

AUTOMATIC RF TECHNIQUES GROUP

MEASUREMENT COMPARISON PROGRAM (MCP) for Type N Scattering Parameters

PLEASE REPLY TO:

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I. Introduction

The ARFTG MCP allows participating laboratories to compare their measurements with measurements obtained from other laboratories. The ARFTG MCP is designed to permit the rapid comparison of a large number of network analyzers (VNAs). The MCP should give participants more confidence in their measurement capability and can assist in identifying measurement deficiencies.

Data obtained from the participating labs will be sent to NIST and maintained in a measurement database. This database will contain data from every lab that has measured the ARFTG standards. Each lab will be provided with a statistical analysis and graphical display of their measurement results in comparison to the measurement database. The lab can expect an analysis of their results normally within 2 weeks after the data is received at NIST.

Individual labs will be coded to retain the privacy of the data.

Each participant will measure the devices in the kit according to the instructions given below. The measurement results will be sent to NIST. NIST will not accept any data that is not received in the format specified below.

II. Measurement Instructions (All Systems)

The Type N kit contains the following components:

- 20 dB Attenuator
- 50 dB Attenuator
- Beatty Impedance Standard
- Reference Airline
- Offset Shorts

Inspection

Inspect and clean connectors on the standards and the VNA test ports before making any measurements. A copy of Hewlett-Packard/Agilent Application Note 326 on connector care and cleaning is enclosed. Please keep this note with the standards kit.

Calibration

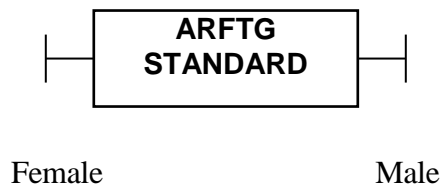
The VNA to be used should be "calibrated" prior to measurements using in-house torque wrenches and standards. The required frequency set for calibration is 100 MHz increments starting at 100 MHz and continuing to at least 18.0 GHz. However, please note that the Data Collection Software provided with the kit for Hewlett-Packard/Agilent 8510 Series Analyzers with 200/300 Series Controllers presently requires calibration at 100 MHz increments from 100 MHz to 20.1 GHz (201 Points).

Important Note for Type N Devices:

Prior to calibration, refer to manufacturer's manual instructions to establish the proper configuration with respect to connector sex at the measurement interfaces. For connection of the devices in this kit per established conventions, the interface connector **on Port 1 of the analyzer** will be male (M) and **Port 2 will be female (F)**; make the appropriate entries on the analyzer.

Measurement

The diagram below shows the proper insertion direction for the ARFTG standards; all standards are connected in the same direction. *Please note when connecting standards that the body must be held stationary and only the coupling nut rotated.*



Measure each of the standards at three (3) orientations, which are 120 degrees apart from the other two. The three orientations are axial rotations of the devices being measured. Since only coupling mechanisms, and not the body, can be turned without disconnecting, it is necessary that the 120 degree rotations be performed with the device *completely removed* from the test port connectors. It is not important if the rotation is counterclockwise or

clockwise as long as the direction is consistent. The 120 degree angle is approximate and need not be set accurately. Measure the offset shorts on both test ports of the ANA. Appendix D contains precautions/recommendations on connection of the airline and the impedance standard.

Each participant may wish to measure the kit devices more than once. Example: you have more than one operator or you wish to compare different techniques of your operation. Some participants may to make additional runs to determine their own repeatability, or consistency. Some participants have made from one to four complete runs for all kit devices on the systems to be compared.

III. Data Storage

Data should be stored in an ASCII file on electronic media such as a hard drive or a 3.5 inch floppy disk (to facilitate the electronic transfer of the data to NIST). The data will be MS/DOS disk format (fully IBM PC compatible). All data is to be formatted the same way regardless of network analyzer or computer involved. The appendices describe how the data files should be formatted. **The format must be followed exactly if data from your facility is to be analyzed.** (Please see example of data format.) Failure to comply with disk and data format specifications will result in return of your data without analysis.

When the Model 8510 Internal Drive is used to store data, the analyzer places values on the disc in real plus imaginary format. The Anritsu Lightning 37xxx/Wiltron Model 360 Network Analyzer contains a disk drive that is MS/DOS compatible.

Please keep a **backup copy of your data** disks in case they become damaged during transit to NIST. For questions regarding data files, structure, etc, contact Rusty Myers via phone at 909-204-3344, or email at rmyers@maurymw.com.

IV. Data Transfer

All the data files should be sent via email to Ron Ginley at rginley@boulder.nist.gov. Any files that are not formatted according will not be analyzed. If you have any questions about the formatting of the data, you can contact Ron Ginley at the address below.

