MICROGRIDS – Novel Architectures for Future Power Systems, Paris, France, 29 January 2010

Field Tests in the Ílhavo Municipal Swimming-Pool

Transfer between grid connected and isalnding modes

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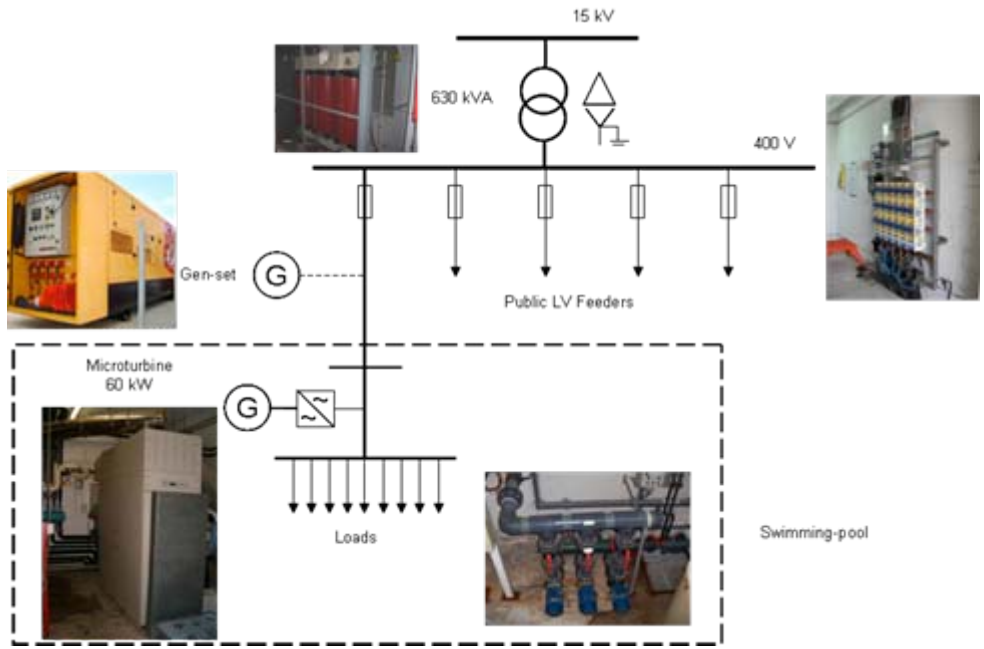
Description of the Portuguese study case

- The first Portuguese application of a CHP microturbine in a swimming-pool
- Analysis of microturbine / Diesel gen-set in grid connected and islanding modes
  - Connected to the public LV grid (400V)
  - Ílhavo MSP maximum demand – 87kVA
  - Microturbine Capstone 60 – 60kW$_e$ 120kW$_{th}$
  - Main loads
    - Air treatment units – Typically 2 fans
    - Residential air conditioning systems
    - Water pumps to drive hydraulic circuits
    - Indoor and outdoor lighting

