

Radio JOVE

Antenna Manual

Version 2.0 – April, 2022



Antenna Kits and Manual
Developed for NASA Radio JOVE Project
by
The Radio JOVE Project Team

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1. Introduction

Welcome to the third edition of the Jove antenna manual. This manual has been expanded over previous editions to include information for southern hemisphere observers as well as those using the Jove radio telescope for solar observations. The antenna configuration you use will be guided by the latitude of your observatory and the position of Jupiter and the Sun in your sky.

1.1 Locating Jupiter and the Sun in the Sky

1.2 Declination, Latitude, and Elevation Angle

We use a system of latitude and longitude to describe locations on Earth, where latitude is measured north or south of the equator. Imagine that the earth's equator is projected outward onto the celestial sphere (sphere of fixed stars). The angular position of a celestial object north or south of the celestial equator is known as *declination*. The angle measured upward from an observer's horizon to a celestial object is called the *elevation angle* or *altitude*.

1.3 Declination and Elevation of the Sun

Due to the tilt of the Earth's axis, the Sun's declination varies between 23.5° north (at the June solstice) and 23.5° south (at the December solstice) of the celestial equator. For observers between 23.5° north and south latitude the Sun will be directly overhead at some time during the year. Folks living at higher northern or southern latitudes never get to view the Sun directly overhead. The further you live from the equator, the lower the Sun appears in the sky. The maximum elevation of the Sun (measured at local noon) varies throughout the year as seen in Figure 1.1 below.

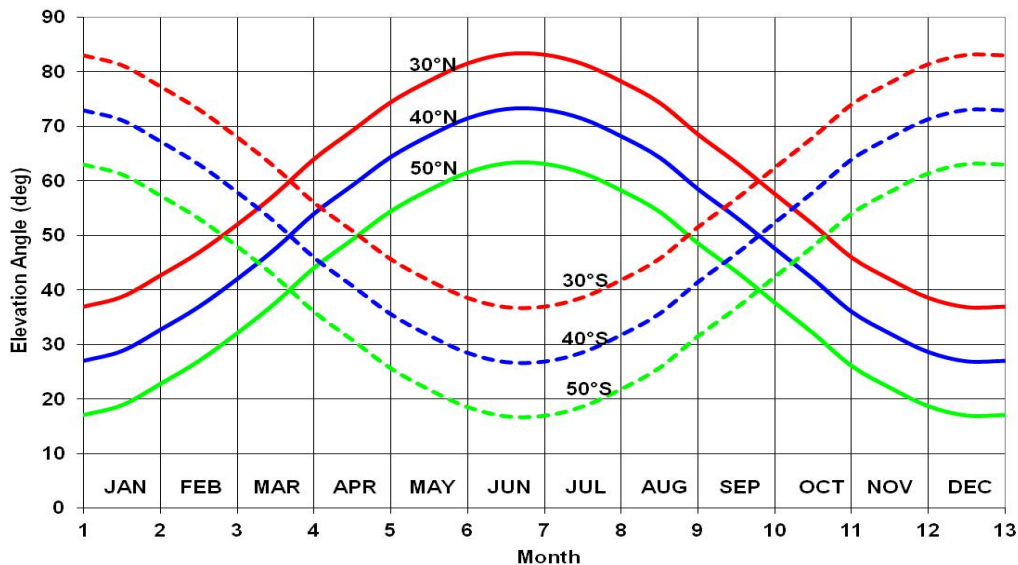


Figure 1.1. Shown is the maximum elevation angle of the Sun throughout the year for observers at different latitudes. Solid curves are for northern hemisphere observers (at 30°N , 40°N , and 50°N) and dashed curves are for southern hemisphere observers (at 30°S , 40°S , and 50°S).

1.4 Declination and Elevation of Jupiter

Jupiter's declination also varies between 23.5°S and 23.5°N , with the complete cycle taking approximately 12 years (Figure 1.2). Northern declinations (+) between 2011 through 2016 favor northern hemisphere observers, while southern declinations (-) from 2017 through 2023 favor the southern hemisphere.



Figure 1.2. Jupiter's declination varies between 23.5°N and 23.5°S .

Jupiter can be observed from the northern hemisphere when it is at southern declinations and from the southern hemisphere while at northern declinations. The Jove antenna beam can be steered north, south, or overhead.

The following two plots show Jupiter's maximum elevation for northern hemisphere (Figure 1.3) and southern hemisphere (Figure 1.4) observing sites for the coming years. When Jupiter is at maximum northern declination in 2013 it will appear lowest for southern hemisphere observers. Six years later the situation is reversed with Jupiter's maximum southern declination favoring southern hemisphere observers.

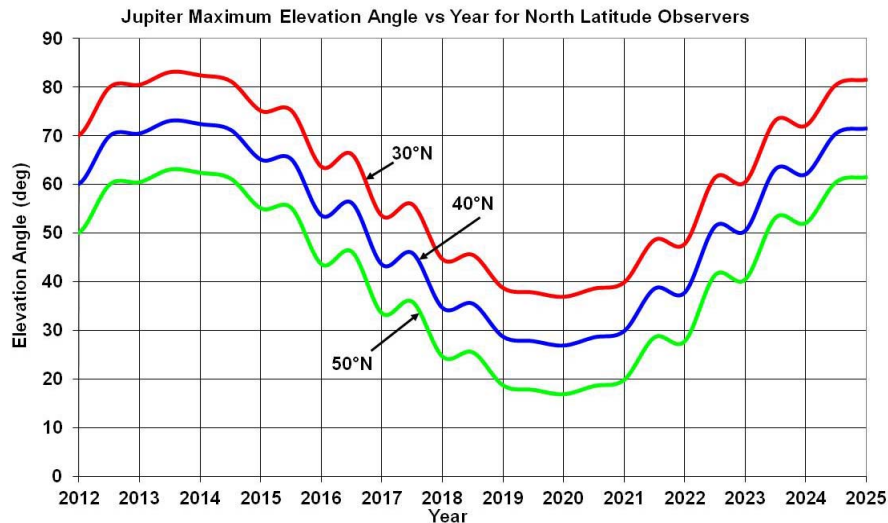


Figure 1.3. In 2013 an observer at 30°N will see Jupiter's elevation peak at 83° , while Jupiter will only reach 63° for an observer at 50°N . Each year is labeled at the January location.

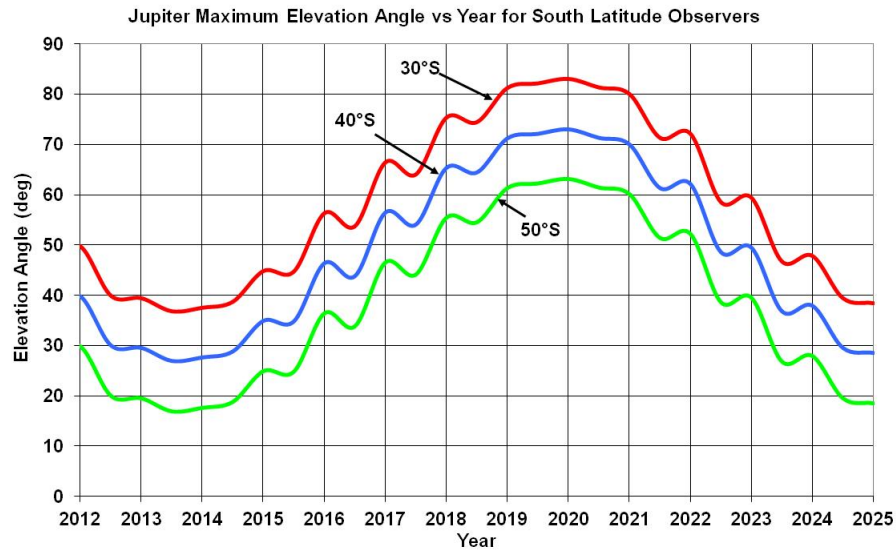


Figure 1.4. These curves show the maximum elevation angle for Jupiter for southern hemisphere observers at three different latitudes.

When installing the Jove antenna it is important to understand where Jupiter (and the Sun) will reside in the sky. You will configure the antenna differently depending on your latitude and the maximum elevation angle of Jupiter (or the Sun) during the planned observing campaign. For the case of Jupiter, the antenna configuration will only change every few years. To control where the antenna beam is steered you can (1) insert a phasing (delay) cable, and/or (2) change the height of the Jove antenna above ground.

2. Basic Antenna Theory

A radio antenna intercepts energy from electromagnetic waves and converts that energy into an electrical signal (current and voltage) at the antenna terminals. This weak radio frequency signal is fed from the antenna through a transmission line (coaxial cable) to the radio receiver.

2.1 Gain and Beaming Pattern

If you held the small end of a cheerleader's megaphone to your ear you would find that it amplifies sounds from certain directions while making it harder to hear sounds from other directions. Antennas have these same properties – the antenna has *gain* (it amplifies signals) because it has a *beaming pattern*; it amplifies signals best coming from some directions and attenuates (reduces) signals from other directions. The Jove antenna beam is tens of degrees wide so when it is aimed properly Jupiter takes several hours to pass through the beam as the Earth rotates.

2.2 Frequency and Wavelength

A radio wave is an electromagnetic wave which travels through the vacuum of space at the speed of light. Two important characteristics of the wave are its *frequency* and its *wavelength*. The frequency of the wave is the number of cycles that occur each second, and the wavelength is the distance that the wave travels during one cycle (Figure 2.1).

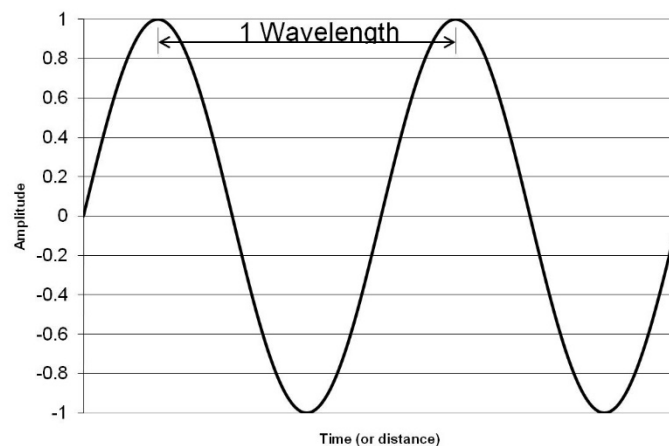


Figure 2.1. Wavelength is the distance between identical points on a repeating waveform

The frequency (f), wavelength (λ – Greek symbol lambda), and speed of light (c) are related by a simple equation:

$$c = \lambda f \quad \text{or} \quad \lambda = \frac{c}{f} \quad [1]$$

If the speed of light is given in meters per second ($c = 3 \times 10^8$ m/s), and the frequency in hertz (Hz, which has units of “per second”), then the unit for wavelength is meters. The Jove antenna operates at a center frequency of 20.1 megahertz (MHz). The free-space wavelength is therefore:

$$\lambda = \frac{3 \times 10^8 \text{ m/s}}{20.1 \times 10^6 \text{ Hz}} = 14.925 \text{ meters}$$

Since there are 3.28 feet per meter the wavelength at the Jove frequency is 48.955 feet.

The formula relating free-space wavelength in feet (meters) to frequency (in MHz), and the speed of light is:

$$\lambda_{ft} = \frac{984}{f_{MHz}} \quad \text{or} \quad \lambda_m = \frac{300}{f_{MHz}} \quad [2]$$

3. Antennas for JOVE

3.1 The Dipole Antenna

One of the simplest antennas is the dipole which can be made from two pieces of wire and three insulators (Figure 3.1). The length of a dipole antenna using infinitely thin wires is exactly half a wavelength ($\lambda/2$). Much like an organ pipe is cut to a specific length to make it resonant for a particular frequency of sound, our dipole antenna is cut to a length of half a wavelength to make it resonant at the frequency of 20.1 MHz. Since we are using real wire that is not infinitely thin we have to take into account some real world effects that shorten the actual antenna (these are called capacitive end effects).

The formula for the length of a **real world half-wavelength dipole** antenna in feet (meters) is:

$$\left(\frac{\lambda}{2}\right)_{ft} = \frac{468}{f_{MHz}} \quad \text{or} \quad \left(\frac{\lambda}{2}\right)_m = \frac{142.65}{f_{MHz}} \quad [3]$$

A dipole cut for 20.1 MHz has a length of 23.28 ft (23' 3" or 7.09 m) as measured from tip to tip of the wire.

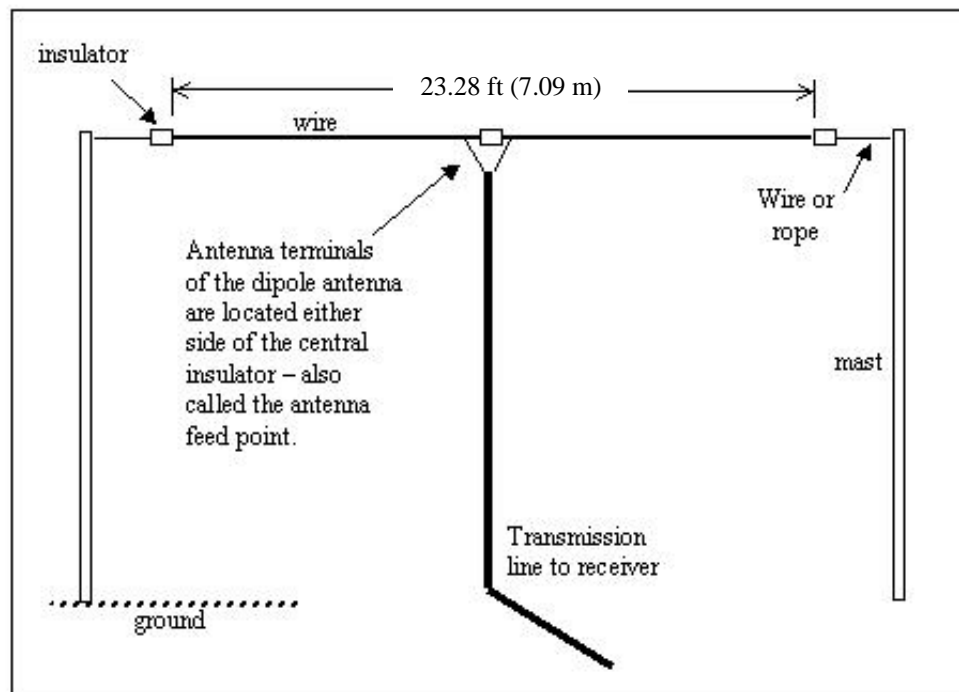


Figure 3.1. The dipole antenna cut to resonance at the Jove frequency of 20.1 MHz.

3.1.1 Dipole Antenna Terminals

Antenna terminals (also called the antenna feed point) are where you connect a transmission line to deliver signals from the antenna to the receiver. In the case of a

dipole, the feed point is located at either side of the central insulator – its where the two wires making up the transmission line connect to the two dipole wires.

3.1.2 Transmission Line

The transmission line used in the Radio Jove project is called coaxial cable (Figure 3.2). It's the same type of cable that you probably have connected to your TV set – about as big around as a pencil with a central wire surrounded by a white insulating material (dielectric) inside of a braid covered with an outer layer of insulation.

