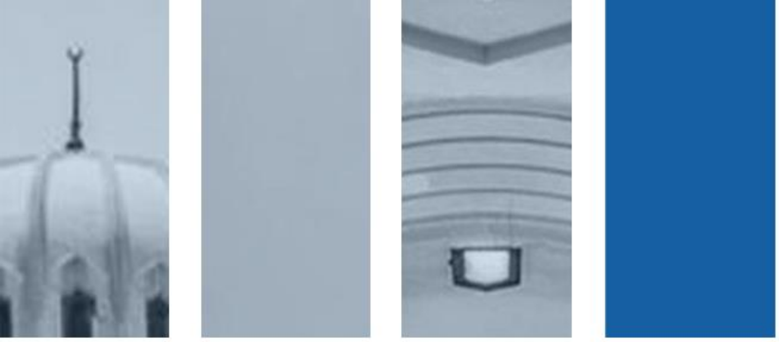

RESEARCH & PROJECT SUBMISSIONS

Program: *Electrical Engineering*

Course Code: EPM 322

Course Name: Machines (2)

Examination Committee

Prof. Adel Yousef Hannalla

Dr. Nabil Mohamed Hamed

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Faculty of Engineering

Spring Semester – 2020

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Signature/Student Name: **Mostafa Badran** **Date:** **5/14/2020**

Submission Contents

Step up transformer simulator

1.0 Abstract

This project is part of course (Machines (2) EPM 322) and it purpose is to compute Electric Transformer design based on the knowledge gain within the course which had been taught by Prof. Adel Yousef Hannalla, Dr. Nabil Mohamed Hamed Mohamed,Dr. Ahmed Mohy Eldeen Ibraheem. This computational system is aiming to minimizing results error which can happen While doing design calculation manually and this system able to notify with design feasibility and which cooling method should and proposed design. its core functions have been built by MATLAB language and for Graphical user interface (GUI) I used MATLAB app designer, but this system produce it result under some assumption:

1- it Step-Up Transformer

2-tank design plain walled tank shape

3- Transformer electric circuit is circuit approximate and refer to H-V side

2.0 INTRODUCTION

2.1 The Objectives of The Project

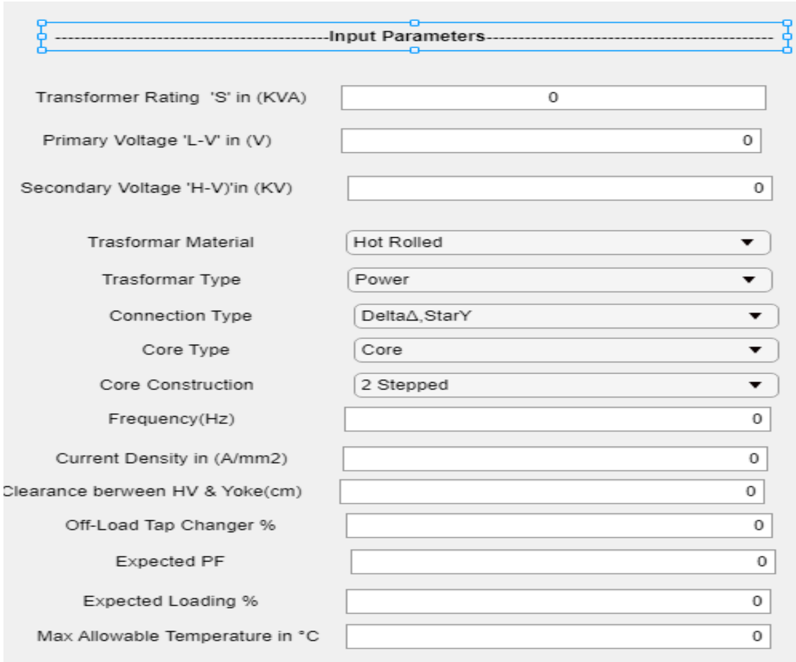
This computational system is aiming to automated Transformer design calculation work and present the new design parameter, so the user be able to choose best design based on his needs without go through calculation iteration a lot.