If you are unable to complete this type of transfer, please use the following address for mailing 3.5" data disks:

Ronald A. Ginley
Group Leader,
Radio Frequency Electronics Group (818.01)
NIST
325 Broadway
Boulder, CO 80305
Email: rginley@boulder.nist.gov
Phone: 303-497-3634

IV. SHIPMENT

When the kit is ready for shipment to the next participant. Please contact Rusty Myers via phone at 909-204-3344, or email at rmyers@maurymw.com to obtain proper address information. Also please observe the following notes in the process of shipment:

NOTES:

1. The ARFTG kit is to be mailed to the next participant insured for \$5000.00 by the shipping party.
2. If possible, it should be shipped so that it will not go through the receiving cycle for purchased equipment; this will avoid delays due to lack of a purchase order.
3. As a courtesy, call the next participant and give them an estimated arrival date so that they can alert dock or mail room personnel.

APPENDIX A

Wiltron 360 and Anritsu Lightning 37xxx Instructions

The Wiltron 360/Anritsu Lightning 37xxx has an internal 3.5 inch microfloppy disk drive; use this drive for data storage.

Measurement Instructions:

1. Preset the network analyzer.
2. Using the Frequency List, set Start Frequency to 100 MHz.
3. Frequency Step to 100 MHz.
4. Number of Points to 200.
5. Note that the Stop Frequency is 20.0 GHz.
6. Number of Averages is determined by the user.
7. Calibrate for Type N connectors. The calibration should be performed in the same manner as precision measurements are normally made and can use any type of calibration kit (SOLT, LRL, etc.).
8. Install an initialized blank disk in the Network Analyzer disk drive.
9. Install the first Device Under Test (DUT).
10. Set the 360 display to 4 Channel with each S-Parameter displayed as log magnitude and phase angle.
11. **Make sure that the header information is turned on or your data will not be processed.**
12. After each measurement, store (list) the data on the floppy using the following convention to name the data files :

File Name	Device	Orientation
an_20db1.txt	20 dB Attenuator	1
an_20db2.txt	20 dB Attenuator	2
an_20db3.txt	20 dB Attenuator	3
an_50db1.txt	50 dB Attenuator	1
an_50db2.txt	50 dB Attenuator	2
an_50db3.txt	50 dB Attenuator	3
an_air11.txt	50 Ohm Airline	1
an_air12.txt	50 Ohm Airline	2
an_air13.txt	50 Ohm Airline	3
an_zstd1.txt	Beatty Z Standard	1
an_zstd2.txt	Beatty Z Standard	2
an_zstd3.txt	Beatty Z Standard	3
an_sho11.txt	Short on Test Port 1	1
an_sho12.txt	Short on Test Port 1	2
an_sho13.txt	Short on Test Port 1	3
an_sho21.txt	Short on Test Port 2	1
an_sho22.txt	Short on Test Port 2	2
an_sho23.txt	Short on Test Port 2	3

13. Label the Data Disk with your Company/Laboratory code. There is a maximum of twenty (20) characters allowed:

APPENDIX B

Hewlett-Packard/Agilent 8510 with HP 200/300 Series Controller Measurement and Data Retrieval Instructions

This service is no longer provided.

All data files must be in ASCII and properly formatted for e-mailing.

APPENDIX C

Data Format Guidelines for users provided software

The analysis of your data is dependent on the correctness of the data formatting. It is important that all data formatting instructions be followed explicitly. Use only those frequencies specified. Perform all three orientations. The data file name must follow the same rigid requirements as the data itself.

DATA FORMAT STRUCTURE

No preamble line is necessary.

The first line is a 'delimiter' line. This line starts with a pound symbol (#) and is included only because **TOUCHSTONE** requires it. This line will read :

GHZ S DB R 50

The data is to be in a string matrix that is 80 characters wide and 201 rows deep. Use the following structure when formatting your data prior to recording on the data disk.

File names : Eight (8) characters are used to identify the kit, device, and orientation number. The first three characters will be an "an_" for ARFTG Type N kit. The next four characters identify the device. The eighth character is for orientation number, either 1, 2, or 3. Legitimate device names are :

20db for 20 dB Attenuator
50db for 50 dB Attenuator
airl for 50 Ohm Airline
zstd for Beatty Impedance Standard
sho1 for the Offset Short on Test Port 1
sho2 for the Offset Short on Test Port 2

Data Fields : Each data field starts with the measurement frequency and is followed by all 4 complex S-Parameters. The frequency is given in GHz, magnitude in dB and phase angle in degrees. The S-Parameters should be in the order:

$|S_{11}| \arg(S_{11}) \ |S_{21}| \arg(S_{21}) \ |S_{12}| \arg(S_{12}) \ |S_{22}| \arg(S_{22})$

Use the following formats:

Frequency format	xx.xxx followed by 3 blank spaces
Log magnitude format	xxxx.xxx followed by a blank space
Phase angle format	xxxx.xxx followed by a blank space

Log magnitude and phase angle is assumed to be positive if the sign is not given. If they are negative the sign must be included.

