Air gapped magnetic core design guidelines

1. Calculate the area product needed for a specific inductor by:

$$A_{p_{des}} = \frac{LI_{pk}I_{rms}}{JKB_{max}} \qquad (1)$$

where L is the desirable inductor value, I_{pk} is the peak current that flow thru the inductor, I_{rms} is the RMS value of the inductor current, J is the current density (typical 4-4.5A/mm^2), K (typical 0.4-0.6) is the fill factor and B_{max} is the flux density.
Note that the values for the Ap equation are taken as the worst-case-scenario of the inductor operation.

2. Search for a proper magnetic element by comparing the desirable area product (1) to the area product of a practical inductor.

$$A_{p_{prc}} = A_e A_w \qquad (2)$$

where A_e is the effective magnetic area and A_w is the winding area. This information is provided by the core manufacturers and can be found in the datasheets, where A_e is found at the core section and A_w at the bobbin section.

3. Determine if there is a need to take into account the skin effect.

Skin depth:

$$S = \frac{72}{\sqrt{f_{sw}}} \qquad (3)$$

where f_{sw} is the switching frequency in MHz, the result of S should be in mm units.

4. Select a wire, calculate the wire area:

$$A_{wire} = \frac{I_{rms}}{J} \qquad (4).$$

Number of strands (for a litz wire):

$$str = \sqrt{\frac{A_{wire}}{\pi \cdot S^2}} \qquad (5)$$

note that this value should be rounded up.

In order to select a practical wire, a conversion to the wire diameter is made:

$$d_{wire} = \sqrt{\frac{4A_{wire}}{\pi \cdot str}} \qquad (6).$$

5. Calculate the number of turns for a given B_{max}:

$$n = \frac{LI_{pk}}{A_e \cdot B_{max}} \qquad (7).$$

6. Determine the air gap by applying:

$$\mu_r = \frac{L \cdot l_e}{\mu_0 \cdot A_e \cdot n^2} \qquad (8),$$

$$l_g = \frac{l_e}{\mu_r} = \frac{\mu_0 \cdot A_e \cdot n^2}{L} \qquad (9).$$

However, it is very common to measure the inductor value using LCR meter and adjust the air gap for the desirable inductance value.