Steerable Array
"The Vertical Beam for Low Bands"

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VA3KGS
VA3AC

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Introduction

- What is a Steerable Array?
- What do you Gain by doing this?
- What Band's to use it on?
- Design Philosophy, K2AV & Steerable
- Construction
- Testing
- Results (Contests)
- Reference Material used

What is a Steerable Array ?

- STEERABLE is to control the direction of the Receiving and Sending signals. (Vertical Beam).
  - By using Relay's switching in and out different Phasing Lines harnesses (Coax).
- ARRAY is to be 2 or more vertical Antenna's that are used for Receiving and Sending.
  - Wire or Poles

What do you Gain?

- Typical Low Band DX Antennas used today are made of ¼ wave single wire, and are vertical in nature (Inverted L).
- 1 Vertical = ~0db Gain
- 2 Verticals = ~3db Gain
- 3 Verticals = ~6db Gain
- 4 Verticals = ~10db Gain

- More Contacts

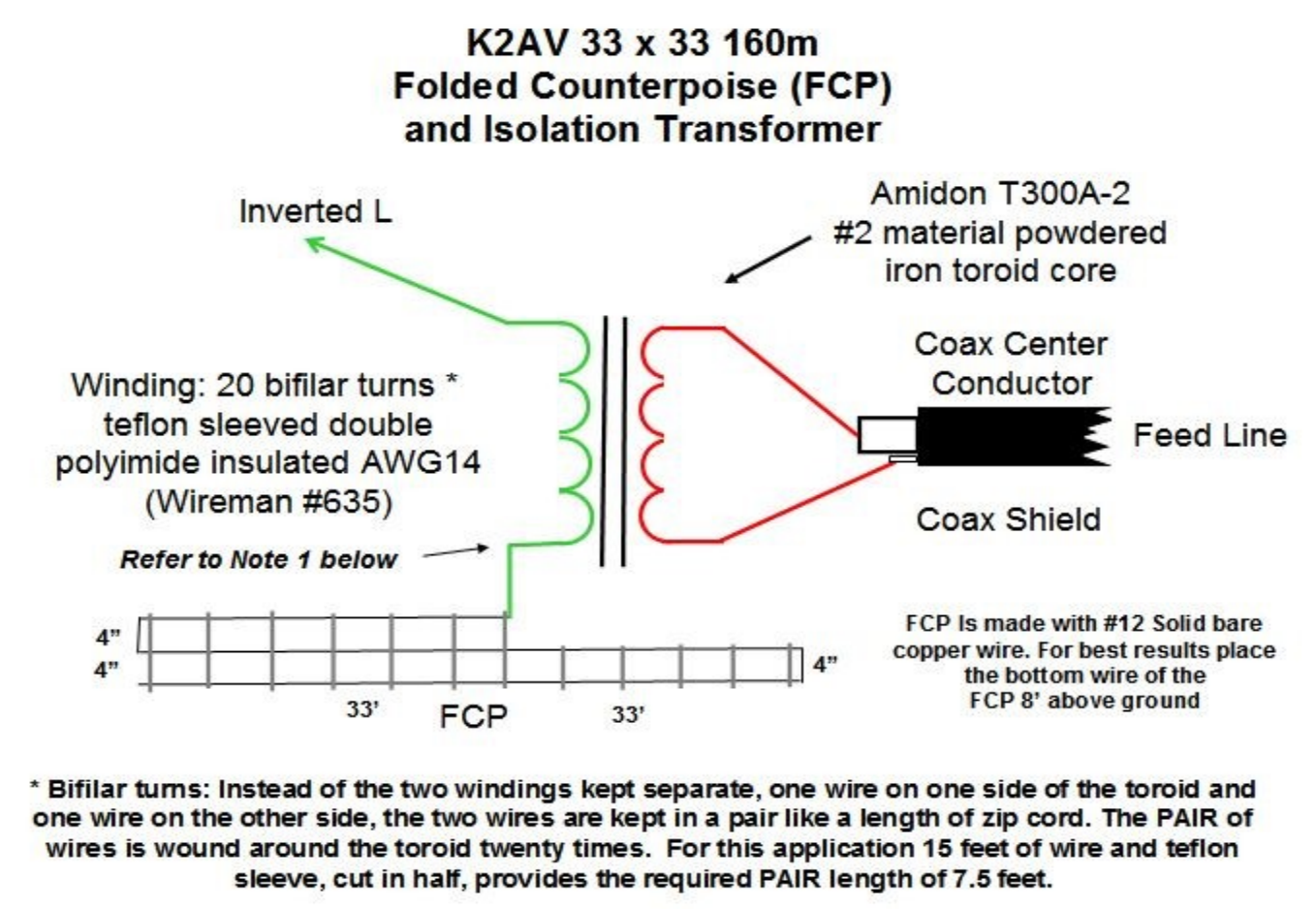
What Bands do I use it on?

- What bands do you plan on using?
- Do you have the space to install the Vertical Array System?
- What is the selected Counterpoise System for the Ground Radials going to be? How many wires do I need?
  - Elevated (Many Radials)
  - Ground Surface (Many Radials)
  - K2AV Folded Counterpoise (1 Radial)

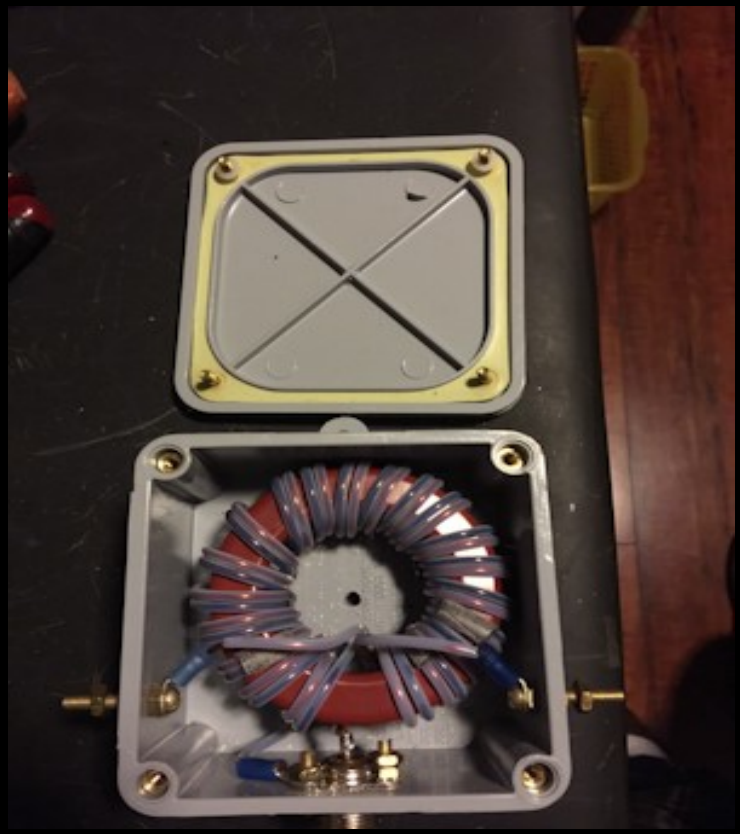
What Bands- Antenna Length

- Free Space Wave Lengths on
  - 7.250Mhz >41.35M (135.6') =33.9' ¼ w
  - 5.4Mhz > 55.57M (182.32') =45.58' ¼ w
  - 3.75Mhz > 79.95M (262.3') =65.58' ¼ w
  - 1.93Mhz > 155.33M (509.61') =127.4' ¼ w
- Typical and easy installation is using wire.
  - Tower support
  - Tree support

