Basic Load Tap Changer Operation
Topics

● Basic Transformer Theory
● Differences from LTC’s to DETC’s
● LTC Definitions
● Transformer Nameplates
● Purpose of a Tap Changer
● How Does an LTC Work?
Topics

- Reactance Type LTC’s
- Resistance Type LTC’s
- Reversing Switches
- Windings Principles
- Access and Use the Applicable Transmission Procedures, Troubleshooting Guide, and Job Plan
Course Objectives

● Recall Basic LTC Definitions & Operation

● Interpret Nameplate Information Applicable to LTC’s and DETC’s

● Using the Nameplate, Identify the Correlations Between High Side and Low Side Windings

● Recall the Components Used in a Reactance Type LTC and How these Components Operate to Change Taps
Course Objectives

- Recall the Components Used in a Resistance Type LTC and How these Components Operate to Change Taps
- Access and Use the Applicable Transmission Procedures, Troubleshooting Guide, and Job Plan
Caution:

- The information provided in this course is general in nature and will not cover all aspects of all Tap Changers.

- For specific information on any Tap Changer, you should refer to the Owners Manual of that specified Make and Model and the applicable Progress Energy Procedures and Job Plans.
Basic Transformer Theory
Differences from LTC’s to DETC’s

There can be more than one type of tap changer on a transformer.

- **DETC** - De-energized Tap Changer.
  - Sometimes referred to as a NLTC - No Load Tap Changer

- **LTC** - Load Tap Changer.
  - Sometimes referred to as a OLTC - On-Load Tap Changer
Differences from LTC’s to DETC’s

- Both tap changers allow you to change the winding connections of the transformer. The main difference is the way the change must take place.
  - The **DETC** must be changed only with the transformer de-energized and without load. (NLTC - **No Load Tap Changer**).
  - The **LTC** is designed to be changed with the transformer energized and under load. (OLTC – **On Load Tap Changer**).
LTC Definitions

● Now, let’s start looking at Load Tap Changers.

● The first step is to learn some LTC Definitions that we will need to use.
LTC Definitions

- **Reactor**
  - The reactor may also be referred to as a "PA, preventive auto or preventive autotransformer".
  - The reactor serves as a circulating current limiting device when the LTC is on a bridging (odd number) tap position.
  - The circulating current is the result of the moving contacts being connected to two separate points on the tapped winding at the same time.
LTC Definitions

- **Bypass Switch**
  - The bypass switch is used to shunt current to and from a vacuum interrupter so the selector switch can switch taps without arcing. Bypass switches are almost always found on vacuum LTC’s.

- **Preventive Autotransformer (PA or Preventive Auto)**
  - The preventive autotransformer may also be referred to as a "reactor" and is found on all Reactance Type LTC’s. The preventive autotransformer serves as a current limiting device when the LTC is sitting on a bridging (odd number) tap position or passing through a bridging (odd number) tap position.
LTC Definitions

- **Spring Drive**
  - The spring drive may be either a single spring or a bank of springs that are utilized to change from one tap to another. A motor charges the spring. When the spring is fully charged, the mechanism then releases the energy contained in the spring to allow the tap change to occur.

- **Full Cycle Position**
  - A Non-bridging position in an LTC. Both or all moveable contacts of the selector switch are on the same stationary contact and only one tap of the tapped winding.
LTC Definitions

- **Half Cycle Position**
  - A Bridging position in an LTC. The moveable contacts of the selector switch are on separate (different) stationary contacts and two points on the tapped winding.

- **Selector Switch**
  - The selector switch is used to determine the tap voltage (select the voltage magnitude) the transformer operates at and supplies to the load.
LTC Definitions

- **Reversing Switch (change over switch)**
  - The reversing switch allow the number of tap positions to be doubled without doubling the number of tap leads coming out of the windings.
  - The standard reversing switch swaps the polarity of the tap windings.
LTC Definitions

- **Standard Reversing Switch**
  - The standard reversing switch is used to reverse the polarity of the tap winding in order to raise (boost) or lower (buck) voltage.
LTC Definitions

