VOLTAGE BASED TAP POSITION INDICATOR

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Abstract : On-Load Tap Changer (OLTC) is indispensable in regulating power transformers used in electrical energy networks and industrial applications.
It is a mechanism in transformers which allows for variable turns ratios to be selected in discrete steps. Transformer with this mechanism obtains the variable turn's ratio by connecting to a number of access points known as taps. These taps are indicated using moving contact potentiometer. This is operated by the rotation mechanism.
The proposed work explains technological improvement in indicating the tap position based on different voltage tapping on primary side and to maintain secondary side be consistent voltage using Arduino and required programming.

I. INTRODUCTION

Power transformer equipped with On-Load Tap Changer has been the main components of electrical networks and industrial applications for nearly 90 years. OLTCs are mainly used to maintain output voltage for a transformer at nominal level, which usually varies due to various load conditions and long distance distribution.

The OLTC changes the ratio of transformer by adding or removing coil turns on primary side. So that the tapped winding which will connect to the OLTC match to maintain secondary voltage.
Usually the power transformer is designed with 17 tapings, equipped with +5% (above rated tapping) and -15% (below rated tapping) of turns correction (each step provides ~1.25% variation). These taps are always provided at the HV windings of the transformer as current at the HV side is lower, these safeguard contacts, cost effective as tap changer contact leads can be taken in smaller sizes and also risk of current interruption is less.

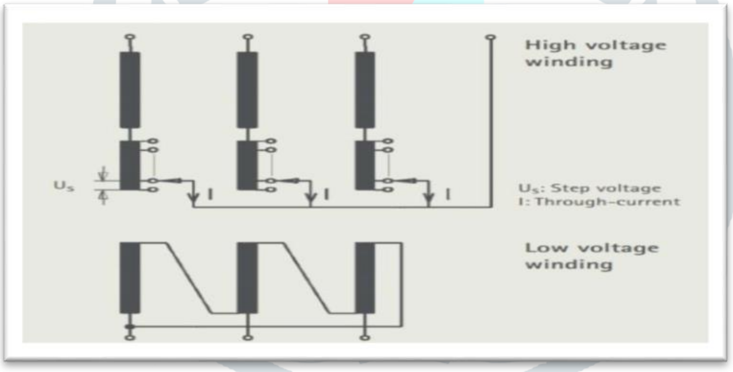

Figure 1: Principle winding arrangement of regulating transformer in wye-delta-connection.

The above figure shows diagram of typical power transformer, the primary side winding (HV winding) consists both main winding and tapped winding, among which tapped positions from all three phases are connected to OLTC. Thereby increasing or decreasing the number of turns on primary side winding by changing tap position, the secondary voltage (LV side) is maintained at nominal predefined voltage.

The ratio of transformer is given by
$N1/N2=V1/V2$
Where, N1=No of turns on primary side i.e., HV side
N2=No of turns on secondary side i.e., LV side
V1=voltage refer to primary winding
V2= voltage refer to secondary winding

From above ratio, as number of turns on the primary side increases, the voltage across the primary side increases, to keep-up secondary voltage constant. But the transformer is designed and constructed in such a way that it will not make and break load current. To maintain continuity throughout, many tap selector switches are used to select one among physical tap position on the transformer winding. They are distinguished into even and odd banks, which eases switching operations and smoothen switching between the banks using a heavy duty diverter switch. This can also work during under load condition.