This system present the results in 4 part : “Core Dimensions ”,”Winding Parameters”, “Circuit’s Electric and Magnetic Parameters ” and ”Tank Measurement & Dimensions ” Based on “Input Parameters” that user set by himself and would go through How the systems work and calculating the results in next part “System Theoretical Background”

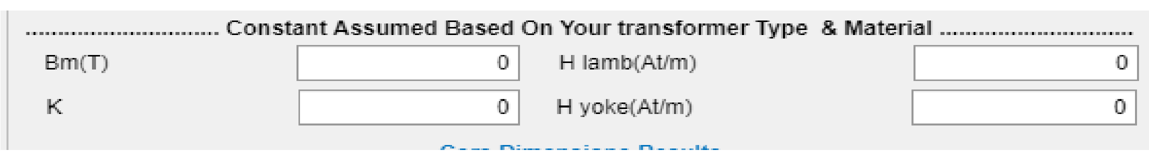
2.2 System Theoretical Background

This system present the results in 4 part : “Core Dimensions ”,”Winding Parameters”, “Circuit’s Electric and Magnetic Parameters ” and ”Tank Measurement & Dimensions ” Based on “Input Parameters” and would go through How the systems work and calculating the results in next part “System Theoretical Background”

2.2.1 Input Parameters

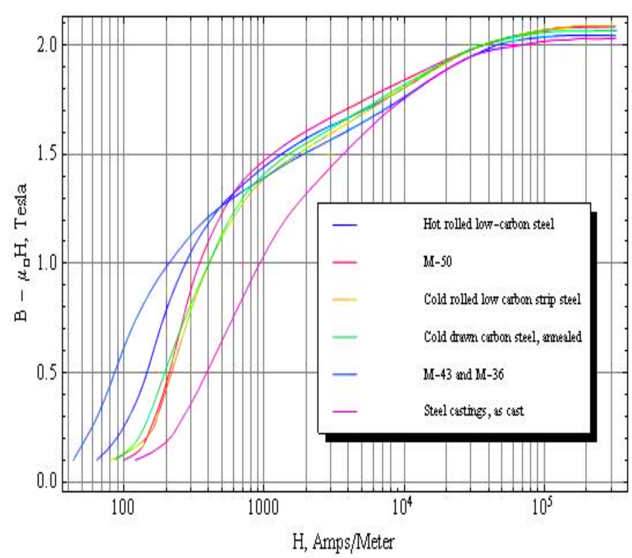


the user set his inputs as with considering the unit presented in every cell.



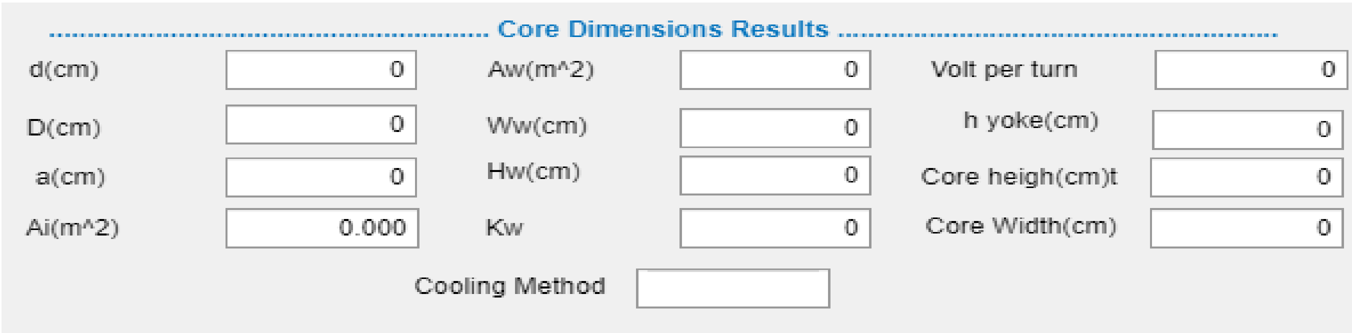
and Based on user input there is constants are decided by assume_Bm() like Bm,Hyoke,Hlimb,K which would be used ahead in a lot of calculation .

And I got Bm,Hyoke,Hlimb constant used in code form this graph for Hot rolled low-carbon steel and cold rolled low strip steel .



