A Communication Technique to Improve the Performance of On Load Tap Changer of Transformer with Renewable Load

Roshni M. Virkhare, Prema Daigavane, and Hari Kumar Naidu

Abstract The regulating power transformers are utilized in industrial applications and electrical energy networks in on load tap changer. The technological advancements of mixed-type of load, including wind power on load tap changer (OLTC) are addressed in this work. The discussion and presentation of OLTC applications include the general switching concepts for OLTCs. However, on load tap changers of the mechanical type were used in the past, they had a number of drawbacks and restrictions, including arcing, expensive maintenance, poor response times, and other issues. Electronic or solid-state tap changers were adopted to solve these issues. A quick running OLTC regulator with solid-state component are added up as tap changer for controllability which consists of insulated gate bipolar transistor and thyristor to reduce arcing instead of mechanical switches. This work describes the development of a quick OLTC solid-state regulator, with results in MATLAB demonstrating the enhanced on load tap changing performance, which will be useful to the industrial experts and R&D professionals, since the drawback of under load tap changer of cumulative effect of change in load, voltage and the impedance effect is addressed by this novel technique to safeguard against voltage stability of the power system. The performance evaluation can be done by digital signal processing communication from remote.

Keywords On load tap changer · Transmission line · Resistive load · Wind generator · MATLAB

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1 Introduction

On load tap changers (OLTC) of power transformers are a crucial component for any contemporary power system. For almost 90 years, the primary elements of electrical networks and industrial applications have been power transformers with on load tap changers (OLTCs). By continuously changing the transformer ratio under load, OLTC regulates the voltage and shift phase. The two switching principles employed for load transfer operations are resistor-type OLTC and reactor-type OLTC since the beginning of tap changer development. The mechanical OLTC regulates the voltage dips but creates contact arcs in the diverter switches while changing the taps, which creates losses during tap changing and noise disturbances. This could be arrested by the use of solid state on load tap changing method.

2 Overview of the System

The functional block diagram of OLTC transformer is shown in Fig. 1.

A transformer is an electrical tool that works by using electromagnetic induction, which means electricity is created when a conductor moves through a magnetic field. A transformer has two parts called primary and secondary windings. This is mostly about moving electricity from one place to another. It's important to make sure the right amount of electricity goes into a transformer. Hence, usage of tapping is to make sure the voltage is steady based on how much the transformer can handle. Therefore taps are attached to different parts of the transformers coils, which changes the number of turns in the coils. There are ways to make this thing automatic by OLTC. Figure 2 shows the internal details of three-phase on load tap changer.

Figure 3 shows the on load tap changer mechanism with diverter switches.

Figure 4 shows tap position in on load tap changer.

Figure 5 shows the next position after tap change in on load tap changer.

3 Three-Phase OLTC Regulating Transformer Yg/(D1)-17 Positions

The three-phase tap-changing transformer (two windings) is used to represent a transformer with two coils that can be adjusted to change the voltage. The first step that changes the tap on the first part is that coil 1 is joined in the shape of a Y. Further, it connects winding 2 in two different ways either wye or delta.

The way the tap is set and controlled decides how much the transformer can increase or decrease its voltage level. When set the mode to tap control, the input signal controls where the tap is. When the voltage regulation mode is turned on, an

