

Antenna Basics

In this chapter you will learn about how antennas catch the signals from a broadcast source and send them to your receiver's tuner/decoder, which processes them into the programming you want to watch. The text will help you decide which antennas are best suited for your needs and will provide information about how to assemble a satellite dish antenna for installation.

How Antennas Work

An antenna's purpose is to catch enough of the transmitted electromagnetic waves to provide an electrical signal level sufficient for the receiver to process the signal into useful audio and video. In the sections that follow, the text will briefly discuss how this works in simple terms.

Signals Have Sources

Radio waves (signals) are electromagnetic fields emitted from a natural source, such as a lightning strike; from an incidental manmade source, such as the arcing brushes of a running electric motor; or from a purpose-filled source, such as a television station's transmitter tower. The TV tower's transmissions are unique in that its signal is designed to carry useful information embedded in the radio wave.

Any time a magnet or magnetic field is passed over a wire, electric current flows through the wire. An *electric current* is simply electrons moving from the outer shell of one atom in the wire to another atom in the wire. Conversely, any time an electric current is passed through a wire, a magnetic field is present. Radio waves (TV signals) are made up of these fields of energy that combine an electric force (moving of electrons) and its companion magnetic force fields.

The antenna captures signals from the manmade sources and sends these signals to one or more of our FTA, OTA, or broadcast radio station receivers. Two physical variables of electromagnetic (radio) waves impact antenna design:

- The strength of the emitted wave, usually measured in watts or milliwatts
- The signal's frequency, measured in Hz, KHz, MHz, or GHz

Signal Strength or Power

You have probably heard radio stations advertise that their antenna tower puts out 100,000 watts, which would mean that the station has a very far-reaching signal in comparison to one that has only 10,000 watts of radiated power. Station signals can be weak or strong from any point on the planet. The further the receiving antenna is from the transmitting antenna, the weaker the signal. The signal's strength weakens with distance, much like sound or light does. FTA satellites orbit the Earth in sync with the rotation of the Earth at an altitude close to 22,236 miles above the equator. Unless the dish antenna is at the equator, the signal has to travel more than the 22,236 miles from the transponder to reach the receiving dish—that's a long way to go to reach the ground-based antenna from a satellite transponder. The output power from satellite transponders is low compared to Earth-bound transmitters, on the order of only 20 to 120 watts.

Frequency

To receive your favorite FM station, for example, you might have to tune in 98.1 MHz, the station's frequency. Frequencies are either high or low, relative to each other along the entire electromagnetic spectrum. When a transmitting station is broadcasting with a high frequency signal, the wavelength is short. Stated another way, with higher frequency signals, the next oscillation or cycle of the wave follows closely behind the previous one. This closeness of the succeeding waves is particularly acute from satellite transponders. In the Ku band, for example, the frequencies are in the 10 to 12.5 GHz range, so the wavelength is very short.

Wavelength

Radio waves and light waves travel at the same speed, regardless of their frequency: they travel at the speed of light. Light travels nearly 300,000,000 meters (186,000 miles) per second. Wave length is the distance the first wave travels before the next one starts its journey away from the transmitting antenna. The wavelength for an FM station at 98.1 MHz on an auto's radio dial is 3.058 meters (10.030 feet). An AM station at 920 KHz on the dial's wavelength is 326.08 meters (1069.56 feet), a much longer wavelength than the FM station. The wavelength for a satellite transponder on the Ku band transmitting at 12 GHz is very small, at 0.025 meters (0.984

inches—less than 1 inch). The formula to calculate wavelength when (f) frequency is known is to divide the 300,000,000 meters per second by the frequency in Hz as the denominator, and the quotient result is the (wl) wavelength in meters (300,000,000 m./f Hz = wl m).

Antenna Size

The ideal long-wire antenna length is one full wavelength. It would be impractical, if not impossible, to have the perfect length antenna for every frequency of the stations or channels to which we want to listen or watch. Even if a half-wave dipole antenna were used for each frequency, it would take a lot of space to have the antennas tuned to each frequency.

Because the satellite transponders are transmitting high frequencies at such great distances and with low wattages (power) in comparison to an Earth station's transmitters, it would be impossible with today's technology for a receiver to receive enough of the satellite signal with a 1-inch antenna. Power levels for transmitting stations are limited by regulation and, in the case of satellites, are also limited by the physics of the available power supply. So multiband (multifrequency) antennas of any sort are a compromise to begin with, because it is impossible to be changing the length or size of the antenna constantly to match the receiver's dialed-in frequency settings. Earth-bound transmitters are emitting strong enough signals to cope with the design limitations of the receiving antennas. Receiving satellite signals of sufficient strength on Earth is accomplished by the dish's unique design and by its size. In regard to satellite dishes, the cliché "bigger is better" isn't the case: the truism is "big enough is necessary." Trying to receive FTA signals from distant satellites with an 18-inch dish simply does not work out particularly well.

Gain

To receive ground-based OTA TV stations that are far away, or signals from satellites in orbit, antennas are designed to be very effective and are rated by the amount of *gain* (directional efficiency) relative to a theoretical *best* antenna—usually a half-wave dipole antenna. Gains, and losses, of signal strength are expressed in decibels. (For example, some of the received energy is lost traveling down the cable to the receiver.) Gain is expressed in positive numbers, and losses are expressed in negative numbers. Decibels are measured as a ratio exponential on a logarithmic function: $10 \times \log(\text{power out}/\text{power in})$.

TIP For readers who do not want to get wrapped up in the math, when you see a design characteristic expressed in dB, simply remember that it is not a linear function. For example, a 3 dB gain means that the signal is 2 times the reference signal's strength. Also keep in mind that measured or stated dB gains or losses, when used to describe an antenna's efficiency, are at a specific test frequency, and if the tuned-in frequency changes, so will the gain or loss ratio.

The Antenna's Work

Transmitting antennas, including transponders on satellites, push electromagnetic waves out and away through space and into the Earth's atmosphere. When the waves strike the receiving antenna dish on Earth, they are reflected to the low noise block (LNB). The energy in the captured waves induces a detectable and measurable electric current in the antenna's LNB that then travels down the cable to the receiver. This induced electric current collected by any antenna is in nearly exact proportion to the transmitted signal in regard to frequency, and with the embedded data it carries through frequency modulations or amplitude modulations. Of course, the signal that is received is much weaker than the signal transmitted, but it has to be strong enough for the receiver to amplify and decode into a video and an audio signal. The transmitted signals for audio and video television programming are said to be digital, meaning that the signal encoding are 1's and 0's, like a computer's internal workings or the data travelling over the Internet. OTA TV signals are also in digital format now in the United States and Canada, which makes high definition television (HDTV) broadcasts possible and practical.

Antenna Variations

To say there are more differences in antenna designs than one could imagine might be an understatement. Earlier in this chapter I mentioned long-wire antennas and the variation in length necessary to tune one to a given frequency. In every case when an antenna design element or characteristic is changed, there are solid engineering principles being applied giving rise to the variation. In the sections that follow, the text will discuss a few of the principles that give rise to the necessary variations in antenna design.

OTA TV Antennas

It is interesting to note the changes that would be necessary in antenna size to match the wavelengths of the various OTA channel frequencies. As stated earlier, antenna design involves compromises in the design. Antenna designers and manufacturers work hard to make antennas that will perform well over a wide range of channel frequencies. The sections that follow demonstrate the different lengths that would be used for a half-wavelength antenna element at example channel frequencies involving broadcast television.

VHF Antenna Element Size for Half-Wavelength at Midchannel Frequency

Notice how dramatically the wavelengths change as the channels change. See the table on page 50.

