

4th-Generation
Stealth
All-Band
Electrically Reversible
Directional Array

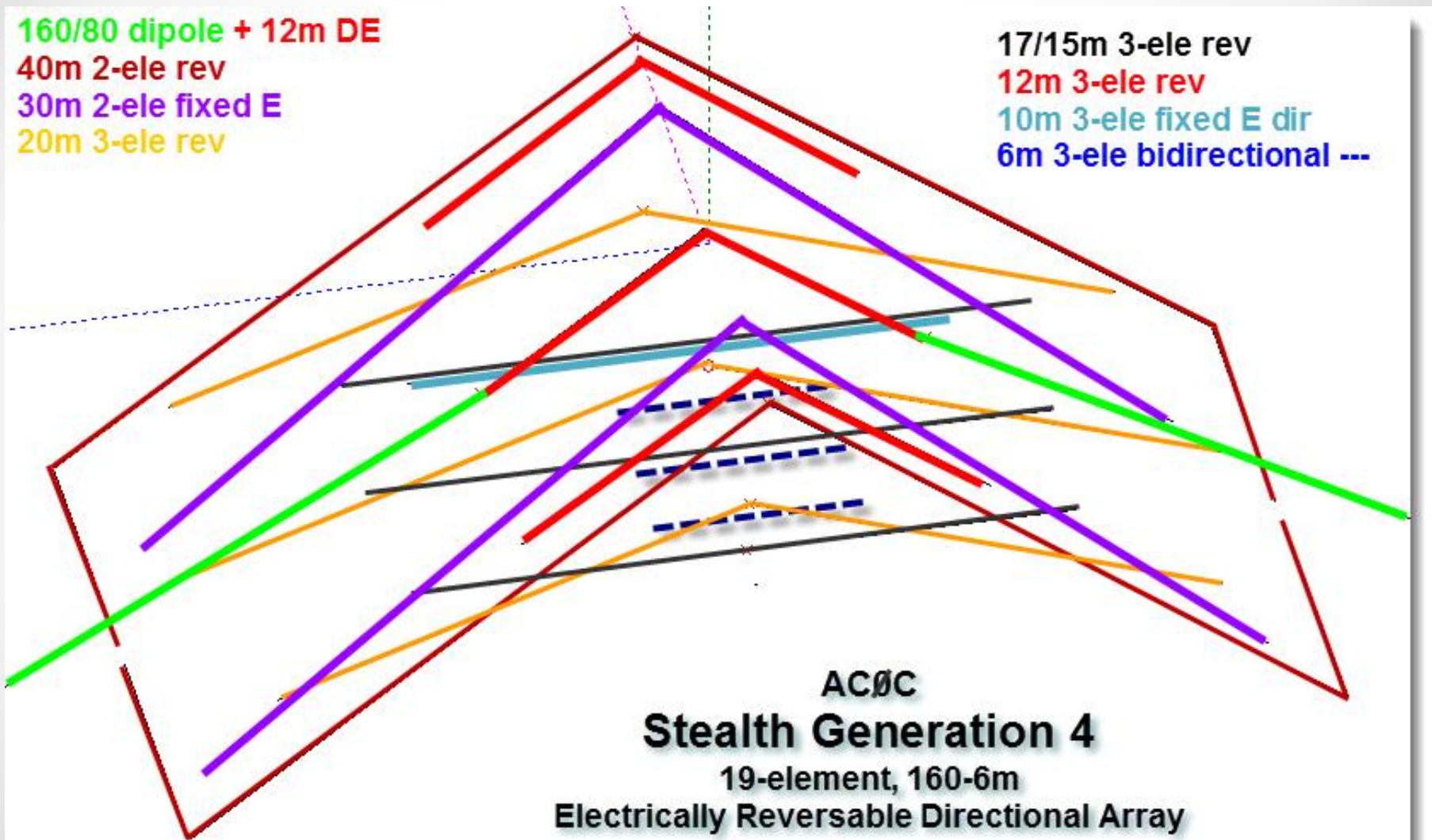
Jeff Blaine – ACØC

Presented to the KC DX Club – 26 July 2010

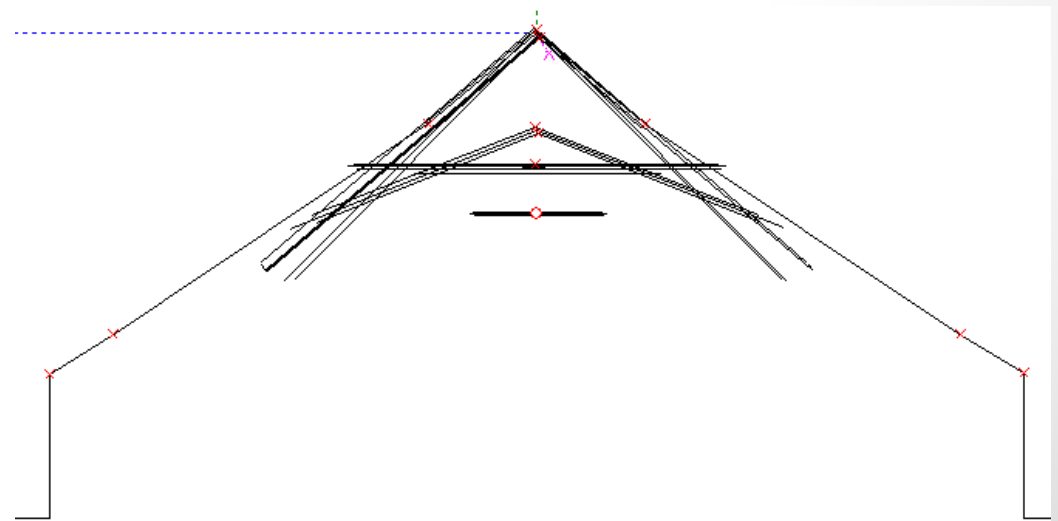
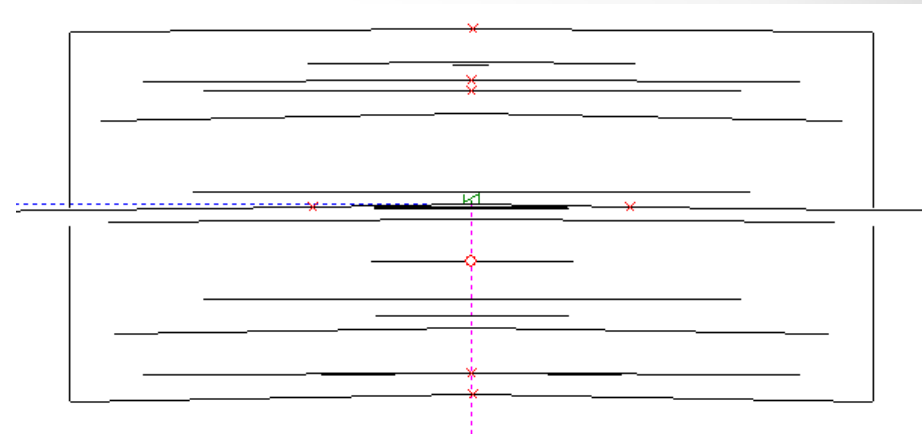
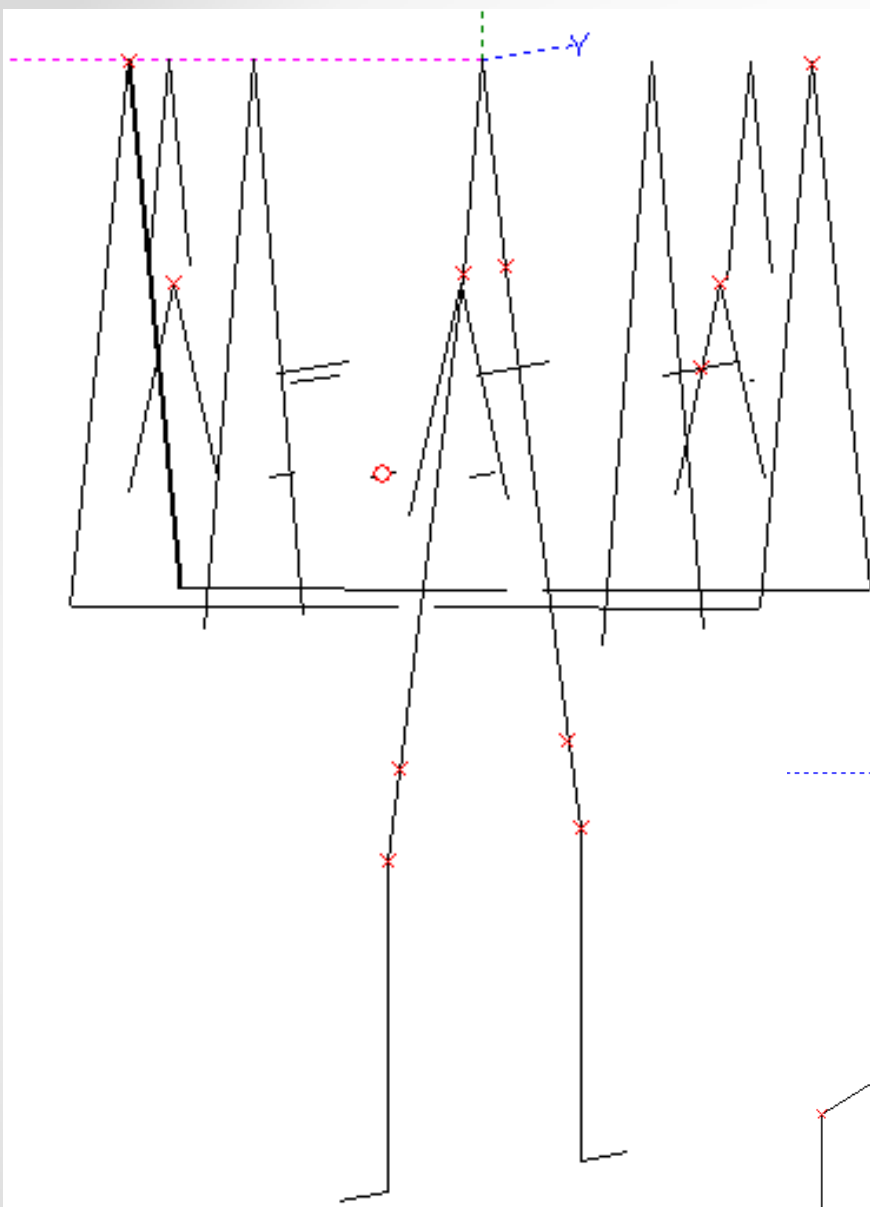
Array Overview

160/80 dipole + 12m DE
40m 2-ele rev
30m 2-ele fixed E
20m 3-ele rev

17/15m 3-ele rev
12m 3-ele rev
10m 3-ele fixed E dir
6m 3-ele bidirectional ---



Array Views



Array Features

- All band coverage 160m – 6m
- Rig driven automatic antenna selection
- Electrically reversible direction
- Computer controlled rotor interface
- Microprocessor driven shack control head
- Mono-band, 2-3 element construction on 40-6m
- No outside elements
- High power contest RTTY duty-cycle capable

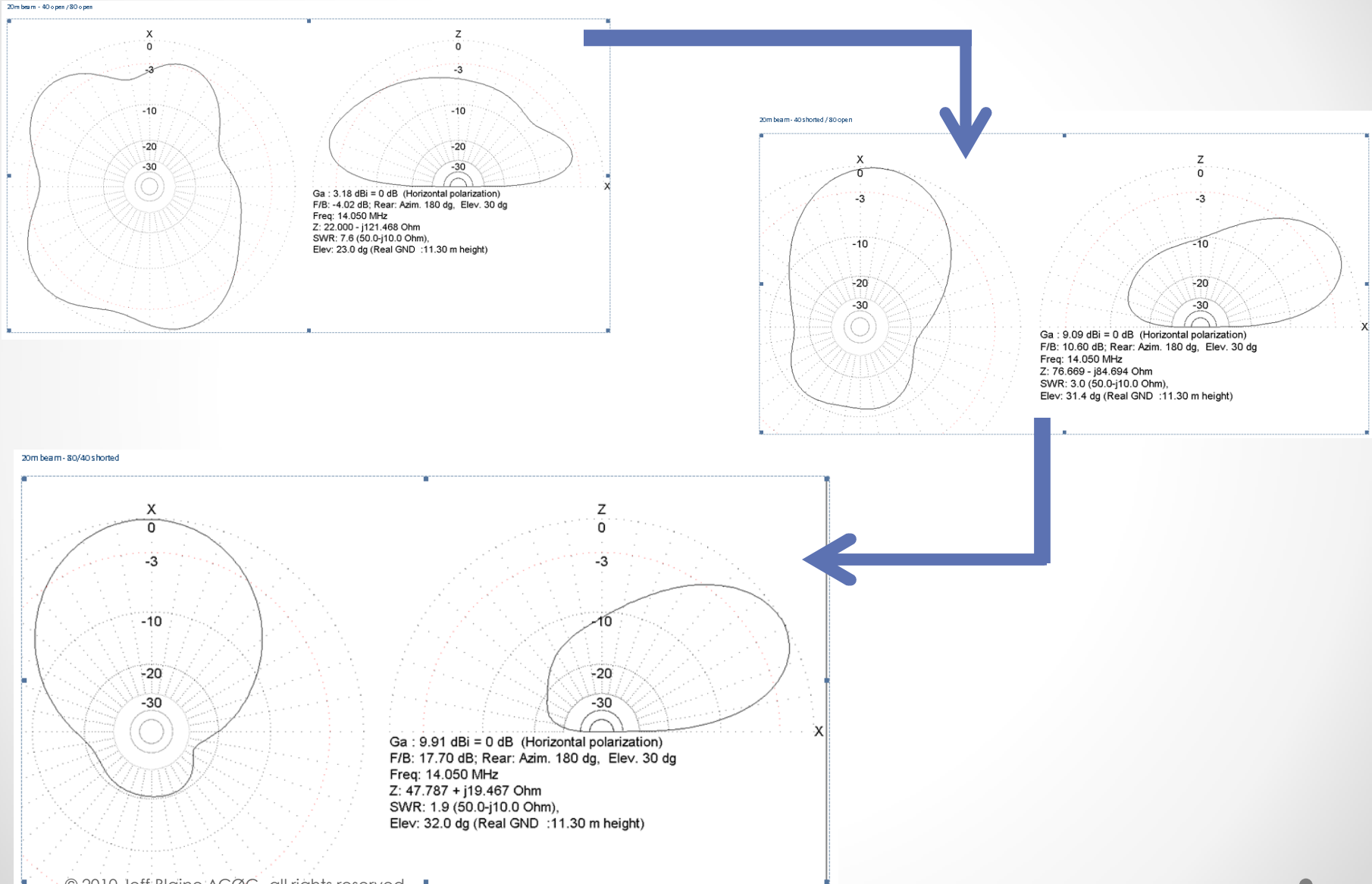
Reliability and Maintainability Factors

- Relay switching (direction, antenna, band select) can be attic controlled
- Mono-band construction simplifies tuning
- PL259 mounted at each element center for easy connection of VNA or MFJ-259
- All elements and coils adjustable from attic floor except 12m
- Ends secured via bungee cord to maintain tension
- 40m bent elements pulley mounted with bungee tie
- Attic-mounted dummy load

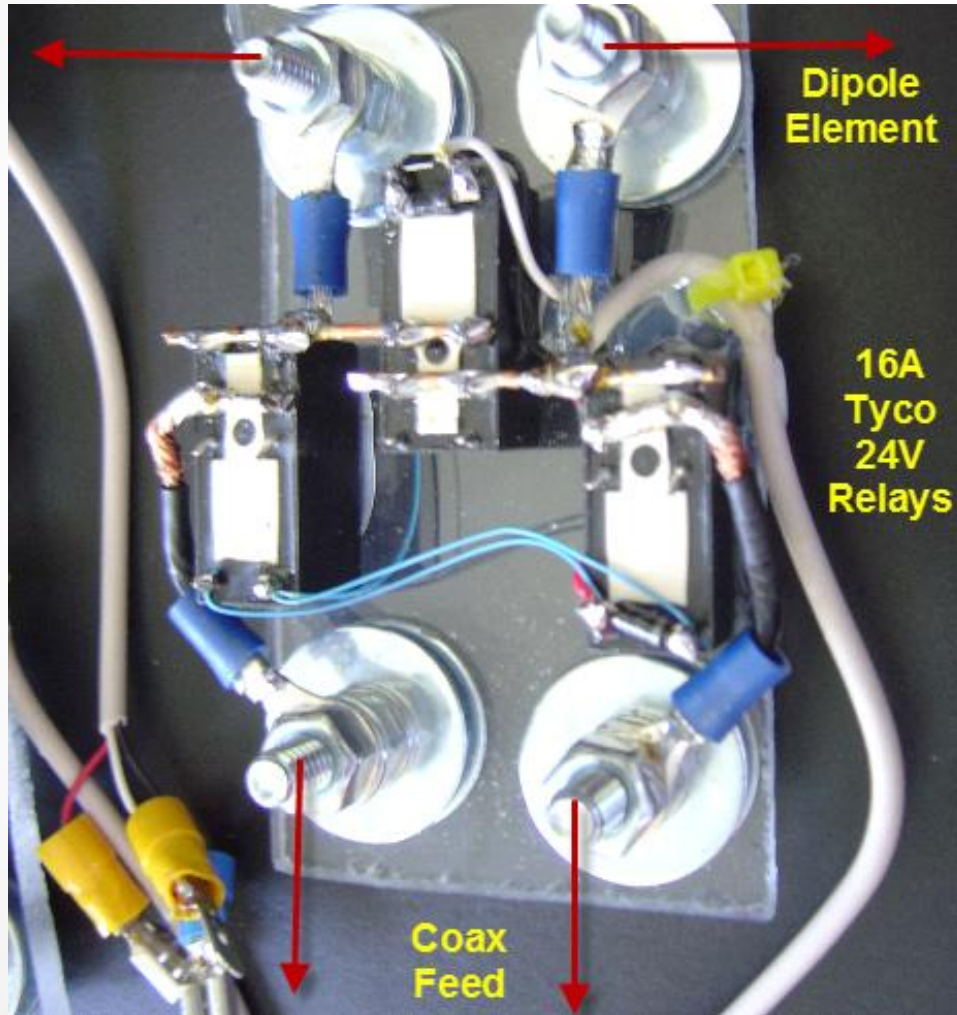
Project Consumption

- 385 MMANA-GAL simulation models built over about 4 months time
- 19 antenna elements
- 6 traps – 12m DE, 15/17/10 DE, 80m dipole
- 37 computer controlled relays
- Atmel AVR micro-controller with 1990-class IBM PC performance
- 600' control cable + 200' RG213
- 800' 12 ga THHN stranded wire strung
- Enough type-31 ferrites purchased to cause a lift in FairRite's stock value
- Hardware + physical antenna construction spread over 6 weeks
- ?? trips up and down the ladder to the attic
- 0 – number of times fell through ceiling – so far