APPENDIX D

RECOMMENDATIONS ON BEADLESS AIRLINE AND IMPEDANCE STANDARD

It has come to the attention of the ARFTG Standards Committee that not all participants in this program are familiar with beadless devices. This is a note of caution when making measurements on these two standards. After connecting an airline, check all four S-parameters to verify that the standard has been properly installed; this can be done by observing data on the analyzer display for each S-parameter. The 50 Ohm airline should show values for S_{21} that are less than 2 dB and S_{11} values greater than 20 dB. The Beatty Standard will display ripple traces for all parameters with minima below 10 dB and maxima approaching 0 dB (See Example). The analyzer should be placed in the "LOCAL" mode with calibration correction and IF averaging functions turned off when making these tests. These functions must be restored manually prior to restarting the program (See Below).

The following procedure has been used to perform the airline connections:

1. Place analyzer in "LOCAL" and "SWEEP" modes. Turn off calibration correction and IF averaging functions. This will allow observing the S-parameter response during connection.
2. Remove the plastic retainers for the center conductor from both ends of the airline.

Note: Use a lint-free glove to handle the center conductor.
3. Let the center conductor slide outward slightly to protrude on the female side. Hold the center conductor and carefully connect it to the male test port center conductor.
4. Move the outer conductor on the airline toward the test port and make a connection. After tightening in the normal manner, loosen the connection by about 15 degrees of rotation from the tightened position.
5. Adjust the airline outer conductor vertically and horizontally so that it is concentric with the inner conductor.
6. Carefully mate the unconnected ports while observing the display for valid responses.
7. Torque both mated connectors to 12 in-lb.
8. Turn on calibration correction and IF averaging.
9. Press "CONTINUE" on computer keyboard to proceed with measurements.

APPENDIX E

TYPICAL DISPLAY RESPONSES WHEN CONNECTING BEATTY STANDARD

The procedure supplied with the kit includes the original responses supplied in 1991.

A copy of this has been placed on the ARFTG WEB site at:

http://www.arftg.org/mcp/Beatty_Std_2.jpg

APPENDIX F

Hewlett-Packard/Agilent 8510C using Internal Disc Drive Measurement and Data Retrieval Instructions

All entries are made using front-panel controls and the data is stored on a 3.5 inch disc in the internal drive. Proceed as follows to complete the desired number of runs:

Measurement Instructions :

1. Initialize a disc in DOS format for each of the expected runs.
2. Preset the network analyzer.
3. Use the keystrokes below to establish the frequency set:
MENU for STIMULUS, MORE, EDIT LIST, EDIT
START: 100 MHz
STOP: 18.0 GHz
STEP SIZE: 100 MHz
DONE to complete.
4. Enter the frequency list for measurement using the following:
MENU for STIMULUS, FREQUENCY LIST, ALL SEGMENTS
5. Averages: User determined.
6. Calibrate the analyzer for precision measurements on devices with Type N connectors.
The calibration method can be SOLT, TRL, etc.

Please note connector conventions as previously discussed!!

7. It is recommended that the analyzer be placed in the SINGLE sweep mode for all measurements on kit devices.
8. Perform the following steps for measurement of each device:
 - A. Connect the device in the first orientation.
 - B. Start the measurement sequence using the SINGLE key.
 - C. When the sweep is complete, these keystrokes store the data:
TAPE/DISC, STORE, MORE, DATA: DATA
The file name must be completed per information shown on the next page.
9. Disconnect the standard as necessary to rotate for measurements at the remaining two orientations. Perform B. and C. above.
10. Repeat steps 8. and 9. for each kit device.