Legal Issues

In the United States, we all have a legal right to receive paid-for programming and no-fee FTA satellite signals, regardless of what a deed covenant, homeowners' association, or landlord might have you believe. Even if you are not a dyed-in-the-wool Federalist, sometimes it is helpful to point to federal laws and regulations when they help ordinary citizens achieve their goals or exercise basic rights. Should you find yourself living in areas of intense zoning, planned communities, or housing developments with deed covenants or restrictions, or in a neighborhoods with out-of-control homeowners' associations, you should know that the Federal Communications Commission (FCC) permits use of satellite dish antennas of 1 meter (39.37 inches) or less in diameter in the lower 49 and of any size in Alaska. The quote that follows is directly from the FCC fact sheet on the topic (www.fcc.gov/mb/facts/otard.html):

The rule (47 C.F.R. Section 1.4000) has been in effect since October 1996, and it prohibits restrictions that impair the installation, maintenance or use of antennas used to receive video programming. The rule applies to video antennas including direct-to-home satellite dishes that are less than one meter (39.37") in diameter (or of any size in Alaska), TV antennas, and wireless cable antennas. The rule prohibits most restrictions that: (1) unreasonably delay or prevent installation, maintenance or use; (2) unreasonably increase the cost of installation, maintenance or use; or (3) preclude reception of an acceptable quality signal.

This is not a *carte blanche* rule that allows a renter to destroy or modify rental properties or take over common areas, but it at least provides a beginning for negotiation with less-than-accommodating landlords and a regulation to show the homeowners' association boards if someone takes exception to a dish or other antenna installation.

A practical tip for dealing with no drilling situations is to use a special flattened cable designed to fit under a casement window, as shown in Figure 4-1. It is still necessary to provide a proper Earth/service ground connection for an antenna cable brought into a dwelling with this type of lead.



FIGURE 4-1 Flat cable for use under windows

Frequencies	Channel	Distance
054.000–060.00	Channel 02	8.6 feet (2.63 meters)
060.000–066.00	Channel 03	7.8 feet (2.38 meters)
066.000–072.00	Channel 04	7.1 feet (2.17 meters)
076.000–082.00	Channel 05	6.2 feet (1.89 meters)
082.000–088.00	Channel 06	5.7 feet (1.76 meters)
(Frequencies between 88 and 174 MHz are used by other services.)		
174.000–180.00	Channel 07	2.8 feet (0.85 meters)
180.000–186.00	Channel 08	2.7 feet (0.82 meters)
186.000–192.00	Channel 09	2.6 feet (0.79 meters)
192.000–198.00	Channel 10	2.5 feet (0.76 meters)
198.000–204.00	Channel 11	2.4 feet (0.74 meters)
204.000–210.00	Channel 12	2.3 feet (0.72 meters)
210.000–216.00	Channel 13	2.3 feet (0.70 meters)

UHF Antenna Element Size for Half-Wavelength at Midchannel Frequency

UHF is in the range of 470.000 to 512.00 MHz as the frequency band for broadcast TV channels 14–20, at 6 MHz increments for each channel. The element width for channel 16 at midrange would be 473 MHz, and the element width would be 12.5 inches (0.32 meter).

Now let's consider broadcast TV channels 21–69 in the assigned frequency range of 512.000 to 806.00 MHz. Picking just one channel, 68, near the end of this range would yield a midrange frequency of 797 MHz and a half-wavelength element of 7.4 inches (0.18 meter).

FM/AM Antenna

From these few examples, it is easy to see the great challenge involved in designing an antenna to work well over the vast differences in bandwidth. Improving radio broadcast reception over greater distances requires a receiver with a port for accepting an external antenna, and an outdoor antenna. If you live where outdoor antennas are not possible, you can consider one of the amplified indoor antennas instead.

Consider antennas that are easy to mount and install. A vertical whip antenna, amplified or unamplified, of at least 50 inches tall with a mounting bracket is a good starting point. Amplified version antennas require a power source. To make this type of antenna most effective and improve performance, mount it at least 25 feet above ground. Use a shielded down-lead and install a properly grounded lightning arrestor. Grounding wire is usually bare wire and should be a minimum of 6-gauge wire.

NOTE See Appendix A for some sources for broadcast radio antennas. For more current information and source links, you can also visit the author's website at www.allaboutfta.com.

Combined UHF/VHF

Several combined antennas on the market will perform reasonably well for receiving channels 2–69 for receivers located less than 30 miles away from the transmitting tower. Omni-directional antennas, double-bay bow-tie antennas, quad-bay bow-tie antennas, and even old-fashioned rabbit ear antennas can work if you are close enough to the OTA station towers. It is also possible to make your own quad-bay bow-tie antenna from a piece of wood, old metal coat hangers, some wire, and a 75–300 ohm matching transformer (a *balun*).

To receive OTA stations from distances of 30–65 miles will require multi-element antennas with high counts of both UHF and VHF elements included on the boom (horizontal center post). Some of the elements measured end to end will reach 110 inches. The boom will reach 130 inches and longer. Usually these larger antennas are mast mounted and are accompanied by a rotor motor on the mounting pipe so the antenna can be pointed at source stations by using a remote-control in the TV room. If you are far from the stations, you might need to use a large, highly engineered antenna which is expensive to set up.

Amplified Antennas

For OTA reception of local and near distant television channels, a wide-band amplifier can be incorporated into the antenna. Antennas attached on the top of RVs and travel trailers are amplified antennas, as shown in Figure 4-2. The RG6 cable leading up to this antenna carries 12 volts from the switch box, which is connected to the RV's 12-volt DC power source. The 12-volt DC current is used to power the wide frequency range amplifier built into the antenna head. These antennas are directional and can be rotated by hand from inside the vehicle. Winegard also manufactures versions of this antenna for installing in homes or apartments. The company also makes indoor amplified antennas to improve OTA digital TV reception, as well as many other antenna styles.

Best OTA Antenna Types

For good OTA reception for far-away stations across a wide range of channels, try an LPDA (log periodic dipole array) antenna, which can be straight or V-shaped. Another choice is a Yagi, which has a lower threshold for tolerating or providing gain across a wide range of frequencies. Choose a Yagi antenna for the highest frequency of the band you intend to view.

A bolt-on accessory to improve steadiness and clarity of HD reception for the antenna shown in Figure 4-2 is the reflector assembly shown in Figure 4-3 (before installation). The installation is simple: Four plastic screw-hole covers are removed from the bottom of the antenna. The assembly is installed pointing away from the post by lining up the holes on the assembly with the four holes and inserting the



FIGURE 4-2 Amplified OTA antenna on an RV

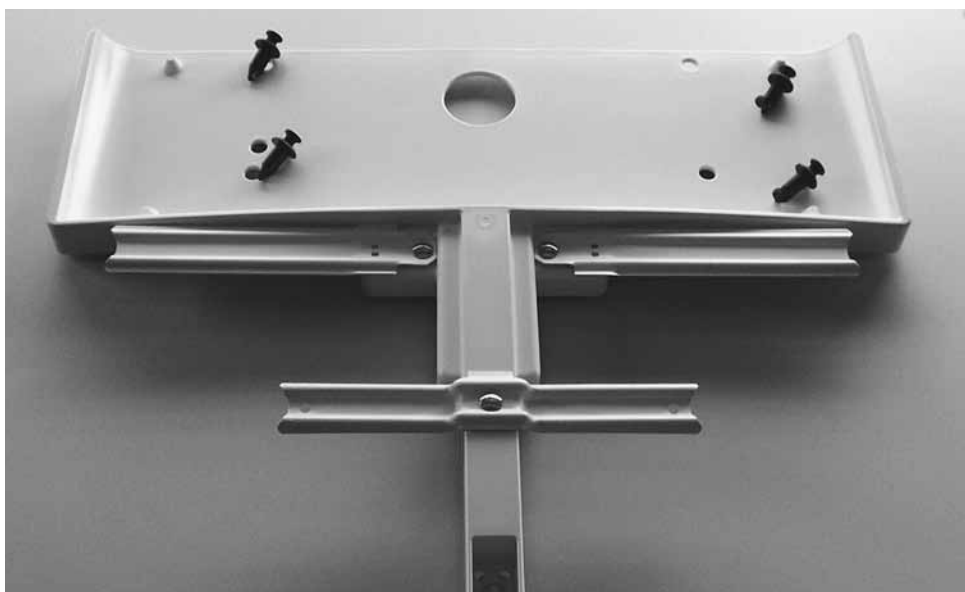


FIGURE 4-3 Reflector assembly improves digital/HD OTA reception.