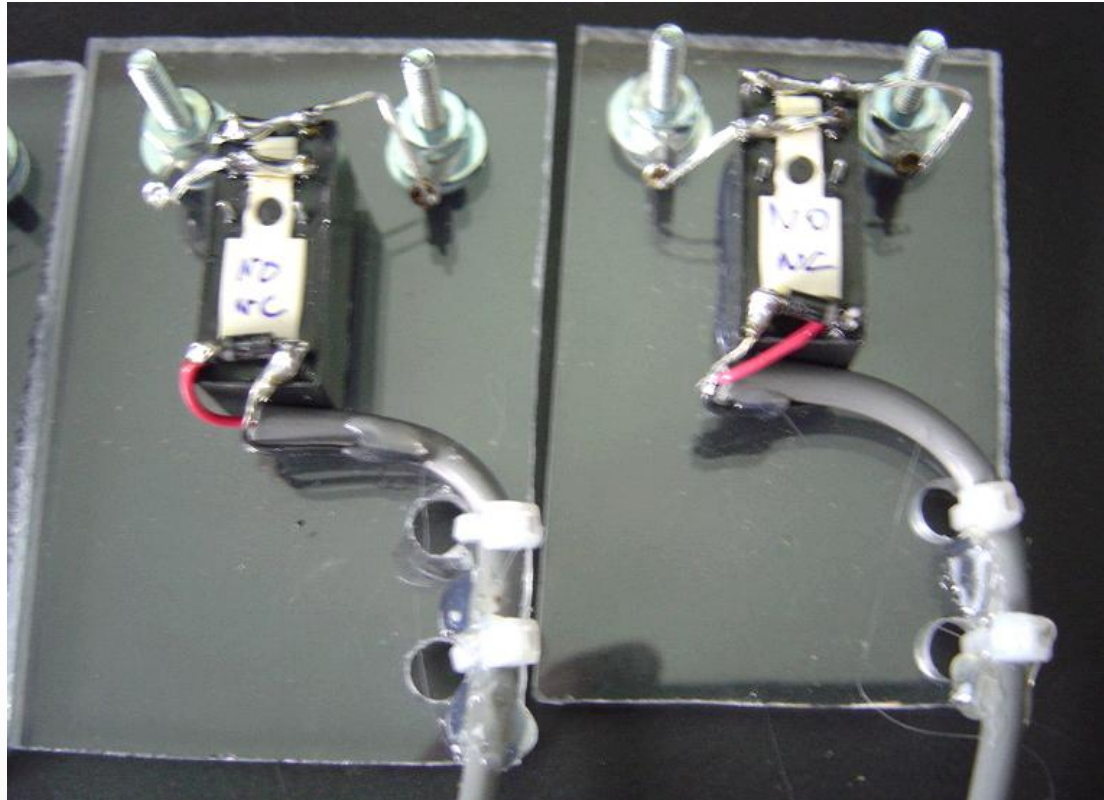
Complexity Driven by Element Detuning



Element Open/Short + Coax Feed-line Disconnect Module



End Element Isolation Modules



Element Detuning Matrix

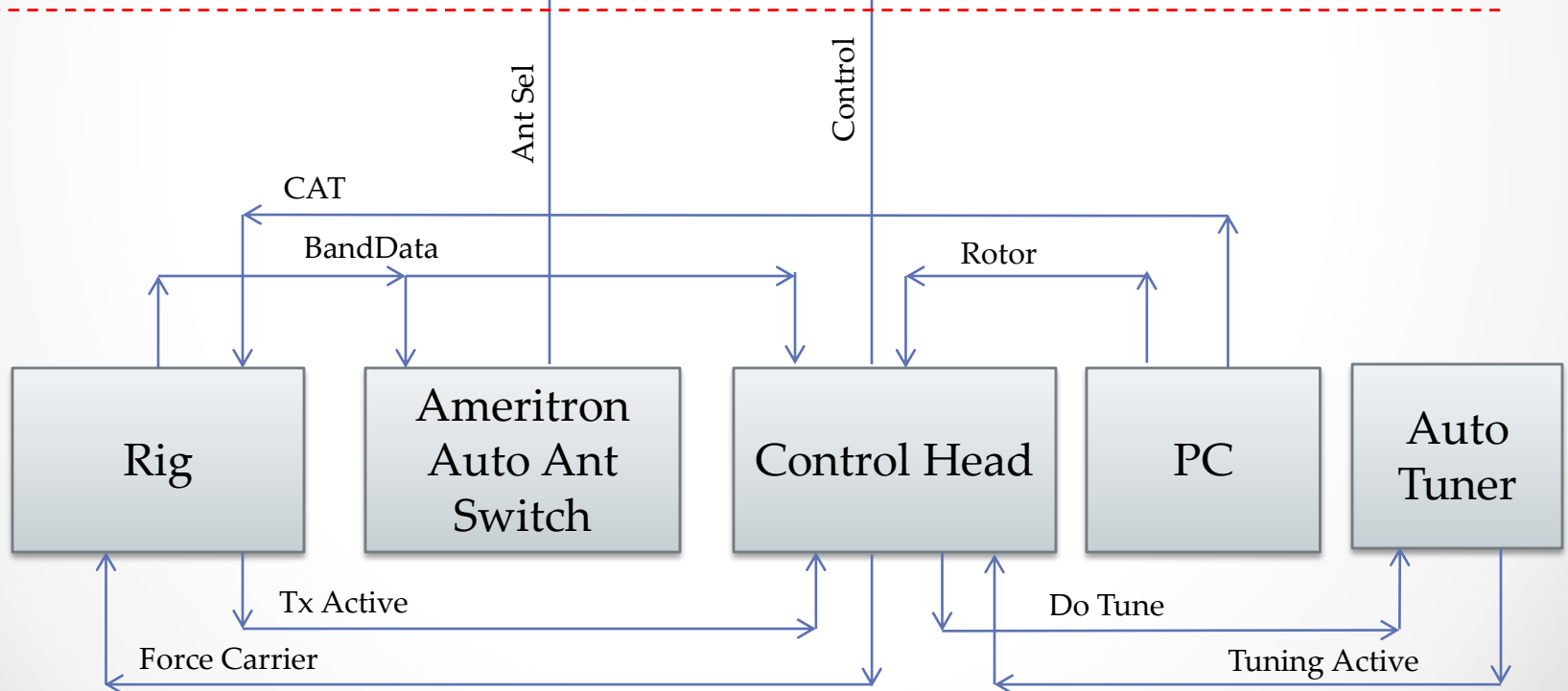
BAND	SEG E/W	CENTER F	ALL ITEMS SHORTED - ITEMS BELOW **OPEN**
160	18	1.825	DIP 40e 40w 30e 30w 20e 20c 12e
80	18	3.550	DIP 40E 40W 30e 30w 20e 20c 12e
40	1/5	7.025	40E 40w 30w 30e 20e 20c
30	9(11)	10.120	DIP 40E 30E 30W
20	31	14.050	20C
17	28	18.080	DIP 17m 12m 40w
15	28	21.050	15m DIP 12m 40E 40w
12E (open)	18	24.900	DIP 40e 40w - 15m, WEST - assumes 15m split in middle of DE
10E	28	24.200	15m 30E 30W 20E 12m - 15m, WEST