11. After the third orientation on the shorts, the current run is complete. Run a directory on the disc to verify that all files have been created.
12. Repeat steps from the sequences listed above as necessary to complete additional measurement runs on this kit.
13. When all measurements are complete, make copies of the data and e-mail a set of data to NIST at the address provided below, identify data set with 20 characters maximum.
Ron Ginley at NIST: rginley@boulder.nist.gov

File Name	Device	Orientation
an_20db1.txt	20 dB Attenuator	1
an_20db2.txt	20 dB Attenuator	2
an_20db3.txt	20 dB Attenuator	3
an_50db1.txt	50 dB Attenuator	1
an_50db2.txt	50 dB Attenuator	2
an_50db3.txt	50 dB Attenuator	3
an_air1.txt	50 Ohm Airline	1
an_air2.txt	50 Ohm Airline	2
an_air3.txt	50 Ohm Airline	3
an_zstd1.txt	Beatty Z Standard	1
an_zstd2.txt	Beatty Z Standard	2
an_zstd3.txt	Beatty Z Standard	3
an_sho11.txt	Short on Test Port 1	1
an_sho12.txt	Short on Test Port 1	2
an_sho13.txt	Short on Test Port 1	3
an_sho21.txt	Short on Test Port 2	1
an_sho22.txt	Short on Test Port 2	2
an_sho23.txt	Short on Test Port 2	3

This procedure was developed at the suggestion of Ken Wong. It was verified to produce 18 files of 4 parameters in X,Y format.

APPENDIX G

Example of Data Format for 20 dB Attenuator

0.100000000	-33.041	-8.791	-19.918	-8.845	-19.918	-8.578	-45.273	167.855
0.200000000	-32.984	-17.427	-19.919	-17.390	-19.910	-17.380	-44.990	160.187
0.300000000	-32.885	-25.906	-19.931	-25.698	-19.939	-25.686	-44.880	150.175
0.400000000	-32.840	-36.089	-19.927	-34.360	-19.950	-34.470	-45.041	142.435
0.500000000	-32.817	-45.059	-19.932	-42.932	-19.937	-42.911	-45.175	133.966
0.600000000	-32.726	-53.998	-19.919	-51.514	-19.917	-51.443	-44.677	124.109
0.700000000	-32.657	-62.820	-19.929	-59.946	-19.919	-60.110	-45.038	119.844
0.800000000	-32.626	-71.198	-19.940	-68.553	-19.926	-68.498	-44.826	110.186
0.900000000	-32.538	-80.658	-19.934	-77.011	-19.929	-77.134	-44.950	102.875
1.000000000	-32.386	-89.343	-19.934	-85.637	-19.928	-85.672	-44.949	97.886
1.100000000	-32.372	-98.179	-19.939	-94.067	-19.942	-94.260	-44.979	90.952
1.200000000	-32.213	-106.843	-19.941	-102.677	-19.929	-102.739	-44.909	83.616
1.300000000	-32.173	-115.312	-19.943	-111.220	-19.938	-111.215	-45.254	76.907
1.400000000	-32.074	-123.772	-19.937	-119.667	-19.937	-119.797	-44.927	68.504
1.500000000	-32.018	-132.478	-19.939	-128.251	-19.933	-128.352	-45.293	63.782
1.600000000	-31.922	-141.036	-19.940	-136.748	-19.944	-136.781	-45.319	57.197
