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A Prototype Design for controlling a Solar Powered Car with a GSM Remote Control

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Abstract

Remote control car technology has been around for decades in the history of technology. Nowadays, lots of research is going on in this area. The remote-control car using radio signals were introduced in the mid-sixties. Therefore, some major drawbacks were faced in these Radio Frequency (RF) systems such as limited frequency, blocking the infrared controller by large obstacles between paths. Also, during day time, sunlight could interface with infrared signals. Later this limitation was solved by using a mobile phone network system for robotic control. This improved system could cover a large working area and also no possibility of interfacing with other controllers. The robotic system also can share the moving structure and mechanical features under the same control. In this paper, a GSM network-based system has been designed where the GSM module is directly connected to the microcontroller. In this system, the instructions are given by SMS instead of the keypad so that we do not need to interface a DTMF decoder in the system. Besides, for the power source of the car, we have used renewable energy solar power to run the whole system. We have used Matlab and Simulink to design and simulate the Solar Photovoltaic cell (PV). The testing results shows the efficiency of our designed solar panel that was good enough to run the car motor even on normal temperature. The Proteus software has been used to design the microcontroller and whole system circuits to get the input from a cell phone. The user

can send the message from the cell phone to move the car. The results show the successful implementation of proposed design with appropriate testing. Our proposed control system of the solar car design has managed to overcome the limitations of standard DTMF technologies such as circuit complications, extra components required for filtering and restriction on the number of features.

Keywords: Remote Control, GSM, IoT, Solar, Renewable Energy, Solar Energy, Matlab, Simulink, Proteus.

Introduction

The control system always takes an important part in the research field, and when this comes to controlling a vehicle, it has always been challenging.

In the beginning, Radio Control simply known as the RC system is used to control a device through radio signals. This RC term is also often used to control a vehicle using a handheld transmitter. A mobile device with the source located outside of the device that is supervised using a way that does not limit its movement can be characterized as a remote-control car utilizing RC. An RC controlled car means there is a regulator device using the radio with infrared or cable connection amid the device and the vehicle. The car can be controlled by RC means that the remote has to be directly pointed to the vehicle. This is the reason why this control system may not work when obstacles exist in the line path between a car and the remote. Thus, to overcome this problem, one of the modern technologies, GSM network systems can be implemented to control a vehicle as it does not suffer from this type of problem.

In this research paper, we propose a design a remote-control system for a car using the GSM network via the operator's mobile phone. Since GSM does not use the radio signal and is accessible to almost all over the world, it can easily overcome the problems that have been faced using the RC system. Moreover, for the power source of our designed car, we have designed a renewable energy source using solar panels on the car. Using this renewable source will make the car environment friendly. GSM network-based controller system along with renewable power source, which is highly recommended nowadays due to energy crisis, enables this mobile phone operated car design a significant development in-vehicle remote control system. The other sections of the

paper are organized as follows: literature review, methodology, experiments and results analysis, conclusion and future work.

Literature Review

The general idea of controlling a device or a system is a well-known fact in today's technology. Using a remote controller to control a single device from a short distance has been used for a long era of time. However, recently people have been progressing in technology and have been able to control large equipment or devices from the maximum possible distance. These developments have decreased the industrial cost by reducing manpower and also increased comfort, efficiency, and accuracy mentioned by Md. Shahinoor et al., (2014).

WiFi technology has been used for controlling purposes along with transmitting and receiving data. Radio frequency has been used to operate this technology. However, this technology is limited to short range and may not operate when there are large obstacles between the device and the remote. On the other hand, Amey Kelkar (2014) discussed that WiFi stills remains in this modern era only to serve the purpose of transmitting data over smartphones. Along with Wifi, there is another technology called IR system which has been used to control large devices, even a vehicle. There have been a few implemented cars based on this system. This technology involves infrared rays to stay connected between the device and remote. Hence, in this case, large obstacles easily disconnected the system, which was a very dangerous issue, especially for cars. Moreover, this system too has range limitations as WiFi mentioned by Amey Kelkar (2014).

Another approach of controlling long-distance devices was made prior to other modern technologies for home and office applications, which involved telephone line systems and personal computers. In this system, DTMF technology was introduced to send the commands to the controlled device. The systems deveopled by B. Koyuncy (1995), Coskun and H. Ardam (1998), the monitored device is not movable, and the system structure is far complicated.

Nowadays, the modern networking system GSM is being used to control devices where an operator's cell phone could be used as a remote controller. This paper is all about proposing a simpler design to control a vehicle via the GSM network. The following section delivers an

overview of all related approach in this project and addditionally, proposes a simple design to implement.

In one of the papers done by Sourangsu Banerji, (2013), the design of the remote controlling car has been proposed using the GSM network and cell phone. In this design, a microcontroller has been interfaced with DTMF decoder and a motor driver, which is connected to the car wheels. DTMF system of this project helps the operator to input the command by pressing the keypad of the cell phone. This project overcomes the distance limitations problem and can be operated from anywhere in the world. Though microcontroller requires programming, it is still used in this system as various applications can be added to the system. On the other hand, the DTMF system complexes the circuitry because it needs an extra filter to separate the frequencies.

