ACTIVATE

Ancillary services in active distribution networks, based on monitoring and control techniques

Issue No 3 **June 2021**

Dear Reader,

It is our pleasure to welcome you to the second edition of the ***ACTIVATE*** **Newsletter!**
"ACTIVATE—Ancillary services in active distribution networks, based on monitoring and control techniques" is an ambitious research project funded by the Hellenic Foundation for Research & Innovation, and is being implemented by a consortium of 4 highly capable and well established Universities.

If you would like to keep up with all the latest developments of our project follow us on Facebook, LinkedIn & Researchgate.

Kind Regards,
The ACTIVATE Research Team

About ACTIVATE

ACTIVATE will propose the design of *hybrid control strategies*, combining features of centralized and decentralized concepts to improve the performance of the network operation. In order to extend the applicability of the proposed hybrid strategy also a *virtual inertia* scheme will be incorporated to modify the control strategies of distributed renewable energy sources (DRES) converters. To enhance further the adaptability of the provided virtual inertia and to modify the overall dynamic response of the power system, *energy storage systems* will be used with novel congestion management techniques.

Additionally, an innovative *network monitoring architecture* will be proposed to determine the converter virtual-inertia parameters and coordinate the hybrid control strategy operation.

Finally, to facilitate the implementation and application of the proposed scheme in existing distribution grids, a *prototype three-phase converter* will be developed.

H.F.R.I. Hellenic Foundation for Research & Innovation
http://www.elidek.gr

This project has received funding from the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "First Call for H.F.R.I. Research Projects to support Faculty members and Researchers and the procurement of high-cost research equipment grant (Project Number: HFRI-FM17-229).

DEMOCRITUS UNIVERSITY OF THRACE

Project Progress So Far

Ancillary services solutions for DSOs and TSOs

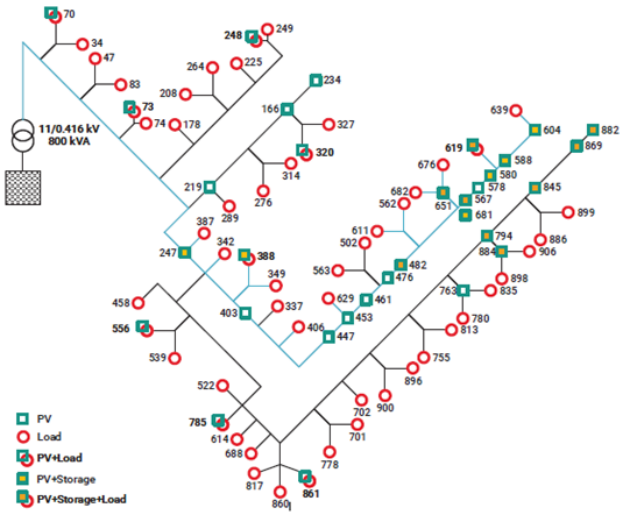
A **unified control strategy for voltage regulation (VR), voltage unbalance mitigation (VUM) and congestion management** (CM) has been developed in ACTIVATE. The proposed architecture uses the reactive power of DRESs and the active/reactive power of distributed battery energy storage systems (DBESSs). The distinct characteristic of the proposed approach is that the implemented algorithms are decoupled allowing the individual handling of VR, VUM, and CM issues. The performance of the proposed control strategy has been tested in the IEEE LV European benchmark network and was compared against well-established control schemes proposed in the literature, including:

a) A control scheme dealing with a consensus algorithm for voltage regulation using only the positive-sequence active power of DBESSs.

b) A control scheme implementing droop-based *Q*(*V*) - *P*(*V*) method proposed to control the output power of both PVs and DBESSs.

c) A phase-based implementation of the consensus algorithm for VR using only the active power of DBESSs.

d) A droop-based *P*(*V*) solution with and without VUM capabilities



Main lessons learnt

1. The developed algorithms are characterized by **low-complexity**, **reduced monitoring needs** and **limited exchange of information**, facilitating their integration to the real distribution grids
2. The proposed approach outperforms the existing solutions in terms of **reduced network losses**, **improved DBESS utilization** and ability to **concurrently address VR, VUM, and CM issues**

