

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 $\frac{1}{4}$ 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

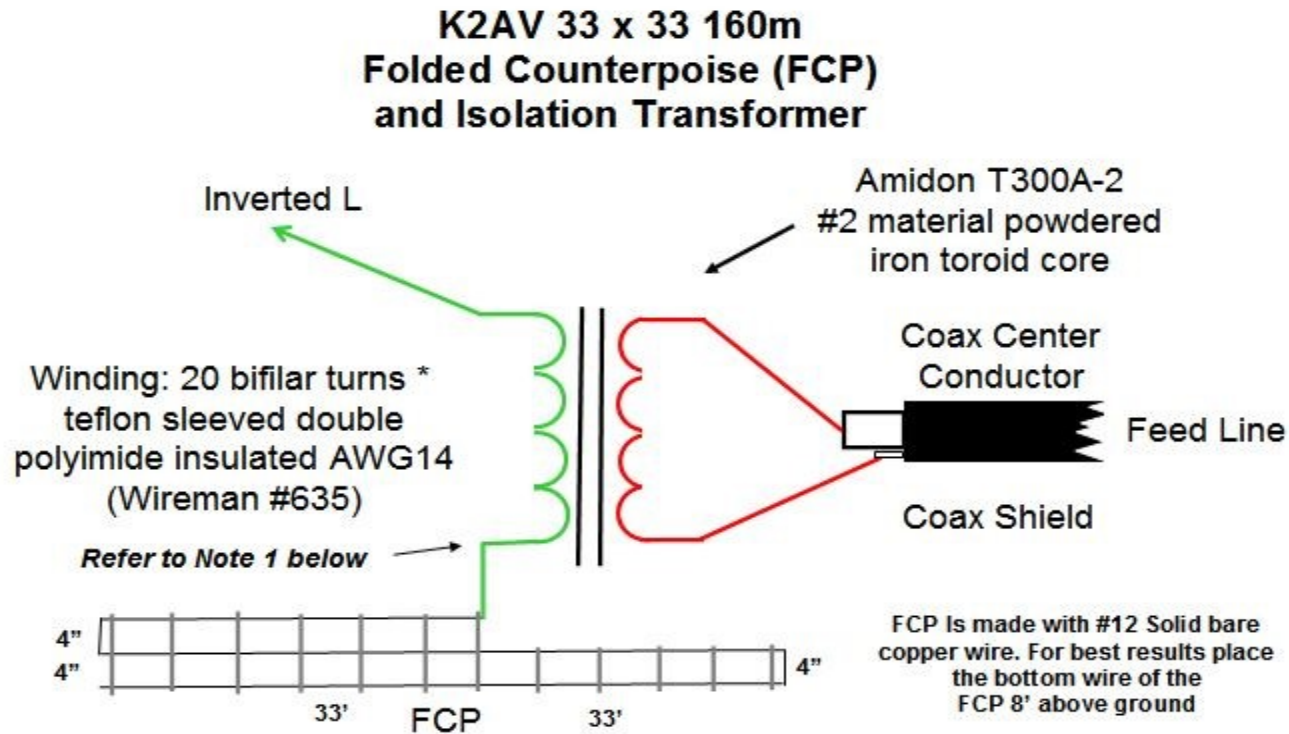
What Bands do I use it on?

- 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
 - ◆ $7.250\text{Mhz} > 41.35\text{M} (135.6') = 33.9' \frac{1}{4} w$
 - ◆ $5.4\text{Mhz} > 55.57\text{M} (182.32') = 45.58' \frac{1}{4} w$
 - ◆ $3.75\text{Mhz} > 79.95\text{M} (262.3') = 65.58' \frac{1}{4} w$
 - ◆ $1.93\text{Mhz} > 155.33\text{M} (509.61') = 127.4' \frac{1}{4} w$
- Typical and easy installation is using wire.
 - ◆ Tower support
 - ◆ Tree support

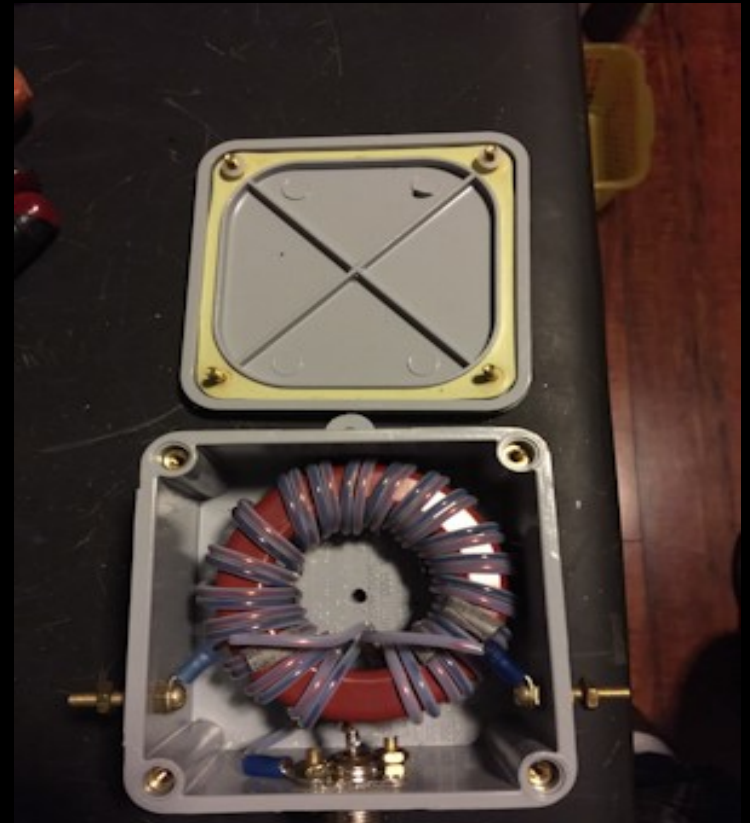
Antenna Selected was the K2AV FCP



* **Bifilar turns:** Instead of the two windings kept separate, one wire on one side of the toroid and one wire on the other side, the two wires are kept in a pair like a length of zip cord. The PAIR of wires is wound around the toroid twenty times. For this application 15 feet of wire and teflon sleeve, cut in half, provides the required PAIR length of 7.5 feet.