Another project was done by Arab Fakih, (2014). The design pattern is almost the same as the first one. The only difference is that, here, two wheels have been used instead of four. Besides, this paper offers various applications to add to the system to make the car more efficient. A few future scope also has been added to improve the design.

The paper which was done by T.T. Oladimeji, (2013) proposed a design to prevent a car from being hijacked. This system uses the GSM network along with operators' cell phones to avoid stealing. The design involves the GSM module, interface box and vehicle sound system. Although the purpose of this system is not to control the car, it ensures a strong and reliable security system of the vehicle.

In a paper done by Amey Kelkar, (2014) , presented a simple design using GSM and cell phone interfacing with a microcontroller. In this design, an Arduino microcontroller has been used to receive the input from the DTMF decoder and drive the motor driver accordingly. The advantage of using Arduino is that various shields like a prototype, Wifi and Bluetooth shields are added in this microcontroller, which makes it more convenient. This design also proposes various applications to implement in the car.

The project was done by Pathik, et al., (2014), a controlling design using GSM and DTMF decoder has been proposed. Unlike other designs, this design does not involve any microcontroller. This design is only to control the car and overcome distance limitations. In this project, instead of a microcontroller, a four relay circuit has been used through which the commands from the DTMF decoder will pass and drive the motor accordingly. Since no microcontroller has been used, no other application other than controlling the vehicle can be implemented using this design. Moreover, this design introduced solar energy as the power source of the car battery.

In the following research paper, a Vehicle Security and Entertainment System was developed using Raspberry Pi Tabassum, et al., (2020) to monitor, track the vehicle, and to offer local entertainment system. Two embedded devices were used to split the entertainment system from the security system to provide isolation and safety. They developed a low-cost passenger safety system for vehicles to use in passenger buses, trains, and even cars. The development was economical and additional modules can be added. When a vehicle is stolen, the device will give an alert signal, through tracking device and camera, live data can be obtained from the vehicle to ensure the passenger's safety.

A different method of control has been done in the paper made by Jen Hao Teng, et al., (2010). This design is based on an RFID controller which involves a microcontroller. This system operates according to the commands that are written in the RFID tag. After receiving the commands written in the tag, it sends the command to the microcontroller, which drives the car according to the commands. This particular method of design overcomes the distance limitations and can be used in various fields of technology.

Another project was done by Sheik Mastavali, (2016) the similar design involving GSM, microcontroller and DTMF decoder has been proposed. Besides, this design allows the vehicle mounting in a 360-degree angle, which is very useful for shooting the target if there is any laser gun added. Moreover, this design adds an AV camera to the system which can display the surroundings of the vehicle.

Methodology and Proposed System Design

In our proposed design, we have used two software to design the system. We have used Matlab and Simulink to design and simulate the Solar Photovoltaic cell (PV) and Proteus software has been used to design the microcontroller and whole system circuits to get the input from a cell phone.

Most of the projects use the DTMF decoder to input the command by using the keypad of a cell phone. DTMF involves key tone and frequency to operate. Therefore, the specific filter is needed to separate the frequency which in turn makes the circuit more complicated. Further, for DTMF technology, a DTMF decoder is required in the system design. Likewise, using this method, silly movement can turn to be a dangerous result of pressing any keypad accidentally, resulting in driving the car in the wrong direction leading to an accident. To overcome these types of problems, in this paper, a different way has been proposed. Instead of using the keypad to insert commands, SMS could be used to send a command to the car. The advantage of sending SMS is that it is more specific and safer. Moreover, using this method, the DTMF decoder can be removed from the design, which makes the design simpler and without any filter. Along with SMS based controlling system, solar power is used as the total energy source of the car, which is a renewable energy source.

GSM (Global System for Mobile Communication), established by European Telecommunications Standards Institute (ETSI) in 1998, was used to standardize cellular communication. It is an open-source system that allows access to the code. Global Telecoms discussed the operation of the three frequencies: 1900 MHz, 1800MHz, or 900MHz. GSM had been produced for superior and effective remote correspondence stated by Techopedia. GSM fundamentally offers cutting-edge voice and information services. The principle favorable benefit of GSM is that it gives a roaming facility, which implies a man can utilize his telephone number of one GSM system using an alternative GSM system. In this manner, individuals can share all GSM systems by using a single number, Tutorialspoint, (2016).

The part that modulates and demodulates the GSM signals keeping in mind the end goal to meet the correspondence pre-requisites is known as a GSM Modem. This modem is conceivable to

modulate an analog signal to encode digital information, and besides, demodulate this sort of signal to decode the data being transferred was discussed by Engineers Garage, (2015). The method of transmitting GSM signal is presented in the following flowchart:

