Online monitoring and control system for Renewable Energy Sources based on Android Platform

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Abstract- This paper describes the development of an online monitoring and control system for distributed Renewable Energy Sources (RES) based on Android platform. This method utilizesthe Bluetooth interface of Android Tablet/ Mobile phone as a communication link for data exchange with digital hardware of Power Conditioning Unit (PCU). The Low Cost Android tablet can replace the graphical LCD displays and internet modem of RES Power Conditioning Unit (PCU) with enhanced graphical visualization and touch screen interface

Index Terms— RES- Renewable Energy Source, PCU- Power Conditioning Unit, SPV-Solar Photovoltaic, UART – Universal asynchronous receiver/transmitter, HMI- Human Machine Interface, LCD- Liquid Crystal Display, DSP- Digital Signal Processor

I. INTRODUCTION

Renewable Energy Sources are becoming anentrusting factor and promising contributor in the electricity production. They are the major players in the electrification of rural areas which are still 'not wired' both electrically and geographically.The effective dissemination of such decentralized RES power plants can be accelerated by better monitoring and control tools. Hence, the selection of communication interface becomes a 'choice of intelligence '. The effective integration of RES sources to existing power grid infrastructure has a great impact on modernization of legacy grid to smart grid, which monitors, controls and optimizes the operation of interconnected elements.

There are different methods for monitoring the RES sources; an on-board web server can be utilized, but it has constraint/limitation on memory and sometimes we have to take care of additional wireless infrastructure as most of RES plants are located in remote areas. There are web servermodules available from different manufactures like Rabbit core, Arduino, Raspberry-pi etc. These are basically an embedded hardware with communication interfaces like Ethernet for internet connection and SCI/SPI forcommunicating with embedded controllers in devices like PCU. These type of hardware demands an additional interfaces for HMI. This paper proposes an android based online web monitoring solution for RES power plants. The Android tablet can also be used as a local Human Machine Interface (HMI) for RES based PCUs. The hardware andsoftware were tested with a 25 kWp grid interactive solar photo voltaic power plant installed at our laboratory and achieved very promising results.

II. DEVELOPED ON-LINE MONITORING SYSTEM

The heart of the system is a tablet running Android OS 3.1 or later. This application demands Bluetooth interface and internet connectivity for the Tablet. The Bluetooth interface of the tablet is utilized as bi-directional communication link between the tablet and solar PCU. The PCU has a DSP and UART interface. A serial to Bluetooth converter module is used to convert the UART data of PCU controller to Bluetooth format which act as an Interface between the PCU and tablet. The system Architecture developed is shown in Figure 2.1.

Fig. 2.1. Architecture of Android based RES on-line monitoring system

A. Solar PCU

The grid connected solar Photovoltaic(SPV) power plant exports power generated by the SPV array to grid during day time, when there is enough solar insolation. Figure 2.2 is theblock diagram of a typical solar PCU. A DC-DC converter connects the SPV array to an intermediate DC bus at a fixed voltage. The grid side inverter connected to this DC bus delivers power from the SPV array to the grid at unity power factor with minimum THD in the exported current. The 25kWp grid interactive SPV power plant is an integration of three basic interface modules (BIM), each of them are rated for 10kWp. Figure 2.3 is the photograph of the solar PCU developed

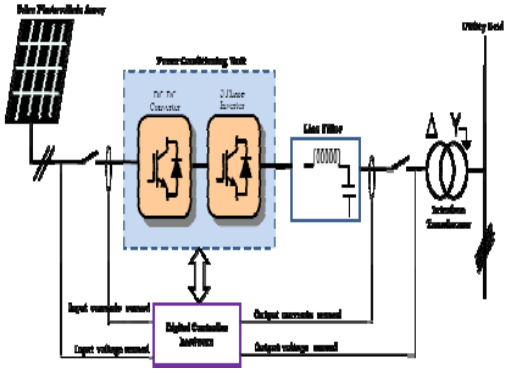

Fig. 2.2. Block diagram of Grid connected SPV system

Fig. 2.3. Photograph of Solar PCU developed by CDA

Operations of these three BIMs are independently controlled and coordinated using embedded digital controller with TMS320F2812 DSP and Altera EP2C5 FPGA. The data acquisition of SPV module is accomplished by four 8 channel simultaneous sampling ADCs with 12 bit resolution. The DSP has in-built UART module for serial communication. Solar PCU communicates its status and other information to tablet through serial port. Figure 2.4 shows the photograph of embedded digital controller hardware platform of solar PCU.

