Android Platform Based Smart Grid Hybrid Load Control System

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Abstract— *The android platform based smart grid hybrid load control system is a cost-effective, reliable, effective, pollution-free and environment friendly system that uses solar and wind energy sources to generate electricity. The system consists of solar panel and wind turbines to generate power, the battery charger to control the charges that flow to the DC backup battery, the inverter which converts DC to AC, the relays switches that switch ON/OFF the loads when they receive a controlling signal from the phone, Bluetooth module that receives signals from the phone, a microcontroller that receives the signal from the Bluetooth module and commands the relays and the loads that are controlled automatically using the developed android application. The design process yielded the anticipated positive results as the design worked perfectly as per the proposed concept.*

Keywords— Atmega328P, Bluetooth module, Inverter, Solar Energy, Wind Energy.

I. INTRODUCTION

Energy has by far become one of the most fundamental elements of our Universe and vital for the progress of any nation (Javaid et al., 2017). It is essential for survival and indispensable for developmental activities to promote education, health, transportation, and infrastructure, improve the standard of living and it is also a very important factor in economic development and employment. It is an ultimate factor responsible for the development of agriculture and industries in developing countries where power consumption is steadily increasing for the past few years. Power supply companies and organizations around the world are now moving away from fossil fuels to generate electrical energy and their attention is now towards more clean energy, energy-efficient and renewable electric power resources (Ingole & Rakhonde, 2015). There is a need for automatic control of loads to ensure the efficient use of electrical energy by its consumers. Thus, through automatic control of loads using a mobile app and a Bluetooth module, efficient use of power is attained and this has solved the problem of wastage of power in developing countries where hydroelectric power cannot be easily accessed by developing a dual power supply system and an external battery charger charge the batteries with a load shedding system controlled by a mobile app.

Existing Systems

In 2019 Suresha et al., Designed a one-time solution to monitor the outages in real-time without the requirement of a meter. A power monitoring system automatically analyzes and retrieves the power quality events. The monitoring system is composed of a smart grid and a centralized workstation.

Kasali et al., 2019. Designed an automatic transfer switch for household solar Photovoltaic systems which saw to it that

households that wanted to continued supply of power even when there is no enough sun irradiance for their solar PV system. On the other hand, it eliminates the problem of drawing more current at a specific time, knowing that most households and small businesses rarely purchase a solar PV system that meets their power load requirements.

Bhalshankar et al., 2018. Modeling of hybrid micro-grid DC-AC distributed generation system for smart homes, this shows that renewable energy resources are becoming more and more preferred because they are environmentally friendly and thus more electricity generation becomes necessary and could provide half of the total energy demands. To meet the demand for electrical energy in the future, the smart grid system can be used as an efficient and effective system for energy security.

De Carne et al., 2017. Proposed that an overload control for smart transformer applications. Its sole purpose was to create an interface with the local generators and loads in a low voltage grid through voltage and frequency variations to restrict the flow of current that will flow in the smart transformer.

De Carne et al., 2015, Described a possible solution to the smart transformer overloading problem in presence of controllable distribution generation. In the case of an emergency, the frequency-based overload control system allows the distributed generation power to re-dispatched to avoid the smart transformer current burden, impacting minimally on the low voltage grid. The control action solves the problem of overloading during transients, allowing the system to operate at its frequency rated value when the system is working under operating conditions

Naik, 2014. Proposed a dynamic modeling and control system for a grid-connected hybrid wind and photovoltaic

energy system interconnected to the electrical grid through a power electronic interface. A gearless permanent magnet synchronous generator is used to capture the maximum wind energy. The photovoltaic and wind systems are connected to the DC side of the voltage source inverter through a booster converter individually and maintain a fixed DC output at DC link.