1.700000000	-31.896	-149.639	-19.951	-145.346	-19.951	-145.328	-45.781	51.730
1.800000000	-31.829	-158.260	-19.946	-153.835	-19.933	-153.987	-46.108	44.642
1.900000000	-31.688	-166.745	-19.940	-162.286	-19.941	-162.468	-46.210	38.978
2.000000000	-31.961	-176.304	-19.939	-170.906	-19.942	-170.980	-46.570	3.190
2.100000000	-31.847	175.487	-19.943	-179.393	-19.951	-179.493	-46.753	-9.155
2.200000000	-31.637	167.018	-19.951	172.029	-19.964	171.994	-46.796	-18.100
2.300000000	-31.459	158.764	-19.950	163.543	-19.946	163.462	-46.660	-28.977
2.400000000	-31.315	150.365	-19.953	155.047	-19.941	154.878	-46.602	-35.293
2.500000000	-31.200	142.618	-19.958	146.483	-19.944	146.314	-46.406	-44.257
2.600000000	-31.096	134.900	-19.961	137.920	-19.944	137.885	-46.727	-52.103
2.700000000	-31.007	127.121	-19.939	129.348	-19.945	129.269	-46.800	-63.997
2.800000000	-30.935	119.308	-19.967	120.898	-19.953	120.743	-46.467	-74.122
2.900000000	-30.859	111.801	-19.956	112.317	-19.951	112.194	-46.451	-79.598
3.000000000	-30.813	103.958	-19.955	103.828	-19.956	103.712	-46.946	-93.367
3.100000000	-30.741	96.255	-19.961	95.217	-19.946	95.133	-46.470	-97.972
3.200000000	-30.677	88.598	-19.959	86.720	-19.966	86.581	-47.304	-110.292
3.300000000	-30.637	81.299	-19.965	78.114	-19.951	78.136	-46.907	-122.433
3.400000000	-30.572	73.697	-19.962	69.639	-19.950	69.600	-46.605	-127.665
3.500000000	-30.554	66.101	-19.963	61.145	-19.955	61.040	-47.175	-142.886
3.600000000	-30.501	58.945	-19.966	52.524	-19.956	52.451	-46.501	-151.173
3.700000000	-30.480	51.714	-19.963	43.995	-19.958	43.879	-46.859	-159.869
3.800000000	-30.501	44.201	-19.958	35.442	-19.947	35.392	-46.667	-173.221
3.900000000	-30.515	37.088	-19.959	26.902	-19.964	26.815	-46.471	176.961
4.000000000	-30.525	29.774	-19.960	18.480	-19.951	18.324	-46.712	166.356
4.100000000	-30.478	22.477	-19.963	9.863	-19.965	9.741	-46.171	156.565
4.200000000	-30.534	15.596	-19.943	1.319	-19.948	1.306	-46.804	145.181
4.300000000	-30.601	9.004	-19.960	-7.212	-19.956	-7.312	-45.831	133.474
4.400000000	-30.678	2.161	-19.952	-15.807	-19.954	-15.817	-46.055	119.561
4.500000000	-30.752	-4.633	-19.951	-24.284	-19.948	-24.400	-45.592	110.628
4.600000000	-30.901	-11.221	-19.939	-32.880	-19.935	-32.892	-44.704	98.222
4.700000000	-30.987	-18.173	-19.946	-41.444	-19.943	-41.534	-44.916	87.216
4.800000000	-31.116	-24.752	-19.949	-50.021	-19.941	-50.057	-44.041	76.365
4.900000000	-31.288	-31.417	-19.939	-58.553	-19.943	-58.670	-43.674	62.481

