Performance Study of Distributed Generation System in Grid Connected/Isolated Modes

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ABSTRACT

The Microturbine Generations (MTG) system is becoming one of the promising sources of Distributed Generation (DG) due to their fuel flexibility, reliability and power quality. Thus, the accurate model of MTG system is required for the grid connected operation and its perturbations. This article presents the performance study of MTG based DG system in grid connected, islanding and re-closed modes of operation. The developed model of MTG system includes a microturbine as prime mover, Permanent Magnet Synchronous Machine (PMSM) and power electronics interacting circuit along with control schemes. The MTG system uses the turbine speed to control the microturbine output power in comparison with the reference speed and shaft speed. The generated AC power is converted to DC using a passive rectifier and this DC power is inverted back to AC power to mach grid frequency. The DC link power is delivered to the grid, islanding load using a three phase voltage source inverter with Pulse Width Modulation (PWM) techniques. While delivering the DC link power to the grid and islanding load, the respective Active, Reactive Power (PQ) and Voltage Frequency (VF) control strategies are used for inverter operation. The detailed model of MTG system along with control schemes is developed using Matlab/Simulink environment and the simulation results show the performance of MTG based DG system. From the simulation study, it is ascertained that, the developed model of MTG system can delivers the power to grid and isolated load significantly, by shifting the converter controller manually.

Keywords: *Distributed generation, Microturbine, Permanent magnet synchronous machine, Power electronics interface.*

INTRODUCTION

Distributed Generation (DG) draws an overwhelming attention in the distribution network due to improvement in power system stability, reliability and power quality. The integrated operation of DG into a distribution network yields advantages like, technical, economical and environmental issues. In order to achieve these benefits, the DG source penetration in an existing utility network causes several technical and operational problems such as, degradation of system stability and islanding issues [1]. The inter-connected operation of DG may get isolated from grid due to grid disturbances, voltage imbalances and fault in distribution network and hence DG may continue to operate in islanding mode [2]. Current trends in designing and operation of networks dissuade the islanded operation for safety and secure region [1, 2].

Note that utilities and distributed generators do islanded operation by splitting a larger interconnected transmission and distribution network into load/generation islands o micro grids, with the aim of preventing a total or larger system outage, while ensuring supply/demand balance and other requirements within the micro grid island(s). Recently due to de-regulation, there is a trend to operate DG intentionally in islanding mode to meet the uninterrupted quality power demand of the customer. Islanding operation of the DG system during utility outage will improve the local reliability and helps in maintaining un-interrupted power supply [3, 4]. Hence, the currently followed practices of disconnecting the DG unit from the local micro grid due to disturbances towards preventing islanding will no longer be a recommended practice or a reliable solution in de-regulated market environment [3]. The IEEE Std1547-2003[4] states the need for implementing intentional islanding operation of DG systems.

The dynamic performance of microturbine generation system under the various grid disturbances has been studied in different ways. In [5], a microturbine generation system, its related control schemes has been analyzed in detail to explore the possibility of small generators operation effectively in grid connected and isolated modes of operation. The MTG system developed in [5] uses a synchronous generator (SG) for power generation and MTG system output power is controlled by the speed and error in speed. The dynamic model of MTG system, suitable for grid connected and isolated modes of operation has been developed in [6].

This model allows the bidirectional power flow between grid and MTG system through a power interfacing circuit. The grid power is utilized to start and bring the MTG system to an ignition speed. A controlled algorithm for utility interactive PWM inverter to maintain a continuous uninterrupted voltage across critical and sensitive loads during the fault in grid has been reported in [7]. The algorithm developed in [7] switches, the inverter between voltage controlled and current controlled modes are implemented using digital signal processing (DSP) for the inverter operation. Also, the model uses the constant DC voltage source (battery) for reliable operation of inverter. The MTG system performance study during the grid faults and grid code requirements has been developed in [8]. In this, the MTG system uses a PMSM along with active and passive rectifier to maintain the DC link voltage for different cases. The long-term dynamic model of microturbine generation system with AC to AC matrix converter as an alternative to AC/DC/AC converter system connected to a utility grid as a DG source is reported in [9]. The MTG system model developed in [9] includes a new switching strategy and mechanism of converter control based on time domain simulation in PSCAD/EMTDC environment. The model of MTG unit has been developed and simulated in PSCAD/EMTDC under on-grid and off-grid operation modes in [10]. Here, the model of microturbine is equipped with controller that allows the unit to operate either in parallel with or without grid. The MTG system along with back to back power converter and the corresponding control methods are analysed and deigned in [11]. In [11, 12] the MTG system uses synchronous generator. The model developed in [11] uses an active rectifier and inverters along with associated controller which are tested in Matlab/simulink environment. The simulation results verifiers that, the MTG system can operates well with these control methods. In [12] the MTG system output power is delivered to the grid without power electronics interfacing circuit.