K2AV FCP Balun Kit & Assembly

1000Watt

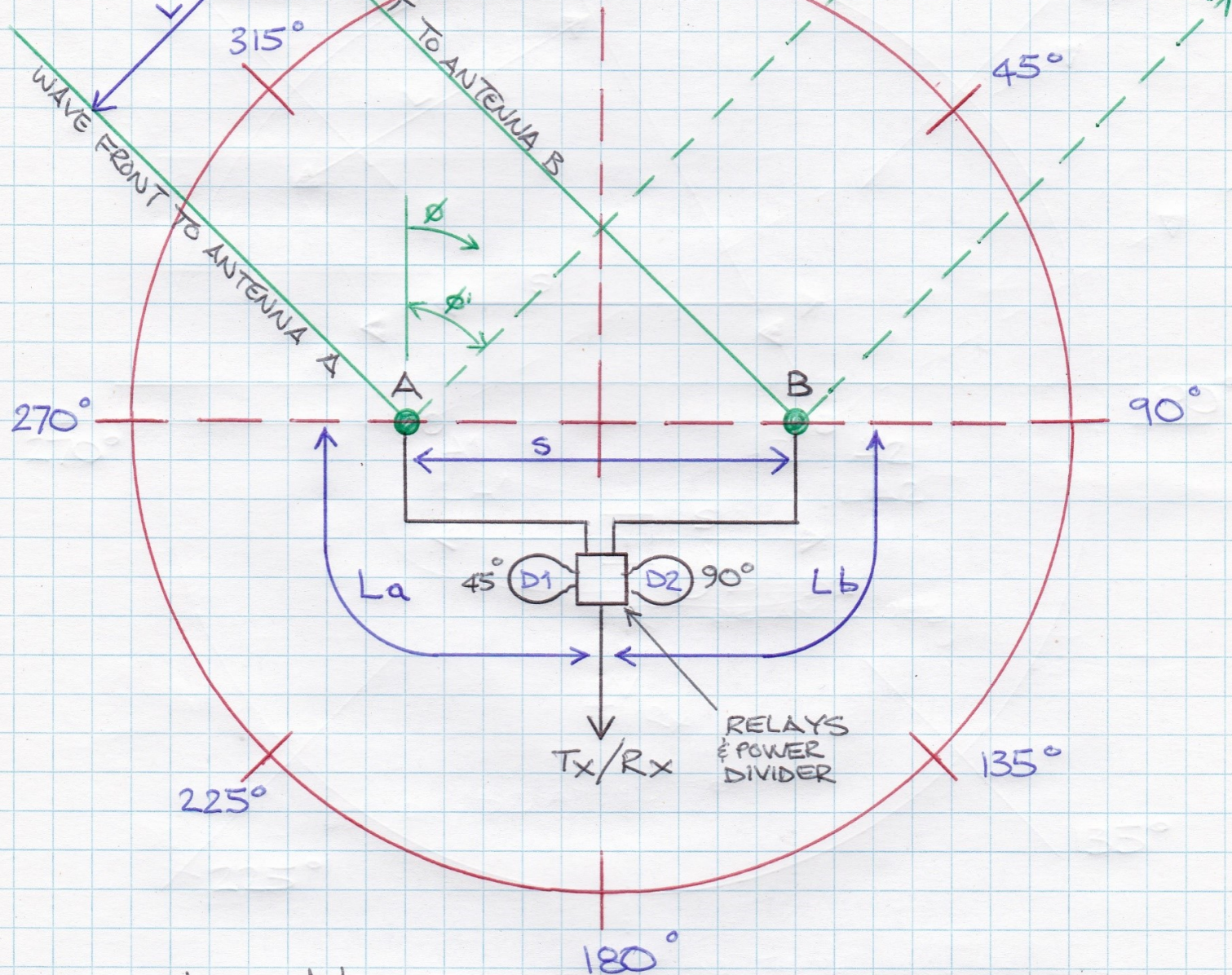


Steering the Antenna

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

Makes reference to:

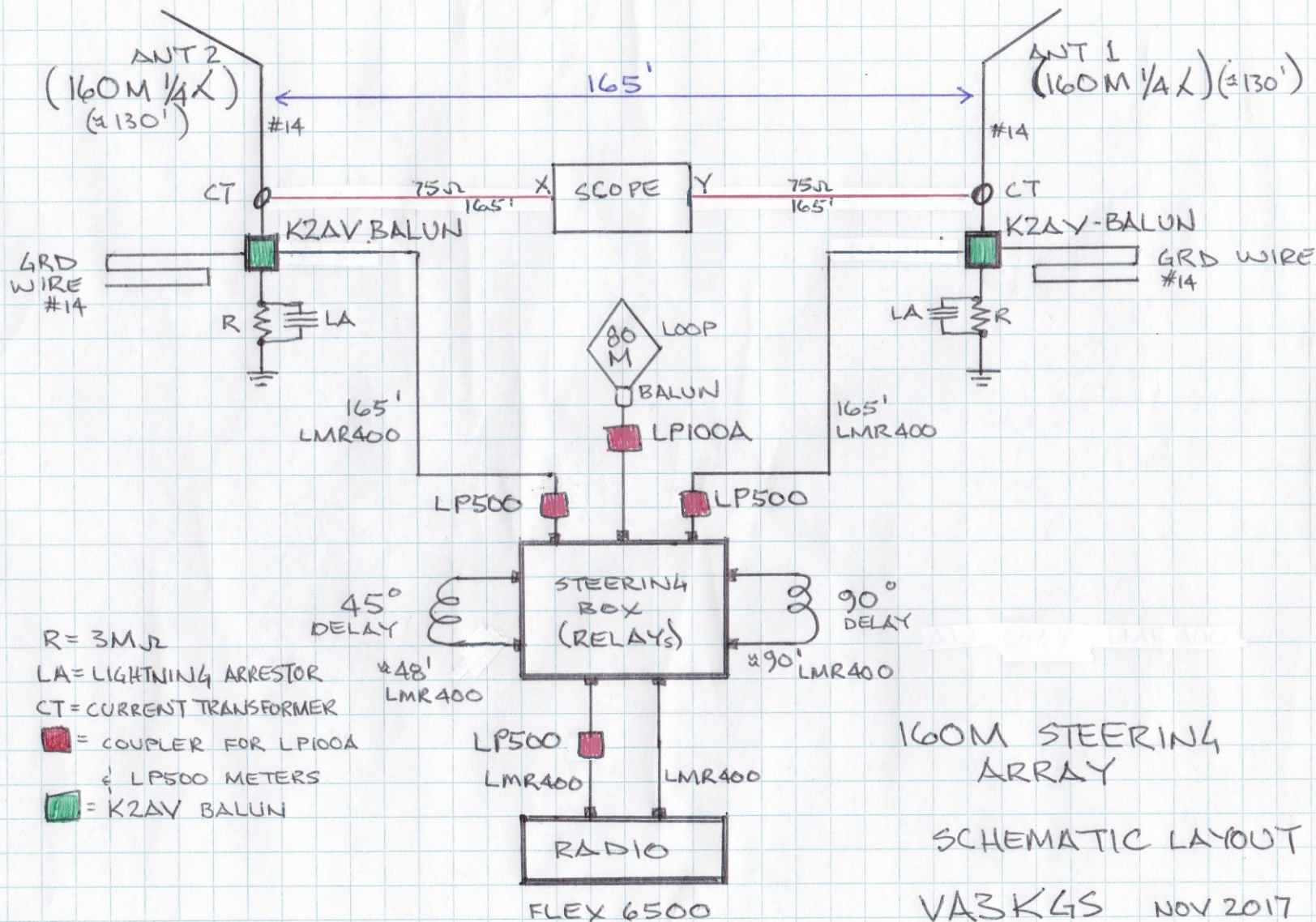
“Broadband Steerable Phased Arrays” by RC Fenwick K5RR & RR Shell PhD, QST April 1977



