Fourth Year Antenna Lab

December 4, 2011

Contents

1 Wire Antennas

1.1 Objectives

- Plot the radiation pattern of simple $\lambda/2$ dipole antenna at 600 MHz.
- Measure the guided wavelength along a 50 Ω microstrip transmission line at 600 MHz.
- Measure the input impedance of a simple $\lambda/2$ dipole antenna at 600 MHz.
- Sense the $\lambda/2$ dipole antenna current distribution at 300 MHz.

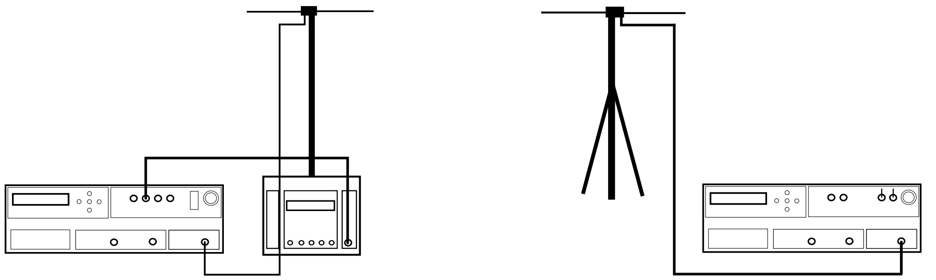
1.2 Equipments

- Antenna Training Lab Transmitter
- Antenna Training Lab Receiver
- 1 wire dipole antennas
- 3 Yagi-Uda wire array
- Rogowski Coil current Probe

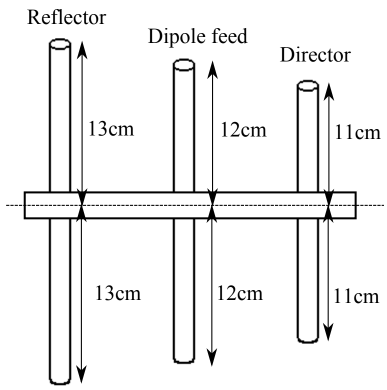
1.3 Procedure:

1.3.1 Radiation Pattern of $\lambda/2$ wire dipole

1. Connect the arms of the three element Yagi-Uda antenna and set their dimensions to that shown in the Fig. 1a after adjusting the Yagi-uda arm lengths according to Fig. 1b.



(a) Setup for measuring the $\lambda/2$ wire dipole radiation pattern. The dipole is mounted on the stepper motor to the right, and the transmitter is the 3 elements Yagi-Uda antenna shown in Fig. 1b.



(b) 3 elements Yagi-Uda antenna operating at 600 Mhz

Figure 1: a) Setup for measuring the $\lambda/2$ wire dipole radiation pattern. b) 3 elements Yagi-Uda antenna operating at 600 Mhz

2. Attach the Yagi-Uda antenna to the tripod stand, and connect it to the transmitter output port in the 87-898 MHz module through a 20 dB attenuator.

3. Set the transmitter frequency to 600 MHz.

4. Set the dipole total length 25 cm and attach it to the mast on the stepper motor.

5. connect it to the receiver input port in the 48-860 MHz module. Make the distance between the Tx and Rx antennas about 1 m.

6. Set the receiver frequency to 600 MHz (the same as the transmitter). You may need to use the a 20 dB attenuator in the RF receiver input if the received power exceeds -35 dBm. Also set the memory count to 1.

7. Set the stepper motor to 0° and its step to 5°.

8. Connect the trigger out from the stepper motor controller to the stepper Trigger port in the receiver using the provided BNC cable.

9. Turn on the PC connected to the receiver serial port, and run the antenna training program.

10. Select radiation pattern plot, and the memory locations from 1 to 72.

11. Click on the real time measurement button.

12. Set the training receiver to Auto mode.

13. Set the stepper motor motor to Auto.

14. Now the program starts to plot the radiation pattern point by point. When it is done, sketch the pattern you got in Figure 2.

