Investigation the transient over voltages and performance of on load tap changer (OLTC)

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Abstract **-** Nowadays, energy satisfactory is one of the fundamental issues. The power system faces issues because of load change. On load tap changers (OLTC) are used to exchange the burden momentarily. tap changer use mechanical switches to alternate the voltage. Mechanical tap changer has troubles which include arcs, mechanical losses, manpower required, maintenance in addition to extra time. sometimes switching the tap changer between two steps gets stuck, which leads to damage to the whole system and additionally affects the steadiness of the device. In this newsletter, the outcomes of tap converting are taken into consideration and additionally the effect of inductive loads is investigated and subsequently, a solution to enhance these troubles is provided.

Keywords **-** On-load tap-changing transformer, On-load tap changer, Automatic voltage regulation, High Voltage Apparatus.

I. INTRODUCTION

Transformer tap changer is the stylish form of voltage control at all voltage situations in a power system. This is based on changing the rate of a transformer, so the voltage in the secondary varies and the voltage control is attained. The tap changer is generally located on the high voltage coil because the current is less, which reduces the need for current and pressure transfer during the relief operation.

The mechanical type of OLTC fluently produces an arc in the change process, which affects the life of the outfit. Despite using a sophisticated way to change the tap, speed and delicacy still need to be bettered. The arc in the switching process affects the life of the OLTC and the safety of the power grid. To more control the switching process, the mechanical type of OLTC has made great strides.

The main technology of accessory load voltage regulation is a combination of electronic power switches and mechanical switches, which weakens the arc in the switching process to cut off the large affair current [1]. OLTCs allow voltage regulation and/ or phase change by changing the ratio of transformer to continued load.

Since the morning of the development of tap changer, two switching principles have been used for load transfer operations, the OLTC resistance type and the OLTC reactor type. Decades latterly, both principles have been added to transformer factors that are available in a wide range of current and voltage operations. This element, cover the requirements of moment's network and transformers, also insure an optimal system and process control [2].

Utmost resistor- type OLTCs are installed inside the transformer tank (in-tank OLTCs) while reactor- type OLTCs are housed in a separate chamber that's typically welded to the transformer tank.

The tap changers are generally mounted on coils that are economically and technically feasible. Utmost are mounted on the star connection or on the high pressure side. In principle, tap changers are used in the following three ways:

1-Three- phase tap changer that are placed on coils with star connection.

2-Three- phase tap changers that are placed on a coil with a triangular connection. In this case, complete sequestration between the phases is needed, and we need three tap changers to work with a common movement medium.

3-Single- phase tap changer used on single-phase or three- phase transformers.

Depending on the type of work, the tap changers are divided into two orders On Load and Off Load.

Incommutable tap changer under load have a simple structure and to change it, the power transformer must be removed from the circuit. Changes of this type of tap changers are generally made according to the need and in agreement with the load oscillations in different seasons of the time [3].

The beats that can be changed under load correspond of corridor similar as the transmission medium, motor drive, diverter switch, tap chooser and the tap changer selection key.

In on load tap changer, the important thing is that the current is nonstop in the circuit, which shouldn't be intruded indeed at the moment of the load path [4]. The number of steps on a tap changer is frequently odd, so we call a step normal, and it's prognosticated to be equal to the number of taps above normal and the same number lower than normal steps to reduce and increase the voltage.

II. SWITCHING PRINCIPLE

Tap changer, changes ratio of the transformer by adding or abating, and turns from either the primary or the secondary winding. The transformer is thus equipped with a tap winding which is connected to OLTC.

Figure 1 shows the main arrangement of a winding of a 3-phase regulating transformer with an OLTC in the wye-delta connection on the high voltage winding.

Changing the tap during the power situation isn't respectable due to the evanescent loss of system load during switch operation (Figure 2). Transmission impedance in the form of a resistor or reactor consists of one or further units that bridge conterminous tap with the end of transferring load from one tap to another without interposing or significantly altering the load inflow. At the same time they limit the circulating current (Ic) for the period of use of both tap. Generally, reactor- type OLTCs use the bridging position as the service position, so this type is designed for nonstop loading (Figure 3).

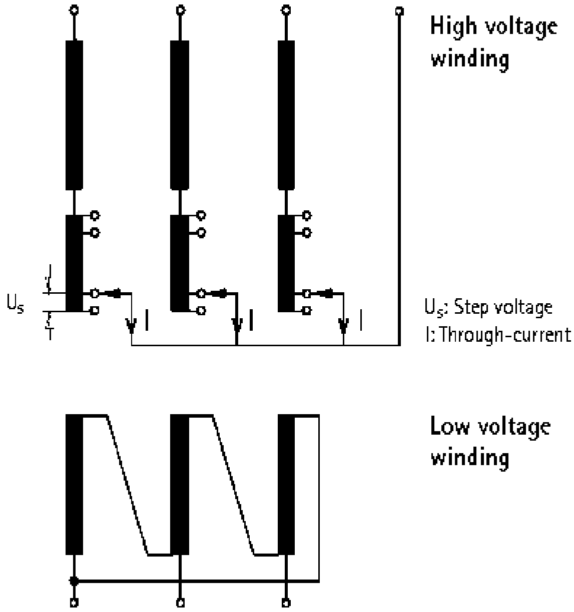

Fig. 1. Principle winding arrangement of a regulating transformer in wye-delta connection

