SUMMER INTERNSHIP REPORT

ARTRO ENERGY

Predictive Maintenance of Grid Tied Solar Power Plant

Submitted by:

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2015104043

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Preface

This report documents the work done during Summer Internship at Artro Energy, an IoT based Start-up, incubated in Centre for Professional Development, Anna university, Chennai. I had done internship on Solar Asset and Predictive maintenance. The report shall first give an overview of tasks completed during the period of internship with technical details. Then the results obtained shall be discussed and analysed.

Report shall also elaborate on the future works which can be persuaded as an advancement of current work

Raghul Raj N

Synopsis

- Abstract
- Problem Statement
- What is Predictive Maintenance?
- Our Solution
- Components Used
- Technical Details
- Case Study
- Dashboard Developed
- Installed Prototype
- References
- Conclusion

Abstract

To increase the utilization and development of solar energy which is Eco friendly. Weather Predication is done in order to improve the performance and maintain its consistency for long term to deliver secure and reliable power while managing uncertainties. In order to enhance and improve the performance, preventive maintenance of solar power plant is done by implementing Operation & Maintenance (O&M) activities using IoT. With the help of internet(cloud)along with IOT devices, Operation and maintenance can be improved. Many industries in India are working towards increasing the performance ratio of solar power plants in large scale.

The report presents the tasks completed during Summer Internship at Artro Energy are listed below:

1) Development of Hardware to Communicate with Inverter using MODBUS protocol
2) Development of Cloud Dashboard for the remote monitoring of 10KW Grid tied Solar Power plant.

Above tasks were completed successfully and the Prototype is currently installed in Institute of Energy Studies, Anna university, Chennai.

What is Predictive Maintenance?

Predictive models (based on machine learning algorithms) aim to assess future outcomes based on analysis of past & present data. Increased processing power, availability of cloud infrastructure and commoditization of data mining has helped these models to move from the “lab” to the realm of “real time decision making”. Maintaining and operating renewable assets according to data driven approach requires tons of data: real time data, historical data, data from similar assets and past maintenance records. The standard maintenance methods adopted are –

- **Periodic** – Conduct checks and replace components at defined frequency
- **Reactive** – Repair the asset or its subsystem after it fails
- **Preventive** – Service the equipment according to the OEMs suggested schedule or based on operational observations

Using the Internet of Things Technology for supervising solar photovoltaic power generation can greatly enhance the performance, monitoring and maintenance of the plant. With advancement of technologies the cost of renewable energy equipment is going down globally encouraging large scale solar photovoltaic installations. This massive scale of solar photovoltaic deployment requires sophisticated systems for automation of the plant monitoring remotely using web-based interfaces as majority of them are installed in inaccessible locations and thus unable to be monitored from a dedicated location. For implementation of new cost-effective methodology, IoT can be used to remotely monitor a solar photovoltaic plant for performance evaluation. This will facilitate preventive maintenance, fault detection, historical analysis of the plant in addition to real time monitoring.

Problem Statement:

IES (Institute of Energy Studies) in Anna University has invested in rooftop solar installations in its building with capacity of 1 0 kW in 2015. If the power generated by the PV Modules exceed more than 6.5 kW out of 10 kW of the installed capacity, then the MPPT efficiency of the Inverter reduces to less than 20%. This event happens during peak sun-hours generally from 10.00 am to 2.00 pm. The plant has been installed with Inverter of capacity 10kW with 2 MPPTs each connected with PV string of 5 kW.

