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IoT-Based Electricity Theft Detection System

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Abstracts: ***Globally, energy sectors face the problem of electricity theft, which causes substantial financial losses, inefficiencies, and unpredictability in the energy supply. It involves the unauthorized use of electrical power through various means such as tampering with meters, bypassing meters, tapping directly into power lines, or manipulating billing mechanisms. Analyze here the performance of the proposed IoT-based system for detecting electricity theft. Show the outcomes of the alert system performance. False Positive Rate (FPR): The proportion of legitimate transactions incorrectly identified as theft. False Negative Rate (FNR): The proportion of theft events that were missed by the system. The IoT-based electricity theft detection system is quite efficient. The system's high accuracy, precision, and recall demonstrate its ability to identify and prevent electricity theft effectively.***

Keywords: ***Internet of Things, Electricity Theft, Meter Bypassing, Wi-Fi, Current Sensors***

Abbreviations:
NTLs: Non-Technical Losses
SVMs: Support Vector Machines
FNR: False Negative Rate
FPR: False Positive Rate

I. INTRODUCTION

Energy companies worldwide struggle with the problems of power theft, which generates unfair behaviour in the energy supply, inefficiencies, or significant financial losses. Among the assigned tasks are direct power line tapping, meter manipulation, bypassing meters, and manipulating the billing system—the illicit use of electrical power over numerous channels. Utility companies have a strong reason to be concerned about this illegal activity, as it is more prevalent in areas with inadequate legislative oversight, social issues, and poor infrastructure. The sector loses billions of dollars annually due to energy theft, which affects its profitability and forces ethical customers to help offset the imbalance. Technically, it compromises grid stability, which would cause delays in infrastructure development and disruptions of the electricity supply.

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Beyond simply financial concerns, energy theft poses safety risks since altered systems and unauthorised connections can cause accidents and electrical burns. The rapid expansion of the Internet of Things and smart grid technology presents fresh and creative opportunities for addressing challenges. Real-time monitoring, innovative meter systems, data analytics, and the Internet of Things raise detection capacities. These devices enable remote actions through anomaly recognition, theft trend prediction, and anomaly detection. Apart from these challenges, using these technologies results in security issues related to information, the necessity for robust communication networks, and significant start-up expenses.

II. LITERATURE REVIEW

In their 2017 work, Gupta et al. proposed an innovative algorithm to detect power theft in low-voltage distribution networks. The method uses detailed analysis of power consumption patterns and network behaviour to identify discrepancies indicative of unauthorised usage. The authors highlight the limitations of conventional detection techniques, particularly in distinguishing between legitimate load variations and illicit consumption. Their algorithm utilises statistical tools and real-time monitoring to improve detection accuracy. This approach offers enhanced reliability and scalability, making it suitable for integrating modern innovative grid systems. The study underscores the importance of deploying intelligent, automated methods to safeguard energy infrastructure and reduce commercial losses [1].

Nagi et al. (2010) addressed the problem of non-technical losses (NTLs), such as electricity theft and meter tampering, by developing a detection method using Support Vector Machines (SVMs). Their research focused on analysing consumption data from metered customers to identify patterns indicative of irregularities. The proposed system classifies customers based on historical usage profiles, enabling the identification of anomalies that may suggest fraudulent activity. The study demonstrates the potential of machine learning techniques, particularly support vector machines (SVMs), in enhancing the accuracy and efficiency of NTL detection. This approach represents a significant step toward automating fraud detection in power utilities, thereby reducing financial losses and improving grid reliability [2].

Sahoo et al. (2015) explored the use of smart meter data for detecting electricity theft, highlighting the growing importance of data-driven techniques in modern power systems. Their approach involves analysing high-resolution consumption data collected from smart meters to uncover suspicious patterns that may indicate theft. By leveraging statistical and machine learning techniques, the study aims to improve detection accuracy while minimizing false positives. The authors emphasise that the rich temporal data

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provided by smart meters allows for more nuanced and precise identification of abnormal usage behaviours. This work advances automated theft detection systems and demonstrates the practical benefits of integrating smart grid technology into utility infrastructure [3].