And based on connection type chosen the function phase_volt () will calculate the right phase voltages for Primary side and secondary side

2.2.2 Core Dimensions



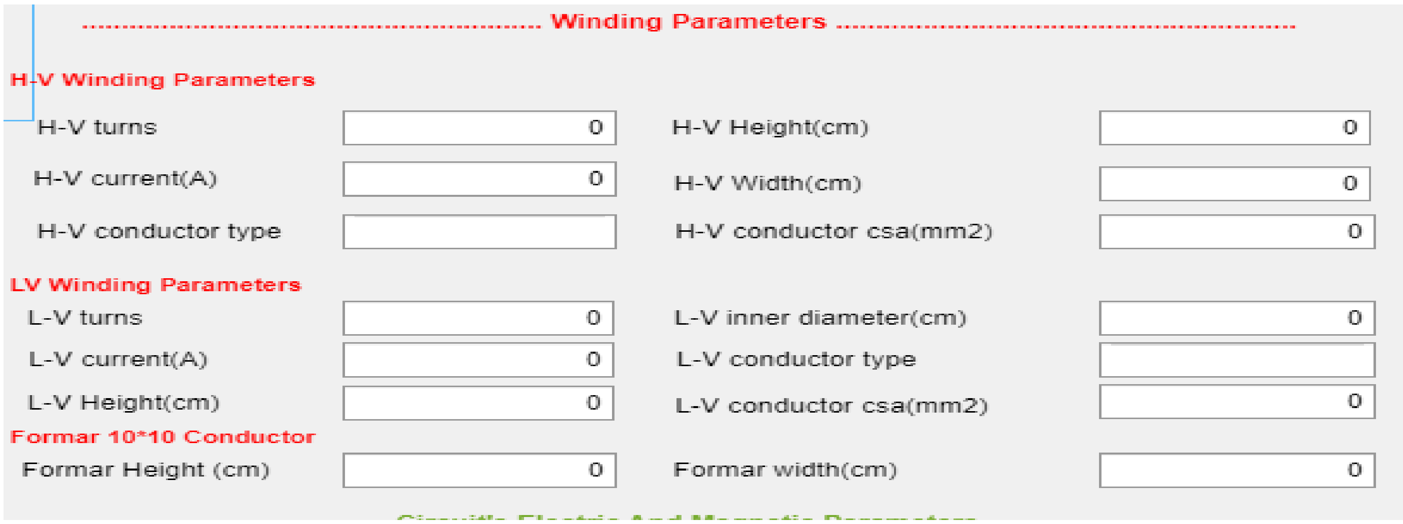
This part will be calculated by function called core_dim() that use Rated power , , frequency , Bm , Current Density And Core Construction That will be used in the following equations .

E_t	= K*$\sqrt{S}$	Where, E_t is the voltage per turn S is the rating of transformer
Ai	= E_t /(4.44*f*bm)	A_i is the net core area
Kw	= 12/(30+ (secondary voltage on (KV)));	Kw is Window factor this equ very accurate for S< 1000 KVA
Aw	=(S)/(3.33*Kw*(current density *10^6)*Bm*Ai*frequency)	A_w is the net window area
d	$=\sqrt{\frac{Ai}{.56}}\, in\ case\ 2\ stepped\ or \sqrt{\frac{Ai}{.6}}\ in\ case\ 3\ stepped$	d is Diameter of circumscribing circle “as it assumed to be cruciform core”
a	=.9*d	core Depth
h	=1.2*.9*d	Yoke Height
Ww	$=\sqrt{(Aw/3)}$	Window Width
Hw	=3*Ww	Window Height
H	=Hw+2h	Core Hight
D	=Ww+d	Bet centerlines of core
W	=2D+a	Core Width

And, in this part Simulator recommended Cooling Method and depend in on Rating of transformer