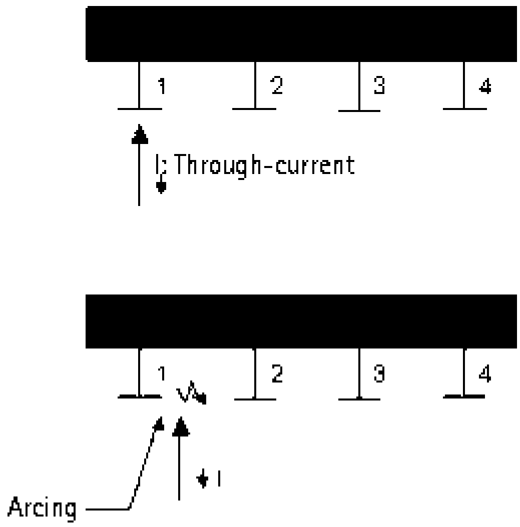

Fig. 2. Loss of system load with single contact switching

Voltage between the taps mentioned over is the step voltage, which is generally between0.8 and2.5 percent of the transformer rated voltage.

The main factors of an OLTC are contact systems for generating and breaking currents as well as carrier currents, transmission impedances, gears, spring energy batteries and selectors. Depending on the different winding arrangements and the OLTC designs, selector separator keys and gear selectors (reverse or large type) are also used [5].

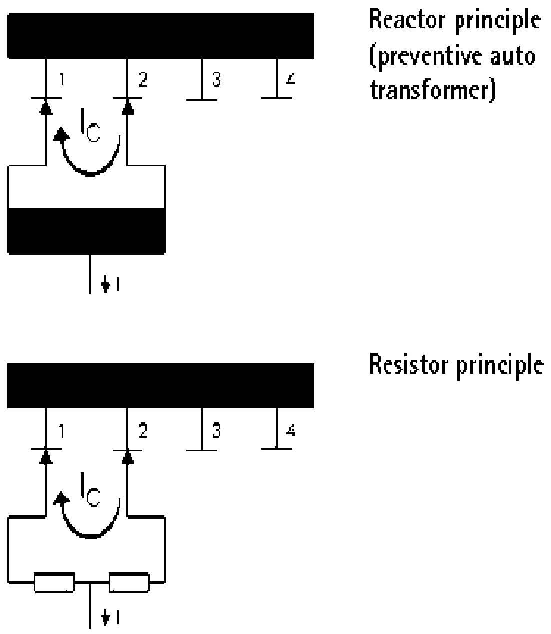

Fig. 3. Basic switching principle using transition impedances

III. ON LOAD TAP CHANGER OPERATION

The following introductory composites are used for the on load tap changer (Figure 4).

Linear arrangement is generally used in power transformers with a medium adaptation range of over to 20. Shock cycles are added in series with the main winding and change the ratio of the transformer. The nominal position can be any of the tapping positions (Figure 4a).

By opting the reverse direction change, the coil is added or abated from the main coil to double the adaptation range or reduce the number of taps. Utmost copper losses do in a situation with a minimal number of effective screws. The nominal position is generally the middle position or the neutral position (Figure 4b).

The reverse gear selector prevents the stopcock coil from being dissociated during the change operation. In phase shifting transformers, this device is called advance-retard switch (ARS) (Figure 4c).

Using a coarse change-over selector the tap winding is connected moreover to the plus or minus tapping of the coarse winding. When coarse selector operation, the tap winding is dissociated from the main winding. In this state, the copper losses are smallest in the position of the smallest effective number of turns. This advantage, still, places advanced demands on insulation material and requires a larger number of windings (Figure 4d).

The multiple coarse change-over selector, enables addition of the regulating range. It's substantially used for artificial process transformers (rectifier/ furnace transformers). The coarse change-over chooser is also part of the OLTC (Figure 4e).

Which of these introductory coil settings is used in each particular case depends on the system and performance conditions. These arrangements are applicable to two winding transformers as well as automatic transformers and phase shift transformers (PSTs), where the valve winding and therefore the OLTC are placed in the windings (high voltage or low voltage side) depending on the design of the transformer.

The OLTC design generally used for advanced voltages includes a diverter switch (arc switch) and a tap selector. For lower voltages, OLTC schemes are used in which the functions of the switch and the tap selector are combined in a selector switch.

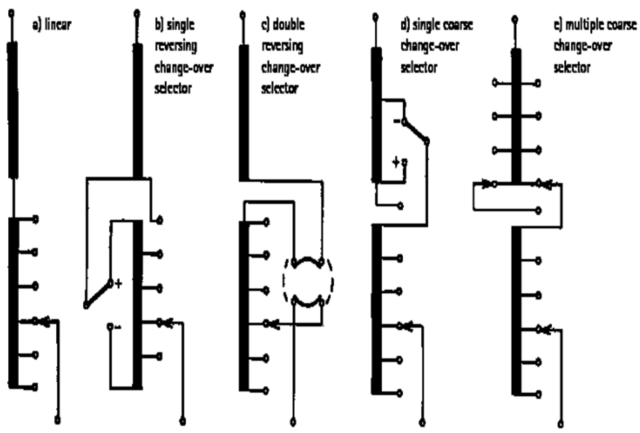

Fig. 4. Basic connections of tap windings

With an OLTC conforming of a switch (arc switch) and a tap selector, the tap switching operation is performed in two steps (Figure 5). The coming tap is first selected by the no- load tap selector (Figure 5 Position a-c). The switch transmits the load current from the active tap to the selected tap (Figure 5 position c-g). OLTC workshop using the drive medium. The selector tap works with the direct gear of the drive medium. At the same time, a spring- loaded battery is pulled, which operates the transmitter switch-after being released in a veritably short period of time- singly of the drive medium. The gear ensures that this function of the diverter switch is always performed after the tap nomination operation is completed. Switching time of a switch with moment's designs is between 40 and 60 milliseconds.

