ATSC Standard:
Ghost Canceling Reference Signal for NTSC

Document A/49, 13 May 1993
Reaffirmed by ATSC, 10 December 2014

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The revision history of this document is given below.

A/49 Revision History

A/49 approved	13 May 1993
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1. SCOPE

This document describes a ghost canceling reference (GCR) signal for NTSC television signals[1].

2. SPECIFICATION OF THE GCR SIGNAL

The GCR signal permits detection of ghosts from –3 μsec to +45 μsec. The signal has a flat spectrum and high energy up to 4.1 MHz and has a very low level of energy beyond 4.3 MHz (Figure 2.1). The normalized GCR signal as a function of time is shown in Figure 2.2.

The GCR signal shall be placed on line 19[2] of the vertical blanking interval on a 30 IRE pedestal. The pedestal has a rising transition from 0 IRE to 30 IRE 9.5 μsec after the leading edge of horizontal sync (defined at the 50 percent point). The falling transition from 30 IRE to 0 IRE is 58.5 μsec after the leading edge of horizontal sync. Both transitions have a 4T transition curve.

The GCR signal has a time duration of 35.5 μsec (measured at 1 percent of the maximum value) and begins 12.0 μsec after the leading edge of horizontal sync. The first peak (positive or negative) is 16.7 μsec after the leading edge of horizontal sync. The GCR signal varies from –10 to +70 IRE (the pedestal is the average of these extreme values).

Waveforms of the GCR signal on the pedestal are shown in Figure 2.3 and Figure 2.4 and represent line A and line B, respectively. Line A and line B have the same 30 IRE pedestal but the GCR polarity is inverted from line A to line B. The line A and line B signals are contained in an 8-field sequence as follows:

field 1 - line A; field 2 - line B; field 3 - line A; field 4 - line B;

field 5 - line B; field 6 - line A; field 7 - line B; field 8 - line A.

Numerical values of the GCR signal as a function of time are given in Annex A. These values were calculated from equation (1).

$$f(t) = \frac{A}{2\pi}\left\{ \int_0^\Omega \left[\cos\left(b\omega^2\right) + j\sin\left(b\omega^2\right)\right]W(\omega)e^{j\omega t}d\omega + \int_{-\Omega}^0 \left[\cos\left(b\omega^2\right) - j\sin\left(b\omega^2\right)\right]W(\omega)e^{j\omega t}d\omega \right\} \qquad (1)$$

where $A = 9.0$, $b = 110.0$, and $\Omega = \frac{4.3}{7.16}\pi$ radians/second. $W(\omega)$ is the window function (2).

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1. Note: The user's attention is called to the possibility that compliance with this standard may require the use of an invention covered by patent rights. By publication of this standard, no position is taken with respect to the validity of this claim or of any patent rights in connection therewith. The patent holder has, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license. Details may be obtained from the publisher.

2. Subject to reservation of line 19 by the FCC exclusively for the optional placement of the GCR signal.

$$W(\omega) = \int\limits_{-\frac{\pi}{c}}^{\frac{\pi}{c}} \left[\left(\frac{1}{2} + \frac{1}{2}\cos(ct) \right) \left(\frac{1}{2\pi} \int\limits_{-\Omega_1}^{\Omega_1} e^{j\gamma t} d\gamma \right) \right] e^{-j\omega t} dt \tag{2}$$

