ANTENNA INTERACTIONS

PART 6

ANTENNAS POINTING

IN THE

SAME DIRECTION

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Reviewing progress to date:

- Part 1 introduced meta-tools that give more comprehensive maps and statistics about antenna radiation patterns.[1]
- Part 2 applied those meta-tools to twisted stacked Yagis where the antennas point in different directions, identifying some problem situations that contesters may encounter.[2]
- Part 3 examined self-interactions of unused antennas within a stack, applying a new meta-tool to compare complete sky-hemisphere patterns. Examples of siting problems in the design of a contesting station antenna farm were given but siting issues were not fully explored.[3]
- Part 4 introduced current tapering to clean up stack patterns.[4]
- Part 5 identified impairments by identical antennas in the near field located on the same tower, or turned 90° on a separate tower.[5]

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1 Scace, Eric K3NA; "Antenna Interactions – Part 1: Stop Squinting! Get the Big Picture", *National Contest Journal*, 2003 Jul/Aug; ARRL, Newington CT USA.

2 Scace, Eric K3NA; "Antenna Interactions – Part 2: Twisting Stacks", *National Contest Journal*, 2003 Sep/Oct; ARRL, Newington CT USA.

3 Scace, Eric K3NA; "Antenna Interactions – Part 3: When Good Aluminum Goes Bad", *National Contest Journal*, 2003 Nov/Dec; ARRL, Newington CT USA.

4 Scace, Eric K3NA; "Antenna Interactions — Part 4: Cleaning Up Stacked Yagis with Current Tapers", *National Contest Journal,* 2004 Jan/Feb; ARRL, Newington CT USA.

5 Scace, Eric K3NA; "Antenna Interactions — Part 5: How Close is Too Close?", *National Contest Journal,* 2004 Mar/Apr; ARRL, Newington CT USA.

1 Same azimuth, separate towers

We continue to examine scenarios involving a short stack of 6-element 20m OWA Yagis, mounted at heights of ½ and 1 λ. A third, identical Yagi stands ¾ λ above ground on a separate tower; we will refer to this as the "multiplier Yagi".

Part 5 of this series examined the scenario when the multiplier Yagi pointed to an azimuth at right angles to the stack's azimuth.

Today we examine the case when both the stack and the multiplier Yagi point to the same azimuth. A contest station designer is unlikely to build two non-rotatable antenna systems such as these fixed on the same azimuth. However, a station containing both a stack and a multiplier Yagi might rotate these systems such that both are temporarily oriented in the same azimuth. What happens to their patterns?

2 Multiplier Yagi fed

We start by examining impairments caused by the unused stack to the pattern of the multiplier Yagi. The feedpoints of the stack's Yagis are short-circuited.

By itself, this multiplier Yagi's peak gain of 14.6 dBi occurs at 17° elevation. The main beam's −3 dB points stand ±28° to the left and right, and at 8 and 28° elevation. These −3 dB points form the target zone for this analysis.

To identify the minor lobes, a range of ±51° in azimuth and 8 and 28° in elevation (representing the −11 dB points on the main beam) was excluded from the non-target zone statistics. This exclusion prevented the sides of the main beam from obscuring information about the behavior of the pattern outside the main beam.

Table 1 summarizes pattern parameters and impairments as a function of relative location between these two antenna systems. The first row gives performance parameters for an isolated multiplier Yagi (i.e., no stack present) for comparison. The columns in this table represent, from left to right:

- Location of the multiplier antenna relative to the stack; e.g., 1 λ at 0° means the multiplier antenna stands one wavelength in front of the stack. Both the stack and multiplier Yagis point to 0° azimuth.
- Peak gain of the multiplier antenna, its azimuth and elevation, and the impairment to peak gain (change in peak gain caused by the presence of the unused stack).
- Median gain over the target zone, and the impairment to median gain.
- Minimum gain within the target zone, and the impairment to that minimum gain. Since no antenna fills a target zone uniformly, we want to know if impairments exist to the least well-served part of the target.
- Largest spot increase in gain, and largest spot decrease in gain, within the target zone. "Spot gain" refers to the gain in a specific direction (azimuth and elevation). A significant change in the gain in any one direction would be an undesirable interaction, even if the overall pattern averaged out to the same level of gain.
- Median gain outside of the main beam, and impairment to that median gain. A well-designed antenna has little sensitivity outside of its main beam; any increase in median gain indicates impaired performance. An entry of "floor" here means the median gain is less than the floor threshold of −15 dBi.
- Worst (highest gain) minor lobe outside the main beam, its location, and the impairment (increase in gain of the worst minor lobe).
- Largest spot increase in gain, and largest spot decrease in gain, outside the main beam.
- Portion of the sky hemisphere with gain of <−15 dBi (quiet regions of reduced QRM and QRN), and impairment to that portion.
- Feedpoint impedance.

