I. Contents

II. General remarks

All file format versions of the AG50x up to version V003 have in common that the sampled data (measurement data) is stored as binary data in a file. The sample width (size of the one sample in byte) of the binary section corresponds directly to the number of channels of the system whereas the channel width/size is identical for pos-files (28 bytes) but depends on the number of transmitters of the system for amp-files (6 transmitters for AG500 (24 bytes), 9 transmitters for AG501 (36 bytes)).

File format versions V003 and V002 include a header-section in ASCII-format preceding the binary-section containing the file format version number, sampling frequency, number of channels and additional information. The header section of a file can be displayed with the program cs5bin2ascii.

Since this header-section is missing in the AG500 file format and the file-format version V001, if in doubt, to distinguish the amplitude-files of these file-types (the position-files are identical) it is necessary to analyze an ini-file created for the amplitude-file. The ini-file contains the calibration factors for each channel (matching the number of transmitters of the system) of the corresponding sweep. So the ini-files of the AG500 contain six calibration factors per channel whereas the ini-files of the AG501 V001 contain nine calibration factors per channel.

III. AG501 data format for 8 to 24 channels (V003)

A. Measurement and position data

1. Amplitudes – amps

The data of the movement recording with cs5recorder are stored in the folder
/data/recorder/current/amps/

For each sweep one *.amp file is created.

The *.amp file contains the recorded samples. One sample consists of nine decoded amplitudes for each channel according to the nine transmitters. This set of amplitudes is recorded 250 times per second.

2. Calculated position and orientation – rawpos

The CalcPos program uses the amps to calculate the position and orientation for each sample. The format is binary and contains x, y, z, Phi, Theta, RMS, and an extra word.

3. Head movement corrected data – pos

The result of the NormPos program looks similar to the rawpos files. The co-ordinate system for each sample is shifted and rotated in a way that all reference sensors remain at the same place. With this the head movement is eliminated.

4. Audio data – wav

In case the data recording is combined with sound recording, there is an additional folder that contains one *.wav file for each sweep.

B. Structure of *.amp- and *.pos-files

The amplitude- and position-files (amp- and pos-files) are stored as binary data files including two sections, the header-section including file-format information and measurement details and the data section containing the sweep-data.

1. The header-section of *.amp- and *.pos-files

The header section starts with two lines containing the AG50x-file-format version (AG50xDATA_V003) in the first line and the full size of the header section as an eight digit number (70 bytes in Figure 1) in the second line. Since each line of the header section is terminated by a line feed (LF), these two lines make up the first 24 bytes of the file.

Following the initial two lines, the number of channels (8, 16 or 24) and the sampling frequency, which is variable, are specified.

The header-section is terminated by a #0-character and filled with filling data up to the beginning of the binary data section.

