Lab2 Dipole Antenna

EERF – 6396
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1. Introduction

Objectives:

a. To measure cell phone transmitted power
b. Design dipole antenna for the specific frequency

Apparatus:

a. Signal Generator: Agilent N5181A (250 kHz – 6 GHz)
b. Spectrum Analyzer
c. Mobile phone
d. Wire
e. N-type to SMA cable
f. SMA connectors

2. Pre-Lab Discussion

1) Spectrum analyzer fundamentals have been reviewed
2) The cellular phone carrier used is T Mobile with frequency of 1700 MHz

1700/2100 MHz AWS	4	UMTS/HSPA+	3G[76][77][78][79]	Reducing Service	T-Mobile has been moving 3G service from AWS to its PCS spectrum. This will free up more capacity for LTE. However, in some markets there still will be 3G service provided, and in other markets there will be no 3G service, as it will be solely provided on PCS spectrum.[56]
				In Service	Refarmed from 3G. Main LTE band in most markets.
	66			In Service/ Building out[84]	Extended AWS block for additional capacity in some areas.[85]

Source: Wikipedia T-Mobile

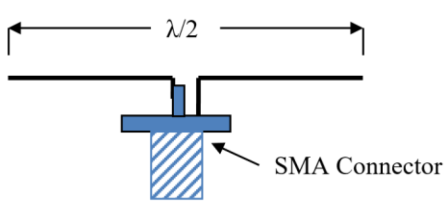
3. Procedure

Part I: Measurement of cell phone transmission frequency using 50Ω co-axial cable

1) Connect the co-axial cable to the spectrum analyzer
2) Adjust the frequency range of the spectrum analyzer and its resolution
3) Reset the spectrum analyzer to clear previous readings and optimize the noise floor level
4) Now make a call and bring the co-axial cable near to the cell phone
5) Note the spike, its corresponding frequency and power from the spectrum analyzer

Part II: Dipole antenna design

1) Design a dipole antenna resonant at the frequency of operation of your cellphone



2) The total length of the antenna should be λ/2, so further cut the λ/2 into 2 parts and solder them to the SMA connector in symmetry
3) Ensure both arms are in the same plane

Part III: Test antenna with cell phone

1) Connect the antenna to the 50 Ω co-axial cable connected to the spectrum analyzer
2) Place the antenna at a short distance from the cell phone and make a call
3) Note the frequency and power again

Part IV: 2 Antenna setups

1) Build another identical antenna
2) Connect one to the signal generator and the other antenna to the spectrum analyzer
3) Set the frequency on the signal generator to the same frequency on which the cellular signals were received and set the magnitude to 0 dBm
4) Turn the RF power ON only while taking readings and promptly set it OFF once the readings have been taken
5) Maintain 30 cm between the transmitting and receiving antenna and measure the results on the spectrum analyzer
6) Note the magnitude of received power by changing the distance between the antenna to 20 cm and 10 cm keeping the same plane of polarization for both the antennas
7) At 20 cm, take a reading by changing the orientation of one of the antenna by 90^{o} and note the power reading from the spectrum analyzer

Part V: Using Cellphone as test antenna

1) Switch off the signal generator
2) Use cell phone as the transmitter antenna now
3) Note readings by maintaining a distance of 30, 20, and 10 cm between the receiving antenna and cell phone
4) Try different orientation to get the best signal strength

4. Data

Part I: Measurement of cell phone transmission frequency using 50Ω co-axial cable

