*International Journal of Engineering Research and Development*
***e**-ISSN: 2278-067X, **p**-ISSN: 2278-800X, www.ijerd.com*
*Volume 4, Issue 3 (October 2012), PP. 77-81*

# Reduction of Harmonics in Microturbine Generation System

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**Abstract:-** In today's global power scenario Distributed Generation (DG) is playing an important role. DG can be obtained from many sources such as wind energy, tidal energy, solar energy, landfill and digester gases etc. In recent DG technologies microturbine generation is proven to be one of the simpler and environment friendly DG systems. DG systems are usually stand alone or they are interconnected to low and or medium voltage grid system. With increasing penetration of DG, it is necessary to analyse its performance and its impact on existing system. Modelling and simulation of DG systems helps in analysing their performance and impact on existing power distribution system. In this paper, a model of a micro- turbine generator system is developed in MATLLAB/Simulink using SimPowerSystems library. The simulink model is built from the mathematical model of each part of system with their interconnections. This simplified model is a useful tool for studying the various operational aspects of micro turbines. The performance of developed model is studied by connecting it to an isolated load. The interconnection of a microturbine generator to a load or distribution system is a critical part and it requires efficient power conditioning system. In this paper, AC/DC/AC power converter is used. Semiconductor power electronics devices such as rectifiers and inverters produce harmonics in the system. The harmonics injected by the microturbine generation system are reduced by using passive filter. The simulations of the microturbine generation system are carried out for resistive as well as inductive load. The output waveforms are presented in the paper.

**Keywords**:- Distributed Generation, Microturbine Generation System, Simulation of MTG system, Power conditioning system, Passive filter

## I. INTRODUCTION

Recently, the world has been focusing on the use of micro sources due to their high operating efficiency, improved reliability, and lower emissions [1]. These systems are either connected to the existing grid system or can be used as stand alone systems. They are usually installed in medium and low voltage power distribution system and called Distributed Generation (DG) systems.

The fundamental concepts for the penetration of Distributed Generation (DG) technologies are the high efficiency of the energy conversion process and the limited emission of pollutants as compared to conventional power plants,[1]. DGs come in different forms such as small gas or diesel fired turbines, reciprocating engines, small hydro induction generators, wind turbines, fuel cells, microturbines etc.[2].

Microturbine generation system is one the most attractive DG units nowadays. This is because microturbines operate with less vibration and low noise, exhibit very fast response to load variation, requires low maintenance, and runs on a variety of fuels [1]. The potential applications of microturbines include peak shaving, stand-alone power and standby power [2,3].

Generally microturbine generation (MTG) systems range from 30 to 400 kilowatts. Microturbines are capable of burning a number of fuels at high and low pressure levels. Because of their design simplicity and relatively fewer moving parts, microturbines have the potential for simpler installation, higher reliability, reduced noise and vibration, lower maintenance requirements, lower emissions, continuous combustion and possibly lower capital costs compared to reciprocating engines.

Modelling and simulation proves to be very helpful for analysing the performance of DG system. It is necessary to have full understanding of impact of DG on distribution feeders and its interaction with the loads. Some of the important operational aspects required to study are voltage control, voltage stability, system protection, islanding etc. Such studies require accurate modelling of Distributed Generation (DG) sources including their interconnection with load or grid.
Design of interconnection of DG with load is a critical part and involves design of power conditioning system. Power electronics interface leads to generation of harmonics. Harmonics reduction is one of the major issues and needs a design of filter system.

## II. RELATED WORKS

In global power scenario Microturbine Generation System(MTG) seems to be an emerging and promising technology. Microturbines are small gas turbines capable of working on variety of fuels such as landfill gases, digester gases and even gases that include significant hydrogen content. There are various applications of MTG system such as peak saving, co-generation, remote power and premium power. Behaviour of MTG system can be studied by modelling and simulating the system. The performance of single shaft MTG system is presented in [1]-[3]. This paper presents design of passive filter for reducing harmonics in single shaft MTG model interconnected with resistive load. The model is developed in MATLAB/Simulink using SIMPowerSystems Library.