Yagi loc		target #1									non-target									
dist	dir	peak gain			median gain	g	minimum gain		largest		median gain		worst minor lobe			largest		%sky <-15 dBi		feedpoint
λ	°	dBi	location	delta	dBi	e	dBi	delta	decr	incr	dBi	delta	dBi	location	delta	decr	incr		change	impedance
no stack		14.60	az 0° el 17°		12.66		8.84				-9.78		3.49	az 0° el 54°				25.0%		30.0 - *j* 10.4
0.5	0°	12.15	az 0° el 19°	-2.45	10.74	-1.92	6.74	-2.10	-3.40	-0.17	-5.32	4.46	6.94	az 0° el 59°	3.45	-3.67	19.30	11.1%	-13.9%	34.6 - *j* 1.0
1.0	0°	14.37	az 0° el 17°	-0.23	12.57	-0.09	8.86	0.02	-0.30	0.26	-10.35	-0.57	3.56	az 308° el 17°	0.07	-8.72	5.52	21.6%	-3.4%	30.1 - *j* 10.1
2.0	0°	14.47	az 0° el 17°	-0.13	12.77	0.11	9.10	0.26	-0.45	0.38	-10.51	-0.73	3.15	az 0° el 53°	-0.34	-5.13	3.19	24.2%	-0.8%	30.0 - *j* 10.3
4.0	0°	14.79	az 0° el 17°	0.19	12.75	0.09	8.65	-0.19	-0.31	0.26	-9.86	-0.08	3.29	az 0° el 53°	-0.20	-2.24	1.69	25.3%	0.3%	29.9 - *j* 10.4
6.0	0°	14.73	az 0° el 17°	0.13	12.59	-0.07	8.66	-0.18	-0.20	0.17	-9.74	0.04	3.49	az 0° el 53°	0.00	-1.20	1.05	24.9%	-0.1%	30.0 - *j* 10.4
8.0	0°	14.64	az 0° el 16°	0.04	12.65	-0.01	8.79	-0.05	-0.12	0.11	-9.74	0.04	3.54	az 0° el 54°	0.05	-0.75	0.61	24.8%	-0.2%	30.0 - *j* 10.4
0.5	30°	14.14	az 348° el 17°	-0.46	12.09	-0.57	5.69	-3.15	-3.17	1.49	-7.29	2.49	6.92	az 308° el 17°	3.43	-10.62	13.64	14.6%	-10.4%	32.1 - *j* 3.9
1.0	30°	14.74	az 357° el 17°	0.14	12.78	0.12	8.47	-0.37	-0.39	0.48	-10.60	-0.82	3.03	az 0° el 54°	-0.46	-7.94	5.19	24.5%	-0.5%	30.0 - *j* 10.2
2.0	30°	14.92	az 0° el 17°	0.32	12.65	-0.01	8.45	-0.39	-0.48	0.36	-10.19	-0.41	3.28	az 51° el 17°	-0.21	-5.12	3.85	24.0%	-1.0%	29.9 - *j* 10.4
4.0	30°	14.42	az 5° el 16°	-0.18	12.66	0.00	8.70	-0.14	-0.23	0.20	-9.77	0.01	3.44	az 358° el 55°	-0.05	-2.16	1.78	24.8%	-0.2%	30.0 - *j* 10.4
8.0	30°	14.63	az 2° el 17°	0.03	12.65	-0.01	8.79	-0.05	-0.07	0.07	-9.76	0.02	3.52	az 358° el 54°	0.03	-0.68	0.66	24.9%	-0.1%	30.0 - *j* 10.4
0.5	60°	14.71	az 351° el 17°	0.11	12.58	-0.08	6.46	-2.38	-2.40	1.53	-9.35	0.43	6.26	az 308° el 17°	2.77	-5.70	8.98	13.0%	-12.0%	30.9 - *j* 10.7
1.0	60°	14.52	az 5° el 17°	-0.08	12.62	-0.04	8.73	-0.11	-0.42	0.38	-9.86	-0.08	3.57	az 308° el 17°	0.08	-4.30	4.83	23.6%	-1.4%	29.9 - *j* 10.5
2.0	60°	14.69	az 358° el 17°	0.09	12.64	-0.02	8.76	-0.08	-0.11	0.12	-9.75	0.03	3.58	az 0° el 54°	0.09	-2.85	2.84	24.7%	-0.3%	30.0 - *j* 10.4
4.0	60°	14.63	az 0° el 17°	0.03	12.66	0.00	8.82	-0.02	-0.04	0.04	-9.75	0.03	3.47	az 0° el 54°	-0.02	-0.88	0.91	24.7%	-0.3%	30.0 - *j* 10.4
8.0	60°	14.61	az 0° el 17°	0.01	12.66	0.00	8.84	0.00	-0.01	0.01	-9.78	0.00	3.48	az 0° el 54°	-0.01	-0.26	0.25	24.9%	-0.1%	30.0 - *j* 10.4
0.5	90°	14.09	az 340° el 16°	-0.51	11.14	-1.52	7.57	-1.27	-3.53	1.83	-8.76	1.02	8.25	az 308° el 17°	4.76	-7.65	10.57	18.9%	-6.1%	33.7 - *j* 10.1
1.0	90°	14.69	az 6° el 17°	0.09	12.64	-0.02	8.51	-0.33	-0.47	0.40	-8.50	1.28	4.03	az 308° el 17°	0.54	-3.04	2.27	23.5%	-1.5%	29.9 - *j* 10.4
1.5	90°	14.67	az 358° el 17°	0.07	12.65	-0.01	8.68	-0.16	-0.17	0.15	-9.75	0.03	3.44	az 308° el 17°	-0.05	-1.82	1.65	24.3%	-0.7%	30.0 - *j* 10.4
2.0	90°	14.57	az 1° el 17°	-0.03	12.69	0.03	8.78	-0.06	-0.07	0.07	-9.75	0.03	3.54	az 1° el 54°	0.05	-1.19	1.06	24.8%	-0.2%	30.0 - *j* 10.4
2.5	90°	14.63	az 0° el 17°	0.03	12.67	0.01	8.87	0.03	-0.04	0.04	-9.77	0.01	3.49	az 0° el 54°	0.00	-0.68	0.63	24.7%	-0.3%	30.0 - *j* 10.4
0.5	120°	13.92	az 337° el 16°	-0.68	9.86	-2.80	5.33	-3.51	-5.80	2.42	-8.44	1.34	9.22	az 308° el 17°	5.73	-10.37	13.59	19.6%	-5.4%	34.7 - *j* 15.7
1.0	120°	14.55	az 14° el 17°	-0.05	12.31	-0.35	7.94	-0.90	-1.70	1.53	-9.84	-0.06	5.37	az 308° el 17°	1.88	-6.75	6.14	24.3%	-0.7%	30.3 - *j* 10.5
2.0	120°	14.94	az 358° el 17°	0.34	12.57	-0.09	8.23	-0.61	-0.61	0.51	-9.60	0.18	3.91	az 308° el 17°	0.42	-3.50	3.39	22.9%	-2.1%	30.0 - *j* 10.4
4.0	120°	14.69	az 0° el 17°	0.09	12.68	0.02	8.78	-0.06	-0.12	0.14	-9.65	0.13	3.70	az 1° el 54°	0.21	-1.41	1.32	24.9%	-0.1%	30.0 - *j* 10.4
8.0	120°	14.62	az 0° el 17°	0.02	12.67	0.01	8.82	-0.02	-0.04	0.03	-9.76	0.02	3.51	az 3° el 54°	0.02	-0.39	0.38	24.9%	-0.1%	30.0 - *j* 10.4
0.5	150°	12.20	az 339° el 15°	-2.40	7.32	-5.34	-1.37	-10.21	12.20	-1.37	-3.04	6.74	9.61	az 51° el 17°	6.12	-12.52	17.65	5.3%	-19.7%	19.6 - *j* 11.9
1.0	150°	13.62	az 27° el 18°	-0.98	10.01	-2.65	5.16	-3.68	-5.33	2.48	-5.92	3.86	8.50	az 51° el 17°	5.01	-13.23	11.95	8.5%	-16.5%	23.0 - *j* 16.4
2.0	150°	15.52	az 15° el 17°	0.92	11.91	-0.75	5.91	-2.93	-2.95	2.21	-7.97	1.81	6.61	az 51° el 17°	3.12	-13.44	9.39	14.7%	-10.3%	29.0 - *j* 13.2
4.0	150°	15.50	az 3° el 17°	0.90	12.41	-0.25	7.66	-1.18	-1.27	1.21	-9.60	0.18	5.04	az 355° el 52°	1.55	-10.53	6.54	21.0%	-4.0%	30.4 - *j* 11.1
8.0	150°	14.78	az 6° el 17°	0.18	12.61	-0.05	8.94	0.10	-0.45	0.42	-9.77	0.01	4.11	az 0° el 53°	0.62	-3.40	2.70	24.6%	-0.4%	30.1 - *j* 10.4
16.0	150°	14.69	az 1° el 17°	0.09	12.68	0.02	8.73	-0.11	-0.13	0.12	-9.76	0.02	3.67	az 0° el 54°	0.18	-0.84	0.84	24.7%	-0.3%	30.0 - *j* 10.4
0.5	180°	12.83	az 0° el 14°	-1.77	9.52	-3.14	-0.84	-9.68	-9.68	-0.87	-3.25	6.53	8.41	az 180° el 75°	4.92	-10.58	21.65	7.6%	-17.4%	20.4 + *j* 16.4
1.0	180°	9.51	az 0° el 14°	-5.09	5.00	-7.66	-2.93	-11.77	-11.79	-4.00	-1.98	7.80	9.44	az 180° el 15°	5.95	-12.81	17.70	5.3%	-19.7%	8.9 - *j* 11.4
2.0	180°	11.30	az 0° el 13°	-3.30	7.79	-4.87	2.89	-5.95	-6.64	-0.38	-4.80	4.98	9.05	az 308° el 17°	5.56	-12.82	13.75	6.8%	-18.2%	24.2 - *j* 21.0
4.0	180°	13.23	az 332° el 19°	-1.37	11.41	-1.25	7.01	-1.83	-3.17	2.18	-7.81	1.97	6.24	az 0° el 55°	2.75	-13.10	9.56	15.0%	-10.0%	32.5 - *j* 12.4
8.0	180°	14.08	az 344° el 19°	-0.52	12.84	0.18	8.75	-0.09	-0.99	0.96	-10.06	-0.28	4.29	az 0° el 50°	0.80	-7.32	4.40	24.5%	-0.5%	30.3 - *j* 10.3
16.0	180°	14.74	az 0° el 18°	0.14	12.71	0.05	8.73	-0.11	-0.28	0.28	-9.72	0.06	3.81	az 0° el 55°	0.32	-1.52	1.39	24.7%	-0.3%	30.0 - *j* 10.4
20.0	180°	14.74	az 0° el 17°	0.14	12.66	0.00	8.66	-0.18	-0.20	0.18	-9.74	0.04	3.59	az 0° el 56°	0.10	-1.01	0.89	24.8%	-0.2%	30.0 - *j* 10.4

