ISSN 2395-6216 (PRINT VERSION)
ISSN 2395-6224 (ONLINE VERSION)
Volume 11 Number 2 August 2021

Centurion Journal of Multidisciplinary Research

Special issue :

Proceedings of

National e-conference on repair and maintenance of distribution transformer (TRANSCON-2021)
25 and 26 August 2021

Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

centurion university of technology and management

Centurion Journal of Multidisciplinary Research
ISSN 2395-6216 (PRINT VERSION) ISSN 2395-6224 (ONLINE VERSION)

Centurion Journal of Multidisciplinary Research is published by Centurion University of Technology and Management, Odisha, bi-annually. Copyright @ 2021 Centurion University of Technology and Management. All rights reserved. No portion of the contents may be reproduced in any form without permission in writing from the publisher.

Annual Subscription: Rs 300 (within India) excluding postage charges. Outside India USD 30, excluding postage charges.
The designations employed and the presentation of material in the CJMR journal do not imply the expression of an opinion whatsoever on the part of Centurion University of Technology and Management concerning the legal status of any country, territory, city or area of its authorities, or concerning the delimitation of its frontiers or boundaries.

The authors are responsible for the choice and the presentation of the facts contained in the journal and for the opinions expressed therein, which are not necessarily those of Centurion University of Technology and Management.

@Centurion University of Technology and Management, 2021

Published by:
Registrar, Centurion University of Technology and Management
R. Sitapur, Parlakhemundi, Gajapati, Odisha
Pin – 761211

Printer:
Srimandira Publication
EPF Colony, E-Block, Saheed Nagar, Bhubaneswar, Odisha 751007

Volume 11 Number 2
August 2021

Centurion Journal of Multidisciplinary Research

Special issue :

Proceedings of National e-conference on repair and maintenance of distribution transformer (TRANSCON-2021)
Organized by: Department of Electrical and Electronics Engineering, Centurion University of Technology and Management, Odisha
Sponsored by: All India Council for Technical Education

Centurion
UNIVERSITY
Shaping Lives...
Empowering Communities...

CENTURION UNIVERSITY PRESS, ODISHA, INDIA

TRANSCON-2021

Editorial

Preamble Trends of power sector in India are dynamically changing; it is now more decentralized with system approach. The grid system is more resilient with less human dependence. The heavy electrical machines are also being enabled with digital technology. The technology related to Repair, Maintenance and Refurbishment of heavy electrical machinery has gone through drastic change. Furthermore, with the advent of new normal and innovations in information & knowledge sharing, significant increase in international mobility of human capital, materials and state-of-the-art technology there has been a sea change in transformer R&M process, in a sophisticated way.

In the current scenario there is requirement for critical thinking and a desire to question and seek creative answers and outcomes in order to create a innovative Ramp; M system for distribution transformer to enhance grid reliability & availability of electricity in rural pockets of India. In this context this e-conference provides opportunities to present and discuss issues dealing with modern trends in Repair, Maintenance and Refurbishment of Electrical Distribution Transformer, in Indian environment from the perspective of managers, businesses, academicians, and entrepreneurs.

Message from Vice Chancellor

The curriculum and learning methods of Centurion University are designed and delivered in active partnership with industry and foreign universities to enhance students' employability, and potential for higher education and entrepreneurship. An optimal blending of learning by listening, seeing, doing and Discovery in class and in the field is unique to Centurion University. In this process the department of electrical and electronics engineering is organizing a National Level Conference on “Repair & Maintenance of Distribution Transformer, which will be facilitated by our state-of-the-art transformer manufacturing workshop in Bhubaneswar campus. I am sure students, faculty members, research scholars, industry consultant, entrepreneurs will be benefited and take advantage of the National Level Conference on “Repair & Maintenance of Distribution Transformer.

I wish the conference all Success.
Dr. Supriya Pattnaik

Message from Pro Vice Chancellor

Centurion belongs to the genre of New Age Universities which delivers appropriate, relevant and meaningful education by converging traditional, applied and action learning, while ensuring the robust linkage of education to

employability, employment and entrepreneurship. So to enhance such thing the department of electrical and electronics engineering is organizing a National Level Conference on “Repair & amp; Maintenance of Distribution Transformer, The prime focus of the conference is to put spotlight on the new technology and challenges that needs to be addressed during Repair & Maintenance of Distribution
Transformer.

Best Wishes to TRANSCO-2021.
Dr. Ardhendu Mohanty

Message from Director

The e-conference aims to bring together leading academic professionals, industry experts and research scholars to exchange and share their experiences and research results on all aspects of Distribution Transformer Repair and Maintenance. It also provides a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Distribution Transformer Repair and Maintenance.

The AICTE sponsored e-conference will be endorsed by our own state-of-the –art action learning lab & Transformer Manufacturing unit under the banner of “Gramtaranng”, the social outreach of Centurion University.

I wish all Success to TRANSCON-2021.
Prof. Jagannath Padhi.

Sl. No.	Topic	Page No.
1	Analysis of Co-Ordinated Design of PSS and SSSC Based Damping Controller Considering Transmission Delay	1-4
2	A Comprehensive Study of Compact Substation	5-7
3	EV Charging System: An Overview	8-11
4	IoT based Condition Monitoring System for Distributed Transformer	12-16
5	Maintenance Schedule of Substation Equipped with Transformers up to 1000 kVA	17-19
6	Fault location estimation on overhead transmission line	20-23
7	Smart home monitoring system using ESP32 and IOT	24-29
8	Hot Spot: The Key in Deciding the Residual Life of Transformer	30-33
9	CRGO Core Saturation & Its Impact on Differential Protection in Transformer .	34-37
10	Simulation of a smart Agri Pesticide Sprayer operated by Solar System	38-40
11	Off-grid Solar PV System: Design, Connection and Applications	41-43
12	Aging of Transformer: Repair or Replace	44-46
13	Fault finding and Maintenance of Distribution Transformer	47-51
14	An Intelligent Frequency Control Approach for an A.C. Microgrid	51-55

Analysis of Co-Ordinated Design of PSS and SSSC Based Damping Controller Considering Transmission Delay

Rajendra Ku. Khadanga
Department of Electrical & Electronics Engineering
CUTM, Bhubaneswar, Odisha, India
E-mail: rajendra.khadanga@cutm.ac.in

Preeti Ranjan Sahu
Department of Electrical Engineering
NIST, Berhampur, Odisha
E-mail: preetiranjan.sahu@nist.edu

Sidhartha Panda
Department of Electrical Engineering,
VSSUT, Burla, Odisha, India
E-mail: spanda_eee@vssut.ac.in

Abstract—**This paper exhibited an effective methodology for planning an organized PSS and a SSSC based advantageous damping regulator. The planned methodology is used for damping low frequency motions in a SMIB power system considering the different framework transmission time delays. PSS are utilized in system to decrease the low frequency oscillation however utilization of PSS is inadequate in some situations. Thus, the plan issue related with the planned regulator is considered to as an optimization issue. The heuristic calculations like GA, PSO and GSA are utilized to find the organized design boundaries. The proposed work essentially analyzes the three calculations.**

Keywords - Damping controller; flexible AC transmission systems; genetic algorithm (GA); gravitational search algorithm; particle swarm optimization (PSO);power system stabilizer (PSS).

I. INTRODUCTION

The PSSs are all around utilized in the power industry to wash out the low frequency oscillation [1]. Notwithstanding, in some strange circumstances, the utilization of PSS is lacking to give adequate damping. This is chiefly when the system is upset by some strange abnormal conditions. Hence, different choices are extremely fundamental to keep away from such system possibility [2]. During the last decade, FACTS goes about as a promising idea for power system applications. The SSSC is viewed as perhaps the most flexible gadgets in the FACTS family. The fundamental capacity of SSSC the transmission line, reduce system wavering and offer voltage support.

A damping regulator is by and large utilized in the system for strength examines. The boundary tuning for a damping regulator is consistently a troublesome process [4]. The presentation of a system can be improved by planning a PSS and a FACTS-based damping regulator which can be worked in a coordinated way [5]. The different soft computing methods or Evolutionary processing have been applied to discover these boundaries [6]. GA is an individual from delicate figuring methods, which chips away at Darwin's hypothesis of advancement " survival of the fittest " [7]. Once more, to take care of the complex advancement issue, the PSO strategy is utilized [8]. The PSO calculation is motivated by the capacity of the groups of birds. The PSO calculation consistently attempts to further develop the candidate solution, subsequently can tackle or upgrade a complex optimization problem [9]. As of late, the advancement of the GSA calculation gives a powerful device that can deal with complex issues. In scholarly world and the business reason, GSA has been mainstream [10-11].

II. MODELING THE POWER SYSTEM WITH SSSC

An SMIB power system is shown in Fig. 1 alongside an SSSC. The SSSC utilizes the idea of VSC and is generally associated with the line through a transformer and powerfully the degree of remuneration of the SSSC. Consequently, the damping regulator is utilized with the SSSC to shape an organized design, which can further develop the system damping accordingly further develops dynamic security [1].

A. Modelling of Generator:-

The expression of the system equation is given by [2]:

$$V_d = R_s i_d + \frac{d}{dt}\phi_q - \omega_R \phi_q \quad (1)$$

$$V_q = R_s i_q + \frac{d}{dt}\phi_q + \omega_R \phi_d \quad (2)$$

$$V'_{fd} = R'_{fd} i'_{fd} + \frac{d}{dt}\phi'_{fd} \quad (3)$$

$$V'_{kd} = R'_{kd} i'_{kd} + \frac{d}{dt}\phi'_{kd} \quad (4)$$

$$V'_{kq1} = R'_{kq1} i'_{kq1} + \frac{d}{dt}\phi'_{kq1} \quad (5)$$

$$V'_{kq2} = R'_{kq2} i'_{kq2} + \frac{d}{dt}\phi'_{kq2} \quad (6)$$

Where:

$$\phi_d = L_d i_d + L_{md}\left(i_{fd} + i'_{kd}\right),\ \phi_q = L_q i_q + L_{mq} + i'_{kq},$$
$$\phi'_{fd} = L'_{fd} i'_{fd} + L_{md}\left(i_d + i'_{kd}\right), \phi'_{kd} = L'_{kd} i'_{kd} + L_{md}\left(i_d + i'_{fd}\right),$$
$$\phi'_{kq1} = L'_{kq1} i'_{kq1} + L_{mq} i_q \phi'_{kq2} = L'_{kq2} i'_{kq2} + L_{mq} i_q$$

Where d & q shows d and q-axis quantities.

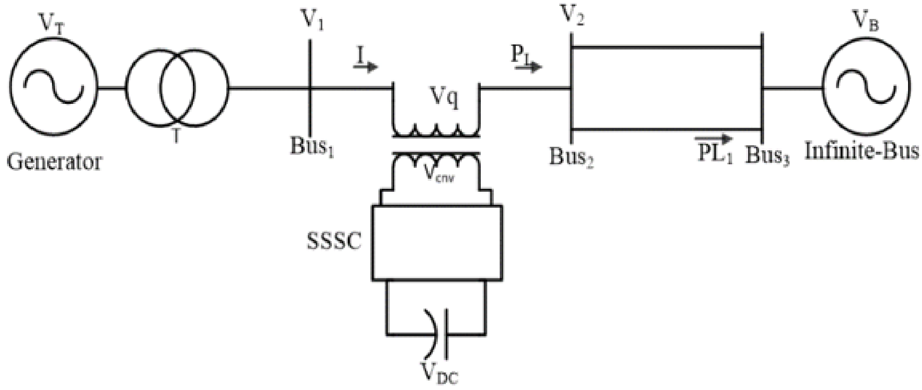


Fig. 1. SMIB power system with SSSC

The expression for the mechanical power is:

$$\frac{d}{dt}\omega_r = \frac{1}{J}\left(P_e - F\omega_r - P_m\right) \quad (7)$$

$$\frac{d}{dt}\theta = \omega_r \quad (8)$$

III. THE PROPOSED APPROACH

A. Coordinated design of SSSC based Damping Controller and PSS

The lead-lag construction of the damping regulator is displayed in Fig. 3. The construction primarily comprises of three components. They are: - phase compensation block, gain block and a signal washout block [2].

B. Objective Function

Here the J for integral time absolute error of the speed deviations. This might be communicated as [12]:

$$J = \int_0^{t_1} t\,|e(t)|\,dt \quad (9)$$

Where, 'e' is addresses the error signal of $\Delta\omega$ and t_1 addresses the scope of simulation time.

The simulation for the above system is done for a specified time which can be considered as a optimization issue [13]:

Minimize J (10)

Subject to

$$K_i^{\min} \le K_i \le K_i^{\max}$$
$$T_{1i}^{\min} \le T_{1i} \le T_{1i}^{\max}$$
$$T_{2i}^{\min} \le T_{21i} \le T_{2i}^{\max}$$
$$T_{3i}^{\min} \le T_{3i} \le T_{3i}^{\max}$$
$$T_{4i}^{\min} \le T_{4i} \le T_{4i}^{\max} \quad (11)$$

IV. EXPLANATION OF DIFFERENT ALGORITHM TUNING METHODS

A. GA Algorithm

The GA is essentially an inquiry calculation in which the laws of hereditary qualities and the law of normal determination are applied. For arrangement of any optimization issue, an initial population is assessed which contains a gathering of chromosomes [8, 10].

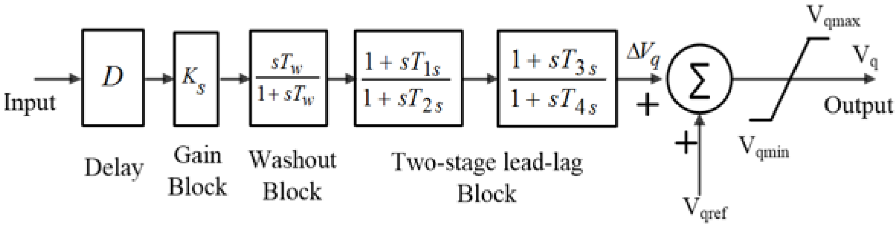


Fig. 2. SSSC based damping Controller

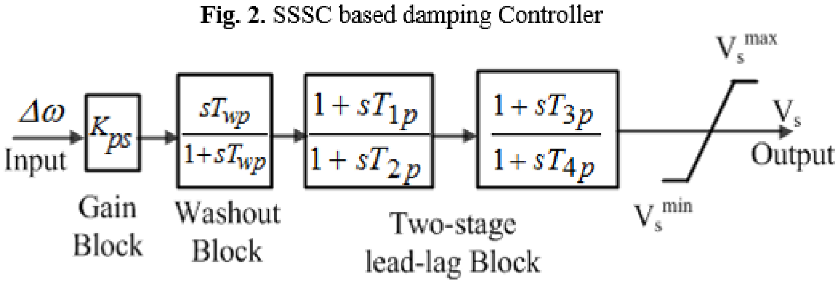


Fig. 3. Structure of power system stabilizer

B. PSO Optimization Algorithm

In the mid of 1990s the PSO procedure was developed while endeavoring to mimic the arranged, movement of multitudes of birds as a feature of a socio intellectual examination researching the idea of aggregate insight in organic populaces [11,12].

C. GSA Algorithm

For tracking down an optimal solution of a planned damping regulator GSA is an elective methodology. Here the GSA calculations is with a formerly evolved calculation and is by all accounts an intriguing strategy and gives better execution which can be seen from the different simulated results [13].

V. Results And Discussions

The best SSSC based facilitated regulator boundaries are displayed in table-I, II and III. Tables shows the parameters in term of K_T, T_1-T_4, and the best, greatest and the avg. values upsides of the above plan. An end can be drawn that, the three said calculations GSA, PSO and GA tuned SSSC based facilitated regulator keeps up with stability.

A. Disturbance 1: -3-phase self-clearing fault

At the principal case, a disturbance aggravation at nominal loading (P_e=0.75 pu and δ_0=48.40) is thought of. A 3 phase 3 cycle shortcoming is applied at t=1 sec and the first system is reestablished after the fault is cleared. The system reaction as far as $\Delta\omega$, δ, PL and Vq is displayed in fig.7 (I-III). Reaction bends inferred that with the above sort of aggravation the system gives better performance when GSA algorithm is applied.

B. Distubance: 2:- Considering System Time Delays

Finally, the system is verified by considering various system time delays. The different delays are considered as 100 sec, 70 sec and 25 secs. Fig. 9 shows the system response and a conclusion can be drawn as the system reaches to a stable equilibrium point when the system delay is less.

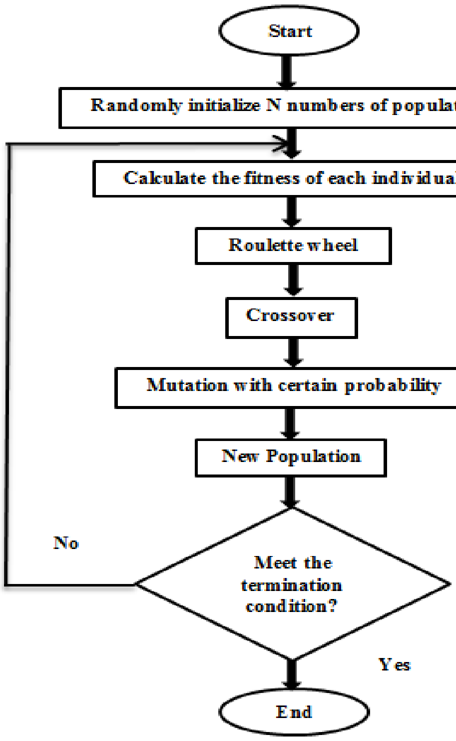


Fig. 4. GA Flow chart

Table I: Optimized Controller Parameters Using GSA

	K_T	T_1, T_2	T_3, T_4	Min	Max	Avg.
Damping Controller	59.125	0.978,0.751	0.364,0.546	$7.458*10^{-4}$	$9.598*10^{-4}$	$8.598*10^{-4}$
Power System Stabilizer	18.695	0.421,0.612	0.325,0.356			

Table II: Optimized Controller Parameters Using PSO

	K_T	T_1, T_2	T_3, T_4	Min	Max	Avg.
Damping Controller	60.365	0.725,0.546	0.785,0.321	$10.03*10^{-4}$	$10.75*10^{-4}$	$10.56*10^{-4}$
Power System Stabilizer	12.125	0.326,0.569	0.456,0.265			

Table III: Optimized Controller Parameters Using GA

	K_T	T_1, T_2	T_3, T_4	Min	Max	Avg.
Damping Controller	70.454	0.695,0.265	0.695,0.458	$11.25*10^{-4}$	$11.56*10^{-4}$	$11.65*10^{-4}$
Power System Stabilizer	19.698	0.546,0.986	0.526,0.459			

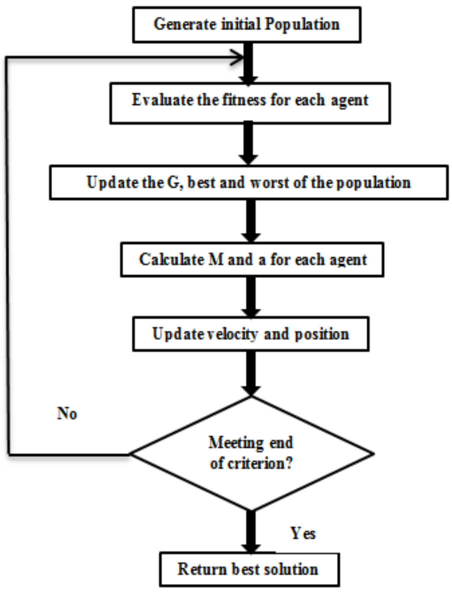
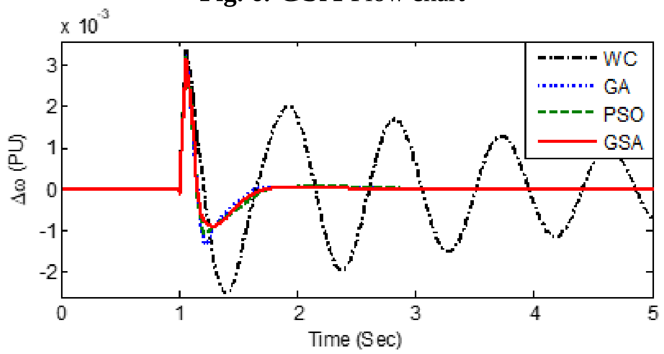
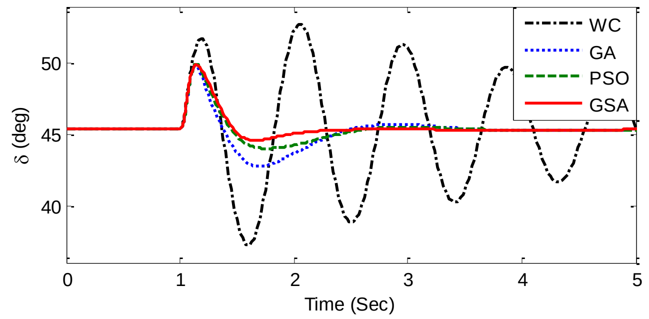


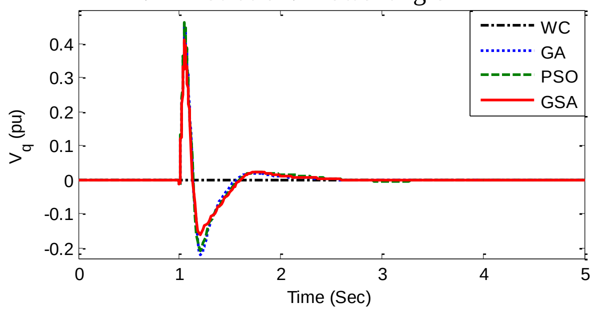
Fig. 6. GSA Flow chart



I. Deviation:- Speed



II. Deviation:- Power angle



III. Deviation:- Injected voltage SSSC

Fig. 7. Sytem response for disturbance-1

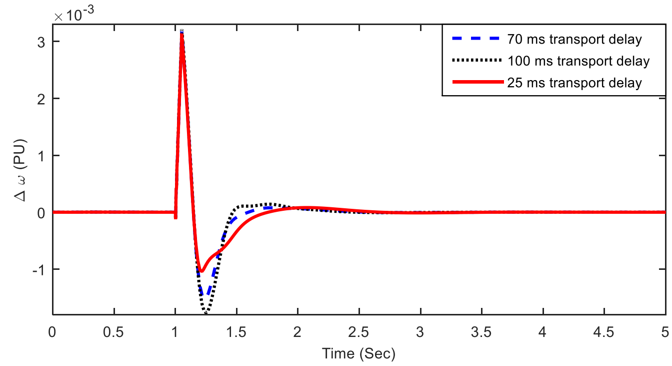


Fig. 9. System response curve for Disturbance -2

VI. Conclusion

In the current investigation, to plan a SSSC-based coordinated damping regulator, the heuristics calculations GA, PSO and GSA are utilized by considering different time delays. This is viewed as an optimization issue for the above examination. The three said calculations have been utilized to track down the ideal/best boundaries of the damping regulator just as for the PSS. To look at the calculations, different reproduction results are introduced which are recreated under different framework unsettling influence and issue areas. An end can be made as, to tune the organized regulator boundary, the GSA calculation shows prevalence as far as different consideration.

References

[1] P. Kundur, *Power System Stability and Control*, McGraw-Hill; 1994.

[2] S. Panda , N. K. Yegireddy, S. K. Mohapatra, "Hybrid BFOA–PSO approach for coordinated design of PSS and SSSC-based controller considering time delays," Int. Journal Electr. Power Energy Syst. 2013; 49:221-233.

[3] N. G. Hingorani and L. Gyugyi, *Understanding FACTS*, IEEE Press, 2000.

[4] K. R. Padiyar, N. Prabhu, "Design and performance evaluation of subsynchronous damping controller with STATCOM," *IEEE Trans. Power Delivery*, vol.21, no.3, pp.1398-1405, July 2006.

[5] R.K. Khadanga, V. Kumar, A. Kumar, and S. Padhy, "Robust Frequency Control in an Islanded Microgrid: A Novel Stochastic Fractal Search Algorithm Approach," IEEE India Council International Conference (INDICON), pp. 1-6, 2017.

[6] S. Panda, "Robust coordinated design of multiple and multi-type damping controller using differential evolution algorithm," Int. Journal Electr. Power Energy Syst. Vol. 33, no. 4, pp. 1018-1030, 2011.

[7] R.K. Khadanga and S. Panda, "Gravitational search algorithm for Unified Power Flow Controller based damping controller design," in Energy, Automation, and Signal (ICEAS), pp. 1-6, 2011

[8] S. Panda, "Multi-objective PID controller tuning for a FACTS-based damping stabilizer using Non-dominated Sorting Genetic Algorithm-II," Int. Journal Electr. Power Energy Syst. vol. 33, no. 7, pp. 1296-1308, 2011.

[9] R.K Khadanga and J.K. Satapathy, "A new hybrid GA–GSA algorithm for tuning damping controller parameters for a unified power flow controller," Int. Journal Electr. Power Energy Syst., vol. 73. Pp. 1060-1069, Mar. 2015.

[10] R. K. Khadanga, J. K. Satapathy, "Time delay approach for PSS and SSSC based coordinated controller design using hybrid PSO–GSA algorithm," Int. Journal Electr. Power Energy Syst. Vol. 71. pp. 262-273, 2015.

[11] R. K. Khadanga, A. Kumar and S. Panda, "Frequency control in hybrid distributed power systems via type - 2 fuzzy PID controller," IET Renewable Power Generation, Vol. 15, No. 8, pp. 1706-1723, 2021.

