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IDEA PITCH

TEAM AKATSUKI

Presented by Dheepak and Harish | January 2026

Kalasalingam Academy of Research and Education

IKSC

IUCEE

Indo Universal Collaboration for Engineering Education FOUNDATION

4 QUALITY EDUCATION

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Data-Driven Smith Chart Visualization for Transmission Lines Education

Improving Conceptual Understanding through Interactive Simulation

(Based on Course Survey – Transmission Lines and Waveguides)

Prepared by **Team akatsuki,** Innovation beyond limits

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Introduction

Problem Identification

Smith Chart is a core analytical tool in the Transmission Lines & Waveguides course, used for impedance matching, VSWR, and stub design. However, due to its nonlinear and graphical nature, many students find it difficult to visualize and interpret using static diagrams.

Survey-Driven Evidence

A Course Exit Survey of 326 students, conducted by IQAC (IUCEE-aligned quality body), shows that 82.8% of students strongly felt the need for a dedicated interactive Smith Chart environment to improve conceptual clarity.

Proposed Solution

We propose an interactive Smith Chart visualization app that enables students to dynamically explore impedance, admittance, VSWR, and single-stub matching—transforming abstract theory into intuitive visual learning.

Survey Background

Survey Context

- Course: Transmission Lines & Waveguides
- Participants: 326 students
- Conducted by: IQAC (Quality Cell)
- Quality Framework: IUCEE-aligned
- Type: Institutional Course Exit Survey

📌 Why this matters:

This project is not assumption-based, but evidence-based.

Core Survey Question (Smith Chart Focus)

📊 Responses (326 students):

- Strongly Agree + Agree: 82.8%
- Neutral: 10.7%
- Disagree: 6.4%
- Mean Score: 4.18 / 5

📌 Inference:

More than 4 out of 5 students explicitly demand Smith Chart interactivity.

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Proposed Solution

Interactive Smith Chart Visualization App :

We propose an interactive Smith Chart–based learning application that allows students to dynamically visualize impedance, admittance, VSWR, and reflection behavior, addressing the core visualization gap identified in the TLW course survey.

Real-Time Matching & Design Support:

The app enables step-by-step single-stub matching, showing stub length and stub location directly on the Smith Chart. Manual calculations are mirrored by interactive simulation, ensuring theoretical correctness and conceptual clarity.

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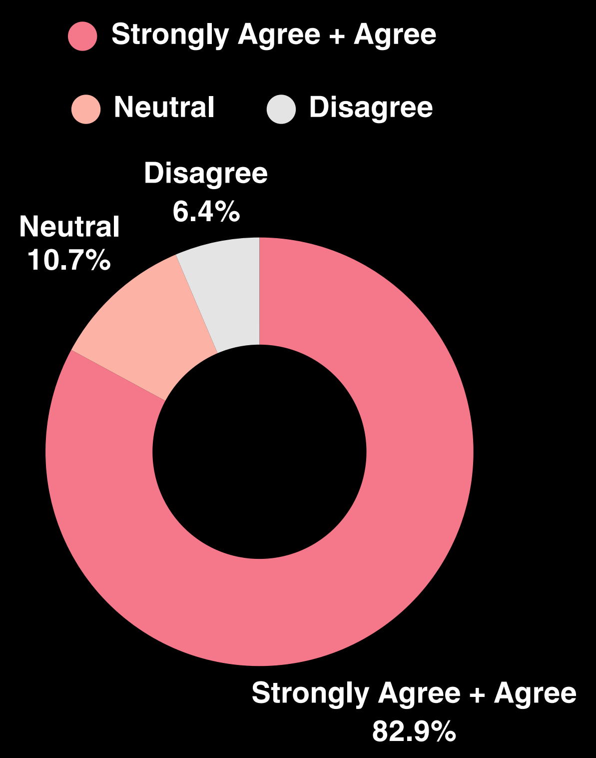
Learning Opportunity

Based on a Course Exit Survey of 326 TLW students (IQAC, IUCEE-aligned), a strong learning gap was identified in Smith Chart visualization, creating a clear opportunity for an interactive educational solution.