System Topology

ATTIC



SHACK

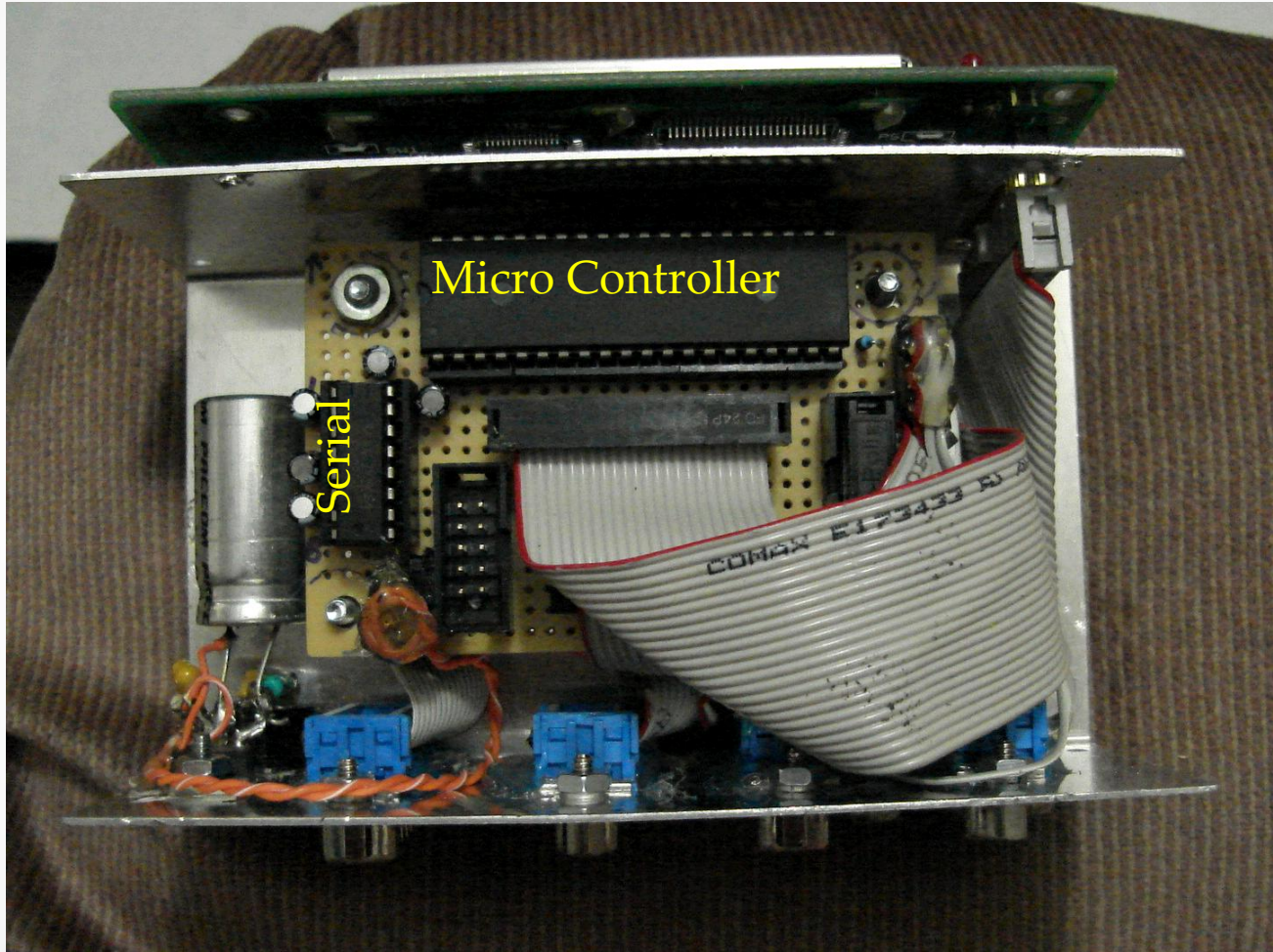


Hardware Implementation

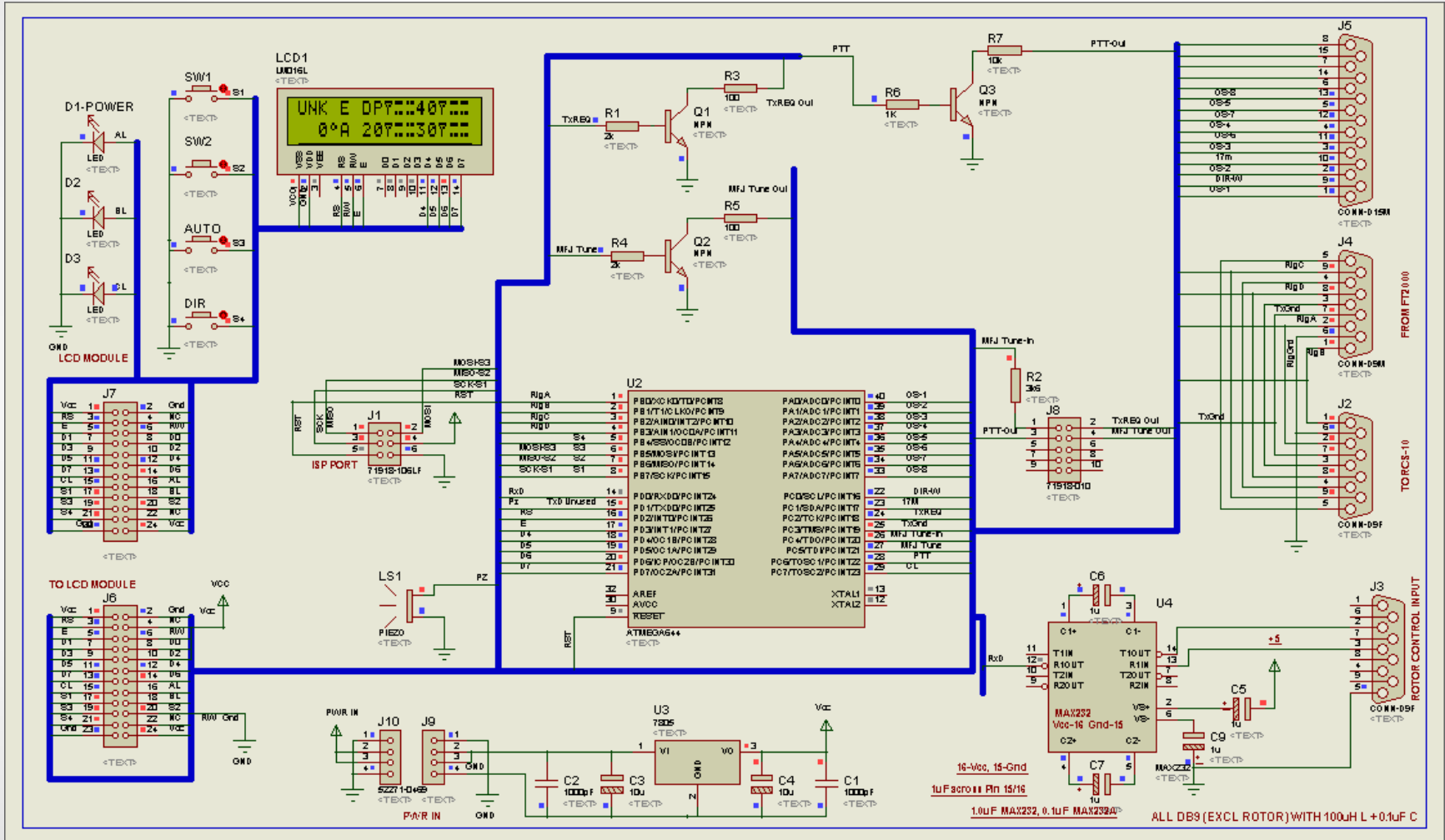
Shack Control Head Function



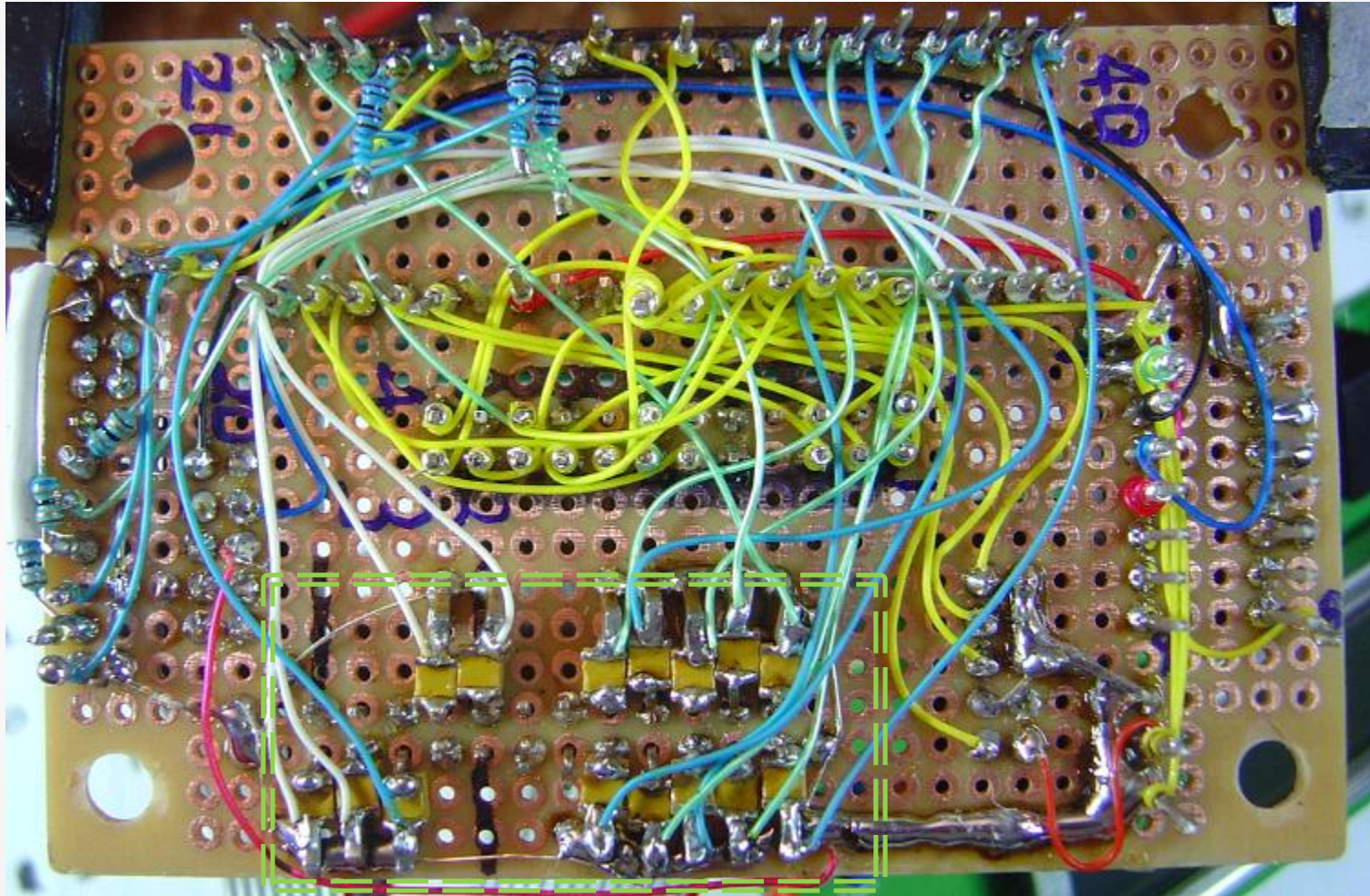
Shack Control Head



Shack Control Head

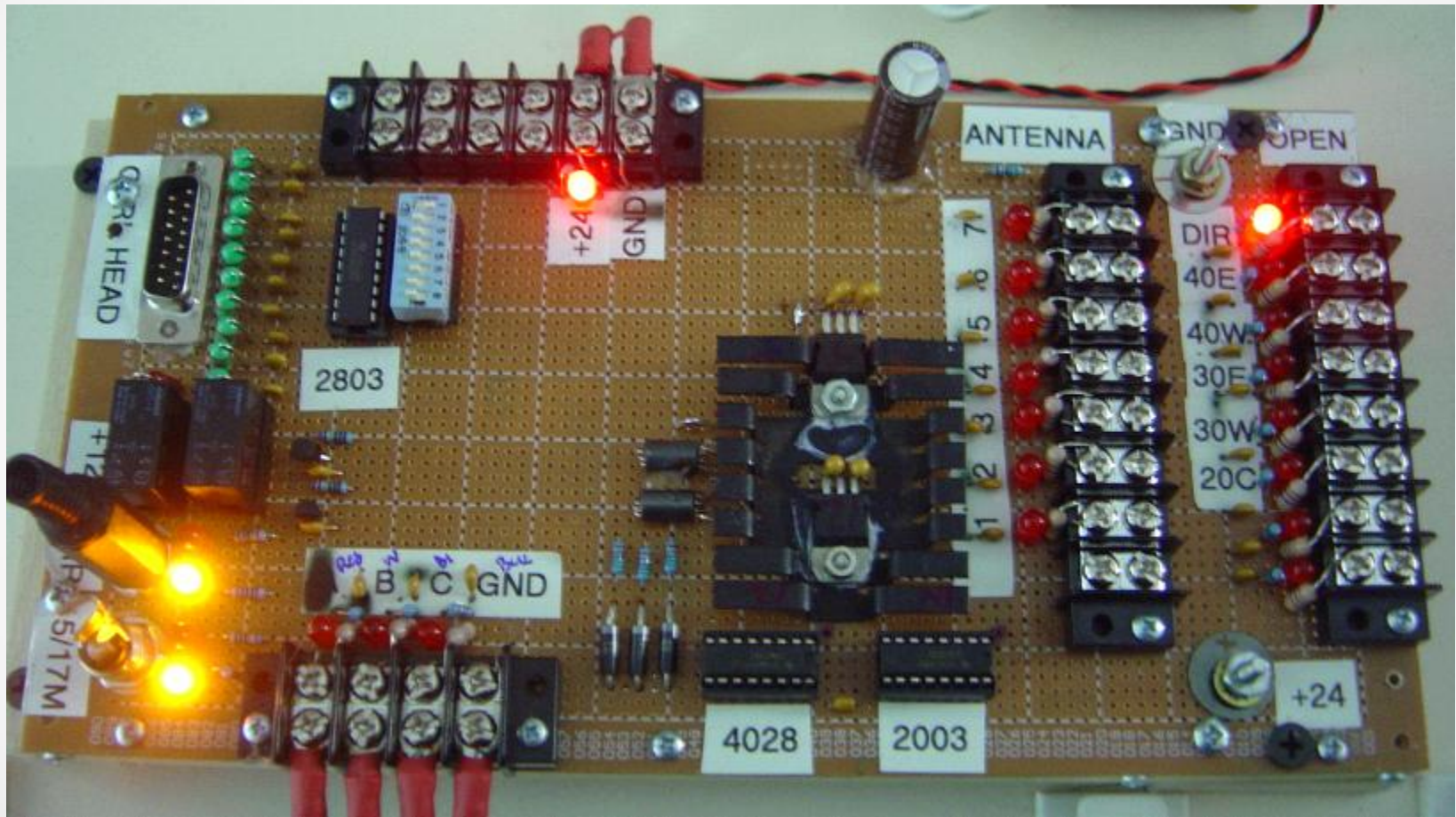


Shack Control Head

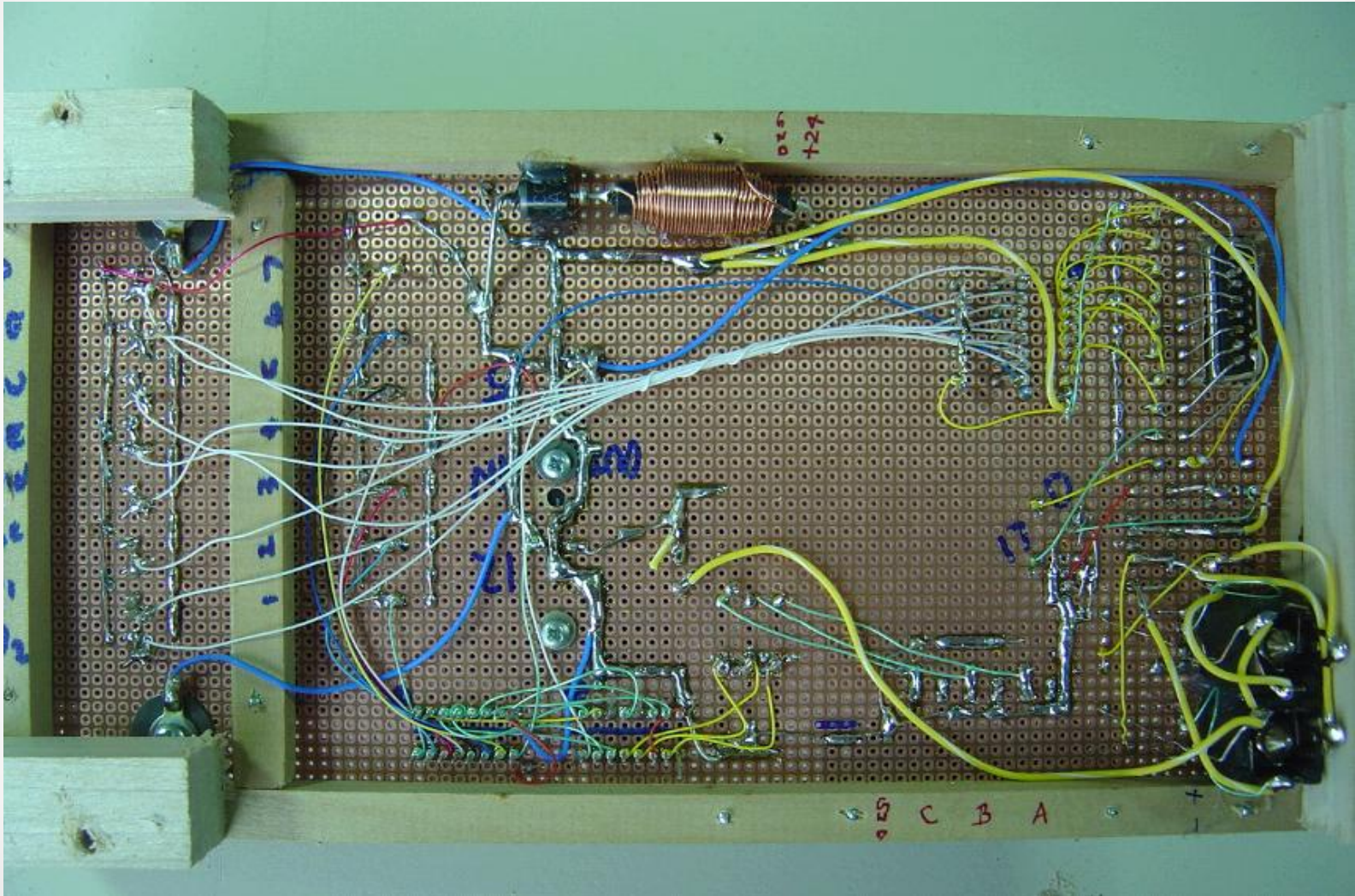


Green Dashed Box - L/C Bypass of Lines to Attic Relay Control Board

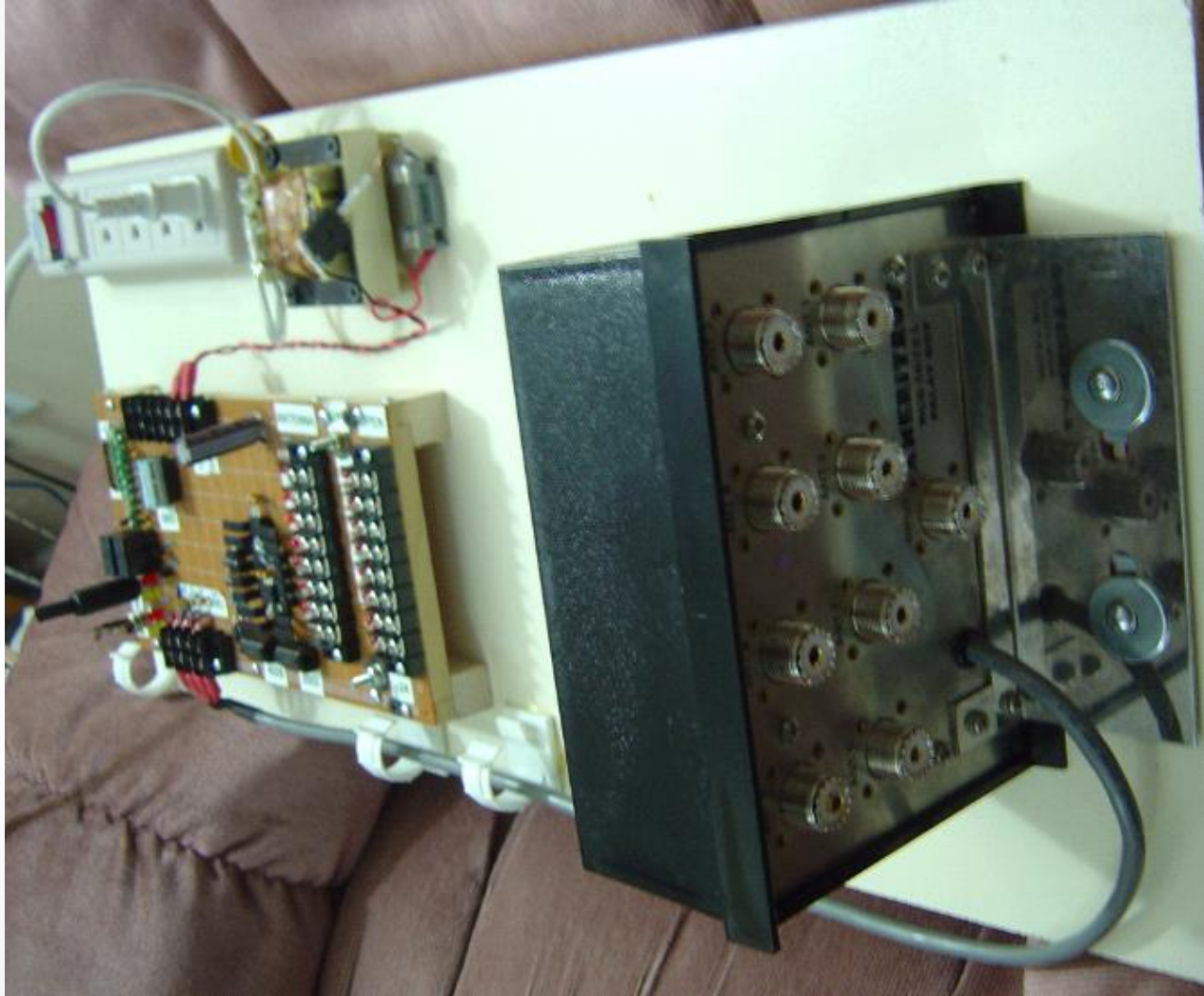
Relay Control Board



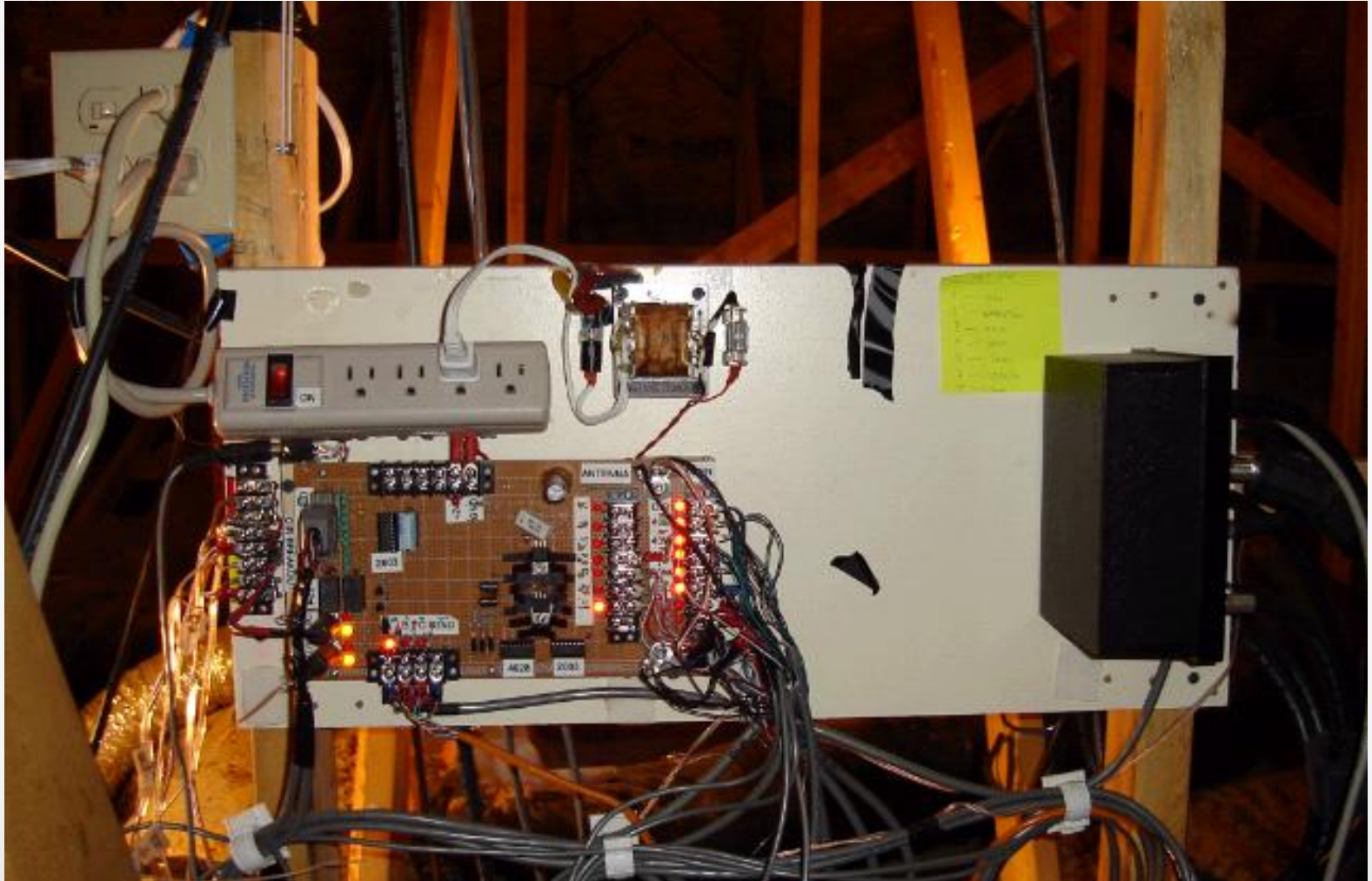
Relay Control Board



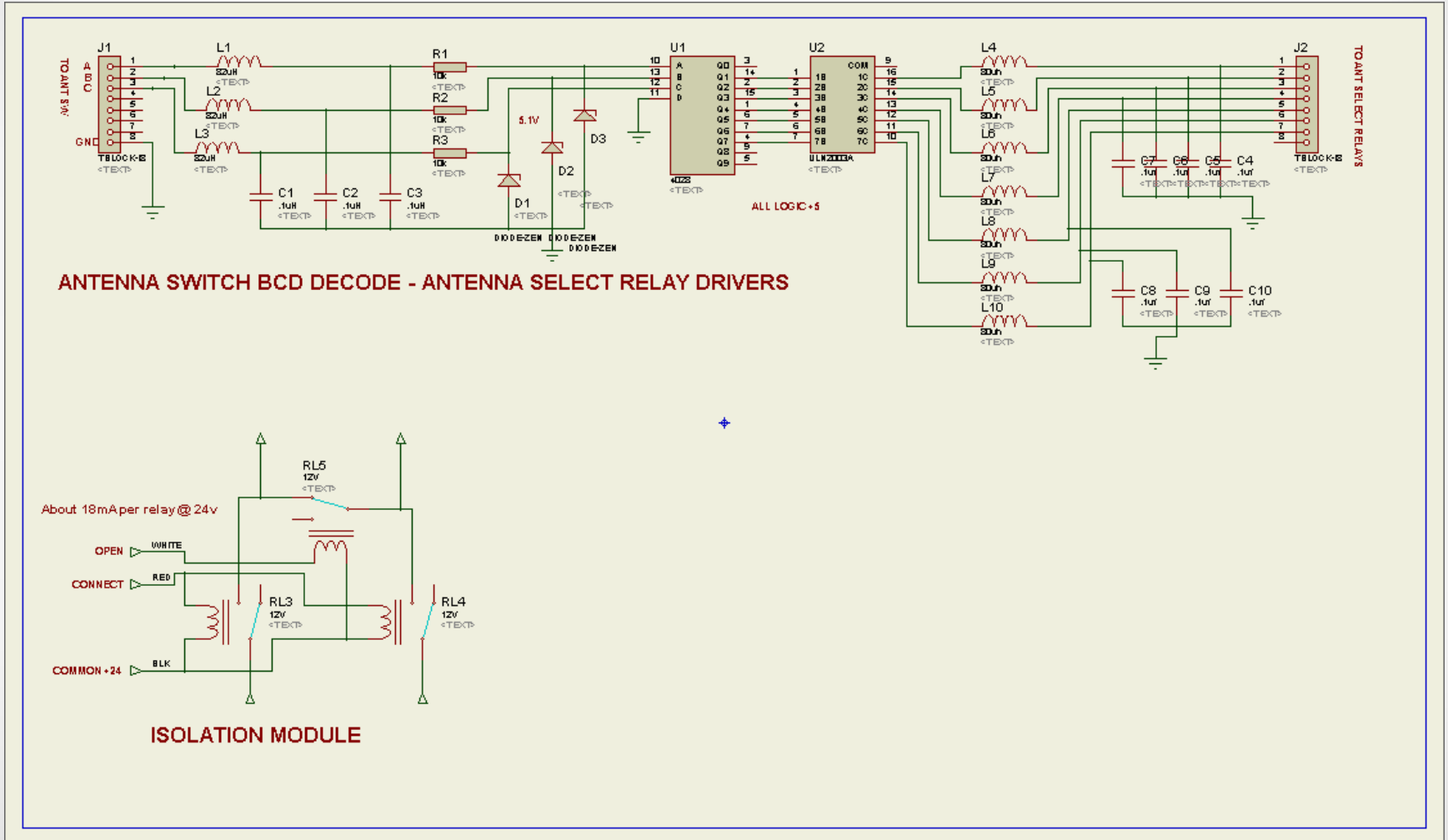
Relay Control Board



Relay Control Board

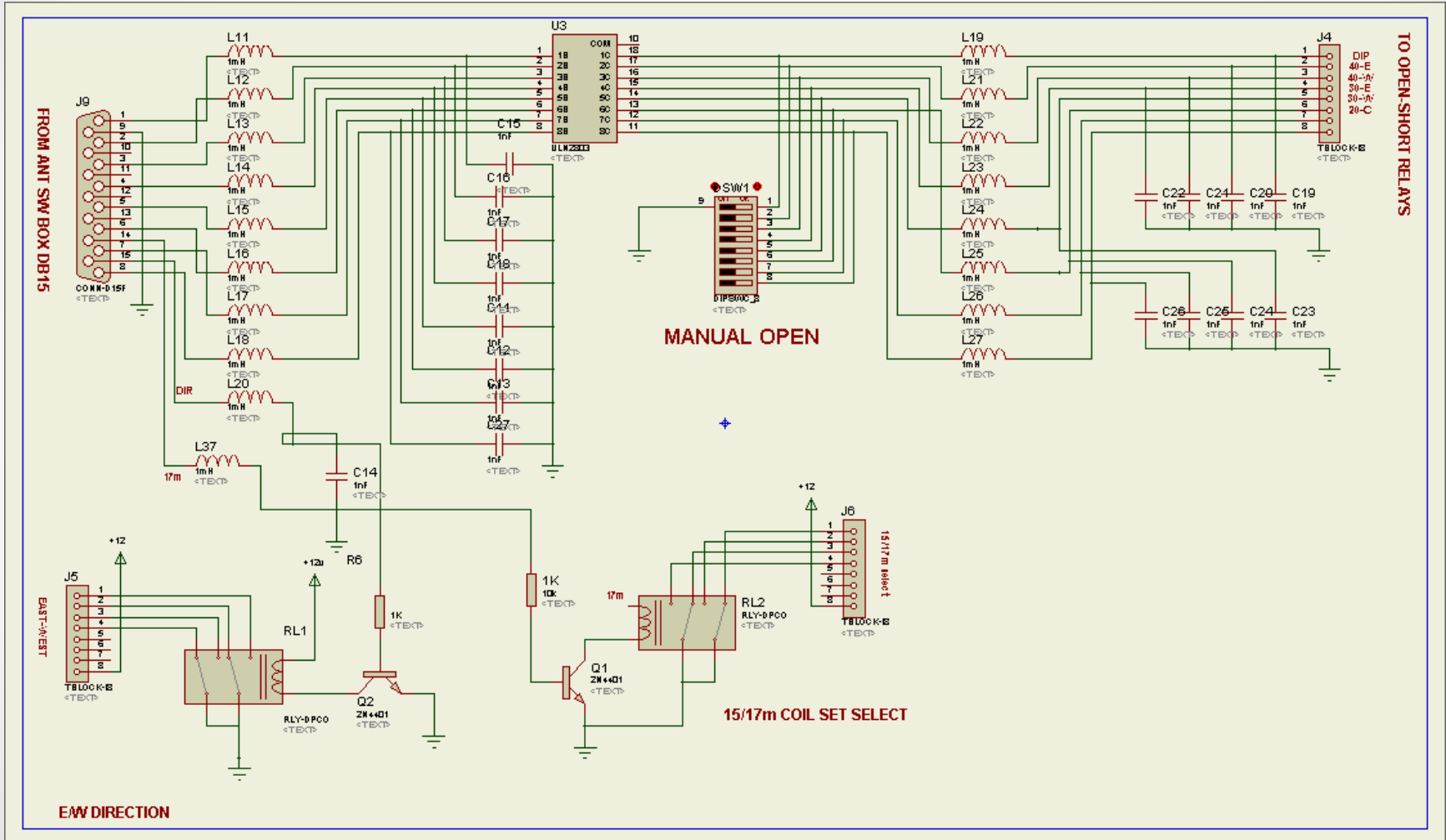


Relay Control Board