A Comprehensive Study of Compact Substation

Rama Prasanna Dalai
Department of Electrical &
Electronics Engineering
CUTM, Bhubaneswar, Odisha, India,
rama.dalai@cutm.ac.in

Suraj Rath
Department of Project,
Feedback energy distribution
company limited, Odisha,
surajrath88@gmail.com

Surya Narayan Sahu
Department of Electrical &
Electronics Engineering
CUTM, Bhubaneswar, Odisha, India,
surya1888@gmail.com

Abstract- **This paper explains modern technology for the distribution substation which reduces cost and size of distribution substation thereby improving the safety and reliability issues. Moreover various components of this Compact substation which includes RMU & metering unit, Transformer and LV panel has been described in details with their circuit diagram & characteristics . This paper also discusses about the traditional earthing mechanism, factors affecting earthing and the earthing mechanism that are used in the compact substation. Based on the several advantages and advanced features authors finally concluded that compact substation are more widely used now a days as compared to traditional substation.**

Keywords— Compact substation, MV switchgear, RMU, LV switchboard

VII. INTRODUCTION

The Compact substation is something that consists of RMU, a transformer and an LV panel which are placed in three separate chambers separated from one another by means of partitions in order to maintain personnel safety. Accessibility to operate or maintain the equipment is through lockable doors provided for each compartment to maximize security. Assembly of the complete substation is factory ready to minimize site installation time and cost. All equipment is of high quality and tested as a complete unit. The benefits of compact substation are as follows: 1. It consists of a Single Unit of all Medium voltage items making it a single window solution. 2. It Looks elegant and beautiful for public spaces. Moreover Most modern design facilitates Well-equipped canopy design. 3. This saves Space upto 70% area. 4. This Saving of labour work , man-hours , and skilled electricians. 5- Here Only connection needed is HT Cable from Govt Substation and LT Cable to further Power Distribution Panel. 6. This is Shift able from one place to another easily. 6. There will be Saving of Civil Work –Separate Room for VCB , Foundation of Transformer & LT Panel Box not needed But Single Foundation base for CSS required. 7. Here Separate Earthing is not required for all equipments. CSS has 2 Earthing that is already interconnected with all Equipments inside. 8. All equipment is inside single canopy with Lockable doors , making it safe for all equipments, which cannot be accessed by unauthorized persons. 9. Safe , Compact , Reliable and Single solution to everyone's medium voltage requirement. After analyzing the advantages of compact substation authors discussed about the components used in compact substation. These are as follows (i) RMU and metering unit (ii) Transformer (iii) LV panel. The functions of all 3 components are discussed in details with their circuit diagrams. Next authors discussed in details about the earthing systems which is implemented in the Compact substation. Actually the principal cause for creating earthing in electrical network is for the safety. When all conducting parts in electrical equipment are grounded then if the insulation inside the equipment fails there are no dangerous voltages present in the equipment case. The purpose of earthing is given as follows: (i) Safety of human life/ Building/equipment which also includes human life to be saved from electric shock or death by blowing a fuse, to protect building, machinery & appliances under fault condition, to ensure all exposed conducting parts should not reach a hazardous potential, to provide safe path thereby dissipating lightning & short circuit currents, to provide stable platform for operation of sensitive electronic equipment. (ii) Overvoltage protection which means lightning or unintentional contact with higher voltage lines can abruptly large voltages to the electrical distribution systems because earthing provides alternative path around the electrical system to reduce damages in the system. (iii) Voltage stabilization which means there are many sources of electricity. Every transformer can be considered as single source [4]. If there were not a common reference point for all these sources it would have been tough to find out their relationship to each other. Conventional earthing methods mainly consists of (i) Plate type earthing (ii) Pipe type earthing. There are various factors which affects earth resistance are as follows: (i) Soil resistivity (ii) Soil condition (iii) Moisture (iv) Dissolved salts (v) Climate condition (vi) Physical composition (vii) Location of earth pit (viii) effect of current magnitude (ix) Available area (x) Obstructions etc. Besides this authors describes briefly about the 2 types earthing mechanism that are implemented (i) Transformer neutral earthing (ii) Transformer body earthing

II. COMPONENTS OF COMPACT SUBSTATION

There are 4 components of Compact substations which basically consists of (i) MV Switchgear (ii) Transformer (iii) LV Switchboard.

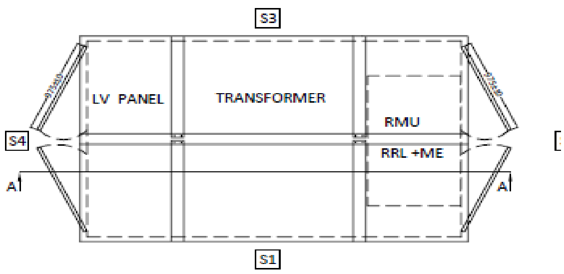


Fig.1 Components of Compact substation

Figure shows the components Compact substation where right most part indicates the Ring main unit and metering unit and left most part indicates Low voltage panel and middle unit refers to Transformer.

MV Switchgear

i. Ring Main Unit insulated with SF_6 gas
ii. Mano meter with self-operated switch installed for measuring SF_6
iii. CT & PT for RMU
iv. Other instruments installed as follows:-
    Bus bar with control switch,
    Load break switch,
    Isolator auxiliary switch
    Cable chamber and circuit breaker chamber
    Outgoing VCB panel
    Power circuit
    Voltage presence indication system

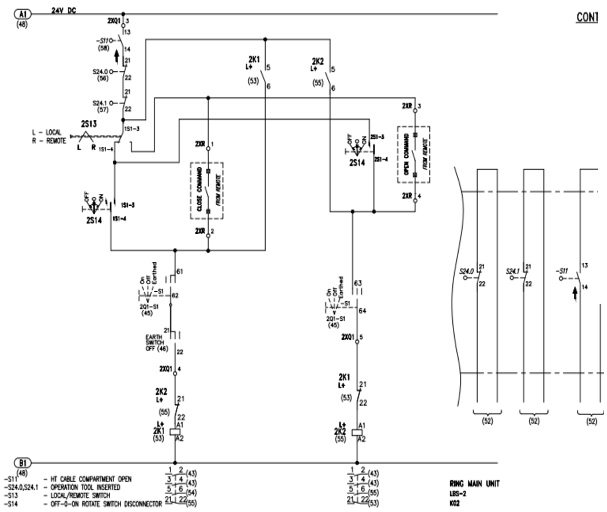


Fig.2 MV switchgear diagram

Transformer

i. Wide range of transformers up to 1000kVA
ii. Highly energy efficient minimizing losses.
iii. Dry or sealed type.
iv. Plug-in bushings.
v. Off-load tap changer.
vi. Winding temperature and oil monitoring relay.

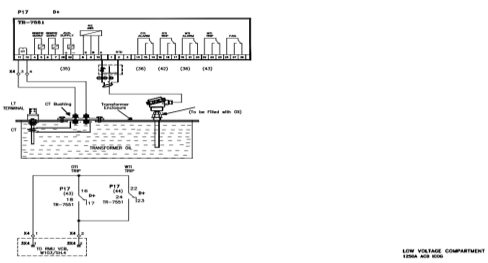


Fig 3 Transformer diagram

LV Switchboard

i. ACB(1250 A) and control circuit
ii. Multi-function meter (3 phase 4 wire)
iii. Circuit switching using Moulded Case Circuit Breakers protection (MCCB).
iv. MCCB type of incomer up to 1600A.
v. MCCB type of outgoing feeders up to 400A.
vi. Feeder terminals suitable for both Cu/Al.
vii. Current transformers for power metering.

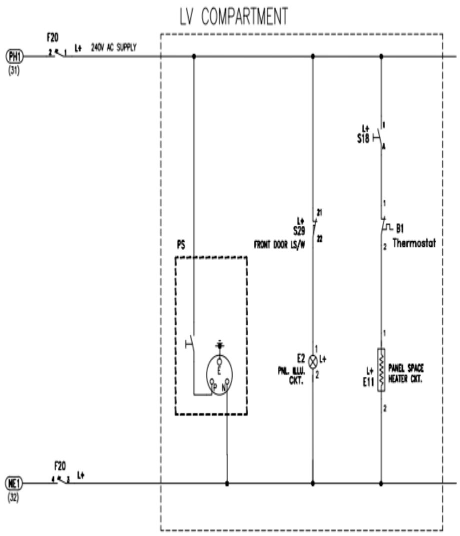


Fig..4. LV Switchboard diagram

III. EARTHING OF COMPACT SUBSTATION

Earthing in electrical system is a conductor that gives low reluctance path to the earth to stop high voltages from becoming visible on equipment. It is basically of 2 types. (i) System earthing (ii) Equipment earthing. System earthing deals with the physical metallic connection of transformer neutral with earth pit where as Equipment earthing deals with the physical metallic connection of all non conducting metallic parts with the earth pit. The objective of an earthing system in a substation is to ensure safety and reliability of the protection of the equipment. System substation in general should possess (i) An increase in fault level (ii) A huge earth grid that is walked over by substation people. (iii) A number of items of electrical equipment with electrical protection of various clearing times. (iv) A number of aerial and/or cable feeders . (v) Fences with associated prospective touch voltage for people external to the substation. (vi) Other services (e.g. water, communications) connected [5]. In case of ground earthing living components of the systems are termed as Ground such as grounding of motor, generator, transformer, battery charger, inverter etc. where as neutral earthing is where equipment/ structure earthing is termed as neutral such as connection of non current carrying parts of the equipment
i.e. body of transformer , CT, PT, circuit breaker, motor , generator etc. Similarly there are mainly 2 types of earthing

used in the Compact Substations. These are mainly (i) Transformer neutral earthing (ii) Transformer body earthing.

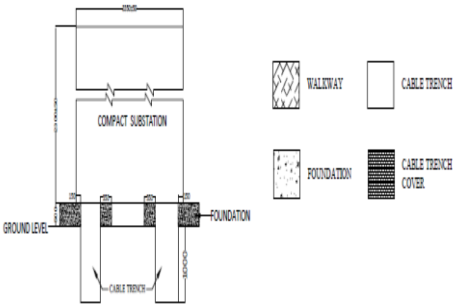


Fig. 5 Earthing of Compact substation

Transformer neutral earthing: A neutral earthing system is a system where the neutral is joined to earth, either firmly, or via a resistance or reactance of value sufficient to materially decrease transients, and to provide sufficient current for selective earth fault protection devices to function**.** Neutral earthing systems are equivalent to fuses in which they perform nothing until there is mal operation in the system. Then, like fuses, they safeguard personnel and equipment from damage

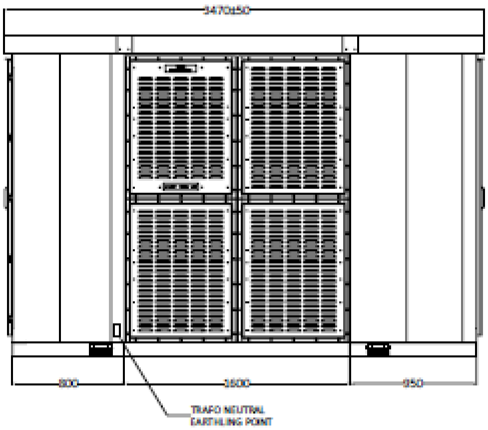


Fig..6. Transformer neutral earthing

Transformer body earthing: In this type of transformer body earthing, mainly tank, is connected to ground rod with two separate earth materials. Body earthing is ued for earth the leakage current passing through equipment body. the other purpose is to protect human body against passing the leakage current.

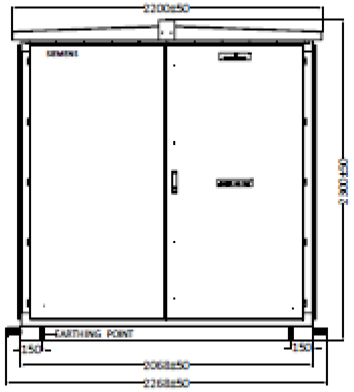


Fig..7. Transformer body earthing

IV. Conclusion

In this paper authors presented the various advantages of Compact Substation over Conventional Substation. Then discussed regarding the components of Compact substions and earthing systems used in Compact substation. Hence finally concluded that due to the several advantages and advanced features of the compact substations it is widely used in modern day to practice.

References

[1] https://electrical-engineering-portal.com/gis-vs-ais-substation-earthing
[2] https://electrical-engineering-portal.com/gis-gas-insulated-switchgear-components
[3] https://ieeexplore.ieee.org/document/4517307
[4] http://www.jrps.in/uploads/2019/v10i3/11.v10i3.pdf
[5] https://electrical-engineering-portal.com/earthing-in-electrical-network-purpose-methods-and-measurement
[6] https://www.slideshare.net/ashokktiwari/earthing-system-53541440?from_m_app=android

EV Charging System: An Overview

Amit Kumar Sahoo
Department of EEE
Centurion University of Technology and Management
Odisha, India
amitkumar@cutm.ac.in

***Abstract*— Electric vehicles is a new technology has emerging in transportation sector to counter the drawbacks of conventional vehicle in terms of economic and environmental. Now a days, battery is the single source of energy, which plays the vital role in the transportation sector. The battery gets charged from an external source, like grid, solar etc. Mainly, the nature of source is an alternating current (AC), which needs to convert to DC with the help of rectifier and feed to DC-DC converter for fast charging. There are two types of charger provided by the manufacturer, i.e., On-board and Off-board charger. This paper presents the various charging infrastructure including battery charger, charging station and it focused on the technology behind the DC fast charging. A comparative study has been given based on electric range, charger power and charging time.**

Keywords—Electric vehicle; PHEV; EVSE; CHAdeMO; Fast Charging; SAE Combo

VIII. Introduction

In late many years, oil utilization in the vehicle area has expanded at a higher rate than n some other areas. As per a factual examination, worldwide oil stores will run out by 2049, with the current rate at which new oil saves are found and the current utilization rate. The expansion in oil utilization was mostly because of new requests for vehicles controlled by regular inner burning motors. The boundless utilization of inside ignition motor (ICE) vehicles has drastically added to contamination in medium and enormous urban communities. Since the ecological issues of the nursery impact and an Earth-wide temperature boost are straightforwardly identified with vehicle outflows, government organizations and offices have created stricter norms for fuel utilization and emanations [1], [2].

In this situation, battery-fueled electric vehicles (EVs) seem, by all accounts, to be the ideal answer for settle the energy emergency and a worldwide temperature alteration since they have zero oil utilization and zero outflows out and about. Zero neighborhood discharges and calm driving of electric vehicles are a portion of the highlights that will help reestablish expectations for everyday comforts in urban areas. Contingent upon the brief distance and continuous unpredictable driving qualities of city driving, electric vehicles can give execution like that of the ICE vehicle at a lower cost than conventional fuel motor vehicles under city driving.

The research and Development (R&D) community is concerned that the use of fossil fuels has been on the rise since the later 1900s. Fossil fuel consumption is rising, posing environmental risks such as GHG emissions and energy independence. It has spurred governments all around the world to devise methods to deal with these problems. CO2 emissions from the transportation industry are considerable. Electrification of the transportation industry has recently gotten a lot of attention as a possible and good answer to the challenges mentioned above. In the near future, several European nations have started to establish and implement surface transportation electrification systems. Despite its tiny population, Norway is one of the world's top buyers of electric vehicles.

IX. Types of EV Charging

Generally, there are three levels of charging devices are used for the charging of EVs, which are Level 1, Level 2 and DC Fast Charging.

A. Level 1, 120 Volt Charging:

Level 1 requires 120 volt for charging a EVs. So, for Level 1 charger, during charging, a home or business outlet may deliver 15-20 amps of current, resulting in a power demand of about 1.4 kW. The manufacturers are providing the Level 1 EVSE with EVs as shown in Figure 1. In general, Level 1 EVSE will take 10-14 hours to fully charge an EV with a range of 90-120 kilometers.

Advantages

- Installation cost is low.

Disadvantages

- Slow charging, i.e. EVs will get around 5 or 8 km of range added per hour of charging

B. Level 2, 208/240 Volt Charging

Level 2 requires 208/240V volt AC power for charging a EVs and also it reduces the charging time as shown in Figure 1 and a J1772 connector. Domestics users commonly use 240 V supply for home appliances for day-to-day affairs. Although most EVs utilize up to 30 amps for 3.3 to 6.6 kW charging, the J1772 standard connection may potentially supply up to 80 amps of power (19.2 kW). Depending on the capacity of the EVSE and the car charging system, EVs with a range of 90-120 km will typically take 3-7 hours to charge fully using Level 2 equipment.

Advantages

- Charge time is very less than Level 1 charger. EVs will get between 16 and 32 km of range per hour of charge
- More energy efficient than Level 1.

Disadvantages

- Installation costs are higher than Level 1.
- Potentially higher impact on electric utility peak demand charges.

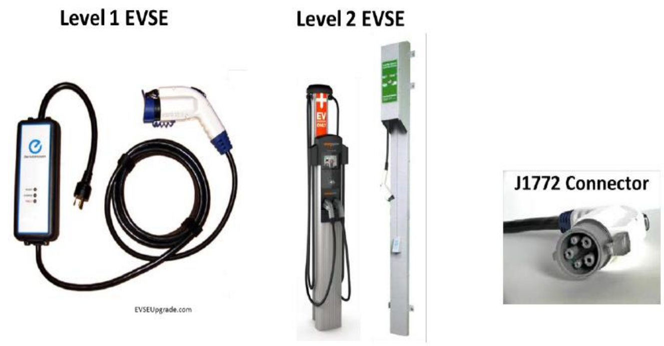


Figure 1. Level 1 and Level 2 EVSE Equipment and J1772 Connector

C. DC Fast Charging

Level 3 is also referred as DC fast charging, which is capable of delivering high power directly into an EV's battery system and it leads to rapid charging. Generally, with in 30 minutes a EV can be charged up to 80% by using DC fast charging. This type of equipment is generally used in the charging station, so that the consumers waiting period for charging is less.

Figure 2. SAE Combo connector

Figure 3. CHAdeMO connector

The DC rapid charging design differs from Level 2 J1772 plug connections. As illustrated in Figures 2 and 3, different manufacturers use three different connections for rapid charging equipment:

1. CHAdeMO
2. SAE Combo
3. Tesla's Supercharger

Advantages

- Charge time is very less, around 30 minutes for an 80% of charge.

X. DC Fast Charging Architecture

For EVs, battery is the single source of energy, which plays the vital role in the transportation sector. The battery gets charged from an external source, like grid, solar etc. Mainly, the nature of source is an alternating current (AC), which needs to convert to DC with the help of rectifier and feed to DC-DC converter for fast charging. There are two types of charger provided by the manufacturer, i.e., On-board and Off-board charger.

Generally, On-board chargers are compact and lightweight and it has been specially designed for the charging of EVs with high power ratings, which leads to slow charging. But, off-board chargers are designed for fast charging of battery due to the additional DC-DC converter, which is install at different charging station located at different location.

There are some fast charger has been designed, which is accepted by the international community for optimal use of it. These are the Society of Automotive Engineers (SAE), the International Electro technical Commission (IEC), and the CHAdeMO EV standards. But, for consumer charging time is the main concern for them. So, charging time needs to be reduced as much as possible. At this point, the DC fast charging plays the vital role to meet the consumers expectation as it has charging time as compared to AC charging. As DC fast charging stations are designed to provide around 50kW to charge a battery. But, the size of the charger becomes gigantic, which can affect the performance of the EVs. So, it is always kept in off-board and in a charging station.

Fast charging includes 3 stages with an input filter, which reduces the harmonics and also optimizes the power factor. AC-DC rectifier, and a DC-DC converter helps to transmit the power to battery as shown in Figure 4 [7].

The onboard charger has an AC-DC rectifier and a DC-DC converter for AC charging, demonstrating another advantage of DC charging. The size of the onboard charging unit is limited by the vehicle's interior space. Due to the tiny size of the onboard converter, the amount of power it can send to the battery is generally modest (3–6 kW). The DC charger, on the other hand, is external to the car and so has no size or cost constraints. In addition, DC fast chargers may connect to three-phase electricity and adapt the charge amount to the battery's condition [8].

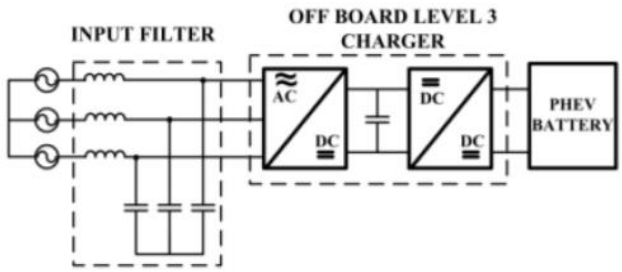


Figure 4. DC fast-charging circuit from grid to a plug-in hybrid electric vehicle (PHEV) battery

The grid power is rectified to a DC bus in the AC-DC conversion step. Researchers are working on a universal DC bus for EV charging stations, with each charger drawing power from the same DC bus. Alternatively, each charger can be connected to a shared AC bus, however each charger will require its own AC-DC rectifier step [9]. A shared DC bus also makes it easier to integrate renewable energy sources and local energy storage, which is another reason why a common DC bus is needed. Typical DC bus voltages are around 750 V.

The DC-DC converter step converts the DC bus voltage into the appropriate charging voltage and current parameters set by the electric vehicle battery. For fast-charging applications, this DC-DC converter will also use a dynamic control approach to reduce the impacts of temperature rise and battery polarization [10]. This is also where the pulse generator for pulse and negative pulse fast-charging would be installed. This converter must be designed to be durable and versatile, having the flexibility to apply different power levels to the battery. The DC-DC stage's isolation is also crucial since the car owner will need to connect the charging port to their vehicle without being exposed to the DC bus voltage. As shown in Figure 5, several designs include an isolation transformer to increase driver safety at the charging station.

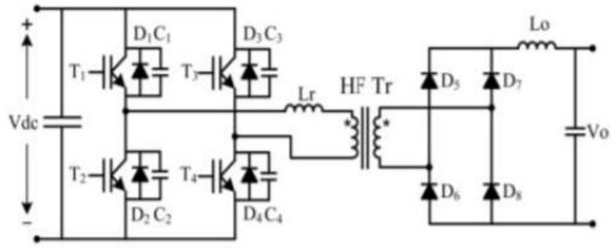


Figure 5. A full-bridge DC-DC converter topology with isolation

Vehicle to grid (V2G) applications are also being explored using bidirectional power electronic systems. A bidirectional converter may be made by replacing the secondary diodes in the circuit with switches. Switching losses become a source of worry for efficiency when there are a lot of switches. High electrical efficiency may be achieved by using zero voltage switching (ZVS) and zero current switching (ZCS) methods. Switching losses are almost reduced when switching at a zero voltage or zero current state.

XI. CONCLUSION

This paper presented detailed architecture and operation of fast-charging technologies and also compared to other charging method. Fuel based transportation will be reduced in future due to pollution and scarcity of fuel and it will be replaced by the electrified transportation. Slow EV battery charging time is a major concern for consumer during the journey. So, fast charging is very much necessary to reduces the charging time as well as maximum user can avail the facility provided by the EV charging station. This paper focused on the fast and safe charging, which protect the battery and grid from any damage. Due to the this new development, the users are very much interested to adopt EVs, which leads to a more sustainable energy future.

REFERENCES

[1] Z. L. A. Khaligh, “Battery, Ultracapacitor, Fuel Cell and Hybrid Energy Storage Systems for Electric, Hybrid Electric, Fuel Cell, and Plug-In Hybrid Electric Vehicles: State-of-the- Art,” *IEEE Trans. Veh. Technol.*, vol. 59, no. 6, pp. 2806–2814, 2010.

[2] K. C. C.C. Chan, A. Bouscayrol, “Electric, Hybrid, and Fuel-Cell Vehicles: Architectures and Modeling,” *IEEE Trans. Veh. Technol.*, vol. 59, no. 2, pp. 589–598, 2010.

[3] J. A. P. L. R.J. Rei, F.J. Soares, P.M.R. Almeida, “Grid Interactive Charging Control for Plug-in Electric Vehicles,” *13th Int. IEEE Conf. Intell. Transp. Syst.*, pp. 386–391, 2010

[4] F. M. H. Turton, “Vehicle-to-Grid Systems for Sustainable Development: An Integrated Energy Analysis,” *Technol. Forecast. Soc. Change*, vol. 75, no. 8, pp. 1091–1108, 2008.
[5] P. M. R. A. J.A.P. Lopes, F.J. Soares, “Integration of Electric Vehicles in the Electric Power System,” *Proc. IEEE*, vol. 99, no. 1, pp. 168–183, 2011.
[6] C. R. M. M.M. Morcos, N.G. Dillman, “Battery Chargers for Electric Vehicles,” *IEEE Power Eng. Rev.*, vol. 20, no. 11, pp. 8–11, 2000.
[7] Frank Lambert, “Secondary Distribution Impacts of Residential Electric Vehicle Charging,” *Calif. Energy Comm.*, 2000.
[8] P. F. P. Kadurek, C. Ioakimidis, “Electric Vehicles and their Impact to the Electric Grid in isolated systems,” *IEEE POWERENG Power Eng. Energy Electr. Drives*, pp. 49–54, 2009.
[9] J. D. K. Clement, E. Haesen, “Coordinated Charging of Multiple PHEV in Residential Distribution Grids,” *IEEE PES Power Syst. Conf. Expo.*, pp. 1–7, 2009.
[10] J. T. W. Kempton, “Vehicle-to-Grid Power Fundamentals: Calculating Capacity and net Revenue,” *J. Power Sources*, vol. 144, no. 1, pp. 268–279, 2005.

IoT based Condition Monitoring System for Distributed Transformer

Sudhansu Kumar Samal
Department of Electrical and Electronics
Centurion University of Technology and Management, Odisha
India,752050
sudhansu.nitrkl@gmail.com

Anjan Kumar Sahoo
Department of Electrical and Electronics
Collage of Engineering Bhubaneswar, Odisha
India, 751024
anjan.sahoo86@gmail.com,

***Abstract*— For the automation of a small substation, a low-cost automation solution based on current IoT technology and GSM utilizing embedded processors like the ARDUINO UNO is available. The Arduino IDE software is utilized to operate a feeder with the aid of a GSM module in this article. Analog and digital field characteristics are monitored and controlled via the Arduino Uno controller's analogue pins, interface relays, and communication ports. The automation sequences for system control, monitoring, and protection are specified in a c program that transmits the field side input parameters to the registered cellphone number. If the current exceeds the microcontroller's limitations, the circuit breakers are immediately tripped, and the information is sent to the user through SMS. The ESP8266 module is used in IoT, whereas the SIM800 module is used in GSM. Also, design and installation of a distribution transformer monitoring and recording system that includes load currents, oil level, voltage level, and temperature. The concept of an online monitoring system combines a standalone Arduino and several sensors. The ARDUINO Microcontroller is used to record the above parameters, which are situated on the distribution transformer side. If the system encounters an abnormality or an emergency scenario, the values will be shown on the monitor in accordance with the predetermined instructions stored in the microcontroller.**

Keywords— ***Transformer health Monitoring, Distribution Transformer, Power system fault***

XII. INTRODUCTION

The Transformer Monitoring System is a collection of components designed to detect and monitor different characteristics of a pole-mounted transformer or ground transformer that are critical to its operation. This device is easily connected to the lines of an existing transformer and is non-intrusive to the lines and their component. Because pole-mounted and ground transformers are the most frequent types of transformers in the general public, the device is inexpensive enough that it is feasible to install one on every transformer. Because the gadget is not directly linked to the transformer, the technique for powering it and monitoring the transformer's characteristics was initially a challenge that needed to be overcome. Induction coils were utilized to pull electricity to the gadget without using any internal power sources. This inductive power pickup is wrapped around the transformer's low side (120V) to save money by reducing the amount of insulation required. Because the voltage passing through the induction coils might be much higher than the voltage required to power the device, a couple of voltage regulators were employed to control the amount of voltage entering the device.

