Station Description

16 Jan 2022

www.aj4co.org

Dave Typinski

CONTENTS

AJ4CO OBSERVATORY

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OBSERVATORY OUTLINE

Location

29° 50′ 13″ N 29.8369° N EL89qu
82° 37′ 17″ W 82.6214° W
53 ft (16 m) MSL

Antennas

TFD Array

Two square arrays on a NS line, eight 30-foot TFD elements, beam steering in 5° increments NS and 15° increments EW.

16 MHz HPBW at zenith: 18° NS x 40° EW
20 MHz HPBW at zenith: 15° NS x 35° EW, D ≈ 14 dBic
24 MHz HPBW at zenith: 12° NS x 30° EW
32 MHz HPBW at zenith: 8° NS x 20° EW
For more about the TFD Array, see: **The DPS and TFD Array**

Antenna Test Range

Presently conducting galactic background measurement series with ½λ dipoles.

Receivers

Dual Polarization Spectrograph (DPS)

24 x 7 x 365 unattended operation
16–32 MHz, simultaneous (correlated) RCP and LCP
300 channels per polarization (600 total)
Swept frequency, selectable 7.5, 15, 30, 60 kHz pre-detection BW
~ 6.7 sweeps/sec, integration time = 500 μs per sample
Frequency resolution = 53 kHz, Δt = 150 ms
For more about the DPS, see: **The DPS and TFD Array**

Receivers (cont'd)

Radio Jove Receivers

24 x 7 x 365 unattended operation
~ 20.1 MHz, uncorrelated RCP and LCP
7 kHz RF BW folded via direct conversion into a baseband
3.5 kHz pre-detection audio BW
Integration time = 100 ms per sample
For more about the Jove Receivers, See: **Radio Jove Receiver Manual**

Icom R8500 + 10.7 MHz Jove Receiver

7 kHz RF BW folded via direct conversion into a baseband
3.5 kHz pre-detection BW
Integration time = 100 ms per sample

Tunable Wideband Receiver (TWB) Mark III

Attended operation only
Tunable from 16 to 32 MHz, RCP or LCP
2 MHz IF BW direct to high speed digitizer
FFT post-processing, RBW = 4.88 kHz, $\Delta t = 205\ \mu s$
For more about the TWB, see: **The TWB**

Icom R75 Receivers 1 & 2

Used for live audio stream and as required for antenna test range operations.

Sensitivity

Formal sensitivity calculations and measurements have not been made. A rough estimate considering only the number of dipoles is a 20 MHz on-axis and at zenith 3σ sensitivity on the order of 100 kJy. All receivers presently in use have noise figures between 6 and 8 dB, making their internal noise of little concern given the modest losses between the TFD array and the receivers and the fact that in the upper HF band, system noise is dominated by the galactic background emission.

Timing

All radio telescope data collection systems use a PC's internal clock to apply timestamps to the data. Each PC runs a Network Time Protocol (NTP) daemon to keep its system clock within a few milliseconds of UTC. The NTP server is a GPS-ntp-pi stand-alone unit using multiple GNSS signals to provide the correct time on the local network.
For more information, see: **GPS-NTP Pi**
For more information, see: **Meinberg NTP Server** and **Meinberg NTP Server Monitor**

Calibration

All radio telescope systems are calibrated in terms of antenna temperature using a noise source calibrated against a 5722 noise diode. An automatic calibrator runs a step calibration on all receivers, usually twice per day at ±3 hours from Jupiter transit. The step cal runs 17 steps each separated by 3 dB. Calibration timing, step duration, and noise temperature varies as required by telescope and test range operations. For more information see: **AJ4CO Automatic Calibrator**

Computers

Three identical PCs are used to record data from the receivers. Each has a 2.4 GHz AMD Opteron dual-core processor, 4 GB RAM, and a 1 TB hard drive. All run Windows XP SP3. All are connected to the observatory LAN.

Internet

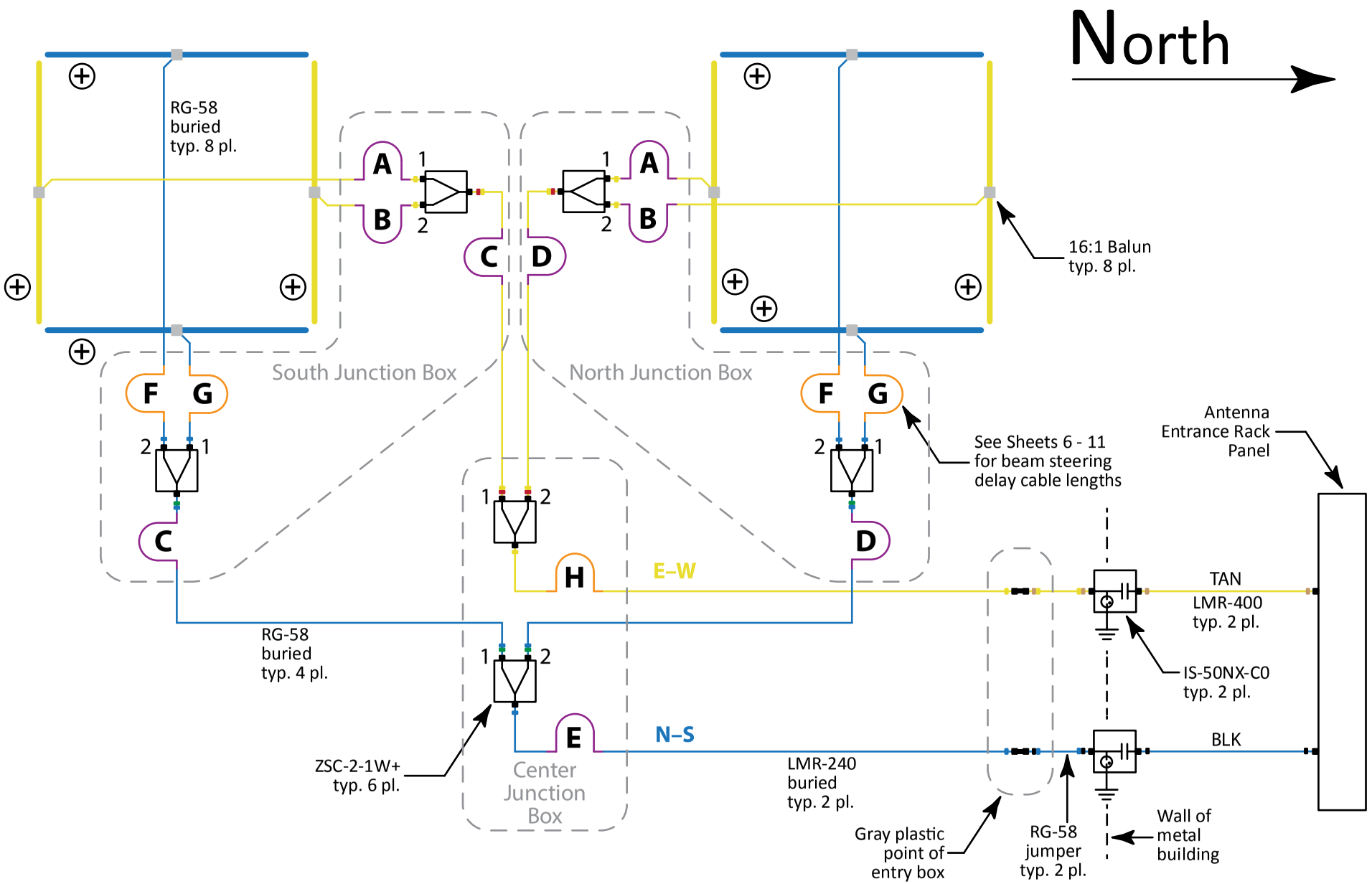
The observatory has internet access via a 6 Mbps DSL connection. This connection allows the Radio Sky Pipe (RSS) and Radio Sky Spectrograph (RSS) software to serve data to interested remote observers.

Power

The receivers, computers, and network hardware are fed by six 1.5 kVA battery backup units providing at least 15 minutes of power if the AC mains fail.

Operations

Several radio telescopes operate all day, every day (see "Receivers" above). Useful Jupiter observations are made any time Jupiter is within 3 hours of transit, but this is extended to around 4.5 hours when Jupiter's transit elevation is greater than 70° and Jupiter is near opposition.



30’ terminated folded dipoles, top wire 9’2” height,
8” wire spacing, 32’ element spacing,
800 Ω termination resistors, 16:1 baluns.

AJ4CO OBSERVATORY

TFD Array - Electrical

SIZE	DATE	PART NUMBER	REV
A	02 FEB 2020	N/A	B

SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	1 OF 1

TFD Array Feed System Losses

Device sweeps performed 11 Aug 2013
Feed line loss sweeps performed 28 Mar 2015
TFE Element Efficiency Measured Jan 2020

Freq (MHz)	TRA AN-TFD-30 Element Efficiency Loss (dB)	Element Balun to Outer J-box RG-58 Loss (dB)	Mini-Circuits ZSC-2-1W+ Combiners (two) Loss (dB)	Outer J-box to center J-box RG-58 Loss (dB)	Mini-Circuits ZSC-2-1W+ Combiners (two) Loss (dB)	Center J-box to gray point of entry box LMR-240 Loss (dB)	Rack panel to gray point of entry box LMR-400 Loss (dB)	Loss between sky side of TFD element and Hybrid Inputs (CAL PLANE) (dB)
16	-6.8	-0.33	-0.20	-0.75	-0.20	-0.94	-0.99	-10.2
18	-5.2	-0.35	-0.21	-0.79	-0.21	-0.99	-1.04	-8.8
20	**-4.8**	**-0.37**	**-0.21**	**-0.84**	**-0.21**	**-1.03**	**-1.09**	**-8.6**
22	-5.0	-0.39	-0.22	-0.89	-0.22	-1.07	-1.15	-8.9
24	-5.2	-0.40	-0.22	-0.93	-0.22	-1.11	-1.20	-9.3
26	-5.1	-0.42	-0.23	-0.97	-0.23	-1.16	-1.24	-9.3
28	-4.9	-0.45	-0.24	-1.00	-0.24	-1.20	-1.28	-9.3
30	-4.7	-0.46	-0.24	-1.04	-0.24	-1.23	-1.32	-9.2
32	-5.2	-0.46	-0.25	-1.09	-0.25	-1.27	-1.36	-9.9