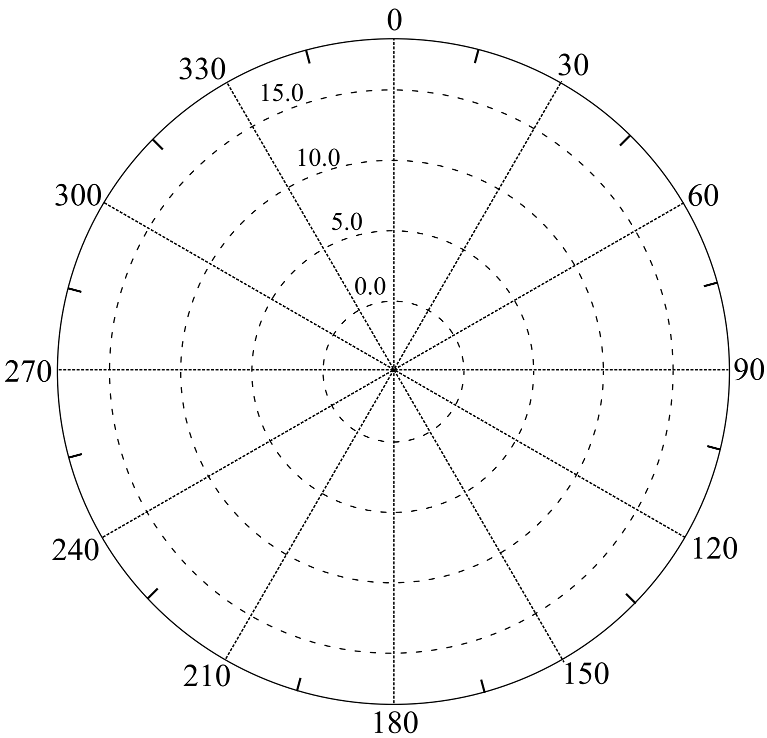


Figure 2: E-plane radiation pattern for $\lambda/2$ wire dipole operating at 600 MHz.

1.3.2 Radiation Pattern of the three-elements Yagi Udah

Repeat the previous procedure steps after interchanging the dipole and the Yagi Udah antennas. Sketch the pattern you got in Figure 3.

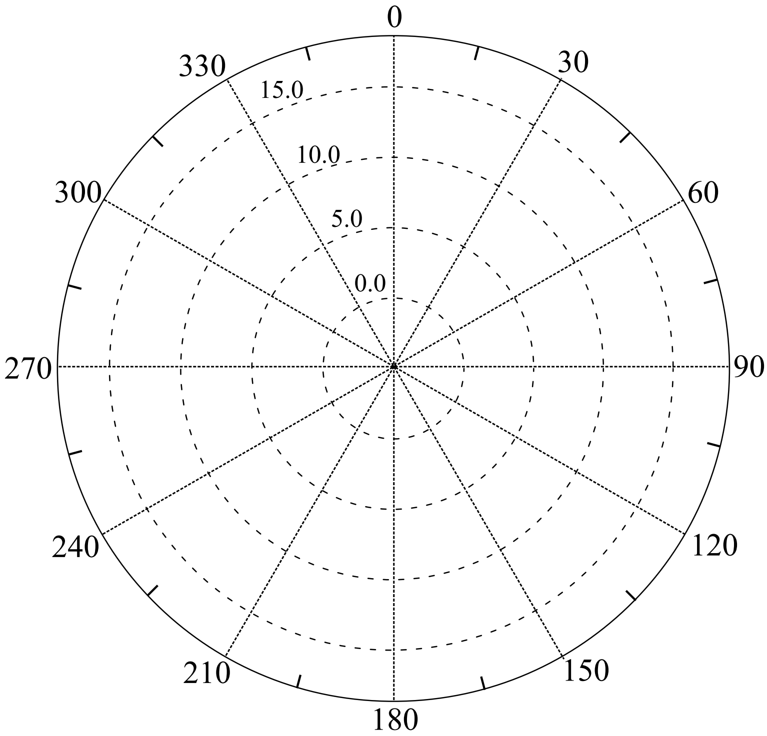


Figure 3: E-plane radiation pattern for the 3 element Yagi-Uda antenna operating at 600 MHz

The forward to backward radiation ratio=············ dB.