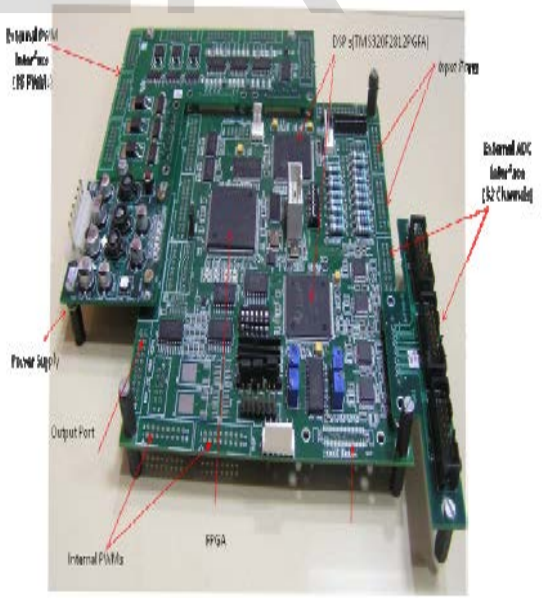

Fig. 2.4. Embedded controller of PCU

B. HMI communication PCB

HMI communication PCB is a key element in online monitoring and control system which is designed to facilitate the interconnection with PCU as shown in Fig 2.5. It consists of PIC18F4550 microcontroller and Serial to Bluetooth converter module, HC-04/HC-05/HC-06. The micro controller is used for data manipulation as well as to provide an optional USB interface to the Tablet. The whole system has been incorporated with both USB and Bluetooth interface which acts a communication link via the Tablet to the global network environment. The HMI PCB has a physical UART communication interface with PCU with bi-directional data exchange capability with PCU. The remote control system has yet been implemented with HMI as the proto type is still atrunning stage. More features will be incorporated in future with further development of any new plug-in equipment.

Fig. 2.5 Photograph of HMI PCB

C. Android application

Developed application requires an android tablet with operating system 3.1 or later with Bluetooth interface and internet connectivity. The internet connectivity is not mandatory, if it is planned to explore the local HMI function alone. A free downloadable android development tool (ADT) isused to develop application on android platform which is an eclipse based Integrated Development Environment (IDE)n where JAVA programming language is used for application development.

1) Local HMI

Tablet runs an application to display various parameters like solar DC input voltage & currents, grid voltage, grid currents, frequency and system status etc. Figure 2.6 is the screen shot of local HMI taken from an Android device

Fig. 2.6 Screen shot of HMI from Android device

Figure 2.7 shows flow chart of android application running in tablet. The code is written in JAVA language and the platform is Android Development Tool freely downloadable fromhttp://developer.android.com.

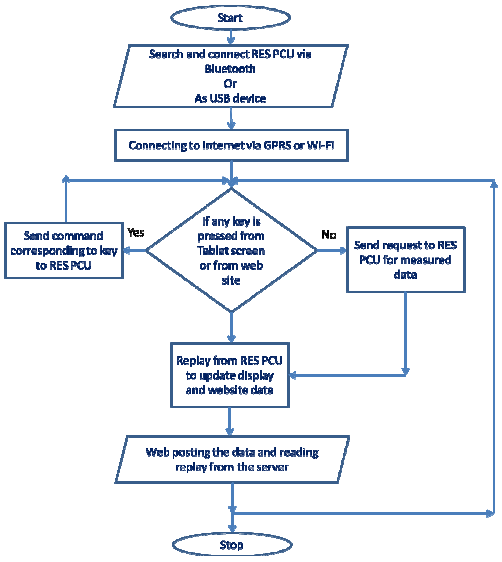

Fig. 2.7 Flowchart of Android application

2) Web monitoring and control

The information from the RES PCU is made available through on-line by an android application. The PCU is communicating to server via this android tablet. The method of web posting is utilized for web enabling the system. The datacommunication between Android tablet and the web server is through a PHP file in the web server and it appends an XML file in the server. The data updated in XML file is read by a Java script function in regular interval. All parameters which bare available in the local display now become accessible to remote user through internet.

