

# IoT-Based Smart Electricity Energy Meter using ESP32 and Blynk Application for Energy Management

Dr.R.Senthilkumar<sup>1</sup>, Dr.S. Perumal<sup>2</sup>, Karthikeyan<sup>3</sup>, M.Naveen kumar<sup>4</sup>, N.Naveenkumar<sup>5</sup>

Head of the Department, Department of Mechatronics Engineering, Muthayammal Engineering College, Rasipuram, Namakkal, Tamil Nadu, India<sup>1</sup>

Assistant Professor, Department of Mechanical Engineering, Muthayammal Engineering College, Rasipuram, Namakkal, Tamil Nadu, India<sup>2</sup>

UG Scholar, Department of Mechatronics Engineering, Muthayammal Engineering College, Rasipuram, Namakkal, Tamil Nadu, India<sup>3,4,5</sup>

**Publication History:** Received: 25.02.2026; Revised: 20.03.2026; Accepted: 25.03.2026; Published: 28.03.2026.

**ABSTRACT:** Materials and processes applied for the development of IoT-based smart electricity energy meters for energy management in Somalia are presented. The system involves the ESP32 microcontroller and a Blynk application that allows one to monitor and manage electricity consumption remotely. Hardware setup, sensors, and power modules are described in detail, as well as software configurations regarding the acquisition and real-time data monitoring.

**KEYWORDS:** Blynk, IoT Energy Meter, ESP32 Smart Meter, Energy Monitoring System, Smart Electricity Meter, Wireless Energy Management, Real-Time Power Monitoring, Home Energy Automation

## I. INTRODUCTION

The ESP32S is a powerful microcontroller including the chip that is low cost, with low consumption, integrated Wi-Fi, and Bluetooth. This board is widely used in IoT applications due to its dual-core processor for quick data processing and multitasking capabilities, among other factors, besides having integrated connectivity which allows for seamless communication between devices and with the code on mobile applications such as Blynk. Energy Meter design centers on the ESP32S, which is in charge of real-time monitoring, control, and the transmission of data in energy management as shown in Figure 1.



Fig. 1 ESP32S Microcontroller

### 1.2: ZMPT101B Voltage Sensor

The ZMPT101B Voltage Sensor has been designed to ensure accurate measurement of AC voltage in real-time. It possesses very high precision and sensitivity, making it suitable for applications requiring accurate voltage monitoring, such as smart energy meters. By converting the AC voltage reading to digital signals, the ZMPT101B enables the ESP32S microcontroller to monitor electricity consumption effectively as illustrated in Figure 2 and detailed specifications are given in Table 2.

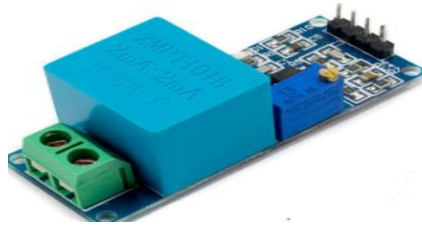


Fig. 2: ZMPT101B Voltage Sensor

### 1.1: SCT013 Current Sensor

The SCT013 Current Sensor is a non-invasive sensor that is used to measure AC current flow. This clamps onto a conductor to find current without being in any form of contact with the conductor, hence safe and easy installation. It outputs accurate readings of current to the microcontroller ESP32S for the implementation of real-time monitoring of the electricity consumption in the smart energy meter system (see Figure 3). The specifications of the SCT013 Current Transformer are presented in Table 1.



Fig. 3: SCT013 Current Sensor

### 1.3: 20x4 LCD with I2C Interface

The LCD Display Module I2C Interface 20x4 is a display type module to provide local indication of measured data for clear and convenient on-site monitoring of energy usage. This I2C interface further simplifies the connections to be made with the ESP32S microcontroller, hence minimizing the complexity of wiring in displaying real-time voltage, current, and power for easy on-site viewing as shown in Figure 4. This helps users in instant visualization of energy consumption without the use of additional gadgets. The 20x4 character format display gives room for detailed data to be displayed; hence, it is very usable. The compact design makes it ideal for integration into energy meters for home and industrial use. The I2C interface further simplifies the connections to be made with the ESP32S microcontroller for easy on-site viewing Interface



Fig. 4: 20x4 LCD with I2C

#### 1.4: CAPACITORS

A capacitor is an electronic component used to store electrical energy for release at a given time. It helps to smooth voltage ripples, filter out noise, and stabilize the supply in the circuit. In an energy meter system, the use of capacitors ensures accuracy in sensor readings and reliability in the operation as depicted in Figure 5.



