

APPLICATION NOTE





Establish LTE & 2G/3G connections to HEAD acoustics equipment via R&S®CMW500

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1. Introduction

This Application Note suggests different measurement setups using the Rohde & Schwarz (R&S[®]) radio communication tester CMW500 in combination with specific HEAD acoustics equipment.

The presented measurement setups are intended to test mobile devices with current mobile communication standards. The setups are designed for testing communication via VoLTE, 3G or 2G.

Both setup guides (VoLTE, 2G/3G) have a similar structure. First the interconnection setup is illustrated. All necessary hardware and software equipment is listed. Then the document guides through the configuration of the HEAD acoustics hardware with the measurement software ACQUA. Eventually the last section instructs the correct configuration of the radio communication tester for the mentioned communication standards.

The Application Note is written assuming that the user has an advanced knowledge of handling HEAD acoustics equipment and the R&S[®]CMW500. HEAD acoustics will not respond to support requests concerning general handling and technical configuration of the R&S[®]CMW500.

2. VoLTE Setup with MFE VIII.1 and CMW500

The first section illustrates the VoLTE setup using the Rohde & Schwarz radio communication tester CMW500 in combination with HEAD acoustics hardware. The second section describes the main configurations in ACQUA followed by the MFE VIII.1 configuration in the third section. The fourth section explains the connection buildup between the device under test with the CMW500.



2.1 Measurement Setup

Figure 1: Overview of the measurement setup



The measurement setup (Figure 1) consists of the following components:

- ACQUA Analysis System (Code 6810) (Version 3.2.200 and higher)
- HMS II.3 (Code 1230) with HHP III.1 (Code 1403) or HHP IV (Code 1406)
- MFE VI.1 (Code 6462)
- MFE VIII.1 (Code 6484) with Option Cod-AMR (Code 6485) and IMP (Code 6496)
- Optional MFE IX (Code 6480) for network impairment measurements
- Optional HAE-BGN Background Noise Simulation (Code 6971)
- Optional 3PASS Background Noise Simulation (Code 6990)
- <u>CMW500</u>

The CMW500 is connected via Ethernet cable to the MFE VIII.1 (optional MFE IX interconnected). **Note:** Newer models of the CMW500 exclusively support Gigabit Ethernet and therefore are not compatible with the Fast Ethernet port of MFE VIII.1. In case a network connection cannot be established, please insert a Gigabit Ethernet switch capable of both transmission speeds inbetween the devices to mediate. The MFE VIII.1 is connected via AES/EBU to the MFE VI.1 and via USB to ACQUA (see Figure 1: Overview of the measurement setup).





2.2 Configuration in ACQUA

2.2.1 Hardware Configuration

| ACQUA Settings | | × |
|-------------------------|--|---|
| Table State State State | Hardware Configuration | |
| Measurement/Report | | |
| | | |
| MFE VI "Telecon" | | |
| MFE VIII. 1 "64840030" | ACQUAN USB ACCOUNT AES ACCOUNT AFE VIL 1 | |
| Hardware Configuration | | |
| | | |
| | | |

Figure 2: ACQUA Hardware Configuration with MFE VI.1 and MFE VIII.1



2.2.2 MFE VI.1 Settings





2.2.3 MFE VIII.1 Settings



Figure 4: MFE VIII.1 Settings in ACQUA

Open the configuration menu of the MFE VIII.1 by double-clicking on the VoIP field (see Figure 4).



2.3 Configuration of MFE VIII.1

2.3.1 Mandatory Settings

| | - 🖸 🖬 🕍 | | |
|------------------------------|-----------------|---------------------|--|
| asic Settings RTP Settings S | P Settings Call | Call Stats | |
| SIP Call | | Clock Control | |
| SIP Address | • | Sampling Rate | |
| Call | On Hook | 48000,00 [Hz] | 0,0 [ppm] |
| TD Shaan | | Miscellaneous | |
| | | | Send Codec Parameter |
| Remote IP | Chan | 0 | Send DTMF |
| Start | Stop | Reset Jitter Buffer | |
| | | Automatic | Manual |
| og | | | |
| 1 09:47:20 SIP idle | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Figure 5: Mandatory settings for MFE VIII.1

- 1. Select the "Call" tabulator (see Figure 5).
- 2. Enable the automatic jitter buffer reset function (see Figure 5).
- 3. Start the radio tester wizard by by clicking on the symbol in Pigure 5. The radio tester wizard prepares the front end for the RTP stream to and from the radio tester.
- 4. Follow steps 1–4 of section 2.3.2 MFE VIII.1 Radio Tester Wizard and adjust the settings.

Do **not** start the RTP stream by hand. The RTP stream is automatically detected by the MFE VIII.1 after closing the wizard.



2.3.2 MFE VIII.1 Radio Tester Wizard

| 1. Select CMW500 as the radio | | Radio Tester Wizard |
|--|------------------------------------|---|
| tester. | Select radio tester IP Settings | Select radio tester Select the active radio tester |
| | Check Parameter | ○ Anritsu MD8475A LTE (IPv4) |
| | | ○ Anritsu MD8475A LTE (IPv6) |
| | | O Anritsu MD8475A 2G/3G |
| | | Rohde & Schwarz CMW 500 |
| | | < Back Next > Cancel |
| | Figure 6 | 6: Radio tester Selection |
| 2. The MFE VIII.1 must have the | | Radio Tester Wizard |
| IP address where the CMW500 expects to find the media server. Typically, this is | Select radio tester IP Settings | IP Settings Set the IP-address of the MFE VIII.1 to the IP-address expected by the CMW as Media-Server. |
| 172.22.2.2, and the corresponding subnet mask is 255.255.0.0. | Check Parameter | IP 172 22 2 2 2 Subnet Mask 255 . 255 . 0 . 0 Gateway 0 . 0 . 0 . 0 DNS 0 . 0 . 0 . 0 |
| | | |
| | | < <u>B</u> ack <u>N</u> ext > Cancel |