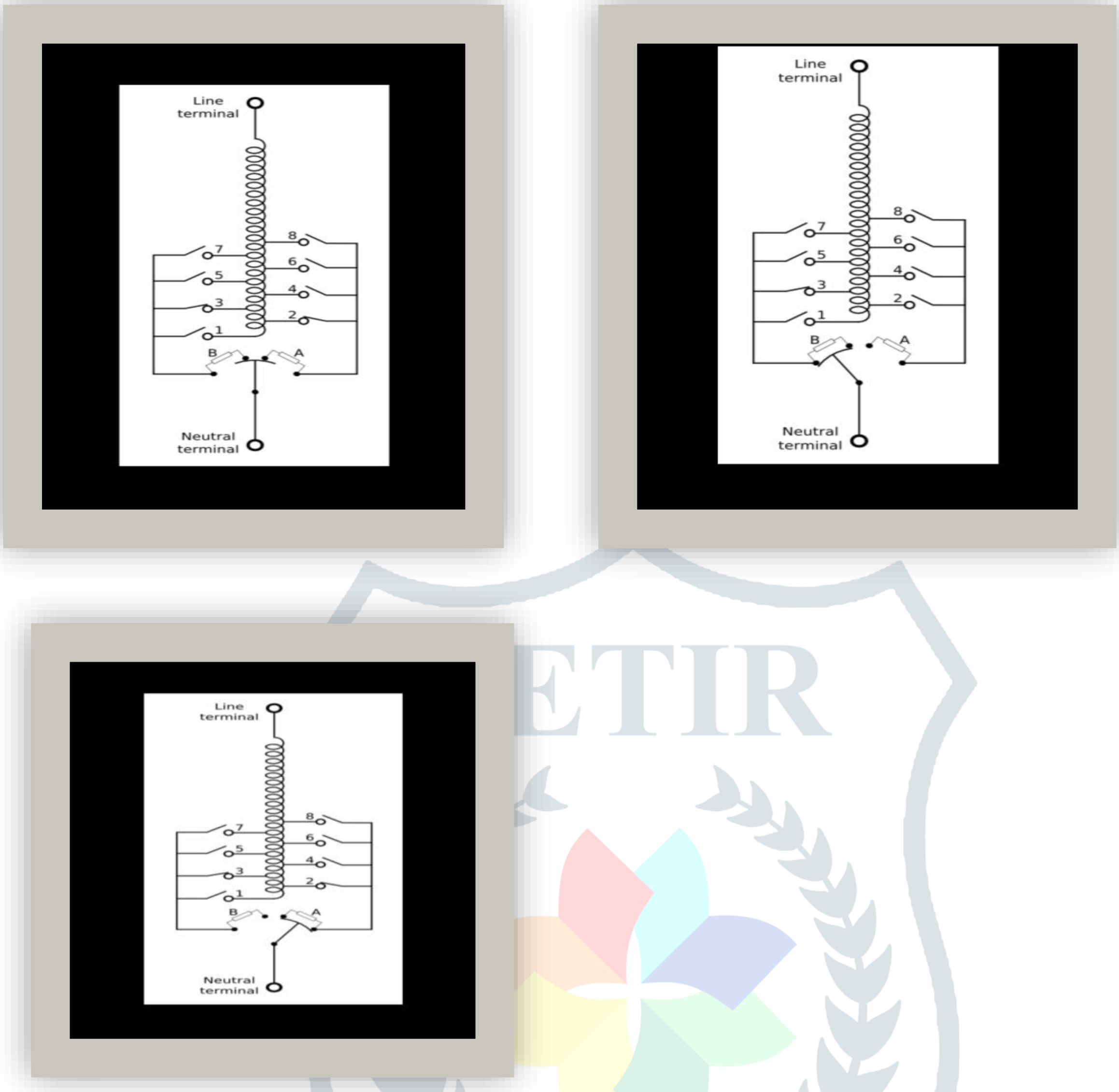

Figure 2: Diverter switch switching between the selector switches.

The change in voltage is due to corresponding variations of turns with respect to the tap position. This is indicated by “Tap Position Indicator”.

At present, in all substations, power transformer tap position is indicated by moving potentiometer which is contact type tap position indicator is operated using rotational mechanism. It includes a contact dial which is connected to the series resistors from 1k ohm to 17k ohm (each tap is indicated by 1k ohm, ex: for 5k ohm it represents fifth tap). The contact dial to be rotated manually when tap change is required from one position to other. According to resistance value which was selected by contact dial the position is indicated i.e., if the contact dial hand points to 2k ohm then tap position will be two.

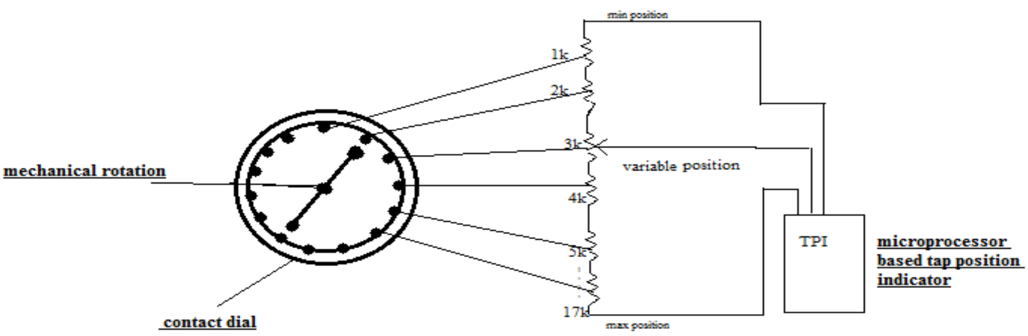

Figure 3: Project implementation area

This method is prone to a lot of errors while indicating tap position: Improper contact with resistors, accumulation of dust in contacts, loose connection of wires, corrosions due to high temperature and oxidations may lead to incorrect tap position indication.

