

SMART OFF-GRID SOLAR INVERTER

POWER MONITORING USING BLE(Bluetooth Low Energy) MODULE

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Abstract - Emerging technological world is demanding mainly for the devices which has low latency, maximum throughput by occupying less space and by consuming low power. Bluetooth Low Energy module is a specialized Bluetooth device which works faster than the traditional Bluetooth device by consuming low power. In this regard Bluetooth Low Energy module is of low power consumption division, it is operated with the frequency of traditional Bluetooth device. For intercommunication Bluetooth Low Energy module is a key component which can be placed at the side part of the actual machine because the transmission and reception of the information takes place in the form of radio waves. The Bluetooth Low Energy module is designed using BlueNRG MS a network processor with 4.1 specification, integrated Balun and a chip antenna.

Key Words: ROI, BLE, Off grid inverter, BLE scanner.

1.INTRODUCTION

Now-a-days with the emerging modernization the 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 bluetooth low energy is a trending technology in this modernized market with its low power consumption and its resistance to the echoes of signals. The main concern with this bluetooth low energy is its distance range.

Since it consumes very low power it can be attached to any existing power modules such as inverters, refrigerators 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. 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.

As the electricity is one of the major problems that the country is facing currently in order to overcome that drawback the inverters came into existence in order to have more flexibility and to use the renewable resources effectively the solar inverters were introduced

in the market..

In order to increase the comfort level of the user the inverter performance is linked with the mobile application. Through the mobile app the user can able to know the battery level to how many devices it can be used for how many hours information.

To carry on with this application the stm32 microcontroller is chosen because of its features and the core flexibility to develop the new application. For the code generation the stm32 cube Mx is used and for the code development Keil version 5.1 is used.

1.1 Bluetooth low energy

The bluetooth low energy module is mainly based on BlueNRG-MS, a single mode network master/slave processor with specification 4.1, multiple roles can be supported by BlueNRG-MS simultaneously. The BlueNRG-MS can act as both hub device and a bluetooth smart sensor. The embedded ARM-Cortex M0 is the core on which the bluetooth low energy stack runs and the stack is dumped on a on-chip flash memory which is non-volatile and integrates a 2.4 GHz RF transceiver.

The non-volatile flash memory can be upgraded easily using SPI. At 1 dbm of output power the maximum peak current is 10 mA only. Longer battery life can be attained because of the short transition times between operating modes and ultra low power sleep modes allows network processor to consume low average current. Through SPI the BlueNRG-MS can be interfaced with the external microcontroller.

1.2 Objective

The aim of this paper is to use bluetooth low energy technology to transfer the performance details of an inverter which in parallel displayed on the LCD screen of an inverter and the details is displayed through an mobile application as an interface to the Bluetooth low energy users by using bluetooth enable smart phone. This is established by referring to different properties of bluetooth. In possibilities and restrictions in connecting to the bluetooth low energy smart phone can be displayed once an BLE application is installed on the smart phone. Besides the power consideration of the bluetooth low

energy it provides the distance information and range details of the surrounding bluetooth devices.

2.COMPONENTS USED

2.1 Off-Grid Inverter

Off-Grid Inverter is one type PV Inverters where solar energy is consumed and is converted to AC for using as a power supply as well and stored in the battery for future use. The main operation of Off-Grid Inverter is to get the solar power through PV Array and it is termed as input DC supply .Off-Grid 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 and the DC is stored in the battery.

2.2 STM32F401RE Microcontroller

The Stm32F401RE microcontroller is of ARM cortex M4 32-bit RISC high performance core category. It can be operated at a frequency upto 84MHz. 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 Stm32F401RE is incorporated with 512KB of flash memory and 96KB of SRAM, enhanced range of I/o and peripherals. It features the applications with its low power consumption factor that is run mode it is 146 microamp/MHz, stop mode 10 microamp at 25 degree celsius.