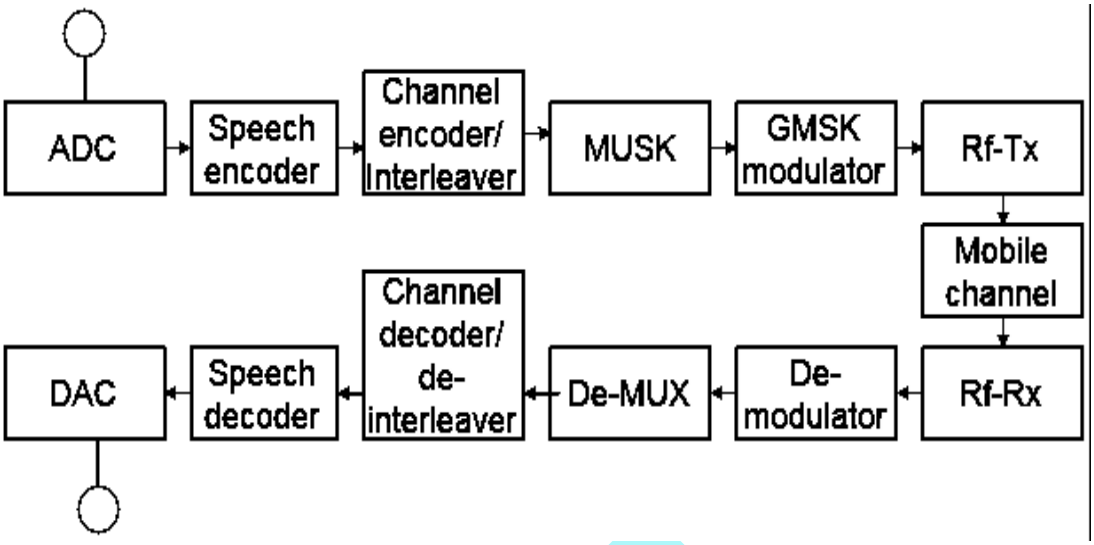

Figure 1: *Block diagram illustrating the data structure of the implemented GSM*

SIMCOM SIM300 is the modem being used in this particular project. SIMCOM SIM300, created for an international market, is a Tri-band GSM/GPRS engine that works on the three frequencies of GSM. This device can be used to send SMS and also to make the call. We can easily control this device from a microcontroller using simple instructions as used in T.T. Oladimeji, (2013).

Jen Hao Teng, et al., (2010) utilized a microcontroller AT89C51, which is linked to the GSM module and acquired the decoded signal from it. AT89C51 is an eight-bit microcontroller. It comprises of one hundred and twenty-eight bytes of RAM and four-kilo bytes of Flash Programmable Read Only Memory (PROM). This microcontroller will get an instructive signal from the GSM module and regulate the motor driver. The output from this microcontroller pins is fed into the input pins and enables the pins of the motor driver which will drive the motor according to the command. Therefore, microcontroller output is not sufficient for the motors to drive; that is why current drivers are required for the motor rotation. 5V voltage supply is needed to drive this microcontroller. The pin planning and programming requirement has been collected for this microcontroller.

LCD stands for liquid crystal display. The term liquid crystal is utilized to portray a substance in a state between liquid and solid, yet, it shows the characteristics of both. Atoms in liquid crystals tend to orchestrate themselves until they all point in the same particular way. This course of action

of molecules empowers the medium to move like a fluid. A sixteen by two LCD is quite a common component that is very often used in numerous kinds of devices and circuits. There are no restrictions on displaying special, custom characters, animations on LCDs. The LCD used in our project consists of two registers, which are called Command and Data mentioned by Mastanvali S., et al., (2016). The command register saves the commands given to the LCD. Instruction is given to an LCD to do a pre-outlined task like resetting it, clearing its screen, positioning the cursor, directing the display, etc. which are called commands. The data is saved by the data register to be displayed on the LCD. The ASCII value of the character to be displayed on the LCD is known as data stated in Mastanvali S., et al., (2016). Sixteen by two LCD modules is an exceptionally basic sort of LCD module that is utilized as a part of 8051 embedded developments. The LCD directly shows the message that has been received by the microcontroller.

A circuit, gadget, component, or framework which transforms one signal level to another is known as a level converter; for instance, the component that changes a voltage or current level of an information signal. MAX232 IC is utilized amidst serial communication of the GSM module with the AT89C51 microcontroller. The microcontroller AT89C51 operates at the TTL logic level and the serial connection in the GSM module works on the RS232 voltage level that makes it extremely difficult to build up an immediate association between them to commune with each other Engineer Garage, (2015).

Consequently, the RS-232 signal levels are too high. TTL hardware and the negative RS-232 voltage for high cannot be at all controlled by GSM module logic. To get serial information from an RS-232 interface, two things should be done: the voltage must be brought down in addition to the low and high voltage level being inverted Ekstrom, et al., (1997). MAX232 IC changes the voltage from low level to high state level as well as the other way around Kushagra., (2012).

In this research, max232 is used to change the voltage levels between GSM and microcontroller as they function at different voltages. A dual H-bridge motor driver Integrated Circuit (IC) known as L293D is being used in our project. Motor drivers function as current amplifiers as they accept a low-current control signal and deliver a higher-current signal. This higher current signal is utilized to work the motors. The motor driver comprises two H-bridge driver circuits built inside

it. Two DC motors can be operated at the same time, both in forward and reverse direction in its common mode of operation. The input logic pins 2,7,10 and 15 can be used to regulate the motors. The motor can be halted by the input logic 00 or 11. On the other hand, the corresponding motor will revolve it in clockwise and anticlockwise directions if logic 01 or 10 is used as discussed in Robot., (2010) and Kushagra., (2012).

