International Journal of Scientific Engineering and Applied Science (IJSEAS) - Volume-1, Issue-8,November 2015
ISSN: 2395-3470
www.ijseas.com

PV SYSTEM FOR RESIDENTIAL MONITORING SYSTEM BASED ON POWER LINE COMMUNICATION

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Abstract

In human life management and residential areas electricity energy have been efficient source in consumption for home appliance and user terms. Nowadays photovoltaic system based technology has been largely used in residential areas in order to reduce use of electric energy and cost base. In many cases PV based system has not detail monitored in performance of system. Through detail monitoring it has give detail performance and functioning of PV system. To obtain these needs PV based monitoring system this paper proposes PV system for residential monitoring system based on low cost power line communication and way to provide monitored detail. In cost reduction base it has developed without communication modem but it cause many technical problems and huge man power as employee. This paper propose, in detail monitoring system it has developed with communication modem and has PV module, through data logger shows the monitored data detail in each PV module and PV inverter. In order to obtain detail monitored data, smart app is used to indicate data detail as graphically representation. This method also proposed in field test, through PV monitoring system is also used and deployed in real PV system its situation can understand through smart device such as laptaps, mobile etc. This paper is implemented to provide save electricity consumption and to reduce cost in energy by developing PV system in residential areas.

Index Terms—*Photovoltaic system, Reduce electricity consumption. Low cost, Smart device, Monitoring system.*

I. INTRODUCTION

For several years of decennium, In residential areas electric energy consumption have increased constantly through many reasons such as home appliance, commercial use in consumer based types. In residential areas total electricity consumption have increased in range of 47.8%. Many technology and methods have implemented to reduce electricity consumption for consumer needs. In many residential areas inverters, batteries, generators have used for electricity consumption. By usage of these type methods it cause high power consumption and high cost in installation and in implementation. It uses electrical energy for power storage for power supply. The photovoltaic energy source is one of the most efficient and fore standing method in renewable energies in residential sector that use solar power in power supply.

The PV system has widely deployed in residential sector in order reduce use of utility in electricity. The residential PV system is implemented to reduce electric energy consumption and to minimize cost. Through monitoring it is easier in manage the performance of PV system. In many technology terms residential PV systems have not monitored through that it is difficult to find out performance and status of PV system and data of residential PV system generates. In need of monitoring residential PV system, each PV system has assigned with PV module. Each PV module affects total electricity generation of the whole PV system because the total generation current depends on current of each PV module. In total residential PV system if any one PV module is affected it cause degrade the performance of total residential PV system. Therefore it is necessary to monitoring of each one PV module and important term to maintain proper performance of residential PV system. For easier implementation, user-friendly user interface (UI) is also implemented to provide an easier way in monitoring residential PV system.

From various technologies in communication field can used to monitor the status of residential PV system from each PV module. Both wired and wireless communication technology used in inducement of residential PV system. Wired communication technology has induced with high cost and circuit design is complex. But in wireless technology easier in implementation and circuit

design is simple and man power as employee is in very low level.

Power line communication (PLC) is considered as adequate communication technology. PLC communication technology enables communication over power lines and it does not requires additional communication lines. Many PV monitoring system systems are based upon PLC line technology have been studied. It has been adopted in communication modem which used to modulate signals and demodulate signals. Some communication modems are highly reliable and high cost it makes easier method in monitoring residential PV system. Residential monitoring PV system provides user-friendly way to access to monitoring data. So that only a low cost PLC technology are used in PV system monitoring and to maintain the performance of PV system.

In this paper, a low cost PLC technology has provided for PV system monitoring is developed. Through this technology it reduces the cost of PLC module for PV system monitoring by removing an expensive communication modem. In addition user friendly monitoring system is provided through monitor data logger. It can easily monitor out the status and performance of residential PV system through smart devices.

