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Power Quality Issues in IEEE 14 Bus Ring Main System with Integration of Renewable Distributed Generation

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Abstract: ***In order to have a sustainable electrical energy, reduction in environment pollution and to improve energy efficiency integrating distributed generation (DG) will be desirable in fulfilling the modern societal energy needs. On the flip side their integration to the grid strikes the major technical challenges. This paper addresses the power quality issues of IEEE 14 bus system during the penetration of PV and wind farm with different loads under fault condition for both grid and islanded mode.***

Keywords: ***Photo voltaic system, Wind energy system, Distributed generation, Grid Integration, power quality.***

I. INTRODUCTION

Due to the rapid growth of Industries and Information Technology, the need for electrical power has increased significantly. Large gap exists between the supply and the load demand. To overcome this gap Renewable Energy Sources plays a vital role and an environment friendly. Over the last few years, power generation using Distributed Energy Resources has increased considerably which contributes majorly for total power generation in the grid. Renewable Energy in India falls within the ambit of Ministry of New and Renewable Energy (MNRE). Currently, our country's installed solar plant capacity is 30GW and the capital cost per MW installation is lowest as compared globally**.**

In recent years, Wind power Generation capacity has significantly increased in India and accounts for about 10% of installed total power generation capacity. According to the statistics, currently the entire installed wind power capacity in India is 37 GW and is the fourth largest installed wind power capacity in the world. As on July 2019, in the country a total of 81GW of renewable energy capacity has been installed out of which 30 GW is from solar power & 37 GW from wind power.

Integration of Distributed Energy Resources to the gird offers several benefits such as reduction in carbon emission [1],improves power system resiliency and reliability [4] decreases the need on fossil fuels [2] , [3] and offers several benefits economically.

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Regardless of its benefits, increased usage of Renewable Energy Resources originates new challenges due to its aperiodic nature. In the recent years, with the increased propagation of Distributed Energy Resources to the grid, Power quality at the Distribution System has become a key concern.

The paper deals with the PQ issues which is caused due to penetration of PV and wind farm to the 11KV ring main distribution system. IEEE 14bus system is modeled and power quality will be compared in below two cases.

Case 1: When PV is integrated to the distribution system with RL load and Induction Motor load.

Case 2: Integration of wind system with RL load and Induction Motor load. The model is simulated using MATLAB/SIMULINK.

II. GRID INTEGRATION OF RENEWABLE ENERGY RESOURCES

A. Solar Photovoltaic Systems

The photovoltaic energy is the most promising source of energy and is available abundantly throughout the world. Grid-connected Power generation can be achieved either by residential or commercial PV systems. According to literature survey, the world's PV system capacity is 22GWand has generated 25 TWh of electricity in 2010 [10]. Although the power generation capacity of PV system is small compared to capacity of the wind system [11], over the next several decades

It is expected to grow rapidly over wind power.

Currently, India's installed capacity of solar system is 32GW, and the growth was significant between 2015-2019[12].Although the solar output power depends on radiation intensity and cloudbust, when integrated to the grid PQ issues depends on solar radiation and on the overall performance of PV system as well. However, Studies presented in [13], show that with ingression of PV system for distribution grids the cloud cover and short fluctuation of irradiance play a vital role and therefore, needs a special attention to the voltage profile and the power flow on the line. The basic grid connected PV system block diagram is shown in Fig 1.

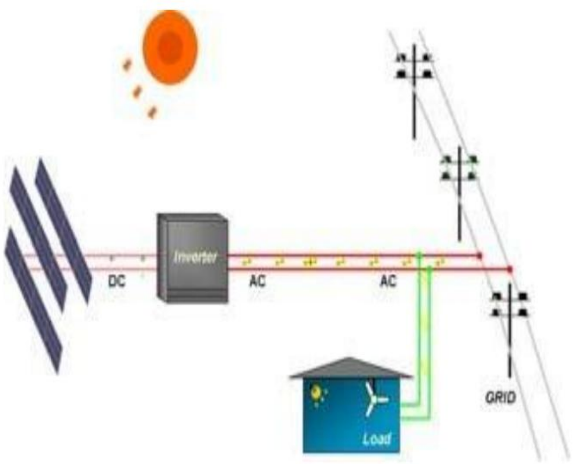

Fig1. General structure of grid-connected PV system

The system can be a single-phase or three phase depending on the requirements of the grid connection and mode of PV connection can be series or parallel with a single PV panel or string of PV panels as per the requirement.