Objectives

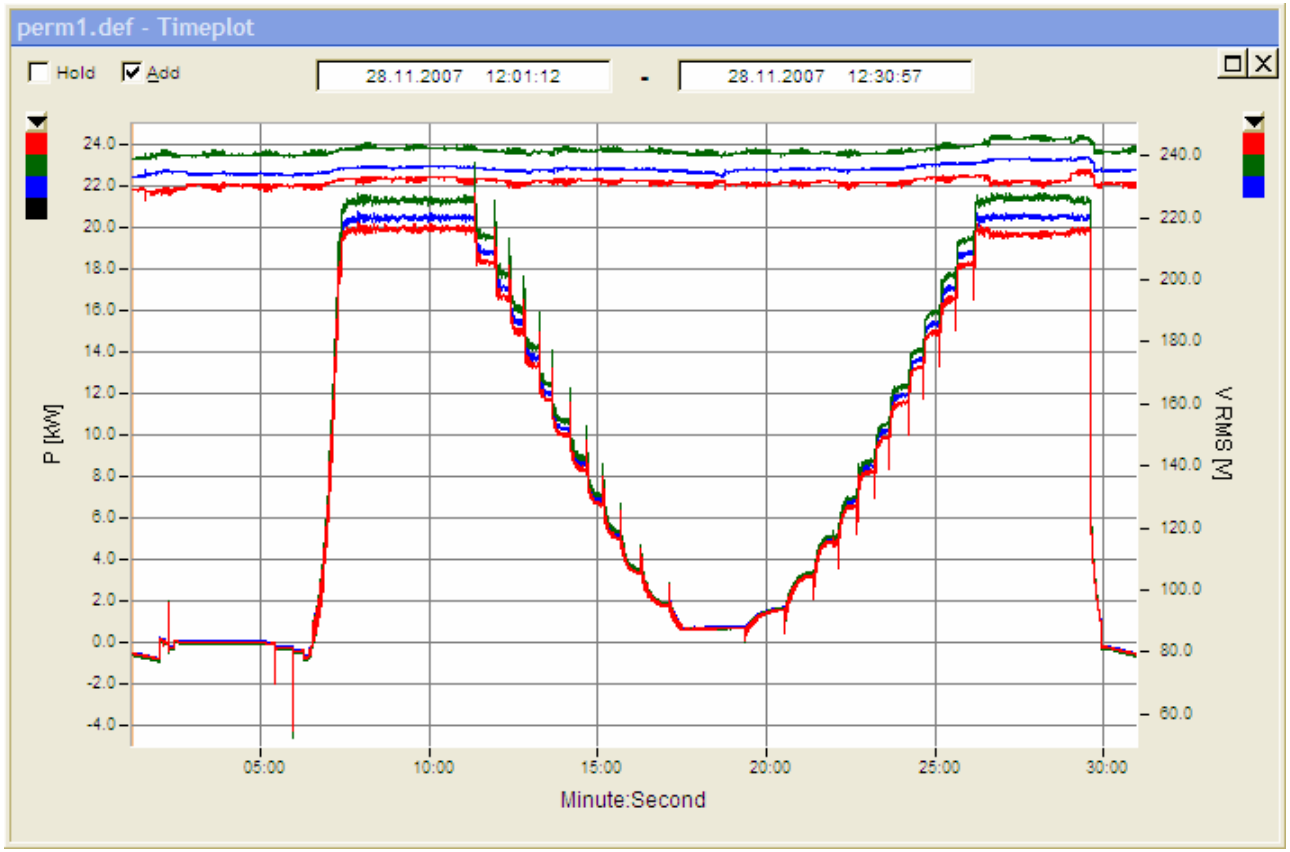
- Transition of microturbine and MSP loads from grid connected to islanding mode under several operating conditions
  - Black-starting of the microturbine
  - Operation in grid connected mode
  - Operation in islanding mode in several load regimens
  - Switching between grid connected and islanding modes, including simulation of network failure



- Operation of 2 micro-sources in islanding mode (microturbine /gen-set)
- Microturbine parallel after gen-set black-starting
- Microturbine operation in several generation regimens
- Operation in several load regimens
- Gen-set operation almost as voltage controller and reactive power supplier

