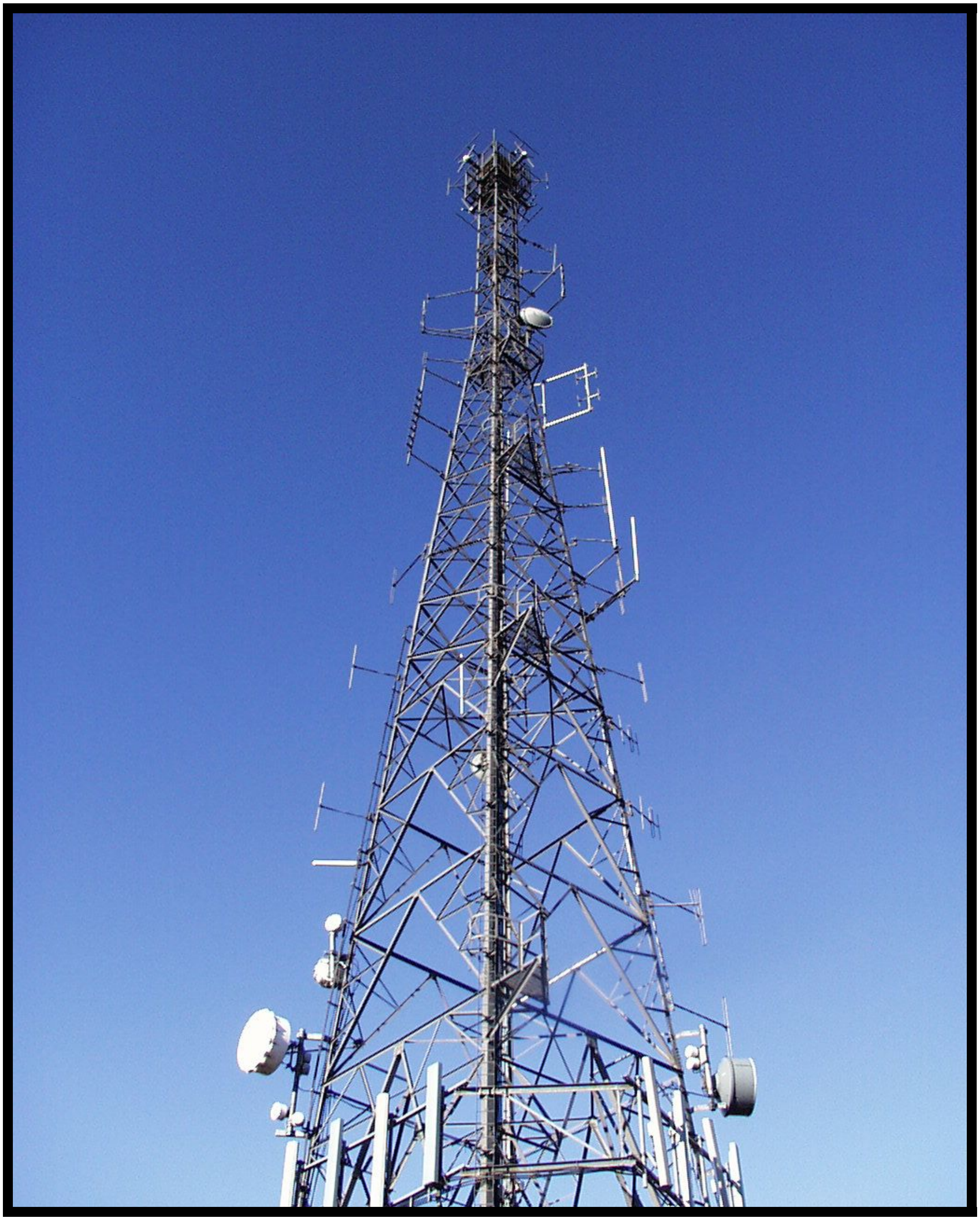
IV. Antenna Basics



IV. Antenna Basics

Detecting Radio Waves from the Sun

Introduction

It may surprise you to find out that Thomas Edison attempted to detect radio waves from the Sun and was unsuccessful. Thomas Edison more than likely wasn't a lone visionary in attempting to detect radio waves from the Sun, but he is the first on record to suggest that radio waves might be detected from celestial objects. In a letter sent to Lick Observatory that dates back to 1890, Thomas Edison described his plan to detect radio waves from the Sun using steel cables wrapped around an iron core. The experiment was more than likely never carried out. No evidence that such an experiment was performed exists. What is important however is that Thomas Edison knew how radio waves were produced and how to detect them. It was his genius that saw the likely possibility of radio waves being exceedingly common, being naturally produced in space as they could be by lightning storms on Earth. You have an opportunity to succeed where Edison failed but be humbled, Edison would surely have found a way to detect radio waves had be persisted along his line of inquiry.

Materials

- AR3000-A Receiver
- Computer with SEARFE spectrum scanning software
- Yagi antenna
- Disconne antenna
- Long wire antenna
- Small Radio Telescope (optional)

Part I: Antenna Directionality

Procedure

1. Connect the AR3000-A Communications Receiver to a computer with the SEARFE spectrum scanning software installed.
2. Connect a Yagi antenna to the AR3000-A receiver. The frequency of the antenna should be around 500 MHz.
3. Adjust the AR3000-A to scan a small bandwidth around the peak efficiency frequency of the antenna. If you are scanning around 300 MHz choose a bandwidth of 10 MHz.
4. **Important: Use caution for this step. Do not look at the Sun. Look at the shadow behind you.** Point the Yagi antenna directly toward the Sun. You can judge whether or not you are pointing directly toward the Sun by looking at the shadow behind you.
5. Perform a single scan with the antenna pointed toward the Sun. Save all scans for later printing to include with your report.
6. Now point the antenna away from the Sun at a 90-degree angle. Perform another scan, this time with the antenna pointed away.
7. Repeat steps 4-6 with the disconne antenna and the long wire antenna respectively.