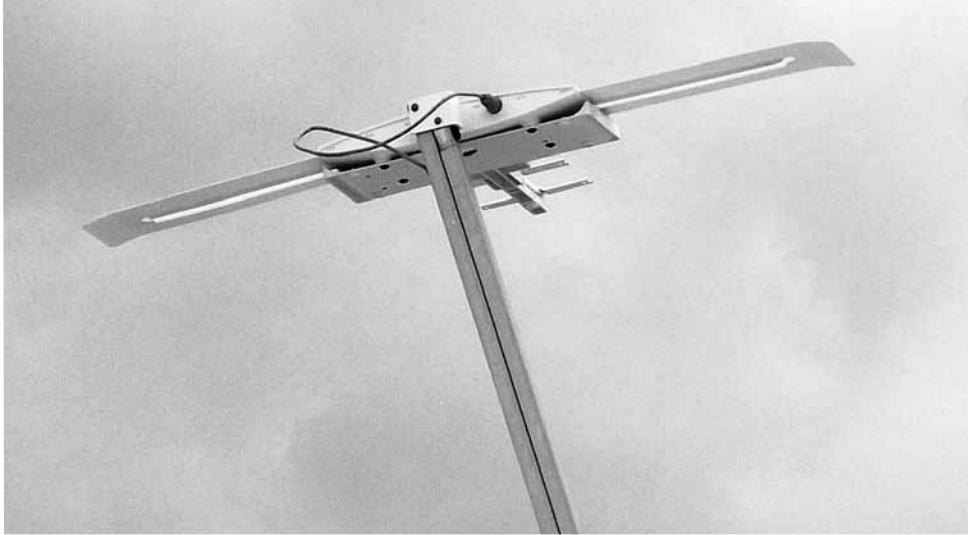


FIGURE 4-4 Antenna with reflector assembly installed

twist-on plastic screws supplied in the package. The final assembly in use is shown in Figure 4-4.

How Satellite Dish Antennas Work

I could go through all the theory and mathematics to explain why a parabolic shape is necessary to get a sufficient signal to the FTA receiver, or I could demonstrate with something much more familiar to everyone. I'll choose the latter.

Light waves are simply the not-so-distant cousins of radio waves, and the two behave in similar ways. To help you understand the principle of the benefits of a parabolic dish antenna, you can perform the following experiment:

Shine a flashlight at a mirror. If you hold the lit flashlight perpendicular to the mirror's flat surface, a zero degree angle, the light will be reflected back exactly to its source. The physics theory rule regarding reflected light says that the angle of reflection is equal to the angle of incidence. Test the rule by shining the flashlight at the mirror at a 45-degree angle (use your best judgment; no need to measure it). You will see that the light's reflection leaves the mirror at 45 degrees. Move the flashlight through an arc of 180 degrees and watch the angle of the reflected light change as you move the source. You can see the light reflected to opposite walls as you move through a full arc.

The radio (electromagnetic) waves from the satellite's transponder signal behave in a similar fashion when they strike the curved surface of the dish antenna. The radio waves approaching the dish are basically parallel to the dish and to each other, because of the huge distance they've traveled from the source. So the dish

surface is hit by this energy field over its entire surface. Because of the curved shape, any energy hitting the surface of the dish is reflected to the same point above the dish's frontal surface. This point, when measured from the center of the dish, is called the *focal point*.

Regardless of where the electromagnetic field energy from a single wave originally strikes the dish surface, it is reflected and strikes the focal point at the same time. This happens because the total distance the reflected energy of that wave of energy traveled to get to the focal point is equal to the distance all of the other energy in that wave striking on the parabola traveled to get to the focal point. This is an important factor, because the wave's energy arrives at the collecting LNB in-phase, converging and creating a stronger signal. The phenomenon happens over and over again as each successive wave strikes the dish. This partially makes up for the energy lost over such great distances. The amount of gain for a given dish is a ratio of the energy received in relation to some point of reference and is expressed in decibels (dB).

Another use of a parabola shape is for audio listening devices, and it works in basically the same way. The sound strikes the surface, and the reflected sound waves are focused on the microphone located at the focal point. You might have seen parabolic listening devices advertised in comic books or in magazine classifieds. They collect so much sound energy traveling through the air because of their large size, and they focus that energy on a microphone mounted at the focal point of the parabola. Ever cup your hand behind your ear to hear better? You were using the same principle that makes a parabolic dish function, albeit in a more primitive way. So it is safe to say that the early application of the parabola shape is as old as mankind.

The larger the dish antenna (with a favorable geometry), the more wave energy will strike the dish surface and reflect back to the LNB mounted at the focal point, yielding a stronger signal to send down to the FTA receiver. Because of the dish's unique geometry, the collected electromagnetic wave energy reflected and received at the LNB from the dish's surface is in-phase regardless of where the energy in the wave strikes the dish's surface. This compounding of the energy in sync at the LNB creates enough of a voltage change to send energy down the cable to meet the receiver's need for processing the signal. There would simply not be enough energy to run the receiver from a 1-inch element, for example.

Types of Satellite Dish Antennas

Some variations occur in the design of satellite dishes and how they are implemented. In the next sections the text will discuss some of those variables relevant to FTA dishes.

Stationary Dish

A single stationary dish with one LNB can point at only one satellite to receive its signals.

Ganged Dishes

Two or more dishes can be separately aimed at separate satellites and the 4-to-1 switch can be used to select a particular dish as the channel is changed on the FTA receiver. These switches which allow the connection of one receiver to more than one LNB or dish are discussed in more detail in Chapter 8.

Motorized Dish

A single dish can be mounted on a pipe mast with a motor responding to a Universal Satellites Automatic Location System (USALS) command from the receiver, and the motor can rotate the dish to the correct satellite for that channel. The motor simply rotates the dish across an arc proportional to the Earth's horizon, allowing the dish to "see" all of the satellites on the horizon not blocked by a barrier or by the curvature of the Earth.

Portable Dish

Small, portable satellite dishes less than 30 inches (75 cm) in size are usually used with the pay-for-services satellite programming providers. A 30-inch dish mounted on a tripod is the smallest practical dish for an FTA portable.

Toroidal Satellite Dish

A toroidal dish is a unique design that uses two reflectors and multiple LNBS to acquire signals from multiple satellites across a 40-degree arc and a 60-degree azimuth change. Up to 16 LNBS can be installed on a 35-inch (90 cm) toroidal dish.

Automatic (Mobile) in Motion

In-motion antennas are motorized and will lock on to a satellite and maintain direction to that satellite as the vehicle moves down the road. These units work only with the pay-for-TV satellite providers.

Multiple LNB Dish

A dish with multiple LNBS mounted on the focal arm collects signals from satellites that are separated by only a few degrees. The parabola shape works with an offset angle to the original satellite and focuses the energy received from the second satellite to a new focal point, where a second or third LNB is mounted. Spacing of the target satellites and the extra LNBS cannot be much closer than 4 or 5 degrees.

You need to be aware of two tricks of the trade if you plan to experiment with multiple LNBS on the same dish:

- Set up the weakest satellite signal as the center one using the designed focal point of the dish. Place any secondary pickups to one or both sides of the center.

- Use two dishes with separations that skip what the first one is aimed at, maintaining a 4 degree or greater separation. The satellite signals that are closer than 4 or 5 degrees are set up to be received on the alternate dish.

It can be fun to experiment with how many LNBs can be received from only one or two dishes. Depending on your geographic location, the signal quality can be sufficient using this technique. At some point, though, the time and budget economics of a motor-driven dish prevail. Trying to receive from many satellites might be more fun than, say, bowling! For sure, it's more fun than shuffleboard.

Dish Assembly

The prototype selected for this section is a Pansat 90 cm (on the horizontal, as shown in Figure 4-5) dish. This dish will work well for receiving satellite signals during heavy cloud cover and can pick up some satellites that place a receiving location in the fringe areas of having only marginally sufficient EIRP (effective isotropic radiated power). Figure 4-6 shows the vertical axis measurement. For receiving FTA signals in the United States (lower 48), a 75 cm dish is considered sufficient by most vendors.

