Development of a Smart Inverter Controller System

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Abstract:

This paper develops a smart inverter controlling system that uses Semi-Conductor Technology to keep track in real-time of the charging current and battery voltage and ubiquitously, measured data are wirelessly sent to the operator. The device is a universal watt meter based on ACS756b200 current sensor and a voltage divider technique voltage sensor. This device is built around ATMEGA328 based Arduino Uno programmed to estimate the charging current and voltage of any inverter using the ACS756b200 current sensor and voltage sensor. The measured data are displayed on an LCD screen while a report of charging rate is sent by SMS to the operator through an interface with a SIM900 GSM module for communication of the monitored data to the operators. The response rate of the device was estimated to be 1 minute and 24sec in which an SMS reply will be received with the current and voltage measured sent as SMS remotely to the operator.

Keywords —Microcontroller, semi-conductor, current sensor, WiFi Module, Home Automation, photovoltaic, solar charger

I. INTRODUCTION

Electricity is a global essential which its availability and reliability determine in a great measure the economic development of any country. Nearly every facet of human life is dependent on electricity [1][2][3]. Over the years hands have been on deck by all stakeholders to ensure adequate and constant supply of electricity to the citizen as this will ensure them developmental advancement. Nevertheless, all these efforts have yielded little results in Nigeria as a country. The experience of the citizen has been that of erratic and incessant power outages, this has hampered the economic growth of the Nation. Investors are not encouraged to come in to the nation, and industrialization being the wheel of economy progress, has been on the low ebb [5][6].

As a result of the incapability of the power sector to cater for energy demands of the population, attention has been shifted to alternative source of energy. Renewable energy is taking the lead in this act. Renewable energy uses energy sources that are continually replenished by nature element such as sun radiation, unlike the generated energy supply from fossil and water turbine which are insufficient to meet the demands of the citizen. Some examples of renewable energy sources are hydropower, Geothermal energy, wind energy and solar energy. Among these renewable sources of electricity, Photovoltaic and inverter system is now the common place in homes and industries for constant, and reliable source of electricity.

Solar energy or photovoltaic (PV) technology converts sunlight directly into electricity. It has also been used to power small electronics and rural and agricultural applications for about three decades. Solar energy system comprises of three parts: modules that convert sunlight into electricity; inverters that convert that electricity into alternating current so it can be used by most household appliances; and possibly batteries that store excess electricity produced by the system.[7] [8].

II. RELATED WORK

An improved SMS based metering system that automatically keep track records of used

energy by the consumers was worked on by [1]. By this automation, consumers are intimated in real time of the credit worthiness through an SMS via GSM network. With this in place, the stress of travelling to energy providers office to recharge and that of viewing the credit level on the physical metering system is alleviated. A low-cost SMS based monitoring system for distribution transformers was designed and implemented in [9]. This system interface with a software to receives signal for record purpose in the data base while the operator can view the information on the displayed screen. Tests conducted on the system shows that the monitoring node continues to receive periodic status data while intermittent delay experienced is due to congestion in GSM network. A real time data acquisition and control system using GSM based power plant temperature remote technique was proposed in [10]. This is applicable in industries power plants for load lifting every moment of the day. These activities demand real time remote monitoring of the system information since down time as a results of system breakdown will be detrimental to the effective service delivery of the plant sector. It was pointed out that one of the main challenges of a power generating plant is inaccurate failure prediction. This work becomes handy as a system that will monitor, keeps tracks of power generating plant operations remotely for changes in the plant's parameters which can lead to failure or malfunctioning and such is relayed to the operators via GSM network. An SMS enabled system by interfacing Atmega2560 with GSM module for the prepayment energy meter monitoring system for consumers and utility companies was presented in [11] The system consists of a server made of Atmega328P and SIM900 GSM module to provide the utility company accessibility to the meter. The server is interfaced to a PC to create a management and administrative Platform. In [6], a GSM-based SMS power notification system for network operation centers was proposed. For the effective operation of a network operation center (NOC) in times of power outages or restorations, a GSM based SMS notification system which incorporates a shift timetable arrangement was developed. The system was tested and was found to work satisfactorily with an average user satisfaction of 87%.

