# Source: HEAD acoustics GmbH

**Title: EVS – Objective Codec Evaluation - including results of codec release version 12.1.0**

## Document for: Discussion

## Agenda Item: 6

# Introduction

The new 3GPP voice and audio codec *Enhanced Voice Service* (EVS) [1] will be used in future 4G networks. In consequence, testing close to typical application scenarios is reasonable to perform already in the development phase. In this contribution the results of several experiments conducted based on measurements derived from acoustic terminal testing (TS 26.132 [4]) are shown. Different to terminal tests only the codec itself is the “device under test”. These selected tests mainly consider transfer function, idle noise, and non-linear distortions.

The measurement results presented in **clause 3** are based on the codec version i.e. the codec used for the EVS codec selection. The measurement results presented in the following sections are based on the release version of the codec.

The measurement results presented in **clause 4** are based on the release codec version 12.1.0. The measurement results presented include the fullband version which is available in the release version. It shows that the error found in the codec selection version in super-wideband 9.6 kbit/s mode is corrected. For all tests except 5.9 kbit/s bitrate DTX was deactivated.

# Evaluation Setup

The first step in the evaluation is the scaling with regard to a certain overload point. In [2] the problem of different values (3.0 vs 9.0 dBm0) was discussed. In this contribution, these two overload points for the conversion from the physical unit Volt to 16-bit scale were taken into account.

Since the overload point (OVLP) refers to a full-scale sine wave (with level Tmax = -3.01 dBov according to [3]), for the scaling between dBov and dBm0 resp. dBV, the following notation can be made:

Tmax = -3.01 dBov





Example: For an OVLP of 3.0 dBm0, the scaling between dBV and dBov is defined as:





The scaling back to the physical unit Volt was applied in the corresponding inverse way.

After scaling, the next step included the encoding and decoding of the audio data. This was conducted with the provided command line executable. The source code was not recompiled to a new binary.

For the evaluation of narrowband, wideband, and super-wideband mode, all bit rates which are available in each bandwidth mode according to Table 1 of [1] were used.

# Tests derived from 3GPP TS 26-131/-132 with the codec used for the EVS codec selection

## General

Several tests according to 3GPP TS 26-132 [4] were performed in order to evaluate the performance according to [5] of the EVS codec. This measurement standard is originally intended for acoustic testing of terminals. Since the EVS codec is regarded as the “device under test”, only electrical insertions are reasonable for testing and thus only measurements in (acoustic) receiving direction are taken into account.

In narrowband the test signal bandlimitation as defined in 3GPP TS 26-132 [4] was used. For superwideband the itu-t P.501 [6] test signals were downsampled to 32 kHz, cut-off frequency 14.4 kHz, >80 dB/oct. For fullband the original speech signals from ITU-T P.501 [6] were used.

With this approach, the EVS codec can be evaluated with typical test scenarios, which will occur in real-life applications with mobile phones.

The following graphs include multiple curves representing the different bit rates within each bandwidth mode. For the sake of clarity, the corresponding legends are not repeated in each graph, Table 1 shows the legends used in the following sections.

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|  |  |
| NB mode | WB mode |
|  |  |
| SWB mode | FB mode |

Table 1: Legends for different bit rates

## EVS-Mode: Narrowband (NB)

In narrowband mode, a sampling rate of 8 kHz and all bit rates (5.9, 7.2, 8.0, 9.6, 13.2, 16.4 and 24.4 kbit/s) according to Table 1 of [1] were used. The two possible target overload points 3.0 and 9.0 dBm0 were used by default for all analyses.

It should be noted, that even though Table 1 of [1] states that a narrowband signal can be encoded with 16.4 and 24.4 kbit/s, the provided command line executable produces a bitstream with 13.2 kbit/s. Therefore, the magenta, the blue, and the grey curves are identical in the plots of this section and the last three rows of Table 2 and Table 3 state the same values.

### Transfer Function

#### Frequency Response with real speech

The following results are produced by applying the measurement instructions according to clause 7.4.2 of [4]. To simulate also the impact of level variations, additional overload points of 21.0 and 39.0 dBm0 were also simulated. These overload points do not represent a realistic conversion, they are only used for checking the linearity of the codec and can be regarded as attenuations of 18.0 resp. 36.0 dB compared to the overload point of 3.0 dBm0.

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| Figure 1: Frequency response for different overload points | |

The results of this analysis are shown in Figure 1. For the default and extra overload points, the codec does not violate the given tolerance scheme according to [5] for all bit rates.

#### Frequency Response with composite source signal (CSS)

The following results are produced by applying the measurement instructions according to clause 7.3.2 of [4] which is intended to be reported only for informative reasons. The composite source according to ITU-T P.501 [6] signal is used as a reference for the calculation.

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| Figure 2: Frequency response for different overload points | |

The results of this analysis are shown in Figure 2. For the default overload points, the codec does not violate the given tolerance scheme for all bit rates. In contrast to the results with real speech, the frequency responses for the extra overload points, i.e., with additional attenuation of the source signal, violate the given tolerance scheme several times. Especially for low bit rates (red/green curves) the codec does not perform well.

### Idle Noise with Activation

#### Idle noise generated with activation and digital zero input

The following results are produced by applying the measurement instructions and requirements according to clause 7.3.2 of [4]. This includes an activation of the device under test with a CSS burst before the measured idle segment.

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| Figure 3: Idle noise spectrum with activation for different overload points | |

Neither in the frequency representation shown in Figure 3 nor in the absolute level values shown in Table 2, a violation of the requirements according to [5] can be observed for any narrowband bit rate.

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| --- | --- | --- |
|  | overload point [dBm0] | |
| bit rate | 3.0 | 9.0 |
| 5.9 kbit/s | -97.2 | -90.2 |
| 7.2 kbit/s | -97.9 | -87.8 |
| 8.0 kbit/s | -98.0 | -86.9 |
| 9.6 kbit/s | -106.7 | -108.2 |
| 13.2 kbit/s | -97.7 | -93.3 |
| 16.4 kbit/s | -97.7 | -93.3 |
| 24.4 kbit/s | -97.7 | -93.3 |

Table 2: Idle noise levels with activation in dB(A) (requirement: -57.0 dB(A))

#### Idle noise generated with activation and dithering noise

The original measurement described in section 3.2.2.1 was conducted with an input signal which consists only of digital zeros. In order to analyze the impact of non-zero samples, two different dithering noises were used instead as a source signal. This dithering noise was created by randomly modifying the last N bits of each 16-bit sample. By increasing N, the dithering noise power increases. In this evaluation, N = 1 and N = 2 was used.

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| Figure 4: Idle noise spectrum with activation and 1-bit dithering noise | |

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| Figure 5: Idle noise spectrum with activation and 2-bit dithering noise | |

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| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3.0 | 9.0 | 3.0 | 9.0 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 5.9 kbit/s | -97.2 | -90.2 | -85.5 | -77.2 | -76.6 | -71.9 |
| 7.2 kbit/s | -97.9 | -87.8 | -81.4 | -80.2 | -81.4 | -75.3 |
| 8.0 kbit/s | -98.0 | -86.9 | -87.6 | -79.9 | -81.1 | -74.8 |
| 9.6 kbit/s | -106.7 | -108.2 | -90.6 | -84.6 | -89.8 | -83.9 |
| 13.2 kbit/s | -97.7 | -93.3 | -86.8 | -79.0 | -80.3 | -74.0 |
| 16.4 kbit/s | -97.7 | -93.3 | -86.8 | -79.0 | -80.3 | -74.0 |
| 24.4 kbit/s | -97.7 | -93.3 | -86.8 | -79.0 | -80.3 | -74.0 |

Table 3: Idle noise levels with activation and dithering noise in dB(A)

Neither in the frequency representations shown in Figure 4 and Figure 5 nor in the absolute level values shown in Table 3, a violation of the requirements can be observed for any narrowband bit rate or overload point.

The results for the two overload points, however, show a different behavior with respect to the same dithering noise power. This is attributed to the different states of the codec depending on the overload point specific scalings of the activation sequence. Therefore, the next section describes the same measurement without activation.

### Idle Noise without Activation

The following results are produced by applying measurement instructions and requirements of section 3.2.2 but without the preceding activation sequence.