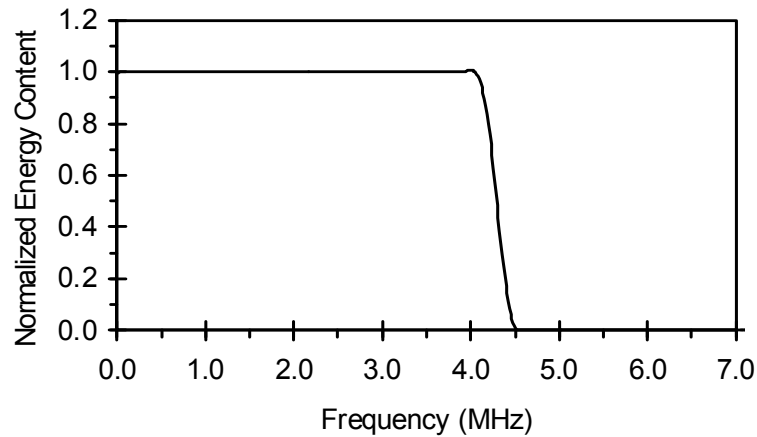where $c = \dfrac{\pi}{49.0}$ radians/second and $\Omega_1 = \dfrac{4.15}{7.16}\pi$ radians/second.
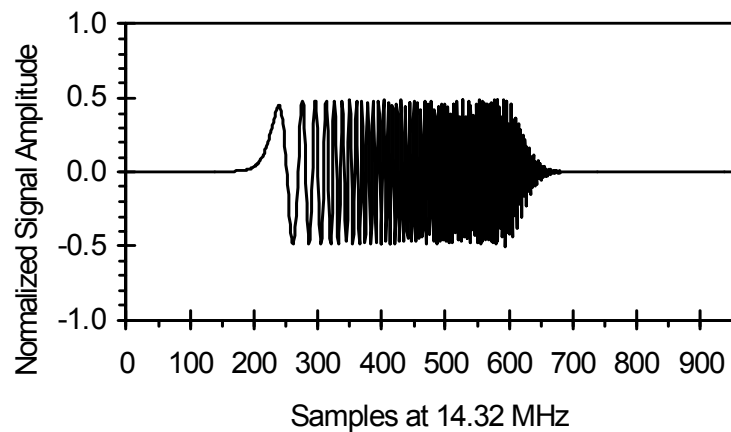
Figure 2.1 Spectrum of the GCR signal.

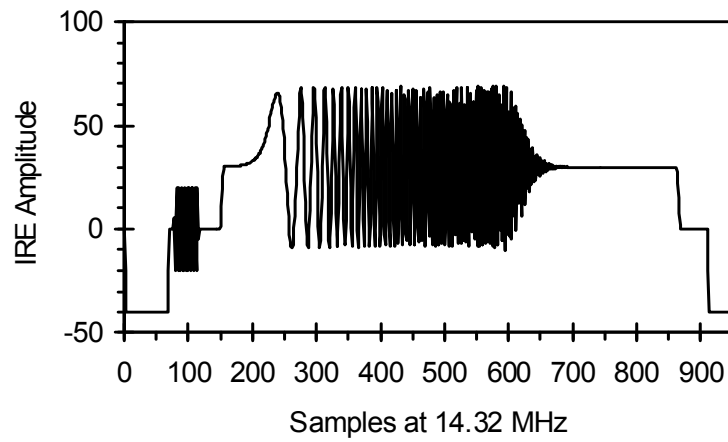**Figure 2.2** GCR signal amplitude as a function of time.
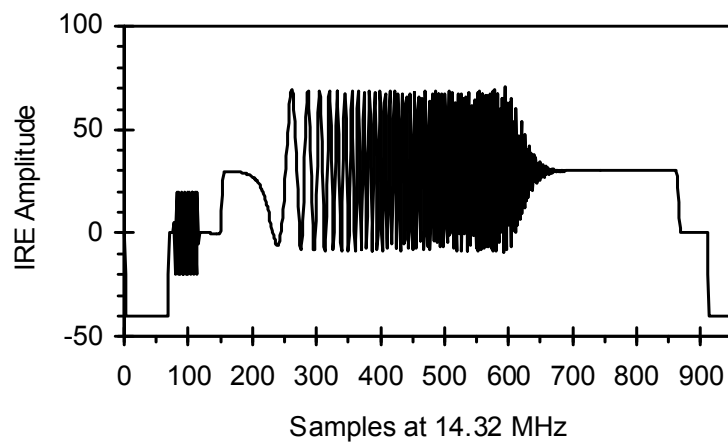
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Figure 2.3 GCR signal on Line A.

Figure 2.4 GCR signal on Line B.

A1. INTRODUCTION

This Annex contains the GCR signal values. The 910 data values were sampled at 14.3 MHz (4 times color subcarrier) and represent a complete GCR waveform in a full TV line (63.5 µs). The first sample is coincident with the 50 percent point of the leading edge of horizontal sync. The data are normalized to 1.0 unit peak to peak and represent the GCR signal with positive polarity. A negative polarity GCR signal can be obtained by multiplying all the data by –1.