1.3.3 $\lambda/2$ Dipole Input Impedance

- Measuring the guided wavelength

  1. Connect the transmitter to one side of the slotted line, and connect the sliding port to the receiver. You may need to use 20 dB attenuators at the Tx and Rx.
  2. Connect the short circuit termination to the other terminal port of the slotted line, see Figure 4.

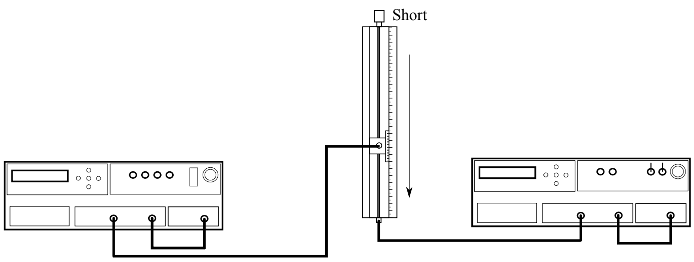


Figure 4: Setup for measuring guided wavelength.

  3. Set the Tx and Rx frequency to 600 MHz.
  4. Record the positions d_1 and d_2 of two successive minima.

Guided Wavelength $\lambda_g = \cdots\cdots\cdots$ cm.

- Measuring the SWR

  1. Now, remove the short circuit termination and connect the $\lambda/2$ wire dipole instead, see Figure 5.

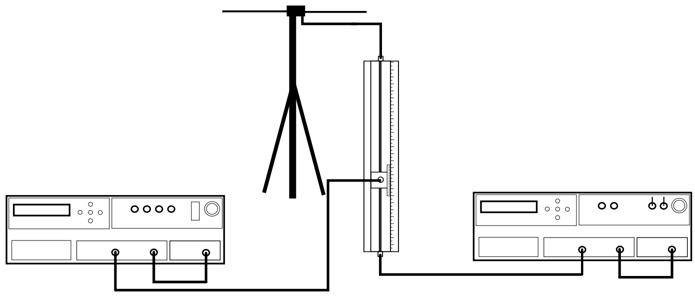


Figure 5: Setup for measuring the $\lambda/2$ wire dipole SWR.

  2. Measure the maximum and minimum power reading dBm along the slotted line

$p_{max} = \cdots\cdots\cdots\cdots$ dBm $\qquad$ $p_{min} = \cdots\cdots\cdots\cdots$ dBm

SWR(dB)$=p_{max} - p_{min} = \cdots\cdots\cdots\cdots$ dB $\qquad$ SWR$=\cdots\cdots\cdots\cdots$

- Measuring the input impedance

  1. Move the slide towards the generator and measure the distance the minimum has moved towards the generator d, see Fig. 6.