For FTA Ku band, you might choose a 75 cm, 90 cm, or 1.2 meter dish, depending on your available space, interests, or needs. In the Ku band, an efficient LNB on a 75 cm dish will receive signals that have an EIRP as low as 47 dBW. A 90 cm will push that number down to 44 dBW, and a 1.2 meter will receive signals as low as



FIGURE 4-5 Horizontal axis measurement on 90 cm dish in inches

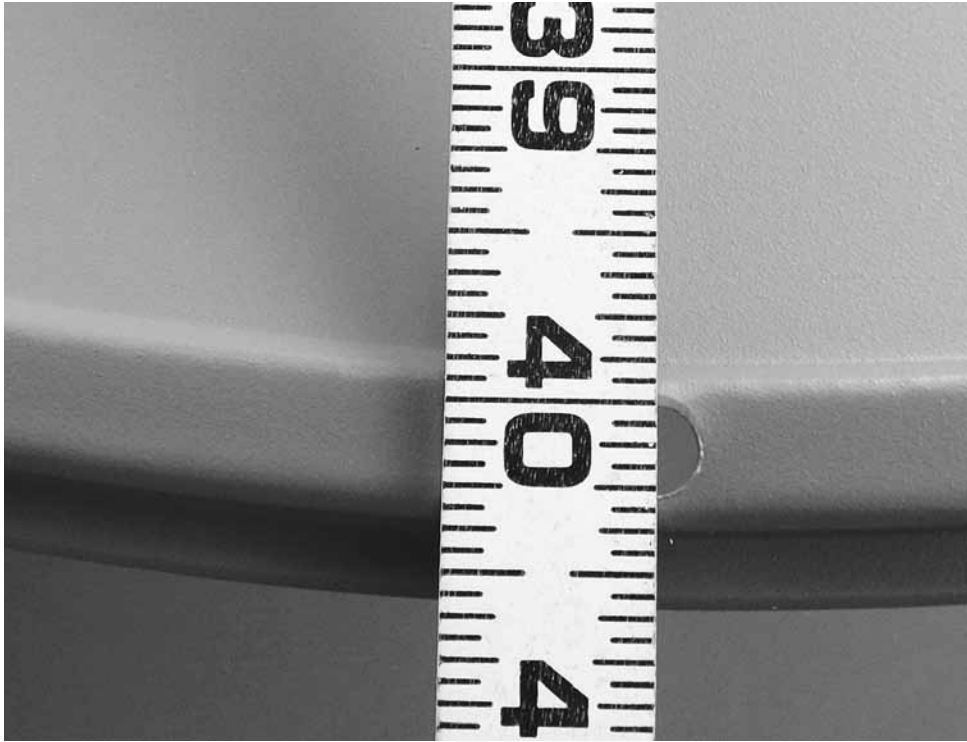


FIGURE 4-6 Vertical axis measurement on 90 cm dish in inches

41 dBW. Looking at the satellite footprint maps for the signals you want to receive, your geographic location will yield the EIRP number. Use the EIRP to help you select a dish, or simply buy the biggest dish you can accommodate.

You don't need to know everything about a car to drive it, and you don't need to know everything there is to know about satellite dish antenna theory to assemble and use one to pick up FTA satellite programming. Between this chapter and the one-page assembly guide that might be included with your dish antenna, you should be able to assemble a dish in a few hours—or take a few days if you like or need to. The dish you acquire might be different from the one covered in this chapter, but very similar steps will be needed to assemble and mount it. Solicit some help if necessary to mount the dish and get ready to enjoy some free TV programming.

NOTE *One of the best pieces of advice I ever received was from an art instructor in a college art class in mixed flat media. I needed to cut along a line with scissors, and I found it difficult to cut exactly on the line. She told me to “look where you are going, not where you have been.” This advice applied to art, and it has applied to just about every other undertaking in my life. Cutting along a line or reaching a major goal became a lot easier from then on. So now it's my turn to advise the reader. When you are following step-by-step instruc-*

tions, after the first step, always read them in groups of three. Read the step you just performed, the step you are going to do now, and the one you will do next. As you work through this dish assembly project, keep the mental spotlight on the moving three instructions sets and the assembly will go much better. It takes more time to check the previous steps as you go, but so does going many steps back to correct mistakes.

Tools

You'll need the following tools to assemble this dish:

- Flat-blade long shank screwdriver
- 10 mm open end/box-end wrench
- 7/16-inch open end/box-end wrench
- Phillips #2 screwdriver
- Electric drill motor
- 13/64-inch drill bit
- Pencil
- Ruler
- Level

The dish arrives in a large cardboard carton, and the adventure begins.



Assembly of Dish, Feedhorn (LNB), and Adjustment Flange

1. Remove the outer carton by cutting the flaps on one end and lifting the opposite end to reveal the components. This side is up:



2. Retrieve the LNB feedhorn box and set it aside in a safe place. The LNB is the most fragile of the parts needed for the dish antenna. It will be installed toward the end of the assembly.



3. Break out all the pieces and parts, lay them out, and match them to the bill of materials included in the box. It would be unusual to be missing a part, but it can happen. At this point, leave the hardware, nuts, machine screws, and washers in their respective bags. Do not open the bags until it's time to use the hardware.

The large curved pipe is the mounting mast. The larger diameter braces will help hold the mounting mast in a vertical orientation. The braces connect to the toothed circular clamp and to the mounting surface for the dish. The L-shaped brace will hold the LNB, and the two narrow diameter braces will help steady the LNB's L-brace. The longer of the two 90-degree offset flanges connects the dish to the mounting mast, commonly called the "butterfly." This larger flange will provide the ability to adjust the dish for elevation. The smaller flange connects to the bottom of the mast and to the mounting surface for the dish, such as the porch roof or pole.



4. The actual assembly could begin at any number of points. For the first-time assembler, it is easier to start by attaching the butterfly to the back of the dish. At this point, open the bag and look for two bags of hardware and the mast pipe clamp. One bag contains mostly machine screws, hex nuts, and washers for dish assembly, and the other includes six large lag screws for attaching the smaller flange to the house or pole.



5. Empty the dish hardware bag to separate and lay out the hardware pieces, matching like items to like items. Notice the machine screws are of a par-



ticular type, with a square neck above the thread and in front of the rounded head. These are called *carriage bolts*. If you examine the clamp, the dish itself, and the flanges, you will notice many square holes punched into the metal. The square neck on the carriage bolts fits in the square holes and allows tightening of the carriage bolt with a wrench at the nut end only. The rounded heads of the carriage bolts are smooth and present a low profile where clearances are an issue. Two of the bolts are carriage bolts with completely flat heads and are used under the butterfly to attach the L-brace.

Notice the four square holes near the center of the dish. These holes are for mounting the butterfly flange on the back of the dish, using four each of the shorter carriage bolts, serrated flange nuts, and flat washers. For reference, the top of the dish has the manufacturer's name on it.



6. Take a close look at the butterfly flange and the pipe clamp. The clamp is reversible so that the orientation of the face of the dish can be adjusted for vertical angle. Sides A (square hole A to round hole A) together will allow dish angles from the teens and up to and into the 60-degree range.



Flipping the orientation of the butterfly flange and the pipe clamp to sides B permits dish orientations to the vertical from 50 to 90 degrees. At this point, you need to know what orientations for vertical alignment will be necessary from your location on the planet. As a general rule, the closer you



are to the equator and the closer you are in latitude to the satellite you want to receive from, the more likely it will be necessary for orientations above 60 degrees. For example, to view programming from Horizons 2 at 74.0 degrees West from Bogota, Columbia, the dish elevation will be 84.6 degrees. Locations such as Miami and Key West, Florida, and Brownsville, Texas, will reach above 60-degree orientations for some satellites. Most places in the lower 48 will have dish elevation orientations below 60 degrees.

7. Slip the pipe clamp in between the flanges of the butterfly flange, making sure that the correct holes are lined up for the range of elevations needed. Because this assembly is for locations north of the equator, check to make sure that the long machine screw will be placed in square hole A on the butterfly flange and then through round hole A on the pipe clamp. This way, the finished assembly will work for adjusting the dish's elevations from in the teens of degrees through and into the 60s of degrees.