Note: One could set the receiver remote control to *off* and perform the scans manually using the receiver console.

Questions

1. Based on your experiment which antennas are sensitive to direction and which are not?

2. Did each antenna receive the same amount of power from the Sun? What could account for some of these differences?

Part II: Peak Efficiency Frequency

Every antenna is designed for use at some frequency. An antenna resonates best at its peak efficiency frequency. Although the power from the Sun naturally varies with frequency, one should be able to determine the peak efficiency frequency of an antenna. The peaks observed due to antenna design far outweigh any peaking effects you'll observe from the Sun.

Procedure

1. Point the Yagi Antenna directly at the Sun. Perform a single wide scan using the AR3000-A.
2. Note any peaks in the wide scan. Rescan around the peak in a smaller bandwidth to pinpoint the frequency of maximum antenna gain.
3. Repeat the above procedure for the disconne and long wire antennas.

Antenna	**Maximum gain frequency in MHz**
Yagi	
Disconne	
Long Wire	

Questions

1. Why does an antenna resonate around a particular frequency?

2. Calculate the wavelength of a radio wave with maximum gain for an antenna using the formula $c = f * \lambda$.

3. Does this length or fraction of it, appear in your antennas basic design?

4. How would you construct an optimal AM and FM radio antenna? Why might optimal design actually be a bad idea?

5. How can a sub-optimal antenna length still work and work very well as is the case for AM radio antennas?

6. What is the source of radio waves coming from the Sun? What frequencies can we expect to detect from the Sun?

7. Based on your experimental results what are some practical uses for one type of antenna over another? In which situations would you prefer a Yagi antenna to a disconne? When is a long wire antenna best?

Part III: Wave Polarization

Try rotating the antenna as you point it to toward the Sun and other locations in the sky. You might not notice any effects if there is a lot of glare in the sky. If a cloud passes overhead it might reduce the glare enough to detect a change in power when the antenna is rotated. Try this for all three antennas. If you can't detect any difference, try the experiment at a different time.

