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09 October 2000

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
445 12th St., S.W.
Washington, DC 20554

Re: ***Ex Parte* Notification**
ET Docket No. 98-153
Ultra-Wideband

Dear Ms. Salas:

The Applied Research Laboratories: The University of Texas at Austin would like to inform you of the availability of the first data sets from our testing effort. Interested parties can access the data by going to the following web page and registering:

http://sgl.arlut.utexas.edu/asd/Cure/testplan.html

After registering, the party will be granted access to the directories that currently house the test data. Because there are currently 6.5 Gigabytes available, we ask that parties do not try to download it all at once. Instead, try to locate the data of most interest and download it. The attached document is intended to be a guide to accessing and analyzing the data and will hopefully answer some of the questions that may arise about the testing effort.

We expect to be posting additional test data to the web site noted above as it becomes available.

Sincerely,

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Miguel A. Cardoza
Program Manager

Enclosure
cc: Mr. Fred Thomas (via email FTHOMAS@fcc.gov)
Mr. Greg Czumak (via email GCZUMAK@fcc.gov)

Using the Data

It is the intent of this document to act as a guide in utilizing the data that the Applied Research Laboratories, the University of Texas at Austin has collected on the interactions between Ultra Wideband systems and GPS receivers. This document provides important facts such as the path losses present in the test setup, the types of receivers utilized, and the path structure in which the data is resides. The data now available represents the conduct Ranging and Acquisition testing on the first four receivers.

There is approximately 6.4 Gigabytes of data currently available, spanning the Conducted Ranging and Acquisition tests on the first four receivers, so we ask that you PLEASE do NOT try to download it all at once. Instead, find particular sections you are interested in analyzing and download those.

Overview of Testing

This data set is the first data set produced by ARL:UT and represents the results of a set of conducted tests in which four receivers were simultaneously fed the output of a Global Simulations Systems 4760, 12 channel GPS simulator combined with the output of one of two sources. First, an Ultra Wideband transmitter running in a variety of operational modes that are intended to be representative of potential commercial products was combined with the simulator output and fed to the receivers. Second, a broadband white noise source, the Micronetics Wireless Noise Generator, model number NOD–2413, was combined with the simulator output and fed to the receivers. The Test Setup is shown in Figure 1 with the Ultra Wideband source.

There have been 3 classes of tests completed:

Baseline Tests – Receivers were subjected to only the output of the GSS 4760 Simulator and data was logged. No Ultra Wideband signal was injected into the test setup. These tests were accomplished so that there would be a baseline data set for each receiver against which the effects of the white noise source and the Ultra Wideband source could be compared.

White Noise Tests – Receivers were subjected to the output of the GSS 4760 Simulator combined with the output of a broadband white noise source with the power output approximately the same as the Ultra Wideband power output in the L1 band.

Ultra Wideband Tests – Receivers were subjected to the output of the GSS 4760 Simulator combined with the output of the Time Domain Pulson Applications Developer (PAD), the Ultra Wideband transmitter for the conducted tests.

For the all three classes of tests, two performance criteria test structures were completed. The first was a **Ranging** test structure in which the performance criteria to be evaluated are the impacts on pseudorange, carrier phase, Doppler frequency, and other position-type criteria are evaluated. The second performance criteria test completed was an **Acquisition** test structure in which the receivers are evaluated for their “hot” acquisition performance, in other words, their ability to acquire satellites with an accurate ephemeris database. Each class of tests, Baseline Tests, White Noise Tests, and Ultra Wideband Tests have had both of these performance criteria tests performed.

