GE910 Family Digital Voice Interface

Application Note

80000NT10099A Rev. 0 – 2013-05-23

APPLICABILITY TABLE

	SW Versions
GE Family (Embedded)	**13.00.xx4**
GE910-QUAD	
GE910-GNSS	

Note: the present document covers the SW versions shown in the Applicability Table and may mention features which are not present or behave differently in previous SW versions.

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1. Introduction

The present document provides the reader with a guideline concerning the setting and use of the Digital Voice Interface developed on the Telit's modules of the GE910 family.

1.1. Scope

This Application Note covers the configurations of the Digital Voice Interface, e.g.: the selections of the voice sampling frequency, the bit number of the voice sample, the audio formats, etc. In addition, the document shows some configurations of a popular Audio Codec connected to the module. These activities are accomplished via I^2S and I^2C buses; the hardware characteristics of the two buses are beyond the scope of the document.

1.2. Audience

The document is intended for those users that need to develop applications dealing with signal voice in digital format.

1.3. Contact Information, Support

For general contact, technical support, to report documentation errors and to order manuals, contact Telit Technical Support Center (TTSC) at:

TS-EMEA@telit.com
TS-NORTHAMERICA@telit.com
TS-LATINAMERICA@telit.com
TS-APAC@telit.com

Alternatively, use:

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For detailed information about where you can buy the Telit Modules or for recommendations on accessories and components visit:

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Our aim is to make this guide as helpful as possible. Keep us informed of your comments and suggestions for improvements.
Telit appreciates feedback from the users of our information.

1.4. Related Documents

[1] GE910 Hardware User Guide, 1vv0300962
[2] MAX9867 Ultra-Low Power Stereo Audio Codec, MAXIM
[3] AT Commands Reference Guide, 80000ST10025A

1.5. Document History

Revision	Date	Changes
0	2013-05-23	First issue

1.6. Abbreviations and Acronyms

DTE Data Terminal Equipment
DVI Digital Voice Interface
GPIO General Purpose Input/Output
I2C Inter-Integrated Circuit
I2S Inter-IC Sound
MSB Most Significant Bit

2. Digital Voice Interface Use

Before dealing with the configuration and technical aspects of the Telit's Digital Voice Interface (DVI) it is useful to illustrate briefly how this interface can be used, refer to fig. 1.

The voice coming from the downlink, in digital format, is captured by the dedicated software running on the Telit's module and directed to the Digital Voice Interface. The Audio Codec decodes the voice and sends it to the speaker. The other way round the voice captured by the microphone is coded by the Audio Codec and directed through the Digital Voice Interface to the module that collects the received voice, in digital format, and sends it on the uplink.

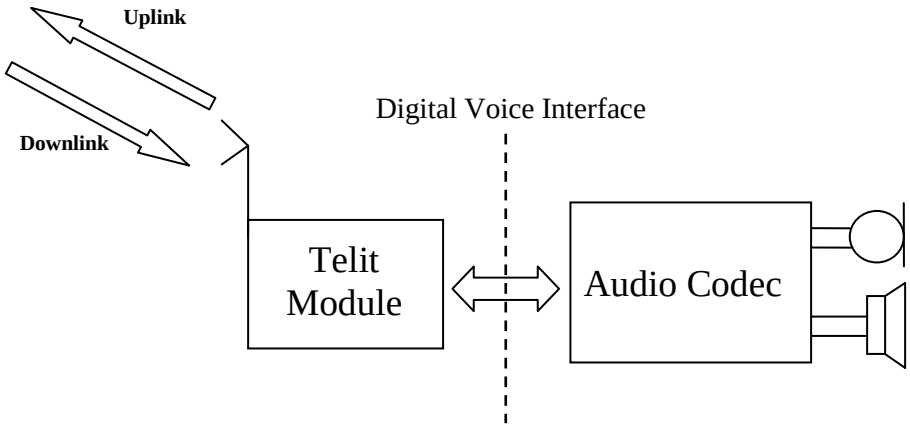


fig. 1: Example of Digital Voice Interface Use

2.1. DVI Introduction

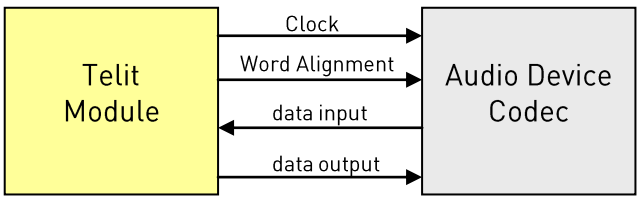
The physical DVI interface provided by the modules of the Telit's GE910 family is based on the standard I^2S Bus. An overview of the standard I^2S Bus is described in chapter 4.1. Tab. 1 summarizes the DVI signals and a short description for each one of them; refer to document [1] to have information on electrical characteristics and signals pin-out.

I^2S Signal	DVI Signal	Description
Clock	DVI_CLK	Data Clock
Word Alignment	DVI_WAO	Frame Synchronism
serial audio data input	DVI_RX	Received Data
serial audio data output	DVI_TX	Transmitted Data

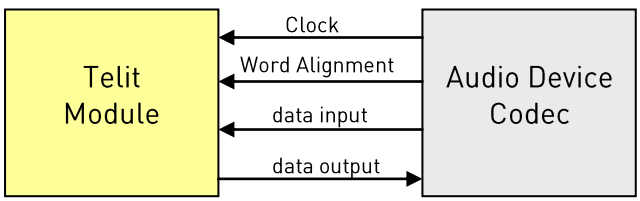
Tab. 1: DVI Signals

The figures below show the two configurations of the DVI interface relating to the Word Alignment and Clock signals. When the module is Master the Clock and Word Alignment signals (also called Word Alignment Output WAO) are generated by the module itself, otherwise, when it is Slave, both signals are generated by the connected Audio Device Codec.