In this article, the complete model of MTG system along with power converter and control strategies has been developed for grid connected and isolated modes of operation. The MTG system uses a PMSM over an induction generator or synchronous generator which requires separate field excitation control system are used in [11, 12]. The model developed in this work uses a speed and error in speed to control the MTG system output power.

From the literature study, most of the research article uses a constant DC voltage source (Battery) as a DG and the DC voltage is inverted to the grid frequency AC power [14-16]. For such a DG system an islanding detection technique (algorithm) has been applied for reliable or seamless operation of DG for grid connected and isolated modes of operation. The fixed DC voltage source does not affect the inverter operation even if DG gets isolated from grid or islanded to grid. When the dynamic model of DG (DG source) is incorporated, this study of maintaining a DC link voltage is challenging. In this work, the MTG system (AC source) is used as DG system, whose performance varies according to the grid predominating. The generated AC power of MTG system is converted to DC and this DC link voltage is maintained by the MTG system, and is again inverted back to grid frequency AC power. Since this work mainly concentrate on the performance of MTG system for grid connected to isolated and reclosing operation, the islanding detection techniques is not considered in this work. Whereas, the respective PQ and VF control strategies are switched for grid connected and isolated modes of operation manually. The model of MTG system along with power converter and control techniques are built using Matlab/Simulink blocks. The simulation is performed for the grid connected, islanding and reclosed modes of operation. The results show the behaviour of MTG based DG system for the same.

MICROTURBINE GENERATION SYSTEM

Microturbines are evolution of gas turbine technology with high speed rotation, compact in size and low inertia. Normally, there are two types of microturbines which are classified based on the position of compressor, turbine and generator. First is high speed single shaft design, which has compressor and turbine mounted on the same shaft along with the generator and the second is split shaft design, which has high speed compressor and turbines which are mounted on one shaft and driving turbine, generator is mounted on the other shaft of microturbine. Figure 1 illustrates the typical model of microturbine generation system in grid connected and isolated modes of operation through the power interfacing circuit. The prime mover microturbine includes a compressor, heat exchanger, burner and the turbine. The PMSM will transform the mechanical power to electrical power. The stator of PMSM is connected to the grid through a power electronics interfacing circuit with PWM control technique along with DC link capacitor and line filters. The power flow can be controlled both in magnitude and direction so that, it is possible to generate the electrical power at constant voltage and frequency. The DG system is regulated by the different control system which consists of two parts, namely the electrical and mechanical control of microturbine generation system.

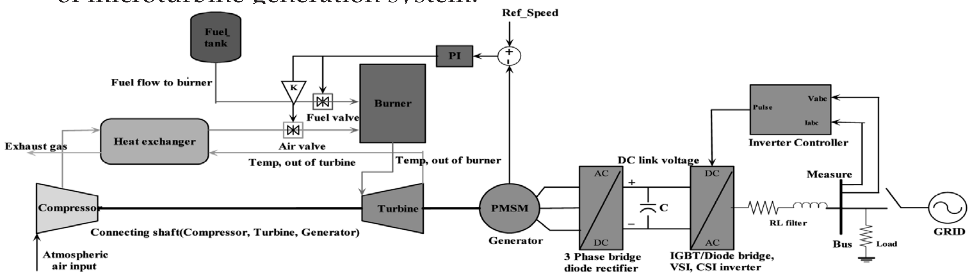


Figure 1. Schematic of MTG system connected to grid

Microturbine: In this model of microturbine, the mechanical power to the compressor is transferred through the turbine for air pressurizing. Thus, the mechanical power consumed by the compressor to compress the air [11][13], can be calculated with the following mathematical equation.

$$P_c = \frac{1}{\eta_c} m'_c \, C_p \left[PRc^{\left(\frac{\gamma-1}{\gamma}\right)} - 1 \right] T_{in.c} \tag{7}$$

Where, $T_{in,c}$ is the input temperature(K),

PR_c is the pressure ratio of compressor

γ is the specific heat ratio of air.

m'_c is the mass flow rate(g/s).

η_c is the thermal efficiency of compressor

C_p is the specific heat ratio of air ($KJ/kg,K$).

The combustion chamber of microturbine normally involves heat production by burning the fuel along with air. The combustor used in this work burns the fuel along with atmospheric oxygen to increase the air pressure further [11, 13]. The energy balance equation of combustion process inside the microturbine can be written as first order equation.

Whereas, the last term of the equation is heat transfer to the ambient as,

$$\frac{dT_b}{dT} = \frac{1}{C_b m_b}\left(\sum N_r \left(h'_f + h(T) - h'\right)_r - \sum N_p \left(h'_f + h(T)h'\right)_p - A_x h_x \left(T_b - T_{amb}\right)\right)$$

(8)

Where, N_r is a molar flow rate of input,

N_p is the molar flow rate of the output of product,

$h'(T)$ is the sensible enthalpy which is a function of temperature(K),

h'_f is the enthalpy of formation.

