**MicroFinder Technical Note #6**

**July 11, 1998**

**Added ground plane detail 11/7/1998**

# Building an Antenna Array for the MicroFinder

## Introduction

The MicroFinder does not include an antenna array, and as such you need to make one yourself. While building an antenna array isn't very difficult, we are including some information that will be of use to you in building an antenna system. Your antenna array is the first place where the signal encounters your doppler system, so you want to construct a system that is efficient as possible.

When you are deciding how to design and build your system, several factors should be taken into account:

- Size
- Cost
- Mounting technique

Each each of the above parameters will alter one or more of the physical parameters of your antenna array. As you examine the system design possibilities, keep these parameters in mind.

## Antenna Types

This note describes two antenna arrays which use different types of antennas. Each type of antenna has advantages and disadvantages:

- The ground plane antenna
- The vertical dipole antenna

The MicroFinder will support arrays with three, four, six, or eight antenna elements, and both antenna types are adaptable to the number of elements you desire. We have found that four elements work fine for every day doppler use. Since the MicroFinder contains reflection detection features, the added elements in six or eight element arrays really help the MicroFinder operate better. Because of this, we recommend that new antenna builders choose six or eight element systems. If you happen to have a four element system, go for it, they work fine! But if you are just starting out, spring for the extra elements.

This design note describes six and eight element antenna systems. Note that it is easy to create a four or six element system, by adjusting the angle between the elements. In all cases, the angles between elements are all the same. (eight elements, 45 degrees. six elements, 60 degrees). While the MicroFinder supports three element arrays, we recommend that you use six or eight element systems on a vehicle.

The antenna system is composed of several major parts:

- The antenna elements
- The switching logic
- The interconnect cable to the MicroFinder (the easiest part, a nine connector cable. The pin out is detailed in the MicroFinder construction manual, and the switching section, later in this note).

The ground plane is the easiest form to construct and it adapts itself to a wide variety of vehicles. This antenna is built using a flat metal plate, BNC connectors screwed into the plate, and magnets (or some other mounting technique). This antenna is the most common and the easiest to use.

The vertical dipole system requires more effort to build, and mounting is much more of a challenge. Because the antenna uses vertical dipole elements, the gain of this system is greater than the ground plane system. Since there is more gain, this may be the system of choice for you.

Each system arranges the antennas in a circle. The circle parameters for 146 MHz are (scale appropriately for other frequencies):

- eight elements - 25 inches diameter - 45 degrees between elements.
- six elements - 24 inches diameter - 60 degrees between elements.

**The Ground Plane Antenna**

Figure 1 shows a ground plane antenna. This diagram shows eight elements, but is adjustable to six (or four) as previously discussed. Antenna elements may be permanently attached to the plate, but we recommend using BNC connectors. This makes it easy to disassemble the antenna to stow it in your trunk or garage.

On the bottom of the plate, attach magnets. This will allow you to quickly mount the antenna on the top of your vehicle. Other mounting options include clamps or brackets. Clamping the unit is useful if you have a luggage rack, or non metallic roof.