Antenna Select Decoding – From Ameritron Switch to Relay Control Board

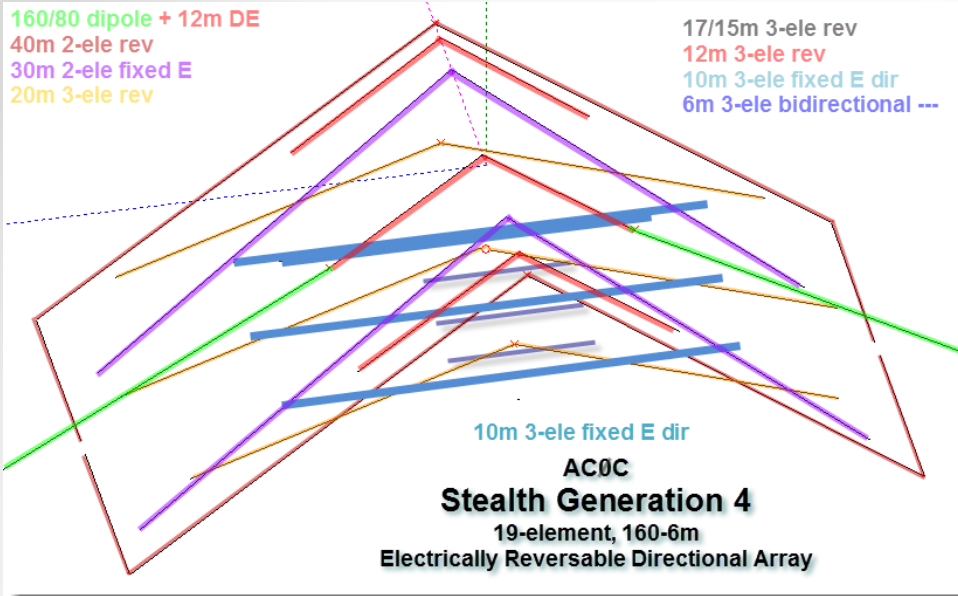
Relay Control Board



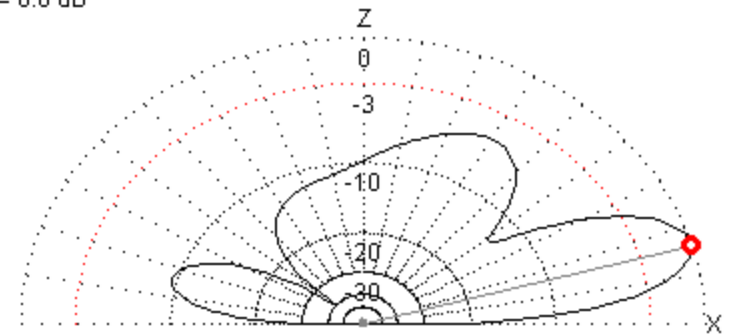
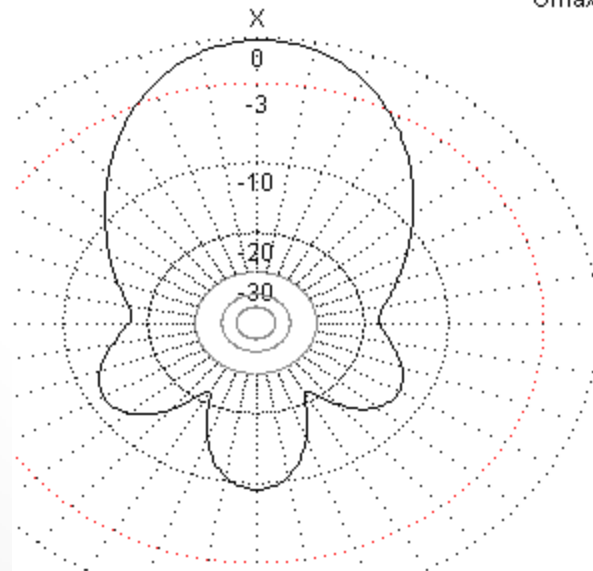
Open-Short, Direction and 15/17 Mode Schematic

Simulation Results and Construction Details

10m Simulation

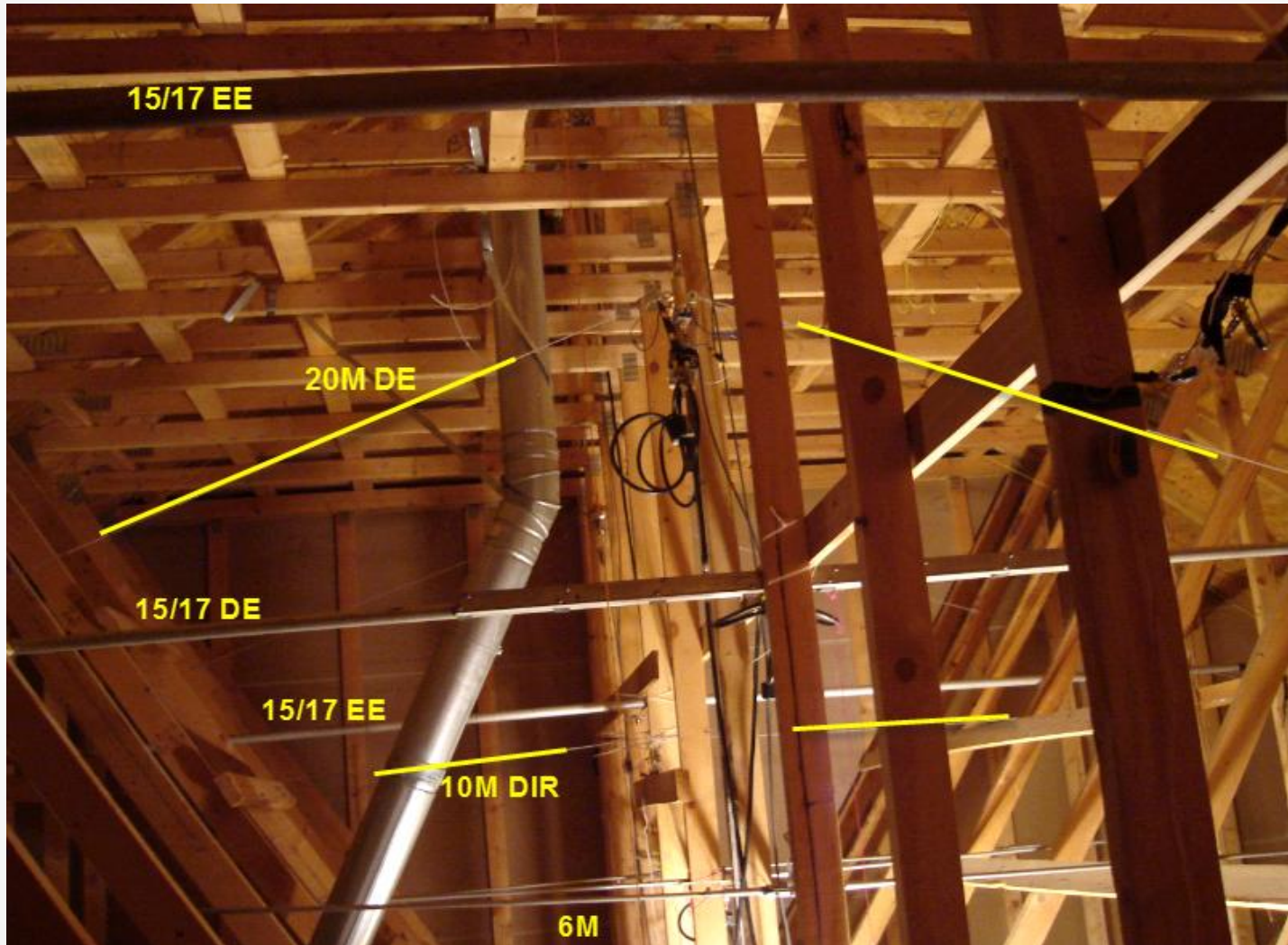


Elevation angle = 16dg
Ga = 11.6 dBi
Gmax - Ga = 0.0 dB

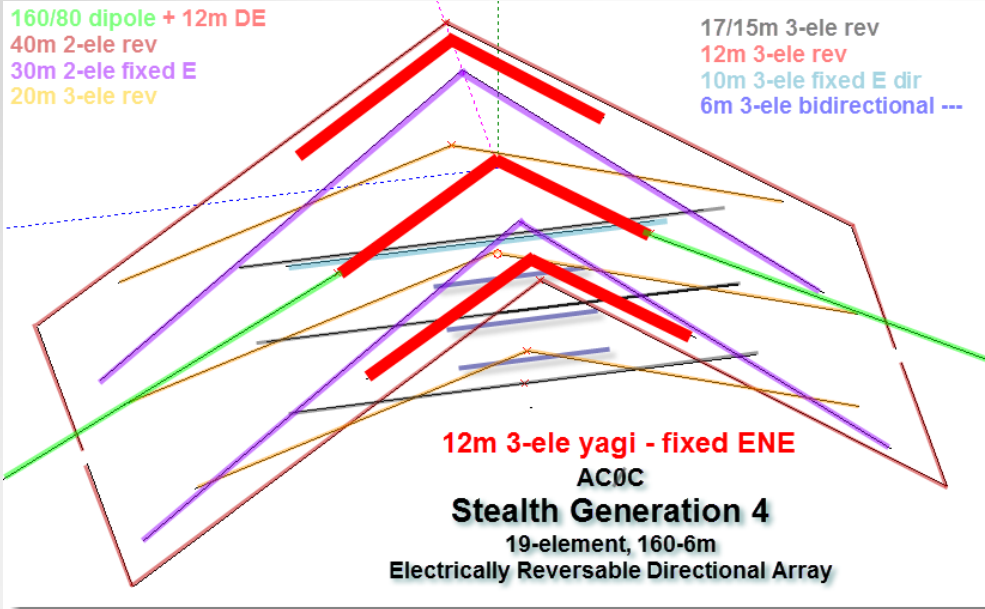


Ga : 11.63 dBi = 0 dB (Horizontal polarization)
F/B: 9.25 dB; Rear: Azim. 180 dg, Elev. 30 dg
Freq: 28.200 MHz
Z: 43.439 + j0.972 Ohm
SWR: 1.2 (50.0 Ohm),
Elev: 16.9 dg (Real GND :11.30 m height)

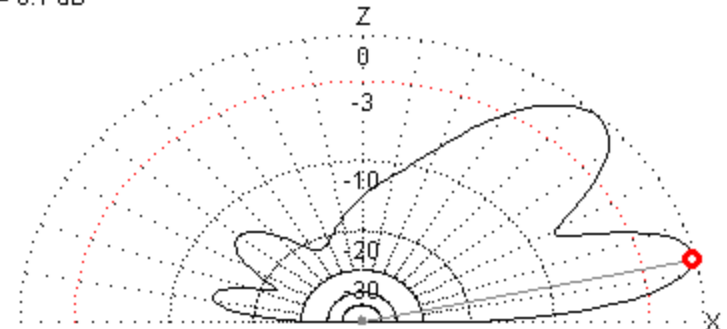
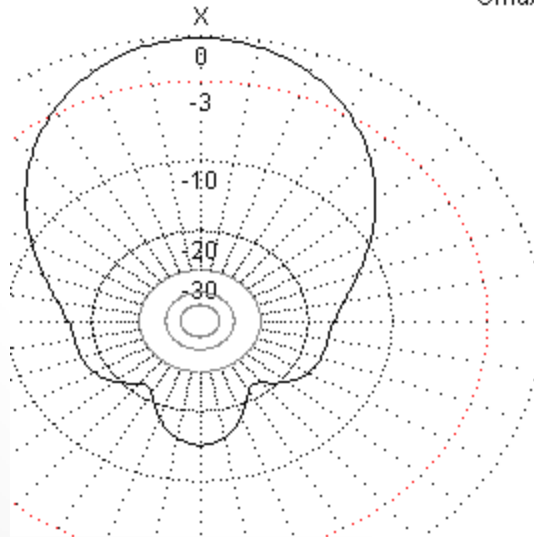
Attic View Facing East