Antenna Selected was the K2AV FCP



K2AV FCP Balun Kit & Assembly
1000Watt

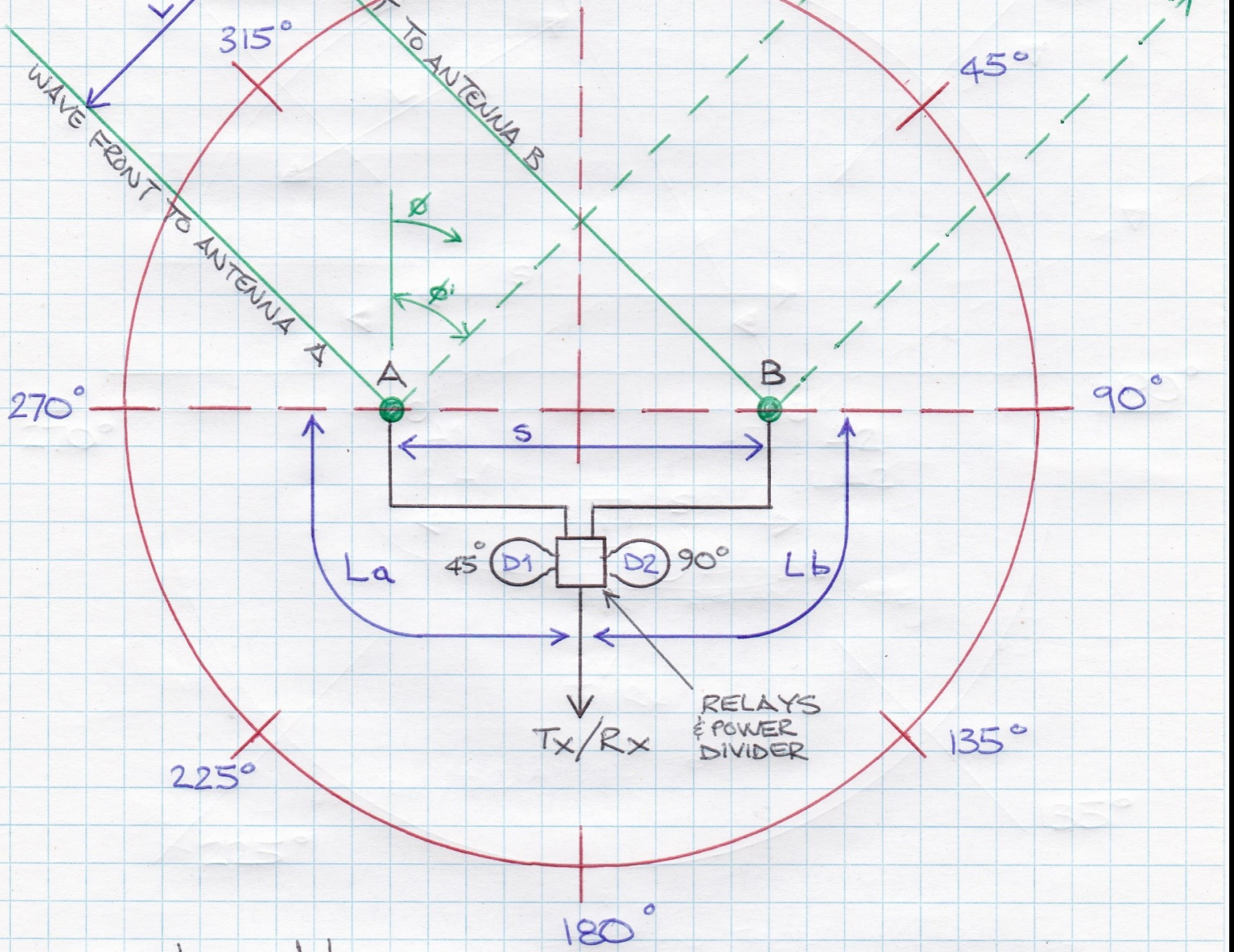


Steering the Antenna

"Steerable Arrays for the Low Bands" by B. Alexander W5AH, The ARRL Antenna Compendium Volume 2 1989

Makes reference to:

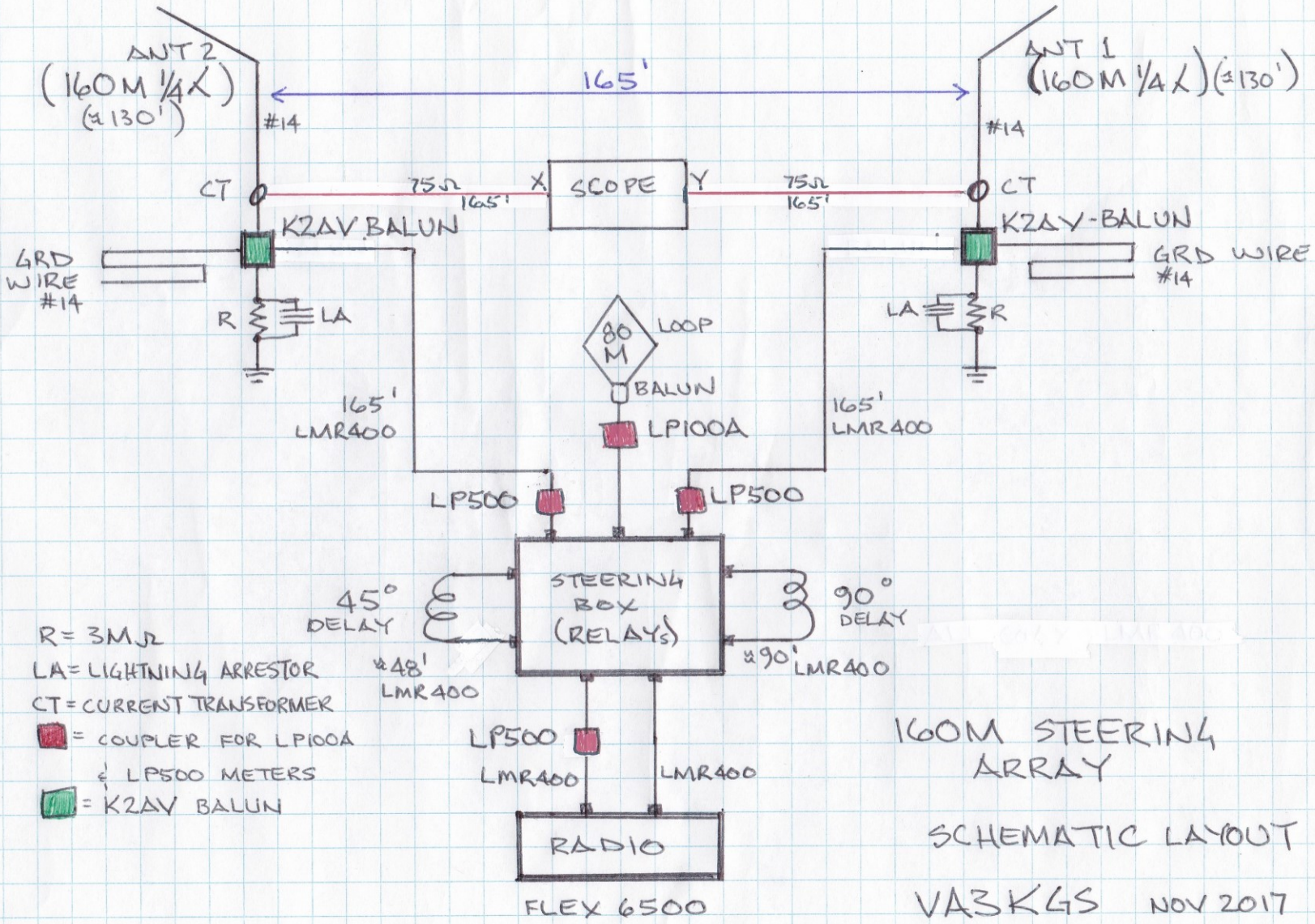
"Broadband Steerable Phased Arrays" by RC Fenwick K5RR & RR Shell PhD, QST April 1977



