**ELECTRONIC TAP CHANGER FOR DISTRIBUTION TRANSFORMER.**

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***ABSTRACT :***  *Recently electronic tap-changer has received more attention due to its quick response, better performance and simpler maintenance compared to the mechanical tap-changer. This paper presents the capability of the distribution transformer equipped with an electronic tap-changer for improving power quality.* *Meanwhile, the impact of the electronic tap-changer in power quality parameter improvement is compared with that of other custom power tools. This paper briefly introduced an electronic tap-changer. The capability of the distribution transformer equipped with such tap-changer in improving power quality was presented.* *In the transformers used in power systems the main reason for taps application is adjusting and controlling the voltage.* *Application of the full-electronic tap-changer is preferred to the conventional mechanical tap-changer. Because low cost of maintenance and Service use high speed, better capability and performance, standing higher than the rated current and voltage in the fault conditions in network.*

***Keywords-*** *Electronic tap changer, power quality,* *Custom Power Tools, Distribution transformer, custom power tools.*

1. **INTRODUCTION.**

Distribution transformer tap is a connection which is taken out from a node located between two ends of a winding. This permits changes in voltage, current or turns ratio of the transformer after it has left the factory. The reasons to have a series of taps in the transformer are as follows

a. To fix the secondary voltage against the primary voltage changes;

b. To change the secondary voltage;

c. To provide an auxiliary secondary voltage for a specific application such as lighting;

d. To reduce voltage for starting rotating motors;

e. To provide a natural point for earthing or conducting unbalanced current in three-wire single-phase circuit or four-wire three-phase circuits.

In the transformers used in power systems the main reason for taps application is adjusting and controlling the voltage. The load fluctuations change the voltage of the power system. It is noted that sometimes taps in power transformers are used to shift the phase angle. Tap-changers are categorized into two main groups :

a. Off-circuit or no-load tap-changers;

b. On-load or under-load tap-changers.

Tap-changer with the ability to change taps while power is on called under-load tap-changer. If a tap-changer is built as such that its fixing requires its being disconnected from the power line, the tap-changer is called no-load tap-changer. If there is a need to change the turns ratio over a long interval (for instance

seasonal), the no-load tap-changer is used. Normally in the no-load tap-changerstaps are changed manually by means of a selector outside the transformer tank. This selector may move linearly or circularly.

 **II. LIMITATIONS: MECHANICAL UNDER-LOAD TAP CHANGERS.**

In spite of advancement in the structure of mechanical under-load tap-changers, these tap-changers have some drawbacks; for example, the major factor which causes damage to power transformers is their tap-changer failure . Some drawbacks of mechanical under-load tap-changers are as follows.

 a. Contact Arc in Diverter Switches During Tap-Changing Process.

 An arc appears in the contacts of diverter switches at the time of make and breaks the load current. This arc causes impurity of the oil surrounding the diverter switches and wearing out of the contacts of the switches.

 b. High Maintenance and Service Cost

 Conditions of oil, contacts and mechanical parts of the mechanical under-load tap-changers must be inspected regularly. This is required due to arc and wearing-out of the moving mechanical parts of tap-changer.

 c. Low Speed of Tap-Changing.

 d. High Losses of Tap-Changer During Tap-Changing.

In order to remove the above-mentioned limitations and drawbacks, the following new circuits and structures have been suggested for under-load tap-changers.These are categorized into two major groups

 a. Electronically Assisted Under-Load Tap-Changers (or Hybrid On-Load Tap-Changer)

In these tap-changers solid-state power switches have been used beside the mechanical switches in order to reduce the arc caused by tap-changing. Mechanical parts of the conventional under-load tap-changer systems have been still used.

 b. Fully Electronic Under-Load Tap-Changer (or Solid-State Under-Load Tap-Changer or Static On-Load Tap-Changer)

There is no moving mechanical part in fully electronic tap-changers and whole tap-changer has been built by solid-state power switches.

