ADS-B Antenna

Build this 8.6 dBi 1090MHz Vertical Dipole Array for $20

Automatic Dependent Surveillance-Broadcast, or ADS-B, is a surveillance technology in which an aircraft determines its position via satellite navigation or other sensors and broadcasts it, enabling it to be tracked. There are several smartphone apps available that allow users to monitor aircraft positions, flight numbers, speed, altitude and several more parameters. A receiving system can be built with a Raspberry Pi, a receiver dongle, and an antenna. This article is based on using the Flightradar24 and FlightAware apps.

Vertical Dipole Arrays
My first antenna was a magnetic base ½ wavelength vertical whip. It worked and allowed me to get my system running. I then decided to try to improve the antenna and built a J-Pole base on an old L.B. Cebik design. The result was a bit disappointing, so I decided to try scaling my Vertical Dipole Array design (www.kg4jjh.com/vda.html) from 2m (146 MHz) to 1090 MHz. I saw an immediate doubling of the number of aircraft received.

Living in an HOA restricted neighborhood, I am forced to place my antennas in the attic. This attenuates all RF signals. I try to compensate for this loss by building the highest gain antennas that will fit in the attic space.

Construction
Drawing Sheet 1 presents an overview of the 4-element vertical dipole array assembly. Cut the 8 dipole elements from 14 AWG solid wire. I am a stickler for accuracy, so I ground the wire lengths to size using a circular sander. Measure and mark the poplar board according to the drawing. Place a length of tape along the entire ¼" edge of the board. Tin one of each copper wire element with solder. Place each dipole element (with the tinned end of the elements facing each other) against the tape and affix the elements with clear Gorilla glue and allow to dry. The 8-element array was built using 3 sheets of ¼" x 6" x 36" poplar to get a panel 77" long. The third sheet was cut to extend the length from 72" to 77" and to make splice panels which were glued to the bottom of the panel.

Phasing Harness
The phasing harness is based on feeding four 50Ω antennas from one 50Ω feedline. When cutting cable lengths, remember that the velocity factor applies only to that portion of coax where the center conductor insulation is still in place. The math involved for calculating coax impedance and length is as follows:

Lambda (λ) is the physical wavelength of coax and is defined as:
λ = (Electrical Wavelength at F_O) X (Velocity Factor of the Coax)

Equation 1: $\frac{1}{4}\lambda = (2952/F_O) \times (VF)$

Where:
1/4WL=2952/Fo X VF
Fo=1090 MHz
VF=0.82
1/4WL=2952/1090 x 0.82
1/4WL=2.2208"=2.25"

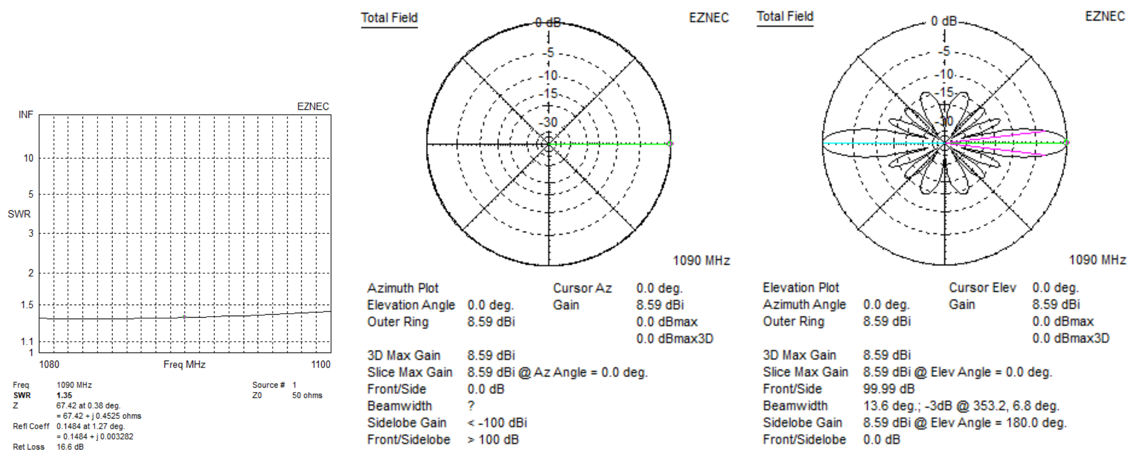
1 x 1/4WL=2.25"
3 x 1/4WL=6.75"
5 x 1/4WL=11.25"
7 x 1/4WL=15.75"
9 x 1/4WL=20.25"
11x 1/4WL=24.75"

Cut the mini 75Ω coax to the lengths shown on the drawing. Remove the aluminum foil near the braided shield. Solder each coax length to the elements and hot glue the coax to the board near the solder joints. Solder the coax center to the upper dipole wire and the coax shield to the lower dipole wire for all four dipoles. Using an ohmmeter, verify that all upper dipole elements are connected to the SMA connector center pin. Next, verify all lower dipole elements are connected to the SMA connector shell. Also, verify that there are no short circuits between the SMA connector center and shell.

