On Load Tap Changer of Transformer using Microcontroller

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Abstract— On-load tap-change transformers (OLTCs) are widely used since the introduction of electric power. They provide good control of the output voltage in the presence of large variations of the input voltage with a typical response time of a few milliseconds to a few seconds. An earlier mechanical type of load tap changers was in practice. But they had significant limitations and disadvantages, such as arcs, high maintenance, service costs and slow response times. To overcome these limitations and disadvantages were electronic (or solid state) tap changers developed. The continuous growth of power semiconductor devices, such as the bipolar transistor with isolated gate (IGBT), triac, thyristor, has made the OLTC rapid-action transformer development possible, which is also useful in correcting other problems in the power line, such as flicker and sags. The main idea in the solid state assisted tap changer, is that semiconductor switches operate with more controllability during the tap change process instead of mechanical switches, which helps in reducing the arcing phenomena during the tap-changing process. This project presents the implementation of a fast OLTC transformer. The control strategy is based on the microcontroller and provides flexibility in the programming of the control algorithms. The experimental results show that the switch under fast OLTC is able to correct various distortions of the AC. In addition, the long duration in the time difference is much smaller than that corresponding to the traditional transformer.

Key words: Multi Tap Transformer, Microcontroller, Octocoupler, Triac, Load

I. Introduction

The main application of a transformer with alternating is to control the amplitude of the output voltage. The main purpose of the controller in the tape changer system is to minimize the fluctuation of the voltage amplitude with respect to the reference voltage of the control bus. This bus must be far from the secondary of the transformer. The controller must control the voltage within a certain range. The quality of the current is also one of the most important things today. Both the power utilities and consumers are very concerned about the quality of the power supply. This requires that the requirements be optimal for the costs to be efficient; otherwise, problems such as overvoltage, under voltage, voltage swelling, voltage increase, noise and harmonics caused by disturbances in the power supply could be disastrous. Several methods have been proposed and applied as a solution to these problems. One of the methods is the use of on-load power transformer with tap changing, where the output voltage of the transformer remains constant, regardless of the input voltage or load variation.

The existing mechanical tap changer power transformer has few drawbacks because it causes sparks, requires regular maintenance, maintenance costs and slow response times. With the use of high power semiconductor devices such as TRIAC, IGBT, thyristors, the problems related to the mechanical on-load tap changing power transformer have been eliminated. To overcome these limitations and disadvantages, new circuits and configurations for tap changers have been introduced. These can be divided into two groups.

- Electronically assisted (or hybrid) on-load and
- Fully electronic (or solid-state) tap-changers

The first circuit for the hybrid tap changer was introduced in 1996. This structure significantly reduces arc formation. The main drawback, however, is that although two thyristors are ON for short periods during the tap change process, they are permanently connected to the circuit of the bypass switches and are likely to burn. This can therefore reduce the reliability of the system. To eliminate this disadvantage, an alternative configuration has been introduced.

The main idea of this circuit is that two thyristors are only connected during the period in which the tap is changed, which improves the reliability of the system. Up to now, the proposed constructions have been able to reduce arc formation, using a tap-changer, quick operation of the tap-changer is desirable. In such a case, a traditional tap changer cannot respond correctly, while an electronic tap changer allows to work correctly.

A. *Project Objectives*

It is an objective of this invention to provide an improvement which overcomes for the mentioned in adequacies of the prior art controllers and provides an improvement which is a significant contribution to the advancement of the tap-changer controller art. Another objective of this invention is to provide a microcontroller-based tap-changer controller that accurately controls a conventional tap-changer and yet comprises a simpler and less expensive design than is presently available in microcontroller-based tap-changer controllers.

A further objective of this invention is to provide a single control that can be used interchangeably with a variety of regulators and LTC transformers.

II. Literature Survey

Reference [1] presented the problem of conventional tap changers is due to the mechanical structure of complicated gear mechanisms of selectors, diverters and switches. These devices react slowly and are sensitive to contact wear and deterioration of the insulation oil, and therefore require regular maintenance. Due to its property, the mechanically on-load tap changer power transformer arched during tap changing processes. This is further developed in a single bypass resistor and then in pairs of parallel reverse thyristors connected through a series of mechanical switching contacts. The bipolar transistor of isolated port (IGBT), TRIAC, thyristor is mainly used in semiconductor power devices. By using these devices we can improve the performance of the system by using those devices, we can improve the fast operation of the system due to that other problem in the AC head, such as flicker and sag. Also it have more controllability. The experimental results show that the rapid change is able to correct several interruptions of the AC network. In addition, the long period of time in time is much lower than that corresponding to traditional controllers.

Reference [2] presented Design as a fully electronic on-load tap changer for this TRIAC used as a switching device. The author suggested that the use of a TRIAC device reduces electric arc, contact wear and maintenance that associated with conventional mechanical tap changer. In this paper semiconductor device and microcontroller as processing elements are used that improve the response of the tap changer.

