REMOTE MONITORING SYSTEM FOR SOLAR INVERTERS

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Abstract - *A traditional power management system requires a third-party technician, whenever there is a need to perform a hard reboot arises. These services can cost in terms of money, labor and time. A remote monitoring system diminishes dependency on maintenance, third-party services, facilitating cost-effective lights-out operation at remote offices and branch locations and shortens the mean time to refurbish. This system consists of microcontroller based monitoring system which monitors the parameters of solar inverter continuously. These real time parameters of solar inverter uploaded on a server through GSM module. Employing this system can monitor solar inverter 24x7 and from anywhere in the world. This paper deals with the Remote Monitoring System for power back up system which is controlled by dsPIC33EP32MC202 controller and data is monitored on server.*

***Key Words*: Remote Monitoring System (RMS), solar inverter, dsPIC33EP32MC202 controller, GSM SIM800**

1. Introduction

The consumption of energy on tremendously large scale is made all over the world for numerous reasons possible. From household to industries, every appliance available requires energy for it to function and this Energy is primarily obtained from Non-Renewable Energy sources. Since the ages this sources are utilized almost completely and at present they are on the verge of depletion. Hence it has become extremely important to find the alternate source of energy. Solar energy is widely available throughout the world and can contribute to minimize the dependence on energy imports. In 90 minutes, an adequate amount of sunlight strikes the earth to supply the entire planet's energy requirements for one year. It also eliminates the hazards caused by Non-Renewable Energy sources as it entails no greenhouse gas emissions during operation and does not emit other pollutants. Solar has many benefits like system-friendly consumption, improved operating strategies, like advanced renewable energy forecasting and enhanced scheduling of power plants and also investment in added flexible resources.

Recently solar PV plants are being installed all over the world every day to generate large amount of energy from them. Hence, there is an increasing necessity to obtain the optimum results from solar PV for better advancements. There are many ways in which one can utilize the energy generated from PV panels. One of the methods is to use it as an input power source to the inverters. As a result, solar inverters are developed on large scale and are being commercialized all over the world. In industries solar inverters are installed in enormous numbers and in order to ensure that solar inverters provide the optimum results, they must be monitored and built. But it gets very difficult and time overriding task to scrutinize all of them manually. Hence, to reduce the time and complexity required to monitor them remote monitoring systems are implemented. It also makes sure that these systems are monitored without any corporal intervention, and also reduces the chance of their failure to the greater extent. Thus this paper deals with the implementation of optimal, economical and reliable Remote Monitoring system which can be used not only for solar inverters but also for other types of inverters.

2. Remote Monitoring Systems

Remote Monitoring System (RMS) is principally designed to communicate with the devices in this technological world remotely. Many systems like Smart grids, Positive train control, Structural health monitoring, Pipeline sensors, Patient monitoring, Desktop/server monitoring requires monitoring on regular basis. Such systems can be monitored and controlled remotely using RMS. These systems provide onsite status information of the devices to RMS which can be monitored remotely at anytime from every ingredient of the world. This paper specifically deals with the remote monitoring and control of solar inverter.

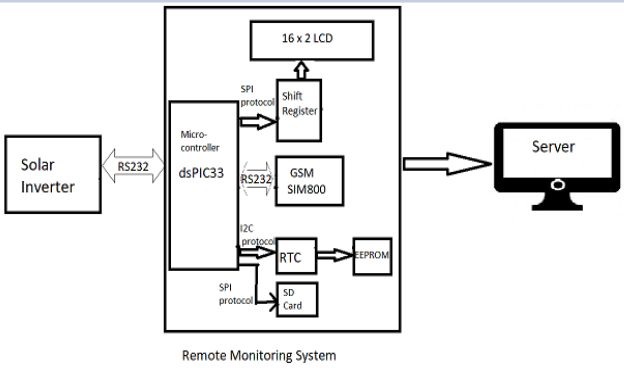

Fig1: Block diagram of RMS

Information such as voltage, current and power is supplied by the solar inverter to the black box (Remote monitoring system) through UART communication (RS232). The data collected by RMS is then uploaded on the web server. This data can be accessed by anyone at any part of the world. The components in the Remote Monitoring System are explained below:

2.1 dsPIC33EP32MC202

Microchip's dsPIC33E family of digital signal controllers (DSCs) features a 70 MIPS dsPIC DSC core with integrated DSP and enhanced on-chip peripherals. These DSCs facilitate the design of high-performance, precision motor control systems that are more energy competent, quieter in operation, have a great range and extended life. These devices are also ideal for high-performance general purpose applications. It has following features:

1. Operating conditions are (3.0V to 3.6V, -40C to +85C, DC to 70 MIPS) and (3.0V to 3.6V, -40C to +125C, DC to 60 MIPS).
2. It has 16-bit CPU.
3. Code efficient architecture(C and Assembly).
4. Upto 8 MHz internal oscillator frequency.
5. 32 kb program memory and 4kb RAM.
6. 28 pin count with 21 I/O pins.
7. 2-UART, 2-I2C and 2-SPI Digital Communication Peripherals
8. It comes with the special feature of peripheral pin select which allows the user to utilize the pins according to the user requirements.