COAX $L_a = L_b = 50\Omega$

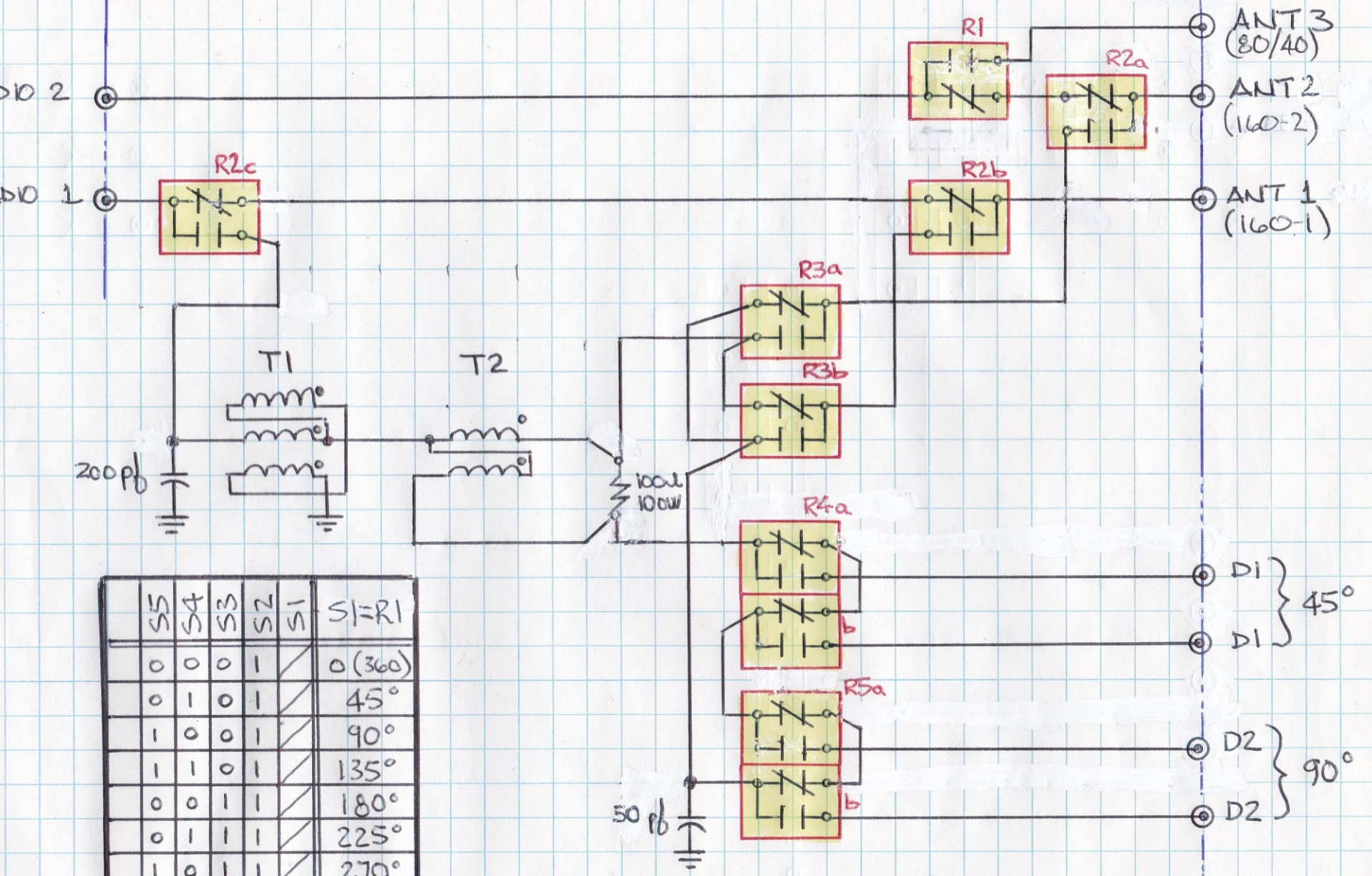
COAX $D1 = 45^\circ$, $D2 = 90^\circ \Rightarrow$
 $VF = \text{VELOCITY FACTOR of COAX}$

$D1 = S(VF)\sin 45$
 $D2 = S(VF)\sin 90$



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

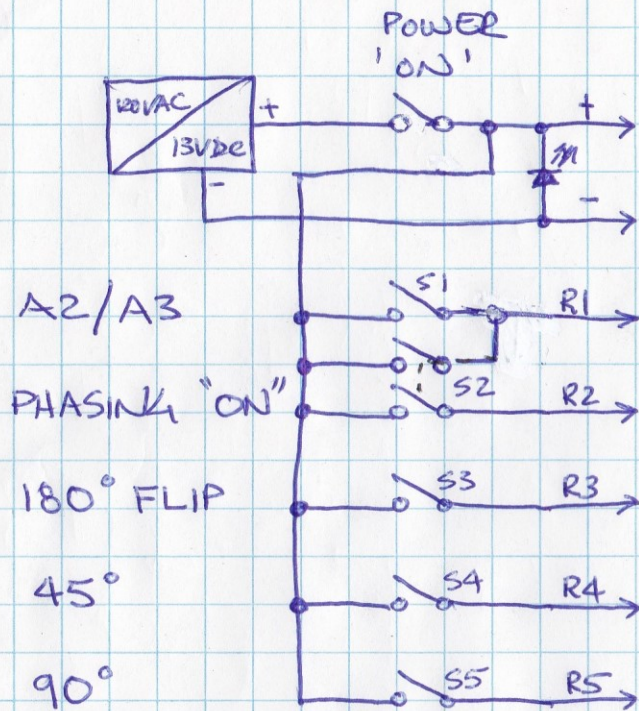


S5	S4	S3	S2	S1	S1=R1
0	0	0	1	/	0 (360)
0	1	0	1	/	45°
1	0	0	1	/	90°
1	1	0	1	/	135°
0	0	1	1	/	180°
0	1	1	1	/	225°
1	0	1	1	/	270°
1	1	1	1	/	315°