COAX La = Lb = 50Ω

COAX D1 = 45°, D2 = 90° ⇒ D1 = S(VF)SIN 45

VF = VELOCITY FACTOR of COAX D2 = S(VF)SIN 90



160M STEERING ARRAY

SCHEMATIC LAYOUT

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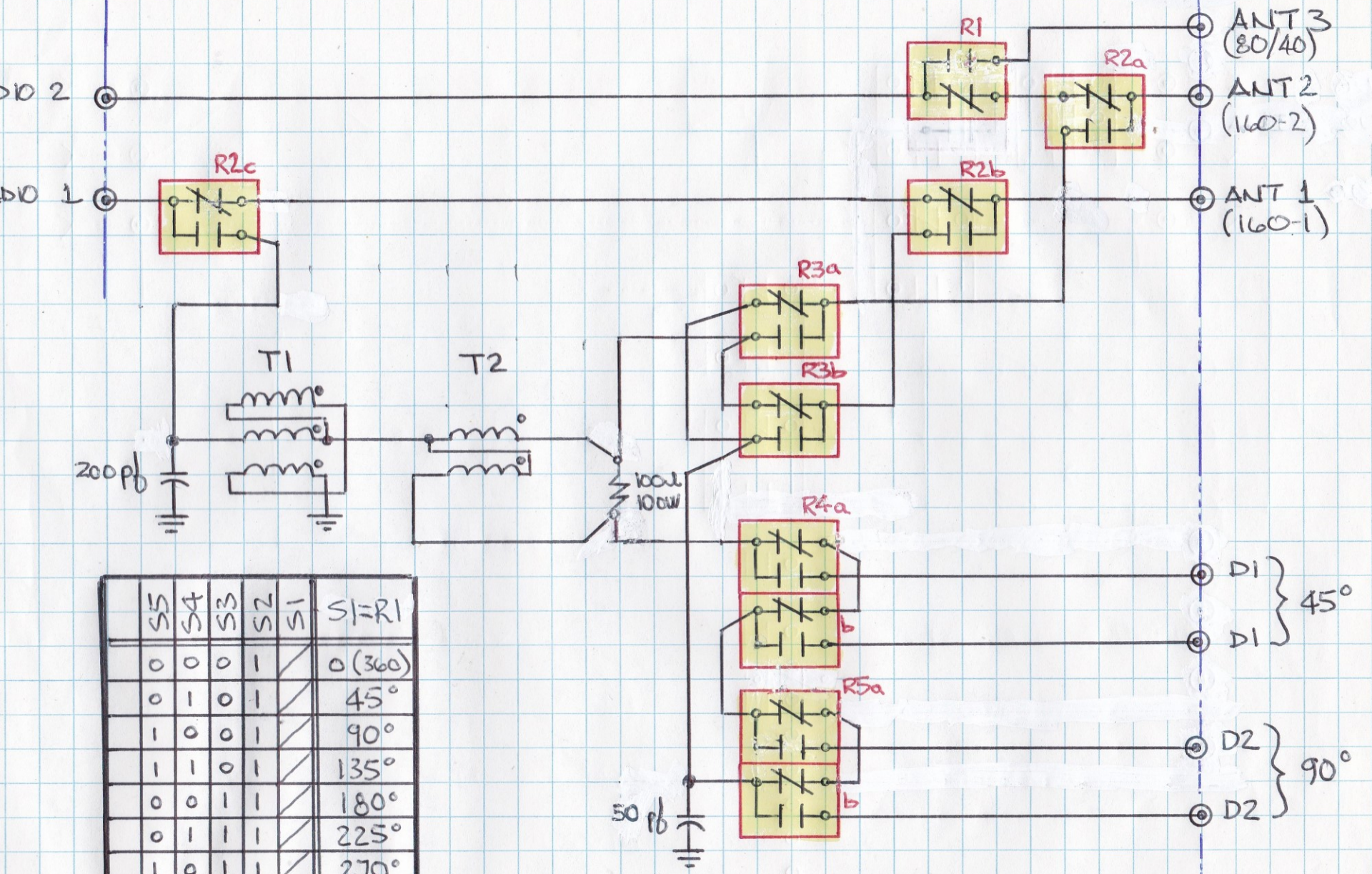
The Switching Control Scheme

- Out of 360 degrees, I would like to switch the antennas every 45 degrees giving 8 positions to play with.
- By using;
  - 40A 12Vdc Control Relays
  - Impedance Matching 2:1 Transformer
  - Hybrid Power Divider
  - Control Switches
  - 50 ohm LMR400 coax for all cables



	S5	S4	S3	S2	S1	S1=R1
	0	0	0	1		0 (360)
	0	1	0	1		45°
	1	0	0	1		90°
	1	1	0	1		135°
	0	0	1	1		180°
	0	1	1	1		225°
	1	0	1	1		270°
	1	1	1	1		315°

PHASED ARRAY SWITCHING RF SCHEMATIC

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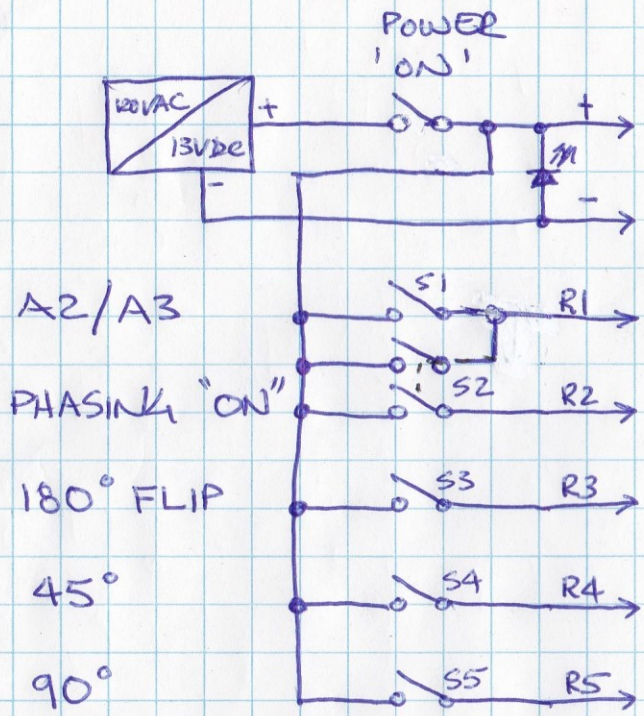
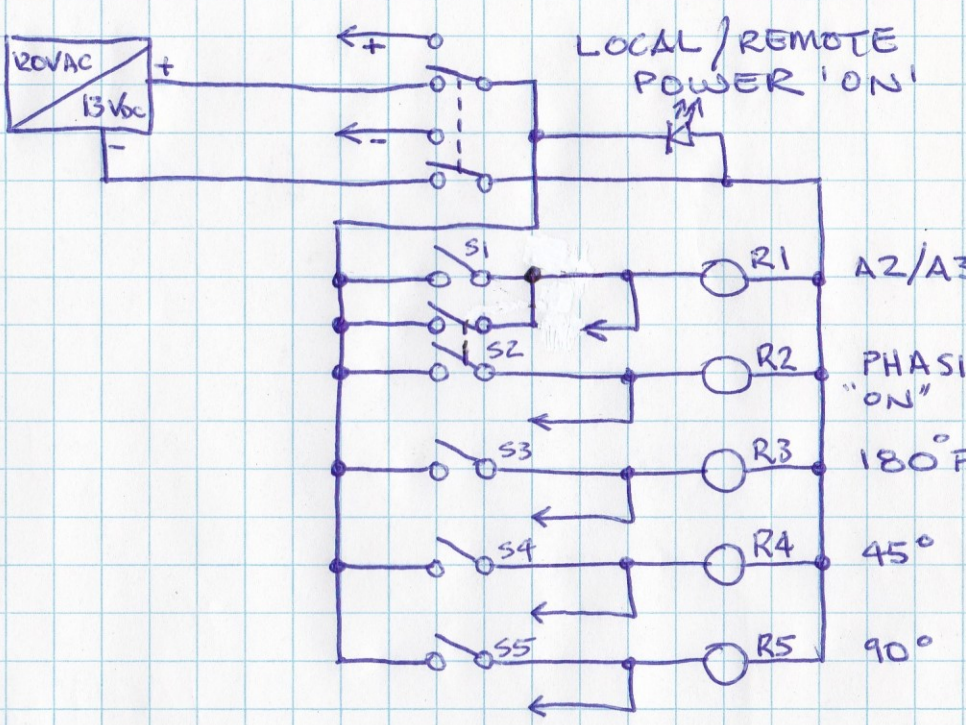
MAY 21, 20



