SMART HYBRID DEVICE

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Abstract : As the world is nearing to a technological singularity our energy needs are increasing day by day. Not only we need to reduce the energy consumption from non renewable sources for the betterment of mother earth but also need to reduce cost. We would need a system which intelligently switches between these energy sources according to the load demand.This system will try to maximize the power from renewable sources like solar energy and use it whenever possible. Our system is specifically is designed to be used with solar PV-systems. This system is designed to be used specifically with on grid type solar inverters. These type of inverters do not have storage capability, instead they take power from other energy sources to synchronize with phase and frequency. This accounts to approximate 30 % of power supplied by inverter, rest will be supplied the solar cells. This system monitors load power requirement with the help of a energy meter. It will also have a smart switch connected to it for switching between other loads when the PV-system is unavailable. To the switch energy sources like DG generator and Grid power can be connected. It will also have a SD card and flash/EEPROM memory interfaced for storage of past data collected. System will also be interfaced with RTC for real time data collection and monitoring.

IndexTerms **- -Pv system,energy meter,microcontroller,modbus,energy management**

I. INTRODUCTION

The greatest boon the 20th century gave to mankind is invention of electricity. Slowly as the time passed by all the inventions and research was centered around it. Today we cannot even comprehend a single day without it. As we know the world today is going through what we call as the 4th industrial revolution. With this all the devices in this world will be connected with each other.Also today all the cutting edge research is going on in what we call Artificial intelligence(A.I).And as we all know Artificial intelligence relays on one thing that is huge amount of data. This data is of the magnitude of 10^18 bytes.Which require huge amount of data centers for storage. To fulfill such big dreams what we require is power. This power requirement can be fulfilled by various energy sources such as solar,wind,hydro,coal,nuclear,biomass etc. All of these energy sources do not have same impact on environment.

Those which are not replenished in human timescale are termed as non renewable energy source.Those energy sources which are replenished in human timescale are termed as non renewable energy sources. Also these non renewable energy sources such as fuel,coal,nuclear are harmful to the environment and they are fast getting replenished. Therefore we need to find alternative way to get energy. This project is concentrated on one of the many available renewable energy sources,Solar energy. As we all know,this solar energy is getting more and more popular and replacing conventional energy sources. This design is meant to be used in compliance with Solar energy. There are mainly two type of solar inverter available in the market based on its storage style and functioning,these are called on grid and off grid type solar inverter. This classification is based on whether it can store energy,to be used when solar energy is not available. The off grid type has storage available in the form of either super capacitor or battery.But this increases cost and size.What our product is designed to be used with is called as the on grid solar inverter. The on grid type needs a alternative energy source to synchronize and provide power. This type of inverter cannot be operated at night time or when it is cloudy. Therefore it needs a compliance system with it, to prevent degradation of user experience due to frequent power cuts. The inverter used is string type inverter.This string type will aggregate all the small voltages to produce bigger voltage which will be converted into AC supply by the inverter.This design will need a energy meter which supports modbus RTU. This will communicate with controller with this protocol. The meter is used to continuously monitor the load conditions. The controller will communicate with the solar inverter string using modbus Ethernet protocol. The string of inverter will be connected to a switch or hub. The controller will also be interfaced with SD card/Nand flash to store the data.The data can be used to further gain insight about the pattern of load. It will also be interfaced with EEPROM to store any type of permanent data. It will also be interfaced with RTC to keep track of the time and date and will be used to store the data with time stamp. The controller will control the alternative energy sources,namely Diesel Generator and Grid power through a Relay or a no contact switch. In this inverter,the grid which is used to kick start the inverter provides approximately 30% of the overall power to the load. The inverter will automatically control the percentage of power provided,according to the weather conditions and the cloud cover. This is possible through the use of Maximum solar power point tracking system (MPPT) Algorithm.

II. RELATED WORK

This system is designed with the aim of reducing carbon emission and cost for the user,also it can be installed in remote areas and villages where solar energy is available in abundance.The load is continuously monitored to prevent under-loading and

overloading.This will in turn improve overall experience of the user as in [1]. The hybrid system also has advantage of improved power quality and stability as compared to regular energy source. This hybrid device can also be further improved by using energy sources such as wind and fuel cell instead of diesel generator and grid to further reduce the carbon emission and impact on the environment as in [2].