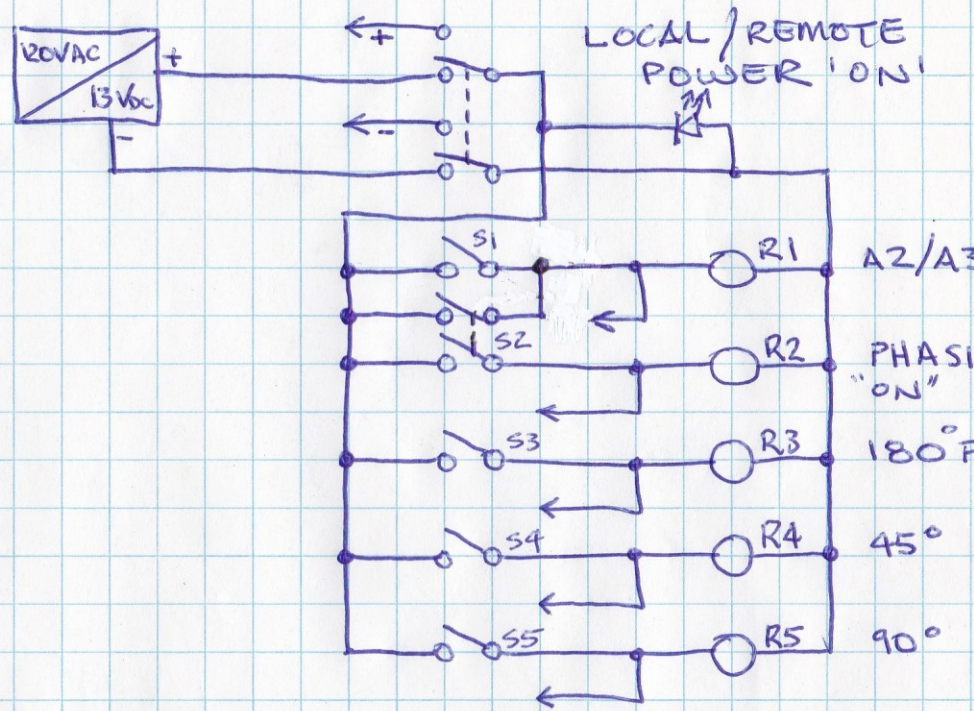
PHASED ARRAY SWITCHING
RF SCHEMATIC

VA3KGS

MAY 21, 20



LOCAL SWITCH BOX



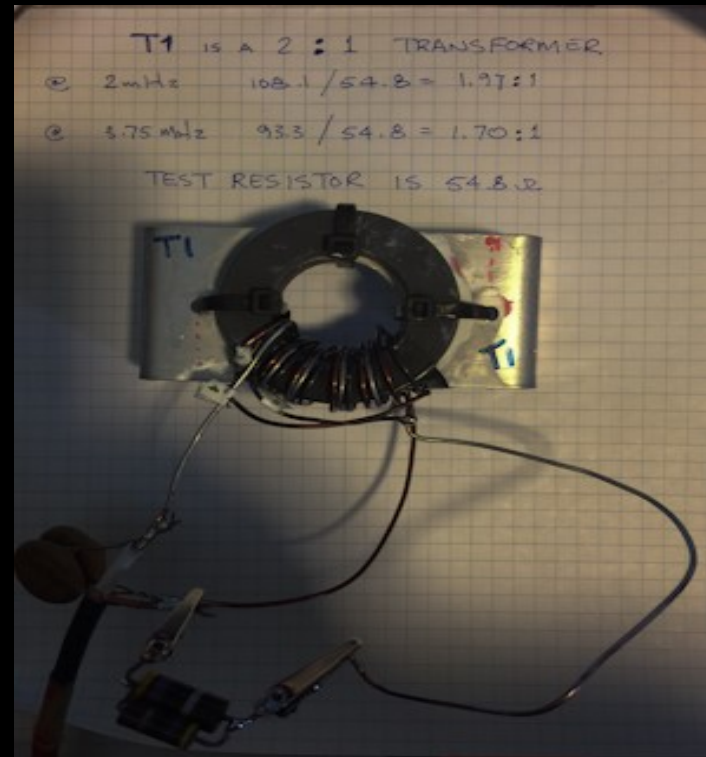
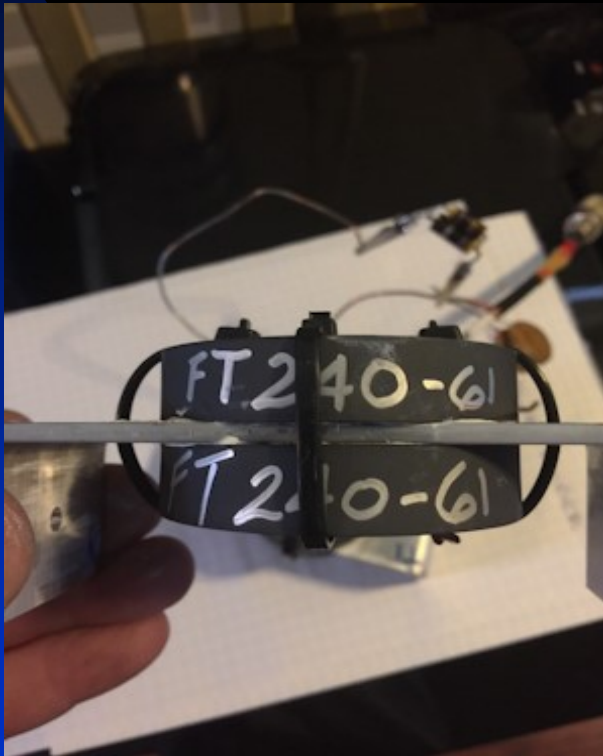
REMOTE SWITCH BOX