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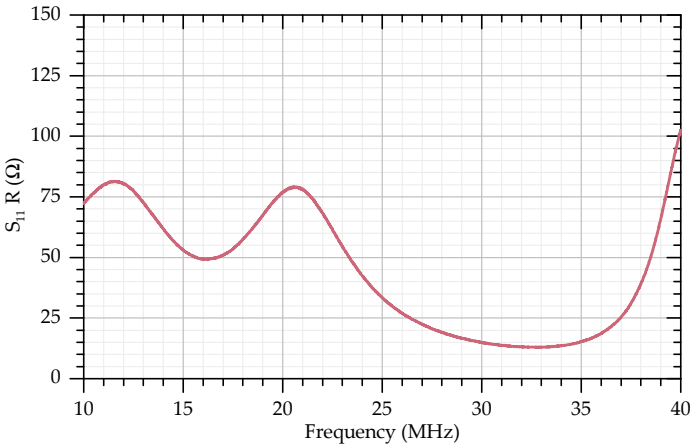
TFD Array Feed System Losses

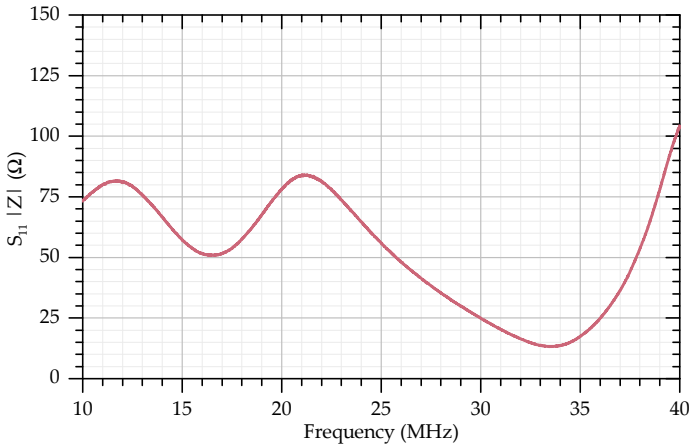
SIZE	DATE	PART NUMBER	REV
A	02 FEB 2020	N/A	B

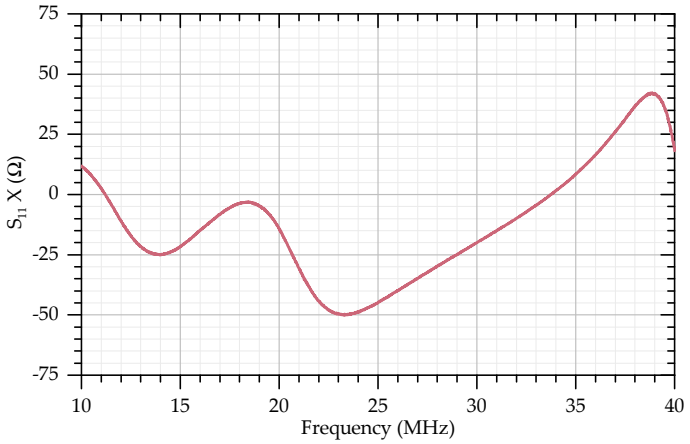
SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	1 OF 1

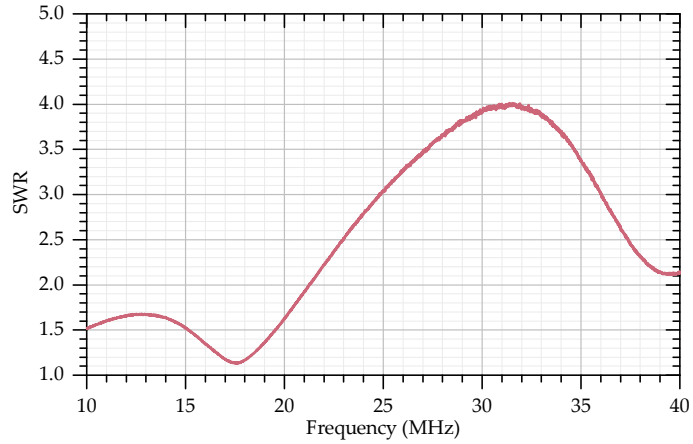
30′ TFD Element Feed Point (Balun Output) Characteristics Plots

Measured above natural ground (no ground screen).



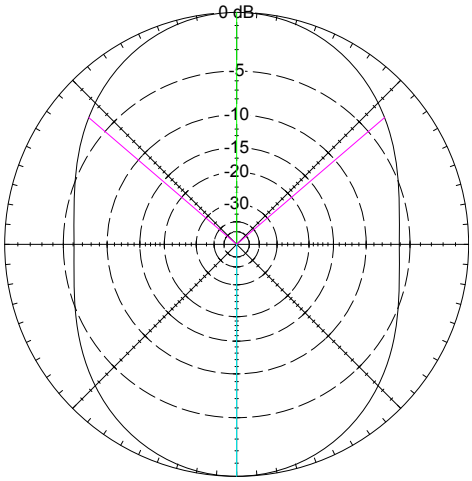


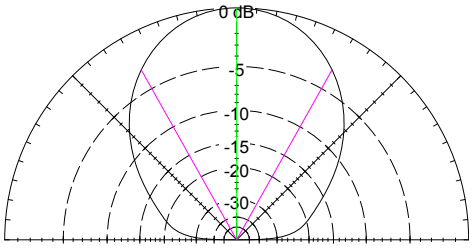


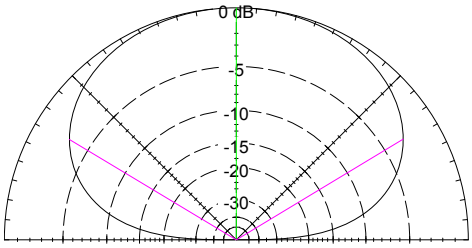


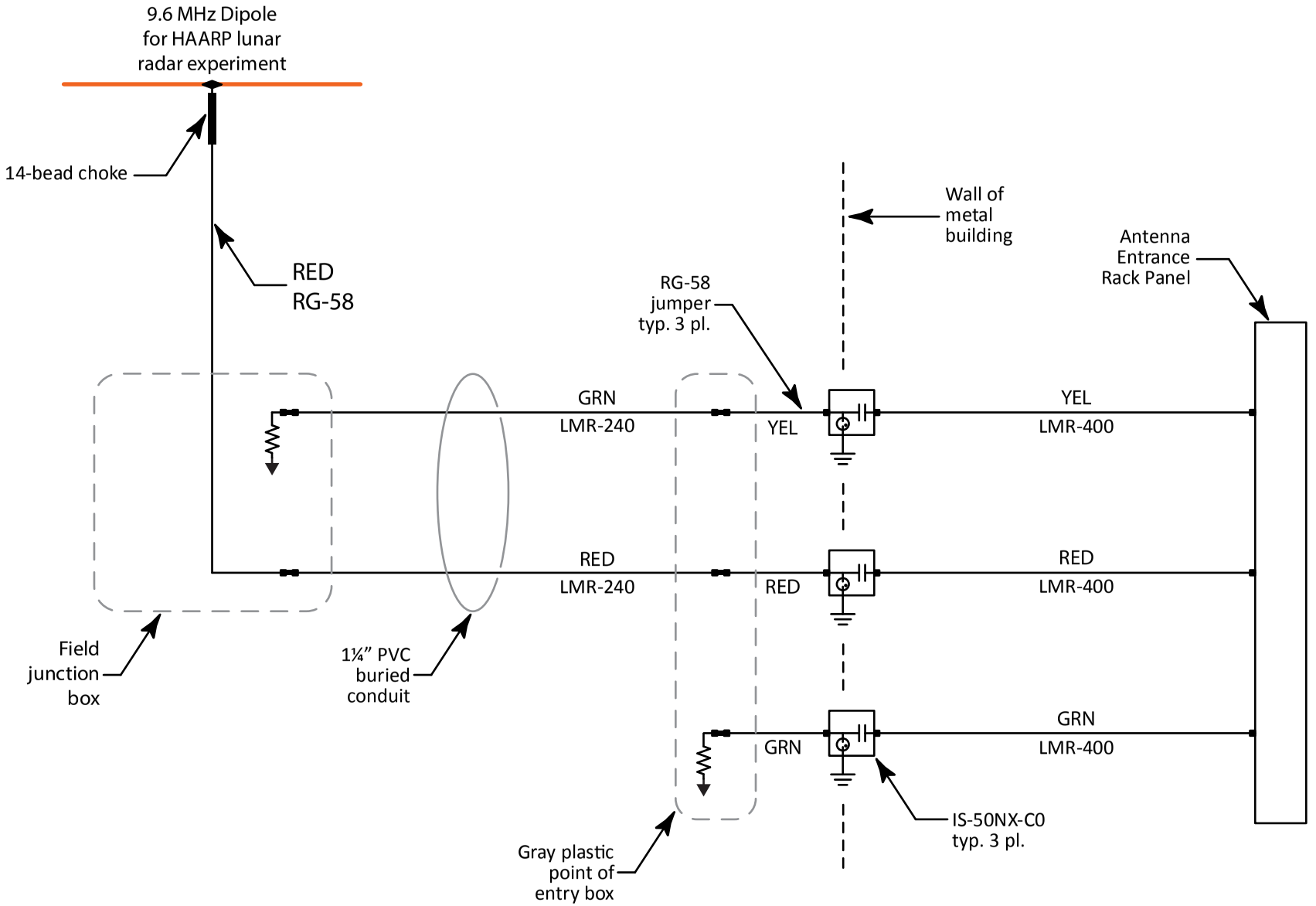
30′ TFD 20.1 MHz EZNEC predicted element beam pattern

Modeled above poor ground. Azimuth pattern at 45° elevation.