LOCAL SWITCH BOX



REMOTE SWITCH BOX

PHASED ARRAY SWITCHING CONTROL

12VDC SCHEMATIC

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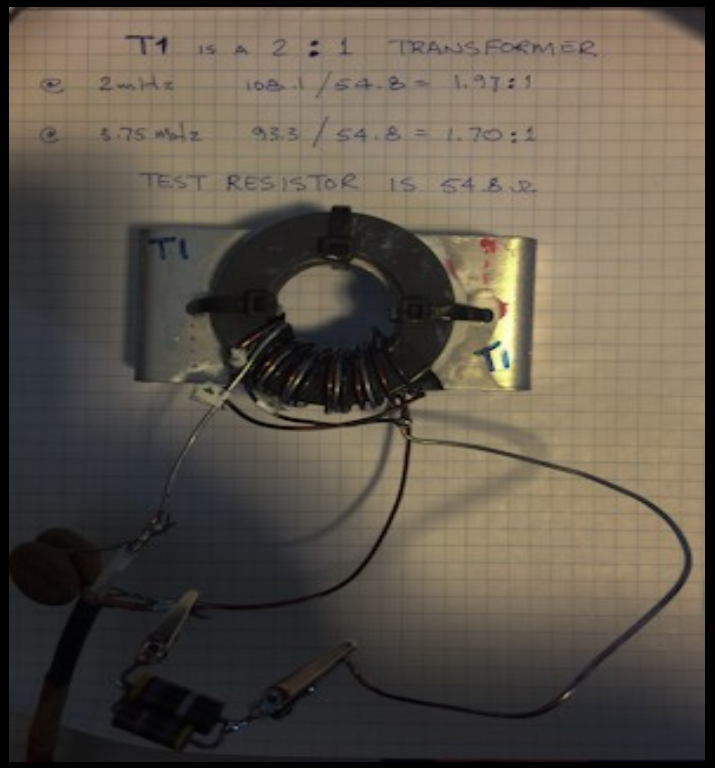
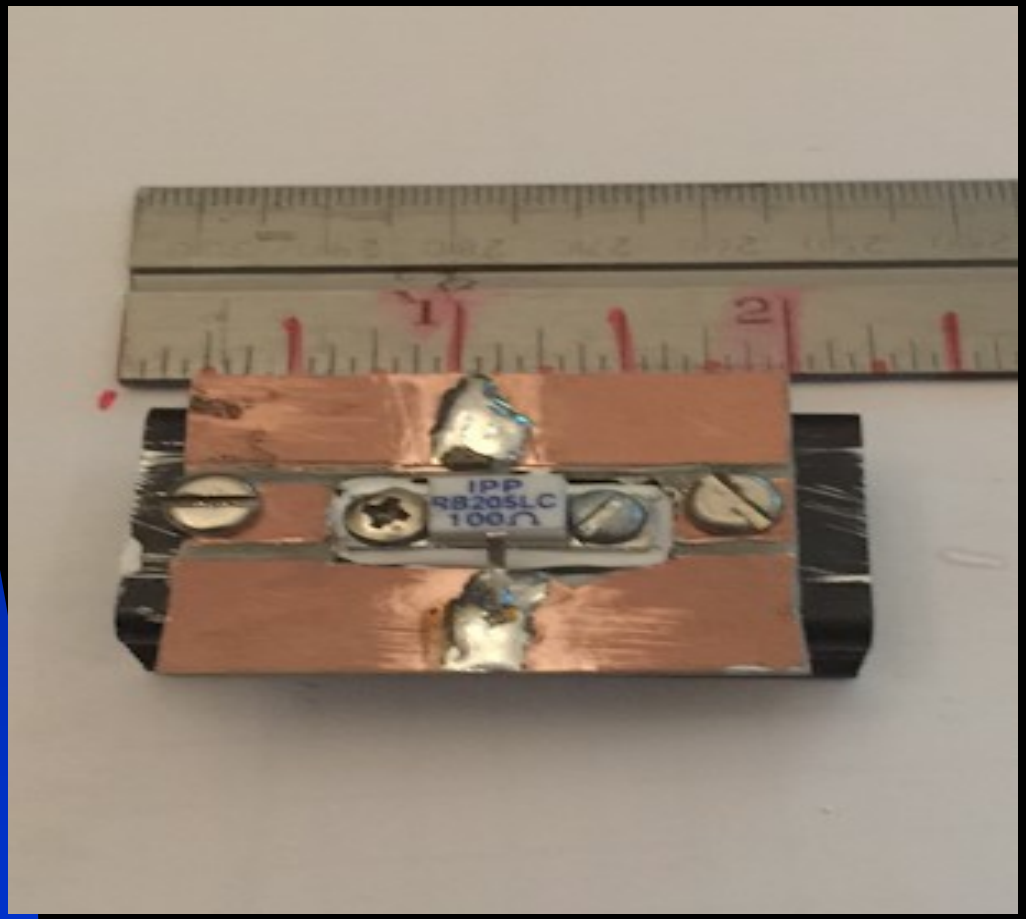
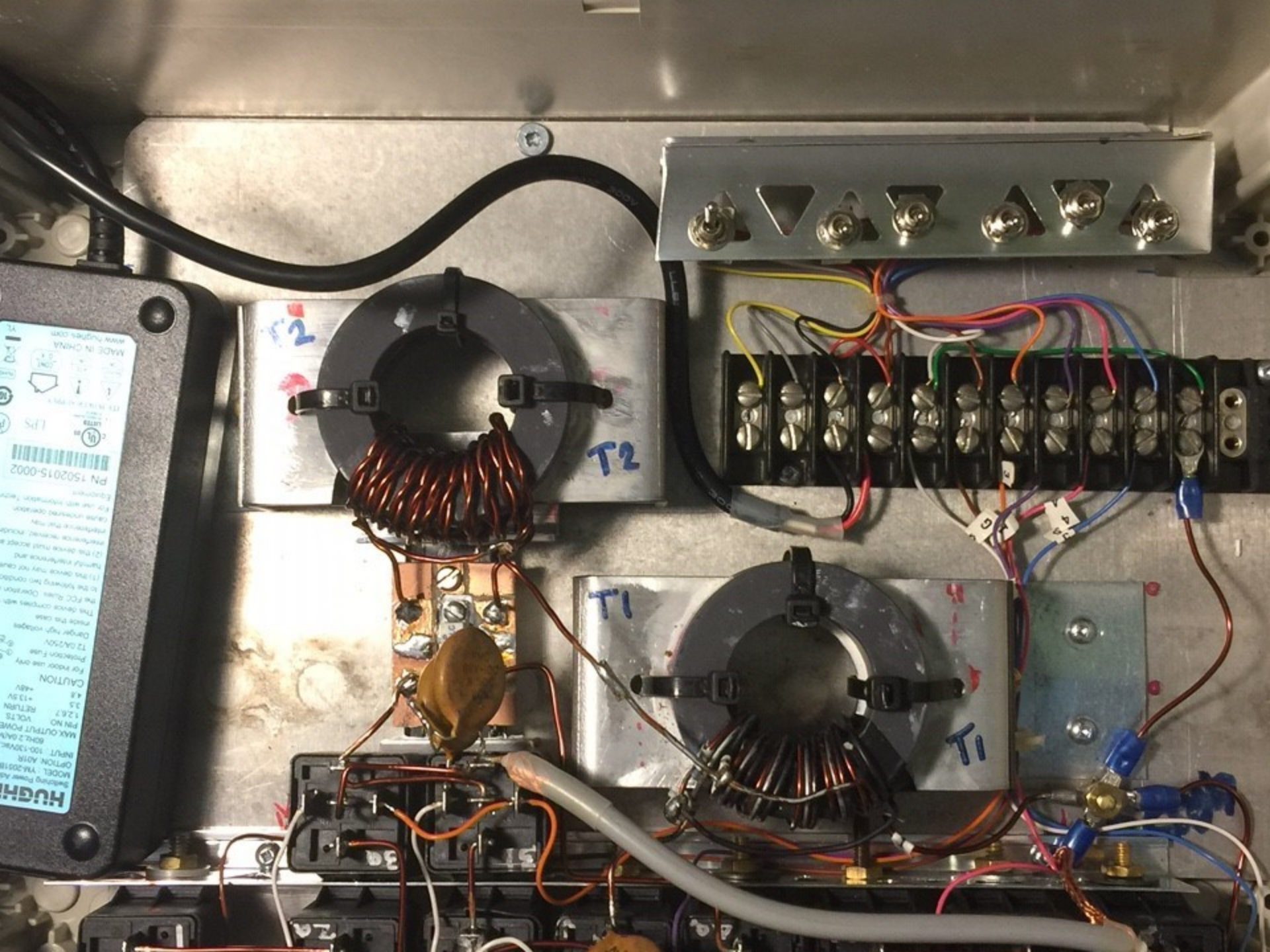
MAY 21, 2017

