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Real-Time Hand Sign Detection using Deep Learning and TensorFlow Object Detection

A Project Submitted to the Department of Electrical Engineering in Partial Fulfilment for the Requirements of the Degree of B.Sc. in Electrical Engineering

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Declaration

We hereby declare that this project report is based on our original work except for citations and quotations, which have been duly acknowledged

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Abstract

This research project focuses on the development of a real-time object detection network using TensorFlow, a widely adopted deep learning framework. The primary objective of our study is to design an efficient and accurate system capable of detecting specific hand gestures in real-time scenarios. The hand gestures considered are thumbs up, thumbs down, victory sign, and live long sign.

To accomplish this, we employ deep learning techniques, particularly convolutional neural networks (CNNs), which have demonstrated exceptional performance in image recognition tasks, making them well-suited for object detection.The network is implemented and trained using TensorFlow, a powerful and flexible framework specifically designed for deep learning applications.

The main goal of the proposed network is to achieve real-time performance, enabling it to swiftly process video or image frames and provide precise and timely detection of hand gestures. Real-time hand gesture detection holds practical significance in various fields, including human-computer interaction and gesture-based control systems.

The research involves the design and optimization of the object detection network architecture. We train the network using a small custom dataset that we collected and annotated, consisting of hand images depicting thumbs up, thumbs down, victory sign, and live long sign gestures. The performance of the network is evaluated using appropriate metrics, including object detection accuracy, processing speed, and resource utilization.

Furthermore, we explore supplementary techniques such as transfer learning, data augmentation, and model compression to enhance the performance and efficiency of the network. These techniques are implemented to reduce computational requirements while maintaining or even improving the accuracy of hand gesture detection.

By combining the capabilities of TensorFlow, our custom dataset, and deep learning

techniques, our research aims to provide an effective and reliable system for real-time hand gesture detection. The outcomes of this study contribute to advancements in human-computer interaction, sign language recognition, and various applications that benefit from precise hand gesture analysis.

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Chapter 1

Introduction

1.1 Background and Motivation

In our research project, we focused on the task of hand detection and classification, which holds significant relevance in various applications. The ability to accurately detect and classify hand gestures can enable intuitive human-computer interaction, sign language recognition, and gesture-based control systems, among other applications.

To accomplish this task, we employed the TensorFlow Object Detection API , which provides a framework for developing object detection models using deep learning techniques(23) . Specifically, we utilized a pretrained model available in the TensorFlow Object Detection API and fine-tuned it on our custom small dataset of hand images. The dataset was collected and annotated to include four distinct labels, allowing us to classify different hand gestures accurately.

Range-based obstacle detection systems, such as ultrasonic sensors, lasers, radar, stereo vision, and optical flow, are commonly utilized in various mobile applications. However, for the specific task of hand detection and classification, these range-based sensors may not be the most suitable option. Range sensors typically excel at detecting obstacles in the environment but may face challenges when it comes to precise hand detection and classification due to their limitations in measuring fine details and capturing color information.

Deep learning, a subset of machine learning, offers a powerful approach to address the complexities of hand detection and classification(7). By leveraging mathematical functions, deep learning models can extract non-redundant information and patterns from data, enabling the establishment of a relationship between input (hand images) and output (classification labels).

In traditional computer programming, achieving the desired output often relies on explicit rules and logic. In contrast, deep learning models learn the underlying patterns and features directly from the data through a training process(3). This flexibility allows the models to adapt and generalize well to unseen hand gestures, improving overall accuracy and performance.

By utilizing the TensorFlow Object Detection API (which is an open-source framework built on top of TensorFlow that makes it easy to construct, train and deploy object detection models)(17) and deep learning techniques, our research aims to develop an efficient and accurate system for real-time hand detection and classification. This system has the potential to contribute to advancements in human-computer interaction, gesture recognition, and various other applications that benefit from precise hand gesture analysis.

1.2 Problem Statement

The objective of our research is to address the challenge of real-time identification and classification of hand gestures using deep learning techniques. Specifically, we aim to develop a robust and efficient system that can accurately detect and classify hand gestures, including thumbs up, thumbs down, victory sign, and live long sign, in real-time scenarios.

To achieve this, we utilized a custom hand dataset and leveraged the TensorFlow Object

Detection (TFOD) models within the Colab and Kaggle environments. Our Python-based implementation capitalizes on the capabilities of deep learning to build an effective neural network model.

Previous studies have demonstrated the effectiveness of neural networks in object detection tasks. However, adapting these techniques specifically for hand gesture identification presents unique challenges. Our research builds upon this prior work, taking into account the lessons learned and developing innovative solutions to address these challenges.

In our study, we employed the Python programming language and utilized a neural network to detect and classify the hand gestures of interest. The proposed methodology involves training the neural network to detect the edges and features of thumbs up, thumbs down, victory sign, and live long sign gestures. We utilized the TensorFlow framework to facilitate training, testing, and evaluation of the neural network model's performance.

Through detailed analysis and evaluation, we assess the accuracy and efficiency of our proposed approach in real-time hand gesture identification. The outcomes of this research will contribute to advancements in human-computer interaction, gesture recognition, and related applications, allowing for intuitive and natural interaction with digital systems.

1.3 Research Objectives

Object detection is a fundamental task in computer vision that involves identifying and localizing objects within an image or video. Real-time object detection refers to the ability to perform this task in real-time, typically at high frame rates, enabling applications such as autonomous driving, surveillance systems, and robotics.

The problem at hand is to develop a deep learning model for real-time object detection using TensorFlow, a popular deep learning framework. The goal is to design a network architecture that can accurately and efficiently detect objects in real-time, providing both bounding box coordinates and class labels for each detected object.The primary objective of our research is to develop a deep learning model for real-time object detection using TensorFlow, a widely adopted deep learning framework. The specific goals of our study are as follows:

1. Network Architecture Design: Design an efficient and effective network architecture that can accurately detect objects in real-time scenarios.

2. Object Localization: Develop a model that provides precise bounding box coordinates for each detected object, allowing for accurate localization within the image or video.

3. Real-Time Performance: Achieve real-time performance by optimizing the network's processing speed, enabling it to process image or video frames at high frame rates.

4. Object Classification: Implement a system that assigns appropriate class labels to the detected objects, enabling comprehensive object identification and categorization.

5. Evaluation Metrics: Establish appropriate evaluation metrics to assess the accuracy and efficiency of the proposed deep learning model, considering factors such as object detection accuracy, processing speed, and resource utilization.

By addressing these research objectives, we aim to contribute to the advancement of real-time object detection capabilities, enabling the development of applications in various domains, including autonomous driving, surveillance systems, and robotics.

1.4 Scope and Limitations

1. Data Availability: The effectiveness of our deep learning model for real-time object detection using TensorFlow is reliant on the availability and quality of the hand ges-

ture dataset we collected and annotated. Sufficient data is crucial for the model to learn the intricate patterns and variations associated with thumbs up, thumbs down, victory sign, and live long sign gestures.

2. Model Complexity: Developing an optimal deep learning model for our specific hand gesture detection task requires careful consideration of the model's complexity. Finding the right balance between model complexity and the complexity of the hand gesture data is essential to ensure accurate and efficient detection.

3. Generalization to Similar Gestures: The focus of our research is on real-time detection and classification of thumbs up, thumbs down, victory sign, and live long sign gestures. The model's performance may vary when applied to other similar hand gestures or gestures outside the defined scope. The model's ability to generalize to unseen variations or different hand orientations may be limited.

4. Computational Requirements: Deep learning models, including the one developed in this research, tend to be computationally intensive. Training and running the model on large-scale datasets can require significant computational resources and time. The availability of suitable hardware and computational infrastructure is essential to support the training and real-time inference of the model.

5. Energy Consumption: The computational intensity of deep learning models, coupled with their resource requirements, can result in high energy consumption during training and inference. Energy efficiency considerations may be necessary when deploying the real-time object detection system in power-constrained environments or resource-limited devices.

6. Understanding the scope and limitations specific to our research on real-time hand gesture detection using TensorFlow helps provide a clear understanding of the factors

that may influence the performance and practicality of the developed system.

Chapter 2

Literature Review

2.1 Introduction to Deep Learning

Deep learning algorithms have shown superior learning and classification performance in areas such as transfer learning, speech and handwritten character recognition among others (11). In other words, a deep learning algorithm automatically extracts the low- and high-level features necessary for classification. By high level features, one means feature that hierarchically depends on other features. For instance, in the context of computer vision, this implies that a deep learning algorithm will learn its own low level representations from a raw image (such as edge detector, gabor filters, etc...), then build representations that depend on those low level representations (such as a linear or non-linear combinations of those low-level representations), and successively repeat the same process for higher levels. Automatic representation learning is key point of interest of this kind of approach as the need for potentially time consuming handcrafted feature design is eliminated. In statistical machine learning, a major issue is the selection of an appropriate feature space where input instances have desired properties for solving a particular problem. For example, in the context of supervised learning for binary classification, it is often required that the two classes are separable by an hyperplane. In the case where this property is not directly satisfied in the input space, one is given the possibility to map instances into an intermediate feature space where the classes are linearly separable. This intermediate space can either be specified explicitly by hand-coded features, be defined implicitly with a so-called kernel function, or be automatically learned. In both of the first cases, it is the user's responsibility to design the feature space. This can incur a huge cost in terms of computational time or expert knowledge, especially with highly dimensional input spaces, such as when dealing with images. As for the third alternative, automatically learning the features with deep architectures, i.e. architectures composed of multiple layers of nonlinear processing, can be considered as a relevant choice. Indeed, some highly nonlinear functions can be represented much more compactly in terms of number of parameters with deep architectures than with shallow ones (e.g. SVM). For example, it has been proven that the parity function for n-bit inputs can be coded by a feed-forward neural network with O(log n) hidden layers and O(n) neurons, while a feed-forward neural network

2.2 Convolutional Neural Networks for Object Detection

Convolutional Neural Networks (CNNs) have proven to be highly effective for object detection tasks (21). Object detection involves localizing and classifying objects within an image or a video. CNNs excel at capturing hierarchical representations of images, making them ideal for object detection.

These CNN-based object detection approaches have achieved state-of-the-art performance on benchmark datasets such as COCO (Common Objects in Context) and PASCAL VOC (Visual Object Classes). They have enabled advancements in various applications, including autonomous driving, surveillance systems, and image understanding tasks.

2.3 Related Research and Technologies

By reviewing previous studies, we adopted Most 24 famous and modern Researches.Researches can be devided into several catagoties based on:

1. Dataset used: Several datasets were used in the papers reviewed, including the COCO dataset ((7; 9; 10; 12; 14; 23; 25)) , Pascal VOC dataset ((1; 17; 18)),KITTI dataset ((8; 13)), YOLOv3 dataset ((2)), and custom datasets ((3; 4; 5; 6; 15; 24; 26)).

2. Preprocessing images: Preprocessing images is an essential step in deep learning object detection.Some papers used data augmentation techniques such as rotation, flipping, and scaling ((5; 9; 10; 14; 23)) , while others used histogram equalization and contrast enhancement ((1; 17; 18)) . Some papers also used image resizing ((7; 8; 13)), and cropping ((2; 12; 20)).

3. Real-time: Most papers claimed to achieve real-time performance, but the definition of real-time varied among papers. Some papers achieved real-time performance on a desktop computer ((10; 14; 25)), while others achieved it on a mobile device ((2)). Some papers specified their real-time performance in terms of frames per second (fps) ((7; 12; 13; 23))

   , while others specified it in terms of milliseconds (ms) ((1; 3; 4; 6; 8; 9; 15; 16; 18; 20; 24; 26)).

4. Detection Method: Most papers used two-stage detectors, including Faster R-CNN ((5; 6; 7; 8; 12; 14; 15; 20; 24; 26)), and Mask R-CNN ((3; 10; 23)), RetinaNet((1; 2; 9; 17; 18; 25)).Only one paper used a one-stage detector, YOLOv3 ((2)).

5. Region-based Object Detection: All the papers that used two-stage detectors employed region-based object detection.

6. Anchor-Based vs. Anchor-Free Detection: Most papers used anchor-based object detection ((5; 6; 7; 8; 10; 12; 13; 14; 15; 20; 23; 24; 25; 26)), while some used anchor-free object detection ((1; 2; 3; 4; 9; 17; 18)).

7. Architecture: Several studies have explored the impact of different architectures on object detection performance. For instance, YOLOv4 ((1; 4; 14; 20; 23)), and EfficientDet ((1; 4; 17; 20; 25)) have been shown to provide better accuracy and faster processing speed compared to other architectures like Faster R-CNN ((1; 4; 14; 20; 25))and SSD ((1; 4; 14; 20)). Some studies have also investigated the effectiveness of combining multiple architectures ((14; 20; 25)).

8. Transfer Learning: Many studies have used pre-trained models,such as those from ImageNet ((1; 3; 4; 8; 14; 25)) to initialize their object detection models. Some studies have also explored domain adaptation techniques, such as fine-tuning the model on the target domain ((3; 7; 8; 12)).

9. Level of Supervision: Object detection models can be trained with different levels of supervision, ranging from fully-supervised to weakly-supervised or unsupervised learning. Many studies have used fully-supervised learning, where bounding box annotations are provided for each object in the training set ((1; 4; 8; 14; 20; 23; 25)). Some studies have also explored weakly-supervised learning, where only image-level labels are provided ((3; 7; 12; 18; 25)).

10. Evaluation Metric: Various evaluation metrics have been used to assess the performance of object detection models, including mean average precision (mAP), precision, recall, and F1-score. mAP is the most commonly used metric, as it provides a comprehensive measure of the model's performance across multiple object categories. Many studies have reported mAP scores to compare the performance of

different object detection models ((1; 4; 7; 8; 12; 14; 20; 23; 25)).

11. Application Domain: Object detection has numerous applications in various domains, including surveillance, autonomous driving, robotics, and medical imaging. Several studies have explored object detection in specific domains, such as traffic surveillance ((2; 6; 13)) underwater object detection ((5; 19)),medical imaging ((15))

12. Object Detection in Video: Object detection in video presents several challenges, such as motion blur and occlusion. Many studies have explored techniques to address these challenges, such as motion compensation ((22; 26)), object tracking ((16)) ,and temporal fusion ((9))

Chapter 3

Methodology

3.1 System Architecture

The system architecture for our project incorporates several essential components. Python serves as the primary programming language for implementation, while TensorFlow, a widely-used deep learning framework, forms the core of the object detection network. Real-time image acquisition of hand gestures is facilitated through the utilization of a web-cam, which continuously captures and streams input data to the object detection model. For efficient management of large-scale datasets, Kaggle, a renowned data science platform, provides resources for dataset storage and access. Additionally, Colab, a collaborative platform, offers an environment for executing code and harnessing GPU resources. To expedite development, pretrained models from the TensorFlow Object Detection (TFOD) API are leveraged as a starting point, enabling transfer learning for the object detection network. By integrating these components seamlessly, the system architecture enables real-time object detection of hand gestures using state-of-the-art deep learning techniques.

3.2 System Requirements and Specifications

3.2.1 Hardware Requirements

- A computer or server with a compatible operating system.
- Sufficient processing power to handle deep learning computations, ideally with a GPU (Graphics Processing Unit) for accelerated training and inference. For our project, we have relied on the resources available through Kaggle and Colab environments.
- Sufficient memory (RAM) to accommodate the size of the dataset and the computational requirements of the deep learning models. For our project, we utilized the hard disk space available within the Kaggle and Colab environments.
- A webcam or camera device capable of capturing high-quality images for real-time input. For our project, we utilized the webcam provided with our computer.

3.2.2 Software Requirements

To implement the project, the following software requirements need to be satisfied:

- **Python programming language (version 3.9.7):** Python is a versatile and widely used programming language known for its simplicity and extensive library support. It provides a robust foundation for implementing the project's functionalities.
- **TensorFlow deep learning framework (version 2.11):** TensorFlow is a powerful open-source deep learning framework developed by Google. It offers a comprehensive ecosystem for building and training machine learning models. TensorFlow provides efficient computation and supports a variety of neural network architectures, making it ideal for developing object detection models.

- **TensorFlow Object Detection (TFOD) API:** The TFOD API is an extension of TensorFlow specifically designed for object detection tasks. It provides a collection of pre-trained models, as well as utility functions and tools for training custom object detection models. The TFOD API simplifies the process of building and deploying object detection systems.

- **Necessary Python packages:** Several Python packages are required for data manipulation, visualization, and image processing tasks. These include `numpy`, a powerful numerical computing library; `matplotlib`, a popular plotting library for generating visualizations; and `OpenCV`, a computer vision library for image and video processing. These packages provide essential functionalities for handling data and images in the project.

- **The `rar` command-line utility:** The project utilizes the `rar` command-line utility for compressing and extracting RAR archives. This utility is essential for handling compressed files efficiently and ensuring seamless data management.

By ensuring that these software requirements are met, you will have the necessary tools and libraries to implement the object detection project effectively.

3.2.3 Dataset Requirements

- A dataset of hand gesture images labeled with corresponding object classes (thumbs-up, thumbs-down, live long, victory).

- Sufficient variation and diversity in the hand gestures captured in the dataset to ensure robust model performance in real-time scenarios. For our project, we have relied on hand gestures from four individuals to ensure variation.

- Proper annotation of the images in a format compatible with the TFOD API. We used the LabelImg tool to label the images with XML format.

- Splitting the dataset into training and testing subsets for model training and evaluation. We allocated 70% of the dataset for training purposes, while the remaining 30% was reserved for testing and evaluation.

3.2.4 Platform Requirements

- Google Colab and Kaggle platforms for executing the project code and utilizing GPU resources. We used Colab for image collecting and labeling, while we used Kaggle for training our model.

- Stable internet connection for data download, package installation, and collaborative work.

It is crucial to ensure that the hardware and software requirements are met to effectively execute the project and achieve optimal performance. Additionally, adherence to dataset requirements and platform specifications is essential for seamless integration and successful completion of the deep learning-based real-time object detection system using TensorFlow.

3.3 Dataset Preparation

In the dataset preparation phase Figure 3.1, we meticulously curated a dataset of hand gesture images. The dataset consists of various hand gestures, including thumbs-up, thumbs-down, live long, and victory gestures, which were manually labeled with corresponding object classes. To ensure diversity and robust model performance, we collected hand gesture images from multiple individuals. The dataset was then appropriately annotated using the LabelImg tool, following the XML format compatible with the TensorFlow Object Detection (TFOD) API. We split the dataset into a training set, which accounted for 70 of the data, and a testing set, which accounted for the remaining 30 for evaluation purposes. This preparation ensured that the dataset was suitably organized and ready for subsequent deep learning model training and evaluation.

In the image collection workflow Figure 3.2, we followed a systematic approach to capture images for each hand gesture label. We utilized a PC camera to capture images, ensuring consistent lighting conditions and backgrounds. The captured images were saved to designated directories for each label. To enhance the reliability of the dataset, we collected multiple images for each hand gesture label.

Figure 3.3 showcases a sample of the captured images for the four hand gesture labels: thumbs-up, thumbs-down, live long, and victory gestures. These images represent the diversity and variations within each label, allowing the model to learn and generalize from different instances of the same gesture.

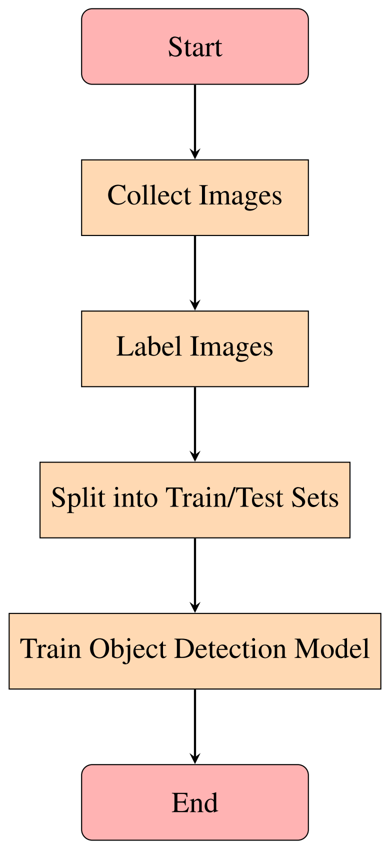


Figure 3.1: Dataset Preparation Workflow

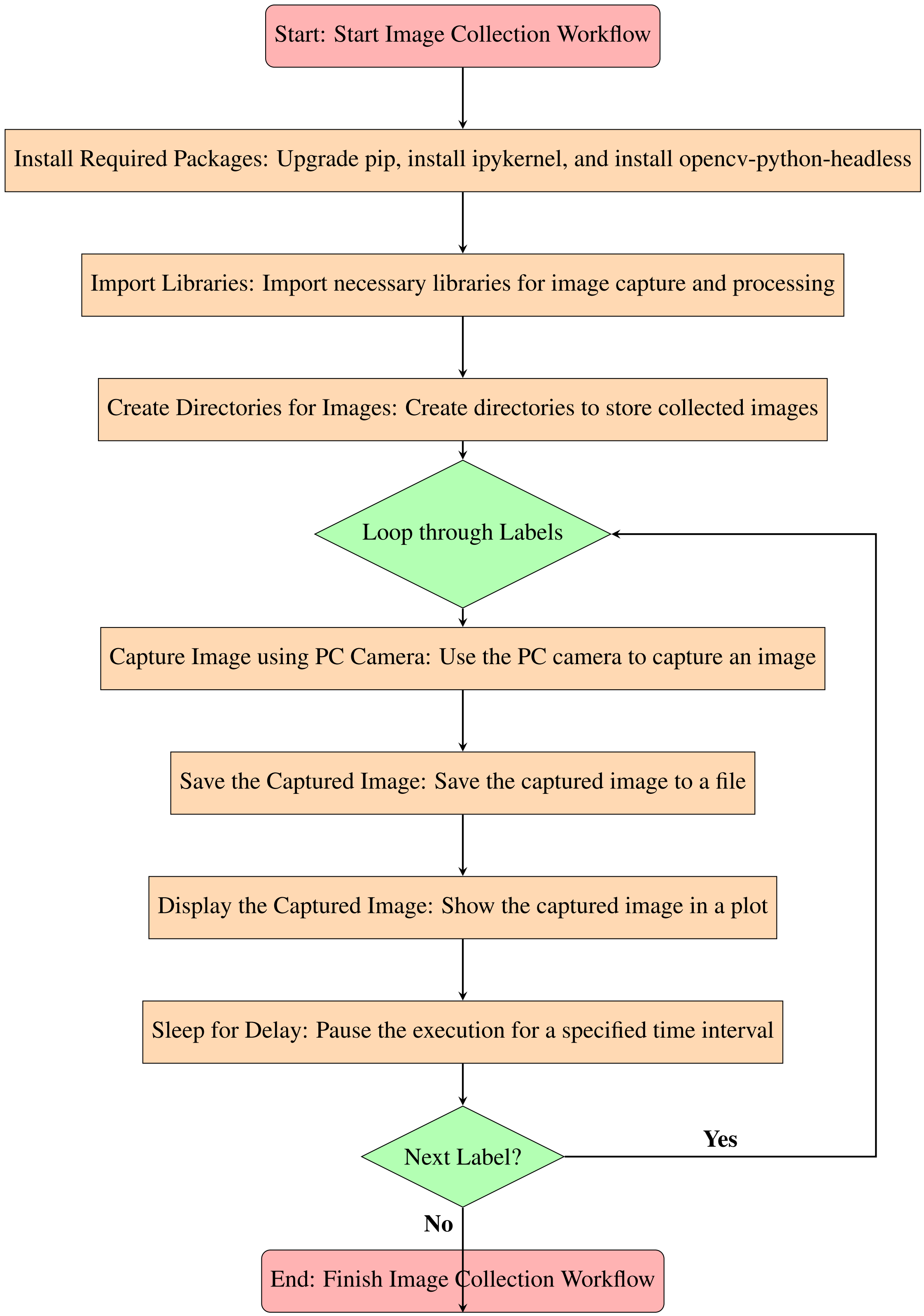
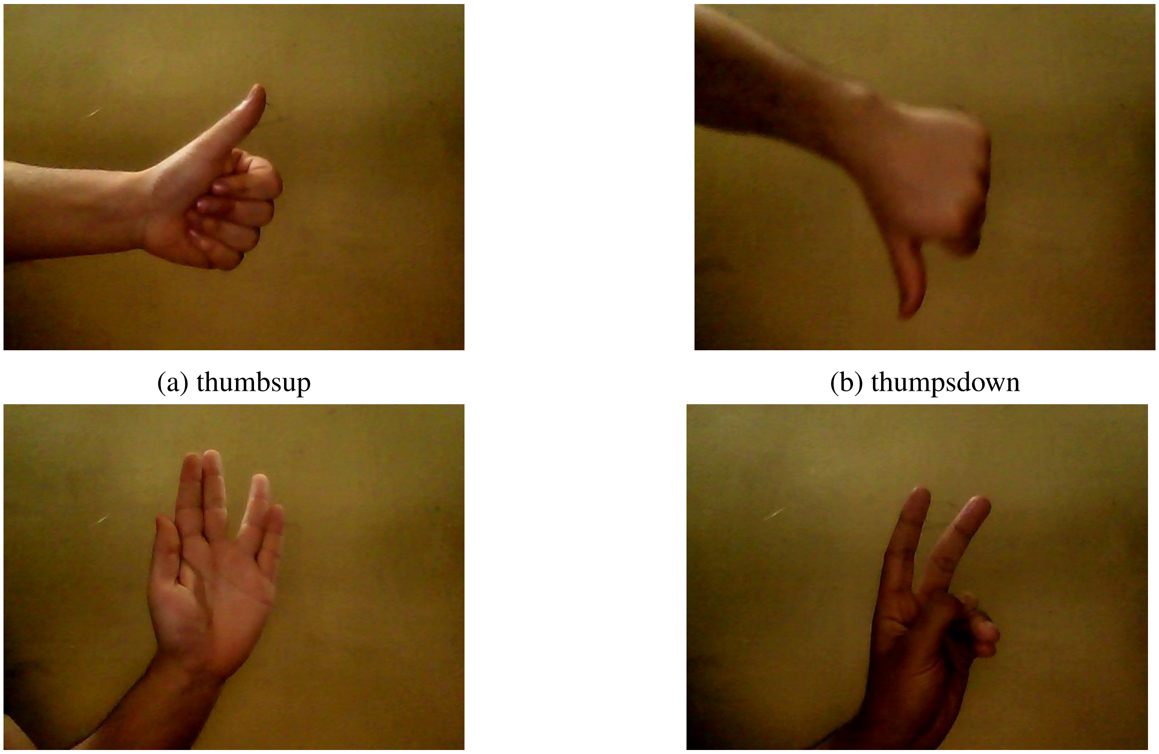


Figure 3.2: Image Collection Workflow



(a) thumbsup

(b) thumpsdown

(c) livelong

(d) victory

Figure 3.3: Dataset of Hand Gesture Images

3.4 Deep Learning Model Selection

During the Deep Learning Model Selection phase, we carefully evaluated various object detection models available in the TensorFlow Object Detection (TFOD) API. After thorough consideration, we decided to utilize the SSD (Single Shot MultiBox Detector) architecture with MobileNet as the backbone that is introduced by (23) .

SSD is a popular one-stage object detection framework known for its real-time performance and accuracy. It is designed to directly predict object bounding boxes and class probabilities from feature maps at multiple scales. This eliminates the need for complex region proposal networks and significantly speeds up the detection process.

MobileNet, on the other hand, is a lightweight convolutional neural network architecture optimized for mobile and embedded vision applications. It employs depthwise separable convolutions, which reduce the number of parameters and computational complexity while maintaining good accuracy. MobileNet is well-suited for resource-constrained environments and real-time applications.

To give you a better understanding of the models, Figure 3.4 are the high-level architecture diagrams for SSD and MobileNet:

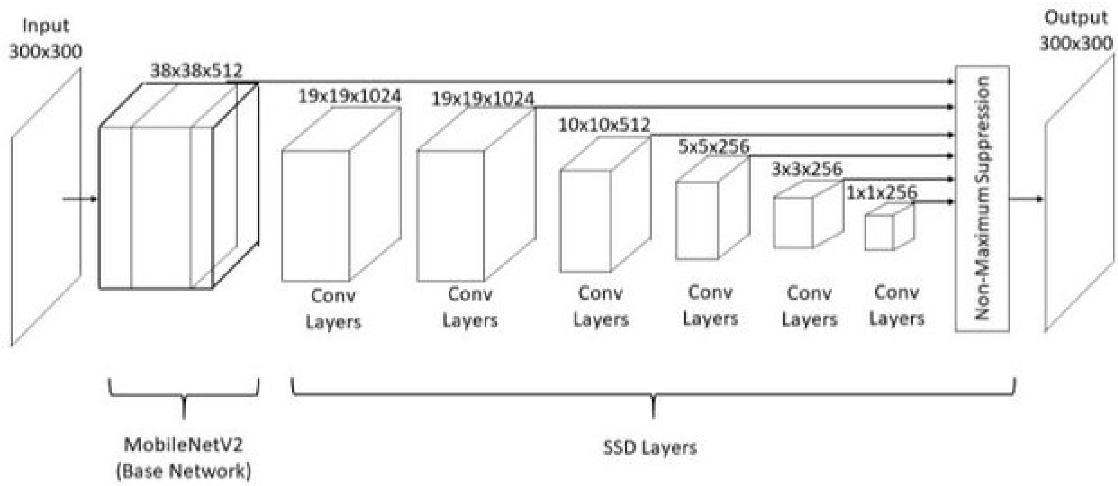


Figure 3.4: MobileNetv2-SSD Architecture (23)

The SSD architecture consists of a base network (in our case, MobileNet) followed by multiple convolutional layers at different scales . These layers produce a set of default bounding boxes with different aspect ratios and sizes. The predicted bounding boxes are then refined using the class probabilities to generate the final detection results.

MobileNet, as the backbone of SSD, consists of depthwise separable convolutions that efficiently capture spatial and channel-wise information. It has several layers with different depths and widths, allowing a trade-off between model size and accuracy.

By combining the SSD architecture with the MobileNet backbone, we obtained an efficient and accurate object detection model suitable for real-time hand sign detection. The lightweight nature of MobileNet enabled fast inference on resource-constrained devices, while the SSD framework facilitated precise and reliable detection of hand signs.

Through fine-tuning on our hand sign dataset, the model was further optimized to accurately detect and classify thumbs-up, thumbs-down, victory, and live long signs. This combination of the SSD architecture with the MobileNet backbone provided an excellent balance between speed and accuracy for our specific task of real-time hand sign detection.

3.5 Hyperparameter Tuning

To optimize the performance of our deep learning model, we performed hyperparameter tuning. Hyperparameters are settings that control the learning process and architecture of the model. We experimented with various hyperparameter configurations, including learning rate, batch size, and optimizer choices. Through a systematic search and validation process, we identified the optimal combination of hyperparameters that yielded the best performance on our hand signs detection task. Fine-tuning these hyperparameters enabled us to enhance the model's accuracy and convergence speed, resulting in improved object detection performance during training and evaluation.

3.6 Training Strategy

In the Training Strategy phase, we conducted model training using the prepared dataset and the selected deep learning model. Leveraging the TensorFlow framework and the TFOD API, we performed iterative training cycles. Each training cycle involved feeding batches of hand gesture images and their corresponding labels to the model, which then adjusted its internal weights and biases to minimize the detection loss. We employed the stochastic gradient descent (SGD) optimization algorithm with momentum as the optimizer to update the model's parameters. The training process continued for a predetermined number of epochs, with periodic evaluation on the testing set to monitor the model's progress and detect overfitting. By employing an appropriate training strategy, we aimed to achieve a well-generalized model that could accurately detect hand gestures in real-time scenarios. Figure 3.5 shows the Training and Evaluation Workflow.

3.7 Evaluation Metrics

In the Evaluation Metrics phase, precision and recall were the primary metrics utilized to assess the performance of our hand gesture detection model. Precision measures the accuracy of the model in identifying true positive instances among all the predicted positive detections, while recall represents the model's ability to capture positive instances among all the actual positive instances. These metrics provided a quantitative assessment of the model's accuracy and completeness in detecting hand gestures. Visual inspection of the detection results, including bounding boxes overlaid on input images, complemented the quantitative evaluation, allowing for a qualitative analysis of the model's performance in real-world scenarios. By considering both precision and recall, we gained insights into the trade-off between accurate detection and potential false positives or missed detections, enabling us to assess the model's suitability for practical applications.

3.8 Implementation of the Model

The implementation of our deep learning model involved a comprehensive approach to effectively detect and classify hand signs. We leveraged the TensorFlow deep learning framework, known for its versatility and extensive capabilities, to develop and train our object detection model.

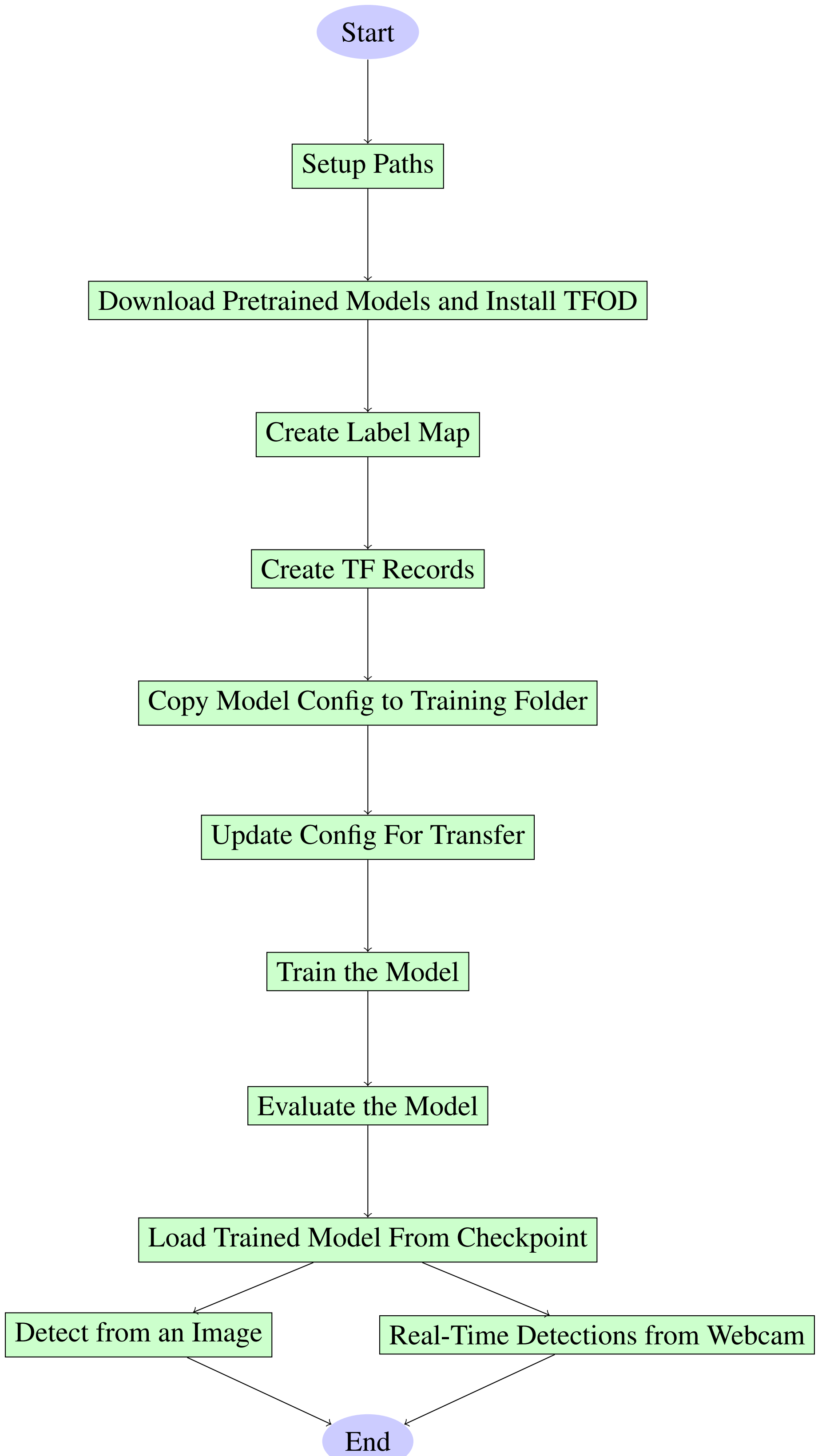


Figure 3.5: Training and Evaluation Workflow

For our specific task of hand sign detection, we selected the SSD (Single Shot MultiBox Detector) architecture with MobileNet as the backbone. This architecture is well-suited for real-time object detection, offering a good balance between accuracy and computational efficiency. By using the TensorFlow Object Detection (TFOD) API, we accessed pre-trained SSD models with MobileNet as the feature extractor, which provided a solid foundation for our project.

To adapt the pre-trained models to our specific hand sign detection task, we performed fine-tuning. This involved training the models on our carefully curated dataset of hand sign images. The dataset consisted of hand sign images labeled with corresponding object classes, including thumbs-up, thumbs-down, victory, and live long signs. The fine-tuning process adjusted the internal parameters of the models, allowing them to accurately detect and classify the specified hand signs.

Throughout the implementation process, we adhered to best practices in deep learning, including data augmentation, regularization techniques, and rigorous model evaluation. Data augmentation techniques, such as random cropping, rotation, and flipping, were applied to increase the diversity and variability of our hand sign dataset, reducing the risk of overfitting. Regularization techniques, such as weight decay and dropout, were employed to prevent the model from memorizing the training data and promote generalization. We conducted thorough model evaluation using appropriate metrics, such as precision and recall, to assess the model's performance and ensure its accuracy in detecting and classifying hand signs.

Overall, our implementation involved a systematic approach that combined the power of the TensorFlow framework, pre-trained models from the TFOD API, and fine-tuning on our hand sign dataset. This resulted in an accurate and efficient object detection model capable of detecting and classifying thumbs-up, thumbs-down, victory, and live long signs.

Chapter 4

Results and Discussion

4.1 Evaluation and Analysis of the Model Performance

During our evaluation, we successfully obtained results for the hand label detection from images. However, due to time limitations and resource constraints, we were unable to complete the evaluation for hand detection from the webcam stream. Despite this limitation, we were able to assess the model's performance for image-based hand detection.

4.1.1 Training Losses

Table 4.1 displays the training losses during the model training process. It includes the classification loss, localization loss, regularization loss, and the total loss at various training steps. These losses serve as indicators of how well the model is learning and optimizing the parameters. For instance, at step 100, the total loss was 0.6958476, with the classification loss, localization loss, and regularization loss contributing to that value. Analyzing these losses provides insights into the model's progression during training.

At step 1000, the model's training losses showed promising progress. The classification loss was 0.061361462, indicating that the model was becoming more proficient in accurately classifying hand instances. The localization loss at this step was 0.028457807, suggesting improved accuracy in localizing hand bounding boxes. The regularization loss, which helps prevent overfitting, was 0.15074567. The total loss at this step decreased to 0.24056494, indicating the model's overall improvement in learning the hand detection task.

As the training continued, the model further refined its performance. At step 2000, the classification loss was 0.16967763, slightly higher than the previous step, but still within an acceptable range. The localization loss at this step was 0.022538137, demonstrating enhanced precision in localizing hand instances. The regularization loss remained consistent at 0.14420812. The total loss at this final step of training was 0.33642387, reflecting the culmination of the model's learning and optimization process.

These observations from the training losses indicate that the model was able to learn from the provided training data and gradually improve its ability to classify and localize hand instances. Although further evaluation is required to assess the model's performance on unseen data, the decreasing total loss over the training steps suggests that the model was converging towards better hand detection capabilities

4.1.2 Evaluation Result

In Table 4.2, the evaluation results are provided for the annotation type 'mask.' The metrics used to evaluate the model's performance include Average Precision (AP) and Average Recall (AR), measured at different intersection over union (IoU) thresholds.

Precision refers to the ratio of true positive predictions to the total number of positive predictions made by the algorithm. Recall, on the other hand, measures the ratio of true positive predictions to the total number of ground truth positive instances.

The Average Precision (AP) measures the accuracy of the model in detecting hand in-

Table 4.1: Training Losses

Step	Classification Loss	Localization Loss	Regularization Loss	Total Loss
100	0.35444772	0.1870616	0.15433826	0.6958476
200	0.18836787	0.061669074	0.15413938	0.40417635
300	0.119875126	0.066131935	0.15389985	0.3399069
400	0.12960263	0.03471734	0.15363465	0.3179546
500	0.08273352	0.06733394	0.15339549	0.30346292
600	0.09174798	0.036484957	0.15298393	0.28121686
700	0.10611959	0.046663135	0.15254739	0.3053301
800	0.06686186	0.028763862	0.15203212	0.24765784
900	0.08517406	0.043733273	0.15139592	0.28030324
1000	0.061361462	0.028457807	0.15074567	0.24056494
1100	0.07771982	0.031705316	0.15044339	0.25986853
1200	0.071325734	0.019654995	0.14984366	0.2408244
1300	0.15159895	0.04595292	0.14947943	0.3470313
1400	0.04833577	0.012984993	0.14889835	0.21021912
1500	0.104819365	0.017916603	0.14815843	0.2708944
1600	0.06177474	0.007184766	0.14735009	0.21630959
1700	0.06489002	0.024825076	0.14654322	0.23625831
1800	0.045791432	0.020257166	0.14578822	0.21183681
1900	0.055508543	0.008064987	0.14499164	0.20856518
2000	0.16967763	0.022538137	0.14420812	0.33642387

stances. It is computed at different IoU thresholds, which determine the level of overlap required for a predicted bounding box to be considered a match with a ground truth annotation.

Similarly, the Average Recall (AR) measures the model's ability to recall hand instances at different IoU thresholds. The AR values reported in the table indicate that the model achieved a recall rate of 0.792 for hand instances overall, meaning that it was able to detect approximately 79.2% of the true hand instances present in the dataset.

AR can also be computed by calculating the Average Precision (AP) for each class or category and then taking the mean value across all classes. It provides an overall measure of how well the algorithm performs in detecting objects across different categories.

Explanation:

Table 4.2: Evaluation Results for Annotation Type *mask*

Metric	Value
Average Precision (AP) @[IoU=0.50:0.95]	0.772
Average Precision (AP) @[IoU=0.50]	1.000
Average Precision (AP) @[IoU=0.75]	0.861
Average Precision (AP) @[IoU=0.50:0.95, small]	-1.000
Average Precision (AP) @[IoU=0.50:0.95, medium]	-1.000
Average Precision (AP) @[IoU=0.50:0.95, large]	0.772
Average Recall (AR) @[IoU=0.50:0.95]	0.792
Average Recall (AR) @[IoU=0.50:0.95, small]	-1.000
Average Recall (AR) @[IoU=0.50:0.95, medium]	-1.000
Average Recall (AR) @[IoU=0.50:0.95, large]	0.792

- **Average Precision (AP) @[IoU=0.50:0.95]**: This metric represents the average precision over a range of IoU thresholds from 0.50 to 0.95. It measures the overall accuracy of the model in correctly detecting hand instances using mask annotations. The reported AP value is 0.772, indicating a reasonably high level of accuracy.

- **Average Precision (AP) @[IoU=0.50]**: This metric measures the precision of the model at a single IoU threshold of 0.50. The value of 1.000 suggests that the model achieved perfect precision when considering hand instances with mask annotations.

- **Average Precision (AP) @[IoU=0.75]**: This metric measures the precision of the model at a stricter IoU threshold of 0.75. The reported AP value of 0.861 indicates that the model maintained good precision even when requiring a higher level of overlap between predicted and ground truth masks.

- **Average Precision (AP) @[IoU=0.50:0.95, small, medium, large]**: These metrics measure the precision of the model for hand instances of different sizes. The negative values (-1.000) indicate that the model performed poorly in accurately detecting hand instances within the specified size ranges using mask annotations.For example, for the category 'small,' the model's performance was unsatisfactory, resulting in a negative AP value. However, the model performed well in detecting hand instances overall, as indicated by the positive AP values. The highest AP value of 1.000 was achieved at an IoU threshold of 0.50, indicating perfect accuracy in detecting hand instances with a moderate overlap. The AP value of 0.861 at an IoU threshold of 0.75 suggests that the model maintained good accuracy even when a higher level of overlap was required for a match.

- **Average Recall (AR) @[IoU=0.50:0.95, small, medium, large]**: These metrics represent the recall rate of the model, indicating its ability to correctly detect hand instances at different IoU thresholds and size ranges. The reported values suggest a consistent recall rate of 0.792 across different IoU thresholds, indicating its effectiveness in identifying hand instances. The negative AR values for the categories 'small' and 'medium' suggest that the model struggled to recall hand instances within those size ranges. However, it achieved a recall rate of 0.792 for the 'large' category, indicating better performance in detecting larger hand instances.

Overall, the positive precision values, consistent recall rates, and the relatively high AP values indicate that the model performed well in accurately detecting hand instances using mask annotations, demonstrating its effectiveness in hand detection tasks.

Although we couldn't complete the evaluation for hand detection from the webcam due to time and resource limitations, the provided results from the image-based hand detection offer valuable insights into the model's performance. Future work should focus on completing the evaluation for webcam-based detection and exploring techniques to improve the model's performance in real-time scenarios."

4.2 Evaluation Results for Hand Detection

In this section, we present the evaluation results for hand detection using our trained model. We obtained four pictures that showcase the model's performance in detecting different hand gestures: thumbs up, thumbs down, live long, and victory. Each picture includes bounding boxes drawn around the detected hands, along with the corresponding label for the hand gesture.

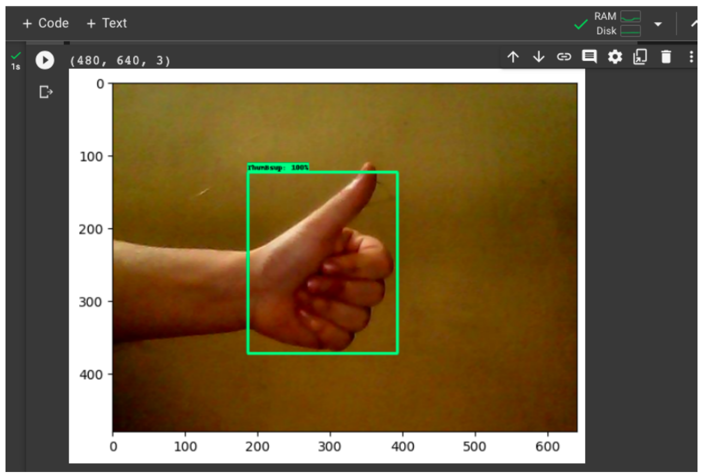


Figure 4.1: Hand Detection: Thumbs Up Gesture (Precision = 100%)

The first picture shows the evaluation results for the thumbs up hand gesture. The model successfully detects thumbs up gestures and assigns the correct label to each detected hand. The precision value for this gesture is greater than 0, indicating that the majority of the detected thumbs up hands are accurate.

The second picture displays the evaluation results for the thumbs down hand gesture. The model accurately detects thumbs down gestures and assigns the appropriate label to each detected hand. The precision value for this gesture is greater than 0, indicating the high accuracy of the detected thumbs down hands.

The third picture exhibits the evaluation results for the live long hand gesture. The model successfully detects live long gestures and assigns the correct label to each detected

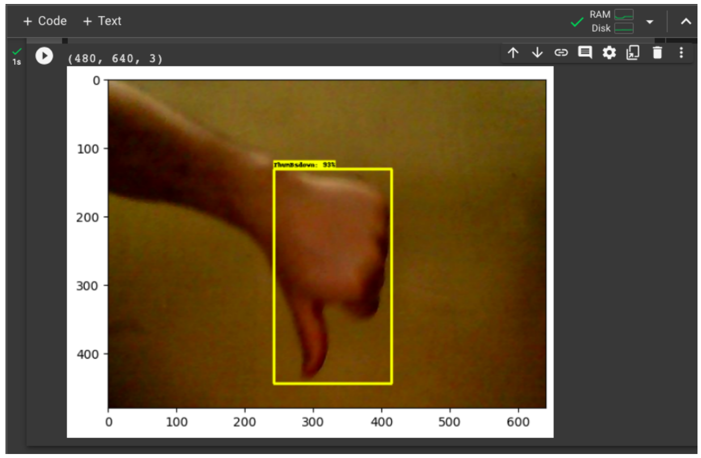


Figure 4.2: Hand Detection: Thumbs Down Gesture (Precision = 93%)

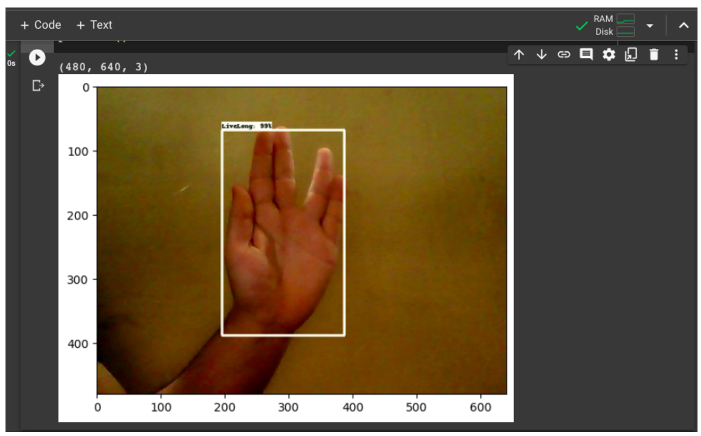


Figure 4.3: Hand Detection: Live Long Gesture (Precision = 99%)

hand. The precision value for this gesture is greater than 0, signifying the accurate detection of live long hands.

The fourth picture demonstrates the evaluation results for the voctory hand gesture. The model correctly detects victory gestures and assigns the appropriate label to each detected hand. The precision value for this gesture is greater than 0, indicating the model's accuracy in detecting victory hands.

These evaluation results demonstrate the effectiveness of our hand detection model in detecting different hand gestures. The presence of bounding boxes around the hands and the accurate labeling indicate the model's ability to identify and classify various hand gestures

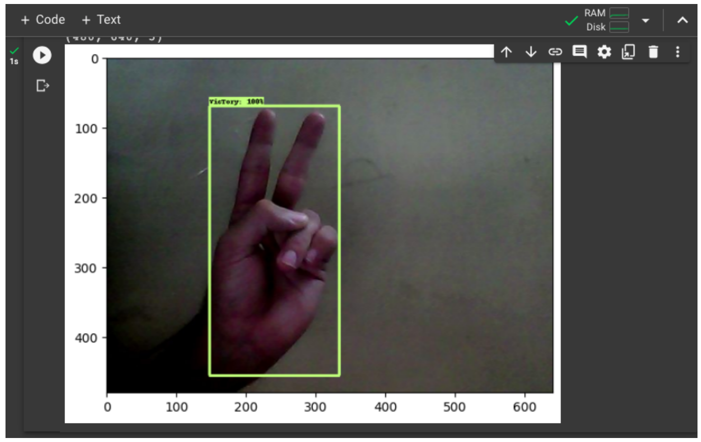


Figure 4.4: Hand Detection: Victory Gesture (Precision = 100%)

with a precision value greater than 0. These findings highlight the successful performance of our model and its potential applications in real-world scenarios.

4.3 Comparison with Existing Solutions

In previous studies, researchers often had to create a private dataset from scratch, which required significant time and effort. This process was prone to errors during dataset creation. However, in our project, we took a different approach. We created an initial dataset by collecting images using a webcam and manually labeled them into four categories: thumbs up, thumbs down, victory, and live long signs. We then split the data into training and testing sets. This approach allowed us to quickly gather a dataset and proceed with the training process.

