HEAD acoustics

Application Note

Measurements with ACQUA 4 & *lab*CORE

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Measurements with ACQUA 4 & *lab*CORE

Revision 1

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Table of Contents

1 Introduction

1.1 Brief description

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

1.2 Acronyms and abbreviations

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

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 *lab*CORE options

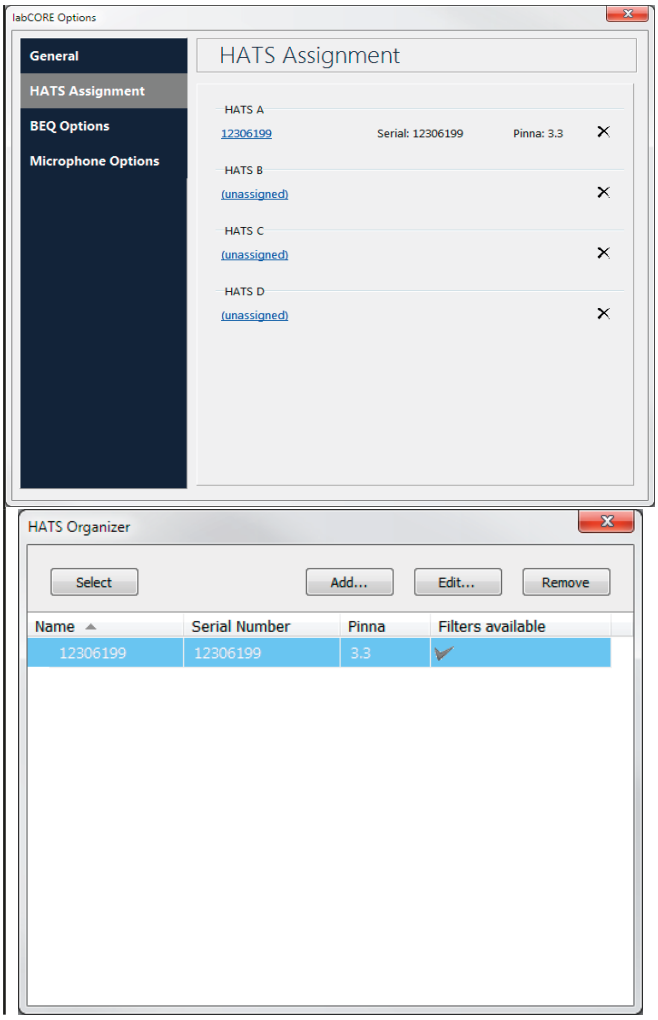
Before starting any measurements, complete standard settings in ACQUA.

1. Start ACQUA 4.
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.

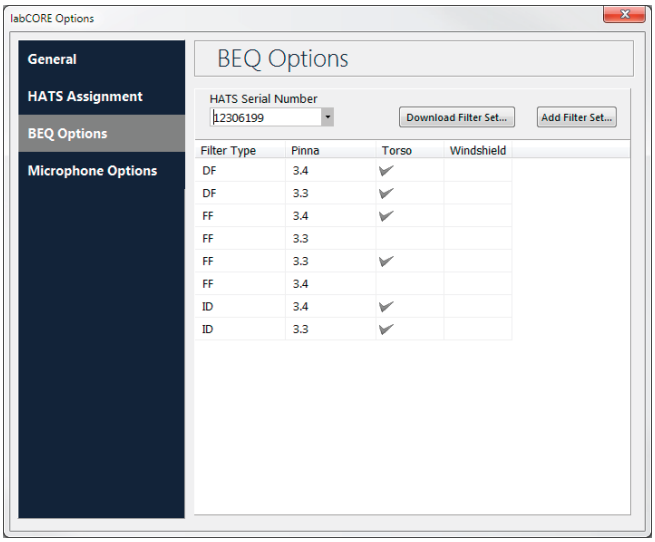


3. Select Add… to add a HATS to the list.
4. Highlight the desired HATS in the list by clicking on it.
5. Select Select.

2.1.2 BEQ options

If a BEQ option is required:

1. Select BEQ Options.
2. Select the desired HATS from the drop-down list HATS Serial Number 12306396.
3. Download or add filter set if necessary.

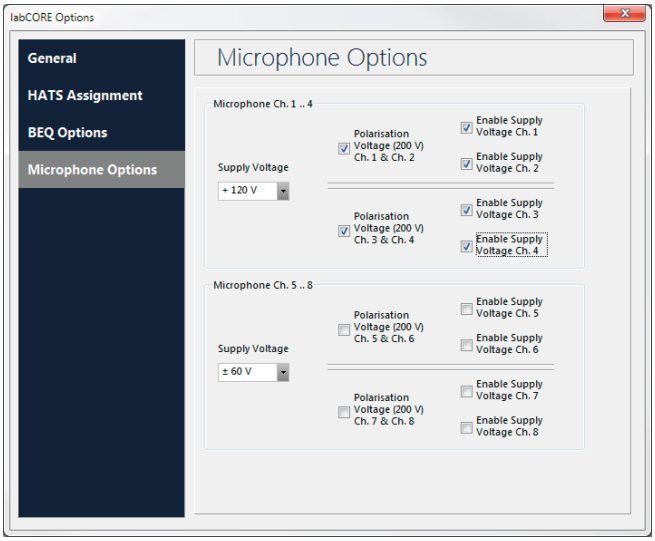


2.1.3 Microphone options

If a microphone is required:

1. Select Microphone Options.
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.

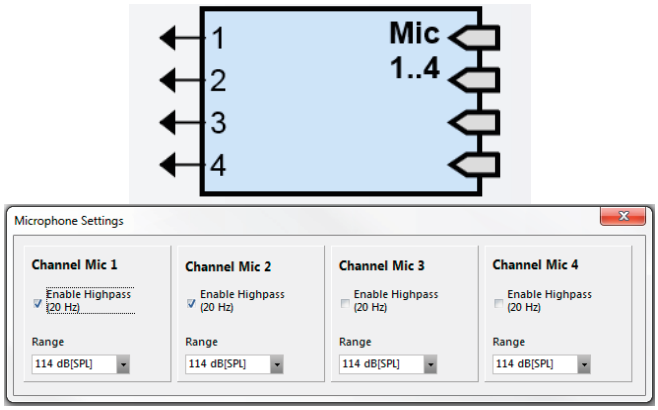


2.2 ACQUA 4 hardware configuration

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).



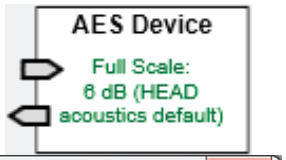
2.2.2 Assign BEQ filter to HATS

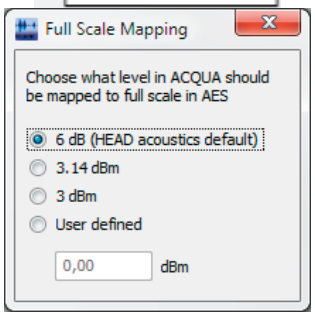
If a BEQ option is required:

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.

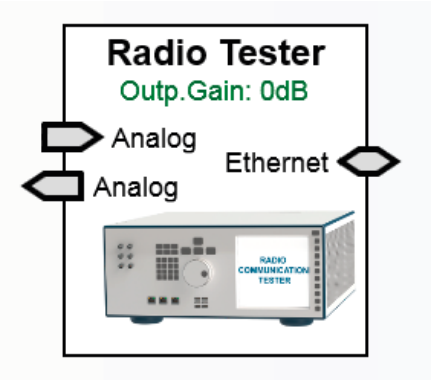


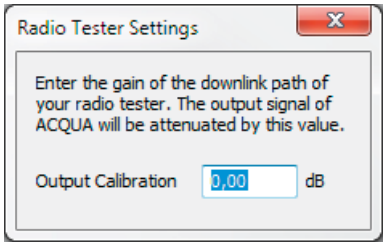


2.2.4 Radio tester settings

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).

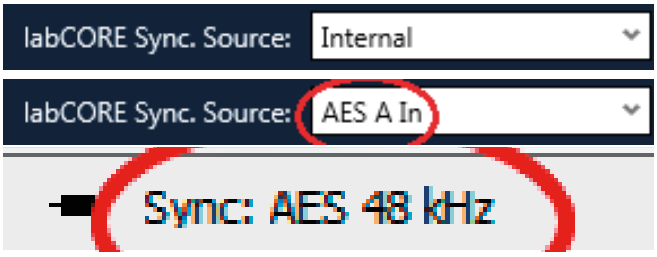




2.2.5 Clock synchronization

The *lab*CORE 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 *lab*CORE



2.3 ACQUA 4 calibration assignment

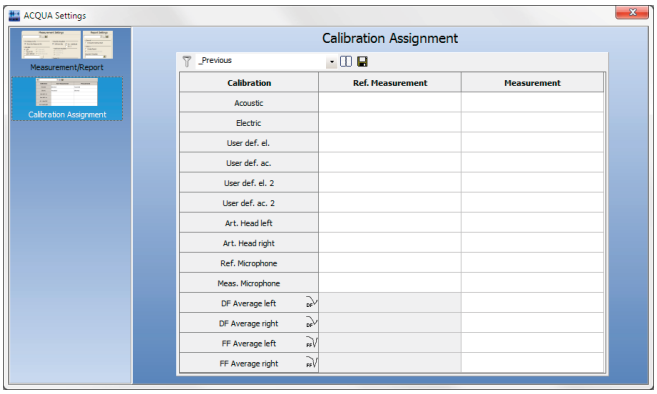
In ACQUA 4 main menu:

- 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 *lab*CORE

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

3.1 Measurement equipment

3.1.1 Modules and delays for *lab*CORE

The configurations of this chapter require *lab*CORE with optional modules. The equipment may differ between configurations:

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

  Delay @ BNC Out 1 / Out 2:

  DAC_delay = d_{DAC} * 1/ fs

  d_{DAC} = 28.8 clock pulses

  @ 48 kHz = 0.6 ms

  @ 96 kHz = 0.3 ms

  @ 192 kHz = 0.15 ms

  Delay @ BNC In 1/ In 2

  ADC_delay = d_{ADC} * 1/ fs

  d_{ADC} = 19 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

  $d_{AES\ in}$ = 2 clock pulses

  AES_in_delay = $d_{AES\ in}$ * 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

  $d_{AES\ out}$ = 1 clock pulses

  AES_out_delay = $d_{AES\ out}$ * 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

- *core*BUS (Code 7710), I/O bus mainboard

- *core*OUT-Amp2 (Code 7720), Mouth / loudspeaker amplifier module

  Delay @ Loudspeaker 1/2

  DAC_delay = d_{DAC} * 1/ fs + $d_{FPGA\ Card}$ * 1/ fs

  d_{DAC} = 28.8 clock pulses

  $d_{FPGA\ Card}$ = 3 clock pulses

  @ 48 kHz = 0.6 ms + 0.0625 ms ≈ 0.66 ms

  @ 96 kHz = 0.3 ms + 0.03125 ≈ 0.33 ms

  @ 192 kHz = 0.15 ms + 0.015625 ≈ 0.17 ms

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

  Delay @ Mic 1 / 2 / 3 / 4

  ADC_delay = d_{ADC} * 1/ fs + $d_{FPGA\ Card}$ * 1/ fs

  d_{ADC} = 19 clock pulses

  $d_{FPGA\ Card}$ = 3 clock pulses

  @ 48 kHz = 0.3958 ms + 0.0625 ms ≈ 0.46 ms

  @ 96 kHz ≈ 0.1979 ms + 0.03125 ms ≈ 0.23 ms

  @ 192 kHZ ≈ 0.099 + 0.015625 ≈ 0.11 ms

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

Codec	ptime [ms]	Delay receiving direction [ms]	Delay sending direction [ms]	Round-trip delay [ms]
G.726	10	35.0	75.0	110.1
	20	45.0	75.0	120.1
	30	55.0	75.0	130.1
	40	65.0	75.0	140.1
	50	75.0	75.0	150.1
	60	85.0	75.0	160.1
AMR	20	100.0	125.0	225.1
	40	120.0	125.0	245.1
	60	140.0	125.0	265.1
AMR-WB	20	98.5	122.5	221.0
	40	118.5	122.5	241.0
	60	138.5	122.5	261.0
EVS	20	59.7	72.4	132.1
	40	79.7	72.4	152.1
	60	99.7	72.4	172.1

Codec	ptime [ms]	Delay receiving direction [ms]	Delay sending direction [ms]	Round trip delay [ms]
G.722	10	33.9	72.5	106.4
	20	43.9	72.5	116.4
	30	53.9	72.5	126.4
	40	63.9	72.5	136.4
	50	73.9	72.5	146.4
	60	83.9	72.5	156.4
G.729	10	40.0	75.0	115.1
	20	50.0	75.0	125.1
	30	60.0	75.0	135.1
	40	70.0	75.0	145.1
	50	80.0	75.0	155.1
	60	90.0	75.0	165.1
GSM	20	45.0	75.0	120.0
	40	75.0	75.0	140.0
	60	85.0	75.0	160.0
GSM-EFR	20	100.0	125.0	225.1
iLBC	30	55.0	75.0	130.1
L16 (48 kHz)	10	30.0	70.0	100.1
	20	40.0	70.0	110.1
	30	50.0	70.0	120.1
	40	60.0	70.0	130.1
	50	70.0	70.0	140.1
	60	80.0	70.0	150.1
L16 (32 kHz)	10	31.3	71.3	102.6
	20	41.3	71.3	112.6
	30	51.3	71.3	122.6
	40	71.3	71.3	132.6
	50	71.3	71.3	142.6
	60	81.3	71.3	152.6
L16 (16kHz)	10	32.5	72.5	105.1
	20	42.5	72.5	115.1
	30	52.5	72.5	125.1
	40	72.5	72.5	135.1
	50	72.5	72.5	145.1
	60	82.5	72.5	155.1
L16 (8 kHz)	10	35.0	75.0	110.1
	20	45.0	75.0	120.1
	30	55.0	75.0	130.1
	40	75.0	75.0	140.1
	50	75.0	75.0	150.1
	60	85.0	75.0	160.1

Codec	ptime [ms]	Delay receiving direction [ms]	Delay sending direction [ms]	Round trip delay [ms]
G.711	10	35.0	75.0	110.1
	20	45.0	75.0	120.1
	30	55.0	75.0	130.1
	40	65.0	75.0	140.1
	50	75.0	75.0	150.1
	60	85.0	75.0	160.1
SILK (24 kHz)	20	47.2	71.7	118.9
SILK (16 kHz)	20	48.0	72.5	120.6
SILK (12 kHz)	20	49.3	73.4	122.6
SILK (8 kHz)	20	50.0	75.0	125.1
speex (32 kHz)	20	57.2	71.3	128.5
	40	77.2	71.3	148.5
	60	97.2	71.3	168.5
speex (16 kHz)	20	56.5	72.5	129.1
	40	76.5	72.5	149.1
	60	96.5	72.5	169.1
speex (8 kHz)	20	55.0	75.0	130.0
	40	75.0	75.0	150.0
	60	95.0	75.0	170.0
Opus	20	45.8	70.8	116.6
	40	65.8	70.8	136.6
	60	85.8	70.8	156.6

- *core*BT (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
- *core*BT-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:

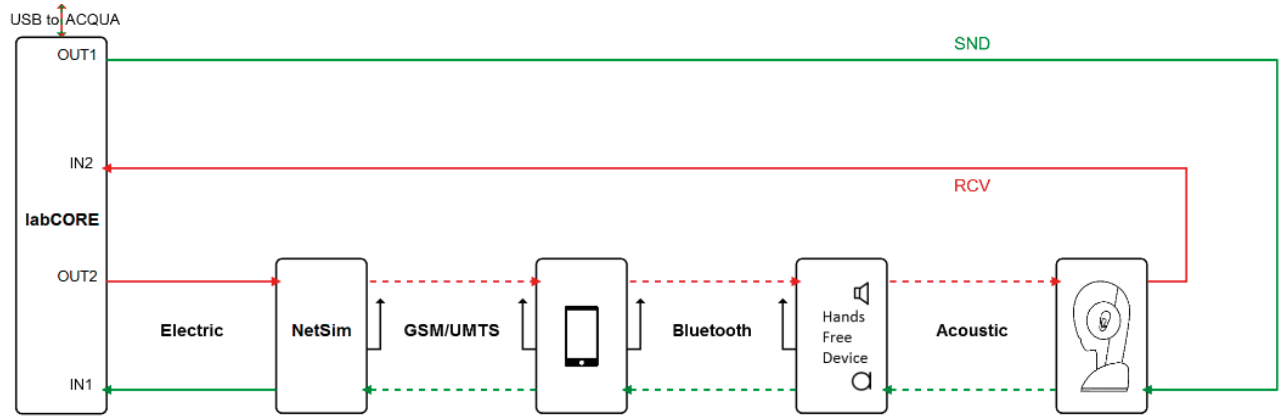
- integrated hands-free systems of motor vehicles.
- after-market hands-free kits for motor vehicles.
- corded and wireless headsets for use in motor vehicles.