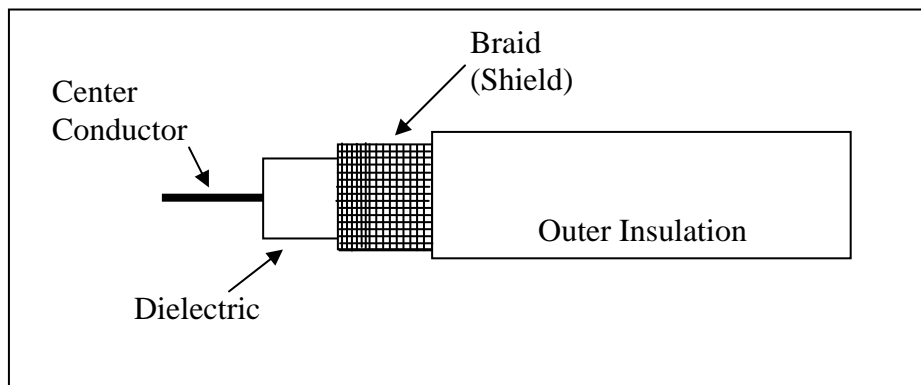


Fig.3.2 Coaxial transmission line (coax), showing the layers of wire and insulation.

Coaxial cable has two wires – the center conductor and the shield, which is either braided copper wire or a thin metallic sheath. Signals are conducted along the center conductor and on the inside of the braid. Several characteristics are important in describing coaxial cable. These include:

Impedance – measured in ohms and determined by the internal dimensions and geometry of the cable. The coax used in the Jove antenna has an impedance of 75 ohms.

Attenuation – a measure of how much signal is lost due to wire resistance and dielectric losses in the transmission line. *Less loss is better.* Attenuation increases with frequency and is typically measured in decibels (dB) per hundred feet of cable. A loss of 3 dB means half the power that enters the cable is lost before reaching the other end. For a Radio Jove installation, the maximum acceptable loss is 6 dB. The coax cable provided with the Jove kit is manufactured by Belden Company (their type 8241) and is designated as RG-59. At 20.1 MHz it has a loss of 1.5 dB per 100 ft, which means that when using this cable the recommended separation between the antenna and the receiver is less than 200 feet (*i.e.*, less than a 3dB loss; see Table 4.1).

Velocity Factor (Vf) – a measure of the speed of an electrical signal moving through the cable. The velocity factor is given as a percent of the speed of light in vacuum. RG-59 has a velocity factor of 0.66, meaning that signal velocity is 66% of the speed of light. RG-6 has a velocity factor of 0.83. Several cables in the Jove antenna system are described in terms of wavelength, so we need to know the wavelength of a 20.1 MHz

signal traveling through RG-59 or RG-6. The wavelength of a 20.1 MHz wave in free-space is 48.955 feet. The wavelength in RG-59 equals the free-space wavelength times the velocity factor (48.955×0.66) = 32.31 feet. [The equation reads:

$\lambda_{cable} = Vf \times \lambda_{freespace}$]. One wavelength at 20.1 MHz in RG-6 is 40.633 feet.

3.2 Beaming Pattern of a Dipole above Ground

The beaming pattern of a dipole mounted at a height of 10 feet above ground is seen in Figure 3.3. This view depicts the dipole wires running E–W at the center of the plot with the antenna beam directed up into the sky. The projection is similar to a star map – which you orient toward north while holding it up over your head and looking straight up. This map is one of many available in Radio Jupiter Pro – the Jupiter radio noise storm prediction program that every Jove observer should become familiar with. The antenna beam is represented by the green ellipse, depicting the so-called *half-power beamwidth* of the antenna. Signals from a celestial source would be strongest straight overhead and would be half as strong at the edges of the beam. Outside of the ellipse signals could still be received but they would be weaker as the source got further from the center of the main beam. Notice that the beam is not omnidirectional, but favors directions broadside to the wire. The dipole is much less responsive off the ends of the wires.

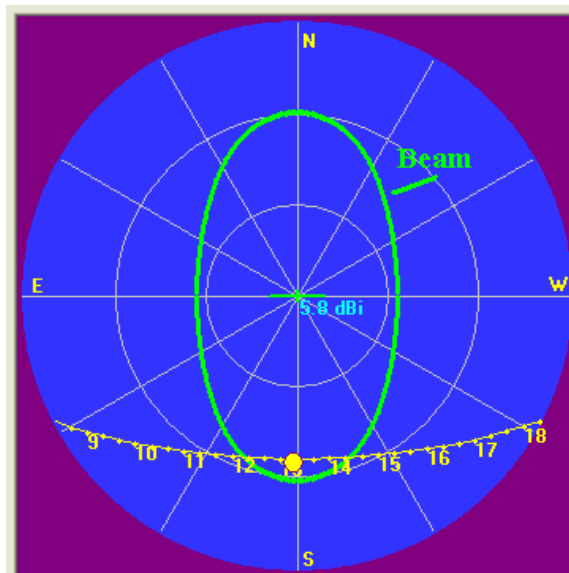


Figure 3.3. The beaming pattern for a single dipole antenna mounted at a height of 10 ft at a station at 30°N. The track of the Sun is for December when it is furthest south.

At this time the Sun is in the beam for only 2 hours but throughout the rest of the year when the Sun is further north observing time is longer.

The antenna pattern may also be depicted as a 2-dimensional plot of gain vs. elevation angle (Figure 3.4). This view represents a north-south slice through the center of the beam shown above in Figure 3.3. Maximum gain (the 0 dB arc) is straight overhead. Interior semicircles (-5, -10, etc) represent lower gain. Without going into too much detail, the units (-5, -10, etc) are in decibels relative to the maximum gain.

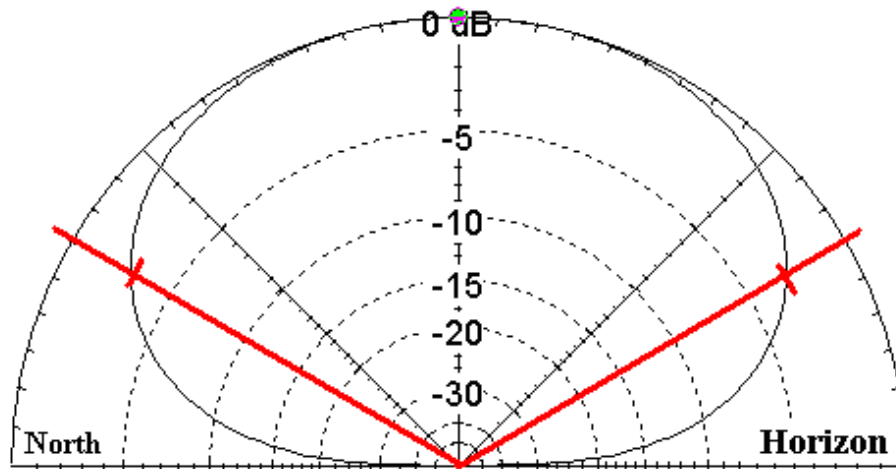


Figure 3.4. An elevation angle cut through the antenna pattern of a single Jove dipole with wires running east-west, mounted 10 ft above ground. The north-south half-power (-3dB) beamwidth (the enclosed angle between the red lines) is about 120°. Maximum gain is 5.8 dBi (dB referenced to an isotropic antenna)

3.3 Jove Dual Dipole Array

The Jove dual dipole antenna array uses two dipole antennas (Figure 3.5) to achieve almost twice the gain of a single dipole. With no phasing cable it produces an overhead beam (Figure 3.6), somewhat narrower than that of a single dipole alone. (It is an important principle of antennas that the higher the gain the narrower will be the antenna beam).

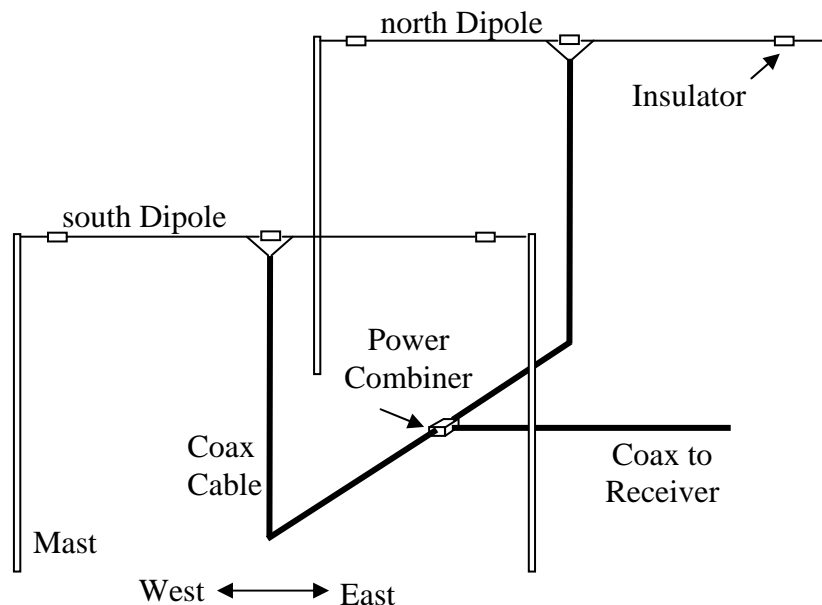


Figure 3.5. The Jove dual dipole antenna, shown with equal lengths of transmission line connecting each dipole to the power combiner.

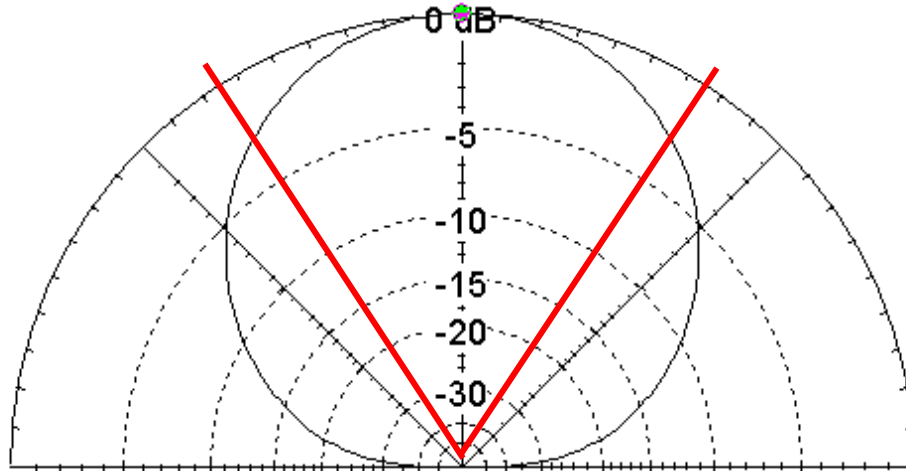


Figure 3.6. The dual dipole array produces a narrower beam with more gain than a single dipole. The half-power (-3dB) beamwidth (the enclosed angle between the red lines) is about 60° and the gain is 7.8 dBi..

3.4 The Principle of Antenna Beam Steering

3.4.1 Overhead Beam

It's easy to understand why the Jove antenna beam is overhead and how the antenna gain is increased over that of a single dipole. Consider a signal arriving from a point directly overhead (Figure 3.7A). In this figure the antenna wires run east-west and the black dots (labeled N and S, for north and south) represent the ends of the wires (viewing the dipoles from the west). The wavefront has traveled the same distance from the source to each dipole so the voltages induced in each antenna are in-phase with one another. The signals then travel through equal lengths of transmission line to the power combiner (C). The power combiner adds the two signals together and since they are in-phase with one another the resulting signal sent to the receiver is twice that of a single dipole alone.

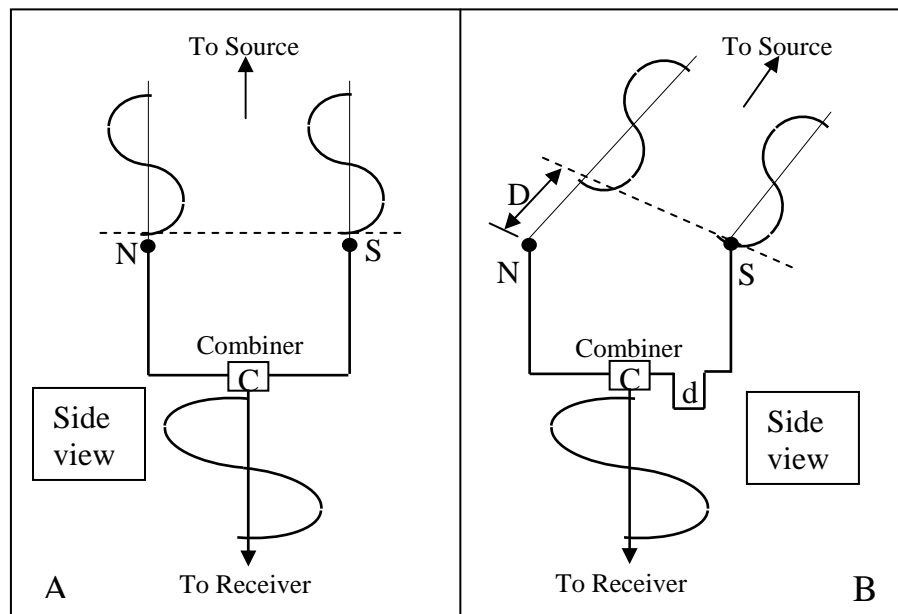


Figure 3.7. Beam steering relies on combining signals from two or more antennas so that waves from a given direction in space are combined in-phase with one another.

3.4.2 Steering the Antenna Beam

Now suppose the source (Jupiter or the Sun) were in the southern sky (Figure 3.7B). The wavefront (dashed line) would strike the south dipole first and then, after traveling distance (D), reach the north dipole. Because the waves have traveled different distances, the voltages induced in the two dipoles are out of phase with one another. If the two antennas were connected to the combiner through equal lengths of transmission line, the signals would arrive at the combiner (C) out-of-phase. When two out-of-phase signals are combined, the resulting signal is weaker than if the two waves were in-phase. By delaying the signal from the south dipole by the proper amount of time, the waves from each antenna will arrive in-phase at the combiner. This extra length of cable (d) delays the signal from the south antenna exactly the same amount as the signal to the north antenna was delayed by traveling extra distance (D). The extra length of cable is called a phasing cable (Figure 3.8). The delay required in the phasing cable depends on the elevation of the source. The effect of a 90° phasing cable in the south antenna is seen in Figure 3.9. If the observer were in the southern hemisphere and the source were at northern declinations then the beam should be steered north by using a phasing cable in the line leading from the north antenna. Fortunately the beam is quite wide so it is only necessary to change the phasing cable length every few years for Jupiter observations.