PHASED ARRAY SWITCHING CONTROL 12VDC SCHEMATIC

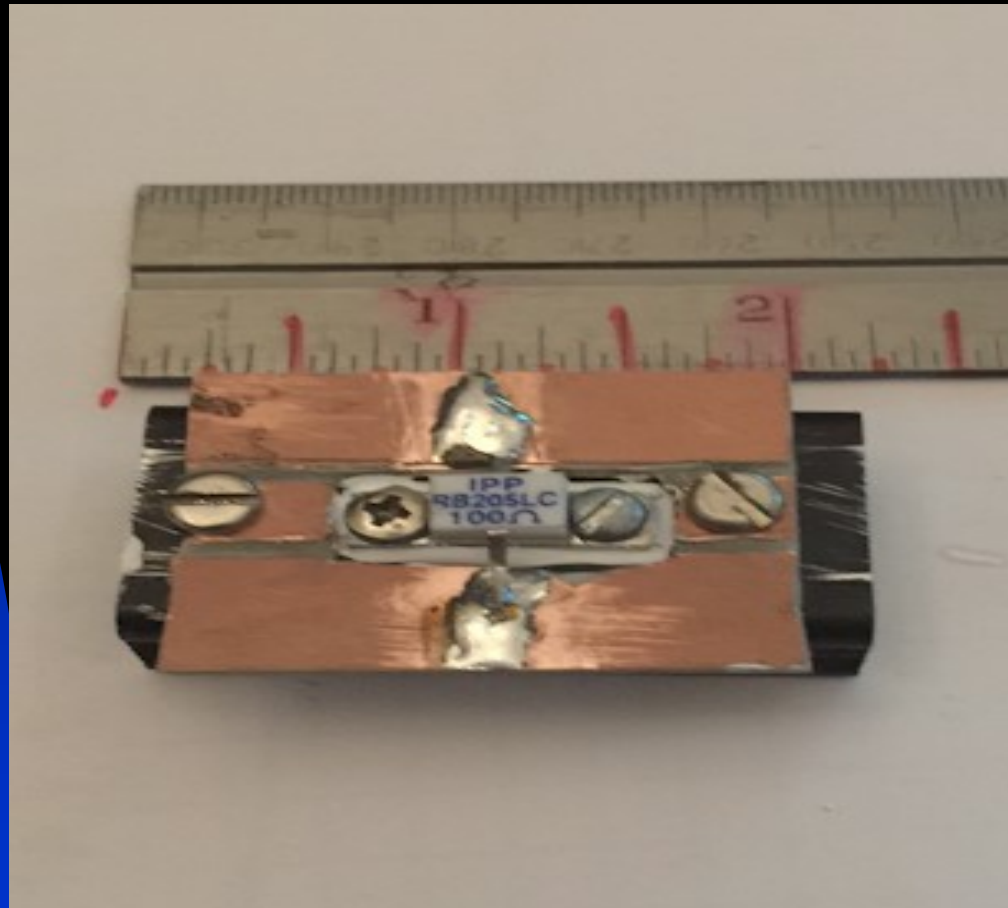
VA3KGS

MAY 21, 2017

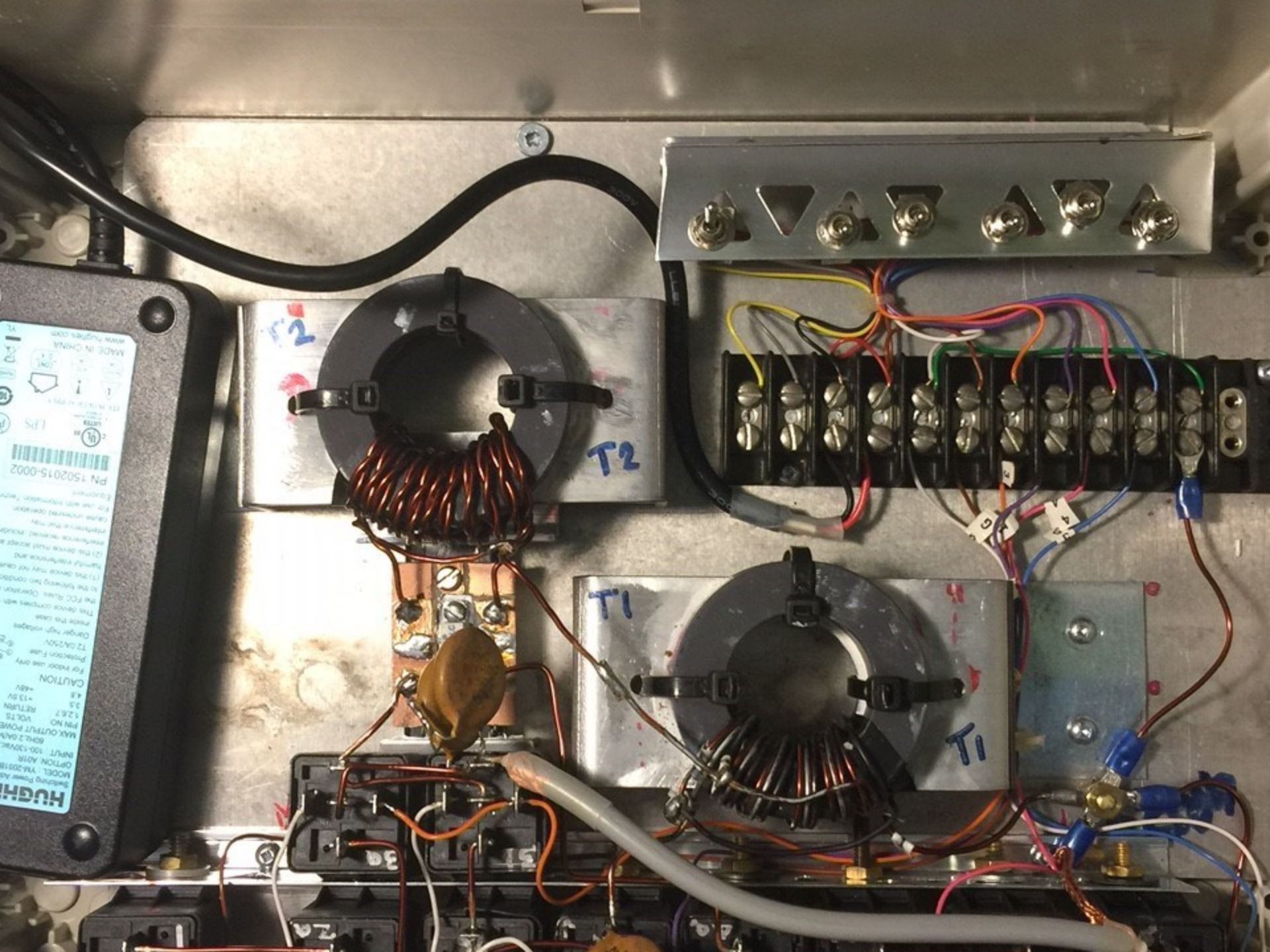
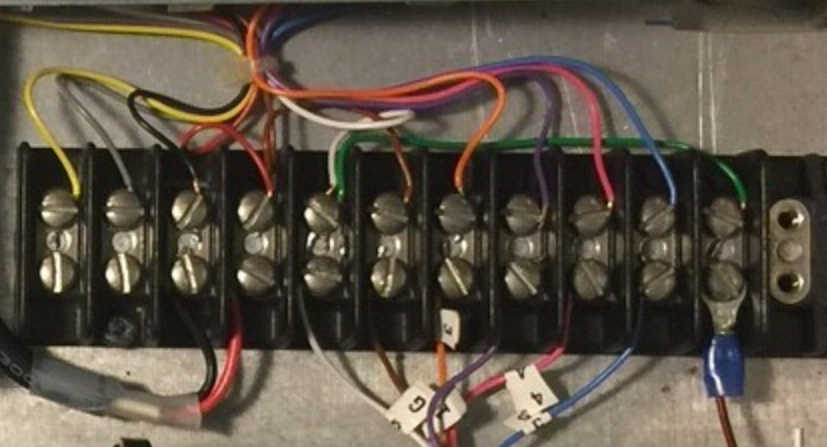
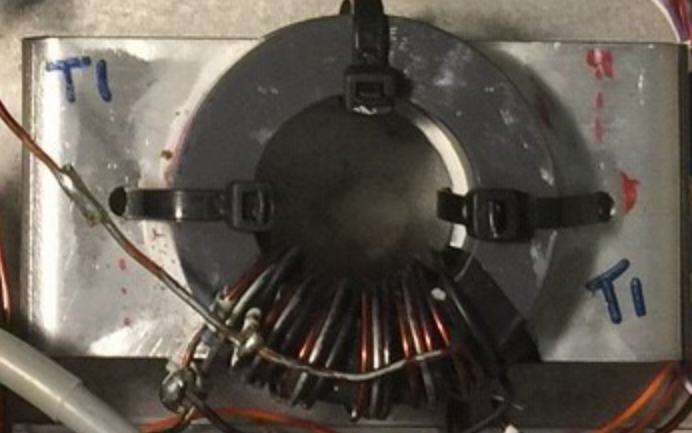
2:1 Transformer (100:50)



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



HUGHES
Model: YMA-20818
Output: 40W
Input: 100-120VAC
MAX OUTPUT POWER: 80W @ 2.0A
VOLTAGE: 12.6V
RELATIVE HUMIDITY: 13.5%
CAUTION: For indoor use only
Protection Fuse: T2 0A/250V
Danger: High voltages inside this case
This device complies with the FCC class B digital device limits. Operation to the following two conditions may not cause harmful interference and (2) this device must accept any interference received, including that which may cause unwanted operation.
Equipment: PN 1502019-0002
MADE IN CHINA
www.hughes.com



Phasing Harness Design

- LMR 400 with 84% VF
 - ◆ 45 Degree Harness
 - $L(VF)\sin 45$ (1/8 wave).
 - $(63.7 \times 0.84)\sin 45 = 37.84\text{feet}$
 - Spectrum Analyzer cut at 48'
 - ◆ 90 Degree Harness
 - $L(VF)\sin 90$ (1/4 wave).
 - $(127.4 \times 0.84)\sin 90 = 107\text{ feet}$
 - Spectrum Analyzer cut at 96'

Steering Box with Phasing Harnesses



Testing

Equipment used:

SigLent Digital Scope SDS-1202X-E

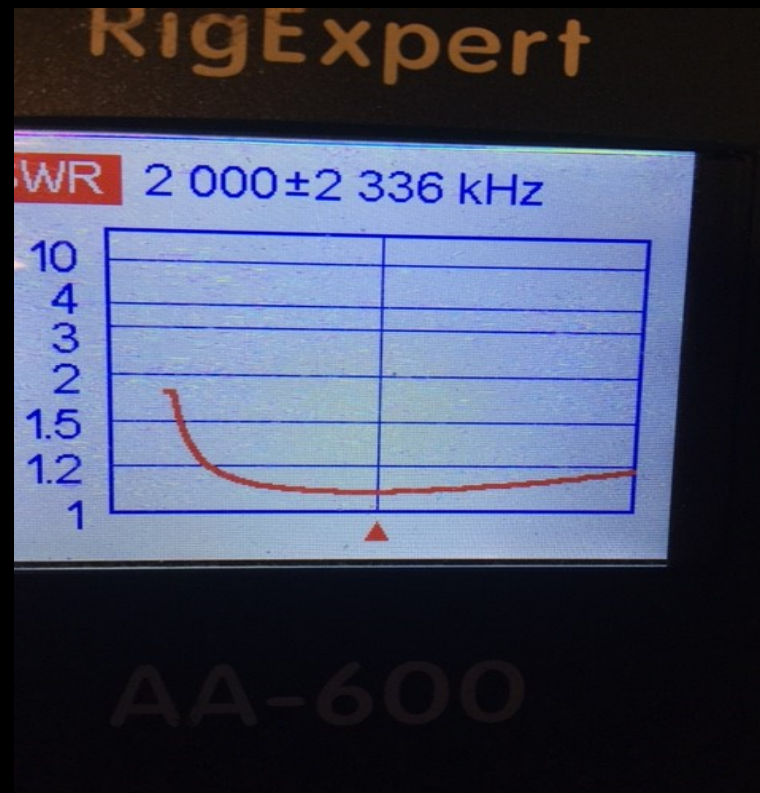
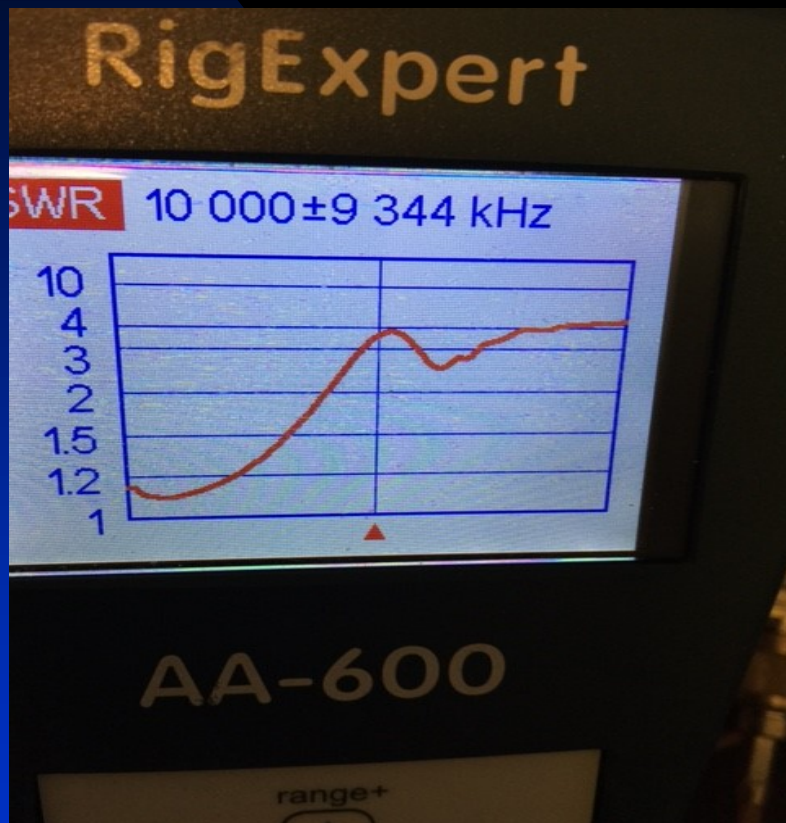
SigLent Spectrum Analyzer SSA 3021X

