Digital Voice Interface Application Note

80000NT10004A Rev. 7 – 2014-04-14

APPLICABILITY TABLE

	SW Versions
GC Family (Compact)	
GC864-QUAD	10.00.xx2
GC864-QUAD V2	10.00.xx2
GC864-DUAL V2	10.00.xx2
GE/GL Family (Embedded)	
GE864-QUAD	10.00.xx2
GE864-QUAD V2	10.00.xx2
GE864-QUAD Automotive V2	10.00.xx2
GE864-QUAD ATEX	10.00.xx2
GE864-DUAL V2	10.00.xx2
GE864-GPS	10.00.xx4
GE865-QUAD	10.00.xx2
GL865-DUAL	10.00.xx4
GL865-QUAD	10.00.xx4
GL868-DUAL	10.00.xx4

Note: the features described in the present document are provided by the products equipped with the software versions equal or higher than the versions shown in the table. See also the Document History chapter.

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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 shown in the Applicability Table.

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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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] MAX9867 Ultra-Low Power Stereo Audio Codec, MAXIM
[2] AT Commands Reference Guide, 80000ST10025A

1.5. Document History

Revision	Date	Products / SW Versions	Changes
0	2007-09-12	/	First release
1	2008-09-18	/	Updated P/N list applicability table Added GE864-QUAD Automotive to Applicability List Updated protocol description Updated description of DVI port setting in Slave mode
2	2009-01-15	/	Updated applicability table Modified chapter 3 due to GE865-QUAD Automotive pin out description
3	2010-03-16	/	Document updated to general Telit template Chapter1 & 2 updated to general Telit template The chapter 3 is new Chapter 4 is the previous Chapter 8 but modified Chapter 5 is the previous Chapter 4 but modified The chapter 6 is new The chapter 7 is new Chapter 8 is the previous Chapter 9 but modified
4	2010-10-04	/	Added GL865-DUAL to the applicability table
5	2012-07-02	/	Updated field DVI_CLK clock period of the table showed in Chapter 2.7.2
6	2012-08-02	/	Cosmetics
7	2014-04-14	/	The present release supersedes all previous releases. The document has been totally reorganized.

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. DVI Overview

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 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.

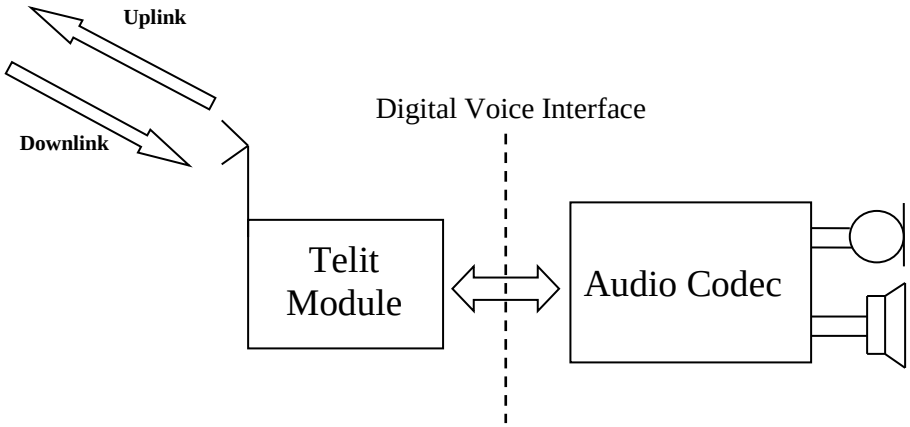


fig. 1: Example of Digital Voice Interface Use

NOTICE: the Digital Voice Interface supports the Echo canceller functionality, which is beyond the scope of the present document. Refer to document [2] for the specific AT commands.

