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Noval Approach to Draw Zero Sequence Reactance Diagram of Transformer & To Determine the Short Circuit MVA

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Abstract

Zero sequence diagram of a transformer plays an extremely important role, in power system analysis, helps in fault detection, protection, and stability assessment. In this paper, we present a comprehensive exploration of the conventional method for constructing the zero sequence diagrams of transformers. This method, though rooted in traditional principles, offers innovative strategies for solving problems efficiently, making it particularly valuable for competitive examination and cross-checking solutions. Beginning with an introduction to transformers and zero sequence analysis, we delve into the step-by-step process of the conventional method. Through a detailed exposition of equations, algorithms, and assumptions, we analyze the methodology's inner workings. Moreover, we highlight the method's advantages, including its simplicity, accuracy, and applicability across various transformer configurations. Furthermore, we discuss practical applications of the conventional method, showcasing its utility in competitive exams and as a tool for verifying solution correctness. Real world examples and case studies illustrate its effectiveness in problem-solving scenarios.

Keywords
Innovative Technique, Sequence Diagram, Fault, Conventional Method, Zero Sequence Method

INTRODUCTION

Keeping the lights on! That's what power grids do, but sometimes things go wrong. We need to understand these problems to fix them quickly. This is where transformers, the power grid's workhorses, come in. Imagine transformers as special machines that adjust electricity flow. But what if the flow gets uneven, like a traffic jam in the wires? Here's where zero sequence diagrams step in. Think of a zero sequence diagram as a secret map for transformers. This map helps us see how a transformer reacts when electricity isn't flowing smoothly. By studying these maps, engineers can identify problems and keep the electricity flowing without interruptions. This paper explains a traditional way to create these zero sequence diagrams. It's a step-by-step guide, even though it might involve some technical stuff. The good news is, this method works for many different transformers, making it super useful. We'll also explore how this method helps people in real life. Students preparing for exams can use it to understand transformers better, and engineers can use it to double-check their work and keep the power grids efficient. We'll even how real- life examples of how this method helps solve problems! So, if you're curious about how transformers work during power grid issues, this paper will give you a clear picture of the magic behind zero sequence diagrams.

CONVENTIONAL METHOD FOR ZERO SEQUENCE DIAGRAM OF TRANSFORMER.

Various types of transformer connections:

Case - I: Y-Y transformer bank with any one neutral grounded

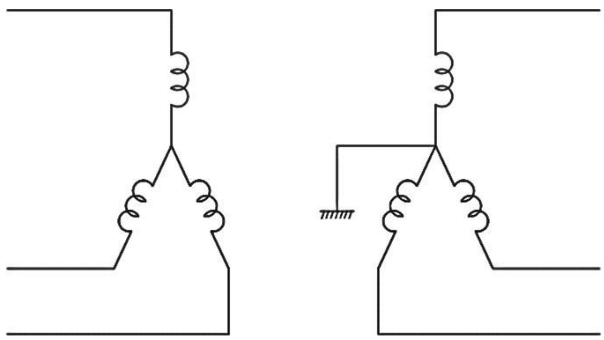

Fig. 1

If any one of two neutral of Y-Y transformers is ungrounded zero sequence Currents cannot flow in the ungrounded star as well as grounded star. Hence open circuit exists in zero seq. network between H and L, as shown in Fig 8.

Case – II: Y-Y Transformer bank both neutral grounded

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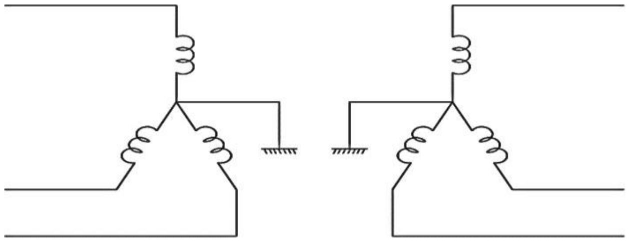

Fig.2

When both neutral grounded, zero seq. Current's flow in both windings via two grounded neutrals hence in this Case H & L is connected by zero sequence Impedance of transformer as shown in Fig 10.