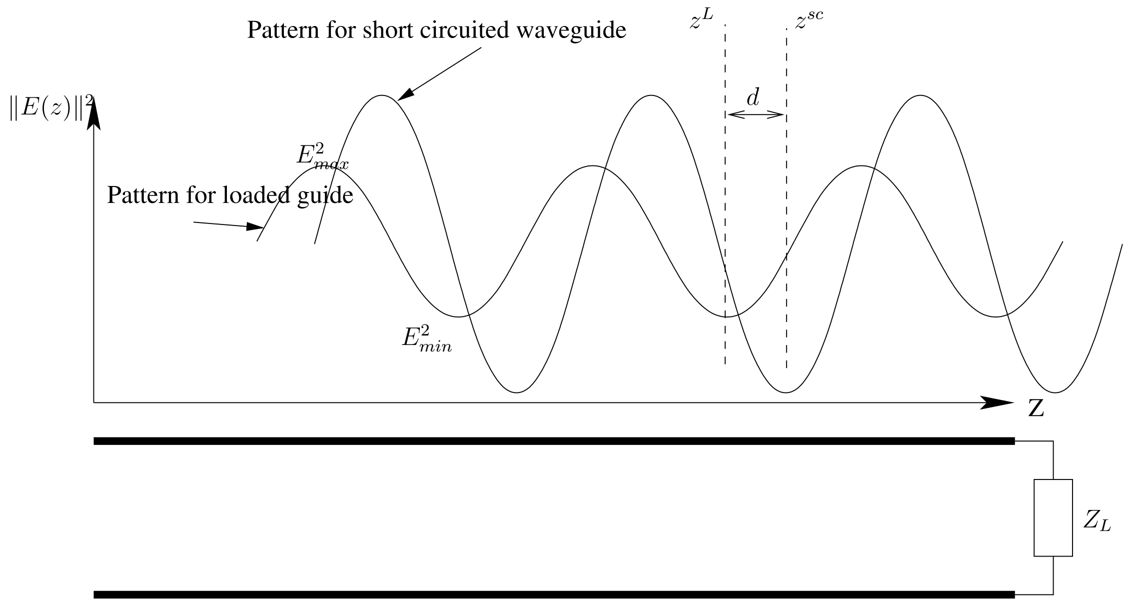


Figure 6: Measuring the distance d the minimum has moved towards the generator.

$d = \cdots\cdots\cdots\cdots$ cm, Phase of the reflection coefficient $\theta = 2\pi d/\lambda_g = \cdots\cdots\cdots$ rad.

$$Z_{antenna} = Z_0 \frac{1 - j\,(\text{SWR}) \tan\theta}{(\text{SWR}) - j \tan\theta} = \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad \Omega.$$

- Sense the $\lambda/2$ dipole antenna current distribution at 300 MHz

  1. Set the dipole total length to 50 cm.
  2. Connect the dipole to the transmitter and adjust the frequency to 300 MHz.
  3. Connect the Rogowski coil current probe to the receiver.
  4. Move the probe along the dipole wire and sketch the recorded received power as an indication of the current distribution.

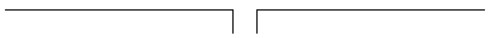


Figure 7: $\lambda/2$ dipole current distribution

2 Patch antenna with inset feed (1.62 GHz)

2.1 Objectives

- Measure the radiation pattern of simple microstrip patch antenna.
- Measure the directional pattern characteristics.
- Measure the patch antenna with inset feed return loss versus frequency.

2.2 Equipments

- Antenna Training Lab Transmitter
- Antenna Training Lab Reciever
- $\lambda/2$ printed dipole antenna operating at 1.62 GHz.
- Microstrip patch antenna with inset feed.
- Directional coupler.

2.3 Procedure

2.3.1 Radiation Pattern

1. Attach the microstrip patch antenna to the mast on the stepper motor, and connect it to input port of the 861-2000 MHz down-converter module. You need to connect the output of the down-converter to the 48-860 MHz, see Fig. 8.

2. Attach the $\lambda/2$ dipole antenna to the tripod stand, and connect it to the transmitter output port in the 861-2000 MHz down-converter module. You need to connect the output port of the 87-898 MHz module through a 20 dB attenuator to the input of the upconverter, see Fig. 8.