In general, before establishing a voice call it is possible to select one of the two configurations and in accordance with the selected setting, configure the module and the codec via the AT commands provided by Telit [3]. The next pages describe the use of these AT commands.



Module = Master



Module = Slave

fig. 2: Master and Slave Configurations

2.1.1. DVI AT Commands

Several DVI audio bus configurations are available via AT#DVI and AT#DVIEXT commands as summarized by the following tables, refer to [3].

AT#DVI command enables/disables the DVI interface, selects the DVI port, and sets the module in Master or Slave configuration.

The following table shows the AT command parameters values.

AT#DVI =<mode>,<dviport>,<clockmode>		
<mode>	<dviport>	<clockmode>
0 → disable DVI interface	1 → select DVI port 1[1]	0 → DVI slave
1 → enable DVI interface	2 → reserved	1 → DVI master
2 → reserved		

Tab. 2: DVI configuration via AT#DVI command

AT#DVIEXT command sets the module in Normal or Burst DVI Audio Format:

- In Normal DVI Audio Format the WAO signal defines the left and right audio channel.
- In Burst DVI Audio Format the WAO signal defines the beginning of the audio frame.

The following table shows the AT command parameters values.

DVI Audio Format (Mode)	AT#DVIEXT <config>,<samplerate>,<samplewidth>,<audiomode>,<edge>				
	<config>	<samplerate>	<samplewidth>	<audiomode>	<edge>
Normal (I^2S)	1	0 → 8 [KHz] sample rate 1 → reserved	0 → 16 bits per sample 1 → reserved 2 → reserved 3 → 24 bits per sample 4 → 32 bits per sample	0 → Mono 1 → Dual Mono[2]	0 → data is transmitted on falling edge of clock and sampled on rising edge of clock, factory setting. 1 → data is transmitted on rising edge of clock and sampled on falling edge of clock.
Burst (PCM)	0				1 → the rising edge of the clock is used to shift out the next data to transmit. The received data bit is captured on the falling edge of the clock. 0 → has the same behavior of 1.

Tab. 3: DVI Audio Format configuration via AT#DVIEXT command

[1] Factory setting.
[2] In Dual Mono the same Data Word is transmitted on both audio channels (right and left).

3. DVI Setting Examples

The next chapters show examples concerning the audio formats supported by the DVI audio bus in Master and Slave configurations. All the following setting examples are performed using the hardware configuration shown in fig. 3. I²C bus is used to configure the MAX9867 Codec[3] [2]: the user by means of AT commands can control the codec. The DVI bus provides the voice connection between the two devices.

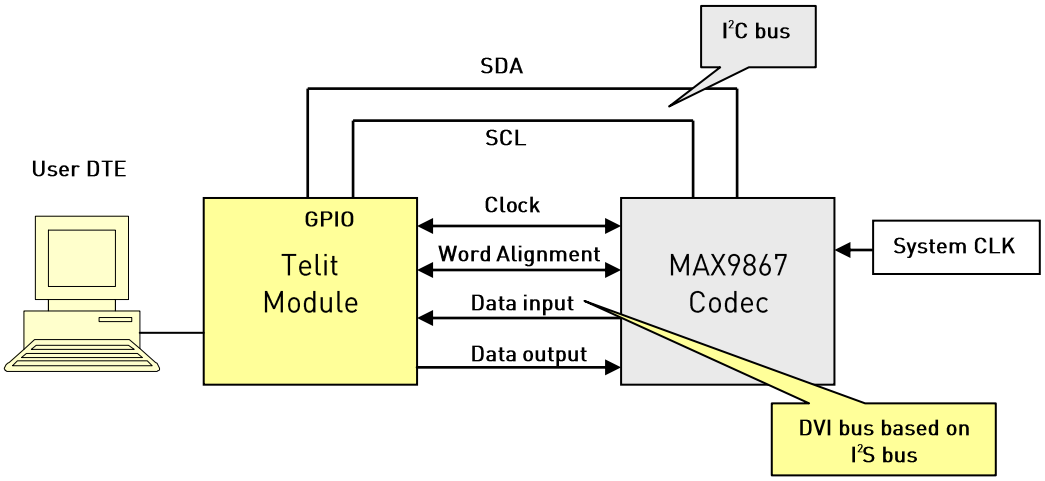


fig. 3: Telit Module/Codec Connections

The setting examples are organized as shown in the figure below.