Learning Demand



326 Students

Learner Insight

Course Level

Undergraduate ECE students

Core Difficulty Areas:

- Impedance ↔ Admittance transformation
- VSWR interpretation

Learning Behavior

- High theory understanding
- Low graphical intuition

Learning Impact

Before App → After App

Static Smith Chart → Interactive movement

Manual plotting errors → Visual accuracy

Memorization → Conceptual understanding

Validation Method

✓ Manual single-stub matching

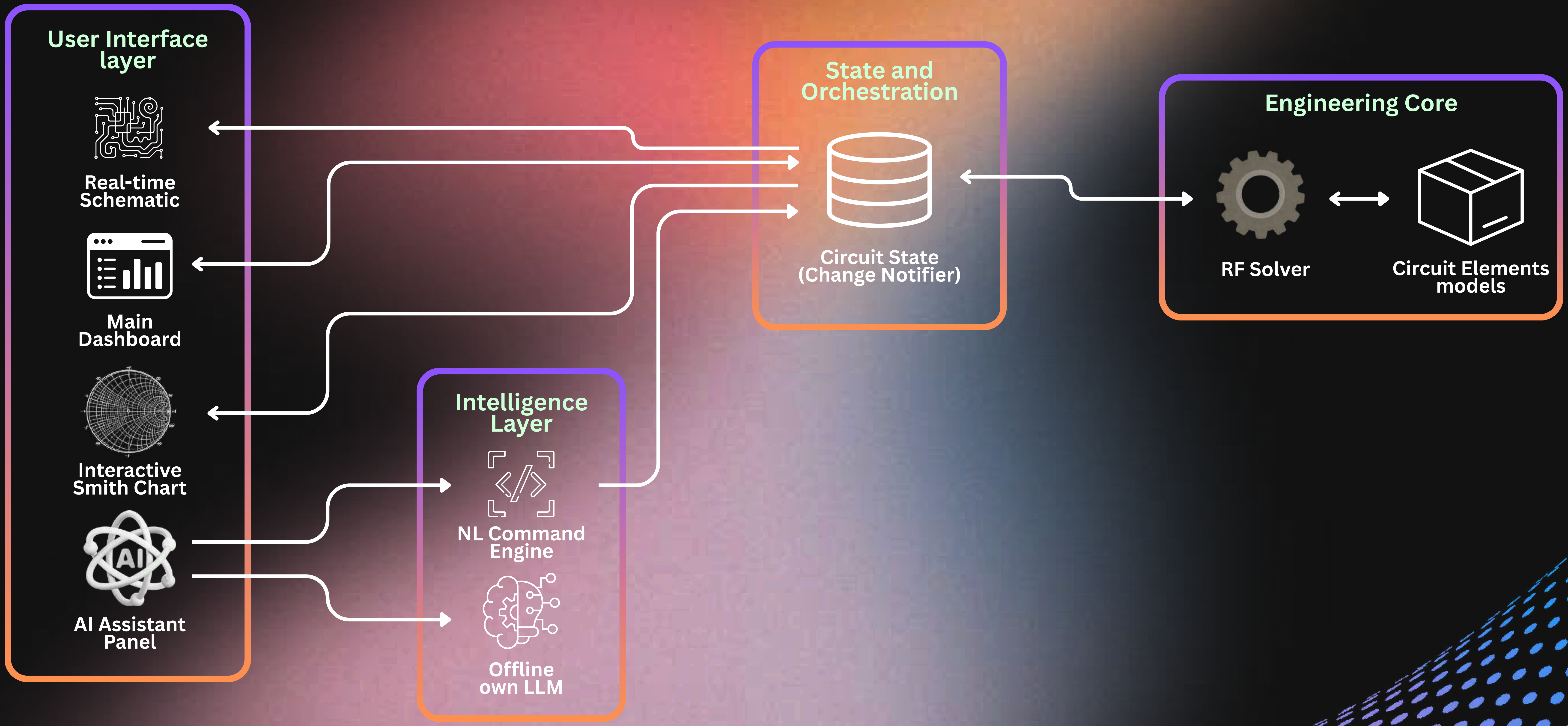
✓ App-based interactive simulation

✓ Matching numerical results

Summary

- Identified using institutional survey data
- Targets core TLW learning bottleneck
- Improves Smith Chart intuition
- Verified using manual vs simulation comparison

Architecture Flow



Validation Strategy

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How We Prove the Project is Effective

To validate effectiveness, we solve one complete single-stub matching problem using:

- Manual Smith Chart calculation
- Interactive simulation using the proposed app

Manual Calculation Approach

Steps:

1. Normalize load impedance
2. Plot on Smith Chart
3. Move along constant VSWR circle
4. Find stub location
5. Determine stub length
6. Achieve impedance matching

App-Based Simulation Approach

Steps in App:

1. Enter load impedance
2. Interactive movement on Smith Chart
3. Automatic VSWR circle
4. Direct visualization of:
   - Stub location
   - Stub length
5. Instant numerical output

Manual Calculation (Single stub)

The line at radio frequencies 2.33

SMITH CHART – STUB MATCHING

Single Stub Matching

Determine the stub length and the distance of the stub from the load. Given that a complex load $Z_L = 50 - j100$ is to be matched to a 75Ω transmission line using a short–circuited stub.