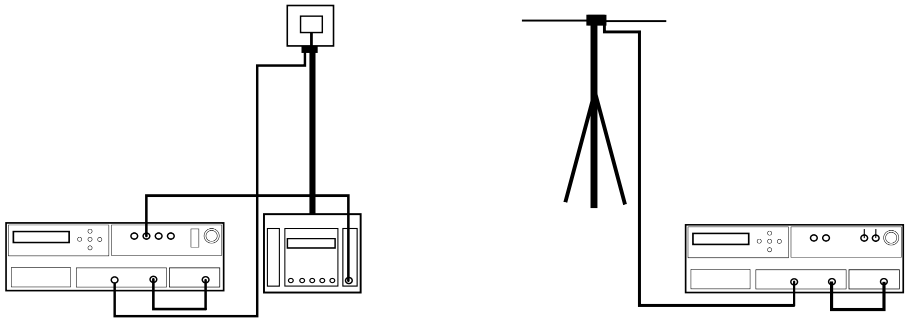


Figure 8: Setup for measurement of the microstrip patch antenna radiation pattern. The patch antenna is connected to the receiver module. The microstrip dipole is connected to transmitter to the right.

3. Make sure that the patch is vertical (with port pointing downward and the dipole is horizontal for E-plane; and port pointing to the side and the dipole is vertical for the H-plane).
4. Set the transmitter and receiver frequency to 1620 MHz.
5. You may need to use the a 20 dB attenuator in the RF receiver input if the received power exceeds -35 dBm. Also set the memory count to 1.
6. Set the stepper motor to 0° and its step to 5°.
7. Connect the trigger out from the stepper motor controller to the stepper Trig. port in the receiver using the provided BNC cable.
8. Turn on the PC connected to the receiver serial port, and run the antenna training program.
9. Select radiation pattern plot, and the memory locations from 1 to 72.
10. Click on the real time measurement button.
11. Set the training receiver to Auto mode.
12. Set the stepper motor motor to Auto.
13. Now the program starts to plot the radiation pattern point by point. When it is done, sketch the pattern you got in Figure 9 and 10 for E-plane and H-plane, respectively.

