AN12897

NxH3670 performance

Rev. G9.0 — 19 August 2021 Application note

Document information

Information	Content
Keywords	NXH3670
Abstract	The AN Performance describes the measured performance and the measurement context

Revision history

Rev	Date	Description
G9.0	20210827	Updated the meausrements with G9.0 release
G8.1	20210129	Re-run of some performance measurements
G8.0	20201118	Measurement performance of release G8.0, add explanation how the system latency is measured
G6.0	20200331	Updated values and figures of sections 2 and 4
G5.2	20191224	Updated values and figures of sections 2 and 4
G5.1	20191126	Updated values and figures of sections 2 and 4
G5.0	20190722	Updated performance summary and power figures Update of section 6.2
G4.0	20190320	Updated for G4.0 and extended with more performance data Processed final-review outcome
G3.0	20181220	Measurement performance of the release G3.0

1 Introduction

This document describes:

- The measured performance characteristics of the NxH3670
- The measurement conditions

Throughout the document, FWD stands for Forward channel and BWD stands for Backward channel.

Before reading this document, study the signal flow in both the SDK board and ADK board.

2 Performance summary

Table 1. Performance figures

Measurements	Value	Unit	Details
audio bandwidth forward channel	~21	kHz	
audio bandwidth backward channel	~7	kHz	
latency forward channel (ulo/lo/mid/hi)	15.3/20.3/25.3//30.3	ms	Section 3.1.1.8
latency backward channel (ulo/lo/mid/hi)	25.0/30.2/35.3/40.0	ms	Section 3.1.4.10
time to audio (bonded/unbonded)		s	Section 3.3.3
SNR forward channel	144	dB	1 kHz; Section 3.1.1.1
SNR backward channel	79	dB	1 kHz; Section 3.1.4.1
power consumption	7.4	mA	headset = active at 1.2 V; NxHxxxx only
power consumption	9.46	mA	dongle = active at 1.2 V; NxHxxxx only
power consumption	0.73	mA	headset = advertising at 1.2 V; NxHxxxx only
power consumption	3.3	mA	dongle = scanning at 1.2 V; NxHxxxx only

Unless explicitly indicated otherwise, measurements are always conducted in low latency mode.

Table 2. SDK – Power performance

Dongle/ Headset	State	NxHxxxx at 1.2 V (mA)	KL at 1.8 V (mA)	Codec at 1.2 V (mA)	Codec at 1.8 V (mA)	At 3.8 V (mA)
D	SLEEP	0.0997	0.1	-	-	-
D	CONNECTING - scan	3.34	5.08	-	-	-
D	CONNECTED	0.36	5.07	-	-	-
D	STREAMING - low latency	9.46	7.26	-	-	-
H	SLEEP	0.10	0.10	0.002	0.13	1.14
H	CONNECTING - advertise	0.73	0.14	0.2	0.93	1.89
H	CONNECTED	0.38	0.1	0.002	0.13	1.73
H	STREAMING - low latency	7.37	0.1	1.45	12.1	10.89

The headset power consumption is measured at the battery contacts (input of the DC/DC convertors). The battery is removed and a bench power supply is used.

Table 3. ADK – Power performance

Dongle/ Headset	State	At 3.8 V (mA)	at 5 V (mA)
D	SLEEP	-	0.0 (Vbus is off)

Table 3. ADK – Power performance*...continued*

Dongle/ Headset	State	At 3.8 V (mA)	at 5 V (mA)
D	CONNECTING - scan	-	20.2
D	CONNECTED	-	17.1
D	STREAMING – low latency	-	30
H	CONNECTING - advertise	1.1	-
H	CONNECTED	1	-
H	STREAMING - low latency (0 V (RMS) out)	5.7	-
H	STREAMING - low latency (100 mV (RMS) out)	7.4	-

Table 4. Radio Link (last run G5.0)

Setup/case	Measurement	Measured value	Unit
range line-of-sight	low latency	23	m
	mid Latency	37	m
	high latency	42	m
outdoor range	PLC kick-in	12…23	m
	first mute	33…58	m
	end of range (MOS = 1)	77…119	m
interference resilience	min, max lost audio frames after interference enabled	2..17	frames
	min, max lost audio frames after CA settled	0…2	frames
	min, max settling time after interference enabled	3…42	s
	min, max PER during 5 minute run	3.3…5.0	%

“End of range” is the distance at which the MOS has dropped to 1.

The Wikipedia definition of MOS: “MOS or Mean Opinion Score is a measure used in the domain of Quality of Experience and telecommunications engineering, representing overall quality of a stimulus or system.”

“Range Line-of-Sight” is the distance at which MOS has dropped one level compared to the quality with perfect reception.

“Range Line-of-Sight” is measured indoors in an office environment, therefore there is an uncontrolled level of interference.

The lower the latency, the less time there is for retries. So, the range drops significantly.

“Outdoor range” is measured in a location without interference.

3 Audio measurements

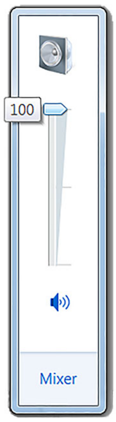
The following configurations are evaluated:

Table 5. Measured configurations

#		Configuration
Section 3.1.1	SDK	forward channel: I^2S-to-I^2S
Section 3.1.2		forward channel: I^2S-to-analog
Section 3.1.3		forward channel: analog-to-analog
Section 3.1.4		back channel: I^2S-to-I^2S
Section 3.1.5		back channel: Analog
Section 3.2.1	ADK	forward channel: I^2S-to-analog
Section 3.2.2		back channel: Analog-to-I^2S

Although numbers are published on the performance of the SDK, these numbers are 'for information only'. Only the ADK board has been designed tuned for performance.

All measurements are done with the Windows volume sliders at maximum level.



aaa-038160

Figure 1. Windows volume slider

3.1 NXH3670SDK board

Although numbers are published on the performance of the SDK, these numbers are ‘for information only’. Only the ADK board has been designed tuned for performance.

3.1.1 Forward channel: I^2S to I^2S

In this section, I^2S audio signals from the APX525 are directly connected to the NxH3670. The I^2S transmitter is connected to the dongle while the I^2S receiver is connected to the headset. The audio is sampled at 48 kHz and is using a 24-bit resolution (see Figure 2).

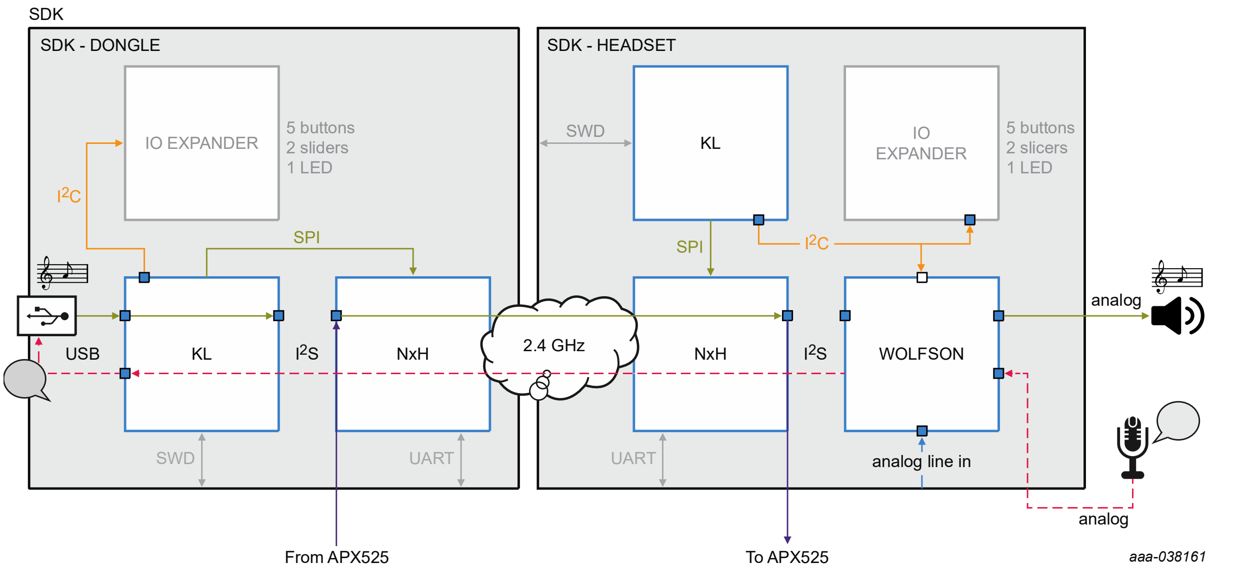


Figure 2. SDK – FWD – I^2S to I^2S

3.1.1.1 SNR

Table 6. SDK – FWD – SNR – measurement settings

Setting	Value
signal level	0 dBFS
low pass filter	20 kHz elliptical
high pass filter	20 Hz elliptical
weighting filter	A-wt
audio frequency	1 kHz

Table 7. SDK – FWD – SNR

Board	Channel	Dithering	SNR (dB)
SDK	FWD	Off	144 (24 bit)

The SNR can not be measured with the APX as the noise level is 0. In stead the SNR value based on the number of bits is put.

3.1.1.2 Frequency sweep

Table 8. SDK – FWD – frequency sweep – measurement settings

Setting	Value
signal level	0 dBFS
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	256
start frequency	20 Hz
stop frequency	23.9520 kHz

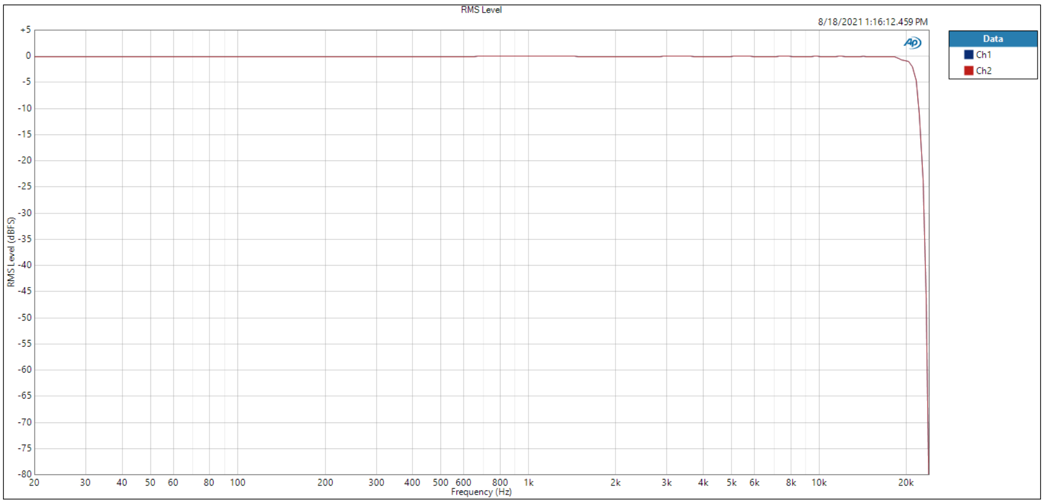


Figure 3. SDK – FWD –Frequency response (log scale)

The −3 dB point is ~21 kHz.

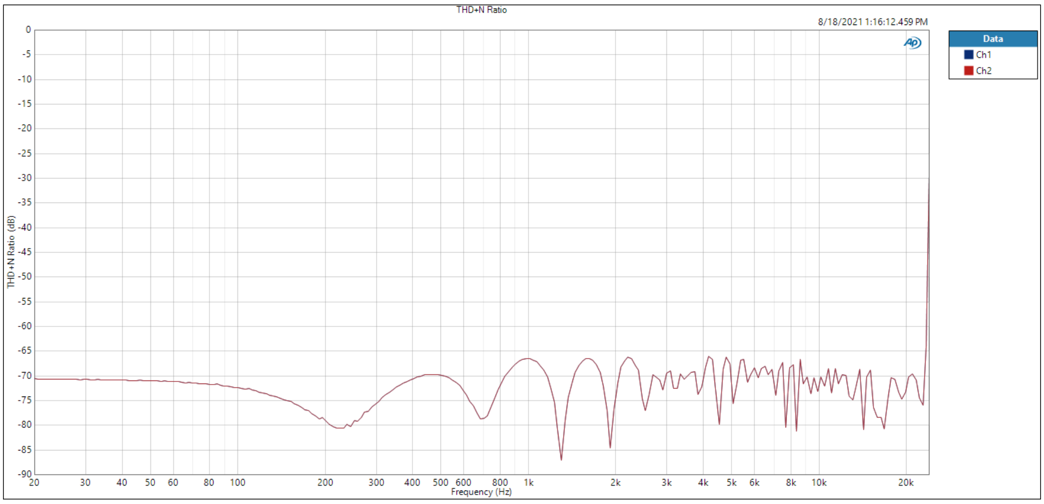


Figure 4. SDK – FWD – THD+N ratio

Since a signal level of 0 dBFS was used, the THD+N-ratio and THD+N-level show the same result.

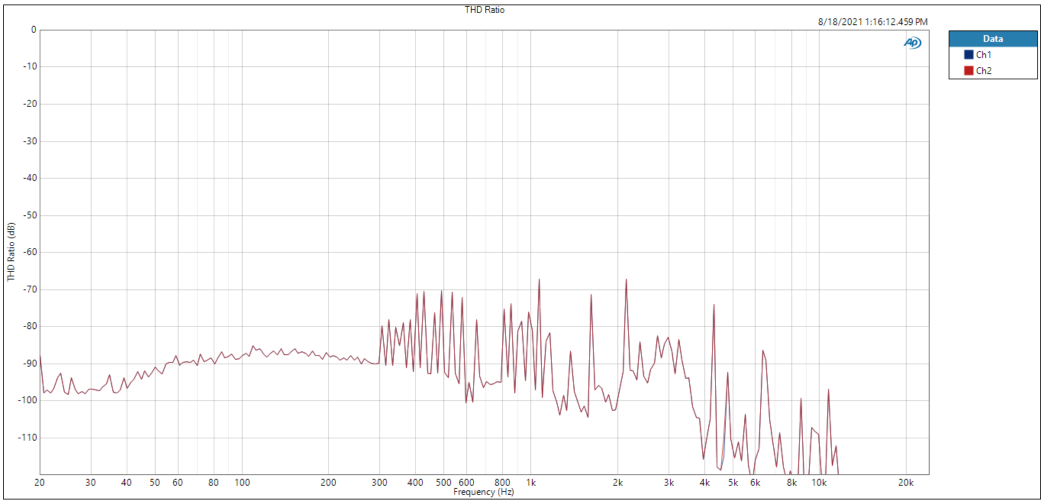


Figure 5. SDK – FWD – THD ratio

Since a signal level of 0 dBFS was used, the THD-ratio and THD-level show the same result.

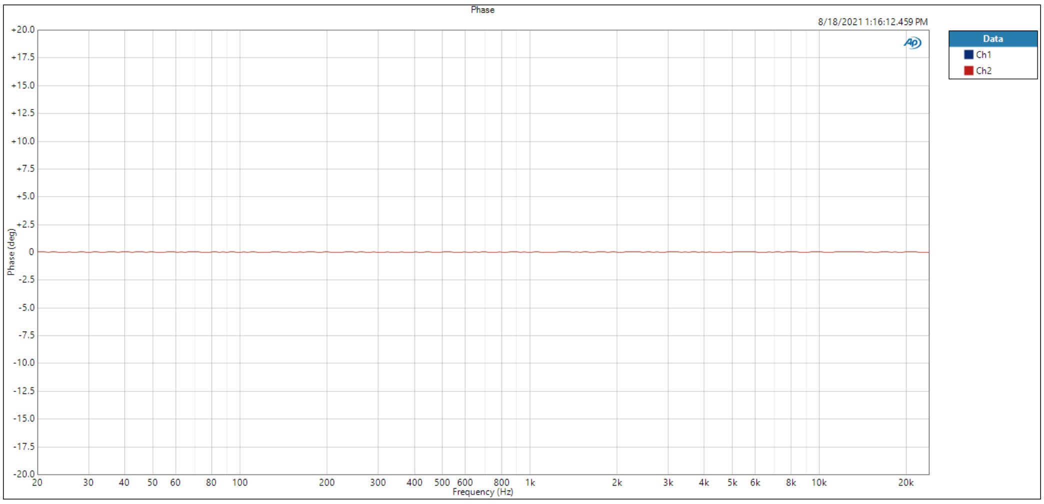


Figure 6. SDK – FWD – Phase

3.1.1.3 Frequency sweep equalizer -12dB

Table 9. SDK – FWD equalizer -12dB – frequency sweep – measurement settings

Setting	Value
signal level	-6 dBFS
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	256
start frequency	20 Hz
stop frequency	23.9520 kHz

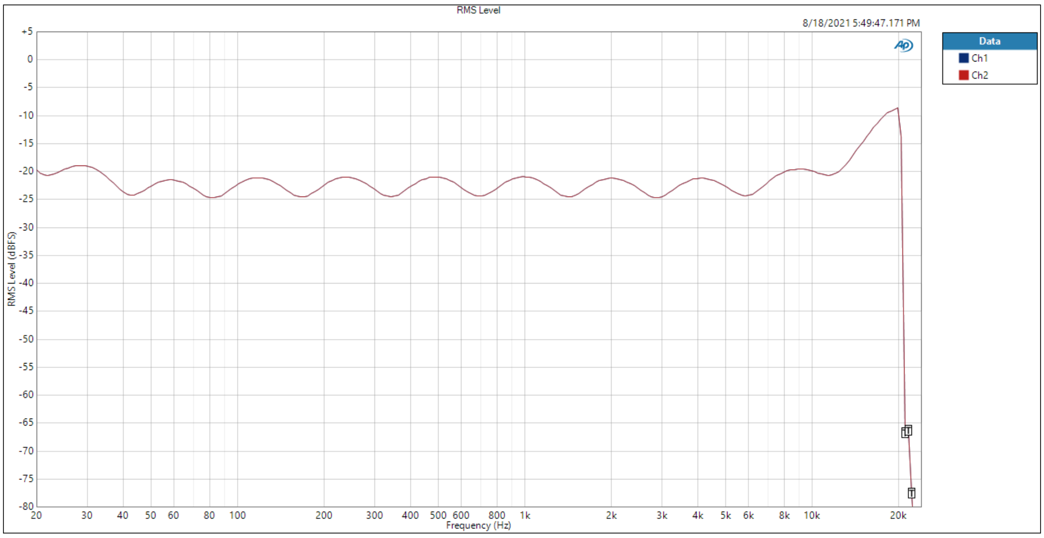


Figure 7. SDK – FWD equalizer -12dB –Frequency response (log scale)