The thrust released out of the burner is passed to the turbine section which converts the potential energy of steam into rotational energy in the shaft. The mechanical power produced by the turbine can be calculated using an equation,

$$P_t = \left\{\eta_t \left[1 - PR_t^{\left(\frac{\gamma-1}{\gamma}\right)}\right] T_b \sum \left(N_p C_p \left(T_b\right) m_p\right)\right\} \tag{9}$$

Where, T_b is the turbine temperature (K),

PR_t is the turbine pressure ratio of turbine,

C_p is the specific heat of produced in the burner which is a function of temperature (K), m_p is the mass flow rate of the product(g/s).

Since the developed microturbine is a single shaft microturbine, the shaft mechanical power is the difference between the compressor power and turbine power and is given by the equation,

$$P_{mt} = P_t - P_c$$

(10)

The mechanical power of the microturbine is converted to equivalent torque for PMSM operation in Matlab/Simulink and it is given by the expression,

$$T_{mt} = \frac{P_{mt}}{\omega}$$

(11)

Where,

P_{mt} is the mechanical power of microturbine (W),
P_t is the mechanical power of turbine (W),
P_c is the mechanical power of compressor (W),
T_{mt} is the mechanical torque (N/m),
ω is the angular speed(rad/s).

The model of microturbine (prime mover) developed using Matlab / simulink is shown in Figure 2. In this, the microturbine components viz. compressor, heat exchanger, burner and turbine are modeled individually using mathematical expression for each blocks.

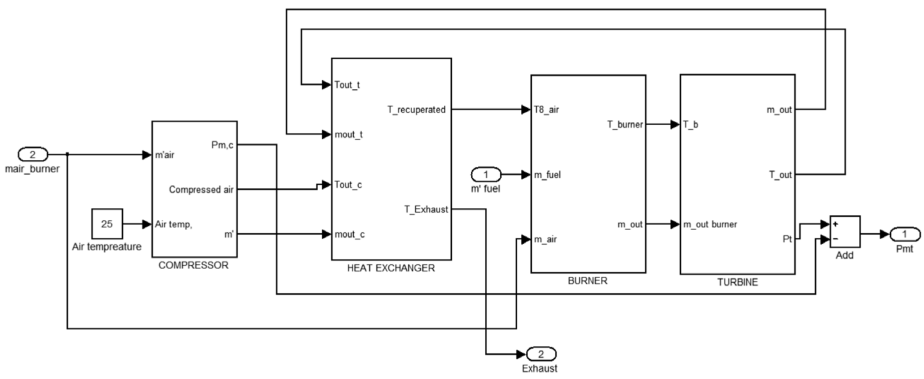


Figure 2. Matlab/Simulink model of microturbine

PMSM: The mathematical model of a PMSM is similar to that of the wound rotor synchronous machine. The permanent magnets used in the PMSM are of modern rare-earth variety with high resistivity. Hence induced currents in the rotor are negligible. In addition, there is no difference between the back EMF produced by a permanent magnet and that produced by an excited coil. Hence the mathematical model of a PMSM is similar to that of the wound rotor synchronous machine. The PMSM drive modeling is done with the assumption of sinusoidal distributed windings, saturation is neglected, **e**ddy currents and hysteresis losses are negligible. The dq axis equivalent circuit of developed model is shown in Figure 3. The following electrical and mechanical system equations are used to implement the PMSM model [17].

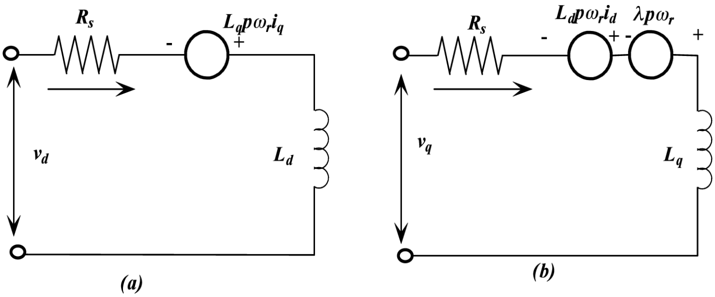


Figure 3. (a) d-axis, and (b) q-axis equivalent of PMSM

By applying Kirchhoff's voltage law to the *d* and *q* axis equivalent circuit of PMSM circuit, the obtained equations are,

$$v_d = R_s i_d + L_d \frac{di_d}{dt} - L_q p\omega_r i_q \quad (12)$$

$$v_q = R_s i_q + L_q \frac{di_d}{dt} + L_d p\omega_r i_d + \lambda p\omega_r \quad (13)$$

$$T_e = \frac{3}{2} p\left[\lambda i_q + \left(L_d - L_q\right) i_d i_q\right] \quad (14)$$

Where, L_q, L_d: are the q and d axis inductance,
R is a stator resistance,
i_q, i_d: are *q* and *d* axis current,
v_d *and* v_q: are *d* and *q* axis voltage,
p: are number of poles,
T_e: is electromagnetic torque,
F: is a viscous friction of rotor and load,
T_m: is the mechanical torque,
λ: Flux linkage of PM reference to stator.

