	166		x	**4.75**	0.11	x	**4.33**	0.08	x	**3.72**	0.12
	167		x	**4.84**	0.09	x	**4.34**	0.18	x	**3.49**	0.37
	168		x	**4.80**	0.34	x	**4.13**	0.42	x	**3.79**	0.63
	0	128	x	**2.90**	0.31	x	**2.38**	0.25	x	**2.33**	0.22
	3	131	x	**2.44**	0.13	x	**2.18**	0.15	x	**1.86**	0.18
	6	134	x	**5.21**	0.58	x	**4.43**	0.61	x	**3.97**	0.53
	7	135	x	**4.53**	0.31	x	**4.21**	0.16	x	**3.56**	0.13
	8	136	x	**5.65**	0.40	x	**4.92**	0.46	x	**4.63**	0.56
	9	137	x	**5.65**	0.72	x	**4.59**	0.63	x	**4.19**	0.55
	18	146	x	**4.65**	0.53	x	**4.21**	0.43	x	**3.73**	0.34
	19	147	x	**5.62**	0.21	x	**4.93**	0.31	x	**4.53**	0.46
	20	148	x	**5.74**	0.65	x	**4.73**	0.59	x	**4.36**	0.59
	27	155	x	**9.07**	1.62	x	**8.30**	1.30	x	**7.67**	0.93
	28	156	x	**9.75**	0.63	x	**8.39**	0.32	x	**7.19**	0.33
	29	157	x	**9.45**	0.38	x	**8.39**	0.44	x	**7.09**	0.49
	30	158	x	**10.00**	0.66	x	**8.69**	0.63	x	**8.12**	1.40
	31	159	x	**8.92**	1.28	x	**8.03**	1.55	x	**7.84**	1.34
	37	165	x	**9.48**	1.07	x	**7.88**	0.73	x	**7.17**	0.47
	38	166	x	**9.96**	0.33	x	**8.58**	0.42	x	**7.50**	0.51
	39	167	x	**9.39**	0.46	x	**8.27**	0.57	x	**7.62**	0.97
	40	168	x	**9.80**	0.94	x	**8.49**	1.10	x	**8.12**	1.46

i) *Simulated PD (mW/cm^2) at 4 cm^2 averaging for back array 2 at n260.*

			4 cm^2 PD (mW/cm^2) at 11 dBm per port, n260								
Module ID	Beam ID 1	Beam ID 2	LB			MB			HB		
0			**S2**	S3	S5	**S2**	S3	S5	**S2**	S3	S5
Back Array 2	1		**0.34**	0.02	0.03	**0.24**	0.02	0.03	**0.21**	0.01	0.02
	4		**0.84**	0.03	0.09	**0.77**	0.02	0.08	**0.36**	0.02	0.05
	10		**1.11**	0.04	0.08	**1.02**	0.04	0.05	**0.39**	0.03	0.03
	11		**1.15**	0.07	0.17	**1.06**	0.04	0.10	**0.61**	0.04	0.07
	12		**1.18**	0.06	0.19	**0.99**	0.04	0.16	**0.76**	0.03	0.10
	13		**1.17**	0.05	0.14	**0.89**	0.03	0.13	**0.54**	0.03	0.09
	21		**1.12**	0.06	0.12	**1.05**	0.04	0.07	**0.46**	0.03	0.04
	22		**1.17**	0.07	0.19	**1.04**	0.04	0.14	**0.71**	0.04	0.09
	23		**1.18**	0.05	0.16	**0.89**	0.03	0.15	**0.61**	0.03	0.10
	129		**0.80**	0.02	0.08	**0.69**	0.03	0.05	**0.59**	0.03	0.06
	132		**0.50**	0.02	0.07	**0.61**	0.02	0.09	**0.50**	0.02	0.09
	138		**1.42**	0.07	0.15	**1.06**	0.04	0.09	**0.70**	0.06	0.08
	139		**1.16**	0.03	0.25	**1.35**	0.04	0.24	**1.31**	0.04	0.23
	140		**1.10**	0.03	0.22	**1.43**	0.04	0.24	**1.42**	0.04	0.25
	141		**1.21**	0.06	0.07	**1.25**	0.06	0.09	**1.00**	0.07	0.11
	149		**1.36**	0.05	0.21	**1.14**	0.04	0.15	**0.90**	0.05	0.13
	150		**1.19**	0.03	0.25	**1.32**	0.04	0.23	**1.25**	0.03	0.22
	151		**1.15**	0.05	0.07	**1.32**	0.05	0.13	**1.14**	0.07	0.15
	1	129	**1.28**	0.05	0.16	**1.13**	0.07	0.11	**1.00**	0.05	0.10
	4	132	**1.64**	0.09	0.24	**1.60**	0.04	0.23	**1.02**	0.06	0.14

	10	138	**2.78**	0.16	0.28	**2.43**	0.10	0.20	**1.36**	0.11	0.12
	11	139	**3.14**	0.11	0.56	**2.92**	0.13	0.41	**2.21**	0.08	0.30
	12	140	**3.08**	0.08	0.61	**2.98**	0.12	0.53	**2.56**	0.08	0.34
	13	141	**2.43**	0.11	0.28	**2.35**	0.10	0.28	**1.80**	0.12	0.22
	21	149	**2.96**	0.16	0.41	**2.62**	0.12	0.25	**1.68**	0.10	0.18
	22	150	**3.20**	0.13	0.62	**2.95**	0.13	0.47	**2.36**	0.08	0.30
	23	151	**2.50**	0.11	0.35	**2.49**	0.09	0.36	**2.05**	0.12	0.27

Scaling factor calculation: The following tables show the scaling factor results for all three different modules, at both n258, n261 and band n260. The scaling factor is defined as the MPE internal design limit (0.6 mW/cm^2) divided by the simulated averaged power density. Table a), b), and c) show the results for n258, for side, back, and front modules, respectively; table d), e), and f) show the results for n261, for side, back, and front modules, respectively; table g), h) and i) show the results for n260, for side, back, and front modules, respectively.

a) *Scaling factor for side array n258*

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
2		0.47	0.30	0.31	0.30
5		0.23	0.28	0.27	0.23
14		0.14	0.17	0.12	0.12
15		0.13	0.15	0.12	0.12
16		0.17	0.12	0.13	0.12
17		0.21	0.19	0.13	0.13
24		0.25	0.14	0.14	0.14
25		0.21	0.15	0.14	0.14
26		0.21	0.18	0.13	0.13
32		0.08	0.07	0.06	0.06
33		0.08	0.07	0.07	0.07
34		0.09	0.08	0.07	0.07
35		0.09	0.06	0.07	0.06
36		0.10	0.07	0.06	0.06
41		0.08	0.07	0.06	0.06
42		0.09	0.07	0.07	0.07
43		0.09	0.07	0.08	0.07
44		0.09	0.06	0.06	0.06
130		0.68	0.47	0.25	0.25
133		0.74	0.29	0.30	0.29
142		0.29	0.20	0.13	0.13
143		0.24	0.19	0.13	0.13
144		0.31	0.26	0.15	0.15
145		0.29	0.25	0.14	0.14
152		0.30	0.20	0.14	0.14
153		0.25	0.18	0.14	0.14
154		0.24	0.17	0.14	0.14
160		0.12	0.09	0.06	0.06
161		0.13	0.11	0.08	0.08

