

Modelling and Simulation of Microturbine Generation System for on-grid and off-grid Operation Modes

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Microturbine unit (MTU) is well suitable for a different distributed generation applications, because the MTU is flexible in connection method, can be stacked in parallel to serve larger loads, can provide reliable power and has low-emissions profile [1]-[2]. The potential applications of the MTU configuration include peak shaving, premium power, remote power, and grid support [1]-[2]. In locations where power from the local grid is unavailable or extremely expensive to install, or the customer is far from the distribution system the MTU can be a competitive option. In this case, MTU is operated in off-grid mode. In the growing distribution system, the MTU can be a grid support. In this case, MTU is in on-grid mode. In this paper, a model for single shaft MTU has been developed and simulated by PSCAD/EMTDC and evaluated under on-grid and off-grid operation modes.

1. MTU Configuration

Fig. 1 shows the schematic diagram of a MTU, which has been studied in this paper. The MTU components are: single-shaft turbine with its control system, high speed permanent magnet generator, power electronic interfacing (rectifier and voltage source inverter) and control system for power electronic interface. The DC bus, shown in Fig. 1, is assumed to be lossless. Power electronic interface in the single shaft microturbine is a critical component. Microturbine is generally equipped with controls that allow the unit to be operated either in parallel with, or independent of the grid.

2. Modelling of Microturbine

The block diagram of the single shaft gas turbine is shown in Fig. 2. The model includes the temperature control, fuel system, turbine dynamic, speed governor and acceleration control blocks. The output of the speed control, temperature control, and acceleration control are all inputs of a low value select (LVS) block, whose output is the input of fuel system.

3. Power Electronic Interface

Power conditioning unit consist of a rectifier-inverter system with DC link. It is a general configuration of power electronic interface in the MT units.

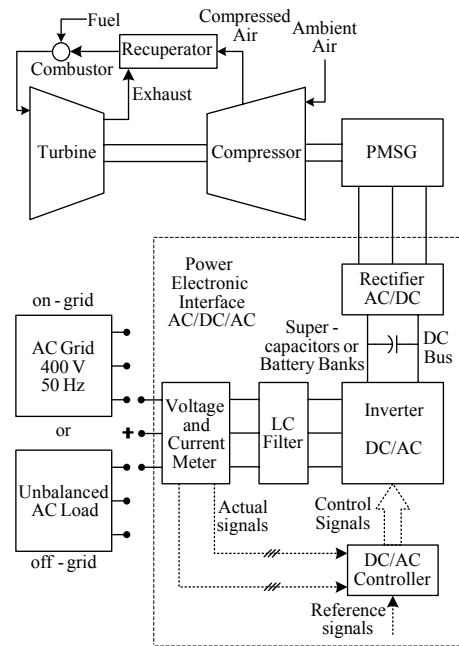


Fig. 1. Schematic diagram of MTU

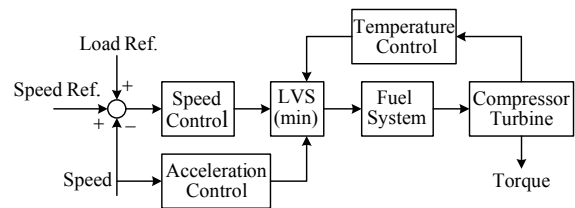


Fig. 2. Block diagram microturbine

The MT units are connected in parallel to achieve the required total system capacity and provide a level of redundancy. Grid connected mode (on-grid mode) allows the MTU to operate parallel to the grid, providing base loading and peak shaving and grid support. Stand alone mode (off-grid mode) allows the MTU to operate completely isolated from the grid.

A. ON-GRID OPERATION

In this operation mode, the inverter must regulate the DC link voltage at 0.75 kV, and control the active and reactive powers injected into the AC grid, considering the

set points, P_{ref} and Q_{ref} . These set points can be chosen by the customer or remote power management units. The P-Q control strategy is shown in Fig. 3.

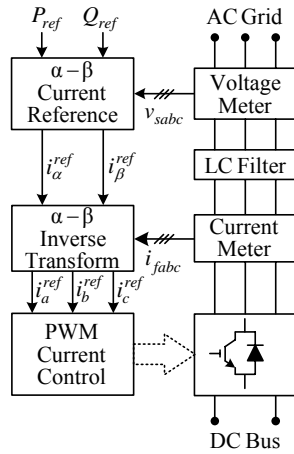


Fig. 3. P-Q control scheme

B. OFF-GRID OPERATION

In this control mode, MTU should supply AC loads, such as sensitive, nonlinear and unbalanced loads. Fig. 4 shows the control scheme, which regulates the voltage and frequency of the islanded operation mode.

