Building the Antenna Foundation

Once you have found a suitable sight for your small radio telescope, you must build the pier that will serve as the base assembly for the two-axis mount. Soil mechanics can vary widely depending on the geographical location of the installation site. For this reason, it is recommended that you consult local building codes for information on how to properly install the pillar mount.

Pier Foundation

**Step 1:** A pier foundation requires a round hole 30 inches in diameter and 4 feet deep. For areas that experience severe weather, be sure to dig the hole below the frost line. Angle out the sides of the hole so that it tapers towards the bottom. This will prevent the pillar from shifting during severe weather.

**Step 2:** To improve drainage, fill the bottom of the hole with several inches of loose gravel.
Step 3: Place the mounting pole into the hole and then back fill the hole with cement. (Approximately 2/3 cubic yards)

Step 4: Using a 4 foot carpenter’s level, check the position of the post at several points 90 degrees apart. Adjust the post until it is perfectly level in both directions.

It may be necessary to support the post with blocks of wood or stone to prevent the post from shifting while the cement cures.

Constructing a Temporary Mount

If a permanent mounting arrangement is not possible, one alternative is to use a roof top mount for a ground installation. Kaul-Tronic’s NPRM-10 is an ideal roof mount for this type of installation. The NPRM-10 as shown below is constructed from a steel frame and is held in place by 2600 lbs of concrete block.

The NPRM-10 roof mount is very easy to assemble and fits in an area 13-feet by 15-feet. Adjustable pole supports make it a simple matter to level the mounting pole prior to assembling the two-axis mount.
Antenna Assembly Instructions

Required Tools:

1 - 1/2” & 7/16” Open End Wrenches
1 - 16” Adjustable Wrench
1 - Steel Tape Measure
1 - 7/16” Socket and Ratchet
1 - 3/4” Open End Wrench

Step 1. It is necessary to assemble the reflector on a flat surface to ensure proper alignment of the sections. It is a good idea to protect the surface finish by placing cardboard, etc., under the edge of the reflector. Begin by assembling any two quadrants with the 1/4”-20 x 2” bolts through the three outermost pre-drilled and the innermost hole of the sections on the Quad 7.5’ antenna. Use 1/4” flat washers on both sides of the rib, at each assembly point. **Finger Tighten Only At This Time.**

Figure 1. Place all four quadrants on a flat surface prior to assembly.

Figure 2. Only install the outer 2 bolts (7.5-foot dish) or outer 3 bolts (10-foot dish)
Step 2. Repeat step 1 by assembling the remaining two quadrants. Now you have two halves. The two halves can be bolted together remembering to **Finger Tighten Only** at this time. Now make sure all the quadrants are properly joined and flush at each assembly point. **THIS IS VERY IMPORTANT TO ASSURE THE CURVE OF THE REFLECTOR IS MAINTAINED AND SUPPORTED CORRECTLY.** Wrench tighten all bolts at this time.

![Step 2 images](image)

Figure 3. Assembly of the parabolic dish as described in the instructions above.

Step 3. You may stand the assembled reflector on edge for easy access to the center. Attach the center hub plates to the antenna by inserting four 5/16” x 2” carriage bolts through the front plate, between the ribs, and through the rear plate on the backside of the reflector. Be sure to use 5/16” washers on the rear hub plate. **SECURELY TIGHTEN THE CARRIAGE BOLTS WITH A WRENCH.**

Step 4. This step involves attaching the quad feed supports. Carefully lay the antenna down on its back so the reflective surface is facing up.

Holes are drilled in each reflector section to accommodate the Quad Feed Support. Attach the end of the feed support rod with the round hole to the outside perimeter of the antenna with 1/4”-20 x 1-1/2” bolts. The feed supports attach through holes in the face of the reflector. The slotted end of the feed support rod attaches to the feed horn with 1/4”-20 x 3/4” bolts. **THE FEED SUPPORTS SHOULD BE POSITIONED EQUALLY TO PROPERLY CENTER THE FEED HORN.**

![Step 4 image](image)

Figure 4. SRT feed horn

When installing the feed supports place the head of the 1/4-20 bolt inside the feed. This creates a lower profile than placing the nut and lock washer inside the feed.
Secure the slotted ends of the feed supports to the feed horn.

Figure 5. Properly installed feed horn.

The dish is now ready to be mounted on the two-axis mount using the mounting ring provided.

