

Grid-Tie Inverter with Smart Power Monitoring through IOT using Cloud Data Storage

C. Dinesh kumar¹, D. Lohitha²

¹Student, VIT University, Department of Embedded System Technology, Vellore, Tamil Nadu 632014, India

²Student, VIT University, Department of Embedded System Technology, Vellore, Tamil Nadu 632014, India

Abstract: Today the world is on the verge of Energy Crisis and also the Global Warming issue. As a result we feel a strong need of Energy Monitoring for Grid-Tie Inverter. Energy Monitoring means nothing but a plan to Monitor power Parameters of Grid-Tie Inverter to Customer by Hour wise, Day wise and Month wise reports through web page using TCP/IP . ROI(Return Of Investment) is the one thing customer want to know after how many years he will get profit of Grid-Tie Inverter after Installation. Grid-Tie Inverter Power parameters are monitored through remote monitoring using GPRS as Gateway.

Keywords: ROI, GPRS, Grid-Tie Inverter, TCP/IP.

1. Introduction

Electricity is the most basic need of everyone in this modern world. Energy consumption graph is increasing day by day where as the resources of energy are diminishing parallel. Usage of power is growing drastically paving the way for energy efficient technologies and digging for renewable energy sources. Since prevention is better than cure awareness of energy consumption should be brought into every place before resources get extinguished. Industrial users consume about 37 percent of the total energy, personal and commercial transportation consumes 20 percent whereas residential appliances consume 11 percent; and commercial uses amount to 5 percent of the total energy and remaining 27 percent of the world's energy is lost in energy transmission and generation.

Emerging modernization in market is demanding for highly specialized smart wireless technologies which are able to provide a wide range of comfort and robustness to the user with low investment and low power and area occupancy. In boosting up that currently IOT is a trending technology in this modernized market with its availability of Internet over world wide. The main advantage of this is we can send information to any distant areas .we are using GPRS Module which consumes very low power. it can be attached to any existing power modules such as batteries, adapters, Microcontroller discovery boards and so on. The features of the technology raising up the new ideas to come up with a new module so that with less power that is even it can run with a single coin cell battery, an end user can fulfill the applications. The designed system will help in reducing the energy wastage by continuously monitoring.

Among all the microcontrollers, STM is selected because of the features it has like simplicity, STM32 cube code generator, comfortable start-up and peripheral libraries to implement IoT. The monitored values from Grid-Tie Inverter can be continuously stored and updated in a cloud database. We can Visualize Monitoring parameters through Designed web page.

1.1 Internet of Things

IoT is an emerging technology that enables the physical devices to communicate with each other. IoT enables the physical devices with embedded electronics to take decisions themselves and to act autonomously. Smart devices are the major foundation for IoT. IoT provides the facility to control objects remotely. IoT enables the integration of physical world into computer based systems and thereby improving the efficiency, accuracy as well as imparting economic benefits. It has been predicted by experts that there will be 50 million devices connected to internet by 2020. The development in the field of wireless sensors, MEMS devices and internet leads to the development of IoT. The development in the field of cloud computing also added pace in the growth of IoT.

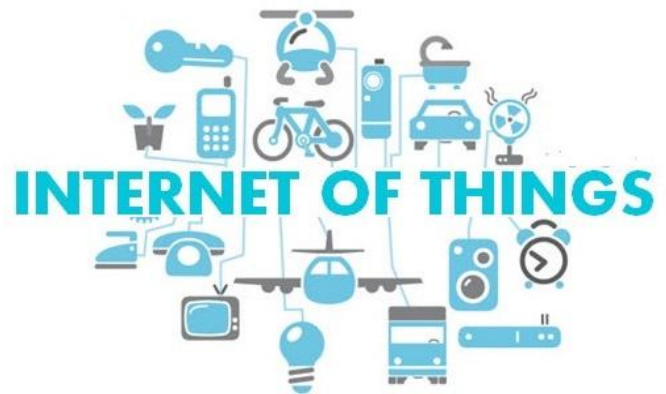


Figure 1: Internet Of Things

1.2. Objective

The aim of this paper is to use Internet of Things technology by using GPRS Modem as wireless medium for transmission to transfer the performance details of an Grid-Tie Inverter which in parallel displayed on the LCD screen of an Grid-Tie Inverter and the details is displayed through an Designed Webpage as an interface to SQL Server Database users can access Monitoring parameters by any browser. This is established by referring to different properties of wireless technologies. In possibilities and restrictions in connecting to the Internet can be displayed with an indication of net light

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LED in GPRS Module. Besides the power consideration of the GPRS it provides the distance information.