Establish LTE & 2G/3G connections to HEAD acoustics equipment via R&S[®]CMW500

| 3. | Select a suitable initial jitter | | Radio Tester Wizard |
|----|---|---|--|
| | buffer length. Default setting is | Select radio tester | |
| Δ | Select the preferred (audio) | IP Settings | and MFE VIII.1 |
| ч. | codec. | RTP Settings | General |
| | | Check Parameter | Initial jitter buffer length |
| | | | Packet Length 20 V ms |
| | | | Codec Configuration |
| | | | Codec AMR-WB V Encoder Param. octet-align=1:fixed-local-mode V |
| | | | Decoder Param. octet-align=1;max-red=0 v |
| | | | |
| | | | |
| | | | < Back Next > Cancel |
| | | Fig | uro 8: PTP Sottings |
| | | ı ıg | ure o. KTP Settings |
| 5. | Double check the settings and | | Radio Tester Wizard |
| 5. | Double check the settings and close the wizard by selecting "Finish" | Select radio tester | Radio Tester Wizard Check Parameters Prove Eight for trappointing the parameters |
| 5. | Double check the settings and close the wizard by selecting "Finish". | Select radio tester IP Settings | Radio Tester Wizard Check Parameters Press Finish for transmitting the parameters to the MFE VIII. 1. |
| 5. | Double check the settings and close the wizard by selecting "Finish". | Select radio tester IP Settings RTP Settings Check Parameter | Radio Tester Wizard Check Parameters Press Finish for transmitting the parameters to the MFE VIII.1. IP: 172.22.2.2 Subnet Mask: 255.255.0.0 |
| 5. | Double check the settings and close the wizard by selecting "Finish". | Select radio tester IP Settings RTP Settings Check Parameter | Radio Tester Wizard Check Parameters Press Finish for transmitting the parameters to the MFE VIII.1. IP: 172.22.2.2 Subnet Mask: 255.255.0.0 Gateway: 0.0.0.0 DNS: 0.0.0.0 DNS: 0.0.0.0 |
| 5. | Double check the settings and close the wizard by selecting "Finish". | Select radio tester IP Settings RTP Settings Check Parameter | Radio Tester Wizard Check Parameters Press Finish for transmitting the parameters to the MFE IP: 172.22.2 Subnet Mask: 255.255.0.0 Gateway: 0.0.0.0 DNS: 0.0.0 Packet Length: 20 Initial jitter buffer length: 140 Codec: AMR-WB |
| 5. | Double check the settings and close the wizard by selecting "Finish". | Select radio tester IP Settings RTP Settings Check Parameter | Radio Tester Wizard Check Parameters Press Finish for transmitting the parameters to the MFE VIII.1. IP: 172.22.2.2 Subnet Mask: 255.255.0.0 Gateway: 0.0.0.0 DNS: 0.0.0 Packet Length: 20 Initial jitter buffer length: 140 Codee: AMR-WB Encoder Parameter: octet-align=1;fixed-local-mode=2 Decoder Parameter: octet-align=1;max-red=0 |
| 5. | Double check the settings and close the wizard by selecting "Finish". | Select radio tester IP Settings RTP Settings Check Parameter | Radio Tester Wizard Check Parameters Press Finish for transmitting the parameters to the MFE VIII.1. IP: 172.22.2.2 Subnet Mask: 255.255.0.0 Gateway: 0.0.0.0 DNS: 0.0.0 Packet Length: 20 Initial jitter buffer length: 140 Codec: AMR-VB Encoder Parameter: octet-align=1;fixed-local-mode=2 Decoder Parameter: octet-align=1;max-red=0 |
| 5. | Double check the settings and close the wizard by selecting "Finish". | Select radio tester IP Settings RTP Settings Check Parameter | Radio Tester Wizard Check Parameters Press Finish for transmitting the parameters to the MFE VIII.1. IP: 172.22.2.2 Subnet Mask: 255.255.0.0 Gateway: 0.0.0 DNS: 0.0.0 Packet Length: 20 Initial jitter buffer length: 140 Code: AMR-WB Encoder Parameter: octet-align=1;fixed-local-mode=2 Decoder Parameter: octet-align=1;max-red=0 |
| 5. | Double check the settings and close the wizard by selecting "Finish". | Select radio tester IP Settings RTP Settings Check Parameter | Radio Tester Wizard Check Parameters Press Finish for transmitting the parameters to the MFE III: 1. IP: 172.22.2.2 Subnet Mask: 255.255.0.0 Gateway: 0.0.00 DNS: 0.0.00 Packet Length: 20 Initial jitter buffer length: 140 Codec: AMR-WB Encoder Parameter: octet-align=1;fixed-local-mode=2 Decoder Parameter: octet-align=1;max-red=0 |
| 5. | Double check the settings and close the wizard by selecting "Finish". | Select radio tester IP Settings RTP Settings Check Parameter | Radio Tester Wizard Check Parameters Press Finish for transmitting the parameters to the MFE VIII.1. IP: 172.22.2.2 Subnet Mask: 255.255.0.0 Gateway: 0.0.0.0 DNS: 0.0.0.0 Packet Length: 20 Initial jitter buffer length: 140 Codec: AMR-WB Encoder Parameter: octet-align=1;fixed-local-mode=2 Decoder Parameter: octet-align=1;max-red=0 < |
| 5. | Double check the settings and close the wizard by selecting "Finish". | Select radio tester IP Settings RTP Settings Check Parameter | Radio Tester Wizard Check Parameters Press Finish for transmitting the parameters to the MFE IP: 172.22.2.2 Subnet Mask: 255.255.0.0 Gateway: 0.0.0.0 DNS: 0.0.0.0 DATAMET WB Encoder Parameter: octet-align=1;fixed-local-mode=2 Decoder Parameter: octet-align=1;max-red=0 Calcet < |

2.4 Configuration of CMW500

2.4.1 Presets of CMW500

Please ensure that all necessary Rohde & Schwarz measuring equipment for the VoLTE setup is available. For example, CMW500 Options or CMW500 Routing Options. If in doubt, please contact the Rohde & Schwarz sales department.



Figure 10: CMW500 front panel



Figure 11: CMW500 back view

- Press the button MEASURE at the front panel of the CMW500 (blue box in Figure 10). Select Data Appl. → Measurement 1 and Selected RAN → LTE Signaling 1 (see Figure 12).
- Press the button SIGNAL GEN (red box in Figure 10) and select LTE Signaling 1 (see Figure 13).

To switch between Data Measurement and LTE Signaling press TASKS (green box in Figure 10).

