SARA-G450

Audio interface

Application note

Abstract

This document provides information about the software audio functionality and application interfaces.

UBX-20028599 - R02
C1-Public

Document information

Title	**SARA-G450**	
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This document applies to the following products:

Product name	
SARA-G450	“01C” product version

Contents

1 Introduction

This document provides information and procedures about the volume management and the player features on SARA-G450 modules. It also addresses audio routing and profiles, speech codecs and the DTMF signaling decoder functionality available via the +UDTMFD AT command, implemented following the multi-part ETSI standard ES 201 235 [6].

For common hints to prevent echo and for preliminary tuning of transducers external gains, see the u-blox echo reduction pre-tuning guidelines [10].

Hardware features and characteristics of audio interface are described in the SARA-G450 system integration manual [2].

The following symbols are used to highlight important information within the document:

☞ An index finger points out key information pertaining to integration and performance.

⚠ A warning symbol indicates actions that could negatively impact or damage the module.

Feature		Supported
Volumes and muting management	Microphone gain control	Yes
	Speaker gain control	Yes
	Sidetone configuration	Yes
	Ringer volume	Yes
	Speech volume DL	Yes
	Generic PCM player volume (DL)	Yes
	Speech muting UL	Yes
	Alert tone muting	Yes
	Message sound muting	No
	Silent alarm parameter management	No
Audio routing and profiles	Audio path mode setting	No
Speech codecs	Speech codec information	No
	Speech codec configuration	No
Supervisory tones	Enabled supervisory tones	Yes
Player management	Pre-defined tone player	Yes
	Stop player	Yes
	Tone generator UL/DL	No
	Custom tone ringer	No
Audio file player / recorder	Player	Yes
	Recorder	No
	Custom ringer melody	No
	Answering machine	No
Speech player / recorder		No
Indication of sound activity		No
Audio parameters tuning		Yes
External codec management		No
DTMF decoder		Yes
DTMF generator		No

Table 1: Supported features

2 Volumes and muting management

On the downlink path there is a unique gain controlling the speech, ringer, and player (+UPAR and +UPLAYFILE) levels. The gain is configurable by means of the +CLVL and +CRSL AT commands, but only the +CRSL AT command controls the player level.

For more details on the AT command syntax, see the u-blox AT commands manual [1]. For use of the SARA-G450 AudioCalibrator tool, see the SARA-G450 extended audio application note [3].

To avoid conflicts, the application processor shall use only one of these commands.

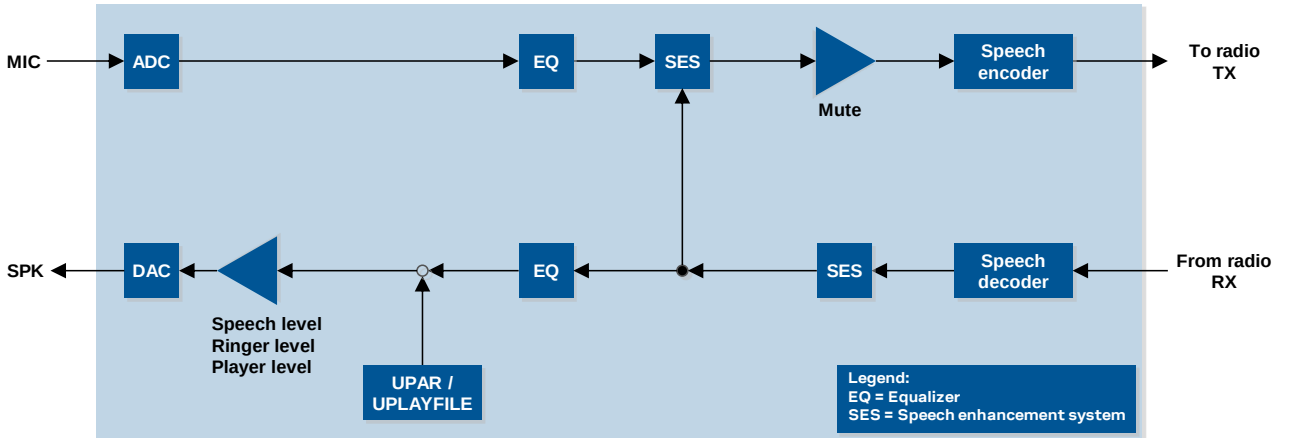

Figure 1: Downlink ringer/speech/player level gain

2.1 Microphone gain control

The microphone gain can be configured only by means of the SARA-G450 AudioCalibrator tool.

2.2 Speaker gain control

The speaker gain can be configured only by means of the SARA-G450 AudioCalibrator tool.

2.3 Sidetone configuration

The side tone can be configured only by means of the SARA-G450 AudioCalibrator tool.

2.4 Ringer volume

The sound level for the incoming call ringer can be configured by means of the +CRSL AT command.

