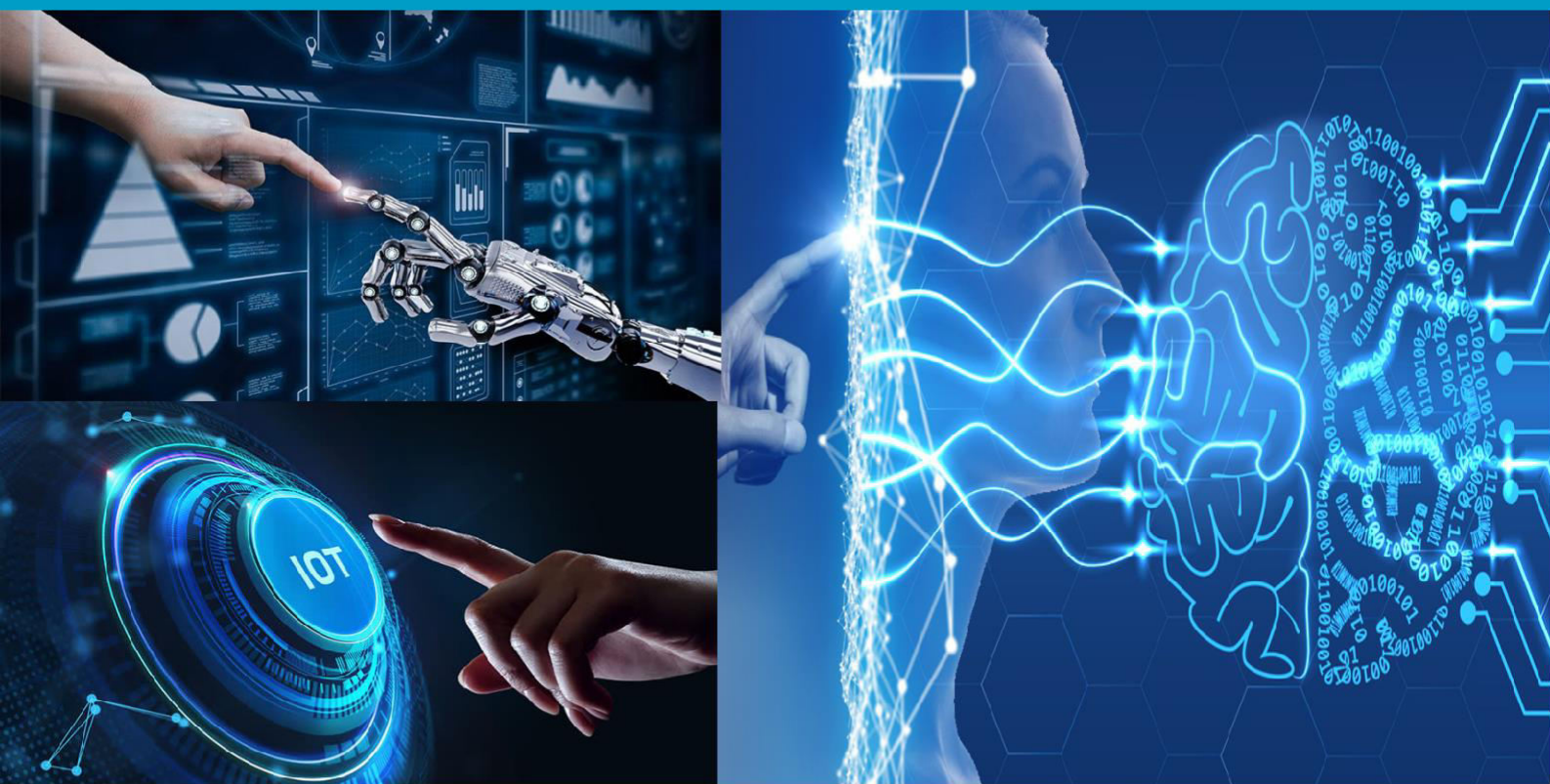




INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING, TECHNOLOGY AND MANAGEMENT

Volume 11, Issue 5, May 2024



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.802



ijmrsetm@gmail.com



www.ijmrsetm.com

A Network Intrusion Detection System Building Automation and Control System KNX

A. Soundar¹, L. Pranesh², S. Sivaperumal³, C. Ramkumar⁴ and S. Saravanan⁵

UG Students, Department of Electrical and Electronics Engineering, Muthayammal Engineering College,
Tamil Nadu, India^{1,2,3}

Associate Professor, Department of Electrical and Electronics Engineering, Muthayammal Engineering College,
Tamil Nadu, India⁴

Professor, Department of Electrical and Electronics Engineering, Muthayammal Engineering College,
Tamil Nadu, India⁵

ABSTRACT: Building Automation and Control Systems (BACS) are traditionally based on specialized communications protocols, such as KNX or BACnet, and dedicated sensing and actuating devices. Despite the increased awareness about the security risks associated with BACS, there is a lack of security tools for protecting this special breed of cyber-physical systems. This is further aggravated by the fact that general-purpose security tools are typically not able to cope with the specific requirements and technologies associated with BACS, making it necessary to devise domain-specific approaches – as shown, for instance, by the KNX Secure initiative led by the KNX Association. In this paper, we address this gap by proposing a Network Intrusion Detection System (NIDS) specifically designed for BACS. This NIDS is protocol-agnostic and can potentially support different BACS protocols and technologies, such as KNX, BACnet, Modbus or mixed ecosystems, without loss of generality.