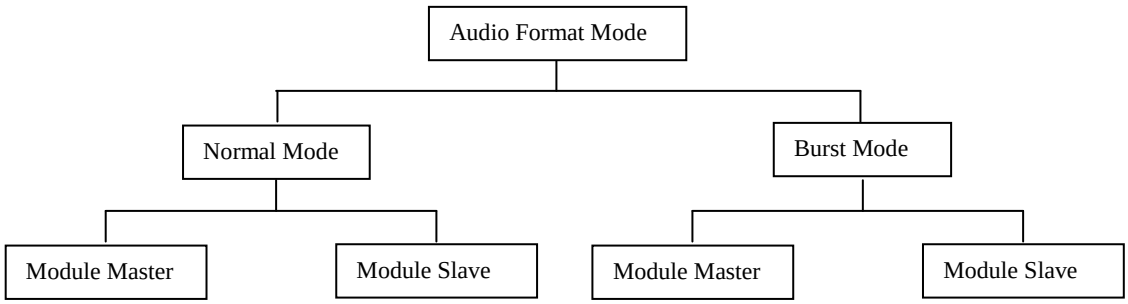


fig. 4: DVI Configurations

[3] The following examples use the MAX9867 Codec, see chapter 4.2 for a schematic reference design. In general, the user can use any codec compliant with the technical requirements of the GE910 modules.

3.1. Normal (I^2S) Mode

3.1.1. Module is Master

The fig. 5 shows a timing diagram that refers to the module in the role of master. In this case, the WAO and CLK signals are generated by the module. The WAO signal defines the frame of the two audio channels: left and right.

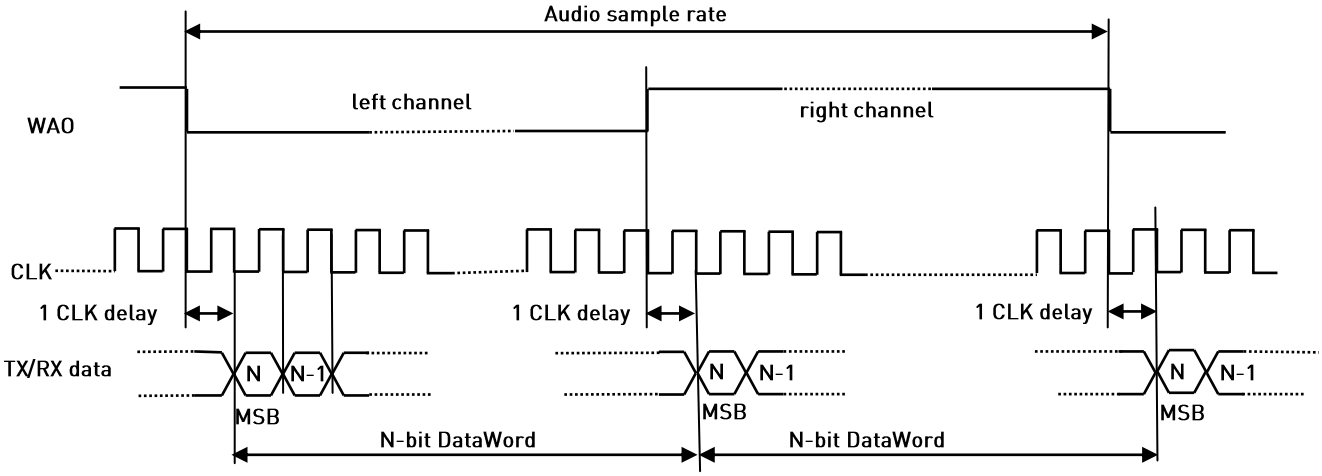


fig. 5: Module is Master/Normal mode/ N bits per sample/Dual Mono

When module is Master the BitClockFrequency (CLK) is provided by the following expression:

$$BitClockFrequency = DataWordBit \times ChannelNumber \times AudioSamplingRate$$

Refer to Tab. 4 for the BitClockFrequency generated by the module.

<samplewidth>	DataWordBit	Audio channels	AudioSampleRate: 8 KHz
			BitClockFrequency in KHz
0	16	2	256
1	reserved		
2	reserved		
3	24	2	384
4	32	2	512

Tab. 4: BitClockFrequency generated by the module in Master/Normal Mode

Hereafter are shown the lists of AT commands used to set the module in Master Normal (I^2S) Mode, and configure the codec in accordance with the module setting. After each command is described the used parameters values meaning.

Configure the module in Master Normal (I^2S) Mode

DVI bus

AT#DVI=1,1,1
OK

1 enable DVI interface
1 use DVI port 1 (mandatory)
1 set the module as Master (factory setting)

AT#DVIEXT=1,0,0,1,0
OK

1 Normal Mode (factory setting)
0 sample rate 8 KHz (mandatory)
0 16 bits per sample
1 Dual Mono, the same Data Word is transmitted on both audio channels
0 data is transmitted on falling edge of clock and sampled on rising edge of clock

Configure the codec in Slave Normal (I^2S) Mode

I^2C bus

AT#I2CWR=X,Y,30,4,19
>00109000100A330000330C0C09092424400060
OK

X GPIO number used as SDA, refer to [3]
Y GPIO number used as SCL, refer to [3]
30 Device address on I^2C, refer to [2]
4 Register address from which start the writing, refer to [2]
19 number of bytes to write
>00109000…..refer to [2]

AT#I2CWR=X,Y,30,17,1
>8A
OK

X GPIO number used as SDA, refer to [3]
Y GPIO number used as SCL, refer to [3]
30 Device address on I^2C, refer to [2]
17 Register address where write data, refer to [2]
1 number of bytes to write
>8A refer to [2]

The following figure shows the timing diagram, captured by a logic analyzer, concerning the above described module/codec setting. The CLK (256 KHz) and WAO signals are generated by the module.

