# Study the Performance of 60kW grid connected solar photovoltaic power plant at Shraddha Park, Raisoni Group of Institution

**[1]Manish J. Katira, [2]Devesh U. Sarkar**

[1]Head of Department, [2]Assistant Professor
[1]Electrical Engineering Department
[1]G H Raisoni Institute of Engineering & Technology, Nagpur, India

***Abstract*– Renewable energy sources can offer isolated communities the chance for employment to regulate their energy use in a manner that best suits their needs. In this paper, the grid connected solar photovoltaic (SPV) power plant of Raisoni Group of Institution, Hariganga campus, Nagpur, India is presented and its performance is being noted. This power plant has a capacity of 60kW and has been in operation since 13th May 2014.**

***Keywords* – Solar PV modules, 3 phase Inverter, Transformer, 11kv transmission line, HT panels**

## I. INTRODUCTION

Raisoni Group of Institution 60KW Solar Plant which is mounted on the teris of G H Raisoni polytechnic, Hariganga campus, Nagpur. The Plant is Installed on 13th May 2014. In Hariganga campus there is one more solar plant, which is mounted on G H Raisoni Academy of Engineering & Technology whose installed capacity is 112.5KW. The combination of this two solar plant makes it as 172.5KW Capacity of solar power. The Generation of this two Solar Plant gives the supply to the total campus as possible. The remaining unused Generation gives back to Substation (Hingna Substation no.1) by 11KV transmission line.

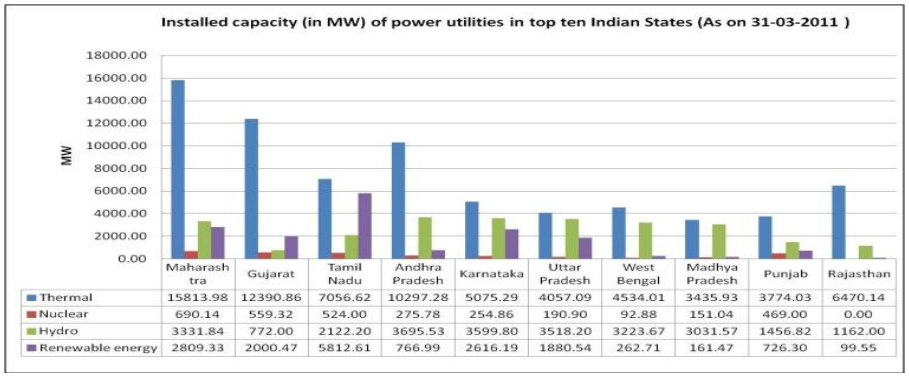
**Location & Area:**
Latitude: 21.12501476015897°
Longitude: 79.00256752967836°
Area is 1642.1836 Sq-m

**Land:** G H Raisoni Polytechnic.

**Installed By**: Amplus Solar Power Private Limited, New Delhi

### *A. Present PV Scenarioin India*

The State of Maharashtra is on number one position for the installed capacity of power utilities. Presently the State has 22645 MW of installed capacity from all power generation sources (Conventional and Renewable). As per the latest data by CEA (March 2011), Maharashtra has an installed capacity of 15813.98 MW from thermal, 690.14 MW from Nuclear, 3331.84 from Hydro and 2809.33 from other renewable energy sources. Maharashtra State Electricity board (MSEB) was the solo organization looking after electricity operations in the state before the year 2005. Due to operational issues of over sizing of the MSEB, it has been restructured into four daughter organizations. These four companies came into existence in July 06, 2005 – MSEB Holding Company, Maharashtra State Electricity Distribution Company (Mahavitaran), Maharashtra State Electricity Transmission Company (Mahapareshan) and Maharashtra State Electricity Generation Company (Mahagenco) after unbundling the MSEB.




| | Maharashtra | Gujarat | Tamil Nadu | Andhra Pradesh | Karnataka | Uttar Pradesh | West Bengal | Madhya Pradesh | Punjab | Rajasthan |
|---|---|---|---|---|---|---|---|---|---|---|
| Thermal | 15813.98 | 12390.86 | 7056.62 | 10297.28 | 5075.29 | 4057.09 | 4534.01 | 3435.93 | 3774.03 | 6470.14 |
| Nuclear | 690.14 | 559.32 | 524.00 | 275.78 | 254.86 | 190.90 | 92.88 | 151.04 | 469.00 | 0.00 |
| Hydro | 3331.84 | 772.00 | 2122.20 | 3695.53 | 3599.80 | 3518.20 | 3223.67 | 3031.57 | 1456.82 | 1162.00 |
| Renewable energy | 2809.33 | 2000.47 | 5812.61 | 766.99 | 2616.19 | 1880.54 | 262.71 | 161.47 | 726.30 | 99.55 |

