



Code 7700

labCORE

**ACQUA/lab Modular Multi-Channel Hardware Platform
for Voice and Audio Quality Testing**

OVERVIEW

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ACQUA/lab Modular Multi-Channel Hardware Platform for Voice and Audio Quality Testing

labCORE is a modular multi-channel hardware platform for voice and audio quality testing. Its wide choice of high-performance analog and digital interfaces as well as its versatility and future-proof technology make labCORE the state-of-the-art all-in-one solution for testing voice and audio quality precisely and efficiently.

Measuring digital and analog telecommunication and audio devices as well as transmission systems, evaluating headsets or headphones, binaural equalization, setups with multiple artificial head measurement systems, VoIP reference gateway: labCORE is versatile and provides everything in one device – depending on the selected configuration and optional extensions.

KEY FEATURES

High-performance digital and analog inputs and outputs

Modular concept with a wide choice of additional interfaces:

- › Up to ten optional hardware extension boards
- › Various software extensions

Multi-channel signal processing

ASIO driver: 64-bit and 32-bit included

Versatile individual tailoring to specific measurement tasks

Fast, easy configuration and control via ACQUA and other control software

Silent operation

APPLICATIONS

Testing of:

- › Mobile phones and handsets
- › (In-vehicle) hands-free systems
- › Conference devices
- › (ANC) headsets and headphones
- › High-quality audio equipment
- › Transmission systems for instance networks and routers
- › Voice and audio quality of IoT devices (e.g. smart speakers)

Research and development

Conformance tests

Quality control

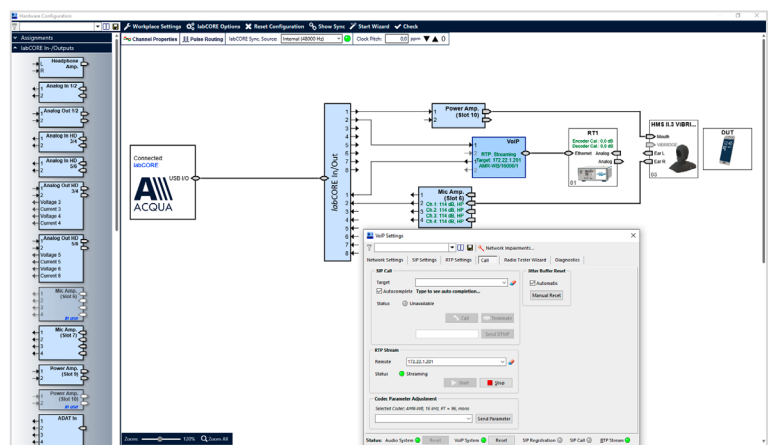
DETAILS

labCORE is a high-precision measurement hardware platform for voice and audio quality. It provides multiple channels, a wide variety of analog and digital inputs and outputs, high processing power, and high-performance interfaces. *labCORE* is the all-in-one solution for measuring the voice and audio quality of a wide range of voice and audio devices.

DESCRIPTION

Control

labCORE is mainly used in conjunction with the communication quality analysis software ACQUA. It connects via USB to a computer running ACQUA. The ACQUA software configures and controls *labCORE*. Its user interface provides settings for each *labCORE* interface as well as general settings for *labCORE*. These settings can be stored and assigned to selectable measurement sequences. Combinations with other HEAD acoustics hardware platforms and control by other HEAD acoustics software applications (VoCAS, RC-*labCORE*) are possible, too.



Equipping

labCORE can be equipped with additional hardware and software extensions for demanding audio analysis with superior signal quality. The boards can be combined in different combinations for using *labCORE* in various use cases. This modularity makes *labCORE* future-proof. It is possible to add new interfaces and technologies quickly and easily through optional hardware or software extensions.

Ventilation and Housing

labCORE operates silently because the ventilation slots of the housing provide sufficient heat dissipation. The compact housing of *labCORE* has a height of two rack units and fits into a standard 19-inch rack.



Application

labCORE is applicable for system optimization, development, quality control, as well as benchmark testing. It addresses all industries where voice and audio quality of telecommunication, and audio devices, as well as transmission systems play a decisive role. That includes following devices amongst others:

- › Mobile phones and handsets
- › (In-vehicle) hands-free systems
- › Conference devices
- › (ANC) headsets and headphones
- › High-quality audio equipment
- › Transmission systems for instance networks and routers
- › Voice and audio quality of IoT devices (e.g., smart speakers)



Connections

labCORE provides audio connections from wired connections, such as BNC, XLR, speakON, or LEMO, to wireless Bluetooth® connections. Furthermore, the Ethernet interface enables Voice over IP communication with radio testers or VoIP telecommunication devices. *labCORE* has a USB socket for exchanging audio signals via USB as USB audio host, as well as for simulating a USB audio device to a connected USB audio host. For high performance audio analyzing, there are extension boards with high-precision and low-noise signal transmission. Data and signal exchange to other HEAD acoustics hardware devices provides the HEADlink interface. Moreover, internal signal routing between *labCORE* interfaces can be established via the ACQUA user interface.

