International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 04, April-2023

Design and Development of Smart Huts for Sustainable Development

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***Abstract*— Large scale urbanization has been a growing trend in the recent years with cities becoming the development centers, yet the rural economy still plays a major role in the overall development of any country. In a recent survey, nearly 69 percent of India's population lives in its villages, accounting for nearly 50% of the GDP of the nation. These rural areas range from being small settlements with less than 500 people to small towns. Similar scenarios exist in western countries also. In spite of their contribution to the economy, the smaller villages tend to receive less in the way of infrastructural investment.**

Keywords—Smart Hut, Panchayat office, Transport, Public Distribution system(PDS).

I. INTRODUCTION

The design and development of smart huts for sustainable development is an important and timely topic given the current global challenges of climate change, resource scarcity, and inadequate housing. Smart huts are designed to be energy-efficient, durable, and cost-effective structures that can improve the living conditions of communities while minimizing environmental impact. The integration of smart technologies such as sensors, control systems, and renewable energy sources in the design of these huts enables optimization of resource utilization and reduces energy consumption, making them an attractive option for sustainable development. Additionally, the lightweight, durable and easy-to-install materials used in their construction make them a practical and affordable option for communities that lack adequate housing. The development of smart huts for sustainable development requires a multidisciplinary approach that encompasses the fields of architecture, engineering, materials science, and renewable energy. Through collaboration and innovation, designers and developers can create structures that are not only functional and efficient but also aesthetically pleasing and culturally appropriate.

II. RELATED WORK

The smart village is built up using heterogeneous digital technologies pillared around the Internet-of-Thing (IoT). There exist many opportunities in research to design a low-cost, secure, and efficient technical ecosystem. This article identifies the key application areas, where the IoT can be applied in the smart village. The article also presents a comparative study of communication technology options. The disadvantages are They rely heavily on the internet and are unable to function effectively without it. With the complexity of systems, there are many ways for them to fail[1]. Smart cities concept has been practiced for the last decade, the new concepts of smart villages on a smaller scale as well as smart states and smart countries on a bigger scale are evolving for the same reason, i.e. better utilization of man-made and natural limited resources. IoT integrated with physical systems make the cyber-physical systems (CPS) which are essentially individual smart components like smart agriculture (agriculture CPS), smart healthcare (healthcare CPS), and smart transportation (transportation CPS). A combination of these CPS of different sizes and varieties are ingredients of the system-of-systems like smart villages, smart cities, or smart countries. The disadvantages are they rely heavily on the internet and are unable to function effectively without it and Deploying IoT devices is very costly and time-consuming [2]. Smart cities are essentially cyber-physical systems or CPS which are built using Internet of Things (IoT). A smart city utilizes information gathered from interconnected sensors to enhance city activities, oversee resources and assets, and improve the everyday existence of its residents. Smart village concept that combines renewable energy and community-based education can have impact on estimated 940 million population worldwide. Further, smart villages target consumer technologies in rural areas to develop innovative solutions to improve the quality of life and provide growth opportunities to its residents. The smart villages exhibit certain characteristics which may have some commonalities with smart cities, but also some distinctly different. The disadvantages are Significant capital investment in technology is required[3]. the smart village in Indonesia, where the Indonesian population is now more than 250 million peoples. with several islands as much as 17,504 islands, consisting of 53.3% were in urban areas, the rest spread in rural areas, but it will turn around if there is no solution currently to address the disparity in the village in terms of infrastructure and technology. One of the concepts can be applied to overcome these problems is "Smart Village using Enterprise Architecture Framework. The disadvantages are Potential breakdowns in communication, High costs and data organization can be more time-consuming than expected[4]. Integrated online service information system application is a necessity that cannot be negotiated anymore. To create a village with the Smart Village concept, the village government or the village community itself requires the application of sophisticated technology, in order to improve the quality of services in the village so that it is more able to provide comfort and satisfaction to the community. Researchers and practitioners have developed various applications of village administration service information systems. However, in fact there are still many villages that have not utilized this technology. This study aims to identify problems in village community services that are still low and provide solutions in the form of information dissemination service models to facilitate the dissemination of information and communication media between the village official and its society. A major disadvantage is the risk of data loss or unauthorized access to confidential project information by hackers[5].