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| 🚸 Measurement Controller | | × | Meas Ctrl |
|---------------------------------|---------------|------------------------------|-----------|
| | Taskbar entry | State A | |
| ⊕ 1xEV-DO | | | |
| TX Measurement | | | |
| RX Measurement | | | > |
| ⊕ Audio | | | |
| Measurements 1 | | | |
| Measurements 2 | | | → |
| 4- CDMA2000 | | | |
| TX Measurement | | | |
| RX Measurement | | | <u> </u> |
| 🕀 Data Appl. | | | |
| Measurement 1 | | Selected RAN LTE Signaling 1 | |
| Measurement 2 | | Selected RAN no selection | |
| & General Purpose RF | | | |
| Measurements | | | |
| ⊕ GSM | | | ≻ |
| Multi Evaluation | | OFF | 1 |
| RX Measurement | | | |
| ⊕ LTE | | | <u>}</u> |
| | | | 1 |
| RX Measurement 1 | | | |
| RX Measurement 2 | | | |
| S WCDMA FDD UE | | | - |
| -TY Measurement | • | | |
| | | | |
| Data 1 TE 1 | | | |
| Meas 🚯 <mark>Eignaling 🔳</mark> | | | |



3. Select LTE Signaling (Figure 13) and continue with section 2.4.2.







2.4.2 LTE Signaling

This section provides hints to obtain a good LTE connection between the device under test and the CMW500.

- 1. Set the **RS EPRE Power** to **-62,8** *dBm* / **15** *kHz* and the **PUSCH Open Loop Nom. Power** to **0** *dBm* (see Figure 14).
- 2. Select Config... to continue with the advanced settings (see Figure 14).

| onnection Status | PCC SCC1 | SCC2 SCC3 | | |
|--|--|-----------------------------------|---------------------------------|--------------------------|
| Cell | Operating Band | Band 13 | ▼ FDD ▼ | LTE 1 TX Meas. |
| Packet Switched DFF RRC State Idle | Channel | 5230 Ch | Uplink 23230 Ch 782.0 MHz | LTE 1 RX Meas. |
| | Cell Bandwidth | -62.8 dBm/15kl | ▼ 10.0 MHz | |
| vent Log | Full Cell BW/Pov | w -35.0 dBm | _ | GO TO |
| 2:12:39 State 'Cell Off' (2:05:00 State 'Attached' | PUSCH Open Lo PUSCH Closed L | op Nom.Power .oop Target Power | 0 dBm -20.0 dBm | |
| JE Info IMEI IMSI | Construction of the second sec | n. channeis • • • • | | |
| Voice Domain Pre | 400 | Downlink U | Jplink | |
| Default Bearer IPv4 address IPv6 pre | fix Start RB | 0 | 0 | |
| 21 | Mod / TBSI | QPSK 🕶 9 | QPSK 7 5 | - |
| Leans 2000 Leans 20000 Leans 2000 | Code Rate / TBS | S 0.61852 7992 | 0.30667 4392 | LTE Signali <u>ng</u> |
| Lease TFT Port Range | Code Rate / TBS | 3 0.61852 7992 7.992 Mbit/s | 0.30667 4392 4.392 Mbit/s | LTE Signaling |

Figure 14: Main LTE Settings



- 3. Set the external attenuation of **RF Output (TX)** and **RF Input (RX)** according to the attenuation of the antenna and antenna cable (**External Attenuation** in <u>Figure 15</u>).
- The RF Frequency → Operating Band (Figure 15) depends on the device under test. Set accordingly.



Figure 15: Configuration Menu LTE Signaling

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- 5. The proper values for Network → Network Identity → MCC/MNC (Figure 16) depend on the SIM card that is used. The Rohde & Schwarz test SIM card uses MCC 001 and MNC 01.
- 6. The Network → Security Settings (Figure 16: MCC/MNC Settings) must match with the used SIM card. Refer to the technical data of the used sim card if in doubt. Set the security settings accordingly.



Figure 16: MCC/MNC Settings



- 7. Enable the **Send DNS PCO** and **EPS Network Feature Support** in the menu **NAS Signaling** (see <u>Figure 17</u>).
- 8. Set the **IMS Voice over PS Sess. Ind.** to *Supported* in the menu **NAS Signaling** (Figure 17).
- 9. In the menu **Connection**: Set the **Connection Type** to **Data Application** (Figure <u>17</u>).



Figure 17: NAS Signaling and Connection



- 10.If all settings are configured correctly, switch on the LTE Signaling by pressing the button ON/OFF at the front panel (yellow box in Figure 10).
- 11. The device under test registers at the LTE cell automatically (see Figure 18).
- 12. View the measured RSRP value by switching the **UE Info** to **UE Measurement Report** (Figure 19).

To ensure a good radio communication quality, the value shall be similar to the adjusted RS EPRE Power (–62,8 dBm / 15 kHz, cf. Figure 14).

13. Change the external attenuation of the **RF Output** and **RF Input** (Figure 15) to adjust the appropriate target value.

| V LTE Signaling 1 - V3.5.21 - Base V 3.5.40 | | | | | | - 2 | LTE |
|---|---------|------------|-----------------|------------|---------------|---------|-----------|
| Connection Status | PCC | SCC1 | SCC2 SCC | 3 | | | (|
| Cell | Operat | ing Band | Band 13 | | FDD | | TX Meas. |
| Desired Curitational | | | Downlink | | Uplink | | |
| Packet Switched Attached | Chann | el | 5230 |) Ch | 23 | 230 Ch | LTE 1 |
| Connected | Freque | ency | 751.0 |) MHz | 78 | 2.0 MHz | RX Meas. |
| | Cell Ba | andwidth | 10.0 MHz | | 10.0 MH | z | } |
| | RS EF | RE | -62.8 | 3 dBm/15kH | z | | Go to |
| event Log | Full Ce | ell BW Pov | w35.0 |) dBm | | | |
| 12:18:52 State 'Attached' | PUSCH | H Open Lo | oop Nom.Power | | | 0 dBm | } |
| 12:18:52 CEPS Default Bearer Established, Id 6 12:18:51 EPS Default Bearer Established, Id 5 | PUSCH | H Closed I | Loop Target Pov | ver | -2 | 0.0 dBm | Routing |
| 12:18:50 ORRC Connection Established | | | | | | | |
| 12:18:47 State 'Cell On' | | | | | | | |
| UE Info 💌 🗆 | Schee | d. User d | ef. Channels ' | - M | ulticluster U | L | |
| | | | | | | | - |
| IMEI 990004810601892 | | | | | | | |
| MSI 001010123456789 Voice Domain Pre IMS DS Voice prefered CS Voic | | | | | | | |
| UE's Usage Setting Voice centric | | | Downlink | Up | link | | |
| Default Bearer IPv4 address IPv6 prefix | #RB | | | 50 | | 50 | |
| | Start I | RB | | 0 | | 0 | |
| Dedicated Bearer TFT Port Range | Mod / | TBSI | QPSK 🔻 | 9 | QPSK 🔻 | 5 | L TE |
| · | Code | Rate / TB | S 0.61852 | 7992 | 0.30667 | 4392 | Signaling |
| | Throu | ghput | 7.992 | Mbit/s | 4,392 | Mbit/s | ON |
| Detail | | | | Canad GMG | Inter | /Intra- | 0 |
| Detacii Connect | | | | Send SMS | RAT | | Coning |

