

## 8.0 FCC RF Exposure Limitations

# Compliance with the RF Exposure Limitations for the VHDD-550S

Peak Power = 550kW

Pulse Width = 2.0  $\mu$ S

Pulse Repetition Frequency = 500 Hz

Average Power (P) = 550W

Wavelength ( $\lambda$ ) = 10.71 cm (S-Band Wavelength)

Reflector Diameter (D) = 8 m

Reflector Surface Area (A) = 50.26 m square

Reflector Isotropic Gain = 45 dBi

Given that the above parameters are fixed, the power density is a function of range and location with regard to the axis of the main beam. The power density is greatest along the main beam axis, so all calculations will be made for this condition.

Three different methods are used to estimate power density, depending on whether the point of interest is in the near-field region, the transition region, or the far-field region of the antenna. For  $\lambda = 10.71$  cm, the near field region extends to 149.39 m (490.12 ft), the transition region extends to 298.78 m (980.25 ft) and the far-field region extends from this point.

$$R_{nf} = D^2 / 4\lambda \quad \text{or} \quad 149.39 \text{ meters}$$

$$R_{ff} = 2D^2 / 4\lambda \quad \text{or} \quad 298.78 \text{ meters}$$

Within the near-field region the power density can reach a maximum of 131480.82  $\text{mw}/\text{cm}^2$  at the front of the antenna.

The power density decreases inversely with the distance from the antenna within the transition region. At the start of the transition region the power density is 5.617  $\text{mw}/\text{cm}^2$ . Near the end, (298.78 m) the power density is 1.491  $\text{mw}/\text{cm}^2$ .

Beyond 298.78 m (838.58 ft), the power density can be calculated as follows.

$$S = PG / (4\pi R^2)$$

Where S is power density, P is power, G is antenna gain and R is distance from the antenna.

Utilizing this equation, we can solve for the distance at which the power density is below the FCC controlled exposure limit of  $5 \text{ mw/cm}^2$ . This distance is 162 m (531.5 ft). We can also solve for the distance at which the power density is below the FCC uncontrolled exposure limit of  $1 \text{ mw/cm}^2$ . This distance is 364 m (1194 ft)

If the point of interest is beyond 1194 ft, then the power density is such that it is below the uncontrolled exposure limit. **This is even if the point of interest remains on-axis at all times because the antenna is not rotating.**

If the point of interest is at least one antenna diameter (8m) off-axis within the near field or transition region, the power density is at least a factor of 100 less than the values calculated above. The tower height should be such that the main beam is 10m above ground level at 200m distance when the main beam is pointing 1 degree below the horizon. Therefore, the tower should be at a minimum:

$$10\text{m} + 3.5\text{m} + 8\text{m} = 21.5\text{m} \text{ (70.54 ft)}$$

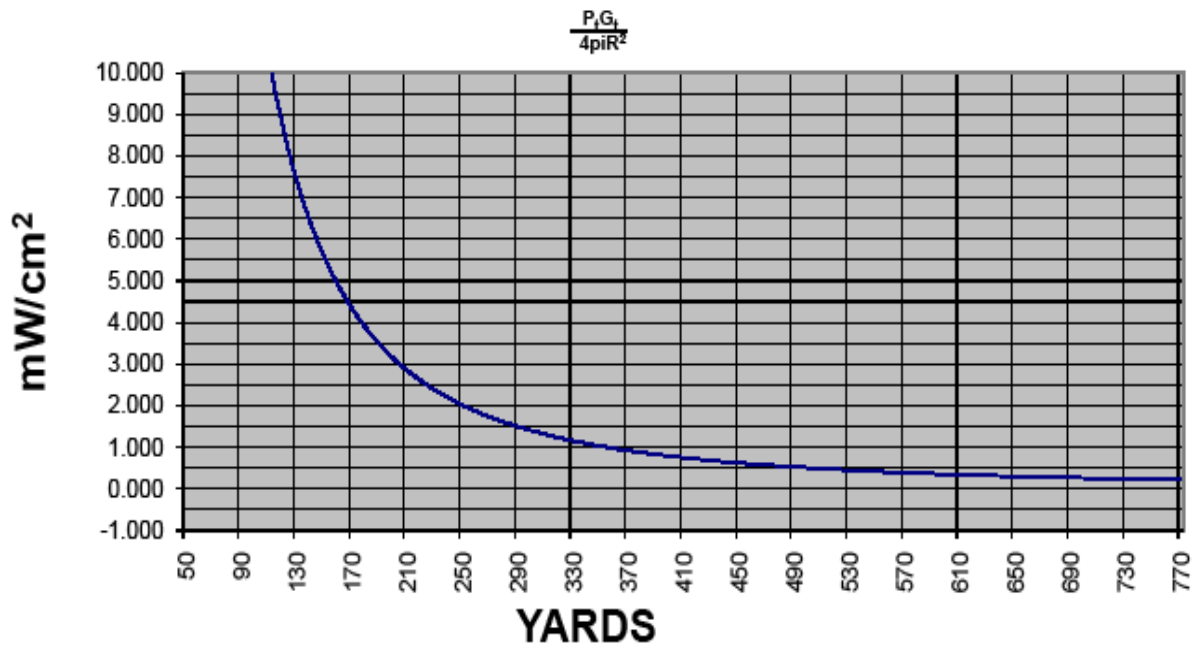
At this height, all points along the ground (near-field included) will have a power density below the FCC controlled limit of  $5 \text{ mw/cm}^2$ .