KEYWORDS: Home Automation, Building Automation and Control Systems, BACS, NIDS, Smart Buildings, Security, Safety, KNX

I. INTRODUCTION

OVER the past few years, there has been a progressive mindset shift in the automation domain towards considering security as much of a critical requirement as reliability or safety. From this perspective, Building Automation and Control Systems (BACS) constitute no exception, as both the need for monitoring the proper operation of physical devices and the security of the whole building operation should be considered as key requirements. This is especially important if one considers the increasing permeability between building automation and traditional IT systems, which increases the security challenges faced by BACS, since most of the current BACS implementations were originally designed with isolation as an acquired safety guarantee. The growing awareness of security problems led to various improvements to the standards used in building automation, for instance incorporating authentication and encryption mechanisms. However, in most deployments it will not be easy or even possible to retrofit these improvements, since existing devices lack memory and/or computational power to implement those novel security features. Moreover, even buildings where these improvements are retrofitted are still vulnerable to a wide range of attacks.

In this paper we explore the concept of a domain-specific Network Intrusion Detection System (NIDS) for BACS as a way of mitigating this situation. The proposed NIDS is a monitoring probe that can intercept all the fieldbus traffic of the building automation network (control network) and also observe the local area network (LAN). In this way, all the messages can be observed (e.g. firmware updates, command messages, sensors' outputs, actuators' inputs and status). The feasibility of this BACS-specific NIDS concept depends on two key capabilities. First, it must incorporate anomaly detection mechanisms able to ingest the data obtained from both the legacy BACS control network and the general-purpose building LAN, to detect system anomalies and potential cyberattacks. Second, this domain-specific NIDS must target a suitable cost-efficiency balance, ideally within the magnitude of a single device retail price.

KNX-BASED BACS

This section provides a basic description of the KNX protocol and related technology ecosystem. More detailed information can be found on the KNX Association repositories. The KNX standard appeared in the early 1990s, driven

by the European Installation Bus Association as a way to enable the connection, configuration and communication between multiple building automation devices (e.g. sensors, actuators, buttons and other user interfaces), using a common language and a standard communications protocol. It is widely used for home and building automation, for instance to control lighting, shutters, security systems, energy management, heating, ventilation, air-conditioning systems, signalling and monitoring systems, remote control, and audio/video control. All these functions are managed via the KNX protocol set. The smallest entity within the KNX network topology is a line. A line contains a maximum of 64 devices, which is enough for most small scale projects.

CYBERSECURITY AND BACS

Historically, BACS have been designed to work in an isolated fashion, without any connection to ICT networks. Security was supposedly achieved by isolation (the "airgap principle") and by the use of obscure proprietary solutions with poor or non-accessible documentation. Meanwhile, the popularity of ICT commodity technologies – driven by simplicity, lower total cost of ownership and improved operation, configuration and management – has led to the introduction of network bridging mechanisms. Suddenly, several underlying security assumptions were broken, and BACS became connected to globally accessible networks such as the Internet, without taking into account the potential implications in terms of security and safety.

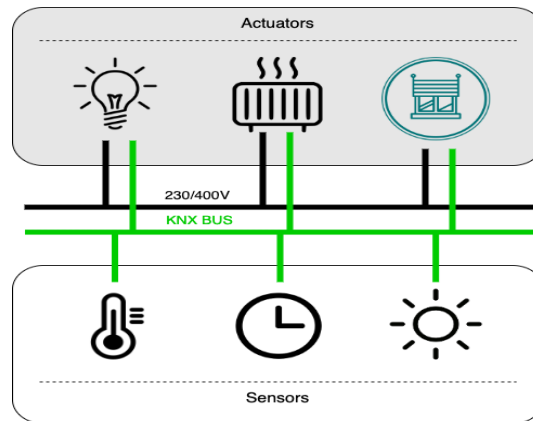


Figure.1. Cyber security and Bacs

As pointed out by Graveto et al., BACS security breaches are often considered to be a consequence of using systems, protocols and standards that were originally conceived to operate in isolated environments, without any connection to ICT networks or the Internet. This is aggravated by the fact that many legacy devices cannot be patched, often meaning that only isolation or complete replacement might ensure adequate security. In general, most attack categories that are characteristic of Industrial Automation and Control Systems (IACS) may be somehow transposed to BACS scenarios. However, even though some the protection strategies used in IACS might somehow provide hints on how to keep BACS secure, there are considerable context differences that require domain-specific approaches. Similarly, the protections typically used in IACS at network level also need to be adapted to BACS.

