

Antenna pattern test

distance Wt-Vr: 50 m

distance It-Vr: 30 m, circular around Vr

transmission power for Vr and It: 33 dBm

antenna height for Wt, Vr and It: 1,5 m

blocking: 0 dB

unwanted emission of It in the band of Vr: -40 dB

ϕ (in case of horizontal movement of It): angle with respect to Vr

180 deg: It directly between Wt and Vr

270 deg: It „below“ Vr

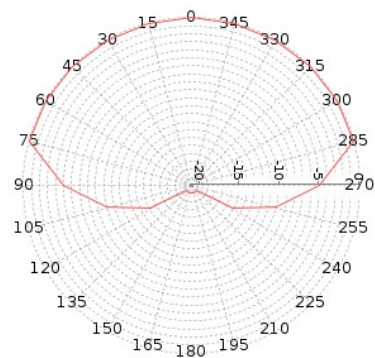
360 deg = 0 deg: It behind Vr

90 deg: It „above“ Vr

(180 deg have to be switched to 0 deg when It is moving above Vr, i.e. circulating vertically)

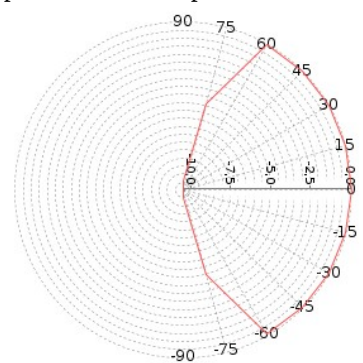
0	0.00
15	0.00
30	0.00
45	0.00
60	0.00
75	0.00
90	-5.00
105	-10.00
120	-15.00
135	-20.00
150	-20.00
165	-20.00
180	-20.00
195	-20.00
210	-20.00
225	-20.00
240	-15.00
255	-10.00
270	-5.00
285	0.00
300	0.00
315	0.00
330	0.00
345	0.00
360	0.00

horizontal antenna pattern test-half-sphere-c0



-90	-10.00
-75	-5.00
-60	0.00
-45	0.00
-30	0.00
-15	0.00
0	0.00
15	0.00
30	0.00
45	0.00
60	0.00
75	-5.00
90	-10.00

vertical antenna pattern test-half-sphere-c0_v



using the test-half-sphere-c0 as Vr's horizontal antenna pattern, moving It around Vr

φ / deg	0	15	30	45	60	75	90	105	120	135	150	165
iRSS blocking	-56,73	-56,73	-56,73	-56,73	-51,73	-46,73	-41,73	-36,73	-36,73	-36,73	-36,73	-36,73
iRSS unwanted	-103,72	-103,72	-103,72	-103,72	-98,72	-93,72	-88,72	-83,72	-83,72	-83,72	-83,72	-83,72
φ / deg	180	195	210	225	240	255	270	285	300	315	330	345
iRSS blocking	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-41,73	-46,73	-51,73	-56,73	-56,73	-56,73
iRSS unwanted	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-88,72	-93,72	-98,72	-103,72	-103,72	-103,72

>> ok, the horizontal pattern is visible

when moving the It in a vertical circle above Vr, then up to the point directly above the Vr, the value for 0° is used, from the point above Vr (and including that point!) the value for 180° is used >> ok

the same scenario, using the test-half-sphere-c0_v as Vr's vertical antenna pattern, moving It around Vr

φ / deg	0	15	30	45	60	75	90	105	120	135	150	165
iRSS blocking	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73
iRSS unwanted	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72
φ / deg	180	195	210	225	240	255	270	285	300	315	330	345
iRSS blocking	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73	-36,73
iRSS unwanted	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72	-83,72

>> ok, there is no pattern visible, only the vertical value for 0° is used for the whole circle

the same scenario, using the test-half-sphere-c0_v as Vr's vertical antenna pattern, moving It above Vr to Vr's back now phi is the vertical angle (x-distance and height are adapted to keep the 30 m between Vr and It)!

φ / deg	0	15	30	45	60	75	90	105	120	135	150	165
iRSS blocking	-36,73	-36,74	-36,74	-36,72	-36,74	-41,72	-46,73	-41,72	-36,74	-36,72	-36,74	-36,74
iRSS unwanted	-83,72	-83,73	-83,72	-83,71	-83,73	-88,71	-93,72	-88,71	-83,73	-83,71	-83,72	-83,73
x-dist.	30	29	26	21,2	15	7.8	0					
h	0	7,8	15	21,1	26	29	30					

>> ok, the vertical pattern is visible

the same scenario, using the test-half-sphere-c0_v as Vr's vertical antenna pattern and test-half-sphere-c0 as Vr's horizontal antenna pattern, moving It above Vr to Vr's back

phi is the vertical angle (x-distance and height are adapted to keep the 30 m between Vr and It)!

φ / deg	0	15	30	45	60	75	90	105	120	135	150	165
iRSS blocking	-36,73	-36,74	-36,74	-36,72	-36,74	-41,72	-56,73*	-56,74	-56,74	-56,72	-56,74	-56,74
iRSS unwanted	-83,72	-83,73	-83,72	-83,71	-83,73	-88,71	-103,72	-103,73	-103,72	-103,71	-103,72	-103,73

* (-46,67 and -93,66 in case of x-dist. 0,0001 m, i.e. before the value from the „other“ side is used)

>> bug?: when moving It down the way from the point above Vr to the point behind Vr, the vertical pattern should be visible, weighted with the value from the horizontal pattern!

