Using Tap Changers to Match the System Voltage

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A transformer’s rated voltage may not match the system voltage exactly, or it may be necessary to raise or lower the output voltage to supply a certain load. In these cases, a portion of a winding can be removed or added to change the transformer turns ratio.

The simplest tap-changing device operates on a “break before make” principle and changes taps on the primary winding.

Obviously, such a device cannot be operated when the transformer is carrying load or even when the transformer is energized because it would break load current and/or magnetizing current otherwise. This device is called a tap changer for deenergized operation.

Years ago, it was called a no-load tap changer, but this description has fallen out of favor because the name implies that it can be operated when the transformer is energized but not carrying load, which is not the case. Most tap changers for deenergized operation have a total of five tap positions.

There are usually two tap positions above the nominal voltage rating and two tap positions below the nominal voltage plus a tap at the nominal voltage.

The voltage increments between taps are generally 2 1/2% of the nominal voltage, so the full tap range is ±5%.

A rotary drum-type tap changer and the winding connections are shown in Figure 1. An insulated rotating shaft aligns a spring-loaded shorting wedge between pairs of hollow cylindrical electrodes. The winding taps are connected to the cylindrical electrodes by soldering or brazing.

Different manufacturers have used other rotary tap changer configurations and mechanisms with linear movement are available. The tap changers for deenergized operation are usually mounted above the transformer core and coil assembly to make inspection and maintenance possible. The taps are changed by a wheel on the outside of the trans-former that locks in each tap position with indicating markers to show what tap the transformer is on.

In three-phase transformers, the tap changers of all three phases are mechanically ganged together so that all three phases are always on the same taps.

If the tap changer is in the primary winding, then the primary current increases with respect to the load current on the lower taps, increasing the primary winding current with respect to the load current. The fact that part of the winding resistance is removed from the circuit on the lower taps partially compensates for the increased current; however, the lowest tap still has the highest total $I^2R$ losses for a given load current.

The winding taps are always in the middle portion of the winding to keep the magnetic center aligned with the other windings as sections of the winding are removed from the circuit by changing taps.
Since the winding is never quite balanced on two of the five taps, the winding can be split into three sections, as shown in Figure 2. This arrangement requires two tap-changing mechanisms per phase, but the magnetic center of the winding is always aligned at the number 6 tap to help control short-circuit forces.

Tap changers for deenergized operation are designed to be moved *infrequently*. The tap settings are generally specified for the particular location on the electrical system and the settings do not change unless system conditions permanently change.

Because a good electrical contact often depends on contact "wiping" it is generally a good idea to operate the tap changer periodically (when the transformer is out of service) to wipe the contacts clean. The contacts themselves are generally silver- or tin-coated since bare copper has a tendency to develop a copper sulfate film under oil which increases the contact resistance. 

*This can lead to a thermal runaway effect from oil coking.*

As the temperature around the contacts increases, the oil around the contacts can coke or turn into carbon. This forms a carbon film that can actually force the contacts apart so the load current must pass through a layer of high-resistance carbon. This increases the temperature still further, leading to more coking and so forth until the contacts overheat and are destroyed.

After a tap changer is operated, it is important that the tap position is verified by a transformer turns ratio (TTR) test. There have been numerous cases where the tap changers of one or more phases were not correctly aligned even when the external markings indicated that they were.

Energizing a transformer with tap changer contacts parted will result in immediate failure when the winding current arcs across the gap.

*Resource: Power Transformers (Power Engineering) – J. Winders*

*Source:*