"Design & development of Simulink based model for harmonic reduction in output of DFIG based wind turbine using hybrid active filter"

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Abstract

Electricity in the modern time has become one of the most important need of the world. There are several sources of electricity present in form of conventional and non conventional sources. But the conventional energy crisis forced the world to prepare for alternate energy source as wind energy system. Installations of wind turbine have been rapidly rising throughout the world, because of simplicity of this system and proliferation of government policies. annual percentage increase in the wind farm is very high and now India is the fifth in the world with an installed capacity of about 21262 MW [1]. The proposed work shows the reduced harmonic in generated electrical energy by wind connected DFIG system using hybrid active filter with Maximum Power Point Tracking (MPPT). This work has a simulation of Grid Side Control (GSC) and Rotor Side Control (RSC) with hybrid active filter to reduce the harmonics in case of non linear load. MPPT system is used to track that point or value of wind turbine at which DFIG generates the maximum electrical power. The model for the proposed work is developed in MATLAB R2018a version. The model is drawn in simulink part of the MATLAB Software

Key words:
Wind Energy, Active hybrid filter, Doubly fed Induction Generator, Maximum Power Point (MPP).

Introduction:

Energy sources which retain their form even when energy is extracted from them are called Renewable energy sources. In simple words, those resources which are naturally restored on a human timescale. Out of all non-conventional energy sources, the wind power is drawing the wide attention because of its low cost. Earlier most of the installed Wind Energy Conversion Systems (WECS) are the fixed speed constant frequency systems because of their simple control and design but they are not efficient [2]. For fluctuating wind speeds it is better to vary the rotor speed for getting the maximum amount of power.

The generation of electricity by wind energy in India growing continuously as shown in following figure.

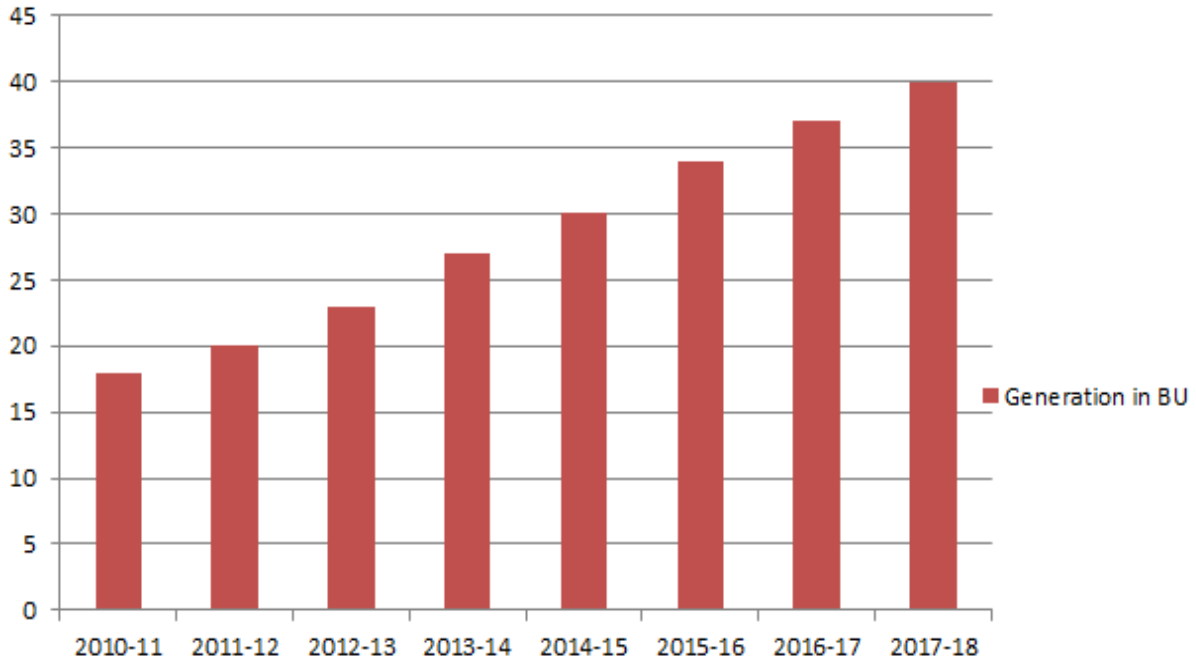

Fig.1.1

Generation of electricity by wind energy in India [6]

In this proposed work, it is shown that when non linear load is connected to wind connected DFIG system, there is large amount of harmonic distortion. If we will use hybrid active filter under non linear load condition, the harmonic distortion can be reduced in a good amount. Recently, the independent DFIG operation has attracted more attention. Some researchers have already demonstrated the variable speed, the constant frequency DFIG used in independent mode. The guaranteed power source is the main requirement of any consumer. But the wind is the width that fluctuates in nature [7].