2:1 Transformer (100:50)



RF Power Resistor
100 ohms @ 100 watts
(for SWR Mismatch)




T2
T1

Phasing Harness Design

- LMR 400 with 84% VF
  - 45 Degree Harness

    L(VF)Sin45 (1/8 wave).
    - (63.7*0.84)Sin45 = 37.84feet
    - Spectrum Analyzer cut at 48’
  - 90 Degree Harness

    L(VF)Sin90 (1/4 wave).
    - (127.4*0.84)Sin90 = 107 feet
    - Spectrum Analyzer cut at 96’

Steering Box with Phasing Harnesses

Testing

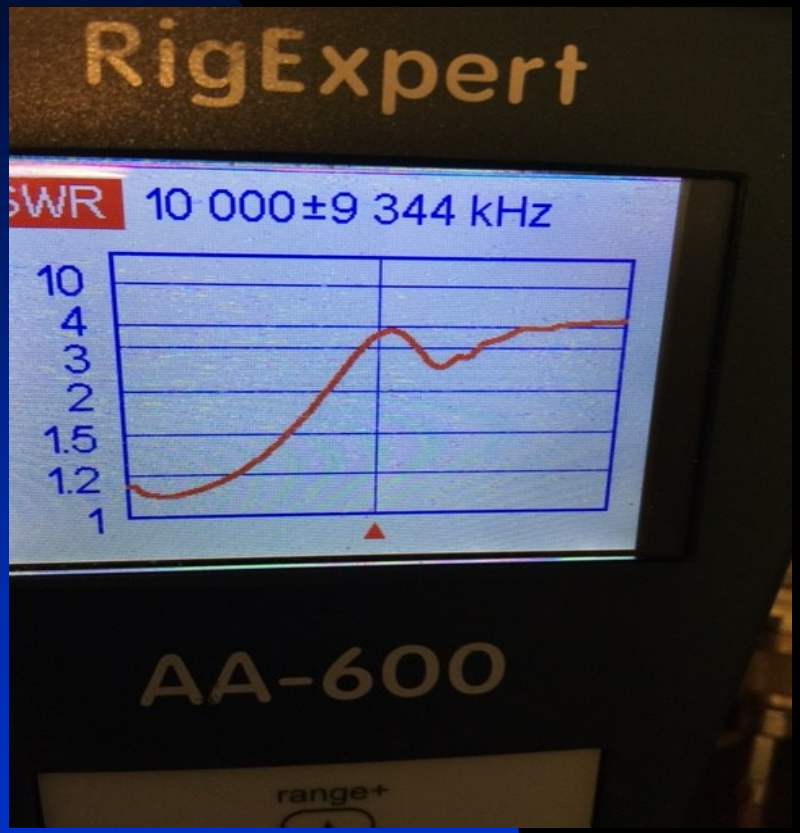
Equipment used:

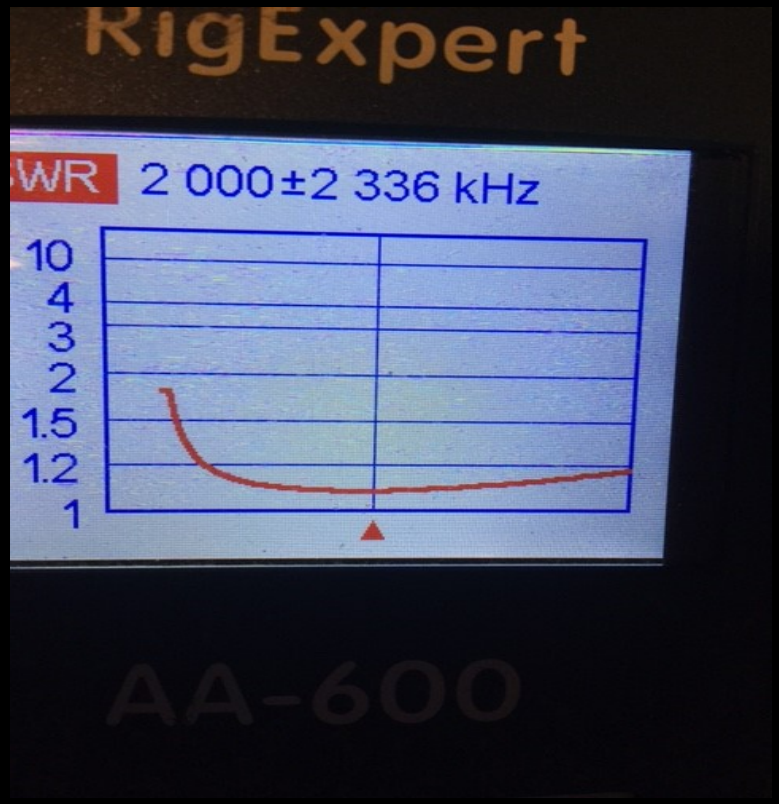
SigLent Digital Scope SDS-1202X-E
SigLent Spectrum Analyzer SSA 3021X

RigExpert Antenna Analyzer AA-600

Telepost Digital Station Monitor LP-500
Telepost Digial Vector RF Wattmeter LP-100A