One item not considered is that exposure limits may be averaged (6 minutes for controlled access and 30 for uncontrolled access.) The fact that the antenna is rotating and a fix point of interest is on-axis for only a brief period of time (factor of .0027), greatly reduces the average power density. Thus, **all** points of interest not on the antenna surface are below both exposure limits while the antenna is rotating.

In conclusion, a radar system with the above characteristics can be within compliance with FCC exposure limit guidelines by mounting the antenna 70ft or higher above any occurred areas within 531ft of the antenna.

Tx Average Power (dBm)	57.4	dBm	Antenna Gain	45	dBi	RADAR #	VHDD-550S
Transmission Loss (dB)	1.2	dB	Start Range	50	yards	EIRP	13.18 Gigawatts Pulse
Power @ Antenna	56.2	dBm	Plot Every	4	Yards	ERP	13.18 Mwatts Ave
OET 65, Supplement B (Edition 97-01)			Controlled Access - 8 minute average exposure			Rad Hazard	Minimum Distance
Pulsed Radar Calculations			Uncontrolled Access - 30 minute average exposure			5mW/cm <sup>2</sup>	475.4 feet
						1mW/cm <sup>2</sup>	1063.0 feet

## On-Axis RF Power Density



meters	yards	ft	cm	mW/cm <sup>2</sup>
0.9146	1	3	91	131480.826
4.9146	5	15	457	5259.233
8.9146	9	27	823	1623.220
12.9146	13	39	1189	777.993
16.9146	17	51	1554	454.951
20.9146	21	63	1920	298.142
24.9146	25	75	2286	210.369
28.9146	29	87	2652	156.339
32.9146	33	99	3018	120.735
36.9146	37	111	3383	96.042
40.9146	41	123	3749	78.216
44.9146	45	135	4115	64.929
48.9146	49	147	4481	54.761
52.9146	53	159	4846	46.807
56.9146	57	171	5212	40.468
60.9146	61	183	5578	35.335
64.9146	65	195	5944	31.120
68.9146	69	207	6309	27.616
72.9146	73	219	6675	24.673
76.9146	77	231	7041	22.176
80.9146	81	243	7407	20.040
84.9146	85	255	7772	18.198
88.9146	89	267	8138	16.599
92.9146	93	279	8504	15.202
96.9146	97	291	8870	13.974
100.9146	101	303	9235	12.889
104.9146	105	315	9601	11.926
108.9146	109	327	9967	11.066
112.9146	113	339	10333	10.297
116.9146	117	351	10698	9.605
120.9146	121	363	11064	8.980
124.9146	125	375	11430	8.415
128.9146	129	387	11796	7.901
132.9146	133	399	12162	7.433
136.9146	137	411	12527	7.005
140.9146	141	423	12893	6.613
144.9146	145	435	13259	6.254
148.9146	149	447	13625	5.922
152.9146	153	459	13990	5.617
156.9146	157	471	14356	5.334
160.9146	161	483	14722	5.072
164.9146	165	495	15088	4.829
168.9146	169	507	15453	4.604
172.9146	173	519	15819	4.393
176.9146	177	531	16185	4.197
180.9146	181	543	16551	4.013