During operation of the diverter switch, transition resistors are introduced (for illustration, 5 positions d-f) which are loaded for 20-30 milliseconds, i.e. Resistors can be designed for short loads. Thus, the quantum of resistance material needed is fairly small. Total operating time of an OLTC is between 3 and 10 seconds, depending on the design [5].

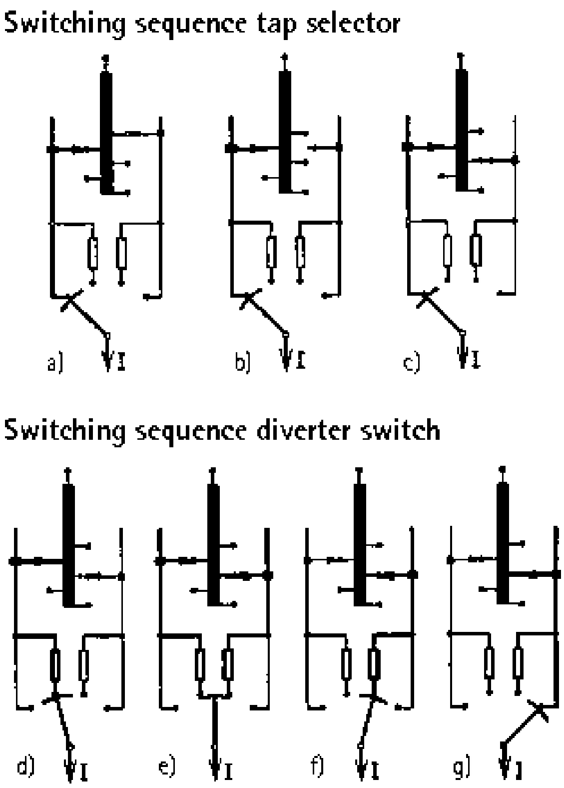

Fig. 5. Switching sequence of tap selector – diverter switch (arcing switch)

IV. DISCUSSION AND SIMULATION

In a power system, overvoltage due to system failure or circuit breaker switching performance is called overvoltage efficiency. The reason for the overvoltage is that the instantaneous change in the working condition of the capacitors or inductors causes a severe transient electromagnetic effect. This results in serious damage to electrical devices [6,7]. Traditional OLTC has some disadvantages while changing the taps, such as causing arc, switching slowly, having high malfunction rate. In this paper, we intend to investigate the effects of OLTC dysfunction by simulating a OLTC in MATLAB.

For this purpose, a 132/20 kV and 50 MVA transformer with an OLTC with steps of 10% and ±8% of the rated voltage is considered. The simulation is performed when the transformer load is 5, 15, 30 and 45 MVA, and the voltage waveform is examined. The simulation examines how the primary and secondary voltage changes, as well as the active and reactive power. On the 20 kV side, we put a capacitor for better performance of the tap changer. Tap selection time is 4 seconds.

Also, in the process of taps changing, the circulating current will turn up in the transition circuit. There may be over-voltage and over-current created by circulating current.

1. LOAD OF 5MVA

The simulation is performed with a load of 5 MVA at the output. The results are as follows (Figure 6,7). As can be seen, in order to compensate for the voltage, drop in the secondary and bring it closer to 1pu, the tap changes and for the -5th tap, the primary voltage is 1.22pu and the secondary voltage is 1.05pu. The noteworthy point is the fluctuations created when changing the pulse, which can also be seen in the figure.

Fluctuations created when changing the tap, as can be seen, also cause power swing and can be problematic for the protection system.

