Automatic Voltage Regulation Using IEC 61850

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ABSTRACT

Nowadays, protection and control can be integrated in an IED (Intelligent Electronic Device). In addition, communication network technology has developed fast over the past years, enabling a more centralized control. This all has led to an increasing need to gather data from larger networks. One example of this discussion is voltage regulation with automatic tap changer. A tap changer control operates to connect appropriate tap position of winding in power transformers to maintain correct voltage level in the power transmission and distribution system. This paper, describe conventional tap changer and development in transformer tap changer control using IEC61850.

KEYWORDS: Transformer Bay, IEC61850, Automatic Voltage regulation.

1. INTRODUCTION

Automatic tap-changer control of transformers is used to maintain the voltage level of electric supply in the transmission and distribution system and also controls the power sharing among parallel transformers. Most of the transformers in power transmission and distribution system operate in parallel, so failure in one of them, the total electrical load in demand is transferred to the other transformers operating in parallel. In the parallel operation, the existing tap-changer
controls of transformers have many limitations and complexities. For example none of the existing controls can be used when parallel transformers are connected across the network, i.e., their primaries are connected to different sections of a complex power network. The use of a huge number of relays in some of the existing control circuit causes disruption in parallel operation for a minor fault until technicians fix it. Since the failure rate of relays is high, such fault may occur frequently. Some control systems are incapable of parallel operation of more than two transformers and others operate well only if the load power factor is near to unity but fails to function properly if the power factor deviates far from unity. Therefore, conventional tap changer control and new IEC61850 are describe is this paper (Bahadornejad, Xinbo, & Nair, 2011; Sichwart, Eltom, & Kobet, 2013; Yarza & Cimadevilla, 2014; Ye, Nair, & Sing-Kiong, 2010).

2. CONVENTIONAL TAP CHANGER
An important aspect of operating power transformers is being able to vary the ratio. This is done to match the voltage if the load fluctuates. Besides, it is to distribute load, to adjust active and reactive currents in interconnected system and for voltage matching purposes with electric furnaces and rectifiers. To specify voltage on the output side, the transformer’s high-voltage winding is provided with tapings which are connected in different sequences according to their load. The respective winding sections are selected by means of off load or on-load tap changer. Off-load tap changer is used in network with little fluctuation in load and On-load tap changer is used in network with frequent brief load fluctuations.
Tap changers are mechanically driven by a motor drive which attached to the transformer tank. The tap changer can be operated at the transformers with aid of a crank handle. Besides, electrical control from control room is possible. In this case, switching from one tap to another requires a separate command so that a single command cannot be execute more than one change.

3. IEC61850

The IEC 61850 standard was introduced in 2005. It was developed to control and protect power systems by standardizing the exchange of information between all IEDs within an automated substation and a remote control. The IEC 61850 standard includes two real-time, peer-to-peer communications messaging protocols that are particularly useful for protection applications: Generic Object Oriented Substation Event (GOOSE) messaging and Sampled Values (SV) messages. These communications mechanisms permit the development of revolutionary
protection schemes (Byunghun et al., 2015; Nair & Jenkins, 2013; Ridwan et al., 2014; Schossig, 2014; Srinivasan, Kumar, & Vain, 2013; Yang, Xu, & Vyatkin, 2014; Yarza & Cimadevilla, 2014).

Definitely, the conception of the fundamental mechanisms involved in these messages can be effectively utilized to affect the performance of messages and therefore the speed, safety and reliability of the protection schemes. One of the benefits of the IEC61850 is reduce construction cost by eliminating most copper wiring. In the traditional substation, copper wires run from the trip contacts of a relay to the trip coil on a circuit breaker. In an IEC 61850 substation instead of copper wires the trip GOOSE message will be sent via the Ethernet to trip the circuit breaker.