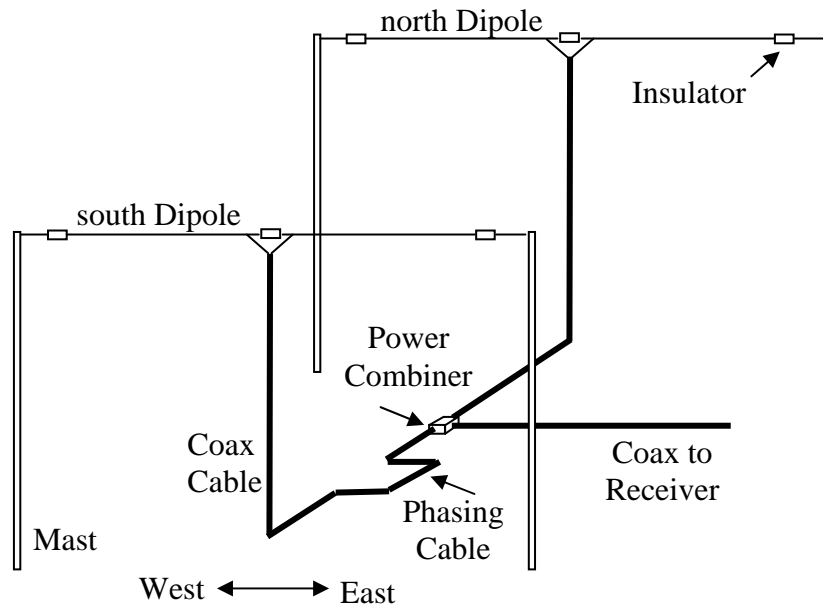


Figure 3.8. This shows the Jove dual dipole array with a phasing cable inserted in the transmission line leading from the south dipole to the power combiner. This is a configuration for northern hemisphere observers. For an observer in the southern hemisphere the phasing cable would be installed in the line leading from the north antenna to the power combiner.

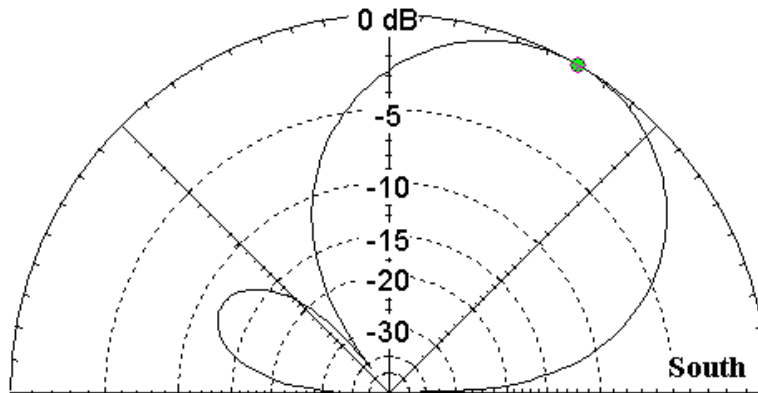


Figure 3.9. A 90° phasing cable added to the south dipole coax steers the antenna beam south. In this example the dipole array is 10ft high and the beam center is approximately 60° above the southern horizon.

3.4.3 Height of the Antenna

As we have seen, the direction of the antenna beam can be changed by using a phasing cable. Another controlling factor is the height of the antenna. The beaming pattern can be brought closer to the horizon by raising the dipoles. This is particularly important for observers at high latitudes.

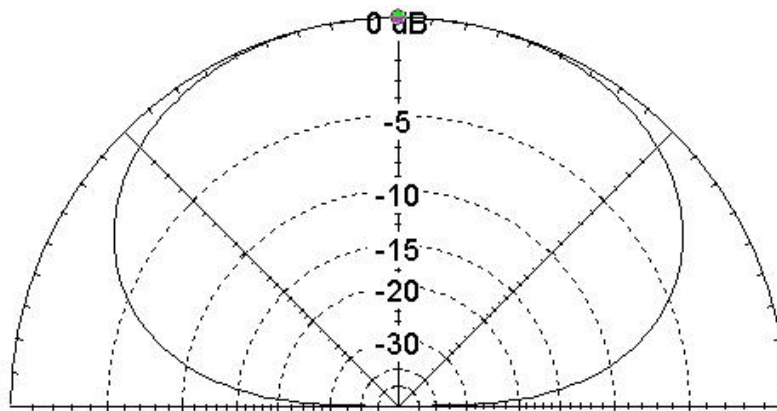
3.4.4 Jove Beaming Patterns

The Jove antenna beam can be steered north and south by adjusting the length of the phasing cable and the height of the antenna. The optimum beam elevation depends upon the latitude of the observer and the declination of Jupiter (or the Sun).

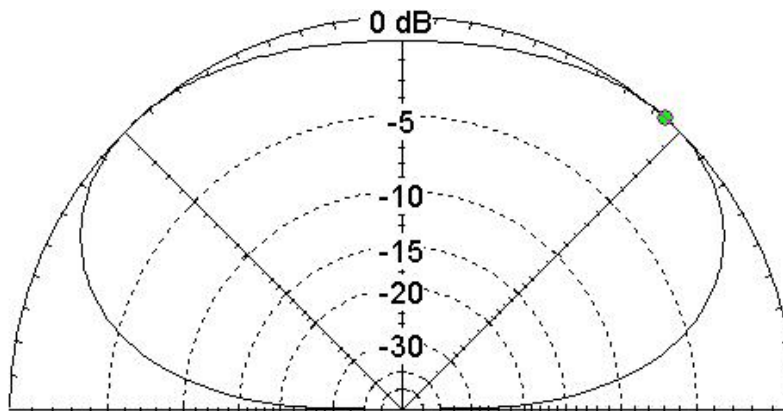
To obtain the strongest signals, antenna phasing and height should be set so that the beam center (maximum gain) is directed toward the celestial object of interest. However, it's not critical to be absolutely on target, as a variation of a dB or so in gain will hardly be noticed. Beaming patterns for several different configurations are seen on the following pages. Remember that these beaming patterns are viewed from the tips of the dipole wires. With the dipole wires running east–west, they represent a north–south cut through the antenna beaming pattern. The following patterns are presented:

1. Single dipole at 10, 15, and 20 feet (Figure 3.10).
2. Dual dipole at 10, 15, and 20 feet with no phasing, as well as 90° and 135° phasing (Figures 3.11, 3.12, and 3.13).

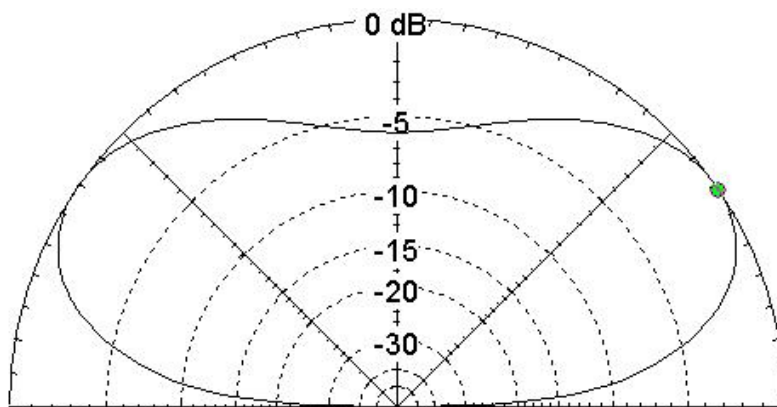
The observer should use Figures 1.3 or 1.4 to determine the maximum elevation angle of Jupiter during their upcoming observing years. Determine an average elevation angle and then use the beaming patterns to decide on how to configure your Jove antenna. If you live in the southern hemisphere and Jupiter is at northern declinations then you will install the phasing line in the northern dipole feedline. If you live in the northern hemisphere and Jupiter is at southern declinations you will install the phasing line in the southern dipole feedline. Choose the antenna height and phasing cable length that best suits your observing latitude.



Single dipole, 10 ft, gain = 5.8 dBi at el = 90 deg

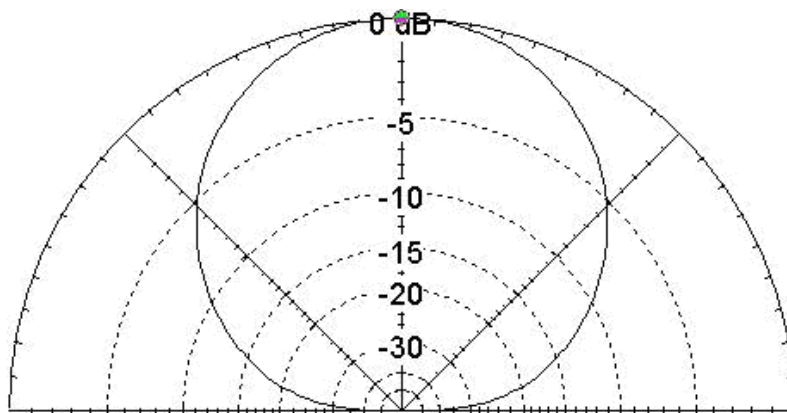


Single dipole, 15 ft, gain = 5.7 dBi at el = 48 deg

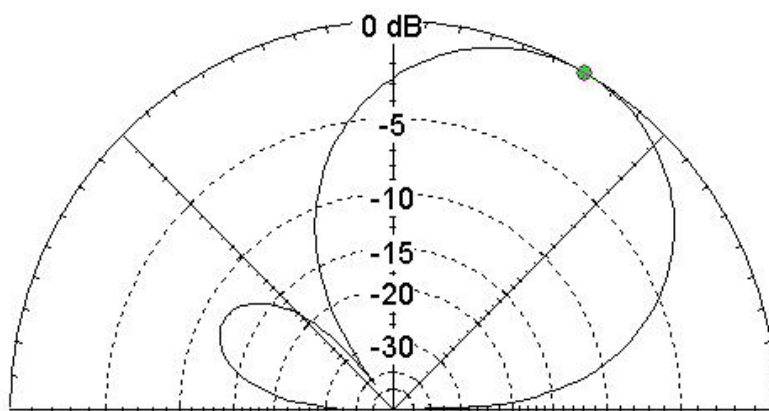


Single dipole, 20 ft, gain = 6.3 dBi at el = 34 deg

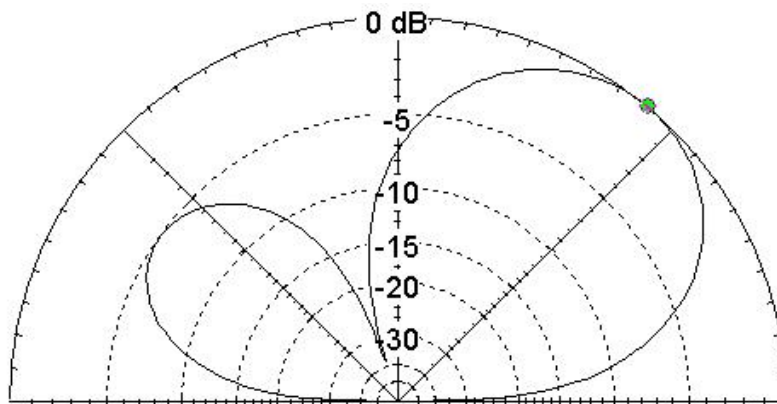
Figure 3.10. Elevation beaming patterns of a single dipole mounted at different heights above average ground.



Dual dipole, 10 ft, no phasing, gain = 7.8 dBi at el = 90

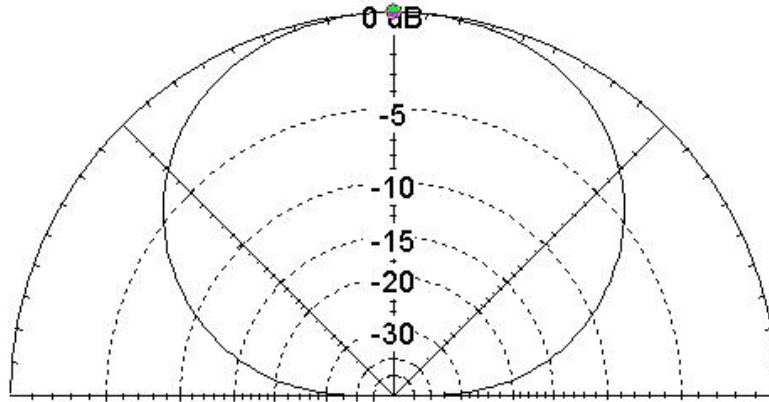


Dual dipole, 10 ft, 90 deg phasing, gain = 8.5 dBi at el = 60

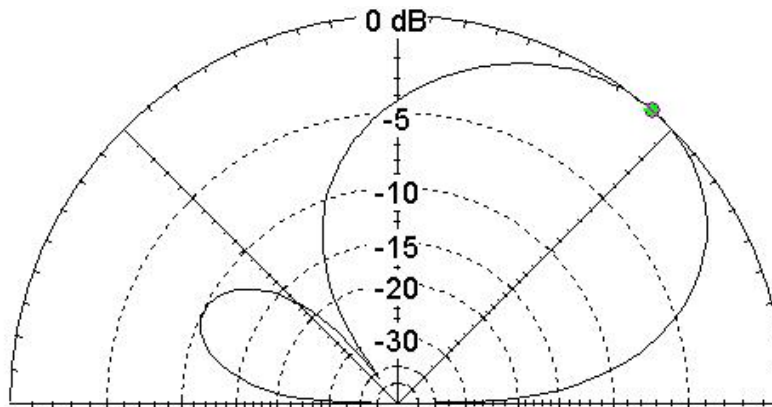


Dual dipole, 10 ft, 135 deg phasing, gain = 8.5 dBi at el = 50

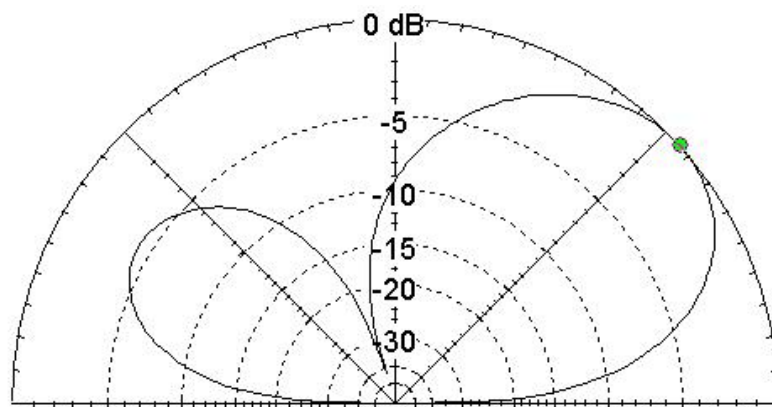
Figure 3.11. Elevation beaming patterns of a Jove dual dipole array mounted 10 ft above ground with different phasing cable lengths.