162		0.15	0.12	0.09	0.09
163		0.13	0.11	0.09	0.09
164		0.12	0.09	0.06	0.06
169		0.12	0.09	0.07	0.07
170		0.15	0.12	0.08	0.08
171		0.14	0.12	0.09	0.09
172		0.12	0.10	0.07	0.07
2	130	0.18	0.15	0.13	0.13
5	133	0.15	0.13	0.13	0.13
14	142	0.10	0.09	0.07	0.07
15	143	0.07	0.07	0.06	0.06
16	144	0.11	0.08	0.07	0.07
17	145	0.10	0.10	0.07	0.07
24	152	0.11	0.07	0.06	0.06
25	153	0.12	0.09	0.07	0.07
26	154	0.11	0.09	0.07	0.07
32	160	0.04	0.03	0.03	0.03
33	161	0.04	0.03	0.03	0.03
34	162	0.04	0.04	0.04	0.04
35	163	0.04	0.03	0.04	0.03
36	164	0.05	0.03	0.03	0.03
41	169	0.04	0.03	0.03	0.03
42	170	0.04	0.04	0.03	0.03
43	171	0.05	0.04	0.04	0.04
44	172	0.04	0.03	0.03	0.03

b) *Scaling factor for back array 1 n258*

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
0		0.32	0.33	0.41	0.32
3		0.31	0.28	0.35	0.28
6		0.21	0.22	0.23	0.21
7		0.14	0.14	0.16	0.14
8		0.13	0.14	0.18	0.13
9		0.19	0.18	0.22	0.18
18		0.17	0.15	0.18	0.15
19		0.13	0.14	0.16	0.13
20		0.16	0.15	0.21	0.15
27		0.11	0.10	0.11	0.10
28		0.07	0.08	0.09	0.07
29		0.07	0.08	0.09	0.07
30		0.06	0.07	0.08	0.06
31		0.09	0.10	0.15	0.09
37		0.09	0.08	0.10	0.08
38		0.07	0.08	0.09	0.07
39		0.06	0.07	0.09	0.06
40		0.07	0.07	0.10	0.07
128		0.34	0.33	0.39	0.33
131		0.31	0.29	0.39	0.29

134		0.16	0.16	0.22	0.16
135		0.14	0.15	0.21	0.14
136		0.17	0.15	0.18	0.15
137		0.15	0.14	0.22	0.14
146		0.19	0.20	0.23	0.19
147		0.15	0.15	0.16	0.15
148		0.17	0.15	0.18	0.15
155		0.07	0.06	0.11	0.06
156		0.08	0.08	0.11	0.08
157		0.09	0.10	0.10	0.09
158		0.09	0.08	0.09	0.08
159		0.07	0.06	0.10	0.06
165		0.07	0.07	0.11	0.07
166		0.09	0.09	0.10	0.09
167		0.09	0.09	0.10	0.09
168		0.08	0.07	0.09	0.07
0	128	0.15	0.14	0.19	0.14
3	131	0.15	0.14	0.17	0.14
6	134	0.08	0.09	0.11	0.08
7	135	0.07	0.07	0.09	0.07
8	136	0.07	0.07	0.09	0.07
9	137	0.07	0.07	0.09	0.07
18	146	0.09	0.07	0.09	0.07
19	147	0.07	0.08	0.08	0.07
20	148	0.08	0.07	0.10	0.07
27	155	0.04	0.04	0.04	0.04
28	156	0.03	0.03	0.05	0.03
29	157	0.04	0.04	0.04	0.04
30	158	0.04	0.04	0.04	0.04
31	159	0.03	0.03	0.05	0.03
37	165	0.03	0.03	0.05	0.03
38	166	0.04	0.04	0.05	0.04
39	167	0.04	0.04	0.04	0.04
40	168	0.03	0.03	0.04	0.03

c) *Scaling factor for back array 2 n258*

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
1		0.91	0.46	0.70	0.46
4		0.66	0.51	0.51	0.51
10		0.39	0.24	0.25	0.24
11		0.33	0.21	0.32	0.21
12		0.41	0.26	0.40	0.26
13		0.39	0.25	0.31	0.25
21		0.34	0.22	0.27	0.22
22		0.38	0.23	0.41	0.23
23		0.40	0.26	0.35	0.26
129		0.75	0.47	0.47	0.47
132		0.45	0.65	0.71	0.45

138		0.33	0.30	0.31	0.30
139		0.24	0.25	0.30	0.24
140		0.24	0.25	0.29	0.24
141		0.26	0.27	0.27	0.26
149		0.31	0.29	0.32	0.29
150		0.25	0.26	0.30	0.25
151		0.25	0.26	0.28	0.25
1	129	0.36	0.21	0.23	0.21
4	132	0.25	0.26	0.22	0.22
10	138	0.16	0.12	0.12	0.12
11	139	0.12	0.10	0.11	0.10
12	140	0.14	0.11	0.12	0.11
13	141	0.15	0.11	0.12	0.11
21	149	0.14	0.12	0.12	0.12
22	150	0.13	0.11	0.12	0.11
23	151	0.15	0.11	0.12	0.11

d) *Scaling factor for side array n261*

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
2		0.26	0.25	0.30	0.25
5		0.23	0.24	0.38	0.23
14		0.17	0.12	0.18	0.12
15		0.16	0.12	0.21	0.12
16		0.12	0.12	0.20	0.12
17		0.20	0.13	0.15	0.13
24		0.16	0.14	0.14	0.14
25		0.15	0.12	0.18	0.12
26		0.12	0.12	0.18	0.12
32		0.09	0.07	0.07	0.07
33		0.07	0.06	0.09	0.06
34		0.09	0.07	0.10	0.07
35		0.07	0.06	0.09	0.06
36		0.08	0.07	0.08	0.07
41		0.07	0.06	0.08	0.06
42		0.08	0.07	0.10	0.07
43		0.08	0.07	0.10	0.07
44		0.07	0.06	0.08	0.06
130		0.38	0.27	0.24	0.24
133		0.32	0.22	0.36	0.22
142		0.18	0.12	0.15	0.12
143		0.20	0.13	0.17	0.13
144		0.20	0.13	0.15	0.13
145		0.20	0.12	0.14	0.12
152		0.18	0.13	0.13	0.13
153		0.16	0.14	0.14	0.14
154		0.17	0.13	0.14	0.13
160		0.10	0.06	0.09	0.06