The hybrid device comes in many different forms such as parallel,switched,centralized,distributed as in [3]. The further improve efficiency and versatility of the system support for both on grid and off grid inverter can be added as in [4]. To further improve load forecasting and load line fluctuation prediction we can install this system at two locations,one in a centralized system and other at as a local system , and have a communication between the two as in [5]. This hetrogenous no of load and energy sources are modeled as separate entity,each ably to communicate with the controller as in [6]. The data generated and stored will be used to generate insight from data using Artificial intelligence algorithms as in [7]. The communication between the microgrid and the centralized grid can facilitated with the use of zigbee technology as in [8]. The system integrates Demand side system with Energy management system to improve efficiency as in [9]. The system can be integrated in rural areas which get solar energy in abundance and experience frequent power cuts as in [10]. To facilitate need for communication between various entities in the system,master slave protocol such as modbus was implemented as in [11].

III.RESEARCH METHODOLOGY

This system uses a ARM cortex M4 powered microcontroller which is a 32 bit microcontroller,used for faster processing power. It also has inbuilt RTC,SD card slot, Nand flash,EEPROM along with RS485 and Ethernet interface support which drastically reduce cost and space, as discrete components are not required. Apart from this there are various things required, such as timer,DMA,interrupt. These peripherals come inbuilt in the microcontroller,no external interfacing is required. Now let us look at roll of each block and its interfacing with the microcontroller in detail. First we will connect the energy meter to monitor the electrical parameters of the load like power,voltage etc. This is required because depending on that the energy source are required to send power to the load. The energy meter is a computerized one unlike the traditional meter found in our homes. So it is interfaced with the microcontroller on a RS485 serial line. As we know RS485 uses differential Signalling to transmit and receive instead of a single ended as in case of RS232, to reduce noise and corruption of data along with long distance transmission. This will communicate with the controller using Modbus RTU protocol over RS485 serial line. The controller's USART is programmed for this purpose.The Modbus RTU is a master-slave protocol,therefore for one request only one response is sent.Therefore programming the inbuilt advanced control timer in the microcontroller for accurate delay, we request the electrical parameter once every 5 seconds to the energy meter. The response is processed and converted into proper format. The power received is then monitored, to make sure that enough power is provided to the load. Also the data is sent to SD card/Nand flash for storage,which will be used for gaining insight from data and further optimization of energy supplied. Now let us look at how the SD card will be interfaced. SD card as we very well know will communicate with the controller with SPI protocol,which is the preferred protocol to communicate with SD card. Also with the microcontroller having native support of SD card. The job only becomes easier to program and store data in it.Also the flash memory can be interfaced for added storage. The EEPROM,which is also present on the controller board can be used to store permanent storage such as OS and firmware. Also the RTC is used for keeping tab of time,so that data can be collected in real time. The data will be stored along with time stamp.This can help to get data of specific date and time if required.The RTC can also be interfaced externally using I2C protocol. But as in our case it is integrated in microcontroller itself there is no need to connect externally. To deliver sufficient power,one inverter driving a PV system may not suffice,So in this case a string of inverter will be connected to a hub or switch.This switch will communicate with the microcontroller using Modbus Ethernet protocol. This is done to get faster speed in comparison with serial communication. The Ethernet can provide speed up to 100Gbps. We can send packet requesting the inverter to turn on and percentage of power to deliver. Apart from this the inverter we are using is a on grid inverter.It means it does not have any storage capacity. It takes power from either the grid or diesel generator to synchronize itself and will provide 70% of total power,rest will be provided by grid/DG. As a result it cannot provide power when the other energy sources are not available. This is the disadvantage of this system.To overcome this, a off grid inverter can be used,but it comes with its disadvantage of additional cost and size. Therefore at least one energy source has to be available other than the PV system at all time. At night when PV system is unavailable,this system can provide power to the load. The loads are connected to the microcontroller through a no contact(NC) sensor or a relay.In this way this system takes care that the load is always powered. This system will also take care that the PV system has the highest priority, to use it whenever possible,thus reducing cost and increasing utilization of renewable energy.