Fig. 5: Capacitor

#### 1.5: RESISTORS

The resistor is a component used in impeding the flow of electrical current through a circuit. They help in controlling the voltage level and protection of components as shown in Figure 6.



Fig. 6: Resistor

#### 1.6: BULBS

A bulb is an electrical component that converts electrical energy into light. In the energy meter system, a bulb can be used as a load to simulate real-world electricity consumption as illustrated in Figure 7.



Fig. 7: BULB

## II. BREADBOARD

The breadboard is a device for making temporary assemblies of electronic circuits without the use of solder. It provides a means to connect and test components such as resistors, capacitors, and sensors. In an energy meter system, it allows one to assemble and experiment with the circuitry easily before the design is finalized as shown in figure 8.

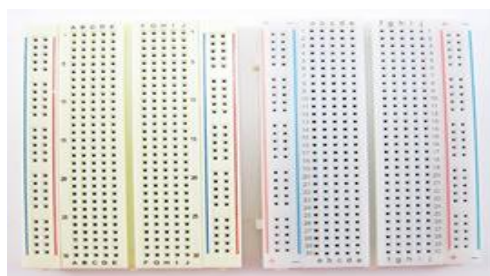


Fig. 8: Breadboard

Table.2. Specifications for SCT-013 Current Transformer

Specification	SCT-013
Input Current	0-30A AC
Output Signal	DC 0-1 V
Non-linearity	2-3 %
Build-in sampling resistance (RL)	62 $\Omega$
Turn Ratio	1800:1
Resistance Grade	Grade B
Working Temperature	-25 °C~+70 °C
Dielectric Strength	1000 V AC / 1 min 5 mA



**Table.3. Specifications for ZMPT101B AC Voltage Sensor**

Specification	ZMPT101B AC Voltage Sensor
Output Signal	0-5V
Operating Voltage	DC 5V-30V
Measure within	250V AC.
Rated input current	2mA
Size	49.5 mm x 19.4 mm
Operating temperature	40°C ~ + 70°C

### III. SYSTEM SOFTWARE REQUIREMENTS

**Arduino IDE:** This is an open-source Arduino software and is used to create and test instructions that make up a program or a sketch for Arduino boards. It makes the writing of code quite easy. It's pretty simple to use and allows uploading sketches to the microcontroller boards. It supports Windows, Linux, and Mac OS X. Before designing the programming for ESP32 in this study, several things have been put into consideration. First of all, the package of ESP32 has been added to the IDE. Secondly, adding library inclusion, namely, the EmonLib and Blynk libraries.

**Library EmonLib:** This library is utilized by Electricity Energy Meter. The Continuous Monitoring of Electricity Energy, called the EmonLib, runs in a continuously loop each 5 or 10 seconds to make several voltage and current measurements. Voltage and current input channels are continuously measured in the background by the EmonLib. Afterwards, it calculates a real average value for each channel and notifies the sketch when the measurements are ready to be read and then processed.

**Blynk libraries:** With Blynk - the most popular and largest Internet of Things platform - you are free to scale up the products that you deploy, connect any device to the cloud, and build apps to control it. Using the Blynk Library, more than 400 hardware models-including Arduino, ESP8266, and ESP32-can be connected to the Blynk Cloud. The Blynk application serves as the controlling application of any IoT-based application. The Blynk application is available for both Android and iOS mobile devices. It provides a facility for any user in designing his own custom Graphical User Interface for an IoT application. The Blynk application serves as the controlling application of any IoT-based application as summarized in Table 3.

