

УДК 621.316

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MODELING OF OLTC REGULATING TRANSFORMER IN MATLAB SOFTWARE

Today's advanced industrial processes are often sensitive to power supply interruptions and voltage distortions. On the other hand, the growing

use of non-linear loads generates interference and contributes to the increased levels of voltage contamination in power networks. This situation can affect normal operation of other customers connected to those networks. Thus, in recent years the sensitivity towards power quality issues has been increasing mainly as a result of the demands posed by many consumers.

Currently, the power systems use a large number of devices, which ensure the maintenance of the required voltage level. First of all, transformers with an adjustable transformation ratio under load, capacitors, secondary batteries, reactors, synchronous compensators, generators, power plants, and so on are used. [1, 2]. These devices are equipped with regulators that maintain the voltage at a predetermined level. The main means of regulating the voltage in electrical networks are power transformers with on-load tap changers (OLTC).

To increase the regulation stability [3, 4] a model that allows take into account the sign of the derivative enveloping the regulated voltage is proposed. It allows not to make additional transformer tap switch, if regulating my parameter is out of the deadband, but under the influence of external factors moves in this zone.

It allows not making additional transformer tap switch, if regulating my parameter is out of the deadband, but under the influence of external factors moves in this zone. Assessment of the stability of the investigated automatic control systems (ACP) in [4] is combined with the assessment of the quality of its transient (the latter in case of stable system will damp over time). In turn, the transition process in the system is measured by its response to the greatest possible jumps setting or exciting effects of voltage. Obviously, the synthesized system refers to the essentially nonlinear, and the investigation of its stability should be carried out by computer simulation. The mathematical model of the ACP-voltage power transformer with on-load tap changer of RNTA – 60/630 (eight switching steps) can be implemented by dependencies [3]:

Simulation model of three-phase three-winding power transformer with on-load tap changer, as shown in figure 1, is created in the software package MATLAB (Simulink 4) [4] to solve the provided dependencies. Since the voltage control channels in the direction of its decrease or increase work uniformly, only one channel was implemented in the model, which greatly simplifies the calculations. In addition, one can take into account that at significant deviations of voltage, regulation system provides switching of OLTC without delay (at least for two positions). Therefore, to simplify the model, it was assumed that the device has only two tap-changer section. A transformer with OLTC was simulated in MATLAB package using controlled transmission system (FACTS) [4]. This was possible because the OLTC switch is used to switch the load and carry current in the windings of the

transformer without breaking the circuit. Since the real time of the windings switching (30 ... 60 ms) is much smaller than the actual time of selection taps (3 ... 10 s), this block can be represented by vector model to investigate the stability of the power system in range from several seconds to several minutes.

A 25 kV distribution network consisting of three 30km distribution feeders connected in parallel supplies power to a 36 MW/10Mvar load (0.964 PF lagging) from a 120 kV, 1000 MVA system and a 120kV/25 kV OLTC regulating transformer. Reactive power compensation is provided at load bus by a 15Mvar capacitor bank. The same circuit is duplicated in order to compare the performance of two different models of OLTC transformers:

1. Model 1 is a detailed model where all OLTC switches and transformer characteristics are represented. This model can be used with either continuous or discrete solvers to get detailed wave shapes or with the phasor simulation method to observe variations of phasor voltages and currents.

2. Model 2 is a simplified phasor model where the transformer and OLTC are simulated by current sources. This model can be used only with the phasor solution method. It is much faster to execute and it should be the preferred model for transient stability studies, when several such devices are used in the same system.

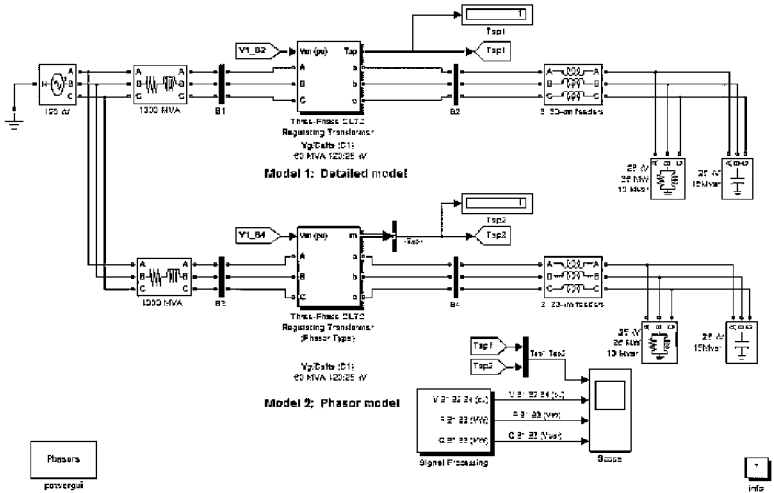


Figure 1 – Model used

Both OLTC transformer models implement a three-phase regulating transformer rated 47MVA, 120kV/25 kV, Wye/ Delta, with the OLTC con-

nected on the high voltage side (120 kV). The OLTC transformers are used to regulate system voltage at 25 kV buses B 2 and B 4.