IV.HARDWARE IMPLEMENTATION

The block diagram below depicts the prime components of the project. They are as follows:

1.ARM cortex M4 microcontroller

2.Energy meter

3.RTC

4.Flash/ROM chip for storage

5.Diesel generator

6.Grid power

7.A Ethernet switch

8.String of inverter

9.Load

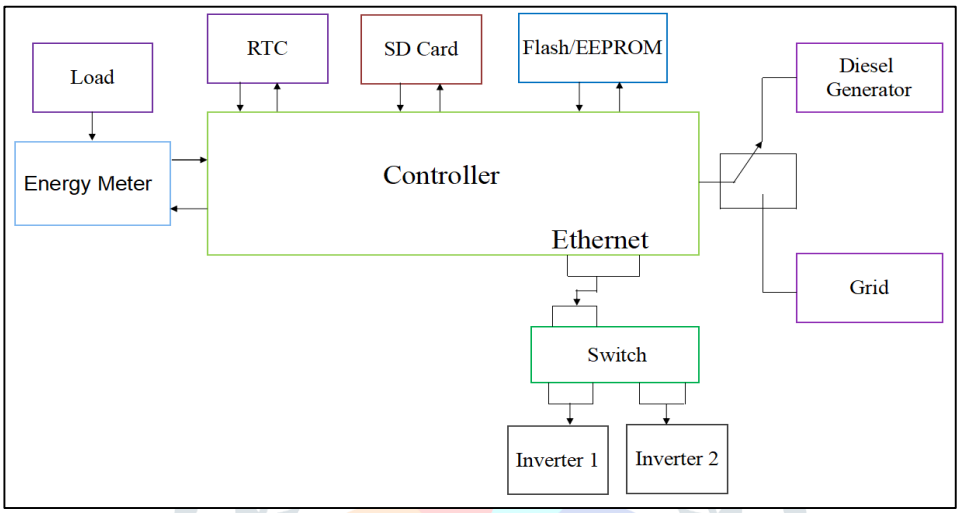

Fig.1 Block diagram of project

Fig 1. shows a small scale implementation of the project for testing purposes.

Solar inverter: The solar inverter is a on grid type,which has to have a alternative power supply connected to it at all times for it to function. This is used for synchronization and start up purposes. The excess load can also be sent back to the grid for overloading protection purposes. A typical solar cell array produces voltage in the range of 500-650 volts.Which when connected in a string fashion can provide voltage in the range of kilo volts. The solar cell array is controlled by a device which has the Maximum power point tracking (MPPT) Algorithm implemented. The energy generated is then converted into AC source by use of Insulated Gate bipolar transistor (IGBT) connected in a H bridge fashion.These IGBT connected in H bridge fashion are On in alternative cycles providing AC power in the output. This power is then fed into grid or can be used by the user. Fig 2 shows the flow of power in a flowchart fashion.

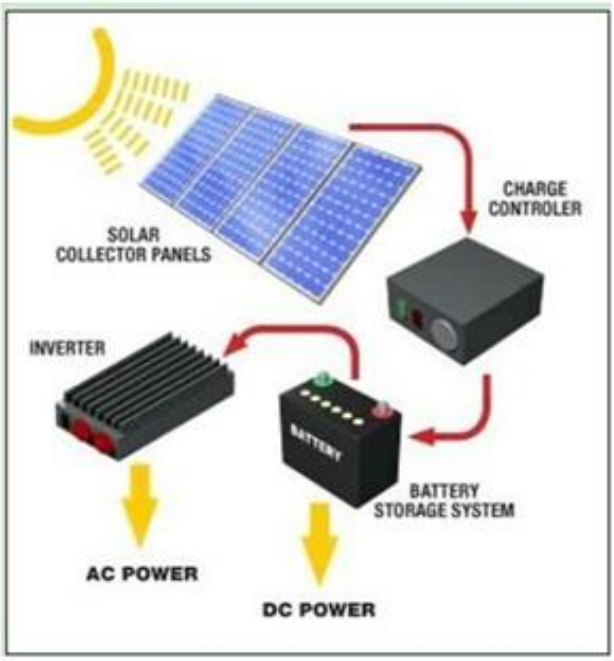

Fig 2. Solar inverter system

V. SOFTWARE IMPLEMENTATION

A. Algorithm:

1.Request the energy meter to send the power consumption of the load every 10 seconds.