III. OVERVIEW OF THE PROJECT

A. Scope of the project

The scope of smart villages needs to be broadened into managing the public distributions system, transportation, information dissemination etc. while using the existing infrastructure put in place for solar energy and connectivity. Our proposed solution looks at the implementation of smart villages from a micro level and aims to empower each household in the region. It emphasizes the importance of meeting the community's needs. Rural development implies both the economic betterment of people as well as greater social transformation. As per the need of the village in particular includes Physical infrastructure facilities (Water, Drainage, Road, Electricity, Telecommunication & Other), and renewable energy (Smoke detection, Water level indication, Solar Street lights & Other) for Sustainable development which can help in developing villages in sustainable manner, reduce migration from villages and prevent the cities from the urban pressure.

B. Proposed work

The power supply to the entire rural village model is provided from the solar panel. The smart hut consists of microcontroller which is connected to LDR sensor, Temperature and humidity sensor, and IR flame sensor. It is shown in the below Fig:1 block diagram of smart Hut.

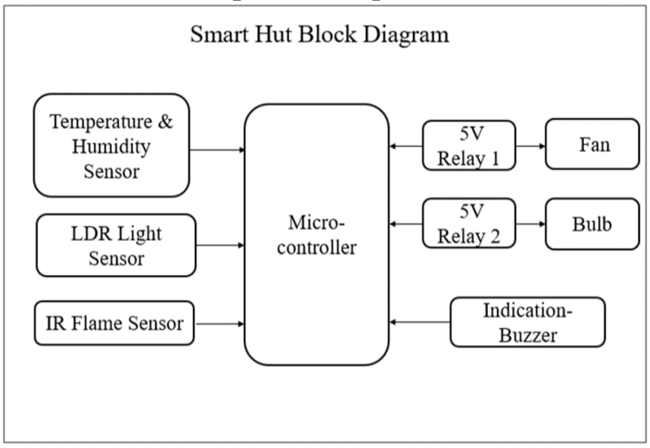

Fig:1 Smart Hut Block Diagram

Village panchayat office consist of microcontroller which is connected to RF RX Module, LCD Display Indication and a GPS module. The Public Distribution Shop has a RF TX Module which is used to Transfer the Message to RF RX Module in the village panchayat office. The Fig:2 shows the block diagram of village panchayat office.

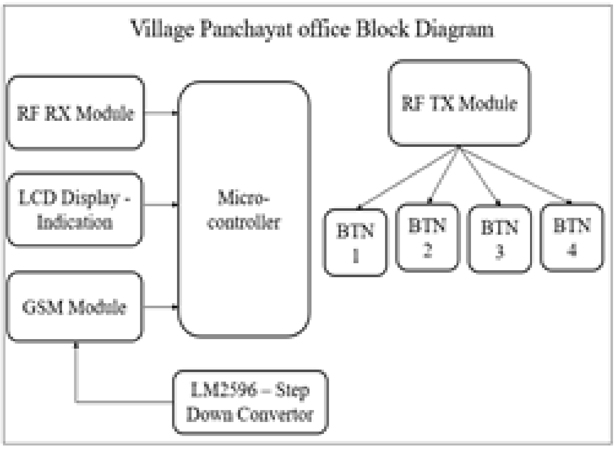

Fig:2 Panchayat office Block Diagram

The Transport TX Module has a GPS and GSM Module to Send the exact Location of the Transport which is shown in the below Fig:3. This entire setup is used for achieving development in the rural village.