#### System Circuit Schematic Diagram

The link to the schematic diagram of the circuit is rather self-explanatory. An SCT-013 Current Transformer and a ZMPT101B Voltage Sensor VCC are connected to Vin of the ESP32 5V supply. Similarly, both modules GNDs are connected to GND of the ESP32. GPIO35 of ESP32 is connected with the analogue output pin of a ZMPT101B Voltage Sensor. Similarly, the analog output pin of the SCT-013 Current Sensor is connected with the GPIO 34 of ESP32. The voltage divider and filter circuit consists of a 10uF capacitor, two 10K resistors, one 100-ohm resistor, and two 10K resistors. The input AC terminal of the voltage sensor will be wired with AC wires that need to be measured for current and voltage. Also, the current sensor clip is not connected and only one live or neutral wire is placed inside the clip as shown in figure 9.

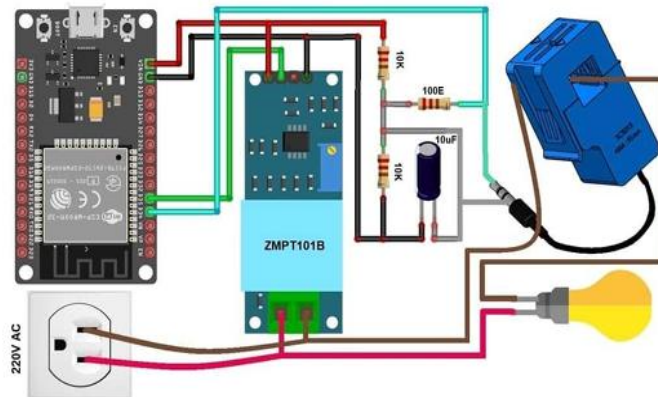


Fig. 9: Circuit Schematic Diagram of Electric Energy Meter.

The methodology for implementing the "IoT Based Smart Electricity Monitoring System using ESP32 and Blynk" involves the following steps:

**Hardware Setup:** Connect the ACS712 Current Sensor and ZMPT101b Voltage Sensor to the AC power supply and loads as per the schematic diagram. Interface the ESP32 microcontroller with the sensors and establish a Wi-Fi connection for communication with the Blynk platform.

**Software Development:** Develop the firmware for the ESP32 microcontroller to read sensor data, perform calculations for power consumption, and transmit data to the Blynk application. Design the Blynk dashboard to display real-time data using gauges and graphs.

**Testing and Validation:** Test the system to ensure proper functionality and accuracy in measuring electricity consumption. Validate the results against known values and conduct thorough testing under various load conditions.

**Deployment:** Deploy the system in the desired environment, such as residential or commercial buildings, to monitor electricity consumption in real-time. Provide user training and support for effective utilization of the system.

#### IV. RESULTS & DISCUSSIONS

An IoT-based smart electricity energy meter based on ESP32 and a Blynk application has been presented in this paper, showing very effective energy management, especially for meeting the peculiar energy needs of Somalia. From the results obtained, there were a number of energy consumptions in real time that were monitored with high precision, efficient energy management that would enable users to monitor power consumption, switch appliances remotely, and also obtain notifications in case of anomalies.

Connectivity and data visualization. Discussions center on the benefits of remote access, potential energy savings, and the practicality of deploying this system widely in Somalia, where it could address electricity challenges, promote efficient energy use, and reduce operational costs. The real-time data visualization and user interface provided by the Blynk platform are shown in Figure 10, demonstrating how users can monitor electricity consumption remotely through both mobile and web applications.