RigExpert Antenna Analyzer AA-600

Telepost Digital Station Monitor LP-500

Telepost Digial Vector RF Wattmeter LP-100A

Balun Transformer



Power Divider

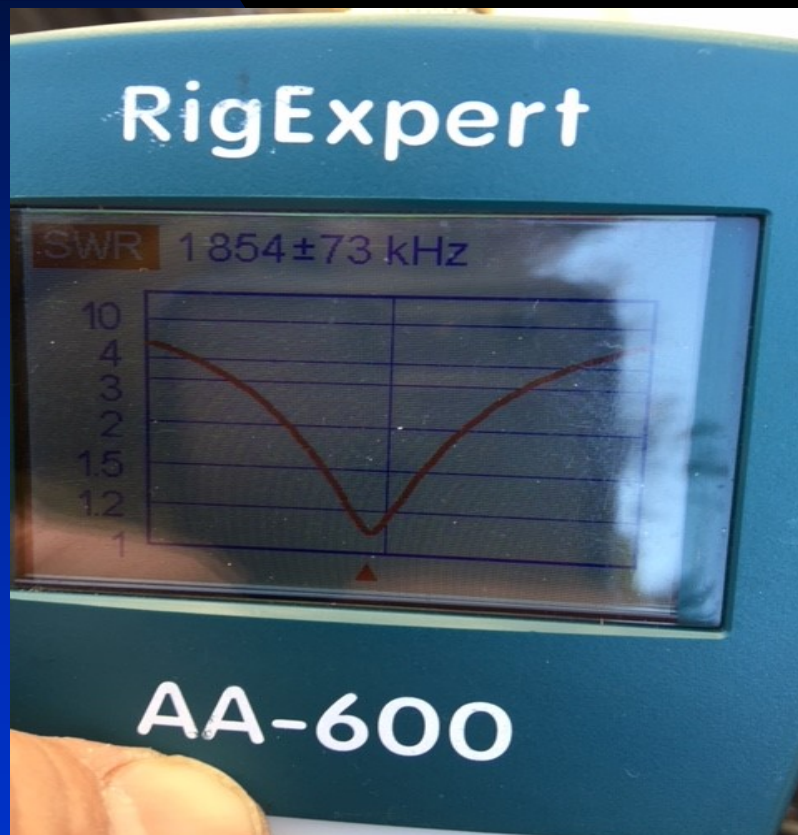
Input

Ant 1

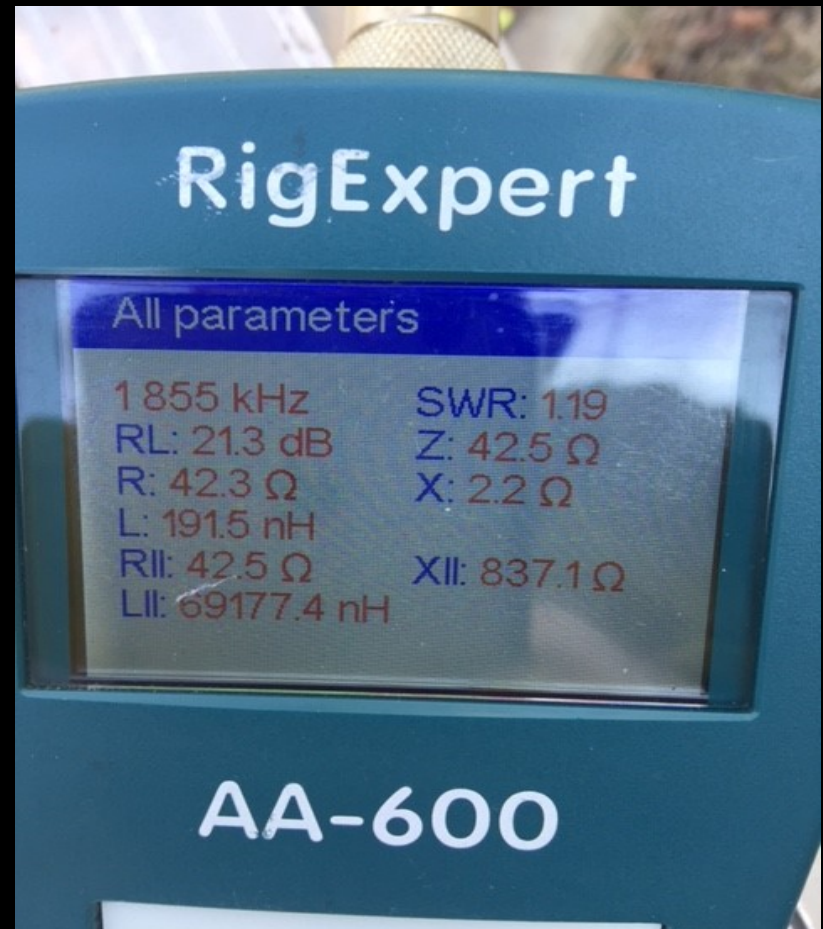
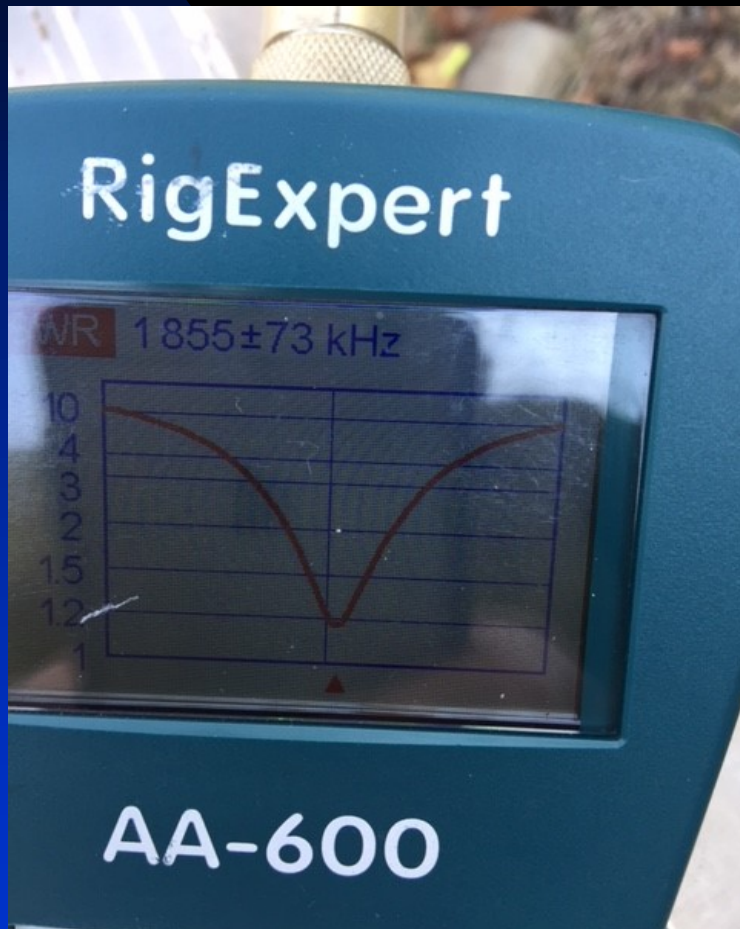
Ant 2