2. Description

2.1 Hardware Description

2.1.1 Grid-Tie Inverter

Grid-Tie Inverter is one type PV Inverters where solar energy is consumed to give us AC power supply as well as to Grid. The main operation of Grid-Tie Inverter is to get the solar power through PV Array and it is termed as input DC supply .Grid-Tie Inverter consists of DC-DC converter to get constant power. For converting DC power to AC power we need DC-AC converter .and then finally we place filters to get complete Synchronization output and control session to pass AC power Supply to AC Load as well as for Grid.

2.1.2 STM32F0308RX Microcontroller

The STM32F0308RXT6 microcontroller is of ARM cortex M0 32-bit Entry level core category. It can be operated at a frequency upto 48MHz. Its core is featured with floating point unit (FPU) single precision which can support all ARM Single precision data processing instructions and data types. It can also enhance application security by implementing DSP instructions and a memory protection unit (MPU). The STM32F0308RXT6 is incorporated with 256KB of flash memory and 96KB of SRAM, enhanced range of I/O and peripherals. It features the applications with its low power consumption factor.

The above features put on STM32F0308RXT6 micro controller suitable to the far scope of applications like medical equipments, printers, scanners, video intercom, PLC, Inverters and circuit breakers etc.... Because of all these features and characteristics the Stm32F0308RXT6 micro controller provides users a flexible and convenient way to give up with new ideas and choice to choose various combinations of power consumption, features and performance.

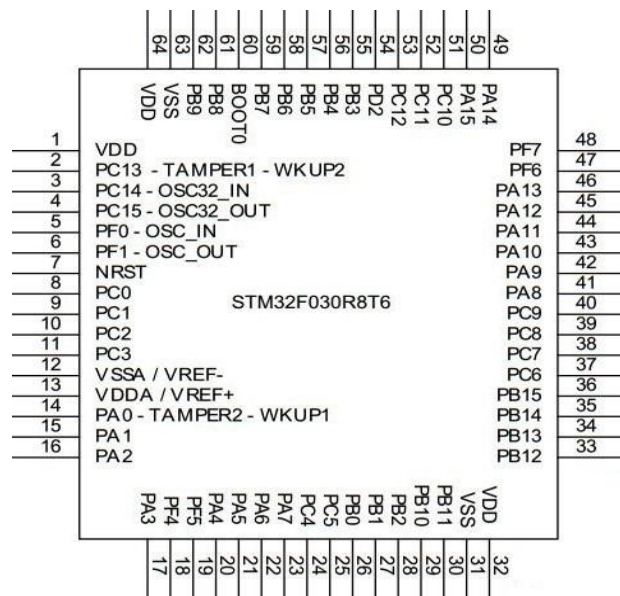


Figure 2: STM32F0308RXT6 Microcontroller Pin Diagram

2.1.3 SIM800C GPRS Module

SIM800C Module consists of SIM800C which is a complete Quad-band GSM/GPRS with 42 SMT pin chip. It has very tiny size of 17.6*15.7*2.3mm.we can fit easily because it can smoothly fit into slim.SIM800C is very useful for compact demands of customers. Quad-band refers to 850/900/1800/1900MHZ.SIM800C is available with very less weight of 1.3 grams.

SIM800C is working with very low power consumption ranging from 3.4V to 4.4V.SIM800C has operating Temperature ranging from -40 degrees to 85 degrees. This helps to use in many applications. Some of the key features to use SIM800C for GPRS Data are It has GPRS of Class 12 with maximum speed of 85.6 kbps by adding both uplink/downlink. we will use TCP/IP Communication between SIM800C and SQL server Database.TCP is connection oriented protocol. The data packets sent using TCP are received in the same order. Since the reliability of the data transfer overshadows the efficiency at which the data is sent TCP is an ideal choice.



Figure 3: SIM800C Module

2.1.4 RS-485 Communication

RS-485 is also to be known as TIA-485(-A),EIA-485 is maintained with certain standards for electrical characteristics of drivers and receivers which is to be used in serial communication .By using RS-485 we can maintain electrical balance and it can also support multipoint systems. Telecommunications Industry Association and Electronic Industries Alliance (TIA/EIA) both have published RS-485 standard. In Electrically noisy environment digital communication is carried by RS-485 over long distances because of Higher efficiency over network.

RS-485 is capable to provide local networks as well as multi drop communication links with inexpensive. we can achieve data rates upto 10 Mbit/sec and communication possible upto 1,200 m(4000 ft).Linear bus topology is possible in RS-485 standard when we are using 2-wire. we can operate RS-485 in Half-Duplex as well as Full-Duplex.

