Application Note

Measurements with ACQUA 4 & labCORE
Application Note

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Revision 1
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Table of Contents

1 Introduction ........................................................................................................................................... 7
   1.1 Brief description .............................................................................................................................. 7
   1.2 Acronyms and abbreviations ......................................................................................................... 7

2 ACQUA 4 presets .................................................................................................................................. 8
   2.1 ACQUA 4 labCORE options ......................................................................................................... 8
      2.1.1 HATS assignment .................................................................................................................. 8
      2.1.2 BEQ options .......................................................................................................................... 9
      2.1.3 Microphone options .............................................................................................................. 9
   2.2 ACQUA 4 hardware configuration ................................................................................................ 10
      2.2.1 Microphone settings .............................................................................................................. 10
      2.2.2 Assign BEQ filter to HATS .................................................................................................. 10
      2.2.3 Set ACQUA level to full-scale of AES signal ...................................................................... 10
      2.2.4 Radio tester settings ............................................................................................................. 11
      2.2.5 Clock synchronization ........................................................................................................... 11
   2.3 ACQUA 4 calibration assignment .................................................................................................. 11

3 Measurement configurations – Common configurations with labCORE ............................................. 12
   3.1 Measurement equipment ............................................................................................................... 12
      3.1.1 Modules and delays for labCORE ....................................................................................... 12
      3.1.2 Required HEAD acoustics equipment .............................................................................. 15
      3.1.3 Additional HEAD acoustics equipment .............................................................................. 15
   3.2 Hands-free communication in motor vehicles ............................................................................. 16
      3.2.1 Setup for GSM / UMTS access ............................................................................................ 16
      3.2.2 Setups for Voice over LTE (VoLTE) access .......................................................................... 17
      3.2.3 Setups for Bluetooth ............................................................................................................ 20
   3.3 In-vehicle emergency call device / system (GSM / UMTS) ............................................................ 23
   3.4 Digital interface communication devices (VoIP and DECT bundle) ............................................. 24
   3.5 Digital interface communication devices (DECT PP) .................................................................... 27
   3.6 Acoustic characteristics for mobile telephony .............................................................................. 28
      3.6.1 Setup for GSM / UMTS access ............................................................................................ 28
      3.6.2 Setups for Voice over LTE (VoLTE) access .......................................................................... 29
   3.7 In-car communication system ....................................................................................................... 32

4 Measurement configurations – labCORE for Skype audio test specification ........................................ 33
   4.1 Measurement equipment ............................................................................................................... 33
      4.1.1 Modules and delays for labCORE ....................................................................................... 33
      4.1.2 HEAD acoustics equipment ................................................................................................. 34
      4.1.3 Additional HEAD acoustics equipment .............................................................................. 34
   4.2 Configuration – Anechoic, Headset, HATS ............................................................................... 35
      4.2.1 Equipment and environment ............................................................................................... 35
4.2.2 Hardware configuration ACQUA 4

4.3 Configuration – Reverberant room, Speakerphone, HATS

4.3.1 Equipment and environment

4.3.2 Hardware configuration ACQUA 4

4.4 Configuration – Reverberant room, Speakerphone, Artificial mouth, Measurement microphones

4.4.1 Equipment and environment

4.4.2 Hardware configuration ACQUA 4

4.5 Configuration – Reverberant room, Speakerphone, Artificial mouth, Measurement microphone

4.5.1 Equipment and environment

4.5.2 Hardware configuration ACQUA 4

4.6 Configuration – Anechoic room, Speakerphone, Artificial mouth, Measurement microphone

4.6.1 Equipment and environment

4.6.2 Hardware configuration ACQUA 4

4.7 Configuration – Reverberant room, Conferencing device, HATS, Artificial mouth

4.7.1 Equipment and environment

4.7.2 Hardware configuration ACQUA 4

4.8 Configuration – Reverberant room, Headset, HATS, Measurement microphone

4.8.1 Equipment and environment

4.8.2 Hardware configuration ACQUA 4

4.9 Configuration – Reverberant room, Speakerphone, HATS, Measurement microphone

4.9.1 Equipment and environment

4.9.2 Hardware configuration ACQUA 4

4.10 Configuration – Reverberant room, Conferencing device, HATS, Artificial mouth, Measurement microphone

4.10.1 Equipment and environment

4.10.2 Hardware configuration ACQUA 4
1 Introduction

1.1 Brief description
This application note introduces different measurement configurations regarding ACQUA 4 and HEAD acoustics modular multi-channel hardware platform labCORE. The document helps users to perform measurements with labCORE, ACQUA 4 and common measurement standards. It supports the transition from previous to new HEAD acoustics equipment.