Fig. 1 Maharashtra Electricity Scenario

Fig. 2 New fractal-like concentrating solar power receivers are better at absorbing sunlight

Year-round Sandia National Laboratories intern Jesus Ortega inspects one of the new bladed receivers at Sandia's National Solar Thermal Testing Facility.

## II. LITERATURE SURVEY

**[1]High-Performance Constant Power Generation in Grid-Connected PV Systems**

In this paper the PV system has been proposed the maximum supply in power due to that there is a fast & smooth transition between maximum power point tracking & constant power generation. The control strategy proposed that the solar irradiance levels, high- performance & stable operation are always achieved.

Conclusion:

1.Maximum power point tracking operation is mandatory for Grid connected PV systems in order to maximum the energy yield.

2.The proposed solution can ensure a stable contant power generation operation.

3.In comparison with traditional methods, the proposed control strategy forces the PV system to operate at the left side of the maximum power point & hence it can achieve a stable operation as well as smooth transitions.

**[2]Reactive Power Capacity Enhancement of a PV-Grid System to Increase PV Penetration Level in Smart Grid Scenario**

This paper provides a possible solution of reactive power support to improve the voltage profile. In this paper a novel scheme is proposed that the auxillary circuit in conjunction with a PV grid system which increases the system reactive power compensation capacity compared to the original capacity of the main PV system.

Conclusion:

1.Distributed power generation is being contemplated for reducing the stress on the power grid.

2.Reactive power compensation without hampering power quality is a challenging task.

3.The demonstrated proposed scheme method of enhancing the reactive power capacity of the inveter based distributed generation system.

**[3]Stability of Photovoltaic and Wind Turbine Grid-Connected Inverters for a Large Set of Grid Impedance Values**

This paper proposed the analysis of stability problems of grid connected inverters used in distributed generation. The measurement is vast which is made on a single phase system & on a three phase system used as scale prototype for photovoltaic & wind turbines which validates the analysis.

**Conclusion**:

1.Wind turbine three phase systems & photovoltaic is a single phase system can be connected at different grid conditions.

2.The conclusion shows that as the grid condition is different then the designing can be compromised.

3.The system can become unstable due to the reduced bandwidth or the change in the resonance frequency.

**[4] System Stability Impact of Large-Scale and Distributed Solar Photovoltaic Generation: The Case of Ontario, Canada**

This paper presents a comparative investigation of solar photovoltaic effect on system stability at different penetrating levels. There is a relavant dyanamics models. Based on that the impact is examined through Eigen values, voltage stability & transient stability analysis.

**Conclusion**:

1.In this paper, the impact of solar photovoltaic generator penetration level on the stability on power system was assessed.

2.The dynamic behaviour of the system containing SPVG installations was examined for different penetration levels by means of small signal stability, voltage stability & time domain contigency analysis.

3.Voltage stability & transient stability demonstrated that the dynamic SPVG can considerably improves system stability.