Dual dipole, 15 ft, no phasing, gain = 6.8 dBi at el = 90 deg

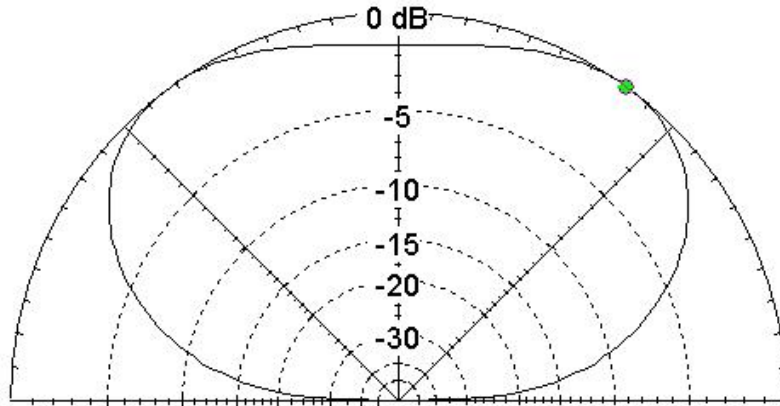


Dual dipole, 15 ft, 90 deg phasing, gain = 8.7 dBi at el = 49

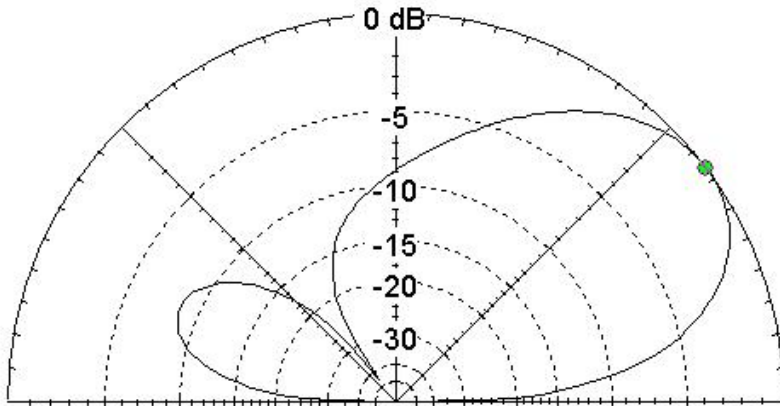


Dual dipole, 15 ft, 135 deg phasing, gain = 9.1 dBi at el = 42

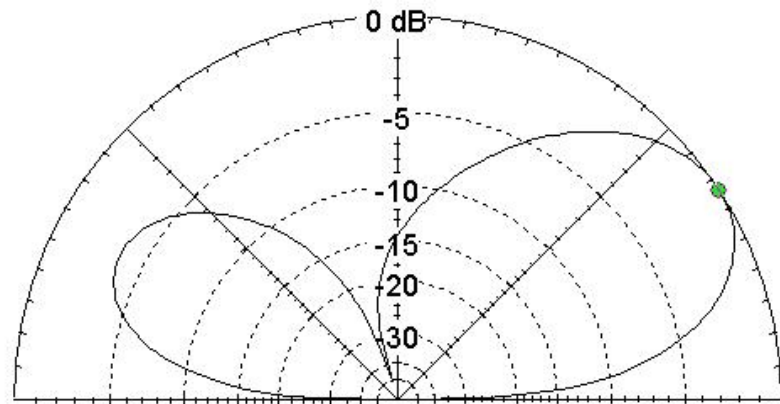
Figure 3.12. Elevation beaming patterns of a Jove dual dipole array mounted 15 ft above ground with different phasing cable lengths.



Dual dipole, 20 ft, no phasing, gain = 4.5 dBi at el = 54 deg



Dual dipole, 20 ft, 90 deg phasing, gain = 9.1 dBi at el = 37



Dual dipole, 20 ft, 135 deg phasing, gain = 9.5 dBi at el = 33

Figure 3.13. Elevation beaming patterns of a Jove dual dipole array mounted 20 ft above ground with different phasing cable lengths.

3.5 Radio Jupiter Pro (RJP)

Radio Jupiter Pro is used to predict when Jupiter emissions are likely to occur, allows us to see the track of Jupiter (or the Sun) across the sky, and to visualize the antenna beam pattern on the sky (use the Sky Map display in RJP). Figure 3.14 depicts the sky above an observer station using a Jove dual dipole antenna with the wires running east-west (the two parallel lines near the center of the plot represent the dipoles). The antenna at 10 ft with zero phasing produces an overhead beam. The track shows Jupiter entering the antenna beam at 0730 UTC and leaving the beam at 11 UTC. Figure 3.15 shows a track for the Sun and the pattern for a single N-S dipole.

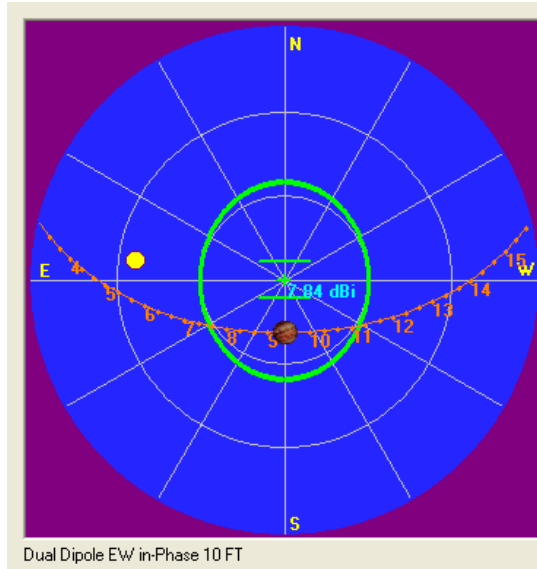


Figure 3.14. RJP plot showing the overhead antenna beam and the track of Jupiter across the sky in July 2011 for a station located at 30°N.

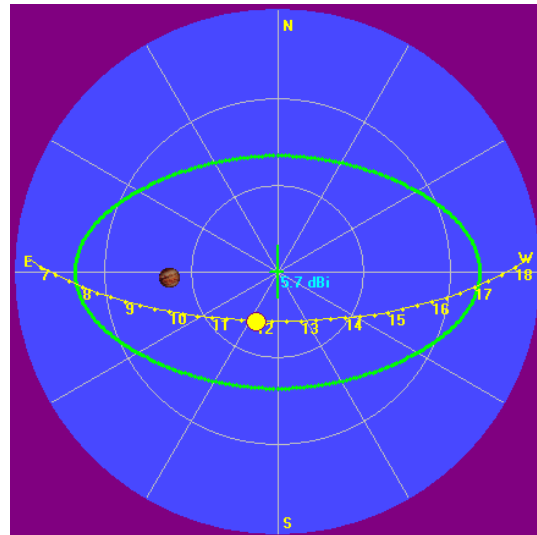


Figure 3.15. RJP plot showing the pattern of a single N-S dipole and the track of the Sun for a station at 20°N latitude in early April.

3.6 Some examples

A. An observer living at 30°N latitude wants to observe Jupiter starting in October of 2012. Figure 3 shows that Jupiter's peak elevation at that time is 80°, and it will stay close to this value for the next two years. The best choice is to use the dual dipole configuration at 10 feet with no phasing cable (Fig. 3.11 top).

B. An observer living at 35°S latitude wants to observe Jupiter starting in January of 2016. Figure 4 shows that Jupiter's peak elevation at that time is about 50° and will be increasing to 70° over the next two years. The dual dipole at a height of 10 ft with a 90° phasing cable in the north dipole feedline is the best configuration (Fig. 3.11 middle).

C. An observer at 50°N latitude wants to observe Jupiter in 2017. Figure 1.3 shows that Jupiter's peak elevation is near 35 degrees and will be decreasing during the following years. The dual dipole at a height of 20 ft with a 135° phasing cable in the south dipole feedline is the best configuration (Figure 3.13 bottom).

D. For solar observations a single dipole is sufficient since radio noise bursts from the Sun can be much stronger than Jupiter. The single dipole takes less space and is simpler to construct and this may be an advantage for some observers. Signals will be weaker than if using the dual dipole array but should be plenty strong for easy detection of many solar bursts. A single dipole oriented east-west at a height of 15 feet will provide good coverage for a few hours of solar observations around local noon throughout the whole year for stations located between about 35° north and south latitude (Fig. 3.10). A single dipole oriented north-south will provide a wide east-west beam and may be preferable for some stations at some times of the year (Figure 3.15).

3.7 Antenna Configuration Summary

Before beginning construction of your Jove antenna you should decide on the configuration, based on your latitude and where Jupiter (and /or the Sun) will be in the sky.

Observers Latitude _____

If you are going to observe just the Sun then a single dipole is adequate. Determine the elevation angle using Figure 1.1 and the dipole height and orientation using Figures 3.3, 3.10, and 3.15. You can also run RJP and study the antenna pattern and tracks across the sky for the Sun.

Dipole Height _____

Jupiter observations should be made using the dual dipole configuration. Select the elevation of Jupiter from Figures 1.3 or 1.4 and select your antenna configuration based on the antenna patterns in Figures 3.11, 3.12, and 3.13.

Antenna Height _____ Phasing Cable _____

4. Antenna Pre-Assembly

4.1 Site Requirements and Considerations

The area required for a single Jove dipole is approximately 15 x 45 ft. The Jove dual dipole array requires a reasonably flat area 30 ft N-S by 45 ft. E-W. The soil should be suitable for putting stakes into the ground. Since the antenna is sensitive to electrical noise it is best not to set it up near power lines or close to buildings. **For safety reasons, keep the antenna away from power lines during construction and operation.** The best location may be a sports field or a rural setting. Since Jupiter observations occur at night it is wise to practice setting up the antenna during the day to make sure the site is safe and easily accessible.

The Jove antenna kit is supplied with 95 ft. (29 m) of RG-59 coaxial cable (Belden 8241). If you are installing a single dipole then this cable will run directly from the dipole feedpoint to the receiver.

If you are installing the dual dipole array then this cable will be cut to provide a 1λ run from each dipole feedpoint to the power combiner (32.31 ft each), the phasing cable (either 135 degree [12.12 ft], or 90 degree [8.33 ft]), and a 0.5λ (16.16 ft) cable to run from the power combiner to the receiver.

The cable run from the power combiner to the receiver using the provided cable is quite short, just long enough to situate the receiver outside of the antenna array. You may wish to use a longer cable, allowing a greater separation between antenna and receiver.

The cable running from the power combiner to the receiver should be a multiple half wavelength long. Additional cable can be purchased from Radio Shack or an electronics distributor or hardware store. These stores do not generally carry RG-59, but they do have RG-6 and the higher grade RG-6QS (quad shield), which is also 75-ohm cable. The RG-6 type cables are low loss and have a velocity factor of between 78% and 83%. One wavelength at 20.1 MHz in RG-6 cable is between 38.18 ft (11.64 m) and 40.63 feet (12.38 m). If you are going to put in a longer feedline we recommend that you completely replace the existing 0.5λ piece of RG-59- rather than coupling another length of cable onto the end.

Type F-male cable connectors are not interchangeable between RG-59 and RG-6 (because the diameter of the cables is slightly different). Be sure to buy F connectors for the RG-6 type cable if you use that cable. The F-male connectors for both cable types are identical as far as mating to the power combiner and receiver F-female connectors.

An important factor related to the distance between the antenna and receiver is attenuation (signal loss) in the connecting cable. Ranging up to a maximum loss of 3 dB (half power) the following table shows that the antenna and receiver can be separated by over 350 ft if you are using RG-6 type cable. In fact, double that attenuation should be acceptable, but less is always better.

Table 4.1 Cable lengths for RG-59 and RG-6 accounting for the velocity factor
(RG-59 velocity factor 0.66; RG-6 or RG-6 QS (quad shield) velocity factor 0.78)

Cable length in wavelengths	RG-59 Feet (m)	RG-59 Attenuation (dB)	RG-6 or QS Feet (m)	RG-6 or QS Attenuation (dB)
0.5	16.16 (4.93)	0.25	19.09 (5.82)	0.16
1	32.32 (9.85)	0.5	38.19 (11.64)	0.32
1.5	48.48 (14.78)	0.75	57.29 (17.46)	0.48
2	64.64 (19.70)	1.0	76.39 (23.28)	0.64
2.5	80.80 (24.63)	1.25	95.48 (29.10)	0.80
3	96.96 (29.55)	1.5	114.58 (34.93)	0.96
3.5	113.12 (34.48)	1.75	133.68 (40.75)	1.12
4	129.27 (39.40)	2.0	152.78 (46.57)	1.28
4.5	145.43 (44.33)	2.25	171.88 (52.39)	1.44
5	161.59 (49.25)	2.5	190.97 (58.21)	1.6
5.5	177.75 (54.18)	2.75	210.07 (64.03)	1.76
6	193.91 (59.18)	3.0	229.17 (69.85)	1.92
6.5			248.27 (75.67)	2.08
7			267.36 (81.49)	2.24
7.5			286.46 (87.31)	2.4
8			305.56 (93.13)	2.56
8.5			324.66 (98.96)	2.72
9			343.75 (104.78)	2.88
9.5			362.85 (110.60)	3.04

If you have no clear open space on the ground to erect the antenna then it may be worth trying it on a flat rooftop. Buckets full of concrete can be used to anchor the guy ropes and antenna masts. However, we offer a fair warning that the antenna pattern may be seriously affected by the lack of a good ground plane, and nearby air conditioning units and other motors may generate undesirable electrical noise. A rooftop antenna may also be more susceptible to lightning and should always be disconnected when not in use.

Disconnect the Jove antenna when not in use - particularly during lightning season.

4.2 Construction Time Estimate

Table 4.2 Construction Time Estimates

Wire and Coaxial Cable Construction	2 hours
Antenna Mast Fabrication	1 hour
Antenna site layout	1 hour
Field Setup and Testing (first time)	1.5 hours
Approximate Total Time	5.5 hrs.

4.3 Antenna Components

The dual dipole antenna is composed of copper wire, coaxial cable, connectors, insulators, toroid cores, a power combiner, rope, support masts, and hardware. Figure 4.1a shows the antenna parts provided in the Jove antenna kit while Figure 4.1b shows the additional hardware required for the dipole support masts. Parts required to build the support masts are not provided in the kit. These support structure parts depend upon the height of the antenna and the type of mast to be assembled. Parts lists are included in manual sections (4.1-4.2). The estimated PVC antenna mast costs = \$75; the estimated metal antenna mast costs = \$100.

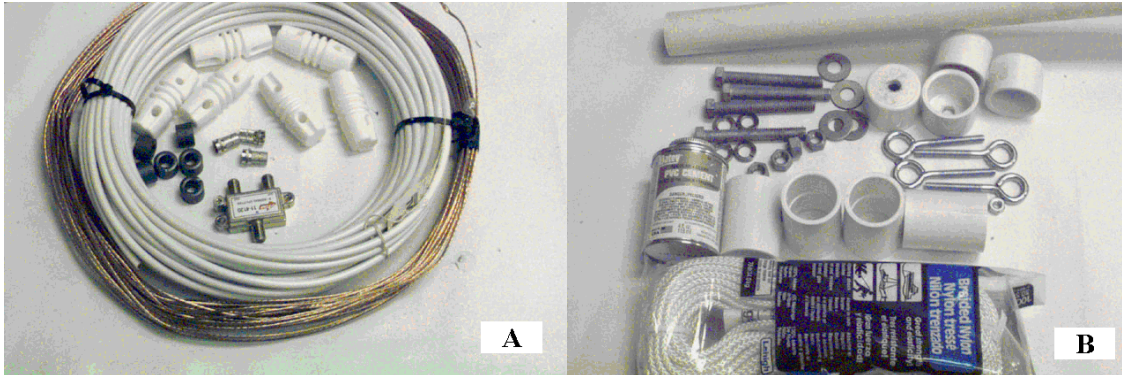


Figure 4.1A shows parts included in the Jove kit. Figure 4.1 B shows additional materials needed to fabricate the support masts.

4.4 Radio JOVE Antenna Kit Parts List

Table 4.3 Antenna Parts List

#	Parts included in the Radio JOVE Antenna Kit	Parts Checklist
	Description	
1	50 ft. (15.24 m) #14 Gauge Bare Copper Wire (7-stranded)	
1	95 ft. (29 m) RG-59 Coaxial Cable (Belden 8241)	
6	Insulators	
6	Twist-on F-connectors	
1	Coaxial cable coupler	
1	Power combiner / splitter (2-to-1)	
6	Ferrite toroid cores	
4	Black plastic tie-wraps	

4.5 Items Supplied in Kit – Unassembled Antenna Kit

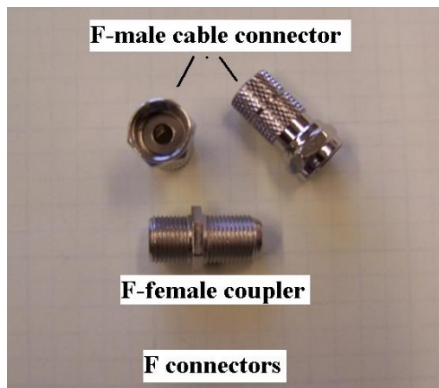
Copper Wire is used for the dipole elements. You will build two identical half-wave dipole antennas. The tip-to-tip length (Figure 3.1) of the dipole wires is 23.28 ft.