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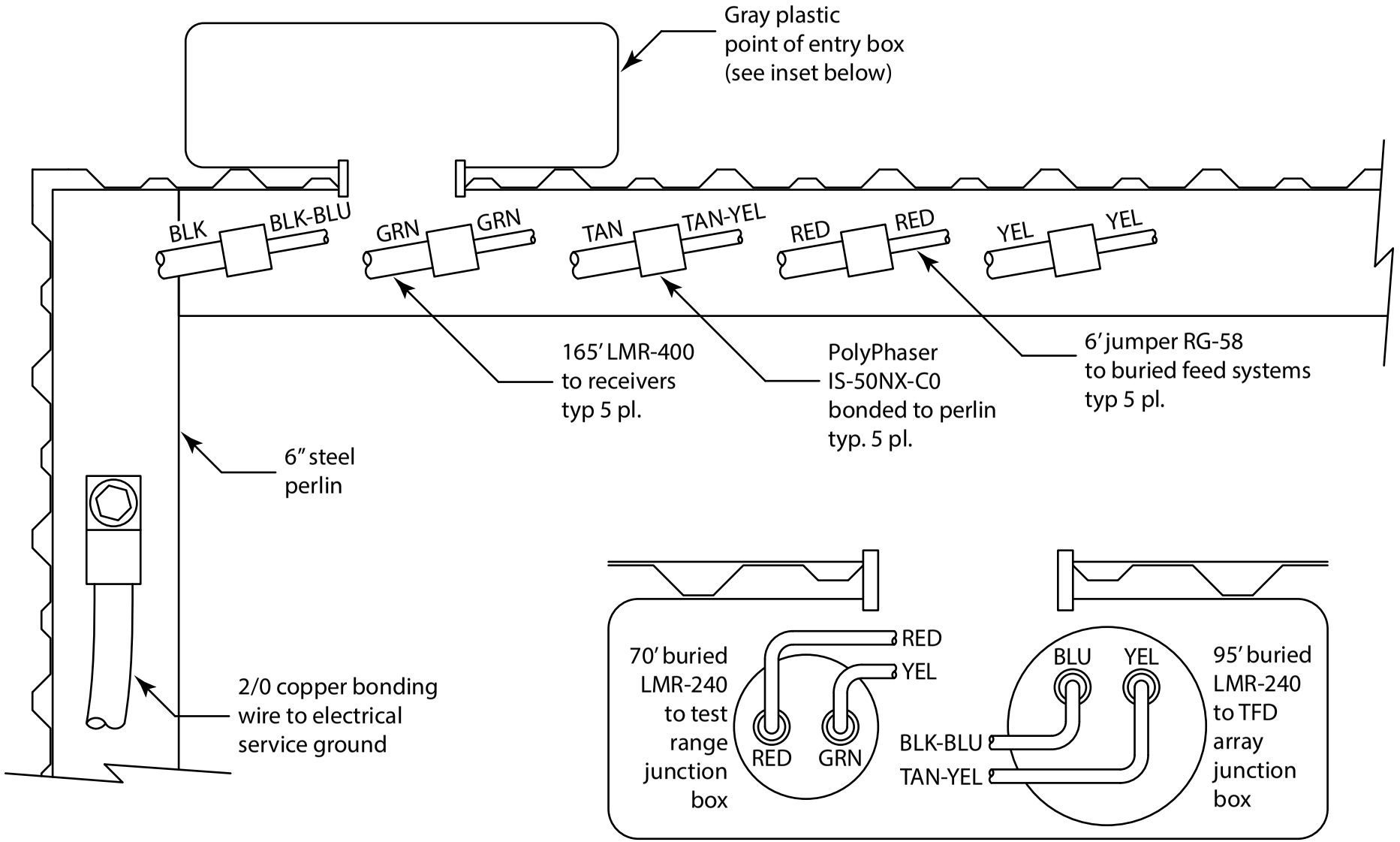
Antenna Test Range - Electrical

SIZE	DATE	PART NUMBER	REV
A	14 JAN 2022	N/A	E

SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	1 OF 1



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RF Surge Suppressors

SIZE	DATE	PART NUMBER	REV
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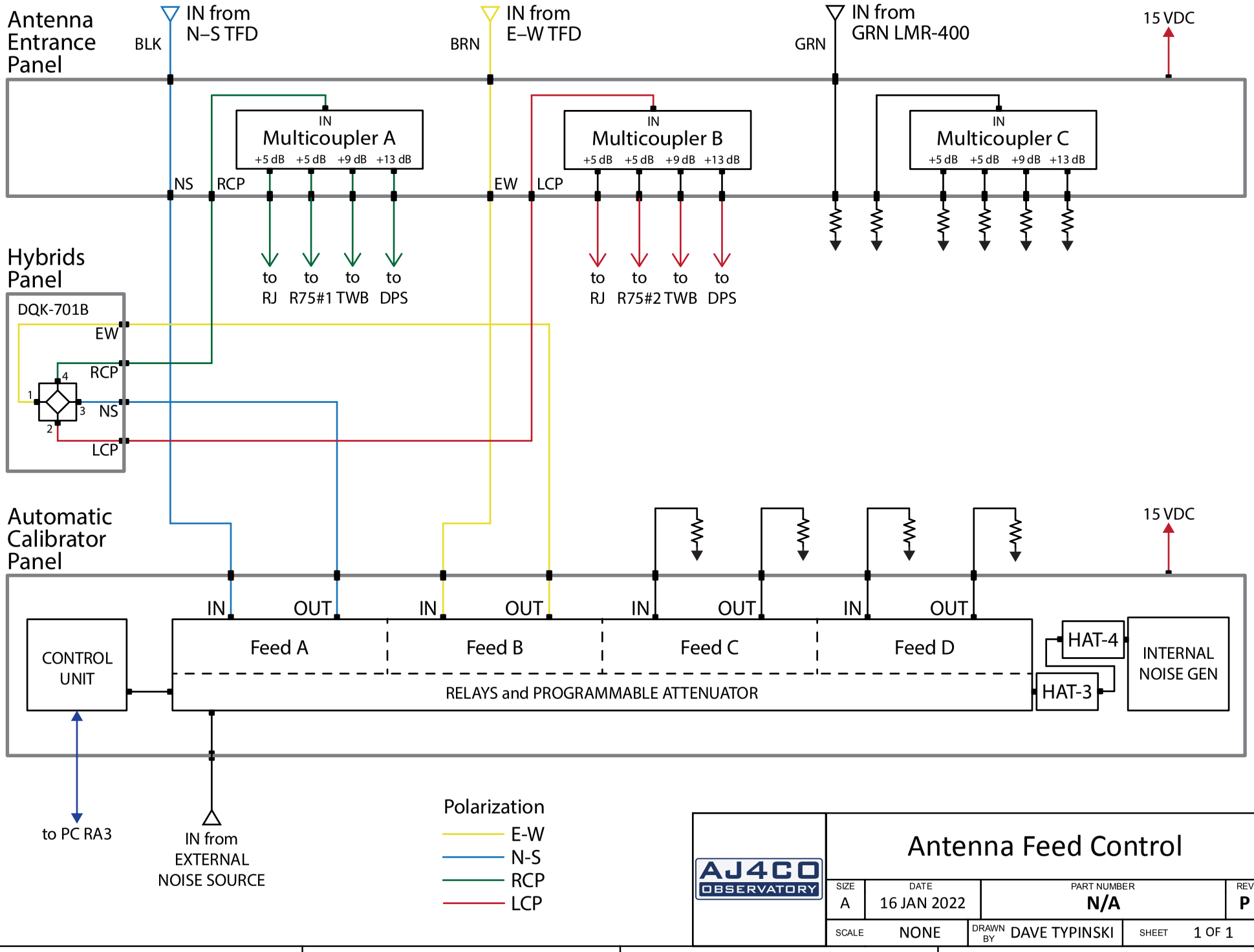
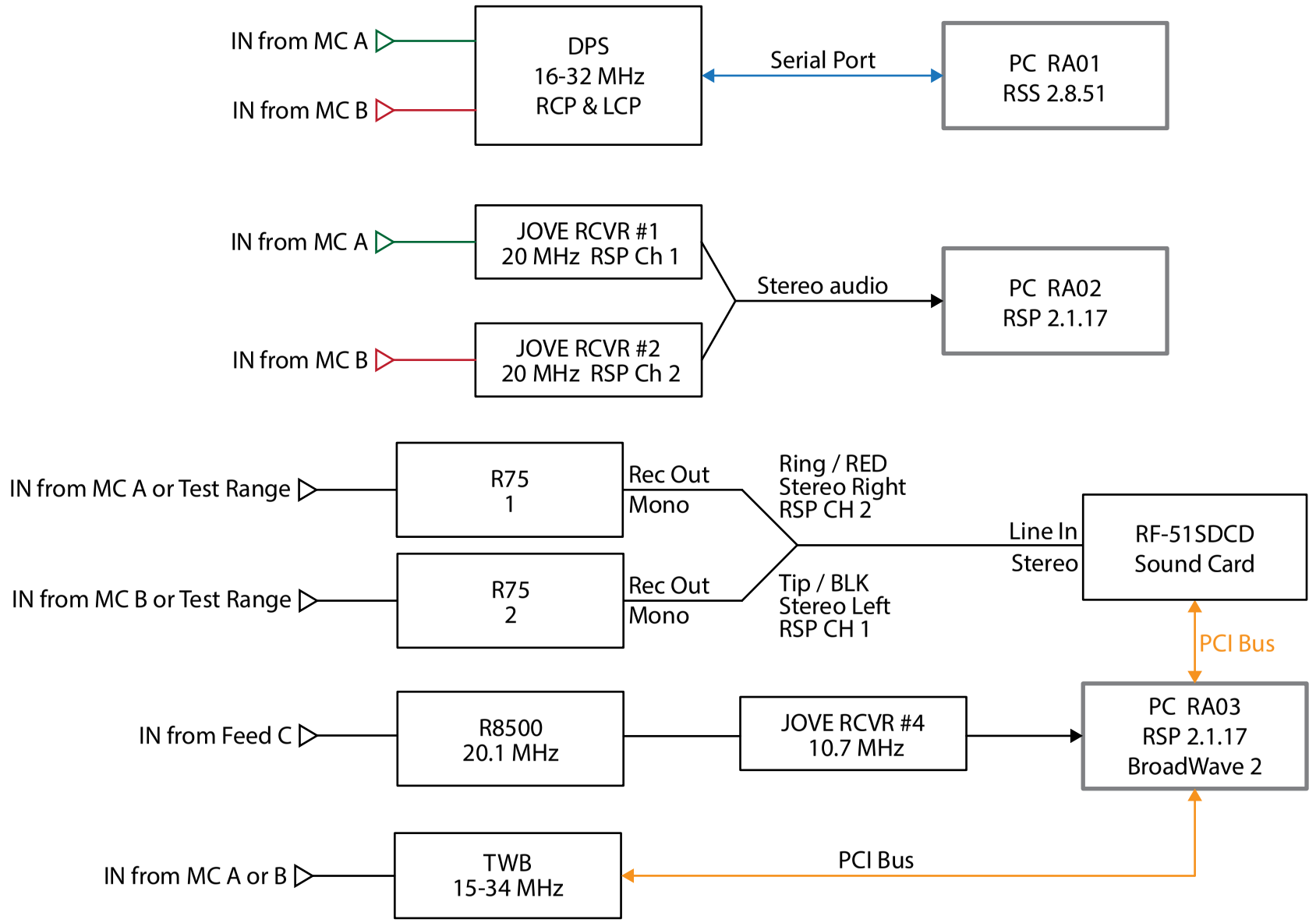
SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	1 OF 1


