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Commutation System Analysis

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Commutation System: On-Load Tap-Changer (OLTC) Analysis

I. System: On-Load Tap-Changer (OLTC)

System description: The on-load tap-changer provides uninterrupted voltage regulation of transformers under load. The voltage is regulated by changing the voltage ratio. This is done in steps. The transformer is equipped with a tap winding whose tappings are connected with the tap selector of the on-load tap-changer.

II. Components (incomplete)

1.) Load gear of the motor drive
Gear to transmit the mechanical power generated by the drive motor to the drive shafts.

2.) Control unit and control gear inside the motor drive
Electrical system which receives and processes external control impulses and controls all electrical processes of the commutation system.

3.) Diverter Switch
Major on-load tap-changer component which is used to transfer the load from the selected to the pre-selected tap without interruption of the transformer load current. Diverter switches are installed in the tap-changer oil compartment, which separates the tap-changer oil from the oil of the transformer main tank. The diverter switches of OILTAP® tap-changers are equipped with arcing contacts that operate under oil, whereas in case of VACUTAP® tap-changers vacuum bottles interrupters are used.

4.) Transition Reactor
Impedance as part of a reactor-based on-load tap-changer. The reactor's function is to limit the circulating current between two taps during the commutation process in order to avoid a short circuit between these taps.

5.) Through Bushing
???????????

6.) Drive Shaft of the Diverter Switch
Major part of the OLTC which operates both the diverter switch and the selector by transmitting mechanical force from the OLTC's gear unit to the commutation system.

7.) Electrical Connections of the OLTC
All electrical conductors inside the OLTC, such as contact leads, connections between the diverter switch and the selector, connections between the regulation winding and the selector etc.

8.) Electrical Connections of the Motor Drive Unit
All electrical conductors inside the motor drive's housing, such as electrical wiring.

9.) Selector and Pre-Selector Contacts
Electroconductive components of the OLTC's selector and pre-selector which mechanically connect and disconnect the taps of the regulation winding to the diverter switch. The selector and pre-selector contacts always operate off load.

10.) Mechanical Blocking of the End Position
Physical barrier as part of the diverter switch to avoid tap-changer operation beyond one of the end positions.

11.) Auxiliary Contacts (???)
??????????????????

12.) Oil Filter Unit
Filtering device to clean the tap-changer oil from solid particles and/or humidity.

13.) Drive Shaft and Bevel Gear
The drive shaft is the mechanical connection between motor drive and tap-changer head. The bevel gear serves for diverting from the vertical to the horizontal direction.

14.)Heater and Heating Circuit
Electrical installation inside the motor drive housing to protect the inside from condensed water and frost damage.

15.) Tap-Changer Insulating Oil
Oil with certain lubrification and insulation properties.

16.) Insulating Cylinder of the Diverter Switch
Cylindrical spacer made of an insulating material to ensure a certain insulation distance between the energised parts of the diverter switch and the transformer tank.

17.) OLTC Oil Compartment
Cylindrical container of the diverter switch insert which is made of an insulating material and filled with tap-changer oil. The oil compartment contains the diverter switch and insulates its conductive parts against ground and the active component of the transformer.

18.) Olhais de Suspensão (???????????)
???????

19.) Pre-Selector
Mechanical arrangement as part of the OLTC tap selector which preselects the coarse tap or reverses the regulation winding of the transformer.

20.) Motor of the Motor Drive Unit
Electrically driven motor used to operate the tap-changer

21.) Hand crank
Hand crank for manual operation of the motor drive's load gear

22.) Illumination circuit
Electrical circuit to supply a lamp to illuminate the interior o f the motor drive's housing

23.) Lubricating Oil of the Motor Drive Unit
Lubricant for mechanically moved parts of the motor drive.

24.) End Position Switch
Cam-operated switch inside the motor drive unit which is activated in one of the two end positions to ensure the drive not being driven beyond an end position by disabling the motor supply circuit.

25.) Remote Control Device
Electronical device to initiate a tap-changer operation by sending an impulse to the motor drive unit.

26.) Oil Conservator
Tank which is physically located above the tap-changer's head and connected to the oil compartment by pipes. The oil conservator is partly filled with tap-changer oil. Ensures that no air gets into the OLTC due to expansion and contraction of the tap-changer oil because of temperature variation.

27.) Dehydrating Breather
Device to deshumidify the air which flows into or is blown out of the OLTC by leading the air through a humidity filter, usually silica gel.

28.) Tap Selector

Connects a common terminal to a multiplicity of leads connected to the tap-winding of a transformer. Tap selectors are usually arranged beneath the tap-changer oil compartment and are immersed in the insulating oil of the transformer main tank. A tap-changer with change-over selector allows the tap selector to move through a second revolution and thus can increase the tapping range.