5.000000000	-31.373	-38.050	-19.948	-67.125	-19.938	-67.147	-42.973	53.392
5.100000000	-31.517	-44.433	-19.944	-75.634	-19.940	-75.734	-42.527	41.535
5.200000000	-31.642	-50.664	-19.940	-84.229	-19.940	-84.358	-41.697	33.084
5.300000000	-31.820	-56.802	-19.928	-92.730	-19.932	-92.891	-40.865	22.975
5.400000000	-32.010	-62.892	-19.930	-101.303	-19.932	-101.415	-40.579	12.158
5.500000000	-32.212	-69.326	-19.929	-109.958	-19.937	-109.979	-39.323	2.776
5.600000000	-32.425	-75.868	-19.934	-118.478	-19.918	-118.592	-39.214	-4.583
5.700000000	-32.650	-82.378	-19.918	-127.124	-19.925	-127.197	-38.394	-14.354
5.800000000	-32.866	-88.571	-19.915	-135.637	-19.907	-135.790	-37.545	-22.914
5.900000000	-33.053	-94.746	-19.922	-144.214	-19.919	-144.290	-37.289	-30.184
6.000000000	-33.350	-100.611	-19.916	-152.781	-19.912	-152.866	-36.461	-39.912
6.100000000	-33.538	-106.533	-19.912	-161.449	-19.905	-161.485	-35.868	-47.221
6.200000000	-33.764	-111.952	-19.907	-169.982	-19.912	-170.052	-35.246	-54.684
6.300000000	-34.021	-117.684	-19.902	-178.548	-19.899	-178.672	-34.731	-62.140
6.400000000	-34.255	-123.269	-19.907	172.852	-19.893	172.778	-34.097	-70.729
6.500000000	-34.387	-128.817	-19.906	164.334	-19.899	164.139	-33.541	-77.257
6.600000000	-34.605	-134.059	-19.898	155.641	-19.892	155.586	-33.063	-84.549
6.700000000	-34.741	-139.388	-19.903	147.060	-19.893	147.041	-32.467	-92.350
6.800000000	-34.911	-144.318	-19.883	138.479	-19.903	138.440	-32.077	-97.952
6.900000000	-35.091	-148.515	-19.882	129.832	-19.875	129.798	-31.641	-106.003
7.000000000	-35.155	-152.734	-19.892	121.274	-19.886	121.136	-31.136	-112.464
7.100000000	-35.307	-156.991	-19.885	112.600	-19.879	112.546	-30.790	-119.216
7.200000000	-35.355	-160.919	-19.881	104.053	-19.882	103.975	-30.284	-126.436
7.300000000	-35.497	-164.781	-19.864	95.452	-19.880	95.373	-29.910	-132.506
7.400000000	-35.470	-168.639	-19.874	86.806	-19.879	86.740	-29.540	-139.863
7.500000000	-35.420	-172.174	-19.871	78.219	-19.868	78.074	-29.176	-145.955
7.600000000	-35.402	-175.943	-19.863	69.558	-19.864	69.434	-28.822	-153.044
7.700000000	-35.191	-179.759	-19.871	60.949	-19.874	60.907	-28.487	-159.263
7.800000000	-35.022	176.285	-19.854	52.326	-19.861	52.190	-28.154	-165.673
7.900000000	-34.930	172.893	-19.857	43.709	-19.857	43.585	-27.883	-172.549
8.000000000	-34.638	168.950	-19.842	35.091	-19.847	34.895	-27.537	-178.407
8.100000000	-34.422	165.419	-19.844	26.479	-19.839	26.320	-27.355	174.779
8.200000000	-34.153	161.342	-19.829	17.884	-19.836	17.745	-27.038	168.610
8.300000000	-33.839	157.142	-19.842	9.209	-19.843	9.091	-26.807	162.216
8.400000000	-33.521	152.769	-19.848	0.550	-19.843	0.402	-26.660	155.834
8.500000000	-33.177	148.235	-19.832	-8.156	-19.846	-8.201	-26.378	148.997
8.600000000	-32.840	143.865	-19.831	-16.865	-19.852	-16.925	-26.274	143.037
8.700000000	-32.461	139.102	-19.828	-25.391	-19.829	-25.553	-26.043	136.419
8.800000000	-32.060	134.409	-19.825	-34.073	-19.809	-34.162	-25.939	129.940
8.900000000	-31.724	129.562	-19.835	-42.797	-19.822	-42.871	-25.740	123.888
9.000000000	-31.316	124.826	-19.798	-51.493	-19.796	-51.557	-25.653	116.959
9.100000000	-30.999	119.591	-19.817	-60.092	-19.818	-60.236	-25.518	111.050
9.200000000	-30.660	114.168	-19.809	-68.788	-19.802	-68.860	-25.423	104.270
9.300000000	-30.326	108.857	-19.812	-77.446	-19.821	-77.585	-25.363	98.180
9.400000000	-29.964	103.307	-19.813	-86.066	-19.804	-86.183	-25.216	91.202
9.500000000	-29.604	97.569	-19.816	-94.725	-19.815	-94.883	-25.228	84.981
9.600000000	-29.246	91.955	-19.805	-103.477	-19.812	-103.548	-25.136	78.224
9.700000000	-28.925	86.133	-19.813	-112.143	-19.806	-112.278	-25.162	71.454
9.800000000	-28.614	80.603	-19.796	-120.780	-19.802	-120.925	-25.079	65.023
9.900000000	-28.331	74.604	-19.793	-129.585	-19.798	-129.649	-25.075	57.758
10.000000000	-28.050	68.916	-19.796	-138.237	-19.804	-138.377	-25.068	51.560
10.100000000	-27.788	63.040	-19.803	-146.921	-19.805	-146.966	-25.038	43.975
10.200000000	-27.524	56.856	-19.797	-155.540	-19.789	-155.770	-25.037	37.590

