I M P E D A N C E S I N T R A N S F O R M E R S

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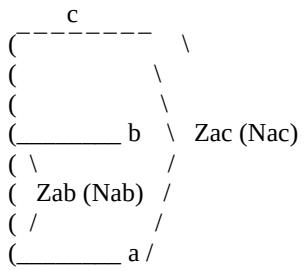
Let’s suppose we have a transformer, normally an audio one, with a secondary as in the figure below.



The manufacturer specifies the output impedance between terminals 'a' and 'b' and between terminals 'a' and 'c'. We want to know the output impedance between terminals 'b' and 'c'.

The number of turns between 'a' and 'b' is Nab and between 'a' and 'c' is Nac, both unknown. Obviously the number of turns between terminals 'b' and 'c' is Nbc = Nac - Nab.

As the impedances are proportional to the number of turns squared, we may write:

$Zab = k \cdot Nab^2$ or $\sqrt{Zab} = \sqrt{k} \cdot Nab$ (I)

$Zac = k \cdot Nac^2$ or $\sqrt{Zac} = \sqrt{k} \cdot Nac$ (II)

$Zbc = k \cdot Nbc^2$ or $\sqrt{Zbc} = \sqrt{k} \cdot Nbc$ (III)

Subtracting (I) from (II), we have:

$\sqrt{k} \cdot (Nac - Nab) = \sqrt{Zac} - \sqrt{Zab}$

As Nac – Nab = Nbc, we have:

$\sqrt{k} \cdot Nbc = \sqrt{Zac} - \sqrt{Zab}$ (IV)

Using (III) in (IV), we get:

$\sqrt{Zbc} = \sqrt{Zac} - \sqrt{Zab}$, that, squared, results finally in:

$Zbc = Zac + Zab - 2 \cdot \sqrt{Zac} \cdot \sqrt{Zab}$ (V)

As we see in (V), the impedance Zab is not the simple difference between Zac and Zab, as one could imagine, as series impedance sum. Why? Simply because the impedances Zab and Zbc are not in simple series, as there is a magnetic coupling via transformer between them.

As a practical example, suppose that Zab is 4 Ohm and Zac 16 Ohm. Using (V), we have:

Zbc = 4 + 16 - 2 . 4 . 2 = 4 Ohm

This case can be used to couple two 4 Ohm speakers, for example, when one has one 4 Ohm output and another one of 16 Ohm in the secondary.

An advice: if the transformer secondary is wound with only one wire gauge from end to end, there is no problem; but, if the part ‘bc’ is wound with a thinner wire (as the current is smaller for a higher impedances), we cannot get the maximum power via winding ‘bc’ (as we can in ‘ab’ or ‘ac’) or the transformer can heat or burn out.

The process may be generalized for impedances between taps of any transformer.

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