Salinas and Li (2016) presented a novel approach to detecting energy theft in microgrids while maintaining consumer privacy. Their method is based on state estimation techniques that infer system behaviour without requiring access to individual user data. This privacy-preserving framework leverages aggregated measurements and network-level state information to identify inconsistencies that may signal unauthorised consumption. The authors demonstrate that their approach effectively protects sensitive customer information while maintaining high detection accuracy. This research is particularly relevant in decentralised power systems, where privacy concerns and data security are increasingly important. The proposed model contributes to the development of secure and intelligent monitoring systems for future innovative grid applications [4].

Yip et al. (2017) proposed a method for identifying energy theft and malfunctioning smart meters in innovative grid environments using linear regression models. Their approach studies discrepancies between expected and actual energy consumption by building predictive models from historical usage data. By comparing predicted consumption with real-time meter readings, the system can flag anomalies that may indicate theft or device faults. The study emphasizes the effectiveness of linear regression as a lightweight yet robust tool for anomaly detection in large-scale power systems. Additionally, the approach supports efficient monitoring and maintenance of smart metering infrastructure, making it a practical solution for enhancing grid reliability and security [5].

Hashmi and Priolkar (2015) explored the development of anti-theft energy metering systems tailored for intelligent electrical distribution networks. Their work focuses on enhancing metering infrastructure with built-in mechanisms to detect and deter unauthorised energy usage. The proposed system integrates hardware-based solutions with communication capabilities to monitor real-time energy flow and identify anomalies indicative of theft. The authors emphasise the importance of tamper-proof design and continuous data logging in enhancing security and traceability within the distribution network. This approach contributes to building a more secure smart grid ecosystem by combining physical and digital safeguards to combat energy theft effectively [6].

Singh and Sanduja (2015) proposed utilising the Internet of Things (IoT) technology to minimise electricity theft in power distribution systems. Their approach involves deploying IoT-enabled smart meters and sensors throughout the network to facilitate continuous monitoring and real-time data collection. These devices communicate with a central system, allowing for rapid detection of irregular consumption patterns and potential tampering. The authors emphasise that IoT integration enhances transparency, enables automated control, and reduces the need for human intervention, which collectively strengthens the overall security of the energy distribution system. The study demonstrates the potential of IoT to modernise infrastructure and serve as a proactive tool in theft prevention [7].

Lekha, Jegan, and Ranganathan (2016) introduced an IoT-based system for controlling household appliances and detecting tampering in electricity meters. Their framework enables users to remotely monitor and manage home appliances, while also allowing utility providers to detect unauthorised interference with energy meters. The system uses IoT devices to transmit real-time data to a centralised platform, facilitating early identification of energy consumption or meter functioning irregularities. The authors highlight the benefits of improved user convenience and enhanced meter security, positioning their solution as a step toward smarter, more secure energy management in residential settings. The integration of tamper detection with appliance control reflects the growing trend of multi-functional smart grid technologies [8].

Han and Xiao (2014) presented a practical framework called NFD (Non-Technical Fraud Detection) to identify fraudulent activities in innovative grid systems, which contribute to non-technical losses. Their method analyses power usage data to uncover inconsistencies typically linked to electricity theft or meter tampering. NFD combines data-driven techniques with heuristic rules to distinguish between legitimate consumption variations and malicious behaviour. The scheme is designed to be scalable and applicable in real-world scenarios, making it suitable for deployment across large smart grid infrastructures. The study underscores the importance of efficient, real-time fraud detection mechanisms to protect utilities from significant revenue loss [9].

Nagi et al. (2010) proposed a machine learning-based approach for detecting non-technical losses (NTLs) in power utilities, such as electricity theft. Their method utilises Support Vector Machines (SVM) to analyse consumption data from metered customers and classify usage patterns as usual or suspicious. The authors trained the SVM model using historical consumption profiles, enabling it to identify deviations that could indicate fraudulent activity. This technique enhances the accuracy of NTL detection while reducing the reliance on manual inspections. The study highlights the effectiveness of supervised learning methods in identifying energy fraud and offers a scalable solution for utilities aiming to safeguard revenue and improve operational efficiency [10].