Coaxial Cable (coax) is used to feed the signal from the dipoles to the receiver. The kit is supplied with RG-59 coax with a velocity factor of 0.66. The lengths of cables used in the Jove antenna system are tabulated below (Table 4.4).

Table 4.4 Coax cable lengths for RG-59 cable (velocity factor 0.66)

Antenna Part	Number of cables needed	Cable length in wavelengths	Cable length
Cable from dipole	2	1λ	32.31 ft. (9.85 m)
Phasing cable	1	0.375λ (135 deg) OR 0.25λ (90 deg)	12.12 ft. (3.69 m) 8.08 ft. (2.46 m)
Cable to Receiver	1	0.5λ	16.16 ft. (4.93 m)

F-Connectors are used to connect coax cables to the power combiner and to the antenna input of the JOVE receiver. An F-female coupler is used to join the phasing cable.



Insulators support the antenna wires while isolating the received signals from ground. Six insulators are used for the antenna, one at the feed point in the middle of each dipole, and one on each end.

Toroid cores slipped over the coax cable near the feedpoint restrict current flow on the outer surface of the coaxial shield and help to improve antenna performance.



Ferrite Toroids

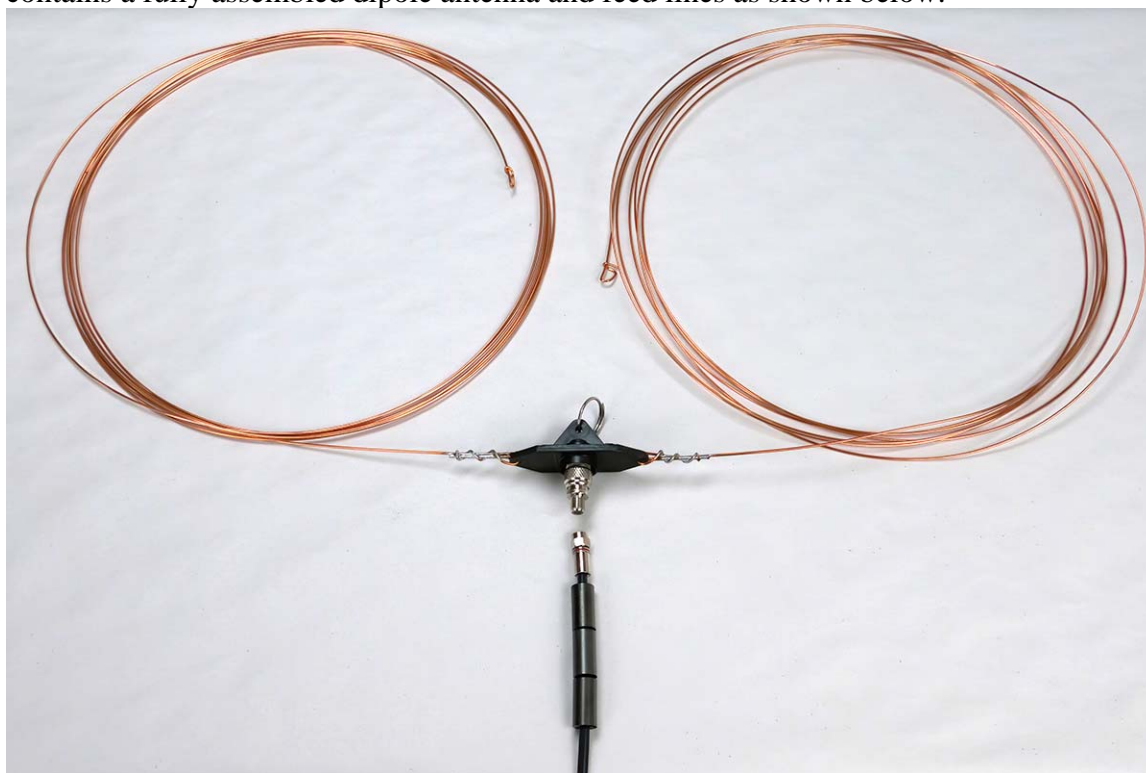


Power Combiner

A **Power combiner** adds the signals from both dipoles together. The combined signals are then sent to the receiver.

4.6 Items Supplied in Kit – Professionally Built Antenna Kit

The Professionally Built Antenna Kit does not require any assembly beyond connecting the coax cable to the components and attaching ropes to the dipole wires. This kit contains a fully assembled dipole antenna and feed lines as shown below.



4.7 Additional Materials

Support masts support the dipoles. Metal, wood or PVC may be used. PVC tubing is inexpensive and lightweight but requires more guying than metal tubing.

Rope is used as guy lines for each support mast.

Hardware in the form of bolts and nuts are used to connect and anchor various parts of the antenna. Bolts are used as foot pegs to help keep the masts in place and eyebolts are used to help attach the guy lines to the masts. For long outdoor exposure stainless steel hardware is desirable, although it is more expensive than plated steel (See Tables 4.1 and 4.2).

4.8 Tools

Radio Shack (RS) part numbers are given for convenience, but other quality tools will work fine. Note that it will take longer to make good solder joints using a lower-wattage soldering iron. Just make sure to hold the iron on long enough to let the solder flow.

- Soldering Iron (RS 64-2071; 40 Watt) or or 40-Watt Weller WLC100 or Velleman 50W Soldering Station (part # VTSS5U; check Amazon.com)
[NOTE: A small wattage soldering iron or soldering pencil (25-30 watts) is ideal for building the receiver but is not big enough for the larger wires and joints in the antenna. A 50 watt soldering iron, or a higher wattage (100-150 watts) soldering gun is best for the antenna, although if you are patient you may get by with a 40 watt iron (make sure the solder flows throughout the wire strands). A variable wattage iron (25-50 watts) like the Velleman 50W Soldering Station is recommended since it can be used for both the receiver and antenna. If you purchase a simple soldering iron with no stand, please obtain a stand to hold the hot iron. Another advantage of purchasing a soldering station is that it includes a stand for the hot iron. Whatever soldering equipment you purchase clean and tin the tip frequently for best performance.]
- Solder, rosin core 60/40 (.050 in., RS64-006 or .032 in., RS 64-005)
- Wire Cutters and Wire Strippers (RS 64-080)
- Nippy Cutter (RS 640-0064)
- Long Nose Pliers (RS 640-0062)
- X-acto Knife (or equivalent)
- Lighter
- Tape measure (at least 25 ft. is best)
- Black Marker
- Small flat screwdriver
- Crescent Wrench
- Pliers
- Drill with 1/8 in., 1/4 in., and 3/8 in. drill bits

5. Preparing the Dipoles and Coaxial Cable – Unassembled Antenna Kit

Regardless of the height of your antenna the wire and coax portions are identical.

5.1 Cutting the Wire and Coax

Measure and cut the proper lengths of copper wire, coaxial cable, and rope. A long hallway is excellent for this job. Use tape on the floor to mark the lengths for each cut. Use the ○ markers to check off each step as you complete it.

1. ○ Cut 4 pieces of copper wire each to a length of 12 ft. 4 in. (3.76 m). This length includes 5 inches extra on each end for attaching to the insulators.
2. ○ Using dimensions from Table 4.4, cut 4 lengths of the coaxial cable.
3. ○ Cut two lengths of rope, each 2 ft. (0.61m). Melt the ends with a lighter to keep the end from fraying.

5.2 Wrapping the Insulators

1. ○ Attach an end insulator to each wire. Thread 5 in. (12.7 cm) of copper wire through the hole in the end insulator and wrap it back on itself as seen in Figure 5.1a.
2. ○ As seen in Figure 5.1, thread each rope through the end insulator. Tie one end of each rope to an end insulator (use 6 in. of rope for each knot).
3. ○ Attach the pairs of wires to the center (dogbone) insulator. Thread 5 in. (12.7 cm) of copper wire through the hole in the center insulator and wrap the wire back on itself as seen in Figure 5.1b.
4. ○ As seen in Figure 3.1, the total length of the dipole wires (from one end insulator to the other end insulator) should be 23 ft. 3 in. (7.09 m). Ropes should extend about 1.5 ft (45 cm) from each end insulator.



Figure 5.1a and 5.1b. Wrap the center and end insulators with the antenna wire.

5.3 Preparing and Soldering the 1 λ Coax Lines

1. ○ Strip back (remove) the outer covering about 4 - 5 inches (10 - 12 cm) from *one end only* of each of the 1 λ cables. [Note: Be careful not to cut the braided copper shielding wires underneath the outer cover].
2. ○ Unweave the braided copper shielding using a small screwdriver or the tip of a pen or pencil. Start at the end of the wire and carefully unbraid all of the exposed copper shielding (Figure 5.2a and 5.2b). A few broken strands of braid are normal.



Figure 5.2a and 5.2b. Unbraid the copper shielding.

3. ○ Twist all the individual wires together to form one continuous wire (Figure 5.2c).

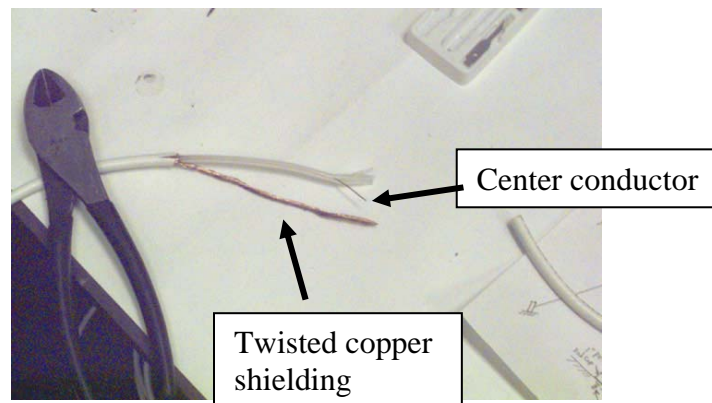


Figure 5.2c. Twist the copper shielding and expose the center conductor.

4. ○ Strip off the insulation around the center conductor approximately 2 inches (5 cm). This is polyethylene and is fairly tough, so use a sharp knife with caution. **WARNING: Be careful not to nick the center conductor when cutting and stripping off the insulation around it.** Nicking the center conductor will weaken it and most likely cause it to break after swinging in the wind.
5. ○ Loop the coaxial cable over the center insulator and tie wrap it (Figure 5.3) just below the section of stripped coax using one of the black tie wraps provided in the kit. This will provide strain relief so the solder joints will not break.

6. ○ Wrap the bare center conductor around the end of one of the copper wires attached to the center insulator. Wrap the twisted shielding around the other copper wire attached to the center conductor (see Figures 5.3 and 5.4).
7. ○ Solder the coax center conductor and shield to the copper wires (we recommend using a soldering gun or a soldering iron of at least 50 watt capacity). Use plenty of solder and heat the wires until the solder seeps into the wires. Apply heat all around the connection to achieve a good flow of solder (Figure 5.4).
8. ○ Repeat for the other dipole.

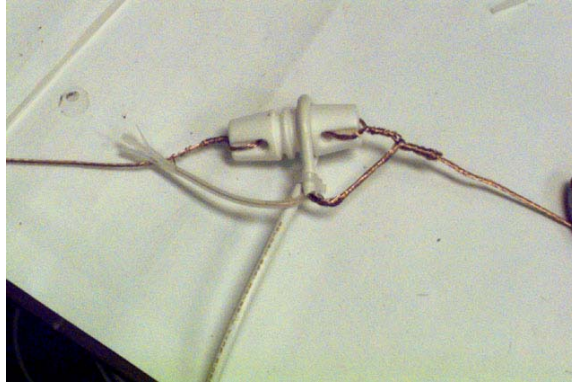


Figure 5.3. Tie wrap the coax over the center insulator. Wrap the center conductor around one side of the dipole and the twisted shielding around the other.

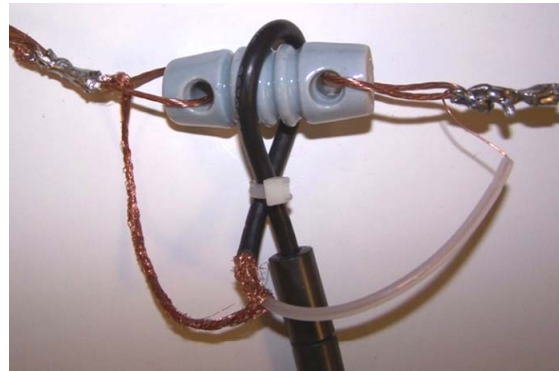
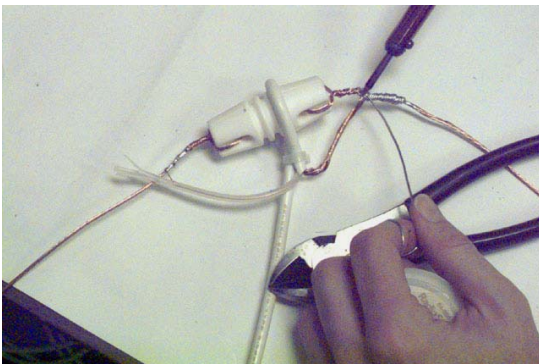


Figure 5.4. Solder the shielding and center conductor to the copper wires. Figure 5.5. Install the ferrite toroid cores.

5.4 Installing the Toroids and Connectors

1. ○ For each dipole, slide 3 ferrite toroids cores up the cable to the very top of the coax near the dipole. Secure them all in a row with tape and a tie wrap. Be sure this is secure because they may slide down the coax after the antenna is up (Figure 5.5).
2. ○ Install the F-connector on the coax feed line to each dipole. To install, remove about 1 inch (2.5 cm) of the outer coax casing (Figure 5.6a).
3. ○ Carefully unbraid about half of the exposed shielding about 1/2 inch (1.25 cm) and fold it back over the other half of the copper shielding and over the outer casing (Figure 5.6b).
4. ○ Remove the insulation around the center conductor leaving about 1/2 inch (1.3 cm) of bare center conductor (Figure 5.6c, 5.6d).
5. ○ Push the F-connector over the end of the coax and twist on as tightly as possible. The teeth of the F-connector will bite into the shielding that has been folded back and this will provide good contact for ground. About 1/8 - 1/4 inch (0.3- 0.6 cm) of center conductor should stick out of the end of the F-connector (Figure 5.6e).
6. ○ Repeat this connector installation procedure for each end of the phasing cable and for the 0.5λ cable, which will run to the receiver.

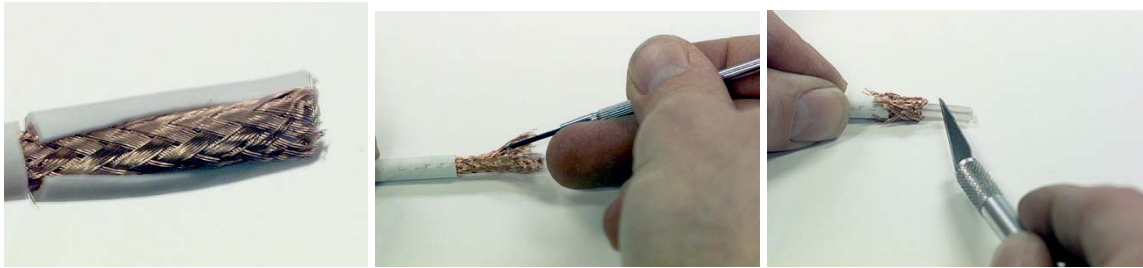


Figure 5.6a – 5.6c. Prepare the coax and install the F-connector.