And this slides lecture 3

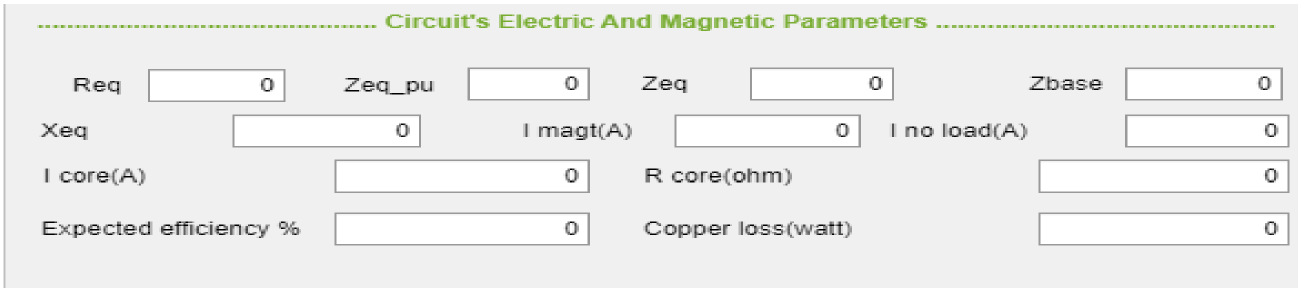
2.2.3 Winding Parameters



This part will be calculated by function called winding_parameters() that use Rated power ,Et , secondary volt, phase secondary volt, primary volt, phase primary volt, Off-Load Tap Changer %, current density and Diameter of circumscribing and That will be used in the following equations .

H-V turns	= Secondary Volt / Et
H-V conductor csa(mm2)	= H-V current/ current density
H-V conductor type	=Cross-over Circular
H-V current(A)	=S/3*phase secondary volt
H-V Height(cm)	= Formar Height * total number of 10*10 conductor formars
H-V Width(cm)	= 2 Formar width + L-V outer dimeter
L-V turns	= primary Volt / Et
L-V conductor type	= (4*3) Helical Rectangular
L-V conductor csa(mm2)	= L-V current / current density
L-V current(A)	=S/3* phase primary volt
L-V inner diameter(cm)	= d+2+((conductor width+4)*10^-1*2)
L-V Height(cm)	= (L-V conductor height +5mm insulation) *L-V turns
Formar Height	10*(Conductor Dim *10^-1)+2mm insulation
Formar width(cm)	10*(Conductor Dim *10^-1)+1mm insulation

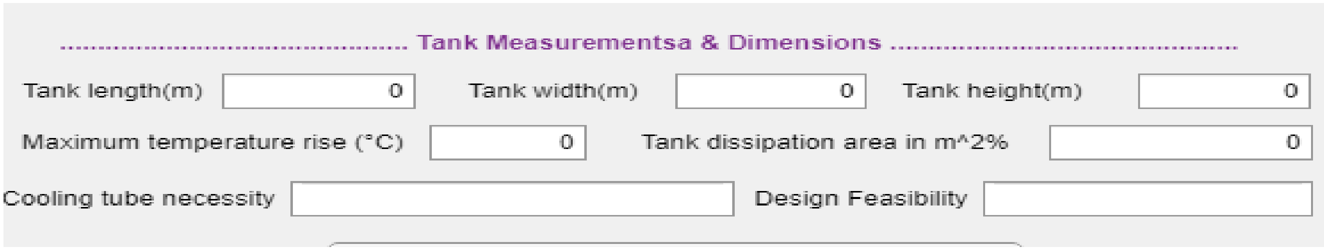
2.2.4 Circuit's Electric and Magnetic Parameters



This part will be calculated by two function called Loses_eff () , Z_eq_calc () that use Diameter of circumscribing , L-V inner diameter, L-V turns, H-V turns, L-V conductor CSA,H-V conductor CSA ,L_V conductor width- V Conductor dim, H-V volt, H-V current, H-V outer diameter-V width, frequency ,Ai,Hw,width,H_limb, H_yoke, Expected PF, Expected Loading %.

