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STRATEGIC MANAGEMENT TECHNIQUES OF SMART SYSTEM FOR POWER DISTRIBUTION OPERATIONS: AN OVERVIEW

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A B S T R A C T

The distribution system is the power grid component that forms the network pathways of distributing the power generated to their various feeders connected across it to meet the required load demand. As of recent, its operation of distributing quality power to its cherished feeders and consumers has become a major challenge due to the complicated nature of applying smart systems to meet the high and sophisticated load demands in this dispensation where advancement in engineering, science and technology is becoming predominant. Currently, high concerns have been raised on soliciting effective management techniques to curb these problems bedeviling the power distribution network. Hence this research article sort to present an overview of some of the pertinent strategic management techniques of smart systems for power distribution operations to bring security, stability, reliability, power quality to the distribution network and also enhance the system performance of the power grid as a whole.

1. INTRODUCTION

The industrial world has come to an age of automation with unprecedented levels of power. This increase is used from the improvement of a person's quality of living to the streamlining of company processes through many industries. All facets of automation in today's world are presented with innovation. In this dispensation of technology; power management and distribution management systems, these two popular systems have emerged (Schneider, 2018).

Strategic management may be described as the decision-making process leading to the creation of the strategic role, thus, to the determination of the organization's future viability and profitability, while integrating the management skills, obligations, motivation and award-winner framework. It synergizes the strategic and organizational guidelines and offers an overarching basis for allocating resources across various units and time horizons. It can be seen as an inclusive decision-making architecture. It articulates the corporate strategy, and the strategies are competitive and practical (Smith, 2014).

A power management system is a process for controlling, monitoring and safe operation of an electric system. This is guaranteed through the automation of many processes involved, such as synchronization, load sharing, frequency regulation, tension adaptation, and

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load division. Moreover, it depends on the simultaneous integration of a power management system with another system which ensures the correct operation of that mechanism (Schneider, 2018).

This research paper proposed an overview of strategic management techniques as a method for smart power distributions which ensures that a major task is achieved, with the necessity to distribute vast quantities of electricity in a multitude of devices. It is also obvious that the power delivery should be controlled properly if this service is to ensure that the functionality and reliability of this service are sufficient. It reduces power outages, minimizes failure times and maintains controlled frequency and voltage levels are the most important tasks of this scheme (Schneider, 2018).

2. SMART MANAGEMENT SYSTEM (SMS)

By combining distributed sources and various loads, the smart grid system, which is considered an intelligent power system with self-control, function preservation and management, is developed. Implementation of rapidly fluctuating distributed generation (e.g. PVs, wind turbines, energy storage systems for electric vehicles) jeopardizes the reliability of the power and distribution systems. This is mostly due to the lack of a balance between supply and demand energy ratios. A power generation or used surplus or shortage can disturb the network and lead to serious problems like drop/up voltage and, in severe cases, blackouts. Intelligent management systems are used to cost-effectively boost the supply-demand balance and to reduce maximum load over volatile periods.

2.1 Information Communication and Smart Monitoring System (ICSMS)

A smart management framework is aimed primarily at reducing financial costs and losses. The administration of information and smart monitoring cannot be successful in this respect (figure 1).

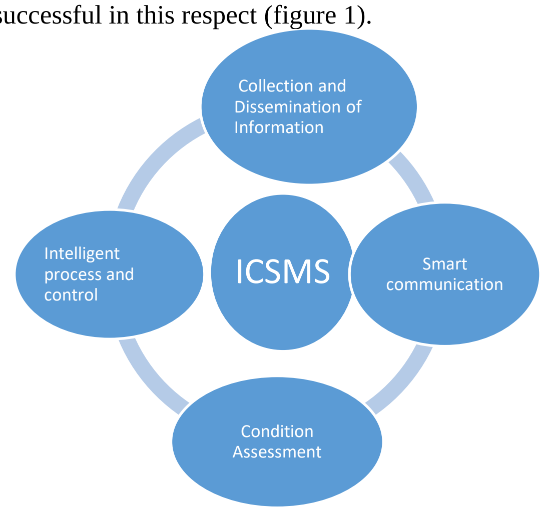

Figure1. Flow diagram of ICSMS

The diagram shows clearly the flow model for efficient management of the intelligent system through the exchange of information and the monitoring of the intelligent system (ICSMS).

A. Collection and Dissemination of Information

Exhibition of smart grid configuration and optimization initiatives include broad-scale monitoring, security and control (WAMPAC), large-scale renewable generations, adaptive protection/SPS, advanced automation, active voltage and reactive power management, distributed micro-grid management, advanced meters, an EV charging infrastructure. These intelligent infrastructures help to collect relevant information on the past, current and future events of the proposed nature of the research and its ecosystem. This method helps to disseminate quality information to different research design equipment.

B. Smart Communication

In a centralized structure, various data elements can be analyzed by communication technology tools connected through the Internet of Things. To be able to communicate and obtain key information from the proposed project, every device in the Smart Grid system must be linked fluidly with the environment. This enables adaptation and intelligent responses to changes quicker. Digital communications may include calendars, weather and climate feeds, external transport schedules, load engagement, and emergency alerts to ensure that the correct information is provided on a certain date.

Digital technology is used to display information in real-time and thereby reduce perceived system errors and enhance the smart experience. A new approach to smart grid governance and service based on real-time information is being developed by Smart Communication. Strengthening operations and increasing the reliability of customers' voltage and actual levels can be achieved using power equipment such as the proposed smart Transformer. The ICSMS approach allows device engineers to collect process and transmit targeted data on any screen quickly and enhance their most critical efficiency with power equipment.

