ELECTRONICS SOLID STATE VOLTAGE REGULATING RELAY FOR ON LOAD TAP CHANGER DISTRIBUTION TRANSFORMER FOR AVR (AUTOMATIC VOLTAGE REGULATION)

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Abstract—This paper presents a system, specially designed for the Distribution transformer tap changer with the continuous operation of tap changing and control of the secondary voltage brings a remarkable improvement in power supply quality, keeping voltage in the net constant. Design and practical evaluation of the electronic tap changer for three-phase 1000KVA distribution power transformer. The on-load tap changing (OLTC) regulators have been widely used since the introduction of electric energy. They ensure a good regulation of the output voltage in presence of large variations of the input voltage with typical response time from 100 ms to several seconds. The continuous growth of power semi-conductor devices, such as the insulated gate bipolar transistor, allows the development of fast OLTC regulators being able to fix other problems in the ac mains, like sags and flicker. The suitable condition of an on-load tap-changer (OLTC) is essential for the operation of converter transformer due to its frequent switch for the voltage regulation of power system. This can be applicable to tap changers and release commutation from the zero-current crossing, thus allowing a faster voltage regulation.

Keywords—On-load tap changer, voltage regulation, smart grid, distribution power transformer.

I. INTRODUCTION

Currently, mechanical no-load tap changers are widely employed in distribution transformers to adequately the voltage levels. However, it is important to emphasize that they do not allow online voltage regulation, since they are unable to automatically commutate the taps. Although these devices are extensively used due to their low cost, the tap commutation must be executed in loco by specialized workers. Additionally, the grid must be de-energized, which increases the overall operational costs of the distribution system. On the other hand, electromechanical on-load tap changers (OLTC) enable the automatic tap commutation and consequent voltage regulation. Even though they have been adopted in both medium and high power systems, their high implementation costs prohibit from being used in medium to low voltage distribution systems. In addition, the commutation of taps in these devices results in arcing and carbonization of the contacts and degradation of the insulation oil, requiring regular maintenance. In the recent past, the increase in voltage and current ratings of semi-conductor devices has enabled the application of power electronic solutions to distribution systems, including the replacement of mechanically operated tap changers by electronic counterparts. Two approaches has been a subject of study in the last few years: mechanical tap changers assisted by electronic switches and fully electronic tap changers. Moreover, under fault conditions, electronic switches of the OLTC are subjected to high voltage and current stresses. As a result, the protection scheme may be suitably designed in order to obtain a system with high reliability. This issue is addressed in previous works, but a detailed design and the experimental validation of the components which comprise the protection scheme have not been fully presented.
II. LITERATURE SURVEY

The early generalization of ac voltage in the electric lines was an obvious encouragement to take advantage of tap-changers associated to the transformers involved in energy distribution to accomplish easy voltage stabilization. Taps were first selected manually and then electromechanically (5) the fault detection and diagnosis (FDD) technique of device in industry, such as data-driven FDD based on PCA/PLS method has been rapidly developed in recent years [4]. Since mechanical failure is the main cause of OLTC fault and several electrical failures have resulted from them, the mechanical diagnostic methods such as vibration analysis should be the most effective and convenient method to solve such problems, which has already been widely applied in fault diagnosis of transformers [6-8]. Vibration signal, which is caused by the contact movement during a tap change, is composed of a number of sharp oscillations and contains large amounts of information related to the working condition of OLTC. The theoretical foundation of vibration analysis is verified by Bengtsson in the early 1990s. Later, Kang et al. has developed.

A monitoring and assessing system of OLTC based on Self-organizing Map and wavelet method. The wavelet, which is the mathematical tool proposed to identify modes of nonperiodic oscillations, as well as those that evolve in time, has also been adopted to improve the condition assessment with Hilbert transform added. Meanwhile, the genetic algorithm has been applied in the OLTC condition monitoring. So far, the existing researches mainly focus on the characteristics in time domain. Since the vibration signals should be nonlinear and nonstationary, the features such as bursts overlapped by the contiguous contact vibration is difficult to accurately identify. What’s more, considering the complex inner structure and frequent switches of OLTC in converter transformer, the fault diagnosis is even harder, which is less involved in current researches. In order to identify the corresponding characteristics effectively and accurately, the time-frequency method should be taken into consideration. The frequency alone cannot be considered as a stable and persuasive index so that the simple FFT is not applied here for the analysis of such signals.