II. PROPOSED BACS NIDS

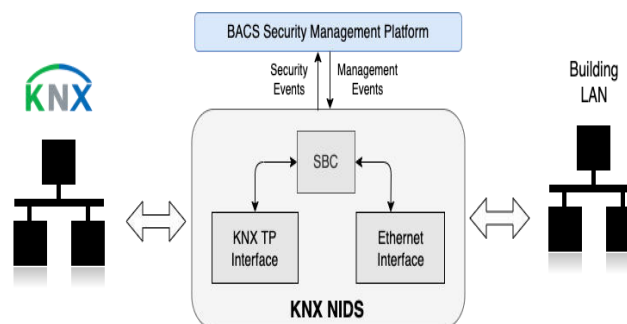


Figure.2. Proposed Bacs Nids

The discussion presented in the previous section clearly identified a gap of security mechanisms for BACS environments. This motivated us to develop the BACS NIDS, an intrusion and anomaly detector that operates mainly at the control network level(fieldbus). The concept and main requirements are outlined in this section, with the architecture being presented in Section.

HARDWARE COMPONENTS

ATMEGA-8



Figure.3.ATMEGA

Micro-controller with Wi-Fi capability. Integrated TCP/IP Protocol stack. MAC/ Baseband Processor. Integrated TR Switch, Balun, LNA, Power Amplifier, matching network. Integrated PLL, regulator, DCXO, PMU.Can be programmed just like any other MCU, it has GPIO, SPI, I2C, UART, I2S.

FILTER

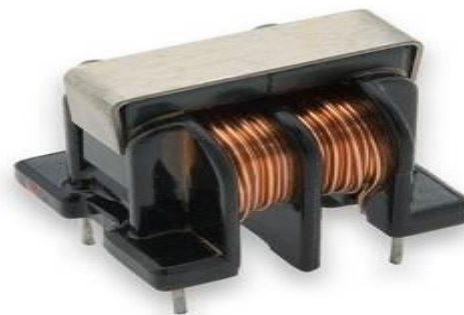


Figure.4.Filter

The Filter is used to remove the pulsated AC. A filter circuit uses capacitor and inductor. The function of the capacitor is to block the DC voltage and bypass the AC voltage. The function of the inductor is to block the AC voltage and bypass the DC voltage.

VOLTAGE REGULATOR



Figure.5.Voltage Regulator

Voltage regulator constitutes an indispensable part of the power supply section of any electronic systems. The main advantage of the regulator ICs is that it regulates or maintains the output constant, in spite of the variation in the input supply. Voltage regulator keeps the voltage from a power supply within a range that is compatible within a range that is compatible with a other electrical components. Voltage regulator is a circuit that creates and maintains a fixed output voltage, irrespective of changes to the input voltages or load conditions.

III.RESULT AND DISCUSSION

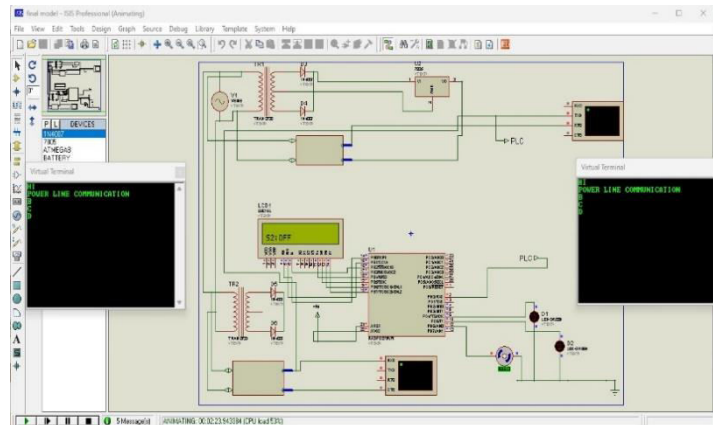


Figure.6.Simulation Results

Power Line Communication (PLC) is a communication method that uses power lines as the medium. By using power lines as the communication network, it is possible to build a system quickly at low cost. For this reason, PLC is used for communications in smart meters (advanced metering infrastructure - AMI), home energy management systems (HEMS), building energy management systems (BEMS), and solar panel monitoring systems, part of a smart society. Communication data can be propagated through AC or DC power lines. Renesas offers power line communication solutions consisting of high-performance and flexible PLC devices, optimized evaluation boards, and a software stack that makes it easy to realize robust communication to support the development of projects.