II. MATERIALS AND METHODS

2.1 Power Source

Power sources in this system are used to generate the power that is used by the loads. The two power sources that are used:

2.1.1 Solar energy

Solar energy is the energy through light and heat emitted from the sun that is harnessed using a range of ever-evolving technologies such as artificial photosynthesis, solar heating, photovoltaics, solar thermal energy, solar architecture, and molten salt power plants. Solar energy is ever-present on the earth continuously and can never be depleted for as long the sun continues to shine. It is provided freely by nature and it is always readily available. It is friendly to the environment in the sense that it does not produce any gases that cause pollution. It is an affordable energy resource as the initial costs are very low. Maintenance costs are very low and it has a longer life span. The major drawback of the solar system is that it cannot produce energy in rainy weather conditions because its efficiency depends on the intensity of the heat radiated by the sun. On the other hand, it has greater efficiency than other energy resources. It only needs initial investment and it has a long life span and has almost zero emissions.
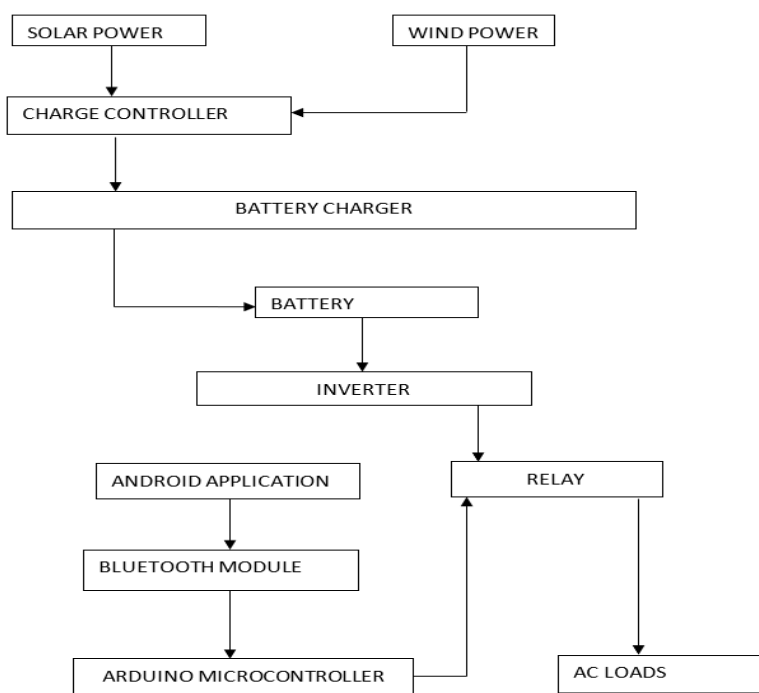

Figure 1. Showing Snapshot Block Diagram.

Power = voltage * current

To determine the rating of the battery to be used, since we need 12VDC at 50Watts,

50 =12*current,

Current = 4.17A.

Therefore, to generate 4.17A DC, a solar panel of 50Watts, 12V was used to generate the power and this power was stored using a12V rechargeable battery.

2.1.2 Wind energy

Wind energy is the energy that is captured by the use of wind turbines to generated energy from the flowing wind. Suitable blades of suitable length and cross-sectional area are used for this purpose that converts the kinetic energy of the flowing wind into mechanical energy. A generator then converts the mechanical energy into electrical energy. Wind energy is also a renewable energy resource. Wind energy needs less cost to set up for the generation of electrical energy. Wind energy systems require low maintenance costs and it is present almost 24 hours of the day. This system has no emissions and the initial cost is also less of this system. The generation of electricity from wind depends upon the speed of wind flowing and the length of the turbine blades. It is advisable to set up the towers of the wind power plant in hilly areas where winds move at very high velocities.

The DC voltage generated by a DC generator is given by

V = (v * B) * l

Where V is the DC voltage, v is the velocity of rotation, B is the magnetic flux and l is the length of the conductor.

In this setup, the dynamo was used for demonstration and it could generate 12V at 4m/s speed.

To determine the required flux,

12 = 4.17 (4 * B),

B = 0.7195Henrys

Therefore, to produce 50Watts, 12V the windmill was rotated at 4m/s speed.

2.1.3 Battery

The battery was used to store power that is generated using the solar and wind combined. The battery rated 12V, 10Ah was the suitable one to use and it was able to store DC power and when it is fully charged, it could supply power to the specified loads connected to it for 56.26 hours

2.1.3 Inverter

The inverter was used to convert DC power to AC power and in this system, the inverter used was a 300W inverter and it could produce a pure sine wave AC power. The power from the inverter was used to supply AC loads and to supply the battery charger circuit.