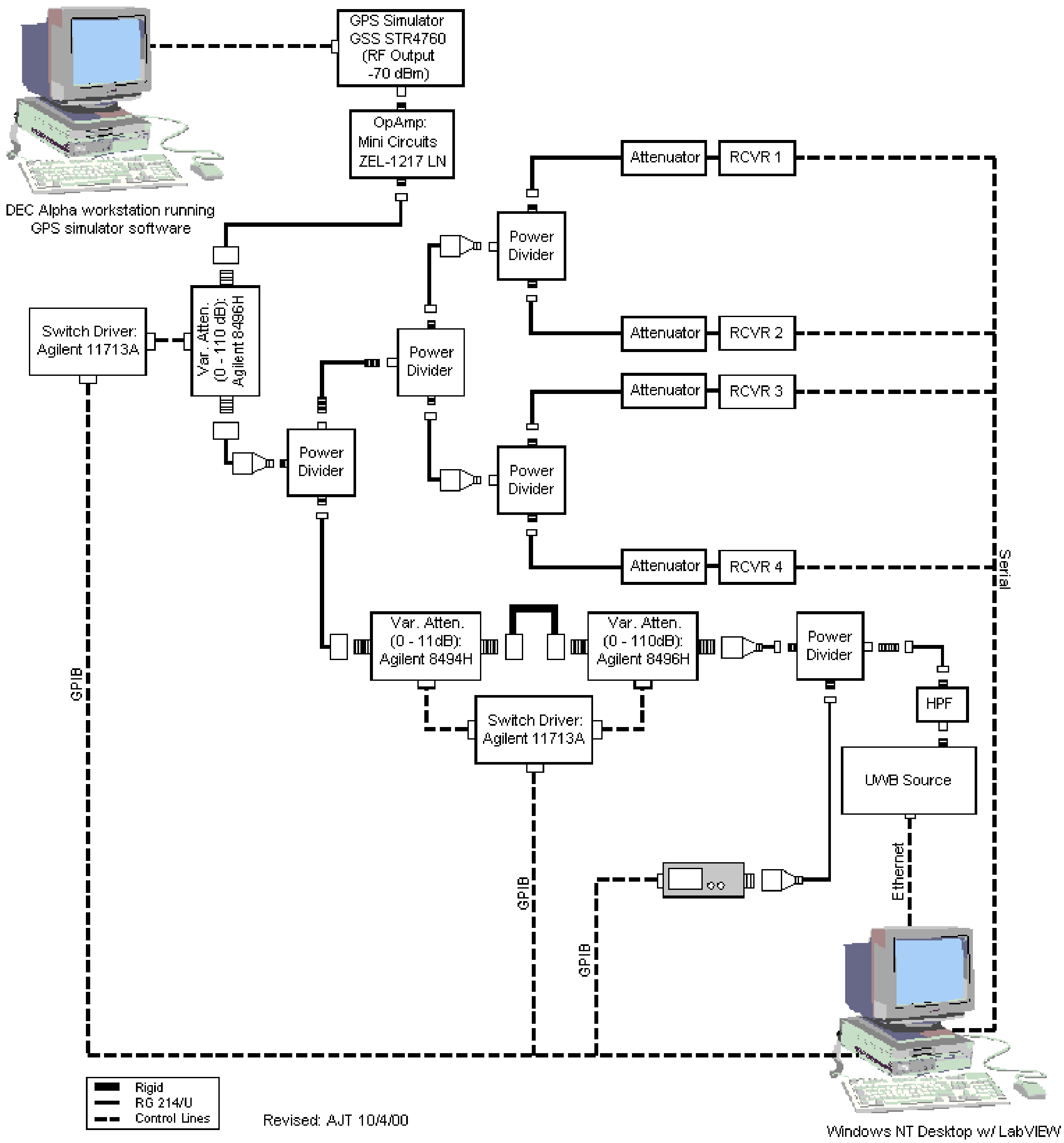

Figure 1: Test Setup

Analyzing the Data

If this data is to be analyzed properly, several factors need to be taken into consideration. This is not intended to be a recommendation of how to factor in these considerations, only a notice that they exist and, if not taken into account, their omission from the analysis could lead to erroneous conclusions on the estimated radius of impact for an Ultra Wideband device on a GPS receiver or to the receiver's performance in the face of a broadband noise source.