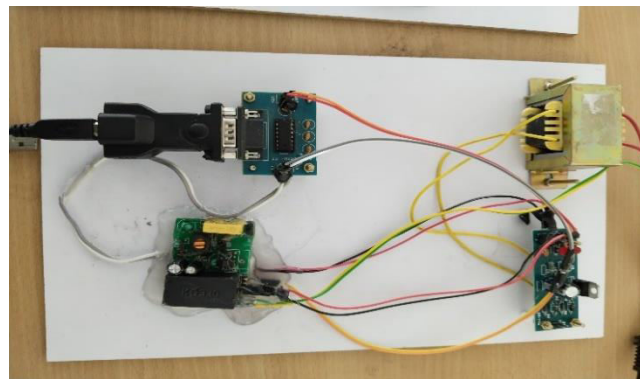


Figure.7. Hardware Model

To address this gap, in this paper we proposed a domain-specific NIDS designed for BACS environments, able to monitor and analyse fieldbus traffic and able to fit into typical BACS scenarios, in terms of physical deployment, costs and management interfaces. After introducing the proposed concept, we described a specific PoC implementation for KNX TP fieldbus, discussing its software architecture, hardware details and generic detection and management capabilities. Afterwards, we demonstrated these capabilities in the scope of a real BACS scenario, injecting several types of attacks and using statistical analysis, signature-based rules and artificial intelligence techniques to detect those attacks. Overall, these examples show how the NIDS can cope with a wide range of real-life attacks.

IV.CONCLUSION

Despite their relevance, from a security and privacy point of view, BACS ecosystems suffer from a lack of domain-specific security tools, since general-purpose tools are unable to fully address the requirements of such environments. To address this gap, in this paper we proposed a domain-specific NIDS designed for BACS environments, able to monitor and analyse fieldbus traffic and able to fit into typical BACS scenarios, in terms of physical deployment, costs and management interfaces. After introducing the proposed concept, we described a specific PoC implementation for KNX TP fieldbus, discussing its software architecture, hardware details and generic detection and management capabilities. Afterwards, we demonstrated these capabilities in the scope of a real BACS scenario, injecting several types of attacks and using statistical analysis, signature-based rules and artificial intelligence techniques to detect those attacks. Overall, these examples show how the NIDS can cope with a wide range of real-life attacks.

REFERENCES

1. V. Graveto, T. Cruz, and P. Simões, "Security of building automation and control systems: Survey and future research directions," *Computers & Security*, vol. 112, p. 102527, 2022.
2. S. Wendzel, J. Tonejc, J. Kaur, and A. Kobekova, *Cyber Security of Smart Buildings*. John Wiley & Sons, Ltd, 2017, ch. 16, pp. 327–351.[Online].Available:<https://onlinelibrary.wiley.com/doi/abs/10.1002/9781119226079.ch16>.
3. T. Macaulay and B. Singer, *Cybersecurity for Industrial Control Systems*. CRC Press, 2011. [Online]. Available: <https://www.taylorfrancis.com/books/mono/10.1201/b11352/cybersecurity-industrial-control-systems-tyson-macaulay-bryan-singer>.
4. V.Dhinesh, T.Premkumar, S.Saravanan and G.Vijayakumar," Online Grid Integrated Photovoltaic System with New Level Inverter System" *International Research Journal of Engineering and Technology (IRJET)*, Vol.5, Issue 12, pp.1544-1547, 2018.
5. J.Vinoth, T.Muthukumar, M.Murugandam and S.Saravanan," Efficiency Improvement of Partially Shaded PV System, *International Journal of Innovative Research in Science, Engineering and Technology*, Vol.4, Special issue 6, pp.1502-1510, 2015.
6. M.B.Malayandi, Dr.S.Saravanan, Dr. M.Muruganandam, "A Single Phase Bridgeless Boost Converter for Power Factor Correction on Three State Switching Cells", *International Journal of Innovative Research in Science, Engineering and Technology*, Vol. 4, Special Issue 6, pp. 1560-1566, May 2015.
7. A.Sasipriya, T.Malathi, and S.Saravanan, "Analysis of Peak to Average Power Ratio Reduction Techniques in SFBC OFDM System" *IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)*, Vol. 7, No.5, 2013.
8. P.Ranjitha, V.Dhinesh, M.Muruganandam, S.Saravanan, "Implementation of Soft Switching with Cascaded Transformers to drive the PMDC Motor", *International Journal of Innovative Research in Science, Engineering and Technology*, Vol. 4, Special Issue 6, pp. 1411-1418, May 2015.
9. C.Sowmiya, N.Mohanandhini, S.Saravanan and M.Ranjitha,"Inverter Power Control Based On DC-Link Voltage Regulation for IPMSM Drives using ANN" *International Research Journal of Engineering and Technology (IRJET)*, Vol.5, Issue 11, pp.1442-1448, 2018.
10. N.Yuvaraj, B.Deepan, M.Muruganandam, S.Saravanan, "STATCOM Based of Adaptive Control Technique to Enhance Voltage Stability on Power Grid", *International Journal of Innovative Research in Science, Engineering and Technology*, Vol. 4, Special Issue 6, pp. 1454-1461, May 2015.
11. P.Manikandan, S.Karthick, S.Saravanan and T.Divya," Role of Solar Powered Automatic Traffic Light Controller for Energy Conservation" *International Research Journal of Engineering and Technology (IRJET)*, Vol.5, Issue 12, pp.989-992, 2018.
12. R.Satheesh Kumar, D. Kanimozhi, S. Saravanan, "An Efficient Control Scheme for Wind Farm Using Back to Back Converter," *International Journal of Engineering Research & Technology (IJERT)*, Vol. 2, No.9, pp.3282-3289, 2013.
13. K.Prakashraj, G.Vijayakumar, S.Saravanan and S.Saranraj, "IoT Based Energy Monitoring and Management System for Smart Home Using Renewable Energy Resources," *International Research Journal of Engineering and Technology*, Vol.7, Issue 2, pp.1790-1797, 2020.
14. J Mohammed siddi, A. Senthil kumar, S.Saravanan, M. Swathisriranjani, "Hybrid Renewable Energy Sources for Power Quality Improvement with Intelligent Controller," *International Research Journal of Engineering and Technology*, Vol.7, Issue 2, pp.1782-1789, 2020.
15. S. Raveendar, P.M. Manikandan, S. Saravanan, V. Dhinesh, M. Swathisriranjani, "Flyback Converter Based BLDC Motor Drives for Power Device Applications," *International Research Journal of Engineering and Technology*, Vol.7, Issue 2, pp.1632-1637, 2020.

