ACTIVATE

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

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Dear Reader,

It is our pleasure to welcome you to the fifth 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

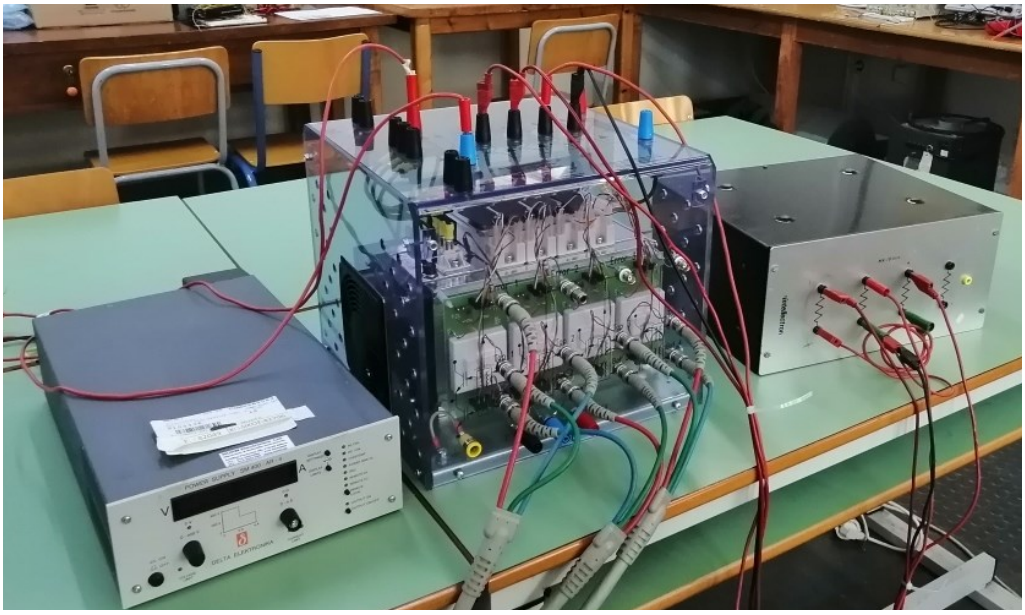
Project Progress So Far

Prototype power converter design

A power converter system has been designed consisting of a three-phase four-wire dc/ac converter, a series dc/dc converter, a battery storage system (BSS), an output filter and four control units enabling the provision of the following **ancillary services** to DSOs:

- voltage regulation
- voltage unbalance mitigation
- virtual inertia and primary frequency response
- power oscillations mitigation at the output of the converter

The converter incorporates not only **control** but also **monitoring functions**, similarly to distribution phasor measurement units (D-PMUs).



Main lessons learnt and next steps

1. Laboratory experiments carried out in DUTH have evaluated and verified the performance of the converter system.
2. We have applied for a **National Patent** for the proposed system design.
3. Next steps include the evaluation of the proposed system by conducting also **power hardware in the loop simulations**.

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Validation of the proposed control and monitoring architecture with simulation and experimental results

The **control strategies**, the **monitoring architecture** and the **prototype converter** developed in ACTIVATE will be validated by means of **simulation and laboratory tests**.