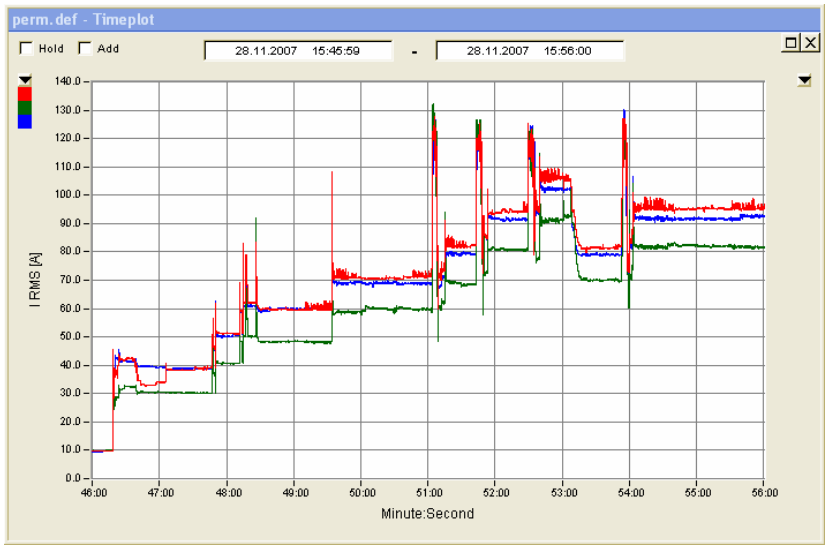
Main field tests

- Operation in grid connected mode
  - Impact of the microturbine on the LV grid
  - Power variation in 5kW steps

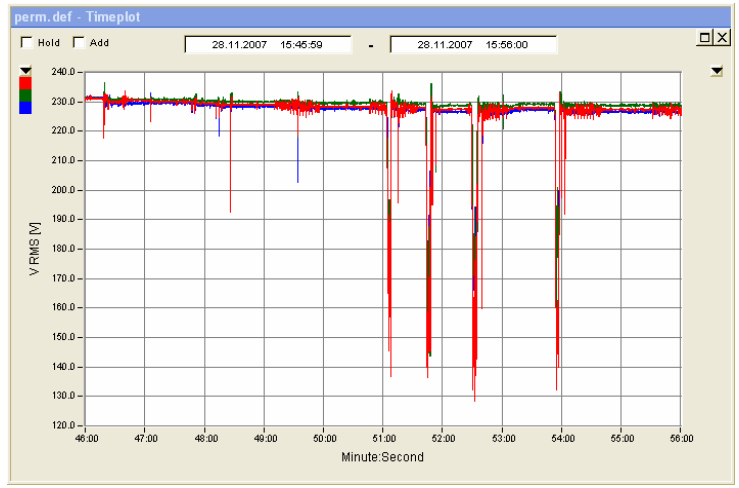


Main field tests

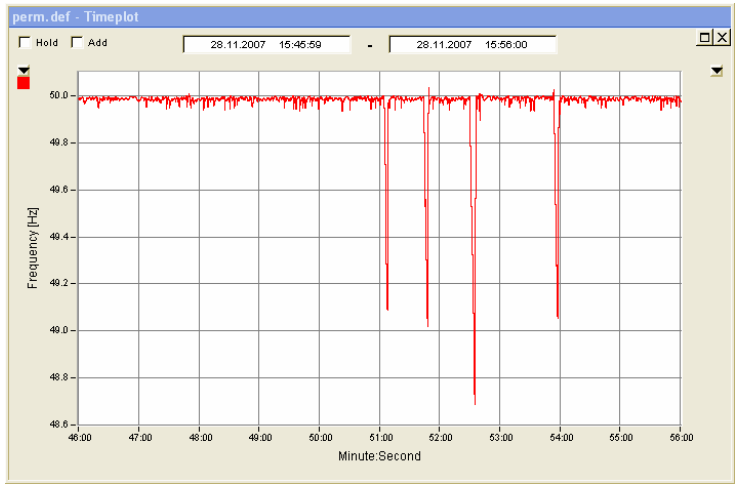
- Operation of the microturbine in islanding mode
  - Connection of several loads, fans and pumps with rated power of 4kW, 5kW and 7.5kW, to analyse the voltage and frequency stability



