

I asked the A.I. app 'Chat GPT' about RF transformers.....

If an RF transformer - with the primary winding having 4 turns, and the secondary 20 turns - has an inductance of 5.3uH, what would the inductance be if the windings were changed to 6 turns and 24 turns, with everything else remaining the same?.....

To calculate the inductance of an RF transformer with different numbers of turns, we can use the formula for the inductance of an ideal solenoid (coil): $L = (\mu_0 * N^2 * A) / l$

Where:

L = Inductance (in henries, H)

μ_0 = Permeability of free space = $4\pi \times 10^{-7}$ H/m

N = Number of turns

A = Cross-sectional area of the coil's core (in square meters, m²)

l = Length of the coil's core (in meters, m)

Assuming the core dimensions and material remain the same (which is often the case for this type of question), we can find the inductance for the new configuration with 6 turns and 24 turns.

Given:

Initial configuration: $N_1 = 4$ turns and $N_2 = 20$ turns

Initial inductance: $L_1 = 5.3 \text{ uH} = 5.3 \times 10^{-6} \text{ H}$

We'll calculate the initial cross-sectional area A_1 using the initial inductance formula and then use it to find the inductance for the new configuration.

Step 1: Calculate the initial cross-sectional area (A_1):

$$L_1 = (\mu_0 * N_1^2 * A_1) / l$$

$$5.3 \times 10^{-6} \text{ H} = (4\pi \times 10^{-7} \text{ H/m} * 4^2 * A_1) / l$$

$$A_1 = (5.3 \times 10^{-6} \text{ H} * l) / (4\pi \times 10^{-7} \text{ H/m} * 4^2)$$

Step 2: Calculate the inductance for the new configuration (6 turns and 24 turns):

$N_1 = 6$ turns and $N_2 = 24$ turns

Using the same core cross-sectional area A_1 and new number of turns (6 and 24):

$$L_2 = (\mu_0 * N_2^2 * A_1) / l$$

$$L_2 = (4\pi \times 10^{-7} \text{ H/m} * 6^2 * A_1) / l$$

Step 3: Substitute the value of A_1 from Step 1 into the equation in Step 2:

$$L_2 = (4\pi \times 10^{-7} \text{ H/m} * 6^2 * [(5.3 \times 10^{-6} \text{ H} * l) / (4\pi \times 10^{-7} \text{ H/m} * 4^2)]) / l$$

Step 4: Simplify the equation:

$$L_2 = (6^2 * 5.3 \times 10^{-6} \text{ H}) / (4^2)$$

$$L_2 = (36 * 5.3 \times 10^{-6} \text{ H}) / 16$$

$$L_2 = 1.1975 \times 10^{-6} \text{ H}$$

So, the inductance of the RF transformer with 6 turns and 24 turns would be approximately 1.1975uH.....

I would have expected the new inductance to be greater, not smaller... Did you mean 11.975uH rather than 1.1975uH?

Apologies for the oversight in my previous response. You are absolutely right. The new inductance should be greater when increasing the number of turns in the windings. Let's re-calculate the inductance for the new configuration (6 turns and 24 turns):

Given:

Initial configuration: $N_1 = 4$ turns and $N_2 = 20$ turns

Initial inductance: $L_1 = 5.3 \text{ uH} = 5.3 \times 10^{-6} \text{ H}$

We had already calculated the initial cross-sectional area (A_1) as:

$$A_1 = (5.3 \times 10^{-6} \text{ H} * l) / (4\pi \times 10^{-7} \text{ H/m} * 4^2)$$

Now, let's calculate the inductance for the new configuration (6 turns and 24 turns):

$N_1 = 6$ turns and $N_2 = 24$ turns

Using the same core cross-sectional area A_1 and new number of turns (6 and 24):

$$L_2 = (\mu_0 * N_1^2 * A_1) / l$$
$$L_2 = (4\pi * 10^{-7} \text{ H/m} * 6^2 * A_1) / l$$

Substitute the value of A_1 :

$$L_2 = (4\pi * 10^{-7} \text{ H/m} * 6^2 * [(5.3 * 10^{-6} \text{ H} * l) / (4\pi * 10^{-7} \text{ H/m} * 4^2)]) / l$$

Simplify the equation:

$$L_2 = (6^2 * 5.3 * 10^{-6} \text{ H}) / (4^2)$$
$$L_2 = (36 * 5.3 * 10^{-6} \text{ H}) / 16$$
$$L_2 = 11.925 * 10^{-6} \text{ H}$$
$$L_2 = 11.925 \text{ uH}$$

So, you are correct. The inductance of the RF transformer with 6 turns and 24 turns would be approximately 11.925 uH.

***That seems to be more like it -- I can see you have used the value of 6 turns for the N1 calculation....
Where does the value of N2 - (24 turns) - enter into things?***

I made an error in the explanation. The value of N_2 (number of turns in the second winding) does not play a direct role in calculating the inductance for the new configuration.

When we are comparing two RF transformers with different winding configurations but with the same core and geometric dimensions, the inductance is primarily influenced by the number of turns in the first winding (N_1) and the core's properties. The second winding's number of turns (N_2) does not directly affect the inductance calculation.

So, in this scenario, the inductance for the new configuration with 6 turns in the first winding remains the same as the one calculated earlier:

$$L_2 \approx 11.925 \text{ uH}$$

I apologize for the confusion in my previous response, and I appreciate your attention to detail. If you have any more questions or need further clarification, feel free to ask!

I hadn't realised that only the primary (6 turn) winding affects the inductance. Does that mean I could add - say another 20 turns - to the secondary winding and still not affect the inductance value?

Yes, that's correct. When considering an ideal transformer, the inductance of the primary winding (the one connected to the input voltage) is the main factor determining the overall inductance of the transformer. The secondary winding (the one connected to the load) does not directly impact the inductance value.

In an ideal transformer, the primary and secondary windings are perfectly coupled, meaning that all the magnetic flux generated by the primary winding passes through the secondary winding. Therefore, the inductance of the primary winding dominates the transformer's behaviour, and the inductance seen by the primary winding is effectively the inductance of the entire transformer.

Adding or changing turns in the secondary winding will not affect the inductance value of the transformer as long as the magnetic coupling between the windings remains ideal. In practical transformers, some leakage inductance and other factors may cause slight changes, but the general principle holds true: the inductance of the primary winding is the primary factor determining the transformer's behaviour.

So, in your example, adding another 20 turns to the secondary winding would not affect the inductance value of the transformer, assuming ideal magnetic coupling between the windings. The inductance would still be approximately 11.925 uH, as calculated earlier for the primary winding with 6 turns.