



Technical University of Lodz  
Institute of Electrical Power Engineering

# Control of Low Voltage Microgrid in Autonomous Operation Mode

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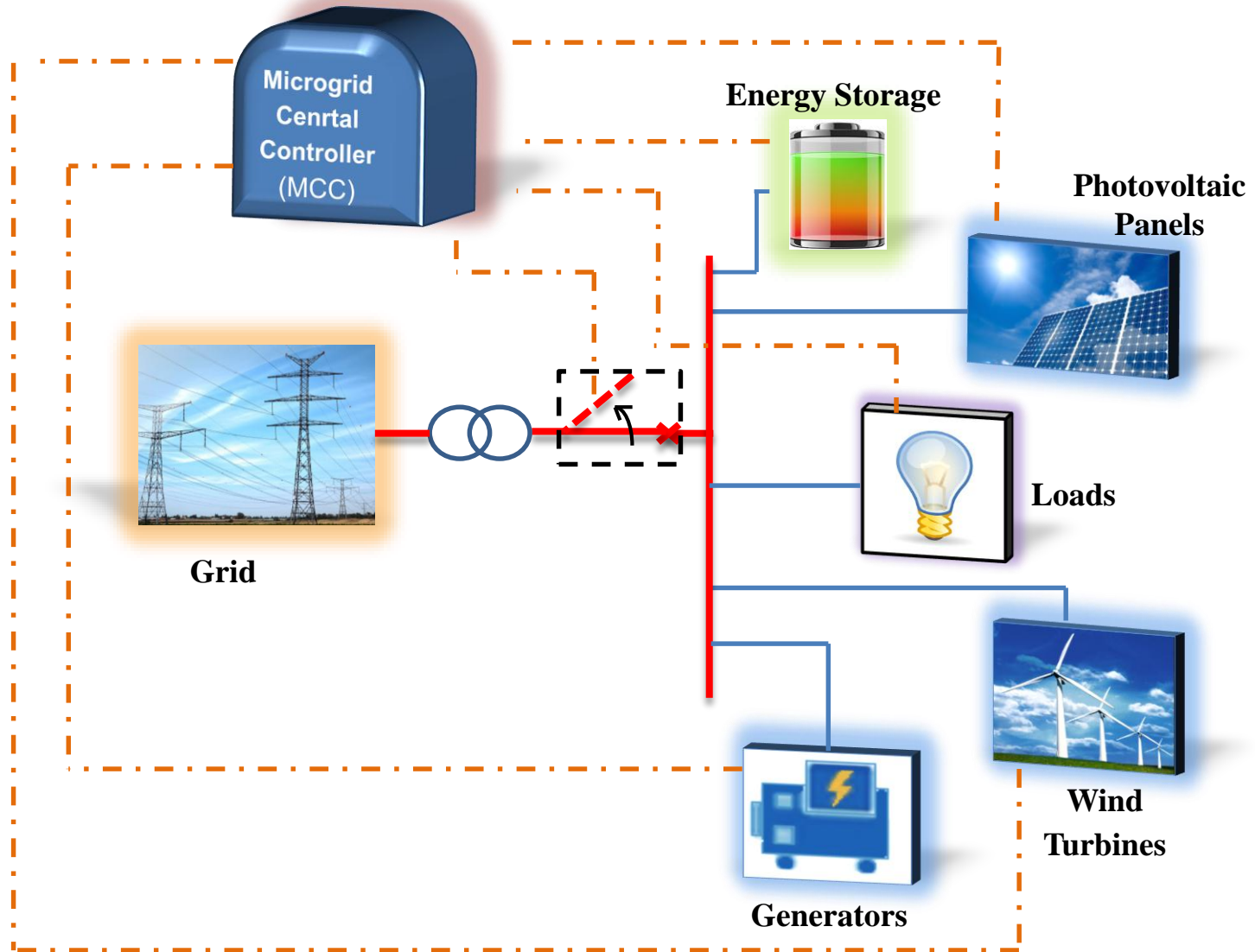
# Presentation Outline

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- **Introduction**
- **Objective of the paper**
- **Microgrid operation modes**
- **Proposed control strategy**
- **Microgrid simulation model**
- **Simulation results**
- **Conclusions**