3. DVI Bus

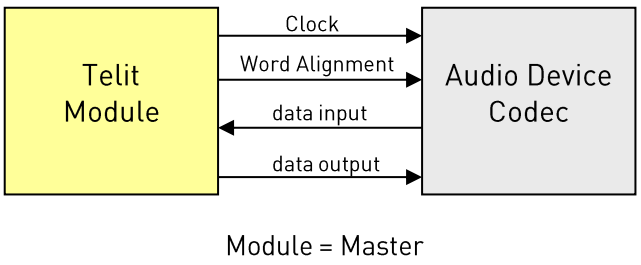
The physical DVI interface provided by the Telit's modules is based on the standard I^2S Bus. An overview of the standard I^2S Bus is described in chapter 6.1. Tab. 1 summarizes the DVI signals and a short description for each one of them; refer to Telit Hardware User Guide, in accordance with the used module, to have information on electrical characteristics, number of DVI ports, and signals pin-out.

DVI Signal	DVI Signal name	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

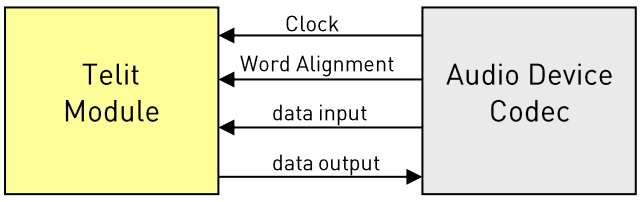
Tab. 1: DVI Signals

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 document [2]. The next pages describe the use of these AT commands.



Module = Master



Module = Slave

fig. 2: Master and Slave Configurations

4. DVI AT Commands

Several DVI audio bus configurations are available via AT#DVI and AT#DVIEXT commands. The tables in the following sub-sections summarize their parameters; refer to document [2] for AT commands syntax details.

4.1. AT#DVI

AT#DVI command enables/disables the DVI interface, selects the DVI port, and sets the module in Master or Slave configuration. The table below shows the AT command parameters values.

AT#DVI =<mode>,<dviport>,<clockmode>		
<mode>	<dviport>	<clockmode>
0 →disable DVI interface 1 → enable DVI interface 2 → enable DVI interface and analog lines	1 → select DVI port 1, factory setting 2 → select DVI port 2, refer to the Hardware User Guide of the used module to know if it supports the DVI port 2	0 → DVI slave 1 → DVI master, factory setting

Tab. 2: DVI configuration via AT#DVI command

4.2. AT#DVIEXT

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 factory setting 1 → reserved	0 → 16 bits per sample 1 → reserved 2 → reserved 3 → 24 bits per sample 4 → 32 bits per sample	0 → reserved 1 → Dual Mono The same Data Word is transmitted on both audio channels (right and left) 2 → reserved	0 → data is transmitted on the falling edge of the clock and sampled on its rising edge, factory setting. 1 → data is transmitted on the rising edge of the clock and sampled on its falling edge.
Burst (PCM)	0 factory setting			0	don't care if the <edge> value is 1 or 0, data is always transmitted on the rising edge of the clock and sampled on its falling edge

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

5. 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[1] [1]: the user by means of AT commands can control the codec. The DVI bus provides the voice connection between the two devices.

