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Revision 5

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## II. Conventions

### ➤ An important advice is indicated by the following symbol:



It refers to a separate document (i.e. manual) which contains further information. **Since all manuals are directly linked, it is required that they are all kept in one folder!**

### A. FCC Declaration of Conformance:

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

- (1) This device may not cause harmful interference, and
- (2) This device must accept any interference received, including interference that may cause undesired operation.

**FCC Caution:** Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

### B. Safety instructions:



**Please read the document “AG501 security information” carefully before using the Articulograph AG501 for the first time!**



**The user is obliged to inform himself about the local regulations.**

### C. Environment:

Avoid exposing the gadget to varying temperatures. It might result in inaccurate data. Keep the AG501 away from electrically conductive material. Electromagnetic interference may have an influence on the test reading. Very small electrically conductive parts, however, are negligible.

Apart from those three points, a usual laboratory environment is sufficient to guarantee that the system runs smoothly.

### III. Principle function of the Articulograph AG501

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The Articulograph AG501 allows the digital recording and presentation and evaluation of the movements of the articulators (tip and body of tongue, lips, lower jaw, and soft palate) during speech production. Its principle function is based on the inductive measurement of distances.

Nine transmitter coils are fixed inside the Transmitterholder, each of them producing an alternating magnetic field at different frequencies. Four to sixteen sensors - which come as small coils - are attached to the articulators of the subject using physiological glue. The head of the subject has to be positioned within the spherical measuring range underneath the Transmitterholder.

The alternating magnetic field induces alternating currents in the sensor just as is happening in a transformer. It can be registered as analogous signals. The strength of the induced current is a function of the distance and the angle of the sensor to the respective transmitter coil. Therefore, and because of the different frequencies of the transmitters, it is possible to simultaneously obtain the amplitudes of each sensor from all of the transmitter coils.

The combination of 9 amplitudes (one from each transmitter) allows the evaluation of the position and orientation of each sensor.

The E-Box contains special soft- and hardware to control all of the functions of the Articulograph AG501:

1. the transmitter's signal strength and frequencies
2. the analog sensor signals are digitized and evaluated
3. motor control and position measuring for the circal calibration unit

The synchronous recording of the acoustic signal is achieved with the Alesis iO2 EXPRESS sound card.

The signals are digitized and evaluated regarding temporal and geometric parameters. Those are combined with the synchronously recorded acoustic signal. By means of reference sensors, distractive head movements (which are independent from speech) can be subtracted after recording. This is usually done in order to get the movement of the articulators independent of the head movement. After this correction, the measured points correspond to the three coordinate planes of motion (x; y; z) and two angles ( $\varphi$ ;  $\theta$ ).

