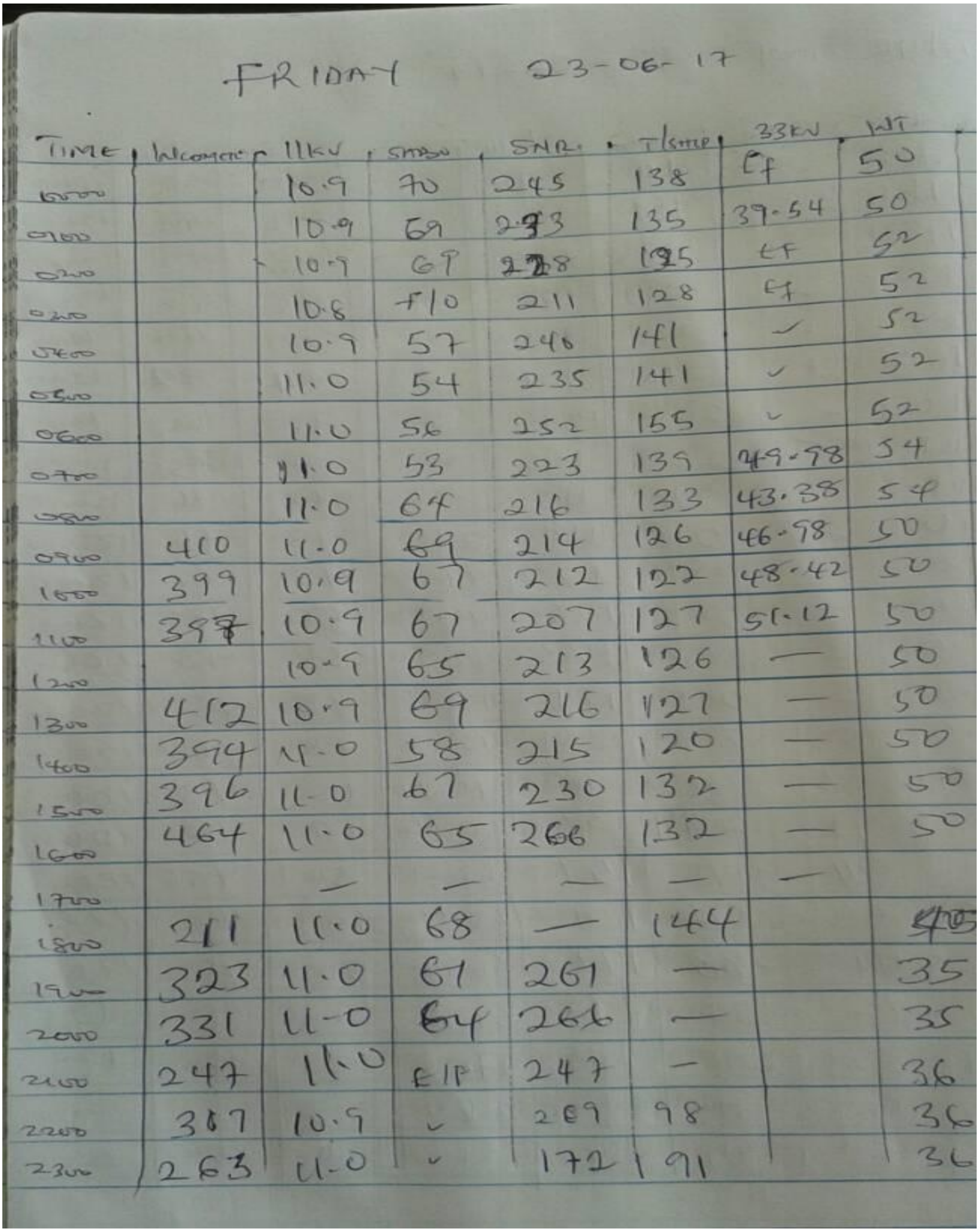
Appendix 7: Sample 3 of daily hourly load readings for New Bussa Injection Substation



Friday 26 – 5 – 17

Time	Incomer	11KV	Sabo Nassarawa	SND Comp	TSHS Power	33kv I	OW	OT
0000	433	11.1	67	230	136	45.78	60	60
0100		11.1	65	235	132	42.12	58	58
0200		11.0	50	227	120	40.80	56	56
0300		11.0	50	220	122	39.42	56	56
0400	383	11.0	56	203	124	39.06	52	52
0500	414	11.1	55	221	138	39.84	40	40
0600	492	10.9	56	270	165	47.58	42	42
0700	490	11.0	61	275	156	49.56	42	4
0800	427	11.1	67	228	133	45.42	42	42
0900	423	11.0	72	220	134	47.40	43	47
1000	412	11.0	71	217	124	47.66	45	45
1100	421	11.0	75	217	129	46.62	45	45
1200	438	11.0	80	228	131	45.66	46	4
1300	449	11.0	74	235	140	48.18	46	4
1400	411	11.0	63	217	130	43.98	45	4
1500	447	10.9	76	231	138	47.70	46	4
1600	461	11.0	72	243	146	51.98	48	4
1700	460	11.1	69	241	149	29.16	50	5
1800	467	11.0	72	245	150	27.54	54	5
1900	492	10.9	73	253	167	27.96	56	5
2000	554	10.9	76	287	191	65.97	54	5
2100		10.9	76	284	155	63.00		
2200	526	10.9	77	280	169	64.32		
2300	–	–	–	–	–			

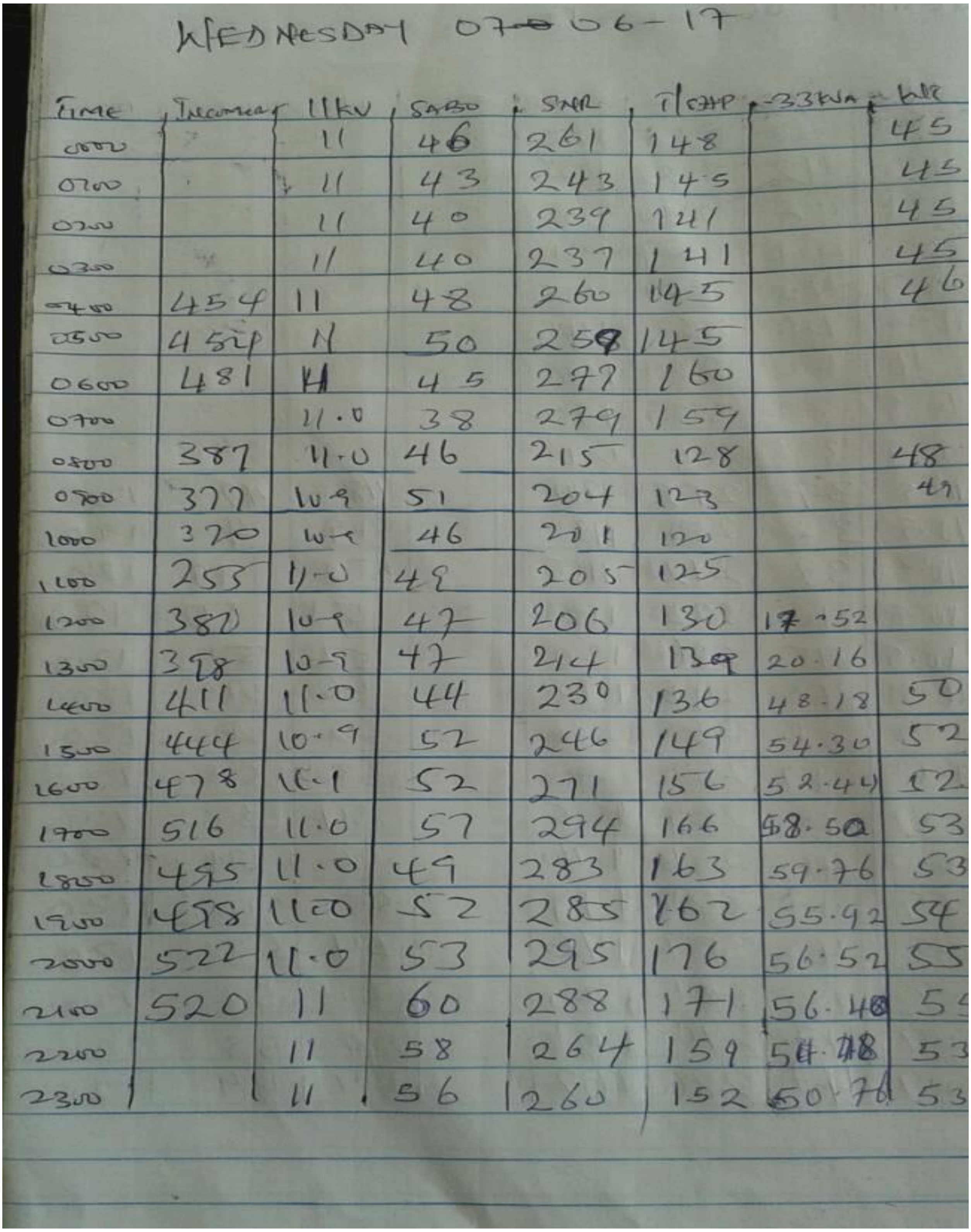
Appendix 8: Sample 4 of daily hourly load readings for New Bussa Injection Substation



FRIDAY 23-06-17

TIME	INCOMER	11KV	SMBO	SNR.	T/SHOP	33KV	WT
0000		10.9	70	245	138	Ef	50
0100		10.9	69	233	135	39.54	50
0200		10.9	69	228	125	EF	52
0300		10.8	F/0	211	128	Ef	52
0400		10.9	57	246	141	✓	52
0500		11.0	54	235	141	✓	52
0600		11.0	56	252	155	✓	52
0700		11.0	53	223	139	49.98	54
0800		11.0	64	216	133	43.38	54
0900	410	11.0	69	214	126	46.98	50
1000	399	10.9	67	212	122	48.42	50
1100	397	10.9	67	207	127	51.12	50
1200		10.9	65	213	126	—	50
1300	412	10.9	69	216	127	—	50
1400	394	11.0	58	215	120	—	50
1500	396	11.0	67	230	132	—	50
1600	464	11.0	65	266	132	—	50
1700		—	—	—	—	—	
1800	211	11.0	68	—	144		45
1900	323	11.0	61	261	—		35
2000	331	11.0	64	266	—		35
2100	247	11.0	E/P	247	—		36
2200	367	10.9	✓	269	98		36
2300	263	11.0	✓	172	91		36

Appendix 9: Sample 5 of daily hourly load readings for New Bussa Injection Substation



WEDNESDAY 07-06-17

TIME	INCOMER	11KV	SABO	SNR	T/CHP	33KVA	WR
0000		11	46	261	148		45
0100		11	43	243	145		45
0200		11	40	239	141		45
0300		11	40	237	141		45
0400	454	11	48	260	145		46
0500	452	11	50	258	145		
0600	481	11	45	277	160		
0700		11.0	38	279	159		
0800	387	11.0	46	215	128		48
0900	377	10.9	51	204	123		47
1000	370	10.9	46	201	120		
1100	253	11.0	49	205	125		
1200	382	10.9	47	206	130	17.52	
1300	358	10.9	47	214	139	20.16	
1400	411	11.0	44	230	136	48.18	50
1500	444	10.9	52	246	149	54.30	52