2.5 Speech volume DL

The incoming speech volume of calls can be configured by means of the +CLVL AT command.

2.6 Generic PCM player volume (DL)

The generic PCM player volume is set by means of the +CRSL AT command.

2.7 Speech muting UL

The uplink voice can be muted during voice calls by means of the +CMUT AT command.

2.8 Alert tone muting

The alert tones can be muted by means of the +CALM AT command.

3 Speech codecs

The module supports the following speech codecs for GSM:

- Full Rate speech codec (8 kHz sampling rate)
- Enhanced Full Rate speech codec (8 kHz sampling rate)
- Half Rate speech codec (8 kHz sampling rate)
- NB-AMR speech codec (8 kHz sampling rate)

4 Supervisory tones

4.1 Enabled supervisory tones

☑ Ringing / ring back tone on mobile originated calls (free tone).

☑ Call waiting tone on mobile terminated calls.

☑ Ringer on mobile terminated calls (ringtone).

☑ Incoming SMS tone.

☑ Alarm tone.

The ringing / ring back tone can be reproduced locally or sent by the network using in-band tones.

5 Player management

The module implements an audio generator that can be used to play predefined tones on the downlink path. The playback of these tones is controlled by means of the +UPAR and +USAR AT commands to start and stop them, respectively. For more details on the AT commands syntax and the list of available tones, see u-blox AT commands manual [1].

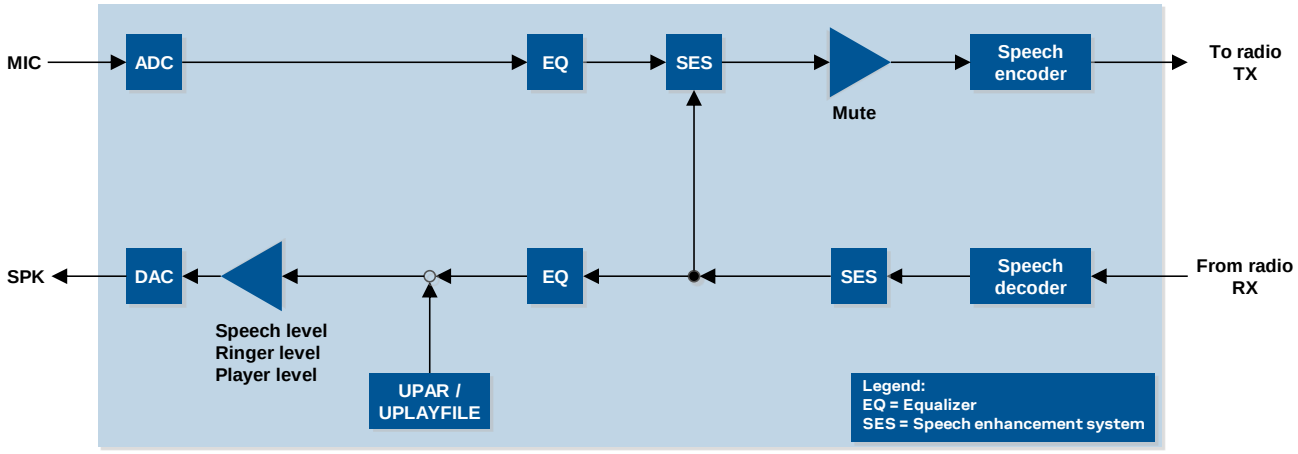

Figure 2: +UPAR tone player

6 Audio file player / recorder

6.1 Player

The audio generator implemented on the downlink path allows (SPK) audio files previously stored in the user file system to be played through the speaker. The generator is controlled by +UPLAYFILE AT command. For more details on AT command syntax, see u-blox AT commands manual [1].

The supported file format is WAV. The <filename> parameter extension shall be ".wav". The storage format of audio data has to be: 8, 11.025, 16, 22.050, 24, 32, 44.100 or 48 kHz sample rate, signed 16 bits PCM, little endian, mono.

Playing is allowed only if a call is not in progress; if the command is issued during a voice call, then an error result code is returned.

The player can be stopped before the end of file by the +USTOPFILE AT command.

The player volume can be set by means of the +CRSL AT command, which at the same time also changes the ringer and speech level. The original speech and ringer level can be restored after the playing is complete and before or during the voice call by issuing the +CRSL AT command again.

It is not possible to play audio files while the +UPAR AT command is running with any audio resource (for more details on supported audio resources, see u-blox AT commands manual [1]). The +UPLAYFILE AT command is automatically stopped when the +UPAR AT command is started or when a voice call starts.