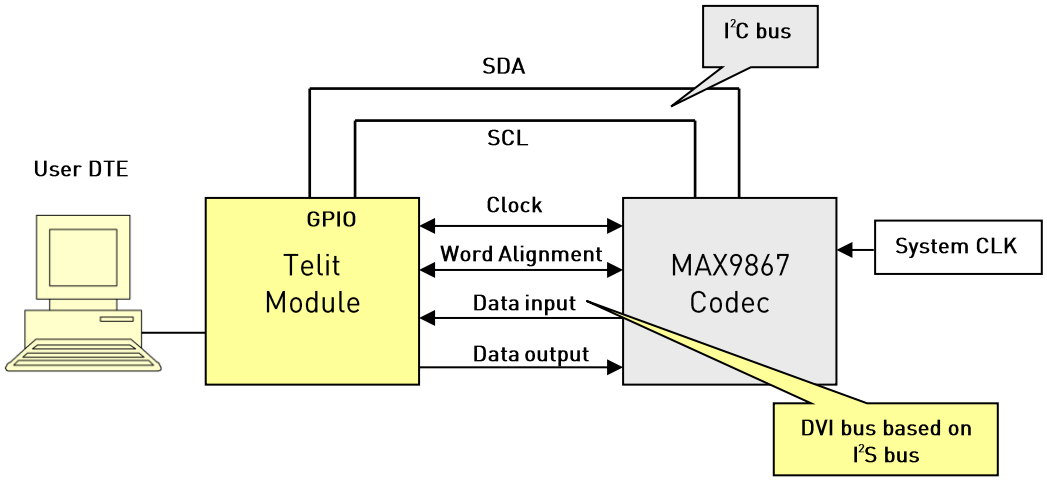


fig. 3: Telit Module/Codec Connections

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

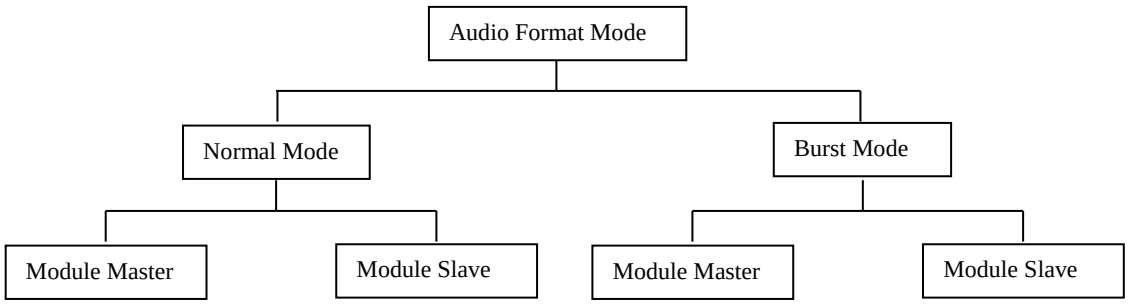


fig. 4: DVI Configurations

[1] The following examples use the MAX9867 Codec, see chapter 6.2 for a schematic reference design. In general, the user can use any codec compliant with the technical requirements of the used module.

5.1. Normal (I^2S) Mode

5.1.1. Module is Master

In this configuration the WAO and CLK signals are generated by the module. The WAO signal defines the frame of the two audio channels: left and right, refer to fig. 5. The BitClockFrequency (CLK) is provided by the following expression:

$$BitClockFrequency = DataWordBit \times ChannelNumber \times AudioSampleRate$$

The BitClockFrequency values are shown in Tab. 4.

<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

Here are 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. The meanings of the used parameters values are described after each command.

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

AT#DVI=1,1,1
OK

DVI bus

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

Setting for BitClockFrequency = 256 KHz

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

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

Setting for BitClockFrequency = 512 KHz

AT#DVIEXT=1,0,4,1,1
OK

1 Normal Mode
0 sample rate 8 KHz (mandatory)
4 32 bits per sample
1 Dual Mono, the same Data Word is transmitted on both audio channels
1 data is transmitted on the rising edge of clock and sampled on the falling edge

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

I^2C bus

AT#I2CWR=X,Y,30,4,19
>00109000200A330000330C0C09092424400060
OK

X GPIO number used as SDA, refer to [2]
Y GPIO number used as SCL, refer to [2]
30 Device address on I^2C, refer to [1]
4 Register address from which start the writing, refer to [1]
19 number of bytes to write
>00109000…..refer to [1]

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

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

The fig. 5 shows the screenshot of the timing diagram, captured by a logic analyzer, using the above described module/codec setting. The CLK (256 KHz) and WAO signals are generated by the module, data is transmitted on the rising edge of clock and sampled on the falling edge.

Left channel:

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

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

Right channel:

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

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

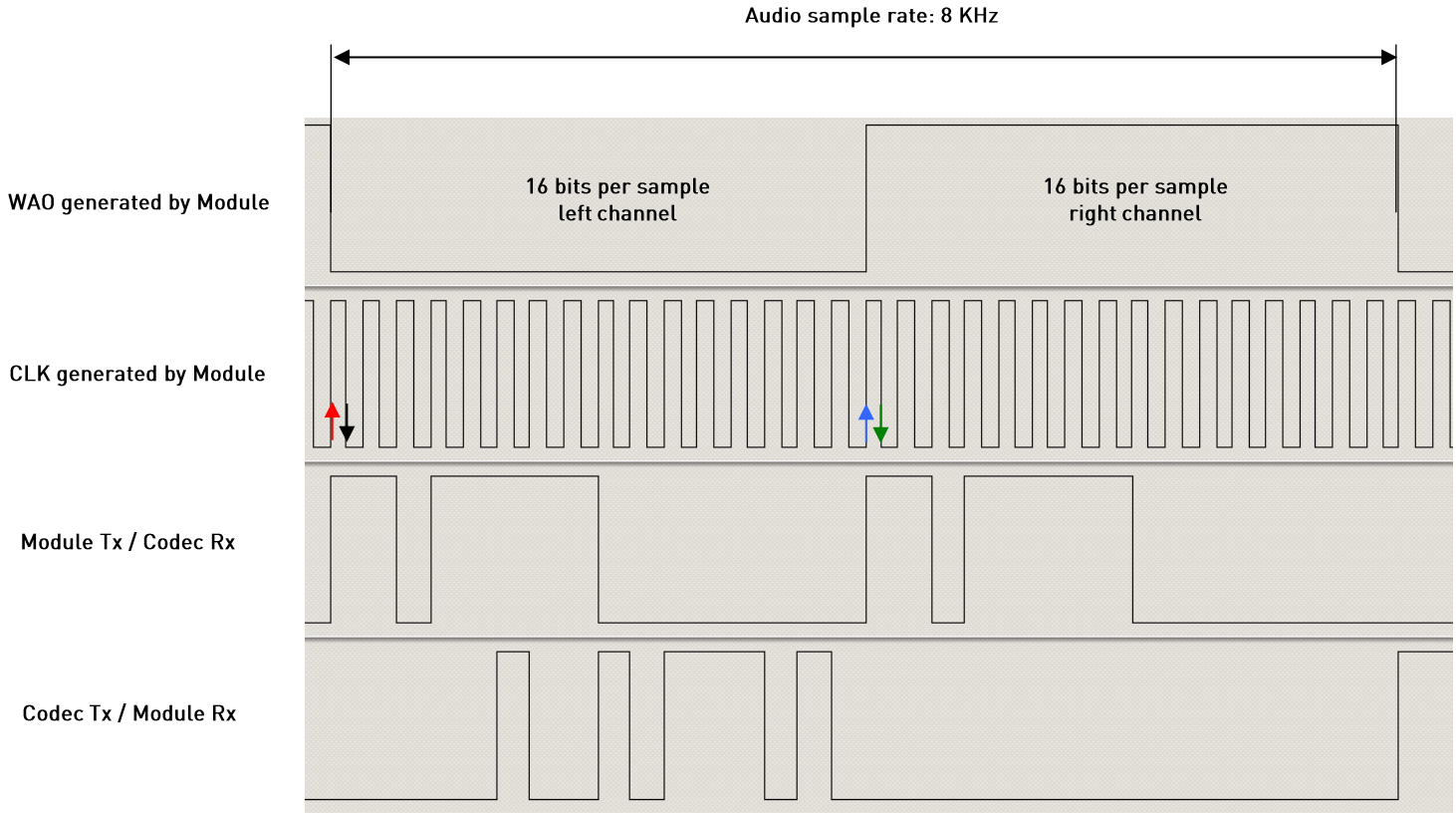


fig. 5: Module is Master/Normal mode/16 bits per sample/Dual Mono/<edge> = 1

5.1.2. Module is Slave

Below are 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. The meanings of the used parameters values are described after each command.

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
0 set the module as Slave

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

1 Normal Mode
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 the falling edge of the clock and sampled on the rising edge

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

I^2C bus

AT#I2CWR=X,Y,30,4,19
>00101000800233000033OC0C09092424400060
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 [1]

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 [1]

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 fig. 6 shows the screenshot of the timing diagram, captured by a logic analyzer, using the above described module/codec setting. The CLK (384 KHz) and WAO signals are generated by the codec, data is transmitted on the falling edge of the clock and sampled on the rising edge.