1.2 Acronyms and abbreviations

<table>
<thead>
<tr>
<th>Acronym / Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACQUA</td>
<td>Advanced Communication Quality Analysis</td>
</tr>
<tr>
<td>BEQ</td>
<td>Binaural equalizer</td>
</tr>
<tr>
<td>dB</td>
<td>Decibel</td>
</tr>
<tr>
<td>dB [SPL]</td>
<td>Decibel sound pressure level</td>
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<tr>
<td>DF</td>
<td>Diffuse field</td>
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<tr>
<td>FF</td>
<td>Free-field</td>
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<tr>
<td>GSM</td>
<td>Global System for Mobile Communications</td>
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<tr>
<td>HATS</td>
<td>Head and torso simulator</td>
</tr>
<tr>
<td>HMS</td>
<td>HEAD measurement system</td>
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<tr>
<td>Hz</td>
<td>Hertz</td>
</tr>
<tr>
<td>ID</td>
<td>Independent of direction</td>
</tr>
<tr>
<td>Lin</td>
<td>Linear</td>
</tr>
<tr>
<td>MFE</td>
<td>Measurement front end</td>
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<tr>
<td>ms</td>
<td>Millisecond</td>
</tr>
<tr>
<td>RCV</td>
<td>Receiving direction</td>
</tr>
<tr>
<td>SND</td>
<td>Sending direction</td>
</tr>
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<td>UMTS</td>
<td>Universal Mobile Telecommunications System</td>
</tr>
<tr>
<td>VoLTE</td>
<td>Voice over LTE</td>
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</table>
2 ACQUA 4 presets

Set up the interconnection of the hardware and start all devices before starting hardware configuration with ACQUA 4. The interconnection depends on the desired measurement configuration.

2.1 ACQUA 4 labCORE options

Before starting any measurements, complete standard settings in ACQUA.

2. Select Hardware Configuration on the quick start screen. 
   or 
   Press F5
   or 
   In main menu: Select Setting → Hardware Configuration.
3. Select labCORE Options...

2.1.1 HATS assignment

1. Select HATS Assignment.
2. Select (unassigned) to assign a HATS.
   - The maximum number of assigned HATS is four.
   - Each HATS has its own binaural equalization.
3. Select Add... to add a HATS to the list.
4. Highlight the desired HATS in the list by clicking on it.
5. Select Select
2.1.2 **BEQ options**

If a BEQ option is required:

1. Select the option.
2. Select the desired HATS from the drop-down list.
3. Download or add filter set if necessary.

2.1.3 **Microphone options**

If a microphone is required:

1. Select the option.
2. Check the box of the applied microphone channels to enable the microphone power supply and polarization voltage.
3. Select the correct supply voltage according to the product information of the used microphone.

Notice: Wrong supply voltage may damage the connected microphone.
2.2 ACQUA 4 hardware configuration

2.2.1 Microphone settings
If a microphone is required:

- Double-click on the Mic 1...4 block.
- Check the box to enable high-pass filter to the microphone(s) if desired.
- Set the desired range to one of the microphone(s).

2.2.2 Assign BEQ filter to HATS
If a BEQ option is required:

1. Double-click on the BEQ Filter block.
2. Select desired HATS from the drop-down list.
3. Assign desired filter to selected HATS.

2.2.3 Set ACQUA level to full-scale of AES signal

1. Double-click on the AES device block.
2. Select / enter desired level to be mapped as full scale in ACQUA.
3. Close the Full scal mapping window.
4. The selected value is displayed in the AES device block.
2.2.4 Radio tester settings
If a radio tester option is used:

1. Double-click on the radio tester block.
2. Enter the desired value for the output gain (calibration).

2.2.5 Clock synchronization
The labCORE synchronization source is set to Internal by default.

- Set the clock synchronization to internal via the drop-down list.
- Set the clock synchronization to an external source (e.g. AES A In) via the drop-down list.
- Set the clock synchronization of the MFE (if part of setup) accordingly to the clock synchronization of labCORE.

2.3 ACQUA 4 calibration assignment
In ACQUA 4 main menu:
- Press F2 key on the keyboard.
or
- Select Preparation → Calibration Assignment.

Refer to the ACQUA 4 Help System for further information about calibration assignments.
3 Measurement configurations – Common configurations with labCORE

The presented configurations are designated for several existing ACQUA standards. In all configurations labCORE substitutes previous generation hardware platforms (MFEs). Some configurations include previous generation hardware platforms (MFEs) that complement labCORE with certain functions and vice versa. The chapter starts with the delays of the various interfaces from labCORE, followed by a selection of common measurement configurations that include labCORE.

