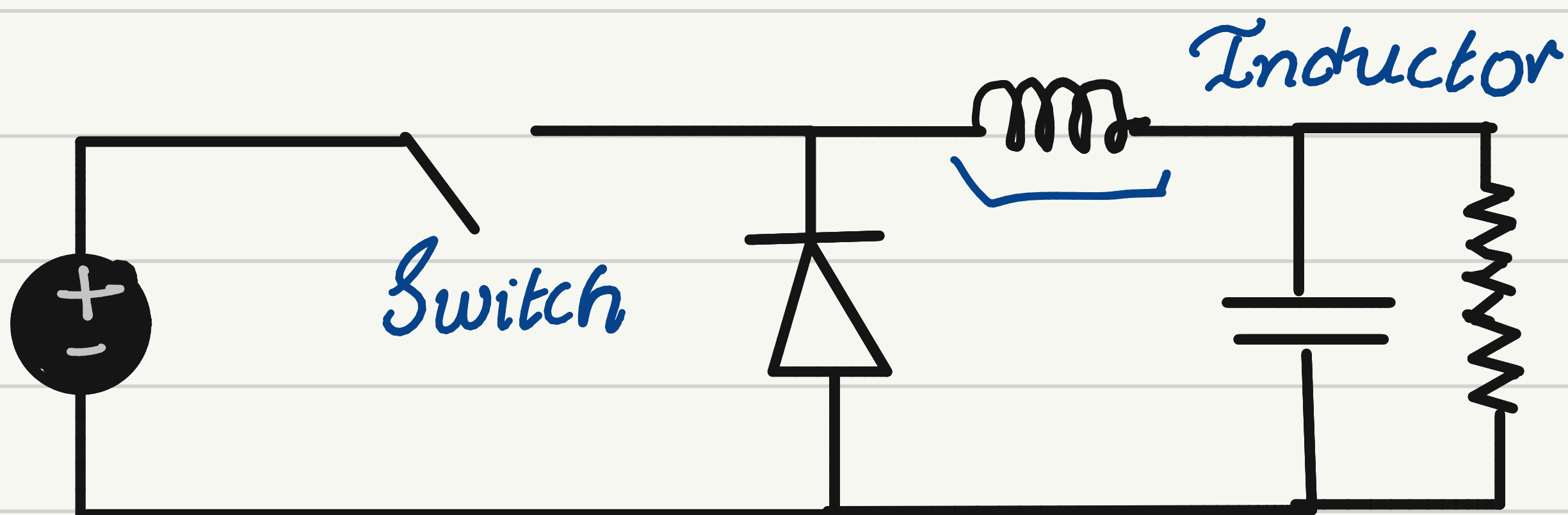


# Design of magnetics: Assignment 210020050

Problem statement: Design an inductor with specification for buck converter

Input voltage	50V
Output voltage	20V
Inductance	34μH
DC current	20A
frequency	80kHz
ΔT	15°C
T	70°C
window Kv	0.8



$$V_L = V_{IN} - V_{OUT} = L \frac{dI}{dt} \quad (\text{On state})$$

$$V_L = L \frac{\Delta I}{\Delta T}$$

$$\Delta T = DT_s \quad T_s = \text{Switching time}$$

$$\Delta I = \frac{(V_{IN} - V_{OUT}) DT_s}{L} =$$

$$\frac{30 \times \left(\frac{20}{50}\right) \times \frac{1}{80 \times 10^3}}{34 \times 10^{-6}} = 4.41 \text{A}$$

maximum current:  $I_m = I_{avg} + \Delta I / 2$

$$I_m = 20 + 2.2 = 22.2 \text{ A}$$

⇒ area product of inductor

$$B_{max} = 0.25 \text{ T} ; \Delta T = 15^\circ \text{C} ; \delta_w = 1.72 \times 10^{-8} \Omega \text{ m}$$

$$K_u = 0.8 ; h = 10 \text{ W/m}^2 ; k_w = 10 ; K_a = 40 ; k_i = 1$$

$$A_p = \left( \frac{\sqrt{1+r} k_i L I_m^2}{B_{max} K_t \sqrt{k_u \Delta T}} \right)^{8/7}$$

$$K_t = \sqrt{h K_a / \delta_w k_w}$$

$$A_p = \left( \frac{\sqrt{1+0} \times 1 \times 34 \times 10^{-6} \times (22.2)^2}{0.25 \times K_t \times \sqrt{0.8 \times 15}} \right)^{8/7}$$

$$K_t = \sqrt{\frac{10 \times 40}{1.72 \times 10^{-8} \times 10}} = 4.8 \times 10^4$$

$$\Rightarrow A_p = 4.22 \times 10^{-8} \text{ m}^2 = 4.22$$

from  $A_p$  core selection; near appropriate

core is EE-625

$$A_c = 2.390 \text{ cm}^2 ; W_a = 1.930$$

and other dimensions taken from  
Marcel Dekker, Inc - [1]

$$\mu_{opt} = \frac{B_{max} l_c k_i}{\mu_0 \sqrt{\frac{P k_u W a}{\epsilon_w M L T}}} =$$