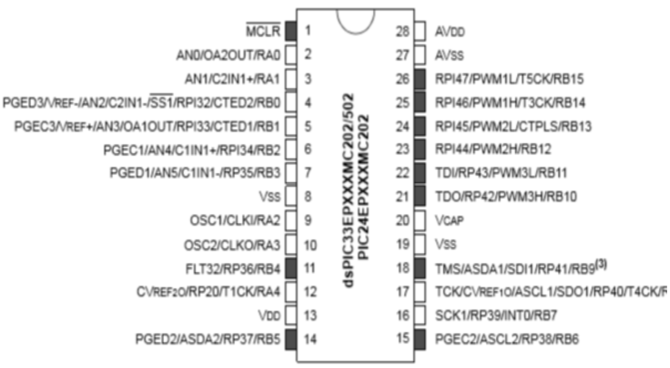

Fig2: dsPIC33EP32MC202

2.2 EEPROM and I2C Protocol

RMS also consists of modules like 24LC256 which is external EEPROM that can store upto 256kb of data into it. The PIC controller controls the EEPROM through I2C protocol. I2C is a master slave protocol. It means that devices connected to I2C bus will be either master or slave. The master is the device which initiates communication and it drives clock (SCL) line. Slaves are the devices which respond to master and it cannot initiate a communication. The master sends the address of slave + R/W bit first, then followed by other data. R/W bit indicates whether the master wants to read data from or write data to the slave. The PIC here acts as a master device and controls EEPROM which acts as a slave. The read-write operations are accomplished by sending a set of control signals including the address and/or data bits. The control signals must be accompanied with proper clock signals. The Interfacing of I2C-EEPROM with PIC microcontroller performs read, write and erase operations in EEPROM and the corresponding values are displayed on LCD.

2.3 RTC and I2C Protocol

RMS system uses DS1307, a real time clock (RTC) for real time generation of data. It is necessary to get a data with the time it was generated so that technician can know the exact condition of the UPS systems. For this purpose real time clock (RTC) is used to get the time and date. The DS1307 Serial Real-Time Clock is a low-power; full binary-coded decimal (BCD) clock/calendar plus 56 bytes of NV SRAM. Address and data are transferred serially via a 2-wire, bi-directional bus. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The clock operates in either the 24-hour or 12-hour format with AM/PM indicator. The controller designed controls the RTC DS1307 device through I2C protocol. The I2C Controller here acts as a master device and controls RTC which acts as a slave. The read operation is accomplished by sending a set of control signals including the address and/or data bits. The control signals must be accompanied with proper clock signals. Wiring up an I2C based RTC to the I2C port is relatively simple. The RTC also makes the software easier as it takes care of all calendar functions; accounting for leap years etc

As we saw, an EEPROM and RTC both are using I2C protocol for communication with controller where they both are controlled by same I2C bus. This uses single master multiple slave I2C protocol.

2.4 LCD and SPI Protocol

SPI (Serial Peripheral Interface) is a full duplex synchronous serial communication interface used for short distance communications. SPI devices communicate each other using master slave architecture with a single master. SPI is called as a 4-wire bus as it requires four wires for its communication. Interfacing LCD with controller requires at least 6 wires for communication. But using SPI Protocol, only 4 wires are required. When LCD is interfaced using SPI protocol, shift register is used to convert the serial data to parallel data. The data gets write onto shift register using SPI. Shift register converts this data into parallel data and provides it on its four output pins. This data is then given to the LCD which displays it.

2.5 SD card and SPI Protocol

It has an additional option as SDCARD for storing the data which can be used by a technician to store and access this data later on.SD card is communicating with the controller using SPI protocol. The SD cards have a microcontroller that shows its availability to the PIC microcontroller. The PIC sees the SD card as an addressable sector on which read/write functions are possible. Once the microcontroller is in the SPI mode, communication between the master and the slave is done via 4 pins viz. clock, chip select, data in and data out.

2.6 GSM Module

GSM (Global System for Mobile) / GPRS (General Packet Radio Service) Modem is compatible with SIM900A, SIM900 and SIM800 modules. This modem is Quad-band and dual band device which works on frequencies 850 MHz, 900 MHz, 1800 MHz and 1900MHz.This GSM/GPRS modem has internal TCP/IP stack to enable user to connect with internet through GPRS feature. It is suitable for SMS, Call as well as Data transfer application.