B. Wind Power

Power production using wind technology has evolved rapidly over the past few decades. At first, wind power plant capacity was small varying with a range of 1MW to 10MW. But there is a significant increase in size over the past four decades[14].Estimated installed capacity of Wind farms over the globe is 159 GW and was able to produce 373 TWh of electricity in 2010.Basic arrangement of wind farm is shown in Fig. 2

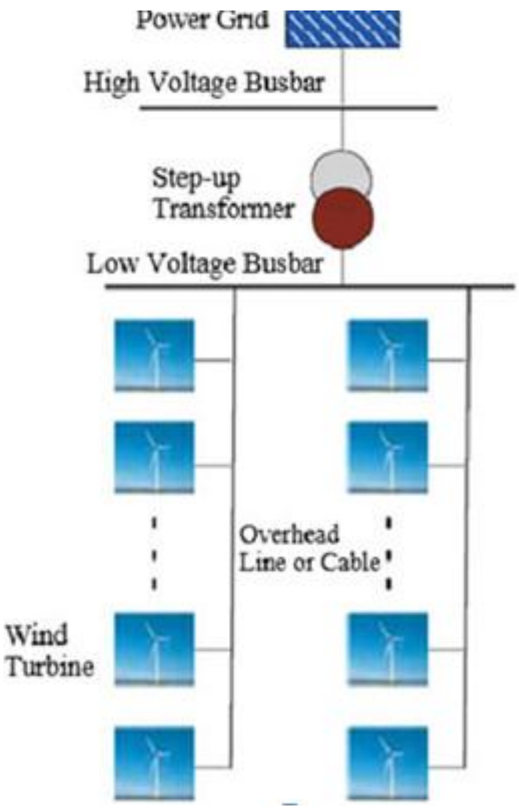

Fig: 2 Wind Power Plant Arrangements

Model of wind power plant can be of two types : 1) single turbine presentation; 2) multi turbine presentation [15], [16]. For power system planning[16] the single turbine presentation is fairly satisfying. However, multiple wind turbines are used to model large power plant which represents the distinct behaviour of its types and location [15].There exists a variety of wind power plant turbines and is split into various classes. Multiturbine presentation possess uniform wind speed in each group. when it is used, power fluctuation and variation in voltage will be less which represents merely the actual wind farm[15]. Reactive power compensation can be achieved using capacitors at the terminals of generator in order to correct power factor in case of single turbine and multi turbine generators. Reactive power can either be generated or absorbed in Type-3 and Type-4 wind turbine generators.

III. PROPOSED METHOD

Proposed method consists of simulation results carried out on IEEE 14 bus 11KV ring main distribution system when it is integrated with solar and wind systems under grid connected mode and island mode for RL and Induction Motor load. Three phase to ground fault is created at bus 11 for a duration 0.05sec to 0.06sec and the Voltage and frequency response of three phases are observed.

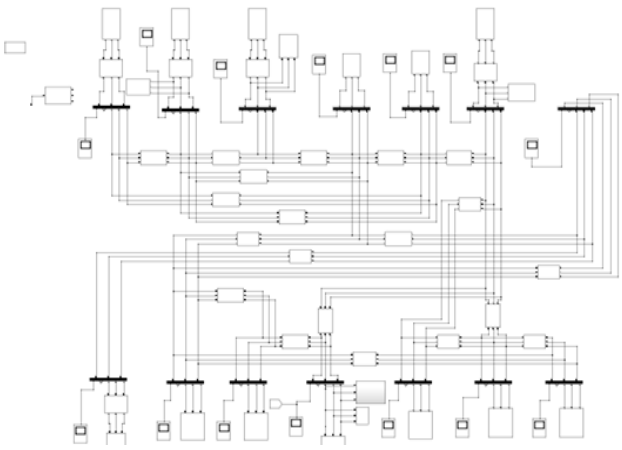

Fig 3: IEEE 14bus Test System

Table-I and II provides the line and load data of the 14 bus Radial Distribution System.