Antenna 1 (West)



Antenna 2 (East)

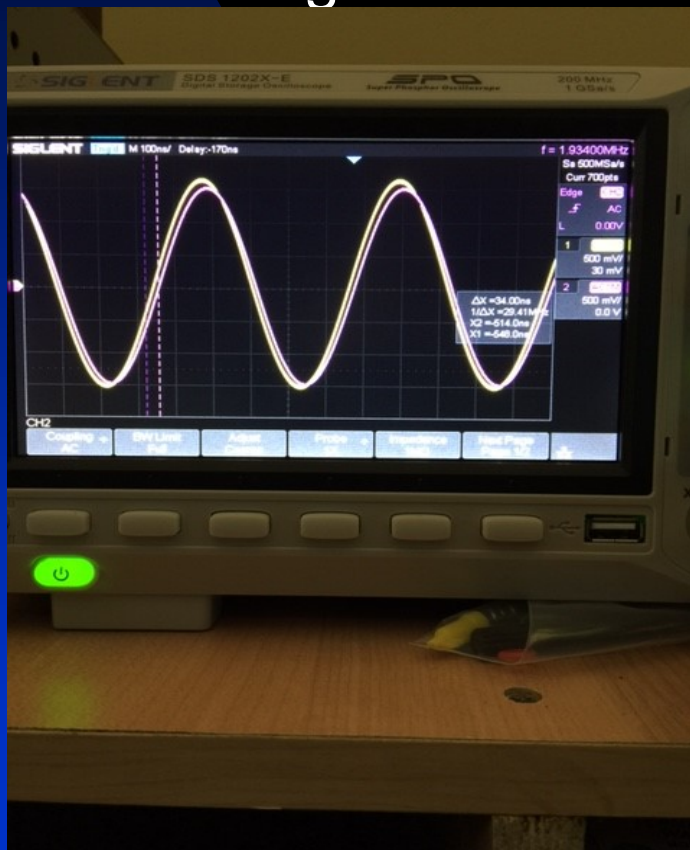


RF FeedBack from CT's @ A1 & A2

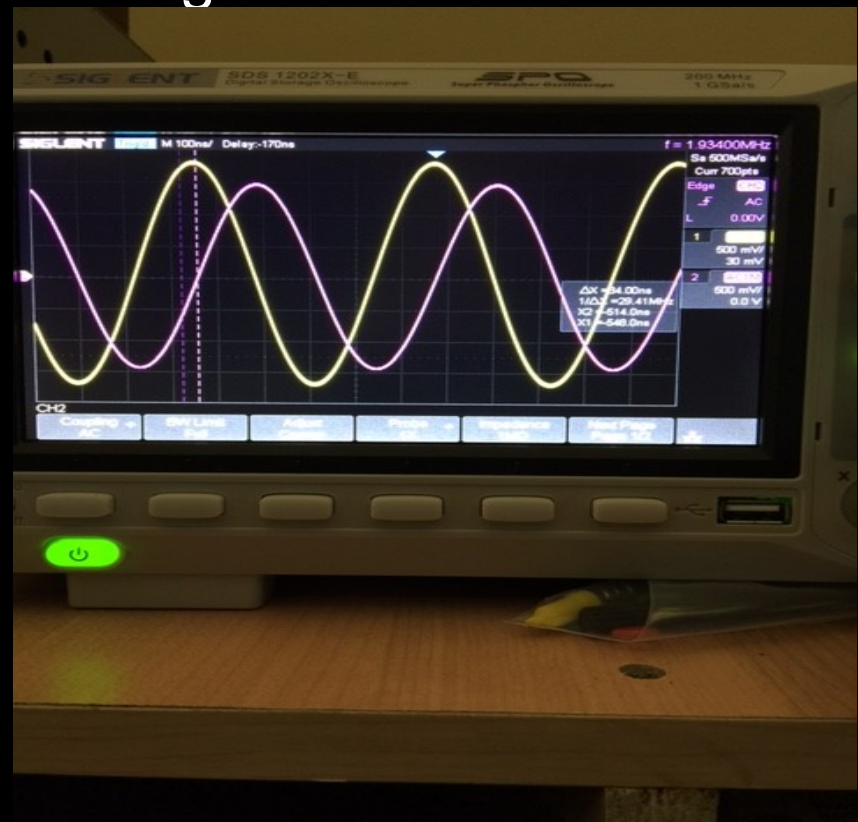
10:1



0/360 Degree

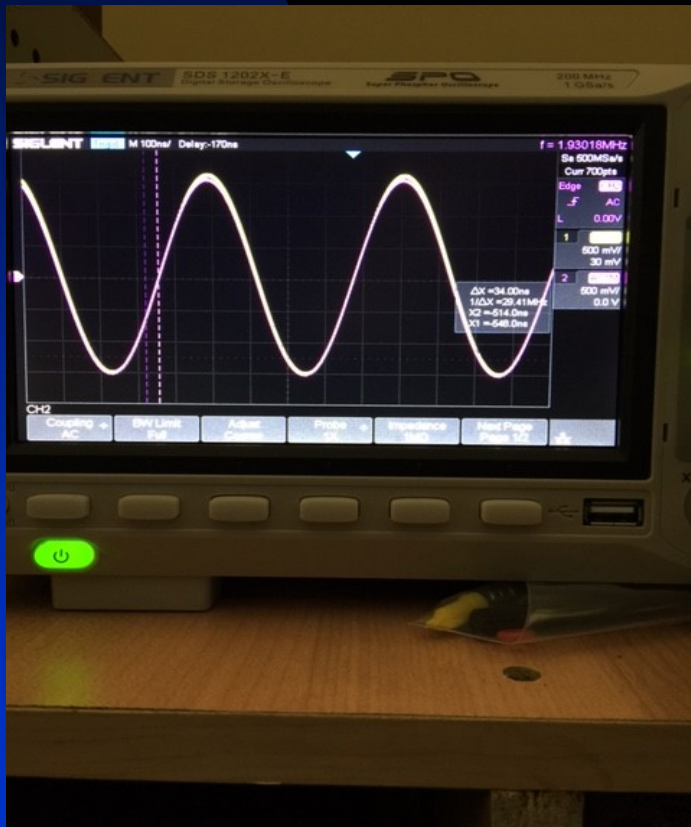


45 Degree

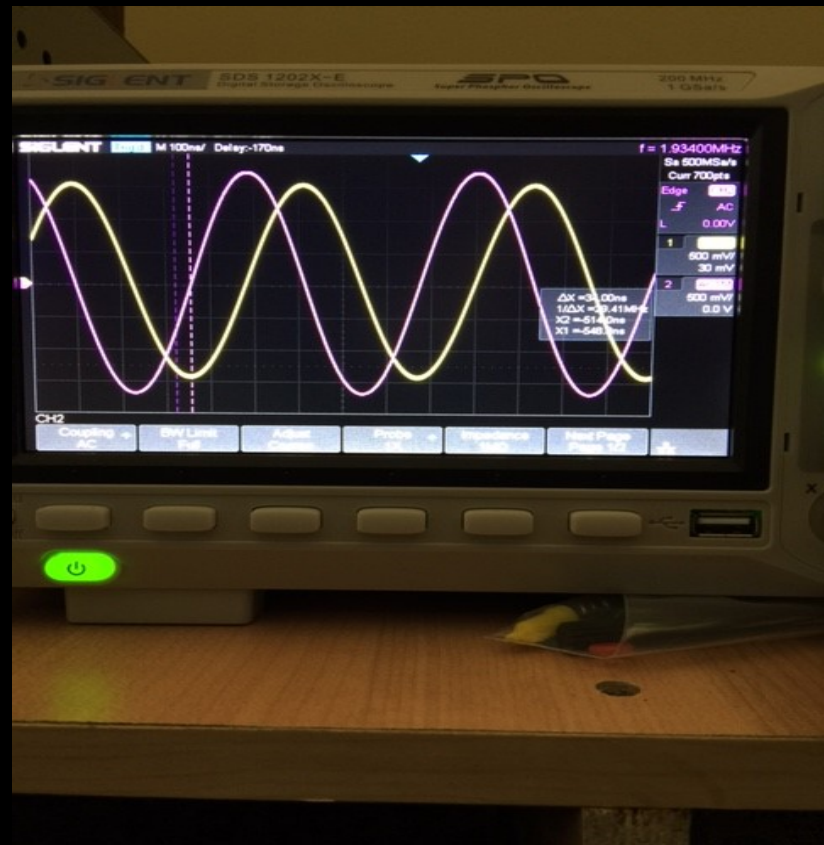


The image shows a Tektronix SDS 1202X-E digital storage oscilloscope. The screen displays two sine waves, one yellow and one purple, with a time scale of 100ns and a delay of 170ns. The frequency is 1.93400MHz. The screen also shows various settings like coupling, limit, and probe, and a green power button is visible on the front panel.

