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Intelligent Electrical Systems

Edited By
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Contents

Preface

Modern intelligent buildings increasingly depend on electrical services since most traditional mechanical systems, such as hydraulic and pneumatic ones, have already experienced technical advancements and been updated to direct digital control mode. We'll examine a few applications of AI in electrical systems in this chapter, including computer vision-based metering and lighting control, fuzzy logic-based harmonic pattern detection, neural network-based harmonic assessment, and computer algebra-based lighting design.

Only once flawlessly linked logistical operations provide the required preconditions does the smart factor own the future. Speaking about power, we discover that on the one hand, electricians develop the Smart Grid, and on the other, logisticians provide the Smart Supply chain, two ideas that connect the intelligence to the management of electricity in two distinct methods. By first contrasting the traditional power supply chain, the electricity supply chain based on a smart grid, and the smart supply chain as seen by industrialists, we are able to reconcile the two notions in this study. We concentrate on the "interconnectivity" aspect of the smart supply chain and provide a set of metrics to assess the suggested supply chain. Electrical engineering experts and academics throughout the globe have been discussing and debating intelligent and effective electrical systems extensively. This book on "Intelligent Electrical Systems" is the result of the chosen articles that diverse writers submitted. This book's objective is to bring together scholars from business and academia to discuss concepts, practical applications, and cutting-edge methods in the field of intelligent and effective electrical systems. Since these systems are extremely nonlinear, multivariable, and time-varying, numerous issues with their design, management, and operation have come to the attention of academics in recent years. The expansion of electrical networks and the significant use of renewable energy sources in electrical systems may be the cause of these issues. The correct and efficient running of any facility depends on the electrical power switchboards' and control panels' condition monitoring. In older installations, shift duty staff is required to visit each plant room and record the instantaneous readings of each meter. Alternatively, a large number of signals that reflect the instantaneous plant conditions are wired back to the central control room through current loops and presented to the operators as chart recorders or different types of meters. Parameters including temperature, current, voltage, pressure, and flow rate, among others, are measured using general instrumentation.

Modern power systems need increasingly sophisticated control techniques in order to be autonomous, intelligent, and dependable. The main strategy for improving the system's dependability and effectiveness is thought to be the adoption of sophisticated, contemporary, and intelligent control systems. Additionally, greater focus should be placed on creating and examining the sophisticated control techniques used in contemporary electrical systems, taking into account difficult theoretical and practical control challenges. The goal of this book is to inspire scholars to submit unique research proposals and papers addressing cutting-edge intelligent control techniques for electrical systems.

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CHAPTER 1
NEURAL NETWORK IN ENERGY PREDICTION

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An artificial network of artificial neurons or nodes, neural networks are networks or circuits of biological neurons. To tackle issues using artificial intelligence, a neural network is utilised. Neuronal networks represent biological neuron connections as weights between nodes. Inhibitory connections have a negative weight, while excitatory connections have a positive weight. The weight is applied to the inputs before they are summed. Linear combination is the term for this. Finally, an activation function regulates the output's amplitude.

Neural networks may be used for adaptive control, predictive modelling, and other applications where they can be taught using data. Networks that can draw inferences from a complicated and apparently unconnected collection of information are capable of self-learning as a consequence of experience. The way that biological brain systems process data serves as the model for information processing paradigms such as artificial intelligence, cognitive modelling, and neural networks. Some characteristics of organic brain networks are attempted to be replicated by artificial intelligence and cognitive modelling. Artificial neural networks have been effectively utilised in the area of artificial intelligence to voice recognition, image analysis, and adaptive control in order to build software agents or autonomous robots [1]–[3]. The foundation for attempts to develop artificial intelligence is provided by neural network theory, which has helped to better understand how brain neurons operate.

Recurrent Neural Network

Recurrent neural networks are a subclass of artificial neural networks in which nodes are connected in the form of a directed or undirected graph along a temporal sequence. It may behave in a temporally dynamic way because of this. RNNs can handle variable length input sequences since they are descended from feed forward networks and can utilise their internal state. They may thus be used for tasks like voice recognition or unsegmented, linked handwriting recognition.

A sort of artificial neural network called a recurrent neural network utilises sequential data or time series data. These deep learning algorithms are often employed for ordinal or temporal issues in speech recognition, picture captioning, natural language processing, and language translation; they are included in well-known programmes like Siri, voice search, and Google Translate like convolutional neural networks and feedforward algorithms. Recurrent neural networks learn from training data. Their "memory," which allows them to use data from earlier inputs to affect the present input and output, sets them apart from other systems. Unlike recurrent neural networks, which rely on the previous parts in the sequence, classic deep neural networks presume that inputs and outputs are independent of one another [4]–[6]. Unidirectional recurrent neural networks are unable to anticipate future occurrences, even if

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they would be useful in predicting how a series would turn out. Recurrent neural network has a variety of uses, including:

- Time series prediction
- Robot control
- speech synthesis
- speech recognition
- brain-computer interfacing
- time series anomaly detection
- rhythm learning;
- music creation

Learning grammar; Recognizing handwriting; Recognizing human actions; Detecting protein homology; Predicting the subcellular location of proteins; Several tasks involving predictions in business process management; Recognizing human actions in medical care routes,

Time Series

A time series is a collection of data points arranged chronologically. A time series is a collection of images typically collected at a number of moments in time that are evenly spaced apart. It is thus a collection of discrete-time data. Time series examples include the height of ocean tides, the closing value of the BSE Sensex each day, the location of the sun every hour, etc.

A run chart is a relatively common tool for plotting a time series. Statistics, signal processing, pattern recognition, econometrics, mathematical finance, weather forecasting, earthquake prediction, control engineering, astronomy, communications engineering, and essentially every other area of applied science and engineering that uses temporal measurements make use of time series. Time series analysis refers to techniques for examining time series data in order to draw out relevant statistics and other aspects of the data.

Using a model to anticipate future values based on observed values from the past is known as time series forecasting. When an intervention may have an impact on the underlying variable, interrupted time series analysis is used to identify changes in a time series' evolution from before to after the intervention. Various applications for data analysis for time series are available. Motivation, exploratory analysis, curve fitting, function approximation, forecasting and prediction, classification, signal estimation, segmentation, etc. are a few of them. Research on energy prediction has recently focused on predicting energy use for industrial, commercial, and residential buildings.

Cities, states, nations, and even the whole planet may be predicted in terms of energy. Energy prediction is becoming a crucial technique due to the increased use of renewable energy sources and the rising demand for electrical energy. The ability to anticipate energy has also increased as a result of research into new, more accurate prediction algorithms and the growth of processing power. Generating firms are the largest consumers of energy since energy produced must match energy consumed in a grid. Although there is a growing trend toward distributed renewable power and smart grids, customers may now utilize energy prediction algorithms to visualise and optimise their usage patterns in order to increase their efficiency and participate more actively in the electrical grid.

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Bibliography

[1] K. Muralitharan, R. Sakthivel, and R. Vishnuvarthan, "Neural network based optimization approach for energy demand prediction in smart grid," *Neurocomputing*, 2018, doi: 10.1016/j.neucom.2017.08.017.

[2] S. Lee, S. Cho, S. H. Kim, J. Kim, S. Chae, H. Jeong, and T. Kim, "Deep neural network approach for prediction of heating energy consumption in old houses," *Energies*, 2021, doi: 10.3390/en14010122.

[3] X. J. Luo, L. O. Oyedele, A. O. Ajayi, O. O. Akinade, H. A. Owolabi, and A. Ahmed, "Feature extraction and genetic algorithm enhanced adaptive deep neural network for energy consumption prediction in buildings," *Renew. Sustain. Energy Rev.*, 2020, doi: 10.1016/j.rser.2020.109980.

[4] J. Huang, C. Pang, W. Yang, X. Zeng, J. Zhang, and C. Huang, "A Deep Learning Neural Network for the Residential Energy Consumption Prediction," *IEEJ Trans. Electr. Electron. Eng.*, 2022, doi: 10.1002/tee.23543.

[5] J. de J. Rubio, M. A. Islas, G. Ochoa, D. R. Cruz, E. Garcia, and J. Pacheco, "Convergent newton method and neural network for the electric energy usage prediction," *Inf. Sci. (Ny).*, 2022, doi: 10.1016/j.ins.2021.11.038.

[6] A. Chari and S. Christodoulou, "Building energy performance prediction using neural networks," *Energy Effic.*, 2017, doi: 10.1007/s12053-017-9524-5.

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CHAPTER 2
PERFORMANCE ANALYSIS OF A VIENNA AND UTILITY MINING

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Along with simulation using MATLAB-Simulink®, a thorough investigation of several control methods, including hysteresis current control, average current control, and one cycle control methods, was conducted. Following a thorough analysis and examination of the various control methods, it was discovered that the device operates in the continuous inductor current mode and necessitates instantaneous input current measurements; the switching frequency in the hysteresis control method is variable because it is load dependent. Due to the low switching frequencies in Continuous Conduction Mode, the harmonics in low input currents are not effectively limited (CCM). In Discontinuous Conduction Mode (DCM), stresses in semiconductors increased, which resulted in erroneous input current sampling and subpar power factor [1]–[3].

Where the THD is high, there is a higher likelihood of dual mode operating. Without input current measurement, a mathematical mode has evolved for many modes of operation. The erroneous samples are eliminated by the suggested control approach since it does not call for CT to measure the input current. Using feedforward components, the input current is anticipated. The unique control strategy that has been suggested detects the load state and works in either CCM or DCM mode. It avoids operating in multiple modes and maintains a consistent switching frequency for each mode. When compared to CCM operation, DCM has a lower boost inductance need. By maximising the inductance value, the converter's size is also decreased. The suggested method's simulation results in CCM and DCM have been reported in this paper. Using CCM and DCM under different load circumstances, the power factor has been determined to be more than 0.9. The effectiveness of the suggested control approach has been evaluated in terms of power factor, THD level, control complexity, operation under a broad range of load variations, and stability in DC link voltage. A comparison of several control strategies has been provided. According to the comparison, the predictive input current control technique has more advantages than the other control methods.

This study also shows how a PMBLDC drive's power quality may be improved by employing a Vienna rectifier as the front end converter. For the rectifier front end, motor driving often requires a Power factor adjustment [4]–[6]. Harmonic injection and poor power factor are the primary drawbacks of the PMBLDC motor drive. The traditional three-phase front end power factor adjustment techniques have significant THD and losses. In the case of a six switch active front end, the increased number of switching devices or the larger magnetic components in the case of a single switch Boost converter make the present options very costly. Therefore, the Vienna rectifier solution is suggested for applications where better power factor and higher power density are required at a cheap cost. A certain switching frequency regulates the architecture of the Vienna rectifier.

The PMBLDC motor's mathematical model has been created and implemented in Matlab Simulink®. Matlab Simulink® has been used to verify the Vienna rectifier fed PMBLDC

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motor drive system's design and performance. The results of modelling and simulating the PMBLDC drive using Matlab Simulink® are shown. The PMBLDC drive is controlled by conventional techniques such as PI, PID, and FLC. The comparison shows that, when compared to the other two techniques, the FLC controller for PMBLDC drive provides greater performance.

The central component of analytics is data, and as its exploration increases, so do the services that the different apps provide. The many methods to decision-making and the present trend in analytical viewpoints brag of the uniqueness in overcoming the unanticipated challenges that transitions in modern commercial environment bring about. As analytics are increasingly data-centric and centred on data, its characteristics, manipulation, and the capacity to approach business processes, choices, and actions, this leads to maximising the business benefits that come from leveraging the related technologies and methodologies. Nowadays, wherever technology is investigated and invested, it leads to fast progress, which is to the advantage of people. In order to accurately assess the value of these advantages, it is necessary to consider how the application of knowledge with various technologies progressively impacts the person, culture, economy, and society.

To understand the shift that these technologies bring about, it is vital from a number of perspectives to conduct an analysis. Regardless of the application, a study of the disciplines that these applications include or modify may offer insight into perceptions, patterns, sequences, trends, and undetected anomalies that can provide priceless knowledge to maintain the competitive edge that the world confronts today. An examination from a wider perspective points to analytics, where the data involved in these applications are conducted in a systematic way, not only addressing all the features of data but also includes the analysis of scientific understanding of the instruments and methods that are employed.