Our Solution:

To create a remote monitoring system of Solar inverter and tracking the performance of plant. The system runs all the day collects data from the inverter through **MODBUS** communication and send the data to cloud platform via Internet. The system also locally saves the Data in local **Sqlite3** database, so in case of any network problem, system automatically send the missing data to cloud once the connection is restored. We used **Raspberry pi** to communicate to inverter and for sending Data to the cloud. We used **Ubidots** as our cloud platform to visualise the data using a web browser without any additional software

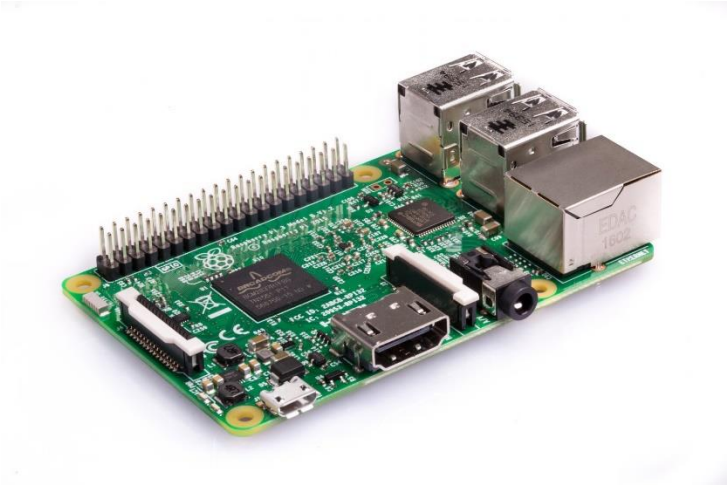
Components Used:

- Raspberry pi
- RS232 cable
- Wi-Fi modem

Raspberry pi:

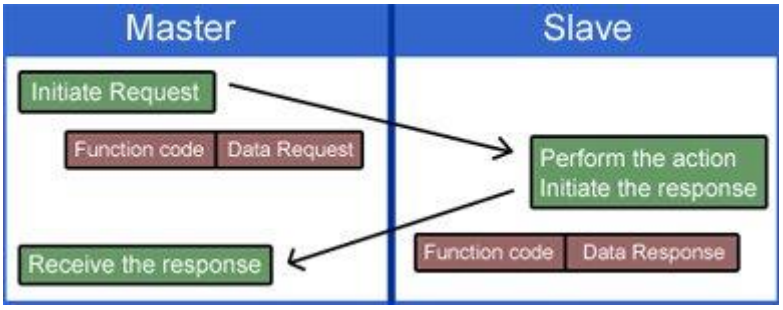
Raspberry pi is a single board computer which runs on Ubuntu platform.

- Broadcom BCM2387 chipset
- 1.2GHz Quad-Core ARM Cortex-A53
- 802.11 bgn Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)
- 1GB RAM
- 64 Bit CPU
- 4 x USB ports

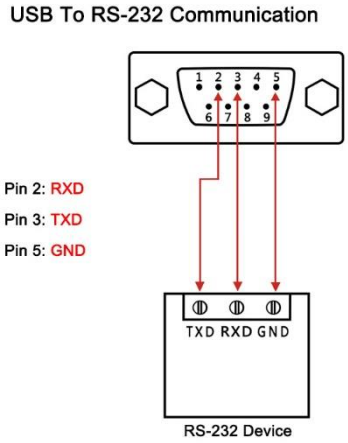


Modbus Communication:

Modbus RTU is an open, serial (RS-232 or RS-485) protocol derived from the Master/Slave architecture. It is a widely accepted protocol due to its ease of use and reliability. Modbus RTU is widely used within Building Management Systems (BMS) and Industrial Automation Systems (IAS). This wide acceptance is due in large part to MODBUS RTU's ease of use. MODBUS is considered an application layer messaging protocol, providing Master/Slave communication between devices connected together through buses or networks.



RS-232 is a standard communication protocol for linking computer and its peripheral devices to allow serial data exchange. In simple terms RS232 defines the voltage for the path used for data exchange between the devices. It includes specifications on voltage levels; slew rate and voltage withstand level. RS232 pin out signals are represented by voltage levels with respect to common. It specifies maximum circuit voltage as 25v. At the transmitter side, driver output specifies voltage +3v to +15v as high level and -3v to -15v for low level. In the same way for the receiver output high level for voltage is +3v to +15v and low-level voltage is -3v to -15v. It should be known that the receiver logic provides the +2v noise margin. The output signal level usually swings between +12V and -12V.