## III. SIMULATION OF MTG SYSTEM AND DESIGN OF PASSIVE FILTER

Microturbines (MT) are high speed gas turbines working on Brayton cycle. Microturbine generation systems are broadly classified as single shaft MTG and split shaft MTG. In single shaft system, turbine, compressor and generator are on one and the same shaft. In split shaft system, turbine and compressor are on one shaft and generator is coupled to turbine system by means of suitable gear box coupling. Single shaft system is preferred over split shaft as it contains comparatively fewer moving parts resulting in less dynamics.This paper presents modelling of single shaft MTG system.
Components of MTG system are:

1. Microturbine
2. Permanent Magenet Synchronous Generator (PMSG)
3. Power conditioning system

**Modelling and Simulation of Microturbine:[1]**
Following systems are considered for modelling and simulation of MT.

1. Speed control system
2. Acceleration system
3. Temperature control system
4. Fuel system
5. Compressor turbine system

Figure 1 represents the entire model of microturbine developed in MATLAB/Simulink.

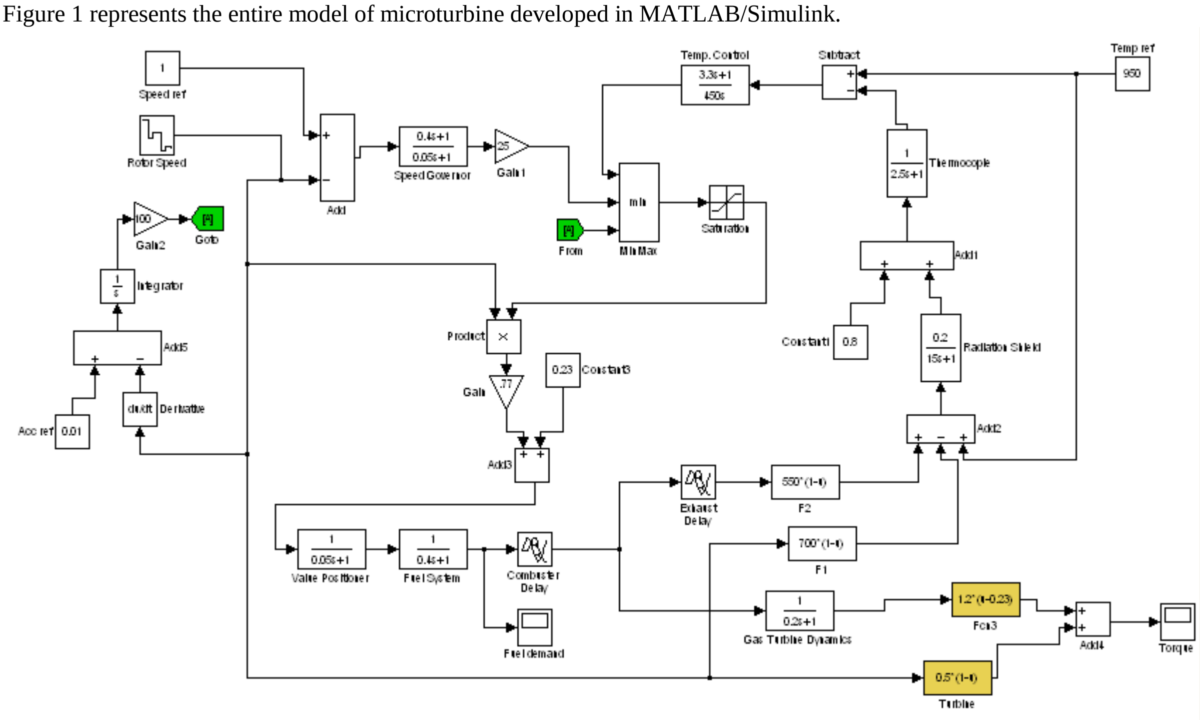


**Fig. 1** Simulink model of microturbine

Microturbine is used as a prime mover for PMSG. Speed of microturbine is 96000 rpm. High energy permanent magnets and high yield-strength materials like neodymium-iron-boron (NdBFe) or Samarium-cobalt magnets are very suitable for such high speed electrical machines. As a result PMSG produces electrical energy at a very high frequency of 1600Hz. In this paper the performance of MTG is studied by connecting it to resistive load. Total simulation time is of 2 seconds. Initially system runs at no load condition. Once system achieves it rated speed of 96000rpm, at the end of 1.3 seconds 15kW load is applied to system. At the end of 1.8 seconds additional load of 9kW is applied to the system. High speed MTG system is interconnected to load by using AC/DC/AC conversion system. High frequency voltage is first rectified by means of a rectifier and 50Hz voltage output is obtained using PWM IGBT inverter. The IGBT inverter uses Pulse Width Modulation (PWM) at a 6.4 kHz carrier frequency and sample time of 2μs.