161		0.09	0.07	0.08	0.07
162		0.11	0.08	0.10	0.08
163		0.10	0.08	0.09	0.08
164		0.09	0.06	0.08	0.06
169		0.09	0.06	0.08	0.06
170		0.11	0.08	0.09	0.08
171		0.10	0.08	0.10	0.08
172		0.09	0.06	0.08	0.06
2	130	0.13	0.12	0.13	0.12
5	133	0.11	0.11	0.15	0.11
14	142	0.08	0.05	0.08	0.05
15	143	0.08	0.06	0.09	0.06
16	144	0.07	0.06	0.08	0.06
17	145	0.09	0.06	0.08	0.06
24	152	0.07	0.06	0.07	0.06
25	153	0.09	0.07	0.08	0.07
26	154	0.06	0.06	0.07	0.06
32	160	0.04	0.03	0.04	0.03
33	161	0.03	0.03	0.04	0.03
34	162	0.04	0.03	0.05	0.03
35	163	0.03	0.03	0.04	0.03
36	164	0.03	0.03	0.04	0.03
41	169	0.03	0.03	0.04	0.03
42	170	0.04	0.03	0.05	0.03
43	171	0.04	0.04	0.05	0.04
44	172	0.03	0.03	0.04	0.03

e) *Scaling factor for back array 1 n261*

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
0		0.30	0.36	0.41	0.30
3		0.40	0.44	0.50	0.40
6		0.23	0.25	0.22	0.22
7		0.14	0.16	0.21	0.14
8		0.17	0.20	0.22	0.17
9		0.18	0.21	0.26	0.18
18		0.15	0.17	0.24	0.15
19		0.18	0.21	0.20	0.18
20		0.17	0.21	0.25	0.17
27		0.10	0.10	0.12	0.10
28		0.08	0.10	0.10	0.08
29		0.09	0.09	0.10	0.09
30		0.07	0.09	0.10	0.07
31		0.08	0.12	0.17	0.08
37		0.08	0.10	0.10	0.08
38		0.08	0.09	0.10	0.08
39		0.08	0.10	0.09	0.08
40		0.07	0.10	0.12	0.07
128		0.32	0.42	0.46	0.32

131		0.42	0.51	0.46	0.42
134		0.21	0.25	0.24	0.21
135		0.15	0.17	0.18	0.15
136		0.16	0.22	0.21	0.16
137		0.15	0.20	0.25	0.15
146		0.17	0.22	0.23	0.17
147		0.15	0.17	0.19	0.15
148		0.15	0.18	0.23	0.15
155		0.07	0.11	0.11	0.07
156		0.08	0.11	0.11	0.08
157		0.10	0.11	0.11	0.10
158		0.10	0.11	0.11	0.10
159		0.08	0.10	0.12	0.08
165		0.07	0.11	0.11	0.07
166		0.10	0.11	0.11	0.10
167		0.10	0.11	0.11	0.10
168		0.09	0.10	0.11	0.09
0	128	0.15	0.18	0.20	0.15
3	131	0.19	0.23	0.22	0.19
6	134	0.09	0.12	0.10	0.09
7	135	0.07	0.08	0.09	0.07
8	136	0.08	0.10	0.10	0.08
9	137	0.08	0.09	0.12	0.08
18	146	0.08	0.08	0.10	0.08
19	147	0.09	0.10	0.10	0.09
20	148	0.08	0.09	0.12	0.08
27	155	0.04	0.05	0.05	0.04
28	156	0.04	0.05	0.05	0.04
29	157	0.04	0.05	0.05	0.04
30	158	0.04	0.05	0.05	0.04
31	159	0.04	0.05	0.07	0.04
37	165	0.03	0.04	0.05	0.03
38	166	0.04	0.05	0.05	0.04
39	167	0.04	0.05	0.05	0.04
40	168	0.04	0.05	0.05	0.04

f) Scaling factor for back array 2 n261

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
1		0.43	0.39	0.68	0.39
4		0.79	0.23	0.37	0.23
10		0.25	0.14	0.25	0.14
11		0.28	0.18	0.30	0.18
12		0.32	0.17	0.27	0.17
13		0.30	0.14	0.22	0.14
21		0.25	0.16	0.28	0.16
22		0.31	0.18	0.29	0.18
23		0.32	0.16	0.24	0.16

129		0.63	0.35	0.35	0.35
132		0.54	0.33	0.27	0.27
138		0.26	0.19	0.15	0.15
139		0.30	0.17	0.15	0.15
140		0.30	0.17	0.15	0.15
141		0.32	0.15	0.16	0.15
149		0.27	0.20	0.15	0.15
150		0.30	0.17	0.15	0.15
151		0.34	0.16	0.16	0.16
1	129	0.22	0.16	0.18	0.16
4	132	0.26	0.10	0.13	0.10
10	138	0.12	0.07	0.09	0.07
11	139	0.11	0.06	0.08	0.06
12	140	0.12	0.06	0.08	0.06
13	141	0.14	0.06	0.09	0.06
21	149	0.11	0.07	0.08	0.07
22	150	0.12	0.06	0.08	0.06
23	151	0.13	0.06	0.09	0.06

g) *Scaling factor for side array n260*

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
2		0.59	0.41	0.47	0.41
5		0.55	0.44	0.44	0.44
14		0.30	0.26	0.25	0.25
15		0.28	0.22	0.21	0.21
16		0.28	0.24	0.28	0.24
17		0.35	0.21	0.22	0.21
24		0.29	0.20	0.20	0.20
25		0.26	0.22	0.26	0.22
26		0.34	0.27	0.22	0.22
32		0.18	0.14	0.12	0.12
33		0.14	0.11	0.12	0.11
34		0.13	0.11	0.13	0.11
35		0.18	0.14	0.15	0.14
36		0.19	0.13	0.12	0.12
41		0.15	0.13	0.13	0.13
42		0.14	0.11	0.11	0.11
43		0.15	0.13	0.16	0.13
44		0.19	0.13	0.13	0.13
130		0.54	0.41	0.44	0.41
133		0.39	0.36	0.56	0.36
142		0.27	0.20	0.26	0.20
143		0.27	0.22	0.30	0.22
144		0.24	0.26	0.22	0.22
145		0.27	0.20	0.24	0.20
152		0.26	0.30	0.26	0.26
153		0.24	0.28	0.22	0.22
154		0.24	0.26	0.23	0.23