III. SYSTEM DESIGN

The developed smart inverter control system consists of two main parts: the hardware and software. The hardware consists of five components: Inverter system, SIM900 GSM Module, Inverter Battery, Arduino Uno R3 and ACS756 D.C Current Sensor. Details of the system components is shown in block diagram of Fig 1.

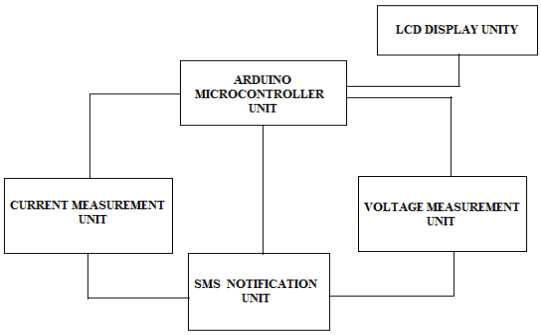

Fig. 1 Block Diagram of the System

The device is a universal watt meter based on ACS756b200 current sensor and a voltage divider-based voltage sensor. It is developed around the ATMEGA328 based Arduino Uno and it has a SIM900 GSM module interfaced with it. The Arduino Uno microcontroller was programmed to estimate the charging current and voltage of inverter using the current and voltage sensor interfaced with it.

It has the facility of receiving an SMS command and reply the sender by sending the charging voltage and current as an SMS to the sender of the command.

A. Hardware Components

1. Inverter

An inverter, is a power electronic device or circuitry that changes direct current (DC) to alternating current (AC) [7][13]. It can be said to be an electronic device that is specially designed to convert a direct current to an alternating current. They are made up of three major units which are, the inverter unit, the battery unit and the charger unit. The charger unit can either be a part of the inverter system thereby converting alternating current back to direct current when there is Mains (not from the inverter) in order to charge the battery unit or the charger unit can be a standalone A.C charger or a solar panel charge which is a solar energy based D.C charger. The battery unit is a very important unit of the inverter system, it has a lot to do with how long the inverter is going to last (although it is load dependent too) so much attention should be given to the unit.

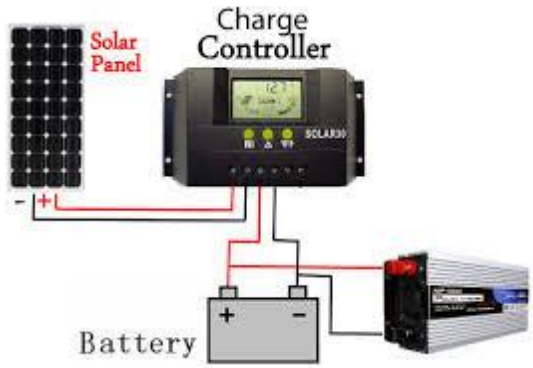

Fig. 2 Inverter set up for both solar panel and A.C charger [7]

2. SIM900 GSM Module

SIM900 GSM/GPRS shield is a GSM modem, and the global standard for mobile communication. Which can be integrated into a great number of IoT projects. The shield can be used in place of a cell phone for operations such as SMS , make or receive phone calls, connecting to internet through GPRS, TCP/IP. It also supports quad-band GSM/GPRS network and is designed based on SIM900 chip with ability to interface with Arduino microcontroller.

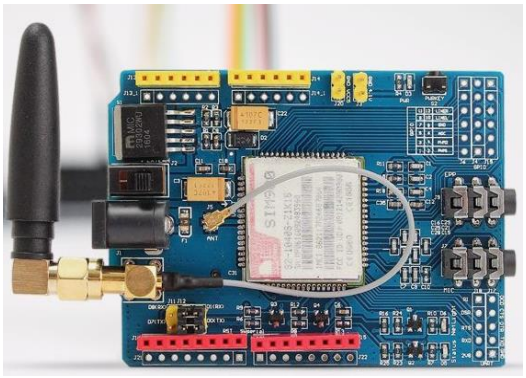

Fig. 3 A Typical SIM900 GSM Module [11]