Diodes Incorporated AP1186 regulators were utilized to obtain the required results. Although the gadget pulls electricity from the lines to prevent system failure in the case of a power outage, it also includes a battery backup inside the system. Overall, the transformer monitoring system may track the voltage, current, temperature, and perhaps phase angle of the transformer. The voltage sensor, which consists of a plate, an op-amp, two capacitors, and four resistors, was built from the ground up to satisfy our requirements. The current flowing into and out of the transformer was monitored using a Rogowski coil. This option was created since the current across the lines fluctuates dramatically over time, and the Rogowski coil can measure such a wide range of currents. The methods for measuring the transformer's temperature varied almost as much as the current in the lines.

A thermal infrared sensor was chosen after much thought: the MLX90614ESF-AAA Infrared Temperature Sensor 90 FOV. This sensor was installed in such a way that it has a straight line of sight to the transformer. The phase angles of both the high and low sides of the transformer are the last characteristic that the gadget measures. The information is sent to the CPU inside the gadget once all of the sensors have received an accurate reading from the power lines. It has two primary functions: it connects all of the hardware at a central location and relays information to the wireless component at the appropriate moment. Power generation, transmission, and distribution are all required to provide energy to customers. Automation of substation parameters is a critical task for supplying healthy power to consumers in this automated world, but the risk of blackouts, brownouts, and fire is rapidly increasing due to ageing distribution grid infrastructure (substations) and a lack of automation systems that monitor critical conditions at the substations. Substations are made up of various electrical components such as transformers, circuit breakers, and relays. Overheating and breakdowns are caused by transformer fluid leaks or internal insulation degradation. The old technique entails manual system checks on a regular basis, which is time consuming and inaccurate. Furthermore, substations in rural locations are considerably more difficult to manually monitor, necessitating additional time to take appropriate steps. The automation of substations is the solution to all of these issues. With the aid of numerous sensors, various characteristics such as current, temperature, and voltage are continually detected. Sensor output signals are sent to an Analog to Digital Converter (ADC), which then sends them to the microcontroller. The microcontroller is pre-programmed in such a way that if any of the parameters surpass a predetermined threshold value, it will alert the intermediate or main station via wireless communication technologies such as BLUETOOTH, GSM, and so on.

XIII. PROBLEM STATEMENT

The unit is a mounting device that monitors a single transformer in real time. This gadget opens the way for a smarter grid system, allowing residents to enjoy the basic requirements of modern life without the worry or stress of extended electricity outages. Currently, power providers rely largely on consumer reactions to give vital input when a transformer blows or the electricity goes out. This is not an effective method of detecting whether a transformer requires repair or when the power provider should be contacted. For example, an elderly couple lives in the country and only has a cordless house phone. A lightning storm sweeps across the area, striking the single transformer in the area, knocking out all of the power in the old house as well as the only phone they have. The elderly, who rely on electricity to keep their emergency air pumps going, must now worry about running out of backup battery power. Because the downtime is dependent on the customer's abilities, it must be replenished. GSM is used in the traditional way. Because IoT is less expensive than SMS, system monitoring is more dependable and accurate reading data are obtained from energy-using devices. The Android application may display live device readings. The readings are also available to view online. Human intervention is avoided, and all values are maintained on a central server. In comparison to the intended system, maintenance is inadequate.

XIV. PROPOSED METHOD

A. Objective

The Transformer Monitoring System's ultimate objective is to read and record useful information about pole-mounted or ground-based transformers in an efficient and precise manner. After being captured, the data is transmitted to a central hub computer placed at the electric company's transfer stations or substations through wireless links. The daemon application, which is installed on the computer, sends the data to a database on the electric company's server. The online application then shows all of the data in a tidy, clear, and structured manner, allowing energy providers to quickly detect a power line problem. Due of the huge number of transformers in a given radius, many major aims of this device were being relatively cheap and tiny enough to fit on the same pole as the transformer. Apart from those two purposes, the device is divided into three areas, each with its own set of aims and objectives: power, sensors, and logic hardware. The device's power supply is the most important component of this project, and it comes with a lot of demands and requirements to meet. For example, to run our system, our gadget requires a little quantity of electricity from the power cables itself. Because of the risks associated with working with high-voltage power lines and the potential for external contact, safety was the primary goal.

The transformer also has to be trustworthy and not interfere with existing electrical lines. Because the dependability of any product is always a top consideration, our device had to operate within a specific voltage, current, and temperature range. Any high value of the three would damage our device's internal components, potentially wasting time and money for the electric company. Three sensors measure the voltage and current across the lines, as well as the temperature inside the transformer. The goal was to attach a coil to both the input and output lines in order to record both the high and low sides of the voltages and currents.

The components had to convey information to the wireless elements without losing precision, which was the second main aim. This phase was critical since the detection system and warning mechanism would not function properly if any of the data got corrupted or changed in any manner. We attempted to keep the overall cost of the complete package to a few dollars because today's microchips are only a few cents to produce. Another aim we sought to achieve was making the microchips as simple to remove and install as possible. These characteristics enable the client to repair any broken portion of the logic circuitry quickly and efficiently at a cost-effective price. Finally, the Transformer Monitoring System should be able to achieve all of the aforementioned goals and objectives. These goals and objectives assured that our gadget system operates efficiently and successfully in every circumstance it may face in the actual world.

The notion of the IoT allows us to link everyday objects to one other over the internet. The IoT idea allows for remote analysis of linked devices. The IoT idea establishes the necessary infrastructure and opportunity for establishing a link between the real world and computer-based systems. The notion is gaining traction as the number of wireless devices on the market continues to grow at a rapid pace. Over the internet, hardware devices communicate with one another. The ESP 8266 Wi-Fi module used in the system allows the system to connect to the internet. Electricity consumption is rising at a steady rate in the population these days, and it is being used for a variety of reasons such as agriculture, industry, home uses, hospitals, and so on. As a result, managing power maintenance and demand is getting increasingly difficult.

As a result, there is an immediate need to conserve as much energy as possible. As the need for power from younger generations grows, so does the necessity for technological advancement. The suggested system makes advantage of IoT technologies. There are also other concerns to solve, such as electricity theft, which results in economic loss for the country. The key objectives that lay ahead for a better system are monitoring, optimized power consumption, and reduced power waste. The Smart Sub Station energy meter with Wi-Fi system was created with three primary goals in mind.

They are: -

1. To offer instantaneous automatic load energy readings.
2. Cut down on electricity waste.
3. To enhance the power quality.
4. Using remote sensing to ensure supply continuity

5. Monitoring in real time.

The data from the system is posted on a webpage that the EB service provider may view. The Arduino microcontroller is at the heart of the system. The project is divided into three sections: a controller, a theft detecting circuit, and a Wi-Fi device. The controller is in charge of performing the fundamental computations and processing the data. Stolen detection circuit gives information about any excess or theft load energy readings, and the Wi-Fi unit plays the most essential function in sending data from the controller over the Internet. The Arduino controller is programmed using the Arduino software IDE (Integrated Development Environment), which is required in order for the Arduino board to function. It uses the C programming language to write its code. The Internet of Things allows users to connect to a wide range of embedded devices and online services from any location on the planet. ThingSpeak is an open data platform that lets us gather, store, analyze, and visualize data from sensors like Arduino, the Beagle Bone Black, and other devices. Data fields, location fields, and a status field are all available in Thingspeak. After creating a ThingSpeak channel, we may submit data to it, analyze it, and receive it based on the sensors. The suggested method may be utilized to show Watts-based load energy use readings. Every user would have access to the data from anywhere on the planet. Thingspeak.com is an example of a website that uses MathWorks MATLAB analytics to offer device data in a more thorough way, both in terms of explanation and visualization. Thingspeak.com allows users to add any number of channels to a single account, with information supplied into eight fields per account. An account may be allocated to a single area division, and n channels can be formed for a set of n meters in the area. Both the consumer and the service provider have access to the analytics.

Power Supply

The following is a list of the blocks:

- A transformer is a device that converts high-voltage AC mains to low-voltage AC.
- Rectifier - converts AC to DC with variable DC output.
- Smoothing - Reduces the DC's range of variation to a tiny ripple.
- Regulator - reduces ripple by setting the DC output voltage to a constant value.

Analysis of Transfermor Faults

There are certain significant problems that occur in transformers that should be examined and monitored on a regular basis so that they may be linked to the issues listed below.

B. Proposed Block Diagram

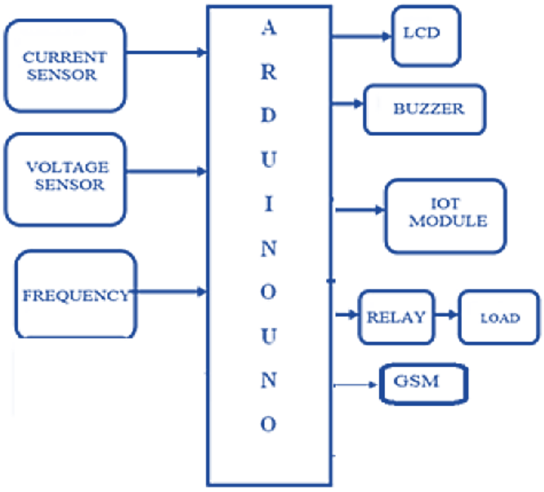


Fig. 1 Proposed Block Diagram

Over Load

The current flowing through the transformer as a result of power system failures is known as over load / over current. Because protection relays normally work to separate problems from the power supply, over current circumstances are usually brief (less than two seconds).

Over / Under Voltage

The applied voltage is directly proportional to the flux in the transformer core, whereas the frequency is inversely proportional. When the per-unit ratio of voltage to frequency (Volts/Hz) reaches 1.05 p.u. at full load and 1.10 p.u. at no load, over voltage might develop.

Temperature

If the absolute temperature of the windings and transformer oil stays within prescribed limits, excessive load current alone may not cause damage to the transformer. The ratings for transformers are based on an average ambient temperature of 30°C (86°F) during a 24-hour period. Temperature of oil rises as a result of excess voltage and current, causing transformer winding insulation to break.

Oil Level Fault

Oil is primarily used in transformers for two purposes: one, to cool the transformer, and the other, to provide insulation. Due to the heating effect, when the temperature of the transformer rises, the oil level in the transformer tank falls. The transformer oil level should be kept at the necessary level for normal functioning. If the oil level falls below the necessary level, the transformer's cooling and insulation will suffer.

XV. BLOCK DESCRIPTION

A. IOT AND GSM

A low-cost automation system for a small substation based on current IoT and GSM technology and embedded processors such as the ARDUINO UNO. This has the benefit of cost savings as well as a wide range of connectivity choices. The Arduino IDE software is utilised to operate a feeder with the aid of a GSM module in this article. Analog and digital field characteristics are monitored and controlled via the Arduino Uno controller's analogue pins, interface relays, and communication ports. The automation sequences for system control, monitoring, and protection are designed using a c programme that communicates the input parameters through GSM networks on a regular basis. The relays and buzzers are controlled by the controller based on those signals. If the value is too high, the controller trips the circuit breaker, and information is sent to the user through GSM. The ESP8266 module is used in IoT, whereas the SIM800 module is used in GSM.

B. WORKING PRINCIPLE:

With the usage of GSM and IoT, the planned job is meant to be entirely automated. We can take a parameter of feeder information and breaker circuit on the output side. Voltage, current, and frequency data are gathered and compared to the value supplied in the Arduino Uno controller for information collecting and process control. If IOT is used to display changes in value and send SMS through GSM, Furthermore, the feeder data is sent to GSM, and we may manage this operation using GSM commands and the AT command. If a feeder or breaker fails, the controller sends an SMS to the user or operator. We can easily control this without any network interferences. All of the processes are handled by the Android phone, thus there is no need for a computer. We can automate the substation feeder and breaker circuit using this method. Using an LCD monitor, we can see the current progress of our project. The standard ThingSpeak process allows you to do the following:

1. Make a Channel and start collecting data.
2. Examine the facts and create a visual representation of it. The system may be used to show load energy consumption in Watts. Every user would have access to the data from anywhere on the planet.
3. Thingspeak.com is an example of a website that uses MathWorks MATLAB analytics to offer device data in a more thorough way, both in terms of explanation and visualisation. Thingspeak.com allows users to add any number of channels to a single account, with information supplied into eight fields per account.
4. An account may be allocated to a single area division, and n channels can be formed for a set of n metres in the area. Both the consumer and the service provider have access to the analytics.
5. Because IOT is less expensive than SMS, it is feasible to monitor energy use at a cheaper cost. The Android application may display live device readings. The readings are also available to view online. Human intervention is avoided, and all values are maintained on a central server.

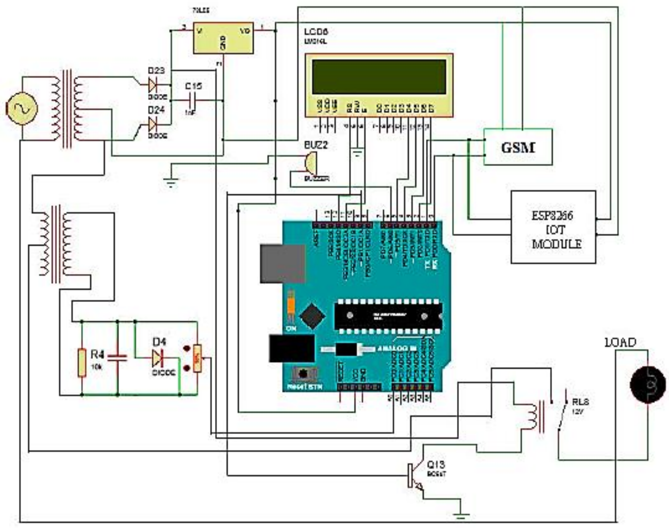


Fig. 2 proposed circuit diagram

6. The communication channel is safe, and tampering with energy metres or electricity theft may be quickly detected. The value on the central server will not be updated if the system encounters an error.

C. Software used:

1. Arduino IDE
2. ThinkSpeak

XVI. RESULTS AND DISCUSSION

The project “Transformer Condition Monitoring System Using Arduino with IoT” was designed such that the devices can be monitored using IOT module. All the read values from sensor are graphically noted using IOT in the below image. Thus, the proposed concept has been successfully implemented and tested in hardware and software.

XVII. CONCLUSION

After our project, we will be able to improve the quality of power transferred and provide an uninterrupted power supply. Sub-station Automation with IoT is a cutting-edge IoT application that allows you to operate your home appliances from anywhere in the world via the cloud. The current sensor is utilised in the proposed project to sense the current and show it on the internet via IOT. The system uses the public cloud THINGSPEAK to update the information every 1 to 2 seconds on the internet. Wi-Fi is used to access energy load usage in the current system, which will assist consumers in avoiding unnecessary electricity use. The GSM module SIM800 controls the automation in response to human commands. As a result, the project has been implemented effectively in both hardware and simulation.

Flow chart

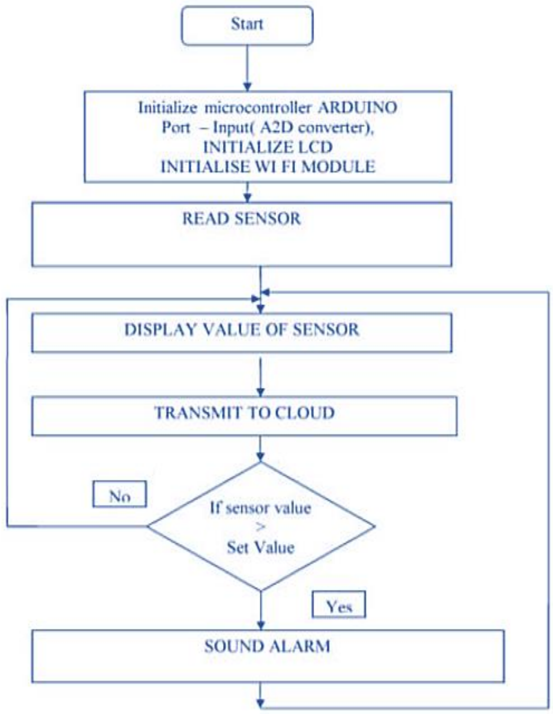


Fig.3 Flow Chart of Proposed Work

Fig. 4 IOT Server Results

REFERENCES

[1] AmitSachan "gsm based Automated Embedded System for Monitoring and Controlling of Smart grid" International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering Vol:7, No:12, 2013.

[2] Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M, " Internet of Things (IoT): A vision, architectural elements, and future directions", Future Generation Computer Systems Journal, Volume 29, Issue 7, ELSEVIER, pp.1645- 1660,2013.

[3] M. Frankowiak, R. Grosvenor, and P. Prickett, "A review of the evolution of microcontroller-based machine and process monitoring", International Journal of Machine Tools and Manufacture, vol. 45, pp. 573-582, 2005.

[4] J. M. Alonso, J. Ribas, J. Coz, A. J. Calleja, E. L. Corominas, and M. Rico-Secades, "Development of a distributive control scheme for fluorescent lighting based on LonWorks technology", Industrial Electronics, IEEE Transactions on, vol. 47, pp. 1253-1262, 2000.

[5] J. M. Alonso, P. J. Villegas, J. Diaz, C. Blanco, and M. Rico, "A microcontroller-based emergency ballast for fluorescent lamps", Industrial Electronics, IEEE Transactions on, vol. 44, pp. 207- 216, 1997.

[6] AHMED AfazUddin , KHALED Mohammed Shahriar , ALI Mohammed , RAHMAN Mohammad Mahbubur Controlling and Monitoring of Electric Feeders Using GSM Network Technology

[7] Qinghai Ou, Yan Zhen ,Xiangzhen Li, Yiying Zhang ,LingkangZeng "Application of Internet of things in smart grid power transmission 2012.

[8] G. Pudlo, S. Tenbohlen, M. Linders and G. Krost, "Integration of Power Transformer Monitoring and Overload Calculation into the Power System Control Surface", IEEE/PES Transmission and Distribution Conference and Exhibition, Vol. 1, pp: 470-474 Asia Pacific, 2002.

[9] Zhi-Hua Zhou, Yuan Jiang, Xu-Ri Yin, and Shi- Fu Chen, "The Application of Visualization and Neural Network Techniques in a Power Transformer Condition Monitoring System", In: T. Hendtlass and M. Ali eds. Lecture Notes in Artificial Intelligence 2358, Berlin: Springer- Verlag, pp: 325-334, 2002.

[10] Phutane, Pravin S., and A. K. Jhala. "International Journal Of Electrical Engineering & Technology (Ijeet)."Journal Impact Factor" 5.5 (2014): 36-43.

[11] Phutane, Pravin S., et al. "Graphene photovoltaic panel (GPP)." Advances in Electrical, Electronics, Information, Communication and Bio- Informatics (AEEICB), 2017 Third International Conference on.IEEE, 2017.

Maintenance Schedule of Substation Equipped with Transformers up to 1000 kVA

Bibhu Prasad Panda, Rajat Bisoe, Subhashree Mishra, Swetaleena Sahoo
M.Tech Research Scholar, Electrical Engineering, Indira Gandhi Institute of Technology, Sarang, Dhenkanal, Odisha, India

Abstract: Our modern power system equipped with sensitive equipments for better efficiency for the generation, transmission and distributions. The equipments needs proper maintenance and proper monitoring for quality power flow. For both commercial and domestic power supply, each section associated with the power system should be kept under proper and experienced supervisions. This paper illustrates the maintenance schedule for the various types of equipments associated with the substation and highlights the inspection schedules and the actions required for the quality maintenance.

Keywords: Maintenance, Transformer, Substation, Circuit Breakers, Power quality.

1. Introduction

Planned maintenance is a task that has a time limit and a technician's assignment. It might be a recurrent task performed on a regular basis or a single task. Planned maintenance primarily aims at decreasing reactive maintenance, failure of equipment and backlog of maintenance. The maintenance schedule is a valuable tool for reducing costs and ensuring property operation and look. This enables the most efficient and cost effective job to be done. An example of planned maintenance at repeated intervals is replacing a conveyor belt per 30 days or checking the motor's condition each 90 days. Planned maintenance might also be a one-time request. If an asset or part problem is detected, the asset must be examined and repaired for a period of time. Planned maintenance primarily aims at decreasing reactive maintenance, failure of equipment and backlog of maintenance. Standard controls assist to enhance asset life and to decrease the number of repairs and replacements to the equipment. The planning tasks also help you to deploy resources more efficiently and cost-effectively. Often interchangeable during scheduled maintenance and planned maintenance. Planned maintenance is the anticipation of maintenance activities and the implementation of a process to complete these works. This encompasses everything from how to identify a task, the materials and processes needed to analyze the completed tasks. The planned maintenance includes reactive maintenance, preventive maintenance, condition-based maintenance and predictive maintenance in all forms and sizes. Whether it runs a light bulb till it breaks, whether it lubricates the engine bi-weekly, it is a scheduled maintenance, provided there is a strategy in place to solve a condition. Scheduled maintenance is the decision to complete and finish the planned maintenance activities. During planned maintenance, scheduled maintenance is an element of the process. If a problem or job is discovered, a deadline can also be set to a technician for completion. This is when maintenance is planned.

2. During transformer repair, the safety precautions should be followed:

Ensure that all methods and solutions are safe.

- Separate the transformer correctly from the power supply and earth it.
- Unseal the tank and unscrew the nuts and bolts and Check & record the oil level in the tank.
- Ensure that the location of work is an evidence of the fire.
- “NO SMOKING” Place this Caution board.
- The personnel are not supposed to carry a watch or ring in their chest pocket.

3. The following items are used in different substation schedules equipped with transformers up to 1000 kVA:

a) 3.1 Daily Schedule

Items	Schedule Inspection	Action required
Switch yard		
All jumpers & other connections	Check visually for flash/ spark marks	Tighten the respective bi-metallic clamp/ connection
Transformer		
Temperature	Check oil temperature during peak load hours. Check ambient temperature	Either switch off some load or share with other transformer
Tank	Check for oil leakage	Arrest the leakage
Dehydrating breather	Check visually colour of silica gel	Ensure blue colour of silica gel
Control Panel Room		
Relays	Check visually target position	Take corrective action
MCCB/Fuse		
Load (amp.)	Check against rated figure	Reduce load if higher
Voltage	Check against rated figure	Take corrective action
PF meter	Monitor the PF reading	Take corrective action. It should be nearly unity
General	Ensure general cleanliness of room and panels	
Capacitor Bank		
All connections	Check visually for flash/ spark marks	Tighten the clamp/ connection

b) 3.2 Monthly Schedule

Items	Schedule Inspection	Action required
Switch yard		
Yard	Growth of unwanted shrubs, garbage etc.	Keep the yard free from shrubs, garbage etc.
Earth pits	Check neatness and tidiness	Maintain tidiness and do watering
Earth connections	Check all connection ends at earth pits and metal parts	Ensure solid connection
Transformer		
Oil level	Check oil level in conservator	If low, top up with dry oil.
Connections	Open terminal box cover and check connections visually for flash/spark marks	Take corrective action
Dehydrating breather	Check air passages. Check colour of silica gel	Clear passages, if required. Reactivate silica gel if found pink
Cleaning	Entire transformer body externally	Clean entire transformer externally including bushings
Buchholz Relay	Check gas in the chamber	Take corrective action
Control Panel Room		
Load (amp.)	Check load balancing	If found unbalance, distribute the load equally on all phases
MCCB/Fuse	Check current ratings	Provide proper size of MCCB/ Fuse according to load condition

c) 3.3 Quarterly Schedule

Items	Schedule Inspection	Action required
Switch yard		
Support Insulators	Examine for cracks, rust and flash/ spark marks	Clean and replace if required
Lightning arresters	Check line and earth connection	Clean and ensure rigid connection
AB switch/ Isolator	Check for proper operation Check line and earth connection	Clean and lubricate Ensure rigid connection
Jumpers	Check all jumpers	Tighten, if required
HT bus bars	Examine bus-bar expansion joints etc.	Tighten, if required

d) 3.4 Half Yearly Schedule

Items	Schedule Inspection	Action required
Transformer		
Bushing	Examine for cracks, rust and flash/ spark marks Check for oil seepage	Clean and replace if required Arrest leakage
Control Panel Room		
Load (amp.)	Check load balancing	If found unbalance, distribute the load equally on all phases
MCCB/Fuse	Check condition for overheating	Replace, if required
LT Bus bars	Check visually for overheating, flash/ spark marks	Take corrective action

e) 3.5 Yearly Schedule

Items	Schedule Inspection	Action required
Switch yard		
Concreting/ coping of the supports	Check the condition of the concreting/ coping of the supports of the structures. The supports fixing to earth become weal and during the time of heavy rains, cyclone or flooding, the structure may fall, leading to a major breakdown.	If there are cracks or the coping of concreting is coming off, preventive action may be taken to concrete or coping.
Gravel/crushed rock	Check leveling, oil stain and dust accumulation	Spray water to remove oil stain and accumulated dust. Maintain leveling to avoid formation of water pools.
Earth resistance	Measure the earth resistance of individual equipment earth pit, preferably during summer	If it is beyond permissible limits, take corrective action
Earth connection of metal parts	Check the earth connection of metal parts to ensure that the metal parts are properly connected to the earth so that any earth fault of the metal parts is cleared quickly and efficiently. If not, accidents may happen.	Take corrective action
AB switches	Check operation.	Lubricate and ensure proper operation
	Check the line and earth connection of AB switches.	Ensure they are connected properly
HT lightning arresters	Measure IR value Line-Earth	If low, replace it.
	Check the line and earth connection of HT lightning arresters	Ensure they are connected properly
Connections from and to bus-bars	Check the connections	Tighten the connections properly from the bus bars and bars to the lines.