Figure 5.6d – 5.6e. Prepare the coax and install the F-connector.

6. Antenna Mast Assembly

Section 1 of this manual described how to select the antenna height based on your latitude and Jupiter's elevation. The wire and coax portion of the antenna is the same for each height. There are 3 choices of antenna height: 10, 15, and 20 ft. The next sections of the manual describe two different antenna mast options. [For solar observations, a single dipole is all that is needed. A manual to build a single dipole antenna is found Online here: http://radiojove.gsfc.nasa.gov/telescope/equipment_manuals.htm]

6.1 PVC Masts – more guy ropes, less rigid (approximate cost for all parts \$75)

6.3 Metal Masts – fewer guy ropes, more rigid (approximate cost for all parts \$100)

6.1 PVC Masts

Table 6.1 PVC Antenna Parts List for 10 – 20 ft. adjustable height mast assembly

Parts needed for 10 – 20 ft. Adjustable Antenna Mast Assembly		Parts Checklist
#	Description	
1	300 ft. (30.48 m) x 3/16 in. Nylon Rope	
4	10 ft. (3.048 m) x 1 in. PVC Sch40 pipes (White)	
4	10 ft. (3.048 m) x 1¼ in. Non-metallic Conduit pipes (Gray)	
4	1¼ in. Non-metallic Conduit End Caps	
12	4 in. x ¼ in. Eye Bolts	
4	4 in. x ¼ in. regular Bolts (Stop Bolts)	
16	¼ in. Nuts/Lock washers	
4	4 in. x 3/8 in. Bolts (for end caps)	
4	3/8 in. Nuts, Flat Washers, and Lock Washers (for end caps)	
10	Ground Spikes (or tent stakes)	
6	6 in. black Tie wraps (optional)	

6.2. PVC Mast Assembly (Refer to Figures 6.1, 6.2, and 6.3)

1. O The dipole mast assembly consists of a 10 ft bottom section (1.25 inch gray electrical conduit, schedule 40, PVC) and a 10ft top section (1 inch white schedule 40 PVC). The 10, 15, and 20 ft antenna heights are achieved by telescoping the top mast up or down inside the bottom mast. Overall antenna heights may vary a few inches (or cm); this is perfectly acceptable.

2. O *Drill all holes through the masts at ¼ inch diameter.* The hole through the end-cap for the spike is 3/8-inch diameter. All holes in the masts should be in the same plane (i.e. not rotated around the mast pipe). A hammer and punch (or nail) can be used to make a starting point for drilling. A pilot hole using a 1/8 in drill bit is recommended. Eyebolts and regular bolts should be secured using a flat washer, lock washer and a nut.

3. O Draw a guide line the length of the top mast to insure that all holes line up. (You can draw this line by laying the mast on the floor and moving the side of the pen along the floor). Use the guideline and drill holes (A and B) through the top mast.



Figures 6.1a and 6.1b. Drill the PVC piping (1/4 in. drill bit) and end cap (3/8 in. bit).

4. O Draw a guide line from the top to the midpoint of the bottom mast. Using the guideline for orientation, drill holes (E and F) through the mast. Secure the stop bolt in hole (F).
5. O With the guide lines on the two mast sections aligned, insert the top mast 6 inches into the bottom mast section. Using hole (E) as a guide, match-drill a hole through the top mast section – this becomes hole (D). The best way to match-drill the holes is to drill the mast from each side – using hole E as a guide. Then without moving the two masts relative to each other, run the drill all the way through both masts.
6. O With the guide lines on the two mast sections aligned, push the top mast section into the bottom mast section until it hits the stop bolt at (F). Using hole (E) as a guide, match drill a hole through the top mast section – this becomes hole (C).
7. O Secure an eyebolt in hole (B).
8. O Assemble and attach the bottom cap and spike. (Glue optional)
9. O Repeat assembly steps above for the remaining masts.
- 10a. O For the 20 foot antenna assembly, insert the top mast 6 inches into the bottom mast and secure with a 4 inch eyebolt thru holes E/D.
- 10b. O For the 15 foot assembly insert the top mast until it hits the stop bolt and secure with an eyebolt through holes E/C
- 10c. O For the 10-foot assembly remove the stop bolt. Insert the top mast until eyebolt (B) hits the top of the bottom support mast. The inner guy rope is not used. The total antenna height will be closer to 11 feet; this is perfectly acceptable.

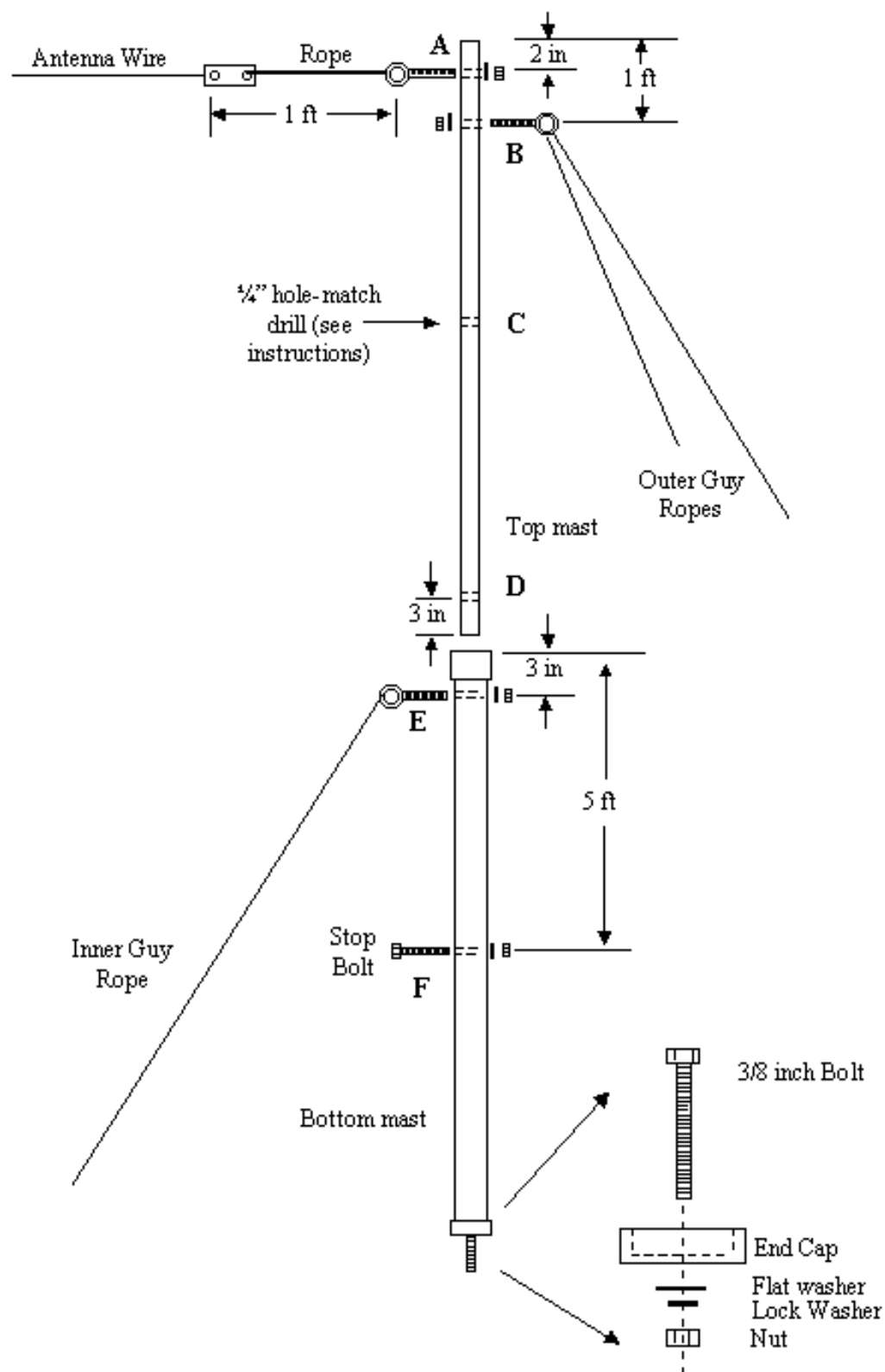


Figure 6.2. PVC Mast Assembly.

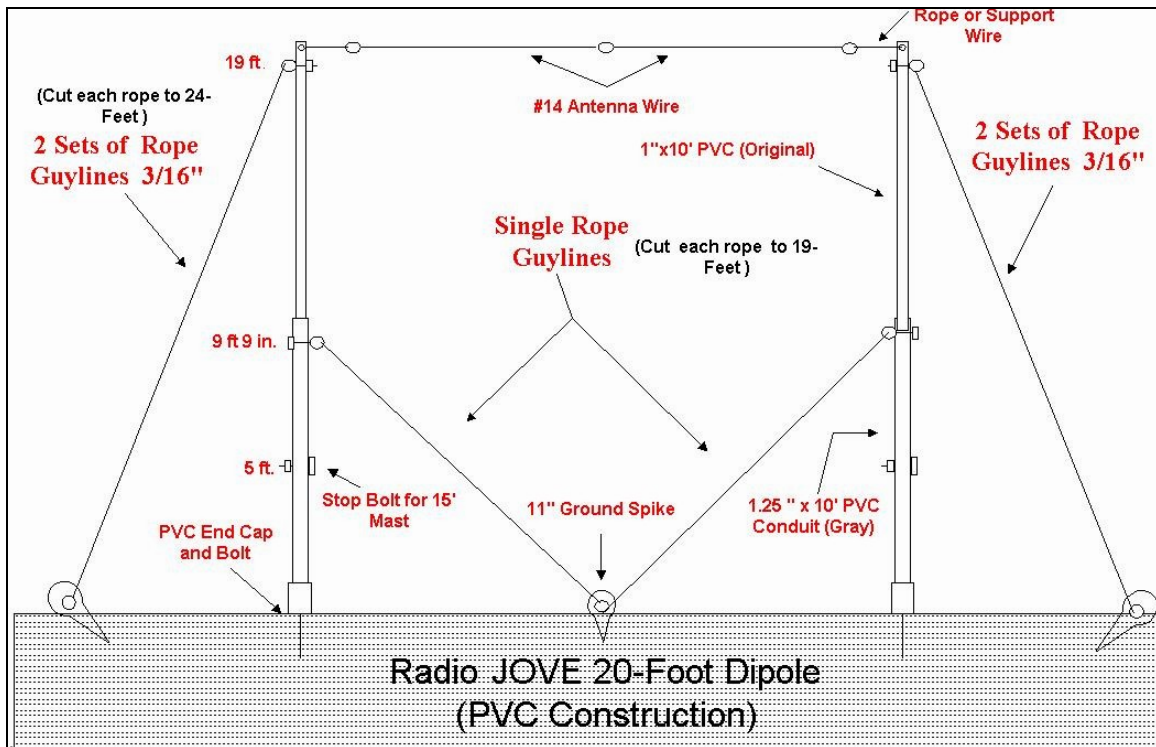


Figure 6.3. Side-view schematic of PVC mast dipole installation.

**End PVC antenna mast assembly instructions.
Go to section 7 for field setup and testing.**

6.3 Metal Masts

Table 6.2 Metal Antenna Parts List for 10 -20 ft. adjustable height mast assembly

Parts needed for 10-20 ft. Adjustable Antenna Metal Mast Assembly		Parts Checklist
#	Description	
1	200 ft. (30.48 m) x 3/16 in. Nylon Rope	
8	10 ft. 6 in. (3.2 m) x 1-3/8 in. Metal Fence Top Rail (approx. \$8 at Home Depot)	
8	4 in. x 1/4 in. Eye Bolts	
12	1/4 in. Nuts/Lock washers	
4	2 in. x 1/4 in. Bolts	
8	Ground Spikes (or tent stakes)	

6.4. Metal Mast Assembly (Refer to Figures 6.4 and 6.5)

1. O Each dipole mast assembly consists of two metal pipes (commonly sold as the top rail in a chain-link fence). Each pipe is 10'6" long with a 6" necked down section at one end. Two of the pipes are connected to form a mast that can be used to support the Jove dual dipoles at either 15 or 20 ft. (a single mast could be used for a 10 ft installation). Overall antenna heights may vary a few inches (or cm); this is perfectly acceptable.
2. O **Refer to Figure 6.4.** *All holes through the masts are 1/4 inch diameter.* A hammer and punch (or nail) can be used to make a starting point for drilling. A pilot hole using a 1/8 in drill bit is recommended. Eyebolts and bolts should be secured using a flat washer, lock washer and a nut. All holes in the top mast should be in the same plane.
3. O Draw a guideline the length of the top mast to insure that all holes line up. (You can draw this line by laying the mast on the floor and moving the pen along the floor). Using the guideline, drill holes (A, B and C) thru the top mast.
4. O Drill hole (E) thru the bottom mast.
5. O Insert the top mast section 6 inches into the bottom mast section. Using hole (E) as a guide, match-drill a hole though the top mast section – this becomes hole (D). The best way to match-drill the holes is to drill the inner mast from each side – using hole E as a guide. Then without moving the two masts relative to each other, run the drill all the way thru both masts
6. O Secure eyebolt in hole (B).
7. O Repeat assembly steps above for the remaining masts.
8. O Insert top mast into bottom mast and secure with a 2-inch bolt thru holes E/D.
- 9a. O For a 20-foot high antenna attach the antenna eyebolt at hole (A).
- 9b. O For a 15-foot high antenna attach the antenna eyebolt at hole (C).
- 9c. O For a 10-foot assembly simply use the top mast section.