16. K. Manikanth, P. Manikandan, V. Dhinesh, Dr. N. Mohananthini, Dr. S. Saravanan, "Optimal Scheduling of Solar Wind Bio-Mass Systems and Evaluating the Demand Response Impacts on Effective Load Carrying Capability," International Research Journal of Engineering and Technology, Vol.7, Issue 2, pp.1632-1637, 2020.
17. T.R. Vignesh, M.Swathisriranjani, R.Sundar, S.Saravanan, T.Thenmozhi, "Controller for Charging Electric Vehicles Using Solar Energy", Journal of Engineering Research and Application, vol.10, Issue.01, pp.49-53, 2020.
18. V.Dhinesh, Dr.G.Vijayakumar, Dr.S.Saravanan, "A Photovoltaic Modeling module with different Converters for Grid Operations", International Journal of Innovative Research in Technology, vol.6, Issue 8, pp.89-95, 2020.
19. V. Dhinesh, R. Raja, S. Karthick, Dr. S. Saravanan, "A Dual Stage Flyback Converter using VC Method", International Research Journal of Engineering and Technology, Vol.7, Issue 1, pp.1057-1062, 2020.
20. G. Poovarasan, S. Susikumar, S. Naveen, N. Mohananthini, S. Saravanan, "Study of Poultry Fodder Passing Through Trolley in Feeder Box," International Journal of Engineering Technology Research & Management, vol.4, Issue.1, pp.76-83, 2020.
21. C. Sowmya, N. Mohananthini, S. Saravanan, and A. Senthil kumar, "Using artificial intelligence inverter power control which is based on DC link voltage regulation for IPMSM drives with electrolytic capacitor," AIP Conference Proceedings 2207, 050001 (2020); <https://doi.org/10.1063/5.0000390>, Published Online: 28 February 2020.
22. M.Revathi, S.Saravanan, R.Raja, P.Manikandan, "A Multiport System for A Battery Storage System Based on Modified Converter with MANFIS Algorithm," International Journal of Engineering Technology Research & Management, vol.4, issue 2, pp.217-222, 2020.
23. D Boopathi, S Saravanan, Kaliannan Jagatheesan, B Anand, "Performance estimation of frequency regulation for a micro-grid power system using PSO-PID controller", International Journal of Applied Evolutionary Computation (IJAE), Vol.12, Issue.4, pp.36-49, 2021.
24. V Deepika, S Saravanan, N Mohananthini, G Dineshkumar, S Saranraj, M Swathisriranjani, "Design and Implementation of Battery Management System for Electric Vehicle Charging Station", Annals of the Romanian Society for Cell Biology, Vol.25, Issue.6, 17769-17774, 2021.
25. A Senthilkumar, S Saravanan, N Mohananthini, M Pushparaj, "Investigation on Mitigation of Power Quality Problems in Utility and Customer side Using Unified Power Quality Conditioner", Journal of Electrical Systems, Vol.18, Issue.4, pp.434-445, 2022.
26. V Kumarakrishnan, G Vijayakumar, D Boopathi, K Jagatheesan, S Saravanan, B Anand, "Frequency regulation of interconnected power generating system using ant colony optimization technique tuned PID controller", Control and Measurement Applications for Smart Grid: Select Proceedings of SGESC 2021, pp.129-141.
27. C Nagarajan, B Tharani, S Saravanan, R Prakash, "Performance estimation and control analysis of AC-DC/DC-DC hybrid multi-port intelligent controllers based power flow optimizing using STEM strategy and RPFC technique", International Journal of Robotics and Control Systems", Vol.2, Issue.1, pp.124-139, 2022.
28. G Vijayakumar, M Sujith, S Saravanan, Dipesh B Pardeshi, MA Inayathullaa, "An optimized MPPT method for PV system with fast convergence under rapidly changing of irradiation", 2022 International Virtual Conference on Power Engineering Computing and Control: Developments in Electric Vehicles and Energy Sector for Sustainable Future (PECCON), pp.1-4.
29. C Nagarajan, K Umadevi, S Saravanan, M Muruganandam, "Performance Analysis of PSO DFFP Based DC-DC Converter with Non Isolated CI using PV Panel", International Journal of Robotics and Control Systems' Vol.2, Issue.2, pp.408-423, 2022.
30. VM Geetha, S Saravanan, M Swathisriranjani, CS Satheesh, S Saranraj, "Partial Power Processing Based Bidirectional Converter for Electric Vehicle Fast Charging Stations", Journal of Physics: Conference Series, Vol.2325, Issue.1, pp.012028, 2022.
31. M Santhosh Kumar, G Dineshkumar, S Saravanan, M Swathisriranjani, M Selvakumari, "Converter Design and Control of Grid Connected Hybrid Renewable Energy System Using Neuro Fuzzy Logic Model", 2022 Second International Conference on Computer Science, Engineering and Applications (ICCSEA), pp.1-6, 2022.
32. C Gnanavel, A Johny Renoald, S Saravanan, K Vanchinathan, P Sathishkhanna, "An Experimental Investigation of Fuzzy-Based Voltage-Lift Multilevel Inverter Using Solar Photovoltaic Application", Smart Grids and Green Energy Systems, pp.59-74, 2022.
33. C Nagarajan, K Umadevi, S Saravanan, M Muruganandam, "Performance investigation of ANFIS and PSO DFFP based boost converter with NICI using solar panel", International Journal of Engineering, Science and Technology, Vol.14, Issue.2, pp.11-21, 2022.
34. K Priyanka, N Mohananthini, S Saravanan, S Saranraj, R Manikandan, "Renewable operated electrical vehicle battery charging based on fuzzy logic control system", AIP Conference Proceedings, Vol.2452, Issue.1, pp.030007, 2022.
35. V Kumarakrishnan, G Vijayakumar, D Boopathi, K Jagatheesan, S Saravanan, B Anand, "Optimized PSO technique based PID controller for load frequency control of single area power system", Solid State Technology,

