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Tables of Square-Law Signal Detection Statistics for Hann Spectra with 50% Overlap

Stanley R. Deans and D. Kent Cullers

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Stanley R. Deans, University of South Florida, Tampa, Florida
D. Kent Cullers, Ames Research Center, Moffett Field, California

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Ames Research Center
Moffett Field, California 94035-1000

SUMMARY

The Search for Extraterrestrial Intelligence, currently being planned by NASA, will require that an enormous amount of data be analyzed in real time by special–purpose hardware, and it is expected that overlapped Hann data windows will play an important role in this analysis. In order to understand the statistical implications of this approach, it has been necessary to compute detection statistics for overlapped Hann spectra. Tables of signal detection statistics are given for false alarm rates from 10^{-14} to 10^{-1} and signal detection probabilities from 0.50 to 0.99; the number of computed spectra ranges from 4 to 2000.

INTRODUCTION

The Search for Extraterrestrial Intelligence (SETI), currently being planned by NASA, will require that an enormous amount of data be analyzed in real time by special-purpose hardware, and it is expected that overlapped Hann (sometimes called Hanning) data windows will play an important role in this analysis. (A discussion of signal processing in SETI, and arguments for using overlapped Hann spectra, are given in refs. 1 and 2, and a good technical discussion of overlapped Hann spectra is given by Harris in ref. 3.) In order to understand the statistical implications of this approach, it has been necessary to compute detection statistics for overlapped Hann spectra. The main purpose of this report is to present tables of signal detection statistics for overlapped Hann spectra and demonstrate how to use them. Tables are given for false alarm rates from 10^{-14} to 10^{-1} and signal detection probabilities from 0.50 to 0.99; the number of computed spectra ranges from 4 to 2000 (tables 1–14).

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METHOD OF COMPUTATION

The statistical parameters are found by integrating the characteristic function ϕ to find the cumulative distribution function F. Given the characteristic function, there are several ways to find the cumulative distribution function and the probability density function f (ref. 4, chap. 29). Three different methods have been used, as a cross-check to guard against programming mistakes. One of the more useful approaches is to compute the cumulative distribution directly from the characteristic function:

$$F(x) = \frac{1}{2} - \frac{1}{\pi}\int_0^{\infty} Im\{e^{-i\omega x}\,\phi(\omega)\}\frac{d\omega}{\omega}$$

All of the needed statistical parameters can be found by using this equation, although this is a tricky integral for two reasons: the integral is an oscillatory integral, and the upper limit is infinity. These problems can be overcome by using Q–precision Gauss–Legendre quadrature and determining an "effective infinity" related to the number of computed spectra. The appropriate characteristic function, which is quite complicated, is discussed in some detail by Deans, Cullers, and Stauduhar (ref. 2).

USE OF THE TABLES

Use of the tables is straightforward. The quantity m represents the number of computed spectra. This is related to the number n of independent spectra by $m = 2n - 1$ when there is a 50% overlap and end effects are included. (Here it is assumed that the probability density function for the n sample average of the output of a square-law detector is a noncentral chi-square distribution with $2n$ degrees of freedom.) If τ represents the threshold, then the false alarm probability is given by

$$P_{fa} = \int_{\tau}^{\infty} f(x)\, dx$$

where $f(x)$ is the central overlapped Hann probability density function with $2m$ degrees of freedom, normalized so the mean noise power is unity. In the tables this threshold is expressed in decibels (dB),

$$T(\mathrm{dB}) = 10 \log_{10} \tau$$

Given the threshold, the detection probability can be computed in terms of the signal–to–noise ratio r. This ratio is often expressed in decibels,

$$\mathrm{SNR(dB)} = 10 \log_{10} r$$

The detection probability is found by integrating the noncentral probability density function for overlapped Hann spectra,

$$P_d = \int_{\tau}^{\infty} g(x, r)\, dx$$

EXAMPLE. Suppose $P_{fa} = 10^{-12}$ and $m = 500$. The signal–to–noise ratio that yields a detection probability of 0.50 is -4.4235 dB.

