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Smart Digital Inverter

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Abstract: -- **In present days, power consumption is increasing than power production and there will be regular power interruption from the suppliers due to lack of availability of power. Hence, use of inverters is inevitable. There are plenty of inverters that are available in the market from many manufacturers. All the inverters have limited control indicators within it. This paper explains the need of digital inverters which displays the details like Battery backup time, actual time, Voltage level in percentage and deep sleep mode indicator. As the population of India is drastically increasing, simultaneously the electronic technology is tremendously upgrading which expects more power supply. Due to lack of power sources/ power plant, one has to make use of the power effectively. The smart inverter discussed in this paper also monitors the power consumed in a day automatically and informs the owner with the help of Internet of Things (IOT). Actuator and Sensors reading are processed and driven by Arduino Mega 2560 Microcontroller used in the smart inverter.**

Keywords: -- **Digital Inverter, Internet of Things (IOT), cloud storage, Real Time Clock (RTC), Arduino Mega Microcontroller**

I. INTRODUCTION

An Inverter is an essential electronic device which is used to supply power in the case of power failure. An inverter converts Direct current (DC) into Alternating current (AC). The DC power is produced by the batteries and solar panels. During power failure these stored charges are used which provides electric power for household devices which will consume less power. The generated power can be used for many day to day activities. For the devices, which consume more power, large capacity inverters or AC generators are used. To maintain constant power, inverter boosts the DC voltage, maintaining lower AC current. A photovoltaic (PV) converter or solar inverter converts the Direct current of a PV solar energy to alternating current of some particular frequency (say 50 Hz) that can be fed into electrical grid used for commercial purpose. The inverters are classified as: stand alone inverters, Grid Tie inverters, Battery backup inverters.

1.1 Stand alone inverters: used in isolated system which draws DC supply from the battery by array of photovoltaic cells arrays. Many stand-alone inverters also incorporate integral battery charges to replenish the battery from an alternating current source, when available. Normally these do not interface in any way with the utility grid, and as such, are not required to have anti-islanding protection [5].

1.2 Grid-tie inverters: are the one which match phase with a utility-supplied sine wave. For safety reasons, Grid-tie inverters are designed to shut down automatically upon loss of utility supply. They do not provide backup power during utility outages [5].

1.3 Battery backup inverters: are special inverters which are designed to draw energy from a battery, manage the battery charge via an onboard charger, and export excess energy to the utility grid. These inverters are capable of supplying AC energy to selected loads during a utility outage, and are required to have anti-islanding protection [5]

Without battery backup, due to improper shutdown many electronic systems may suffer from hardware and software failure. Nowadays many persons are getting addicted to social media, watching TV and also they are power dependent for various means. In the case of power failure, for the activities not to get stopped/ postponed/ disturbed, smart inverters are preferred. Normal Inverters which are available in the market will have two indicators. First one indicates main power supply presence (Normal mode), second one indicates the power supply by UPS (UPS mode). A special feature of the designed inverters is it has RTC which provides the information with respect to interruption of supply power.

Ardunio microcontroller platform is preferred as it supports open source hardware and open source software platforms. It is a tiny computer with inextensible hardware, completely works stand alone,

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interacts with other devices. Code/ program can be easily programmed in Arduino. Arduino has several versions like Arduino Nano, Arduino UNO, Arduino MEGA 2560, Arduino Yun. One of the basic board where the project is more cost effective as well as programming is easy and the cost of the Arduino UNO board is more than that of Arduino MEGA 2560, which also acts like a stand-alone PC. Both microcontrollers supports cross platform. But UNO has limited analog pins, PWM pins, digital pins when compared to Arduino MEGA microcontroller. Hence Arduino MEGA 2560 is preferred and has been adopted.

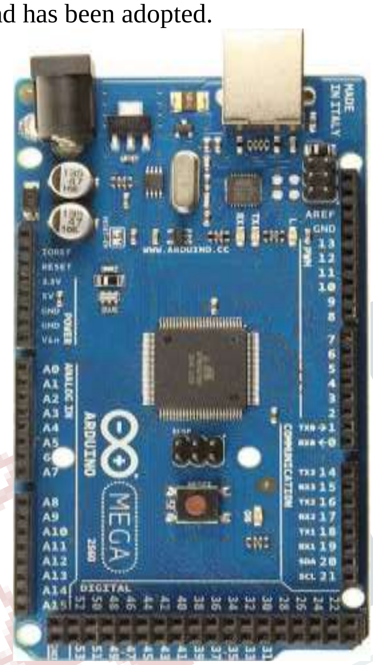

Figure 1 Arduino mega Microcontroller

Atmega328 is used as a memory element IC chip and is used for progamming the controller. Voltage given to it is of the order of +6V to +11V. The DC available voltage is +5V and +3.3V. The maximum safe current that can be supplied by the microcontroller is 500mA. To achieve enough RPM from the DC motor, 500mA current is not enough, so make use of external circuitry like LM293 which acts as motor driver by supplying a larger curreny which is capable of driving small DC motors. The microcontroller can be powered up by USB power or by external DC power supply. Reset pin is internally connected to pin2 of the microcontroller and for testing purpose pin13 can be used.