- Vol.63. Issue.5, pp.7979-7990, 2020.
36. G. Poovarasan, S. Susikumar, S. Naveen, N. Mohananthini, S. Saravanan, "Implementation of IoT Based Poultry Feeder Box", International Journal of Innovative Research In Technology, Vol.6, Issue.2, pp.33-38, 2020.
 37. N.Gokulnath, B.Jasim Khan, S.Kumaravel, Dr.A.Senthil Kumar and Dr.S.Saravanan, "Soldier Health and Position Tracking System", International Journal of Innovative Research In Technology (IJIRT)), Vol-6 Issues 12, pp.39-45, 2020.
 38. P.Navaneetha, R.Ramiya Devi, S.Vennila, P.Manikandan and Dr.S.Saravanan , " IOT Based Crop Protection System against Birds and Wild Animal Attacks", International Journal of Innovative Research In Technology (IJIRT)), Vol-6 Issues 11, pp.133-143, 2020.
 39. V. Dhinesh, D. Prasad, G. Jeevitha, V. Silambarasan, Dr. S. Saravanan, " A Zero Voltage Switching Pulse Width Modulated Multilevel Buck Converter", International Research Journal of Engineering and Technology (IRJET), Vol 7 Issue 3, pp.1764,2020.
 40. K. Punitha, M. Rajkumar, S. Karthick and Dr. S. Saravanan, " Impact of Solar And Wind Integration on Frequency Control System", International Research Journal of Engineering and Technology (IRJET), Vol 7 Issue 3, pp.1357-1362,2020.
 41. A.Arulkumar, S.Balaji, M.Balakrishnan, G.Dineshkumar and S.Saravanan, "Design And Implementation of Low Cost Automatic Wall Painting Machine" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.170-176, 2020.
 42. V.Periyasamy, S.Surya, K. Vasanth, Dr.G.Vijayakumar and Dr.S.Saravanan, "Design And Implementation of Iot Based Modern Weaving Loom Monitoring System" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 04, pp.11-18, 2020.
 43. M.Yogheshwaran, D.Praveenkumar,S.Pravin,P.M.Manikandan and Dr.S.Saravanan, "IoT Based Intelligent Traffic Control System" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 04, pp.59-63, 2020.
 44. R.Pradhap, P.Radhakrishnan, P.Vijayakumar, R.Raja and Dr.S.Saravanan, "Solar Powered Hybrid Charging Station For Electrical Vehicle" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 04, pp.19-27, 2020
 45. S.Shenbagavalli, T.Priyadharshini, S.Sowntharya, P.Manikandan and Dr.S.Saravanan, "Design and Implementation of Smart Traffic Controlling System" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 04, pp.28-36, 2020.
 46. M.Pavithra, S.Pavithra, R.Rama Priya, M.Vaishnavee, M.Ranjitha and S.Saravanan, "Fingerprint Based Medical Information System Using IoT" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 04, pp.45-51, 2020.
 47. A.Ananthan, A.M.Dhanesh, J.Gowtham, R.Dhinesh, G.Jeevitha and Dr.S.Saravanan, "IoT Based Clean Water Supply" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.154-162, 2020.
 48. R.Anbarsan, A.Arsathparvez, K.S.Arunachalam, M.Swathisriranjani and Dr.S.Saravanan, "Automatic Class Room Light Controlling Using Arduino" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.192-201, 2020.
 49. S.Karthikeyan, A.Krishnaraj, P.Magendran, T.Divya and Dr.S.Saravanan , "The Dairy Data Acquisition System" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.163-169, 2020.
 50. M.Amaran, S.Mannar Mannan, M.Madhu, Dr.R.Sagayaraj and Dr. S.Saravanan, "Design And Implementation of Low Cost Solar Based Meat Cutting Machine" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.202-208, 2020.
 51. N.Harish, R.Jayakumar, P.Kalaiyarasan, G.Vijayakumar and S. Saravanan, "IoT Based Smart Home Energy Meter" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.177-183, 2020.
 52. K.Subashchandrabose, G.Moulieshwaran, M.Raghul, V.Dhinesh and S.Saravanan, "Design of Portable Sanitary Napkin Vending Machine", International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.52-58, 2020.
 53. R.Gopi, K.Gowdhaman, M.Ashok, S.Divith, S.Saravanan and G.Dineshkumar, "An Online Method of Estimating State of Health of A Li-Ion Battery", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.31-36, 2023.
 54. S.Azhaganandham, P.Elangovan, M.S.Kayalkanan, M.Dineshkumar and S.Saravanan, "Automatic Direct Torque Control System For 3 Phase Induction Motor", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.1-3, 2023.
 55. K. Ranjith Kumar, A.Naveen, R.Ragupathi, S. Savitha and S. Saravanan, "Automatic Industrial-Based Air