Programming language - Python:

Python is an interpreted high-level programming language for general-purpose programming. It provides constructs that enable clear programming on both small and large scales. Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object-oriented, imperative, functional and procedural, and has a large and comprehensive standard library.

For Storing the data - Sqlite3:

SQLite is an in-process library that implements a self-contained, serverless, zero-configuration, transactional SQL database engine. The code for SQLite is in the public domain and is thus free for use for any purpose, commercial or private. SQLite is the most widely deployed database in the world with more applications.

For Cloud Dashboard- Ubidots:

Ubidots is an Internet of Things (IoT) data analytics and visualization company, which turn sensor data into information that matters for business-decisions, machine-to-machine interactions, educational research, and increase economization of global resources.

Ubidots technology and engineering stack was developed to deliver a secure, white-glove experience for our users. Device friendly APIs (accessed over HTTP/MQTT/TCP/UDP protocols) provide a simple and secure connection for sending and retrieving data to and from our cloud service in real-time.

Algorithm:

The raspberry pi connected to the inverter via RS232 will poll the inverter on a regular interval say 150 sec. In MODBUS protocol, Data are stored in their corresponding registers by polling the correct register we collected the required data.

For example, in Growatt 10000UE inverter, register 33 corresponds to temperature of the inverter. This data is converted into JSON format (Java script object notation). This is used for storing and exchanging data. Once the data is converted into JSON format, it is pushed to cloud via HTTP protocol. If the return value is 200, posting is successful otherwise there may be some network issues. Also, all the data are stored locally in a Sqlite3 database on a daily basis. Once the network issue is solved, all the missing data is pushed to the cloud. This also helps the user to retrieve the data later for analysis. These data are converted into Graphs and Charts in Ubidots cloud platform. This gives user an easy understanding about the current working status of Solar plant.

Case study of Energy losses:

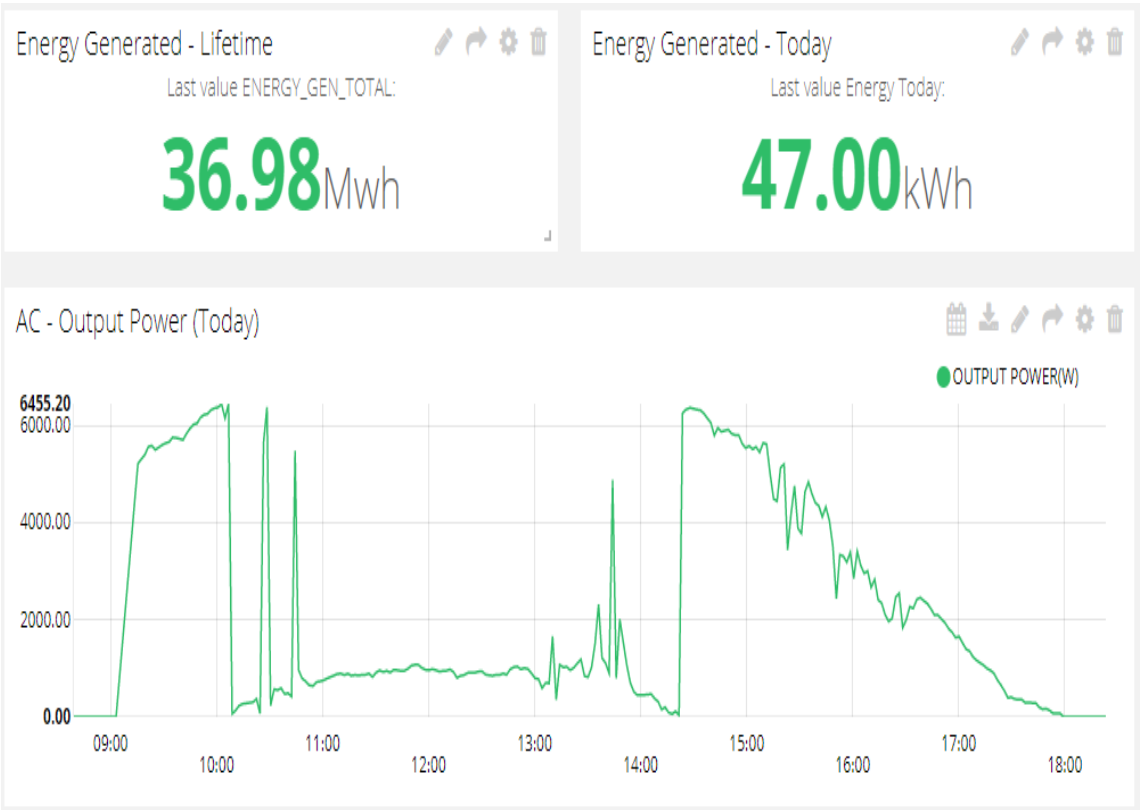
Peak Sun-hours = 10 am to 2 pm.
Average Input power generated during Peak Sun-hours = 7.5 kW
Peak Sun-hours duration = 4 hrs.
Total energy generated by PV modules = 30 kWh