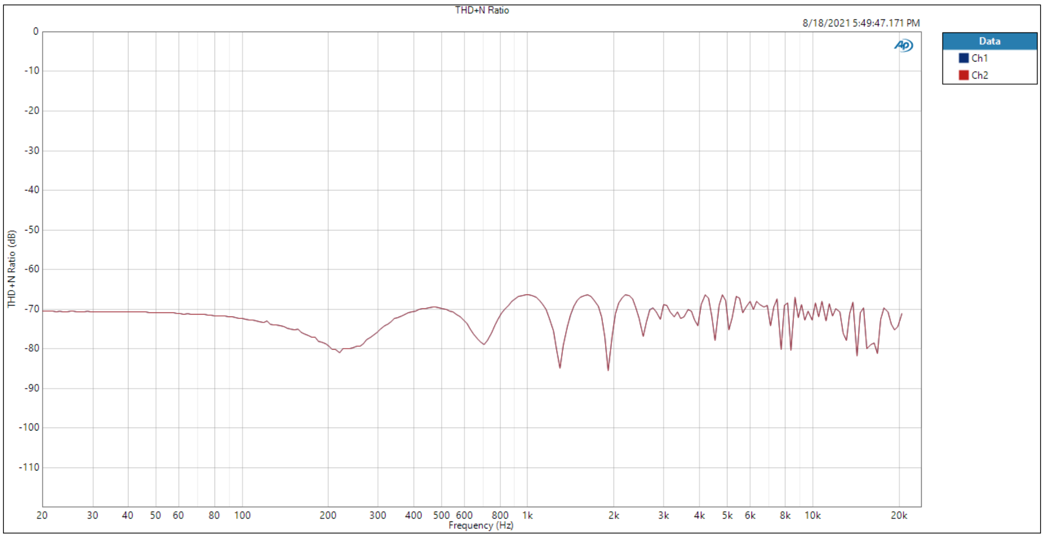


Figure 8. SDK – FWD equalizer -12dB – THD+N ratio

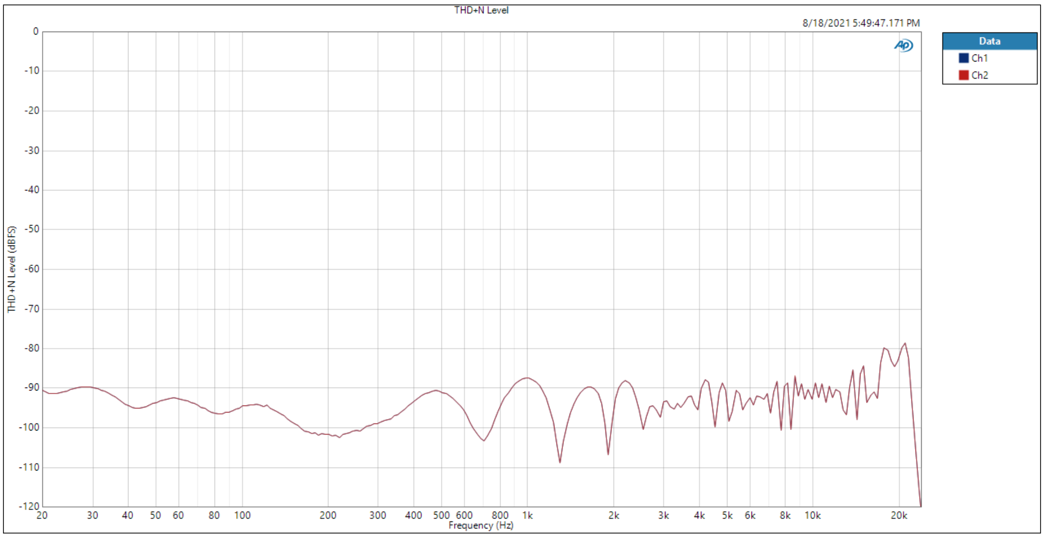


Figure 9. SDK – FWD equalizer -12dB – THD ratio

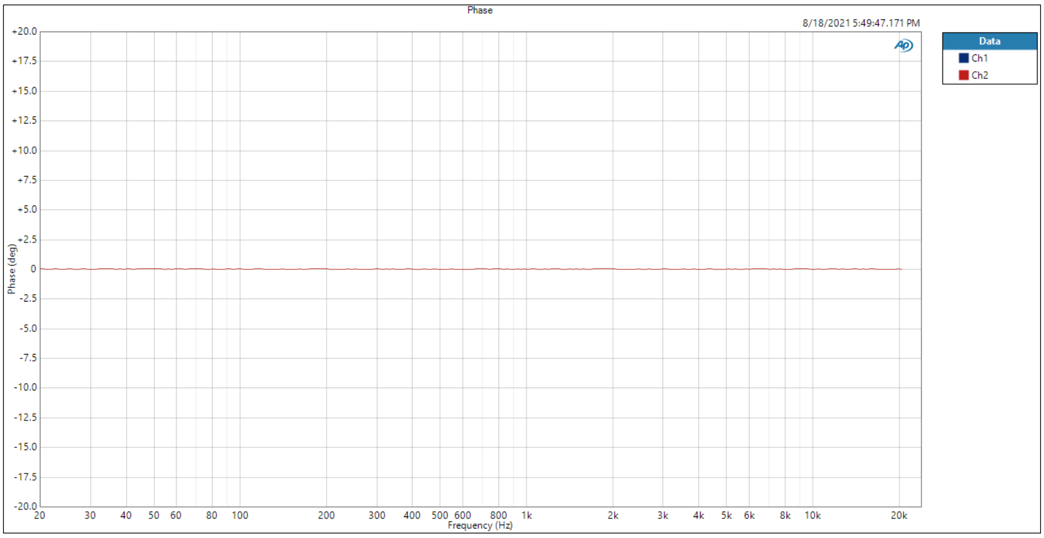


Figure 10. SDK – FWD equalizer -12dB – Phase

3.1.1.4 Frequency sweep equalizer +12dB

Table 10. SDK – FWD equalizer +12dB – frequency sweep – measurement settings

Setting	Value
signal level	-20 dBFS
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	256
start frequency	20 Hz
stop frequency	23.9520 kHz

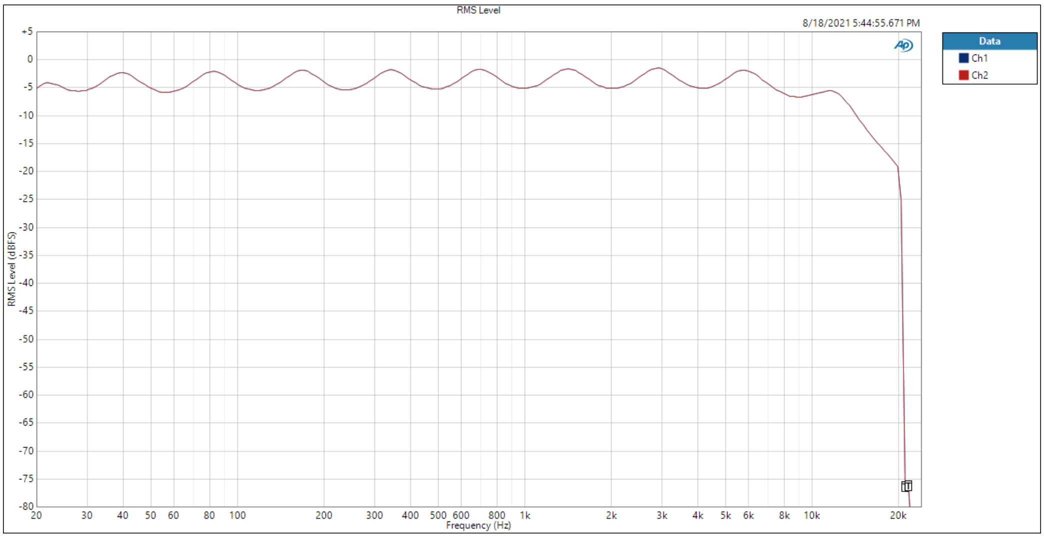


Figure 11. SDK – FWD equalizer +12dB – Frequency response (log scale)

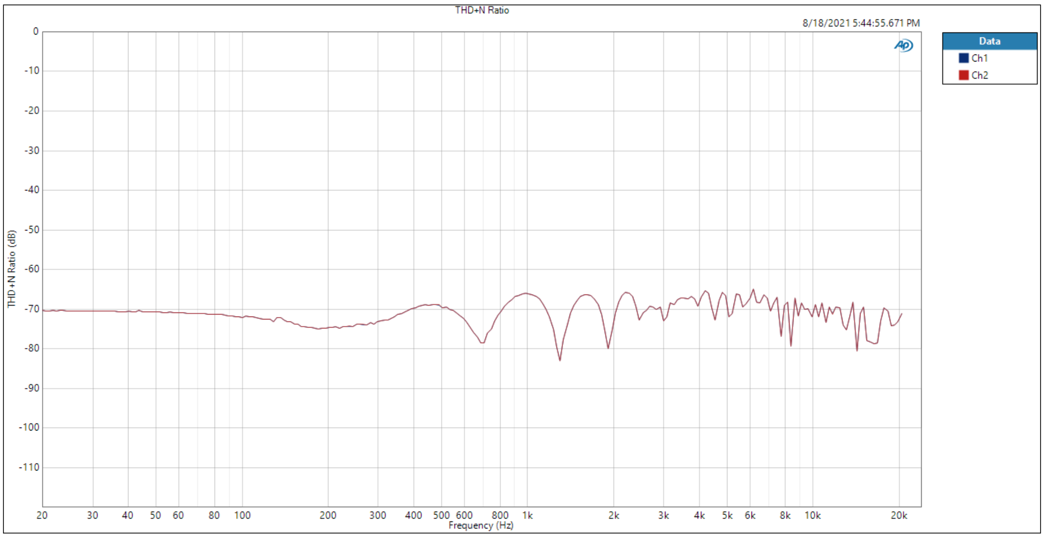


Figure 12. SDK – FWD equalizer +12dB– THD+N ratio

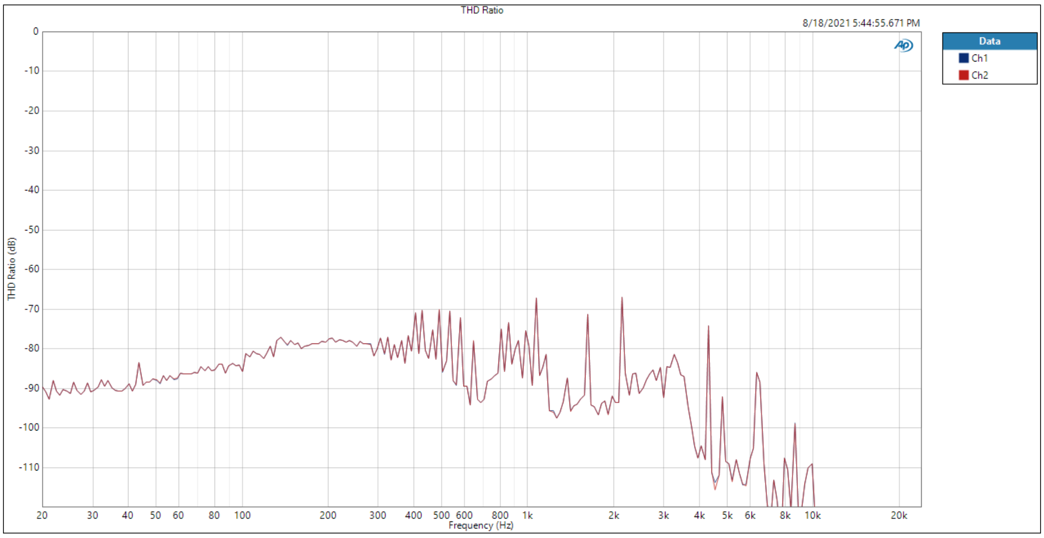


Figure 13. SDK – FWD equalizer +12dB – THD ratio

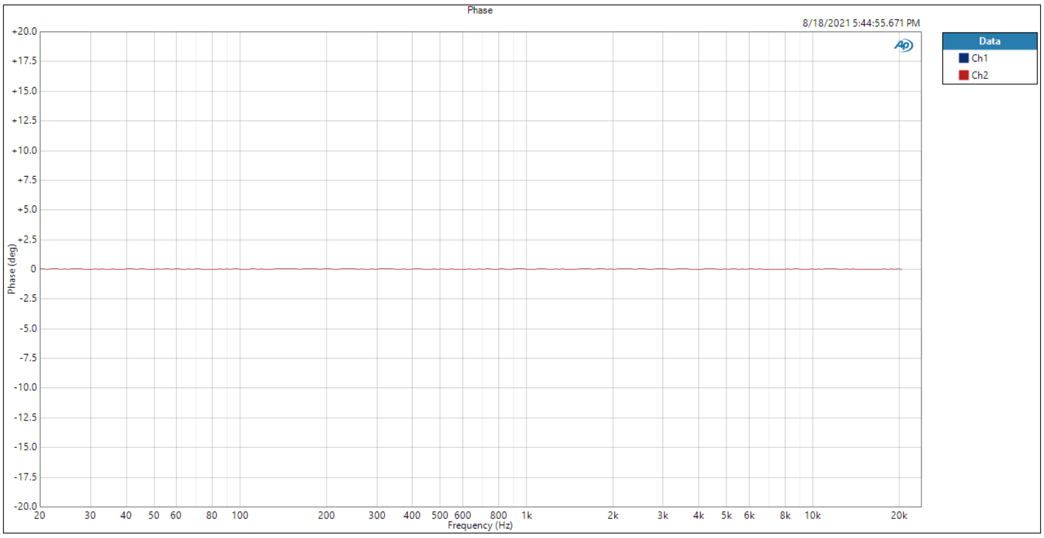


Figure 14. SDK – FWD equalizer +12dB – Phase

3.1.1.5 Stepped level response

Table 11. SDK – FWD – stepped level response – measurement settings

Setting	Value
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	151
start level	−150 dBFS
stop level	0 dBFS
frequency	1 kHz

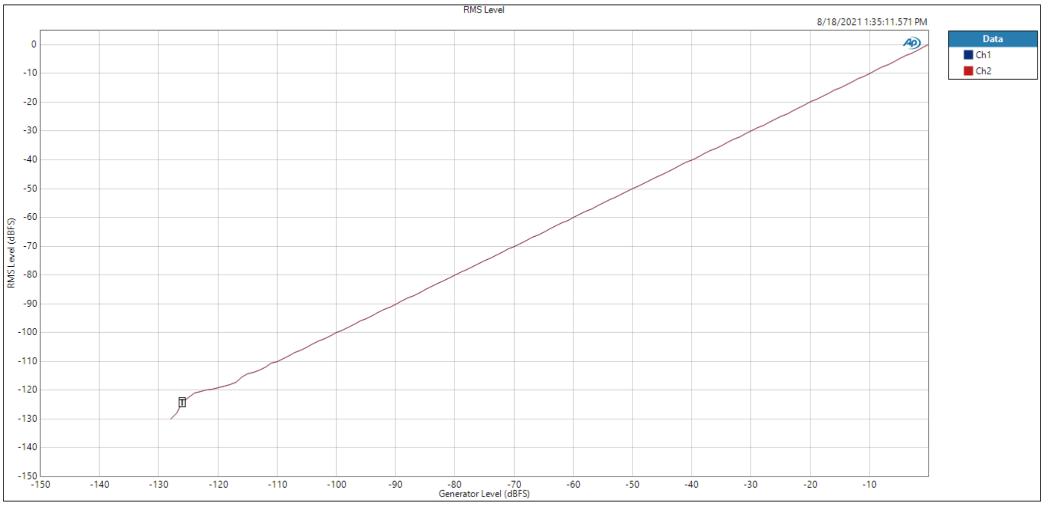


Figure 15. SDK – FWD – stepped level response

Figure 15 shows a 0 dB gain between the input and output.

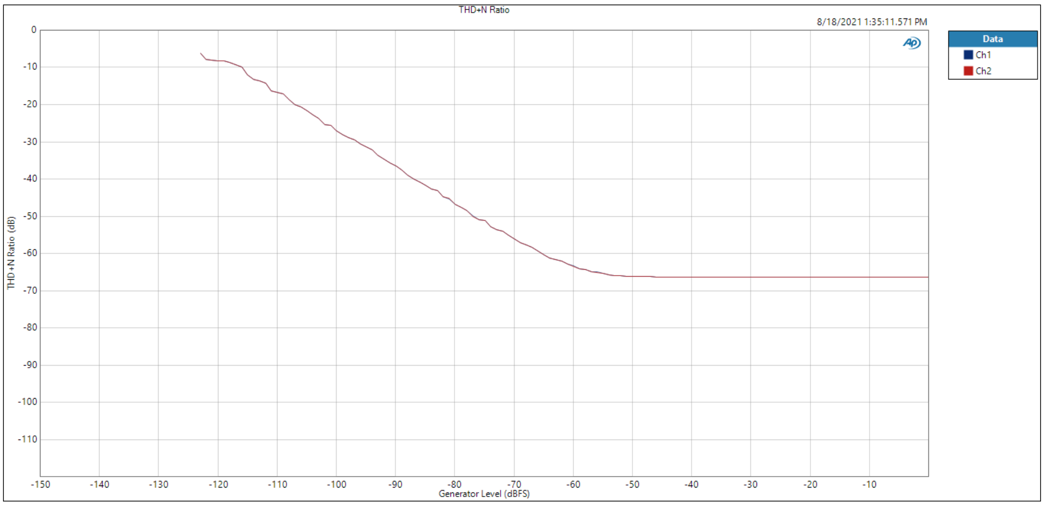


Figure 16. SDK – FWD – THD+N ratio (1 kHz)

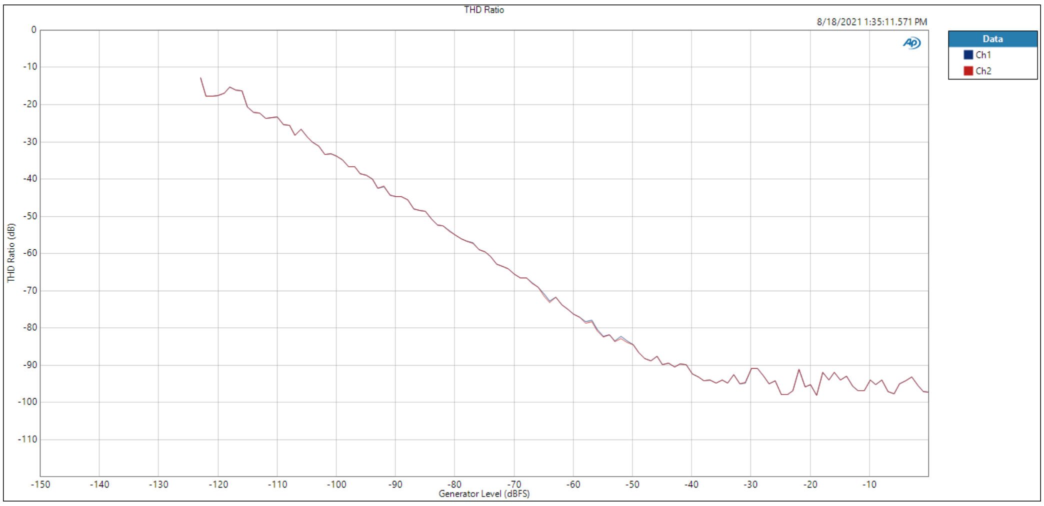


Figure 17. SDK – FWD – THD ratio (1 kHz)

3.1.1.6 Stepped level response equalizer -12dB

Table 12. SDK – FWD equalizer -12dB – stepped level response – measurement settings

Setting	Value
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	151
start level	−150 dBFS
stop level	0 dBFS
frequency	1 kHz