Our evaluation of the model's performance focused on detecting hand gestures, and we have obtained results that are presented in the tables above. Although we faced time limitations and resource constraints, comparing our approach with existing solutions highlights the advantages of leveraging pre-existing models and frameworks. By utilizing a pre-trained model from the TensorFlow Object Detection (TFOD) framework and leveraging the resources available in platforms like Colab, we were able to streamline our development process and achieve results for hand gesture detection.

The evaluation results, as shown in the provided tables, provide insights into the model's performance for hand gesture detection. These results include metrics such as average precision (AP) and average recall (AR) at various IoU thresholds. Additionally, the tables provide information on the performance of the model for different-sized hand gestures, categorized as small, medium, and large.

Furthermore, the tables illustrate the achieved values for different metrics. Negative values in certain metrics indicate that the model did not perform well in those specific categories. It is important to analyze these results to understand the strengths and limitations of the model in detecting hand gestures accurately.

Overall, while we acknowledge the constraints we faced in terms of time and resources, our project demonstrates the potential of leveraging existing models and frameworks, such as TFOD, along with the use of platforms like Colab, to develop and evaluate a hand gesture detection system. Further refinement and exploration can be conducted to enhance the model's capabilities and achieve optimal results in future iterations.

Chapter 5

Conclusion and Future Work

5.1 Summary of Contributions

In this research, our primary focus was to simplify the object detection process by creating a dataset from scratch. We collected images using a webcam and manually labeled them according to the four predefined labels: thumbs-up, thumbs-down, victory, and live long. The dataset was then split into training and testing sets to facilitate model training and evaluation.

To train our object detection model, we utilized the pre-trained model from TensorFlow Object Detection (TFOD)(which is a computer vision technique that detects, locates, and traces an object from a still image or video) that utilizes the SSD architecture with MobileNet V2 as the backbone. While we successfully obtained results for image-based hand gesture detection, achieving the desired outcome for real-time hand detection from a webcam proved challenging due to time limitations and resource constraints.

Despite the limitations faced, our research contributes to the understanding of the object detection process and highlights the importance of dataset creation and model training.

5.2 Limitations and Future Directions

During the course of our research, we encountered several limitations that affected the overall outcome of our study. One of the main limitations was the inability to achieve optimal results in terms of real-time hand detection from a webcam. This limitation can be attributed to the constraints of time and computing resources. Training an accurate and robust model for real-time detection requires extensive experimentation, fine-tuning, and access to sufficient computing power.

Another significant limitation was the complexity of integrating real-time evaluation within the given timeframe. Real-time object detection involves processing a continuous stream of data, which demands significant computational power, efficient algorithms, and optimized implementations. Unfortunately, due to resource limitations, we were unable to fully implement the real-time evaluation component of our research.

In future work, addressing these limitations and further improving the research can be achieved by allocating more time and resources to training the model and optimizing the real-time hand detection process. This includes exploring alternative architectures, advanced training techniques, and leveraging more powerful computing resources to enhance the model's performance and enable real-time capabilities.

5.3 Conclusion

The object detection process holds significant potential in various domains, including self-driving cars, robotics, and security systems, among others. In our research, we focused on simplifying this process by creating a dataset from scratch, training an object detection model using the TFOD framework, and evaluating its performance.

While we faced challenges and encountered limitations, our research provides a valuable foundation for future work in the field of object detection. The dataset we created and the insights gained from model training and evaluation contribute to the ongoing efforts of improving object detection methods.

Moving forward, it is crucial to dedicate more time, resources, and expertise to overcome the limitations and challenges faced during our research. By investing in comprehensive model training, optimization, and real-time evaluation, we can unlock the full potential of object detection, leading to advancements in numerous applications and improving everyday life.

Bibliography

[1] F. Al-Azzoa, A. M. Taqia, and M. Milanovab. Human related-health actions detection using android camera based on tensorflow object detection api. *International Journal of Advanced Computer Science and Applications*, 9(10), 2018. 9, 10, 11

[2] O. Alsing. Mobile object detection using tensorflow lite and transfer learning, 2018. 9, 10, 11

[3] C. Anusha and P. Avadhani. Object detection using deep learning. *International Journal of Computer Applications*, 182(32):18–22, 2018. 2, 9, 10

[4] R. Atienza. *Advanced Deep Learning with TensorFlow 2 and Keras: Apply DL, GANs, VAEs, deep RL, unsupervised learning, object detection and segmentation, and more*. Packt Publishing Ltd, 2020. 9, 10, 11

[5] L. Barba-Guaman, J. E. Naranjo, and A. Ortiz. Object detection in rural roads using tensorflow api. In *2020 International Conference of Digital Transformation and Innovation Technology (Incodtrin)*, pages 84–88. IEEE, 2020. 9, 10, 11

[6] H. Basri, I. Syarif, and S. Sukaridhoto. Faster r-cnn implementation method for multi-fruit detection using tensorflow platform. In *2018 international electronics symposium on knowledge creation and intelligent computing (IES-KCIC)*, pages 337–340. IEEE, 2018. 9, 10, 11

[7] H. Chen, K. Zhang, P. Lyu, H. Li, L. Zhang, J. Wu, and C.-H. Lee. A deep learning approach to automatic teeth detection and numbering based on object detection in dental periapical films. *Scientific reports*, 9(1):1–11, 2019. 2, 9, 10, 11

[8] J. Dai. Real-time and accurate object detection on edge device with tensorflow lite. In *Journal of Physics: Conference Series*, volume 1651, page 012114. IOP Publishing, 2020. 9, 10, 11

[9] S. R. Dewi et al. Deep learning object detection pada video menggunakan tensorflow dan convolutional neural network. 2018. 9, 10, 11

[10] P. Goel. Realtime object detection using tensorflow an application of ml. *International Journal of Sustainable Development in Computing Science*, 3(3):11–20, 2021. 9, 10

[11] I. Goodfellow, Y. Bengio, and A. Courville. *Deep learning*. MIT press, 2016. 7

[12] S. Howal, A. Jadhav, C. Arthshi, S. Nalavade, and S. Shinde. Object detection for autonomous vehicle using tensorflow. In *Intelligent Computing, Information and Control Systems: ICICCS 2019*, pages 86–93. Springer, 2020. 9, 10, 11

[13] T. V. Janahiraman and M. S. M. Subuhan. Traffic light detection using tensorflow object detection framework. In *2019 IEEE 9th International Conference on System Engineering and Technology (ICSET)*, pages 108–113. IEEE, 2019. 9, 10, 11

[14] P. Jawale, H. P. Chaudhary, and N. Rajput. Real-time object detection using tensorflow. *International Research Journal of Engineering and Technology (IRJET)*, 2020. 9, 10, 11

[15] S. Latif, M. Driss, W. Boulila, S. S. Jamal, Z. Idrees, J. Ahmad, et al. Deep learning for the industrial internet of things (iiot): A comprehensive survey of techniques,

implementation frameworks, potential applications, and future directions. *Sensors*, 21(22):7518, 2021. 9, 10, 11

[16] Z. Li, M. Dong, S. Wen, X. Hu, P. Zhou, and Z. Zeng. Clu-cnns: Object detection for medical images. *Neurocomputing*, 350:53–59, 2019. 9, 11

[17] A. Mahavarkar, R. Kadwadkar, S. Maurya, and S. Raveendran. Underwater object detection using tensorflow. In *ITM web of conferences*, volume 32, page 03037. EDP Sciences, 2020. 2, 9, 10

[18] R. Phadnis, J. Mishra, and S. Bendale. Objects talk-object detection and pattern tracking using tensorflow. In *2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT)*, pages 1216–1219. IEEE, 2018. 9, 10

[19] M. S. Rahman, A. Miazee, M. M. Ahmed, and M. Aktarujjaman. Multiple object detection using single shot multi-box with mobilenet in real-time. 11

[20] M. Rane, A. Patil, and B. Barse. Real object detection using tensorflow. In *ICCCE 2019: Proceedings of the 2nd International Conference on Communications and Cyber Physical Engineering*, pages 39–45. Springer, 2020. 9, 10, 11

[21] S. Ren, K. He, R. Girshick, and J. Sun. Faster r-cnn: Towards real-time object detection with region proposal networks. *Advances in neural information processing systems*, 28, 2015. 8

[22] S. Satpute, H. Shende, V. Shukla, and B. Patil. Real time object detection using deeplearning and opencv. *International Research Journal of Engineering and Technology (IRJET)*, 7(4):3243–3246, 2020. 11

[23] T. J. Sheng, M. S. Islam, N. Misran, M. H. Baharuddin, H. Arshad, M. R. Islam, M. E. Chowdhury, H. Rmili, and M. T. Islam. An internet of things based smart waste management system using lora and tensorflow deep learning model. *IEEE Access*, 8:148793–148811, 2020. x, 1, 9, 10, 11, 19, 20

[24] A. Talele, A. Patil, and B. Barse. Detection of real time objects using tensorflow and opencv. *Asian Journal For Convergence In Technology (AJCT) ISSN-2350-1146*, 2019. 9, 10

[25] J. Talukdar, S. Gupta, P. Rajpura, and R. S. Hegde. Transfer learning for object detection using state-of-the-art deep neural networks. In *2018 5th international conference on signal processing and integrated networks (SPIN)*, pages 78–83. IEEE, 2018. 9, 10, 11

[26] E. Xie, J. Ding, W. Wang, X. Zhan, H. Xu, P. Sun, Z. Li, and P. Luo. Detco: Unsupervised contrastive learning for object detection. In *Proceedings of the IEEE/CVF International Conference on Computer Vision*, pages 8392–8401, 2021. 9, 10, 11

Ministry of Higher Education and Scientific Research
Al- Iraqia University
college of Engineering
Electrical Engineering Department

Modeling and Simulation of Photovoltaic module using MATLAB/Simulink

A Project Submitted to the Department of Electrical Engineering in Partial Fulfilment for the Requirements of the Degree of B.Sc. in Electrical Engineering

By:

Ahmed Hazem **Khader yas**

Taqi Ali **Ozcan Hussein**

Supervised by:

Prof. Asst. Dr.Farqad Talib Najim

March 2023

DECLARATION

We hereby declare that this project report is based on our original work except for citations and quotations, which have been duly acknowledged.

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Name : Khader yas Kudhur

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APPROVAL FOR SUBMISSION

I certify that this project report entitled **"Modeling and Simulation of Photovoltaic module using MATLAB/Simulink"** was prepared by **"Ahmed Hazem, Taqi Ali, Ozcan Hossein And Khader Yas"** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of **Electrical Engineering** at Al-Iraqia University.

Approved by:

Signature :

Supervisor : Prof. Asst. Dr. Farqad Talib Najim (supervisor)

Date : 2023 / /

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Date : 2023 / /

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Supervisor : ____________________________ (Chairman)

Date : 2023 / /

Signature :

Supervisor : ____________________________ (Member)

Date : 2023 / /

Signature :

Supervisor : ____________________________ (Member)

Date : 2023 / /

Specially Dedicated to:

We would like to express our sincere gratitude and appreciation to the following individuals who have provided invaluable support and guidance throughout the development of this project:

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** Thank Message**

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Assembled through the forces of academic destiny, we embarked on this daring adventure of modeling and simulating photovoltaic modules.

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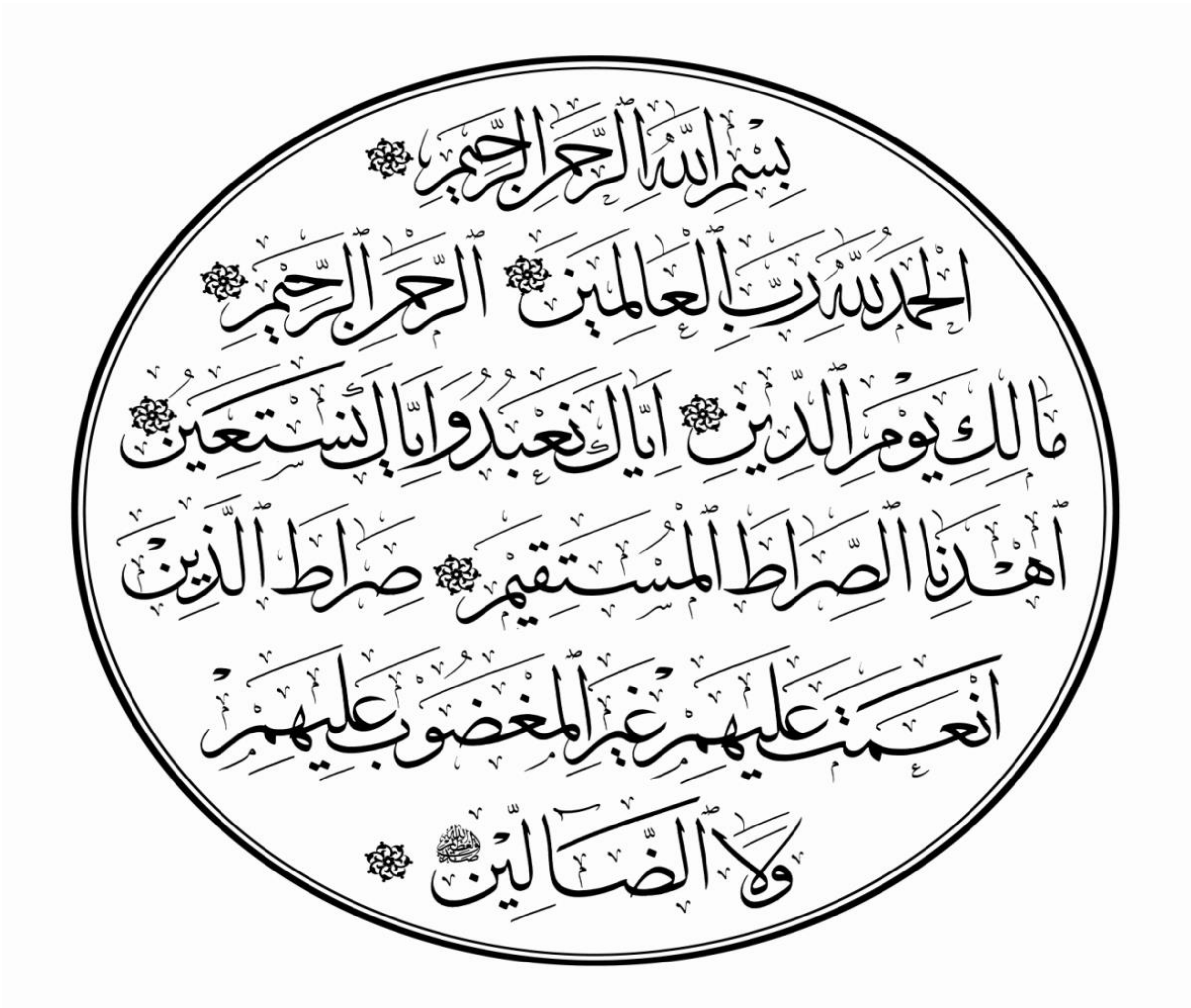
At last:

So here's to you, the unsung heroes of our project report. May the sun shine brightly upon your path as it did upon ours. Thank you for being the rays of light that guided us through this adventure!


بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ
ٱلْحَمْدُ لِلَّهِ رَبِّ ٱلْعَٰلَمِينَ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ
مَٰلِكِ يَوْمِ ٱلدِّينِ إِيَّاكَ نَعْبُدُ وَإِيَّاكَ نَسْتَعِينُ
ٱهْدِنَا ٱلصِّرَٰطَ ٱلْمُسْتَقِيمَ صِرَٰطَ ٱلَّذِينَ
أَنْعَمْتَ عَلَيْهِمْ غَيْرِ ٱلْمَغْضُوبِ عَلَيْهِمْ
وَلَا ٱلضَّآلِّينَ

Abstract:

Representation and demonstrating of sun based cells is critical for the photovoltaic framework configuration keeping in mind the end goal to get best productivity from the sun and decrease the shore of sun based cell framework. The fundamental subject of this article concentrates on a software created in MATLAB/Simulink of photovoltaic unite. This software depends on numerical equation and is depicted through a comparable The electric circuit is integrated into the photocurrent source, a diode, and a set of series and parallel resistors. The reenactment utilized as a part of this article to get the attributes (I-V), and afterward we will concentrate the impact of each parameter on the curve. The created demonstrate permits the expectation of photo-voltaic unite conduct beneath various physical and characteristic parameters. The unite can likewise be utilized to separate the physical parameters for a given sun based PV cell as an element of temperature and sunlight based irradiance.

List of Contents

List of Table

Table of figure

Table of Abbreviation, Meaning, Value and Unit

Abbreviation	Meaning	Value	Unit
Eg	Band Gap Energy Of The Semiconductor	eV	1.1
G	Solar Irradiation	W/m^2	700-500-300
I	Current	Amp	---
Io	Diode Reverse Saturation Current	Amp	---
Id	Diode Current	Amp	---
Iph	Photo-Current	Amp	---
Isc	Short Circuit Current	Amp	3.8
k	Solar Cell Short Circuit Current	Amp	0.0017
Ki	Boltzmann's Constant	J/K	1.380649×10^-23
Voc	Output Voltage At Open Circuit	volt	---
Ns	Number Of Cells Connected In Series		36
Np	Number Of PV Modules Connected In Parallel		1
n	Diode Ideality Factor		---
q	Electron Charge	coulomb	1.602×10^-19
Rs	Series Resistance	W	0.002
Rsh	Shunt Resistance	W	100000
T	Operating Temperature	Kelvin	25-30-35
Tn	Nominal Temperature	Siles	---
V	Voltage Over The Terminals	volt	21.2
Vt	Diode Thermal Voltage	volt	---
Vj	Voltage Across Both Diode And Resistor Rsh	Volt	---
Voc	Output Voltage At Open Circuit	volt	---

CHAPTER 1

CONTENT

1.1 INTRODUCTION:

The use of photovoltaic (PV) modules has increased dramatically in recent years as a way to generate clean, renewable energy. The efficiency and effectiveness of PV modules are crucial in determining the performance of PV systems. Therefore, it is essential to understand and optimize the behavior of PV modules to ensure the efficient and reliable operation of PV systems. The improvement of new vitality sources are ceaselessly upgraded due to the basic circumstance of the synthetic chemical powers. Therefore, the inexhaustible vitality sources turned into a more critical patron to the aggregate vitality devoured on the planet. Modeling and simulation of PV modules are important tools for designing, analyzing, and optimizing the performance of PV systems. MATLAB/Simulink is a powerful platform that can be used to develop detailed models of PV modules that capture their electrical behavior and the effects of external factors such as temperature and solar irradiance.

The process of modeling and simulating a PV module involves developing a mathematical representation of the module's electrical behavior, which includes modeling the internal workings of the module, such as the solar cells and interconnects, as well as the external factors that affect the module's performance, such as temperature and shading. Simulating the model allows for testing of the module's performance under different operating conditions, enabling optimization of the design of the module and the identification of ways to improve its efficiency and effectiveness show in Figure 1-1.

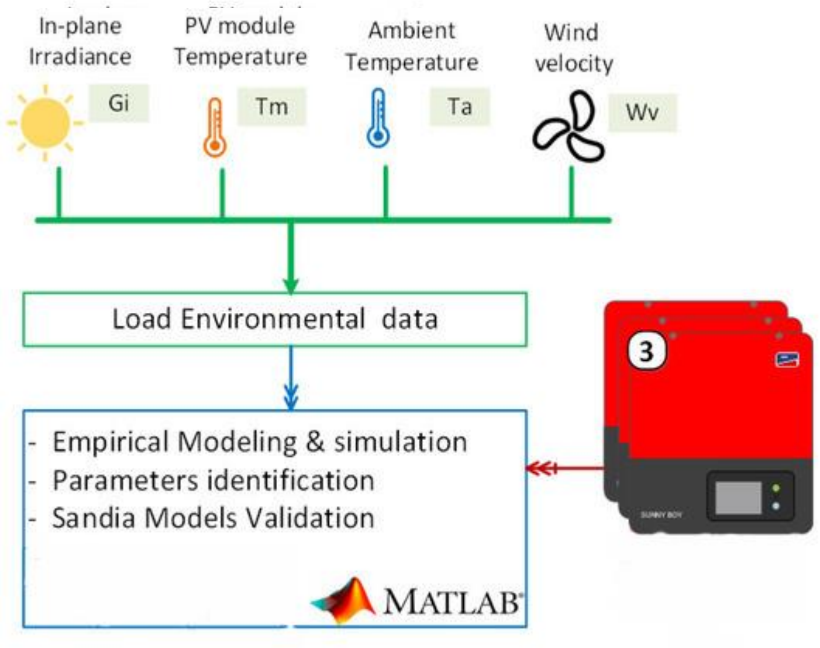


Figure 1-1: Synoptic scheme of the turnkey monitoring system provided by SMA manufacturer

An exact learning of sun based cell variables from exploratory information is of fundamental significance for the outline of sun powered cells and for the evaluations of their execution. The electrical proportional circuit is a helpful and regular route in most reproduction studies. The five variables of enthusiasm for the proportionate circuit are the photocurrent (IPV), series resistance (RS), diode immersion current (I0), shunt resistance (RSH) and the idealism consider (A) show in figure 1-2.

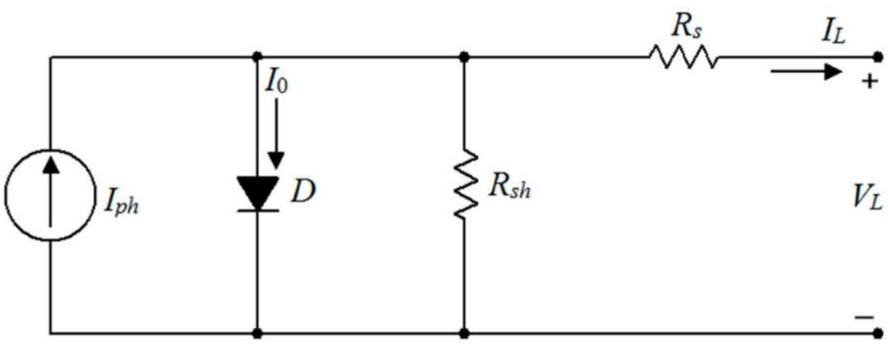


Figure 1-2: PV circuit

The present relation voltage of a sun powered cell is depicted by a scientific condition both certain what's more, nonlinear. In this work, MATLAB script document program has been utilized to register the five variables of the a unite diode model of lit up sun powered cells.

The outcomes acquired by reenactment demonstrate the consistency between the information and got the parameters given by the maker, to be specific: short circuit current (ISC), open circuit voltage (VOC) and most extreme power (Pmax). For example, these variables can be utilized for quality control amid creation or to give bits of knowledge into the operation of the gadgets [1, 2, 3, 4 and 5].

This graduation project aims to develop a comprehensive model of a photovoltaic module using MATLAB/Simulink. The model will take into account the electrical behavior of the module, as well as the effects of temperature and solar irradiance. The simulated performance of the model will be compared with the actual performance of a physical PV module to validate the accuracy of the model.
With a specific end goal to get advantage from the utilization of PV systems, explore exercises are being led trying to increase promote change in their cost, productivity and unwavering quality, therefore numerical displaying of sun powered cells is fundamental for any operation yield improvement.

1.2 Keywords:

Matlab-Simulink
PV solar cell model
solar array model.

1.3 How to PV Works:

A photovoltaic (PV) module, also known as a solar panel, is an electrical device that converts sunlight into electrical energy. The basic building block of a PV module is the solar cell, which is made of semiconductor materials such as silicon. When sunlight hits the solar cell, it causes the electrons in the semiconductor material to be excited and flow in a certain direction, creating an electric current. 12 A PV module consists of multiple solar cells connected in series and parallel to increase the overall voltage and current output. Each solar cell has a specific current-voltage (I-V) curve, which describes the relationship between the current and voltage output for different levels of sunlight intensity.

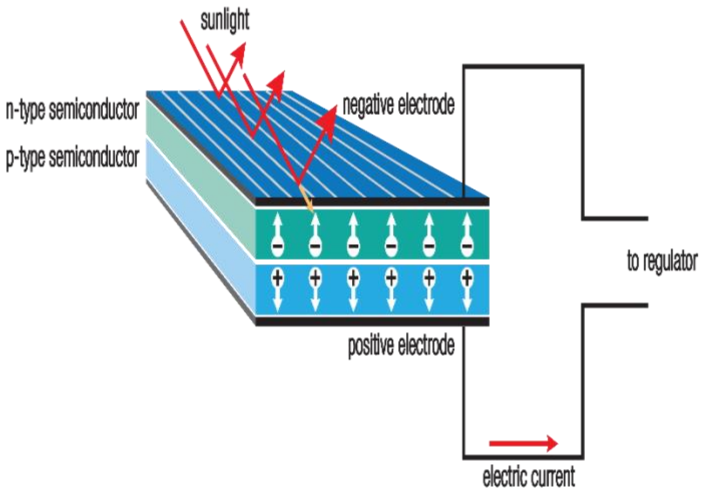


Figure 1-3: Cross section of a solar cell

The I-V curve of a solar cell can be modeled using a single diode equation, which is a mathematical formula that describes the current flow through a diode. In a PV module, the single diode equation is used to model the current-voltage behavior of the module as a whole, taking into account the characteristics of each individual solar cell.

The single diode equation for a solar cell can be written as:

$$= I_{ph} - I_o \left\{ e^{\left(\frac{v+IR_S}{nxV_T}\right)} - 1 \right\} - \frac{V + IR_s}{R_{sh}}$$

where I is the current output of the solar cell, Iph is the photocurrent generated by the solar cell, I0 is the reverse saturation current of the diode, V is the voltage across the solar cell, IRs is the series resistance of the solar cell, n is the ideality factor of the diode, VT is the thermal voltage (kT/q), and Rsh is the shunt resistance of the solar cell.

The photocurrent, Iph, is the current generated by the solar cell when it is exposed to sunlight. The reverse saturation current, I0, is the current that flows through the diode when there is no sunlight. The series resistance, IRs, is the resistance of the solar cell's electrical contacts and wiring. The ideality factor, n, is a parameter that describes the non-ideal behavior of the diode, and the thermal voltage, VT, is a constant that depends on the temperature of the solar cell. The shunt resistance, Rsh, is the resistance between the solar cell's p-n junction and the surrounding material. 14 The single diode equation can be used to calculate the maximum power output of a PV module, which occurs at a specific voltage and current level. This maximum power point (MPP) varies depending on the intensity of sunlight, temperature, and other environmental factors.

1.4 Developments & Hypotheses:

To increase the efficiency of a PV module, various techniques can be used to reduce the losses associated with the single diode equation. For example, the series resistance of the solar cells can be minimized by using low-resistance electrical contacts and wiring. The shunt resistance can be increased by improving the quality of the semiconductor material and reducing defects in the p-n junction. In addition, various technologies have been developed to improve the overall efficiency of PV modules, such as concentrator photovoltaics, which use lenses or mirrors to focus sunlight onto a small area of highly efficient solar cells. Other techniques include thin-film solar cells, which use less material than traditional crystalline silicon cells, and tandem solar cells, which combine multiple layers of semiconducting materials to capture a wider range of sunlight wavelengths. We'll see that is sumlink

CHAPTER 2

CONTENT

2.1 ELECTRIC MODELING OF SOLAR CELL:

A photovoltaic cell can be demonstrated as a present electrical current source PN associated in shunt with a diode. Current source delivers a steady present. This current is corresponding to the power of the light hit the upon cell. Photovoltaic frameworks influenced specifically with climate conditions and sun oriented radiation. The execution of a sun oriented cell is expected to comprehend the relationship amongst's current and voltage of the cell [6]. The ideal proportional circuit of a PV cell (Duffie and Beckman, 1980) is appeared in Figure 2-1. It incorporates a current source, a diode, a series arrangement resistance (Rs) and a shunt resistance (Rsh), these two resistances added because there is no ideal solar cell in practice [7, 8].

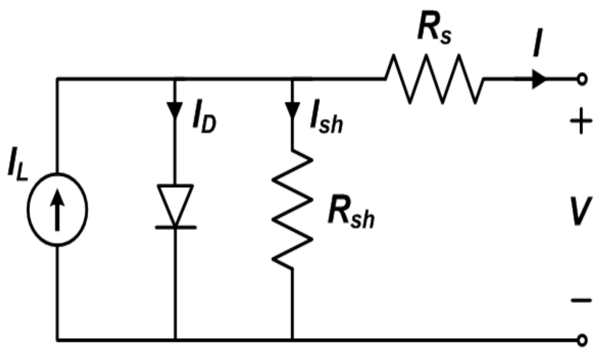


Figure 2-1: Diode model of the PV cell

2.2 MATHEMATICAL MODELING OF SOLAR CELL:

With the identical circuit figure 1 and utilizing Kirchhoff's law, we get the accompanying condition for the load current [9, 10]:

$$I = Iph - Id - Ish \qquad (1)$$

Where: I = O/P current (Amp.)

Iph = Photo produced current (Amp.)

Id = Diode current (Amp.)

Ish = Shunt resistance current (Amp.)

The current passes these components is administered bythe voltage crosswise over them:

Vj =V + IRs

Where:

V = voltage over the terminals (volt)

Vj = voltage across both diode and resistor Rsh (volt)

I = output current (ampere)

Rs = series resistance (Ω)

By the Shockley diode condition, the current occupied through the diode is:

$$I_d = I_o\{e^{\left[\frac{V_j}{n\times V}\right]} - 1\} \qquad (3)$$

Where:

Io = is the diode reverse saturation current.

V = is the thermal voltage given by:

$$V = \frac{KxIR_s}{q} \qquad (4)$$

$V = KxIRs\ q$ (4) V the thermal voltage at 25o C × 0.0259 volt

n = Diode ideality factor (unitless, usually between 1 and 2 for a single junction cell).

q = Electron charge (1.602 × 10-19 C).

k = Boltizman's constant (1.381 × 10-23 J/K).

T = Operating temperature.

Using Ohm's law, the current occupied in the shunt resistor is:

$$I_{sh} = \frac{V_j}{R_{sh}} = \frac{v+IR_S}{R_{sh}} \qquad (5)$$

Where:

Rsh = Shunt resistance (Ω).

Replace these values into the first equation creates the trademark condition of a sun-oriented cell, which communicates sub powered cell variables to the yield volt and current [11, 12]:

$$I = I_{ph} - I_o \left\{ e^{\left(\frac{v+IR_S}{nxV_T}\right)} - 1 \right\} - \frac{V+IR_S}{R_{sh}} \qquad (6)$$

Photo current is administered by the following equation:

I= [I+ K (T - 298)]($\frac{G}{1000}$) (7)

Where:

Isc = Short circuit current (A).

K = Solar cell short circuit current

Temperature coefficient = 0.0017

T = Operating temperature (Kelvin).

G = Irradiance (mW/m) in this equation irradiance divide by 1000 to get (W/m²).

There are two states for the solar cell, the first one is open circuit and the second one is short circuit.

At the point if the cell is worked at open circuit, I = 0 and the voltage over the yield terminals is characterized as the open-circuit voltage Voc Expecting the parallel resistance is sufficiently large to disregard the last term of the trademark condition, the open-circuit voltage Voc is:

At short circuit condition, all the current will go over the short out so Ish is equivalent to Isc.

$$I = I_{ph} - I_d$$

Id = as shown in equation 3 So

$$I = I_{sh} - I_o\{e^{\left[\frac{V_j}{nxV_T}\right]} - 1\}$$

We can decide the invert immersion current I0 by setting I = zero (situation when no yield current) and that case called open circuit. At short circuit I = 0 and V = Voc Where:

Voc = output voltage at open circuit state.

In addition, that cause the all current go through the diode since the shunt resistance is high as clarified already so.

$$I = I_{ph} - I_o\left[e^{\frac{(qxV)}{N_SxKxnxT}} - 1\right] \quad (8)$$

$$I_o = \frac{I_{sh}}{\left[e^{\frac{(qxV)}{N_sxKxnxT}} - 1\right]}$$

What's more, the current in the shunt resistance acquired from the accompanying condition:

$$I_{sh} = I_o\left(\frac{T}{T_{ref}}\right)^3 x\left[e^{\left(\frac{qxE_g\left(\frac{1}{T_{ref}}-\frac{1}{T}\right)}{Kxn}\right)}\right] \quad (9)$$

Where:

Terf = Reference temperature (Kelvin).

Eg = Band gap for Silicon.

For a photovoltaic array or cluster containing Ns cells in series, Np cells in parallel and expecting all cells are indistinguishable and under uniform and equivalent irradiance and temperature (i.e., generate equal current and voltage).

$$I_{module} = N_p x I_{cell} \quad and \qquad V_{module} = N_s x V_s$$

The last single diode condition for a module or exhibitgets to be:

$$I = (N_p \times I_{ph}) - N_p \times I_{sh}\left[e^{\left(\frac{q(V+(IR_S))}{(N_S\times n\times K\times T)}\right)} - 1\right] - \frac{V+IR_S}{R_{sh}} \quad (10)$$

CHAPTER 3

CONTENT

3.1 PARAMETERS:

Conditions depicted in past segment are demonstrated to acquire IV and PV Characteristics of a solitary diode sun powered cell module. The reproduction incorporates numerous subsystems: one that figures the PV cell working and temperature (T), the second ascertain Iph (Photo cell current), the third one compute Io (Diode turn around immersion current), the fourth one ascertain Ish (Current in shunt resistance) while the last one figure the aggregate yield current and aggregate yield voltage (I, V) [13, 14]. All the blocks obtained by using Matlab-Simulink to represent all the equations explained in previous section by using source, sinks and math's relation.

Parameters	Value
Eg	1.1
G	300- 500- 700
Isc	3.8 (A)
K	0.0017
Ki	$1.381´10^{-23}$ (J/K)
n	1.1
Np	1
Ns	36
q	$1.602´10^{-19}$ (C)
Rs	0.002 (W)
Rsh	100000 (W)
T	25- 30-35 C
V	21.2 (V)
q	$1.602´10^{-19}$ (C)

Table 3-3: parameters

3.2 SOLAR CELL SIMULATION:

- ## TEMPERATURE MODULE (T)

One of the simulation blocks is the temperature (in Kelvin) as shown in figure 3-1. The subsystem contain four blocks, the input is the operating temperature in degree centigrade and the two outputs is the temperature (T) in Kelvin. figure 3-2 shows details of the temperature subsystem.

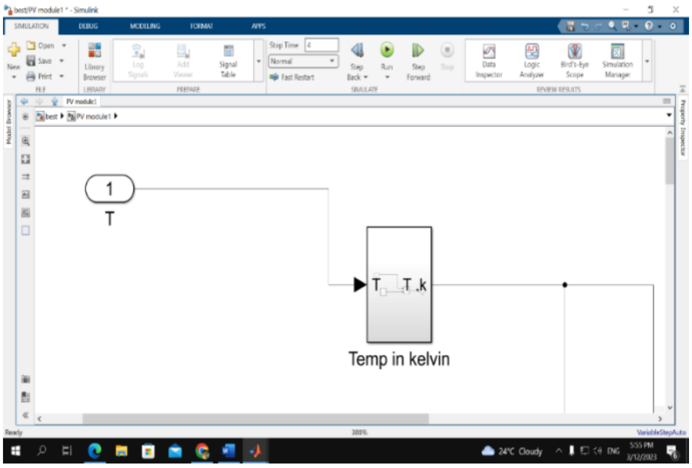


Figure 3-1: Temperature block

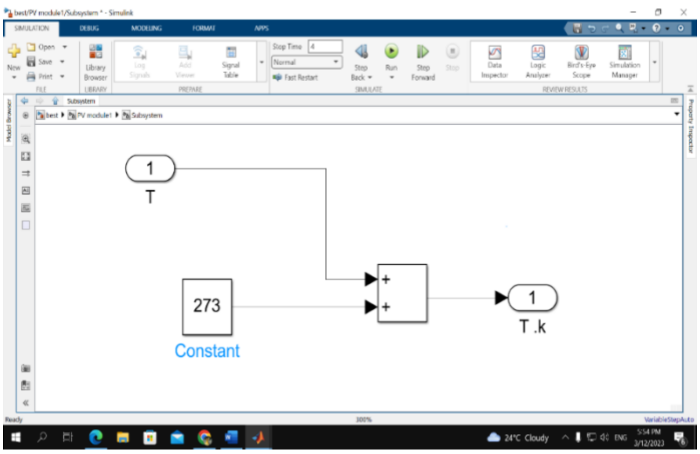


Figure 3-2: Details of the temperature subsystem

• PHOTO CELL CURRENT MODULE (IPH)

This block represents the photocell current according to equation 7 as shown in figure 3-3. The inputs are irradiance (mW/m^2), short circuit current (A) and operating temperature (Kelvin) while the output is the photocell current in (A), the details of this block shown in figure 3-4, which is the subsystem of the block.

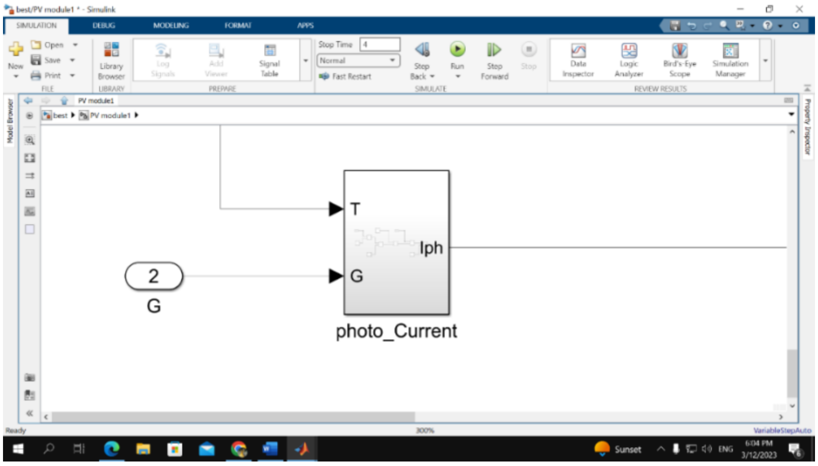


Figure 3-3: Photocell current module in the system

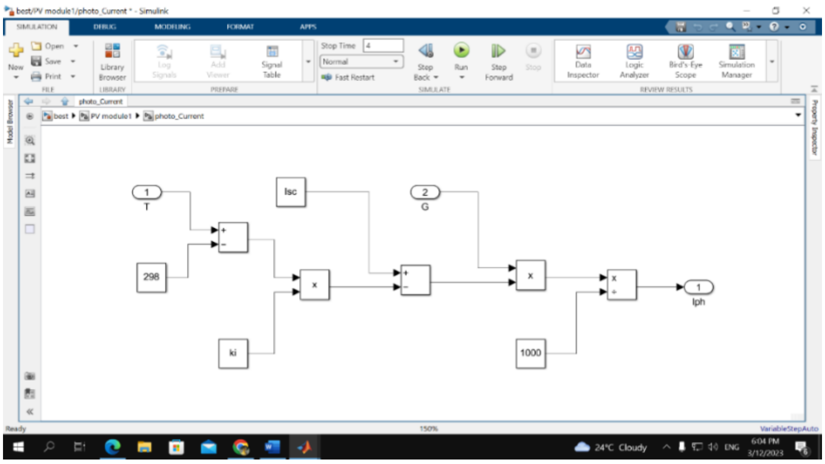


Figure 3-4: Photocell current subsystem module

- ## DIODE REVERSE SATURATION CURRENT MODULE (IO)

This block represents the diode reverse saturation current according to equation 8 as shown in figure 3-5. The inputs are short circuit current (A) and operating temperature (Kelvin) and the output is the diode reverse saturation current (A), the parameters used in this block is electron charge, voltage across the output terminal, number of series cells, Boltzman'n constant and diode ideality factor. The details of this block shown in figure 7, which is the subsystem of the block.

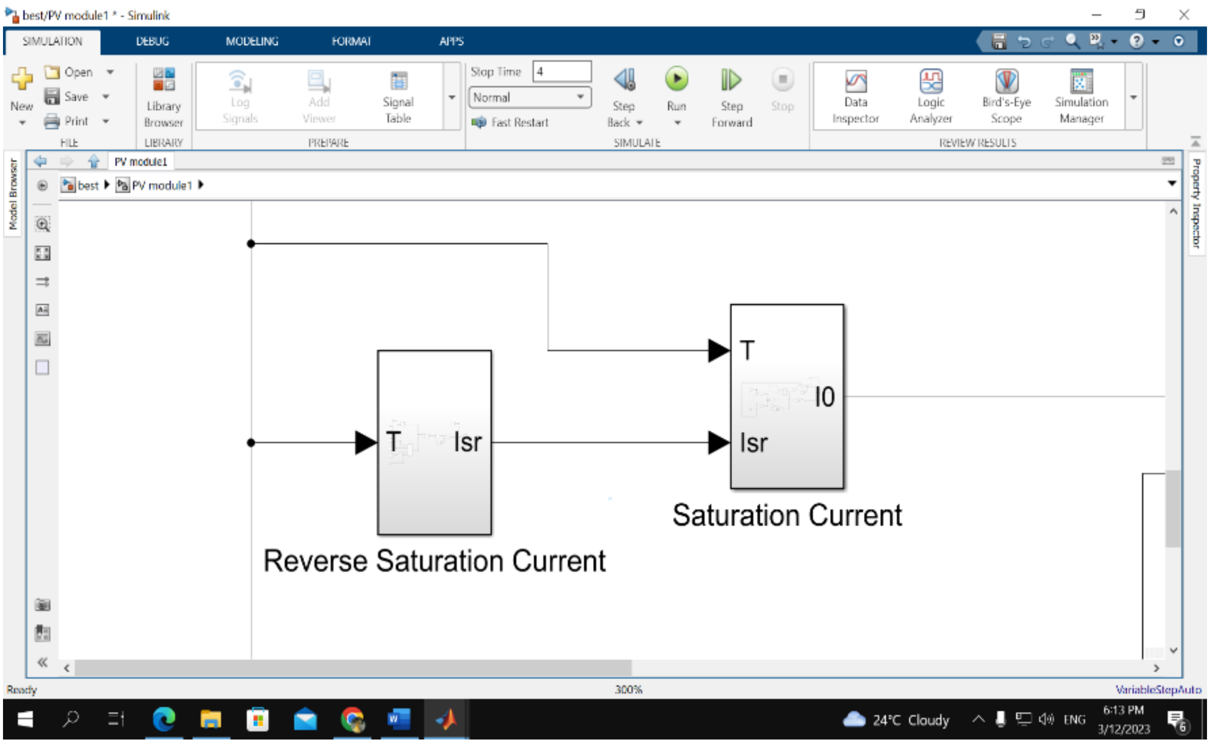
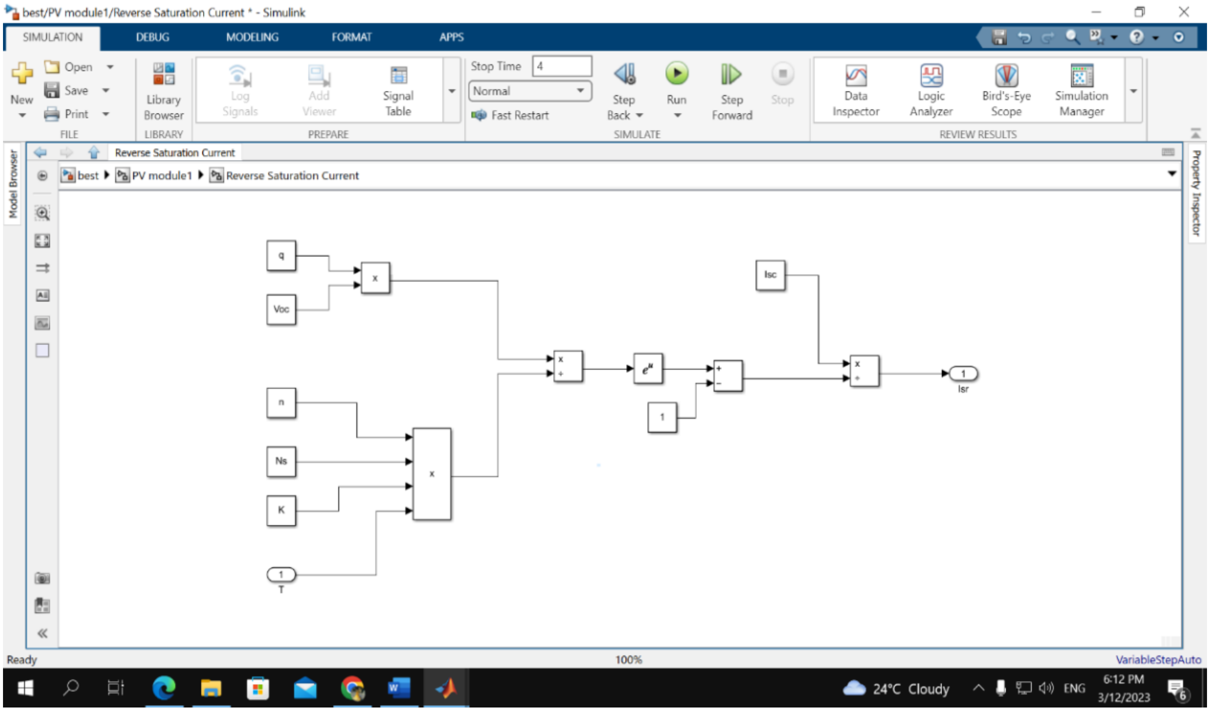


Figure 3-5: Diode reverse and current saturation module in the system



Diode reverse

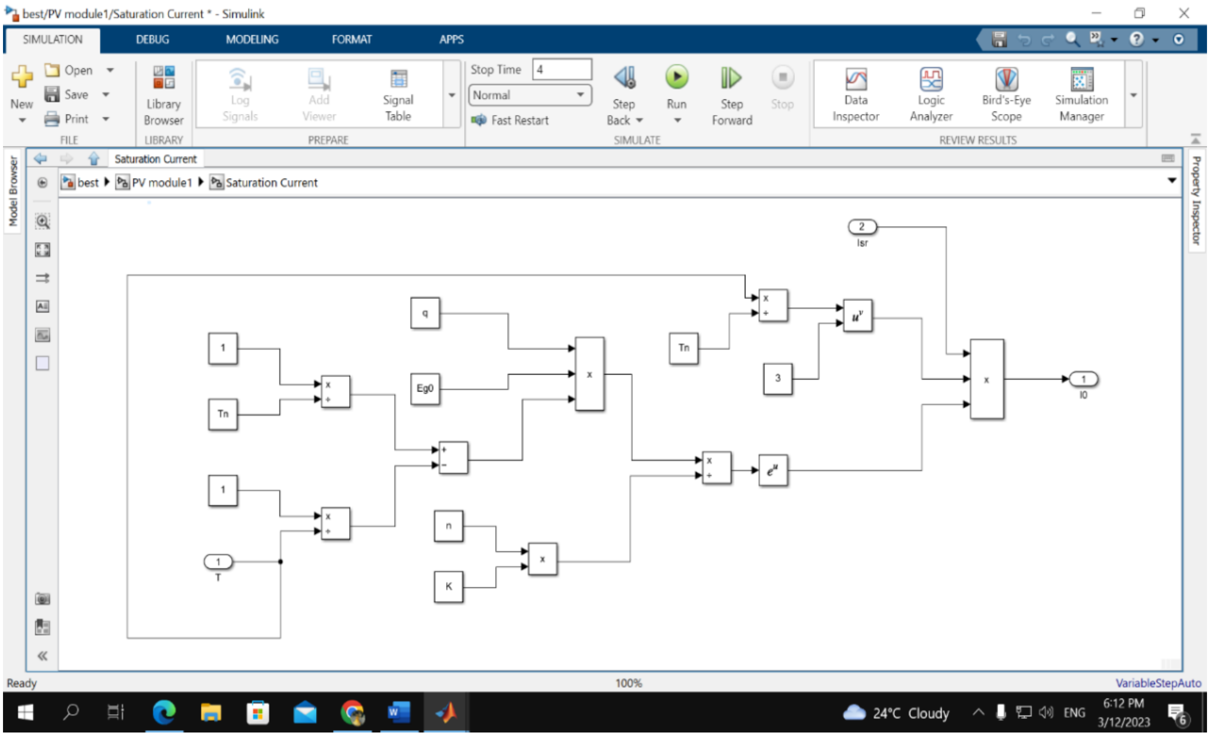


Figure 3-6: Diode reverse saturation subsystem module

• SHUNT RESISTANCE CURRENT MODULE (ISH)

This block as shown in figure 3-7 represents shunt resistance current according to equation 9. The inputs are diode reverse saturation current (A), the temperature (T) in Kelvin. The parameters used in this block are electron charge, Boltzman'n constant, band gap for Silicon and diode ideality factor.

The details of this block shown in figure 3-8, which is the subsystem of the block.

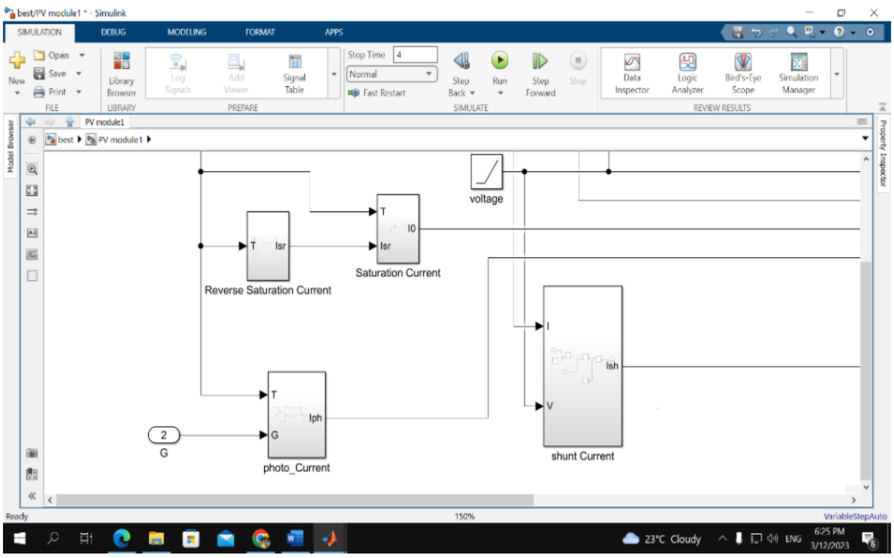


Figure 3-7: Shunt resistance current module in the system

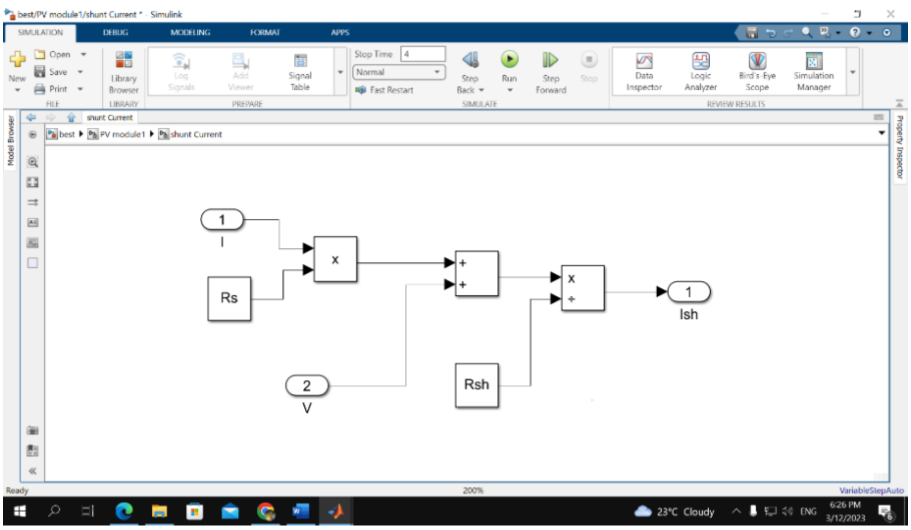


Figure 3-8: Shunt resistance current subsystem module

- ## PHOTOVOLTAIC OUTPUT CURRENT MODULE (IPV)

This block represents photovoltaic output current according to equation 10. The inputs are temperature (T) in Kelvin, short circuit current (A), Photocell current (A) and voltage across the output terminals (volt) while the outputs are photovoltaic current and voltage. The parameters used in this block are electron charge, Boltzman'n constant, diode ideality factor, number of series and parallel cells and value of series and shunt resistance. The details of this block shown in figure 3-9, which is the subsystem of the block.