Figure 6. Antenna assembly
Assembly of Wiring Harness and Control Cables

All electrical connections necessary for proper operation of the small radio telescope can be made with two RG-59 coaxial cables, and a total of nine 16-guage conductors. Constructing a reliable wiring harness requires careful consideration of the power requirements of the devices to be wired and the environment to which the harness will be exposed. General guidelines for completing all electrical connections are given below.

Coaxial Cable

Two coaxial cables must be run from the location of the ground control box to the back of the receiver. Because part of the cable will be exposed to the elements, care must be taken when purchasing the cable.

**Recommendation:**

Belden
Serial Digital Video Cable
RG-59/U Type
20 AWG
Belden part number: 1505A
*Not rated for direct burial*

Operating Temperature Range: −40 to 80 degrees Celsius

Both ends of each coaxial cable need to be terminated with F connectors to make them compatible with the ground control box and the receiver. Due to the stiffness of the coaxial cable, it may be more convenient to run the wire from the receiver to a junction box near the location of the computer and ground control unit. A more flexible commercially available cable can then be used to complete the connection (see figure below).
Multiconductor Control Cables

Nine conductors are necessary for providing power and controlling the SRT mount. Specifications for the multiconductor cables are determined by the power requirements of the two Pro-Form H180 mounts. Each mount requires 24 to 36 volts, with a peak current draw of 4 amperes.

For installations where the antenna is located a long distance from the ground control unit, it may be helpful to double-up the conductors powering the two H-180 mounts. This will cut the voltage drop in the line by one half. Multiconductor control cables are ideally suited for this type of installation.

**Recommendation:**

Belden
Instrumentation and Control Cable
16 AWG, 7 conductor
Suggested working voltage: 600V
Belden part number: 8621
*Not rated for direct burial*

**Installation Tips:**

1) It is strongly recommended that a CPC connector be placed at the antenna end of the control cables. By tapping into this connector the antenna can be moved during maintenance and trouble shooting procedures. This is important for installations where the antenna is not visible from the PC controlling the antenna.

2) If a CPC connector is placed at the antenna end of the control cables, it must be protected from the elements to prevent corrosion.
3) Make sure a sufficient loop is left in the cable wrap between the elevation motor and the parabolic dish. The antenna must be free to move over its entire range of motion.

4) Placing the control cables in ¾ inch split loom will help prolong the life of the wiring by protecting it from the elements.

Pro-Form H-180 Wiring Connections

Remove the left side weather covers from both motors and connect the wiring harness as follows:

Terminal block connections:

1) Connect motor wires to terminals one and two.
2) Connect sensor or pulse wire to terminal three.
3) Connect ground wire to terminal five.

Reversing the motor wires on terminals one and two will reverse the direction the Pro-Form H-180 moves.

In order to connect the motors to the ground control box, the female end of the CPC connector provided with the kit must be placed at one end of the control cables. To properly connect the wires to the connector follow the diagram shown below.

In the description given below, TB1-1 refers to the terminal block located on the azimuth drive. The number after the dash signifies the pin number on the terminal block. It follows that TB2-1 means pin 1 on the elevation terminal block. For terminal-block pin numbering see figure 1 above.

1-Azimuth Motor (Connect to TB1-1)
2-Azimuth Motor (Connect to TB1-2)
3-Calibration Motor A (Red Wire)
4-Elevation Motor A (Connect to TB2-1)
5-Elevation Motor B (Connect to TB2-2)
6-Calibration Motor B (Black Wire)
7-Elevation Pulse (Connect to TB2-3)
8-GND (Connect to TB1-5 and TB2-5)
9-Azimuth Pulse (Connect to TB1-3)

The female end of the CPC connector can
now be plugged into the back of the ground control unit. Be sure to double check all connections before applying power to the ground unit.

Figure 2: Back panel of the SRT ground control unit showing electrical connectors

Connectors

1- Male end of CPC connector (looking towards chassis)

1-Az drive A
2-Az drive B
3-Cal A
4-El A
5-El B
6-Cal B
7-El Pulse
8-GND
9-Az Pulse

2- DB-9 serial communications connection
   Connect to the serial port on the back of the PC

3- Receiver power and communications connection (F-Connector)
   (See receiver and LNA section for details)
Connecting the Receiver and LNA

To simplify the installation of the receiver and LNA move the dish to a convenient location for accessing the area surrounding the antenna feed. The LNA should be mounted to the receiver prior to installing it on the antenna. To correctly install all components located at the antenna feed carefully follow the instructions listed below.