- **Standard Reversing Switch**
  - Connection Diagram of a Typical Load Tap Changer with a *Standard Reversing Switch* that is used to reverse polarity (Without a Series Transformer)
LTC Definitions

- **Standard Reversing Switch** - Connection Diagram of a Typical Load Tap Changer with a **Standard Reversing Switch** used to reverse polarity (With a Series Transformer)
LTC Definitions

- There are two types of Load Tap Changers

- **Reactance (Reactive) LTC’s**
  - Reactive LTC’s are designed to arc either on the selector switch, the transfer (diverter) switch, or the vacuum interrupter.
  - They can be designed to operate at high speeds (0.3 - 0.7 seconds) or at relatively slow speeds (1 - 3 seconds).
LTC Definitions

- **Reactance (Reactive) LTC’s**
  - The reactive LTC utilizes a reactor or preventive autotransformer to limit the circulating current when in the bridging position.
  - The bridging position is a normal stopping tap position for a reactive LTC.
  - A vacuum tap changer is a reactive type LTC.
LTC Definitions

- **Resistance (Resistor)**
  - Resistive LTC’s are typically designed to arc either at the selector switch or the transfer (diverter) and operate at higher speeds (0.3 - 0.7 seconds).
  - The resistive LTC utilizes a resistor to limit the circulating current during a tap change.
  - The bridging position is **NOT** a normal stopping tap position for a resistive LTC.
LTC Definitions

- **Transfer Switch**
  - The transfer switch may also be referred to as the “Diverter Switch”.
  - The transfer switch is used to interrupt the load so the selector switch can change position without arcing.
  - The transfer switch contacts are made of an arc erosion resistant material called Elkonite (copper-tungsten) and is designed to arc (not heat) under normal conditions.
LTC Definitions

- **Transition Resistor**
  - A resistor that is used to limit the circulating current **during transition only** from one tap position to another.
  - The transition resistor is **only** utilized in transition.
  - The transition resistor is not designed to carry full load current.
  - The Transition resistor is found only in a resistance type LTC.
LTC Definitions

- **Stationary Contact**
  - A contact that is fixed in position.

- **Moving Contact**
  - A contact that is not fixed in position. A contact that is allowed to change positions.

- **Reversing Contact**
  - This contact is associated with the reversing switch of an LTC mechanism. (See Stationary Contact and Moving Contact for definition of term).
LTC Definitions

- **Neutral Position**
  - The neutral position is the position where the LTC is neither bucking nor boosting voltage and/or where the tap windings are not in the circuit.
  - This is nominal position.
  - The neutral position is the only position where the reversing switch is not carrying current.
The Transformer Nameplate is the “go to” information depot. The Nameplate provides information such as:

- Weights
- Impedance
- Winding Configuration
- Voltage Ratings
- Basic Impulse Level
- High Voltage and Low Voltage Tap Information
Purpose of a Tap Changer

- The DETC may be used to do the following:
  - Adjust the transformer primary to match the transmission line voltage.
  - Adjust the travel of the LTC (Load Tap Changer).
  - Adjust the transformer turns to match the core flux density.
Purpose of a Tap Changer

- A Load Tap Changer is a devise that is used to change the taps of a power transformer with the transformer energized and under load.

- A Load Tap Changer (when working correctly) allows the power output of the transformer to be changed without interruption.

- The purpose of the Load Tap Changer is to allow the voltage output to be regulated up or down without interruption to keep a set voltage available for distribution to customers.
Purpose of a Tap Changer

- The tap or regulating windings of a load tap changing transformer are used to adjust the number of transformer turns usually in the secondary or low voltage windings.

- The regulating windings are divided in sections (taps) that can be added in series to the low voltage windings.
Purpose of a Tap Changer

- Voltage change must be provided smoothly and efficiently without interruption to the secondary current flow.

- In other words, when changing tap positions, the LTC mechanism must **MAKE-BEFORE-BREAK** to avoid opening the secondary circuit thus dropping voltage to your customers.
How Does an LTC Work?

- There are two types of Load Tap Changers

**Reactance**
- For example: Reinhausen RMV-1
- Prolec GE-LRT200A

**Resistance**
- For example: RTE/ASEA UZD
- ABB UZF
How Does an LTC Work?

- A Resistance Load Tap Changer utilizes a resistor to limit the circulating current during a tap changer operation.