MTG System Control

In this work, the control system is used to limit the output power of MTG system by comparing the reference speed and shaft speed of turbine. When the demand power changes on the MTG system the speed changes, which will changes MTG system output power by controlling fuel and air flow to the burner. The power flow has linear relation with fuel and air flow rates in the MTG system. As the angular speed changes, the fuel and air flow changes by controlling the respective valves. This is the reason behind the speed that is used to control the MTG system output power. The control block for the MTG system is shown in Figure 1.

Power electronic interface and control

The MTG system connected to grid and isolated modes need different converter control strategies for respective operation. For the grid connected mode an active and reactive (PQ) power control strategies is required. Whereas, in isolated operation voltage and frequency (VF) control strategies are required.

The IGBT bridge inverter with line filters, resistors and inductor connected in series to inverter along with the DC link capacitor are shown in Figure 4. The DC link capacitor is used to maintain the constant DC link voltage which varies due to load variation and RL filter are used to minimize the harmonics generated by the inverter.

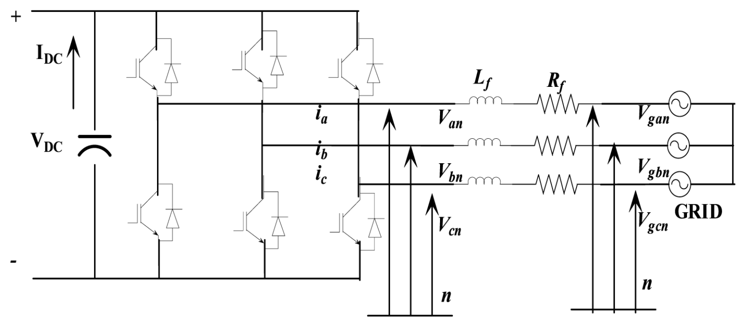


Figure 4. IGBT bridge inverter

By applying Kirchhoff's voltage law to the inverter circuit shown in Figure 4, the obtain equation are,

$$v_{an} = L_f \frac{di_a}{dt} + R_f i_a + v_{gan} \tag{15}$$

$$v_{bn} = L_f \frac{di_b}{dt} + R_f i_b + v_{gbn} \tag{16}$$

$$v_{cn} = L_f \frac{di_c}{dt} + R_f i_c + v_{gcn} \tag{17}$$

Grid connected mode: In this mode, a PQ control strategy has been employed for the grid-connected operation of MTG system. The grid connected inverter needs to insure that the MTG can provide an active and reactive power to the loads according to the given references i_d and i_q respectively. The insufficient redundant power can be supplied or consumed by the grid. An active and a reactive power can be independently controlled, and MTG system can meet grid or load dynamics requirement.

By applying the Park transformation to the equation (15), (16) and (17) the obtained equivalent equation for v_d and v_q can be written as,

$$v_d = L_f \frac{di_d}{dt} + R_f i_d - \omega L_f i_q + v'_d \tag{18}$$

$$v_q = L_f \frac{di_q}{dt} + R_f i_q + \omega L_f i_d + v'_q \tag{19}$$

Using the equations (18), (19), the PQ control topology is designed for grid connected operation as shown in Figure 5. The grid voltage and current V_{abc} and I_{abc} are used to generate the i_d and $i_{q.}$ The standard PI controllers are used to regulate the current the *dq* synchronous frame. In order to obtain only transfer of active power, the i_q current references is set to zero. Also, to have an independent control of the current components i_d and i_q the decoupling voltage components are added to the output of the PI current controller. In this scheme, the power injected to the grid is regulated by controlling the injected current i_d. The grid side converter uses a vector control approach with reference frame oriented along with the stator voltage position enabling independent control of the active and reactive power injected to the grid.

SIMULATION AND RESULTS

Figure 7 shows, the model of MTG system for grid connected and islanding modes of operation developed using Matlab/Simulink environment. The model of MTG system includes microturbine, PMSM and power converter along with control schemes. The utility network, to which the MTG system is connected, is represented by three phase sinusoidal source with impedance. The series resistor and inductor filter