C. Condition Assessment

A smart framework for the management of transforming assets has been proposed with a focus on transformer condition control, diagnosis and evaluation. The key components of the system are clarified in this section. The first element of the proposed architecture is an aggregation of different online sensor measurements to provide dynamic information on the transformer's state. Examples of these measurements are current and voltage measurements, temperature measurements, field sensor measurements, feedback measurements, PD detection and acoustic/vibration surveillance.

To acquire the measured sensor signals, the necessary data acquisition hardware will be added to transmit them for further data processing via communications peripheral. Different interference and noise can be put in sub-stationery position on signals acquired from sensors for practical transformer control. Interference and noise can significantly affect the sensitivity and precision of sensor measurements, which has a negative effect on the correct identification of transformer defects.

The second component of the proposed system is therefore a set of signal processing algorithms that can eliminate noise from measured signals, appliance heating and harmonics provided by semi-leading electronic device switching operations.

D. Intelligent Process and Control

This ICSMS method uses the data collected to compare the details of the proposed project concept for the intelligent management and control of different field devices in the intelligent grid system. Load management is made simpler by computer-based control systems and highly effective smart algorithms and the inclusion of ICT into the electricity grid. Some of the most popular control systems are as follows: Supervisory Control and Data Acquisition (SACADA), EMS (Energy Management System), BMS (Building Management System), Distribution Automation Systems, Automation Systems, Programmable Logic Controller, … etc.

There are software and hardware-based control systems to operate correctly. The software is usually developed by engineers, software developers and experts.

2.2 Smart Load Control and Automatic Power distribution

When demand-related power generation is inadequate, a smart charge management and automatic power distribution system (SLMAPDS) interface in the proposed device design is provided, which can be used effectively for satisfying emergency demand from AC and DC users. A GSM-based mobile network is used to establish contact between the powers distributed authority, the SLMAPDS system, and the user through a GSM-based identification number and the unit identification number.

The SLMAPDS device can be configured and reconfigured via SMS without changing hardware or software. The design system allows the power supply agency to supply power for the emergency loads of all customers and to control the allowed load as much as possible. The SLMAPDS system enables switching from allowable to emergency loads rather than blackouts, vice-versa, depending on the availability of the power source. The SLMAPDS system can be used effectively in a country where the electricity demand is above the generation.

3. ADVANCED SYSTEM PLANNING AND STRATEGIC MAINTENANCE SYSTEM

The present state of electricity distribution forces distribution companies areto strengthen maintenance management to make their activities more effective and at a lower cost. Power transformers are a complex and important physical asset for distribution networks, and their maintenance activities must be carefully assessed to improve the tasks that must be completed cost-effectively.

The smart grid infrastructure should be maintained strategically for efficient operations and the advancement of system planning processes because of the intelligent implementations of the proposed research concept. Hence (figure 2) shows the proposed research design for smart grid operations as the strategic maintenance and advancing system preparation procedure.

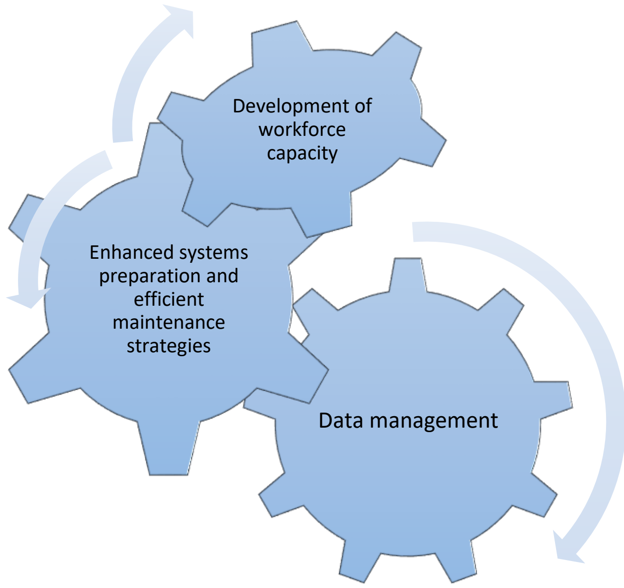

Figure 2. Advanced System Planning and Strategic Maintenance System

A. Development of Workforce Capacity

The acquisition of highly qualified staff is a vital part of the success of this maintenance policy. Parts of the usual internal maintenance tasks have been outsourced to increase the cost-effectiveness of the maintenance operation. Due to this dedication, the organization has maintained its maintenance know-how, strategic core abilities that cannot be removed under any conditions. The outsourcing of such maintenance activities will reduce personal expenses and skills can be focused on the area of intelligent transformer maintenance.

The establishment of highly qualified in-house work teams was, therefore, a high priority. The best maintenance practices for quality assurance are underlined in regular use for recycling and improvement of their knowledge and skills, and to expose them to the possibilities and benefits of the application of emerging technologies to allow them to expertly utilize them. Consequently, not only the benefits but also the performance, output and service improvements, maintenance was given the best value.

B. Smart Communication

Timely, effective information management is essential for any maintenance strategy's success. As a consequence, a corporate computer structure supports the maintenance and decision-making processes, which forms the basis of a database that inventories all the equipment which must be maintained. This software helps to schedule and program maintenance activities through the provision of workflows, order issuance, tracking and data storage functionality (i.e. history, results of measures and tests performed, maintenance records, and equipment condition data).