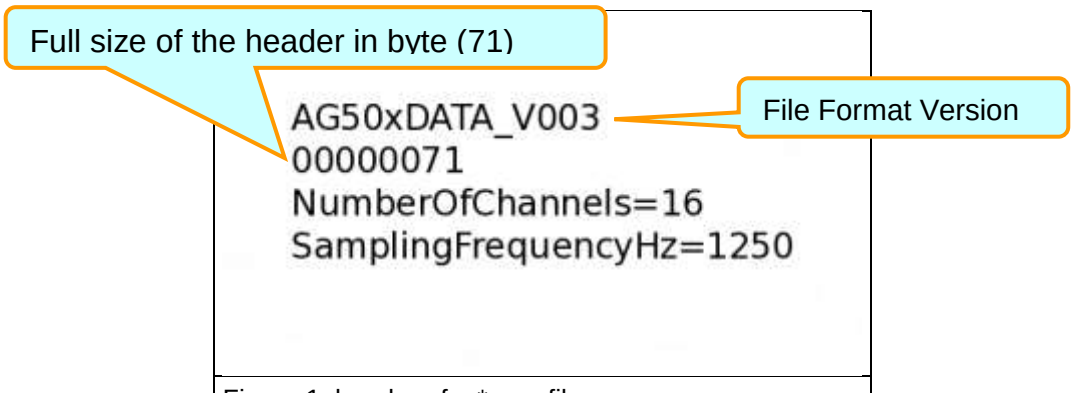

Figure 1: header of a *.pos-file

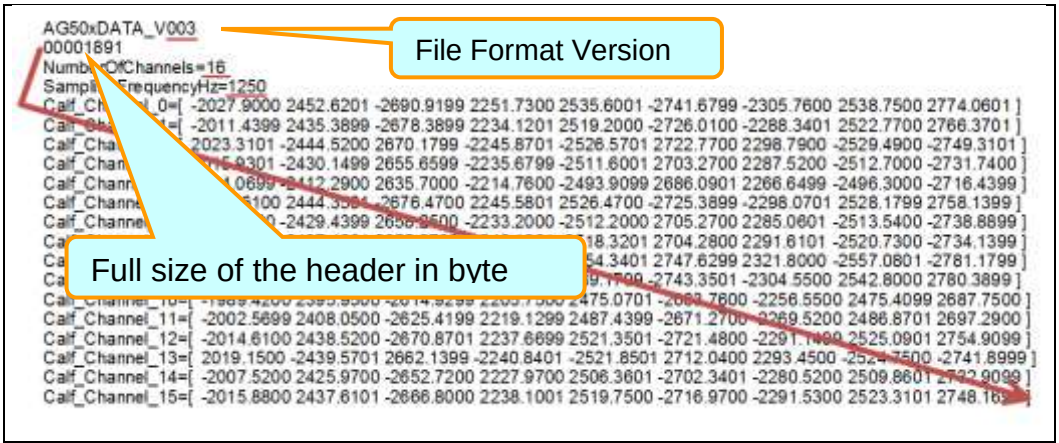

Figure 2: header of an *.amp-file

The header of the amplitude-files also contains the calibration factors of each channel (Figure 2).
Additional information can be added to the header. However it is recommended to add the program name as a prefix to the custom information (for example “myProgram_SweepComment = ...”) in the header-section to avoid conflicting key-value pairs.

2. The data section of *.amp files

The data section starts following the header. The offset in bytes is specified in line two of the header section. The amps are stored as 4 byte 'single precision' values.
A whole sample comprises 8, 16 or 24 channels and nine values per channel adding up to 72, 144 or 216 values and 288, 576 or 864 bytes per sample. The samples are written sequentially in the *.amp file as shown in the following table:

Sample 1													Sample 2				
Channel 1						…	Channel 8 / 16 / 24						Channel 1				
S1	S2	S3	S4	..	S9	…	S1	S2	S3	S4	..	S9	S1	S2	S3	S4	…

288 / 576 / 864 bytes

S1 to S9 are the measured amplitudes of the transmitter coils 1 to 9. These values are already normalized by the calibration factors. They are directly comparable to the expected amplitudes which are calculated using a mathematical model of the magnetic field.

3. The data section of *.pos files

The data section of the pos-files also follows the header (the offset is specified in the header). The calculated positions are saved as 4 byte 'single precision' values. A whole sample comprises 8, 16 or 24 channels and 7 values per channel. This makes it 56, 112 or 168 values and 224, 448 or 672 bytes per sample. The samples are written sequentially in the *.pos file as shown in the following table:

Sample 1															Sample 2				
Channel 1							…	Channel 8 / 16 / 24							Channel 1				
x	y	z	phi	theta	rms	extra	…	x	y	z	phi	theta	rms	extra	x	y	z	phi	…

224 / 448 / 672 bytes

x, y, and z represent the position of the corresponding sensor at this moment. phi and theta describe the alignment of the sensor. The rms value reflects the 'root mean square' between the expected and the measured transmitter amplitudes.
The extra field is reserved for future use.