Given :

Characteristic impedance of the transmission line $Z_0 = 75\Omega$

Load impedance to be matched to the transmission line $Z_L = 50 - j100$

Steps :

1) The normalized impedance is determined by dividing the load impedance by the characteristic impedance of the transmission Line.

$$z_L = \frac{Z_L}{Z_0} = \frac{50 - j100}{75} = 0.667 - j1.33$$

2) The normalized impedance, z_L is plotted on the Smith chart by determining the point of intersection between the constant R circle with R = 0.667 and constant X circle with X = 1.33.

The impedance circle is drawn.

Because stubs are connected in parallel with the load, admittances can be much easily used rather than impedances to simplify the calculations.

3) The normalized admittance y is determined from the Smith chart by simply rotating the impedance plot, by 180°. This is simply done by drawing a line from point A through the center of the chart to the opposite side of the circle, point B.

4) The admittance point is rotated clockwise to a point on the impedance circle where it intersects the R = 1 circlé, at point C. The real component of the input impedance at this point is equal to the characteristic impedance Z_0. At the point C, the admittance is $y = 1 + j1.7$.

5) The distance from point B to point C, in terms of the wavelength is how far from load the stub must be placed, i.e, *d*.

The stub must have a zero resistive component impedance and a susceptance that has the opposite polarity.

6) To determine the length of the shorted stub that has an opposite reactive component to the input admittance, the outside of the Smith Chart (R=0) is moved around with the starting point at D {since at point D t = 0 and hence γ = ∞}, until an admittance y = 1.7 is found.

7) The distance between point D and E is the length of the stub. For this quantity the notation is, *l*

2.34 *Transmission lines & Wave gu*

From the Smith Chart ,

length of the stub l = 0.086 λ ; position of the stub from the load : d = 0.088 λ