A team should establish internal health and assess its criticality based on information collected from the equipment responses and should decide their condition. In the dynamic query linked to the main database, frequencies and priorities for voltage and current analysis are defined by the different conditions and critical levels. Other outputs, such as extracting trends and patterns from collected data and knowledge-based rules, monitoring the evolution of identified anomalies, prioritizing corrective actions that are to be performed and the outcomes achieved, are used in the maintenance management decision-making process. Maintenance priorities can be established and results can be systematically evaluated using this supporting tool.

C. Enhanced Systems Preparation and Efficient Maintenance Strategies

The use of available technological advancements must be assisted and complemented by the implementation of adequate proactive maintenance practices to ensure a reasonable distribution of resources. Different maintenance practices have therefore been developed. Based on experience, each work was developed, taking into account field knowledge, examination of existing procedures and performance of a failure mode analysis. This involves the execution of tasks, routine measures and the definition of a suitable threshold used to identify the transformer situation and to discuss the behavior required to perform more tasks.

A risk map of the HV network was created to assess the criticality levels of the installations. As a result, transformer maintenance priorities are identified and activities are scheduled for the various units because of the overall risk assessment of the HV network. Since maintenance, including PMs, is not always inherently healthy, a range of predictive online or offline activities is carried out to aid us in determining if important maintenance tasks need to be performed, i.e., if necessary to dry the isolated device, thereby reducing unnecessary maintenance (Edenor & José, 2011).

4. TRENDS IN STRATEGIC MANAGEMENT PERFORMANCE – FUTURISTIC VIEW

Potential modification in powering the company data centers: from the use hybrid of both alternative (AC) and Direct current (DC), are the strategic management strategies explained in this article. This innovation has been selected as a response to new business demands relating to productivity savings and environmental sustainability. We believe that innovation is both topical and important to current stresses and practices; we will address this very closely, draw on theoretical principles and consider possible broader consequences.

This transition has led businesses to use DC power and to return to Thomas Edison's original concept from 1800. In the fight for Altering Current (AC), Nikola Tesla and George Westinghouse periodically change the current course. At the time, the features of using AC power provided advantages that cannot be realized so easily via DC. AC won the War at the moment primarily because a Ghana falls-constructed hydropower facility, which was mostly powered by India and AC, was more practical to use for heavy industries (Brotherton, 2015).

As shown in (figure 3) is the smart process of various system components to achieve maximum management performance strategically.

Due to the complexity in the recent load demands, the technical sense of AC power is getting compromised. Hence hybrid systems as discussed in (figure 3) gives the progressive ideas meant toascertain the distribution and use of quality power to satisfy both AC and DC load demands to enhance system performance and management.