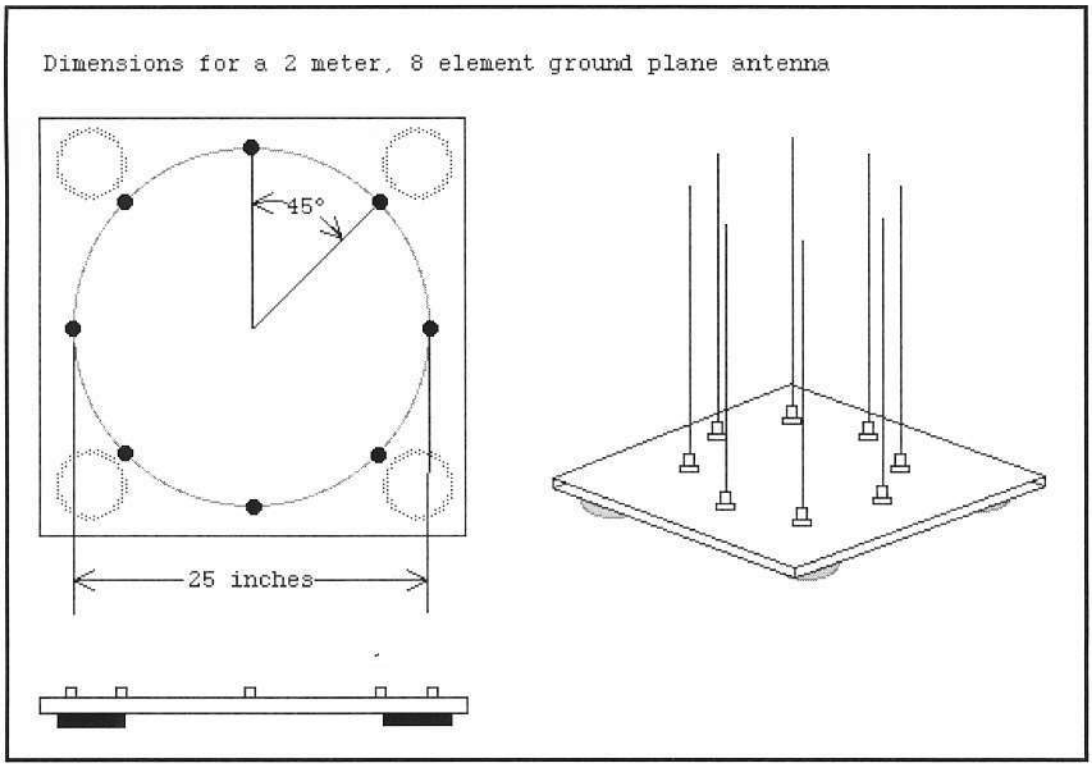


Figure 1 - A Ground Plane Antenna

We have noticed that these antennas require a very symmetric ground plane. If you place the antenna in the middle of a square vehicle roof, the antenna will work fine. Vans or sport utility vehicles have a non-symmetric roof (rectangular). Roofs with non metallic material, or luggage racks do not provide a symmetric ground plane. Figure 2 shows how a ground plane can be extended to be more symmetric, and improve performance and accuracy of your antenna. For two meters, the ground plane needs to extend about 20 inches beyond the elements.

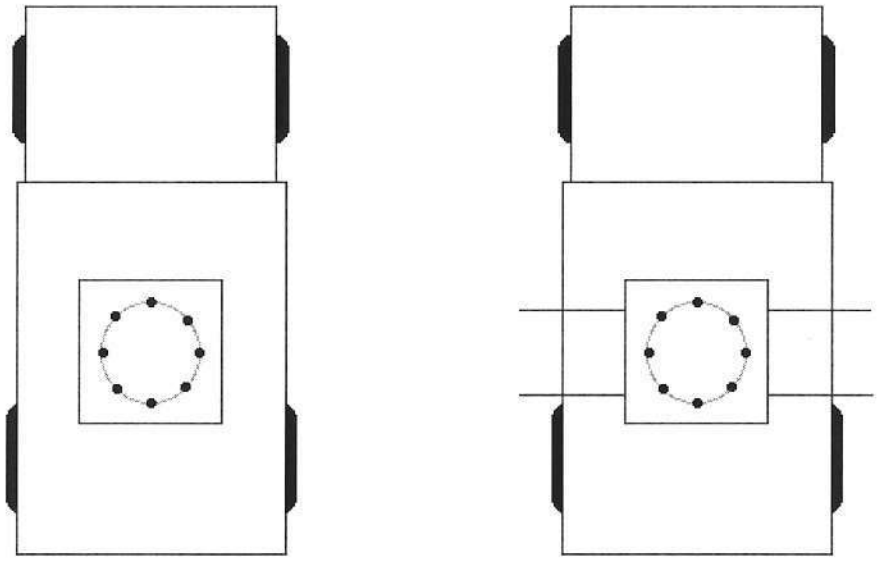

Figure 2 - Creating a more symmetric ground plane

**The Vertical Dipole Antenna**

As we noted before, the vertical dipole antenna has more gain than the ground plane array. Because of the lower (grounded) elements, the antenna must be higher above the vehicle. This can be a serious disadvantage and can restrict your vehicle to locations with enough clearance. (Don't ask us about certain trees or parking garages!)

Figure 3 shows a six element vertical dipole system. The antennas are composed of two elements, instead of just one. The lower element is always grounded, and the top element is switched, just like the ground plane. Instead of a solid sheet of aluminum, the supporting structure is built from 1 inch PVC pipe. The mast is constructed from 1.5 inch PVC pipe. The cross arm structure is mounted on the vertical mast, which is then mounted on, or in, the vehicle.

Dimensions for the cross arm pieces are given in the figure 3. The "T" connector used to connect the cross arm structure to the mast is has two 1 inch slip joints, and 1.5 inch joint on the bottom for the mast. At the end of each arm is a 1 inch "slip-slip" coupler. This couple is used to adjust the final dimensions to place the antenna elements in the correct location. These couplers also provide a stronger mounting base for the antenna elements.