2.1.4 Battery charger

The battery charging circuit was comprised of a 230VAC to 12VAC step-down transformer, bridge rectifiers consisting of the diodes, filter capacitors (2000 and 100 microfarad), voltage regulators LM7812, LM7809, and LM7805. These regulators could regulate the DC voltage to the value required to make a perfect battery charging system of 12V, 9V and 5V respectively.

2.2. Control Section

2.2.1 Atmega328P microcontroller

The Atmega328P microcontroller was programmed using the Arduino compiler. The microcontroller was powered using 5V from a voltage regulator. The microcontroller received commands from the Bluetooth module to control the relays that were used to switch on and off AC loads.

2.2.2 Android application

The android application was developed using online software called MIT app inventor. All the connectivity and configurations were done online.
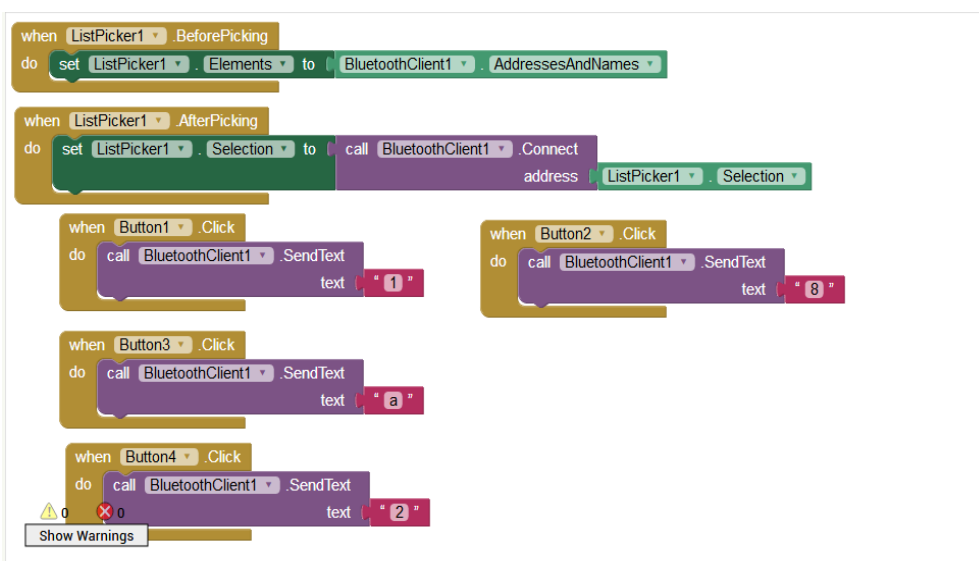

Figure 2. The Bluetooth configurations

The App was downloaded and stored in the PC where it was further transferred to the phone. The installation was done as usual and after installation, the connection to the Bluetooth module is done by tapping on the "connect to the device button". After connecting to the device, the commands for switching on and off of the loads are serially sent via the module to the microcontroller which is used to switch on and off relays thus controlling the loads.

2.2.3 Bluetooth module

The Bluetooth module HC05 is a serial communication device that is used to transmit and receive signals that are within a range of 10 meters from the device to the phone. The Bluetooth module was interfaced with the Atmega328P microcontroller to control the output signals from the microcontroller.

2.2.4 Relays

A relay is a switch that opens or closes its contacts once it is powered ON or OFF. Relay switches have different ratings

i.e. 24VDC, 12VDC, and 5VDC relays, but since the microcontroller output is 5VDC, the 5VDC relay was used for this paper

The relays used were 5VDC, 110-230VAC powered with 5V from the 5V regulator and they were interfaced between the microcontroller and the AC loads in a way that when the microcontroller sends a HIGH signal, the normally open contact closes and the AC power circuit is completed to power the load. And when the microcontroller sends a LOW signal, the closed contact opens and the circuit is broken to switch off the load.

2.2.5 Loads

The loads used were two 18Watts AC bulbs, a DC fan, and a Socket and the power that was generated and stored was enough to support these loads for 56.26 hours according to the analysis made.

The total power input of the inverter was 300W at a Voltage of 230V.