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Table 1. Overlap Hann, $P_{fa} = 10^{-1}$

Spectra	Threshold	Signal–to–Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	2.2584	−0.8806	1.1946	3.4293	5.7244
5	2.0699	−1.4406	0.6005	2.7973	5.0544
6	1.9242	−1.8966	0.1166	2.2825	4.5083
8	1.7096	−2.6117	−0.6419	1.4754	3.6516
10	1.5561	−3.1619	−1.2250	0.8552	2.9932
13	1.3900	−3.8034	−1.9038	0.1338	2.2272
16	1.2693	−4.3066	−2.4355	−0.4307	1.6282
20	1.1495	−4.8431	−3.0013	−1.0305	0.9920
25	1.0397	−5.3752	−3.5612	−1.6232	0.3639
32	0.9292	−5.9589	−4.1740	−2.2706	−0.3212
40	0.8385	−6.4823	−4.7221	−2.8484	−0.9318
50	0.7559	−7.0020	−5.2650	−3.4193	−1.5342
64	0.6734	−7.5728	−5.8597	−4.0432	−2.1912
80	0.6061	−8.0855	−6.3923	−4.6006	−2.7770
100	0.5452	−8.5953	−6.9205	−5.1520	−3.3552
125	0.4901	−9.1024	−7.4447	−5.6977	−3.9263
160	0.4353	−9.6607	−8.0203	−6.2954	−4.5501
200	0.3909	−10.1631	−8.5370	−6.8305	−5.1073
250	0.3509	−10.6635	−9.0505	−7.3610	−5.6584
320	0.3112	−11.2152	−9.6153	−7.9431	−6.2616
400	0.2792	−11.7122	−10.1231	−8.4652	−6.8013
500	0.2503	−12.2079	−10.6286	−8.9838	−7.3361
640	0.2218	−12.7549	−11.1854	−9.5537	−7.9226
800	0.1988	−13.2482	−11.6867	−10.0658	−8.4483
1000	0.1781	−13.7406	−12.1863	−10.5752	−8.9702
1250	0.1596	−14.2321	−12.6844	−11.0821	−9.4887
1600	0.1413	−14.7749	−13.2337	−11.6404	−10.0585
2000	0.1265	−15.2648	−13.7289	−12.1429	−10.5704

Table 2. Overlap Hann, $P_{fa} = 10^{-2}$

Spectra	Threshold	Signal-to-Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	4.0868	2.3229	3.7076	5.3575	7.1906
5	3.7431	1.7126	3.0715	4.6919	6.4945
6	3.4781	1.2180	2.5554	4.1513	5.9284
8	3.0890	0.4462	1.7497	3.3066	5.0425
10	2.8114	−0.1445	1.1329	2.6594	4.3631
13	2.5113	−0.8300	0.4174	1.9086	3.5743
16	2.2932	−1.3653	−0.1411	1.3226	2.9585
20	2.0772	−1.9338	−0.7337	0.7012	2.3054
25	1.8791	−2.4954	−1.3185	0.0884	1.6616
32	1.6797	−3.1090	−1.9567	−0.5796	0.9602
40	1.5161	−3.6571	−2.5258	−1.1746	0.3359
50	1.3672	−4.1994	−3.0880	−1.7615	−0.2792
64	1.2183	−4.7930	−3.7024	−2.4017	−0.9494
80	1.0968	−5.3243	−4.2512	−2.9727	−1.5462
100	0.9868	−5.8511	−4.7944	−3.5367	−2.1347
125	0.8873	−6.3736	−5.3322	−4.0941	−2.7153
160	0.7883	−6.9473	−5.9214	−4.7035	−3.3490
200	0.7081	−7.4622	−6.4493	−5.2484	−3.9144
250	0.6357	−7.9740	−6.9731	−5.7879	−4.4731
320	0.5640	−8.5369	−7.5482	−6.3790	−5.0841
400	0.5059	−9.0431	−8.0644	−6.9086	−5.6303
500	0.4537	−9.5470	−8.5775	−7.4340	−6.1711
640	0.4021	−10.1021	−9.1418	−8.0108	−6.7636
800	0.3604	−10.6020	−9.6493	−8.5285	−7.2944
1000	0.3230	−11.1003	−10.1544	−9.0430	−7.8209
1250	0.2894	−11.5971	−10.6575	−9.5546	−8.3436
1600	0.2562	−12.1452	−11.2118	−10.1175	−8.9176
2000	0.2295	−12.6395	−11.7111	−10.6239	−9.4331