KN6FW really likes these types of arrays. He even modified his truck to easily mount this type of system. The photo at the start of this design note shows his six element version, all built from PVC. Note that he drilled a hole into the roof of his truck and finished it off with a brass, marine gasket. Inside of the truck is a steel pipe to act as a mast, which is strong enough to stand up to freeway speeds.

Note that this antenna can be mounted on the front or rear of a vehicle. One caveat, check you local vehicle codes first. Some states have restrictions on overhang and projections, or items perceived as visual impediments to the driver.

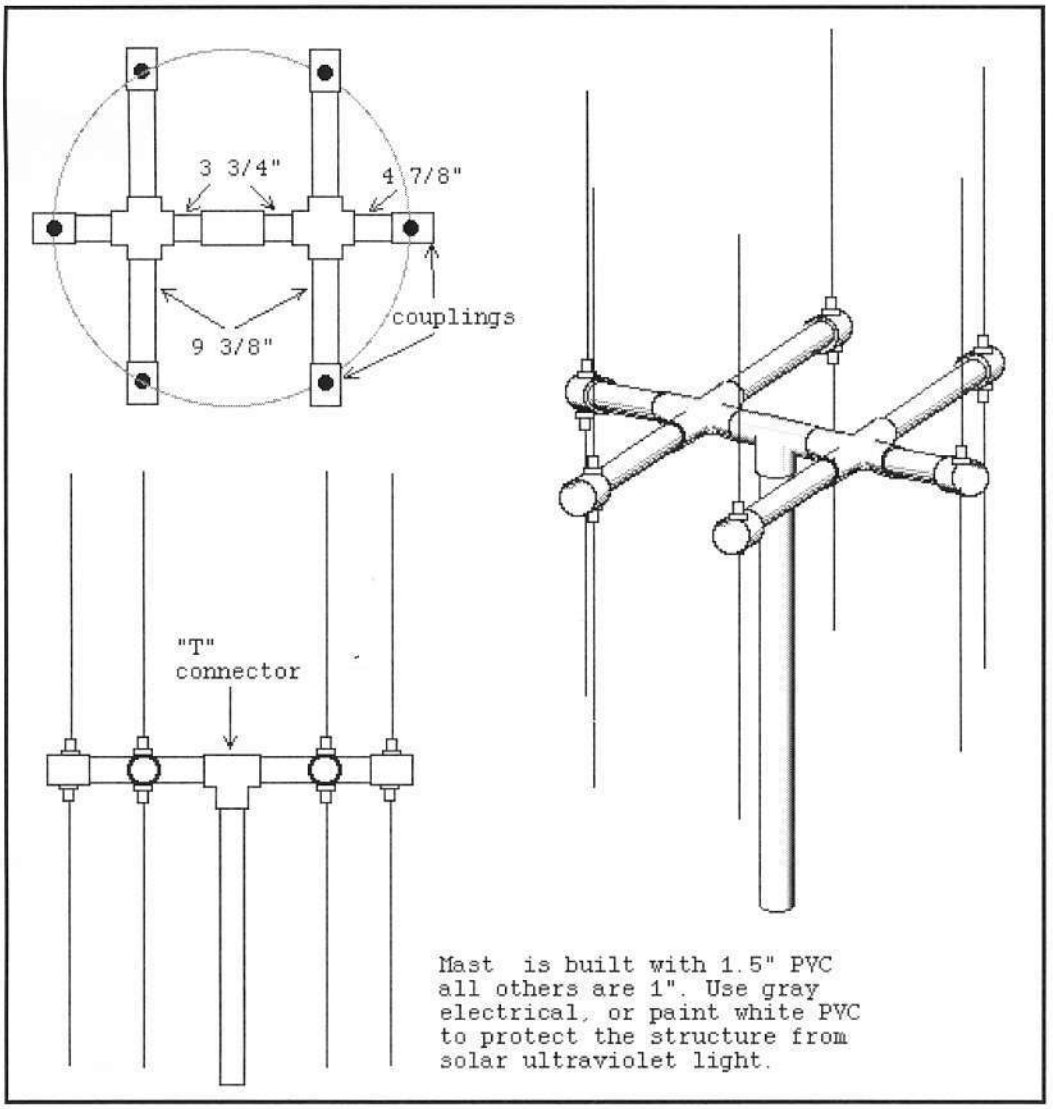


Figure 3 - A Vertical Dipole Antenna

**Making Antenna Elements on the Cheap**

AHHA! Solutions does sell two meter whips, but if you don't want to pay 12 dollars each, you can build some quite easily. To make these elements you will need:

- BNC to RCA phono plug (female)
- 1/8 inch brass welding rod
- Epoxy glue

Insert the rod into the connector, it should be a nice snug fit. Place epoxy around top edge of the connector, making sure it there are no gaps and that the glue evenly fills between the rod and BNC connector. Let the glue cure for 24 hours. Cut the rod to length (19 inches for two meters). Done!