Case –III: Y - Δ transformer bank with grounded Y-network

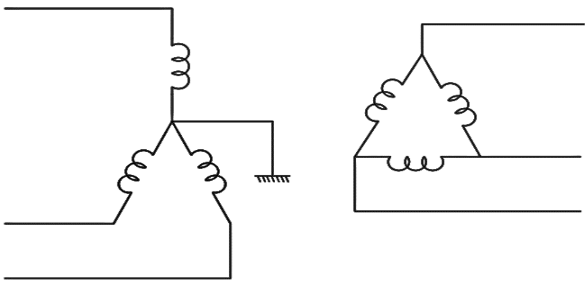

Fig. 3

If the neutral of Star Side is grounded, zero sequence Currents can flow in star because a path is available to ground and the balancing zero sequence Currents can flow in delta (Legs) zero sequence Currents Can flow in the line on the delta side.

The Zero Sequence N/W must have a path from the line H on the Star side through Zero sequence impedance of transformer to the reference bus, as shown in Fig 12.

Case – IV: Y - Δ transformer bank with ungrounded star.

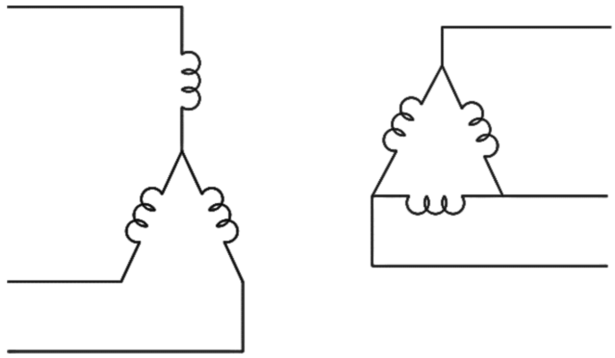

Fig.4

In this case, where the impedance Z_n between Neutral and ground is infinite, as shown in Fig 14.

Case– V: ΔΔ Transformer bank

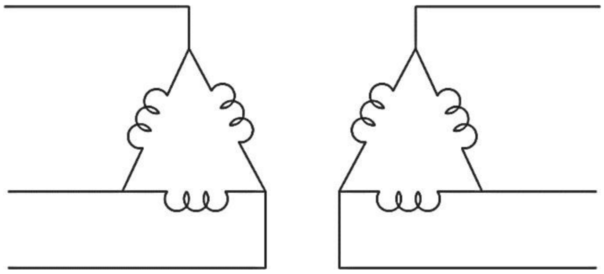

Fig. 5

The Zero sequence Current flow in or out of delta- delta transformer because delta circuit cannot provide return path. It can Circulate in the Delta winding Therefore, this is an open circuit between H and L and Zo is Connected to the reference Bus on both ends to allow it for any circulating zero sequence current in the two delta, as shown in Fig 16.

INNOVATIVE TECHNIQUE FOR ZERO SEQUENCE DIAGRAM OF TRANSFORMER

Consider the switches diagram as shown in below figure:

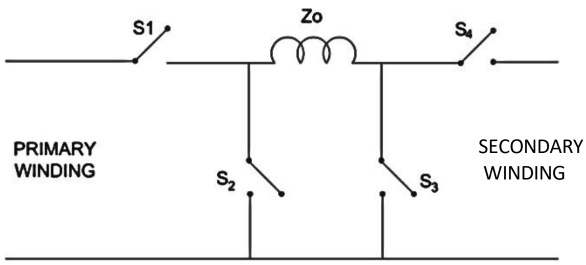

Fig. 6

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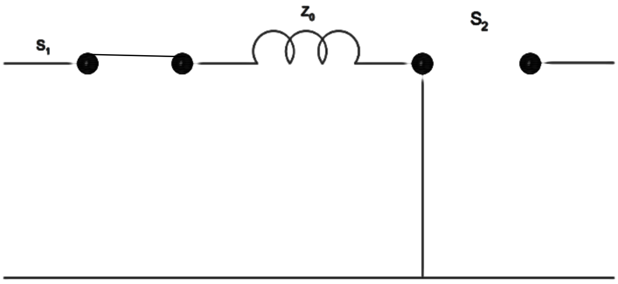

STEP1: When there is star connection with neutral grounded, then series switches i.e., S1 & S4 will be active.

STEP 2: When there is delta connection, parallel switches S2 & S3will be active.

DRAWING ZERO SEQUENCE DIAGRAM OF TRANSFORMER USING NOVAL APPROACH.