Table 3. Overlap Hann, $P_{fa} = 10^{-3}$

Spectra	Threshold	Signal-to-Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	5.2749	4.0092	5.1376	6.5319	8.1344
5	4.8425	3.3618	4.4698	5.8404	7.4177
6	4.5076	2.8385	3.9293	5.2798	6.8355
8	4.0137	2.0244	3.0875	4.4054	5.9259
10	3.6598	1.4033	2.4448	3.7369	5.2294
13	3.2758	0.6850	1.7012	2.9629	4.4221
16	2.9958	0.1257	1.1221	2.3599	3.7926
20	2.7176	−0.4666	0.5090	1.7215	3.1258
25	2.4619	−1.0500	−0.0948	1.0929	2.4692
32	2.2038	−1.6857	−0.7521	0.4089	1.7548
40	1.9914	−2.2520	−1.3371	−0.1995	1.1196
50	1.7977	−2.8109	−1.9139	−0.7987	0.4944
64	1.6036	−3.4212	−2.5429	−1.4514	−0.1861
80	1.4450	−3.9661	−3.1038	−2.0328	−0.7915
100	1.3011	−4.5053	−3.6580	−2.6063	−1.3880
125	1.1707	−5.0391	−4.2059	−3.1724	−1.9760
160	1.0409	−5.6239	−4.8053	−3.7907	−2.6172
200	0.9355	−6.1479	−5.3415	−4.3428	−3.1889
250	0.8403	−6.6680	−5.8728	−4.8890	−3.7533
320	0.7459	−7.2391	−6.4553	−5.4869	−4.3701
400	0.6695	−7.7519	−6.9777	−6.0220	−4.9212
500	0.6006	−8.2618	−7.4963	−6.5524	−5.4664
640	0.5325	−8.8228	−8.0662	−7.1342	−6.0634
800	0.4774	−9.3275	−8.5781	−7.6560	−6.5979
1000	0.4280	−9.8300	−9.0873	−8.1743	−7.1279
1250	0.3835	−10.3307	−9.5941	−8.6894	−7.6536
1600	0.3397	−10.8826	−10.1520	−9.2557	−8.2308
2000	0.3043	−11.3799	−10.6543	−9.7648	−8.7488

Table 4. Overlap Hann, $P_{fa} = 10^{-4}$

Spectra	Threshold	Signal–to–Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	6.1742	5.1775	6.1591	7.3974	8.8499
5	5.6805	4.5017	5.4667	6.6852	8.1162
6	5.2967	3.9560	4.9068	6.1083	7.5208
8	4.7282	3.1086	4.0360	5.2096	6.5913
10	4.3191	2.4634	3.3723	4.5235	5.8804
13	3.8735	1.7188	2.6057	3.7301	5.0573
16	3.5476	1.1402	2.0098	3.1129	4.4161
20	3.2228	0.5287	1.3798	2.4602	3.7376
25	2.9235	−0.0724	0.7605	1.8184	3.0701
32	2.6205	−0.7260	0.0874	1.1209	2.3445
40	2.3707	−1.3071	−0.5107	0.5013	1.7000
50	2.1423	−1.8795	−1.0995	−0.1082	1.0662
64	1.9130	−2.5034	−1.7407	−0.7715	0.3769
80	1.7252	−3.0594	−2.3116	−1.3615	−0.2358
100	1.5546	−3.6087	−2.8749	−1.9429	−0.8391
125	1.3998	−4.1516	−3.4311	−2.5164	−1.4333
160	1.2455	−4.7457	−4.0388	−3.1420	−2.0808
200	1.1200	−5.2771	−4.5818	−3.7002	−2.6577
250	1.0066	−5.8039	−5.1193	−4.2519	−3.2270
320	0.8940	−6.3817	−5.7080	−4.8554	−3.8487
400	0.8027	−6.8999	−6.2354	−5.3950	−4.4038
500	0.7204	−7.4147	−6.7586	−5.9296	−4.9528
640	0.6389	−7.9805	−7.3331	−6.5156	−5.5535
800	0.5730	−8.4891	−7.8486	−7.0409	−6.0911
1000	0.5138	−8.9952	−8.3612	−7.5622	−6.6238
1250	0.4606	−9.4990	−8.8709	−8.0801	−7.1521
1600	0.4080	−10.0541	−9.4319	−8.6492	−7.7319
2000	0.3656	−10.5539	−9.9365	−9.1606	−8.2520