Balun Transformer





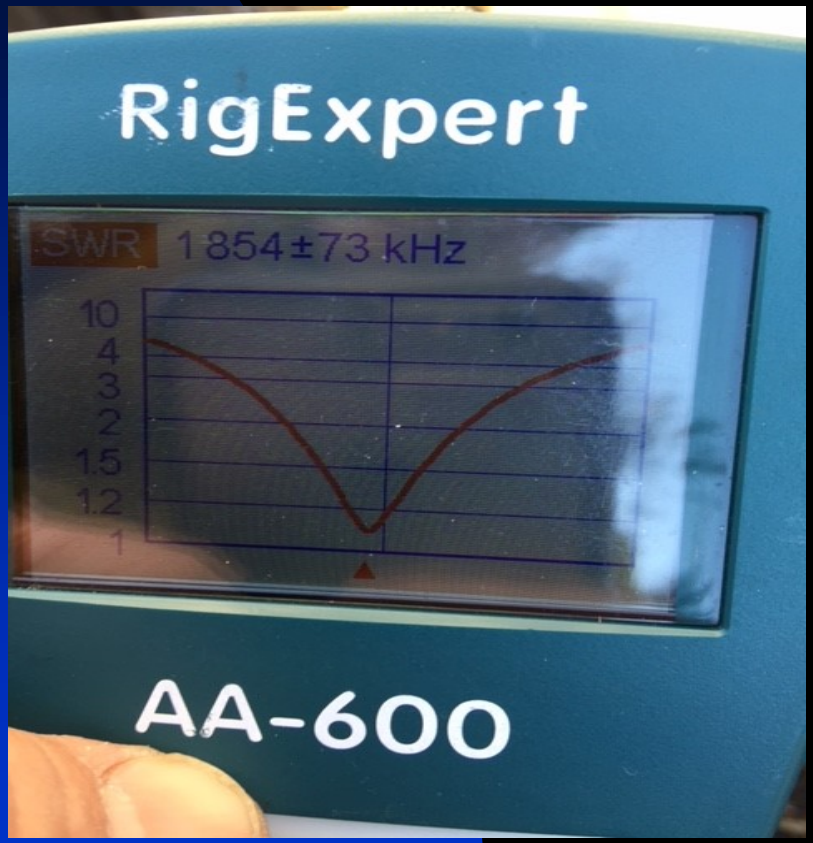
Power Divider

Input

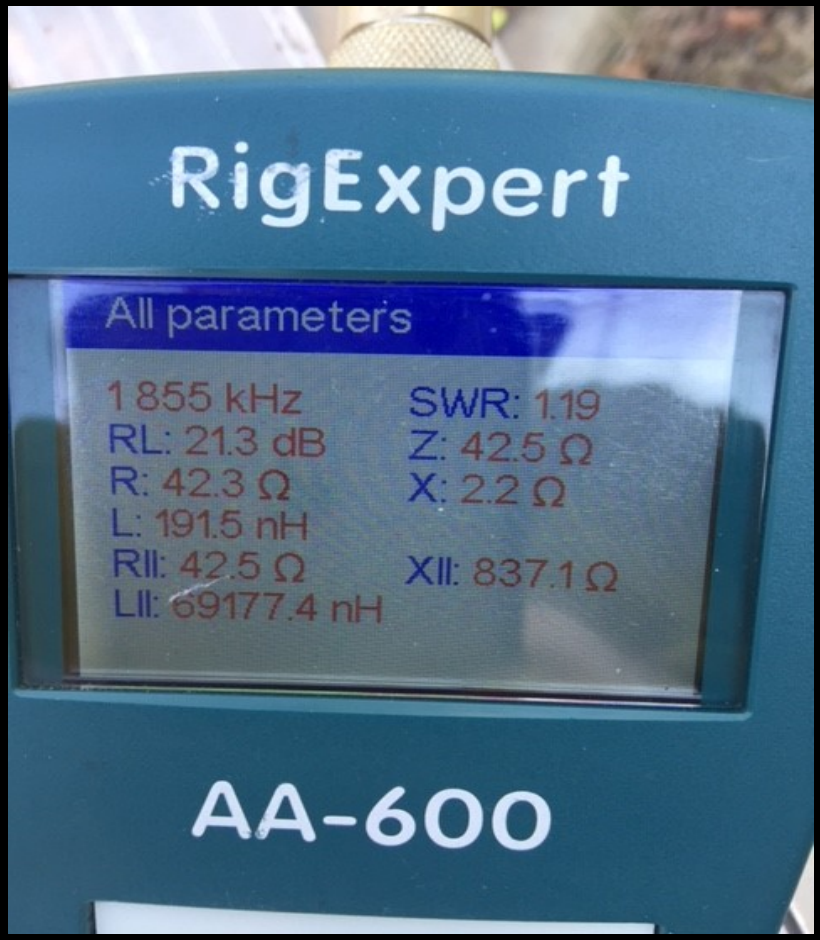
Ant 1

Ant 2

Antenna 1 (West)



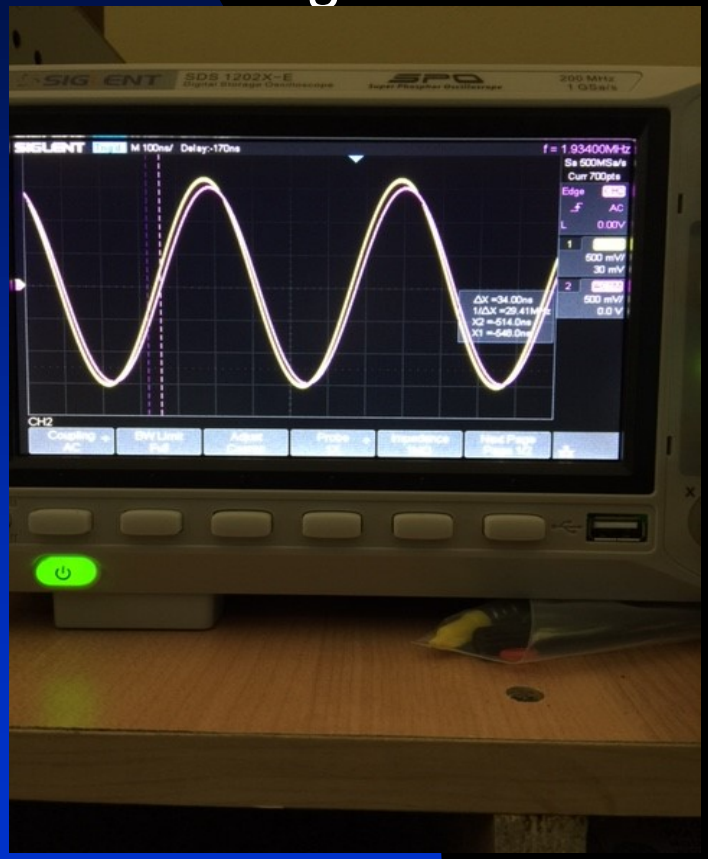
Antenna 2 (East)