2.Process the received packet by converting it into floating single precision big endian format.

3.Store the received data with timestamp from RTC in flash/SD card memory.

4.Compare the load requirement with the PV system ‘s current power providing capability.

5.Check the register on the inverter to check if the PV system can provide sufficient provide power.

6.This has to be continuously monitored.

7.And in a preset time(in evening) the system will automatically switch to either grid or DG power supply.

B. Flowchart

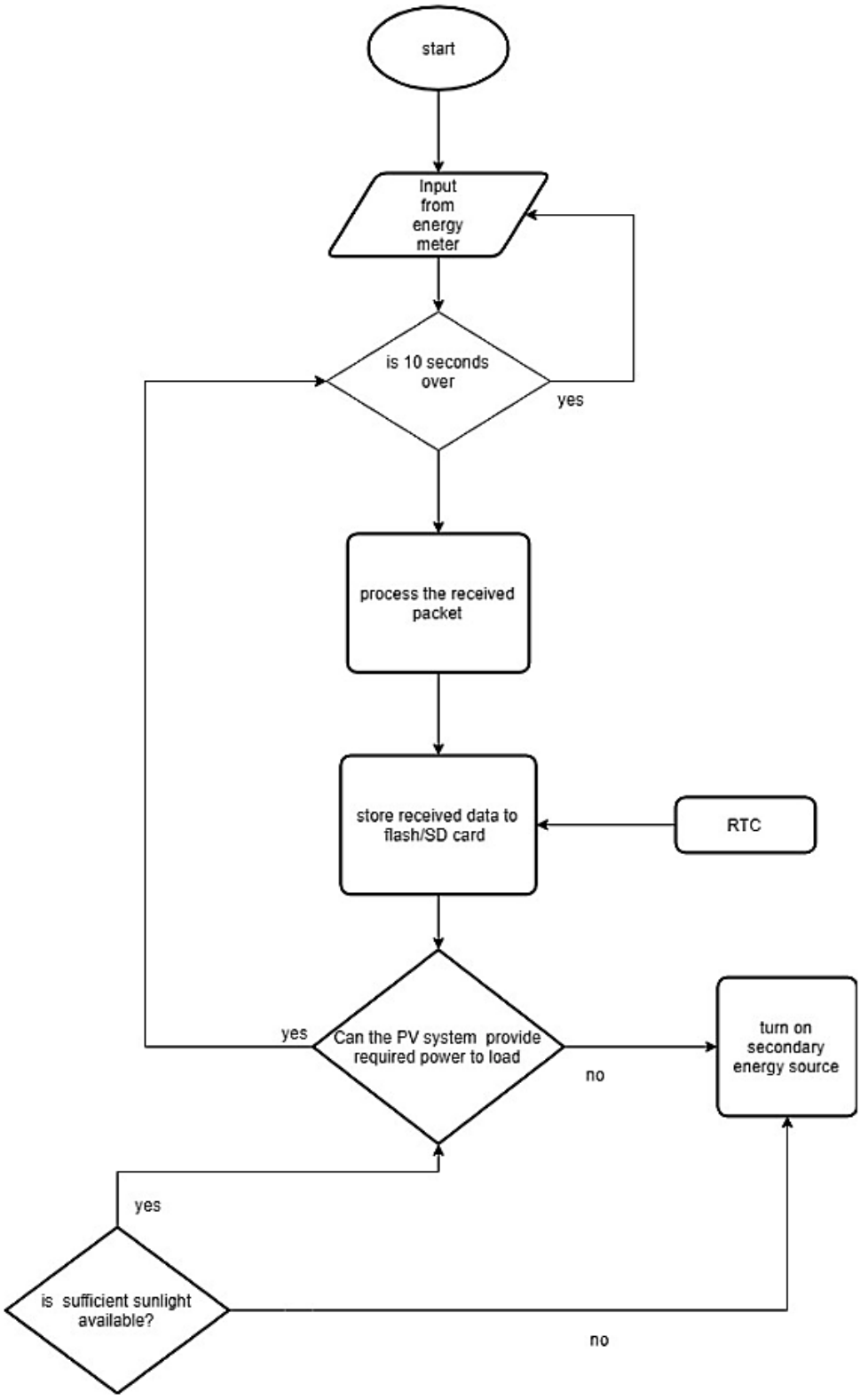

Fig 3. Flowchart of Design

Fig 3. shows a high level algorithmic flow of how one system entity will interact with other step by step. First the energy meter will take input from load and send the monitored data over a RS485 line to the controller. The controller then stores the data in either the Flash/SD card. This then based upon the retrieved packet takes a decision or keeps receiving further packet every 10 seconds.