It provides flexibility in debug modes with two diverted options they are serial wire debug(SWD) and JTAG interfaces and cortex M4 embedded trace macrocell. It can be extended to the real time applications because its core is incorporated with real time clock which provides subsecond accuracy and a hardware calendar. For the usage in various applications the StmF401RE is available in various packages those are WLCSP49,LQFP64/100,UFQFPN48 and UFBGA100. In order to avail the microcontroller in multitasking applications the core is incorporated with 12 communication interfaces. Upto three I2C interfaces, three USARTS, four SPIs, one SDIO interface and advanced connectivity with USB 2.0 full speed device/host/OTG controllers.

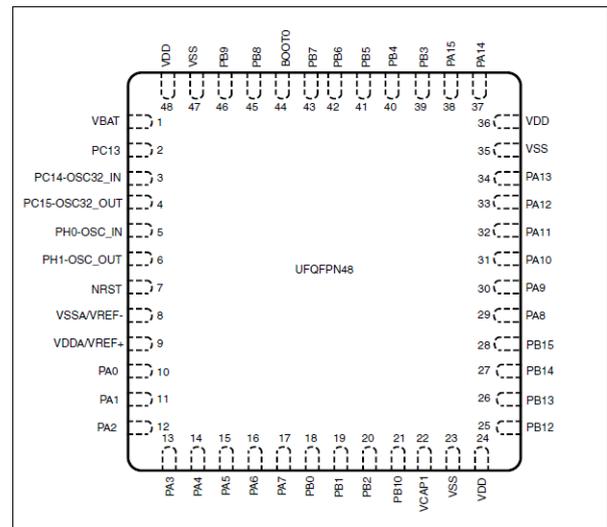


Fig -1: STM32F401RE Pin Description

2.3 BLE Expansion Board

In the application layer in order to define the modes of Bluetooth the Generic Access profile(GATT) is used. The bluetooth modes are Advertising, Scanning, Master device and Slave device. In the mode of advertising the BLE synchronously sends the data packets which consists of the device information and the offered services. the connection link is established once the advertisement is scanned by the device this is all happens in the scan mode. If the connection has been completed, then the device which is advertised acts as a master and the device which scanned the device acts as a slave.

The slave should have one master at any given point of time whereas a master can handle two or more slaves at a time. In order to the battery usage the BLE module elapses less time in between advertisement and the scanning process that is duration of about 20ms to 10s. If the interval between these modes is set to high then the desired application can be completed and in addition it leads to irrelevant responses.

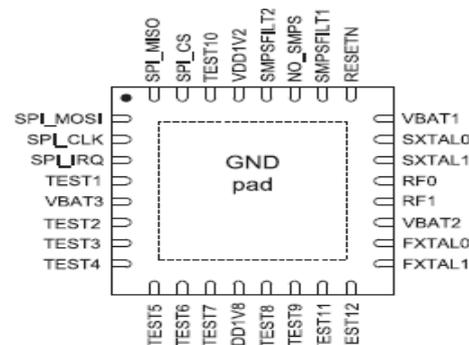


Fig -2: Pin Description

2.4 Nucleo F401RE

The STM32 Nucleo-64 board supports the new conceptualized view of the user. Since the STM32 microcontrollers are available in LQFP64 package which allows for prototype building with various mappings of power consumption, features and the performance. The Nucleo board comes with the ST-LINK/V2-1 debugger port so that there is no need for a different probe. This board is also integrated with Arduino V3 connections so that an additional shield can be easily mounted. Since it is directly mounted the Arduino connectors the programming involves less complexity.

The Nucleo board comes with the compressive software the HAL libraries with various examples relevant to the specific packages of the microcontroller. The microcontroller core flexibility allows for the online compilation of the examples. The Nucleo board provides two ways to extend the resources they are Morpho pin headers and Arduino V3 connections. The Nucleo board supports two types of loading mechanisms of the code either through SWD connector or ST-LINK/V2-1 debugger. This board is flexible for 3.3V, 5V and 7-12V power supplies.