Table -I: Line data

Bus No.	From Bus	To Bus	R in p.u	X in p.u
1	1	2	0.01938	0.05917
2	1	5	0.05403	0.22304
3	2	3	0.04699	0.19789 7
4	2	4	0.05811	0.17632
5	2	5	0.0595	0.17388
6	3	4	0.06701	0.17103
7	4	5	0.01335	0.04211
8	4	7	0	0.20912

9	4	9	0	0.55618
10	5	6	0	0.25202
11	6	11	0.09498	0.1989
12	6	12	0.12291	0.25581
13	6	13	0.06615	0.1302
14	7	8	0	0.17615
15	7	9	0	0.110011
16	9	10	0.03181	0.0845
17	9	14	0.12711	0.27038
18	10	11	0.08205	0.19207
19	12	13	0.22092	0.19988
20	13	14	0.17093	0.34802

Table -II: Load data

Bus no.	P_L (MW)	Q_L (MVAr)
1	114017	-16.9
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0

Case 1: Integration of PV system with RL Load

a. Grid connected Mode


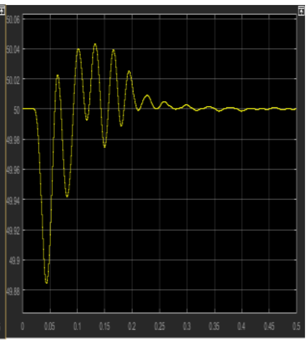

Fig 4: Voltage Response **Fig 5: Frequency Response**

b. Islanded Mode


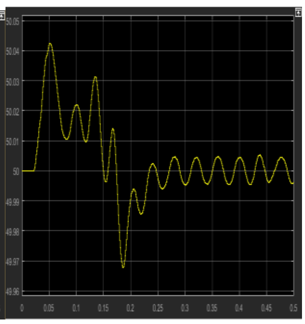

Fig 6: Voltage Response **Fig 7: Frequency Response**

a. Grid connected Mode

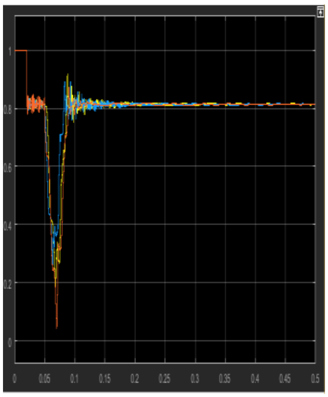
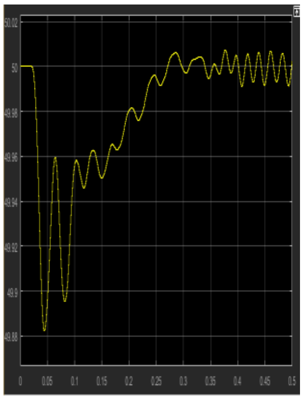

Fig 8: Voltage Response **Fig 9: Frequency Response**

b. Islanded Mode

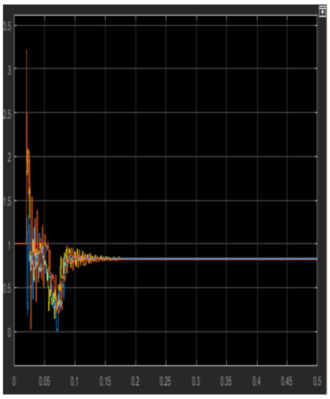
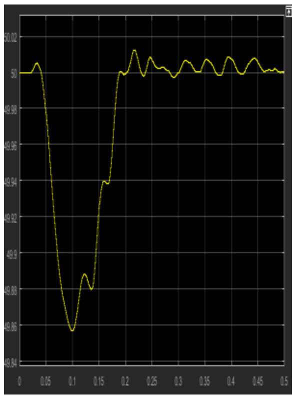

Fig 10: Voltage Response **Fig 11: Frequency Response**

From the voltage response plots we can see that with the integration of PV system for RL load and Induction Motor load, more disturbances in voltage is noticed under Induction Motor load in grid connected mode. In the islanded mode more disturbances is induced when the system is integrated with PV system due to non support of reactive power from grid. No much variation noticed in frequency response plots and is maintained constant.