## III. PLANT LAYOUT

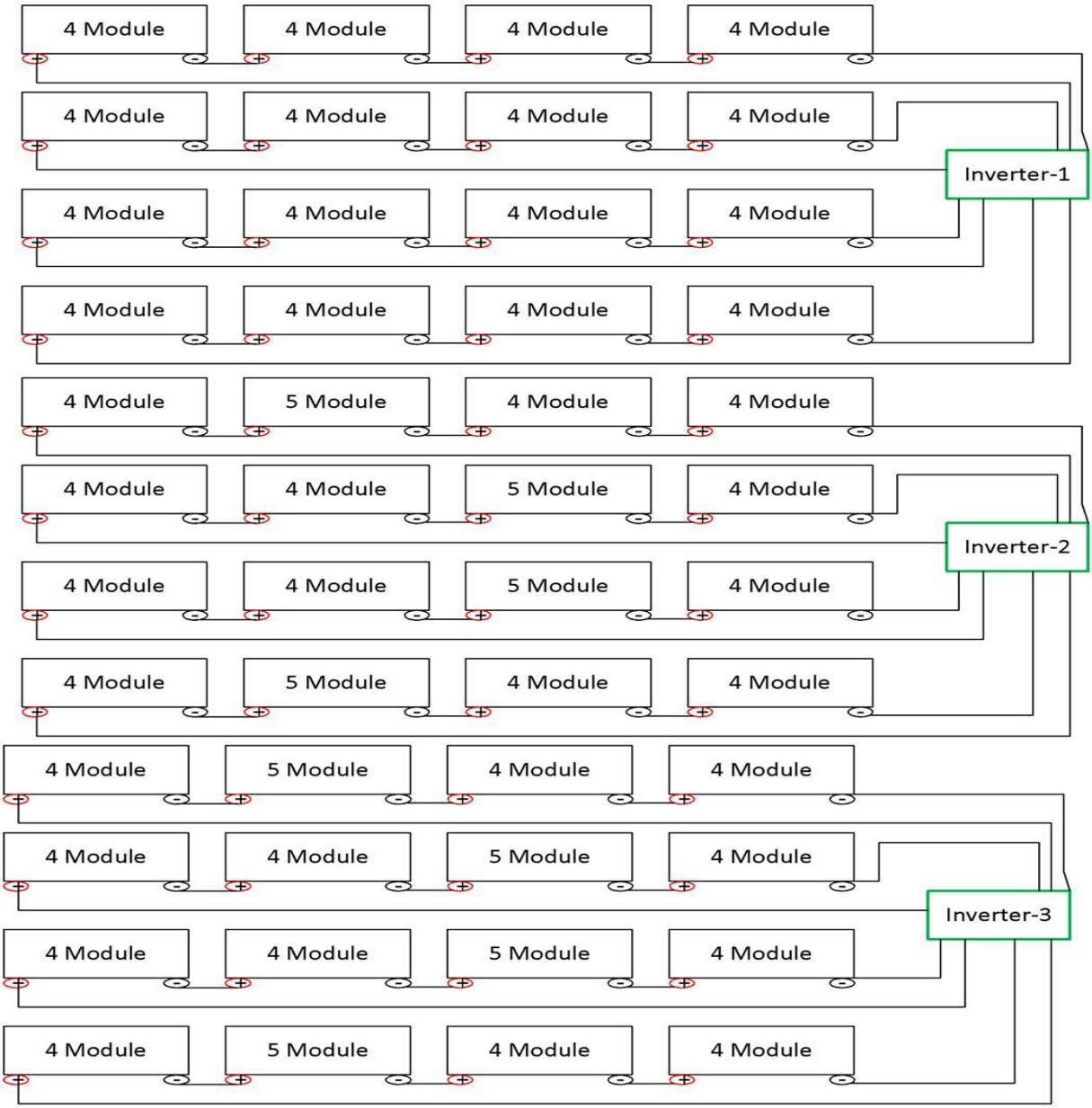



Fig. 3 Plant Layout

## IV. SYSTEM DIAGRAM

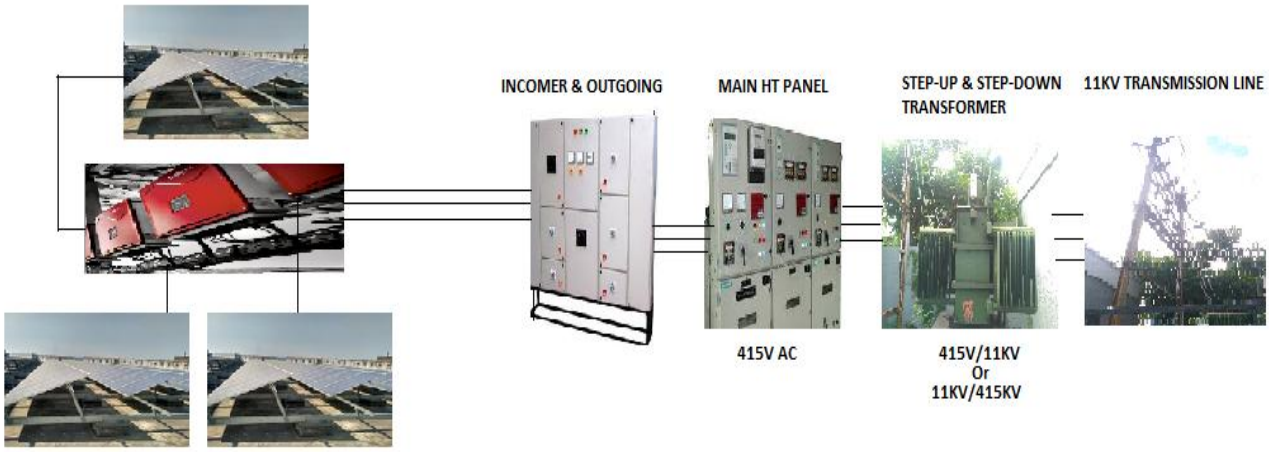



Fig. 4 System Block Diagram

### A. *Details Specification With Ratings*

**[a] Solar Photovoltaic Module:**

Company: TrinaSolar
Rated Peak Power (0~+4.99wp)(Pmpp): 300W
Open Circuit Voltage (Voc): 45.3V
Short Circuit Current (Isc): 8.60A
Rated Voltage (Vmpp): 36.9V
Rated Current (Impp): 8.13A
Efficiency (%): 15.53%
Maximum series Fuse: 15A
Module Application(Type): Class A
Maximum System Operating Voltage: DC1000V
Irradiation: 1000w/m2
Cell Temperature: 25 Degree Celcius
Electrical Rating at STC
AM : 1.5
For field connections, use minimum 4mm2 copper wires insulated for a minimum 90°C

**[c] Three Phase String Inverter:**

TECHNICAL DATA
REFUsol 023K- 460 VAC
DC data
Recommanded max. PV power, kWp: 27.6kW
MPPT range, V: 575 to 850V
DC start voltage, V: 350V
Max. DC voltage, V: 1000V
Max. DC current, A: 41A
MPP tracker 1
Number of DC connections : 6 x MC4
DC isolator : Yes

**AC data**

Rated AC power: 23kW
Max. apparent power: 23KVA
AC power supply connection L1, L2, L3, N, PE
Rated power factor / range: 1 / 0.9i to 0.9c
Rated voltage AC: 460V
Voltage range AC : 365 to 529V
Rated frequency / frequency range,Hz:50, 60 / 45 to 65Hz

Max. AC current: 3 x 29.2A
Max. distortion factor THD, %:1.8
Max. efficiency, %:98.3
European efficiency, %:98.1
Feed-in starting at 20W
Internal consumption in night operation, W< 0.5

**FEATURES**
Cooling Natural convection
Ambient temperature, °C -25 to +55
Relative ambient humidity, % : 0 to 100
Site altitude: 2000
Noise level, dBA< 45
Internal overvoltage protection (EN 61643-11) Type3
Protection class (IEC 62103), PCL I
Overvoltage category (EN 60664-1) DC: II, AC: III
Environmental classifications IEC 721-3-4 4K4H
Environment classification 4K4H acc. to DIN IEC721-3-4

**GENERAL DATA**
Interfaces Ethernet, RS485
temperature and isolation sensor