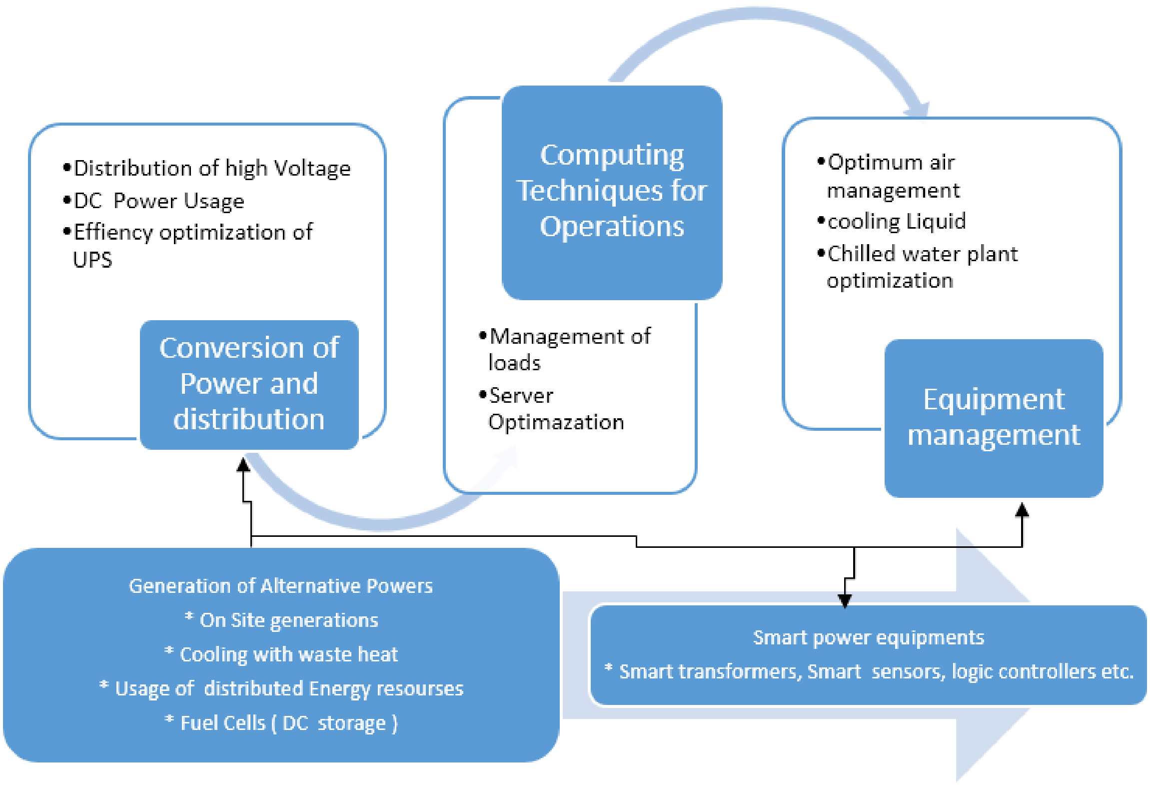

Figure 3. System for Strategic Management Performance

New inventions have taken place since the AC/DC contentions. More importantly, the growth of the Internet and the marketing of energy-consuming technology such as PCs have ledto more places to use more electricity. Cloud computing; autonomous vehicles; and renewable technologies have been adapted from existing platforms, but have been limited by AC power limits.The development and implementations of widespread use of inline power transformers and smart transformers have been a short-term solution until recently. DC reflects a real advance in saving energy because it becomes less feasible and the lack of efficiency is known. Power is at the forefront of many important debates on sustainability, cost and delivery, and the use of DC power only constitutes a small part of the overall objective of the SMART grid (Brotherton, 2015). Hence the combination of both AC and DC system as of recent could bring better overall system performance if its management is done strategically as this paper describes some of the most important techniques.

5. STRATEGIC MANAGEMENT OF SMART SYSTEMS

The smart system used to manage the power distribution system effectively as proposed in this research paper is the Smart Transformer. The Smart Transformer is a key component of this fast-growing smart grid infrastructure that delivers high-quality, accessible and confident power to meet the resentful complexities and applications of both AC and DC demand.

5.1 Operation and Control of the Proposed Smart System for Power distribution

In the voltage control in the power system, the transformer plays a key role. However, since ST plays a major role in smart systems, it uses the electrical power-dependent method and phenomenon, frequency is zero and alternating current for easy operation and monitoring is converted into direct current. Therefore, ST is the primary control point to meet load requests with the DC to DC boost converter but AC to DC (cutting machine) and DC to AC converter are linked (inverter).The Smart Transformer's main structure consists of three-stage power converters. The first stage is the rectifier for KV ac-dc, the second phase is an insulator for KV to LV dc-dc and the second is the LV-Dc-ac converter for the distribution grid (Kumar & Liserre, 2015).

In addition, ST has several additional features including balanced sinusoidal voltage in an LV distribution system, balanced unit unity factor current on the side of the MV grid, no effect on loads, availability o of MV side disorders like sag, swell, transients etc. In addition, it can offer benefits including voltages and isolation from the KV and LV sides like LCVs (Kumar & Liserre, 2015).

To achieve high reliability, lower cost, increase voltage and capacity for the management of power, increase fault tolerance and reduce harmonics, and substantial improvement, continuous research is underway to devise new circuit topologies for different stages of the ST. Using the Matlab software, this research article aims to highlight the operating characteristics of the ST in a double feeder (both AC and DC feeders) system to enhance the performances of the low-voltage distribution system.

The parameters and it corresponding values for the system modeling have been classified in table 1.

The key component structure of the Smart Transformer consists of three-stage power converters and control and contact points, as shown in (figure 4).

Table 1 Parameters for Load configuration

Parameters	Values
Nominal voltage Vn(Vrms):	415V
Nominal frequency fn (Hz):	50Hz
Active power P (W):	10kW
Inductive reactive Power QL (positive var):	100

The first stage is an AC-DC corrective, the second stage is a DC-DC chopper and the third phase is a DC-AC converter, which is a controlled hybrid grid application connected to the AC distribution lines (inverter). It also has controls in place from the stage of link dc-dc to provide special load DC voltages for military and hospital equipment.