Figure 18: LTE Registration

| 🚸 LTE Signaling 1 - V3.5.21 - Base V 3.5.40 | | | | | -8 | LTE |
|--|----------------|-----------------------|-----------|-----------------|-------|-----------|
| Connection Status | PCC SCC1 | SCC2 SCC | 3 | | | |
| Cell (W) | Operating Band | Band 13 | • | FDD | | TX Meas. |
| Packet Switched | | Downlink | | Uplink | | <u> </u> |
| RRC State Connected | Channel | 5230 | Ch | 23230 | Ch | LTE 1 |
| | Frequency | 751.0 | MHz | 782.0 | MHz | RX Meas. |
| | Cell Bandwidth | 10.0 MHz | • | 10.0 MHz | | |
| | RS EPRE | -62.8 | dBm/15kHz | | | Go to |
| | PUISCH Open Lo | v33.0 on Nom Power | abm | 0 | dBm | |
| tivent Log | PUSCH Closed L | .oop Target Pov | /er | -20.0 | dBm | |
| 11:36:30 RC Connection Established 11:36:17 State 'Cell On' 11:28:47 State 'Cell On' 11:25:44 State 'Cell Off' 11:25:44 State 'Attached' 11:25:44 EPS Default Bearer Established, M 6 | Sched. User de | ef. Channels 🤊 | Mult | iicluster UL | | |
| JE Measurement Report 🔻 🔽 On 📃 | | | | | | |
| | | Downlink | Upli | nk | | |
| | #RB | | 50 | | 50 | |
| RSRP RSRQ | Start RB | anav | 0 | a Day | 0 | |
| FCC 78 (-0310 -02 (IDIII) 22 (-310 -0.3 (ID) | Mod / TBSI | QPSK • | 7002 | 1 20667 / | 5 | LTE |
| | Throughput | 7.992 | Mbit/s | 4.392 Mi | it/s | Signaling |
| Detach Connect | | | Send SMS | Inter/In RAT | ntra- | Config |

Figure 19: UE Measurement Report



2.4.3 IMS Server

This section instructs how to register the device under test at the IMS Server.

- 1. Press the button MEASURE at the front panel of the CMW500 (**blue** box in Figure <u>10</u>) and select **Data Appl. Measurement 1** (see Figure <u>12</u>).
- 2. Select the Task Data 1 Meas (lower part of Figure 12).
- 3. Select Configure Services (Figure 20).
- 4. Select the tab IMS.
- 5. Select Config... (Figure 22, right side, lower part).

| 🚸 Data Application Measurement 1 - V3.5.20 | | | IP Logging |
|--|--|---|---------------|
| Select RAN: LTE Signaling 1 | Max. possible Throughput Up Max. possible Throughput Do | blink (RAN): 4.392 Mbit/s wnlink (RAN): 7.992 Mbit/s | IP Logging |
| Overview 🔍 Ping 🔍 IPerf 💽 Throughput 💽 | DNS req. 🔍 IP Logging | j 🕒 IP Replay 💽 Audio Dela | |
| IP Logging | | | Configuro |
| Logging Interface: U–Plane IP | | | Services |
| Log File Folder: Z:\ip_logging\Data4 | pplMeas1_U-Plane_IP_01 | 7.рсар | |
| Log File Name: DataApplMeas1 U | -Plane IP 018.pcap | | le le |
| | | | |
| -DataApplMeas1 U-Plane IP 003.pcap | 762 KB | 29.10.2014 14:10:11 | |
| DataAppIMeas1 U-Plane IP 004.pcap | 28 KB | 06.11.2014 11:18:48 | |
| DataAppIMeas1_U-Plane_IP_005.pcap | 550 KB | 06.11.2014 11:27:40 | Network |
| DataAppIMeas1_U-Plane_IP_006.pcap | 6 KB | 06.11.2014 11:27:42 | Impairm. |
| DataAppIMeas1_U-Plane_IP_007.pcap | 28 KB | 24.11.2014 15:18:29 | |
| DataApplMeas1_U-Plane_IP_008.pcap | 71 KB | 24.11.2014 15:54:29 | |
| DataAppIMeas1_U-Plane_IP_009.pcap | 566 KB | 25.11.2014 15:24:05 | |
| DataAppIMeas1_U-Plane_IP_010.pcap | 35 KB | 20.03.2015 12:40:27 | |
| DataAppIMeas1_U-Plane_IP_011.pcap | 11 KB | 13.04.2015 14:24:08 | - |
| -DataAppIMeas1_U-Plane_IP_012.pcap | 21 KB | 13.04.2015 14:32:15 | |
| DataAppIMeas1_U-Plane_IP_013.pcap | 89 KB | 13.04.2015 14:47:26 | |
| DataAppIMeas1_U-Plane_IP_014.pcap | 49 KB | 13.04.2015 15:15:26 | |
| DataAppIMeas1_U-Plane_IP_015.pcap | 219 KB | 28.05.2015 11:27:52 | |
| DataAppIMeas1_U-Plane_IP_016.pcap | 26778 KB | 28.05.2015 14:12:37 | Signaling |
| DataAppIMeas1_U-Plane_IP_017.pcap | 221 KB | 28.05.2015 16:05:08 | Parameter |
| CZY:UD reblav(DAUShare IPReblav) | 3 | Directory | |
| Selected File: DataApplMeas1_U-Plane_IP_017.pcap | | | Signaling |
| | | 🛅 Open | |
| Data 1 LTE 1 Meas 🚯 Signaling 📵 | | | |

Figure 20: Configure Services



| Use IMS Server as | intern IMS 💌 |
|----------------------|-----------------|
| external | |
| -P-CSCF IPv4 Address | 192.168.168.200 |
| P-CSCF IPv6 Address | fcb1:cafe::200 |
| | |



- 6. Set the IMS server to *intern IMS* (Figure 21).
- 7. Whether to select *IPv4* or *IPv6* as **Address Type**, depends on the device under test.
- 8. Confirm IMS server and address type by selecting OK.
- 9. Select the section Subscribers Configuration (yellow box in Figure 22).