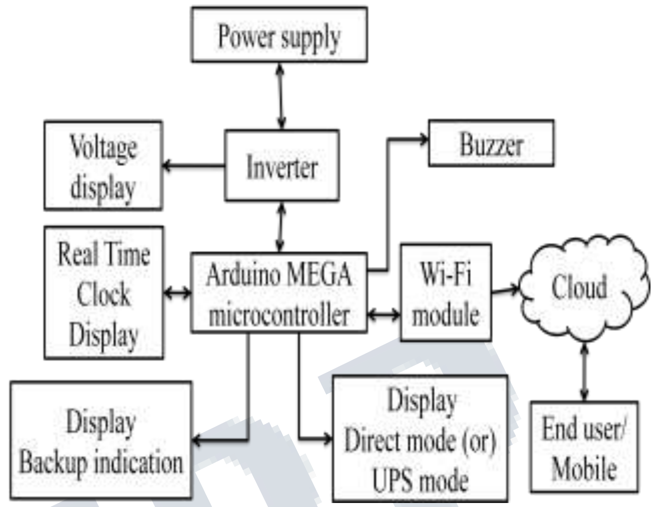

Figure 2 Block Diagram of Smart Inverter

The external power is given initially to charge the UPS/ inverter. Corresponding voltage level is displayed on the display. All the activities are recorded by the Arduino microcontroller based on RTC timings. In case of power failure, the power is supplied by the smart inverter. The time elapsed in backing up the power is stored in the cloud and the same is passed to the end user and is displayed on the display unit of the inverter. When the voltage level reaches 6%, buzzer is turned ON, it is the indication that the user must turn OFF the entire electronic appliances which are being driven by UPS power. When the voltage level reaches 5%, UPS undergoes into deep sleep mode. In this mode UPS doesn't provide any backup power, thereby it avoids complete battery dry out.

The inverters that are available in the market are not cost effective and also it doesn't indicate battery backup time. This paper describes the mechanism involved in displaying battery backup time as well as voltage level in terms of percentage, when the Inverter is operating in UPS mode. Generally when the system is operating in UPS mode, care must be taken by the user not to power up the devices which consumes more power.

II. RELATED WORK

The development of common set of the function is complete; very little date, has addressed the impact these common functions will have on grid performance at the distribution level. EPRI has established a method for determining the PV hosting capacity of distribution feeders by making use of model analysis and simulation [1].

The analysis in this paper focuses on the impact of 3 different smart inverter functions [1] - power factor, volt-var, volt-watt- on 4 feeders in the Northeastern United States. Four feeders were chosen with varying characteristics, and the three different functions were applied to determine the possible increase in hosting capacity utilizing these smart inverter functions [2].

RFID-powered environment supporting new pervasive healthcare services could be a Smart-House equipped with a distributed network of readers, enforcing a uniform and robust coverage [2] in the most relevant spaces, and a heterogeneous set of battery-less tags with sensing capability. Readers may interact, for instance, through Wi-Fi or Bluetooth links, with a concentrator node enables the interconnection with external services that take care of data processing of assistance procedures activation. The interactions between people and their habitat bring precious information on behavioral parameters concerning the activity rate during the different phases of the day and of the night. The environment itself may have the role of continuous “sampling” the state of a user by means of specific and nonspecific devices [4] at the purpose to support diagnostics and even to activate remote alarms in case of precursors of anomalous events. By processing physical data, mostly backscattered signals, from previously reviewed sensor-oriented RFID devices, the specific patterns of daily actions may be recognized, e.g., cooking, eating, bathing, taking medicine and sleeping, without altering the everyday life-style of the person. Three examples of in-house human behavior detection and classification are given below, involving only ambient tags, only wearable tags and a combination of both the kinds [10] [11].