For the motors to commence working, it is essential for the enable pins 1 and 9 (relating to the two motors) to be high. Consequently, the outputs become active and begin to function in phase with their inputs. Likewise, when the enable input is low, the corresponding driver is disabled and their outputs are in the high-impedance state and turn off as discussed in Robot., (2010) and Kushagra., (2012).

Experiments and Result Analysis

In this system, motor driver input pins are connected to the microcontroller output through which the driver will get command from the microcontroller to move forward and backward. There are four wheels attached to the motor driver. The motor driver will drive these wheels accordingly. To convert sunlight into electricity to charge the car battery, solar cars use photovoltaic cells. Most of the vehicles in production nowadays carry 12V battery. Nowadays, solar panels have improved and highly efficient solar panels have been produced Tabassum, M., et al., (2017). These panels can be used in solar cars to improve the efficiency and charging system Maaji, S.S., et al., (2013). Since we have been using solar power as our power source of the car, we need to design a suitable PV module that will be implemented in the car.

An array of photovoltaic modules is actualized by the photovoltaic array piece that is made out of strings of modules associated in parallel, where each string is comprised of the modules related in series Abdul, S.B. et al., (2020). The photovoltaic array block consists of a current source $I_{L,}$ which is produced from light, a diode, a series resistance $R_{s,}$ and a shunt resistance $R_{sh,}$ to signify the irradiance- and temperature reliant current-voltage features of the modules discussed by Bellia, et al., (2014).

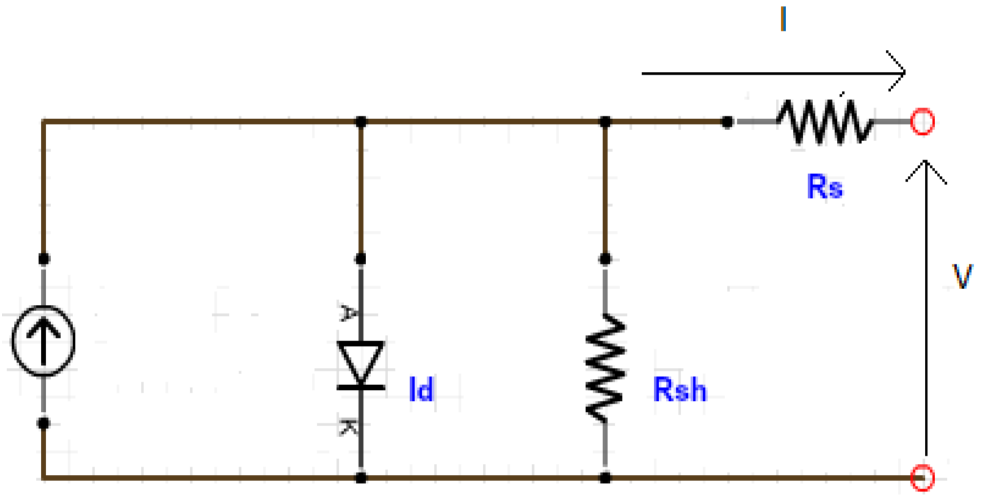

Figure 2: Solar cell and PV device equivalent circuit

The diode of this circuit has certain features. Some equations of current and voltage have been derived from the photovoltaic module. We simulated this circuit equation to obtain the current-voltage and power-voltage features of the PV module discussed by University Colorado., (2008). We ensured to get enough voltage for the car battery by studying the graph derived from our simulations.

For charging the car battery, we have set a charger controller in the car connecting to the solar panel and car battery. As we know, the temperature of the sun is not the same all the time. So the solar panel may produce a different voltage at different times. The voltage also depends on the angle between the sunlight and the solar panel. Therefore, to the charge up the car battery, we need to provide a constant voltage to the battery because the excessive voltage will damage the battery. The charger controller will support in this case, which will control the voltage getting from the panel and provide a constant voltage to the battery. It also prevents the battery from overcharging and blocks reverse current mentioned in BatteryStuff., (1997), Northern., (2016) and Wholesale Solar., (2016).

