Configuring H5 Devices

Using AT RUN, Setting up Digital Voice Interface and Configuring Ports Reference Guide

H5 AT Commands Reference Guide for the following products:

MTSMC-H5-xx, MTPCIE-H5-xx, MTC-H5-xx, MTR-H5-xx, MTRZ-H5-xx, MTCMR-H5-xx, MT100UCC-H5-xx, MT100EOCG-H5-xx, MTCDP-H5-xx, MTD-H5-xx
Part Number S000552A, Revision A

Copyright

Multi-Tech Systems, Inc. makes no representations or warranty with respect to the contents hereof and specifically disclaim any implied warranties of merchantability or fitness for any particular purpose. Furthermore, Multi-Tech Systems, Inc. reserves the right to revise this publication and to make changes from time to time in the content hereof without obligation of Multi-Tech Systems, Inc. to notify any person or organization of such revisions or changes.

Revisions

Revision Level	Date	Description
A	11/28/12	Initial release.

Trademarks

Multi-Tech and the Multi-Tech logo are registered trademarks of Multi-Tech Systems, Inc.

Contacting Multi-Tech

Knowledge Base

The Knowledge Base provides immediate access to support information and resolutions for all Multi-Tech products. Visit http://www.multitech.com/kb.go.

Support Portal

To create an account and submit a support case directly to our technical support team, visit: https://support.multitech.com

Technical Support

Business Hours: M-F, 9am to 5pm CT

Country	By Email	By Phone
Europe, Middle East, Africa:	support@multitech.co.uk	+(44) 118 959 7774
U.S., Canada, all others:	support@multitech.com	(800) 972-2439 or (763) 717-5863

World Headquarters

Multi-Tech Systems, Inc.
2205 Woodale Drive
Mounds View, Minnesota 55112
Phone: 763-785-3500 or 800-328-9717
Fax: 763-785-9874

Warranty

To read the warranty statement for your product, please visit: http://www.multitech.com/warranty.go.

Contents

Document Overview

This guide describes the following for the radio module running on many MultiTech H5 devices:

- Using the SMS AT Run, TCP AT Run and Event Monitor Services
- Using the digital voice interface
- Arranging ports to avoid resource conflicts

Abbreviations and acronyms

BTS	Base Transceiver Station
DTE	Data Terminal Equipment
GGSN	Gateway GPRS Support Node
GPIO	General Purpose Input/Output
GPRS	General Packet Radio services
I2CBUS	I-squared-C Bus
PAP	Password Authentication Protocol
PDP	Packet Data Protocol
PLMN	Public Land Mobile Network
RDTSB	Remote Digital Temperature Sensor Board
RRTC	Remote Room Temperature Control
SGSN	Serving GPRS Support Node
NMEA	National Marine Electronics Association
SPI	Serial Peripheral Interface
TT	Trace Tool (generic trace tool)
USIFx	Universal Serial Interface
VSD	Virtual Service Device
DVI	Digital Voice Interface
I2C	Inter-Integrated Circuit
I2S	Inter-IC Sound
MSB	Most Significant Bit

Using AT Run Services and Event Monitor Services

This section describes how to use the AT Run services (SMS AT Run, TCP AT Run) and Event Monitor services.

The following models support these services:

MTSMC-H5 (non UIP)	MTSMC-EV3-N2 (non UIP)	MTSMC-EV3-N3 (non UIP)
MTSMC-EV3-N16 (non UIP)	MTSMC-G3 (non UIP)	MTSMC-C2-N2 (non UIP)
MTSMC-C2-N3 (non UIP)	MTSMC-C2-N16 (non UIP)	MTSMC-Telit-UIP
MT100UCC-H5	MT100UCC-EV3-N2	MT100UCC-EV3-N3
MT100UCC-EV3-N16	MTCBA-H5-EN2	MTCMR-H5
MTCMR-EV3-N2	MTCMR-EV3-N3	MTCMR-EV3-N16
MTCMR-C2-N2	MTCMR-C2-N3	MTCMR-C2-N16
MT100EOCG-H5	MT100EOCG-EV3-N2	MT100EOCG-EV3-N3
MT100EOCG-EV3-N16	MTCDP-H5	Physio-EV3-N3
MTPCIE-H5 and MTPCIE-DK1	MTPCIE-EV3-N2	MTPCIE-EV3-N3
MTPCIE-EV3-N16	MTD-H5-Bxx	MTD-EV3-Bxx-N2
MTD-EV3-Bxx-N3	MTD-EV3-Bxx-N16	MTOCGD3/MTOCGD2-H5
MTOCGD3/MTOCGD2-EV3-N2	MTOCGD3/MTOCGD2-EV3-N3	MTOCGD3/MTOCGD2-EV3-N16
MTC-H5-Bxx	MTC-EV3-Bxx-N2	MTC-EV3-Bxx-N3
MTC-EV3-Bxx-N16	MTC-G3-Bxx	MTC-C2-Bxx-N2
MTC-C2-Bxx-N3	MTC-C2-Bxx-N16	

AT Run Services Overview

The AT Run services let you run AT commands on a remote module by means of a communication protocol which connects a local module and a module located on a remote site. Figure 1 illustrates this concept.

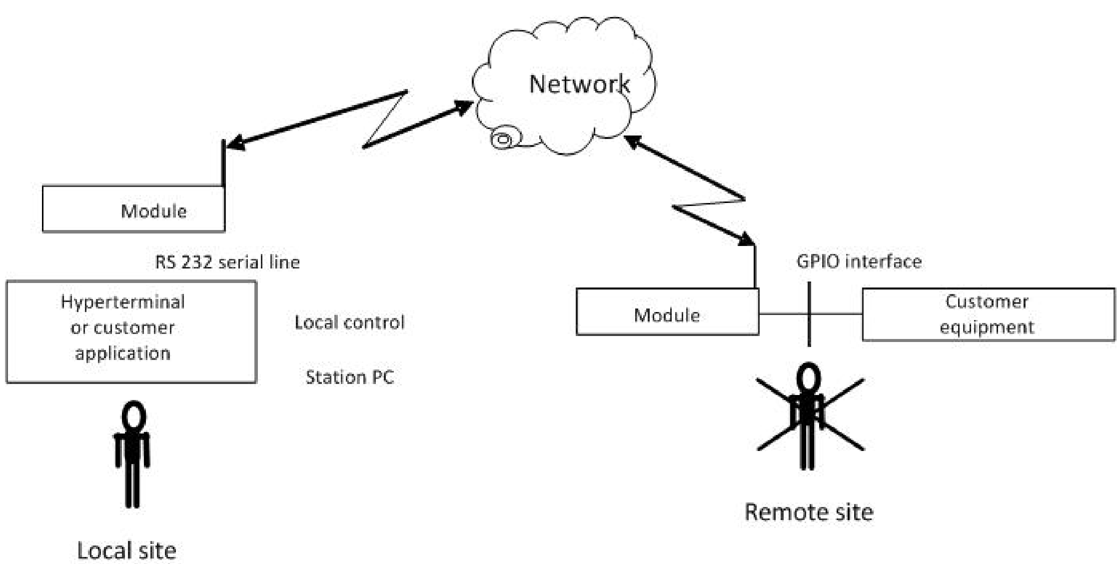


Figure 1 AT Run services basic configuration

The modules provide the following types of AT Run services:

- SMS AT Run service:
  - Simple SMS AT Run service
  - Digest SMS AT Run service

  You can use the SMS AT Run service in GSM mode or in GPRS mode. For GPRS, the network operator must support SMS.

- TCP AT Run service
  - Client mode
  - Server (listen) mode

Note: The Event Monitor service provided by the module lets you associate an AT command with a specified event monitored by the module itself. When the module recognizes the event occurring, it executes the associated AT command. You can use the Event Monitor service jointly with the AT Run services. For further information about the Event Monitor service, see the section “

Event Monitor Service Overview” in this guide.

SMS AT Run Service Overview

The SMS AT Run service is supported by the SMS protocol to receive the AT commands and to send back the results of the AT command.