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

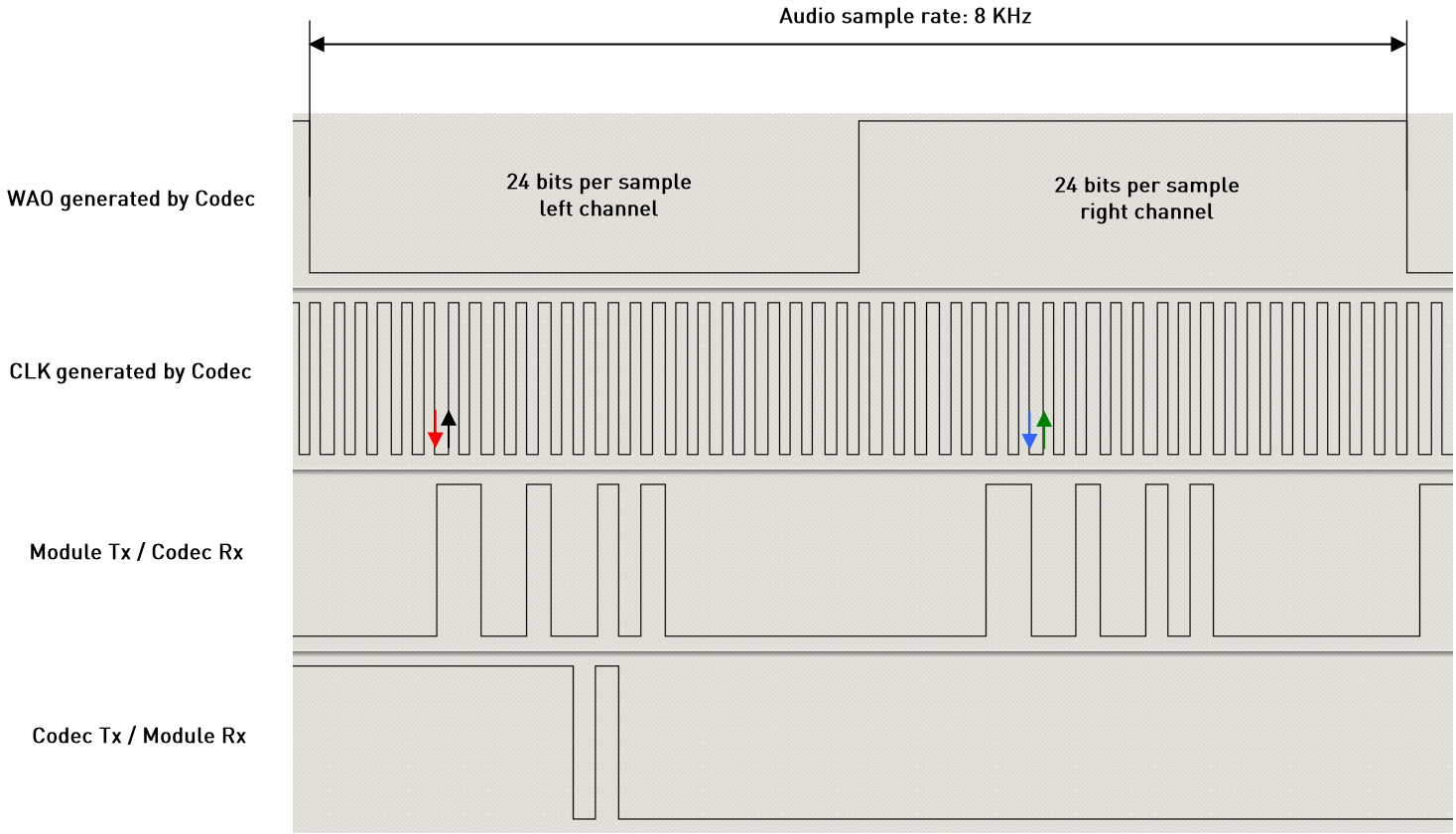


fig. 6: Module is Slave/Normal mode/24 bits per sample/Dual Mono/ <edge> = 0

5.2. Burst Mode (PCM)

5.2.1. Module is Master

This configuration is not available yet.