160		0.17	0.14	0.15	0.14
161		0.14	0.14	0.17	0.14
162		0.13	0.13	0.12	0.12
163		0.14	0.15	0.14	0.14
164		0.15	0.12	0.13	0.12
169		0.16	0.16	0.18	0.16
170		0.14	0.13	0.13	0.13
171		0.13	0.15	0.13	0.13
172		0.14	0.12	0.13	0.12
2	130	0.24	0.20	0.21	0.20
5	133	0.20	0.18	0.22	0.18
14	142	0.16	0.13	0.13	0.13
15	143	0.11	0.10	0.11	0.10
16	144	0.12	0.11	0.11	0.11
17	145	0.14	0.09	0.10	0.09
24	152	0.13	0.12	0.11	0.11
25	153	0.11	0.12	0.11	0.11
26	154	0.12	0.12	0.11	0.11
32	160	0.07	0.06	0.06	0.06
33	161	0.06	0.05	0.06	0.05
34	162	0.05	0.05	0.06	0.05
35	163	0.07	0.07	0.06	0.06
36	164	0.07	0.05	0.05	0.05
41	169	0.07	0.06	0.07	0.06
42	170	0.06	0.05	0.05	0.05
43	171	0.07	0.06	0.06	0.06
44	172	0.07	0.06	0.06	0.06

h) *Scaling factor for back array 1 n260*

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
0		0.48	0.65	0.63	0.48
3		0.56	0.63	0.75	0.56
6		0.27	0.33	0.38	0.27
7		0.28	0.30	0.38	0.28
8		0.24	0.33	0.32	0.24
9		0.26	0.36	0.35	0.26
18		0.30	0.34	0.38	0.30
19		0.24	0.31	0.32	0.24
20		0.25	0.35	0.33	0.25
27		0.14	0.17	0.20	0.14
28		0.14	0.17	0.19	0.14
29		0.13	0.17	0.19	0.13
30		0.14	0.19	0.20	0.14
31		0.16	0.19	0.19	0.16
37		0.14	0.17	0.20	0.14
38		0.13	0.15	0.18	0.13
39		0.14	0.18	0.20	0.14
40		0.15	0.19	0.19	0.15

128		0.41	0.45	0.50	0.41
131		0.52	0.55	0.63	0.52
134		0.24	0.26	0.31	0.24
135		0.26	0.33	0.38	0.26
136		0.22	0.23	0.28	0.22
137		0.20	0.23	0.27	0.20
146		0.22	0.25	0.28	0.22
147		0.23	0.23	0.28	0.23
148		0.21	0.23	0.27	0.21
155		0.13	0.15	0.17	0.13
156		0.12	0.14	0.16	0.12
157		0.13	0.14	0.17	0.13
158		0.12	0.14	0.16	0.12
159		0.13	0.15	0.15	0.13
165		0.13	0.15	0.17	0.13
166		0.13	0.14	0.16	0.13
167		0.12	0.14	0.17	0.12
168		0.13	0.15	0.16	0.13
0	128	0.21	0.25	0.26	0.21
3	131	0.25	0.28	0.32	0.25
6	134	0.12	0.14	0.15	0.12
7	135	0.13	0.14	0.17	0.13
8	136	0.11	0.12	0.13	0.11
9	137	0.11	0.13	0.14	0.11
18	146	0.13	0.14	0.16	0.13
19	147	0.11	0.12	0.13	0.11
20	148	0.10	0.13	0.14	0.10
27	155	0.07	0.07	0.08	0.07
28	156	0.06	0.07	0.08	0.06
29	157	0.06	0.07	0.08	0.06
30	158	0.06	0.07	0.07	0.06
31	159	0.07	0.07	0.08	0.07
37	165	0.06	0.08	0.08	0.06
38	166	0.06	0.07	0.08	0.06
39	167	0.06	0.07	0.08	0.06
40	168	0.06	0.07	0.07	0.06

i) *Scaling factor for back array 2 n260*

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
1		1.76	2.50	2.92	1.76
4		0.71	0.78	1.65	0.71
10		0.54	0.59	1.56	0.54
11		0.52	0.57	0.98	0.52
12		0.51	0.60	0.79	0.51
13		0.51	0.68	1.12	0.51
21		0.53	0.57	1.31	0.53
22		0.51	0.58	0.85	0.51
23		0.51	0.68	0.98	0.51

129		0.75	0.87	1.01	0.75
132		1.21	0.98	1.20	0.98
138		0.42	0.57	0.85	0.42
139		0.52	0.44	0.46	0.44
140		0.55	0.42	0.42	0.42
141		0.50	0.48	0.60	0.48
149		0.44	0.53	0.67	0.44
150		0.50	0.46	0.48	0.46
151		0.52	0.45	0.52	0.45
1	129	0.47	0.53	0.60	0.47
4	132	0.37	0.38	0.59	0.37
10	138	0.22	0.25	0.44	0.22
11	139	0.19	0.21	0.27	0.19
12	140	0.19	0.20	0.23	0.19
13	141	0.25	0.26	0.33	0.25
21	149	0.20	0.23	0.36	0.20
22	150	0.19	0.20	0.25	0.19
23	151	0.24	0.24	0.29	0.24

Appendix C: MPE (PD) Simulation Using New Guideline from Qualcomm

This document provides the changes from what we have submitted from last year, following the new guidelines from Qualcomm, that 2nd generation of Smart Transmit (Smart-Tx GEN2) is used in this year's iPhone program.

The 1st generation of Smart Transmit (GEN1) assumes all transmit antennas are co-located and RF exposure is 100% overlapped, while the 2nd generation of Smart Transmit (GEN2) operates based on pre-defined antenna groups. In this revision, the antenna grouping is based on mmW module placement.

As an example of a wireless device having three mmW antenna (i.e., back-firing antenna 1 (BF1), back-firing antenna 2 (BF2) and side-firing (SF) antenna), Figure C.1 illustrates GEN1 and GEN2 operation.

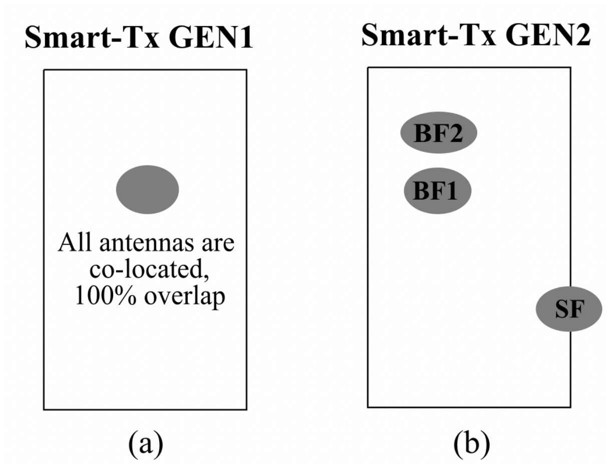


Figure C.1. Smart transmit generate illustration, (a) GEN1, and (b) GEN2

The requirement and guidelines stated for GEN1 in all previous sections apply to GEN2. The additional requirement to characterize PD for GEN2 is described in this inclusion.