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| Figure 6: Idle noise spectrum without activation for different overload points | |

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| Figure 7: Idle noise spectrum without activation with 1-bit dithering noise | |

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| Figure 8: Idle noise spectrum without activation with 2-bit dithering noise | |

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| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3 | 9 | 3 | 9 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 5.9 kbit/s | -107.5 | -101.5 | -86.8 | -80.8 | -81.8 | -75.8 |
| 7.2 kbit/s | -108.2 | -102.7 | -87 | -80.9 | -81.8 | -75.7 |
| 8.0 kbit/s | -108.4 | -107.9 | -85.9 | -80 | -81.4 | -75.1 |
| 9.6 kbit/s | < -200.0 | < -200.0 | -92.1 | -86.1 | -87.8 | -81.8 |
| 13.2 kbit/s | -101.9 | -96.3 | -85.3 | -79.2 | -79.9 | -73.9 |
| 16.4 kbit/s | -101.9 | -96.3 | -85.3 | -79.2 | -79.9 | -73.9 |
| 24.4 kbit/s | -101.9 | -96.3 | -85.3 | -79.2 | -79.9 | -73.9 |

Table 4: Idle noise levels without activation with dithering noise in dB(A)

Again, neither in the frequency representations shown in Figure 6, Figure 7, and Figure 8 nor in the absolute level values shown in Table 4, a violation of the requirements can be observed for any wideband bit rate or overload point.

For the bit rates 9.6 kbit/s, the digital zero input is encoded to a digital zero output leading to idle noise levels lower than -200 dB(A), which are outside the plotting range in Figure 6. The other bit rates, however, generate a non-zero output even for digital zero input.

With dithering noise, the results for the two overload points are shifted by 6 dB but otherwise show the same behavior. Changing the overload point from 3 dB to 9 dB as well as enlarging the dithering noise power from 1-bit to 2-bit, both increase the idle noise spectrum by about 6 dB. This is consistent and to be expected as in both cases 1 bit of coding precision is lost.

### Distortion vs. input level

The following results are produced by applying the measurement instructions and requirements according to clause 7.8.2 of [4]. It measures the signal-to-distortion ratio for a 1020 Hz sine with different source levels. For levels -40 and -45 dBm0, the limits of 22.5 dB and 17.5 dB, respectively, are recommendations and not be regarded as a failing result.

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| Figure 9: Signal-to-distortion ratio for different input levels | |

The results of this analysis are shown in Figure 9. For all mandatory levels of -30 dBm0 and above, the codec does not violate the given tolerance scheme according to [5] for all bit rates.

### Distortion vs. frequency

The following results are produced by applying the measurement instructions and requirements according to clause 7.8.2 of [4] which are extended with source frequencies above 1 kHz. It measures the signal-to-distortion ratio for different frequencies and constant input level.

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| Figure 10: Signal-to-distortion ratio for different frequencies | |

The results of this analysis are shown in Figure 10. For all tested frequencies, the codec does not violate the given tolerance scheme according to [5] for all bit rates.

## EVS-Mode: Wideband (WB)

In wideband mode, a sampling rate of 16 kHz and all bit rates (5.9, 7.2, 8.0, 9.6, 13.2, 16.4, 24.4, 32.0, 48.0, 64.0, 96.0 and 128.0 kbit/s) according to Table 1 of [1] were used. The two possible target overload points 3.0 and 9.0 dBm0 were used by default for all analyses.

### Transfer Function

#### Frequency Response with real speech

The following results are produced by applying the measurement instructions according to clause 8.4.2 of [4]. To simulate also the impact of level variations, additional overload points of 21.0 and 39.0 dBm0 were also simulated. These overload points do not represent a realistic conversion, they are only used for checking the linearity of the codec and can be regarded as attenuations of 18.0 resp. 36.0 dB compared to the overload point 3.0 dBm0.

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| Figure 11: Frequency response for different overload points | |

The results of this analysis are shown in Figure 11. For the default and extra overload points, the codec does not violate the given tolerance scheme according to [5] for all bit rates.

#### Frequency Response with composite source signal (CSS)

The following results are produced by applying the measurement instructions similar to clause 8.3.2 of [4] which is intended to be reported only for informative reasons. The composite source according to ITU-T P.501 [6] signal is used as a reference for the calculation.

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| Figure 12: Frequency response for different overload points | |

The results of this analysis are shown in Figure 12. For the default overload points, the codec does not violate the given tolerance scheme for all bit rates. As for the narrowband mode, the frequency responses for the extra overload points, i.e., with additional attenuation of the source signal, violate the given tolerance scheme again several times. Especially for low bit rates (red/green/cyan curves) the codec does not perform well when using the CSS.

### Idle Noise with Activation

#### Idle noise generated with activation and digital zero input

The following results are produced by applying the measurement instructions and requirements according to clause 8.3.2 of [4]. This includes an activation of the device under test with a CSS burst before the measured idle segment.

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| Figure 13: Idle noise spectrum with activation for different overload points | |

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|  | overload point [dBm0] | |
| bit rate | 3.0 | 9.0 |
| 5.9 kbit/s | -92.1 | -86.4 |
| 7.2 kbit/s | -88.7 | -89.3 |
| 8.0 kbit/s | -88.9 | -89.8 |
| 9.6 kbit/s | -107.9 | -107.1 |
| 13.2 kbit/s | -94.7 | -92.1 |
| 16.4 kbit/s | -105.0 | -106.3 |
| 24.4 kbit/s | -108.7 | -108.4 |
| 32.0 kbit/s | -103.5 | -103.5 |
| 48.0 kbit/s | -112.3 | -111.1 |
| 64.0 kbit/s | -102.3 | -105.5 |
| 96.0 kbit/s | -111.4 | -112.9 |
| 128.0 kbit/s | -111.5 | -113.9 |

Table 5: Idle noise levels with activation in dB(A) (requirement: -57.0 dB(A))

Neither in the frequency representation shown in Figure 13 nor in the absolute level values shown in Table 5, a violation of the requirements according to [5] can be observed for any wideband bit rate.

#### Idle noise generated with activation and dithering noise

The original measurement described in section 3.3.2.1 was conducted with an input signal which consists only of digital zeros. In order to analyze the impact of non-zero samples, two different dithering noises were used instead as a source signal. This dithering noise was created by randomly modifying the last N bits of each 16-bit sample. By increasing N, the dithering noise power increases. In this evaluation, N = 1 and N = 2 was used.

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| Figure 14: Idle noise spectrum with activation and 1-bit dithering noise | |

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| Figure 15: Idle noise spectrum with activation and 2-bit dithering noise | |

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| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3.0 | 9.0 | 3.0 | 9.0 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 5.9 kbit/s | -92.1 | -86.4 | -85.5 | -80.0 | -80.1 | -74.4 |
| 7.2 kbit/s | -88.7 | -89.3 | -86.1 | -80.7 | -81.0 | -75.7 |
| 8.0 kbit/s | -88.9 | -89.8 | -86.2 | -78.7 | -79.4 | -74.1 |
| 9.6 kbit/s | -107.9 | -107.1 | -90.5 | -84.7 | -84.5 | -78.6 |
| 13.2 kbit/s | -94.7 | -92.1 | -88.6 | -83.0 | -81.5 | -75.5 |
| 16.4 kbit/s | -105.0 | -106.3 | -89.8 | -83.9 | -82.7 | -76.7 |
| 24.4 kbit/s | -108.7 | -108.4 | -84.4 | -83.8 | -82.0 | -75.8 |
| 32.0 kbit/s | -103.5 | -103.5 | -89.1 | -82.7 | -81.4 | -75.4 |
| 48.0 kbit/s | -112.3 | -111.1 | -87.9 | -81.9 | -80.6 | -74.7 |
| 64.0 kbit/s | -102.3 | -105.5 | -88.0 | -81.6 | -80.8 | -74.9 |
| 96.0 kbit/s | -111.4 | -112.9 | -88.2 | -82.3 | -80.9 | -74.9 |
| 128.0 kbit/s | -111.5 | -113.9 | -88.3 | -82.3 | -80.9 | -74.9 |

Table 6: Idle noise levels with activation and dithering noise in dB(A)

Neither in the frequency representations shown in Figure 14 and Figure 15 nor in the absolute level values shown in Table 6, a violation of the requirements can be observed for any wideband bit rate or overload point.

The results for the two overload points, however, show a different behavior with respect to the same dithering noise power, especially at bit rate 24.4 kbit/s. The codec produces a higher amount of low frequency noise after the activation signal compared to other bitrates. Probably this can be attributed to the different states of the codec depending on the overload point specific scaling of the activation sequence. The low frequency noise disappears shortly after the activation. Therefore, the next section describes the same measurement without activation.