Microturbine output current



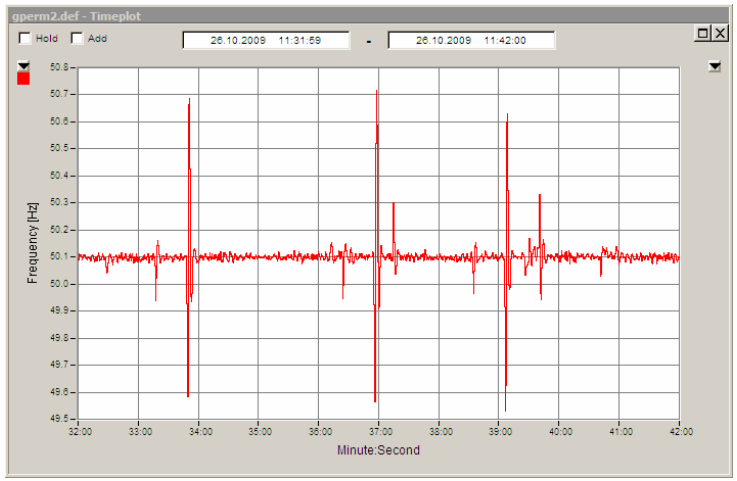
Microturbine output voltage



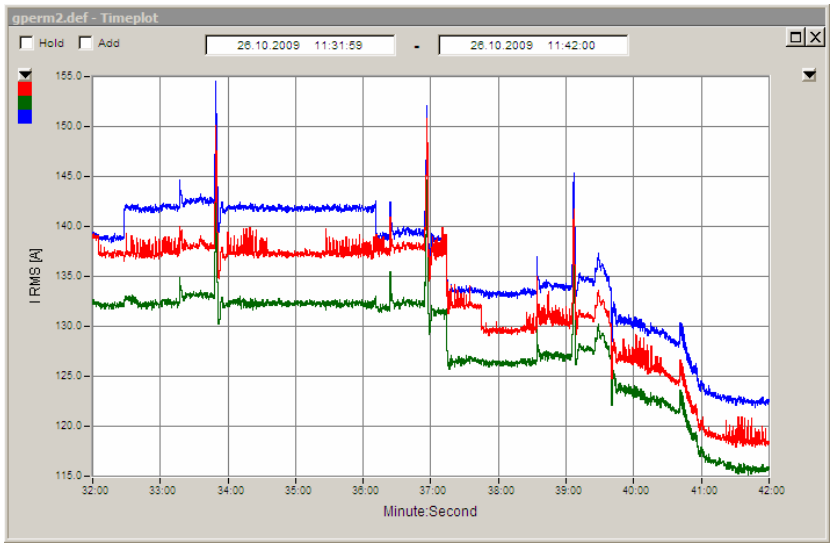
Microturbine output frequency

Main field tests

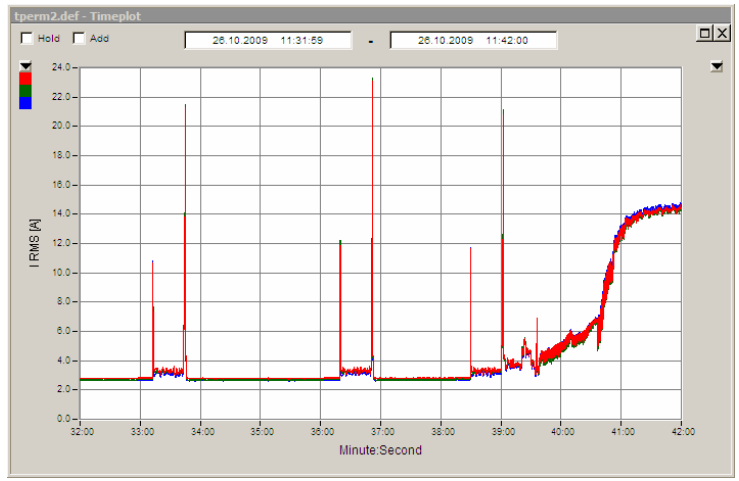
- Microturbine starting and parallel with the Diesel gen-set in islanding mode
  - Settings of the frequency protections were changed, from 50.5Hz to 51.5Hz, in order to allow the parallel