Preamplifier and front-end filtering effects

Because the Ultra Wideband (or white noise source) signal is being directly injected into each receiver's antenna port, effects from the preamplifier and front-end filters are not accounted for in the data. Some method of including or accounting for these potential effects needs to be considered.

Antenna mismatch effects

Because the Ultra Wideband (or white noise source) signal is being directly injected into each receiver's antenna port, mismatches in the antenna patterns and polarizations are not accounted for in this data. For example, the Ultra Wideband antenna that comes with the Pulson Applications Developer (PAD) is linearly polarized while the GPS antennas are normally right-hand circularly polarized. These types of effects need to be taken into account.

Ultra Wideband Antenna issues

Because the Ultra Wideband (or white noise source) signal is being directly injected into each receiver's antenna port, the efficiency and patterns of the Ultra Wideband antenna are not taken into account. For example, if the Ultra Wideband antenna truly isotropic, it would spread the conducted power out over 4 Pi R^2 steradians. Although this is not the case, these potential issues need to be taken into account.

Folder Definitions

UWB_Test_Data_Folder – Root directory holding all data

Conducted_Test_Data_Folder – Directory holding all conducted test data

Radiated_Test_Data_Folder – Directory holding all radiated test data

Documents Folder – Directory holding important documents such as current version of test plan

Ranging_Test Data Folder – Directory holding ranging test data

Acquisition_Test Data Folder – Directory holding acquisition test data

Receiver_Baselines Folder – Directory holding baseline data sets for each receiver that were taken in the absence of either the white noise source or the ultra wideband source.

White_NoiseSource Folder – Directory holding data sets for each receiver in which the white noise source is combined with the simulator signal and presented to the individual receivers.

UltraWideband Folder – Directory holding data sets for each receiver in which the Ultra Wideband source is combined with the simulator signal and presented to the individual receivers for a number of different Ultra Wideband parameters.

Live_Sky Folders – Directories holding data for tests in which the GPS simulator was outputting a power level approximating what the receivers reported in a live sky data collection period during which the receivers were operated in their standard configurations.

Min_Level Folders – Directories holding data sets for tests in which the GPS simulator signal at the antenna port of receiver 3 was approximately a –136 dBm.

Directory Structure

The directory structure for the data is as follows:

UWB_Test_Data Folder
|
Conducted_Test_Data Folder **Documents Folder** **Radiated_Test_Data Folder**

Both the Conducted Test Data Folder and the Radiated Test Data Folder have the same structure shown as follows:

Conducted (*or Radiated*)_Test_Data Folder
|
Ranging_Test_Data Folder **Acquisition_Test_Data Folder**
| |
……… …….

The directory structure for both the Ranging Test Data folder and the Acquisition Test Data Folder are similar, but there are differences due to the differences in the testing. The Ranging Test Data Folder structure appears as follows:

Ranging_Test_Data Folder
|
Receiver_Baselines Folder **White_Noise Folder** **UltraWideband Folder**
| | |
Min_Level Folder **Live_Sky Folder** **……** **……**

The directory structure within both the White Noise Folder and the Ultra Wideband Folder are the same and appear as follows:

White_Noise (*or Ultra Wideband*) Folder
|
Min_Level Folder **Live_Sky Folder**
| |
UWBMode1, UWBMode2…… UWBMode13 **UWBMode1, UWBMode7,**

With each ***UWBMode# Folder***, the directory structure is as follows:

UWBMode# Folder
|
RCV1 Folder **RCV2 Folder** **RCV3 Folder** **RCV4 Folder**

For the ranging data, within each **RCV# Folder**, the directory structure is as follows:

RCV# Folder
|
0dB Folder
2dB Folder
4dB Folder
6dB Folder
8dB Folder
10dB Folder
12dB Folder
14dB Folder
16dB Folder
18dB Folder
20dB Folder
22dB Folder
25dB Folder
28dB Folder
31dB Folder
34dB Folder
37dB Folder
40dB Folder
43dB Folder
60dB Folder

RCV#_01_*UWBMode#*_concat_live_CON_RA.GRC

The **#dB Folder** is a folder holding two files, the first of which is a data file from the particular receiver representing a 20 minute data collection interval for which the programmable attenuators were set to the folder value. The second file is a spectrum analyzer file representing the sweep data taken at the end of each run. For example, the 22dB Folder will hold two files, one a receiver data file representing 20 minutes of data and one a spectrum analyzer sweep taken at the end of the data collection run, where the programmable attenuators in the UWB path were set to 22 dB. Looking up the values in table 6 below gives a total UWB attenuation value of 54.33 dB for receiver one for this particular folder.

The file that resides in the **UWBMode# Folder**, the RCV#_01_UWBMode#_concat_live_CON_RA.GRC file, represents a DOS concatenation of the receiver files from all of the folders within this UWBMode# Folder and can be used to view an approximately 8 hour run which covers one complete UWB operating mode test.

For the acquisition data, the directory structure becomes different below the **RCV# Folder** and appears as follows:

RCV# Folder
|
5db_rcv1 Folder
10db_rcv1 Folder
15db_rcv1 Folder
20db_rcv1 Folder
25db_rcv1 Folder
30db_rcv1 Folder
35db_rcv1 Folder
40db_rcv1 Folder
45db_rcv1 Folder

Where each **#db_rcv# Folder** represents the programmable attenuator settings for the given test and the given receiver. For example, the **5db_rcv1 Folder** holds receiver 1 acquisition testing data from the test where the programmable attenuators were set to a total value of 5 dB.

Below each of the **#db_rcv# Folders**, the directory structure appears as follows:

#db_rcv# Folder
|
Trial0_files Folder Trial1_files Folder Trial2_files Folder ….. Trial29_files Folder Trial30_files Folder

There are 30 Folders, each representing one acquisition trial. Also in the **#db_rcv# Folder** is a file that is the receiver-dependent DOS concatenation of all 30 individual trials. Within each trial folder is one file that is the receiver-dependent data file for that particular trial.

Key Information

Ultra Wideband Power Output

An important factor needed in analyzing this data is that in the conducted tests, the PADs are radiating 2 dB hotter than they were during the FCC Part 15, class B evaluation due to the removal of two 1-dB attenuators that were used in the FCC testing. Therefore, the power output measured with the spectrum analyzer and the power meters are all 2 dB higher than they were during the FCC evaluation. Scanned copies of the FCC laboratory's evaluation documents are available in the documents folder.

Taking all internal attenuation into account and the external High-Pass Filter (HPF), at a 10 MHz Pulse Repetition Frequency (PRF) in a continuous mode, the total aggregate average power ~= -15 dBm for the PAD configuration used in this testing. This number is roughly the same feeding into the antenna as well as radiating out of antenna since the gain on the antenna ~= 0.8 dB. Regardless of the settings, the peak envelope power is +23 dB above the average number, which for these settings gives a peak power = +8 dBm.

To calculate the average power levels for different PRFs (only in continuous modes) use the following calculation:

Average power at new PRF = average power at 10 MHz + 10 log (PRF (in MHz) / 10)

e.g. for 1 MHz, Average power = -15 + 10 log (1/10) = -25 dBm

To calculate the average power levels for different burst modes (at the same PRF as the continuous mode of interest), use the following calculation:

Average power of burst mode = average power at PRF in continuous mode + 10 log (duty cycle)

e.g. for a 10 MHz PRF and a burst mode with a 50% duty cycle, Average power = -15 dBm + 10 log (.5) = -18 dBm.