5.2.2. Module is Slave

The fig. 7 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.

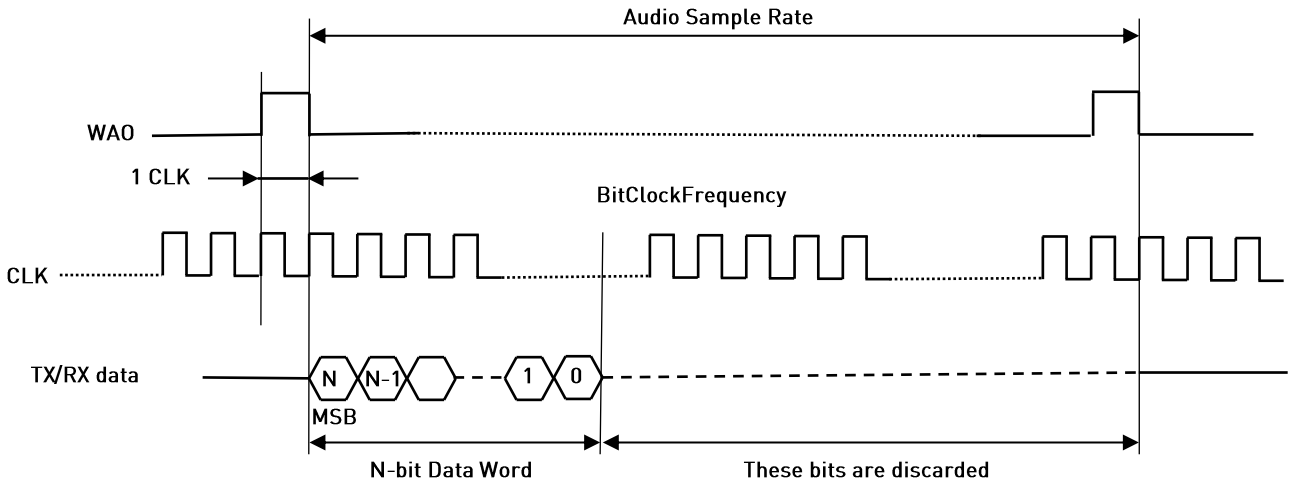


fig. 7: Module is Slave/Burst mode/N bits per sample/Mono Mode

DataWordBit	Bits discarded	AudioSampleRate: 8 KHz
		BitClockFrequency in KHz
16	32	(DataWordBit + Bits discarded) x 8KHz = 384KHz

Tab. 5: BitClockFrequency generated by the codec in Master/Burst Mode (PCM)

Here are the lists of AT commands used to set the module in Slave/Burst (PCM) Mode, and configure the codec in accordance with the module setting. The meanings of the used parameters values are described after each command.

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
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 fixed value
1/0 data is transmitted on the rising edge of the clock and sampled on the falling edge

Configure the Codec in Master/Burst (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 [1]

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 [1]

The fig. 8 shows the screenshot of the timing diagram, captured by a logic analyzer, using the above described module/codec setting. The CLK (384 KHz) and WAO signals are generated by the codec, data is transmitted on the rising edge of clock and sampled on the falling edge.

