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Harmonics Reduction in Micro Turbine Generation System

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Abstract *:Now a day's comprehensive power setup distributed generation system is playing an significant virtual role. In distributed generation system is acquired from many bases like as wind energy, tidal energy, solar energy, landfill and digester gases etc. In this paper self-motivated model of micro turbine generation system has been established and a new converter supervisor is introduced. It has been proposed dynamic simulation prototypical of a micro turbine system has been recommended. The various controller models of Micro turbine systems are executed in the MATLAB using SIMPOWER Systems library. The micro turbine model is analyze and performed with an isolated load considering RL and LC filter with and without reactive power instillation into the system. The micro turbine generation system will maintain the quality power and fewer harmonics.*

Index Terms*: *Micro turbine, Power Co-generation, combustion, Filter.

I. INTRODUCTION

Electrical system is more dependability and normal operation of electrical equipment trust heavily upon a clean distortion and unrestricted power supply. In nonlinear harmonic generating loads are coupled to power distribution network in order to diminish the level of harmonic pollution in the system. There is several harmonic mitigation methods are used subsequently of the number and diversity of available methods, selection of the best-suited available technique for an individual application is not always an easy process or forthright practice [2]. The micro turbine system is fed to connect by a power converter device and followed by an active filter design. The AC/AC converter recycled to renovate extraordinary frequency to normal frequency at 50Hz.The power converter device is also performed to supply valuable supplementary services to the micro grid [1]. These supplementary services may involve supporting the voltage, voltage sag compensation, and static volt-amp-reactive compensation, load following performance service, revolving or non-revolving operating reserve, standby supply and start-up power for the micro turbine system. The voltage support of the organization is conventional for the grid connected and self-determining process while load subsequent is recycled for the grid-connected well-designed system [3]. The functional fallback proficiency may or may not be accepted by the limited electricity supplier depending on their existing pricelists and the potential of the micro turbine generation organization connection. The prevalence of backup supply and start-up to increases the power through micro turbine manufacturer as well as through the options that may be obtained with the micro turbine. The favor conventional, power converter topology used for linking the micro turbine systems to the grid by DC link converter [22]-[24].The Micro-generator will have to be converted high frequency power from to DC previously the inverter may re-arranged a three-phase supply voltage at inferior frequency essential for the network association. This controller accomplishes the function of the converter and inverter circuit topology by confirming that utilities such as voltage and current succeeding phase identical and harmonic dominance. These are done unfailingly and at optimum proficiency. The controller based depending on the limitations and factors such as expected micro turbine system packaging, desired multi-purpose outputs and type of availability in features and the refinement of the system design. During the starting synchronous mechanism performances as a electrically powered and pulls power after the grid to fetch the micro turbine system at that time to maintain the certain speed [5]-[6]. The presentation of the micro turbine generation system operation is illustrated Fig.1.The power conditioning system comprises rectifier, inverter and a filter.

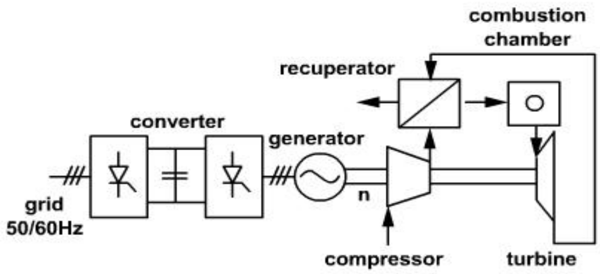

Fig.1.Model of the micro turbine system

II. MICROTURBINE GENERATION PLANNING MODEL

In implementation of micro turbine generation organization is displayed in Fig. 2. For a solo shaft micro turbine is interfacing power to the circuit is recycled to turn extraordinary frequency AC power shaped by the permanent magnet synchronous machine hooked on functional electrical power[8]. The power circuits is one of the essential mechanisms in a particular trough micro turbine design and stand alone for a significant challenge in designing especially in not supporting the turbine output to the load demanded. In almost all commercial and non commercial applications, the cost reduction of the energy generated is a vital point.