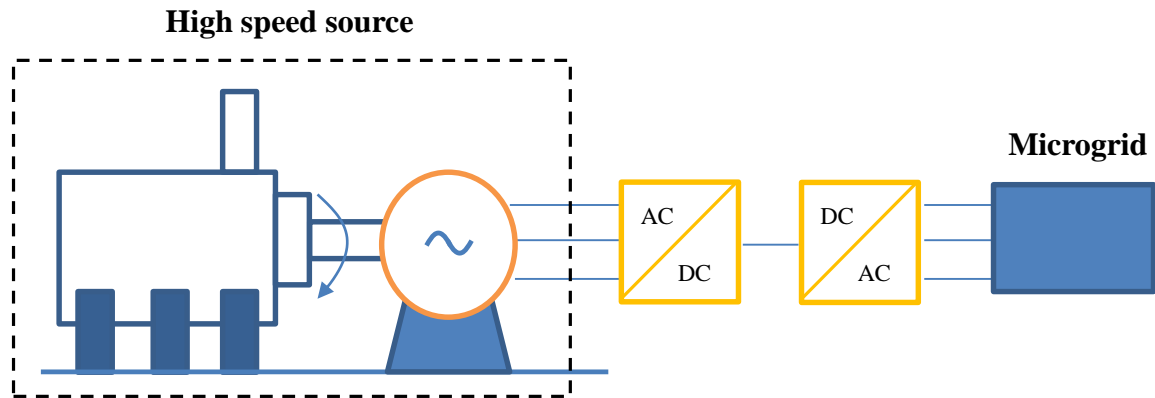


# Typical structure of the Microgrid

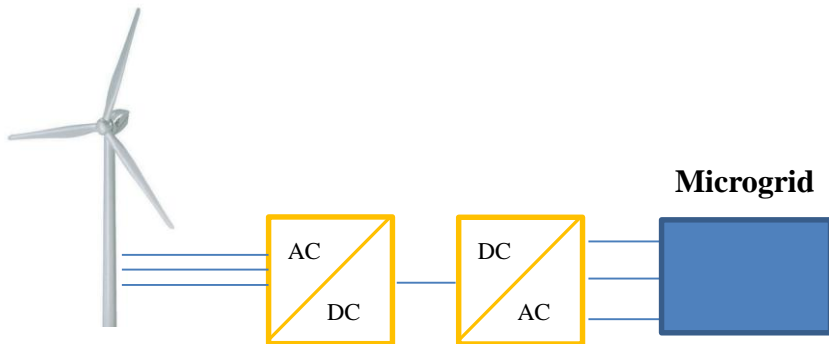




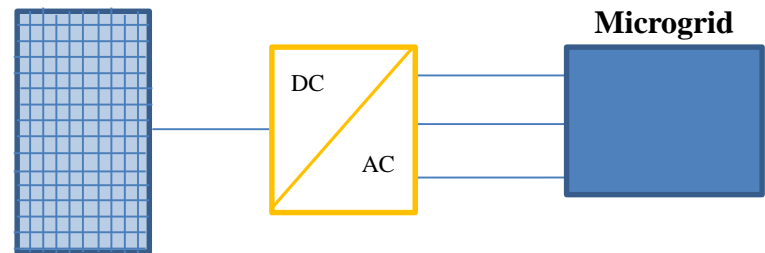
# Distributed generation units installed in Microgrid



**Variable speed source**



**Photovoltaic Panel**





# Objective of the paper

It could be expected from the microgrid to ensure sufficient generation capacity, controls and operational strategy to supply loads after being disconnected from the supplying network even if the microgrid delivers electricity with less power and lower quality.

With an appropriate control strategy of the sources there is a possibility to provide power supply to local customers even if any disruption occurs in the power system.

**The major purpose of the work is to demonstrate the control strategy for autonomous mode of microgrid operation.**

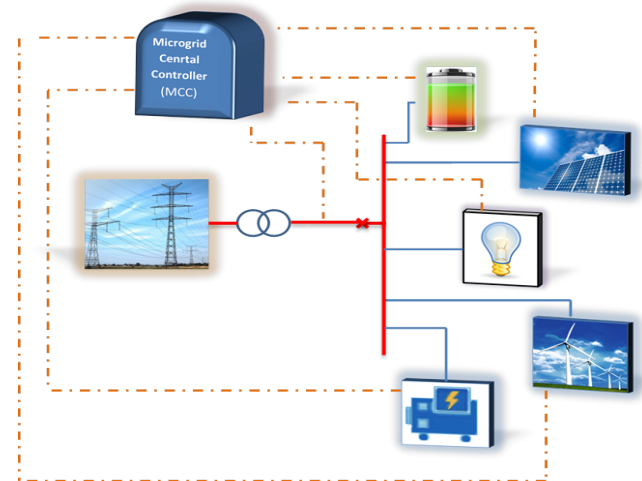




# Grid-connected mode

When a microgrid operates in grid-connected mode:

- No direct **voltage** and **frequency** control is required
- Utility grid constitutes a reference voltage and frequency source
- Energy sources are controlled as current sources
- Interface converters are Voltage Source Converters (VSC) operating in current controlled mode (**CC-VSC**) in synchronization with the supplying voltage, according to P-Q control strategy

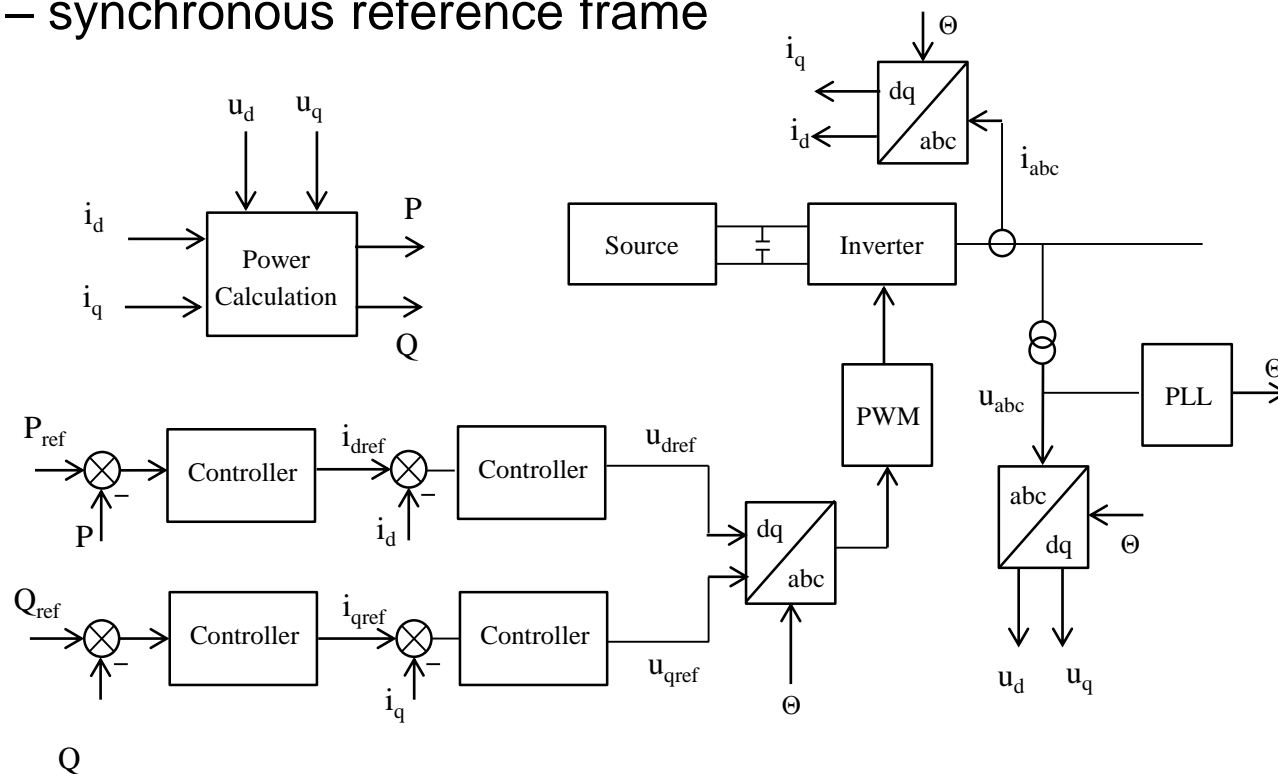




# Grid-connected mode

Control algorithms can be delivered in various coordinate systems, such as:

- $\alpha\beta 0$  – stationary reference frame
- abc – natural reference frame
- dq0 – synchronous reference frame



**Block diagram of P-Q control in dq reference frame**



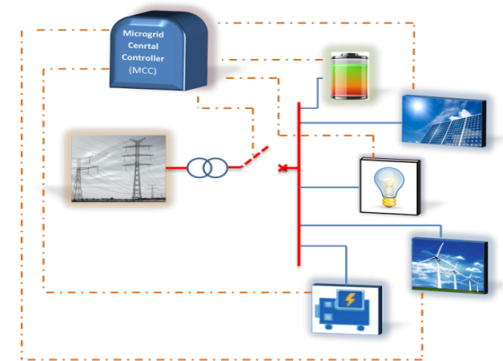
# Autonomous mode

The objectives of control strategy in autonomous microgrid operation is to:

- Ensure power balance
- Maintain the required values of voltage amplitude and its frequency at the point of connection with the supplying network

In order to meet these requirements it is necessary to have “grid-forming” unit within the microgrid which has adequate power reserve to cover power demand changes.

Such unit is assigned to regulate the voltage at the PCC and set the system frequency. It employs voltage controlled mode for voltage source converter (VC-VSC) and follow U-f strategy.

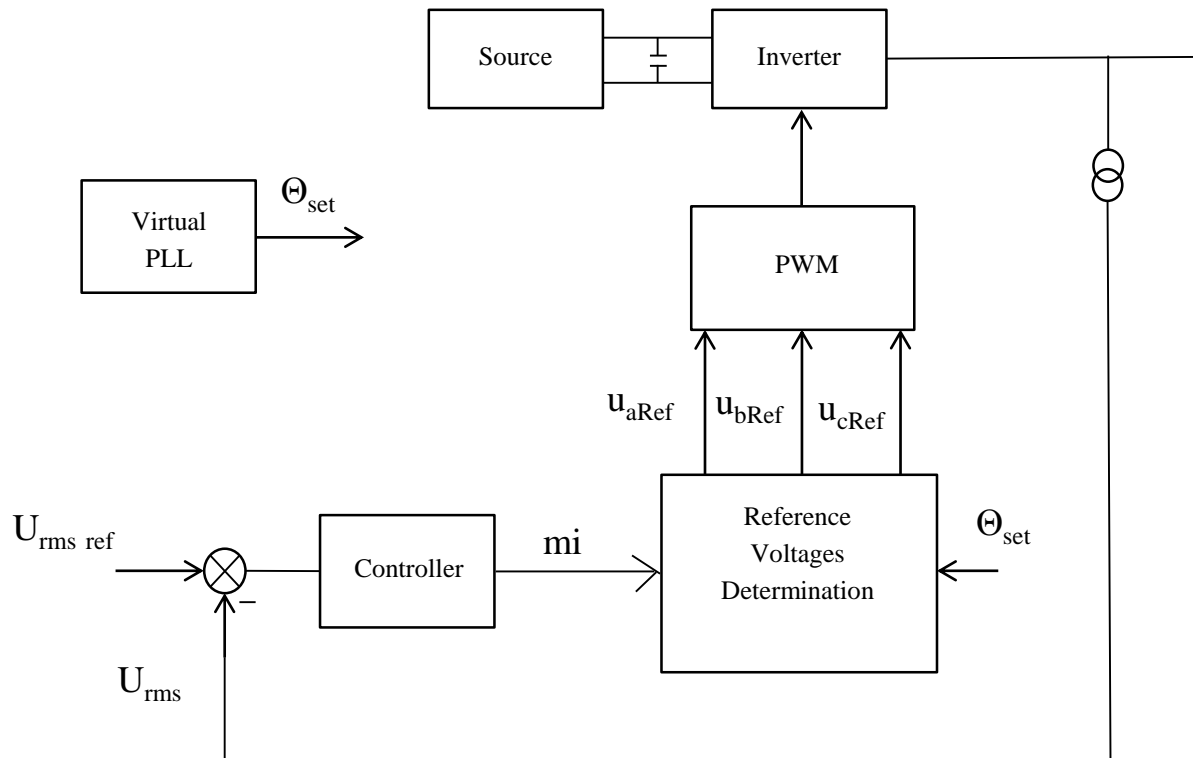






# Autonomous mode

Control algorithm for VC-VSC according to U-f control strategy



**Block diagram of U-f control**

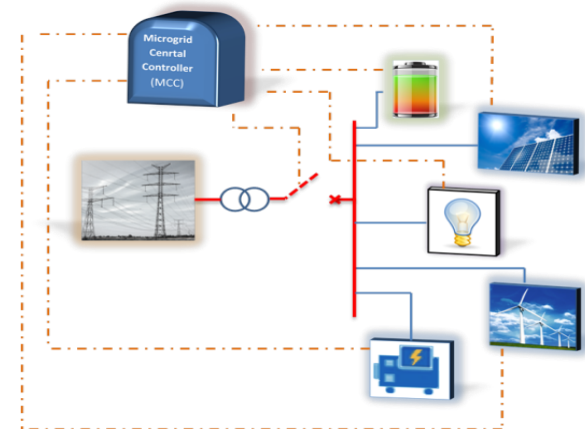


# Autonomous mode

Under autonomous operation mode microgrid can be controlled according to two possible control strategies:

- Single Master Operation (SMO)
- Multi Master Operation (MMO)

In the case of **SMO** strategy when two or more energy units are connected to the microgrid operating autonomously, only one of these can be the source of reference voltage. This unit follows the U-f control, while the other sources implement the P-Q control.