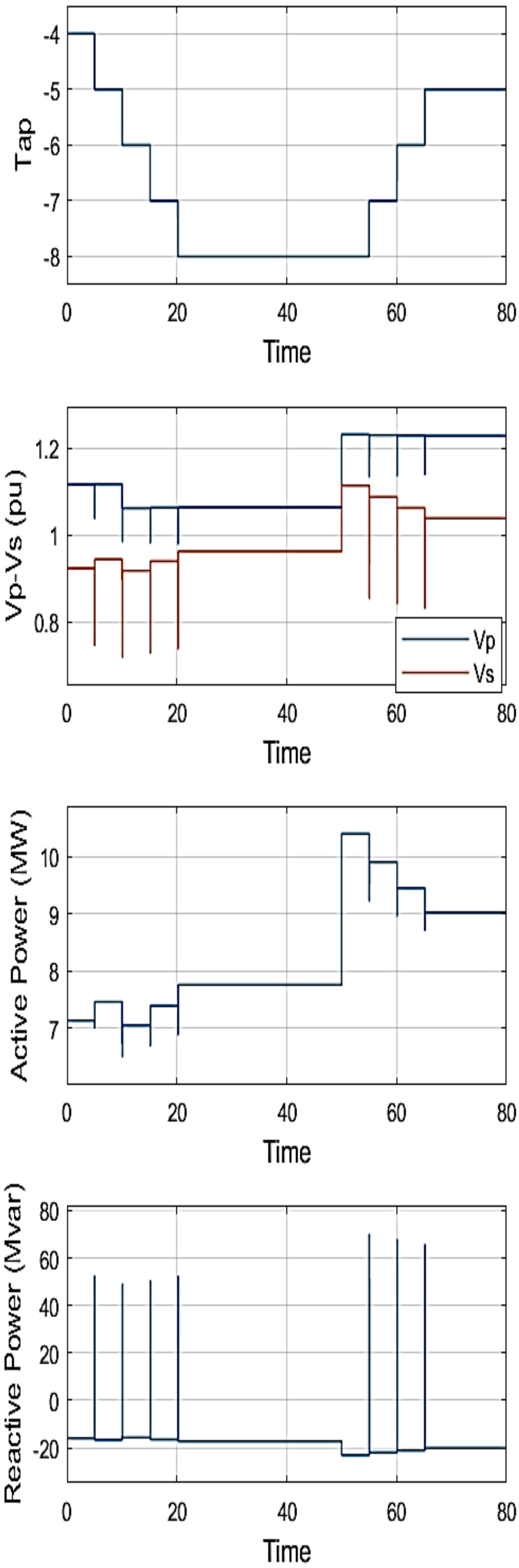

Fig. 6. Voltage and power changes with tap changing (Cos φ = 0.8)

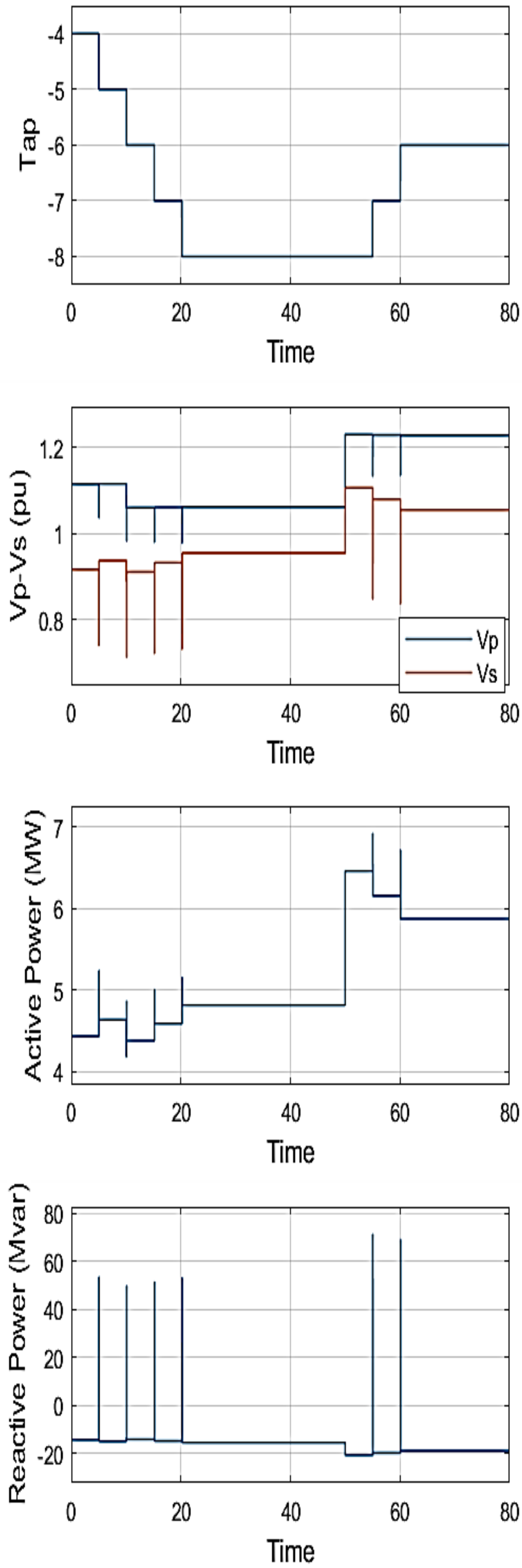

Fig. 7. Voltage and power changes with tap changing (Cos φ = 0.5)

2. LOAD OF 15MVA

Once again, the simulation is performed taking into account the load of 15 MVA. In this case, to compensate for the voltage drop in the secondary, the -6th tap is selected. Voltage fluctuations have increased and the amount of active power fluctuation has also increased due to the increased current of the transformer (figure 8,9).