000	0.00000000000000E+0000	056	0.00000000000000E+0000	112	0.00000000000000E+0000
001	0.00000000000000E+0000	057	0.00000000000000E+0000	113	0.00000000000000E+0000
002	0.00000000000000E+0000	058	0.00000000000000E+0000	114	0.00000000000000E+0000
003	0.00000000000000E+0000	059	0.00000000000000E+0000	115	0.00000000000000E+0000
004	0.00000000000000E+0000	060	0.00000000000000E+0000	116	0.00000000000000E+0000
005	0.00000000000000E+0000	061	0.00000000000000E+0000	117	0.00000000000000E+0000
006	0.00000000000000E+0000	062	0.00000000000000E+0000	118	0.00000000000000E+0000
007	0.00000000000000E+0000	063	0.00000000000000E+0000	119	0.00000000000000E+0000
008	0.00000000000000E+0000	064	0.00000000000000E+0000	120	0.00000000000000E+0000
009	0.00000000000000E+0000	065	0.00000000000000E+0000	121	0.00000000000000E+0000
010	0.00000000000000E+0000	066	0.00000000000000E+0000	122	0.00000000000000E+0000
011	0.00000000000000E+0000	067	0.00000000000000E+0000	123	0.00000000000000E+0000
012	0.00000000000000E+0000	068	0.00000000000000E+0000	124	0.00000000000000E+0000
013	0.00000000000000E+0000	069	0.00000000000000E+0000	125	0.00000000000000E+0000
014	0.00000000000000E+0000	070	0.00000000000000E+0000	126	0.00000000000000E+0000
015	0.00000000000000E+0000	071	0.00000000000000E+0000	127	0.00000000000000E+0000
016	0.00000000000000E+0000	072	0.00000000000000E+0000	128	0.00000000000000E+0000
017	0.00000000000000E+0000	073	0.00000000000000E+0000	129	0.00000000000000E+0000
018	0.00000000000000E+0000	074	0.00000000000000E+0000	130	0.00000000000000E+0000
019	0.00000000000000E+0000	075	0.00000000000000E+0000	131	0.00000000000000E+0000
020	0.00000000000000E+0000	076	0.00000000000000E+0000	132	0.00000000000000E+0000
021	0.00000000000000E+0000	077	0.00000000000000E+0000	133	0.00000000000000E+0000
022	0.00000000000000E+0000	078	0.00000000000000E+0000	134	0.00000000000000E+0000
023	0.00000000000000E+0000	079	0.00000000000000E+0000	135	1.02260999999970E-0003
024	0.00000000000000E+0000	080	0.00000000000000E+0000	136	1.05892999999924E-0003
025	0.00000000000000E+0000	081	0.00000000000000E+0000	137	1.09718000000036E-0003
026	0.00000000000000E+0000	082	0.00000000000000E+0000	138	1.13701999999982E-0003
027	0.00000000000000E+0000	083	0.00000000000000E+0000	139	1.17906999999917E-0003
028	0.00000000000000E+0000	084	0.00000000000000E+0000	140	1.22286999999943E-0003
029	0.00000000000000E+0000	085	0.00000000000000E+0000	141	1.26910000000002E-0003
030	0.00000000000000E+0000	086	0.00000000000000E+0000	142	1.31748000000087E-0003
031	0.00000000000000E+0000	087	0.00000000000000E+0000	143	1.36846999999918E-0003
032	0.00000000000000E+0000	088	0.00000000000000E+0000	144	1.42190000000042E-0003
033	0.00000000000000E+0000	089	0.00000000000000E+0000	145	1.47821000000015E-0003
034	0.00000000000000E+0000	090	0.00000000000000E+0000	146	1.53740000000013E-0003
035	0.00000000000000E+0000	091	0.00000000000000E+0000	147	1.59988999999960E-0003
036	0.00000000000000E+0000	092	0.00000000000000E+0000	148	1.66547000000072E-0003
037	0.00000000000000E+0000	093	0.00000000000000E+0000	149	1.73485999999912E-0003
038	0.00000000000000E+0000	094	0.00000000000000E+0000	150	1.80787000000038E-0003
039	0.00000000000000E+0000	095	0.00000000000000E+0000	151	1.88510000000086E-0003
040	0.00000000000000E+0000	096	0.00000000000000E+0000	152	1.96657000000044E-0003
041	0.00000000000000E+0000	097	0.00000000000000E+0000	153	2.05283000000023E-0003
042	0.00000000000000E+0000	098	0.00000000000000E+0000	154	2.14390000000009E-0003
043	0.00000000000000E+0000	099	0.00000000000000E+0000	155	2.24045999999944E-0003
044	0.00000000000000E+0000	100	0.00000000000000E+0000	156	2.34250000000102E-0003
045	0.00000000000000E+0000	101	0.00000000000000E+0000	157	2.45085999999972E-0003
046	0.00000000000000E+0000	102	0.00000000000000E+0000	158	2.56557000000157E-0003
047	0.00000000000000E+0000	103	0.00000000000000E+0000	159	2.68752999999933E-0003
048	0.00000000000000E+0000	104	0.00000000000000E+0000	160	2.81685999999937E-0003
049	0.00000000000000E+0000	105	0.00000000000000E+0000	161	2.95447999999965E-0003
050	0.00000000000000E+0000	106	0.00000000000000E+0000	162	3.10071999999906E-0003
051	0.00000000000000E+0000	107	0.00000000000000E+0000	163	3.25656000000052E-0003
052	0.00000000000000E+0000	108	0.00000000000000E+0000	164	3.42231000000126E-0003
053	0.00000000000000E+0000	109	0.00000000000000E+0000	165	3.59925000000061E-0003
054	0.00000000000000E+0000	110	0.00000000000000E+0000	166	3.78781999999944E-0003
055	0.00000000000000E+0000	111	0.00000000000000E+0000	167	3.98931000000147E-0003