Using the analytical techniques of DS, data can be thoroughly searched, meaningful information can be derived, correlated and matched, and organised to find out where there are gaps or inefficiencies or where a problem might arise in the future. Reports can then be generated in accordance with the results. There have been instances in huge distribution organisations when orders for certain stocks were made, invoices were received, but the actual stocks were not received and were misplaced in the process. In another instance, training premises were hired, although they were regularly left empty. These problems were discovered while the data was being tracked; otherwise, these inefficiencies may not have been discovered until the situation became worse and became more problematic.

Artificial intelligence (AI) is essentially a technology created to simulate the human brain and intellect, which is based on learning, reasoning, and perception. It provides quick processing and simple access to vast amounts of data, and by using its methods, it has altered how businesses function today. Automated Machine Learning (AutoML): Machine learning and other related technologies employ automated machine learning to improve and create better goods. AutoML enhances prediction accuracy and fine-tunes the models to address complicated issues.

Bibliography

[1] E. Madrid, D. Murillo-Yarce, C. Restrepo, J. Muñoz, and R. Giral, “Modelling of sepic, Ćuk and zeta converters in discontinuous conduction mode and performance

evaluation," *Sensors*, 2021, doi: 10.3390/s21227434.

[2] J. G. P. Salado, C. A. H. Ramírez, A. G. S. Sánchez, and M. A. R. Licea, "Nonlinear stabilization controller for the boost converter with a constant power load in both continuous and discontinuous conduction modes," *Micromachines*, 2021, doi: 10.3390/mi12050522.

[3] G. K. Ottman, H. F. Hofmann, and G. A. Lesieutre, "Optimized piezoelectric energy harvesting circuit using step-down converter in discontinuous conduction mode," *IEEE Trans. Power Electron.*, 2003, doi: 10.1109/TPEL.2003.809379.

[4] M. Kumar, K. Chaudhary, R. K. Saket, and B. Khan, "Bidirectional Quadratic Converter-Based PMBLDC Motor Drive for LEV Application," *J. Electr. Comput. Eng.*, 2022, doi: 10.1155/2022/5984969.

[5] A. N. Patel and B. N. Suthar, "Cogging torque reduction of sandwiched stator axial flux permanent magnet brushless dc motor using magnet notching technique," *Int. J. Eng. Trans. A Basics*, 2019, doi: 10.5829/ije.2019.32.07a.06.

[6] A. Terki, A. Moussi, A. Betka, and N. Terki, "An improved efficiency of fuzzy logic control of PMBLDC for PV pumping system," *Appl. Math. Model.*, 2012, doi: 10.1016/j.apm.2011. 07.042.

CHAPTER 3
THEORY OF MACHINE LEARNING

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Similar to intelligence, learning encompasses a wide variety of processes, making its exact definition challenging. A dictionary definition contains terms like "adjustment of a behavioural propensity by experience" and "to acquire knowledge, or insight, or competence in, through study, teaching, or experience." Animals and people both learn, according to zoologists and psychologists. This book focuses on machine learning. There are many similarities between animal learning and computer learning. Undoubtedly, a lot of machine learning approaches come from psychologists' attempts to use computer models to further their ideas of animal and human learning. Additionally, it is possible that certain elements of biological learning may be clarified by the ideas and methods being researched in machine learning [1]–[3].

In general, we may say that a machine learns anytime it modifies its software, data, or structure (based on inputs or in reaction to outside information) in a way that enhances its predicted future performance. Some of these alterations, like the insertion of a record to a database, easily belong to different disciplines and are not necessarily better understood because they are referred to as learning. However, when a voice-recognition system's performance increases after hearing multiple samples of a person's speech, for instance, we feel fairly comfortable in claiming that the system has learnt. Machine learning is the term used to describe modifications made to systems that carry out activities related to artificial intelligence (AI). These include activities like prediction, planning, robot control, diagnostics, and recognition. The "changes" might be either improvements to existing functioning systems or the creation of new ones from scratch. We demonstrate the architecture of a common AI to provide a little more detail.

Machines created by human designers often perform less well than ideal in the situations in which they are employed. In actuality, certain aspects of the working environment may not be fully recognised at the time of creation. The on-the-job upgrading of current machine designs is possible with the use of machine learning techniques. There may be too much information accessible about certain activities to explicitly encode by humans. Machines that progressively pick up this information could be able to record more of it than people would wish to record [4]–[6].

Over time, environments change. Machines that can change with their surroundings would eliminate the need for ongoing redesign.

Humans are continually learning new information about activities. Language changes. New occurrences are happening all the time in the globe. It is impossible to continually construct AI systems to reflect new information, but machine learning techniques could be able to keep track of much of it.

The more crucial issue of what has to be learnt stands in opposition to that of the historical origin of any learning approach. In this book, we assume that the lesson to be learnt is some

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kind of computational structure. We'll look at a range of various computational architectures, including:

Functions

- Logic programs and rule sets
- Finite-state machines
- Grammars
- Problem solving systems

The scientific discipline of machine learning enables computers to learn without explicit programming. One of the most intriguing technologies that has ever been developed is machine learning. The capacity to learn is what, as the name suggests, gives the computer a more human-like quality. Today, machine learning is being actively employed, maybe in a lot more areas than one would think. When predicting the probability of a certain result, such as whether or not a customer would churn in 30 days, "prediction" refers to the output of an algorithm that has been trained on past data and applied to current data. For every record in the new data, the algorithm will provide probable values for an unknown variable, enabling the model builder to determine what that value will most likely be.

The term "prediction" itself might be deceptive. When you use machine learning to choose the next best step in a marketing campaign, for example, you are effectively anticipating a future consequence. However, sometimes the "prediction" is about something that has already happened, like whether a transaction was fraudulent or not. In such situation, the transaction is already complete, but you're attempting to determine whether or not it was valid so that you may decide what course of action to follow.

Based on historical data, machine learning model predictions enable businesses to make extremely precise assumptions about the most likely outcomes of a question. These assumptions can be made about a variety of topics, including the likelihood of customer churn, potential fraudulent activity, and more. These provide the company knowledge that has a real economic impact. For instance, if a model indicates a client is going to leave, the company may reach out to them with targeted messaging to stop the loss of that customer. In its simplest form, machine learning relies on preprogrammed algorithms that take input data and analyse it to forecast output values that fall within a certain range. These algorithms learn from fresh data as it is given to them, optimising their processes to increase performance and gaining "intelligence" over time. Machine learning algorithms come in four different varieties: Reinforcement that is supervised, semi-supervised, unsupervised, or not at all.

Bibliography

[1] R. Roscher, B. Bohn, M. F. Duarte, and J. Garcke, “Explainable Machine Learning for Scientific Insights and Discoveries,” *IEEE Access*, 2020, doi: 10.1109/ACCESS.2020.2976199.

[2] J. Waring, C. Lindvall, and R. Umeton, “Automated machine learning: Review of the state-of-the-art and opportunities for healthcare,” *Artificial Intelligence in Medicine*. 2020. doi: 10.1016/j.artmed.2020.101822.

[3] T. Baltrusaitis, C. Ahuja, and L. P. Morency, "Multimodal Machine Learning: A Survey and Taxonomy," *IEEE Transactions on Pattern Analysis and Machine Intelligence*. 2019. doi: 10.1109/TPAMI.2018.2798607.

[4] V. Vanchurin, "Toward a theory of machine learning," *Mach. Learn. Sci. Technol.*, 2021, doi: 10.1088/2632-2153/abe6d7.

[5] A. V. D. P. Adombi, R. Chesnaux, and M. A. Boucher, "Review: Theory-guided machine learning applied to hydrogeology—state of the art, opportunities and future challenges," *Hydrogeology Journal*. 2021. doi: 10.1007/s10040-021-02403-2.

[6] S. S. Lin, S. L. Shen, A. Zhou, and Y. S. Xu, "Risk assessment and management of excavation system based on fuzzy set theory and machine learning methods," *Automation in Construction*. 2021. doi: 10.1016/j.autcon.2020.103490.

CHAPTER 4
COMMON AND POPULAR MACHINE LEARNING ALGORITHMS

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Supervised learning

The computer is instructed by example in supervised learning. The machine learning algorithm is given a known dataset by the operator that contains the intended inputs and outputs, and it then has to figure out how to get to those inputs and outputs. The algorithm creates predictions while the operator recognises the proper solutions to the issue from data patterns and observations. The algorithm produces predictions, the operator corrects them, and the cycle repeats itself until the algorithm performs and performs accurately [1]–[3].

Semi-supervised learning

Similar to supervised learning, semi-supervised learning makes use of both labelled and unlabeled data. Unlabelled data is information that doesn't have any tags that are relevant enough for the algorithm to interpret it, while labelled data does. This combination enables machine learning algorithms to teach themselves how to identify unlabeled data.

Unsupervised learning

In this case, the machine learning algorithm examines the data to find patterns. There isn't a manual or operator to provide instructions, either. Instead, by analysing the data at hand, the algorithm finds the connections and linkages. The machine learning algorithm is given free rein to analyse huge data sets and respond to them appropriately in an unsupervised learning process. This data is organised in some manner by the algorithm to try to characterise its structure. This can include clustering the data or organising it to make it seem more organized [4], [5]. Its capacity to draw conclusions from additional data is progressively enhanced and polished as it is assessed.

Fall under the unsupervised learning category are: Organizing groups of related data into clusters is called clustering (based on defined criteria). It is helpful for breaking up data into several groups and doing analyses on each data set to look for trends. Reduce the amount of variables taken into account to get the precise information you need by using dimension reduction.

Reinforcement learning

In reinforcement learning, a machine learning algorithm is given a set of actions, parameters, and end values in order to conduct structured learning processes. After setting the criteria, the machine learning algorithm attempts to investigate several alternatives and possibilities, monitoring and assessing each outcome to ascertain which is best. Machine learning is taught via reinforcement. In order to get the greatest outcome possible, it draws lessons from the past and starts to modify its strategy in reaction to the circumstance [6], [7]. The best machine learning algorithm to use will rely on a number of variables, such as the quantity, quality, and

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variety of the data available, as well as the business objectives for using the data. Accuracy, training duration, parameters, data points, and many other factors also need to be taken into account. To choose the best algorithm, consider the business requirement, the specification, the experimentation, and the time available. Before testing several algorithms, not even the most seasoned data scientists can predict which one would perform the best. However, we've put up a "cheat sheet" of machine learning algorithms to assist you in selecting the best one for your particular problems.

A simple Bayes classifier algorithm (Supervised Learning - Classification)

The Naive Bayes classifier classifies each value as independent of every other value and is based on the Bayes theorem. It enables us to make probabilistic predictions about a class or category based on a collection of characteristics. The classifier works remarkably well despite its simplicity and is often used since it outperforms more complex classification techniques.

K-Means Clustering (Unsupervised Learning - Clustering)

When categorising unlabelled data, or data without clearly defined categories or groups, the K Means Clustering technique is utilised, which is a sort of unsupervised learning. Finding groups within the data is how the algorithm works, and the value K indicates how many groups are found. Using the given attributes, it then works iteratively to categorise each data point into one of K groups.

Support Vector Machine algorithm (Supervised Learning - Classification)

Algorithms called support vector machines (SVMs) analyse the data used in classification and regression analysis. They effectively categorise the data by using a set of training examples, with each set designated as falling into one of the two categories. The algorithm then goes to work creating a model that gives either category new values.

Linear Regression

The simplest kind of regression is linear regression. Understanding the associations between two continuous variables is made possible by simple linear regression.

Logistic Regression

Based on the previously supplied data, logistic regression focuses on calculating the likelihood that an event will occur. It is used to cover a binary dependent variable, in which only the outcomes represented by the values 0 and 1 are considered.

Artificial Neural Networks (Reinforcement Learning)

An artificial neural network (ANN) is made up of "units" that are organised in a succession of layers, with connections between each layer and the layers on either side. The way that biological systems like the brain process information is an inspiration for artificial neural networks (ANNs). ANNs are simply a vast collection of linked processing components that cooperate to address certain issues.

When modelling non-linear interactions in high-dimensional data or in situations where the relationship between the input variables is complex, ANNs are quite helpful since they also learn by doing and by experience. Using decision trees for classification and regression under

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supervision. A decision tree is a tree structure that resembles a flowchart and use branching to represent all the outcomes of a choice. Every node in the tree represents a test on a particular variable, and every branch reflects the result of that test.