Utilizing an Agilent E4418B power meter and an Agilent 8482A power sensor, the power was measured directly out of back of PAD, with no external attenuation and no HPF. The power measured at different frequencies on the power meter for a 10 MHz PRF, in a continuous mode are shown in table 1. **It is important to note that in all the testing currently being completed, the HPF is used on the output of the PAD.**

Table 1

Frequency (GHz)	Power (dBm)
4	1.33
3	1.25
2	1.16
1.5756 (L1)	1.12
1.2276 (L2)	1.09
1	1.07
0.5	1.05

With the external HPF connected (**as is used in all of the testing**), the power measured at different frequencies on power meter for a 10 MHz PRF in a continuous mode are shown in table 2.

Table 2

Frequency (GHz)	Power (dBm)
4	-14.88
3	-14.95
2	-15.05
1.5756 (L1)	-15.09
1.2276 (L2)	-15.11
1	-15.13
0.5	-15.15

Path Losses in Test Setup

The path losses for each path, the Ultra Wideband Path, the GPS simulator path, and the Spectrum Analyzer path have been measured with a vector network analyzer. Table 3 lists the path losses for the Ultra Wideband paths to each receiver.

Table 3

Receiver	UWB Path Loss at GPS L1 (dB)	UWB Path Loss at GPS L2 (dB)
RCV1	32.33	31.97
RCV2	27.00	26.47
RCV3	39.19	38.73
RCV4	26.73	26.21

Table 4 lists the path losses for the GPS signals from the simulator to each individual receiver.

Table 4

Receiver	Path Loss at GPS L1 (dB)	Path Loss at GPS L2 (dB)
RCV1	26.28	25.43
RCV2	20.60	19.80
RCV3	33.08	32.10
RCV4	20.60	19.66

Table 5 lists the path losses from the UWB source to the Spectrum Analyzer.

Table 5

Path Loss at GPS L1 (dB)	Path Loss at GPS L2 (dB)
7.17	7.09

The following are the definitions of each path:

Ultra Wideband Path – starting at the cable connection that terminates on the Ultra Wideband (or white noise) signal source and then terminates on each individual receiver. With the exception of the programmable attenuator values, all connector, adapter, power combiner, and cable losses in the path are accounted for in the number given above.

GPS Simulator Path – starting at the cable connection that terminates on the power amplifier attached to the output of the GPS simulator and then terminates on the individual receivers. With the exception of the programmable attenuator values, all connector, adapter, power combiner, and cable losses in the path are accounted for in the number given above.

Spectrum Analyzer Path – starting at the cable connection that terminates on the Ultra Wideband (or white noise) signal source and then terminates on the spectrum analyzer. All connector, adapter, power combiner, and cable losses in the path are accounted for in the number given above.

The High-Pass Filer (HPF) shown in figure 1 is only utilized with the Ultra Wideband source.

For the ranging tests, with the addition of the attenuation provided by the programmable attenuators, the total path losses for each test at a given programmable attenuator value are shown in table 6.