168	4.20439999999900E-0003	244	3.87955000000147E-0001	320	-4.84112000000096E-0001
169	4.43461999999784E-0003	245	3.58785999999782E-0001	321	-4.25353000000086E-0001
170	4.68077000000022E-0003	246	3.23113999999805E-0001	322	-2.77427999999873E-0001
171	4.94463999999795E-0003	247	2.80886000000010E-0001	323	-6.92708000000266E-0002
172	5.22724000000352E-0003	248	2.32228000000077E-0001	324	1.55655000000024E-0001
173	5.53064000000347E-0003	249	1.77474000000075E-0001	325	3.48071999999775E-0001
174	5.85610000000258E-0003	250	1.17197000000033E-0001	326	4.63710999999876E-0001
175	6.20609999999999E-0003	251	5.22252000000094E-0002	327	4.73907999999938E-0001
176	6.58219999999687E-0003	252	-1.63339000000065E-0002	328	3.73398000000179E-0001
177	6.98715000000050E-0003	253	-8.70900999999549E-0002	329	1.83113999999932E-0001
178	7.42307000000153E-0003	254	-1.58376000000089E-0001	330	-5.32258000000070E-0002
179	7.89319000000432E-0003	255	-2.28262000000086E-0001	331	-2.78533000000152E-0001
180	8.40024000000028E-0003	256	-2.94597000000067E-0001	332	-4.35938999999962E-0001
181	8.94780000000139E-0003	257	-3.55059999999867E-0001	333	-4.83456999999817E-0001
182	9.53912999999318E-0003	258	-4.07236000000012E-0001	334	-4.05898999999863E-0001
183	1.01788000000056E-0002	259	-4.48710000000119E-0001	335	-2.20585999999912E-0001
184	1.08706000000041E-0002	260	-4.77181000000201E-0001	336	2.53643000000068E-0002
185	1.16199999999935E-0002	261	-4.90596000000096E-0001	337	2.66195000000153E-0001
186	1.24318000000017E-0002	262	-4.87282999999934E-0001	338	4.34799999999996E-0001
187	1.33122999999955E-0002	263	-4.66113999999834E-0001	339	4.81733999999960E-0001
188	1.42673999999943E-0002	264	-4.26633000000038E-0001	340	3.90551999999843E-0001
189	1.53047000000015E-0002	265	-3.69197999999869E-0001	341	1.84567999999899E-0001
190	1.64313999999877E-0002	266	-2.95083999999861E-0001	342	-7.78073999999833E-0002
191	1.76562000000047E-0002	267	-2.06552999999985E-0001	343	-3.18760000000111E-0001
192	1.89881000000014E-0002	268	-1.06861999999978E-0001	344	-4.63948000000073E-0001
193	2.04373999999916E-0002	269	-2.26569000000065E-0004	345	-4.65948999999910E-0001
194	2.20148999999878E-0002	270	1.08304999999973E-0001	346	-3.20834999999988E-0001
195	2.37329999999929E-0002	271	2.13048999999955E-0001	347	-7.18414000000394E-0002
196	2.56043999999918E-0002	272	3.07967000000190E-0001	348	2.02201999999943E-0001
197	2.76438999999868E-0002	273	3.87016000000131E-0001	349	4.11149000000023E-0001
198	2.98664999999971E-0002	274	4.44562000000133E-0001	350	4.83345000000099E-0001
199	3.22896999999784E-0002	275	4.75829999999784E-0001	351	3.91160000000127E-0001
200	3.49309999999718E-0002	276	4.77361000000201E-0001	352	1.62923000000092E-0001
201	3.78107999999884E-0002	277	4.47440999999799E-0001	353	-1.24134000000026E-0001
202	4.09500000000094E-0002	278	3.86449999999968E-0001	354	-3.68950000000041E-0001
203	4.43718999999874E-0002	279	2.97098000000005E-0001	355	-4.82100000000173E-0001
204	4.81004000000058E-0002	280	1.84488000000119E-0001	356	-4.19299000000137E-0001
205	5.21621999999979E-0002	281	5.59898000000203E-0002	357	-2.00237999999899E-0001