12m Simulation



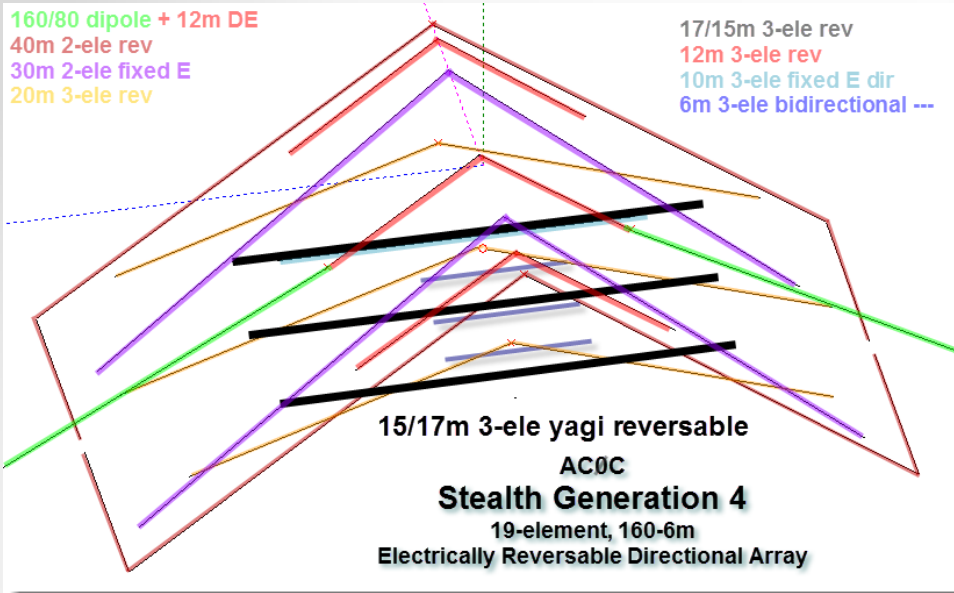
Elevation angle = 13dg
Ga = 8.3 dBi
Gmax - Ga = 0.1 dB



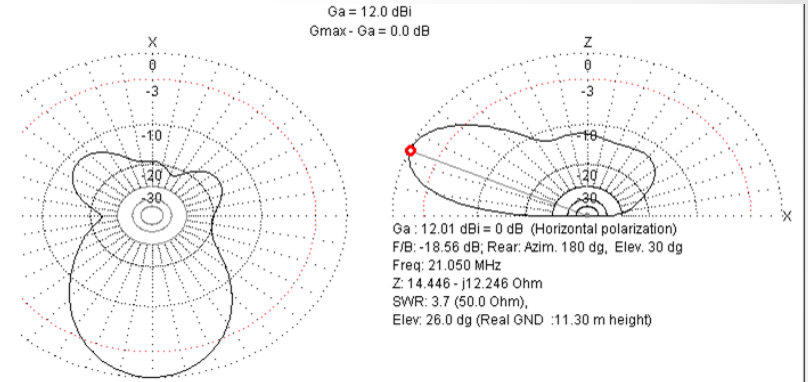
Ga : 8.35 dBi = 0 dB (Horizontal polarization)
F/B: 13.92 dB; Rear: Azim. 180 dg, Elev. 30 dg
Freq: 24.900 MHz
Z: 27.450 - j1.665 Ohm
SWR: 1.8 (50.0 Ohm),
Elev: 46.6 dg (Real GND :11.30 m height)

160/80 dipole + 12m DE
 40m 2-ele rev
 30m 2-ele fixed E
 20m 3-ele rev

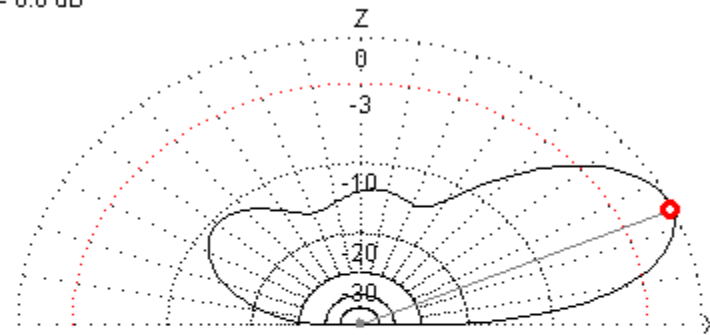
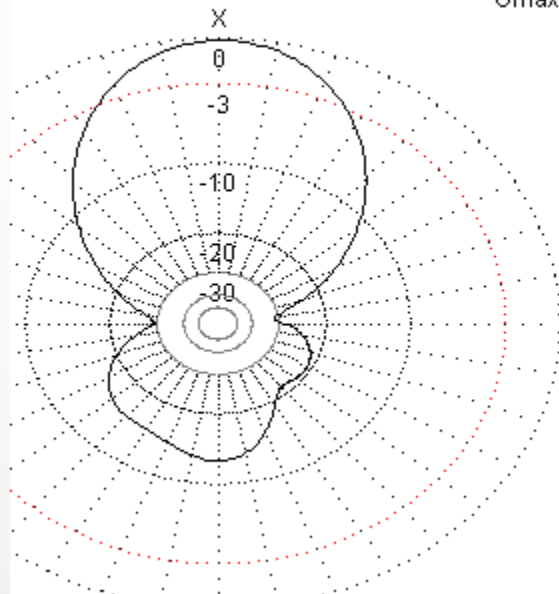
17/15m 3-ele rev
 12m 3-ele rev
 10m 3-ele fixed E dir
 6m 3-ele bidirectional ---



15m Simulation

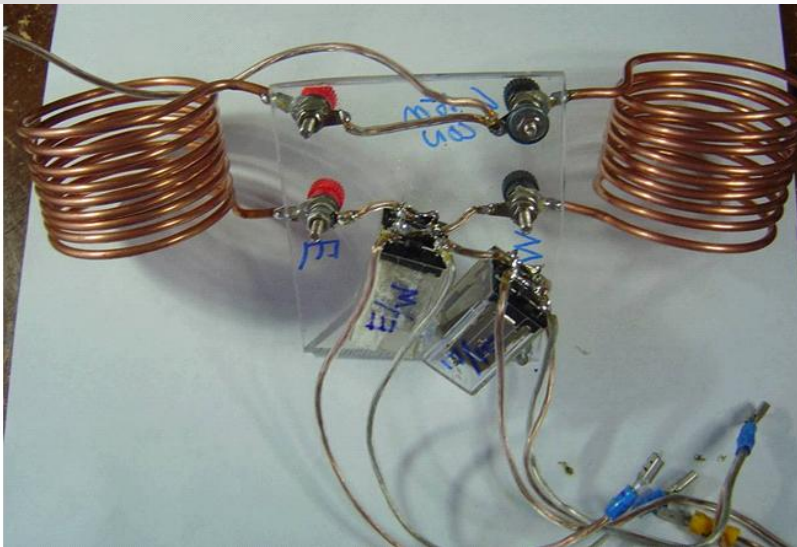


Elevation angle = 24dg
 Ga = 12.1 dBi
 Gmax - Ga = 0.0 dB

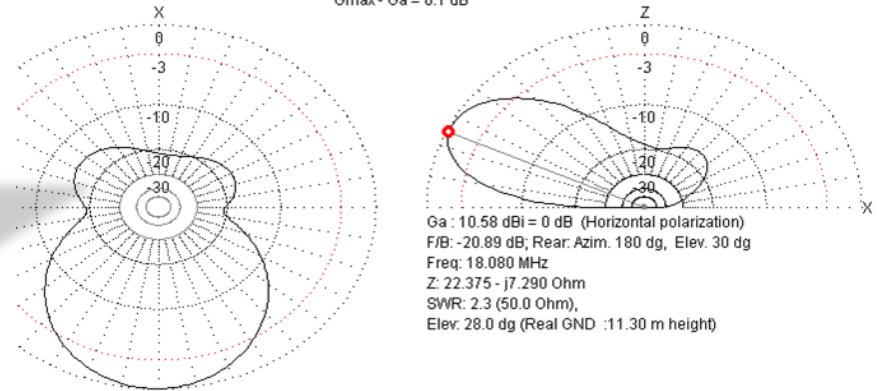


Ga : 12.14 dBi = 0 dB (Horizontal polarization)
 F/B: 11.44 dB; Rear: Azim. 180 dg, Elev. 30 dg
 Freq: 21.050 MHz
 Z: 20.918 - j8.657 Ohm
 SWR: 2.5 (50.0 Ohm),
 Elev: 25.4 dg (Real GND :11.30 m height)

17m Simulation

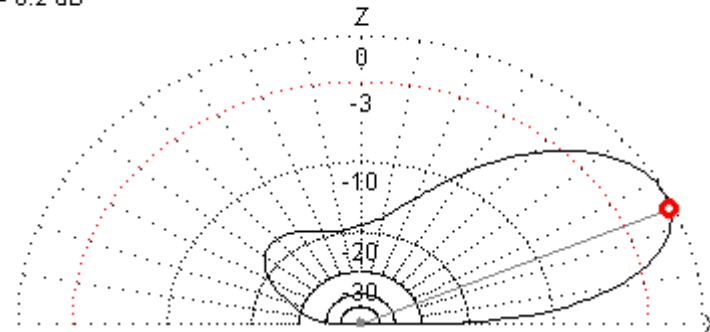
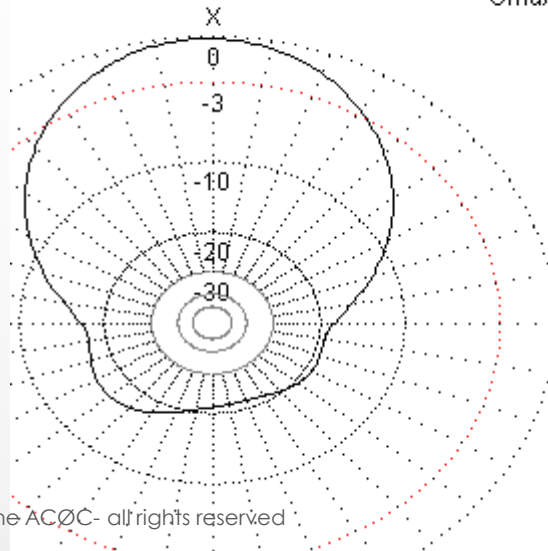


Elevation angle = 155dg
Ga = 10.5 dBi
Gmax - Ga = 0.1 dB



Ga : 10.58 dBi = 0 dB (Horizontal polarization)
F/B: -20.89 dB; Rear: Azim. 180 dg, Elev. 30 dg
Freq: 18.080 MHz
Z: 22.375 - j7.290 Ohm
SWR: 2.3 (50.0 Ohm),
Elev: 28.0 dg (Real GND :11.30 m height)

Elevation angle = 24dg
Ga = 10.7 dBi
Gmax - Ga = 0.2 dB



Ga : 10.85 dBi = 0 dB (Horizontal polarization)
F/B: 15.94 dB; Rear: Azim. 180 dg, Elev. 30 dg
Freq: 18.080 MHz
Z: 13.549 + j4.841 Ohm
SWR: 3.7 (50.0 Ohm),
Elev: 27.7 dg (Real GND :11.30 m height)

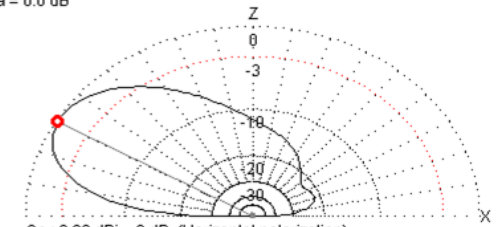
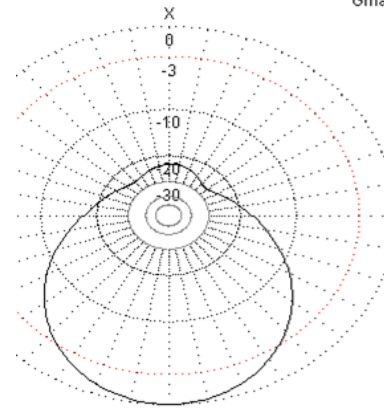
160/80 dipole + 12m DE
 40m 2-ele rev
 30m 2-ele fixed E
 20m 3-ele rev

17/15m 3-ele rev
 12m 3-ele rev
 10m 3-ele fixed E dir
 6m 3-ele bidirectional ---

20m 3-ele reversible yagi
 ACØC
Stealth Generation 4
 19-element, 160-6m
 Electrically Reversible Directional Array

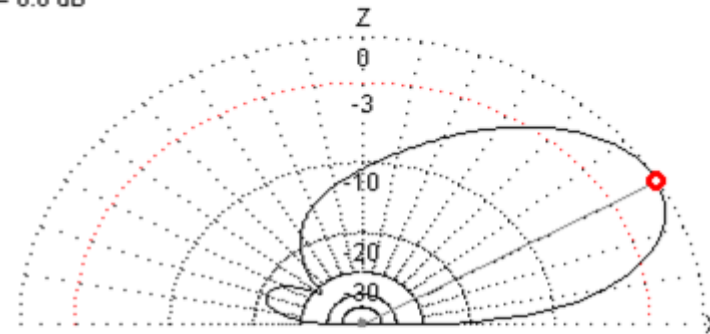
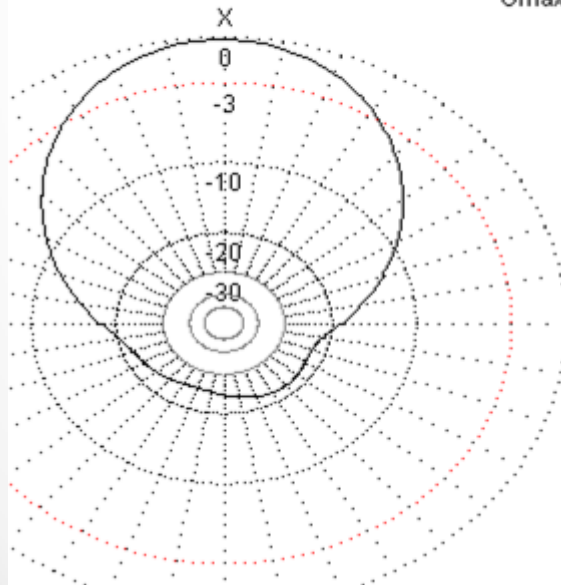
20m Simulation

Elevation angle = 150dg
 Ga = 9.8 dBi
 Gmax - Ga = 0.0 dB



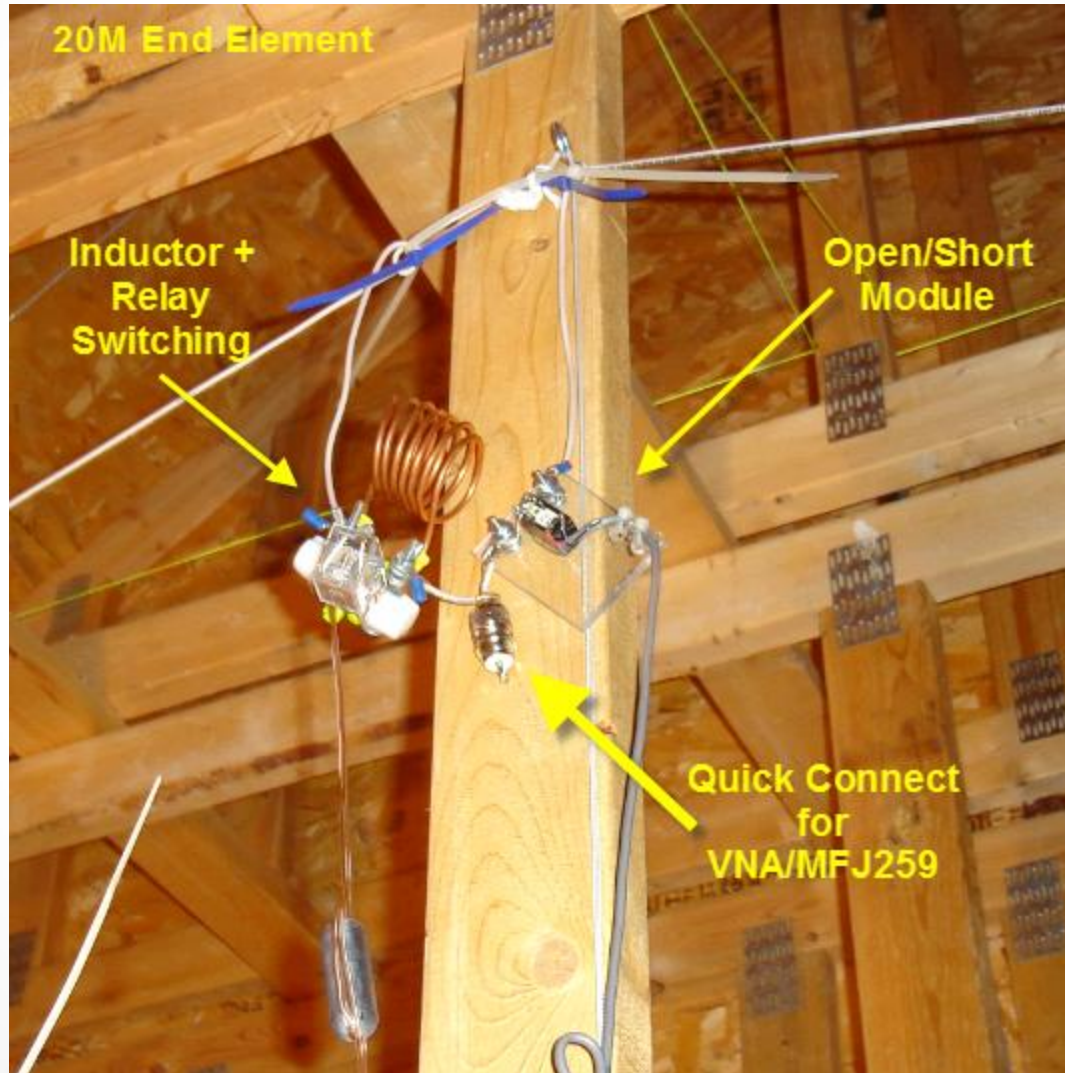
Ga : 9.83 dBi = 0 dB (Horizontal polarization)
 F/B: -22.24 dB; Rear: Azim. 180 dg, Elev. 30 dg
 Freq: 14.050 MHz
 Z: 38.484 - j3.184 Ohm
 SWR: 1.3 (50.0 Ohm),
 Elev: 32.0 dg (Real GND :11.30 m height)