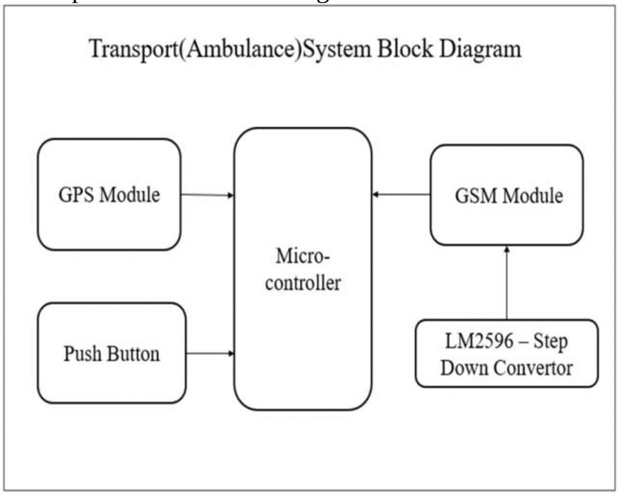

Fig:3 Transport system Block Diagram

The Fig:4 shows Smart energy Generation block this concept deals with the production of solar energy with the use of solar panel and a solar Boost converter with MPPT technique is used to Charge the Battery.

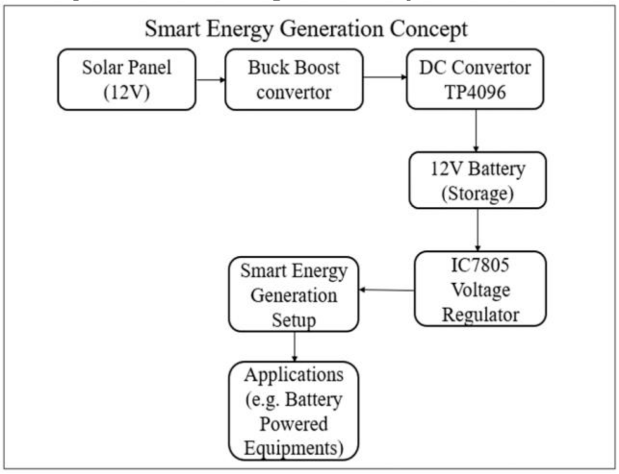

Fig:4 Smart Energy Generation Block Diagram

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IV. HARDWARE DISCRIPTION

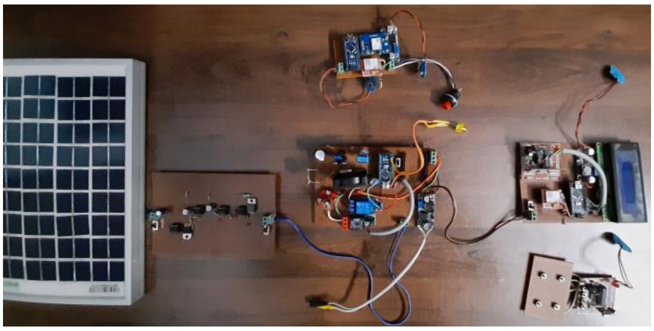


Fig:5

The Fig:5 shows the overall Smart Modules used in the project. The detailed description about each module is discussed below,

A. Smart Hut

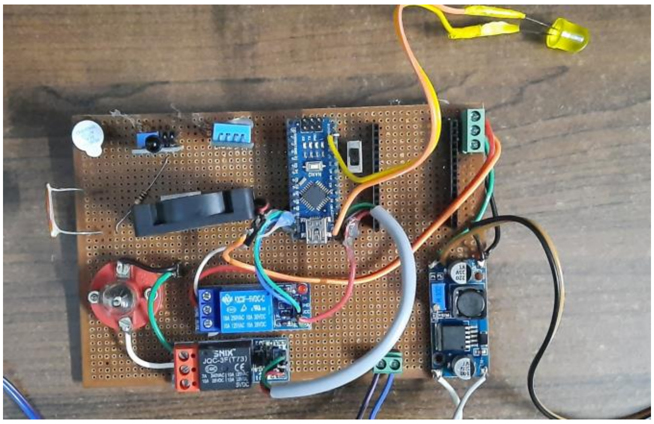


Fig:6 Hardware of Smart Hut

The Fig:6 is the Smart Hut Module which uses Sensors for automatic controlling of lights, Fan and to give alert during fire.

