RICHARD TELL ASSOCIATES, INC.

October 6, 1998

Robert F. Cleveland, Ph.D.
Federal Communications Commission
Office of Engineering and Technology
Suite 230
2000 M Street, NW
Washington, DC 20554

Reference: Spatial averaging issues

Dear Bob:

In response to your e-mail question regarding spatial averaging, I have assembled some data that I recently obtained during one of my field studies that relates directly to your question.

The data were obtained during a study at a major broadcast site comprised of six towers that support numerous FM radio and TV broadcast antennas. I divided the site up into 48 areas wherein I performed measurements of RF fields using a Narda Model 8742 frequency shaped probe connected to the Narda Model 8718 digital meter which provides measurement of the spatial peak and spatial average fields, expressed in terms of a percentage of the Maximum Permissible Exposure (MPE) limit for controlled exposures.

In each of the 48 areas of the site, I made measurements of the volumetric spatial average and spatial peak fields. In this case, I walked about each area and continuously moved the prove in an oscillatory fashion, up and down and in a circular fashion. At the end of the walk-about, I recorded the spatial peak and spatial average values. These data are given in Table 1. I computed the ratio of the spatial average to spatial peak values, given in the right hand column of Table 1, and plotted this ratio in Figure 1 for the 48 areas vs. the measured peak percentage of the MPE.

These data provide an insight to the relationship between measured peak fields and measured average fields at the site. The overall average of the ratio was determined to be 0.378 with a minimum value of 0.115 and a maximum value of 0.656. I think that it is interesting to note that this ratio tended to become more stable and lower in value when the measured spatial peak fields exceeded 100% of the MPE.

At 20 different points on this same site, distributed among the 48 areas, I carefully measured the six-foot vertical spatial average field and corresponding spatial peak field. These data are given in Table 2 and plotted in Figure 2. The overall average of the ratio was determined to be 0.544 with a minimum value of 0.192 and a maximum value of 0.856. Again, it can be seen that for fields exceeding 100% MPE, this ratio is generally lower in value than for points with weaker spatial peak fields.

(702)645-3338 • FAX(702)645-8842 • 8309 Garnet Canyon Lane • Las Vegas, NV 89129

If the ratio obtained from the 48 area survey measurements is examined for just those areas having spatial peak values of fields equal to or greater than 100% of the MPE, then the average ratio of spatial average to spatial peak fields is 0.31. When the same check is made of the data for six-foot vertical spatial averages, the average is 0.35.

My conclusion, based on these measurement data, is that, on average, spatial average values of fields at the transmitter site are typically in the range of 38% to 54% of the spatial peak fields. However, for more intense fields that more closely approach the MPE limits, this figure is closer to about 31% to 35% of the spatial peak values. Obviously, more data should be acquired for more analysis, but these data do provide you with some insight to this relationship.

These measurement data also shed light on the issue of applying certain ground reflection factors in calculations of RF fields. For example, it is common for individuals to compute RF fields using conventional far-field formulations to obtain a value for the RF field at a point in space and, then, to multiply this value by a factor, typically 2.56 as called out in FCC OET-65, to account for the possibility of ground reflections. For assessing the spatial peak value of field, this is a reasonable approach. However, when calculating RF fields in terms of spatial averages, inclusion of the ground reflection factor, in general, will yield values that are excessive. This can be understood by simply considering the phase addition AND phase cancellation of resulting fields as a function of height above ground. On average, along a six-foot vertical line, one would expect that the spatial average field (power density) would tend to approximate the free-space computed value, without applying a ground reflection factor.

This is in fact the situation in many cases. Earlier this year, I modeled a six-element FM broadcast antenna and computed the RF fields as a function of height above ground at different points adjacent to the antenna (mounted at 30 meters above ground). I found that the true spatial average value of power densities, along a six-foot vertical path, more closely approximated the free-space computed value, based simply on the pattern of the antenna, without the application of the 2.56 ground reflection factor. More work is necessary before I can provide you with a definitive result from that analysis, but it certainly seems to support the contention that doing away with the ground reflection factor may be appropriate when modeling RF fields in terms of spatial averages.

I hope that these comments and data are responsive to your e-mail. Please give me a call if you would like to discuss this interesting issue further.

Respectfully yours,

Richard A. Tell

Richard A. Tell
President

Attachments: Two figures and two tables

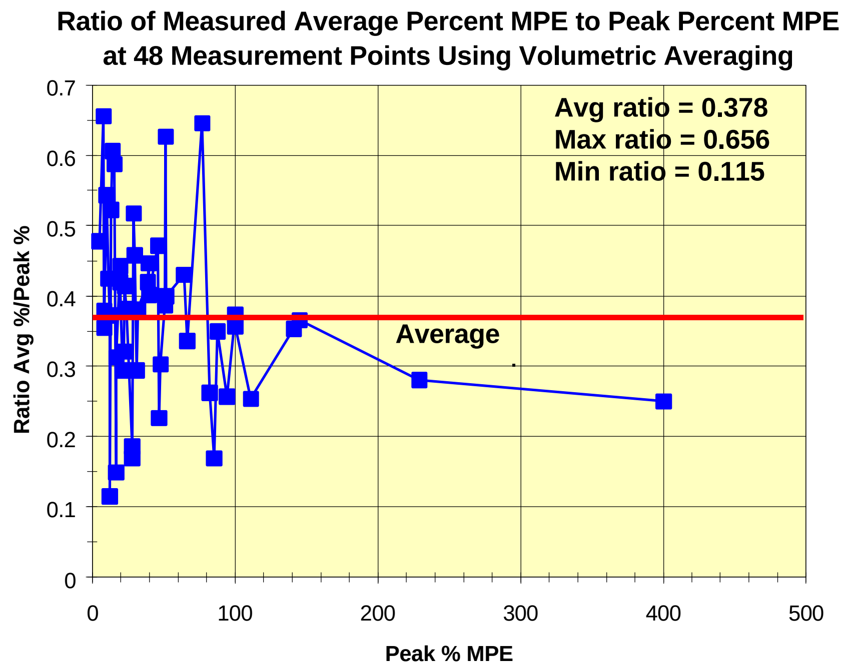

Figure 1. Ratio of measured average percent of MPE to peak percent of MPE at 48 measurement points using volumetric averaging.