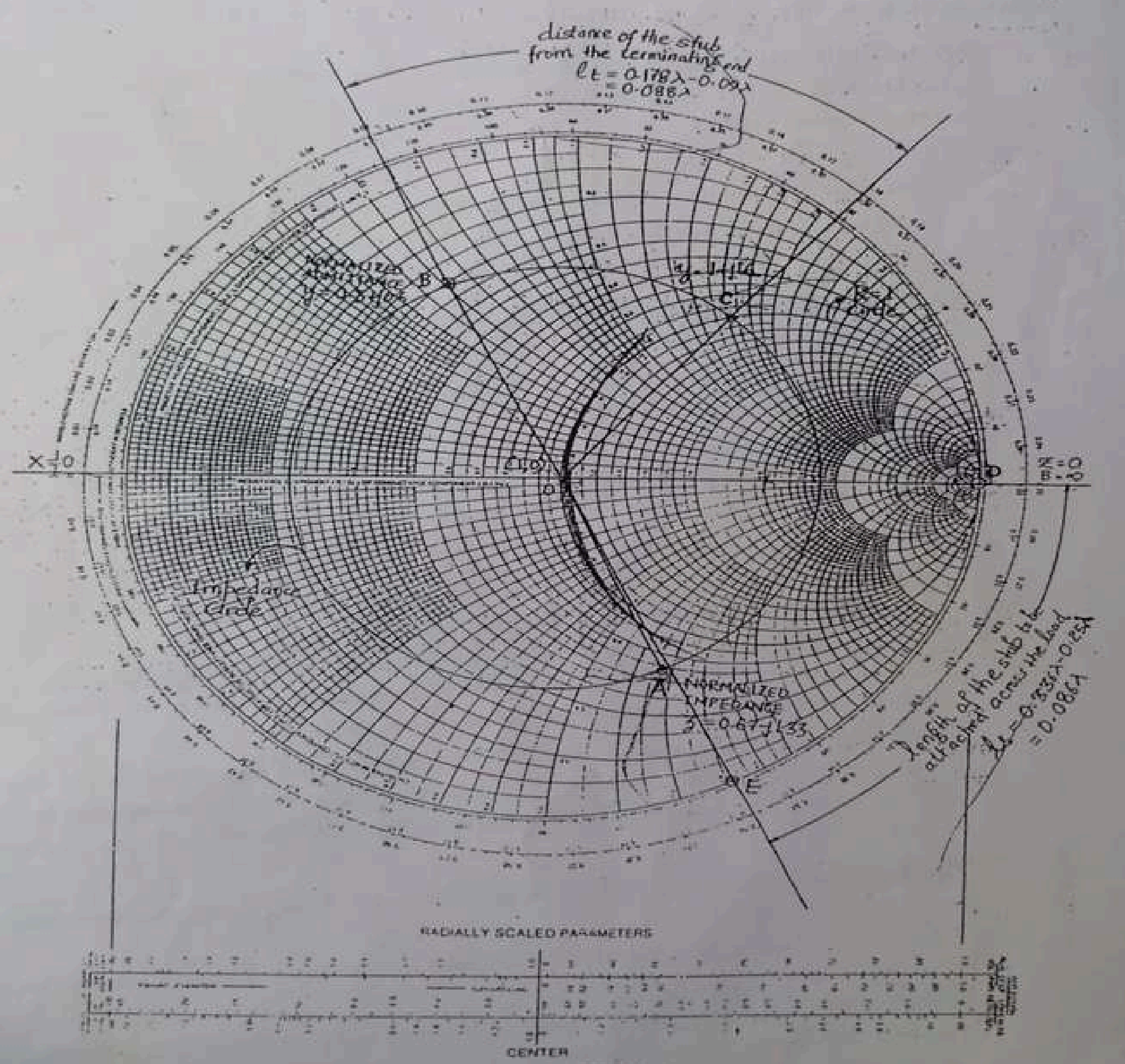


Fig. 2.14 Single Stub Matching

Manual Calculation (Double stub)

Double Stub Matching

Using Double stub matching, match a complex load of $Z_L = 18.75 + j56.25$ to a line with characteristic impedance $Z_0 = 75\Omega$.

Determine the stub lengths, assuming a quarter wavelength spacing is maintained between the two short circuited stubs.

A spacing of $\lambda/4$ is maintained between the stubs, stub 2 and stub 1. For smooth line operation of the transmission line the input admittance looking into the terminals 2, 2 of the line should be,

$$Y_{22} = {}^{1}/Z_0$$

i.e. the line beyond the point 2, 2, should appear to be a pure resistance of value 'Z_0'. {considering Z_0 is purely resistive}. Similar, to the single stub matching, the admittance (normalized) at the point 2,2 must be,

$$\frac{Y_S}{G_0} = 1 \pm jba$$

The stub at 1, 1 must be capable to transform the admittance at the terminating impedance end to the circle B which is displaced from the circle A ; R = 1 by '$\lambda/4$'.

The quarter wavelength line will further transform the admittance into a value at 2,2 which will plot on the circle A. Thus the line to load distance between position 2, 2 is not required to be determined.

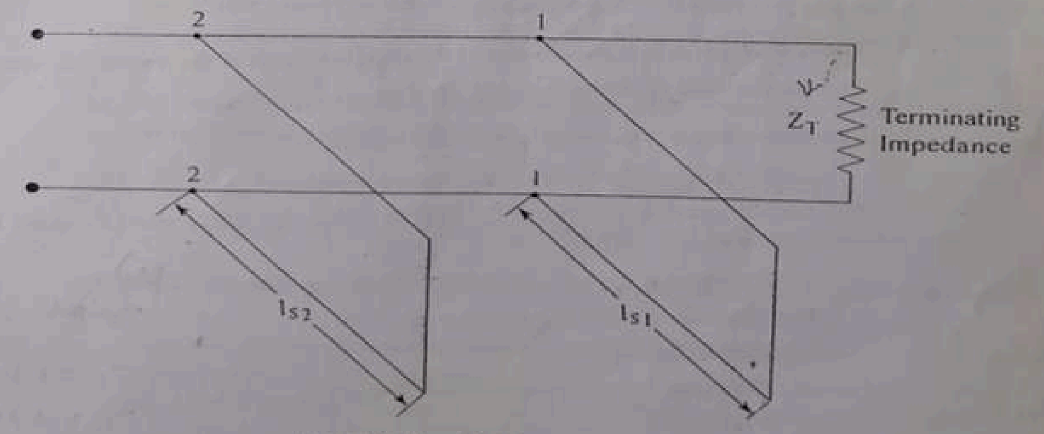


Fig. 2.15 Double Stub Matching

1. The normalized load impedance $z_L = \dfrac{Z_l}{Z_0} = \dfrac{18.75 + j\,56.25}{75}$

$$z_L = 0.25 + j0.75$$

plotting the normalized impedance on the Smith Chart, the impedance circle is drawn with distance between the point (1, 0) and the point of the normalized impedance as the radius {distance, OA}

2. Moving by 180° (0.25λ) on the impedance circle, i.e., at a diametrically opposite point to the point A, i.e., point B will give the normalized admittance.