Table 1: Performance parameters for the multiplier Yagi and impairments caused by a near-by stack. Both antennas point toward 0° azimuth. See text for explanation of column entries.

3 Implication of design objectives

Each station designer must choose his design objectives. Let's examine the implications of choosing three different, increasingly strict, thresholds for tolerable impairments between a stack and a multiplier antenna:

- No impairment within the target zone exceeding 1 dB, but accept any degree of impairment outside the main beam.
- No impairment to the median gain outside the mean beam exceeding 1 dB, and no variation in spot gain by more than 6 dB (an S-unit).
- No variation in spot gain at any point in the pattern exceeding 1 dB.

Careful study of Table 1 reveals that all impairments vary in a coordinated fashion, rising and falling together. But while impairments to the main beam rapidly dwindle in significance as spacing between the antenna systems increases, the antenna pattern outside the main beam can remain impaired at greater distances.

The most extreme example occurs when the multiplier Yagi stands behind, and pointing towards, the stack. The stack, illuminated by radiation from the multiplier Yagi, re-radiates parasitically, producing a classic interference pattern. In this alignment one must separate these systems by about 6 λ before impairments to the main beam fall below 1 dB, our first design threshold.

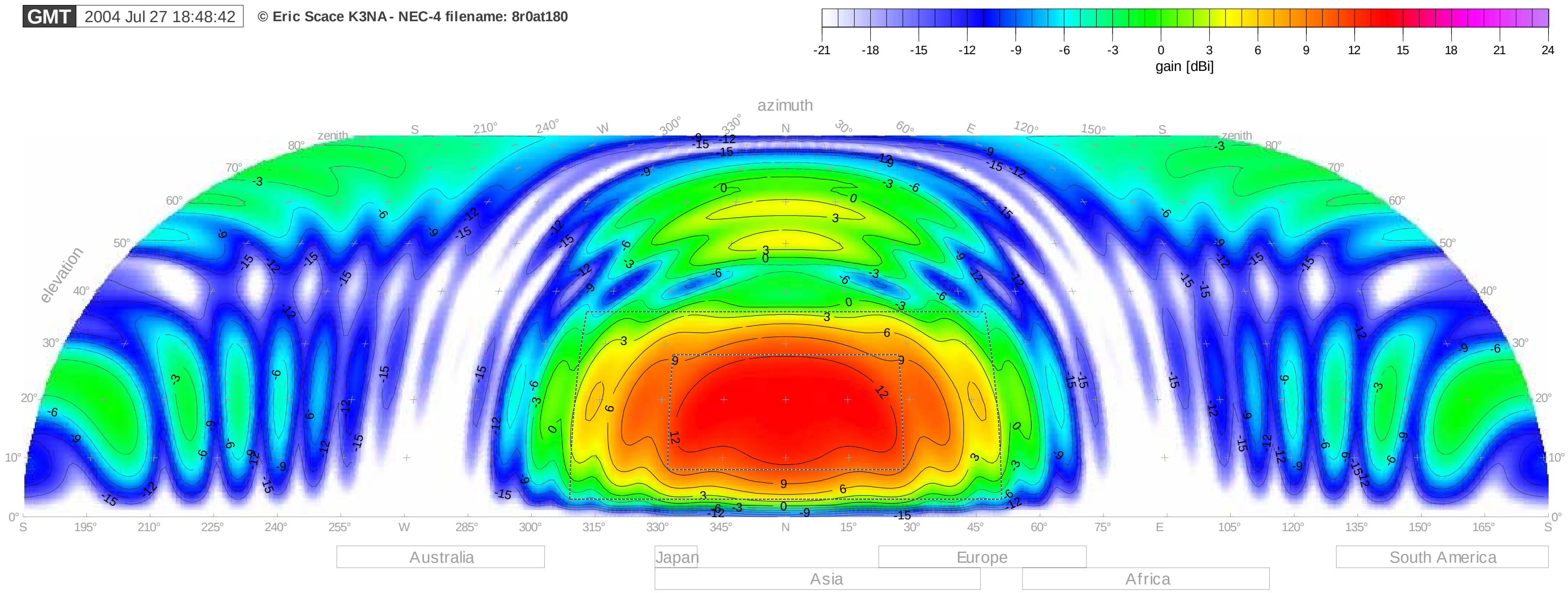
Figure 1 shows continued pattern impairments in this alignment at a separation of 8 λ. The ripples reveal parasitic re-radiation from the unused stack's Yagis. This separation nearly achieves our second design criterion: the median gain outside the main beam varies less than a dB from a multiplier Yagi standing alone. But certain directions outside the main beam show gain decreases over −7 dB or gain increases over 4 dB. To achieve the third criterion in this alignment requires an enormous separation of 20 λ!

In contrast, when the multiplier Yagi stands off to the side of the stack, at right angles to the stack's azimuth, just over 2 λ separation achieves our most stringent third design criterion.