Sahoo et al. (2015) investigated the use of smart meter data to detect electricity theft in modern power systems. Their approach leverages the high-frequency consumption data generated by smart meters to identify irregularities that may indicate unauthorised energy use. Using statistical and machine learning techniques, the authors were able to distinguish between normal consumption fluctuations and potential theft activities. The study highlights the role of advanced data analytics in enhancing the security and efficiency of the smart grid. Additionally, the authors discuss the scalability and effectiveness of their detection method in large, decentralised networks, emphasising the advantages of real-time monitoring and automated anomaly detection in reducing non-technical losses [11].

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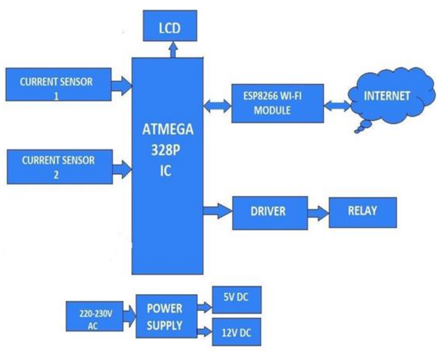
Salinas and Li (2016) proposed a state estimation-based approach to detect energy theft in microgrids while ensuring the privacy of consumers. Their method involves aggregated data from the grid rather than individual user consumption data, preserving end-users' privacy while still enabling the detection of unauthorised energy use. By applying state estimation techniques, they could identify discrepancies between the system's expected and actual energy flows, which could indicate theft. This approach is particularly relevant for decentralised microgrids where privacy concerns are paramount. The authors' work emphasises the importance of balancing privacy with effective fraud detection in the evolving landscape of smart grid technologies [12].

Yip et al. (2017) developed a linear regression-based method for detecting energy theft and faulty smart meters in smart grids. Their approach uses regression models to predict expected energy consumption, comparing it with actual readings from smart meters. Discrepancies between these values are analysed to identify potential theft or meter defects. The authors highlight the simplicity and efficiency of linear regression for large-scale applications, demonstrating its effectiveness in identifying anomalies within innovative grid systems while maintaining computational feasibility [13].

III. METHODOLOGY

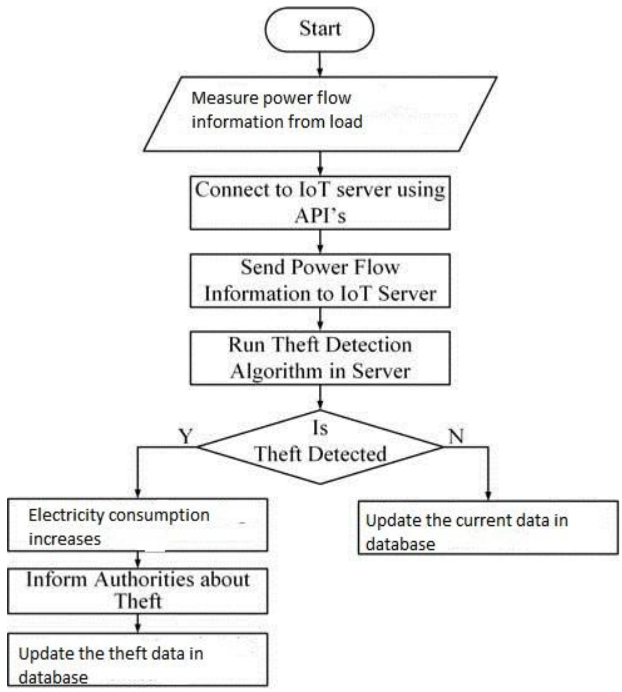
The project's primary objective is to develop an IoT (Internet of Things)-based energy meter reading system that displays units consumed and costs over the internet in chart and gauge formats. For this innovative work, we had taken a digital energy meter whose blinking LED signal is interfaced to a microcontroller through an Optocoupler (4N35). The blinking LED flashes 3200 times for 1 unit; however, for demonstration purposes, none of the LEDs blink for the 1-unit setting. The flashing rate is directly proportional to the power passing through the meter, allowing for the collection of valuable information. This type of meter will always be labelled with a certain number of Imp/kWh. Imp/kWh is short for Impressions per kWh (unit) of electricity, which passes through the meter, where one „impression" is a brief flash of an LED.