Table 5. Overlap Hann, $P_{fa} = 10^{-5}$

Spectra	Threshold	Signal–to–Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	6.9043	6.0788	6.9615	8.0903	9.4334
5	6.3646	5.3802	6.2489	7.3609	8.6855
6	5.9435	4.8164	5.6730	6.7704	8.0787
8	5.3175	3.9416	4.7781	5.8511	7.1321
10	4.8653	3.2765	4.0968	5.1499	6.4088
13	4.3711	2.5099	3.3108	4.3400	5.5718
16	4.0085	1.9152	2.7005	3.7104	4.9204
20	3.6463	1.2875	2.0561	3.0453	4.2315
25	3.3116	0.6713	1.4235	2.3920	3.5544
32	2.9721	0.0024	0.7367	1.6828	2.8190
40	2.6915	−0.5912	0.1273	1.0534	2.1662
50	2.4345	−1.1752	−0.4719	0.4348	1.5247
64	2.1760	−1.8107	−1.1235	−0.2376	0.8277
80	1.9639	−2.3763	−1.7031	−0.8352	0.2085
100	1.7710	−2.9342	−2.2743	−1.4236	−0.4007
125	1.5957	−3.4851	−2.8377	−2.0034	−1.0004
160	1.4207	−4.0870	−3.4526	−2.6355	−1.6535
200	1.2783	−4.6249	−4.0015	−3.1990	−2.2350
250	1.1494	−5.1574	−4.5443	−3.7555	−2.8086
320	1.0212	−5.7410	−5.1385	−4.3638	−3.4346
400	0.9173	−6.2639	−5.6702	−4.9075	−3.9932
500	0.8236	−6.7829	−6.1974	−5.4457	−4.5454
640	0.7307	−7.3530	−6.7757	−6.0353	−5.1494
800	0.6555	−7.8649	−7.2946	−6.5635	−5.6896
1000	0.5879	−8.3740	−7.8100	−7.0876	−6.2248
1250	0.5271	−8.8806	−8.3223	−7.6079	−6.7554
1600	0.4670	−9.4383	−8.8859	−8.1794	−7.3374
2000	0.4185	−9.9403	−9.3926	−8.6928	−7.8594

Table 6. Overlap Hann, $P_{fa} = 10^{-6}$

Spectra	Threshold	Signal–to–Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	7.5217	6.8158	7.6255	8.6715	9.9294
5	6.9458	6.0983	6.8961	7.9276	9.1693
6	6.4949	5.5194	6.3067	7.3254	8.5527
8	5.8224	4.6216	5.3913	6.3882	7.5912
10	5.3349	3.9394	4.6947	5.6739	6.8568
13	4.8007	3.1540	3.8919	4.8494	6.0075
16	4.4077	2.5453	3.2690	4.2090	5.3470
20	4.0141	1.9035	2.6121	3.5330	4.6489
25	3.6497	1.2742	1.9676	2.8694	3.9631
32	3.2791	0.5920	1.2689	2.1497	3.2187
40	2.9723	−0.0128	0.6494	1.5115	2.5586
50	2.6908	−0.6069	0.0411	0.8849	1.9102
64	2.4071	−1.2527	−0.6199	0.2042	1.2060
80	2.1741	−1.8267	−1.2072	−0.4001	0.5810
100	1.9618	−2.3923	−1.7854	−0.9948	−0.0336
125	1.7687	−2.9502	−2.3552	−1.5803	−0.6383
160	1.5757	−3.5591	−2.9766	−2.2182	−1.2964
200	1.4184	−4.1026	−3.5308	−2.7864	−1.8821
250	1.2759	−4.6404	−4.0784	−3.3473	−2.4594
320	1.1342	−5.2290	−4.6773	−3.9600	−3.0893
400	1.0191	−5.7561	−5.2129	−4.5072	−3.6511
500	0.9153	−6.2789	−5.7436	−5.0486	−4.2062
640	0.8123	−6.8527	−6.3255	−5.6415	−4.8132
800	0.7289	−7.3676	−6.8472	−6.1724	−5.3558
1000	0.6539	−7.8795	−7.3652	−6.6989	−5.8933
1250	0.5864	−8.3884	−7.8798	−7.2213	−6.4258
1600	0.5197	−8.9486	−8.4457	−7.7950	−7.0099
2000	0.4658	−9.4526	−8.9543	−8.3102	−7.5335

