The Computation of Winding Impedances in a Three-Winding Transformer

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Transformer data:

$kVA_p := 15000 \qquad kVLL_p := 69$

$kVA_s := 10000 \qquad kVLL_s := 13.2$

$kVA_t := 5000 \qquad kVLL_t := 2.4$

where: p = primary winding
s = secondary winding
t = tertiary winding

Transfer impedance measurements in per-cent:

$Z\%_{ps} := 0.15 + j\cdot 7$ per-cent based upon 15,000 kVA

$Z\%_{pt} := 0.2 + j\cdot 9$ per-cent based upon 15,000 kVA

$Z\%_{st} := 0.17 + 8j$ per-cent based upon 10,000 kVA

Convert Zpu_{st} to per-cent based upon 15,000 kVA

$$Z\%_{st} := Z\%_{st}\cdot\frac{kVA_p}{kVA_s} \qquad Z\%_{st} = 0.255 + 12j$$

Convert transfer impedances to per-unit

$$Zpu_{ps} := \frac{Z\%_{ps}}{100} \qquad Zpu_{ps} = 0.0015 + 0.07j$$

$$Zpu_{pt} := \frac{Z\%_{pt}}{100} \qquad Zpu_{pt} = 0.002 + 0.09j$$

$$Zpu_{st} := \frac{Z\%_{st}}{100} \qquad Zpu_{st} = 0.00255 + 0.12j$$

Calculate winding impedances in per-unit

$$Zpu_p := \frac{1}{2}\cdot\left(Zpu_{ps} + Zpu_{pt} - Zpu_{st}\right) \qquad Zpu_p = 0.0005 + 0.02j$$

$$Zpu_s := \frac{1}{2}\cdot\left(Zpu_{ps} + Zpu_{st} - Zpu_{pt}\right) \qquad Zpu_s = 0.001 + 0.05j$$

$$Zpu_t := \frac{1}{2}\cdot\left(Zpu_{pt} + Zpu_{st} - Zpu_{ps}\right) \qquad Zpu_t = 0.0015 + 0.07j$$

Compute base impedance for each winding using primary kVA as common base:

$$kVA_{base} := kVA_p \qquad kVA_{base} = 15000$$

Primary bases:

$$kVLN_p := \frac{kVLL_p}{\sqrt{3}} \qquad kVLN_p = 39.8372$$

$$Ibase_p := \frac{kVA_{base}}{\sqrt{3}\cdot kVLL_p} \qquad Ibase_p = 125.5109$$

$$Zbase_p := \frac{kVLN_p\cdot 1000}{Ibase_p} \qquad Zbase_p = 317.4$$

Secondary bases:

$$kVLN_s := \frac{kVLL_s}{\sqrt{3}} \qquad kVLN_s = 7.621$$

$$Ibase_s := \frac{kVA_{base}}{\sqrt{3}\cdot kVLL_s} \qquad Ibase_s = 656.0799$$

$$Zbase_s := \frac{kVLN_s\cdot 1000}{Ibase_s} \qquad Ibase_s = 656.0799$$

Tertiary delta bases:

$$Ibase_t := \frac{kVA_{base}}{3\cdot kVLL_t} \qquad Ibase_t = 2083.3333$$

$$Zbase_t := \frac{kVLL_t\cdot 1000}{Ibase_t} \qquad Zbase_t = 1.152$$

Note: The base tertiary impedance is used to compute the actual tertiary winding impedance in Ohms inside the detla.

Compute the winding impedances in Ohms:

$$Z_p := Zpu_p\cdot Zbase_p \qquad Z_p = 0.1508 + 6.348j$$

$$Z_s := Zpu_s\cdot Zbase_s \qquad Z_s = 0.0119 + 0.5808j$$

$$Z_t := Zpu_t\cdot Zbase_t \qquad Z_t = 0.0018 + 0.0806j$$