Elevation angle = 30dg
 Ga = 9.9 dBi
 Gmax - Ga = 0.0 dB



Ga : 9.97 dBi = 0 dB (Horizontal polarization)
 F/B: 17.50 dB; Rear: Azim. 180 dg, Elev. 30 dg
 Freq: 14.050 MHz
 Z: 21.280 + j18.891 Ohm
 SWR: 2.7 (50.0 Ohm),
 Elev: 31.9 dg (Real GND :11.30 m height)

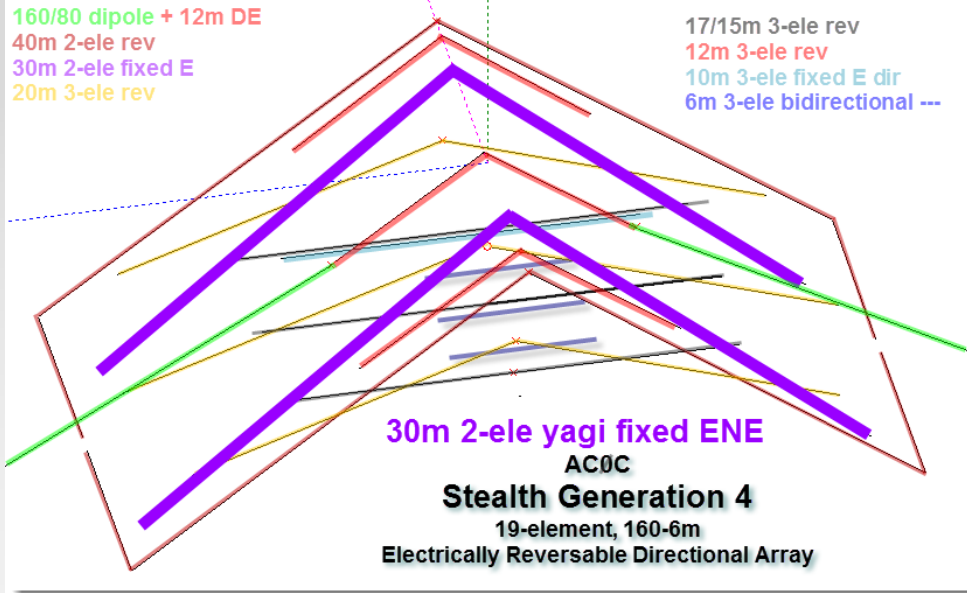
20m End Element Detail



30m Simulation

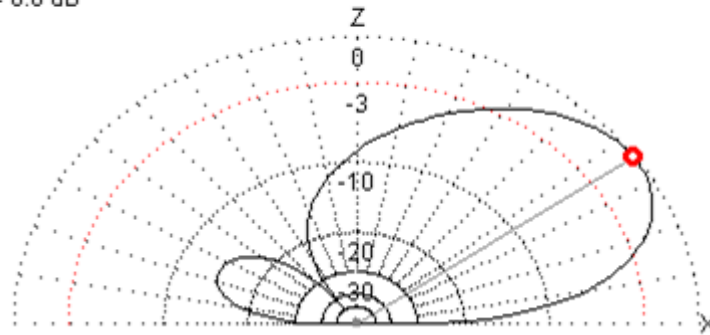
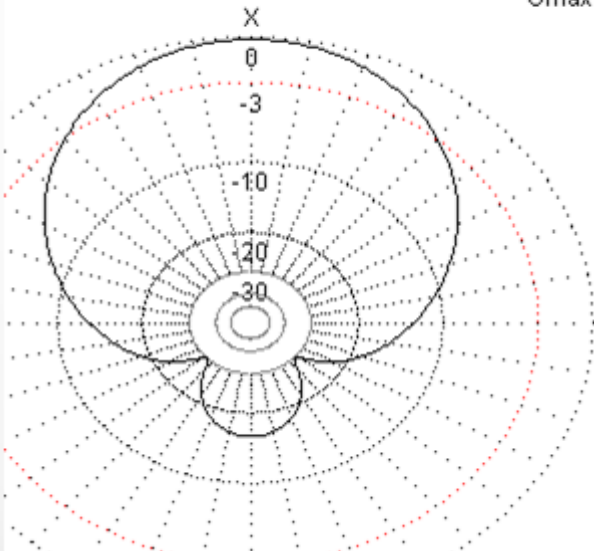
160/80 dipole + 12m DE
 40m 2-ele rev
 30m 2-ele fixed E
 20m 3-ele rev

17/15m 3-ele rev
 12m 3-ele rev
 10m 3-ele fixed E dir
 6m 3-ele bidirectional ---



30m 2-ele yagi fixed ENE
 ACØC
Stealth Generation 4
 19-element, 160-6m
 Electrically Reversible Directional Array

Elevation angle = 36dg
 Ga = 8.9 dBi
 Gmax - Ga = 0.0 dB



Ga : 8.86 dBi = 0 dB (Horizontal polarization)
 F/B: 12.92 dB; Rear: Azim. 180 dg, Elev. 30 dg
 Freq: 10.120 MHz
 Z: 12.875 - j0.262 Ohm
 SWR: 3.9 (50.0 Ohm),
 Elev: 36.1 dg (Real GND :11.30 m height)

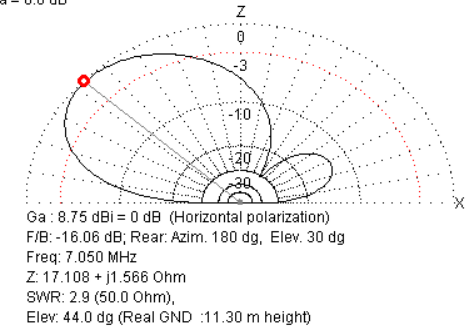
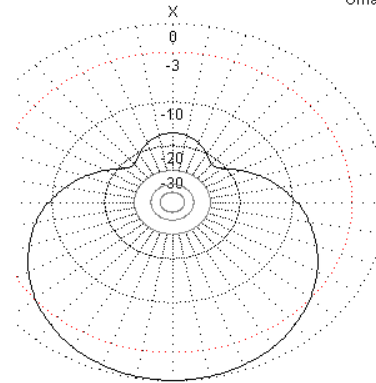
160/80 dipole + 12m DE
 40m 2-ele rev
 30m 2-ele fixed E
 20m 3-ele rev

17/15m 3-ele rev
 12m 3-ele rev
 10m 3-ele fixed E dir
 6m 3-ele bidirectional ---

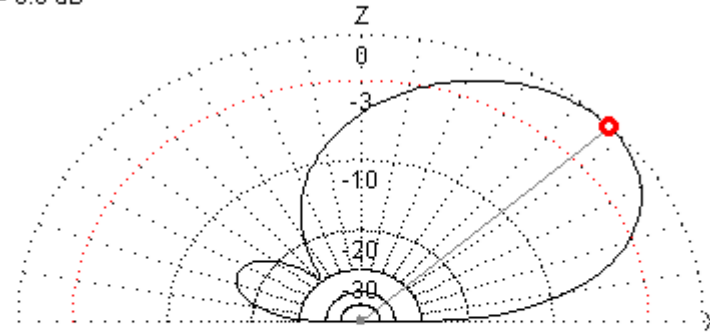
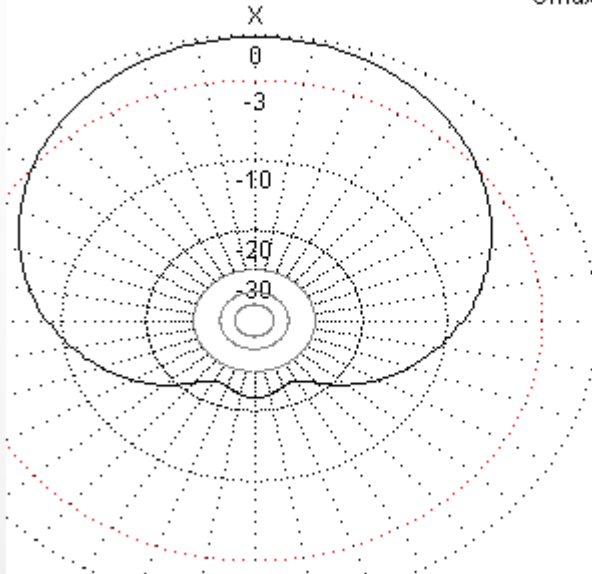
40m 2-ele yagi reversible ENE
 ACØC
Stealth Generation 4
 19-element, 160-6m
 Electrically Reversible Directional Array

40m Simulation

Elevation angle = 137 dg
 Ga = 8.8 dBi
 Gmax - Ga = 0.0 dB

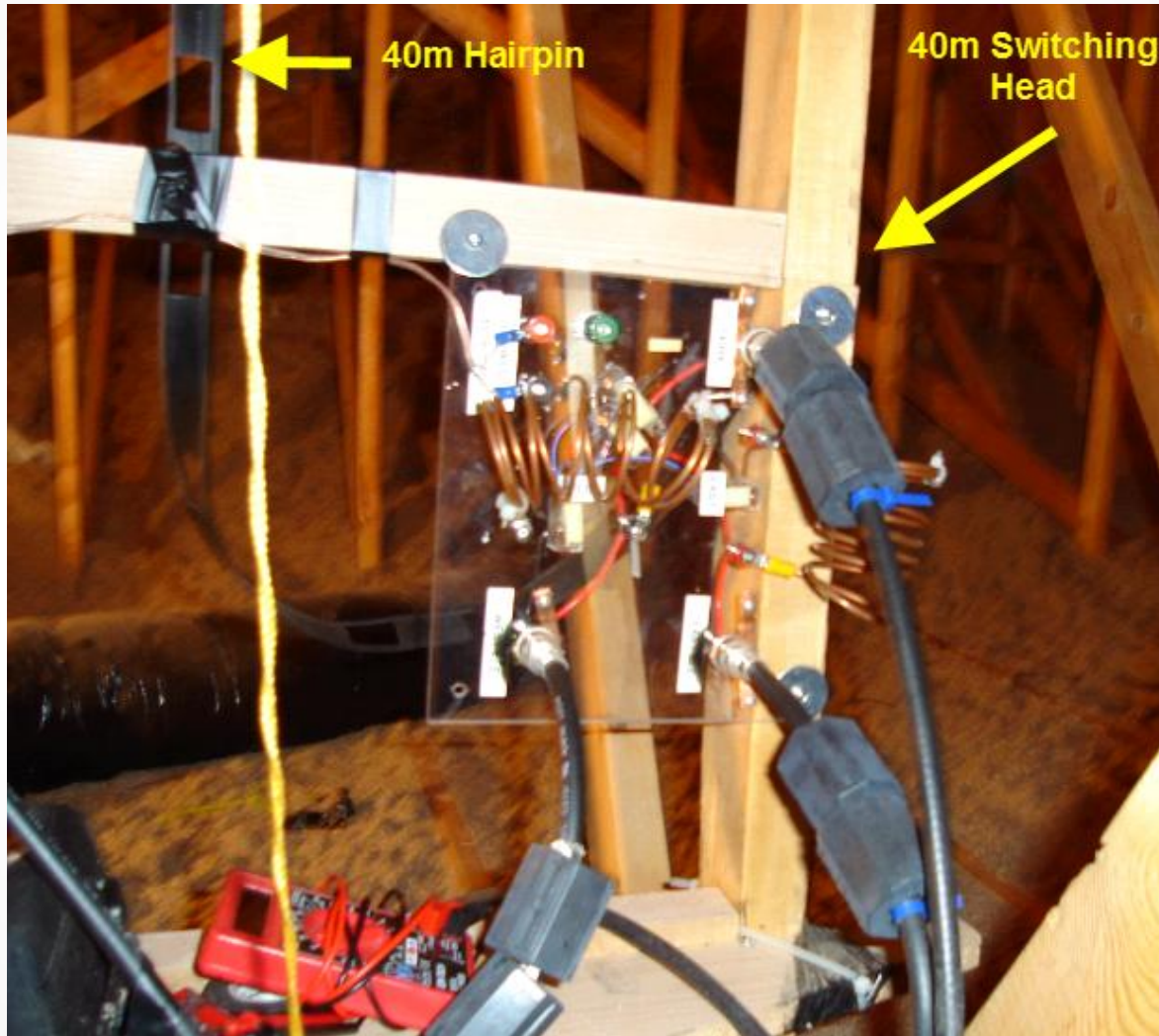


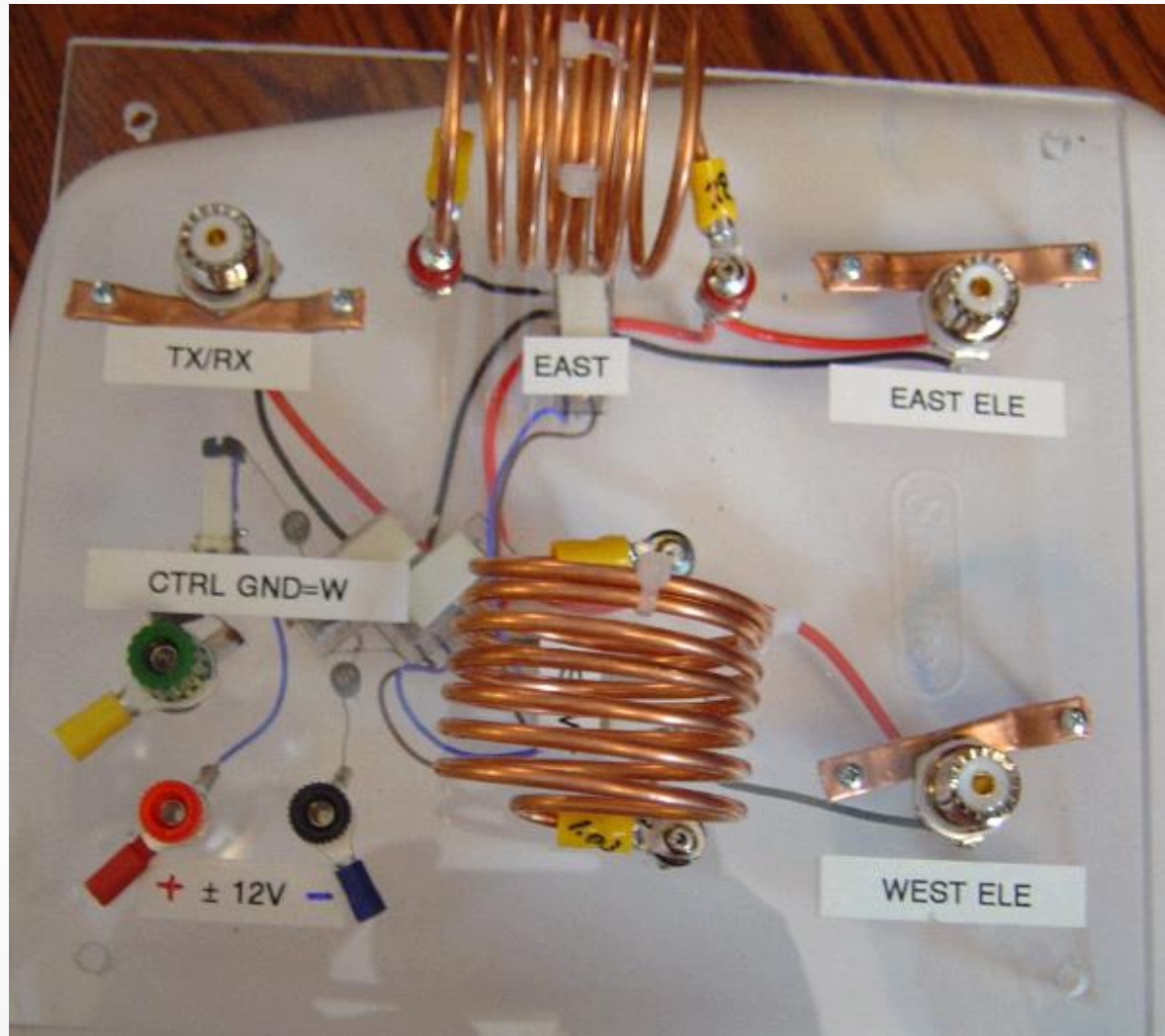
Elevation angle = 43 dg
 Ga = 8.6 dBi
 Gmax - Ga = 0.0 dB