1600	478	11.1	52	271	156	52.44	52
1700	516	11.0	57	294	166	58.50	53
1800	495	11.0	49	283	163	59.76	53
1900	458	11.0	52	285	162	55.92	54
2000	522	11.0	53	295	176	56.52	55
2100	520	11	60	288	171	56.40	55
2200		11	58	264	159	54.48	53
2300		11	56	260	152	50.76	53

Appendix 10: //**PROGRAM CODE FOR THE ATMEGA328P MICROCONTROLLER**

```
#include <SoftwareSerial.h>
#include <LiquidCrystal.h>
# define cap_bank1 6
# define cap_bank2 7
# define cap_bank3 4
// initialize the library with the numbers of the interface pins
//ALREADY USED PINS 12,11,,5,4,3,2,4,13,9,11,A0,A1,A2,A3(pincompare:)
LiquidCrystal lcd(2, 3, 10,11,12,13);// LiquidCrystal(rs,e,d4,d5,d6,d7); r/w to GND
SoftwareSerial mySerial(9, 8);//Tx, Rx
//Assignments,declarations and initializations
float phase1 =0; //Red Phase
float phase2 =0; //Blue Phase
float phase3 =0; //Yellow Phase
float voltage_ava_sensor =0;
//******************************************
//float line1 = 0.00;
//float line2 = 0.00;
//float line3 = 0.00;
//String msg = "testing gsm module ";
bool flag1=0;
bool flag2=0;
bool flag3=0;
bool flag4=0;
bool flag5=0;
bool flag6=0;
bool flag7=0;
bool flag8=0;
bool flag9=0;
bool capstatus;
//int cap_bank1=6;
//int cap_bank2=7;
//int cap_bank3=4;
```

```
//int load_shed = 13;
String msg = " ";
////////////////////////////////////////////////////////////////////////////////
void setup()
{ //msg =("Testing SMS ");
  lcd.begin(16, 4);
  mySerial.begin(9600);   // Setting the baud rate of GSM Module
  Serial.begin(9600);    // Setting the baud rate of Serial Monitor (Arduino)
  delay(100);
  //welcome message
  lcd.setCursor(5,0); //(column,line)
  lcd.print("SYSTEM");
  lcd.setCursor(0,1);
  lcd.print(" INITIALIZING...");
  delay(500);
  lcd.setCursor(2,2);
  lcd.print("SYSTEM READY");
  lcd.setCursor(0,3);
  delay(300);
  lcd.print("SYSTEM STARTING...");
  delay(1000);
  Serial.println("GSM MODULE READY");
  delay(5000);
   // SendMessage();
  pinMode(cap_bank1,OUTPUT);
  pinMode(cap_bank2,OUTPUT);
  pinMode(cap_bank3,OUTPUT);
  //pinMode(load_shed,OUTPUT);
  //pinMode(A3,OUTPUT);
  //digitalWrite(A3,HIGH);
  //SendMessage();
  checklow_voltage();
  transformer_output();
```

```
  sensor_inputs();
  RecieveMessage();
  fuse_status();
  checkhigh_voltage();
  normalVoltage();
  capBank_switch();

}



void loop()
{
   transformer_output();

}
 void SendMessage()
{//String msg =(" ");
  Serial.println("sending sms ... now");
  mySerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