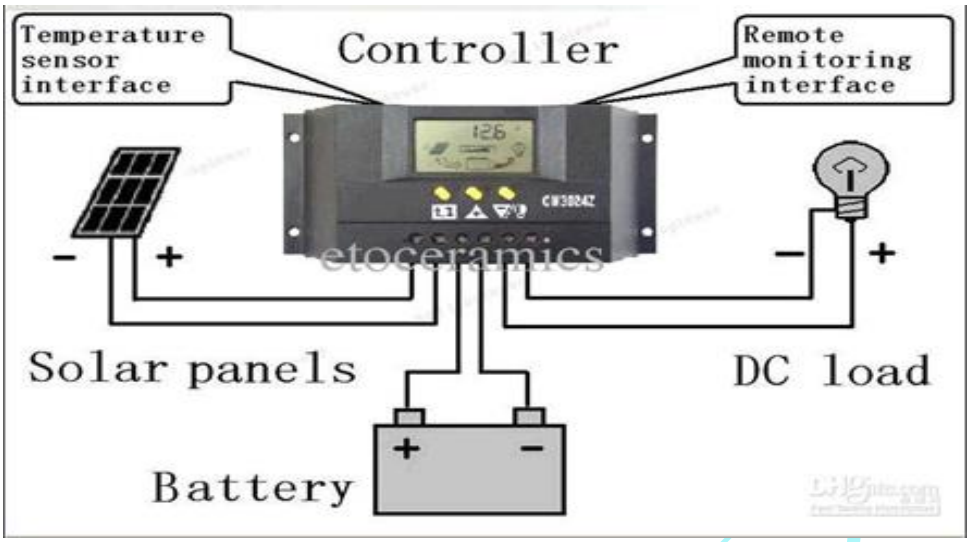

Figure 3: Setup of a charge controller (DHgate, 2004)

The overall system sequence of GSM network is given below:

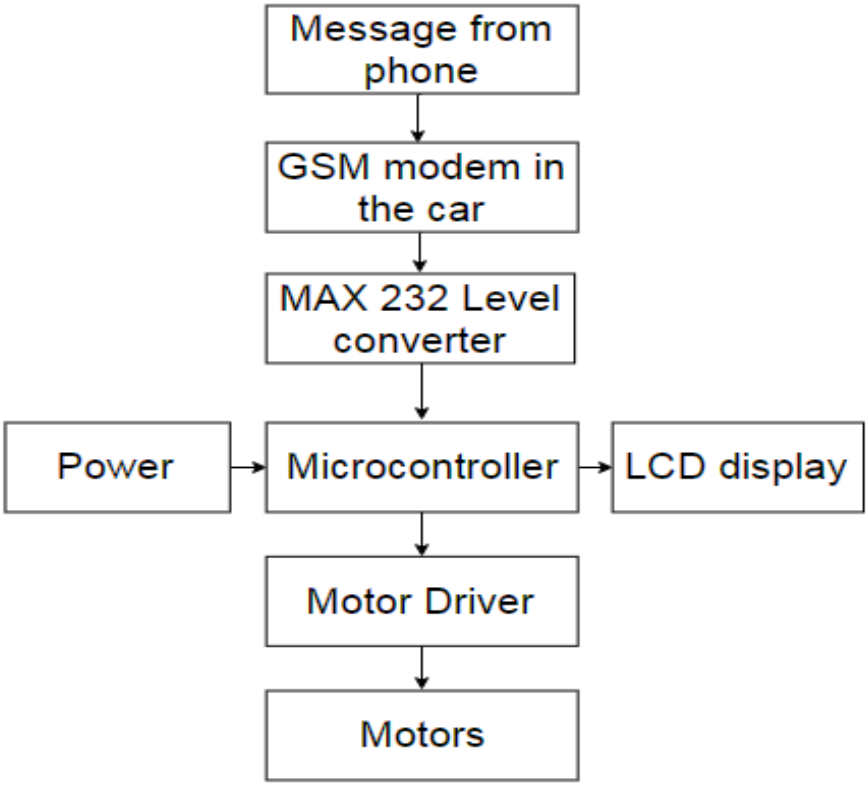

Figure 4: GSM controller based car system flow chart

Figure 4 shows the procedure of charging the car battery through the solar panel, which will power up the whole car and also the GSM system. First of all, when the sunlight falls on the solar panel,

the photovoltaic cell of the panels will convert the sunlight into electrical energy. This energy will charge the car battery connecting through the charge controller. This controller maintains the right amount of current flow through the battery and prevents it from overcharging.

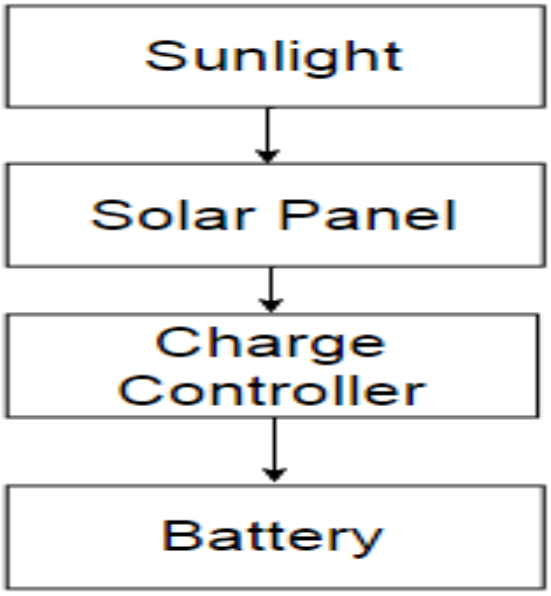

Figure 5: Car battery charging procedure

Figure 5 describes the operation of the GSM controller-based car system. The operator sends an SMS to the GSM module in the car by using a mobile. We can see the same message on LCD. On the off chance that the got message matches with any pre- delineated string, then the vehicle moves subsequently. In conclusion, the engine driver drives the engine, as indicated by the instructions.