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Total load consumption was (18+18+5) =41W

The current that was consumed by the bulb P=36W, V=230V, I=36/230, I= 0.156A

The current that was consumed by the fan P=5W, V=230V, I= 5/230, I = 0.02174A

Total current that was consumed by the loads = 0.156+0.02174 = 0.17774 A

The total output current from the inverter

From P=IV, P=300W, V=230, I= 300/230, I = 1.3043 A

The supply current from the battery =10AH

Therefore, the time it can take = (the supply current from the battery) / (the total current consumed)

$$= 10/0.17774 = 56.26 \text{ hours}$$

One of the AC bulbs was used to represent the indoor lights, another was used to represent outdoor light, DC fan to represent the air conditioner. And these loads could be automatically controlled via Bluetooth using a Bluetooth module, a microcontroller, and the relays.

III. WORKING PRINCIPLE

The direct current (DC) from the solar and wind sources of energy is used in charging and to store electrical power in the 12V battery. The battery supplies power to the inverter which converts the direct current (DC) into alternating current (AC). The AC power is connected to the loads via the open terminals of the relays. Also, the output from the 240V/12V transformer is connected to the bridge rectifier circuit where the 12V AC is converted into 12V DC and the electrolytic capacitor connected across is to filter the ripples from the 12V DC. This voltage is fed to the voltage regulators whose output is 12Vand 9V for battery charger terminals. 9V DC is supplied to another voltage regulator whose output is 5V DC which is output voltage supply that is needed as an input voltage of the microcontroller. The 5V DC was used to power the microcontroller, Bluetooth module, and the relays. The loads are controlled with an android application via a Bluetooth module.
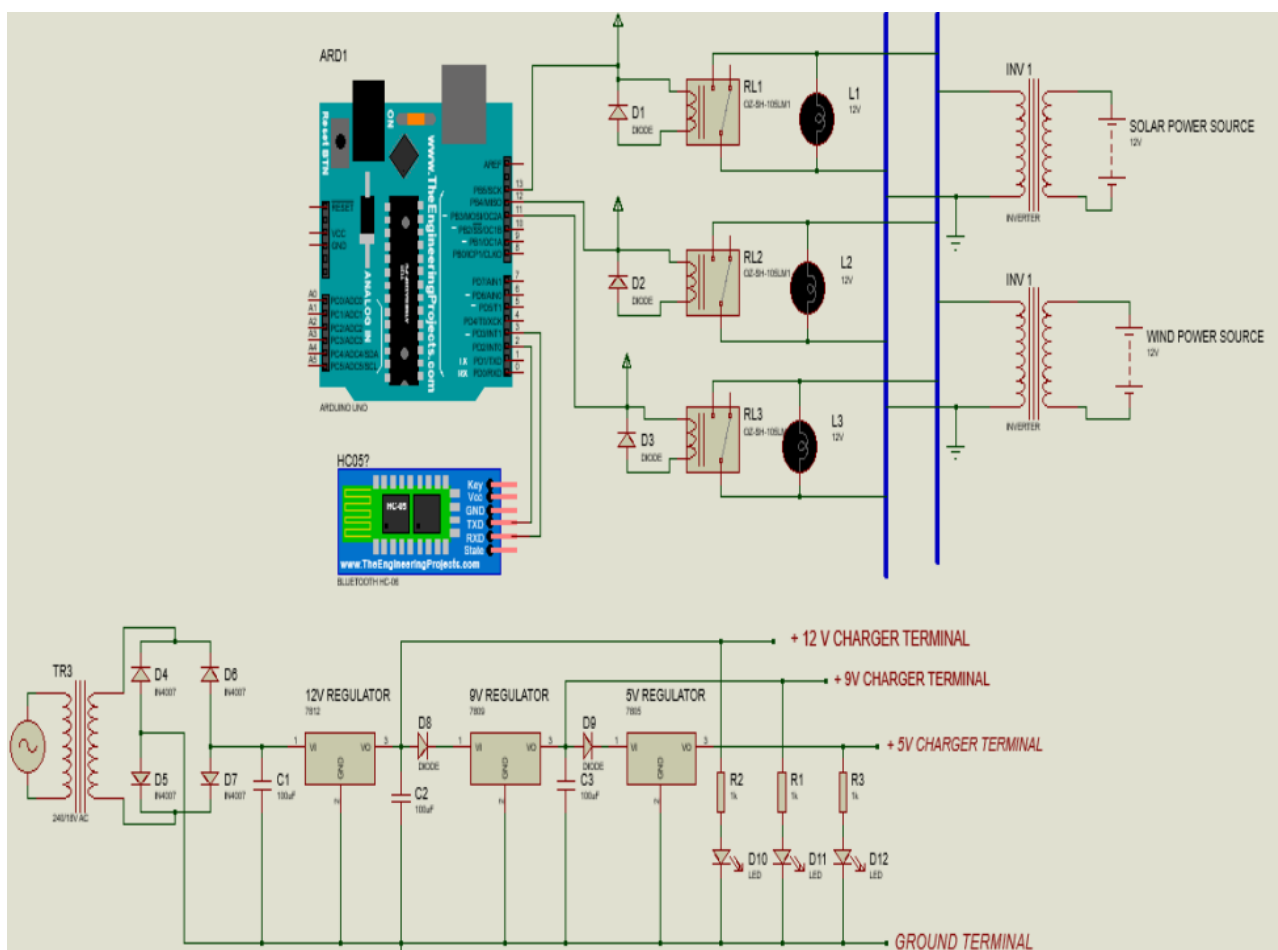

