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Revision 3

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## II. Conventions

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➤ **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. 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.**

### B. 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.

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## 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 circular 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 ( $\varphi$ ;  $\vartheta$ ).

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

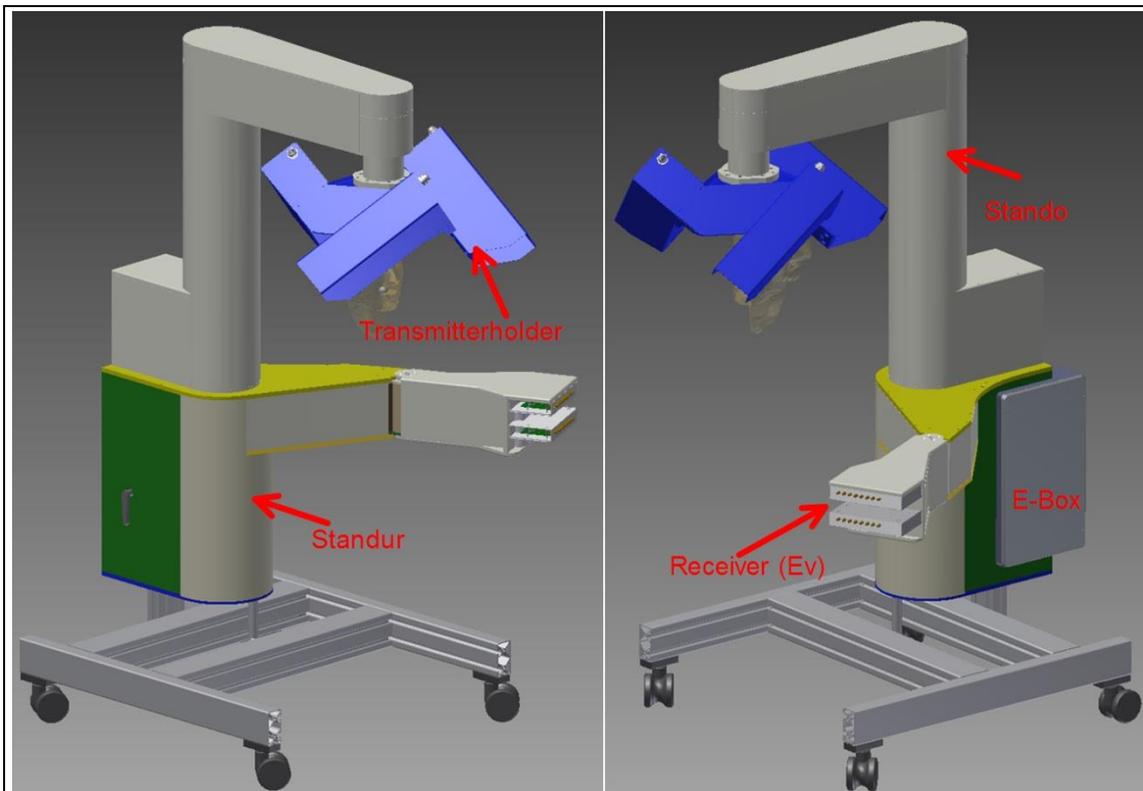


Figure 1: Articulograph AG501

##### A. E-Box

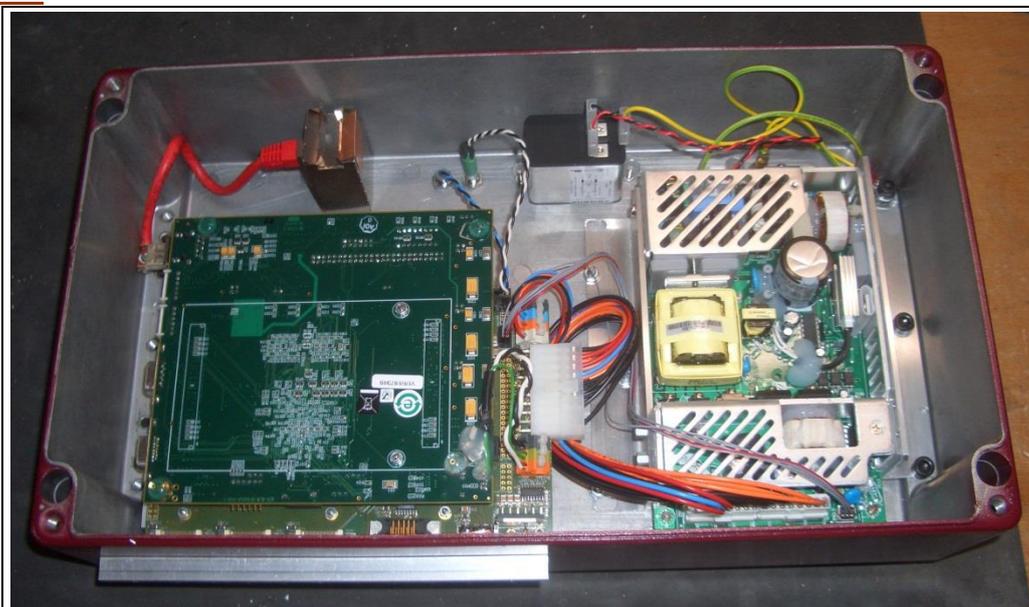


Figure 2: E-Box without cover

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

- Receiver (Ev)
- Transmitter
- Sybox

- Encoder
- Motor

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

### B. Transmitterholder

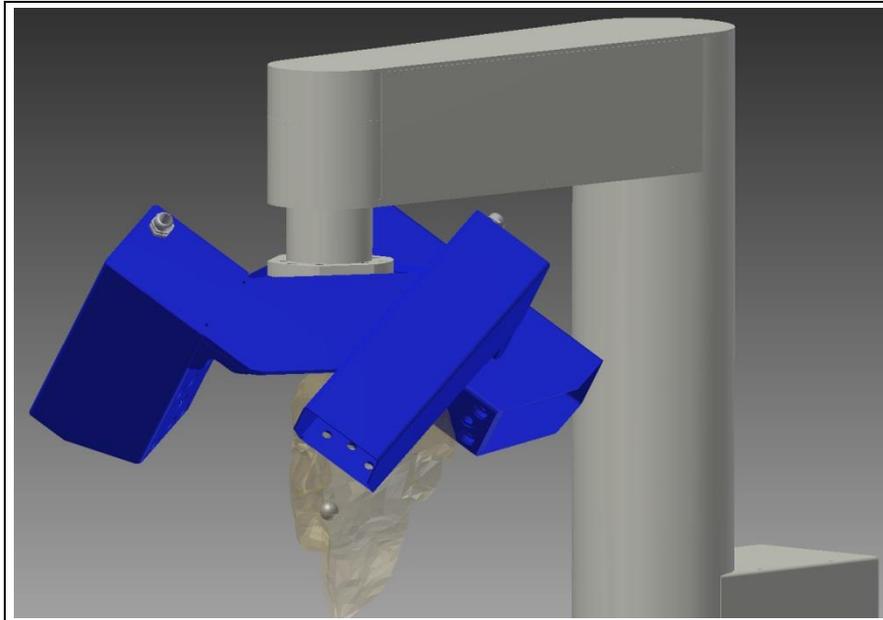


Figure 3: The Transmitterholder (blue)

The Transmitterholder is attached to the Stando and is height-adjustable by moving the whole device up and 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.