3.2.1 Setup for GSM / UMTS access

Relevant standards

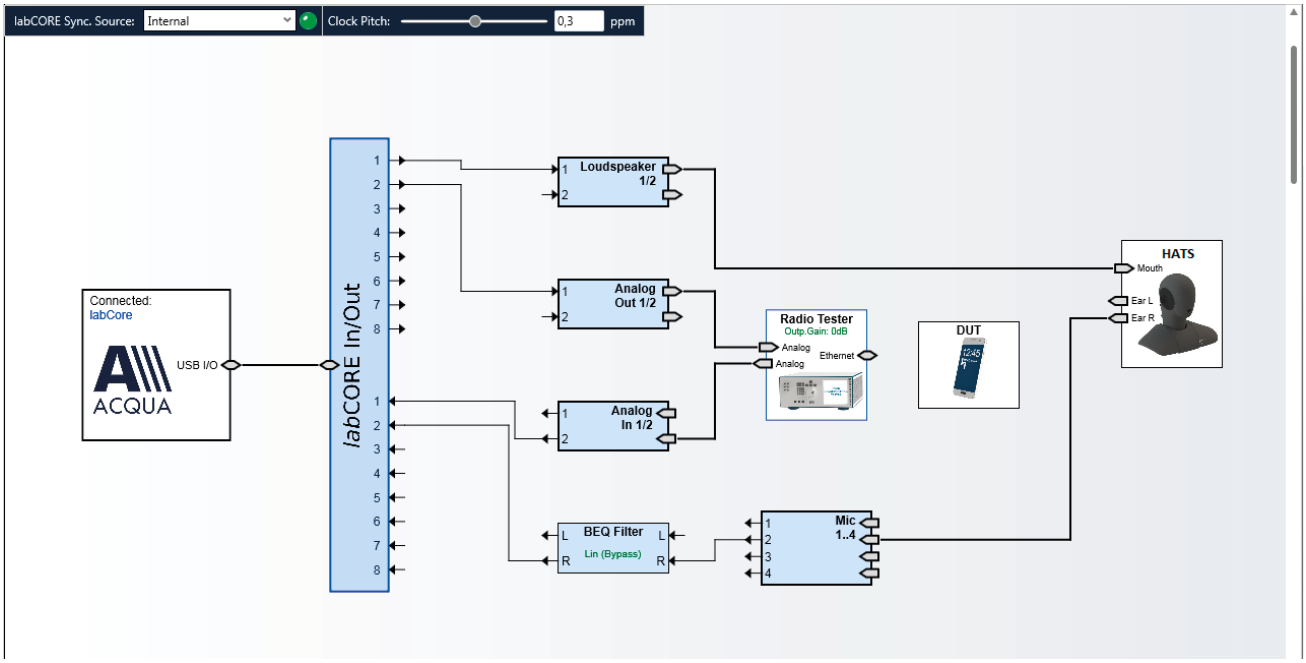
- P.1100, Speech Quality Assessment of Narrowband Car Hands-free Terminals.
- P.1110, Speech Quality Assessment of Wideband Car Hands-free Terminals.

Block diagram for application of *lab*CORE



Hardware configuration for application of *lab*CORE

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

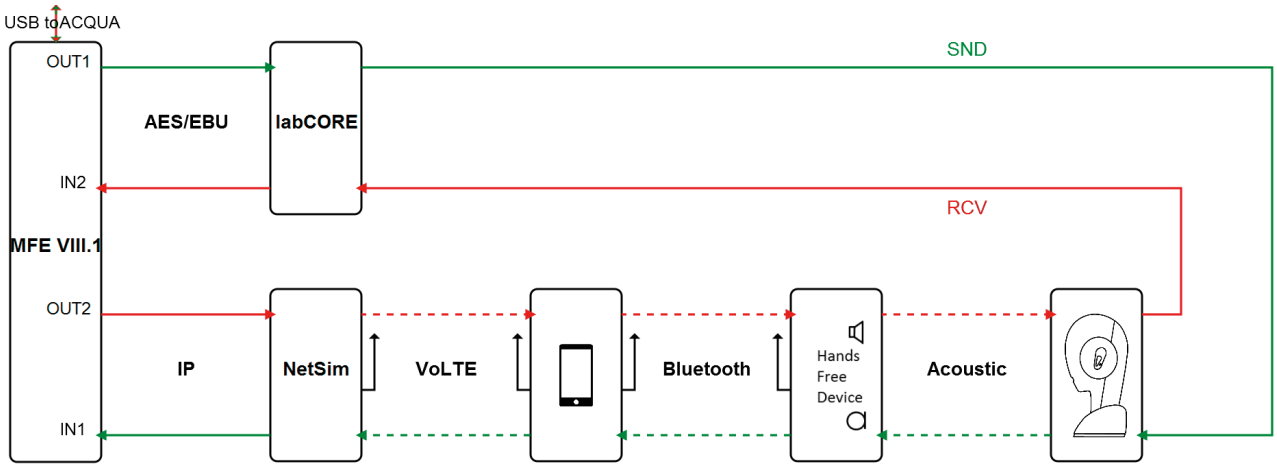


3.2.2 Setups for Voice over LTE (VoLTE) access

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.

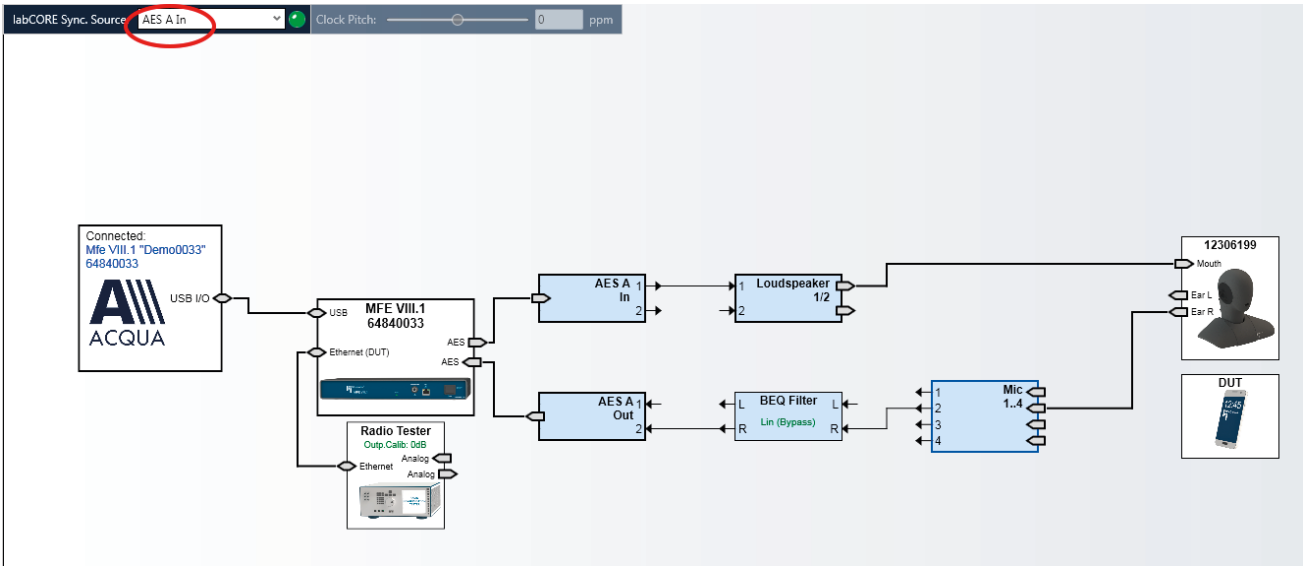
Setup 1: Block diagram for application of *lab*CORE and MFE VIII.1



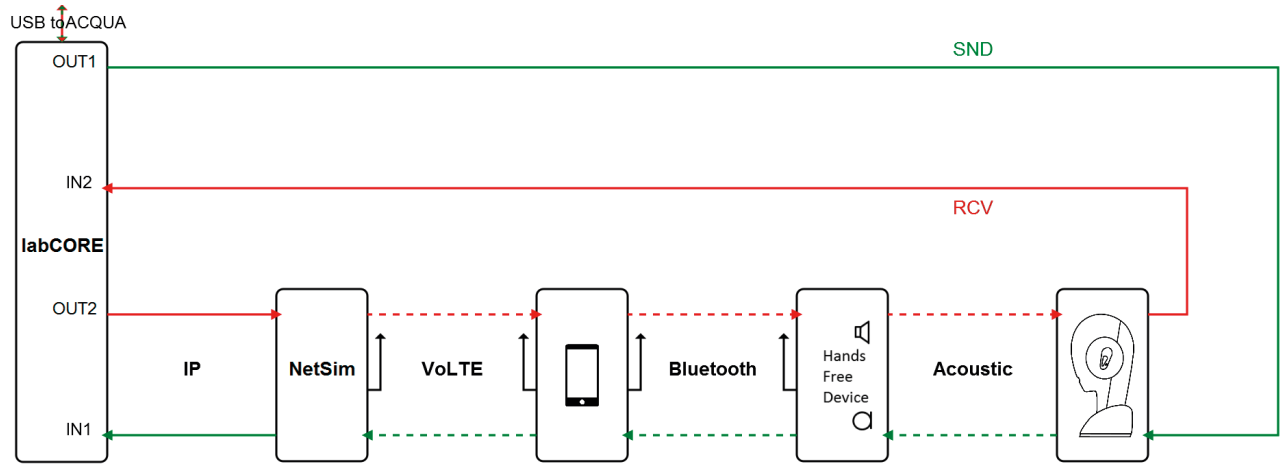
Setup 1: Hardware configuration for application of *lab*CORE and MFE VIII.1

Blue boxes represent *lab*CORE 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
- *lab*CORE > Playback and receiving of audio signal

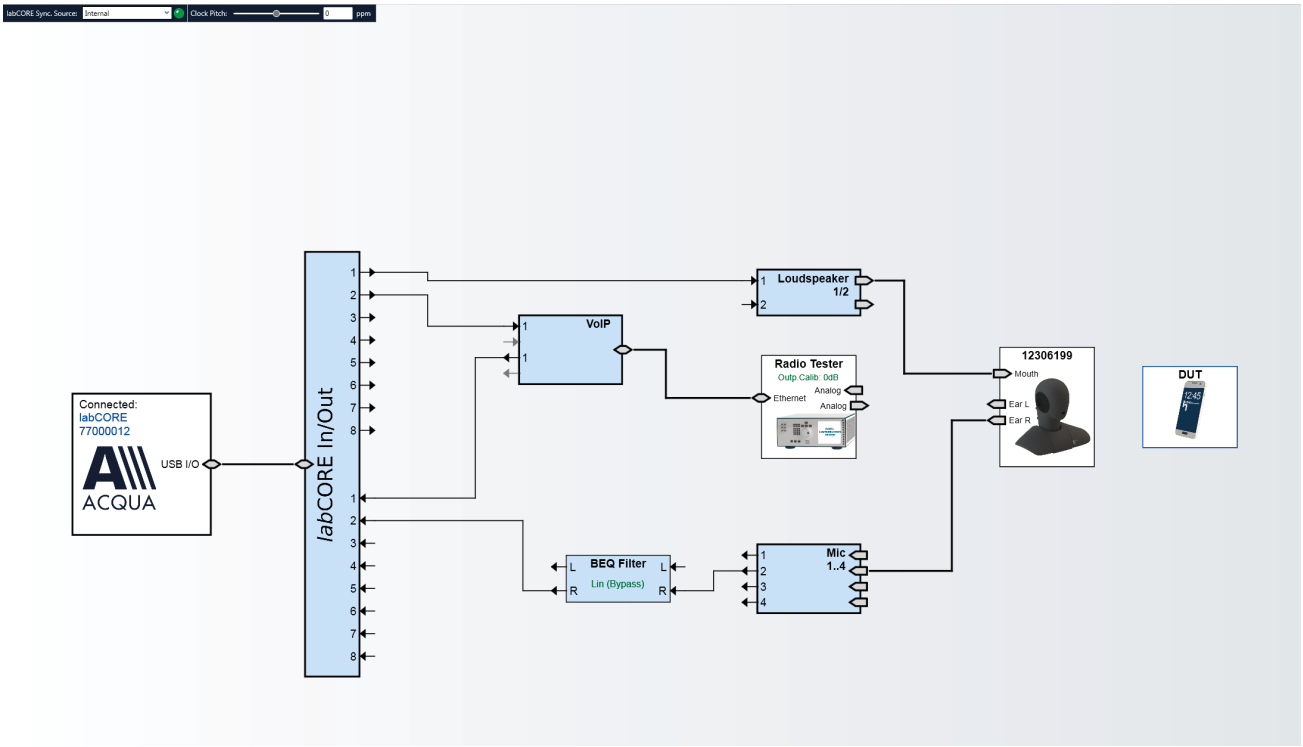


Setup 2: Block diagram for application of *lab*CORE with *core*IP

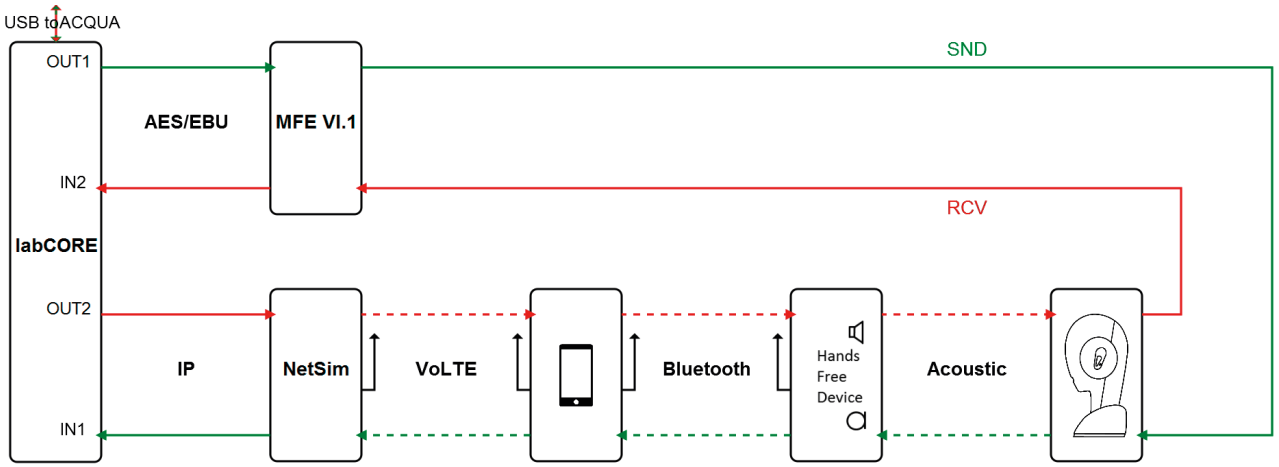


Setup 2: Hardware configuration for application of *lab*CORE with *core*IP

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



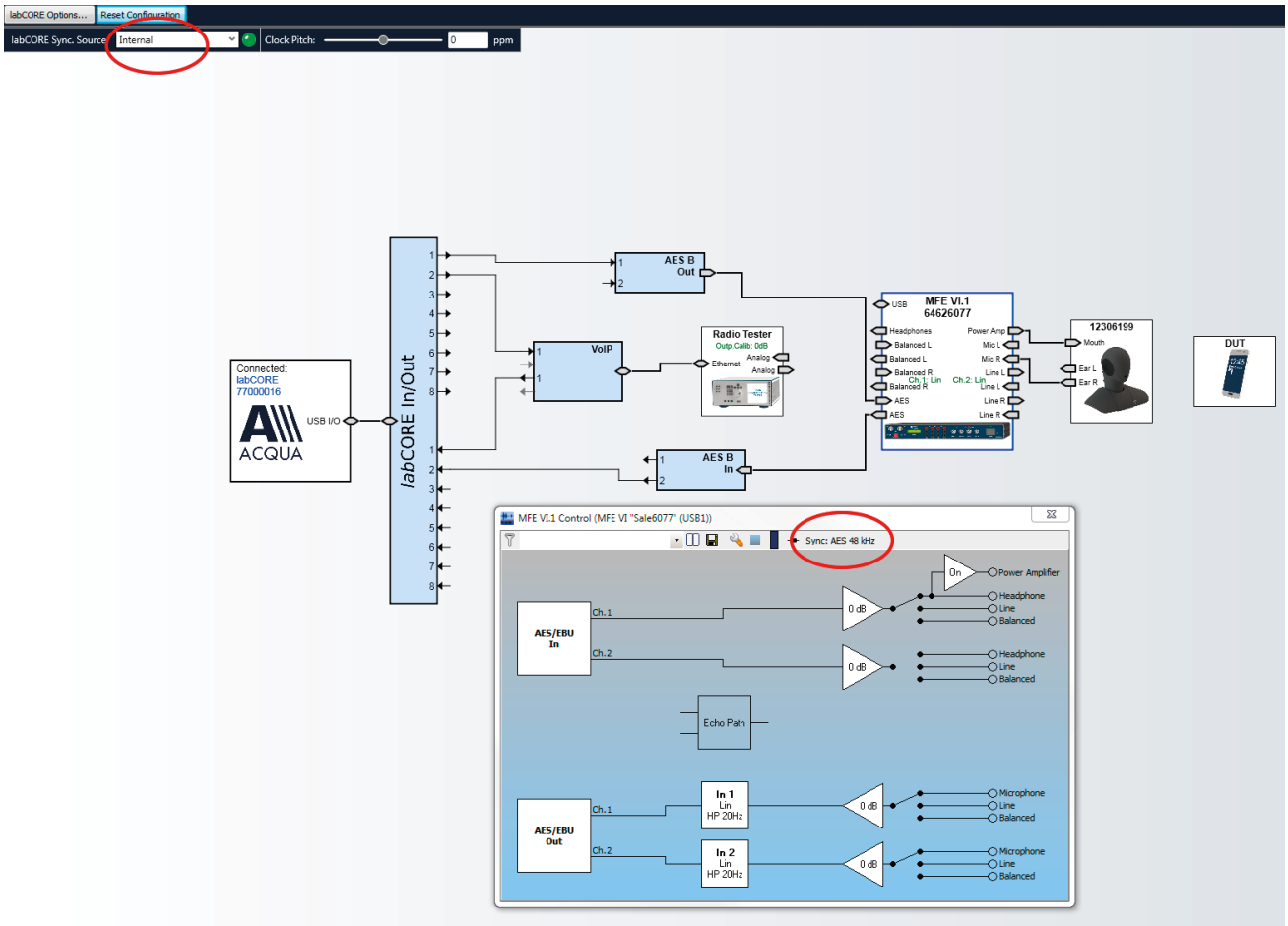
Setup 3: Block diagram for application of MFE VI.1 and *lab*CORE with *core*IP