- LDR based Light ON OFF: It reads the LDR sensor's value and compares it with a threshold value. If the value is below the threshold, it means that it is dark outside, so it turns the LED ON. Otherwise, it turns the LED OFF.
- DTH11 Temperature Controlled DC Fan: It reads the temperature and humidity values from the DHT11 sensor and computes the heat index. Then, it sets the fan speed based on the temperature value. If the temperature is below 26 degrees Celsius, it turns the fan OFF. If the temperature is between 26 and 29 degrees Celsius, it sets the fan speed to 20%. If the temperature is between 29 and 30 degrees Celsius, it sets the fan speed to 40%. If the temperature is between 30 and 31 degrees Celsius, it sets the fan speed to 60%. If the temperature is between 31 and 33 degrees Celsius, it sets the fan speed to 80%. If the temperature is above 33 degrees Celsius, it sets the fan speed to 100%.
- Fire Detection using IR Flame Sensor: It reads the IR flame sensor's value and checks if it is LOW or HIGH. If the value is LOW, it means that the sensor has detected a flame, so it turns the buzzer ON. Otherwise, it turns the buzzer OFF.

B. Panchayat office

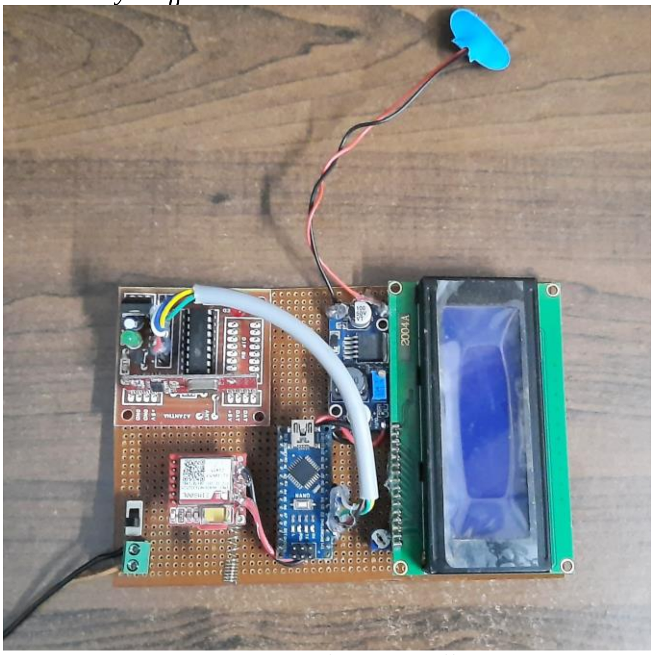


Fig:7 Hardware of Panchayat office

The availability of essential commodities in a Public distribution system (PDS)is displayed on an LCD screen which is shown in the Fig:7. Four switches are connected to digital input pins 2-5 to detect the availability of four essential commodities - sugar, grocery, wheat, and oil. The system continuously monitors the state of these switches using the digitalRead() function in the loop() function. If any switch is detected to be low, the system prints a message on the serial monitor indicating the availability of the corresponding commodity and displays the same on the LCD screen. The system also listens to the serial port for any incoming SMS message. When the serialEvent() function is triggered, the system reads the incoming message and stores it in a character array called str. If the message starts with the character 'a', the system prints a message on the serial monitor indicating the availability of nearby buses and displays the same on the LCD screen. The system is also programmed to send an SMS notification to a predefined mobile number when it receives an SMS message that starts with the character '/'. The system sends the SMS using the AT commands by communicating with the GSM module. The predefined mobile number is stored in a character array called number. The setup() function initializes the serial communication at a baud rate of 9600 and sets the mode of the GSM module for SMS reception and transmission. It also sends an initial SMS message to the predefined mobile number to indicate that the system is ready. The loop() function runs continuously and monitors the state of the switches and waits for any incoming SMS message.