Left channel:

↓: Data transitions occur on the falling edge of the CLK

↑: Data are latched on the rising edge of the CLK

Right channel:

↓: Data transitions occur on the falling edge of the CLK

↑: Data are latched on the rising edge of the CLK

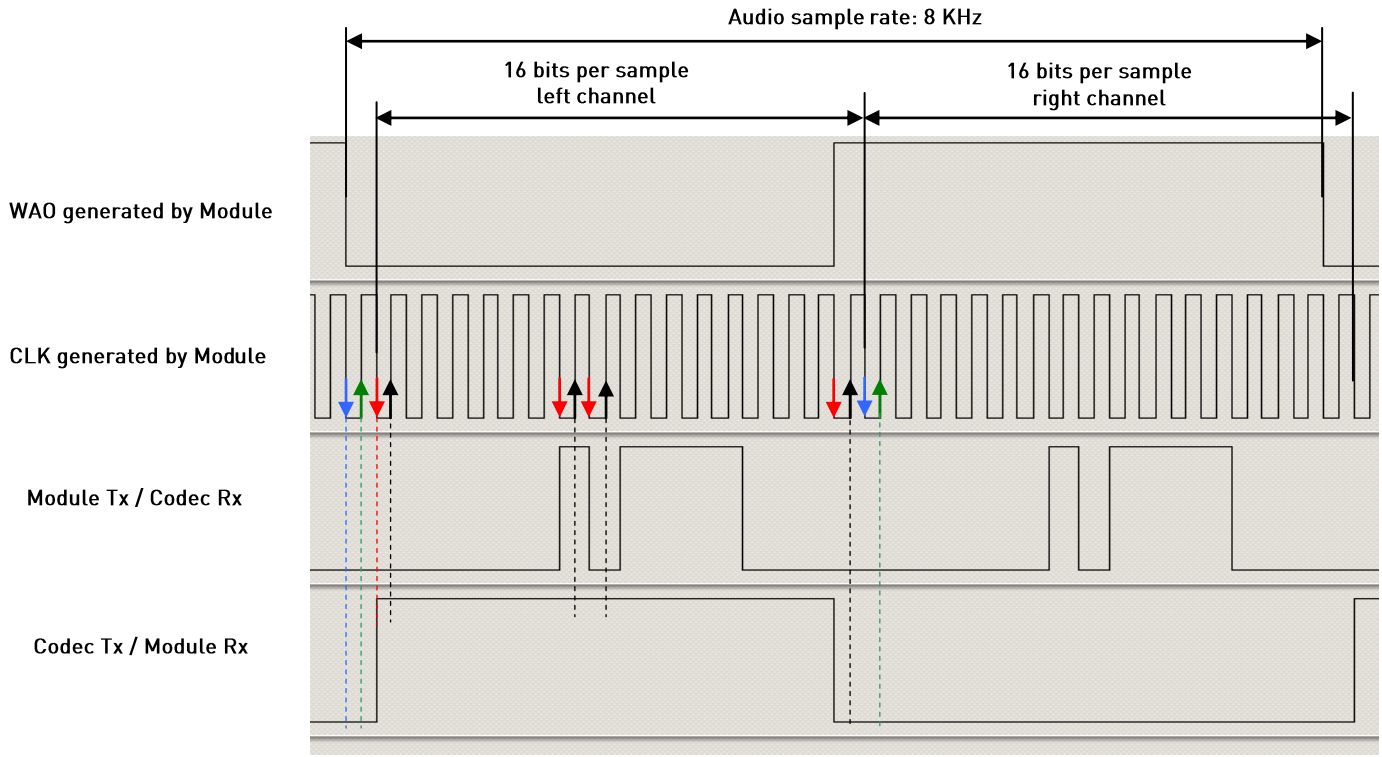


fig. 6: Module is Master/Normal mode/16 bits per sample/Dual Mono/<edge>=0

3.1.2. Module is Slave

Hereunder are shown the lists of the AT commands used to set the module in Slave Normal (I^2S) Mode, and configure the Codec in accordance with the module setting. After each command is described the used parameters values meaning.

Configure the Module in Slave-Normal (I^2S) Mode

DVI bus

AT#DVI=1,1,0
OK

1	enable DVI interface
1	use DVI port 1 (mandatory)
0	set the module as Slave

AT#DVIEXT=1,0,3,1,0
OK

1	Normal Mode (factory setting)
0	sample rate 8 KHz (mandatory)
3	24 bits per sample
1	Dual Mono, the same Data Word is transmitted on both audio channels
0	data is transmitted on falling edge of clock and sampled on rising edge of clock

Configure the Codec in Master-Normal (I^2S) Mode

I^2C bus

AT#I2CWR=X,Y,30,4,19
>00101000900233000033OC0C09092424400060
OK

X	GPIO number used as SDA
Y	GPIO number used as SCL
30	Device address on I2C
4	Register address from which start the writing
19	number of bytes to write
>00101000…..refer to [2]	

AT#I2CWR=X,Y,30,17,1
>8A
OK

X	GPIO number used as SDA
Y	GPIO number used as SCL
30	Device address on I2C
17	Register address where write data
1	number of bytes to write
>8A	refer to [2]

NOTICE: *the Codec is in Master configuration and generates a clock equal to 384 KHz. On the module the selected number of bits per sample is 24, see Tab. 4*

The following figure shows the timing diagram, captured by a logic analyzer, concerning the above described module/codec setting. The CLK (384 KHz) and WAO signals are generated by the codec.

