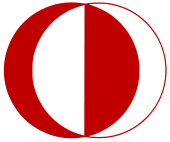
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**MIDDLE EAST TECHNICAL UNIVERSITY**

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

**EE 564** Project #1

***INDUCTANCE AND TRANSFORMER MODELING***

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# Inductor Design

In the design, a toroid inductor core from Magnetics with part number 0077739A7 are chosen. Its properties are summarized in the Table 1.

Table 1: Properties of Chosen Inductor Core

|  |  |
| --- | --- |
| Property | Value |
| Core Type | Kool Mu |
| Inductance Factor (AL) | 306 (nH/turns2) |
| Outer Diameter (OD) | 74.1 mm |
| Inner Diameter (ID) | 45.3 mm |
| Height (HT) | 35 mm |
| Cross Section Area (Ae) | 497 mm2 |
| Path Length (Le) | 184 mm |

With given parameters of the given core, first B-H characteristics are obtained. Also, relative permeability vs H characteristics are obtained. This can be seen in following figures.

Figure 1: B-H Characteristics of Selected Core

Figure 2: Permeability vs H characteristics

Note that, in figures above, same characteristics are plotted with different scales of H. With this characteristics, we can determine operation point of the core. We see that core has linear behavior up to 0.2 T. Therefore, we can choose as linear operation point at 0.1636 T. Accordingly, number of turns are found as follows. To find number of turns, current of 5 A assumption is made.

## Analytical Calculations

### Homogenous and Linear Core

After determining number of turns of our inductor, we can easily find inductance of linear and homogenous core by finding reluctance of the core. In linear core, core has constant permeability and core is not saturated. This permeability value is obtained from datasheet of the given core and found as 83.82 as relative permeability. Additionally, homogenous core means that flux distribution in the core is homogenous. Every point inside of the core has the same magnetic field density. In reality, inner side of the core has shorter length and therefore, flux density is higher in inner side of the core as we will see in following sections. First, let’s find inductance for linear and homogenous core.

### Non-Homogenous and Linear Core

Now, core is no longer homogenous and it is composed of many discrete parts. In Matlab environment, core is divided into many parts axially. Each part has different length and therefore each part has different reluctance and inductance. More accurate results are obtained when core is divided as many parts as possible. First, reluctance of each part is found and then equivalent reluctance is found. Using this, inductance is found as follows.

0.94 mH

It is observed that 3% more inductance is calculated in non-homogenous linear core. This is more realistic value and this calculation can be used in practical applications.

### Homogenous and Non-Linear Core

In this part, we will investigate the effect of non-linear core and saturation. DC current is increased by 50% and therefore total ampere-turn increases. Since we have now non-linear core, relative permeability is decreased with increasing ampere-turns. This relation can be seen in Figure 2. With this operation point, we have following results.

This result shows us that in non-linear core, inductance reduces with increasing current. This is due to the decrease in relative permeability of the core. In linear core, we would not observe decrease in inductance with increasing current. Now, let’s see the results in non-homogenous, non-linear core.

### Non-Homogenous and Non-Linear Core

Like in the non-homogenous linear case, we divide core into small pieces and reluctance of each piece is calculated separately. Then, equivalent reluctance is calculated from these individual reluctances. From equivalent reluctance, inductance of the core is calculated. Results can be seen below.

0.83 mH

With this results, 3.6% more inductance is calculated compared to homogenous and non-linear core. The results of four case are summarized in following table.

Table 2: Inductance Values for Different Cases

|  |  |  |
| --- | --- | --- |
|  | **Linear**  **(At=285.2)** | **Non-linear**  **(At=427.5)** |
| **Homogenous** | 0.91 mH | 0.80 mH |
| **Non-homogenous** | 0.94 mH | 0.83 mH |