1. Why would the polarization of light matter when measuring the gain of an antenna?

2. Which antennas were most successful at measuring polarization? Why do you think this is so?

Mapping Antenna Patterns

Every antenna responds best to certain frequencies and not others. The orientation of an antenna to its source also plays a significant role. The gain of the received signal depends extensively on the direction from which the source is received. We will explore the basic antenna patterns only in the plane between the line of sight of the source (the Sun) and two imaginary points on the ground. The measurements we make here will necessarily be crude. Only a very exacting experiment will expose the fine details of antenna gain patterns. We can however, detect the basic pattern and map it on a graph.

Our graph will be a polar coordinate graph, radius versus angle (r vs. θ). The radial distance from the origin indicates the signal power received at a given angle. This experiment is best performed in the morning when the Sun is low to the ground. We can ignore the elevation of the Sun and simply rotate the antenna to point to various locations along the horizon. (Some variant of the procedure is necessary if noontime measurements are going to be made. The following procedure is intended for early morning when the Sun's elevation is low enough to be ignored.)

Procedure

1. Choose a very narrow bandwidth, 0.1 MHz, around the maximum gain frequency of your antenna.
2. Setup the AR3000-A receiver to scan around this frequency.
3. **Caution: Do not look at the Sun. Use the shadow to determine whether or not you are pointing directly toward the Sun.** Point the antenna toward the Sun. Position a protractor underneath the antenna to measure angle. Estimate the angle as best you can to within 5-degrees.
4. Perform a scan while directly pointing at the Sun.
5. Do not save any graphs made by the computer, there's no purpose in keeping them once you get the main information from them. From the computer graph, note the maximum value of the power received in the bandwidth from the graph displayed on the computer. Enter this value for power in the data table below.
6. Change the angle by 15 degrees counter-clockwise and perform steps 3-5, repeating until all angle values on the data table are used, completing one complete revolution.
7. Perform the same test using the disconne and long wire antenna.

Data Table I. Yagi Antenna Pattern

Maximum gain frequency of antenna ________________

Angle in degrees	Peak Power (Watts) or Peak Power Flux
0	
15	
30	
45	
60	
75	
90	
105	
120	
135	
150	

165	
180	
195	
210	
225	
240	
255	
270	
285	
300	
315	
330	
345	

Data Table II. Disconne Antenna Pattern

Maximum gain frequency of antenna ________________

Angle in degrees	Peak Power (Watts) or Peak Power Flux
0	
15	
30	
45	
60	
75	
90	
105	
120	
135	
150	
165	
180	
195	
210	
225	
240	
255	
270	
285	
300	
315	
330	

345	

Data Table III. Yagi Antenna Pattern

Maximum gain frequency of antenna ________________

Angle in degrees	Peak Power (Watts) or Peak Power Flux
0	
15	
30	
45	
60	
75	
90	
105	
120	
135	
150	
165	
180	
195	
210	
225	
240	
255	
270	
285	
300	
315	
330	
345	

Graphing

Graph power vs. angle where power will be indicated by radial distance from the origin and angle will be given by the angle between the x-axis. An *r vs.* θ graph is very simple to make but takes a little bit of practice. Connect all the dots with a smooth curve to reveal the antenna pattern.

Questions

1. Obtain detailed antenna patterns from Kraus' *Radio Astronomy* or other antenna handbook/reference. Notice the lobe patterns on some of the antennas. Did you observe any lobes on your graphed antenna patterns? Are there any signs of emergent lobes on you graph? What are they?

2. What effect should changing the size of your antenna while preserving the shape have on the antenna pattern and maximum gain frequency?

3. What antenna patterns are most useful for detecting polarization in light? The polarization of light from stars and galaxies carries lots of information about the types of physical processes occurring.

4. Compare your antenna patterns with those published by a handbook. How closely does your pattern resemble the published pattern? Give details.