10.300000000	-27.287	51.021	-19.787	-164.287	-19.796	-164.407	-25.097	30.153
10.400000000	-27.039	44.659	-19.790	-173.021	-19.797	-173.105	-25.097	23.066
10.500000000	-26.820	38.460	-19.800	178.209	-19.786	178.125	-25.161	15.944
10.600000000	-26.589	32.098	-19.785	169.585	-19.793	169.422	-25.244	8.103
10.700000000	-26.396	25.828	-19.800	160.901	-19.796	160.789	-25.296	0.973
10.800000000	-26.202	19.676	-19.788	152.091	-19.788	152.057	-25.343	-6.999
10.900000000	-25.998	13.463	-19.779	143.306	-19.799	143.369	-25.359	-13.870
11.000000000	-25.844	7.030	-19.788	134.673	-19.789	134.568	-25.409	-21.026
11.100000000	-25.684	0.411	-19.772	125.990	-19.772	125.885	-25.455	-28.675
11.200000000	-25.527	-6.046	-19.773	117.158	-19.788	117.185	-25.501	-35.780
11.300000000	-25.403	-12.745	-19.774	108.481	-19.781	108.396	-25.554	-44.132
11.400000000	-25.240	-19.353	-19.771	99.707	-19.782	99.628	-25.590	-51.602
11.500000000	-25.130	-25.851	-19.776	90.981	-19.774	90.951	-25.630	-59.513
11.600000000	-24.975	-32.446	-19.768	82.239	-19.776	82.171	-25.708	-67.396
11.700000000	-24.851	-39.212	-19.769	73.432	-19.775	73.382	-25.735	-75.693
11.800000000	-24.719	-45.933	-19.771	64.685	-19.784	64.629	-25.754	-83.811
11.900000000	-24.571	-52.683	-19.764	55.871	-19.763	55.882	-25.709	-91.161
12.000000000	-24.496	-59.490	-19.771	47.127	-19.774	47.267	-25.776	-99.802
12.100000000	-24.388	-66.549	-19.779	38.302	-19.769	38.328	-25.728	-107.240
12.200000000	-24.291	-73.257	-19.771	29.547	-19.742	29.539	-25.689	-115.728
12.300000000	-24.214	-80.200	-19.780	20.852	-19.755	20.858	-25.720	-123.137
12.400000000	-24.122	-87.113	-19.777	12.170	-19.758	12.076	-25.630	-131.495
12.500000000	-24.062	-94.116	-19.766	3.413	-19.749	3.263	-25.680	-138.954
12.600000000	-23.958	-101.095	-19.771	-5.389	-19.757	-5.408	-25.542	-146.957
12.700000000	-23.855	-108.205	-19.748	-14.177	-19.749	-14.245	-25.555	-154.521
12.800000000	-23.784	-115.170	-19.757	-22.979	-19.746	-23.029	-25.415	-161.826
12.900000000	-23.711	-122.116	-19.746	-31.743	-19.756	-31.822	-25.505	-169.231
13.000000000	-23.635	-129.274	-19.749	-40.645	-19.763	-40.696	-25.395	-176.747
13.100000000	-23.542	-136.292	-19.735	-49.418	-19.736	-49.446	-25.386	175.479
13.200000000	-23.471	-143.175	-19.731	-58.220	-19.743	-58.250	-25.379	169.035
13.300000000	-23.422	-150.373	-19.749	-67.073	-19.728	-67.104	-25.251	160.647
13.400000000	-23.378	-157.380	-19.736	-75.872	-19.727	-75.949	-25.323	154.495
13.500000000	-23.336	-164.449	-19.745	-84.794	-19.743	-84.837	-25.316	146.710
13.600000000	-23.273	-171.628	-19.741	-93.566	-19.739	-93.516	-25.407	140.116
13.700000000	-23.224	-178.760	-19.752	-102.403	-19.744	-102.391	-25.371	133.518
13.800000000	-23.174	174.048	-19.741	-111.296	-19.725	-111.279	-25.494	126.202
13.900000000	-23.143	166.966	-19.760	-120.205	-19.739	-120.098	-25.573	120.071
14.000000000	-23.106	160.046	-19.754	-128.952	-19.726	-128.982	-25.578	112.215
14.100000000	-23.069	153.005	-19.761	-137.728	-19.743	-137.812	-25.656	106.961
14.200000000	-23.055	146.183	-19.749	-146.537	-19.746	-146.712	-25.773	99.971
14.300000000	-23.060	139.319	-19.749	-155.448	-19.745	-155.544	-26.017	93.757
14.400000000	-23.045	132.431	-19.755	-164.242	-19.756	-164.361	-26.087	87.022
14.500000000	-23.046	125.654	-19.760	-173.060	-19.763	-173.231	-26.341	80.427
14.600000000	-23.052	118.854	-19.765	178.063	-19.764	177.935	-26.470	73.955
14.700000000	-23.040	111.969	-19.744	169.177	-19.758	169.104	-26.687	67.755
14.800000000	-23.043	105.168	-19.754	160.371	-19.754	160.260	-26.868	63.234
14.900000000	-23.040	98.437	-19.752	151.501	-19.762	151.412	-27.222	56.405
15.000000000	-23.051	91.846	-19.750	142.685	-19.759	142.551	-27.459	50.045
15.100000000	-23.054	85.289	-19.744	133.763	-19.750	133.673	-27.646	44.130
15.200000000	-23.081	78.607	-19.740	124.860	-19.758	124.866	-27.983	37.986
15.300000000	-23.089	71.956	-19.751	116.053	-19.750	115.992	-28.228	33.260
15.400000000	-23.108	65.444	-19.743	107.143	-19.742	107.093	-28.667	27.419
15.500000000	-23.152	58.748	-19.748	98.330	-19.744	98.223	-29.138	22.211