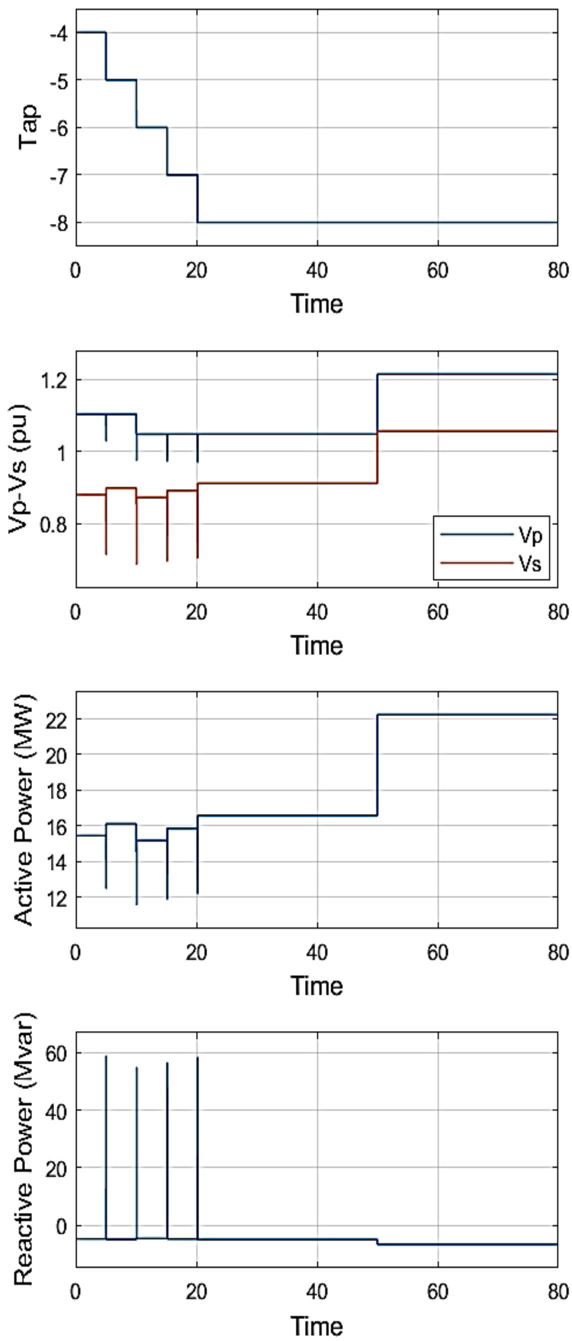

Fig. 8. Voltage and power changes with tap changing (Cos φ = 0.8)

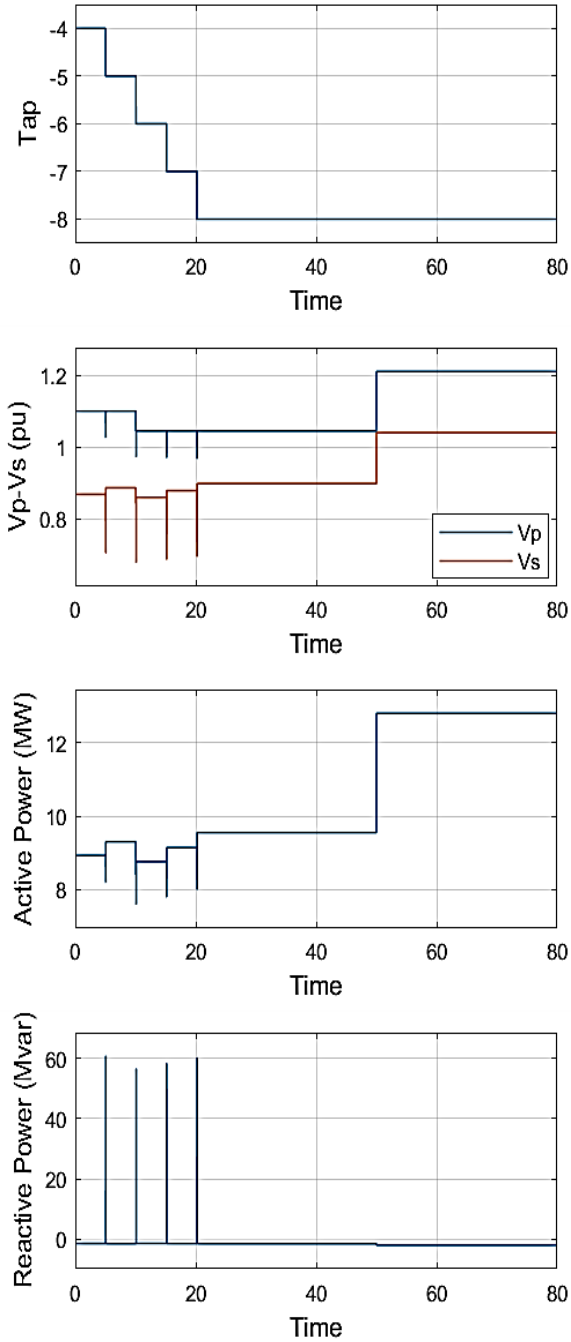

Fig. 9. Voltage and power changes with tap changing (Cos φ = 0.5)

3. LOAD OF 30MVA

Considering a load of 30 MVA, it is selected to compensate for the voltage drop across the -8th tap. Due to the high amount of load applied to the transformer, the amount of voltage fluctuations and power is high. In the simulation, 8 tap are selected for the tap changer, so due to the high amount of load, the pulse is set to the maximum value. According to Figure 10 and 11, the secondary voltage of the transformer is set to 1pu by selecting -8th tap.