Left channel:

↓: Data transitions occur on the falling edge of the CLK

↑: Data are latched on the rising edge of the CLK

Right channel:

↓: Data transitions occur on the falling edge of the CLK

↑: Data are latched on the rising edge of the CLK

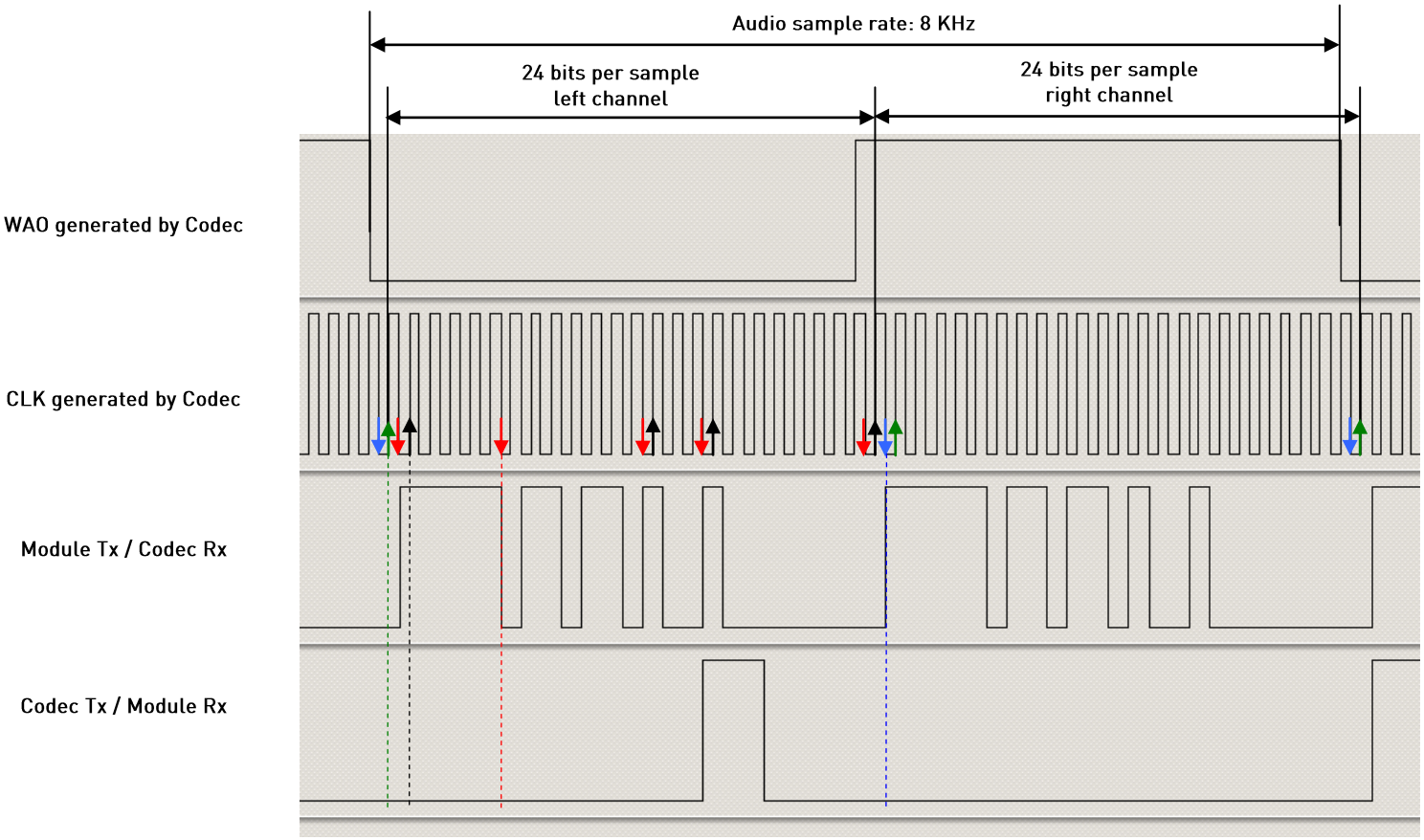


fig. 7: Module is Slave/Normal mode/24 bits per sample/Dual Mono/<edge>=0

3.2. Burst Mode (PCM)

3.2.1. Module is Master

The fig. 8 shows a timing diagram that refers to the module in the role of master. In this case, the WAO and CLK signals are generated by the module. The WAO signal defines the frame of the audio channel.