Case 2: Integration of Wind system with RL Load

a. Grid connected Mode


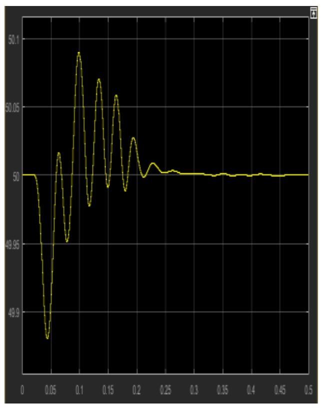

Fig 12: Voltage Response **Fig 13: Frequency Response**

b. Islanded Mode

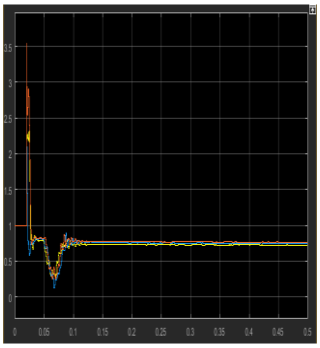

Fig 14: Voltage Response

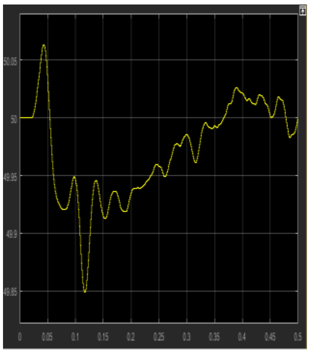

Fig 15: Frequency Response

Integration of Wind system for IM Load

a. Grid connected Mode

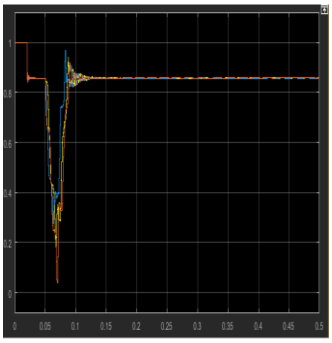

Fig 16: Voltage Response

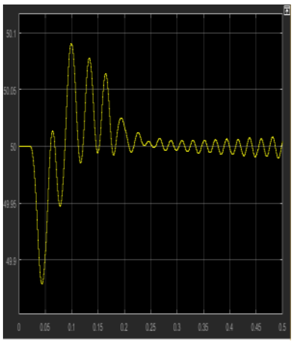

Fig 17: Frequency Response

b. Islanded Mode

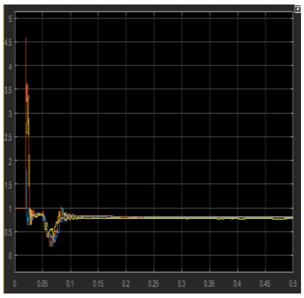

Fig 18: Voltage Response

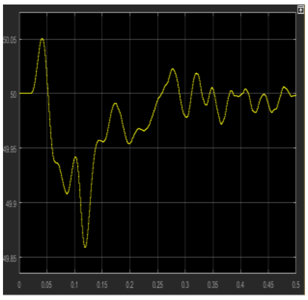

Fig 19: Frequency Response

IV. SUMMARY OF RESULTS

Table-III Grid Connected & Islanded Mode using PV system

Load Type	Voltage Fall	Voltage Rise	F min	F max
R	0.02	1.02	49.88	50.06
RL	0.02	1.02	49.88	50.07
IM	0.02	1	49.88	50
Load Type	**Voltage Fall**	**Voltage Rise**	**F min**	**Fmax**
R	0.02	1.02	49.85	50.07
RL	0.02	1.02	49.8	50.07
IM	0.02	1	49.87	50.07

Table-IV Grid Connected Mode using wind system

Load Type	Voltage Fall	Voltage Rise	F min	F max
R	0.02	1.1	49.85	50.01
RL	0.02	1.1	49.85	50.01
IM	0.02	0.98	49.85	50.01

Table-V Islanded Mode using wind system

Load Type	Voltage Fall	Voltage Rise	F min	F max
R	0.02	3.6	49.95	50.06
RL	0.02	3.5	49.92	50.06
IM	0.02	4.5	49.9	50.05

V. CONCLUSION

Grid integration solar energy System and Wind energy System causes deviation of voltage and frequency. From the simulation results we can say that wind system tend to cause more disturbance than PV system with RL and Induction Motor Load. Using power electronic devices, active filters and voltage source converters solar system and wind energy system can improve power quality of grid thereby providing reliable power supply to consumers.

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