- All mmW modules need to be included in each simulation model
- 2D PD plots for different surfaces are not needed for Smart-Tx GEN2

C.1 Changes in Modeling Approach Using Smart-Tx GEN2

Simulation model needs to be large enough to include all the antenna modules located inside the EUT, so that the mutual coupling can be properly calculated. Unlike GEN1, simulation of a part of the EUT (right part of Figure C.2) will not work. Instead, the entire EUT must be simulated as illustrated in the left side example in Figure C.2 for GEN2.

Additionally, the simulation domain needs to be sufficiently large for "Qualcomm MG Script" to extract valid E- and H-fields from all adjacent exposure surfaces of the EUT extended by at least 35 mm in all directions. To accomplish this, if HFSS is used, recommended setting for the "radiation boundary" is at least 40 mm away from EUT to well contain all adjacent exposure surfaces (S1~S6 in Figure 2).

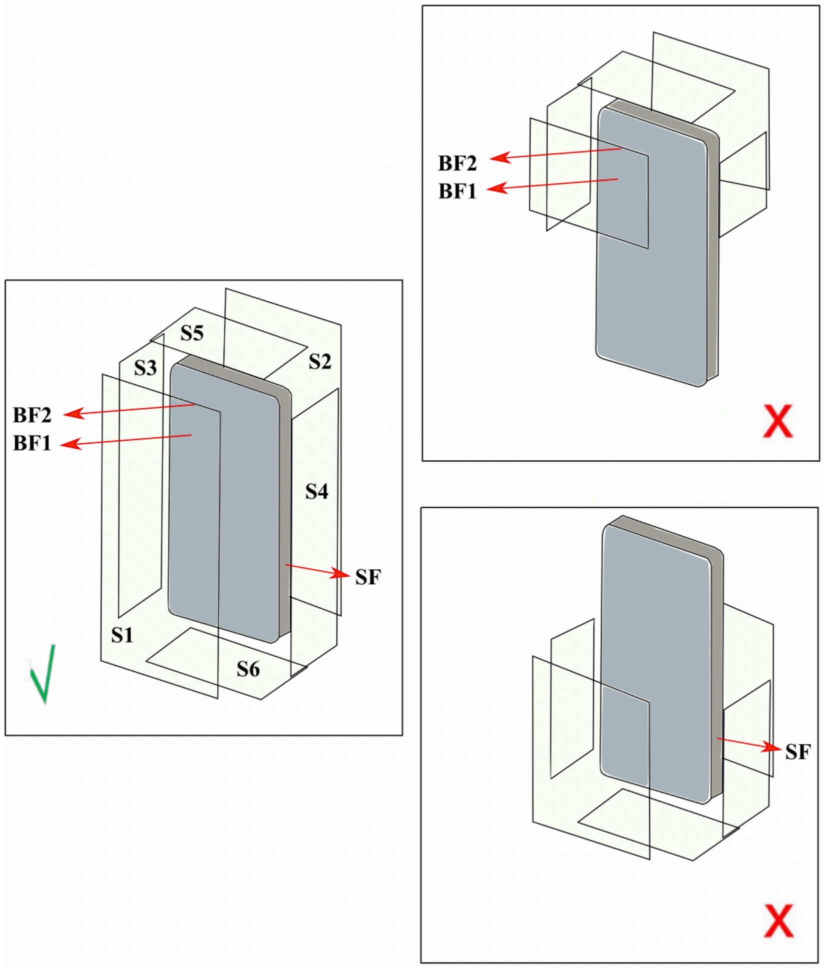


Figure C.2. Simulation model examples.

C.2 GEN2 PD Generation Using Qualcomm MG Script

Use "Qualcomm MG script" to extract E- and H-fields from the validated simulation and to assess the mutual coupling between all the mmW modules and all the beams in the codebook to determine the backoff value for each mmW module. Note the assessment and backoff value derivation are automated with "Qualcomm MG script". Once the script is done with assessment, it will provide the $sim.power_{limit}$ (backoff is already included) for all the beams for all three channels for the specified *PD_design_target*.

C.3 Additional Verifications for GEN2

The PD for GEN2 cannot be finalized until the additional verifications described in this section are performed and passed. The below steps are followed for verifications in the mid channel.

VERIFICATION 1: Use "Qualcomm MG script" to print the PD plots for all the beams selected and evaluated for model validation. Compare the printed PD plot to the corresponding simulated/measured PD, the printed PD distributions should match the simulated PD distributions as shown in Table C.1 and C.4 to verify that "Qualcomm MG script" is properly used.

VERIFICATION 2: "Qualcomm MG script" identifies the worst-case 4cm^2 PD and its location (*x,y,z*). This worst-case 4cm^2 PD is maximum 4cm^2 PD value out of all exposure surfaces when assuming the worst beam from each of the antenna modules are active. The script will then identify the worst beam from each module that contributes the most to the worst 4cm^2 PD and print their contribution factor, as well as the worst surface corresponding to the worst-case 4cm^2 PD, backoff value for each antenna module and *verification.sim.powerlimit* (before backoff) value for each identified beams.

Use HFSS (or other EM simulation tool) to calculate the simulated contribution factor for the identified beams. The simulated contribution factor, $c_{simulated}(i,j)$, for beam i from QTM j can be computed by

$$csimulated\ (i, j) = 4cm^2\ PD\ at\ (x, y, z)\ at\ verification.\ sim.\ power\ limit\ /\ PD\_design\_target$$

Verify:

1. the printed contribution factor, $c(i,j)$, matches the simulated contribution factor, $c_{simulated}(i,j)$, obtained from HFSS (or other EM simulation tool) within 2% of numerical tolerance.
2. the normalized *combined PD* does not exceed 1.0, i.e., *normalized combined PD* = $\sum(b_j * c(i,j)) \leq 1.0$

where *combined PD* = PD from current antenna module + PD contributions from other antenna modules; b_j = backoff value for antenna module j, j = antenna module #; $c(i,j)$ = contribution factor of beam i from antenna module j to the worst 4cm^2 PD. Both bj and $c(i,j)$ are printed from "Qualcomm MG script".

VERIFICATION 3: Measure power density for the beams identified by "Qualcomm MG script" on their corresponding worst surfaces printed from the script. Set the device in FTM mode, the PD measurement should be performed at the reference power level with CW modulation. Scale the measured PD to obtain 4cm^2 PD(i,j) for beam i from antenna module j at their *input.power.limit*. Demonstrate that the *combined PD* (i.e., $\sum[c(i,j)*PD(i,j)]$) is less than or equal to *PD_design_target* within the uncertainty at reference power level, i.e., *combined PD* = $\sum[c(i,j)*measured\ 4cm^2\ PD(i,j)] \leq PD\_design\_target$ + uncertainty **at reference power level.**

As an example of one of the iPhone programs, which contains 2 antenna modules (i.e., Module0 (back-firing array 1 and back-firing array 2) and Module1 (side-firing array)), the following verifications are for n258, n261 and n260, respectively.