The connectors can be purchased at swap meets for about $1.00 to $1.50, and if the welding rod is bought in bulk, it can be had for about $0.50. Total cost is $2.00 per element, and total cost for eight elements is $16.00. Almost one tenth of the retail price of the antenna elements for pre-made. The connectors are also available from Radio Shack for $2.99 (PN: 278-254), still below the cost of pre-built elements (if you don't want to build you own, we will sell you some).

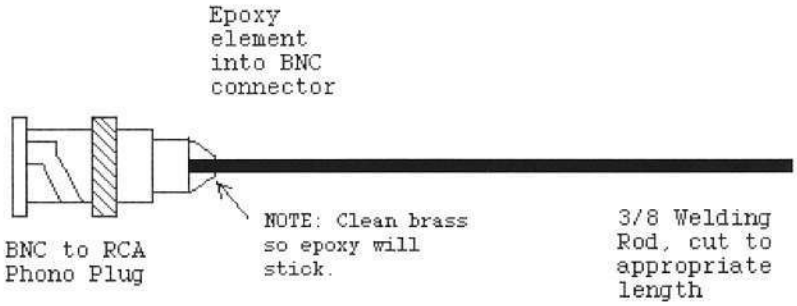


Figure 4 - An inexpensive element

**The Switching Unit**

Once you have built your antenna structure, you will need to build a switching unit. Many antenna systems fail because of poor construction techniques when building the switching unit, so pay close attention to your construction techniques. Figure 5 shows the pin out of the MicroFinder unit. The right hand side of figure four shows the schematic of the connections to the antenna.

Current flows through one pair of diodes at a time. The forward biased diodes act as low impedance to RF signals and the RF flows to the radio. When a pair of diodes is not forward biased, they act like large impedances to the RF, preventing the signal from getting to the radio. The capacitor prevents DC from reaching the radio, and the chokes act as a DC ground return path.

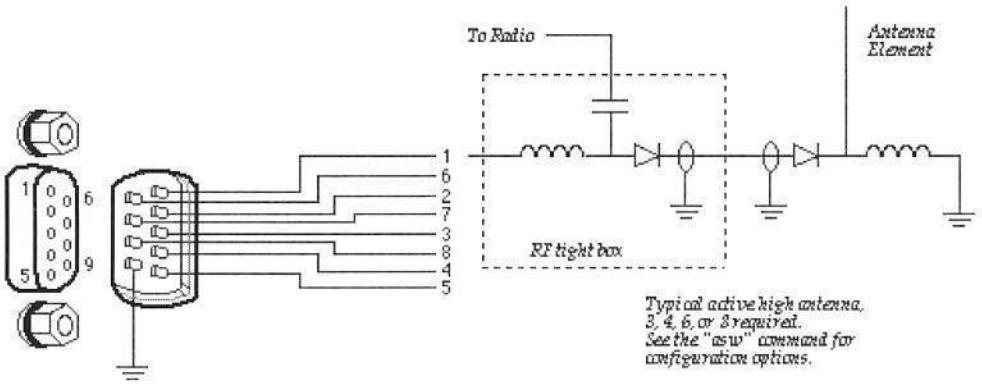


Figure 5 - MicroFinder connections to the switcher

Figure 6 shows the schematic of a four element switch box. While the rest of this design note demonstrates six or eight element antenna arrays, figure 6 uses four elements to keep the schematic simple. Extension to six or eight elements is obvious. The switcher is built with the following components:

Diodes are 1N914 or 1N4148
Chokes are 1 uH
Capacitors are 680 pF
Cable from box to antenna is RG-174 or RG-58, any length as long as all are the same length.