This paper is extended for preliminary work. Section II provides related works for PLC technology that adopted in residential PV system. Section III describes the proposed system architecture that used in low cost PLC technology and user friendly interface monitoring system. Section IV provides implementation of PV monitoring system and in field test. Finally, section V provides conclusion of this paper.

II RELATED WORKS

Residential monitoring PV system in PLC technology has been used for monitoring in smart grid and home appliance network in residential areas. Both narrow band and wide band are well known technology as international standard PLC technology. PLC technology have widely used in many technology and in many areas. This section reviews various types of PLC technology that provided for PV monitoring system from previous literatures.

Roman developed the intelligent module that has capabilities of maximum power point tracking (MPPT) and PLC technologies are also used in plc communication. The PLC technology has based on frequency shift keying (FSK) with communication features of 132 kHz carrier frequency and 2, 4000 bps of baud rate. Through that a monitoring user interface was not issued.

Jonke developed one master unit and slave units. A power line transceiver added to the microcontroller unit (MCU) in both units for communication. The power line transceiver was provide bit rates from 9.6 kbps to 115.2 kbps. It used a multi phase modulation scheme in the frequency range from 1.75 MHz to 13.0 MHz A monitoring user interface was implemented in desktop PC to control system and visualize the data from master unit.

Sanchez-Pacheco developed monitoring system and communication module working in CENELEC EN 50065 with frequency range of 3 KHz to 148.5 KHz. It supports a baud rate upto 16 kbps. It used FSK modems . The measured PV module transferred string monitoring PLC module. The desktop PC was connected to the string monitoring PLC module and user can check status of each PV module.

Napoli developed a PLC on DC bus with series connected PV modules. A half duplex FSK modem was developed and provides frequency in range of 132.5 KHz with in CENELEC standard C-band. An MCU was connected with PLC FSK modem through serial peripheral interface and send data. A user interface monitoring system show status of each PV module was not provided.

Herndon developed a smart combiner adopting a FSK modem for communication over DC power line. The FSK modem for communication has optimized filters, amplifiers, and cyclic redundancy check (CRC); it also provide with a carrier sense multiple access (CSMA).it modulates the signal in range of 131.85 KHz for logic ‘1’ and 133.3 kHz for logic ‘0’. Its baud rate was 2,400 bps. No monitoring user interface was provided.

Han developed a PV monitoring system base on Home Plug Green PHY (HPGP) PLC modem. The HPGP used orthogonal frequency division multiplexing (OFDM) in frequency range of 2 to 30 MHz It provides in range of 4 Mbps data rates. The OFDM is provided for modulation scheme that has high noise immunity and band efficiency. The renewable energy gateway (REG) aggregate monitored data from each PLC module that deployed with PV modules. Through this method the user can access the REG and they can browse and figure out the status or each PV module and PV system that have monitored in PLC module provided from renewable energy gateway.

TABLE I
COMPARISON OF RELATED WORKS

Authors[reference]	Modem scheme	Baud rate(Kbps)	Frequency
Roman	FSK	2.4	132
Jonke	Multiple Phase	9.6-115.2	1,750-13,000
Sanchez-Pacheco	FSK	16	3-148.5
Napoli	FSK	-	132.5
Herndon	FSK	2.4	131.8, 133.3
Han	OFDM	4,000	2,000-30,000

The related works achieved a PV monitoring is based on PLC technology through PLC modem such as FSK, multi phase and OFDM.
A simple and cheap PLC module is required to PV monitoring system in residential PV system.