Antenna Entrance Panel
IN from N–S TFD
BLK
IN from E–W TFD
BRN
IN from GRN LMR-400
GRN
15 VDC
IN
Multicoupler A
+5 dB +5 dB +9 dB +13 dB
NS
RCP
EW
LCP
Multicoupler B
Multicoupler C
to RJ
to R75#1 TWB
to DPS
to R75#2 TWB
Hybrids Panel
DQK-701B
EW
RCP
NS
LCP
Automatic Calibrator Panel
IN
OUT
CONTROL UNIT
Feed A
Feed B
Feed C
Feed D
RELAYS and PROGRAMMABLE ATTENUATOR
HAT-4
HAT-3
INTERNAL NOISE GEN
to PC RA3
IN from EXTERNAL NOISE SOURCE
Polarization
E-W
N-S
RCP
LCP
AJ4CO OBSERVATORY
Antenna Feed Control
SIZE A
DATE 16 JAN 2022
PART NUMBER N/A
REV P
SCALE NONE
DRAWN BY DAVE TYPINSKI
SHEET 1 OF 1



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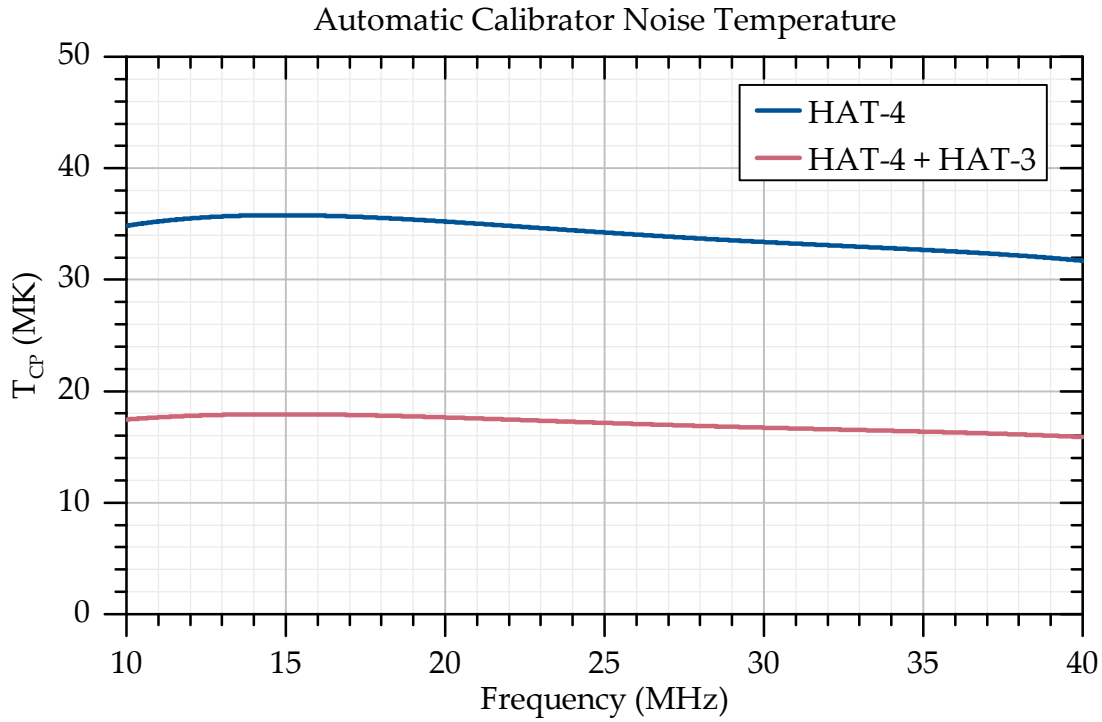
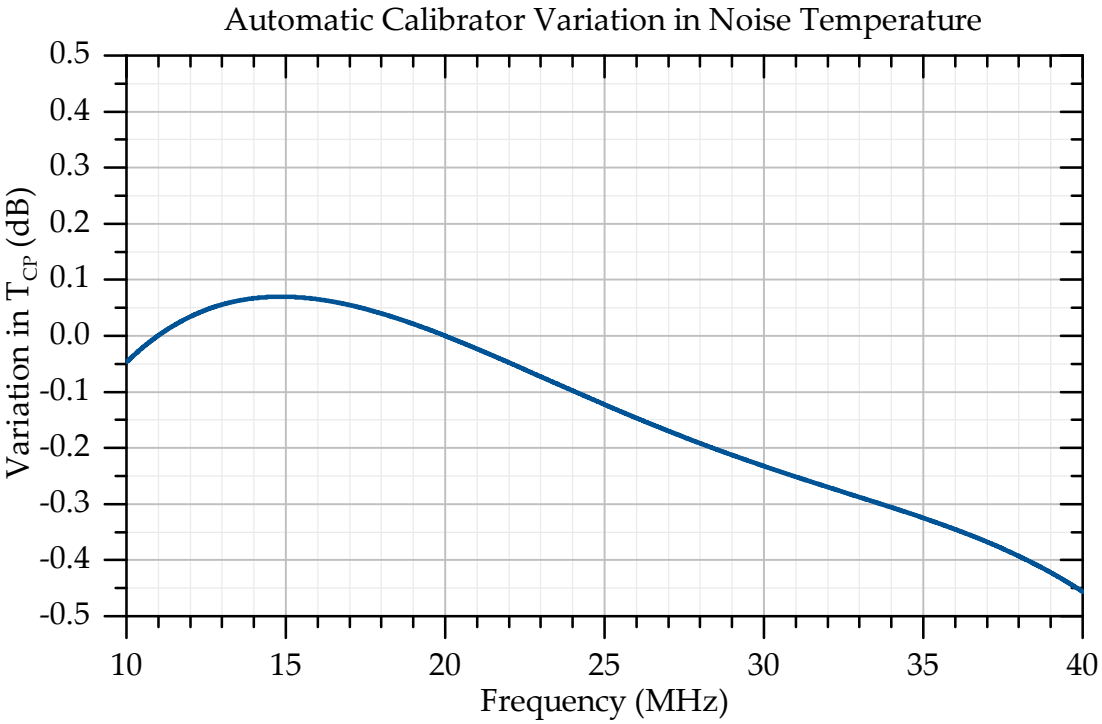
Receivers

SIZE	DATE	PART NUMBER	REV
A	16 JAN 2022	N/A	J

SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	1 OF 1

The AJ4CO automatic calibrator is presently modified by the addition of a HAT-4 and a HAT-3 in series at the internal noise generator's output connector. Plots below show the noise temperature and variation at the automatic calibrator front panel connectors (the calibration plane) during the calibrator's 0 dB attenuation step. The internal noise generator was measurad at 430 MK ± 0.1 dB on 05 Jan 2020.





Automatic Calibrator Calibration Plane Noise Temperatures at 20 MHz

Internal Noise Generator Calibrated Against 5722 on 05 Jan 2020

T_0 (K)	290	
Noise Source 20 MHz Temperature (MK)	430	
Splitter 20 MHz Loss (dB)	13.4	(6.35 splitter + HAT-4 + HAT-3)

Calibration Plane: CAL relays between Antenna Feeds Entrance and Hybrid Ring Inputs.

Nominal Attn. (dB)	Measured Attn. @ 20 MHz (dB)	Cal Plane Tnoise (K)
0	0.56	17.5 MK
1	1.52	14.0 MK
2	2.56	11.0 MK
4	4.57	6.94 MK
8	8.55	2.78 MK
16	16.58	437 kK
32	32.50	11.5 kK
64	64.65	297 K

Auto Cal Step	Nominal Attn. (dB)	Measured Attn. @ 20 MHz (dB)	Cal Plane Tnoise (K)
1	0	0.56	17.5 MK
2	3	3.43	9.03 MK
3	6	6.47	4.48 MK
4	9	9.45	2.26 MK
5	12	12.58	1.10 MK
6	15	15.48	563 kK
7	18	18.55	278 kK
8	21	21.50	141 kK
9	24	24.55	70.0 kK
10	27	27.51	35.6 kK
11	30	30.58	17.7 kK
12	33	33.49	9.19 kK
13	36	36.54	4.70 kK
14	39	39.55	2.50 kK
15	42	42.55	1.40 kK
16	45	45.59	839 K
17	48	48.55	568 K

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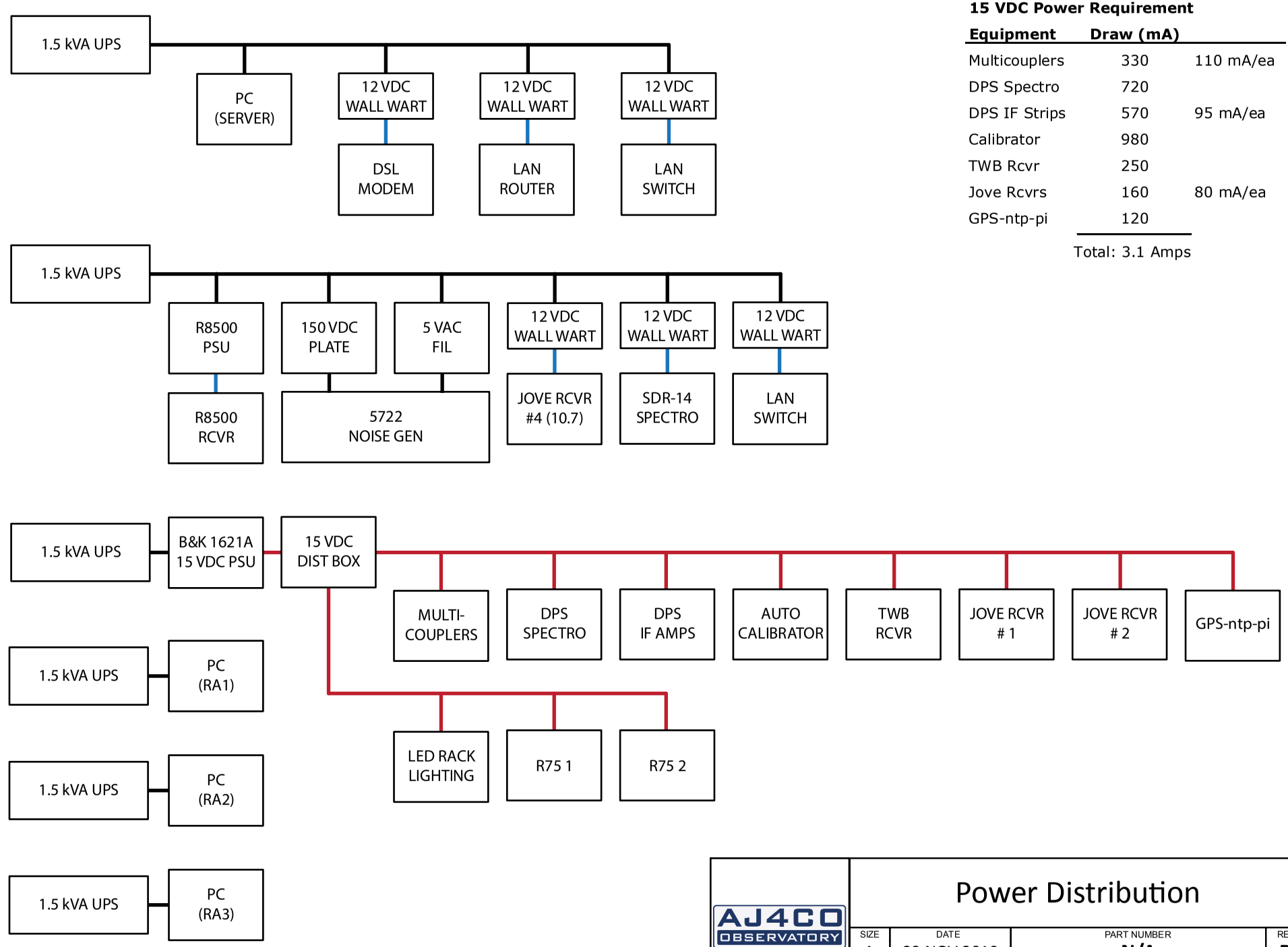
Calibration Temperatures

