TIM-3 – The Diagnostic Monitoring System for Power Transformers of 110 ÷ 330 kV

The «TIM-3» (Transformer Insulation Monitor) monitoring system is for the transformers with the operating voltage of 110 ÷ 330 kV. This class of transformers is the most wide-spread in Power Generation and Distribution industry. At the same time, due to a number of objective and subjective reasons, there is little or no means of effective on-line monitoring and diagnostic for the transformers of this class.

«TIM-3» system provides comprehensive and effective power transformer defect diagnostics. It is fully functionally complete and rather cheap software-technical complex, unmatched in the market of monitoring systems.

«TIM-3» system monitors the following parameters:

- The condition of the transformer insulation winding - it is diagnosed by high-frequency partial discharge (PD) measurement and analysis. For this purpose, a part of the system software includes an automated PD-Expert expert system, which allows specifying the type of the defect and the level of its development.
- The transformer bushing (OIP and RIP) condition - by leakage current measurement, bushing capacity C1 calculation and dissipation factor calculation. Such calculations are done for absolute and relative dissipation factors, in dependence of the primary sensors’ arrangement. An additional parameter for bushing insulation condition monitoring is the measurement and analysis of PD in bushings.
- The vibration condition of the transformer - by analyzing the signals of the three sensors installed on the transformer tank surface. The vibration signal level and spectrum analysis allows assessing the transformer condition in the whole, as well as that of the transformer structural elements.
- The efficiency of the transformer cooling system - by using the simplified adaptive heat model of the power transformer.
- The condition of the transformer OLTC – by using «LTC-Monitor» intellectual sensor, connected to «TIM-3» system by RS-485 interface.

The «TIM-3» measuring device can operate in wide temperature range, that is why it is usually mounted near the monitored transformer or on the transformer tank. Such a way of installation allows using shorter connection cables, which adds to the system sensitivity and noise rejection.

«TIM-3» Features

The measurement device of «TIM-3» system is a functionally complete and self-sufficient device for transformer equipment monitoring.

«TIM-3» system provides:

- The most informative data collection from the primary sensors.
- Checking of the measured parameters for possible surpassing of the threshold levels.
- The use of the measured data in the in-built mathematic models for transformer condition diagnostics.
- Analysis of the transformer condition trends; forecasting qualitative, quantitative and temporal changes in the parameters of the transformer using adaptive mathematical models.
- Informing the staff about the current transformer conditions by inbuilt relays and SCADA connection channels. This information considerably benefits from adding the results of the trend analysis and the defect development forecasts.

The presence of built-in archiving, and large memory capacity for data storage allows «TIM-3» system to operate in standalone mode for rather a long time – up to one year – without regard to the SCADA system.
«TIM-3» system is supplied with specialized «SKI» software («INVA» software optionally) intended for use with PC. The software gets the data from the device, displays it, and allows carrying out additional transformer condition analysis.

«SKI» software is mainly designed for local monitoring systems. The more advanced «INVA» software is intended to provide comprehensive monitoring systems, as it allows to integrate the resulting information into «Smart Grid» system, using IEC 61850.

For «TIM-3» to operate efficiently, up to 16 sensors should be installed on the transformer. The sensors are:

- «DB-2» universal sensors for leakage current and PD measuring – 3 pieces; the sensors are mounted on the transformer bushing test taps. Through the use of the duplicate protection system in the sensors, the test tap is securely protected even if the sensor breaks. By the sensors, the leakage current and PD in the transformer winding insulation and bushings are measured.
- «IFCT-5» sensors for load current measuring – 3 pieces; the sensors are mounted on the conductors of the measuring transformers HV windings. The values of the transformer primary winding load currents are used in the mathematic diagnostic models of «TIM-3» system.
- Sensors in the neutral circuit of the transformer primary winding for zero string power frequency measurement and high-frequency PD currents measurement in the neutral – 2 pieces.
- Vibration sensors – 3 pieces; the sensors are mounted on the transformer tank surface. The sensors monitor the fixing of the basic transformer elements.

- Temperature sensors – 2 pieces; the sensors are mounted on the top and bottom of the transformer tank. The temperature values are used in the transformer cooling system mathematic model.
- The ambient temperature and humidity sensors. The data from the sensors increases the efficiency of the inbuilt mathematic models.
- «LTC-Monitor» sensor for OLTC condition monitoring (option). The sensor monitors OLTC running under different conditions and analyzes the electromechanical processes during switching.
- The sensor of dissolved gases in oil monitoring (not by DIMRUS; option). Using the information from such a device, in parallel with the PD analysis in the transformer tank, greatly improves the reliability of the defect diagnosis algorithms.

Depending on the task set before a specific monitoring system, the number of primary sensors mounted on the transformer can be reduced.

«TIM-3» System Design.

The measuring device of «TIM-3» system is a complete module of 240*180*50 mm. The cables can be connected to the device directly, but the best is to connect the sensors with the help of the input terminals in the enclosure.

The measuring device of the monitoring system, as well as all the sensors, is designed to operate in the standard industrial ambient temperatures. If the system is planned for the use in the lower ambient temperatures (up to -60°C) then the additional heater should be used. The device constantly measures the temperature inside the enclosure with a special internal relay; it can automatically control the operation of the heater depending on the temperature inside the enclosure.

### «TIM-3» Monitoring System Specifications

<table>
<thead>
<tr>
<th>№</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rated voltage HV of the monitored transformer, kV</td>
<td>110 and more</td>
</tr>
<tr>
<td>2</td>
<td>The number of the monitored bushings</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>HV leakage current range, mA</td>
<td>5 ÷ 30</td>
</tr>
<tr>
<td>4</td>
<td>The number of PD measurement cannons</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>PD frequency range, mHz</td>
<td>0,5 ÷ 15,0</td>
</tr>
<tr>
<td>6</td>
<td>SCADA connection interface through RS-485</td>
<td>twisted pair</td>
</tr>
<tr>
<td>7</td>
<td>PC connection port</td>
<td>USB</td>
</tr>
<tr>
<td>8</td>
<td>Operational temperature range, °C</td>
<td>-40 ÷ +60</td>
</tr>
<tr>
<td>9</td>
<td>Power supply, V</td>
<td>AC/DC 120 ÷ 260</td>
</tr>
<tr>
<td>10</td>
<td>Consumer power, W</td>
<td>50</td>
</tr>
<tr>
<td>11</td>
<td>Enclosure dimensions, mm</td>
<td>400<em>500</em>200</td>
</tr>
</tbody>
</table>