 **III. ELECTRONICALLY ASSISTED UNDER-LOAD TAP-CHANGERS**

One of the most important problems of mechanical under-load tap-changers is the arc in the contacts of diverter switches during the tap-changing process. The reason for appearance of arc is the mechanical nature of the switches. Of course, mechanical switches are interesting in the connecting of instant due to a very low voltage, however during tap-changing it has arc.

The main idea in the use of fully electronic under-load tap-changer is that during tap-changing process solid-state power switches with more controllability compared with the mechanical switches, come in and reduce the arc. But in a fixed tap, solid-state power switches exit the circuit and mechanical switches pass the load current. The reason is a very low connection voltage of mechanical switches compared with the solid-state power switches.

 **IV. FULL ELECTRONIC TAP CHANGER** .

Although the idea of the full-electronic tap-changers was proposed in 1973 they was restricted for special applications. The first comprehensive and academic study of this system was carried out in the 90 decay then research continued. To introduce the progress and research trend on full-electronic

tap-changers and to clarify its position, activities in this area are reviewed. There is no movable part in full-electronic tap-changers and only solid-state power switches are used. The basic advantages of the full-electronic tap-changers are as follows:

a.Very Low Maintenance Cost

 There is no movable mechanical part in full-electronic tap-changers, and no arc can appear during the tap- changing process as there is basically no contact therefore the maintenance cost is very low (almost zero).

 b. High Speed

 The very fast switching process of solid-state power switches leads to the fast tap-changing in full-electronic tap-changers, as such that it is possible to change the tap at least once in any half-cycle.

 c. Tap Jumping

 There is no passing resistor in the full-electronic tap-changers and basically the circulation current between the taps is zero, so tap jumping becomes possible

 d. Better Performance

 High speed and controllability of the solid-state switches and non-existence of mechanical limitations in the configuration of these switches enhance the capability and performance of the full-electronic tap-changers. Some of these capabilities are as follows:

 1. Obtaining more steps with lower tap numbers and solid-state power switches. The reason is that there is non-limit in the configuration of the solid-state power switches. The reason is that there is non-limit in the configuration of the solid-state power switches.

 2. A full-electronic tap-changer is a rapid static regulator as such that it can be considered as a custom power devices in power quality. It is capable to compensate the voltage sag, swell and also flicker.

e. Non-limit in tap-changing time.

 The reason is that if power switches are correctly switched-on there will be slight fatigue in the switches. Of course, besides of the above-mentioned advantages, full-electronic tap-changers have some problems and limitations. These limitations are as follows:

1. Switch-on voltage drop of solid-state switch is larger than that of the mechanical switch, so operational losses of the full-electronic tap-changer is higher than that of the mechanical tap-changer.
2. b. Cost of full-electronic tap-changer is higher than that of the mechanical tap-changers because there are many solid-state power switch in the full-electronic tap-changer.
3. Full-electronic tap-changers must stand against short-circuit faults and large transient peaks power system voltage due to the lightening.

**V. PRACTICAL IMPLEMENTATION.**

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The rated voltage of 210 V, two tapped-windings each has three taps and the rated voltages of ‘‘2 V, 4 V’’ and ‘‘14 V, 28 V’’. The rated secondary voltage means a voltage that is induced when the primary voltage is 220 V.

 **5.1** **Electronic Tap-Changer Switches**

Figure6.3shows the schematic circuit of electronic tap-changer switches and their connection to the tapped-transformer. To realize bi-directional solid-state switches two uni-directional solid-state switches (MOSFET or IGBT) are used. Meanwhile, the uni-directional switches are connected such that their sources (in MOSFET) or emitters (in IGBT) are connected to each other, so there is no need to have two isolated power supplies. If in each one of the following four groups of switches: (S1, S2, S3), (S10, S20 , S30),(S4, S5, S6), (S40, S50, S60) one switch is on at all time (even at switching time).