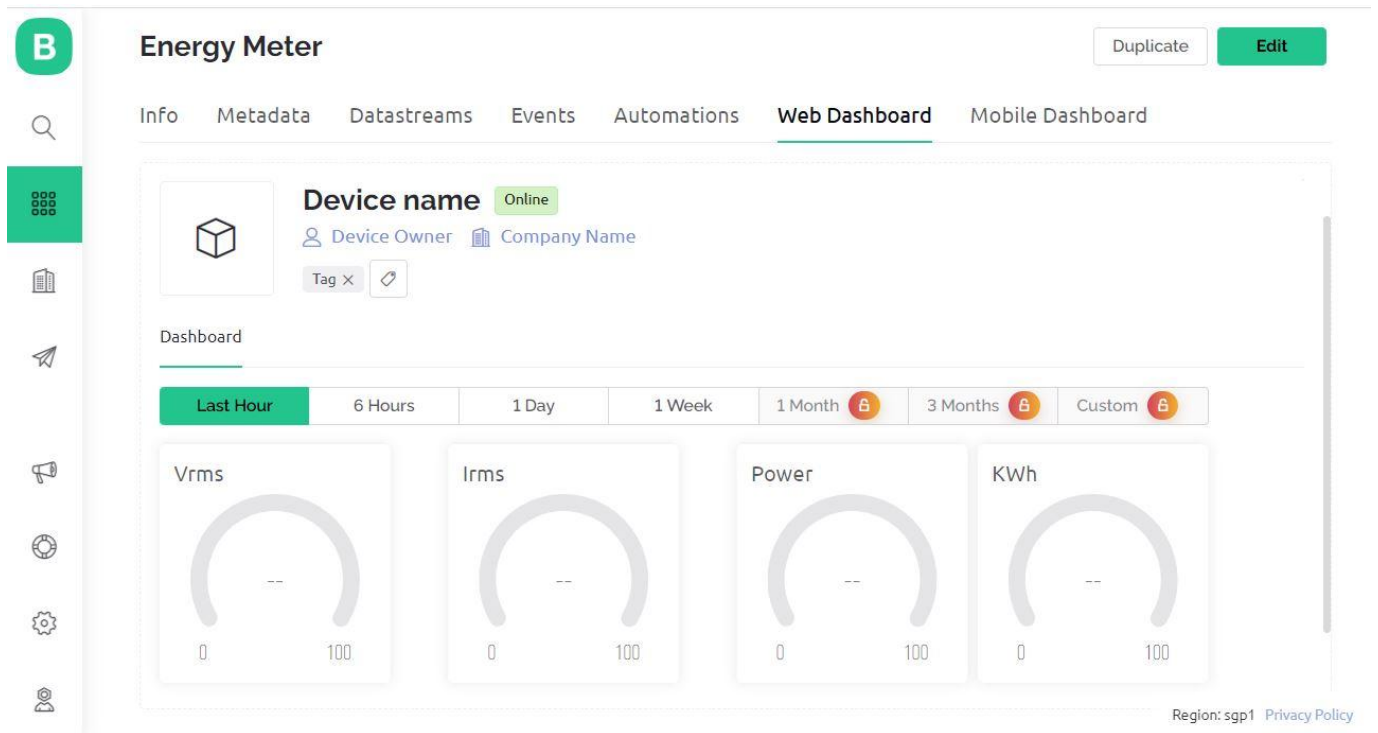


Fig. 10: System Dashboard for Blynk Application and Web Applications

#### 4.1: Serial Monitor Result Display

The sensor data comprising of Vrms, Irms, Power and Energy consumption can be observed on Serial Monitor COM port 4 as from the ESP32 electric energy consumption meter using the baud rate of 9600.

The sensor data, including RMS voltage, current, power, and energy consumption, can be observed on the serial monitor as illustrated in Figure 11.

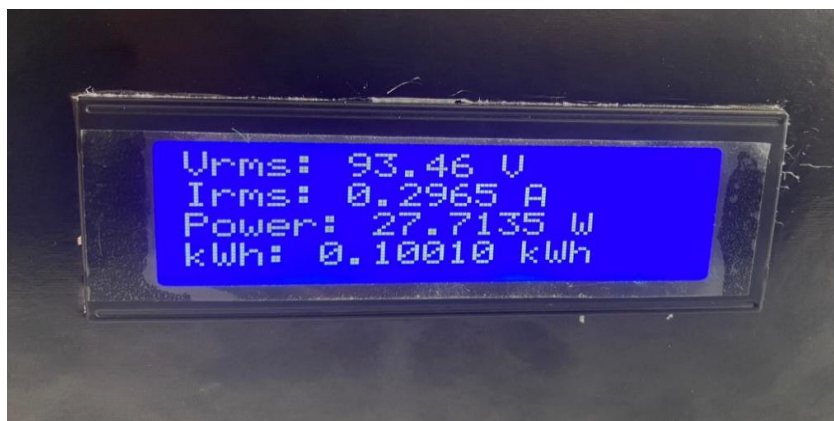


Fig. 11: Electric Energy Consumption Displaying RMS Voltage, Current, power and Energy