   From the smith chart $y_L = 0.4 - j1.2$

3. Circle A is the constant R circle for R = 1. Circle B is the locus of all the points on the circle A displaced by λ/4, quarter wavelength. The stub 1 adds a susceptance (1/reactance) in parallel, this is done to change the value of y to such a value that it plots on the circle B.

   Since stub 1 cannot alter the conductance (1/resistance), to a point on the circle B, point C,

   y(at point C) = 0.4 – j0.5

   It is observed that the susceptance is changed by + j0.7.

4. Transforming the point C to the point D on the circle A, since the line between 1, 1 and 2, 2 is a quarter wave line that transforms the admittance at 1, 1 to 2, 2 such that the conductance equals the characteristic conductance, ${}^{1}/Z_0$.

   y(at point D) = 1.0 + j1.2

5. The stub length at 2, 2 should cancel the imaginary part of the above admittance.

   The susceptance of the stub at 2, 2 must be –j1.2.

6. To find the length of the stub with an admittance,

   (a) + j 0.7 and (b) –j 1.2

   The outside circle of the Smith Chart (the circle, R = 0), is moved around having a reference at point P, until

   an admittance y = –1.2 is found at point E and

   an admittance y = +0.7 is found at point F.

7. From the Smith Chart,

   Length of the stub 1 = distance between P and F l_{S1} = 0.348λ .

   Length of the stub 2 = distance between P and E l_{S2} = 0.11λ .