III. Residential PV System Based On Low Cost Power Line Communication

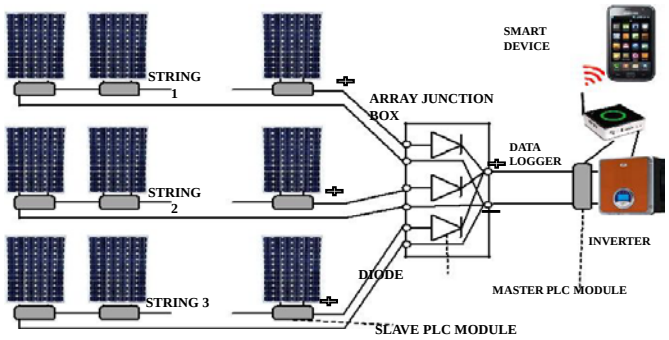
A.PV monitoring System Architecture

A Residential PV system consists of PV modules, an array junction box, and a PV inverter. The PV modules are grouped into one string connection. The PV modules that are in one string connection are connected in series one by one. Each string is connected in array junction box. The power is transferred through PV inverter by DC power line. The residential household is supplied with inverted AC supply.

In this paper, the proposed PV monitoring system is composed of four elements slave PLC module, master PLC module, data logger, smart device. The slave PLC modules are deployed at the rear side of V modules. They measure each PV modules status based on three factors: voltage, current, and temperature. The master PLC module is deployed beside PV inverter. The master PLC module measure data of each PV module.

The data logger is a storage system for PV monitoring data. It is connected to the master PLC module that transfers monitored data value to data logger. The PV inverter communicates with data logger through serial connection. It transfer status such as generated power and energy, voltage and current, and temperature. The transmitted are stored in data logger. The data logger communicates with user interface method.

The proposed PV monitoring system architecture transmit user figure out PV module is normal or abnormal in user friendly manner. Smart device are used to execute smart app to measure and read the status of PV system in residential household. From smart app it can notify user an abnormal PV module. Through that user can identify abnormal PV module.



B. Low Cost PLC module

The proposed low cost PLC module is composed of four parts: a DC/DC unit, a microcontroller unit (MCU), a sensing unit, an analog coupling circuit. The DC/DC unit converts volts PV module down +5 V and -5 V are used for amplifiers.

The turn on and turn off band is also required to protect PV module. The MCU unit measures the voltage, current, and temperature of each PV module using analog-to-digital converter (ADC). A voltage divider is used to measure the output voltage of a PV module.

For data communication MCU use universal asynchronous receiver and transmitter (UART) serial communication. The software used for sensing algorithm in MCU unit.

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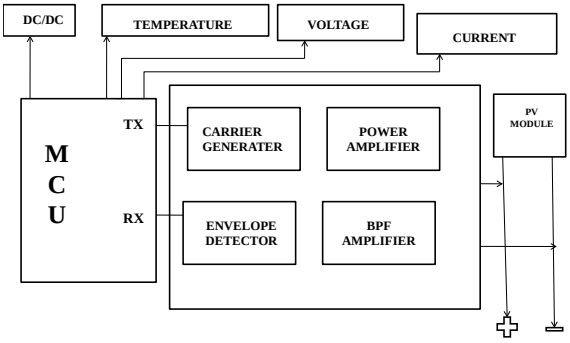

Fig 2. Structured low cost PLC module

The analog coupling circuit is used to communicate signal to and from power line. The transmitting part is composed of carrier generator and power amplifier.

The carrier generator generates a carrier when transmitting signal from the UART is logic system "1" and no carrier when logic "0". The proposed PLC modules use amplitude shift key in digital modulation and ASK signal amplified by power amplifier.

The receiving part has composed of band pass filter(BPF) and an envelope detector.

C. Data logger as monitored data storage

The data logger receives measured data from master PLC module that provide data from slave PLC module. The data logger stores monitored data.