SMS AT Run Configuration Example

1. Issue the following commands to configure the MultiTech H5 device:

`AT#REGMODE=1`	
`AT#SMSATRUN=0`	Disable SMS AT RUN
`AT#TCPATRUNL=0`	Disable TCP AT RUN listen (server)
`AT#TCPATRUND=0`	Disable TCP AT RUN dial (client)
`AT#ENAEVMONI=0`	Disable Event Monitor
`AT#SMSATRUNCFG=3,1,5`	Set up SMS AT Run service
`AT#SMSATWL=0,1,0,”6124241372”`	Add telephone number to white list. This commands is described in the guide HSPA-H5 AT Commands Reference Guide part number S000528x.
`AT#SMSATRUN=1`	Enable SMS AT Run service

2. Send a SMS message containing any AT command—for example command AT#MONI—to the phone number of the H5 radio. Your message must be sent from a device whose phone number is listed in the device’s white list. The white list is described in greater detail in the guide HSPA-H5 AT Commands Reference Guide part number S000528x.

   In response to the sent message, the device that sent the SMS message receives an SMS from the H5 device, indicating the H5 device response to the AT Command.

   +PACSP0 #MWI: 1,1,1 #MONI: AT&T BSIC:06 RxQual:0 LAC:7D09 Id:2AF5 ARFCN:178 PWR:-81dbm TA:5 OK

Notes:

- The device sending the SMS to the H5 must have its phone number listed in the H5’s White List.
- You only need to issue the commands AT#SMSATRUN=0, AT#TCPATRUNL=0, AT#TCPATRUND=0 and AT#ENAEVMONI=0 if the commands were previously enabled in the device.

AT Command Log to H5

```
AT#REGMODE=1
OK
AT#SMSATRUN=0
OK
AT#TCPATRUNL=0
OK
AT#TCPATRUND=0
OK
AT#ENAEVMONI=0
OK
AT#SMSATRUNCFG=3,1,5
OK
AT#SMSATWL=0,1,0,"6124241372"
OK
AT#SMSATRUN=1
OK
```

When SMS is received from device specified via command AT#SMSATWL the following appears:

```
#SMSATRUN: AT#MONI
```

TCP AT Run Service Overview

The TCP AT Run service is supported by the TCP protocol to receive the AT commands sent by the local station and to send back the results of the AT command.

TCP AT Run Service

This example illustrates the enabling of TCP AT Run service on an H5 device which allows the remote issuing of AT commands to the H5 radio.

1. Issue the following commands to configure the MultiTech H5 device:

AT#REGMODE=1	VALID COMMAND NOT IN AT COMMAND GUIDE
AT#SMSATRUN=0	Disable SMS AT RUN
AT#TCPATRUNL=0	Disable TCP AT RUN Listen (Server)
AT#TCPATRUND=0	Disable TCP AT RUN Dial (Client)
AT#ENAEVMONI=0	Disable Event Monitor
AT#TCPATRUNCFG=1,2,1024,12345,"",1,5,1,5,2	TCP AT Run service configuration
AT#TCPATRUNFRWL=2	Remove previous firewall configuration
AT#TCPATRUNFRWL=1,"204.26.122.49","255.255.255.255"	Define Firewall to allow allowed connection to H5 from the specified IP address
AT#TCPATRUNAUTH=2	Remove previous username and password
AT#TCPATRUNAUTH=1, "username","password"	Define new username and password
AT+CGDCONT=1,"IP","internet"	Define PDP Context 1 (Enter APN)

2. Issue the following commands to check MultiTech H5 device attachment status, if necessary attach to network, and then establish IP connection and display IP address.

AT+CGATT?	Check if H5 Is attached to network (response +CGATT: 1)
AT+CGATT=1 <only issue if not attached>	Attach to network (if not already attached)
AT#SGACT=1,1	PDP activation and obtain IP address

`AT#TCPATRUNL=1` Enable TCP AT Run service in listen mode (server)

3. From a TCP terminal application originating from within the IP address range specified in the Firewall Configuration command, make a connection to the IP address of the device on port 1024.
    a. When prompted enter the username.
    b. When prompted enter the password.
    c. Type an AT command in the terminal application to send it to the H5 device. For example AT#MONI <CR>.
    d. **Result:** *#MONI: AT&T BSIC:06 RxQual:0 LAC:7D09 Id:2AF5 ARFCN:178 PWR:-79dbm TA:0*
    OK

Note:

- This feature requires obtaining an account, SIM, and APN from carrier which allows the H5 to obtain a public IP address and which does not block the connection to the port specified in the AT#TCPATRUNCFG command.

AT Command Log to H5

```
AT#REGMODE=1
OK
AT#SMSATRUN=0
OK
AT#TCPATRUNL=0
OK
AT#TCPATRUND=0
OK
AT#ENAEVMONI=0
OK
AT#TCPATRUNCFG=1,2,1024,12345,"",1,5,1,5,2
OK
AT#TCPATRUNFRWL=2
OK
AT#TCPATRUNFRWL=1,"204.26.122.49","255.255.255.255"
OK
AT#TCPATRUNAUTH=2
OK
AT#TCPATRUNAUTH=1, "username","password"
OK
AT+CGATT?
+CGATT: 1
OK
AT#SGACT=1,1
#SGACT: 155.163.88.49
OK
AT#TCPATRUNL=1
OK
TCPATRUN: <204.26.122.49>
```

Terminal Application Log

```
Username:
Password:
Login successful.
+PACSP0
#MONI: AT&T BSIC:74 RxQual:0 LAC:7D0E Id:2806 ARFCN:233 PWR:-82dbm TA:6
OK
```

Event Monitor Service Overview

The Event Monitor service lets you associate an AT command to a specified event monitored by the module itself. You do not need to develop a program or script to perform the monitoring events actions. When the module recognizes that the event is occurring, it executes the associated AT command.

Configuring Event Monitor Service

This section provides an example of how to enable the Event Monitor service on an H5 device. In response to inbound "RING" the Event Monitor is configured to issue the command "ATA". You can specify the event trigger and the response to the trigger.

1. To configure the MultiTech device, issue the following commands:

`AT#REGMODE=1`	Enable advanced registration mode
`AT#SMSATRUN=0`	Disable SMS AT RUN
`AT#TCPATRUNL=0`	Disable TCP AT RUN listen (server)
`AT#TCPATRUND=0`	Disable TCP AT RUN dial (client)
`AT#ENAEVMONI=0`	Disable Event Monitor
`AT#ENAEVMONICFG=3,1,5`	Set up Event Monitor service
`AT#EVMONI="RING",0,0,"ATA"`	Set up Ring event to trigger ATA command
`AT#EVMONI="RING",1`	Enable the single "RING" event
`AT#ENAEVMONI=1`	Enable Event Monitor

2. To test the Event Monitor, call the phone number of the H5 device. Once the ring is detected the device issues the command ATA and answers the call.

AT Command Log to H5

```
AT#REGMODE=1
OK
AT#SMSATRUN=0
OK
AT#TCPATRUNL=0
OK
AT#TCPATRUND=0
OK
AT#ENAEVMONI=0
OK
AT#ENAEVMONICFG=3,1,5
OK
AT#EVMONI="RING",0,0,"ATA"
OK
AT#EVMONI="RING",1
OK
AT#ENAEVMONI=1
OK
RING
#EVMONI: ATA
```

Using the Digital Voice Interface

This section describes the Digital Voice Interface (DVI). It explains how to configure the interface and the audio formats of the DVI. This section provides examples and timing figures to help you better understand DVI. This section only applies to models that support voice.

The information is intended for users who need to develop applications dealing with signal voice in digital format.

This section describes the configurations of the Digital Voice Interface, for example, selecting the voice sampling frequency, the bit number of the voice sample, the audio formats, and so on. In addition, the configuration of a popular audio codec connected to the module is described. These activities are accomplished through I^2S and I^2C buses.

The following models support DIV:

MTPCIE-H5 MTPCIE-DK1	MTPCIE-EV3-N2	MTPCIE-EV3-N3	MTPCIE-EV3-N16

Overview of Where and How Digital Voice Interface is Used

This section describes where and how you can use the Digital Voice Interface (DVI).

The voice coming from the downlink, in digital format, is captured by the dedicated software running on the module and directed to the Digital Voice Interface. The audio codec decodes the voice and sends it to the speaker.

Conversely, 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.

Figure 2 shows these concepts.