The flowchart above shows the procedure of charging the car battery through the solar panel, which will power up the whole car and also the GSM system. (One paragraph was given two times, I removed one)

Simulation of PV panel model

According to the circuit of PV cell voltage, current characteristic can be defined

$$I_d = I_O \left[\exp\left(\frac{V_d}{V_T}\right) - 1\right]$$

$$V_T = \frac{kT}{q} \times nI \times Ncell$$

Using these equations, a PV model in Simulink has been built from which the I-V and P-V characteristic graph can be obtained.

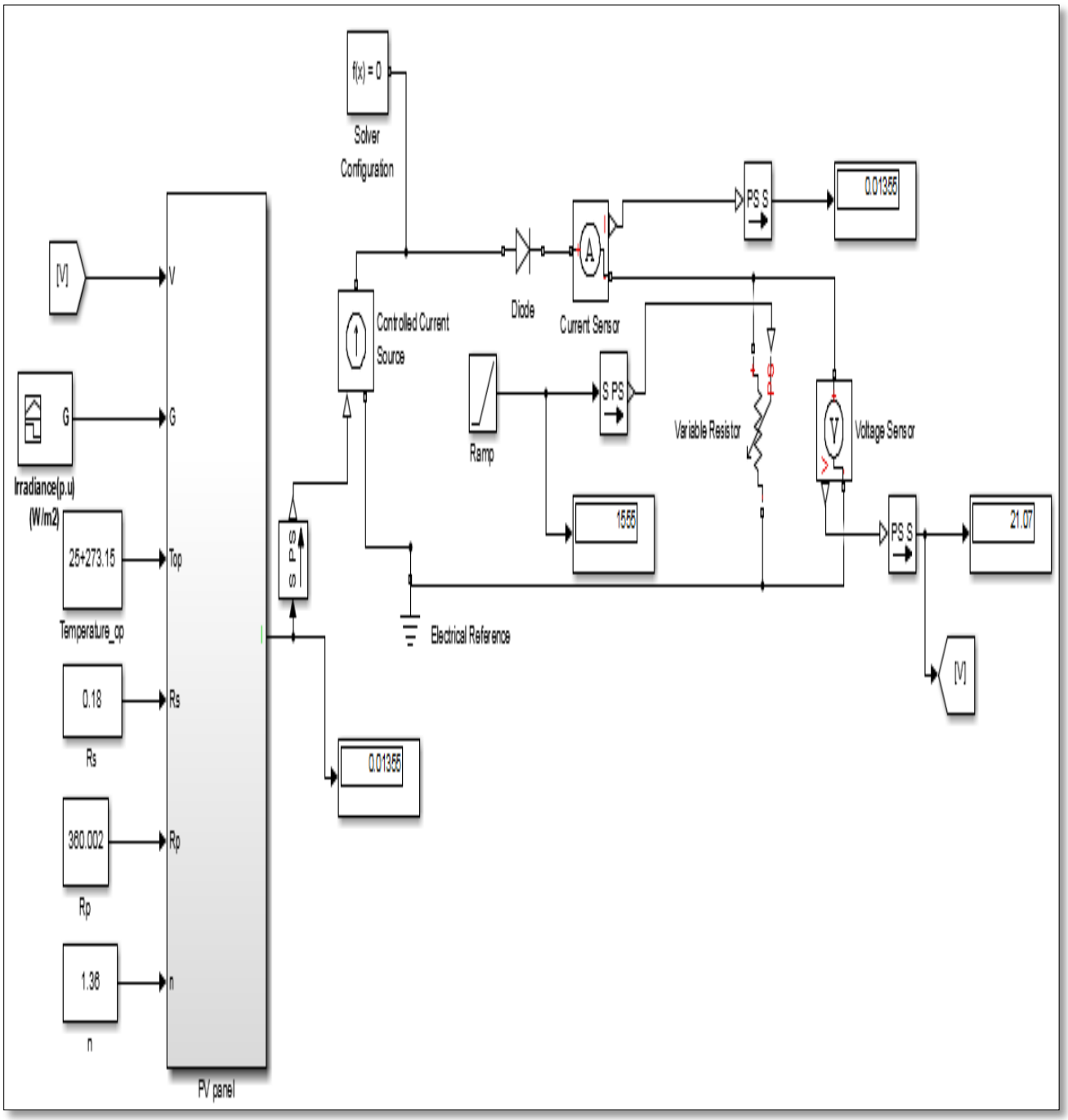

Figure 6: PV model

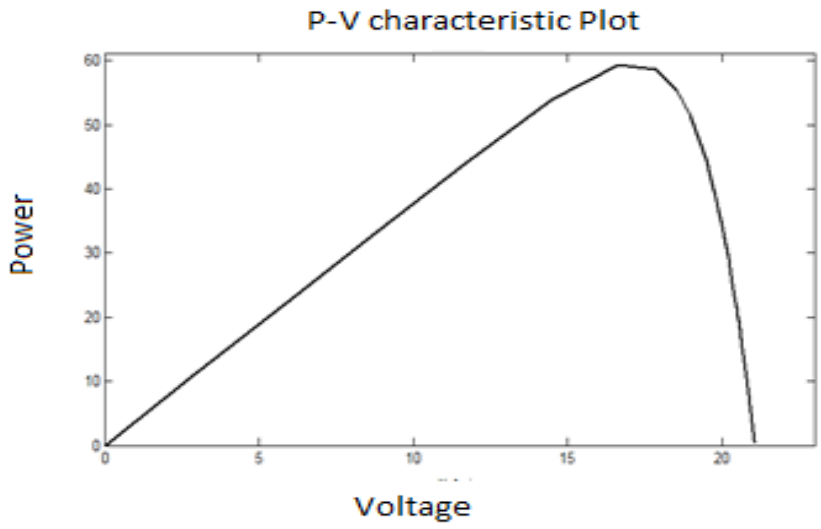

Figure 7: PV characteristic graph

From the power versus voltage characteristic graph, it can be observed that the power of the panel increases with the voltage, but the excessive level of voltage power decreases down to zero. Therefore, the solar panel does not function at excessive voltage.