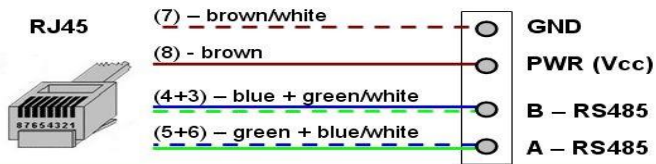


Figure 4: RS-485 Communication through RJ-45

2.2 Software Description

2.2.1 STM32 CubeMX

STM32CubeMX is an integral of ST micro electronics STM32Cube in order to provide flexibility to the users in the code generation with low cost and efforts. This is a software configuration tool which allows the code initialization in C by the assistance of the graphical view of the selected micro controller.

First we have to select the appropriate micro controller which is best suited for our application. Then we have an excellent user interface in order to delete the configurations that are assigned to the pins of the micro controller with the pinout option. Once the pinout procedure is carried out according to the need we can assign the functionality to the pins available on the micro controller. There exists a flexible option of selecting the peripherals like SPI, I2c, USART, GPIO and so on. In this project we are using STM32F0308RX Microcontroller. STM32CubeMX is used for generating corresponding Initialization C code for RTC, LEDs and UARTs Functioning. For this we select LED pins and UART pins. We can change pin names easily.

2.2.2 Keil MDK V5

Among the packages of Keil micro version we have chosen MDK v5 because it is compatible with ST-LINK of STM for debugging. Microcontroller chosen for our project is ARM CORTEX M0. Which suits with MDK version five. In Keil micro version software development looks same.

Steps in Software Development cycle :-

- 1) In the first step we are supposed to create the project, select the target chip from the device database and configure the tool settings correctly.
- 2) We can create source files either in C/C++ or Assembly language.
- 3) Then build the application using project manager.
- 4) If any errors we will get means solve the errors in source files.
- 5) After completing above four steps we can test the linked application.

2.2.3 Visual Studio

Visual studio is one of the best software to develop web page designing. We are designing ASPX web pages in our own server to monitor parameters of Grid-Tie inverter. We are maintaining an SQL database to store data what we get from Grid-Tie Inverter. We are storing all the data in hour wise, Day wise and Month wise reports to easily connect with ASPX web pages for monitoring. Visual studio we have used is 2015 version of Visual studio. The web page what we have designed is compatible with PC, mobile, Tablet as well as Mac. We can use any browser to Monitor the data in the server IP along with particular port number.

2.2.4 Hercules SETUP Utility

Hercules SETUP utility software is used as a serial port terminal for both RS-485 Terminal as well as for RS-232 terminal. It is also used for TCP/IP Client server terminal and UDP/IP terminal. This software is developed by Hercules for their internal use. Later on it is given as Freeware for Serial/Ethernet converter, RS-232/USB converter and RS-485/USB converter. It's very easy to use simple TCP with TEA support. We can work with Implementation of serial port terminal in working with the virtual serial ports. By using this software we can check and control all serial lines (CTS, RTS, DTR, DSR, RI, CD).

3. Block Diagram

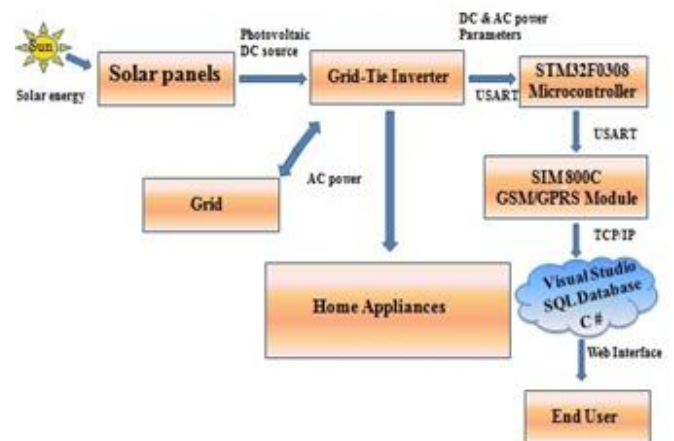


Figure 4: Block Diagram of Proposed System

We will discuss step by step procedure of our project:-

- 1) At the start the available solar energy has to be trapped by use of solar panels and connect Photovoltaic DC power to Grid-Tie Inverter.
- 2) The obtained DC is converted to AC and AC power is then utilized by the Home Appliances and extra generated electricity is given to grid.
- 3) STM32F0 series Microcontroller which is connected to Grid-Tie Inverter is responsible for real time data transmission through RS-485 Communication then data is processed and sent to the SIM800C GSM/GPRS Modem through UART Serial transmission.
- 4) The collected performance parameters are sent to SQL server using TCP/IP of SIM 800C GSM/GPRS Modem then we create a webpage which is useful to Monitor the parameters anywhere to User.
- 5) User can be able to access server for Monitoring parameters with given authentication in any browser.