H.F.R.I. Hellenic Foundation for Research & Innovation
http://www.elidek.gr
The project is funded by the Hellenic Foundation for Research & Innovation

Project Progress So Far

Power smoothing techniques

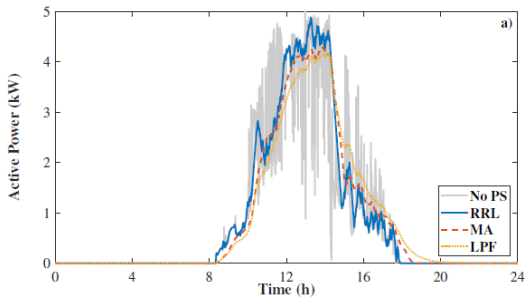
The vast majority of DRESs consists of photovoltaics and wind turbines. Their common characteristic is the highly variable output power depending mainly on the availability of the primary energy source. This variability affects the reliable operation of distribution networks, since voltage fluctuations may occur affecting the performance of voltage-sensitive devices. Generally, the power smoothing capability can be provided by adopting at least one of the following solutions:

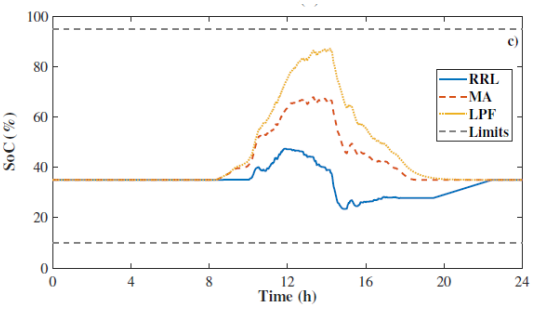
- control of DRESs to operate below the MPP
- active participation of loads to mitigate the variable output power of DRESs
- utilization of ESSs by applying smoothing techniques as **filtering-based algorithms**, e.g., moving-average (MA) and low-pass filtering (LPF), where the output power is filtered to reduce the frequency spectrum of the injected power or use **ramp rate controls** (RRC), where the output power saturates when the calculated ramp rate reaches a specific limit.

In ACTIVATE in order to develop an efficient **power smoothing control strategy** the impact of the most well-established power smoothing techniques (LPF, MA, and RRC) on the long-term performance of BESS has been investigated systematically. In the examined studies, **BESS aging** has been also considered by applying the rainflow cycle-counting algorithm to estimate the cycle aging, and thus BESS capacity degradation.

Main lessons learnt and future work

1. The most critical parameters that affect the **power smoothing** capability and the **BESS aging** have been identified by applying parametric analysis with high-resolution measurements.
2. At least one **BESS replacement** is needed with the PV lifetime.
3. **RRC outperforms** MA and LPF-based methods in terms of required BESS sizing, achieved smoothing, and capacity degradation.
4. In future **work** additional parameters that may affect the BESS capacity degradation, e.g., BESS temperature will be investigated. Furthermore, the impact of recently proposed sophisticated Kalman-filter and wavelet techniques will be examined.





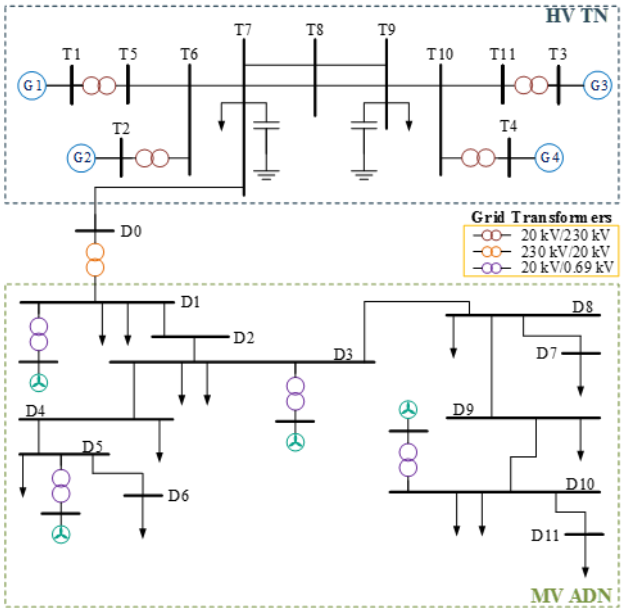
The project is funded by the Hellenic Foundation for Research & Innovation
H.F.R.I. Hellenic Foundation for Research & Innovation
http://www.elidek.gr