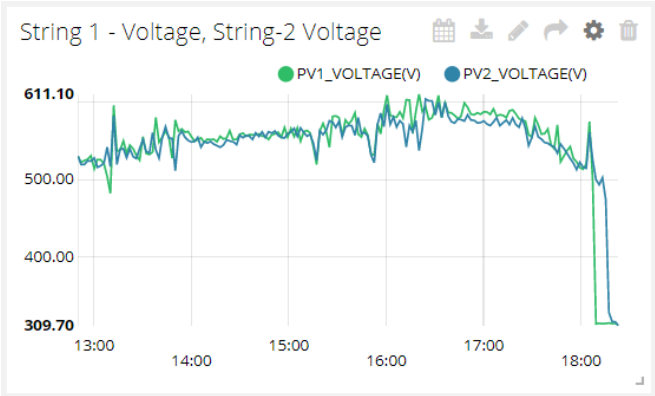
MPPT is operating with the efficiency less than 20% during the Peak sun-hours.
MPPT Loss = 80%
Total energy loss = Total energy generated by PV modules (kWh) X MPPT Loss (%)
Total energy loss = 24 kWh
The case study showing the impact of **loss of energy of around 240 kWh/ Month** if the above event is not rectified for a long time

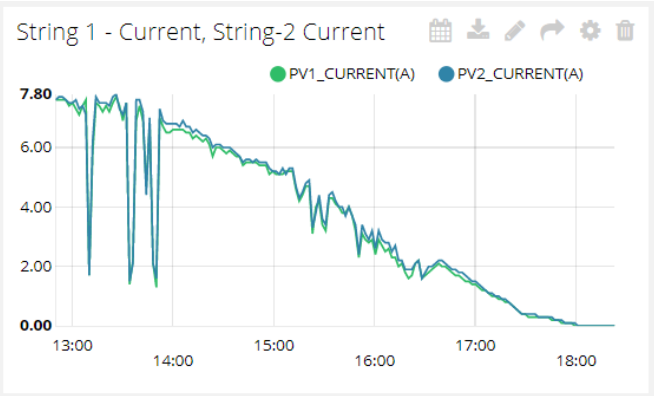
Energy loss per day in units = 24 kWh (Approximate)
No of day with energy loss in a month = 10 day
Total energy loss in units for a month = 240 kWh (Approximate)