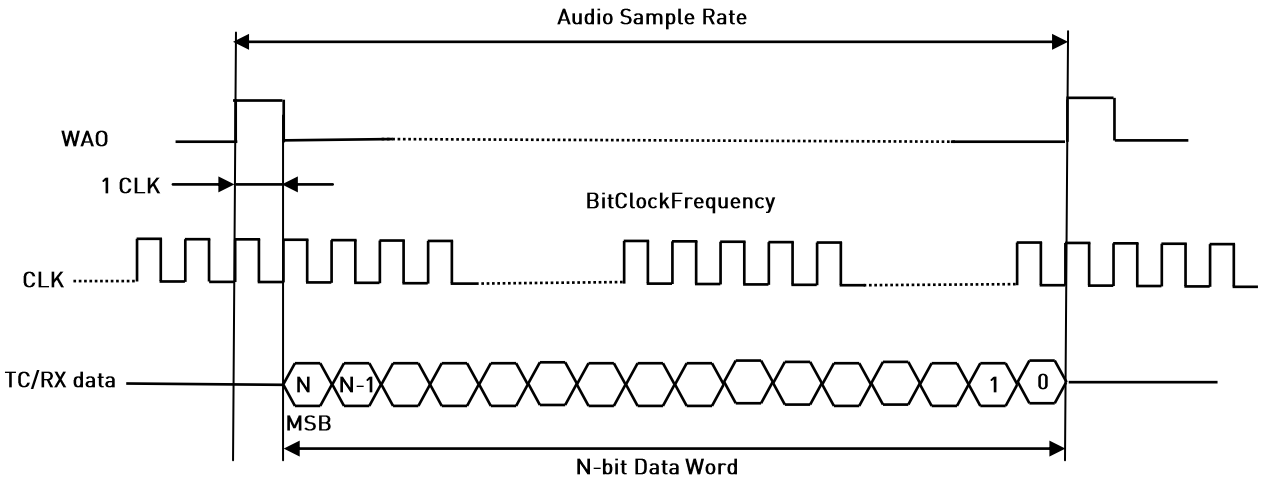


fig. 8: Module is Master/Burst mode/N bits per sample/Mono Mode

When module is Master the BitClockFrequency (CLK) is provided by the following expression:

$$BitClockFrequency = (DataWordBit + 1) \times AudioSampleRate$$

Refer to Tab. 5 for the BitClockFrequency generated by the Module.

<samplewidth>	DataWordBit	Audio channels	AudioSampleRate: 8 KHz
			BitClockFrequency in KHz
0	16 (+ 1[4])	1	136
1	reserved		
2	reserved		
3	reserved		
4	32 (+ 1)	1	264

Tab. 5: BitClockFrequency generated by the module in Master/Burst Mode

[4] The width of the WAO pulse is 1 CLK.

Hereafter is shown the list of AT commands used to set the module in Master Burst (PCM) Mode, no AT commands example is given for the codec.

Configure the module in Master-Burst (PCM) Mode

DVI bus

AT#DVI=1,1,1
OK

1 enable DVI interface
1 use DVI port 1 (mandatory)
1 set the module DVI as Master (factory setting)

AT#DVIEXT=0,0,0,0,1
OK

0 Burst Mode (PCM)
0 sample rate 8 KHz (mandatory)
0 16 bits per sample
0 Mono Mode
1 the rising edge of the clock is used to shift out the next data to transmit. The received data bit is captured on the falling edge of the clock (0 has the same behavior).

3.2.2. Module is Slave

The fig. 9 shows a timing diagram that refers to the codec in master configuration. In this case, the WAO and CLK signals are generated by the codec.

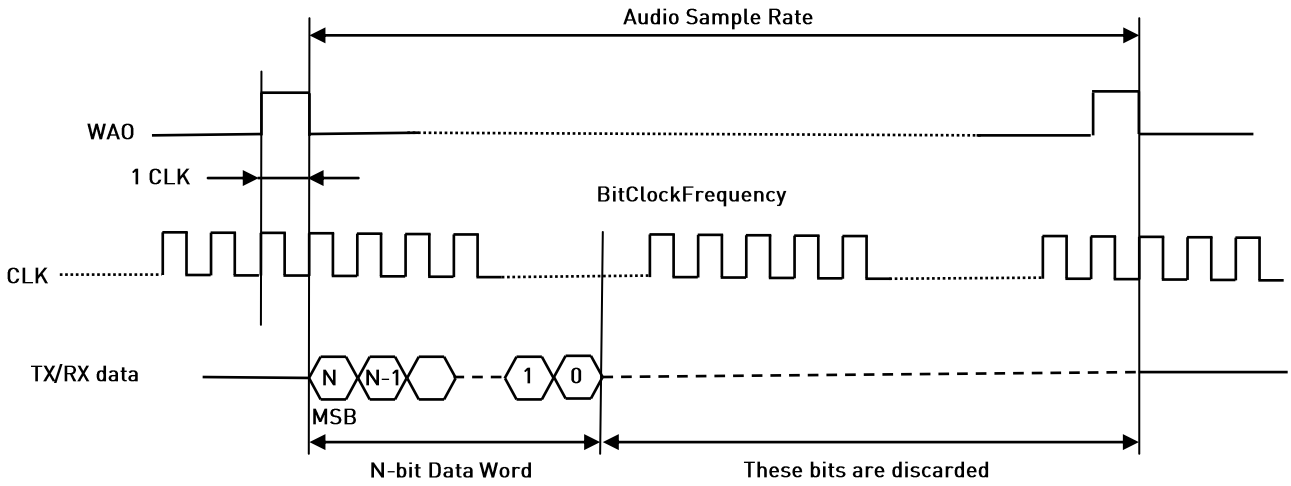


fig. 9: Module is Slave/Burst mode/N bits per sample/Mono Mode

Hereunder are shown the lists of AT commands used to set the module in Slave Burst (PCM) Mode, and configure the Codec in accordance with the current module setting. After each command is described the used parameters values meaning.

Configure the module in Slave-Burst (PCM) Mode.