3.1 Measurement equipment

3.1.1 Modules and delays for labCORE

The configurations of this chapter require labCORE with optional modules. The equipment may differ between configurations:

- labCORE (Code 7700), ACQUA lab modular multi-channel hardware platform

  Delay @ BNC Out 1 / Out 2:
  
  \[ \text{DAC\_delay} = d_{\text{DAC}} \times \frac{1}{fs} \]
  
  \( d_{\text{DAC}} = 28.8 \text{ clock pulses} \)
  
  @ 48 kHz = 0.6 ms
  
  @ 96 kHz = 0.3 ms
  
  @ 192 kHz = 0.15 ms

  Delay @ BNC In 1/ In 2
  
  \[ \text{ADC\_delay} = d_{\text{ADC}} \times \frac{1}{fs} \]
  
  \( d_{\text{ADC}} = 19 \text{ clock pulses} \)
  
  @ 48 kHz = 0.3958 ms ≈ 0.4 ms
  
  @ 96 kHz = 0.1979 ms ≈ 0.2 ms
  
  @ 192 kHz = 0.0989 ms ≈ 0.1 ms

  Delay @ AES
  
  \( d_{\text{AES\_in}} = 2 \text{ clock pulses} \)
  
  \[ \text{AES\_in\_delay} = d_{\text{AES\_in}} \times \frac{1}{fs} \]
  
  AES\_in\_delay @ 48 kHz = 0.04 ms
  
  AES\_in\_delay @ 96 kHz = 0.02 ms
  
  AES\_in\_delay @ 192 kHz = 0.01 ms

  \( d_{\text{AES\_out}} = 1 \text{ clock pulses} \)
  
  \[ \text{AES\_out\_delay} = d_{\text{AES\_out}} \times \frac{1}{fs} \]
  
  AES\_out\_delay @ 48 kHz = 0.02 ms
  
  AES\_out\_delay @ 96 kHz = 0.01 ms
  
  AES\_out\_delay @ 192 kHz = 0.005 ms

- coreBUS (Code 7710), I/O bus mainboard
- **coreOUT-Amp2** (Code 7720), Mouth / loudspeaker amplifier module

  Delay @ Loudspeaker 1/2
  \[
  \text{DAC}_\text{delay} = d_{\text{DAC}} * 1/\text{fs} + d_{\text{FPGA Card}} * 1/\text{fs}
  \]
  \[
  d_{\text{DAC}} = 28.8 \text{ clock pulses}
  \]
  \[
  d_{\text{FPGA Card}} = 3 \text{ clock pulses}
  \]
  \[
  @ 48 \text{ kHz} = 0.6 \text{ ms} + 0.0625 \text{ ms} \approx 0.66 \text{ ms}
  \]
  \[
  @ 96 \text{ kHz} = 0.3 \text{ ms} + 0.03125 \text{ ms} \approx 0.33 \text{ ms}
  \]
  \[
  @ 192 \text{ kHz} = 0.15 \text{ ms} + 0.015625 \text{ ms} \approx 0.17 \text{ ms}
  \]

- **coreIN-Mic4** (Code 7730), Microphone input module

  Delay @ Mic 1 / 2 / 3 / 4
  \[
  \text{ADC}_\text{delay} = d_{\text{ADC}} * 1/\text{fs} + d_{\text{FPGA Card}} * 1/\text{fs}
  \]
  \[
  d_{\text{ADC}} = 19 \text{ clock pulses}
  \]
  \[
  d_{\text{FPGA Card}} = 3 \text{ clock pulses}
  \]
  \[
  @ 48 \text{ kHz} = 0.3958 \text{ ms} + 0.0625 \text{ ms} \approx 0.46 \text{ ms}
  \]
  \[
  @ 96 \text{ kHz} \approx 0.1979 \text{ ms} + 0.03125 \text{ ms} \approx 0.23 \text{ ms}
  \]
  \[
  @ 192 \text{ kHz} \approx 0.099 \text{ ms} + 0.015625 \text{ ms} \approx 0.11 \text{ ms}
  \]

- **coreBEQ** (Code 7740), Binaural equalization

- **coreIP** (Code 7770), Voice over IP reference gateway

  The delays are measured with an initial jitter buffer length of 0 ms and an ideal network with 0 ms delay. For jitter buffer lengths larger than zero, the delay sending direction and the round-trip delay increase by the jitter buffer length.