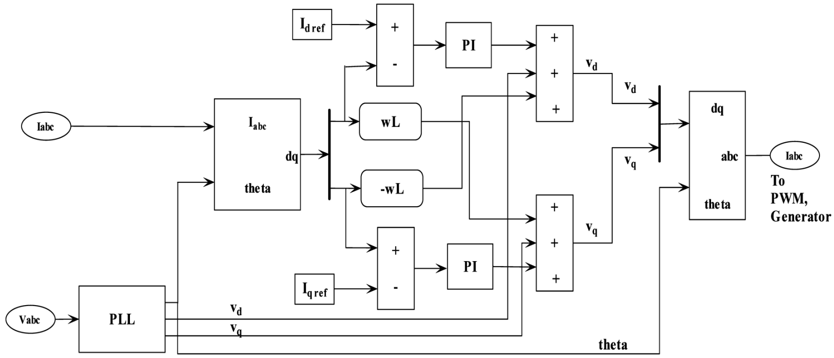


Figure 5. PQ Control technique

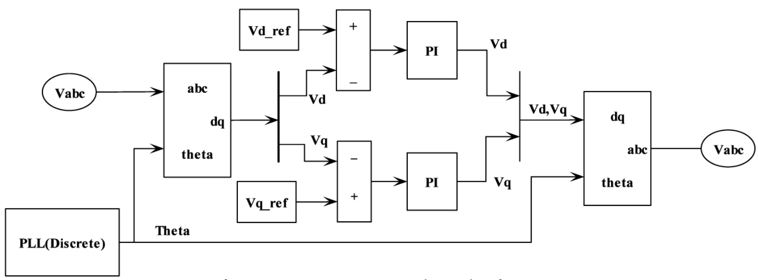


Figure 6. VF control technique

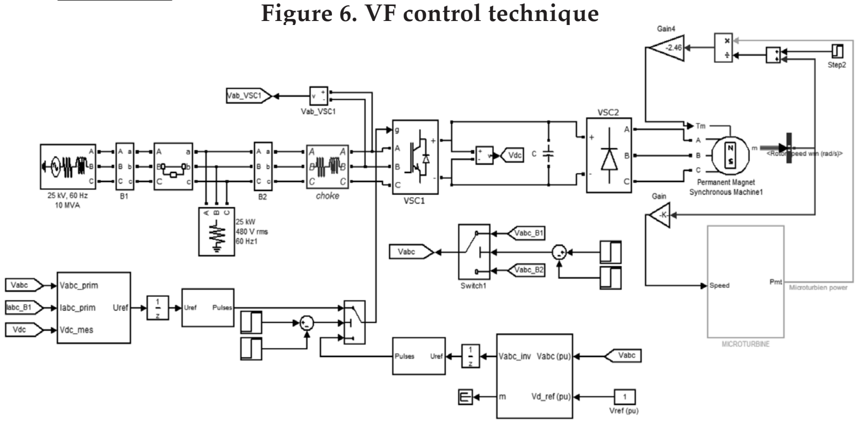


Figure 7. Matlab/Simulink model of MTG system connected to grid

(RL) are used at the grid side. The MTG system uses a speed and reference speed to control its output power. The output mechanical power of the microturbine is converted to an equivalent torque and it is given as an input to the PMSM. The direction of torque may be positive or negative for the motoring and generating modes of operation respectively.

Table 1. Simulation parameter of MTG

Grid parameter	480V, 60Hz, Rs=0.68Ω and Ls=2.5e-3H
Filter parameter	L=0.85mH, R=0.21Ω
Switching frequency	20kHz
DC link capacitance	5000µF
PMSM parameter	480V,16kHz,96,000rpm, Rs=0.25Ω, Ld=Lq=0.687e-3H
Microturbine	30kW, 96,000rpm.
Thermal efficiency of compressor, $\eta_{th,c}$	0.75
Specific heat of the air, C_p	1.005(KJ/kgK)
Compressor pressure ratio, PR_c	2.712
Time constant for compressor, τ_c	1.3(ms)
Specific heat ratio of air, γ	1.4
Specific heat of the gas, $C_{p,gas}$	1.005(KJ/kgK)
Average heat capacity of burner, C_b	1.45(J/kg,K)
Lower heating value of fuel, LHV_f	1,44000(kJ/kg)
Thermal efficiency of burner, $\eta_{th,b}$	0.70
Turbine pressure ratio, PR_t	3.712
Time constant for turbine, τ_t	294(µs)
Ambient temperature T_{amb}	298(K)
Power converter controller(PQ) 1) K_p and K_i (I_d controller) 2) K_p and K_i (I_q controller)	 1) 45 and 0.10 2) 12 and 0.65
Power converter controller(PQ) 1) K_p and K_i (V_d controller) 2) K_p and K_i (V_q controller)	 1) 5.5 and 112 2) 56 and 105

In this work, the system is started and brought to a rated speed (Ex, starting MTG system is not considered in this work) and made to run as generator thus the torque is negative. The simulation parameter of the MTG system are given in Table 1.

The MTG system starts and launches the microturbine to an ignition speed by taking power from the grid. Once the microturbine reaches to the ignition speed (10000 rad/sec), the MTG starts generating the power and delivers to the grid. At t=0.3sec, the MTG system gets isolated from the grid due to the voltage imbalances in the distribution network. This results in the formation of a planned islanding situation comprising the local load and MTG system. Opening of circuit breaker can occur due to the fault and grid disturbances. When the circuit breaker is opened, the phase angle difference ($\Delta\theta$) between grid voltage and inverter voltage obtained from the PLL start to increase. The islanding detection technique is required, which is not considered in this work.