### C. Receiver (Ev)



Figure 4: Receiver Ev

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



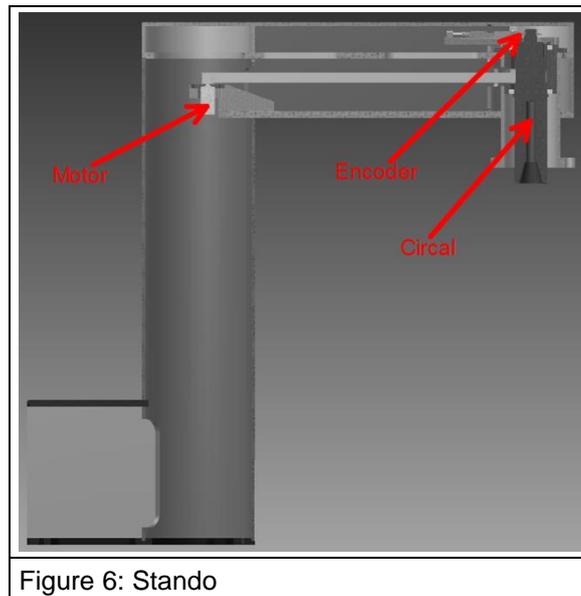
Figure 5: Sybox-Opto4 front side view

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

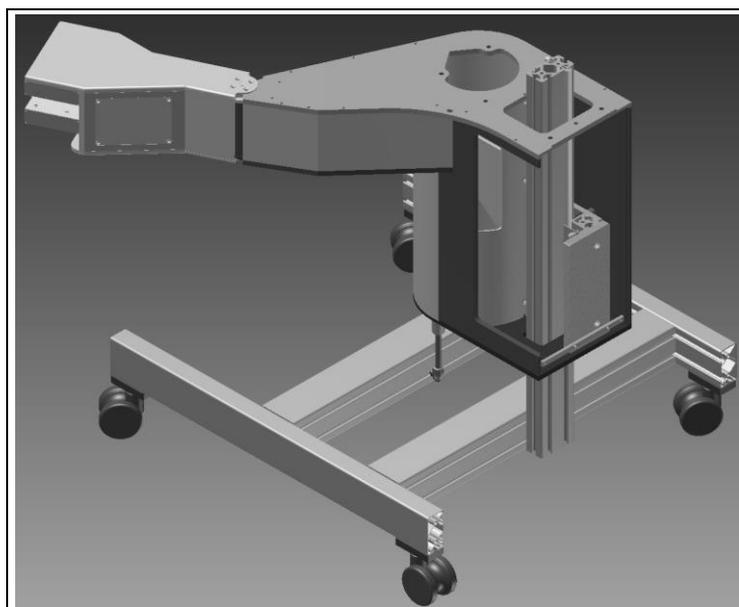


Figure 7: Standur

### G. Sensors HQ220-L120-B

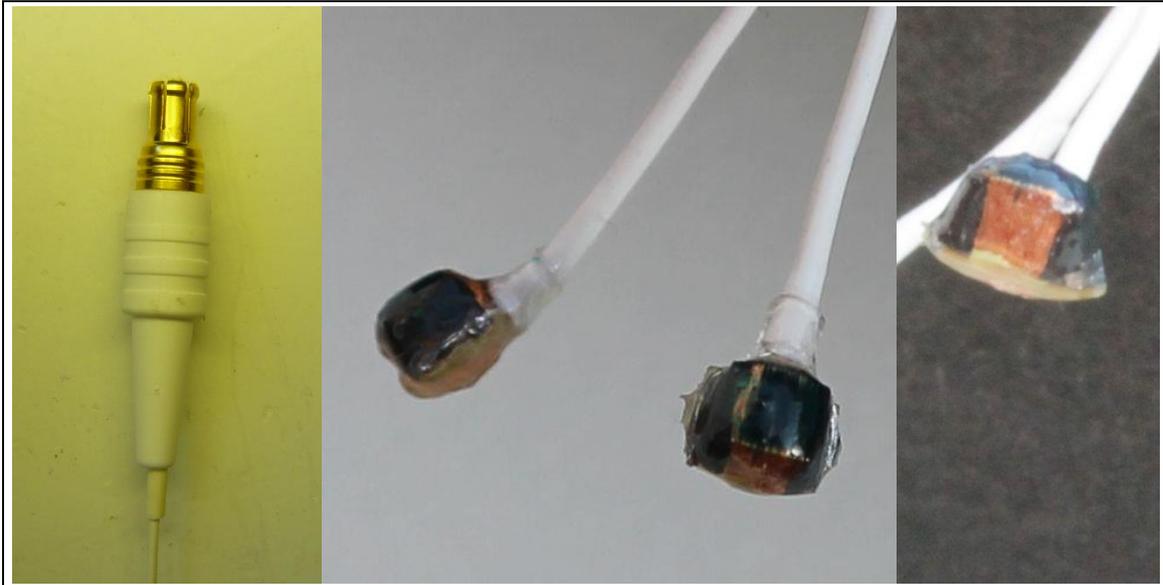


Figure 8: Sensors HQ220-L120-B

The sensors HQ220-L120-B contain the receiver coils which are attached to the articulators of the subject.

### H. Control server



Figure 9: 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.

I. Packing

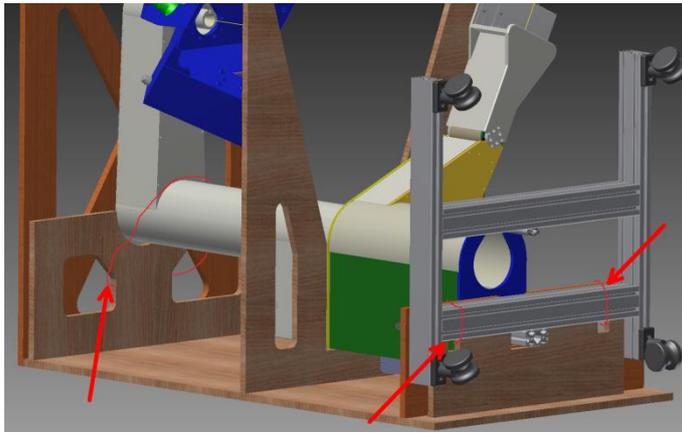


Figure 10: shipping box

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## V. Commissioning

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### A. Setting up the AG501

- Unpack the device
- Check the height adjustment
- Connect the Sybox
- Plug in the AC Power cable
- Plug in the TCP/IP cable

### B. Preparing the Control server

- Plug in the AC Power cable
- Plug in the TCP/IP cable
- Connect the Sybox and audio components



[ag501\\_sound.pdf](#)

### C. Running the system

Run a calibration and check the result.



[ag501-user-guide.pdf](#)

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## VI. Performing an investigation

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### A. Preparations

#### 1. Warm-up

In order to reach a stable temperature, the Articulograph AG501 needs to warm up for at least 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 is 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 and 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. Analysing data

### 1. Calculating the positions



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

### 2. Performing head correction



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

### 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.

#### E. 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. | 3/11 |
| ➤ Sensor set-up has been changed after calibration.             | 11   |
| ➤ Sensors to close together.                                    | 12   |

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## VII. Parts of the Articulograph AG501

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### A. Articulograph AG501

- Articulograph AG501
- Circal 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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## VIII. 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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## IX. Revision history

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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