Table 1 shows the variation in spot gain outside the main beam represents the most sensitive detector of pattern impairments. Figure 2 maps out this variation as a function of the relative location of the two antenna systems. The X and Y axes represent distances to the multiplier Yagi from the stack, which stands at the origin in the center of the figure. The contours represent constant values for the largest spot gain variation (either negative or positive). Both antenna systems point to the right.

4 Azimuthal beam stretch

The tabular data also reveals one other form of interaction. Figure 3 illustrates the multiplier Yagi's pattern when that Yagi stands 1 λ behind and to the right of the stack. Main beam distortion forces the peak gain 14° to the right of its normal position in azimuth. Look for variations in azimuth in the table to identify beam stretch. In some situations gain at the center of the target zone falls −3 dB due to stretch; in other words, the main beam isn't pointing in the direction indicated by the rotator!



Yagi positioned around a stack.
3 20m 6-el 48-ft boom OWA Yagis.
Single Yagi located 8.0 wvlngths at 180° relative to stack.
Single Yagi: Height: 0.75 wavelngth. 0° azimuth. <-- Feedpoint # 1
Stack Top: Height: 1.00 wavelngth. 0° azimuth. <-- Feedpoint # 2
Stack Bot: Height: 0.50 wavelngth. 0° azimuth. <-- Feedpoint # 3

Card deck created 04 Jul 25 Sun 23:07:43 -0500 NECInputClean v2.0 2004 Jul 6

OWA 6-el Yagi pointing North, ht=0. Dimensions in wavelengths.

NEC version 4.1. K3NA NOUTrim v4.5 2004 Jun 30 Wed.

14.025 MHz

finite ground. sommerfeld solution
13.0 dielectric constant
5.0 mS/m

Drive impedance; voltage or current:
#1: 30.3 j -10.3Ω 1.000A ∠ -90.0°
#2: -29290600.0 j+3668440000.0Ω 0.000A ∠ -90.0°
#3: -2165080000.0 j-1494340000.0Ω 0.000A ∠ -90.0°

Maximum gain: +14.08 dBi at 344° az 19° el.
82.4 % power efficiency.

Target 1 - YagiMainBeam-3dBpoints: 332- 28° az 8-28° el.
Median gain*: +12.84 dBi. Avg dev: +0.74 above, -1.27 below.
Min: +8.75 dBi at 335° az 27° el. Max: +14.08 dBi at 344° az 19° el.

Target 2 - YagiMainBeam-11dBpoints: 309- 51° az 3-36° el.
Median gain*: +5.86 dBi. Avg dev: +2.83 above, -2.46 below.
Min: -6.79 dBi at 312° az 35° el. Max: +11.46 dBi at 360° az 28° el.

Non-targeted area statistics:
Median gain*: -10.06 dBi. Avg dev: +6.73 above, -3.52 below.
Min: -60.25 dBi at 276° az 0° el. Max: +4.29 dBi at 360° az 50° el.

Combined target 1 and 2 statistics:
Median gain*: +8.57 dBi. Avg dev: +3.39 above, -3.47 below.
Min: -6.79 dBi at 312° az 35° el. Max: +14.08 dBi at 344° az 19° el.
Mean median: +10.62 dBi. Mean min: +5.86 dBi. Mean max: +12.96 dBi.

* Gain floor for calculating median, mean and deviation is -15.0 dBi.
Points at or below floor: 5062, 24.5% of sky.
NEC x-axis is North azimuth.

Figure 1: Gain pattern of the multiplier Yagi when it stands 8 λ directly behind the stack. Both antennas point toward 0° azimuth Parasitic re-radiation by the stack modulates the Yagi's pattern with a rippled pattern of constructive and destructive interference.