Req	=H-V resistance + L-V resistance *turn_ratio^2
Xeq	=2pi*freq* µ*(H-V turns^2)*(Lmean between hv and lv/L_c)*(b3+((b1+b2)/3)
Zeq	$=\sqrt{\mathrm{Req}^2+\mathrm{Xeq}^{\wedge}2}$
Zbase	$= Z_{BASE}=\frac{(KV_{LL})^2}{MVA_{3\phi}}\ (ohms)$
Zeq_pu	$Z_{PU}=\frac{Z\ (In\ ohms)}{Z_{BASE}}$
Core Resistance (ohm)	=(3* H-V phase current ^2)/PI_tot
Core Current(A)	= H-V phase current /R core;
Magnetic Current(A)	=AT/(3*$\sqrt{2}$* H-V turns)
No load Current (A)	$=\sqrt{\text{Magnetic Current}^2+\text{No load Current}^{\wedge}2}$
Copper loss(watt)	=3*(Power Rating /(3* H-V phase current))^2)* Req
Expected Efficiency %	=Output/(Output+Loss)

2.2.5 Tank Measurement & Dimensions



This part will be calculated by two function called tank_dim() ,suggest_redesign() that use Core Width, H-V Width , Core Depth ,Core Height, H-V volt, Copper loss, Max Allowable Temperature in °C, Window Height, H-V height,H-V height, Clearance between H-V winding and Yoke, bet centerlines of core, Z_eq_pu, No load Current .

suggest_redesign() check Design Feasibility as it check 5 condition need to be satisfied to say it's a feasible design (L-V height < Window Height),((H_V height + 2*clearance between yoke and H-V winding) < Window Height) ,(D >= (H-V width +2* clearance between yoke and H-V winding)) , (Z_eq_pu <= 0.1) and (no load current/H-V current <= 0.05)

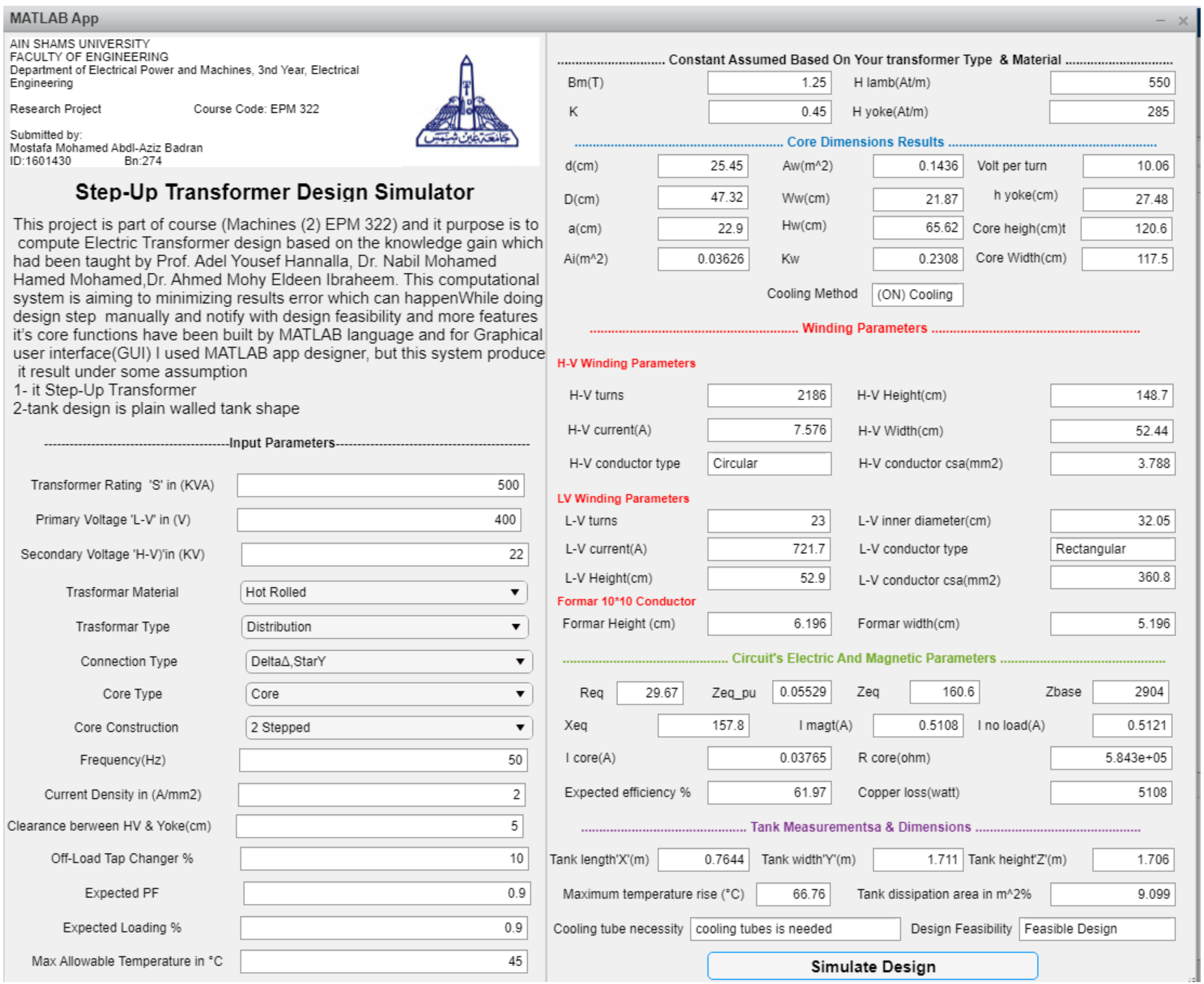
Tank length'X'(m)	=Core Width +2Dt
Tank width'Y'(m)	=Core Width + H-V Width+2Dt-Core Depth
Tank height'Z'(m)	=Core Height+.5
Tank Dissipation Area	=(2*Tank length* Tank height)+(2* Tank width* Tank height)+(Tank length* Tank width)/2