[Fig.1: Block Diagram of IoT-Based Electricity Theft Detection System]

The Optocoupler gives a reading each time the meter LED flashes to the programmed microcontroller. The microcontroller takes this reading and sends it to the cloud using ESP 8266. ESP 8266 is a Wi-Fi module that provides internet access for microcontrollers. Here, the Arduino is used as a microcontroller. The ESP8266 transmits the data serially to the ThingSpeak web page for display, which can be viewed from anywhere in the world in a multi-level graphical format. The consumed power reading is displayed on the ThingSpeak website, along with the cost to be paid for consumption in graphical and gauge formats. The ACS712-05B can measure current up to ±5A and provides an output sensitivity of 185mV/A (at a +5V power supply), which means that for every 1A increase in current through the conduction terminals in a positive direction, the output voltage also rises by 185mV.

The precision of any A/D conversion depends upon the stability of the reference voltage used in the ADC operation. In most microcontroller circuits, the supply voltage is the reference voltage for A/D conversion. The curve below illustrates the nominal sensitivity and transfer characteristics of the ACS712-05B sensor, powered by a 5.0V supply. This is attributed to an innovative chopper stabilisation technique implemented on the chip for theft detection. When the current is switched off, the contacts open again, switching the circuit off. A valuable property of relays is that the circuit powering the coil is separate from the circuit switched on by the relay. For this reason, relays are used to control a high-voltage circuit from a safe, low-voltage circuit. Figure 1. Showing a block diagram of the proposed system. Figure 3.2. Showing a flow diagram of the Electricity Theft Detection System.



[Fig.2: Flow Chart of IoT-Based Electricity Theft Detection System]

IV. RESULTS & DISCUSSIONS

Analyse the performance of the proposed IoT-based system for detecting electricity theft here. The IoT-based electricity theft detection system has significantly increased energy efficiency by reducing energy losses and enhancing

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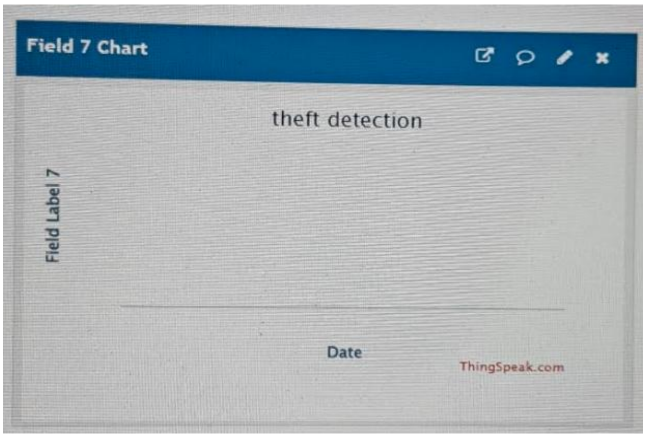
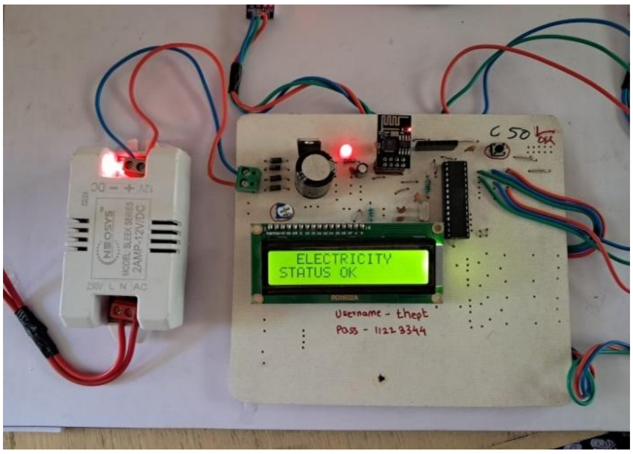
operational performance. Extensive simulation and testing were conducted to obtain the results, utilising hypothetical data to demonstrate system performance under various scenarios. Several performance indicators were applied to evaluate the suggested approach:

A. Accuracy: Calculates the percentage of appropriately found theft incidents.
B. Precision: Shows among all expected thefts the number of actual positives.
C. False Positive Rate (FPR): The proportion of legitimate transactions incorrectly identified as theft.
D. False Negative Rate (FNR): The proportion of theft events that were missed by the system.



[Fig.3: Software Result for No Theft Condition]



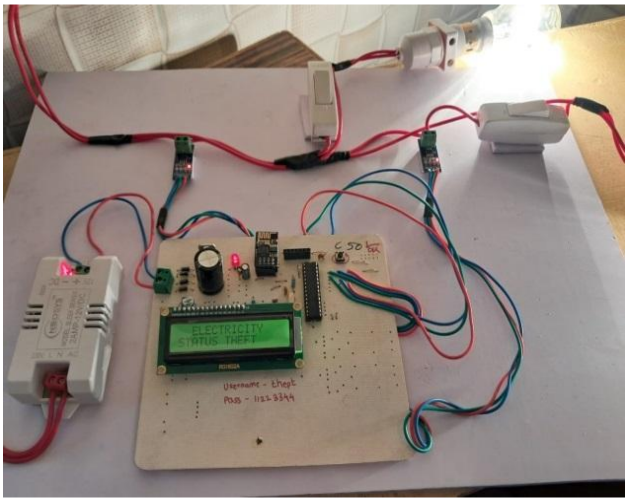
[Fig.4: Hardware Result for No Theft Condition]

The above figure (Fig. 3) shows that the system's current flow is normal, indicating that no theft has been detected. The straight line means that there is normal voltage and current flow into the main electrical supply line, and there is no unauthorised user, suggesting that there is no evidence of theft.

Figure 4 above shows that the OK Status on the system's LCD Display is normal, indicating that no theft has been detected. The sensor detects the current, which is found to be normal, and therefore, the IoT system detects no robbery. Hence, the status is OK.

[Fig.5: Software Result for Theft Detection]

Figure 5 above shows a sudden increase in current. The high range point represents an unauthorised user who uses electricity in the main line, indicating theft.



[Fig.6: Hardware Result for Theft Detection]

Fig. 6 above shows the theft detection Status on the system's LCD Display. It detects that there is theft. The sensor senses the current, which finds it's faulty, and theft is detected. That is why the IOT detects theft. Hence, the status is Theft Detected.

V. CONCLUSIONS

We are doing automatic meter reading, connection and disconnection using a Wi-Fi module. The meter reading has come faster. It is publicly available to the customers as well as to the KPTCL. Both parties will use the information according to their requirements, and they will have the freedom to verify the bill, including checking for tampering, when the meter has been connected and disconnected before the due date. All the information will be displayed by using the smart app. Firstly, upon concluding our project, we successfully monitored tampering, specifically seal tampering, and read the meter bills, which are also uploaded to the website using the IoT concept. Overall, the new components we are working with in our project include an ARM controller, an Arduino controller, and the IoT model. An IoT-based energy meter has been developed to calculate costs and display the results on an LCD, utilising MPLAB

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and the PIC 16F877A microcontroller. The power cost is sent through serial communication to the Virtual terminal constructed in PROTEUS. An attempt has been made to create a practical model of an IoT-based intelligent Energy Meter used to calculate a household's energy consumption and make the energy unit reading more convenient. Hence, it reduces energy wastage and brings awareness, even if it reduces manual intervention.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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- **Author's Contributions:** The authorship of this article is contributed equally to all participating individuals.