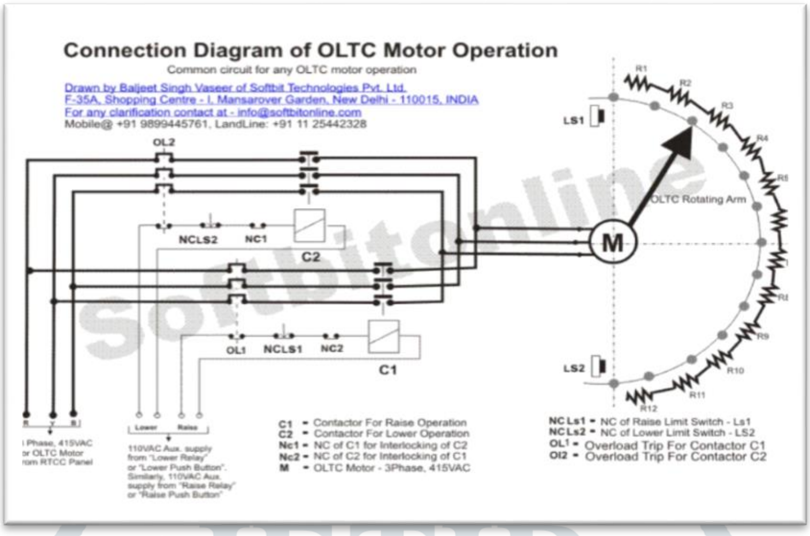

Figure 4: Oltc circuit diagram

Figure 5: Current rotary position changer

To overcome many such problems, we are implementing voltage based tap position indicator.

METHODOLOGY:

The voltage based tap position indicator works from output voltages obtained from the potential transformer which are connected across both sides of Power Transformer (i.e., HV side and LV side).

As we are designing the tap position indicator for a three phase power transformer (66000/11000V). To obtain the nominal voltage level of 11000KV at LV side, voltage across 66000V (HV side) needs to be varied in by changing tap position.

BLOCK DIAGRAM:

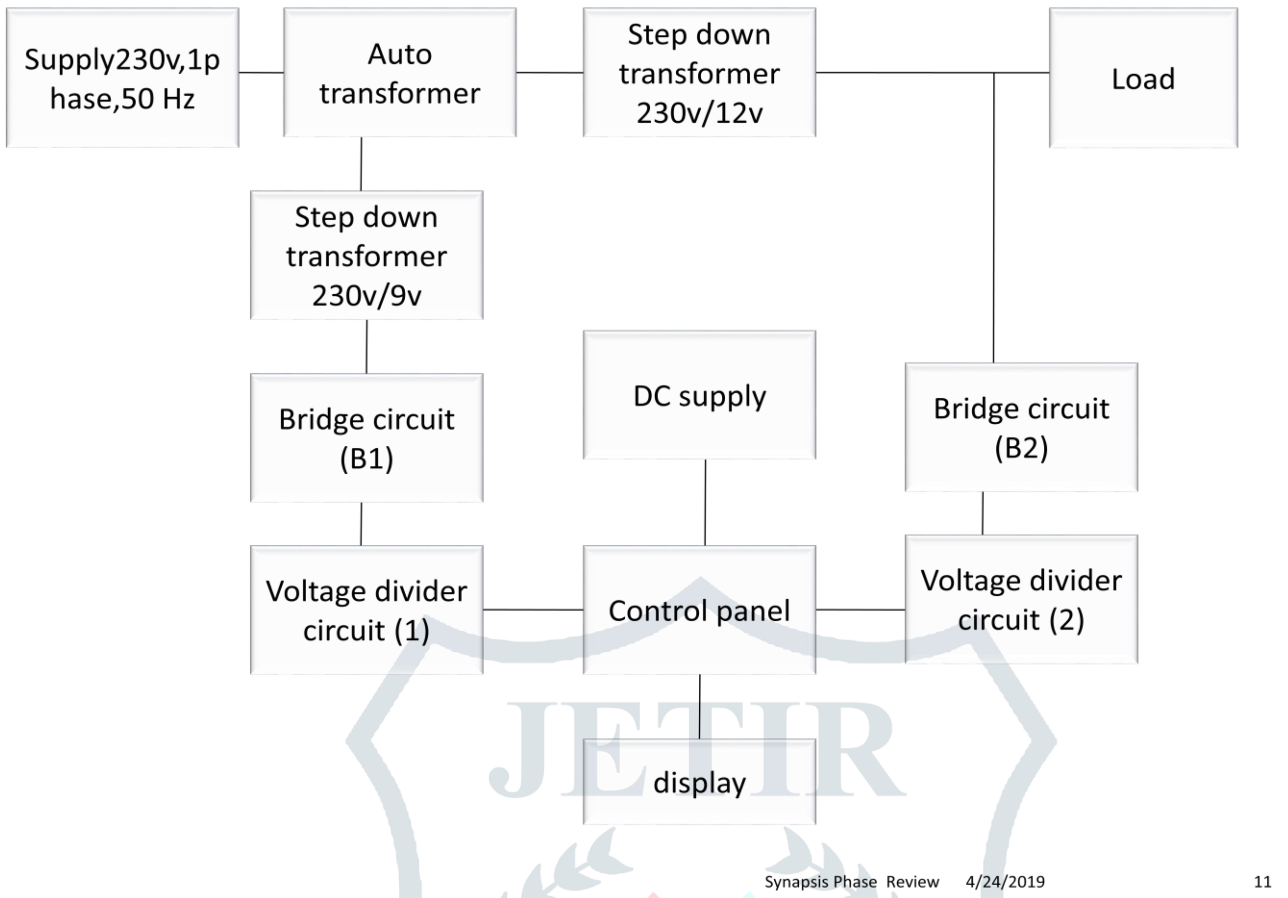

Figure 6: Block diagram of voltage based tap position indicator

Table 1: Ratio tabulation for Tap Positioning

Tap position (no)	Primary voltage V1(volts)	Secondary Voltage V2(volts)	Ratio for Star connection	Ratio for delta connection	Tolerance
1	69300		6.3	10.9119	
2	68475		6.22	10.7820	
3	67650		6.15	10.6521	
4	66825		6.075	10.5222	
5	66000		6	10.3923	
6	65175		5.925	10.2624	
7	64350		5.85	10.1324	10.1324-10.0025
8	63525	11000	5.775	10.0025	=0.1299
9	62700		5.7	9.8726	
10	61875		5.625	9.7427	0.1299/2=0.0649
11	61050		5.55	9.6128	
12	60225		5.475	9.4829	
13	59400		5.4	9.3530	
14	58575		5.325	9.2231	

15	57750		5.25	9.0932	
16	56925		5.175	8.9633	
17	56100		5.1	8.8334	

The potential transformers connected to both sides of the power transformer measures the voltage by stepping down to 110v as per IS. i.e., at HV side 66000V/110V and at LV side 11000/110V.

At HV side, the potential transformer ratio is given by:
66000v/110v=600 (HV side reference potential transformer ratio)
At LV side, the potential transformer ratio is given by:
11000v/110v=100 (LV side reference potential transformer ratio)

Three phase to phase voltages form each potential transformer is taken and average is calculated for values from both sides. To obtain the tapping voltage, average obtained is multiplied with reference to potential transformer ratio on both sides.

Example:

Primary side samples (HV side): **Secondary side samples(LV Side)**

V_{RY}=110.5V V_{ry}=110.2V
V_{YB}=110.6V V_{yb}=110.3V
V_{RB}=110.7V V_{rb}=110.4V
Average HV Side Average LV Side
V2=110.6V V2=110.3V
Hence,
V1/V2=600 (ratio of PT at HV side) V1/V2=100(ratio of PT at LV side) V1=600*V2.
=600*110.6V V1=100*V2=100*110.3
=66,360V =11,030V

Now the ratio of the power transformer will be:
66,360V/11,030V=6.0163(voltage ratio when in star topology)
For delta topology: it is as follows.
= 6.0163*sqrt(3)
=10.4205 (it is between the tapping 4 and tapping 5)

During occurrences of Tolerance ratio: Delay is introduced to microcontroller; so as to match designed ratio and corresponding Tap Position.

ADVANTAGES:

- This system has backward compatibility: That is without much changes it can be adapted to present system.
- Requires minimal production and commissioning time: Easy to make and implement.
- Manual errors are minimized: Uses sensors to read voltages and hence can display tapped positions easily.
- Cost effective: Very minimal expenditure for production of each unit.

ENHANCEMENTS:

- This can be input for AVR system
- An improved; very cost effective AVR can be built, as extension to this system.

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