IV. AG501 data format for 16 channels (V002)

A. Measurement and position data

1. Amplitudes – amps

The data of the movement recording with cs5recorder are stored in the folder
/data/recorder/current/amps/

For each sweep one *.amp file is created.

The *.amp file contains the recorded samples. One sample consists of nine decoded amplitudes for each channel according to the nine transmitters. This set of amplitudes is recorded 250 times per second.

2. Calculated position and orientation – rawpos

The CalcPos program uses the amps to calculate the position and orientation for each sample. The format is binary and contains x, y, z, Phi, Theta, RMS, and an extra word.

3. Head movement corrected data – pos

The result of the NormPos program looks similar to the rawpos files. The co-ordinate system for each sample is shifted and rotated in a way that all reference sensors remain at the same place. With this the head movement is eliminated.

4. Audio data – wav

In case the data recording is combined with sound recording, there is an additional folder that contains one *.wav file for each sweep.

B. Structure of *.amp- and *.pos-files

The amplitude- and position-files (amp- and pos-files) are stored as binary data files including two sections, the header-section including file-format information and measurement details and the data section containing the sweep-data.

1. The header-section of *.amp- and *.pos-files

The header section starts with two lines containing the AG50x-file-format version (AG50xDATA_V002) in the first line and the full size of the header section as an eight digit number (70 bytes in Figure 3) in the second line. Since each line of the header section is terminated by a line feed (LF), these two lines make up the first 24 bytes of the file.

Following the initial two lines, the number of channels (16) and the sampling frequency are specified (250 Hz). Since the file-format V002 only works with 16 channels and 250 Hz this information is fixed and does not need parsing.

The header-section is terminated by a #0-character and filled with filling data up to the beginning of the binary data section.

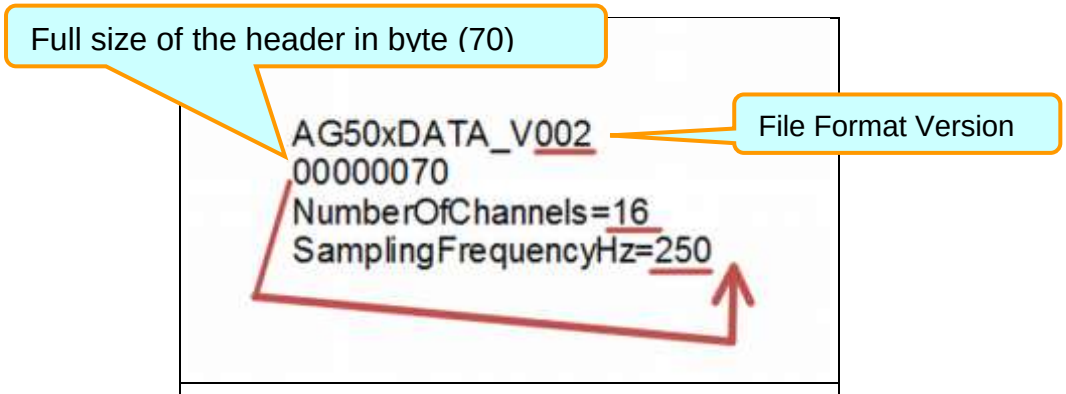

Figure 3: header of a *.pos-file (V002)