Protection class (IEC 60529) IP65
Dimensions w x h x d, mm 535 x 601 x 277
Weight, kg:41.5

## V. INVERTER TECHNOLOGY

The transformerless REFUsol 023K string inverter with 460 VAC complements the product range between the 008K–020K string inverters with 400 VAC and the high-power REFUsol 333K central inverter with 690 VAC. With an output voltage of 460 V and a input voltage range from 575 to 850 V, the REFUsol 023K-460 VAC is the perfect choice for medium voltage applications in large-scale PV systems. It has an efficiency level of more than 98%.
Like the other inverters in the REFUsol range, the REFUsol 023K- 460 VAC works with the fast and precise REFUsol MPP tracking system. The data-logger, RS485 interface and Ethernet connection make data communication easy. It can be configured quickly and easily over a network – even wirelessly with our REFUconnect solution. You can analyze the power budget of the systems being operated using the web-based evaluation tool REFUlog. Here you can focus fully on parameters, curves and values as there is no need to worry about maintaining the 023K-460 VAC. It works with maintenance-free convection cooling.

## VI. DISIGNING

3-ph Inverter: 3 nos
Modules: 200 nos
Strings: 12 nos
17Module: 1 String
3-ph Inverter 1no. or 2no. or3no.: 4 Strings
Installed capacity: 200x300W= 60KW

## VII. OPERATION & WORKING

In Raisoni Group of Institution (RGI) at Hariganga campus, Nagpur there are the installation of two solar plants [1]GHRAET whose installed capacity is 112.5KW & [2] GHRPN whose installed capacity is 60KW and they provide the supply to RGI at Hariganga campus and try to fulfill the requirement of supply but unfortunately solar plant haven't capable to supply the required amount of power. So in addition MSCB fulfill their required need of power through 11KV transmission line from hingna substation no.1 The rate of amount of solar power used by RGI at Hariganga campus whose charges is payed to Amplus solar company, delhi.