Setup 3: Hardware configuration for application of MFE VI.1 and *lab*CORE with *core*IP

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

- *lab*CORE > VoIP reference gateway
- MFE VI.1 > Playback and receiving of audio signal

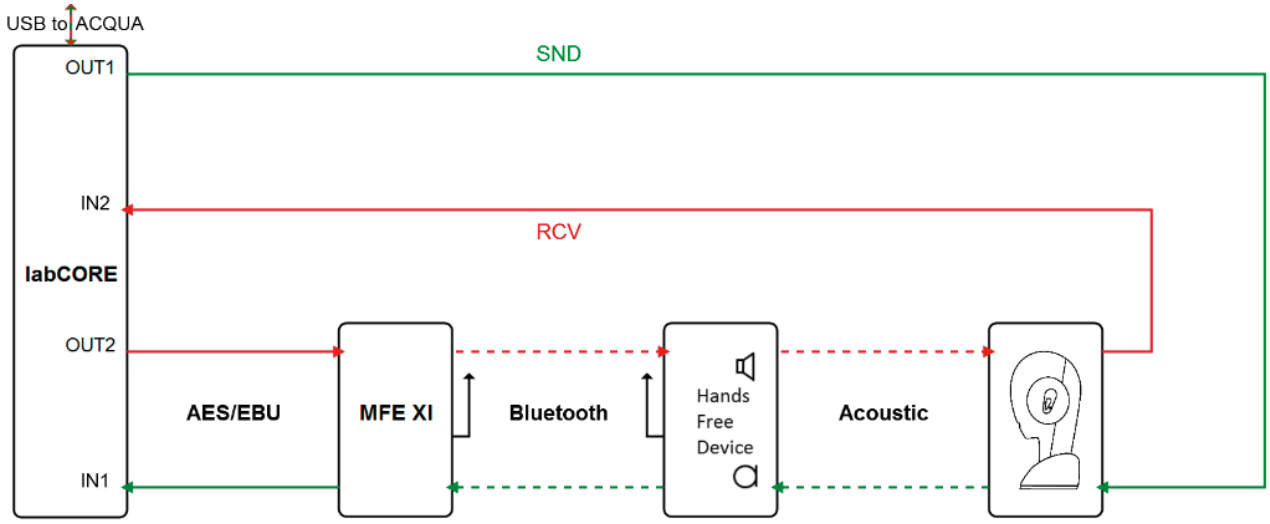


3.2.3 Setups for Bluetooth

Relevant standards

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

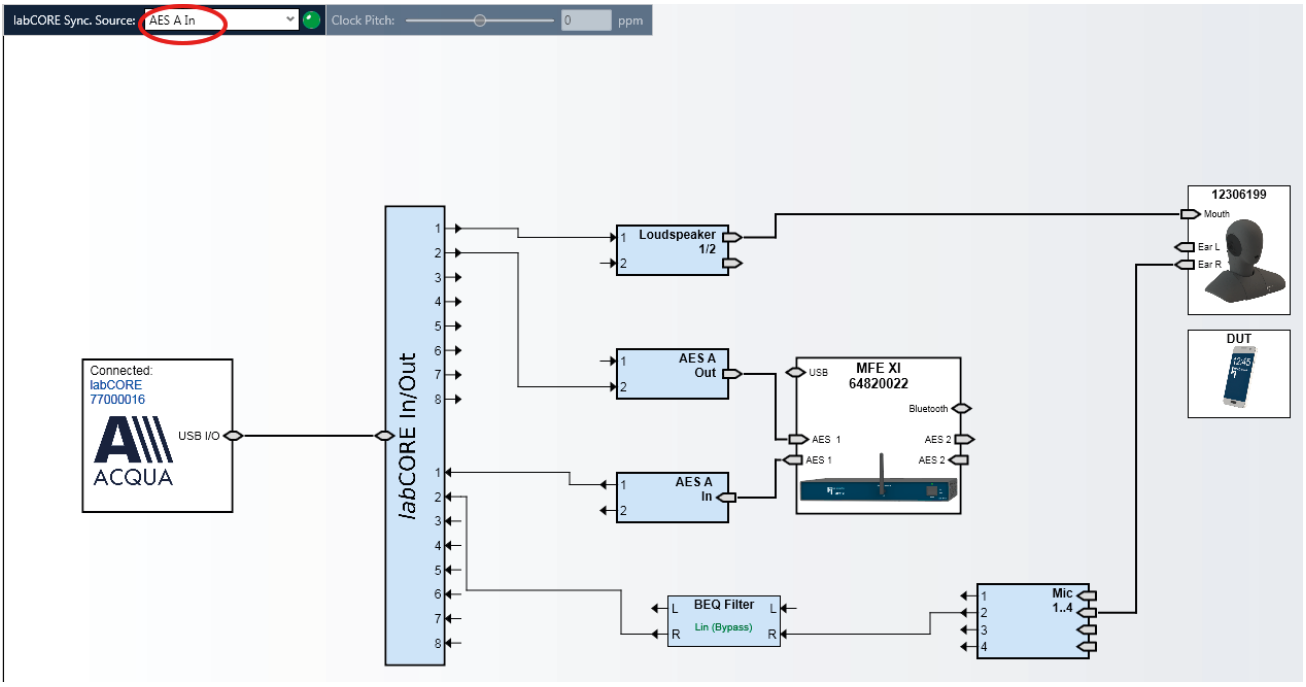
Setup 1: Block diagram for application of *lab*CORE & MFE XI



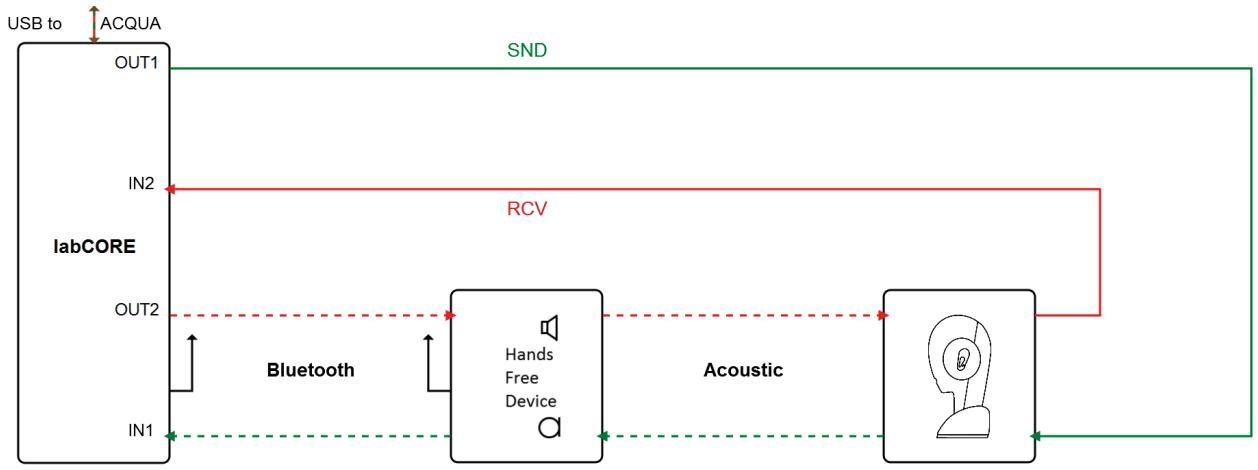
Setup 1: Hardware configuration for application of *lab*CORE & MFE XI

Blue boxes represent *lab*CORE 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
- *lab*CORE > Playback and receiving of audio signal

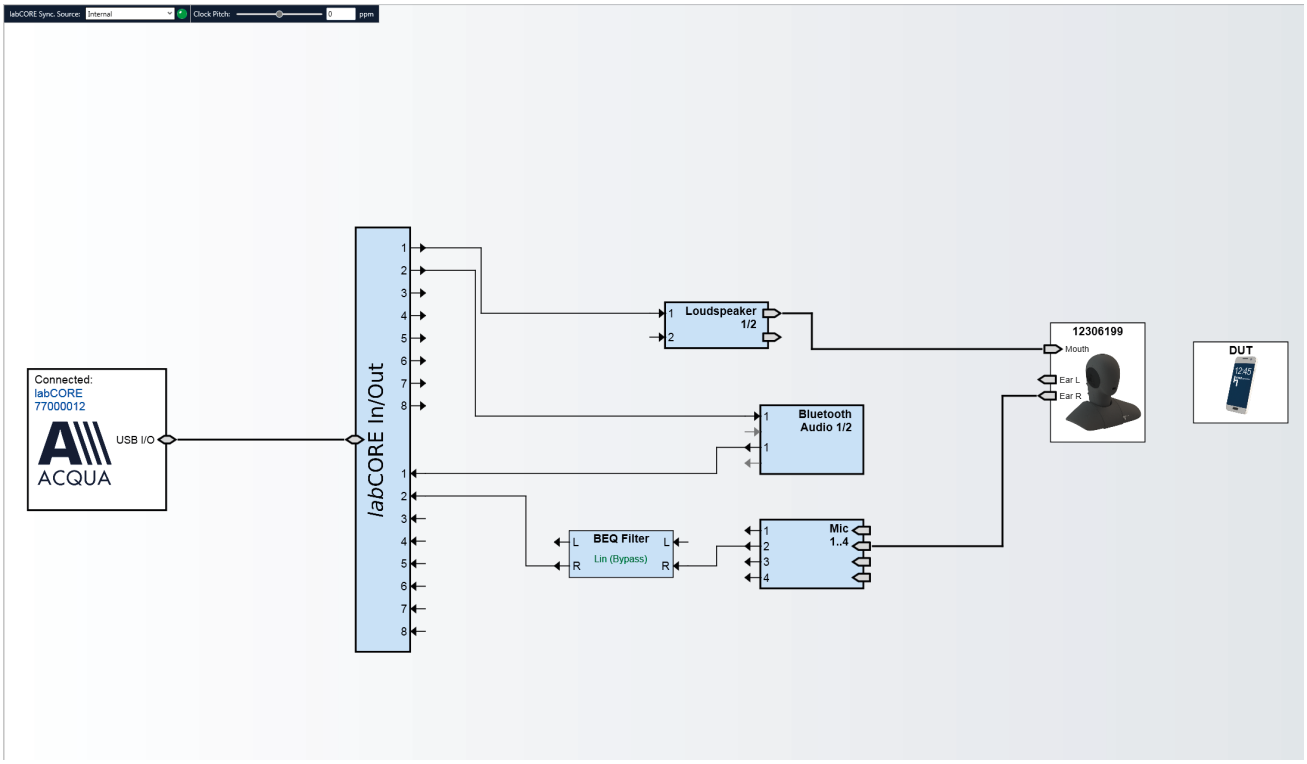


Setup 2: Block diagram for application of *lab*CORE with *core*BT

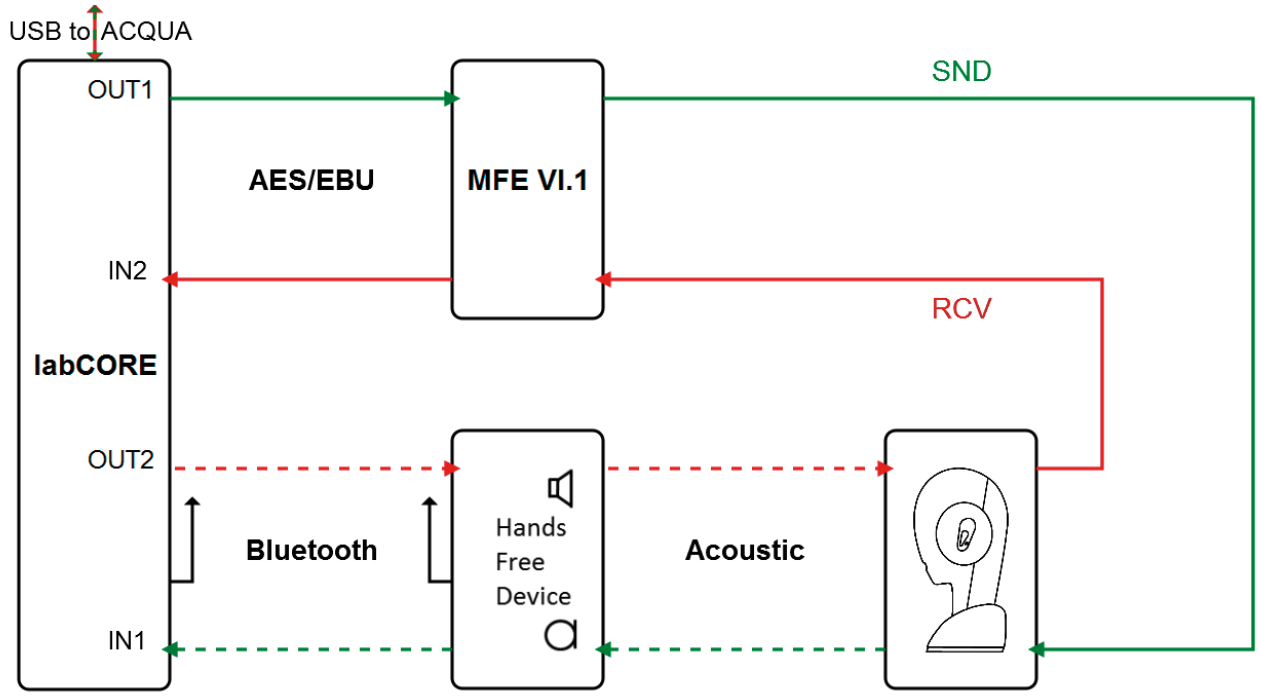


Setup 2: Hardware configuration for application of *lab*CORE with *core*BT

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



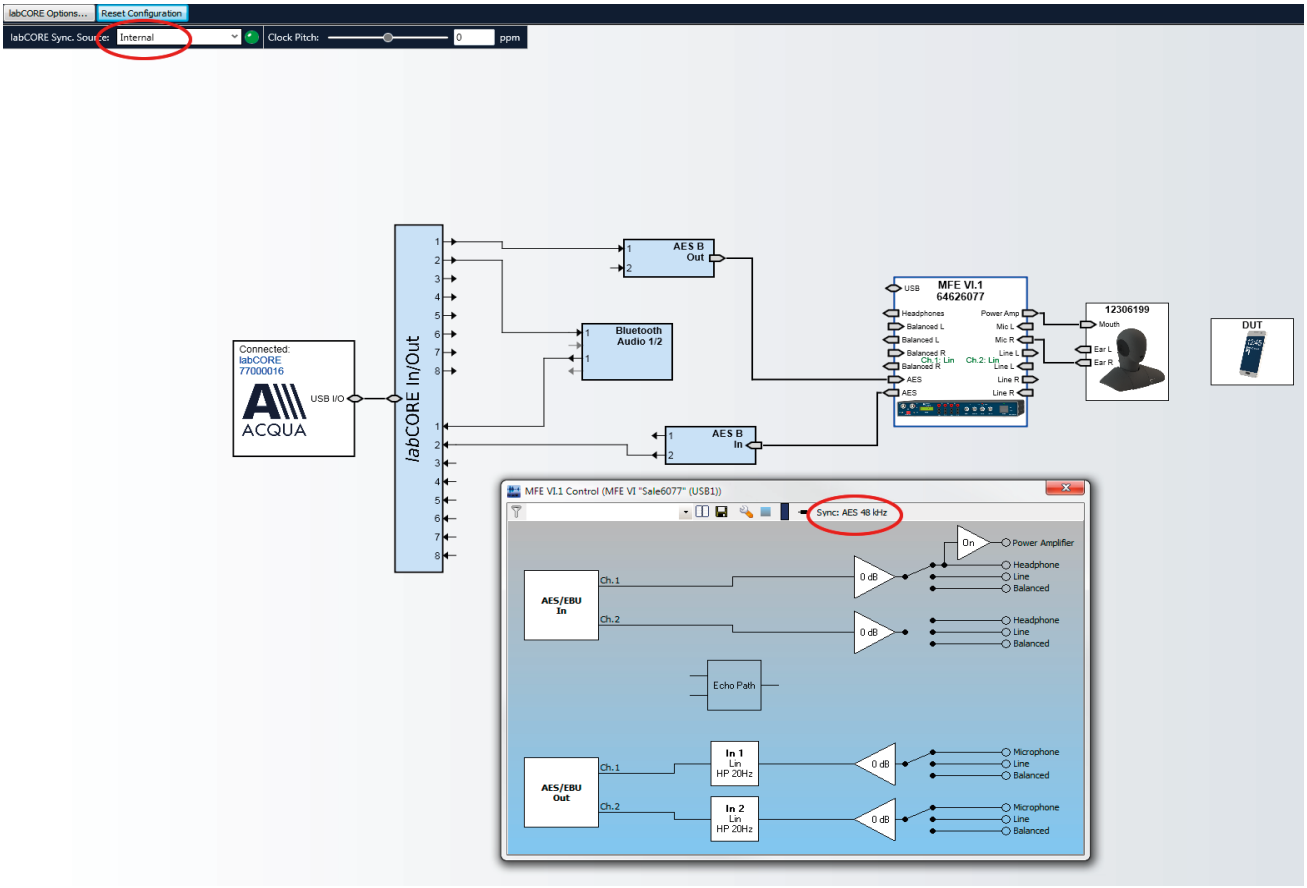
Setup 3: Block diagram for application of MFE VI.1 and *lab*CORE with *core*BT