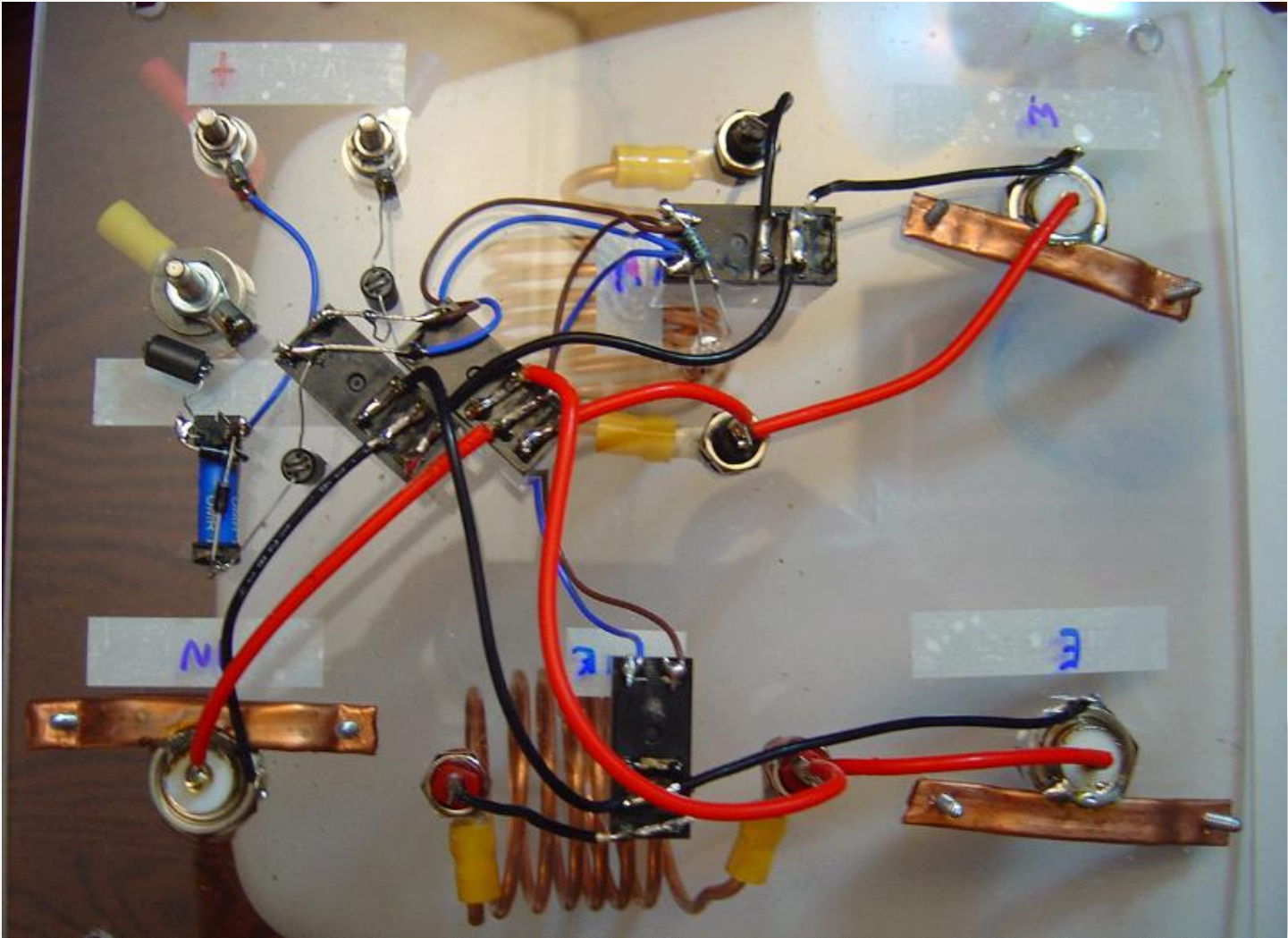


Ga : 8.6 dBi = 0 dB (Horizontal polarization)
 F/B: 8.61 dB; Rear: Azim. 180 dg, Elev. 30 dg
 Freq: 7.050 MHz
 Z: 20.998 + j1.659 Ohm
 SWR: 2.4 (50.0 Ohm),
 Elev: 44.9 dg (Real GND :11.30 m height)

40m Direction Switching Head

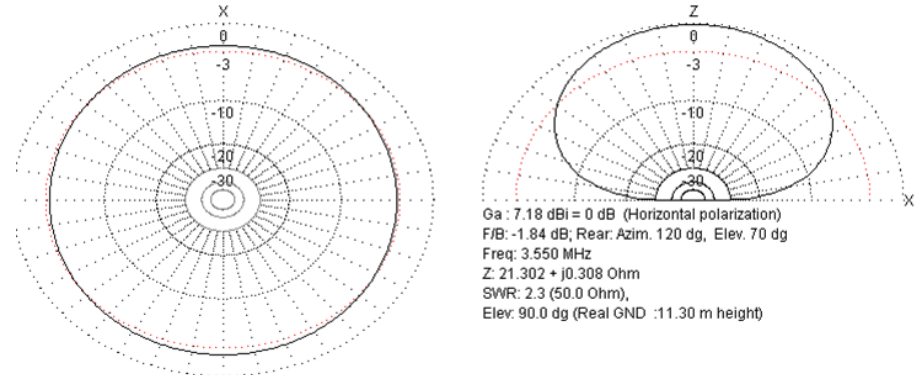
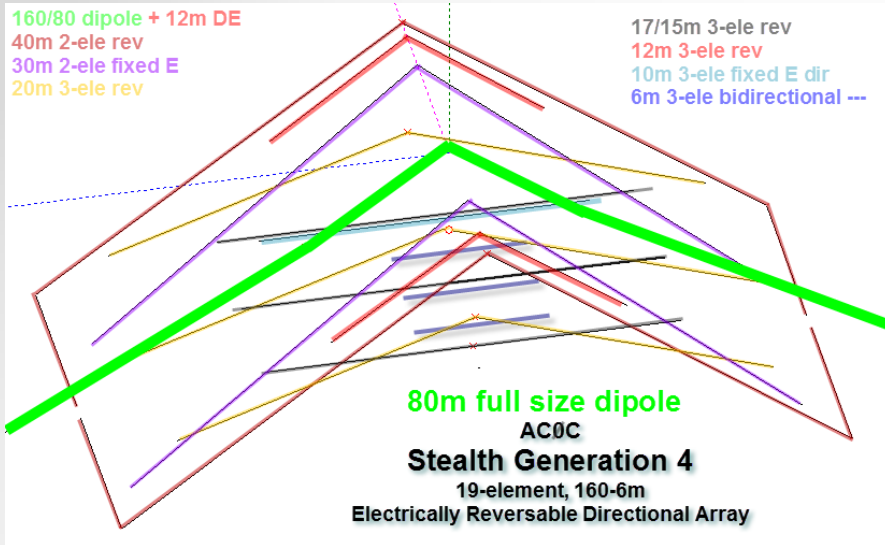




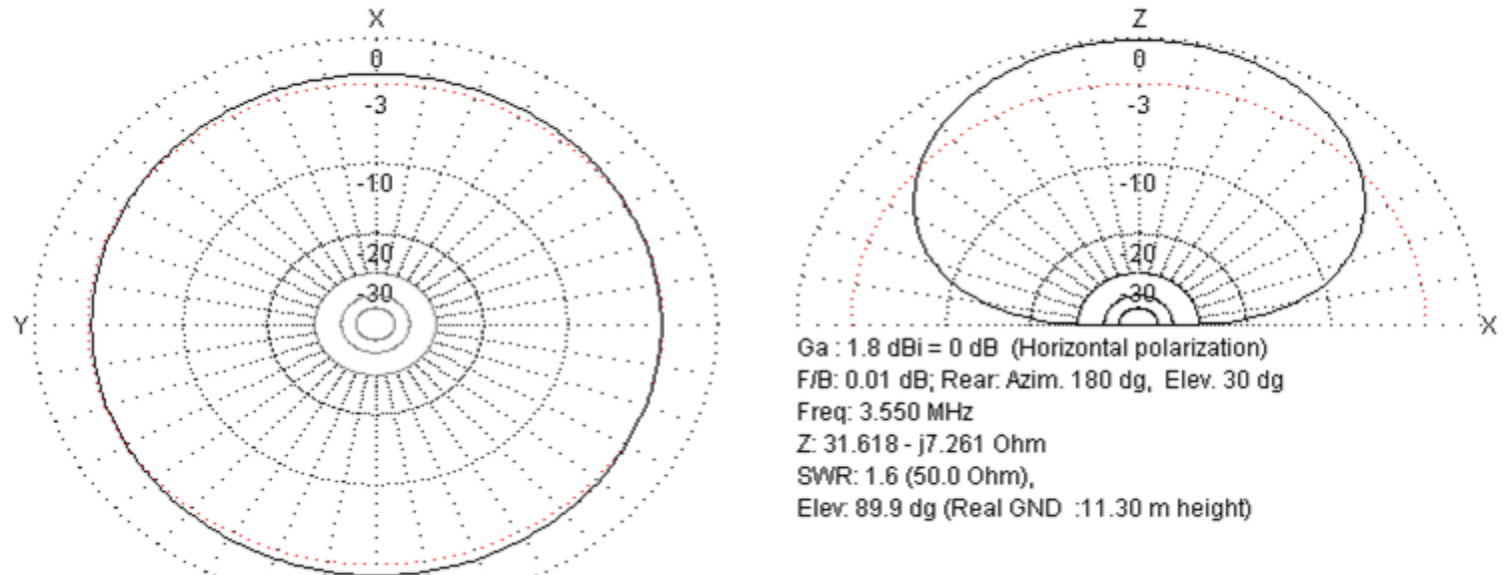


80m Simulation

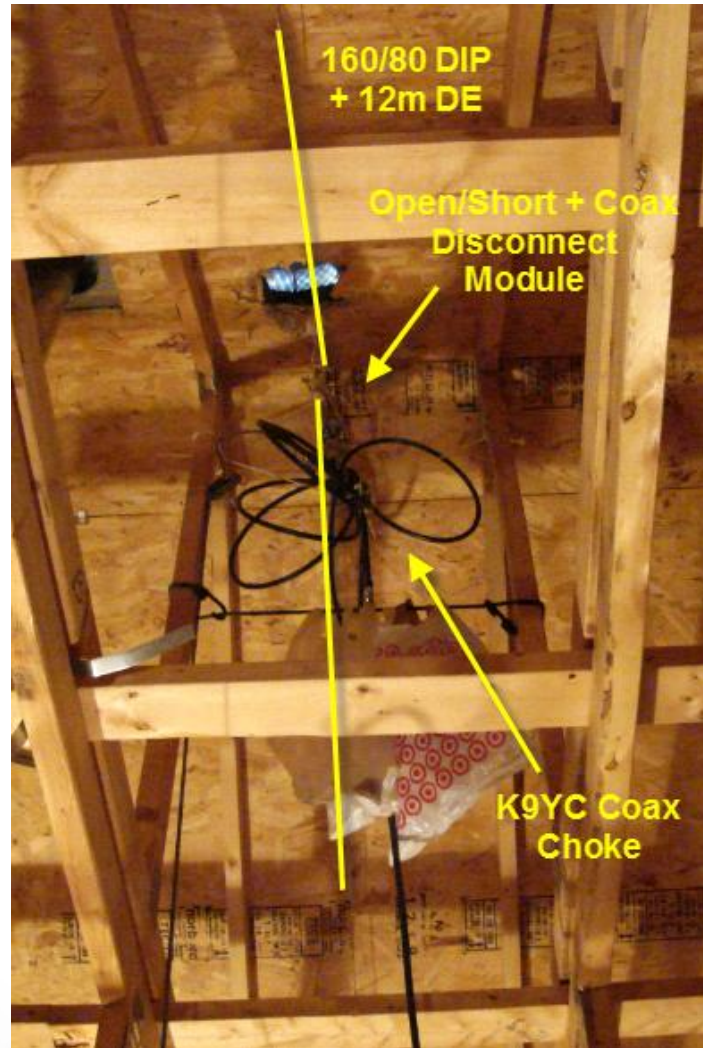
Comparison with free-standing, complete V shape at same height – 6db delta



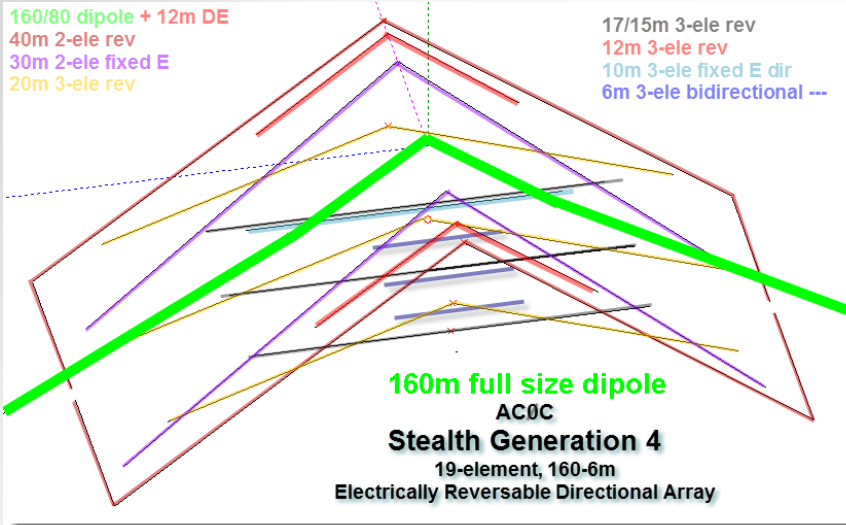
+90 dg



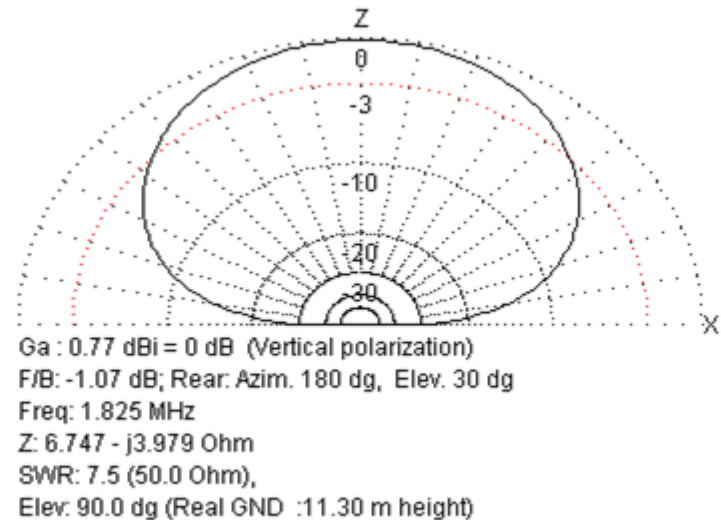
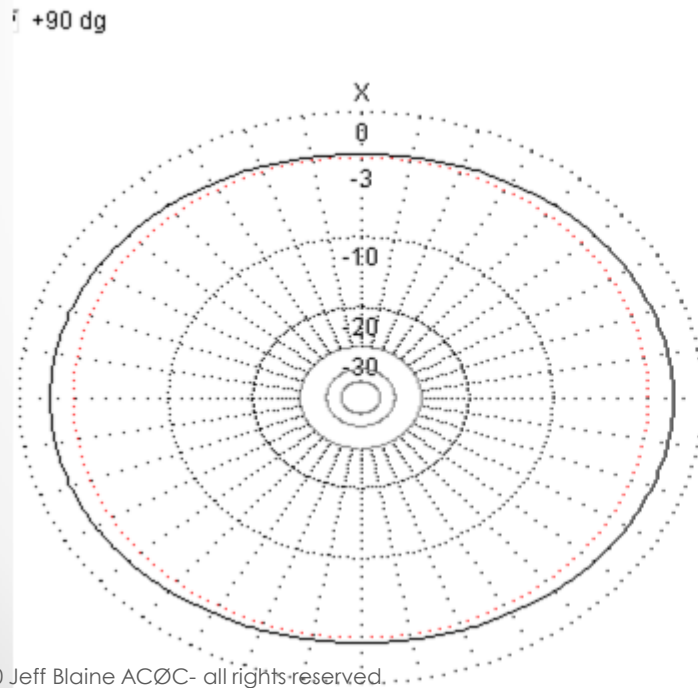
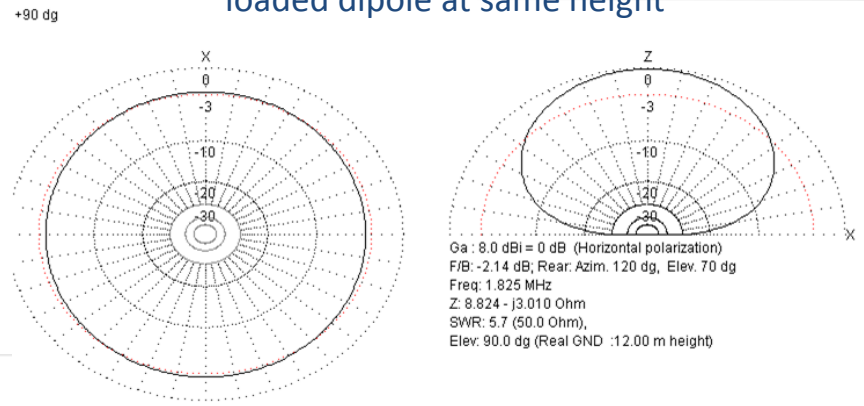
160/80m Dipole + 12m DE Detail