Codecs and Protocols

- › *labCORE* supports many audio codecs for VoIP, Bluetooth Classic, or Bluetooth Low Energy. Thus, *labCORE* is compatible for exchanging audio signals with appropriate devices.
- › *labCORE* has the capability for exchanging and processing audio signals via audio protocols, such as AES/EBU, I²S, or TOSLINK.
- › For optimal compatibility with appropriate audio software applications, *labCORE* includes the ASIO driver (64-bit and 32-bit).



BASIC CONNECTIONS

Front Panel

LCD DISPLAY

The display shows information about current settings, firmware, or level.

HEADPHONE OUTPUT

- › 6.3 mm headphone connection
- › For monitoring or measuring

IN 1/2 AND OUT 1/2

- › BNC connection
- › 2 × analog inputs
- › 2 × analog outputs



USB HOST

- › USB-C®/USB-A connection
- › For connecting USB devices e.g., USB headsets

ETHERNET

- › RJ45 connection
- › Connection for IP-based communication devices, radio tester, etc.

ADAT / S/PDIF

- › ADAT / S/PDIF input/output connection
- › 2 × TOSLINK sockets

Rear Panel

DIGITAL AUDIO

- › D-sub 15-pin (DA-15)
- › I²S Inter-IC interface

AES A IN/OUT

- › AES input (XLR female)
- › AES output (XLR male)

GPIO 1/2

- › BNC connection
- › 2 × pulse in/out



PULSE/AES B

- › D-sub 15-pin (DE-15)
- › Pulse in/out
- › AES in/out

USB

- › USB-B for connection to control computer
- › 2 × USB-A for connecting e.g., Bluetooth transceiver

HEADlink

- › LEMO 8-pin for connection to HEAD acoustics equipment, e.g., MSA I, or MSA II

OPTIONAL HARDWARE EXTENSIONS

Front Panel

coreUSB-DR

- › USB-C/USB-A connection
- › Enabling *labCORE* to simulate a USB audio device to an external USB audio host

coreOUT-A2

- › 2 × BNC connection (unbalanced)
- › 2 × XLR connection (balanced)
- › High-precision low-noise analog outputs

coreIN-A2

- › 2 × BNC connection (unbalanced)
- › 2 × XLR connection (balanced)
- › High-precision low-noise analog inputs

coreIN-Mic4

- › 4 × LEMO 7-pin
- › High-precision low-noise microphone inputs
- › TEDS support
- › Switchable 200 V polarization voltage



Rear Panel

coreIN-Mic4

- › 4 × LEMO 7-pin
- › High-precision low-noise microphone inputs
- › TEDS support
- › Switchable 200 V polarization voltage

coreIN-ICP4

- › 4 × BNC connection
- › High-precision low-noise ICP® sensor inputs
- › Low self-noise
- › High resilience to ground noise
- › TEDS support

coreA2B-Basic

- › Interface for A²B® (Automotive Audio Bus®)
- › Input and output of audio and configuration data
- › A²B evaluation board

core/O-Dante

- › Interface for Dante® network
- › Input and output of audio and configuration data

coreOUT-Amp2

- › speakON 4-pin connection
- › Amplified outputs for, e.g., artificial mouth or small loudspeaker
- › Efficient class-D technology with low heat dissipation
- › 20 W_{RMS} output per channel



coreBUS

coreBUS is a bus board for connecting optional extension boards to the mainboard of *labCORE*. Thus, installing any hardware extension board requires coreBUS. The bus board provides ten slots for the individual extension boards. Five extension slots at the front panel are designated for the extension boards coreOUT-A2, coreIN-A2, and coreIN-Mic4. The slots at the rear panel have separated slot covers, allowing customized configurations. coreIN-Mic4, coreIN-ICP4, and coreA2B-Basic can be installed arbitrarily in any of the rear slots, preferably slot 6, 7, and 8. Slots 9 and 10 are internally prepared for the high power requirements of coreOUT-Amp2.



Front panel with slot numbers



Rear panel with slot numbers

OPTIONAL MODULAR AND SOFTWARE EXTENSIONS

coreBT2

coreBT2 consists of an internal Bluetooth stack within *labCORE* together with a externally connected Bluetooth transceiver. It is the basic requirement for *labCORE* to become a reference access point for Bluetooth Classic. With coreBT2, *labCORE* pairs with compatible Bluetooth devices to perform acoustic and electric measurements.

coreBT2HID

The HID functionality is available with coreBT2HID. It enables *labCORE* to act as a human interface device. Thus, *labCORE* can send control commands via Bluetooth to a connected device, e.g., volume control commands.

coreBT2-AAC-LDAC

The codecs AAC and LDAC are available with coreBT2-AAC-LDAC. AAC supports a sampling rate up to 96 kHz and has a maximal bit rate of 320 kbps. LDAC supports a sampling rate up to 96 kHz and high bit rates.