8. Insert the long carriage bolt through the square hole labeled A on the butterfly flange and through the round hole A on the pipe clamp. When you are finished, it will look like this:



On the other side is a flanged nut and washer. Do not put washers on the bolt head side when using carriage bolts. When you are assembling metal parts, do not tighten the nuts and bolts beyond “finger loose” until all the pieces are together.

NOTE *By “finger loose,” I mean turn the nuts down just until you feel the resistance of the metal, and then stop turning. “Finger tight” is a finished condition, where you torque a nut, such as a wing nut, as tight as you can by using only fingers/hands. Rotate nuts right for tight and left for loose.*

TIP *You can upgrade the elevation adjusting part of the butterfly flange using wing nuts with the three carriage bolts used to clamp down the elevation setting. If you decide to do that on this unit, remember the threads are metric sizes. Using wing nuts makes frequent elevation adjustments easier.*

9. The pipe clamp at this point in the assembly should swing freely inside the flange. Three carriage bolts will secure the elevation setting on the finished dish assembly. With the long bolt in place, swing the pipe clamp into the flanges until the arced slot of the flange aligns with one set of the square holes in the pipe clamp, one on each side.
10. From the inside of the clamp, insert one of the small carriage bolts through the clamp’s square hole into the arced flange slot, placing a flat washer and serrated flange nut on the bolt and tightening slightly. The illustration shows the second carriage bolt ready to be inserted on the opposite side.



11. Place the butterfly flange with the pipe clamp attached to it on the back face (convex surface) of the dish near the four square holes. Notice that an arrow is cut into one wing of the butterfly flange. This arrow must point to the top of the dish. Because the holes are offset, to install the dish correctly, the arrow must be pointing toward the top. Look at the other side of the dish



and read the manufacturer's label information, if necessary, to determine where the top of this dish is. At this point, it's nice to have a workbench or table, long arms, or a helper to put the first short carriage bolt into the upper-right square hole from the concave side of the dish. After that is done, place a flat washer and flange nut very loosely on the bolt, with perhaps one revolution of the nut—just enough so the butterfly flange will stay connected to the back of the dish. Final tightening will be done after all assembly steps are completed.

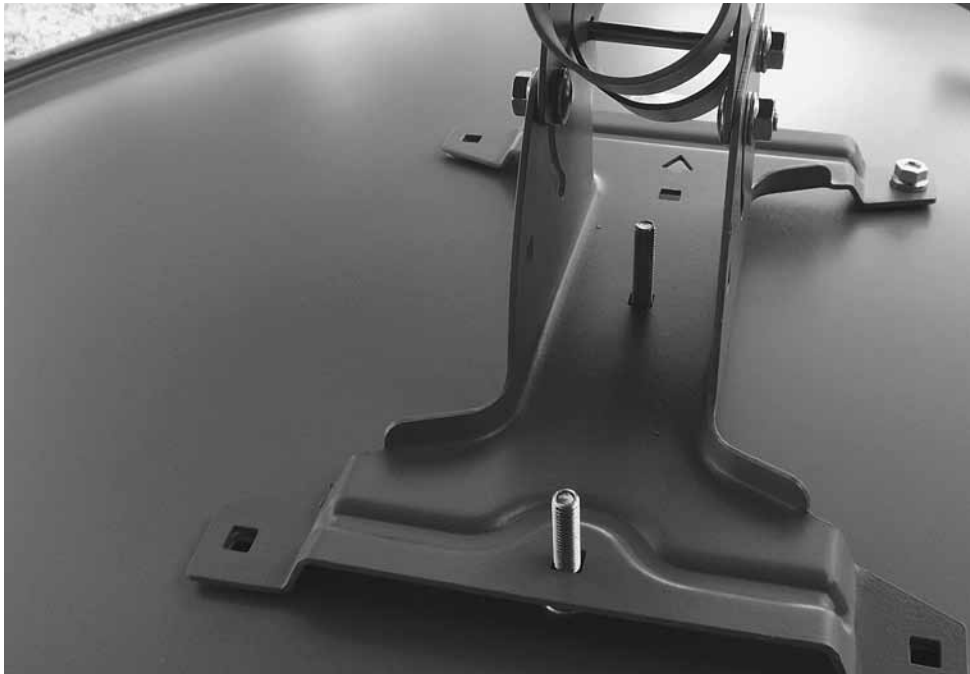
Viewing from the right side, notice the one nut in the upper-right holes of the dish and butterfly flange. Notice that the arrow is pointing to the top of the dish. Many parts of this assembly can be done in a sequence different than the instructions here. This next step, however, must occur before any more of the butterfly connector bolts are installed.



12. Find the two carriage bolts whose heads are different from all of the others. They have flat heads rather than rounded, because of the low clearance between the butterfly clamp and the back of the dish. Using the wrong bolt could damage the surface of the dish and change its electrical reflective properties. Lift the butterfly flange away from the surface of the dish and install one flat-head bolt up through the square hole in the bottom of the flange.



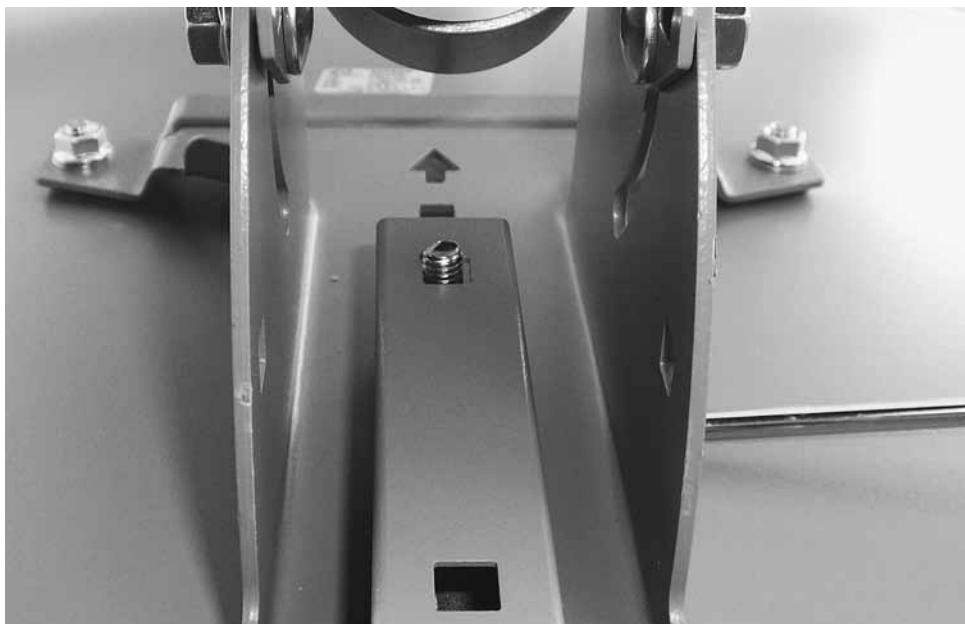
13. While holding the flat-head carriage bolt in the butterfly flange, lift the flange away from the dish surface again and insert the second flat-head bolt in the center (the next available) square hole, leaving the top one empty. Then return the flange to the surface of the dish, lining up the remaining three mounting holes so the dish can be securely mounted to the butterfly flange with short carriage bolts. Check to make sure everything is lined up, as shown in the next illustration.



14. Insert the remaining three short carriage bolts, one at a time, through from the front of the dish into the butterfly flange, and place the flat washers and flange nuts on each one as it is inserted. Loosely tighten the nuts on all four bolts. Check the front to be sure the square shoulders of the bolts are through the square holes in the front of the dish and that the bolt heads are flush with the inner surface of the dish.
15. The L-shaped brace for the LNB is the next piece to install. Place the bottom of the dish over the edge of a table or workbench to make this step easier if it is not there already. This step will require use of a long-shanked flat blade screwdriver. Insert the screwdriver under the flat-head carriage bolt to push it up, and then place the L-shaped brace over the bolt to line up with the third hole from the top of the L-brace. Place a flat washer and flange nut on the bolt and tighten loosely. At this point, the foot of the L extends out and under to the front side of the dish to suspend the LNB at the focal point of the dish.