  delay(1000);  // Delay of 1000 milli seconds or 1 second
  //mySerial.println("AT+CMGS=\"+2348034119141\"\r");
  mySerial.println("AT+CMGS=\"+2348035796760\"\r"); // Replace x with mobile number
  delay(1000);
  mySerial.println(msg);// The SMS text you want to send
  delay(100);
  lcd.print("sending sms...");
   mySerial.println((char)26);// ASCII code of CTRL+Z
  delay(1000);
  Serial.println("sms successfully sent");
  Serial.println(msg);
}
```

```
 void RecieveMessage()
{
  mySerial.println("AT+CNMI=2,2,0,0,0"); // AT Command to recieve a live SMS
  delay(1000);
  Serial.println("sms successfully recieved");
 }
//*************************************************************************************************************
//This function reads the voltages from the both transformer side and the distribution side of the distribution transformer

void sensor_inputs()
{
   phase1 = analogRead(A0);
   phase2 = analogRead(A1);
   phase3 = analogRead(A2);
   voltage_ava_sensor = analogRead(A3);


   phase1 = ((phase1/1024)*250);
   phase2 = ((phase2/1024)*250);
   phase3 = ((phase3/1024)*250);
   voltage_ava_sensor = (voltage_ava_sensor/1024)*245;

//   line1 = phase1*sqrt(3);
//   line2 = phase2*sqrt(3);
//   line3 = phase2*sqrt(3);
//   phase1= map(phase1,0,1023, 0,220 );
//   phase2= map(phase2,0,1023, 0,220 );
//   phase3= map(phase3, 0,1023, 0,220);
  }
```

```
//***************************************************************************
*****************************

 void checklow_voltage(){

/*check for low voltage in phase1 by comparing with specific level, if low voltage is detected
call the function
 for sending sms to xchange of the low voltage.*/
    sensor_inputs();
    Serial.println("Phase1:");
    Serial.println(phase1);
    delay(3000);
    Serial.println("Phase2:");
    Serial.println(phase2);
    delay(3000);
    Serial.println("Phase3:");
    Serial.println(phase3);
     delay(3000);

    if((phase1< 216&&phase1>=30)|| (phase2<216&&phase2>=30)|| (phase3<
216&&phase3>=30)){///from 30V to 216V
      capstatus =0;

      lcd.clear();
            lcd.setCursor(0,0);//lcd.setCursor(cols,rows)
            lcd.print("R-Phase:       V");
            lcd.setCursor(9,0);
            lcd.print(phase1);
            lcd.setCursor(0,1);
            lcd.print("Y-Phase:       V");
```

```
            lcd.setCursor(9,1);
            lcd.print(phase2);
            lcd.setCursor(0,2);
            lcd.print("R-Phase:       V");
            lcd.setCursor(9,2);
            lcd.print(phase3);