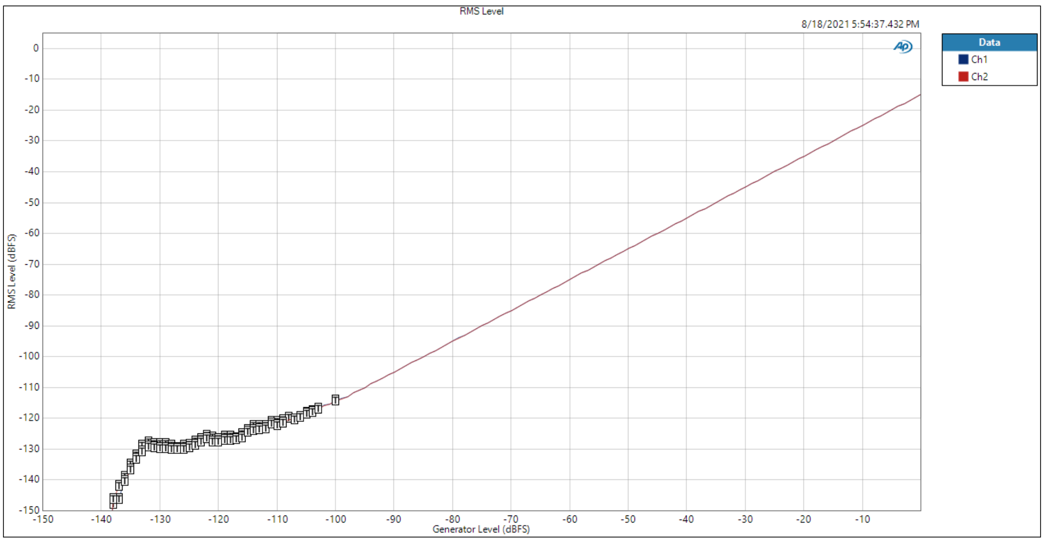


Figure 18. SDK – FWD equalizer -12dB– stepped level response

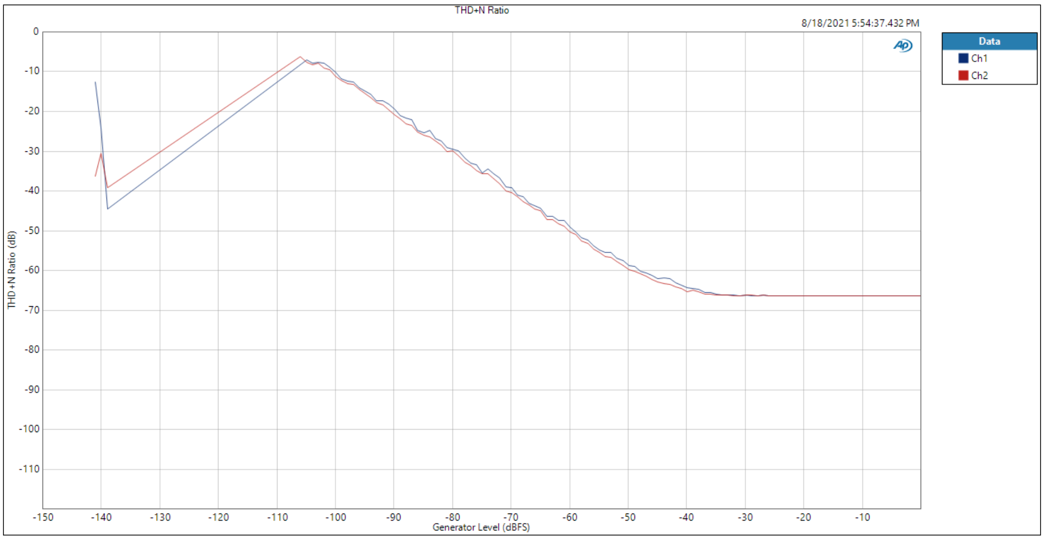


Figure 19. SDK – FWD equalizer -12dB – THD+N ratio (1 kHz)

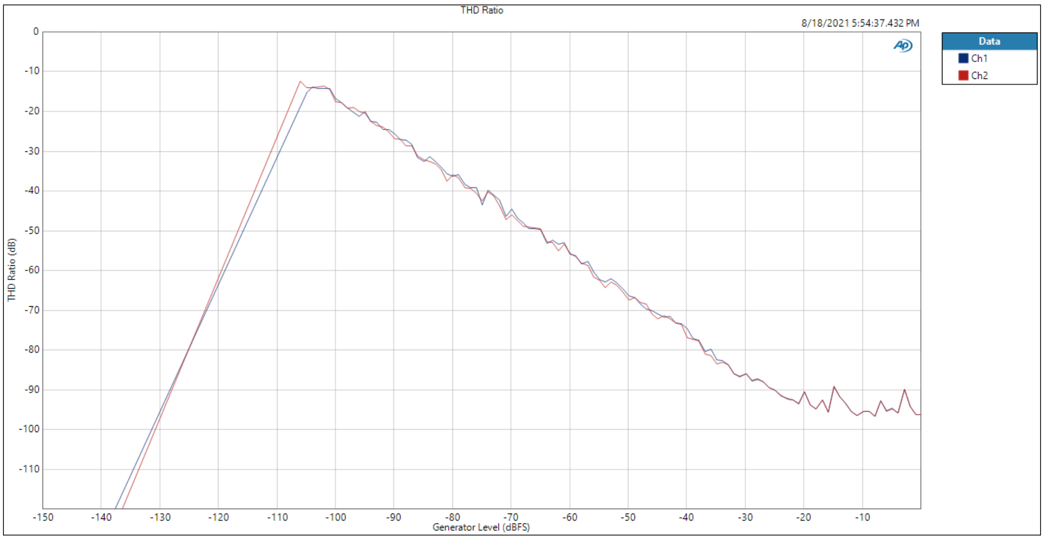


Figure 20. SDK – FWD equalizer -12dB – THD ratio (1 kHz)

3.1.1.7 Stepped level response equalizer +12dB

Table 13. SDK – FWD equalizer +12dB – stepped level response – measurement settings

Setting	Value
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	151
start level	−150 dBFS
stop level	0 dBFS
frequency	1 kHz

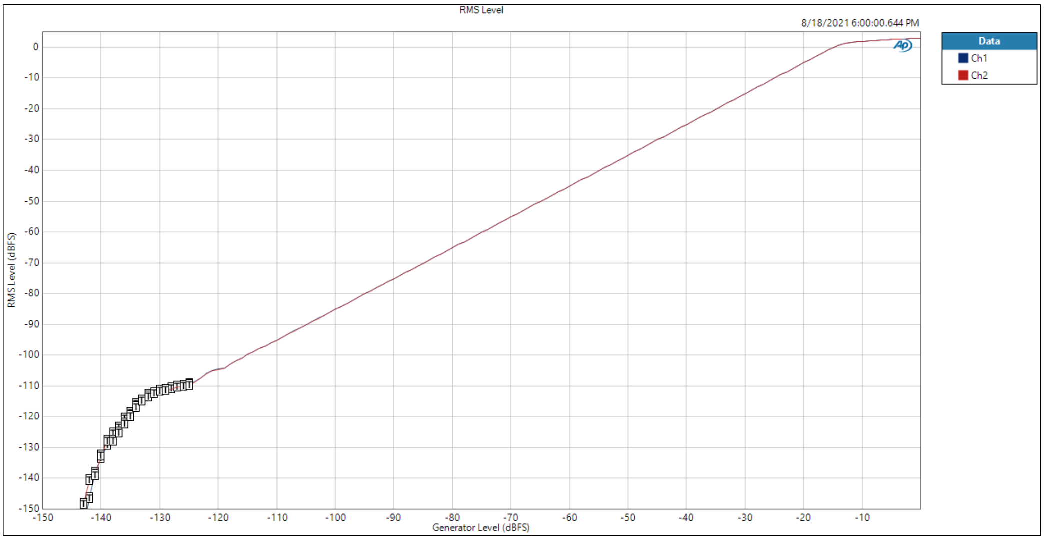


Figure 21. SDK – FWD equalizer +12dB – stepped level response

Figure 21 shows a 0 dB gain between the input and output.

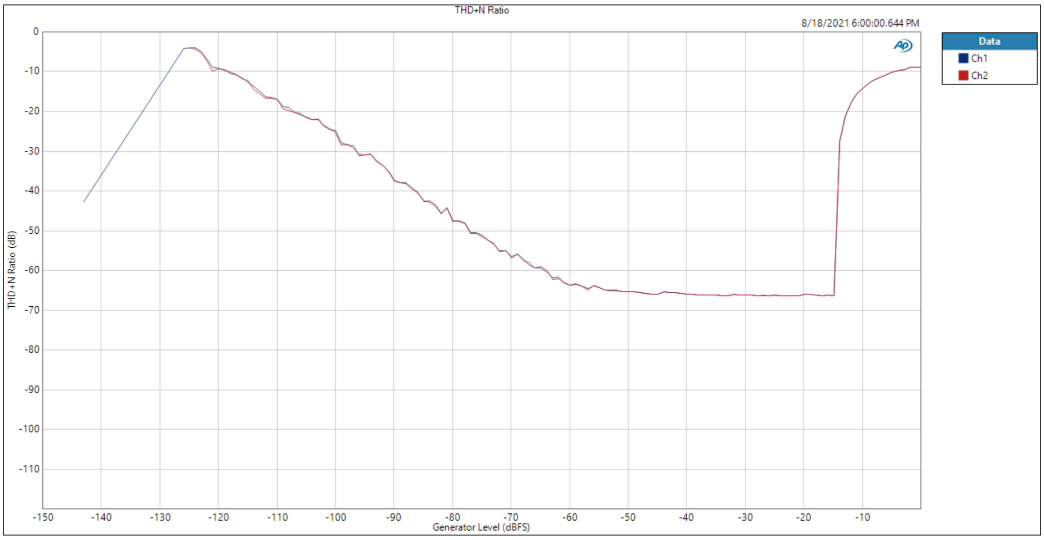


Figure 22. SDK – FWD equalizer +12dB – THD+N ratio (1 kHz)

Since a signal level of 0 dBFS was used the THD-ratio and THD-level are giving the same result.

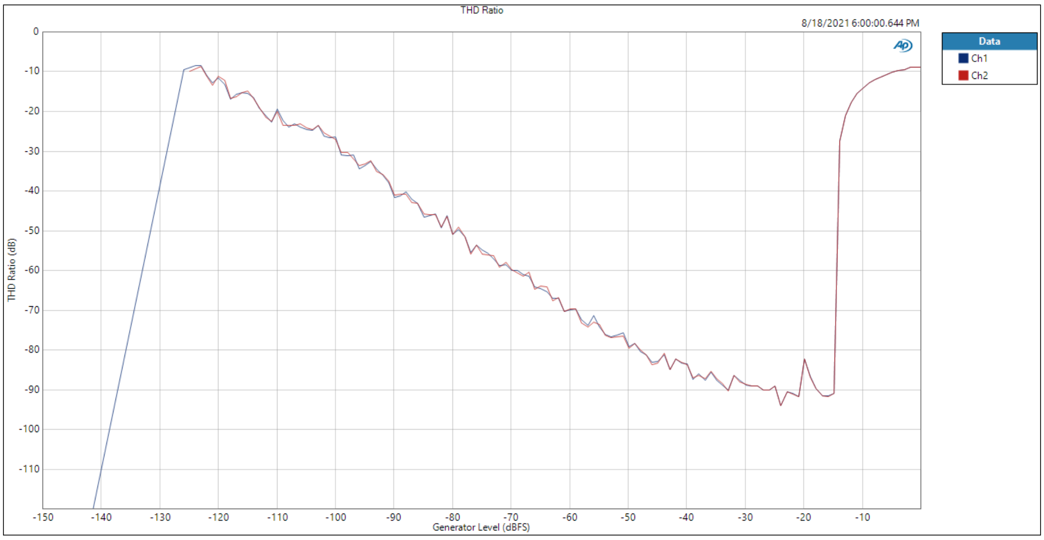


Figure 23. SDK – FWD equalizer +12dB – THD ratio (1 kHz)

Since a signal level of 0 dBFS was used the THD-ratio and THD-level are giving the same result.

3.1.1.8 Latency

Table 14. SDK – FWD – latency – measurement settings

Setting	Value
stimulus type	pseudo random sequence
noise shape	pink
sequence length	16 k
signal level	0 dBFS

Table 15. SDK – FWD – latency

Board	Channel	Latency setting (ms)	Latency (ms)
SDK	FWD	15	15.3
SDK	FWD	20	20.3
SDK	FWD	25	25.3
SDK	FWD	30	30.3
SDK	FWD (EQ 0dB enabled)	20	22.1
SDK	FWD (MBDRC enabled)	20	22.1

3.1.2 Forward channel: I²S to analog

In this section, I²S audio signals from the APX525 are injected in the NxH3670 dongle.

The audio is sampled at 48 kHz and is using a 24-bit resolution. At the headset, the audio is measured at the headphone output of the codec. The codec is loaded with a 32 Ω resistor on the L and R channel (see Figure 24).

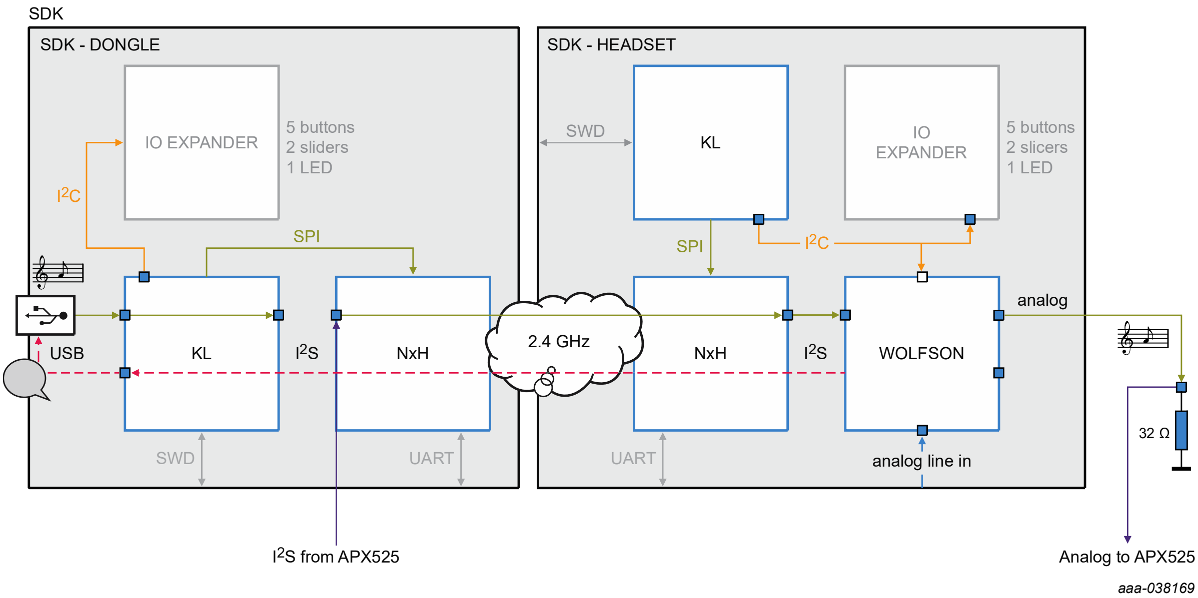


Figure 24. SDK – FWD – I2S to analog

3.1.2.1 SNR

Table 16. SDK – FWD – SNR – analog – measurement settings

Setting	Value
low pass filter	20 kHz
high pass filter	20 Hz
input level	0 dBFS
frequency	1 kHz
headphone volume	maximum
dither	off
weithing filter	None

Table 17. SDK – FWD – SNR – analog at headphone side

Board	Channel	SNR (dB)
SDK	FWD	90

3.1.2.2 Analog noise floor level

Table 18. SDK – FWD – analog noise floor – measurement settings

Setting	Value
low pass filter	20 kHz
high pass filter	20 Hz
input level	none
headphone volume	maximum
dither	off
weighting	none

Table 19. SDK – FWD – analog noise floor

Board	Channel	Noise Floor (μVrms)
SDK	FWD	8.1

3.1.2.3 THD+N

Table 20. SDK – FWD – SNR – analog – measurement settings

Setting	Value
low pass filter	20 kHz
high pass filter	20 Hz
input level	0 dBFS
frequency	1 kHz
headphone volume	maximum
dither	off
weighting	none

Table 21. SDK – FWD – THD+N on the analog headset

Board	Channel	THD+N (dB)
SDK	FWD	−66 (for an ouput level of 263mVrms)

3.1.3 Forward channel: analog to analog

For this measurement, an analog signal is injected in the analog dongle and measured at the headphone output of the headset.

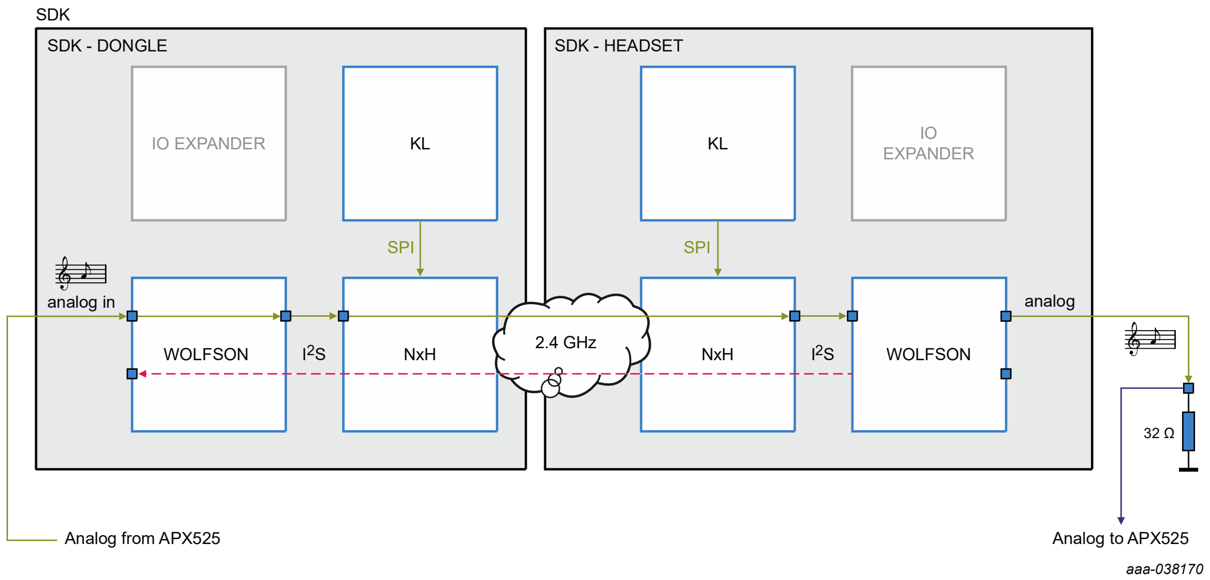


Figure 25. SDK – FWD – analog dongle and analog headset

3.1.3.1 SNR

Table 22. SDK – FWD – SNR – Measurement Settings

Setting	Value
input level	250 mV (RMS)
low pass filter	20 kHz elliptical
high pass filter	20 Hz elliptical
audio frequency	1 kHz
weighting	none

Table 23. SDK – FWD – SNR of analog dongle with analog headset

Board	Channel	SNR (dB)
SDK	FWD	84

3.1.3.2 THD+N

The settings of Section 3.1.3.1 are used.