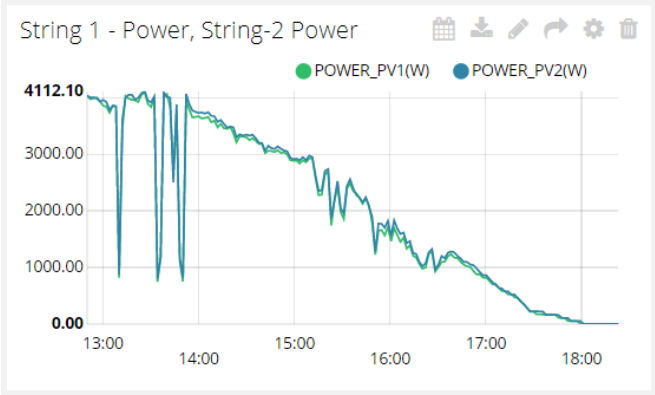
Our Prototype is an integrated, OEM independent solution for managing the performance and the health of solar plants which helps in achieving lesser energy bills for commercial and Industrial buildings. Key metrics such as performance and yield can be obtained easily through any web browser or mobile device from anywhere in the world, without the requirement of any additional software.

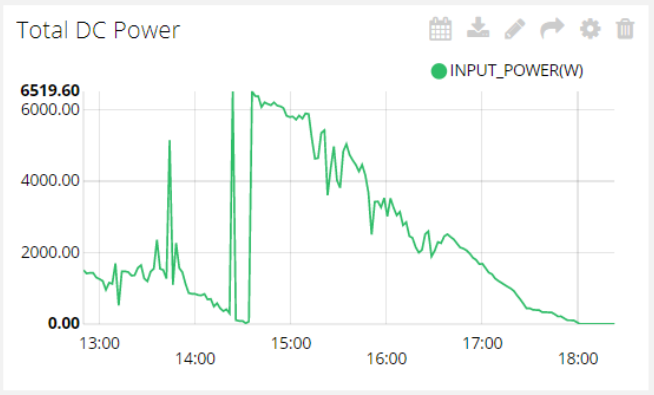
Our Dashboard:

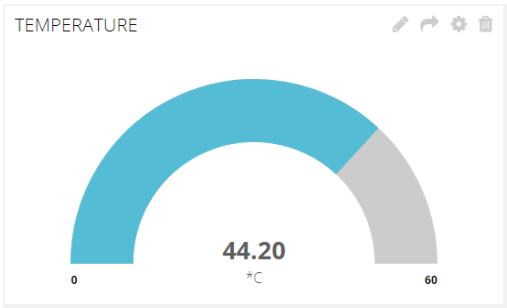








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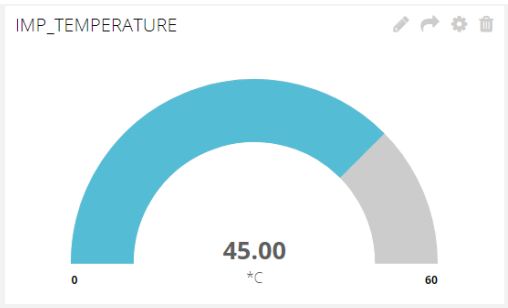
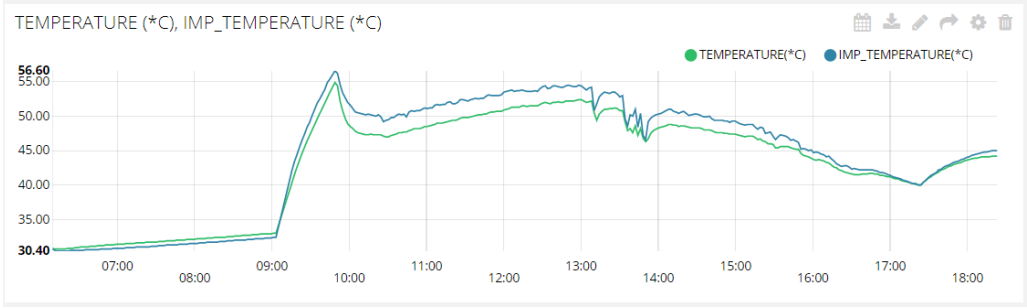
44.20
*C
0
60