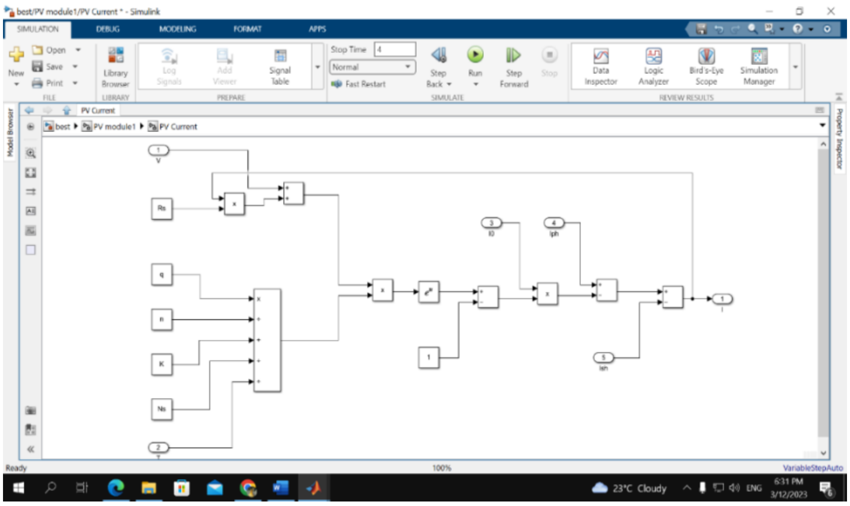


Figure 3-9: Photovoltaic current subsystem module

Finally, figure 3-10 shows the overall system module that simulates the Solar cell system.

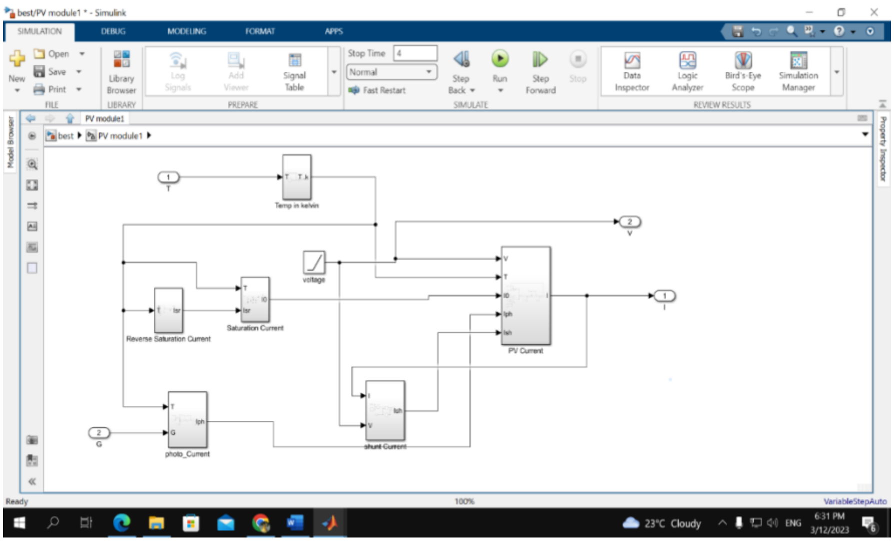


Figure 3-10: Solar cell system modeling simulation

CHAPTER 4

CONTENT

4 RESULTS:

In this simulation, solar cell specification curves I-V and P-V have been obtained for various irradiance and different operating temperature. In addition, in this simulation, changing the parameters of table 1 can be done very easily by changing the constants block. These results obtained by using output scope block and to workspace block in Matlab-Simulink. Figure 4-1 and 4-2 shows the I-V curves for different irradiance and different temperature respectively.

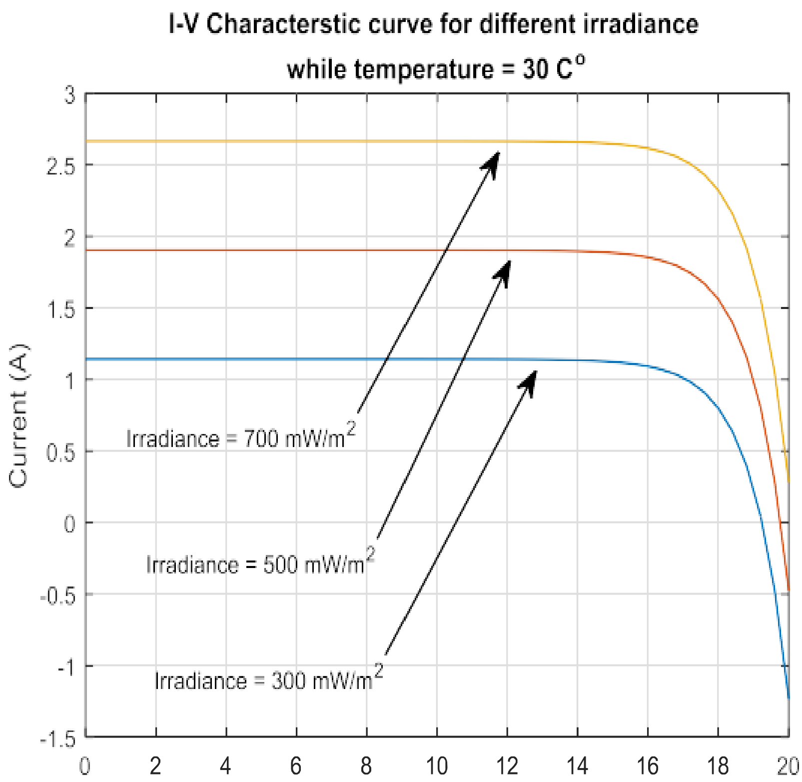


Figure 4-1: I-V Assorted curves for various irradiance and constant Temperature

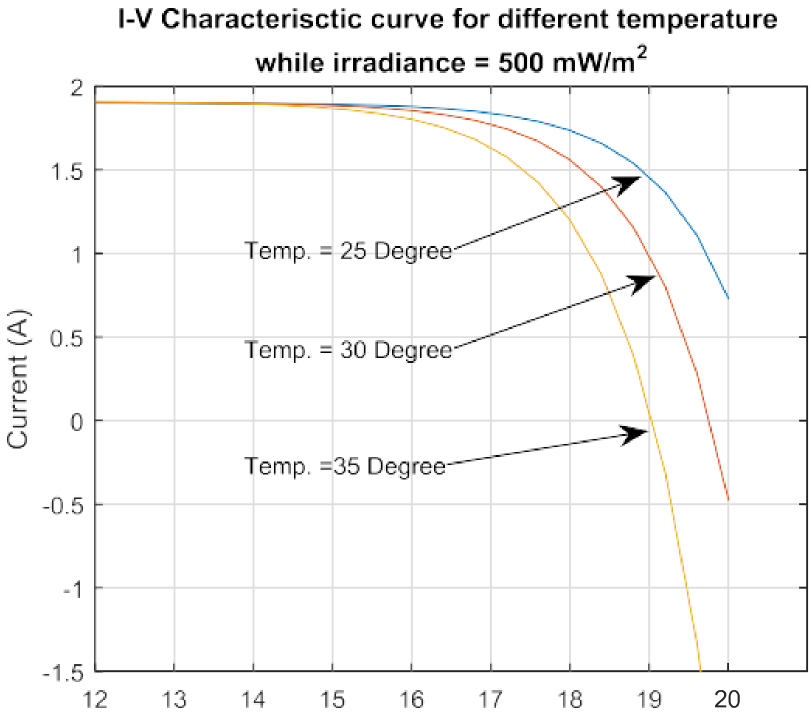


Figure 4-2: I-V Assorted curves for various Temperature and constant Irradiance

The effect of increasing irradiance while temperature was fixed (30o) is increasing the output and short circuit current, the output voltage almost not affected very much. In the second test, the output voltage decrease when the operating temperature increase whiles the irradiance was constant (500mW/m2). The third and fourth tests show the P-V curves for different irradiance and operating temperature as shown in figure 4-3 and 4-4, increasing the irradiance cause increasing the max power and max peak current, on the other hand increasing temperature cause to reduce the max power and max peak voltage [15].

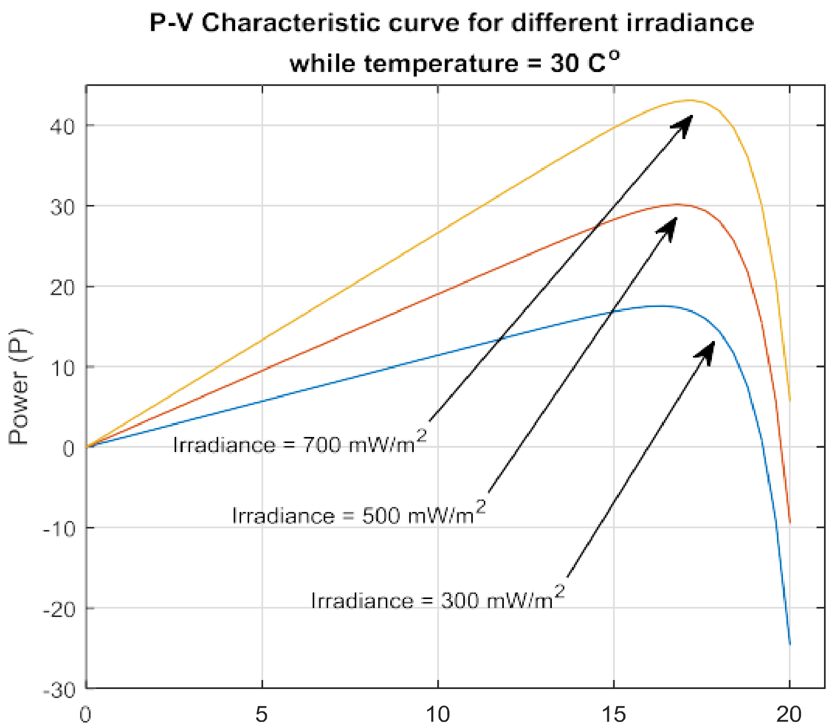


Figure 4-3: P-V Assorted curves for various radiation and constant temperature

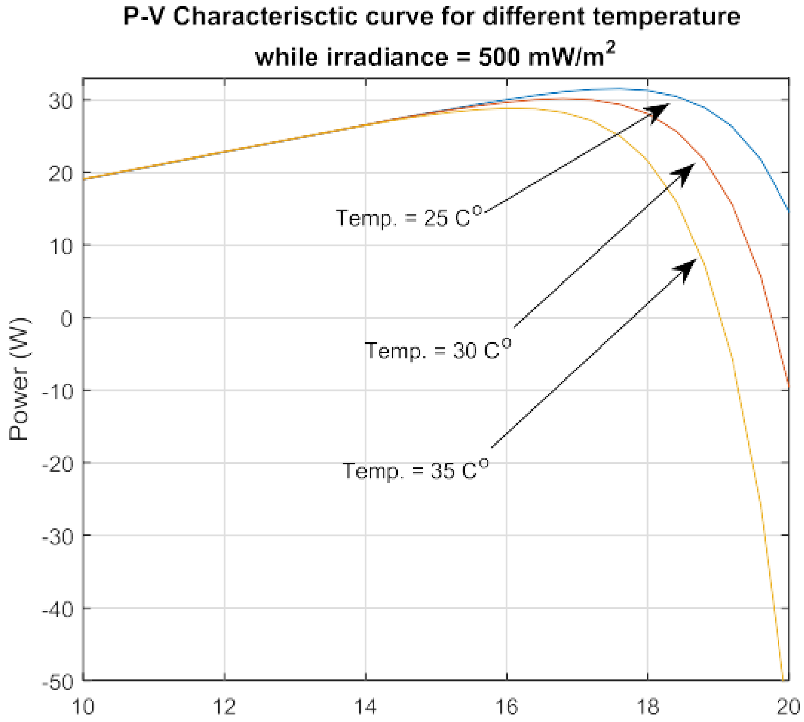


Figure 4-4: P-V Assorted curves for various Temperature and constant Irradiance

CHAPTER 5

CONTENT

5.1 Conclusion

5 CONCLUSION:

In this project, Matlab-Simulink used to get the I-V and P-V characteristic curves of a solar cell system. These curves used to calculate the specifications of a solar cell system such as short circuit current, open circuit voltage, power and maximum power.

From the experimental results, one can know the parameters that affect the solar cell efficiency and quality such as irradiance and temperature.

This solar cell simulation is a general design so one can change the electrical segments such as resisters, diode and number of parallel and series cells very easily in order to get other solar cell system design.

REFERENCE:

Advanced Energy: An International Journal (AEIJ), Vol. 1, No. 2, April 2014, "STUDY OF THE EQUIVALENT CIRCUIT OF A DYESENSITIZED SOLAR CELLS", M. Belarbi , A. Benyoucef, B. Benyoucef Research Unit Materials and Renewable Energy, Department of Physics University of Abou Bekr Belkaid-Tlemcen, BP: 119 Tlemcen 13000, Algeria.

B.BA and M.KANE, "Determination of polysilicon solar cell parameters using electrical short-circuit current Decay method", Solid-State Electronics,vol.42,N0.4,pp.541-545, 1998.

E.E. van Dyk, B.J. Scott, E.L. Meyer and A.W.R. Leitch, "Temperature dependence of performance of crystalline silicon photovoltaic modules," South African Journal of Science 96, 198-200 (2000).

E.L. Meyer, E.E. van Dyk, "Assessing the reliability and degradation of PV module performance parameters", (IEEE Transactions on Reliability, 53, No.1, March 2004).

H. Tsai, C. Tu, Yi-Jie Su, "Development of Generalized Photovoltaic Model Using MATLAB/SIMULINK", Proceedings of the World Congress on Engineering and Computer Science WCECS, San Francisco, USA, 2008.

H. Al-Hamdani, S. I. Ibrahim, and S. K. Abud Alrda, "Effects of Luminous Solar Concentrator Parameters (Dyes Mixture, Host type and LSC Thickness) on the Si Solar Cell Performance Efficiency" , International Journal of Current Engineering and Technology, Vol.5, No.4, pp(2439- 2443), Aug. 2015.

Ishaque, Z. Salam, S. Mkhilef, A. Shamsudin, "Parameter extraction of solar photovoltaic modules using penalty-based differential evolution" Applied Energy 99 (2012),297-308.

J. Decker, "Performance of 170 grid connected PV plants in northern Germany-analysis of yields and optimization potentials." (Solar Energy 59 1997) 127-133.

J. Nelson, The Physics of Solar Cells (Imperial College Press, London, 2003).

J. Selvaraj, N. A. Rahim, “Multilevel Inverter For Grid-Connected PV System Employing Digital PI Controller”, IEEE Transactions On Industrial Electronics,vol. 56, No. 1, pp. 149-158 , 2009.

M. Chegaar, Z Ouennought, A. Hoffmann, “A new method for evaluating solar cell parameters,” Solid-State Electronics 45, 293-296 (2001).

M. Francisco, G. Longatt, “Model of Photovoltaic Module in Matlab™”, 2do congresoı beroamerı cano de estudıantes de ıngenıeríaeléctrı ca, electrónıcaly computacıón pp.1-5, 2005.

M. Ö. Yatak, “ Fotovoltaik Beslemeli Aralıklı Tip –2 Bulanık Mantık Denetleyicili İki Kademeli Dönüştürücünün Gerçekleştirilmesi”, Elektronik ve Bilgisayar Eğitimi Gazi Üniversitesi Bilişim Enstitüsü Doktora Tezi, 2012, Ankara.

M.A. Green, K. Emery, Y. Hishikawa and W. Warta, “Solar Efficiency tables(version 36)”, Progress in Photovoltaics: Research and Applications 18,346-352 (2010)

M.A. Green, Solar Cells. (Artic House, Boston, 1992). BP, 2011. Statistical Review of World Energy 2011.BP,http://www.bp.com/sectionbodycopy.do?categoryId=7500&contentId=7068481S, Accessed: 19 Dec. 11.

M.C. Alonso-Garcia and J.M. Rui, “Analysis and modeling the reverse characteristic of photovoltaic cells”, Solar Energy Materials & Solar Cells 90, 1105–1120 (2006).

S. Rustemli, F. Dincer, “Modeling of Photovoltaic Panel and Examining Effects of Temperature in Matlab/Simulink”, Electronics and Electrical Engineering, ISSN 1392-1215, no. 3(109), pp. 35-40, 2011.

S. Silvestre, A. Boronat, A Chouder, “Study of bypass diodes configuration on PV modules,” Applied Energy 86, 1632-1940 (2009).

Ş. Yılmaz, M. Aksu, Z. Özer, H. R. Özçalık, “ Matlab İle Gerçekleştirilen Fotovoltaik (PV) Güneş Pili Modeli İle Güneş Enerjisi Üretimindeki Önemli Etkenlerin Tespit Edilmesi”, ELECO 2012,Bursa.

Ministry of Higher Education and Scientific research
Al-Iraqia University
Engineering College
Electrical Engineering Department

Intrusion Detection System Design Using Arduino With Android Apps as Real Time Client

A Project Submitted to the Department of Electrical Engineering in Partial Fulfilment for the Requirements of the Degree of B.Sc. in Electrical Engineering

By:

Hassan Mazin Abass

Zain Alabideen Ali Hussien

Fadil Abass Abd

Supervisor:

Dr. Wassan Saad Hayale, Ph.D.

2022-2023

Declaration

We hereby declare that this project report is based on our original work except for citations and quotations, which have been duly acknowledged

Signature :

Name :

Date :

Signature :

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Date :

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Name :

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Name :

Date :

Approval for Submission

I certify that this project report entitled “Intrusion Detection System Design Using Arduino with Android Apps as Real-Time Client”was prepared by ""Hassan Mazin Abass, Zain Al-abideen Ali Hussien, and Fadil Abass Abd" has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Electrical Engineering at Al-Iraqia University .

Approved by :

Signature :

Supervisor :

Date :

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Finally, I want to dedicate this dissertation to my Parents, who have been the best supporters during the period of study and alienation. I am always getting my strength from their prayers for me.

Abstract

With the increasing amount of network throughput and security threat, the study of intrusion detection systems (IDSs) has received a lot of attention throughout the computer science field. Current IDSs pose challenges on not only capricious intrusion categories, but also huge computational power. Though there is a number of existing literatures to IDS issues, we attempt to give a more elaborate image for a comprehensive review. Through the extensive survey and sophisticated organization, we propose the taxonomy to outline modern IDSs. In addition, tables and figures we summarized in the content contribute to easily grasp the overall picture of IDSs.Intrusion detection systems (IDS) strive to catch computer system intrusion utilize by any garnering and analyzing data. Wireless IDSs garner all local wireless transmissions and generate alerts based either on predefined signatures or on anomalies in the traffic. These wireless IDS can monitor and analyze user and system activities of known attacks, identity abnormal network activity and detect policy violations. Intrusion detection systems (IDSs) should be designed to facilitate the detection of attempted and actual unauthorized entry into designated areas and should complement the security response by providing the security force with prompt notification of the detected activity from which an assessment can be made and a response initiated. We intended to avoid the access and keep track of the intruder's attempts and intensions.

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Chapter 1

Introduction

1.1 Background and Motivation

As we advance further into the digital age, cybersecurity has become a major concern for organizations and individuals alike . With increasing reliance on digital systems for a wide array of tasks and services, these systems have become attractive targets for malicious actors seeking to exploit vulnerabilities for illicit gains or disrupt operations. Intrusion Detection Systems (IDS) have become a crucial component of a robust cybersecurity infrastructure, designed to detect and thwart such attacks . (15)

The motivation behind this project stems from the clear and present need for improved and more reliable IDS. With the evolving landscape of cyber threats, traditional IDSs, which mainly rely on signature-based detection, are no longer adequate . These systems struggle to detect zero-day attacks, for which no known signatures exist.(2)

As a consequence, there is a growing need for more sophisticated IDSs, employing techniques such as anomaly detection and machine learning, to identify and counteract these novel threats.

Furthermore, the rise of the Internet of Things (IoT) has expanded the scope of IDS application . As billions of devices, ranging from fridges and thermostats to industrial machinery, get connected to the internet, they become potential entry points for cyberattacks . These devices often lack the computational power to run traditional IDS software, necessitating the development of lightweight, yet effective, IDS solutions tailored for IoT environments.

This project is motivated by these needs and challenges. The aim is not only to study and understand existing IDS methodologies but also to design and implement an IDS that addresses these contemporary issues. We aspire that our work will contribute to the ongoing efforts to fortify our digital systems against the ever-growing cyber threats.

1.2 Problem Statement

The issue at hand is the efficient detection and prevention of intrusions in increasingly complex network systems. There is a need for an in-depth understanding of contemporary IDS strategies, their implementations, and areas of application. Intrusion detection is the process of identifying unauthorized access to a system or facility. Traditional methods of intrusion detection involve using physical barriers, such as locks and cameras, but these methods can be bypassed by determined intruders. Intrusion detection systems are designed to provide an additional layer of security by detecting and alerting security personnel to potential intrusions. However, traditional intrusion detection systems can be expensive and complex to implement. In addition, they may not be effective in detecting all types of intrusions, such as stealthy attacks.

1.3 Reserach Objectives

The purpose of this research project is to design an Intrusion Detection System using Arduino with Android apps as a real-time client while considering the following objectives:

1. Review literature on different Intrusion Detection System (IDS) approaches: Conduct a comprehensive review of existing research and literature to gain insights into various IDS techniques and methodologies. This analysis will provide a foundation for understanding the current state-of-the-art in intrusion detection.

2. Analyze the role of sensor technologies and communication protocols: Investigate the significance of sensor technologies and communication protocols in the design and implementation of an effective IDS. This analysis will explore different sensor options and communication protocols to ensure accurate and reliable intrusion detection.

3. Study the contexts in which different IDS strategies are implemented: Examine different scenarios and contexts in which IDS strategies are employed to gain a better understanding of their practical applications. This study will consider various environments, such as residential, commercial, or industrial, to assess the suitability and adaptability of IDS strategies.

4. Identify key features determining the effectiveness of an IDS: Identify and evaluate the critical features and factors that contribute to the effectiveness of an IDS. This assessment will consider aspects such as detection accuracy, response time, scalability, adaptability, and system integration to establish the key elements for designing a robust and efficient IDS.

By addressing these objectives, the research aims to contribute to the field of intrusion detection by designing an IDS using Arduino with Android apps as a real-time client.

This system will leverage sensor technologies, communication protocols, and the identified key features to achieve accurate and timely detection of unauthorized access or intrusion attempts.

1.4 Scope and Limitations

The scope of this study involves not only the review and analysis of literature on Intrusion Detection Systems (IDS) but also the actual implementation of a hardware-based IDS. The project aims to cover a broad range of topics, including different IDS approaches, sensor technologies, communication protocols, the contexts in which IDSs are commonly implemented, and their key features. Furthermore, the study extends to the development of a real-world IDS, allowing us to observe the practical application of theoretical concepts.

While we strive for a comprehensive approach, certain limitations are inherent in our study. The hardware-based IDS that we implement may not cover all possible scenarios or configurations due to constraints like budget, availability of components, and time. Additionally, while every effort is made to stay updated with the latest research and advancements in IDS technology, the rapidly evolving nature of this field means that some recent developments might not be included. Lastly, our analysis of the effectiveness of our IDS will be based on controlled tests, which may not fully replicate all real-world intrusion scenarios.

Despite these limitations, we believe our study will provide valuable insights into the design and implementation of IDSs, serving as a beneficial resource for both researchers and practitioners in the field.

Chapter 2

Related Work

In this chapter, we present a comprehensive review of the related work in the field of intrusion detection systems (IDS). To organize the extensive literature on IDS, we categorize the reviewed studies into five types, namely intrusion detection techniques, sensor technologies, communication protocols, implementation contexts, and key IDS features. By structuring the literature review in this manner, we aim to provide a comprehensive understanding of the various aspects related to IDS design and implementation. Each type explores specific areas of research, shedding light on the advancements, challenges, and key findings in each respective area. Through this systematic review, we identify relevant studies that have contributed to the development and enhancement of intrusion detection systems, providing valuable insights and guiding our research approach.

2.1 Intrusion Detection Techniques

Several intrusion detection techniques have been used in IDS design, including rule-based methods, machine learning algorithms, IoT platforms, and hybrid approaches. Rule-based methods are based on pre-defined rules that specify what constitutes an intrusion.

For example, Karthikeyan et al. (12) proposed a rule-based approach that uses predefined patterns to detect intrusion events. Machine learning algorithms, such as MLP neural networks, have been widely adopted in intrusion detection systems. Idrissi et al. (8) utilized machine learning techniques to identify anomalies in network traffic and detect intrusion attempts. IoT platforms, such as those utilizing PIR sensors, have also been employed for intrusion detection. Sharma et al. (21) proposed an IoT-based intrusion detection system that utilizes PIR sensors to detect unauthorized physical access. Hybrid approaches combine different techniques to improve the accuracy of intrusion detection. Khan et al. (13) presented a hybrid intrusion detection system that combines machine learning and rule-based approaches for effective intrusion detection.

2.2 Sensor Technologies

The role of sensor technologies within IDS is crucial for detecting and capturing intrusion events. Various sensor technologies have been utilized in intrusion detection systems:

1. IR sensor: Infrared (IR) sensors, as studied by Kumar et al. (15) , are effective in detecting the presence of intruders based on their heat signatures. These sensors can accurately identify changes in temperature and movement within the monitored area.

2. PIR sensor: Passive Infrared (PIR) sensors, as explored by Yadahalli et al. (23) , are commonly used in intrusion detection systems. They detect changes in infrared radiation caused by moving objects, enabling the system to identify potential intrusions accurately.

3. Ultrasonic sensor: Sahoo et al. (20) investigated the use of ultrasonic sensors in intrusion detection systems. These sensors emit ultrasonic waves and measure the

time it takes for the waves to bounce back, allowing the system to determine the presence of objects or individuals within the monitored area.

4. Temperature sensor: Kiran et al. (14) incorporated temperature sensors in their intrusion detection system. These sensors are used to detect abnormal temperature changes, which could indicate the presence of intruders or fire hazards.

5. Humidity sensors: Kiran et al. (14) also integrated humidity sensors into their intrusion detection system. These sensors measure the level of moisture in the environment and can help detect abnormal humidity levels caused by water leaks or condensation, which may indicate unauthorized access.

2.3 Communication Protocols

Communication protocols play a significant role in ensuring the effective transmission of data within an IDS. The following communication protocols have been employed in intrusion detection systems:

1. WiFi modules: Mazunga et al. (18) investigated the use of WiFi modules for transmitting data in an intrusion detection system. WiFi provides reliable and high-speed wireless communication, making it suitable for real-time transmission of intrusion-related data.

2. Bluetooth modules: De et al. (2) explored the use of Bluetooth modules for communication in intrusion detection systems. Bluetooth enables short-range wireless communication and can be utilized for local communication between the IDS components.

2.4 Implementation Contexts

The implementation contexts of intrusion detection systems vary based on the environment and specific requirements. Different scenarios where IDS has been implemented include:

1. Indoor scenarios: Zhuang et al. (24) , Lv et al. (16) , and Lv et al. (17) studied the implementation of IDS in indoor environments. They focused on developing robust intrusion detection systems for residential and commercial settings, considering factors such as scalability, adaptability, and real-time monitoring.

2. Outdoor scenarios: Barriga et al. (1) investigated the implementation of IDS in outdoor environments. Their research focused on securing outdoor spaces, such as parking lots or public areas, by deploying intrusion detection systems tailored to the unique challenges of open spaces and varying weather conditions.

2.5 Key IDS Features

Effective intrusion detection systems possess key features that contribute to their accuracy, scalability, and overall performance. The following features have been identified as crucial for successful IDS:

1. Real-time monitoring: Phatak et al. (19) emphasized the importance of real-time monitoring in intrusion detection systems. Real-time monitoring enables prompt detection and response to intrusion events, minimizing the potential damage caused by unauthorized access.

2. Low power consumption: Gendreau et al. (6) highlighted the significance of low power consumption in IDS. Energy-efficient systems ensure prolonged operation and

reduce the maintenance requirements of intrusion detection systems.

3. Integration with other smart devices: Venkateshkumar et al. (22) explored the integration of intrusion detection systems with other smart devices. This integration enables enhanced collaboration between different devices and systems, leading to a more comprehensive and robust security infrastructure.

Chapter 3

Intrusion Detection System

3.1 Introduction

An Intrusion Detection System (IDS) is a monitoring system that detects suspicious activities and generates alerts when they are detected. It plays a critical role in identifying potential security breaches and protecting computer networks from unauthorized access and malicious activities. Based upon these alerts, a security operations center (SOC) analyst or incident responder can investigate the issue and take appropriate actions to remediate the threat, ensuring the security and integrity of the network.

3.2 Types of Intrusion Detection Systems

There are different types of Intrusion Detection Systems, each with its own approach to identifying and detecting threats. The three main types are signature-based IDS, anomaly-based IDS, and hybrid IDS.

3.2.1 Signature-based IDS

Signature-based intrusion detection detects possible threats by comparing network traffic and log data to existing attack patterns, known as signatures (3). The system matches observed patterns with known attack signatures to identify and raise alerts for potential intrusions. Signature-based detection offers high processing speed for known attacks and low false positive rates, allowing it to quickly and accurately identify malicious events. However, its effectiveness is limited to attacks that match existing signatures, making it less effective against novel or unknown attacks.

3.2.2 Anomaly-based IDS

Anomaly-based intrusion detection detects both network and computer intrusions by monitoring system activity and classifying it as either normal or anomalous (10). It establishes a baseline of normal behavior and identifies deviations from this baseline, which may indicate suspicious or malicious activities. Anomaly-based detection has the advantage of detecting novel attacks that do not match known attack patterns. By identifying abnormal behavior, it can detect previously unseen threats. However, anomaly-based IDS may have a higher false positive rate and require more computational resources for analyzing and classifying system behavior.

3.2.3 Hybrid IDS

Hybrid Intrusion Detection Systems combine the strengths of both signature-based and anomaly-based IDS (5) . They integrate signature-based and anomaly-based techniques to detect both known and unknown attacks. Hybrid IDS capture data from both host and network sources for comprehensive analysis of system behavior and possible intrusions. They capture data from both host and network, allowing for a more comprehensive analysis of system behavior and possible intrusions. By combining the strengths of signature-based and anomaly-based detection, they offer improved detection accuracy and a reduced false positive rate. However, hybrid IDS may have increased complexity and resource requirements compared to individual detection approaches.

The choice of Intrusion Detection System type depends on the specific requirements and characteristics of the network environment. Understanding the strengths, limitations, and trade-offs of each IDS type is crucial in designing an effective intrusion detection system.

3.3 Intrusion Detection Techniques

Intrusion Detection Systems (IDS) employ various techniques to detect and mitigate unauthorized activities and potential threats within a network. These techniques provide an overview of common methods such as rule-based approaches, machine learning algorithms, statistical methods, and anomaly detection. They explore the principles, advantages, and limitations of each technique, highlighting their suitability for different types of attacks and network environments. The section may also discuss emerging techniques, such as deep learning-based IDS, and their potential impact on improving detection accuracy and robustness.

1. **Rule-based Methods:** Rule-based IDS rely on predefined rules or signatures to identify known attack patterns (9). These rules are typically created by security experts and are based on specific characteristics or behaviors associated with different types of attacks. Rule-based methods offer high detection accuracy for known attacks but may struggle with detecting novel or sophisticated attacks that do not match any existing rules.

2. **Machine Learning Algorithms:** Machine learning-based IDS utilize algorithms to

learn patterns and behaviors from labeled data (7) . These algorithms can be trained to classify network traffic as normal or malicious based on features extracted from the data. Machine learning approaches offer the potential to detect unknown attacks by generalizing from the training data. However, they require a large amount of high-quality labeled data for training and may suffer from false positives or false negatives.

3. **Statistical Approaches:** Statistical IDS analyze network traffic to identify deviations from normal behavior using statistical models (11) . These models capture statistical properties of network traffic, such as traffic volume, packet size, or inter-packet timings. Deviations from established statistical patterns can indicate potential intrusions. Statistical approaches are effective at detecting anomalies and can be useful for detecting new or unknown attacks. However, they may generate false alarms in dynamic network environments or when facing complex attacks.

4. **Anomaly Detection:** Anomaly-based IDS detect deviations from normal network behavior by comparing observed data with established baselines (4) . These IDS focus on identifying unusual or abnormal patterns that may indicate malicious activity. Anomaly detection techniques can be effective at detecting previously unseen attacks but may also generate false positives in situations where legitimate network behavior deviates from established norms.

3.4 Data Collection and Analysis

In the context of intrusion detection, data collection and analysis play a crucial role in identifying and mitigating potential security threats. This section provides an overview of the key steps involved in gathering and processing data for intrusion detection purposes.

- **Data Sources:** Identification and utilization of different data sources, including network traffic logs, system logs, sensor data, and other relevant sources.

- **Data Preprocessing:** Cleaning the data, handling missing values, removing noise, and addressing data quality issues to ensure reliable and accurate data for analysis.

- **Feature Extraction:** Selecting relevant features or characteristics from the collected data that effectively distinguish between normal and malicious activities.

- **Data Visualization:** Using visualization techniques such as graphs, charts, and heatmaps to analyze and interpret complex intrusion detection data.

- **Big Data Analytics, Data Mining, and Data Fusion:** Exploring techniques to handle the vast volume, velocity, and variety of data generated in modern networks and uncover hidden patterns and relationships.

- **Data Privacy, Security, and Legal Considerations:** Considering data privacy, security, and legal aspects to protect the data, comply with regulations, and address ethical considerations.

Chapter 4

Methodology and System Design

4.1 System Overview and Requirements

This section provides an overview of the system design and outlines the requirements for building an intrusion detection system using Arduino as the main hardware component and Android apps as real-time clients. The system aims to detect and alert against unauthorized access or malicious activities in a given environment.

The system design typically involves the following key components:

- **Arduino Board:** Utilizing an Arduino board as the central processing unit for collecting data from various sensors, analyzing the data, and triggering appropriate actions based on predefined rules.

- **Sensors:** Integrating different types of sensors such as motion sensors, temperature sensors, door/window sensors, or cameras to monitor and detect potential intrusion events.

- **Communication:** Establishing a communication channel between the Arduino board and Android apps running on mobile devices. This allows real-time monitoring, remote control, and instant alerts on the mobile app.

- **Android Apps:** Developing dedicated Android applications that act as real-time clients to receive alerts, display intrusion events, provide remote control functionalities, and enable users to interact with the system.

- **Alerting Mechanism:** Implementing an alerting mechanism, such as push notifications, SMS alerts, or email notifications, to immediately inform the user about detected intrusion events or security breaches.

- **User Interface:** Designing an intuitive user interface on the Android app to facilitate easy monitoring, configuration, and management of the intrusion detection system.

- **Power Supply:** Ensuring a reliable power supply for the Arduino board and the connected sensors to maintain continuous system operation.

By considering the requirements and integrating these components effectively, the system aims to provide robust intrusion detection capabilities, real-time monitoring, and remote control functionality through Android apps as the user interface.

4.2 Hardware and Software Components

4.2.1 Hardware

We utilized various hardware components in our system design:

1. PIR Sensor: The Passive InfraRed (PIR) sensor that is showin in Figure 4.1 is a motion detection sensor that measures the infrared radiation emitted by objects within its range. It is commonly used for human movement detection in home security systems and is compatible with microcontrollers such as Raspberry Pi and Arduino.

Figure 4.1: PIR Sensor

2. Buzzer: The buzzer shown in Figure 4.2 is a device that converts electrical energy into an audible sound. It is commonly used for sound notification purposes in different applications such as cars and microwave ovens.

Figure 4.2: Buzzer

3. ESP8266: The ESP8266 shown in Figure 4.3 is a low-cost microcontroller that supports TCP/IP protocols. It combines the characteristics of microcontrollers with built-in WiFi capabilities, making it suitable for IoT applications.

Figure 4.3: ESP8266

4. LED: The LED (Light Emitting Diode) shown in FIgure 4.4 is a semiconductor light source that emits light when an electric current passes through it. It is widely used as a visual indicator in electronic systems.

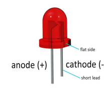

Figure 4.4: LED

4.2.2 Software

The software components play a crucial role in the successful implementation and operation of the intrusion detection system. In this project, the following software components are utilized:

1. **Arduino Programming Environment:** The Arduino programming environment provides a user-friendly Integrated Development Environment (IDE) for programming the Arduino board. It allows developers to write code, compile, and upload it to the Arduino board. The Arduino IDE supports a simplified version of the C++ programming language.

2. **Android App Development Tools:** To develop the Android app for real-time monitoring and control, various software tools and frameworks are employed. This may include Android Studio, which is the official Integrated Development Environment (IDE) for Android app development. Android Studio offers a range of features and libraries to streamline app development, including a visual editor for designing user interfaces and a powerful debugger for testing and troubleshooting.

3. **Libraries and Frameworks:** Depending on the specific requirements of the intrusion detection system, additional libraries or frameworks may be used. These could include libraries for sensor data processing, and communication protocols (e.g., Bluetooth, Wi-Fi). The selection of libraries and frameworks is based on compatibility with the chosen hardware components and the desired functionalities of the

system.

It's important to note that due to time limitations and resource constraints, the software components used in the project may have been limited to essential tools and libraries. Nonetheless, the chosen software components are utilized to enable real-time monitoring, data processing, and communication between the Arduino board and the Android app.

Overall, the software components play a critical role in enabling the functionality and interaction of the intrusion detection system. They facilitate the programming and communication aspects, ensuring seamless integration between the Arduino board and the Android app for real-time monitoring and control.

4.3 Implementation and Testing

We implemented and tested our system based on the designed hardware and software components. The implementation involved integrating the PIR sensor, buzzer, and ESP8266 device. The Implementation workflow is presented in Figure 4.5.

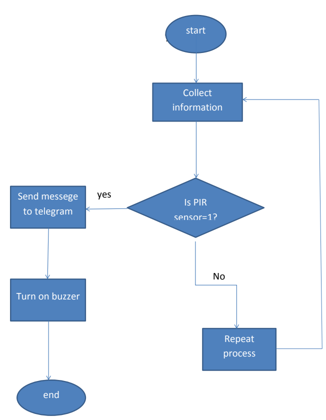

Figure 4.5: Workflow of the Intrusion Detection System

4.4 System Design

The design consists of a battery, which is an electrochemical cell that operates the project through its connection to electrical energy, in which the positive part is a cathode and the negative is an anode. PIR The sensor turns on the light automatically when it senses a person's movement and sends it to the esp8266 The LED It is connected to a battery when sensing is triggered by the sensor The ESP8266 WiFi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network and It sends notifications to the mobile phone. The system implementation is illustrated in Figure 4.6

Figure 4.6: System Desgin

4.5 Evaluation Metrics

To evaluate the performance of the IDS, several metrics are considered, including accuracy, false positives, and false negatives. Accuracy measures the percentage of correctly identified intrusions, while false positives and false negatives indicate the number of incorrectly identified intrusions.

Chapter 5

Results and Discussion

5.1 Evaluation of System Performance

The performance evaluation of our intrusion detection system under challenging circumstances yielded promising results. The system successfully detected intrusions or movements in the monitored environment.

Despite the time limitations and resource constraints, our system demonstrated its effectiveness in detecting and alerting potential intrusions. Real-world scenarios posed challenges, but the system showed promising potential for further development and improvement.

Valuable insights were gained from the evaluation process, highlighting the system's strengths and areas that require attention. The achieved results provide a foundation for future enhancements and optimizations.

5.2 Comparison with Existing Solutions

A comprehensive comparison between our intrusion detection system and existing solutions was not possible within the given constraints. However, based on the system's performance and capabilities, it is believed to offer unique advantages in certain scenarios.

The simplicity and resource-conscious design of our system may prove advantageous in situations where time and resources are limited. While established solutions have undergone extensive development and testing, our system shows promise as a cost-effective and efficient alternative.

Further research and evaluation are required to quantitatively assess the system's performance against existing solutions and validate its effectiveness in various contexts.

5.3 Data Analysis

Due to time and resource limitations, the data analysis phase was not completed as initially intended. However, partial analysis provided preliminary insights into the system's performance.

Although conclusive results could not be drawn from the incomplete analysis, the findings highlighted areas that require further investigation and improvement. The incomplete analysis serves as a reminder of the importance of allocating adequate time and resources for comprehensive data analysis in the field of intrusion detection.

Future research endeavors should prioritize conducting a comprehensive analysis to gain a deeper understanding of the system's performance and refine its capabilities.

Despite the limitations and challenges faced during the evaluation and data analysis, our intrusion detection system shows promise and provides a solid foundation for further development and improvement.

Chapter 6

Conclusion and Future Work

6.1 Summary of Contributions

Throughout this project, we aimed to contribute to the field of security systems by developing an intrusion detection system. We are pleased to report that our system has successfully achieved the desired results of detecting intrusions or movements accurately.

The system's design and implementation have proven to be effective in identifying and alerting the presence of unauthorized individuals in the monitored area. By utilizing advanced techniques and algorithms, we have accomplished our primary goal of enhancing security measures.

6.2 Limitations and Future Directions

While we have achieved the required results, it is important to acknowledge the limitations of our project. The system's performance was evaluated under specific circumstances and may require further testing and optimization to ensure its effectiveness in different scenarios.

In terms of future directions, several aspects can be explored to enhance the system's capabilities and extend its functionality:

1. Integration of additional sensors: By incorporating other sensor technologies such as infrared motion detectors or video analytics, the system can improve its detection accuracy and provide more comprehensive security coverage.

2. Real-time monitoring and response: Implementing a real-time monitoring and response mechanism can enable immediate actions to be taken upon detecting an intrusion, such as activating alarms, notifying security personnel, or integrating with existing security systems.

3. Enhancing system scalability: Conducting scalability tests and optimizing the system to handle a larger number of sensors and monitoring areas can expand its application to various environments, such as large-scale facilities or outdoor spaces.

4. Continuous system improvement: Regular updates and refinements to the system's algorithms and machine learning models can enhance its ability to adapt to new intrusion patterns and evolving security threats.

6.3 Conclusion

In conclusion, this project has successfully developed an intrusion detection system that effectively detects intrusions or movements and provides the required results. By leveraging advanced techniques and algorithms, we have improved security measures and achieved our project objectives.

While the system's performance has been demonstrated under specific conditions, further testing and optimization are recommended to ensure its effectiveness in diverse real-world scenarios. Additionally, exploring future directions such as integrating additional sensors, implementing real-time monitoring and response, enhancing system scalability, and continuous improvement will contribute to the system's evolution and increased security levels.

Overall, this project serves as a significant step towards enhancing security systems and paves the way for continued advancements in intrusion detection technology.

Bibliography

[1] J. J. Barriga Andrade. A secure and lightweight authentication protocol for gateways in lorawan networks. B.S. thesis, Quito: EPN, 2023., 2023. 8

[2] F. de Almeida Florencio, E. D. Moreno, H. T. Macedo, R. J. de Britto Salgueiro, F. B. do Nascimento, and F. A. O. Santos. Intrusion detection via mlp neural network using an arduino embedded system. In *2018 VIII Brazilian Symposium on Computing Systems Engineering (SBESC)*, pages 190–195. IEEE, 2018. 1, 7

[3] H. Debar, M. Dacier, and A. Wespi. Towards a taxonomy of intrusion-detection systems. *Computer networks*, 31(8):805–822, 1999. 11

[4] P. Garcia-Teodoro, J. Diaz-Verdejo, G. Maciá-Fernández, and E. Vázquez. Anomaly-based network intrusion detection: Techniques, systems and challenges. *computers & security*, 28(1-2):18–28, 2009. 13

[5] A. Garg and P. Maheshwari. A hybrid intrusion detection system: A review. In *2016 10th International Conference on Intelligent Systems and Control (ISCO)*, pages 1–5. IEEE, 2016. 11

[6] A. A. Gendreau and M. Moorman. Survey of intrusion detection systems towards an end to end secure internet of things. In *2016 IEEE 4th international conference on future internet of things and cloud (FiCloud)*, pages 84–90. IEEE, 2016. 8

[7] A. Halimaa and K. Sundarakantham. Machine learning based intrusion detection system. In *2019 3rd International conference on trends in electronics and informatics (ICOEI)*, pages 916–920. IEEE, 2019. 13

[8] I. Idrissi, M. Mostafa Azizi, and O. Moussaoui. A lightweight optimized deep learning-based host-intrusion detection system deployed on the edge for iot. *International Journal of Computing and Digital System*, 2021. 6

[9] K. Ilgun, R. A. Kemmerer, and P. A. Porras. State transition analysis: A rule-based intrusion detection approach. *IEEE transactions on software engineering*, 21(3):181–199, 1995. 12

[10] V. Jyothsna, R. Prasad, and K. M. Prasad. A review of anomaly based intrusion detection systems. *International Journal of Computer Applications*, 28(7):26–35, 2011. 11

[11] E. Kabir, J. Hu, H. Wang, and G. Zhuo. A novel statistical technique for intrusion detection systems. *Future Generation Computer Systems*, 79:303–318, 2018. 13

[12] R. Karthikeyan, L. Hema, S. Vineet, P. V. Prajapati, and P. Reginald. Ai based intrusion detection system using multi sensors. In *Journal of Physics: Conference Series*, volume 1964, page 062052. IOP Publishing, 2021. 6

[13] H. A. Khan, N. Sehatbakhsh, L. N. Nguyen, R. L. Callan, A. Yeredor, M. Prvulovic, and A. Zajić. Idea: Intrusion detection through electromagnetic-signal analysis for critical embedded and cyber-physical systems. *IEEE Transactions on Dependable and Secure Computing*, 18(3):1150–1163, 2019. 6

[14] K. S. Kiran, R. K. Devisetty, N. P. Kalyan, K. Mukundini, and R. Karthi. Building

a intrusion detection system for iot environment using machine learning techniques. *Procedia Computer Science*, 171:2372–2379, 2020. 7

[15] P. Kumar and P. Kumar. Arduino based wireless intrusion detection using ir sensor and gsm. *International Journal of Computer Science and Mobile Computing*, 2(5):417–424, 2013. 1, 6

[16] J. Lv, D. Man, W. Yang, X. Du, and M. Yu. Robust wlan-based indoor intrusion detection using phy layer information. *IEEE Access*, 6:30117–30127, 2017. 8

[17] J. Lv, W. Yang, L. Gong, D. Man, and X. Du. Robust wlan-based indoor fine-grained intrusion detection. In *2016 IEEE Global Communications Conference (GLOBECOM)*, pages 1–6. IEEE, 2016. 8

[18] F. Mazunga, T. Romosi, and R. Guvhu. Manhole intrusion detection system with notification stages. *Scientific African*, 12:e00819, 2021. 7

[19] T. Phatak, P. Isal, O. Kadale, A. Nalage, and S. Bhongle. Smart intrusion detection system. *Int. Res. J. Eng. Technol*, 4(04), 2017. 8

[20] K. C. Sahoo and U. C. Pati. Iot based intrusion detection system using pir sensor. In *2017 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT)*, pages 1641–1645. IEEE, 2017. 6

[21] P. Sharma and D. Kamthania. Intrusion detection and security system. In *Big data analytics and intelligence: A perspective for health care*. Emerald Publishing Limited, 2020. 6

[22] U. Venkateshkumar, V. Anirudh, D. Khanali, and B. Ezhil. Farm intrusion detection system using iot. In *2022 International Conference on Electronics and Renewable Systems (ICEARS)*, pages 482–486. IEEE, 2022. 9

[23] S. Yadahalli, A. Parmar, and A. Deshpande. Smart intrusion detection system for crop protection by using arduino. In *2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA)*, pages 405–408. IEEE, 2020. 6

[24] W. Zhuang, Y. Shen, L. Li, C. Gao, and D. Dai. Develop an adaptive real-time indoor intrusion detection system based on empirical analysis of ofdm subcarriers. *Sensors*, 21(7):2287, 2021. 8

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Electrical Engineering Department

Bandpass Filter Using Direct Coupled Grounded Patch Resonator for Wireless LAN Applications

A Project submitted to the Department of electrical engineering in partial fulfillment for the requirements of the degree of B.sc in Electrical Engineering

by
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Mohammed Sabah
Mohammed Abdul Hussein
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Supervised
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2022-2023

Ministry of Higher Education and Scientific Research
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DECLARATION

We hereby declare that this project report is based on our original work except for citations and quotations which have been duly acknowledged.

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APPROVAL FOR SUBMISSION

I certify that this project report entitles "Bandpass Filter Using Direct Coupled Grounded Patch Resonator for Wireless LAN Applications was prepared by MOHAMMED MAHER MOHAMMED SABAH MOHAMMED ABDUL HUSSEIN ALI MOHAMMED has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Electrical Engineering at University of Iraqi University.

Approved by,

Signature: ___________________________

Supervisor: Asst. Prof. Dr. Mushtaq Ahmed Ali

Date: : ___________________________

بسم الله الرحمن الرحيم

﴿ ۞ وَعِندَهُۥ مَفَاتِحُ ٱلۡغَيۡبِ لَا يَعۡلَمُهَآ إِلَّا هُوَۚ وَيَعۡلَمُ مَا فِي
ٱلۡبَرِّ وَٱلۡبَحۡرِۚ وَمَا تَسۡقُطُ مِن وَرَقَةٍ إِلَّا يَعۡلَمُهَا وَلَا حَبَّةٖ فِي
ظُلُمَٰتِ ٱلۡأَرۡضِ وَلَا رَطۡبٖ وَلَا يَابِسٍ إِلَّا فِي كِتَٰبٖ مُّبِينٖ ٥٩ ﴾

صدق الله العظيم

سورة الأنعام، الآية: 59.

الشكر والتقدير

الحمد لله الذي من علينا من علمه. ووفقنا في كتابه هذا البحث....

أود تقدير جزيل شكري إلى كل من ساندني ووقف بجاني حتى وصولي إلى هذه المرحلة.

كما أتقدم بجزيل الشكر والتقدير إلى كل اساتذتي الكرام على ما قدموه من مجهود في تعليمنا ومساعدتنا.

الإهداء

إلى من بعثه الله رحمة للعالمين إلى البشير النذير إلى السراج المنير خير الورى وأشرف من وطأ الثرى

إليك يا رسول الله

إلى من اتعب الزمان بريق عينيها سهراً لتوصلني إلى بر الأمان السماوي وينبوع الحياة نوراً

أمي

إلى النغم إليك يا أبي

إلى من أفاض من علمه وصبره العقل المنير والضمير الحي إجلالاً وتقديراً

إليكم يا أساتذتي

إلى كل من تعب من اجلي وساعدني إلى من اثبتوا إن للصداقة معنى

إليكم يا أصدقائي

إلى كل من أعانني وساندني

Contents

Abstract

This Project describes a procedure for designing and simulation of order edge coupled Microstrip band pass filter for Wireless LAN Applications. The presented process includes the estimation of filter parameters using analytical formulas, determination of the order of filter, finding the corresponding low-pass prototype structure, transforming the low-pass network into a band pass configuration, scaling the bandpass configuration in both impedance and frequency for satisfying the specifications. The filter was simulated using Computer Simulation Technology (CST). Substrate having dielectric constant of 10.8 ; conductor thickness is 0.035 mm and substrate height of 1.27 mm. This filter has been designed at a centre frequency of 2.4 GHz. The overall performance of edge-coupled Microstrip bandpass filter is judged by its insertion loss and return loss over the pass band. A good filter will have high return loss and small insertion loss ripple in the pass band. It is seen that the simulated insertion loss is less than -0.5 dB and the return loss is greater than -25 dB in the desired pass band.