The microturbine speed for grid connected, isolated and reclosed mode of operation is shown in Figure 8 (a). From the Figure 8 (a) it is observed that, at t=3sec there is a drop in the speed when the MTG system is isolated from the grid and it maintains the constant speed to maintain the frequency. Also, at t=6 sec there is an increase in speed when MTG system gets connected back to the grid. The MTG system output power depends on speed variation, the variation of turbine output power during the grid connected, isolated and reclosed modes of operation is shown in Figure 8 (b). Figure 8(c) shows the electromagnetic and mechanical torque of MTG system for different modes of operation. From Figure 8(c) it is observed that, between t=3 and 6 sec the torque increases due to disconnection of MTG system form the grid, hence the load shared by the MTG system increases.

The DC link voltage is an important parameter to be maintained at certain level voltage for the continuous operation of inverter irrespective of power injected to the grid or load. The descend of DC link voltage may fail the inverter operation for delivering the MTG system power to the grid or load. The variation of DC link voltage between t=3sec and t=6sec is shown in Figure 8 (d). During the grid connected and isolated modes, the DC link voltage is maintained by the MTG system thus varying the input torque for the reliable operation of inverter. The DC link voltage is inverted to AC using a there phase voltage source inverter. The inverter output voltage before filter with harmonics and distortion is shown in Figure 8 (e). The inverter output voltage is filtered using a series inductor and resistor filter. The three phases sinusoidal voltage during the grid connected and isolated mode of operation is shown in Figure 8 (f). From Figure 8 (f) it is observed that, the deviation in voltage from switching over to grid (at t=3sec, and t=6sec) and isolated modes of operation the load is shared by the grid and MTG system only between t=3 and 6sec.

The load current shared by the MTG system is shown in Figure 8 (g). Here, the load current is 10A before and after 3 and 6 sec, and 20A between 3 to 6 sec respectively. The uninterruptible grid voltage for isolated mode and interconnected mode is shown in Figure 8 (h).

When the DG is isolated from the grid, the load on the MTG increases, this is due to grid contribution becomes zero during islanding