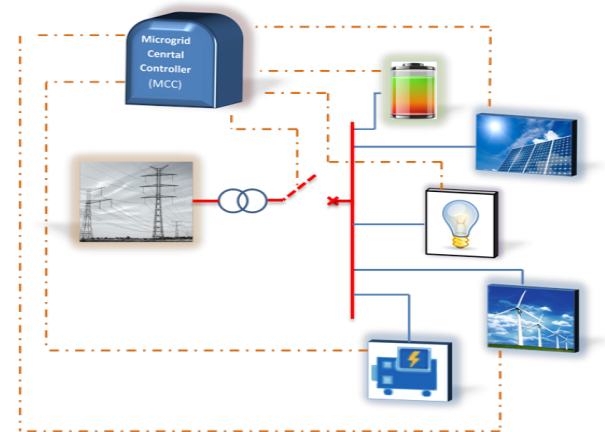




# Autonomous mode

**MMO** strategy is applied if two or more sources actively participate in microgrid voltage and frequency control.

In such a case a frequency-droop and voltage-droop control is derived that share active and reactive powers between sources.





# Proposed control strategy

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The proposed control strategy assumes that:

- All energy sources within the microgrid are CC-VSC controlled independently on the operation mode.
- In autonomous microgrid operation SMO strategy is applied and the source of reference voltage is the energy storage.
- The control of energy storage changes from P-Q in grid-connected regime to U-f in autonomous operation.
- Operation of the microgrid is coordinated by central controller



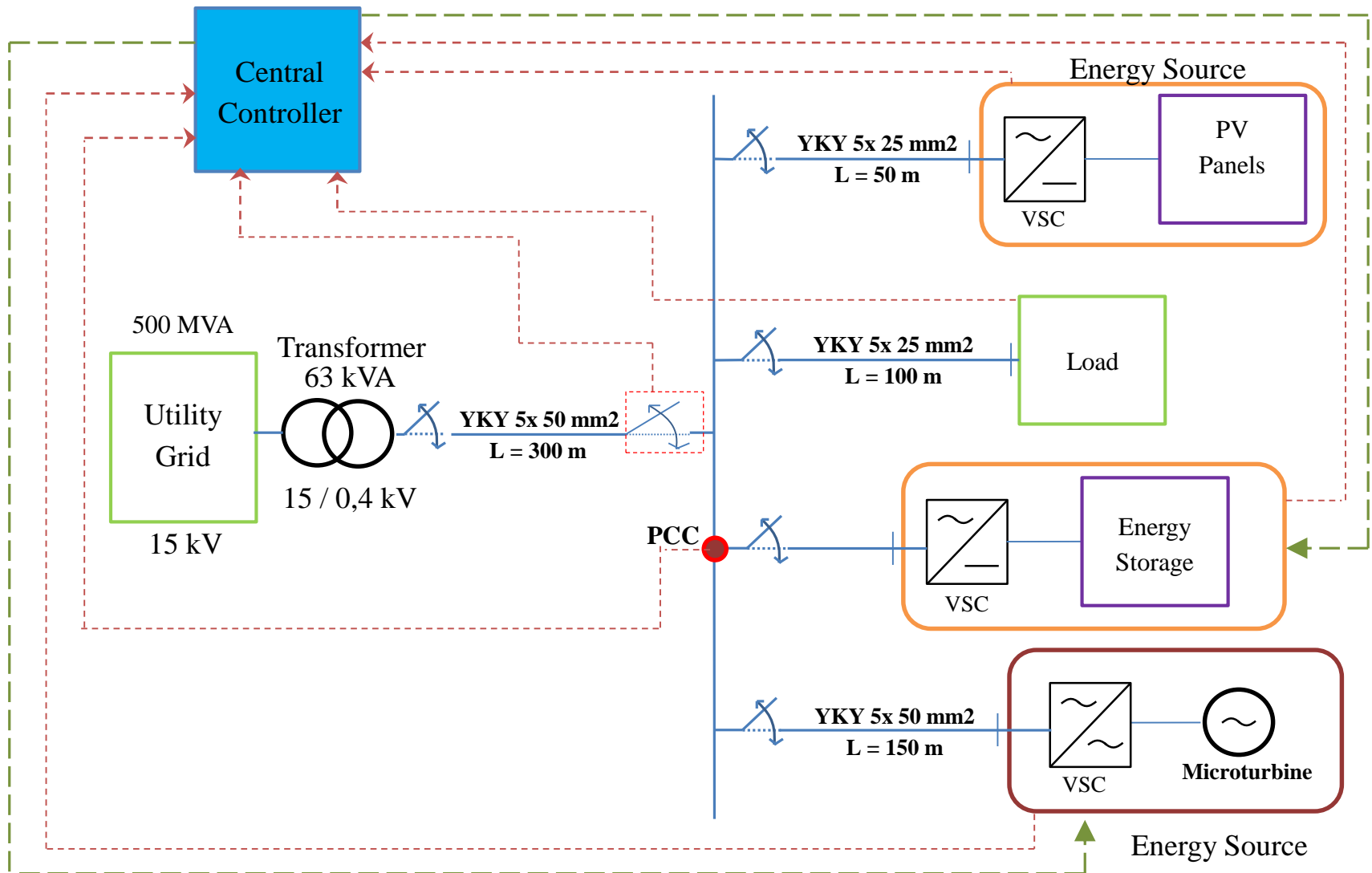
# Proposed control strategy

The **central controller** can performs the following functions:

- Keeps constant active power exchange with the network during grid connected mode of microgrid operation (optional)
- Identifies the conditions for island creation
- Changes the storage control from P-Q to U-f
- Determines set points for MT during autonomous operation
- Identifies the condition for reconnection of the microgrid with the network