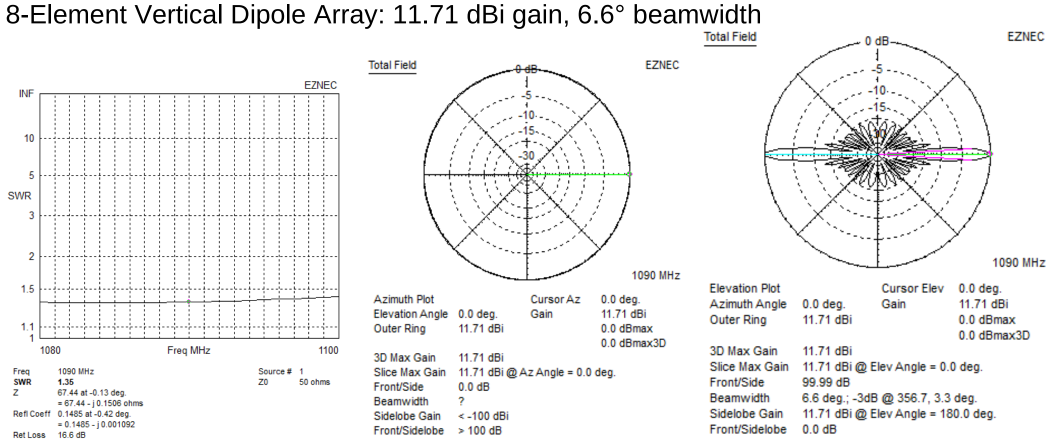
The antenna is not weatherproof, so it was mounted in the attic. Drawing sheet 2 illustrates an idea of enclosing the elements and coax inside PVC pipe. (I tried this but had no success. It turns out that PVC, 0.164" wall, lowers the resonant frequency to 760 MHz). Replace the SMA connector with any length of 50Ω coax to the N connector.