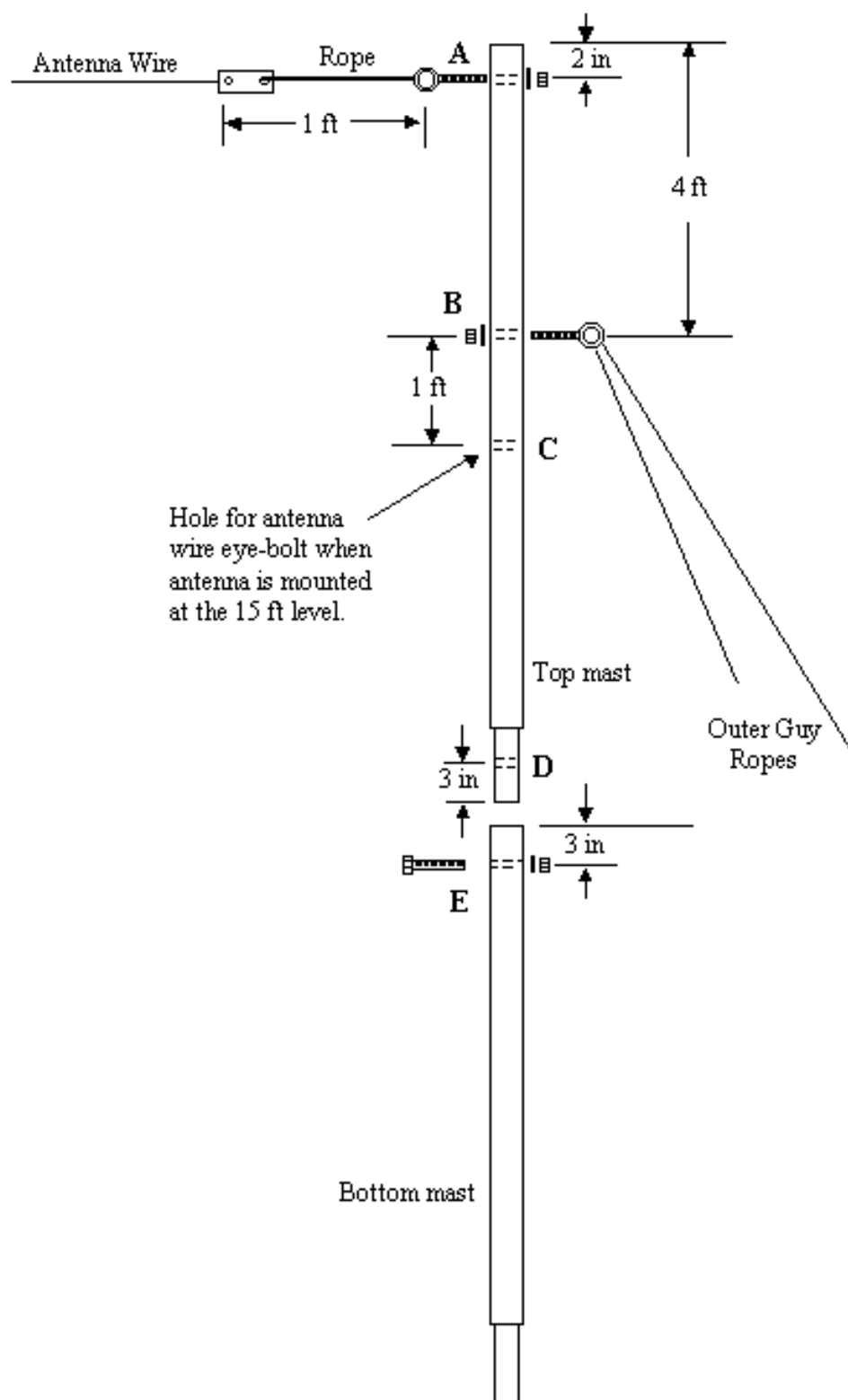


Figure 6.4. Metal Mast Assembly.

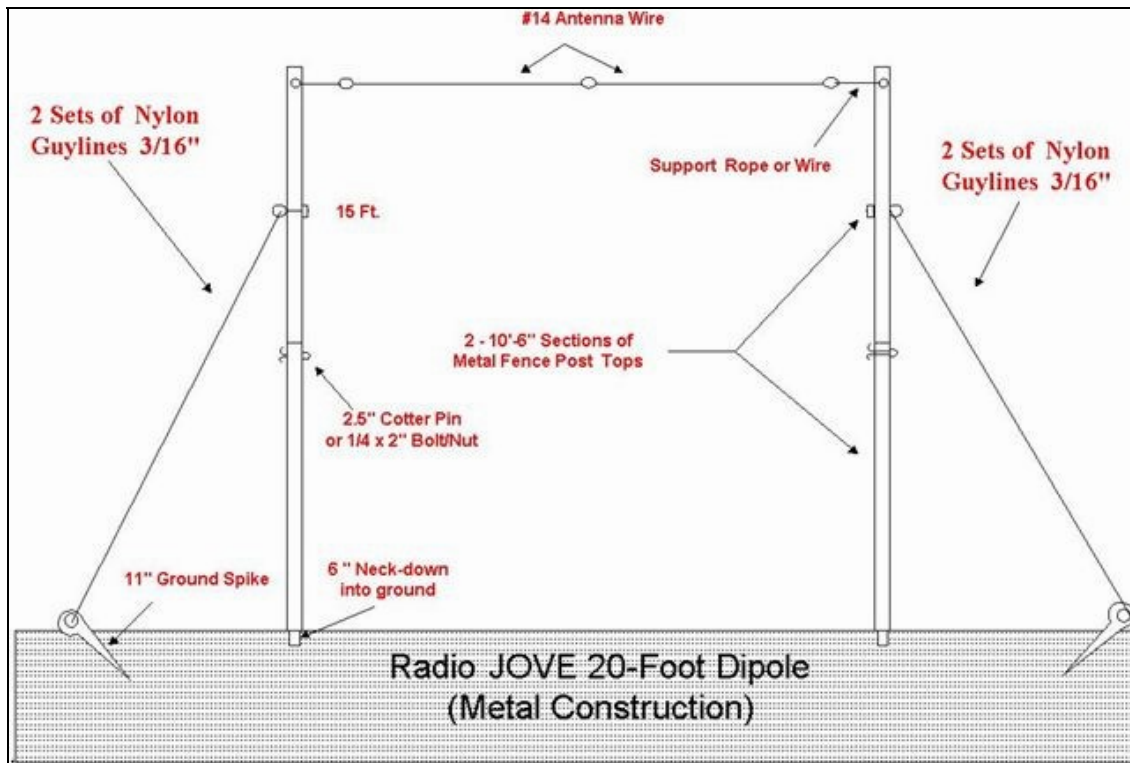


Figure 6.5. Side-view schematic of metal mast dipole installation.

**End metal antenna mast assembly instructions.
Go to section 7 for field setup and testing.**

7. Field Setup, Safety and Testing

7.1 Weatherproofing the Antenna

It is important to weatherproof the coaxial cable connections at the antenna feedpoint, the power combiner, and the cable coupler, particularly if the antenna will be subject to moisture. Simply wrapping them in electrical tape will help, but a better solution is to use Radio Shack Coax Sealing tape. The rubberized plastic compound sold at hardware stores to insulate tool handles makes a great outer coating on top of the tape and will help ensure complete protection from moisture penetration.

7.2 Field Setup

7.2.1 Grounds Preparation

Before the antenna masts can be assembled and raised, you must layout the antenna field. Study Figure 7.1 and note that the antenna wires run in an East-West direction. Also note the mast locations and the guy spike locations. Proceed as follows.

1. Find a clear area about 30 ft N-S by 45 ft E-W. The further from power lines, metal fences, tall buildings and other obstacles the better. An unobstructed view in the direction of Jupiter (or the Sun) is desirable.
2. The basic tools you will need to layout the antenna array are: a magnetic compass, 25 to 50-foot measuring tape, guy rope, stakes, hammer, and at least two helpers. It may be useful to use a can of spray paint to mark the ground where the stakes are to be pounded in.
3. Establish the mast and guy stake locations on the antenna field using the compass and tape measure. Take one of the guy stakes and pound it into the ground to create a hole at each mast mounting point. Then remove the stake – these holes are where you will insert the bottom end of the metal masts or the spikes on the bottom of the PVC masts. Hammer in the guy stakes (with the top of each stake tilted outward from its mast at about a 45 degree angle).

The antenna field is now ready for installation of the masts and dipoles.

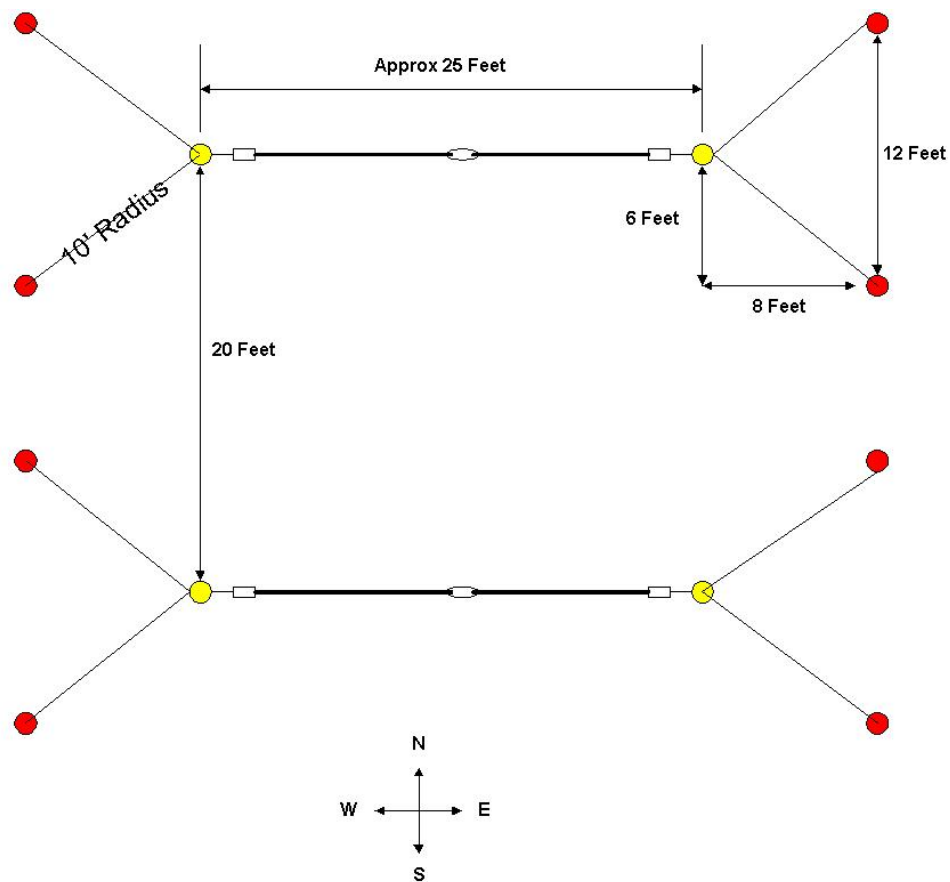


Figure 7.1. Antenna field layout for masts and guy stakes.

7.2.2 Mast and Antenna Installation

Read all installation instructions before starting. Do not attempt installation of antenna masts with fewer than 3 people.

DO NOT INSTALL NEAR POWER LINES

ITEMS NECESSARY ON HAND:

4 masts, dipole assemblies (which includes the soldered one-wavelength coax and ferrites), all coax cable with F-connectors attached, eyebolts, bolts, washers, nuts, rope, sharp knife, lighter (After cutting the rope, melt the end with the lighter to keep the end from unraveling).

Step 1. (Refer to Figures 7.1 – 7.3)

Lay out the 4 masts, with the base of each mast near its hole. Stretch out the dipoles. If you have the Professionally Built Antenna kit, attach ropes directly to the ends of the dipole wires. Attach one end of the dipole to its mast by tying the rope attached to the dipole end insulator (or wire end for the Professionally Built version) to the eyebolt attached to the mast. Do not connect the other end of the dipole to its mast yet. **Be sure that the dipoles are oriented in phase – that is, be sure that the side (or arm) of the dipole soldered to the center conductor is on the same side on both dipoles.**

- A. *For the PVC mast installation refer to Figures 6.2 and 6.3.* Cut 8 ropes to 24-feet. Attach 2 ropes to each of the eyebolts at the 19 ft level (hole B). Cut 4 ropes to 19-feet and attach each to an eyebolt at the 9-foot 9-inch level (holes D/E).
- B. *For the metal mast installation refer to Figures 6.4 and 6.5.* Cut 8 ropes to 21 feet. Attach 2 ropes to each of the eyebolts at the 16 ft level (hole B).

Step 2.

Insert the mast with the dipole wire attached into its hole in the ground and erect it to the vertical position. Tie guy ropes to their stakes so that the mast is approximately vertical.

Step 3.

Attach the dangling end of the dipole to its mast using the attached eyebolt. Stick the second mast into its hole, and secure the guy ropes so that the mast is approximately vertical. The antenna should be fairly taut with both masts near vertical. If it is not, move one mast as needed along the E-W line, reinsert in ground, and retie the guy ropes.

USE CAUTION ERECTING MASTS – BE SURE THAT GUY ROPES ARE SECURE.

Step 4.

You may have to adjust all guy ropes to make the antenna masts vertical. It is normal for the PVC top section of the masts to pull inward due to the force from the guy ropes. It may take a few adjustments to get the best fit. Do not expect perfectly straight PVC masts, as the PVC pipes will flex one direction or another.

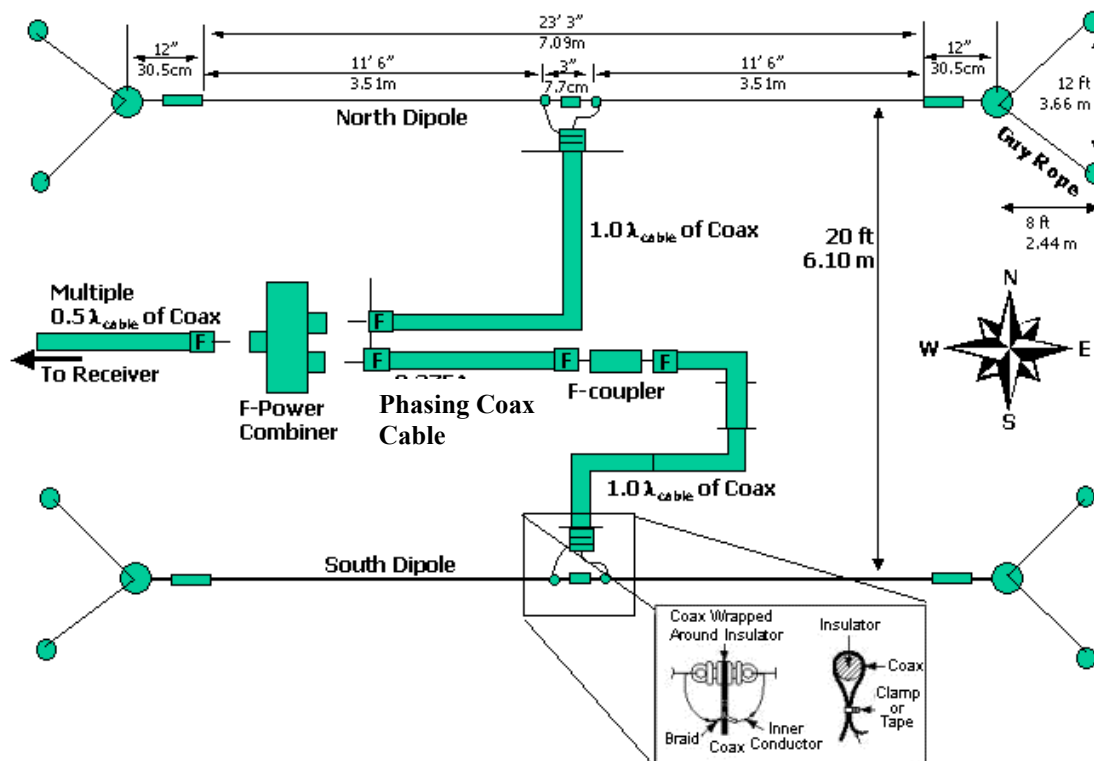


Figure 7.2. Top-view schematic of Radio JOVE dual dipole. Note the orientation of the center conductor of the feed line where it attaches to each dipole. Both dipoles must be oriented the same way; i.e., with the center conductor arm of the dipole to the east (or west; it is required only that they are the same). The phasing cable is inserted in the southern dipole feedline. This will steer the beam to the south. For southern hemisphere use, the phasing cable will be in the north dipole feedline. Connections for the Professionally Built Antenna are the same, but without the glass insulators (refer to Section 4.6 on page 25) and with the “+” marks on top of the center insulator to the east (or west; it is required only that they are the same).