29.) Motor-Drive Unit

The motor-drive unit is used for operating on-load tap-changers as also off-circuit tap-changers in regulating transformers. It works by adjusting the operating position of tap-changers to the individual operating requirements. The motor-drive is started by a single control pulse, either given manually or triggered by a voltage regulator

30.) Energy Accumulator

Spring system as a part of the OLTC to guarantee the very fast commutation between two taps. The energy accumulator operates, when released, the diverter switch within milliseconds.

31.) Contact Leads

Conductor to electrically connect the diverter switch's contacts to the outgoing contductor, (star point in star point applications).

32.) Local-Remote-Switch

Manually operated switch that is a part of the motor drive, which enables the operator to select between a local and a remote impulse to initiate a motor drive operation. Usually the local is given by the "raise" and "lower" pushbuttons at the motor drive whereas the remote impulse is provided by an automatic voltage regulator.

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III: Faults/Defects of Componente (Incomplete)

1.) Load gear of the motor drive

a) Impossibility of operating the gear due to technical failure

2.) Motor drive cabinet and control gear inside the motor drive

a) Failure due to acess of humidity into the motor drive cabinet which eroded electrical connections or caused short circuits.
b) Malfunction of the tightness of the motor drive cabinet
c) Operational error in the control cabinet or at the control gear

3.) Diverter Switch

a) Failure due to mechanical wear of moving parts

b) Increased resistance of diverter switch contacts
c) Contact failure in the diverter switch
d) Impossibility of mechanically operating the diverter switch

4.) Transition Reactor
a) short circuit inside the reactor
b) lowered level of insulation of the reactor
c) interrupted circuit at the reactor
d) Change in the reactance value

5.) Contact Leads
a) Mechanical wear of lead material or even torn lead

6.) OLTC Gaskets
a) Material erosion of OLTC gaskets
b) Access of air, dirt and/or humidity into the tap-changer's interior

7.) Energy Accumulator
a) Loss of energy storage capacity of the accumulator springs
b) Breakage of one or more accumulator springs

8.) Oil Filter Unit
a) Incorrect connection of the oil filter unit to the oil pipes
b) Corrosion or separation of the filter material
c) Saturation of the filter
d) Pump motor fases are connected in the wrong order
e) Failure of the oil filter unit control
f) Loss of tightness against access of air, dirt and/or humidity into the oil circuit

IV. Functions (Incomplete)

1.) Operate the commutation mechanism
The commutation mechanism of the OLTC can be operated manually by means of the hand crank at the motor drive, manually via an electrical impulse to the motor drive or automatically via an automatic voltage regulator.

2.) Block the OLTC beyond its end positions electrically and mechanically
The blocking beyond the end positions is done automatically in the motor drive unit. It is needed to protect the motor drive unit and thus the OLTC from connecting the first and the last tap of the regulation winding. The drive blocking is first realised electically and, if the electrical blocking does not work, mechanically. There is another mechanical blocking beyond end positions in the OLTC itself.

3.) Initiate a tap change operation manually
Tap change operations are initiated manually via manual switches and received as electrical impulses at the motor drive unit, which will start a tap-changer operation.

4.) Initiate a tap change operation automatically
Tap change operations are initiated automatically by an automatic voltage regulator. The regulator measures the voltage to be regulated and compares the actual value with a desired value. In case of deviation it gives an electric impulse to the motor drive unit, which will start a tap-changer operation.

5.) Change a tap of the regulation winding
A tap change is carried through by operating the OLTC. This can be done manually by means of the hand crank, manually via an electrical impulse to the motor drive or automatically via an automatic voltage regulator.

6.) Connect the OLTC to the transformer windings
??? (OLTC is steadily connected to the regulation winding and does not need to be connected by the operator)

V. Failure of Functions/Malfunction (Incomplete)

1.) The commutation mechanism cannot be operated
The commutation mechanism of the OLTC cannot be operated manually nor automatically but the motor drive works. This indicates a mechanical failure of the system. The reason can be a failure of the drive shafts and the bevel gear or a failure of the OLTC itself.

2.) Operation of the OLTC beyond its end positions
Operation of the OLTC to an undefinded position beyond its end positions, in which

3.) Initiating a tap change operation manually is not possible
When pressing a push-button at the motor drive unit to initiate a tap-changer operation, the drive does not react due to an electrical failure of the motor drive. This could be a defect as well as a wrong connection.

4.) Initiating a tap change operation automatically is not possible
The automatic voltage regulator, which is used to operate the tap-changer automatically, does not give impulses to the motor drive unit and thus does not initiate tap changes due to a failure of the regulating system. This can be a defect of the regulator itself as well as a faulty connection.