Random Forests

An ensemble learning technique called random forests, sometimes known as "random decision forests," combines many algorithms to provide improved classification, regression, and other task-related outcomes. While each classifier works best when used in conjunction with others, they are all poor alone. The method begins with a "decision tree" (a model of choices that resembles a tree), with an input inserted at the top. The data is separated into smaller and smaller groupings as it moves down the tree depending on specified factors.

Nearest neighbours (Supervised Learning)

The K-Nearest-Neighbor method calculates the likelihood that each data point belongs to a certain group. It basically examines the data points around a particular data point to identify which group it truly belongs to. For instance, if a data point is on a grid and the algorithm wants to know which group it belongs to (for example, Group A or Group B), it will look at the data points nearby to see which group the majority of the points are in.

Bibliography

[1] J. E. Van Engelen And H. H. Hoos, "A Survey On Semi-Supervised Learning," *Mach. Learn.*, 2020, Doi: 10.1007/S10994-019-05855-6.

[2] A. Cholaquidis, R. Fraiman, And M. Sued, "On Semi-Supervised Learning," *Test*, 2020, Doi: 10.1007/S11749-019-00690-2.

[3] V. Verma, K. Kawaguchi, A. Lamb, J. Kannala, A. Solin, Y. Bengio, And D. Lopez-Paz, "Interpolation Consistency Training For Semi-Supervised Learning," *Neural Networks*, 2022, Doi: 10.1016/J.Neunet.2021.10.008.

[4] I. Croitoru, S.-V. Bogolin, And M. Leordeanu, "Unsupervised Learning Of Foreground Object Segmentation," *Int. J. Comput. Vis.*, Vol. 127, No. 9, Pp. 1279–1302, Sep. 2019, Doi: 10.1007/S11263-019-01183-3.

[5] M. Caron, P. Bojanowski, A. Joulin, And M. Douze, "Deep Clustering For Unsupervised Learning Of Visual Features," 2018. Doi: 10.1007/978-3-030-01264-9_9.

[6] D. J. Joshi, I. Kale, S. Gandewar, O. Korate, D. Patwari, And S. Patil, "Reinforcement Learning: A Survey," 2021. Doi: 10.1007/978-981-33-4859-2_29.

[7] M. Samieiyeganeh, R. W. B. O. K. Rahmat, F. B. Khalid, And K. A. Bin Kasmiran, "Deep Reinforcement Learning To Multi-Agent Deep Reinforcement Learning," *J. Theor. Appl. Inf. Technol.*, 2022.

CHAPTER 5
CHALLENGES IN USING MACHINE LEARNING

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The importance of machine learning in the education sector is growing quickly, and it has the potential to improve many crucial facets of instruction, learning, research, and decision-making. It focuses on logic and behaviour that are mimicked from humans. Medical educators are very interested in and using the prognostic capabilities of naive Bayes, decision trees, and many other similar algorithms. Machine learning models become more active after learning from experiences or observations in order to mimic human behaviour. By learning about each student's skills and limitations as well as potential explanations for academic difficulty, investigations have shown that ML has predicting capabilities [1]–[3].

The forecasting of learning outcomes using a machine learning technique may assist educational institutions in better understanding the learning styles and behaviours of their students, which can be helpful in enhancing school policies, curriculum planning, and teaching methods. In fact, machine learning algorithms provide potential for businesses, including educational institutions, to achieve minimum prediction mistakes (accuracy), enhance their operational performance, and enhance their decision-making process. In recent years, many forecasters and their customers have been concerned about prediction faults or errors, which ML helps to decrease.

Forecasting errors often pose serious issues for systems and may result in bad decisions being made as well as system failure. Learning analytics can make it easier to accommodate unique learners and those who need more individualised instruction or attention. Machine learning models that track students' progress and suggest future steps have been developed. The advantages of ML and its drawbacks when used for academic forecasting are examined in this paper. The research would go a long way toward assisting forecasters and education authorities in comprehending the developing opportunities and problems of machine learning and how best to employ it in the education sector to decrease student failures and to improve the decision-making process. This study contributes to the corpus of knowledge concerning the uses of artificial intelligence and machine learning in education [4]–[6].

Smart factories can automate their processes to greatly increase their efficiency and production quality thanks to the rapid development of the Fourth Industrial Revolution, or Industry 4.0, the widely increased use of sensors, the development of massive data collection and information systems (Internet of Things), and the adoption of artificial intelligence techniques. In order to reduce production costs and improve plant and employee safety, equipment downtime and machine failure must be maintained to a minimal as manufacturing processes grow more sophisticated and throughput rises. However, unplanned downtime is an unavoidable reality of industry.

PHM is thus a crucial component of production and is in charge of tracking and analysing equipment status in order to ensure adequate machine maintenance and performance. The

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practise of doing maintenance has swiftly progressed from reactive maintenance, which is done after a breakdown occurs, through preventive maintenance (PvM), which is done at predetermined intervals, and finally to predictive maintenance. Due to its advantages over other maintenance methodologies, such as a reduction in factory downtime, a reduction in maintenance and manufacturing costs, an increase in safety, production, and equipment life, as well as an increase in overall profit, predictive maintenance has become a hot topic in academic research and among manufacturing companies. In order to enable industrial organisations to plan maintenance before a failure occurs, predictive maintenance seeks to anticipate the remaining useful life (RUL) of the equipment and identify component and equipment failure before it occurs. The potential for data-driven problem detection approaches increases as smart factories monitor equipment and gather more data than is practical for professionals to check. With three or more layers of neural networks, deep learning (DL) is a form of machine learning (ML) that can learn from enormous amounts of data.

Deep learning seems to be the ideal method for processing the data and conducting problem detection due to the fast advancement of machine learning and the enormous quantity of data that condition monitoring systems gather. Because of their toughness, dependability, and affordability, induction motors are one of the most crucial parts in modern manufacturing companies. Therefore, it is crucial that induction motors be properly monitored and maintained in order to make production operations as streamlined and effective as possible.

The availability of data is one of the largest obstacles to a successful predictive maintenance strategy. The amount and calibre of the data used to train machine learning and deep learning algorithms has a significant impact on their performance. The data-driven strategy is thus difficult to implement without a sizable volume of high-quality data. In this thesis, induction motor data are used to diagnose faults. No data existed prior to purchasing such an engine. The thesis selection and development were hampered by this aspect. A temporary solution to this issue was to temporarily train and test the models and approach using a public dataset with comparable features.

Newer equipment now has sensors that can be utilised to gather data due to the growth in IoT sensor availability. However, given that induction motors are very dependable and have a lifespan of 15–20 years on average, current enterprises must find a means to gather information on machinery that is already in use. Although it could be a wise investment, retrofitting current equipment with sensors is costly and not feasible for everyone. As a relatively new issue, predictive maintenance and its application need a lot of knowledge.

Greater safety, increased machine uptime, longer equipment life, and partlife optimization are all benefits of early machine fault detection and effective maintenance of industrial equipment. In the end, all of these advantages will result in better, leaner production processes at lower costs that can be passed directly on to the customer and society. Less waste and less resources are needed as a result of increased equipment efficiency.

Bibliography

[1] K. Shaukat, S. Luo, V. Varadharajan, I. A. Hameed, S. Chen, D. Liu, and J. Li, “Performance comparison and current challenges of using machine learning techniques in cybersecurity,” *Energies*. 2020. doi: 10.3390/en13102509.

[2] A. Moubayed, M. Injadat, A. B. Nassif, H. Lutfiyya, and A. Shami, “E-Learning:

Challenges and Research Opportunities Using Machine Learning Data Analytics," *IEEE Access*, 2018, doi: 10.1109/ACCESS.2018.2851790.

[3] A. Ahmad, S. Garhwal, S. K. Ray, G. Kumar, S. J. Malebary, and O. M. Barukab, "The Number of Confirmed Cases of Covid-19 by using Machine Learning: Methods and Challenges," *Arch. Comput. Methods Eng.*, 2021, doi: 10.1007/s11831-020-09472-8.

[4] T. Saba, "Recent advancement in cancer detection using machine learning: Systematic survey of decades, comparisons and challenges," *Journal of Infection and Public Health*. 2020. doi: 10.1016/j.jiph.2020.06.033.

[5] A. Mughees, M. Tahir, M. A. Sheikh, and A. Ahad, "Towards energy efficient 5G networks using machine learning: Taxonomy, research challenges, and future research directions," *IEEE Access*, 2020, doi: 10.1109/ACCESS.2020.3029903.

[6] S. Albaradei, M. Thafar, A. Alsaedi, C. Van Neste, T. Gojobori, M. Essack, and X. Gao, "Machine learning and deep learning methods that use omics data for metastasis prediction," *Computational and Structural Biotechnology Journal*. 2021. doi: 10.1016/j.csbj.2021.09.001.

CHAPTER 6
INTRODUCTION TO SMART TRANSFORMER USING IOT

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Electricity is crucial to our daily lives. Electricity is a necessity for every second of our existence. There are many systems and pieces of technology that enable humans transfer and monitor the distribution of electricity based on average. Transformers represent the most important piece of equipment for the generation and distribution of electric power. A power equipment distribution transformer in a power system directly distribute electricity to low-voltage applications, and the condition of its function is a crucial factor in the overall platform's performance. In various electrical, mechanical, and environmental settings, the bulk of these devices have been employed for a long time. They compose the majority of capital investment and are the integral elements. Distribution transformers' extended service life is ensured by functioning them under rated conditions in conformity with their nameplate standards [1].

Transformer Advancement in Technologies

Distribution transformer malformations are accompanied by changes in a wide range of parameters, which would include load current (which significantly influences temperature variations), moisture in oil which examines the humidity level of the transformer cooling medium, dissolved gas in oil, bushing condition, integrated inductor, three phase, capacitance (LTC) monitoring, and oil level. However, we are interested with the load current, relative humidity, and oil level. An online monitoring system is consisting of an embedded system, a GSM modem, mobile users, GSM networks, and instruments put in place at transformer locations. On the transformer portion, sensors are installed that monitor and measure the measured value coming from the distribution transformer before converting it to a digital signal. The transformer site contains the embedded module is. The parameters from the GSM modem are gathered, processed, displayed, transmitted, etc received using it.

The GSM module is really the second. The embedded system and the general GSM network are connected by it. The utility control panel houses a PC-based server for the proposed network, which is a utility module. The server is connected to a GSM modem, and the GSM module is used to both receive and send SMS to and from the transformer installation. Without routine monitoring of their Kilo Volt Ampere (KVA) requirements, temperature difference, oil level, and the humidity levels formed in the transformer cooling environment, distribution transformers should occasionally be under heavy load. These characteristics typically result in unexpected transformer failures and substantial system damage.

The researchers plan to create an IoT-based distribution feeders monitoring system that is a truly human machine interface device that does require any human interaction during its processes in order to decrease the prevalence of transformer breakdowns that result from a lack of monitoring. Since the sensors offer real-time information on the crucial states of the transformers, the system will deliver credible data [2].

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Implemented of IoT

The project includes a smart electronic transformer surveillance device and an Internet of Things gadget. Numerous transformer indicators, including warmth and oil level, are continuously monitored by an electrical appliance. If any of the parameters are off, the ability to react right away and creates a notification that is automatically sent through IoT device to the official state website. If necessary, it can be configured to send to several recipients. The modem uses a distinctive way to communicate with the embedded system. A sophisticated microcontroller that can integrate with the IoT device makes up the embedded system. This same authorities will respond more quickly as a consequence of the direct information communication, and the bogus shut-off time will also be least a minimum amount [3].

About IoT

The term Internet of Things (IoT) refers to physical objects or collections of such objects comprised of sensors, processing power, software, and other technologies that communicate to each other and exchange data through the Internet or other communications infrastructure. The term internet of things has been criticized because devices only require to be individually addressable and associated with a network, not the whole internet. The fusion of technology innovations, such as cloud computing, widely available sensors, sophisticated embedded software, and machine learning, has caused this same sector to advance. The Internet of things is enabled by the traditional industries of embedded systems, wireless communication networks, control systems, and automation (including home and building automation). IoT technology is most often associated with household goods that relate here to idea of the smart home including fixtures, heat pumps, home safety systems, cameras, and other appliances, that encourage one or more common ecosystems and are able to controlled by gadgets capable of connecting to that ecosystem, like smart phones and speakers. Systems for providing health insurance also leverage IoT [4].