 **5.2** **Analog Processor Board**

The responsibility of the analog board is to receive analog feedback signals (voltage and current of load from PT and CT) and then filtering, amplifying and rectifying them and finally delivering to the microprocessor control board. To reduce the quantizer error in the microprocessor board processing, three different gains in the analog processing board are considered for each voltage and current signal. Meanwhile, this board generates the required reference voltage for analog/digital converter located in the microprocessor processing board. In addi-tion, the analog processing board generates two square wave signals, by zero- crossing of each voltage and current signal in a synchronous order. These square-wave signals, called digital voltage signal and digital current signal, are used in the microprocessor processing board.

 **5.3 Microprocessor Processing Board**

Microprocessor processing board from microprocessor 80196 is used as the main processor. This processor has an internal A/D converter with eight analog inputs. This board receives the analog signal related to the output voltage and current with synchronous square-wave signals by zero-crossing of sinusoidal variables as input, and generating switch-on and switch-off commands in electronic tap-changer switches. Meanwhile, communication with the panel board (receiving data from the switches in the panel board and sending data to LCD) is also the responsibility of this board.

 **5.4 Panel Board**

The panel board consists of a 2092 LCD display and four switches. Adjustments of the set are entered by the user through the switches on the panel board and the data of the set given to the user by the LCD display. The panel switches are as follows: Enter, Escape, Up and Down.

 **5.5**  **PT and CT**

To measure the output voltage and current, a PT and CT is used. Step-down factor of CT is 0:1/

8:75 and PT is 5/220.

 **5.6 Software**

This section presents the software used in the microprocessor processing board and is briefly described. It should be noted that familiarity with the microprocessor 80196 is necessary to understand this section.

 **VI**. **FUTURE WORK AND GOALS.**

Full-electronic tap-changer is faster, has better performance, more capabilities and lower maintenance costs compared with mechanical tap-changers and hybrid tap-changers; however, the cost of electronic tap-changers is higher than that of the conventional ones. This is one of the most important factors that prevents a wide application of this system . Two cost deterministic factors in an electronic tap-changer are:

a. The number of solid-state power switches and their voltages and currents.

b. The number of transformer taps because every tap requires isolation equipment and its own specific insulators. Therefore, if (a) and (b) decrease, the cost of tap-changers will be largely reduced. On the other hand, the higher the number of voltage steps over electronic tap-changer adjustment range, the more precise the regulation will be, and this is the most important characteristic of this system. Therefore, the major goals of the design of the power section of an electronic tap-changer are as follows :

 1. The number of solid-state power switches and their voltages and currents should be minimal.

 2. The number of transformer taps should be minimal.

 3. The number of voltage steps over output voltage regulation range should be maximal in order to enhance the regulation precision.

Of course, other lateral goals are also proposed and some of these goals are:

 1. System losses including losses of switches, as well as transformer losses should be minimal.

 2. System reliability should be high.

 **VII.** **CONCLUSION**

This paper presents the capability of the distribution transformer equipped with an electronic tap-changer for improving power quality and application of the full-electronic tap-changer is preferred to the conventional mechanical tap-changer because low cost of maintainance and service, high speed, better reliability,jumping in tap changing , better capability and performance. Further studies are possible in the full-electronic tap-changer which are designing essential protections for the full-electronic tap-changer, design of the tap-changer for high power transformer, Optimization of the switches configuration in the full-electronic tap-changer assuming pre-defined structure for taps winding, Extending the designs to three-phase case. In order to replace the mechanical tap-changers by the full-electronic tap-changers, the latter tap-changers must have the following features :low cost and high reliabilityStanding higher than the rated current and voltage in the fault conditions in network. For the fault conditions of the network (such as short circuit or voltage rise due to the lightning etc.). The voltage and current become higher than their rated values. The full electronic tap-changer must be designed such that it could stand these conditions and does not burn.

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