(To find air gap)

$$P = \frac{\Delta T}{R} = \frac{15^\circ C}{11} = 1.36 W$$

$$\mu_{opt} = \frac{0.25 \times (8 \times 10^{-2}) \times 1}{4\pi \times 10^{-7} \sqrt{\frac{1.36 \times 0.8 \times 1.93 \times 10^4}{1.72 \times 10^8 \times 9.4 \times 10^{-2}}}}$$

$$\mu_{opt} = 41.83$$

$$l_g = \frac{8 \times 10^{-2}}{41.83} = 1.91 \text{ mm}$$

$$A_L = 203 \text{ nH} \quad (* \text{ normalized for } 1 \text{ k} \times \mu)$$

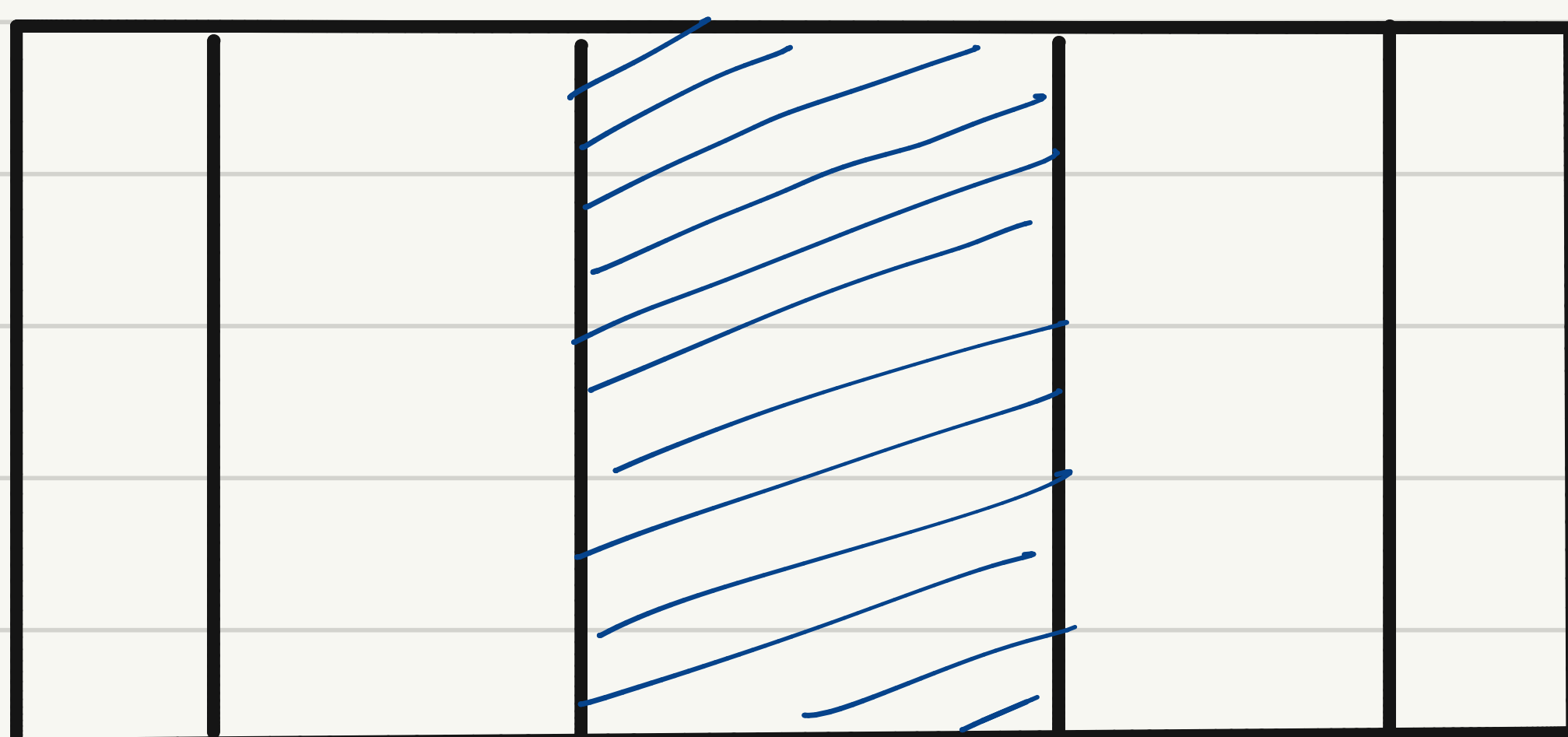
$$\text{Turns} = \sqrt{L / A_L} \cong 13 \text{ turns}$$