Project Progress So Far

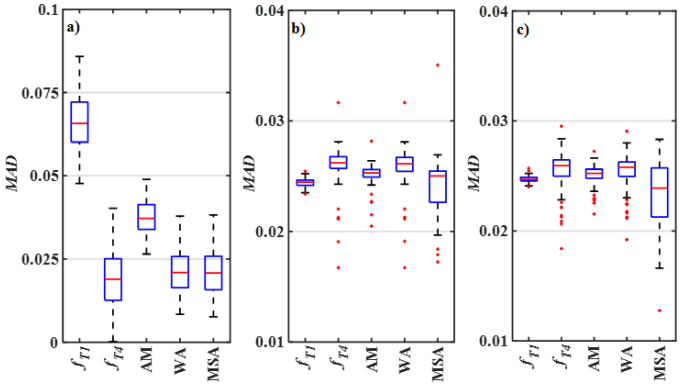
Multi-channel measurement-based identification methods

Vital information regarding grid oscillations and stability margins of the power system can be provided by mode estimation. Mode estimation can be implemented in terms of **single-channel analysis** (system responses are analyzed as single entities) and **multi-channel analysis** (a set of measured signals is processed). Generally, multi-channel analysis results into more accurate and generic results, by either analyzing **multiple signals simultaneously** (multi-signal fitting) or single-channel analysis is applied to each of the signals to derive modal estimates and the final estimates are calculated by **means of arithmetic mean** or **weighted averaging**. In this context, within ACTIVATE the following tasks have been done:

- The applicability and performance of different **multi-channel identification** approaches has been evaluated
- The analysis has been implemented in a **combined transmission-active distribution network (ADN)** to investigate mode propagation as well as the applicability of multi-signal architectures for the analysis of complex **TN - ADN** interactions
- Comparative analysis between **single-** and **multi-channel** approaches has been performed



Main lessons learnt



1. **Inter-area modes** can be identified by using responses from both the TN and ADNs
2. **Multi-channel techniques** are more accurate, significantly reducing the impact of noise, canceling out also erroneous mode estimates (single channel analysis)
3. All multi-channel techniques present similar accuracy. **VF** and **MP** provide the most accurate estimates and are practically not affected from SNR .
4. **VF** is the most suitable for **close to real time applications**, presenting **low computational burden** and **high immunity to noise**.

H.F.R.I. Hellenic Foundation for Research & Innovation
http://www.elidek.gr
The project is funded by the Hellenic Foundation for Research & Innovation

Communication & Dissemination activities

Conference on Power System Transients, IPST 2021

In our conference paper entitled '***Multi-channel measurement-based identification methods for mode estimation in power systems',*** the applicability and the performance of the most known multi-channel measurement-based identification approaches for the modal analysis of modern power systems incorporating active distribution networks was analysed. The paper was presented in the IPST 2021 on 6-10 June 2021. The paper has been also accepted for publication in **Electric Power Systems Research journal** as part of the Special Issue "*Proceedings of the 15th International Conference on Power Systems Transients (IPST 2021)*".

URL: *https://doi.org/10.1016/j.epsr.2021.107157*

Journal publication

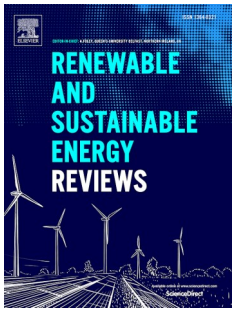
The project paper entitled '***Methodology for the Techno-Economic Assessment of Medium-Voltage Photovoltaic Prosumers Under Net-Metering Policy***' was published in IEEE Access. The paper presents a techno-economic assessment methodology to evaluate the viability of net-metering policy in medium-voltage prosumers, incorporating different decentralized voltage regulation techniques contained in the PV systems of the prosumers.