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<tr>
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<td>75.0</td>
<td>75.0</td>
<td>150.1</td>
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</tr>
<tr>
<td>60</td>
<td>85.0</td>
<td>75.0</td>
<td>160.1</td>
<td></td>
</tr>
<tr>
<td>Codec</td>
<td>ptime [ms]</td>
<td>Delay receiving direction [ms]</td>
<td>Delay sending direction [ms]</td>
<td>Round trip delay [ms]</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------</td>
<td>---------------------------------</td>
<td>------------------------------</td>
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</tr>
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<td>10</td>
<td>35.0</td>
<td>75.0</td>
<td>110.1</td>
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<td>45.0</td>
<td>75.0</td>
<td>120.1</td>
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<tr>
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<td>130.1</td>
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<td></td>
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<td>140.1</td>
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<tr>
<td></td>
<td>60</td>
<td>85.0</td>
<td>75.0</td>
<td>160.1</td>
</tr>
<tr>
<td>SILK (24 kHz)</td>
<td>20</td>
<td>47.2</td>
<td>71.7</td>
<td>118.9</td>
</tr>
<tr>
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<td>72.5</td>
<td>120.6</td>
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<tr>
<td>SILK (12 kHz)</td>
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<td>49.3</td>
<td>73.4</td>
<td>122.6</td>
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<tr>
<td>SILK (8 kHz)</td>
<td>20</td>
<td>50.0</td>
<td>75.0</td>
<td>125.1</td>
</tr>
<tr>
<td>speex (32 kHz)</td>
<td>20</td>
<td>57.2</td>
<td>71.3</td>
<td>128.5</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>77.2</td>
<td>71.3</td>
<td>148.5</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>97.2</td>
<td>71.3</td>
<td>168.5</td>
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<tr>
<td>speex (16 kHz)</td>
<td>20</td>
<td>56.5</td>
<td>72.5</td>
<td>129.1</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>76.5</td>
<td>72.5</td>
<td>149.1</td>
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<td>169.1</td>
</tr>
<tr>
<td>speex (8 kHz)</td>
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<td>75.0</td>
<td>130.0</td>
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<td>40</td>
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<td>150.0</td>
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<td></td>
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<tr>
<td>Opus</td>
<td>20</td>
<td>45.8</td>
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<td>116.6</td>
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<tr>
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</tr>
<tr>
<td></td>
<td>60</td>
<td>85.8</td>
<td>70.8</td>
<td>156.6</td>
</tr>
</tbody>
</table>

- **coreBT** (Code 7780), Bluetooth reference access point

  Delay in sending direction (@ 48 kHz, 2-EV3 packet type, values determined empirically)
  
  15.8 ms ±2.5 ms

  Delay in receiving direction (@ 48 kHz, 2-EV3 packet type, values determined empirically)

  9.5 ms ±2.5 ms

- **coreBT-EXT**

  Delay in sending direction (@ 48 kHz, 2-EV3 packet type, values determined empirically)

  16.3 ms ±5.0 ms

  Delay in receiving direction (@ 48 kHz, 2-EV3 packet type, values determined empirically)

  9 ms ±5.0 ms

3.1.2 **Required HEAD acoustics equipment**

- **ACQUA 4** (Code 6810)

3.1.3 **Additional HEAD acoustics equipment**

The additional HEAD acoustics equipment depends on the respective measurement configuration.

- **MFE VIII.1** (Code 6484)
- **MFE X** (Code 6481)
- **MFE XI** (Code 6482)
- **HMS II.3** (Code 1230)
3.2 Hands-free communication in motor vehicles

These measurement configurations especially applies to:
- integrated hands-free systems of motor vehicles.
- after-market hands-free kits for motor vehicles.
- corded and wireless headsets for use in motor vehicles.

3.2.1 Setup for GSM / UMTS access

Relevant standards
- P.1100, Speech Quality Assessment of Narrowband Car Hands-free Terminals.
- P.1110, Speech Quality Assessment of Wideband Car Hands-free Terminals.

Block diagram for application of labCORE

Hardware configuration for application of labCORE
Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.
3.2.2 Setups for Voice over LTE (VoLTE) access

Relevant standards
- P.1100, Speech Quality Assessment of Narrowband Car Hands-free Terminals.
- P.1110, Speech Quality Assessment of Wideband Car Hands-free Terminals.
- P.1120, Super-wideband and Fullband Car Hands-free Terminals.

Setup 1: Block diagram for application of labCORE and MFE VIII.1

- MFE VIII.1 > VoIP reference gateway
- labCORE > Playback and receiving of audio signal
Setup 2: Block diagram for application of labCORE with coreIP

Setup 2: Hardware configuration for application of labCORE with coreIP

Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.
Setup 3: Block diagram for application of MFE VI.1 and labCORE with coreIP

Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.