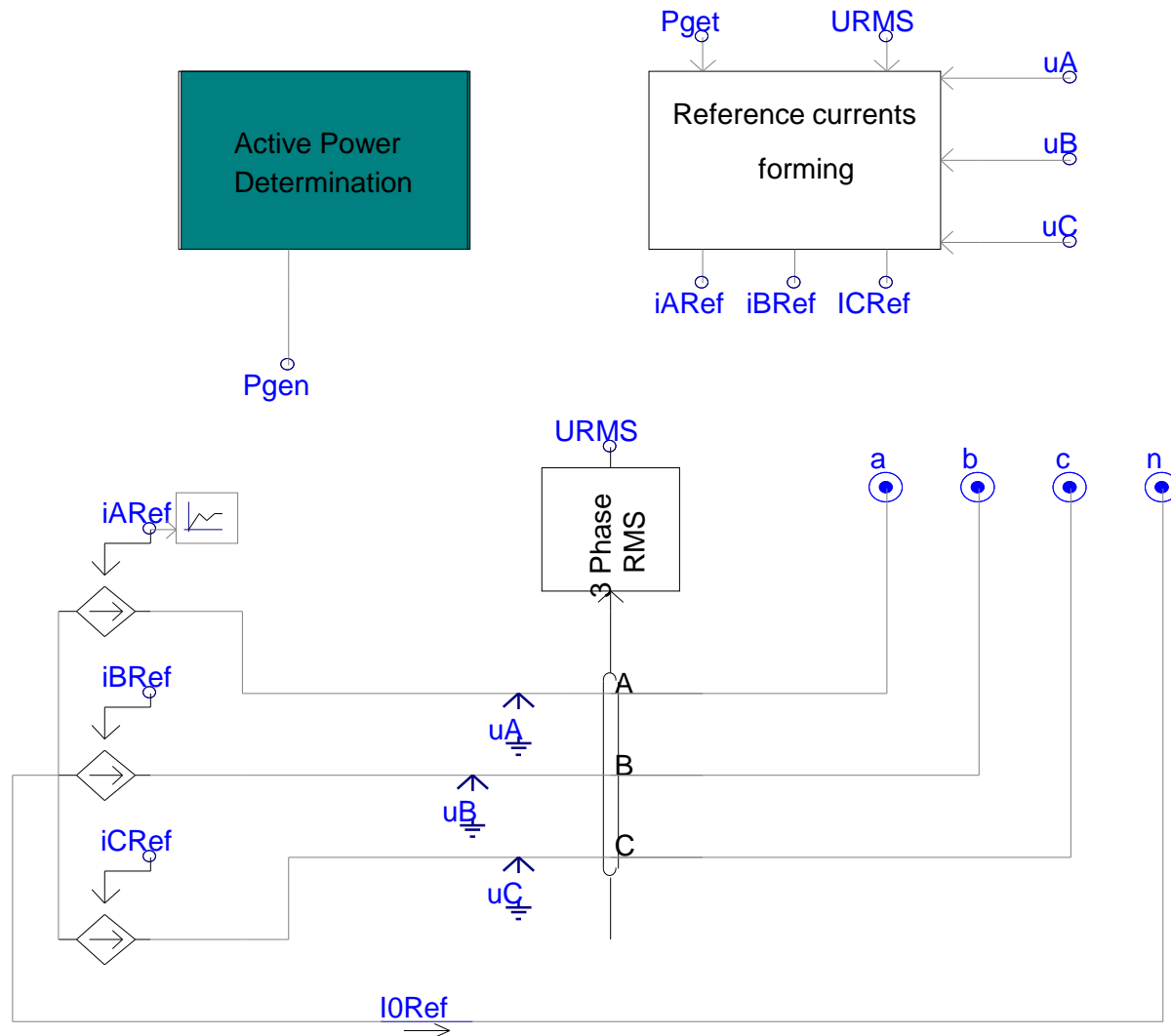
# Microgrid Simulation Model





# Microgrid Simulation Model

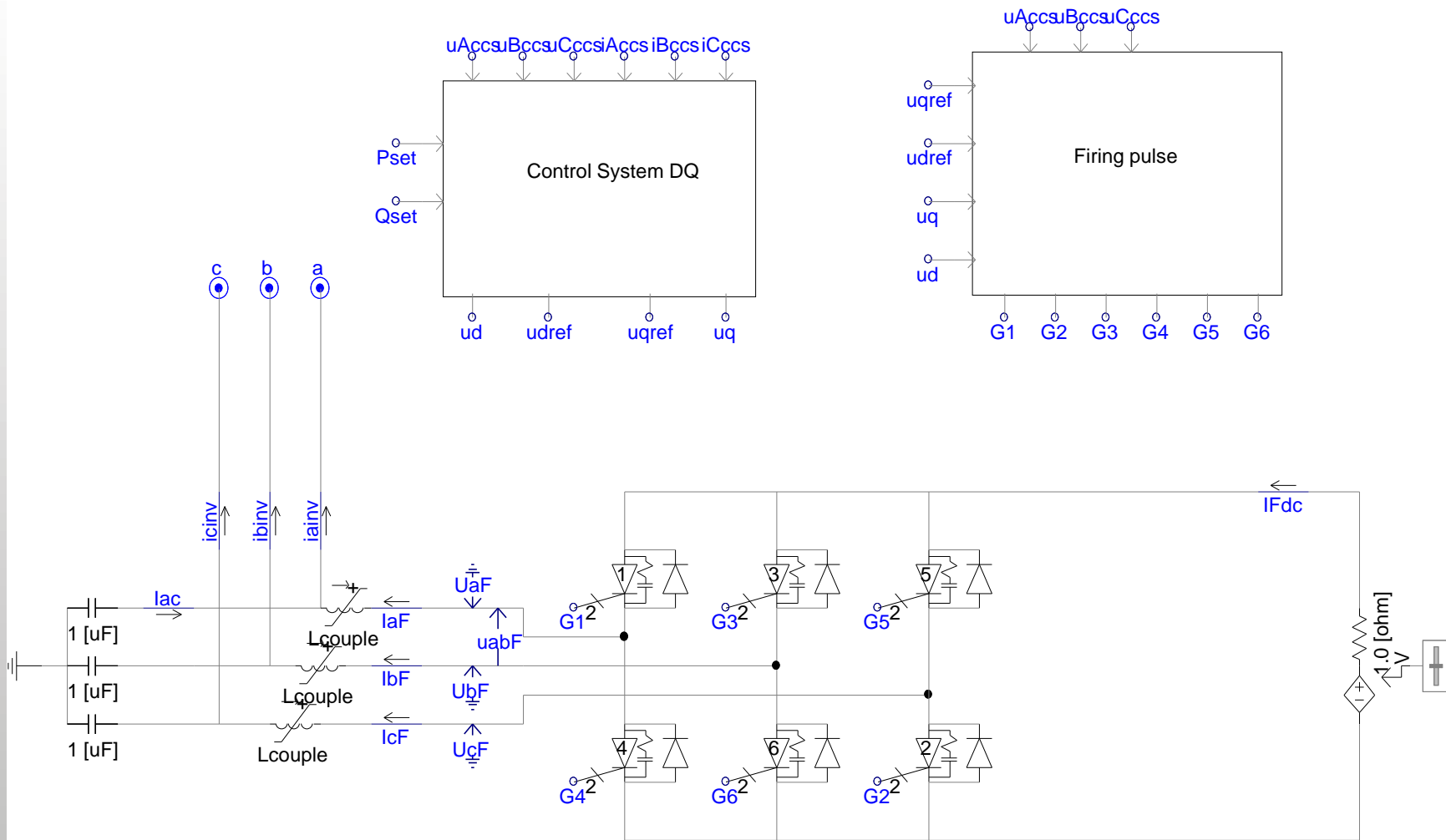
## Model of PV source in PSCAD