1) Band n258

"Qualcomm MG script" identifies beam *137* and *143* from Module0 and Module1, respectively. The script prints below information corresponding to the identified worst-case 4cm^2 PD:

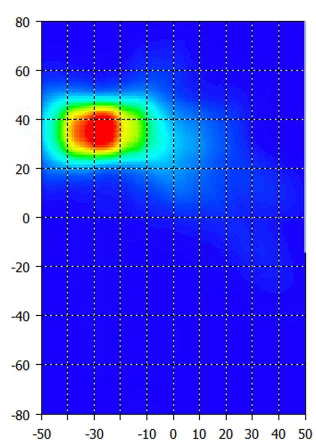
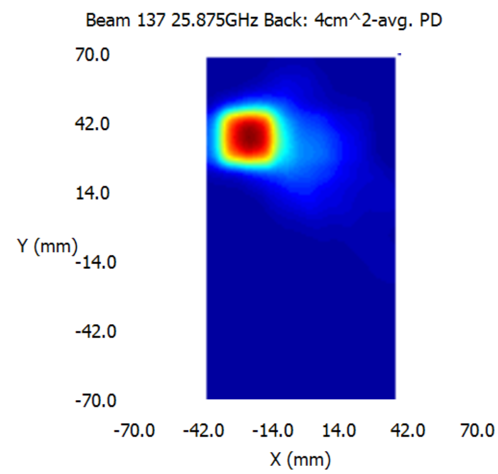
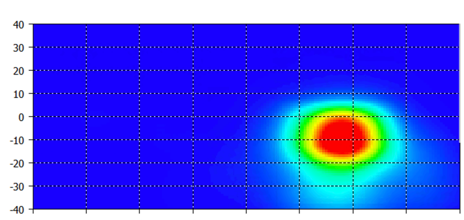
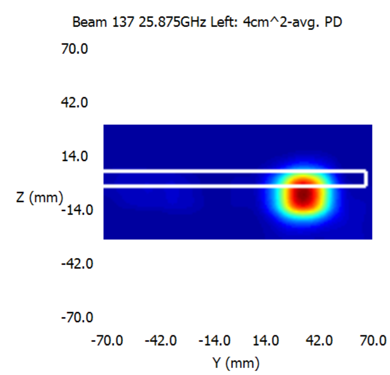
- the backoff values (in linear) for Module0 and Module1: b_0 = 0.9772; b_1 = 0.9772

- the worst location coordinates (*x, y, z*) in meter = (0.04104, -0.02700, 0.00000)
- the worst-surface = S4 (right surface, see Figure C.2)
- the $verification.sim.power_{limit}$ (before backoff) for the beams *137* and *143* is 3.58 dBm and 4.74 dBm, respectively.
- worst surface for Module0 is S2 (back); worst surface for Module1 is S4 (right)
- the contribution factors $c(137, 0) = 0.0215$ and $c(143, 1) = 1.0000$ at the worst-case 4cm^2 PD location (0.04104, -0.02700, 0.00000)

As shown in Table C.2, the printed contribution factor matches the simulated contribution factor within 2%, and the *normalized combined PD* is less than 1.0. Thus, the verification 2 is completed for this program.

As shown in Table C.3, the *combined* measured *PD* at the worst location ≤ *PD_design_target* uncertainty at reference power level. Thus, the verification 3 is competed for this program.

Table C.1 - Simulated PD distributions for selected beams.

Beam ID	Surface	Simulated PD	Printed out from Qualcomm MG Script
137	S2		
	S3		

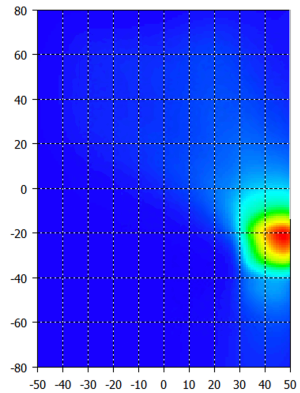
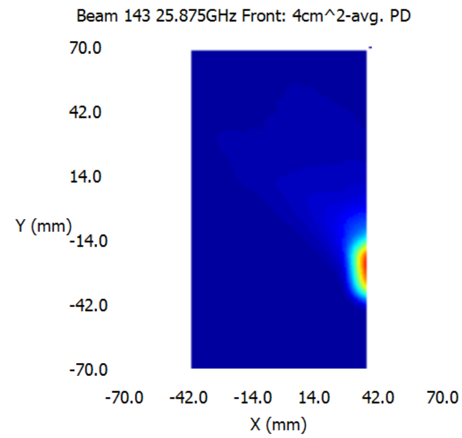
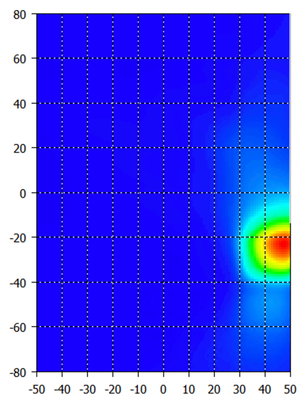
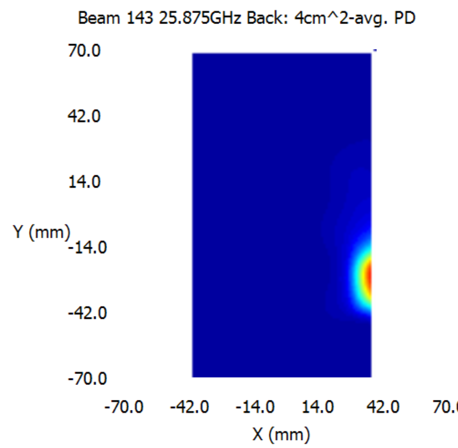
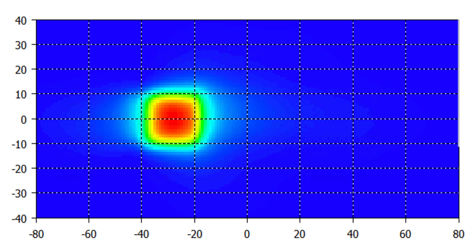
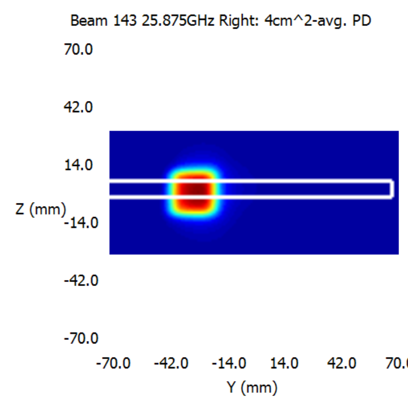
143	S1		
	S2		
	S4		

Table C.2 - Contribution factors from Qualcomm MG script and from HFSS for selected beams, and normalized *combined PD* verification, for device with 2 antenna modules.