meters	yards	ft	cm	mW/cm <sup>2</sup>
184.9146	185	555	16916	3.842
188.9146	189	567	17282	3.681
196.9146	197	591	18014	3.388
200.9146	201	603	18379	3.254
204.9146	205	615	18745	3.129
208.9146	209	627	19111	3.010
212.9146	213	639	19477	2.898
216.9146	217	651	19842	2.792
220.9146	221	663	20208	2.692
224.9146	225	675	20574	2.597
228.9146	229	687	20940	2.507
232.9146	233	699	21306	2.422
236.9146	237	711	21671	2.341
240.9146	241	723	22037	2.264
244.9146	245	735	22403	2.190
248.9146	249	747	22769	2.121
252.9146	253	759	23134	2.054
256.9146	257	771	23500	1.991
260.9146	261	783	23866	1.930
264.9146	265	795	24232	1.872
268.9146	269	807	24597	1.817
272.9146	273	819	24963	1.764
276.9146	277	831	25329	1.714
280.9146	281	843	25695	1.665
284.9146	285	855	26060	1.619
288.9146	289	867	26426	1.574
292.9146	293	879	26792	1.532
296.9146	297	891	27158	1.491
300.9146	301	903	27523	1.451
304.9146	305	915	27889	1.413
308.9146	309	927	28255	1.377
312.9146	313	939	28621	1.342
316.9146	317	951	28986	1.308
320.9146	321	963	29352	1.276
324.9146	325	975	29718	1.245
328.9146	329	987	30084	1.215
332.9146	333	999	30450	1.186
336.9146	337	1011	30815	1.158
340.9146	341	1023	31181	1.131
344.9146	345	1035	31547	1.105
348.9146	349	1047	31913	1.079
352.9146	353	1059	32278	1.055
356.9146	357	1071	32644	1.032
360.9146	361	1083	33010	1.009
364.9146	365	1095	33376	0.987
368.9146	369	1107	33741	0.966

meters	yards	ft	cm	mW/cm <sup>2</sup>
372.9146	373	1119	34107	0.945
376.9146	377	1131	34473	0.925
380.9146	381	1143	34839	0.906
384.9146	385	1155	35204	0.887
392.9146	393	1179	35936	0.851
396.9146	397	1191	36302	0.834
400.9146	401	1203	36667	0.818
404.9146	405	1215	37033	0.802
408.9146	409	1227	37399	0.786
412.9146	413	1239	37765	0.771
416.9146	417	1251	38130	0.756
420.9146	421	1263	38496	0.742
424.9146	425	1275	38862	0.728
428.9146	429	1287	39228	0.714
432.9146	433	1299	39594	0.701
436.9146	437	1311	39959	0.688
440.9146	441	1323	40325	0.676
444.9146	445	1335	40691	0.664
448.9146	449	1347	41057	0.652
452.9146	453	1359	41422	0.641
456.9146	457	1371	41788	0.630
460.9146	461	1383	42154	0.619
464.9146	465	1395	42520	0.608
468.9146	469	1407	42885	0.598
472.9146	473	1419	43251	0.588
476.9146	477	1431	43617	0.578
480.9146	481	1443	43983	0.568
484.9146	485	1455	44348	0.559
488.9146	489	1467	44714	0.550
492.9146	493	1479	45080	0.541
496.9146	497	1491	45446	0.532
500.9146	501	1503	45811	0.524
504.9146	505	1515	46177	0.516
508.9146	509	1527	46543	0.507
512.9146	513	1539	46909	0.500
516.9146	517	1551	47274	0.492
520.9146	521	1563	47640	0.484
524.9146	525	1575	48006	0.477
528.9146	529	1587	48372	0.470
532.9146	533	1599	48738	0.463
536.9146	537	1611	49103	0.456
540.9146	541	1623	49469	0.449
544.9146	545	1635	49835	0.443
548.9146	549	1647	50201	0.436
552.9146	553	1659	50566	0.430
556.9146	557	1671	50932	0.424

meters	yards	ft	cm	mW/cm <sup>2</sup>
560.9146	561	1683	51298	0.418
564.9146	565	1695	51664	0.412
568.9146	569	1707	52029	0.406
572.9146	573	1719	52395	0.400
576.9146	577	1731	52761	0.395
580.9146	581	1743	53127	0.390
588.9146	589	1767	53858	0.379
592.9146	593	1779	54224	0.374
596.9146	597	1791	54590	0.369
600.9146	601	1803	54955	0.364
604.9146	605	1815	55321	0.359
608.9146	609	1827	55687	0.355
612.9146	613	1839	56053	0.350
616.9146	617	1851	56418	0.345
620.9146	621	1863	56784	0.341
624.9146	625	1875	57150	0.337
628.9146	629	1887	57516	0.332
632.9146	633	1899	57882	0.328
636.9146	637	1911	58247	0.324
640.9146	641	1923	58613	0.320
644.9146	645	1935	58979	0.316
648.9146	649	1947	59345	0.312
652.9146	653	1959	59710	0.308
656.9146	657	1971	60076	0.305
660.9146	661	1983	60442	0.301
664.9146	665	1995	60808	0.297
668.9146	669	2007	61173	0.294
672.9146	673	2019	61539	0.290
676.9146	677	2031	61905	0.287
680.9146	681	2043	62271	0.284
684.9146	685	2055	62636	0.280
688.9146	689	2067	63002	0.277
692.9146	693	2079	63368	0.274
696.9146	697	2091	63734	0.271
700.9146	701	2103	64099	0.268
704.9146	705	2115	64465	0.265
708.9146	709	2127	64831	0.262
712.9146	713	2139	65197	0.259
716.9146	717	2151	65562	0.256
720.9146	721	2163	65928	0.253