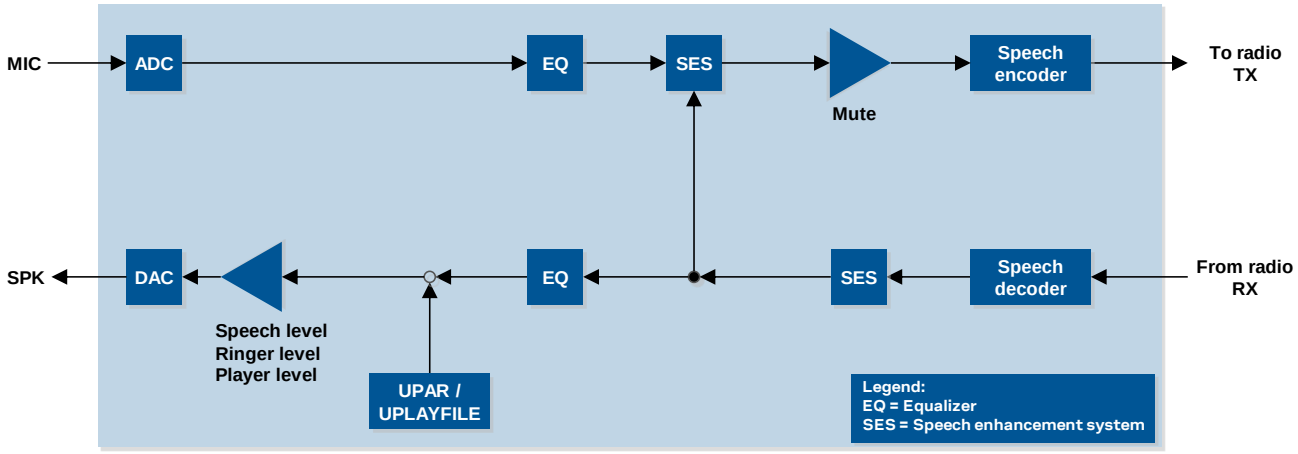

Figure 3: Generic WAV player on speaker (SPK)

7 Audio parameters tuning

The audio parameter tuning is performed through a dedicated software tool, AudioCalibration tool. For more details on the tool and the usage instructions, see the SARA-G450 extended audio tuning commands application note [3].

The following sections describe the AT commands script that applies a few basic and predefined audio configurations. At the end of the script execution, the module will turn off; it must be powered on again to apply the new settings.

After power on, set the nominal volume, e.g.:

```
AT+CLVL=10   (Headset)
AT+CLVL=6   (Desktop)
```

7.1 Headset default audio profile

The following AT commands apply an audio configuration suitable for using the device with a headset. It is the audio configuration set by default.

```
AT+CACCP=0,0,"0600"
AT+CACCP=0,2,"00e6d30012e9f40012e8f70012e7fa0012e9fa0012ebfa0012edfa0012effa0012f1fa001
2f3fa0012f5fa0012f7fa0012f9fa0012fbfa0012fdfa0012fffa00"
AT+CACCP=0,4,"80"
AT+CAVCP=0,0,"01000000e9392e8ce93900403d7399cb00000200b400000000000000"
AT+CAVCP=0,2,"0000430018003e007600cd004501590055ff14fd14fc9ffcccfc7b00e5fd96fe71fd3ffbf
9f9f7fc70faf1fabdff1cfc89ff83fdd1003afb1dead71410e972f0ff7f72f010e9d7141dea3afbd10083fd
89ff1cfcefffbcfe70faf7fcf9f93ffb71fd96fee5fd7b00ccfc9ffc14fc14fd55ff59004501cd0076003e0
0180043000000"
AT+CAVCP=0,4,"0100004000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000"
AT+CAVCP=0,6,"0100000006000800040000a00200000004000040000d0000000400200010000300020033000
0001000000000000ff0300001400030008000500030001000100010001000100010000007f0080004000a0000400
0001800040000600a000100010007300400000004700 1e00f401d00788136400c8002c01900100018000800
0000110000900000fa0000000000eb0108000400050000000 5000800"
AT+CAVCP=0,8,"0100e2ff1e001e001e001e0000000000"
AT+CAVCP=0,10,"0100e2ff1e001e001e001e0000000000"
AT+CAVCP=0,12,"00001e000a000600"
AT+CAVCP=0,14,"00001e000a000600"
AT+CAVCP=0,16,"010000008a3ceb868a3c0040e578bbc60000020064000 7000a000a00372cabcaeb190040
5535ddf9f6ff0300840307000a000a00f2470590372b0040fb6fd6cc070003002c0107000a000a002244569
9d0270040aa660dd4030003009001 07000a000a000040000000000040000000000000000e80307000a000a
0000400000000000400000000000000000d00707000a000a00b337666fb3370040ae9185cf00000100a60e0
7000a000a00"
AT+CAVCP=0,18,"0100010000400040"
AT+CAVCP=0,20,"010001000d00010000040000bffff40118fcdc05e8030400"
AT+CAVCP=0,22,"010001000d00010000040000bffff40118fcdc05e8030400"
AT+CAWTF=0,0,""
ECHO "Headset profile (default) has been saved and the modem switched off."
ECHO "Please power on the module again, if needed."
```