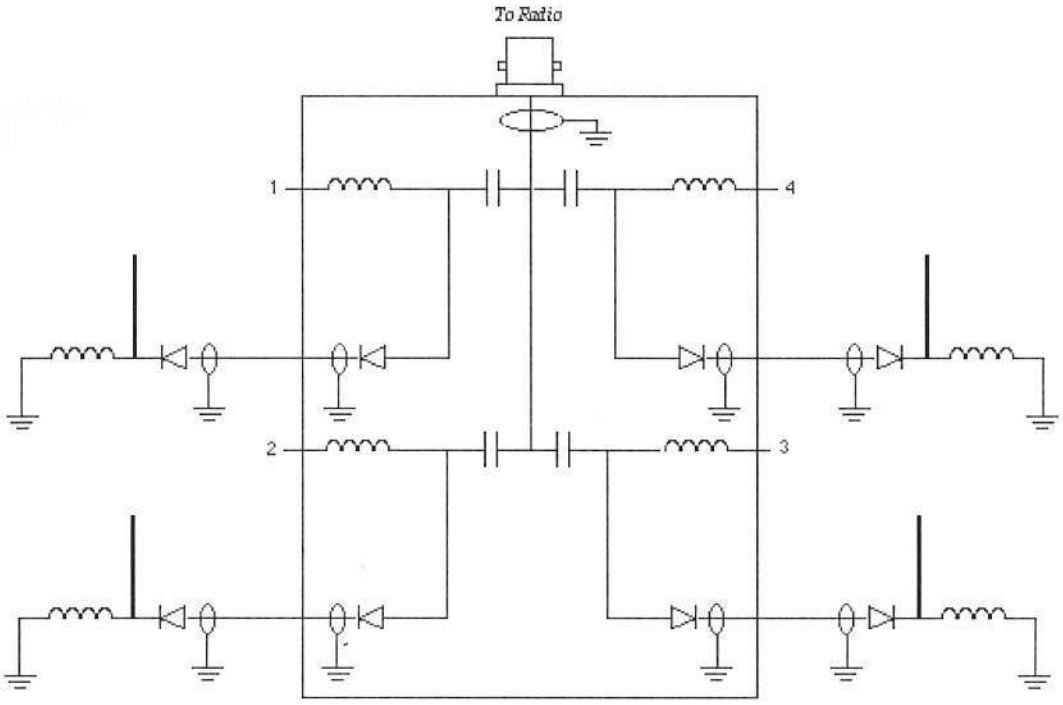


Figure 6 - A switcher for four antennas

When building the switch box, here are some things to keep in mind. Remember, you are dealing with RF:

- Keep all leads as short as possible
- Keep all leads and lengths the same for similar sections
- Do not coil wires or leads, these act as inductors
- Plan the switch box for final placement within the antenna array.
- The coax cables between the switch box and antenna elements (with diode and choke) must all be the same length (this avoids introducing unequal phase delays into the system, which would reduce accuracy).
- The MicroFinder wants to rotate the antennas in a counter clockwise direction, wire the antennas from the control box so that the antenna sequence proceeds counterclockwise (from 1 to 8, or 1 to 6).

**Antenna element detail for diode and inductor**

This diagram shows how to connect the diode and inductor at the antenna. The BNC connectors are standard connectors and may be purchased from a variety of suppliers. Figure 7 illustrates how the three components are connected. The diode is connected between the center conductor of the coax and center pin of the BNC. The inductor is connected between the center BNC pin and the ground. The shield of the coax is connected to the ground. The easiest way to provide a ground connection is to use a "lug washer". This washer fits over the threaded end of the BNC connector and has a solder lug off to one side. You will solder one end of the inductor and the coax shield to the lug to obtain a good ground.

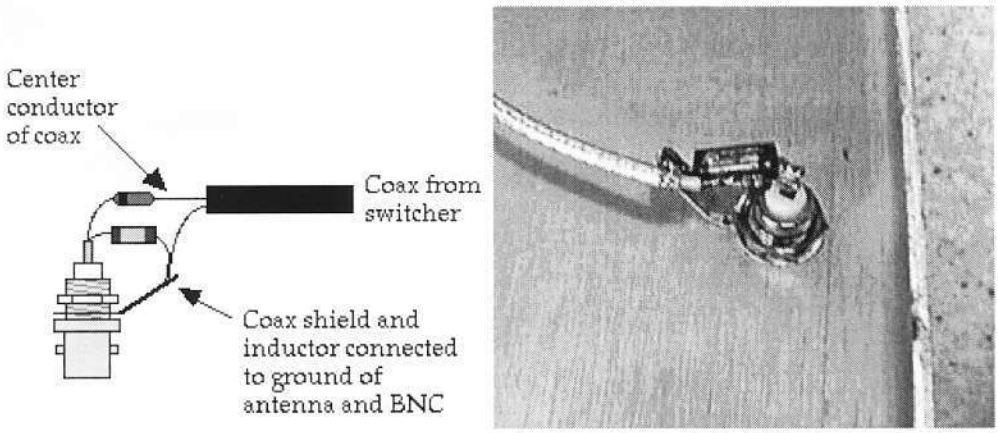


Figure 7 - BNC, diode, and inductor detail

**Testing the Antenna System**

When you are finished, you will want to test and debug your antenna prior to using it. Tech note #5, Debugging a Doppler Antenna shows how to do this.

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