Items		Schedule Inspection	Action required
	Oil	Check BDV	If BDV < 30 kV/cm, do filtration to restore quality of oil.
		Check for incipient faults	Perform dissolve gas analysis (DGA) as per annexure - B
	Buchholz relay, alarms and their circuits etc.	Check floats, alarm contacts, their operation, fuses etc. Check relay accuracy, etc.	Clean components and replace contacts and fuses if necessary. Change the setting, if necessary.
	Earth resistance	Check values of earth resistance	If high, investigate and take corrective action
	Body	Check for peelings/ rusting/ damage	Repaint, as required
	Cable box	Check the sealing arrangement for filling holes	Ensure sealing arrangement for filling holes

f) 3.6 Five Yearly Schedule

Items		Schedule Inspection	Action required
Switch yard			
	Gravel/crushed rock	Check condition, up layer and size	Remove rounded pieces and muck by screening. Maintain up layer of 100 mm by additional quantity of size 40mm
Transformer			
	Conservator	Inspect inside for sludge etc.	Clean or flush inside with oil
	Core and windings	Overall inspection including lifting of core and coils	Wash with clean dry oil.
	Rollers	Examine carefully during overhauling	Grease them properly
	Circuit breaker	Examine carefully during overhauling	Overhaul every circuit breaker completely

4. Conclusion

The planned and corrective maintenance is necessary for all substation equipments. This paper devoted that each equipment associated with the modern power system should be examined properly for stable and smooth power generation, transmission and distribution purposes. The daily, monthly, quarterly, half yearly and yearly maintenance schedules for each core equipments fopr the substation illustrated in this paper. It will guide the researchers and readers to acquire sufficient knowledge on maintenance schedule of substation equipments.

References

1. Power System Commissioning and Maintenance Practice (Energy Engineering), Keith Harker, 30 June, 1997
2. Electrical Equipment Handbook: Troubleshooting and Maintenance, Philip Kiameh, ISBN: 9780071396035, 2003, The McGraw-Hill Companies, Inc.
3. Maintenance Scheduling in Restructured Power Systems, Shahidehpour, M., Marwali, M.
4. https://www.fiixsoftware.com/scheduled-maintenance-critical-percent/
5. https://www.pega.com/digital-
6. prescriptive-maintenance

FAULT LOCATION ESTIMATION ON OVERHEAD TRANSMISSION LINE

Aitihyajeet Mohapatra
Department of Electrical Engineering
Indira Gandhi Institute of Technology
Sarang, Odisha, India
aitihyajeetmohapatra@gmail.com

Kali Charan Pradhan
Department of Electrical Engineering
Indira Gandhi Institute of Technology
Sarang, Odisha, India
kali4028@gmail.com

***Abstract*- Electric power transmission lines transmit bulk amount of power from the generating plants to the substation to deliver electricity to consumers at their homes, offices and industries. So it is always necessary to maintain the smooth operation of the transmission lines so as to provide a minimum interrupted power supply. Fault in transmission lines are common and it has to be detected quickly to restore the power supply within minimum time interval. So it is very important to have the knowledge about the fault location in the transmission line. The purpose of this paper is to detect the location of the different faults on a transmission line from the sending ends. In this paper, we discuss about the impedance based fault location detection method in transmission line.**

Keywords—transmission line, fault location estimation, impedance based method.

XVIII. INTRODUCTION

The electric power system is the combination of generation, transfer, and use electric power. A bulk amount of electric power is transmitted from a generating site to an electrical substation. The interconnected lines that transmit the electric power from generating site to the substation are known as a transmission network. Transmission lines experience both temporary and permanent faults. When there will be a permanent fault occur in the transmission line the restoration of power supply can be done only after the damaged caused by the fault will repair. For this purpose we have to know the fault position otherwise we have to inspect the entire transmission line to find the damage. This work becomes very difficult as the high voltage transmission lines have the length of hundreds of kilometer or in case of underground cable the cables have to be uncovered. So it requires more man power or in case of populated area the roads have to be blocked. Thus, it becomes important that the fault location is either known or can be estimated with a reasonable accuracy. This results in saving of time and money for the inspection of fault location.

II. METHODS OF FAULT LOCATION ESTIMATION

They are different methods that are used to estimate the fault location on the transmission line. These methods are classified as impedance based method, travelling wave method, artificial neural network based method. In this paper we discussed about the impedance based method. The impedance based method, the fault location is calculated from apparent impedance by considering the line from one end or two ends. In this method we have to calculated phase to ground voltage and current in each phase.

The impedance-based fault location method is divided into

1. One- end impedance method
2. Two- end impedance method

In case of one-ended impedance method, the date of voltage and current of end is required but in the case of two-end impedance method, both side data is required. The two end method is quite accurate than the one end method.

The most popular impedance based methods are discussed below.

1. Simple reactance method (one-ended)
2. Takagi method (one-ended)
3. Modified Takagi Method

1. SIMPLE REACTANCE METOD

In the simple reactance method, the apparent impedance is measured and then ratio of the measured reactance to the reactance of the entire transmission line is determined. This ratio is proportional to fault location on transmission line. The reactance fault location method depends on positive sequence impedance (Z_{1L}) and zero sequence impedance (Z_{0L}) to determine the fault location on the transmission line.

Tabulation for simple reactance method

Fault Type	Positive Sequence Impedance Equation (mZ_{1L})
a-g	$V_a/(I_a+3*k*I_0)$
b-g	$V_b/(I_b+3*k*I_0)$
c-g	$V_c/(I_c+3*k*I_0)$
a-b or a-b-g	V_{ab}/I_{ab}
a-c or a-c-g	V_{ac}/I_{ac}
b-c or b-c-g	V_{bc}/I_{bc}
a-b-c or a-b-c-g	V_{ab}/I_{ab} or V_{ac}/I_{ac} or V_{bc}/I_{bc}

Z_{0L} is the zero-sequence line impedance,
Z_{1L} is the positive-sequence line impedance,
m is the distance to fault from the sending end
I_0 is the zero-sequence current

$$V_s = m * Z_{1L} * I_s + I_f . R_f$$

Where,
I_f is the fault current
R_f is the fault resistance
V_s is the phase to ground voltage for a given fault
I_s is the compensating current

$$m * Z_{1L} = \left(\frac{V_S}{I_S}\right) - R_f * \left(\frac{I_f}{I_S}\right) \quad (2)$$

The imagery part in the equation (2) is only computed, to compensate the effect of fault resistance

$$m = \frac{Imag\ (\frac{V_S}{I_S})}{Imag\ (Z_{1L})}$$

2. TAKAGI METHOD

The Takagi method requires both pre-fault and fault data. This method reduces the effect of load flow and minimizing the effect of fault resistance it is more improved method than simple reactance method.

In this method, the value of current and voltage of the transmission line from one end is used to calculate the fault location. This method required pre fault current value so the value is stored just before the fault will occur on the transmission line.

$$m = \frac{Imag\left(V_S * (I_{sup})^*\right)}{Imag\left(Z_{1L} * I_S * (I_{sup})^*\right)}$$

V_s = source voltage
I_s = source current
I_{sup} = superimposed current

3. MODIFIED TAKAGI METHOD

This method is the modified version of Takagi method, which eliminates the requirement of pre fault data. This method uses the zero-sequence current for ground fault. This means method does not requires pre-fault data. Modified Takagi method suitable for ground fault does not require pre-fault current measurement.

In this method it is assumed that the zero sequence system voltage is homogenous. The angle correction (T) can be calculated by using the zero sequence fault current, if the source impedance and zero sequence impedance values are known.

$$m = \frac{Imag\left(V_S * (3 * I_{0S})^* e^{-jT}\right)}{Imag\left(Z_{1L} * I_S * (3 * I_{0S})^* e^{-jT}\right)}$$

TRAVELLING WAVE METHOD

Transient voltage and current waves will travel from the fault location in both directions towards the terminals to where the conductor is connected, when there is a fault occurs on a transmission line. The travelling wave fault location method requires the arrival instance of one or more of these fault waves. The fault location can be estimated from the information extracted from the data.

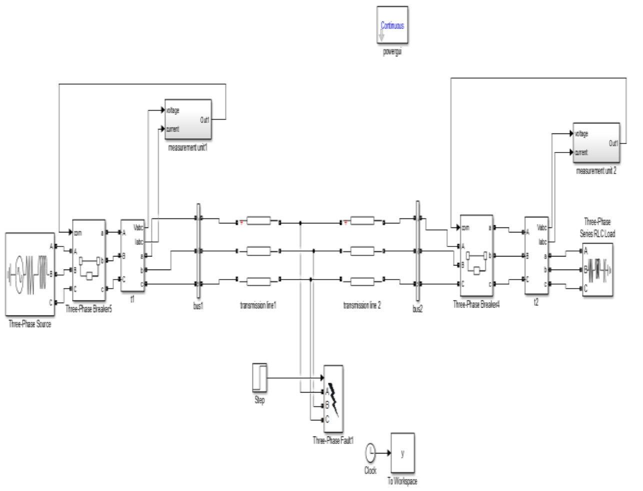
$$x = \frac{v_n * \tau_d}{2}$$

Where,

v_n is the velocity of n^{th} mode of wave

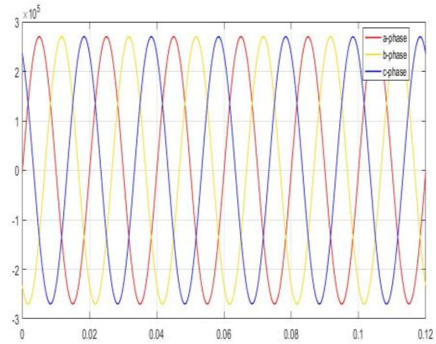
τ_d is the time difference between the time arrival of the first two waves from the fault

III. SIMULATION MODEL

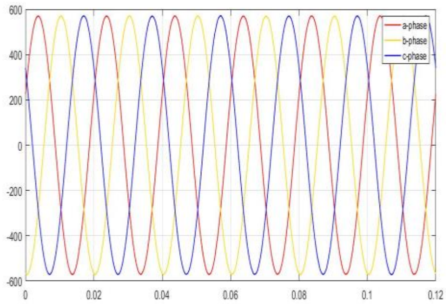


TRANSMISSION LINE SIMULATION MODEL

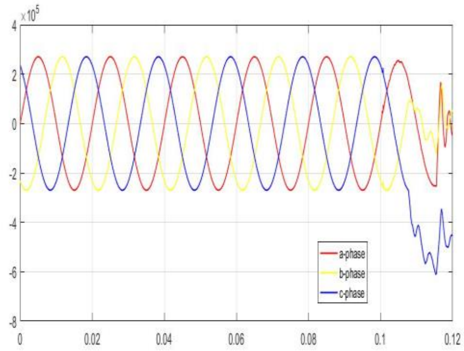
IV. SIMULATION OUTPUT



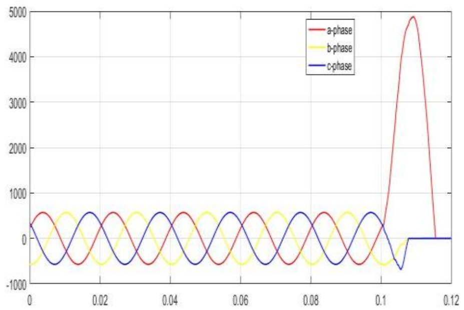
VOLTAGE WAVEFORM MEASURED AT SENDING END



CURRENT WAVEFORM MEASURED AT SENDING END



VOLTAGE WAVEFORM MEASURED AT SENDING END DURING A-G FAULT



CURRENT WAVEFORM MEASURED AT SENDING END DURING A-G FAULT

V. TABULATION

RESULT FOR SIMPLE REACTANCE METHOD

Parameter of Transmission line	Value
Total Length	400 km
Normal frequency	50Hz
Zero sequence resistance	0.3864 Ω/km
Zero sequence inductance	0.004126 H/km
Positive sequence resistance	0.01273 Ω/km
Positive sequence inductance	0.0009337 H/km

RESULT FOR SIMPLE REACTANCE METHOD

For transmission line length 200 km

Type of fault	Fault location(km)	Total length (km)	Calculated fault location (km)	% error
a-g	75	200	75.068	0.0906
b-g	75	200	74.99	0.0133
c-g	75	200	74.289	0.9480
a-b	75	200	75.129	0.1613
a-b-g	75	200	74.66	0.4453
a-c	75	200	75.685	0.9133
a-c-g	75	200	74.393	0.8093
b-c	75	200	74.295	0.9400
b-c-g	75	200	74.35	0.8600
a-b-c	75	200	74.921	0.1053
a-b-c-g	75	200	74.595	0.5400

For transmission line length 400 km

Type of fault	Fault location(km)	Total length (km)	Calculated fault location (km)	% error
a-g	125	400	125.587	0.4696
b-g	125	400	123.891	0.8872
c-g	125	400	124.416	0.4672
a-b	125	400	124.654	0.2768
a-b-g	125	400	124.707	0.2368
a-c	125	400	125.632	0.5056
a-c-g	125	400	125.715	0.5720
b-c	125	400	124.62	0.3040
b-c-g	125	400	123.838	0.9296
a-b-c	125	400	124.247	0.6020
a-b-c-g	125	400	124.208	0.6330

VI. CALCULATION

V_0= zero sequence voltage
V_1=positive sequence voltage
V_2=negative sequence voltage
I_0=zero sequence current
For a-g fault
$V_s=V_a= V_0+V_1+V_2$
$I_s=I_a+ 3*k*I_0$
For simple reactance method, total length 400 km, the fault location is
m= 125.587km
% error= 0.4696

VII. CONCLUSION

In this paper, we discuss about the detection of fault location on transmission lines where fault location is estimate by using impedance method. The fault location is fixed that means we have the idea about fault location but we have to estimate the location and also error. The method discuss in this paper requires post fault and pre fault signal of the three phase currents and the ground current signal at the one end of the transmission line and voltage value from one end. In this paper we have give more priority on one of one end impedance method that is simple reactance method.

VIII. FUTURE WORK

In this paper, we discuss the impedance based method that is one end impedance method and two end impedance method to calculate the fault location manually but it should be implemented by using codes so that it will less time to calculate the location. When the calculation is done by code is more faster than manual calculation and become less time consuming. In this paper, we are fixed the fault distance but we can also change the fault location and fault resistance. Similarly different fault location algorithm can be implemented to get more accurate result.

Ix. REFERENCES

BOOKS

[B.1] Hadi Saadat. "Power System Analysis" ISBN 0071239553 9780071239554.

[B.2] Grainger, John J.(2003). Power System Analysis. Tata McGraw-Hill.p.380. ISBN 978-0-07-058515-7.

PAPERS

[7] A Birajdar and S. Tajane, "Modeling and simulation of transmission line to detect single line to ground fault location", 2016 IEEE 1st International Conference on power Electronic , Intelligent Control and Energy Systems (ICPEICES), Delhi, 2016, pp1-4

[8] S. Das, S. Santoso, A. Gaikward and M. Patel, "Impedance based fault location in transmission networks: theory and application", IEEE Access, vol2.pp. 537-557,2014

[9] K. Zimmerman and D. Costello, "Impedance-Based Fault Location Experience," 2006 IEEE, Rural Electric Power Conference, Albuquerque, NM, 2006, pp.1-16

[10] M. M. Hashim, H. W. Ping, and V. Ramachandaramurthy, "Impedance-based fault location techniques for transmission lines," in TENCON 2009-2009 IEEE Region 10 Conference, pp. 1–6, IEEE, 2009

SMART HOME MONITORING SYSTEM USING ESP32 AND IOT

M. Abdul Rahiman
Department of EEE
GATES Institute of Technology, Gooty, Anantapur
Andhra Pradesh, India.
abdul0259@gmail.com

D.Manohar
Department of EEE
GATES Institute of Technology, Gooty, Anantapur,
Andhra Pradesh, India.
dasarimanohar963@gmail.com

ABSTRACT: In the today's world the security of the home is the prime concern. The traditional methods of securing our home are very easy to break and lead to theft. To protect the home, we need to install the costly security system. To overcome this problem, we are presenting IoT based solution where we can setup a smart home security system. This chapter deals with the implementation of our own monitoring system with home security. The system is designed using IoT modules and uses ESP32 micro-controller. The chapter describes the design of the system, its hardware components, software implementation, security solutions, communication, the collecting and monitoring of processed data, as well as the quantification of costs for the production and deployment of this system. The proposed system secures a house by detecting an intruder in the building, triggering an alarm and capturing it all with camera images, and then sending data to the owner's smart mobile phone.

KEYWORDS:
Esp32 Development board, Esp32 WIFI module, Magnetic-switch, Mobile phone, Siren.

INDEX TERMS:
Introduction, literature review, Methodology, Block diagram, Operation, Hardware and software requirements, result, conclusion, future scope and References

I. INTRODUCTION

A home security is the prime concern to anybody. A home security system is required to keep our belongings and valuables safe from any kind of robbery or theft. In the United States, there is a home related burglary that takes place every 13 seconds, 4 burglaries a minute, 240 an hour and nearly 6,000 a day! some of the statistics are 88% of all burglaries are residential in nature, 77% of all crimes are property crimes, 38% of all robberies are committed with guns, identity theft is the fastest growing crime in the U.S., Canada and UK,3 out of 4 homes in the U.S. Will be broken within the next 20 years. The traditional home security system is easily breakable and quite outdated. This in turns results in the robbery and also needs installation of the costly security system. The main idea was to
use the ESP32 chip, which we have installed with a camera module to remotely monitor a house. Our method consists of Esp32 Microcontroller, Magnetic and an alarm which get activated when an intruder tries to break the lock, and informs the owner by sending Notification through WhatsApp, Gmail and Telegram.

II.LITERATURE REVIEW

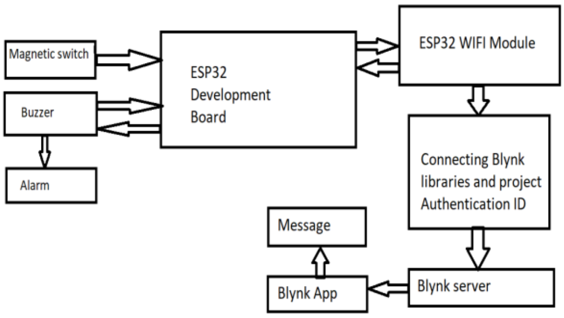
The latest technologies which are available for security includes RFID card technologyes biometric, OTP based unlock system and many more. Each of which is effective in some areas but don't provide the complete security system.
The existing system consist of IR sensor, Buzzer, GSM module, 8051 microcontroller, Infrared transmitter, fingerprint sensor. The power supply unit provides supply to all the units. The PIR sensor is used to detect the presence of a person n the house. If the PIR sensor senses any human presence. The fingerprint pattern of house members is already stored into the memory. A Person has to verify his fingerprint pattern with fingerprint sensor. If the password is correct then the door will automatically open. If any unauthorized person tries to break the door and enters into the house, the IR sensor will detect the presence of the person and it send to the controller. The buzzer will alert its surrounding people and also GSM module is used to communicatee with the owner of the house and by nearby police station. Our methodology is quite well explained in detailed; the working of the door unlock is very good, but use of Wi-Fi limits its area of coverage and home owner can access the system remotely.

III.PROPOSED METHOD

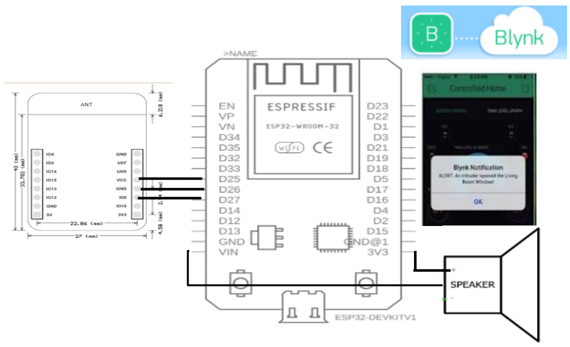
Our proposed system consists of Esp32 micro- controller which is cost effective and requires very less power to operate, Magnetic Switch and Blynk app. The main objective of this proposed work is to install a home security system, which will function to detect robbers from entering the house using esp32 camera module. As the intruders arrive/enter, the magnetic switch circuit located near the door gets open and detects the motion of the intruders and then the system will activate the camera and captures the image. Intruder alarms keep home safe and contribute to a safer neighbourhood. The captured images are then sent to users email account. In addition to that, It also contains Solenoid Lock which can be operated automatically by our smartphone.

3.1. Working: On the Esp32 development board we are connecting the Siren, Magnetic-Switch and the solenoid lock. Whenever the intruder tries to break the lock, the magnetic switch which works in the presence of magnetic field detects the someone is trying to break the lock and the camera module takes the pictures of the person and send those pictures to the owner of the house. As the board is connected to the blink libraries, the owner receives images of the intruder through Telegram, WhatsApp and Gmail, and also the Siren connected to the Board will alert the surroundings.

3.2 Block Diagram



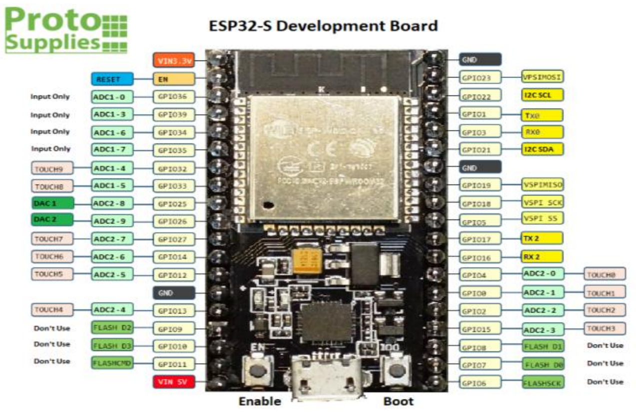
3.3 Schematic Diagram



IV. HARDWARE COMPONENTS

1. Esp32 Development Board
2. Esp32 Camera WIFI module
3. FTDI
4. Mobile Phone
5. Soleniod Lock
6. Magnetic Switch

4.1 Esp32 Development board



The Esp32 is the Esp8266 successor. The Esp32 is loaded with lots of new features when compared with its predecessor. It combines WiFi and Bluetooth wireless capabilities and dual-core.

It is a standalone chip or full-featured development board.

Features

- ✧ **Wireless connectivity** WiFi**:** 150.0 Mbps data rate with HT40
- ✧ **Bluetooth: BLE an Bluetooth classic**
- ✧ **Processor:** Tensilica Xtensa Dual-Core 32-bit LX6 microprocessor, running at 160 or 240 MHz
- ✧ **ROM:** 448 KB
- ✧ **SRAM:** 520 KB
- ✧ **Low Power:** ensures that you can still use ADC conversions, for example, during deep sleep.

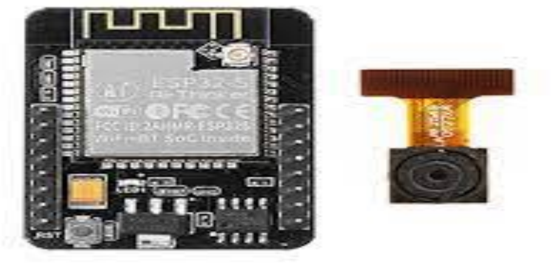
Peripheral Input/Output:

- ✓ peripheral interface with DMA that includes capacitive touch.
- ✓ ADCs (Analog-to-Digital Converter)
- ✓ DACs (Digital-to-Analog Converter)
- ✓ I²C (Inter-Integrated Circuit)
- ✓ UART(Universal Asynchronous Receiver/Transmitter)
- ✓ SPI (Serial Peripheral Interface)
- ✓ I²S (Integrated Interchip Sound)
- ✓ RMII (Reduced Media-Independent Interface)
- ✓ **Security:** hardware accelerators for AES and SSL/TLS

4.2. Esp32 Camera WIFI Module

A. *The ESP32 CAM WiFi Module Bluetooth with OV2640 Camera Module 2MP For Face Recognition has a very competitive small-size camera module that can operate independently as a minimum system with a footprint of only 40 x 27 mm; a deep sleep current of up to 6mA and is widely used in various IoT applications.*

It is suitable for home smart devices, industrial wireless control, wireless monitoring and other IoT applications. This module adopts a DIP package and can be directly inserted into the backplane to realize rapid production of products, providing customers with high-reliability connection mode, which is convenient for applications in various IoT hardware terminals.

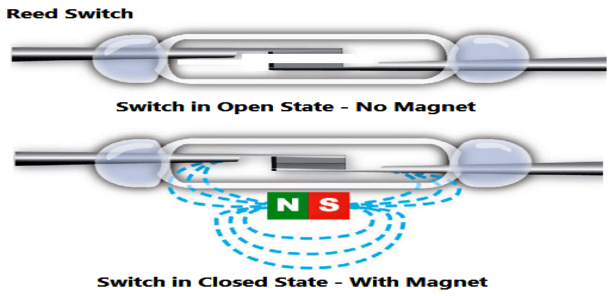


4.3 FTDI

Future Technology Devices International Limited, commonly known by its acronym FTDI, is a Scottish privately held semiconductor device company, specialising in Universal Serial Bus (USB) technology. USB to serial UART bridge products designed to allow a user to communicate with a serial UART through a common USB port. It is harder to find computers with serial UART ports on them these days, but super common to find serial devices. Many of the official NODEMCU ESP32 and clones share a common interface. This interface is essentially the 6 pin Single-In-Line (SIL), 0.1” pitch version of FTDI's TTL-232R cables.

4.4 Magnetic Switch

Magnetic door sensors, also called reed switches, are sensors that use a magnet to establish whether a door is open or closed.It consists of two parts encased in a plastic shell - a magnet and a sensor/switch.In combination, it basically works by opening/closing a reed switch by using the magnet’s magnetic field. When the two parts are next to each other the switch is closed and when they are far apart the switch is open.



4.5.Siren:

Electronic sirens are increasingly used for mass warning systems due to their advantages of low energy consumption and low maintenance effort. Their modular construction offers individual structure and power stages possibilities.

Siren

4.6. SOLENOID LOCK

The solenoids are simple electrical components and it has many uses in daily life. The term itself is derived from the Greek name “solen”, which illustrates a channel or a pipe. The second part of the name is taken from the Greek name “eidos”, which refers to an outline. Basically, it is a component in the form of a pipe. The solenoid is used in a variety of applications, and there are numerous types of solenoid designs available. Each of them has their own properties that make it useful in many precise applications. The various designs of these components do not change their necessary operating feature and the designing of the solenoids can be done in different ways. Generally, solenoid works on general electrical principle, but the mechanical energy of this device is distributed in a different way in different designs.