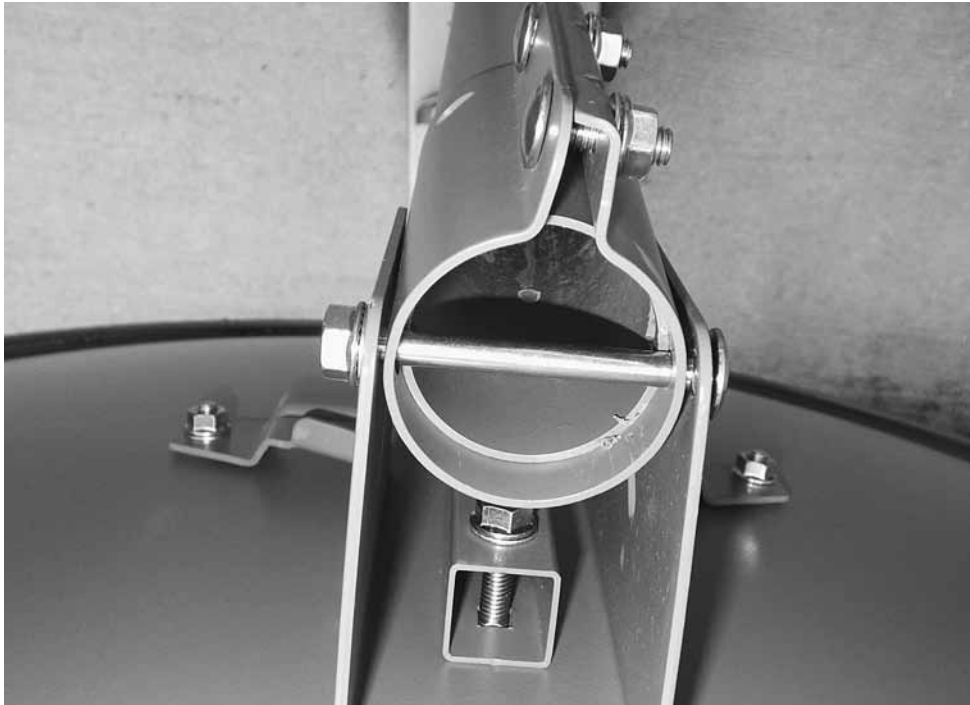
16. The second flat-head bolt should already be lined up into the top hole of the L-brace. Place the screwdriver under the second flat-head bolt and attach the washer and loosely tighten the flange nut.



17. Install two more each—carriage bolts, washers, and flange nuts—on the pipe clamp for the eventual insertion of the mounting mast pipe.



18. Carefully position the mounting mast to be inserted into the pipe clamp. The mast mounting pipe has a bend at the bottom for the style of installation in these instructions. Insert the long end after the bend into the pipe clamp on the butterfly assembly. The top of the mast pipe should be just under the long bolt passing through the clamp when the pipe is inserted, as shown in the next illustration.

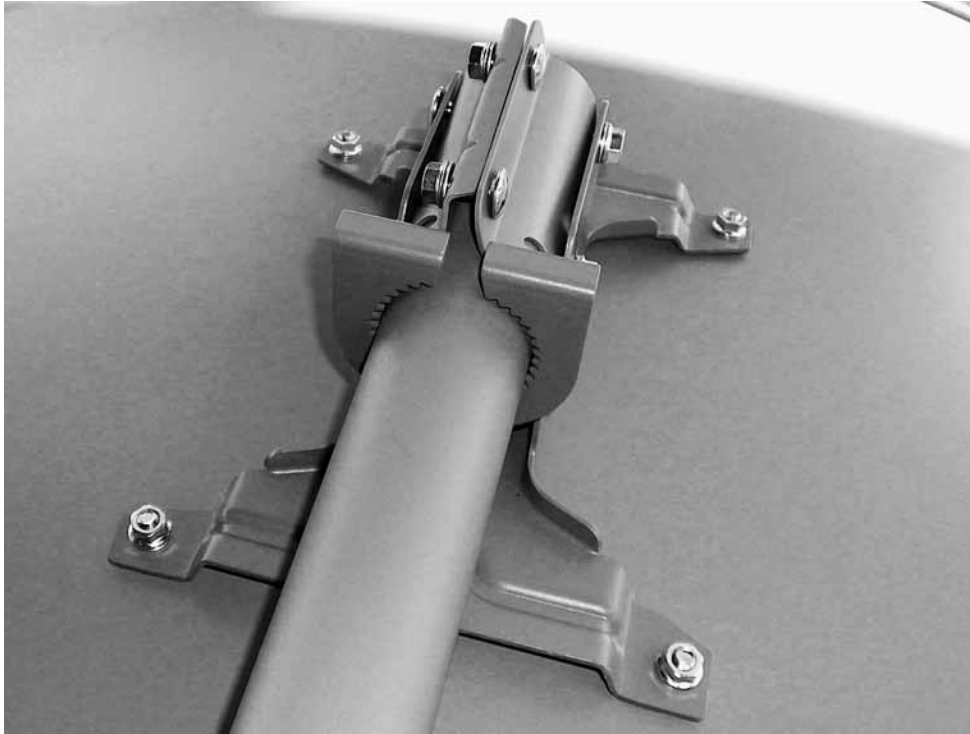


19. Go back to the breakout illustration for step three and notice the mounting mast pipe has the same holes drilled and punched in each end. The reason for this is that on some final installations, the pipe will be reversed end-for-end using the longer throw of the pipe to reach under a roof eave, for example. Assembly instructions here are based on ground mounting on a flat surface. Having the through-bolt (fulcrum bolt) ride on the top of the pipe is necessary for adjusting the direction later as far as the satellite look azimuth is concerned. This allows the dish to be rotated manually through azimuth adjustments of some number less than 360 degrees on the mounting post, depending on the full geometry of the installation. The two pipe clamp bolts are more than capable of holding the dish to a correct azimuth when fully tightened after final azimuth adjustment. The down-lead cable and the LNB arm clearance and dish clearance are the delimiters for full rotations. This would not matter so much for mounting in portable mode where the dish

(tripod or other mounting hardware) can be rotated for dish azimuth adjustments. In that case, it would be OK, but not necessary, to remove the bolt and insert it into the top hole in the pipe for added stability.

The second alternative at this point is to install an automated positioning motor. Install the positioning motor according to the manufacturer's instructions between the mounting pipe mast and the dish. Many variations are possible, so follow the manufacturer's instructions. The motor must mount to a correct mast pipe size.

20. From the bottom of the mast pipe, slip the toothed clamp over the pipe and slide it up to the bottom of the pipe clamp. It will need to be in place for connection later. Consider putting a piece of masking tape or transparent tape temporarily on the clamp so it won't slip off.



21. At this point, the focus of the assembly will move to setting the braces in place to mount the LNB L-brace and holder securely. Carefully flip over the disk assembly so it is resting on the back of the dish with the mast pipe on the work surface or bench. Find the LNB brace with the letter *R* stamped near one end. Use the standard machine bolt, ordinary hex nut, and flat washer to connect the brace to the raised rim of the dish.

As for the dish being right or left, think like port or starboard on a ship, which never changes. With the dish pointing at the sky, and you behind the dish, the right side of the dish is on your right. If you move to the front of the dish, facing the dish the right side of the dish is still the same. Bends in the ends of the brackets will work only if the R-stamped end is installed on the right side of the dish and the L-stamped brace is installed on the raised rim on the left side of the dish.

22. After the round hole near the R is lined up with the hole on the raised rim of the dish, insert the bolt with the flat washer from the front going through the brace and then into the round hole in the dish. Place the nut on from under the dish. Do not use a washer under the nut. The raised rim of the dish will mesh against two flats of the hex nut and keep it firmly in place. The flanged bolt will be tightened later with a Phillips screwdriver. So for now, tighten just enough to get the nut to slip into the underside of the raised rim and for the brace to stand up at its designed angle to mate up with the LNB plastic bracket.