### Idle Noise without Activation

The following results are produced by applying measurement instructions and requirements of section 3.3.2 but without the preceding activation sequence.

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| Figure 16: Idle noise spectrum without activation for different overload points | |

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| Figure 17: Idle noise spectrum without activation with 1-bit dithering noise | |

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| Figure 18: Idle noise spectrum without activation with 2-bit dithering noise | |

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| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3.0 | 9.0 | 3 | 9 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 5.9 kbit/s | -101.6 | -95.6 | -87.7 | -81.7 | -76.5 | -70.5 |
| 7.2 kbit/s | -102.6 | -96.6 | -82.6 | -76.6 | -78.3 | -72.3 |
| 8.0 kbit/s | -100.9 | -94.9 | -82.2 | -76.2 | -77.9 | -71.9 |
| 9.6 kbit/s | < -200.0 | < -200.0 | -90.2 | -84.2 | -83.9 | -77.9 |
| 13.2 kbit/s | -96.4 | -90.4 | -86.0 | -80.0 | -79.2 | -73.2 |
| 16.4 kbit/s | < -200.0 | < -200.0 | -90.2 | -84.2 | -82.8 | -76.8 |
| 24.4 kbit/s | < -200.0 | < -200.0 | -89.6 | -83.6 | -82.1 | -76.1 |
| 32.0 kbit/s | -122.4 | -116.4 | -88.6 | -82.6 | -82.5 | -76.5 |
| 48.0 kbit/s | < -200.0 | < -200.0 | -88.0 | -82.0 | -80.5 | -74.5 |
| 64.0 kbit/s | < -200.0 | < -200.0 | -87.8 | -81.8 | -82.3 | -76.3 |
| 96.0 kbit/s | < -200.0 | < -200.0 | -88.3 | -82.3 | -80.6 | -74.6 |
| 128.0 kbit/s | < -200.0 | < -200.0 | -88.3 | -82.3 | -80.6 | -74.6 |

Table 7: Idle noise levels without activation with dithering noise in dB(A)

Again, neither in the spectral analysis of the noise floor shown in Figure 16, Figure 17, and Figure 18 nor in the absolute level values shown in Table 7, a violation of the requirements can be observed for any wideband bit rate or overload point.

For the bit rates 9.6, 16.4, 24.4, 48.0, 64.0, 96.0, and 128.0 kbit/s, the digital zero input is encoded to a digital zero output leading to idle noise levels lower than -200 dB(A), which are outside the plotting range in Figure 16. The other bit rates 5.9, 7.2, 8.0, 13.2, and 32.0 kbit/s, however, generate a non-zero output even for digital zero input.

With dithering noise, the results for the two overload points are shifted by 6 dB but otherwise show the same behavior.

### Distortion vs. input level

The following results are produced by applying the measurement instructions and requirements according to clause 8.8.2 of [4]. The signal-to-distortion ratio is measured for a 1020 Hz sine with different source levels. For levels -40 and -45 dBm0, the limits of 22.5 dB and 17.5 dB, respectively, are recommendations and not be regarded as a failing result.

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| Figure 19: Signal-to-distortion ratio for different input levels | |

The results of this analysis are shown in Figure 19. It can be observed that for lower bit rates (red/green/cyan/yellow curves) the signal-to-distortion ratio violates the tolerance scheme according to [5] at some gain points. All other bit rates pass the test. Note, that the apparently strong variances of distortion curves are mainly caused by the sinusoidal source signal which is used here. For these bit rates, sine signals are not well encoded/decoded. Distortion measurements with real speech or at least speech-like signals might lead to more uniform results.

### Distortion vs. frequency

The following results are produced by applying the measurement instructions and requirements according to clause 8.8.2 of [4] which are extended with source frequencies above 1 kHz. The signal-to-distortion ratio for different frequencies and constant input level is measured.

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| Figure 20: Signal-to-distortion ratio for different frequencies | |

The results of this analysis are shown in Figure 20. Again, the signal-to-distortion ratio violates the tolerance scheme according to [5] at lower bit rates (red/green/cyan curves) for the same reason as above. All other bit rates pass the test.

## EVS-Mode: Super-Wideband (SWB)

In super-wideband mode, a sampling rate of 32 kHz and all bit rates (9.6, 13.2, 16.4, 24.4, 32.0, 48.0, 64.0, 96.0 and 128.0 kbit/s) according to Table 1 of [1] were used. The two possible target overload points 3.0 and 9.0 dBm0 were used by default for all analyses.

It should be noted, that even though Table 1 of [1] states that a signal can be encoded in super-wideband mode with 9.6 kbit/s, the provided command line executable encodes effectively only the wideband bandwidth up to 8 kHz. Therefore, the green curve violates the tolerance schema in Figure 21, Figure 22, and Figure 30.

### Transfer Function

#### Frequency Response with real speech

The following results are produced by applying measurement instructions similar to clause 8.4.2 of [4] which are adapted to super-wideband by replacing the source signal with a fullband version of the same file and extending the tolerance schema to 14 kHz. To simulate also the impact of level variations, additional overload points of 21.0 and 39.0 dBm0 were also simulated. These overload points do not represent a realistic conversion; they are only used for checking the linearity of the codec and can be regarded as attenuations of 18.0 resp. 36.0 dB compared to the overload point 3.0 dBm0.

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| Figure 21: Frequency response for different overload points | |

The results of this analysis are shown in Figure 21. For the default and extra overload points, the codec does not violate the given tolerance scheme according to [5] for all bit rates but 9.6 kbit/s as explained above.

#### Frequency Response with composite source signal (CSS)

The following results are produced by applying the measurement instructions similar to clause 8.3.2 of [4] which is intended to be reported only for informative reasons. The composite source according to ITU-T P.501 [6] signal is used as a reference for the calculation.

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| Figure 22: Frequency response for different overload points | |

The results of this analysis are shown in Figure 22. For the default overload points, the codec does not violate the given tolerance scheme for all bit rates but 9.6 kbit/s as explained above. As for the narrowband mode, the frequency responses for the extra overload points, i.e., with additional attenuation of the source signal, violate the given tolerance scheme again several times. Especially for low bit rates (red/green curves) the codec does not perform well.

### Idle Noise with Activation

#### Idle noise generated with activation and digital zero input

The following results are produced by applying measurement instructions and requirements similar to clause 8.3.2 of [4] which are adapted to super-wideband by replacing the source signal with a fullband version of the same file. This includes an activation of the device under test with a CSS burst before the measured idle segment.

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| Figure 23: Idle noise spectrum with activation for different overload points | |

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| --- | --- | --- |
|  | overload point [dBm0] | |
| bit rate | 3.0 | 9.0 |
| 9.6 kbit/s | -106.1 | -108.2 |
| 13.2 kbit/s | -92.1 | -91.6 |
| 16.4 kbit/s | -106.0 | -105.6 |
| 24.4 kbit/s | -109.5 | -108.1 |
| 32.0 kbit/s | -94.6 | -91.3 |
| 48.0 kbit/s | -111.6 | -109.8 |
| 64.0 kbit/s | -107.8 | -106.6 |
| 96.0 kbit/s | -110.3 | -111.8 |
| 128.0 kbit/s | -110.8 | -114.7 |

Table 8: Idle noise levels with activation in dB(A) (requirement: -57.0 dB(A))

Neither in the frequency representation shown in Figure 23 nor in the absolute level values shown in Table 8, a violation of the requirements according to [5] can be observed for any super-wideband bit rate.