Figure 3. Shows Complete Simulated Circuit using Microcontroller.

The flow chart illustrates the system flow from the solar and wind power sources, and from these power sources, the power is regulated to 12V DC by the charge controller where it further charges the battery through the charge controller.

The output from the battery is 12V DC which is inverted to 240V AC by the inverter to supply to the loads through the relays which are controlled by the Android application using a phone.
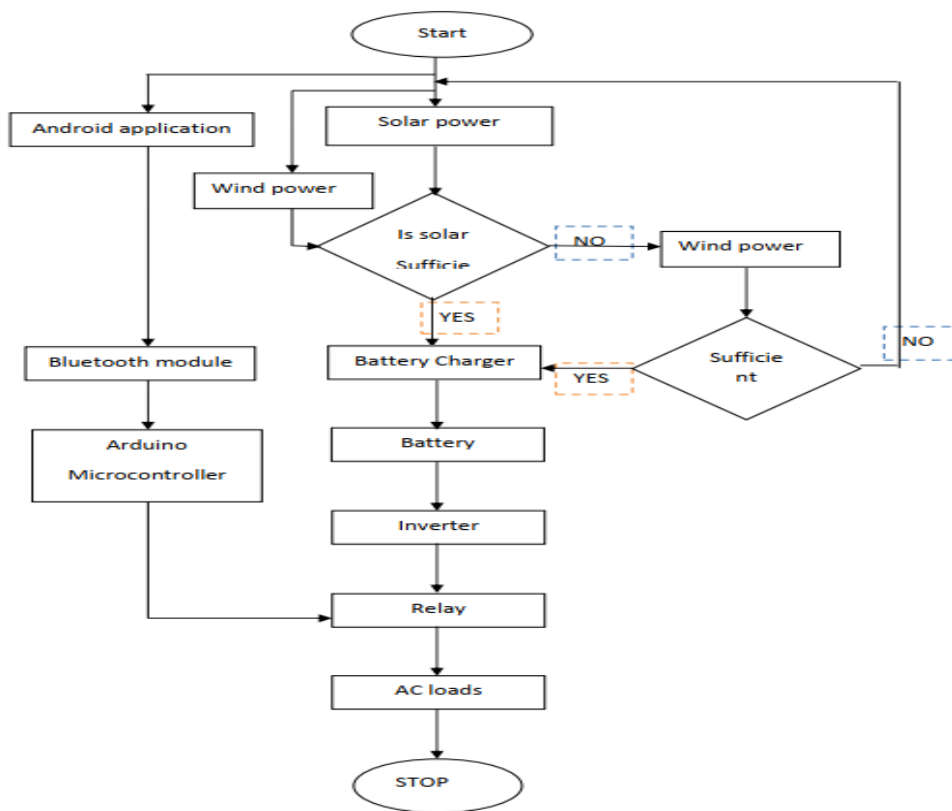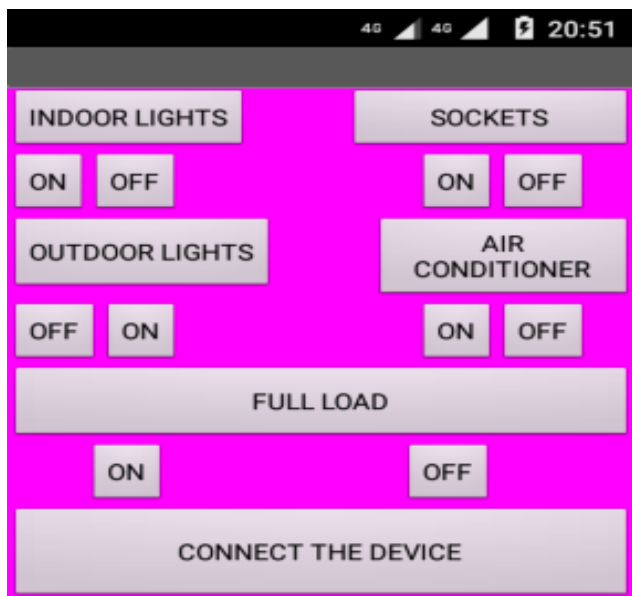
Figure 4. Flow Chart of the System.