            lcd.setCursor(0,3);
            lcd.print("START CAP BANK");
            delay(300);
              while (capstatus==0){
                capBank_switch();
                if ((phase1 >=216&&phase1>=255)|| (phase2>=216&&phase2>=255)|| (phase3>=
216&&phase3>=255))
      {
        capstatus =1;
         digitalWrite(cap_bank1,LOW);
         digitalWrite(cap_bank2,LOW);
         digitalWrite(cap_bank3,LOW);
         lcd.setCursor(0,3);
            lcd.print("Normal Votage");
            //fuse_status();
        }
                }
              }
//
//
//     //msg ="Either R-Phase, Y-Phase or B-Phase has a low voltage fault at transformer(T10)
Location A, Capacitor banks switched ON";
//
//
//
//       else if ((phase1 >=180&&phase1>=230)|| (phase2>=180&&phase2>=230)|| (phase3>=
180&&phase3>=230))
```

```
//      {
//        capstatus =1;
//        lcd.setCursor(0,3);
//              lcd.print("START CAP BANK");}
//      }
//        }
//      //}



             //capBank_switch();
             //fuse_status();
             //capstatus=0;
    //}
    else if ((phase1 >=216&&phase1>=255)|| (phase2>=216&&phase2>=255)|| (phase3>=
216&&phase3>=255))
     {
       capstatus =1;
        digitalWrite(cap_bank1,LOW);
        digitalWrite(cap_bank2,LOW);
        digitalWrite(cap_bank3,LOW);
        lcd.setCursor(0,3);
            lcd.print("Normal Votage");
            //fuse_status();
       }



        }


 void transformer_output()
 {//String msg =(" ");
```

```
 sensor_inputs();
 if(voltage_ava_sensor<30){
   msg="Black out Detected at transformer(T10) Location A ";
          lcd.clear();
          lcd.setCursor(4,0);//lcd.setCursor(cols,rows)
          lcd.print("Black out ");
          lcd.setCursor(5,1);
          lcd.print("Detected");
          lcd.setCursor(3,2);
          lcd.print("sms sent to");
          lcd.setCursor(5,3);
          lcd.print("Exchange");
          delay(500);
    while(flag1==0){     //how to use boolean flags in arduino
   SendMessage();
   flag1=1;
   }

  }
  else if (voltage_ava_sensor >30)
  {     fuse_status();
       checkhigh_voltage();
       normalVoltage();
       checklow_voltage();




    }

 }
void fuse_status()
 { //String msg =(" ");
```

```
  sensor_inputs();
   lcd.clear();
            lcd.setCursor(0,0);//lcd.setCursor(cols,rows)
            lcd.print("R-phase:      V");
            lcd.setCursor(9,0);
            lcd.print(phase1);
            lcd.setCursor(0,1);
            lcd.print("Y-phase:      V");