## VIII.COSTING

1 Watt= 53 Rs.
1 Module= 300W= 300 x 53= 15,900/-
200 Module= 200x 15,900= 31,80,000/-
1 Three phase string Inverter= 400,000/-
3 Three phase string inverter= 12,00,000/-
Total= 43,80,000/-

## IX. SOLAR DAILY GENERATION READING

| Date | Reading | UNIT |
|---|---|---|
| 04/01/2017 | 43547 | 325 |
| 05/01/2017 | 43874 | 327 |
| 06/01/2017 | 44200 | 326 |
| 07/01/2017 | 44541 | 341 |
| 08/01/2017 | sunday | sunday |
| 09/01/2017 | 45170 | 629 |
| 10/01/2017 | 45439 | 269 |
| 11/01/2017 | 45754 | 315 |
| 12/01/2017 | 46127 | 373 |
| 13/01/2017 | 46506 | 379 |
| 14/01/2017 | 46860 | 354 |
| 15/01/2017 | sunday | sunday |
| 16/01/2017 | 47538 | 678 |
| 17/01/2017 | 47843 | 305 |
| 18/01/2017 | 48115 | 272 |
| 19/01/2017 | 48417 | 302 |
| 20/01/2017 | 48733 | 316 |
| 21/01/2017 | 49036 | 303 |
| 22/01/2017 | sunday | sunday |
| 23/01/2017 | 49905 | 869 |
| 24/01/2017 | 50057 | 152 |
| 25/01/2017 | 50400 | 343 |
| 26/01/2017 | HOLIDAY | HOLIDAY |
| 27/01/2017 | 50971 | 571 |
| 28/01/2017 | 51315 | 344 |
| 29/01/2017 | sunday | sunday |
| 30/01/2017 | 52026 | 711 |
| 31/01/2017 | 52282 | 256 |
| 01/02/2017 | 52641 | 359 |
| 02/02/2017 | 52997 | 356 |
| 03/02/2017 | 53342 | 345 |
| 04/02/2017 | 53696 | 354 |
| 05/02/2017 | sunday | sunday |
| 06/02/2017 | 54418 | 722 |
| 07/02/2017 | 54753 | 335 |
| 08/02/2017 | 55167 | 414 |
| 09/02/2017 | 55554 | 387 |
| 10/02/2017 | 55919 | 365 |
| 11/02/2017 | 56250 | 331 |
| 12/02/2017 | sunday | sunday |
| 13/02/2017 | 56878 | 628 |
| 14/02/2017 | 57212 | 334 |
| 15/02/2017 | 57542 | 330 |

| Date | Reading | UNIT |
|---|---|---|
| 16/02/2017 | 57913 | 371 |
| 17/02/2017 | 58321 | 408 |
| 18/02/2017 | 58725 | 404 |
| 19/02/2017 | sunday | sunday |
| 20/02/2017 | 59562 | 837 |
| 21/02/2017 | 59961 | 399 |
| 22/02/2017 | 60368 | 407 |
| 23/02/2017 | 60799 | 431 |
| 24/02/2017 | HOLIDAY | HOLIDAY |
| 25/02/2017 | 61650 | 851 |
| 26/02/2017 | sunday | sunday |
| 27/02/2017 | 62521 | 871 |
| 28/02/2017 | 62913 | 392 |
| 01/03/2017 | 63317 | 404 |
| 02/03/2017 | 63713 | 396 |
| 03/03/2017 | 64092 | 379 |
| 04/03/2017 | 64455 | 363 |
| 05/03/2017 | sunday | sunday |
| 06/03/2017 | 65210 | 755 |
| 07/03/2017 | 65613 | 403 |
| 08/03/2017 | 65997 | 384 |
| 09/03/2017 | 66305 | 308 |
| 10/03/2017 | 66666 | 361 |
| 11/03/2017 | 67055 | 389 |
| 12/03/2017 | sunday | sunday |
| 13/03/2017 | HOLIDAY | HOLIDAY |
| 14/03/2017 | 68292 | 1237 |
| 15/03/2017 | 68710 | 418 |
| 16/03/2017 | 69107 | 397 |
| 17/03/2017 | 69470 | 363 |
| 18/03/2017 | 69879 | 409 |
| 19/03/2017 | sunday | sunday |
| 20/03/2017 | 70683 | 804 |
| 21/03/2017 | 71118 | 435 |
| 22/03/2017 | 71549 | 431 |
| 23/03/2017 | 71961 | 412 |
| 24/03/2017 | 72345 | 384 |
| 25/03/2017 | 72705 | 360 |
| 26/03/2017 | sunday | sunday |
| 27/03/2017 | 73518 | 813 |
| 28/03/2017 | HOLIDAY | HOLIDAY |
| 29/03/2017 | 74300 | 782 |
| 30/03/2017 | 74693 | 393 |