2.5 RS-232

RS-232 which is widely used standard for the serial transmission of data. It is connected in order to transmit the signals between DTE(data terminal equipment) and DCE(data circuit-terminating equipment). Mostly the DTE will be computer and the DCE will be a modem. But based on the applications the terminal devices. Using RS-232 the data can be transmitted both synchronously and asynchronously. It has the capability to identify the difference between the signal levels that is as logic 0 and logic 1. The logic 1 level represents +12v and logic 0 represents -12v.

The RS-232 have the capability to work at different baud rates those are 9600Bits/sec, 2400Bits/sec, 4800Bits/sec and so on. Both DTE and DCE can send and receive the signals. The RS-232 comes with the DB-25 and DB-9 connectors it can be male/female. Most of the applications prefer DB-9 connector. 50 feet is the maximum length of the RS-232 cable. For the short range of point-t-point communication the RS-232 cable is used because of its length limitation. Because of its simplicity it is used in many industrial applications, networking applications and in the scientific instruments.

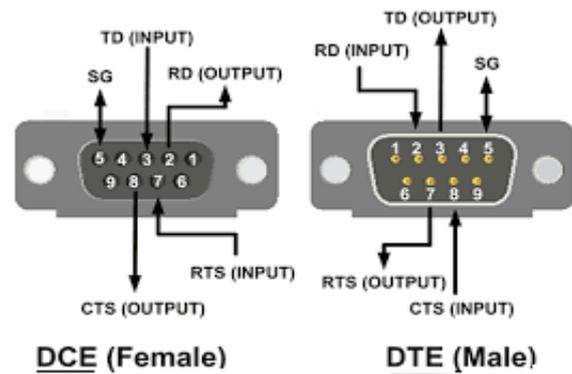


Fig -3: RS-232 Cable Connectors

2.6 App Development

There are many application development are available which are open environment. We can select the suitable software whatever may be the software we use the basics for the app development are same. With the flexibility of the development tools everything became work on hands. Creating an application by providing an authentication especially for the applications which are going to be used in the industrial applications or economical applications.

2.7 STM32 CubeMX

The STMCubeMX is an integral of ST microelectronics 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 microcontroller. This generation of code in this software involves a sequence of steps to be performed.

First we have to select the appropriate microcontroller which is best suited for our application. Then we have a excellent user interface in order to delete the configurations that are assigned to the pins of the microcontroller 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 microcontroller. There exists an flexible option of selecting the peripherals like SPI, I2c, USART, GPIO and so on.

2.8 X-Cube-BLE1

What exactly the x-cube-ble1 is it is a part of the STM32 cube a development software environment. The developers have categorized the profiles and services that can be offered by a particular core into different software integrals. The x-cube-ble1 provides the complete middleware in order to build various applications on basis

of bluetooth low energy. This is purely based on the technology of the STM32 cube and it is an extend of the STM32 cube package.

2.9 Keil v5.1

The Keil is a software development tool for ARM based core microcontrollers. Now a days every one is trying to develop new applications from the lower level developers to the industry level developers keil has been used abundantly. The ease of use and the flexibility in maintaining and changing the settings has made the users to move up with the keil development tool.

3. DESCRIPTION

The solar inverters now a days are coming up with the LCD displays. As the time is very important in our daily life the user cannot approach the inverter every time. So we are providing application through which he can able to see the display information in hands when the user is present the Bluetooth range.

The information that is coming out of the Rs-232 is given to the UART port pins of the nucleo board. From that port the information is sent to the SPI port. We are sending the information to the SPI port because the interface between the Nucleo board and the BLE board is only through SPI.

Once the information is sent to the SPI port the BLE module is ready to send the data. In order to explore the data into the air we are suppose to define the packet format and we have enable the software layers of the Bluetooth Expansion board. There exists various layers of software when the BLE board is considered.

To establish the communication between the BLE module and the mobile the GATT server has to be included in the mobile in which the API is downloaded through which the user application needs are specified. Once the API layer is designed then the PCI layer consists of the BLE commands through which the information is transmitted in the form of radio waves.