>> no bug! the calculation is according to the information given in the manual

Antenna pattern – current calculation vs. expectations or proposals

Remark: One has to have in mind the reference direction, which might be the path Tx-to-Rx or which might be any given direction.

Case A: Vertical and/or horizontal patterns

Horizontal or vertical pattern only:

The gain is taken directly from the pattern, for values between the given ones an interpolation is done. >> **ok**

In case of interference from directions outside the defined plane (e.g. assuming Wt and Vr antennas at the same height and Vr pattern only, interferer above the horizontal plane), the value according to the horizontal or vertical projection is used. >> **ok**

Horizontal and vertical pattern:

according to the manual the following calculation is done

$$\text{IF } \text{abs}(\mathcal{G}_{wr \rightarrow it}^H - \mathcal{G}_{wr \rightarrow it}^V) < 3 \text{ dB}$$

$$\mathcal{G}_{wr \rightarrow it} = f(\mathcal{G}_{wr}^{\text{max}}, \mathcal{G}_{wr \rightarrow it}^H, \mathcal{G}_{wr \rightarrow it}^V) = \mathcal{G}_{wr}^{\text{max}} \times \sqrt{\frac{\mathcal{G}_{wr \rightarrow it}^H + \mathcal{G}_{wr \rightarrow it}^V}{2}} \quad (\text{in linear domain - not in dB})$$

ELSE

$$\mathcal{G}_{wr \rightarrow it} = \mathcal{G}_{wr}^{\text{max}} \times \min(\mathcal{G}_{wr \rightarrow it}^H, \mathcal{G}_{wr \rightarrow it}^V) \quad (\text{in linear domain - not in dB})$$

>> Maybe this is due to the assumption that both the vertical and horizontal values might result from one measurement. In this case small deviations could be interpreted as measurement uncertainties, the finally used value is the average. If there are bigger deviations, the minimum value is used. The only question is, why the minimum? In case of more complex patterns the resulting pseudo-spherical pattern is hardly to predict.

Proposal: as simple as possible

Take the value resulting from the horizontal pattern and the one resulting from the vertical pattern and do an averaging (as for differences < 3 dB) in any case.

Case B: Spherical patterns

In contrast to the expectation of having two angles (i.e. two coordinates to define a plane), the mask contains only one angle. Looking in the manual, there is a calculation given:

$$\mathcal{G}_{\theta\phi \rightarrow \theta\phi_2}^S = f_{\theta\phi}^{S\text{-pattern}}(\arccos(\cos \theta_{\theta\phi \rightarrow \theta\phi_2} \cos \phi_{\theta\phi \rightarrow \theta\phi_2}))$$

Let's have a closer look on the resulting angles using this calculation:

PI()/8 = 0,392699082		0	1	2	3	4
	theta/phi	0,00	0,39	0,79	1,18	1,57
0	0,00	0,0	22,5	45,0	67,5	90,0
1	0,39	22,5	31,4	49,2	69,3	90,0
2	0,79	45,0	49,2	60,0	74,3	90,0
3	1,18	67,5	69,3	74,3	81,6	90,0
4	1,57	90,0	90,0	90,0	90,0	90,0
5	1,96	112,5	110,7	105,7	98,4	90,0
6	2,36	135,0	130,8	120,0	105,7	90,0
7	2,75	157,5	148,6	130,8	110,7	90,0
8	3,14	180,0	157,5	135,0	112,5	90,0
9	3,53	157,5	148,6	130,8	110,7	90,0
10	3,93	135,0	130,8	120,0	105,7	90,0
11	4,32	112,5	110,7	105,7	98,4	90,0
12	4,71	90,0	90,0	90,0	90,0	90,0
13	5,11	67,5	69,3	74,3	81,6	90,0
14	5,50	45,0	49,2	60,0	74,3	90,0
15	5,89	22,5	31,4	49,2	69,3	90,0
16	6,28	0,0	22,5	45,0	67,5	90,0

One will find some symmetry! Therefore, a calculation of a single angle from two angles defining a sphere is **useless!**

Proposal:

Define a grid, i.e. a (maybe fixed?) stepping of two angles, as roughly shown in the table above. The user might input a step size, and according to that step size a matrix can be presented to be filled with the gain values. For example, a step size of 30 deg will result in the following matrix:

step size: 30 deg

deg/deg	0	30	60	90	120	150	180	210	240	270	300	330
-90	(only one value possible)											
-60												
-30												
0												
30												
60												
90	(only one value possible)											

In the file, there is simply one column more:

vert.	horiz.	
-90.0		<i>value</i>
-60.0	0.0	<i>value</i>
-60.0	30.0	<i>value</i>
:	:	:
-60.0	330.0	<i>value</i>
-30.0	0.0	<i>value</i>
-30.0	30.0	<i>value</i>
:	:	:
-30.0	330.0	<i>value</i>
0.0	0.0	<i>value</i>
0.0	30.0	<i>value</i>
:	:	:

Alternatively, the step size might be set for horizontal and vertical angles separately. An interpolation algorithm can be defined, based on the step size and implemented in the same way as already done for the two-dimensional case.

Ok, these matrices will be somehow big in case of a fine grid, but it is at everyone's own to limit the granularity. But only in this way one can define a spherical pattern, e.g. an antenna characteristic with e.g. two main beams!