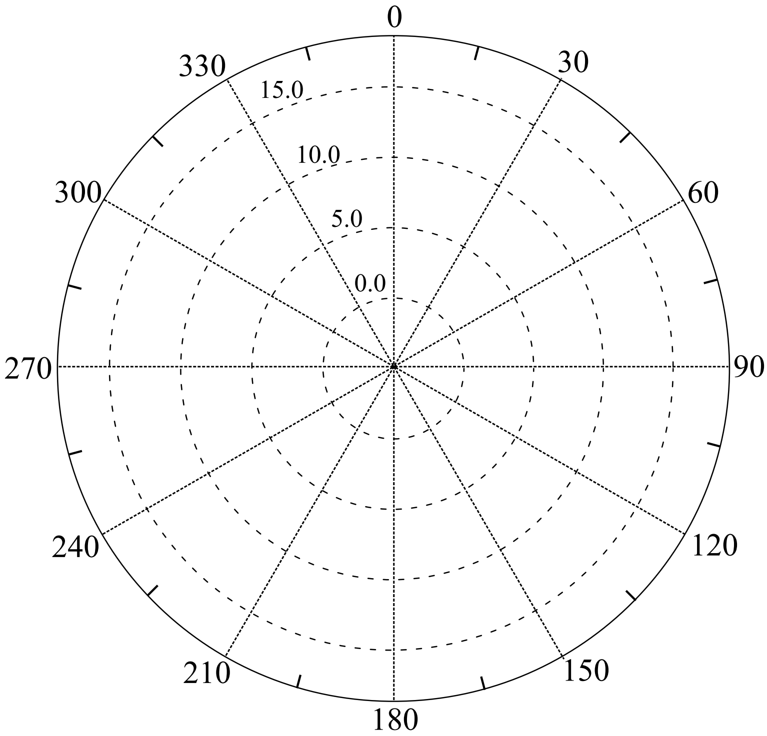


Figure 9: E-plane radiation pattern for microstrip patch antenna

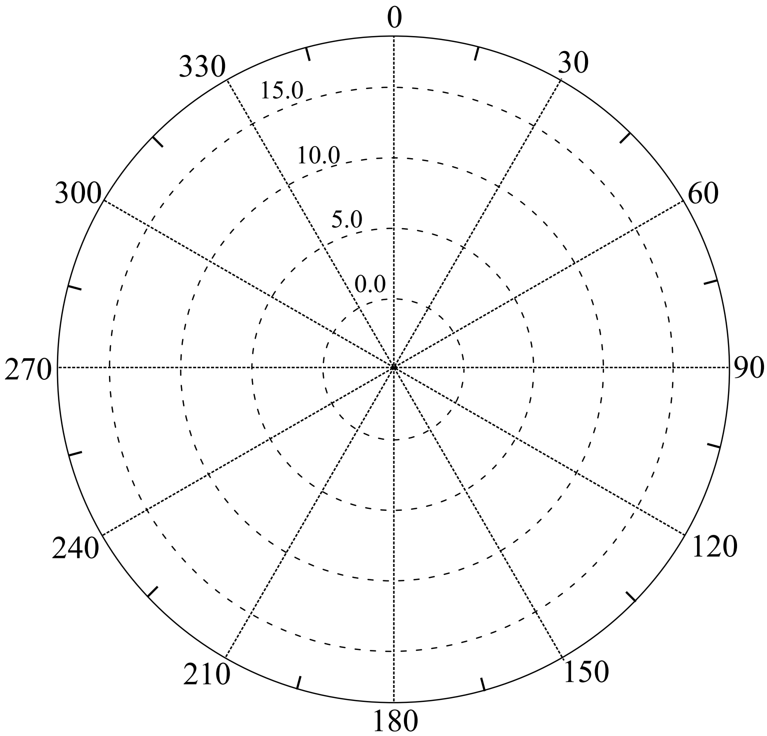


Figure 10: H–plane radiation pattern for microstrip patch antenna

2.3.2 Directional Coupler Characteristics

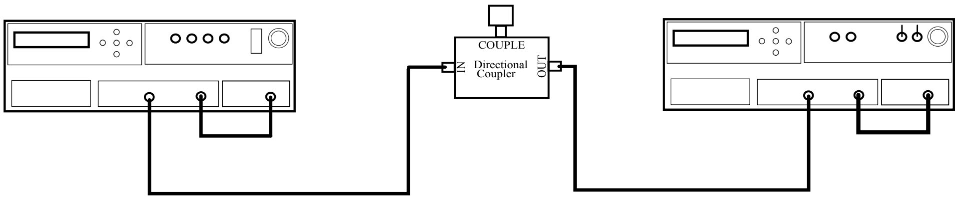


Figure 11: Measure the transmitted power through directional coupler.

1. Set the transmitter frequency to 1500 MHz using the up and down keys.
2. Connect 20 dB attenuator at transmitter output at upconverter block (with upconverter IN connected to RF OUT 87-898 MHz range using small cable).
3. Set the receiver frequency to 1500 MHz using the up and down keys.
4. Directly connect the receiver to the transmitter, you may need to insert 20 dB attenuator in the signal path to avoid saturating the receiver which saturates at -27 dBm.
5. Measure the output power from transmitter p_{out}=··············· dBm.
6. Connect the output of the transmitter to the RF IN of the directional coupler, as in Fig. 11.
7. Connect the receiver input to the directional coupler RF OUT.
8. Connect a matched load 50 Ω to the forward coupled port.
9. Measure the transmitted power through the coupler p_t=··············· dBm