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

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

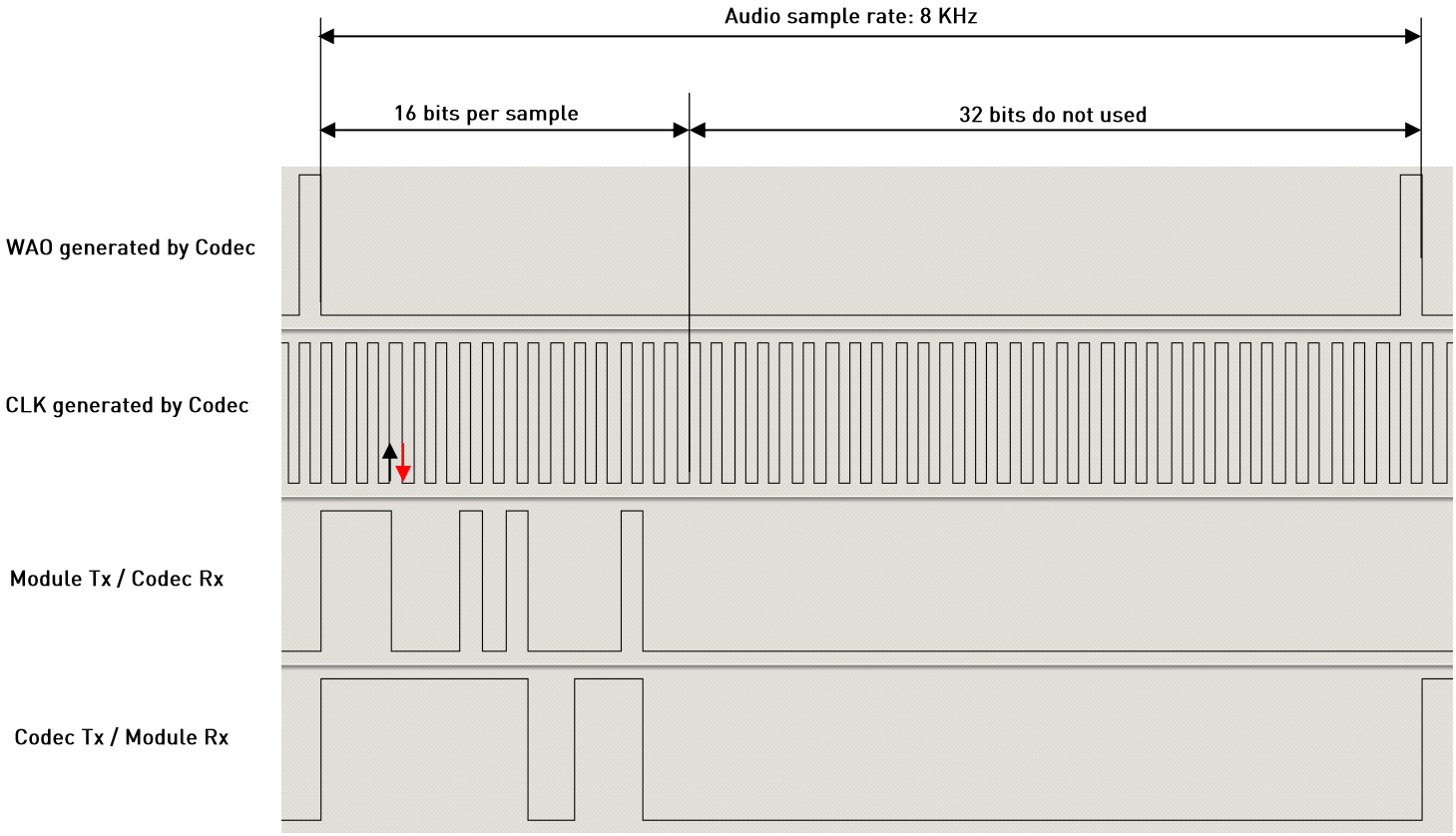


fig. 8: Module is Slave/Burst mode/16 bits per sample/Mono Mode

6. Annex

6.1. 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 Telit modules.

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. 9: 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.

