EE 483L/583L Antennas for Wireless Communications (Spring 2026)
Laboratory 9- Rectangular Microstrip Patch Antenna

Background

For this project, you or your team will analyze a rectangular microstrip patch antenna. Then, you will measure the input impedance of the antenna.

Initial Analysis

A rectangular microstrip patch antenna with a centered & inset 50 Ω (SMA connector) microstrip feed was designed and fabricated for operation at 2.4 GHz. Measured with a caliper/ruler, the antenna has a width of 40.3 mm, length of 31.9 mm, the feed is inset 10.2 mm w/ notch widths of 0.3 mm on either side, and the feeding microstrip trace is 1.7 to 1.8 mm wide. It wa fabricated on a Rogers Corporation RO4003C microwave laminate of thickness 0.032” with 1 oz. copper cladding.

1) Locate the datasheet for this laminate (give reference).
2) Using the datasheet, find the appropriate relative permittivity $\varepsilon_{r,\mathrm{data}}$ and loss tangent tan δ. Include relevant excerpts from the datasheet to support your values.
3) Per the optimum (for radiation) patch width equation, find the relative permittivity $\varepsilon_{r,\mathrm{opt}}$ based on the given width and design resonant frequency. Does this value agree with $\varepsilon_{r,\mathrm{data}}$?
4) Using the given laminate & patch dimensions as well as $\boldsymbol{\varepsilon_{r,\mathrm{opt}}}$, find the effective relative permittivity $\varepsilon_{r,\mathrm{eff}}$, fringing lengths ΔL and effective length L_{eff} of this antenna (mm). Then, calculate the slot conductance G_1, susceptance B_1, and admittance Y_1 as well as the mutual conductance between the slots G_{12}. Next, calculate the characteristic impedance $Z_{c,\mathrm{ant}}$ and admittance $Y_{c,\mathrm{ant}}$ of the antenna.
5) Calculate input resistance R_{in} and the inset resistance R_{in}(10.2 mm). How do these resistances compare with 50 Ω?
6) Next, calculate the range of characteristic impedances $Z_{c,\mathrm{feed}}$ for the given trace width range. How does this compare with 50 Ω?

<u>Experiment</u> (All partners must be <u>present</u>. Bring a USB drive to save data.)

1) The instructor will have the antenna, 6’ coaxial cable, adapters, Keysight E5063A vector network analyzer (VNA), and Agilent 85033E 3.5mm Calibration Kit available. Include an **equipment table** with all relevant equipment information in logbook, i.e., description, manufacturer, and model number (as applicable).
2) Take **picture(s)** showing the antenna. Insert in logbook.
3) If necessary, power on the VNA. Connect a male type N to female SMA adaptor to PORT 1 (finger tight is adequate) and the 6’ coaxial cable to Port 1 of the VNA.

Wear a static wristband whenever working with the VNA!

Torque coaxial connections using torque and box wrenches (mechanical support)!

4) To begin, select the frequency range and settings for the VNA. The frequency should range from 2.4 GHz to 2.5 GHz in steps of 0.2 MHz. Calculate and record the number of data points N_{dat} required. Use data averaging with an averaging factor of 8. Press the Format button and use the mouse to select <Smith> and then <R +jX> to display an impedance Smith chart.

5) Per earlier labs, calibrate the VNA to the reference plane of the SMA (m) connector on the open end of the coaxial cable.

6) Connect cable to the SMA (f) edge launch connector of antenna. Place antenna in a location where it will not be disturbed. **Draw a block diagram(s) of the test set-up.**

7) Change the display format to SWR.
   - Adjust the display so that an SWR of 1 is at the bottom and the scale is 0.5/div.
   - Place Marker 1 at the lowest frequency where SWR = 2.
   - Place Marker 2 at the frequency f_{Slow} where the SWR is lowest.
   - Place Marker 3 at the highest frequency where SWR = 2.
   - **Save a screen shot of the SWR display.** Leave room for screen shot in logbook.

8) Return to impedance Smith chart display.
   - Leave Markers 1-3 at same frequencies as prior step.
   - Place Marker 4 at the resonant frequency f_r, i.e., where $X \approx 0$.
   - **Save a screen shot of the Smith chart display**. Leave room for screen shot in logbook.
   - **Save impedance Smith chart trace data.** Pull the USB drive from the USB port.

9) If no other groups are waiting, power down the VNA; else, push Preset button.

Post Analysis

1) How do f_{Slow} & Z_{Slow} compare to f_r & $Z_r = R_r$?

2) How do f_r & $Z_r = R_r$ compare to the desired design values of $f_{\text{des}} = 2.4$ GHz & $Z_{\text{des}} = 50\ \Omega$?

3) Based on the measured data, estimate the actual laminate relative permittivity $\varepsilon_{r,\text{act}}$.

4) Based on $\varepsilon_{r,\text{act}}$, redesign the antenna to achieve the desired design values of $f_{\text{des}} = 2.4$ GHz & $Z_{\text{des}} = 50\ \Omega$. Tabulate a comparison of the original design (col. 2) and redesign (col. 3) dimensions (col. 1) W, L, W_0, and y_0. Assume notch width n is held constant.

5) Based on $\boldsymbol{\varepsilon_{r,\text{act}}}$, tabulate a comparison of the original design (col. 2) and redesign (col. 3) for the quantities (col. 1) G_1, B_1, G_{12}, R_{in}, $Z_{C,\text{ant}}$, $Z_{C,\text{feed}}$, and $R_{\text{in}}(y_0)$.

6) Discussion and conclusions.

Report and Logbook

- Show initial work in logbook. Following syllabus guidelines, compose a short report on this lab.

Report & logbook due Monday, April 20, 2026 at class.