Concerns of IoT

The establishment of worldwide and local standards, recommendations, and regulatory frameworks is just another step in the industry and governments efforts to address the risks related to the expansion of IoT technology and products, primarily in the areas of privacy and security. The internet of things, or IoT, is a network of connected operating systems, mechanical and digital equipment, items, animals, or people that may communicate data across a network without requiring human-to-human or human-to-computer engagement.

IoT in Different Sectors

The term "thing" refers to any natural or artificial object who can be given an Internet Protocol (IP) contact information and has the ability to transfer data across a network, including citizens with implanted blood pressure monitors, farm animals with biochip tracking systems, cars with built-in tire pressure trackers, and other examples. Corporations across a range of industries are increasing utilizing IoT to run more reliably, better understand their customer to provide better customer service, boost outcome, and raise the value of the organization [5].

Bibliography

[1] S. Mittra, A. Aprameya, and B. K. Mohanta, “Smart Grid Power Theft and Fault Detection using IoT and Blockchain,” 2021. doi: 10.1109/ICAECA52838.2021.

9675491.

[2] B. Sai Ram, A. K. Paul, and S. V. Kulkarni, “Soft magnetic materials and their applications in transformers,” Journal of Magnetism and Magnetic Materials. 2021. doi: 10.1016/j.jmmm.2021.168210.

[3] W. Li and S. Wang, “A fully distributed optimal control approach for multi-zone dedicated outdoor air systems to be implemented in IoT-enabled building automation networks,” Appl. Energy, 2022, doi: 10.1016/j.apenergy.2021.118408.

[4] S. K. Lee, M. Bae, and H. Kim, “Future of IoT networks: A survey,” Appl. Sci., 2017, doi: 10.3390/app7101072.

[5] F. Almugari, P. Bajaj, M. I. Tabash, A. Khan, and M. A. Ali, “An examination of consumers’ adoption of internet of things (IoT) in Indian banks,” Cogent Bus. Manag., 2020, doi: 10.1080/23311975.2020.1809071.

CHAPTER 7
WORKING OF IOT

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The Internet of Things (IoT) ecosystem is made up of web-enabled smart devices that rely on embedded systems, such as microprocessor, sensors, and communication gear, to obtain, send, and act on the data those who get from their surroundings. By communicating to an IoT gateway and perhaps other edge device, which either sends data to a cloud for analysis or analyses it locally, IoT devices exchange the sensor data they collect. These gadgets connect with other similar devices on occasion, acting on the data they exchange. Although individuals can engage with the instruments to set them up, give them instruction, or retrieve the data, the gadgets accomplish the majority of the job without their help. The spread of Broadband internet into tangible objects and ordinary commodities is known as the Internet of things (IoT). These devices are capable of communicating with others over the Internet and can also be remotely monitored and controlled since they are embedded with semiconductors, Internet connectivity, and other types of technology like sensors [1]–[3].

Thing-speak App

- MATLAB support from MathWorks has been added into ThingSpeak, enabling users to analyses and visualize processing facility using MATLAB without having to purchase a MATLAB license from MathWorks.
- Ruby-based open-source software called ThingSpeak lets users speak with internet-connected devices. By giving an API to both the devices as well as social network websites, it simplifies data access, retrieval, and logging easier. In order to facilitate IoT applications, ioBridge initially introduced ThingSpeak in 2010.
- ThingSpeak is an IoT analytics software platform that allows live data streams to be aggregated, presented, and analyzed in the cloud. Data sent by your devices to ThingSpeak is instantly presented by ThingSpeak. You can undertake online analysis and analyze the data as it comes in with the option to run MATLAB code in ThingSpeak. For IoT systems that would need analytics, ThingSpeak is frequently used for prototyping and proof-of-concept systems.
- You can use a Rest API or MQTT to communicate data directly to ThingSpeak from any internet-connected device. In addition, sensor data may be communicated to ThingSpeak over LoRaWAN and 4G/3G cellular networks thanks to cloud-to-cloud integrations with The Things Network, Senet, the Libelium Meshlium gateway, and Particle.io.
- With Thing Speak, you can construct comprehensive event-based email notifications that were already triggered obviously it depends on data from your connected devices. You can also store as well as analyses information on the cloud without setting web servers.

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Secondary winding between two circuits connected by a comparable magnetic flux serves as the fundamental operating element of a transform. A fundamental transformer is constructed of two inductive, electrically autonomous coils that are magnetically interconnected by a channel of reluctance. In essentially, a transformer completes the following tasks: electricity moving from one circuit to another. Electric power exchange without a change in frequency. Transference using the electromagnetic induction concept. Mutual induction ties together the two electrical circuits.

Transformer Errors & Unusual Conditions

i. Internal Faults

- insulation deterioration,
- winding Failure,
- overheating,
- contamination of oil

An internal problem can also emerge from phase to phase. A software glitch inside the transformer may result from deteriorated insulation, a situation that could cause it to shut down. Overheating and wrapping issues can also result from a high current flow. Because when cooling system malfunctions, maintenance problems can also occur. High lower patterns can also cause the insulation to disintegrate, which is a main reason why everything go wrong. Testing and maintenance can most often minimize these issues [4]–[6].

ii. External faults:

- Lightning Strikes,
- System Overload,
- Short circuit

Peripheral faults are problems that occur outside the transformer and seem to be typically impossible to resolve through maintenance. The capacitors are vulnerable to outside threats like static electricity and other unavoidable harm. Since these occurrences are unforeseeable, it's critical to have an approach in place to expedite repairs. These may also be somewhat modest in nature, but they can harm the insulation as well as eventually lead to issues from the inside of the transformer. The situation because when transformer is abruptly cut out due of an event outside is so much more concerning.

iii. Transformer Protection:

A transformer is a passive elements device that uses electromagnetic waves to transmit the electricity from one circuit to another. The voltage levels connecting circuits are most speed is generally (step up) or decreased (step down) when it is utilized.

iv. Working Principle of Transformer:

A transformer operates on something like a fairly straightforward principle. Electrical energy might move between circuits thanks to a condition called mutual induction involving two or more windings sometimes made reference to as coils.

Bibliography

[1] H. Aftab, K. Gilani, J. E. Lee, L. Nkenyereye, S. M. Jeong, and J. S. Song, “Analysis of identifiers in IoT platforms,” *Digit. Commun. Networks*, 2020, doi: 10.1016/j.dcan.2019.05.003.

[2] H. HaddadPajouh, A. Dehghantanha, R. M. Parizi, M. Aledhari, and H. Karimipour, "A survey on internet of things security: Requirements, challenges, and solutions," *Internet of Things (Netherlands)*, 2021, doi: 10.1016/j.iot.2019.100129.

[3] G. Reggio, M. Leotta, M. Cerioli, R. Spalazzese, and F. Alkhabbas, "What are IoT systems for real? An experts' survey on software engineering aspects," *Internet of Things (Netherlands)*, 2020, doi: 10.1016/j.iot.2020.100313.

[4] H. Manglani, G. L. Hodge, and W. Oxenham, "Application of the Internet of Things in the textile industry," *Text. Prog.*, 2019, doi: 10.1080/00405167.2020.1763701.

[5] V. Mähler and U. H. Westergren, "Working with IoT – A Case Study Detailing Workplace Digitalization Through IoT System Adoption," 2019. doi: 10.1007/978-3-030-15651-0_15.

[6] M. McCaig, D. Rezania, and R. Dara, "Is the Internet of Things a helpful employee? An exploratory study of discourses of Canadian farmers," *Internet of Things (Netherlands)*, 2022, doi: 10.1016/j.iot.2021.100466.

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CHAPTER 8
DEMAND SIDE MANAGEMENT TECHNIQUE

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Using the tools at its disposal, we will use this approach to shift this same load curve from high peak hours to off-peak hours after examining the load curve of client demand. This technology manages load balancing, which adds to that same sub transformer's material cost. Consumption-side managing is an improved way to regulate consumer electricity consumption using multiple methods including financial incentives and help project through education. Capital market management often strives to persuade consumers to use less energy around peak periods or to shift their power consumption to off-peak times like that of the night. Increased power management does not always reduce energy utilization, but it is possible that it will reduce corporate requirement for operating expenses on power plants and/or network connections as when energy is stored in energy storage batteries, then they are discharged during peak hours and in Figure 1 shows the Basic Load Curve [1].

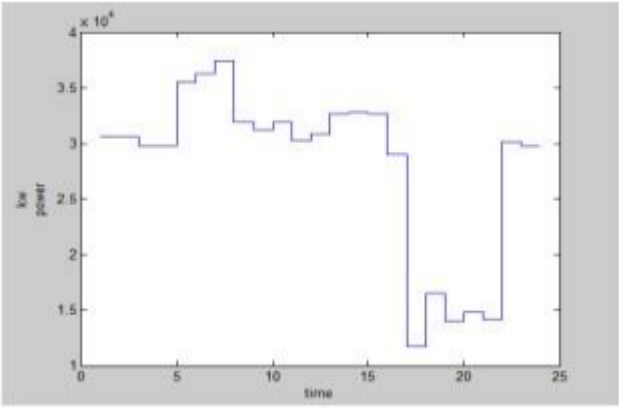

Figure 1: Illustrated that the Basic Load Curve.

A more accurate application for DSM is to assist transmission lines in balancing sporadic power from solar, wind, and hydroelectric providers, particularly when the time and volume of energy requirements do not match the renewable supply [2], [3]. DSM focuses entirely on decreasing the amount of power used between peak and off-peak times, which aids in maintaining the consumer's load curve in agreement with the goal load curve. Our goal is to use macro-economic management to split the residential area's load throughout peak and off-peak hours. And use the tools at our disposal, we employ this approach to shift the load curve from peak traffic hours to off-peak hours after studying the load curve of client demand. To do this, we will create a microcontroller that works at both ends and allowing us to operate both adaptable and non-flexible devices [2].

Three stages made up so this whole project. We will choose an information collection location in the first stage. We will figure out the total demand, rating, number of flexible and non-flexible devices, and rating for each dwelling using the development of information. Then, using MATLAB, we will generate the data's load curve and modify it to create a programmable load curve that enable the load to change from rush periods to off-peak hours. The second step of that kind of project is designing computer controller for both the utility and consumers ends,

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where both end interactions will be maintained between consumer and utility. In a nutshell, this project's accomplishments will contribute to lowering the energy problems in developing counties while quickly increasing the GDP. Energy issues may be lessened relatively quickly if this initiative is successfully implemented on a big scale [3].

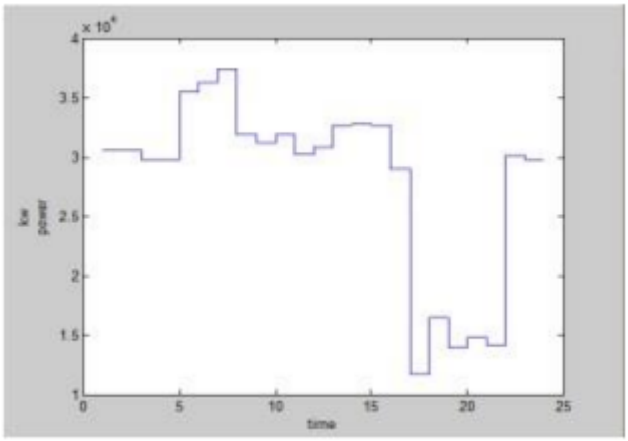

Figure 2: Display the Reshaping of Load Curve.

A load curve in an electrical network is a chart that shows the alterations in the demand for the electrical load over a certain period of time and represent in Figure 2. Companies that produce electricity have been using this information to plan that however much power they will need to produce at any given moment to fulfil demand [4], [5]. A load curve is comparable to something like a load time curve. Although the content is the same, it is presented throughout many ways. When choosing power generating unit to provide power at a given period of time, these curves are helpful. Peak clipping, demand response, and valley filling are three distinct forms of load management practices [6].

Bibliography

[1] E. Guelpa and V. Verda, "Demand response and other demand side management techniques for district heating: A review," *Energy*. 2021. doi: 10.1016/j.energy.2020.119440.

