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Hybrid AC / DC Micro grid Power Quality Analysis in Distribution Network

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ABSTRACT: Micro grid is a complex structure that is a localized group of generating, storing and loading electricity that is usually connected to a macro grid. The quality of the energy supplied to the grid during interconnection is one of the main variables determining the efficiency of the micro grid and is impacted for multiple reasons, including electronic components leading to overheating of machinery. The level of power quality in micro grid must be quantified and analysis necessary to investigate the impact of power quality in the micro grid network must be carried out. In this document, THD assessment of the hybrid system is explored using MATLAB/SIMULINK. PV and DFIG in grid-connected and insulated mode. It is discovered that when both PV and wind are attached to the grid and when isolated, the THD is lowered and rises. The main advantage of this analysis is that this system can be used together with the grid for highly nonlinear and variable PV and wind systems. Simulation findings also show that this scheme with variable inputs is efficient for micro grid.

KEY WORDS: Micro grid, Power Quality, Grid Connected, Isolated, Photovoltaic Array, DFIG.

I. INTRODUCTION

A Microgrid is an integrated system of autonomous Small-scale power grids consisting of interconnected distributed energy resources and loads, capable of functioning both in isolated mode and parallel to the grid, making it extremely reliable and versatile. A hybrid AC / DC micro grid consists of AC grid and DC grid providing AC and DC load. The problem of power quality in micro grids can happen owing to the elevated penetration of Distributed generators such as PV, wind etc. and also due to harmonics induced by enhanced load reactive power requirements. In order to enhance reliability, a technical survey on the various effects of power quality [1] on micro grid such as voltage and frequency variation, power variation, voltage and present harmonics, unbalance voltage and neutral current rate on the utility grid[2] is needed. Among the above-mentioned problems of power quality, the impact of odd harmonics such as 3rd, 5th, 7th, 9th etc. on electrical distribution systems[3][4] is of greater importance. Current harmonics generated as a result of nonlinear loads have waveforms that are not sinusoidal owing to extra waveforms superimposed on them and generate various frequencies in relation to the basic sine wave frequency. Responsible for voltage distortions are current distortions.

Harmonic present measurements show the load's harmonic content of generation while the device reaction is defined by voltage measurements. DFIG's PI controller design is outlined in[5]. Photovoltaic systems usually incorporate power electronic interface to extract maximum power from the PV source and to convert DC to AC for grid connection. The main problems following excessive harmonics generated in a system[6][7] are overheating of the neutral in the three-phase scheme, voltage difference in the secondary of the distribution transformer and thus increasing the loss of copper and heat in electrical equipment.

Current or voltage harmonics are called the summation of greater frequency sinusoidal parts that are integer multiple of the fundamental harmonic. Current harmonic dominance is due to electronic power converters and non-linear loads, resulting in increased voltage harmonics owing to impedance of the device. Nonlinear loads are also

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responsible for harmonics which has a heavy impact. Current THD analysis should be provided more significance than voltage THD analysis, particularly for grid-connected PV system and variable insulation operation[8]. In addition, PV with low irradiation generates more present harmonics and it is necessary to take or disconnect suitable filtering steps during low irradiation.

This document uses MATLAB SIMULINK to investigate the harmonic analysis of the DFIG scheme by linking the PV-DFIG mixture to the micro grid. Detailed simulation is carried out for distinct load circumstances by evaluating distinct system circumstances and studying the impact on the scheme of the fresh harmonic sources[9]. DFIG's grid side and rotor side are controlled by the PI controller. The interface between the utility and the consumer is taken as the point of common coupling. Both the theoretical assessment .

II. PROPOSED METHOD

This combination is connected to a common DC bus where a battery is also connected which supplements the intermittency and complementary nature of the sources. The output of DC bus is inverted and then connected to three phase transformer before connecting to AC bus. From there it is connected to the grid where three phase AC load is connected. The suggested scheme comprises of an intermittent and complementary hybrid mixture of DFIG and PV shown in figure 1. It comprises of a wind turbine-driven DFIG scheme in which the converters used in grid side and rotor side controllers only use 25-30% of the complete production energy capability. DFIG's output is rectified and linked to the PV system that utilizes the DC-DC converter to generate continuous DC voltage and the MPPT controller monitored input to monitor maximum energy.