![Image of Receiver and LNA connected to antenna feed]

Figure 4: Receiver and LNA installed on the antenna feed

Component Identification:

1-L-band probe terminated with a male SMA connector
2-Low Noise Amplifier
3-Universal Male F to F Coupler (Digi-Key CP-2010-ND or equivalent)
4-Receiver mounting bracket
5-Video test port (female bulkhead receptacle)
   This connector provides access to the analog signal from the receiver.
6-Receiver power and communications connection.

Step 1: Connect the LNA to the receiver using the Universal F to F coupler provided.

Be careful not to overtighten either end of the coupler. The printed circuit board in the pre-amp may rotate and become damaged as a result of over tightening.
Step 2: Install the mounting bracket on the pre-amp end of the receiver.

Using two 10/32x1/2 bolts, install the mounting bracket and sufficiently tighten both fasteners. Now secure the mounting bracket to the C-band amplifier housing on the feed horn (see item 4 above).

![Image of receiver mounting bracket]

Figure 5: Receiver mounting bracket

Details for constructing the bracket can be found in Appendix A.

Step 3: With the receiver and pre-amp now securely attached to the feed, go ahead and connect the L-band probe to the SMA connector on the pre-amp and tighten.

Step 4: Attach the two coaxial cables to the bulkhead receptacles on the back end of the receiver. Secure all wiring running up to the receiver and calibrator motor to the closest feed support.

To prevent moisture from entering the receiver and pre-amp it is a good idea to seal all seams with silicon caulking.

Do not install the feed horn cover until the section on focusing the SRT is completed.

Vane Calibrator Connections

A 12-volt DC motor driven by an H-bridge circuit in the ground control box controls the vane calibrator. The motor leads should be wired to the female CPC connector as shown in figure XXX.

![Image of vane calibration motor]

Vane Calibration Motor

Connect the red motor lead to pin 3 and the black lead to pin 6 of the CPC connector at the end of the control cable. Test the vane calibrator using the computer interface.
Focusing the Small Radio Telescope

Having assembled the dish and feed supports, the focal point of the dish must now be adjusted to maximize the antenna efficiency. Some adjustment can be made by moving the feed in the grooves located at the ends of the feed supports. This will not provide enough adjustment to properly focus the dish. A simple modification is necessary and can be completed by carefully following the steps given below.

Step 1: Accurately measure the focal length of the dish and compare the results to the values given below:

<table>
<thead>
<tr>
<th>Diameter of Dish (feet)</th>
<th>Focal Length (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>47.6</td>
</tr>
<tr>
<td>7.5</td>
<td>37.7</td>
</tr>
</tbody>
</table>

Note: Finding the exact focal length of the dish requires knowing the precise location of the phase center of the feed. For this application the phase center is located at the position of the first scalar ring in the feed. The focal length can be found by measuring from this point to the center of the dish.

Step 2: The feed must now be moved by an amount equal to the difference between the actual focal length given in the table above and the measured focal length. The length of the feed supports should be modified accordingly.

The focal length of the dish can be calculated using the formula for the focal length of a parabola given in any math handbook.

\[ f = \frac{D^2}{16x} \]

\( D = \) diameter of the dish
\( x = \) depth of the dish (see figure)
Feed Support Bracket (10 foot dish)

The feed supports for the Kaul-Tronics X1-10 only need to be adjusted by about 2 inches. A bracket should be fabricated to hold the feed support flush to the outer edge of the dish.

The bracket shown in the figure was purchased at a local hardware store and required no special modifications.

Feed Support Bracket (7.5 foot dish)

The Kaul-Tronics X1-7.5 requires a 3-inch extension of the feed supports.

The bracket shown in the figure was also purchased at a local hardware store. This bracket is constructed from 1/8 inch steel making it stiff enough to resist bending.
Mount Adjustments and Pointing Corrections

It is now time to adjust the SRT mount and make the necessary pointing corrections. Correcting the pointing requires adjustments to both the hardware and software controlling the motion of the antenna. Before proceeding make sure that the antenna is fully operational and capable of receiving commands for the software interface.

Before attempting to correct the pointing make sure that the computer clock time is correct and that the correct station longitude and latitude have been entered into the SRT.CAT file.

* first word is key word
* station: latitude longitude west in degrees
* sat: satellite ID then longitude west
* sou: source ra, dec, name

If necessary, change these coordinates to those of your installation site.