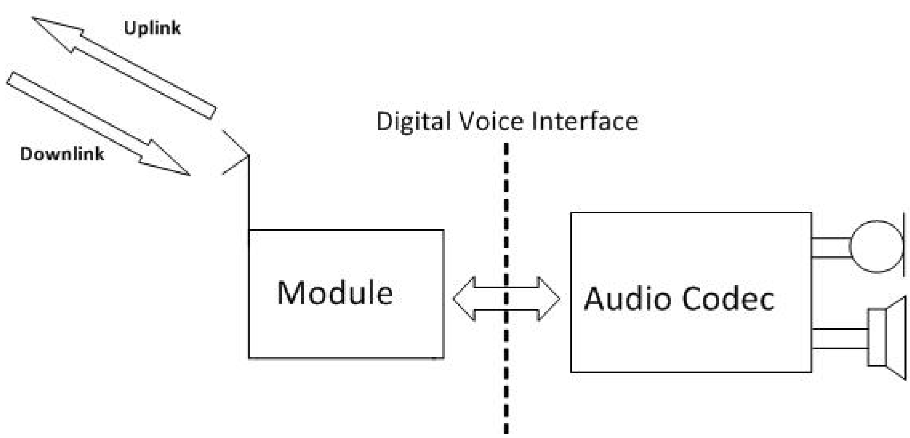


Figure 2 Example of Digital Voice Interface Use

DVI Overview

The physical DVI interface is based on the I^2S Bus provided by the module to perform digital audio transfer. The I^2S is further described in the section "I^2S Overview." Table 1 describes the DVI signals.

I2S Signal	DVI Signal	Description
Clock	DVI_CLK	Data clock

I2S Signal	DVI Signal	Description
Word alignment	DVI_WAO	Frame synchronism
Serial audio data input	DVI_RX	Received data
Serial audio data output	DVI_TX	Transmitted data

Table 1 DVI Signals

The figures that follow show the two basic configurations of the DVI interface relating the Word alignment and Clock signals. These configurations are derived from the concepts of the first I^2S bus design described in the section "I^2S Overview." When the module is master the Clock and Word alignment signals (also called Word alignment Output WAO) are generated by the module itself. When the module is slave, both signals are generated by the connected device: the codec.

For example, before establishing a call you can use AT commands to select one of the two configurations and properly set the module and the codec.

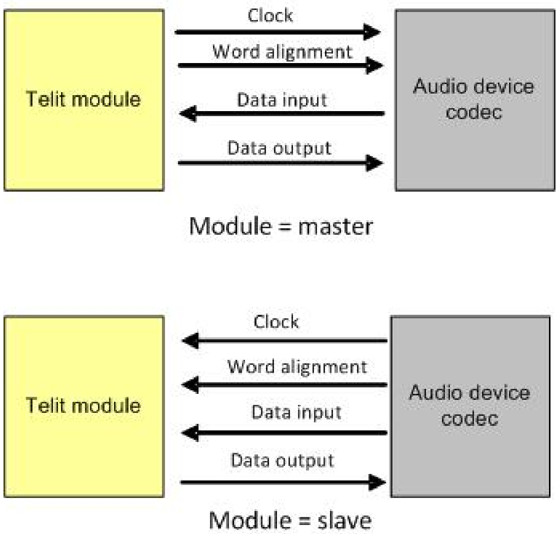


Figure 3 Master and slave configurations

DVI Configurations

The following tables describe several DVI audio bus configurations that are available through the AT#DVI and AT#DVIEXT commands.

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

Table 2 DVI configuration via AT#DVI command

AT#DVIEXT=<config>,<samplerate>,<samplewidth>,<audiomode>,<edge>	
<samplerate>	<samplewidth>
0 → 8 [KHz] sampling frequency	0 → 16 bits per sample
1 → 16 [KHz] sampling frequency	1 → 18 bits per sample
	2 → 20 bits per sample
	3 → 24 bits per sample
	4 → 32 bits per sample

Table 3 DVI configuration via AT#DVIEXT command

DVI modes	Audio format	WAO signal	AT#DVIEXT <remaining parameters>		
			<config>	<edge>	<audiomode>
Normal	I^2S	Square-wave	1	0 (1 reserved)	0 - Mono 1 – DualMono Mono mode and Dual mode are equivalent in normal mode.
Burst	PCM	Pulse	0	0 → WAO transition is synchronized with the CLK falling edge.	
				1 → WAO transition is synchronized with the CLK rising edge.	

DVI audio bus supports normal and burst modes that are relating to the audio formats and the shape of the Word Alignment Output signal (WAO). The WAO signal is used to define the beginning of a frame. You can program the signal as a pulse or a square-wave signal. For each DVI mode you can select the master or slave configuration.

Application Examples

Application examples show some audio formats supported by the DVI audio bus in master and slave configurations. All the examples use the ideas presented in Figure 4.

I^2C bus is used to configure the MAX9867 codec. For examples in this guide, the MAX9867 codec is used. See the section “Schematic” for a reference design. You can choose your own codec, as long as it complies with the technical characteristics of the module.

You can use AT commands to completely control the codec. The DVI bus provides the voice connection between the two devices. For a reference design see the section “Schematic.”

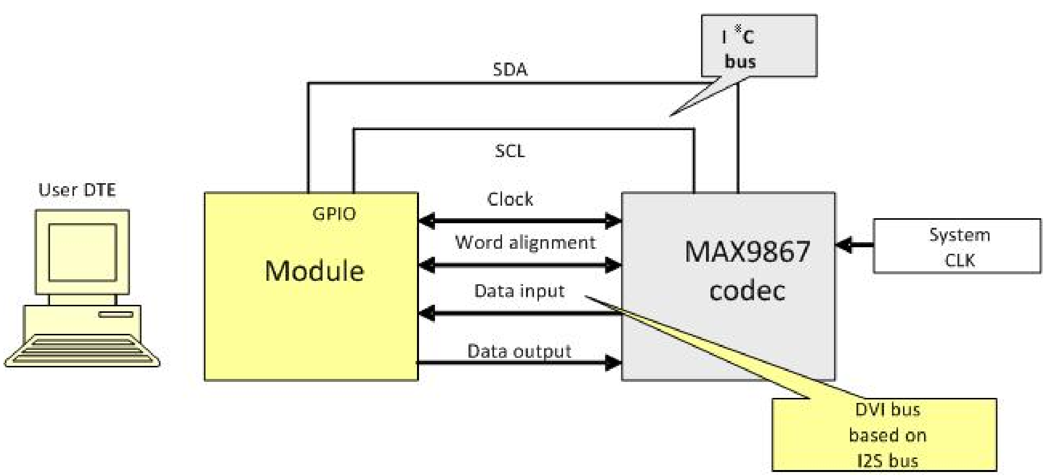


Figure 4 Module and codec connections

Normal Mode (I^2S)

Module is Master

The figure that follows shows that the MSB of the left channel is clocked on the second CLK rising edge after WAO transitions. When WAO is low, left channel data is transmitted. When WAO is high, right channel data is transmitted (right + left = 2 channels).

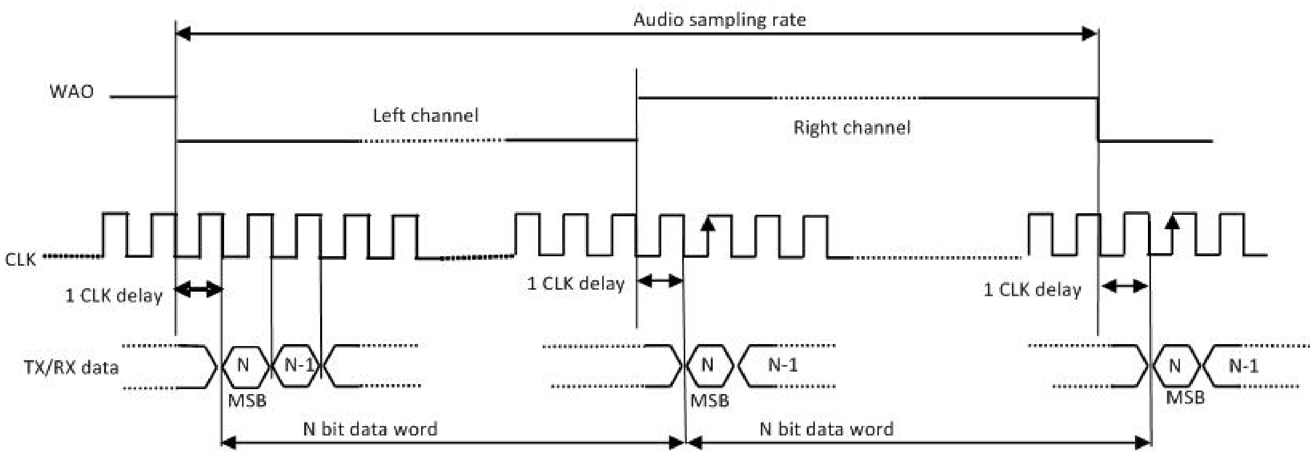


Figure 5 Timing diagram of I^2S audio format

In general, the BitClockFrequency (CLK) is furnished by the following expression:

$$BitClockFrequency = DataWordBit \times ChannelNumber \times SamplingFrequency$$

Table 4 describes the BitClockFrequency that the module generates.