DVI bus

```
AT#DVI=1,1,0
OK
```

1 enable DVI interface
1 use DVI port 1 (mandatory)
0 set the module as Slave

```
AT#DVIEXT=0,0,0,0,1
OK
```

0 Burst Mode
0 sample rate 8 KHz (mandatory)
0 16 bits per sample
0 Mono Mode
1 the rising edge of the clock is used to shift out the next data to transmit. The received data bit is captured on the falling edge of the clock (0 has the same behavior).

Configure the Codec in Master-PCM Mode.

I^2C bus

AT#I2CWR=X,Y,30,4,19
> 00101000A40A330000330C0C09092424400060
OK

X GPIO number used as SDA
Y GPIO number used as SCL
30 Device address on I^2C
4 Register address from which start the writing
19 number of bytes to write
>00101000…..refer to [2]

AT#I2CWR=X,Y,30,17,1
>8A
OK

X GPIO number used as SDA
Y GPIO number used as SCL
30 Device address on I^2C
17 Register address where write data
1 number of bytes to write
>8A refer to [2]

The following figure shows the timing diagram, captured by a logic analyzer, concerning the above described module/codec setting. The CLK (364 KHz) and WAO signals are generated by the codec.

↑: Data transitions occur on the rising edge of the CLK

↓: Data are latched on the falling edge of the CLK

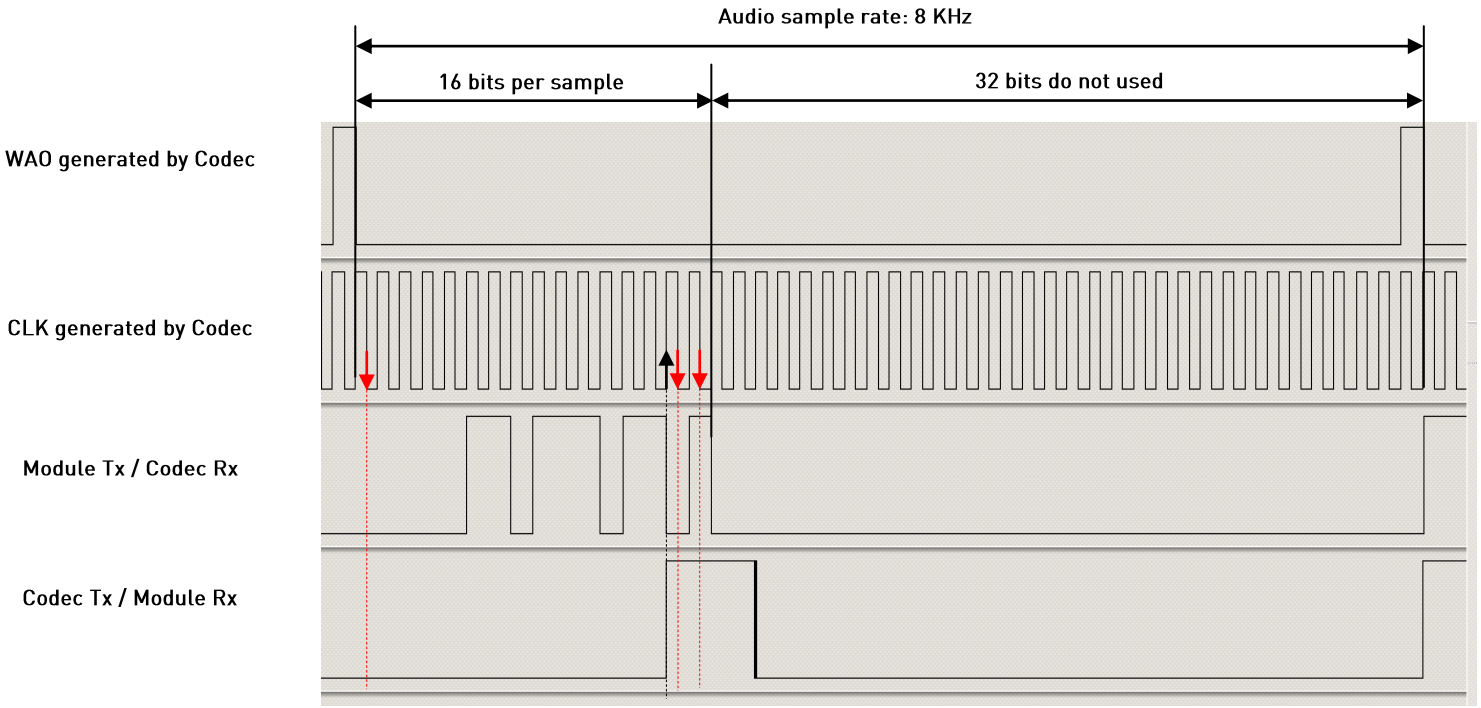


fig. 10: Module is Slave/Burst mode/16 bits per sample/Mono Mode

4. Annex

4.1. I²S Bus Overview

This chapter provides a short description of the standard I²S bus. This standard suitably modified is used by the DVI interface implemented on the GE910 family.

The standard I²S is an electrical serial bus designed for connecting digital audio devices. This popular serial bus has been developed by Philips® in 1986 as a 3-wire bus for interfacing to audio chips such as codecs. It is a simple data interface, without any form of address or device selection.

Refer to fig. 11: the I²S design handles audio data separately from clock signals. On an I²S bus, there is only one bus master and one transmitter.

In high-quality audio applications involving a codec, the codec is typically the master so that it has precise control over the I²S bus clock.