program





# Microgrid Simulation Model

## Microturbine model in PSCAD program

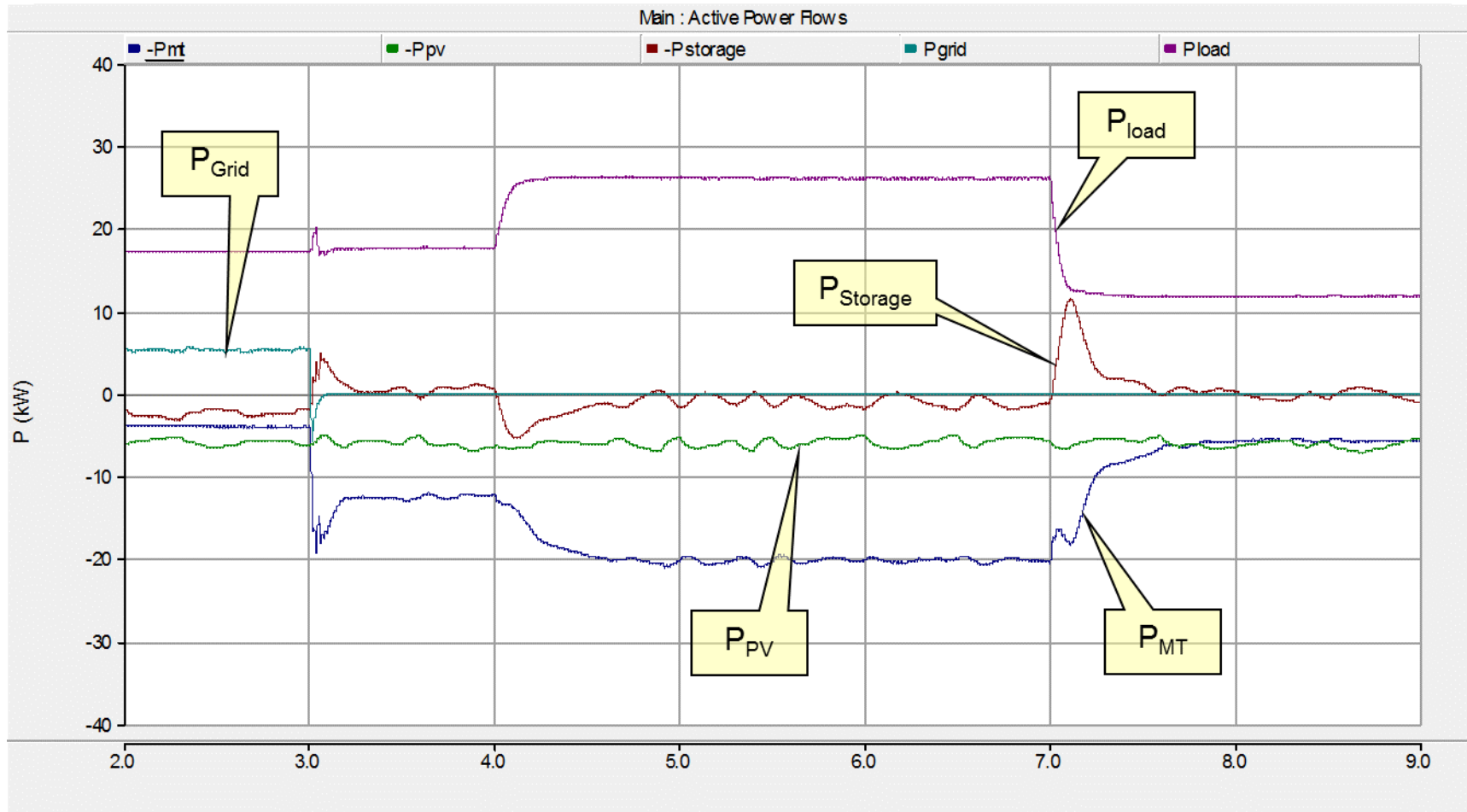






# Simulation results

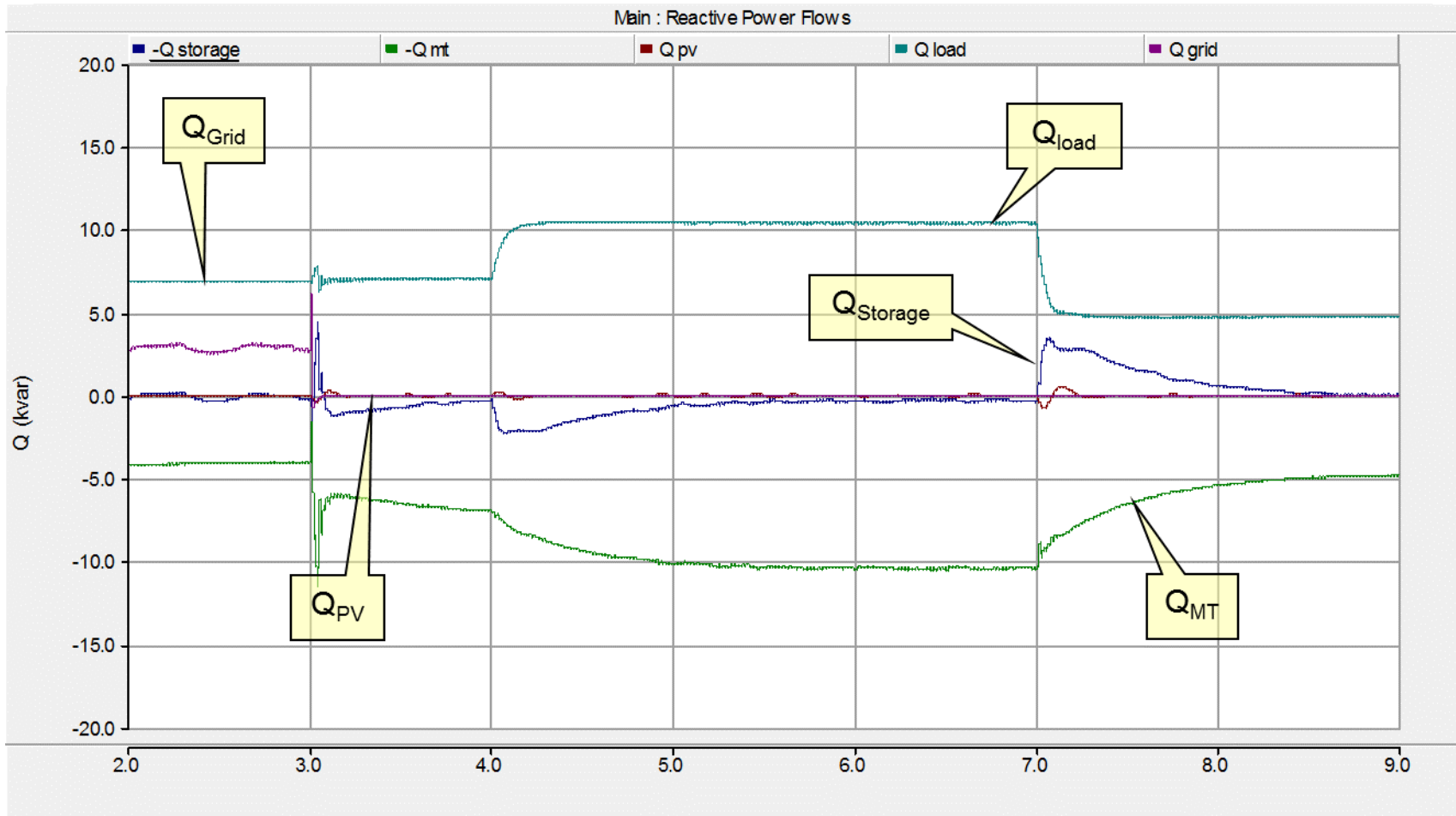