Diesel gen-set output frequency



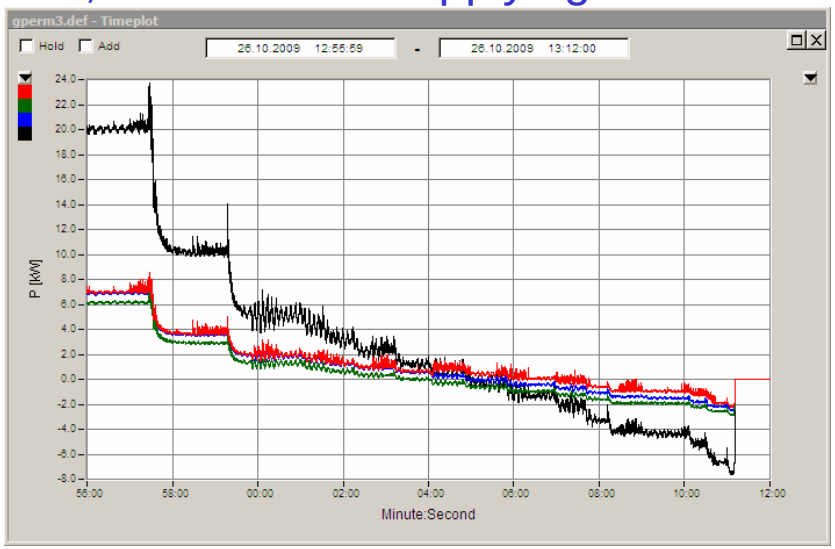
Diesel gen-set output current



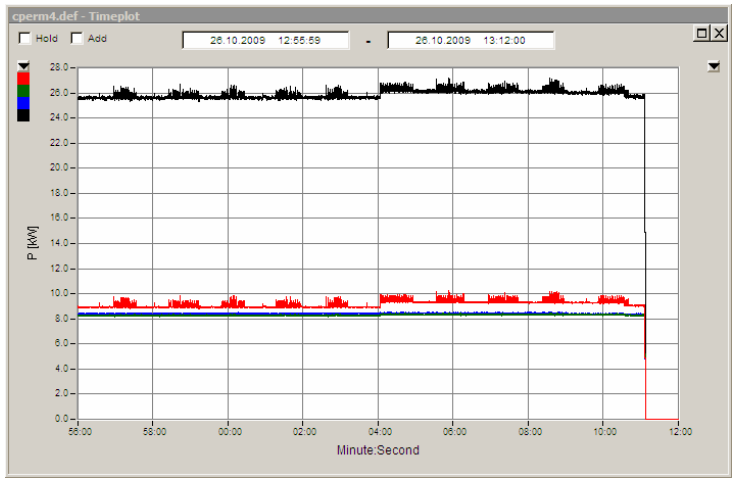
Microturbine in/output current

Main field tests

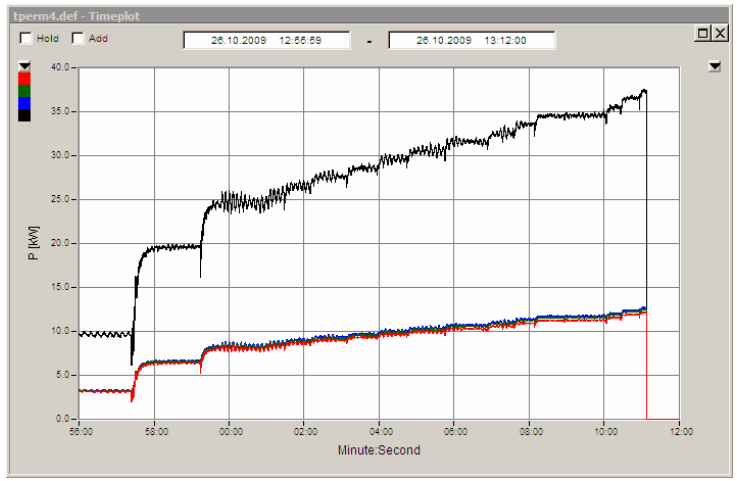
- Operation of the Diesel gen-set almost as voltage controller and reactive power supplier
  - Constant load: 26 kW
  - Increasing generation by microturbine
  - System tripped: gen-set absorbing 8 kW; microturbine supplying 37 kW