SIZE	DATE	PART NUMBER	REV
A	02 FEB 2020	N/A	E

SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	1 OF 1



15 VDC Power Requirement

Equipment	Draw (mA)	
Multicouplers	330	110 mA/ea
DPS Spectro	720	
DPS IF Strips	570	95 mA/ea
Calibrator	980	
TWB Rcvr	250	
Jove Rcvrs	160	80 mA/ea
GPS-ntp-pi	120	
	Total: 3.1 Amps	

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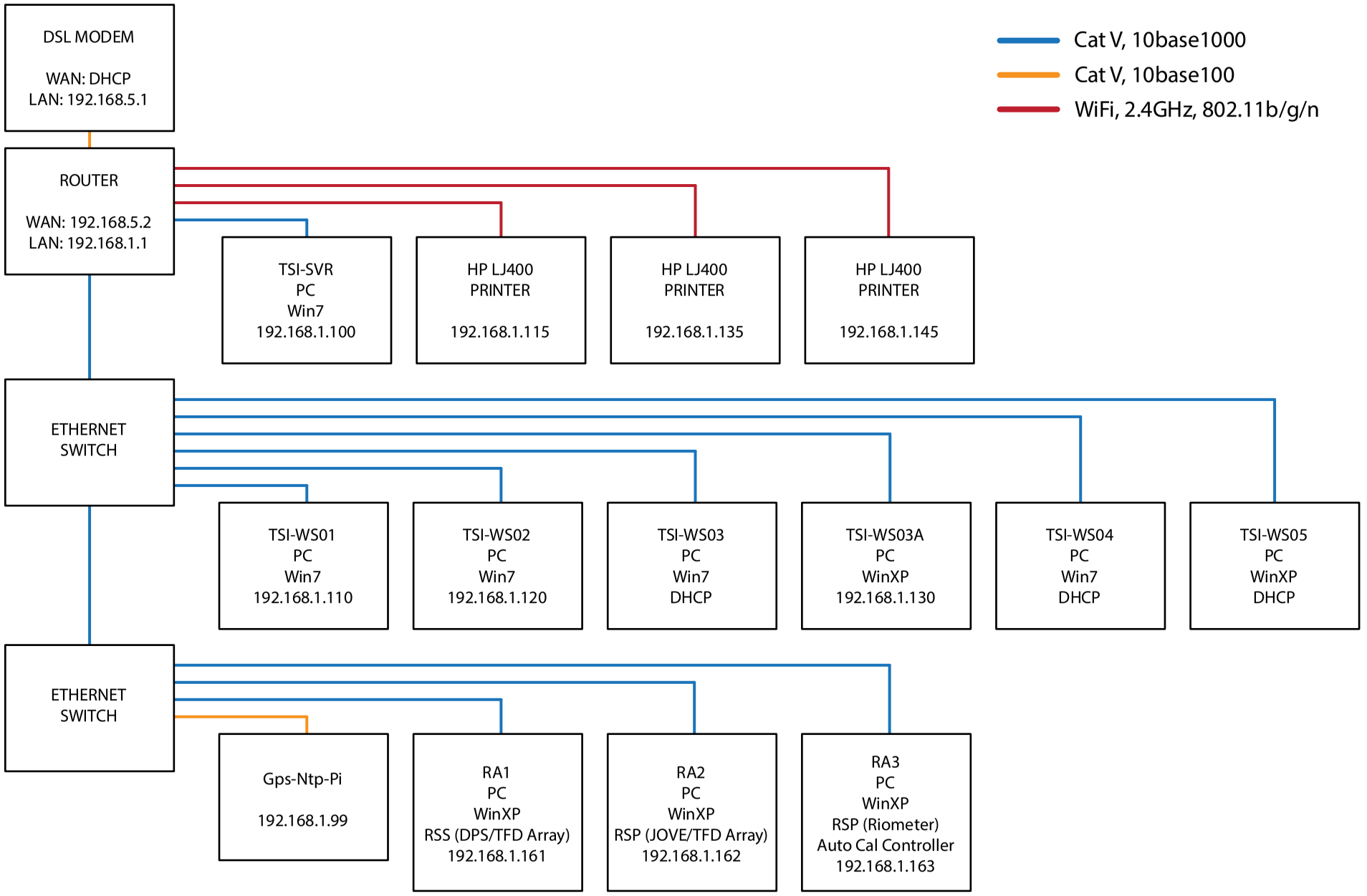
Power Distribution

SIZE	DATE	PART NUMBER	REV
A	29 NOV 2019	N/A	D

SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	1 OF 1



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Ethernet Diagram

SIZE	DATE	PART NUMBER	REV
A	20 AUG 2019	N/A	A

SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	1 OF 1

TFD Array Beam Steering

Time Delay Cable VoP: **66%**

ray elements N-S baseline spacing (feet): **32**

Array elements E-W baseline spacing (feet): **32**

N-S Offset (degrees)	E-W Offset (degrees)	Delay Cable Lengths (feet & inches) A (S) / B (N)	C (S) / D (N)	E	F (W) / G (E)	H	AZ (degrees)	EL (degrees)
20 N	60 E	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	18' 3-1/2"	9' 1-3/4"	78	29
20 N	45 E	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	14' 11-1/4"	7' 5-1/2"	70	43
20 N	30 E	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	10' 6-3/4"	5' 3-1/4"	58	56
20 N	15 E	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	5' 5-1/2"	2' 8-3/4"	36	66
20 N	0	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	0"	0"	0	70
20 N	15 W	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	5' 5-1/2"	2' 8-3/4"	324	66
20 N	30 W	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	10' 6-3/4"	5' 3-1/4"	302	56
20 N	45 W	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	14' 11-1/4"	7' 5-1/2"	290	43
20 N	60 W	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	18' 3-1/2"	9' 1-3/4"	282	29
15 N	60 E	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	18' 3-1/2"	9' 1-3/4"	81	30
15 N	45 E	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	14' 11-1/4"	7' 5-1/2"	75	44
15 N	30 E	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	10' 6-3/4"	5' 3-1/4"	65	58
15 N	15 E	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	5' 5-1/2"	2' 8-3/4"	45	69
15 N	0	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	0"	0"	360	75
15 N	15 W	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	5' 5-1/2"	2' 8-3/4"	315	69
15 N	30 W	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	10' 6-3/4"	5' 3-1/4"	295	58
15 N	45 W	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	14' 11-1/4"	7' 5-1/2"	285	44
15 N	60 W	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	18' 3-1/2"	9' 1-3/4"	279	30
10 N	60 E	3' 8"	7' 4"	1' 10"	18' 3-1/2"	9' 1-3/4"	84	30
10 N	45 E	3' 8"	7' 4"	1' 10"	14' 11-1/4"	7' 5-1/2"	80	45
10 N	30 E	3' 8"	7' 4"	1' 10"	10' 6-3/4"	5' 3-1/4"	73	59
10 N	15 E	3' 8"	7' 4"	1' 10"	5' 5-1/2"	2' 8-3/4"	57	72
10 N	0	3' 8"	7' 4"	1' 10"	0"	0"	360	80
10 N	15 W	3' 8"	7' 4"	1' 10"	5' 5-1/2"	2' 8-3/4"	303	72
10 N	30 W	3' 8"	7' 4"	1' 10"	10' 6-3/4"	5' 3-1/4"	287	59
10 N	45 W	3' 8"	7' 4"	1' 10"	14' 11-1/4"	7' 5-1/2"	280	45
10 N	60 W	3' 8"	7' 4"	1' 10"	18' 3-1/2"	9' 1-3/4"	276	30

AJ4CO OBSERVATORY

TFD Array Beam Steering

SIZE	DATE	PART NUMBER	REV
A	01 OCT 2014	N/A	A

SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	1 OF 6

TFD Array Beam Steering

Time Delay Cable VoP: 66%

Array elements N-S baseline spacing (feet): 32

Array elements E-W baseline spacing (feet): 32

N-S Offset (degrees)	E-W Offset (degrees)	Delay Cable Lengths (feet & inches)					AZ (degrees)	EL (degrees)
		A (S) / B (N)	C (S) / D (N)	E	F (W) / G (E)	H		
5 N	60 E	1' 10"	3' 8-1/4"	11"	18' 3-1/2"	9' 1-3/4"	87	30
5 N	45 E	1' 10"	3' 8-1/4"	11"	14' 11-1/4"	7' 5-1/2"	85	45
5 N	30 E	1' 10"	3' 8-1/4"	11"	10' 6-3/4"	5' 3-1/4"	81	60
5 N	15 E	1' 10"	3' 8-1/4"	11"	5' 5-1/2"	2' 8-3/4"	72	74
5 N	0	1' 10"	3' 8-1/4"	11"	0"	0"	360	85
5 N	15 W	1' 10"	3' 8-1/4"	11"	5' 5-1/2"	2' 8-3/4"	288	74
5 N	30 W	1' 10"	3' 8-1/4"	11"	10' 6-3/4"	5' 3-1/4"	279	60
5 N	45 W	1' 10"	3' 8-1/4"	11"	14' 11-1/4"	7' 5-1/2"	275	45
5 N	60 W	1' 10"	3' 8-1/4"	11"	18' 3-1/2"	9' 1-3/4"	273	30
0	60 E	0"	0"	0"	18' 3-1/2"	9' 1-3/4"	90	30
0	45 E	0"	0"	0"	14' 11-1/4"	7' 5-1/2"	90	45
0	30 E	0"	0"	0"	10' 6-3/4"	5' 3-1/4"	90	60
0	15 E	0"	0"	0"	5' 5-1/2"	2' 8-3/4"	90	75
0	0	0"	0"	0"	0"	0"	180	90
0	15 W	0"	0"	0"	5' 5-1/2"	2' 8-3/4"	270	75
0	30 W	0"	0"	0"	10' 6-3/4"	5' 3-1/4"	270	60
0	45 W	0"	0"	0"	14' 11-1/4"	7' 5-1/2"	270	45
0	60 W	0"	0"	0"	18' 3-1/2"	9' 1-3/4"	270	30
5 S	60 E	1' 10"	3' 8-1/4"	11"	18' 3-1/2"	9' 1-3/4"	93	30
5 S	45 E	1' 10"	3' 8-1/4"	11"	14' 11-1/4"	7' 5-1/2"	95	45
5 S	30 E	1' 10"	3' 8-1/4"	11"	10' 6-3/4"	5' 3-1/4"	99	60
5 S	15 E	1' 10"	3' 8-1/4"	11"	5' 5-1/2"	2' 8-3/4"	108	74
5 S	0	1' 10"	3' 8-1/4"	11"	0"	0"	180	85
5 S	15 W	1' 10"	3' 8-1/4"	11"	5' 5-1/2"	2' 8-3/4"	252	74
5 S	30 W	1' 10"	3' 8-1/4"	11"	10' 6-3/4"	5' 3-1/4"	261	60
5 S	45 W	1' 10"	3' 8-1/4"	11"	14' 11-1/4"	7' 5-1/2"	265	45
5 S	60 W	1' 10"	3' 8-1/4"	11"	18' 3-1/2"	9' 1-3/4"	267	30