Setup 3: Hardware configuration for application of MFE VI.1 and *lab*CORE with *core*BT

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

- *lab*CORE > Bluetooth reference access point
- MFE VI.1 > Playback and receiving of audio signal



3.3 In-vehicle emergency call device / system (GSM / UMTS)

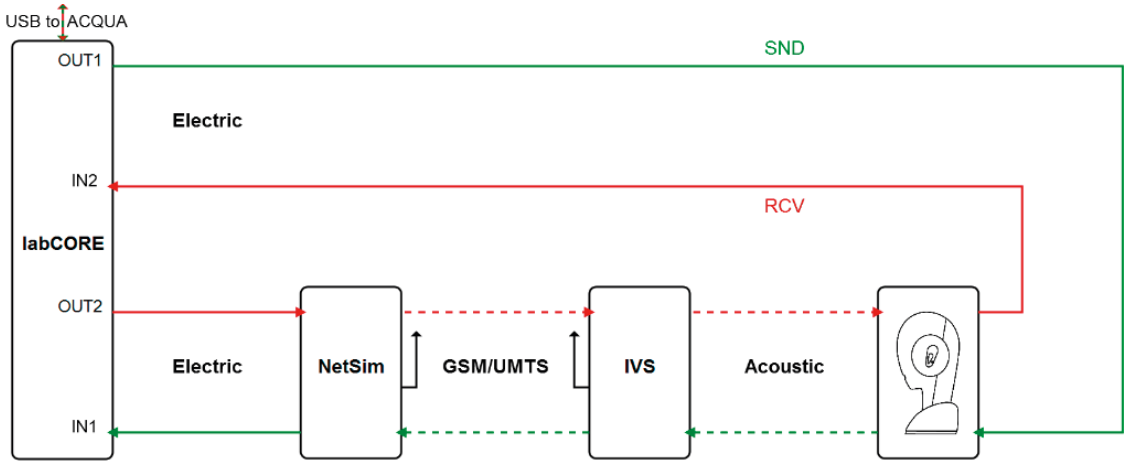
This measurement configurations especially applies to:

- eCall systems.

Relevant standards

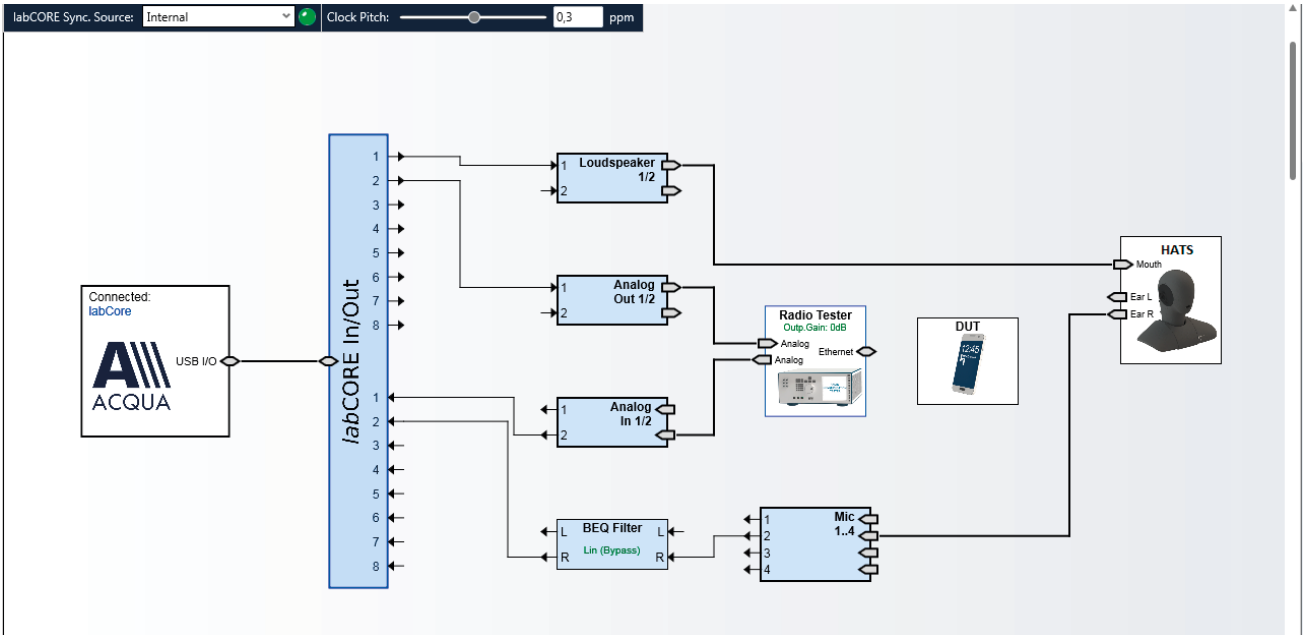
- P.1140-NB, Emergency call (eCall) Devices, Narrowband Part.
- UG P.1140-WB, Emergency call (eCall) Devices, Wideband Extension.
- GOST 33468-NB, GOST 33468 (ERA-GLONASS), Emergency Call (eCall) Devices, Narrowband Part.
- GOST 33468-WB, UG GOST R55531-WB (ERA-GLONASS), Emergency Call (eCall) Devices,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

Block diagram for application of *lab*CORE



Hardware configuration for application *lab*CORE

Blue boxes represent *lab*CORE 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)

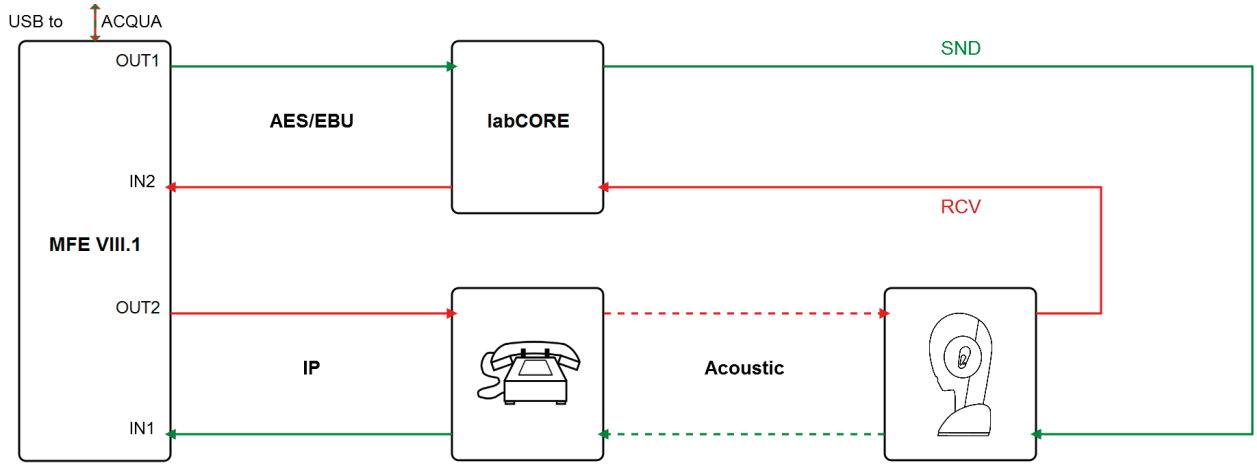
This measurement configuration especially applies to:

- IP terminals.
- VoIP handset and headset terminals.

Relevant standards

- TIA-920.110B, ANSI/TIA-920.110-B, Digital Interface Communications Devices with Handsets.
- ES 202 737 / 38, ETSI ES 202 737/ ES 202 738, Narrowband IP phones.
- ES 202 739 / 40, ETSI ES 202 739/ ES 202 740, Wideband IP phones.

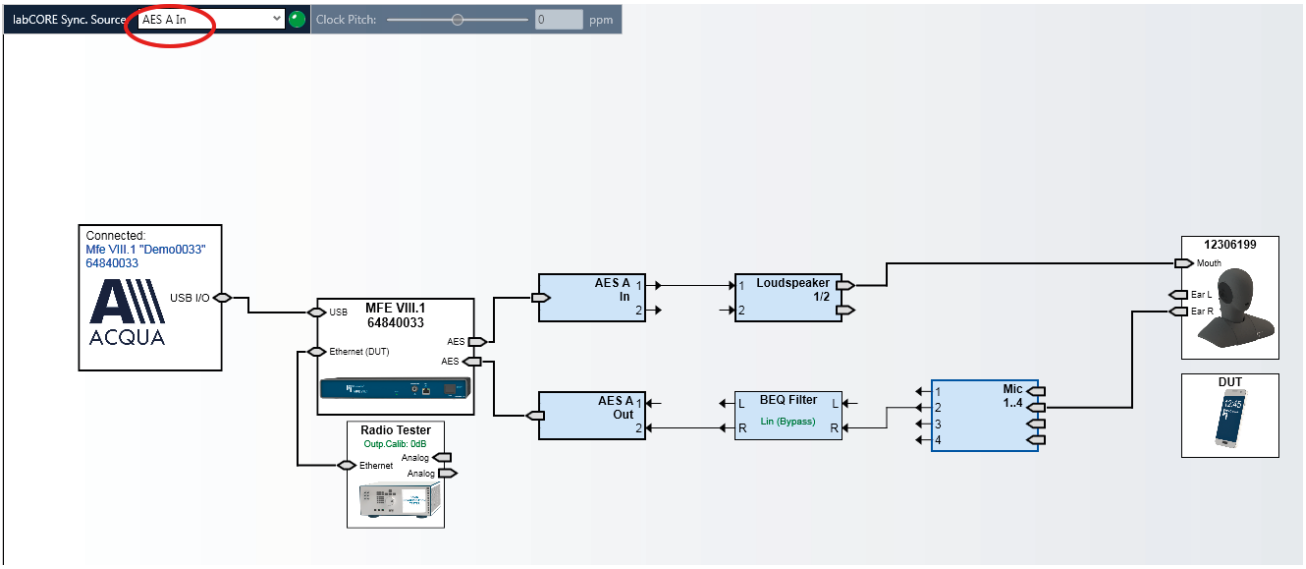
Setup 1: Block diagram for application of *lab*CORE & MFE VIII.1



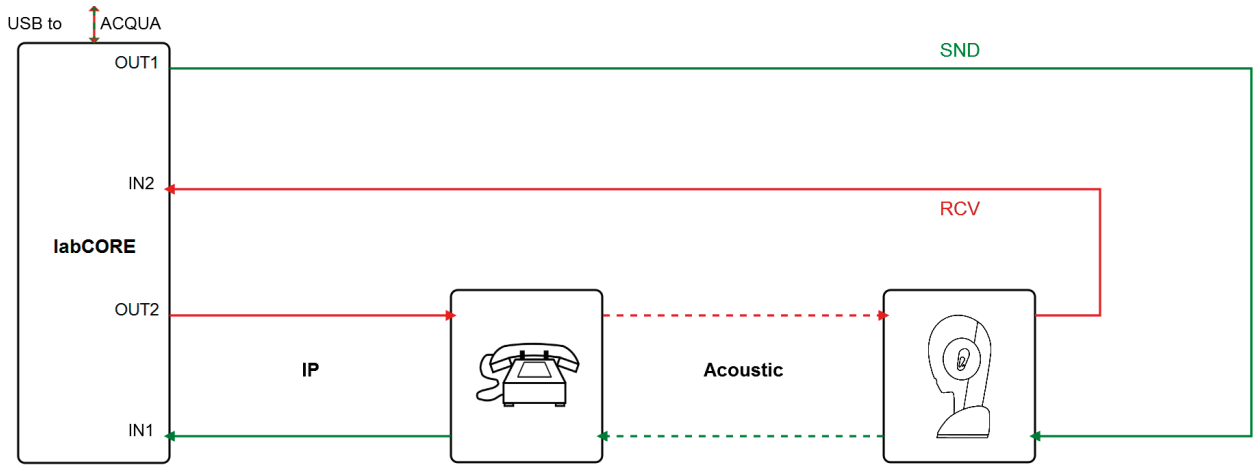
Setup 1: Hardware configuration for application of *lab*CORE & MFE VIII.1

Blue boxes represent *lab*CORE 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
- *lab*CORE > Playback and receiving of audio signal