[2] D. Javor and A. Janjic, "Application of Demand Side Management Techniques in Successive Optimization Procedures," *Commun. Dependability Qual. Manag. an Int. J.*, 2017.

[3] M. M. Hussain, R. Akram, Z. A. Memon, M. H. Nazir, W. Javed, and M. Siddique, "Demand side management techniques for home energy management systems for smart cities," *Sustain.*, 2021, doi: 10.3390/su132111740.

[4] S. J. Ben Christopher, "Dynamic demand balancing using demand side management techniques in a grid connected hybrid system," *Int. J. Renew. Energy Res.*, 2014.

[5] K. Muralitharan, R. Sakthivel, and Y. Shi, "Multiobjective optimization technique for demand side management with load balancing approach in smart grid," *Neurocomputing*, 2016, doi: 10.1016/j.neucom.2015.11.015.

[6] A. Nasef, H. Khattab, and F. Awad, "Evaluating the Impact of Demand Side Management Techniques on Household Electricity Consumption, A real case," *ERJ. Eng. Res. J.*, 2021, doi: 10.21608/erjm.2021.62524.1081.

CHAPTER 9
DESIGN AND SIMULATION OF CENTRALIZED AUTOMATED POWER SYSTEM NETWORK (CAPSN)

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This system combines a microcontroller microprocessor, sensors, and then a Global Service Mobile (GSM) modem. The system's main weakness is the usage of GSM, which increases the cost of adoption. By using the available resources effectively, power outages may indeed be reduced. Our goal was to create an automated network of power lines that can centrally command the loads. Implementing effective resource consumption requires control over the distribution network [1], [2]. Digitalization in the distribution sector essentially allows utilities to implement increase effectiveness system control, which can be used to enhance the efficiency dependability, and quality of power or water. However, controlling loads necessarily involves a connection between the recipient's loads and the central control unit. Many people have explored utilizing SMS to build wireless networks. We may discriminate between required loads and unnecessary loads, or more specifically, less necessary burdens, by separating the loads into several groups. We may well be able to offer more consumers one by one with their daily need if we turn off the superfluous loads (Figure 1).

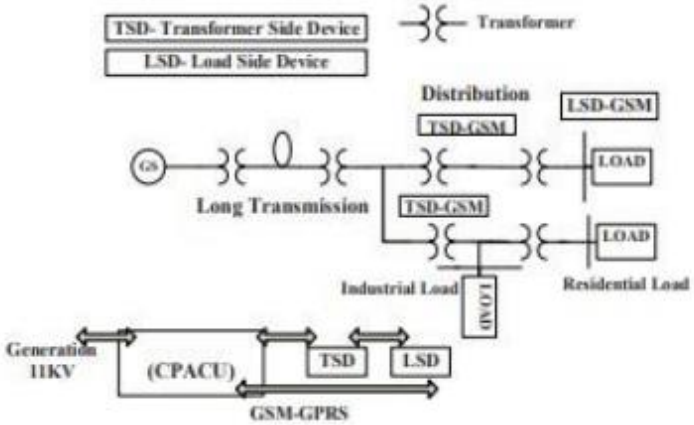

Figure 1: Represented that the Centralized Automated Power System Network.

Three major units are:

- Load Side Device (LSD) (User Device)
- Central Processing & Controlling Unit (CPCU)
- Transformer Side Device (TSD)

As the "Brain" of the power system, the Central Processing & Controlling Unit (CPCU) is responsible. After acquiring the data and analyzing it, CPCU decides whether to stabilize the system. A vast database of data is periodically obtained from LSD. Given that it has information on every user's load across all times and locations, that will be able to forecast the future. As it is a computer -based system, any algorithm may be used. Since the platform is

prepaid, each user will have a unique ID, which CPCU will keep an eye on. The CPCU will also handle confirmation and recharging the balances (billing). In our project, we will use a webserver, receive the data through the internet, and then take the appropriate action. Since the system is prepaid, each subscriber will have a unique ID, which CPCU will keep an eye on. The CPCU will also handle confirming and recharging the excess.

Cost-effective Remote Transformer Monitor System

It is inexpensive and accomplishes the job of remote monitored by computer based. It offers a user-friendly interface with very many features, real-time data, setup opportunities, and more. There is currently no real-time implementation accessible since such system has only been utilized for the project's onsite operation. The state of the remote management system is introduced, and the system's construction and implementation approach are discussed. On the basis of it, each software module's feature and function as well as physical database modules are also introduced. The technology decreases power outages, increases power supply performance and stability, and forecasts potential faults via machine learning. With China's quick population development, a new stage of development has been reached for the electric power industry. New demands have been manufactured, including those for information technology advancement, productivity improvements, and security precautions [3]–[5].

This same question now is whether the electric power sector can keep up with these changes. As systems become more automated in this environment, unexpected power outages may be minimized, supply dependability, and power quality can all be improved. End users will reflect the consistency and quality of the power supply, therefore the alternator monitor plays a crucial role in enhancing essential factors. In this study, the Remote Transformer Monitor System primarily completes remote monitoring of the Transformer's lifetime parameters, which directly influence power quality performance. There are some transformer monitoring systems available right now, but most of them monitor a small area or a specialized kind of transformer, and they use sophisticated remote monitoring methodologies. As a result, the accuracy and functionality of something like the transformer failure prediction function deteriorate.

In order to efficiently address the aforementioned challenges, we established a successful, remote monitoring system for transformers that seems to be affordable employing central monitoring technology and network telecommunications to manage the distribution and different independent remote transformers by consolidated monitor, which utilizes GSM network to manage the voltage regulator by consolidated monitor. By using sensors, controllers, collected runtime data, and real-time failure detection, the transformer will be remotely monitored. Potential transformer problems may be predicted via intelligent analysis of the available data. The on-site monitor module principally handles the real-time data collection and transformer control in the Remote Transformer Monitor System (RTMA) system. The on-site measurement module collects the low-voltage side runtime characteristics of the transformers (such as the three phase voltage and current of the AC sample), computes the low side of the line voltage, phase current, power factor, frequency, and may compute active power and reactive power.

The RTMA system satisfies the extensive and comprehensive monitoring needs of our clients using network technology and software development. The centralize monitor software is built with the distinctive aspects of the RTMA system in mind. It adheres to the standards of software engineering and is based on the idea of an intuitive, simple interface. The algorithm

continuously tracked the apparatus and provided quick and precise feedback. This brand-new communications channel approach for all-time management systems raised services content, broadened the breadth of the organization, and enhance the customer happiness and service quality. Protecting the power system's social standing may be favorable, and it may also lead to substantial economic and social gains.

Bibliography

[1] K. A. A. Fuad, M. M. I. Hasan, L. N. Manzoor, M. A. Mannan, and C. A. Hossain, "Design and simulation of centralized load controlled automated power system network (CLCAPSN)," 2016. doi: 10.1109/WIECON-ECE.2015.7443999.

[2] S. Chouhan, "A Multi-Agent Design for Smart Distribution Automation System with Distributed Energy Resources and Microgrids," 2017.

[3] Z. Wang and A. Sharma, "Research on transformer vibration monitoring and diagnosis based on Internet of things," *J. Intell. Syst.*, 2021, doi: 10.1515/jisys-2020-0111.

[4] I. Ikhwanto, R. A. Kusumoputro, and N. Azman, "Rancang Bangun Host Sistem Mini SCADA Untuk Pengontrolan Beban Trafo 20 KV Pada Gardu Induk," *J. Ilm. Giga*, 2019, doi: 10.47313/jig.v16i1.585.

[5] M. Hasır, S. Cekli, and C. P. Uzunoğlu, "Simultaneous remote monitoring of transformers' ambient parameters by using IoT," *Internet of Things (Netherlands)*, 2021, doi: 10.1016/j.iot.2021.100390.

CHAPTER 10
INTRODUCTION TO SMART METERING SYSTEM

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The notion put out and the development of the technology employed is covered in the introductory chapter. The problem description and the primary goals of the notion are thoroughly explained. Sustainable, effective, and clever solutions are now more necessary than ever in the domains of commuting, management, environment, quality of life, etc. due to urbanisation. Since its initial conception in the early 2000s, the Internet of Things has developed into a variety of sophisticated and pervasive applications inside smart cities. It is a technique for exchanging information between gadgets, networks, and sensors both with and without the aid of people. The fundamental steps in an Internet of Things (IoT) workflow are: detecting an item, recognising and sending its unique information, initiating an action, and having the smart device provide the service. Applications continue to need more energy, and both the quantity of and the need for IoT devices are growing. Therefore, a new smart city has to be able to use energy efficiently and handle the problems that come with it [1]–[3].

Traditional electromechanical energy metres are a significant source of energy loss. The major factor is that consumers can only monitor their energy use regularly since the metres are post-paid. However, a smart metre may be configured to manage household appliances to reduce power usage. Smart metres also make fewer mistakes. Smart metres are electronic measuring tools that utilities employ to control the electric grid and charge consumers. A metering unit plus a communication link between its measurement unit and the utility make up this system. To send and receive knowledge between the utility and the metering unit in industries, universities, etc., the communication module is attached to the microcontroller [4]–[6].

In developing nations, customers' premises have electromechanical metre reading devices, and human labour is used once a month to gather data. As a result, this sort of metre has several drawbacks, such as the need for a metre reader to read the metre for each user to calculate the amount of power used. Electromechanical metres increase the likelihood of reading alterations and mistakes. When severe weather conditions arise and metre reading is difficult or impossible, calculated bills are employed, which is troublesome for both the customer and the provider.

Currently, AMR (advanced metre reading) systems and many other applications in industrialised and developing nations, respectively, utilise wireless smart technology, which has been created.

- Due to the development of technology and its integration into every area of contemporary life, electricity has become indispensable. We use the internet of things to create smart metres.
- The utility application receives and stores user data in a database, which is continually updated with information from metres and is then editable on the utility website.

ISBN 978-81-962236-9-4 March 2023

- With the suggested design, power consumption was lowered by 16% in comparison to the present global market design. This system might be of great assistance to poor nations. The Android application executes consumption plans and online payments.

To reduce the inaccuracy that often results in confusion and corruption connected to energy usage, this study offers a method that eliminates human interaction in metre readings and bill creation. The suggested system is developed utilising an LDR sensor and relay together with a GSM shield module on a microcontroller. The suggested metre may be implemented with very few changes to the current metering system. The suggested method involves attaching an LDR sensor to the flickering LED and using a GSM shield to transmit data to the microcontroller. RTC serves as both an interruption and a delay. The system features a feature that enables the user to get updates on their energy use, generate a final bill, and change the configuration of their loads by SMS. A relay was used to execute the power supply being cut off on demand or because of unpaid bills. According to hardware implementation findings, the suggested system's accuracy is somewhat better than that of current smart metres. The technology is anticipated to be less expensive than currently available smart metres while providing the same capabilities. It differs from the widely used smart metres in that it allows for bilateral communication between the user and the system.

The main topic of this study is smart metering for future energy conservation and energy efficiency. The topic of this conversation is the use of new approaches to achieve energy consumption via two-way communication. The main methodologies of this research are improved measurement technology, including automatic metre reading, power system and exported energy measuring capability, energy and cost forecasting for better energy conservation, and display of all per-phase information and three-phase information on LCD at the metre side. The ADE7758 energy metering chip, 18F452 PIC microcontroller, and PCF8583 real-time clock IC were used in the development of the digital metre. The SIM900 GSM module is used to send the data through SMS to a distant server. The server responds to incoming SMS messages and analyses, displays, and saves the necessary data. On the server side, calculations are made about energy use and cost, average daily energy use, and monthly cost projections.

In this study, a wireless energy metre monitoring system utilising a smartphone app called Blynk is proposed. Additionally, this system includes optional features including overuse of energy notifications and the usage of batteries as a backup power source. Due to recent technological advancements along with the Internet of Things (IoT), artificial intelligence (AI) can now be applied in advance as a transitional application from a manual to an automated device, such as a smart metre, which aids smart cities in having an effective energy management system as a novel idea. The ESP32 microcontroller board with Wi-Fi module was utilised in this system to enable IoT connectivity with IoT platforms like the Blynk application. The prototype design aims to track daily energy use via a smartphone app connected to a Blynk server and to promote energy conservation through notifications sent through the app's use of Blynk features.