From thorough review of related work and published literature, researchers have done rigorous work on IOT and power line communication (PLC). It is observed from the careful study of reported work that in the real world, PLC and IOT based meter can improve the efficiency of power system and can help to analyze the unnecessary power loss in different areas. The paper proposed by Merola P, Ianniello G, Landi C on ARM-based energy management system which uses smart meter and Web server gave us the basic idea for IoT based energy meter common set of functions that can provide such capability. The present system only provides feedback to the customer at the end of the month that how much power is consumed in the form of bill. The consumer has no way to track their energy usage on immediate basis. Hence the consumers are growing exponentially fast and load on power providing divisions is rapidly rising. In existing system meter tampering can be done easily which causes huge loss for the government, and it’s one of the major drawback for an energy crisis.[5] [9]

Smart inverters are emerging with increasing renewable energy and smart grid development. While the recent work reviewed mostly focuses on defining standardized control functionalities and smart grid communication protocols, a holistic approach in this paper and propose a Holon-type smart inverter concept, which features autonomous, adaptive, cooperative and plug-and-play functions is explained. Power electronics inherently drives self-awareness. These features can be favorable in a complex environment with more and more small-scale power electronic based devices, and can reduce system communication requirements and control during faulty and normal operations. To collectively achieve a common goal, multiple distributed inverters are required. With Industry 4.0, with which it is expected that smart inverters will have high demand at conversion and connection levels in smart manufacturing environment [6].

III. IMPLEMENTATION DESIGN

3.1 Real Time Clock (RTC)

An RTC is a computer clock which helps to monitor the current time. Even in the absence of the primary power, the RTC can display the time as it is powered up by lithium battery. Due to the advancement in super capacitor technology, the batteries can be recharged. Hence, it is preferred. Most RTC make use of crystal clock oscillator to generate clock pulses in turn generating time. Some RTC makes use of power line frequency of the order of 32.768 KHz (Quartz clock frequency). Some of the microcontrollers such as Arduino, Raspberry Pi system can run without Real Time Clock (RTC)

3.2 Internet of Things (IOT)

IOT is an upcoming technology where things are connected to internet. IOT is an intelligent technology which includes interfacing sensors and actuators with the product. IOT is a combination of

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ubiquitous network, intelligent sensing network, cloud computing. A Ubiquitous network includes GPS, RFID WLAN, 4G/ 3G, Zigbee, Bluetooth and many other wireless technologies. For the system to operate smoothly and error free, good Internet connection is preferred.

3.3 Display devices

Display device always refers to output device; it represents the information in visual. Most popular displays are LCD, LED. For displaying voltages, backup time. When compared to LED displays, LCD displays are available at low cost. Each and every character can be displayed accurately. LCDs are used in computer monitors, aircraft cockpit displays etc. Programming LCD displays are easy when compared to that of LED displays. LCD displays are available in wide variety of sizes; (16*1), (16*2), (16*4) and so on. The available inverter has two built-in LEDs which indicates, whether main power is present or absent and the mode of operation: Inverter mode or Normal mode.

3.4 Flowchart

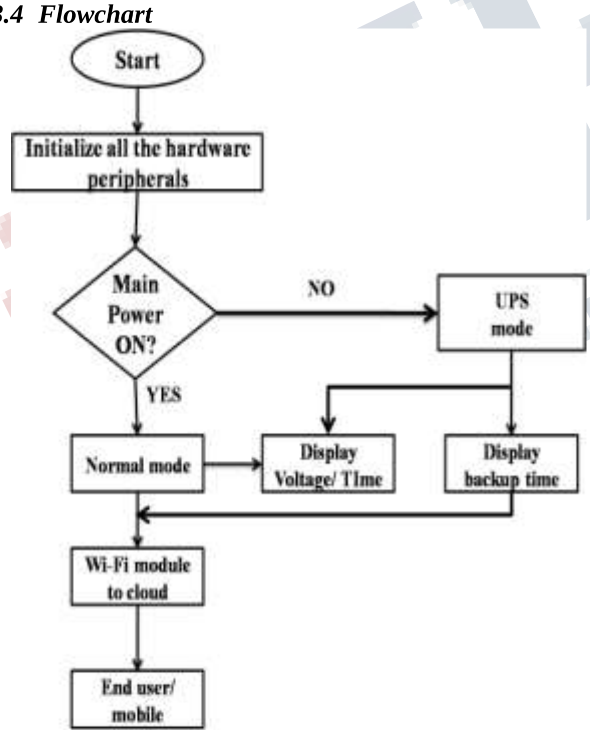

Figure 3 Flowchart determining inverter running in Normal mode or UPS mode

Initialize all the hardware peripherals (Buzzer sensor, controller etc), Buzzer sensor is interfaced with digital pins of Arduino microcontroller. Continuous monitoring of voltage level helps the user to use the electricity in efficient manner. The controller always monitors for the main power and checks whether it is present or not, when the main power exists, the UPS operates in Normal mode and is displayed, corresponding voltage level is displayed and when the main power is absent, corresponding discharging voltage is displayed along with backup time, and the same is stored in cloud via Wi-Fi module, and the same data is shared with the end user and is pictorially explained in Fig. 3