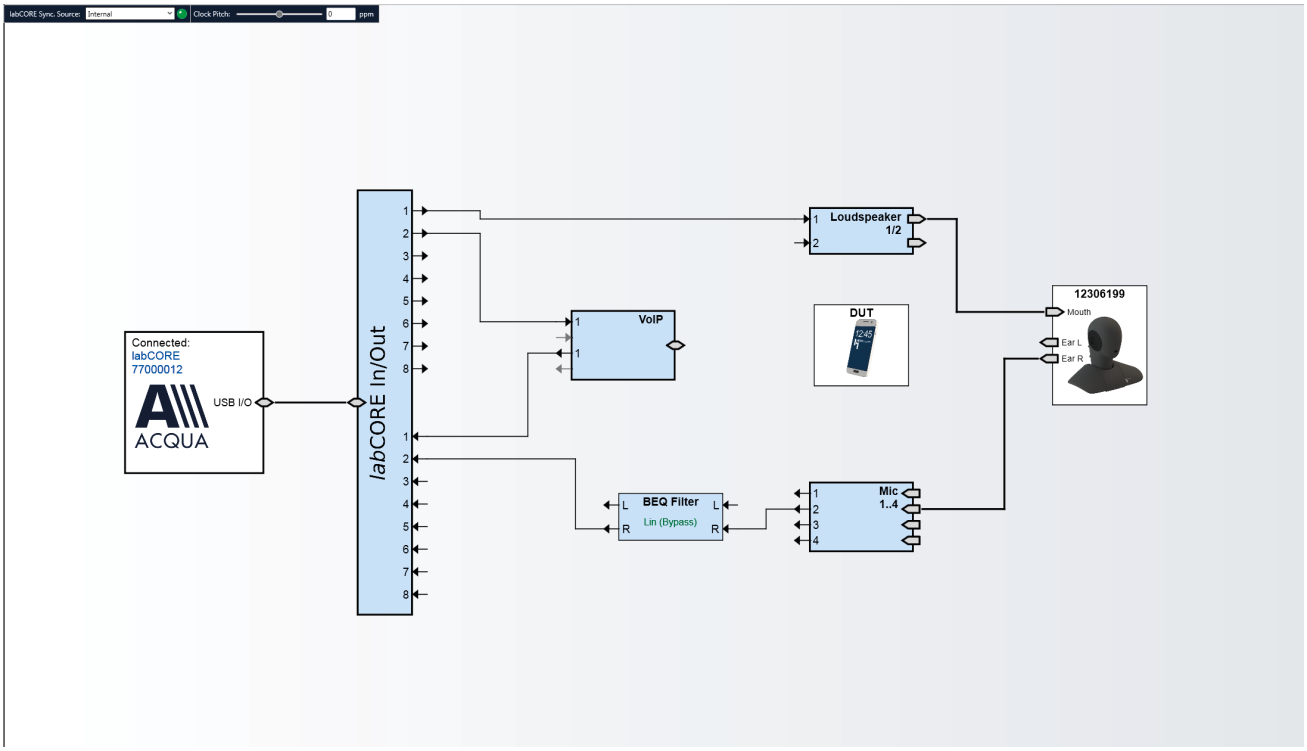


Setup 2: Block diagram for application of *lab*CORE with *core*IP

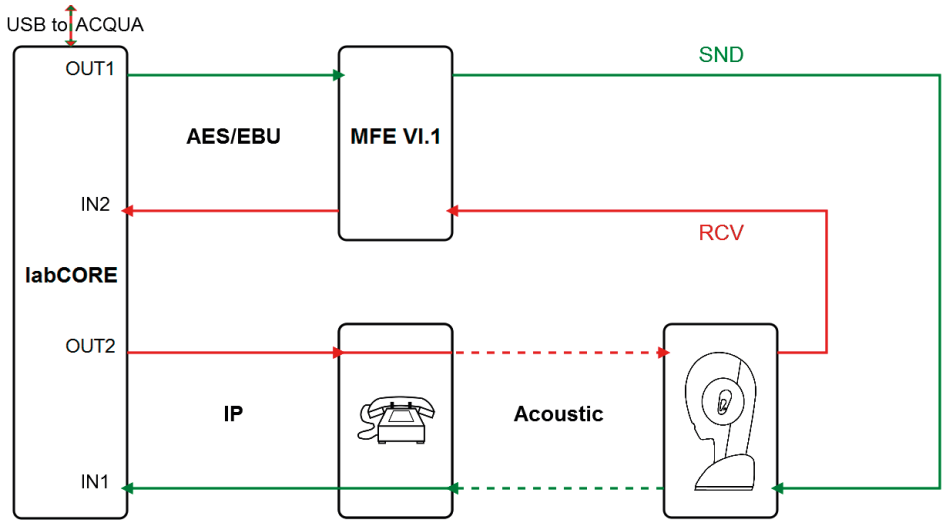


Setup 2: Hardware configuration for application of *lab*CORE with *core*IP

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



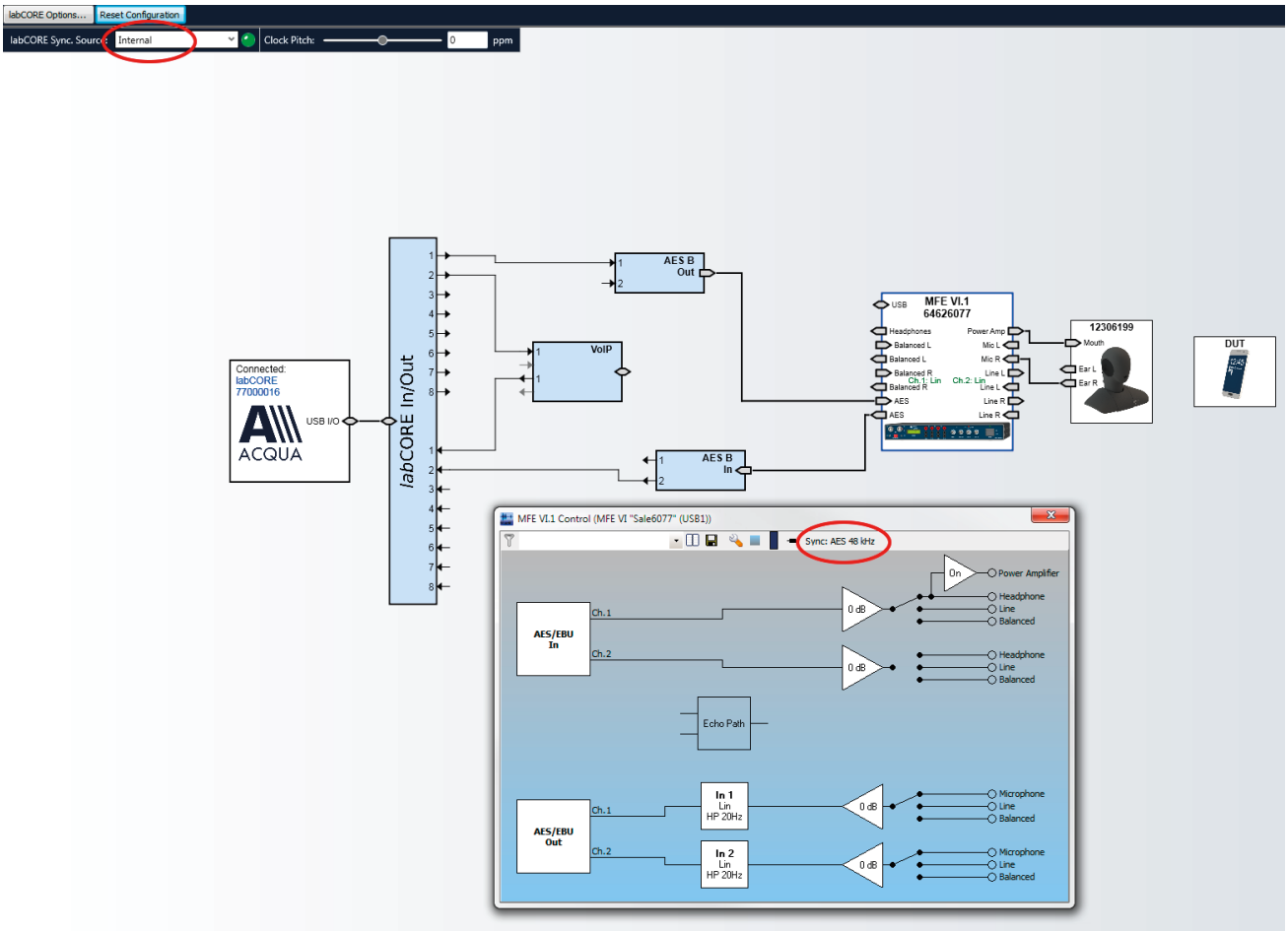
Setup 3: Block diagram for application of MFE VI.1 *lab*CORE with *core*IP



Setup 3: Hardware configuration for application of MFE VI.1 *lab*CORE with *core*IP

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

- *lab*CORE > VoIP reference gateway
- MFE VI.1 > Playback and receiving of audio signal



3.5 Digital interface communication devices (DECT PP)

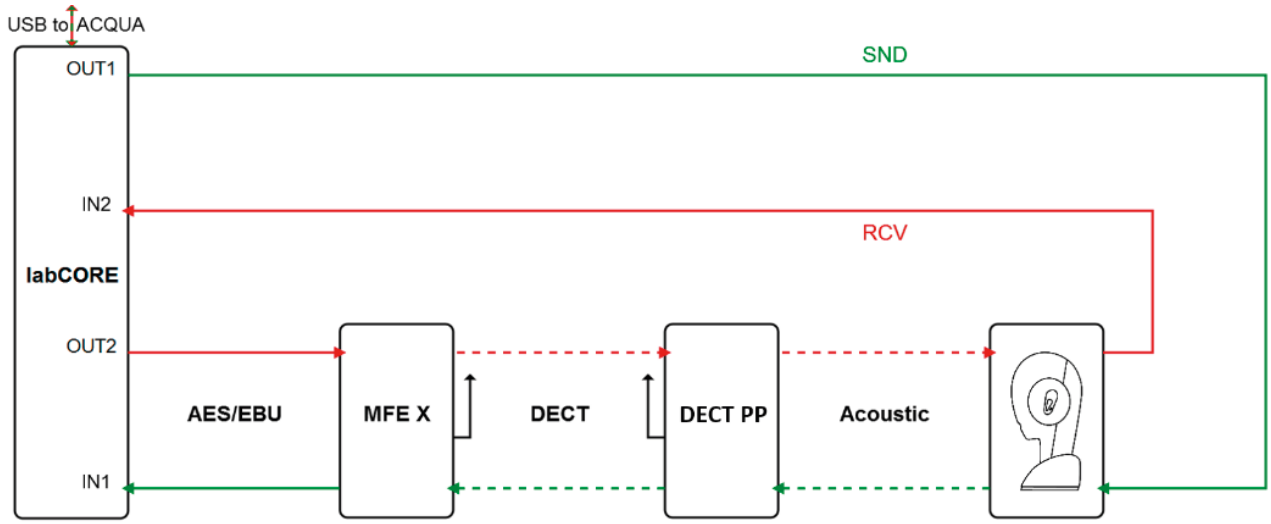
This measurement configuration especially applies to:

- DECT terminals.

Relevant standards

- TIA-920.110B, ANSI/TIA-920.110-B, Digital Interface Communications Devices with Handsets.
- UG DTAG-Mobile-WB, Voice Quality Evaluation of Mobile Phones, Upgrade to Wideband.
- CAT-IQ 1.0, Wideband NG-DECT Terminals.
- CAT-IQ 2.0, Acoustic Tests of DECT/CAT-iq™ Terminals, based on Test Specification Audio for CAT-iq™ 2.0 Devices.

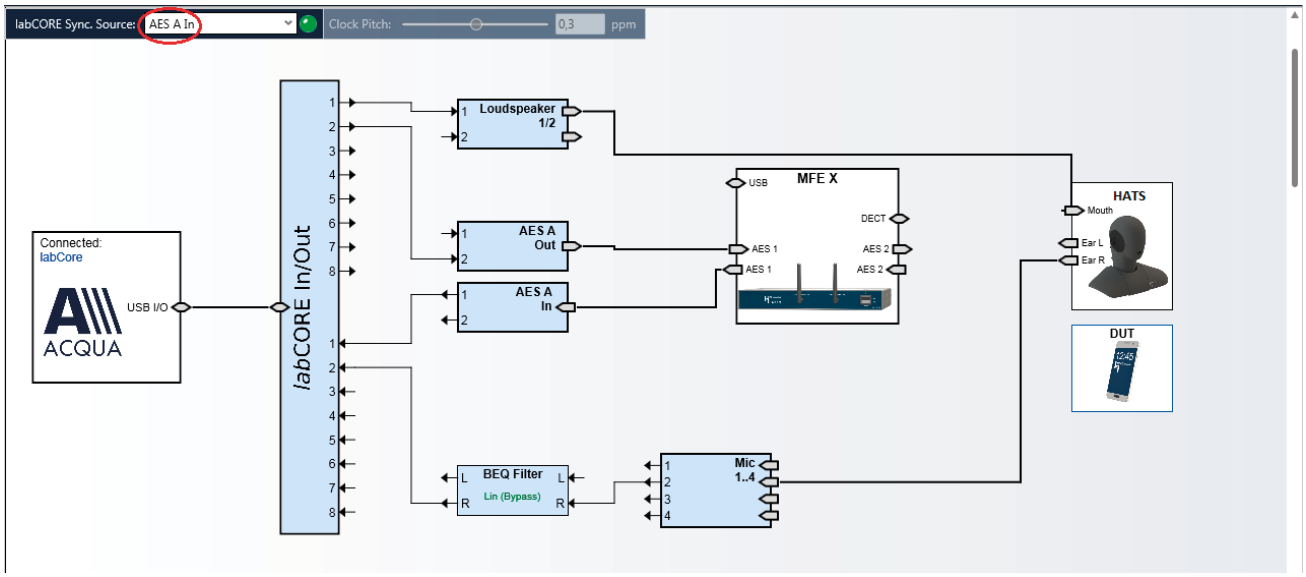
Block diagram for application of *lab*CORE and MFE X



Hardware configuration for application of *lab*CORE and MFE X

Blue boxes represent *lab*CORE 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™)
- *lab*CORE > Playback and receiving of audio signal



3.6 Acoustic characteristics for mobile telephony

3.6.1 Setup for GSM / UMTS access

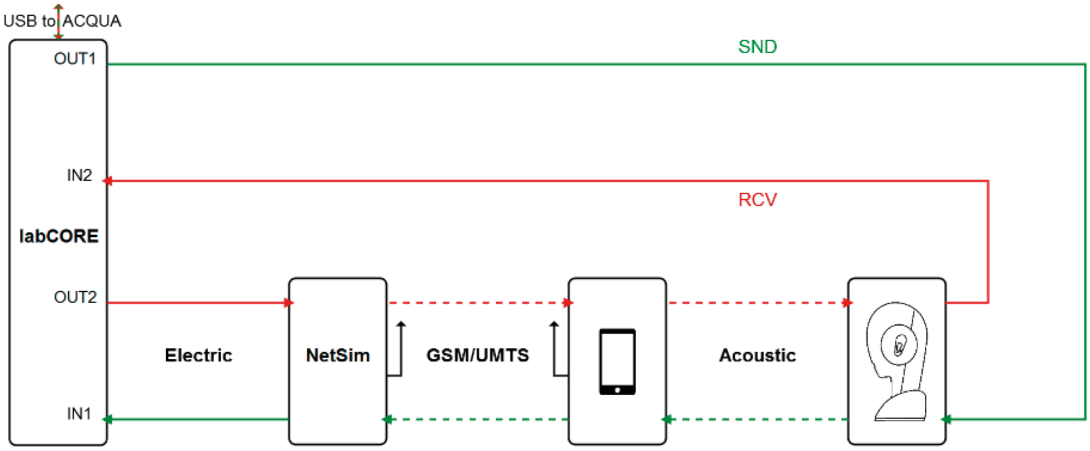
These measurement configurations especially applies to:

- mobile phones.
- wireless terminals.
- headsets.

Relevant standards

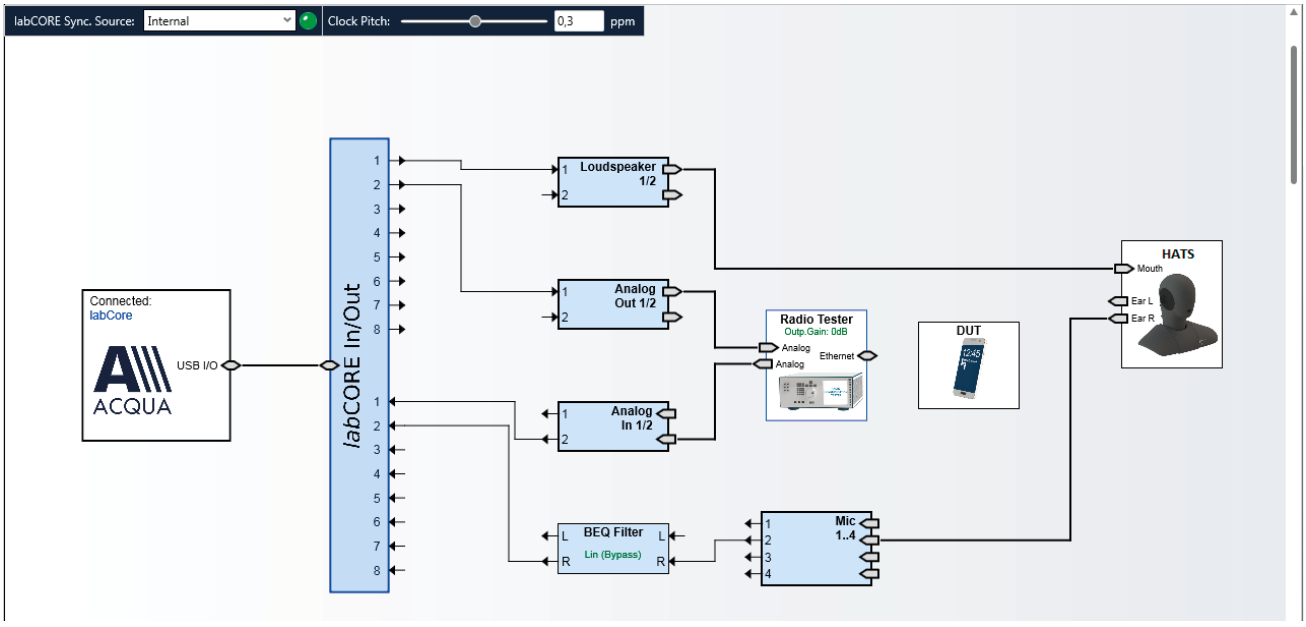
- TS 26 131-32, 3GPP TS 26.131/132, 3G Terminals.
- GSMA HD Voice, GSMA HD Voice Logo Minimum Requirements for Mobile Devices and Headsets.
- TS 103 737 / 38, Narrowband Mobile & Wireless Terminals.
- TS 103 739 / 40, Wideband Mobile & Wireless Terminals.

Block diagram for application of *lab*CORE



Hardware configuration for application of *lab*CORE

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

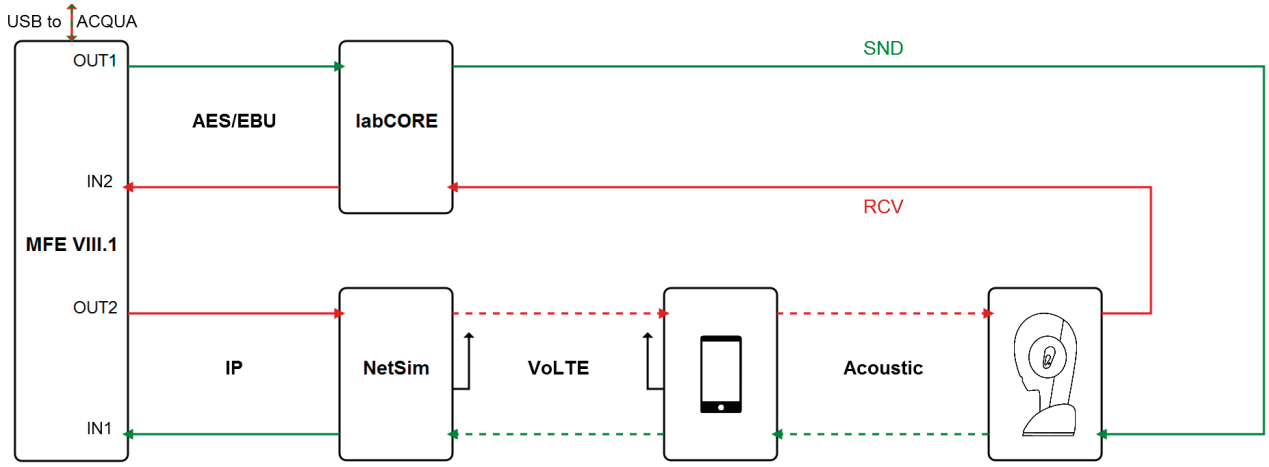


3.6.2 Setups for Voice over LTE (VoLTE) access

Relevant standards

- TS 26 131-32, 3GPP TS 26.131/132, 3G Terminals.
- UG TS 26 SWB / FB, 3GPP TS 26.131/132, Extension Superwideband and Fullband.
- GSMA HD Voice, GSMA HD Voice Logo Minimum Requirements for Mobile Devices and Headsets.
- TS 103 737 / 38, Narrowband Mobile & Wireless Terminals.
- TS 103 739 / 40, Wideband Mobile & Wireless Terminals.