C. Transport Module

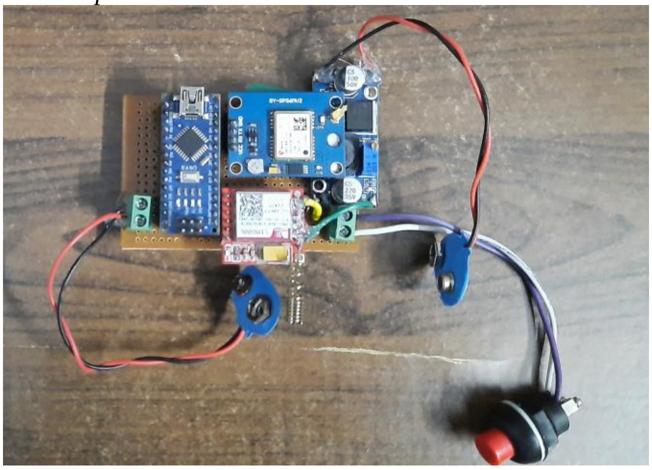


Fig:8 Hardware of transport Module

GPS module and a GSM module to send SMS messages with the current location of the device which is shown in the Fig:8. The GPS module is connected to the Arduino through pins 9 and 10, and the GSM module is connected to the default serial pins of the Arduino. The function starts with defining variables for latitude and longitude with an initial value. Then it initializes the GPS and serial communication with the GSM module. In the loop function, the program first reads the state of a push button connected to pin 2.

If the button is pressed, it calls two functions message2() and message1(), which send an SMS message with different contents. After that, the program checks if there is any GPS data available to be read. If GPS data is available, it is decoded using the TinyGPS library, and the latitude and longitude values are extracted. The current latitude and longitude are then converted to strings and printed to the serial monitor. Finally, the program sends an AT command to the GSM module to check if it is responding, and then waits for 100 milliseconds before starting the loop again. The message1() and message2() functions are responsible for sending SMS messages. They start by sending a series of AT commands to configure the GSM module, then they send the message contents which include the latitude and longitude values obtained from the GPS module. The message is sent to a hardcoded phone number.

D. Smart Energy Generation Setup

Fig:9 Smart Energy Generation Setup

The Fig:9 shows the smart energy generation setup using solar panel, Inductor L1 charges when Q1 turns on. When Q1 turns off, L1 discharges into the battery via D1. Performing this simple operation thousands of times per second results in appreciable output current. It is also called inductive discharge. For this to function, the input voltage must be lower than the output voltage. Also, with a solar panel source, energy storage in the form of a capacitor (C1) is required so that the solar panel may continue to output current between cycles. The circuit consists of essentially three sections including a 555 MOSFET gate driver, 555 PWM modulator and op amp voltage limiter. The 555 with its totem pole output can source as well as sink roughly 200mA and makes a great low power gate driver. The 555 PWM modulator is the classic 555 oscillator circuit. To regulate the C3 discharge time (inductor charge time), pin 5 is held at a regulated 5V. Op amp U1A integrates the battery voltage signal when the divided set point voltage is compared with the 5V reference.

When the voltage exceeds the setting, the output integrates in the negative direction thus reducing the repetition rate of the PWM generator and limiting any subsequent charging. This effectively prevents overcharging. Since the circuit must operate at low voltages (this one works down to about 4V input) a logic level MOSFET is required. It turns on at fully at 4.5V. As the solar panel voltage /current increases, the PWM generator increases its repetition rate thus resulting in increased output current.

At the same time, additional voltage is applied to the inductor thus increasing its charge current. As a result, the boost regulator really digs in as the voltage increases, or lets up as the voltage diminishes. To achieve maximum transfer of power with full sunlight, potentiometer R8 is adjusted so that the battery charging current is maximized –this is the maximum power point. If the circuit is operating properly, there will be a very shallow peak as R5 is rotated. Diode D3 makes the automatic MPPT adjustment function more sensitive by subtracting a fixed voltage from the voltage difference between the battery and the average voltage across C3. Under lower light conditions, you will find that R3 is not exactly at optimum, but it will not be significantly off.