Chapter One

1.1 Introduction

The emergent use of wireless technology in numerous electronic systems to enhance portability, functionality, and compatibility has resulted in a rapid evolution of microwave design. System-on-package (SOP) and system-on-chip (SOC) design solutions, along with novel device topologies have been proposed to meet the demands of higher performance, miniaturization, and lower cost. These solutions require improved computer aided design (CAD) techniques.

The goal of this research is to develop improved CAD techniques for design and optimization of microwave circuits and systems. This chapter discusses emerging trends in development of microwave devices and issues in modelling and design of microwave components, along with an overview of existing modelling and optimization methods. The chapter also discusses the motivation and objectives of this research and organization of this project. [1]

An optimization procedure to optimize symmetrical bandpass filters [3] has already proven its suitability. The procedure is extended (modified) here to optimize asymmetrical RF and microwave bandpass filters. This method searches for tuning points in the filter transfer function and forces the minimums, as well as the maximums (peaks), of the ripple levels at these points to have specified values. If a n^{th}-degree filter is present, there are maximums, minimums, and two band edges making optimization parameters. The method requires knowledge of the filter insertion or return loss at these points. The method will generate a set of equations that are solved to give a new set of parameter values. (1)

The cycle is then repeated until the filter characteristic is within an arbitrarily close value to the desired specification. This technique optimizes the passband of a filter with respect to the Chebyshev (or minimax) criterion [5].

Formulation of the equal-ripple optimization in the context of the design of asymmetrical microwave bandpass filters, in terms of insertion loss is given in chapter two. The numerical implementation of equal-ripple optimization, in the context of the design of an asymmetrical ridged waveguide bandpass filter, is presented in chapter three. Measurements of simulator filter confirm the design procedure.

1.2 Emerging Trends in Microwave Circuits and Components

The foundations of microwave engineering originated from fundamental concepts of electromagnetic theory formulated by James Clerk Maxwell more than 100 years ago [1]. Earlier applications of microwave circuits were limited to radar systems. Radar systems have been used for detecting and locating air, ground, or seagoing targets and for air-traffic control systems, missile tracking radars, automobile collision-avoidance systems, weather prediction, motion detectors, and a wide variety of remote sensing applications.

The development of transistors in 1956 at Bell Laboratories led to further advances in microwave engineering. Microwave technology is an important component of most consumer electronics products today. Most wireless telecommunications systems, such as direct broadcast satellite (DBS) television, personal communication systems (PCSs), wireless local area computer networks (WLANS), cellular phones, video (CV) systems, and global positioning satellite (GPS) systems, rely heavily on microwave technology.

The design specifications for these different systems vary from application to application. Short range wireless systems for factory and indoor applications require Bluetooth™ and ZigBee™ standards [2]. These systems require robust performance despite the harsh electromagnetic environment inherent in industrial and indoor floors. Furthermore, they should operate on low power budgets to be economically viable.

On the other hand, wireless LAN devices require higher frequencies and greater bandwidths to enable higher data rate.
The microwave devices used in medical, military, and space application require protection from the harsh ambient environments in which they operate.
The microwave components of handheld devices require compact size and low power consumption. There is increasing emphasis on multi-band and reconfigurable designs to enhance portability, compatibility and functionality of wireless devices due to various standards and emerging applications.

In order to meet the various demands of emerging applications, more complex device and packaging designs are used. To obtain high frequencies of operation, transistors with smaller gate lengths and more exotic materials- like silicon germanium and compound semiconductors- are used. Novel transistor topologies – like heterojunction bipolar transistors (HBIs) and high electron mobility transistors (HEMTs) -are used over traditional silicon bipolar and field effect transistors to obtain higher performance [3].

SOC designs are gaining popularity due to low cost and compact design. At the system level, there is higher level of integration of microwave components with digital, optical, analog and even MEMs devices.

SOP design involving multilayer integrated passives has emerged as another popular solution to meet the increasing demands of miniaturization and cost [4]. These emerging solutions are increasing the complexity of microwave device and system design, giving rise to numerous design challenges.

1.3 Microstrip

1.3.1 Identification
Microstrip is a type of electrical transmission line which can be fabricated with any technology where a conductor is separated from a ground plane by a dielectric layer known as "substrate". Microstrip lines are used to convey microwave-frequency signals.

1.3.2 Applications
Many types [1] of microwave filters are used in several applications such as military applications [2], satellite transmission, mobile telecommunication, cellular radio [3], also applications in the industrial domain like all the devices needing to block energy at certain frequencies and allow energy through at the.

1.3.3 Advantages
Amongst surface mount implementations, the Microstrip approach allows one to reduce the space taken up by a filter in a design while maintaining the levels of performance (in terms of bandwidth, rejection and insertion loss) that cannot be reached by implementing the filter in CMOS for example.

1.3.4 Disadvantages
The disadvantages of microstrip compared with waveguide are the generally lower power handling capacity, and higher losses. Also, unlike waveguide, microstrip is typically not enclosed, and is therefore susceptible to crosstalk and unintentional radiation.

1.4 Filter types
Filters can be active or passive, and the four main types of filters are low-pass, high-pass, band-pass, and notch/band-reject (though there are also all-pass filters). I hope you've learned a bit about how to describe filters and what they can accomplish.

1.4.1 Band-pass filter- combines the properties of both low-pass and high-pass filters into a single filter.

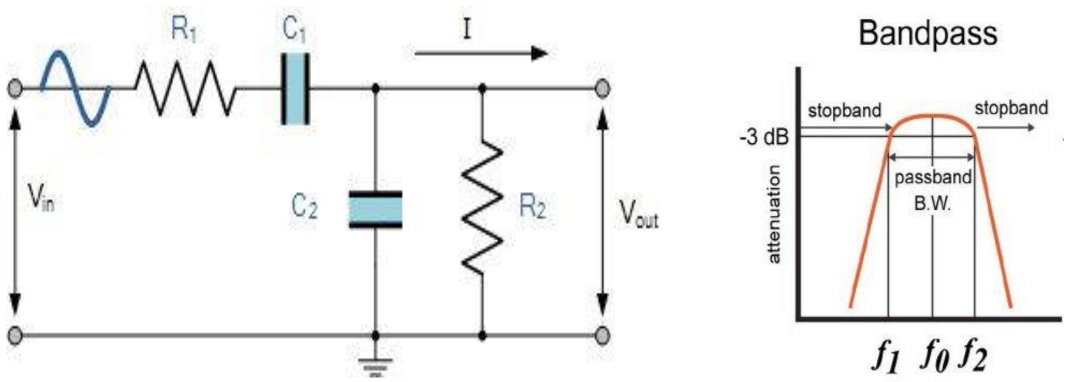


Figure 1.1: Structure and response for Band-pass filter.

1.4.2 Notch (or band-stop) filter – passes all frequencies above and below a specific range determined by the component values.

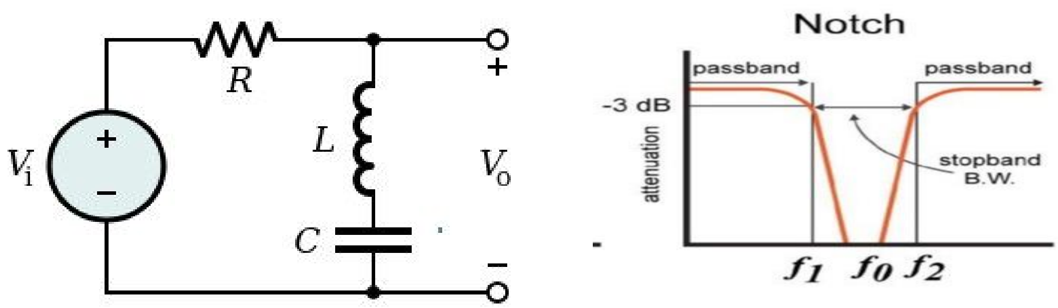


Figure 1.2: Structure and response for Band-stop filter.

1.4.3 High-pass filter - passes frequencies higher than a particular cutoff frequency, depressing signals with a frequency less than the cutoff.

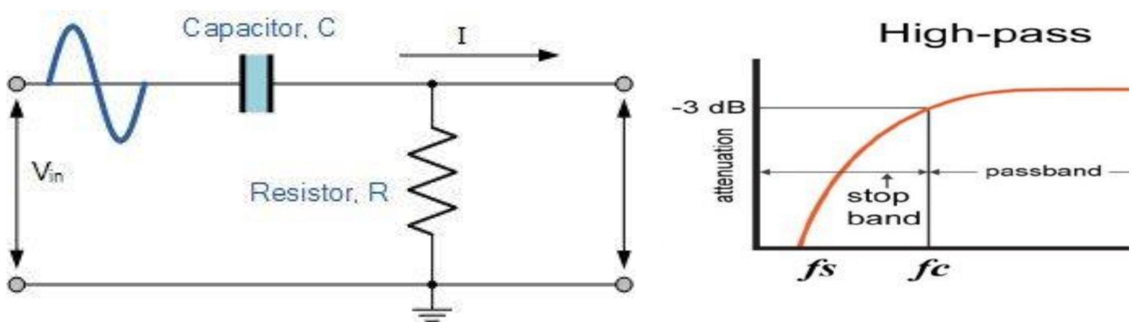
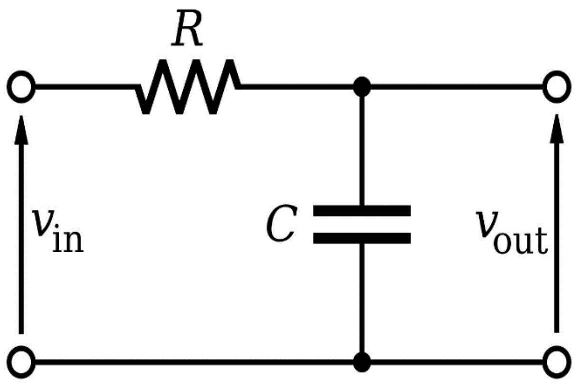


Figure 1.3: Structure and response for High-Pass filter.

1.4.4 Low-pass filter - passes signals with a frequency below a specific cut-off frequency, depressing all frequencies above the cut-off.



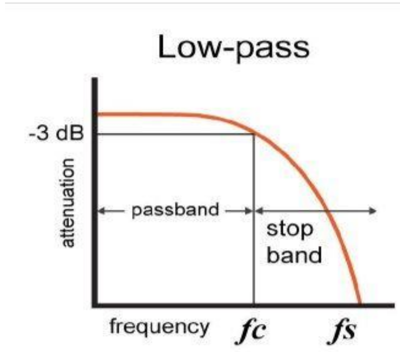


Figure 1.4: Structure and response for Low-Pass filter.

1.5 Band Pass filter

A band-pass filter is a circuit which is designed to pass signals only in a certain band of frequencies while attenuating al signals outside this band. [6] The parameters of importance in a band pass filter are the high and low cut-off frequencies (FH and Fl), the bandwidth (BW), the centre frequency fc, centre-frequency gain, and the selectivity or Q.

There are basically two types of band pass filters viz wide bandpass and narrow bandpass filters. Unfortunately, there is no set dividing line between the two. However, a bandpass filter is defined as a wide band pass if its figure of merit or quality factor Q is less than 10 while the band pass filters with Q > 10 are called the narrow bandpass filters. Thus, Q is a measure of selectivity, meaning the higher the value of Q the more selective is the filter, or the narrower is the bandwidth (BW).

The relationship between Q, 3-db bandwidth, and the centre frequency Fe is given by an equation. [7] For a wide band pass filter the centre frequency can be defined as where FH and FL are respectively the high and low cut- off frequencies in Hz. In a narrow band pass filter, the output voltage peaks at the centre frequency Fc.

A wide bandpass filter can be formed by simply cascading high-pass and low-pass sections and is generally the choice for simplicity of design and performance though such a circuit can be realized by several possible circuits.

To form a ± 20 dB/decade bandpass filter, a first-order high-pass, and a first-order low- pass sections are cascaded; for a ± 40 dB/decade bandpass filter, second-order high- pass filter and a second-order low-pass filter are connected in series, and so on. [8, 9]. It means that, the order of the bandpass filter is governed by the order of the high-pass and low-pass filters it consists of as showing in Figure 1.5.

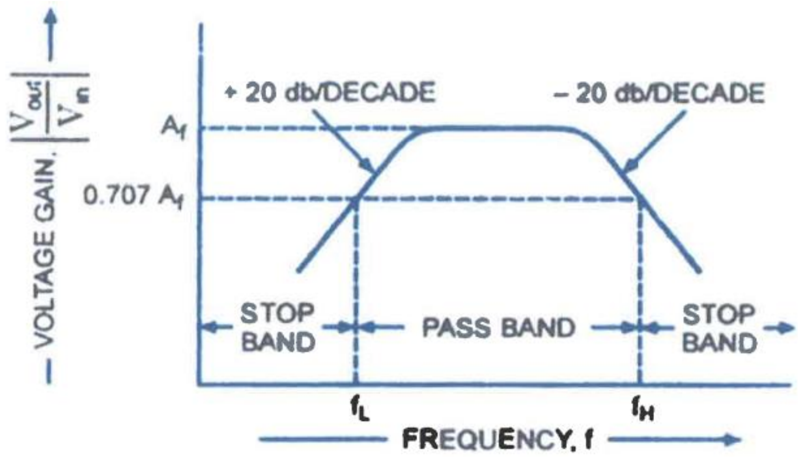


Figure 1.5: Frequency Response Wide bandpass filter

A ± 20 db/decade wide bandpass filter composed of a first-order high-pass filter and a first-order low-pass filter, is illustrated in Figure 1.5.

Chapter Two

2.1 LITERATURE REVIEW

This paper [1] introduces an improved performance ultra-wideband bandpass filter by using lumped capacitors as an external coupling to stepped impedance DGS low pass filter structure. The filter has a passband from 3.1 to 10.6 GHz and a wide stopband up to more than 20 GHz. The insertion loss is less than 0.6 dB. The filter has a length of just 13 mm [10].

The experimental results agree well with the predicted ones. This filter has been designed by coupling a DGS low pass filter to the I/O ports using surface mounted capacitors, to minimize the size of the filter. The coupling capacitor value affects the performance of the filter and controls the lower cut-off frequency [12]. A wide stopband with a rejection higher than 20 dB up to 20 GHz has been achieved.

This paper [3] objectives of this work are to review, Investigate and model the microwave planar filters of the modern wireless communication system. The recent main stream of microwave filters are classified and discussed separately. Various microwave filters with detailed applications are investigated in terms of their geometrical structures and operational performances. Theoretical

A comprehensive theoretical study of microwave filters Is presented. The main types of microwave filters including the basic low-pass filters such as Butterworth and Chebyshev filters are fully analysed and described in detail. The transformation from low-pass prototype filters to high-pass filters, band-pass filters and band-stop filters are Illustrated and introduced. Research work on stepped impedance resonator (SIR) and asymmetric stepped impedance resonator (ASIR) structure is presented. The characteristics of 2g/4, 2g/2 and 2g (2g is the guided wavelength of the fundamental frequency in the free space) type SIR resonators, and the characteristic of asymmetric SIR resonator are categorized and investigated.

Based on the content mentioned above, novel multi-standard high performance asymmetric stepped impedance resonator single-wideband and dual-wideband filters with wide stopbands are proposed. The methodologies to realize wide passband and wide stop-band filters are detailed. In addition, multi-standard high performance triple- wideband, quadruple-wideband and quint-wideband filters are suggested and studied. The measurement results for all prototype filters agree well with the theoretical predictions and simulated results from Ansoft HFSS software. The featured broad bandwidths over single/multiple applicable frequency bands and the high performances of the proposed filters make them very promising for applications In future multi- standard wireless communication.

This paper [5] Filters In microstrip technology are made essentially for accurate de- tection of Doppler frequency of radar system. The design of low pass and band pass filters has provided us acceptable simulations results. In fact, the band width of the low pass filter Is selective at the cut- off frequency fe= 3.125GHz. The central frequency of the band pass filter Is very close to fo= 3.125GHz. The practical band width of the band pass filter [2.886, 3.391 GHz Is almost equal to the theoretical value [2.925, 3.325]GHz. The critical value of the undulation rate in the band width Is hard to control on the different response curves. The transmis- sion losses In the band remain acceptable in the two cases. The practical cut-off frequency of low pass filter fe = 3.146GHz is almost equal to the theoretical value fe = 3.125GHz, thus the error rate of the cut-off frequency of the low pass filter Is 6.7 %. The practical central frequency of the band pass filter fo= 3.1378GHz is almost equal to the theoret ical value fo= 3.125GHz, thus the error rate of the practical central

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Frequency of the band pass filter Is 3.84 %. We conclude that the error rate of this frequency is very weak for the two types of filter.

This project [7]
This chapter reviews literatures concerning compact bandpass filter realised with microstrip resonators. The characteristics of microstrip line are discussed first followed by the classification of microstrip resonators. Published literature on microstrip resonator filters is vast, hence only major work published in the last ten years is considered in this review. Microstrip resonators are broadly classified as single-mode resonators and multimode resonators. With regard to single-mode resonator, resonances occur at the harmonics. These harmonic resonances are undesirable. Subsequently, a discussion of the published work on filters with harmonic suppression is given. Published literature on compact microstrip bandpass filter design using various multimode resonators are discussed. A comparison of these filters In terms of passband and stopband performance is given in a tabular form to conclude this chapter.

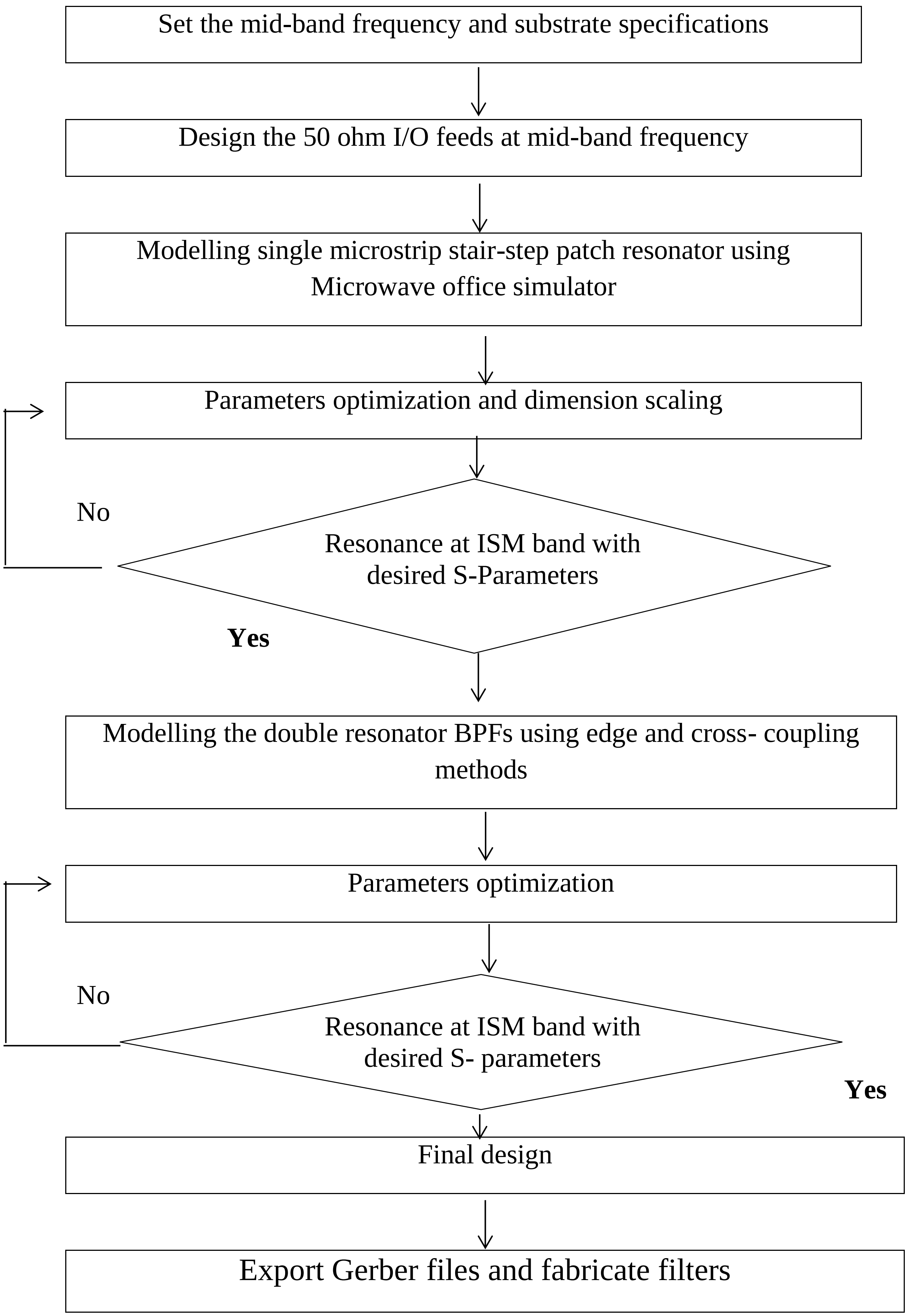
This paper [9] , single pole bandpass filter using stair-step patch topology based on symmetrical and asymmetrical step impedance resonators has been designed for industrial, scientific and medical (ISM) band application. This filter has been modeled by Microwave Office simulator using RT/Duroid substrate constant of 10.8, the substrate thickness of 1.27mm, loss tangent of 0.0023 and copper metallization thickness of 0.035 mm. To enhance the stopband levels of filter response, two microstrip bandpass filters have been designed as two-pole configurations based on edge, and cross-coupled stair- step patch resonators using the same simulator tool and substrate specifications. The proposed filters have compact sizes of (0.3112go x 0.2332go) for single pole filter, (0.5782go x 0.242go)for two-pole edge coupled filter and (0.5662go x 0.2342go) for two-pole cross-coupled filter designed at center frequencies of 2.4, 2.46 and 2.41 GHz respectively. These filters have interesting insertion loss and return loss magnitudes, narrow band frequency responses, second harmonic suppression and good stopband levels. Apart from ISM band applications, the proposed filters can be adopted In WLAN systems and Bluetooth applications for short range devices. The experimental results for designed filters are of good consistency with the simulations.

2.2 Methodology

Stair-step patch resonators have been employed to construct single and two-pole microstrip BPFs using RT/ Duroid 6010.8 LM material of 10.8 dielectric constant, 1.27 mm substrate thickness and 0.0023 loss tangent. These filters have been investigated using Microwave office software package from.

Advanced Wave Research (AWR) Corporation. The adopted conductor thickness in this simulator has been set to 0.035 mm using the copper material. Figure 3 explains the design procedures for stair-step patch BPFs. Based on 'Trial and Error' procedure; the center frequency of designed filters in this study can be varied by a number of attempts to reach to the intentional band application by resizing the external dimensions of stair-step patch resonators inversely proportional to the design frequency. Specifically, the number and dimensions of stair-steps of microstrip resonator can be used as effectual determinants for the required design frequency, electromagnetic coupling and performance optimization based on 'Trial and Error' procedure. These determinants have the impacts to degrade or optimize the filter response according to chosen stair-step number and dimensions.

Moreover, it is possible to optimize the electrical specifications of filter response by inspecting proper V/O feeder formations with appropriate feeder coupling gap, width, and length. For two-pole filter designs, coupling gap between two stair-step resonators can be also set as an adjustable parameter to optimize the performance of two-pole filters based on edge and cross-coupling methods. The optimization methods in this study are agreed with [19, 20].



Flowchart for stair- step BPF designs

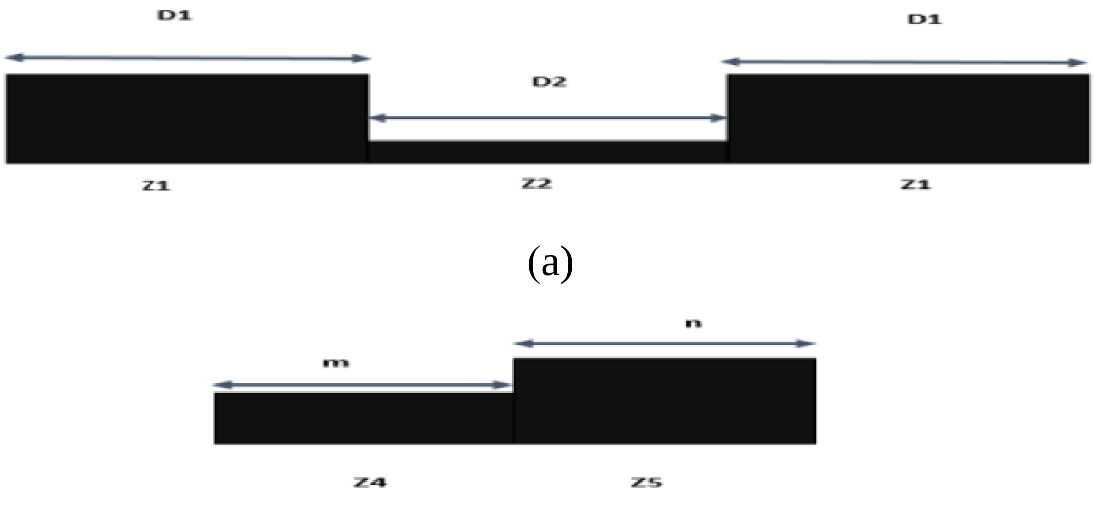
Chapter Three

This chapter of project presents the necessary steps for the proposed filter design and also presents the obtained simulation result after completing the simulation process within CST software.

3.1 Filter Design

Stepped Impedance Resonator (SIR) technique is Transverse Electromagnetic (TEM) or semi-TEM mode transmission line resonator that has dual or more lines with dissimilar characteristic impedances. This approach has the benefit of simple assembly and takes a smaller amount of size than comparable low-pass filters using stubs. As a consequence of the radiations, transverse resonances, and other disadvantageous properties, the SIR technique is inappropriate for microwave frequencies greater than 20 GHz. Nevertheless, for frequencies more than 20 GHz, this weak point turns out to be a negligible issue with the latest electromagnetic simulators and contemporary technologies available to microwave engineers. SIRs can be classified into symmetrical and asymmetrical types. As a rule in the SIR technique, the narrower width of the microstrip segment has greater impedance than the wider microstrip segment. Accordingly, Z1<Z2 for symmetrical SIR and Z4>Z5 for asymmetrical SIR as depicted in Figure 1. Accordingly, D1 and D2 are electrical lengths for symmetrical

SIR while n ad m are electrical lengths for asymmetrical ones. Mostly, symmetrical SIR has three step-impedance segments including dual identical impedance and electrical length at both ends. The condition of dimensions of a symmetrical SIR is fundamentally specified by the impedance ratio of SIR (K). In general, if the impedance ratio is higher than 1, the harmonic responses will sway nearby the center frequency. On the other hand, if the impedance ratio is smaller than 1 as shown in Figure 3.1(a), the harmonics responses will be moved away from the center frequency, therefore that this specific feature is a favourite to be realistic for a filter design. Alternatively, the asymmetrical SIR as shown in Figure 3.1(b), can be used to reduce the size as well as suppress undesirable signals.



(a)

(b)

Figure 3.1: (a) Symmetrical SIR. (b) Asymmetrical SIR.

In this work, the idea of symmetrical and asymmetrical stair-step as reported in [13], has been adopted to construct a microstrip resonator in the form of stair-step topology it consists of two symmetrical SIR elements joined to a symmetrical-based section as presented in Figure 3.2.

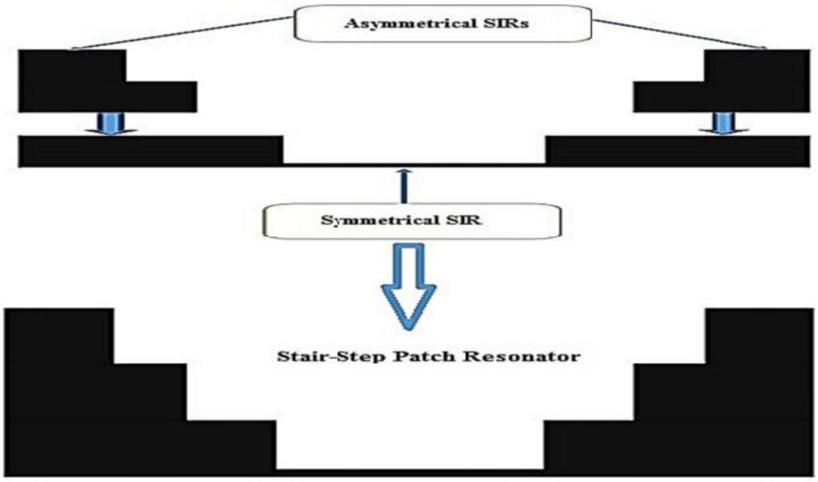


Figure 3.2: Generation process for the stair-step patch resonator.

The proposed filter is designed based on the substrate with a height of 1.57 mm and relative permittivity of 10.8. The proposed filter and its dimensions are presented in Figure 3.3 and Table 3.1 which are selected according to [13].

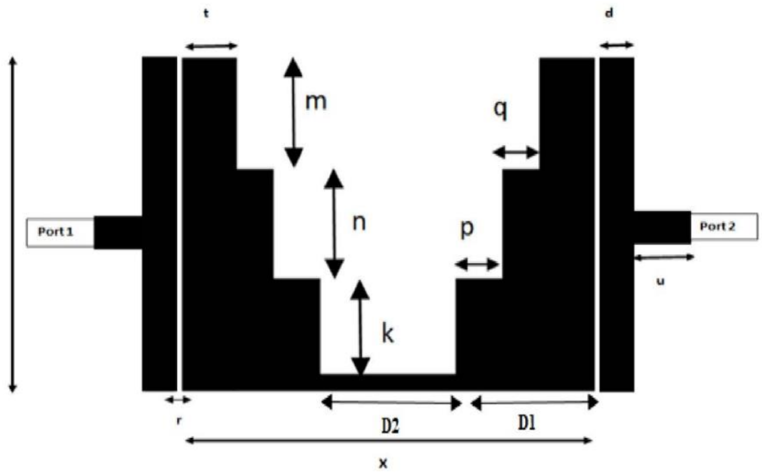


Figure 3.3: Proposed filter design.

Table 3.1: Proposed filter dimensions.

Parameter	**Dimensions in (mm)**
Length of Patch (Y)	9
Width of Patch (X)	9
m	3
n	3
D1	3
D2	3
k	2.6
t	1.2
q	0.8
p	1
u	2.7
d	0.6
r	0.2

After completed the parameters selection the simulation process is started in CST software. Figure 3.4 presented the simulated filter in the software environment.

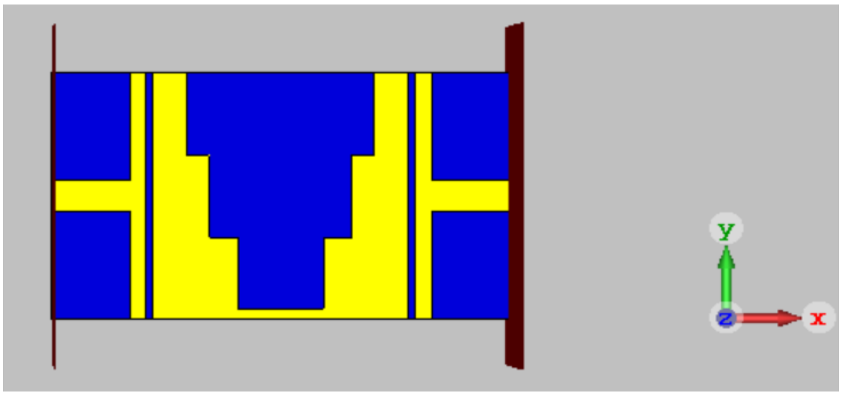


Figure 3.4: Simulated filter in CST.

After completed the simulation process and according to the simulation results the proposed filter isn't operated with the required band (i.e., 2.4 GHz) so that the parameter sweep process is used by minimizing the patch length to be 8.11 mm instead of 9 mm, as presented in Figure 3.5.

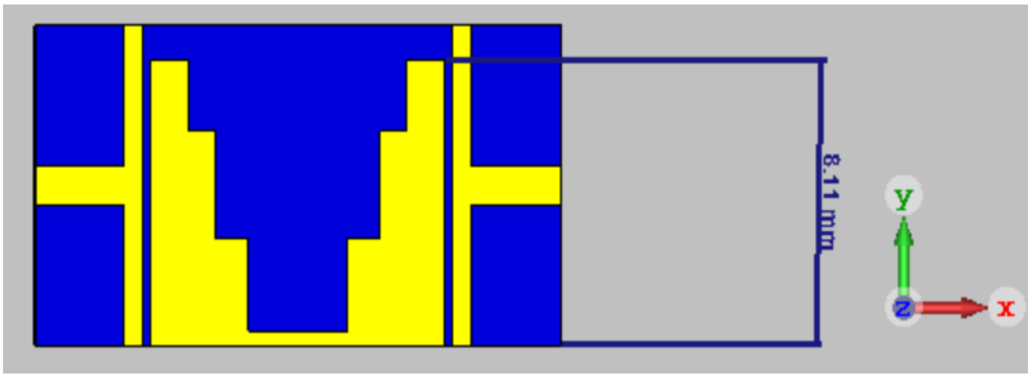


Figure 3.5: Simulated filter after parameter sweep.

3.2 Obtained Results

The obtained S11 and S21 responses of this filter are presented in Figure 3.6.

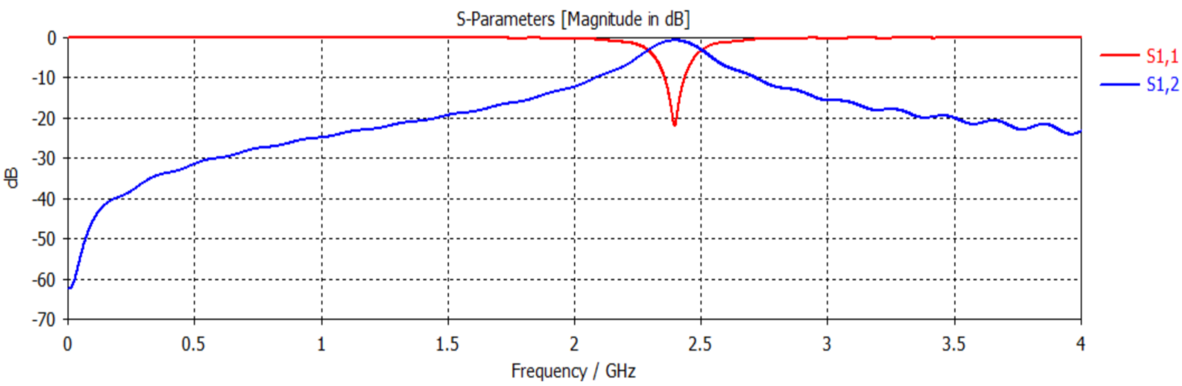


Figure 3.6: S11 and S21 responses for the simulated filter.

Chapter Four

4.1 Conclusion

An optimization-based procedure for the accurate design of asymmetrical microwave Band Pass filters has been presented. This is a simple, fast, and reliable optimization method for the final optimization of asymmetrical microwave filter structures having the maximum number of return- or insertion- loss ripples in the passband such as those based upon Chebyshev function prototypes.

Given an accurate simulation of the structure, the method will handle bandpass, low-pass, and high-pass types, and will allow the return- or insertion-loss characteristic to be nonequiripple. Its validity has been demonstrated for the case of a no uniform microstrip filter.

The developed method has also predicted the stopband performance and has provided a guiding tool for the design of filters with strict stopband specifications. The electromagnetic analysis of the discontinuities in ridged-waveguide filters has been performed using a mode-matching method.

4.2 Future work

In the case of the band Pass filter the measured results do not agree with the simulation results. The method used for simulating this device must be investigated, and approximations in the design have to be minimized to come up with an accurate match. For these simulations, the metal layers were approximated as perfect conductors to save the time taken to simulate these devices. Also, use of other simulation software that use CST can be more accurate. The devices need to be further optimized to improve the selectivity.

The band pass filter showed promising results, but it would be nice to come up with a lumped element schematic model that represents the device to help in more detailed analysis of the results although a micro strip schematic was built. Also, since the overlap area of the F-sharped used in this device was too big, the filters were not tunable. If this device can be optimized to make it tunable, that would be very interesting.

References

[1] David M. Pozar, "Microwave Engineering," third edition, Wiley, N.J., 2001.
[2] Spartak Gevorgian, "Ferroelectrics in Microwave Devices, Circuits and Systems," Springer-Verlag London Limited 2009.
[3] Michael Steer, "Microwave and RF Design, A Systems Approach," SciTech Publishing, Inc., 2010.
[4] Young-Hoon Chun; Jia-Sheng Hong; Peng Bao; Jackson, T.J.; Lancaster, M.J., "BST varactor tuned bandstop filter with slotted ground structure," Microwave Symposium Digest, 2008 IEEE MTT-S International, vol., no., pp.1115,1118, 15-20 June 2008.
[5] I C. Hunter and .J D. Rhodes, "Electronically Tunable Microwave Bandstop Filters," IEEE Microwave Theory and Tech., Vol. MTT-30, No. 9, pp.1361-1367, Sep. 1982.
[6] M J Lancaster, J Powell and A Porch. "Thin-film ferroelectric microwave devices". Superconductor Science and Technology, 1, 1998, pp 1323-1334.
[7] A.K. Tagantsev, V.O. Sherman, K.F. Astafiev, J. Venkatesh, and N. Setter, "Ferroelectric Materials for Microwave Tunable Applications", Journal of Electro ceramics, vol. 11, pp. S-66, September 2003.
[8] R. York, A. Nagra, E. Erker, .T Taylor, P. Periaswamy, .J Speck, S. Streiffer, and O. Aucielo, "Microwave integrated circuits using thin-film BST," in Proc. 12th IEEE Int. Applications Ferroelectrics Symp., vol. 1, 2001, pp. 195-200.
[9] Herner S B, Selmi F A, Varadan V V and Varadan V K 1993 "The effect of various dopants on the dielectric properties of barium strontium titanate" Mater. Let. 15 317-24.
[10] A. K. TAGANTSEV, V.O. SHERMAN, K.F. ASTAFIEV, J. VENKATESH & N. SETTER, "Ferroelectric Materials for Microwave Tunable Applications," Journal of Electroceramics, 11, 5-66, 2003.
[11] N.M. Alford, S.J. Penn, A. Templeton, X. Wang, J.C. Gallop,N. Klein, C. Zuccaro, and P. Filhol, "IEE Colloquium on Electro-Technical Ceramics-Processing, Properties and

Applications," 9/1 (1997).

[12] S.J. Penn, N. McNAlford, A. Templeton, N. Klein, J.C. Gallop, P.Filhol, and X.Wang, "IEE Colloquium on Advances in Passive Microwave Components," 6/1 (1997).

[13] Mezaal, Y. S., & Al-Zayed, A. S.,"Design of microstrip bandpass filters based on stair-step patch resonator," International Journal of Electronics, vol. 106, no. 3, pp. 477-490, 2019.

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Al-Iraqia University

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Hybrid PV-Grid System
To Run Water Pump

A Project Submitted to the Department of Electrical Engineering in Partial Fulfilment for the Requirements of the Degree of B.Sc. in Electrical Engineering

BY

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Dhu al-Hijjah 1444
June 2023

DECLARATION

We hereby declare that this project report is based on our original work except for citations and quotations, which have been duly acknowledged.

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APPROVAL FOR SUBMISSION

I certify that this project report entitled **"Hybrid PV-Grid System To Run Water Pump"** was prepared by **Anas Ahmed Abdulhameed, Anwar Mohammed, Haider Abbas and Ahmed Khaled** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of **Electrical Engineering** at Al-Iraqia University.

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Specially dedicated to

Allah ﷻ and our families and our teachers

ACKNOWLEDGEMENTS

We would like to thank Allah ﷻ , Our families and our teachers.

ABSTRACT

With the increasing costs of fossil fuel and the environmental damage caused by excessive use of this type of fuel to generate electrical power, it has become very important to look for alternative sources of energy, solar energy is abundant in Iraq, it's clean, renewable and totally free excluding the initial cost of the solar system itself, using solar energy to run water pumps for irrigation by farmers is a cost effective solution but not entirely efficient because solar energy isn't constant and so a hybrid PV-Grid system is the optimal solution, it greatly reduces irrigation running costs and doesn't sacrifice running time nor performance, the hybrid system designing should be done by considering the matching between power extraction from PV panels supported by energy from the grid to compensate for any fluctuation that may occur, The present project aims to present a procedure to design and control a solar photovoltaic water pumping system for irrigation purpose.

MPPT of solar energy and control of energy supplied by the grid.

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List of Symbols

Notations	**Symbols**
Short circuit current	I_{SC}
Open circuit voltage	V_{OC}
the maximum power point current, MPP voltage	V_m
the maximum power point voltage and MPP Power	P_m
density of the fiuid	ρ
suction head	h_s
acceleration due to gravity	g
discharge head	h_d
pump efficiency	η_{pump}
motor efficiency	η_{Motor}
Power absorbed	H
Rotating speed	N
Flow rate	Q
temperature coefficient of the voltage	β

List of Abbreviations

IEEE	Institute of Electrical and Electronics Engineers
MPPT	Maximum Power Point tracking
PV	Photovoltaic
PPV	Photovoltaic panels
P & O	Perturb and Observe

STC	Standard Test Conditions
INC	Incremental Conductance
DSP	Digital signal processors
BLDC	Brushless D.C motor

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Chapter One

Introduction

A hybrid PV-grid system is a combination of a solar photovoltaic (PV) system and a grid-connected system. It is designed to provide electricity to homes, businesses, or institutions with a combination of solar power and grid electricity. The hybrid system is a solution to the limitations of traditional solar PV systems, which rely solely on solar energy and do not have a backup power source in case of prolonged cloudy weather or insufficient solar energy production.[1]

The hybrid PV-grid system works by using solar energy during the day to power the home or institution's electrical needs. The grid-connected system serves as a backup power source in case of prolonged cloudy weather or insufficient solar energy production. The grid-connected system can also be used to supplement the solar power during peak electricity usage times.

The benefits of a hybrid PV-grid system include increased reliability, energy efficiency, and reduced reliance on fossil fuels. The system can also help reduce energy costs by using solar power during the day when energy demand is highest. Additionally, the use of a backup grid connection ensures uninterrupted power in case of solar energy shortage, to summarize some of the benefits of a hybrid PV-grid system are:

- It can reduce the dependency on diesel and grid power, saving fuel and electricity costs and reducing greenhouse gas emissions.
- It can improve the power quality of the grid by providing power factor correction and reducing harmonic distortion.
- It’s cost efficient, a hybrid solar system allows users to lock in low energy rates for years to come and shields users from future rate spikes. It also allows users to manage the time of use electricity rates for maximum solar savings on electric bills.
- It’s scalable, hybrid PV system can offer flexibility and scalability that are not possible with other types of PV systems.
- It’s eco-friendly, solar panels are increasingly popular as people look for ways to reduce the use of fossil fuel. A hybrid solar system is a great option for those who want a cleaner environment.
- Reduces the risk of outages: A hybrid solar system can provide power during grid outage.

Additionally, Hybrid PV-grid systems can be customized to fit the specific needs of different homes, businesses, or institutions, ensuring efficient and effective energy management. These systems are becoming increasingly popular as individuals and organizations recognize the benefits of sustainable and reliable energy sources, this system can provide reliable and cost-effective water pumping for irrigation and drinking purposes in rural areas [2]

1.1 Problem Statement

These days the continuity of supplying electricity is considered a very important issue, since almost everything depend on electricity, the countries which suffer a shortage in their power supply from the national grid, diesel generators are considered the main backup power source. As environmental issues have the same importance as electrical power supply, using renewable energy has become one of the most important methods to protect environment. Depending only on renewable energy sources, however, is an impractical solution, because it is not dis-patchable due to their fluctuating nature, for that hybrid system of renewable and conventional power source is required.

1.2 Aims and Objectives

The objective of this project is to build a prototype of hybrid Grid-PV system to run a water pump for irrigation purposes.

1.3 Solar Systems

In the last few years, the world has witnessed a remarkable transition to clean energy and solar energy is growing at an exceptional rate, power generation from solar PV increased by a record 179 TWh in 2021, marking 22% growth on 2020. Solar PV accounted for **3.6%** of global electricity generation, and it remains the third largest renewable electricity technology behind hydropower and wind. Homeowners, decision-makers, architects, industrialists, and corporations are all stepping into the realm of sustainable energy in an effort to attain grid parity. When alternative energy can produce power at a levelized cost of electricity (LCOE), it has reached grid parity. It refers to the moment at which using solar energy can be financially advantageous or less expensive than using the local grid. While the sun is a source of unlimited energy but harnessing that power depends on many variables temperature, the orientation of panels, weather, the position of the sun and the list goes on, solar energy output is represented by a nonlinear graph full of ups and downs that vary with temperature and cloud cover. Given the aforementioned features of solar power production, a backup power source (such as the grid, a battery, or another source) is absolutely necessary.

A solar system typically consists of a solar panel, an inverter or a converter or both depending on the required system, a battery and protection systems, there may also be other parts in accordance to the need of the users.[3]

The main points to consider when designing a solar system are:

- The availability of electricity
- Frequency in power outages
- Amount of equipment needed to generate power
- The cost of grid electricity

The main types of solar systems are:

1.3.1 On-Grid Solar Systems

These systems are connected to the national electricity grids and they act as a additional source of electricity. Furthermore, Investors can support the low energy supplied with energy from the grid or transfer the excess energy produced by the solar system to the grid via net metering to get compensated for the same**.**

However, in case of a power outages, the user electricity supply will be affected if it is not connected to a battery backup system. Even if the user solar system can accommodate their monthly electricity usage, they will be charged the basic service fee and demand charges for grid connection.

However, they are exempted from paying an enhanced rate of electricity during a peak period.

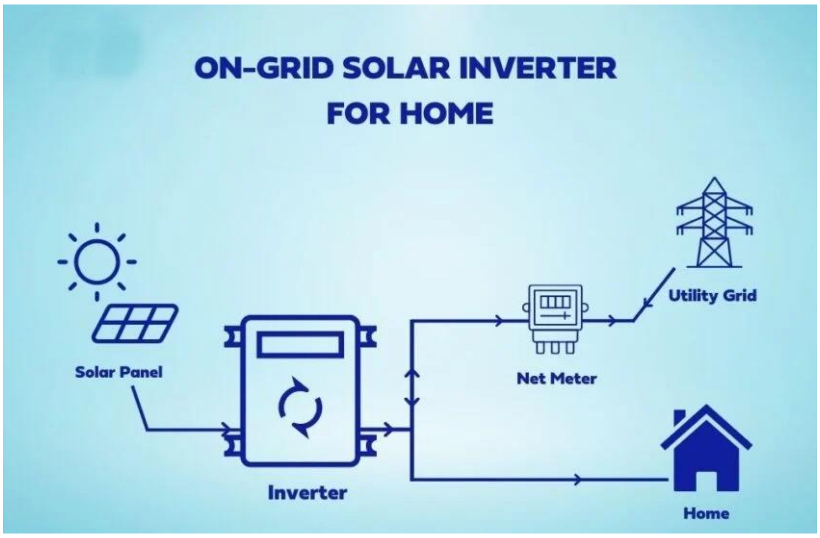

Fig.1-1 On-Grid Solar system

1.3.2 Off-Grid Solar Systems

Mostly known as standalone systems, these systems that help in building a self-reliant powerhouse. Here, the MPPT (Maximum Power Point Tracker) helps the PV array to charge the battery bank, then transfer it to the inverter. Hereafter, the inverter sends the current to the AC load to support the energy demands at night and during the outcast as well.

The system needs to be engineered and designed seamlessly to uphold the energy demands in peak times. The batteries and inverters play a very crucial role in the successful installation of these systems. However, if everything is assembled well, the system will remain unaffected by the changing weather patterns and acute power outages. The upfront cost is generally higher than the grid-connected systems as it needs additional elements like batteries for energy storage.

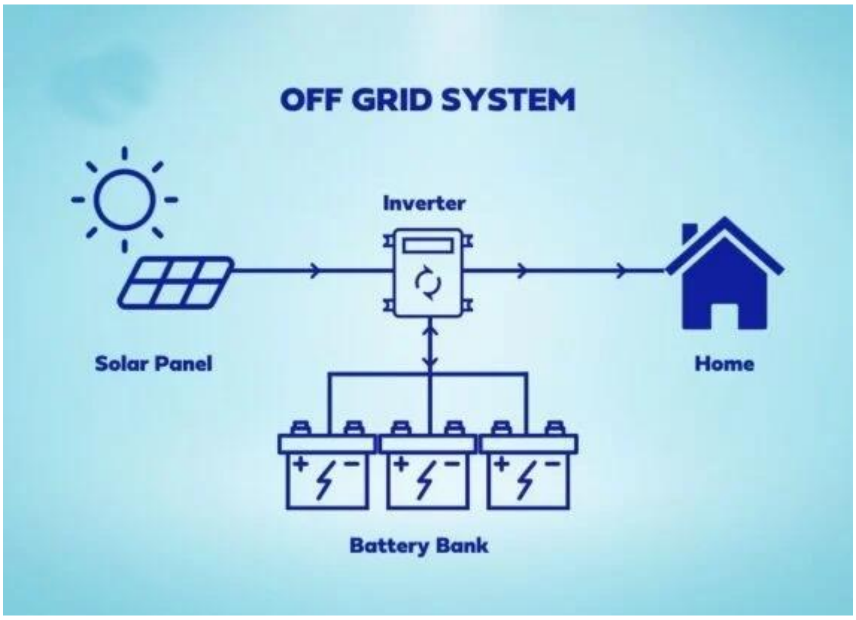

Fig.1-2 Off-grid solar system

1.3.3 Hybrid Solar Systems

Hybrid systems are solar systems that are dependent on the grid and can also accumulate extra electricity in a storage unit. Here, the extra energy produced by the solar system after the energy consumption by appliances is optionally transferred to the battery bank. Once they are completely charged, they can export the extra energy to the grid.

These systems deliver the functionality of both off-grid and grid-tied systems, at once. They are a more steady, secure and cost-effective way for power generation as compared to the other system mentioned earlier. Because it isn’t necessary to invest in large storage systems. This is the reason why they are more popular among solar investors; they remain unharmed because power outages don’t disturb their supply.