4. MODELING OF FUNCTION IN IEC 61850

Logical Node is a small part in function within a physical device. It defined by its methods and data. The LNs may place in one or different physical devices to perform the special task or function. This Logical Nodes are available in all IEDs by Logical interface, this concept shows in Error! Reference source not found.; F1 or function 1 applies Logical Nodes from two IEDs and F2 uses the Logical Nodes in three IEDs. LN1 in Physical Device 1 connects to LN4 in physical device 2 by logical interface 14(Byunghun et al., 2015; Nair & Jenkins, 2013; Ridwan et al., 2014; Schossig, 2014; Srinivasan et al., 2013; Yang et al., 2014; Yarza & Cimadevilla, 2014).
Logical nodes are grouped according to the Logical Node Groups listed in Table 1. The names of Logical Nodes shall begin with the character representing the group to which the Logical Node belongs. As an example, ATCC represent the Automatic Tap Changer Control which can control the position of the tap automatically. The function of ATCC is described in next section("Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in electrical substations related to IEDs," 2012).
Table 1- Logical Nodes class

<table>
<thead>
<tr>
<th>Group Indicator</th>
<th>Logical node groups</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>Automatic Control</td>
</tr>
<tr>
<td>C</td>
<td>Supervisory control</td>
</tr>
<tr>
<td>I</td>
<td>Interfacing and Archiving</td>
</tr>
<tr>
<td>G</td>
<td>Generic Function References</td>
</tr>
<tr>
<td>M</td>
<td>Metering and Measurement</td>
</tr>
<tr>
<td>L</td>
<td>System Logical Nodes</td>
</tr>
<tr>
<td>P</td>
<td>Protection Functions</td>
</tr>
<tr>
<td>R</td>
<td>Protection Related Functions</td>
</tr>
<tr>
<td>S</td>
<td>Sensors, Monitoring</td>
</tr>
<tr>
<td>Y</td>
<td>Power Transformer and Related Functions</td>
</tr>
<tr>
<td>X</td>
<td>Switchgear</td>
</tr>
<tr>
<td>T</td>
<td>Instrument Transformer</td>
</tr>
</tbody>
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5. AUTOMATIC VOLTAGE REGULATION IN IEC 61850

After reviewing IEC 61850, a practical application in Automatic Voltage regulation based on IEC 61850 is described in this section. Figure 3 shows the Logical nodes in transformer bay according to IEC 61850. TVTR1 and TVTR2 measure the voltage at the both sides of transformer. These two LN send the samples value to ATCC by logical interface, ATCC decide whether the tap should be up or down based on the SV and the function which define for ATCC.
Then send the related signal to YLTC to decrease or increase the tap. In the other words, if the voltage decreases then ATCC send the command to increase the tap position ("Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in electrical substations related to IEDs," 2012).

For monitoring the position of the tap from control room, it needs a Logical Node in station level. The Logical Node “IHMI “in station level can monitor the position of tap according to IEC 61850. Figure 4 shows the Logical Nodes for ATCC and monitoring of tap position. The logical nodes PTOV (over-voltage protection), PTUV (under-voltage protection), PIOC (over-current protection).
protection), ATCC (automatic tap change control), MMXU (measuring process) are present inside the IED. The logical nodes TVTR1 and TVTR2 (voltage transformers), TCTR (Current transformer), XCBR (circuit breaker), YLTC (tap changer) are also housed in the IED. However it is possible to have had these nodes external to the main IED when the concerned primary equipment has communication capability. The connection between the logical nodes is implemented using logical connections. When the bus voltage goes below (or above) a threshold set in the ATCC logical node, it decides to increase (or decrease) the tap. This decision also depends on the status of the protection elements (they should not have operated) and the power flow. It also calculates the number of taps to be raised (or lowered). This information is then given to the YLTC through the logical connection. The YLTC node in turn gives pulses to the OLTC control motor to change the tap position. The YLTC returns the present position of the tap to the ATCC node. For implementing this application a low speed data transfer is sufficient (500ms).

![Figure 4- Monitoring the position of tap in control room](image-url)
6. CONCLUSION

With development of microprocessor and control, the performance of the protection relays and control function have been significantly improved. Control and protection of transformer bay is not only important, but also very critical. Therefore, it is need to improve the performance of this bay. IEC61850 virtualizes all information from transformer bay which are accessible anywhere in substation and it is possible to utilize new method for control and protect function. The voltage regulation function based on IEC 61850 is explained in this paper.

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