4. Results

4.1 SIM800C

We are sending the Power parameters by means of SIM800C GPRS Module to SQL server Database by using Hercules SETUP Utility Software for Programming SIM800C TCP/IP Client-Server communication. Later on we will do same in microcontroller to run TCP/IP using UART serial communication.



Figure 5: TCP/IP using in SIM800C with Hercules SETUP Utility

4.2 SQL Cloud Database

Using Visual studio we created a SQL Database in our own server by assigning a port to it to store monitoring parameters in tabular format. we are cable of storing Parameters of panel power, Utility power and Inverter power .How much power our Grid-Tie Inverter is generated by panel, How much power we are getting from Utility and How much power is totally Generated by our Grid-Tie Inverter. we are forming different tables for storing hour wise report, Month wise report as well as Month wise report.

S No	Hour	Panel Energy(KW)	Utility Energy(KW)	Inverter Energy(KW)
1	00.00	00000.00000	00000.14800	00000.14800
2	01.00	00000.00000	00000.14300	00000.14300
3	02.00	00000.00000	00000.15700	00000.15700
4	03.00	00000.00000	00000.14100	00000.14100
5	04.00	00000.00000	00000.15000	00000.15000
6	05.00	00000.00000	00000.16000	00000.16000
7	06.00	00000.04000	00000.15400	00000.19400
8	07.00	00000.06000	00000.13300	00000.19300
9	08.00	00000.12000	00000.12900	00000.24000

Figure 6: Hour wise report of Grid-Tie Inverter

S No	Date	Panel Energy(Kwh)	Utility Energy(Kwh)	Inverter Energy(Kwh)
1	01/03/2017	00019.154	00029.648	00047.597
2	02/03/2017	00018.648	00028.073	00047.79
3	03/03/2017	00022.540	00027.057	00047.395
4	04/03/2017	00021.057	00028.941	00047.997
5	05/03/2017	00008.799	00012.538	00026.783
6	06/03/2017	00021.691	00037.712	00046.721
7	07/03/2017	00017.732	00029.589	00049.736
8	08/03/2017	00012.538	00007.799	00025.783
9	09/03/2017	00024.589	00017.732	00044.736

Figure 7: Day wise report of Grid-Tie Inverter

S No	Month	Panel Energy(Kwh)	Utility Energy(Kwh)	Inverter Energy(Kwh)
1	Mar	00145.004	00350.943	00213.900

Figure 8: Month wise report of Grid-Tie Inverter

4.3 Webpage

We have designed webpage for user interface to customer of Grid-Tie Inverter with some authentication by username as well as password.

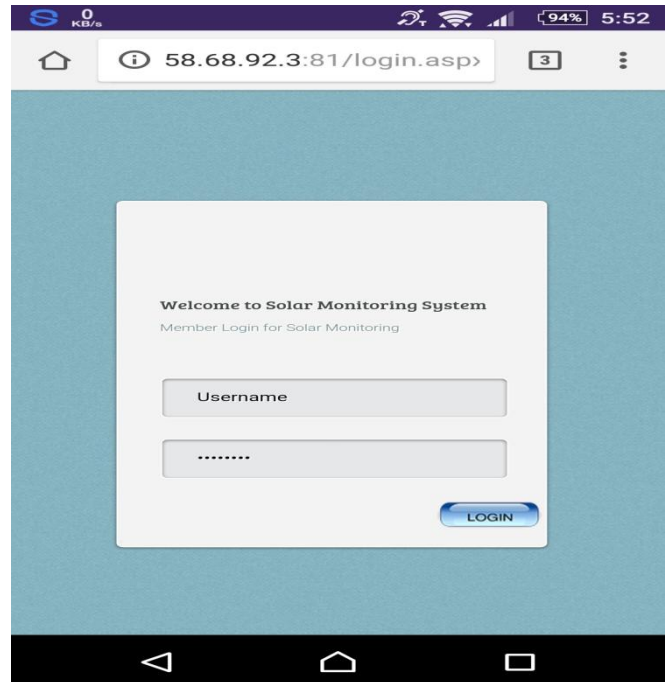


Figure 8: Webpage Design Login page

After Entering the correct username and password we will be able to enter into the home page there we are supposed to choose the meter to view Monitoring parameters . After clicking on meter number we are able to see all these below parameters in a different webpage.