Worse-case surface					S4 (right surface)	
Worst-case location *(x,y,z)* in meters					(0.04104, -0.02700, 0.00000)	
PD_design_target (mW/cm^2)					0.6	
Value printed by MG Script					Value by EM tool	
Module #	Beam ID	*c(i ,j)*, *i*=beam ID, *j*=module #	Backoff factor b_j	$verification.sim.power_{limit}$ (before backoffs) [dBm]	Simulated 4cm^2 PD at (0.04104, -0.02700, 0.00000) with $verification.sim.power_{limit}$ on S4 (mW/cm^2)	$c_{simulated}(i,j)$
0	137	0.0215	0.9772	3.58	0.0130	0.0130/0.6 = 0.0216
1	143	1.0000	0.9772	4.74	0.5899	0.5899/0.6 = 0.9832
Verify 1	$uujc(i,j)=c_{simulated}(i,j)$, i = 137, 143; j = 0, 1					
Verify 2	b_0 x *c(137,0)* + b_1 x *c(143,1)* = 0.9772 x 0.0215 + 0.9772 x 1.0000 = 0.9982 ≤ 1					

Table C.3: Measured 4cm^2 PD on worst surface and *combined PD* at worst-case location for device with 2 antenna modules.

Module#	Beam ID	Dominant Surface	Measured 4cm^2 PD at input.power.limit on dominant surface (mW/cm^2)
0	137	S2 (Back)	0.6032
1	143	S4 (Right)	0.5834
combined PD at the worst-case location (*x,y,z*)			*c(137,0)*xmeas.4cm^{2}PD*(137,0)* + *c(143,1)*xmeas.4cm^{2}PD*(143,1)* = 0.0215 x 0.6032 + 1.0000 x 0.5834 = 0.5964 mW/cm^2
PD_design_target + uncertainty at reference power level of 0.75 dB			= 0.6*10$^{(+0.75/10)}$ = 0.71 mW/cm^2

Verify	combined PD < PD_design_target + uncertainty at reference power level

Note *c(i,j)* is obtained from Table C.2.

2) Band n261

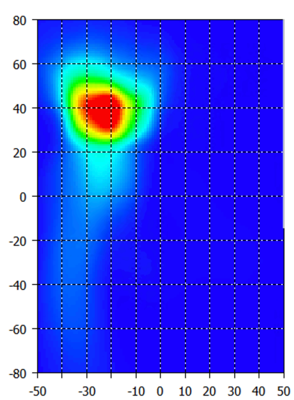
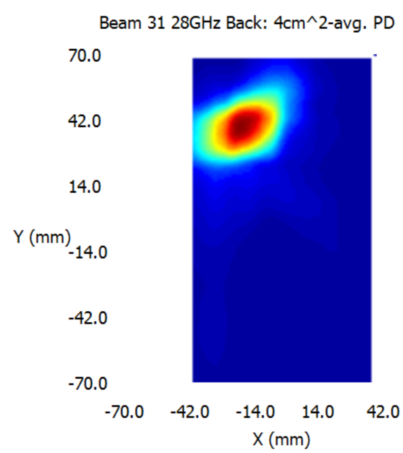
"Qualcomm MG script" identifies beam *31* and *161* from Module0 and Module1, respectively. The script prints below information corresponding to the identified worst-case $4cm^2$ PD:

- the backoff values (in linear) for Module0 and Module1: $b_0 = 0.9772$; $b_1 = 0.9772$
- the worst location coordinates (*x, y, z*) in meter = (0.04104, -0.03500, 0.00000)
- the worst-surface = S4 (right surface, see Figure C.2)
- the $verification.sim.power_{limit}$ (before backoff) for the beams *31* and *161* is 2.93 dBm and 0.23 dBm, respectively.
- worst surface for Module0 is S2 (back); worst surface for Module1 is S4 (right)
- the contribution factors *c*(*31, 0*) = 0.0100 and *c*(*161, 1*) = 1.0000 at the worst-case $4cm^2$ PD location (0.04104, -0.03500, 0.00000)

As shown in Table C.5, the printed contribution factor matches the simulated contribution factor within 2%, and the *normalized combined PD* is less than 1.0. Thus, the verification 2 is completed for this program.

As shown in Table C.6, the *combined* measured *PD* at the worst location ≤ *PD_design_target* uncertainty at reference power level. Thus, the verification 3 is competed for this program.

Table C.4 - Simulated PD distributions for selected beams.

Beam ID	Surface	Simulated PD	Printed out from Qualcomm MG Script
31	S2		

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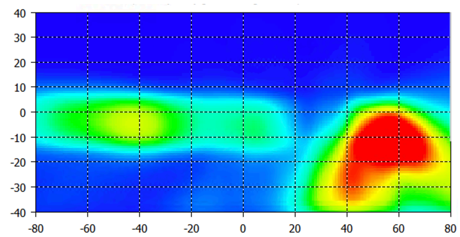
<td>
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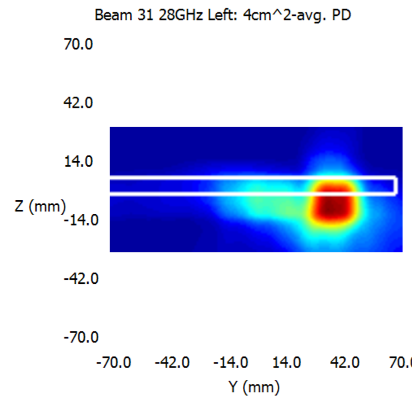
<td>
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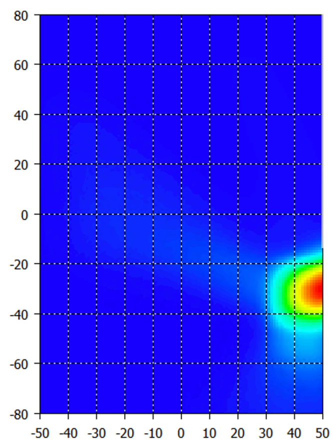
<td>
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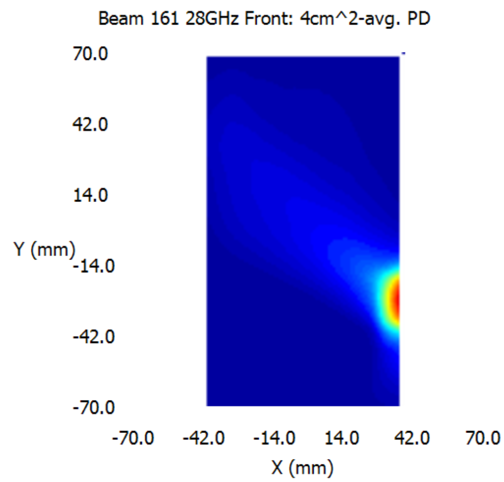
<td>
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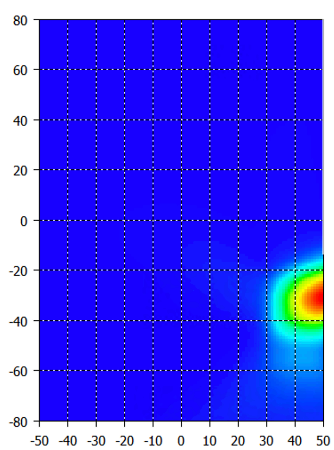
<td>
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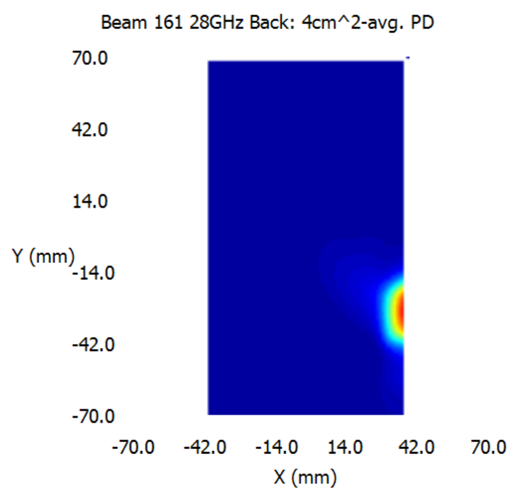
<td>
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</tr>
</table>