Reference [3] presented the disadvantage of conventional tap changer like arcs, high maintenance costs, service costs and slow response time are overcome by the use of a solid state tap changer. In this semiconductor, as thyristor are used for the rapid operation of the OLTC transformer also reduce the problem, such as flicker and sag. In this paper, any variation in the output voltage of the transformer will be detected by the microcontroller and compared with the reference value according to the program. This will produce the appropriate command to turn on the correct pair of antiparallel thyristors to change the appropriate transformer tap. The stability of the system has improved due to the rapid response.

III. Block Diagram & Description

Fig. 1 shows all the main components required for a solid-state OLTC controlled by a microcontroller. A transformer with tap is taken on the primary side. The variations of the input voltage are recognized by the voltage sensor (rectifier circuit) on the primary side. This voltage is applied to an ADC of the controller that converts the analog AC voltage into the sensor output into a digital value. The microcontroller activates the desired static electronic switch (TRIAC) according to the programming logic. These static switches are connected to the transformer taps. So, activating a switch means selecting the taps.

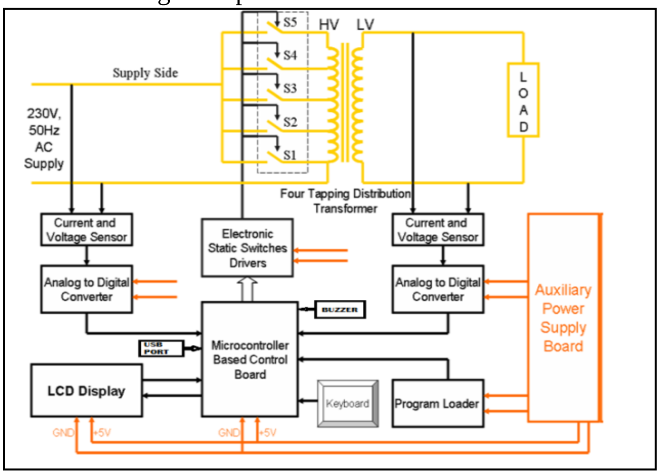

Fig. 1: Block Diagram

An extension of this operation also applies to the secondary side of the transformer. The voltage of the transformer can be detected by a voltage sensor. The ADC on the secondary side produces the necessary digital signal. This paper proposes a tap with a solid state, taking into account variations in the input voltage on the primary side of the transformer. Here the proposed topology is the design using a 1KVA transformer. It can be a direct replacement for the classic controller applied at high power levels. This allows a low cost for the semiconductor devices used and makes the OLTC fast controller suitable for high power applications.

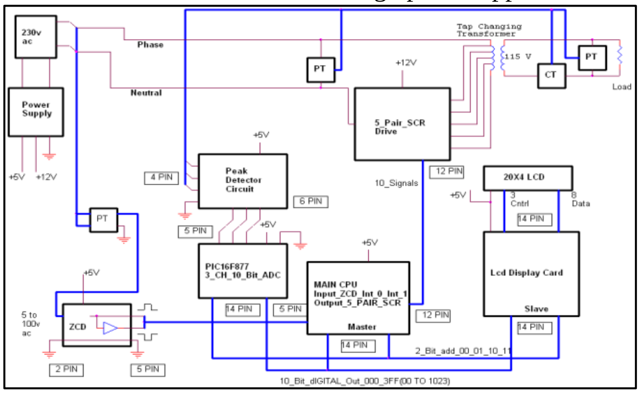

Fig. 2: Circuit Diagram

The main switch S1-5, which is bidirectional in current and voltage. It consists of a TRIAC. This bidirectional switch configuration has the advantage that only a unidirectional switch is used, which also results in simpler control. However, it has the disadvantage of higher conduction losses due to the serial processing of more semiconductor devices, higher switching voltage of the transistor.

Furthermore, with this configuration it is not possible to control the flow in both directions separately, but because the controller is operated with a two-step switching strategy, it has no influence on the switching process. Each main switch is controlled by the same gate signal in both possible current directions. In this case, only a two-step switching strategy can be used, which presents the problem of a short-circuit current between the taps during switching.

IV. Transformer Design

A transformer is designed as shown in FIG. 3 the transformer is equipped with 5 taps each with a difference of 10V on the primary side. The secondary voltage is designed to be 230 V with 1150 turns. Primary voltage taps: 210V, 220V, 230V, 240V, 250V.

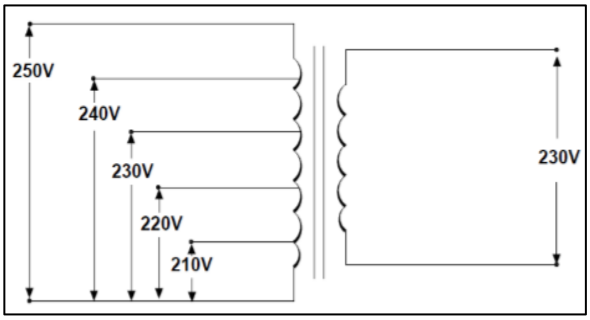

Fig. 3: Transformer Design

Number of laps: 1050 1100 1150 1200 1250. Conditions respectively. The transformer is based on the equation, N2 / N1 = V2 / V1Here N1, V1, N2, V2 are voltage and primary and secondary windings respectively. Here both N2 and V2 are constant. Therefore, according to the above equation, V1 / N1 must be constant. Or, in other words, for an increase in voltage, there must be a proportional increase in the number of turns.