| 🚸 Data Application Control | | | | | | 8 | | IMS |
|--|---|----------------------------------|----------------------|-------------|---------|-----------------------|----|---|
| DAU Unit <mark>ON</mark> Overview A IP Config IP Multimedia Subsystem | DNS FTP H | TTP 😳 IMS | | | MS Serv | er: intern IM | IS | IMS Service ON |
| General IMS Info 11:25:44 UE is subscribe 11:25:44 Registered UE t 11:25:44 Mobile register 11:21:47 MMS Server Run 11:21:46 MGW successf 11:21:45 MMS Server Sta | d for 'reg' event with URI: tel:5551001 and s ed. UE IP address fc01:aba ning ully started tup | Events Timestamps 11:27:07 | Source VS1 S | Destination | Event | Status Established | | Go to Audio Update Call Release Call |
| ☐-Established ☐-Timestamp ☐-Signaling Type ☐-Media Update ☐-Timestamp ☐-Audio └──Settings ☐-Ringing └──Timestamp | 11:27:07 Without Preconditions 11:27:07 Type AMR-WB 11:27:03 | Alignment Octet Aligned | | Mode 2 | | Class | | DAU Unit |
| Select Network Applic Drive m | ap | | Virtual Subscribe | r Subscr | iber | P-CSCF | | Config |

Figure 22: IMS Service



- 10. If the device under test requires Authentication, confirm authentication.
- 11. If user authentication is needed, adjust the **Authentication Data** to the SIM card in use and the device under test (Figure 23).
- 12. Confirm the entered data and return to IMS tab with OK.
- 13. Start the IMS server by pressing the button ON/OFF at the front panel (yellow box in Figure 10).
- 14. Activate and deactivate the airplane/offline mode of the mobile phone to register it to the CMW500.
- 15. Confirm IMS server startup and phone registration in the "General IMS Info" box (Figure 22).

| ubscriber Configure | |
|--------------------------|--|
| Private User ID | 001010123456789@test.3gpp.com |
| Authentication | No Authentication |
| Authentication Data | |
| Key Generation Algorithm | Milenage 👻 |
| Key | 0x000102030405060708090a0b0c0d0e0f hex |
| AMF | 0x0000 hex |
| OPc | 0xcb9dcdc5b9258e6dca4760379fb82581 hex |
| RES Length | 32 |
| IPSec | ∉ Off ⊂ On |
| 🗄 - IP Sec Data | |
| -Integrity Algorithm | HMAC SHA 1 96 |
| Encryption Algorithm | NO CIPH - |
| Public User IDs | |

Figure 23: Subscribers Configuration



- 16. Select the section Virtual Subscribers Configuration (pink box in Figure 22).
- 17. Set **Signaling type** according to the device under test.
- 18. Set the **Audio Routing** to *Forward* (Figure 24). This ensures that the RTP stream is forwarded to the MFE VIII.1 via LAN SWITCH at the back of the CMW500 (Figure <u>11</u>).
- 19. **Media Endpoint** is the IP Address of the MFE VIII.1 (see <u>Figure 7</u> in Wizard, and <u>Figure 24</u>).
- 20. If all settings are correct, the device under test registers at the IMS server (Figure <u>22</u>).
- 21. Open the call menu (Figure 25) in the section **Virtual Subscribers Configuration** via the phone symbol button.

| Airtual Subscriber Configure | |
|---------------------------------|-------------------------|
| Behaviour | Answer |
| Signaling Type | Without Preconditions 💌 |
| Audio Codec AMR | AMR-WB |
| AMR Alignment Mode | Octet Aligned 👻 |
| E Codec Rates Codec Codec | H.263 💌 |
| -Media Endpoint E Forward | Forward • |
| -RTP Port | 1000 |
| -Cmd Port | 1000 |
| AMR Alignment | Bandwidth Efficient 👻 |

Figure 24: Virtual Subscribers Configuration



22. Set the Call Type to Audio.

- 23. The **AMR Type** and the **AMR Codec** have to be selected to match the DUT and the measurement (e.g. **AMR Wideband** with bit rate **12.65 kbps**).
- 24. Ensure that only the desired bit rate is selected during the connection.
- 25. Start the call by pressing Call (Figure 25).

The RTP stream starts automatically, and the status line in the configuration menu of the MFE VIII.1 changes from *SIP idle* to *RTP connected* (see Figure 4: MFE VIII.1 Settings in ACQUA).

| Virtual Subscribers Co Virtual 1 | ntiguration 😿 |
|---|--|
| Destination Call Type Signaling Type Audio Codec AMR Alignment Mode | 1001[tel:5551001] Audio ▼ Without Preconditions ▼ AMR-WB ▼ Octet Aligned ▼ |
| Video Codec Video Attributes Audio Codec AMR-WB | H.263 ▼ [0] □ 6.60 kbit/s [1] □ 8.85 kbit/s [1] □ 12.65 kbit/s [3] □ 14.25 kbit/s [4] □ 15.85 kbit/s [5] □ 18.25 kbit/s [6] □ 19.85 kbit/s [7] □ 23.05 kbit/s [8] □ 23.85 kbit/s Call Ok Cancel |

Figure 25: Call Voice over IMS



3. 2G/3G connection with CMW500 Audio Board

The first section illustrates the 2G/3G setup using the Rohde & Schwarz radio communication tester CMW500 in combination with HEAD acoustics hardware. The second section describes the main configurations in ACQUA. The third section instructs about the configuration of the CMW500 for 2G and 3G network measurements.



3.1 Measurement Setup

Figure 26: Overview of the measurement setup

The MFE VI.1 (Line Out Right (II) and Line In Left (I)) is connected via BNC cables to the CMW500 (AF1 In and AF1 Out):



The measurement setup (Figure 26: Overview of the measurement setup) consists of the following components:

- ACQUA Analysis System (Code 6810) (Version 3.2.200 and higher)
- HMS II.3 (Code 1230) with HHP III.1 (Code 1403) or HHP IV (Code 1406)
- MFE VI.1 (Code 6462)
- Optional HAE-BGN Background Noise Simulation (Code 6971)
- Optional 3PASS Background Noise Simulation (Code 6990)
- CMW500 (Audioboard option)

3.2 Configuration in ACQUA

3.2.1 Hardware Configuration



Figure 27: ACQUA Hardware Configuration with MFE VI.1



3.2.2 MFE VI.1 Settings



Figure 28: MFE VI.1 Settings in ACQUA



3.3 Configuration of CMW500

3.3.1 Presets of CMW500

Please ensure that all necessary Rohde & Schwarz measuring equipment for the 2G/3G connection setup is available. For example, CMW500 Options or CMW500 Routing Options. If in doubt, please contact the Rohde & Schwarz sales department.