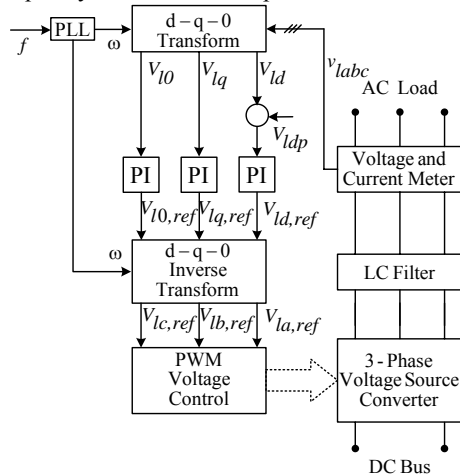


Fig. 4: V-f Control scheme

4. Simulation Results

In this paper, the microturbine generation system units have been investigated to provide the impacts of MTU on distribution system operation. The MTU system, shown in Fig. 1, has been modeled and simulated by PSCAD/EMTDC software. The simulation parameters are given in Appendix. The simulation scenarios are focused on the on-grid and off-grid suitable operation also supplying dead load. The Simulation results are presented for different operating conditions. All time functions are in seconds. Speed reference was kept constant at 1 p.u. for all simulations.

A. ON-GRID OPERATION

In the on-grid operation mode, P-Q control scheme is applied to MTU. Fig. 5 shows active power injected to the AC grid. In this simulation, the active power reference, $P_{ref} = 8$ kW is changed at $t=10$ s to 16 kW.

Also, at $t=20$ s the active power reference, P_{ref} is decreased to 8 kW. As shown in Fig. 5, the active power injected into the AC grid matches the above active power reference variations.

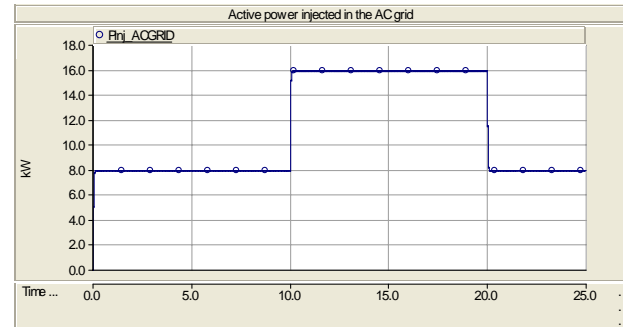


Fig. 5. Active power injected to AC grid

B. OFF-GRID OPERATION

In the off-grid operation mode, the performance of the MTU is studied by connection it to a dead load. Fig. 6 shows the active power consumed by dead loads. As shown in Fig. 6, initially the system is supplying the dead load of 16 kW. At $t=10$ s the load is decreased to 8 kW and then at $t=20$ s increased to 16 kW.

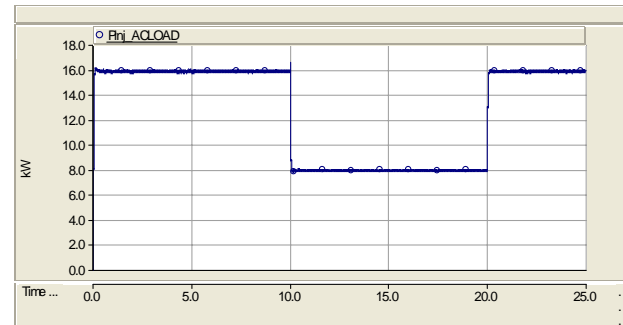


Fig. 6. Active power consumed by AC load

5. Conclusion

The modeling of a single-shaft MTU suitable for off-grid (isolated) and on-grid operation modes is presented in this paper. Detailed modeling of MTU with its control systems has been modeled and simulated by using PSCAD/EMTDC software. The simulation of on-grid and off-grid operation modes shows that the presented model is suitable for dynamic studies.

REFERENCES

- [1] CIGRE Technical Brochure on Modeling New Forms of Generation and Storage, November 2000.
- [2] Gaonkar, D.N., Patel, R.N., "Modeling and simulation of microturbine based distributed generation system," *Power India Conference, 2006 IEEE*, 10-12 April 2006.