AJ4CO OBSERVATORY

TFD Array Beam Steering

SIZE	DATE	PART NUMBER	REV
A	01 OCT 2014	N/A	A

SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	2 OF 6

TFD Array Beam Steering

Time Delay Cable VoP: 66%

Array elements N-S baseline spacing (feet): 32

Array elements E-W baseline spacing (feet): 32

N-S Offset (degrees)	E-W Offset (degrees)	Delay Cable Lengths (feet & inches) A (S) / B (N)	C (S) / D (N)	E	F (W) / G (E)	H	AZ (degrees)	EL (degrees)
10 S	60 E	3' 8"	7' 4"	1' 10"	18' 3-1/2"	9' 1-3/4"	96	30
10 S	45 E	3' 8"	7' 4"	1' 10"	14' 11-1/4"	7' 5-1/2"	100	45
10 S	30 E	3' 8"	7' 4"	1' 10"	10' 6-3/4"	5' 3-1/4"	107	59
10 S	15 E	3' 8"	7' 4"	1' 10"	5' 5-1/2"	2' 8-3/4"	123	72
10 S	0	3' 8"	7' 4"	1' 10"	0"	0"	180	80
10 S	15 W	3' 8"	7' 4"	1' 10"	5' 5-1/2"	2' 8-3/4"	237	72
10 S	30 W	3' 8"	7' 4"	1' 10"	10' 6-3/4"	5' 3-1/4"	253	59
10 S	45 W	3' 8"	7' 4"	1' 10"	14' 11-1/4"	7' 5-1/2"	260	45
10 S	60 W	3' 8"	7' 4"	1' 10"	18' 3-1/2"	9' 1-3/4"	264	30
15 S	60 E	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	18' 3-1/2"	9' 1-3/4"	99	30
15 S	45 E	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	14' 11-1/4"	7' 5-1/2"	105	44
15 S	30 E	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	10' 6-3/4"	5' 3-1/4"	115	58
15 S	15 E	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	5' 5-1/2"	2' 8-3/4"	135	69
15 S	0	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	0"	0"	180	75
15 S	15 W	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	5' 5-1/2"	2' 8-3/4"	225	69
15 S	30 W	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	10' 6-3/4"	5' 3-1/4"	245	58
15 S	45 W	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	14' 11-1/4"	7' 5-1/2"	255	44
15 S	60 W	5' 5-1/2"	10' 11-1/4"	2' 8-3/4"	18' 3-1/2"	9' 1-3/4"	261	30
20 S	60 E	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	18' 3-1/2"	9' 1-3/4"	102	29
20 S	45 E	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	14' 11-1/4"	7' 5-1/2"	110	43
20 S	30 E	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	10' 6-3/4"	5' 3-1/4"	122	56
20 S	15 E	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	5' 5-1/2"	2' 8-3/4"	144	66
20 S	0	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	0"	0"	180	70
20 S	15 W	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	5' 5-1/2"	2' 8-3/4"	216	66
20 S	30 W	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	10' 6-3/4"	5' 3-1/4"	238	56
20 S	45 W	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	14' 11-1/4"	7' 5-1/2"	250	43
20 S	60 W	7' 2-3/4"	14' 5-1/4"	3' 7-1/4"	18' 3-1/2"	9' 1-3/4"	258	29

AJ4CO OBSERVATORY

TFD Array Beam Steering

SIZE	DATE	PART NUMBER	REV
A	01 OCT 2014	N/A	A

SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	3 OF 6

TFD Array Beam Steering

Time Delay Cable VoP: 66%

Array elements N-S baseline spacing (feet): 32

Array elements E-W baseline spacing (feet): 32

N-S Offset (degrees)	E-W Offset (degrees)	Delay Cable Lengths (feet & inches) A (S) / B (N)	C (S) / D (N)	E	F (W) / G (E)	H	AZ (degrees)	EL (degrees)
25 S	60 E	8' 11"	17' 10-1/4"	4' 5-1/2"	18' 3-1/2"	9' 1-3/4"	105	29
25 S	45 E	8' 11"	17' 10-1/4"	4' 5-1/2"	14' 11-1/4"	7' 5-1/2"	115	42
25 S	30 E	8' 11"	17' 10-1/4"	4' 5-1/2"	10' 6-3/4"	5' 3-1/4"	129	53
25 S	15 E	8' 11"	17' 10-1/4"	4' 5-1/2"	5' 5-1/2"	2' 8-3/4"	150	62
25 S	0	8' 11"	17' 10-1/4"	4' 5-1/2"	0"	0"	180	65
25 S	15 W	8' 11"	17' 10-1/4"	4' 5-1/2"	5' 5-1/2"	2' 8-3/4"	210	62
25 S	30 W	8' 11"	17' 10-1/4"	4' 5-1/2"	10' 6-3/4"	5' 3-1/4"	231	53
25 S	45 W	8' 11"	17' 10-1/4"	4' 5-1/2"	14' 11-1/4"	7' 5-1/2"	245	42
25 S	60 W	8' 11"	17' 10-1/4"	4' 5-1/2"	18' 3-1/2"	9' 1-3/4"	255	29
30 S	60 E	10' 6-3/4"	21' 1-1/2"	5' 3-1/4"	18' 3-1/2"	9' 1-3/4"	108	29
30 S	45 E	10' 6-3/4"	21' 1-1/2"	5' 3-1/4"	14' 11-1/4"	7' 5-1/2"	120	41
30 S	30 E	10' 6-3/4"	21' 1-1/2"	5' 3-1/4"	10' 6-3/4"	5' 3-1/4"	135	51
30 S	15 E	10' 6-3/4"	21' 1-1/2"	5' 3-1/4"	5' 5-1/2"	2' 8-3/4"	155	58
30 S	0	10' 6-3/4"	21' 1-1/2"	5' 3-1/4"	0"	0"	180	60
30 S	15 W	10' 6-3/4"	21' 1-1/2"	5' 3-1/4"	5' 5-1/2"	2' 8-3/4"	205	58
30 S	30 W	10' 6-3/4"	21' 1-1/2"	5' 3-1/4"	10' 6-3/4"	5' 3-1/4"	225	51
30 S	45 W	10' 6-3/4"	21' 1-1/2"	5' 3-1/4"	14' 11-1/4"	7' 5-1/2"	240	41
30 S	60 W	10' 6-3/4"	21' 1-1/2"	5' 3-1/4"	18' 3-1/2"	9' 1-3/4"	252	29
35 S	60 E	12' 1-1/4"	24' 2-3/4"	6' 0-3/4"	18' 3-1/2"	9' 1-3/4"	112	28
35 S	45 E	12' 1-1/4"	24' 2-3/4"	6' 0-3/4"	14' 11-1/4"	7' 5-1/2"	125	39
35 S	30 E	12' 1-1/4"	24' 2-3/4"	6' 0-3/4"	10' 6-3/4"	5' 3-1/4"	140	48
35 S	15 E	12' 1-1/4"	24' 2-3/4"	6' 0-3/4"	5' 5-1/2"	2' 8-3/4"	159	53
35 S	0	12' 1-1/4"	24' 2-3/4"	6' 0-3/4"	0"	0"	180	55
35 S	15 W	12' 1-1/4"	24' 2-3/4"	6' 0-3/4"	5' 5-1/2"	2' 8-3/4"	201	53
35 S	30 W	12' 1-1/4"	24' 2-3/4"	6' 0-3/4"	10' 6-3/4"	5' 3-1/4"	220	48
35 S	45 W	12' 1-1/4"	24' 2-3/4"	6' 0-3/4"	14' 11-1/4"	7' 5-1/2"	235	39
35 S	60 W	12' 1-1/4"	24' 2-3/4"	6' 0-3/4"	18' 3-1/2"	9' 1-3/4"	248	28