Table 7. Overlap Hann, $P_{fa} = 10^{-7}$

Spectra	Threshold	Signal–to–Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	8.0581	7.4409	8.1937	9.1738	10.3626
5	7.4525	6.7075	7.4500	8.4174	9.5919
6	6.9771	6.1157	6.8490	7.8051	8.9667
8	6.2659	5.1979	5.9156	6.8523	7.9919
10	5.7488	4.5010	5.2058	6.1264	7.2476
13	5.1805	3.6991	4.3880	5.2888	6.3873
16	4.7615	3.0780	3.7541	4.6387	5.7185
20	4.3410	2.4238	3.0858	3.9528	5.0120
25	3.9508	1.7828	2.4309	3.2800	4.3183
32	3.5533	1.0887	1.7213	2.5507	3.5658
40	3.2236	0.4740	1.0928	1.9047	2.8988
50	2.9206	−0.1293	0.4761	1.2706	2.2441
64	2.6147	−0.7843	−0.1933	0.5825	1.5335
80	2.3632	−1.3660	−0.7875	−0.0281	0.9031
100	2.1337	−1.9385	−1.3721	−0.6284	0.2836
125	1.9247	−2.5027	−1.9478	−1.2192	−0.3258
160	1.7156	−3.1179	−2.5750	−1.8623	−0.9885
200	1.5450	−3.6666	−3.1339	−2.4349	−1.5780
250	1.3904	−4.2090	−3.6859	−2.9998	−2.1589
320	1.2365	−4.8024	−4.2892	−3.6164	−2.7923
400	1.1114	−5.3332	−4.8284	−4.1668	−3.3570
500	0.9985	−5.8594	−5.3623	−4.7113	−3.9148
640	0.8864	−6.4365	−5.9474	−5.3071	−4.5244
800	0.7956	−6.9543	−6.4717	−5.8404	−5.0693
1000	0.7139	−7.4686	−6.9920	−6.3691	−5.6087
1250	0.6403	−7.9798	−7.5088	−6.8936	−6.1432
1600	0.5676	−8.5421	−8.0768	−7.4693	−6.7290
2000	0.5088	−9.0478	−8.5871	−7.9860	−7.2542

Table 8. Overlap Hann, $P_{fa} = 10^{-8}$

Spectra	Threshold	Signal–to–Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	8.5331	7.9844	8.6911	9.6172	10.7482
5	7.9028	7.2374	7.9351	8.8499	9.9682
6	7.4067	6.6344	7.3240	8.2286	9.3354
8	6.6624	5.6993	6.3748	7.2620	8.3487
10	6.1198	4.9893	5.6532	6.5257	7.5954
13	5.5221	4.1727	4.8221	5.6764	6.7251
16	5.0804	3.5406	4.1782	5.0175	6.0487
20	4.6363	2.8752	3.4998	4.3226	5.3345
25	4.2234	2.2237	2.8352	3.6413	4.6336
32	3.8021	1.5188	2.1158	2.9033	3.8735
40	3.4520	0.8951	1.4791	2.2500	3.2002
50	3.1298	0.2835	0.8548	1.6091	2.5396
64	2.8041	−0.3799	0.1776	0.9141	1.8230
80	2.5358	−0.9686	−0.4230	0.2978	1.1877
100	2.2909	−1.5475	−1.0134	−0.3078	0.5635
125	2.0675	−2.1175	−1.5945	−0.9034	−0.0501
160	1.8439	−2.7385	−2.2271	−1.5515	−0.7171
200	1.6612	−3.2920	−2.7904	−2.1280	−1.3102
250	1.4956	−3.8386	−3.3465	−2.6965	−1.8943
320	1.3305	−4.4363	−3.9537	−3.3168	−2.5310
400	1.1963	−4.9706	−4.4962	−3.8703	−3.0984
500	1.0750	−5.4999	−5.0331	−4.4175	−3.6587
640	0.9546	−6.0802	−5.6211	−5.0161	−4.2709
800	0.8570	−6.6004	−6.1478	−5.5516	−4.8178
1000	0.7692	−7.1170	−6.6703	−6.0823	−5.3591
1250	0.6900	−7.6303	−7.1891	−6.6086	−5.8952
1600	0.6117	−8.1946	−7.7590	−7.1862	−6.4828
2000	0.5485	−8.7020	−8.2709	−7.7045	−7.0094