V. SWITCH CIRCUIT

Below is a design based on optocoupler switching circuits in the fig 5. The optocoupler houses an LED and an optically operated TRIAC. When a high signal is given to pin 1 of the optocoupler (MOC3041), the LED illuminates inside the optocoupler, which in turn optically activates the internal TRIAC.

As a result, the TRIAC receives a gate pulse on the taps side and connects it to the appropriate tap. The optocoupler functions as a gate controller for the TRIAC.

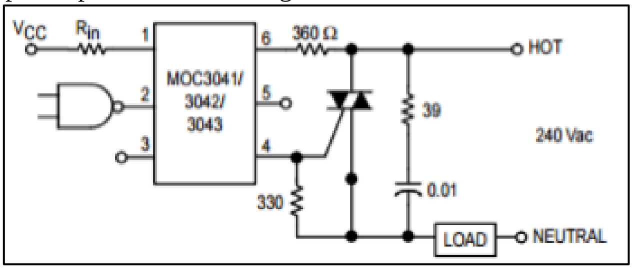

Fig. 4: Switching of TRIAC by Optocoupler

VI. VOLTAGE SENSOR - RECTIFIER CIRCUIT

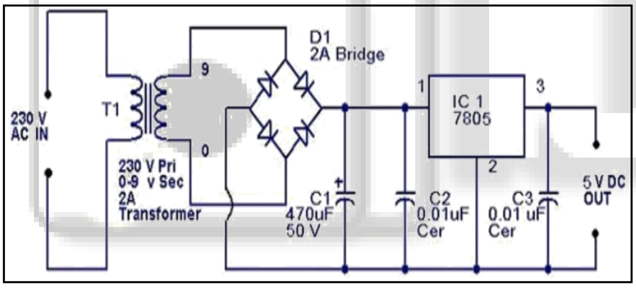

Fig. 5: Rectifier Circuit

There is requirement of DC supply for microcontroller and display. Both units require 5V DC supply for operation. For this by using step down transformer 230V is converted to 12V AC. Further it is converted to 5V DC by using Bridge rectifier, capacitor and LM7805 voltage regulator.

VII. PROGRAM FLOW

The selection logic is shown in FIG. 5. The microcontroller continuously reads the value of the input voltage using its analog pin. Check if the input voltage is within the prescribed voltage limits. If the voltage is within the predetermined limits, the tap corresponding to that input voltage is selected. If that is not the case, the microcontroller checks if there is another condition. This process is repeated until an agreement is obtained.

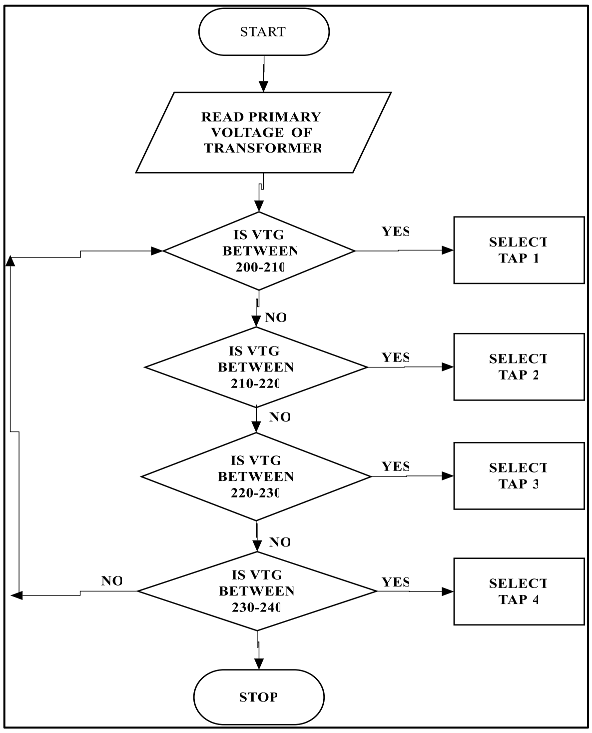

Fig. 6: Tap Selection Flow Chart

VIII. RESULTS

When input voltage is increase or decrease than particular TRIAC is operated and Tap are changing.

IX. CONCLUSIONS

In this work, a totally electronic tap changer with five taps located on the high voltage side of the transformer is designed and built. Each variation in the input voltage of the transformer is detected by the microcontroller and compared with the reference value according to the program. This will produce the appropriate command to activate the right triac for the change in the proper tap of the transformer. The stability of the system has improved due to the rapid response. Static devices reduce maintenance costs due to the elimination of frequent sparks. The input voltage can be controlled within the range of 10 V of the rated voltage.

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