- These resistors are in the circuit for a very short time.
How Does an LTC Work?

- Preventive Autotransformer (PA)
  - Remember, the PA may also be referred to as a "reactor" and is found on Reactance Type LTC's.
  - The PA serves as a current limiting device when the LTC is sitting on a bridging (odd number) tap position or passing through a bridging (odd number) tap position.
How Does an LTC Work?

- Reactance LTC
  - A reactance LTC utilizes reactive impedance to limit the circulating current while in the bridging position.
  - The amount of circulating current cannot be determined from the nameplate.
  - It is a function of the PA winding impedance and values are not released by the manufacture.
How Does an LTC Work?

- Reactance LTC
  - The current level can be quite high and has a significant impact on the duty seen by the tap contacts.
  - A bridging position is a normal operating position of this type of LTC.
How Does an LTC Work?

- Reactance LTC
  - Another name for this reactive impedance is a Reactor, Preventive Autotransformer, or simply a “PA”.
  - They were designed for higher currents and lower insulation levels due to their use in low voltage regulation.
How Does an LTC Work?

- Resistance LTC
  - The resistive LTC utilizes a resistor to limit the circulating current during a tap change.
  - Resistive LTC’s are always designed to operate at high speeds.
  - The bridging position is not a normal stopping tap position for a resistive LTC.
Reactance Type LTC’s

- Reactance LTC’s can operate in two (2) positions. Both bridging and non-bridging positions.

Bridging Position

Non-Bridging Position
Reactance Type LTC’s

- Reactance LTC’s can operate in two (2) positions. Both bridging and non-bridging positions.

- The bridging position is a **normal** operating position of a reactance LTC.

- A reactance LTC utilizes a reactive impedance to limit the circulating current while in the bridging position.
Reactance Type LTC’s

● There are several different types of reactance load tap changers.

● They can be divided into categories by the components or switches included in their design.
  ▪ Arcing on the selector switch
  ▪ Arcing on the transfer/diverter switch
  ▪ Arcing in a vacuum bottle.
Reactance Type LTC’s

- Reactance Type LTC that arc on the Selector Switch
  - Load Tap Changers that arc on the Selector Switch must have special contacts that have arcing tips where the moveable contacts make contact with them.
  - These tips are made of a material called Elkonite or Copper Tungsten.
    - This material is *not* a low resistant material.
Reactance Type LTC’s

- Examples of these types of On-Load Tap Changers are listed below:
  - McGraw Edison 550 Series
  - Siemens/Allis TLS and TLH

- These types of Reactance Type LTC arc on the selector switch.
Reactance Type LTC’s

- Arcing on the Transfer/Diverter switch
  - Some LTC’s are equipped with a transfer or diverter switch.
  - These switches are designed to sustain the arc of the make and break operation while changing tap positions.
Reactance Type LTC’s

● The operation is as follows:
  ▪ The Transfer/Diverter switch opens and breaks the current; the selector switch opens with no arc; the selector switch moves to the next tap position; the selector switch closes with no arc; and the Transfer/Diverter switch closes and makes the arc.

● No arc should occur on the selector switch.
Reactance Type LTC’s

● Examples of these types of On-Load Tap Changers are listed below:
  ▪ Westinghouse UTT Series
  ▪ Westinghouse UTS
  ▪ General Electric ML 32
  ▪ Federal Pacific TC-546 & 525
Reactance Type LTC’s

- With the arc occurring on the diverter/transfer switch, the selector switch contacts could now be made of a low resistance material to reduce heat on the contact.

- Below are examples of Diverter/Transfer switches.
Reactance Type LTC’s

- Arcing on the Transfer/Diverter Switch

- On the next diagram, you can see how the Transfer/Diverter Switch operates.
Reactance Type LTC’s

On Position (non-bridging)

Transfer Switch Opens

Selector SwitchOpens

Selector Switch Closes

Load Current
Circulating Current

Transfer Switch Closes
On Position (bridging)
Reactance Type LTC’s

● Vacuum Load Tap Changers were developed in the United States and introduced in 1965. There are benefits of having the arc contained in a vacuum bottle.