V. HARDWARE RESULTS

A. Overall Result of Hardware Setup

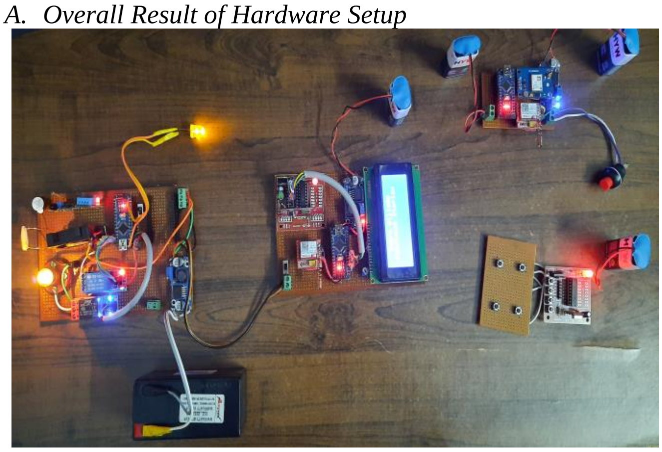


Fig:10 Hardware Setup

B. *Smart Hut Result*

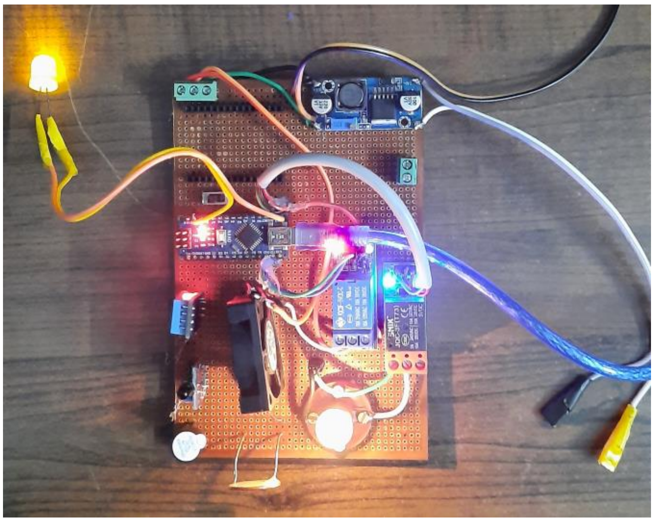
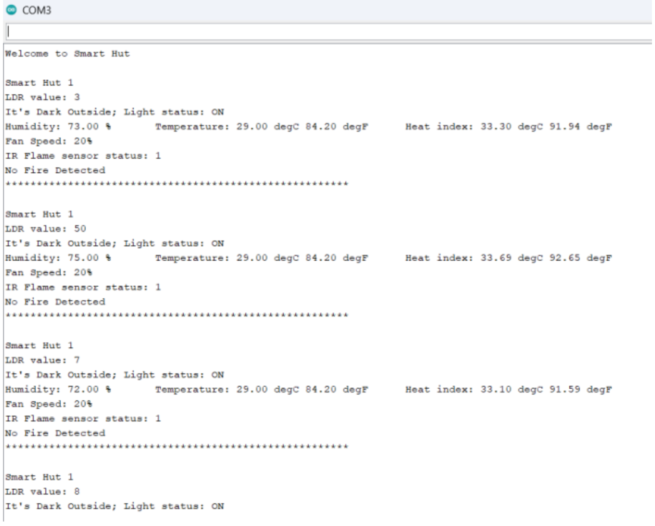