Table 9. Overlap Hann, $P_{fa} = 10^{-9}$

Spectra	Threshold	Signal–to–Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	8.9599	8.4657	9.1342	10.0146	11.0964
5	8.3084	7.7070	8.3674	9.2378	10.3080
6	7.7945	7.0941	7.7473	8.6086	9.6684
8	7.0217	6.1436	6.7842	7.6296	8.6710
10	6.4568	5.4220	6.0519	6.8838	7.9096
13	5.8333	4.5922	5.2088	6.0239	7.0300
16	5.3714	3.9502	4.5558	5.3569	6.3467
20	4.9063	3.2746	3.8681	4.6538	5.6254
25	4.4732	2.6136	3.1948	3.9647	4.9177
32	4.0304	1.8988	2.4663	3.2187	4.1507
40	3.6620	1.2668	1.8220	2.5585	3.4715
50	3.3224	0.6475	1.1907	1.9114	2.8054
64	2.9787	−0.0237	0.5063	1.2099	2.0832
80	2.6953	−0.6187	−0.1002	0.5883	1.4431
100	2.4362	−1.2035	−0.6961	−0.0222	0.8146
125	2.1997	−1.7789	−1.2821	−0.6224	0.1971
160	1.9627	−2.4053	−1.9197	−1.2749	−0.4740
200	1.7690	−2.9632	−2.4872	−1.8553	−1.0704
250	1.5931	−3.5138	−3.0470	−2.4272	−1.6576
320	1.4178	−4.1154	−3.6580	−3.0509	−2.2974
400	1.2751	−4.6530	−4.2035	−3.6072	−2.8673
500	1.1462	−5.1853	−4.7432	−4.1570	−3.4299
640	1.0181	−5.7684	−5.3340	−4.7582	−4.0444
800	0.9142	−6.2910	−5.8629	−5.2958	−4.5933
1000	0.8206	−6.8098	−6.3875	−5.8285	−5.136
1250	0.7364	−7.3249	−6.9080	−6.3564	−5.6741
1600	0.6529	−7.8912	−7.4798	−6.9357	−6.2632
2000	0.5855	−8.4001	−7.9931	−7.4554	−6.7911

Table 10. Overlap Hann, $P_{fa} = 10^{-10}$

Spectra	Threshold	Signal–to–Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	9.3475	8.8980	9.5339	10.3752	11.4140
5	8.6779	8.1289	8.7576	9.5899	10.6184
6	8.1485	7.5074	8.1296	8.9536	9.9725
8	7.3506	6.5431	7.1538	7.9633	8.9654
10	6.7661	5.8111	6.4120	7.2090	8.1966
13	6.1194	4.9693	5.5579	6.3393	7.3085
16	5.6396	4.3182	4.8966	5.6649	6.6187
20	5.1556	3.6333	4.2003	4.9542	5.8908
25	4.7042	2.9635	3.5190	4.2579	5.1768
32	4.2420	2.2396	2.7821	3.5044	4.4033
40	3.8568	1.6000	2.1308	2.8379	3.7185
50	3.5014	0.9736	1.4929	2.1849	3.0473
64	3.1412	0.2952	0.8019	1.4774	2.3198
80	2.8438	−0.3059	0.1898	0.8508	1.6754
100	2.5717	−0.8961	−0.4112	0.2356	1.0428
125	2.3231	−1.4765	−1.0019	−0.3688	0.4215
160	2.0738	−2.1079	−1.6442	−1.0256	−0.2534
200	1.8697	−2.6700	−2.2156	−1.6095	−0.8530
250	1.6845	−3.2244	−2.7788	−2.1846	−1.4430
320	1.4996	−3.8297	−3.3934	−2.8116	−2.0857
400	1.3491	−4.3704	−3.9418	−3.3706	−2.6581
500	1.2129	−4.9053	−4.4840	−3.9227	−3.2229
640	1.0777	−5.4912	−5.0774	−4.5263	−3.8396
800	0.9679	−6.0159	−5.6083	−5.0658	−4.3902
1000	0.8691	−6.5363	−6.1345	−5.6000	−4.9347
1250	0.7799	−7.0537	−6.6572	−6.1300	−5.4742
1600	0.6916	−7.6217	−7.2306	−6.7109	−6.0649
2000	0.6202	−8.1320	−7.7454	−7.2318	−6.5940