This mixture is linked to a prevalent DC bus that also connects a battery that supplements the source's intermittency and supplementary nature. Before linking to the AC bus, the DC bus output is reversed and then linked to three phase transformer. It is linked from there to the grid where three phase AC loads are attached.

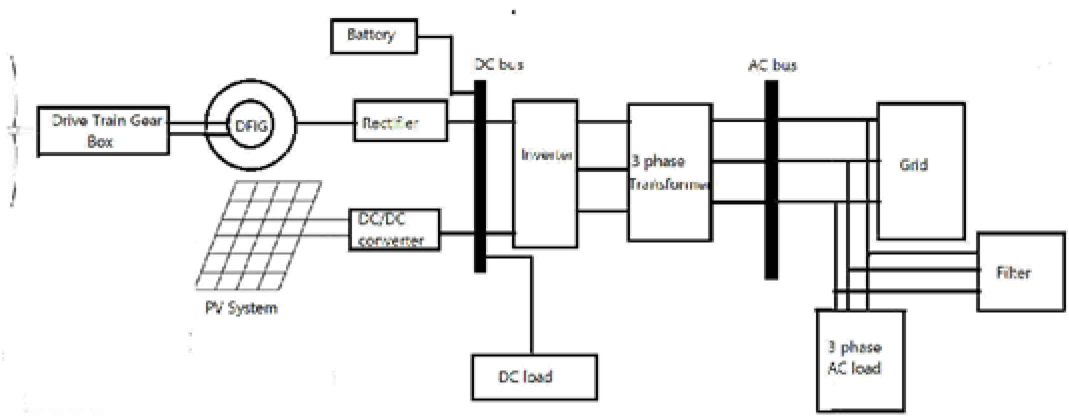

Figure 1 Hybrid PV and DFIG

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III. SYSTEM DESIGN

A. Solar Panel

The PV array construction block is the solar cell, which is basically a p-n semiconductor junction, and is shown in Fig. 2. A photovoltaic source is a current source that depends on the insolation rate and is called Photo Source, Iph. There is some resistance to the electrons flow route that is represented by Rs and linked to the circuit in series[10].

$$I = I_{ph} - I_D - I_{sh} \quad (1)$$

$$= I_{ph} - \left(I_o \left[e^{\frac{q(V+R_s I)}{mkT}} - 1\right]\right) - I_{sh} \quad (2)$$

$$I_{sh} = \frac{V+IR_s}{R_{sh}} \quad (3)$$

The current of the photograph relies primarily on solar insulation and the operating temperature of the cell as outlined in (4).

$$I_{ph} = [I_{sc} + K_1 (T_c - T_{ref})]H \quad (4)$$

Where = 250C and 1kW / m2 cell brief circuit current

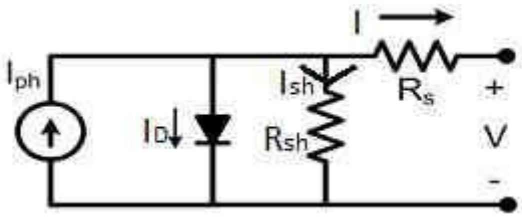

Fig. 2. Solar Cell's equivalent circuit

The boost converter in the source hand is linked to the solar panel which enhances the output voltage by properly altering the duty cycle by matching the impedance of the source with the impedance of load. The Perturb and Observe(P&O) technique is used to monitor the maximum power point using a voltage sensor to detect the PV voltage and to calculate the reference voltage to which the PV voltage should be transported

B. System for conversion of wind energy

The controller is the wind system's brain and is accountable for regulating the generator velocity and torque as well as the electronic energy interfaces. It is possible to control the velocity and torque by controlling the voltage supplied from the machine's stator and rotor. In DFIG the real power and slip depends on voltage magnitude and angle of the rotor[11]. Due to the variable speed operation