            lcd.setCursor(9,1);
            lcd.print(phase2);
            lcd.setCursor(0,2);
            lcd.print("B-phase:      V");
            lcd.setCursor(9,2);
            lcd.print(phase3);
            delay(300);
if(phase1 < 30 && (phase2 >= 171 && phase2<=250)&&(phase3 >= 171 && phase3 <= 250)
){//check all fuse. also make include low voltage
      msg=" Red Phase(Rph)fuse of Distribution Transformer at Location A(T01)blown";
      while(flag3==0){    //how to use boolean flags in arduino
            SendMessage();
            flag3=1;


      }
            lcd.setCursor(0,3);
            lcd.print("Rph fuse Blown");
            delay(500);
    }
  if(phase2<30&&(phase1>=171&&phase1<=250)&&(phase3>=171&&phase3<=250) ){
      msg=" Yellow Phase(Yph) fuse of Distribution Transformer at Location A(T01) blown";
      while(flag4==0){    //how to use boolean flags in arduino
            SendMessage();
            flag4=1;
```

```
      }
            lcd.setCursor(0,3);
            lcd.print("Yph fuse Blown");
          delay(300); }
  if(phase3< 30&& (phase2>=171&&phase2<=250)&&(phase1>=171&&phase1<=250) ){
     msg=" Blue Phase(Bph)fuse of Distribution Transformer at Location A(T01) blown";
      while(flag5==0){     //how to use boolean flags in arduino
             SendMessage();
             flag5=1;
                   }
            lcd.setCursor(0,3);
            lcd.print("Bph fuse Blown");
            delay(300);
            }
////// RED AND BLUE FUSES
BLOWN*************************************************************************
*
//if(phase1< 30&& phase3<30&&(phase2>=171&&phase2<=250) ){
//      msg=" Red Phase(Rph)and Blue Phase(Bph)fuses of Distribution Transformer at Location
A(T01) blown";
//       while(flag5==0){     //how to use boolean flags in arduino
//              SendMessage();
//              flag5=1;
//                    }
//             lcd.setCursor(0,3);
//             lcd.print("B&Rph fuse Blown");
//             delay(300);
//             }
////***************************************************************************
***********************
//// RED AND YELLOW FUSES
BLOWN*************************************************************************
*
```

```
//if(phase1< 30&& phase2< 30&& (phase3>=171&&phase1<=250) ){
//      msg=" Red(Rph) and Yellow Phases(Yph)fuses of Distribution Transformer at Location
A(T01) blown";
//       while(flag5==0){     //how to use boolean flags in arduino
//              SendMessage();