Voltage regulation is performed by varying the transformer turn ratio. This is obtained by connecting on each phase, a tapped winding (regulation winding) in series with each 120/sqrt (3) kV winding. Nine (9) OLTC switches allow selection of 8 different taps (tap positions 1 to 8, plus tap 0 which provides nominal 120 kV/25 kV ratio). A reversing switch included in the OLTC allows reversing connections of the regulation winding so that it is connected either additive (positive tap positions) or subtractive (negative tap positions). For a fixed 25 kV secondary voltage, each tap provides a voltage correction of ± 0.01875 pu or $\pm 0.875\%$ of nominal 120 kV voltage. Therefore, a total of 17 tap positions, including tap 0, allow a voltage variation from 0.85 pu (102 kV) to 1.15 pu (138 kV) by steps of 0.01875 pu (2.25 kV).

Start the simulation and observe OLTC operation on the Scope (look at fig. 2):

- trace 1 shows the tap position;
- trace 2 shows a superposition of positive-sequence voltages at 120 kV bus B1 (yellow), at 25 kV bus B2 (magenta) and bus B4 (cyan);
- traces 3 and 4 show the active and reactive powers measured on 120 kV side (buses B1 and B3).

These graphs allow estimating how quickly transient processes when exposed to step excitation are damped in the synthesized system of automatic voltage regulation of power transformer with on-load tap changer RNTA – 60/630. More than that, whether additional tap switching of OLTC is required until the transition process ends.

Simulation of control voltage in programming software MATLAB (Simulink 4) can significantly improve not only the quality of delivered energy in energy-producing industries, but also the efficiency of production. The results obtained in the simulation and related calculations suggest how rapidly synthesized in the automatic voltage regulation in the power transformer on-load tap changer (in this example RNTA – 60/630) is damped transients-step winding, and whether such an additional tap-tap-changer until the transition process is ended. Prediction of the number and speed of the switching power transformer windings will optimize not only the regulation of the power consumption, but also ultimately provide the requested process.

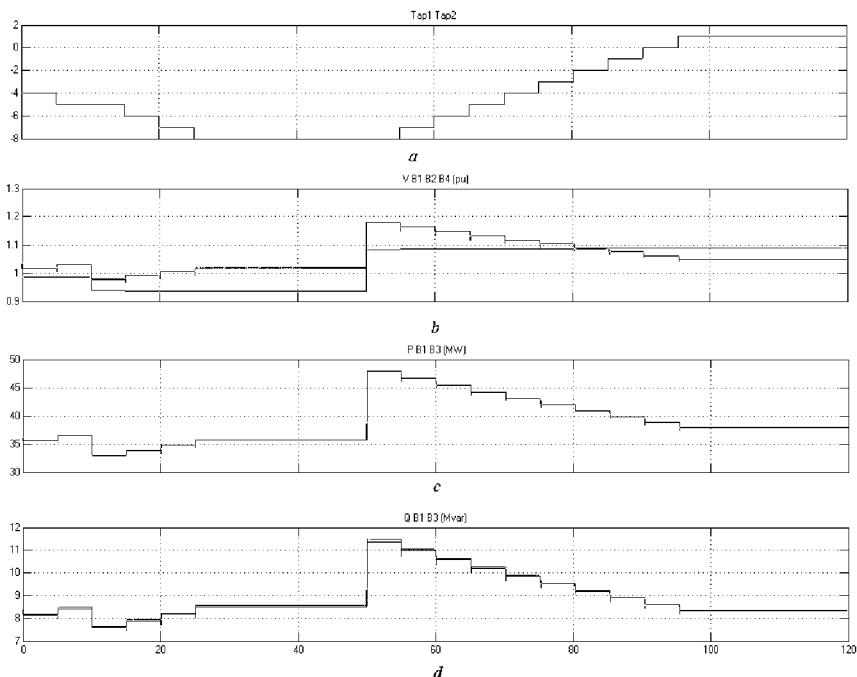


Figure 2 – Waveforms of tap changing process

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