- Pollution Avoidance System Using Iot”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.100-105, 2023.
56. G.T.Nandhini, V.Megasri, T.Jeevitha, S.Sandhiya and S. Saravanan, “Automatic Pick And Drop Helping Robot”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.72-76, 2023.
 57. K.Deepika, S.Divya, A.Hema, R.Meena, V.Deepika and S.Saravanan, “Automatic Solar Panel Cleaning System”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.62-66, 2023.
 58. A.Balaji, K.Harikiruthik, A.Mohamed Hassan, S.Saravanan and S.Saranraj, “Design and Implementation of A Single Stage Multi-Pulse Flexible Topology Thyristor Rectifier for Battery Charging in Electric Vehicles”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.37-42, 2023.
 59. D.Hemalatha, S.Indhumathi, V.Myvizhi and S.Saravanan, “Design and Implementation of Intelligent Controller for Domestic Applications”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.4-7, 2023.
 60. N.Priyadharshini, S.Saraswathi, T.Swetha, K.Sivaranjani, K.Umadevi and S.Saravanan, “Fuel Monitoring System using IoT”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.126-130, 2023.
 61. S. Divyasri, E. Indhu, M. P. Keerthana, M. Selvakumari and S. Saravanan, “Gas Cylinder Monitoring System using IoT”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.67-71, 2023.
 62. J.Arul, R.Balaji, S.Jeyamoorthy, M.Manipathra, R.Sundar and S.Saravanan, “IoT based Air Conditioner Control using ESP32”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.48-52, 2023.
 63. Vundel Munireddy, J.Praathesvaran, C.R.Thirunavukarasu, M.Santhosh Kumar and S.Saravanan, “IoT Based Charge Controller for Direct Fast Charging of Electric Vehicles Using Solar Panel”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.77-81, 2023.
 64. D.Monish Kumar, K.Akash, S.Aswinkumar, S.Saravanan and R. Sagayaraj, “IoT based Industry Surveillance and Air Pollution Monitoring using Drones”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.14-18, 2023.
 65. T.Silambarasan, R.Surya, J.Pravinkumar, R.Sundar and S Saravanan, “IoT based Monitoring System For Sewage Sweeper”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.88-93, 2023.
 66. R.Aravinthan, Alwin.Augustin, P.Divagaran, S.Saravanan and P.Manikandan, “IoT Based Power Consumption and Monitoring System”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.43-47, 2023.
 67. S.Partheeban, S.Sundaravel, S.Umapathi, R.Sagayaraj and S.Saravanan, “IoT based Safety Helmet for Mining Workers”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.116-120, 2023.
 68. D.K.Vignesh, K.Sabarishwaran, S.Yuvaraj, P.Manikandan and S Saravanan, “IoT based Smart Dustbin”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.82-87, 2023.
 69. P Muthukrishnan, P Poovarasam, S Vasanth, R Raja and S Saravanan, “Smart Borewell Child Rescue System”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.121-125, 2023.
 70. S. Gokul, B. Gokulnath, P. Manikandan, S.Saravanan and N. Mohananthini, “Smart Crop Protection From Animals And Birds Using Arduino”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.19-25, 2023.
 71. M.Abinesan, S.Jawahar, S.A.Gopi, A.Gokulraj and S.Saravanan, “Smart EV Charging Hub Integrated with Renewable Energy for Highway Utility”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.58-61, 2023.
 72. K.Eswaramoorthi, R.Manikandan, R.Balamurugan, C.Ramkumar and S.Saravanan, “Smart Parking System using IoT”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.53-57, 2023.
 73. S.Nirmalraj, C.Pranavan, M.Prem and S.Saravanan, “Smart Trolley With IoT Based Billing System”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.111-115, 2023.
 74. S. NithyaSri, S.S.Sabitha, M.Thilagavathi, S.Umamageshwari, C.Nithya and S.Saravanan, “Smart Wireless Notice Board using IoT”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.106-110, 2023.
 75. V.Gunasekaran, M.Gowtham, S. Anubalaji, S.Saravanan and R.Prakash, “Solar based Electric Wheel Chair”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.8-13, 2023.
 76. S.Naveenkumar, S.Prakash, A.P.Shrikirishnaa, C.Ramkumar and S.Saravanan, “Two to Three Phase 5HP Digital Panel”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.94-99, 2023.
 77. Harivignesh K, Jaisankar.A, Chandru.J, Saravanan.S and Raja.R, “Voice Controlled Automatic Writer”,