<samplewidth>	Data word bit	Left, right channels	Sampling frequency	
			8 KHz	16 KHz
			Bit Clock frequencies in KHz	
0	16	2	256	512
1	18	2	384	768
2	20	2		
3	24	2		
4	32	2	512	1024

Table 4 Bit clock frequencies

The following AT commands cause the module to enter master configuration/I^2S-compatible audio format and configure the codec according to the current module settings. The meaning of the used parameters appears after each command, for your convenience.

Configuring the Module to operate with I^2S-compatible audio format

DVI bus

```
AT#DVI=1,2,1
OK
```

where:

1 Enable DVI

2 Use DVI port 2 (mandatory)

1 DVI master (factory setting)

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

where:

1 Normal mode (factory setting)

0 Sample rate 8 KHz (factory setting)

0 16 bits per sample (factory setting)

1 Dual mono (factory setting)

0 I^2S

Note: In the timing shown in Figure 5, the two N-bit data words are equals because the dual mono mode has been selected.

Configuring the codec to operate with I²S audio format

```
AT#I2CWR=x,y,30,4,19
>00109000100A330000330C0C09092424400060
OK
```

I²C bus

where:

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

>00109000

```
AT#I2CWR=x,y,30,17,1
>8A
OK
```

where:

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

The following figure shows the timing diagram, captured by an oscilloscope, for the preceding example. The clock generated by the module is 384 KHz.

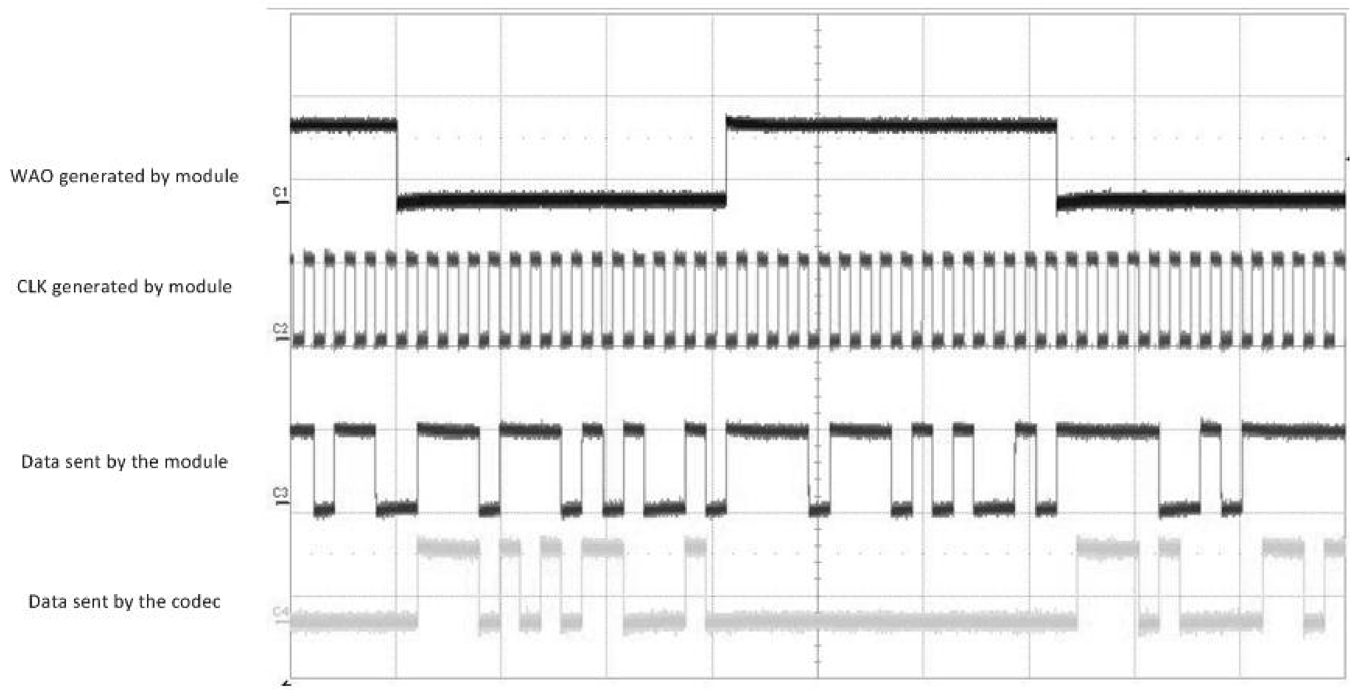


Figure 6 Timing diagram of module in master configuration/normal mode

Module is Slave

For basic timing diagram, see Figure 5.

The following AT commands cause the module to enter slave configuration/I^2S audio format and configure the codec according to the current module setting.

Configure the module to operate with I^2S-compatible audio format

DVI bus

```
AT#DVI=1,2,0
OK
```

1 Enable DVI

2 Use DVI port 2 (mandatory)

0 DVI slave

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

1 Normal mode (factory setting)

0 Sample rate 8 KHz (factory setting)

3 24 bits per sample

1 Dual mono (factory setting)

0 I^2C

Note: The used codec, in master configuration, generates a clock equal to 384 KHz therefore the selected number of bits per sample on module is 24. For more information, see Table 4.