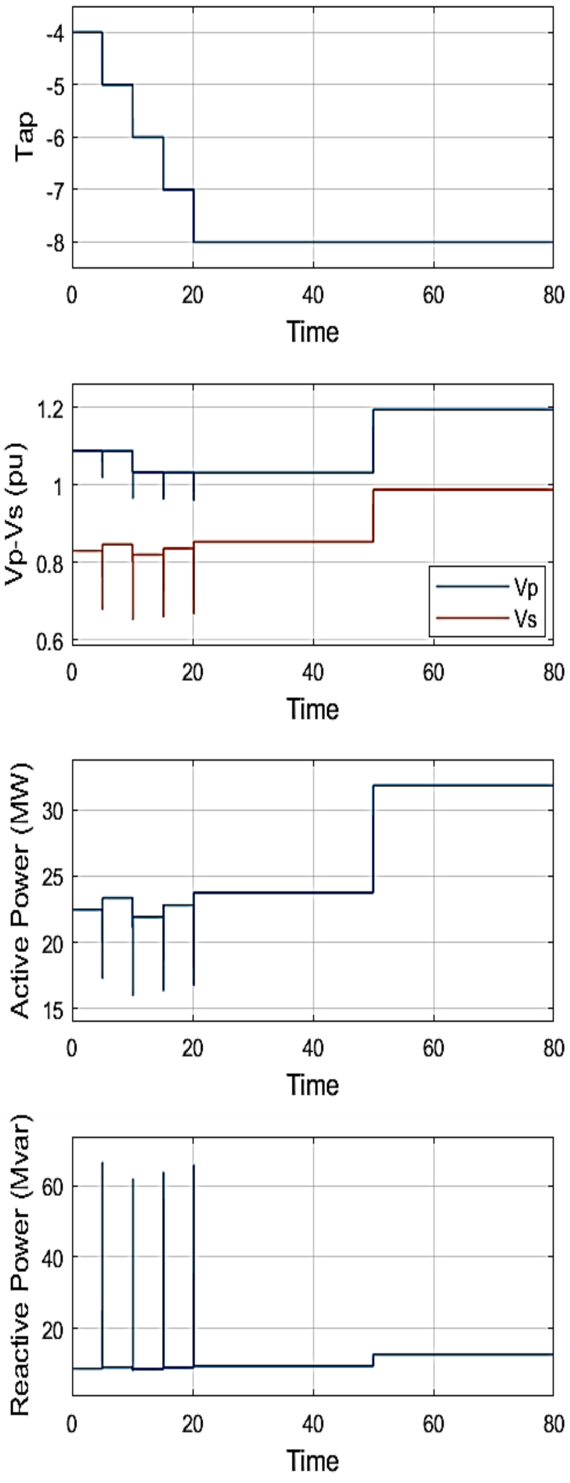

Fig. 10. Voltage and power changes with tap changing (Cos φ = 0.8)

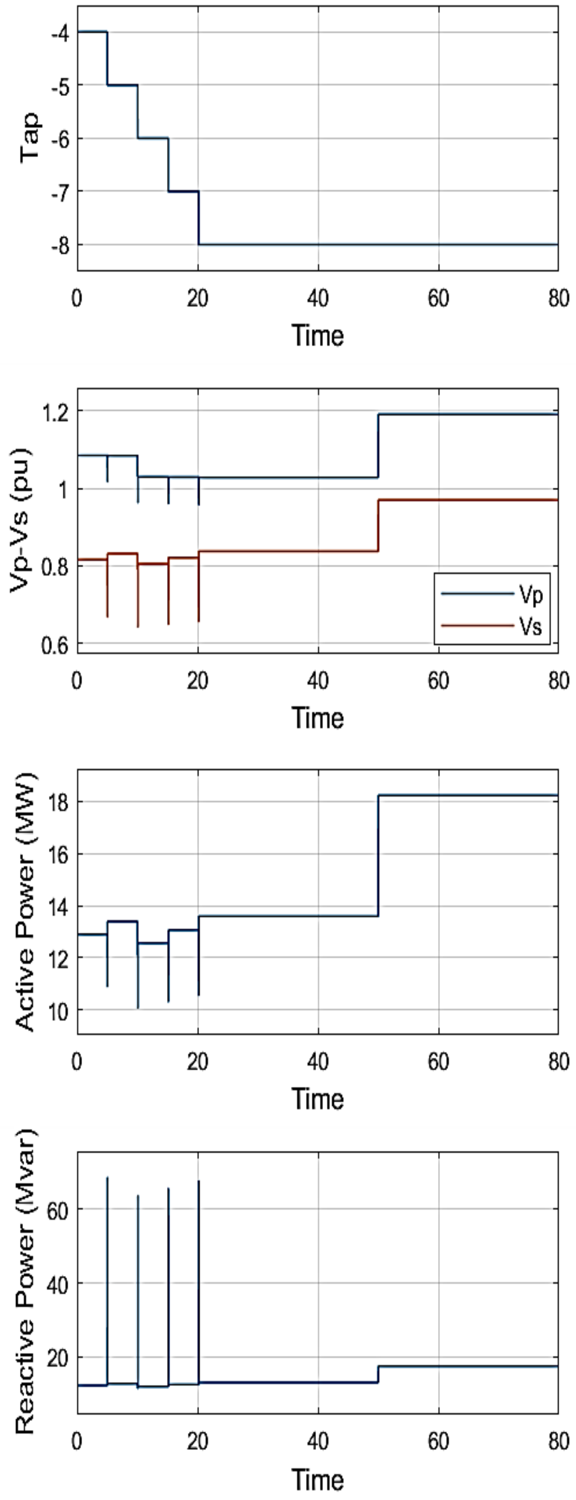

Fig. 11. Voltage and power changes with tap changing (Cos φ = 0.5)

4. LOAD OF 45MVA

Considering the 45 MVA load for the simulated transformer, it is observed that to compensate for the voltage drop generated in the secondary, the maximum pulse is selected due to the proximity of the applied load to the transformer to the rated capacity of the transformer. According to Figure 12, it can be seen that the secondary voltage is not set to 1pu, which is due to the limited number of tap, insufficient compensation has been done and lower tap must be selected to set the voltage to 1pu. And at loads close to the rated capacity of the transformer, there is always a voltage drop in the secondary.