Table 24. SDK – FWD – SNR – Measurement Settings

Setting	Value
input level	250 mV (RMS)
low pass filter	20 kHz elliptical
high pass filter	20 Hz elliptical
audio frequency	1 kHz
weighting	none

Table 25. SDK – FWD – THD+N of analog dongle with analog headset

Board	Channel	THD+N (dB)
SDK	FWD	-65

3.1.3.3 Stepped level response

Table 26. SDK – FWD – stepped level response – measurement settings

Setting	Value
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	51
start level	10 µV (RMS)
stop level	1 V (RMS)
frequency	1 kHz

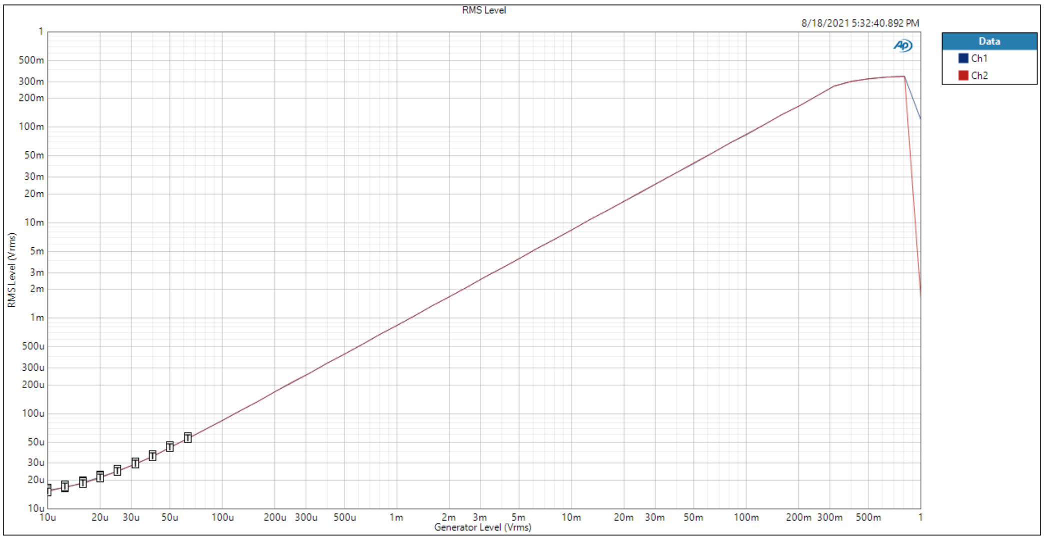


Figure 26. SDK – FWD – stepped level response for the analog dongle and analog headset

3.1.4 Back channel: I^2S to I^2S

In this section, I^2S audio signals from the APX525 are directly connected to the NxH3670. The I^2S receiver is connected to the dongle while the I^2S transmitter is connected to the headset. The audio is sampled at 48 kHz and is using a 16-bit resolution (see Figure 27).

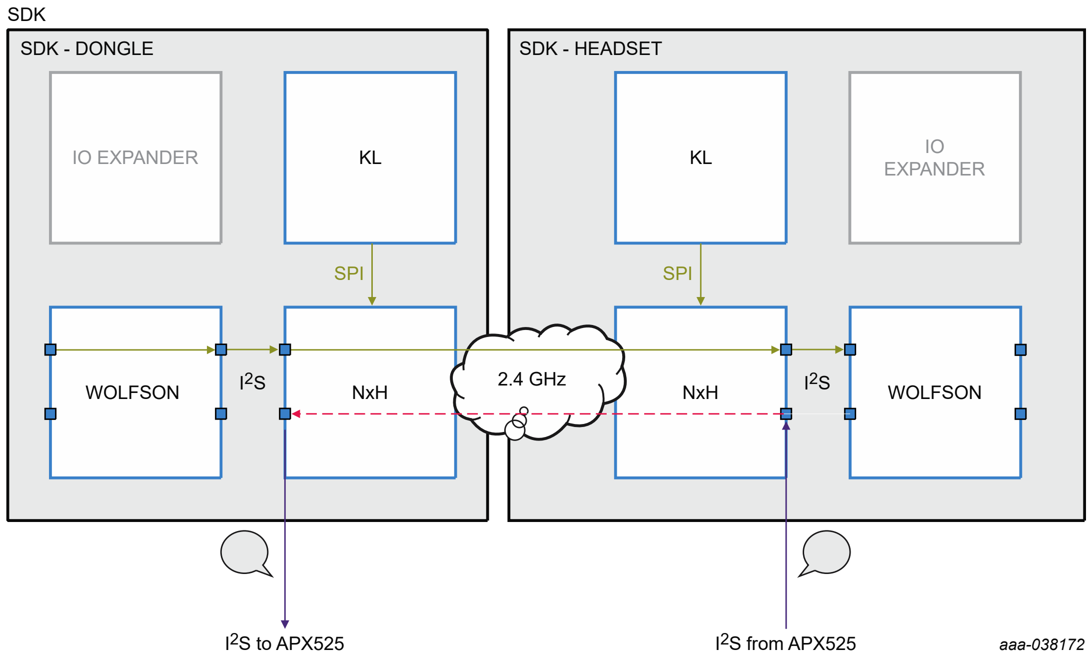


Figure 27. SDK – BWD – I^2S to I^2S

3.1.4.1 SNR

Table 27. – Measurement settings

Setting	Value
signal level	0 dBFS
low pass filter	20 kHz elliptical
high pass filter	20 Hz elliptical
weighting filter	A-wt
audio frequency	1 kHz

Table 28. SDK – FWD – SNR – dither off

Board	Channel	Dithering	SNR (dB)
SDK	BWD	Off	78

3.1.4.2 Frequency sweep

Table 29. SDK – BWD – frequency sweep – measurement settings

Setting	Value
signal level	0 dBFS
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	256
start frequency	20 Hz
stop frequency	20 kHz

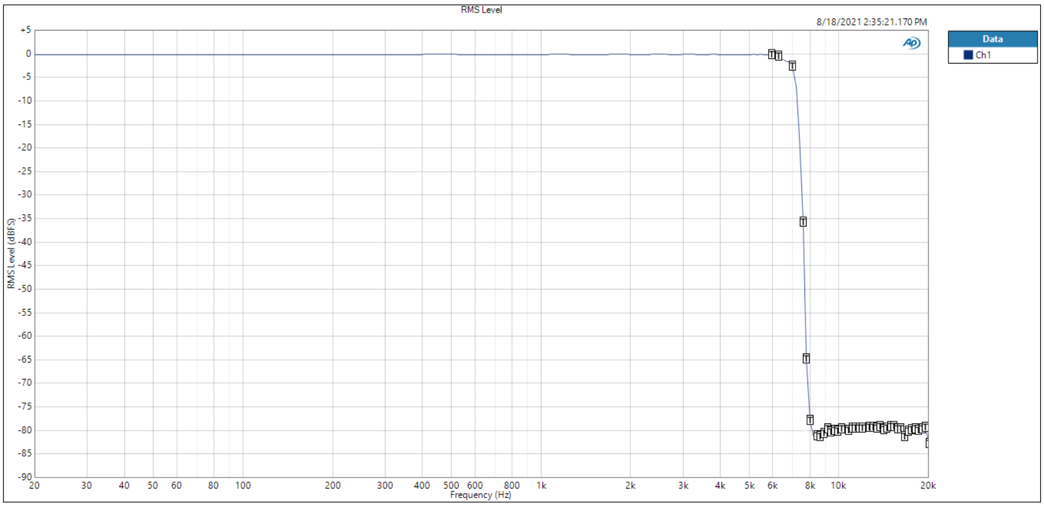


Figure 28. SDK – BWD – frequency response

The bandwidth of the back channel is just below 7 kHz.

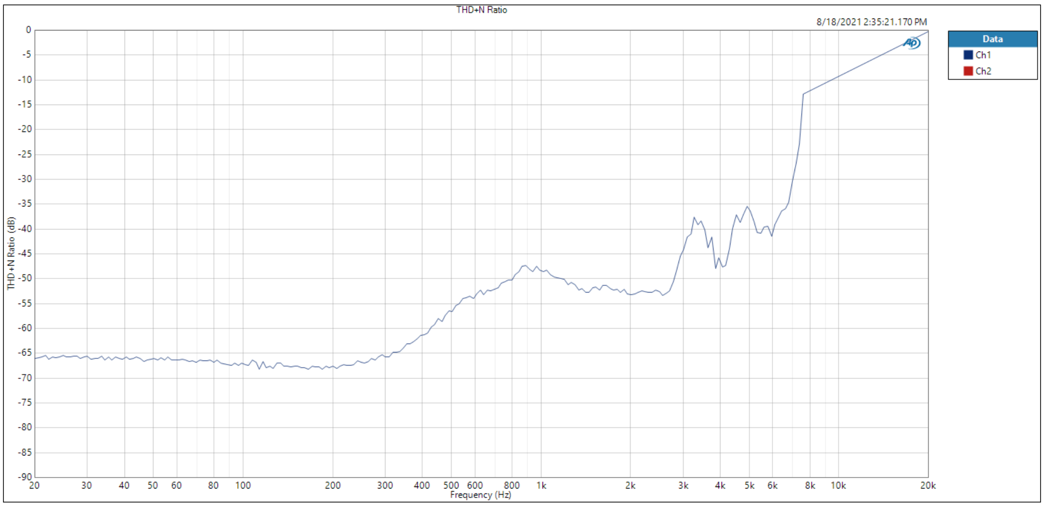


Figure 29. SDK – BWD – THD+N ratio (sweep)

Since a signal level of 0 dBFS was used the THD-ratio and THD-level are giving the same result.

Only the results for frequencies higher than 6 kHz (out of band) are different.

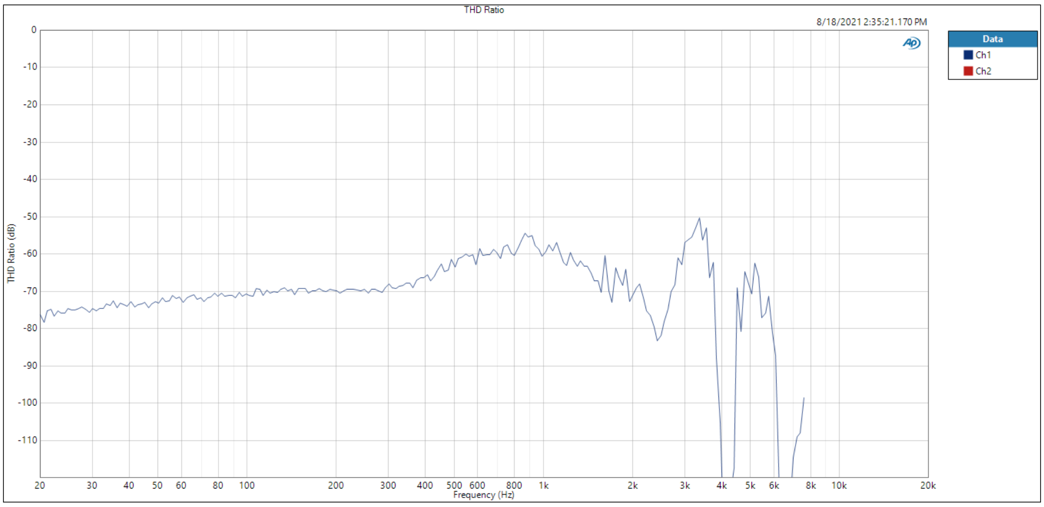


Figure 30. SDK – BWD – THD ratio (sweep)

Since a signal level of 0 dBFS was used the THD-ratio and THD-level are giving the same result.

3.1.4.3 Frequency sweep bit depth 16

Table 30. SDK – BWD bit depth 16 – frequency sweep – measurement settings

Setting	Value
signal level	0 dBFS
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	256
start frequency	20 Hz
stop frequency	20 kHz

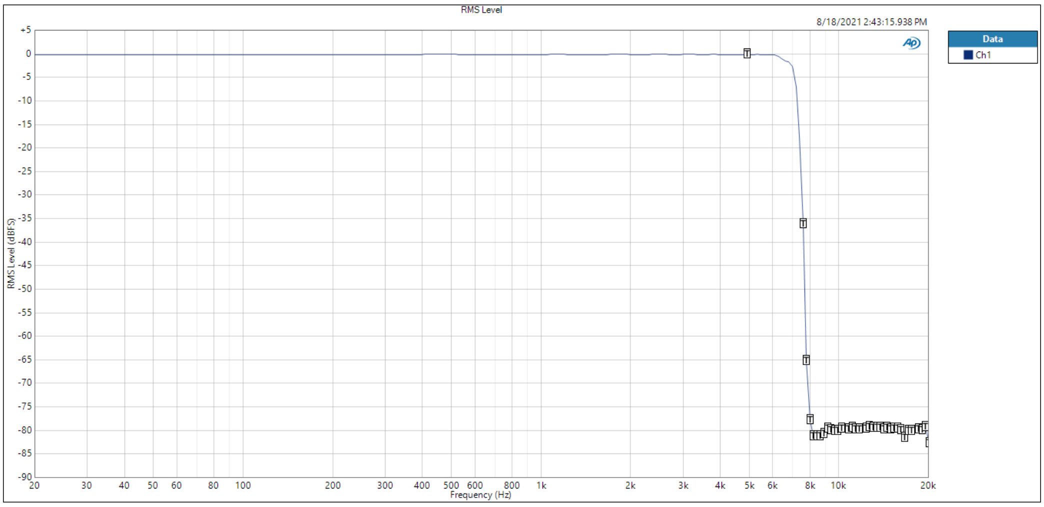


Figure 31. SDK – BWD bit depth 16 – frequency response

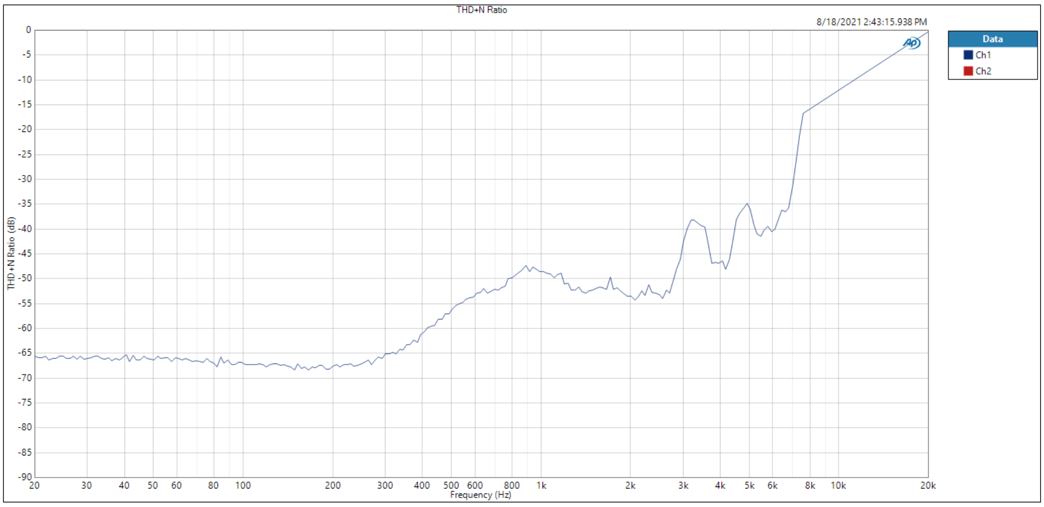


Figure 32. SDK – BWD bit depth 16 – THD+N ratio (sweep)

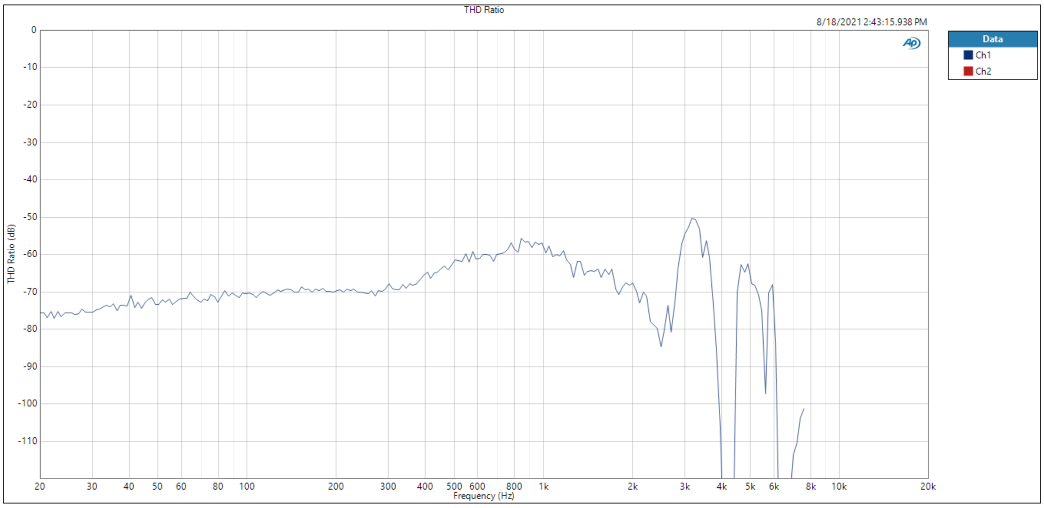


Figure 33. SDK – BWD bit depth 16 – THD ratio (sweep)

3.1.4.4 Frequency sweep equalizer -12dB

Table 31. SDK – BWD equalizer -12dB – frequency sweep – measurement settings

Setting	Value
signal level	-6 dBFS
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	256
start frequency	20 Hz
stop frequency	20 kHz