1. Press the button MEASURE at the front panel of the CMW500 (blue box in Figure 10) and select Audio Measurement 1 (see Figure 29: Selecting Measurement Task).

| Measurement Controller | | | |
|------------------------|---|--------------|-----------------|
| ⊕GSM | | | |
| -Multi Evaluation | | OFF | |
| RX Measurement | | | |
| ⊕WCDMA FDD UE | | | |
| | | | |
| | | | |
| RX Measurement 2 | | | |
| % TDSCDMA UE | | | |
| TX Measurement | | | |
| | | | |
| RX Measurement 2 | | | |
| & Data Appl. | | | |
| Measurement 1 | | Selected RAN | GSM Signaling 1 |
| Measurement 2 | | Selected RAN | no selection |
| ₩LTE | | | |
| | | | |
| | | | |
| RX Measurement 2 | | | |
| & Audio | | | |
| -Measurements 1 | > | | |
| Measurements 2 | | | |
| | 4 | | • |

Figure 29: Selecting Measurement Task



2. Press the button SIGNAL GEN (red box in Figure 10) and select GSM Signaling or WCDMA Signaling (see Figure 30: Selecting Signaling Task).

To switch between Audio Measurement and GSM/WCDMA Signaling press TASKS (green box in Figure 10).

Select **GSM Signaling** and continue with section 3.3.2 or select **WCDMA Signaling** and continue with section 3.3.3.

| Generator/Signaling Controller | | | |
|--------------------------------|-----------|------------|--|
| ≪General Purpose RF | Taskbar e | ntry State | |
| Generator 1 | | OFF | |
| -Generator 2 | | OFF | |
| -Generator 3 | | OFF | |
| Generator 4 | | OFF | |
| ∾GSM | | 102024 | |
| Signaling | | OFF | |
| ≫WCDMA FDD UE | | | |
| -Signaling 1 | | - ON | |
| Signaling 2 | | OFF | |
| > TDSCDMA UE | _ | | |
| Signaling 1 | | OFF | |
| Signaling 2 | | OFF | |
| ≪LTE | | | |
| Signaling 1 | | OFF | |
| -Signaling 2 | | OFF | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Figure 30: Selecting Signaling Task



3.3.2 GSM (2G) Signaling

This section provides hints to obtain a GSM (2G) connection between the device under test (DUT) and the CMW500.

- In the main settings screen, set the DL Reference Level to -60,0 dBm and the PMax (Power Class Level) to 10 (or higher) (see Figure 31: Main GSM Settings).
- 2. Select Config... for the advanced settings (Figure 31).

| 🚸 GSM Signaling - V3.5.20 - Base V 3.5.40 | | | GSM |
|--|---|------------------------------------|---------------------|
| Connection Status | Cell Setup BCCH Channel / Band | 62 GSM900 | GSM 1 Multi Eval |
| Packet Switc OFF | PMax (PCL) PS Domain | 15 13.00 dBm | GSM 1 RX Meas. |
| RX Power | TCH/PDCH Carrier | PDCH Carrier 2 | |
| Event Log | Channel / Band | 62 GSM900 Downlink Uplink | Go to |
| 00:38:59 Call Released, Mobile Originated 00:37:52 OMobile Originated Call Established | Frequency DL Reference Level | 947.4 MHz 902.4 MHz -60.00 dBm | Routing |
| 00:37:15 Call Released, Mobile Originated 00:37:16 Mobile Originated Call Established 00:36:50 Mobile Originated Call failed 00:36:04 Cell On, Standard Cell Scenario 00:36:04 Speech Unit Available | Connection Setup Circuit Switched Slot Packet Switched Slot Circuit Packet Sw.Slot OUL Measurement Slot | DL: 000 € 00000 UL: 000 € 00000 | |
| 00-26-02 AC-II 04 | DTM Slot Config | Edit | |
| MS Measurement Report 👻 📃 | Circuit Switched Pa | acket Switched | |
| | Traffic Mode | FR V1 | - |
| | PCL | 15 13.00 dBm | |
| | Timeslot | 3 | |
| | | | GSM Signaling |
| CS Connect | | Send CS SMS | Config |

Figure 31: Main GSM Settings

3. Set the **RF Output (TX)** and **RF Input (RX)** settings according to the attenuation of the antenna and antenna cable (**External Attenuation** in <u>Figure 32</u>).



| GSM Signaling - Configuration | | |
|-------------------------------|---------------|---|
| ath: Scenario | | |
| Scenario | Standard Cell | • |
| - RF Settings | | |
| ⊡-RF Output (TX) | | |
| Connector | RF1COM 👻 | |
| Converter | RFTX1 🔻 | |
| External Attenuation | 20.00 dB | |
| External Delay Compensation | 0 ns | |
| 🖻 RF Input (RX) | | |
| Connector | RF1COM 🔻 | |
| Converter | RFRX1 🔻 | |
| | 15.00 dB | |
| External Delay Compensation | 0 ns | |
| BCCH | | |
| Band | GSM900 💌 | |
| | 62 947.4 MHz | |
| l evel | -60.00 dBm | |
| -PMax (PCL) | 15 13.00 dBm | |
| Б -ТСН/РДСН | | |
| 🖻 - Carrier 1 | | |
| Channel | 62 | |
| DL Frequency | 947.4 MHz | |
| | 902.4 MHz | |
| DL Reference Level | -60.00 dBm | |
| 🗄 Hopping | | |

Figure 32: GSM Configuration

- 4. Set the preferred codec (Traffic mode) in the section Circuit switched.
- 5. Set Data Source to Speech (Figure 33: GSM Circuit Switched).

| 🚸 GSM Signaling - Configuration | | × |
|---|--|---|
| Path: Connection/Circuit Switched/Caller Id | | |
| ──IMEI Request ⊞- Circuit Switched | | |
| ⊕-Timer and Constants ⊕-Reject Causes ⊕-Security Settings | | |
| | | |
| -Frequency Offset DL Frequency Offset UL | 0 Hz 0 Hz | |
| Random Frequency Offset Timing Advance ElCircuit Switched | 0 | |
| Timeslot | 3 | |
| Traffic Mode HR Subchannel | FR V1 | |
| Data Source | Speech 🔻 | |
| Echo Delay ⊞∽DTX DL | 2 s | |
| Call Release Loop | Immediate Release ▼ □ C ▼ □ re-close after channel change | |
| Caller Id | 12345 very early ▼ | Ŧ |

Figure 33: GSM Circuit Switched



- 6. The proper values for Network Identity → MCC/MNC (Figure 34: GSM Network Identity) depend on the SIM card that is used. The Rohde & Schwarz test SIM card uses MCC 001 and MNC 01.
- 7. Please continue with Section <u>3.3.4</u>.