coreBT2-LC3plus-A2DP

The LC3plus codec is available with coreBT2-LC3plus-A2DP. LC3plus supports a sampling rate up to 96 kHz and a bit rate adaption up to 500 kbps per channel. It allows high speech and audio transmission quality (super-wideband) and has an increased robustness against transmission errors.

coreBT2-LC3-HFP

coreBT2-LC3-HFP provides the LC3 codec for the hands-free profile (HFP). The LC3 codec assures high speech and audio transmission quality (super-wideband). Thus, the EVS speech quality in VoLTE calls is maintained while using Bluetooth. Therefore, coreBT2-LC3-HFP enables measurements with super-wideband signal transmission of Bluetooth devices applying the hands-free profile.



coreBT2 – Bluetooth Classic USB stick with SMA antenna



coreBT2LE-EVO – *labCORE* with BTLE-Ctrl

coreBT2LE-EVO

coreBT2LE-EVO consists of an internal Bluetooth stack within *labCORE* together with an externally connected Bluetooth Low Energy transceiver. It is the basic requirement for *labCORE* to become a reference access point for Bluetooth Low Energy applications, such as Unicast or Auracast™ broadcast audio.

coreBT2LE-Unicast

coreBT2LE-Unicast is a software extension for coreBT2LE-EVO. It enables *labCORE* to apply Unicast audio streams as sink or source.

coreBT2LE-Auracast

coreBT2LE-Auracast is a software extension for coreBT2LE-EVO. It enables *labCORE* to apply Auracast broadcast audio.

coreBT2LE-IMP

coreBT2LE-IMP enables *labCORE* to impair packets of Bluetooth audio streams for evaluating the error processing of appropriate devices supporting Bluetooth LE Audio.

coreBEQ and coreBEQ-Add

coreBEQ is a software extension for digital binaural equalization of ear simulators within an artificial head. coreBEQ-Add is an additional equalization filter set for another artificial head.

coreIP

With the software extension *coreIP*, *labCORE* becomes a reference gateway for voice quality measurements of IP-based communication devices (VoNR, VoLTE, VoIP). The extension contains an integrated Voice over IP SIP-client and RTP.

coreIP-IMP

VoIP software extension for simulating network impairments. *coreIP-IMP* enables delaying or discarding specific RTP packets to simulate impairments like jitter, delay and packet loss. The measurement conditions are reproducible, even with active Discontinued Transmission (DTX)/Silence Compression.

coreIP-AMR

VoIP software extension providing the additional codecs AMR-NB, AMR-WB (G.722.2), and GSM Enhanced Full Rate.

coreIP-EVS

VoIP software extension providing the audio codec EVS in all specified bandwidths from narrowband to fullband with all bit

GENERAL REQUIREMENTS

Software

One of the following software applications:

ACQUA (Code 6810)

- › Advanced Communication Quality Analysis Software, full license version

ACQUA Compact (Code 6860)

- › Compact test system

RC-labCORE (Code 6984)

- › Remote configuration software for *labCORE*

VoCAS (Code 7970)

- › Voice Control Analysis System

3PASS *lab* (Code 6990)

- › Advanced background noise simulation system with automated equalization – lab version

3PASS *flex* (Code 6995)

- › Advanced background noise simulation system with automated equalization – flex version

SCOPE OF DELIVERY

labCORE (Code 7700)

- › Modular multi-channel hardware platform

PS 24-150-L4 (Code 0620B)

- › Power supply, 24 V DC, 150 W, LEMO 4-pin

PCC I.9x (Code 997x)

- › Power cable (according to local specification)

CDM V (Code 1637)

- › Cable D-sub 15-pin <> 2 × XLR (AES/EBU in/out) + 2 × BNC (pulse in/out)

CUSB II.5 (Code 5478-1.5)

- › USB 2.0 cable, with ferrite, USB-B <> USB-A, 1.5 m

CUU II (Code 6094)

- › USB 2.0 adapter, USB-C <> USB-A

HCC-labCORE (Code 1644)

- › Carrying case for *labCORE*

Manual (Hardcopy)

rates and modes (incl. AMR-WB interoperable mode). coreIP-EVS features static jitter buffer for accurate delay conditions instead of EVS' adaptive jitter buffer.

coreIP-OPUS

VoIP software extension providing the audio codec Opus in mono and stereo audio.

coreIP-Alexa

coreIP-Alexa enables *labCORE* to become an Amazon Alexa reference client.

coreIP-WebRTC

coreIP-WebRTC enables *labCORE* for operating as a WebRTC (Web Real-Time Communication) client.