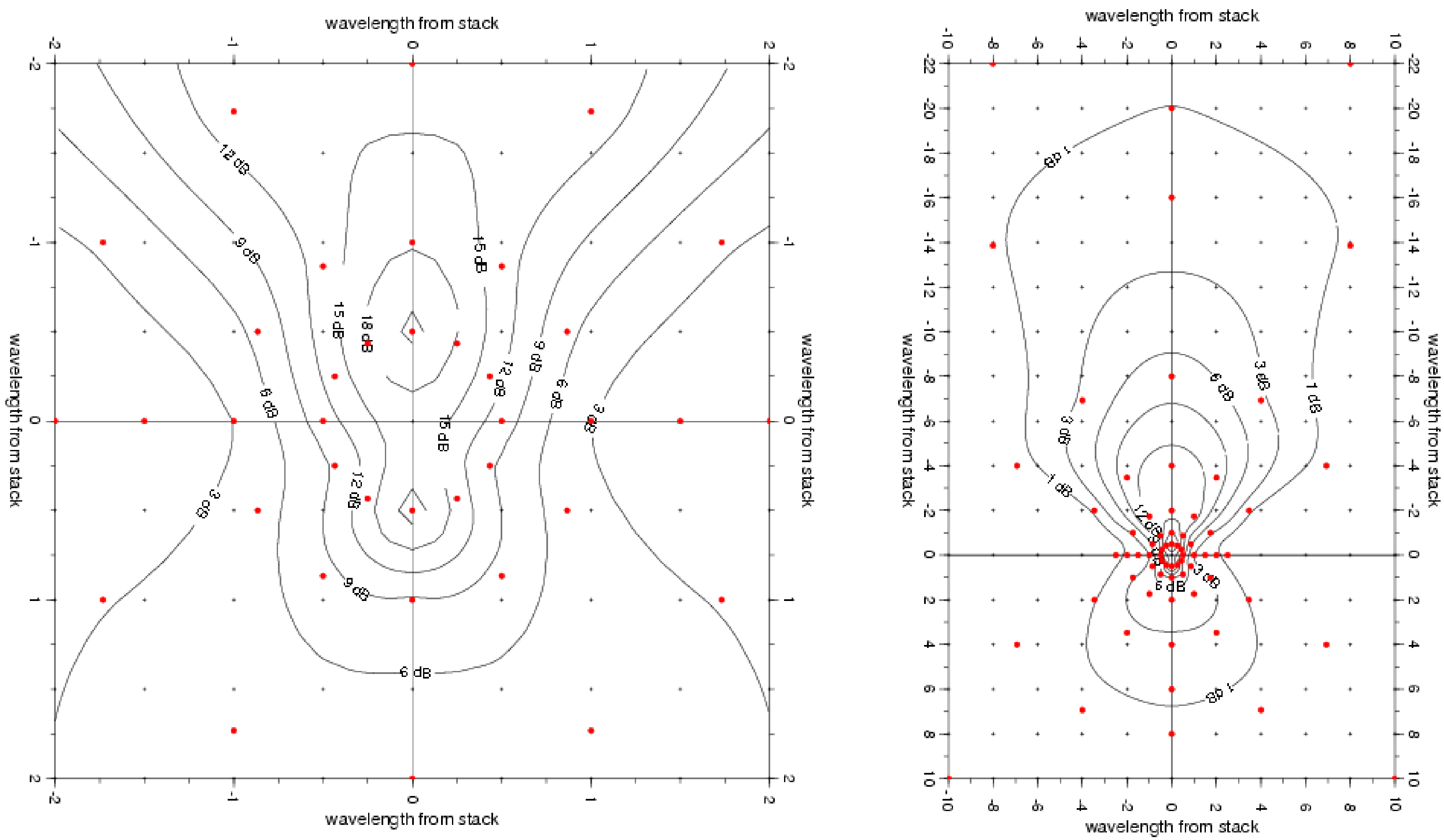
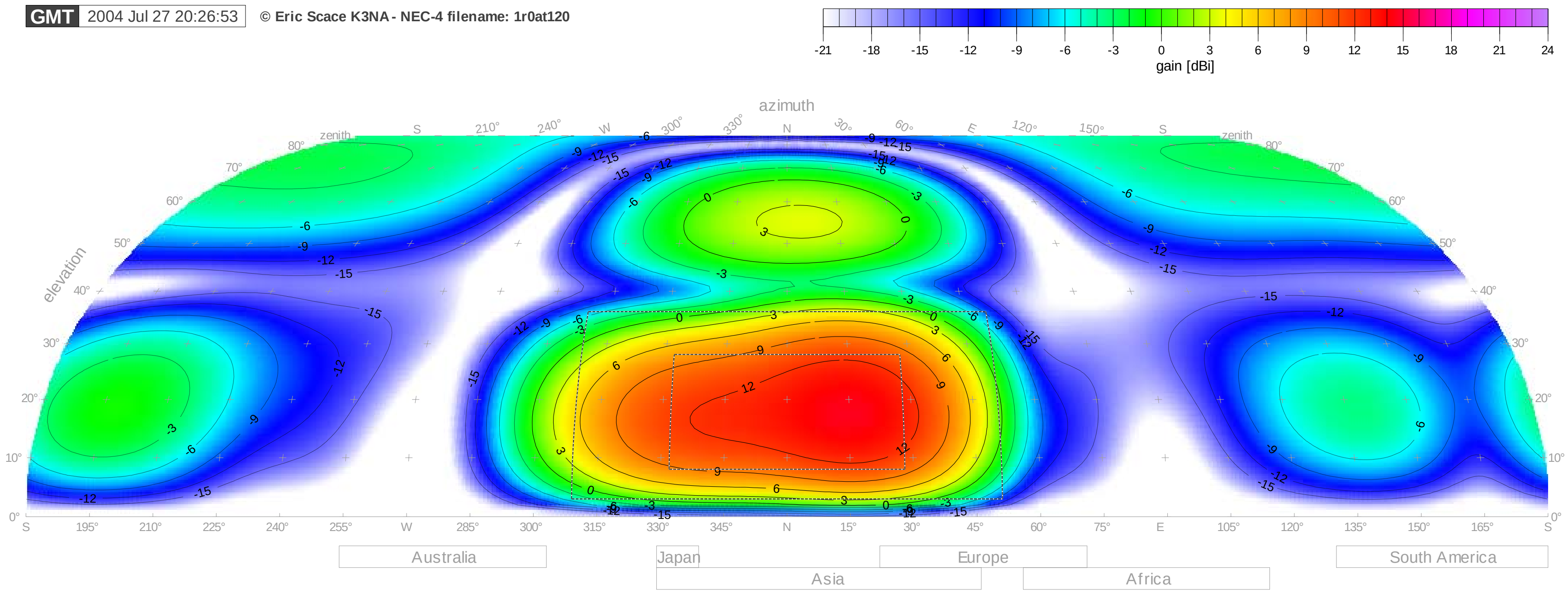


Figure 2: Maximum absolute variation in spot gain in any direction for the multiplier Yagi due to the presence of the stack. The stack stands at the origin of the coordinate system. Dots indicate calculated locations for the multiplier Yagi relative to the stack. In these maps both antennas point down.



Yagi positioned around a stack.
3 20m 6-el 48-ft boom OWA Yagis.
Single Yagi located 0.5 wvlngths at 120° relative to stack.
Single Yagi: Height: 0.75 wavelngth. 0° azimuth. <-- Feedpoint # 1
Stack Top: Height: 1.00 wavelngth. 0° azimuth. <-- Feedpoint # 2
Stack Bot: Height: 0.50 wavelngth. 0° azimuth. <-- Feedpoint # 3

Card deck created 04 Jul 26 Mon 09:21:13 -0500 NECInputClean v2.0 2004 Jul 6 Tue

OWA 6-el Yagi pointing North, ht=0. Dimensions in wavelengths.

NEC version 4.1. K3NA NOUTrim v4.5 2004 Jun 30 Wed.

14.025 MHz

finite ground. sommerfeld solution
13.0 dielectric constant
5.0 mS/m

Drive impedance; voltage or current:
#1: 30.3 j -10.5 Ω 1.000A ∠ -90.0°
#2: 599258000.0 j-8733280000.0 Ω 0.000A ∠ -90.0°
#3: -2601150000.0 j-3795070000.0 Ω 0.000A ∠ -90.0°

Maximum gain: +14.55 dBi at 14° az 17° el.
82.4 % powerefficiency.

Target 1 - YagiMainBeam-3dBpoints: 332- 28° az 8-28° el.
Median gain*: +12.31 dBi. Avg dev: +1.11 above, -1.05 below.
Min: +7.94 dBi at 333° az 27° el. Max: +14.55 dBi at 14° az 17° el.

Target 2 - YagiMainBeam-11dBpoints: 309- 51° az 3-36° el.
Median gain*: +6.39 dBi. Avg dev: +2.75 above, -2.87 below.
Min: -8.40 dBi at 50° az 3° el. Max: +13.01 dBi at 28° az 16° el.

Non-targeted area statistics:
Median gain*: -9.84 dBi. Avg dev: +6.55 above, -3.70 below.
Min: -60.43 dBi at 271° az 0° el. Max: +5.37 dBi at 308° az 17° el.

Combined target 1 and 2 statistics:
Median gain*: +8.75 dBi. Avg dev: +3.13 above, -3.37 below.
Min: -8.40 dBi at 50° az 3° el. Max: +14.55 dBi at 14° az 17° el.
Mean median: +10.29 dBi. Mean min: +5.03 dBi. Mean max: +13.85 dBi.

* Gain floor for calculating median, mean and deviation is -15.0 dBi.
Points at or below floor: 5004, 24.3% of sky.
NEC x-axis is North azimuth.

Figure 3: Gain pattern of the multiplier Yagi when it stands 1 λ behind and to the right of the stack. Both antennas point toward 0° azimuth. The parasitic re-radiation by the stack stretches out the multiplier Yagi's main beam, forcing the point of peak gain to shift 14° in azimuth from the intended direction (0°).

5 Stack fed

Having examined impairments when feeding the multiplier Yagi, now reverse the roles and feed the stack. The multiplier Yagi's feedpoint is now short-circuited. Table 2 itemizes pattern impairments to the stack.