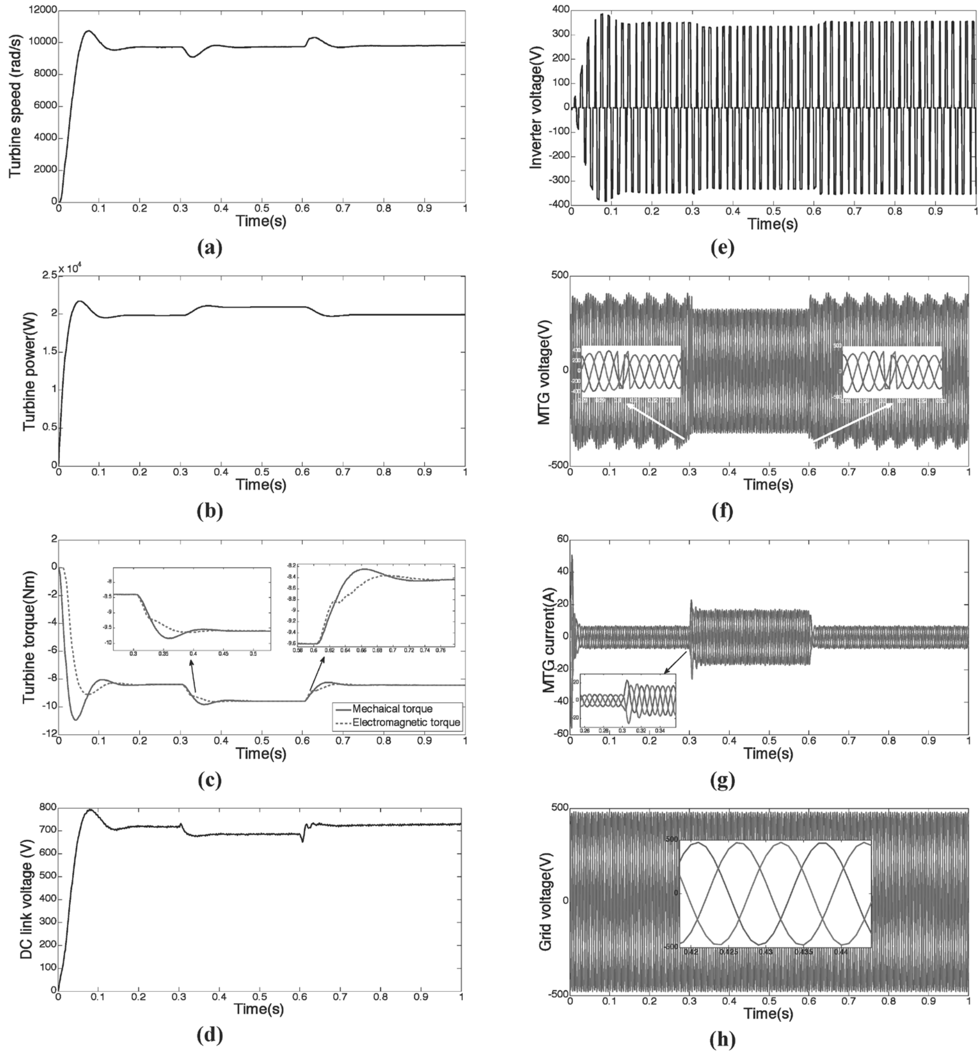


Figure 8 (a) Turbine speed, (b) Turbine power, (c) Turbine torque, (d) DC link voltage, (e) Inverter voltage, (f) MTG voltage, (g) MTG current, (h) Grid voltage

operation. The grid current during this interval of time is shown in Figure 9 (a). In this Figure 9 (a) the current is zero between 0.3 to 0.6 sec.

When the DG system is islanded or reclosed to the grid, the frequency will either go up or down depending on the power imbalance in the

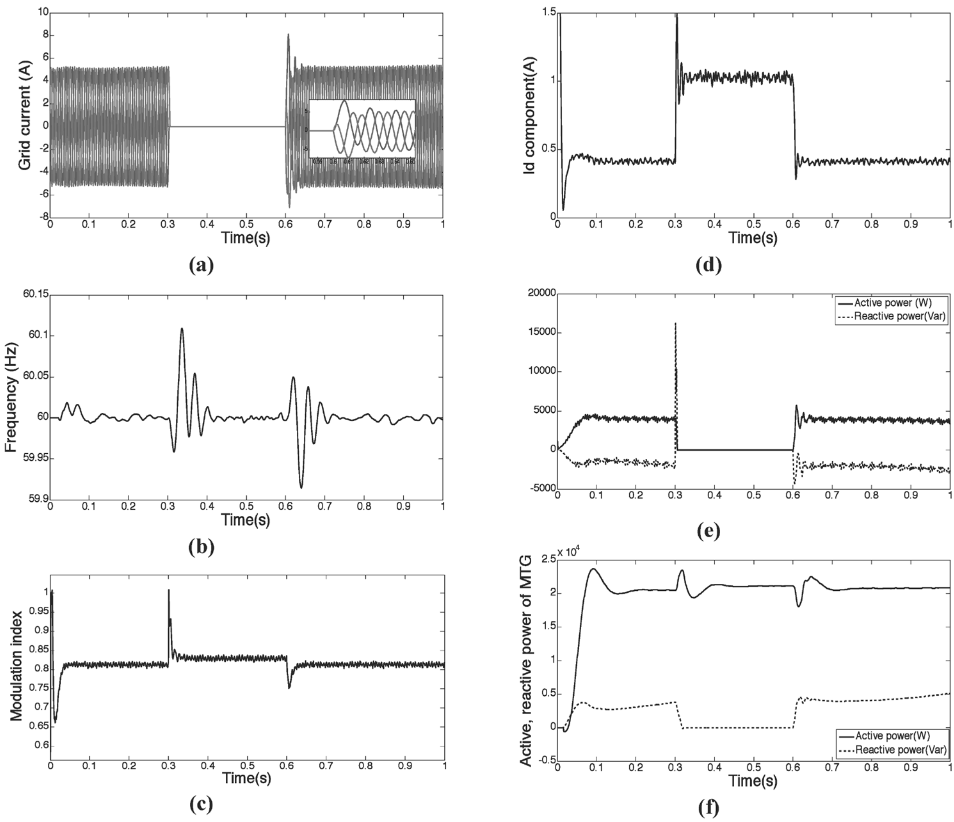


Figure 9 (a) Grid current, (b) Frequency, (c) Modulation index, (d) Id current, (e) Active and reactive power of grid, (f) Active and reactive power of MTG.

distribution system. The frequency of oscillation and synchronization for grid connected and isolated modes of operation are shown in Figure 9 (b). From Figure 9 (b), the frequency at t=3 and t=6 sec will oscillate due to the synchronization of inverter with load and grid frequency. The modulation index for grid connected and an islanded mode of inverter operation is shown in Figure 9 (c). In this Figure 9 (c), at t=3 to 6sec, the modulation index is 0.85 for grid connected operation and 0.85 for isolated operation. The i_d current component is directly proportional to the power injected by the MTG system in to the grid and load. The i_d current is 0.5 p.u for grid connected mode and 1 p.u. for isolated operation as shown in Figure 9 (d).

The active and reactive power shared by the grid is shown in Figure

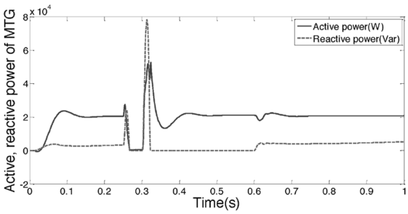
9(e). In this Figure 9 (e), the active and reactive power becomes zero during the islanding mode. The active and reactive powers are appeared during the grid connected operation and this power shared by the MTG system is shown in Figure 9 (f). From the Figure 9 (f) it is seen that, the variation of active power at t=3 and 6 sec is shown, and reactive power is zero between t=3 and 6sec. This is due to isolation of DG from grid where MTG system blocks the reactive power.

