MICRO-TURBINE GENERATOR SYSTEM

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Microturbine generator systems are considered as distributed energy resources which are interfaced with the electric power distribution system. They are most suitable for small to medium-sized commercial and industrial loads. The microturbine provides input mechanical energy for the generator system, which is converted by the generator to electrical energy. The generator nominal frequency is usually in the range of 1.4-4 kHz. This frequency is converted to the supply frequency of 50 Hz by a converter. The electrical energy, passing through the transformer, is delivered to the distribution system and the local load.
A mathematical model of a **microturbine generator system** includes electromechanical sub-system, power electronic converter, filters, interface transformer, local load, distribution system, turbine-generator control and converter control.
CLASSIFICATION

- RECUPERATED MT
- UNRECUPERATED MT

Recuperated microturbines, which recover the heat from the exhaust gas to boost the temperature of combustion and increase the efficiency.

Unrecuperated (or simple cycle) microturbines, which have lower efficiencies, but also lower capital costs.
RECUPERATED MT

Diagram of a recuperated MT system:
- Air In
- Air Filter
- Compressor
- Generator
- Power Conditioning
- Power Shaft
- Turbine Exhaust
- Turbine
- Combustor
- Recuperator
- System Exhaust (Heat Recovery)
- Fuel Injection
- Gas Compressor
- Gas Source
TECHNICAL BACKGROUND

MTG’s are small, high speed power plants that usually include the turbine, compressor, generator and power electronics to deliver the power to the grid. These small power plants typically operate on natural gas. Future units may have the potential to use lower energy fuels such as gas produced from landfill or digester gas. The generic MTG can be divided into three primary subsystems:

- **Mechanical**: including turbine, generator, compressor and recuperator.
- **Electrical**: including main control software, inverter and power firmware.
- **Fuel**: including fuel delivery and combustion chamber.
WORKING

Mechanically the MTG is a single shaft, gas turbine with compressor, power turbine and permanent magnet generator being mounted on the same shaft. The MTG incorporates centrifugal flow compressors and radial inflow turbine.

MTG’s have a high speed gas turbine engine driving an integral electrical generator that produces 20-100 KW power while operating at a high speed generally in the range of 50,000-120,000 rpm. Electric power is produced in the range of 10KHz converted to high voltage dc and then inverted back to 60 Hz, 480 V ac by an inverter.
MTG COMPONENTS
During **engine operation**, engine air is drawn into the unit and passes through the **recuperator** where temperature is increased by hot exhaust gases. The air flows into the **combustor** where it is mixed with fuel, ignited and burnt. The **ignitor** is used only during start up and then the flame is self-sustaining.

The combusted gas passes through the **turbine** nozzle and turbine wheel converting the thermal energy of the hot expanding gases to rotating mechanical energy of the turbine. The turbine drives the **generator**. The gas exhausting from the turbine is directed back through the recuperator and then out of the **stack**.
ELECTRICAL COMPONENTS

A. **ENGINE CONTROLLER**: The features of an engine controller includes:

- automated start sequence
- Battery or utility start
- Gas or liquid fuel algorithm
- Recuperated or simple cycle engines
- Fault detection and protection
- Advanced user interface

The design is fully digital to give it the flexibility of adaptation to different engine types and makes it more precise.
B. Power Conditioning System

The power conditioning system converts the unregulated, variable-frequency output of the generator into a high quality, regulated waveform and manages the interaction with any applied load both in stand-alone and utility connect modes. The waveform quality surpasses general utility standards and is suitable for supplying sensitive equipment.