URL: *https://doi.org/10.1109/ACCESS.2021.3073780*

Journal publication

As a results of our D1.1 "Review of the state-of-the-art and technical solutions" the review paper '*Ancillary services in active distribution networks: A review of technological trends from operational and online analysis perspective*' was published in **Renewable and Sustainable Energy Reviews** of **Elsevier**.

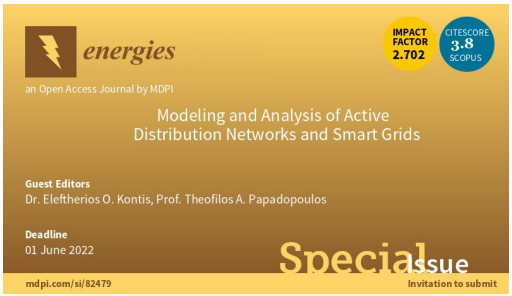
URL: *https://doi.org/10.1016/j.rser.2021.111198*



Special Issue

Within the frame of **ACTIVATE** we are guest editing the Special Issue entitled "*Modeling and Analysis of Active Distribution Networks and Smart Grids*", which will be published in ***Energies MDPI***.

URL: *https://www.mdpi.com/journal/energies/special_issues/Active_Distribution_Networks*



The project is funded by the Hellenic Foundation for Research & Innovation
H.F.R.I. Hellenic Foundation for Research & Innovation
http://www.elidek.gr

Project Consortium

Democritus University of Thrace (DUTH)

Power Systems and Electrical Machines laboratories are involved in ACTIVATE. DUTH is proud to be one of the largest Universities in Greece. In this context, it has attracted a significant number of research programs funded by the EU as well as national and private resources. The research team of ACTIVATE consists from two DUTH academics, three PhD candidates and two MSc students..

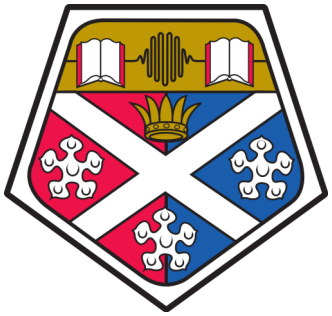
Theofilos A. Papadopoulos thpapad@ee.duth.gr

POWER SYSTEMS LABORATORY
ARISTOTLE UNIVERSITY OF
THESSALONIKI

Aristotle University of Thessaloniki (AUTH)

The Power Systems Laboratory (PSL) of AUTH is running since 1980 and has been involved in 140+ European, bi-lateral and national projects (http://power.ee.auth.gr/). The PSL and the team members involved in this project have significant experience in all topics related to power systems analysis, operation and control, modelling, distributed generation and smart grids and renewable energy sources.

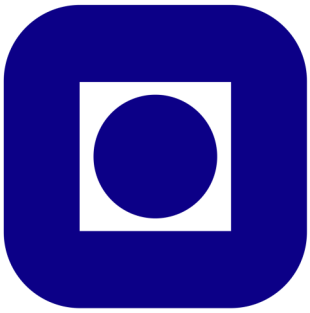
Grigoris Papagiannis grigoris@eng.auth.gr



University of Strathclyde (UoS)

The D-NAP laboratory of the Institute for Energy and Environment provides an environment for research, development and testing of smart grid functions incorporating PHIL functionalities with real-time simulators. Also, experts in the topics related to power systems modeling and near real-time dynamic security assessment from UoS, will participate in the development of ACTIVATE network monitoring techniques.

Graeme Burt graeme.burt@strath.ac.uk



Norwegian University of Science and Technology (NTNU)

Experts from Department of Electric Power Engineering of NTNU will contribute on the development and testing of the three-phase converter. NTNU experts are specialized in the area of wide band gap power converters design, gate and base driver designs for WBG devices, as well as dc-breaker concepts for MV and HVDC systems.

Dimosthenis Peftitsis dimosthenis.peftitsis@ntnu.no

The project is funded by the Hellenic Foundation for Research & Innovation
H.F.R.I. Hellenic Foundation for Research & Innovation
http://www.elidek.gr