VI. RESULTS AND DISCUSSION

Fig 4. Shows data received from energy meter/inverter in modbus simulator

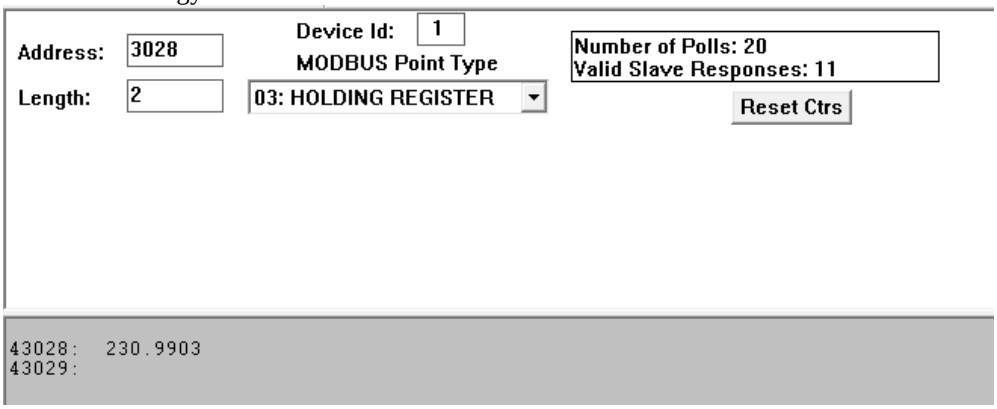

Fig 4. Screenshot of modbus simulator

Fig 5. Shows sent packet from controller to energy meter/inverter

START	ADDRESS	FUNCTION	DATA	CRC CHECK	END
T1–T2–T3–T4	01	03	43 68 78 6B	0D 84	T1–T2–T3–T4

Fig 5. data packet sent from microcontroller

Fig 6. Shows a slave simulator used to test the microcontroller side ‘s packet sending capability.

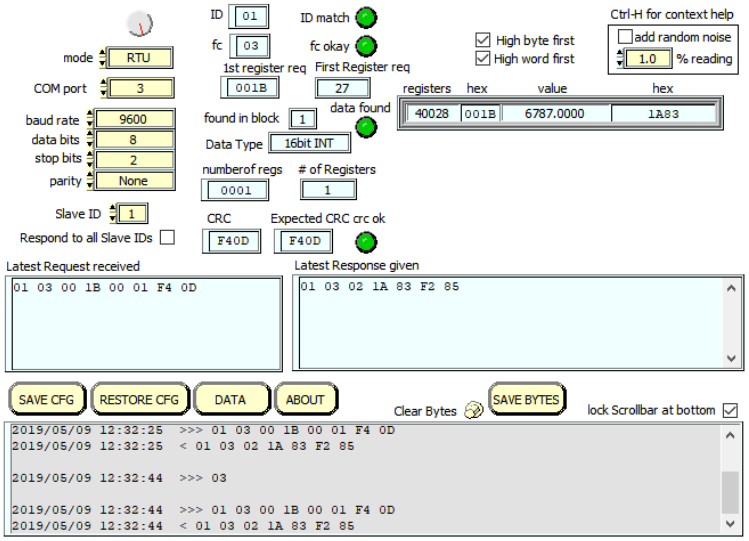

Fig 6. Screenshot of slave simulator

The above pictures depict the testing of modbus protocol.Also Storage using SD card and Nand flash was implemented. Timer which gives accurate delay was designed to give a 10 seconds delay. RTC was successfully synchronized,to use in tandem with the storage medium. Also the communication with a single inverter was implemented,the same can be extended to a multilevel inverter system. The Nand flash and RTC was integrated on the same board as the microcontroller to save space and cost.
A relay was implemented to energize the alternative energy sources. The energy sources used was Diesel Generator and Grid electricity.