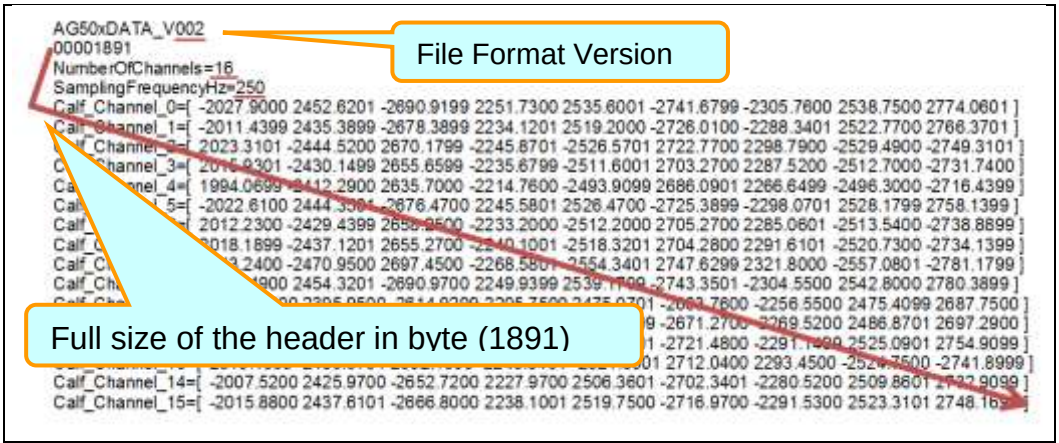

Figure 4: header of an *.amp-file (V002)

The header of the amplitude-files also contains the calibration factors of each channel (Figure 4).

2. The data section of *.amp files

The data section starts following the header. The offset in bytes is specified in line two of the header section. The amps are stored as 4 byte 'single precision' values. A whole sample comprises 16 channels and nine values per channel. These are 144 values and 576 bytes per sample. The samples are written sequentially in the *.amp file as shown in the following table:

Sample 1													Sample 2				
Channel 1						…	Channel 16						Channel 1				
S1	S2	S3	S4	..	S9	…	S1	S2	S3	S4	..	S9	S1	S2	S3	S4	…

576 bytes

S1 to S9 are the measured amplitudes of the transmitter coils 1 to 9. These values are already normalized by the calibration factors. They are directly comparable to the expected amplitudes which are calculated using a mathematical model of the magnetic field.

3. The data section of *.pos files

The data section of the pos-files also follows the header (the offset is specified in the header). The calculated positions are saved as 4 byte 'single precision' values. A whole sample comprises 16 channels and 7 values per channel. This makes it 112 values and 448 byte per sample. The samples are written sequentially in the *.pos file as shown in the following table:

Sample 1															Sample 2				
Channel 1							…	Channel 16							Channel 1				
x	y	z	phi	theta	rms	extra	…	x	y	z	phi	theta	rms	extra	x	y	z	phi	…

448 byte

x, y, and z represent the position of the corresponding sensor at this moment. phi and theta describe the alignment of the sensor. The rms value reflects the 'root mean square' between the expected and the measured transmitter amplitudes.

The extra field is reserved for future use.

V. AG501 data format for 12 channel (V001)

This data format is valid for all early program revisions before service pack 2.0. These data have no header in the *.amp and *.pos files.

A. Measurement and position data

1. Amplitudes - amps

The data of the movement recording with cs5recorder are stored here. For each sweep one *.ini file and one *.amp file is created.

The *.ini file (ASCII) contains the nine calibration factors for each channel.

The *.amp file (binary) contains the recorded samples. One sample consists of nine decoded amplitudes for each channel according to the nine transmitters. This set of amplitudes is recorded 200 times per second.

2. Calculated position and orientation - rawpos

The CalcPos program uses the amps to calculate the position and orientation for each sample. The format is binary and contains x, y, z, Phi, Theta, RMS, and an extra word. The extra word is for future use.

3. Head movement corrected data – pos

The result of the NormPos program looks similar to the rawpos files. The co-ordinate system for each sample is shifted and rotated in a way that all reference sensors remain at the same place. With this the head movement is eliminated.

4. Audio data - wav

In case the data recording is combined with sound recording, there is an additional folder that contains one *.wav file for each sweep.

B. File formats

1. *.amp files

The amps are stored in a binary file as 4 byte single values. A whole sample comprises 12 channels and nine values per channel. This makes it 108 values and 432 bytes per sample. The samples are written sequentially in the *.amp file as shown in the following table:

Sample 1													Sample 2				
Channel 1						…	Channel 12						Channel 1				
S1	S2	S3	S4	..	S9	…	S1	S2	S3	S4	..	S9	S1	S2	S3	S4	…

432 byte

S1 to S9 are the measured amplitudes of the transmitter coils 1 to 9. These values are already normalized by the calibration data. They are directly comparable to the expected amplitudes which are calculated using a mathematical model of the magnetic field.