Table 11. Overlap Hann, $P_{fa} = 10^{-11}$

Spectra	Threshold	Signal–to–Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	9.7028	9.2905	9.8983	10.7054	11.7065
5	9.0173	8.5123	9.1136	9.9126	10.9042
6	8.4743	7.8830	8.4784	9.2699	10.2528
8	7.6541	6.9064	7.4913	8.2694	9.2367
10	7.0520	6.1648	6.7406	7.5073	8.4611
13	6.3847	5.3122	5.8766	6.6286	7.5652
16	5.8887	4.6527	5.2076	5.9473	6.8694
20	5.3876	3.9593	4.5034	5.2295	6.1352
25	4.9195	3.2813	3.8146	4.5265	5.4154
32	4.4395	2.5489	3.0699	3.7659	4.6357
40	4.0390	1.9022	2.4120	3.0935	3.9458
50	3.6689	1.2692	1.7680	2.4350	3.2696
64	3.2935	0.5840	1.0707	1.7218	2.5372
80	2.9832	−0.0226	0.4534	1.0904	1.8885
100	2.6989	−0.6181	−0.1524	0.4709	1.2521
125	2.4391	−1.2031	−0.7475	−0.1375	0.6272
160	2.1782	−1.8393	−1.3943	−0.7984	−0.0513
200	1.9646	−2.4052	−1.9693	−1.3856	−0.6538
250	1.7705	−2.9632	−2.5358	−1.9638	−1.2467
320	1.5766	−3.5721	−3.1538	−2.5939	−1.8922
400	1.4188	−4.1155	−3.7048	−3.1553	−2.4668
500	1.2759	−4.6531	−4.2495	−3.7097	−3.0337
640	1.1339	−5.2416	−4.8453	−4.3156	−3.6525
800	1.0186	−5.7685	−5.3784	−4.8571	−4.2048
1000	0.9147	−6.2911	−5.9066	−5.3932	−4.7511
1250	0.8210	−6.8097	−6.4306	−5.9244	−5.2918
1600	0.7282	−7.3794	−7.0056	−6.5068	−5.8839
2000	0.6531	−7.8911	−7.5217	−7.0290	−6.4142

Table 12. Overlap Hann, $P_{fa} = 10^{-12}$

Spectra	Threshold	Signal–to–Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	10.0309	9.6501	10.2331	11.0101	11.9776
5	9.3314	8.8637	9.4410	10.2105	11.1694
6	8.7763	8.2275	8.7993	9.5621	10.5129
8	7.9362	7.2397	7.8019	8.5523	9.4886
10	7.3183	6.4894	7.0432	7.7829	8.7067
13	6.6323	5.6268	6.1699	6.8960	7.8035
16	6.1214	4.9596	5.4938	6.2083	7.1021
20	5.6046	4.2582	4.7823	5.4838	6.3621
25	5.1213	3.5727	4.0865	4.7745	5.6367
32	4.6249	2.8324	3.3345	4.0074	4.8512
40	4.2102	2.1790	2.6704	3.3294	4.1564
50	3.8266	1.5399	2.0206	2.6656	3.4756
64	3.4370	0.8483	1.3174	1.9471	2.7384
80	3.1146	0.2363	0.6952	1.3112	2.0858
100	2.8191	−0.3640	0.0848	0.6876	1.4457
125	2.5487	−0.9535	−0.5144	0.0754	0.8174
160	2.2770	−1.5942	−1.1654	−0.5894	0.1354
200	2.0544	−2.1637	−1.7438	−1.1798	−0.4699
250	1.8520	−2.7250	−2.3136	−1.7609	−1.0654
320	1.6497	−3.3372	−2.9346	−2.3938	−1.7135
400	1.4849	−3.8835	−3.4883	−2.9577	−2.2903
500	1.3357	−4.4235	−4.0353	−3.5143	−2.8592
640	1.1873	−5.0144	−4.6335	−4.1224	−3.4800
800	1.0668	−5.5433	−5.1684	−4.6656	−4.0340
1000	0.9580	−6.0677	−5.6984	−5.2033	−4.5818
1250	0.8601	−6.5880	−6.2238	−5.7360	−5.1238
1600	0.7629	−7.1593	−6.8004	−6.3199	−5.7173
2000	0.6844	−7.6722	−7.3177	−6.8433	−6.2487