LIST OF EXTENSIONS

Hardware

coreUSB-DR (Code 7705)

- › USB device reference

coreBUS (Code 7710)

- › I/O bus mainboard

coreOUT-Amp2 (Code 7720)

- › Power amplifier board
- › CSB III (Code 6095)
 - » Adapter speakON <> 4 x banana plug female

coreIN-Mic4 (Code 7730)

- › Microphone input board

coreIN-ICP4 (Code 7735)

- › ICP® sensor input board

coreOUT-A2 (Code 7750)

- › Analog output board

coreIN-A2 (Code 7760)

- › Analog input board

coreBT2 (Code 7782)

- › Bluetooth Classic reference access point
- › Bluetooth Classic transceiver

coreBT2LE-EVO (Code 7805)

- › Base for Bluetooth Low Energy audio
- › BTLE-Ctrl, Bluetooth Low Energy controller

coreA2B-Basic (Code 7791)

- › *labCORE* I/O Module, A2B Interface (32 Channels),
Hardware + Main-/Sub-node Mode

Software

coreBEQ (Code 7740)

- › Binaural equalization for artificial head

coreBEQ-Add (Code 7741)

- › Additional binaural equalization for artificial head

coreIP (Code 7770)

- › Voice over IP reference gateway

coreIP-IMP (Code 7771)

- › VoIP impairment extension

coreIP-AMR (Code 7772)

- › VoIP AMR extension

coreIP-EVS (Code 7773)

- › VoIP EVS extension

coreIP-OPUS (Code 7774)

- › VoIP Opus extension

coreIP-Alexa (Code 7775)

- › VoIP Alexa reference client

coreIP-WebRTC (Code 7779)

- › VoIP WebRTC extension

coreBT2-AAC-LDAC (Code 7783)

- › Bluetooth AAC and LDAC codec option

coreBT2-LC3plus-A2DP (Code 7784)

- › Bluetooth LC3plus option for A2DP

coreBT2-LC3-HFP (Code 7785)

- › Bluetooth LC3 option for HFP

Hardware

coreA2B-Bus Monitor (Code 7792)

- › *labCORE* Bus Monitor Mode for A²B, Option for A2B (coreA2B-Basic required)

coreA2B-Proxy (Code 7793)

- › *labCORE* Proxy Mode for A²B, Option for A²B (coreA2B-Basic required)

coreI/O-Dante (Code 7796)

- › I/O board, Dante interface

Software

coreBT2HID (Code 7786)

- › Bluetooth Human Interface Device

coreBT2LE-Auracast (Code 7788)

- › Bluetooth Low Energy audio, Auracast extension

coreBT2LE-Unicast (Code 7789)

- › Bluetooth Low Energy audio, Unicast extension

coreBT2LE-IMP (Code 7810)

- › Bluetooth Low Energy audio, Statistic impairments

OPTIONS

RMB IV.3 2RU (Code 9852.2)

- › 2 × 19" rack mount bracket

labPWR I.2 (Code 3712)

- › HEAD*lab* 11-28 VDC power supply, 100 W

CSC-*labCORE* (Code 9770)

- › Calibration and specification check, *labCORE* (w/o separate I/O modules)

CSC-*labCORE*-ISO (Code 9770ISO)

- › Calibration and specification check, *labCORE* (w/o separate I/O modules) acc. to DIN/EN/ISO 17025

CSC-*coreOUT*-Amp2 (Code 9772)

- › Calibration and specification check, *labCORE* Module *coreOUT*-Amp2

CSC-*coreIN*-Mic4 (Code 9773)

- › Calibration and specification check, *labCORE* Module *coreIN*-Mic4

CSC-*coreIN*-ICP4 (Code 9774)

- › Calibration and specification check, *labCORE* Module *coreIN*-ICP4

CSC-*coreOUT*-A2 (Code 9775)

- › Calibration and specification check, *labCORE* Module *coreOUT*-A2

CSC-*coreIN*-A2 (Code 9776)

- › Calibration and specification check, *labCORE* Module *coreIN*-A2

TECHNICAL DATA

General

Operation	Remote control via control software
System check	Automatic hardware check during boot up
Power supply	External power supply, 24 V _{DC} , 150 W
Power consumption	max. 20 W (when used without additional boards), up to 150 W depending on configuration
Clock accuracy	Calibration accuracy: ±0.25 ppm Temperature stability: ±1 ppm for temperature range 15 °C – 35 °C, 59 °F – 95 °F Aging stability: ±1 ppm within first year after calibration, typically lower

Environmental Conditions

Operating temperature range	0 °C–35 °C, 32 °F–95 °F
Storage temperature range	-20 °C–70 °C, -4 °F–158 °F
Air humidity	20%–80% (non-condensing environment)

Housing

Overall dimensions (W × H × D)	327 mm × 88 (95) mm × 175 mm
Weight	approx. 1.55 kg