Solenoid Lock

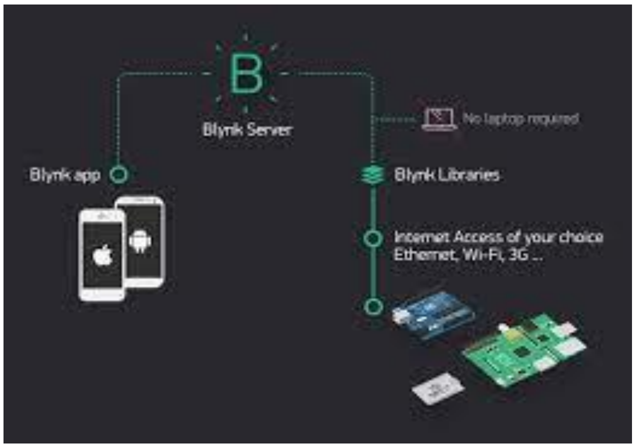
4.6.1 Working Principle: A solenoid is a very simple component, that includes a coil of wire that is covered around a core made out of a metal. When a current is applied to the solenoid, it has the effect of assembling a consistent magnetic field. Electricity changes to magnetism then it changes to electricity and, therefore, these two forces are united into one.An attractive thing about the uniform field in a solenoid is that, if the solenoid has an immeasurable length, the magnetic field would be the similar everywhere along the element. In a solenoid, sometimes this translates to very small electrical components being able to do a marvelous amount of work. For instance, a powerful solenoid can simply slam shut a valve that would be demanding for even the burliest plumber to close by hand.

V.SOFTWARE REQUIREMENTS

BLYNK APP

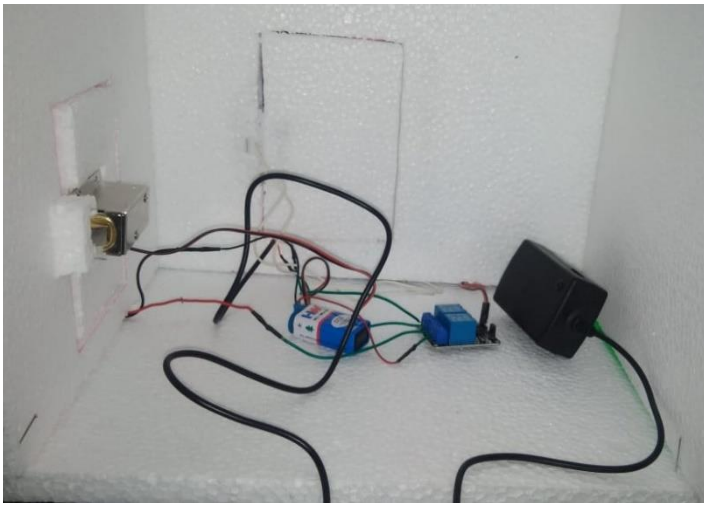
Blynk is a new platform that allows you to quickly build interfaces for controlling and monitoring your hardware projects from your iOS and Android device. After downloading the **Blynk app**, you can create a project dashboard and arrange buttons, sliders, graphs, and other widgets onto the screen.
Blynk doesn't run on Windows Phones, Black-berries and other dead platforms.Blink can run over 400 hardware connected modules.
To connect your hardware to the Internet, you can choose almost any module either built-in, or external shields

Supported connectivity:
- WiFi
- Ethernet
- Cellular (GSM, 2g, 3g, 4g, LTE)
- Serial
- USB via your PC
- Bluetooth (BETA)



VII. RESULT

When an intruder tries to break the lock it sends notification to the owners mobile and also alerts the surroundings, this helps in catching the intruder.



Solenoid position inside the house

Magnetic Switch position

The components are placed inside the house as show in the prototype. The magnetic Switch is placed at the edges of the door. When the intruder tries to break the door the magnetic switch -magnetic field get disturbed and it operates relay and the Owner get notification about the Intruder.

Home Survelliance System

Top view of Home Survellience system

VIII.CONCLUSION

In this paper we have proposed and demonstrated smart home security approach which requires less cost and provide the security to our home. We have the system with the help IoT and Esp32 microcontroller. The proposed implementation uses IoT enabled devices and provides end user with cost effective, portable smart surveillance system and no need of an individual to monitor persistently from control room. Suggested implementation successfully works within the vicinity of soft access point and can be easily implemented at the cost of meagre amount. Since ESP32 along with camera module is the main part of this design, the surveillance and automation are cheaper. Using this design owner could monitor and be alerted any time even if he/she is in any part of the world and can make suitable actions as we are using Internet of Things Technology. This real time system allows us to detect the stranger when he breaks the door and give notification to the owner on his Gmail, WhatsApp and Telegram regarding this and can automatically open and close the solenoid lock.

IX. ADVANTAGES

1.Protect Valuable is the most important benefits of the security system.

2.In many case we lost our many valuable things due to home invasion.

3.A home security has an alarm that scares off many unwanted things and can notify on phone application if someone tries to break-in.

4.Remote surveillance allows you to remotely access to home security system at any hour of the day, from any location. Individual can monitors what happens via cameras through phone as well as lock door and other devices also. With a home surveillance, don't need to worry about home safety.

5.In case of a power failure if problem arise the security system has a backup plan for it and which provide the backup p4ower after the power failure.

X. FUTURE SCOPE

If above security system integrated with internet connectivity through ZigBee module it will help to monitor intrusion remotely from anywhere.

Somewhere we can implement this system to work on real time processing for providing the live recording with camera. System is easy to extend further with different modules and various sensors as per requirement of home.

XI.REFERENCES

1)IndiaBurglaryRate,20032016:https://knoema.com/atlas/India/topics/Crime-Statistics/Burglary-Car-Theft-and Housebreaking/Burglary-ra te

2)https://www.intechopen.com/online-first/smart-home-monitoring-system-using-esp32-microcontrollers.

3)https://robu.in/product/esp32-cam-wifi-module-bluetooth-with-ov2640-camera-module-2mp/

4)https://www.sciencedirect.com/topics/computer-science/magnetic-switch

5)Atmajaya D, Kurniati N., Astuti W, et al. Digital Scales System on NonOrganic Waste Types Based on Load Cell

and ESP32. East Indonesia Conference on Computer and Information Technology: Internet of Things for Industry, EIConCIT 2018. DOI: 10.1109/EIConCIT.2018.8878667.
6)https://www.oreilly.com/library/view/esp8266-robotics-projects/9781788474610/360d44d6-1f01-4176-8a51-c0426d74ce78.xhtml
7)Jiakailin Wang, Jinjin Zheng, Shiwu Zhang, Jijun He, Xiao Liang and Sui Feng, "A Face Recognition System Based on Local Binary Patterns and Support Vector Machine for Home Security Service Robot", 2016 9th International Symposium on Computational Intelligence
8)Anjali Patel, "IoT based Facial door access control home security system", "International Journal of Computer Applications, August 2017

Hot Spot: The Key in Deciding the Residual Life of Transformer

Amalendu Mohanty
Power transformer designs Ex BHEL, Expert Alstom T&D
Ex Technical adviser TBEA Transformers, India
E-mail: amalmohanty@yahoo.com

Jagannath Padhi
Department of Electrical & Electronics Engineering
CUTM, Bhubaneswar, Odisha, India
E-mail: jpadhi@cutm.ac.in

Abstract: **This work presents a philosophy behind temperature rise in a transformer. Transformer temperature rise and gradient plays an important role in effective operational delivery. It is a very critical aspect in terms of design and loading. The life expectancy of any transformer depends on gradient & hotspot rather the temperature rises, if the transformer is withstanding this adverse condition, then it will have good life expectancy. There is different aspect of hot spot temperature which is discussed in this paper. With deeper analysis the authors explained in details winding temperature rise, oil temperature rises and rationale of temperature gradient, how temperature rise test is done with life assessment.**

Keywords: Hot spot in Transformer, Winding Temperature Indicator (WTI), Hot Spot Temperature (HST).

I. INTRODUCTION

A transformer with big MVA capacity termed as a large power transformer needs to be assessed for its residual life in operation. The risk of an unprecedented failure by the degradation of health in normal operation or ageing is very high for this cost intensive equipment in terms of the capital involved and the damages of the outage from operation [1, 2]. A proactive judgment on the residual life keeps the operator prepared for these contingencies in future and budgeted in advance [3]. Though it is an electrical equipment, the life expectancy of a transformer in operation is governed by the temperature it experiences [4].

The temperature degrades the insulation and gradually the degree of polymerization DP value of the cellulose-based class A insulations in use in the transformer reduces. DP basically reflects to the tensile strength of the insulation [5]. We are aware that the paper of the books of our grandfather becomes brittle when it is folded. That shows the value of DP has gone down. It is estimated that when the DP of the insulation reaches a value of 200 it is considered that it has reached its life [6].

When we refer to the temperature, normally two temperatures come to our mind as mentioned in the rating and diagram plate attached to the transformer [7]. They are: - A. Top oil temperature rise B. Average winding temperature rise. However, the temperature that counts for the health of the insulation structure and oil of a transformer and subsequently the life is the Hot Spot Temperature (HST) [8]. The HST is an absolute value and is the sum of Top oil temperature and the Hot spot gradient. This HST is what the Winding Temperature Indicator (WTI) fitted to the cooling control cubicle supposed to read [9,10].

Concept of overloading: - Unlike a generator transformer all substation transformers are expected to be overloaded when circumstances demand [11]. And an over load shoots up the temperature of the unit. It needs an ICU for the health to be monitored and treated properly to avoid a death. When we speak of temperature its again the Hot Spot Temperature [12]. The energy kills. When we speak about energy it is not only the temperature but also the duration. International and national standards have provided guidelines to allow the amount of overload and its duration to avoid unusual ageing of the transformer insulation [13].

The advantage of class A insulation is once it crosses an absolute temperature of 98 Deg C the ageing process becomes abnormal and the life expectancy drops. However, if for some reason the temperature stays below 98 Degs like drop in ambient temperature at night with the similar loading conditions the health recoups. But there is a limitation on this maximum temperature beyond which the damage done becomes irreversible [14].

The top oil temperature can be measured directly by connecting a capillary from the thermometer pocket on the cover and the OTI instrument mounted inside the marshalling box or on the tank. It is a direct measurement [15]. Gradient is the temperature differential between the winding and the local oil at a cross section of the winding (refer the sketch below). The thermal energy is a function of the load current hence the gradient depends on the load connected to the transformer.

At no load the gradient does not exist [16] and WTI reads same as OTI. Ideally the hottest spot inside the transformer should be the addition of top oil temperature and the winding gradient. But it has been observed that the hot spot gradient may be much higher than this or lie away from the winding [17]. The leakage flux produces stray loss on the magnetic tank wall, turrets and steel frames. The eddy loss gets concentrated at localized spots and develops local hot spot. A blocking of cooling ducts inside the winding during manufacturing leads to unusual gradient at local areas which shoots the gradient [18].

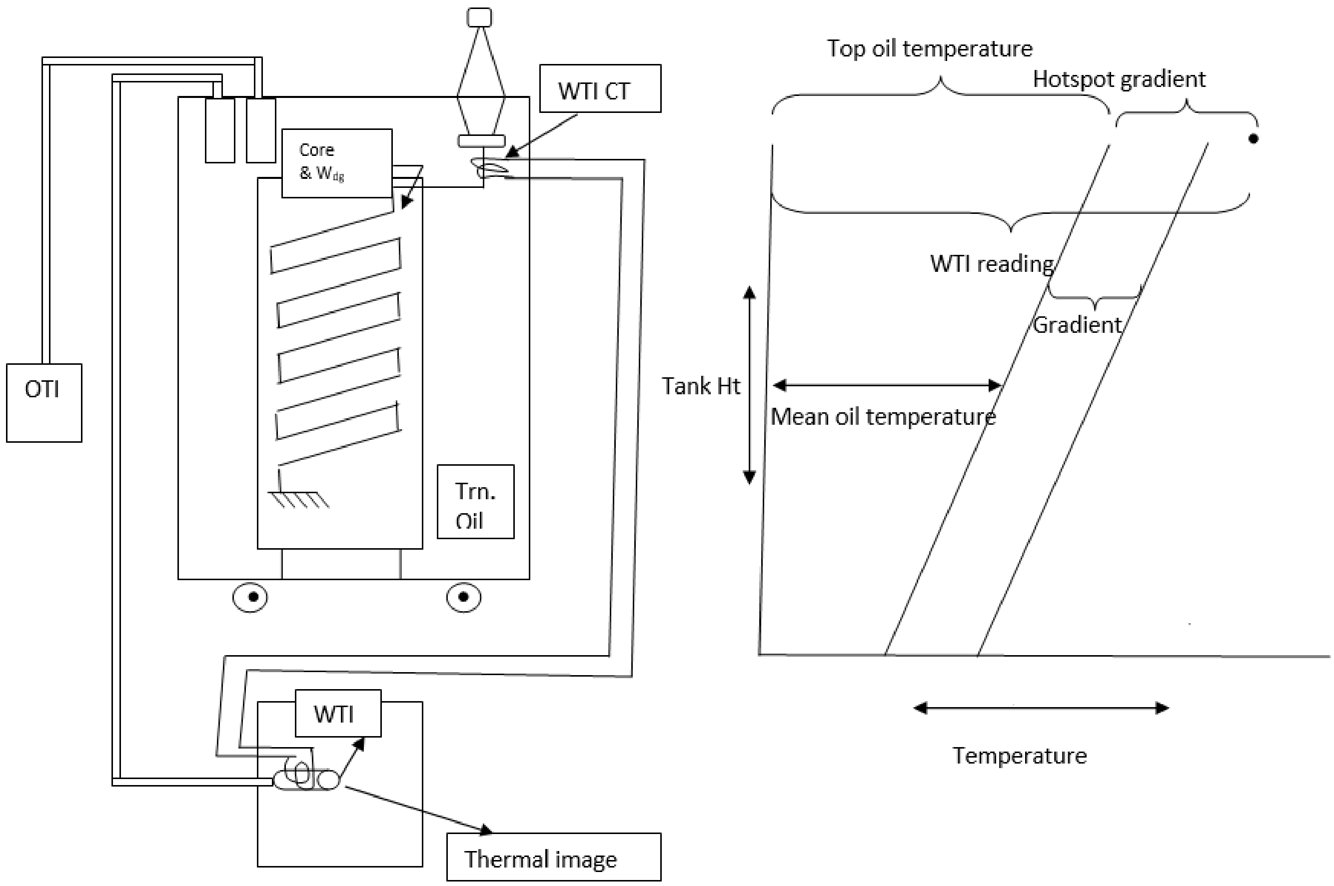


Fig. 1. Proposed schematic structure of a microgrid

II. THEORY

A. CONCEPT OF OIL TEMPERATURE RISE

The main reasons for the oil temperature rise inside a transformer are: -

- Total loss of the transformer at that load. This consists of the no load loss at full excitation which can be obtained from the test report and the load loss corresponding to the load that can also be computed from the test report.
- The top oil rise is directly proportional to the total loss of the transformer. However, the extrapolation loses its accuracy below eighty percent of the full load loss.
- The cooling equipment's' heat dissipation capacity.
- The thermal head of the connected cooling equipment like radiators.

B. CONCEPT OF AVERAGE WINDING RISE

The main reasons for the average winding rise inside a transformer are: -

- The average winding rises which is also guaranteed along with top oil rise is the sum of mean oil rise and the gradient of the winding.
- The mean oil rise is the average of the top and bottom oil temperature rise which is a function of the heat dissipation capacity of the cooling equipment and the thermal head.

C. CONCEPT OF GRADIENT

The reason for the development of gradient inside a transformer are: -

- The load on the transformer and the tap position.
- Current density at the load.
- Radial and axial depth of winding turn or disc.
- Radial and axial cooling duct dimension.
- Type of cooling. Oil natural or oil forced by pump.
- Pressure drops across the axial height of the winding, radial and axial oil flow velocity and distribution of oil along the winding surfaces.
- Provision of directed oil flow washer.

This states that to control the Hot Spot Temperature it is desirable we understand all above parameters well. Prototype studies with the aid of FEM analysis and comparing the outputs with respect to the actual measurements validates the process and have brought confidence with the designers. The results are with minimal deviations.

Of late because of development of fiber optics probes (FOP) as the insulated sensors, the hot spots are being measured directly and are accurate. The cooling controls like start of fans and pumps besides sending signals of alarm and trip as warning and protection to the control room are done automatically by these WTIs.

III. THE PROPOSED APPROACH

A. TEMPERATURE RISE TEST

The temperature rise test on an oil filled transformer is conducted to measure the: -

- Top oil rise at stabilization.
- Average winding rises at various loading conditions that produces maximum load loss.
- Hot spot temperature within core and winding and in the vicinity outside.

The test procedure conforms to national and international standards.

B. PROCEDURE TO BE FOLLOWED

Before conduction of the dielectric tests the no load loss and the load losses are measured and corrected to the operating conditions. The cooling equipment are connected. Air is released from all bleeding points. Particle count measurement is carried out. The low voltage terminals are shorted by links those can carry the full load current in air continuously. The tap is selected that produces maximum load loss. A voltage in the order of the impedance volts is impressed on the HV terminal so that the losses indicated in the wattmeter corresponds to the total of no load and load loss. In this condition the no load loss is supplied in the form of load loss as the excitation is low. So, the current remains higher than the rated amps.

The top oil rise is recorded after each half an hour. After some period depending on the thermal time constant of the filled oil a condition of stabilization is achieved. The stabilization condition as defined in the standards is when the difference of oil rise for the four consecutive hourly reading remains within one degree.

Once the stabilization condition is achieved the current is reduced to the rated value and kept for one hour.

- Supply is shut off. The connecting leads of LV are opened.
- Hot resistance is measured and extrapolated for the period of the instant of shut down.
- This gives the average hot resistance of the winding.
- The average winding temperature is calculated comparing the values at cold condition.
- By deducting the ambient temperature, the average winding rise is calculated.
- The mean oil temperature rise is calculated at the time of shut down by taking the mean of the reading of top and bottom oil temperature rise and is corrected to the value at stabilization by adding the drop in mean oil temperature.
- The gradient is worked out by subtracting the corrected mean oil temperature rise from the average winding rise.
- The gradient is corrected to the rated amp if full rated amps could not be supplied because of test plant limitations.
- The corrected mean oil rise is added to the corrected gradient to give the corrected average winding rise.
- Hot spot temperature is calculated by adding the top oil temperature at stabilization and adding the hot spot gradient as explained above.

IV. CONCLUSION

In this paper, a methodology is proposed for estimation of the hot spot temperature inside a transformer. The different mechanism of hot spot temperature rise is also discussed. A novel methodology is given which can determine the various temperatures inside a transformer and take appropriate action for a trouble-free operation. Finally, a practical implementation of a method is given which is utilized to provide adequate cooling to limit the temperature and maintain a normal ageing of the transformer.

REFERENCES

[1] Susa, Dejan, and Hasse Nordman. "A simple model for calculating transformer hot-spot temperature." IEEE transactions on power delivery 24, no. 3 (2009): 1257-1265.

[2] Skillen, Alex, Alistair Revell, Hector Iacovides, and Wei Wu. "Numerical prediction of local hot-spot phenomena in transformer windings." Applied Thermal Engineering 36 (2012): 96-105.

[3] Ribeiro, AB Lobo, N. F. Eira, J. M. Sousa, P. T. Guerreiro, and J. R. Salcedo. "Multipoint fiber-optic hot-spot sensing network integrated into high power transformer for continuous monitoring." IEEE Sensors Journal 8, no. 7 (2008): 1264-1267.

[4] Marti, L., Rezaei-Zare, A. and Narang, A., 2012. Simulation of transformer hotspot heating due to geomagnetically induced currents. IEEE Transactions on Power Delivery, 28(1), pp.320-327.

[5] Taheri, Shamsodin, Ahmad Gholami, Issouf Fofana, and Hamed Taheri. "Modeling and simulation of transformer loading capability and hot spot temperature under harmonic conditions." Electric Power Systems Research 86 (2012): 68-75.

[6] Rommel, D. P., D. Di Maio, and T. Tinga. "Transformer hot spot temperature prediction based on basic operator information." International Journal of Electrical Power & Energy Systems 124 (2021): 106340.

[7] Patel, Jaykumar, Kinnari Parekh, and R. V. Upadhyay. "Prevention of hot spot temperature in a distribution transformer using magnetic fluid as a coolant." International Journal of Thermal Sciences 103 (2016): 35-40.

[8] Arabul, Ahmet Yigit, and Ibrahim Senol. "Development of a hot-spot temperature calculation method for the loss of life estimation of an ONAN distribution transformer." Electrical Engineering 100, no. 3 (2018): 1651-1659.

[9] McNutt, W. J., J. C. McIver, G. E. Leibinger, D. J. Fallon, and K. A. Wickersheim. "Direct measurement of transformer winding hot spot temperature." IEEE transactions on power apparatus and systems 6 (1984): 1155-1162.

[10] Zhou, L. J., G. N. Wu, J. F. Yu, and X. H. Zhang. "Thermal overshoot analysis for hot-spot temperature rise of transformer." IEEE Transactions on Dielectrics and Electrical Insulation 14, no. 5 (2007): 1316-1322.

[11] Park, Tae-Won, and Seong Ho Han. "Numerical analysis of local hot-spot temperatures in transformer windings by using alternative dielectric fluids." Electrical Engineering 97, no. 4 (2015): 261-268.

[12] Kweon, Dongjin, Kyosun Koo, Jungwook Woo, and Yungsig Kim. "Hot spot temperature for 154 kV transformer filled with mineral oil and natural ester fluid." IEEE Transactions on Dielectrics and Electrical Insulation 19, no. 3 (2012): 1013-1020.

[13] Zhang, Xin, Shenjing Yao, Ronghui Huang, Dan Hou, Weizhao Huang, and Min Zheng. "Oil-immersed transformer online hot spot temperature monitoring and accurate life lose calculation based on liber bragg grating sensor technology." In 2014 China International Conference on Electricity Distribution (CICED), pp. 1256-1260. IEEE, 2014.

[14] Yang, Zhifei, Jiangjun Ruan, Daochun Huang, Zhiye Du, Liezheng Tang, and Taotao Zhou. "Calculation of hot spot temperature of transformer bushing considering current fluctuation." IEEE Access 7 (2019): 120441-120448.

[15] Chen, W. G., H. J. Xi, X. P. Su, and Wen Liu. "Application of generalized regression neural network to transformer winding hot spot temperature forecasting." Gaodianya Jishu/ High Voltage Engineering 38, no. 1 (2012): 16-21.

[16] Gong, Ruohan, Jiangjun Ruan, Jingzhou Chen, Yu Quan, Jian Wang, and Cihan Duan. "Analysis and experiment of hot-spot temperature rise of 110 kV three-phase three-limb transformer." Energies 10, no. 8 (2017): 1079.

[17] Gouda, O.E., Amer, G.M. and Salem, W.A.A., 2012. Predicting transformer temperature rise and loss of life in the presence of harmonic load currents. Ain Shams Engineering Journal, 3(2), pp.113-121.

[18] Ebenezer, Mabel, Rajkumar Mattacaud Ramachandralal, and Chandramohanan Nair Padmanabha Pillai Sarasamma. "Study and analysis of the effect of harmonics on the hot spot temperature of a distribution transformer using finite-volume method." Electric Power Components and Systems 43, no. 20 (2015): 2251-2261.

[19] ome of the books where I was involved in compilation during my tenure with them and have influenced the paper are listed below.These references may be put.

[20] 1.Areva book on Power transformers.

[21] 2.BHEL book on transformers.

3.J&P book transformer book.

J&P Transformers book.

CRGO Core Saturation & Its Impact on Differential Protection in Transformer

Swakantik Mishra
Department of Electrical and Electronics Engineering
Centurion University of Technology and Management
Ramachandrapur,Bhubaneswar-752050 Khurda, Odisha, India

Abstract

When power transformer does not work properly due to core saturation the system faces many difficulties due to such abnormal operating conditions. Disturbance like imbalance loading & faults hampers the dynamics of the system. Maintaining voltage to frequency ratio is crucial in power network, for this power transformers & protective device plays a vital role. So for accurate function of any protection scheme differential protection reliability is essential. A trivial issue with any power transformer is its saturation. In modern power system conventional cores are being replaced with improvised CRGO materials, but it has its own challenges. In this paper I have analyzed & discussed about transformer core saturation & its impact on differential protection system.

Key Word: Core Saturation, Knee Point Voltage, Differential Protection, Impedance measurement, Saturation Flux.

I. INTRODUCTION

In modern Power System protection & measurement plays an important role in stability of grid. This can only be achieved through accuracy & stability of operation of transformer. With state-of-the art development in electrical manufacturing sector the texture of transformer is also modernize to fulfill the requirement, looking to recent development improvised core are replacing conventional cores, but it has its own challenges. As the process of development is gradual, the presence of conventional core material cannot be ruled out. So for a healthy system, stable operation of transformer is critical. Power transformer is a type of machine which is used to exchange level of voltage up to a level workable for protection, measurement and control setting. It produces a secondary current which is proportional to the current in the primary.

Power transformer insulates the secondary side from the high voltage of the primary side so that the secondary side is not exposed. When saturation occurs due to fault in the transmission line, the differential relay that is connected to the transformer cannot operate properly. The secondary current is mainly used for the purpose of loading. For protection high accuracy in core is required as compared to the metering. In this paper Differential protection system is connected with transformer. So, accuracy of the transformer not a major factor as the metering.

II. CONJECTURE OF CORE SATURATION

To understand CORE saturation, first we have to know about the concept of working of CORE, why does it saturate and what is happening after the saturation.

B. Working of CORE

CORE consists of two windings, secondary winding is around the core and the primary winding across as a primary conductor passes through secondary. When current flows in the primary winding, alternating magnetic field is generated. This leads to the generation of alternating magnetic flux around the transformer core that passes through the secondary winding. If a load is connected in secondary, an alternating voltage is created by the magnetic flux across the secondary. This generates an alternating current to flow in the secondary side, which creates its own alternating magnetic field and alternating magnetic flux that oppose which created by the primary. This results in cancelation of fluxes and leaving a net flux of negligible amount in the core.
So, basically in any type of transformer that produces a current in its secondary which is proportional to the current in the primary.