#### IV. The parts of the Articulograph AG501

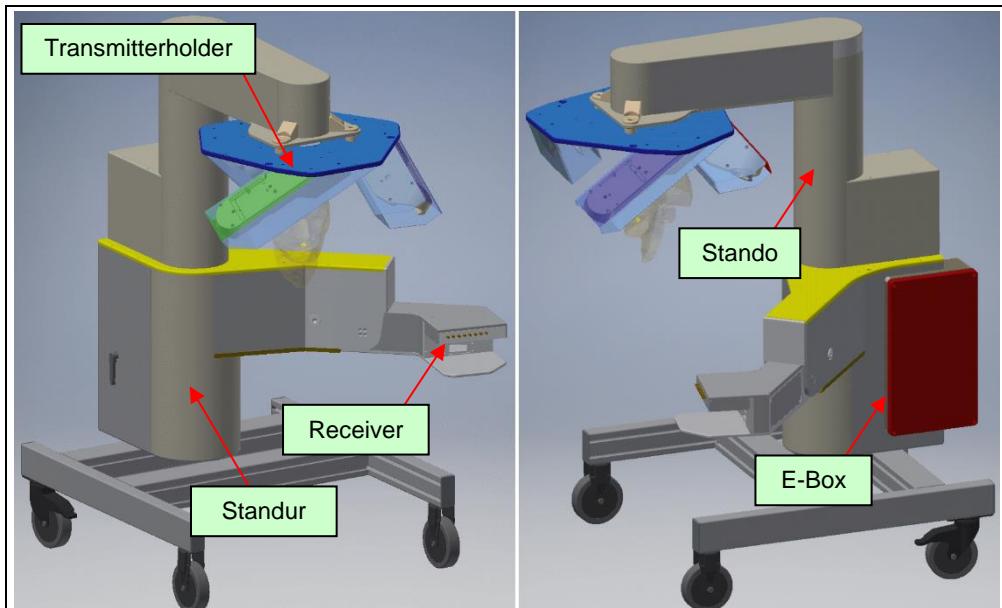


Figure 1: Articulograph AG501

##### A. E-Box

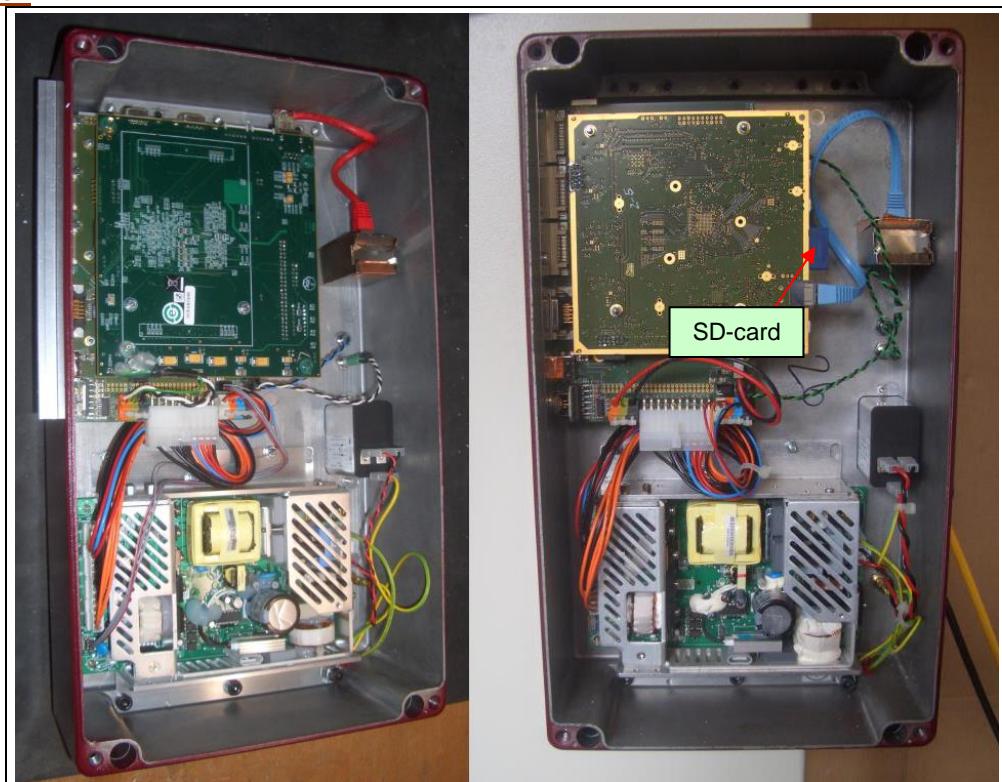


Figure 2: E-Box without cover with Microblaze-board (left) and Z2-FPGA (right)

The E-Box contains the main electronics of the AG501. System-wise it is connected to the

- Receiver
- Transmitter
- Sybox

The linking with peripherals is established via a network connection with the control server.

## B. Transmitterholder

The Transmitterholder is attached to the Stando and is height-adjustable by moving the housing up or down. Loosen the black handle opposite the E-box by turning it clockwise (gentle force may be needed) and push the whole gadget up or down. Tighten the handle when the device is adjusted to the required height. The Transmitterholder defines the measuring area and is positioned above the top of the subjects head. The 9 transmitter coils - which generate the alternating magnetic field - are embedded in the 3 'arms' of the Transmitterholder.