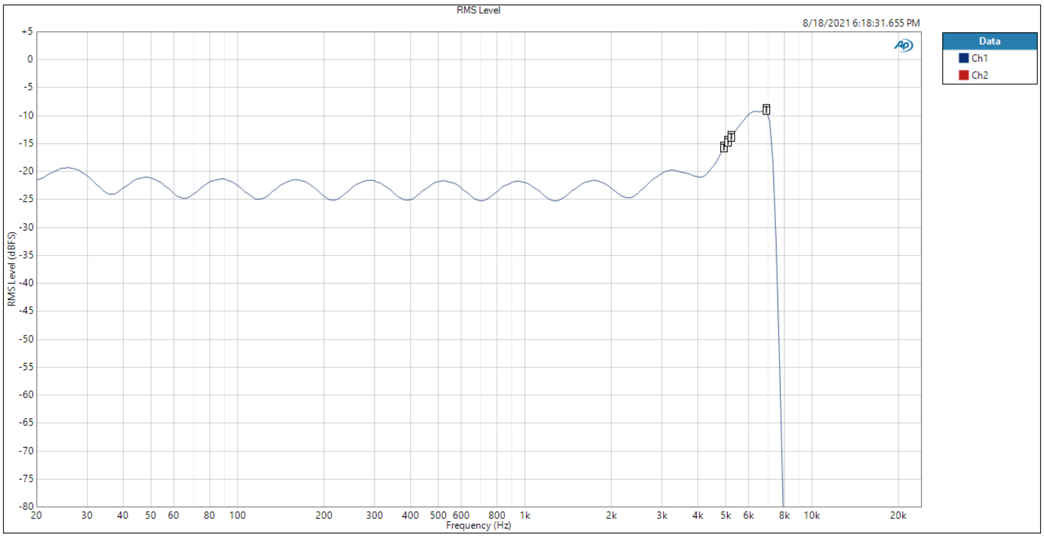


Figure 34. SDK – BWD equalizer -12dB – frequency response

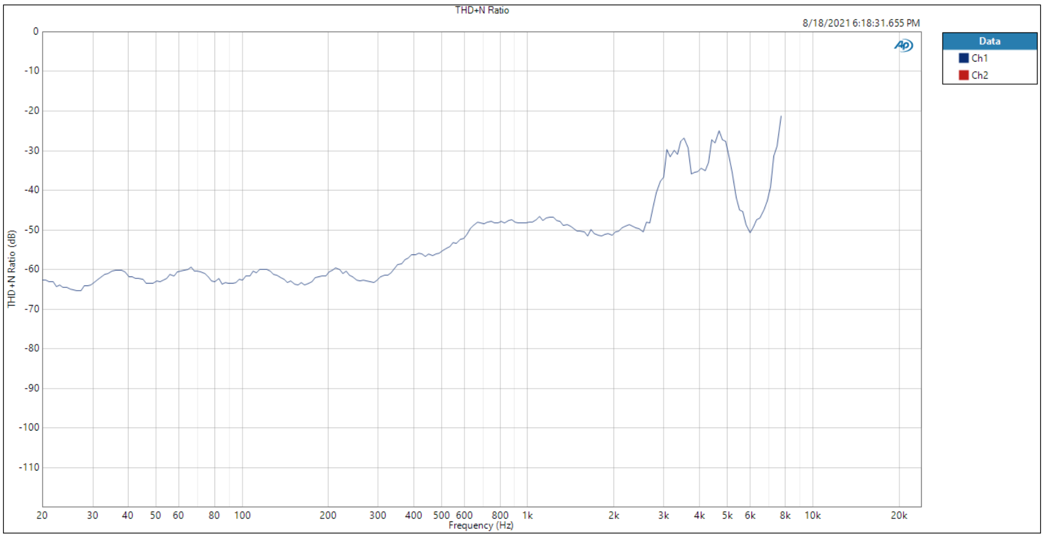


Figure 35. SDK – BWD equalizer -12dB – THD+N ratio (sweep)

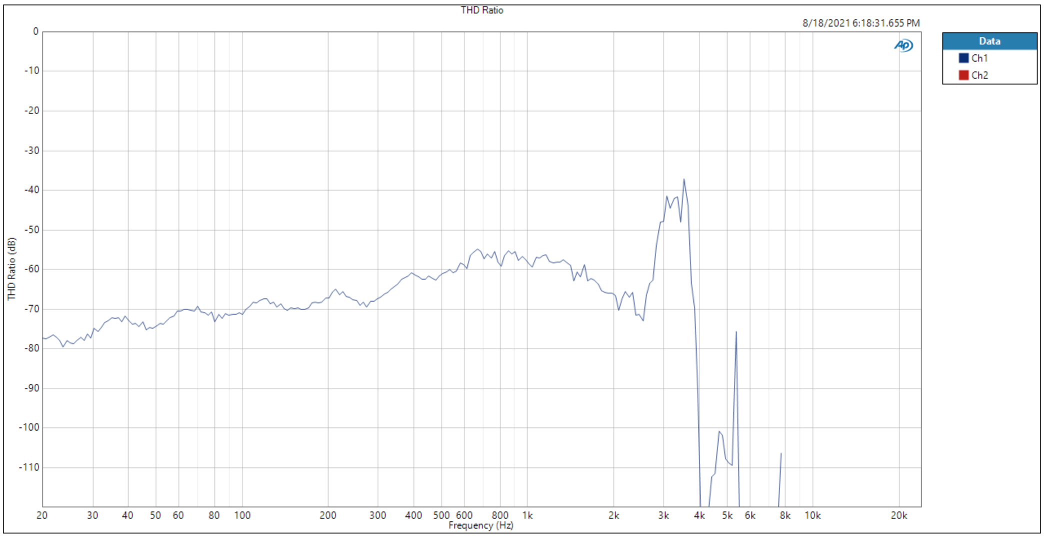


Figure 36. SDK – BWD equalizer -12dB – THD ratio (sweep)

3.1.4.5 Frequency sweep equalizer +12dB

Table 32. SDK – BWD equalizer +12dB – frequency sweep – measurement settings

Setting	Value
signal level	-20 dBFS
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	256
start frequency	20 Hz
stop frequency	20 kHz

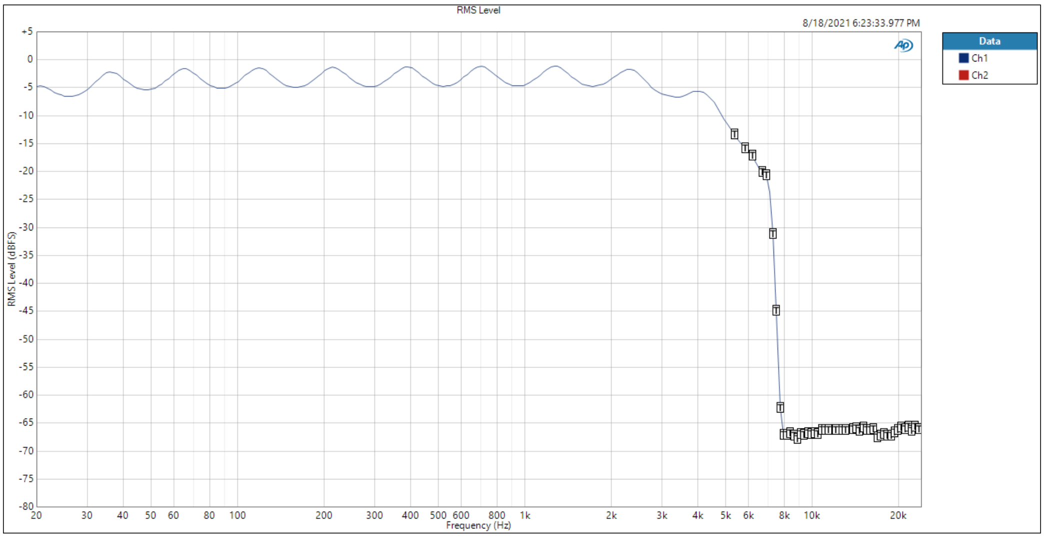


Figure 37. SDK – BWD equalizer +12dB – frequency response

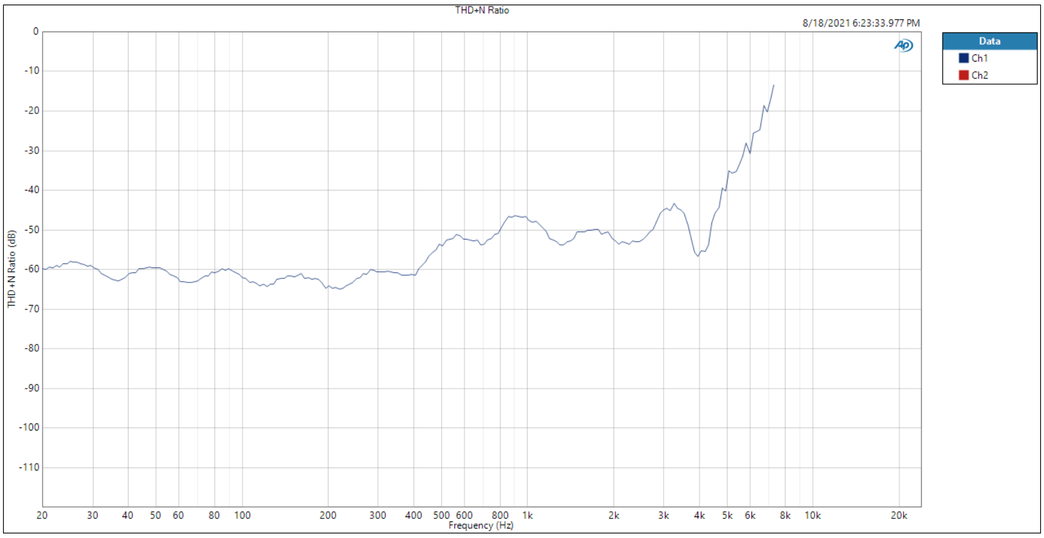


Figure 38. SDK – BWD equalizer +12dB – THD+N ratio (sweep)

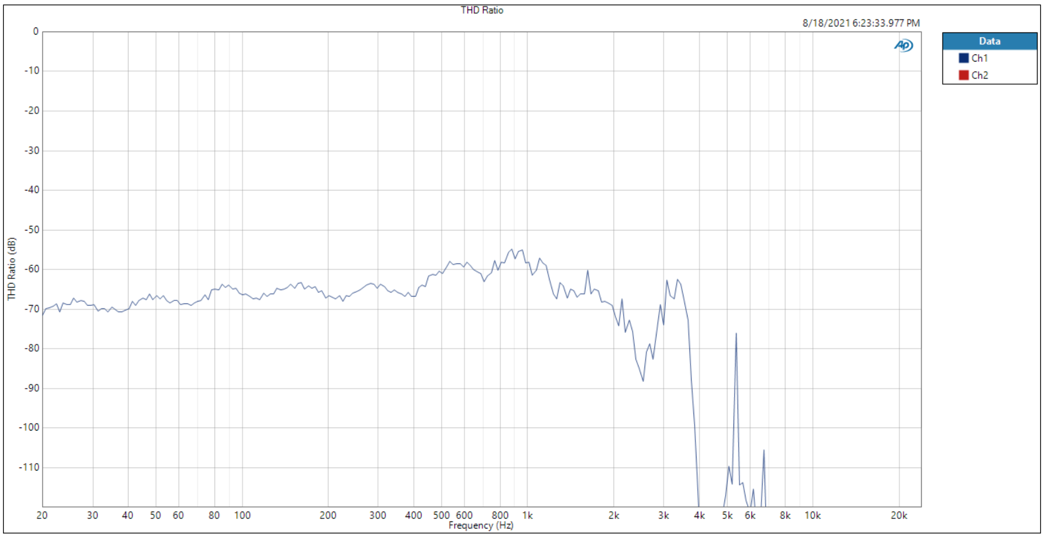


Figure 39. SDK – BWD equalizer +12dB – THD ratio (sweep)

3.1.4.6 Stepped level response

Table 33. SDK – BWD – stepped level response – measurement settings

Setting	Value
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	151
start level	−150 dBFS
stop level	0 dBFS
frequency	1 kHz

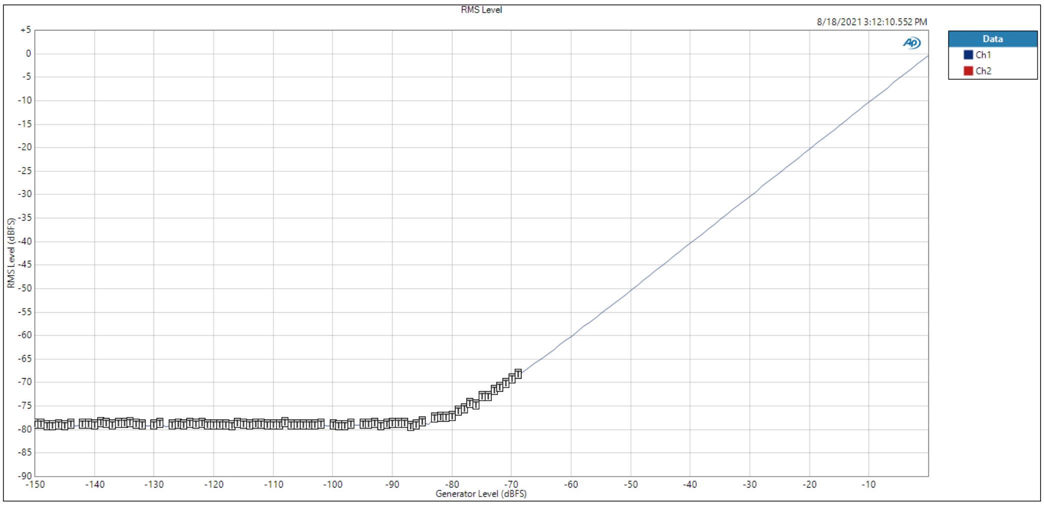


Figure 40. SDK – BWD – stepped level response

An attenuation of 2 dB is observed. Figure 41 shows this 2 dB dip can be observed in the frequency response.

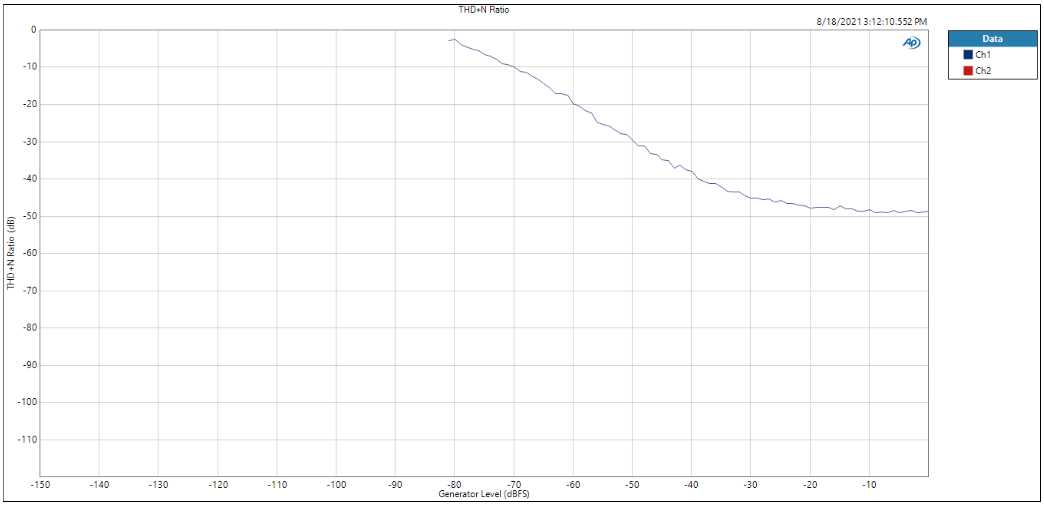


Figure 41. SDK – BWD – THD+N ratio (1 kHz)

Since a signal level of 0 dBFS was used the THD-ratio and THD-level give the same result.

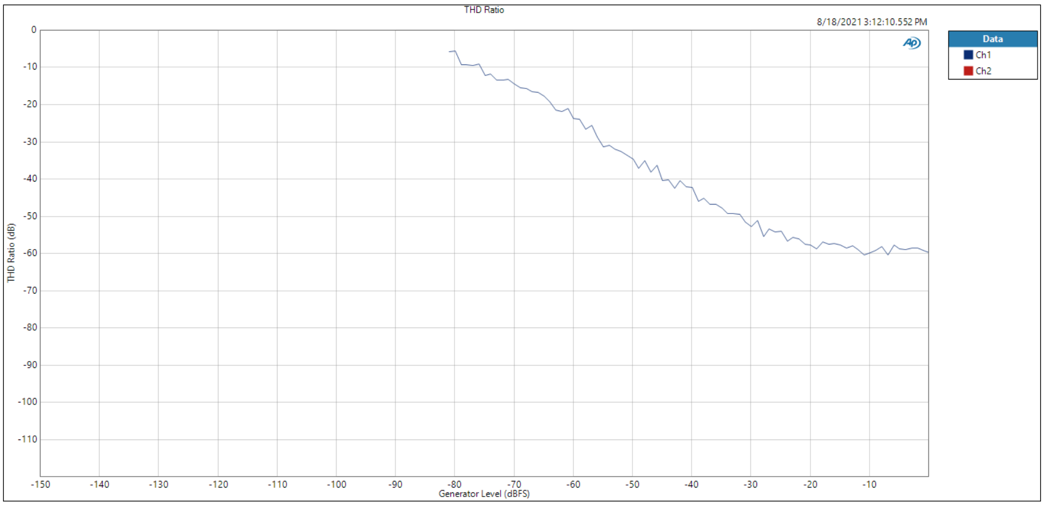


Figure 42. SDK – BWD – THD ratio (1 kHz)

Since a signal level of 0 dBFS was used the THD-ratio and THD-level give the same result.

3.1.4.7 Stepped level response bit depth 16

Table 34. SDK – BWD bit depth 16 – stepped level response – measurement settings

Setting	Value
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	151
start level	−150 dBFS
stop level	0 dBFS
frequency	1 kHz

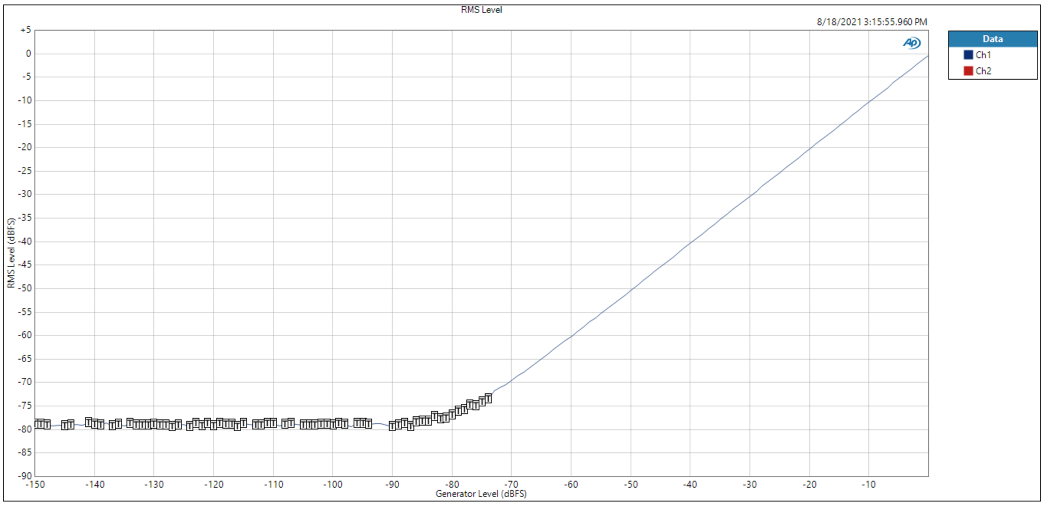


Figure 43. SDK – BWD bit depth 16 – stepped level response

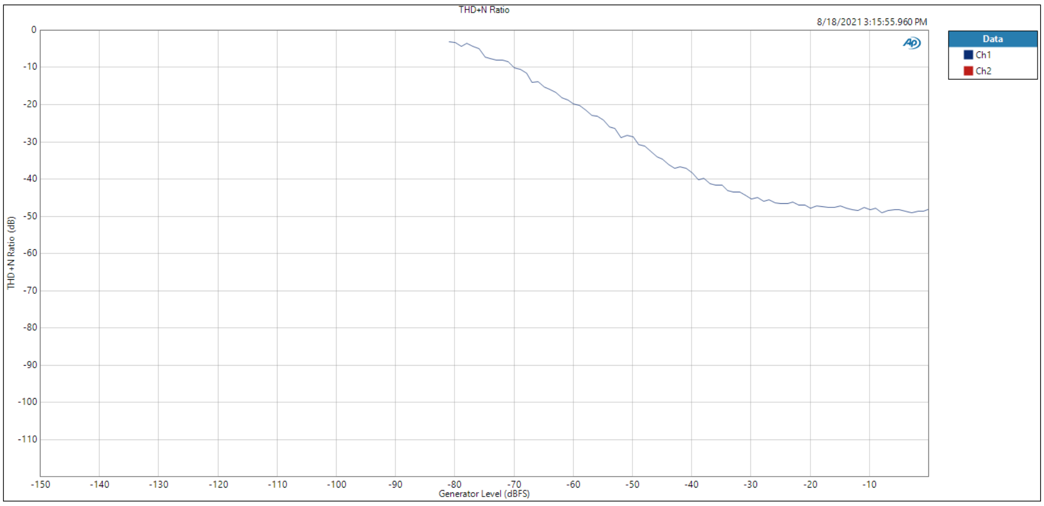


Figure 44. SDK – BWD bit depth 16 – THD+N ratio (1 kHz)