Bibliography

[1] J. C. Olivares-Rojas, E. Reyes-Archundia, J. A. Gutierrez-Gnecchi, J. Cerda-Jacobo, and J. W. Gonzalez-Murueta, “A Novel Multitier Blockchain Architecture to Protect Data in Smart Metering Systems,” *IEEE Trans. Eng. Manag.*, 2020, doi: 10.1109/TEM.2019.

2950410.

[2] A. S. R. Tajwar, A. Ahmed, M. R. Hazari, and M. A. Mannan, "Solar Photovoltaic-Based Smart Metering System," 2021. doi: 10.1109/ICREST51555.2021.9331098.

[3] C. Luciani, F. Casellato, S. Alvisi, and M. Franchini, "Green Smart Technology for Water (GST4Water): Water loss identification at user level by using smart metering systems," *Water (Switzerland)*, 2019, doi: 10.3390/w11030405.

[4] J. C. Olivares-Rojas, E. Reyes-Archundia, J. A. Gutiérrez-Gnecchi, I. Molina-Moreno, J. G. Ramos-Díaz, and J. G. González-Serna, "Towards human-computer interaction on smart metering systems," *Av. en Interacción Humano-Computadora*, 2020, doi: 10.47756/aihc.y5i1.58.

[5] A. Liotta, D. Geelen, G. van Kempen, and F. van Hoogstraten, "A survey on networks for smart-metering systems," *International Journal of Pervasive Computing and Communications*. 2012. doi: 10.1108/17427371211221072.

[6] N. Uribe-Pérez, L. Hernández, D. de la Vega, and I. Angulo, "State of the Art and Trends Review of Smart Metering in Electricity Grids," *Appl. Sci.*, 2016, doi: 10.3390/app6030068.

CHAPTER 11
DEVICES AND COMPONENTS FOR SMART ENERGY METERING

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The different hardware and software elements utilised in the project are covered in the technology and software sections. Along with specs and use cases, it provides a full explanation of every piece of hardware utilised as well as every piece of software used and an overview. Software Flutter Google Cloud Platform Arduino IDE Firebase. Hardware Atmega328p-u ZMPT101B Voltage Sensor ACS712 Current Sensor ESP8266 Wi-Fi Communicator [1]–[3].

ATMEGA328P-U

Microchip's ATMEGA328P is a high-performance, low-power controller. An 8-bit microprocessor built on the AVR RISC architecture is called the ATMEGA328P. Due to its usage in ARDUINO boards, it is the most widely used AVR controller.

Features:

- CPU
- AVR 8 bit
- Quantity of pins
- Operating Voltage 1.8 to 5.5 volts
- I/O lines that may be programmed in number
- SPI Serial Interface Master/Slave Communication Interface (17,18,19 PINS) This controller.
- Flexible Serial USART (2,3 PINS) This controller [can be programmed using this method] Serial Interface using Twowire (27,28 PINS)
- Interface JTAG

Analog Comparators are unavailable:

- 1(12,13 PINS) (12,13 PINS)
- channel PWM
- 6 External Oscillators, 0-4MHz at 1.8 to 5.5 volts, 0-10MHz at 2.7 to 5.5 volts, and 0-20MHz at 4.5 to 5.5 volts
- 1MIPS CPU speed and 1MHz RAM
- 2K internal SRAM bytes
- Operating temperature range: -40°C to +105°C (with -40°C being the absolute lowest and +105°C the highest).

The same techniques as with other controllers are utilised when using the ATMEGA328 controller. The only thing needed is programming. The controller merely runs the specified software as necessary. If the controller is not programmed, it just sits there doing nothing.As previously mentioned, programming the controller requires writing the appropriate application

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file to the ATMEGA328P FLASH memory [4]–[6]. The controller executes the programmed code after copying it, and it reacts accordingly.

The pin's number, name, and function.

- Description of a Pin Function
- One PC6 Reset
- This pin aids in microcontroller reset.
- Digital Pin 2 PD0 (RX)
- This is the serial communication input pin.
- 3 Digital PD1 Pins (TX)
- The 4 PD2 Digital Pin is the serial communication output pin.
- It serves as an outside interrupt 0.
- Digital Pin 5 PD3 (PWM)
- It serves as an outside interrupt. 1
- Digital Pin 6 PD4
- It serves as a Timer0 external counter source.
- 7 Vcc
- Voltage is present.
- System supply is positive.

Ground 8 GND

To provide the device with an external clock pulse, this pin should be linked to one of the crystal oscillator's pins.

Crystal Oscillator 10 XTALTo provide the device an external clock pulse, this pin should also be linked to the other pin of the crystal oscillator.

- PD5 Digital Pin 11, (PWM)
- Timer1's external counter source is connected to pin 11.
- Digital Comparator with 12 PD6 Pins (PWM) for Positive Analog Signals
- 14 PB0 Digital Pin Counter or Timer Input Source Pin 13 PD7 Digital Pin Negative Analog Comparator I/PS
- Compare and match A for the 15 PB1 Digital Pin (PWM) Counter or Timer.
- 16 Digital Pin PB2 (PWM)
- This pin functions as a slave I/P.

PB3 Digital Pin 17, (PWM)

- For the SPI interface, this pin serves as both a master data output and a slave data input.
- PB4 Digital Pin, 18
- This pin serves as both an input and an output for the master clock.
- Nineteen PB5 Digital Pin
- For SPI, this pin functions as both a master clock output and a slave clock input.
- Positive Voltage 20 AVcc
- ADC requires a positive voltage (power)

Analog Reference AREF

ADC analogue reference voltage (Analog to Digital Converter)

ISBN 978-81-962236-9-4 March 2023

Ground 22 GND

The System's Ground

- 23 PC0 Analog Input Digital value input from analogue sources (channel 0)
- 24 PC1 Analog Input Digital Value Analog Input (channel 1)
- 25 PC2 Analog Input Digital Value Analog Input (channel 2)
- 26 PC3 Analog Input Digital value from analogue input (channel 3)
- Analog input digital value for the 27 PC4 (channel 4). Additionally, a serial interface connection for data may be made via this pin.
- 28 PC5 Analog Input Digital Value Analog Input (channel 5). The serial interface clock line is also connected to this pin.
- Table 2: Specifications for the ATMEGA328P-U pins

Voltage sensor

A voltage transformer with excellent precision is the ZMPT101B. With this module, you may quickly and conveniently keep an eye on the AC mains voltage up to 1000 volts. It resembled a bouillon cube in size. Despite having a 1:1 turn ratio, this current transformer has a breakdown voltage capacity of up to 4 kV. Simple series resistor R1 controls the input current, while parallel sampling resistor R2 determines the output voltage.

A high-precision voltage transformer is the ZMPT101B. With this module, it's simple to keep an eye on AC mains voltage up to 1000 volts.Voltage measurements up to 250 volts are possible. Additionally, the device is lightweight and has an on-board micro-precision voltage transformer.

Descriptions

- Suitable input current: 2 mA
- Typical output current: 2 mA
- Range linear 0–1000V, 0–10mA
- 4000V is the isolation withstand voltage.
- Turns Ratio: 1,000 to 1
- measurement precision 0.2 Class, 0.1% Linearity

The schematic design of the voltage sensor's internal circuit is shown in figure 3.3.2 above. ZMPT101B Transformer Calculation R1 is selected to limit the winding's current to no more than 2 mA; it can handle up to 10 mA, but beyond 2 mA, linearity is lost and the output will become obvious.

Bibliography

[1] J. C. Olivares-Rojas, E. Reyes-Archundia, J. A. Gutierrez-Gnecchi, J. Cerda-Jacobo, and J. W. Gonzalez-Murueta, “A Novel Multitier Blockchain Architecture to Protect Data in Smart Metering Systems,” *IEEE Trans. Eng. Manag.*, 2020, doi: 10.1109/TEM.2019.2950410.

[2] S. Tonyali, K. Akkaya, N. Saputro, A. S. Uluagac, and M. Nojoumian, “Privacy-preserving protocols for secure and reliable data aggregation in IoT-enabled Smart Metering systems,” *Futur. Gener. Comput. Syst.*, 2018, doi: 10.1016/j.future.2017.04.031.

[3] A. S. R. Tajwar, A. Ahmed, M. R. Hazari, and M. A. Mannan, "Solar Photovoltaic-Based Smart Metering System," 2021. doi: 10.1109/ICREST51555.2021.9331098.

[4] N. Uribe-Pérez, L. Hernández, D. de la Vega, and I. Angulo, "State of the Art and Trends Review of Smart Metering in Electricity Grids," *Appl. Sci.*, 2016, doi: 10.3390/app6030068.

[5] J. C. Olivares-Rojas, E. Reyes-Archundia, J. A. Gutiérrez-Gnecchi, I. Molina-Moreno, J. G. Ramos-Díaz, and J. G. González-Serna, "Towards human-computer interaction on smart metering systems," *Av. en Interacción Humano-Computadora*, 2020, doi: 10.47756/aihc.y5i1.58.

[6] N. T. Mbungu, R. C. Bansal, R. M. Naidoo, M. Bettayeb, M. W. Siti, and M. Bipath, "A dynamic energy management system using smart metering," *Appl. Energy*, 2020, doi: 10.1016/j.apenergy.2020.115990.

CHAPTER 12
ACUITY SENSOR

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The ACS712 current sensor offers accurate and affordable AC or DC current detecting options. The device package is simple for the client to use [1]–[3]. The sensor consists of a linear Hall sensor circuit with an exact and low-offset copper conduction channel close to the surface of the die. The integrated Hall IC measures and converts the magnetic field into a proportional voltage created by the applied electricity flowing via this copper conduction line. The Hall transducer is maintained close to the magnetic signal, enhancing the accuracy of the apparatus. The accurate, proportional voltage is delivered by the low-offset, chopper-stabilized BiCMOS Hall IC.

ACS712 Current Sensor Module Features:

- 80 kHz of bandwidth
- Output sensitivity from 66 to 185 mV/A
- An analogue signal route with low noise
- Device bandwidth is controlled by the new FILTER pin; internal conductor resistance is 1.2 m; the total output error at 25 TA is 1.5%; and the output offset voltage is stable.
- Nearly nonexistent magnetic hysteresis
- Specifications
- Descriptions
- Operating between 4.5 and 5.5 volts
- Measure Range of Current: -20 to +20A
- 100mV/A is the sensitivity
- 32mm in length by 13mm in width
- Output 10nF Capacitance Load
- 4.7k ohm output resistive load
- 5 microseconds is the rise time.
- Frequency 80 kHz Bandwidth

The schematic representation of the current sensor's internal architecture. Sensitivity (Sens) is the modification in sensor output brought about by a 1 A change in the principal conductor. The sensitivity is the result of the linear IC amplifier gain (mV/G) and the electromagnetic torque sensitivity (G / A). The manufacturer sets the linear IC amplifier gain to maximise sensitivity (mV/A) for the device's full-scale current [4]–[6].

Noise (VNOISE) is the sum of the Allegro Hall effect linear IC noise floor (1 G) and the linear IC amplifier gain (mV/G). The thermoelectric and shot noise that is detected in Hall components is used to calculate the noise floor. The lowest current that the device can resolve is found by dividing the noise (mV) by the sensitivity (mV/A).

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Linearity (ELIN) The main current full-scale amplitude is directly proportional to how much the sensor's voltage output fluctuates. The flux concentrator's saturation as it nears full-scale current is the cause of the output's nonlinearity. The linearity is determined using the following equation where the output voltage (V) is equal to VIOUT full-scale amperes when the detected current is close to full-scale (IP). Symmetry (ESYM) (ESYM) is the extent to which a positive or negative full-scale main current causes a variation in the absolute voltage output from the sensor. To determine symmetry, apply the formula below:

ESP8266

Espressif Systems in Shanghai, China, manufactures the ESP8266, a low-cost Wi-Fi microprocessor with integrated TCP/IP networking software and microcontroller capabilities.

The ESP-01 module, created by a third-party producer Ai-Thinker, brought the chip to the attention of Western manufacturers for the first time in August 2014. With the use of Hayes-style instructions, this tiny module enables microcontrollers to join a Wi-Fi network and establish straightforward TCP/IP connections. However, initially, there was hardly any information available in English on the chip and the orders it would receive. Many hackers were drawn to the module, the chip, and the software on it as well as to translate the Chinese documentation because of the very cheap price and the possibility that it may ultimately be produced in large quantities at very low cost. The ESP8285 is a comparable chip with an integrated 1 MiB flash memory that enables the building of single-chip Wi-Fi-capable devices.