$jb_2 = -j0.57$
$l_2 = 0.416 - 0.25\lambda = 0.166\lambda$

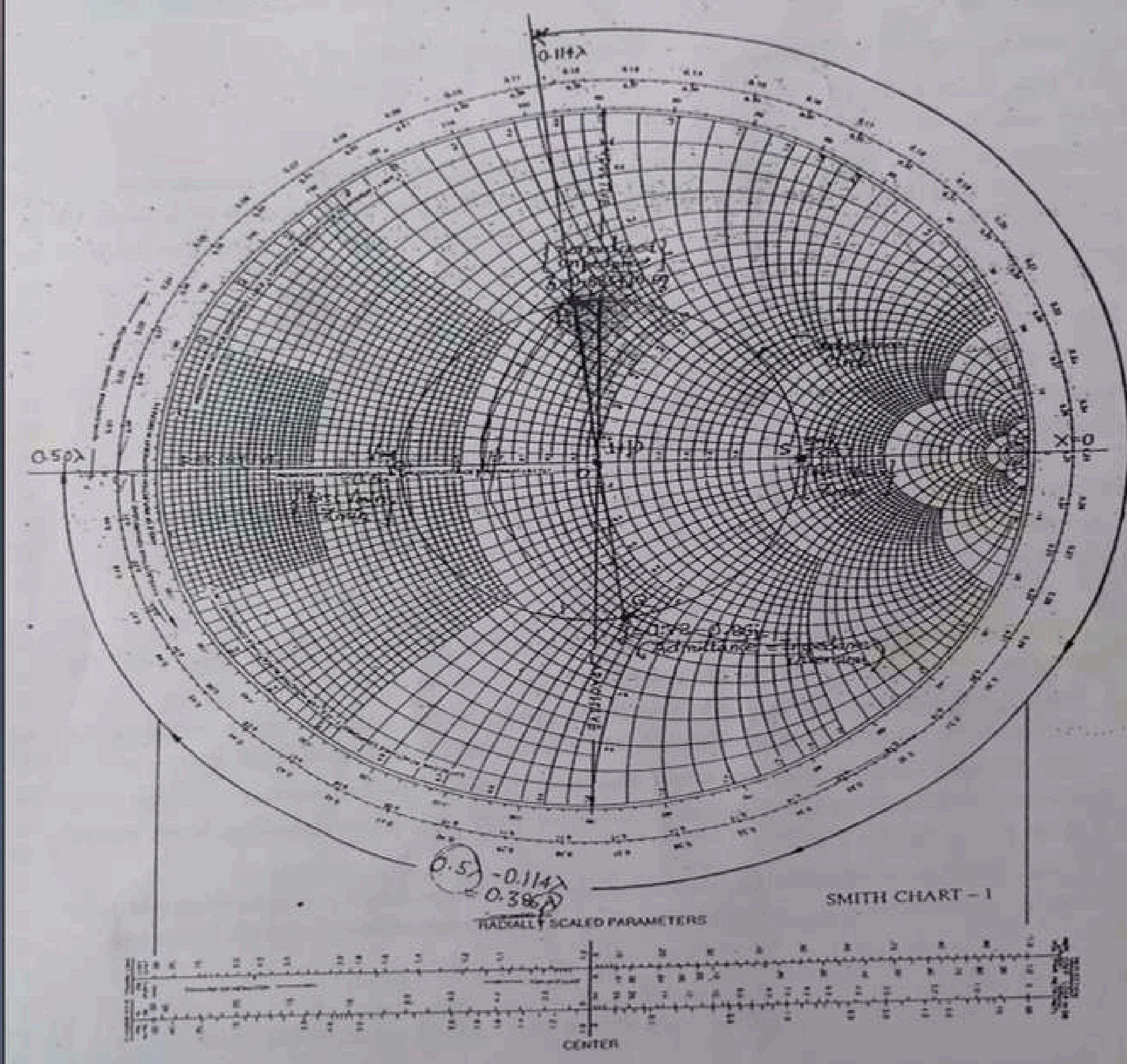
$Z_0 = 50\Omega$

$\lambda/8$

$Z_L = 1.2 + j0.8$

$jb_1 = j0.06$