Table 6

Programmable Attenuator Setting (Db)	Actual Ultra Wideband PathLoss for Each Receiver	L1 Loss	L2 Loss	Programmable Attenuator Setting (Db)	Actual Ultra Wideband PathLoss for Each Receiver	L1 Loss	L2 Loss
60	RCV1	92.33	91.97	18	RCV1	50.33	49.97
	RCV2	87.00	86.47		RCV2	45.00	44.47
	RCV3	99.19	98.73		RCV3	57.19	56.73
	RCV4	86.73	86.21		RCV4	44.73	44.21
43	RCV1	75.33	74.97	16	RCV1	48.33	47.97
	RCV2	70.00	69.47		RCV2	43.00	42.47
	RCV3	82.19	81.73		RCV3	55.19	54.73
	RCV4	69.73	69.21		RCV4	42.73	42.21
40	RCV1	72.33	71.97	14	RCV1	46.33	45.97
	RCV2	67.00	66.47		RCV2	41.00	40.47
	RCV3	79.19	78.73		RCV3	53.19	52.73
	RCV4	66.73	66.21		RCV4	40.73	40.21
37	RCV1	69.33	68.97	12	RCV1	44.33	43.97
	RCV2	64.00	63.47		RCV2	39.00	38.47
	RCV3	76.19	75.73		RCV3	51.19	50.73
	RCV4	63.73	63.21		RCV4	38.73	38.21
34	RCV1	66.33	65.97	10	RCV1	42.33	41.97
	RCV2	61.00	60.47		RCV2	37.00	36.47
	RCV3	73.19	72.73		RCV3	49.19	48.73
	RCV4	60.73	60.21		RCV4	36.73	36.21
31	RCV1	63.33	62.97	8	RCV1	40.33	39.97
	RCV2	58.00	57.47		RCV2	35.00	34.47
	RCV3	70.19	69.73		RCV3	47.19	46.73
	RCV4	57.73	57.21		RCV4	34.73	34.21
28	RCV1	60.33	59.97	6	RCV1	38.33	37.97
	RCV2	55.00	54.47		RCV2	33.00	32.47
	RCV3	67.19	66.73		RCV3	45.19	44.73
	RCV4	54.73	54.21		RCV4	32.73	32.21
25	RCV1	57.33	56.97	4	RCV1	36.33	35.97
	RCV2	52.00	51.47		RCV2	31.00	30.47
	RCV3	64.19	63.73		RCV3	43.19	42.73
	RCV4	51.73	51.21		RCV4	30.73	30.21
22	RCV1	54.33	53.97	2	RCV1	34.33	33.97
	RCV2	49.00	48.47		RCV2	29.00	28.47
	RCV3	61.19	60.73		RCV3	41.19	40.73
	RCV4	48.73	48.21		RCV4	28.73	28.21
20	RCV1	52.33	51.97	0	RCV1	32.33	31.97
	RCV2	47.00	46.47		RCV2	27.00	26.47
	RCV3	59.19	58.73		RCV3	39.19	38.73
	RCV4	46.73	46.21		RCV4	26.73	26.21

For the acquisition tests, with the addition of the attenuation provided by the programmable attenuators, the total path losses for each test at a given programmable attenuator value are shown in table 7.

Table 7

Programmable Attenuator Setting (Db)	Actual Ultra Wideband PathLoss for Each Receiver	L1 Loss	L2 Loss	Programmable Attenuator Setting (Db)	Actual Ultra Wideband PathLoss for Each Receiver	L1 Loss	L2 Loss
5	RCV1	37.33	36.97	10	RCV1	42.33	41.97
	RCV2	32.00	31.47		RCV2	37.00	36.47
	RCV3	44.19	43.73		RCV3	49.19	48.73
	RCV4	31.73	31.21		RCV4	36.73	36.21
15	RCV1	47.33	46.97	20	RCV1	52.33	51.97
	RCV2	42.00	41.47		RCV2	47.00	46.47
	RCV3	54.19	53.73		RCV3	59.19	58.73
	RCV4	41.73	41.21		RCV4	46.73	46.21
25	RCV1	57.33	56.97	30	RCV1	62.33	61.97
	RCV2	52.00	51.47		RCV2	57.00	56.47
	RCV3	64.19	63.73		RCV3	69.19	68.73
	RCV4	51.73	51.21		RCV4	56.73	56.21
35	RCV1	67.33	66.97	40	RCV1	72.33	71.97
	RCV2	62.00	61.47		RCV2	67.00	66.47
	RCV3	74.19	73.73		RCV3	79.19	78.73
	RCV4	61.73	61.21		RCV4	66.73	66.21
45	RCV1	77.33	76.97				
	RCV2	72.00	71.47				
	RCV3	84.19	83.73				
	RCV4	71.73	71.21				