Table 13. Overlap Hann, $P_{fa} = 10^{-13}$

Spectra	Threshold	Signal–to–Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	10.3357	9.9818	10.5431	11.2932	12.2305
5	9.6238	9.1882	9.7442	10.4875	11.4169
6	9.0578	8.5457	9.0967	9.8338	10.7557
8	8.1999	7.5477	8.0898	8.8154	9.7239
10	7.5676	6.7895	7.3238	8.0394	8.9361
13	6.8644	5.9176	6.4419	7.1447	8.0261
16	6.3401	5.2434	5.7592	6.4511	7.3194
20	5.8089	4.5345	5.0409	5.7204	6.5740
25	5.3114	3.8420	4.3385	5.0052	5.8433
32	4.7999	3.0943	3.5796	4.2318	5.0523
40	4.3719	2.4346	2.9097	3.5485	4.3528
50	3.9759	1.7899	2.2547	2.8801	3.6679
64	3.5728	1.0920	1.5456	2.1562	2.9259
80	3.2392	0.4750	0.9187	1.5161	2.2695
100	2.9331	−0.1299	0.3041	0.8885	1.6259
125	2.6528	−0.7237	−0.2991	0.2727	0.9944
160	2.3709	−1.3686	−0.9541	−0.3958	0.3091
200	2.1398	−1.9416	−1.5358	−0.9892	−0.2990
250	1.9295	−2.5061	−2.1086	−1.5731	−0.8969
320	1.7193	−3.1215	−2.7326	−2.2088	−1.5476
400	1.5479	−3.6703	−3.2887	−2.7750	−2.1265
500	1.3927	−4.2127	−3.8380	−3.3337	−2.6973
640	1.2382	−4.8060	−4.4384	−3.9438	−3.3200
800	1.1127	−5.3367	−4.9752	−4.4888	−3.8756
1000	0.9994	−5.8628	−5.5068	−5.0280	−4.4248
1250	0.8973	−6.3846	−6.0337	−5.5621	−4.9681
1600	0.7961	−6.9575	−6.6118	−6.1474	−5.5629
2000	0.7143	−7.4717	−7.1303	−6.6719	−6.0954

Table 14. Overlap Hann, $P_{fa} = 10^{-14}$

Spectra	Threshold	Signal-to-Noise Ratio (dB) for given P_d			
m	(dB)	$P_d = 0.50$	$P_d = 0.70$	$P_d = 0.90$	$P_d = 0.99$
4	10.6204	10.2899	10.8316	11.5575	12.4675
5	9.8974	9.4898	10.0267	10.7464	11.6490
6	9.3217	8.8416	9.3739	10.0878	10.9836
8	8.4475	7.8342	8.3583	9.0616	9.9448
10	7.8021	7.0686	7.5854	8.2794	9.1515
13	7.0832	6.1882	6.6956	7.3775	8.2351
16	6.5464	5.5073	6.0068	6.6783	7.5235
20	6.0019	4.7916	5.2820	5.9418	6.7729
25	5.4913	4.0924	4.5734	5.2210	6.0373
32	4.9656	3.3377	3.8081	4.4417	5.2411
40	4.5254	2.6721	3.1327	3.7534	4.5371
50	4.1193	2.0247	2.4752	3.0827	3.8502
64	3.7020	1.3182	1.7581	2.3515	3.1017
80	3.3578	0.6965	1.1267	1.7073	2.4417
100	3.0416	0.0872	0.5080	1.0759	1.7947
125	2.7520	−0.5105	−0.0990	0.4566	1.1600
160	2.4604	−1.1595	−0.7578	−0.2153	0.4716
200	2.2213	−1.7359	−1.3427	−0.8116	−0.1391
250	2.0035	−2.3036	−1.9184	−1.3983	−0.7396
320	1.7858	−2.9219	−2.5452	−2.0366	−1.3926
400	1.6081	−3.4732	−3.1037	−2.6049	−1.9735
500	1.4471	−4.0178	−3.6551	−3.1656	−2.5461
640	1.2868	−4.6133	−4.2577	−3.7778	−3.1707
800	1.1566	−5.1459	−4.7961	−4.3244	−3.7278
1000	1.0391	−5.6736	−5.3293	−4.8651	−4.2784
1250	0.9331	−6.1969	−5.8577	−5.4005	−4.8229
1600	0.8279	−6.7712	−6.4372	−5.9872	−5.4190
2000	0.7429	−7.2866	−6.9568	−6.5128	−5.9524

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The Search for Extraterrestrial Intelligence, currently being planned by NASA, will require that an enormous amount of data be analyzed in real time by special–purpose hardware, and it is expected that overlapped Hann data windows will play an important role in this analysis. In order to understand the statistical implications of this approach, it has been necessary to compute detection statistics for overlapped Hann spectra. Tables of signal detection statistics are given for false alarm rates from 10^{-14} to 10^{-1} and signal detection probabilities from 0.50 to 0.99; the number of computed spectra ranges from 4 to 2000.

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