Figure 34: GSM Network Identity



3.3.3 WCDMA (3G) Signaling

This section provides hints to obtain a WCDMA (3G) connection between the device under test and the CMW500.

- 1. In the main settings screen, set the **RS EPRE Power** between –60 dBm to -70 dBm (see Figure 35: Main WCDMA Settings).
- 2. Select Config... for the advanced settings (Figure 35: Main WCDMA Settings).

| 🚸 WCDMA UE Signaling 1 - V3.5.22 - B | lase V 3.5.40 | | | | - 🛛 | WCDMA |
|--|--------------------------------------|---------------------------|--------------------------|--------------------------------|---------------------|------------------------|
| Connection Status | PA [CPC] IPA [CM] | Cell Sett Band | ip [| Band 1 Downlink | ▼ Uplink | WCDMA 1 TX Meas |
| Circuit Switched Call Estat | blished | Frequence Output F | ower | 2112.6 MHz -65.00 dBm | 1922.6 MHz | WCDMA 1 RX Meas |
| Event Log | 10: | Scrambli P-CPICI | ng Code | -65.00 dBM 0 hex -3.3 dB | 0 hex | Go to |
| 21:22:04 CS Call Established 21:22:04 Voice Call 21:22:03 UE Originated CS Call 21:22:01 RRC Connection Establish | shed | PS Dom | ain 🗖 ion Setup | Reduc | ed Signaling 🔽 | Routing |
| 21:22:01 TRRC Connection Reques | it 1 hv disabled PS D | SRB Data Rate Voice | •DL <mark>13.6 kb</mark> | ps UL 13.6 kb | ps | |
| UE Measurement Report VIRAFDD (Current Cell) | On Lower Upp | er Codec | Speech Narrow Ba | ▼ and AMR ▼ | | |
| CPICH RSCF [dBin] CPICH Ec/No (dB] Log10(TCH BLER) Transmitted UE Power [dBm] | -00 -05 -3.5 -3 0 0 -29 -28 | NB AMR | A (12.2 kb) | ps) 🔻 | | Signaling Parameter |
| UE RX-TX Time Difference [Chip] Pathloss [dB] | 1024 1025 97 | | | | | WCDMA-UE Signaling |
| Disconnect Voice | | | | Send SMS | Inter/Intra- RAT | Config |

Figure 35: Main WCDMA Settings

3. Set the **RF Output (TX)** and **RF Input (RX)** settings according to the attenuation of the antenna and antenna cable (**External Attenuation** in <u>Figure 36: WCDMA</u> <u>Configuration</u>).



| 🚸 WCDMA UE Signaling 1 - Configuration | | |
|--|--|---|
| Path: Physical Downlink Settings | | |
| Scenario | Standard Cell | × |
| | RF1COM ▼ RFTX1 ▼ 20.0 dB 0 ns RF1COM ▼ RFRX1 ▼ 20.0 dB | |
| Ext. Delay Comp. B-RF Frequency B-RF Power Downlink B-RF Power Uplink D-Physical Downlink Settings | 0 ns | |
| Accumulated Power OCNS Code Conflict Code Domain Diagram Channel Table | 0.00 dB Adjust to 0dB -27.56 dB Auto Release 99 No Code Conflict Detected! Show | |
| | -3.3 dB 0 15 ksps | • |

Figure 36: WCDMA Configuration

- 4. Set the preferred codec (AMR NB or AMR WB) and bitrate in the section **Connection Configuration → Voice**.
- 5. Set Data Source to Speech.
- 6. Set the **UE term. Connection** to **Voice** (Figure 37: WCDMA Connection Configuration).

| 🚸 WCDMA UE Signaling 1 - Configuration | | S |
|--|-------------------------------|---|
| Path: Network/Packet Switched Domain | | |
| HS-PDSCH Enhanced | | • |
| E-AGCH | ✓ -9.3 dB 3 15 ksps | |
| E-HICH | ✓ -12.3 dB 6 30 ksps | |
| -E-RGCH | □ -12.3 dB 6 30 ksps | |
| ⊡ Downlink Power Control | | |
| ⊞-Physical Uplink Settings | | |
| Connection Configuration | | |
| | Voice | |
| SKB Data Kate | DL 13.6 Kbps 🔨 OL 13.6 kbps 🝸 | |
| Caller ID | 764332637249279 | |
| 🖻 Voice | | |
| Data Source | Speech 💌 | |
| Delay | Loopback: 0 s | |
| Speech DTY DL Enable | E | |
| Codec | Narrow Band AMR 🔻 | |
| NB AMR | A (12.2 kbps) 🔻 | |
| WB AMR | l (6.60 kbps) 🔻 | |
| e. video | | |
| ⊞-Single SRB | | |
| ⊞ Test Mode | | |
| ⊞-Packet Data | | |
| ⊟-Network | | |
| Primary Scrambling Code | 0 hex | |
| Packet Switched Domain | | • |





- 7. The proper values for **Network Identity** → **MCC/MNC** depend on the SIM card that is used. The Rohde & Schwarz test SIM card uses **MCC** 001 and **MNC** 01.
- 8. Set the security settings according to the device under test (Figure 38: WCDMA Network Identity and Security Settings).
- 9. Please continue with Section <u>3.3.4</u>.



Figure 38: WCDMA Network Identity and Security Settings



3.3.4 Calibration of Analog Connection

The following steps are necessary to calibrate the Measurement Setup CMW500 and ACQUA.

- 1. Select the Task **Audio Measurement 1** (see Figure 29: Selecting Measurement <u>Task</u>) and select this task by pressing TASKS (green box in Figure 10).
- 2. Select the Scenario "External Analog Speech Analysis" (Figure 39: Audio Measurement 1).
- 3. Ensure that the **Routing** is **Controlled** by the desired Cell (GSM or WCDMA Signaling see <u>Figure 39</u>).
- 4. Set the **Input Level Full-Scale (Peak)** and **Output Level Full-Scale (Peak)** to **1.572V** (See Figure 39).