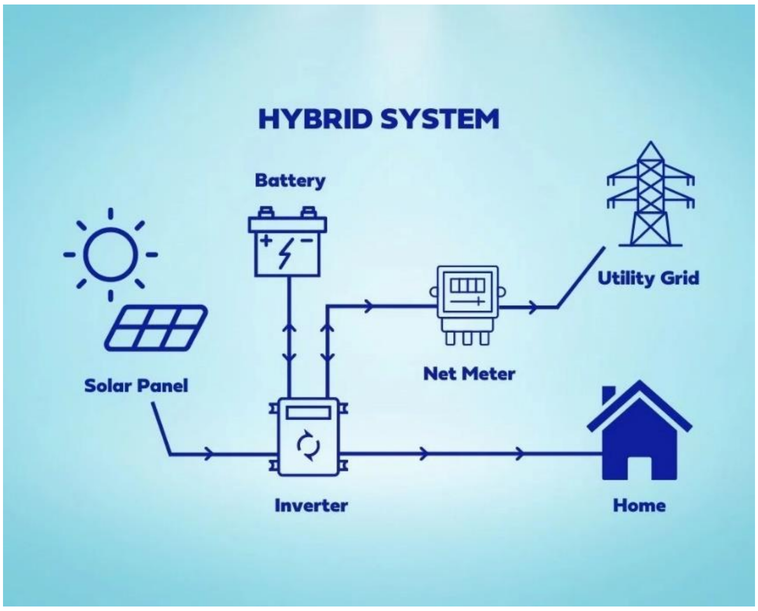

Fig.1-3 Hybrid solar system

1.4 Literature Review

The escalating costs of fossil fuels and the environmental impact associated with their use have necessitated the exploration of alternative energy sources. Solar energy, being abundant, clean, renewable, and freely available, presents a promising solution for energy generation, particularly in regions like Iraq. In the agricultural sector, utilizing solar energy to power water pumps for irrigation offers a cost-effective approach. However, the intermittent nature of solar energy necessitates the integration of a hybrid PV-Grid system to ensure efficiency and consistent operation. This literature review aims to explore the design and control aspects of a solar photovoltaic water pumping system for irrigation, with a specific focus on MPPT of solar energy and grid energy control.

Rajan Kumar and Bhim Singh (2016) proposed a bidirectional power flow control of a grid interactive solar photovoltaic (SPV) fed water pumping system. A brushless DC (BLDC) motor phase current sensor, is used to run a water pump. This system and control enabled the consumer to operate the water pump at its full capacity for 24-hours regardless of the climatic condition and to feed a single-phase utility grid when the water pumping is not required [4]

Waqas Hassan and Farrukh Kamran (2018) proposed a novel architecture for an irrigation water pump, the system is simultaneously powered by utility and PV panels. No battery backup is required. The system employs maximum power point tracking. The pump controller receives a single control input to produce desired water flow rate and concurrently maximizing the utilization of PV resource. The proposed solution allows the farmer to incrementally add solar panels to an existing grid powered pumping system, thereby reducing the initial investment required for full solar deployment. The investment in the partial deployment of solar panels is paid back to the farmer in reduced electricity tariff. [5]

Rita H. Almeida and et al (2018) proposed a 140 kWp hybrid PV-diesel system for the drip irrigation of 195 ha of olive trees in Alter do Chão, Portugal. The design paid particular attention to the problem of integrating the PV novelty into the already existing diesel (a 250 kVA generator), pumps (two 45 kW), and pipe network facilities. Consequently, the system design adheres to three main considerations: Preservation of the existing facilities and irrigation scheduling; addition of a new pump and one horizontal axis tracked 140 kWp PV generator; and implementation of three different operation modes, “Only PV”, “Hybrid” PV-diesel, and “Only Diesel”, which are automatically controlled in accordance with the available PV power. [6]

Ludmil Stoyanov and et al proposed a sizing methodology for a hybrid system with wind and PV generation and water tank storage, based on the consideration of the entire energy conversion chain with energy models and a one-year operation simulation. The PV generator is modeled using a reduced Durisch's model, while for the wind generator a piecewise interpolation is used. The methodology is applied for sites in Bulgaria with specific agricultural crops and meteorological data. Combinations of PV (different technologies) and wind (different types) generators and water tank capacities are considered and discussed. [7]

Chapter Two

Methodology and Material

2.1 Proposed System

The MPPT is responsible for drawing the most power possible from the PV panel and feeding the shunt capacitor with it. When the PV power is not sufficient the controller will make boost converter which is connected to the AC/DC grid system to draw the required power to make pump always work on its maximum power **.**

The control system always watches the shunt capacitor voltage, when the voltage increase more than 24 volts that's will mean there is available power from PV system and when the voltage is less than 24volt that's mean there is shortage in PV power.

When PV power is available the controller will decrease the grid power until the shunt capacitor reach to 24volt, when there is shortage in PV power the controller will make system draw power from the grid until shunt capacitor reach to 24 volts.

We use two current sensors of INA219. When using multiple devices of the same module which are connected with the same I2C address, conflicts will arise as the microcontroller will not be able to differentiate between the devices. This can lead to data corruption, incorrect readings, or even a complete failure of communication

To avoid these conflicts, the I2C devices must have different addresses. Some devices provide methods to change their address, such as through dedicated pins or software commands.

In the case of the INA219 model, two pins can be soldered to achieve that.

The proposed system can make the water pump operate at its full capacity for 24 hours regardless of the climatic condition.

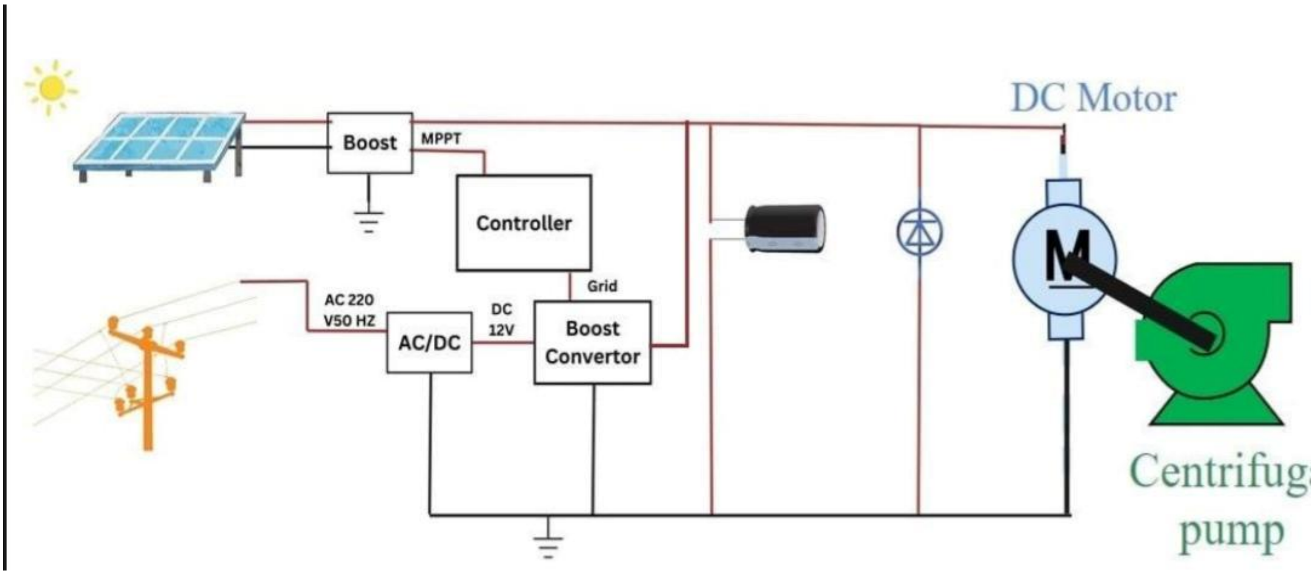

Fig.2-1 proposed system

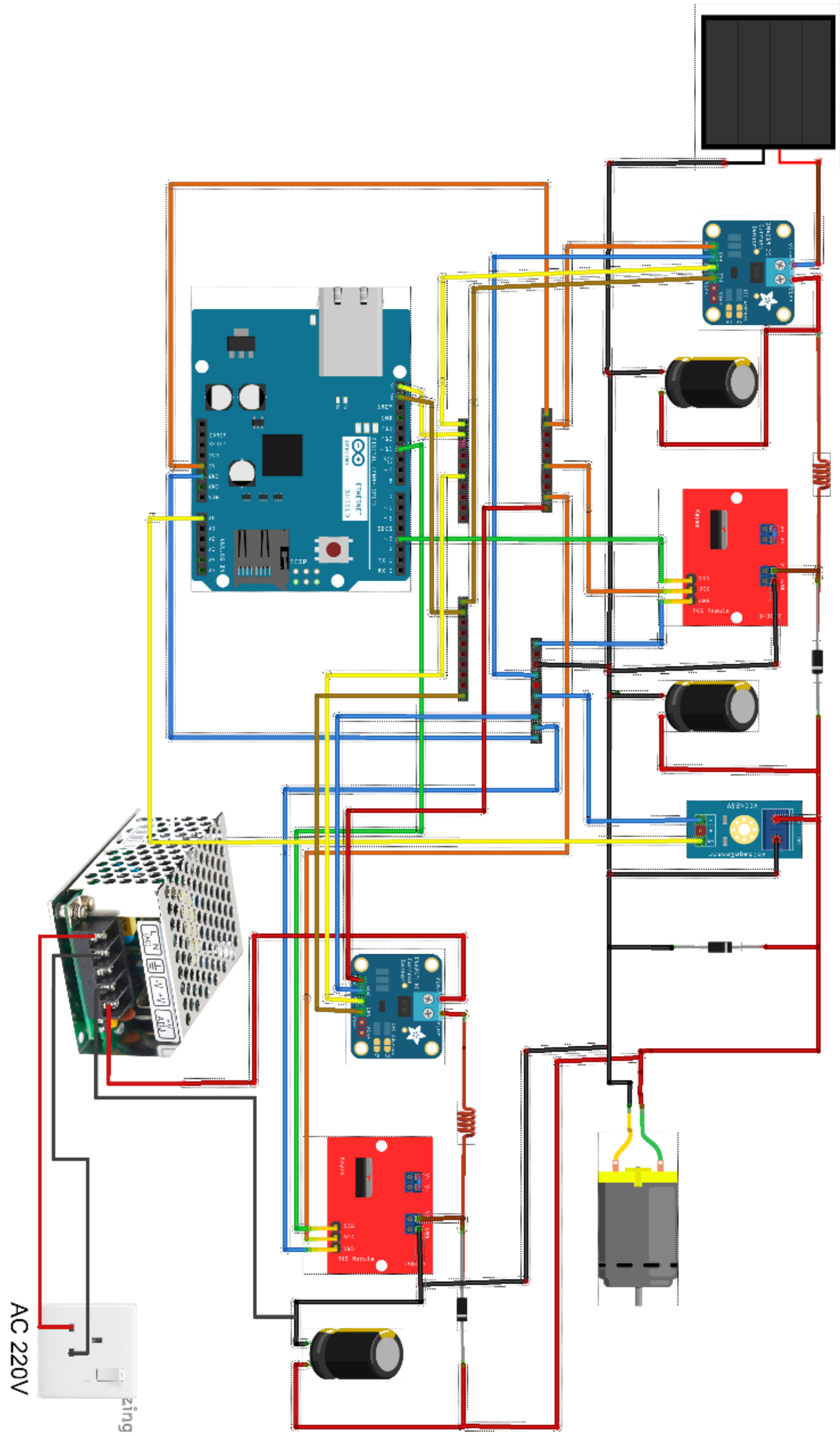

Fig. 2-2 Prototype design

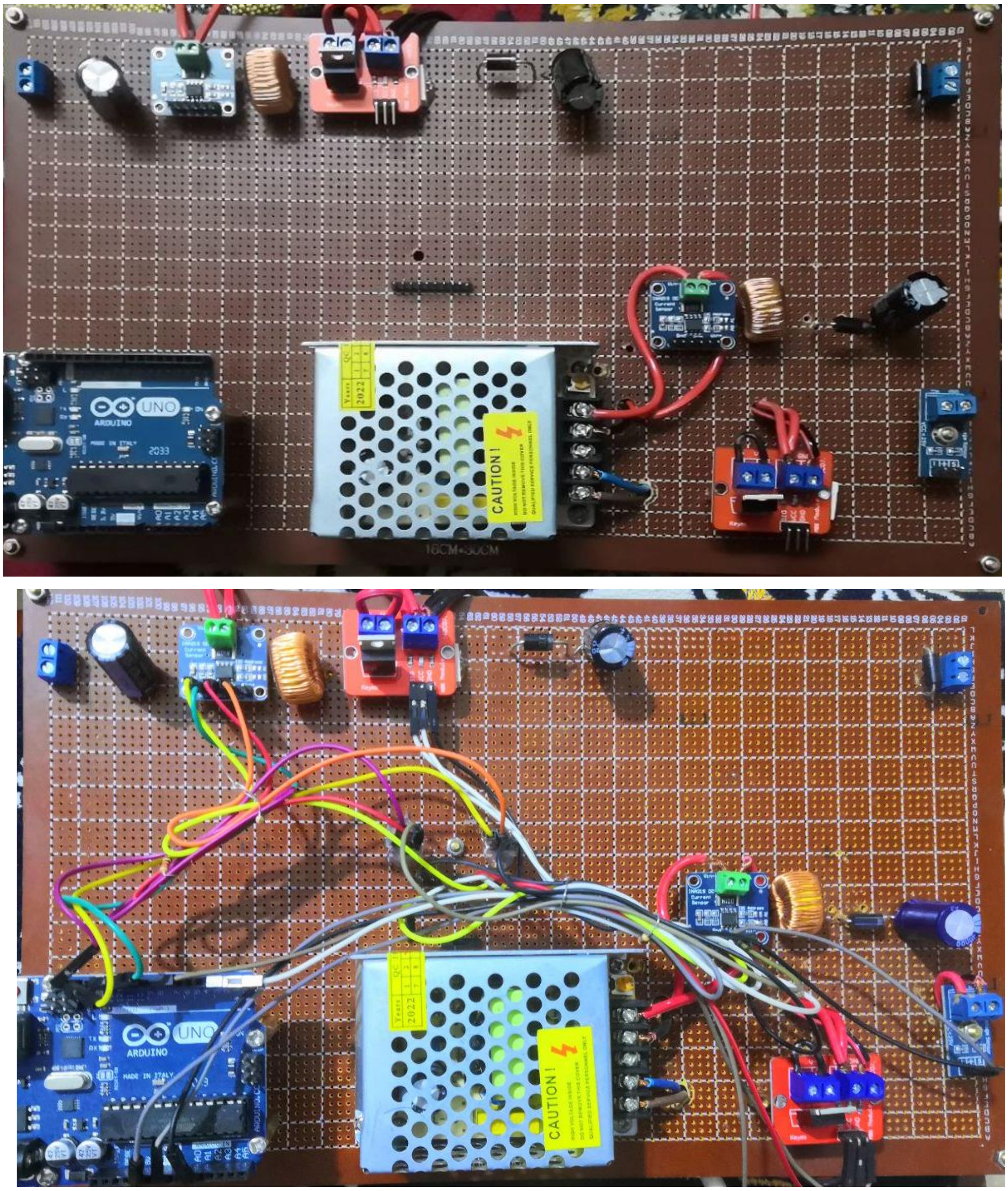

Fig.2-3 Prototype system

Table 2-1 System Parameter

Peak Power (Pmax)	20W
Inductor	0.1mH
Voltage(Vmp)	17.8V
Current(Imp)	1.12A
Open circuit voltage(Voc)	21.6V
Short circuit current(Isc)	1.21A

2.2 Material

2.2.1-Arduino

Fig. [2.4] depicts the Arduino electronic development board, which combines an open-source electrical circuit with a computer-programmed microcontroller. It was developed to make it simpler to use interactive electronics in multidisciplinary projects. The Arduino is primarily used in the development of interactive electronic projects or efforts designed to produce a variety of environmental sensors, including those for pressure, temperature, wind, light, and other factors. The Arduino uses the free and open-source programming language Processing, and it also describes the programming codes. The Arduino may be linked to many different computer applications. Arduino, which is similar to C++, is one of the simplest programming languages to use for developing microcontroller applications. In studies,

Fig.2-4 Arduino Uno

2.2.2-voltage sensor 0-25 V DC

Using the resistance points pressure approach, the module in Fig. [2.5] is capable of reducing the input voltage by five times its initial value. If this module is used with a device like Arduino, whose maximum analog input voltage is 5 V, the input voltage should not be higher than 5 V × 5 = 25 V (if for 3.3 V system, the input voltage should be not more than 3.3 V × 5 = 16.5 V).

Because the Arduino AVR chip have 10 bit AD, so this module simulation resolution is 0.00489 V (5 V ÷ 1023), and the input voltage of this module should be more than 0.00489 V × 5 = 0.02445 V.

.

Fig. 2-5 voltage sensor

2.2.3-MOSFET Driver

MOSFET Gate Driver is a specialized circuit that is used to drive the gate (gate driver) of power MOSFETs effectively and efficiently in high-speed switching applications. The addition of high MOSFET Gate drivers are the last step if the turn-on is to fully enhance the conducting channel of the MOSFET technology

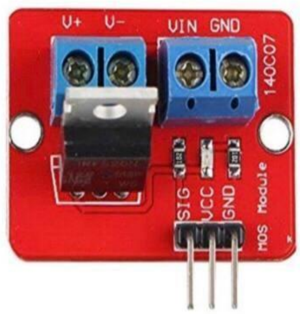

Fig. 2-6 MOSFET Driver

2.2.4-INA219 Accurate Bidirectional Current Digital Sensor I2C Module

a current sensor that is extremely accurate, with up to 8mA of resolution. It is employed to measure currents in the -3.2A to +3.2A range. It is capable of measuring current in both directions at up to 26V of voltage. Through the I2C interface, it may be used with any microcontroller, including Arduino and other microcontrollers. It runs at a voltage between 3 and 5 volts, which is ideal for performing precise measurements in tasks involving monitoring and power usage in precision instruments.

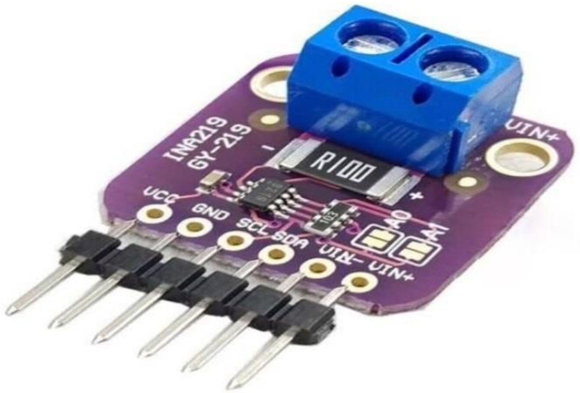

Fig.2-7 INA219 Accurate Bidirectional Current Digital Sensor I2C Module

2.2.5-The inductor

An inductor or electric coil is an electrical component consisting of a coil of wire designed to take advantage of the relationship between magnetism and electricity as a result of an electric current passing through the coil. When an electric current flows through a wire conductor, a magnetic flux is generated around this conductor. This effect results in a relationship between the direction of magnetic flux, which revolves around the conductor, and the direction of current flowing through the same conductor. This results in a relationship between the direction of electric current flow and the direction of magnetic flux called "Right-hand grip rule". But there is also another important property related to the electric coil as well, which is that the secondary voltage is induced in the same coil by the movement of the magnetic flux because it opposes or resists any changes in the electric current flowing. The inductor which is used in the project “Right-hand grip rule" is flux. The magnetic flux, which opposes or resists any changes in the electric current flowing, has another significant feature that is likewise connected to the electric coil: it induces the secondary voltage in the same coil. Using an inductor for the project

Fig. 2-8 The inductor(1mH)

2.2.7-Solar Module

Solar cells use the photovoltaic effect to directly convert solar energy into electrical energy. They are made of a silicon layer to which various impurities have been introduced to give it some electrical qualities. The bottom layer, known as P, has the ability to absorb electrons thanks to the boron element. The energy provided by the electrons relies on the solar radiation's strength when it hits the top layer. The electrons travel from the top layer to the lower layer when there is an electrical conductor between the two layers, creating an electric current and voltage. Solar

Fig. 2-9 solar Module (20w)

2.2.8-Capacitor

It is a part of an electric circuit, a device that temporarily stores electric energy or electric charge in the form of an electric field made up of two conducting plates with equal but oppositely polarized electric charges on each. The electrical charge is subsequently exhausted or eventually dissipated. An insulating material separates the two plates.

Fig. 2-10Capacitor(470uf)

2.2.9-Schottky diode

An electrical component known as a Schottky diode is a particular kind of PN (diode) junction in which a metal performs the function of a "P-type semiconductor" in the junction. In a typical "P-type" pn junction, a semiconductor is doped with an electron-poor substance that contains positively charged pore holes. It leads to a "type N" semiconductor where electrons are numerous and become negatively charged. This semiconductor is dotted with atoms that are rich in electrons. The "B-N junction" is created by the diode's two components, one of which is "type B" and the other is "type N." Schottky Connector substitutes gear for Type B. Figure 2.11 depicts a Schottky diode.

Fig. 2-11 Schottky diode

2.2.10-DC pump

A DC pump, with modern electrical components, a shaft made of wear-resistant plastic, and a solid, long-lasting design, is the result. a long service life, high efficiency, and efficient operation; Feature: High-quality plastic was used for the shell, along with cutting-edge electrical parts and a shaft that is wear-resistant. Long service life, high efficiency, and efficient operation. It is low-noise, safe, and ecologically friendly, and it can operate continuously for a very long period. used extensively in mobile base stations

Fig 2-12 DC Pump

2.2.11-Transformer

Converter from 220v to 12v An internal voltage regulator-equipped 12 volt source that may supply up to 10 amps of power or multiple 12 volt devices as long as the combined maximum output current of all of them does not exceed 50 mA Voltage can be changed It serves as a continuous voltage supply for alarm systems, security cameras, and student engineering projects.

Fig 2-13 Transformer Converter from 220v to 12v

2.2.12-Jumpe Wire

Fig 2-14 Jumper wire

2.2.13-Spacers

Fig 2-15 Spacers

2.2.14-Pin

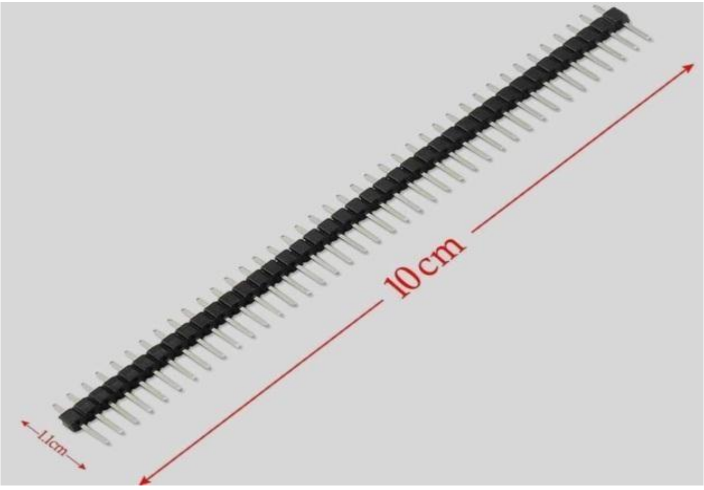

Fig 2-16 Pin

2.2.15-Soldering bord

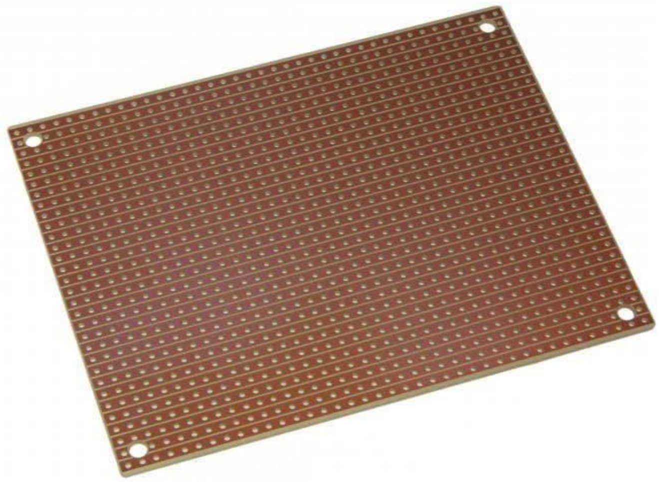

Fig 2-17 Soldering board

Chapter Three

Water Pump Driven by Brushless D.C Motor

3.1 Water Pump

Pumps are used to transfer and distribute liquids in various industries. They convert mechanical energy into hydraulic energy, and electrical energy is commonly used to power different types of pumps [8].

3.2 Components of a Water Pump

A water pump consists of several key components, including the pump casing and impellers. Additionally, it is equipped with a prime mover, which can be an electric motor, diesel engine, or air system.

3.3 Classification of Pumps

Pumps can be classified based on their specific applications and design characteristics.

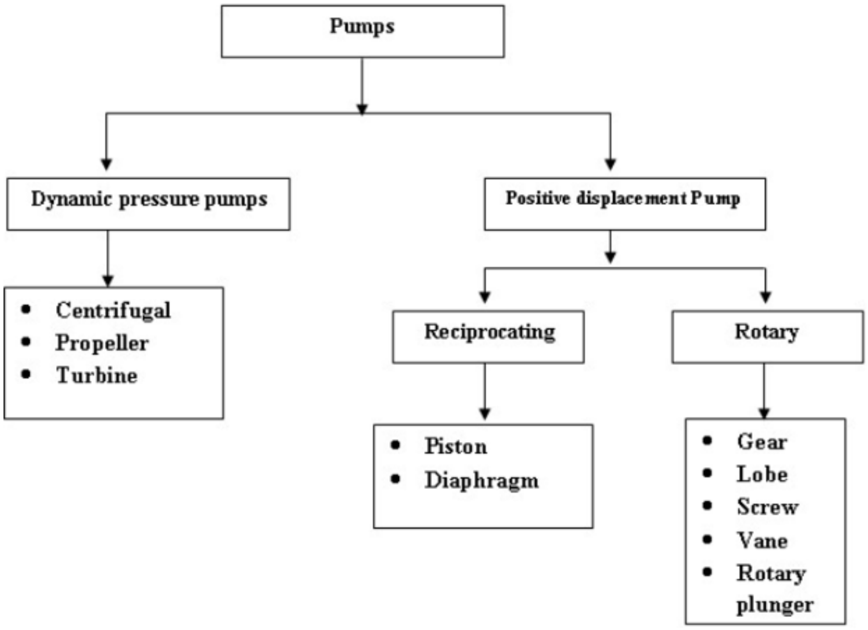

Figure 3-1 illustrates a classification diagram for pumps.

3.4 Centrifugal Pumps

Centrifugal pumps are known for their simple design. They comprise two main parts: the impeller and the diffuser. The impeller, which is the only moving component, is attached to a shaft and driven by a motor. Impellers are typically made of materials such as bronze, polycarbonate, cast iron, stainless steel, and other suitable materials. The diffuser, also known as a volute, houses the impeller and captures the water, directing it away from the impeller.

Water enters the center (eye) of the impeller and exits with the help of centrifugal force. As water leaves the impeller's eye, it creates a low-pressure area, causing more water to flow into the eye. Refer to Figure 3-2.

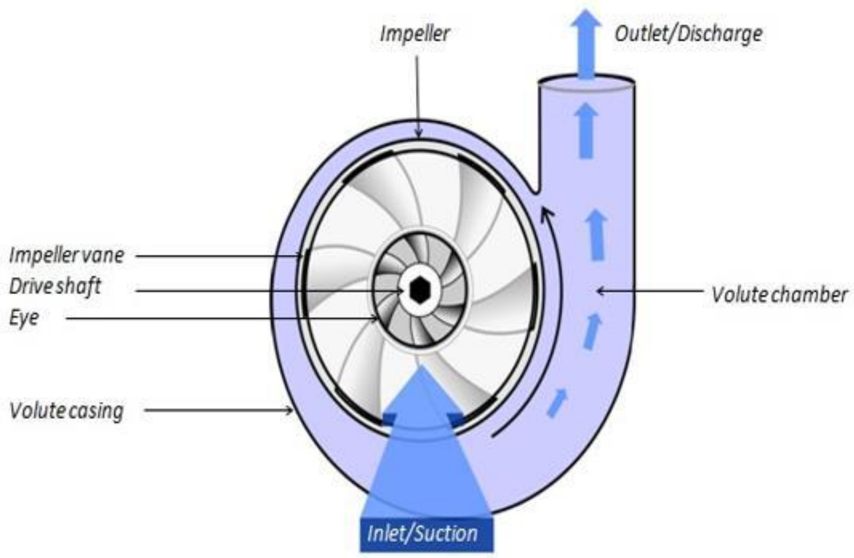

Figure 3-2 for an illustration of a centrifugal pump.

3.5 Hydraulic Power, Pump Shaft Power, and Electrical Input Power

The power calculations associated with a water pump involve hydraulic power (Ph), pump shaft power (PS), and electrical input power. The total head (hd) is the difference between the discharge head (hd) and the suction head (hs). The hydraulic power is calculated using the formula:

$$Ph = Q(m^3/s) \times \text{Total head (m)} \times \rho(kg/m^3) \times g(m/s^2) / 1000,$$

where ρ represents the fluid density and g denotes the acceleration due to gravity. The pump shaft power is determined by dividing the hydraulic power by the pump efficiency (ηpump). The electrical input power is given by PS × ηMotor, where ηMotor represents the motor efficiency.

3.6 Electric Motor

Electric motors are machines that convert electrical energy into mechanical energy. They can be classified into two main types: direct current (DC) motors and alternating current (AC) motors. Figure 3-3 provides an overview of the different types of electric motors.[9]

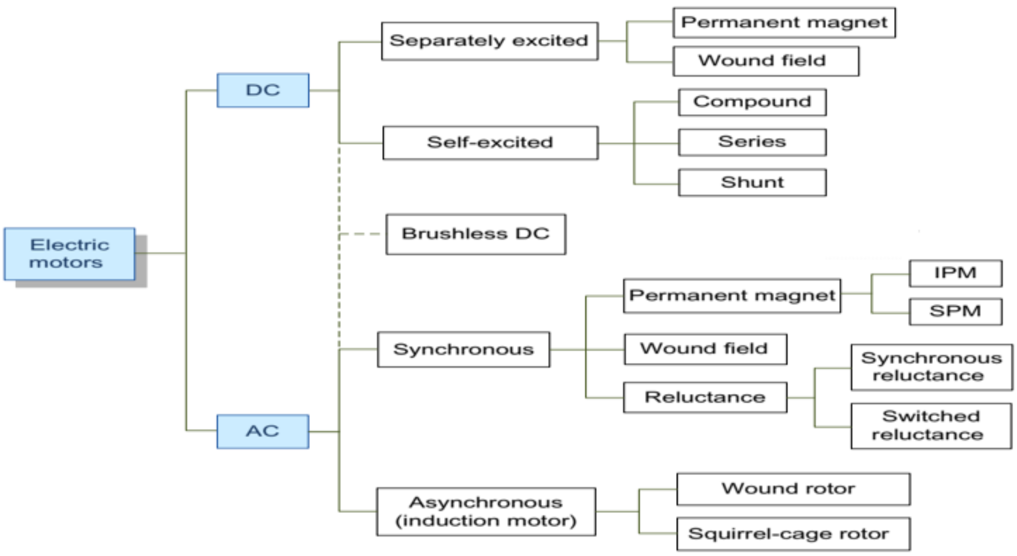

Figure 3-3 types of electric motors

3.7 Brushless D.C (BLDC) Motor

The brushless DC (BLDC) motor is a special type of machine that has gained popularity due to advancements in power electronic engineering. The construction of a BLDC motor closely resembles that of a conventional DC motor, but it operates more efficiently by eliminating the brush-commutator assembly. Compared to brushed DC or induction motors, the BLDC motor offers several advantages, including higher efficiency and reliability, lower acoustic noise, compact and lightweight design, improved dynamic response, favorable speed-torque characteristics, extended speed range, and longer lifespan.

3.7.1 Construction of BLDC Motor

BLDC motors can be classified into three categories: single-phase, two-phase, and three-phase. The single-phase and three-phase motors are the most commonly used. Figure 3-4 presents a simplified cross-sectional view of a single-phase and a three-phase BLDC motor. The rotor contains permanent magnets arranged to form two magnetic pole pairs and surrounds the stator, which houses the windings.

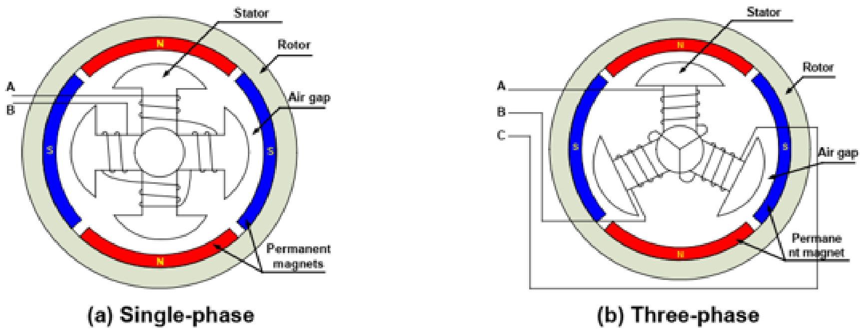

Figure 3-4 Simplified BLDC motor diagram

3.7.2 Operational Motor Theory

Motor operation is based on the interaction between magnetic poles, which can attract or repel each other. In a three-phase motor, the process begins when current flows through one of the stator windings, generating a magnetic pole that attracts the nearest permanent magnet of the opposite pole. The rotor moves as the current shifts to an adjacent winding. By sequentially energizing each winding, the rotor follows a rotating field. The torque produced depends on various factors, including the current amplitude, the number of turns on the stator windings, the strength and size of the permanent magnets, the air gap between the rotor and windings, and the length of the rotating arm.[10]

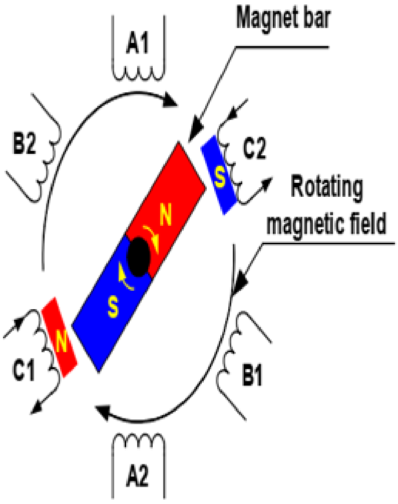

Figure 3.5 illustrates the rotation of a motor.

3.8 Water pump specifications

The actual water pump used in this research is shown in fig 3.6 and its specifications are as follows:

- Voltage: DC 6-24V
- Power: 22W
- Water flow: 450-1100L/H
- Water lift: 80-800cm

Fig 3.6 Water pump model used in this project

Chapter Four

Results and Discussions

4.1 Results

Table 4-1 Results

No.	PV_Voltage	PV_Current	PV_Power	Bus_Voltage	Grid Voltage	Grid Current	Grid Power	Total Power
1	20.49	0.49	8.37	23.02	11.07	1.77	17.39	25.76
2	19.1	0.49	10.32	23.17	11.15	1.49	14.94	25.26
3	18.54	0.6	11.1	22.71	11.18	1.44	14.19	25.29
4	18.21	0.56	10.31	23.29	11.16	1.42	13.69	24
5	18.49	0.62	10.55	22.95	11.2	1.43	14.38	24.93
6	19.07	0.48	9.29	23.22	11.16	1.48	15.22	24.51
7	18.59	0.65	12.13	22.97	11.2	1.37	13.58	25.71
8	18.2	0.62	10.38	23.34	11.18	1.44	14.33	24.71
9	18.61	0.65	12.1	22.88	11.29	1.4	13.95	26.05
10	19.07	0.58	10.16	23.24	11.19	1.51	15.37	25.53
11	18.58	0.68	12.54	22.97	11.15	1.37	13.91	26.45
12	18.21	0.61	11.21	23.32	11.06	1.47	15.11	26.32
13	18.58	0.68	11.55	22.83	11.09	1.42	14.21	25.76
14	2.01	0.01	0.01	22.17	10.92	2.43	23.66	23.67
15	1.33	0	0	22.27	10.89	2.56	24.79	24.79
16	1.32	0	0	22.14	10.9	2.59	25.54	25.54
17	1.53	0	0	22.27	10.91	2.58	25.05	25.05
18	1.34	0	0	22.34	10.89	2.54	24.74	24.74

PV_ Voltage = Voltage of PV Module

PV_ Current = Current of PV Module

PV_ Power = Output Power of PV Module

Grid Voltage = Output Voltage of Grid Rectifier

Grid Current = Output Current of Grid Rectifier

Grid Power = Output Power of Grid Rectifier

Bus_ Voltage = Voltage of the Shunt Capacitor

Total Power = PV_ Power + Grid Power

Table **4.1** show that when there is no PV power the grid will supply the pump with required power. When the sun rises the controller will run MPPT to withdraw the maximum power from the PV module.

The scenario of the test is as follow

- The PV panel is covered so PV power is zero and the grid supplied the pump with the required power (almost 25 Watt)
- When the cover is removed from PV panel, the controller tried to extract the maximum available power from the PV panel which is almost 11 watts. As the required power of the pump is almost 25 watts so the grid will supply the remaining power which is almost 14 watts (25-11=14).
- Now the PV panel is covered again, so the PV power dropped to zero and the grid supplied the pump with the required power.

4.2 Discussion

The results showed that when there is not sufficient PV power the system will absorb the required power from the grid, and when the sun rise the system tried to extracted the maximum power from PV panel. All the time the controller will try to supply the pump with required power and the equation:

Pump Power - PV power = Grid Power

Is always worked for example from first row

25.76 - 8.37 = 17.39

Chapter Five

Conclusion and Recommendations for Future Work

5-1 Conclusion

It has been shown that the suggested system which uses a hybrid PV-grid system for water pumping has worked in good way, where MPPT is utilized to get the most power possible from PV panels and the controller system ensures that the power taken from the grid is enough to make water the pump work at its maximum power.

5-2 Future Work

Iraq frequently experiences power shortages; so is better to set up a battery bank to store the extra energy when the electrical power grid is dormant and the sun is intense, the system draws electricity and store it in the battery bank. Also it is better to use bi-directional grid converter so the system can feed excess power to the grid when water pumping is not required which tends to increase the income for the farmer.

References

[1] Ali Bajwa, What is a hybrid solar system? How does it work? A guide.
Panasonic Official Website

[2] Wadim Strielkowski, Renewable Energy in the Sustainable Development of Electrical Power Sector: A Review, www.mdpi.com 2021

[3] https://www.novergysolar.com/types-solar-systems-on-grid-off-grid-hybrid-use-cases/

[4] Rajan Kumar, Bhim Singh, Grid Interactive Solar PV Based Water pumping using BLDC motor drive
Indian Institute of Technology Delhi 2016

[5] Waqas Hassan & Farrukh Kamra, A hybrid PV/utility powered irrigation Water pumping system for rural agricultural areas.
School of Electrical and Information Engineering The University of Sydney, Australia 2018

[6] Rita H. Almeida, Isaac B. Carrêlo, Eduardo Lorenzo, Luis Narvarte, José Fernández-Ramos, Francisco Martínez-Moreno and Luis M. Carrasco, Development and Test of Solutions to Enlarge the Power of PV Irrigation and Application to a 140 kW PV-Diesel Representative Case, Instituto de Energía Solar—Universidad Politécnic de Madrid, Spain 2018

[7] Ludmil Stoyanov , Ivan Bachev , Zahari Zarkov, Vladimir Lazarov and Gilles Notton, Multivariate Analysis of a Wind–PV-Based Water Pumping Hybrid System for Irrigation Purposes, Laboratory Sciences for Environment, University of Corsica, Ajaccio, France 2021

[8] https://www.basu.org.in/wp-content/uploads/2020/03/CLASSIFICATION-OF-PUMPS.pdf

[9] Sang-Hoon Kim"Electric Motor Control DC, AC, and BLDC Motors." 2017 ".

[10] Jian Zhao and Yangwei Yu "Brushless DC Motor Fundamentals Application Note." 2011".

الخلاصـة

مع ارتفاع أسعار الوقود الاحفوري ونقص الكهرباء، فإن استخدام مضخات الديزل أو المضخات الكهربائية في الري لن يكون خيارًا اقتصاديًا للمزارعين العراقيين. الطاقة الشمسية هي المصدر الرئيسي للطاقة ويمكن الاعتماد عليها في العراق. يعتبر الري الذي يتم عن طريق المضخات التي تعمل بالطاقة الشمسية خيارًا جيدًا للمزارعين. ولكن بسبب الطبيعة المتقلبة للطاقة الشمسية لا يمكن الاستغناء بشكل كامل عن طاقه شبكة الكهرباء الوطنية, على الرغم من التكلفة العالية للمنظومة العاملة بالطاقة الشمسية للنظام الهجين ولكن على العكس من الحال مع الديزل أو المضخات الكهربائية، فإن هذه التقنية لا تتطلب أي نوع من الوقود والصيانة. يجب أن يتم تصميم نظام المضخة الكهروضوئية من خلال مراعاة المطابقة بين أقصى استخلاص للطاقة من الألواح الكهروضوئية والتحكم في كمية الطاقة المسحوبة من شبكة الكهرباء. يهدف المشروع الحالي إلى تقديم طريقة التنفيذ والتصميم والتحكم في نظام ضخ المياه لغرض الري بالطاقة الشمسية مدعومة بطاقة الشبكة الوطنية لتعويض النقص في حالة ضعف الطاقة الشمسية او انعدامها لاستمرار عملية الري بكفاءة عالية في كل الأوقات. والتحكم في MPPT لطاقة الالواح الشمسية.

شكر وتقدير

وقال رسول الله (صلى الله عليه وعلى إله وصحبه وسلم):

" مَنْ صَنَعَ إِلَيْكُمْ مَعْرُوفًا فَكَافِئُوهُ، فَإِنْ لَمْ تَجِدُوا مَا تُكَافِئُونَهُ فَادْعُوا لَهُ حَتَّى تَرَوْا أَنَّكُمْ قَدْ كَافَأْتُمُوهُ "

أحمد الله تعالى أولًا وآخرًا على الفضل العظيم الذي منحني إياه، ثم أتقدم بالشكر لمن فضلهما لا ينقطع عليَّ والدي الحبيبين على كل جهودهم منذ لحظة ولادتي إلى هذه اللحظات المباركة، أنتم يا أبي وأمي نجاحي وفرحتي وكل شيء جميل في حياتي، ويسرني أن أوجه الشكر الجزيل لكل من نصحني أو أرشدني أو ساهم لو بشيء قليل أو وجهني في إعداد هذا البحث وإيصالي للمراجع والمصادر المطلوبة في أي مرحلة من المراحل التي مررت بها، وأشكر على وجه الخصوص الأستاذ الفاضل الدكتور" بشار سكين فرحان" على مساعدتي ومساندتي وإرشادي بالنصح والتعليم والتصحيح وعلى كل ما بذله معي، كما يسرني أن أشكر إدارة الكلية الموقرة: ‘‘الجامعة العراقية -كليه الهندسة- قسم الكهرباء ’’ وأسأل الله أن يكون بحث هذا في صحيفة أعالمهم جميعًا، وأن يجزيهم تعالى خير الجزاء والحمد لله رب العالمين.

كما أشكر القائمين على جامعة العراقية وعلى رأسهم معالي الدكتور (موفق شياع) عميد كلية الهندسة. ووفقهما الله لكل خير لما يبذلونه من اهتمام بطلاب كلية الهندسة بصفة عامة وطلاب كلية الهندسة قسم الكهرباء بصفة خاصة

الطلبة

أنس أحمد عبد الحميد

أنور محمد

حيدر عباس

أحمد خالد

حزيران ٢٠٢٣

نظام هجين يستخدم الطاقة الشمسية وطاقة شبكة الكهرباء الوطنية لتشغيل مضخة ماء

مشروع

مقدمة إلى كلية الهندسة في الجامعة العراقية

وهي جزء من متطلبات نيل درجة بكالوريوس علوم

في الهندسة الكهربائية

من قبل

أنس أحمد عبد الحميد

أنور محمد

حيدر عباس

أحمد خالد

باشراف

بشار سكين فرحان.د

ذو الحجة ١٤٤٤هـ

حزيران ٢٠٢٣

Ministry of Higher Education and Scientific Research
Al-Iraqia University
Engineering College
Department of Electrical Engineering

ROBOT FOR STAIR CLIMBING

A project submitted to the Department of Electrical Engineering in Partial Fulfillment for theRequirements of the Degree of B.Sc. in Electrical Engineering

By

Mustafa Hamid Rashid

Laith Hassan Qassem

Laith Karim Jassim

Noor Karim Glow

Supervisor:

Dr. Rasha Subhi Ali

2022–2023

بسم الله الرحمن الرحيم

﴿ وَقَضَى رَبُّكَ أَلَّا تَعْبُدُوا إِلَّا إِيَّاهُ وَبِالْوَالِدَيْنِ إِحسانا ﴾

صدق الله العلي العظيم

الاسراء آية : (٢٣)

DECLARATION

We hereby declare that this project report is based on our original work except for citations and quotations, which have been duly acknowledged.

Signature : ____________________________

Name : ____________________________

Date : ____________________________

Signature : ____________________________

Name : ____________________________

Date : ____________________________

Signature : ____________________________

Name : ____________________________

Date : ____________________________

Signature : ____________________________

Name : ____________________________

Date : ____________________________

Certificate

I certify that this project is entitled "Design and Implementation of a Stair Climbing Robot" prepared by qualified Mustafa Hamid, Laith Karim, Nour Karim and Laith Hassan under my supervision at the Iraqi University / College of Engineering in partial fulfillment of the requirements for obtaining the degree. Bachelor of Science in Electrical Engineering.

Signature:

Name: Asst. Lect. Dr. Rasha Subhi Ali

(Supervisor)

Date: / 6/2023

Signature:

Name: Asst. PROF. DR. BARAA MUNQITH ALBAKER

(Head of Department)

Date: / /

certificate

We certify, as an examination committee, that we have read this project titled "Design and Implementation of a Stair Climbing Robot", which was examined by students Mustafa Hamid, Nour Karim, Laith Karim and Laith Hassan in the content dissertation and a bachelor's degree in electrical engineering.

Signature:
Name:
(Member).
Date: / /

Signature:
Name:
(Member)
Date: / /

Signature:
Name:
(Chairman)

Approval of the College of Engineering

Signature:
Name:
Asst. Prof. Dr. Mowafaq Shyaa Alwan
(Dean)
Date: / /

Dedication

Whoever taught us How do I start the journey of a thousand miles step by step to my dear father ....

To the nostalgic heart that was beside us in all past stages For those who taught me that great deeds are not completed without patience, determination and perseverance to my dear mother....

My teachers who have guided us It leads us to the path of knowledge ....
My brothers and friends who were a candle on my way.

ACKNOWLEDGEMENTS

Thanks to Allah for giving me this opportunity, the strength and the patience to complete my project finally, after all the challenges and difficulties.

It is a pleasure to thank the many people who made this work possible.

We extend our sincere thanks and respect to the distinguished professor, Dean of the College of Engineering, Professor Dr. Mowafaq the Respected and Head of the Electrical Engineering Department, Dr. Baraa the respected and We would like to thank the project supervisor (Dr. Rasha Subhi Ali) who provided us with all the advice and guidance during the research process and helped us complete this work.

We would also like to express our thanks to the Department of Electrical Engineering / Iraqi University. Finally, a special thank to our families and everyone who helped us for their support through this work.

ABSTRACT

In this project a special stair climbing robot is proposed. In today's world, robots are used for almost all purposes. Now a days many day to day problems are solved due to the implementation of robots. But when it comes to senior citizens or physically disabled persons it is a tough task to climb the steps. This research presents the structure, construction and application of an Arduino controlled special stair climbing robot. The advent of new high-speed technology and the growing computer Capacity provided realistic opportunity for new robot controls and realization of new methods of control theory. This technical improvement together with the need for high performance robots created faster, more accurate and more intelligent robots using new robots control devices, new drivers and advanced control algorithms. This project describes a new economical solution of robot control systems. The main objective of this present work is to build a robot machine which is capable of climbing stairs using Arduino communicating with Bluetooth Module. The automatic adjustment in the robot according to the height of the stair is done by connecting an Android device that has an application programmed in C++ with an Arduino. This design employs an Arduino Uno board to control the robot and other home fabricated custom PCB to interface it with the Arduino Board. The bot is powered by Li-Ion batteries and gear box motors. The presented robot control system can be used for different sophisticated robotic applications

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CHAPTER ONE

INTRODUCTION

1. INTRODUCTION

Today's robots are becoming an essential aspect of our modern lives. After all, the number of robots used in many everyday applications has significantly increased in the last decade, and the variation of tasks and designs of these robots is high, making them suitable for many applications. The number of robots worldwide has increased from 4.5 million in 2006 to 8.6 million in 2008. There are an enormous number of stair-climbing robots, each with a unique design to accomplish certain tasks. A good design of a stair climbing robot is obtained after studying many other designs [1]. A number of robots have robots have been built for climbing stairs and traversing obstacles, such as quadruped and hexapod robots. These robots can climb stairs and traverse obstacles, but they do not have a smooth motion on flat surfaces, which is due to the motion of their legs. Most of them have six legs to maintain good static stability, many have 8 legs for greater speed and higher load capacity and there are some that implement clever balancing algorithms which allow them to walk on two legs to move over sloping ground and to climb up and down stairs, like humans do [2]. Military robots are autonomous robots or remote-controlled devices designed for military applications. Such systems are currently being researched by a number of militaries. There are three types of moving mechanisms for this kind of robot in general: wheel type, track type, and walking type mechanism. Robots with wheel mechanisms are inferior to robots with tracks when they are to move on rough terrain. Walking robots have complex structures so they are usually difficult to control and slower in speed [3] [4].

The result of research and development robots which support and help people with tasks in our daily lives comes out with solutions. Wheeled or crawler-type climbers are useful for carrying heavy loads and people with disability. These types of vehicles have much more capacity to payload than legged-walking robots [5]. Several creative designs of stair-climbing robots were studied and compared in this project. In that sense, the track mechanism has advantages in high-speed driving and mobility under severe conditions. In spite of these merits, it consumes more energy than the others. Therefore it is needed to design a robot to overcome this drawback [6], in near future, robots will take the place of human labor in many areas[2].

1.2- RELATED WORK

There are many models of stair climbing that are automatic, but the main problem with them is either they need human assistance or they are slow. Another important aspect we need to consider is the cost, and need for special care. There are many disadvantages in existing systems like speed, cost, safety, etc.

In [7] presents the structure, construction, and application of an Arduino-controlled special stair-climbing robot attached to a wheelchair. There is a special triangular assembly of three wheels attached to the geared heavy-duty DC motors. The proposed stair-climbing wheelchair bot can be controlled by a smartphone. In [8] An RF remote-controlled stair-climbing robot has been developed. The operator can monitor the robot's operation by using video that is captured through a camera on the surface of the robot. It has a mechanical design with a back wheel to drive the robot over rubble, and large wheels in the front driven by a motor for climbing stairs. In [5] designed a developed stair-climbing robot by using two microcontroller parts to perform the multi-functions. It can run at the bout speed of a manual wheelchair and also can climb standard size of stairs. Wireless communication is used for data transfer between wireless remote control and vehicle. The sensor detection system also uses for safety in auto driving. The combination of two different mechanisms makes it more efficient in carrying a load and reduces friction on the ground or climbing. In [6] a stair-climbing robot exploiting star-wheel methodology was proposed, which has the capability of ascending and descending stairs and traversing obstacles and is flexible while climbing and declining sloped surfaces. A robot is attached to Wheel-Chair for carrying disabled persons over stairs and obstacles. If the robot moves on flat surfaces and comes upon a stair or obstacle, the robot switches to Star-Wheels motion. It allows the robot adapts itself with respect to the path curvature. [9] Discussed the designing and manufacturing of a vehicle that can climb stairs or move along very rough surfaces. The technical issues in designing the vehicle are the stability and speed of the vehicle while climbing stairs, as well as the steepness of the stairs. The vehicle has four sets of wheels arrangement to support its weight when it moves over the flat terrain. The test and trial run showed significant and encouraging results that could help future researchers to incorporate a gear box and steering mechanism to make the vehicle more versatile.