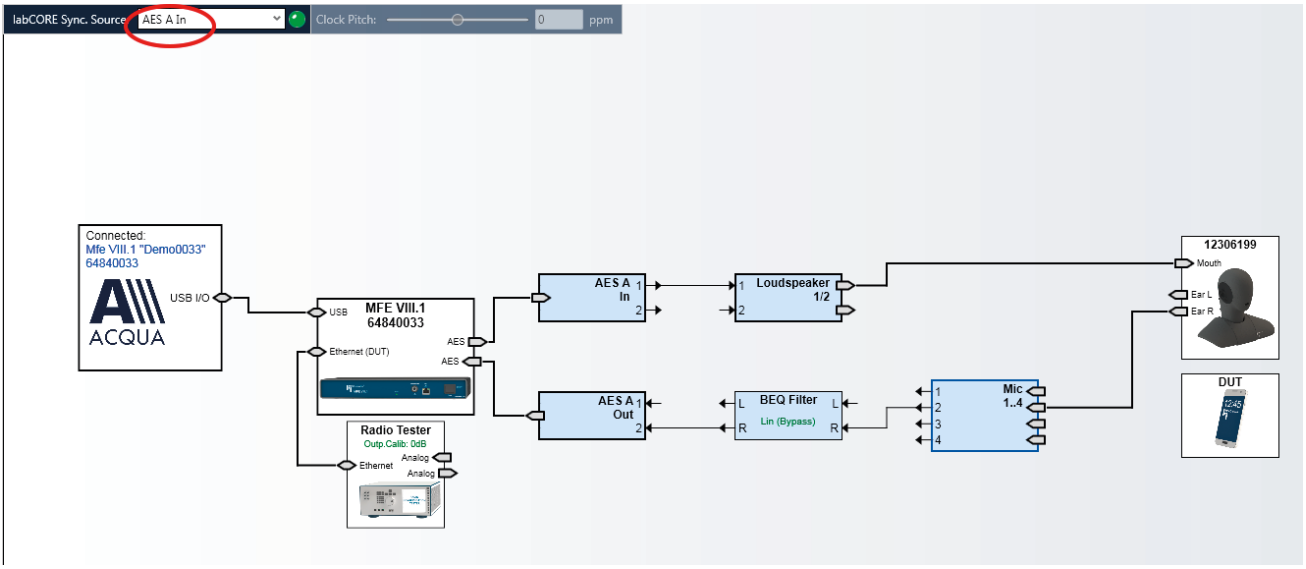
Setup 1: Block diagram for application of *lab*CORE and MFE VIII.1



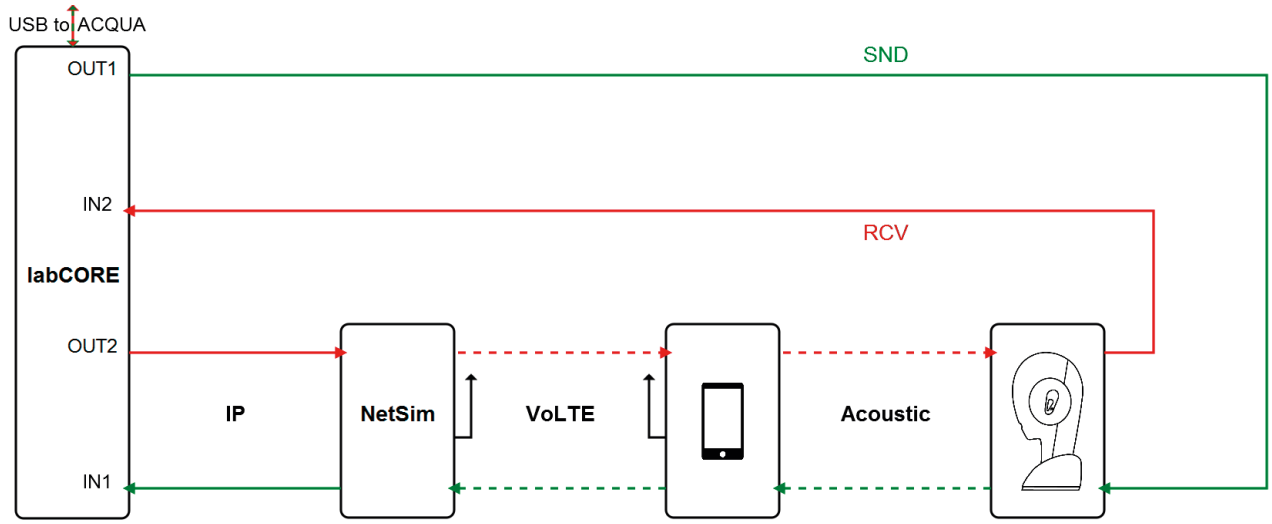
Setup 1: Hardware configuration for application of *lab*CORE & MFE VIII.1

Blue boxes represent *lab*CORE 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
- *lab*CORE > Playback and receiving of audio signal

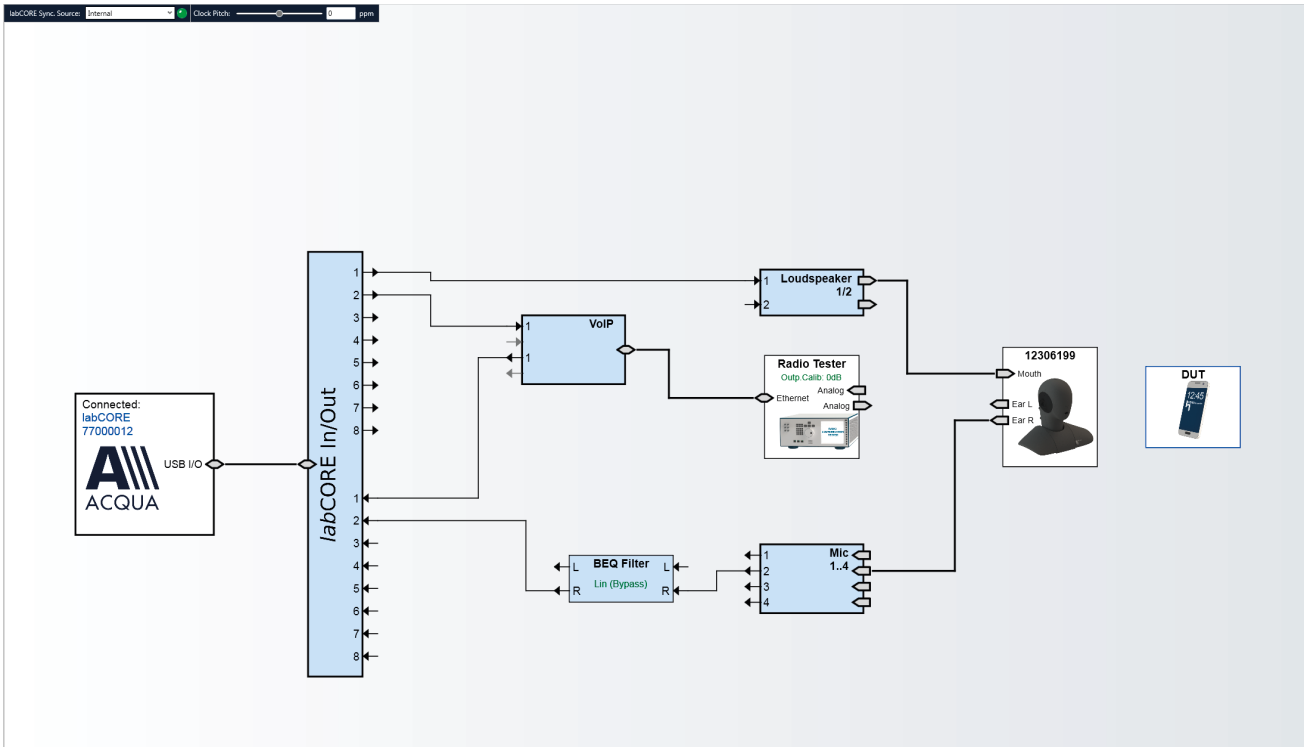


Setup 2: Block diagram for application of *lab*CORE with *core*IP

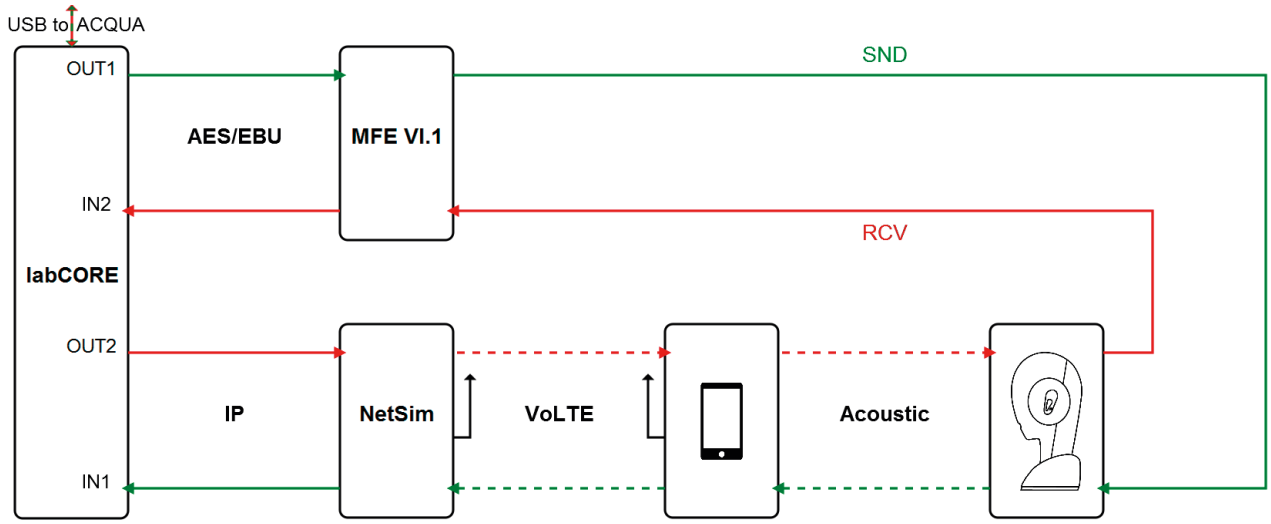


Setup 2: Hardware configuration for application of *lab*CORE with *core*IP

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



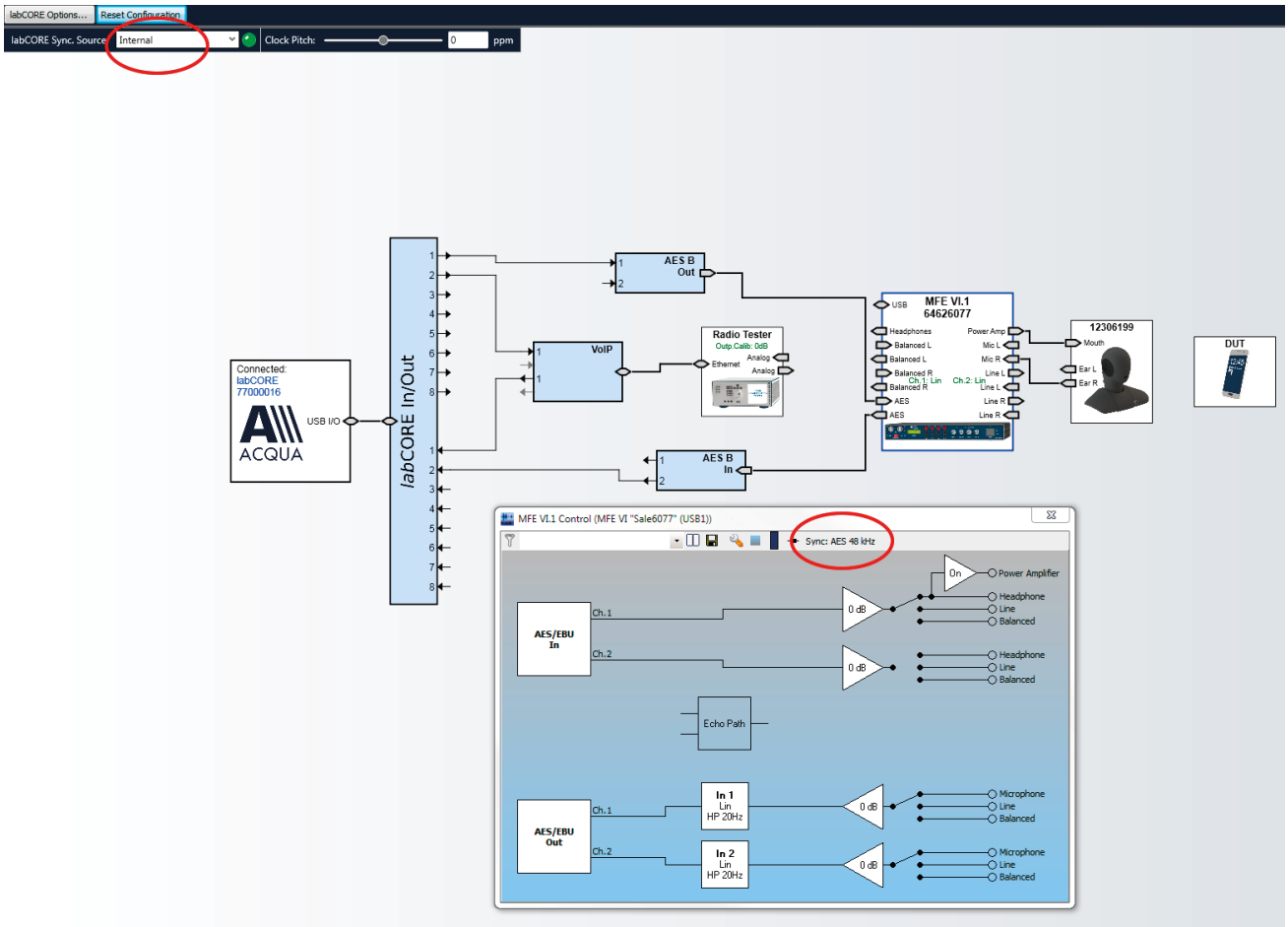
Setup 3: Block diagram for application of MFE VI.1 *lab*CORE with *core*IP



Setup 3: Hardware configuration for application of MFE VI.1 *lab*CORE with *core*IP

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

- *lab*CORE > VoIP reference gateway
- MFE VI.1 > Playback and receiving of audio signal



3.7 In-car communication system

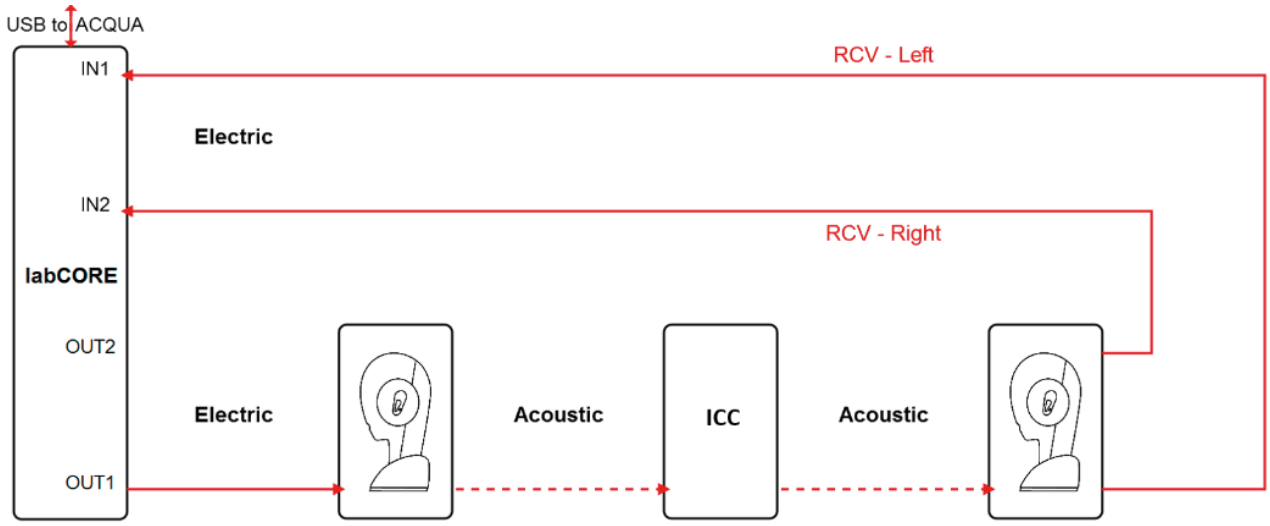
This measurement configuration especially applies to:

- in-car communication systems.