VII. ADVANTAGES AND FEATURES OF MODEL

This configuration has advantages as discussed below:

- Cost:
  Due to use of PV system most of the times,the cost associated with energy sources such as generator or state electricity board charges is reduced.
- Environment friendly:

This design uses renewable energy source,therefore it reduces carbon footprint and makes electricity production more eco-friendly.

- Stability:
  This design is more stable by avoiding voltage overshoots and forecasting load fluctuations and power line failures.
- Reliability:
  If PV-system fails due to some reason, the alternative energy source will automatically turn on thereby making the system more reliable and robust.

CONCLUSION

In this project a hybrid device was designed and implemented. This device helps to reduce cost and reduce carbon footprint. This system can be implemented in any rural area where sunlight is available in abundance and its energy can be harnessed to generate energy. This device also increases stability by staying close to the demand side,by making use of predictions regarding load and power line fluctuations before hand. This project was designed with Diesel Generator and Grid as alternative energy sources.These can be replaced by Wind or biomass energy sources to make it a fully environmental friendly device.

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REFERENCES

[1] .Abhiraj Tawde, Rashmi Chaugule,Rohit Yadav, Solar Hybrid Inverter System Using PIC18 Microcontroller, Volume 9, IOSR Journal of Engineering (IOSRJEN) Pages 09-11

[2]. Aditi,Ashok Kumar Pandey,A Review Paper on Hybrid Power System with Different Controllers and Tracking Methods,International Journal of Engineering Research & Technology (IJERT), Vol. 5 Issue 01, January-2016

[3] Md. Ibrahim, Abul Khair, Shaheer Ansari , "A Review of Hybrid Renewable Energy Systems for Electric Power Generation " in Int. Journal of Engineering Research and Applications , 2017,Vol. 5, Issue 8, (Part - 1) August 2015, pp.42-48.

[4] S.Pradeep,M.Senthil Kumar.Energy Management for on-Grid and Off-Grid Systems Using Hybrid Energy Sources in International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 6 (2018) pp. 3907-3912.

[5]Frédéric Colas, Di Lu, Vladimir Lazarov, Bruno François, Hristiyan Kanchev. Energy management and power planning of a microgrid with a PV-based active generator for Smart Grid Applications. IEEE Transactions on Industrial Electronics, Institute of Electrical and Electronics Engineers, 2011,58 (10), pp.P. 4583-4592. <10.1109/TIE.2011.2119451>. <hal-00713617>

[6] M. Cirrincione, M. Cossentino, S. Gaglio, V. Hilaire1, A. Koukam1, M. Pucci, L. Sabatucci, G. Vitale "Intelligent Energy Management System" in IEEE Xplore,on July 2009

[7] Francisco-Javier,Ferrández-Pastor, Sergio Gómez-Trillo, Mario Nieto-Hidalgo,Juan-Manuel,García-Chamizo and Rafael Valdivieso-Sarabia "Intelligent Power Management System Using Hybrid Renewable Energy Resources and Decision Tree Approach" in mdpi , Proceedings 2018, 2, 1239

[8] R. SUNDARARAJAN, S.VINOTH KUMAR, V.LAVANYA "Smart Energy Distribution Management with Solar - Grid connected Multilevel Inverter" in International Journal of Research in Advent Technology, Vol.2, No.5, May 2014 E-ISSN: 2321-9637

[9] Carlo Cecati, Fellow, IEEE, Costantino Citro, and Pierluigi Siano, Member, IEEE "Combined Operations of Renewable Energy Systems and Responsive Demand in a Smart Grid" in IEEE Transactions on sustainable energy, Vol. 2, no. 4, October 2011

[10] Yashwant Sawle, S.C. Gupta1 and Aashish Kumar Bohre "PV-wind hybrid system: A review with case study" inSawle et al., Cogent Engineering (2016), 3: 1189305

[11] Vehbi C. Güngör, Member, IEEE, Dilan Sahin, Taskin Kocak, Salih Ergüt,Concettina Buccella "Smart Grid Technologies: Communication Technologies and Standards" in IEEE Transactions on industrial informatics, Vol. 7, no. 4, november 2011