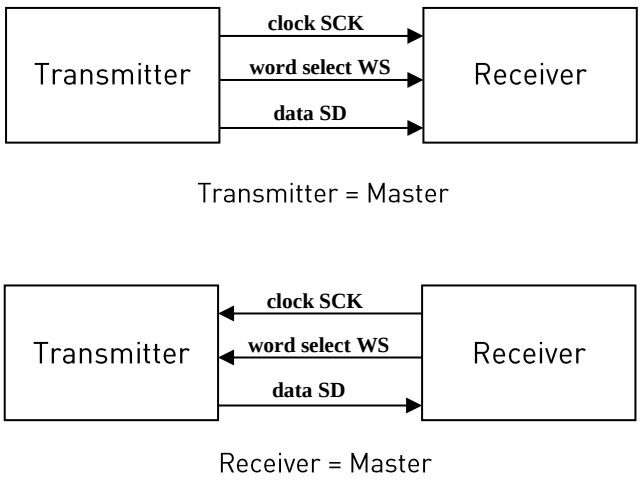


fig. 9: I2S Bus Configurations

6.2. Schematic

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

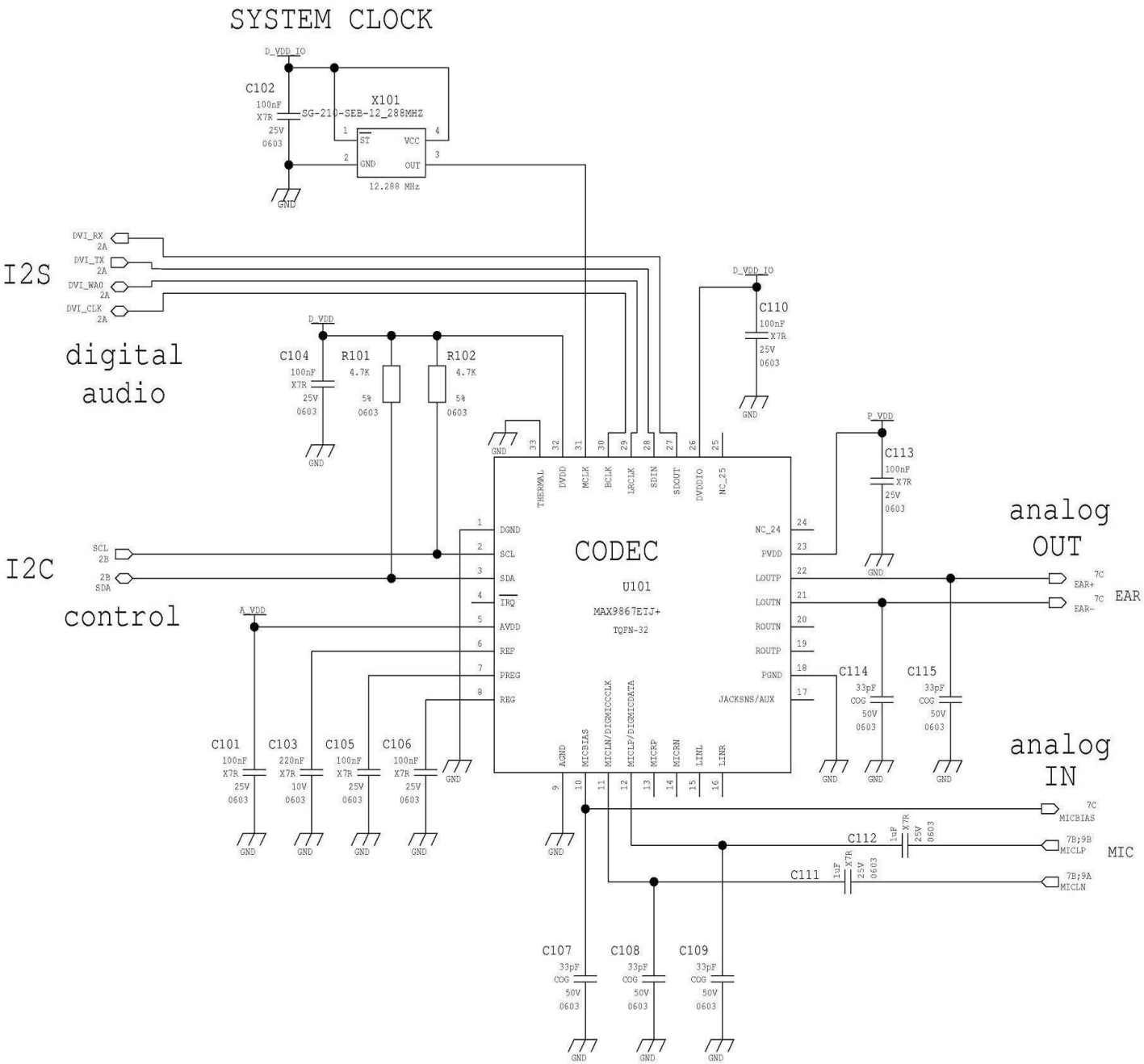


fig. 10: Schematic for Reference Design