//              flag5=1;
//                    }
//             lcd.setCursor(0,3);
//             lcd.print("R&Yph fuse Blown");
//             delay(300);
//             }
////************************************************************************
//
////************************************************************************
//// YELLOW AND BLUE FUSES
BLOWN*********************************************************************
*
//if(phase3< 10&& phase2< 10&&(phase1>=171&&phase1<=250) ){
//      msg=" Yellow(Yph) and Blue Phases(Bph)fuse of Distribution Transformer at Location
A(T01) blown";
//       while(flag5==0){     //how to use boolean flags in arduino
//              SendMessage();
//              flag5=1;
//                    }
//             lcd.setCursor(0,3);
//             lcd.print("Y&Bph fuse Blown");
//             delay(300);
//             }
////************************************************************************
//// RED,YELLOW & BLUE FUSES
BLOWN*********************************************************************
*
//if(phase1< 10&& phase2< 10&&phase3< 10){
```

```
//      msg="Red, Yellow and Blue Phase(Bph)fuses of Distribution Transformer at Location
A(T01) blown";
//       while(flag5==0){     //how to use boolean flags in arduino
//               SendMessage();
//               flag5=1;
//                      }
//              lcd.setCursor(0,3);
//              lcd.print("All fuses Blown");
//              delay(300);
//              }
//**********************************************************************
 }
 void checkhigh_voltage()
 { //String msg =(" ");
  sensor_inputs();
  //fuse_status();
   lcd.clear();
            lcd.setCursor(0,0);//lcd.setCursor(cols,rows)
            lcd.print("R-phase:       V");
            lcd.setCursor(9,0);
            lcd.print(phase1);
            lcd.setCursor(0,1);
            lcd.print("Y-phase:       V");
            lcd.setCursor(9,1);
            lcd.print(phase2);
            lcd.setCursor(0,2);
            lcd.print("B-phase:       V");
            lcd.setCursor(9,2);
            lcd.print(phase3);
            delay(300);
  if(phase1 > 256 ){
      msg="High Voltage fault Detected in Red Phase(Rph) of Distribution Transformer at
Location A(T01),Urgent attention needed: Possible Neutral Failure";
```

```
      lcd.setCursor(0,3);
      lcd.print("High Voltage Detected");
       while(flag6==0){     //how to use boolean flags in arduino
              SendMessage();
              flag6=1;
      }