Of all unconventional energy sources, wind energy is attracting a lot of attention because of its low cost. Previously, most wind energy conversion systems (WECS) were fixed-rate constant-frequency systems because of their simple design and control, but they are not efficient. For fluctuating wind speeds, it is best to vary the rotor speed to obtain maximum power. Among so many variable speed constant frequency generators, the dual feed induction generator (DFIG) is the best solution because of the small classification converters used. The control of DFIG systems connected to the network is also well established.

Wind Turbine & DFIG:

A wind turbine is a rotating machine that converts kinetic energy into wind energy into mechanical energy. If mechanical energy is converted into electricity, the machine is called a wind generator, wind turbine, wind power unit (WPU), wind energy converter (WEC), or aero-generator [6].

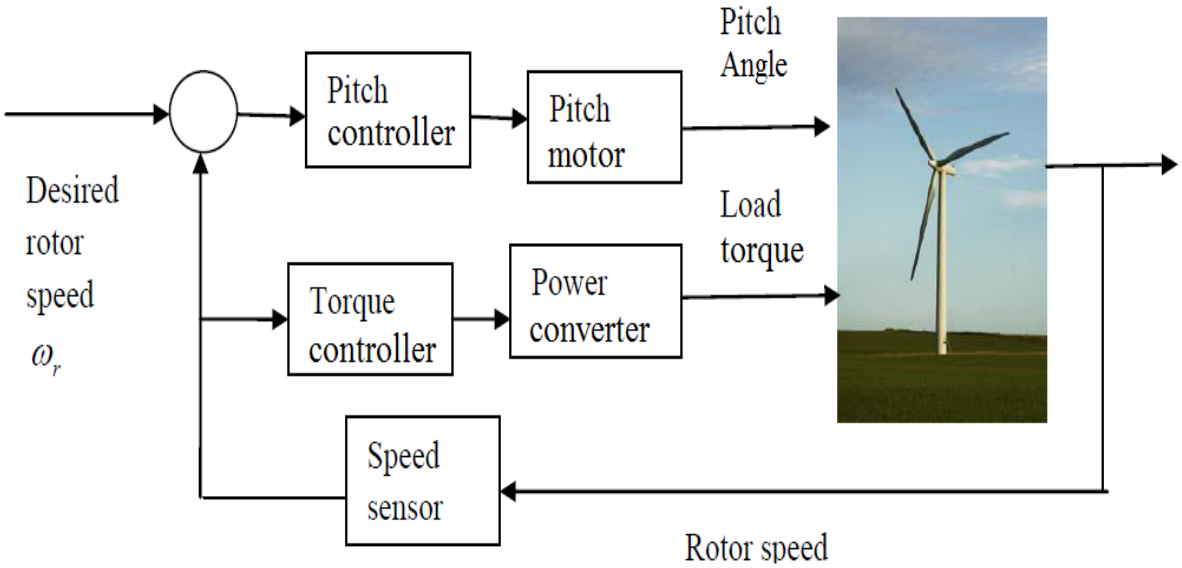

Fig.1.2 Block diagram of wind turbine closed loop control system

Doubly-fed induction generator (DFIG)

DFIG is mainly used in wind turbine systems (WECS). In its construction, the DFIG consists of a multiphase wound rotor and a poly-phase slip-ring arrangement in addition to the brushes for reaching the rotor windings. The doubly Feed Induction Generator System (DFIG) is a widespread system in which the electronic power interface controls the rotor currents to achieve the variable speed required for maximum variable wind energy capture. Since power electronics only handle rotor power, typically less than 25% of total power output, the DFIG offers the benefits of speed control with reduced costs and energy losses [18].

Hybrid Active Filter

The active power filters are better solution for power quality improvement but they require high converter ratings. So to overcome the above drawback, hybrid power filters are designed. The hybrid power filters are the combination of both active and passive power filters [4].

There are different hybrid filters according to the composition and order of the circuit.

They are-

a. Shunt Active Power Filter and Series Active Power Filter
b. Shunt Active Power Filter and Shunt Passive Filter
c. Active Power Filter in series with Shunt Passive Filter
d. Series Active Power Filter with Shunt Passive Filter

MPPT technique

MPPT stands for maximum power point tracking. It is that point or condition at which maximum power can be generated. There are various techniques two track maximum power point. Hill climbing method is one of the techniques out of them.

Each speed has a corresponding point for maximum power production and it keeps attaining that point by continuous iterations. Here, in this method (hill climbing algorithm) we first set a fixed value of rotor speed disturbance artificially, then we monitor the power at a certain speed and analyze increment rotor speed disturbance on the basis of output power of wind turbine. Electro-magnetic torque is then varied in order to attain suitable rotor speed for maximum power production [12].