**Do not adjust the height while the subject is under the Transmitterholder**

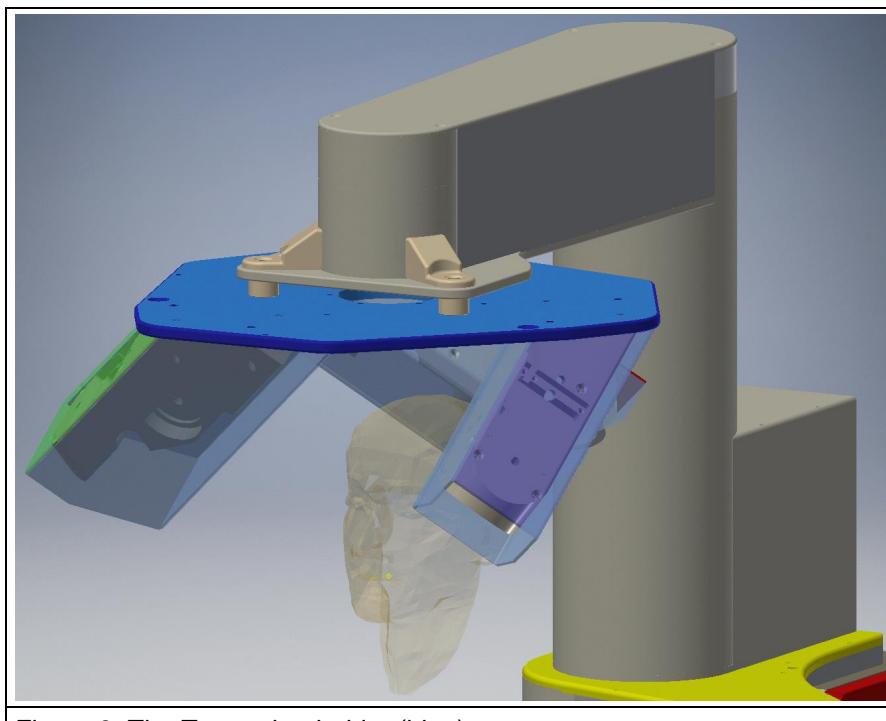


Figure 3: The Transmitterholder (blue)

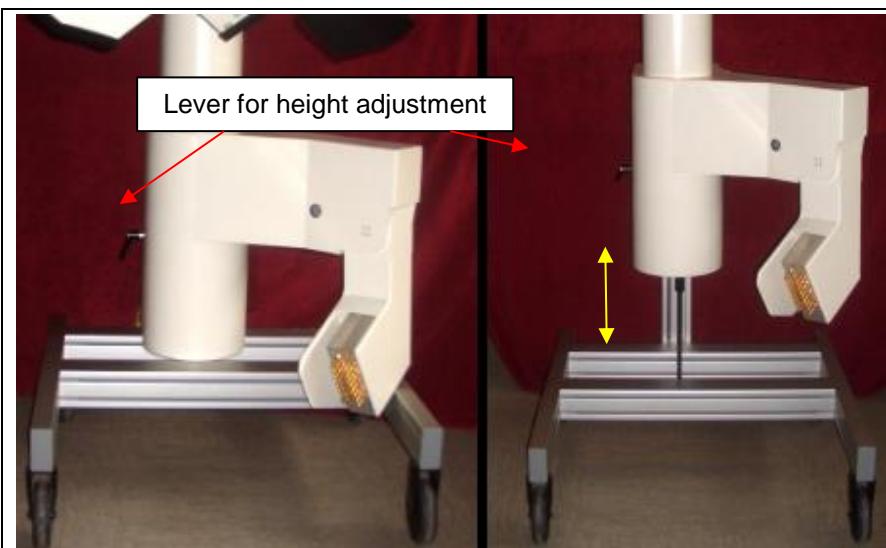


Figure 4: To adjust the height of the AG501 loosen the lever and move the housing up or down.

**Do not adjust the height while the subject is under the Transmitterholder**

### C. Receiver



Figure 5: Receiver

The receiver records the signals of the induced currents. The Articulograph AG501 is designed to receive the signals from up to 24 sensors synchronously. The signals are passed on to the E-Box for further processing.

### D. Sybox



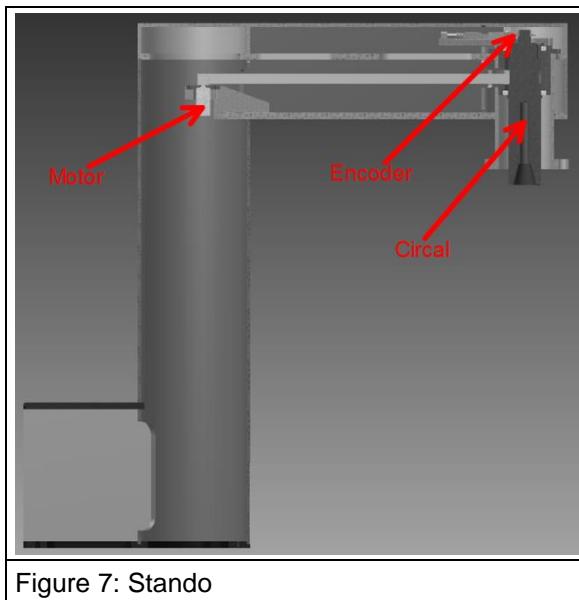
Figure 6: Sybox front side – Sybox 2 (top) and Sybox-Opto4 (bottom)

The Sybox provides the synchronization of AG501 position data with sound data and additional custom devices. It may be further adapted for special purposes. Comprehensive documentation is available.