Features:

- Processor: Tensilica Xtensa Diamond Standard 106Micro-based L106 32-bit RISC CPU core operating at 80 MHz Memory:
- External QSPI flash: up to 16 MiB is supported; 32 KiB instruction RAM; 32 KiB instruction cache RAM; 80 KiB user-data RAM; 16 KiB ETS system-data RAM (512 KiB to 4 MiB typically included)
- IEEE 802.11 b/g/n Wi-Fi, integrated TR switch, balun, LNA, power amplifier, and matching network, WEP or WPA/WPA2 authentication, or open networks, 17 GPIO pins, Serial Peripheral Interface Bus (SPI), I2C (software implementation), I2S interfaces with DMA (sharing pins with GPIO), transmit-only UART on GPIO2, and 10-bit ADC (successive approximation ADC) DIAGRAM OF PINS:

Restrictions on the GPIO Function State

- Select the boot mode 3.3V
- No Hi-Z
- Not used during Serial transmission: 1 TX0
- 2 Pick TX1 for the boot mode
- 3.3V (boot only) (boot only)
- Avoid connecting to the ground during startup.
- transmits debug info during boot
- 3 RX0 - Ineffective for Serial transmission
- 5 SCL (I2C) - - 6 SDA (I2C)
- 6 to 11 Flash connections, please
- not functional and undamaged

ISBN 978-81-962236-9-4 March 2023

- Twelve MISO (SPI), thirteen MOSI (SPI), fourteen SCK (SPI), and fifteen SS (SPI) 0V
- Unusable pull-up resistor 16
- No pull-up resistor is used when you wake up; a pull-down is used instead.
- To awaken, it must be linked to RST.

A software development kit (SDK) for programming the chip directly was made available by Espressif Systems in October 2014, doing away with the need for a second microcontroller. Espressif now maintains two versions of the SDK, one based on FreeRTOS and the other on callbacks. Since then, there have been several official SDK releases from Espressif.

The open-source ESP-Open-SDK, which is based on the GNU Compiler Collection (GCC) toolchain and is maintained by Max Filippov, serves as a substitute for Espressif's official SDK. The "Unofficial Development Kit" by Mikhail Grigorev is an additional option.

Other SDKs, the majority open-source, consist of:

- Arduino is a firmware built using C++. The ESP8266 CPU and its Wi-Fi components may be programmed using this core just like any other Arduino gadget. Through GitHub, the ESP8266 Arduino Core is accessible. An open-source BASIC-like interpreter designed particularly for the Internet of Things is ESP8266 BASIC (IoT). A browser-based, self-hosting programming environment.
- ESP Easy was created by fans of home automation.ESPHome — ESPHome is a way for controlling your ESP8266/ESP32 via remote control through home automation systems and simple but effective setup files.
- Open-source firmware called Tasmota is particularly well-liked by fans of home automation. ESP-Open-RTOS is a free and open-source software framework for the ESP8266.
- Free and open (as far as feasible) integrated SDK for ESP8266/ESP8285 chips is called ESP-Open-SDK.Espruino is a firmware and JavaScript SDK that closely resembles Node.js and is constantly updated. A few MCUs are supported, notably the ESP8266. Open-source ESP8285/ESP8266 firmware is called ESPurna.

Bibliography

[1] N. F. Lepora, U. Martinez-Hernandez, M. Evans, L. Natale, G. Metta, and T. J. Prescott, “Tactile Superresolution and Biomimetic Hyperacuity,” *IEEE Trans. Robot.*, 2015, doi: 10.1109/TRO.2015.2414135.

[2] T. Bornaetxea and I. Marchesini, “r.survey: a tool for calculating visibility of variable-size objects based on orientation,” *Int. J. Geogr. Inf. Sci.*, 2022, doi: 10.1080/13658816.2021.1942476.

[3] A. Jacobson, Z. Chen, and M. Milford, “Leveraging variable sensor spatial acuity with a homogeneous, multi-scale place recognition framework,” *Biol. Cybern.*, 2018, doi: 10.1007/s00422-017-0745-7.

[4] A. G. Anderson, K. Ratnam, A. Roorda, and B. A. Olshausen, “High-acuity vision from retinal image motion,” *J. Vis.*, 2020, doi: 10.1167/JOV.20.7.34.

[5] M. A. Bellavance, J. Takatoh, J. Lu, M. Demers, D. Kleinfeld, F. Wang, and M. Deschênes, “Parallel Inhibitory and Excitatory Trigemino-Facial Feedback Circuitry for Reflexive Vibrissa Movement,” *Neuron*, 2017, doi: 10.1016/j.neuron.2017.06.045.

[6] D. A. C. Brownson and C. E. Banks, "Graphene electrochemistry: Fabricating amperometric biosensors," *Analyst*, 2011, doi: 10.1039/c0an00875c.

CHAPTER 13
FLUTTER IN SMART ENERGY METERING

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A free and open-source mobile UI framework is Google's Flutter. Flutter is made up of two essential parts, namely:

- Software Development Kit (SDK): A software development kit is a collection of tools. This is for creating beautiful desktop, web, and mobile applications.
- Frameworks - A framework is a group of reusable components that may be modified to match our unique needs. Examples include text inputs, glide buttons, hot reinstall, and many more.
- It is larger and doesn't necessarily need the bridge to connect with native modules since it utilises the Dart framework, which has the majority of the components pre-installed. To put it briefly, the Flutter engine has all of the components required to create apps.
- The Flutter framework includes stateful management, testing, navigation, access to device APIs, and a tonne of libraries. There is no longer a need for external libraries thanks to this vast array of components.

There were several new features and improvements in the Beta 2 release. Flutter will only become better and more reliable for deployment as the developer community expands. People are starting to switch to this technology for creating apps since it has made it possible for a community centre to provide the materials required to create the appropriate app modules [1]–[3].

Benefits of Flutter:

- Saves money and time: The programming language Flutter is cross-platform. As a consequence, programmers may use the same code base to build applications for iOS and Android. The best method for cutting costs and accelerating development is cross-platform development.
- Compatibility: Another advantage of Flutter is that it has widgets, which means that compatibility issues are less of an issue. Developers will spend less time testing the software on older OS versions and will run across fewer problems across OS versions.
- Hot Reload: Because of its ability to do hot reloads, Flutter is quite popular among smartphone developers. With hot reloading, you can instantly view on hardware, simulators, and emulators the changes you've made to the code. It takes less than a second to update the changed code. The programme is still running at this period, saving the developer time from having to restart it. Creating user interfaces, adding new features, and fixing problems are now much simpler tasks. Usually, you can solve an app's issue and keep using it thereafter as if nothing had occurred. You may be certain that any necessary whole software refreshes will be completed quickly, cutting down on development time.

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Open-Source: The Flutter platform is open-source, and a strong developer community supports it, adds to the comprehensive documentation, and creates helpful tools. Dart and Flutter may both be used without cost [4]–[6].

The flutter software is shown in the aforementioned figures 3.6.1 and 3.6.2. In the first, the logo is shown, and in the second, the flutter architecture is discussed.

Flutter's widgets:

Flutter creates a contemporary mobile app using widgets (UI), and these widgets are ideal for mobile development. The creation of applications is also made easier by this framework. In actuality, the flutter app is a widget unto itself. In Flutter, "everything is a widget," according to the developer community. Flutter widgets may be useful for gestural and animated applications. Later on, we'll provide you with a link to an app that provides a brief rundown of flutter's UI features. States may or may not exist for widgets. Flutter will compare the states (old and new) and display the widgets with the necessary modifications rather than re-rendering the whole widgets if you make specific changes to the states of the widgets (old and new).

Every widget represents an unchangeable declaration of a component of the user interface. In flutter, there are two categories of widgets:

- Stateful Widgets: These widgets are changeable since they are very responsive to state changes and will change if one is noticed. Throughout their lifespan, these widgets have several state changes. Developers may quickly create a stateful widget in editors by using the abbreviation "stf."
- Stateless Widgets: During the development process, these widgets maintain their statelessness and remain immutable. These widgets' states do not change while they are being used. You are dealing with stateless widgets when the app's icon, icon button, and text remain the same when the app is doing an activity. Using the keyboard shortcut "stl," developers may quickly build a stateless widget in editors.

Platform For Google Cloud

With the help of its services, the Google Cloud Platform (GCP), a public cloud solution, makes several of Google's computing resources accessible to users at large. The actual hardware infrastructure of Google's widely dispersed data centres, including computers, hard drives, solid-state drives, and networking, is referred to as GCP resources.

Software and hardware are provided as integrated services that provide access to the underlying resources as part of a public cloud offering. In the areas of computing, storage & databases, networking, big data, machine learning, identity & security, and management & developer tools, GCP offers Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).

Service architecture for the region:

- On the Google Cloud Platform, each resource and resource may be zone-, region-, or Google-managed across several regions.
- A zone is a place where resources may be used within a territory. Because zones are separated from one another to stop outages from spreading, each zone is categorised as a discrete failure domain within a region.

- When a zone goes down, all of its resources go down with it until service is restored. Zonal resources function inside a single zone. Within an area, redundant regional resources are spread among zones. Google oversees multiregional services to allow for redundancy and dispersion both within and across regions

Bibliography

[1] F. M. Dahunsi, S. O. Eniola, A. A. Ponnle, O. A. Agbolade, C. N. Udekwe, and A. O. Melodi, "A Review of Smart Energy Metering System Projects," *J. Elektron. dan Telekomun.*, 2021, doi: 10.14203/jet.v21.70-78.

[2] J. Ma, Z. Teng, W. Qiu, L. Ma, and J. Liu, "Research on the degradation trend of smart energy metering equipment based on IGA-BP neural network," *Yi Qi Yi Biao Xue Bao/Chinese J. Sci. Instrum.*, 2021, doi: 10.19650/j.cnki.cjsi.J2108020.

[3] A. Michalec, E. Hayes, J. Longhurst, and D. Tudgey, "Enhancing the communication potential of smart metering for energy and water," *Util. Policy*, 2019, doi: 10.1016/j.jup.2018.11.002.

[4] S. Jain, M. Pradish, A. Paventhan, M. Saravanan, and A. Das, "Smart energy metering using LPWAN IoT technology," 2018. doi: 10.1007/978-981-10-8249-8_2.

[5] Parliamentary Office of Science & Technology, "Smart Metering of Energy and Water," *POST Note*, 2014.

[6] P. Kumar, A. Gurtov, M. Sain, A. Martin, and P. H. Ha, "Lightweight Authentication and Key Agreement for Smart Metering in Smart Energy Networks," *IEEE Trans. Smart Grid*, 2019, doi: 10.1109/TSG.2018.2857558.

CHAPTER 14
GCP PROVIDES SEVERAL SERVICES

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Compute Engine is an Infrastructure as a Service (IaaS) offering from Google that provides virtual machines housed on Google's network. Using canister instances configured with one of several runtimes, each of which contains a collection of common App Engine libraries, App Engine is a PaaS service for building online and mobile backends. A cluster orchestration and administration system is utilised to manage Docker containers. A containment Engine is a tool that enables this. It is based on the open-source Kubernetes project [1], [2].

A private Docker repository hosted by Google infrastructure is called Container Registry. One business that specialised in cloud computing is called Cloud Functions. You may create microservices short, focused functions) that react to cloud events using an event-based, asynchronous computing solution without the requirement for a dedicated hosting or runtime environment.

- A geo-redundant, local, nearline, and coldline storage solution is provided by the unified object storage service known as cloud storage.
  For hosting relational MySQL databases, Cloud SQL is a Google-hosted, fully-managed MySQL database service.
- Bigtable is a high-performance NoSQL Big Data database server that has excellent throughput and can manage very huge workloads. Google utilises Bigtable internally to power applications like Search and Gmail.
- A schemaless NoSQL database for non-relational data storage is called Cloud Datastore. It's an excellent alternative to Bigtable when ACID transactions are needed or the data being stored is well-organized.
- BigQuery utilises SQL to store and analyse Big Data and is serverless, fully managed, petabyte-scale data warehousing and analytics platform.
- Cloud Dataflow is a fully-managed real-time data processing service that provides batch and streaming Big Data processing as well as ETL, batch computation, and continuous computing.
- Managed by Apache Hadoop, Apache Spark, Apache Pig, and Apache Hive, Dataproc is a service for processing large datasets.