Result

When non-linear load is connected to the line

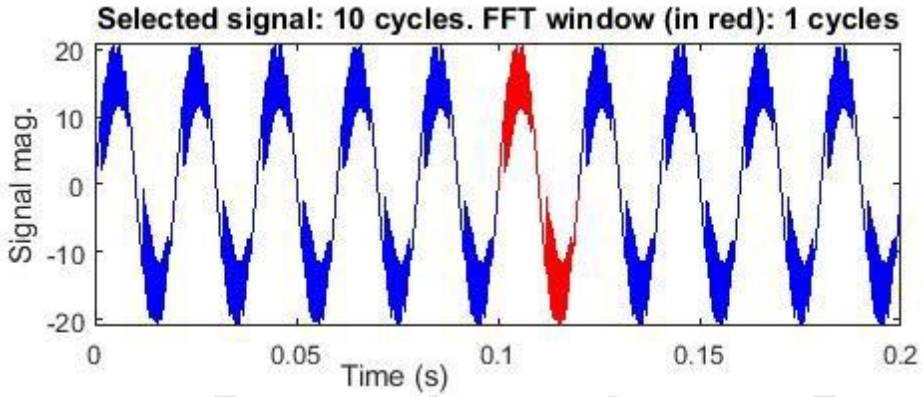

Fig.6.2.1 Simulated waveform

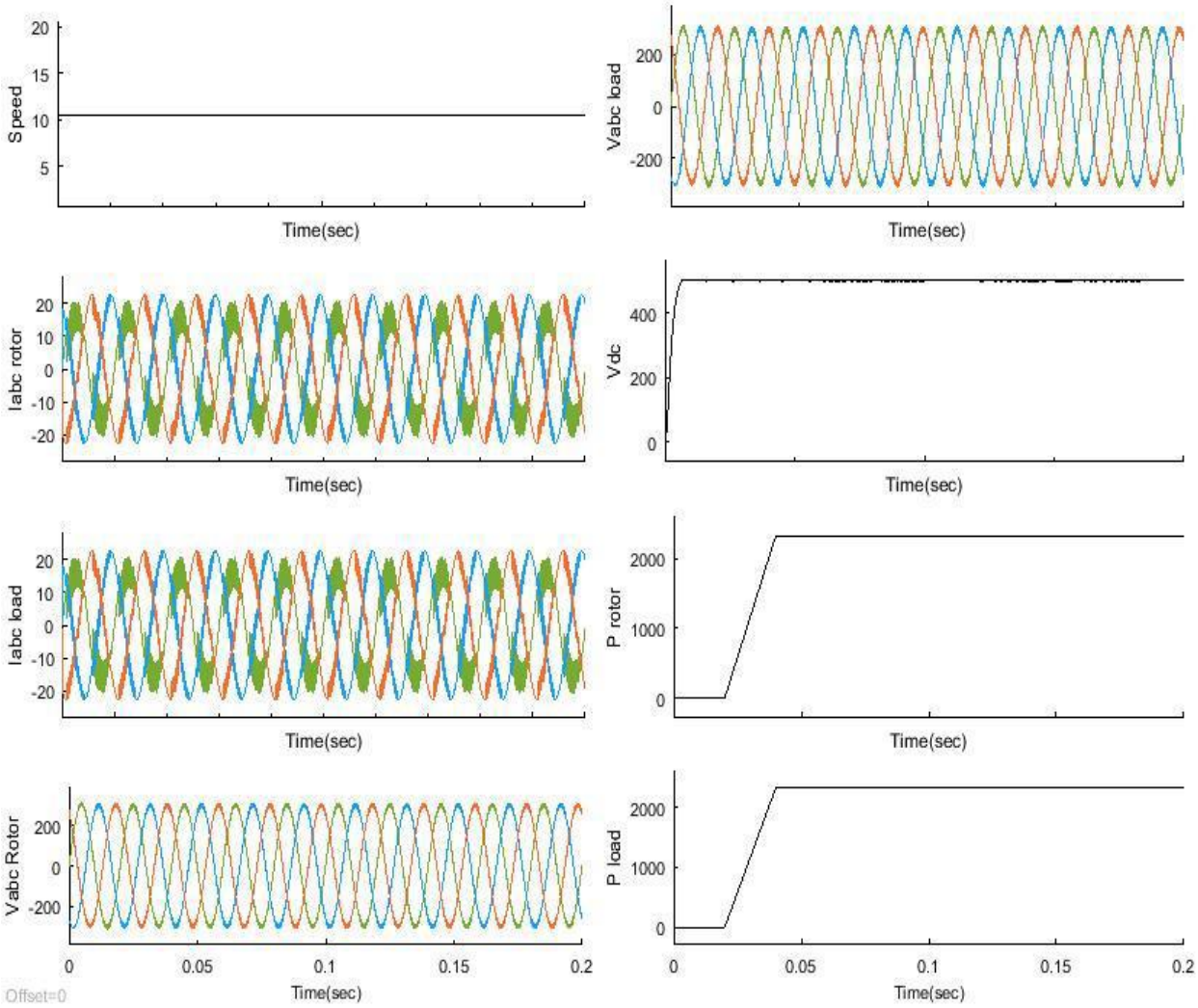

Fig.6.2.2 Resulting current and power

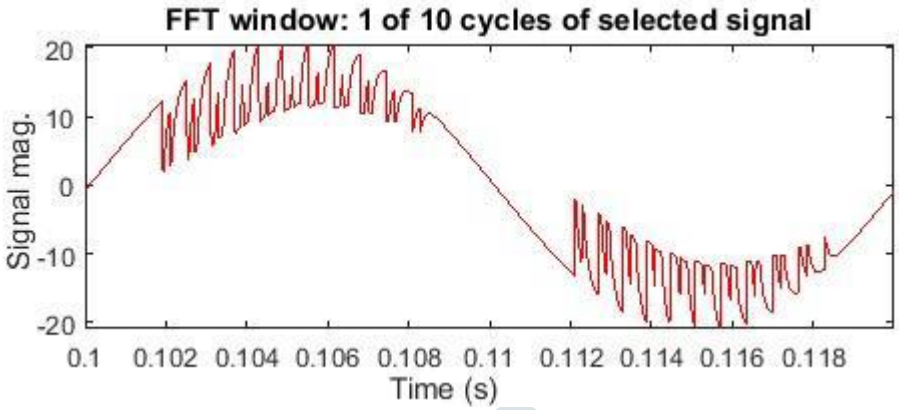

Fig.6.2.3 Single cycle for distortion analysis

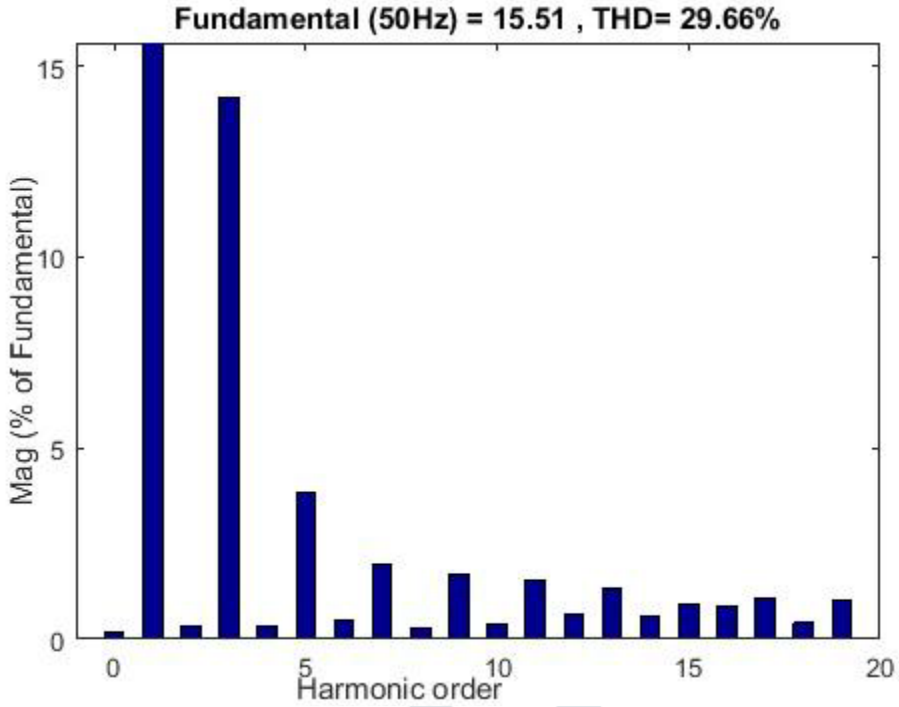

Fig.6.2.4 Harmonic spectra when non-linear was connected

Conclusion & future scope

Conclusion

With the proposed methodology, we conclude that the non-linear load have increased the total harmonic distortion by 29.66% which was 0.14% when non-linear load was not applied ,therefore we have used hybrid active filter for controlling total harmonic distortion to 4.16%.

Table 1.1: Comparative analysis of the system performance

Load condition / Parameter variation	Total harmonic distortion	System state
Non-linear load applied	29.66%	Un-synchronized

Future scope

Many researches are going on for developing filters which can suppress the level of harmonics more than the Hybrid active power filter.

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