CASE1: The primary side is star connected and secondary side is star connected with neutral grounded.

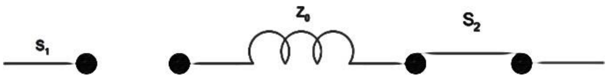

Fig.7

Zero sequence reactance Diagram:

Reference Bus

H L

Fig. 8

CASE 2: Y-Y Transformer bank both neutral grounded

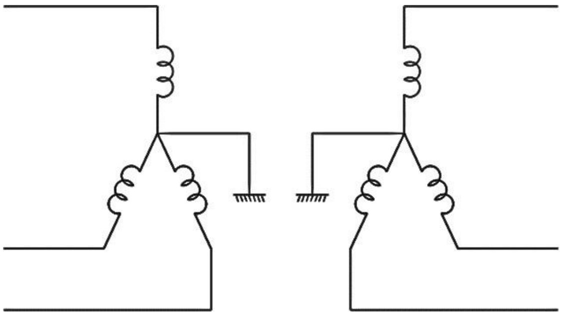

Fig. 9

Zero sequence reactance Diagram:

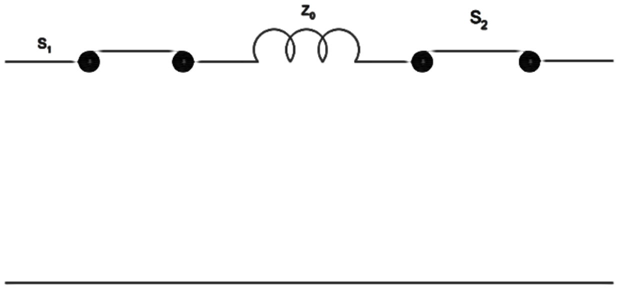

Fig.10

CASE 3: The primary side is star connected with neutral grounded and secondary side is delta connected.

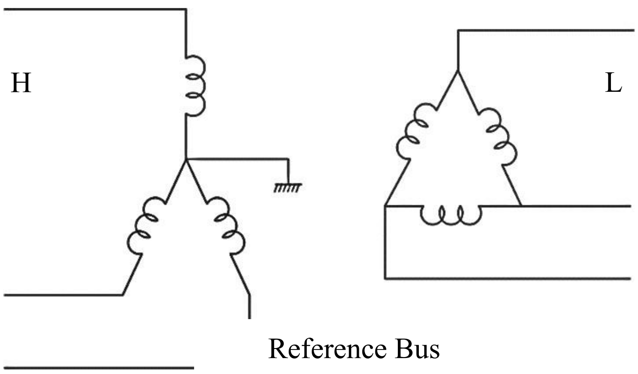

Fig.11

Zero sequence reactance Diagram:

Fig.12

Reference Bus

H L

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CASE 4: The primary side is star connected and secondary side is delta connected

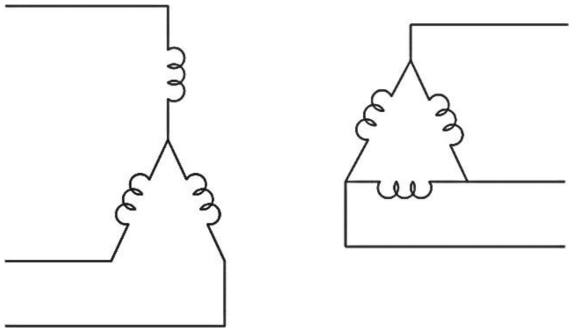

Fig.13

Zero sequence reactance Diagram:

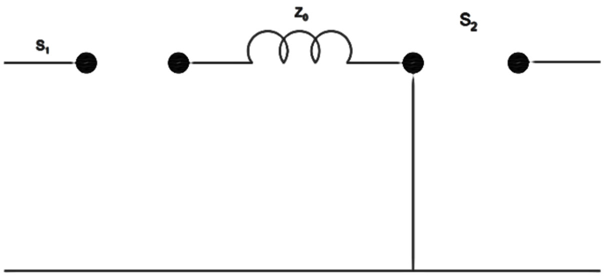

Fig.14

CASE5: The primary side and secondary side both are delta connected

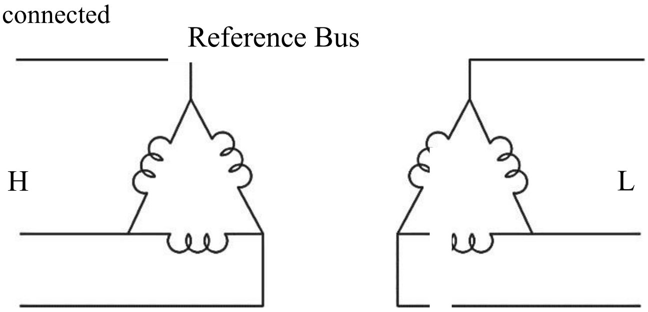

Fig.15

Zero sequence reactance Diagram:

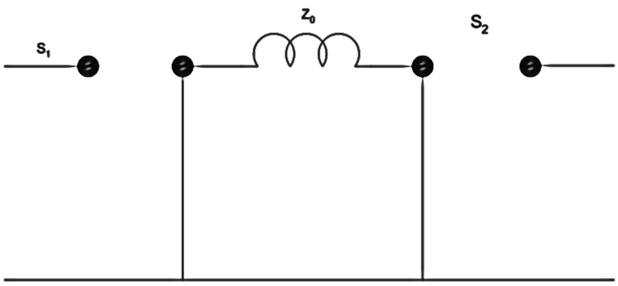

Fig.16

CASE6: The primary side is star connected
With neutral grounded with reactor Zn and secondary side is star connected with neutral grounded.

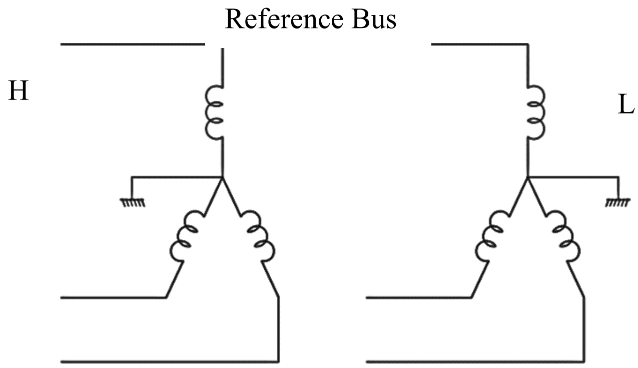

Fig.17

Zero sequence reactance Diagram:

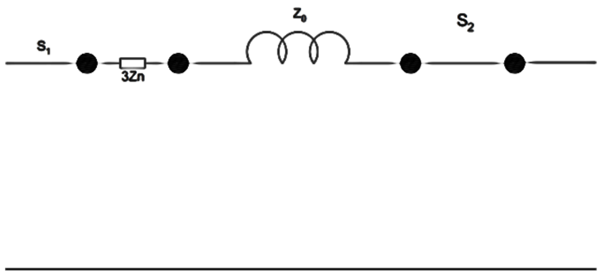

Fig.18

NUMRICAL:

Example: A 100 MVA 11 kV alternator has Z1=Z2=Z0=0.1puIts Reference Bus reactorof0.5Pu.Thealternatorisoperatingatrated voltage w H t load and is disconnected from the system L n single line to ground fault occurs with the fault reactance of 0.5 Pu at its terminals. Calculate