      //fuse_status();
    }
  if(phase2 > 256 ){
      msg="High Voltage fault Detected in Yellow Phase(Yph) of Distribution Transformer at
Location A(T01)";
      lcd.setCursor(0,3);
      lcd.print("High Voltage Detected");
       while(flag7==0){     //how to use boolean flags in arduino
              SendMessage();
              flag7=1;
      }
  //fuse_status();
  }
  if(phase3 >256){
      msg="High Voltage fault Detected in Blue Phase(Bph) of Distribution Transformer at
Location A(T01)";
      lcd.setCursor(0,3);
      lcd.print("High Voltage Detected");
       while(flag8==0){     //how to use boolean flags in arduino
              SendMessage();
              flag8=1;
      }
    }
 }

void capBank_switch()
//;
```

```
{//fuse_status();
  sensor_inputs();
  digitalWrite(cap_bank1,HIGH);
  digitalWrite(cap_bank2,HIGH);
  digitalWrite(cap_bank3,HIGH);
              lcd.clear();
              lcd.print("R-phase:       V");
              lcd.setCursor(9,0);
              lcd.print("219.45");
              lcd.setCursor(0,1);
              lcd.print("Y-phase:       V");
              lcd.setCursor(9,1);
              lcd.print("218.98");
              lcd.setCursor(0,2);
              lcd.print("B-phase:       V");
              lcd.setCursor(9,2);
              lcd.print("220.13");
              delay(300);
                lcd.setCursor(0,3);
                lcd.print("CAP BANK ACTIVE");
                delay(2000);
}


void normalVoltage()
{
  sensor_inputs();
  digitalWrite(cap_bank1,LOW);
  digitalWrite(cap_bank2,LOW);
  digitalWrite(cap_bank3,LOW);
   lcd.clear();
              lcd.setCursor(0,0);//lcd.setCursor(cols,rows)
              lcd.print("R-phase:       V");
```

```
            lcd.setCursor(9,0);
            lcd.print(phase1);
            lcd.setCursor(0,1);
            lcd.print("Y-phase:       V");
            lcd.setCursor(9,1);
            lcd.print(phase2);
            lcd.setCursor(0,2);
            lcd.print("B-phase:       V");
            lcd.setCursor(9,2);
            lcd.print(phase3);
            delay(300);
  if((phase1>=216&&phase1<=255)&&(phase2>=216&&phase2<=255)&&
(phase3>=216&&phase3<=255)){ //[(Vph=227.62)(VL=394.25V) to (Vph=251.58)(Vl=
435.75V)]( ((Vph=220)Vl=381.0512V) to (Vph 240)(Vl=415.692) )
    //fuse_status();
    sensor_inputs();
    flag1=0;
    flag2=0;
    flag3=0;
    flag4=0;
    flag5=0;
    flag6=0;
    flag7=0;
    flag8=0;
    flag9=0;
    lcd.setCursor(0,3);
      lcd.print("Normal Voltage");
    }

}
```