The stack's pattern displays somewhat greater sensitivity to the presence of the multiplier Yagi than vice versa. In the most extreme configuration, with the multiplier Yagi standing in front of the stack and in the stack's main beam, the multiplier Yagi must stand 30 λ away to meet our most stringent impairment design criterion — rather impractical for most contesters. When out of the main beam or behind the stack, that most stringent impairment objective can be met with about 4 λ spacing. See Figure 4 for the map of impairment to spot gain outside the main beam vs. location.

Azimuthal beam stretching also occurs when the multiplier Yagi stands forward and to one side of stack.

6 Impedance and impairment

Feedpoint impedance varies but little, even for closely spaced antennas with significant pattern impairments. In most directions the multiplier Yagi must be located within 1 λ of the stack before a variance of more than 1 Ω occurs — quite close, considering these Yagis have booms of 0.67 λ! One cannot rely solely on impedance irregularities to indicate that antenna patterns have been disturbed.

The data also indicates that a significant variation in impedance indicates a major pattern disruption. If your antenna's impedance changes significantly when rotating the antenna, you should examine your antenna field for undesired interactions. Such impairments might arise from the location and orientation of other antennas, as illustrated here. Other metallic objects also may introduce impairments; e.g., resonant guy wire segments or harmonically related, insulated antenna elements and parts.[6]

7 Next step

This part and the previous article in this series, taken together, have examined two cases: antenna systems pointed at right angles, and pointed to the same azimuth. Next time we will look at these two systems pointed in opposite directions. Taking these three cases together will allow us to draw conclusions about acceptable minimum spacing for rotatable antennas on the same band.

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6 Weber, Dick K5IU, "A Guy-Wire-Interaction Case Study", *QEX,* 2002 Nov/Dec, pp. 42–48; ARRL, Newington CT USA.

