American University of Beirut

Faculty of Engineering and Architecture

Department of Electrical and Computer Engineering

Electric Machines Lab\_EECE 470L

Experiment 2

Unbalanced loading of Three Phase Transformers

Objectives:

The objectives of this experiment are to study the effect of unbalanced loading of three phase transformer with different connections (delta-Wye, Wye-Wye, Wye-Z) and to study the features and limitations of each connection.

Procedure:

Delta\_Wye-n Connection



 Figure 1: Connection for the Delta\_Wye Connection

We started the experiment by connecting the transformer as Delta on the primary and Wye at the secondary. To accomplish an unbalanced loading we load the phase c of the transformer with a varying resistance. The resistance is set at the maximum to ensure that we have minimum current flowing. Theb we minimize the resistance until we have rated current. However before opening the switch we measured the no-load voltage at the secondary in order to calculate the voltage regulation.

Wye-Wye-n Connection



 Figure 2: The Y-Y-n connection

The same procedure as above but the connection at the input is change to Wye.

Wye\_Z-n connection



 Figure 3: Wye\_Z-n Connection

The same procedure as above but the connection at the input is change to Z.

Apparatus:

1. 3-phase transformer

2. Multi-meters (Quantity: 2)

3. 3-phase AC power supply (190V)

4. Variable resistor

5. Connecting electric wires

Measured Data Tabulation:

Delta\_Wye-n

|  |  |
| --- | --- |
| Switch open | Switch closed |
| Vnl (V) | I (A) | Voc (V) | Vob (V) | Voa (V) | $$\frac{V\_{oa}+V\_{ob}+V\_{oc}}{3}$$ |
| 68 | 5.25 | 65.8 | 68.3 | 67.9 | 67.33 |

Wye\_Wye-n

|  |  |
| --- | --- |
| Switch open | Switch closed |
| Vnl (V) | I (A) | Voc (V) | Vob (V) | Voa (V) | $$\frac{V\_{oa}+V\_{ob}+V\_{oc}}{3}$$ |
| 68 | 5.25 | 65.1 | 69.1 | 66.9 | 67 |

Wye\_Z-n

|  |  |
| --- | --- |
| Switch open | Switch closed |
| Vnl (V) | I (A) | Voc (V) | Vob (V) | Voa (V) | $$\frac{V\_{oa}+V\_{ob}+V\_{oc}}{3}$$ |
| 68 | 5.25 | 65.1 | 68 | 67.9 | 67 |

Calculated Data Tabulation

To calculate the voltage regulation X we use the following formula:

$$X=\frac{V\_{nl}-V\_{fl}}{V\_{fl}} x 100\%$$

The value of $V\_{nl}=68 V$ and the value of $V\_{fl}=\frac{V\_{oa}+V\_{ob}+V\_{oc}}{3} $ at each connection.

|  |  |
| --- | --- |
| Connection | Voltage Regulation X |
| ∆/Y | ((68-67.33)/67.33) x 100=0.99% |
| Y/Y | ((68-67)/67) x 100=1.5% |
| Y/Z | ((68-67)/67) x 100=1.5% |

Answers to relevant questions

I- Value of the voltage regulation

|  |  |
| --- | --- |
| Connection | Voltage Regulation X |
| ∆/Y | ((68-67.33)/67.33) x 100=0.99% |
| Y/Y | ((68-67)/67) x 100=1.5% |
| Y/Z | ((68-67)/67) x 100=1.5% |

II- Use the numerical value of the phase voltage (V) that differs most from the rated voltage (Vnl), and calculate: X(%) = (Vnl – V)x100/Vnl

∆/Y-n connection:

$$V=65.8V$$

$$X=\frac{68-65.8}{68}×100=3.34\%$$

Y/Y-n connection:

$$V=65.1V$$

$$X=\frac{68-65.1}{68}×100=4.26\%$$

Y/Z-n connection:

$$V=65.1V$$

$$X=\frac{68-65.1}{68}×100=4.26\%$$

III-Advantages and Disadvantage of each connection

∆/Y-n connection:

Advantages:

* The Delta connection on the primary is responsible for trapping the undesirable third harmonic magnetizing current.
* The ∆ connection ensures stability since it is responsible for the redistribution of the load misbalancing.
* At primary side, $V\_{line}=V\_{∅}$. While at the secondary side, $V\_{line}=\sqrt{3}V\_{∅}$. Thus, it is a step-up transformer.

Disadvantages:

* Secondary voltages lag the primary voltage by 30˚. Thus, paralleling transformers is difficult.

Y/Y-n connection:

Advantages:

* Connections are not very complicated. Thus, this connection simplifies lab measurements.

Disadvantages:

* It is seldom used because of difficulties with third harmonic exciting currents.
* Severely unbalanced voltages due to unbalanced loads.

Y/Z-n connection:

Advantages:

* Theoretically speaking, it has the Highest voltage regulation.

Disadvantages:

* Not used in the actual connection
* Does not eliminate the third harmonic
* Connections are complicated

IV. Which connection is best suited for unbalanced loading? Explain.

The best connection suited for unbalanced loading is the Wye\_Z-n connection since it has the best voltage regulation of 1.5%.

V- Which connection is most commonly used? Explain.

The best connection is however not the most commonly used. The most used connection is the Delta\_Wye-n connection since it eliminate the undesirable harmonics.