Configuring the codec to operate with I^{2}S audio format

I^{2}C bus

```
AT#I2CWR=X,Y,30,4,19
>0010100090023300003З0C0C09092424400060
OK
```

x GPIO number used as SDA

y GPIO number used as SCL

30 Device address on I^{2}C

4 Register address from which start the writing

19 Number of bytes to write

```
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^{2}C

17 Register address where write data

1 Number of bytes to write

The following figure shows the timing diagram, captured by an oscilloscope, concerning the preceding example. The clock generated by the codec is 384 KHz.

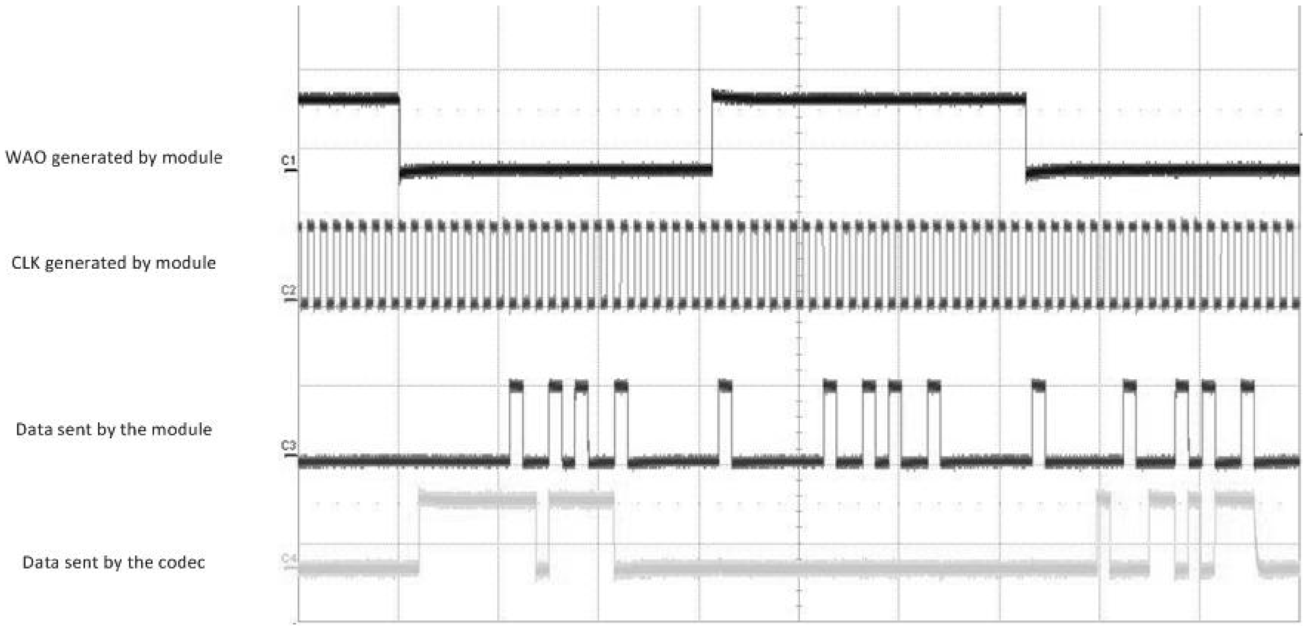


Figure 7 Timing diagram of module in slave configuration/normal mode

Burst Mode (PCM)

Module is Master

In PCM audio format the MSB of the channel included in the frame (WAO) is clocked on the third CLK falling edge after the WAO pulse rising edge. The period of the WAO signal (frame) lasts for data word bit + 2 clock pulses.

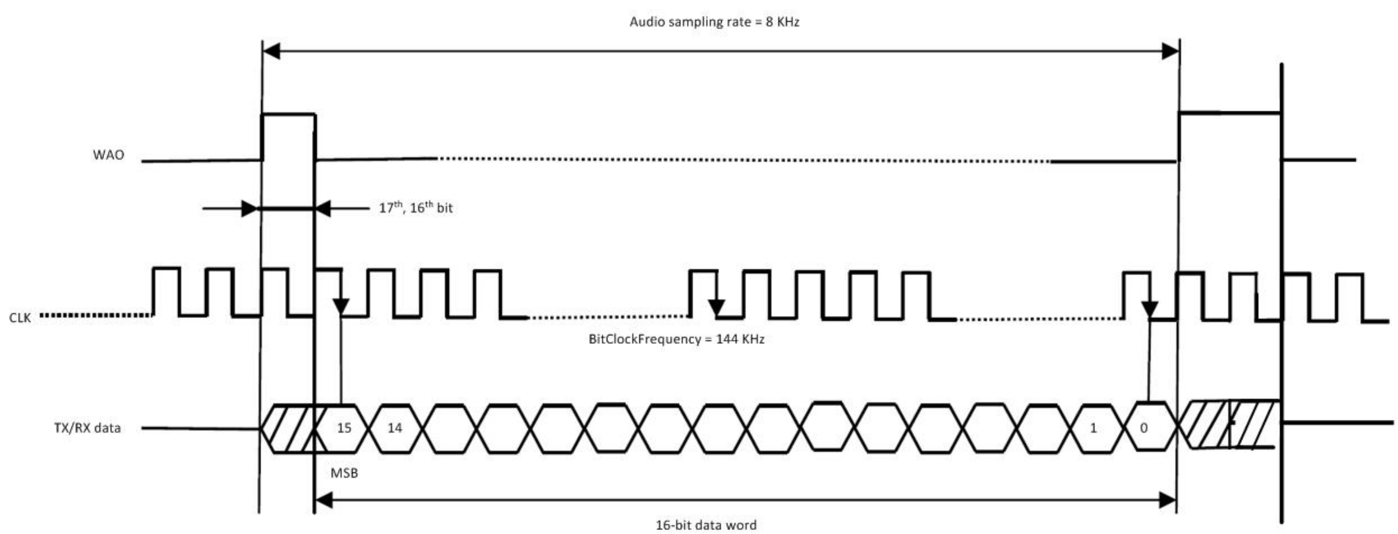


Figure 8 Timing diagram of PCM audio format (burst mode) /mono mode

In general, the BitClockFrequency (CLK) is furnished by the following expression:

$$BitClockFrequency = (DataWordBit + 2) \times SamplingFrequency$$

Refer to Table 5 for the BitClockFrequency that the module generates.

<samplewidth>	DataWordBit	Sampling freq.	Sampling freq.
		8 [KHz]	16 [KHz]
		BitClockFrequency [KHz]	
0	16 + 2	144	288
4	32 + 2	272	544

Table 5 Bit Clock frequency in burst mode

The following AT commands cause the module to enter master configuration/PCM audio format (burst mode).

Configure the Module to operate with PCM audio format (burst mode)

DVI bus

```
AT#DVI=1,2,1
OK
```

1 Enable DVI

2 Use DVI port 2 (mandatory)

1 DVI master (factory setting)

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

0 Burst mode

0 Sample rate 8 KHz (factory setting)

0 16 bits per sample (factory setting)

0 Mono mode

1 WAO transition is synchronized with the CLK rising edge.

No AT commands example is given for the codec.

Module is Slave

In PCM audio format the MSB of the channel is clocked on the second CLK falling edge after the WAO pulse rising edge.

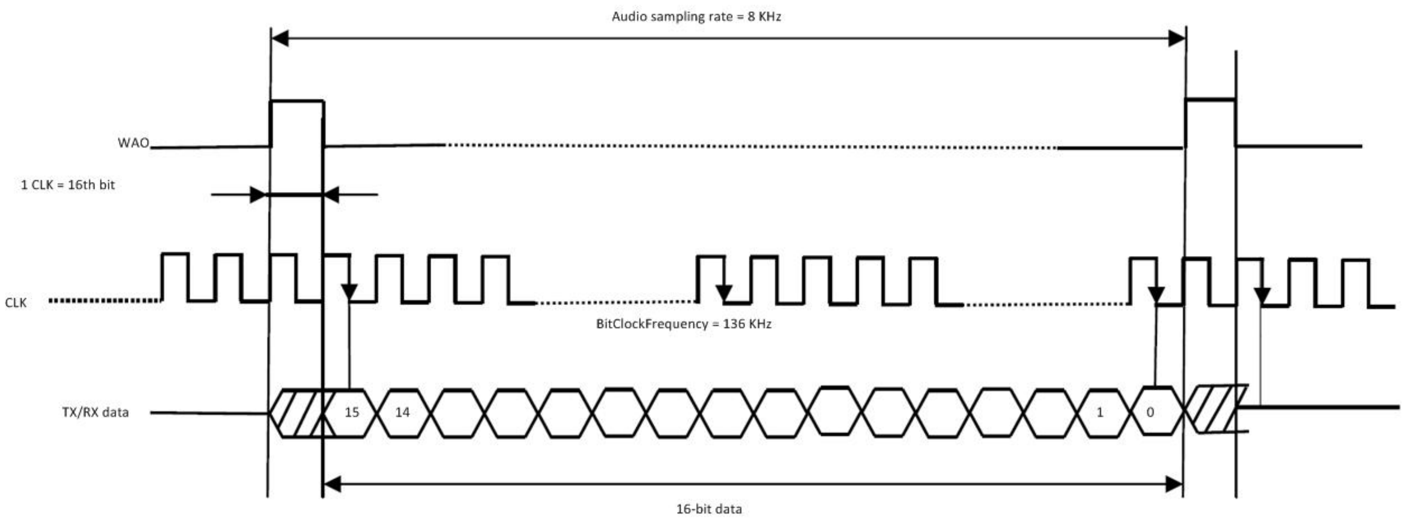


Figure 9 Timing diagram of PCM audio format (burst mode) /mono mode

In general, the lower BitClockFrequency (CLK) is furnished by the following expression:

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

$$BitClockFrequency = (16 + 1) \times 8 = 136\, KHz$$

The following AT commands cause the module to enter slave configuration/PCM audio format (burst mode) and configure the codec according to the current module setting.

Configuring the Module to operate with PCM audio format.

DVI bus

```
AT#DVI=1,2,0
OK
```

1 Enable DVI

2 Use DVI port 2 (mandatory)

0 DVI slave

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

0 Burst mode

0 Sample rate 8 KHz (factory setting)

0 16 bits per sample (factory setting)

0 Mono mode

1 WAO transition is synchronized with the CLK rising edge.

Configuring the codec to operate with PCM audio format

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

```
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

The following figure shows the timing diagram, captured by an oscilloscope, for the preceding example. The clock generated by the codec is 384 KHz.