Yagi loc		target #1									non-target										
dist	dir	peak gain			median gain g		minimum gain		largest		median gain		worst minor lobe			largest		% sky <-15dBi		feedpoint impedance	
λ	°	dBi	location	delta	dBi	e	dBi	delta	decr	incr	dBi	delta	dBi	location	delta	decr	incr		change	top	bottom
no mult		15.76	az 0° el 15°		13.87		10.09				-15.00		-4.88	az 0° el 48°				47.2%		26.7 - *j* 7.8	27.7 - *j* 8.1
0.5	0°	11.31	az 0° el 67°	-4.45	5.55	-8.32	(floor)	-	-26.31	-4.60	-6.86	8.14	11.31	az 0° el 67°	16.19	-6.40	26.31	9.7%	-37.5%	32.7 - *j* 4.0	35.5 - *j* 4.7
1.0	0°	10.93	az 0° el 12°	-4.83	6.60	-7.27	0.45	-9.64	-11.53	-3.67	-2.73	12.27	8.76	az 0° el 62°	13.64	-4.56	23.76	4.8%	-42.4%	15.2 - *j* 2.5	26.7 - *j* 5.4
2.0	0°	13.12	az 0° el 12°	-2.64	9.18	-4.69	5.43	-4.66	-6.57	-0.99	-6.40	8.60	5.05	az 0° el 52°	9.93	-8.76	19.64	10.8%	-36.4%	22.5 - *j* 13.3	23.4 - *j* 9.2
4.0	0°	14.71	az 0° el 13°	-1.05	12.53	-1.34	8.77	-1.32	-2.44	2.38	-10.65	4.35	1.49	az 0° el 56°	6.37	-10.03	13.57	19.2%	-28.0%	27.6 - *j* 8.6	28.0 - *j9.9*
6.0	0°	15.09	az 0° el 13°	-0.67	13.74	-0.13	10.22	0.13	-1.20	1.37	-12.99	2.01	-1.97	az 0° el 47°	2.91	-9.24	9.14	28.9%	-18.3%	27.0 - *j* 7.8	28.1 - *j* 8.4
8.0	0°	15.21	az 0° el 13°	-0.55	14.09	0.22	9.13	-0.96	-1.04	0.81	-14.40	0.60	-2.33	az 0° el 50°	2.55	-7.41	6.14	37.0%	-10.2%	26.8 - *j* 7.8	27.9 - *j* 8.1
16.0	0°	15.72	az 0° el 13°	-0.04	13.80	-0.07	10.08	-0.01	-0.26	0.24	(floor)	-	-4.31	az 0° el 50°	0.57	-2.34	2.59	46.9%	-0.3%	26.7 - *j* 7.8	27.7 - *j* 8.1
24.0	0°	15.83	az 0° el 15°	0.07	13.85	-0.02	10.01	-0.08	-0.12	0.12	(floor)	-	-4.73	az 0° el 47°	0.15	-1.52	1.53	47.4%	0.2%	26.7 - *j* 7.8	27.7 - *j* 8.1
28.0	0°	15.81	az 0° el 15°	0.05	13.87	0.00	10.15	0.06	-0.09	0.10	(floor)	-	-4.69	az 0° el 49°	0.19	-1.07	1.14	47.4%	0.2%	26.7 - *j* 7.8	27.7 - *j* 8.1
32.0	0°	15.77	az 0° el 15°	0.01	13.86	-0.01	10.06	-0.03	-0.07	0.07	(floor)	-	-4.72	az 0° el 48°	0.16	-0.80	0.86	47.4%	0.2%	26.7 - *j* 7.8	27.7 - *j* 8.1
0.5	30°	11.36	az 320° el 17°	-4.40	8.42	-5.45	0.09	-10.00	-12.68	-1.72	-7.69	7.31	8.94	az 357° el 66°	13.82	-8.40	23.94	16.1%	-31.1%	23.8 - *j* 9.5	26.1 - *j* 10.7
1.0	30°	14.35	az 332° el 16°	-1.41	11.48	-2.39	5.57	-4.52	5.92	2.39	-6.80	8.20	5.42	az 354° el 59°	10.30	-8.93	20.34	10.4%	-36.8%	22.3 - *j* 9.0	23.9 - *j* 9.8
2.0	30°	16.30	az 345° el 16°	0.54	13.35	-0.52	6.98	-3.11	-3.14	2.18	-10.13	4.87	1.18	az 12° el 51°	6.06	-10.01	14.61	22.9%	-24.3%	25.9 - *j* 9.4	26.7 - *j* 8.5
4.0	30°	16.47	az 356° el 15°	0.71	13.63	-0.24	8.81	-1.28	-1.35	1.20	-12.83	2.17	-1.31	az 1° el 51°	3.57	-8.52	10.53	29.4%	-17.8%	26.9 - *j* 8.1	27.7 - *j* 8.6
8.0	30°	15.84	az 6° el 15°	0.08	13.80	-0.07	9.86	-0.23	-0.41	0.42	(floor)	-	-3.77	az 353° el 50°	1.11	-4.76	5.19	44.3%	-2.9%	26.7 - *j* 7.8	27.7 - *j* 8.1
16.0	30°	15.81	az 358° el 15°	0.05	13.88	0.01	10.01	-0.08	-0.12	0.11	(floor)	-	-4.55	az 358° el 58°	0.33	-1.55	1.65	47.3%	0.1%	26.7 - *j* 7.8	27.7 - *j* 8.1
20.0	30°	15.79	az 2° el 15°	0.03	13.88	0.01	10.08	-0.01	-0.08	0.08	(floor)	-	-4.69	az 356° el 48°	0.19	-1.12	1.15	47.3%	0.1%	26.7 - *j* 7.8	27.7 - *j* 8.1
24.0	30°	15.79	az 0° el 15°	0.03	13.88	0.01	10.06	-0.03	-0.05	0.05	(floor)	-	-4.76	az 1° el 48°	0.12	-0.83	0.81	47.2%	0.0%	26.7 - *j* 7.8	27.7 - *j* 8.1
0.5	60°	14.10	az 18° el 14°	-1.66	11.19	-2.68	6.06	-4.03	-6.59	1.00	-9.26	5.74	5.06	az 300° el 15°	9.94	-9.36	19.01	19.3%	-27.9%	27.3 - *j* 12.3	30.1 - *j* 12.4
1.0	60°	15.55	az 347° el 15°	-0.21	13.58	-0.29	9.14	-0.95	-1.68	1.58	-13.08	1.92	14.01	az 333° el 16°	18.89	-8.42	12.08	28.6%	-18.6%	27.2 - *j* 7.9	27.8 - *j* 8.1
2.0	60°	16.02	az 1° el 15°	0.26	13.77	-0.10	9.65	-0.44	-0.47	0.37	(floor)	-	-3.62	az 300° el 15°	1.26	-5.39	5.47	43.4%	-3.8%	26.7 - *j* 7.8	27.7 - *j* 8.1
4.0	60°	15.82	az 0° el 15°	0.06	13.86	-0.01	10.06	-0.03	-0.11	0.12	(floor)	-	-4.68	az 353° el 48°	0.20	-1.87	1.79	46.8%	-0.4%	26.7 - *j* 7.8	27.7 - *j* 8.1
8.0	60°	15.77	az 0° el 15°	0.01	13.87	0.00	10.08	-0.01	-0.02	0.03	(floor)	-	-4.85	az 3° el 48°	0.03	-0.48	0.49	47.3%	0.1%	26.7 - *j* 7.8	27.7 - *j* 8.1
0.5	90°	14.84	az 15° el 15°	-0.92	12.75	-1.12	8.50	-1.59	-3.03	1.51	-12.15	2.85	2.61	az 59° el 15°	7.49	-10.12	13.77	30.0%	-17.2%	29.3 - *j* 7.2	30.7 - *j* 6.6
1.0	90°	15.80	az 356° el 15°	0.04	13.83	-0.04	9.79	-0.30	0.46	0.40	(floor)	-	-3.79	az 59° el 15°	1.09	-4.86	5.21	42.9%	-4.3%	26.7 - *j* 7.8	27.6 - *j* 8.1
1.5	90°	15.81	az 0° el 15°	0.05	13.84	-0.03	9.99	-0.10	-0.14	0.12	(floor)	-	-4.54	az 59° el 15°	0.34	-1.99	2.27	46.4%	-0.8%	26.7 - *j* 7.8	27.7 - *j* 8.1
2.0	90°	15.73	az 358° el 15°	-0.03	13.89	0.02	10.06	-0.03	-0.05	0.06	(floor)	-	-4.74	az 59° el 15°	0.14	-1.24	1.40	46.9%	-0.3%	26.7 - *j* 7.8	27.7 - *j* 8.1
2.5	90°	15.78	az 0° el 15°	0.02	13.88	0.01	10.11	0.02	-0.03	0.04	(floor)	-	-4.78	az 0° el 48°	0.10	-0.97	1.11	47.2%	0.0%	26.7 - *j* 7.8	27.7 - *j* 8.1
4.0	90°	15.76	az 0° el 15°	0.00	13.87	0.00	10.09	0.00	-0.01	0.01	(floor)	-	-4.91	az 0° el 48°	-0.03	-0.40	0.42	47.4%	0.2%	26.7 - *j* 7.8	27.7 - *j* 8.1
0.5	120°	15.36	az 9° el 15°	-0.40	13.45	-0.42	7.61	-2.48	-2.51	1.48	-10.91	4.09	0.94	az 59° el 15°	5.82	-8.90	12.07	20.7%	-26.5%	27.3 - *j* 8.9	28.2 - *j* 8.6
1.0	120°	15.72	az 357° el 15°	-0.04	13.83	-0.04	10.00	-0.09	-0.27	0.24	(floor)	-	-4.77	az 59° el 15°	0.11	-2.77	3.61	47.7%	0.5%	26.6 - *j* 7.9	27.7 - *j* 8.1
2.0	120°	15.81	az 0° el 15°	0.05	13.84	-0.03	10.07	-0.02	-0.07	0.07	(floor)	-	-4.82	az 358° el 48°	0.06	-2.39	2.11	45.5%	-1.7%	26.7 - *j* 7.8	27.7 - *j* 8.1
4.0	120°	15.78	az 0° el 15°	0.02	13.88	0.01	10.08	-0.01	-0.03	0.03	(floor)	-	-4.91	az 1° el 48°	-0.03	-1.10	1.31	47.1%	-0.1%	26.7 - *j* 7.8	27.7 - *j* 8.1
8.0	120°	15.76	az 0° el 15°	0.00	13.87	0.00	10.09	0.00	-0.01	0.01	(floor)	-	-4.89	az 0° el 48°	-0.01	-0.41	0.50	47.3%	0.1%	26.7 - *j* 7.8	27.7 - *j* 8.1
0.5	150°	15.39	az 6° el 15°	-0.37	13.45	-0.42	8.20	-1.89	-1.97	0.85	-8.50	6.50	-0.60	az 236° el 18°	4.28	-9.99	13.61	13.6%	-33.6%	25.3 - *j* 3.0	25.8 - *j* 2.5
1.0	150°	15.77	az 0° el 15°	0.01	13.84	-0.03	9.98	-0.11	-0.15	0.11	(floor)	-	-4.60	az 59° el 15°	0.28	-0.92	1.51	48.5%	1.3%	26.7 - *j* 7.8	27.7 - *j* 8.0
2.0	150°	15.74	az 0° el 15°	-0.02	13.87	0.00	10.12	0.03	-0.07	0.06	(floor)	-	-4.90	az 0° el 48°	-0.02	-1.51	2.08	47.0%	-0.2%	26.7 - *j* 7.8	27.7 - *j* 8.1
4.0	150°	15.77	az 0° el 15°	0.01	13.86	-0.01	10.09	0.00	-0.04	0.05	(floor)	-	-4.84	az 1° el 48°	0.04	-0.79	1.25	47.0%	-0.2%	26.7 - *j* 7.8	27.7 - *j* 8.1
8.0	150°	15.75	az 0° el 15°	-0.01	13.88	0.01	10.09	0.00	-0.01	0.02	(floor)	-	-4.90	az 0° el 48°	-0.02	-0.33	0.33	47.3%	0.1%	26.7 - *j* 7.8	27.7 - *j* 8.1
16.0	150°	15.76	az 0° el 15°	0.00	13.87	0.00	10.09	0.00	-0.01	0.01	(floor)	-	-4.88	az 0° el 48°	0.00	-0.09	0.08	47.2%	0.0%	26.7 - *j* 7.8	27.7 - *j* 8.1
0.5	180°	14.62	az 0° el 15°	-1.14	12.89	-0.98	8.99	-1.10	-1.29	-0.61	-9.31	5.69	4.78	az 184° el 84°	9.66	-7.82	19.78	14.9%	-32.3%	19.6 - *j* 0.9	19.7 + *j* 0.1
1.0	180°	15.86	az 0° el 15°	0.10	13.95	0.08	10.08	-0.01	-0.04	0.11	(floor)	-	-5.44	az 59° el 15°	-0.56	-2.54	2.23	54.2%	7.0%	26.8 - *j* 7.8	27.8 - *j* 7.9
2.0	180°	15.84	az 0° el 15°	0.08	13.87	0.00	9.98	-0.11	-0.14	0.12	(floor)	-	-4.49	az 59° el 15°	0.39	-1.78	1.23	47.9%	0.7%	26.7 - *j* 7.8	27.7 - *j* 8.0
4.0	180°	15.70	az 0° el 15°	-0.06	13.82	-0.05	10.09	0.00	-0.08	0.15	(floor)	-	-4.93	az 59° el 15°	-0.05	-0.41	1.06	46.9%	-0.3%	26.7 - *j* 7.8	27.7 - *j* 8.1
8.0	180°	15.75	az 0° el 15°	-0.01	13.89	0.02	10.10	0.01	-0.04	0.04	(floor)	-	-4.82	az 0° el 48°	0.06	-0.42	0.22	47.7%	0.5%	26.7 - *j* 7.8	27.7 - *j* 8.1
16.0	180°	15.77	az 0° el 15°	0.01	13.88	0.01	10.10	0.01	-0.01	0.01	(floor)	-	-4.87	az 0° el 48°	0.01	-0.19	0.11	47.4%	0.2%	26.7 - *j* 7.8	27.7 - *j* 8.1
20.0	180°	15.76	az 0° el 15°	0.00	13.87	0.00	10.09	0.00	-0.01	0.01	(floor)	-	-4.88	az 0° el 48°	0.00	-0.12	0.07	47.3%	0.1%	26.7 - *j* 7.8	27.7 - *j* 8.1