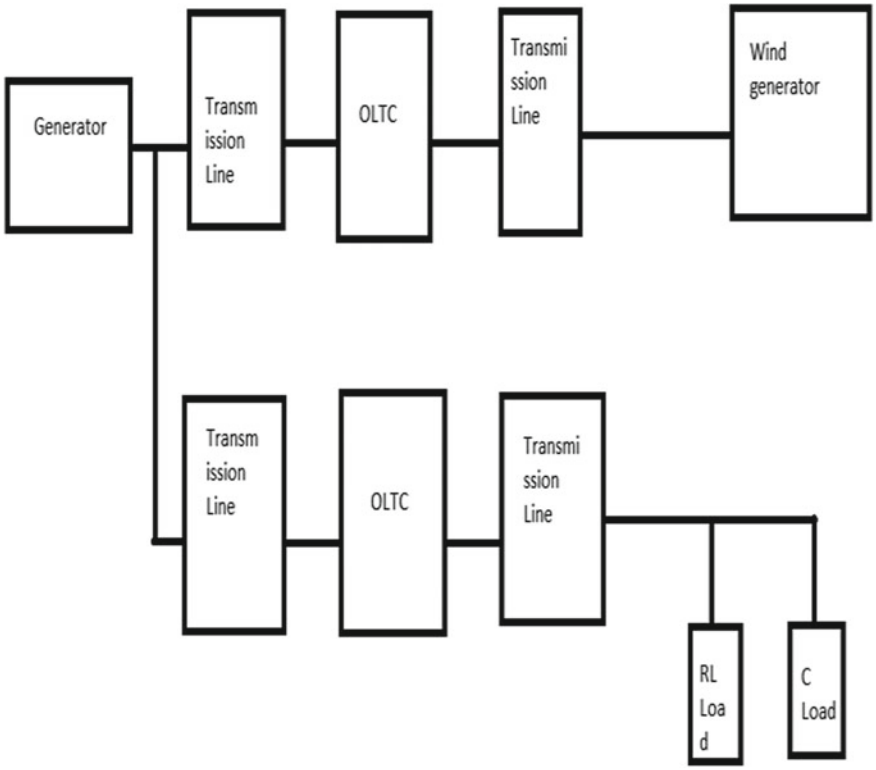

Fig. 1 Functional block diagram of OLTC transformer

internal device compares the input signal with a reference voltage and controls the position of the tap as shown in Fig. 6.

3.1 Three-Phase Mutual Inductance

In three phase, mutual inductance block helps in the setup of three-phase power systems more easily. Instead of using complicated terms, it uses simpler ones called positive and zero sequence resistances and inductances.