- labCORE > VoIP reference gateway
- MFE VI.1 > Playback and receiving of audio signal
3.2.3  Setups for Bluetooth

Relevant standards

- P.1100, Speech Quality Assessment of Narrowband Car Hands-free Terminals.
- P.1110, Speech Quality Assessment of Wideband Car Hands-free Terminals.

Setup 1: Block diagram for application of labCORE & MFE XI

![Block diagram of labCORE & MFE XI setup](image)

Setup 1: Hardware configuration for application of labCORE & MFE XI

Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.

- MFE XI > Bluetooth reference access point
- labCORE > Playback and receiving of audio signal
Setup 2: Block diagram for application of labCORE with coreBT

Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.
Setup 3: Block diagram for application of MFE VI.1 and labCORE with coreBT

Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.

- labCORE > Bluetooth reference access point
- MFE VI.1 > Playback and receiving of audio signal
3.3 In-vehicle emergency call device / system (GSM / UMTS)

This measurement configurations especially applies to:
- eCall systems.

Relevant standards
- P.1140-NB, Emergency call (eCall) Devices, Narrowband Part.
- UG P.1140-WB, Emergency call (eCall) Devices, Wideband Extension.
- GOST 33468-NB, GOST 33468 (ERA-GLONASS), Emergency Call (eCall) Devices, Narrowband Part.
- GOST 33468-WB, UG GOST R55531-WB (ERA-GLONASS), Emergency Call (eCall) Devices, Wideband Part.

Block diagram for application of labCORE

Hardware configuration for application labCORE

Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.
3.4 Digital interface communication devices (VoIP and DECT bundle)

This measurement configuration especially applies to:
- IP terminals.
- VoIP handset and headset terminals.

Relevant standards

Setup 1: Block diagram for application of labCORE & MFE VIII.1

Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.

- MFE VIII.1 > VoIP reference gateway
- labCORE > Playback and receiving of audio signal
Setup 2: Block diagram for application of labCORE with coreIP

Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.
Setup 3: Block diagram for application of MFE VI.1 labCORE with coreIP

Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.

- labCORE > VoIP reference gateway
- MFE VI.1 > Playback and receiving of audio signal
3.5 Digital interface communication devices (DECT PP)

This measurement configuration especially applies to:
- DECT terminals.

Relevant standards
- UG DTAG-Mobile-WB, Voice Quality Evaluation of Mobile Phones, Upgrade to Wideband.
- CAT-IQ 1.0, Wideband NG-DECT Terminals.

Block diagram for application of labCORE and MFE X

Hardware configuration for application of labCORE and MFE X
Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.

- MFE X > Referenced portable / fixed part (DECT/NG-DECT/ CAT-iq™)
- labCORE > Playback and receiving of audio signal
3.6 Acoustic characteristics for mobile telephony

3.6.1 Setup for GSM / UMTS access
These measurement configurations especially applies to:
- mobile phones.
- wireless terminals.
- headsets.

Relevant standards
- TS 103 737 / 38, Narrowband Mobile & Wireless Terminals.
- TS 103 739 / 40, Wideband Mobile & Wireless Terminals.

Block diagram for application of labCORE

Hardware configuration for application of labCORE
Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.
3.6.2  Setups for Voice over LTE (VoLTE) access

Relevant standards
- TS 103 737 / 38, Narrowband Mobile & Wireless Terminals.
- TS 103 739 / 40, Wideband Mobile & Wireless Terminals.

Setup 1: Block diagram for application of labCORE and MFE VIII.1

Setup 1: Hardware configuration for application of labCORE & MFE VIII.1
Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.

- MFE VIII.1 > VoIP reference gateway
- labCORE > Playback and receiving of audio signal
Setup 2: Block diagram for application of labCORE with coreIP

Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.
Setup 3: Block diagram for application of MFE VI.1 labCORE with coreIP

Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.

- labCORE > VoIP reference gateway
- MFE VI.1 > Playback and receiving of audio signal
3.7 In-car communication system
This measurement configuration especially applies to:
- in-car communication systems.

Relevant standards

Block diagram for application of labCORE

Hardware configuration for application of labCORE
Blue boxes represent labCORE features and interfaces. The screenshot is only exemplary. The final configuration may differ due to the requirements of the applied standard.
4 Measurement configurations – labCORE for Skype audio test specification

The presented configurations are designed for measurements according to the Skype audio test specification. The information from this document supplements the usage of the SOP_AudioLab documentation and HEAD acoustics standard documentation. The hardware platform labCORE substitutes its predecessor MFE VI.1 in all configurations.