The Empirical Mode Decomposition (EMD) method is widely used in signal analysis and fault diagnosis in time-frequency domain. However, conventional EMD cannot effectively describe the massive involved information of such non-stationary and nonlinear signal, and the aliasing phenomenon is serious. Thus two improved methods have been put forward, which are Ensemble Empirical Mode Decomposition (EEMD) with white noise added and Band Restricted Empirical
Mode Decomposition (BREMD) [3] A new two-tap chopped ac/ac voltage stabilizer with compensating transformer and PWM frequency in the order of 5 kHz based on this kind of commutation. The circuit proposed, resulted from a topology search guided by an iterative analysis+synthesis cost comparative method, fits well to low voltage stabilizers and regulators in the range of 0.1 to 1000 kVA and 1 ms response time. The switching behavior and the input and output filtering is fully analyzed. On-load tap changers usually insert resistance or reactance during the switching operation to limit the circulating current in the commutating taps. The mechanical operation requires three or four stages and is relatively slow, often many cycles. Solid-state devices are now used extensively in the field of power engineering including motor control, direct-current transmission etc. Thyristors have been used as an aid to facilitate switching in mechanical tap changers [7].

III. ADVANTAGES & APPLICATIONS

Advantages
- Electronic tap changers have been widely used to solve long-term voltage variations in low, medium and high power transformer applications [7].
- Environmentally-friendly operation, low disposal costs for soiled insulating fluids.
- No cutoff arcing in the on-load tap-changer oil
- No oil filter system needed
- Clean oil simplifies and speeds up maintenance work
- Much lower maintenance frequency in comparison to conventional oil switching technology
- SSRs are typically smaller than EMRs, conserving valuable real estate in printed-circuit board
- These relay offer improved system reliability because they have no moving parts or contacts to degrade
- SSRs provide state-of-the-art performance, including no requirement for driver electronics and bounce-free switching

Application
- It is used power transformers for transmission and distribution transformer for industrial Use (e.g. arc-furnace or ladle furnace transformers)
- HVDC transformers phase-shifting-transformers transformers for operation at explosion-prone sites (e.g. offshore platform)
- MECBS of power transformers

IV. SYSTEM ARCHITECTURE

Solid State Automatic Voltage regulating tap changing Relay is designed for maximum operational simplicity. It regulates the secondary voltage of power transformers with on-load tap changers. The bandwidth control allows the deadband to be set in terms of upper (LOWER VOLTS) and lower (RAISE VOLTS) voltage limits around a particular nominal value with specified sensitivity.

The Time Delay control allows the regulator to respond only to voltage fluctuations lasting for periods greater than the selected time delay. Where the voltage correction requires more than one tap change, the time delay is reinitiated before further tap changes. No special provisions are required to reset the time delay which resets automatically after the voltage correction. Solid State Lamps (LEDs) indicate voltage outside the preset limits and control relay operations.

Operation of the RAISE / LOWER Control Relay is automatically inhibited when the voltage falls below the specified under voltage limit or goes above the Overvoltage limit. One pair of normally open relay contacts are provided to effect the tap changer RAISE and LOWER operations and to trigger an alarm in case of Under voltage / Overvoltage conditions. (Only one pair of contacts is available for either UV or OV)

An alarm in the form of normally open contacts is provided in case of control failure i.e. AVR Relay continuously showing either ‘L’ or ‘R’ command for more than 15 minutes due to malfunctioning of AVR/OLTC/ any reason.

A built-in Tap Position Indicator with 1KW step resistance can be provided optionally to indicate the Tap No. of the Power Transformer up to a maximum of 35.
V. CONCLUSION

The proposed system presents similar construction when compared with conventional transformers, permitting substituting manually operated equipment for automatic operated counterparts. Due to the electronic components, the proposed system tends to offer inferior reliability when compared to conventional no-load tap changer transformers. On the other hand, in addition to automatic voltage regulation, the system presents oil free maintenance and faster commutation of the OLTC when compared to electromechanical devices. It also combines modularity and quick maintenance, since the electronic stage can be easily replaced.

In addition to the automatic voltage regulation, when embedded with communication features, the system permits remote control over the voltage levels and monitoring of the grid variables. This can provide revenue control, load shedding, power dispatch control for DG applications, among others. Such features are prospective improvements for actual and smart grid distribution systems.

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