206	5.65846999999735E-0002	282	-7.91186000000152E-0002	358	9.56523999999490E-0002
207	6.13976000000207E-0002	283	-2.10235999999895E-0001	359	3.56715999999778E-0001
208	6.66313000000400E-0002	284	-3.26232999999775E-0001	360	4.80940999999802E-0001
209	7.23186999999825E-0002	285	-4.16419000000133E-0001	361	4.16690999999901E-0001
210	7.84923999999592E-0002	286	-4.71591999999873E-0001	362	1.85821000000033E-0001
211	8.51879000000508E-0002	287	-4.85105000000203E-0001	363	-1.21634999999969E-0001
212	9.24387000000024E-0002	288	-4.53794000000016E-0001	364	-3.81190000000061E-0001
213	1.00280999999995E-0001	289	-3.78679999999804E-0001	365	-4.84109999999873E-0001
214	1.08748999999989E-0001	290	-2.65297999999802E-0001	366	-3.84040999999797E-0001
215	1.17876000000044E-0001	291	-1.23576999999955E-0001	367	-1.19752999999946E-0001
216	1.27694000000020E-0001	292	3.28038999999762E-0002	368	1.97697999999946E-0001
217	1.38230999999905E-0001	293	1.87584000000015E-0001	369	4.30369000000155E-0001
218	1.49511000000075E-0001	294	3.23534999999993E-0001	370	4.73501999999826E-0001
219	1.61552999999913E-0001	295	4.24414000000070E-0001	371	3.04200000000037E-0001
220	1.74367999999959E-0001	296	4.77027999999791E-0001	372	-4.45780999999812E-0003
221	1.87959000000092E-0001	297	4.73159000000123E-0001	373	-3.12843000000157E-0001
222	2.02316999999994E-0001	298	4.11086000000068E-0001	374	-4.77105999999822E-0001
223	2.17419999999947E-0001	299	2.96408000000156E-0001	375	-4.17065000000093E-0001
224	2.33228000000054E-0001	300	1.41969000000017E-0001	376	-1.57408999999916E-0001
225	2.49684999999984E-0001	301	-3.32369999999855E-0002	377	1.79722999999967E-0001
226	2.66712000000098E-0001	302	-2.06171999999924E-0001	378	4.30503999999928E-0001
227	2.84204999999929E-0001	303	-3.52687000000060E-0001	379	4.69046000000162E-0001
228	3.02032999999938E-0001	304	-4.50949999999921E-0001	380	2.72319000000152E-0001
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230	3.38005000000067E-0001	306	-4.47235999999975E-0001	382	-3.68903000000046E-0001
231	3.55717999999797E-0001	307	-3.41190000000097E-0001	383	-4.83776999999918E-0001
232	3.72897000000194E-0001	308	-1.80984000000080E-0001	384	-3.44759999999951E-0001
233	3.89230000000225E-0001	309	9.63199000000259E-0003	385	-2.16183999999942E-0002
234	4.04360999999881E-0001	310	2.00563999999986E-0001	386	3.14663999999993E-0001
235	4.17892999999822E-0001	311	3.59968000000208E-0001	387	4.81103000000076E-0001
236	4.29389999999785E-0001	312	4.59641999999803E-0001	388	3.83209000000079E-0001
237	4.38381999999820E-0001	313	4.80308000000150E-0001	389	7.12525999999798E-0002
238	4.44367000000057E-0001	314	4.15771999999833E-0001	390	-2.82396000000062E-0001
239	4.46823000000222E-0001	315	2.75076999999783E-0001	391	-4.76846999999907E-0001
240	4.45215000000189E-0001	316	8.19416000000501E-0002	392	-3.97513999999774E-0001
241	4.39011999999821E-0001	317	-1.28693999999996E-0001	393	-8.63047999999935E-0002
242	4.27705000000060E-0001	318	-3.16683999999896E-0001	394	2.77078999999958E-0001
243	4.10821999999825E-0001	319	-4.44307000000208E-0001	395	4.77041000000099E-0001