AJ4CO OBSERVATORY

TFD Array Beam Steering

SIZE	DATE	PART NUMBER	REV
A	01 OCT 2014	N/A	A

SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	4 OF 6

TFD Array Beam Steering

Time Delay Cable VoP: 66%

Array elements N-S baseline spacing (feet): 32

Array elements E-W baseline spacing (feet): 32

N-S Offset (degrees)	E-W Offset (degrees)	Delay Cable Lengths (feet & inches) A (S) / B (N)	C (S) / D (N)	E	F (W) / G (E)	H	AZ (degrees)	EL (degrees)
40 S	60 E	13' 7"	27' 1-3/4"	6' 9-1/2"	18' 3-1/2"	9' 1-3/4"	116	27
40 S	45 E	13' 7"	27' 1-3/4"	6' 9-1/2"	14' 11-1/4"	7' 5-1/2"	130	37
40 S	30 E	13' 7"	27' 1-3/4"	6' 9-1/2"	10' 6-3/4"	5' 3-1/4"	145	44
40 S	15 E	13' 7"	27' 1-3/4"	6' 9-1/2"	5' 5-1/2"	2' 8-3/4"	162	49
40 S	0	13' 7"	27' 1-3/4"	6' 9-1/2"	0"	0"	180	50
40 S	15 W	13' 7"	27' 1-3/4"	6' 9-1/2"	5' 5-1/2"	2' 8-3/4"	198	49
40 S	30 W	13' 7"	27' 1-3/4"	6' 9-1/2"	10' 6-3/4"	5' 3-1/4"	215	44
40 S	45 W	13' 7"	27' 1-3/4"	6' 9-1/2"	14' 11-1/4"	7' 5-1/2"	230	37
40 S	60 W	13' 7"	27' 1-3/4"	6' 9-1/2"	18' 3-1/2"	9' 1-3/4"	244	27
45 S	60 E	14' 11-1/4"	29' 10-1/2"	7' 5-1/2"	18' 3-1/2"	9' 1-3/4"	120	27
45 S	45 E	14' 11-1/4"	29' 10-1/2"	7' 5-1/2"	14' 11-1/4"	7' 5-1/2"	135	35
45 S	30 E	14' 11-1/4"	29' 10-1/2"	7' 5-1/2"	10' 6-3/4"	5' 3-1/4"	150	41
45 S	15 E	14' 11-1/4"	29' 10-1/2"	7' 5-1/2"	5' 5-1/2"	2' 8-3/4"	165	44
45 S	0	14' 11-1/4"	29' 10-1/2"	7' 5-1/2"	0"	0"	180	45
45 S	15 W	14' 11-1/4"	29' 10-1/2"	7' 5-1/2"	5' 5-1/2"	2' 8-3/4"	195	44
45 S	30 W	14' 11-1/4"	29' 10-1/2"	7' 5-1/2"	10' 6-3/4"	5' 3-1/4"	210	41
45 S	45 W	14' 11-1/4"	29' 10-1/2"	7' 5-1/2"	14' 11-1/4"	7' 5-1/2"	225	35
45 S	60 W	14' 11-1/4"	29' 10-1/2"	7' 5-1/2"	18' 3-1/2"	9' 1-3/4"	240	27
50 S	60 E	16' 2-1/4"	32' 4-1/4"	8' 1"	18' 3-1/2"	9' 1-3/4"	125	25
50 S	45 E	16' 2-1/4"	32' 4-1/4"	8' 1"	14' 11-1/4"	7' 5-1/2"	140	33
50 S	30 E	16' 2-1/4"	32' 4-1/4"	8' 1"	10' 6-3/4"	5' 3-1/4"	154	37
50 S	15 E	16' 2-1/4"	32' 4-1/4"	8' 1"	5' 5-1/2"	2' 8-3/4"	167	39
50 S	0	16' 2-1/4"	32' 4-1/4"	8' 1"	0"	0"	180	40
50 S	15 W	16' 2-1/4"	32' 4-1/4"	8' 1"	5' 5-1/2"	2' 8-3/4"	193	39
50 S	30 W	16' 2-1/4"	32' 4-1/4"	8' 1"	10' 6-3/4"	5' 3-1/4"	206	37
50 S	45 W	16' 2-1/4"	32' 4-1/4"	8' 1"	14' 11-1/4"	7' 5-1/2"	220	33
50 S	60 W	16' 2-1/4"	32' 4-1/4"	8' 1"	18' 3-1/2"	9' 1-3/4"	235	25

AJ4CO OBSERVATORY

TFD Array Beam Steering

SIZE	DATE	PART NUMBER	REV
A	01 OCT 2014	N/A	A

SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	5 OF 6

TFD Array Beam Steering

Time Delay Cable VoP: **66%**

Array elements N-S baseline spacing (feet): **32**

Array elements E-W baseline spacing (feet): **32**

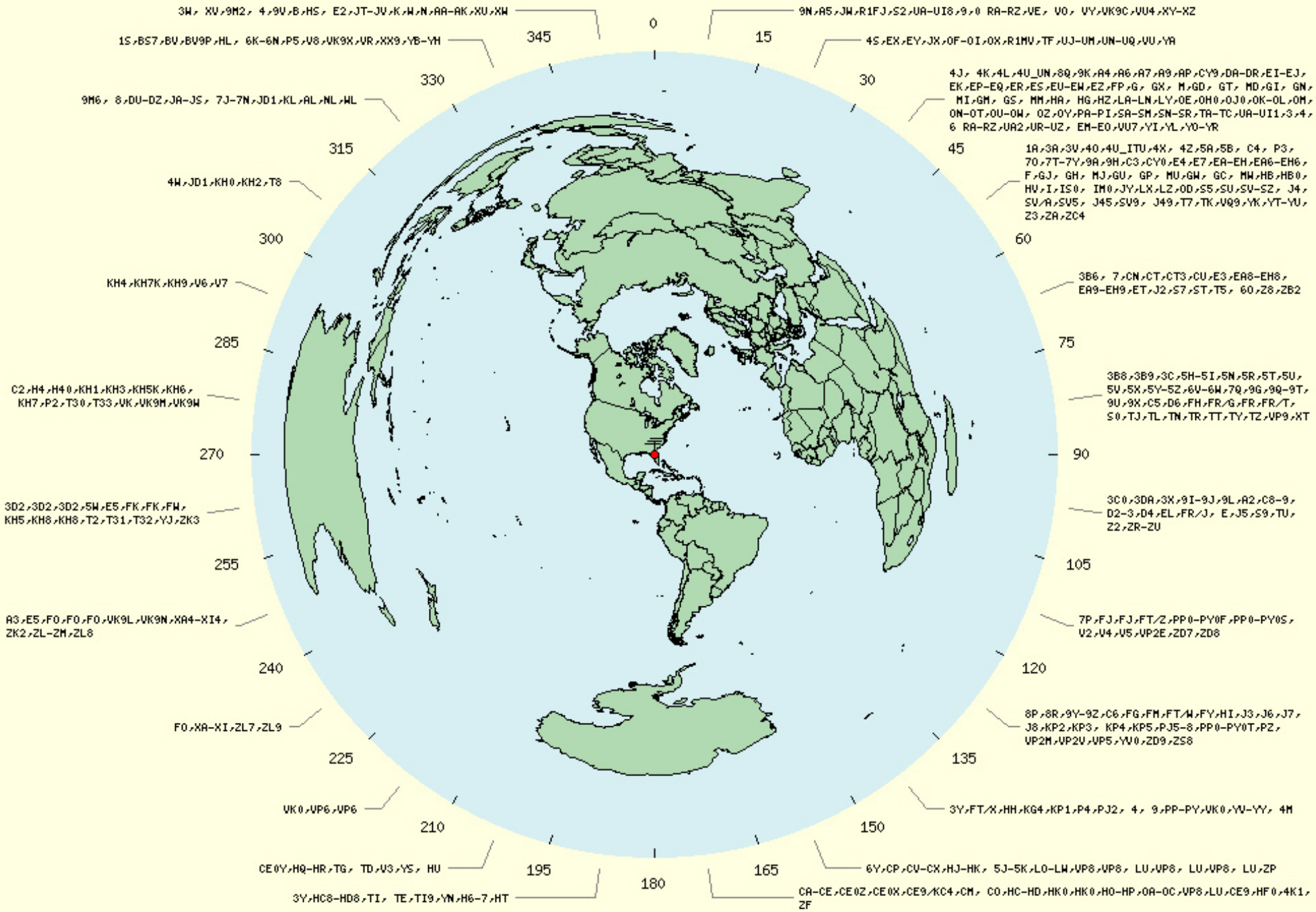
N-S Offset (degrees)	E-W Offset (degrees)	Delay Cable Lengths (feet & inches) A (S) / B (N)	C (S) / D (N)	E	F (W) / G (E)	H	AZ (degrees)	EL (degrees)
55 S	60 E	17' 3-1/2"	34' 7-1/4"	8' 7-3/4"	18' 3-1/2"	9' 1-3/4"	130	24
55 S	45 E	17' 3-1/2"	34' 7-1/4"	8' 7-3/4"	14' 11-1/4"	7' 5-1/2"	145	30
55 S	30 E	17' 3-1/2"	34' 7-1/4"	8' 7-3/4"	10' 6-3/4"	5' 3-1/4"	158	33
55 S	15 E	17' 3-1/2"	34' 7-1/4"	8' 7-3/4"	5' 5-1/2"	2' 8-3/4"	169	35
55 S	0	17' 3-1/2"	34' 7-1/4"	8' 7-3/4"	0"	0"	180	35
55 S	15 W	17' 3-1/2"	34' 7-1/4"	8' 7-3/4"	5' 5-1/2"	2' 8-3/4"	191	35
55 S	30 W	17' 3-1/2"	34' 7-1/4"	8' 7-3/4"	10' 6-3/4"	5' 3-1/4"	202	33
55 S	45 W	17' 3-1/2"	34' 7-1/4"	8' 7-3/4"	14' 11-1/4"	7' 5-1/2"	215	30
55 S	60 W	17' 3-1/2"	34' 7-1/4"	8' 7-3/4"	18' 3-1/2"	9' 1-3/4"	230	24
60 S	60 E	18' 3-1/2"	36' 7"	9' 1-3/4"	18' 3-1/2"	9' 1-3/4"	135	22
60 S	45 E	18' 3-1/2"	36' 7"	9' 1-3/4"	14' 11-1/4"	7' 5-1/2"	150	27
60 S	30 E	18' 3-1/2"	36' 7"	9' 1-3/4"	10' 6-3/4"	5' 3-1/4"	162	29
60 S	15 E	18' 3-1/2"	36' 7"	9' 1-3/4"	5' 5-1/2"	2' 8-3/4"	171	30
60 S	0	18' 3-1/2"	36' 7"	9' 1-3/4"	0"	0"	180	30
60 S	15 W	18' 3-1/2"	36' 7"	9' 1-3/4"	5' 5-1/2"	2' 8-3/4"	189	30
60 S	30 W	18' 3-1/2"	36' 7"	9' 1-3/4"	10' 6-3/4"	5' 3-1/4"	198	29
60 S	45 W	18' 3-1/2"	36' 7"	9' 1-3/4"	14' 11-1/4"	7' 5-1/2"	210	27
60 S	60 W	18' 3-1/2"	36' 7"	9' 1-3/4"	18' 3-1/2"	9' 1-3/4"	225	22

AJ4CO OBSERVATORY

TFD Array Beam Steering

SIZE	DATE	PART NUMBER	REV
A	01 OCT 2014	N/A	A

SCALE	DRAWN BY	SHEET
NONE	DAVE TYPINSKI	6 OF 6



QTH : EL89QU
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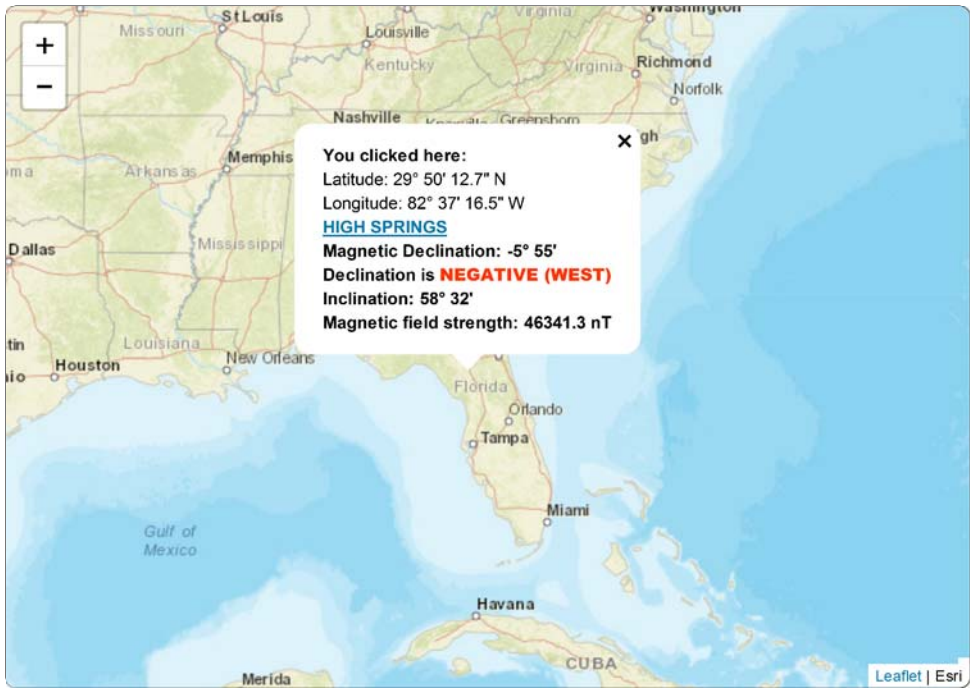
Find the magnetic declination at your location



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Magnetic declination is calculated using the World Magnetic Model WMM2020.