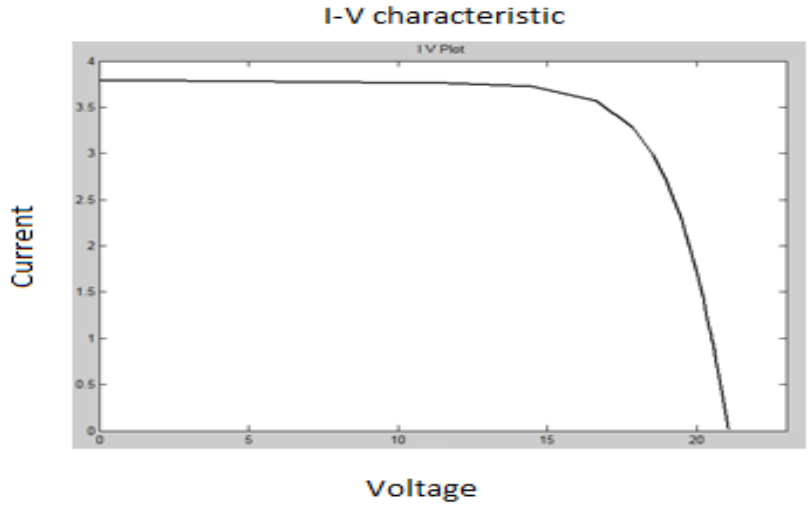

Figure 8: IV characteristic graph

From current vs. voltage characteristics, it can be notified that current is at its highest value at normal voltage. It slightly decreases when the voltage is increasing, and at the excessive level of voltage, the output current becomes zero. To conclude, it can be said that the efficiency of solar is highest when the temperature is normal.

Controlling system

For the controlling system design, Proteus software has been used where the whole system circuit has been drawn and simulated. In the circuit, all the components mentioned have been interfaced with microcontroller and designed as a complete system.