UUID which is a unique identification number given to the module by the manufacturers by which the linking the particular device is possible and the Bluetooth low energy is enabled and the module starts acting in the low energy profiles of the Bluetooth.

4.RESULTS

According to the application, the results part includes the display of the result in the smart phone of the user who is also the consumer of the solar inverter. The results also includes step by step approach in the

application related to the Bluetooth low energy.

Once the mobile application is opened the mobile starts scanning the devices which are in the available bluetooth range. The list of devices are shown in accordance with their respective signal strengths. The order of the list of the available Bluetooth peripherals are arranged in the increasing order of the signal strengths. The generic services cannot be moulded to our application the custom services can be used to our application by connecting to the respective sensors.

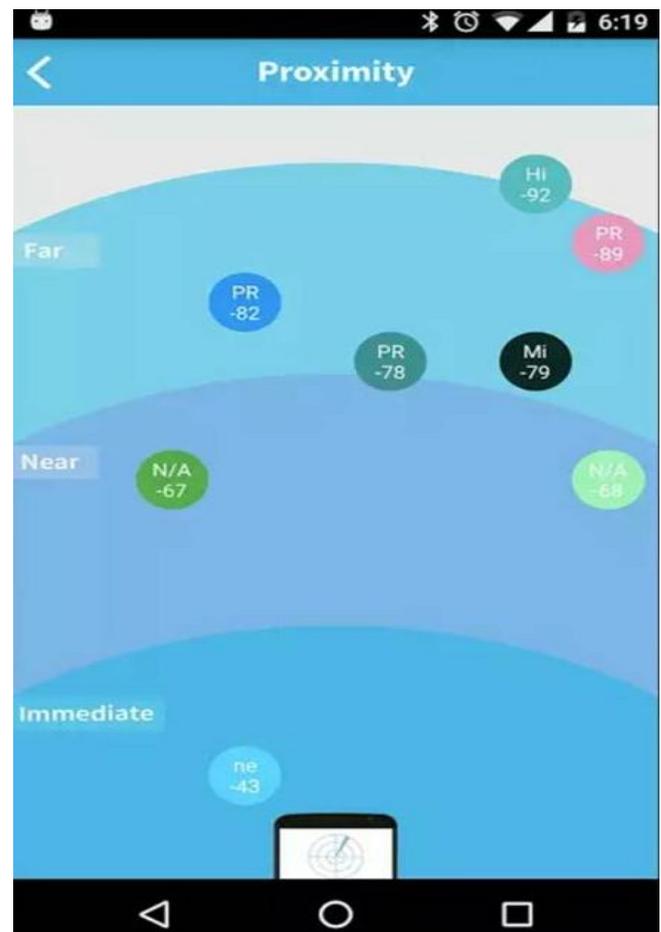


Fig -4: BLE App Scanner page

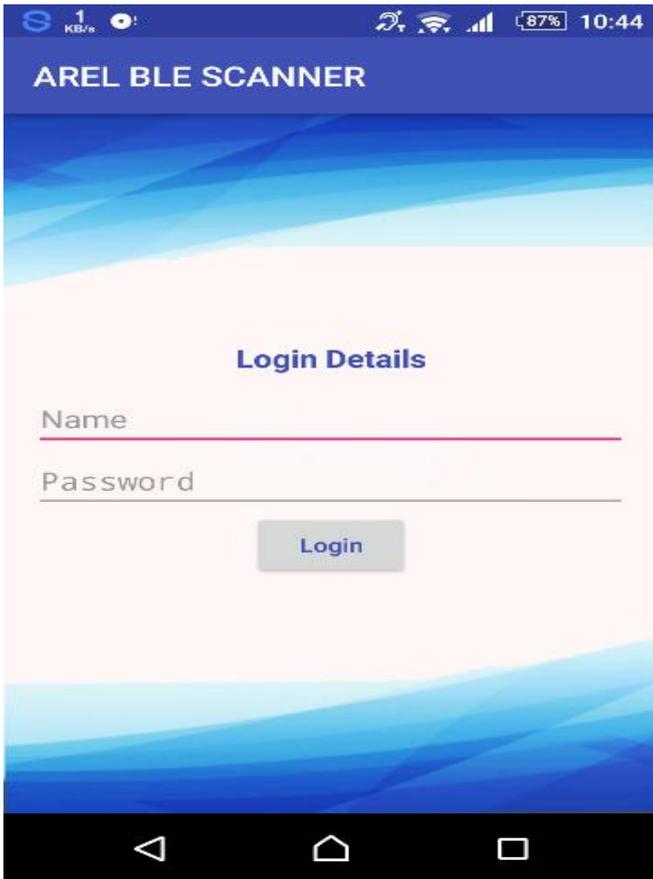


Fig -5: App Login Credentials page