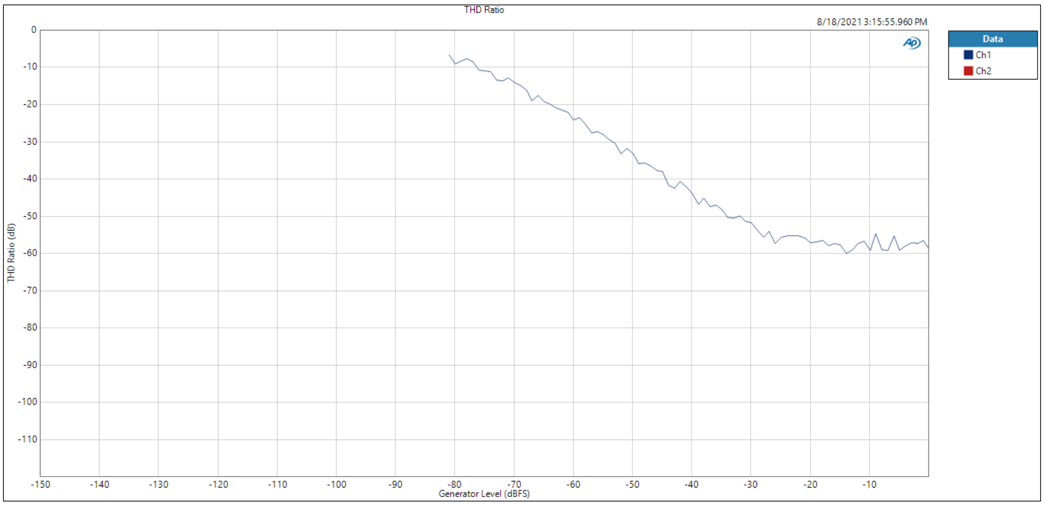


Figure 45. SDK – BWD bit depth 16 – THD ratio (1 kHz)

3.1.4.8 Stepped level response equalizer -12dB

Table 35. SDK – BWD equalizer -12dB – stepped level response – measurement settings

Setting	Value
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	151
start level	−150 dBFS
stop level	0 dBFS
frequency	1 kHz

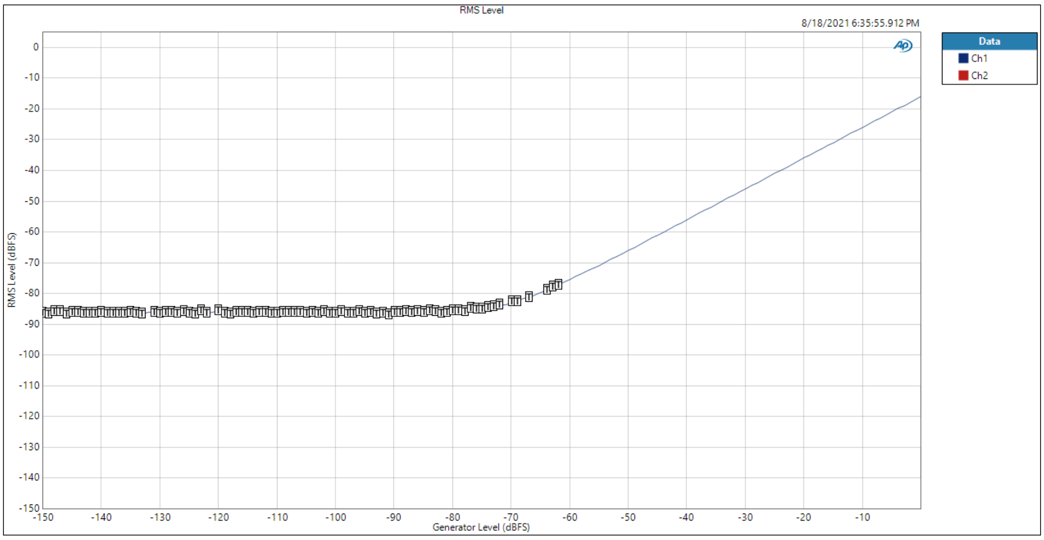


Figure 46. SDK – BWD equalizer -12dB – stepped level response

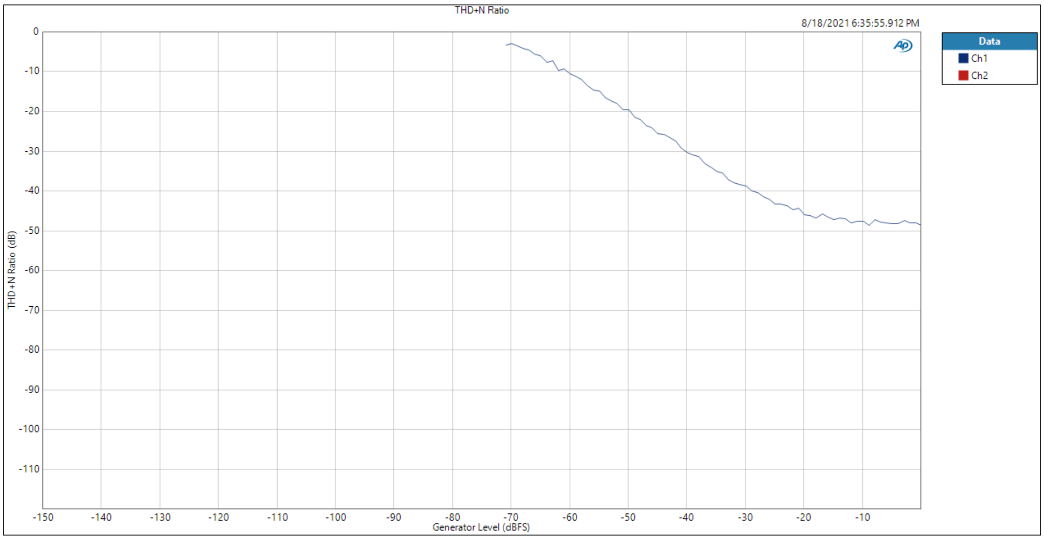


Figure 47. SDK – BWD equalizer -12dB – THD+N ratio (1 kHz)

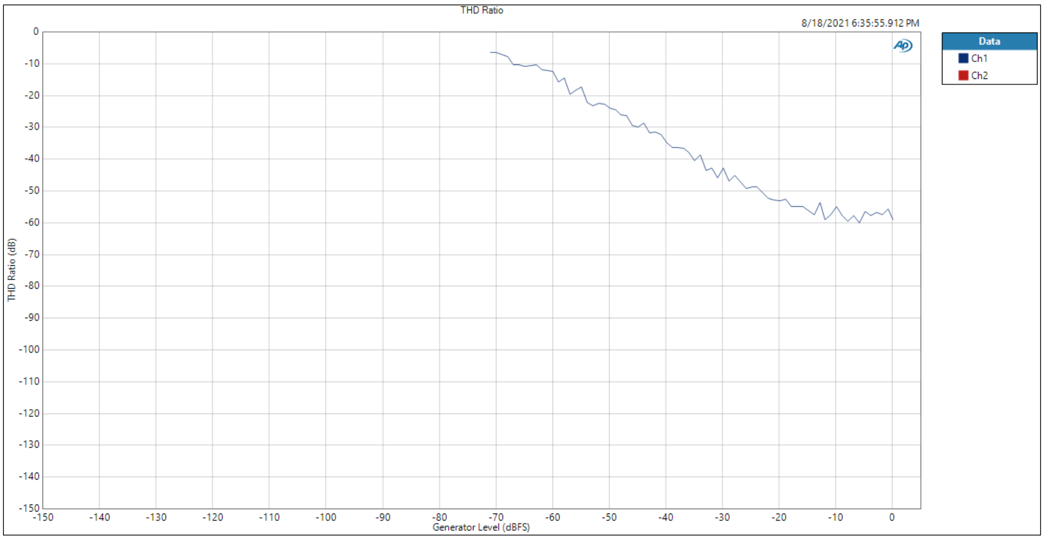


Figure 48. SDK – BWD equalizer -12dB – THD ratio (1 kHz)

3.1.4.9 Stepped level response equalizer +12dB

Table 36. SDK – BWD equalizer +12dB – stepped level response – measurement settings

Setting	Value
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	151
start level	−150 dBFS
stop level	0 dBFS
frequency	1 kHz

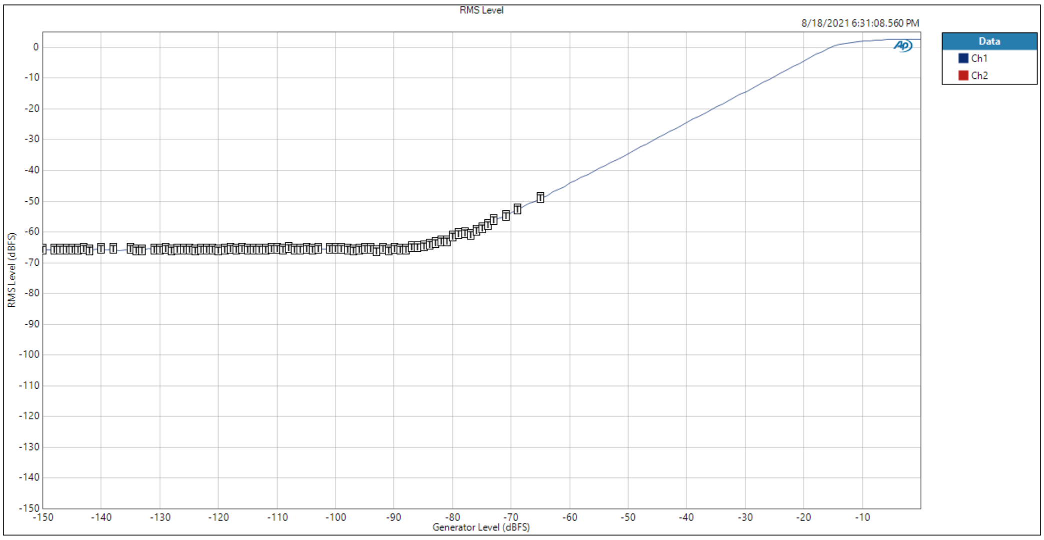


Figure 49. SDK – BWD equalizer +12dB – stepped level response

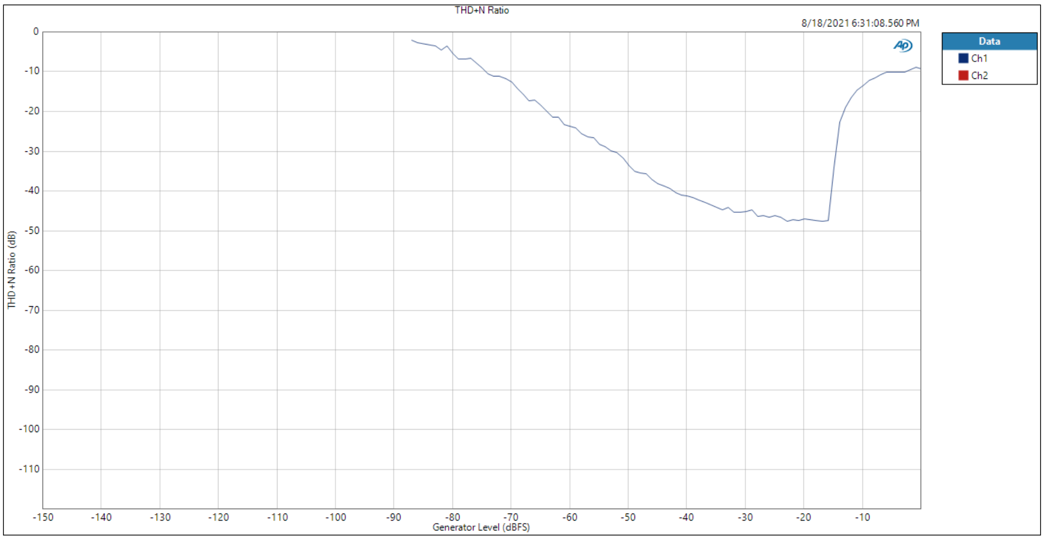


Figure 50. SDK – BWD equalizer +12dB – THD+N ratio (1 kHz)

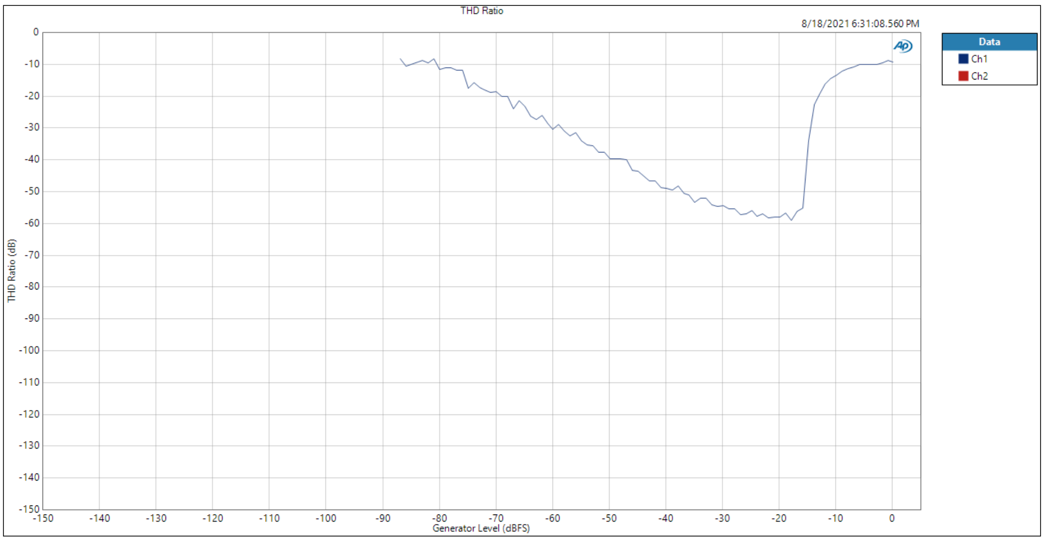


Figure 51. SDK – BWD equalizer +12dB – THD ratio (1 kHz)

3.1.4.10 Latency

Table 37. SDK – BWD – latency – measurement settings

Setting	Value
stimulus type	pseudo random sequence
noise shape	pink
sequence length	16 k
signal level	0 dBFS

Table 38. SDK – BWD – latency

Board	Channel	Latency setting (ms)	Latency (ms)
SDK	BWD	15	25.0
SDK	BWD	20	30.2
SDK	BWD	25	35.3
SDK	BWD	30	40.0
SDK	BWD (EQ 0dB enabled)	20	29.9
SDK	BWD (NG enabled)	20	29.9

The latency on the backward channel is directly coupled to the (selected) latency on the forward channel.

3.1.5 Back channel: Analog to I²S

In this section, analog audio signals from the APX525 are directly connected to the NxH3670 headset. The I²S signal of the dongle is fed back to the APX525. The audio is sampled at 48 kHz and is using a 16-bit resolution (see Figure 52).

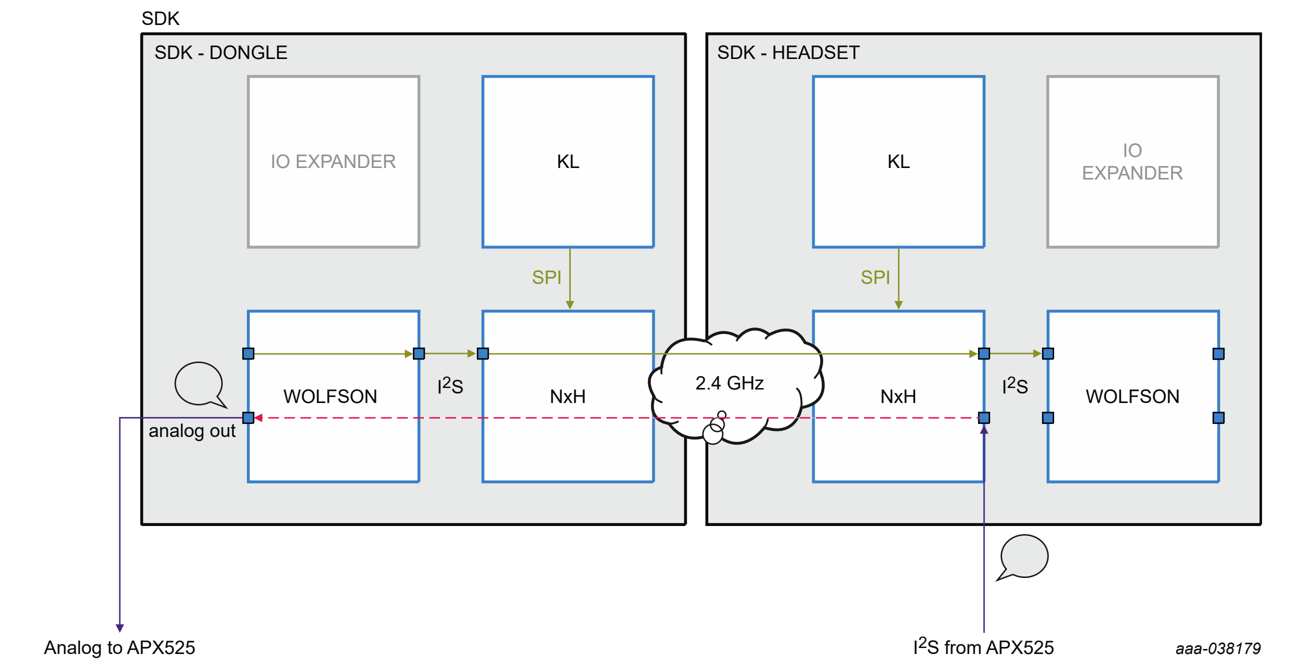


Figure 52. SDK – BWD – I²S to analog

3.1.5.1 SNR

Table 39. SDK – BWD – SNR – measurement Settings

Setting	Value
input level	300 mV (RMS)
frequency	1 kHz
low pass filter	20 kHz elliptical
high pass filter	20 Hz elliptical
weighting filter	Signal Path

Table 40. SDK – BWD – SNR including codec

Board	Channel	SNR (dB)
SDK	BWD	79

3.1.5.2 Noise floor

Table 41. SDK – BWD – digital noise floor – measurement settings

Setting	Value
low pass filter	20 kHz elliptical
high pass filter	20 Hz elliptical
weighting filter	Signal Path

Table 42. SDK – BWD – digital noise floor including codec

Board	Channel	Noise Floor (dB)
SDK	BWD	−79

3.1.5.3 TDH+N

Table 43. SDK – BWD – THD+N – measurement Settings

Setting	Value
input level	300 mV (RMS)
frequency	1 kHz
low pass filter	20 kHz elliptical
high pass filter	20 Hz elliptical
weighting filter	Signal Path

Table 44. SDK – BWD – THD+N including codec

Board	Channel	THD+N (dB)
SDK	BWD	−48

3.2 NXH3670ADK board

3.2.1 Forward channel: I^2S to analog

In this section, an NXH3670SDK board is used as a dongle because it is not possible to inject I^2S audio on the NXH3670ADK dongle. The analog audio is measured at the NXH3670ADK headset. The headphone output of the codec is loaded with a 32 Ω resistor for the L and R channel (Figure 53).