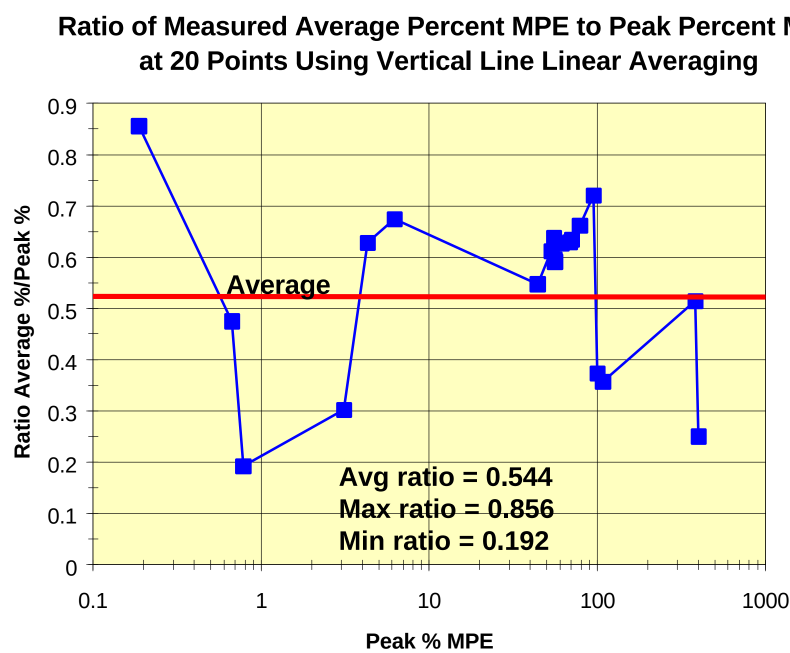

Figure 2. Ratio of measured average percent of MPE to peak percent of MPE at 20 measurement points using 6 foot vertical line linear averaging.

Table 1. Measured volumetric spatial averages and spatial peaks at 48 points.

Area	Avg%	Peak%	Avg%/Peak%
1	3.15	8.3	0.379518
2	8.59	19.4	0.442784
3	2.39	5	0.478
4	5.38	9.9	0.543434
5	5.26	16.8	0.313095
6	2.47	16.6	0.148795
7	4.51	12.1	0.372727
8	8.19	19.5	0.42
9	4.8	11.3	0.424779
10	6.95	13.3	0.522556
11	9.05	15.4	0.587662
12	5.18	7.9	0.655696
13	8.55	14.1	0.606383
14	9.37	22.6	0.414602
15	7.03	21.9	0.321005
16	13.51	29.5	0.457966
17	20.68	51.7	0.4
18	15.9	39.6	0.401515
19	6.3	21.4	0.294393
20	4.68	27.7	0.168953
21	17.64	39.5	0.446582
22	22.27	66.3	0.335897
23	30.63	87.6	0.349658
24	9.13	23.9	0.382008
25	16.3	38.8	0.420103
26	19.68	50.9	0.38664
27	49.66	76.9	0.645774
28	32.22	51.4	0.626848
29	35.7	100	0.357
30	21.54	82.1	0.262363
31	14.45	47.7	0.302935
32	21.7	46	0.471739
33	14.4	85.3	0.168816
34	12.2	32	0.38125
35	53	145	0.365517
36	10.55	46.6	0.226395
37	9.09	30.9	0.294175
38	49.83	141	0.353404
39	24.2	94.2	0.2569
40	5.15	27.7	0.185921
41	64.29	229	0.280742
42	2.98	8.4	0.354762
43	28.16	111	0.253694
44	37.35	100	0.3735
45	15	29	0.517241
46	27.63	64.2	0.430374
47	1.4	12.2	0.114754
48	100	400	0.25
		Average	0.378101
		Maximum	0.656
		Minimum	0.115

Table 2. Measurements of 6 foot vertical spatial average and spatial peak at 20 points.

Point	Avg%	Peak%	Ratio avg/pk
O	100	400	0.25
N	197	383	0.51436
D	38.55	108	0.356944
L	37.35	100	0.3735
M	68.45	95	0.720526
F	52.23	78.9	0.661977
J	44.66	70.44	0.634015
I	43.29	68.8	0.629215
P	38.36	61.2	0.626797
E	33.09	56	0.590893
H	33.18	55.7	0.595691
C	35.23	55.2	0.638225
K	32.65	53.4	0.611423
G	24.18	44.2	0.547059
B	4.18	6.2	0.674194
A	2.7	4.3	0.627907
2	0.937	3.1	0.302258
3	0.15	0.78	0.192308
4	0.318	0.67	0.474627
1	0.16	0.187	0.855615
		Avg	0.543877
		Max	0.855615
		Min	0.192308