REFERENCES

1. Zhang, L., & Wang, H. – 2020, "Influence of steel fibres on the flexural strength of concrete", Journal of Materials in Civil Engineering, Volume-32(4).
   DOI: http://doi.org/10.1061/(ASCE)MT.1943-5533.0003095
   URL: https://ascelibrary.org/doi/10.1061/(ASCE)MT.1943-5533.0003095
2. A. K. Gupta, A. Mukherjee, A. Routray and R. Biswas, "A novel power theft detection algorithm for low voltage distribution network," IECON2017 - 43rd Annual Conference of the IEEE Industrial Electronics Society, Beijing, 2017, pp. 3603-3608.
   DOI: http://doi.org/10.1109/IECON.2017.8216607,
   URL: https://ieeexplore.ieee.org/document/8216607
3. J. Nagi, K. S. Yap, S. K. Tiong, S. K. Ahmed and M. Mohamad, "Nontechnical Loss Detection for Metered Customers in Power Utility Using Support Vector Machines," in IEEE Transactions on Power Delivery, vol. 25, no. 2, pp. 1162-1171, April 2010.
   DOI: https://doi.org/10.1109/TPWRS.2009.2036810
   URL: https://ieeexplore.ieee.org/document/5373832
4. S. Sahoo, D. Nikovski, T. Muso, and K. Tsuru, "Electricity theft detection using smart meter data," in Innovative Smart Grid Technologies Conference (ISGT), IEEE Power and Energy Society, 2015.
   DOI: http://doi.org/10.1109/ISGT.2015.7131870
   URL: https://ieeexplore.ieee.org/document/7131870
5. S. A. Salinas and P. Li, "Privacy-Preserving Energy Theft Detection in Microgrids: A State Estimation Approach," IEEE Trans. Power Syst.,vol. 31, no. 2, pp. 883 - 894, 2016.
   DOI: https://doi.org/10.1109/LPT.2015.2423637
   URL: https://ieeexplore.ieee.org/document/7087333
6. Yip, Sook-Chin, KokSheik Wong, Wooi-Ping Hew, Ming-Tao Gan, Raphael C-W. Phan, and Su-Wei Tan. "Detection of energy theft and defective smart meters in smart grids using linear regression," International Journal of Electrical Power & Energy Systems 2017, vol 91, pp. 230- 240.
   DOI: http://doi.org/10.1016/j.ijepes.2017.03.006
   URL:https://www.sciencedirect.com/science/article/pii/S0142061517301691
7. M. U. Hashmi and J. G. Priolkar, "Anti-theft energy metering for smart electrical distribution system," in 2015 International Conference on Industrial Instrumentation and Control (ICIC),Pune, 2015, pp. 1424-1428. DOI: http://doi.org/10.1109/IIC.2015.7150893
   URL: https://ieeexplore.ieee.org/document/7150893
8. M. Singh and E. V. Sanduja, "Minimizing Electricity Theft by Internet of-Things," International Journal of Advanced Research in Computer and Communication Engineering, Vol. 4(8), pp.326-329, 2015.
   URL: https://www.ijarcce.com/upload/2015/august-15/IJARCCE%2055.pdf
9. L. K. Lekha, G. Jegan and M. D. Ranganathan, "IoT Based Household Appliances Control and Tampering Detection Of Electricity Energy Meter," ARPN Journal of Engineering and Applied Sciences, Vol. 11(11), pp. 7376-7379, 2016.
   URL:http://www.arpnjournals.org/jeas/research_papers/rp_2016/jeas_0616_4442.pdf
10. W. Han and Y. Xiao, "NFD: A practical scheme to detect non-technical loss fraud in smart grid," 2014 IEEE International Conference on Communications (ICC), Sydney, NSW, 2014, pp.605-609. URL: https://ieeexplore.ieee.org/document/6883331
11. J. Nagi, K. S. Yap, S. K. Tiong, S. K. Ahmed and M. Mohamad, "Nontechnical Loss Detection for Metered Customers in Power Utility Using Support Vector Machines," in IEEE Transactions on Power Delivery, vol. 25, no. 2, pp. 1162-1171,April 2010.
    DOI: https://doi.org/10.1109/TPWRS.2009.2036810
    URL: https://ieeexplore.ieee.org/document/5373832
12. S. Sahoo, D. Nikovski, T. Muso, and K. Tsuru, "Electricity theft detection using smart meter data," in Innovative Smart Grid Technologies Conference (ISGT), IEEE Power and Energy Society, 2015.
    DOI: http://doi.org/10.1109/ISGT.2015.7131776
    URL: https://ieeexplore.ieee.org/document/7131776
13. S. A. Salinas and P. Li, "Privacy-Preserving Energy Theft Detection in Microgrids: A State Estimation Approach," IEEE Trans. Power Syst.,vol. 31, no. 2, pp. 883 - 894, 2016. DOI: http://doi.org/10.1109/TPWRS.2015.2406311
    URL: https://ieeexplore.ieee.org/document/7067310