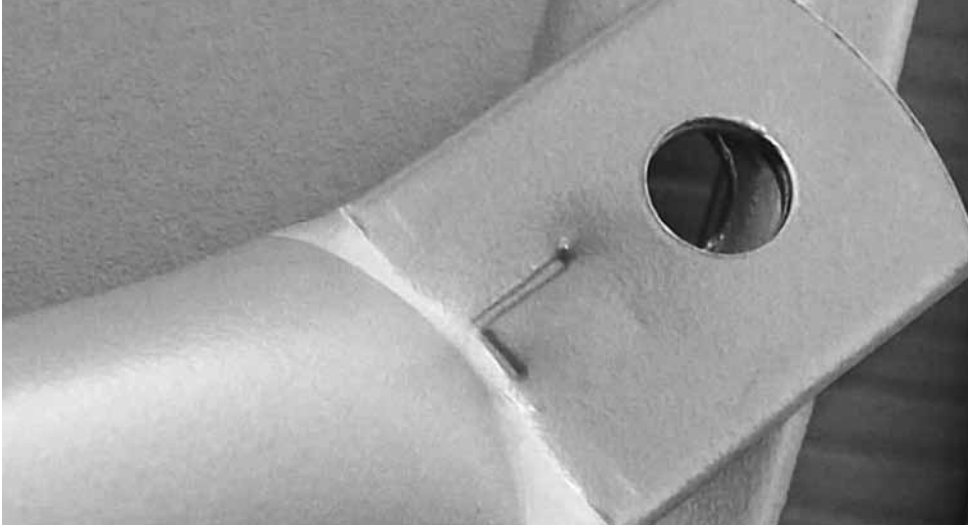
The attachment of the first LNB brace is a good point to go and find the LNB and the LNB mounting bracket. With the first brace attached, the assembly should look like the illustration on the next page.



23. Pass the medium-length hex head bolt with flat washer attached through the bracket, the hole in the plastic LNB bracket, and into and through the L-brace. Notice a hook and eye at the top of the LNB bracket and an alignment pin just below the semicircle.



24. Install the second brace that will help support the LNB. It will be marked with an *L* for the left side of the dish. Insert the bolt with the flat washer from the front going through the brace and then into the round hole in the dish. Place the nut on from under-side of the dish again without a washer.



25. Now install the LNB into the two halves of the plastic bracket and secure the brace.



26. Place the opposite half of the plastic LNB bracket around the LNB, and then clip the hook and eye into each other. Swing the right half into place to line up the alignment pin in the hole for it on the opposite bracket. The LNB is installed with the round microphone-like end pointing at the dish.
27. Place the square notch in the LNB bracket against the top of the L-brace so that the bolt can continue through from the left side bracket half, through the L-brace, and through the right side bracket half. The LNB should be relatively loose inside of the bracket and should rotate freely.



NOTE *This assembly step is a bit tricky and requires that you use both hands, as six parts are involved in a process that brings them all together. It's a bit tricky at times to get all these pieces to come together. Be assured they will come together and without forcing anything. Be particularly careful not to damage the plastic bracket or the LNB. It's OK to remove the left bracket momentarily and practice this assembly away from the L-brace before trying to pull all the pieces together.*

With the LNB swung to one side, look between the halves of the plastic bracket to make sure that the alignment pin is lined up and in the hole in the opposite bracket.



28. The final step for LNB mounting is to install the Phillips-head screw that will be used to lock the LNB firmly in place. Notice that the screw hole is just below the circular halves of the bracket.



NOTE *After lining up with a satellite later, some adjustment of the LNB might be necessary. Chapter 7 discusses dish alignments and fine tuning.*

Notice the label on the bottom of the LNB. It shows the technical data about the LNB frequency domains. The label says “twin” LNB, which means it has outputs for connecting cables to two receivers.



Mounting the Flange, Toothed Clamp, and Braces

Now we'll assemble the mounting flange, the toothed clamp, and the mounting braces. This universal mounting bracket and hardware provides a plethora of options for securing the dish to a permanent or semi-permanent mounting place. Mounting to concrete, the solid wood of a structure, a concrete block foundation of a building, on a pole or post, or on a sturdy fence are all possibilities. Select a sturdy option for mounting, because the dish acts as a sail in the wind and might have to withstand wind velocities in excess of 100 mph (160 kph).

1. Open the second hardware bag and lay out the remaining parts, as shown in the next illustration.



2. Attach the left side brace to the toothed clamp by inserting the long-shanked machine screw through the left brace into the toothed clamp.



3. Attach the right side brace and place a flat washer and flange nut on the bolt. Tighten loosely. Again it is best to wait until all the assembly is complete before totally tightening all the pieces together.



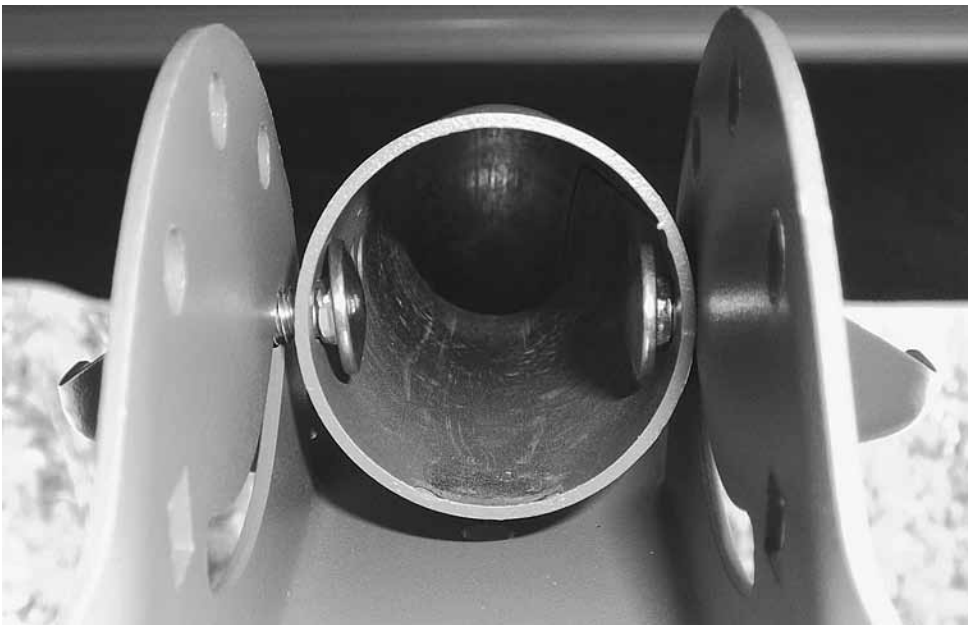
4. Now you'll hang the mounting flange on the bottom of the pipe. Place one of the small carriage bolts through the square holes in the bottom of the pipe from the inside of the pipe.



The carriage bolt will slip through the arc slot in the mounting flange, as shown in the next illustration.



5. Place the second carriage bolt from the inside of the pipe through the arc slot on the other side of the mounting clamp.



6. At this point, the mounting flange will just hang on the pipe so that the flanged nuts can be installed. No washers are necessary, and again tighten just slightly.



7. The bracket is a universal bracket with plenty of angle swing and extra holes, allowing for mounting in any number of orientations from its mooring place. For now, assume this will be mounted in a vertical orientation of the mounting mast, so we will use the center hole as the fulcrum point.



Swing the mounting flange up so that the center hole in the flange lines up with a hole in the mounting pipe when the flange's foot is perpendicular to the pipe. Use the hex-head fully threaded bolt, the smaller of the two from the package, with a flanged nut. No washer is needed on either side. When the dish and flange are permanently mounted for use, this bolt will be torqued very tight and the serrations on the flanged nut should maintain the friction connection. The braces will add extra stability.



Notice twelve holes on the bottom (foot) of the mounting flange that are used for permanent mounting. At a minimum, use the four corner holes for securing to the mounting surface. Two holes are square and provide an opportunity to place a flat-head carriage bolt pointing up for securing something to the flange without your having to fit a wrench underneath the flange. For example, this could be used to secure a guy wire for an overhead cable run or be used during the final mounting steps to secure the down-lead cable with a clamp. Square holes are repeated on the side of the flange for the same reasons.