$l_1 = 0.05\lambda + 0.06\lambda$



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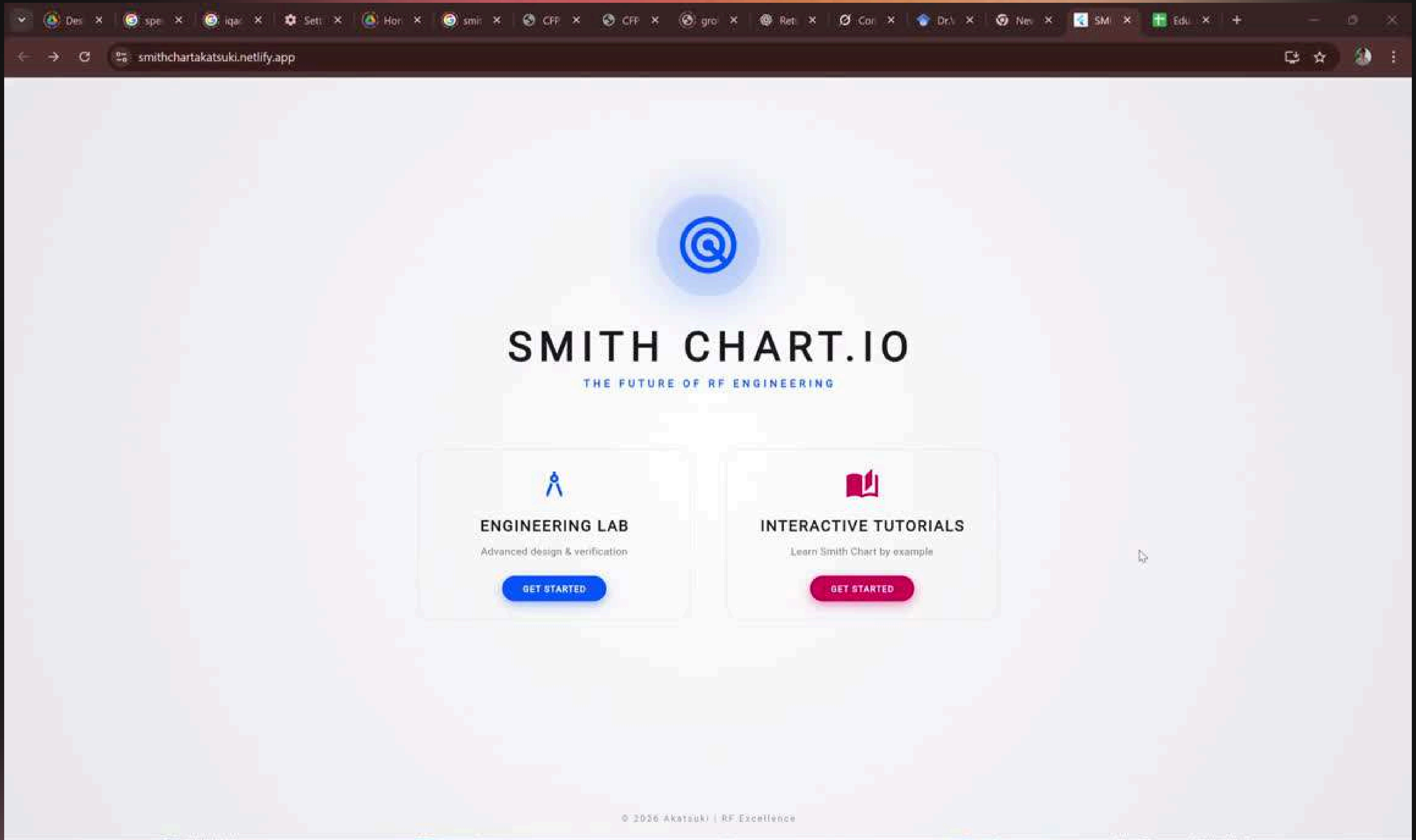
App-Based Simulation (video Presentation)