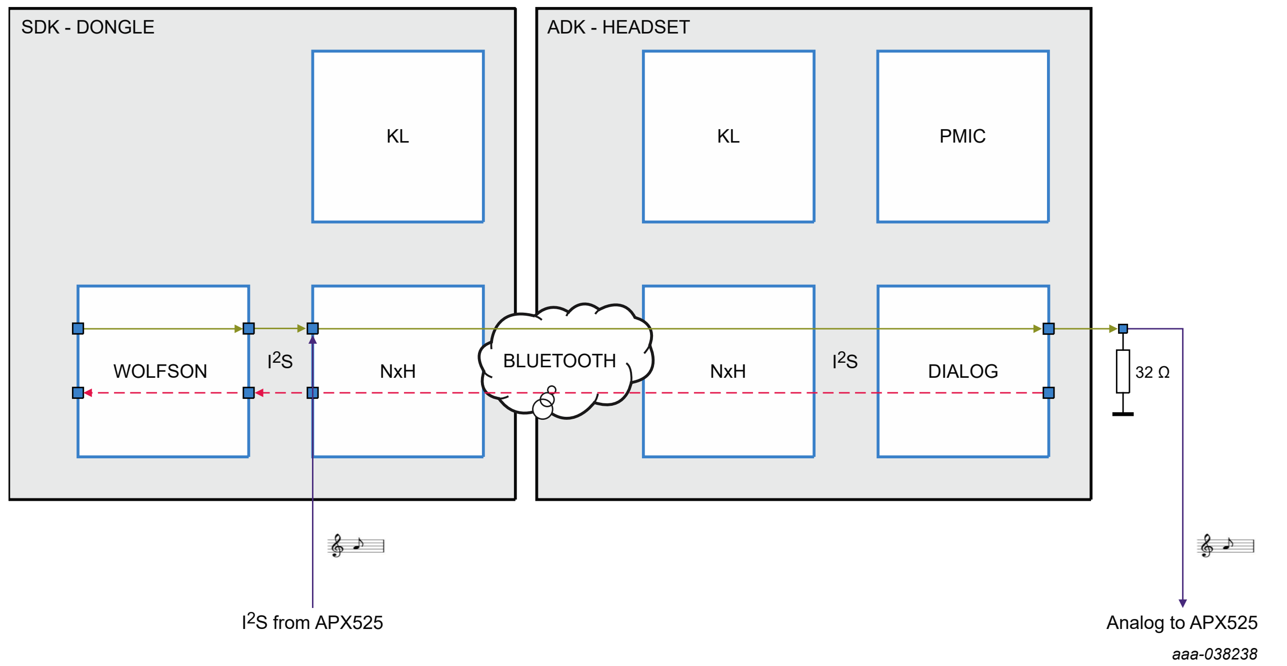


Figure 53. ADK – FWD – I^2S to analog

3.2.1.1 SNR

Table 45. ADK – FWD – SNR – measurement settings

Setting	Value
low pass filter	20 kHz
high pass filter	20 Hz
input level	0 dBFS
frequency	1 kHz
headphone volume	maximum
dither	off
weighting	A-weight

Table 46. ADK – FWD – analog SNR including codec

Board	Channel	SNR (dB)
ADK	FWD	94

3.2.1.2 Analog noise floor measurement

Table 47. ADK – FWD – Analog noise floor – measurement settings

Setting	Value
low pass filter	20 kHz elliptical
high pass filter	20 Hz elliptical
weighting filter	Signal Path

Table 48. ADK – FWD – analog noise floor including codec

Board	Channel	Noise Floor (μVrms)
ADK	FWD	6.3

3.2.1.3 THD+N

Table 49. ADK – FWD – THD+N including codec – measurement settings

Setting	Value
signal level	0 dBFS
low pass filter	20 kHz
high pass filter	20 Hz
frequency	1 kHz
headphone volume	max
dither	off

Table 50. ADK – FWD – THD+N including codec

Board	Channel	THD+N (dB)
ADK	FWD	−64

3.2.1.4 Stepped level response

Table 51. ADK – FWD – stepped level response – measurement settings

Setting	Value
low pass filter	signal path
high pass filter	signal path
weighting filter	signal path
number of points	151
start level	−150 dBFS
stop level	0 dBFS
frequency	1 kHz

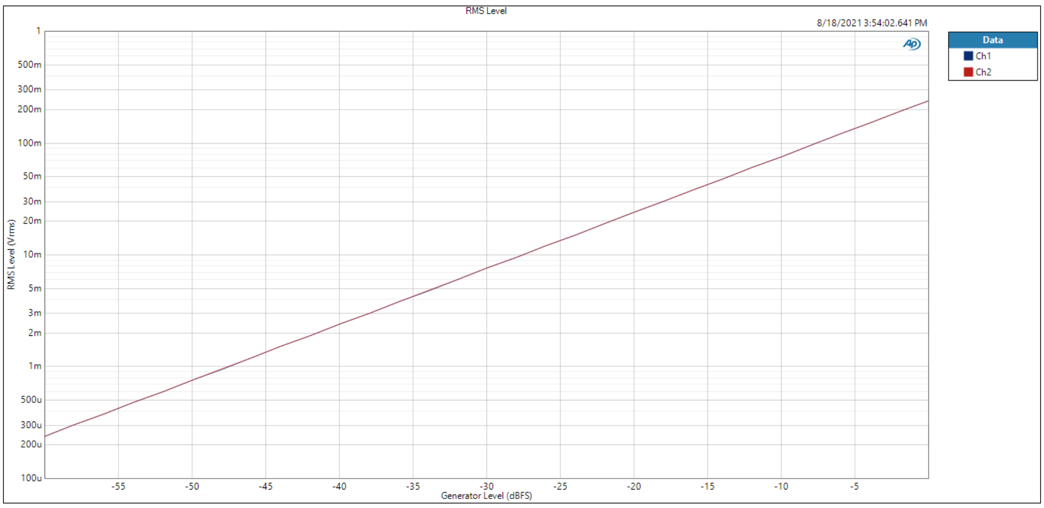


Figure 54. ADK – FWD – analog output response

3.2.2 Back channel: Analog to I^2S

In this section, an analog signal of 125 mVrms is injected in the headset and measured digitally (I^2S) at the dongle side (Figure 55).

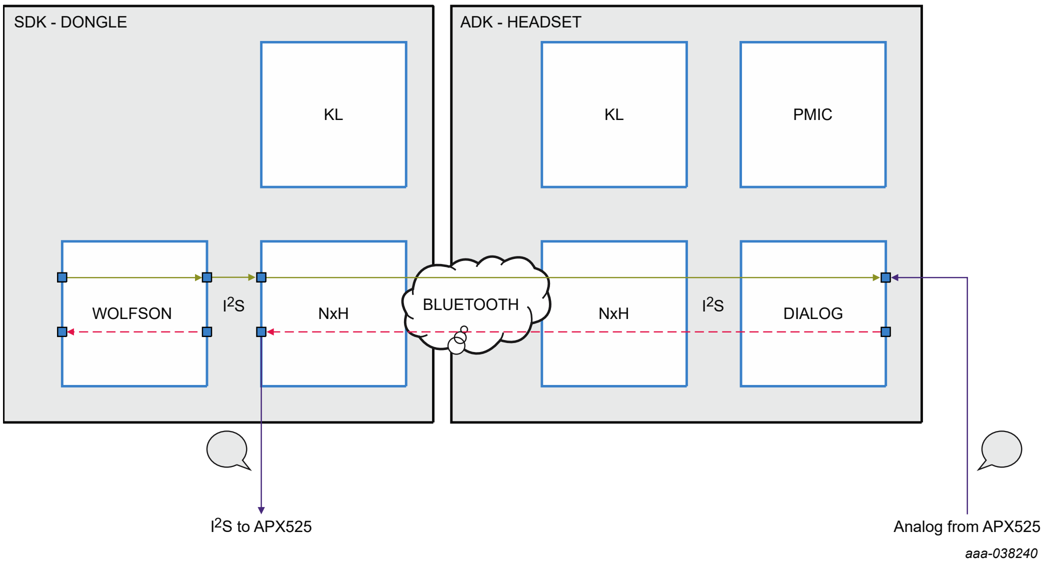


Figure 55. ADK – BWD – analog to I^2S

3.2.2.1 SNR

Table 52. ADK – BWD – SNR – measurement settings

Setting	Value
input level	125 mVrms
low pass filter	20 kHz elliptical
high pass filter	20 Hz elliptical
audio frequency	1 kHz
weighting	A-wt

Table 53. ADK – BWD – SNR including the analog input

Board	Channel	SNR (dB)
ADK	BWD	77

3.2.2.2 Digital noise floor back channel

Table 54. ADK – BWD – digital noise floor – measurement settings

Setting	Value
low pass filter	20 kHz elliptical
high pass filter	20 Hz elliptical
weighting filter	Signal Path

Table 55. SDK – BWD – digital noise floor including analog input

Board	Channel	Noise Floor (dB)
ADK	BWD	−78

3.2.2.3 THD+N

Table 56. ADK – BWD – THD+N – measurement settings

Setting	Value
signal level	125 mVrms
low pass filter	20 kHz
high pass filter	20 Hz
frequency	1 kHz

Table 57. SDK – BWD – THD+N including analog input

Board	Channel	THD+N (dB)
ADK	BWD	−48

3.3 Other audio measurements

3.3.1 Total system latency

In this section, the total system latency is measured from USB at dongle and analog output at the headset. See Figure 56 for an overview of the test setup.

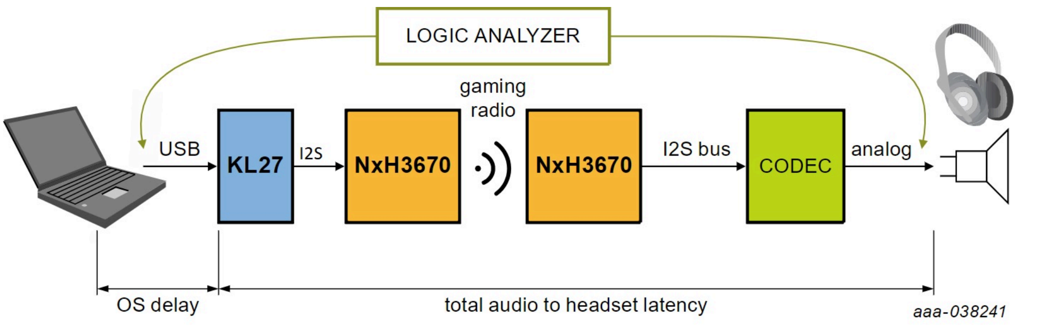


Figure 56. SDK – FWD – USB to analog

To remove the dependencies with the delays in the initial time to audio packets, a custom audio file (wav file, not mp3) with silence in the beginning (less than a second) and a sine wave that starts at its peak amplitude is used. See Figure 57 for an example audio file. Latency measurements are done between these peaks at both the USB side and the analog output side.

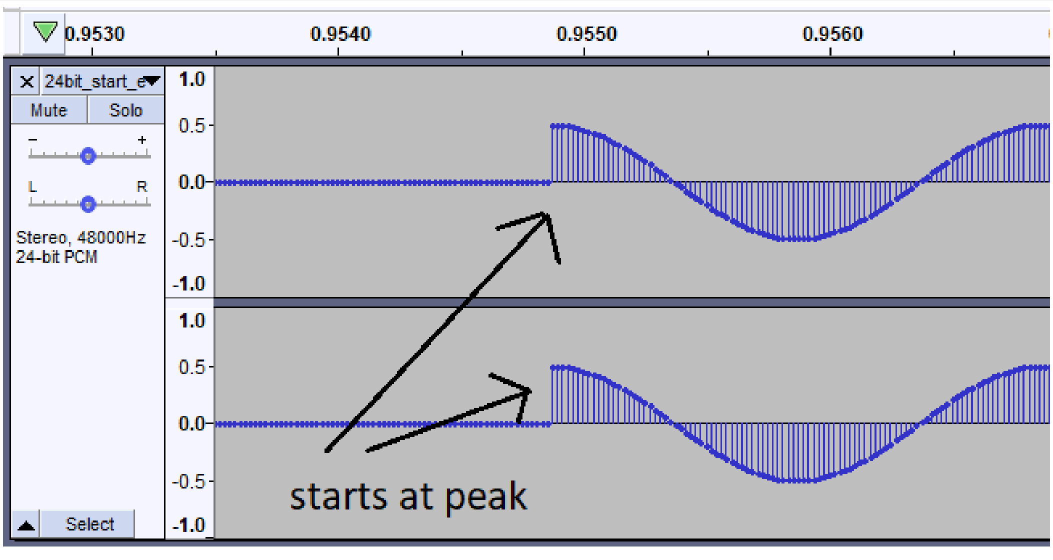


Figure 57. Sine wave starts at Peak after silence

The USB cable through which the audio signals are streamed from the PC to the NxH3670SDK dongle is sniffed using the "Saleae logic analyzer". The data from the USB is analyzed and the time of the first peak in the audio data is noted. See Figure 58 for a screenshot of logic analyzer with the first USB actual packet at USB.

At the NXH3670ADK headset, the audio is measured at the headphone output of the codec. Here again the time of the first peak in the audio is noted. See Figure 59 for a screenshot of the logic analyzer with the analog audio out at the headset. The time difference between these peaks shows the total system latency.

See Table 58 for the latest measurement values.

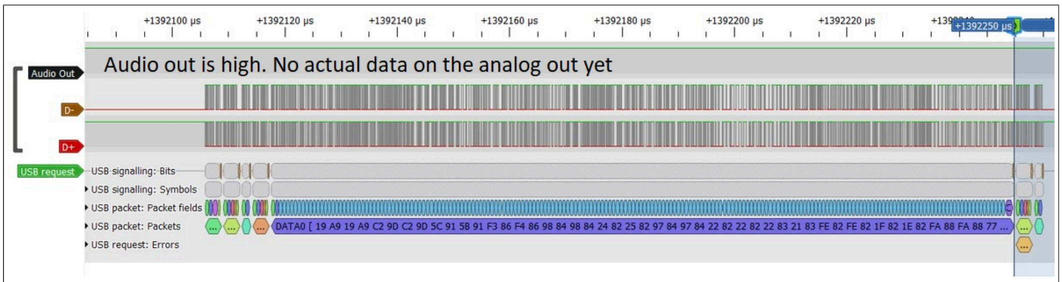


Figure 58. First actual packet at USB

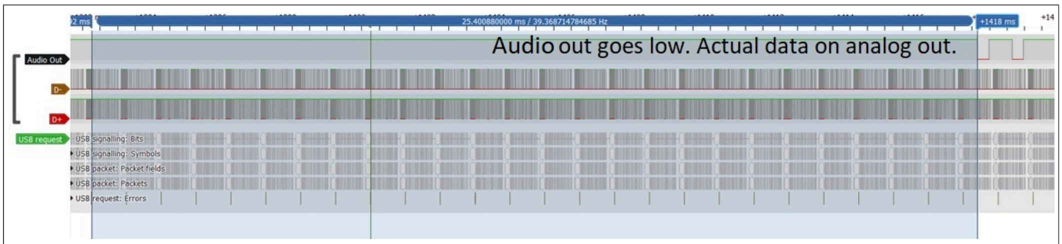


Figure 59. USB analog out measurement

Table 58. SDK – FWD – total system latency

Board	Channel	Latency (ms)
SDK	FWD	25.5 ms

3.3.2 Jitter

This section describes the procedure for jitter measurement on the forward channel.

For the backward channel, dongle and headset are swapped.

Jitter is measured by transmitting a 1 kHz sine wave.

- The sine wave is tracked at the headset side, but not recorded.
- When the actual measurement is started, one zero-crossing is taken as the reference.
- The expected future zero-crossings are now calculated.
- The deviation between expected an actual zero-crossing is calculated.
- The recording is made during exactly 120 s.
- The jitter is now calculated as:

$$jitter = \frac{(|max\_positive\_deviation| + |max\_negative\_deviation|)}{2}$$

3.3.3 Time-to-audio

Time-to-audio is the elapsed time between power-on of the headset and the dongle (simultaneously) and the moment audio is being played back.

Time-to-audio is measured using an automated setup.

Relays are used to control the moment of powering dongle and headset.

To capture the state of the relays of both dongle and headset, a Saleae analyzer is used. The Saleae also monitors the I^2S output.

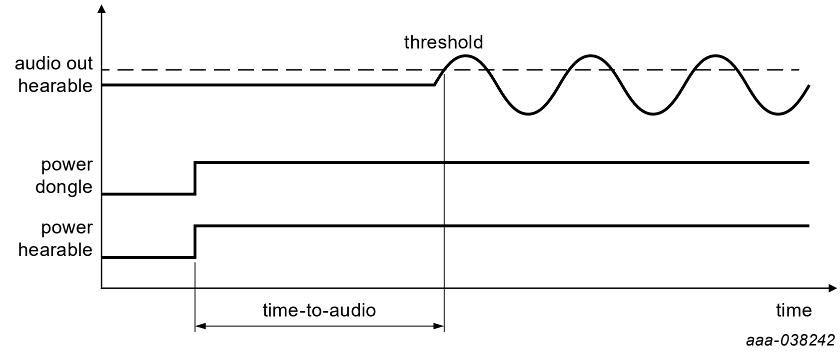


Figure 60. Time-to-audio measurement

After power-up of the dongle, the KL boot loader mode always waits for a few seconds to allow the PC to upgrade the firmware of the dongle.

This time is included in the timing above.

From the collected data, the time between switching on the relays and the start of the audio signal is measured. To avoid noise to be detected as sound, a threshold value must be exceeded.

4 Power performance

4.1 Boundary conditions

For the measurements to correspond with the values reported, the following boundary conditions are to be established:

- Record the average power over 10 seconds, starting 2 seconds after the state change has been initiated.
- When running from battery, the battery must be fully charged at the start of the test.
- When a battery is simulated, a voltage of 3.8 V is applied.
- All configurable LEDs must be switched off.
- The headphone output must have a 32 Ω load on both left and right.
- Audio is simulated with a 1 kHz sine input, producing an output level of 100 mV_{rms} on the loaded headphone output.
- Currents are measured with a Picotest M3511A.