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Hence among the available energy conversion technologies, PMSGs combined with a direct current vector control is most effective because it can operate at variable speeds, which has the potential to satisfy the requirements of the grid effectively[25]-[27]. The DC vector controls operate in both machine side control and grid adjacent control. The converter from the machine sideways converter acts on the control the generator speed to enhance the extraction of power. The grid adjacent converter may practice that direct vector mechanism techniques for DC tie voltage and the power factor at a grid connection point [28]-[30]. At the generator end, torque and the flux control are decoupled. At the grid end, active and reactive power control is decoupled. There is a rotating frame, in which the decoupling between dq components takes place, controlling the resultant torque and power. By employing the direct control strategies, similar but quicker algorithms provide the desired results. Current vector strategies are conventionally capitalized for controlling parameters of electric drives. In direct vector control scheme [7], controlled directly to the stator flux and the electromagnetic torque and also vary independently.

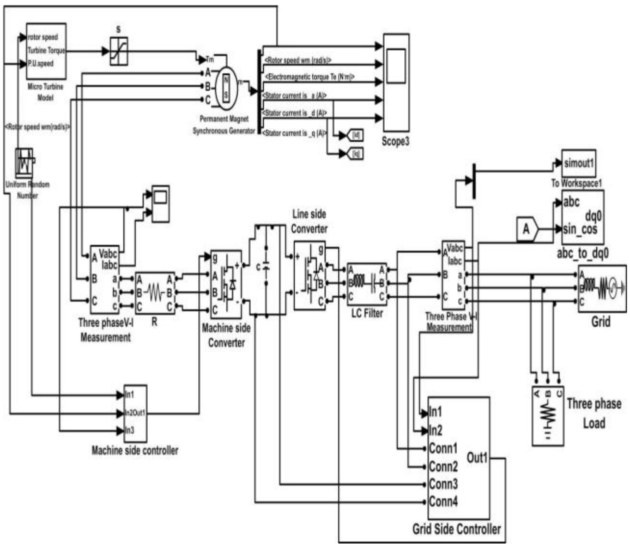

Fig.2. Implementation of Micro Turbine generation system
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III. GRID SIDE CONVERTER METHODOLOGY

During micro turbine variation, the grid adjacent converter is used to amend the DC bus voltage and also regulate the magnitude of the "wattles" and real powers distributed to the network. At that time for achieved unity power factor for any rotation of micro turbine speed. As a result, the direct vector regulator by PI mechanism loops is engaged. In three-phase load current may be collapsed in positive sequence, negative sequence and zero-sequence module. The current in the d-q vector structure and can be altered from the positive sequence and negative sequence using a phase locked loop [9]-[10]. In correlation among the line currents and the network inverter voltages is given by

$$\begin{pmatrix} e_a \\ e_b \\ e_c \end{pmatrix} = R_f \begin{pmatrix} i_a \\ i_b \\ i_c \end{pmatrix} L_F \frac{d}{dt} \begin{pmatrix} i_a \\ i_b \\ i_c \end{pmatrix} + \begin{pmatrix} v_a \\ v_b \\ v_c \end{pmatrix} \tag{7}$$

where: e_a, e_b, e_c inverter system productivity voltages:
V_a, V_b, V_c network voltage :
i_a, i_b, i_c line currents:
L_f inductance filter:
R_f resistance filter:

With the transforming above equation as in the locus casing rotating synchronously with the electrical grid voltage vector, the prototypical for the grid-adjacent converter [11-13] is given by:

$$V_q = e_q - R_f i_{q-f} - L_f \frac{di_{q-f}}{dt} - \omega L_f i_{d-f} \tag{8}$$

$$V_d = e_d - R_f i_{d-f} - L_f \frac{di_{d-f}}{dt} - \omega L_f i_{q-f} \tag{9}$$

Where:
e_d, e_q d-axis and q-axis inverter voltage mechanisms:
V_d, V_q network voltage component in the d-axis and q-axis:
i_{d-f}, i_{q-f} d-axis and q-axis current of network:
ω angular frequency of the system