#### 4.2: Operational Testing

IoT-Based Smart Electricity Energy Meter involved evaluating the system's real-time performance, reliability, and functionality under typical Somali environmental conditions. This included assessing the meter's ability to accurately monitor energy consumption, maintain stable connectivity with the Blynk app, and manage remote appliance control despite potential network instabilities. The testing confirmed that the system effectively supports energy management needs in Somalia and is suitable for deployment and System Completion for Operational Testing in figure 12.

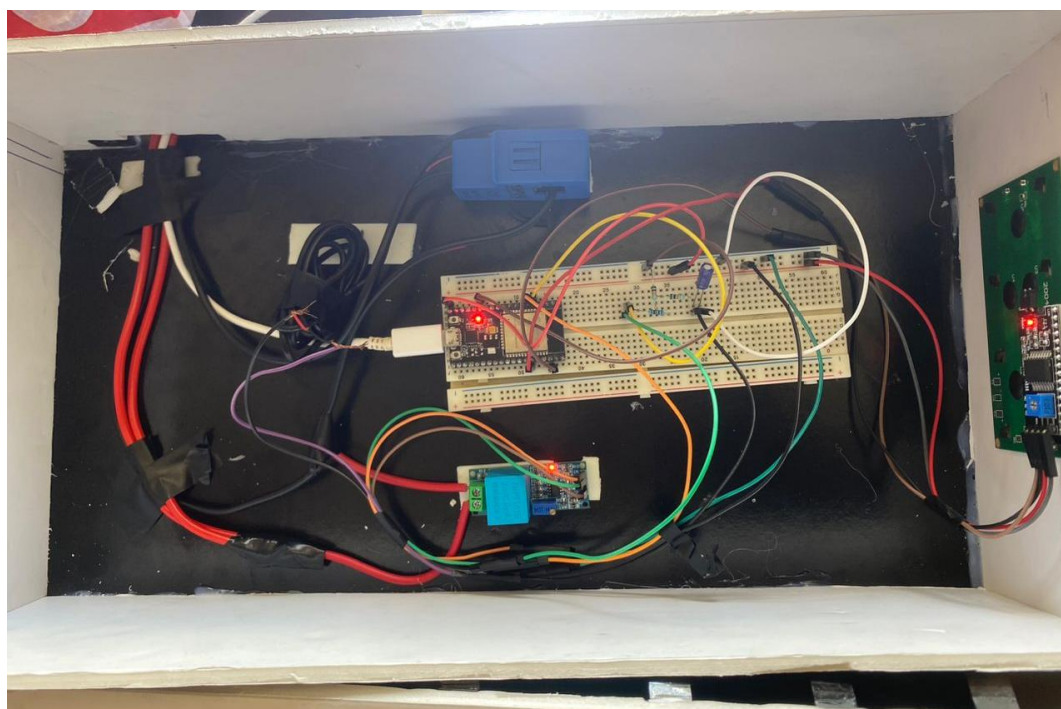


Fig. 12: System Completion for Operational Testing

## V. CONCLUSION

This IoT-based intelligent electricity energy meter, based on the ESP32 microcontroller and Blynk application, provides an effective and feasible solution for managing energy in Somalia. The proposed system will ensure real-time monitoring with remote control, thus enabling users to be proactive in their decisions on electricity consumption and saving potentially money toward improving efficient energy utilization. This solution tends to some of the basic energy problems in Somalia, a country that faces serious infrastructure limitations and very high costs for electricity access. The system's design, centered on the ESP32 microcontroller paired with the Blynk platform, ensures both affordability and user-friendliness. The ESP32's low energy consumption and integrated Wi-Fi capabilities make it ideal for continuous monitoring, while the Blynk application provides an accessible interface for Somali users, many of whom may have limited experience with advanced technology. Users can monitor power usage, receive alerts, and control appliances from their smartphones, giving them greater control over their electricity consumption and enabling energy providers to optimize distribution. The scalability and adaptability of this solution make it suitable for a wide range of applications in Somalia. Beyond households, the system can be deployed in commercial settings, and with potential future integrations, it could incorporate renewable energy sources to support a more sustainable energy framework. As Somalia seeks to modernize its energy infrastructure, such IoT-based solutions can play a crucial role in improving accessibility, transparency, and efficiency in energy management. This study lays the foundation for further research and potential expansion of IoT applications within the country's energy sector, fostering innovation and resilience in the face of Somalia's unique energy challenges.