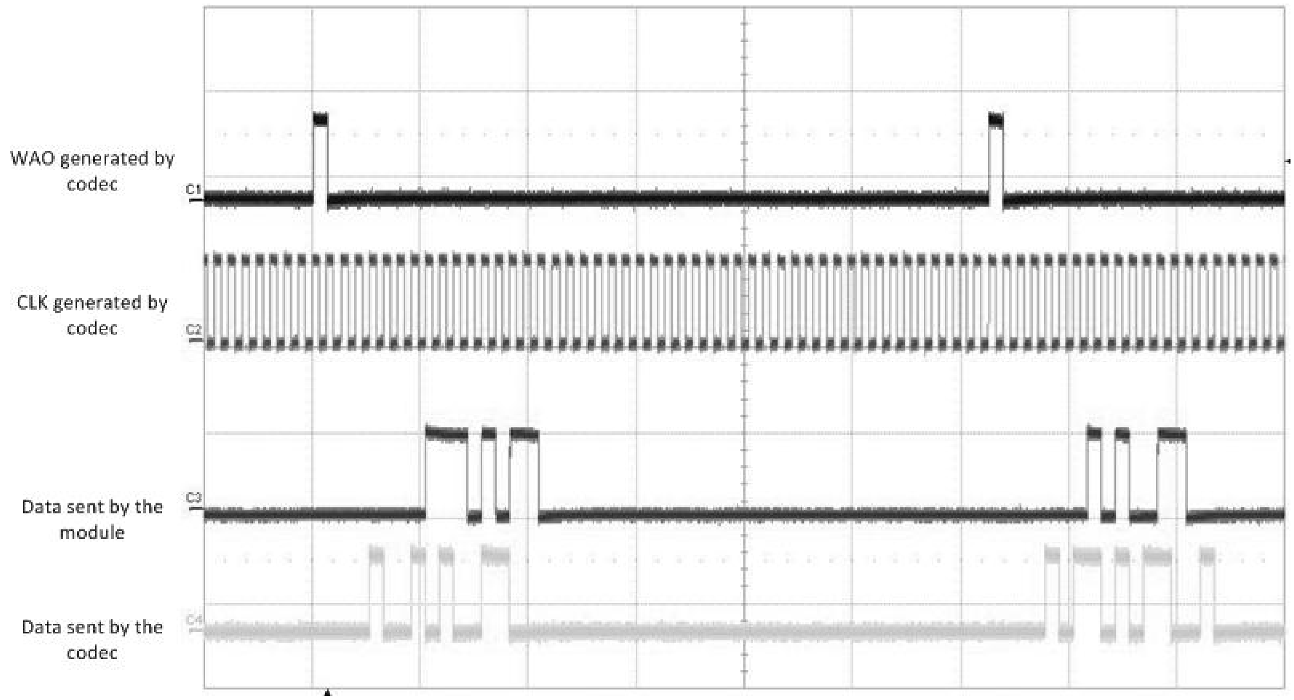


Figure 10 Timing Diagram of module in slave configuration/burst mode

I²S Overview

This section describes the I²S bus so you can better understand the digital audio transmission.

The I²S is an electrical serial bus designed for connecting digital audio devices. Developed by Philips in 1986, this popular serial bus is 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.

The I²S design handles audio data separately from clock signals. On an I²S bus, there is only one bus master and one transmitter. Figure 11 illustrates these concepts.

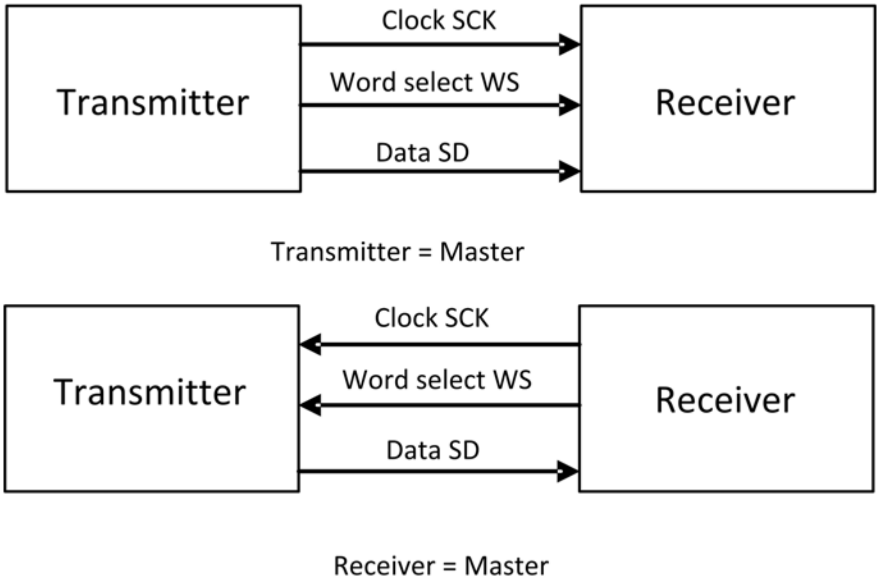


Figure 11 Simple I^2S bus configurations

In high-quality audio applications involving a codec, the codec is typically the master so that it has precise control over the I^2S bus clock.

An I^2S bus design consists of the following serial bus lines:

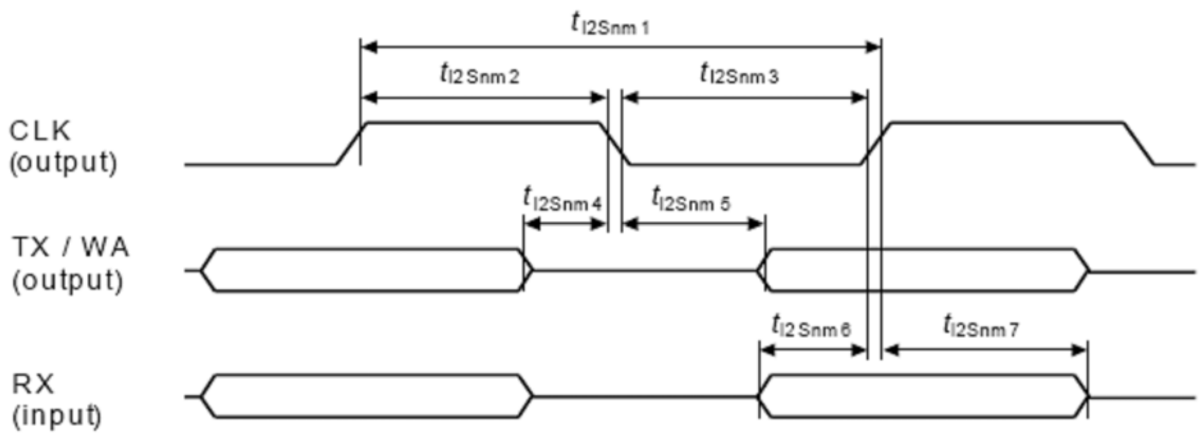
SD: Serial data
WS: Word select
Serial Clock: SCK

The I^2S bus carries two channels (left and right) 8 bits 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.

DVI Timings

Normal Master Mode

The following diagram shows the timings on the main DVI signals when in normal master mode.



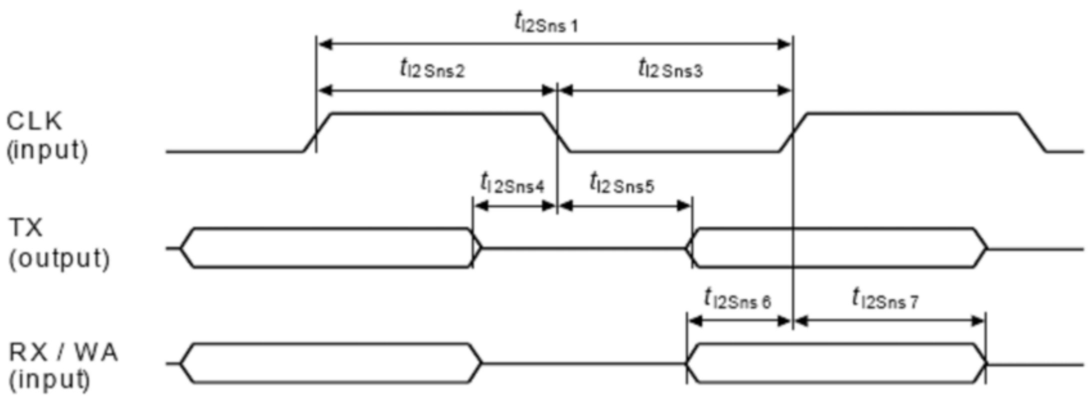
Normal Master Mode Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	**Typ.**	**Max**		
CLK clock period	tI2Snm1	T-4ns	T	–	ns	T=M_T
CLK high time	tI2Snm2	T/2 - 20	T/2	–	ns	T=M_T
CLK low time	tI2Snm3	T/2 - 20	T/2	–	ns	T=M_T
TX invalid before CLK high end (before shifting edge of CLK)	tI2Snm4	–	–	24	ns	
TX valid after CLK low begin (after shifting edge of CLK)	tI2Snm5	–	–	2×tCP + 12	ns	tCP=9.6 ns
RX setup time before CLK low end (before latching edge of CLK)	tI2Sn m6	tCP + 50	–	–	ns	tCP=9.6 ns
RX hold time after CLK high begin (after latching edge of CLK)	tI2Snm7	10	–	–	ns	

Note: T corresponds to the audio sampling rate (16 kHz and 8 kHz) and to the frame length (16 bit, 18 bit, 20 bit, 24 bit or 32 bit).