Fig. 2 On load tap changer

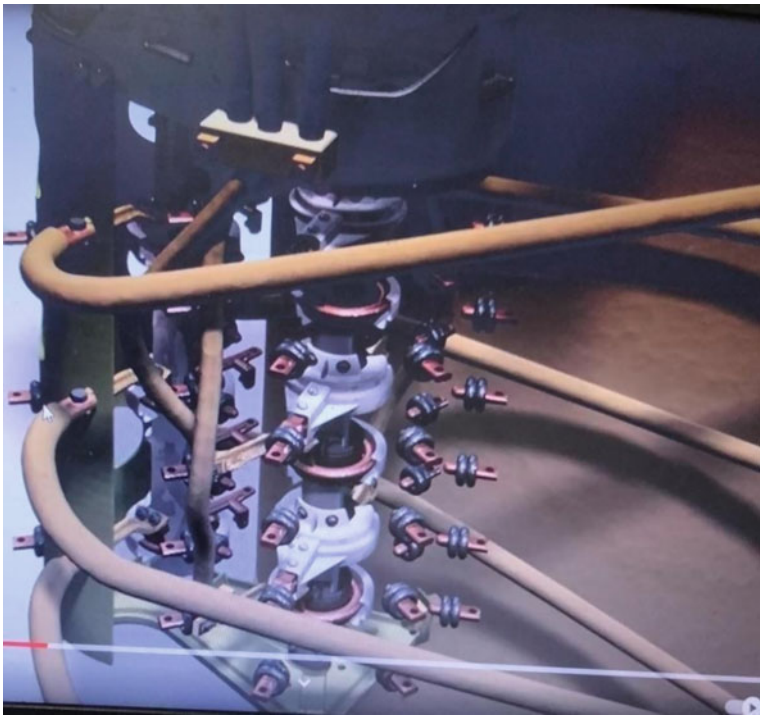

Fig. 3 On load tap changer diverter

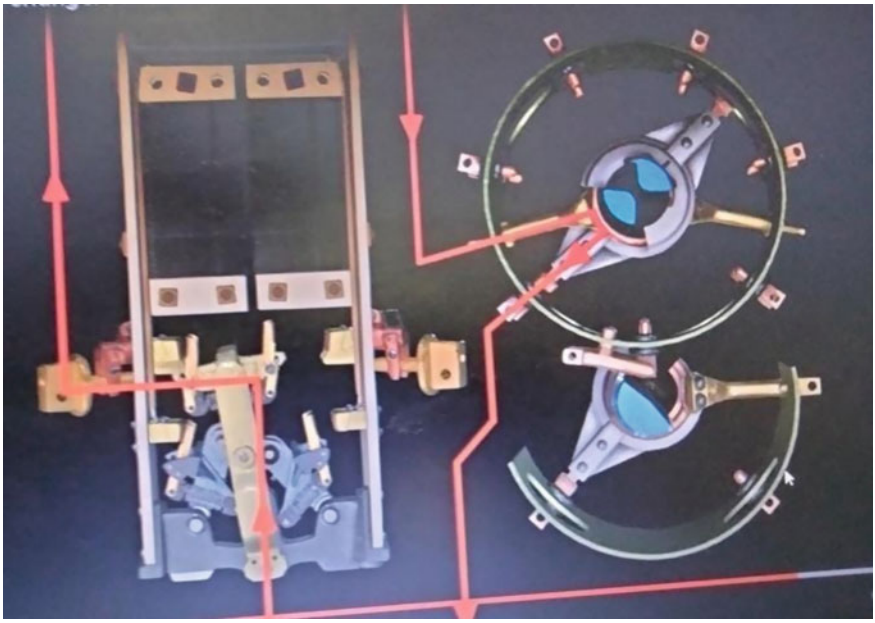

Fig. 4 Tap position in on load tap changer

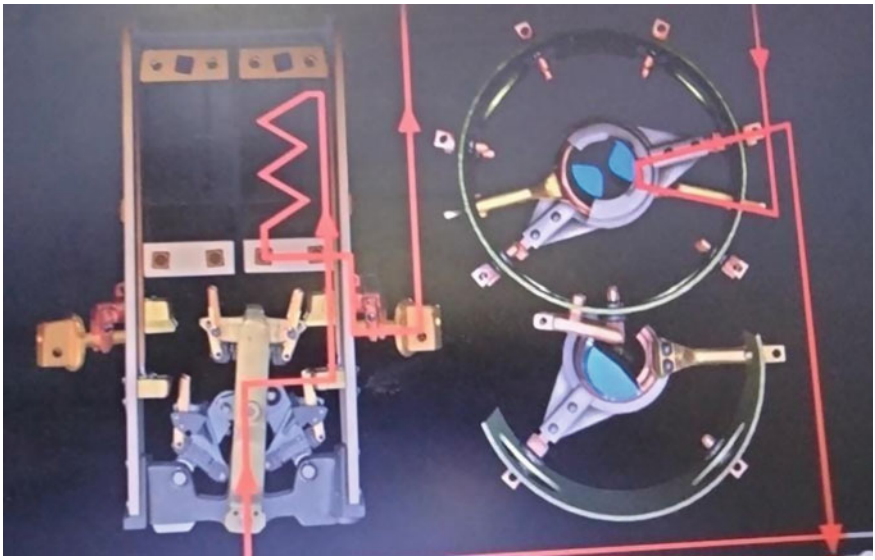

Fig. 5 Tap changing position in on load tap changer

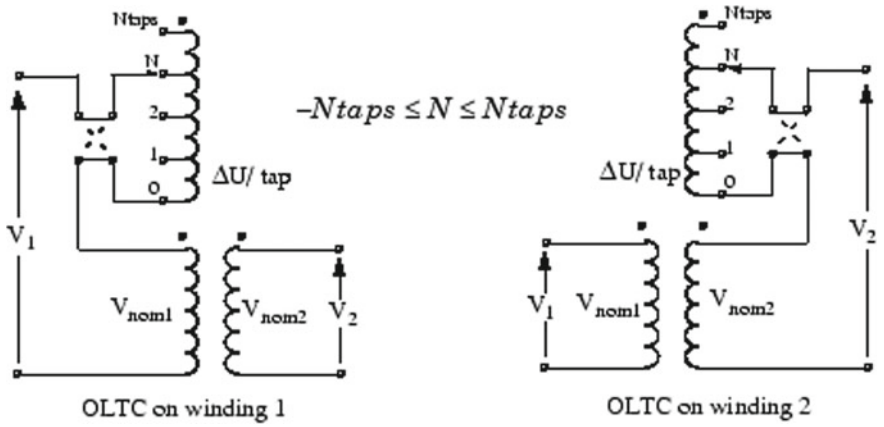

Fig. 6 On load tap changer

4 Wind Turbine and the Doubly-Fed Induction Generator System

The process of changing electricity from AC to DC and back to AC is split into two parts. The rotor and grid are converters that use power electronics to change a DC voltage into an AC voltage. A capacitor connected to the DC side works like a battery for DC power. A special tool called an inductor L is used to join grid to the grid. The rotor is connected to the grid with slip rings and brushes, while the stator is directly connected. The wind turbine turns