The next illustration shows the mounting flange installed perpendicular to the mounting mast pipe. The two other holes are for mounting the pipe at offset angles to accommodate a variety of angled mounting surfaces.



Of the supplied hardware, all that should be remaining are six lag screws and corresponding concrete anchors.



If the flange will be mounted in concrete, the plastic anchors will be pressed into drilled holes to receive the lag screws. The plastic anchors expand when the lag screws are tightened, causing the plastic anchors to grip the walls of the pre-drilled holes. Drill anchor holes in concrete the same size as the anchor's diameter, or follow the recommendations of the anchor manufacturer when buying additional mounting hardware.

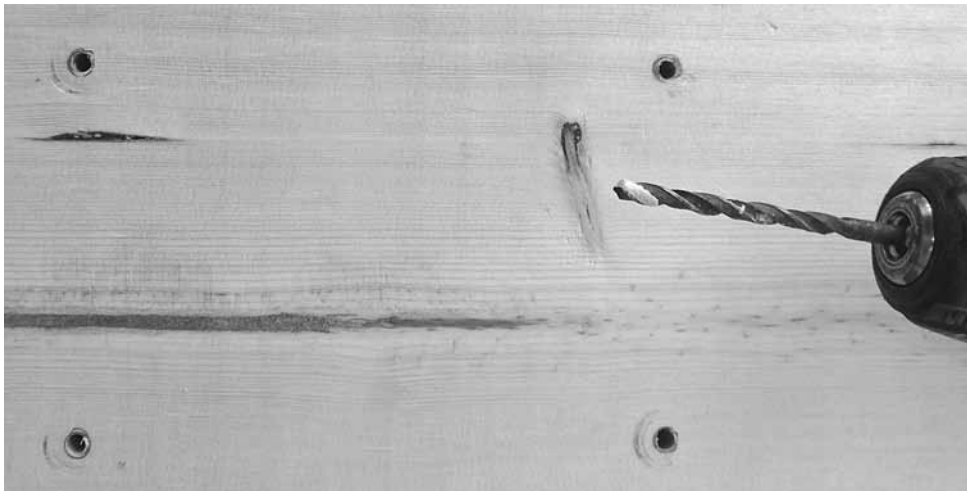
If you are mounting in solid wood, the plastic anchors are not used and the lag screws are set in directly and tightened in smaller pilot holes. The rule of thumb I follow for wood pilot holes is to drill a pilot hole no bigger than three-fourths the size of the diameter of the screw in hardwoods (prone to cracking) and no smaller than five-eighths the diameter in soft woods. As for drill depth, I drill the pilot hole to three-fourths of the length of the bolt and at least $\frac{1}{2}$ inch less than the length of the screw. Look at the recommendations of the screw manufacturer for specifics; they are often included on the packaging from the hardware store.

NOTE *The worst case scenario is that the lag screw snaps in two during final torqueing and you have to start all over. Also, if the pilot holes are drilled too big, the dish can blow away in the wind. Take care to provide a sound and secure mounting for the dish.*

In the next sections, the mounting mast pipe and braces will be placed on a temporary stand to illustrate steps needed for mounting the dish on a horizontal surface.

NOTE *I am a big advocate of using ground-mounting opportunities whenever possible. I use an existing in-ground concrete surface, a basement wall, or a sturdy fence, or I sink a short pole in the ground or pour a 3-by-3 foot or 4-by-4 foot pad—anything that keeps me off of a ladder. The added advantage is that a little readjustment later is easier, because you can walk to the dish, and you don't need a ladder. Ground mounting, or near ground mounting is not possible without a clear unobstructed view of the sky and not advised in areas prone to vandalism. Survey your site to determine what view of the southern sky (or northern sky if in the Southern Hemisphere) will be best in your unique circumstances.*

1. Trace the flange with a pencil to identify the four corners for mounting holes. Alternatively, you can make a cardboard cutout, marking the holes if the installation is above ground level. To make a cutout, tape the cardboard to the flange. Trace the holes with a pencil from the flange to the cardboard. Drill out or cut out the holes in the cardboard. Mark the holes at the mounting point's surface using the flange itself or the cardboard cutout. Then drill out the pilot holes. I had to find shorter lag screws to for my temporary mounting in a 2-by-6.



2. After the holes are drilled, secure the mounting flange. Start all of the lag screws into the holes before tightening any one of them completely. Bring all the screws snug, and then tighten all of them in an X pattern and repeat once, being careful not to over-tighten them.



3. The mounting flange by itself is not enough to hold the dish in place, so anchor the braces in a similar manner.



4. With the braces fastened to a second piece of 2-by-6, orient the mounting mast pipe relative to the ground as close as possible to 90 degrees. For this, use an assistant and a small level to check the vertical position of the pipe.



5. With the pipe at level and a helper holding it in place, drill an anchor for the braces to maintain the relationship at 90 degrees.



NOTE *This will be slightly different if you are mounting to a wall, for example. The braces can be placed against the wall surface. It is best to mount the braces directly into one of the wall's uprights, so use a stud finder to find the stud and long enough lag bolts to reach it. It can be a good idea to securely install a nailer board to the wall and attach the braces to that. Use lag bolts to secure the nailer board in the building's vertical studs. Nails simply will not hold a dish subjected to strong winds for very long, if at all.*

CAUTION *If bolting to a wall surface, be very careful to avoid electrical wires.*

Pole or Wall Mount

You could easily imagine this as a pole mount or wall mount instead. The process is the same. First secure the bracket to the pole, and then add the mounting braces. You don't need to bring the whole assembly up a pole or ladder, and that's not the way to do high mountings. Its weight is too much to handle and wind is not your friend when doing a job like this.

After you set up the assembly for mounting and know what pieces will go where, then remove the mounting bracket, take that up the ladder, and securely mount the bracket to its permanent location first. Then get help and two ladders to bring up the dish to finish the assembly.

You can also mount the mast pipe alone and braces next, and then bring the dish to place on the fully mounted flange, mounting mast, and braces you have already assembled. If working alone and without a bucket truck, this latter method would be preferred. Remember, safety first and use all necessary safety equipment. Use good old common sense in your approach and maintain safety at all times.

TIP *When doing this for the first time, assemble the entire dish assembly first. Then disassemble it into smaller manageable parts for mounting as previously mentioned. If you do more than one dish installation, you can develop your own procedures to get the job done efficiently as you gain experience.*

6. With the dish fully assembled on a perfectly vertical mounting pipe and mounted in its final location, you can completely tighten every nut, bolt, and screw except for the three that set the elevation and the two that will finalize the azimuth setting beginning with the butterfly flange.



Are we there yet? Well almost! There will be more on the alignment topic in Chapter 7. There are just a few remaining tasks.

7. Use the compass to align the azimuth and look angle (elevation) for the particular satellite in which you're interested. After that is done, and the two pipe clamp bolts are fully tightened, you can set the elevation for that satellite. The lead edge of the pipe clamp that can be seen through the arc



- slot with the degrees marked sets is the angle pointer. It's not a bad idea to brush a drop of paint on the leading edge to help identify it. In the previous illustration, you can see that the elevation is 42 degrees. (If you purchase a motor to direct the azimuth and look angle, you will not be doing this step.)
8. Tighten all three serrated flange nuts to maintain the elevation setting. Do a final check and tighten all of the nuts, bolts, and mounting screws over the entire assembly.



9. The LNB distance to the nearest surface of the front of the dish is somewhat adjustable from front to back inside the plastic mounting bracket. It might need some tweaking from front to back later to improve reception. For now, align it so that it is equidistant, centered on the adjustment area, and completely vertical with the wire connection at the bottom, and snug up the Phillips-head screw going through the clamp just tight enough so it cannot move.



Take a few steps back, admire your assembly handiwork, take a picture for the scrapbook, and get a latte and a custard tart. Have a seat and enjoy. It's high time for a break.