Normal Slave Mode

The following diagram shows the timings on the main DVI signals when in normal slave mode.



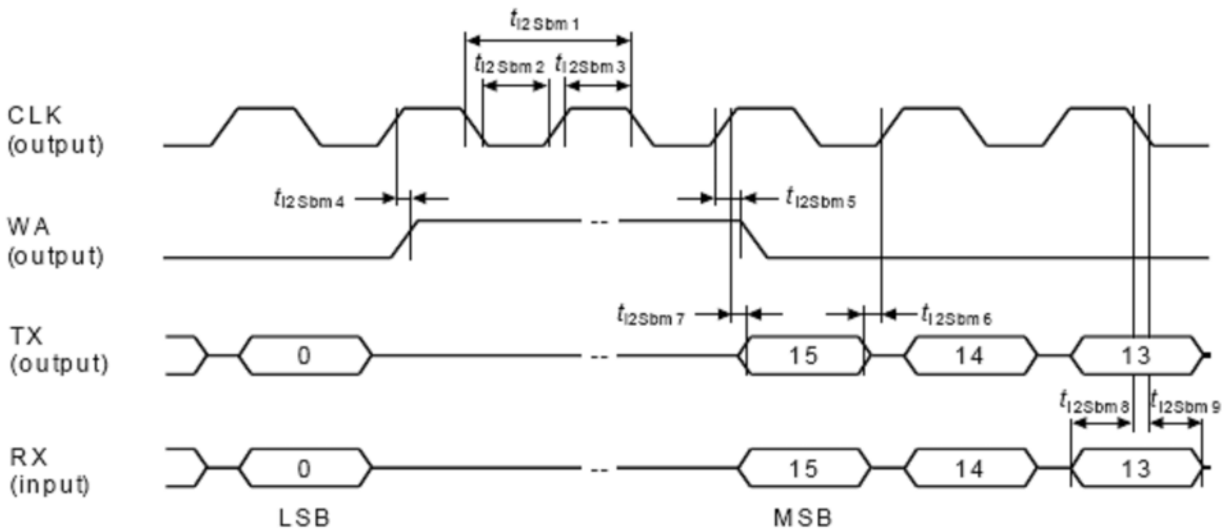
Normal Slave Mode Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max		
CLK clock period	*t*I2Sns1	T	–	–	ns	T=M_T
CLK high time	*t*I2Sns2	120	–	–	ns	
CLK low time	*t*I2Sns3	120	–	–	ns	
TX invalid before CLK falling edge	*t*I2Sns4	–	–	12	ns	
TX (continued) valid after CLK falling edge	*t*I2Sns5	–	–	3×tCP + 50	ns	tCP=9.6 ns
RX setup time before CLK rising edge (before latching edge of CLK)	*t*I2Sns6	tCP + 12	–	–	ns	tCP=9.6 ns
RX hold time after CLK rising edge (after latching edge of CLK)	*t*I2Sns7	24	–	–	ns	

Note: T corresponds to the audio sampling rate (16 kHz and 8 kHz) and to the frame length (16 bit, 18 bit, 20 bit, 24 bit or 32 bit).

PCM Master Mode

The following diagram shows the timings on the main DVI signals when in PCM master mode.



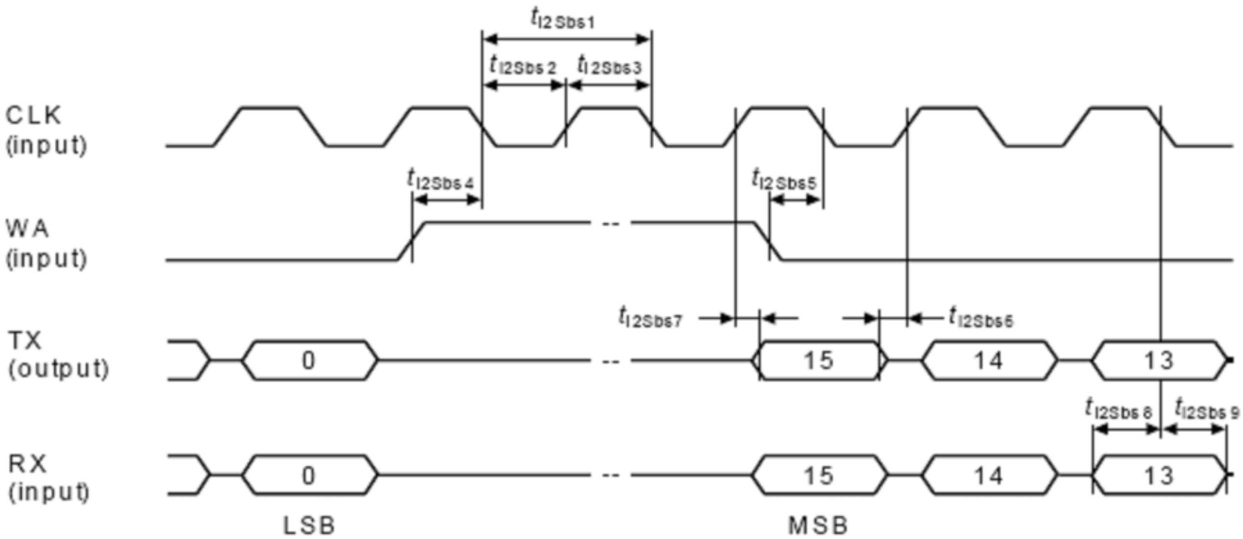
PCM Master Mode Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max		
CLK clock period	tI2Sbm1	T-4	T	–	ns	T=M_T
CLK low time	tI2Sbm2	T/2 - 20	T/2	–	ns	T=M_T
CLK high time	tI2Sbm3	T/2 - 20	T/2	–	ns	T=M_T
WA high begin after clock CLK high begin	tI2Sbm4	-24	–	2×tCP + 12	ns	tCP=9.6 ns
WA high end after CLK low end	tI2Sbm5	-24	–	2×tCP + 12	ns	tCP=9.6 ns
TX invalid before CLK low end	tI2Sbm6	–	–	24	ns	
TX valid after CLK high begin	tI2Sbm7	–	–	tCP + 12	ns	tCP=9.6 ns
RX setup time before CLK high end	tI2Sb m8	tCP + 50	–	–	ns	tCP=9.6 ns
RX hold time after CLK low begin	tI2Sbm9	12	–	–	ns	

Note: T corresponds to the audio sampling rate (16 kHz and 8 kHz) and to the frame length (16 bit, 18 bit, 20 bit, 24 bit or 32 bit).

PCM Slave Mode

The following diagram shows the timings on the main DVI signals when in PCM slave mode.



PCM slave mode parameters

Parameter	symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max		
CLK clock period	tI2Sbs1	T	–	–	ns	T=M_T
CLK low time	tI2Sbs2	120	–	–	ns	
CLK high time	tI2Sbs3	120	–	–	ns	
WA high begin before CLK low begin (latching edge of CLK)	tI2Sbs4	2×tCP + 17	–	–	ns	tCP=9.6 ns
WA low begin before CLK low begin (latching edge of CLK)	tI2Sbs5	2×tCP + 17	–	–	ns	tCP=9.6 ns
TX invalid before CLK rising edge (shifting edge of CLK)	tI2Sbs6	–	–	12	ns	
TX valid after CLK rising edge (shifting edge of CLK)	tI2Sbs7	–	–	3×tCP + 50	ns	tCP=9.6 ns
RX setup time before CLK falling edge	tI2Sb s8	tCP + 12	–	–	ns	tCP=9.6 ns
RX hold time after CLK falling edge	tI2Sbs9	24	–	–	ns	

Note: T corresponds to the audio sampling rate (16 kHz and 8 kHz) and to the frame length (16 bit, 18 bit, 20 bit, 24 bit or 32 bit).

Schematic

The following illustration shows a schematic example of an interface between the modules and the MAX9867 codec.