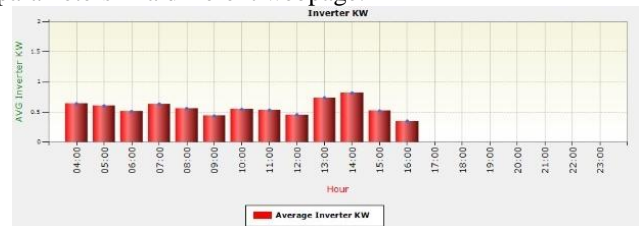


Chart 1: Hourly wise Inverter Delivered Energy

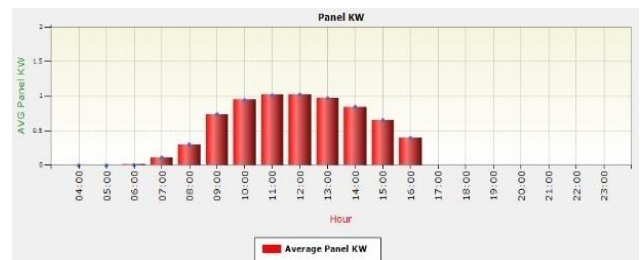


Chart 2: Hourly wise Panel Generated Energy



Chart 3: Hourly wise Battery Voltage



Chart -4: Hourly wise Utility Utilization Energy

Total power parameters of Grid-Tie Inverter we will view by selecting the meter number in homepage of our login.

- 1) Today Generation.
- 2) Total Generation.
- 3) Today Utilization.
- 4) Total Utilization.
- 5) Today Delivered.
- 6) Total Delivered.

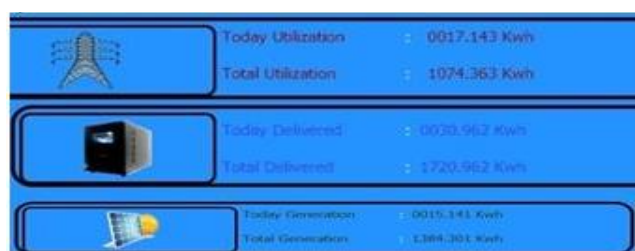


Figure 9: Total parameters view in a single webpage

5. Conclusion

Before our system we studied by sending SMS through GSM module for monitoring any parameters from solar panels. For overcoming charge for every SMS all the time we proposed a new system to send data to server using GPRS. In our study we proposed a system in such a way that to log the data into SQL server from Grid-Tie Inverter with the help of GSM/GPRS module which resembles like use of IOT Technology. which is utilizing wireless communication as medium to transmit data to server. later on we will send that information to webpage with the help of our own created server along with port number. we have used TCP/IP client in GSM/GPRS Module. we verified our system working with proper outputs in webpage in prescribed IP and Port. we proposed cost efficient solution for monitoring power parameters of Grid-Tie Inverter using GPRS Module, Microcontroller by using SQL server database.

6. Future Scope

With the advancement in technology we can propose system like in addition to monitoring we can control appliances in home according to level of power availability in battery of Grid-Tie Inverter. It is possible to work with designing an app to monitor power parameters as well as to control the appliances where we have installed Grid-Tie inverter. We can use any other wireless technology to connect to Internet for sending information to SQL server like Bluetooth, Wi-Fi, Zigbee, Ethernet e.t.c.,

So, This Proposed System can be used and we can develop the complex applications with minimum cost and with desired functionality.

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Author Profile



C. Dinesh kumar received the B.Tech. degree in Electronics and Communication Engineering from Jawaharlal Nehru Technological University (JNTU) in 2014 and M.Tech. degree in Embedded System Technology from VIT University in 2017, respectively. During 2016-2017 he did Internship in Amararaja Electronics Limited, Chittoor, Andhra Pradesh. Now working as an Embedded Engineer to achieve self designed and working modules.



D. Lohitha received the B.Tech. degree in Electronics and Communication Engineering from Jawaharlal Nehru Technological University (JNTU) in 2015 and M.Tech. degree in Embedded System Technology from VIT University in 2017, respectively. During 2016-2017 he did Internship in Amararaja Electronics Limited, Chittoor, Andhra Pradesh. Now working as an Assistant Professor in Private Engineering College, Tirupati, Andhra Pradesh.