Analog In 1/2

Channels	2
Connection	2 × BNC
Absolute max. voltage	-5 V – 5 V
Input ranges	-6 dBV, -3 dBV, 0 dBV, 3 dBV, 6 dBV, 9 dBV, 12 dBV
Input impedance	200 kΩ
Coupling	AC coupled, high-pass filter 1st order, fg=7.05 Hz
Flatness	48 kHz sampling rate, 60 Hz – 20 kHz: ±0.05 dB 96 kHz sampling rate, 60 Hz – 40 kHz: ±0.1 dB
S/N	48 kHz sampling rate, 20 Hz – 20 kHz, +0 dBV range: typical -110 dB 96 kHz sampling rate, 20 Hz – 40 kHz, +0 dBV range: typical -107 dB
THD+N	48 kHz sampling rate, at 1 kHz, +0 dBV range: typical -102 dB 96 kHz sampling rate, at 1 kHz, +0 dBV range: typical -102 dB
Crosstalk	< -120 dB at 1 kHz
Digital resolution	32 bit
Sampling rates	32 kHz, 44.1 kHz, 48 kHz, 64 kHz, 88.2 kHz, 96 kHz

Analog Out 1/2

Channels	2
Connection	2 × BNC
Output range	-36 dBV, -33 dBV, -30 dBV, -27 dBV, -24 dBV, -21 dBV, -18 dBV, -15 dBV, -12 dBV, -9 dBV, -6 dBV, -3 dBV, 0 dBV, 3 dBV
Output impedance	10 Ω
Coupling	DC coupled
Flatness	48 kHz sampling rate, 20 Hz – 20 kHz: ±0.05 dB 96 kHz sampling rate, 20 Hz – 40 kHz: ±0.3 dB

S/N	48 kHz sampling rate, 20 Hz – 20 kHz, +0 dBV range: typical -112 dB 96 kHz sampling rate, 20 Hz – 40 kHz, +0 dBV range: typical -109 dB
THD+N	48 kHz sampling rate, at 1 kHz, +0 dBV range: typical -101 dB 96 kHz sampling rate, at 1 kHz, +0 dBV range: typical -101 dB
Crosstalk	< -120 dB at 1 kHz
Digital resolution	32 bit
Sampling rates	32 kHz, 44.1 kHz, 48 kHz, 64 kHz, 88.2 kHz, 96 kHz

Headphones

Channels	2
Connection	6.3 mm socket
Output range	-90 dBV – 12 dBV
Output impedance	< 1 Ω
Coupling	DC coupled
Flatness	48 kHz sampling rate, 20 Hz – 20 kHz: ± 0.05 dB 96 kHz sampling rate, 20 Hz – 40 kHz: ± 0.3 dB
S/N	48 kHz sampling rate, 20 Hz – 20 kHz, +0 dBV range, at 32 Ω load: typical -110 dB 96 kHz sampling rate, 20 Hz – 20 kHz, +0 dBV range, at 32 Ω load: typical -107 dB
THD+N	48 kHz sampling rate, at 1 kHz, 0 dB slider position, at 32 Ω load: typical -101 dB 96 kHz sampling rate, at 1 kHz, 0 dB slider position, at 32 Ω load: typical -101 dB
Crosstalk	< -100 dB at 1 kHz
Digital resolution	32 bit
Sampling rates	32 kHz, 44.1 kHz, 48 kHz, 64 kHz, 88.2 kHz, 96 kHz

AES A

Connection	2 $\times$ XLR (male & female)
Channels	2
Sampling rates	32 kHz, 44.1 kHz, 48 kHz, 64 kHz, 88.2 kHz, 96 kHz

Pulse

Connection	HD D-Sub 15-pin
Voltage level output	0 / 3.3 V (Open drain output with 1 k Ω pull-up to 3.3 V)
Voltage level input	0 – 3.3 V (low 0 – 0.8 V, high 2...3.3 V)
Impedance	1 k Ω to +3.3 V (Open drain input/output)
Common signal ground, separated from rest of system	

AES B

Connection	HD D-Sub 15-pin
Channels	2
Sampling rates	32 kHz, 44.1 kHz, 48 kHz, 64 kHz, 88.2 kHz, 96 kHz

ADAT

Connection	TOSLINK
Channels (ADAT)	8 (at 48 kHz)
Channels (S/PDIF)	2
Sampling rates (ADAT)	32 kHz, 44.1 kHz, 48 kHz

Sampling rates (S/PDIF)	32 kHz, 44.1 kHz, 48 kHz, 64 kHz, 88.2 kHz, 96 kHz
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GPIO 1/2

Connection	2 × BNC
Voltage level output	0 – 0.5 V / 3.3 V (Open drain output with 1 kΩ pull-up resistor to 3.3 V)
Voltage level input	0 – 3.3 V (low 0 – 0.8 V, high 2 – 3.3 V)
Impedance	1 kΩ to +3.3 V (Open drain input/output)
Common signal ground with GPI1...4 and GPO1...4, separated from rest of system	

GPIO 3/4 (Digital Audio)

Connection	D-Sub 15-pin
Voltage level output	0 – 0.5 V / 3.3 V (Open drain output with 1 kΩ pull-up resistor to 3.3 V)
Voltage level input	0 – 3.3 V (low 0 – 0.8 V, high 2 – 3.3 V)
Impedance	1 kΩ to +3.3 V (Open drain input/output)
Common signal ground with GPI 1 – 4 and GPO 1 – 4, separated from rest of system	