[ag501\\_sound.pdf](#)

## E. Stando



The Stando is the upper part of the Ag501 housing. It holds the 'Transmitterholder' and contains the Circal.

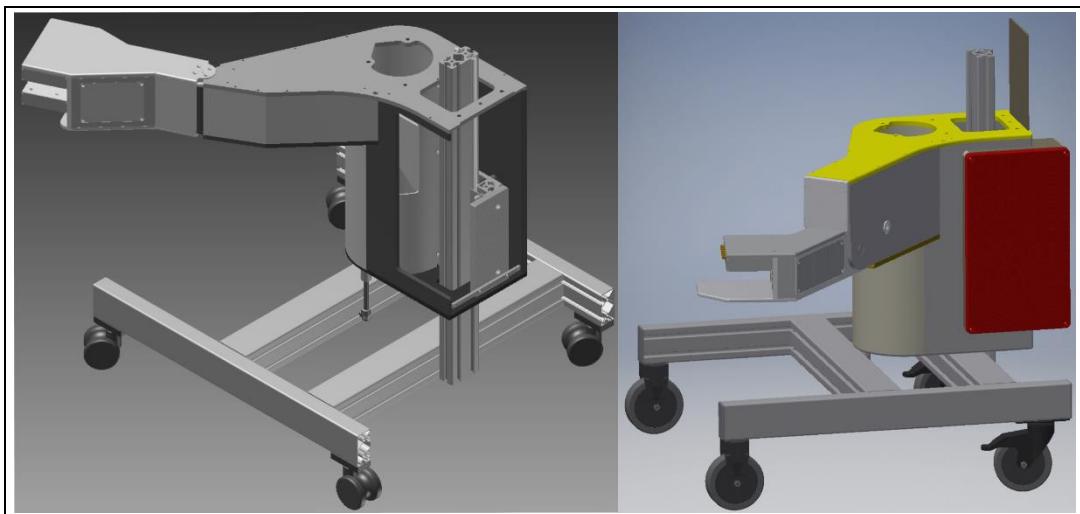
### 1. Circal

The Circal is used for the sensor calibration. The lower part (foot) is detachable. The disc is part of the foot and has 4 gaps. Each gap takes one magazine, which again can hold 4 Sensors.



[ag501-cs5cal.pdf](#)

## F. Standur



### G. Sensors HQ220-L120-B

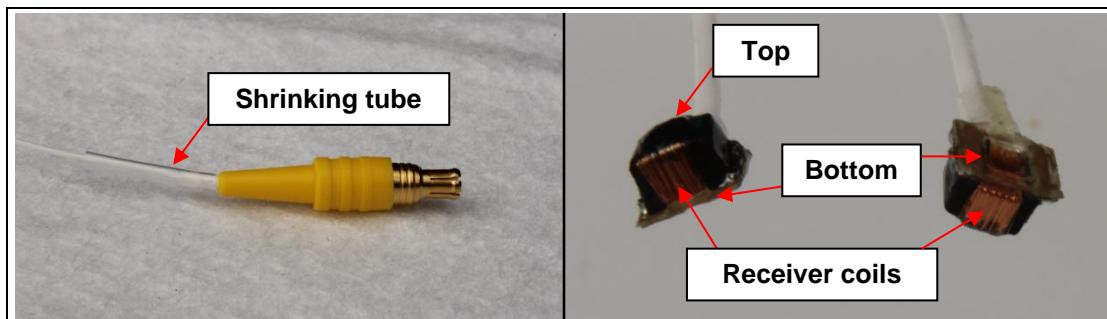


Figure 9: Sensors HQ220-L120-B

The sensors HQ220-L120-B contain the receiver coils, which are attached with the flat surface on the bottom to the articulators of the subject.

The transparent shrinking tube can be used **to fix small cracks in the insulation** of the sensor cable.

### H. Control server



Figure 10: Dell Latitude E6520

The Dell Notebook 'Latitude E6520' with the Linux operating System 'CentOS' operates as a control server. It is connected to the E-Box via a standard network cable and to the Alesis iO2 EXPRESS sound card via an USB-cable.