   Device Insertion Loss IL=p_{out}(dBm) $-$ p_t(dBm)··············· dB

2.3.3 Patch Antenna Return Loss

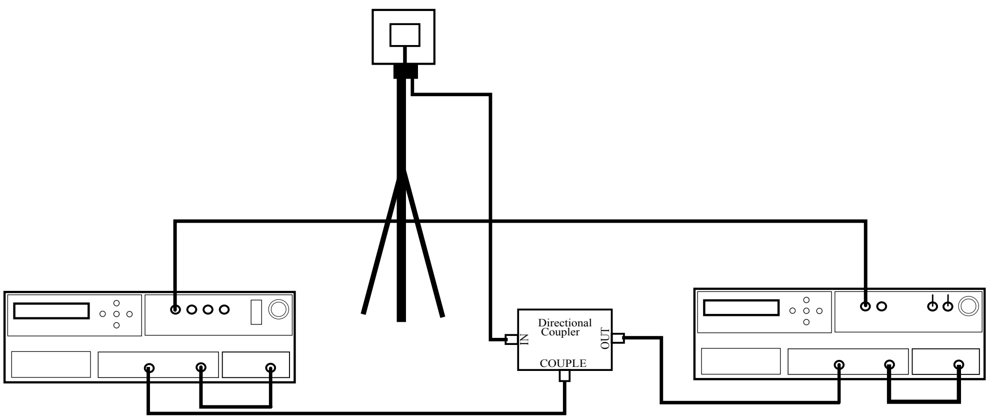


Figure 12: Setup for measuring the patch antenna return loss.

1. Bring the transmitter to 1620 MHz using up and down keys.
2. Connect the upconverter input to RF OUT 87-898 MHz range using small cable.

3. Connect 20dB attenuator at transmitter output at upconverter block.
4. Bring the receiver to 1620 MHz using up and down keys.
5. Connect downconverter output to RF IN 48-860 MHz using small cable.
6. Connect the 20 dB attenuator at receiver at receiver input at downconverter block.
7. Connect directional coupler IN port to upconverter OUTPUT and sample/coupled port (CPL) to downconverter INPUT of receiver. The OUT port of coupler is terminated in antenna. sketch the receiver reading of the forward power (A) versus frequency range 1-2 GHz.
8. Now reverse the directional coupler and connect the antenna at IN port of the directional coupler. Sketch the reverse power (B) versus frequency range 1-2 GHz.
9. Sketch the RL versus frequency:

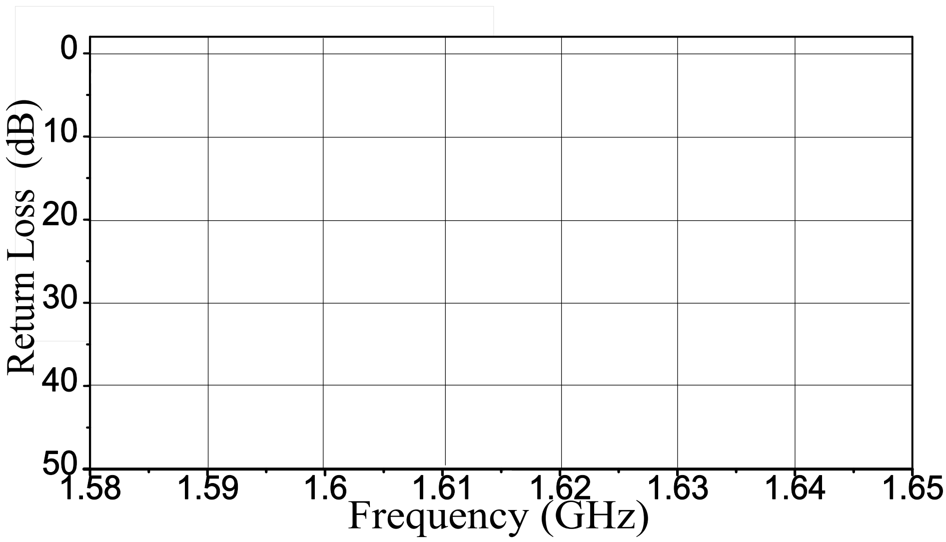


Figure 13: Return loss of the patch microstrip with inset feed.