4.2 Test details

Table 59. Power measurements boundary conditions

<table>
<tr><th></th><th>State</th><th>ADK</th><th>SDK</th></tr>
<tr><td>D</td><td>sleep</td><td>• power on dongle.
• dongle must be scanning
• put the test PC to sleep or send a USB suspend command
• immediately measure the current consumption
• record the settling time (when is the requirement reached)</td><td>• power on dongle
• dongle must be scanning
• change the slider switch that puts the dongle in sleep mode
• immediately measure the current consumption
• record the settling time (when is the requirement reached)</td></tr>
<tr><td>D</td><td>scan</td><td colspan="2">• turn the dongle ON
• leave the headset OFF, so the dongle stays in scanning mode
• wait 2 seconds after the dongle has been turned on</td></tr>
<tr><td>D</td><td>ACL only</td><td colspan="2">• turn the dongle ON
• turn the headset ON, so they can pair and set up an ACL connection.
• disable dongle as playback and as microphone device from the PC; should close the ICO connection.</td></tr>
<tr><td>D</td><td>LL audio</td><td colspan="2">• turn the dongle ON
• turn the headset ON, so they can pair and set up an ACL connection
• select the dongle as audio playback device, start playing audio from the PC; opens the ICO connection</td></tr>
<tr><td>D</td><td>stop audio (ACL only)</td><td colspan="2">• both headset and dongle are turned ON and audio is streamed
• disable dongle as playback and as microphone device from the PC; closes the ICO connection</td></tr>
<tr><td>D</td><td>stop ACL (scanning)</td><td colspan="2">• both headset and dongle are turned on and audio is streamed from the dongle to the headset
• turn off the headset but keep playing audio from PC to dongle</td></tr>
<tr><td>D</td><td>play audio (scanning)</td><td colspan="2">• turn the dongle ON, leave the headset OFF, so that the dongle stays in scanning mode
• select the dongle as audio playback device and start playing audio from the PC.</td></tr>
</table>

Table 59. Power measurements boundary conditions...*continued*

	State	ADK	SDK
	sleep	SDK: • urn the dongle ON • turn the headset ON, so both pair and connect • change the slider switch that puts the headset into sleep mode	
	advertise	• turn the headset ON • leave the dongle OFF, so the headset stays in advertising mode	
	ACL only	• turn the dongle ON • turn the headset ON, so they can pair and set up an ACL connection • Disable dongle as playback and as microphone device from the PC; should close the ICO connection	
	LL audio	• turn the dongle ON, turn the headset ON, so they can pair and set up an ACL connection • select the dongle as audio playback device • start playing audio from the PC; opens the ICO connection	
	stop audio (ACL only)	• both headset and dongle are turned ON and audio is streamed • Disable dongle as playback and as microphone device from the PC; should close the ICO connection	
	stop ACL (advertising)	• both headset and dongle are turned ON, no audio is streamed • power down the dongle, so the headset goes into advertising mode	

5 Radio link performance

5.1 Range

Range measurements are executed outdoors using two trolleys.

The setup is equipped with a reference headphone available on the market, which is not based on the NxH3670 and an NxH3670 ADK-based headphone.

The actual positioning of the headphones on the trolley is not reflected in Figure 61. Figure 62 shows the physical positioning of the headphones.

The music signal is tapped on the headphone drivers, the voice signal is injected on the solder pads of the microphone. The microphones are removed from the headphones.

The NxH3670 ADK-based headphone is built using the same mechanics as the referenced non-NxH3670 headphone.

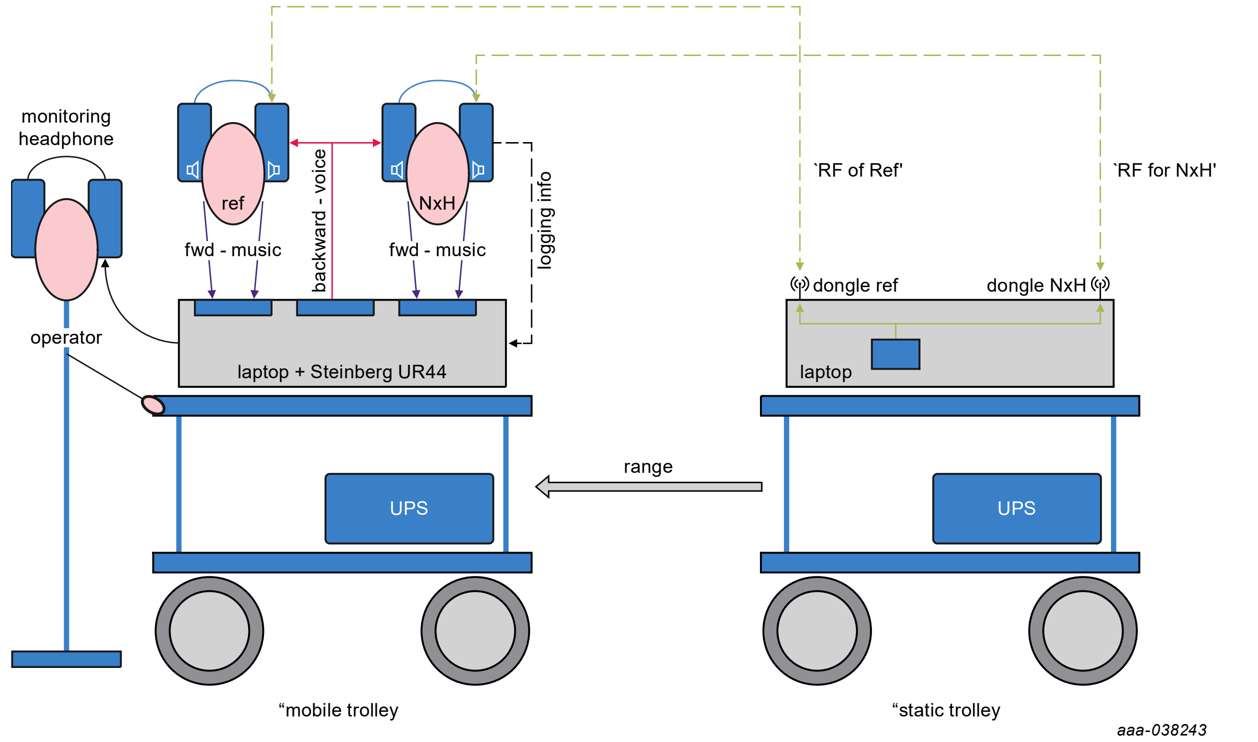


Figure 61. Range measurement using trolleys – side view

To indicate the end-of-the-usable-range, a MOS score is assigned to the recordings. The end-of-the-usable-range is the distance at which the audio quality has degraded to MOS = 1.

Figure 62 shows that the headphones are positioned on a line orthogonal to the line connecting the two trolleys. The headphones are placed on hollow dummy heads, with their antennas at the sides of the trolley.

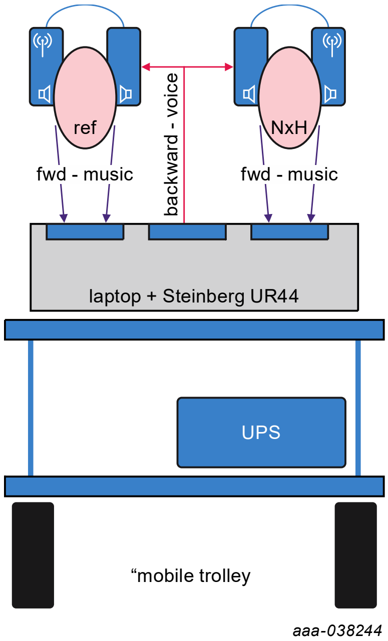


Figure 62. Range measurement using trolleys – mobile trolley – front view

5.2 Interference resilience

5.2.1 Measurement setup

To avoid the impact of external uncontrolled interferers such as WiFi and Bluetooth devices, the interference resilience test is executed inside a Faraday cage.

To maximize the reproducibility the measurement is somehow artificial and done over cable using splitters, combiners, and attenuators. The configuration used emulates a condo scenario with 5 WiFi interferers.

A path loss (PL) of 60 dB is present between the NxH3670 dongle and headset. The path loss between the dongle and headset and the different WiFi interferes are indicated in the figures below.

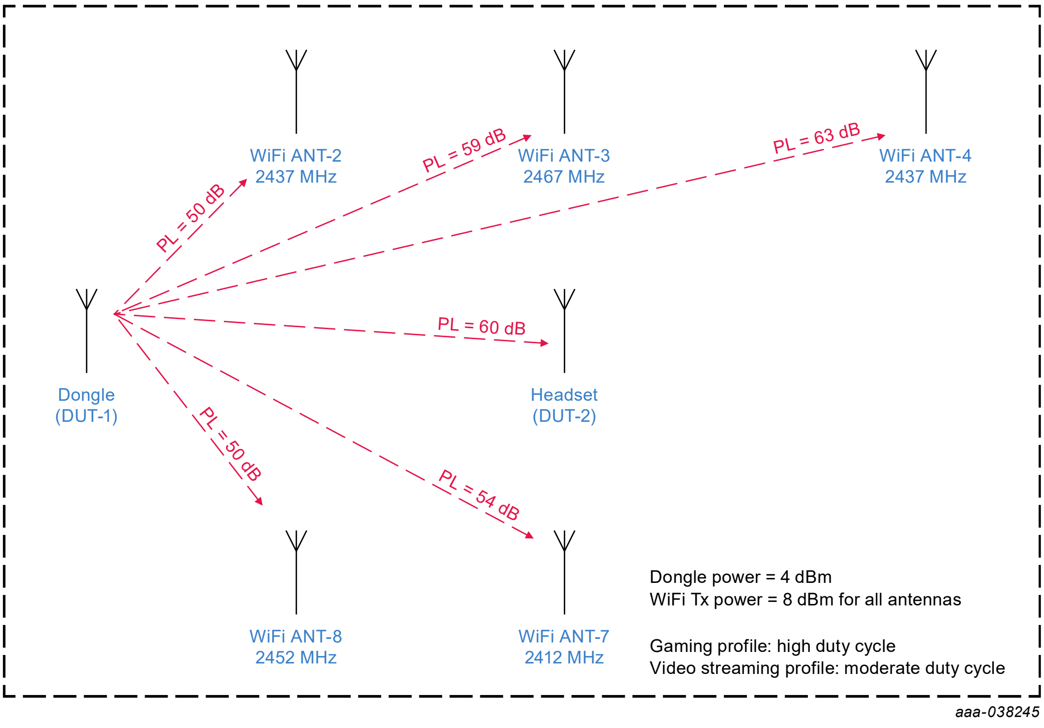


Figure 63. Measurement setup for WiFi coexistence testing - dongle configuration

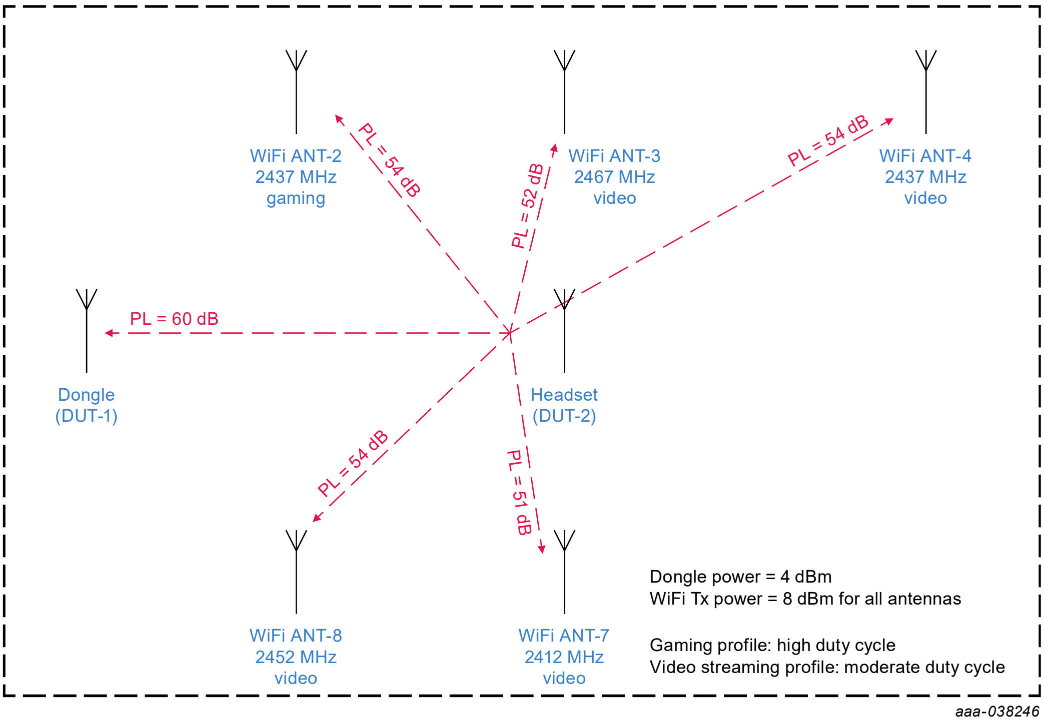


Figure 64. Measurement setup for WiFi coexistence testing - headset configuration

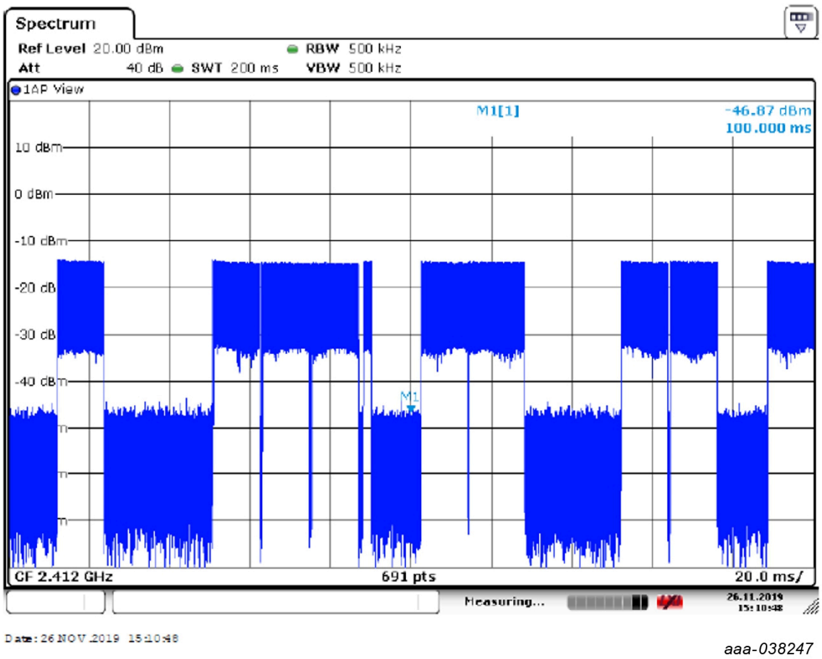


Figure 65. Gaming profile (high duty cycle)

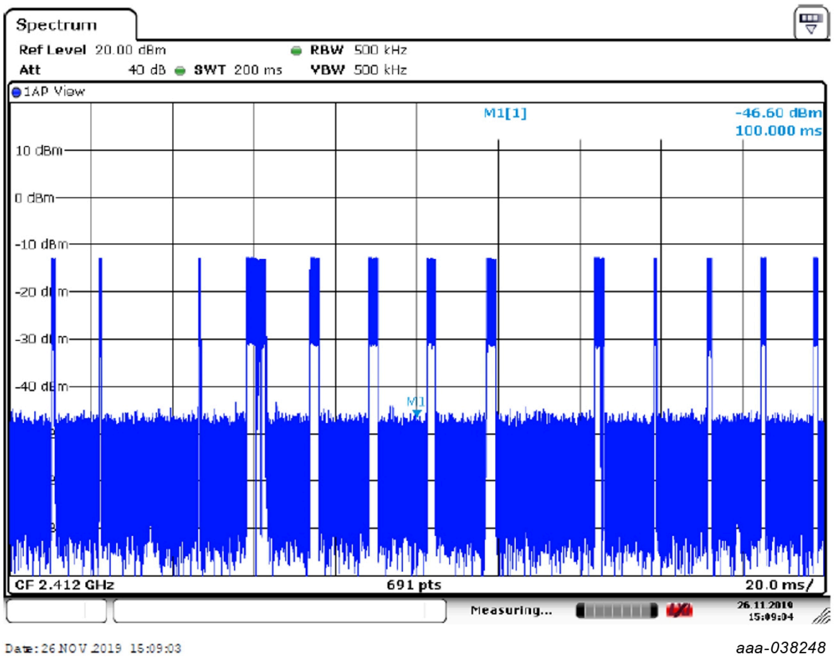


Figure 66. Video streaming profile (moderate duty cycle)

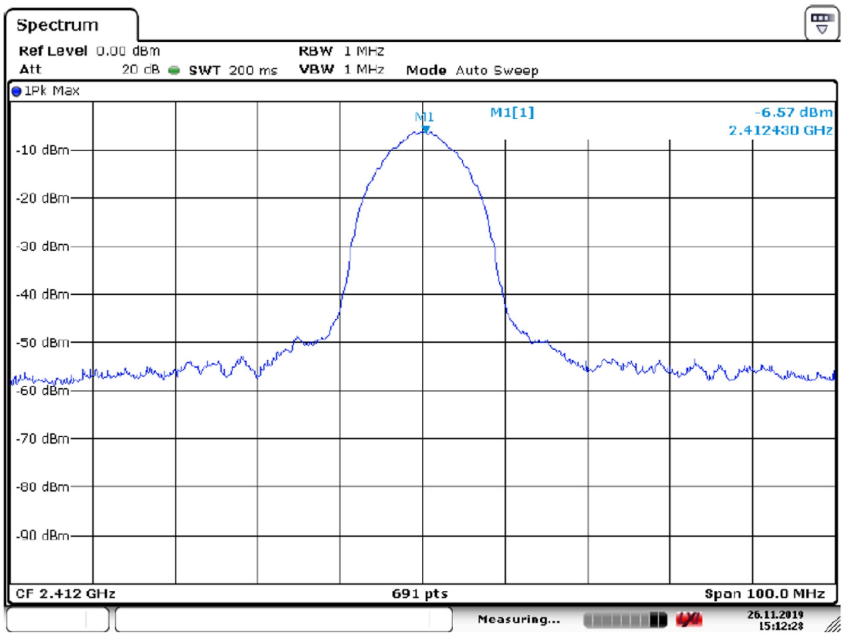


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Figure 67. WiFi interferer spectrum

The WiFi interferer (IEEE 802.11b) has a bandwidth of 22 MHz. The integrated power is ~6.8 dBm. Additionally, ~1 dB cable losses must be added.

5.2.2 Measurement procedure

- Both the ADK dongle and headset are turned ON and configured with the 20 ms latency setting.
- The recording of the packet error rate and audio artifacts starts.
- After running for 10 seconds without any interference, suddenly all Wi-Fi interferers are activated.
- The Wi-Fi interference stays active for the rest of the test run.
- The test is terminated 5 minutes after turn-on of the ADK devices.

5.2.3 Measurement result

- The packet error rate during the test is 4.55 %.
- The audio artifact rate during the test is 0. No audio artifacts were observed from the beginning until the end of the test nor when the WiFi interferers were enabled.

6 References

[1] **UM11150** — SDK board description; 2020, NXP Semiconductors

[2] **UM11161** — ADK board description; 2020, NXP Semiconductors

[3] **UM11148** — HAPI; 2021, NXP Semiconductors

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