Diesel gen-set output power



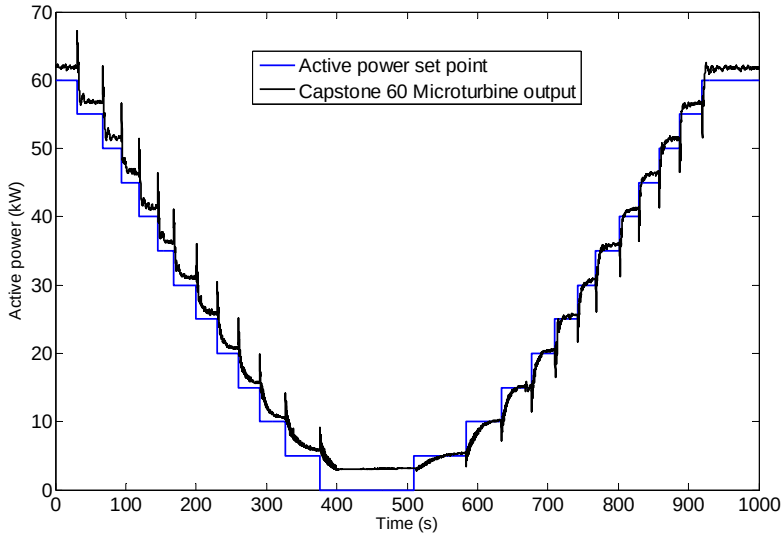
Constant Load

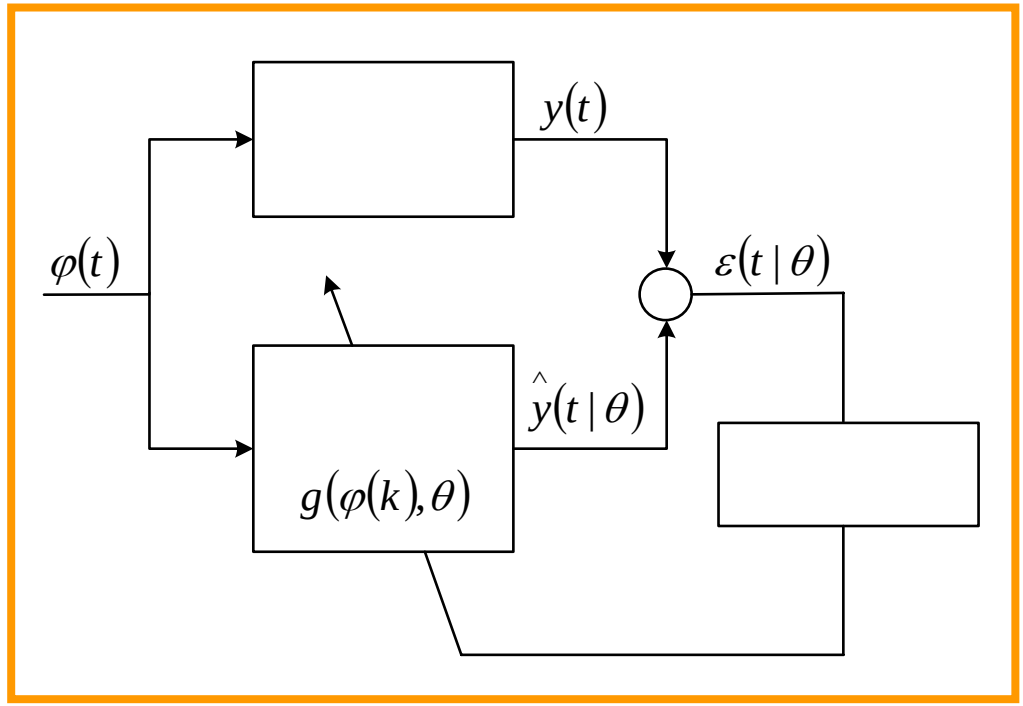


Microturbine output power

Parameter estimation based on experimental data

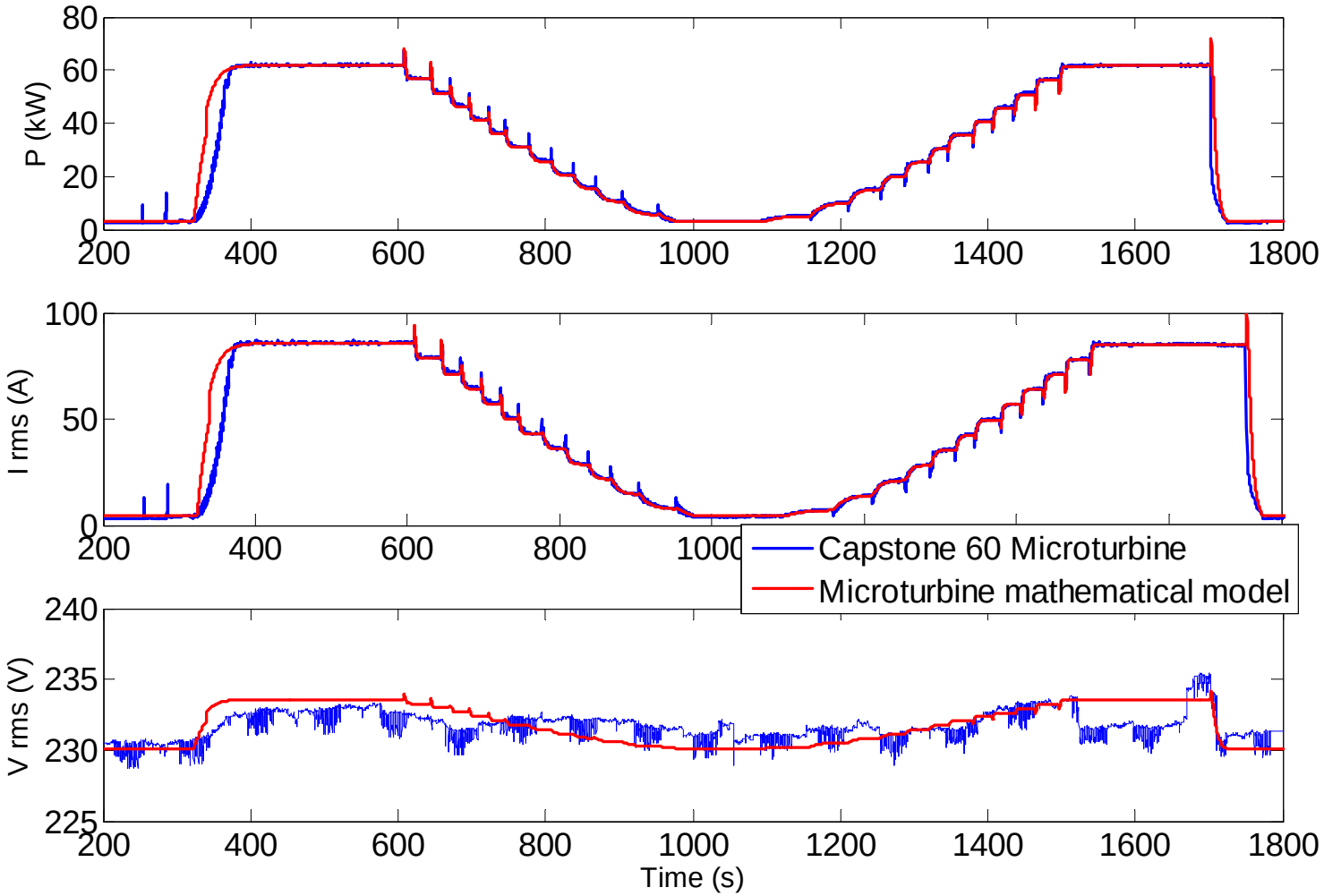
- Parameterization of the microturbine mathematical model and its control systems
- The parameter identification procedure
  - Evolutionary Particle Swarm Optimization
  - Mean Square Error Criterion





Parameter estimation based on experimental data

- Results



Main conclusions

- Demonstrated the possibility of transition between grid connected and islanding mode
- The impact of the microturbine on the grid voltage quality was not significant – Only a slightly increasing of the voltage RMS was recorded
- Microturbine operation in islanding mode was possible without significant voltage and frequency variations for moderate load variations
- Parallel of the microturbine with Diesel gen-set and stable operation were achieved with slacken of the microturbine's frequency protections
- Operation in islanding mode requires control of micro-sources and loads
- Based on these concepts, EDP Group, with some partners as INESC Porto, has been developing the InovGrid project.