Output voltage and frequency are software adjustable between 380-480 V and 50-60 Hz, allowing the system to be easily configured for operation anywhere. The system can be selected to operate as a stand-alone power source [island mode] and in parallel with a site utility supply [utility mode]. Emergency power and back start are also possible.
C. **Power Controller**

The overall power conversion process is managed by an advanced microprocessor-based control system. Unique control algorithms and active filtering techniques are used which allows the system to maintain voltage distortion levels under 3% even with severe non-linear loads [crest factor of 3]. The control system optimizes the capability of the power conditioning electronics and achieves a robust and tolerant supply which surpasses any UPS performance. An intelligent fault-clearing feature permits the supply of sufficient, short duration overload current to operate as appropriately sized circuit breaker. This feature prevents interruption to the remaining site load in the event of localized load faults.
Other real time intelligent algorithms are used to cope with a variety of overload conditions commonly experienced in island mode. These include dc-offset control and current limiting which optimizes transformer energization and motor start capability. Utility mode protection includes over and under voltage and frequency, incorrect phasing and loss of supply.
OPERATIONAL MODES

There are two modes of operation:

- Island mode
- Utility mode

**Island mode operation** allows the generator system to supply a load without a site utility supply present. Typical applications include supply of electrical power in isolated locations, mobile applications and emergency power in the case of utility failure. The output waveform is maintained within the limits defined by the computer.

**Utility mode operation** allows the system to operate in parallel with the utility. This mode is cost effective. There are three modes under this:
Export mode: the system can export power to the utility and meet current harmonic limits as specified.

Load following mode: allows on-site power generation to be balanced with site demand resulting in zero power flow to the utility. This maximizes the benefit of embedded generation.

Peak shaving mode: the system can be operated just during times of peak demand which reduces the tariff.

DUAL MODE SWITCHING: it is the switching between the two modes that is made available to the MTG which enables it to serve dual function of prime power and standby power generator.
SYSTEM BLOCK DIAGRAM

Figure 1 – Normal Operation
Figure 2 – Utility Grid Failure
Figure 3 – Microturbine Down
Figure 4 – Restarting the Microturbine
MACHINE PERFORMANCE TEST CRITERIA

- **Endurance**: is a measure of longevity of MTG. Daily operating parameters: fuel flow, ambient air pressure, operating temperature and humidity, energy [Kwh], operating pressure will be recorded.

- **Transient Response**: MTG should be able to respond immediately to load changes.

- **Harmonic Distortion**: the power output will be measured for total harmonic distortion as well as power factor of the total loaded unit to verify whether the MTG achieves rated output when connected to the utility grid.

- **Noise Measurement**

- **Emissions Level Monitoring**: to check whether NOx and CO levels are within the levels with a small tolerance.

- **Operability**

- **Starts/ Stops**: the number of starts/stops should be equal.
APPLICATIONS OF MTG

- Microturbines can be used for stand-by power, power quality and reliability, peak shaving, and cogeneration applications.
- Microturbines produce between 25 and 100kW of power and are well-suited for small commercial building establishments such as: restaurants, hotels, small offices, retail stores, and many others.
- In addition, because microturbines are being developed to utilize a variety of fuels, they are being used for resource recovery and landfill gas applications.
THE ADVANTAGES AND DISADVANTAGES

**ADVANTAGE**
- Cheap and easy installation and maintenance
- Less emission level and noise production
- Wide range of benefits in terms of operational and fuel flexibility, service performance and maintainability.

**DISADVANTAGE**
- Time-variable electrical and thermal demand distorts MTG’s energy balance sometimes leading to larger fuel requirement.
Manufacturers are moving toward packaging microturbine generators with integrated heat recovery equipment to lower both the cost of installation and operation.

Development is ongoing in a variety of areas:
- Heat recovery/cogeneration
- Fuel flexibility
- Vehicles
- Hybrid systems (e.g., fuel cell/microturbine, flywheel/microturbine)
VENDORS OF MTG

- **Bowman Power Systems** is a U.K. company that develops 80-kW microturbine power generation systems.
- **Capstone Turbine Corporation**, based in Chatsworth, California, is a leader in the commercialization of low-emission, high-reliability microturbine power generators.
- **Ingersoll-Rand Energy Systems of Portsmouth** New Hampshire and Davidson, NC develops the MT70 Induction Microturbine with output of 70-kW grid-parallel electric power.
- **Turbec AB**—The company offers a 100-kW microturbine power generator.
MTG BLOCKS
REFERENCES

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Thank You