1) Transmit Frequency: 1.710 GHz
2) Magnitude: -32.94 dBm

Part II: Dipole antenna design

1) $\lambda = 17.6$ cm
2) $\lambda/2 = 8.8$ cm

Part III: Test antenna with cell phone

1) Transmit Frequency: 1.710 GHz
2) Magnitude: 3.61 dBm

Part IV: 2 Antenna setups

Same Orientation

Distance	Power
10 cm	-24.03 dBm
20 cm	-28.34 dBm
30 cm	-32.86 dBm

90^{o} Orientation

Distance	Power
20 cm	-39.25 dBm

The cross-polarization isolation at 20 cm: |P2| - |P1| = 10.91 dBm

Part V: Using Cellphone as test antenna

Same Orientation

Distance	Power
10 cm	-12.62 dBm
20 cm	-17.13 dBm
30 cm	-18.27 dBm

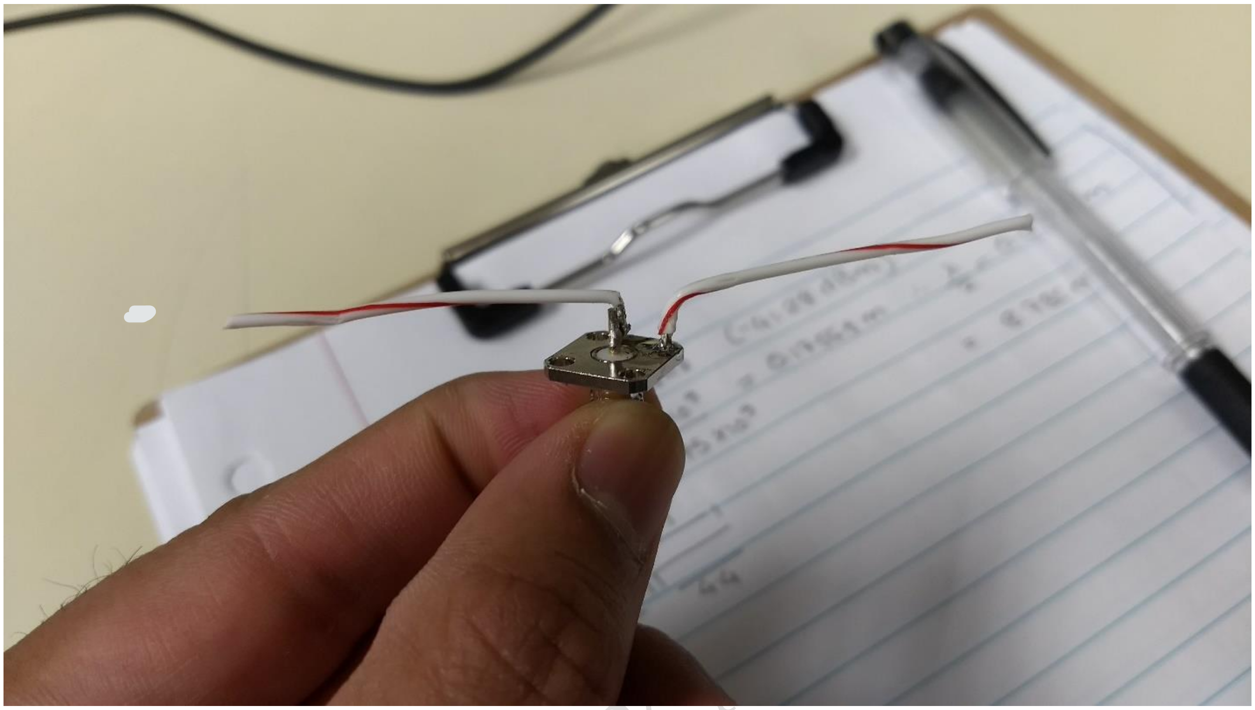
90^{o} Orientation

Distance	Power
20 cm	-36.78 dBm

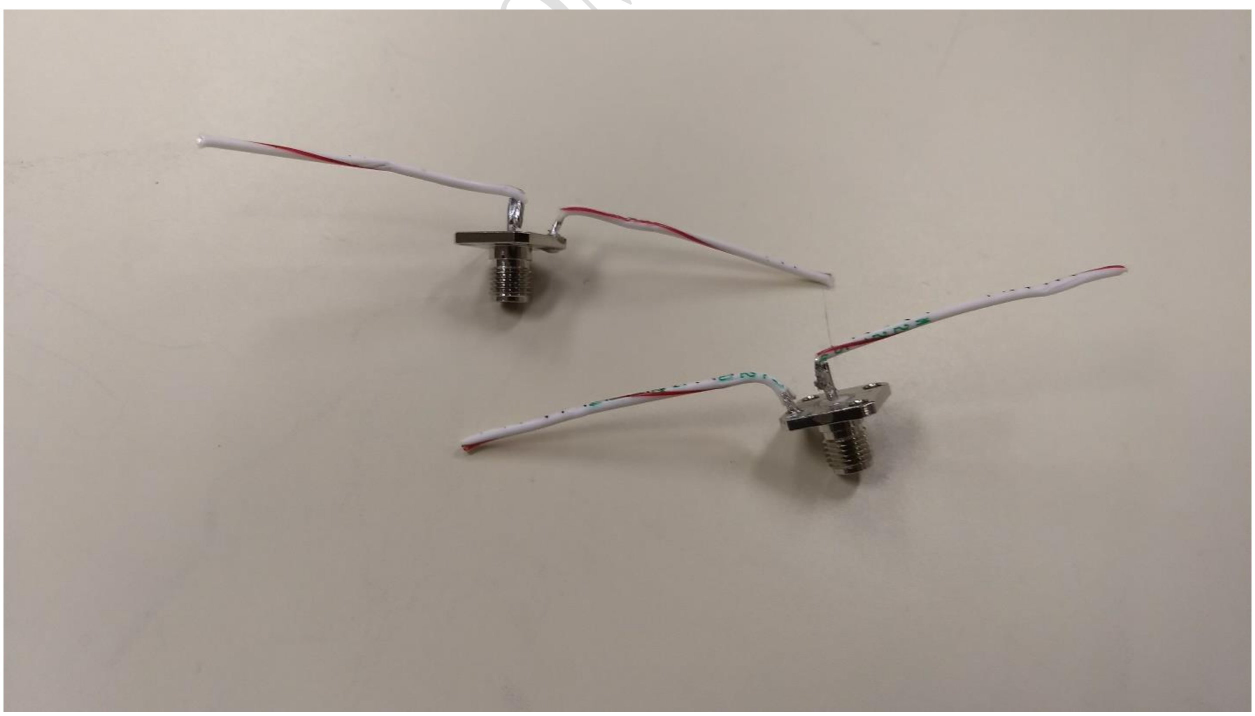
The cross-polarization isolation at 20 cm: |P2| - |P1| = 19.65 dBm

Best signal is received when lower back of the phone is near to the antenna in a face up orientation.

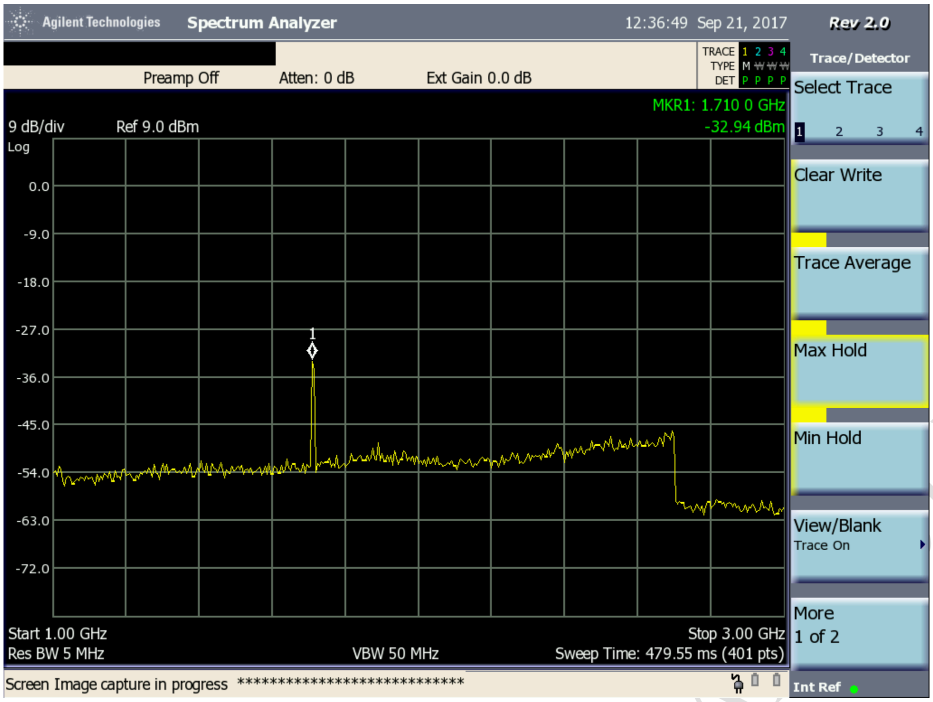
Photos:



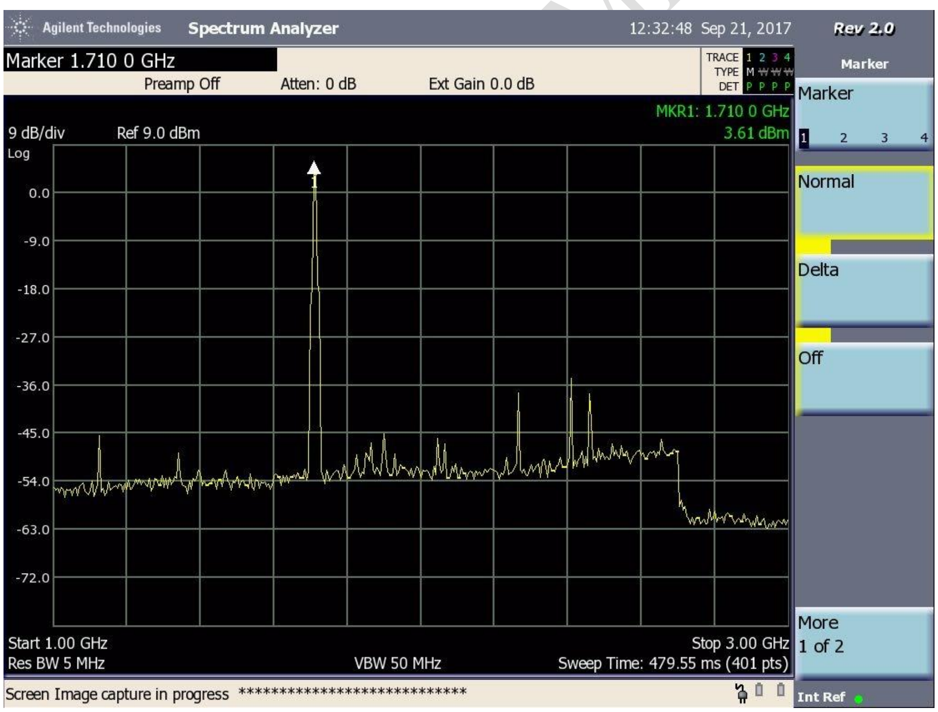
Pic 1: Designed Antenna



Pic 2: Transmitter and receiver antenna



Pic 3: Measurement of cell phone transmission frequency using 50Ω co-axial cable



Pic 4: Test antenna with cell phone

5. Summary

- **The received power increases with the designed antenna rather than just using the co-ax cable**

- **Power transmitted by the cellphone**

First finding the gain of the dipole antenna using friis formula:

$$\text{Pr} = \left(\frac{\lambda}{4\pi \times R}\right)^2 \times G_{a_1} \times G_{a_2} \times P$$

0.003954mW= (17.54/(4*pi*10))^2 * (G^2) * 1mW … (when d = 10 cm)

So, G = 1.42 (1.522 dB)

Now, finding the transmitted power by the cell phone:

$$\text{Pr} = \left(\frac{\lambda}{4\pi \times R}\right)^2 \times G_a \times P_{\text{t}}$$

So, P_{t} = 2.78mW = 4.45 dBm

- **Why is it important to keep antennas aligned with proper polarization?**

Antenna is a transducer which converts electric current to EM energy and vice-a-versa. The plane of the electric field in 3D space determines the orientation of the EM wave associated with the antenna. This is called the polarization. So, the orientation of the antenna in a direction is optimized to receive EM waves in that plane. For example, a vertically polarized wave can be received on a horizontally polarized antenna but at the cost of reduced performance. The power received in this case is quite lower than the power that would be received in same polarization. So, in order to have maximum efficiency in the system it is important to keep antennas aligned with proper orientation.