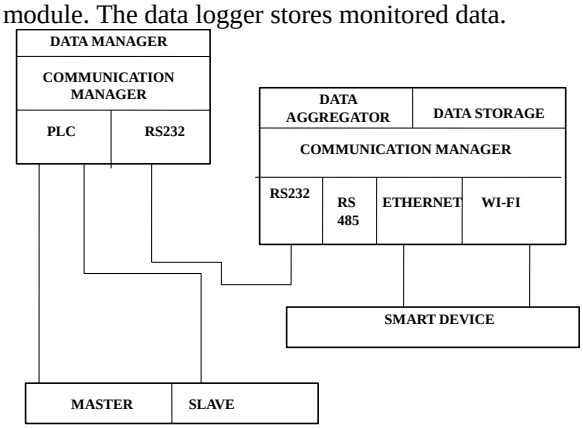

Fig 3. Data logger

IV. IMPLEMENTATION RESULTS

The implemented and developed PV monitoring system is composed of a data logger, PLC modules and smart apps used.

A. Low-Cost PLC module

A low cost PLC module is implemented on 16-bit MCU. It is composed of four parts a DC/DC converter, an ADC and an analog coupling circuit.

Fig 4. PLC modem

The MCU generates 100 KHz carrier and power amplifier amplifies the carrier signal. Through the generated signals the data are monitored in data logger.

B.Data logger and smart app

The data logger provides data storage and point out smart device. The monitor data values shown by graphic value.

```
arrayInfo {
   typeCode = f1
   nArrayNo = 4
   nCount = 1
   stringInfo [0] {
      typeCode = f3
      nStringNo = 1
      nCount = 5
      moduleInfo [0] {
         typeCode = f4
         nModuleqNo = 9
         nInput_V = 45.8 (V)
         nInput_A = 2.38 (A)
         nTemp = 37.8 (C)
```

Fig 5.screen shot data logger

B. Field test

The field test is proposed for PV monitoring system. The PV monitoring system has string connection of PV modules. Each PV modules assigned with characteristic based 51.2 V and 9.2 V and each PV modules are connected in series connection through PV inverter the power is supplied. From data logger the values are monitored.

V. PERFORMANCE AND EXPERIMENTAL RESULTS

In this section we present a set of performance and experimental results. Through this method it reduce total power consumption in

residential areas and industrial areas. The proposed PV generation system and PV modules are well connected in series connection and it provide high power supply and save energy.

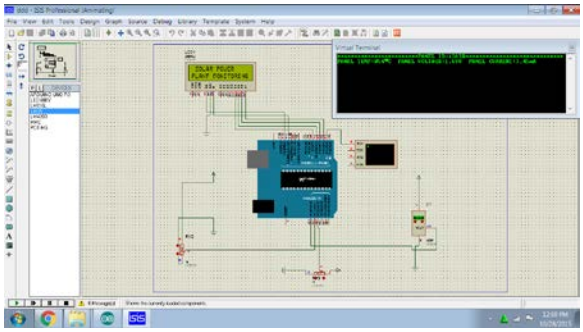

Fig6. Assigning input terms

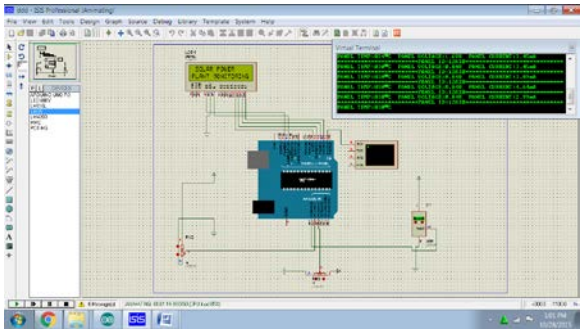

Fig 7.output appear on the screen

It has a much high efficiency which maintaining high power supply and minimize electric energy consumption that simultaneously satisfies residential power requirements.

VI. CONCLUSION

To reduce and save energy cost and electric energy residential PV generation system have widely used in many residential areas. Through proper monitoring of each PV modules its supply power to all users. For low cost implementation communication modem are used to monitor the data of each PV module and showed by graphical method.The field test provide user interface method in residential PV monitoring system.

Through this method we can consume power source without any electric power station and we can store energy and save energy and reduce cost.

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