Figure 7.3a and 7.3b. Sample pictures for 10-foot mast setup. Lay out each dipole on the ground and set up one pole at a time.

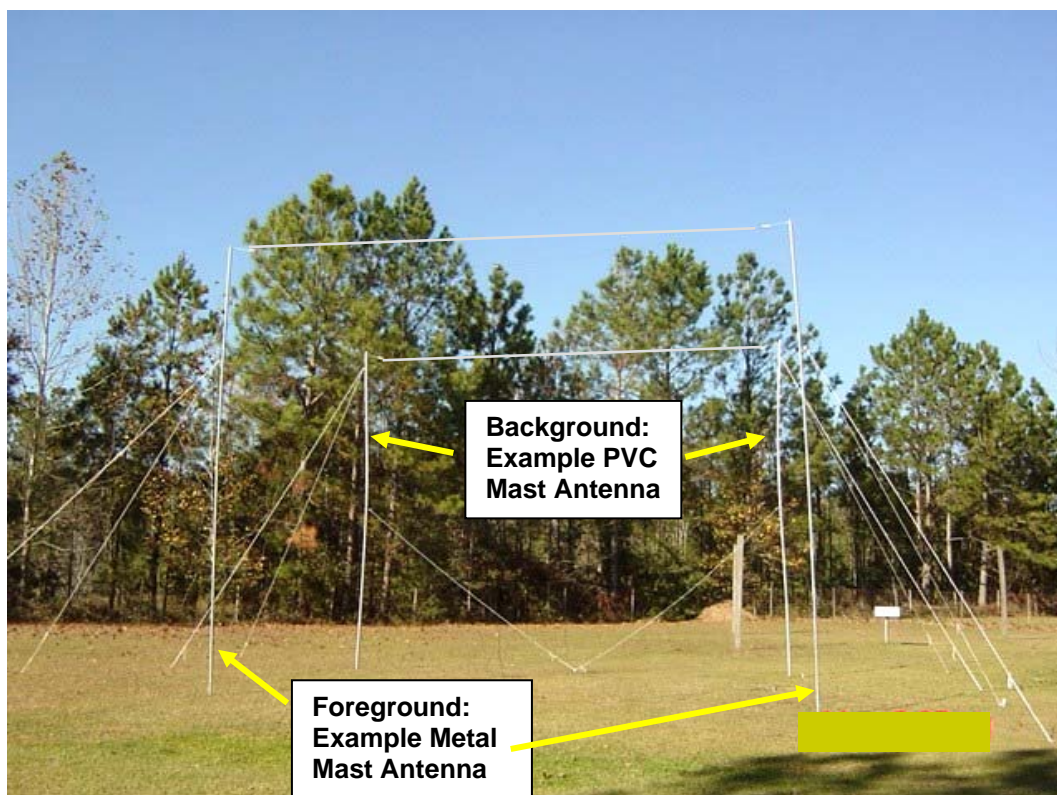


Figure 7.3c. Twenty foot masts comparing PVC and metal.

7.3 Connecting the Cables to the Antenna and Receiver

1. Connect all coax cables as shown in Figure 7.2. Make sure all F-connectors are snug.
Be certain that both dipole antennas are oriented the same direction; the center-conductors should be connected on the same side of each antenna (both to the east or both to the west).
2. Connect all cables to the receiver as shown in Figure 7.4.

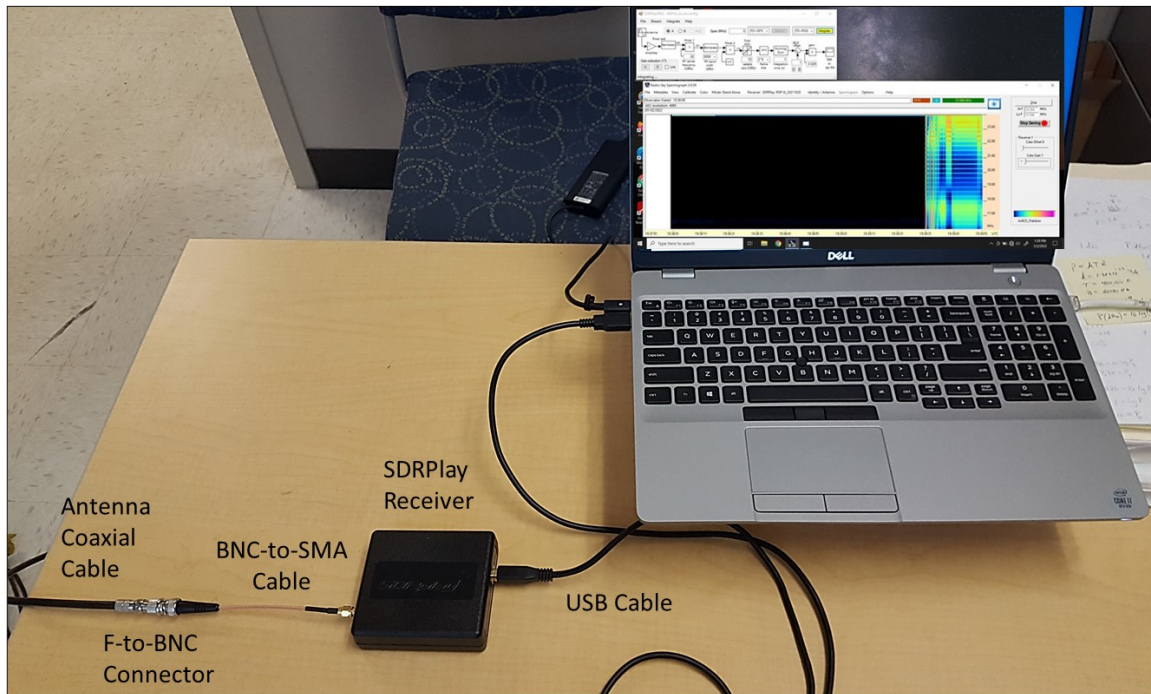


Figure 7.4. SDRPlay RSP1A receiver connections and setup with computer.

7.4 Safety Precautions

1. Avoid Lightning (always disconnect the antenna when not in use, and always disconnect the antenna before a lightning storm is present, and preferably well before the storm arrives.)
2. Never assemble the antenna under overhead power lines. The antenna should be located as far from overhead power lines as is practical – several hundred feet if possible.
3. Mark your guy ropes with reflective high visibility tape

7.5 Testing the Antenna

You may test your new antenna using your SDR, Jove Kit receiver, or other shortwave receiver with automatic gain control. (AGC) disabled. In all cases the primary test is simple, examine the effect on receiver output when the antenna is connected and disconnected.. What we are looking for is a considerable increase in the noise from the receiver when the antenna is connected. That extra noise signal arrives at your antenna from the Galactic Background (GB) radiation, and usually also from local sources of electrical interference like power lines and appliances.

7.5.1 Testing with a Single Frequency Receiver

If you are using a single frequency receiver, the simplest test will be to connect and disconnect the antenna while listening to the receiver audio. The default Radio JOVE band is around 20.1 MHz , plus or minus 100 kHz or so. This is also the resonant frequency of the dual dipole antenna, so this is where you should be listening. If you hear a shortwave station or strong interference move to a quieter frequency but stay in this band. For this test to be effective, you must be using a receiver that is sensitive enough to reliably detect the GB radio signal. The ability to detect a 0.25 micro-volt or less signal across 50 ohms is desirable.

Radio-SkyPipe software allows you to record a chart of the receiver output as you disconnect and reconnect your antenna. This is especially useful if you need to go outside to make a connection change, as you can see the effect on the strip chart when you return. See Figure 7.5 . If you haven't downloaded Radio-SkyPipe you can do so at

<http://radiosky.com/skypeishere.html>

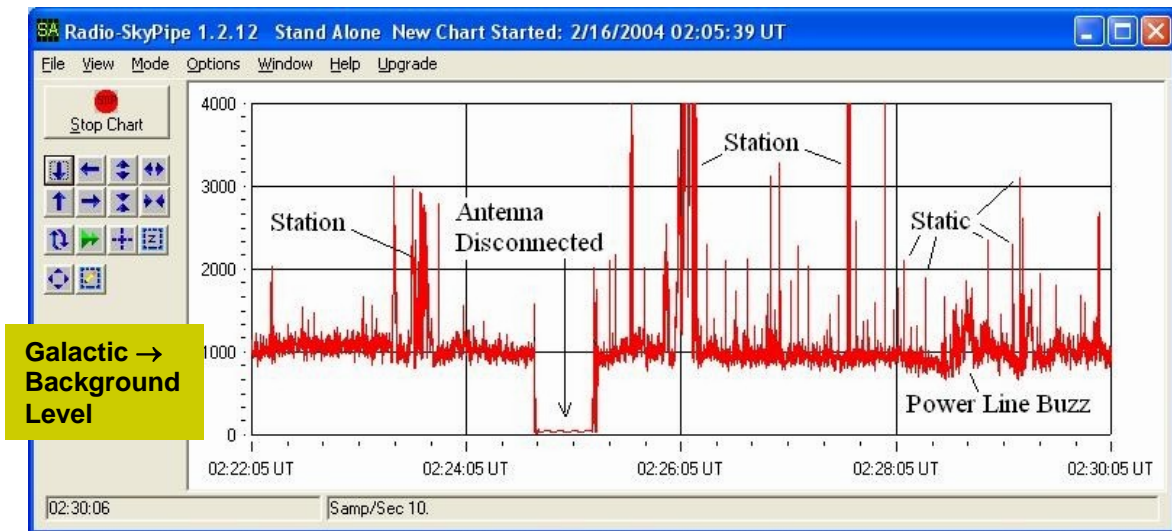


Figure 7.5.1. Sample RJ output showing a typical SkyPipe record. The effect of connecting and disconnecting the antenna is clearly seen.

7.5.2 Testing with an SDR

If you are using an SDRPlay receiver, your simplest test will utilize the SDRuno application from SDRPlay.com . From SDRuno you can get a *quantitative* idea of how strong a signal is. After installing and running SDRuno, use the following settings for the SDRPlay1A;

- RF gain to Max (74.5 dB)
- Mode AM with 6000 Hz filter
- AGC off
- NB off
- Frequency 20.1 MHz

Hit *Run* in the SDRuno Main panel and connect the antenna. On the large spectrum display click on a “quiet” part of the spectrum near 20.1 MHz. Note the signal strength reading in the upper left of the spectrum display. Now disconnect the antenna and look at that reading again. With the RSP1A the open (no antenna) the reading is about -122 dBm. With the antenna connected the reading should be much higher, which confusingly enough, means it will be a smaller negative number, say -100 or -90. The value will strongly depend on how noisy your radio frequency interference (RFI) environment is.

With the SDRuno and its spectral display you should expect to see signals in addition to the GB hiss. Shortwave radio stations, narrow and broadband RFI, lightning transients, and a perennial favorite, frequency sweeping ionosondes, or simply “sweepers”. See Figure 7.5.2 When listening on a single frequency the sweeper will be heard as a quickly ascending whistle. Ionosondes reflect these ascending signals off of the ionosphere and in addition to allowing you to see radio wave reflectivity of the ionosphere, sweepers are a good sign your antenna and receiver are working.

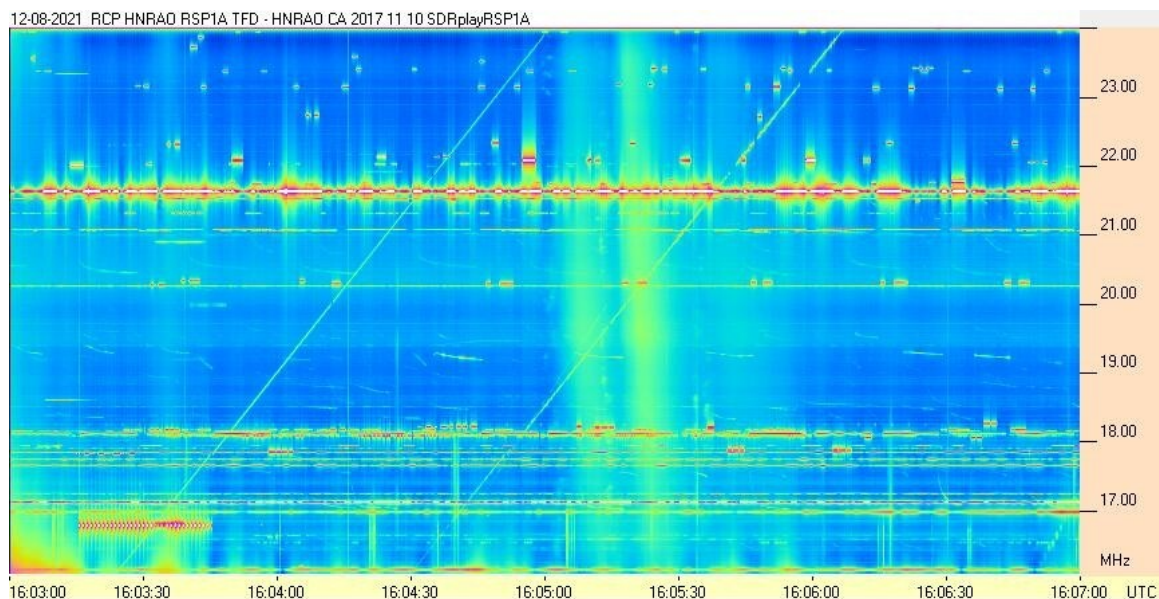


Figure 7.5.2. Sample SDRuno waterfall display showing a strong station at ~21.7 MHz, some broadband solar radio emission ca. 1605 UTC, and a pair of sweepers.

7.6 Troubleshooting the Antenna

A. Check that all F-type coax connectors are tight (on the power combiner and receiver).

B. Disconnect (at the combiner) the coax line running from one of the dipoles to the combiner. Connect this line directly to the receiver. You should hear a large increase in noise when this dipole is connected to the receiver. If you don't hear (or see on SkyPipe) the noise increase, then perform the same test with the other dipole. If you hear the noise increase with one dipole and not the other then look for problems in the dipole assembly which did not yield the noise increase. The problem is likely a short circuit – perhaps a strand of the coax braid touching the center conductor of the coax cable. (look into the end of, or disassemble, the F-connector to check for a short – or use an ohmmeter). If you use an ohmmeter on the coaxial cable coming directly from a dipole (not going thru the combiner) you should measure infinite ohms between the center conductor and the braid (or the shell of the F-connector).

What's Next?

If you have made it this far, CONGRATULATIONS! YOU HAVE JUST BUILT A RADIO TELESCOPE! You will be observing either the Sun or Jupiter or both. You should become familiar with Radio SkyPipe software to display your results and hopefully stream data to other Jove observers. If Jupiter is your target then you should become familiar with Radio Jupiter Pro. This is the program you will use to predict when Jupiter activity is likely. Additional information may be found in “Listening to Jupiter,” available for purchase on the Radio JOVE order form.

The Jove team is always willing to help with advice on technical issues and observation techniques. Please contact us if you need help by subscribing and posting a message to the Radio JOVE email list at <https://groups.io/g/radio-jove>.

CHECK FOR UPDATES TO THIS MANUAL

This manual is a living document, updated as required. New versions are published on the Radio JOVE web site at <https://radiojove.gsfc.nasa.gov>.