the power from the wind into electricity, which goes into a generator. The generator then sends the electricity to the power grid. The control system monitors the convertor rotor and grid how to move by sending signals called pitch angle and voltage commands as shown in Fig. 7.

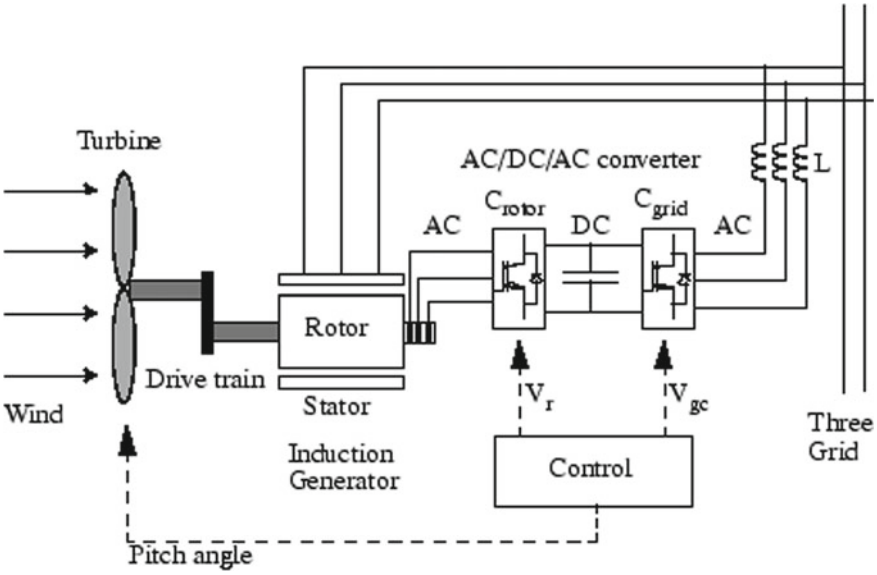

Fig. 7 Block diagram of wind turbine

5 The MATLAB On Load Tap Changer Simulation Model is Shown in Fig. 8

See Fig. 8.

6 Smooth Variation of Voltage

Phasor simulation of on load tap changer (OLTC) regulating transformer gives smooth variation of transformer taps 1 and 2, voltage in per unit B1, B2 and B4, reactive power Mvar B1, B3 and real power MW B1, B3. The results obtained by this new technique which are shown in Fig. 9 address the variation of three-phase smooth voltage by introducing positive and zero sequence resistances and inductances.