Incorporates all accessibility in the app



Result Validation(Predicted)

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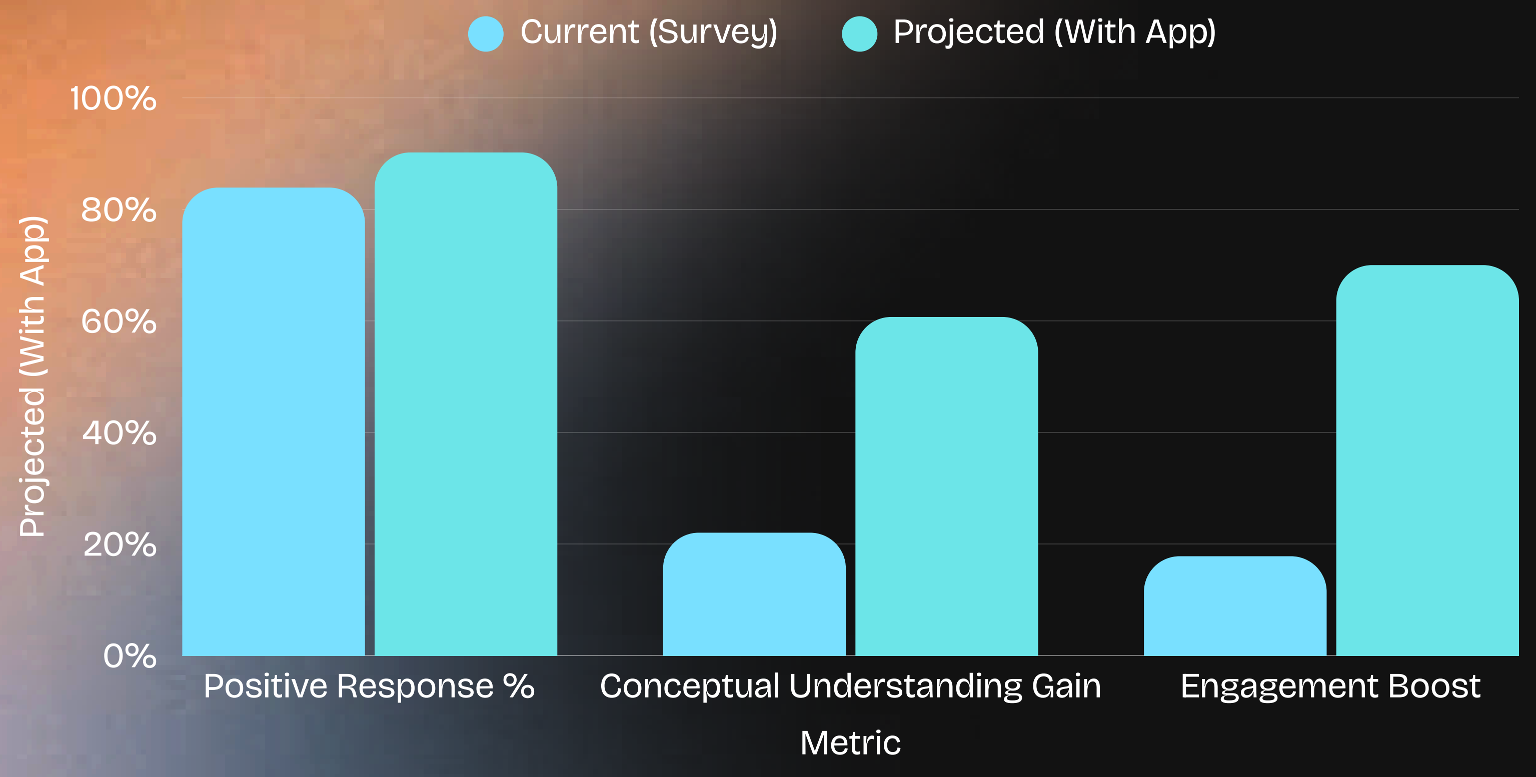
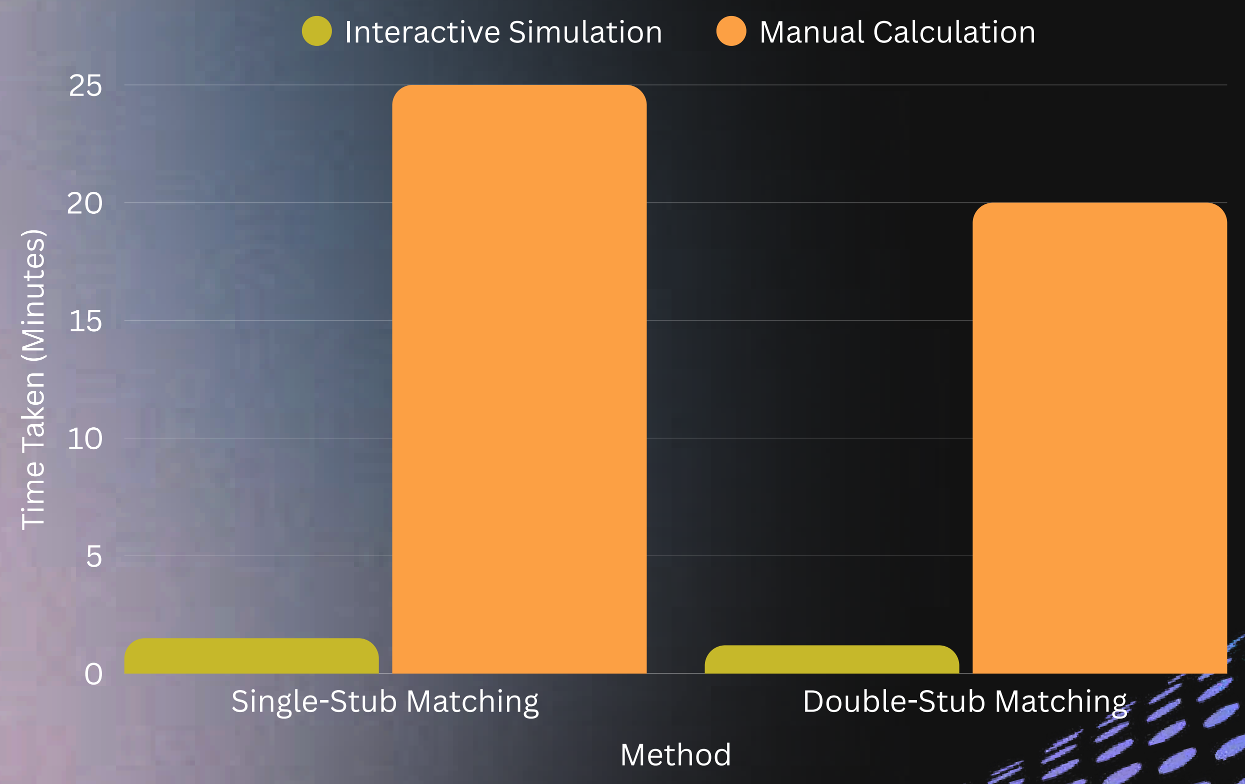
Metric	Current (Survey)	Projected (With App)	Source
Positive Response %	83.90%	90.20%	IQAC Survey + Edtech Uplift
Conceptual Understanding Gain	22%	60.70%	Engineering Simulation Studies
Engagement Boost	18%	70%	AI-Driven Edtech



Method	Interactive Simulation	Manual Calculation
Single-Stub Matching	1.5	25
Double-Stub Matching	1.2	20



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Our Team

Blending engineering insight and user-centric design to convert abstract Smith Chart theory into intuitive learning experiences.

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THANK YOU

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