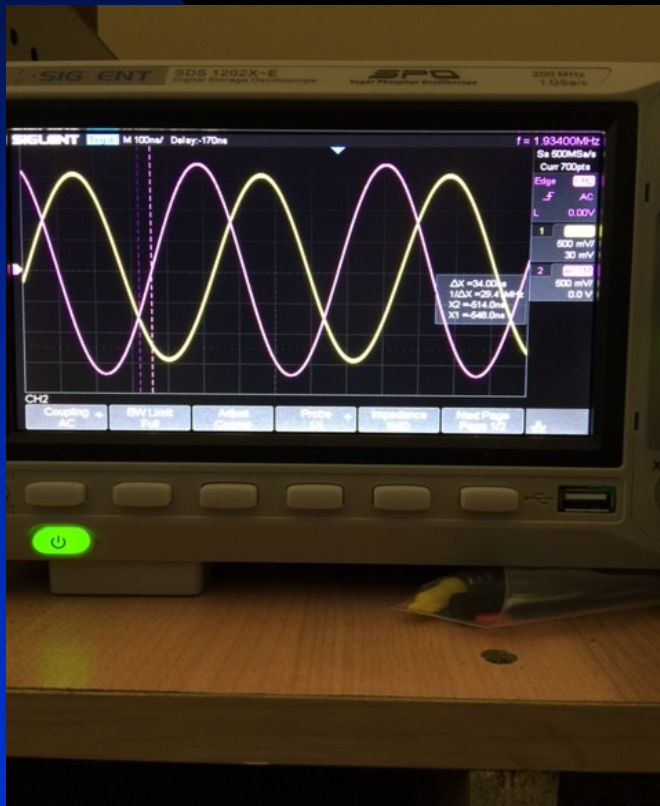
180 Degree



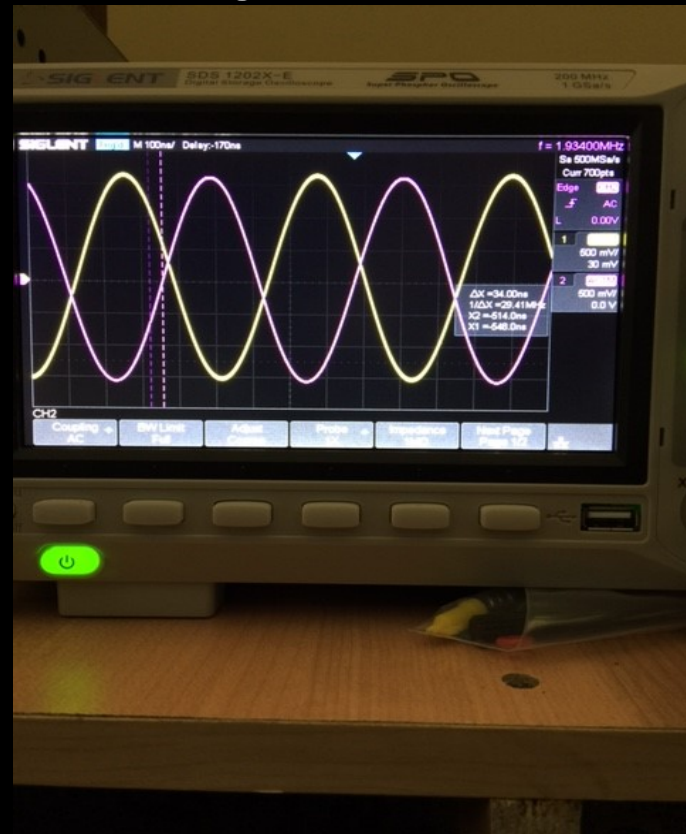
225Degree



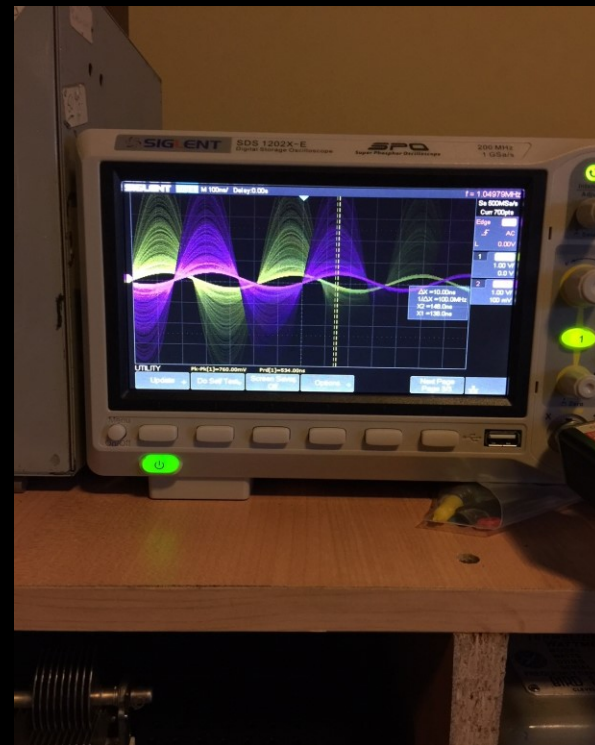
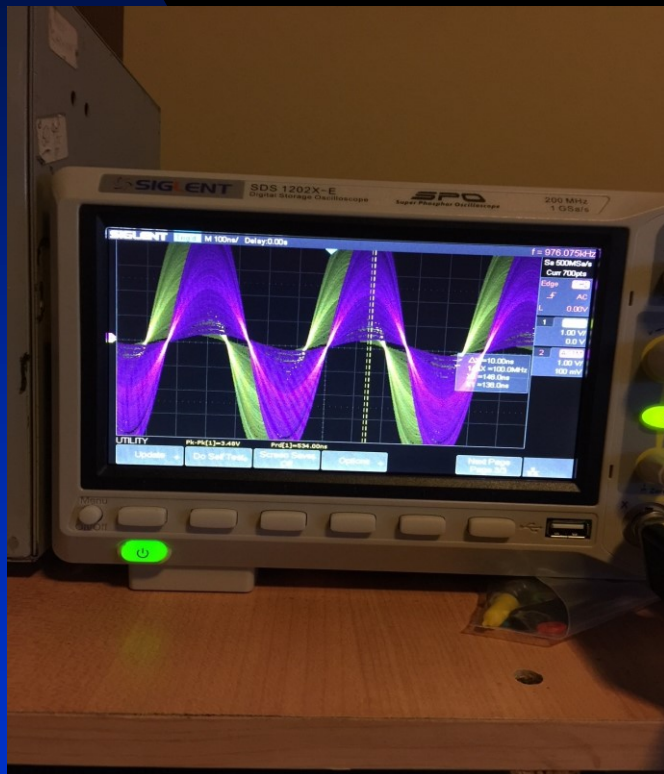
270 Degree



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