GPS Signal Levels

For each class of tests, two different GPS signal levels were utilized and are represented in the Min_Level and Live_Sky folders. The explanation of each signal level is as follows:

Live_Sky – Each Live_Sky test represents a test in which the power output of the simulator is adjusted to provide the same GPS power level at each receiver's antenna port as was seen during the normalization procedure. This resulted in the nominal simulator output power of –130 dBm being adjusted in the simulator by +17.5 dB. Taking into account the path loss from the GPS simulator to each receiver shown in Table 4, and adding in the 22 dB gain from the amplifier used in the GPS path, the GPS power level delivered to each receiver for live sky testing results in the values shown in table 8 below. Due to limited time constraints, only 3 UWB modes were tested for the Live_Sky GPS signal levels.

Table 8

Receiver	GPS L1 Power Delivered to Receiver (dBm)
RCV1	-116.78
RCV2	-111.1
RCV3	-123.58
RCV4	-111.1

Min_Level – Each Min_Level test represents a test in which the power output of the simulator is adjusted to provide the minimum GPS power level, –136 dBm, at receiver three's antenna port as determined by RTCA/DO 229B. This resulted in the nominal simulator output power of –130 dBm being adjusted in the simulator by +4.5 dB. Taking into account the path loss from the GPS simulator to each receiver shown in Table 4, and adding in the 22 dB gain from the amplifier used in the GPS path, the GPS power level delivered to each receiver for Min_Level testing results in the values shown in table 9 below. All UWB modes were tested for the Min_Level GPS signal levels.

Table 9

Receiver	GPS L1 Power Delivered to Receiver (dBm)
RCV1	-129.78
RCV2	-124.1
RCV3	-136.58
RCV4	-124.1

GPS Receiver Files

Each individual GPS receiver file is the raw output of the receiver for the particular test. The receiver files are in the manufacturer's proprietary format or NMEA. Table 10 lists the receiver designator, the manufacturer, the type of data file associated with the receiver, as well as the recommended data extraction/evaluation software.

Table 10

Receiver Designator	Receiver Manufacturer and Model Number	Data File Type	Recommended Data Evaluation Software
RCV1	Novatel 3151	Novatel Binary	Novatel's Checkchannel Software
RCV2	Ashtech Z-12	Ashtech Binary	Ashtech Evaluate
RCV3	Garmin 150 XL	NMEA	Microsoft Excel
RCV4	Ashtech Z-Sensor	Ashtech Binary	Ashtech Evaluate

It is recommended that the appropriate tools be utilized to extract the data from each receiver file.

GPS receiver Messages

For each receiver, the following messages, and their associated data, were collected:

NovAtel 3151 (RCV1):

- REPB ((Raw Ephemeris) NovAtel Command Descriptions Manual, p. 70):
  - PRN;
  - Subframe 1 of ephemeris data;
  - Subframe 2 of ephemeris data;
  - Subframe 3 of ephemeris data;

- RGEC ((Channel Range Measurements) NCDM, p. 71):
  - GPS week;
  - GPS second of week (SoW);
  - Satellites in View (SiV);
  - Receiver self-test status;
  - FOR (int i = 1; i <= SiV; i++){
    - PRN;
    - Pseudorange;
    - Pseudorange standard deviation;
    - Carrier phase;
    - Carrier Doppler frequency (instantaneous);
    - C/N0;
    - Locktime;
    - Tracking state;}

- SATB (Satellite Specific Data) NCDM, p. 77):
  - GPS week;
  - GPS SoW;
  - Solution status;
  - SiV;
  - FOR (int i = 1; i <= SiV; i++){
    - PRN;
    - Azimuth angle;
    - Elevation angle;
    - Residual;
    - Reject code;}

Ashtech Z-12 (RCV2) & Z-Sensor (RCV4):