Table 2: Performance parameters for the stack and impairments caused by a near-by multiplier Yagi. Both antennas point toward 0° azimuth. See text for explanation of column entries.

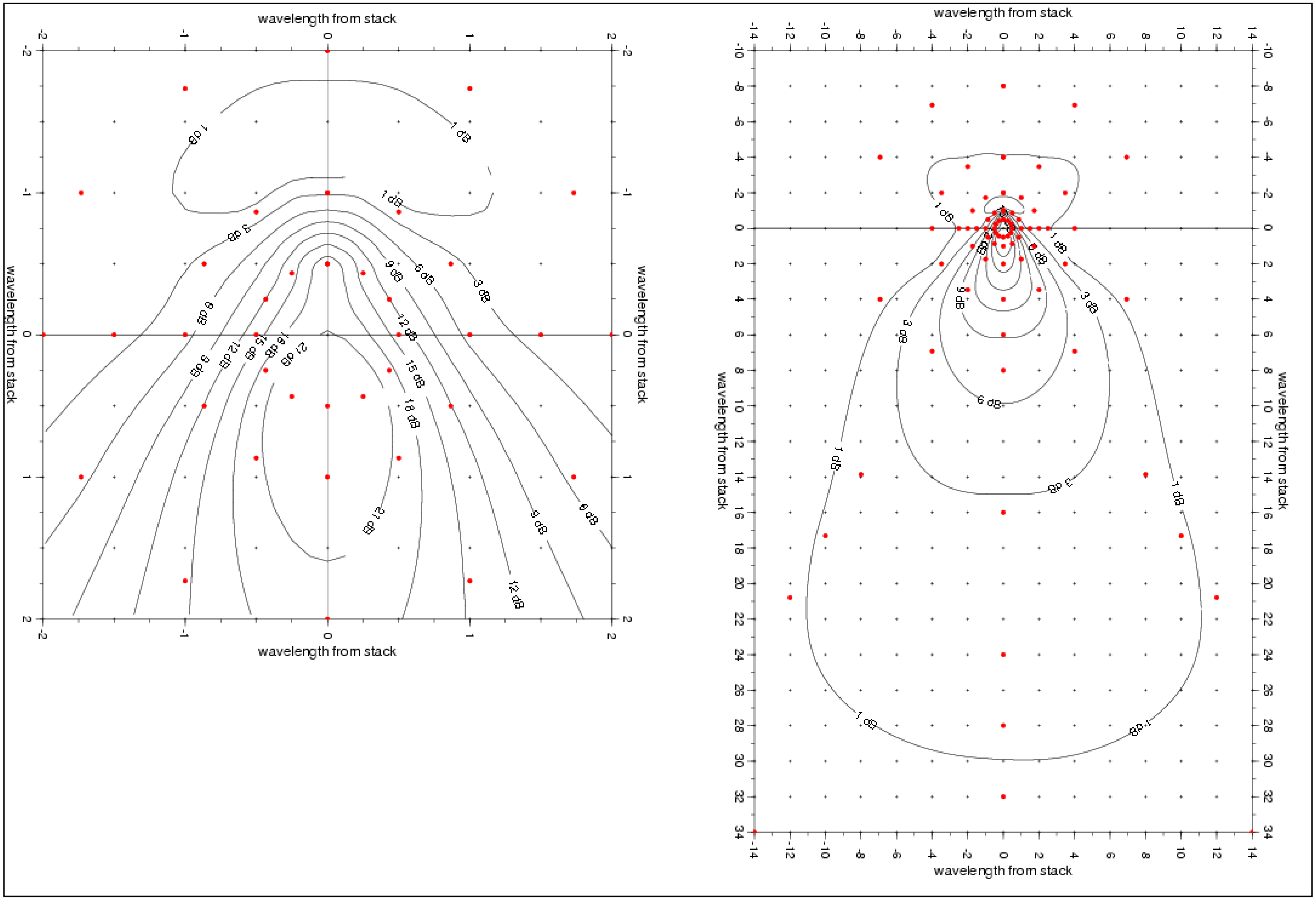

Figure 4: Maximum absolute variation in spot gain in any direction for the stack due to the presence of the multiplier Yagi. The stack stands at the origin of the coordinate system. Dots indicate calculated locations for the multiplier Yagi relative to the stack. Both antennas point toward 0° azimuth.