4.1 Measurement equipment

4.1.1 Modules and delays for labCORE

The configurations of this chapter require labCORE with optional modules. The equipment may differ between configurations:

- labCORE (Code 7700), ACQUA/lab modular multi-channel hardware platform

  Delay @ BNC Out 1 / Out 2:
  \[ \text{DAC\_delay} = \text{d}_{\text{DAC}} \times \frac{1}{\text{fs}} \]
  \[ \text{d}_{\text{DAC}} = 28.8 \text{ clock pulses} \]
  \[ @ 48 \text{ kHz} = 0.6 \text{ ms} \]
  \[ @ 96 \text{ kHz} = 0.3 \text{ ms} \]
  \[ @ 192 \text{ kHz} = 0.15 \text{ ms} \]

  Delay @ BNC In 1/ In 2:
  \[ \text{ADC\_delay} = \text{d}_{\text{ADC}} \times \frac{1}{\text{fs}} \]
  \[ \text{d}_{\text{ADC}} = 19 \text{ clock pulses} \]
  \[ @ 48 \text{ kHz} = 0.3958 \text{ ms} \approx 0.4 \text{ ms} \]
  \[ @ 96 \text{ kHz} \approx 0.1979  \text{ ms} \approx 0.2 \text{ ms} \]
  \[ @ 192 \text{ kHz} = 0.0989 \text{ ms} = 0.1 \text{ ms} \]

  Delay @ AES
  \[ \text{d}_{\text{AES\_in}} = 2 \text{ clock pulses} \]
  \[ \text{AES\_in\_delay} = \text{d}_{\text{AES\_in}} \times \frac{1}{\text{fs}} \]
  \[ \text{AES\_in\_delay} \at 48 \text{ kHz} = 0.04 \text{ ms} \]
  \[ \text{AES\_in\_delay} \at 96 \text{ kHz} = 0.02 \text{ ms} \]
  \[ \text{AES\_in\_delay} \at 192 \text{ kHz} = 0.01 \text{ ms} \]
  \[ \text{d}_{\text{AES\_out}} = 1 \text{ clock pulses} \]
  \[ \text{AES\_out\_delay} = \text{d}_{\text{AES\_out}} \times \frac{1}{\text{fs}} \]
  \[ \text{AES\_out\_delay} \at 48 \text{ kHz} = 0.02 \text{ ms} \]
  \[ \text{AES\_out\_delay} \at 96 \text{ kHz} = 0.01 \text{ ms} \]
  \[ \text{AES\_out\_delay} \at 192 \text{ kHz} = 0.005 \text{ ms} \]

- coreBUS (Code 7710), I/O bus mainboard
  \[ @ 192 \text{ kHz} = 0.099 + 0.015625 = 0.11 \text{ ms} \]
- **core**OUT-Amp2 (Code 7720), Mouth / loudspeaker amplifier module

  Delay @ Loudspeaker 1/2
  \[
  \text{DAC\_delay} = \text{d}_{\text{DAC}} \times 1/\text{fs} + \text{d}_{\text{FPGA\_Card}} \times 1/\text{fs}
  \]
  \[
  \text{d}_{\text{DAC}} = 28.8\text{ clock pulses}
  \]
  \[
  \text{d}_{\text{FPGA\_Card}} = 3\text{ clock pulses}
  \]
  @ 48 kHz = 0.6 ms + 0.0625 ms ≈ 0.66 ms
  @ 96 kHz = 0.3 ms + 0.03125 ms = 0.33 ms
  @ 192 kHz = 0.15 ms + 0.015625 ms = 0.17 ms

- **core**IN-Mic4 (Code 7730), Microphone input module

  Delay @ Mic 1 / 2 / 3 / 4
  \[
  \text{ADC\_delay} = \text{d}_{\text{ADC}} \times 1/\text{fs} + \text{d}_{\text{FPGA\_Card}} \times 1/\text{fs}
  \]
  \[
  \text{d}_{\text{ADC}} = 19\text{ clock pulses}
  \]
  \[
  \text{d}_{\text{FPGA\_Card}} = 3\text{ clock pulses}
  \]
  @ 48 kHz = 0.3958 ms + 0.0625 ms ≈ 0.46 ms
  @ 96 kHz = 0.1979 ms + 0.03125 ms = 0.23 ms

- **core**BEQ (Code 7740), Binaural equalization

### 4.1.2 HEAD acoustics equipment

- ACQUA 4 (Code 6810)

### 4.1.3 Additional HEAD acoustics equipment

The additional HEAD acoustics equipment depends on the respective measurement configuration.