#### Idle noise generated with activation and dithering noise

The original measurement described in section 3.4.2.1 was conducted with an input signal which consists only of digital zeros. In order to analyze the impact of non-zero samples, two different dithering noises were used instead as a source signal. This dithering noise was created by randomly modifying the last N bits of each 16-bit sample. By increasing N, the dithering noise power increases. In this evaluation, N = 1 and N = 2 was used.

|  |  |
| --- | --- |
|  |  |
| Figure 24: Idle noise spectrum with activation and 1-bit dithering noise | |

|  |  |
| --- | --- |
|  |  |
| Figure 25: Idle noise spectrum with activation and 2-bit dithering noise | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3.0 | 9.0 | 3.0 | 9.0 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 9.6 kbit/s | -106.1 | -108.2 | -93.2 | -87.4 | -87.5 | -81.4 |
| 13.2 kbit/s | -92.1 | -91.6 | -89.9 | -84.3 | -83.6 | -77.8 |
| 16.4 kbit/s | -106.0 | -105.6 | -90.2 | -84.6 | -83.2 | -77.3 |
| 24.4 kbit/s | -109.5 | -108.1 | -78.8 | -84.4 | -82.7 | -76.8 |
| 32.0 kbit/s | -94.6 | -91.3 | -89.7 | -84.9 | -82.9 | -76.9 |
| 48.0 kbit/s | -111.6 | -109.8 | -80.4 | -83.8 | -82.3 | -76.3 |
| 64.0 kbit/s | -107.8 | -106.6 | -90.0 | -84.1 | -82.8 | -76.4 |
| 96.0 kbit/s | -110.3 | -111.8 | -90.3 | -84.3 | -82.5 | -76.5 |
| 128.0 kbit/s | -110.8 | -114.7 | -90.3 | -84.3 | -82.5 | -76.5 |

Table 9: Idle noise levels with activation and dithering noise in dB(A)

Neither in the frequency representations shown in Figure 24 and Figure 25 nor in the absolute level values shown in Table 9, a violation of the requirements can be observed for any super-wideband bit rate or overload point.

The results for the two overload points, however, show a different behavior with respect to the same dithering noise power, especially at bit rates 24.4 and 48.0 kbit/s. This is attributed to the different states of the codec depending on the overload point specific scalings of the activation sequence. Therefore, the next section describes the same measurement without activation.

### Idle Noise without Activation

The following results are produced by applying measurement instructions and requirements of section 3.4.2 but without the preceding activation sequence.

|  |  |
| --- | --- |
|  |  |
| Figure 26: Idle noise spectrum without activation for different overload points | |

|  |  |
| --- | --- |
|  |  |
| Figure 27: Idle noise spectrum without activation with 1-bit dithering noise | |

|  |  |
| --- | --- |
|  |  |
| Figure 28: Idle noise spectrum without activation with 2-bit dithering noise | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3.0 | 9.0 | 3.0 | 9.0 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 9.6 kbit/s | < -200.0 | < -200.0 | -92.9 | -86.9 | -88.2 | -82.2 |
| 13.2 kbit/s | -92.9 | -86.9 | -89.6 | -83.6 | -82.5 | -76.5 |
| 16.4 kbit/s | < -200.0 | < -200.0 | -90.6 | -84.6 | -83.6 | -77.6 |
| 24.4 kbit/s | < -200.0 | < -200.0 | -90.4 | -84.4 | -82.9 | -76.9 |
| 32.0 kbit/s | -95.0 | -89.0 | -91.3 | -85.3 | -83.5 | -77.5 |
| 48.0 kbit/s | < -200.0 | < -200.0 | -89.9 | -83.9 | -82.4 | -76.4 |
| 64.0 kbit/s | < -200.0 | < -200.0 | -90.1 | -84.1 | -83.1 | -77.1 |
| 96.0 kbit/s | < -200.0 | < -200.0 | -90.2 | -84.2 | -82.3 | -76.3 |
| 128.0 kbit/s | < -200.0 | < -200.0 | -90.2 | -84.2 | -82.6 | -76.6 |

Table 10: Idle noise levels without activation with dithering noise in dB(A)

Again, neither in the frequency representations shown in Figure 26, Figure 27, and Figure 28 nor in the absolute level values shown in Table 10, a violation of the requirements can be observed for any super-wideband bit rate or overload point.

For all bit rates but 13.2 and 32.0 kbit/s, the digital zero input is encoded to a digital zero output leading to idle noise levels lower than -200 dB(A), which are outside the plotting range in Figure 26. These two bit rates, however, generate a non-zero output even for digital zero input.

With dithering noise, the results for the two overload points are shifted by 6 dB but otherwise show the same behavior.

### Distortion vs. input level

The following results are produced by applying the measurement instructions and requirements according to clause 8.8.2 of [4], which are adapted to super-wideband by evaluating the distortion up to 14 kHz. It measures the signal-to-distortion ratio for a 1020 Hz sine with different source levels. For levels -40 and -45 dBm0, the limits of 22.5 dB and 17.5 dB, respectively, are recommendations and not be regarded as a failing result.

|  |  |
| --- | --- |
|  |  |
| Figure 29: Signal-to-distortion ratio for different input levels | |

The results of this analysis are shown in Figure 29. At low bit rates (red/green curves), the signal-to-distortion ratio violates the tolerance according to [5] scheme at gain as low as -30dB. All other bit rates pass the test.

### Distortion vs. frequency

The following results are produced by applying the measurement instructions and requirements according to clause 8.8.2 of [4] which are extended with source frequencies above 1 kHz and adapted to super-wideband by evaluating the distortion up to 14 kHz. It measures the signal-to-distortion ratio for different frequencies and constant input level.

|  |  |
| --- | --- |
|  |  |
| Figure 30: Signal-to-distortion ratio for different frequencies | |

The results of this analysis are shown in Figure 30. For all tested frequencies, the codec does not violate the given tolerance scheme according to [5] for all bit rates but 9.6 kbit/s. At 9.6 kbit/s, the codec fails for the test frequency of about 13 kHz, which is not encoded at this bit rate as explained above

# Tests derived from 3GPP TS 26.131 and TS 26.132 with EVS v12.1.0 [7]

## EVS-Mode: Narrowband (NB)

### General

In narrowband mode, a sampling rate of 8 kHz and all bit rates (5.9, 7.2, 8.0, 9.6, 13.2, 16.4 and 24.4 kbit/s) according to Table 1 of [1] were used. The two possible target overload points 3.0 and 9.0 dBm0 were used by default for all analyses.

### Frequency response with real speech

The following results are produced by applying the measurement instructions according to clause 7.4.2 of [4]. To simulate also the impact of level variations, additional overload points of 21.0 and 39.0 dBm0 were also simulated. These overload points do not represent a realistic conversion, they are only used for checking the linearity of the codec and can be regarded as attenuations of 18.0 resp. 36.0 dB compared to the overload point of 3.0 dBm0.

|  |  |
| --- | --- |
|  |  |
|  |  |
| Figure 31: Frequency response for different overload points | |

The results of this analysis are shown in Figure 1. For the default and extra overload points, the codec does not violate the given tolerance scheme according to [5] for all bit rates.

The results when using 1/3rd octave instead of 1/12th octave analysis are in Figure 32.

|  |  |
| --- | --- |
|  |  |
|  |  |
| Figure 32: Frequency response EVS NB in 1/3rd Oct. for different overload points with P.501 speech signals | |

### Frequency response with composite source signal (CSS)

The following results are produced by applying the measurement instructions according to clause 7.3.2 of [4] which is intended to be reported only for informative reasons. The composite source according to ITU-T P.501 [6] signal is used as a reference for the calculation.

|  |  |
| --- | --- |
|  |  |
|  |  |
| Figure 33: Frequency response for different overload points | |

The results of this analysis are shown in Figure 33. For none of the overload points, the codec violates the given tolerance scheme. This applies for all bit rates Idle noise generated with activation and digital zero input

The following results are produced by applying the measurement instructions and requirements according to clause 7.3.2 of [4]. This includes an activation of the device under test with a CSS burst before the measured idle segment.

|  |  |
| --- | --- |
|  |  |
| Figure 34: Idle noise spectrum with activation for different overload points | |

Neither in the frequency representation shown in Figure 34 nor in the absolute level values shown in Table 11, a violation of the requirements according to [5] can be observed for any narrowband bit rate.

|  |  |  |
| --- | --- | --- |
|  | overload point [dBm0] | |
| bit rate | 3.0 | 9.0 |
| 5.9 kbit/s | -93.3 | -89.9 |
| 7.2 kbit/s | -100.9 | -97.3 |
| 8.0 kbit/s | -100.1 | -94.7 |
| 9.6 kbit/s | -92.0 | -108.5 |
| 13.2 kbit/s | -99.2 | -94.0 |
| 16.4 kbit/s | -91.7 | -107.2 |
| 24.4 kbit/s | -91.6 | -109.8 |

Table 11: Idle noise levels with activation in dB(A) (requirement: -57.0 dB(A))