- Bluetooth and FM features.
- Input voltage: 9V to 24V DC.
- Tunable antenna circuitry for both GSM and Bluetooth.
- Built in RS232 to TTL and vice versa logic converter
- Configurable baud rate from 9600-11500 through AT command.
- DB9 connector provided for UART communication.
- Built in SIM card holder

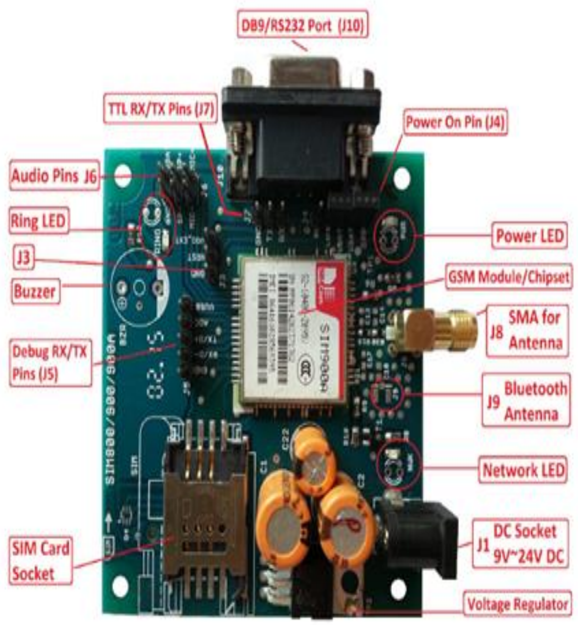

Fig3: GSM Module

2.7 Switch Mode Power Supply (SMPS)

SMPS produce a predetermined or controllable magnitude dc voltage from the available form of input voltage (AC/DC). RMS desires standard dc voltage of fixed magnitude and well-regulated dc supply for proper operation. Similarly, RMS also needs multiple output power supplies. For example, 12V supply for GSM, 5V supply for MAX232, 24LC256, DS1307, LCD and 3.3V supply for dsPIC and SD card. The output voltages from the SMPS have dissimilar current ratings and different voltage regulation necessities. Almost invariably the outputs from SMPS are isolated dc voltages where the dc output is ohmically isolated from the input supply. It also provides the ohmic isolation between 2 or more output which is considered necessary in RMS to isolate dsPIC and MAX232. The input connection to SMPS is taken from the standard utility power plug point (ac voltage of 230V / 50Hz).

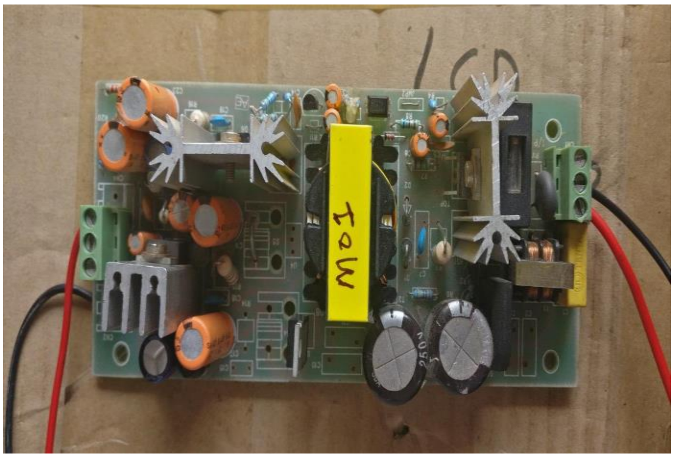

Fig4: SMPS Circuit

In RMS, the power supply is given to the board using Switch mode power supply (SMPS) which converts 230V AC to DC voltages. SMPS offer three output voltages viz. 5V, 9V and 12V. As EEPROM, RTC and LCD modules entail 5V supply they are directly from SMPS. 9V supply is regulated to 5V and this fixed voltage is then fed to the MAX232 IC which is isolated from the microcontroller for the purpose of protection. This device uses DSPIC microcontroller for its operation which is 32bit PIC.

3. MPLAB X Integrated Development Environment (IDE)

MPLAB X IDE is a software program that runs on a personal desktop to broaden applications for Microchip MCU's and digital signal controllers. It provides a single integrated environment to develop code for applications of embedded microcontrollers. MPLABX C8 is the environment for project development and for all tools needed to build an application of PIC controllers. This engrosses understanding the basic structure of a project in C and Assembler -coded source files, along with the basic operation of the C-Compiler, Assembler and Linker. It maintain all 8-bit (PIC10, PIC12, PIC16, PIC18), 16-bit (PIC24) and 32-bit (PIC32 and PIC32C) microcontrollers and 16-bit (DSPIC30 and DSPIC33) digital signal controllers (DSC's).

