About

Provide general information regarding the described model.

Model name	OLTC for transformer
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Short description	An on-load tap changer and control scheme for an MV/LV three phase distribution transformer. The OLTC regulates the voltage by means of the appropriate OLTC control mechanism and algorithms.
Present use / development status	The model was developed for the purposes of the ERIGRID 2.0 H2020 project, based on newly developed OLTC and control system.

Classification

Describe the context of the model regarding application (modelling domain, intended use) and technical details (modelling approach, model dynamics, model of computation, functional representation).

Domain	☐ electrical storage ☐ thermal storage ☐ energy conversion device ☒ other, please specify: electrical distribution
Intended application (including scale and resolution)	The intended application is the electrical-only benchmark network that is being developed in the ERIGRID 2.0 project. This model intends to represent OLTC and controller of an MV/LV distribution transformer. It's resolution is in the range of ms.
Modelling of spatial aspects *Explain the approach of how this model describes the spatial distribution of the system.*	☐ lumped (single device) ☒ discretized (single device) ☐ averaged (multiple devices) ☐ other, please specify:
	This control scheme could be employed with multiple grid-connected distribution transformers with OLTC.
Model dynamics *Explain how the model captures the dynamic behaviour of the system.*	☐quasi-static ☒dynamic ☐other, please specify:
	The controller controls the OLTC tap position by continuously monitoring voltage conditions.

Model of computation *Explain how the model captures the system's evolution with respect to time and/or external stimuli.*	☐time-continuous ☒discrete-event ☐state machine ☒other, please specify: Phasor
	The controller continuously reads the voltage at the transformer connection point and adjusts the OLTC tap position to meet grid voltage requirements.
Functional representation *Are the model functions explicit, i.e., of type y = f(x), or implicit, i.e., of type g(x,y) = 0?*	☒explicit ☐implicit ☐other, please specify:
	The controller functions are typical discretized proportional control functions.

Mathematical Model

This section provides information about the actual mathematical model by specifying variables, parameters and equations. Variables and parameters should be specified with type (Real, Integer, Boolean, String) and (physical) unit. In case the equations are too complex to be reproduced here, also a reference to a book or any other publication can be given.

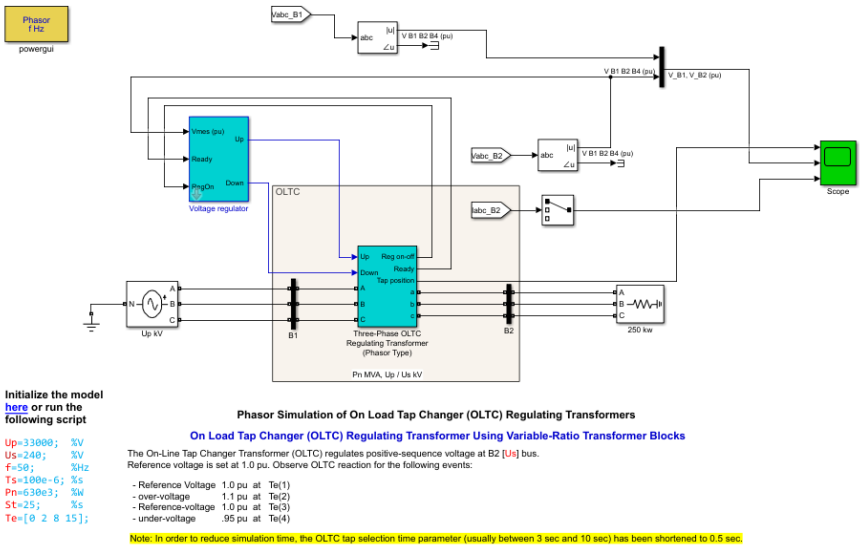
Input variables (name, type, unit, description)	Voltage,
Output variables (name, type, unit, description)	tap position, Voltage, Current
Parameters (name, type, unit, description)	Vref (pu) , Deadband (pu), Time delay (s), Voltage step per tap (pu), Initial tap position, Tap selection time (s)
Internal variables (name, type, unit, description)	Winding 1 and Winding 2 connections, Nominal power (VA) and frequency (Hz), Winding 1 and Winding 2 parameters (pu)
Internal constants (name, type, unit, description)	N/A
Model equations *Formulate or provide references to the model's governing equations (describing the system state) and the constitutive equations (describing material properties)*	Governing equations
	Graphical programming equation
	Constitutive equations
	N/A
Initial conditions	Input to OLTC control tap position is set to 0 and the grid voltage is set to 1pu and then to ±5% or ±10%

Boundary conditions	we choose the following, but all the boundaries are personalized: 9 Taps [-4 -.. 4], 0.025pu/Tap → 1pu ±0.225
Optional: graphical representation (schematic diagram, state transition diagram, etc.)	N/A