7.2 Desktop audio profile

The following AT commands apply an audio configuration tuned for a desktop reference device. The configuration is provided for example only, since any device requires a proper tuning.

```
AT+CACCP=0,0,"1805"
AT+CACCP=0,2,"00e6d30012e9f40012e8f70012e7fa0012e9fa0012ebfa0012edfa0012effa0012f1fa001
2f3fa0012f5fa0012f7fa0012f9fa0012fbfa0012fdfa0012fffa00"
AT+CACCP=0,4,"80"
AT+CAVCP=0,0,"01000000e9392e8ce93900403d7399cb00000200b400000000000000"
AT+CAVCP=0,2,"0100ef00bf0088000900dbff36ff96ff5dff5cff74fe4ffef8fc63faa9f860f783f833fbf
2fbdffe46faf8fb0aea2dfeb5fe1a04dcffd7085e0148fa3fed3b01ff7f3b013fed48fa5e01d708dcff1a04
b5fe2dfe82fafefe46fadffef2fb33fb83f860f7a9f863faf8fc4ffe74fe5cff5dff96ff36ffdbff0900880
0bf00ef000000"
AT+CAVCP=0,4,"0100004000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000"
AT+CAVCP=0,6,"0100000006000800040000a00200000004000040000d0000000400200010000300020033000
0001000000000000ff03000014000300080005000300010001000100010001000100000007f0080004000a0000400
0001800040000600a0001000100073004000000047001e00f401d00788136400c8002c01900100018000800
0000110000900000fa0000000000eb0108000400050000000500080 0"
AT+CAVCP=0,8,"0100e2ff1e001e001e001e0000000000"
AT+CAVCP=0,10,"0100e2ff1e001e001e001e0000000000"
AT+CAVCP=0,12,"00001e000a000600"
AT+CAVCP=0,14,"00001e000a000600"
AT+CAVCP=0,16,"000000003c3387993c330040e763f5d60000020090010100000000000d33a9ed223290040
622d09dcfcff0300780514000000000000400000000000400000000000000000c8000700000000000040000
0000000400000000000000000900107000000000000400000000000400000000000000000e8030700000000
0000400000000000400000000000000000d00707000000000004000000000004000000000000000a60e0
70000000000"
AT+CAVCP=0,18,"0100010000400040"
AT+CAVCP=0,20,"010001000d00010000040000bffff40118fcdc05e8030400"
AT+CAVCP=0,22,"010001000d00010000040000bffff40118fcdc05e8030400"
AT+CAWTF=0,0,""
ECHO "Desktop profile has been saved and the modem switched off."
ECHO "Please power on the module again, if needed."
```

7.3 Flat audio profile

The following AT commands apply a flat profile, therefore all speech enhancement features are disabled. This profile shall be applied in those devices where others speech enhancement components (such as echo canceller) will be used.

```
AT+CACCP=0,0,"0600"
AT+CACCP=0,2,"00e6d30012e9f40012e8f70012e7fa0012e9fa0012ebfa0012edfa0012effa0012f1fa001
2f3fa0012f5fa0012f7fa0012f9fa0012fbfa0012fdfa0012fffa00"
AT+CACCP=0,4,"80"
AT+CAVCP=0,0,"00000000e9392e8ce93900403d7399cb00000200b400000000000000"
AT+CAVCP=0,2,"0000430018003e007600cd004501590055ff14fd14fc9ffcccfc7b00e5fd96fe71fd3ffbf
9f9f7fc70faf1fabdff1cfc89ff83fdd1003afb1dead71410e972f0ff7f72f010e9d7141dea3afbd10083fd
89ff1cfcefffbcfe70faf7fcf9f93ffb71fd96fee5fd7b00ccfc9ffc14fc14fd55ff59004501cd0076003e0
0180043000000"
AT+CAVCP=0,4,"0000004000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000"
AT+CAVCP=0,6,"0000000006000800040000a00200000004000040000d0000000400200010000300020033000
0001000000000000ff03000014000300080005000300010001000100010001000100000007f0080004000a0000400
```

```
0001800040000600a000100010007300400000047001e00f401d00788136400c8002c01900100018000800
0000110000900000fa0000000000eb0108000400050000005000800"
AT+CAVCP=0,8,"0000e2ff1e001e001e001e0000000000"
AT+CAVCP=0,10,"0000e2ff1e001e001e001e0000000000"
AT+CAVCP=0,12,"00001e000a000600"
AT+CAVCP=0,14,"00001e000a000600"
AT+CAVCP=0,16,"000000008a3ceb868a3c0040e578bbc60000020064000700 0a000a00372cabcaeb190040
5535ddf9f6ff0300840307000a000a00f2470590372b0040fb6fd6cc070003002c0107000a000a002244569
9d0270040aa660dd4030003009001070 00a000a000040000000000004000000000000000000e80307000a000a
000040000000000040000000000000000d00707000a000a00b337666fb3370040ae9185cf00000100a60e0
7000a000a00"
AT+CAVCP=0,18,"0100010000400040"
AT+CAVCP=0,20,"000001000d00010000040000bffff40118fcdc05e8030400"
AT+CAVCP=0,22,"000001000d00010000040000bffff40118fcdc05e8030400"
AT+CAWTF=0,0,""
ECHO "Flat profile has been saved and the modem switched off."
ECHO "Please power on the module again, if needed."
```