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## V. Commissioning

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### A. Unboxing and setting up the AG501

The AG501 can be set up and running within minutes. Just follow these steps to get going. A description with all steps covered in detail can be found in the document [ag501-unboxing\\_setup.pdf](#).

- Remove the cardboard packaging and padding material
- Attach the wheels of the AG501
- Arrest the arm of the AG501
- Connect the cables of the AG501
- Start the Control Server and log in as user *csop*
- Open the AG501 user guide to learn about calibration and measuring



[ag501-unboxing\\_setup.pdf](#)

If needed, set up the sound system of the AG501 for audio recording.



[ag501\\_sound.pdf](#)

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## VI. Performing an investigation

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The following steps outline the general procedure for performing an investigation:

- [Warm up](#) the AG501 for 15 minutes (power on)
- [System check](#) (cs5diag)
- [Calibration of sensors](#) (cs5cal)
- [Recording data](#) (cs5recorder (data recording) and cs5view (real-time view))
- [Position calculation](#) (cs5calcpes)
- [Head Correction](#) (cs5normpos)
- [Exporting data](#) (cs5bin2ascii)

### A. Preparations

#### 1. Warm-up

In order to reach a stable temperature, the Articulograph AG501 needs to warm up for 15 minutes. Plug in the power cord and turn on the main switch.

#### 2. System check

If in doubt if the system is working, it is recommended to run a quick check with the AG501-diagnostics software.



[ag501-cs5diag.pdf](#)

### 3. Calibration

Prior to a recording session, the respective sensors need to be calibrated. A calibration is valid for a dedicated sensor setup. Each sensor belongs to one particular channel.

It's recommended to mark each sensor with a different color or number to be able to relate it to the respective channel later. Note that the calibration may take up to 20 minutes. The calibration procedure is described in:



[ag501-cs5cal.pdf](#)

### 4. Preparing the sensors

#### a) Function test

Since the sensor leads are very thin, broken wires are a common problem.

Start-up the Articulograph AG501 and plug in the sensor to be tested. Start the cs5recorder- and the cs5view program.



[ag501-cs5recorder.pdf](#) and [ag501-cs5view.pdf](#)

Perform a dummy recording, move the sensors inside the measuring area, and check if you get feasible results. Do another recording with the sensors attached to the calibration unit. During recording, move only the leads and then calculate the positions or look for the amplitudes. Significant position changes would indicate damaged sensor leads of the corresponding sensor.

#### b) Cleaning and disinfection sensors

In order to avoid cross-contaminations caused by the reuse of sensors, appropriate hygienic measures must be taken in order to minimize the possibility of contamination. It has to be carefully considered whether disinfecting or even sterilizing the sensors is needed.

Immediately after use, the sensors should be cleaned cautiously and thoroughly. The same conditions that are recommended for surgical instruments apply. Before sensors are reused with another subject, they should be disinfected and sterilized. It is the user's duty to guarantee that the chosen means of cleaning meet the required standards of hygiene (check local regulations) as well as the operational indication of the Articulograph AG501.

It is recommended to coat the sensors before attaching them to the articulators. The sensors can be covered with latex which can simply be removed after the examination. Latex keeps the sensors in a clean condition.

Further tips and recommendations by experienced AG500 and AG501 users regarding the preparation of the sensors can be found on our website: [www.articulograph.de](http://www.articulograph.de)

## 5. Mounting the sensors

### a) Affixing the sensors

Further tips and recommendations by experienced AG500 and AG501 users regarding the application of the sensors can be found on our AGwiki site: <http://wiki.ag500.net/>



**Minimum distance between sensors: 8mm**

### b) Affixing sensors to teeth

CAUTION! Physiological glue can damage artificial teeth! It is the user's responsibility to decide whether a particular method for affixing the sensors is applicable in a particular case or not.

### c) Reference sensors

To be able to erase head movement from the recorded data, it is needed to place reference sensors on the head of the subject (usually on the side). They should be affixed to a place that does not move during speech production, e.g. above or behind the ears or on the bridge of the nose.



Information on head movement normalization [ag501-cs5recorder.pdf](#) chapter F

## 6. Grounding the subject

The subject needs to be grounded with a grounding clamp to reduce interferences.

Connect the plug to the gold-plated ground socket of the E-Box.

