Discussion on Secondary Voltage of Distribution Transformers- IS 1180(Part 1)

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This is a short treatise on the choice of secondary voltage of a Distribution transformer up-to a voltage of 33000 **which has an OLTC for regulating a steady output voltage from the Secondary** when variations occur in the Primary side or the Load side. We use a 17 position OLTC for the purpose of this discussion.

What the Standards Say:

In 2019 the fourth revision of the IS 1180 (Part 1) :2014 was Reaffirmed.
In clause 6.3, clause 7.3, and 8.3 the nominal system voltage is defined. While all the voltages from 3.3 kV to 33 kV are specified for the High Voltage for Low Voltage side only 415 V is specified. While in the clause 6.5 and 7.5 and 8.5, No-load Voltage of Secondary is specified as 433-250V a note that is appended says, "Secondary voltage may be selected as 415 -240V subject to agreement between the user and the supplier".
In addition, the British standard includes even 400V in the specification if the user has such a voltage in his premises.

Indian Scene:

But even today we see most specifications from transformer manufacturers asking for OLTCs to regulate +5%to -15% specifying that the transformer secondary voltage is 433 for both 33kV as well as 11kV primary voltages. While this information of the value of the secondary voltage is of no importance to the design of the OLTC, the regulation range is important in fixing the **normal tap position which is 5 in case of +5 % to -15%, and the tap position is 9 in case of +10%to -10% and the incoming voltage will be 11kV in case of a 11kV transformer.**

The problem with specifying 433V:

In most private premises that have a transformer the low voltage distribution is less than 100 feet away from the transformer. Therefore 433 Volts will appear as 250 V in all the single-phase distribution and as 433 V in 3phase. The bulbs are rated for 230Volts and the motors are rated for 400V. (German motors are 390V). When the incoming is 11kV the bulbs are likely to fuse and the motors are likely to get heated if the voltage exceeds 11 kV.

An ingenious (!!!) solution is thought of by the end user. They set the AVR at 400 V instead of 433V which is the normal voltage for the transformer and

expect the OLTC to work to reduce the voltage. 400V is about 7.5% less than the designed normal voltage. This is 6 positions (1.25%/position) as measured by the OLTC.
But the OLTC has only 4 positions to move as the normal tap is Position Number 5 (for +5% /-15%). The OLTC moves to position 1 and stands there with the out put voltage of 411.35V. In this condition when the incoming voltage is 10.16 kV the secondary voltage will be 400 V. The OLTC will move to tap position 5 which is the normal tap and now re-designated as 400V by the altered setting of the AVR at site. When the voltage goes to 9.35 kV which is 15% less than 11 kV the out pot will be 368V. This is 32 volts less than 400V and is 8% less. This represents 6 steps or position 11. Therefore, instead of occupying position 17 the OLTC will stand at position 11.

By designing a transformer for 11kV/ 433V and operating it for 400V by setting the AVR wrongly there is no scope to regulate the voltage if it exceeds 11 kV. This will cause damage to sensitive electronic equipment and to light bulbs. Also, the positions beyond position 11 may not be used by the OLTC if the voltage does not go below 9.35 kV. Please see Table below.

<u>OLG RECOMMENDS:</u>

The transformer designer should consult the site to ascertain the voltage pattern at the end-user’s site before specifying the output voltage. It should be borne in mind that the industrial users have the LT Distribution in close proximity to the transformer and the voltage drop is not a major problem. If the LT distribution provides for adequate cable sizes all through then even 410 Volts no load voltage with assured 400Volts at the usage point will ensure 230V on single-phase equipment. The entire range of 17 positions the OLTC can be used effectively. In fact OLG strongly assures that all their OLTC can handle 2.5% step capacity and their 9 position OLTCs will perform very well in both 11kV and 33 kV applications in ampere ranges up-to 300Amps.

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Table:

Position of the TPI at 433Volt and 400 Volt settings of the AVR for 5%/-15% Regulation

Voltage kV/volt	Pos at 433 volts setting	Pos at 400 volts setting (pos) /Indicated Pos
11+5% / 455	1 raise	Not available. (-5). 1
11+3.75%/ 449.5	2 raise	Not available. (-4). 1
11+2.5%/ 444	3 raise	Not available. (-3). 1
11+1.25%/ 438.5	4 raise	Not available. (-2). 1.
11+0 /433	5 normal tap	Not available. (-1). 1
11-1.25%/ 427.5	6 lower	Not available. (-0). 1
11-2.5%/ 422	7 lower	1
11-3.75%/416.5	8 lower	2
11-5.0%/411	9 lower	3
11+-6.25%/405.5	10 lower	4
11-7.5%/400	11 lower	5normal tap
11-8.75%/394.5o	12 lower	6
11-10.0 %/389	13 lower	7
11-11.25%/ 383.5	14 lower	8
11-12.5%/378	15 lower	9
11- 13.75%/ 372.5	16 lower	10
11- 15.0%/ 367	17 lower	11

Note: Pos (-0) to (-5) or imaginary and will be limited to Pos 1 in reality due to the end limits of the OLTC.