### Idle noise generated with activation and dithering noise

The original measurement described in section 3.2.2.1 was conducted with an input signal which consists only of digital zeros. In order to analyze the impact of non-zero samples, two different dithering noises were used instead as a source signal. This dithering noise was created by randomly modifying the last N bits of each 16-bit sample. By increasing N, the dithering noise power increases. In this evaluation, N = 1 and N = 2 was used.

|  |  |
| --- | --- |
|  |  |
| Figure 35: Idle noise spectrum with activation and 1-bit dithering noise | |

|  |  |
| --- | --- |
|  |  |
| Figure 36: Idle noise spectrum with activation and 2-bit dithering noise | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3.0 | 9.0 | 3.0 | 9.0 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 5.9 kbit/s | -93.3 | -89.9 | -85.0 | -79.1 | -79.6 | -73.3 |
| 7.2 kbit/s | -100.9 | -97.3 | -79.5 | -80.6 | -81.4 | -75.6 |
| 8.0 kbit/s | -100.1 | -94.7 | -86.7 | -79.9 | -81.1 | -75.1 |
| 9.6 kbit/s | -92.0 | -108.5 | -90.3 | -85.9 | -88.9 | -82.9 |
| 13.2 kbit/s | -99.2 | -94.0 | -85.9 | -79.0 | -80.1 | -74.2 |
| 16.4 kbit/s | -91.7 | -107.2 | -89.3 | -83.3 | -82.2 | -76.1 |
| 24.4 kbit/s | -91.6 | -109.8 | -88.7 | -82.6 | -81.2 | -75.2 |

Table 12: Idle noise levels with activation and dithering noise in dB(A)

Neither in the frequency representations shown in Figure 35 and Figure 36 nor in the absolute level values shown in Table 12, a violation of the requirements can be observed for any narrowband bit rate or overload point.

The results for the two overload points, however, show a slightly different behavior with respect to the same dithering noise power. This is attributed to the different states of the codec depending on the overload point specific scalings of the activation sequence.

### Idle Noise without Activation

The following results are produced by applying measurement without the preceding activation sequence.

|  |  |
| --- | --- |
|  |  |
| Figure 37: Idle noise spectrum without activation for different overload points | |

|  |  |
| --- | --- |
|  |  |
| Figure 38: Idle noise spectrum without activation with 1-bit dithering noise | |

|  |  |
| --- | --- |
|  |  |
| Figure 39: Idle noise spectrum without activation with 2-bit dithering noise | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3 | 9 | 3 | 9 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 5.9 kbit/s | -94.8 | -88.8 | -84.1 | -78.1 | -78.5 | -72.6 |
| 7.2 kbit/s | -110.2 | -102.7 | -86.9 | -80.9 | -81.6 | -75.7 |
| 8.0 kbit/s | -108.9 | -107.9 | -86.0 | -80.0 | -81.3 | -75.3 |
| 9.6 kbit/s | -205.8 | -205.8 | -92.5 | -86.5 | -88.1 | -82.1 |
| 13.2 kbit/s | -102.4 | -95.7 | -85.2 | -79.4 | -80.2 | -74.1 |
| 16.4 kbit/s | -205.8 | -205.8 | -89.2 | -83.2 | -82.0 | -76.0 |
| 24.4 kbit/s | -205.8 | -205.8 | -88.2 | -82.2 | -81.2 | -75.2 |

Table 13: Idle noise levels without activation with dithering noise in dB(A)

Again, neither in the frequency representations shown in Figure 37, Figure 38, and Figure 39 nor in the absolute level values shown in Table 13, a violation of the requirements can be observed for any wideband bit rate or overload point.

For the bit rates 9.6 kbit/s, the digital zero input is encoded to a digital zero output leading to idle noise levels lower than -200 dB(A), which are outside the plotting range in Figure 37. The other bit rates, however, generate a non-zero output even for digital zero input.

With dithering noise, the results for the two overload points are shifted by 6 dB but otherwise show the same behavior. Changing the overload point from 3 dB to 9 dB as well as enlarging the dithering noise power from 1-bit to 2-bit, both increase the idle noise spectrum by about 6 dB. This is consistent and to be expected as in both cases 1 bit of coding precision is lost.

### Distortion vs. input level

The following results are produced by applying the measurement instructions and requirements according to clause 7.8.2 of [4]. It measures the signal-to-distortion ratio for a 1020 Hz sine with different source levels. For levels -40 and -45 dBm0, the limits of 22.5 dB and 17.5 dB, respectively, are recommendations and not be regarded as a failing result.

|  |  |
| --- | --- |
|  |  |
| Figure 40: Signal-to-distortion ratio for different input levels | |

The results of this analysis are shown in Figure 40. For all mandatory levels of -30 dBm0 and above, the codec does not violate the given tolerance scheme according to [5] for all bit rates.

### Distortion vs. frequency

The following results are produced by applying the measurement instructions and requirements according to clause 7.8.2 of [4] which are extended with source frequencies above 1 kHz. It measures the signal-to-distortion ratio for different frequencies and constant input level.

|  |  |
| --- | --- |
|  |  |
| Figure 41: Signal-to-distortion ratio for different frequencies | |

The results of this analysis are shown in Figure 41. For all tested frequencies, the codec does not violate the given tolerance scheme according to [5] for all bit rates.

## EVS-Mode: Wideband (WB)

### General

In wideband mode, a sampling rate of 16 kHz and all bit rates (5.9, 7.2, 8.0, 9.6, 13.2, 16.4, 24.4, 32.0, 48.0, 64.0, 96.0 and 128.0 kbit/s) according to Table 1 of [1] were used. The two possible target overload points 3.0 and 9.0 dBm0 were used by default for all analyses.

### Frequency response with real speech

The following results are produced by applying the measurement instructions according to clause 8.4.2 of [4]. To simulate also the impact of level variations, additional overload points of 21.0 and 39.0 dBm0 were also simulated. These overload points do not represent a realistic conversion, they are only used for checking the linearity of the codec and can be regarded as attenuations of 18.0 resp. 36.0 dB compared to the overload point 3.0 dBm0.

|  |  |
| --- | --- |
|  |  |
|  |  |
| Figure 42: Frequency response for different overload points | |

The results of this analysis are shown in Figure 42. For the default and extra overload points, the codec does not violate the given tolerance scheme according to [5] for all bit rates.

Instead of 1/12th octave analysis was used. The results using 1/3rd octave analysis are shown in Figure 43.

|  |  |
| --- | --- |
|  |  |
|  |  |
| Figure 43: Frequency response EVS WB in 1/3rd Oct. for different overload points with P.501 speech signals | |

### Frequency response with composite source signal (CSS)

The following results are produced by applying the measurement instructions similar to clause 8.3.2 of [4] which is intended to be reported only for informative reasons. The composite source according to ITU-T P.501 [6] signal is used as a reference for the calculation.

|  |  |
| --- | --- |
|  |  |
|  |  |
| Figure 44: Frequency response for different overload points | |

The results of this analysis are shown in Figure 44. For none of the overload points, the codec violates the given tolerance scheme. This is valid for all bit rates..

### Idle noise generated with activation and digital zero input

The following results are produced by applying the measurement instructions and requirements according to clause 8.3.2 of [4]. This includes an activation of the device under test with a CSS burst before the measured idle segment.

|  |  |
| --- | --- |
|  |  |
| Figure 45: Idle noise spectrum with activation for different overload points | |

|  |  |  |
| --- | --- | --- |
|  | overload point [dBm0] | |
| bit rate | 3.0 | 9.0 |
| 5.9 kbit/s | -205.8 | -205.8 |
| 7.2 kbit/s | -91.6 | -88.4 |
| 8.0 kbit/s | -92.4 | -87.5 |
| 9.6 kbit/s | -108.1 | -107.2 |
| 13.2 kbit/s | -95.2 | -91.7 |
| 16.4 kbit/s | -105.5 | -106.9 |
| 24.4 kbit/s | -109.2 | -109.1 |
| 32.0 kbit/s | -107.3 | -105.3 |
| 48.0 kbit/s | -113.2 | -111.4 |
| 64.0 kbit/s | -101.8 | -107.8 |
| 96.0 kbit/s | -111.9 | -113.0 |
| 128.0 kbit/s | -111.9 | -114.5 |

Table 14: Idle noise levels with activation in dB(A) (requirement: -57.0 dB(A))

Neither in the frequency representation shown in Figure 44 nor in the absolute level values shown in Table 14, a violation of the requirements according to [5] can be observed for any wideband bit rate.