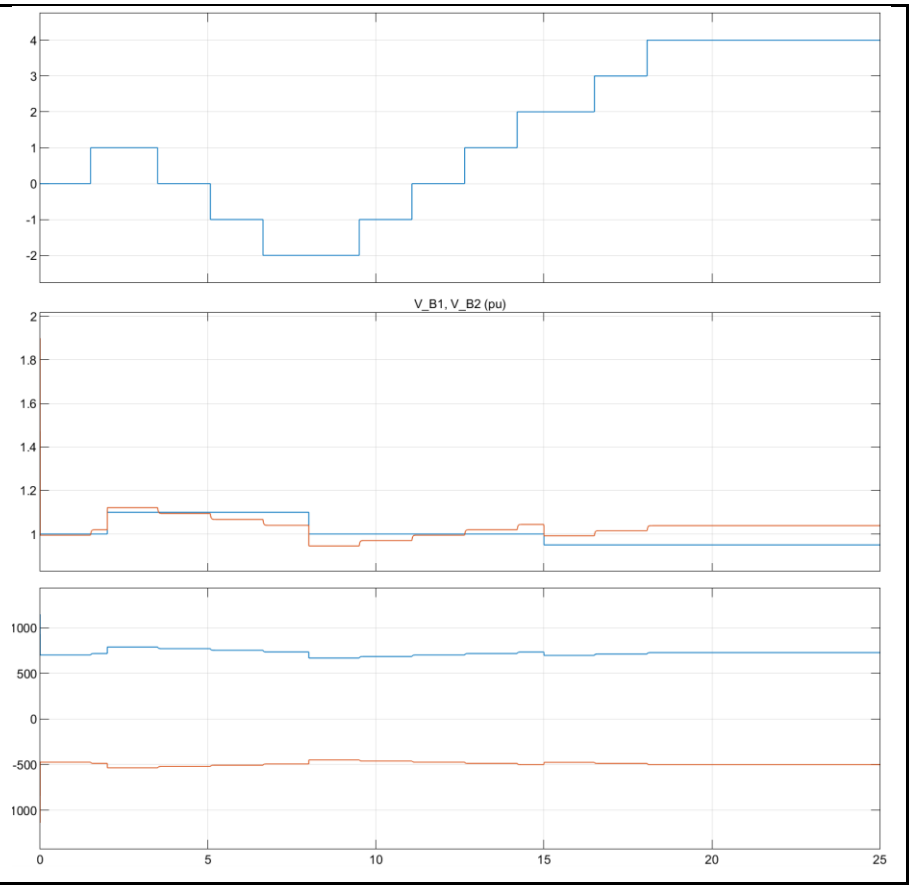
Testing

Please provide a (simple) test design for the purpose of component model validation. This test should enable three different kinds of comparisons:

- ***model validation**: compare the behaviour of an implementation of the exact same model based on time-series data*
- ***model harmonization**: compare the behaviour of an implementation of a (supposedly) similar model with the same or comparable intrinsic time resolution based on the comparison of key performance indicators*
- ***model upscaling**: compare the behaviour of an implementation of a (supposedly) similar model with a lower intrinsic time resolution based on the comparison of aggregated key performance indicators*

Model Validation *Provide the description of a test setup (i.e., simulation) that enables others to validate their implementation of the same model. The results should be provided as time series.*	
Narrative *Provide a simple description of the test specification.*	The controller ensures the correct position of the OLTC tap. When connected to the grid, the controller changes tap position so as to regulate the voltage to its reference threshold values.
Test system configuration *Describe the test setup, including:* *How long does the simulation run?* *Are there any other models required for this setup? If yes, provide a link to their description.* *Is a controller required for this setup (see also below)?*	The controller is applied to the OLTC of grid-connected MV/LV transformer of the electrical only benchmark power system developed through ERIGRID 2.0 project. The simulation may be run from ms to many hours. 
Inputs and parameters	Same as in mathematical model.

Specify the (exogeneous) inputs of the model used in this test. Also specify the model parameters used in this test. If necessary, attach this information as dataset.	
Control function (optional) *Specify any additional control functions used for this test.*	N/A
Initial system state *Describe the initial state of the system.*	Same as "Initial conditions" in the mathematical model.
Temporal resolution *Provide information regarding the temporal resolution of the test simulation, such as integrator step size, time resolution for event handling, etc.*	Sampling time in the MATLAB/Simulink environment is set to Ts=1e-4 in the discrete mode (and to 50Hz in the Phasor mode) to capture appropriate voltage change behaviour of the grid
Evolution of system state *Describe (textual and/or graphical) the expected qualitative behaviour of the component model in this simulation.*	When the transformer is connected to the grid, the OLTC controller changes the tap position so as to regulate the voltage to within required grid thresholds.
Expected results *Provide a quantitative description of the expected simulation output based on time series. This information must be comprehensive enough for someone else to validate his/her own implementation of this model. If necessary,*	The simulation results of the OLTC model show that the controller manages to regulate the voltage safely and quickly so that grid voltage stays within the standard thresholds. Indicative result: the input voltage (1pu) fluctuates by -5% and 10%, the voltage regulation results of by OLTC controller is shown below (Tap Position, in/output voltage and current)

attach this information as dataset.	

Additional Information

Provide any other additional information here.

Reference implementation	N/A
Similar / related models	See ERIGRID 2.0 Github
Related publications	N/A
Intellectual property concerns (if applicable)	N/A