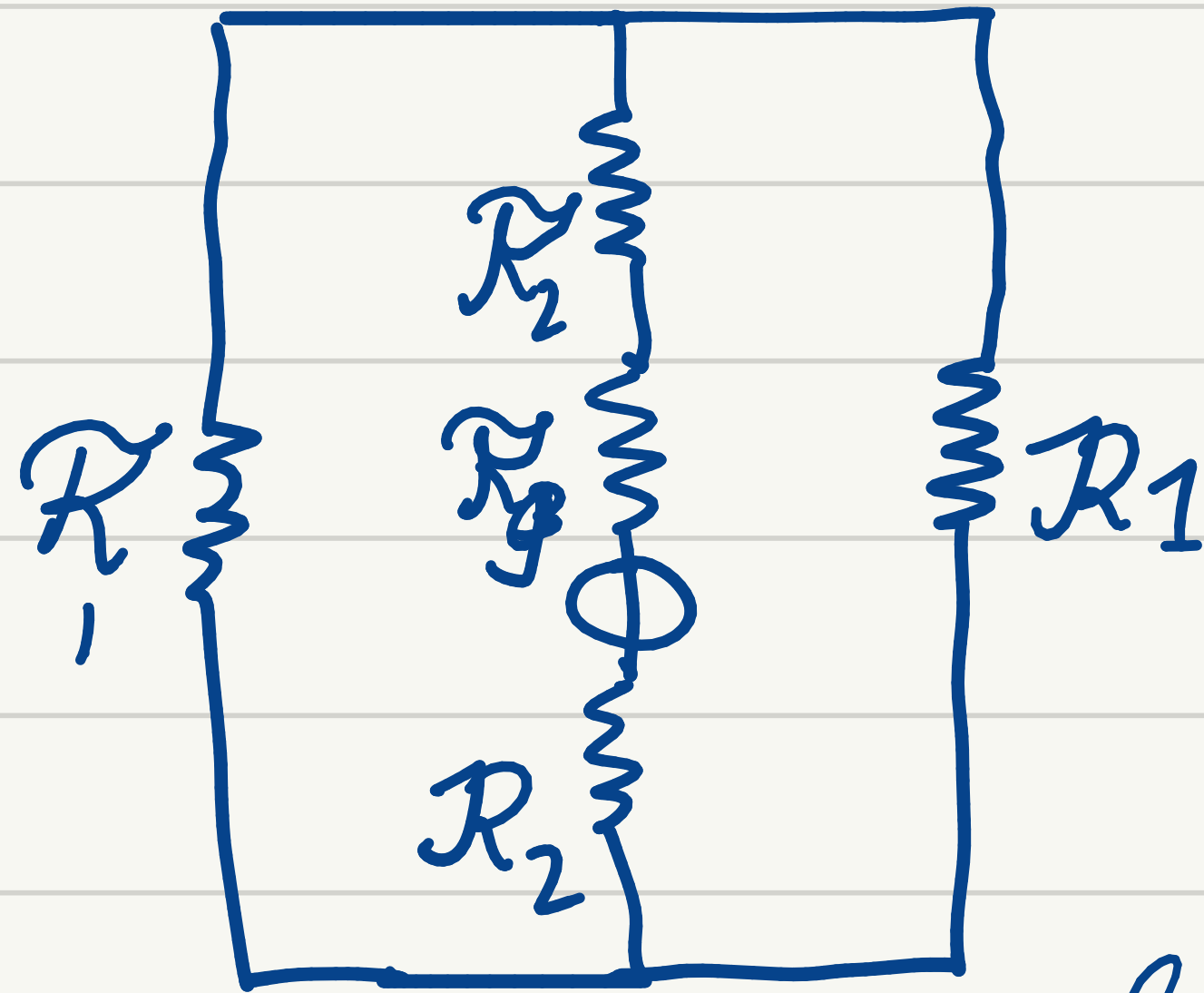
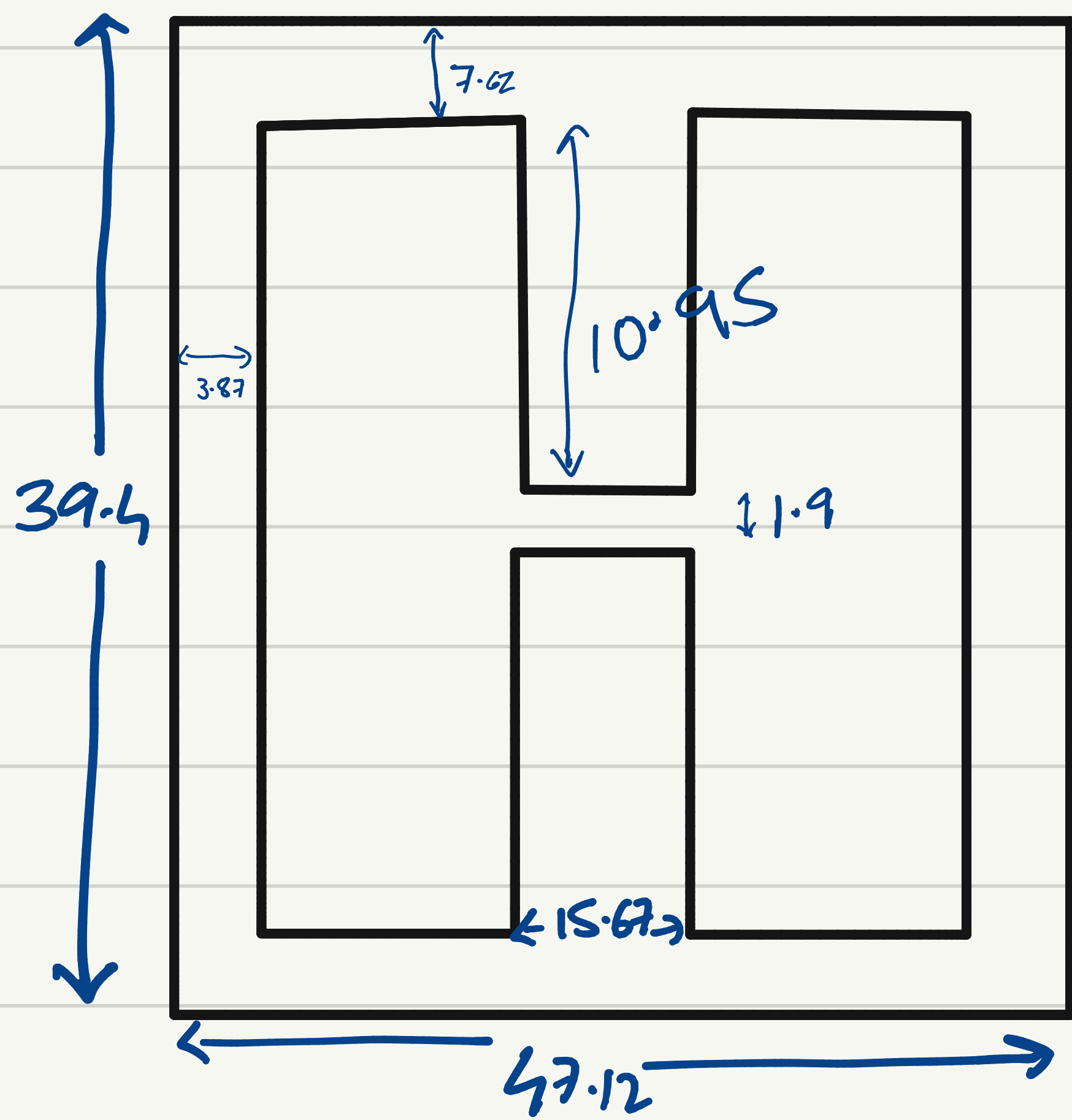
$$J_0 = \frac{k_t \sqrt{\Delta T}}{\sqrt{k_u (1+r)} \sqrt[3]{A_p}} = \frac{48.22 \times 10^3 \times \sqrt{15}}{\sqrt{0.8} \sqrt[3]{4.616 \times 10^8}}$$

$$A_w = I_{rms} / J_0 = 20 / 172 = 0.115 \text{ cm}^2$$

$$T_{max} = 85^\circ C ; R_{DC} = N \times M L T \times 10.75$$

Core - Selection (lengths)





$$l_2 = 10.9 +$$

ETD - CORE

all dimension in mm

$$R_{eff} = 2R_2 + R_g + R_1/2 = \frac{1}{4\pi \times 10^7} \left( \frac{1.9 \times 10^{-3}}{15.67^2 \times 10^{-6}} \right)$$

$$L = \frac{N^2}{R_{eff}} = \frac{13^2}{R_{eff}} \approx 34 \mu H$$