### Idle noise generated with activation and dithering noise

The original measurement was conducted with an input signal which consists only of digital zeros. In order to analyze the impact of non-zero samples, two different dithering noises were used instead as a source signal. This dithering noise was created by randomly modifying the last N bits of each 16-bit sample. By increasing N, the dithering noise power increases. In this evaluation, N = 1 and N = 2 was used.

|  |  |
| --- | --- |
|  |  |
| Figure 46: Idle noise spectrum with activation and 1-bit dithering noise | |

|  |  |
| --- | --- |
|  |  |
| Figure 47: Idle noise spectrum with activation and 2-bit dithering noise | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3.0 | 9.0 | 3.0 | 9.0 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 5.9 kbit/s | -205.8 | -205.8 | -205.8 | -205.8 | -205.8 | -205.8 |
| 7.2 kbit/s | -91.6 | -88.4 | -84.5 | -79.2 | -80.1 | -74.4 |
| 8.0 kbit/s | -92.4 | -87.5 | -84.4 | -79.0 | -78.6 | -72.9 |
| 9.6 kbit/s | -108.1 | -107.2 | -90.5 | -84.5 | -84.3 | -78.3 |
| 13.2 kbit/s | -95.2 | -91.7 | -87.3 | -81.4 | -80.6 | -74.8 |
| 16.4 kbit/s | -105.5 | -106.9 | -89.9 | -84.0 | -82.9 | -76.8 |
| 24.4 kbit/s | -109.2 | -109.1 | -84.4 | -83.7 | -82.1 | -76.0 |
| 32.0 kbit/s | -107.3 | -105.3 | -88.2 | -82.3 | -81.2 | -75.2 |
| 48.0 kbit/s | -113.2 | -111.4 | -87.9 | -81.9 | -80.7 | -74.7 |
| 64.0 kbit/s | -101.8 | -107.8 | -87.2 | -81.1 | -80.5 | -74.5 |
| 96.0 kbit/s | -111.9 | -113.0 | -88.2 | -82.2 | -80.9 | -74.9 |
| 128.0 kbit/s | -111.9 | -114.5 | -88.2 | -82.2 | -80.9 | -74.9 |

Table 15: Idle noise levels with activation and dithering noise in dB(A)

Neither in the frequency representations shown in Figure 46 and Figure 47 nor in the absolute level values shown in Table 15, a violation of the requirements can be observed for any wideband bit rate or overload point.

The results for the two overload points, however, show a different behavior with respect to the same dithering noise power, especially at the bit rate 24.4 kbit/s. The codec produces a higher amount of low frequency noise after the activation signal compared to other bitrates. Probably this can be attributed to the different states of the codec depending on the overload point specific scaling of the activation sequence. The low frequency noise disappears shortly after the activation. Therefore, the next section describes the same measurement without activation.

### Idle Noise without Activation

The following results are produced by applying measurement instructions and requirements without the preceding activation sequence.

|  |  |
| --- | --- |
|  |  |
| Figure 48: Idle noise spectrum without activation for different overload points | |

|  |  |
| --- | --- |
|  |  |
| Figure 49: Idle noise spectrum without activation with 1-bit dithering noise | |

|  |  |
| --- | --- |
|  |  |
| Figure 50: Idle noise spectrum without activation with 2-bit dithering noise | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3.0 | 9.0 | 3 | 9 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 5.9 kbit/s | -205.8 | -205.8 | -205.8 | -205.8 | -205.8 | -205.8 |
| 7.2 kbit/s | -100.1 | -94.1 | -82.2 | -76.2 | -79.0 | -73.0 |
| 8.0 kbit/s | -98.4 | -92.4 | -82.2 | -76.2 | -78.2 | -72.2 |
| 9.6 kbit/s | -205.8 | -205.8 | -90.0 | -84.0 | -84.1 | -78.1 |
| 13.2 kbit/s | -96.4 | -90.4 | -85.9 | -79.9 | -79.5 | -73.5 |
| 16.4 kbit/s | -205.8 | -205.8 | -90.2 | -84.2 | -82.8 | -76.8 |
| 24.4 kbit/s | -205.8 | -205.8 | -89.6 | -83.6 | -82.1 | -76.1 |
| 32.0 kbit/s | -205.8 | -205.8 | -87.3 | -81.3 | -81.1 | -75.1 |
| 48.0 kbit/s | -205.8 | -205.8 | -88.0 | -82.0 | -80.5 | -74.5 |
| 64.0 kbit/s | -205.8 | -205.8 | -86.9 | -80.9 | -80.2 | -74.2 |
| 96.0 kbit/s | -205.8 | -205.8 | -88.3 | -82.3 | -80.6 | -74.6 |
| 128.0 kbit/s | -205.8 | -205.8 | -88.3 | -82.3 | -80.6 | -74.6 |

Table 16: Idle noise levels without activation with dithering noise in dB(A)

Again, neither in the spectral analysis of the noise floor shown in Figure 48, Figure 49, and Figure 50 nor in the absolute level values shown in Table 16, a violation of the requirements can be observed for any wideband bit rate or overload point.

For the bit rates 9.6, 16.4, 24.4, 48.0, 64.0, 96.0, and 128.0 kbit/s, the digital zero input is encoded to a digital zero output leading to idle noise levels lower than -200 dB(A), which are outside the plotting range in Figure 48. The other bit rates 5.9, 7.2, 8.0, 13.2, and 32.0 kbit/s, however, generate a non-zero output even for digital zero input.

With dithering noise, the results for the two overload points are shifted by 6 dB but otherwise show the same behavior.

### Distortion vs. input level

The following results are produced by applying the measurement instructions and requirements according to clause 8.8.2 of [4]. The signal-to-distortion ratio is measured for a 1020 Hz sine with different source levels. For levels -40 and -45 dBm0, the limits of 22.5 dB and 17.5 dB, respectively, are recommendations and not be regarded as a failing result.

|  |  |
| --- | --- |
|  |  |
| Figure 51: Signal-to-distortion ratio for different input levels | |

The results of this analysis are shown in Figure 51. It can be observed that for lower bit rates (red/gree curves) the signal-to-distortion ratio slightly violates the tolerance scheme according to [5] at some gain points when choosing the overload point to 3.0 dBm0. All other bit rates pass the test..

### Distortion vs. frequency

The following results are produced by applying the measurement instructions and requirements according to clause 8.8.2 of [4] which are extended with source frequencies above 1 kHz. The signal-to-distortion ratio for different frequencies and constant input level is measured.

|  |  |
| --- | --- |
|  |  |
| Figure 52: Signal-to-distortion ratio for different frequencies | |

The results of this analysis are shown in Figure 52. Again, the signal-to-distortion ratio violates the tolerance scheme according to [5] at lower bit rates (red/green/cyan curves) for the same reason as above. All other bit rates pass the test.

## EVS-Mode: Super-Wideband (SWB)

### General

In super-wideband mode, a sampling rate of 32 kHz and all bit rates (9.6, 13.2, 16.4, 24.4, 32.0, 48.0, 64.0, 96.0 and 128.0 kbit/s) according to Table 1 of [1] were used. The two possible target overload points 3.0 and 9.0 dBm0 were used by default for all analyses.

### Frequency response with real speech

The following results are produced by applying measurement instructions similar to clause 8.4.2 of [4] which are adapted to super-wideband by replacing the source signal with a fullband version of the same file. To simulate also the impact of level variations, additional overload points of 21.0 and 39.0 dBm0 were also simulated. These overload points do not represent a realistic conversion; they are only used for checking the linearity of the codec and can be regarded as attenuations of 18.0 resp. 36.0 dB compared to the overload point 3.0 dBm0.

|  |  |
| --- | --- |
|  |  |
|  |  |
| Figure 53: Frequency response for different overload points | |

The results of this analysis are shown in Figure 53. For the default and extra overload points, the codec provides an accurate transmission behavior for all bit rates.

The results for the 1/3rd octave analysis are shown in Figure 54.

|  |  |
| --- | --- |
|  |  |
|  |  |
| Figure 54: Frequency response EVS SWB in 1/3rd Oct. for different overload points with P.501 speech signals | |

### Frequency response with composite source signal (CSS)

The following results are produced by applying the measurement instructions similar to clause 8.3.2 of [4] which is intended to be reported only for informative reasons. The composite source according to ITU-T P.501 [6] signal is used as a reference for the calculation.

|  |  |
| --- | --- |
|  |  |
|  |  |
| Figure 55: Frequency response for different overload points | |

The results of this analysis are shown in Figure 55. For the default overload points, the codec provides an accurate transmission behavior for all bit rates.