3.5 Buzzer

A Buzzer (Beeper) is an electromechanical, mechanical or piezo-electric device used for audio signaling. Some of the uses of Buzzer are: it is used in alarm devices, timers, mouse click and key response. In this project, Buzzer is activated when the voltage level reading reaches 6%.

IV. SIMULATION RESULTS

The Battery backup time is estimated and the readings are fetched from the Arduino microcontroller's Serial monitor platform. The data is recorded as a .txt file and is computed in MATLAB for plotting the graph.

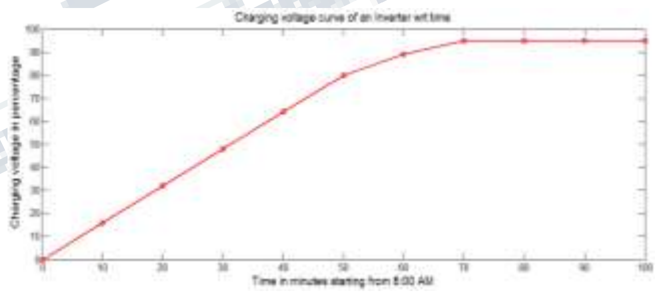

Figure 4 Graph of Voltage Charging curve of an Inverter in percentage v/s time in minutes

Fig 4 shows the Voltage charging curve that was extracted when the UPS starts charging at 8:00 AM. After completion of charging, microcontroller updates the data onto the cloud, and the same is shared with the owner of the house or with the end user.

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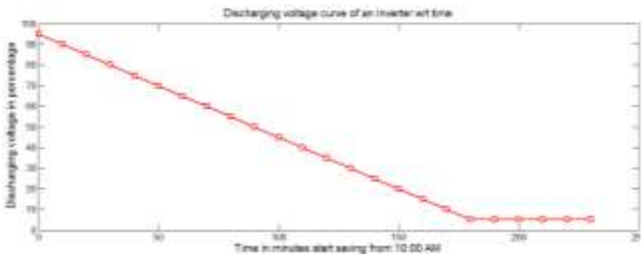

Figure 5 Graph of Voltage discharging curve of an Inverter in percentage v/s time in minutes

Fig 5 shows the Voltage Discharging curve that was extracted when the UPS starts discharging at 10:00 AM during power failure. Then it enters into deep sleep mode once the voltage level reaches 5%. After successful discharging of the voltage, microcontroller updates the data onto the cloud, and the same is shared with the owner of the house or with the end user. For better battery backup, one has to design a system which has:

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Inverter discharging time > Inverter Charging time

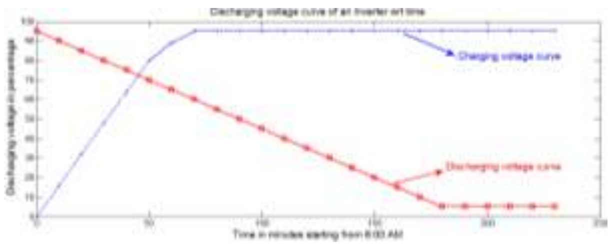

Figure 6 Graph of Voltage Charging and Discharging curve of an Inverter in percentage v/s time in minutes

The Fig 6 shows the Voltage charging and discharging curve that was extracted when the UPS starts charging at 8:00 AM and starts discharging from 10:00 AM. After completion of charging and discharging, microcontroller updates the data onto the cloud, and the same is shared with the owner of the house or with the end user. Usually charging time is maintained less when compared to Discharging time. For safety purpose and to increase battery life, maximum percentage the Inverter can get charged is 98%. Similarly the minimum percentage that the Inverter can get discharged is up to 5% to avoid complete drain off in the voltage potential.

V. CONCLUSION

In this work, it has been concluded that the Inverter with UPS having display system with respect to the power consumption, voltage level indicators in percentage, deep sleep mode indicator and Buzzer alarm that are more suitable than the conventional inverter which are not cost effective and will not be preferred in upcoming days.

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