1.3 Research problems

There are several issues with the system that have become an essential part of our research, including:
1. You adhere to a certain movement and a certain distance
2. Adhere to a specific category service
3. The size of the tools is heavy and it is difficult to move freely
4.Some of the project tools are not available in the country, some of them were made by hand
5.Among the problems we faced, we used a 4 .5 mm D-Axis 280 planetary motor, but it did not perform the required performance, as it did not give enough torque to move the robot. In addition, it was designed for high speeds, and we do not need high speeds in the project. So it was replaced by a zgy370dc12vreduction motor worm turbo geared motor.

1.4 The objective of this Project

The objective of this project is to design, build and analyze a simple portable robot that can climb steep stairs. This type of robot has many applications, such as space exploration, home security monitoring, military drones, robotic vacuum cleaners, farmland surveyors, toys, elderly wellness monitors, and wheelchairs.
We wanted to build a robot capable of climbing full-size stairs and driving at a reasonable pace. This robot should also be able to carry a load of an average adult to act as a way to ascend stairs for those reliant on wheelchairs. Also, the lifting heavy loads over stairs is difficult due to structural constraints. Stair climbing vehicles are used to lift loads over short heights in libraries, hospitals, and construction areas.

We won't be the first to create this kind of robot, but ours will be one of the rare builds capable of climbing full-sized stairs. One is a powered robot like ours, capable of climbing stairs, the other is a passive trolley, not powered but able to climb full sized stairs. This kind of robot is used to help old and disabled people in rough places or to climb stairs, and it can also be managed using a smartphone or computer.

CHAPTER TWO

PROPOSED ROBOTIC SYSTEM DESIGN

METHODOLOGY

CHAPTER TWO
METHODOLOGY

2.1 Introduction

Robotics is an interdisciplinary field that uses machines to perform tasks traditionally done by humans.. Robotics aims to design machines that can help and assist humans, with applications in mechanical engineering, electrical engineering, information engineering, mechatronics, electronics, bioengineering, computer engineering, control engineering, software engineering, and mathematics [10].Navigation of a robot without outside help is one of the most important aspects of developing a fully functioning autonomous mobile robot. Navigation is a control system that focuses on the process of monitoring and controlling the movement of a vehicle from one place to another [11]. The science community has developed mobile robots to move in uneven and irregular terrains and control them remotely. To make them intelligent, technologies have been developed and implemented. Technologies such as localization, odometry, Global navigation units, Artificial intelligence and mapping have improved mobility in rough terrain, but locomotion concepts have not evolved much. Mobile robots are needed for use in rough terrains, but most existing surface locomotion concepts are based on wheels, caterpillars or legs [12]. Several application of robotics include[10]:

1. Working alongside humans in manufacturing plants (known as co-bots)
2. Surgical assistants
3. Autonomous household robots that carry out tasks like vacuuming and mowing the grass
4. Helping during search-and-rescue missions after natural disasters
5. Detecting landmine in war zones
6. Assist fighting forest fires

There are different tools used in designing stair climbing robot such as Arduino Uno microcontroller board (ATMEGA328P), Bluetooth module (HC-05), Bluetooth module (HC-06), Bluetooth enabled Smart phone, different wheels, DC motors, servo motor [13][14]. Stair climbing has been carried out with robots using different types of locomotion. One can roughly distinguish wheeled, legged, and tracked robots [15] [16].

2.2METHODOLOGY

This project focuses on rebuild and design of stair-climbing robot and control system and a flow chart of project plan is shown in Figure 2.1. In this article the design and manufacturing of a stair climbing vehicle has been presented. The vehicle is designed in such a way that it can climb a stepped path (like stairs) with its modified wheel structure. This is the individuality of this vehicle. Different speed combinations are incorporated depending on the working condition through simple gear arrangement, powered by the local motor drive. Speed reduction at any desired rate, is possible to establish over the existing ratio. There are three parts for design of new system.

- Designing
- System Architecture and Hardware Development
- Software Development
- Testing and result

Flow chart

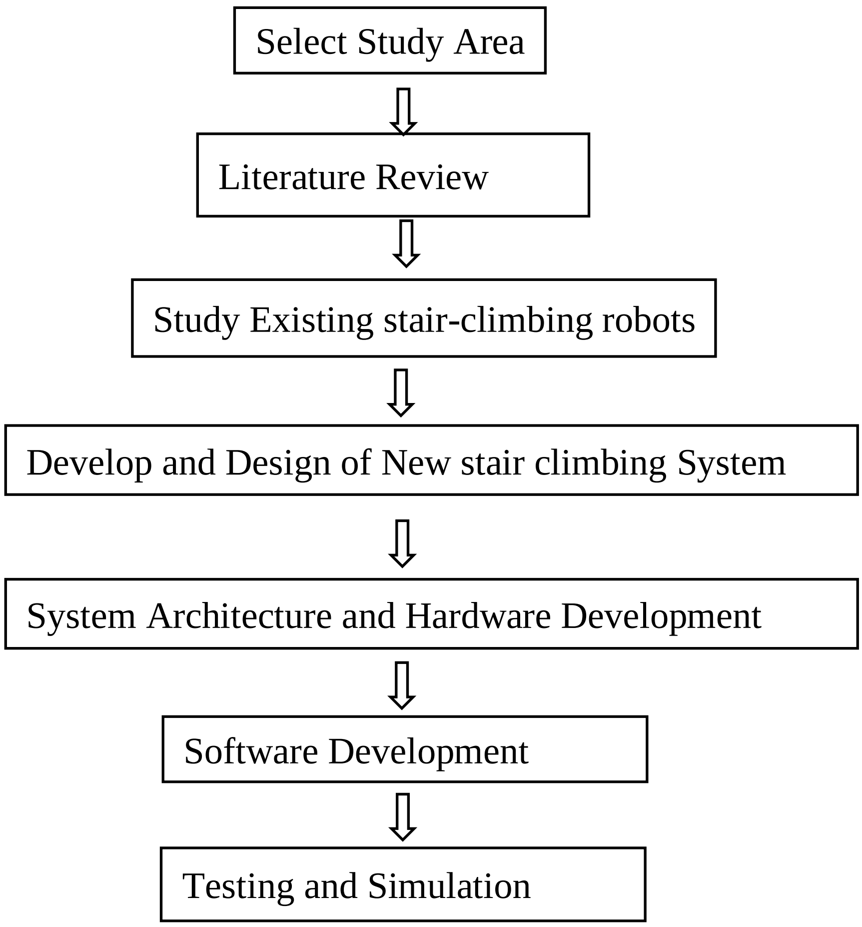


Figure 2.1 Flowchart of the study plan

Table2.1 utilised tools

Ltem	Quantity
ZGY370 DC12V Reduction Motor Worm Turbo Geared Motor	4
Items for robot's platform (e.g. Aluminum channels, screws, etc.)and wires andS witch and board	___
Arduino Uno	1
Battery Lithium	4
Bluetooth Module (HC-06)	1
L298N Motor Driver Module	2
2ch 18650 Series Battery Holder with wires	2
45mm D-axis 280 planetary geared motor DC 6-12V 0.2A 60120rpm	1
Wheels	4

2.3 Arduino software

The Arduino Leonardo deals with open source programming language called Arduino IDE. The Arduino IDE is a cross-platform Java application that serves as a code editor and compiler and is also capable of transferring firmware serially to the board.

The development environment is based on Processing, an IDE designed to introduce programming to artists unfamiliar with software development. The programming language is derived from Wiring, a C-like language that provides similar functionality for a more tightly restricted board design, whose IDE is also based on Processing.

The ATmega32U4 on the Arduino Leonardo comes preboned with a boot loader that allows user to upload new code to it without the use of an external hardware programmer. It communicates using the AVR109 protocol. User can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header . The Arduino is burned with these programs to instruct the board to generate the PWM signals and the pin corresponding to the PWM signals. The ground in the Arduino is shorted with the ground in the power distribution board to avoid noise that is introduced Fig2.2 [18].

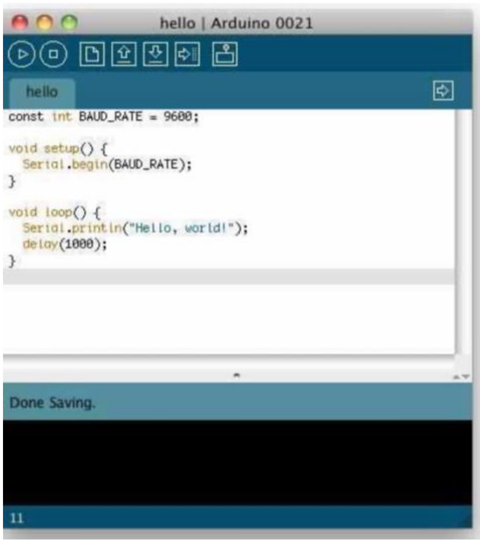


Figure (2.2) The Arduino IDE main interface [18].

2.4 Mobile Software

The mobile application is simple interface built to help to control the robot. The application is built using java and XML languages. There are four major button In the interface each of them control the functionality of the movement of the robot by sending instruction telling it to move forward backward

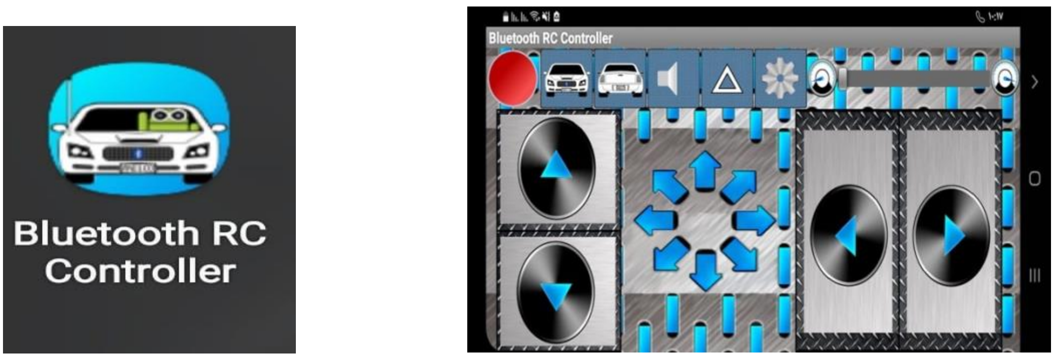


Fig2.3 The program used to program the Arduino

RESEARCH BLOCK DIAGRAM

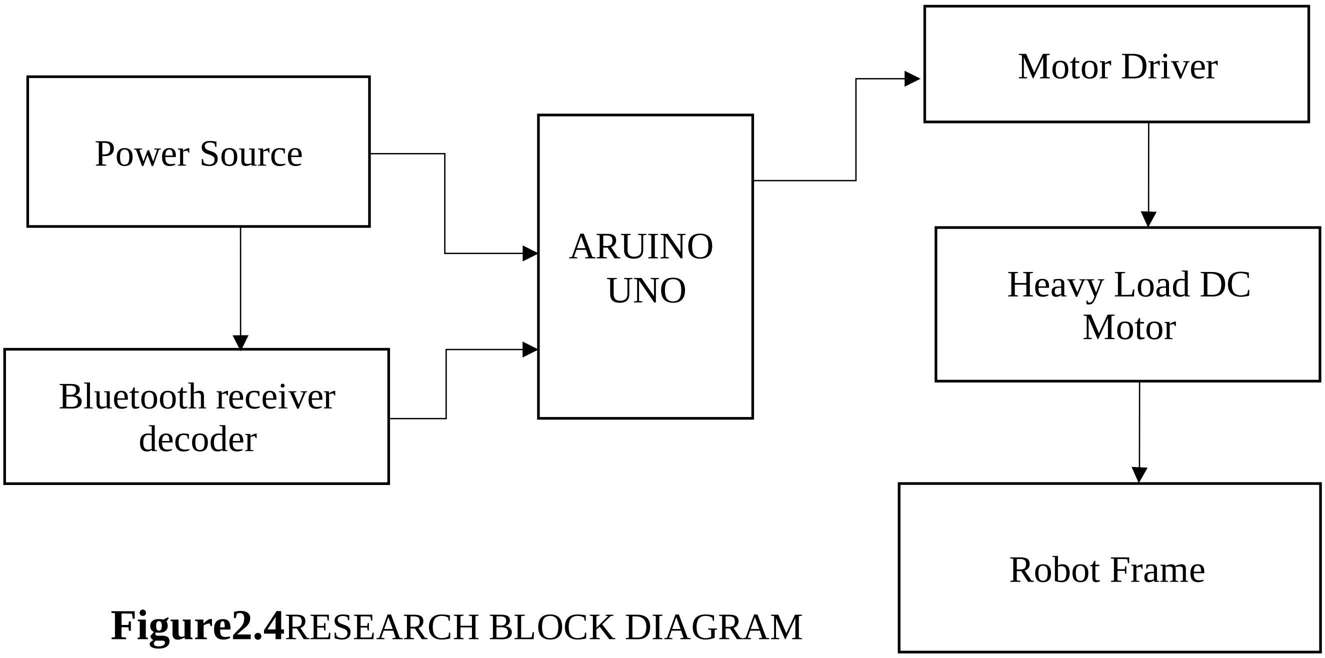


Figure2.4RESEARCH BLOCK DIAGRAM

CHAPTER Three
FABRICATION AND ASSEMBLY

Fabrication of Parts

CHAPTER THREE
FABRICATION AND ASSEMBLY
Fabrication of Parts

3.1 Introduction

The proposed robotic system consists of two separated parts: hardware part and software part. The hardware part represents the designed robot, which is a set of robot contents that includes car body and other devices related to the control equipment, and signal transmission or receiving. The software part is the control system, which is the controller that consists of two modules operated sequentially, these modules are: User module and Automatically module.

This chapter is concerned with the employed algorithms of the proposed mobile robot system; these algorithms will be explained and discussed in details for each stage in the hardware and software parts from the robotic platform and Mobile interface to the vision perception system, including the localization routines and the
obstacles avoidance.

3.2 Manufacture of parts

The manufacturing of the mechanical structure of the robot is mainly composed of 3 parts: the wheels, the leg frame (axles) and the central robot body (the hinge). In the design of the robot, the body of the robot has been divided into two parts, the front and rear leg axes. The legs are made of wood. Driftwood is an inexpensive and readily available material. However, driftwood is relatively heavy..

The robot contain s four wooden legs with small plastic wheels, a rubber contact surface in the peripheral area. The rubber tread greatly reduces the robot's slip because it has a better grip on the stair surface. Most of the weight is due to the wheel axle which must be strong to bear the heavy load of the robot.

Figure 3.1 Make the wheel template

Figure 3.1 shows one of the leg axes of the robot which was constructed using a 1 cm thick chipboard. Workouts on it in order to lose weight. The location of the exercises was obtained by optimizing the weight

using FEA Materials Optimization. Each hub weighs 1.2 lbs. The central hole is to connect the two axles through the central robot body which has a joint that the axles can rotate and steer the wheels according to the terrain conditions. The holes on the left and right connect the motor on the inner side and the wheel on the outer side using a spline wrench.
The four motors are connected to motor drivers on the central electronic board. These motors will be attached to the axles of the legs, and eventually the entire robot frame will be assembled on all four wheels. Motors weights 0.5 kg each. The weight of the hinge, including the battery and other panels, is 5.4 kg.

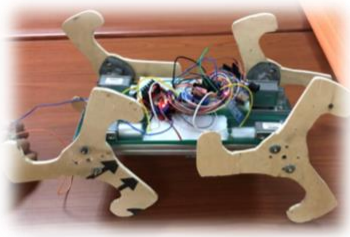


Figure 3.2 The typical shape of a robot

3.3 Assemble the robot

The three parts i.e. robot skeleton, wheels and leg axles are assembled using bolts and nuts. The central hinge is screwed along its length, allowing the robot's wheelbase to be changed. This will be useful for climbing stairs with variable heights.
The robot was experiencing slippage when the wheel legs had a wooden base. It wasn't providing enough friction and the robot was sliding up the ladder surface. Figure 3.3 demonstrates the installation of the robot. The table gives the weight distribution of the different parts. The total weight of the robot is 12.15 kg.

Figure 3.3 installation robot

TABLE 3.1. Electronic Parts and its specifications

S. No.	Part	Weight (in grams)	Quantities
1.	Robot Frame	150g	4
2.	MotorDriverModule	15g	2
3.	Motor	300g	4
4.	Wheel	15g	48
5.	Battery Lithium	10	4
6.	Items for robot's platform(e.g. Aluminum channels, screws, etc.)and wires and Switch and board	30g	______
7.	Arduino	15g	1
8.	Overallc Robot Weight (in kgs)	2.635kg	______

3.4 WParameters Influencing the System Performance

Design parameters are control factors of the system. It is required to find the parameters that affect the system performance. The robot's successful climbing is the performance to study. Without getting overhung or jammed, the climbing of robots on the staircase is a successful activity. The effective climbing capacity of the robot is studied in this research work. Selecting suitable ranges for control factors is essential to exclude the unfeasible solution space. Different control factors with their choices are defined below:

Radius of Wheel (R): Wheels with a small radius make complications in the geometrical traffic ability of the vehicle. If the radius of the wheel is smaller than the size of overhangs then the average reaction force achieved from the overhang acts vertically downwards. If wheel radius is larger than the overhang size, this shifts the vertical downward normal force towards the robot's axis of rotation. So, resultant contact force produces an anti-clockwise moment about the robot's axis of rotation.

3.5 Components Details :

3.5.1 Arduino Uno:

Arduino UNO is a low-cost, flexible, and easy-to-use programmable open- source microcontroller board that can be integrated into a variety of electronic projects. it's features AVR microcontroller Atmega328, 6 analogue input pins, and 14 digital I/O pins out of which 6 are used as PWM output and Arduino IDE software is used to program the board. The operating voltage of the unit is 5V which projects the microcontroller on the board while the recommended input voltage ranges from 7V to 12V. Arduino UNO shown in Figure 3.4.

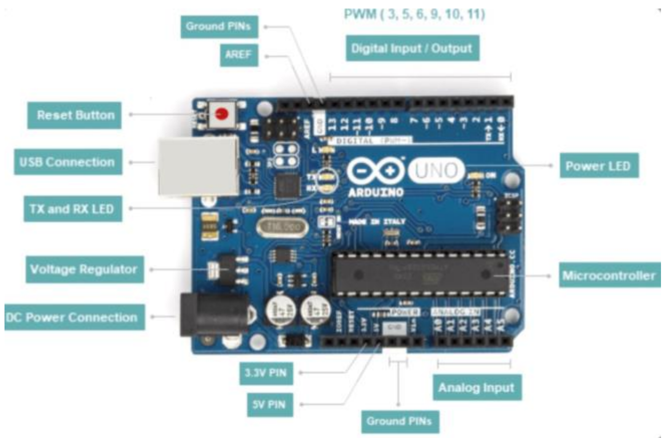


Figure 3.4. Arduino Uno

Table 3.2 *Specification of Arduino Nano*

Microcontroller	*Atmel ATmega168 or ATmega328*
Operating Voltage(logic level)	*5V*
Input Voltage (recommended)	*7-12V*
Input Voltage (limit)	*6-20V*
Digital I/O Pins	*14(of which 6provide PWM output)*
Analog Input Pins	*8*
DC Current per I/O Pin	*40mA*
Flash Memory	*16 KB (ATmega168) or 32 KB (ATmega328) of which 2 KB used by boot loader*
SRAM	*1 KB (ATmega168) or 2 KB (ATmega328)*
EEPROM	*512 bytes (ATmega168) or 1 KB (ATmega328)*
Dimensions	*0.73”x1.70’’*
Clock Speed	*16MHZ*
Length	*45mm*
Width	*18 mm*
Weight	*5g*

3.5.2 Battery:

PANASONIC NCR21700 3.7V 5000mAh Rechargeable Lithium Battery Flat. Safety Precautions for the Lithium Ion Batteries use and Designing Equipment.

In general, lithium ion batteries are used in battery-packs that contain both lithium ion batteries and battery safety circuits. Both items are sealed in a container made of a material such as resin so that the battery-pack cannot be easily disassembled.

3.5.2.1 ChargingtheBatteries

The “constant voltage/constant current „ method is used to charge lithium ion batteries.

Figure 3.5. Battery

3.5.3 Wire:

Wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed. Wires shown in **Figure 3.6**

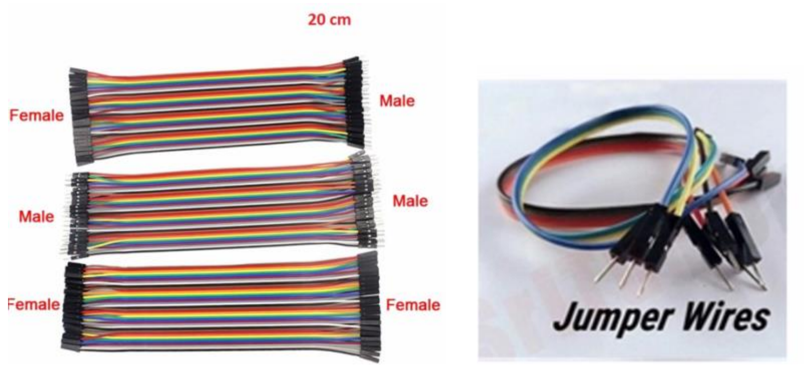


Figure 3.6 Wires

3.5.4 L298N Motor Driver Module

This L298N Motor Driver Module is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control.

3.5.4.1Features & SpecificationsDriver Model: L298N 2A

- Driver Chip: Double H Bridge L298N
- Motor Supply Voltage (Maximum): 46V
- Motor Supply Current (Maximum): 2A
- Logic Voltage: 5V
- Driver Voltage: 5-35V
- Driver Current:2A
- Logical Current:0-36mA
- Maximum Power (W): 25W
- Current Sense for each motor
- Heatsink for better performance
- Power-On LED indicator

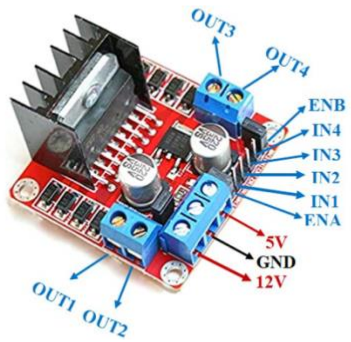


Figure 3.7. L298N Motor Driver Module

3.5.5 Bluetooth Module (HC-05)

• For the communication between mobile phone and microcontroller Bluetooth module(HC-05) is used.
• HC-05 is low power 1.8V operation and is easy to use with Bluetooth SPP (serial port protocol).
• Serial port Bluetooth module have a Bluetooth 2.0+EDR (enhanced data rate), 3Mbps modulation with complete 2.4GHZ radio transceiver and baseband.
• Using Bluetooth profile and android platform architecture different type of Bluetooth applications can be developed.

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module,designed for transparent wireless serial connection setup.The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication.This serial port bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate)3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04- External single chip Rluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature).

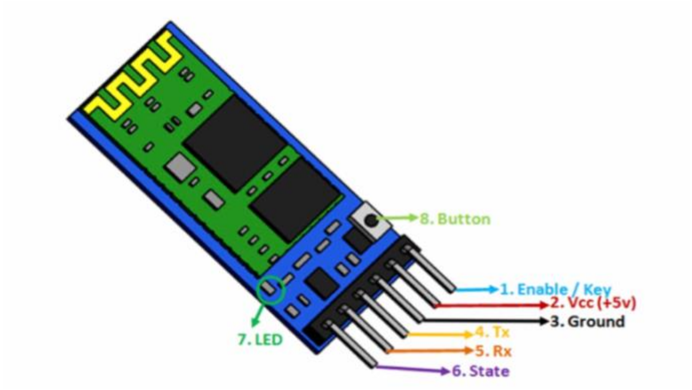
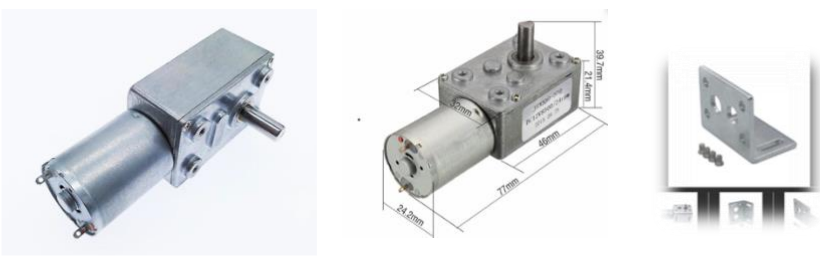


Figure 3.8. Bluetooth Module (HC-05)

3.5.6 zgy370 dc12v reduction motor worm turbo geared motor

A DC motor is any motor within a class of electrical machines whereby direct current electrical power is converted into mechanical power. The speed of a DC motor is controlled using a variable supply voltage or by changing the strength of the current within its field wind rings. A 12v DC motor is small and inexpensive, yet powerful enough to be used for many applications. Because choosing the right DC motor for a specific application can be challenging, it is important to work with the right company. A prime example is METMotors, which has been creating high-quality permanent magnet DC motors for more than 45 years.



(a) **(b)**

Figure3.9. (a)zgy370dc12vreduction motor worm turbo geared motor
(b) Metal Motor Bracket L Shaped for ZGY370 worm gear motor

TABLE3.3. Motor Details

ZGY370,46/32		Technical Parameter						
No load		Load Torque				Sell		Reducer
Speed	Current	Speed	Current	Torque	Output	Torque	Current	Ratio
rpm	ma	rpm	Ma	Kg.cm	V	Kg.cm	A	1:00
5	35	4	180	14.0	1.1	50	1	970

3.5.7 DC-DC Step down 5A Small Module XL4015

A step-down, or buck, converter is a DC/DC power converter that reduces the input voltage and provides a lower output voltage. The XL4015 power module is a DC to DC step-down (BUCK) power module that operates at a switching frequency of 180kHz. In such high frequency, it provides smaller sized filter components compared with low frequency switching regulators.

Figure3.10. DC-DC Step down

Features and Specifications

- Input voltage: 4 - 38V
- Output voltage: 1.25 - 36V (adjustable)
- Output current: Maximum output current 5A
- Note: The higher the voltage, the load current increases. Try to use it within 4.5A.

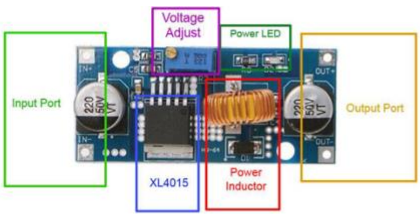


Figure3.11. DC-DC Step down its parts

3.5.8. Switch Control: As shown in the figure below

Figure3.12 Switch Control

3.6 General Research Flowchart

The diagram(3.13) below shows General Research Flowchart:

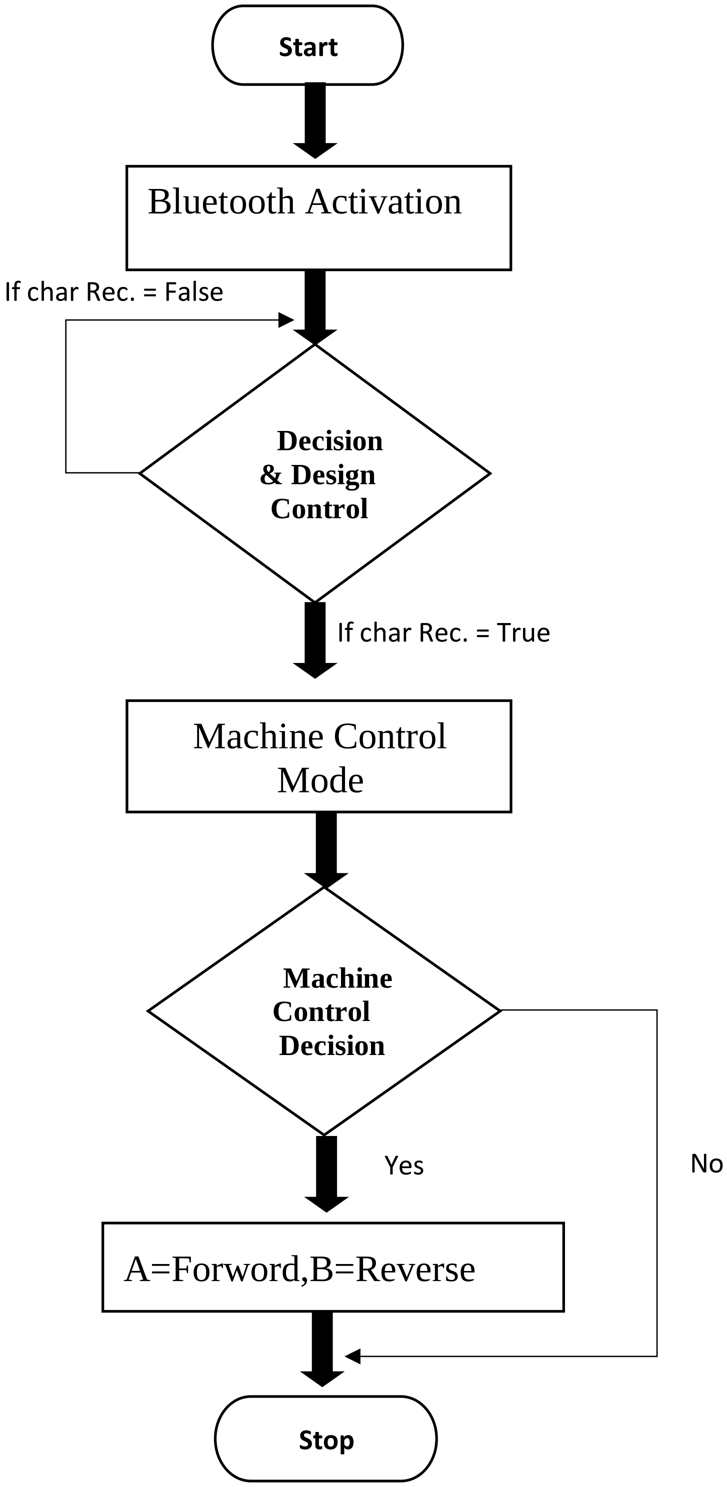


Figure3.13.Proposed Application Flowchart

3. 7 Analysis and Results

It was found that the vehicle was moving well over the stair. Separate motor worked properly for moving over the steps and there was no variation of speed over steps. It was observed that there was very low noise and vibration over flat surface or stair.

The vehicle was disturbed when faced with different step sizes due to the shape and size of the wheel frame. This project used a separate two gear motor to move over the stair, which made the circuit design more complicated and increased the weight of the vehicle.

This project mainly consists of Arduino Uno microcontroller board (ATMEGA328P), Bluetooth module (HC-05), Bluetooth enabled Smart phone, Wheel chair unit with Triangular arrangement, DC motors.

3.7.1ARDUINO UNO

Microcontroller will act as the brain of the robot. The robot movement will be decided by the microcontroller. In this system we will be using microcontroller named Arduino UNO which contains ATMEGA 328P microcontroller chip. The microcontroller is programmed with the help of the Embedded C programming. Arduino has it own programming burnt in its Read Only Memory (ROM). C program is very easy to implement for programming the Arduino UNO.

3.7.2 BLUETOOTH MODULE (HC-05)

HC-05 module is an easy to use Bluetooth SPP (Serial Port Pro- tocol) module, designed for transparent wireless serial connection setup. This is a highly qualified module with Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz**.**

3.7.3 Stair Climbing Test

As mentioned in the objective of the project, the aim of my work is to develop a stair climbing robot which is capable of climbing the stairs of a height at least equal to the outer radius of the legged wheel. The mobility performance of the robot is confirmed through experiments.

We tested the robot for climbing a stair consisting of a number of stairs, with different height and width. The time was recorded for these tests and analysis was done to evaluate the performance of the robot. Fig. shows the robot climbing a staircase of a step height of 11cm and a width of 30cm. As can be seen in the figure, the robot’s front wheel axle is slightly rolled as compared to the rear axle. The legs grip the step which is at the front and pushes the body forward to the next step.[3]

Chapter Four

Conclusions And Recommendations

Conclusions and Recommendations

After applying and operating the system, we present a number of conclusions and recommendations as follows

4.1 CONCLUSION

In this project we have developed an adjustable stair climbing robot to replace human effort to carry out mundane tasks in places like offices, hospitals, industrial and military automation, security systems and hazardous environments.

There is a lot of scope for improvement and this mechanism can be further modified and used in various other applications such as carrying heavy loads and thus further reducing human effort. Another scenario where this mechanism can be employed is during disaster management. A camera can be fitted on the robot to have a wide field of vie. This robot can also be able to carry a load of an average adult to act as a way to ascend stairs for those reliant on wheelchairs

The vehicle was an effective alternative to transporting loads using stairs, but some limitations could not be avoided due to lack of technological availability. This pioneer project was hoped to meet the demand.

4.2 Recommendations

There are some suggestions taken into account in developing an implementation of the present work ,Which help to achieve a higher level of

performance efficiency ,there are given in the following:

- The use of more sensors added to the robot sides well help to increase the sense rate.
- The use of an accurate GPS device with the help of the sensor well increase the overall system performance.
- improve the design of smart phone application to send smart orders.
- Implementing this work in different vehicles such as wheel chair different robots and normal size cars.

References

[1] International Journal of Pure and Applied Mathematics

[2] ISSN No: 2348-4845 International Journal & Magazine of Engineering, Technology, Management and Research Manag A Peer Reviewed Open Access International Journal

[3] Jeyabalaji, C., et al. "Design of low cost stair climbing robot using Arduino." Int. J. of Engg. Research and Applications 4 (2014): 15-18

[4] Mishra A. and Kumari S., " Military Robots Play a Pivotal Role as a Tactical and Operational Tool for Armed Forces", MARKET RESEARCH BLOG, May 23, 2018

[5] Htoo, Phyo Thae. Development of a Stair-Climbing Robot. Diss. MSc Thesis, Asian Institute of Technology, Thailand, 2016.

[6] Zheng, Yi, et al. "KINEMATICS ANALYSIS OF MAGNETIC ADSORPTION TUBE CLIMBING ROBOT BASED ON ADAMS." International Journal of Mechatronics and Applied Mechanics 9 (2021): 201-208.

[7] Rajasekhar, Tumula Mani Kota, and M. Sugadev. "Arduino Controlled Special Stair Climbing Wheel-chair Bot." International Journal of Pure and Applied Mathematics 118.24 (2018).

[8] Hamed, Basil. "Design and implementation of stair-climbing robot for rescue applications." International journal of computer and electrical engineering 3.3 (2011).

[9] Chowdhury, Md A. Hossain Nafis A., Rubaiat I. Linda, and Shamiuzzaman Akhtar. "Design and manufacturing of a stair climbing vehicle." International conference on industrial engineering and operations management Dhaka, Bangladesh. 2010.

[10] F. G. Pereira, F. B. de Sá, B. D. Ferreira and R. F. Vassallo, “Object Transportation Task by a Human and a Mobile Robot”, 2010 IEEE International Conference on Industrial Technology (ICIT), 2010, pp. 1445 – 1450

[11] Wail Gueaieb, Md. Suruz Miah,"An Intelligent Mobile Robot Navigation Technique Using RFID Technology",IEEE Transactions On Instrumentation And Measurement, Vol. 57, No. 9, September 2008

[12] Singh, Ashish. Design, Analysis and Fabrication of a reconfigurable stair climbing robot. Diss. 2015.

[13] E. Tunstel, Evolution of autonomous self-righting behaviors for articulated Nanorovers, in: Proceedings of the Fifth International Symposium on Artificial Intelligence, Robotics and Automation in Space (ESA SP-440), Noordwijk, Netherlands, pp. 341–346, 1999.

[14] M. Van Winnendael, G. Visenti, R. Bertrand, R. Rieder, Nanokhod microrover heading towards Mars, in: Proceedings of the Fifth International Symposium on Artificial Intelligence, Robotics and Automation in Space (ESA SP-440), Noordwijk, Netherlands, pp. 69–76, 1999.

[15]. Yoneda K. & Ota Y. (2003) : Non-Bio-Mimetic Walkers, The International Journal of Robotics Research, Vol. 22 No.3-4, 241-249

[16]. Yoneda K (2007). Light weight Quadruped with Nine Actuators, Journal of Robotics and Mechatronics, Vol.19, No.2, 160-1

[17] ArduinoHomepage.OncoLinkfrom:introduction2013. http://Arduino.cc/

[18] Maik Schmidt ,"Arduino:A Quick-Start Guide",www.it-ebooks.info.2013

According to the programming below

```
#define ENA_m1 5        // Enable/speed motor Front Right
#define ENB_m1 6        // Enable/speed motor Back Right
#define ENA_m2 10       // Enable/speed motor Front Left
#define ENB_m2 11       // Enable/speed   motor Back Left
#define IN_11  2        // L298N #1 in 1 motor Front Right
#define   IN_12  3        // L298N #1 in 2 motor Front Right
#define IN_13  4        //   L298N #1 in 3 motor Back Right
#define IN_14  7        // L298N #1 in 4 motor   Back Right
#define IN_21  8        // L298N #2 in 1 motor Front Left
#define   IN_22  9        // L298N #2 in 2 motor Front Left
#define IN_23  12       //   L298N #2 in 3 motor Back Left
#define IN_24  13       // L298N #2 in 4 motor   Back Left
int command;            //Int to store app command state.
int   speedCar = 100;     // 50 - 255.
int speed_Coeff = 4;
boolean lightFront =   false;
boolean lightBack = false;
boolean horn = false;

void setup()   {

pinMode(ENA_m1, OUTPUT);
pinMode(ENB_m1, OUTPUT);
pinMode(ENA_m2, OUTPUT);
pinMode(ENB_m2, OUTPUT);
 pinMode(IN_11,   OUTPUT);
 pinMode(IN_12, OUTPUT);
 pinMode(IN_13, OUTPUT);
 pinMode(IN_14,   OUTPUT);
 pinMode(IN_21, OUTPUT);
 pinMode(IN_22, OUTPUT);
 pinMode(IN_23, OUTPUT);
pinMode(IN_24, OUTPUT);
 Serial.begin(9600);
 }

void goAhead(){
digitalWrite(IN_11, LOW);
digitalWrite(IN_12,   HIGH);
analogWrite(ENA_m1, speedCar);

 digitalWrite(IN_13,   HIGH);
 digitalWrite(IN_14, LOW);
analogWrite(ENB_m1, speedCar);

 digitalWrite(IN_21, HIGH);
 digitalWrite(IN_22, LOW);
 analogWrite(ENA_m2,   speedCar);

 digitalWrite(IN_23, LOW);
 digitalWrite(IN_24,   HIGH);
 analogWrite(ENB_m2, speedCar);


void goBack(){

digitalWrite(IN_11,   HIGH);
digitalWrite(IN_12, LOW);
analogWrite(ENA_m1, speedCar);

digitalWrite(IN_13, LOW);
digitalWrite(IN_14, HIGH);
 analogWrite(ENB_m1,   speedCar);


 digitalWrite(IN_21, LOW);
 digitalWrite(IN_22,   HIGH);
 analogWrite(ENA_m2, speedCar);

digitalWrite(IN_23,   HIGH);
```

```
digitalWrite(IN_24, LOW);
 analogWrite(ENB_m2, speedCar);
  }

void goRight(){

digitalWrite(IN_11,   LOW);
digitalWrite(IN_12, HIGH);
analogWrite(ENA_m1, speedCar);

 digitalWrite(IN_13, HIGH);
 digitalWrite(IN_14, LOW);
 analogWrite(ENB_m1,   speedCar);

 digitalWrite(IN_21, LOW);
 digitalWrite(IN_22,   HIGH);
 analogWrite(ENA_m2, speedCar);

digitalWrite(IN_23,   HIGH);
digitalWrite(IN_24, LOW);
 analogWrite(ENB_m2, speedCar);

   }
void goLeft(){
digitalWrite(IN_11, HIGH);
digitalWrite(IN_12,   LOW);
analogWrite(ENA_m1, speedCar);
digitalWrite(IN_13,   LOW);
digitalWrite(IN_14, HIGH);
analogWrite(ENB_m1, speedCar);
digitalWrite(IN_21, HIGH);
digitalWrite(IN_22, LOW);
analogWrite(ENA_m2, speedCar);

digitalWrite(IN_23, LOW);
digitalWrite(IN_24, HIGH);
analogWrite(ENB_m2, speedCar);
    }
void goAheadRight(){
digitalWrite(IN_11,   HIGH);
digitalWrite(IN_12, LOW);
analogWrite(ENA_m1, speedCar/speed_Coeff);
digitalWrite(IN_13, LOW);
digitalWrite(IN_14, HIGH);
analogWrite(ENB_m1,   speedCar/speed_Coeff);
digitalWrite(IN_21, LOW);
digitalWrite(IN_22,   HIGH);
analogWrite(ENA_m2, speedCar);

digitalWrite(IN_23,   HIGH);
digitalWrite(IN_24, LOW);
analogWrite(ENB_m2, speedCar);

  }
void goAheadLeft(){

digitalWrite(IN_11, HIGH);
digitalWrite(IN_12, LOW);
analogWrite(ENA_m1, speedCar);
digitalWrite(IN_13, LOW);
digitalWrite(IN_14, HIGH);
analogWrite(ENB_m1,   speedCar);
digitalWrite(IN_21, LOW);
digitalWrite(IN_22,   HIGH);
analogWrite(ENA_m2, speedCar/speed_Coeff);
digitalWrite(IN_23,   HIGH);
digitalWrite(IN_24, LOW);
analogWrite(ENB_m2, speedCar/speed_Coeff);

  }

void goBackRight(){

digitalWrite(IN_11, LOW);
```

```
digitalWrite(IN_12,   HIGH);
analogWrite(ENA_m1, speedCar/speed_Coeff);

digitalWrite(IN_13,   HIGH);
digitalWrite(IN_14, LOW);
analogWrite(ENB_m1, speedCar/speed_Coeff);

digitalWrite(IN_21, HIGH);
digitalWrite(IN_22, LOW);
analogWrite(ENA_m2,   speedCar);

digitalWrite(IN_23, LOW);
digitalWrite(IN_24,   HIGH);
analogWrite(ENB_m2, speedCar);

  }

void goBackLeft(){

digitalWrite(IN_11, LOW);
digitalWrite(IN_12, HIGH);
analogWrite(ENA_m1, speedCar);
digitalWrite(IN_13, HIGH);
digitalWrite(IN_14, LOW);
analogWrite(ENB_m1, speedCar);
digitalWrite(IN_21, HIGH);
digitalWrite(IN_22, LOW);
analogWrite(ENA_m2,   speedCar/speed_Coeff);
digitalWrite(IN_23, LOW);
digitalWrite(IN_24,   HIGH);
analogWrite(ENB_m2, speedCar/speed_Coeff);

  }
void   stopRobot(){
digitalWrite(IN_11, LOW);
digitalWrite(IN_12,   LOW);
analogWrite(ENA_m1, speedCar);

digitalWrite(IN_13,   LOW);
digitalWrite(IN_14, LOW);
analogWrite(ENB_m1, speedCar);
digitalWrite(IN_21, LOW);
digitalWrite(IN_22, LOW);
analogWrite(ENA_m2,   speedCar);
digitalWrite(IN_23, LOW);
digitalWrite(IN_24,   LOW);
analogWrite(ENB_m2, speedCar);
  }
void loop(){
if (Serial.available() > 0) {
 command = Serial.read();
 stopRobot();       //Initialize with motors stopped.
switch (command) {
case 'F':goAhead();break;
case   'B':goBack();break;
case 'L':goLeft();break;
case 'R':goRight();break;
case   'I':goAheadRight();break;
case 'G':goAheadLeft();break;
case 'J':goBackRight();break;
case   'H':goBackLeft();break;
case '0':speedCar = 100;break;
case '1':speedCar =   115;break;
case '2':speedCar = 130;break;
case '3':speedCar = 145;break;
case   '4':speedCar = 160;break;
case '5':speedCar = 175;break;
case '6':speedCar   = 190;break;
case '7':speedCar = 205;break;
case '8':speedCar = 220;break;
case   '9':speedCar = 235;break;
case 'q':speedCar = 255;break;
}
}
```

خلاصة

في هذا البحث تم اقتراح روبوت خاص لتسلق السلالم. في يومنا ها يتم استخدام الروبوتات لجميع الأغراض تقريبًا. حيت يتم حل العديد من المشاكل اليومية باستخدام الروبوتات. ولكن عندما يتعلق الأمر بالمسنين أو الأشخاص المعاقين جسديًا ، فمن الصعب تسلق السلم. يقدم هذا البحث هيكل وبناء وتطبيق روبوت خاص لتسلق السلالم يتم التحكم فيه بواسطة اردوينو .

أتاح ظهور تقنية جديدة عالية السرعة وقدرة الكمبيوتر المتزايدة فرصة واقعية للتحكم في الروبوتات الجديدة وإدراك طرق جديدة لنظرية التحكم. هذا التحسين التقني جنبًا إلى جنب مع الحاجة إلى روبوتات عالية الأداء خلقت روبوتات أسرع وأكثر دقة وأكثر ذكاءً باستخدام أجهزة تحكم جديدة في الروبوتات وبرامج تشغيل جديدة وخوارزميات تحكم متقدمة. يصف هذا المشروع حلاً اقتصاديًا جديدًا لأنظمة التحكم في الروبوت.

الهدف الرئيسي من هذا العمل الحالي هو بناء آلة روبوت قادرة على صعود السلالم باستخدام اردوينو مع وحدة البلوتوث. يتم الضبط التلقائي في الروبوت وفقًا لارتفاع الدرج عن طريق توصيل جهاز Android الذي يتضمن تطبيق مبرمج بلغة C ++ مع اردوينو. يستخدم هذا التصميم لوحة اردينو انو (Arduino Uno) للتحكم في الروبوت وغيرها من PCB المصنوع منزليًا لربطه بلوحة اردوينو. يتم تشغيل الروبوت بواسطة بطاريات الليثيوم ومحركات صندوق التروس (gear box motors). يمكن استخدام نظام التحكم في الروبوت المقدم لمختلف التطبيقات الروبوتية المعقدة.

شكر وتقدير

بفضل الله على إعطائنا هذه الفرصة، والقوة والصبرلاكمال مشروعنا أخيرا، وبعد كل التحديات والصعوبات.

إنه لمن دواعي سروري أن أشكر العديد من الناس الذين قدموا المساعدة لنا في هذا العمل.

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روبوت لتسلق السلم

مشروع مقدم لقسم الهندسة الكهربائية في الوفاء الجزئي
لمتطلبات درجة البكالوريوس. في الهندسة الكهربائية

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Smart home

A project submitted to the Department of Electrical Engineering partially
Meet the requirements of the B. SC degree in electrical engineering

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DECLERATION

We hereby declare that this project report is based on our original work except for citations and quotations, which have been duly acknowledged.

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Name: ______________________________

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Date: ________________________________

Approval of submission

We certify that this project report titled "**Smart Home**" has been prepared By **Hassan AL-Mujtaba Ali Salman** and **Jumana Aayad Abbas** and **Abdullah Nasser Mohi** and **Tabark Dakhel Jabr** Meet the criteria required to apply In partial fulfillment of the requirements for granting a bachelor's degree in **electrical Engineering** at the Iraqi University.

Approved by

Signature: ___________________________

Supervisor: __________________________

Date: _______________________________

DEDICATION

To all those who had the credit after God Almighty in completing this study to whom

He taught me that the world is a struggle and its weapon is science and knowledge

(my dear father)

To the one who’s under her feet the Almighty God put the Paradise,

And he revered it in his great book

(My beloved mother)

To those who supported me in my research my dear teacher

To the teaching professors in the Department of Electrical Engineering

I dedicate my research to you

Acknowledgement

In the name of God, the most Merciful, the most Compassionate Thanks and praise to God Almighty first for the blessing of patience and the ability to accomplish the work Praise be to God for these blessings. We extend our thanks and appreciation to our distinguished professor Dr. Malik Abdul Razzaq, who Please supervise this research, and for all the support, guidance and guidance he has given us Perfection This work for what it is has the highest expressions of praise and appreciation.

Abstract

This project aims to develop a smart home with advanced control devices, focusing on reducing electricity wastage. The goal is to create an energy-efficient house, addressing a crucial issue for humanity in our modern age, where traditional energy sources pose a threat. In terms of appearance and construction materials, these houses are indistinguishable from traditional homes. However, the key distinction lies in the stronger and larger infrastructure required for smart homes compared to regular ones. The objective is to provide intelligent assistance to individuals who face challenges such as disabilities or old age, enabling them to live as independently as possible and combat isolation. By empowering them to manage their lives and enhancing home care, these smart homes promote active participation rather than dependence on assistance, thereby ensuring their safety and well-being.

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Chapter one: Introduction

1.1 Introduction

Smart home technology has gained immense popularity in recent years due to its ability to make daily life more convenient and efficient. A smart home is a residence equipped with devices, appliances, and systems that can be controlled remotely or through automated programming to perform tasks that were previously done manually. These devices can include everything from smart thermostats and lighting to security cameras and voice assistants[1].

This project will analyze the different types of devices used in smart homes, the underlying technologies that make them work, and the implications of using such technology on privacy and security. Additionally, this project will examine the potential for smart home technology to be used in addressing environmental concerns, such as reducing energy consumption and carbon footprint. Moreover, smart home technology does not simply turn devices on and off, it can monitor the internal environment and the activities that are being undertaken whilst the house is occupied. The result of these modifications to the technology is that a smart home can now monitor the activities of the occupant of a home, independently operate devices in set predefined patterns or independently, as the user requires [1]. It can both share resources and communicate within the home, and we can exchange information with your home external network through your home smart gateway. Its main objective is to provide people with an efficient, comfortable, safe, convenient and environment-friendly living environment integrating system, service and management. Smart home is the use of computer technology, control technology, image display technology and communications technology will be connected through the network of various facilities together to meet the automation requirements of the entire system to provide more convenient control and management [2]. meter, electric energy meter and gas meter, which provide more convenient conditions for the high-quality service [3]. Home automation systems face four main challenges, these are high cost of ownership, inflexibility, poor manageability, and difficulty achieving security [4 6]. In research paper [7], the researcher designs a home automation system uses Wi-Fi technology. System consists of three main components; web server, which presents system core that controls, and monitors users’ home and hardware interface module (Arduino PCB (readymade), Wi-Fi shield PCB, 3 input alarmsPCB, and 3 output actuators PCB.), which provides appropriate interface to sensors and actuator of home automation system. The System is better from the scalability and flexibility point of view than the commercially available home automation systems. The User may use the same technology to login to the server web based application. If server is connected to the internet, so remote users can access server web based application through the internet using compatible web browser. In research paper [8], the researcher discussed designing a web service and android app Based home automation system. The application has been developed based on the android system. Aninterface card has been developed to assure communication between the remote user, server, raspberry pi card and the home Appliances. The application has been installed on an android Smartphone, a web server, and a raspberry pi card to control the shutter of windows. Androida pplication on a smart phone issue command to raspberry pi card. An interface card has beenrealized to update signals between the actuator sensors and the raspberry pi card.In research paper [9], the researcher implement and design a smart home system using Arduino microcontroller to receive user commands to execute through an Ethernet shield. The system network used together both wireless ZigBee and wired X10 technologies. The mobile device can be either wired to the central controller through

USB cable or communicates with it wirelessly, within the scope of the home. Arduino contains the web server application that communicates through the HTTP (Hyper Text Transfer Protocol) with Web-based Android application. The system is highly flexible and scalable and expandable. In research paper [10], the researcher discussed a home system automation where the home network monitors the appliances and sensors and transmits data to the cloud-based data server which manages the information and provides services for users by transmitting data and receiving user commands from mobile application. The proposed system has good modularity and configurability characteristics with very low power consumption in cost efficient way. And Finally, the research paper [11]

1.2 Problem Statement

Home automation systems face four main challenges, these are high cost of ownership, inflexibility, poor manageability, and difficulty achieving security. The proposed system has a great flexibility by using Wi-Fi technology to interconnect its distributed modules to home automation server. System will make use of secure wireless LAN connections between distributed hardware modules and server, and secure communication protocols between users and server. The hardware interface module controls its alarms and actuators. System can be accessed from the web browser of any local PC or any smart phone mobile device in the same LAN using server IP.