## 7. Adjusting the height of the Transmitterholder

In order to obtain reasonable data, all sensors need to be within the spherical measurement range of the Transmitterholder. The measurement range reaches 150mm around the center of the Transmitterholder. To control this, record a short sweep and calculate the raw-positions at the beginning of an investigation. The distance of each sensor from the center must not be more than 150mm.

## B. Recording data

Start cs5recorder and cs5view.



[ag501-cs5recorder.pdf](#) and [ag501-cs5view.pdf](#)

## C. Analyzing data

### 1. Calculating the positions



[ag501-cs5recorder.pdf](#) chapter E

### 2. Performing head correction



[ag501-cs5recorder.pdf](#) chapter F

[ag501-cs5normpos.pdf](#)

### 3. Converting data files

The internally used data format is binary (see next paragraph 4. *Data format*). For some applications, it might be useful to convert the data into a text format. For this use the program cs5bin2ASCII.



[ag501-cs5bin2ascii.pdf](#)

### 4. Data format

The recorded and calculated data is saved as binary files. The structure is documented in the following file.



[ag501-data-format.pdf](#)

## D. Shutting down the Articulograph AG501

Switch off the E-Box and shut down the control server.

## VII. Troubleshooting

### A. Hints on possible sources of errors

➤ Grounding of the subject	12
➤ Damaged sensor leads.	11
➤ Large metal surface area close to the AG501.	3
➤ Gadget exposed to carrying temperatures or too short warm-up.	3/10
➤ Sensor set-up has been changed after calibration.	11
➤ Sensors to close together.	12

### B. Logfiles

When you encounter problems with the controlserver, we kindly ask you to generate logfiles of your controlserver and send them to us.

To generate AG501 logfiles please follow these steps:

- Open a web browser and visit <http://wiki.ag500.net/Logfiles> to download the latest version of the log-file-application
- Turn on controlserver
- Copy log-file-application to home folder of the controlserver (or run directly from connected USB stick)
- Start the application by double clicking and follow the instructions  
*NOTE: Although the software acts just like a software update, it does not install any software. It just collects system information necessary for trouble shooting and debugging.*
- Find the generated GPG-file and send it via e-mail to us ([support@articulograph.de](mailto:support@articulograph.de)). The file is named csxx-logs-yyyyMMdd-hhmm.gpg (xx = cs-number; yyyyMMdd = date; hhmm = time) and located in the `/home/csop` folder.
- If you are interested in the content that is included in the gpg-file, there is a second file (tbz-archive) with identical content that is not encrypted.
- You may delete both files after sending the GPG-file to us.

### C. Calibration data

If you need feedback concerning your calibration results (possible causes of error, quality of calibration etc), you can send the compressed calibration data for analysis purposes to us ([support@articulograph.de](mailto:support@articulograph.de)).

You can either pack the calibration data during the calibration process as described in the [cs5cal-manual](#) or pack the calibration data manually.

The command to compress calibration data is

`tarcal {name}.calset`

To execute this command, it is necessary to change to the folder of the desired calibration set. It will create an archive file (\*.tbz) in the `../data/calibration` folder. The name of this archive is the same as the name of the calibration set with the extension `*.tbz`.

The following example shows the command lines to generate the archive from the "inter2" calibration set for an AG501-system:

```
csop@cs61:/> cd /data/calibration/inter2
csop@cs61:/data/calibration/inter2> tarcal inter2.calset
Created /data/calibration/inter2.tbz
```

The archive is found in the calibration folder: `/data/calibration`.

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## VIII. Parts of the Articulograph AG501

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### A. Articulograph AG501

- Articulograph AG501
- Circlal calibration system with magazines
- Initial set of sensors
- Grounding cable

### B. Sound system

- Sybox
- Alesis USB Audio interface
- Condensor microphone
- Cable connections

### C. Control server

- Dell Latitude Laptop
- Power supply
- Computer mouse
- Network connection cable

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## IX. Legend

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Caution! Possible cause of risk

Pay attention to further info

refers to a separate document which contains further information. **Since all manuals are directly linked, it is required that they are all saved in one folder!**

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## X. Revision history - AG501 Manual

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Date	Revision	Annotation
June 6 <sup>th</sup> , 2012	1	Initial Carstens Release
February 18 <sup>th</sup> , 2013	2	Grammar & spelling, readability
February 26 <sup>th</sup> , 2014	3	Minor changes
September 1 <sup>st</sup> , 2014	4	Changes for setting up the AG501
September 30 <sup>th</sup> , 2015	5	Updated images and added troubleshooting