The vector control scheme is established on a rotating position edge. The instantaneous powers are given by

$$Q = \frac{3}{2}(v_d\, i_{q-f} - v_q\, i_{d-f}) \tag{10}$$

$$P = \frac{3}{2}(v_d\, i_{d-f} - v_q\, i_{q-f}) \tag{11}$$

The DC –side equation derived by

$$C\frac{dU_{dc}}{dt} = i_s - i_{grid} \tag{12}$$

where:
U_{ab}- dc –link voltage:
i_s - PMSG side current
i_{grid} - grid adjacent transmission line current
C - dc-tie capacitor.
So, we can rewrite the above equation

$$C\frac{dU_{dc}}{dt} = \frac{P_{gp}}{U_{dc}} - i_{grid} \tag{13}$$

The separation between the harmonic components and reactive mechanisms from the load current is the objective of current orientation generator. The main representative of this vector control method is the direct source of the reimbursing element from the load current, deprived of the practice of some reference d axis-q axis frame transformation. The direct vector control scheme is used from a revolving synchronously reference d-q vector frame as exposed in Fig.3.

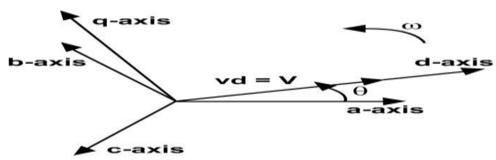

Fig.3. The bus and revolving orientation edge

Then:
$V_d = V$
$V_q = 0$

Then: Equation (8)-(9) may be expressed as:

$$L_f \frac{d_{id-f}}{dt} = e_d - R_f i_{d-f} + \omega L_f i_{q-f} \quad (14)$$

$$L_f \frac{d_{iqf}}{dt} = e_q - R_f i_{q-f} + \omega L \quad (15)$$

Then using equations (10)-(11), the “wattles” power and real power is designed as:

$$P = \frac{3}{2} v_{id-f} \quad (16)$$

$$Q = \frac{3}{2} v_{iq-f} \quad (17)$$

As a result, “wattles” and real power is orderly by quadrature- q reference axis and direct-d reference axis current components. Then

$$i_{qr-f} = \frac{2}{3V} Q_{ref} \quad (18)$$

$$i_{dr-f} = \frac{2}{3V} P_{ref} \quad (19)$$

Where i_{qr-f} and i_{dr-f} are the reference signal of q-axis current. The Q_{ref} and P_{ref} is the orientation of “wattles” power and real power component. Further, the inverter is recycled to transference all the true power produced by the micro turbine generation system to the utility network connected system .At that time the system create no reactive power, and also harmony power factor is maintained. Consequently; the dc-tie voltage should stay endless value. In Fig.4 shows the device structure of DC-bus voltage where P_{gp} is the real power distributed after the permanent magnet synchronous generator [14]-[16].

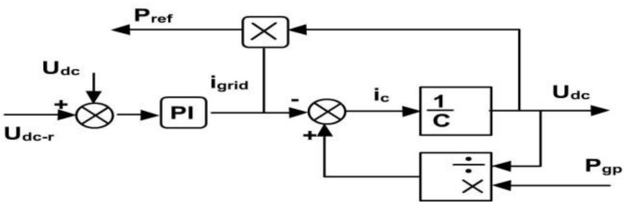

Fig.4. Control of DC-bus voltage

The d-axis orientation vector frame current is resolute by the DC-bus voltage regulator in directive to regulate the converter output active power of the system [17]. For this purpose the PI supervisor is used to produce the position basis current and also monitor the DC voltage, while the orientation signal of the q-axis reference current is spawned by the “wattles” power Q_{ref} rendering to the illustrated in equation (18).With an aim to reward the cross link consequence owing to the output filter in the revolving synchronously orientation vector edging, the decoupling voltages are supplementary to the current regulator outputs. For that reason, we practice: and

$$R_f i_{d-f} + L_f \frac{di_{d-f}}{dt} = e_d'$$

$$R_f i_{q-f} + L_f \frac{di_{q-f}}{dt} = e_q'$$

At that point, the inverter q –axis and d-axis voltage mechanisms may be illustrated as follows:

$$e_d = e_d' - L_f \omega i_{q-f} + V$$

$$e_q = e_q' - L_f \omega i_{d-f}$$

Consequently, they are calculated as follows:

$$e_d' = K_{p(id_{r-f} - i_{d-f})} + K_I \int (id_{r-f} - i_{d-f})\, dt$$

$$e_q' = K_{p(iq_{r-f} - i_{q-f})} + K_I \int (iq_{r-f} - iq_{-f})\, dt$$

There are two secure loop system controls. The Pulse Width Modulation (PWM) is recycled to create the regulator signals to standardize the grid adjacent converter [18]. To counter-balance the cross-coupling effects, the decoupling voltages, Δv_q , Δv_d are supplementary to the current regulator productions. In PWM control attitude, the modulation signal is attained by a current supervisor from the current error signal is overlapped with the triangle wave. The switches of the converters are controlled by the pulse signals obtained. This control method has unassuming operation with dissolute speed of response [19]-[21] with analog PWM circuit.

IV. RESULTS AND DISCUSSION

Micro turbine generation system Voltage and Current Wave forms with RL and LC Filter:

The usefulness link, towards the micro turbine organisation is associated, is signified by a three phase sinusoidal basis with its impedance. The simulation considerations values of the model are given in Table1. In LC the high-pass filter circuits form a low-impedance circuit pathway for a specific value of harmonic frequency [14-16] and Passive harmonic filters are connected to the series or parallel combination of a tuned frequency. To distract the tuned frequency harmonic content current absent after the power supply, this filter is associated in series or parallel with the nonlinear linked load.

Grid Constraints	480V,50Hz,R_s=0.4Ω and L_s=2Mh.
Filter Factors	L=0.97mH,C=10μF
DC tie capacitance	5000μF
PI supervisors selection interval	100μsec
PMSM Limits	480V, 30Kw, 1.6KHz, 96000 rpm,R_s=0.25Ω, L_q=L_d=0.0006875H, Number of poles p=2& λ=0.0534wb.
Micro turbine system considerations	Parameter Gain(k) value=25,X=0.4,Y=0.05 and Z=1

Table.1. Model considerations of the prototype.

The series line reactors reduce all harmonic frequencies and harmonic filters disregard a particular harmonic frequency since the supply harmonic content current waveform. It has been shown in the presence of isolated power system the most effective method to minimize harmonic losses or eliminating harmonics at their source.

With RL filters the PMSM voltage and the current waveforms are obtained and are illustrated in Fig.5. The current waveforms and Load side voltage with RL filter are demonstrated in Fig.6. The organism load adjacent voltage and the current waveforms are not sinusoidal in nature.

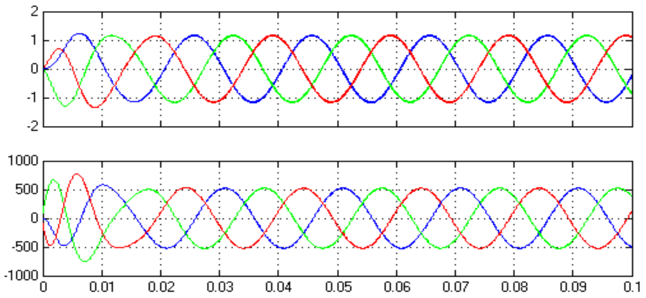

Fig.5. PMSM current and voltage waveforms obtained with RL filter

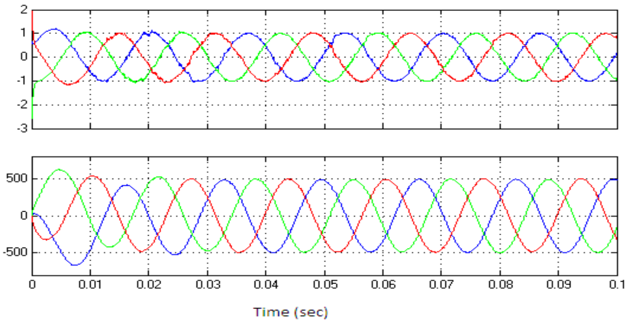

Fig.6. Load side current and voltage waveforms with RL filter

The permanent magnet synchronous machine voltage and current waveform variations are achieved with LC filter are explained in Fig.7. In Fig.8 and Fig. 9 demonstrates the effect of no reactive power injection and the reactive power injection to the micro turbine system on voltage and current waveform with the LC filter. The waveforms are obtained to be nearly sinusoidal nature in reactive power injection to the micro turbine system.