15.600000000	-23.182	51.924	-19.729	89.314	-19.730	89.380	-29.450	16.216
15.700000000	-23.235	45.320	-19.741	80.523	-19.741	80.491	-30.010	10.474
15.800000000	-23.274	38.510	-19.717	71.663	-19.725	71.547	-30.273	5.282
15.900000000	-23.321	32.073	-19.727	62.644	-19.726	62.704	-30.922	-0.066
16.000000000	-23.384	25.434	-19.724	53.882	-19.728	53.709	-31.310	-4.757
16.100000000	-23.449	18.878	-19.715	44.919	-19.724	44.846	-32.073	-10.335
16.200000000	-23.507	12.240	-19.723	35.980	-19.730	35.939	-32.620	-13.442
16.300000000	-23.573	5.640	-19.717	27.107	-19.699	27.013	-33.169	-20.295
16.400000000	-23.660	-0.869	-19.714	18.264	-19.710	18.193	-33.772	-22.139
16.500000000	-23.759	-7.460	-19.710	9.296	-19.707	9.196	-34.108	-29.162
16.600000000	-23.824	-14.240	-19.705	0.390	-19.712	0.297	-34.939	-30.202
16.700000000	-23.913	-20.648	-19.695	-8.533	-19.700	-8.724	-35.169	-37.193
16.800000000	-23.993	-27.386	-19.686	-17.496	-19.689	-17.501	-35.731	-38.841
16.900000000	-24.091	-34.012	-19.680	-26.430	-19.682	-26.415	-35.777	-40.949
17.000000000	-24.197	-40.656	-19.674	-35.327	-19.695	-35.371	-36.763	-45.657
17.100000000	-24.294	-47.237	-19.674	-44.239	-19.673	-44.348	-36.554	-46.633
17.200000000	-24.385	-54.058	-19.676	-53.156	-19.665	-53.162	-37.246	-53.601
17.300000000	-24.469	-60.610	-19.675	-62.065	-19.678	-62.117	-36.426	-51.451
17.400000000	-24.549	-67.394	-19.672	-71.024	-19.658	-71.045	-36.579	-57.501
17.500000000	-24.614	-73.844	-19.646	-79.878	-19.644	-79.934	-36.132	-56.652
17.600000000	-24.704	-80.367	-19.640	-88.747	-19.646	-88.831	-35.892	-62.518
17.700000000	-24.780	-86.846	-19.629	-97.748	-19.631	-97.796	-35.783	-64.965
17.800000000	-24.849	-93.301	-19.629	-106.650	-19.640	-106.639	-34.936	-72.552
17.900000000	-24.937	-99.689	-19.638	-115.522	-19.610	-115.725	-34.468	-75.178
18.000000000	-25.040	-106.158	-19.595	-124.451	-19.593	-124.340	-33.434	-80.156
18.100000000	-25.191	-113.019	-19.593	-133.414	-19.613	-133.343	-33.223	-85.008
18.200000000	-25.739	-120.962	-19.595	-142.214	-19.580	-142.248	-32.266	-90.071
18.300000000	-24.708	-120.239	-19.608	-151.117	-19.600	-151.217	-31.416	-100.022
18.400000000	-24.936	-128.838	-19.531	-159.917	-19.544	-160.072	-31.066	-103.013
18.500000000	-24.487	-133.789	-19.542	-168.817	-19.545	-168.810	-29.885	-108.506
18.600000000	-24.999	-142.713	-19.525	-177.707	-19.518	-177.652	-26.686	-113.483
18.700000000	-25.040	-148.287	-19.518	173.549	-19.493	173.469	-29.489	-133.093
18.800000000	-25.040	-154.129	-19.480	164.719	-19.449	164.733	-28.700	-135.168
18.900000000	-25.030	-160.095	-19.463	156.014	-19.471	156.065	-27.890	-140.461
19.000000000	-25.024	-165.792	-19.433	147.259	-19.403	147.027	-27.190	-148.265
19.100000000	-25.138	-170.527	-19.386	138.351	-19.368	138.285	-26.249	-154.930
19.200000000	-23.989	-177.308	-19.476	131.302	-19.477	130.936	-27.191	-168.781
19.300000000	-24.220	175.043	-19.290	121.843	-19.291	121.844	-25.876	-165.576
19.400000000	-24.110	169.195	-19.218	113.169	-19.231	113.147	-24.950	-173.373
19.500000000	-23.913	163.226	-19.158	104.652	-19.150	104.602	-24.182	178.427
19.600000000	-23.657	156.499	-19.048	96.398	-19.027	96.212	-23.559	172.250
19.700000000	-23.425	149.904	-18.929	87.901	-18.945	88.160	-22.991	163.965
19.800000000	-23.166	143.225	-18.808	79.673	-18.792	79.386	-22.361	156.763
19.900000000	-22.880	136.289	-18.633	71.564	-18.556	71.502	-21.895	148.039
20.000000000	-22.563	128.305	-18.367	63.453	-18.359	63.295	-21.343	139.051