Islanding of DG due do the Fault in distribution network: The interconnected operation of DG system may be isolated from grid due to the grid disturbance or fault in the distribution network. The situation when the DG is isolated from the grid, the DG power and load power should co-inside practically. In this work, the DG is isolated from the grid due to the fault in the distribution network and is continued to operate in isolated mode. The isolated load used for this study is rated power of MTG system. As soon as fault clears in distribution network, the DG is reclosed to grid after distribution system becomes healthy. In this work, the mechanism of fault detection and clearing are not considered. But the fault is created at 0.25sec and cleared at 0.35sec manually to obtain the performance of MTG system under such circumstances. The fault created for this study is a three phase to ground fault.

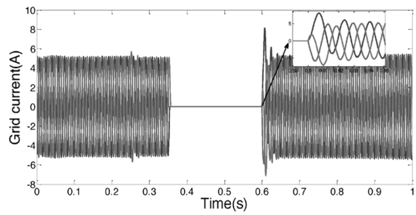
The behaviour of MTG based DG system has been studied by the current and voltage waveform as shown in Figure 10 (a) and 10 (b) respectively.

From these two Fig(s) 10(a) and 10(b), it is observed that, the fault current is high and terminal voltage is almost zero between 0.25sec and 0.3sec and the DG gets isolated from the grid at 0.3 sec. Hence DG does not get affected by the fault after 0.3sec. The effect of fault in the distribution network and its impact on microturbine speed is shown in Figure 10(c). From Figure 10(c) it is observed that, the formation of transients and disturbances in speed at t=0.25sec to 0.3sec, after t=3sec the DG is isolated from grid and turbine tries to obtain its original speed. After the fault is cleared the distribution system becomes healthy the DG is reclosed to grid at t=0.6sec. The influence of fault on the MTG system output power between 0.3sec and 0.35sec is shown in Figure 10(d). The mechanical torque variation with respect to electromagnetic torque is shown in Figure 10 (e). In this, the oscillation of electromagnetic torque with respect to mechanical torque is shown at 0.25sec.

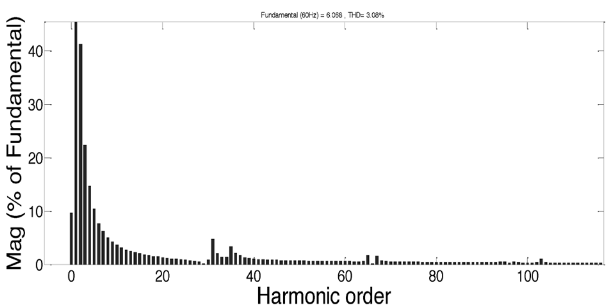
The DC link voltage and the transients formation during the fault is shown in Figure 10 (f). The inverter operation depends on the DC link voltage, thus the inverter output voltage follows the DC link voltage as shown in Figure 10 (g). The active and reactive power variation of grid is shown in Figure 10 (h). In this, the fault clears at 0.35sec, the reactive power transient at fault cleared node is also shown in Figure 10 (h). Also, the active and reactive power shared by the MTG system during the instant of fault occurrence and load variant is shown in Figure 10 (i). The grid current is shown in Figure 10 (j) and the total harmonics distortion for the MTG based DG system in grid connected and isolated modes of operation is shown in Figure 10 (k). From this Fig 10(k), the total harmonics distortion (THD) for the 60 cycles is 3.06% as shown.



(i)



(j)



(k)

Figure 10. (a) MTG current, (b) MTG voltage,(c) Turbine speed, (d) Turbine power (e) Turbine torque, (f) DC link voltage,(g) Inverter voltage, (h) Active and reactive power of grid, (i) Active and reactive power of MTG, (j) Grid current, (k) Total harmonics distortion

CONCLUSION

The performance of MTG based DG system has been studied in grid connected, islanding and re-closed modes of operation using Matlab/

Simulink environment. The MTG system output power has been controlled by using the reference speed and shaft speed which is delivered to the grid and isolated load using a PQ and VF control strategies for the respective inverter operation. Since this work mainly concentrates on the dynamic performance of MTG system for different modes of operation, the islanding detection techniques is not considered in this work. The shifting of PQ to VF switching strategies has been manually operated. The simulation results show the dynamic performance of MTG system for grid connected, isolated, modes of operation. From the simulation study it is ascertained that, the MTG system can significantly delivers the power to the grid or load by a converter control switching operation. The future scope for this work is detection of the islanding techniques which can be applied for seamless power transformation between MTG system and grid connected as well as isolated modes of operation successfully.

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