

Master thesis for Mr./Ms. cand. M.Sc. First name Last name

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Integration of a digital secondary substation based on Weidmüller u-OS into a Digital Twin of the low-voltage grid and evaluation of the integration effort

In the course of the energy transition, large power plants such as nuclear and coal-fired power plants are being shut down in Germany and replaced by decentralized generation plants such as photovoltaic and wind power plants. This leads to a shift of feed-in from the transmission to the distribution grids and thus to bidirectional power flows. To observe the new loading of the low-voltage grids in particular, distribution system operators (DSO) equip their secondary substations with measurement and control technology and turn them into digital secondary substations (dONS). Today, the measurements of a dONS usually stay in the system of the respective manufacturer. Every platform brings its own engineering and its own transport protocol, such as TwinCAT and various IoT and fieldbus protocols at Beckhoff or u-OS and NATS at Weidmüller. At ie3, a Digital Twin of the low-voltage grid based on the Asset Administration Shell (AAS) has been developed, which describes the measurements of its source systems by an IEC 61850 data model and carries a provenance reference to the data source for every measurand. For intelligent measurement systems (iMSys) this reference is fully derivable from tariff application case 10. For the Beckhoff-based dONS at ie3, however, the mapping of the measurands to their MQTT topics exists only in a TwinCAT project and is maintained by hand. Since the Digital Twin is to grow with every further dONS platform, methods are required that bind a new platform to the IEC 61850 model of the twin with the least possible and a measurable effort.

In this master's thesis, a dONS based on the Weidmüller platform u-OS with the controller, the remote I/O system UR20 and split-core current transformers is to be commissioned in the Smart Grid Technology Laboratory (SGTL) at ie3. The hardware is provided by Weidmüller and installed in the low-voltage grid of the SGTL. The measurements of the feeders are to be published via the u-OS Data Hub and its NATS interface. As with the existing Beckhoff dONS, the IEC 61850 data model is to sit above the IoT transport and describe the measurements semantically. To this end, the Asset Administration Shells of the edge device, the transformers and the measurement points are to be created in the Digital Twin, the IEC 61850 device configuration (IID) is to be generated from the AAS with the existing ie3 tool, and the provenance reference to the NATS subject is to be entered for every measurand. For the ie3 application IEC 61850 Field Gateway, which binds source systems to the IEC 61850 model, an adapter for the dONS source is to be developed, so that the real-time measurements arrive in the Digital Twin. As a use case, a vendor-independent feeder monitoring is to be realised, which reads voltages and currents of both dONS, Beckhoff and Weidmüller, from the Digital Twin without knowing the manufacturer. The evaluation focuses on the integration effort of a new dONS platform. For this purpose, measures are to be defined, in particular the share of mappings derivable by machine from the device or its interface, the number of manual steps and platform-specific artefacts of the adapter, and the reusable share of the adapter for a further platform. The Beckhoff dONS is to be described as the comparison case based on the existing documentation. The functionality is to be checked by the completeness of the mappings and the plausibility of the measurements against the reference measurement of the SGTL. The results are made available to Weidmüller.

The following structuring of the work is proposed:

- 1) Familiarisation with the Digital Twin at ie3, the Asset Administration Shell, IEC 61850 and the existing Beckhoff dONS
- 2) Literature research on the integration of field devices into digital twins and on the measurement of integration effort

- 3) Commissioning of the Weidmüller dONS in the SGTL and publication of the measurements via the u-OS Data Hub
- 4) Modelling of the edge device, the transformers and the measurement points in the AAS and generation of the IID with provenance references
- 5) Development of the dONS adapter for the application IEC 61850 Field Gateway and connection of the real-time measurements to the Digital Twin
- 6) Realisation of the vendor-independent feeder monitoring for both dONS
- 7) Definition of the integration-effort measures, evaluation of the Weidmüller integration and comparison with the Beckhoff dONS
- 8) Optional: handover of the generated IID to the IEC 61850 app of u-OS, or development of a second adapter for the Beckhoff dONS

Following this work, the results are to be reported in a presentation.

This thesis is immediately assigned as a master's thesis to cand. M.Sc. First name Last name

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