8 Production testing

The audio hardware functionality of SARA-G450 modules can be tested by the end user with the +UPAR AT command (for more details about the AT command syntax, see the u-blox AT commands manual [1]).

8.1 Loop activation

An uplink audio path to downlink loop can be enabled via the +UPAR AT command without need to perform a call. The command is:

```
AT+UPAR=2,0,0
OK
```

This allows the end user to test audio functionality of the module after it is mounted on his/her product.

The audio path functionality can be tested by injecting a source signal on the uplink path and recording the signal resulting from the internal loop on the downlink path.

For example, in the implementation shown in Figure 4, a source signal can be played on a reference speaker near the DUT microphone (MIC) or if MIC is unmounted, a source signal can be injected electrically on microphone connector J1. The downlink signal can be recorded from LSPK acoustically by a reference microphone or can be recorded electrically on J2 connector.

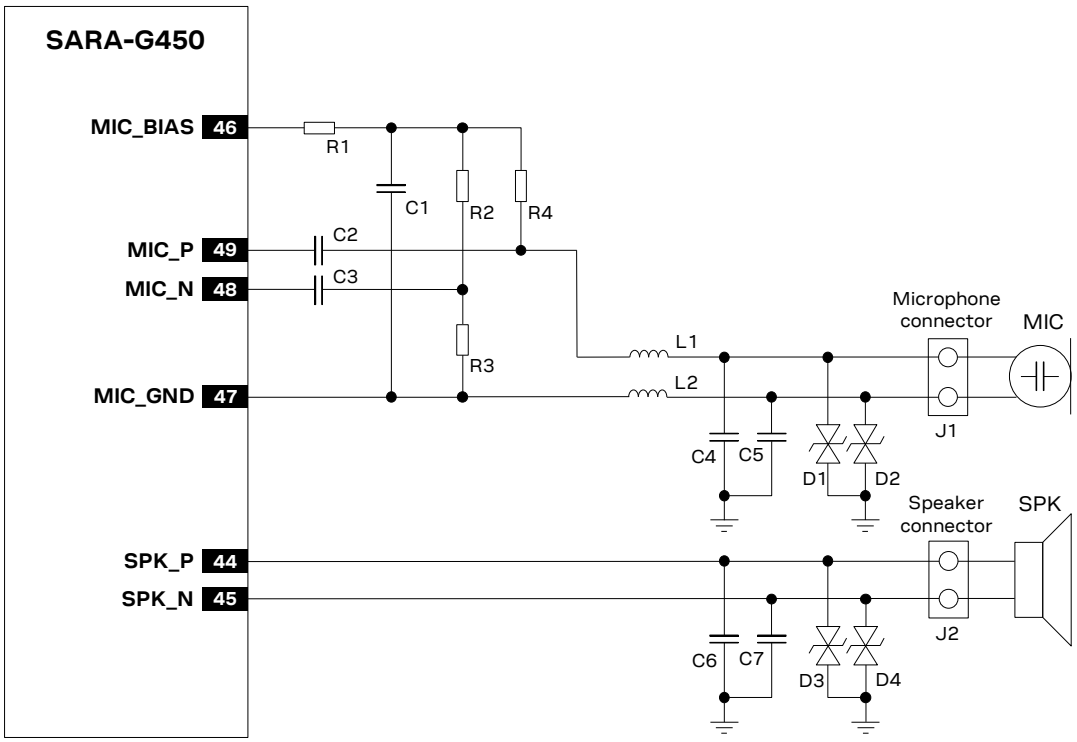

Figure 4: Analog audio interface application circuit

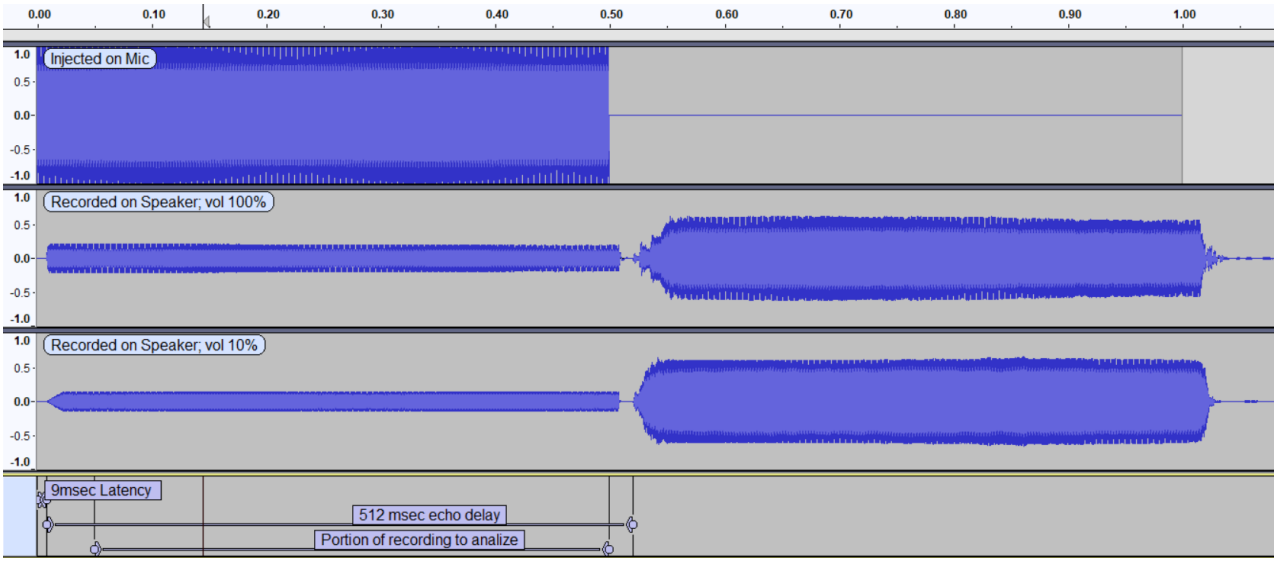

Figure 5: Audio loop activation example

The following signals are shown in the example in Figure 5:

- A signal injected on the uplink path can be a 500 ms sinusoidal signal at frequency 1000 Hz, level 0 dBFS.
- A signal recorded on the downlink shows a looped signal starting with some milliseconds delay due to system latency (in the example, 9 ms). An echo signal with a 512 ms delay is also generated.
- There is a 450 ms long portion (from 0.030 ms to 0.480 ms) where the looped signal is stable (do not consider the louder echoed signal starting after 512 ms).

Use a spectrum analyzer to check the distortion of downlink signals.