- HMS II.3 (Code 1230)
4.2 Configuration – Anechoic, Headset, HATS

Configuration name in SOP_Audiolab:
- | Anechoic | Headset | HATS | HATS-Rear | |

4.2.1 Equipment and environment
- Room: Anechoic
- DUT: Headset
- Microphone: HATS
- Loudspeaker / mouth: HATS

4.2.2 Hardware configuration ACQUA 4
- Enable highpass for the applied microphone channels, refer to section 2.2.1.
- Select required BEQ filter, refer to section 2.2.2.
- Set the full scale of the AES signal to 3.14 dBm, refer to section 2.2.3.
- Skip the script “Set ACQUA Calibrations” during the measurement sequence to prevent the automatic calibration of AES input and AES output.
- In calibration assignment, set the User defined electrical calibration “Skype_IN_SND” to 0.00 dB, refer to section 2.3 and the HEAD acoustics standard documentation. Define “Skype_IN_SND” with “Calibration values” in ACQUA.
4.3 Configuration – Reverberant room, Speakerphone, HATS

Configuration name in SOP_Audiolab:
- | Reverbroom | Speakerphone | HATS | HATS-Rear | - |

4.3.1 Equipment and environment
- Room: Reverberant
- DUT: Speakerphone
- Microphone: HATS
- Loudspeaker: HATS

4.3.2 Hardware configuration ACQUA 4
- Enable highpass for the applied microphone channels, refer to section 2.2.1.
- Select required BEQ filter, refer to section 2.2.2.
- Set the full scale of the AES signal to 3.14 dBm, refer to section 2.2.3.
- Skip the script “Set ACQUA Calibrations” during the measurement sequence to prevent the automatic calibration of AES input and AES output.
- In calibration assignment, set the User defined electrical calibration “Skype_IN_SND” to 0.00 dB, refer to section 2.3 and the HEAD acoustics standard documentation. Define “Skype_IN_SND” with “Calibration values” in ACQUA.
4.4 Configuration – Reverberant room, Speakerphone, Artificial mouth, Measurement microphones

Configuration name in SOP_Audiolab:
- ReverbRoom | Speakerphone | Art.Mouth | - | MEASmic-IN2line | -option1/2

4.4.1 Equipment and environment
- Room: Reverberant
- DUT: Speakerphone
- Microphone: 2 x free-field microphones
- Loudspeaker: Artificial mouth

4.4.2 Hardware configuration ACQUA 4
- Enable highpass for the applied microphone channels, refer to section 2.2.1.
- Select required BEQ filter, refer to section 2.2.2.
- Set the full scale of the AES signal to 3.14 dBm, refer to section 2.2.3.
- Skip the script “Set ACQUA Calibrations” during the measurement sequence to prevent the automatic calibration of AES input and AES output.
- In calibration assignment, set the User defined electrical calibration “Skype_IN_SND” to 0.00 dB, refer to section 2.3 and the HEAD acoustics standard documentation. Define “Skype_IN_SND” with “Calibration values” in ACQUA.
4.5 Configuration – Reverberant room, Speakerphone, Artificial mouth, Measurement microphone

Configuration name in SOP_Audiolab:
- | Reverbroom | Speakerphone | Art.Mouth | FFmic-IN2mic | - |

4.5.1 Equipment and environment
- Room: Reverberant
- DUT: Speakerphone
- Microphone: Free-field microphone
- Loudspeaker: Artificial mouth

4.5.2 Hardware configuration ACQUA 4
- Enable highpass for the applied microphone channels, refer to section 2.2.1.
- Select required BEQ filter, refer to section 2.2.2.
- Set the full scale of the AES signal to 3.14 dBm, refer to section 2.2.3.
- Skip the script “Set ACQUA Calibrations” during the measurement sequence to prevent the automatic calibration of AES input and AES output.
- In calibration assignment, set the User defined electrical calibration “Skype_IN_SND” to 0.00 dB, refer to section 2.3 and the HEAD acoustics standard documentation. Define “Skype_IN_SND” with “Calibration values” in ACQUA.
4.6 Configuration – Anechoic room, Speakerphone, Artificial mouth, Measurement microphone

Configuration name in SOP_Audiolab:
- | Anechoic | Speakerphone | Art.Mouth | FFmic-IN2mic | - |

4.6.1 Equipment and environment
- Room: Anechoic
- DUT: Speakerphone
- Microphone: Free-field microphone
- Loudspeaker: Artificial mouth