**Acknowledgements** The authors would like to thank and extend their heartfelt gratitude to SIMAD University for their continuous support throughout this research project. Their provision of resources and encouragement has been instrumental in the successful completion of this work

**Author contribution** Osman Diriye Hussein was responsible for the study's conception, design, development, data collection, analysis, and interpretation, and also reviewed and edited the entire manuscript. Adam Muhudin wrote the introduction and edited the paper and also contributed to writing parts of the methodology section. All authors have read and approved the final version of the manuscript.



**Funding** The authors declare that no funding was received for conducting this study.

## Declarations

**Conflicts of Interest:** All authors declare that they have no conflicts of interest.

**Ethical Approval** Not applicable.

**Consent to Participate** Not applicable.

**Consent for publication** Not applicable.

**Clinical trial number** Not applicable.

## REFERENCES

1. Impact of the shape of electrode-tool on radical overcut of micro-hole in electrochemical micromachining R. Thanigaivelan, R. Senthilkumar, R. M. Arunachalam, and N. Natarajan, "Impact of the shape of electrode-tool on radical overcut of micro-hole in electrochemical micromachining," *Surface Engineering and Applied Electrochemistry*, vol. 53, no. 5, pp. 486–492, 2017.
2. Study on tool steel machining with ZNC EDM by RSM, GREY and NSGA S. Kumar Ramuvel and S. Paramasivam, "Study on tool steel machining with ZNC EDM by RSM, GREY and NSGA," *Journal of Materials Research and Technology*, vol. 9, no. 3, pp. 3885–3896, 2020.
3. R. Senthilkumar, K. Tamizharasan, T. Sowndharya, and M. Kirthikajain, "Fabrication and Analysis of Regenerative Braking System," *Journal for Research*, vol. 3, no. 2, 2017.
4. Investigation over the surface integrity of Tungsten Carbide using ZNC-EDM R. Senthil Kumar and P. Suresh, "Investigation over the surface integrity of Tungsten Carbide using ZNC-EDM," *International Journal of Management Technology and Engineering*, vol. 9, no. 1, pp. 1–6, 2019.
5. Kumar, R. S., Perumal, S., Chandru, M., & Nanthakumar, S. (2026). ESP-32 quadx drone. *International Journal of Engineering & Extended Technologies Research (IJEETR)*, 8(2), 4529–4537.
6. Kumar, R., Perumal, S., Sriram, G., & Seshathri, S. (2026). Electrical steering system in automobile. *International Journal of Engineering & Extended Technologies Research (IJEETR)*, 8(2), 4539–4549.
7. Venkatachalam, R., Ashokan, A., Ganesan, M. P., Perumal, S., Pandian, B., & Pant, R. (2026). Optimization of pyrolysis parameters for enhanced bio-oil yield from lignocellulosic biomass using response surface methodology. *Renewable Energy*. (SCI, submitted for publication).
8. Ashokan, A., Murugesan, S., Muthaiyan, R., Arumugam, S., & Perumal, S. (2025). Numerically analyzing a heat transmission in blood using a cardioplegia concentric tube heat exchanger during open cardiac surgery. *International Journal of Environmental Sciences*, 11(18s).
9. Senthilkumar, R., Perumal, S., & Vinoth, A. (2025). A smart waste management system using IoT. *International Journal of Scientific Development and Research*, 10(5), d351–d360.
10. Perumal, S., Arunkumar, N., Gopi Krishna, B., Kirubainathan, S., & Navukkarasar, M. (2025). Smart AI-powered chatbot using ESP8266 for real-time responses. *International Journal of Scientific Development and Research*, 10(5), d357–d364.
11. Senthilkumar, R., Perumal, S., & Vishal, R. D. (2025). AI-powered drone for electricity pylon inspection. *International Journal of Scientific Development and Research*, 10(5), d617–d627.
12. Senthilkumar, R., Perumal, S., & Vinoth, A. (2025). A smart waste management system using IoT. *International Journal of Scientific Development and Research*, 10(5), d351–d360.
13. Vasanthamohan, R., Senthil Kumar, R., Perumal, S., Bagavathi, T., Karthikeyan, M., & Ranjith, R. (2024). Arm based pick and place robot vehicle using IoT. *International Journal of Advances in Engineering and Management (IJAEM)*, 6(4), 185–194.
14. Senthil Kumar, R., Perumal, S., Lokesh, K., Venkatesh, C., Ajithkumar, M., & Sanjay Kumar, M. (2024). An IoT based industrial platform for remote real-time power plant monitoring. *International Journal of Advances in Engineering and Management (IJAEM)*, 6(4), 376–388.
15. Senthil Kumar, R., Perumal, S., Kaviya, P., Ajay, M., Gokulakannan, K., & Gowtham, S. (2024). Solar smart air pollution monitoring framework using Arduino and IoT applications. *International Journal of Advances in Engineering and Management (IJAEM)*, 6(4), 147–185.