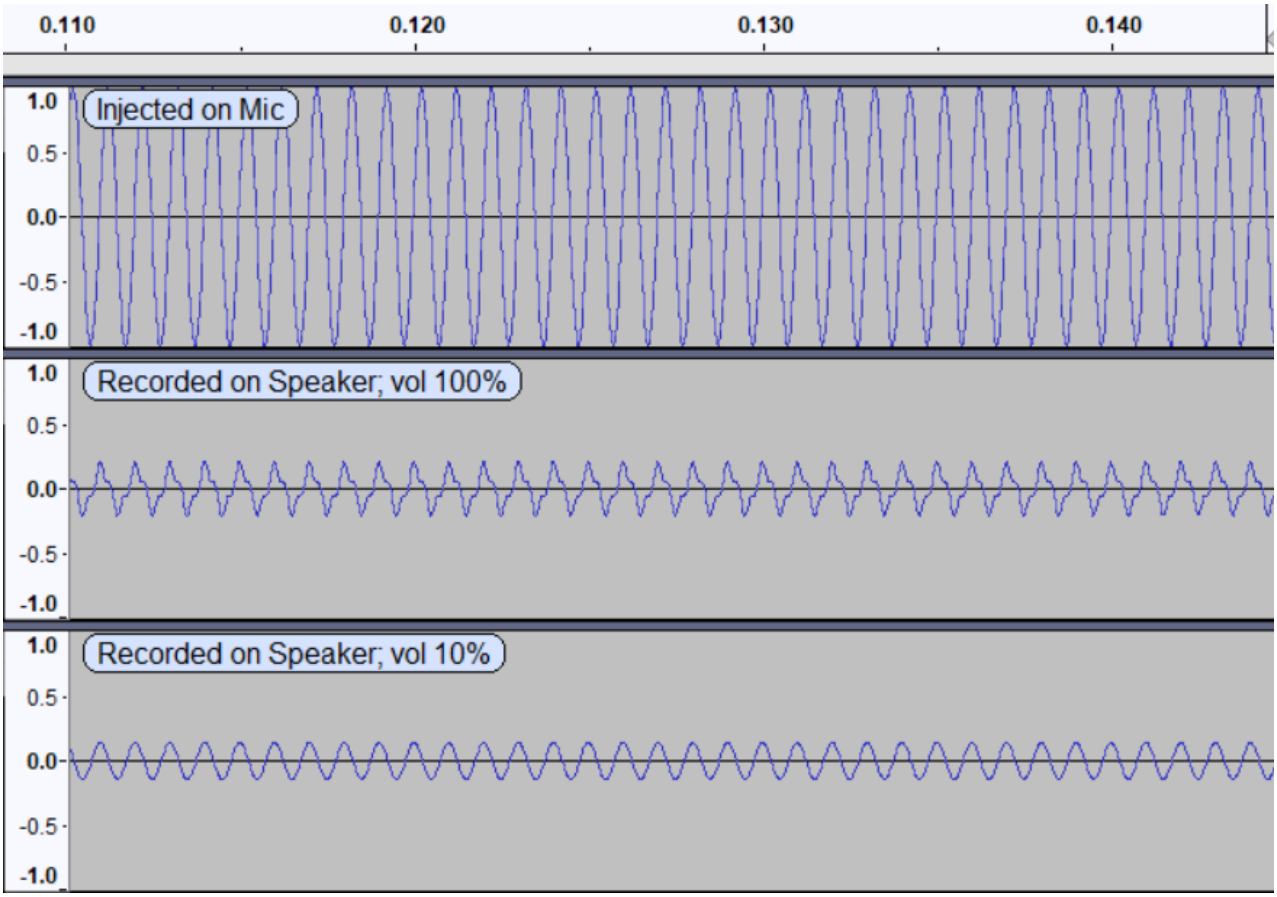

Figure 6: Audio loop example, detailed view of injected and recorder signal

In recordings shown in Figure 6, when the signal generator is playing at 100% volume, the signal recorded electrically at speaker connector is distorted. In Figure 7, frequency analysis shows presence of important second (2000 Hz) and third harmonics (3000 Hz).

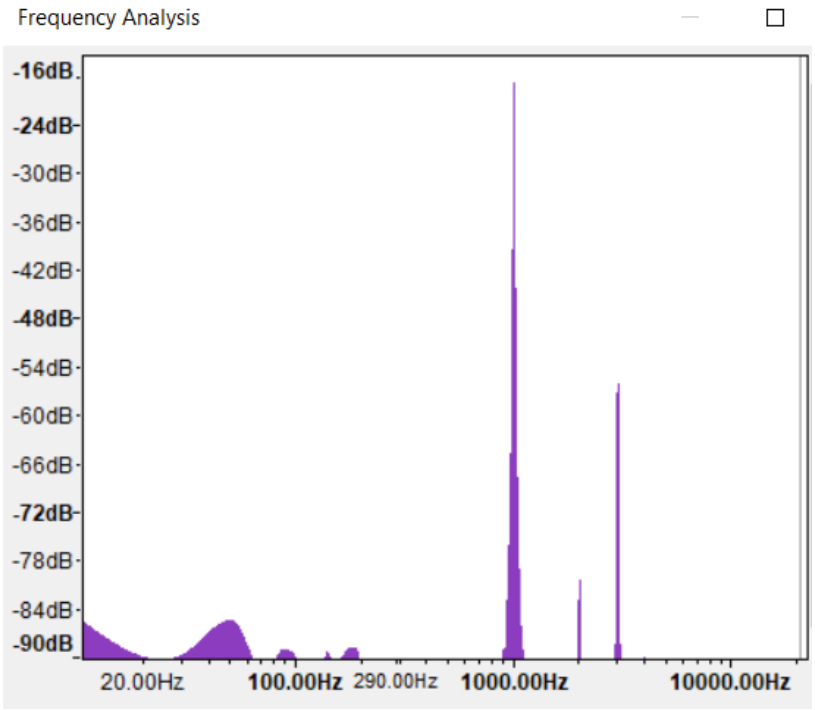

Figure 7: Audio loop example, frequency analysis of signal generator playing at 100% volume

Lower the volume of signal generator until the recorded signal appears as a pure sinus.

For a signal generator playing at 10% volume, the signal recorded electrically at speaker connector is not distorted.

In Figure 8, the frequency analysis shows presence of very low second harmonic (2000 Hz) and no third harmonic (3000 Hz) at all.