- ALM (Almanac (Z Family Technical Reference, p. 145)):
  - PRN;
  - Health;
  - Eccentricity;
  - Reference time for orbit;
  - Inclination angle at reference time;
  - Rate of right Asc.;
  - (Semi-major axis)^(0.5);
  - Lon of Asc. node;
  - Argument of perigee;
  - Mean anomaly at reference time;
  - af0;
  - af1;
  - Almanac week number;
  - GPS week;

GPS SoW;

MPC (ZFTR, p. 138):

PRN;
Elevation angle;
Azimuth angle;
Channel;
FOR (i = C/A Code Block Data, PL1 Code Data Block, PL2 Code Data Block){
S/N;
Full carrier phase;
Code xmit time;
Doppler measurement;
Range smoothing correction;
Range smoothing quality;}

PBN (Position (ZFTR, p. 141)):

GPS SoW;
Position X, Y, Z (ECEF);
Latitude;
Longitude;
Altitude;
Velocity X, Y, Z (ECEF);
Number of satellites used position calculation;
PDOP;
HDOP;
VDOP;
TDOP;

SNV (Ephemeris Data (ZFTR, p. 146)):

GPS week;
GPS SoW;
Tgd. group delay;
Iodc. clock data issue;
toc. second;
af2;
af1;
af0;
IODE Orbit data issue;
Mean anomaly correction;
Mean anomaly at reference time;
Eccentricity;
(Semi-major axis)^(0.5);
Reference time for orbit;
Cic. harmonic correction term;
Crc. harmonic correction term;
Cis. harmonic correction term;
Crs. harmonic correction term;
Cuc. harmonic correction term;
Cus. harmonic correction term;
Lon of Asc. node;
Argument of perigee;
Inclination angle at reference time;

Rate of inclination;
Accuracy;
Health;
Curve fit interval;
PRN;

Garmin 150XL (RCV3):

GPBOD (Bearing Origin to Destination (Garmin Fax, p. 1)):
Bearing (true);
Bearing (magnetic);

GPGGA (GPS Fix Data (GF, p.2)):
UTC time (HHMMSS);
Latitude;
Longitude;
GPS quality (no fix | GPS fix | DGPS fix);
Number of satellites in use;
HDOP;
Antenna altitude (MSL);
Geoidal separation differnce between WGS84 and MSL);

GPGSA (GPS DOP and Active Satellites (GF, p. 2)):
Mode (no fix | 2D Fix | 3D fix);
SiV;
PDOP;
HDOP;
VDOP;

GPGSV (GPS Satellites in View (GF, p. 2)):
SiV;
FOR (int i = 1; i <= SiV; i++){
PRN;
Elevation angle;
Azimuth angle;
S/N;}

GPRMC (GPS and Transit Specific (GF, p. 4)):
UTC1 time (HHMMSS);
Position valid (T | F);
Latitude;
Longitude;
Speed over ground;
Course over ground;
Date;
Magnetic variation;

GPWPL (Waypoint Location (GF, p. 3)):
Nothing useful here;

PGRME (Proprietary Garmin Altitude (GF, p. 3)):

Estimated horizontal position error (HPE);
HPE measure;
Estimated vertical position error (VPE);
VPE measure;
Estimated position error (EPE);
EPE measure;

UWB Operational Modes

The following 18 Ultra Wideband operational modes have been tested in the Min_Level tests, each representing a different combination of parameters outlined in table 11.

Table 11

UWBMode #	Nominal PRF	On Time	Off Time	Duty Cycle
	(MHz)	(ms)	(ms)	%
1	1	na	0	100
2	1	1	1	50
3	1	4	4	50
4	1	10	10	50
5	1	2	6	25
6	1	8	4	66
7	5	na	0	100
8	5	1	1	50
9	5	4	4	50
10	5	10	10	50
11	5	2	6	25
12	5	8	4	66
13	10	na	0	100
14	10	1	1	50
15	10	4	4	50
16	10	10	10	50
17	10	2	6	25
18	10	8	4	66