An I²S bus design consists of the following serial bus lines:

- SD: Serial Data
- WS: Word Select
- Serial Clock: SCK

The I²S bus carries two channels (left and right) 8 bit long, which are typically used to carry stereo audio data streams. The data alternates between left and right channels, as controlled by the word select signal driven by the bus master.

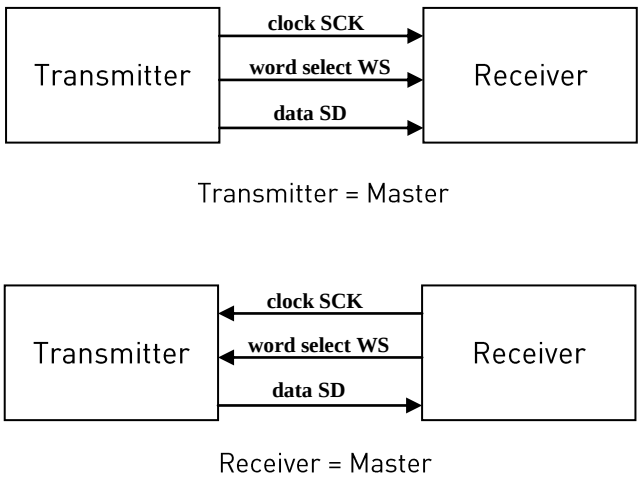


fig. 11: I²S Bus Configurations

4.2. Schematic

A schematic example of an interface between the GE910 Telit Modules and the MAX9867 Codec could be the following:

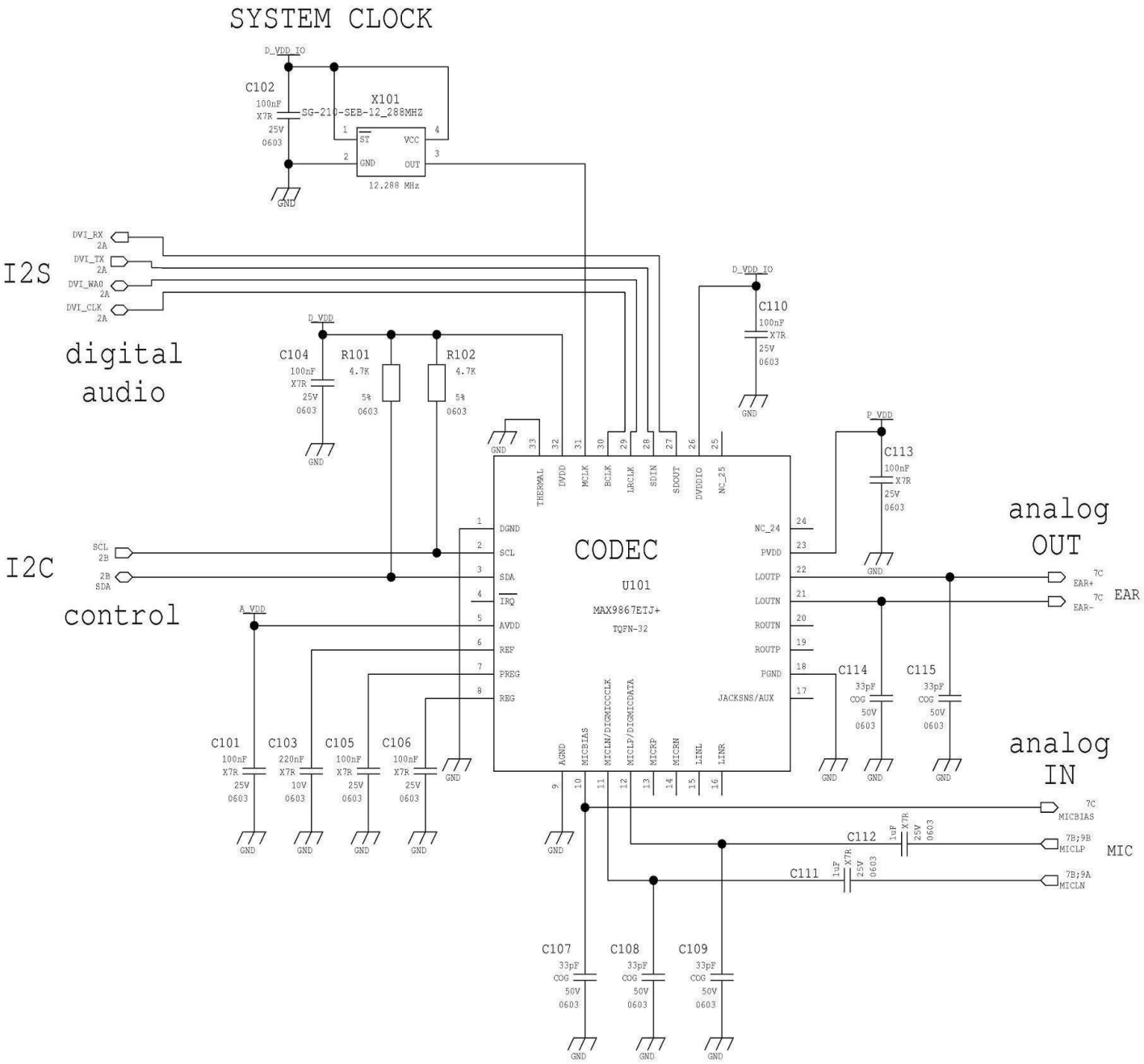


fig. 12: Schematic for Reference Design