16. Perumal, S., Johnrajan, A., Raja, S., Praveenkumar, V., & Arun Kumar, K. (2023). A systematic review of hybrid renewable energy systems about their optimization techniques with analytic hierarchy process. *International Journal of Power System Operation and Energy Management*, 3(3), 147–185. <https://doi.org/09.0014.MSJ>
17. Perumal, S., Madheswaran, M., Ragul, N., Srilakshman, T., & Naveenkumar, R. (2023). CFD analysis of ground heat exchanger by different configurations. *Mukt Shabd Journal*, 7(5). <https://doi.org/09.0014.MSJ>
18. Raman, M., Perumal, S., Muthusamy, S., & Subramaniam, S. (2022). Studies on diesel engine exhaust gas for retrieving the waste heat through triple tube heat exchanger (TTHE) through different tubes. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 44(2), 4149–4164.
19. Perumal, S., & Mohan, R. (2020). Numerical and experimental study of a triple concentric tube heat exchanger for waste heat recovery from engine exhaust gas. *Thermal Science*, 6(2), 216–228.
20. Palanisamy, P., Perumal, S., & Manojkumar, P. (2021). Optimization of process parameters on reliability for twisted drill life in drilling. *International Journal of Engineering Research & Technology*, 1(1).
21. Perumal, S., Naveenkumar, D., Manikandan, M., & Mohan Kumar, M. (2020). Experimental investigation of triple tube heat exchanger for waste heat recovery from IC engine exhaust gas. *International Journal for Scientific Research and Development*, 3(3).
22. Murali, T., Perumal, S., Lijo, S., & Sasidharan, S. (2020). Design and synthesis of six-legged walking robot using single degree of freedom linkage. *Global Research and Development Journal*, 2(3).
23. Perumal, S., Mohan, R., Sasidharan, S., & Venkadesh, K. (2017). Study on concentric tube heat exchanger with different nanofluids for enhancing the heat transfer: A review. *International Journal of Impotence Research*, 3(9).
24. Perumal, S., Manikandan, T., Mounaraj, K., & Mubarak, S. (2017). Design and synthesis of multipurpose hand driller machine for various processes. *International Journal of Science Technology and Engineering*, 4(3).
25. Senthilkumar, K., Perumal, S., Mohan, R., & Kalidoss, K. (2016). Numerical analysis of triple concentric tube heat exchanger using dimpled tube geometry. *Asian Journal of Research in Social Sciences and Humanities*, 6(8), 2078–2088.
26. Murali, T., Perumal, S., Mohan, R., & Palanisamy, P. (2016). Design and synthesis of six-legged walking robot using single degree of freedom linkage. *International Journal of Impotence Research*, 2(3).
27. Perumal, S., Mohan, R., Palanisamy, P., & Senthilkumar, K. (2015). Study on double pipe heat exchanger using different enhancement techniques. *International Journal of Impotence Research*, 5(1).
28. Perumal, S., Senthilkumar, K., Palanisamy, P., & Vinoth, R. (2014). Numerical study of a concentric tube heat exchanger using dimpled tubes with Al<sub>2</sub>O<sub>3</sub> nanofluid. *Australian Journal of Basic and Applied Sciences*, 8(7), 185–193.