Antenna EZNEC Models

4-Element Vertical Dipole Array: 8.59 dBi gain, 13.6° beamwidth

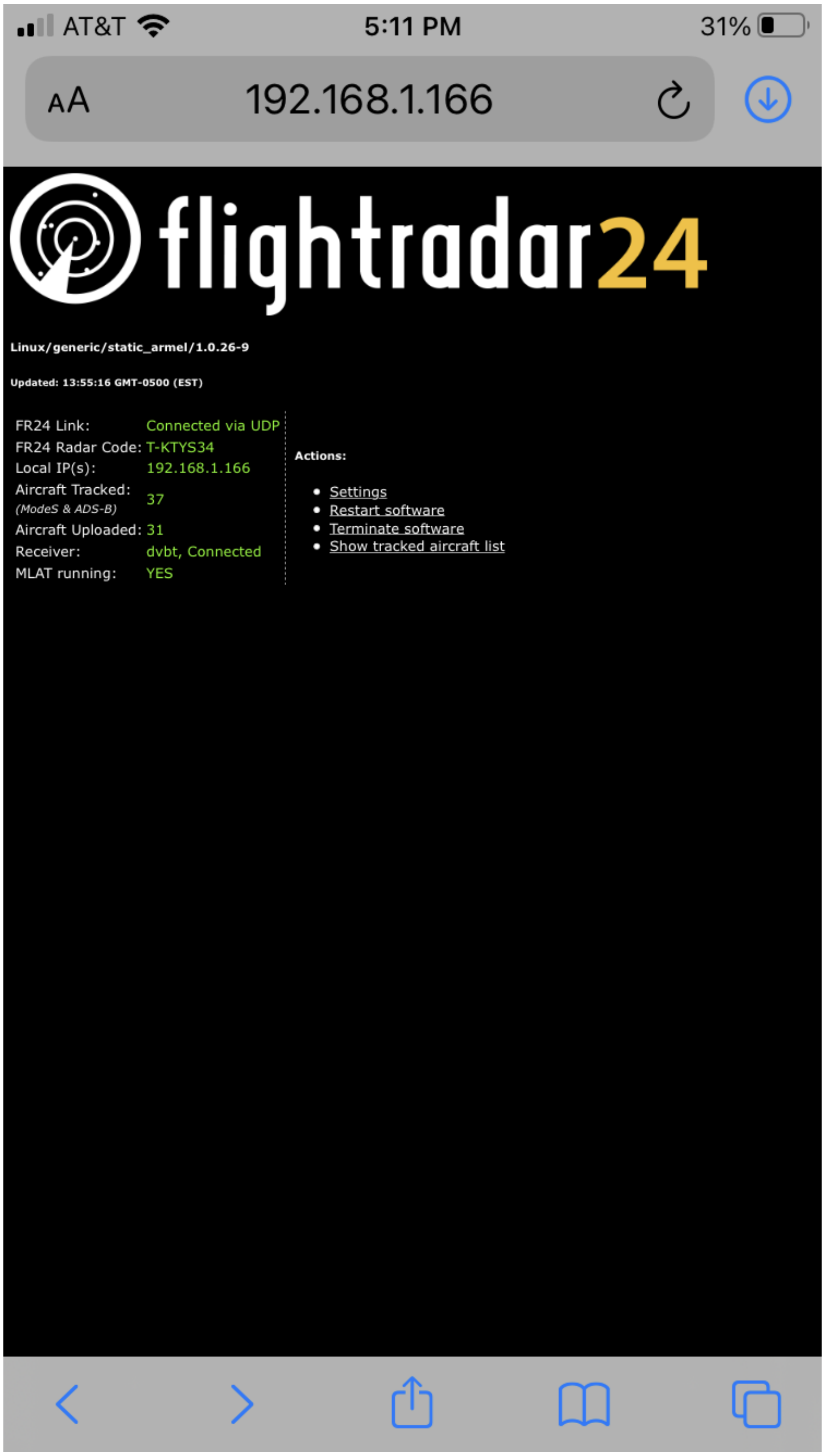


8-Element Vertical Dipole Array: 11.71 dBi gain, 6.6° beamwidth



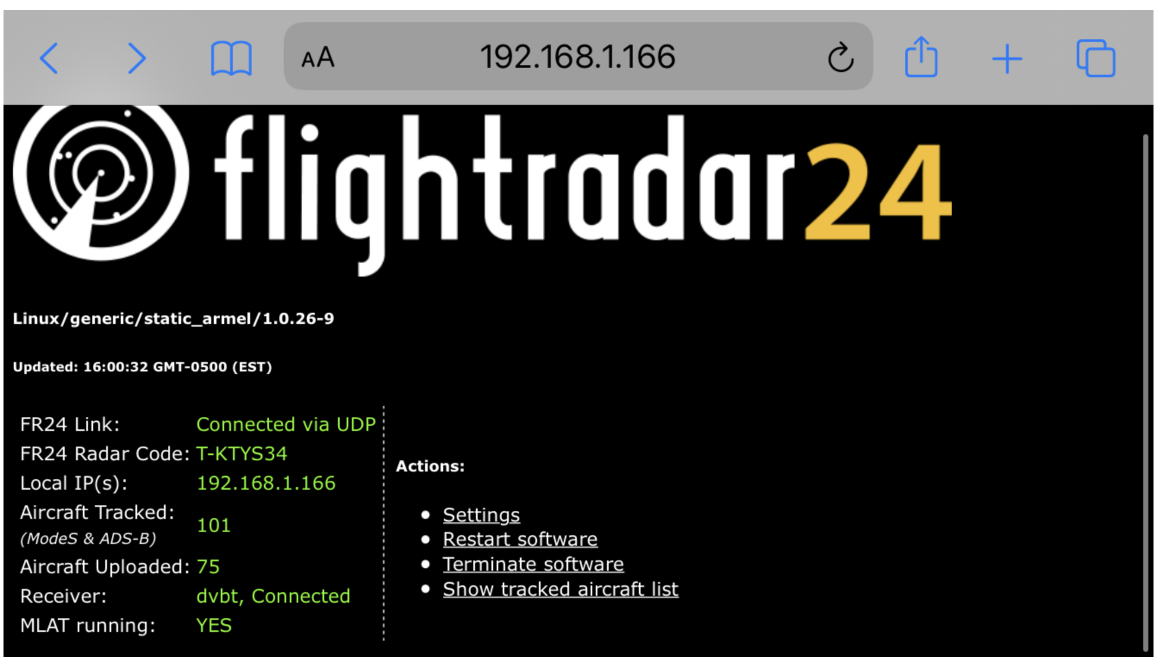
SWR Measurement
A newly purchased MiniVNA showed the 4-Element Vertical Dipole Array SWR to be 1.14:1 at 1090 MHz. The 8-Element Vertical Dipole Array measured 1.09:1.

Aircraft Tracked
Flightradar24 display using a vertical whip antenna. Aircraft detection range is approximately 50 miles.