### Idle noise generated with activation and digital zero input

The following results are produced by applying measurement instructions and requirements similar to clause 8.3.2 of [4] which are adapted to super-wideband by replacing the source signal with a fullband version of the same file. This includes an activation of the device under test with a CSS burst before the measured idle segment.

|  |  |
| --- | --- |
|  |  |
| Figure 56: Idle noise spectrum with activation for different overload points | |

|  |  |  |
| --- | --- | --- |
|  | overload point [dBm0] | |
| bit rate | 3.0 | 9.0 |
| 9.6 kbit/s | -97.8 | -107.7 |
| 13.2 kbit/s | -92.2 | -91.3 |
| 16.4 kbit/s | -106.1 | -106.1 |
| 24.4 kbit/s | -111.7 | -108.9 |
| 32.0 kbit/s | -82.3 | -90.9 |
| 48.0 kbit/s | -112.4 | -110.1 |
| 64.0 kbit/s | -108.0 | -111.7 |
| 96.0 kbit/s | -110.6 | -112.2 |
| 128.0 kbit/s | -111.2 | -115.7 |

Table 17: Idle noise levels with activation in dB(A) (requirement: -57.0 dB(A))

Neither in the frequency representation shown in Figure 56 nor in the absolute level values shown in Table 17, a violation of the requirements according to [5] can be observed for any super-wideband bit rate.

### Idle noise generated with activation and dithering noise

The original measurement was conducted with an input signal which consists only of digital zeros. In order to analyze the impact of non-zero samples, two different dithering noises were used instead as a source signal. This dithering noise was created by randomly modifying the last N bits of each 16-bit sample. By increasing N, the dithering noise power increases. In this evaluation, N = 1 and N = 2 was used.

|  |  |
| --- | --- |
|  |  |
| Figure 57: Idle noise spectrum with activation and 1-bit dithering noise | |

|  |  |
| --- | --- |
|  |  |
| Figure 58: Idle noise spectrum with activation and 2-bit dithering noise | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3.0 | 9.0 | 3.0 | 9.0 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 9.6 kbit/s | -97.8 | -107.7 | -90.4 | -85.2 | -84.5 | -78.7 |
| 13.2 kbit/s | -92.2 | -91.3 | -89.5 | -84.0 | -83.1 | -77.4 |
| 16.4 kbit/s | -106.1 | -106.1 | -90.1 | -84.3 | -83.3 | -77.4 |
| 24.4 kbit/s | -111.7 | -108.9 | -90.0 | -84.3 | -82.7 | -76.8 |
| 32.0 kbit/s | -82.3 | -90.9 | -90.9 | -84.9 | -82.7 | -77.0 |
| 48.0 kbit/s | -112.4 | -110.1 | -89.6 | -83.7 | -82.3 | -76.3 |
| 64.0 kbit/s | -108.0 | -111.7 | -89.7 | -83.8 | -82.3 | -76.4 |
| 96.0 kbit/s | -110.6 | -112.2 | -90.2 | -84.2 | -82.4 | -76.4 |
| 128.0 kbit/s | -111.2 | -115.7 | -90.2 | -84.2 | -82.5 | -76.5 |

Table 18: Idle noise levels with activation and dithering noise in dB(A)

Neither in the frequency representations shown in Figure 57 and Figure 58, nor in the absolute level values shown in Table 18, a violation of the requirements can be observed for any super-wideband bit rate or overload point.

### Idle Noise without Activation

The following results are produced by applying the tests without the preceding activation sequence.

|  |  |
| --- | --- |
|  |  |
| Figure 59: Idle noise spectrum without activation for different overload points | |

|  |  |
| --- | --- |
|  |  |
| Figure 60: Idle noise spectrum without activation with 1-bit dithering noise | |

|  |  |
| --- | --- |
|  |  |
| Figure 61: Idle noise spectrum without activation with 2-bit dithering noise | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3.0 | 9.0 | 3.0 | 9.0 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 9.6 kbit/s | -205.8 | -205.8 | -91.3 | -85.3 | -85.3 | -79.3 |
| 13.2 kbit/s | -92.9 | -86.9 | -89.7 | -83.7 | -82.7 | -76.7 |
| 16.4 kbit/s | -205.8 | -205.8 | -90.4 | -84.4 | -83.5 | -77.5 |
| 24.4 kbit/s | -205.8 | -205.8 | -90.4 | -84.4 | -82.9 | -76.9 |
| 32.0 kbit/s | -95.2 | -89.2 | -91.1 | -85.1 | -83.1 | -77.1 |
| 48.0 kbit/s | -205.8 | -205.8 | -89.7 | -83.7 | -82.4 | -76.4 |
| 64.0 kbit/s | -205.8 | -205.8 | -89.7 | -83.7 | -82.0 | -76.0 |
| 96.0 kbit/s | -205.8 | -205.8 | -90.2 | -84.2 | -82.3 | -76.3 |
| 128.0 kbit/s | -205.8 | -205.8 | -90.2 | -84.2 | -82.6 | -76.6 |

Table 19: Idle noise levels without activation with dithering noise in dB(A)

Again, neither in the frequency representations shown in Figure 59, Figure 60, and Figure 61 nor in the absolute level values shown in Table 19, a violation of the requirements can be observed for any super-wideband bit rate or overload point.

For all bit rates but 13.2 and 32.0 kbit/s, the digital zero input is encoded to a digital zero output leading to idle noise levels lower than -200 dB(A), which are outside the plotting range in Figure 59. These two bit rates, however, generate a non-zero output even for digital zero input.

With dithering noise, the results for the two overload points are shifted by 6 dB but otherwise show the same behavior.

### Distortion vs. input level

The following results are produced by applying the measurement instructions and requirements according to clause 8.8.2 of [4], which are adapted to super-wideband by evaluating the distortion up to 14 kHz. It measures the signal-to-distortion ratio for a 1020 Hz sine with different source levels.

|  |  |
| --- | --- |
|  |  |
| Figure 62: Signal-to-distortion ratio for different input levels | |

The results of this analysis are shown in Figure 62. At all bit rates and gains, the signal-to-distortion ratio extends at least 40dB.

### Distortion vs. frequency

The following results are produced by applying the measurement instructions and requirements according to clause 8.8.2 of [4] which are extended with source frequencies above 1 kHz and adapted to super-wideband by evaluating the distortion up to 14 kHz. It measures the signal-to-distortion ratio for different frequencies and constant input level.

|  |  |
| --- | --- |
|  |  |
| Figure 63: Signal-to-distortion ratio for different frequencies | |

The results of this analysis are shown in Figure 63. For all bit rates and gains, the signal-to-distortion ratio extends at least 40dB, except one frequency (about 8 kHz) for rate 16.4kbit/s (light blue curve).

## EVS-Mode: Fullband (FB)

In fullband mode, a sampling rate of 48 kHz and all possible bit rates (16.4, 24.4, 32.0, 48.0, 64.0, 96.0 and 128.0 kbit/s) according to Table 1 of [1] were used. The two possible target overload points 3.0 and 9.0 dBm0 were used by default for all analyses.

### Frequency Response with real speech

The following results are produced by applying measurement instructions similar to clause 8.4.2 of [4] which are adapted to fullband by replacing the source signal with a fullband version of the same. To simulate also the impact of level variations, additional overload points of 21.0 and 39.0 dBm0 were also simulated. These overload points do not represent a realistic conversion; they are only used for checking the linearity of the codec and can be regarded as attenuations of 18.0 resp. 36.0 dB compared to the overload point 3.0 dBm0. The results of this analysis are shown in Figure 64.

|  |  |
| --- | --- |
|  |  |
|  |  |
| Figure 64: Frequency response for different overload points | |

For lower codec rates (16.4 and 24.4 kbit/s, red/green curves), the transmission characteristics show some slight degradations for frequencies between 15 and 20 kHz.