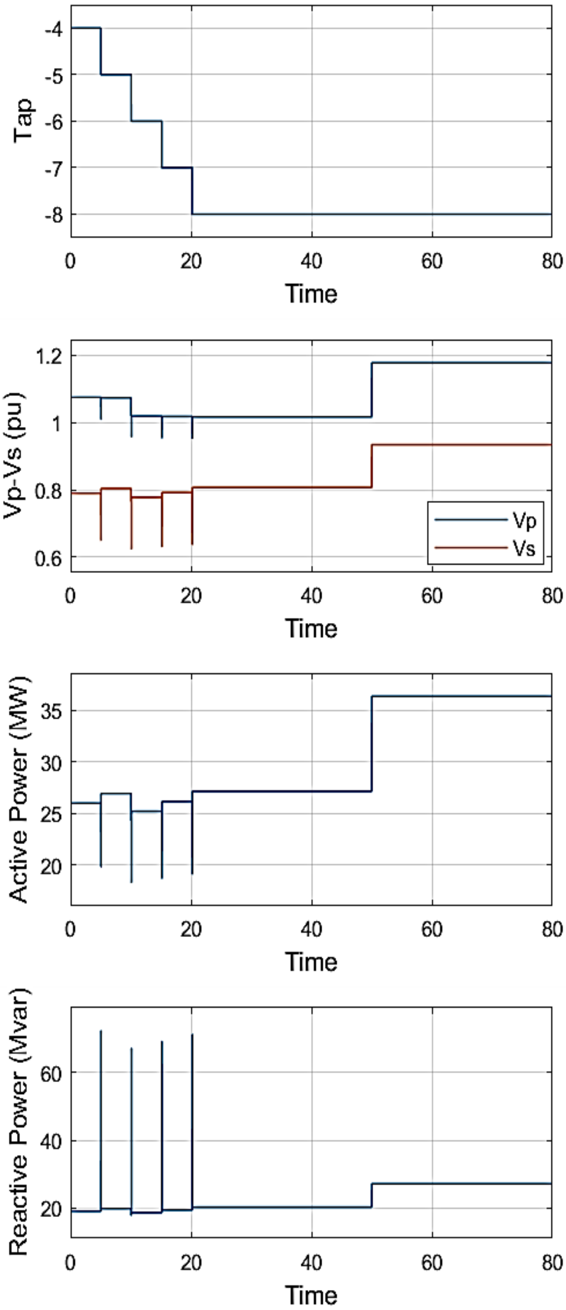

Fig. 12. Voltage and power changes with tap changing (Cos φ = 0.8)

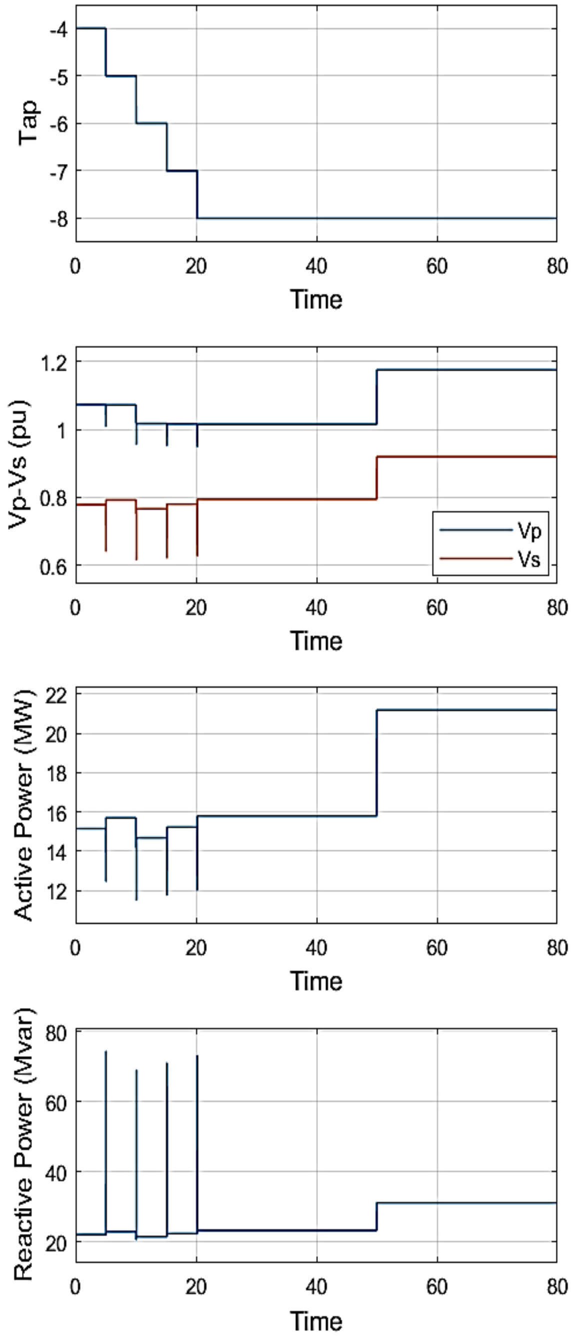

Fig. 13. Voltage and power changes with tap changing (Cos φ = 0.5)