4.6.2 Hardware configuration ACQUA 4
- Enable highpass for the applied microphone channels, refer to section 2.2.1.
- Select required BEQ filter, refer to section 2.2.2.
- Set the full scale of the AES signal to 3.14 dBm, refer to section 2.2.3.
- Skip the script “Set ACQUA Calibrations” during the measurement sequence to prevent the automatic calibration of AES input and AES output.
- In calibration assignment, set the User defined electrical calibration “Skype_IN_SND” to 0.00 dB, refer to section 2.3 and the HEAD acoustics standard documentation. Define “Skype_IN_SND” with “Calibration values” in ACQUA.
4.7 Configuration – Reverberant room, Conferencing device, HATS, Artificial mouth

Configuration name in SOP_Audiolab:
- | Reverbroom | Conferencing | HATS+Art.Mouth | HATS-Rear | - |

4.7.1 Equipment and environment
- Room: Reverberant
- DUT: Conferencing device
- Microphone: HATS
- Loudspeaker: HATS and artificial mouth

4.7.2 Hardware configuration ACQUA 4
- Enable highpass for the applied microphone channels, refer to section 2.2.1.
- Select required BEQ filter, refer to section 2.2.2.
- Set the full scale of the AES signal to 3.14 dBm, refer to section 2.2.3.
- Skip the script “Set ACQUA Calibrations” during the measurement sequence to prevent the automatic calibration of AES input and AES output.
- In calibration assignment, set the User defined electrical calibration “Skype_IN_SND” to 0.00 dB, refer to section 2.3 and the HEAD acoustics standard documentation. Define “Skype_IN_SND” with “Calibration values” in ACQUA.
4.8 Configuration – Reverberant room, Headset, HATS, Measurement microphone

Configuration name in SOP_Audiolab:
- | ReverbRoom | Headset | HATS | MEASmic-IN2line | -option1/2

4.8.1 Equipment and environment
- Room: Reverberant
- DUT: Headset
- Microphone: HATS and free-field microphone
- Loudspeaker: HATS

4.8.2 Hardware configuration ACQUA 4
- Enable highpass for the applied microphone channels, refer to section 2.2.1.
- Select required BEQ filter, refer to section 2.2.2.
- Set the full scale of the AES signal to 3.14 dBm, refer to section 2.2.3.
- Skip the script “Set ACQUA Calibrations” during the measurement sequence to prevent the automatic calibration of AES input and AES output.
- In calibration assignment, set the User defined electrical calibration “Skype_IN_SND” to 0.00 dB, refer to section 2.3 and the HEAD acoustics standard documentation. Define “Skype_IN_SND” with “Calibration values” in ACQUA.
4.9 Configuration – Reverberant room, Speakerphone, HATS, Measurement microphone

Configuration name in SOP_Audiolab:
- | Reverbroom | Speakerphone | HATS | - | MEASmic-IN2line | -option1/2

4.9.1 Equipment and environment
- Room: Reverberant
- DUT: Speakerphone
- Microphone: HATS and free-field microphone
- Loudspeaker: HATS

4.9.2 Hardware configuration ACQUA 4
- Enable highpass for the applied microphone channels, refer to section 2.2.1.
- Select required BEQ filter, refer to section 2.2.2.
- Set the full scale of the AES signal to 3.14 dBm, refer to section 2.2.3.
- Skip the script “Set ACQUA Calibrations” during the measurement sequence to prevent the automatic calibration of AES input and AES output.
- In calibration assignment, set the User defined electrical calibration “Skype_IN_SND” to 0.00 dB, refer to section 2.3 and the HEAD acoustics standard documentation. Define “Skype_IN_SND” with “Calibration values” in ACQUA.
4.10 Configuration – Reverberant room, Conferencing device, HATS, Artificial mouth, Measurement microphone

Configuration name in SOP_Audiolab:
- | ReverbRoom | Conferencing | HATS | +Art.Mouth | - | REFmicIN2line | -option1/2

4.10.1 Equipment and environment
- Room: Reverberant
- DUT: Conferencing device
- Microphone: HATS and free-field microphone
- Loudspeaker: HATS and artificial mouth

4.10.2 Hardware configuration ACQUA 4
- Enable highpass for the applied microphone channels, refer to section 2.2.1.
- Select required BEQ filter, refer to section 2.2.2.
- Set the full scale of the AES signal to 3.14 dBm, refer to section 2.2.3.
- Skip the script “Set ACQUA Calibrations” during the measurement sequence to prevent the automatic calibration of AES input and AES output.
- In calibration assignment, set the User defined electrical calibration “Skype_IN_SND” to 0.00 dB, refer to section 2.3 and the HEAD acoustics standard documentation. Define “Skype_IN_SND” with “Calibration values” in ACQUA.