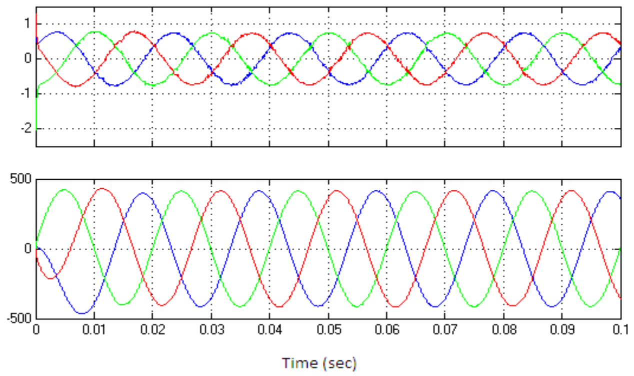

Fig.7 PMSM current and Voltage waveforms obtained with LC filter

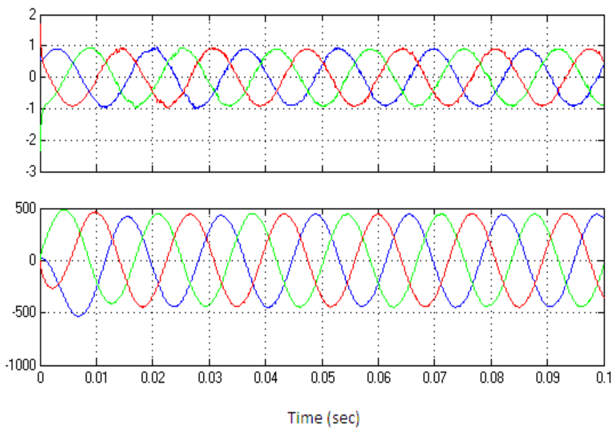

Fig.8.Load side current and voltage with LC filter with no reactive power booster

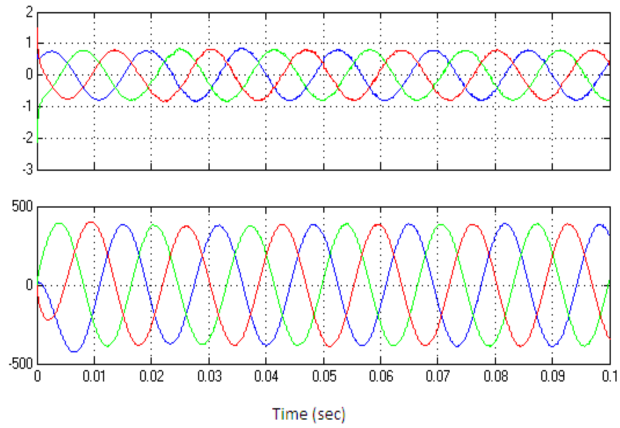

Fig.9. Load side current and voltage with LC filter with reactive power booster

The line side and load side voltage level of converters are always sustaining the constant DC voltage level. From Fig. 5 to Fig.9, the situation is experimental that both the instrument adjacent and the link adjacent converter supervisors are operated very smoothly. Therefore, the micro-turbine preserves the explosion speed, and the permanent magnet synchronous machine runs to operate as a generator. The micro turbine generation system is distributing the regarded real power to the system consignment unremittingly as the load adjacent variations of voltage and current waveform are sinusoidal in nature.

V. CONCLUSION

The micro turbine generation system is implemented in MATLAB / SIMULINK and derived a direct converter controller systems have been planned. The case study is elaborate with RL and LC filters with and without reactive power injection into the scheme. The LC filter provisions the reactive power to the scheme, as well as diminish the high order harmonics content and sinusoidal waveforms are achieved at the load side. From the simulation study of the micro turbine generation scheme, it is revealed that power is delivered to the grid connected system, and performance of load following character is also determined.

Hence it is observed that the technique can optimize the performance of a system.

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