V. IMPROVE OLTC PERFORMANCE USING SEMICONDUCTOR DEVICES

One way to improve OLTC performance is to use a transistor (MOSFET), an insulated gate bipolar transistor (IGBT), and a gate shut-off thyristor (GTO) [8]. On load Tap Changer is a device that can be used to improve voltage quality or power quality using TRIAC, which offers more benefits in reducing arc and increasing switching performance. The only advantage of using TRAIC is that it can operate in both positive and negative semicircles. Since TRAIC switching can be done at a zero degree firing angle, there will be no compatibility issues [9].

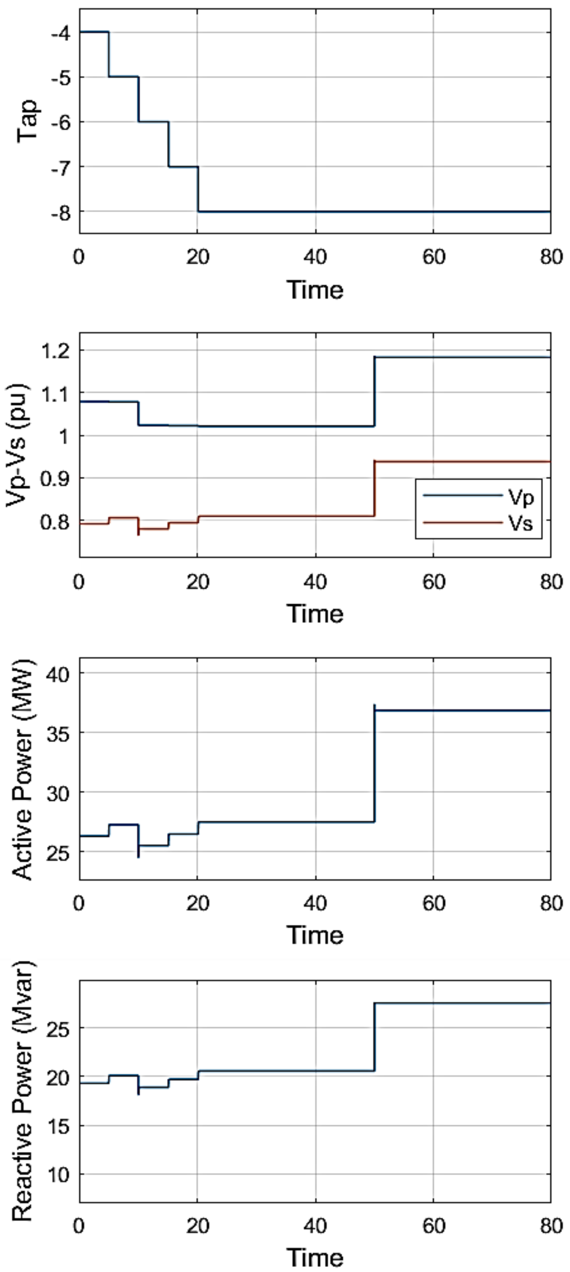

Fig. 14. Voltage and power changes with tap changing (Cos φ = 0.8)

Dynamic performance of regulator transformer can be increased by replacing the thyristor base tap changer instead of mechanical tap changer. Once again, we perform the simulation using the implementation of a pulse changer with a thyristor and compare the results with the previous step. The simulation is based on a 45 MVA output load.

As can be seen, with the use of semiconductor devices, the amount of voltage fluctuation during the change of tap is significantly reduced and the tap changer has a better performance. Therefore, the use of semiconductor equipment in the manufacture of tap changer can help to improve its performance.

VI. CONCLUSIONS

According to the obtained results, it is concluded that with increasing the amount of load applied to the transformer, the destructive effects of switching on the tap changer increase.

Also, according to the obtained results, the effect of tap changing increases in loads with inductive properties and causes more severe destructive effects. The overvoltage generated when changing the tap causes significant destructive effects in terms of insulation. Due to the sparks created when changing the tap, the tap changer in the transformers inside the main tank of the transformer has a part for the main part of the tap changer (diverter switch). This part is completely waterproof and is also tested against pressure tolerance. The inside is also filled with transformer oil. This oil is completely separate from the main tank oil and does not mix together.

According to the simulation, it is observed that the voltage in the secondary is always a deviation of 1pu. Due to the fact that in the simulated transformer, the number of taps is 8 and the rate of change of each tap is 10%, so the difference is due to the discrete amount of change of each step. The more taps or the smaller the change in each tap (for example, 1%), the better the voltage regulation and the closer the voltage is to 1pu. The number of tap changer steps usually depends on the voltage regulation in the network, but generally the standards provide these values in tabular form. The number of steps in distribution transformers is 3 and the number of steps in the sub transmission and transmission transformers is up to 31 steps. The use of semiconductor devices also has a significant effect on the better performance of the tap changer.

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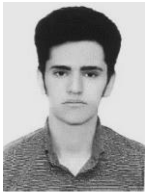

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