| Date | Reading | UNIT |
|---|---|---|
| 01/04/2017 | 75438 | 369 |
| 02/04/2017 | sunday | sunday |
| 03/04/2017 | 76097 | 659 |
| 04/04/2017 | HOLIDAY | HOLIDAY |
| 05/04/2017 | 76742 | 645 |
| 06/04/2017 | 77114 | 372 |
| 07/04/2017 | 77504 | 390 |
| 08/04/2017 | 77912 | 408 |
| 09/04/2017 | sunday | sunday |
| 10/04/2017 | 78704 | 792 |
| 11/04/2017 | 79143 | 439 |
| 12/04/2017 | 79628 | 485 |
| 13/04/2017 | 80015 | 387 |
| 14/04/2017 | HOLIDAY | HOLIDAY |
| 15/04/2017 | 80811 | 796 |
| 16/04/2017 | sunday | sunday |
| 17/04/2017 | 81596 | 785 |
| 18/04/2017 | 81968 | 372 |
| 19/04/2017 | 82348 | 380 |
| 20/04/2017 | 82722 | 374 |
| 21/04/2017 | 83125 | 403 |
| 22/04/2017 | 83534 | 409 |
| 23/04/2017 | sunday | sunday |
| 24/04/2017 | 84367 | 833 |
| 25/04/2017 | 84816 | 449 |
| 26/04/2017 | 85239 | 423 |
| 27/04/2017 | 85631 | 392 |
| 28/04/2017 | 86058 | 427 |
| 29/04/2017 | 86418 | 360 |
| 30/04/2017 | sunday | sunday |
| 01/05/2017 | HOLIDAY | HOLIDAY |
| 02/05/2017 | 87315 | 897 |
| 03/05/2017 | 87737 | 422 |
| 04/05/2017 | 88031 | 294 |
| 05/05/2017 | 88418 | 387 |
| 06/05/2017 | 88753 | 335 |
| 07/05/2017 | sunday | sunday |
| 08/05/2017 | 89448 | 695 |
| 09/05/2017 | 89823 | 375 |
| 10/05/2017 | HOLIDAY | HOLIDAY |
| 11/05/2017 | 90407 | 584 |
| 12/05/2017 | 90681 | 274 |
| 13/05/2017 | 91030 | 349 |

| Date | Reading | UNIT |
|---|---|---|
| 14/05/2017 | sunday | sunday |
| 15/05/2017 | 91730 | 700 |
| 16/05/2017 | 92084 | 354 |
| 17/05/2017 | 92490 | 406 |
| 18/05/2017 | 92831 | 341 |
| 19/05/2017 | 93211 | 380 |
| 20/05/2017 | 93615 | 404 |
| 21/05/2017 | sunday | sunday |
| 22/05/2017 | 94382 | 767 |
| 23/05/2017 | 94782 | 400 |
| 24/05/2017 | 95147 | 365 |
| 25/05/2017 | 95480 | 333 |
| 26/05/2017 | 95767 | 287 |
| 27/05/2017 | 96053 | 286 |
| 28/05/2017 | sunday | sunday |
| 29/05/2017 | 96749 | 696 |
| 30/05/2017 | 97127 | 378 |
| 31/05/2017 | 97437 | 310 |
| 01/06/2017 | 97703 | 266 |
| 02/06/2017 | 97988 | 285 |
| 03/06/2017 | 98342 | 354 |

## X. CONCLUSION

Thus it is conclude that the performance of Solar photovoltaic power plant is good & the Efficiency is also maintaining good because of daily washing of solar modules and futher due to weekly maintenance of solar module and by checking the inverter performance its power factor is also better nearly 0.985PF.