Parameters of PMSG used for simulation are:[1]
R = 0.25 Ohms, number of poles p = 2, Ld = Lq = 6.875×10-04 Henrys, λ(flux linkages) =0.0534 wb,
Load Parameters: 24 kW, 480 V, 50 Hz.

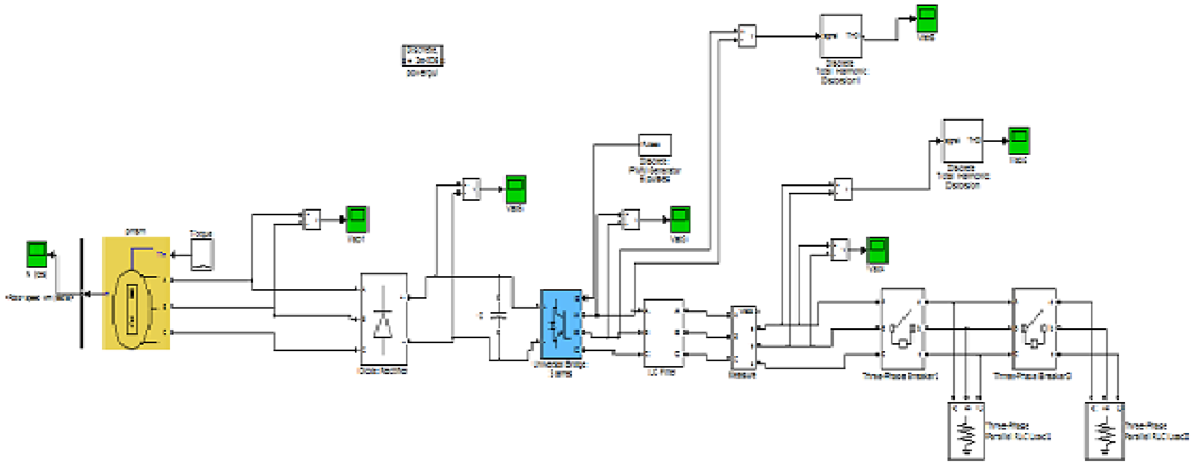

**Fig 2: MTG interconnected to resistive load**

Inverter used in the system is 6 pulse inverter. It generates harmonics of the order of n±1 i.e. 6±1. The lowest harmonic is of 5th order with frequency 5*50 i.e. 250Hz. To get a sinusoidal output low pass passive filter is introduced in the system. The formula for cut off frequency of filter is:

$f_c = 1/2\pi\sqrt{LC}$

where,
$f_c$ = cut off frequency (250 Hz)
L = value of inductor in Henry
C = value of capacitor in farad
To avoid the losses in inductor the value chosen here is: 0.0005H from which value of C can be calculated.

Following are the output waveforms of the system:

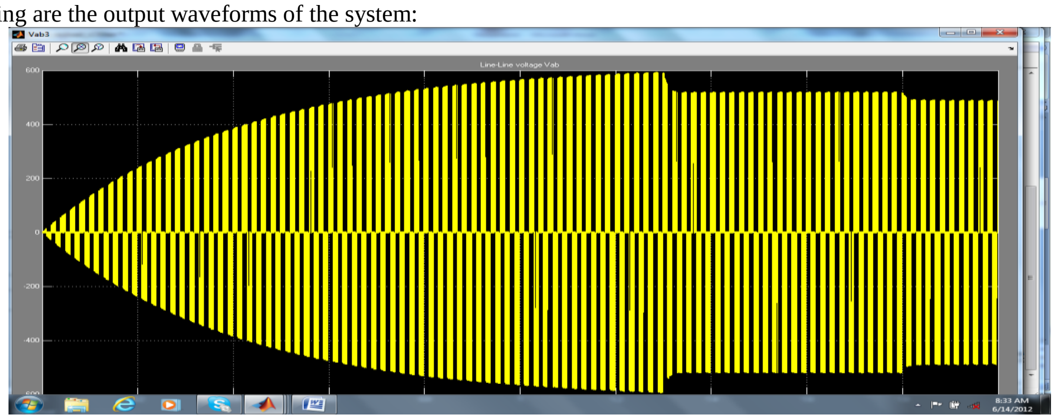

**Fig 3: Inverter output (without filter)**

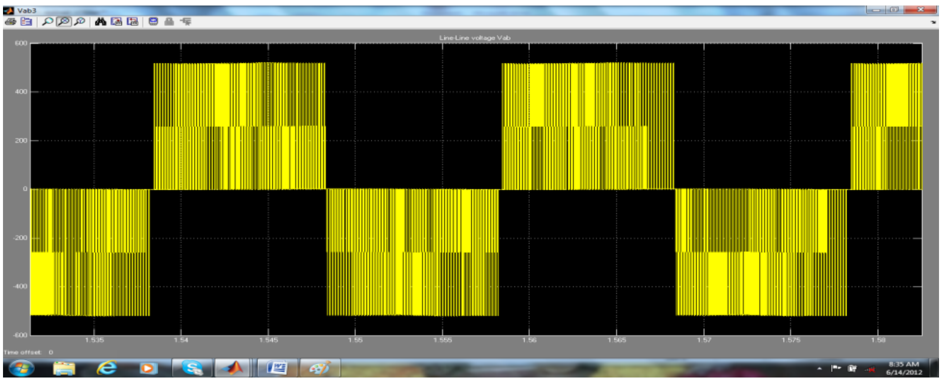

**Fig 4: Enlarged view of inverter output (without filter)**

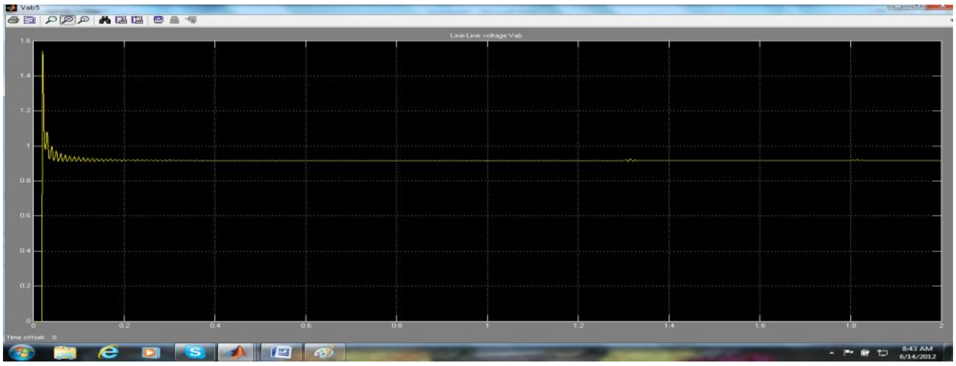

**Fig 2: Total Harmonic Distortion (THD) in inverter output (without filter)**

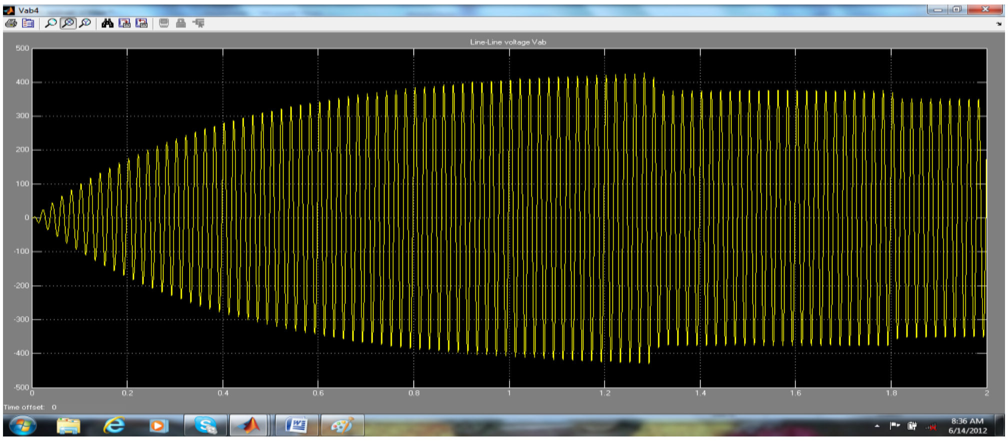

**Fig 2: Inverter output (with filter)**

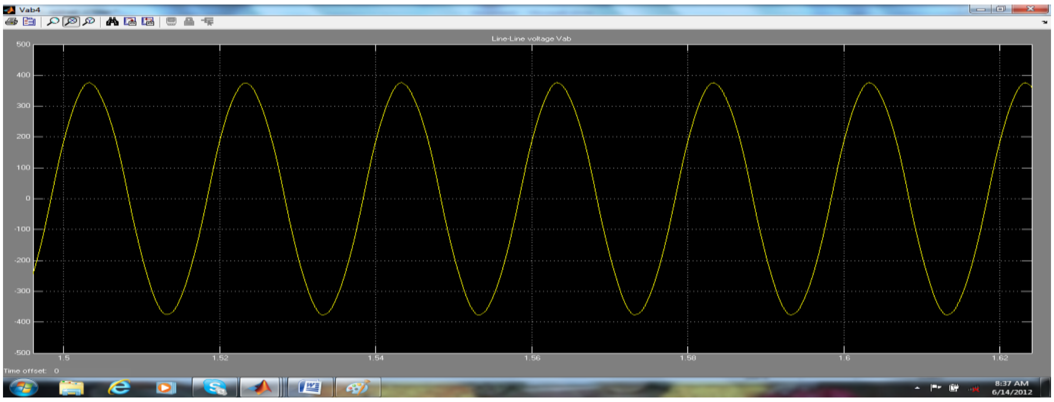

**Fig 4: Enlarged view of inverter output (with filter)**

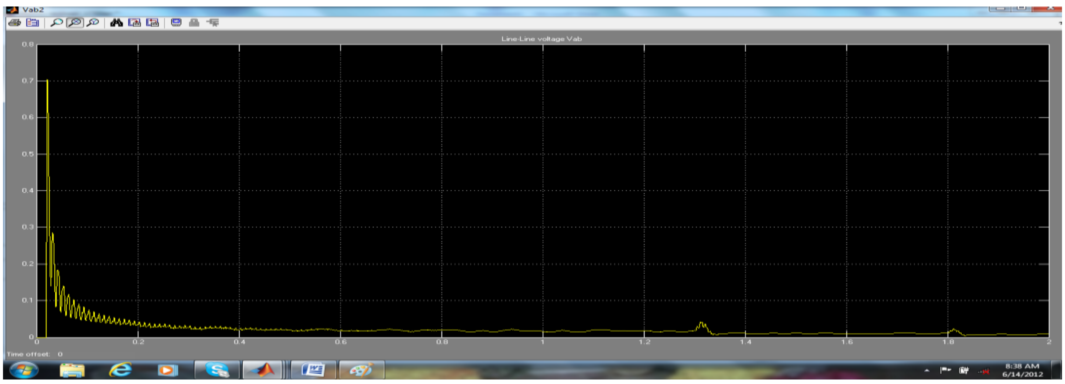

**Fig 2: Total Harmonic Distortion (THD) in inverter output (with filter)**

## IV. CONCLUSIONS

Thus the microturbine generator system can be successfully implemented as a standalone system. The harmonics can be reduced to acceptable level by using passive filters. Without filter THD of output is more than 0.9 but with the use of passive filter it is less than 0.05. As, system considered here is stand alone passive filter is a good solution for reducing the harmonics. However when MTG is interconnected to grid one has to take into account harmonics generated by grid system. In such cases active filters or hybrid filters can be used for reducing the harmonics.

## ACKNOWLEDGMENT

My special thanks to Prof. Dr. Mrs. Vrunda Joshi, PVG COET Pune-09, for her suggestions and encouragement in the process of this paper. I would like to dedicate this paper to my husband, Mr Anant Y. Aphale, for his constant support and motivation towards completion of this paper which is based on my dissertation topic.

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