1.3 Aims and Objectives

The aim of the project is to develop a working prototype of a web based home automation System which is reliable, affordable to home owners, schools, hotels, lodges and individuals such as the elderly and the disabled. The purposed system is capable of controlling and automating most of the house appliance through an easy manageable web interface to run and maintain the home automation system. Also we exchange the security cameras with laser system to achieve security. One of the most important objective of this project is that you can access the system through the web page and it's support all smart devices type (Android, iPhone or any PC). Specific objectives are to design a system that will be able to:

1. Model the home layout on the user web interface.
2. Provides a unique service
3. Rationalization of energy consumption
4. A friend of the environment

Chapter Two: Literature Review

2.1 Security and home automation based on Raspberry

With advancement of Automation technology, life is getting simpler and easier in all aspects. In today's world Automatic systems are being preferred over manual system. With the rapid increase in the number of users of internet over the past decade has made Internet a part and parcel of life, and IoT is the latest and emerging internet technology. Internet of things is a growing network of everyday object-from industrial machine to consumer goods that can share information and complete tasks while you are busy with other activities. Wireless Home Automation system(WHAS) using IoT is a system that uses computers or mobile devices to control basic home functions and features automatically through internet from anywhere around the world, an automated home is sometimes called a smart home. It is meant to save the electric power and human energy. The home automation system differs from other system by allowing the user to operate the system from anywhere around the world through internet connection. In this project we present a Home Automation system (HAS) using Raspberry Pi 3, Arduino Uno and Node MCU wireless communication, to provide the user with remote control of various lights, fans, and appliances within their home and Security application. The system will automatically change on the basis of sensors'. This system is designed to be low cost and expandable allowing a variety of devices to be controlled. Key Words: Home automation System (HAS), Internet of Things (IoT), Cloud networking, Wi-Fi network. There's a four application of security gas leak and smoke using MQ2, detecting fire using flame sensor, detecting carbon monoxide using MQ9, detecting light using LDR and surveillance camera using webcam with Raspberry Pi 3 live streaming on the cloud. I faced to many problems, I bought too many components, I would like to use LCD and to let the webcam sends emails when detect motion, but not enough time left [11].

2.2 A review of Internet of Things for smart home: Challenges and solutions

Although Internet of Things (IoT) brings significant advantages over traditional communication technologies for smart grid and smart home applications, these implementations are still very rare. Relying on a comprehensive literature review, this paper aims to contribute towards narrowing the gap between the existing state-of-the-art smart home applications and the prospect of their integration into an IoT enabled environment. We propose a holistic framework which incorporates different components from IoT architectures/frameworks proposed in the literature, in order to efficiently integrate smart home objects in a cloud-centric IoT based solution. We identify a smart home management model for the proposed framework and the main tasks that should be performed at each level. We additionally discuss practical design challenges with emphasis on data processing, as well as smart home communication protocols and their interoperability. We believe that the holistic framework ascertained in this paper can be used as a solid base for the future developers of Internet of Things based smart home solutions [12].

2.3 Applications, Systems and Methods in Smart Home Technology

Smart Home technology started for more than a decade to introduce the concept of networking devices and equipment in the house. According to the Smart Homes Association the best definition of smart home technology is: the integration of technology and services through home networking for a better quality of living. Many tools that are used in computer systems can also be integrated in Smart Home Systems. In this paper, we present the Technologies and tools that can be integrated or applied in Smart Home systems [13].

2.4 Principles of Smart Home Control

Seeking to be sensitive to users, smart home researchers have focused on the concept of control. They attempt to allow users to gain control over their lives by framing the problem as one of end-user programming. But families are not users as we typically conceive them, and a large body of ethnographic research shows how their activities and routines do not map well to programming tasks. Enduser programming ultimately provides control of devices. But families want more control of their lives. In this paper, we explore this disconnect. Using grounded contextual fieldwork with dual-income families, we describe the control that families want, and suggest seven design principles that will help end-user programming systems deliver that control [14].

2.5 A Smart Home in a Box

The physical layer contains hardware including sensors and actuators. The architecture utilizes a ZigBee wireless mesh which communicates directly with hardware components. A publish/subscribe manager governs the middleware layer. The manager provides named broadcast channels that allow component bridges to publish and receive messages. The middleware provides valuable services, such as adding time stamps to events, assigning universally unique identifiers (UUIDs), and maintaining site-wide sensor state. Every component of the CASAS architecture communicates via a customized Extensible Messaging and Presence Protocol (XMPP) bridge to this manager. Examples include the ZigBee bridge; the Scribe bridge, which archives messages in permanent storage; and bridges for each applicationlayer software component [15].

2.6 Title: Learning to live in a smart home Building Research & Information

Smart homes promise to significantly enhance domestic comfort, convenience, security and leisure whilst simultaneously reducing energy use through optimized home energy management. Their ability to achieve these multiple aims rests fundamentally on how they are used by householders, yet very little is currently known about this topic. The few studies that have explored the use of smart homes have tended to focus on special-interest groups and be quite short-term. This paper reports on new in-depth qualitative data that explore the domestication of a range of smart home technologies in 10 households participating in a nine-month field trial. Four core themes emerge: (1) smart home technologies are both technically and socially disruptive; (2) smart homes require forms of adaptation and familiarization from householders that can limit their use; (3) learning to use smart home technologies is a demanding and time-consuming task for which there is currently very little support available; and (4) there is little evidence that smart home technologies will generate substantial energy savings and, indeed, there is a risk that they may generate forms of energy intensification. The paper concludes by discussing the implications of these findings for policy, design and further research [16].

2.7 Smart Home System

Smart home technology is emerging rapidly as an exciting new paradigm. A wide range of aspects that includes security, energy saving, ventilation, smart kitchen is covered in this paper. All of the above is executed with the help of smart devices such as remote control, security alarms, sensors etc. In this paper we present the above mentioned technologies and tools that can be integrated in smart home systems which can provide security energy saving and other such smart systems. Keywords— Smart home technology, Security alarm, Sensors, Remote Control, Energy Management, Smart Network [17].

2.8 The role of prediction algorithms in the MavHome smart home architecture

The goal of the MavHome project is to create a home that acts as a rational agent. The agent seeks to maximize inhabitant comfort and minimize operation cost. To achieve these goals, the agent must be able to predict the mobility patterns and device usages of the inhabitants. We introduce the MavHome project and its underlying architecture. The role of prediction algorithms within the architecture is discussed, and three prediction algorithms that are central to home operations are presented. We demonstrate the effectiveness of these algorithms on synthetic and/or actual smart home data [18].

2.9 Securing IoT for smart home system

This paper presents an approach to incorporate strong security in deploying Internet of Things (IoT) for smart home system, together with due consideration given to user convenience in operating the system. The IoT smart home system runs on conventional wifi network implemented based on the AllJoyn framework, using an asymmetric Elliptic Curve Cryptography to perform the authentications during system operation. A wifi gateway is used as the center node of the system to perform the system initial configuration. It is then responsible for authenticating the communication between the IoT devices as well as providing a mean for the

A smart home is an application of ubiquitous computing in which the home environment is monitored by ambient intelligence to provide context-aware services and facilitate remote home control. This paper presents an overview of previous smart home research as well as the associated technologies. A brief discussion on the building blocks of smart homes and their interrelationships is presented. It describes collective information about sensors, multimedia devices, communication protocols, and systems, which are widely used in smart home implementation. Special algorithms from different fields and their significance are explained according to their scope of use in smart homes. This paper also presents a concrete guideline for future researchers to follow in developing a practical and sustainable smart home [19].

2.10 State of the art of smart homes Engineering Applications of Artificial Intelligence

In this paper we present a review of the state of the art of smart homes. We will first look at the research work related to smart homes from various view points; first in the view point of specific techniques such as smart homes that utilize computer vision based techniques, smart homes that utilize audio-based techniques and then smart homes that utilize multimodal techniques. Then we look at it from the view point of specific applications of smart homes such as eldercare and childcare applications, energy efficiency applications and finally in the research directions of multimedia retrieval for ubiquitous environments. We will summarize the smart homes based research into these two categories. In the survey we found out that some well-known smart home applications like video based security applications has seen the maturity in terms of new research directions while some topics like smart homes for energy efficiency and video summarization are gaining momentum [20].

2.11 Smart home technologies for health and social care support

The integration of smart home technology to support health and social care is acquiring an increasing global significance. Provision is framed within the context of a rapidly changing population profile, which is impacting on the number of people requiring health and social care, workforce availability and the funding of healthcare systems [21].

2.12 Smart Homes Current features and future perspectives

In an ageing world, maintaining good health and independence for as long as possible is essential. Instead of hospitalization or institutionalization, the elderly and disabled can be assisted in their own environment 24 h a day with numerous ‘smart’ devices. The concept of the smart home is a promising and cost-effective way of improving home care for the elderly and the disabled in a non-obtrusive way, allowing greater independence, maintaining good health and preventing social isolation. Smart homes are equipped with sensors, actuators, and/or biomedical monitors. The devices operate in a network connected to a remote center for data collection and processing. The remote center diagnoses the ongoing situation and initiates assistance procedures as required. The technology can be extended to wearable and in vivo to monitor people 24 h a day both inside and outside the house. This review describes a selection of projects in developed countries on smart homes examining the various technologies available. Advantages and disadvantages, as well as the impact on modern society, are discussed. Finally, future perspectives on smart homes as part of a home-based health care network are presented [22].

2.13 Smart home technologies in Europe

Smart home technologies refer to devices that provide some degree of digitally connected, automated, or enhanced services to building occupants. Smart homes have become central in recent technology and policy discussions about energy efficiency, climate change, and the sustainability of buildings. Nevertheless, do they truly promote sustainability goals? In addition, what sorts of benefits, risks, and policies do they entail? Based on an extensive original dataset involving expert interviews, site visits to retailers, and a comprehensive review of the literature, this study critically examines the promise and peril of smart home technologies. Drawing on original data collected in the United Kingdom, which has access to European markets, the study first examines definitions of smart homes before offering a new classification involving 13 categories of smart technology covering 267 specific options commercially available from 113 companies. It situates these different technology classes alongside six degrees or levels of smartness, from the basic or traditional home to the fully automated and sentient home. It then elaborates on the 13 distinct benefits smart homes may offer alongside potential 17 risks and barriers, before introducing seven policy recommendations from the material. It lastly suggests three areas of future research on the demographics and behavior of actual smart home adopters, rethinking the duality of "control," and looking beyond "homes" towards socio-technical systems, practices, and justice [23].

2.14 Healthcare in the Smart Home

Ubiquitous or Pervasive Computing is an increasingly used term throughout the technology industry and is beginning to enter the consumer electronics space in its most recent form under the umbrella term: "Internet of Things". One area of focus is in augmenting the home with intelligent, networked sensors and computers to create a Smart Home which opens a host of possibilities for the role of tomorrow's dwelling. As the world's population continues to live longer and consequently experience more medicalrelated ailments, at the same time institutional healthcare is struggling to cope, the role of the Smart Home becomes paramount to monitoring a dweller's health and providing any necessary intervention. This study looks at the history of Smart Home Healthcare, current research areas, and potential areas of future investigation. Unique categorizations are presented in Activities of Daily Living (ADL) and Personal Sensors, and a thorough look at the application of Smart Home Healthcare is presented. Technology can augment traditional methods of healthcare delivery and in some cases completely replace it. Costs can be reduced and medical adherence can be increased, all of which contribute to a more sustainable and effective model of care. Keywords: healthcare; smart home; sensors; IoT; ADL; automation; augmented reality; implantable medical devices; wearables; telemonitoring [24].

2.15 A SMART HOME SYSTEM BASED ON SENSOR TECHNOLOGY

This paper presents a new approach to utilize technology in a practical and meaningful manner within a smart home system that can be widely deployed into residential settings. In the modern world, people are rapidly turning to technology as a fast and cost-effective way of improving quality of daily living. This primary goal is to address the needs of the end user by employing networked low-power sensors sensitive to the environment, so it can be altered to their liking. The proposed system consists of following steps: direct environment sensing, collecting and analyzing data and then allowing user to customize the settings and initiate specific commands. This research will present the design and implementation of a practical and simple smart home system, which can be further extended. The system is based on: group of sensors, Raspberry Pi device as a server system and Bluetooth as a communication protocol. These devices can be easily controlled via user-friendly interface for Android phones. The main advantage of the proposed system is that it is a sensible, secure and easily configurable system that provides end users with a neat home automation solution [25].

2.16 Smart Home Intelligence

A smart home (sometimes referred to as a smart house or eHome) is one that has highly advanced automatic systems. A smart home appears "intelligent" because its computer systems can monitor many aspects of daily life. Our research, presented in this paper, is based on a universal implementation model for the smart home. The “Home Intelligence” (HI) module of the smart home, offers important addedvalue to the intelligent behavior of the smart-home environment. The HI creates an integrated environment in which the Artificial Intelligence (AI) mechanism can infer and suitably react according to changing conditions and events. By identifying abnormal or unexpected events and, when necessary alerting the home’s occupants, the AI module can provide an immediate automatic response if desired. Because of the complexity of the systems, their diverse areas of control and supervision, the variety of information technologies and learning mechanisms, and the reasoning capabilities used in updating the information system, developers, suppliers and users must cooperate. Cooperation will be expressed by agreeing to anonymously transfer information from the client to the developer through the suppliers. The transferred information will include characteristics of abnormal events, which have actually occurred in reality (true life scenarios), and the responses of the smart home. This information is then analyzed and used for AI learning and to improve the system’s reasoning mechanisms. Collecting information from a large number of clients will allow for faster learning and updating of the home intelligence system. A simulation system was developed in order to illustrate the HI module. The simulation illustrates the learning and the reasoning processes as well as demonstrates the smart home's responses to abnormal events [26].

2.17 A smart home as digital ecosystem

Smart homes have become increasingly popular in the past few years. Similarly, new buildings are nowadays planned and built following sustainability guidelines. Energy efficient residential homes have gained importance for two reasons. They contribute to the protection of our environment and they simultaneously reduce operational costs over the whole building lifecycle. However, the full potential of smart homes still lies fallow due to the high complexity of the underlying automation systems as well as the physical processes that are to be controlled. This is the motivation to review smart homes under a digital ecosystem perspective. With respect to this viewpoint, this paper proposes a system concept that applies artificial intelligence in smart homes. Main goals are to minimize energy consumption while at the same time guaranteeing user comfort. Therefore, intelligent control strategies are developed that take a multitude of parameters into consideration and operate automatically. For this purpose, an agent part populated by a society of autonomous agents that implement artificial intelligence is developed. It is supported by an ontology based knowledge representation that contains all relevant data in a structured way [27].

2.18 Improving Smart Home Security

This paper explains various security issues in the existing home automation systems and proposes the use of logic-based security algorithms to improve home security. This paper classifies natural access points to a home as primary and secondary access points depending on their use. Logic-based sensing is implemented by identifying normal user behavior at these access points and requesting user verification when necessary. User position is also considered when various access points changed states. Moreover, the algorithm also verifies the legitimacy of a fire alarm by measuring the change in temperature, humidity, and carbon monoxide levels, thus defending against manipulative attackers. The experiment conducted in this paper used a combination of sensors, microcontrollers, Raspberry Pi and ZigBee communication to identify user behavior at various access points and implement the logical sensing algorithm. In the experiment, the proposed logical sensing algorithm was successfully implemented for a month in a studio apartment. During the course of the experiment, the algorithm was able to detect all the state changes of the primary and secondary access points and also successfully verified user identity 55 times generating 14 warnings and 5 alarms [28].

2.19 Practical trigger-action programming in the smart home

We investigate the practicality of letting average users customize smart-home devices using trigger-action ("if, then") programming. We find trigger-action programming can express most desired behaviors submitted by participants in an online study. We identify a class of triggers requiring machine learning that has received little attention. We evaluate the uniqueness of the 67,169 trigger-action programs shared on IFTTT.com, finding that real users have written a large [29].

Chapter Three: Methodology

3.1 The most important components of a smart home

You may think for a moment that the smart home project differs from the traditional home in only simple things, but in fact the difference between them is great, as the smart home works entirely through artificial intelligence technologies, and it also includes many additional tools and features that distinguish it from the traditional home.

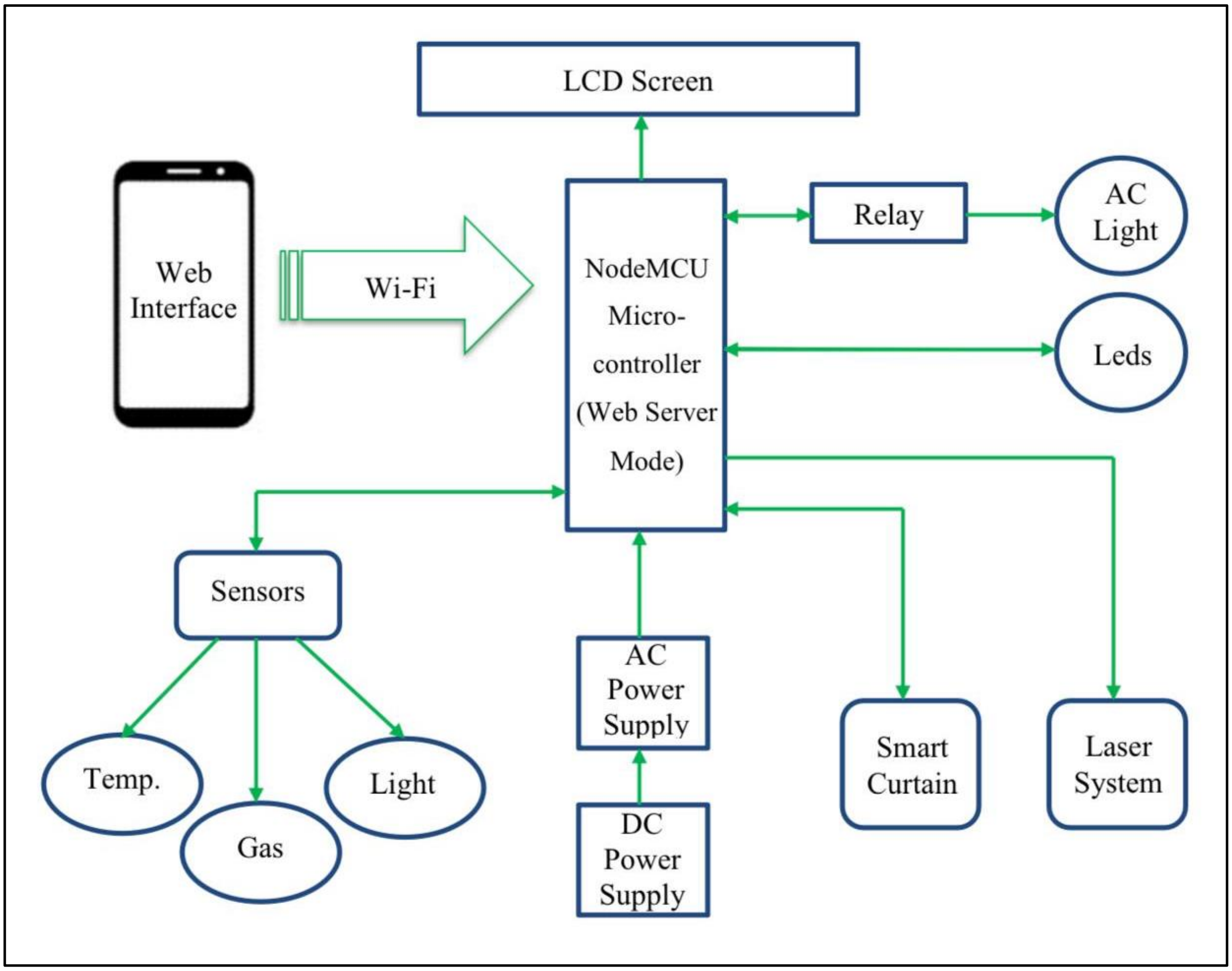


Figure 1 Workflow

3.2 ESP32

The ESP32 is a popular microcontroller and system-on-a-chip (SoC) designed for embedded systems and IoT (Internet of Things) applications. It is developed by Espressif Systems and is a successor to the ESP8266 chip. The ESP32 provides a wide range of features and capabilities, making it suitable for a variety of projects [36].

3.2.1 Key features of the ESP32

1. Dual-core processor: The ESP32 has two CPU cores, which allows for simultaneous execution of multiple tasks and enhances performance.

2. Wi-Fi and Bluetooth connectivity: The ESP32 includes built-in Wi-Fi and Bluetooth capabilities, enabling it to connect to wireless networks and communicate with other devices.

3. Low-power consumption: The chip is designed to operate efficiently in low-power applications, making it suitable for battery-powered devices and energy-conscious projects.

4. GPIO pins: The ESP32 offers a large number of General Purpose Input/ Output (GPIO) pins, allowing it to interface with various external components and sensors.

5. Integrated peripherals: It features a wide range of integrated peripherals such as SPI, I2C, UART, ADC, DAC, PWM, and more, which facilitate communication with external devices.

6. Memory and storage: The ESP32 typically comes with a generous amount of flash memory for program storage and RAM for data storage, enabling the execution of complex applications.

7. Development ecosystem: The ESP32 has gained significant popularity due to its extensive development ecosystem. It is supported by various programming frameworks, including the Arduino IDE, ESP-IDF (Espressif IoT Development Framework), and Micro Python, making it accessible to a wide range of developers.

8. Rich set of libraries: The ESP32 has a robust set of libraries and software tools available, simplifying the development process and enabling quick prototyping.

The ESP32's versatility and feature set make it well-suited for a wide range of applications, including home automation, smart devices, industrial automation, robotics, wireless sensor networks, and more [36].

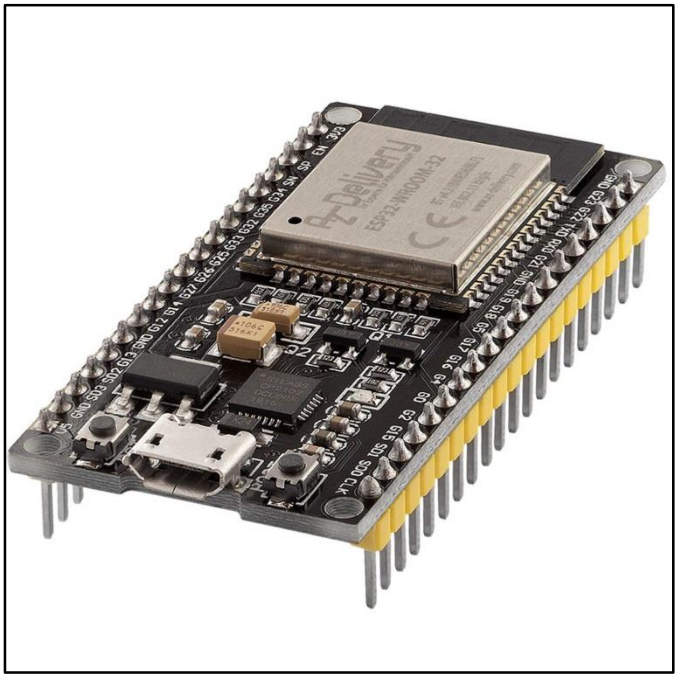


Figure 2 ESP32 [40]

3.3 Arduino UNO

The Arduino Uno is a popular microcontroller board that is widely used in the maker and electronics communities. It is based on the Atmega328P microcontroller and is part of the Arduino family of development boards. The Uno is known for its simplicity, ease of use, and wide availability of resources and community support [37].

3.3.1 Key features of the Arduino Uno

1. Microcontroller: The Uno is built around the Atmega328P microcontroller, which operates at 16 MHz and has 32KB of flash memory for program storage, 2KB of SRAM for data storage, and 1KB of EEPROM for non-volatile data storage.

2. Digital and Analog I/O: The Uno provides 14 digital input/output pins, among which 6 can be used for pulse-width modulation (PWM) output. It also has 6 analog input pins.

3. Programming: The Arduino Uno can be programmed using the Arduino programming language, which is a simplified version of C++. The Arduino IDE (Integrated Development Environment) is commonly used to write, compile, and upload code to the board.

4. USB Interface: The Uno has a built-in USB interface, allowing it to connect to a computer for programming and communication. It appears as a virtual COM port, making it easy to upload sketches (programs) to the board.

5. Power Options: The board can be powered using a USB cable, an external DC power supply, or by connecting it to a computer via USB. It also has a built-in voltage regulator that can provide 5V or 3.3V power to external components.

6. Shields: The Uno is compatible with a wide range of Arduino shields, which are add-on boards that provide additional functionality. Shields are available for various purposes, such as Ethernet connectivity, wireless communication (Wi-Fi, Bluetooth), motor control, and more.

7. Community and Resources: The Arduino Uno has a large and active community of users, with plenty of documentation, tutorials, and example projects available. This makes it easy to find help and inspiration for your own projects.

The Arduino Uno is commonly used for prototyping, educational purposes, and small-scale projects. It offers a beginner-friendly entry point into the world of microcontrollers and can be a great starting point for learning electronics and programming [31].

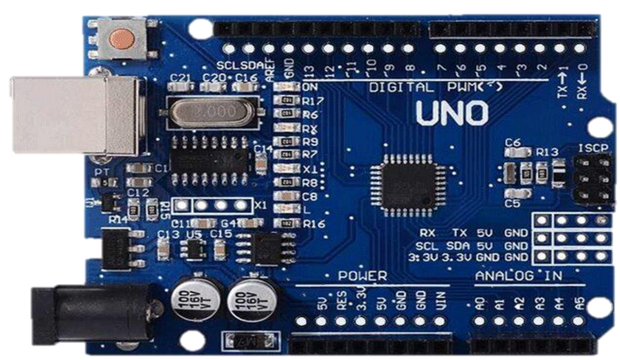


Figure 3 Arduino UNO [40]

3.4 Smart Locks

A smart fingerprint lock is a must-have at home as one of the most popular entrances for smart homes, smart fingerprint locks have been widely used. From smart phones to access control systems in some large areas, smart fingerprint locks can often be seen. Of course, the most reflected in modern family life. The fingerprint door lock uses human fingerprints to determine identity security and authentication. With high-tech digital image processing, biometrics, and DSP algorithms, it has become a new generation of access control systems that meet modern security [32].

Figure 4 Finger Print [40]

Keypad

Keypad locks, also known as keypad door locks or combination locks, are electronic locking systems that use a keypad to enter a numeric code or a combination of characters to unlock a door. These locks provide a convenient and keyless entry method for homes, offices, and other secure areas.

Here are some key features and characteristics of keypad locks:

1. Keypad: Keypad locks have a physical or touch-sensitive keypad interface where users enter a pre-defined code or combination to gain access. The keypad may have numeric buttons, alphanumeric buttons, or even touchscreen functionality.

2. Security: Keypad locks offer a higher level of security compared to traditional key locks as they eliminate the need for physical keys, which can be lost, stolen, or duplicated. The lock's security primarily relies on the strength of the code or combination used, so it's important to choose a unique and secure one.

3. Multiple user codes: Many keypad locks allow the programming of multiple user codes, enabling different individuals to have their own unique codes for access. This feature is particularly useful in environments with multiple authorized users.

4. Audible feedback: Keypad locks often provide audible feedback such as beeps or tones to indicate successful or unsuccessful code entry. This feedback can help users know if their code was accepted or if they need to try again.

5. Battery-powered: Most keypad locks are battery-powered, typically using standard alkaline batteries. This eliminates the need for wiring and allows for easy installation. Some locks also offer low-battery indicators to alert users when the batteries need to be replaced.

6. Additional features: Depending on the model, keypad locks may offer additional features such as built-in alarms, remote control capabilities, temporary access codes for guests, and integration with smart home systems.

It's worth noting that keypad locks, like any electronic security system, may have vulnerabilities and can be susceptible to hacking or code guessing. It's essential to choose a reputable and well-reviewed keypad lock and follow best practices for code selection and security. Keypad locks can be a convenient and secure option for controlling access to doors, providing a keyless and customizable entry method. They are commonly used in residential homes, commercial buildings, hotels, offices, and other locations where secure access control is needed [33].

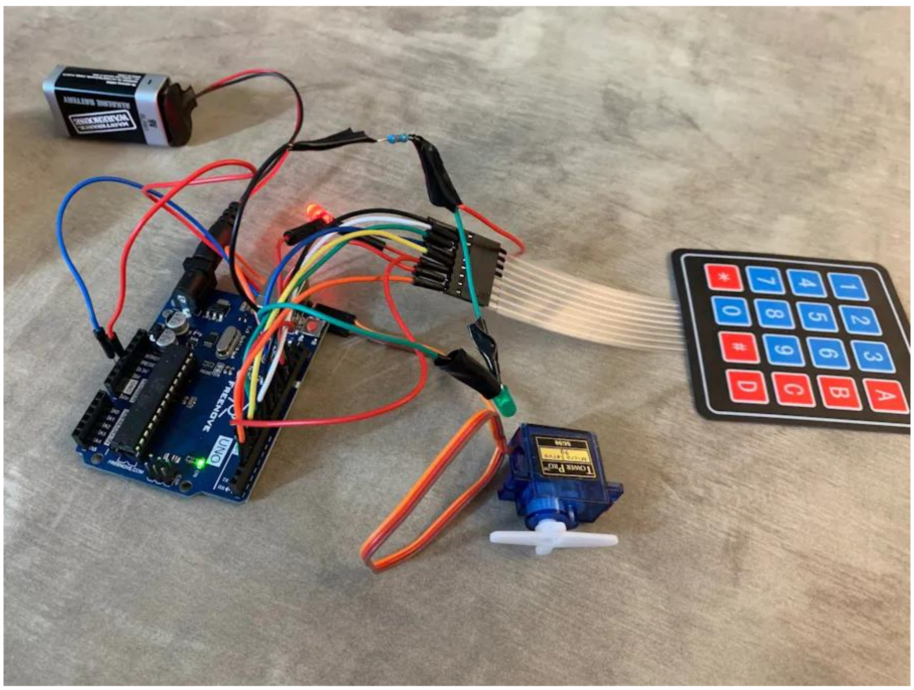


Figure 5 Keypad [40]

3.5 Servo motor

A servo motor is a type of motor commonly used in robotics and automation applications. It is designed to provide precise control of angular position, velocity, and acceleration. Arduino is a popular microcontroller platform that can be used to control servo motors [33].

The basic construction of a servo motor includes a small DC motor, a gear system, and a feedback control mechanism. The motor is connected to a control circuit that receives signals from an external source, such as an Arduino board. The control circuit interprets these signals and adjusts the motor's position based on the desired input [34].

Servo motors are known for their ability to rotate to a specific angle and hold that position accurately. This is achieved through a closed-loop control system. The motor's position is continuously monitored by a potentiometer or an optical encoder, providing feedback to the control circuit. If the motor deviates from the desired position, the control circuit adjusts the motor's speed and direction to correct the error and maintain the desired position [34].

Figure 6 Servo motor [40]

3.6 Smart Luminaires

The smart home has phone or clapping luminaires, as well as systems that automatically turn the lights on and off as soon as you enter and leave the room, which is a great feature to indicate that someone is in the house.

3.7 Light Dependent Resistor LDR

It means light-dependent resistance, as its name suggests. It is a light-sensitive resistance whose value depends on the light falling on it. The value of the resistance decreases with the increase in the intensity of the light, and its value increases with the decrease in it. That is, it is inversely proportional to the intensity of the light.

The working principle of the photoresist Photo resistance works according to the principle of photoconductivity. When light falls on a conductive material, it absorbs light energy and excites the electrons in the last orbit (valence band) of the conductive material. Then the free electrons work on conduction and thus the conductivity increases according to the increase in the intensity of the light. And the energy of the incident light must be greater than the energy of the (band gap) so that the electrons in the valence band are excited and conducting [36].

Figure 7 LDR [40]

3.7.1 Advantages of photo resistance

1. has a high sensitivity.
2. Simple to install and small in size.
3. ease of use.

4. cheap and inexpensive.
5. The percentage of (light-dark) resistance is high.
6. Connecting them is simple

3.7.2 photoresist defects

1. The temperature stability is low for the best materials.
2. Stabilized substances respond very slowly.
3. Their use is limited in cases where the light intensity changes rapidly.
4. Their response to change in light is not fast.
5. is affected by the change in the surrounding temperature.

3.8 Precision sensors

The smart home provides you with many multi-tasking sensors to protect you from any unwanted interference, thus maintaining your safety in the event of any danger, as the smart home includes sensors that make thieves feel afraid to enter or even approach it, such as calling the police or sounding sirens, in addition to the presence of sensors that alert you in the event of a fire or gas leak [36].

3.9 motion sensor PIR

What is a motion sensor used for? A motion sensor, or motion detector, is an electronic device that uses a sensor to detect nearby people or objects. Motion sensors are an important component of any security system. When a sensor detects motion, it will send an alert to your security system, and with newer systems, right to your mobile phone an active ultrasonic motion detector emits ultrasonic sound waves that reflect off objects and bounce back to the original emission point. When a moving object disrupts the waves, the sensor triggers and completes the desired action, whether this is switching on a light or sounding an alarm PIR stand for “Passive Infrared”. Basically, the PIR motion sensor measures infrared light from objects in its field of view. So, it can detect motion based on changes in infrared light in the environment. It is ideal to detect if a human has moved in or out of the sensor range [36].

Figure 8 motion sensor PIR [40]

3.10Temperature and Humidity Sensor Module- DHT11

DHTXX sensors are among the most popular multi-use components in Arduino as they are an inexpensive way to measure temperature and humidity. These sensors contain a chip that converts analog values to digital, and gives a digital signal corresponding to temperature and humidity at its output, and these signals are easy to read by any MCU [37].

3.11 Advantages

1. high accuracy

2. capacitive type
3. full range temperature compensation
4. Relative humidity and temperature measurement
5. Calibrated digital signal
6. Outstanding long-term stability
7. Plug-ins are not required
8. long transmission distance
9. low power consumption
10. fully encapsulated and interchangeable pins

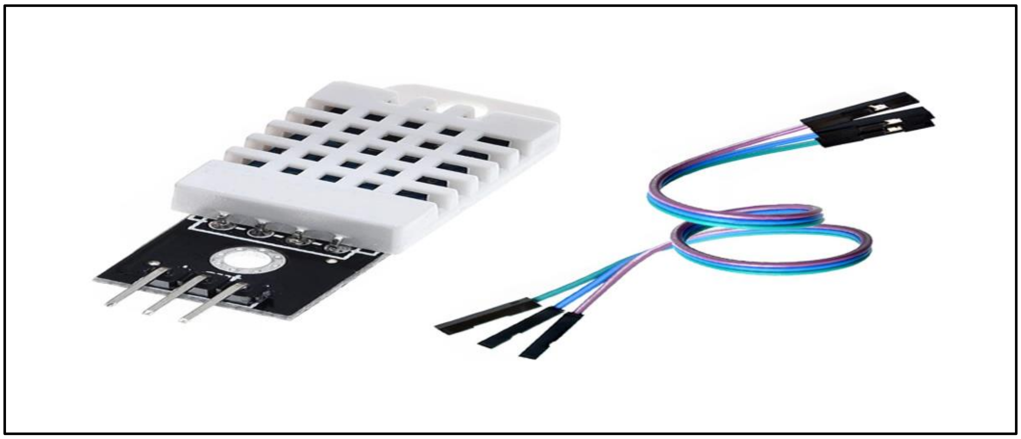


Figure 9 Temperature and Humidity Sensor Module- DHT11 [40]

3.12 Gas sensor

It is a sensor that detects gas leakage in the place. The gas sensor can detect flammable gases such as butane, propane, methane and hydrogen. When the gas concentration in the atmosphere increases, the voltage value increases accordingly, and when the gas concentration decreases or is not there, the voltage value in the sensor decreases Connecting the gas sensor with the Arduino; So you can detect gas leaks in homes, factories or offices at a fraction of the cost. After connecting the gas sensor with the Arduino, you can add a crystal screen that displays the amount of gas in the place and a sound source as an alarm siren so that individuals are notified of any leakage and the building is evacuated immediately before falling into the danger of fire, God forbid [37].

Figure 10 Gas sensor [40]

How does the gas sensor work? When the source dioxide (semiconductor molecules) in air is heated at a high temperature, absorption of oxygen at the surface. In clean air, the donor electrons in the source dioxide are attracted towards the oxygen that is adsorbed on the surface of the sensing material. This prevents the flow of electric current. In the presence of reducing gases, the surface density of the absorbed oxygen decreases during its reaction with the reducing gases. The electrons are then released into the sorce dioxide, allowing current to flow freely through the sensor [37].

3.13 fire sensor

Flame sensors are utilized in a number of hazardous environments, such as hydrogen stations, industrial heating and drying systems, industrial gas turbines, domestic heating systems and gas-powered cooking devices. Their primary purpose is to minimise the risks associated with combustion [38].

Smoke alarms detect fires by sensing small particles in the air using two different types of technologies. Once they detect those particles above a certain threshold, they sound an alarm A flame sensor detects the presence of fire or flames. In extremely hazardous environments, flame sensors work to minimise the risks associated with fire. There are several different types of flame sensor - some will raise an alarm while others may activate a fire suppression system or deactivate a combustible fuel line. Among the many different types of flame sensor, ultraviolet flame sensors, near IR array flame sensors, infrared flame sensors and IR3 flame detection sensors are the most prominent [38].

In a hazardous environment, such as a petrochemical processing plant, failing to detect gas leaks, fires or explosions could prove disastrous. However, more needs

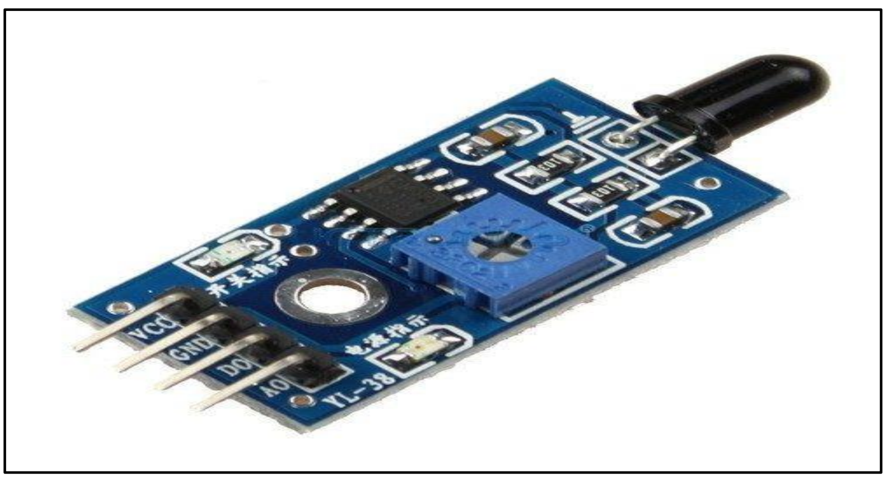


Figure 11 fire sensor [40]

to be done to help distinguish dangerous gas leaks or flames from annoying false alarms. In this article [38].

3.14 Water level sensor

Which is the best sensor for water level? Ultrasonic. Ultrasonic level sensors are ideal for a wide range of applications including water, wastewater, bulk solids and high viscocity liquids. Ultrasonic controllers are ideal for pump and level control

Figure 12 Water level sensor [40]

applications How do I monitor my water tank level? We personally recommend

hydrostatic water level sensors for water tank monitoring. They're reliable, low-cost, and easy to install. Hydrostatic water sensors work very well for monitoring water tank levels How does a tank level sensor work? The Submersible level sensor works by measuring the hydrostatic pressure emitted by a liquid in the tank. Since hydrostatic pressure is a measure of two variables, one being the density of the fluid and the other being the height of the fluid [38].

3.15 Soil Sensor

Sensor description: The “Soil moisture detector sensor is used to sense moisture in the soil, and it is considered one of the easy-to-use sensors, and it is an analog sensor, and its work is based on two copper rods, the contact ratio between which increases with the increase of water in the soil, and it is considered suitable for monitoring the moisture content in Soil for plants and control the amount of water for irrigation How does the sensor work? The sensor output voltage changes according to the change in soil moisture, when: The soil is wet: the output voltage drops The soil is dry, the output voltage rises [39].

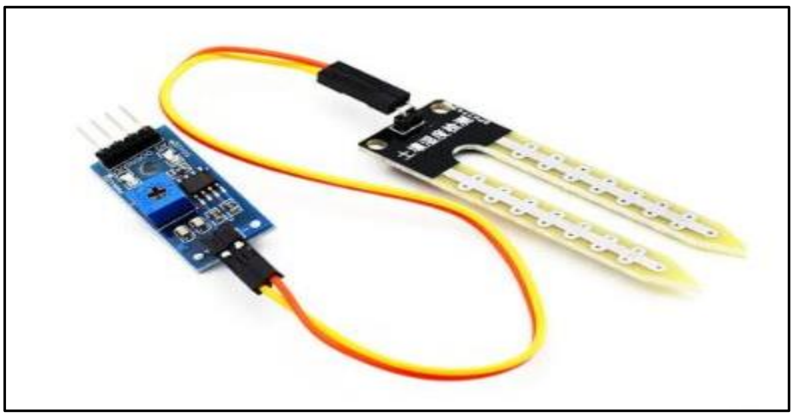
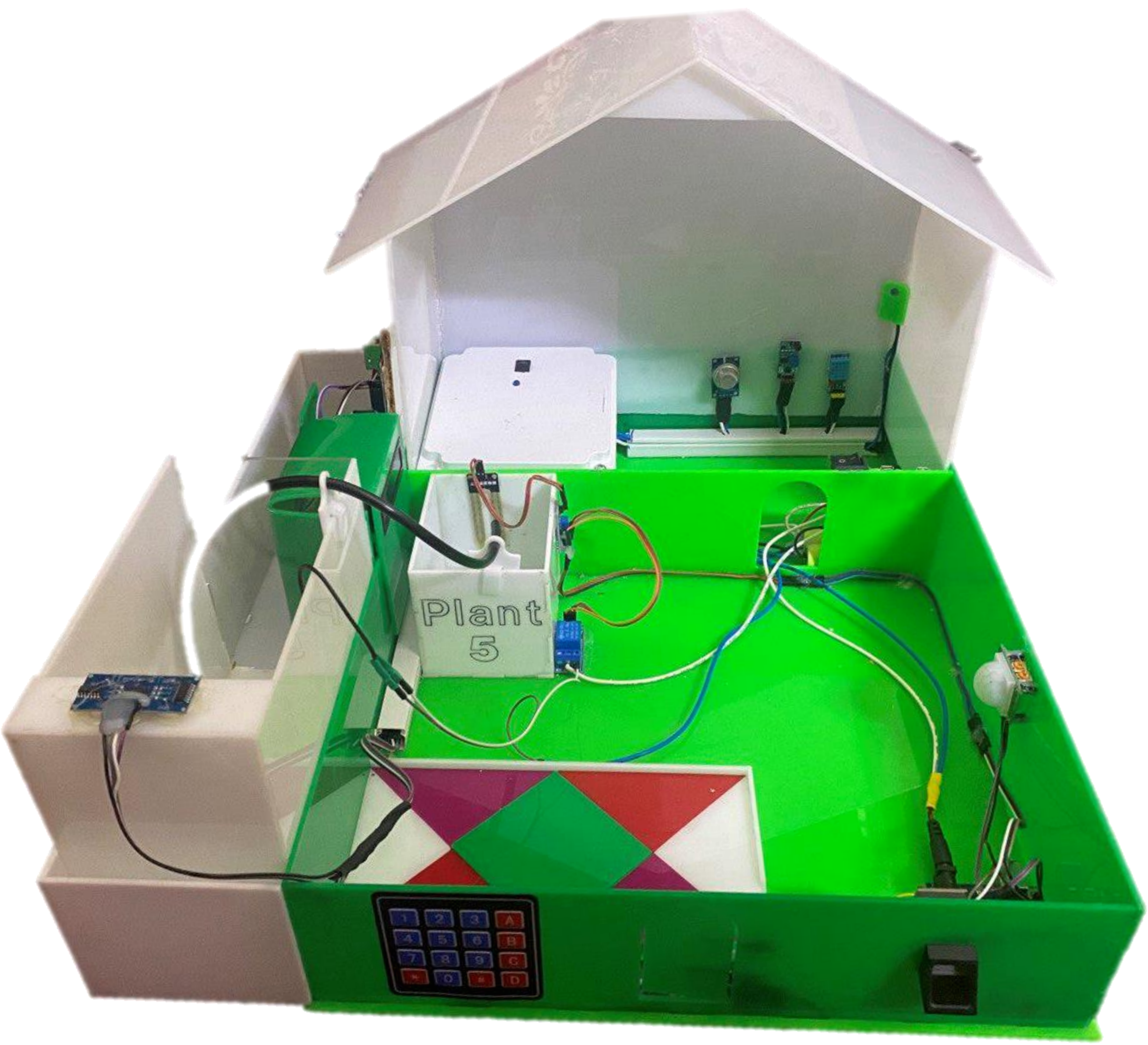


Figure 13 Soil Sensor [40]

3.16 Project final form

The Figure14 represents the prototype model of this project. In web application we can easily control the appliances and get the sensors data simultaneously. This project work is done on NodeMCU platform which communicate with the sensors by serial communication



14 pictur of smart home

Software

The only software we used in our project to program the microcontroller, ESP32 and designthe web page is Arduino IDE.The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains acontent manager for composing code, a message region, a content comfort, a toolbar withbuttons for normal capacities and a progression of menus. It associates with the Arduino andGenuine equipment to transfer programs and speak with them. Projects composed utilizing Arduino Software (IDE) is called outlines. These representations are written in the word
processor and are spared with the record augmentation. The editorial manager has highlights for cutting/gluing and for looking/supplanting content. The message territory gives criticism while sparing and sending out and furthermore shows mistakes. The comfort shows content
yield by the Arduino Software (IDE), including total mistake messages and other data. The base right-hand corner of the window shows the designed board and sequential port. The toolbar catches enable you to confirm and transfer programs, make, open, and spare portrays, and openthe sequential screen . Implementation and code programming System has a central controller acting as central processing unit which is connected with the web server and sensors. Central processing unit (CPU) represented by the ESP32 NodeMCU;
here controller is also connected with the electrical home appliances through electrical relays and some other different loads like motors and sensors. Central controller follows different algorithms to collect information, compare and make decisions, show results and control appliances. To create a web server ESP32 module has been used which has a storage for data and Wi-Fi module in a single

chip. the ESP32 module takes the name of the Wi-Fi network

and the password of that network as input from the user and then establishes its own Wi-Fi network. According to the load list a web page is written and designed and already stored in the memory of the ESP32 module. Once the user is connected to a network, the ESP32 is ready to show the states of lightings and different results and also take command from the client to control the lighting through the web page. To execute our desired applications, we used algorithms and codes as follows

Chapter Four: Results

4.1 Results

Turn the System On

To turn the system on, the user has to connect it with AC and DC power supply. As soon as you press the switch, the system will work and the LCD screen will show phrase "Smart Wi-Fi Home Networks Engineering" as shown in after few seconds the phrases will disappear from the LCD screen

1- Remote Access: the smart home system allows users to remotely access the home from any device that is connected to the internet. This enables you to control the devices in your home from anywhere, at any time.

2- Device Status: the smart home system is able to provide real-time status updates for all devices connected to it. This means that you can easily see whether a device is on or off, and whether it is functioning properly.

3- Device Control: You can toggle the status of any device connected to your smart home system, turning it on or off as needed. This allows you to conserve energy by turning off devices that are not in use.

4- Energy Rationalization: the smart home system is designed to conserve energy by monitoring and adjusting the power usage of devices. This helps to reduce energy waste and lower utility bills.

5- Environmentally Friendly: the smart home system is designed with environmental considerations in mind such as outside temperature, features that promote sustainable living, such as energy-efficient lighting and water-saving devices.

6- Security and Protection: the smart home system includes security features that protect your home and your family. This could include smart locks and motion sensors that detect and alert you to potential intruders.

7- High Safety Scores: the smart home system has been designed and tested to ensure that it meets high safety standards. This means that you can trust that it will function reliably and safely, and that it will protect your home and your family from potential hazards.

8- people identifications: the smart home system utilizes fingerprint sensor for specific individuals such as family members, these fingerprints included in system database and can be updated to add or remove persons. The system also sends a message to the owner about who

Access The System

When turn the system on, the Wi-Fi network (named Smart_Home) will appear directly in the Wi-Fi networks list . To access the system, the user has to connect the Wi-Fi network and add the password which is 123456789 and also can be changed by the user

User Interface Access

To access the website, the user has to open any web browser and enter the authenticate IP address of the web server to reach the web site. When he/she hit enter, the website page will load for the first time without any sensors readings and no lights opened

Display Sensors Readings

After few seconds of loading the website, the readings will start appears in the website. The readings will be changed very fast if any physical changing happened in the home environment because the server updates the reading values shown in the website every two seconds

Controlling The Lighting

Every light or led has a button on the website to open and close it. In this section we will show the state of buttons in the website and LEDs when closing or opening. shows the state of every button in the website when they are closing and opening

Chapter Five: Conclusion and Future work

5.1 Conclusion

The project aims to develop a web-based home automation system that is reliable, affordable, and easy to manage for homeowners, schools, hotels and individuals such as the elderly and the disabled. The system will be capable of controlling and automating most of the house appliances through an easy-to-use web interface, which can be accessed from any device connected to the network. The project will also focus on security and energy efficiency by using secure wireless LAN connections between distributed hardware modules and the server.

The project identified smart locks, smart luminaires, precision sensors, and energy management systems as the most important components of a smart home. These components enhance security, comfort, and energy efficiency. The project also highlighted the advantages and disadvantages of using light-dependent resistors as part of a smart home lighting system.

Overall, the project recognizes the growing popularity of smart home technology and its potential to improve daily life. However, the project also acknowledges the privacy and security implications of using such technology and emphasizes the need for secure communication protocols and systems to protect user data.

5.2 Future Work Recommendation

As the innovation for savvy homes keeps on advancing, the scope of capacities is just going to grow. And because we are a part of this world, we are thinking of developing our project more and adding more features and appliances to be control and monitor. For example, we arethinking of adding a police call system and linking it with the laser system to call the police when the system detects an unauthorized individual in the home. Also we are thinking of light intensity controlling system according to the state of the time to save the unnecessary wasting of energy. We can also connect the air conditions to the temperature and humidity sensor to open it when the temperature reaches a certain threshold value. Also we could add an alarm to the gas and smoke detecting system to enhance safety inside the house.

References

1. Jain, R., & Jain, R. (2020). Design and development of fingerprint door lock system using Arduino. International Journal of Emerging Technologies and Innovative Research, 7(1), 1-9.

2. Li, Y., Wang, H., & Sun, Y. (2019). An IoT-Based Smart Door Lock System Using Fingerprint Verification. IEEE Access, 7, 138073-138085.

3. Tondi, B., & Tosato, P. (2021). Security and privacy issues of smart locks: a comprehensive review. Journal of Ambient Intelligence and Humanized Computing, 1-20.

4. Xie, L., Luo, J., Peng, C., & Li, X. (2019). A Smart Fingerprint Door Lock System for Home Security. In 2019 International Conference on Electronic Technology (ICET) (pp. 1-4). IEEE.

5. Zeng, Y., & Li, Y. (2021). Intelligent Security Door Lock Based on Fingerprint Recognition. IEEE Transactions on Industrial Informatics, 17(4), 2618-2626.

6. Ravi, S., Seshagiri Rao, B., & Vamsidhar, R. (2020). Smart Home Automation Using IoT. In Internet of Things (IoT) in 5G Mobile Technologies (pp. 23-44). Springer, Cham.