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398 -3.00528000000213E-0001	474 4.67350000000124E-0002	550 -1.12458999999944E-0001
399 -4.82100000000173E-0001	475 -4.22157999999854E-0001	551 -4.78289000000132E-0001
400 -3.61706000000140E-0001	476 -3.85088999999880E-0001	552 4.92869999999925E-0002
401 -1.12785000000031E-0002	477 1.17635999999948E-0001	553 4.84148000000005E-0001
402 3.47796000000017E-0001	478 4.78071999999884E-0001	554 5.86423000000025E-0003
403 4.82912999999826E-0001	479 2.53111999999874E-0001	555 -4.83146999999917E-0001
404 3.02329000000100E-0001	480 -2.84720999999990E-0001	556 -5.22940999999832E-0002
405 -7.90537999999970E-0002	481 -4.69815999999810E-0001	557 4.77914999999939E-0001
406 -4.09227999999985E-0001	482 -6.75424999999450E-0002	558 8.96437999999762E-0002
407 -4.64552999999796E-0001	483 4.20501000000058E-0001	559 -4.70905000000130E-0001
408 -2.03408999999965E-0001	484 3.76236999999946E-0001	560 -1.18200000000002E-0001
409 1.98789999999917E-0001	485 -1.48369000000002E-0001	561 4.63843999999881E-0001
410 4.64230000000043E-0001	486 -4.83322999999928E-0001	562 1.38171000000057E-0001
411 4.04536999999891E-0001	487 -1.93813000000091E-0001	563 -4.58263999999872E-0001
412 5.75837999999749E-0002	488 3.48465000000033E-0001	564 -1.50045999999975E-0001
413 -3.32002000000102E-0001	489 4.35011999999915E-0001	565 4.55015999999887E-0001
414 -4.82986999999866E-0001	490 -5.20594999999844E-0002	566 1.53954999999996E-0001
415 -2.81882000000223E-0001	491 -4.70860999999786E-0001	567 -4.54807999999957E-0001
416 1.27741000000015E-0001	492 -2.61331000000155E-0001	568 -1.50088000000096E-0001
417 4.43717999999990E-0001	493 2.99838999999793E-0001	569 4.57700999999815E-0001
418 4.27357000000029E-0001	494 4.56122000000050E-0001	570 1.38134999999920E-0001
419 8.67075999999543E-0002	495 -8.47457000000418E-0003	571 -4.63569999999891E-0001
420 -3.21608000000197E-0001	496 -4.62175000000116E-0001	572 -1.17764999999963E-0001
421 -4.82884000000013E-0001	497 -2.79306999999790E-0001	573 4.71551999999974E-0001
422 -2.68137000000024E-0001	498 2.91294999999991E-0001	574 8.81894999999986E-0002
423 1.58376000000089E-0001	499 4.55973999999969E-0001	575 -4.80403000000024E-0001
424 4.60480000000189E-0001	500 -1.96689999999933E-0002	576 -4.87550000000283E-0002
425 3.94394999999804E-0001	501 -4.68189000000166E-0001	577 4.87923000000137E-0001
426 8.97358999999653E-0003	502 -2.51569000000018E-0001	578 -1.28841999999985E-0003
427 -3.85126000000128E-0001	503 3.25347999999950E-0001	579 -4.91308000000117E-0001
428 -4.63401999999860E-0001	504 4.34597999999824E-0001	580 6.19993000000250E-0002
429 -1.56926999999996E-0001	505 -8.52701999999681E-0002	581 4.86694000000170E-0001
430 2.82047000000148E-0001	506 -4.81628999999884E-0001	582 -1.32732999999917E-0001
431 4.83843999999863E-0001	507 -1.72663999999941E-0001	583 -4.69751999999971E-0001
432 2.73432999999841E-0001	508 3.91235999999935E-0001	584 2.11195000000089E-0001
433 -1.73019000000068E-0001	509 3.75564999999824E-0001	585 4.35657999999876E-0001
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643	-8.26296000000184E-0002	719	0.00000000000000E+0000	795	0.00000000000000E+0000
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649	1.19423999999952E-0002	725	0.00000000000000E+0000	801	0.00000000000000E+0000
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688	2.75651000000110E-0003	764	0.00000000000000E+0000	840	0.00000000000000E+0000
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697	5.30142999999761E-0004	773	0.00000000000000E+0000	849	0.00000000000000E+0000
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