1. Fault current
2. Actual fault current
3. Short circuit MVA
4. Actual short circuit

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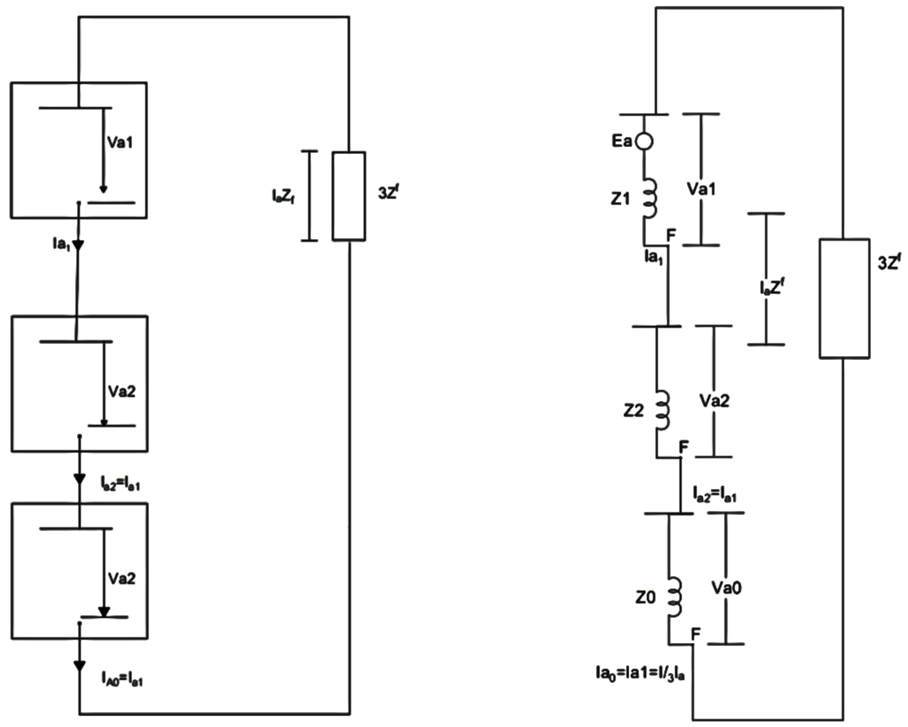

Fig.19 Connection of sequence network for a single line-to-ground (LG) fault

Solution:
For an L-G fault the sequence network is connected in series as shown in the above fig.

1. $I_f=3\ (Ea/\ Z_1 + Z_2 + Z_0 + 3Z_n + 3Z_f)$

$I_f=3(1/0.1+0.1+0.1+0.15+0.15)$
$I_f=3(1/0.6)=5$ pu
$I_f=3I_{a0}$
$I_{a0}=I_1=I_2=5/3$ pu
I_1(actual)=5/3×100/√3×11 I_1(actual) = 8.74 kA

2. I_f(actual)=5(100×10^6)/√3×11×10^3

I_f(actual)=26.24 kA

3. Short circuit MVA

Conventional Method:

Method1:
SC MVA =Ea_1(ph.) ×I_f(amp) SC MVA=(11×10^3)/√3×26.24×10^3
SC MVA=166.667 MVA

=1.0×5/3
=5/3PU

4. SCMVA(actual)= MVA(pu)×Base MVA

=5/3 × 100
=166.66 MVA

Innovative Method:

Method2:
SCMVA=3 [Ea1 (ph.) ×Ia1]

=3[11/√3×8.74]
=166.52 MVA

Method3:
SC MVA(pu)=Ea_1(pu)×Ia_1(pu)

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1. In this method connect the sequence reactance as shown in below
2. Add all the sequence reactance
3. The short circuit MVA =MVA(rating)/Z(eq)

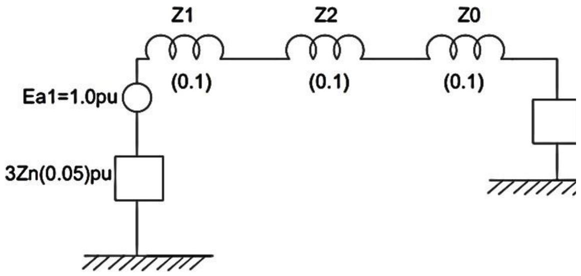

Fig.20

Zeq=0.1+0.1+0.1+0.15+0.15=0.6 pu

SC MVA = 100/0.6 = 166.66 MVA

Therefore, calculated SC MVA by conventional method and our approach is found to be exactly same.

Conclusion:

Conventional pathway for determining zero sequence diagram of transformer create confusion which may lead to an error, while doing it with an innovative technique might make it easy to understand and draw zero sequence diagram of transformer much efficiently with better accuracy. It requires more time for the calculation of short circuit MVA through conventional methods as mentioned in the problem solved above, on the other hand calculation of short circuit MVA using innovative method makes it quicker and easier.

Since these innovative methods are not conventional, so it cannot be applied while solving a university examination.

On other hand this method can be used in other competitive exams live GATES to avoid time consumption to solve a problem.

This research paper underscores the significance of the conventional method for zero sequence diagram analysis, emphasizing its innovative approach to simplifying complex problems. By presenting a structured framework for understanding and implementing this method, we aim to empower engineers, students, and practitioners in the field of Electrical engineering.

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