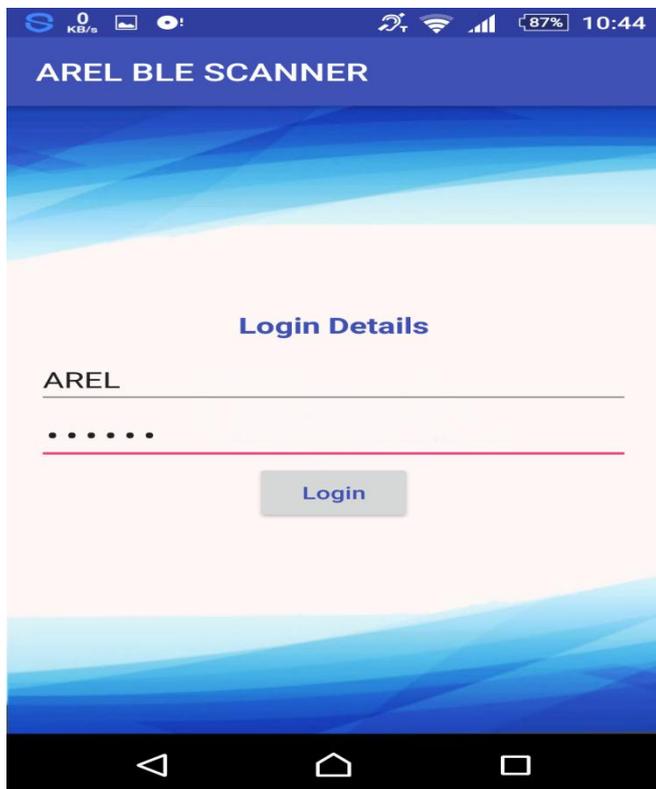


Fig -6: After typing Login and Password

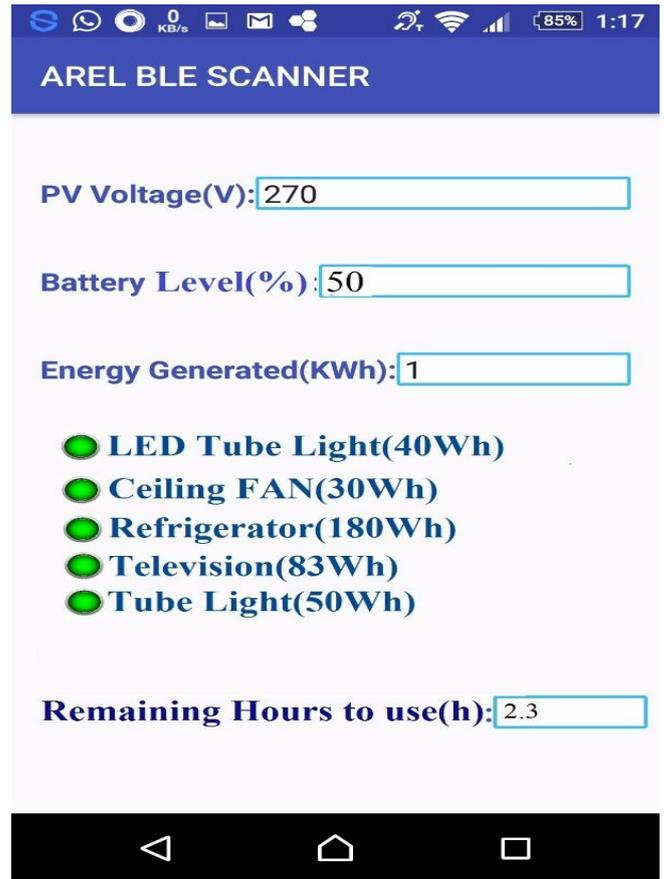


Fig -7: If all Appliances are ON App view Details

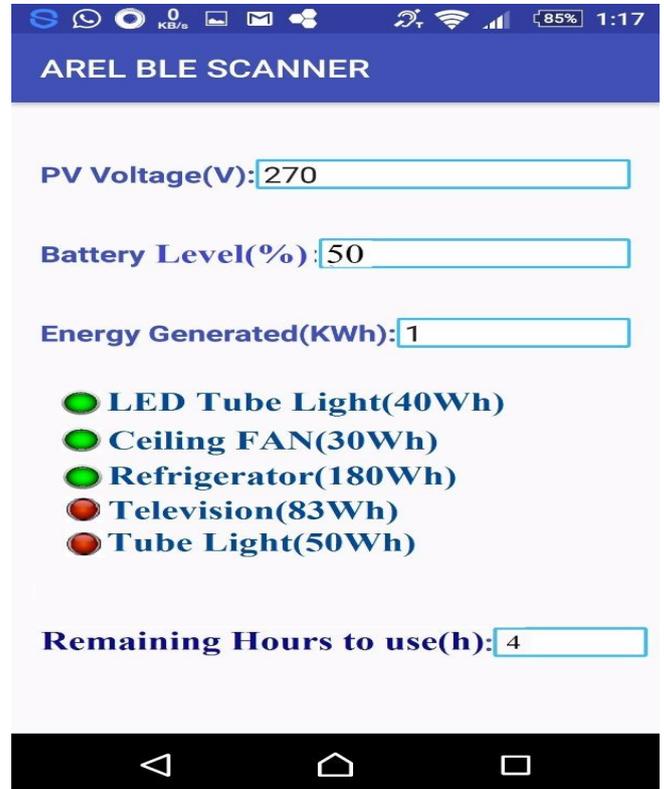


Fig -8: If Two Appliances are OFF App view Details

5.CONCLUSION

Since the non renewable resources cannot be used at the markable extent in order to get rid of the power costs people are turning towards the renewable resources and the companies are manufactured the products which uses the renewable energy resources and exhibits the satisfactory results with maximum life time. The solar panels which is a revolutionary technique emerged out through which the solar energy is utilized to fulfill a wide range of applications. Almost the solar energy production is reaching to the 55 percent of the total energy production. The installation cost may be high but the cost can be earned back within less than a year. The industries and several manufacturing plants are turning towards solar energy. So that the water which is serving as a main role in the energy production is used for the needs where it cannot be replaced with any another source.

6.FUTURE SCOPE

Now-a-days everyone wants to operate every appliances and gadgets with a single touch. Since the people are depending more on the products through which they can fill their needs. AS the part of that the solar inverter can also be remotized. So that without approaching the inverter a user can operate the inverter. We are displaying the production details of the energy of an inverter in hands of the user bluetooth enabled smart phone. Whenever he wants to calculate the return on investment the details has to be stored so that the user can come to know how much grid power he has saved and the power saving cost can be analyzed.

If the produced details is saved in the cloud data storage then on analyzing the report the user can extend the usage of the power so that user can use the solar energy at the maximum. Because if the user is installed with the off grid inverter then the energy can be stored in the battery to its maximum the energy is produced continuously if the energy that is produced is not used. Then the energy that will be produced will be wasted.

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