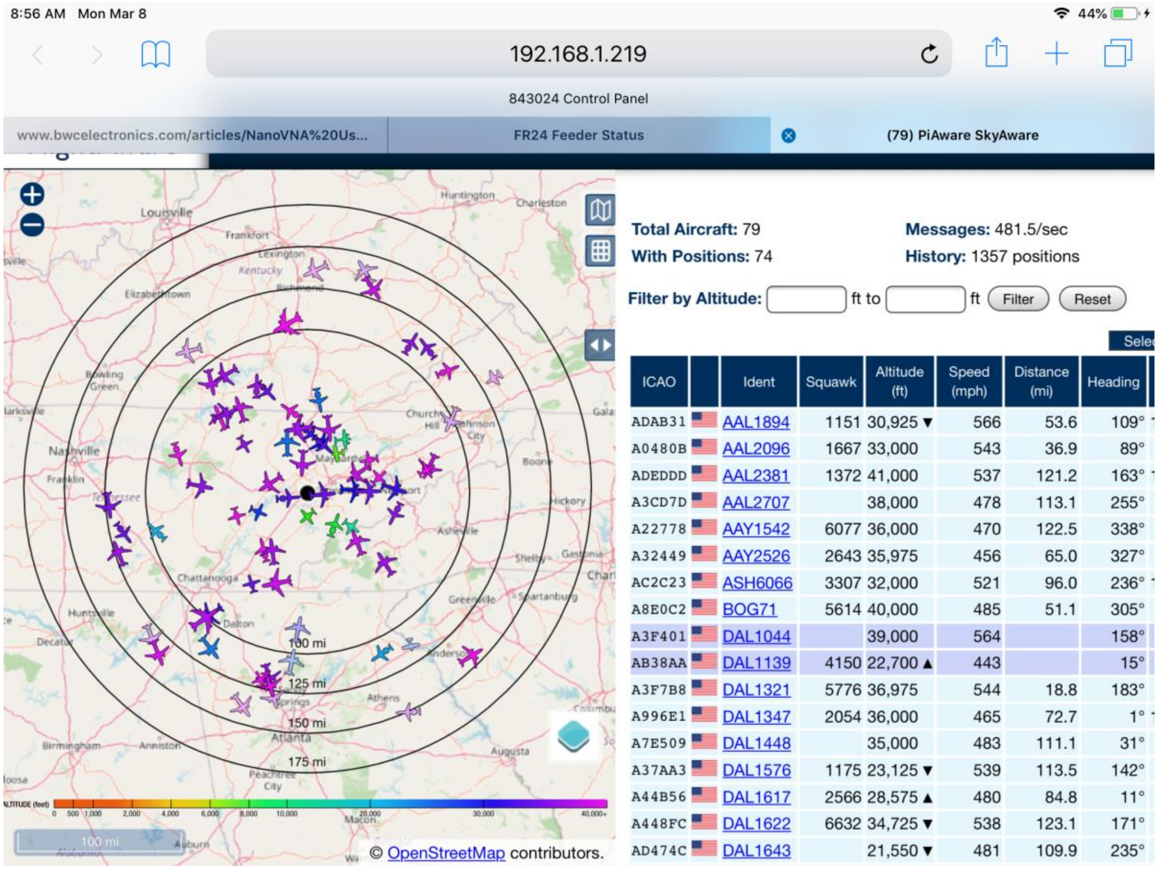


Flightradar24 display using the 4-Elment Vertical Dipole Array. Aircraft detection range is approximately 100 miles.

Preliminary data shows the 8-Element Vertical Dipole Array has expanded my aircraft detection range to 130 miles.



Attempts to get Dump1090 working for Flightradar24 were unsuccessful, so I built a new station and loaded FlightAware. This gave me the ability to view aircraft positions on a map with distance rings. The FlightAware station is using the 8-Element Vertical Dipole Array and, so far, tracks aircraft up to 165 miles. Also, this station has a much higher percentage of tracking aircraft with positions vs total aircraft detected (95% vs 75%).



ICAO		Ident	Squawk	Altitude (ft)	Speed (mph)	Distance (mi)	Heading
ADAB31		AAL1894	1151	30,925 ▼	566	53.6	109°
A0480B		AAL2096	1667	33,000	543	36.9	89°
ADEDDD		AAL2381	1372	41,000	537	121.2	163°
A3CD7D		AAL2707		38,000	478	113.1	255°
A22778		AAY1542	6077	36,000	470	122.5	338°
A32449		AAY2526	2643	35,975	456	65.0	327°
AC2C23		ASH6066	3307	32,000	521	96.0	236°
A8E0C2		BOG71	5614	40,000	485	51.1	305°
A3F401		DAL1044		39,000	564		158°
AB38AA		DAL1139	4150	22,700 ▲	443		15°
A3F7B8		DAL1321	5776	36,975	544	18.8	183°
A996E1		DAL1347	2054	36,000	465	72.7	1°
A7E509		DAL1448		35,000	483	111.1	31°
A37AA3		DAL1576	1175	23,125 ▼	539	113.5	142°
A44B56		DAL1617	2566	28,575 ▲	480	84.8	11°
A448FC		DAL1622	6632	34,725 ▼	538	123.1	171°
AD474C		DAL1643		21,550 ▼	481	109.9	235°

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