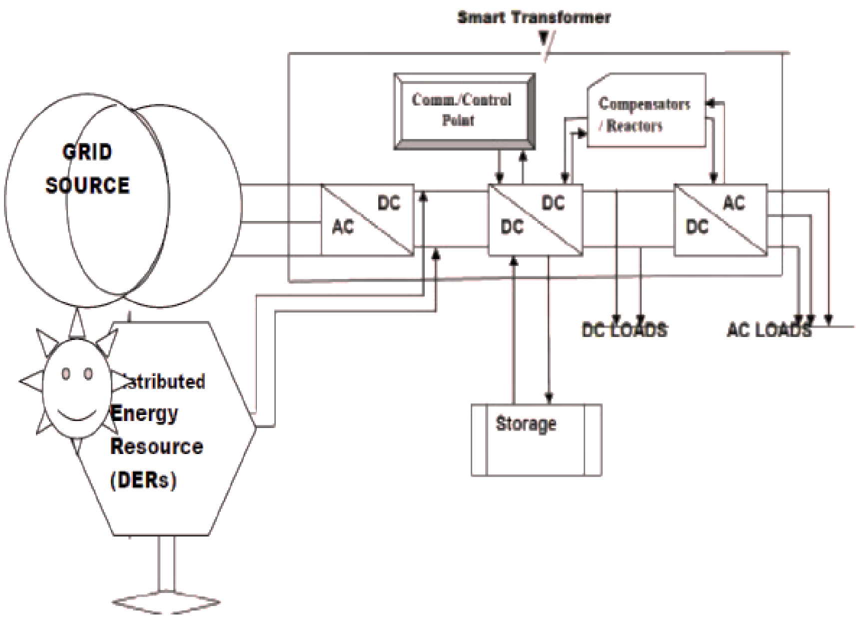

Figure 4. Block diagram of the proposed smart Systems

A. The AC to DC converter (Rectifier) portion:

Transforms alternate current for quick controlling and manipulation to Direct current. Figure shows the topology of an AC-DC converter in three stages transmitting power between an AC voltage power supply and a DC voltage bus. The bidirectional AC-DC converter consists of six IGBT diode switches (S 1-S 6) which are attached via Series Filter Inductivity (Ls) and Resistance to three-phase AC voltage supply (Rs). A DC capacitor (CDC) is attached to the DC voltage bus, to keep the voltage (Vdc) constant. There are two operating modes in the AC-DC bidirectional converter. The bidirectional AC-DC converter in rectifier mode is used as a front end rectifier to transmit power from the three-phase AC voltage terminal into the DC voltage bus. The second mode is inverter mode, where power is transferred to the three-phase AC voltage terminal of the converter from the DC voltage bus (Akter et al., 2015).

B. DC to DC converter (buck-boost) section:

This part is used to descend, step up and lift converted DC voltage for high voltage applications. This part is the DC to DC Converter (buck-boost). This segment also provides demand for DC load. Buck-Boost is a form of switched-mode power supply that integrates a single circuit into Buck and Boost converters. It offers regulated DC voltage, like other SMPS designs, from an AC or a DC supply. Buck's DC output is slightly less than the input voltage from 0V to slightly less. The output voltage of the boost converter is far higher from the input to the input stage. In several different applications, such as powered battery systems, the input voltage can however vary widely, starting at maximum charge and gradually decreasing with the depletion of the battery load.

C. The DC to AC converter (Inverter) Section:

High DC voltages for AC load applications are inverted into AC voltage. The inverter is commonly used by the power industry to convert DC voltage for efficient transmission and distribution from a range of generation sources to AC voltages. They can also be used to obtain energy from the continuous power series (UPS). To control the power Electronic switches on the conversion circuit, inverters require a gate driver circuit. There are various types of door signals that can be used.

D. Compensation/Reactors:

These devices can compensate voltage and distortion of current induced by switching effects of harmonics in power electronic systems. The integrated generation of energy sources is controlled and managed in the proposed research as a major source of compensation.

E. System of Storage Section:

The energy storage system component, where energy is stored during peak stress hours, is known as an energy storage system for special load applications. It also contributes to the maintenance and integration of EV facilities and future growth for all power stations (conventions and renewable).

The Simulink model of the proposed 180-mode smart transformer controlling and configuration is shown in figure 5 using Table 1 load parameters. An external source is not required, since the filter in figure 5 is DERs, as opposed to a conventional transformer that usually works on a separate external DC source. In addition, a storage device is installed as a condenser, which results in the negligibility of disruptions, as seen in the simulated findings in chapter 6 to improve the functioning and management of this proposed drafted research article. MOSFETs are used as power electro-devices in the setup because, of their acceptable efficacy for high-frequency applications.

6. SIMULATION AND ANALYSIS

Simulation results of the proposed intelligent smart system for strategic management of smart power distributions are displayed below to show its efficacy over the normal conventional power distribution system using the MATLAB program. The results show how the systems respond to dynamic load; in voltage, current, power distortion and restore reactions.
Shown in figure 5 (see Appendix) is the Matlab Simulink model of the proposed smart system. The model consist of the grid connected source and wind sourced tied through the smart transformer which consist of an AC to DC converter, boost-buck converter and an inverter for AC supply.

6.1 Current and Voltage Management Output of the Conventional Power Distribution System

Figure 6 clearly shows the effect the voltage waveform distortions on Conventional systems due the dynamic load demands.

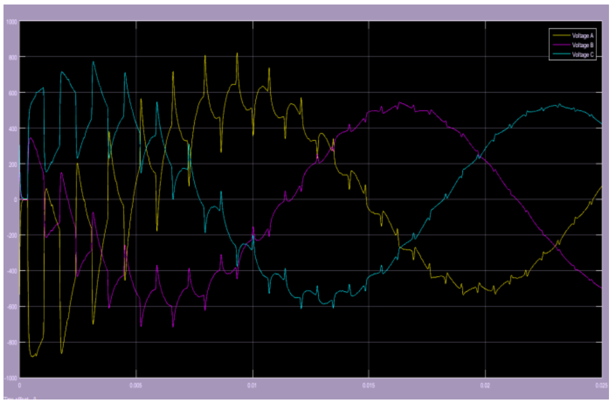

Figure 6. Voltage response of Conventional system with dynamic load condition

Shown also in (figure 7) is the effect of the current waveform distortions on Conventional systems due to dynamic load demands and harmonic conditions.

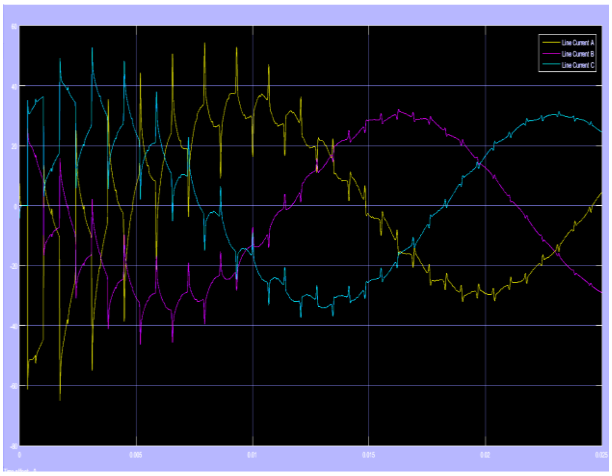

Figure 7. Current response of Conventional system with dynamic load condition

6.2 Current and Voltage Management Output of the Smart System for Power distributions

Shown in (figure 8) is the product of the balanced DER-approved filters as a compensator connected to the Smart system with modeled basic output voltage and current with a less harmonic portion in the unit. Although the harmonic part is smaller, it is still sufficiently high to cause the basic frequency low or high frequency, 50HZ.