With these settings the analog connection between CMW500 and MFE VI.1 is calibrated.

| 🚸 Audio Measurement 1 | - V3.5.12 - Base V | 3.5.80 | | | - 2 | Audio |
|-------------------------------------|--------------------|---------------|--|-----------------------|----------------|---------------------------|
| Scenario <mark>External Anal</mark> | og Speech Ana | lysis 🔻 | AF IN Encoder | Decoder AF OI | TL | Speech Analysis |
| Speech Analysis | | | | | | |
| Routing | | | _ | | | |
| Signaling: | GSM Sig1 Co | nnector: | AF-1 C | ontrolled by: GSM | Sig1 🔻 | |
| Speech Setup | | Event Log | | | | |
| Clock Drift: | O ppn | 21:54:05 Spee | ch codec is ready to inte | eract with GSM Sig | 1 🔺 🗙 | |
| Input Level (FS-Peak): | 1.572 V | 21:54:02 Code | c is being downloaded f ding is going to be suppl | or GSM Sig1 ressed | | |
| Output Level (FS-Peak): | 1.572 V | 21:32:09 Spee | ch codec is ready to inte | eract with WCDMA | Sig1 | - |
| High Pass Filter: | 6 H | 21:32:06 Code | | | | |
| | | | | | | |
| MS Info IMSI: | | | CMW Voice Info Loopback Delay : Downlink Encoder | Delay : | | GSM 1 Signaling |
| Caller Id: 12345 | | | Unlink Decoder De | lav: | | Parameter |
| CS: | | PS: 📕 OFF | DL UL | | MCS-1 MCS-1 | GSM 1 Signaling OFF |
| Input Output Level Level. | t | | High Pass | | Clock Drift | Config |

Figure 39: Audio Measurement 1

With the CMW500 settings described as above, both the **calibration value** for CMW500 and the corresponding **External Output Amplifier** setting for **Channel 2** will be **0 dB**.

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In ACQUA:

Create two calibration values and use them accordingly. Hence the report will have customized names for the calibrations:

| Main menu, select Settings > Calibration Values | Settings Tools Help Meas./Report Settings F2 Calibration Assignment Hardware Configuration Hardware Configuration F5 Calibration Values Mouth/Loudspeaker Equalizations Edit System Variables |
|---|---|
| Select New (click the icon ²) or press the <i>Insert</i> key on the keyboard). | Image: Calibration Values Image: Calibration Values Image: Calibration Value Image: Calibration Value Image: Name Kind Value Date State Comment |
| 3. Use the following properties for the first calibration value: Name: CMW500 AF 1 In Kind: Output Value: 0.00 | Change Calibration No History Name CMW 500 AF 1 In Kind Output Value 0,00 Comment OK Cancel |
| 4. Create another calibration value by repeating steps 1–3 with following parameters: Name: CMW500 AF 1 Out Kind: Electrical Value: 0.00 | Change Calibration No History Name CMW 500 AF 1 Out Kind Electrical Value 0,00 Comment OK Cancel |



| 5 | In Measurement Settings use | Measurement Settings | | | | |
|--------------------------------|-----------------------------------|--|--|---|--|--|
| 5. | | | | | | |
| the "CMW500 AF 1 In" value for | | | Mouth / S Ea | fouth/LS Equalizer | | |
| | External Output Amplifier Gain | © <u>o</u> ff | Channel 1 Default | ▼ <u>Show</u> | | |
| | Ch 2 | © O <u>n</u> (P.57) ○ <u>U</u> ser defined | Channel 2 Both Channels Softwar | EQ Ch. 1 (Default) | | |
| | 0 | Pre Measure Info | Digital I/O Pulse In/Out | t | | |
| | | Close after 5 | s Info | n 🗹 Output On | | |
| | | Text SMD | Record Extend by | 0 ms | | |
| | | Close after 5 | s File Format | ormat 16 Bit | | |
| | | - Show Correction Varia | bles MFE VI, VIII, | MFE VI, VIII, X, XI | | |
| | | Show only undefine Show all Variables | ned Variables 🔽 Echo Par | ✓ Echo Parameters from SMD | | |
| | | Close after 1 | s Gain Ch. 1 | External Output Amplifiers Gain Ch. 1 20.00 dB | | |
| | | Result Check Results | Channel Names Gain Ch. 2 | 0.00 dB | | |
| | | Don't show Result | s Status | <u>:h2): CMW 500 AF 1 In</u> | | |
| | | Show all Results | Accuracy Scripting ot ok <u>Colors</u> Run Scri | pt before each Meas. Edit | | |
| | | Close after 5 | s Run Scri | pt after each Meas. <u>Edit</u> | | |
| • | | | | | | |
| 6. | in Calibration Assignment, use | Calibration Assignment | | | | |
| | the "CMW500 AF 1 Out" value for | | | | | |
| | User Defined Electric calibration | Calibration | Ref. Measurement | Measurement | | |
| | | Acoustic | 200 200 | HERINELSKY OL | | |
| for measurement. | | Electric | Owned | Detroit | | |
| | | User def. el. | | CMW 500 AF 1 Out | | |
| | | User det. ac. | | | | |
| | | Liner def. el. 2 | | HERITHERSKY OL | | |
| | | User def. el. 2 | | HERE MAILER TO L | | |
| | | User def. el. 2 User def. ac. 2 Art. Head left | | HERITAL CRITCH | | |
| | | User def. el. 2 User def. ac. 2 Art. Head left Art. Head right | | HELEMEDIATION | | |
| | | User def. el. 2 User def. ac. 2 Art. Head left Art. Head right Ref. Microphone | Olini Olek | HERE MELERICAL HERE MELERICAL HERE MELERICAL GEODEK | | |
| | | User def. el. 2 User def. ac. 2 Art. Head left Art. Head right Ref. Microphone Meas. Microphone | 2014 204K 2014 204K | HERE MILLION | | |
| | | User def. el. 2 User def. ac. 2 Art. Head left Art. Head left Ref. Microphone Meas. Microphone DF Average left | - 2011 2014. - 2011 2014. | 99011990-08701 99011990-08701 99011990-08701 0901096 0901096 9001096 | | |
| | | User def. el. 2 User def. ac. 2 Art. Head left Art. Head right Ref. Microphone Meas. Microphone DF Average left DF Average right | | HERE MELERITON HERE MELERITON HERE MELERITON GREATER GREATER HERE MELERITON HERE MELERITON | | |
| | | User def. el. 2 User def. ac. 2 Art. Head left Art. Head right Ref. Microphone Meas. Microphone DF Average left DF Average left FF Average left | | HER THE EXTON HER THE EXTON HER THE EXTON HER THE EXTON GRE SHK GRE SHK HER THE EXTON | | |
| | | User def. el. 2 User def. ac. 2 Art. Head left Art. Head right Ref. Microphone Meas. Microphone DF Average left OF Average right FF Average left FF Average left FF Average left | | HER THE EXTON HER THE EXTON HER THE EXTON HER THE EXTON GRE SHK HER THE EXTON HER THE EXTON | | |