3. Inverter Battery

Inverter batteries serve as energy storage of inverter which determines how long an inverter can run and when the stored energy gets depleted, the inverter goes off. Inverters run on minimum of 12V battery, some requires 24V, 36V, 48V and so on. The charger unit of an inverter plays a big role in determining the lifespan of the battery of the inverter system, and how well charged an inverter battery is, is totally a determined by the charging unit of the inverter. Generally, batteries have both voltage and current rating, and so also are chargers. Violation of the charging specification by the manufacturer shortens the lifespan of the battery

4. Arduino Uno R3

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; it can be connected to a computer with a USB cable or power it with a AC-to-DC adapter or battery.

Fig. 4 Arduino Uno R3 Board [12]

5. ACS756 D.C Current Sensor

The Allegro ACS756 family of current sensor ICs provides economical and precise solutions for AC or DC current sensing in industrial, automotive, commercial, and communications systems. The device consists of a precision, low-offset linear Hall sensor circuit with a copper conduction path located near the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy at the factory.

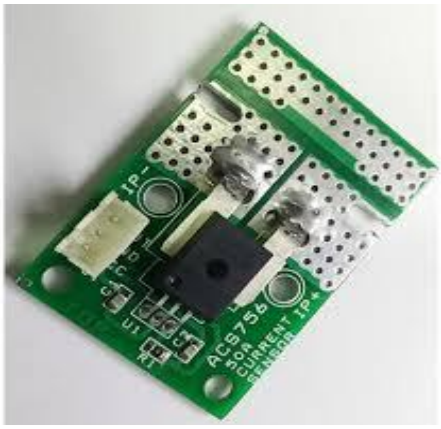

Fig. 5 ACS756 D.C Current Sensor [11]

B. Software Design

In this work, Arduino developer is used to develop program for Arduino controller. The flow chart of the whole system is shown in Fig 6.

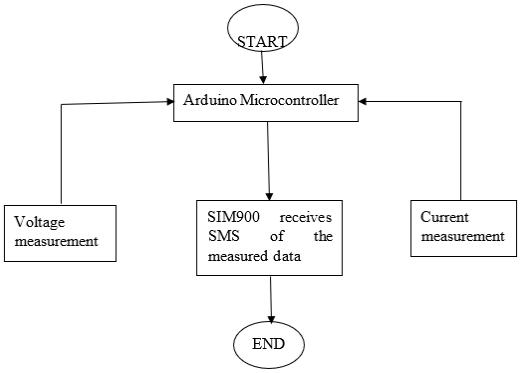

Fig. 6 the flowchart of the device

IV. RESULTS

The input end of the device is connected to the battery to be charged and the output end connected to the charger so that the current to be measured flows through the sensor or a shunt. The device was then powered ON and left for a minimum period of about 15 seconds for the Arduino microcontroller to get ready the GSM module. An SMS COMMAND was sent to the device. After about 1 minute and 24, an SMS reply was received with the current and voltage measured sent as SMS. Fig 7 shows the meter reading and the SMS alert received.

Fig. 7 Measured current and voltage as displayed on the LCD

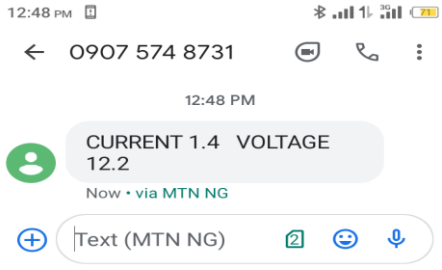

Fig. 8 SMS Received containing the voltage and current measured

IV. CONCLUSION

This paper presents the development of a smart inverter controlling system for monitoring and controlling of inverter system around microcontroller system together with GSM module. With the developed system, the charging current and the battery voltage of the inverter system can be monitored remotely through a command via SMS. Received information about the battery voltage and charging current can be used to control the operation of the inverter remotely. The developed system eliminates the problem of physical contact in detecting inverter condition and timing on and off of the same.

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