Relevant standards

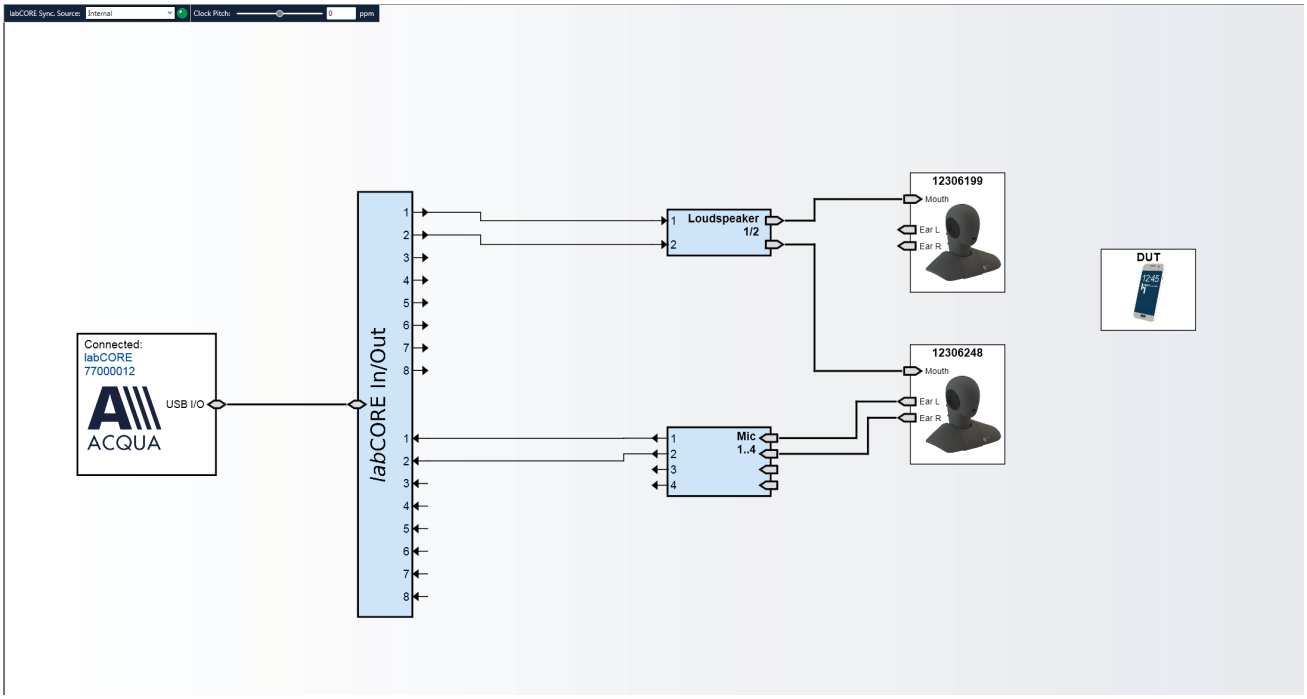
- HQS-ICC, In-Car Communication Systems.

Block diagram for application of *lab*CORE



Hardware configuration for application of *lab*CORE

Blue boxes represent *lab*CORE 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 *lab*CORE substitutes its predecessor MFE VI.1 in all configurations.

4.1 Measurement equipment

4.1.1 Modules and delays for *lab*CORE

The configurations of this chapter require *lab*CORE with optional modules. The equipment may differ between configurations::

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

  Delay @ BNC Out 1 / Out 2:

  DAC_delay = d_{DAC} * 1/ fs

  d_{DAC} = 28.8 clock pulses

  @ 48 kHz = 0.6 ms

  @ 96 kHz = 0.3 ms

  @ 192 kHz = 0.15 ms

  Delay @ BNC In 1/ In 2

  ADC_delay = d_{ADC} * 1/ f s

  d_{ADC} = 19 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

  $d_{AES\ in}$ = 2 clock pulses

  AES_in_delay = $d_{AES\ in}$* 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

  $d_{AES\ out}$ = 1 clock pulses

  AES_out_delay = $d_{AES\ out}$ * 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

- *core*BUS (Code 7710), I/O bus mainboard

  @ 192 kHZ ≈ 0.099 + 0.015625 ≈ 0.11 ms

- *core*OUT-Amp2 (Code 7720), Mouth / loudspeaker amplifier module

  Delay @ Loudspeaker 1/2

  DAC_delay = d_{DAC} * 1/ fs + $d_{FPGA\ Card}$ * 1/ f s

  d_{DAC} = 28.8 clock pulses

  $d_{FPGA\ Card}$ = 3 clock pulses

  @ 48 kHz = 0.6 ms + 0.0625 ms ≈ 0.66 ms

  @ 96 kHz = 0.3 ms + 0.03125 ≈ 0.33 ms

  @ 192 kHz = 0.15 ms + 0.015625 ≈ 0.17 ms

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

  Delay @ Mic 1 / 2 / 3 / 4

  ADC_delay = d_{ADC} * 1/ fs + $d_{FPGA\ Card}$ * 1/ fs

  d_{ADC} = 19 clock pulses

  $d_{FPGA\ Card}$ = 3 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:

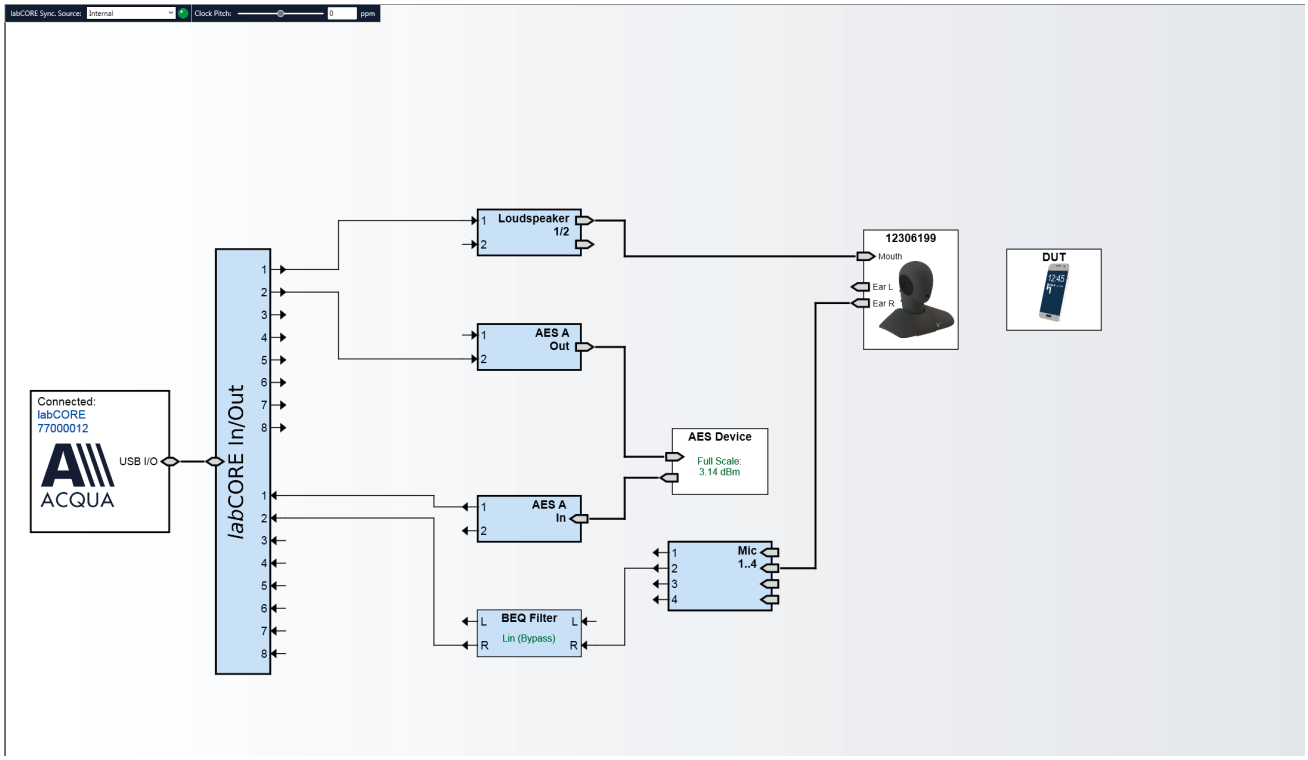
- | Anechoic | Headset | HATS | HATS-Rear | - |

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:

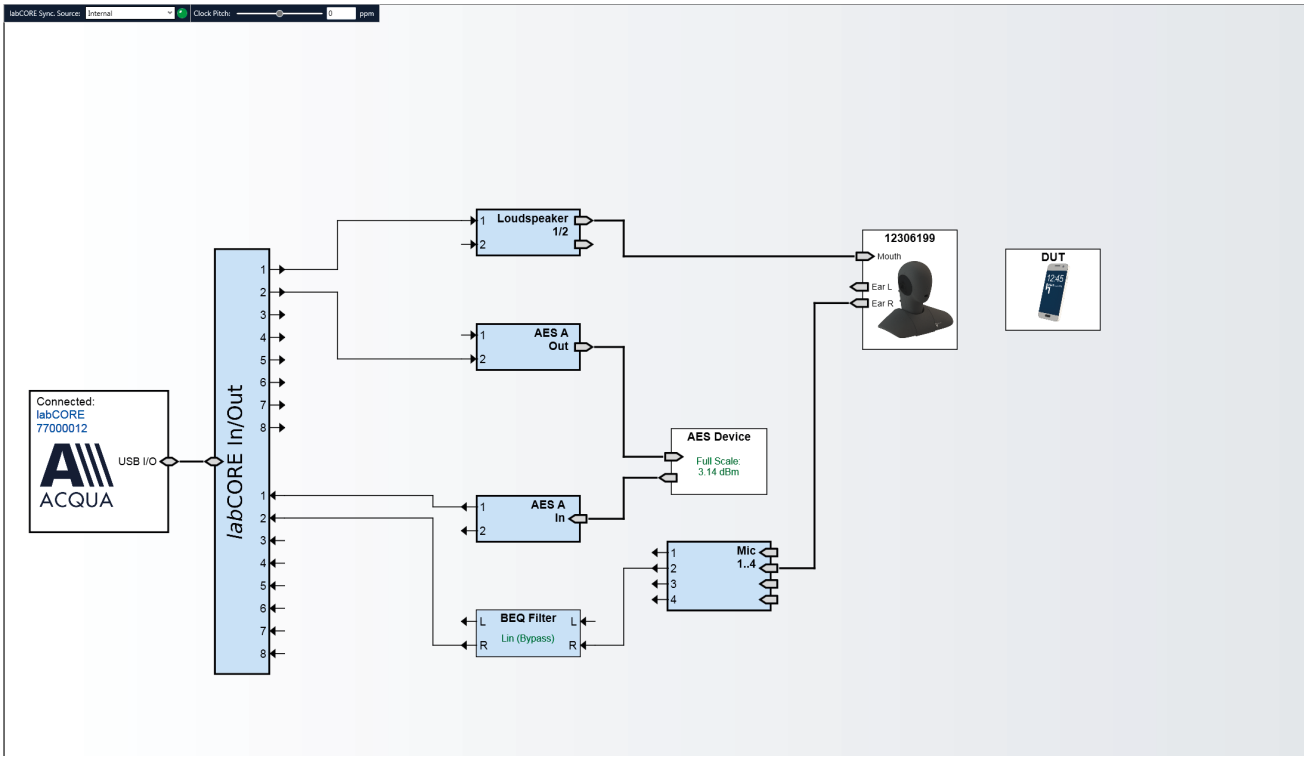
- | Reverbroom | Speakerphone | HATS | HATS-Rear | - |

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:

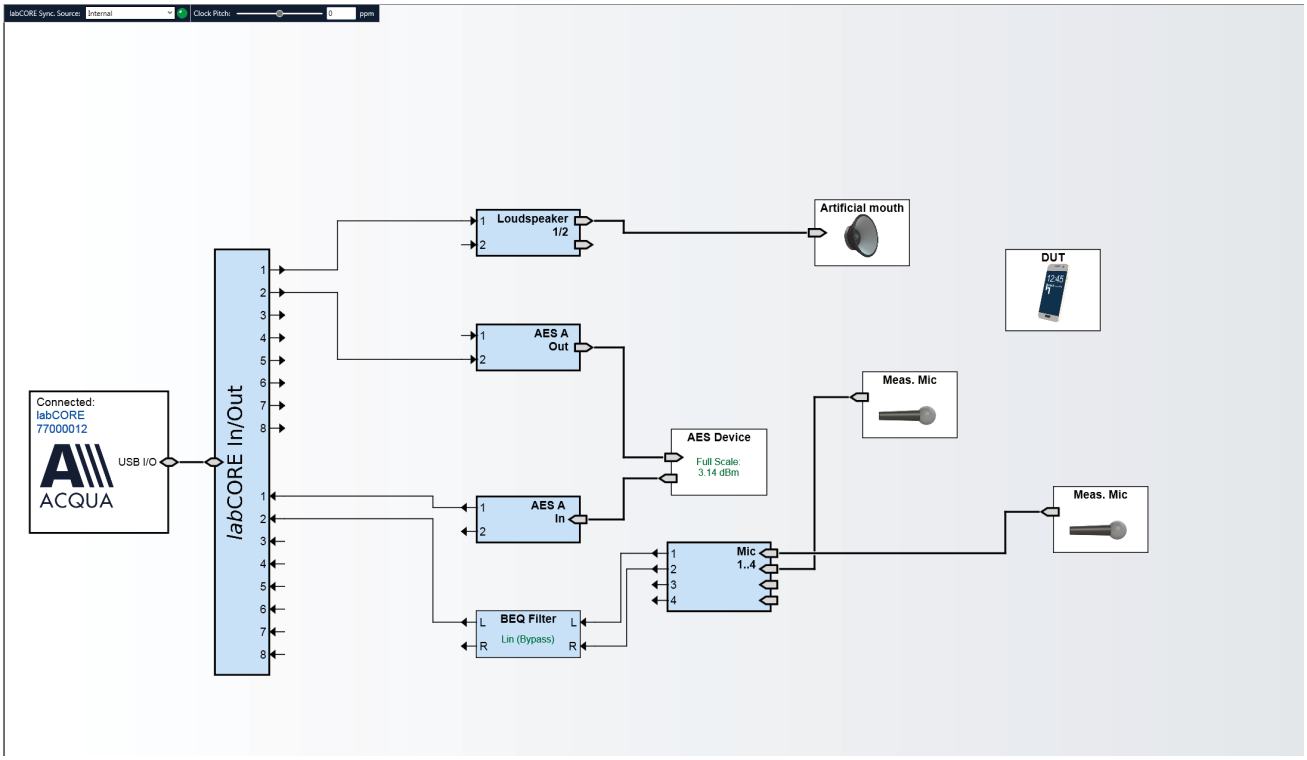
- | ReverbRoom | Speakerphone | Art.Mouth | - | MEASmic-IN2line | -option1/2

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:

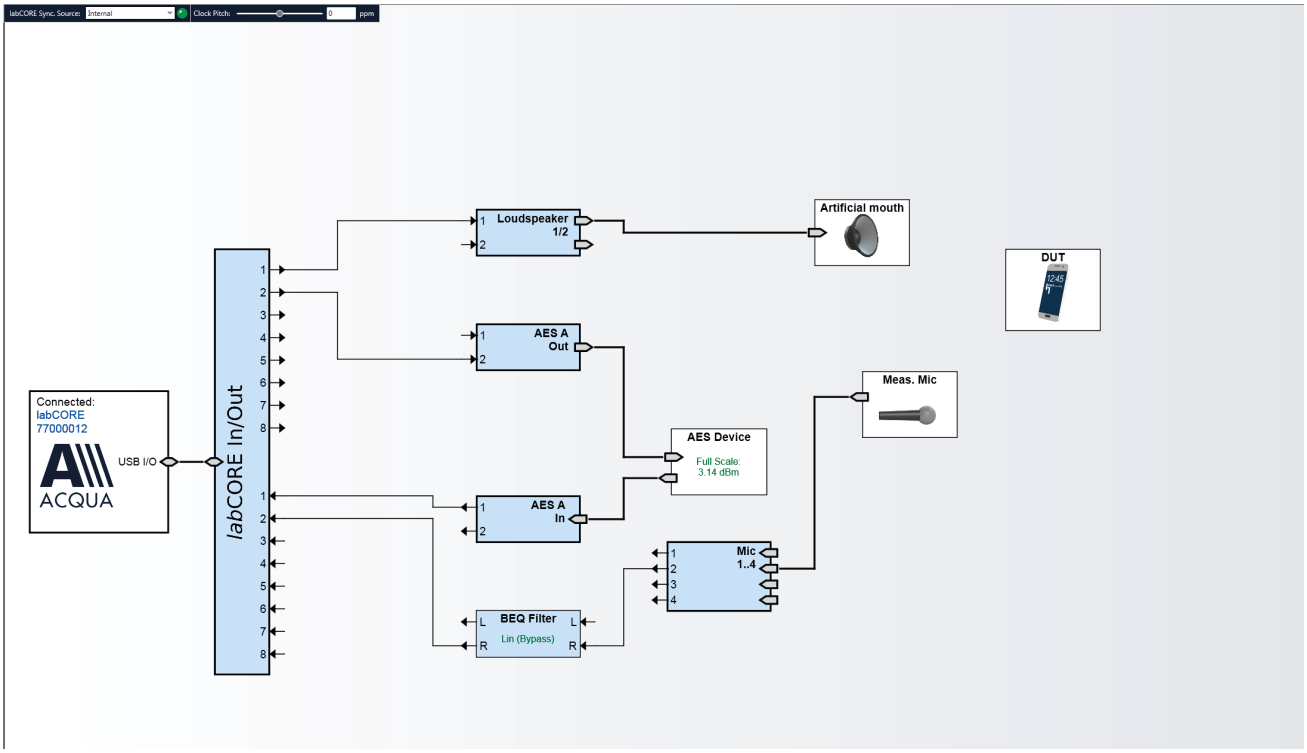
- | Reverbroom | Speakerphone | Art.Mouth | FFmic-IN2mic | - |