### Frequency Response with composite source signal (CSS)

The following results are produced by applying the measurement instructions similar to clause 8.3.2 of [4] which is intended to be reported only for informative reasons. The composite source according to ITU-T P.501 [6] signal is used as a reference for the calculation. The results of this analysis are shown in Figure 65.

|  |  |
| --- | --- |
|  |  |
|  |  |
| Figure 65: Frequency response for different overload points | |

### Idle Noise with Activation

#### Idle noise generated with activation and digital zero input

The following results are produced by applying measurement instructions and requirements similar to clause 8.3.2 of [4] which are adapted to fullband by replacing the source signal with a fullband version of the same file. This includes an activation of the device under test with a CSS burst before the measured idle segment.

|  |  |
| --- | --- |
|  |  |
| Figure 66: Idle noise spectrum with activation for different overload points | |

|  |  |  |
| --- | --- | --- |
|  | overload point [dBm0] | |
| bit rate | 3.0 | 9.0 |
| 16.4 kbit/s | -105.1 | -105.3 |
| 24.4 kbit/s | -108.1 | -109.8 |
| 32.0 kbit/s | -86.4 | -85.9 |
| 48.0 kbit/s | -111.5 | -105.5 |
| 64.0 kbit/s | -103.7 | -102.7 |
| 96.0 kbit/s | -111.1 | -110.6 |
| 128.0 kbit/s | -110.9 | -110.9 |

Table 20: Idle noise levels with activation in dB(A) (requirement: -57.0 dB(A))

Neither in the frequency representation shown in Figure 66, nor in the absolute level values shown in Table 20, a violation of the requirements according to [5] can be observed for any fullband bit rate.

#### Idle noise generated with activation and dithering noise

The original measurement described in the previous section was conducted with an input signal which consists only of digital zeros. In order to analyze the impact of non-zero samples, two different dithering noises were used instead as a source signal. This dithering noise was created by randomly modifying the last N bits of each 16-bit sample. By increasing N, the dithering noise power increases. In this evaluation, N = 1 and N = 2 was used.

|  |  |
| --- | --- |
|  |  |
| Figure 67: Idle noise spectrum with activation and 1-bit dithering noise | |

|  |  |
| --- | --- |
|  |  |
| Figure 68: Idle noise spectrum with activation and 2-bit dithering noise | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3.0 | 9.0 | 3.0 | 9.0 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 16.4 kbit/s | -105.1 | -105.3 | -89.1 | -83.3 | -82.6 | -76.7 |
| 24.4 kbit/s | -108.1 | -109.8 | -89.2 | -83.5 | -82.3 | -76.3 |
| 32.0 kbit/s | -86.4 | -85.9 | -88.4 | -82.6 | -82.0 | -76.0 |
| 48.0 kbit/s | -111.5 | -105.5 | -88.8 | -82.8 | -81.6 | -75.6 |
| 64.0 kbit/s | -103.7 | -102.7 | -87.9 | -81.9 | -81.5 | -75.5 |
| 96.0 kbit/s | -111.1 | -110.6 | -89.6 | -83.6 | -81.9 | -75.9 |
| 128.0 kbit/s | -110.9 | -110.9 | -89.6 | -83.6 | -81.9 | -75.9 |

Table 21: Idle noise levels with activation and dithering noise in dB(A)

Neither in the frequency representations shown in Figure 67 and Figure 68, nor in the absolute level values shown in Table 21, a violation of the requirements can be observed for any fullband bit rate or overload point.

The results for the two overload points, however, show a different behavior with respect to the same dithering noise power. This is attributed to the different states of the codec depending on the overload point specific scaling of the activation sequence. Therefore, the next section describes the same measurement without activation.

### Idle Noise without Activation

The following results are produced by applying measurement instructions and requirements of the previous section,3.4.2 but without the preceding activation sequence.

|  |  |
| --- | --- |
|  |  |
| Figure 69: Idle noise spectrum without activation for different overload points | |

|  |  |
| --- | --- |
|  |  |
| Figure 70: Idle noise spectrum without activation with 1-bit dithering noise | |

|  |  |
| --- | --- |
|  |  |
| Figure 71: Idle noise spectrum without activation with 2-bit dithering noise | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | overload point [dBm0] | | | | | |
|  | 3.0 | 9.0 | 3.0 | 9.0 | 3.0 | 9.0 |
| bit rate | no dithering | | 1-bit dithering | | 2-bit dithering | |
| 16.4 kbit/s | -205.8 | -205.8 | -91.3 | -85.3 | -84.5 | -78.5 |
| 24.4 kbit/s | -205.8 | -205.8 | -91.3 | -85.3 | -84.2 | -78.2 |
| 32.0 kbit/s | -94.5 | -88.5 | -89.0 | -83.0 | -83.1 | -77.1 |
| 48.0 kbit/s | -205.8 | -205.8 | -90.7 | -84.7 | -83.4 | -77.4 |
| 64.0 kbit/s | -205.8 | -205.8 | -87.8 | -81.8 | -81.9 | -75.9 |
| 96.0 kbit/s | -205.8 | -205.8 | -91.1 | -85.1 | -83.6 | -77.6 |
| 128.0 kbit/s | -205.8 | -205.8 | -91.1 | -85.1 | -83.7 | -77.7 |

Table 22: Idle noise levels without activation with dithering noise in dB(A)

Again, neither in the frequency representations shown in Figure 69, Figure 70 or Figure 71, nor in the absolute level values shown in Table 22, a violation of the requirements can be observed for any fullband bit rate or overload point.

For all bit rates but 32.0 kbit/s, the digital zero input is encoded to a digital zero output leading to idle noise levels lower than -200 dB(A), which are outside the plotting range of Figure 69. These two bit rates, however, generate a non-zero output even for digital zero input.

With dithering noise, the results for the two overload points are shifted by 6 dB but otherwise show the same behavior.

### Distortion vs. input level

The following results are produced by applying the measurement instructions and requirements according to clause 8.8.2 of [4], which are adapted to fullband by evaluating the distortion up to 14 kHz. It measures the signal-to-distortion ratio for a 1020 Hz sine with different source levels.

|  |  |
| --- | --- |
|  |  |
| Figure 72: Signal-to-distortion ratio for different input levels | |

The results of this analysis are shown in Figure 72. At all bit rates and gains, the signal-to-distortion ratio extends at least 40dB.

### Distortion vs. frequency

The following results are produced by applying the measurement instructions and requirements according to clause 8.8.2 of [4] which are extended with source frequencies above 1 kHz and adapted to fullband by evaluating the distortion up to 14 kHz. It measures the signal-to-distortion ratio for different frequencies and constant input level. The results of this analysis are shown in Figure 73.

|  |  |
| --- | --- |
|  |  |
| Figure 73: Signal-to-distortion ratio for different frequencies | |

# Conclusions

This contribution introduces the results of several measurements of the EVS codec using adapted tests originally intended for acoustic terminal testing. Two versions of the codec were evaluated: the codec version which was used in the selection phase; version 12.1 provides the current release.

In narrowband mode, all bit rates pass all requirements of [5]. No noticeable differences between both versionscould be observed.

EVS WB at 5.9, 7.2, and 8.0 kbit/s demonstrates lower than 40 dB signal-to-distortion ratio (SDR) at certain frequencies with pure tones (Figures 19,20, 51,52) in both, the codec version used in selection as well as in version12.1.0. In version 12.1.0 this behavior is improved, for rates above 8 kbps, the SDR extends to at least 40 dB with pure tones (Figure 51, 52).

While the codec version used in the selection phase shows some degradation in distortion at 9.6 kbit/s and 13.2 kbit/s, EVS SWB version 12.1.0 at all bit rates produces at least 40 dB signal-to-distortion ratio (Figure 62, 63), except at 16.4 kbit/s and at one frequency (about 8 kHz @16.4 kbit/s in Fig. 63).

Across all bitrates and for various operating bandwidths NB/WB/SWB, the EVS codec version 12.1 exceeds the frequency response tolerance requirements over an extended range of overload points when tested using both real speech and composite source signal.

The fullband mode was introduced with the release version 12.1. Since no requirements are available for this mode, results can only be reported. However, besides some slight degradation in the frequency response evaluations, the codec accurately performs on all tests.

# References

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3. ITU-T Rec. G.100.1: “The use of the decibel and of relative levels in speechband telecommunications”, 11/2001.
4. 3GPP TS 26.132: “Speech and video telephony terminal acoustic test specification (Release 12)”.
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6. Recommendation ITU-T P.501: “Test signals for use in telephonometry”
7. 3GPP TS 26.442: “Codec for Enhanced Voice Services (EVS); ANSI C code (fixed-point) (Release 12)”