Figure (1) shows an equivalent circuit diagram of transformer with core. Where I_p(the primary current), I_s(the secondary load current), I_0 (the magnetizing current) N1 and N2 represent the turns ratio of the transformer, and the ratio current $I_{st}$is the primary current divided by this ratio.

The resistance R_{core} represents the secondary winding resistance and R_{load} represents the resistance of the load. Here R_{core} value is constant whereas the value of R_{load} varies according to the load.

In CORE the constant current source $I_p$drives the total secondary current $I_s$as determined by the turns ratio. I_s is the current that is measured by the load if the CORE is ideal.

I_{st} R_{co} I_s

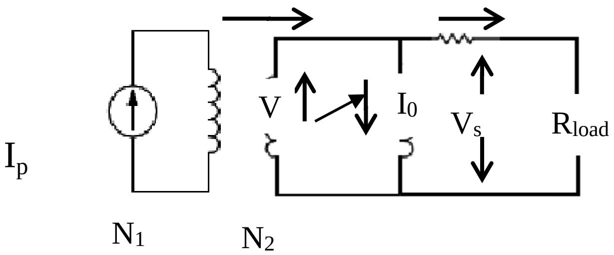


Fig.1.*Equivalent Circuit diagram for Transformer with core*

C. Transformer Saturation

If an open circuited condition occurred on the secondary of CORE, in the secondary side very high alternating voltage flows due to the alternating magnetic flux.This results in high burden on the secondary side, creates a low impedance path due to fault condition causes a very high primary current, which leads to the saturation of the current transformer.

When CORE gets saturated they can no longer maintain the current ratio between the primary and the secondary winding. Saturation may leads to malfunction of the relay devices as the measured current does not correspond to the current on the system.

III. SIMULATION OF CORE SATURATION

Figure (2) represents the matlab simulation of a transformer where there is connection between the source and output voltage and current. A voltage source of 120 KV is connected to the primary side of the current transformer through a circuit breaker. The rated current of the current transformer iss 2000/5.

The turns ratio of the transformer is repsented by,

$N_1 I_P = N_2 I_S$ (1)

Where N_1= primary turns and N_2 = secondary turns

The primary of the transformer is taken as 1 turn for testing. That means seconadary current is fixed as 5A and so accornding to equation (1) , the secondary turns is 80 turns and 400 A current is flowing in the primary side.

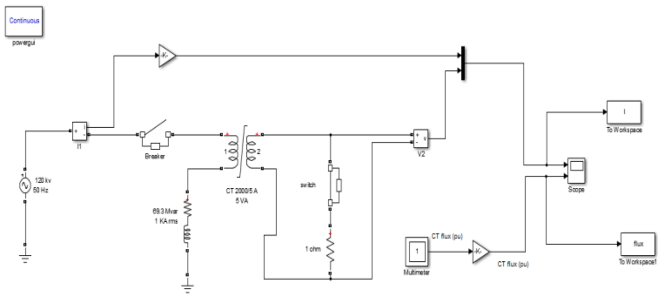


Fig. 2. *Transformer Simulation Block*

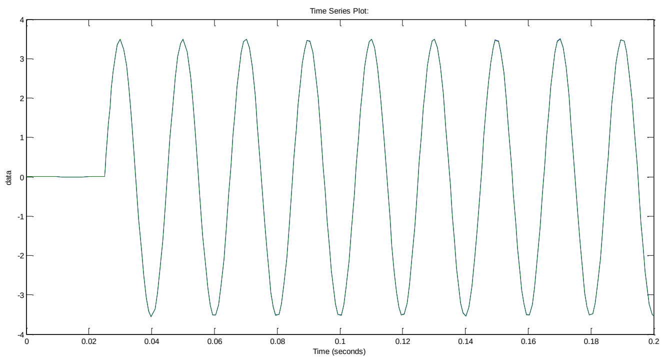
The output current and the flux can be represented by using the scope connected in the Simulink block. By using this block we can observe the behavior of transformer for both normal and saturation condition.

Figure (3) explains the generated secondary current of the transformer without saturation. It can be observed from the graph that the variation in curve is synchronized with time which indicates that ratio transformation is occurring in a smooth way, i.e. as per the current level in the line, the replication in reduced level as per ratio is availed for protection & measurement

Figure (4) explains the generated flux of the transformer due to the secondary current and can be measured by using the multi-meter. It can be observed from the curve that the envelope reduction is gradual with diminishing margin in positive and negative quadrant. With diminishing marginal shifting there will cause heavy fluctuation of current, this will lead to unnecessary relay operation & circuit breaker triggering.

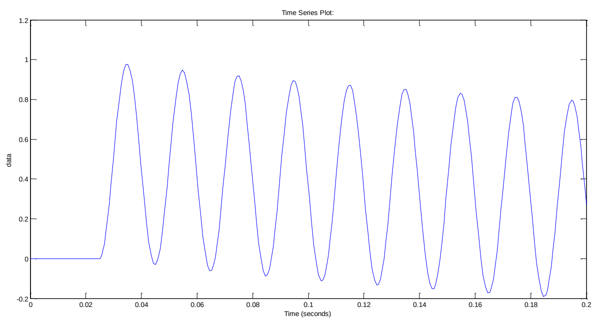
Figure (5) explains the influence of current saturation on the secondary current of the transformer. It clearly indicates that during saturation the peak current value reduces drastically and varies in-uniformly w.r.t. time. That is in spite of standing ratio the current value does not change accordingly as it should be.

Figure (6) explains the of current saturation on the flux. It indicates that the exchange of flux becomes constant after excitation flux reaches knee point voltage as shown in graph the flux increases to peak value as remains constant in positive quadrant w.r.t. time period without any variation or negligible variation, for which there will be no mutual exchange of flux form Core core to secondary. Which will leads to excess accumulation of charge in CORE core, resulting in heating of the core.



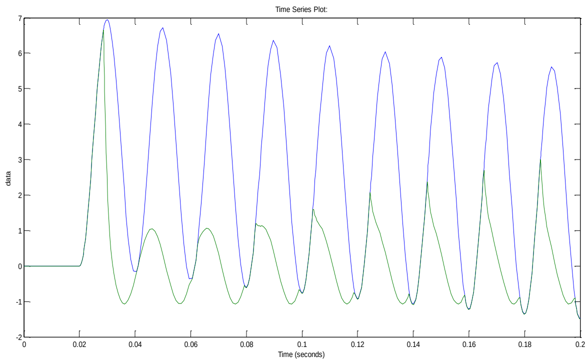
Current Vs Time

Fig. 3. *Secondary current of transformer without CORE Saturation*



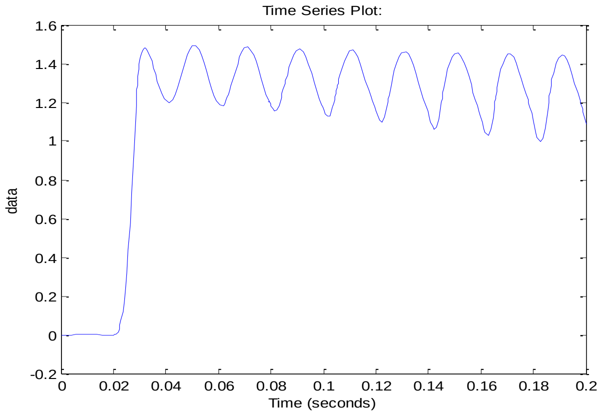
Flux Vs Time

Fig.4. *Current Transformer Flux without CORE Saturation*



Current Vs Time

Fig. 5. *Secondary current of transformer with CORE Saturation*



Flux Vs Time

Fig.6. *Current Transformer Flux with CORE Saturation*

A. Differential Protection Block

Differential protection is designed to detect the faults which occurred in the transmission lines. The main functions included in the relay model are to detection of faults, measurement of impedance and transformer protection.

B. Detection of faults

The relay allows the detection of the faulty phase and tripping of the appropriate Differential measuring zone. Without phase selection under reach or over reach problem might occur.

C. Impedance Measurement Block

The impedance measurement block consists of subsystem used to calculate the fault impedance of single phase fault. The block uses an algorithm for the fault detection shown in equation (1).

$$Z_{slg} = \frac{VA}{IA+3KoIo} \quad (1)$$

$$K_0 = \frac{Zo-Z1}{KZ1} \quad (2)$$

$$I_0 = \frac{Vs}{Zo+2Z1} \quad (3)$$

Where,

Z_{slg}= single line to ground Fault impedance
A = phase where fault occurs
VA= phase voltage
IA = phase current
Io = zero- sequence current
Zo = zero-sequence impedance (75 ohm)
Z1 = positive-sequence impedance (50 ohm)
K = residual compensation factor (taken as 0.9)
Vs = phase voltage during the phase to ground fault

Figure (7) shows the subsystem of the impedance measurement block.

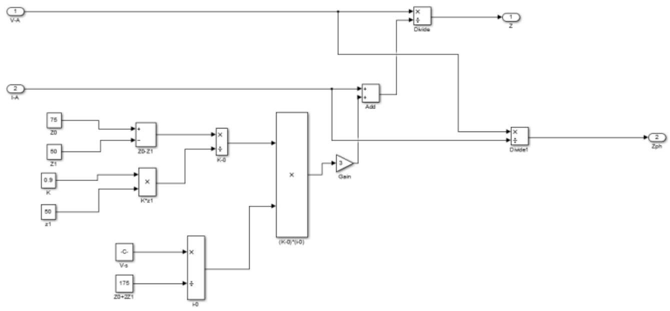


Figure 7.Apparent impedance model for Fault

V. RESULT AND DISCUSSION

The parameters of the designed Differential protection which cover different parts of transmission line under study. It explains the behavior of different parameters in a power system where Differential protection is connected and the CORE is operated without saturation. The behavior of the parameters when the CORE is saturated. Transformer saturation leads to an error in the calculated fault impedance (Zslg) and also there is an error occurred in the algorithm which is used to calculate the fault impedance. Due to this error, the Differential protection is not working as it should.

VI. CONCLUSIONS

The CORE saturation could force the Differential protection, because of the algorithm which is used for the calculation of fault impedance in the protection system. This algorithm is using both the current and voltage signals. The saturation in CORE has resulted in a failure in the operation. This error leads to the problems in fuction of the protection. So the CORE saturation boost the measured impedance in the system.

REFERNCES

1. A. Hargrave, M. J. Thompson and B. Heilman, "Beyond the knee point: A pracoreical guide to CORE saturation," 2018 71st Annual Conference for Protecoreive Relay Engineers (CPRE), College Station, TX, 2018, pp. 1-23.

2. K. Wannous and P. Toman, "The impacore of current transformer saturation on the Diffrential protecoreion," 2016 17th International Scientific Conference on Elecoreric Power Engineering (EPE), Prague, 2016, pp. 1-5.

3. J. Mooney, "Diffrential Element Performance Under Conditions of CORE Saturation," 2008 61st Annual Conference for Protecoreive Relay Engineers, College Station, TX, 2008, pp. 491-497.

4. Muhd, Hafizi&Idris, muhdhafizi&Hardi, Surya &Mohd, Zamri&Hasan, Syafruddin. (2013). Teaching Diffrential Relay Using Matlab/Simulink Graphical User Interface. PharmaceuticalEngineering. 53. 10.1016/j.proeng.2013.02.035.

5. Mrehel, Omar &Elfetori, Hassan & Hawal, Abdallah. (2020). Implementation and Evaluation a SIMULINK Model of a Diffrential Relay in MATLAB/SIMULINK. 2020/3/25, pp. 1-6.

Simulation of a smart Agri Pesticide Sprayer operated by Solar System

Debashree Debadatta Behera[1], Shiv Sankar Das[2], Soumya Ranjan Giri[3]

[1]Department of Mechanical Engineering, Centurion University of Technology and Management, Odisha, India.

[2] Zenith School of Management, Bhubaneswar, Odisha, India

[3] Department of Mechanical, Zenith college of Science and Technology, Bhubaneswar, Odisha, India

***Abstract*— Accesses to modern energy services are necessary for improved health and agricultural productivity (UNDP, 2001). In the present paper a smart agri pesticide sprayer was developed which was operated by solar power. It was efficient as compared to conventional sprayer (operated by diesel fuel) and required less time for spraying larger area and also reduced back pain. The main components are solar panel, charge controller, battery, DC pump, and nozzle with sprayer and further the entire system was analyzed by PVSYST software.**

Keywords— Smart Agri pesticide sprayer, PVSYST, PV panel

XIX. INTRODUCTION

"Electrification is linked to a range of development improvements, such as increasing in income, generating employment, and achieving better health and education" (Barron and Torero, 2017; Chakravorty et al. 2016). In recent era, the demand of electricity has raised drastically. In order to overcome that smart agri sprayer had fabricated which consist of 1.Solar panel, battery, charge controller, DC pump, and sprayer. It is easy to install, operate and maintain and diesel was not required.

The present development of sprayer has following objectives.It is operated by clean energy which is pollution free and maintenance cost is less.

XX. Literature Review

S. charvani et al [1] developed a sprayer which was operated by solar Panel, battery and pump. R.Joshua et al [2] developed a sprayer for discharging pesticide and it was operated by DC motor. Harshit Jain et al [3] E. Zahab et al [4] designed solar water pumping system which consists of three speed controller and MPPT device for charging and discharging battery. Nithin Vasanth et al [5] had done experimental work on solar powered sprayer and all data had been submitted through GSM. Yallappa D et al [6] developed multipurpose solar operated sprayer. Kohle [7] had done experimental work solar water pumping by using manual tracking system.

XXI. Diagram of spraying system

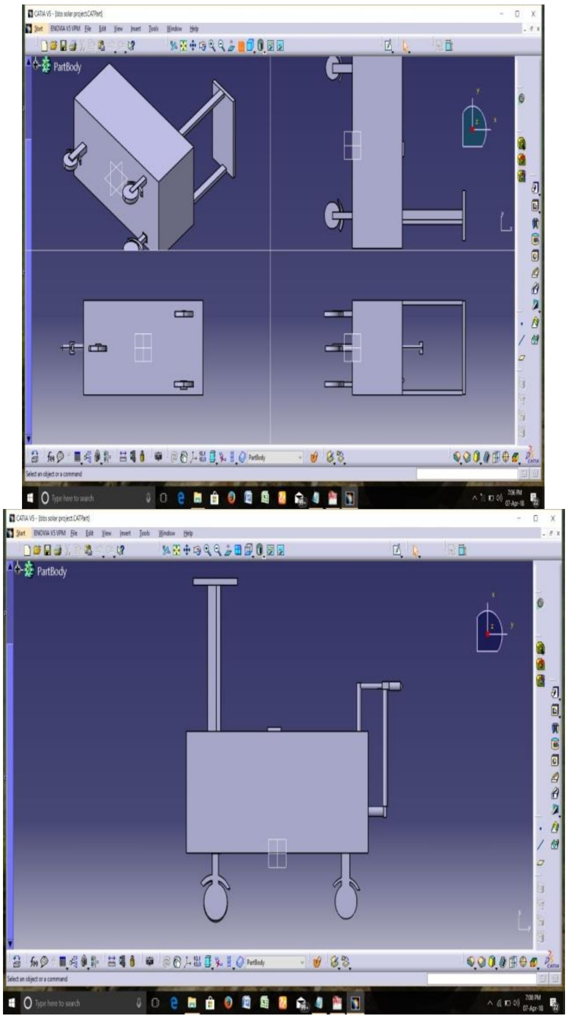
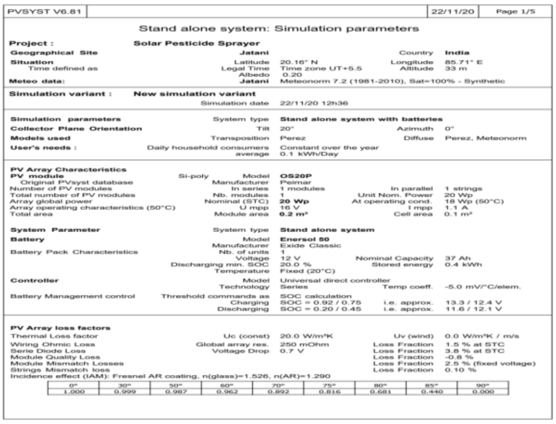


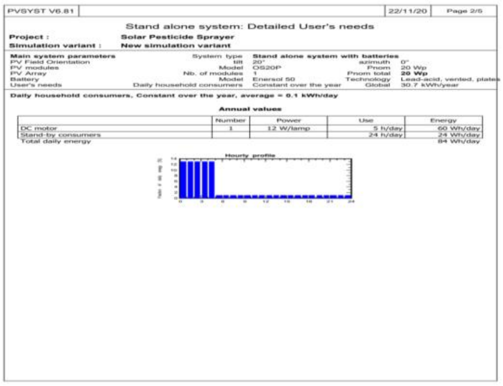
Figure 1. Modeling of spraying system by Catia Software

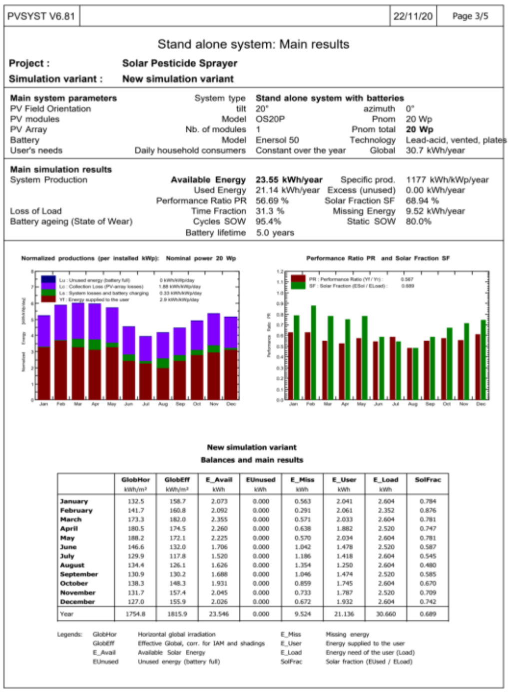
A. Analysis by using PVSYST software

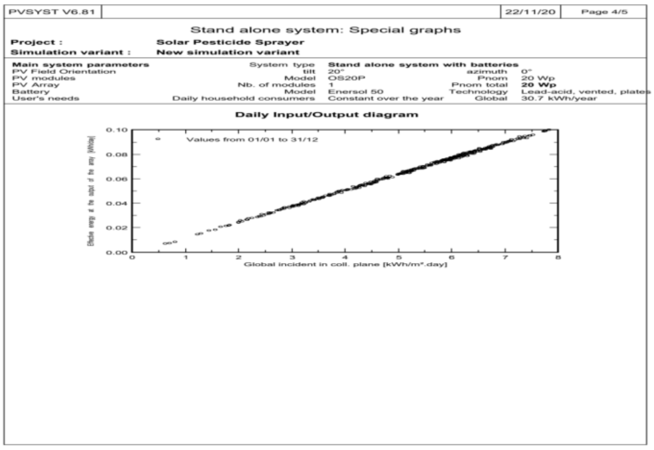
By considering simulation parameter such as geographical data of Bhubaneswar, Odisha location, system parameters (sizing of solar panel and battery), used energy, performance ratio, loss of head were obtained. In the figure 3.3 it has been shown below

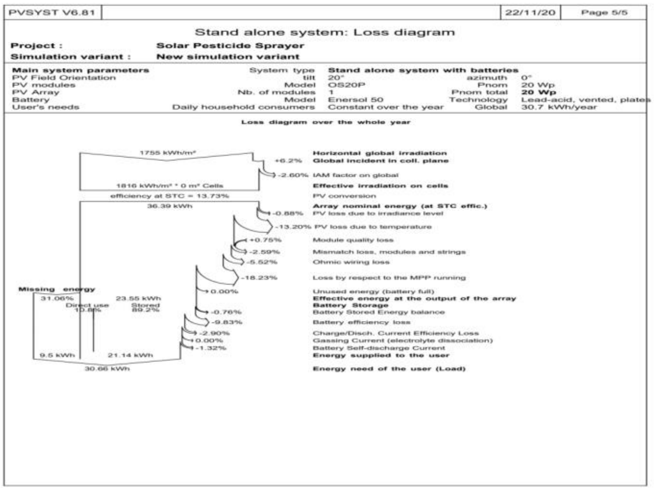
Figure 2. Analysis report by using PVSYST software











IV. RESULT AND DISCUSSION

A. Power Conversion Efficiency of the Panel

Ƞ=Maximum power/Minimum power= output power/ input power Where,

Under STD condition

Irradiance = 1000 W/m²

Area of solar cell =0.4m x 0.4m

Input power = 160 W

Output power = Voc x Isc x FF

Voc = 21.5, Isc= Short circuit current= 1.29

B. File factor (FF)

The output in the solar panel is not 100%. So it is the resistance in the solar panel. FF= loss due to file factor = (Voc-ln (Voc+0.72))/ (Voc+1). FF= 81.7%

Output power = open circuit voltage x short circuit current x Fill factor = 22.6 W

Ƞ = output power / input power = 14 % which power conversion efficiency

$\eta = (\rho \times g \times Q \times Hm)/(V_{oc} \times I_{sc}) = 0.36 = 36\%$

Figure 3- Testing operation

CONCLUSION

From the experiment it was found that maximum discharge rate at outlet of DC pump was 4.3 Liter per minute by taking Solar panel(20W),battery (12V,7.2Ah), charge controller (12V,10A), DC Pump (12V,4.2 LPM).It was cost effective as compared electric operated pump. It can used for multipurpose such as charging mobile and operating LED light. Due to battery back it can be used in night or in cloudy weather.

REFERENCE

[1]. S.Charvani, K.Sowmya, M.Malathi , P.Rajani4, K.Saibaba"Design and fabrication of a solar sprayer", International Journal of science Technology and Management, 6(2017), pp.589-596.

[2]. R. Joshua, V. Vasu and P. Vincent. "Solar Sprayer - An Agriculture Implement", International Journal of Sustainable Agriculture, 2(2010), pp.16-19.

[3]. Harshit Jain,Nikunj Gangrade, Sumit Paul, Harshal Gangrade, Jishnu Ghosh, "Design and fabrication of solar pesticide sprayer", IJARIIE, 4(2018), P.1715-1727.

[4]. Essam E. Aboul Zahaba, Aziza M.Zakib and Mohamed M.EI-SotouhyDesign and control of a Standalone PV water pumping system. Journal of Electrical system and Information Technology, 2017, pp.322-337.

[5]. Vasanath N., Akash G., Srikanth KR., Pavan, S, TN and Sinha R. Solar Powered Automatic Pesticide Sprayer. Internal Conference on Energy, Communication, Data Analytic and Soft Computing, 2017, pp. 3438-3440.

[6]. Yallapa, D., Vijaykumar P., Veerangouda M., and Sushilendra. Development and Evaluation of Solar powered Sprayer with Multipurpose Application. Global Humanitarian Technology Conference, 2016, pp. 1-5.

[7]. Kolhe M, Joshi J.C, and Kothari D. P. Performance Analysis of a Direct Coupled Photovoltaic Water-Pumping system. IEEE Transactions on Energy Conversion, 2004, pp.613-618.

Off-grid Solar PV System: Design, Connection and Applications

Nimay Chandra Giri[1], Smruti Ranjan Nayak[2] Siba Prasad Mishra[3]
[1,2]CREE, Centurion University of Technology and Management
[3]Civil Engineering, Centurion University of Technology and Management
Odisha, India
nimay.giri@cutm.ac.in, smrutiranjan@cutm.ac.in

Surya Narayan Sahu[4], Rajendra Khadanga[5] and R. C. Mohanty[6]
[4,5]EEE, Centurion University of Technology and Management
[6]Mechanical Engineering, Centurion University of Technology and Management
Odisha, India

Abstract—**The use of reliable and affordable sustainable energy sources is one of the biggest challenges in 20th century. About 200 million people of India are destitute of grid power supply, prominently in unreachable hilly and rural locations of the country. Solar energy is a free, green and a main source of sustainable energy to produce electricity and can overcome the gap between energy demand and generation in the developing countries. Solar energy technologies are photovoltaic and thermal types for power and heat generation respectively. Present novel research is an effort to design, connection and suitable applications at Centurion University, Odisha. The approach is to develop low cost solar off-grid systems such as emergency light, street light, and water pumps for suitable locations in-side and out-side of the University. The efficient design of off-grid system plays a vital role in the larger development of solar power generation in the country. Further, the system setup can be protracted for additional load connection in order to electrify vast area. Thus, the off-grid system can be implemented at any commercial area.**

Keywords—Solar Energy; Photovoltaic (PV); Off-grid system; Electricity

XXII. Introduction (*Heading 1*)

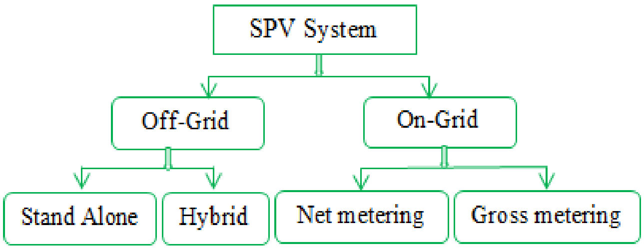
World is speedily moving towards generating electricity from sustainable sources to maintain Greenhouse Gas Emission (GHGs) [1-2]. Energy can be harnessed two ways from Sun as heat or light through thermal route and photovoltaic route respectively. Solar energy can be harvested to generate electricity by photovoltaic (PV) panels or thermal systems. In applications where electricity is required, it can be a genuine deliberation [3, 4]. A solar photovoltaic (SPV) system alters the solar light energy into electrical energy. The SPV system comprised of solar panel, charge controller (CCR) or inverter, battery and electrical appliances. One of the prominent models of such a technology is solar off-grid system [5, 6]. The off-grid system is not connected to the grid and power can be stored in battery for further applications. Photovoltaics (PV) use solar cells (mostly Si type) bundled in solar panels to produce direct current (DC) [7, 8]. Furthermore, solar PV energy systems have provided the versatility solution for many sectors in all over the world especially in rural areas where outage of utility connection is the case. Also depending on the availability of the solar resources at the location where the system is to be installed. Hence, the potential of the off-grid solar PV systems stands out so clearly to compensate the outage of the utility connection. It is now possible to set up several system configurations for designing solar off-grid PV systems. Energy requirements needed to be supplied and the availability of the solar resources in the location where the solar off-grid PV system is being installed [9-12].