Figure 5. Showing Snapshot Android Interface.

The android application controls the loads through the Bluetooth module which serially communicates with the microcontroller and the microcontroller gives a controlling signal to the relay to switch ON/OFF the loads. The loads can be turned either ON or OFF by pressing the buttons, in the process of controlling the loads, the phone is configured with the system by turning the Bluetooth on the phone ON, then by pressing "CONNECT THE DEVICE" button, the HC05 Bluetooth device and the phone will have connected automatically and the loads can be controlled using the smartphone.

IV. RESULTS AND DISCUSSIONS

The transformer output was checked and measured and the required 12V AC voltage was obtained, which was then applied to the power supply circuit and the terminal voltages of 12.00V, 0.00V, 4.308V and 7.692V DC voltage at positive, negative terminals, AC1 and AC2 of the bridge rectifier were measured respectively. This voltage was then applied to the 470uF capacitor, and the voltage at the anode terminal and the cathode of the capacitor was 12.00V and 0.00V respectively. Then this voltage was applied to the voltage regulator LM7805 and LM7812, i.e., An input of 12VDC and output of 5VDC and 9VDC was obtained according to the requirements.

TABLE 1. Output Voltage Power Sources

Output of the Solar	The output of the wind at 4m/s	Input into the battery	Output of battery	Input into inverter	Output of inverter
12.5 VDC	10.4VDC	12 VDC	11.9 VDC	11.9 VDC	230VAC

TABLE 2. Controlling Loads

Phone to Bluetooth module	Controlling the relays	Outdoor light	Indoor light	Air conditioner	Sockets	Full load
Connect to the device using a phone	The microcontroller sends a HIGH or LOW signal according to the button placed on the phone.	Turns ON if the ON button is tapped on the phone and turns OFF if the OFF button is placed on the phone.	Turns ON if the ON button is tapped on the phone and turns OFF if the OFF button is placed on the phone.	Turns ON if the ON button is tapped on the phone and turns OFF if the OFF button is placed on the phone.	Turns ON if the ON button is tapped on the phone and turns OFF if the OFF button is placed on the phone.	Turns all the loads connected ON and off once

V. RESULTS

The power supply products and output of 12V, 9V and 5V using LM7812, LM7809, and LM7812 ICs respectively, and after 5V output was connected to the microcontroller which supplies power to the microcontroller, Bluetooth and relays. When the microcontroller receives the commands from the phone via the Bluetooth, the relays turn ON or OFF the loads according to the command sent via the Bluetooth. If the ON button is placed on the phone screen, the Bluetooth module decodes this message and feeds this information to the microcontroller and the microcontroller sends a signal to energize or de-energize the relay coils to open or close the circuit thus turning ON/OFF the loads.

VI. CONCLUSION

Electrical energy consumption is one of the vital elements that human beings would like to possess at a cheaper price and convenience, although using electrical energy is a bit expensive and hard to acquire, this can be achieved through the electrical smart grid. This paper of the android platform based smart grid hybrid load control system can be used to control appliances using a mobile application to help prevent energy wastage and at a minimum possible cost.

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