GPI 1 – 4 (Digital Audio)

Connection	D-Sub 15-pin
Voltage level input	0 – 3.3 V (low 0 – 0.8 V, high 2 – 3.3 V)
Common signal ground with GPI 1 – 4 and GPO 1 – 4, separated from rest of system	

GPO 1 – 4 (Digital Audio)

Connection	D-Sub 15-pin
Voltage level input	0 – 0.4 V (low) / 2.9 – 3.3 V (high)
Common signal ground with GPI 1 – 4 and GPO 1 – 4, separated from rest of system	

Ethernet Front Panel/Rear Panel

Connection	RJ45
Data rate	10/100/1000 Mbit/s

USB Front Panel

Connection	USB 2.0 Type-C™
Output current as host	max. 500 mA, 5 V

USB Device Rear Panel

Connection	USB-B 2.0 high-speed
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USB Host Rear Panel

Connection	2 × USB-A 2.0 high-speed
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HEADlink

Connection	LEMO 8-pin socket
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Power

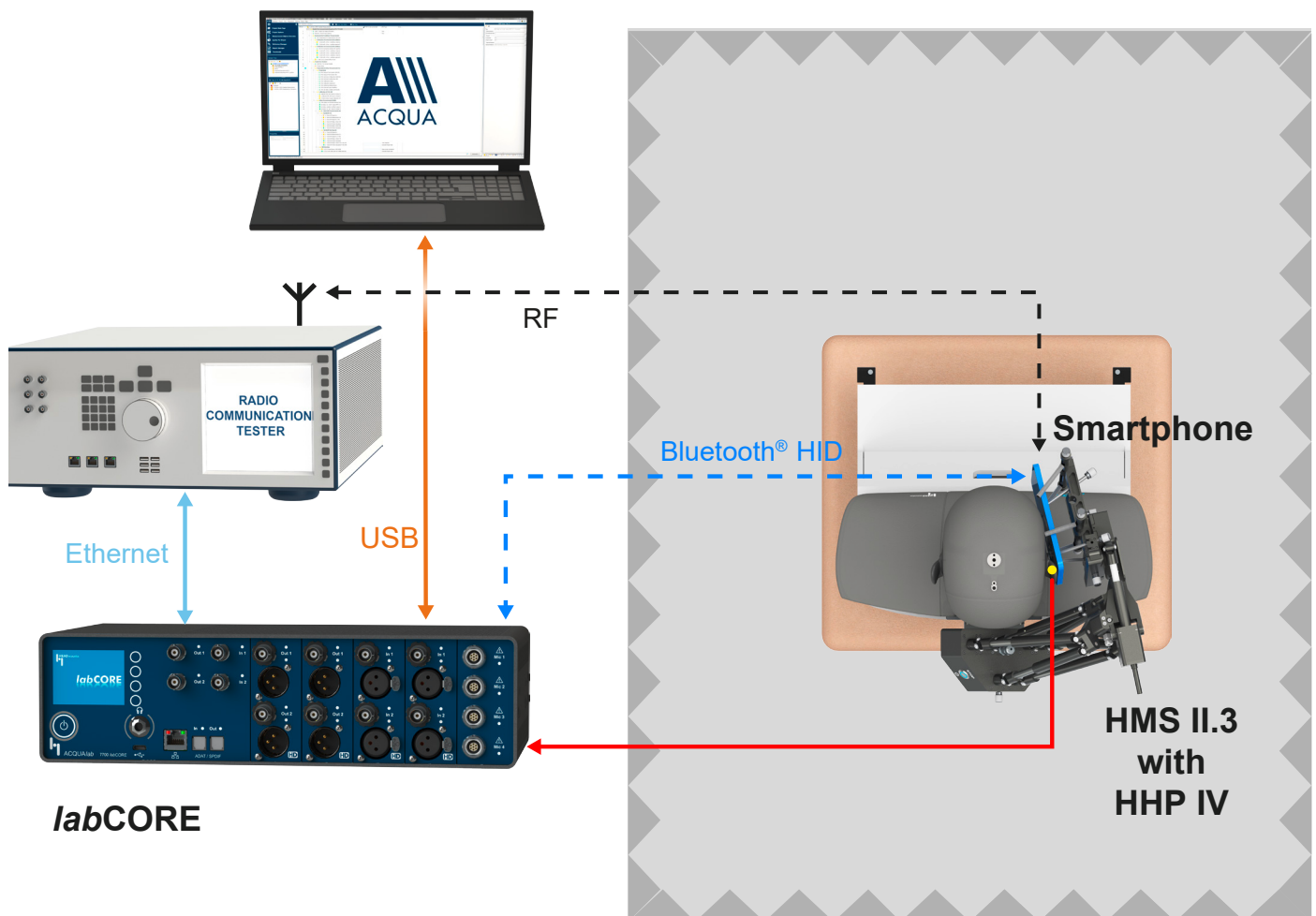
Connection	LEMO 4-pin hermaphroditic connector
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IN PRACTICE