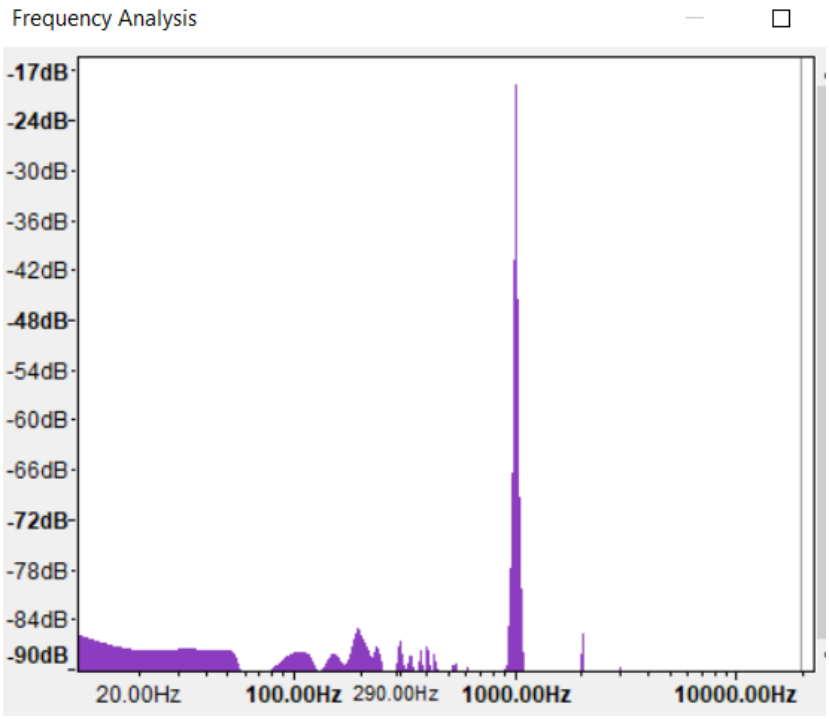

Figure 8: Audio loop example, frequency analysis of signal generator playing at 10% volume

Once the volumes of the signal generator are correct, calculate level, frequency and distortion of the recorded downlink signal for a golden sample and use these measures as a target for testing other devices.

Set thresholds of tolerance around target measures of level, frequency, and distortion, to decide PASS/FAIL of the test.

9 DTMF decoder

SARA-G450 modules can be configured to perform DTMF detection on the RX speech channel. The DTMF decoder is part of the In-Band modem feature and the +UDTMFD AT command is used to configure it. For more details on the command description, see the u-blox AT commands manual [1].

9.1.1 Decoder activation

Enable the DTMF decoder via the +UDTMFD AT command once per module power cycle and before the first call set up:

```
AT+UDTMFD=1,1
OK
```

The DTMF decoder is started at each call setup. During the call, the DTMF decoder provides URCs for each detected digit. In the following example, the digit "4" has been detected:

```
+UUDTMFD: 4
```

9.2 Performance criteria

There are two main performance indicators for DTMF detectors:

- **Detection performance** – is the ability to correctly decode the DTMF tones in various network conditions. The modern networks use compression which introduces distortions that may invalidate at detector input a correctly generated DTMF tone.
- **Speech immunity** – is the DTMF talk-off abatement performance. Talk-off is the term that describes when a human voice can trigger DTMF tones during a telephone call. Talk-off occurs when the DTMF detector tries to translate sounds into DTMF tones causing false detections.

9.2.1 Accepted signal level and tone duration

The detection rate is about 100% with a high speech immunity when:

- the signal level is above -16 dBm
- the tone duration is at least 80 ms

Appendix

A Glossary

Abbreviation	Definition
AMR	Adaptive Multi-Rate
AT	AT command Interpreter software subsystem, or attention
DL	Downlink
DTMF	Dual Tone Multi Frequency
EQ	Equalizer
NB	Narrow Band
NVM	Non-Volatile Memory
PCM	Pulse Code Modulation
RX	Receiver
SES	Speech Enhancement System
SMS	Short Message Service
TX	Transmitter
UL	Uplink
URC	Unsolicited result code

Table 2: Explanation of the abbreviations and terms used

Related documentation

[1] u-blox AT commands manual, UBX-13002752
[2] SARA-G450 system integration manual, UBX-18046432
[3] SARA-G450 extended audio tuning commands application note, UBX-20013500
[4] ETSI ES 201 235-3 V1.3.1, Specification of Dual Tone Multi-Frequency (DTMF) Transmitters and Receivers; Part 3: Receivers
[5] ETSI ES 201 235-4 V1.3.1, Specification of Dual Tone Multi-Frequency (DTMF) Transmitters and Receivers; Part 4: Receivers for use in Terminal Equipment for end-to-end signalling
[6] Work Items with ETSI Document Number ”201 235”; see Work Programme search database, http://www.etsi.org/
[7] ETSI TR 126 975 V10.0.0 (2011-04), Performance characterization of the Adaptive Multi-Rate (AMR) speech codec (also 3GPP TR 26.975 version 10.0.0 Release 10)
[8] ITU-T Recommendation Q.23: Technical features of push-button telephone sets
[9] ETR 229: October 1995 (GSM 06.08 version 4.0.0), Performance characterization of the GSM half rate speech codec
[10] u-blox AE-CEL echo reduction pre-tuning guidelines, UBX-20032649

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Revision history

Revision	Date	Name	Comments
R01	13-May-2021	ague	Initial release
R02	20-Oct-2021	mrod	Added sections 7.1, 7.2, 7.3 which reports some scripts to apply basic profile configuration.

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