AUTHOR'S PROFILE

Priyanka Ashok Bhoite is pursuing my master of Technology (M. Tech) in Electronics Engineering at Karmaveer Bhaurao Patil College of Engineering, Satara. My academic interests include artificial intelligence, Internet of Things, Machine learning, and Robotics. This paper is a part of my ongoing research. I am committed to deepening my knowledge in the field through academic study and practical application. I aim to contribute to innovative and efficient solutions within the engineering domain. My area of interest includes embedded systems, IoT, VLSI design, and machine learning applications in electronics. I am particularly passionate about working on real-world problems where hardware and software intersect. My M.Tech project is titled "Electricity Theft Detection Using Smart Meter Data and Machine Learning", where I am using techniques like Support Vector Machines and data analytics to identify anomalies in energy usage patterns. Regarding technical skills, I am proficient in C, C++, Python, and MATLAB, and I have experience with Arduino, Raspberry Pi, and VHDL/Verilog for hardware programming and simulation. I enjoy working on hands-on projects and have completed internships and mini-projects in [mention any relevant areas, if applicable]. Apart from academics, I believe in continuous learning and enjoy reading about the latest trends in electronics and automation. I am looking forward to contributing to innovative and impactful projects in the electronics domain, and eventually aim to work in [mention your career goal – e.g., R&D, embedded systems industry, teaching, etc.].

Dr. Yuvraj K. Kanse is a recognised guide at Shivaji University, Kolhapur. He holds a Ph.D. in electronics engineering. He has published various national and international journal and conference papers. He also guides research scholars at Shivaji University, Kolhapur. My primary research interests include [e.g., low-power VLSI systems, IoT-based innovative energy systems, advanced signal processing, RF circuits, AI integration in electronics]. I am particularly interested in solving real-world engineering challenges by combining theoretical knowledge with experimental research. I have published/presented papers in [mention any conferences/journals if applicable]. I am proficient in tools such as MATLAB, Python, Cadence, Xilinx, and Proteus, as well as programming languages including C/C++ and HDL. I have also worked with microcontrollers, including Arduino, ARM, and Raspberry Pi, in

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both academic and project-based settings. My long-term goal is to contribute to academia and research by developing innovative electronic solutions with practical industrial and societal applications. I am equally passionate about mentoring and teaching, and aspire to be a researcher-educator who bridges the gap between theoretical instruction and industry application.

Dr. Supriya P. Salave is a Ph.D. student in Electronics. She is awarded B.E. (E&TC), M.E. (Electronics Engg.) from Shivaji University, Kolhapur. She is awarded by the Institute of Engineers (South section) for First University E & TC Ranker in Shivaji University, Kolhapur (Academic Year 2011-12). She is a life member of ISTE. My research interests lie in power semiconductor devices, DC-DC and AC-DC converters, motor drives, electric vehicle (EV) powertrains, and grid-connected renewable energy systems. I am particularly interested in developing robust, energy-efficient converter topologies for future smart grid and electric vehicle (EV) applications. I have hands-on experience with tools such as MATLAB/Simulink, PSpice, LTspice, PSIM, and hardware platforms like dSPACE and FPGA-based control systems. I am also proficient in programming languages such as C, Python, and VHDL/Verilog, which I use for modelling and control system development. In the long term, I aim to contribute to cutting-edge research in sustainable power electronics systems and actively engage in collaborative projects with academia and industry.

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