A Jupyter-based interactive tool for exploring, analysing, and visualising massive volumes of data is called Cloud Datalab. To facilitate data analysis utilising BigQuery, Compute Engine, and Cloud Storage, it makes use of Python, SQL, and JavaScript. Currently, Cloud Datalab is in a public beta. Google Genomics is an API that uses the standards set out by the Global Alliance for Genomics and Health to store, analyse, explore, and share genomics data. Included is a provision for controlling datasets, readings, and variations as well as search, slice, and access control settings for sharing. Google Cloud IAM is a GCP service that offers built-in auditing and enables administrators to manage who has access to certain resources.

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Cloud Resource Manager is a resource container that can be managed programmatically and groups and hierarchically arranges GCP resources.

An application that searches the internet for vulnerabilities is called Cloud Security Scanner. An online security scanner that checks App Engine programmes for outdated or vulnerable libraries, Flash injection, mixed content, and cross-site scripting [3]–[5].

ARDUINO IDE

A cross-platform (Windows, macOS, Linux) software called the Arduino Integrated Development Environment (IDE) is used to create and upload programmes to Arduino-compatible panels and other vendor development boards. A code editor, a compiler, and an uploader are also included. There are other code libraries available for accessing peripherals like serial connections and various screen kinds .

The code for Arduino sketches is written in a language like C or C++.

Arduino software serves two basic purposes:

setup() — The board's settings are configured using the setup() function. This function only executes once when the board is switched on. In contrast to setup(), loop() is called after setup() has ended and runs endlessly [6]–[8].

Upload

The code entered on the screen is compiled and runs when you press the Upload button. The linked board is then updated with the new code. Before uploading the schematic, the right board and ports must be chosen.

- The board's microcontroller is loaded with a brief software called a bootloader.
- Open
- To open a previously produced file, click the Open button. The currently open window will be used to open the specified file.
- Save
- The current drawing or code may be saved by pressing the save button.
- New
- You may use it to start a new drawing or tab.
- Verify
- The Verify button is used to check for compilation errors in the written code or the sketch.
- Serial Watcher
- The toolbar's right-hand corner has a button for the serial monitor. The serial monitor is shown on the screen.

Bibliography

[1] R. V. Alvarez, L. Mariño-Ramírez, and D. Landsman, “Transcriptome annotation in the cloud: Complexity, best practices, and cost,” *Gigascience*, 2021, doi: 10.1093/gigascience/giaa163.

[2] C. R. Figley, K. R. Figley, and J. Norman, “Tuesday morning september 11, 2001: The green cross projects’ role as a case study in community-based traumatology services,” *J. Trauma Pract.*, 2002, doi: 10.1300/J189v01n03_02.

[3] M. Sun, S. Zhao, C. Gilvary, O. Elemento, J. Zhou, and F. Wang, "Graph convolutional networks for computational drug development and discovery," *Briefings in Bioinformatics*. 2020. doi: 10.1093/bib/bbz042.

[4] P. Forster, L. Forster, C. Renfrew, and M. Forster, "Phylogenetic network analysis of SARS-CoV-2 genomes," *Proc. Natl. Acad. Sci. U. S. A.*, 2020, doi: 10.1073/pnas.2004999117.

[5] M. G. Bright, J. R. Whittaker, I. D. Driver, and K. Murphy, "Vascular physiology drives functional brain networks," *Neuroimage*, 2020, doi: 10.1016/j.neuroimage.2020.116907.

[6] E. H. Klijn, I. van Meerkerk, and J. Edelenbos, "How do network characteristics influence network managers' choice of strategies?," *Public Money Manag.*, 2020, doi: 10.1080/09540962.2019.1665828.

[7] R. Damasevicius *et al.*, "Litnet-2020: An annotated real-world network flow dataset for network intrusion detection," *Electron.*, 2020, doi: 10.3390/electronics9050800.

[8] T. Sommer, M. Sulzer, M. Wetter, A. Sotnikov, S. Mennel, and C. Stettler, "The reservoir network: A new network topology for district heating and cooling," *Energy*, 2020, doi: 10.1016/j.energy.2020.117418.

CHAPTER 15
CONCEPT OF FIREBASE

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A strong platform for creating online and mobile applications is Firebase. Firebase can power the backend of your project and provide features like data storage, user authentication, static hosting, and more. With Firebase, it's easy to create mobile and internet applications that grow from one to one million users. Firebase gives you the ability to develop more potent, secure, and scalable applications using the top-notch infrastructure. Web Firestore: For use with mobile, web, and server applications, it is a flexible, scalable collection of data from Firebase and Google Cloud Platform. Data for your mobile and internet applications can be easily stored, synced, and accessed thanks to our global NoSQL document database. It works with the Web Platform, iOS, and Android [1]–[3].

Google's machine learning capabilities are made available to Android and iOS applications via the ML Kit, a mobile SDK that is both robust and easy to use. With only a few lines of code, you can get the functionality you want, regardless of your level of machine learning expertise. You don't need a lot of prior knowledge of neural networks or model optimization to get started. On the other hand, ML Kit offers simple-to-use APIs for integrating your own TensorFlow Lite models into your mobile applications if you are an experienced machine learning developer. It works with both the Android and iOS operating systems [4]–[6]. Firebase Cloud Functions: This feature enables you to execute backend code in response to events produced by Firebase features and HTTPS requests. Your code is run in a regulated environment and saved on Google's servers. You are not required to scale or operate your servers. It is compatible with the Web Platform, C++, Unity, Android, and iOS.

To assist you with authenticating users in your project, backend services, simple SDKs, and ready-to-use UI frameworks are all available. It allows a variety of ways, including passwords, phone numbers, and well-known federated identity providers like Google, Facebook, and Twitter. It works with the Web Platform, iOS, and Android. This kind of online content hosting is appropriate for developers. With a single command, you can quickly launch web applications and serve both static and dynamic content to a worldwide CDN (content delivery network). Integrate Cloud Functions with Firebase Hosting to create and host microservices on Firebase. Only the Web Platform is supported.

Online storage: This object storage service was created by Google. The Firebase SDKs for Cloud Storage give Google security to file uploads and downloads for your Firebase applications regardless of network conditions. Our SDKs allow you to preserve user-generated content such as photos, music, and video. You may use Google Cloud Storage to have access to the same files that are stored on the server. It is compatible with the Web Platform, C++, Unity, Android, and iOS.

Real-time Database: This is a NoSQL database hosted in the cloud that enables real-time data synchronisation across users. In essence, the Real-time Database is a sizable JSON object that

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developers may alter in real-time. It is compatible with the Web Platform, C++, Unity, Android, and iOS. The technique used to create a fully functional model of the energy metering system is described in detail in the proposed work chapter. With the use of a block diagram, the project's working theory, and a flow diagram, the chapter outlines the technique employed.

In contrast to traditional methods, the smart energy metering system proposed by our proposal automates invoicing. Arduino Uno, ESP8266, ZMPT101B voltage sensor, and ACS712 current sensor are all used in the developed system. With the aid of the voltage and current sensor, it calculates energy usage. To monitor the energy flow, the voltage sensor and the current sensor are put into the circuit. The measured values are sent to the Arduino Uno, which transforms them into a digital format and then transmits them to the ESP8266 module. The user may see the readings at any time by entering into the specially created Android application once the ESP8266 delivers this data to a database where they are saved. The programme not only displays the amount of energy being used, but it may also assist users in tracking their energy usage by enabling them to set alarms. It also computes the bill for the user, eliminating the need for an agent to visit the metre each month to generate the bill.

Methods

The Arduino Uno microcontroller receives data from the current and voltage sensors that are wired to it in analogue format. The data is then converted to digital format and calculated as Kilowatt units by the microcontroller and is then transmitted to a remote database using the Bluetooth module ESP328. All of the customer data and measurement data from the ESP328 module are stored in the remote database, which is then accessible by the android application to allow consumers to keep track of their energy use.

Sensing unit, first

The voltage transformer and the current sensor, which are coupled to the main supply, make up the sensing unit. A 240v to 6v step-down transformer was employed as the voltage transformer. The current sensor, on the other hand, was a non-intrusive ACS712 sensor that was clipped over a single wire, either live or neutral, to detect the flowing current. The output of this sensor is voltage, hence a load resistor must be connected to its two terminals to read current. Both components' readings are sent to the next unit for processing.

Tropic Unit

The microcontroller, an Arduino Uno with an ATmega328 processor, makes up the majority of the control unit. The microcontroller's integrated analogue to digital converter (ADC) receives data from the sensing device as input. The data is then processed in kilowatt hours to determine the amount of remaining credit and the number of spent units. When 20% or 10% of the amount is left, the control unit gives alerts to the user. The user is provided 24 hours at zero balance as a chance to recharge before the energy is turned off. The communication unit receives the computed data next.

Communication Unit (C)

The connection between the control unit and the Firebase database is this unit's primary role. The database and the Bluetooth module make up its structure. In the metering system, a serial connection is made between the module and the control unit. Two digital pins on the Arduino Uno are linked to the Tx and Rx Bluetooth pins. Each customer's billing information, including

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first and last name, mobile number, metre ID, balance, remaining balance, used units, and remaining units, is included in the implemented database. Communication between the managing unit and the control unit is its primary purpose.

Administration Unit

The android application serves as the management unit. Due to the capability of this device, customers may obtain billing information and keep a record of it to monitor their power use. Data that has been processed by the control unit is sent from the communication unit to the management unit. An open-source platform created for IoT applications is the ESP8266. Utilize the hardware using the ESP12 module and the software running on the ESP8266 WiFi module. It employs a unique processor with power-saving capabilities including deep sleep mode, making it a superior choice in terms of power usage. There is no need for a separate WiFi module since the ESP12 WiFi module is incorporated. The board is tiny in both cost and total size. An electrical signal is produced by the ACS712 Current Sensor Module in proportion to the current found in the wire. The measured AC voltage from the circuit is produced as an analogue output by the ZMPT101B High-precision Voltage sensor module. The Arduino Uno microcontroller's built-in ADC (Analog to Digital Converter) receives the analogue values obtained from the sensor.

To estimate the utilised and remaining units, the data is afterwards converted to kilowatt hours. The following computations are made: First calibration values for the current and voltage are computed as indicated in equations (1) and (2), where 1024 is the maximum reading of Arduino input pins, 36 is the value of the load resistance used with the current sensor, and 240 is the highest voltage that the metre can read. A loop that collects 200 samples from the microcontroller analogue pins attached to the sensor and determines the maximum and lowest values is used to compute the current value received from the supply.

Bibliography

[1] M. I. Mahali, “Smart Door Locks Based on Internet of Things Concept with mobile Backend as a Service,” *Elinvo (Electronics, Informatics, Vocat. Educ.*, 2017, doi: 10.21831/elinvo.v1i3. 14260.

[2] C. Khawas and P. Shah, “Application of Firebase in Android App Development-A Study,” *Int. J. Comput. Appl.*, 2018, doi: 10.5120/ijca2018917200.

[3] M. I. Syaiffullah, S. Sadi, and R. Suyono, “Gas Leak Detection System Monitoring Based Iot Using Mcu Nodes With Google Firebase CommunicatioN,” *J. Tek.*, 2020, doi: 10.31000/jt.v9i2.3202.

[4] A. Rahmatulloh, F. M. S. Nursuwars, I. Darmawan, and G. Febrizki, “Applied Internet of Things (IoT): The Prototype Bus Passenger Monitoring System Using PIR Sensor,” 2020. doi: 10.1109/ICoICT49345.2020.9166420.

[5] S. Singh, S. Verma, S. Kumar, and S. Kumar Singh, “Home Automation Using Node MCU, Firebase & IOT,” *Int. J. Sci. Res. Rev.*, 2019.

[6] S. A. Khan, G. Aggarwal, Virender, and P. K. Tiwari, “Graph Theory Compliant Technical Intelligence Implementation in NoSQL Database,” 2022. doi: 10.1007/978-981-16-2877-1_41.

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