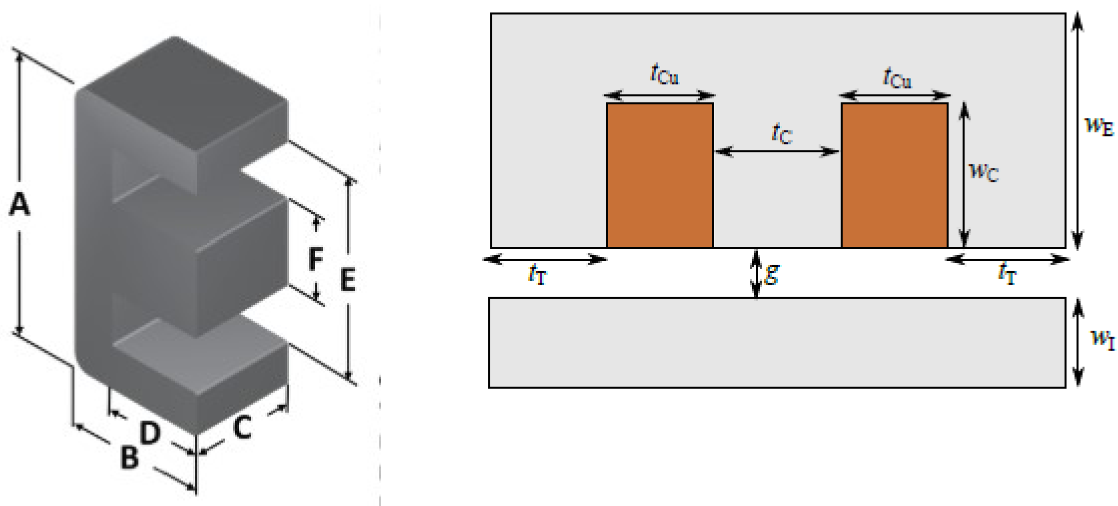
<u>**Core selection for preliminary example**</u>

The purpose of this document is to provide details of core selection and B-H data, core loss model considerations for FEA.

The preliminary example aims to design a 1mH inductor. As FEA requires an accurate model of the core material, it was decided to use one material which has BH and loss data provided by the manufacturer. A lot of materials were surveyed, and it was found that the FluxSan® series by Micrometals Inc would be the best one to consider for now.

The FluxSan® series has several materials of which, FS-014 was considered. The different core geometries available are listed at <https://www.micrometals.com/products/product-finder/?ordering=shapes&units=in&material=FS>.
Five E-cores among these were considered and are listed below. The parameterized geometries are shown in Fig.1



(a) (b)

Figure 1: Parameterization of the E-core (a) Per manufacturer website; (b) For optimization.

Table I: Core dimensions [mm]

Design	A	B	C	D	E	F
1	12.7	6.4	3.56	4.42	8.89	3.56
2	19.3	8.1	4.77	5.55	13.89	4.77
3	25.4	9.5	6.50	6.19	18.97	6.19
4	30.0	15.0	7.06	9.70	19.50	6.95
5	34.5	14.1	9.39	9.60	25.30	9.30

The parameterized geometry can be obtained for each of the cores using the manufacturer supplied dimensions listed in Table I as follows:

$w_E = B$; $\quad w_C = D$; $\quad$ depth $(d) = C$; $\quad t_C = F$; $\quad t_{Cu} = \frac{E-F}{2}$; $\quad t_T = \frac{A-E}{2}$;

The block (rectangular or I) core's dimensions available in the manufacturer website were quite large. Therefore, for this optimization, the I-core dimensions of length and depth are selected to be same as that of the E core. The height (w_I) is computed as $w_I = B - D$;

Table I is used to construct a lookup table for optimization. The optimization variables will be the dimensions, airgap, number of turns and the wire AWG.

BH Data:
The following B-H relation for the core is supplied by the manufacturer

$$\mathrm{B} = \frac{\mu}{\frac{1}{\mathrm{H} + \mathrm{a} \cdot \mathrm{H}^{\mathrm{b}}} + \frac{1}{\mathrm{c} \cdot \mathrm{H}^{\mathrm{d}}} + \frac{1}{\mathrm{e}}}$$

Note that B is expressed in Gauss and H in Oersteds.

Where, initial permeability $\mu = 14$, and the coefficients a, b,….e are listed below:

Core	a	b	c	d	e
FS-014	4.22×10^{-3}	1.88	3.99×10^{2}	0.345	1.09×10^{3}

The saturation flux density is $B_{sat} = 1.53\ T$

Using the following curve-fit data, a BH curve is introduced for the material model, in FEMM.

Core Loss:

The following core loss relation is supplied by the manufacturer

$$\text{Loss in } (\mathrm{mW/cm^3}) = \frac{\mathrm{f}}{\frac{\mathrm{a}}{\mathrm{B}^3} + \frac{\mathrm{b}}{\mathrm{B}^{2.3}} + \frac{\mathrm{c}}{\mathrm{B}^{1.65}}} + \mathrm{d} \cdot \mathrm{B}^2 \cdot \mathrm{f}^2$$

Note that B is expressed in Gauss and f in Hz.

Where, f is the frequency, B is the flux density. The loss coefficients a, b, c are listed below:

$$a = 1 \times 10^6;\ b = 6.13 \times 10^7;\ c = 2.05 \times 10^6;\ d = 6.1 \times 10^{-14}$$

The core loss will be computed by extracting the fundamental and harmonic components of B.