3.0 Results and Discussion

It is required to design a three-phase, 50 Hz, 1000 kVA, 22 / 0.4 kV, Dy1, core type, ON cooled, distribution transformer. The ambient temperature is 35° C, and the maximum allowable temperature rise is 45° C.
You may take k = 0.5. This is the ratio of voltage per turn to the square root of the three phase kVA.
The window factor k_w may be taken from 0.2 to 0.3.
The maximum flux density in the core limbs ranges from 1.1 to 1.3 T.
The current density in the windings ranges from 1.8 to 2.25 A/mm^2.

(i) Design the transformer core using a cruciform cross-section for the limbs. Make clear choice of the core material. Select the flux densities in limbs and yokes, and the current density in the windings. Calculate the dimensions of the core and make a simple sketch for the core showing these dimensions.
(ii) Calculate the number of turns on both sides and the conductor cross-sectional area. Select the type and conductor material of the winding on each side. .
(iii) If the transformer is to be equipped with taps, decide on which side must they be arranged, and why. If there are 4 steps below, and 4 steps above the normal voltage each step of 2.5%, calculate the number of turns in each step.
(iv) Make simple sketches.

Minimum allowable clearances: Between H.V. and L.V. coils = 3 cm, between H.V. coils = 5 cm, between H.V. coils and tank walls = 10 cm, between core and tank top = 50 cm.



The simulator works without any error when I checked using the couple of examples attached with project. The calculation for second example has been examined and presented above and results go side by side with distribution transformer properties. However, the output will need more test to discover if there any corner cases that cause the simulator produce inaccurate results to verify its capability on solving for different transformer types and categories.

4.0 Conclusions

This simulator was made to verify results of solving this course problem. analyze the transformer parameter coding is done in MATLAB software. Application was developed with the friendly GUI to take the input which is processed by the program coded giving the design parameters and but still doesn't give the user full control especially in part of choosing constant as Bm , Kw as the simulator choose it based on user input . There a room of growth and development for Simulator can be done to accommodate More feathers and more user control on its inputs. But I count this as start.

5.0 Appendix

Code walkthrough: https://drive.google.com/open?id=1mR6iZf6k0e4buD8HA1erP143USiiU3pE

TA example results: https://drive.google.com/open?id=1hGrULkel1Ntn9k0RO7hvHMXfyocEHxvJ

Core Functions code : https://drive.google.com/open?id=1GWf3YL9jbaJkRPeSqT53FEBP7E8yGfTj

Step-Up Transformer Simulator:

https://drive.google.com/open?id=13DE9_OB9to_XMkxQtIVm2Cgo0IjwAYP-