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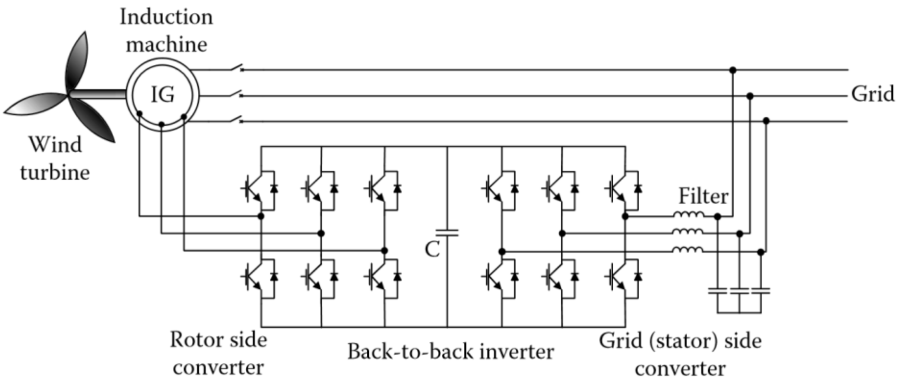

Figure 3: Generator of Double Fed Induction

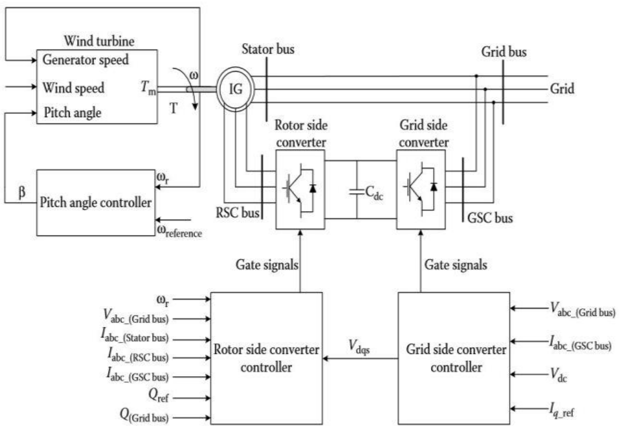

Figure 4: Topology of DFIG

Figure 3 and Figure 4 show the DFIG scheme and topology respectively. One of DFIG's most important advantages is that the power flowing through the rotor is only about 25-30% of the power flow through the stator and can thus be designed for 25-30% of the total power[14]. The rotor con verter is capable of controlling the induction generator slip andThe electrical equivalent circuit of DFIG for steady state is shown in fig 5.

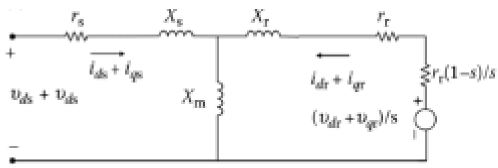

Figure 5: DFIG's electrical equivalent circuit

The direction and magnitude of the energy between the stator and the windings of the rotor can be regulated by changing the inverter's PWM signals[15].

The total power of a DFIG is

$$P_e = P_m - P_g = sP_g = P_r + P_{\chi r},$$

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Where Pm – total mechanical power from the wind turbine'sshaft

Pg – air gap power

Pr – rotor power

$P_{\chi r}$ - power of rotor losses

It is therefore possible to adjust the power factor by regulating the angle between rotor voltage Vr and rotor present Ir.

$$P_e = sP_g = 3\left[I_r^2 R_r + V_r I_r \cos\varphi_r\right]$$

Here rotor current Ir is

$$I_r = \frac{V\angle 0^\circ - (V_r/s)\angle\theta_r}{(R_s + R_r/s) + j(X_s + X_r)}.$$

C. Rotor Side Controller

Using the earlier produced switching signal, the DC signal is reversed. The inverter is a converter of the voltage source and is therefore used as a DC connection.

D. Battery System

Many distributed generators have a big time limit and are also intermittent and unstable, so a battery storage scheme in micro grid is vital to accommodate differences in energy generation and load. The energy is stored in an electrochemical form and the primary function of the micro grid energy storage system is to preserve stability, enhance the quality of the power and help in the process.