With about 310 clear and sunny days in a year, the considered solar energy incidence on India's land area is about 5000 trillion kilowatt-hours (kWh) per year. Till March 2021, the solar power system installed capacity was 40 GW in India targeted to augment to 100GW (including 40 GW rooftop) by 2022 [13-15]. The designer of the system is responsible for selecting the value of the different parameters: number and type of PV modules, controller or inverter type, distribution of components in the installation field. India is facing a severe energy scarcity which is hindering its industrial growth and economic progress [16, 17]. Setting up of modern solar power systems is certainly dependent on import of highly volatile fossil fuels. Thus, it is essential to tackle the energy crisis through judicious utilization of abundant the solar energy, especially solar photovoltaic system [18-20].

XXIII. Methods and Methodology

The solar photovoltaic (SPV) system is a power system intended to supply serviceable solar power by means of photovoltaics. This converts light energy from the sun to generate electricity.

On-Grid systems are solar PV systems that only generate power when the utility power grid is available. They must



connect to the grid to function [1-3]. Off-Grid systems allow you to store your solar power in batteries for use when the power grid goes down or if you are not on the grid [4-5], illustrated in Figure-1.

Figure 1. Classification of Solar PV System

A. Solar PV System Components

Solar PV system consists of following components;

1. Solar Panel or Module
2. Solar Charge Controller (CCR)
3. Solar Inverter (optional)
4. Solar Battery
5. Solar Lamps (load)

1. Solar PV Cell and Module

The majority solar cell is made up by silicon material to produce electricity, illustrated in Figure-2. To achieve a required voltage and current [6-8], a group of PV modules or panels are wired into large array that called PV array.

Mathematically, I=IL-ID

$$I = I_L - I_0 \left[exp\left(\frac{eV}{KT}\right) - 1\right] \qquad (1)$$

Where, I= electric current

IL= solar light generated current

ID= diode current

I0= saturation current

e= electron charge

V= voltage across the junction

K= Boltzmann's constant and

T= absolute temperature.

In India, Poly-crystalline panel is more used as compare to other type [9-10]. Different types of solar modules or panels are illustrated in Figure-3. Rating of solar panels is in Watts with specified voltage for an off-grid system.

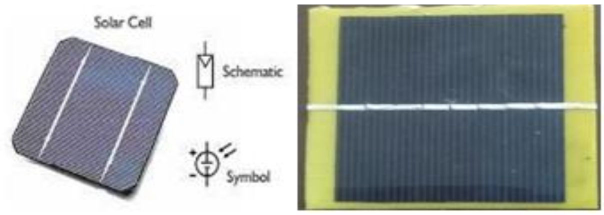


Figure 2. Solar Cell (Si)

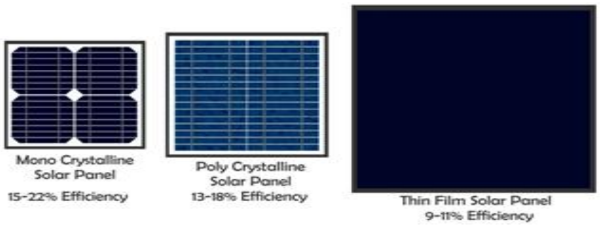


Figure 3. Different types Solar Modules

2. Solar Charge Controller

A solar charge controller limits the rate at which electric current is added to or drawn from electric batteries, illustrated in Figure-4.

- It is a DC device (DC to DC converter).
- There are different types of solar charge controllers, such as PWM and MPPT solar charge controllers [11].
- Rating: Volt Ampere Hour (V Ah)

Figure 4. Solar Charge Controller (CCR)

3. Solar Inverter

A solar inverter is a power electronic device that converts direct current (DC) to alternating current (AC), illustrated in Figure-5.

- Rating: Volt-Ampere (VA) or Kilo-Volta-Ampere (kVA).

Figure 5. Solar Hybrid Inverter

4. Solar Battery

A solar battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices [12-14], illustrated in Figure-6.

- Rating: Volt Ampere-hour (V Ah)

Figure 6. Solar Tubular, Maintenance free and Li-ion Battery

XXIV. STYLING SYSTEM CONNECTION AND OPERATION

The following steps need to be followed for suitable implementation of a solar off-grid system any geographical area of the world.

Step-1: At first Civil and mounting structure must be completed after proper site survey

Step-2: Solar PV system need to be connected after proper checking [15-17]

Step-3: Positive (red) and negative (black) color wire of each component need to be connected with solar charge controller or inverter of the system [18-20]

Step-4: After connection of all the apparatus, proper checking is needed for its successful operation and applications

Step-5: Operation and Maintenance

XXV. USING THE TEMPLATE

The design, connection practice and applications are carryout in Centurion University of technology and management, Odisha, illustrated in Figure-7.

Figure 7. Different solar off-grid applications in Centurion University**,** Odisha

XXVI. CONCLUSION AND RECOMMENDATIONS

The solar PV technology it's designed and applications at Centurion University of technology and management, Odisha is carried out in both theoretical and practical aspects. Based on the empirical study, the main observation, calculation and experimentation values are as follows:

- The annual average global horizontal irradiance of the Place is having 5.30 kWh/m2/day.
- The solar off-grid system is easy to design and implement.
- The system is very efficient to install and maintain in different location of India.
- The solar battery is charged in 6-7 hours and can provide power up to 11 hours at night.

The above data will help in efficient design and implementation in different location in Odisha, India and welcome to a better tomorrow.

REFERENCES

[22] Energy: The World Bank. Available at: https://www.worldbank.org/

[23] Sinha S, Chandel SS (2015). Review of recent trends in optimization techniques for solar photovoltaic–wind based hybrid energy systems. Renew Sustain Energy Rev 50: 755–69

[24] GOI (2018). National Action Plan on Climate Change Government of India. Available at: http://pmindia.nic.in/climate change.htm

[25] Giri, N.C., et al. (2021). "Fault Detection and Troubleshooting in a PV Grid-Tied Inverter", Indian Journal of Science and Technology, 0974-6846, 14(x): 1-10.

[26] Giri, N.C., Mishra, S.P. and Mohanty, R.C. (2020). Performance Parameters, Optimization, and Recommendation in Large Scale On-Grid SPV Power Plant, Odisha, India. International Journal of Modern Agriculture. 9 (4), 159-167.

[27] Initiative GE (2014). Global electricity initiative executive summary. GEI2014

[28] IRENA (2019). Global Energy Transformation: A roadmap to 2050. Available at: https://www.irena.org/

[29] Energy for a Sustainable Future, New York, (April 2010). Available at: https://www.un.org/chinese/millenniumgoals/pdf/AGECCsummaryreport%5B1%5D.pdf

[30] Kowalskia MF, Rovenskayab E, Krausmanna F, Palluac I, John R, Neilld M (2019) Energy transitions and social revolutions. Tech Forec & Soc Chan 138: 69–77

[31] Sustainable Energy for All (SEforALL), 2019. Available at: https://www.seforall.org/.

[32] IEA (2018). Renewable market analysis and forecast from 2018 to 2023. Available at: https://www.iea.org/renewables2018/

[33] Energy Perspectives (2019). Long-term macro and market outlook", by equinor. Available at: https://www.equinor.com/

[34] WEO (2020). The gold standard of energy analysis. Available at: https://www.iea.org/weo2018/

[35] IEA (2019). Energy, Economic Times Energyworld. Available at: https://energy.economictimes.indiatimes.com/news/renewable/renewable-energy-capacity-additions-to-grow-by-12-this-year-iea/71217706 (Accessed 20 September 2019)

[36] WEC India (2019). Alternate Methodology for Electricity Demand Assessment and Forecasting. Available at: https://www.wecindia.in/wp-content/uploads/2019/08/WEC-India-study-on-Demand-side-forecasting-Full-report-1.pdf

[37] Renewables (2019). "Global Status Report" by Renewable Energy Policy Network for the 21st Century (REN21). Available at: https://www.ren21.net/gsr-2019/chapters/chapter_01/chapter_01/

[38] Government of India and the United Nations (UN), Sustainable Development Framework. 2018-2022 Available at: https://in.one.un.org/wp-content/uploads/2019/05/UNSDF_Print-Revised-To-be-Approved-low-res.pdf.

[39] Sustainable Development Goals 2018 A handbook, by NITI Aayog of Indian Government and UN. Available at: https://in.one.un.org/.

[40] Giri, N.C. and Mishra, S.P. (2017). Energy remediation by alternate dissemination: SPV/PSO power in India. International Journal of Current Research. 9 (8): 56391-56397.

[41] Giri, N.C. (2019). Analysis and Designing of 1 MW SPV Gross Metering Power Plant in Odisha. International Journal of Emerging Technologies and Innovative Research. 6(6): 608-619.

Aging of Transformer: Repair or Replace

Swakantik Mishra
Department of Electrical & Electronics Engineering
Centurion University of Technology and Management
Bhubaneswar, India
Swakantik.mishra@cutm.ac.in

***Abstract*— aging of distribution transformer is a natural process, but sometimes due to lack of proper up keeping activities and environmental conditions the deterioration of transformer in terms of useful life occur in a faster manner which degrades its quality output. this paper gives an outlook towards economic life cycle of distribution transformer.**

Keywords— Life Cycle Costing, Cost of owing, Utilization

XXVII. Introduction

The economics of advancement distribution transformers during routine utility maintenance entails a life-cycle cost (LCC) comparison. The LCC of ongoing to use an offered transformer is compared to the LCC of substitution with a new transformer. This comparison is referred to as "transformer replacement economics." The method of assessment and the expansion of required conjecture, and then build up cases that reveal what conditions favor continued use of refurbished transformers or replacement with new transformers.

XXVIII. Economics of New Transformer Alternatives

Industry sources point to that most utility purchases of new transformers are based on an assessment of TOC, which is deliberated by adding the purchase price or first cost of the transformer to the expected capitalized value of the transformer's energy losses. This estimation of a transformer's energy costs formulates them to directly compare to its first cost. The loss formula specify how a particular utility can estimate the capitalized value of no-load and load losses for new transformers over a study period, For instance, typical values might be Rs 3.00 per watt of no-load loss and Rs 1.00 per watt of load loss for a 30-year study period. Therefore, a transformer with losses of 100 watts (no-load) and 280 watts (load) would have a present value of losses for the entire study period of Rs 300 (no-load) and Rs 280 (load). The total capitalized value of the losses would be Rs 580, and if it is assumed that the initial cost of a new transformer is Rs 500, the TOC of the transformer over the 30-year study period would be Rs 1080. Owing cost some times becomes liability if the rate of failure of a particular transformer is high, this will lead to stiff increase in bath tub curve. The bath tub curve generally reflects the rate of failure with life expectancy of transformer, with initial failure to final stage outage of a transformer.

A. TOC & LCC

The total owning cost (TOC) is a capitalized value, creation of the first cost of the transformer comparable to the lifetime energy costs. The life cycle costs (LCCs) reflect the discounted life time costs of the transformer, where capital costs reflect interest and declined plus other costs associated with the transformer's initial cost. The capitalized values can be converted to the equivalent discounted present values of LCC by multiplying by the ratio of the fixed charge rate over the capital recovery factor..

XXIX. Formulation of TOC

TOC is given by the following equation:

$$TOC = NLL * A + LL * B + C \qquad (1)$$

TOC = total owning cost,
NLL = no-load loss in watts,
A = cost per watt of no-load loss (this is termed the A factor),
LL = load loss in watts at the transformer's rated load,
B = cost per watt of load loss (this is termed the B factor),
C = the initial cost of the transformer, including transportation, sales taxes, and other costs to prepare it for service.

A. Economics of untimely Transformer Replacement

The economics of untimely transformer replacement considers the LCC of a new transformer as outlined above, compared to continuing to use an existing transformer. The present values for capital and energy in the LCC analysis can be calculated directly from the corresponding TOC (capitalized) values and are proportionate. Therefore, a assessment of transformer costs using present values or capitalized values will yield the same result in terms of the comparison, although the total cost of the option will vary depending on the scheme used.

B. Refurbishment of Transformer

The disparity in the value of the energy competence is weighted by the years of left over life of the refurbished transformer because, as stated above, after the refurbished transformer is swapped, there is no difference in energy use through the residue of the study period.

A shorter life diminishes the present value of capital cost savings and boosts the present value of the take-down and re-establishment costs. A longer life has the opposite effect. This is also an exceptionally significant assumption because it has a relatively noteworthy effect on the outcome of the comparison and because of its vagueness.

C. Cost Contrast

The cost contrast can be broken down into three categories: capital costs, energy costs, and costs related to change-out and refurbishment. The chief lead of the refurbish and replace later option is that it delays the procure of a new transformer and therefore trim down the present value of capital costs. The replace now option evades the cost of refurbishment and the extra costs of take-down and reinstalling in year 11. The poise of the trade-off is the difference in energy efficiency in years 1 through 10. In years 11 through 30, transformers have the same rate of energy utilize.

The economics of early substitute should also version for a difference in the residual value of the refurbishment alternative versus the replace-now substitute at the end of the
study period. At the end of the 30-year study period, the transformer of the replace-now alternative will be older than the transformer that replaced the refurbished transformer at the
end of its remaining life. This study accounts for this unequal residual life as an end-effects fine-tuning to capital costs. This alteration is about 8 percent of the present value for a 50-kVA transformer assessment where the left over life of the refurbished transformer is 10 years.

This has been resolute by ruling the years of remaining life at which a refurbished transformer's LCCs equal the LCCs of substituted it with a new one. This can be defined as the break-even point for early replacement. If the remaining life of the transformer is greater than this, then near the beginning replacement is not cost-effective. Transformers that come in for routine maintenance with less years of remaining life than the break-even point can be replaced cost-effectively. The transformer's break-even age was firm from an assumed distribution of transformer life and the remaining life of the transformer at the break-even point. This provides an age decisive factor for preferring between refurbishment and withdrawal based on choosing the cost effective substitute. It also establishes the vintage of the refurbished transformer, which is used to presume it's no-load and load losses in the economic investigation.

However, instant substitute of all distribution transformers is not practical. This move towards to saving energy would not be cost-effective, while the benefit-to cost ratio is only 0.6, significantly less than 1.0. Total system substitute is also not viable because it could not be proficient during routine utility maintenance and because transformer manufacturers do not have the capacity to produce the large number of transformers required to meet such a high demand, which would be ten to twenty times, Most utilities have a distribution transformer maintenance agenda that rivets inspection and testing, minor and/or major refurbishment, and retirements. Distribution transformers are removed from service for a array of grounds: because transformers have become overloaded, because they have failed as a result of lightning or traffic accident damage, because of lane repositioning due to street or highway construction, because of voltage upgrade, and so on. The impassive units are delivered to the transformer Up-holding department, where they are examined to determine if they are to be refurbished and returned to store or retired to wisp. Refurbishments include both minor in-house and major on-site works.

XXX. Other Life cycle issues

The digit of distribution transformers rewound is very little according to a investigation of utilities. Based on investigation information, most of the refurbishments take place on transformers less than 20 years old with a momentous sum of remaining life, and for this reason, these transformers are not good entrant for cost-effective substitute. A lot of utilities have an age criterion afar which they would not deem a transformer for refurbishment. Of those utilities with an age measure for retirement (as about 49 percent of the utilities surveyed), the retirement age ranges from 14 to 35 years, with the average being about 25 years.

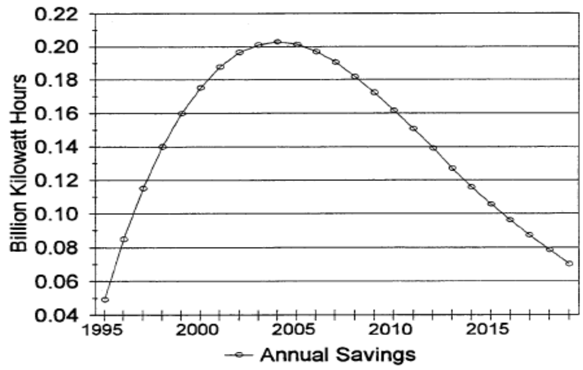


Figure 1. Energy Saving by Early Replacement

Untimely replacement of transformers would tend to faintly diminish the average life of a utility's in-service transformers. At the same time it would tend to slightly increase total capital costs for purchasing transformers. The energy savings from early transformer replacement would reduce a utility's operating costs, but this cost savings would tend to be passed through to customers. The slightly increased capital cost for purchasing more new transformers would be absorbed by the utility until it could be incorporated into the rate base. The amount of time this required would depend on the utility's schedule for rate hearings.

Therefore, before the added capital costs could be incorporated into the rate base, the outcome on utilities would tend to be vaguely negative, since they would not be able to recuperate the carrying charge on the increased capital investment resulting from early replacement. In the long run, however, there would be little if any effect because utilities would eventually be able to adjust their rate base to include the increased capital costs. The prior evaluation presumes that utilities would have no additional regulatory burden in complying with early replacement requirements.

CONCLUSION

The distribution transformer manufacturing industry is currently in a state of over capacity, and most transformer manufacturers are at present manufacturing at 60 to 70 percent of their capacity. Ten manufacturers produce roughly 80 percent of the distribution transformers in the Odisha States. The annual distribution transformer sales (including R&M) to utilities is about 0.5 million units; however, survey data indicate that there can be significant annual fluctuations. But after deregulation of electricity market in Odisha and introduction of private player in industry mostly the age old transformers are being replaced after second rewinding event. So its is clear that firms are more focused on quality output of a transformer than enduring losses, in terms of commercial and technical aspects.

REFERENCES

[42] *Sotiropoulos, F., Alefragis, P., & Housos, E. (2007). A Hidden Markov Models tool for estimating the deterioration level ofa power transformer. IEEE conference on emerging tech- nologies and factory automation (ETFA), Patras, Greece, 2005, pp. 784–787.*

[43] *C. Jak Mac Downaled, Transformer Repair & Maintenace, 2rd ed., vol. 1. PEARSON, 2006, pp.86-93.*

[44] *M.K. Zigus and K.L. Ban, "Insulation Life Assessment in Power Transformer," vol. I, Parks Eds. Londoan: Academic, 2003, pp. 162-230.*

[45] *IEEE/PES Task Force (Reliability, Risk and Probability Applica-tions Subcommittee). (1999). Impact of maintenance strategy on reliability. Final report. Piscataway, NJ, USA.*

[46] *Bartley, W. H. (2000a). Analysis of transformer failures. Proceed- ings of the sixty-seventh annual international doble client conference, Boston, MA, USA, 1–12.*

Fault finding and Maintenance of Distribution Transformer

Surya Narayan Sahu
Department of Electrical & Electronics Engineering
CUTM, Bhubaneswar, Odisha, India
surya1888@gmail.com

Rama Prasanna Dalai
Department of Electrical &Electronics Engineering
CUTM, Bhubaneswar, Odisha, India
Rama.dalai@cutm.ac.in

Biswajit Mohapatra
Department of Electrical Engineering
EATM, Bhubaneswar
biswajitkiit04@gmail.com

***Abstract*- This paper explains about the different failures occurring in a distribution transformer as well as the reason of these type of failures with the methods of protection for different types of faults. This paper also suggests different types of protection practices to be adopted to avoid different faults. The analysis is carried out in accordance with IEEE standards and summarized to present the reasons and possible remedial measures for prevention of transformer failures.**

Keywords—transformer failure, transformer maintenance, protection.

XXXI. Introduction

An electrical power system consists of network of electrical components which are been deployed to transmit and distribute the electrical energy. In this system transformer plays a important role in stepping up and down as per required value. Transformer is a static electrical machine with very high efficiency and rugged construction. Distribution transformer has large number transformer of various capacities. Any failure of these transformers will cause great inconvenience to the consumers and great financial losses to the utilities. In India, the failure rate of distribution transformers is higher around 12-17% as compared to some developed countries which ranges from 2-3%.

Due to this high rate of failure, the distribution companies spent around 200 crores for either repair of replacement of the distribution transformers [1]. Not only this even if the financial loss becomes huge, if the revenue loss for supply outage is also taken into consideration. It has become a serious concern for the distribution companies as the failure rate is increasing every year. A transformer can fail due many reasons such as electrical, mechanical or thermal factors or combination of all these and it is always very difficult to find-out a particular reason of failure.

XXXII. Reasons for poor performance and failure OF DISTRIBUTION TRANSFORMER:

- Low oil level
- Oil leakage
- Improper Earthing
- Frequent faults on LT lines due to loose spans
- Mechanical failure of winding
- Improper tree clearance of LT lines
- Use of defective breather and consequent ingress of moisture
- Low dielectric strength of oil/ winding insulation
- Corrosion in laminations of core
- Improper protection like:
- Using defective or over rated fuses
- Consistent overloading
- Not providing lightning arrestors
- Manufacturing defects, like:
- Improper or Inadequate design: Transformer tank size, percentage impedance, improper use of aluminum wire, improper use of inter layer papers, use of inferior quality materials.
- Poor quality of material: Manufacturing of transformer using poor quality material, may lead to early failure of transformer.
- Bad workmanship: Improper alignment of HV winding, improper clamping arrangement, improper connection, inadequate tightening f core.
- Poor short circuit withstand capacity
- Ageing
- Improper Structure of distribution transformer: When a transformer is erected, adequate clearances to be maintained when distribution transformers are to be erected.
- Failure due to contact with birds and other animals:
- To avoid failure of HT/LT bushing and HT/LT jumper leads from the bushing should be covered with yellow tape insulation. This yellow tape insulation will also indicate the overloaded operation of the transformer by the change of the colour.

Reasons for failure	Failure rate	Causes
Damage to LV Coils	65%	• Compressed windings • Circuit insulation failure

		• Dislodged spacers • Broken Support/ Inadequate bolts
Damage to HV Coils	5%	• Overloading • Inadequate size of fuses • Defective termination
Damage to both	10%	• Any of the above
Other reasons	20%	• Poor construction • Defective joints • Oil oozing out • Punctured radiators and bushing gaskets • Damaged tap changers

XXXIII. TRANSFORMER MAINTENANCE:

Transformer maintenance is done at regular interval for trouble free operation and to prevent breakdown of transformer from service. So, there are some recommended maintenance practices which are done based on the following inspections: analysis of oil sample, electrical parameter measurements, measurement of temperatures by non-contact thermometer, monitoring (on-line or off-line).

1. Maintenance in Energized Condition

Only some of the specific maintenance activities are performed on the transformer on site when it is operation after taking necessary safety precautions.

a. Inspection of transformer tank: Transformer tank can be inspected online. Leakages, cracks in the bushings etc.
b. Conservator Breather: Checking of silica gel which acts as drying material.
c. Measuring temperature: Measurement of temperature of different joints, bushings etc by using a thermo vision camera.
d. Inspection of oil level: Due to leakage of oil in transformer tank, oil level will decreases which causes excessive heat inside the tank which in turn damage the insulation of the winding. Oil level indicator need to check periodically.
e. Testing of Oil sample: As load increases, temperature of oil changes. The oil expands and shrinks. The conservator extracts air through breather, so that moisture cannot enter into the main tank. Otherwise the quality of oil gets deteriorated. Measurement of breakdown voltage of oil samples to be taken from bottom and top of the transformer.

Visual Characteristics	Reason
Cloudiness	Suspended solid matter such as iron oxide/sludge
Muddy colour	Moisture
Dark Brown	Presence of dissolved asphalteness
Green Colour	Presence of dissolved copper compounds
Acidic Smell	Presence of volatile acids which can corrosion

f. Analysis of dissolved gases: The permissible level of different dissolved gases in the oil of a healthy transformer are given by:

Gases	Less than 4-years of service	4-10 yrs in service	More than 10 yrs of service
Hydrogen	100-150 ppm	200-300 ppm	200-300 ppm
Methane	50-70 ppm	100-150 ppm	200-300 ppm
Acetylene	20-30 ppm	30-50 ppm	100-150 ppm
Ethylene	100-150 ppm	150-200 ppm	200-400 ppm
Ethane	30-50 ppm	100-150 ppm	800-1000 ppm
Carbon Dioxide	200-300 ppm	400-500 ppm	600-700 ppm
Carbon Monoxide	3000-3500 ppm	400-500 ppm	600-700 ppm

2. Maintenance in De-energized condition:

In this type of testing, the transformer has to be disconnected from the line and should be properly earthed. Proper precautionary measures should be taken:

g. Measurement of Insulation resistance of each winding.

h. Bushing gaskets: If any leak has occurred near the bushings then tightening of the gaskets will help in fixing the problem. If the gasket has lost its elasticity due to excessive heating or ageing, it must be replaced such practices can also be carried out in case of cover gaskets, valves and gaskets of the tap changer. If still leakage is there then it can be fixed by tightening the bolts.

i. Welded joints. Leakage of the oil at the joints can be only be repaired by welding it again.

j. Cleaning of bushing using mentholated spirit.

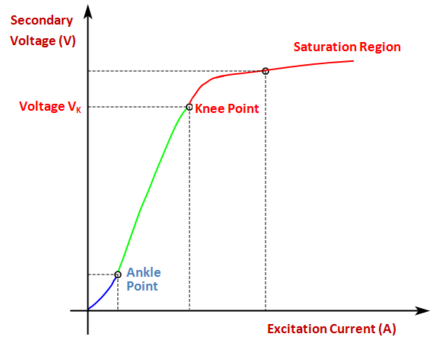
k. Tap-changers are very important components in transformers and the electrical system. It helps in maintaining the voltage in secondary side. As they are of mechanical operated, they cause concern due to their maintenance needs and their high failure probability. It contains selector switch, reactors, vacuum switch, bypass switch and gear mechanism. It is therefore important to be able to assure the integrity of tap-changers as cost effective and reliably as possible.

l. Cleaning of glasses on gas relay, thermometer and liquid level indicator.

XXXIV. FAULTS AND SYMPTOMS:

The entire core is inserted inside the tank and tank is filled with the oil. The oil has two purpose: one is for insulation and other is for cooling purpose. Conservation tank provides the extra buffer for expansion of oil during heating. The oil when contracts during cooling it absorbs the moisture and the moisture degrades the oil insulation property i.e., dielectric strength decreases. Between two adjustment turn the insulation may get brittle. Leakage current will pass, it is called as inte-rturn faults.

A transformer generally operates at knee point.



The reason behind this is to decrease the size of the core. In small change in flux, the magnetising component of the transformer will change drastically. It will create a heavy burden on the system.The iron losses which depends on the voltage and flux also increase. This is known as over-fluxing. It can protected by measuring V/f ratio and sense it.