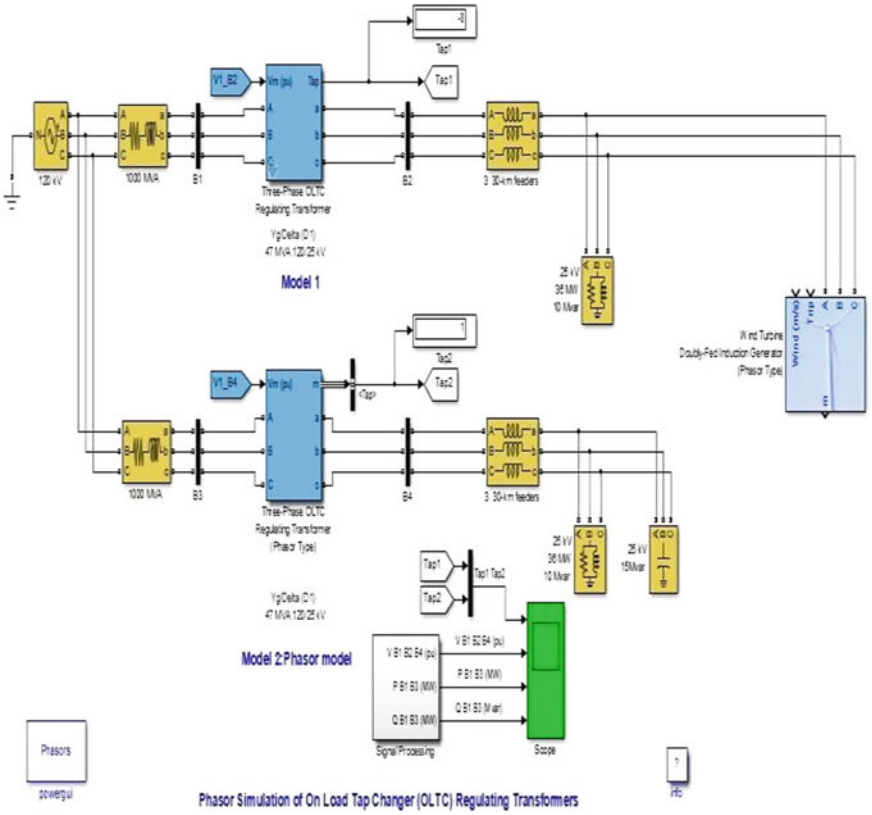

Fig. 8 On load tap changer simulation model

7 Analog to Digital Signal with PCM

On line performance monitoring from remote through digital communication system of on load tap changer process is as shown in Figs. 2 and 3.

The steps in conversion of analog to digital signal goes through filtration to limit bandwidth and thereafter PCM encoder consisting of sampling, quantizing and encoding. The elements of PCM system are transmitter, transmission path and receiver as shown in Fig. 10.