APPLICATION EXAMPLES

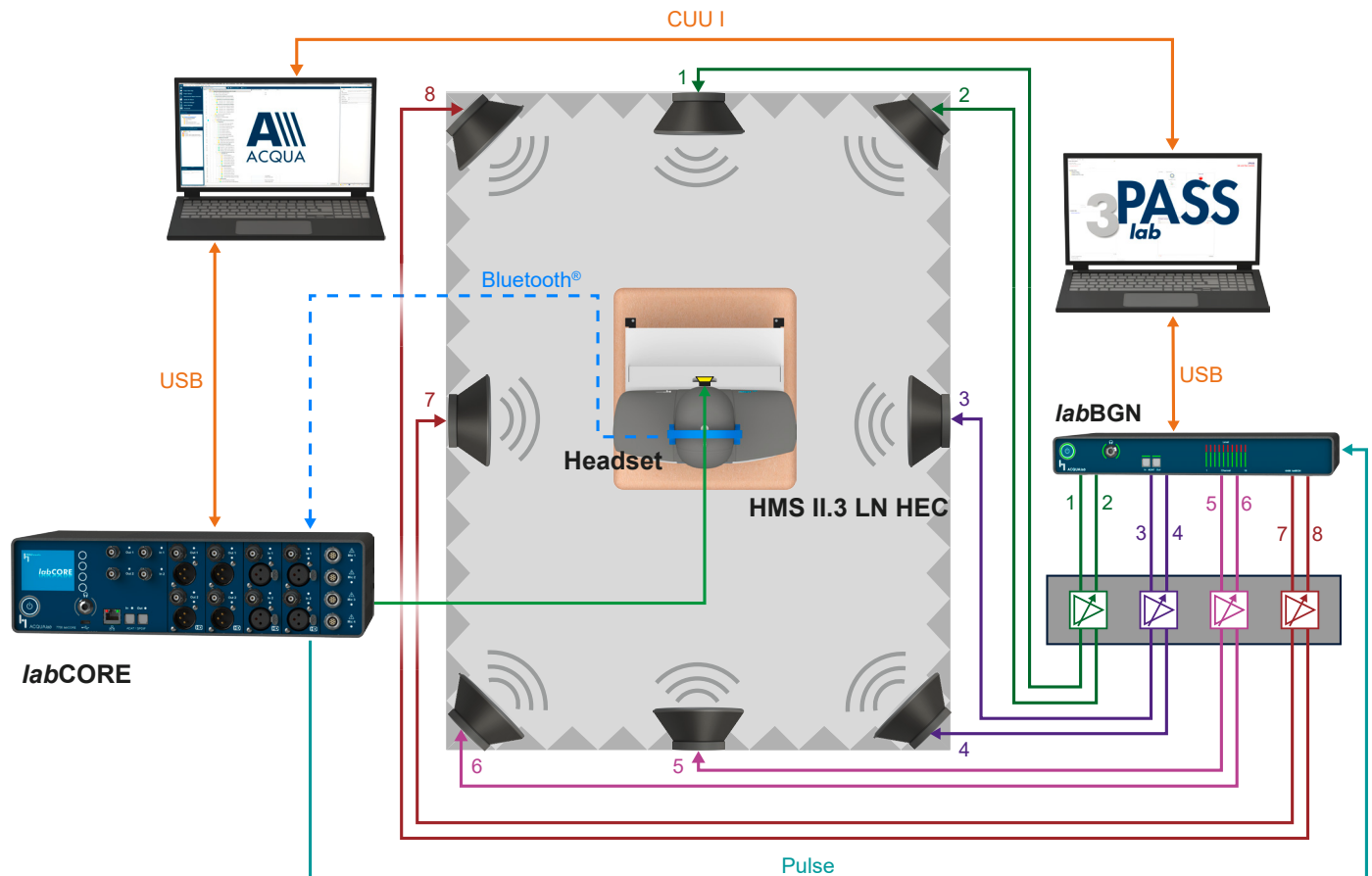
Handset: Automatic Determination of Nominal Volume

The handset is clamped into HHP IV and connects via packet-switched network to a radio tester. *labCORE* transmits the audio signal via the radio tester to the handset. Furthermore, it connects to the handset by Bluetooth HID profile for setting the required volume step automatically. The handset plays back the signal through its earpiece. *labCORE* receives the signal from HMS II.3 and transmits it to ACQUA for recording. ACQUA plays back signals, determines the volume step of the handset, as well as analyses the recorded signals.