In-turn faults: Sometimes due to insulation failure between core and turn or between two turns. It will create in-turn faults. Also between turns and tank which is grounded. It should be protected at the earliest. This is called ground fault. This can be detected by differential relay. Also Buchholz relay are used to protect from these incipient fault.

Open Circuit Fault: It means, any one or two phases are open circuited. This creates unbalances in the system. It creates over-heating.

Over-Heating: This fault can be either due internal fault and external fault. Whenever the fault current passes the I^2R loss increases with the result of increase in heat. Also overload is one of the cause of overheating. If heat due to losses is not dissipated properly, it may cause leakage of oil. Which ultimately decrease the level of oil. Unavailability of proper oil level, may also cause overheating.

Short Circuit Fault: It can be either internal or external. This can happen due to insulation failure. The main cause of insulation failure is deterioration of oil or increase in temperature. External faults happening outside of transformer like L-G fault and L-L fault also termed as external fault.
Magnetic Inrush Current: Whenever switching is there, a magnetic inrush current will pass. When transformer switched-on even during no-load, the current will be 5-6 times the full load current for short time duration. It contains 2^{nd} harmonic current. To avoid this, we have to provide a restraining coil.

Internal Faults	Protetcion

Phase Fault	Percentage(%) differential relay
Ground Fault	Percentage(%) differential relay
Inter-Turn Fault	Bucholz Relay
Tap-Changer Failures	By inspecting and repairing of LTC
Leakage of Oil	Bucholz Relay
External Fault	
System phase fault	Overcurrent Relay
System Ground Fault	Overcurrent Relay
Over load	Overcurrent Relay
Over fluxing	V/f relay/ over fluxing relay

VII. CONCLUSION

In this paper we tried to elaborate the faults and its effects in the transformer. Also we have suggested the types of protection we should provide to avoid and detect any fault inside or outside the transformer. Also required on site and off site maintenance is mentioned in this paper.

VIII. FUTURE WORK

The calculation of the fault current and harmonics during different transformer faults needed to be calculated. Effect of %-impedance on fault current needed to analyzed.

REFERENCES

[11] J Singh, S Singh, "Transformer Failure Analysis: Reasons and Methods", 2016 International Journal of Engineering Research & Technology 4 (15), 1-5

[12] J Singh, S Singh, A Singh, "Distribution transformer failure modes, effects and criticality analysis (FMECA)", Engineering Failure Analysis 99, 180-191

[13] https://electrical-engineering-portal.com/transformer-main-tenance-inspection-repair

[14] https://www.linkedin.com/pulse/failure-rate-transformers-p-ramachandran

An Intelligent Frequency Control Approach for an A.C. Microgrid

Rajendra Ku. Khadanga
Department of Electrical & Electronics Engineering
CUTM, Bhubaneswar, Odisha, India
E-mail: rajendra.khadanga@cutm.ac.in

Amit Kumar
Department of Electrical & Instrumentation Engineering
TIET, Patiala, Punjab, India
E-mail: amit.kumar2@thapar.edu

Sidhartha Panda
Department of Electrical Engineering,
VSSUT, Burla, Odisha, India
E-mail: spanda_eee@vssut.ac.in

Abstract: **This work presents a methodology for a A.C microgrid frequency control. The proposed MG can be framed by consolidating the various sources like sustainable power source, wind power age and the sun-based energy age. The MG response is greatly relying on variation of these sources and thus the frequency control for MG is consistently difficult for the analyst business. Considering these hardships, this paper utilizes a TID controller for the above problem. A mixture of Dragonfly and Pattern Search termed as hDF-PS algorithm is utilized to tune the regulator boundaries. It very well may be exhibited that the said hybrid algorithm based TID regulator approach gives ideally better execution.**

Keywords: Renewal Energy Sources, Hybrid Dragonfly Algorithm & Pattern Search (hDF-PS) Algorithm, Microgrid (MG), Tilt Integral Derivative (TID) controller.

V. INTRODUCTION

Recently, improvement of off-network MGs enhances provincial regions where the traditional method of providing energy from a system is excessively expensive. The islanded method of MG is more problematic contrasted with the grid associated mode. This is on the grounds that in the matrix associated mode the guideline of frequency is upheld by the principal supply though in the islanded method of activity, the change in wind and sun-based illumination assets are utilized to remunerate the load varieties [1, 2].

The distributed resources FC, BES, DEG, WTG, PV, FES and FC frameworks expect an imperative part for a MG. The power created by the reestablishment sources like PV and WTG are for the most part depends on the environment condition thus not being used in the secondary frequency control [3, 4]. The essential point here is to develop a powerful frequency control approach for a MG [5-7]. The secondary control on the MG structures is given in literary works [8-10]. The secondary control of MG is portrayed in the writing [11-14]. The uses of various strategies for the recurrence control of MGs are given in [15-17]. Further frequency control strategies are additionally portrayed in MG control [18].

This paper uses a TID regulator for the Microgrid frequency control issues. A TID regulator, the comparing part of PID regulator is superseded with a tilted segment. Hybrid DFPS algorithm is used to tune the damping regulator boundaries and their execution has been investigated considering system reaction. Subsequently, by improving the system dependability and reaction, the TID regulator shows ideal better execution.

VI. MODELING OF MICROGRID

An improved-on arrangement for a MG is displayed in Fig.1. Mostly the MG is comprising of PV, MT, DEG, WTG, FC and BES with AC loads as showed up in Fig. 1. The total produced power produced is given by [19]:

$$P_{Load} = P_{PV} + P_{FC} + P_{WTG} + P_{MT} + P_{DEG} \pm P_{FES} \pm P_{BES} \tag{1}$$

The adjustment of MG frequency regulation can be communicated as: -

$$\Delta P_{Load} + \Delta P_{FC} + + \Delta P_{DEG} + \Delta P_{MT} + P_{PV} \cdots\cdots \Delta P_{WTG} \pm P_{FES} \pm \Delta P_{BES} = 0 \tag{2}$$

Fig. 2 exhibits the frequency response model with the distinctive framework boundaries are in Table I.

VII. PROPOSED CONTROLLER STRUCTURE WITH OBJECTIVE FUNCTION

A. TILT INTEGRAL DERIVATIVE CONROLLER DESIGN

The TID regulator is essentially a tuneable compensator having K_P, K_I and K_D as three control boundaries with a tuning boundary as n. The construction of TID resembles PID, beside the relative conduct is displaced by a shifted corresponding conduct having move work $s^{-1/n}$. This exchange work block is alluded to as a "Tilt" compensator and the total construction of the compensator is alluded to as a TID compensator. A piece outline depiction of the TID control shows up in Fig. 3 [15].

B. OBJECTIVE FUNCTION

the ITAE is utilized here as:

$$J = ITAE = \int_0^{t_{sim}} |\Delta F| \cdot t.dt \tag{3}$$

where, ΔF & t_{sim} shows represents frequency deviation simulation time respectively.

Thusly, the consider issue might be planned as an improvement issue as portrayed underneath [20]: -

$$\text{Minimize } J \tag{4}$$

List of Nomenclature			
ΔP_{ϕ}	Variation in solar irradiation	FC	Fuel cell
ΔP_L	Load power change	ITAE	Integral time absolute error
Δf	Deviation in Frequency	MG	Microgrid
ΔP_{FC}	Variation in FC output	MT	Micro-turbine
ΔP_{BES}	Variation in BES output	M	Inertia constant
ΔP_{DEG}	Variation in DEG output	PID	Proportional integral derivative
ΔP_{FES}	Change in FES output power	PV	Photovoltaic panels
ΔP_{MT}	Variation in MT output	RES	Renewable energy system
BESS	Battery energy storage system	SFS	Stochastic fractal search
FESS	Flywheel energy storage system	WTG	Wind turbine generator
DER	Distributed energy resources	T_{BES}, T_{FES}	Time constants for BES and FES
DEG	Diesel engine generator	T_{WTG}, T_{PV}	Time constants for WTG and PV
D	Damping coefficient	T_{DEG}	Time constants for DEG
T_{MT}	Time constants for MT	T_{FC}	Time constants for FC

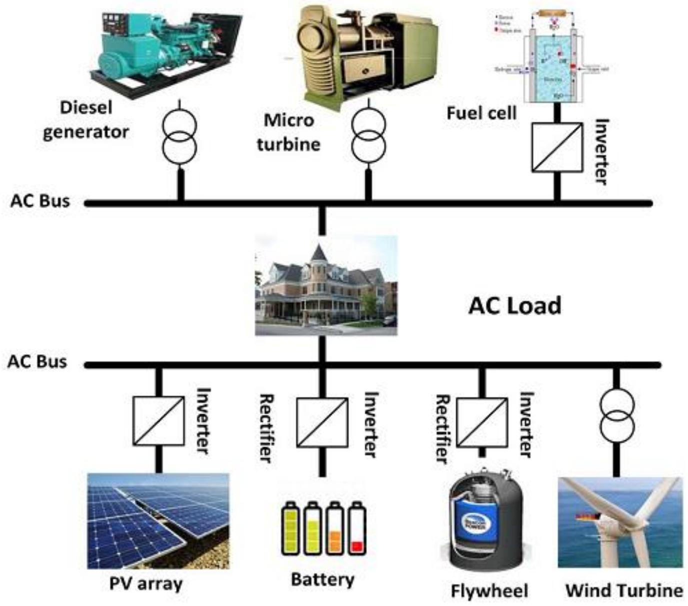


Fig. 1. Proposed schematic structure of a microgrid

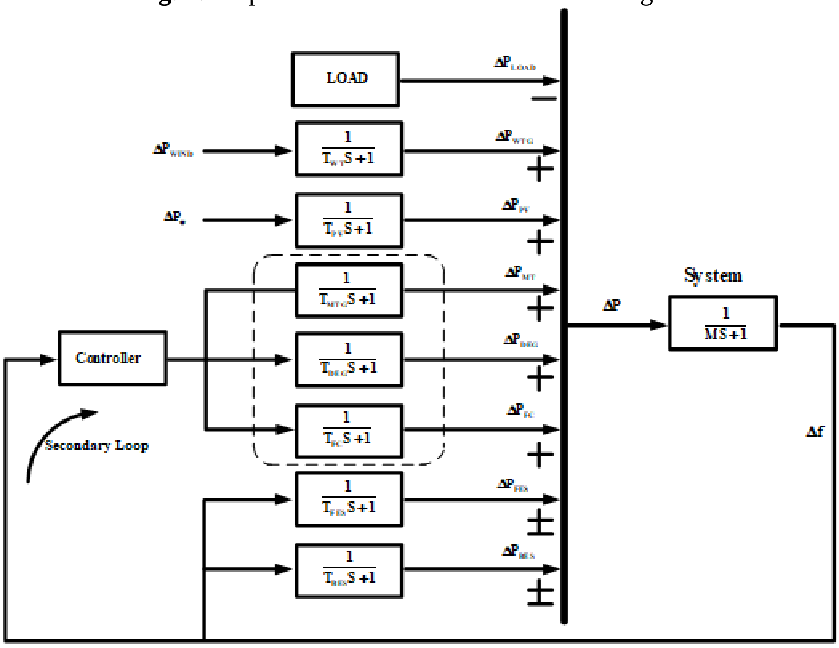


Fig. 2. Frequency response structure of the microgrid

Table 1: Microgrid components nominal parameters

Parameter	Value
D (pu/HZ)	0.012
M (pu/s)	0.2
T_{FC}(S)	4
T_{BESS}(s)	0.1
T_{FESS}(s)	0.1
T_{DEG}(s)	2
T_{MT}(s)	2
T_{WTG}(s)	1.5
T_{PV}(s)	1.8

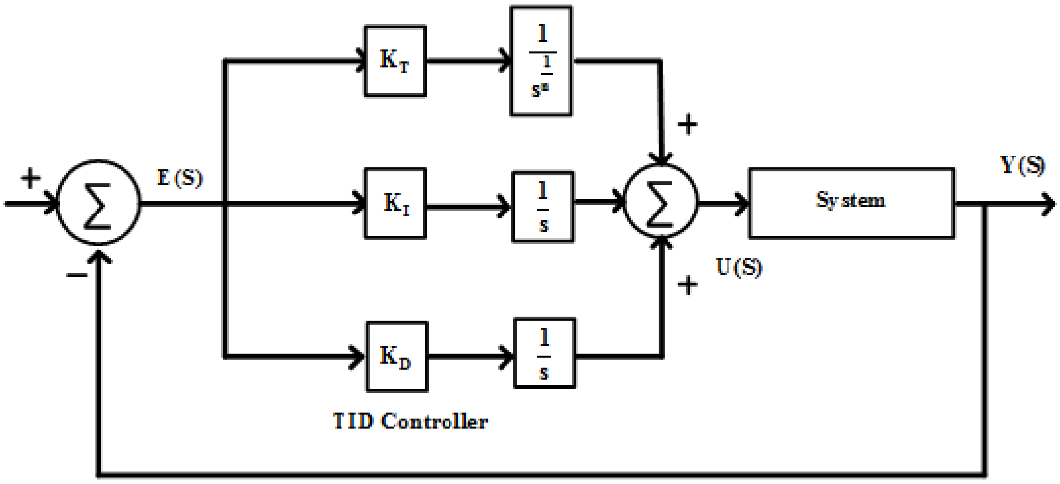


Fig. 3. Proposed TID controller Structure

Subject to

$$K_{Smin} \le K_S \le K_{Smax}$$
$$K_{Tmin} \le K_T \le K_{Tmax}$$
$$K_{Umin} \le K_U \le K_{Umax}$$
$$K_{min} \le K \le K_{max} \quad (5)$$

VIII. HYBRID DRAGONFLY PATTERN SEARCH ALGORITHM

D. DRAGONFLY ALGORITHM

In this algorithm every person in a locale should be pulled towards the wellspring of food and redirected the adversaries. The partitions are determined as takes after [14]:

$$S_i = -\sum_{j=1}^{N} x - x_j \quad (6)$$

The alignment can be written as:

$$A_i = \frac{\sum_{j=1}^{N} V_j}{N} \quad (7)$$

The cohesion expression is:

$$C_i = \frac{\sum_{j=1}^{N} x_j}{N} - X \quad (8)$$

To collect the food, force can be written as:

$$F_i = X^{+} - X \quad (9)$$

The distraction of enemy's is:

$$E_i = X^{-} + X \quad (10)$$

The dragonflies movement is :

$$\Delta X_{t+1} = (sS_i + aA_i + cC_i + fF_i + eE_i) + w\Delta X_t \quad (11)$$

Then the position vector can be obtained as:

$$X_{t+1} = X_t + \Delta X_{t+1} \quad (12)$$

To upgrade the position of each dragonfly:

$$X_{t+1} = X_t + L\acute{e}vy(d) \times X_t \quad (13)$$

Lévy flight is represented as:

$$L\acute{e}vy(x) = 0.01 \times \frac{r_1 \times \sigma}{|r_2|^{\frac{1}{\beta}}} \quad (14)$$

E. PATTERN SEARCH ALGORITHM

The Pattern Search (PS) calculation is a new evolved calculation. The PS calculation begins with an underlying point X_0 is the beginning stage of the calculation. The underlying point X_0 is essentially given by the DF calculation. Then, at that point an example arrangement is finished with the arrangement of current vectors. Presently this is the initial point for the following emphasis in the event that it chronicles a superior objective function.

IX. RESULTS AND DISCUSSION

This part manages the results of the MG by checking diverse system boundaries as unsettling influences like ΔP_{ϕ}, ΔP_L and ΔP_{Wind}. The use of our proposed hDF-PS calculation on the TID controller is examined.

The reasonability of the proposed solid techniques is exhibited. The controller boundaries are gotten utilizing hybrid algorithm. The system is verified by thinking about the accompanying test circumstances.

Table II: Controller parameters for Microgrid

Parameter	**Proposed hDF-PS based Tilt Integral Derivative controller**	hDF-PS based PID controller	hDF-PS based PI controller	hDF-PS based I controller
K_{P1}	**-1.9885**	-1.897	-1.7898	---
K_{I1}	**-0.1425**	-0.1425	-0.1680	-0.0405
K_{D1}	**-1.1865**	-1.1865	---	---
N	**5.0852**	---	---	---
ITAE	**1.178**	1.338	1.4	3.865

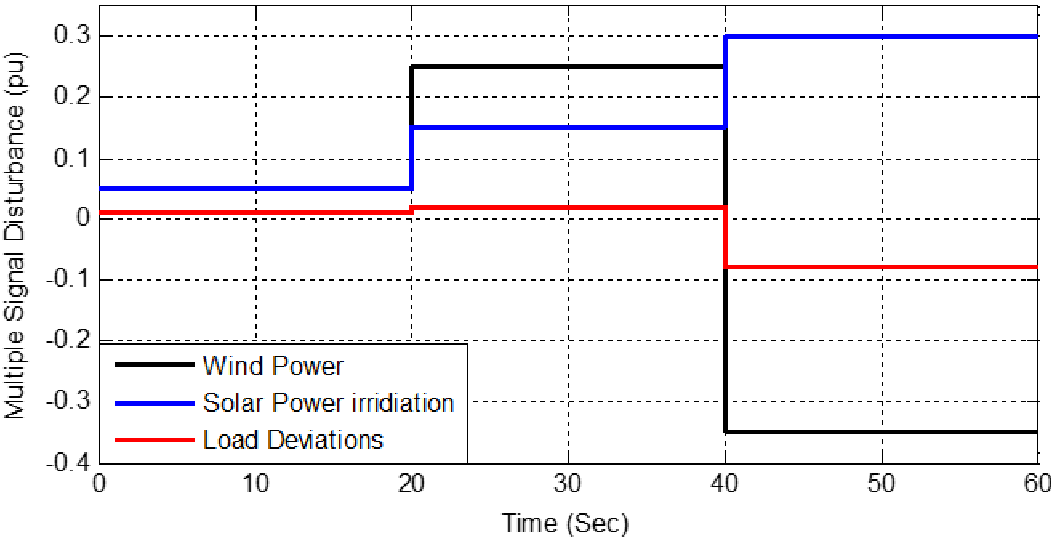


Fig. 7. Change in all power variation

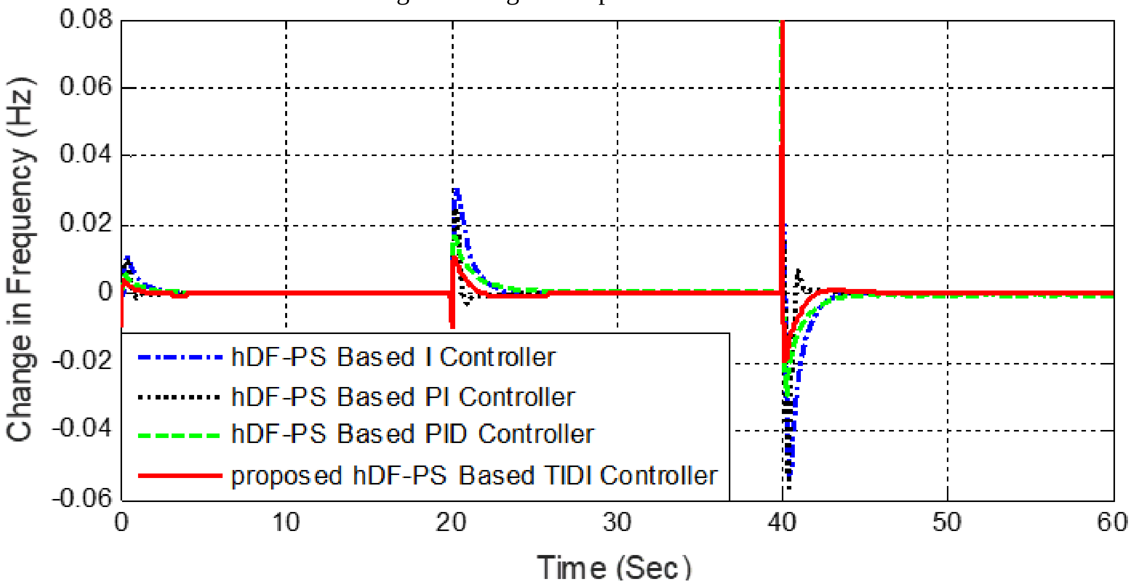


Fig. 8. Change in output frequency

A. Scenario -2: - Combine changes in wind, solar and load variation

For this situation, a concurrent change in the diverse system boundaries like load change, wind power and sun light are thought of. Fig. 7 shows the example for the said disturbance and Fig. 8 shows the system response. Table VI shows the regulator boundaries utilizing the hybrid calculation. From Fig. 8, it is unmistakably seen that the system yields less an ideal opportunity to recover with the proposed structure when contrasted with different types of controllers.

X. CONCLUSION

In this paper, a novel methodology is made by proposing a hybrid DF-PS calculation for a Tilt integral derivative controller for the frequency control of an islanded MG. As discussed, using the said robust regulators give various benefits. The hDF-PS based TID regulators alongside the ordinary regulators are arranged in a way to deal with decline the effects of ΔP_{Wind}, ΔP_{ϕ}, and ΔP_{Load} unsettling influences and dynamic irritations. An end can be made that, due to the shifted conduct of the proposed the hDF-PS based TID regulator gives better execution over the other traditional regulators.

REFERENCES

[47] J.A. Alzola, I. Vechiu, H. Camblong, M. Santos, M. Sall, G. Sow.: Microgrids project, Part 2: Design of an electrification kit with high content of renewable energy sources in Senegal, Renewable Energy 2009 (10), pp. 2151-2159.

[48] R. K. Khadanga, A. Kumar and S. Panda, "Application of Interval Type-2 Fuzzy PID Controller for Frequency Regulation of AC Islanded Microgrid Using Modified Equilibrium Optimization Algorithm. Arabian Journal for Science and Engineering, pp. 1-17, 2021.

[49] Z. Lingwei, S. Liu, X. Xie.: Frequency domain-based configuration and power follow-up control for power sources in a grid-connected Microgrid, International Transactions on Electrical Energy Systems 2015 (10), pp. 2499-2514.

[50] J. M. Guerrero, P. C. Loh, T.-L. Lee, M. Chandorkar.: Advanced control architectures for intelligent microgrids—Part II: Power quality, energy storage, and AC/DC microgrids,' IEEE Trans. Ind. Electron 2013 (60), pp. 1263–1270.

[51] V. Nayanar, N. Kumaresan, N.G. Gounden.: Wind-driven SEIG supplying DC microgrid through a single-stage power converter. Engineering Science and Tech., an International Journal. 2016 (3), pp. 1600-1607.

[52] R. K. Khadanga, A. Kumar and S. Panda, "Application of Interval Type-2 Fuzzy PID Controller for Frequency Regulation of AC Islanded Microgrid Using Modified Equilibrium Optimization Algorithm. Arabian Journal for Science and Engineering, pp. 1-17, 2021.

[53] R. K. Khadanga and A. Kumar, "A Novel Hybrid Adaptive gbest Guided Gravitational Search and Pattern Search Algorithm for Automatic Generation Control of Multi Area Power System," IET Generation, Transmission & Distribution, Vol. 11, No. 13, pp. 3257-3267, 2016.

[54] A. H. Etemadi, E. J. Davison, R. Iravani.: A decentralized robust control strategy for multi-DER microgrids—Part I: Fundamental concepts,' IEEE Trans. Power Del., 2012 (27), pp. 1843–1853.

[55] Y. Han, P. M. Young, A. Jain, D. Zimmerle.: Robust control for microgrid frequency deviation reduction with attached storage system,' IEEE Trans. Smart Grid 2015 (6), pp. 557–565.

[56] A. Kahrobaeian, Y. A. I. Mohamed.: Direct single-loop μ-synthesis voltage control for suppression of multiple resonances in microgrids with power-factor correction capacitors,' IEEE Trans. Smart Grid 2013 (4), pp. 1151–1161.

[57] R. K. Khadanga, A. Kumar and S. Panda, "A novel sine augmented scaled sine cosine algorithm for frequency control issues of a hybrid distributed two-area power system," Neural Computing and Applications, pp. 1-14, 2021.

[58] R.K Khadanga and J.K. Satapathy, "A new hybrid GA–GSA algorithm for tuning damping controller parameters for a unified power flow controller," Int. Journal Electr. Power Energy Syst., vol. 73. Pp. 1060-1069, Mar. 2015.

[59] Q. Shafiee, J. M. Guerrero, J. C. Vasquez.: Distributed secondary control for islanded microgrid—A novel approach,' IEEE Trans. Power Electron., 2014 (29), pp. 1018–1031.

[60] A. Bidram, A. Davoudi, F. L. Lewis, J. M. Guerrero.: Distributed cooperative secondary control of microgrids using feedback linearization,' IEEE Trans. Power Syst., 2013 (28), pp. 3462–3470.

[61] R. K. Khadanga, A. Kumar and S. Panda, "Frequency control in hybrid distributed power systems via type-2 fuzzy PID controller," IET Renewable Power Generation, Vol. 15, No. 8, pp. 1706-1723, 2021.

[62] R. K. Khadanga and J. K. Satapathy, "A hybrid gravitational search and pattern search algorithm for tuning damping controller parameters for a unified power flow controller-a comparative approach," International Journal of Numerical Modelling: Electronic Networks, Devices and Fields, Vol. 31, No. 3, pp. 2312, 2018.

[63] R.K. Khadanga, S. Padhy, S. Panda and A. Kumar, "Design and Analysis of Tilt Integral Derivative Controller for Frequency Control in an Islanded Microgrid: A Novel Hybrid Dragonfly and Pattern Search Algorithm Approach, "Arabian Journal for Science & Engineering, Vol. 43, No. 6, pp. 3103-3114. 2018.

[64] R.K. Sahu, S. Panda, A. Biswal, G.C. Sekhar.: Design and analysis of tilt integral derivative controller with filter for load frequency control of multi-area interconnected power systems,' ISA transactions, 2016(61), pp.251-264.

[65] R.K. Khadanga, V. Kumar, A. Kumar, and S. Padhy, "Robust Frequency Control in an Islanded Microgrid: A Novel Stochastic Fractal Search Algorithm Approach," IEEE India Council International Conference (INDICON), pp. 1-6, 2017.

[66] R. K. Khadanga, A. Kumar and S. Panda. "A Novel Modified Whale Optimization Algorithm for Load Frequency Controller Design of a Two-Area Power System Composing of PV Grid and Thermal Generator" Neural Computing and Applications-Springer, Vol. 13, No. 3, pp.1-12, June 2019.

Centurion Journal of Multidisciplinary Research (India)
Volume 11 Number 2 August 2021