E. Three phase Inverter

The PV system generates DC output and therefore only generates actual energy and has to rely on the inverter to promote reactive power. Using the earlier produced switching signal, the DC signal is reversed. The inverter is a converter of the voltage source and is therefore used as a DC connection.

F. AC Filter

The distortions in the inverter's output voltage are smoothed by the second order AC filter, the cut-off frequency of which is 50 Hz.

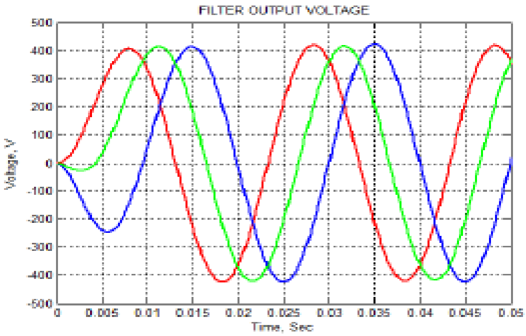

Fig 6. Output of Inverter With Filter

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G. Transformer

A 50Hz grid-operated delta-star transformer 0.1 KVA is used for galvanic insulation and the low-voltage side 250V is linked to the inverter while the high-voltage side 400V is attached to the inverter. grid. This transformer is connected at the output of the inverter to avoid dc injection and to block the path for dc current into the grid.

H. Utility Grid

The utility grid system is depicted as a 400V and 50 Hz equivalent source, which falls within the range of the low voltage (LV) energy system.

IV. CONTROLLERS

The controllers play a significant role in controlling the output voltage in a micro grid and the DC bus voltage in the hybrid micro grid must be controlled during the insulated service by the DC sources and storage devices linked to the DC portion. Meanwhile, the inverter has to regulate the voltage and frequency of the ac.

1) Controllers for PV:

In the Photovoltaic system, a DC / DC boost converter is used to alter the panel's input resistance by changing the duty cycle to suit the load resistance. The battery is a bidirectional DC / DC converter that charges and discharges during off-peak period when abundant radiation is accessible and retains stable DC connection voltage during insulated operation. A capacitor is added between PV

2) DFIG Controllers:

The rotor control system is shown in the block diagram in Figure 7 using the PI controller to regulate the rotor current. It is used to create the voltages of the rotor reference according to the reactive power and rotor velocity.

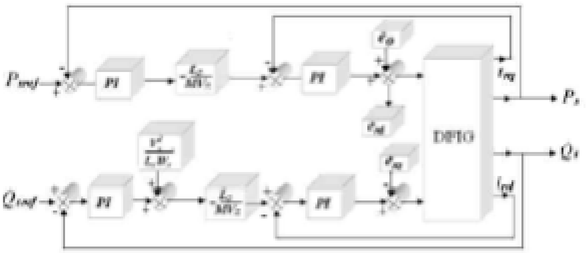

Fig 7 Block diagram of rotor control scheme

V. RESULTS AND INTERPRETATION

Considered as the test scheme and established in MATLAB / SIMULINK, the hybrid system consisting of the distributed generators DFIG and PV under the grid connected and isolated system.

In order to evaluate the efficiency of the hybrid micro grid with wind, solar and battery linked scheme, a harmonic analysis is carried out at the point of popular coupling (PCC) where the electrical utility and customers are attached. Here the DG is discovered to absorb from the local load the harmonic current. This situation is verified by linking three phase ac loads of 1KW and 0 with a non-linear moment

Case i) Grid connected mode

The converter connects the micro sources to the primary grid in grid-connected mode, and the utility grid maintains the energy. Table 1 indicates the respective voltage THD values at the load when connecting the system to the grid.