7. Gou, W., Liu, Y., Liu, X., & Yang, L. T. (2020). Smart home automation: A literature review. IEEE Internet of Things Journal, 7(8), 6873-6883.

8. Mahmud, M. A., & Chowdhury, M. Z. (2021). Performance evaluation of light dependent resistor (LDR) based security system. In 2021 International Conference on Electrical, Computer and Communication Engineering (ECCE) (pp. 1-4). IEEE.

9. Ponce, D., Ramirez, G., & Ramirez, P. (2021). Implementation of a Precision Sensor System for Smart Homes Using Machine Learning. IEEE Access, 9, 35538-35551.

10. Ahmad, T., Qamar, R., & Al-Sumaiti, A. (2021). Smart Home Safety: An Integrated Gas and Fire Detection System. In 2021 5th International Conferenc

11 - Security and home automation based on Raspberry Pi, Arduino Uno and Node MCU Authors: DJEMA, Noureddine Issue: 24-Jun-2018

12 - A review of Internet of Things for smart home: Challenges and solutions Journal of Cleaner Production Volume 140, Part 3, 1 January 2017, Pages 1454-1464

13 - Applications, Systems and Methods in Smart Home Technology Rosslin John Robles1 and Tai-hood Kim1 1School of Multimedia, Hanna University, Daejeon, Korea

14 - Principles of Smart Home Control Scott Davidoff, Min Kyung Lee, Charles Yiu, John Zimmerman, and Anind K. Dey Human-Computer Interaction Institute + School of Design Carnegie Mellon University

15 - A Smart Home in a Box Published in: Computer (Volume: 46, Issue: 7, July 2013) Page(s): 62 - 69 Date of Publication: 26 September 2012

16 - Learning to live in a smart home Building Research & Information Volume 46, 2018 - Issue 1: Energy performance gaps: promises, people, practices Smart Home System Mr.Rohit Kadam1 ,Mr.Pranav Mahamuni ,Mr.Yash Parikh3 1 (Department of Computer Engineering, Sinhgad Institute of Technology and Science, Pune, India) 2 (Department of Mechanical Engineering, Sinhgad Institute of Technology and Science, Pune, India) 3 (Department of Mechanical Engineering, Symbiosis Institute of Technology, Pune, India) International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163 Volume 2 Issue 1 (January 2015)

17 - The role of prediction algorithms in the MavHome smart home architecture Published in: IEEE Wireless Communications (Volume: 9, Issue: 6, December 2002) Page(s): 77 - 84Date of Publication: December 2002

18 - Securing IoT for smart home system Published in: 2015 International Symposium on Consumer Electronics (ISCE) Date of Conference: 24-26 June 2015 Date Added to IEEE Xplore: 06 August 2015

19 - A Review of Smart Homes—Past, Present, and Future Published in: IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews) (Volume: 42, Issue: 6, November 2012) Page(s): 1190 - 1203 Date of Publication: 03 April 2012

20 - State of the art of smart homes Engineering Applications of Artificial Intelligence Volume 25, Issue 7, October 2012, Pages 1313-1321

21 - Smart home technologies for health and social care support Greg Kelly W, George Kernohan, Bernadette McCreight, Christopher Nugent declarations of interest Version published: 08 October 2008 Version history.

22 - Smart Homes Current features and future perspectives Volume 64, Issue 2, 20 October 2009, Pages 90-97

23 - Smart home technologies in Europe A critical review of concepts, benefits, risks and policies Renewable and Sustainable Energy Reviews Volume 120, March 2020, 109663

24 - Healthcare in the Smart Home A Study of Past, Present and Future School of Computer Science and Informatics, De Montfort University, Leicester LE1 9BH, UK Author to whom correspondence should be addressed. Sustainability 2017, 9(5), 840; https://doi.org/10.3390/su9050840 ReCceived: 31 March 2017 / Revised: 3 May 2017 / Accepted: 11 May 2017 / Published: 17 May 2017 (This article belongs to the Special Issue the Advent of Smart Homes)

25 - A SMART HOME SYSTEM BASED ON SENSOR TECHNOLOGY Boban Davidovic, Aleksandra Labus DOI Number 10.2298/FUEE1603451D First page 451 Last page 460

26 - Smart Home Intelligence The eHome that Learns David Bregman School of Business, The College of Management Academic Studies, 7 Rabin Blvd., P.O.B 25073, Rishon LeZion,

27 - A smart home as digital ecosystem Published in: 4th IEEE International Conference on Digital Ecosystems and Technologies Date of Conference: 13-16 April 2010 Date Added to IEEE Xplore: 25 October 2010

28 - Improving Smart Home Security Integrating Logical Sensing into Smart Home Published in: IEEE Sensors Journal (Volume: 17, Issue: 13, 01 July 2017) Page(s): 4269 - 4286 Date of Publication: 17 May 2017

29 - Practical trigger-action programming in the smart home Proceedings of the SIGCHI Conference on Human Factors in Computing Systems April 2014 Pages 803–812 Published:26 April 2014

30 - Shiu Kumar,” Ubiquitous Smart Home System Using Android Application “, InternationalJournal of Computer Networks & Communications (IJCNC) Vol.6, No.1, January 2014

31 - Jain, R., & Jain, R. (2020). Design and development of fingerprint door lock system using Arduino. International Journal of Emerging Technologies and Innovative Research, 7(1), 1-9

32 - Li, Y., Wang, H., & Sun, Y. (2019). An IoT-Based Smart Door Lock System Using Fingerprint Verification. IEEE Access, 7, 138073-138085

33 - Tondi, B., & Tosato, P. (2021). Security and privacy issues of smart locks: a comprehensive review. Journal of Ambient Intelligence and Humanized Computing,

34 - Xie, L., Luo, J., Peng, C., & Li, X. (2019). A Smart Fingerprint Door Lock System for Home Security. In 2019 International Conference on Electronic Technology (ICET) (pp. 1-4). IEEE.

35 - Zeng, Y., & Li, Y. (2021). Intelligent Security Door Lock Based on Fingerprint Recognition. IEEE Transactions on Industrial Informatics, 17(4), 2618-2626.

36 - Ravi, S., Seshagiri Rao, B., & Vamsidhar, R. (2020). Smart Home Automation Using IoT. In Internet of Things (IoT) in 5G Mobile Technologies (pp. 23-44). Springer, Cham.

37 - Gou, W., Liu, Y., Liu, X., & Yang, L. T. (2020). Smart home automation: A literature review. IEEE Internet of Things Journal, 7(8), 6873-6883.

38 - Mahmud, M. A., & Chowdhury, M. Z. (2021). Performance evaluation of light dependent resistor (LDR) based security system. In 2021 International Conference on Electrical, Computer and Communication Engineering (ECCE) (pp. 1-4). IEEE

39 - Ponce, D., Ramirez, G., & Ramirez, P. (2021). Implementation of a Precision Sensor System for Smart Homes Using Machine Learning. IEEE Access, 9, 35538

40 – WWW.pinterest.com

Ministry of Higher Education and Scientific research
Al-Iraqia University
Engineering College
Electrical Engineering Department

Experimental study of the effect of cooling and cleaning on the performance of PV Panel.

A Project Submitted to the Department of Electrical Engineering in Partial Fulfilment for the Requirements of the Degree of B.Sc. in Networks Engineering

BY

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2022-2023

DECLARATION

We hereby declare that this project report is based on our original work except for citations and quotations, which have been duly acknowledged.

Signature : ____________________________

Name : ____________________________

Date : ____________________________

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Date : ____________________________

APPROVAL FOR SUBMISSION

I certify that this project report entitled **"Experimental study of the effect of cooling and cleaning on the performance of PV Panel"** was prepared by**,Karrar ammar khlaf, Hussein Saad Yasser, Murtada Nayef Abdulhadi ,Ali Khaled Jalil** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of **Networks Engineering** at Al-Iraqia University .

Signature : _____________________________

Name : _____________________________

Date : _____________________________

Signature : _____________________________

Name : _____________________________

Date : _____________________________

االهداء

مرت قاطرة البحث بكثير من العوائق ,ومع ذلك حاولت ان اتخطاها بفضل من هللا ومنه ....

الى ابي وامي واخوتي وإصدقائي فلقد كانوا بمثابة العضد والسند في سبيل استكمال البحث ....

وال ينبغي ان أنسي اساتذتي ممن كان لهم الدور األكبر في مساندتي ومدي بالمعلومات القيمة ....

اهدي لكم بحث تخرجي ....

داعيا المولى عز وجل ان يطيل في اعماركم ,ويرزقكم بالخيرات

Abstract

Solar photovoltaic (PV) technology is a widely accepted technology for power generation worldwide. However, it is scientifically proven that its power output decreases with an increase in the temperature of the PV module. Such an important issue is controlled by adopting a number of cooling mechanisms for the PV module.High operating temperature and dust buildup on the front side of the solar panelsEspecially in arid and semi-arid desert areas is a major issue leading to lower performance and Photovoltaic cell damage. This pilot investigation aims to improve solar panels Where electrical performance is integrated into a single system that combines both active systems Synchronous self-cleaning and cooling technology Also, a water spray based cooling system has been developed for photovoltaic panels A system was used to define the start time of cooling the PV panels as the temperature of the panels up to 39 max temperature allowed

TABLE OF CONTENTS

Chapter One
Introduction

1.1 Introduction

Renewable energies are the best option for developing the energy reality and covering energy requirements in a sustainable way on the earth. Fortunately, humans have become more aware of protecting the environment and searching for energy sources that cause less pollution, are free, inexhaustible, and do not threaten the environment. The term "renewable" refers to the energy sources that can be regenerated continuously. [1].Renewable energy such as the sun or wind is readily available everywhere in the world, traditional energy sources need to be replaced by “green” or environmentally friendly sources if we need to make significant changes in total gases emission. Using renewable energy technology, you may convert renewable energy into more useable types of energy such as electric energy, heat energy, chemical energy, or mechanical energy. Because they emit little or no emissions, these technologies are frequently referred to as "clean" or "green.".The sun is the main source of renewable energies directly and indirectly, as solar energy is transmitted by solar radiation for heating or lighthouses, cooking food, heating water, and generating electricity. The sun is necessary for growing plants and trees that are called biomass. Bioenergy is a term referring to a biomass process that is also utilized to create electricity, fuel automobiles, and produce a yield chemical. Solar energy is ideal for generating electricity [2].

1.2 Solar Energy

The sun is the most important source of energy in the world and life depends on the energy of the sun. The term “solar energy” describes each method that uses solar sources to produce energy. There are two main types of renewable energy sources (RES), the most important of which are solar energy, both directly (thermal and photovoltaic (PV), which are obtained as a result of solar radiation's direct conversion into heat and electricity) and indirectly (wind, hydroelectric, tide energy, biomass energy, ocean's energy, geothermal, bioenergy, etc.). All these sources deriving energy from the sun are shown in Figure (1.1) [3].

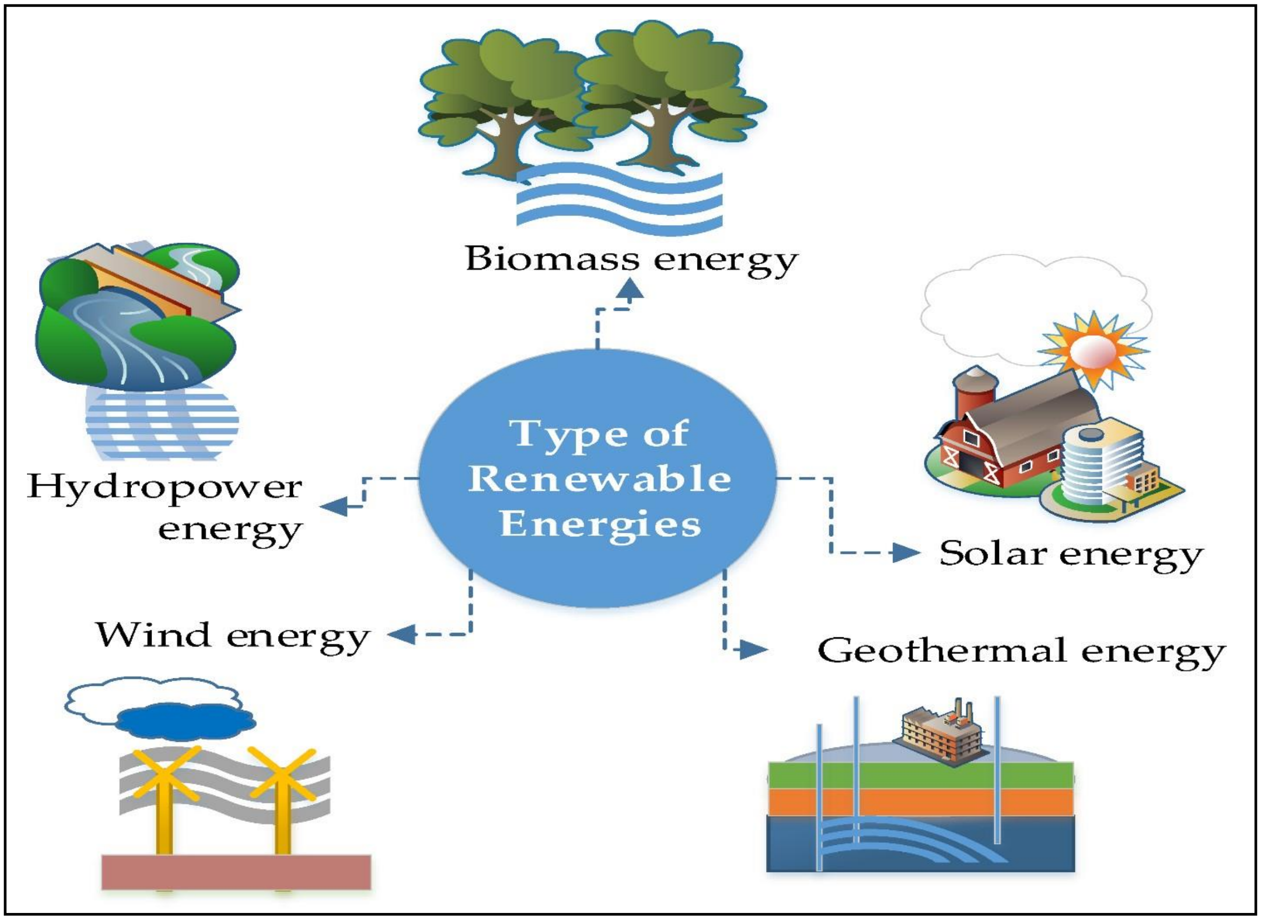


Figure 1.1 Solar sources (direct, indirect) [3].

Recently, the world is looking for non-conventional sources of energy to reduce dependence on traditional sources of energy, including fossil fuels and gas. These non-traditional sources represent a lesser risk to the environment and are not depleted, available, and constantly renewed. Solar energy is gaining attention and has taken precedence over other sources because solar is the most abundant in the world, can meet human energy needs, and can be converted into other types of energy such as electrical energy, mechanical energy, and thermal energy. The sun is light and heat, and it is the beginning of all the biological and chemical processes on the ground, and is the most suitable energy form for the environment as it can be used in multiple ways, and is suitable for all systems [3]. Lately, the research about solar energy has witnessed fast expansion in the applications including in the arab countries. A large number of techniques are being developed to improve efficiency and reduce the cost of harnessing solar energy. There is no suspicion that Iraq is one of the countries that enjoys a suitable moderate weather with high temperatures and has a great opportunity and ability to maximize the production of solar energy with high efficiency. Additionally, it is capable of receiving solar radiation for an estimated 4000 hours per year at convenient locations for solar energy.The energy of Sunlight received in Iraq on a daily basis ranges from an annualaverage of 4.5 – 5.4 kWh/m² [4]. Figure 1.2 Daily-averaged solar exposure radiation for different locations in Iraq [5]. When talking about solar energy, there are two ways to exploit solar energy, the first is the photovoltaic system that converts the light from solar radiation to electricity, and the second is solar water heating systems. Solar thermal systems concentrate solar energy into a compact space and produce high temperatures, which are used in high-temperature applications such as steam production for power generation, industrial process heat, and other uses [6].

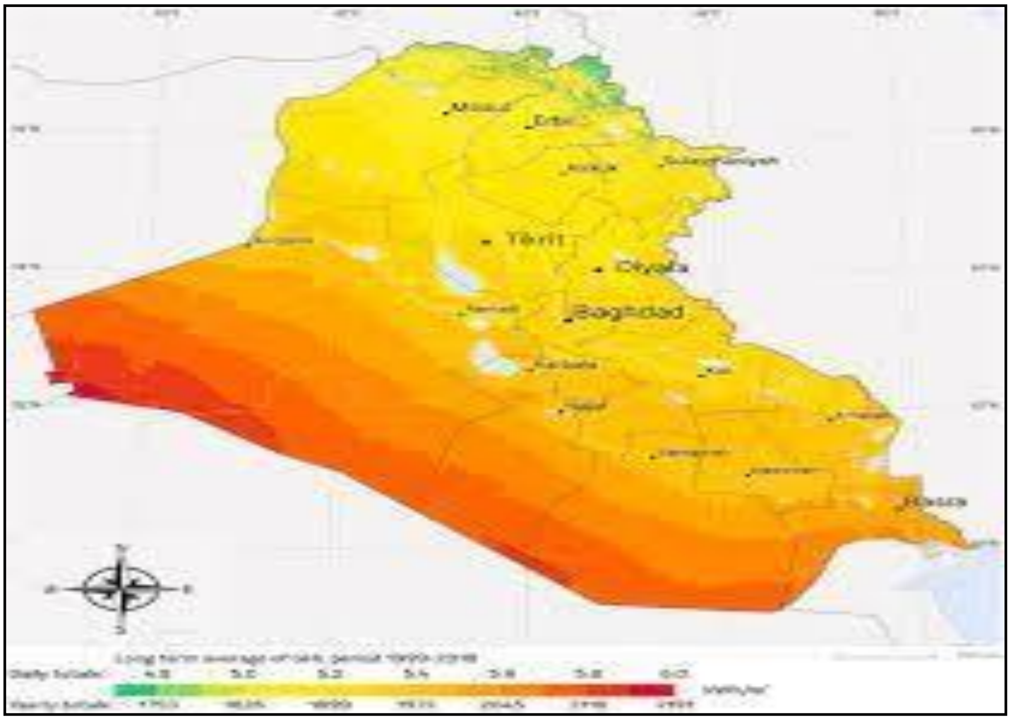


Figure (1.2) shows the daily exposure to sunlight in Iraq that nearly all of the country has the potential for large-scale solar installations.

1.3 Solar Photovoltaic Technology

Solar cells generate electricity directly by converting the energy in sunlight (photons) into electricity (voltage) through the photovoltaic effect. Scientists call them photovoltaic (PV) cells "photo means light and voltaic means electricity". PV got its name from this process as shown in Figures (1.3).In 1954 the PV effect was discovered, scientists of bell telephone discovered that silicon (extracted from pure sand) when exposed to sunlight created an electriccharge that cause a movement in the electrons that lead to generating an electric current [7].

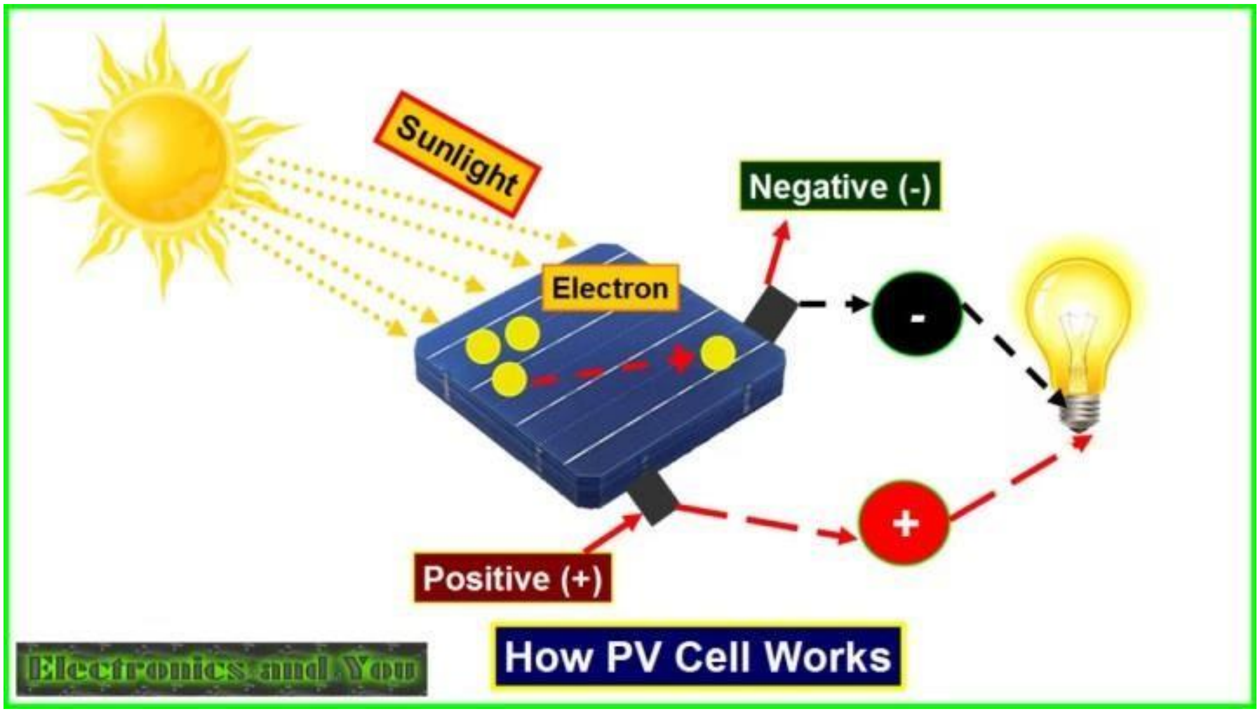


Figure 1.3 The principle of the solar cell [8].

Solar cells are categorized into three generations, the first generation cells or traditional PV cells are made from silicon which are usually the most efficient and made flat-plate, the materials include monocrystalline silicon and polysilicon. Amorphous silicon, Cadmium Telluride (CdTe), and Copper Indium Gallium Selenide (CIGS) cells are second-generation cells. They are made of non-silicon materials or amorphous silicon, and they are called thinfilm solar cells. This type of cell has significant commercial importance in small standalone power systems as well as utility-scale photovoltaic power. Lastly, third type of solar cell generation includes a thin film technologies and is described as the photovoltaic cells emerging and still in the research phase with no applications yet. Many use organic materials, often organometallic compounds as well as inorganic substances and it is Manufactured from a type of new materials with silicon, like solar inks that are used in printing press technology, solar dyes, and conductive polymers.

Plastic lenses or mirrors are being used in some new types of solar cells to direct sunlight onto a narrow band of very efficient solar cells but has low efficiency and their absorber material was short, but there is extensive research about this technology to develop it [9]. The solar cell is composed mostly of various layers and connecting points, with the layers beginning with a non-reflective and semiconductor layer at the bottom (negative and positive). When photons hit the surfaces of the semiconductor materials shown in figure (1-5), they cause the ionization of their atoms (which are electrically charged), which leads to the release of outer electrons from atomic bonds and the formation of new atomic bonds. As a result, some positively charged crystalline atoms are still there, and the charge can freely flow from one atom to another. When the electrons inside of the solar cell have acquired enough electric charge, they begin moving as a result of their acquisition of the charge. They combine to generate an electric field (difference voltage at the ends of the cell). As a result of releasing electrons from a silicon crystal "or any type of material utilized in the solar cell work," current flows through the solar cell, resulting in the generation of an electric current [10].

Solar cells are connected to make a PV module, and the modules are connected to make a PV array. There are two different ways depending on current or voltage requirement, firstly to increase the output current will be made a parallel connection between the solar arrays., and secondly to increase the output voltage the array will be connected in series [10].

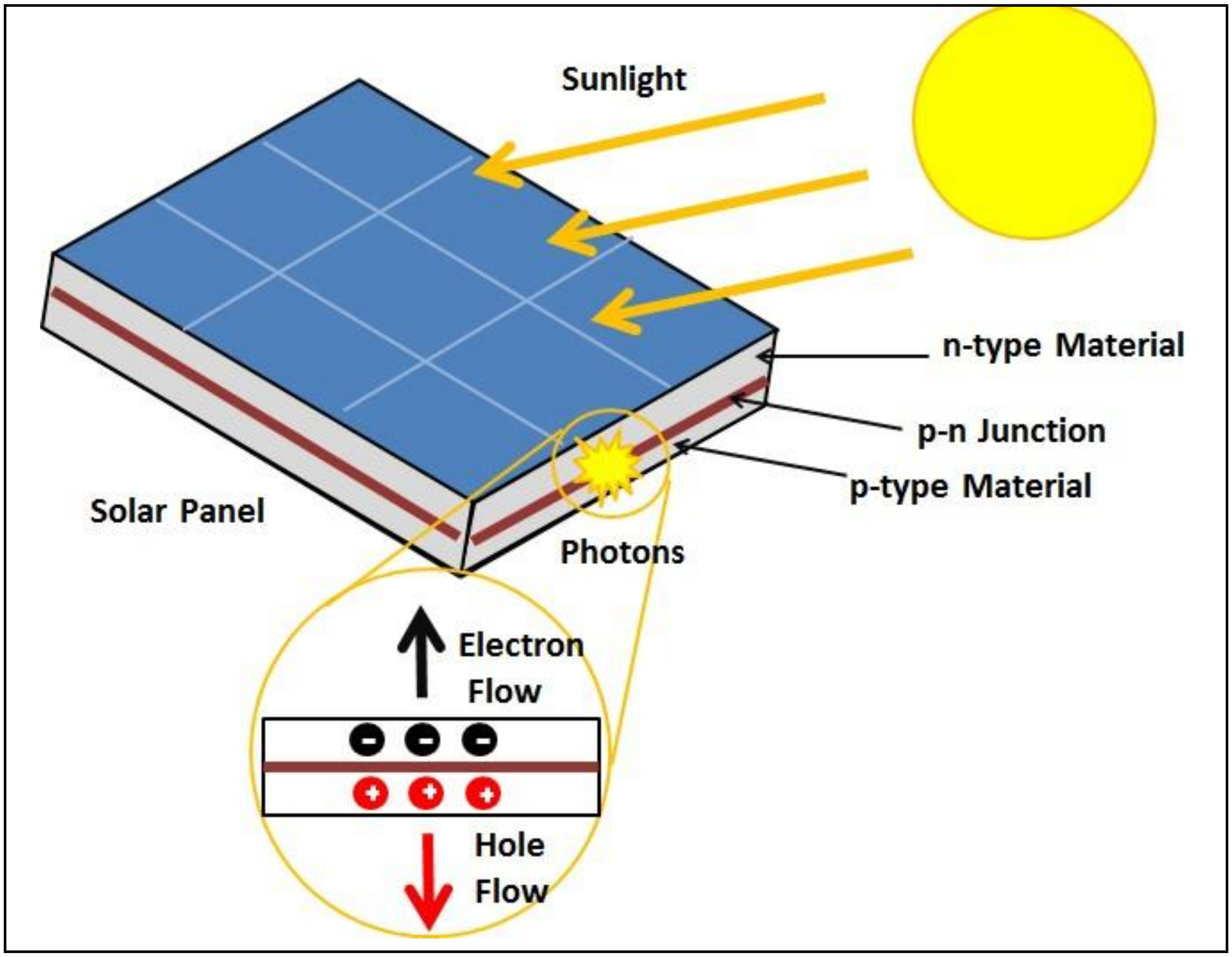


Figure 1.5 Solar photovoltaic effect cell [10].

During the last few decades Photovoltaic (PV) applications gaineserious interest; it considered as a promising re- newable energy solution for intense energy supply prob- lems all over the world. PV modules can participate consider- ably in a central part of the increasing energy demand [1]. Till now, this technology usageis limited in Iraq due to many op- erational parameters related to the country topographic and environmental conditions. On the other hand, Iraq suffers from a high rate of population increments, rapid economic development of urban areas and acute shortage in electricity [11].Crowter [12] in his study suggested that, The flow of cooling water membrane over the surface of the cell reduces the temperature Largely as a result their efficiency can be enhanced through about 10%. In other studies, Elnozahy et al. [13] was evaluated empirically Shapingself-cooling and cleaning PV unit in hot arid regions.c- According to its results, the energy efficiency of PV with self-cooling andThe cleaning system was 11.7% compared to the PV system without refrigerant And the cleaning system is 9%. Abdelzadeh and Amiri [14] examined The effect of spray cooling on the front of the solar panelswas found to be 48%. Enhance the strength of the system at a temperature It decreased from 58°C to 37°C. Baloch et al

1.4 Objective

This pilot investigation aims to improve solar panels Electrical performance is fitted into the new PV/T Bi-fluid hybrid system that combines both active systems Simultaneous cooling and self-cleaning technology, while its front side is cooled and The flowing water cleans them. The experimental results showed a linear decrease Relationship between electrical efficiency[6] and PV module temperature increase Up to 15 °C was an average The average overall energy efficiency was found to be 85.3%, while the average energy efficiency It was approximately 14.7%.

1.5 Advantages

1. An ideal source of energy because it is free and unlimited
2. A clean resource that has been used and replaced in place of fossil fuels
3. Cheap and inexpensive energy

4. Highly efficient energy compared to fossil fuels such as coal, oil and gas[7]

1.5 Disadvantage

Solar isn’t perfect – here are some disadvantages of solar energy to keep in mind whenconsidering installing solar panele[8]

1. Solar doesn’t work for every roof type
2. Solar isn’t ideal if you’re about to move
3. Low electricity costs = low savings
4. Upfront costs can be high
5. Solar panels don’t work at night
6. Solar panels sometimes contain toxic metals
7. Finding the right installer can be a challenging process

Chapter Two

Methodology

1.1 Introduction

Today the main concern for the World is renewable energy without the use of fuel derivatives. By and by, out of around 7 billion populaces, just 65-69% approach power. Essentially our goal is to serve populations to generate energy that is more environmentally friendly due to climate changes on the ground and looking at what to expect within restricted assets, we used assets to meet this assumption as Figure (2-1)

Figure2.1: Different renewable energy sources with user-friendly graphics

Utilizing sun-based energy in relationship with the power gadgets, we can supply the power to the buyers inside their capacity and we will want to limit the power issue as could really be expected. Presently a-days, the coordinated circuits (IC) are entirely solid and modest, this is what was presented to the point that makeconveying and reversing or changing over components most straightforward and simple than utilizing the massive and expensive instruments utilized in the traditional power supply framework. Solar energy is a rapidly growing resource, already providing 4.5% of electricity in the World and projected to supply up to 35%

by 2050.[15] In this research, we will present a simplified application model for renewable energy generation using solar energy through the use of an integrated power generation system using solar photovoltaic energy to generate electricity. Energy can be harnessed directly from the sun, even in cloudy weather. Solar energy is used worldwide and is increasingly popular for generating electricity or heating and desalinating water. Solar power is generated in two main ways but in our research we will focus on (PV) because it is less expensive cost practically for us:[15]

PhotoVoltaics (PV), also called solar cells, are electronic devices that convert sunlight directly into electricity as Fig2.2. A modern solar cell is likely to be an image most people recognize - it is found in panels mounted on homes and in calculators. It was invented in 1954 at Bell's telephone laboratories in the United States. Today, photovoltaic is one of the fastest growing renewable energy technologies, ready to play a key role in the global electricity generation mixof the future. The use of solar photovoltaic power to power small grids is an excellent way to connect electricity to people who do not live near power transmission lines, especially in developing countries with excellent solar resources. The cost of making solar panels has dropped dramatically in the last decade, making it more affordable but often the cheapest forms of electricity. Solar panels are about 30 years old. Where a solar panel with a capacity of (131.32 watt) was brought, it outputs a current of (7A) and a voltage of (22.16v), an inverter with a capacity of (1000watt) was connected, a solar power controller was connected, Optima batteries with a capacity of (12v) and (60A) were used, an Arduino Uno was connected, and temperature and dust sensors were used in the same system as shown in the figure

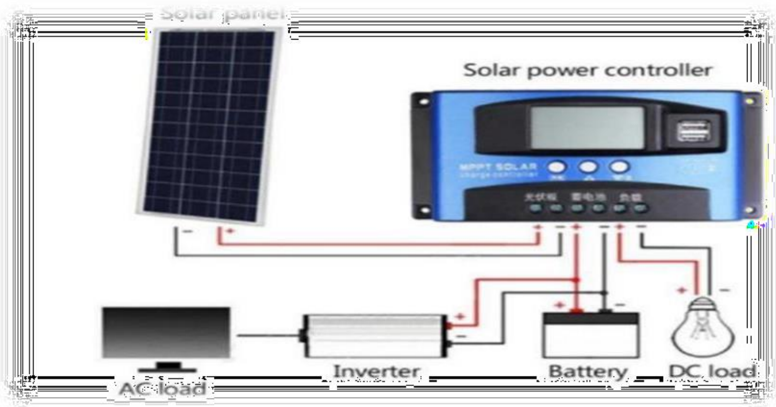


Figure2.2: Main contents of project

Concentrated Solar Power (CSP), uses mirrors to concentrate solar rays. These rays heat fluid, which creates steam to drive a turbine and generate electricity. CSP is used to generate electricity in large-scale power plants

A CSP power plant usually features a field of mirrors that redirect rays to a tall thin tower. One of the main advantages of a CSP power plant over a solar PV power plant is that it can be equipped with molten salts in which heat can be stored, allowing electricity to be generated after the sun has set. The Sun is the star that dominates our solar system. The amount of energy emitted by the Sun as radiation is quite constant. This energy output is generated deep within the Sun. As a star, the Sun is made up of 71% hydrogen, 27% helium, and 2% other elements. At the center of the Sun the density is 150 times that of water and the temperature is almost 16,000,000 Kelvin, which causes the nuclei of individual hydrogen atoms to undergo nuclear fusion (in other words they join-together). The result of this is that two hydrogen nuclei combine to make one helium nucleus, and energy is released in the form of radiation. Vast numbers of fusions occur every second, generating energy beyond our imagination. The energy produced moves out towards the solar surface by radiation and then by convection through the turbulent mixing of gases on the Sun's surface as Fig2.3. The Sun has produced energy for many millions of years and will do so for many millions more. It is estimated that there is enough hydrogen still in the Sun's core to last another 4.5 billion years

Chapter Three
Experimental Work

3.1 Introduction

This chapter explains how a two-axis solar tracking system was manufactured and implemented to convert solar radiation into electrical energy. Furthermore, this chapter details the components used in manufacturing with components that are cheap and available in the local market, as well as the method and type of control used to implement the solar tracking process. The system is made up of a mechanical part that acts as the body and an electronic part that acts as the brain.

3.2 Experimental Setup

The Basic Part on the Project as Fig

1. Solar panel
2. Solar power controller
3. AC load any.
4. Inverter 12 to 220 volt
5. Battery 12 volt
6. DC load 12 volt

3.3 Schematic Diagram

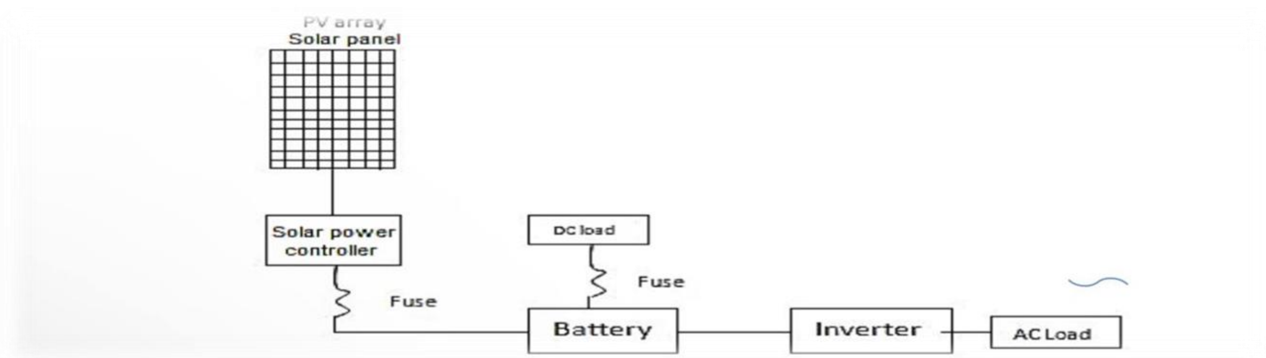


Figure3.3: Schematic diagram of a off-grid PV system with AC and DC loads

3.4 Parts of the project

1- Solar panel

Solar cells are merged into larger units - the panels - in panel production.They are framed and weather - proofed . The solar energy panels are final products ready to generate power . Sunlight is converted into electrical energy in the panels . The direct current produced this way is converted to alternating current by a device called an inverter so that it can be fed into the utility grid or , if ap pliable , straight into the house as shown fig3.4.[16]

Figure 3.4: Solar panel

2- Solar power controller

The charging regulator has a great importance and role in regulating and improving the voltage and current coming from the solar panels to values compatible with the voltage of the system (the battery voltage and the input voltage of the inverter). Filling the batteries, also protects the batteries from overcharging and fully discharging as shown fig3.5.[17]

Figure 3.5: Solar power controller

3- Battery

Is a chemical energy bundle that can produce a limited amount of electrical energy when you need it, unlike regular electricity that runs through your home through wires from electric power plants is shown fig3.6.[18]

Figure 3.6: Battery

4- Inverter DC to AC

An inverter is an electronic device that converts low voltage DC into high pressure alternating current. Because we usually use 220V AC inverters in order to use direct current, a sine wave inverter is the opposite as shown fig3.7 [19]

Figure 3.7: Inverter DC to AC

5- LED lamp

(LED lamp or LED light bulb) is a type of electric lamp that produces light using one or more light-emitting diodes (LEDs). LED lights have a much longer life than equivalent incandescent bulbs, and are much more effective than most fluorescent lights ac shown fig3.8[20]

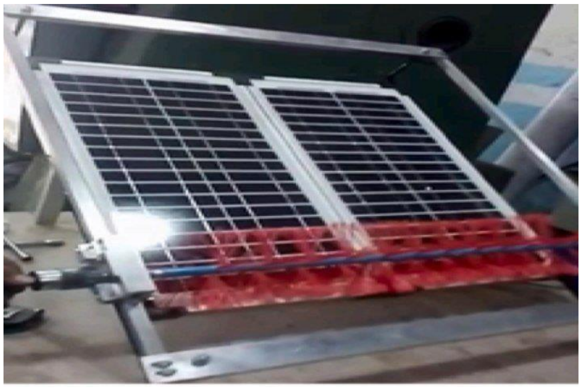
Figure 3.8: LED lamp

3.9 Cleaning systems of solar panels

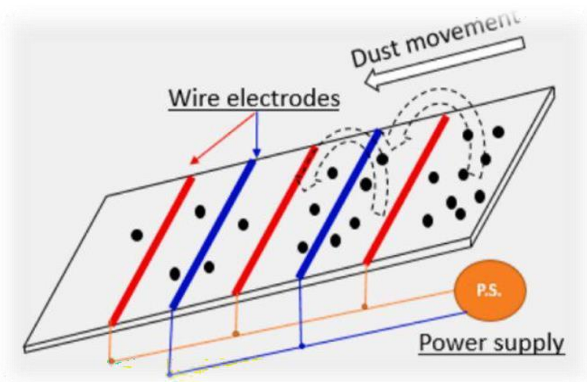
The existing automatic cleaning systems of solar panels are various and can be categorized into two main types: i) active, and ii) passive cleaning systems. Active systems require power for self-cleaning methods, such as electrostatic and mechanical methods. However, there is no need for input power for the passive systems, such as the coating method [21]. Among these two groups, harsh mechanical cleaning systems, such as automated brushes [22], can damage the surface of PV during the operation, leading to reduced PV performance and working lifespan efficiency

Automated cleaning methods comparison

In this section, prevalent automated cleaning systems, which are recently employed, are chosen as shown in Table 4. Then, the detail of each mechanism is presented and discussed accordingly in the following sections. The selected cleaning systems have been employed for the last two decades, comprising of the brush cleaning system (BCS), electro- static cleaning system (ECS), heliotex cleaning system (HCS), robotic cleaning system (RCS), and coating cleaning system (CCS). Brush cleaning system (BCS)/ Active system

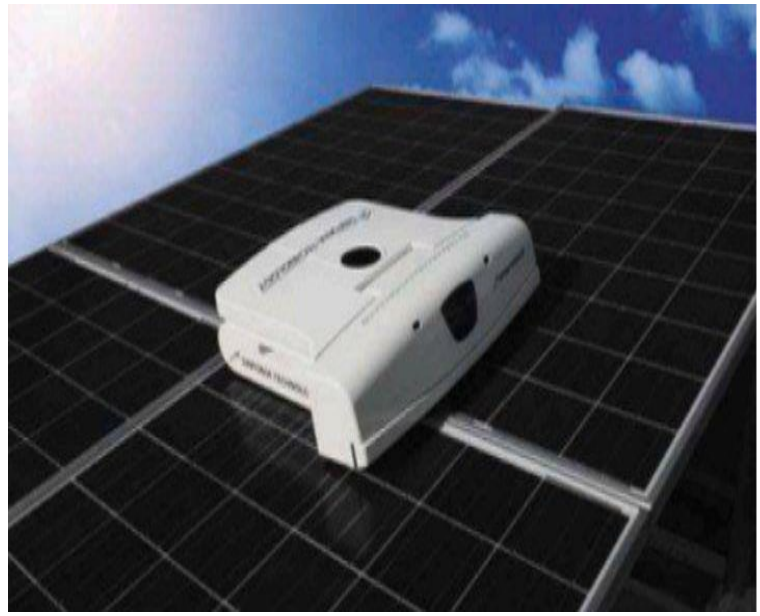


Fig;3.9Brush cleaning system

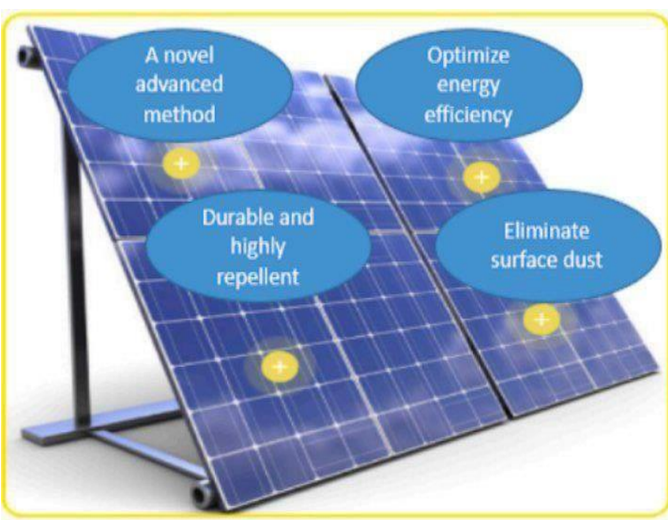


Electrostatic cleaning system (ECS

Heliotex cleaning system (Hcs)[23]



Robotic cleaning system (RCS) [24] Public Domain



Coating cleaning system (CCS)

Fig : Automated cleaning methods comparison

Chapter Four

1.4 Result and Discussion

The cleaning system of one group in the 15 kW photovoltaic system has been working for six months in 2019 To analyze the effect of dust deposits and thus the effect of cleaning photovoltaic modules on energy performance of its photovoltaic modules. Measurements were recorded daily, and the relevant calculations Carried out as shown in Table 2 the percentage power gain of two arrays of 15 kW solar photovoltaic system for the study period with a description of weather conditions. Energy percentage The gain is calculated as the rate of the power differences (between the clean PV array and the reference matrix) to Reference PV array power. The average energy gain is the average of four days in each month. Based on Table 1, the average energy gain is obtained from the percentage energy gain over a four-day period [25] in each month included in the study. indicates that the maximum energy gain was in January with The average power is 7.69% as a result of dust build-up and dust storm. While the minimum energy gain Occurred in March and April with average values of 2.68% and 2.87%, respectively, due to the abundance of precipitation Showers reduce dust build-up on the reference solar array Table 4.1

Day-Month	Reference array energy (kW)	Clean array energy (kW)	Energy Gain (%)	Weather Status
7 Jan.	7.614	7.947	4.363	Dust accumulation
14 Jan.	10.392	11.373	9.435	Dust storm
21 Jan.	7.529	8.447	12.19	Dust accumulation
28 Jan.	9.763	10.228	4.76	Heavy Rainfall
7 Feb.	10.801	11.277	5.99	Dust accumulation
14 Feb.	9.975	10.491	8.71	Dust accumulation
21 Feb.	8.061	8.222	4.098	Rain shower
28 Feb.	11.803	11.949	2.83	Rain shower
7 Mar.	8.457	8.612	3.45	Dust accumulation
14 Mar.	8.230	8.340	2.82	Rain shower
21 Mar.	7.710	7.780	1.86	Heavy Rainfall
28 Mar.	1.753	1.770	2.61	Rain shower
7 Apr.	8.601	8.801	3.23	Rain showers
14 Apr.	7.347	7.431	2.10	Rain showers
21 Apr.	10.901	11.210	3.89	Dust accumulation
28 Apr.	10.885	10.999	2.28	Rain full
7 May	8.268	8.633	5.367	Dust accumulation
14 May	8.341	8.816	6.602	Dust accumulation
21 May	7.954	8.353	5.868	Wind (9-14) km/h
28 May	8.115	8.523	5.76	Wind (5-14) km/h
6 Jun.	7.143	7.447	6.07	Dust accumulation
13 Jun.	9.385	9.792	5.17	Wind (6-15) km/h
20 Jun.	9.414	9.791	4.87	Wind (4-11) km/h
27 Jun.	9.789	10.622	9.26	Dust storm and wind

Table4.1 . The weather status and the percentage energy gain of the test system

While in the year 2023 an experimental study was conducted to find out the effect of cleaning and cooling on the efficiency of the solar panel. This was done using temperature sensors and a dust sensor. Water mist was used to work at the same time as cooling and cleaning the solar panel to reduce the amount of water used to maintain the efficiency of the solar panel and with the presence of a charging regulator and an inverter of that capacity (1000w) and a battery (60) and a solar panel that gives a capacity of 131.32w) where when the temperature rises to (30) (640.72) the water mist sprays for 10 seconds, which leads to a decrease in temperature approximately (1 degree) and dust until it reaches (134.37). Record readings as per the table 4.2

Table (4.2) the result of temp

No.	temp	result	time
1	39.00	38	10s
2	38.00	36	30s
3	36.00	32	1mi m

Table (4.3) the result of dust

No	dust	result	time
1	640.72	134.37	10s

Chapter Five

5.1 Conclusion

The main objective of this research is to study photovoltaic cooling with aqueousfilmFront flip with minimal time and energy used. Contains water mist cooling systemIt has been developed. An arithmetic unit for quantitative estimation has also beendevelopedThe flow rate and time required to reach a steady state state based on a givenParameters to simulate different types of climate throughout the year. Based on theresults of this Study can conclude that;

1- Cooling and cleaning photovoltaic panels with the proposed cooling system effective.

2- Front water cooling can provide cooling rate of 1°C/min. Which means that

The cooling system should run for (10sec) to reduce the cell temperature of 28 degrees Celsius.

3- The board works more efficiently when cooled and reaches 16.2% compared to 13.72% without refrigeration.

4- The power produced by the photovoltaic panel increased by 43.3W compared to the photovoltaic panel without refrigeration.

References

[1] J.K. Kaldellis, A. Kokala, “Quantifying the Decrease of the Photovoltaic Panels’ Energy Yield Due to Phenomena of Natural Air Pollution Disposal”, Energy, vol. 35, pp. 4862-4869, 2010.

[2] D. G. f. Sonnenenergie and E. GmbH, Solar thermal systems: a guide for installers, architects and engineers, London: James & James, 2005.

[3] I Bostan, AV Gheorghe, V Dulgheru, I Sobor, V Bostan, Resilient Energy Systems: Renewables: Wind, Solar, Hydro, london: Springer Science & Business Media, 2012.

[4] T, Mutlak f. Baha, "Design and Fabrication of Parabolic Trough Solar Collector for Thermal Energy Applications," University of Baghdad, Baghdad, 2012.

[5] NASA, "Surface Meteorology and Solar Energy," Atmospheric science Data Center, 2008.

[6] Y. Zhang and S. J. Smith, Long-Term Modeling of Solar Energy: Analysis of Concentrating Solar Power (CSP) and PV Technologies., United States: Pacific Northwest National Lab.(PNNL), 2007.

[7] Herzog A. V., Lipman T. E., "Renewable energy sources," Energy and Resources Group Renewable and Appropriate Energy Laboratory (RAEL) University of California, USA, 2001.

[8] Basil M H., Mohammed S El-M, "Fuzzy controller design using FPGA for sun tracking in solar array system," International Journal of Intelligent Systems and Applications, vol. 4, no. 1, p. 46, 2012.

[9] Askari M. B, Mirzaei M A, Mirhabibi M, "Types of Solar Cells and Application," American Journal of Optics and Photonics, vol. 3, no. 2330-8494, pp. pp. 94-113., 2015.

[10] A. Dutta and S. A. Barua, "Design of an arduino based Maximum Power Point Tracking (MPPT) solar charge controller," PhD diss , the Department of Electrical and Electronic Engineering BRAC University, 2016.

[11] M.T. Chaichan and H.A. Kazem, “Status and Future Prospects of Renewable Energy in Iraq”, Renewable and Sustainable Energy Reviews, vol. 16, no. 1, pp. 6007–6012, 2012

[12] S. Krauter, Increased electrical yield via water flow over the front of photovoltaic panels, Sol. Energy Mater. Sol. Cell. 82 (2004) 131–137.

[13] A. Elnozahy, A.K.A. Rahman, A.H.H. Ali, M. Abdel-Salam, S. Ookawara, Performance of a PV module integrated with standalone building in hot arid areas as enhanced by surface cooling and cleaning, Energy Build. 88 (2015) 100–109.

[14] M. Abdolzadeh, M. Ameri, Improving the effectiveness of a photovoltaic water pumping system by spraying water over the front of photovoltaic cells, Renew Energy 34 (2009) 91–96.

[15] https://doi.org/10.1016/j.applthermaleng.2020.116033

[16] Why Not the Sun? Advantages of and Problems with Solar Energy by Ethan Goffman.

[17] http://doi.org/10.11591/ijece.v11i1.pp74-83

[18] Nithiyananthan.K and Ashish Kumar Loomba (2011) MATLAB/SIMULINK based Speed control model for converster controlled DC

[19] Kaur, Daljeet, and P. S. Cheema. "Software tools for analyzing the hybrid renewable energy sources:-a review." 2017 International Conference on Inventive Systems and Control (ICISC). IEEE, 2017.

[20] Rosa-Clot, Marco, et al. "Submerged photovoltaic solar panel: SP2." Renewable Energy 35.8 (2010): 1862-1865.

[21] Farajdadian, Shahriar, and SM Hassan Hosseini. "Design of an optimal fuzzy controller to obtain maximum power in solar power generation system." Solar Energy 182 (2019): 161-178.

[22] Crompton, Thomas Roy, Thomas PJ Crompton, and Thomas Roy Crompton. Battery reference book. Newnes, 2000.

[23] Sanchis, Pablo, et al. "Boost DC-AC inverter: a new control strategy." IEEE Transactions on power electronics 20.2 (2005): 343-353.

[24] Costa, Vítor AF, and António MG Lopes. "Improved radial heat sink for led lamp cooling." Applied Thermal Engineering 70.1 (2014): 131- 138.

[25] Arabatzis I, Todorova N, Fasaki I, Tsesmeli C, Peppas A, Li WX, et al. Photocatalytic, self-cleaning, antireflective coating for photovoltaic panels: Characterization and monitoring in real conditions. Sol Energy 2018;159:251–9.