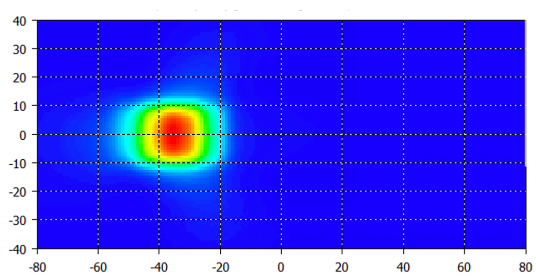
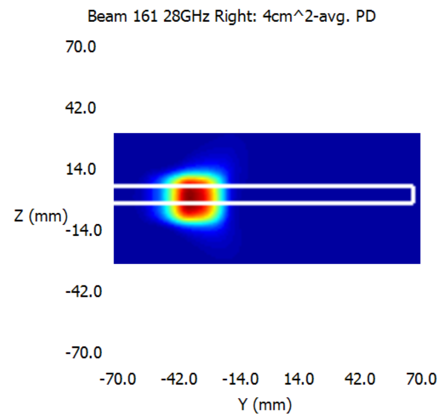
	S4		

Table C.5 - Contribution factors from Qualcomm MG script and from HFSS for selected beams, and normalized *combined PD* verification, for device with 2 antenna modules.

<table>
<tr><td colspan="5">Worse-case surface</td><td colspan="2">S4 (right surface)</td></tr>
<tr><td colspan="5">Worst-case location (x,y,z) in meters</td><td colspan="2">(0.04104, -0.03500, 0.00000)</td></tr>
<tr><td colspan="5">PD_design_target (mW/cm^2)</td><td colspan="2">0.6</td></tr>
<tr><td colspan="5">Value printed by MG Script</td><td colspan="2">Value by EM tool</td></tr>
<tr><td>Module #</td><td>Beam ID</td><td>c(i ,j), i=beam ID, j=module #</td><td>Backoff factor b_j</td><td>$verification.sim.power_{limit}$ (before backoffs) [dBm]</td><td>Simulated $4cm^2$ PD at (0.04104, -0.03500, 0.00000) with $verification.sim.power_{limit}$ on S4 (mW/cm^2)</td><td>$c_{simulated}(i ,j)$</td></tr>
<tr><td>0</td><td>31</td><td>0.0100</td><td>0.9772</td><td>2.93</td><td>0.0059</td><td>0.0059/0.6 = 0.0098</td></tr>
<tr><td>1</td><td>161</td><td>1.0000</td><td>0.9772</td><td>0.23</td><td>0.5926</td><td>0.5926/0.6 = 0.9876</td></tr>
<tr><td>Verify 1</td><td colspan="6">$ujc(i ,j)=c_{simulated}(i ,j)$, i = 31, 161; j = 0, 1</td></tr>
<tr><td>Verify 2</td><td colspan="6">b_0 x $c(31,0)$ + b_1 x $c(161,1)$ = 0.9772 x 0.0100+ 0.9772 x 1.0000 = 0.9870 ≤ 1</td></tr>
</table>

Table C.6: Measured 4cm^2 PD on worst surface and *combined PD* at worst-case location for device with 2 antenna modules.

Module#	Beam ID	Dominant Surface	Measured 4cm^2 PD at input.power.limit on dominant surface (mW/cm^2)
0	31	S2 (Back)	0.6175
1	161	S4 (Right)	0.6203
combined PD at the worst-case location (*x,y,z*)			*c(31,0)*xmeas.4cm^{2}PD*(31,0)* + *c(161,1)*xmeas.4cm^{2}PD*(161,1)* = 0.0100 x 0.6175 + 1.0000 x 0.6203 = 0.6265 mW/cm^2
PD_design_target + uncertainty at reference power level of 0.75 dB			= 0.6*10$^{(+0.75/10)}$ = 0.71 mW/cm^2
Verify			combined PD < PD_design_target + uncertainty at reference power level

Note *c(i,j)* is obtained from Table C.5.

3) Band n260

"Qualcomm MG script" identifies beam *40* and *162* from Module0 and Module1, respectively. The script prints below information corresponding to the identified worst-case 4cm^2 PD:

- the backoff values (in linear) for Module0 and Module1: b_0 = 0.9772; b_1 = 0.9772
- the worst location coordinates (*x, y, z*) in meter = (0.04104, -0.03600, 0.00000)
- the worst-surface = S4 (right surface, see Figure C.2)
- the $verification.sim.power_{limit}$ (before backoff) for the beams *40* and *162* is 3.85 dBm and 2.15 dBm, respectively.
- worst surface for Module0 is S2 (back); worst surface for Module1 is S4 (right)
- the contribution factors *c*(*40, 0*) = 0.0119 and *c*(*162, 1*) = 1.0000 at the worst-case 4cm^2 PD location (0.04104, -0.03600, 0.00000)

As shown in Table C.8, the printed contribution factor matches the simulated contribution factor within 2%, and the *normalized combined PD* is less than 1.0. Thus, the verification 2 is completed for this program.

As shown in Table C.9, the *combined* measured *PD* at the worst location ≤ *PD_design_target* uncertainty at reference power level. Thus, the verification 3 is competed for this program.

Table C.7 - Simulated PD distributions for selected beams.