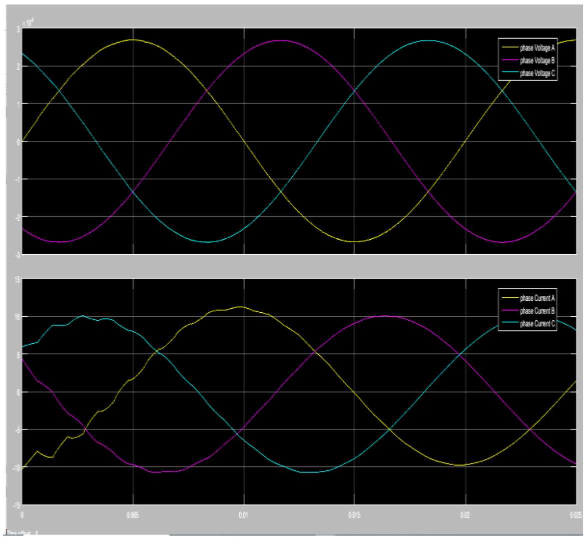

Figure 8. Voltage andCurrent response of the managed smart system for dynamic load condition

6.3 Harmonic Simulations of the Conventional System and the Proposed Smart System

The results of the harmonic analysis of the Conventional system (CS) and the Smart system (SS) are seen in figure 9 and 10 during variable loading; the fundamental frequency of figure 9 of the CS was found in large harmonic components (THD 50.13%). The fundamental frequency of 50Hz has been reduced to approximately 30.9Hz after a sampling time cycle of 0.025s, which may result in a complete system failure. While the Smart system simulation results in a distortion of around 10.35% of its basic frequency, resulting in a THD = 3.19% rise compared to the Conventional system, in the current signal, the Smart system proposed design was able, even without any external compensation, to restore the voltage levels by a controlled harmonic component in less than 0.012s.

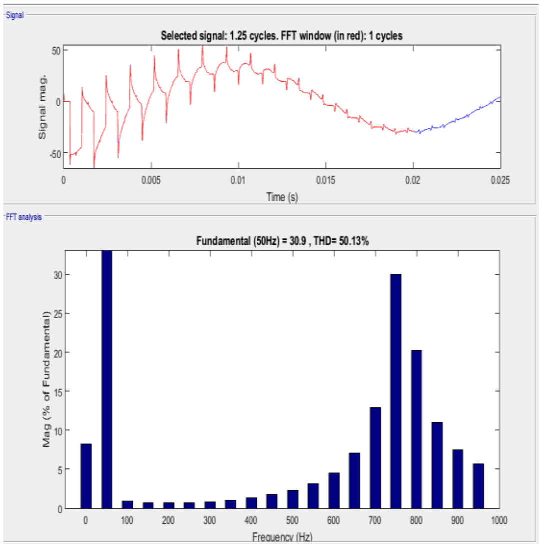

Figure 9. THD analysis of Conventional system management

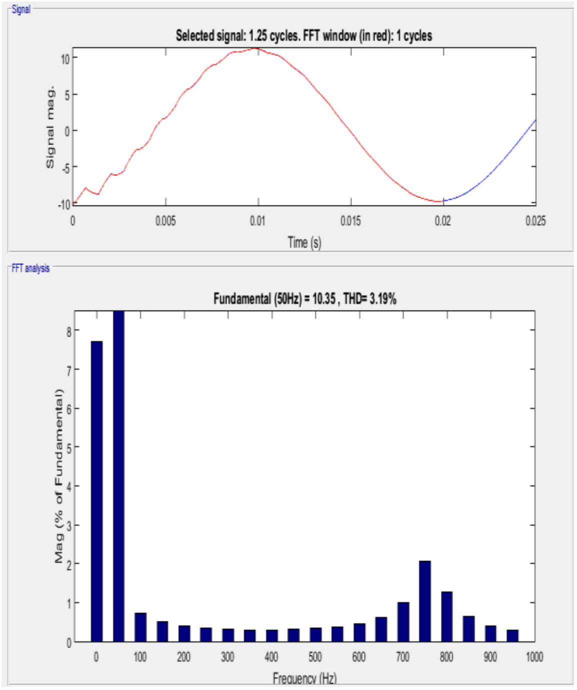

Figure 10. THD analysis of Smart system without smart Management strategies

Figure 11 shows the analysis drawn from smart managerial strategies of ST which makes the THD of the device decreased dramatically to 0.30% of the essential frequency by smartly regulated and managed compensated signal (50Hz).