4. Working

When device initiate, power is functional and the microcontroller goes through some configuration and initialization functions. The dsPIC acquire data of different parameters from UPS system throughout serial communication with UPS. RS232 is used for serial communication between dsPIC and UPS system. Lcd is initialized in 4bit mode using shift register (74HC595). DsPIC sends the data serially to shift register using bit banging method which converts that serial data into parallel data which is then displayed on LCD. Real time clock is interfaced with dsPIC using Inter Integrated Circuit(I2C) protocol which generates real time and date. This real time and date along with data from UPS system is stored in EEPROM. The external EEPROM is interfaced with dsPIC using I2C protocol. The controller then fling this data from EEPROM to GSM module. The GSM module which is serially linked to dsPIC provides the internet connectivity. Using this internet connectivity data is uploaded on to the web server. dsPIC sends this data to the SD card using SPI protocol . SD card stores this data in its memory. It can be detached from the device and can be connected to computer using memory card reader. The data stored in it can be accessed anytime later and can be saved in the PC/mobile.

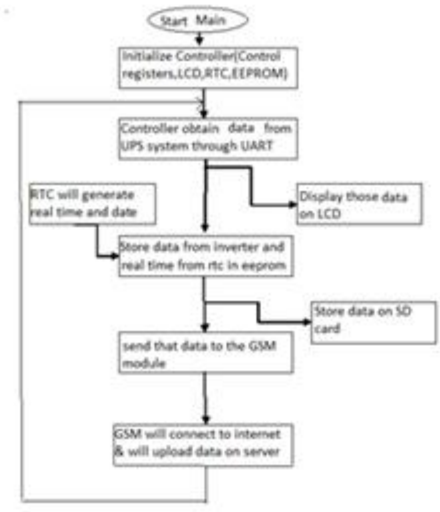

Fig5: Flow of Project

5. Results

Remote monitoring system is displaying ouput parameters of solar inverter on LCD display. Following figure shows the output parameters of solar inverter on LCD display of RMS system.

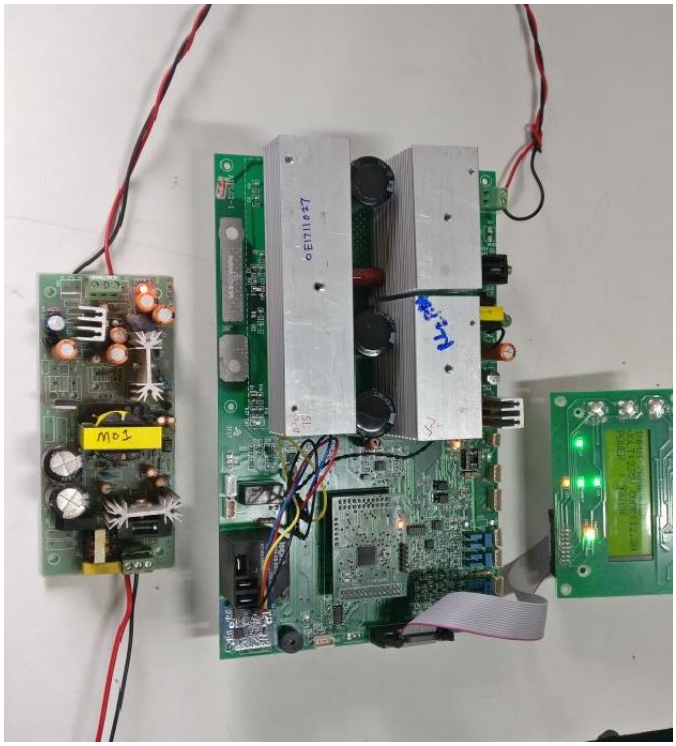

Fig6: Hardware setup

6. Conclusions

The status of the solar inverter can be monitored easily from any point of presence. The software provides values of all parameters available in the solar inverter. Remote monitoring reduces the equipment's downtime, outages and losses, and shortens the mean time to repair. Reduces dependency on maintenance staff and third-party services, facilitating cost-effective "lights-out" operations at remote offices and branch locations. Performs remote hardware settings without attending to the systems physically by maintenance personnel.

7. Future Scope

1) It is possible to build RMS for other systems like UPS systems, power inverters, hybrid inverters, etc.

2) In future it is possible to not only monitor but also control these systems using RMS by modifying the circuitry for that purpose.

3) UPS can be build in such a way that RMS can be installed itself in the system and will not be a separate part.

4) GSM can be used to send SMS to the technician whenever there is failure in the systems so that they get notified about it and can take immediate actions.

5) it is possible to use GSM to E-MAIL the file in which data is stored using SMTP protocol.

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