Table 1: THD voltage connected to the grid mode

	%THD	3rd harmonics	5th harmonics	7th harmonics
Voltage in Phase a	0.66	0.3	0.1	0.05
Voltage in Phase b	4.06	1.75	1.0	0.75
Voltage in Phase c	4.08	1.75	1.0	0.75

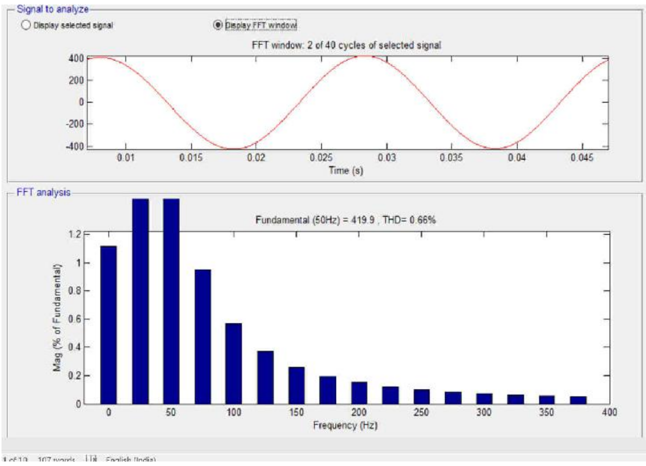

Figure 8: percentage of THD in the Under Grid mode

It is evident from fig 8 that when attached to the grid, the percentage of THD is 0.66.

Case ii) islanded mode

When the grid is disconnected, it may be necessary for the converter to continue providing critical load while retaining voltage and frequency regardless of the load type. The DG unit should supply voltage and the local load side THD is shown in Figure 9.

Table 2: THD voltage in island condition

	%THD	3rd harmonics	5th harmonics	7th harmonics
Voltage in Phase a	6.15	0.75	2.0	0.5
Voltage in Phase b	7.35	1.75	1.75	0.25
Voltage in Phase c	6.90	1.0	1.5	0.25

Table 2 shows that the THD improves in insulated mode. It is due to the reality that the DG should supply energy to the linked loads under insulated condition and to the remainder of the distribution network that enters creates some charging modifications in the micro grid that produce harmonic voltage and current and contribute to THD

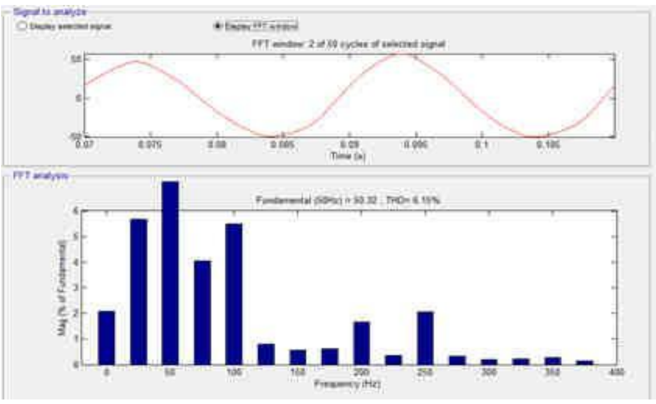

Fig 9: %THD in Phase a Under Islanded Mode

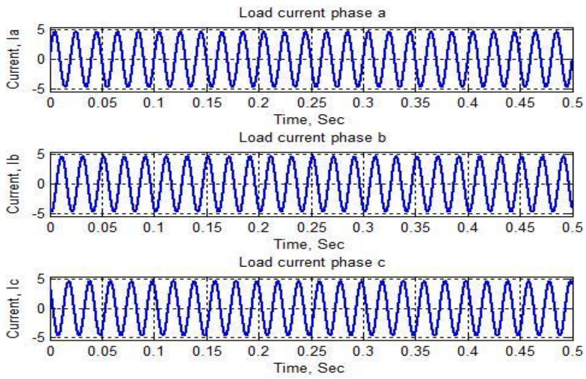

Figure 10: Different phases load current

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The load current is shown in fig 10 at distinct stages. From the evaluation of linked grid and insulated modes, it is evident that the system can be applied together with the grid to extremely nonlinear and variable PV and wind systems.

VI. CONCLUSION

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The micro grid should provide high-quality, reliable power supply for sensitive loads. Micro grid behavior is simulated during grid connected and insulated mode based on the Double Fed Induction Generator, Photovoltaic Cell, Battery and Inverter, and THD analysis when attached to AC and DC charges. If the micro grid is insulated, it is found that the THD is increasingly lower

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