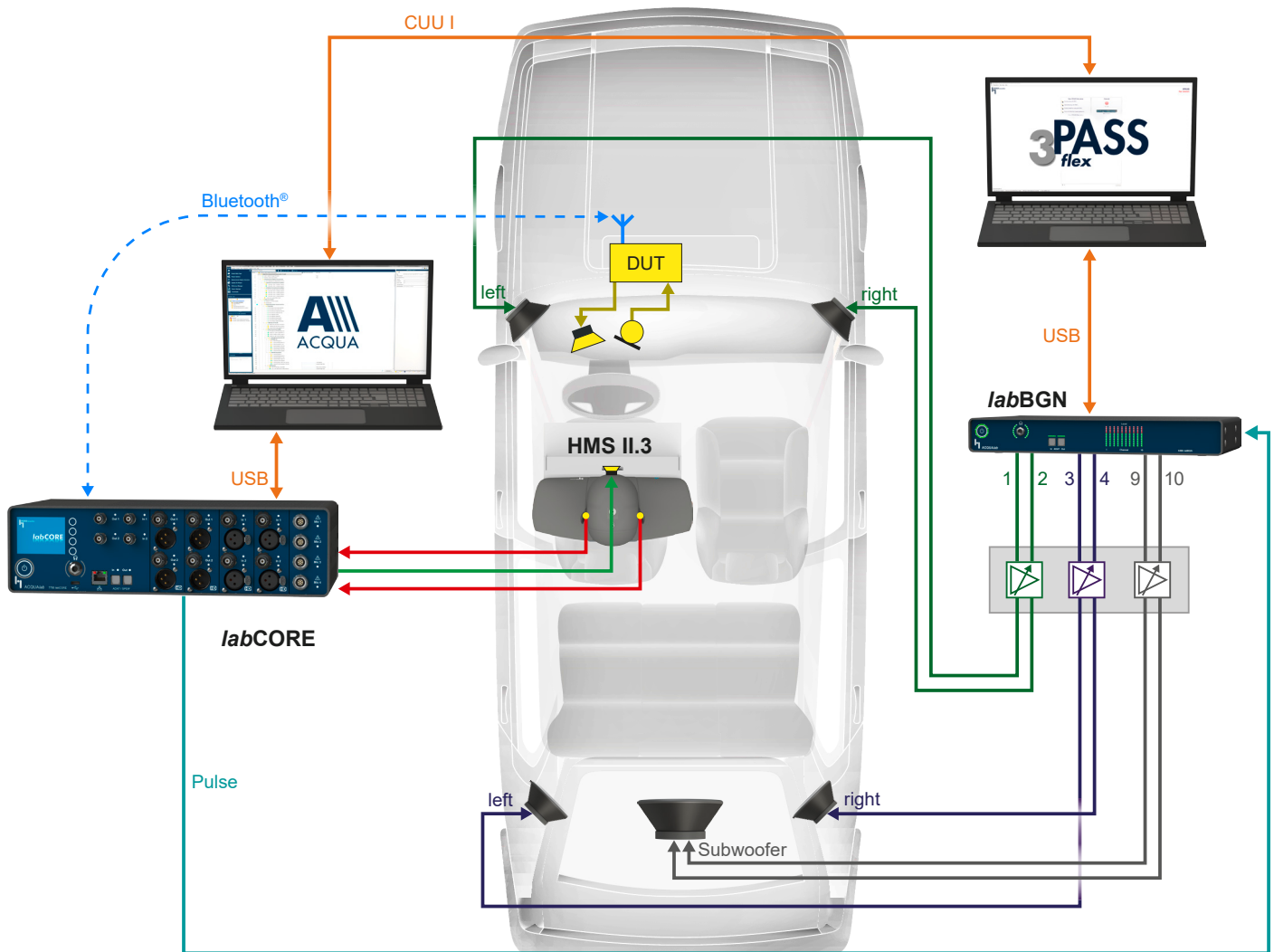
Headset: Speech Quality in the Presence of Background Noise

This configuration presents the assessment of speech signal processing by a wireless over-ear ANC headset in the presence of background noise. The headset is mounted on HMS II.3 LN HEC. Measurements are executed with activated and deactivated ANC functionality. *labCORE* connects to the headset via Bluetooth. HMS II.3 LN HEC is connected to *labCORE* for playback. Background noise is simulated by 3PASS *lab*. For full repeatability of measurements, background noise playback is synchronized by *labCORE* through a pulse connection to *labBGN*. ACQUA is the control software for generating, recording, and analyzing signals. The recorded signal is analyzed by the 3QUEST (3-fold Quality Evaluation of Speech in Telecommunications) algorithm according to ETSI TS 103 106.



In-vehicle Hands-Free System

HMS II.3 connects to *labCORE* for operation of artificial ear and artificial mouth. One computer runs ACQUA and connects to *labCORE*. Another computer runs 3PASS *flex* and connects to *labBGN*. ACQUA controls *labCORE*, as well as generates and analyses incoming signals. *labCORE* distributes and receives the signals via its interfaces. The hands-free system of this vehicle uses Bluetooth for communication. *labCORE* connects directly to the hands-free system via coreBT2. The playback of background noises is synchronized with the playback from HMS II.3 by a pulse signal.



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