Questions? webmaster@magnetic-declination.com

Sites of Interest

Cosmos Plus!

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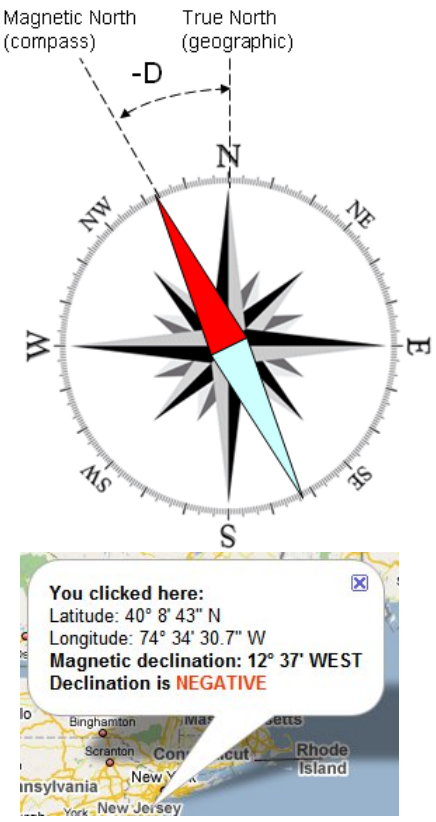
Satellite tracking

Radio Astronomy

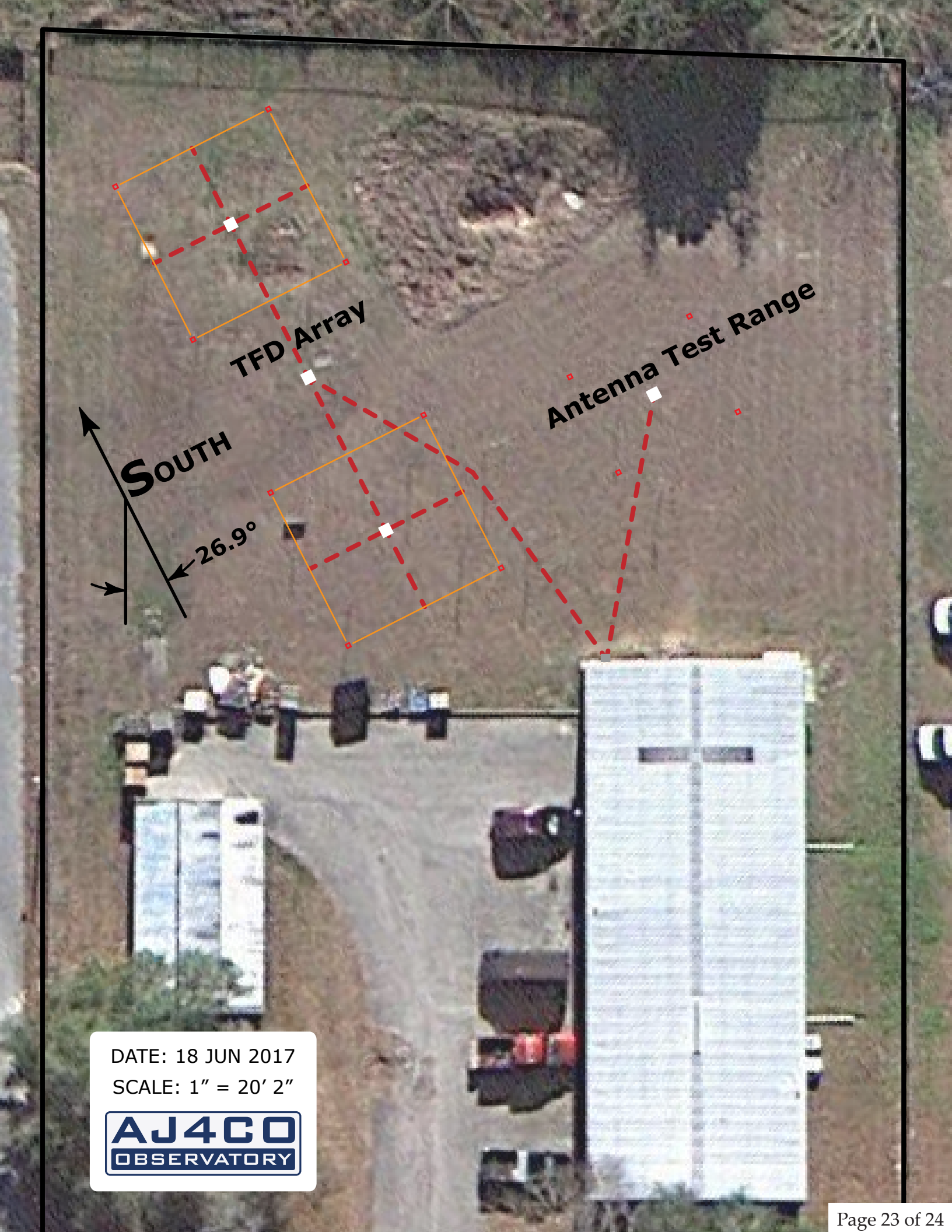
...If the compass at your place is pointing **clockwise** with respect to the True North, declination is **positive** or **EAST**

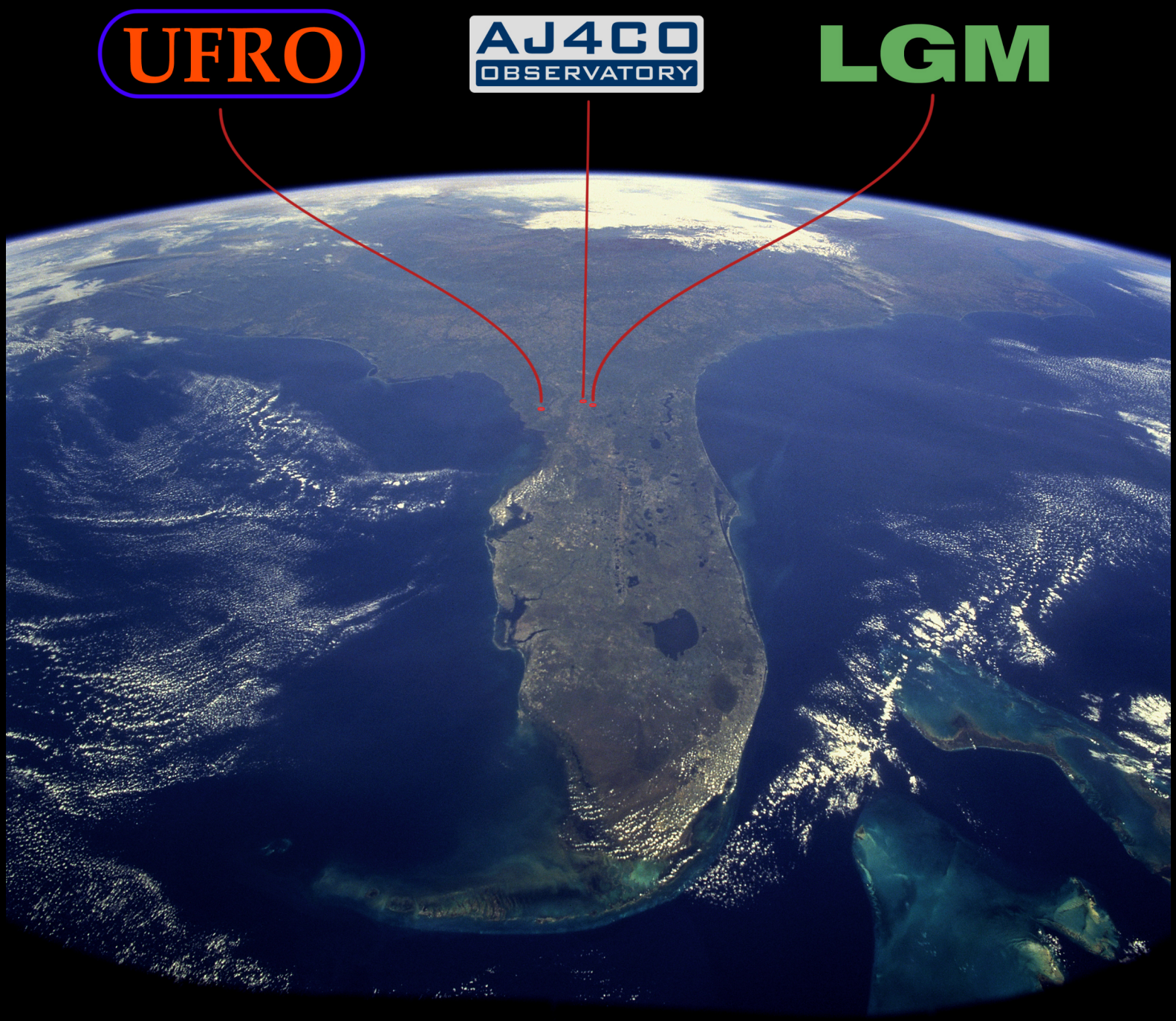
If the compass at your place is pointing **counter-clockwise** with respect to the True North, declination is **negative** or **WEST**



Negative declination (WEST)

Positive declination (EAST)


TFD Array
Antenna Test Range
SOUTH
26.9°
DATE: 18 JUN 2017
SCALE: 1” = 20’ 2”
AJ4CO
OBSERVATORY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LGM