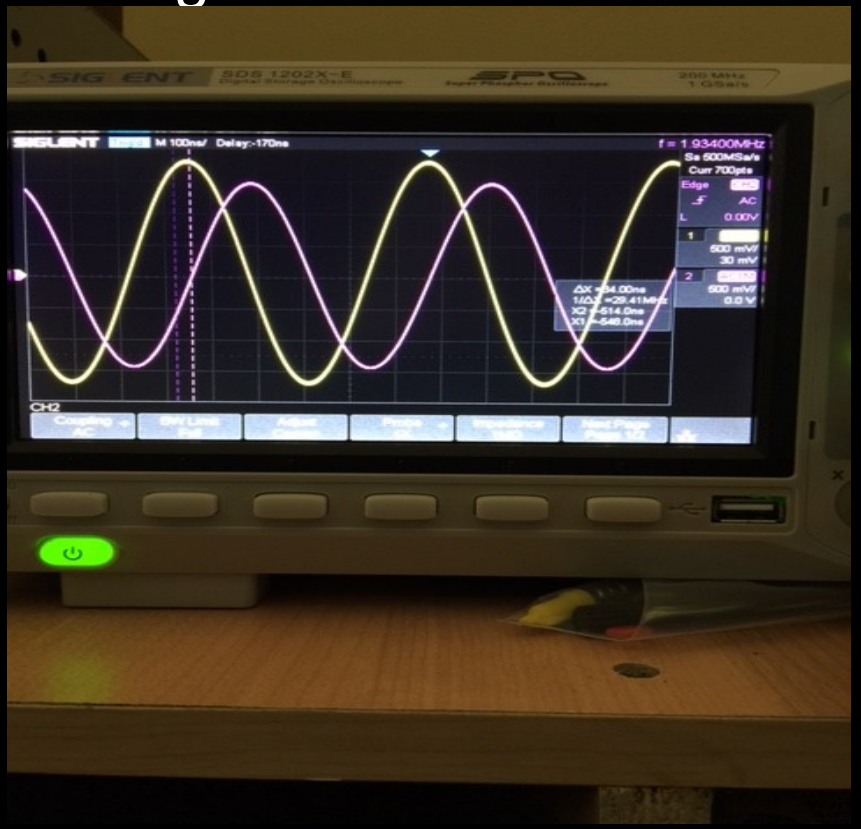
RF FeedBack from CT's @ A1 & A2

10:1

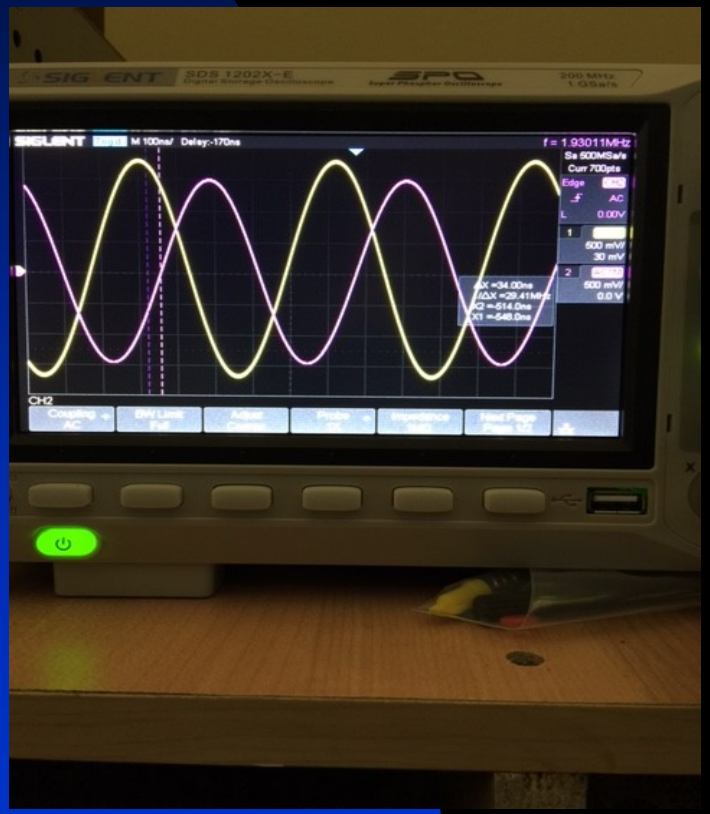
0/360 Degree



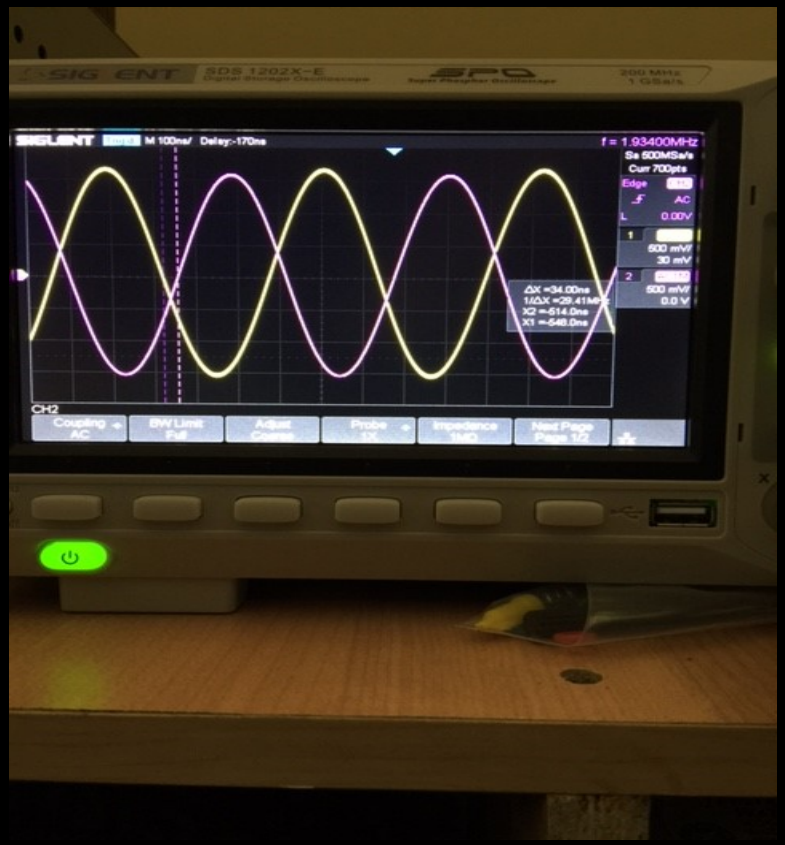
45 Degree



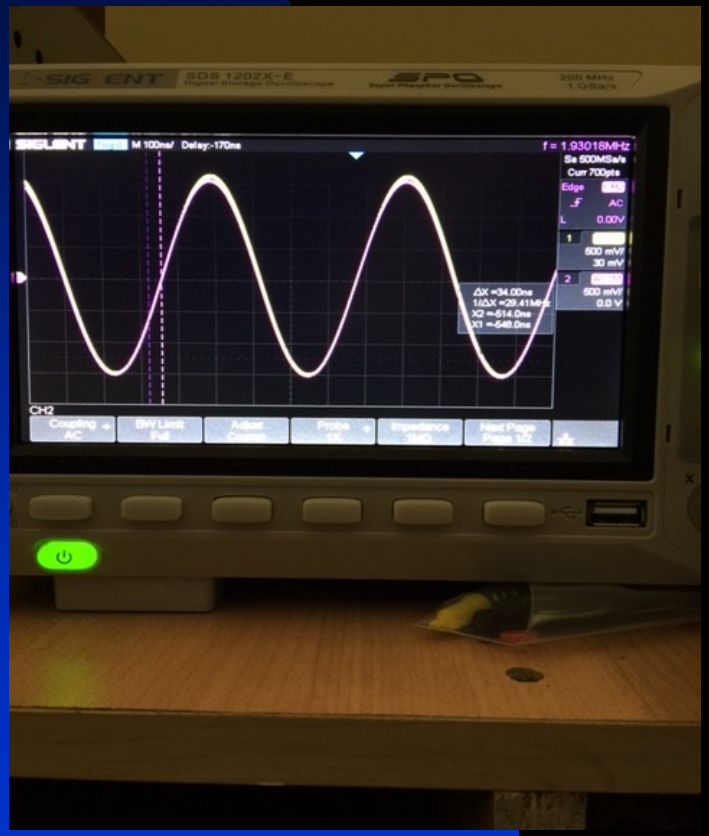
90 Degree



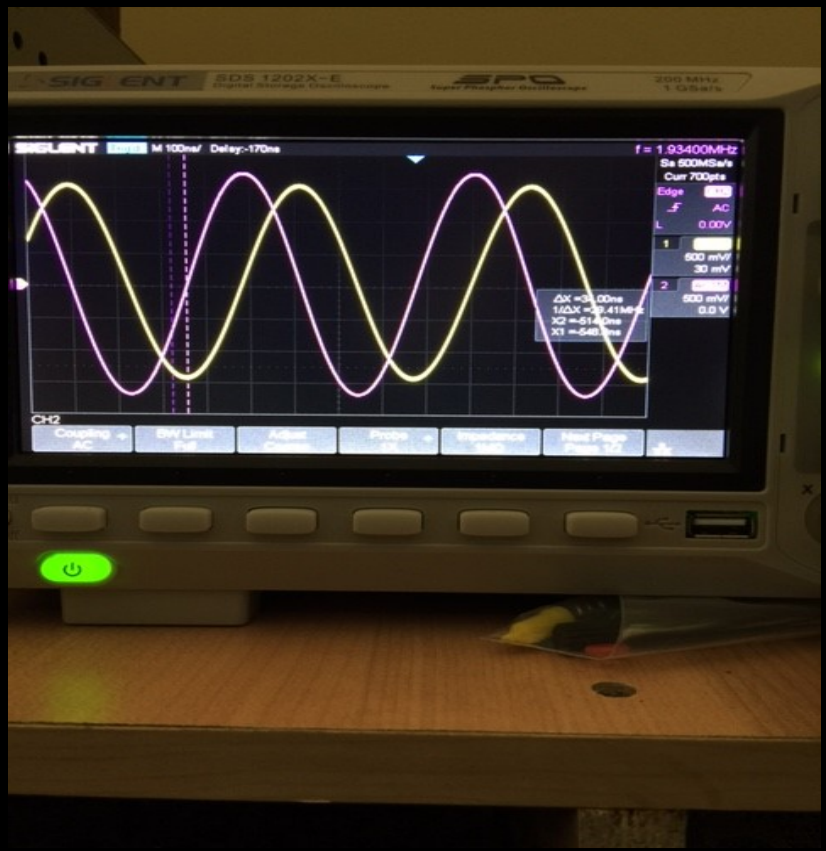
135 Degree



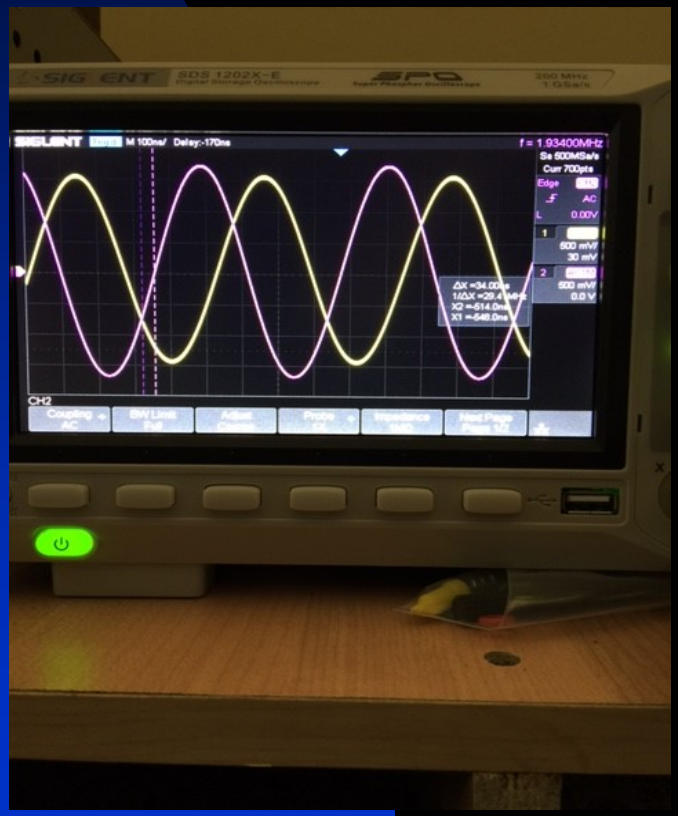
180 Degree



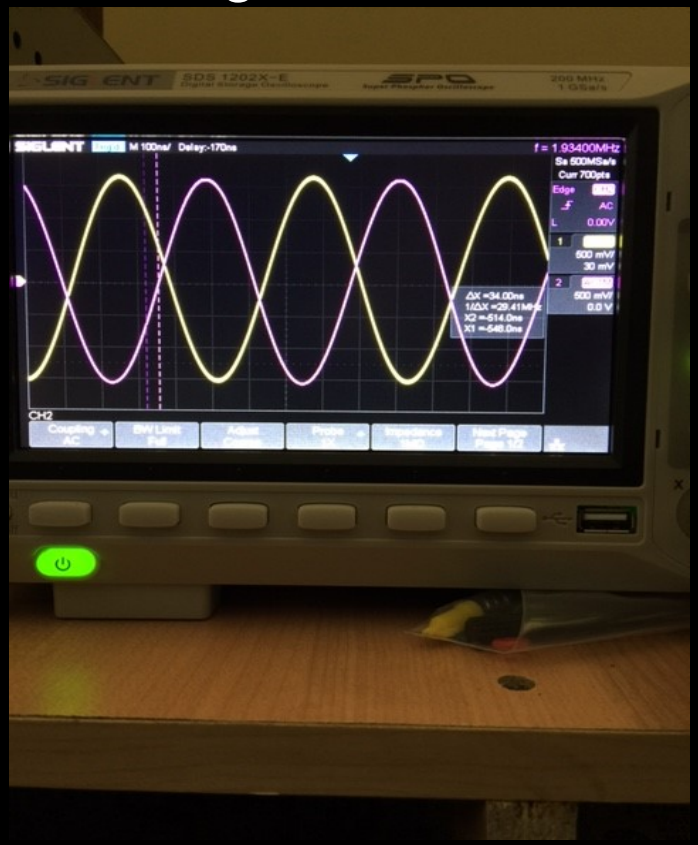
225Degree



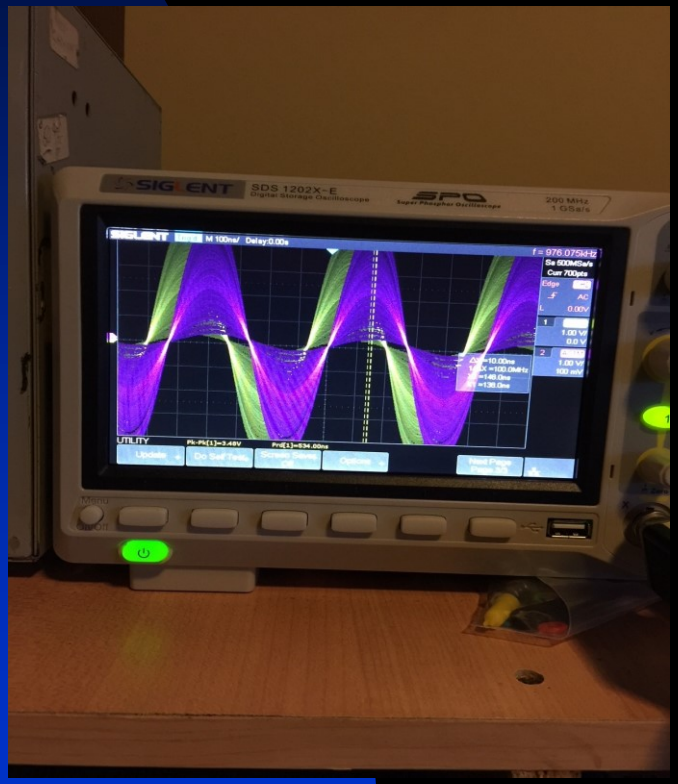
270 Degree

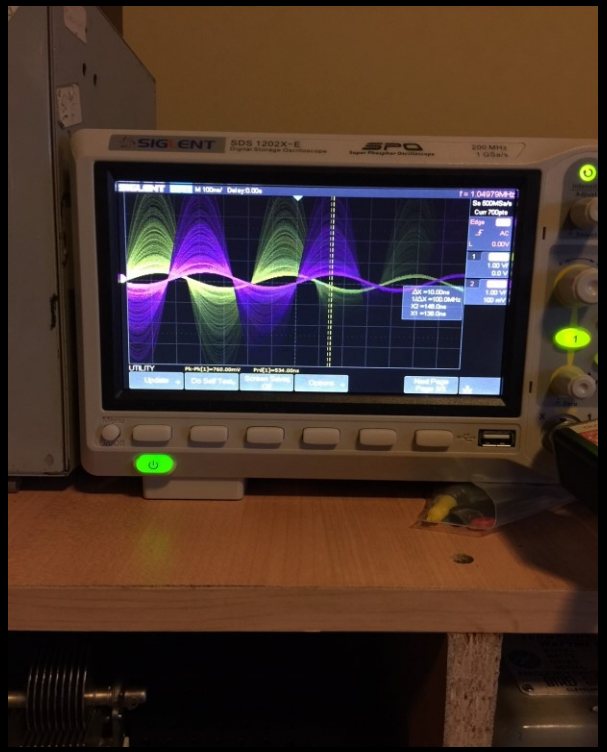


315 Degree



SSB Modulated





Other Things to Consider

- Mutual Inductance between antenna's
  - Testing required to see if there is any reaction between the two antenna's. I suspect that there would not be any interaction as there is no common ground connection using the FCP Design.
- Counterpoise mounting height above ground.
  - Both counterpoises are 6-8 feet above ground.
  - Tuning was done on the counterpoise portion, not the vertical wire.
- Keep Counterpoise away from metal objects as much as possible. ie Tower, Chain Link fence, Eavestroughs, etc…

Other Things to Consider, Cont'd

Support system for wire antenna's

- #12awg (19 Strand) insulated wire, reinforced string (parachute), Egg and standoff insulators, springs.
- Boat steering pulley's work well.

Above ground, or underground installation using conduits for cable routing.

Results from this Design

- 2017 CQWW 160m SSB -100W SO UA
  - Used single vertical wire with 7 raised radials
  - Placed; 2nd Canada; 6th NA; 27th World
- 2017 CQWW SSB (160m) -100W SO UA
  - Used 2 160m vertical FCP & Switchbox
  - Placed; 1st Canada; 1st NA; 9th World
- 2018 CQWW 160M SSB -100W SO UA
  - Used 2 160m vertical FCP & Switchbox
  - (score has not been released yet)

References

- ON4UN's Low-Band Dxing, by J Devoldere, 5th Edition 2015
- The ARRL Antenna Book, 21st Edition 2007
- "Steerable Arrays for the Low Bands" by B. Alexander W5AH, The ARRL Antenna Compendium Volume 2 1989
- "Broadband Steerable Phased Arrays" by RC Fenwick K5RR & RR Shell PhD, QST April 1977
- Guy Oliver www.K2AV.com