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Step 1: Command the antenna to track the sun by left clicking the mouse button on the word SUN on the interface display. Next left click the button at the top of the display marked TRACK. At this time the antenna will move to where the software determines the location of the sun to be. The antenna will most likely not be pointed in the actual direction of the sun once the move is complete.

Step 2: Once the antenna has moved in both azimuth and elevation, visually check the pointing by looking at the location of the shadow cast by the feed horn. If the pointing is correct, the shadow should be perfectly aligned to the center plate in the middle of the dish.

Step 3: If the shadow is not centered, begin correcting the pointing by rotating the azimuth drive on the mounting pole until the shadow of the feed is lined up with the center plate. After moving the drive unit, securely tighten all hardware on the azimuth drive.
Step 4: Adjustments to the vertical alignment of the shadow can only be made through software corrections. It may be helpful at this point to review the instructions on using the SRT.CAT file at this time.
Any offset in the elevation angle can be corrected by simply changing the ELLIMITS in the SRT.CAT file. Open the file in any convenient text editor and change the value of the lower elevation limit. In the figure below the lower limit is 13.5 degrees.

An increase in the lower elevation limit will move the feed horn shadow upwards on the dish. The shadow will always move in a direction opposite to the change made in the elevation limit angle.

```
* SOU 03 29 11 54 24 37 Pulsar 1.00
* SOU 03 29 11 54 24 37 Pulsar 0.71451866398
*AZLIMITS 104.0 250.0 /* mid az range is south */
*ELLIMITS 14.0 160.0 /* elevation limit south - north */
AZLIMITS 103.0 250.0
ELLIMITS 13.5 160.0
UTHOURS 5.0 /* hours from local to UT */
COMM 1 /* COM1 */
CALCONS 0.5 /* gain correction constant to put power in units of K */
BEAMWIDTH 5.0 /* 3 dB antenna beamwidth in degrees */
MANCAL 0 /* 0 or absence indicates automated cal vane */
ANTILT 0.0 0.0 /* antenna basetilt north_up east_up degrees */
```

Alternative Method for Making Pointing Corrections

Instead of using the shadow of the feed horn to correct the pointing, the antenna can be moved using the pointing offsets until the power is peaked on the sun. This method is a little more tedious but slightly more accurate.

Step 1: Command the antenna to move to the position of the sun as explained above.

Step 2: Command the antenna to move to the position of the sun as explained above. Next, loosen the bolts that secure the azimuth drive to the stationary mounting pole.

Step 3: Have a helper rotate the dish in azimuth forwards and backwards until the peak power level displayed on the SRT interface is found. Move the dish to the position of the peak and securely fasten the bolts to the azimuth drive.

Step 4: Using pointing offsets, find the peak power in elevation and adjust the ELLIMITS in the SRT.CAT file.
Using the SRT as a Satellite Dish

Using the C-Band probe, a Low Noise Block downconverter (LNB), a satellite receiver, and a TV monitor, SRT users can view broadcasts from synchronous satellites. Pointing the telescope toward these satellites can be accomplished with the SRT software. Coordinates for NASA Television satellite (http://www.nasa.gov/ntv/) and other satellites can be found on the web.

Installing the LNB is simple. The LNB fastens to the receiver on the telescope. It replaces the plate currently in place. A RG 59 coaxial cable connects the LNB to the satellite receiver. RG 59 cables can be purchased at any electronic appliance store. The C-Band Polarizer is connected to the satellite receiver by a cable. The cable connects to the wires coming from the polarizer, then to the satellite receiver. The color code for the cable and polarizer is: black - ground, white - pulse, and red - +5 volts.

To be able to track a synchronous satellite you need to edit the srt.cat file. The keyword for satellites is SSAT; the format should consist of the satellite's ID and then its longitude west. A sample entry would look like this:

SSAT NASATV 85

Be sure to save the srt.cat file after the change is made. The next time you run the software the satellite will appear on the screen. Clicking on it and then on "track" will move the telescope to the satellite.

NOTE: When using the SRT for astronomy the satellite receiver should be unplugged. The set up generates a noise signal in the receiver at the telescope. This signal is present regardless of the power button position; to eliminate the
signal the receiver must be completely disconnected from the power supply. The signal results in higher system temperatures and the inability to calibrate the telescope.

*Updated: 19 July 2000*