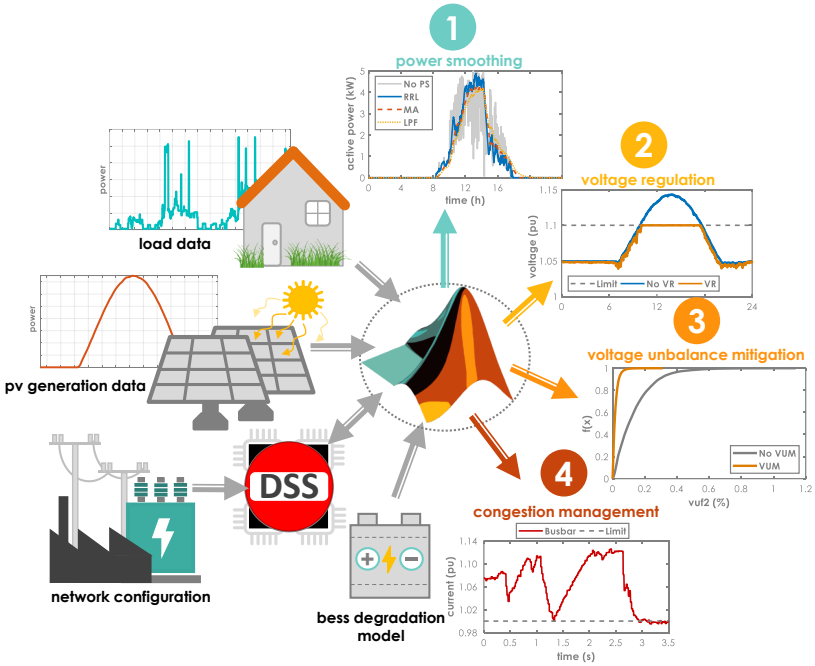
Towards this objective, the performance of the designed ACTIVATE **ancillary services (ASs)**, are tested by means of simulations in a combined transmission, primary and secondary distribution network, designed specifically for the needs of ACTIVATE. Some of the provided ASs include **(1) power smoothing**, **(2) voltage regulation**, **(3) voltage unbalance mitigation** and **(4) congestion management**. In the investigations, a calendar and cyclic battery degradation model is also incorporated into quasi-static simulations to replicate real operating conditions and assess the long-term impact of the ASs on the BSS lifetime.

Using the combined transmission, primary and secondary distribution network model, dynamic simulations were also conducted to test the features of the proposed three-level distribution architecture. At this step, our work focuses on the development of **digitally twin distribution network equivalent** models and the application of the proposed ARMAX method for the estimation of oscillatory modes in experimental results.

Lessons learnt

Investigations are ongoing. From the analysis conducted up to now it was shown that:

1. the proposed power smoothing, voltage regulation, voltage unbalance mitigation and congestion management ASs can be harmoniously combined and solve problems in active distribution networks,
2. the provision of multiple ASs does not necessarily lead to accelerated BSS capacity degradation compared to the case where less ASs are considered,
3. BSS aging is mainly influenced my the mean SOC operating value as higher mean SOC leads to accelerated BSS degradation,
4. the ARMAX method can accurately identify oscillatory modes by using measurements obtained at all levels of the grid.



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Communication & Dissemination activities

XXII Power Systems Computation Conference (PSCC)

Our paper "**A Multi-Signal Least-Squares-Based Optimization Technique for the Identification of Power System Oscillatory Modes**" has been accepted for presentation in the XXII Power Systems Computation Conference (PSCC) that will take place in June in Porto, Portugal. In this paper, a multi-signal identification technique is proposed to estimate oscillatory modes contained in power system responses. The proposed technique utilizes least-squares optimization to analyse simultaneously several system measurements and determine close -to-real-time the modal parameters of the examined power system.

5th International Conference on Smart Energy Systems and Technologies (SEST)

Our paper "**Assessing the Provision of Ancillary Services Considering BSS Capacity Degradation**" has been accepted for presentation in the 5th International Conference on Smart Energy Systems and Technologies (SEST) that will take place in September in Eindhoven, the Netherlands. In this paper, a methodology for the assessment of the provision of voltage regulation and power smoothing services by PV-BSS systems is presented, by taking into account the capacity degradation of BSS. The proposed framework involves quasi-static simulations incorporating the operating conditions of the distribution network. A battery aging model is used to estimate the BSS capacity loss caused by both the calendar and the cyclic aging mechanisms.

The project is funded by the Hellenic Foundation for Research & Innovation
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Journal publication

The project paper entitled '**A Three-Level Distributed Architecture for the Real-Time Monitoring of Modern Power Systems**' was published in IEEE Access. The paper is the result of the research effort within WP3 and describes the ACTIVATE three-level distributed architecture for the monitoring and analysis of modern power systems.

URL: *https://doi.org/10.1109/ACCESS.2022.3159340*

Journal publication

ACTIVATE has also contributed to the development of a methodology for identifying the applicability range in terms of accuracy and generalization capability of several conventional and newly developed equivalent models for the dynamic analysis of modern distribution networks. The results of this work were published in the journal paper entitled '*Methodology for Evaluating Equivalent Models for the Dynamic Analysis of Power Systems*' in IEEE Trans. On Power Delivery

URL: *https://10.1109/TPWRD.2022.3167136*

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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..

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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.

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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.

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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.

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