IMP_TEMPERATURE
45.00
*C
0
60


TEMPERATURE (*C), IMP_TEMPERATURE (*C)
TEMPERATURE(*C)
IMP_TEMPERATURE(*C)
56.60
55.00
50.00
45.00
40.00
35.00
30.40
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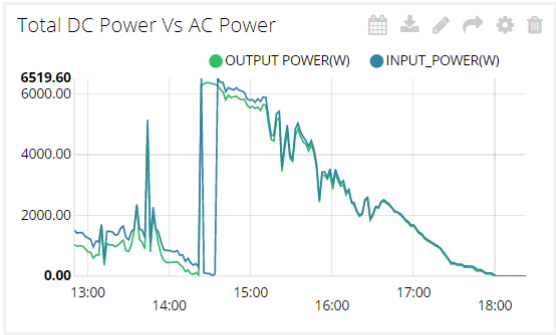
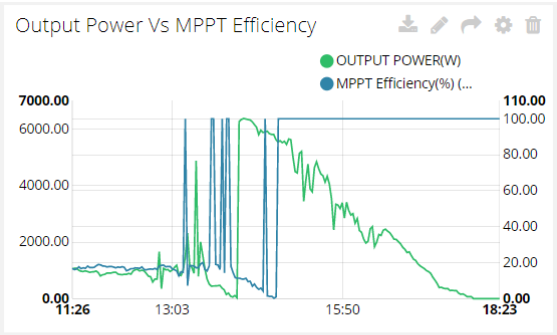
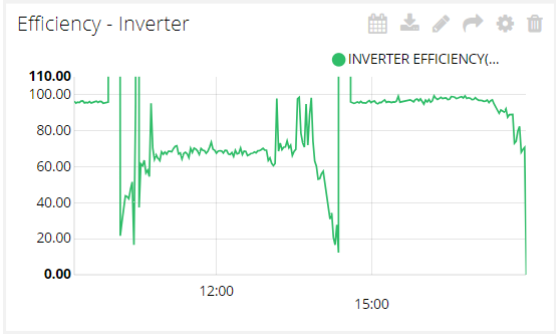
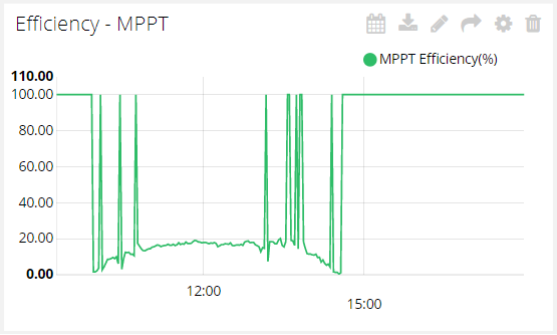
17:00
18:00


Total DC Power Vs AC Power
OUTPUT POWER(W)
INPUT_POWER(W)
6519.60
6000.00
4000.00
2000.00
0.00
13:00
14:00
15:00
16:00
17:00
18:00


Output Power Vs MPPT Efficiency
OUTPUT POWER(W)
MPPT Efficiency(%) (...
7000.00
6000.00
4000.00
2000.00
0.00
11:26
13:03
15:50
18:23
110.00
100.00
80.00
60.00
40.00
20.00
0.00


Efficiency - Inverter
INVERTER EFFICIENCY(...
110.00
100.00
80.00
60.00
40.00
20.00
0.00
12:00
15:00


Efficiency - MPPT
MPPT Efficiency(%)
110.00
100.00
80.00
60.00
40.00
20.00
0.00
12:00
15:00

Installed Prototype:

References:

1. SQLite official site - *https://www.sqlite.org/index.html*
2. Python official site - *https://www.python.org*
3. Internet of Things Wikipedia - *https://en.wikipedia.org/wiki/Internet_of_things*
4. Ubidots official site- *https://industrial.ubidots.com*

Conclusion:

By collecting data from the inverter, a simple dashboard is created in cloud platform for the remote monitoring of a Solar plant. In future, by implementing Machine learning Algorithm in to collected data which acts as training dataset, and predicts the fault in the system before occurs thus improving the life of the plant and reducing the Operational and Maintenance cost of the Solar Power plant.