## Active power flows within microgrid





# Simulation results

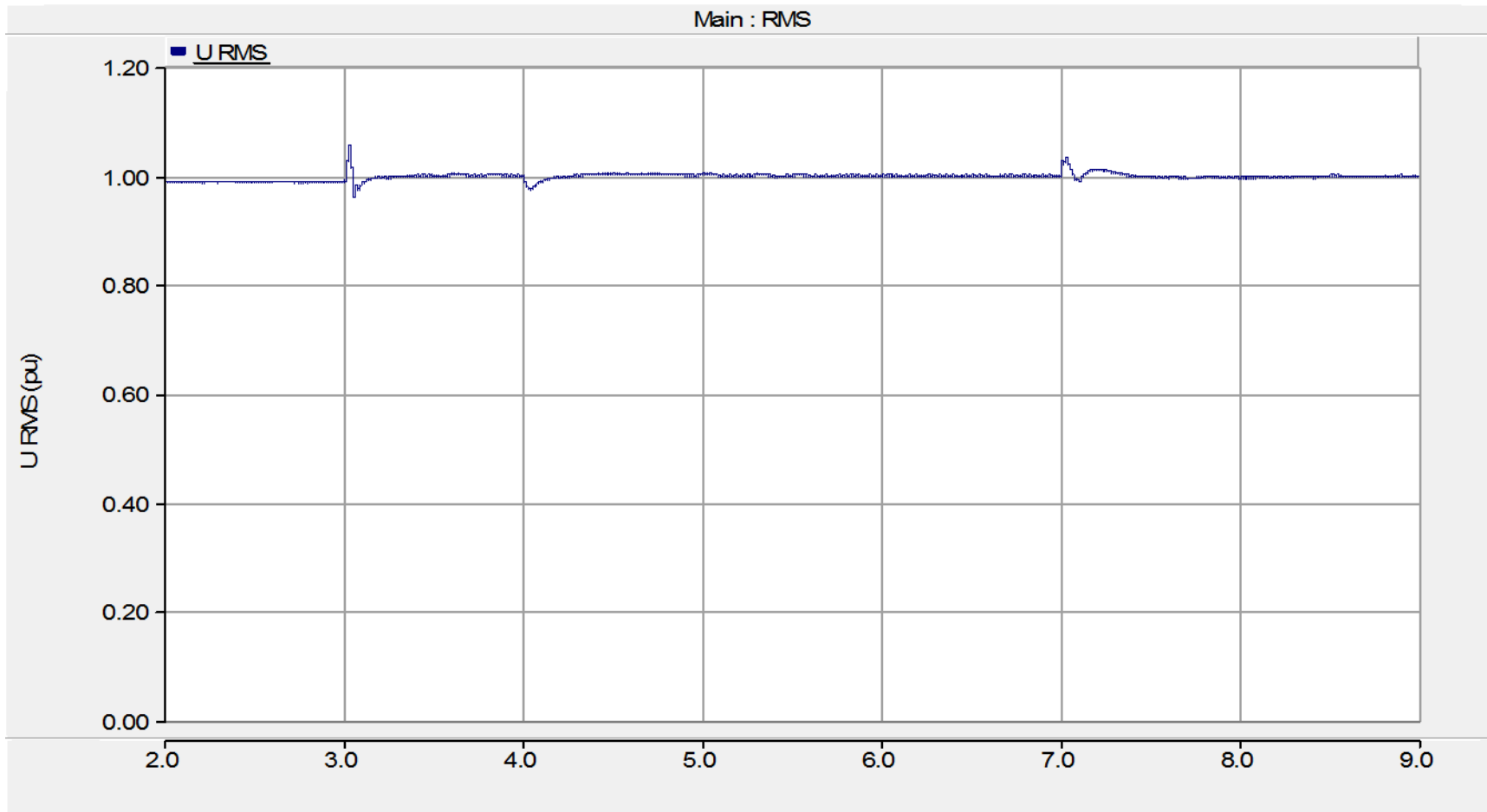
## Reactive power flows within microgrid