29. C.Nagarajan and M.Madheswaran - 'Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques'- Taylor & Francis, Electric Power Components and Systems, Vol.39 (8), pp.780-793, May 2011. DOI: 10.1080/15325008.2010.541746
30. C.Nagarajan and M.Madheswaran - 'Experimental verification and stability state space analysis of CLL-T Series Parallel Resonant Converter' - Journal of Electrical Engineering, Vol.63 (6), pp.365-372, Dec.2012. DOI: 10.2478/v10187-012-0054-2
31. C.Nagarajan and M.Madheswaran - 'Performance Analysis of LCL-T Resonant Converter with Fuzzy/PID Using State Space Analysis'- Springer, Electrical Engineering, Vol.93 (3), pp.167-178, September 2011. DOI 10.1007/s00202-011-0203-9
32. S.Tamilselvi, R.Prakash, C.Nagarajan, "Solar System Integrated Smart Grid Utilizing Hybrid Coot-Genetic Algorithm Optimized ANN Controller" Iranian Journal Of Science And Technology-Transactions Of Electrical Engineering, DOI10.1007/s40998-025-00917-z,2025
33. S.Tamilselvi, R.Prakash, C.Nagarajan, " Adaptive sliding mode control of multilevel grid-connected inverters using reinforcement learning for enhanced LVRT performance" Electric Power Systems Research 253 (2026) 112428, doi.org/10.1016/j.epr.2025.112428
34. S.Thirunavukkarasu, C. Nagarajan, 2024, "Performance Investigation on OCF and SCF study in BLDC machine using FTANN Controller," Journal of Electrical Engineering And Technology, Volume 20, pages 2675–2688, (2025), doi.org/10.1007/s42835-024-02126-w
35. C. Nagarajan, M.Madheswaran and D.Ramasubramanian- 'Development of DSP based Robust Control Method for General Resonant Converter Topologies using Transfer Function Model'- *Acta Electrotechnica et Informatica Journal*, Vol.13 (2), pp.18-31, April-June.2013, DOI: 10.2478/aei-2013-0025.
36. C.Nagarajan and M.Madheswaran - 'DSP Based Fuzzy Controller for Series Parallel Resonant converter'- Springer, *Frontiers of Electrical and Electronic Engineering*, Vol. 7(4), pp. 438-446, Dec.12. DOI 10.1007/s11460-012-0212-0.



37. C.Nagarajan and M.Madheswaran - 'Experimental Study and steady state stability analysis of CLL-T Series Parallel Resonant Converter with Fuzzy controller using State Space Analysis'- *Iranian Journal of Electrical & Electronic Engineering*, Vol.8 (3), pp.259-267, September 2012.
38. C.Nagarajan and M.Madheswaran, "Analysis and Simulation of LCL Series Resonant Full Bridge Converter Using PWM Technique with Load Independent Operation" has been presented in ICTES'08, a IEEE / IET International Conference organized by M.G.R.University, Chennai.Vol.no.1, pp.190-195, Dec.2007
39. Suganthi Mullainathan, Ramesh Natarajan, "An SPSS and CNN modelling based quality assessment using ceramic materials and membrane filtration techniques", *Revista Materia (Rio J.)* Vol. 30, 2025, DOI: <https://doi.org/10.1590/1517-7076-RMAT-2024-0721>
40. M Suganthi, N Ramesh, "Treatment of water using natural zeolite as membrane filter", *Journal of Environmental Protection and Ecology*, Volume 23, Issue 2, pp: 520-530,2022