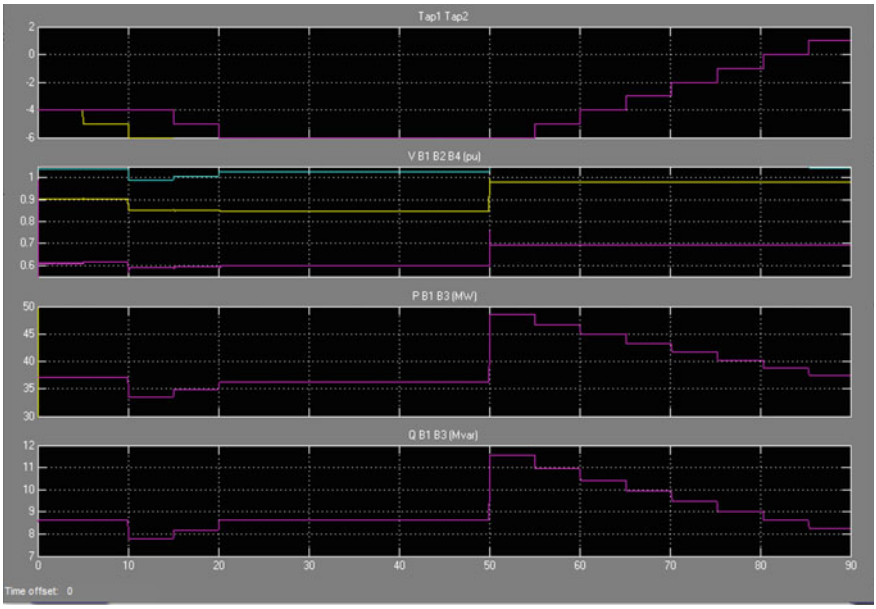

Fig. 9 Smooth variation of voltage

8 Results

In a radial transmission line connected through the transformer and if the load is being increased gradually. The action of the under load tap changer (ULTC) is to maintain the voltage at load terminal by changing the transformation ratio N1/N2, when applied voltage is same; however, when the load impedance is reflected on primary side of the transformer the input impedance gets reduced and it further reduces the voltage, and in turn, ULTC tries to increase the voltage which is cumulative phenomena results into voltage stability situation.

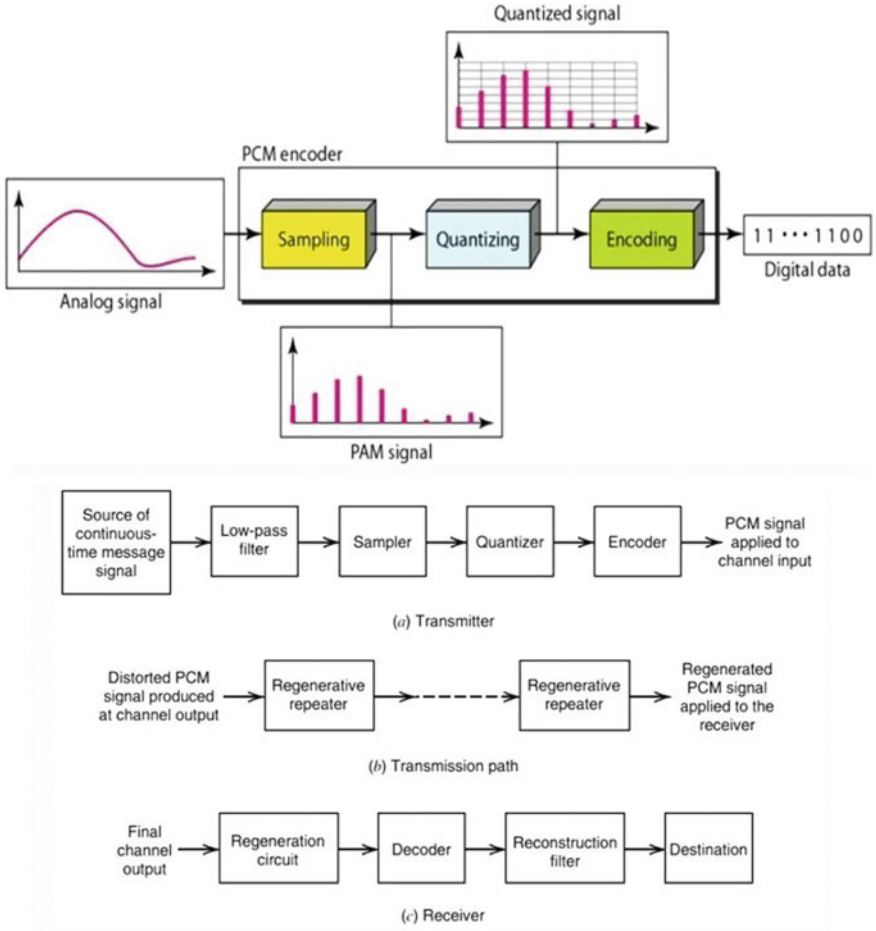

Fig. 10 Analog to digital signal with PCM

9 Conclusion

The performance result indicates that the on load tap changer operates satisfactorily during the load including wind energy, without causing sparking in the diverter chamber and thus protecting the transformer from fire hazards. Also the results indicate the input impedance effect reduction due to change of load has little effect on the performance of on load tap changer due to the introduction of positive and zero sequence resistances and inductances. The performance evaluation can be done from remote by digital communication technique.

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