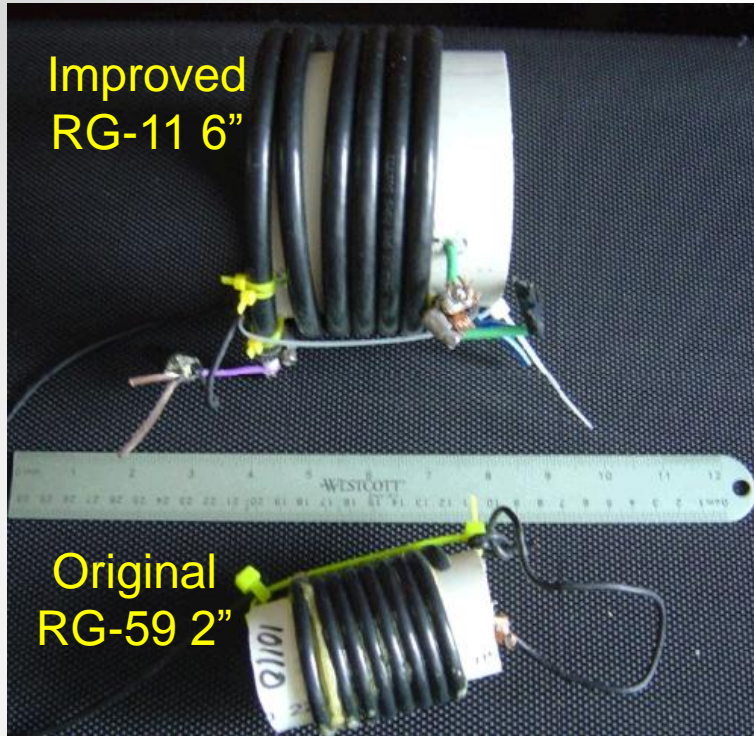
160m Simulation



Comparison to free standing 160m loaded dipole at same height



3rd Gen Trap Evolution



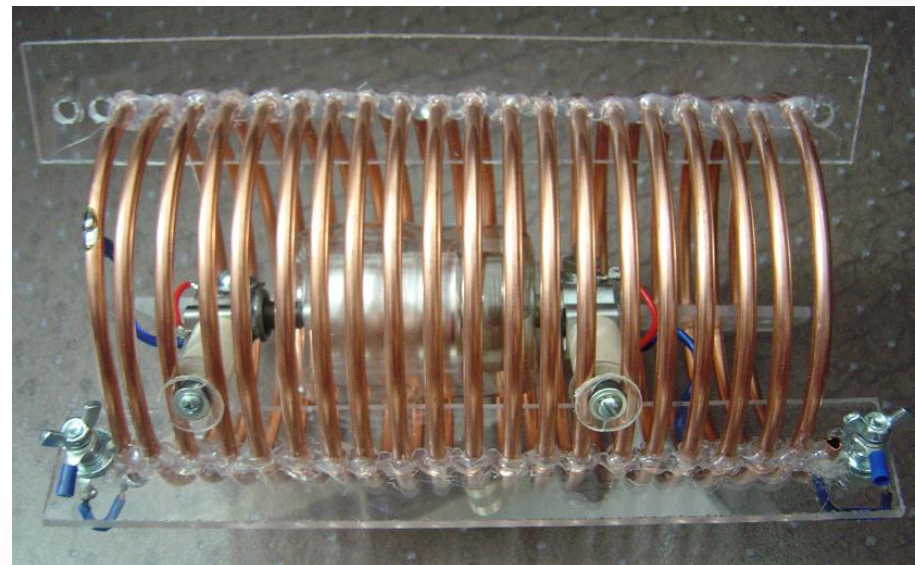
New 80m Trap + 160m Loading Coil Construction Details

1/4 " copper tubing

6" diameter form

1/4" lexan separators

15 Kv 100 pF fixed vac cap

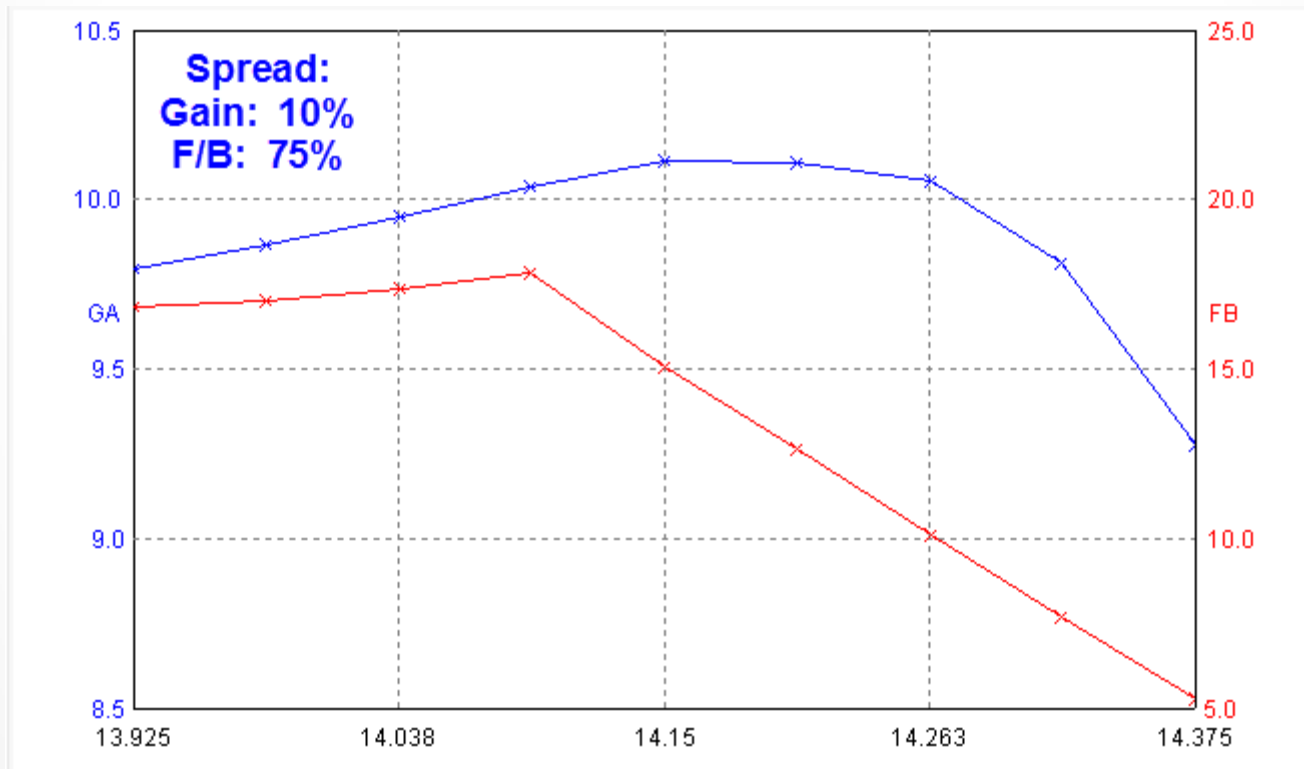


Remaining Work

- **DX (high RDF best) & Contesting (low RDF best)**
Putting F/B vs. Gain Sensitivity into Context?
- Measure antenna element phasing & interactions between antenna sets
 - W8WWV 2008 Dayton Antenna Forum Method
A New Approach for Measuring Complex Antenna Currents in Vertical Arrays
- Measure actual field pattern
 - W8WWV 2010 Dayton Antenna Forum Method
Exotic Antenna Pattern Measurement
- Backlight for LCD & new enclosure

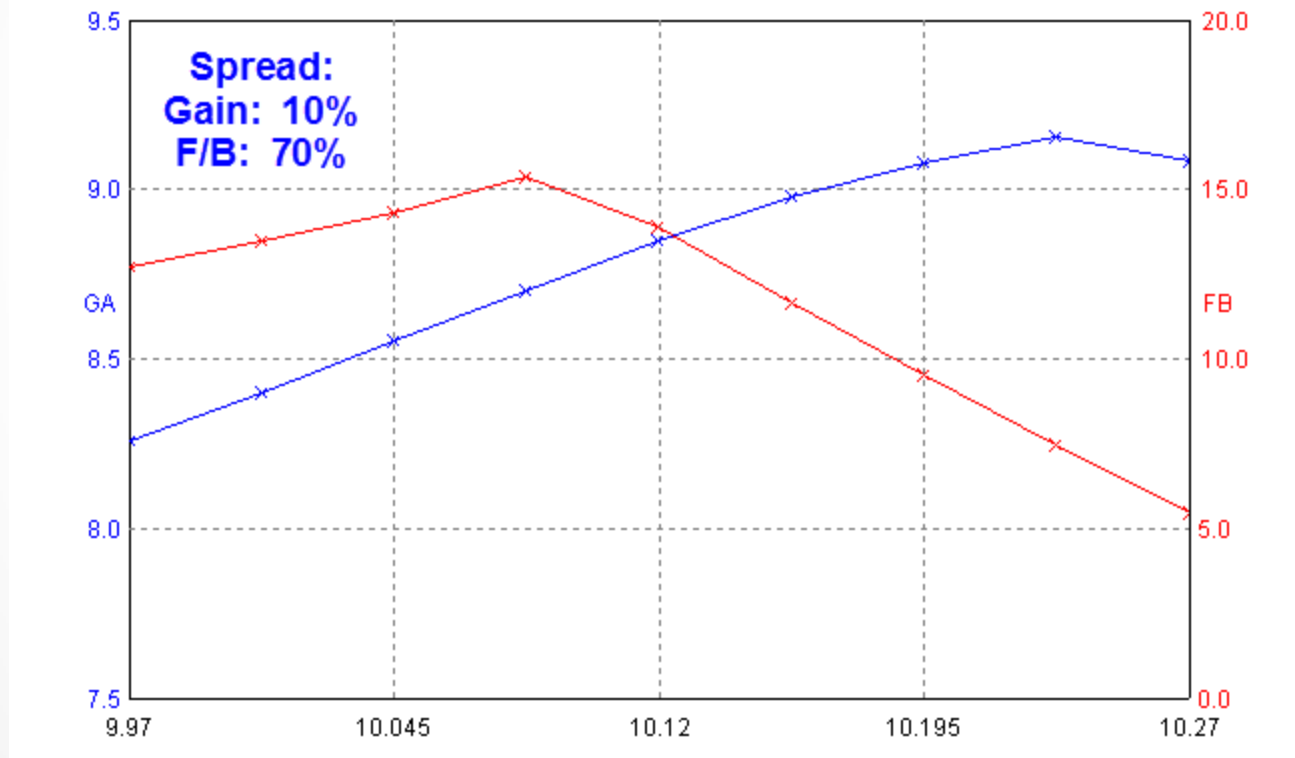
F/B vs. Gain Sensitivity

- 20m Example



F/B vs. Gain Sensitivity

- 30m Example



- Putting F/B vs. Gain Sensitivity into Context
- **Measure antenna element phasing & interactions between antenna sets**
 - **W8WWV 2008 Dayton Antenna Forum Method**
A New Approach for Measuring Complex Antenna Currents in Vertical Arrays
- Measure actual field pattern
 - W8WWV 2010 Dayton Antenna Forum Method
Exotic Antenna Pattern Measurement
- Backlight for LCD & new enclosure

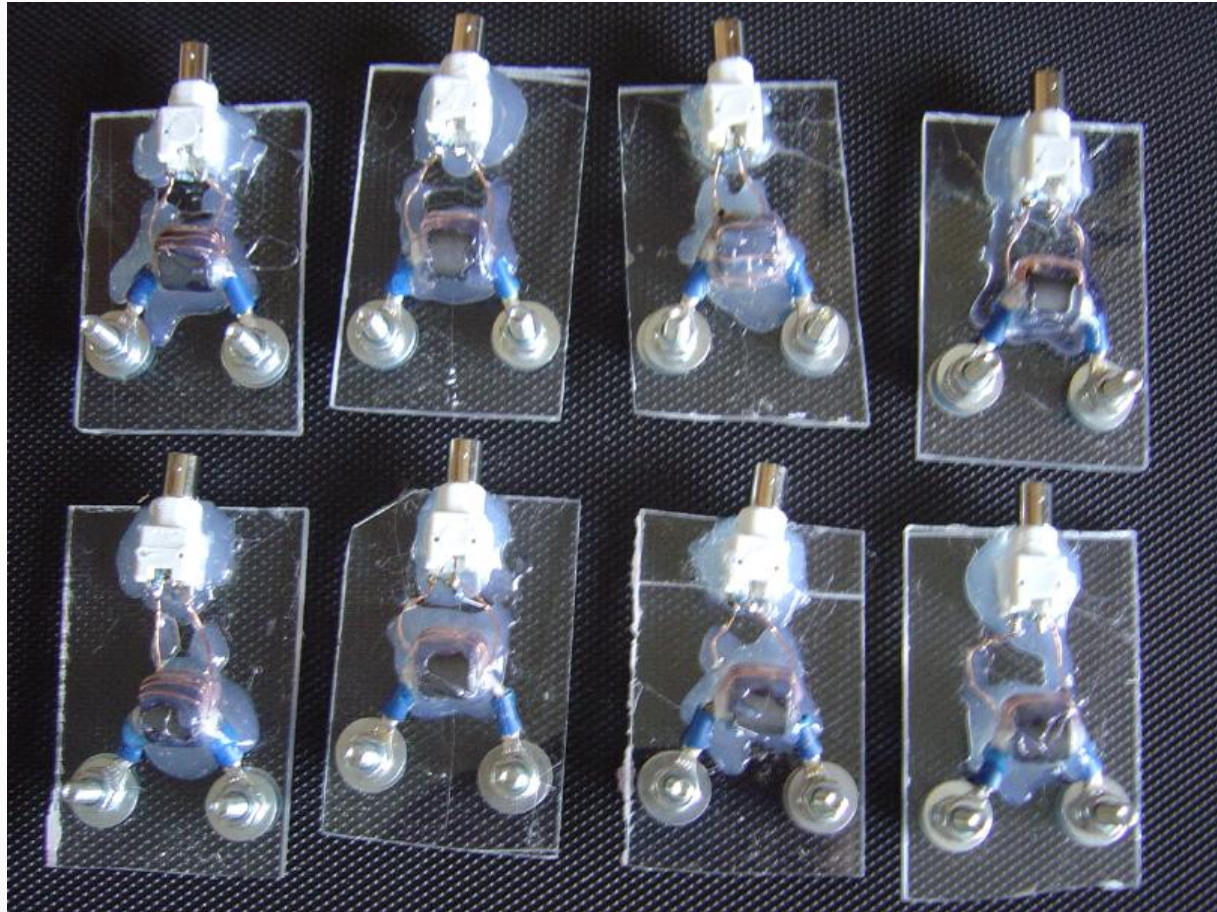
W8WWV Reverse Simulation Overview

Measure Element
RF Currents with
VNA + Mux -
Magnitude/Phase

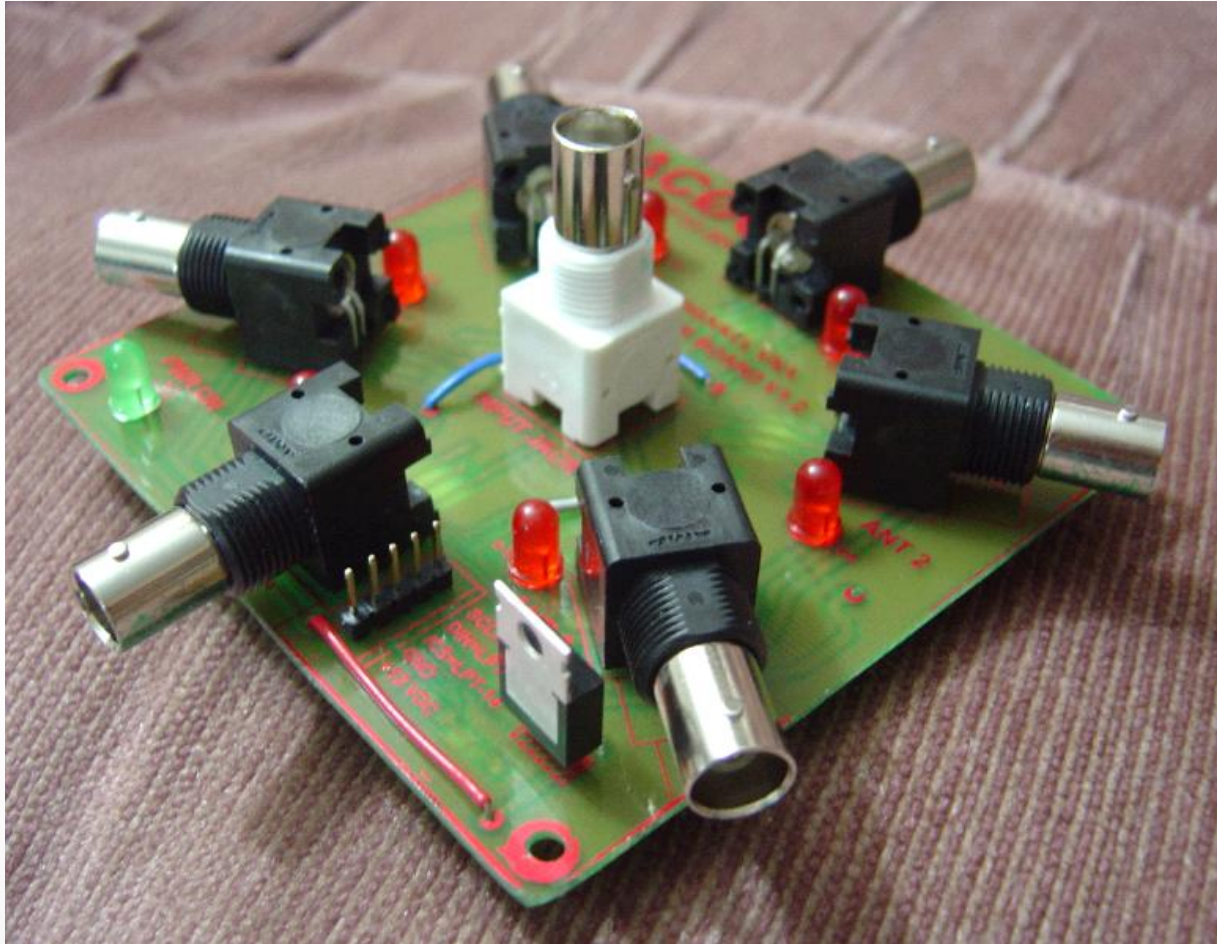
Load Data
into
Simulation
Model

Simulation
Generates
Plot of **Actual**
Antenna
Performance

RF Current Sensors



Multiplex Board for N2PK VNA



Design Concept – W8WWV – Circuit, PCB and Build – KØRU

- Putting F/B vs. Gain Sensitivity into Context
- Measure antenna element phasing & interactions between antenna sets
 - W8WWV 2008 Dayton Antenna Forum Method
A New Approach for Measuring Complex Antenna Currents in Vertical Arrays
- **Measure actual field pattern**
 - **W8WWV 2010 Dayton Antenna Forum Method
Exotic Antenna Pattern Measurement**
- **Backlight for LCD & new enclosure**