The developed web application not only providing the status display parameters but it can also be equipped with control functionalities available to the user. The authorized user can login with valid password and control the system remotely. Figure 2.8 is the screen shot of on-line monitoring system

Fig. 2.8 Screen shot of on-line HMI

This Android based local HMI and on-line monitoring system is feasible and cost effective solution for monitoring of RES PCUs where a single platform can replace both local HMIwith graphical LCD and keypad. The on-board web server for web enabling of the system is established without any additional requirements with the help of UART module embedded inside digital controller hardware of RES PCU, Since UART is a cheap and common interface in almost every micro controllers and DSPs available in the market. Nowadays, the price of Android based tablets are being reduced and this display can also be used as a local storage infrastructure for logging of important events and data for post analysis.

III. COST COMPARISON TABLE

The Table I shows the Cost comparison between the proposed Android based online monitoring and control with Rabbit core/ Microchip Ethernet and similar microcontroller based conventional online monitoring and control system.

The existing user interface with local display and keypad can also be replaced with the Proposed Online Monitoring systems with Android tablet. The Table II

shows comparison with Android display with conventional Graphical LCD (GLCD) with keypad interface

The cost saving information is manifest from the Table I & II. For the conventional system, the total cost is evaluated as`25,200(Approx.) whereas the proposed android based monitoring system is only `7,300(Approx.).So, it is evident that the proposed system has the capability to achieve the cost effective solution with additional communication infrastructures that can be located in remote/rural areas

IV. SUMMARY AND FUTURE SCOPE OF THE WORK

Field evaluation of the developed system with 25 kWp Solar PCU is carried out and established as a good alternative to its counterparts. Most of the RES power plants are very remotely situated and communication infrastructure available at such areas may be limited. Using this platform, we can choose the internet connection via Wi-Fi or GPRS based on the availability.

Grid integration of large RES power plants can be triggered by on-line monitoring & control of RES PCUs. More complex control methodologies can be developed for Grid integrated RES power plants instead complete shutdown of RES plants in case of grid failure as higher capacity RES plants are being installed. This system may be integrated as a part of smart grid technology.

TABLE I.
COMPARISON BETWEEN CONVENTIONAL & PROPOSED SOLUTIONS FOR ONLINE MONITORING &CONTROL

Parameters	Conventional Online Monitoring System	Proposed Android Tablet based Online monitoring System
Communication link between RES PCU and Ethernet	Can be achieved through Rabbit core processor (RCM3000) cost ₹ 8,000	Serial to Bluetooth converter module(HC-04/HC-05/HC-06) cost ₹ 600
Establishment of internet connection	Requires internet modem with public IP address approximate cost ₹ 6,000 per annum	The Existing webserver inbuilt with Public IP can be utilized thereby avoiding the use of internet modem
Other maintenance cost	Renewal of Public IP every year and each system need unique IP, so this cost will get multiplied while number of system increases	Since web posting method is used with unique login gateway /unique domain name, Cost won't change irrespective of number of system

TABLE II.
COMPARISON BETWEEN CONVENTIONAL &PROPOSED SOLUTIONS FOR LOCAL HMI

Item Resources	Conventional GLCD System	Proposed Android based system
Display device	Graphical LCD 128x64 (CFAG320240CX-YMI-T) cost ~ ₹ 6,200	Cheap android tablet cost ~ ₹ 6,500
Keypad	16WAY Keypad(GS160201) cost ~ ₹5 ,000	Utilizing tablet's touch pad

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