- International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.26-30, 2023.
78. N.Sakthiselvam, S.Srinivasan, S.Raajkumar, M.Selvakumari, S.Saravanan, "An Integrated Fault Isolation and Prognosis Method for Electric Drive Systems of Battery Electric Vehicles", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.166-171, 2023.
 79. P Thava Prakash, P.Venketesan, D.Vignesh, S.Prakash, S.Saravanan, "Design of Low Cost E-Bicycle using Brushless DC Motor with Speed Regulator", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.148-153, 2023.
 80. D.Tamilarasan, V.S.Vairamuthu, Y.Vasanth, K.Umadevi, S.Saravanan, "GSM based Agricultural Motor Control", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.172-177, 2023.
 81. P. Vimal, S.Veerasingamani, R.Srihari, C.S.Satheesh, S.Saravanan, "IoT Based Optimal Power Management System For Smart Grid", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.160-165, 2023.
 82. S.Abimanyu, P.Jagadheeswaran, S.Jaganath, K.Sanjay, R.Sivapranesh, K.Velmurugan, N.Mohananthini, C.S.Satheesh, S.Saravanan, "Portable Solar Tree", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.154-159, 2023.
 83. J.Sriboopathi, G.Sridhar, R.Sharunesh, S.Tamilarasan, S.Saranraj and S.Saravanan, "A Dual Stage Power Electronic Converter for Electric Vehicle Charger", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.197-202, 2023.
 84. M.Karthikeyan, S.Bilalahamad, V.A.Chandru, V.Deepika and S.Saravanan, "Design and Development of IoT based Motor Starter", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.178-183, 2023.
 85. S.Yokesh, M.Manoj Kumar, M.Sankar, G.Dineshkumar and S.Saravanan, "Estimation of Maximum Power in Lithium Ion Batteries using IoT", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.191-196, 2023.
 86. P.Preedeeppa, S.Sivaranjani, M.Nandhini, M.Swathisriranjani and S.Saravanan, "Optimization of Power Quality Issues in EV Charging Station", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.203-209, 2023.
 87. R. GokulRaj, N. Kannan, S. Karthick, M.Swathisriranjani and S.Saravanan, "Power Quality Enhancement in Smart Grids for Electric Vehicles Charging Station", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.184-190, 2023.



INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING, TECHNOLOGY AND MANAGEMENT



+91 99405 72462



+91 63819 07438



ijmrsetm@gmail.com

www.ijmrsetm.com