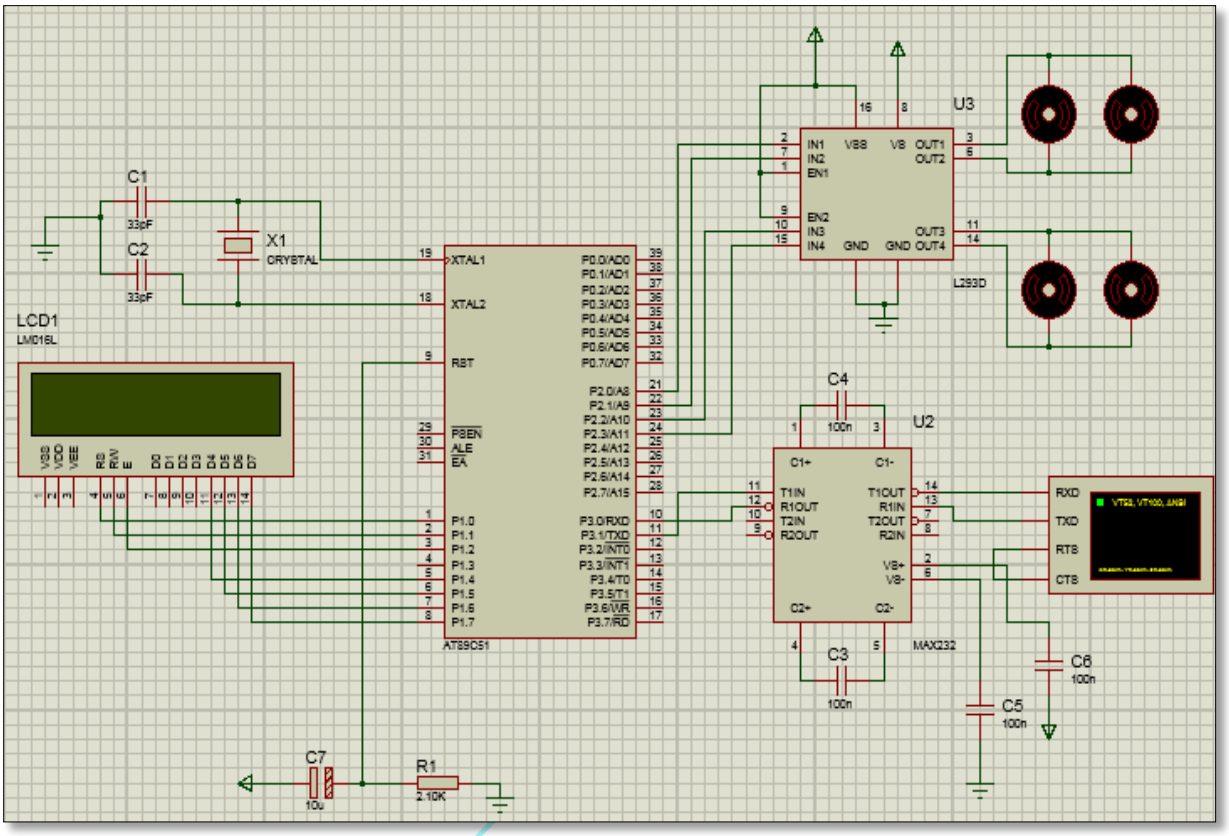

Figure 9: PV mode

To drive the motor, some commands need to be entered into the virtual terminal which is given below:

at

OK

at+cmgf=1

OK

+CMTI: "SM", 3

(when a sms is sent from the modem the GSM modem sends this command to indicate that new sms has arrived, where number 3 indicates the location of the sms)

+CMGR: "REC UNREAD","MD-WAYSMS",,"16/06/02,14:31:48+34" *//("REC UNREAD" shows that the sms is unread, "MD-WAYSMS" directs the mobile number of the sender,"16/06/02,14:31:48+34 shows the time and the date)*

Forward //(instruction SMS)

+CMTI: "SM", 2

at+cmgr=2

+CMGR: "REC UNREAD","MD-WAYSMS",,"16/06/02,14:31:48+34"

Backward

+CMTI: "SM", 1

at+cmgr=1

+CMGR: "REC UNREAD","MD-WAYSMS",,"16/06/02,14:31:48+34"

Left

+CMTI: "SM", 5

at+cmgr=5

+CMGR: "REC UNREAD","MD-WAYSMS",,"16/06/02,14:31:48+34"

Right

+CMTI: "SM", 3

at+cmgr=3

OK

at+cmgd=1

Therefore, the motor will drive according to the message sent to the GSM module. The whole interfacing system in a block diagram can be shown in figure 10:

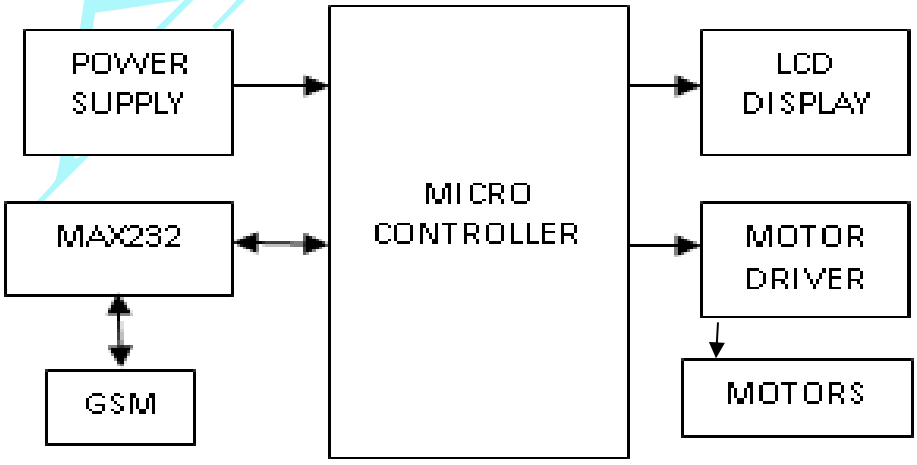

Figure 10: controlling system block diagram.

Conclusion and Future Work

The microcontroller can be programmed in such a way that only certain authorized people can control the car via SMS. If someone outside the approved list sends an SMS to the GSM module in the car, then, the car will not operate, and a message will be issued to the original owner of the vehicle. This will prevent hackers from committing theft in the car. The car can also be attached with infrared sensors and ultra-sonic sensors. The system can be altered in such a way that the vehicle automatically stops if it is about to run into obstacles. This will prevent the car from breaking down due to an accident. In addition to this, a GPS module can be attached to the control system of the vehicle which will enable us to understand the location of the car and have a way to salvage the car if it breaks down for some reason. Currently, the car in this research runs at only one speed; further modifications can be done, so travel at different speeds is possible. Additional work on streamlining the body of the car can be done. More features such as attaching a camera to the car that sends video feedback to the operator can be implemented, which will enable the operator to control the car even when it is out of sight. The solar power system of the car can also be adjusted so that the car runs longer on less amount of sun.

Solar-powered vehicles are the future of the transportation industry. As petroleum-based fuels are going to run out sometime in the future, it is very important to develop our renewable energy-related technologies while we still have time. In addition to this, GSM and GPS systems are being more widely used today than they ever have been before with the ongoing trend of owning the latest smart phones. Thus it makes sense to combine the two different technologies, the task that we have accomplished in this research. The control system of the solar car designed in this paper has managed to overcome the limitations of standard DTMF technologies such as circuit complications, extra components required for filtering and restriction on the number of features. The GSM based solar car works over a long distance, the interference suffered by its network is minimal and its flexible design makes it easy for modifications to be made in the future.

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