# Simulation results

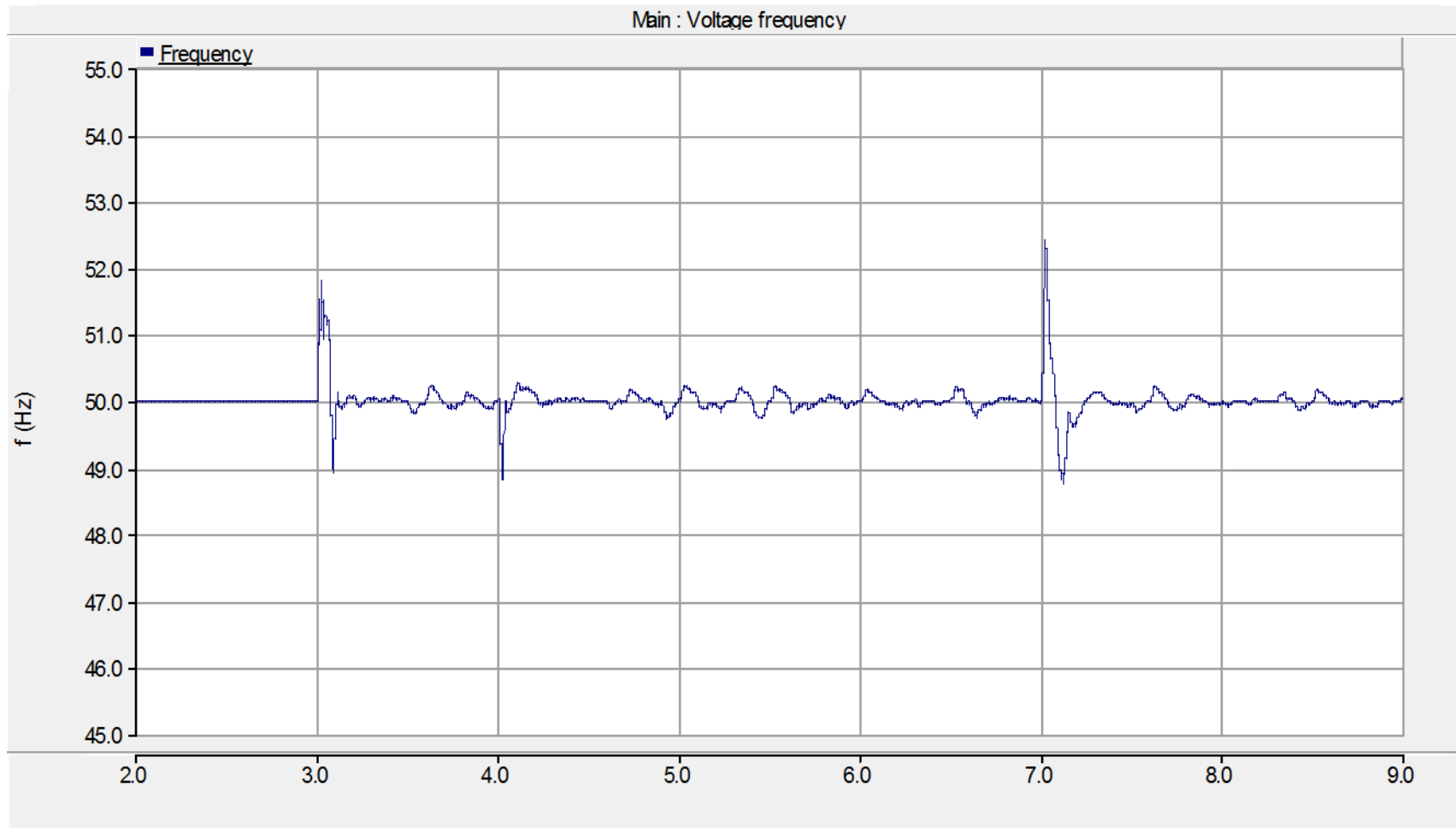
## RMS voltage at the PCC (pu)





# Simulation results

## Voltage frequency within the microgrid





# Conclusions

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- The idea of proposed control allows to continue load supply after microgrid disconnection from the utility network
- The applied strategy assumes that energy storage maintains the reference voltage in the microgrid. Thus, the control of energy sources can remain the same as in grid-connected mode and uninterrupted transition from grid-connected to islanding operation is possible.
- The central controller is designed which determine set points for the controllable source to cover load power changes in the microgrid. As a result the storage power is maintained close to zero which makes the autonomous operation of the microgrid possible in longer-term



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Thank you for your  
attention