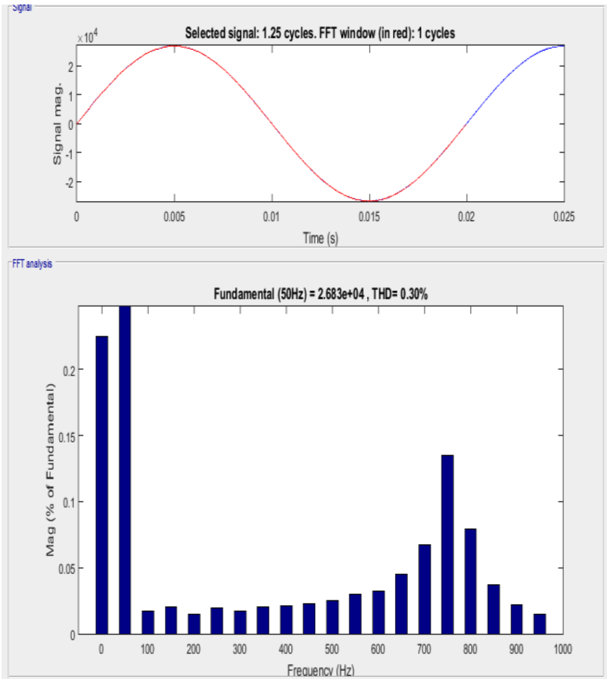

Figure 11. THD analysis of Smart system with smart management strategies

6.4 Load Management Outputs of Both Systems

Observed in (figure12) is the simulated output of the load frequency control of a conventional transformer for power distributions.

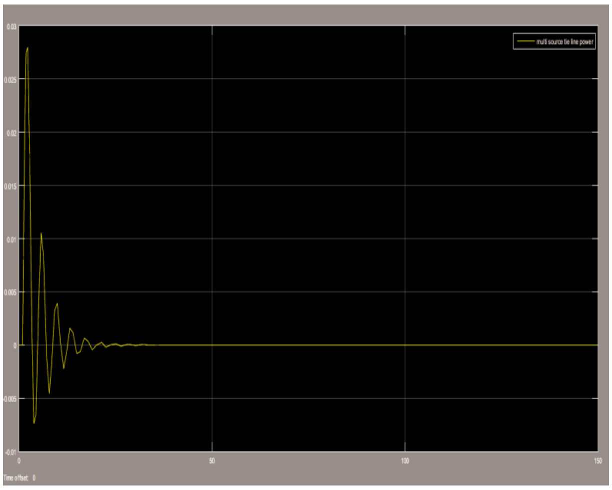

Figure 12. Outcome of conventional system load management

Figure 13 also shows the output analysis of how the proposed smart managerial techniques drastically reduced the settling time of the system under disturbance conditions.

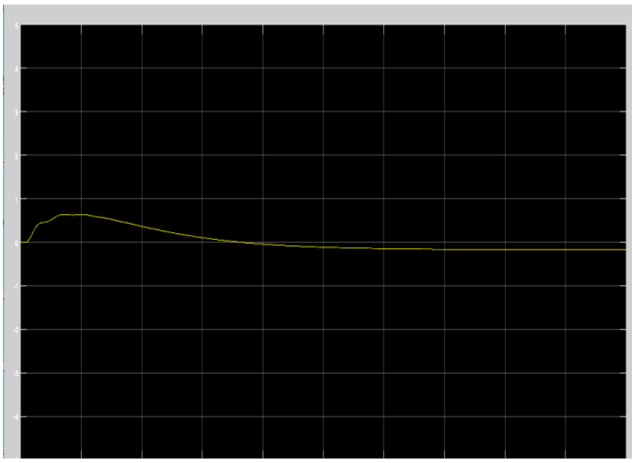

Figure 13. Outcome of Smart system load management

6.5 Simulation Analysis

The results of both the conventional and intelligent device management in its current and operating voltage (power) modes supplying around 10kW and 50HZ in most urban areas for both AC and DC load demands are clearly shown in the above simulations.

The effect of the current and the voltage waveform distortions on Conventional systems are shown in (Figures 6 and 7) when the system is operated under variable load conditions, while the voltage and current signal in each stage is distorting in the sample time (t) of T = 0.248s and not reaching its peak, limiting the current flow through the system to around 0.1s.

Shown in (figure 8) is the product of the balanced DER-approved filters as a compensator connected to the Smart system with modeled basic output voltage and current with a less harmonic portion in the unit. Although the harmonic part is smaller, it is still sufficiently high to cause the basic frequency low or high frequency, 50HZ. The configuration mode and intelligent management control as shown in figure 5 allow for the rapid compensation of each line voltage, resulting in efficient perturbation management and control. Harmonics or other forms of disruptions, therefore, have no effect on the waveform levels of the system.

The results of the harmonic analysis of the Conventional system (CS) and the Smart system (SS) are seen in figure 9 and 10 during variable loading; the fundamental frequency of (figure 9) of the CS was found in large harmonic components (THD 50.13%). The fundamental frequency of 50Hz has been reduced to approximately 30.9Hz after a sampling time cycle of 0.025s, which may result in a complete system failure. While the Smart system simulation results in a distortion of around 10.35% of its basic frequency, resulting in a THD =3.19% rise compared to the Conventional system, in the current signal, the Smart system proposed design was able, even without any external compensation, to restore the voltage levels by a controlled harmonic component in less than 0.012s. Figure 11 shows also that the THD of the device decreased dramatically to 0.30% of the essential frequency by smartly regulated and managed compensated signal (50Hz). Consequently, the harmonic variable has an impact of approximately 2.683e+04 on the fundamental frequency (50Hz), which usually has no significant effect, on the device efficiency. With the load management control, The conventional sampling method took approximately 16 seconds to achieve overall system stability at 0.01 kHz sample frequency, zero set-off time and 0.1s sample time; the concept has, however, been successfully operated and managed using Matlab software R2015a for the smart grid system applications' management operations.