● With the arcing contacts contained in the vacuum bottle, there is no arc to contaminate the oil.
Reactance Type LTC’s

- When a tap changer has vacuum bottles they have cleaner oil and the probability of filming is greatly reduced.

- Since the oil has no carbon particulates, there will be less mechanical wear.
Reactance Type LTC’s

Examples of these types of On-Load Tap Changers are:

- General Electric LRT-200
- Reinhausen RMV-A
- Reinhausen RMV-1
- Reinhausen RMV-II
Reactance Type LTC’s

Sequence of Operation - Arcing in a Vacuum Bottle

1. On Position (non-bridging)
2. By-pass Switch Opens
3. Vacuum Bottle Opens
4. Selector Switch Opens
5. Selector Switch Closes
6. Vacuum Bottle Closes
7. Load Current
8. Circulating Current
Resistance Type LTC’s

- You should **never** see a resistance load tap changer stopped in the position displayed in this picture. This is a “transition-bridging” position.
Resistance Type LTC’s

- The transition-bridging position must occur to provide a “Make-Before-Break” operation.

- This make-before-break operation is a requirement of all on-load tap changers.
A reversing switch (if equipped) located inside the LTC mechanism, enables the windings to **double the number of tap positions without doubling the number of tap leads** from the tap (regulating) windings.
Reversing Switches

- The most common type is the “Standard Reversing Switch”.

- Some manufactures call a reversing switch a “change-over-selector” switch.
Reversing Switches

- The standard reversing switch swaps the polarity of the regulating windings.

- This means that the end of the regulating winding that is connected in series with the secondary windings is changed when the reversing switch goes through neutral.
Reversing Switches

- Heating is a problem in LTC’s as heat aids in the filming process.

- Filming aids in coking and coking causes failure.

- If you have coking on contacts, what do you do?
  - Check for the heat source. It could be from contacts that are worn and need replacing; unbalanced spring pressure; too little spring pressure; a weak contact point; a loose connection or other issues that could cause a hot spot or elevated heating in the LTC oil compartment.
Reversing Switches

Regulated Windings are covered with the Secondary (low voltage) Windings.

The Secondary (low voltage) Windings are covered with the Primary (high voltage) Windings.

*This is assuming that there are NO tertiary Windings.*
Reversing Switches

- Notice in each of the diagrams below, the reversing switch is in a different position.
Reversing Switches

- Anytime the reversing switch changes position, the load current must be shunted around the reversing switch.

- This occurs with tap changers where the total load is through the reversing switch and tap changers where only a portion of the load is through the reversing switch as with a series winding.
Reversing Switches

- When series windings are present they must be short circuited before the reversing switch can change positions.

- The actual electrical connections in these circuits are often difficult to understand and normally do not provide valuable information to the Electrician.
Windings Principles

- The winding configuration provides details on how the current flows through the high and low side windings.

- The next few slides show how this works.
Winding Principals

- A reactive LTC designed for ±5% regulation and 16 steps will have **8 taps** brought out of the regulating winding. This is due to the fact that a bridging position is an operating position.

- A resistive LTC designed for ±5% regulation and 16 steps will have **16 taps** brought out of the regulating winding. This is due to the fact that a bridging position is not an operating position.
Winding Principals

- On some reactive LTCs 100% of load current is through the reversing switch and tap contacts.

- On some reactive LTCs 50% load current is through the reversing switch and tap contacts and 50% is through a parallel series winding.

- No resistive LTCs carry 100% of load current through the reversing switch and tap contacts.
Winding Principals

- On resistive LTCs that have full load rating of 1200 amps the ratio of the series transformer may be as great as 6:1 so that only 200 amps will be carried by the reversing switch and tap contacts.
Winding Principals

First, let’s look at the various windings on the UZD winding configuration.
Procedures applicable to LTC’s include:

- General Inspection and Maintenance on Regulator and LTC Transformer MNT-TRMX-00010

Troubleshooting Guide

- Contact Asset Management

Job Plan

- Contact Asset Management