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:

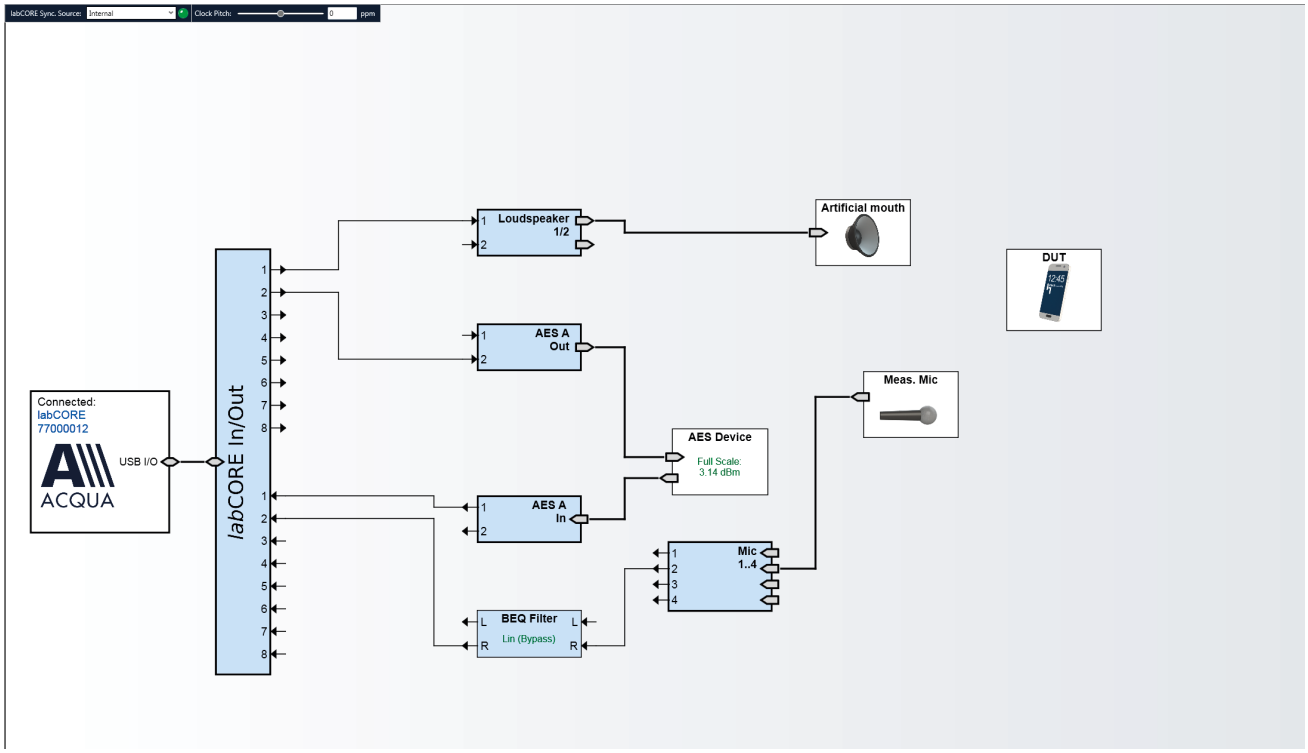
- | Anechoic | Speakerphone | Art.Mouth | FFmic-IN2mic | - |

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:

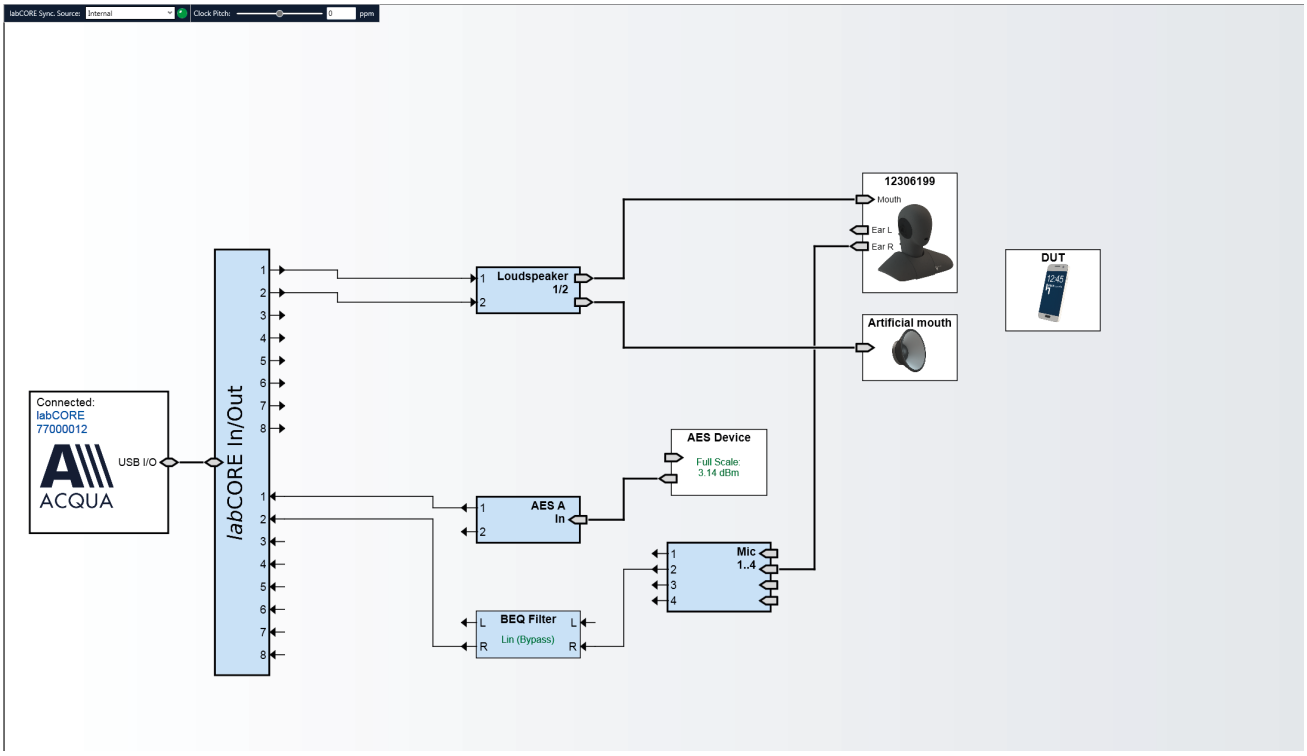
- | Reverbroom | Conferencing | HATS+Art.Mouth | HATS-Rear | - |

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:

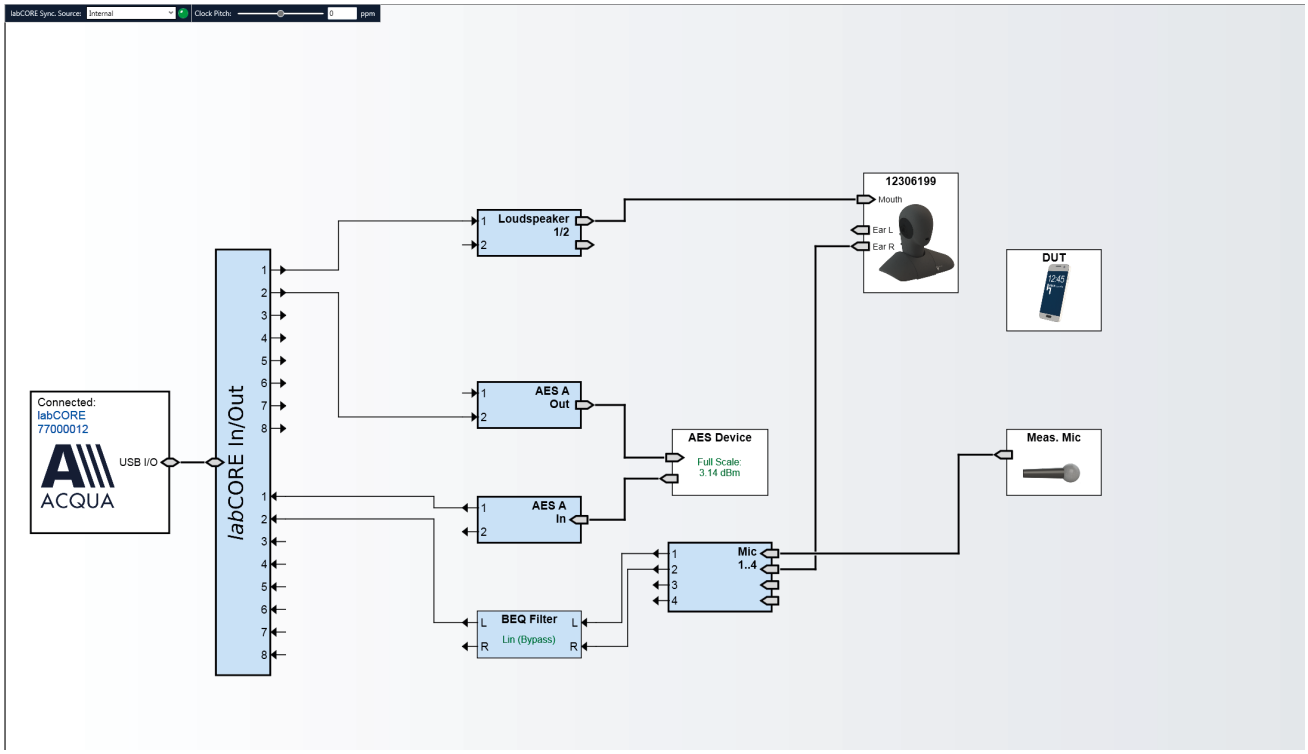
- | ReverbRoom | Headset | HATS | MEASmic-IN2line | -option1/2

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:

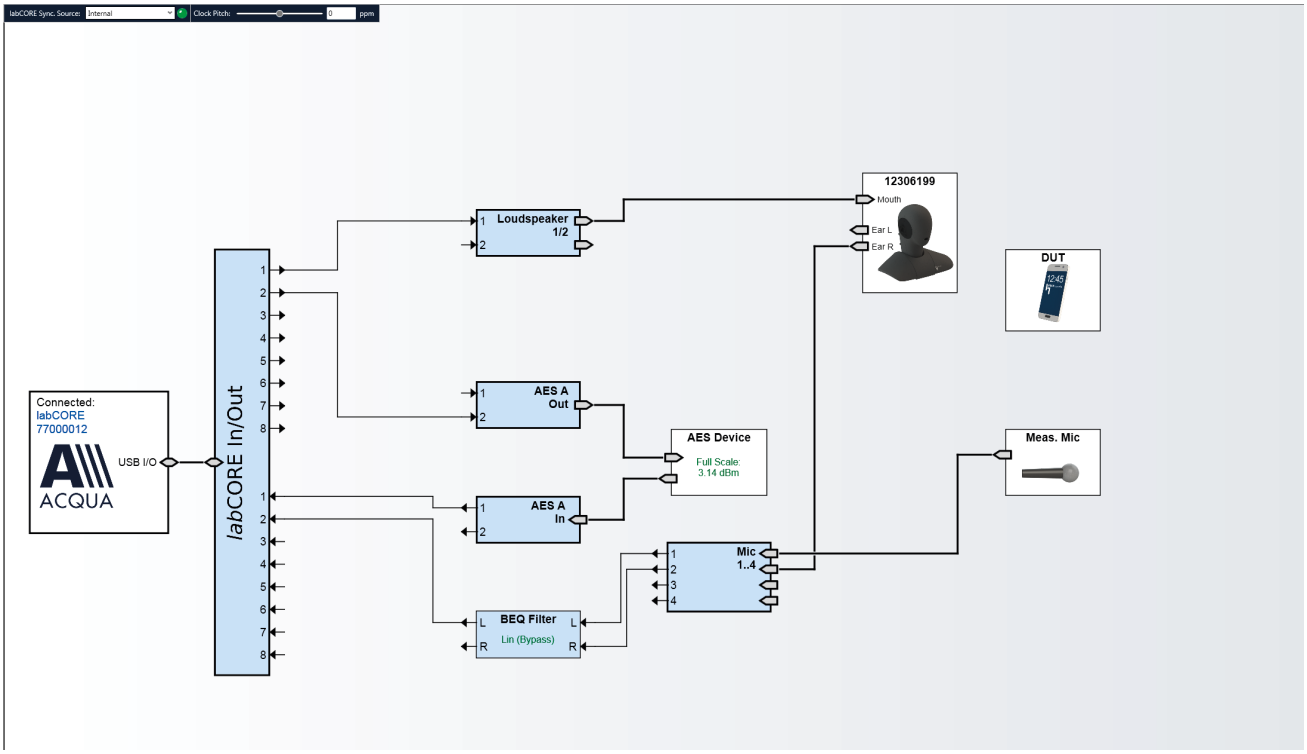
- | Reverbroom | Speakerphone | HATS | - | MEASmic-IN2line | -option1/2

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:

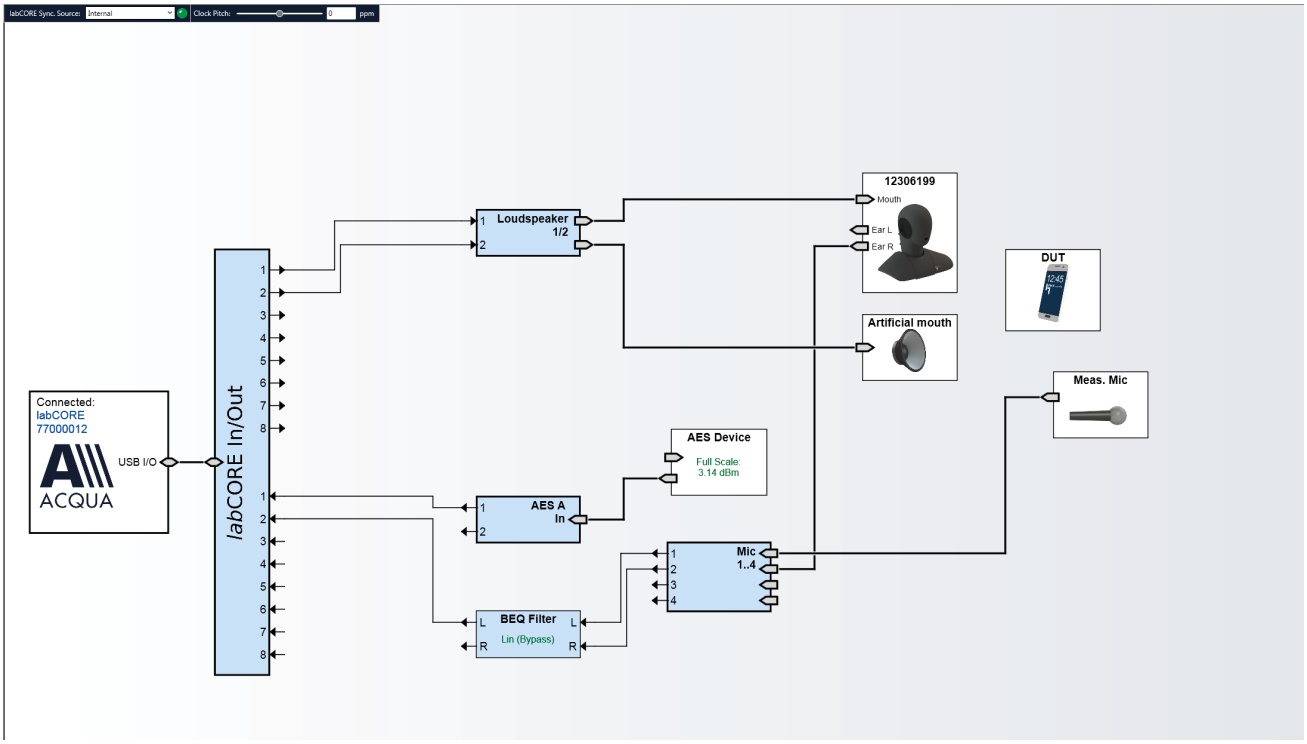
- | ReverbRoom | Conferencing | HATS |+Art.Mouth | - | REFmicIN2line | -option1/2

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.



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