Using the same load parameters from table 1, figure7 clearly illustrates the Simulink model of the proposed smart transformer with 180 mode inverter control and configuration. The filter shown in figure7 on-like what is shown in the CT model in figure 3 is wind sourced and hence there is no need for any external source. In addition, for a better operation and control of this proposed project, storage system in form of a capacitor shown in the diagram are installed resulting in the negligibility of disturbances in the system as illustrated in (figure 9) of simulated results. MOSFETs are used as power electronic device for the configurations because of its reasonable efficiency for high frequency application.

7. CONCLUSION

Synoptically, this paper showed the smart controls and management operation of Smart systems and presented its result output of simulations for better system efficiency, by increasing the system's sensitivity to variable load demands and failure requirements. Due to the smart nature of the proposed system developed, the harmonic components that were present in the system due to non-linear loads, switching effects and other related faulty conditions were controlled and compensated smartly. The system, therefore, had a stronger sinusoidal signal for the smart grid system to provide stable, high quality, safe and reliable electricity. Although smart infrastructures could result in high initial implementation costs, researchers and system engineers could develop future-oriented models and designs to reduce costs. The proposed research strategic management technique of smart system helped to ensure very quick overall system stability of approximately 0.44ms, meaning zero under load and frequency control as shown in figure 12 and 13 respectively.

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APPENDIX:

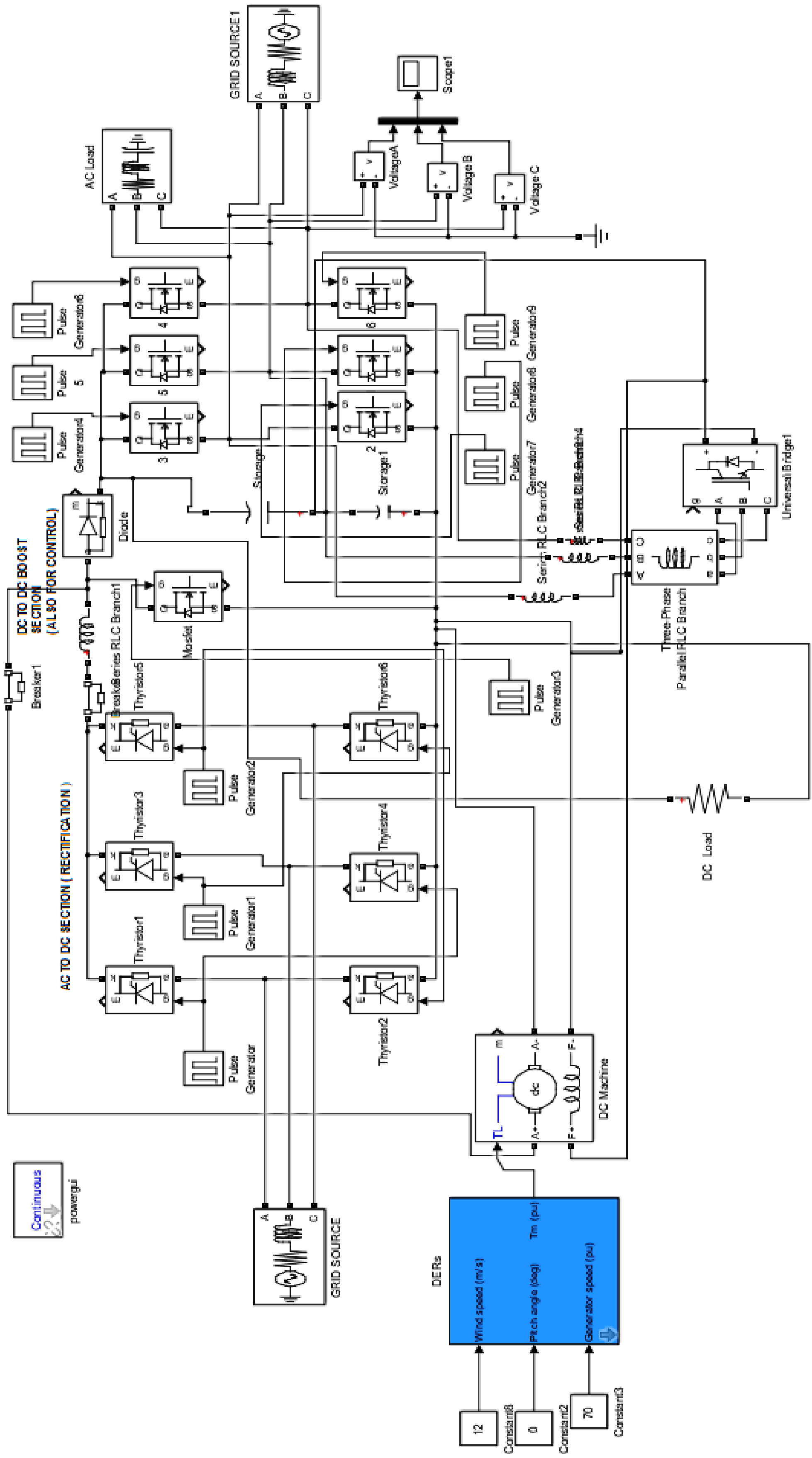

Figure 5. Simulink application model of the proposed Smart System