2. *.pos files

The calculated positions are stored in a binary file as 4 byte single values. A whole sample comprises 12 channels and 7 values per channel. This makes it 84 values and 336 bytes per sample. The samples are written sequentially in the *.pos file as shown in the following table:

Sample 1															Sample 2				
Channel 1							…	Channel 12							Channel 1				
x	y	z	phi	theta	rms	extra	…	x	y	z	phi	theta	rms	extra	x	y	z	phi	…

336 byte

x, y, z represent the position of the corresponding sensor at this moment. phi and theta describe the alignment of the sensor. The rms value reflects the 'root mean square' between the expected and measured transmitter amplitudes.

The extra field is reserved for future use.

The data format for the *.pos files is exactly the same as in the AG500 data.

VI. AG500 data format

A. Measurement and position data

1. Amplitudes - amps

The data of the movement recording with cs5recorder are stored here. For each sweep one *.ini file and one *.amp file is created.

The *.ini file (ASCII) contains the six calibration factors for each channel.

The *.amp file (binary) holds the recorded samples. One sample consists of six decoded amplitudes for each channel according to the six transmitters. This set of amplitudes is recorded 200 times per second.

2. Calculated position and orientation - rawpos

The CalcPos program uses the amps to calculate the position and orientation for each sample. The format is binary and contains x, y, z, Phi, Theta, RMS, and an extra word. The extra word is for future use.

3. Expected amplitudes at "rawpos" - posamps

The calculated position and orientation (rawpos) is used to calculate the expected amplitudes. The calculated reference values is based on the mathematical field model from the six transmitters which are stored as posamps.

4. Head movement corrected data - pos

The result of the NormPos program looks similar to the rawpos files. The co-ordinate system for each sample is shifted and rotated in a way that all reference sensors remain at the same place. With this the head movement is eliminated.

5. Audio data - wav

In case the data recording is combined with sound recording, there is an additional folder that contains one *.wav file for each sweep.

B. File formats

1. *.amp files

The amps are stored in a binary file as 4 byte single values. A whole sample comprises 12 channels and six values per channel. This makes it 72 values and 288 bytes per sample. The samples are written sequentially in the *.amp file as shown in the following table:

Sample 1													Sample 2				
Channel 1						…	Channel 12						Channel 1				
S1	S2	S3	S4	S5	S6	…	S1	S2	S3	S4	S5	S6	S1	S2	S3	S4	…

288 byte

S1 to S6 are the measured amplitudes of the transmitter coils 1 to 6. These values are already normalized by the calibration factor. They are directly comparable to the expected amplitudes which are calculated using a mathematical model of the magnetic field. The expected amplitudes are stored in the 'posamps' folder in the same format.

2. *.pos files

The calculated positions are stored in a binary file as 4 byte single values. A whole sample comprises 12 channels and 7 values per channel. These are 84 values and 336 byte per sample. The samples are written sequentially in the *.pos file like shown in the following table:

Sample 1															Sample 2				
Channel 1							…	Channel 12							Channel 1				
x	y	z	phi	theta	rms	extra	…	x	y	z	phi	theta	rms	extra	x	y	z	phi	…

336 byte

x, y, z represent the position of the corresponding sensor at this moment. phi and theta describe the alignment of the sensor. The rms value reflects the 'root mean square' between the expected and measured transmitter amplitudes.

The extra field is reserved for future use.

The data format for the *.pos files is exactly the same as in the 12 channel data of the AG501.

VII. Revision history - AG501-data-format

Date	Revision	Annotation
June 12th, 2012	1	Initial Carstens Release
November 5th, 2012	2	new 16 channel / 250 Hz data format for AG501
February 7th, 2013	3	Grammar & spelling, readability (by Johannes)
February 20th, 2014	4	Data version V003 added