DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

Real-frequency technique impedance matching tool for ultrasound transducer matching circuit design

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Client: Adamson Lab

Introduction

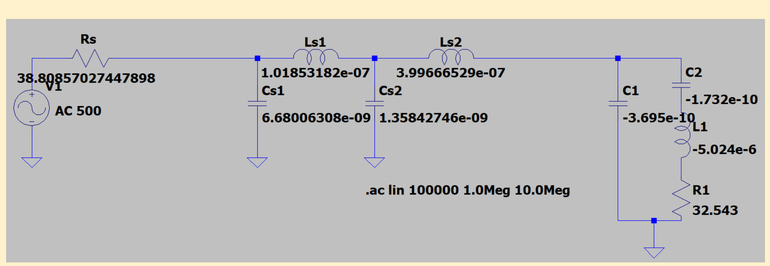
The project is to develop an easy-to-use, fully automated software that can load a transducer impedance file in with desired circuit parameters, generate ideal matching circuit, and output parameters of each components in the process. It needs to be fully functional between frequency range from 20 MHz up to 60 MHz.

Design Process

- Getting requirement for project
- Design UI, that can take resistance input for piezo electric transducer, and the circuit specification.
- Design an algorithm to calculate the specific R, L and C value used for the matching circuit.
- Simulate output data in LTSpice to test if algorithm output is correct.
  - If the result is accurate, continue to order PCB, and components mounted onto them.
  - If result is not accurate, continue to improve details in algorithm to meet requirement.
- Design a few PCB according based on the output circuit schematic, and the calculated component value.
  - Test finished PCB in the lab to confirm the result from software design is accurate.

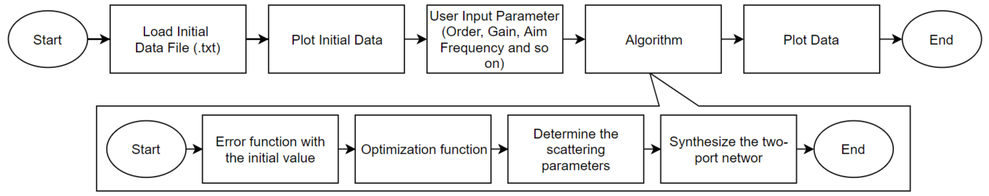
Testing

- Get impedance reading by using impedance analyzer, as an txt file, showing the impedance characteristic of the transducer from 1MHz to 10MHz.
- Import impedance reading data as input file of final program, specify the order of output LC circuit.
- Get resistance, capacitance, and inductance values. Construct the LC matching circuit as shown, measure the input power, the output power at piezo electric transducer, and calculate the power output ratio of the circuit.
- To maximize power output ratio of circuit, adjust the nominal center frequency (nomcenter in the program) to the value where the frequency range with acceptable gain is wide enough within the 1MHz to 10MHz range.

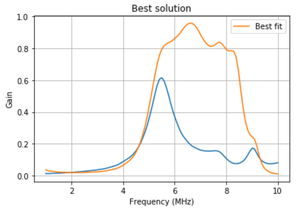


Details of Design

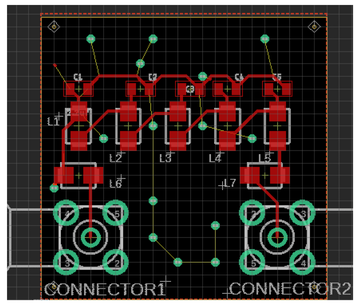
Flow Chart

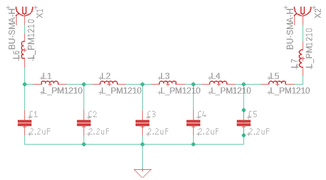


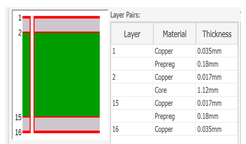
Results



PCB







$T = 0.035mm$

$H = 0.18mm$

$W = 0.3213mm$

$\varepsilon_r = 4.3$

$z_0 = 50.4\Omega$

For $\frac{W}{h} < 1$ $Z_0 = \frac{60}{\sqrt{\varepsilon_{eff}}} \times \ln\left(\frac{8h}{W} + \frac{W}{4h}\right)$

Else $Z_0 = \frac{120\pi}{\sqrt{\varepsilon_{eff}}} \times \frac{1}{\left(\frac{W}{h} + 1.393 + 0.677 \times \ln\left(\frac{W}{h} + 1.444\right)\right)}$

For $\frac{W}{h} < 1$ $\varepsilon_{eff} = \frac{\varepsilon_r + 1.0}{2} + \frac{\varepsilon_r - 1.0}{2}\left[\frac{1}{\sqrt{1 + \frac{12h}{W}}} + 0.04\left(1 - \frac{W}{h}\right)^2\right]$

Else $\varepsilon_{eff} = \frac{\varepsilon_r + 1.0}{2} + \frac{\varepsilon_r - 1.0}{2}\left[\frac{1}{\sqrt{1 + \frac{12h}{W}}}\right]$

Where ε_r is the Relative Dielectric Constant

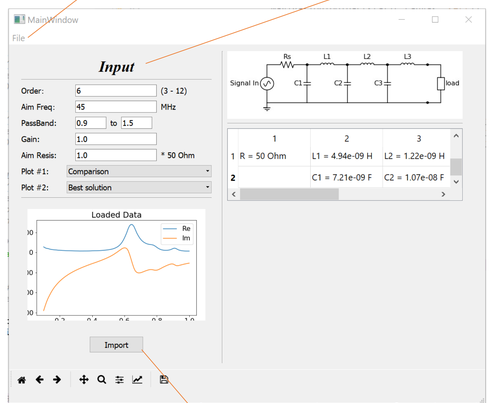
W is the Width of track

t is the Thickness of track (1 oz/ft2 = 0.035 mm)

h is the Thickness of dielectric

The board will have 4 layers with ground plane running under all signal traces.
The board signal traces will be 50 ohms.

UI



Conclusion & Recommendation

- The User Interface has been successfully implemented.
- The algorithm has been proper optimized.
- The PCB design has been completed.
- Due to the time limit, the PCB board is not ordered from the websites.
- It is recommended that further optimization on the software should be done to ensure the UI is easily to use and the calculated results are reasonable.
- It is recommended that more simulations should be implemented to ensure the results are accurate for the power transfer.

Reference

- Yarman, B. S. (2010). Design of ultra wideband power transfer networks. John Wiley & Sons.
- An, J., Song, K., Zhang, S., Yang, J., & Cao, P. (2014). Design of a broadband electrical impedance matching network for piezoelectric ultrasound transducers based on a genetic algorithm. Sensors, 14(4), 6828-6843.
- Yarman, B., & Carlin, H. (1982). A Simplified "Real Frequency" Technique Applied to Broad-Band Multistage Microwave Amplifiers. Microwave Theory and Techniques, IEEE Transactions on, 30(12), 2216-2222.