Fig:11 Smart Hut

C. *Smart Hut Data in Serial Monitor*



```
COM3

Welcome to Smart Hut

Smart Hut 1
LDR value: 3
It's Dark Outside; Light status: ON
Humidity: 73.00 %       Temperature: 29.00 degC 84.20 degF      Heat index: 33.30 degC 91.94 degF
Fan Speed: 20%
IR Flame sensor status: 1
No Fire Detected
*******************************************************

Smart Hut 1
LDR value: 50
It's Dark Outside; Light status: ON
Humidity: 75.00 %       Temperature: 29.00 degC 84.20 degF      Heat index: 33.69 degC 92.65 degF
Fan Speed: 20%
IR Flame sensor status: 1
No Fire Detected
*******************************************************

Smart Hut 1
LDR value: 7
It's Dark Outside; Light status: ON
Humidity: 72.00 %       Temperature: 29.00 degC 84.20 degF      Heat index: 33.10 degC 91.59 degF
Fan Speed: 20%
IR Flame sensor status: 1
No Fire Detected
*******************************************************

Smart Hut 1
LDR value: 8
It's Dark Outside; Light status: ON
```

Fig:12 Data of Smart Hut

D. *Panchayat office Display*

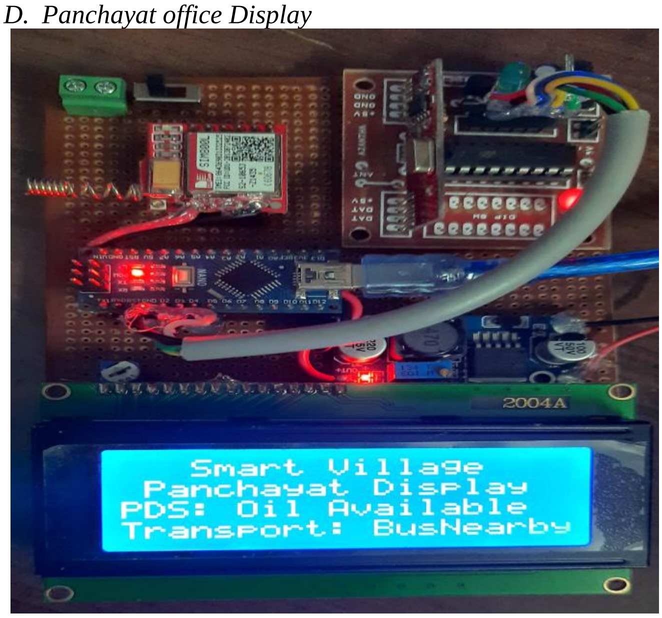


Fig:13 Display

VI. CONCLUSION AND FUTURE SCOPE

A. *Conclusion*

The project focuses on providing power supply to the rural villages through renewable energy source that is solar energy instead of providing power supply through Grid and to achieve rural development through the use of inexpensive sensors and actuators to improve the quality of living in rural areas. In an effort to revitalize rural communities and make them more sustainable, we have to focus on developing the rural ecosystem. It is important to provide the technologies and other services present in urban areas to the rural areas.

B. *Future Scope*

The design and development of smart huts has immense potential for future growth and innovation. Some of the possible future scopes of this technology include:

- Integration with Smart City Infrastructure: Smart huts can be integrated with the smart city infrastructure to provide real-time information about traffic, weather, public transportation, and emergency services. This can help in improving the overall quality of life for citizens.
- Use of Artificial Intelligence: Artificial intelligence can be used to analyze the data collected by smart huts and provide useful insights. This can help in optimizing traffic flow, predicting traffic congestion, and improving public transportation services.
- Renewable Energy: Smart huts can be designed to incorporate renewable energy sources such as solar panels and wind turbines. This can help in reducing the carbon footprint of the city and provide a sustainable source of energy.
- Advanced Communication: The communication infrastructure of smart huts can be improved with the use of advanced technologies such as 5G and IoT. This can enable real-time communication between various smart huts and other devices in the city.
- Personalization: Smart huts can be customized to meet the specific needs of individuals. For example, personalized lighting, temperature control, and entertainment systems can be integrated into the huts.

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