## XI. FUTURE SCOPE

[1] The Efficiency of Solar PV cell is low in order to increase the efficiency certain techniques may be employed like MPPT. In future lots of works will be done on efficiency of Solar PV cell.
[2] Change the Solar panel with new technology Solar panel for increasing the Solar module efficiency.
[2] To increase the plant efficiency, Micro-Inverter technology will be adopted for preventing plant breakdown, Overload also to preventing the damage of Solar Module.
[3] Dual axis technique will be adopt for getting maximum time irradiation from sun.
[4] For voltage stability we will also use such devices like STATCOM, which is very much effective and compensate the voltage.

## REFERENCES

[1] Ariya Sangwongwanich, Yongheng Yang, and Frede Blaabjerg, "High-Performance Constant Power Generation in Grid-Connected PV Systems," IEEE Transactions On Power Electronics, Vol. 31, No. 3, March 2016, pp.1822-1825
[2] Rupesh G. Wandhare, Vivek Agarwal, "Reactive Power Capacity Enhancement of a PV-Grid System to Increase PV Penetration Level in Smart Grid Scenario," IEEE Transactions On Smart Grid, Vol. 5, No. 4, July 2014, pp.1845-1853
[3] Marco Liserre, Remus Teodorescu, Frede Blaabjerg, "Stability of Photovoltaic and Wind Turbine Grid-Connected Inverters for a Large Set of Grid Impedance Values," IEEE Transactions On Power Electronics, Vol. 21, No. 1, January 2006, pp.263-272
[4] Behnam Tamimi, Claudio Cañizares, and Kankar Bhattacharya, "System Stability Impact of Large-Scale and Distributed Solar Photovoltaic Generation: The Case of Ontario, Canada," IEEE Transactions On Sustainable Energy, Vol. 4, No. 3, July 2013, pp.680-688
[5] Rajiv K. Varma, Shah Arifur Rahman, Tim Vanderheide, "New Control of PV Solar Farm as STATCOM (PV-STATCOM) for Increasing Grid Power Transmission Limits During Night and Day," IEEE Transactions On Power Delivery, Vol. 30, No. 2, April 2015, pp.755-763
[6] Rupesh G. Wandhare, and Vivek Agarwal, "Novel Stability Enhancing Control Strategy for Centralized PV-Grid Systems for Smart Grid Applications," IEEE transactions on Smart Grid, vol. 5, no. 3, May 2014, pp.1389-1396
[7] Habbati Bellia, Ramdani Youcef, Moulay Fatima, "A Detailed modelling of photovoltaic module using MATLAB," NRIAG Journal of Astronomy and Geophysics, May 2014, pp. 53-61
[8] S.V. Swarna Kumary, V.Arangarajan Aman Maung Than Oo, GM Shafiullah, Alex Stojcevski, "Modeling and Power quality analysis of a Grid connected Solar PV System," Australasian Universities Power Engineering Conference, AUPEC 2014, Curtin University, Perth, Australia, 28 September – 1 October 2014, pp. 1-6
[9] Chinmay Jain, Bhim Singh, "Solar Energy Used for Grid Connection: A Detailed Assessment Including Frequency Response and Algorithm Comparisons for an Energy Conversion System" IEEE Industry Applications Society, Volume: 23 Issue: 2, December 2016, pp.37-50

[10] G. Deepak, M. Jaya Bharata Reddy, D. K. Mohanta, "Hardware implementation of grid connected PV system with energy management scheme" IEEE, Environment and Electrical Engineering (EEEIC), February 2014
[11] Mohamed Amine Fakhfakh, Moez Ayadi, Rafik Neji, "Implementation of photovoltaic system into microcontroller" IEEE, Renewable Energies and Vehicular Technology (REVET), May 2012

[12] Neha Adhikari, Bhim Singh, A. L. Vyas, Ambrish Chandra, Kamal-Al-Haddad, "Analysis and design of isolated solar-PV energy generating system" IEEE, Industry Applications Society Annual Meeting (IAS), November 2011, PP. 1-6

[13] 3S. A. Lakshmanan, B. S. Rajpourhit, Amit Jain, "Modeling and analysis of 3-phase VSI using SPWM technique for grid connected solar PV system" IEEE, Electrical, Electronics and Computer Science (SCEECS), April 2014, pp. 1-6