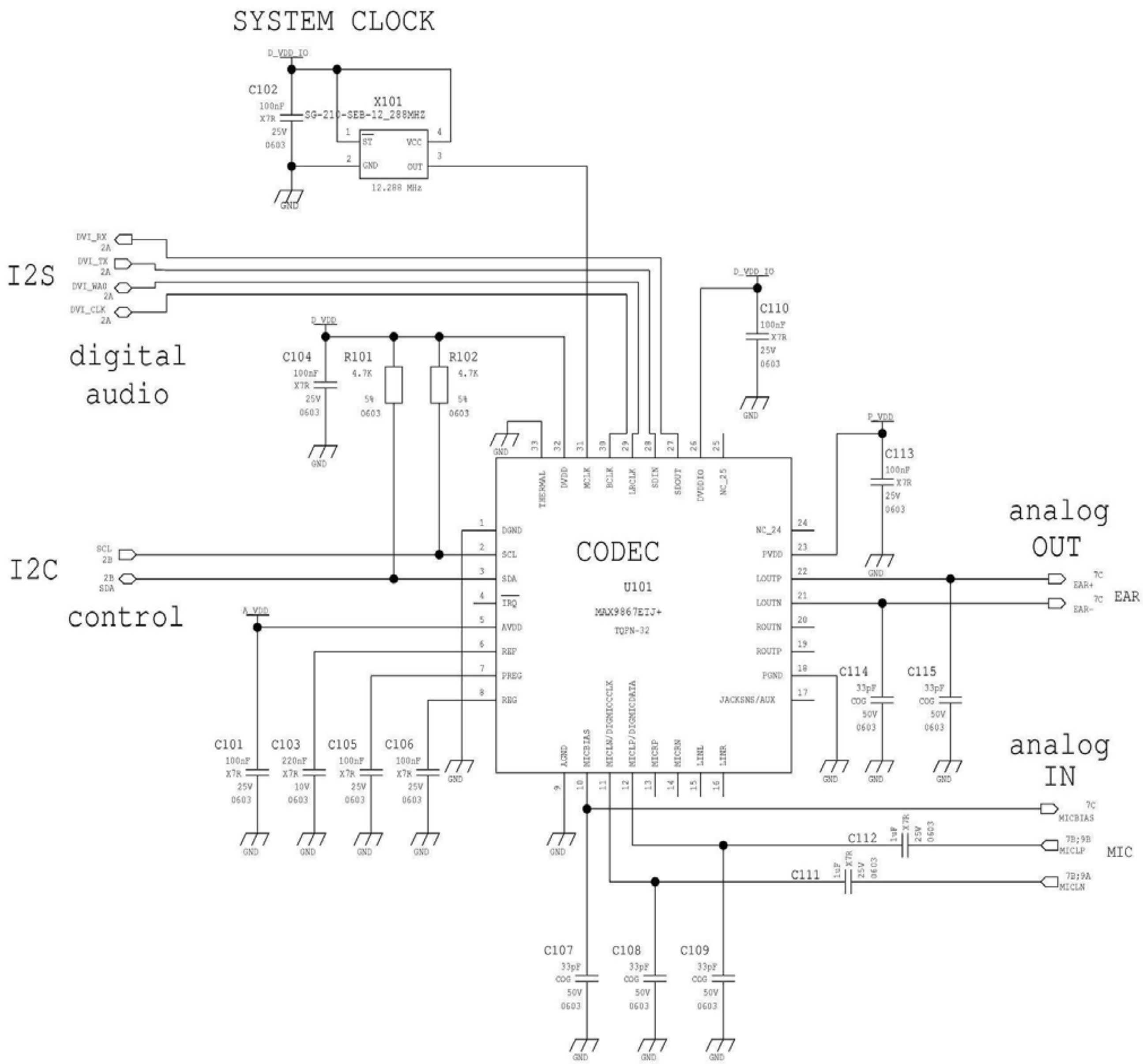


Figure 12 Schematic for reference design

Arranging Ports and Avoiding Contended Resources

This section describes the contemporaneous use of services such as Python and TT implemented on the module. This section describes how to configure your module to avoid hardware and software resource conflicts, without running up against contended resources among services.

It describes the virtual serial device and services implemented on the module.

This section applies to the following models:

MTSMC-H5 (non UIP)	MTSMC-EV3-N2 (non UIP)	MTSMC-EV3-N3 (non UIP)
MTSMC-EV3-N16 (non UIP)	MTSMC-G3 (non UIP)	MTSMC-C2-N2 (non UIP)
MTSMC-C2-N3 (non UIP)	MTSMC-C2-N16 (non UIP)	MTSMC-Telit-UIP
MT100UCC-H5	MT100UCC-EV3-N2	MT100UCC-EV3-N3
MT100UCC-EV3-N16	MTCBA-H5-EN2	MTCMR-H5
MTCMR-EV3-N2	MTCMR-EV3-N3	MTCMR-EV3-N16
MTCMR-C2-N2	MTCMR-C2-N3	MTCMR-C2-N16
MT100EOCG-H5	MT100EOCG-EV3-N2	MT100EOCG-EV3-N3
MT100EOCG-EV3-N16	MTCDP-H5	Physio-EV3-N3
MTPCIE-H5 and MTPCIE-DK1	MTPCIE-EV3-N2	MTPCIE-EV3-N3
MTPCIE-EV3-N16	MTD-H5-Bxx	MTD-EV3-Bxx-N2
MTD-EV3-Bxx-N3	MTD-EV3-Bxx-N16	MTOCGD3/MTOCGD2-H5
MTOCGD3/MTOCGD2-EV3-N2	MTOCGD3/MTOCGD2-EV3-N3	MTOCGD3/MTOCGD2-EV3-N16
MTC-H5-Bxx	MTC-EV3-Bxx-N2	MTC-EV3-Bxx-N3
MTC-EV3-Bxx-N16	MTC-G3-Bxx	MTC-C2-Bxx-N2
MTC-C2-Bxx-N3	MTC-C2-Bxx-N16	

Port Arrangements and Virtual Serial Device

Virtual Serial Device (VSD) is software that manages virtual connections among the physical serial ports and the services running on the module. To do so, VSD supports several Access Points used as anchor points for the logical connections.

The items involved in connections management—physical serial ports, logical access points, AT parser and TT utility, services and protocols—appear in the table that follows. The VSD supports several configurations of these items. The section that follows describes these configurations.

Physical Serial Ports	Logical Access Points	AT Parsers and TT Utility	Services	Protocols
USIF0 USIF0 and USIF1 are called respectively Modem Serial Port 1 and Modem Serial Port 2.	AT0	Instance 1	Python	CMUX (VC1-VC4) 4 channels: VC1-VC4
USIF1	AT1	Instance 2		
USB (USB0-USB5)	AT2	Instance 3		

6 channels: USB0-USB5				
SPI	TT	TT		
	VHWDTE0			
	VHWDTE1			
	PYSER			

Table 6 Services and other items

It is useful to review instances and their relationships with the Access Points. There are three AT command parser instances that are logically independent. Each one is managed by the same control software block and is connected to an Access Point as shown in the figure that follows.

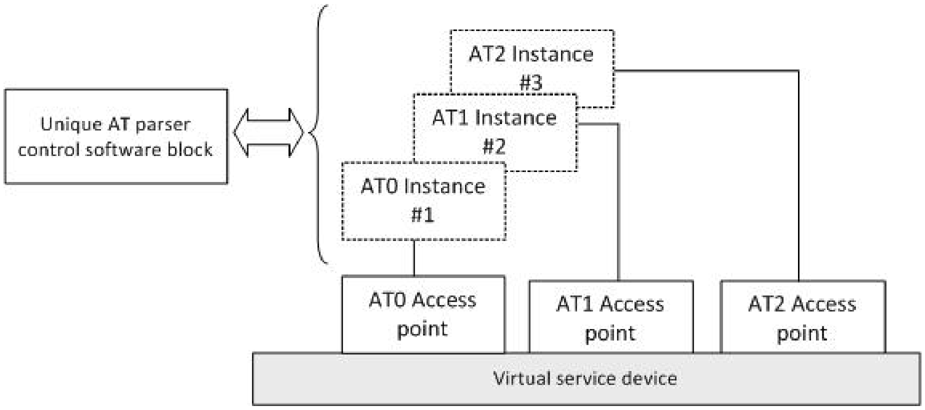


Figure 13 AT parser instance

Factory Ports Arrangement with no USB cable

Assume that the factory setting of the module is not changed (AT#PORTCFG=0) and the USB cable is not connected to it.

Power on the module. The factory arrangement of the internal connections between physical ports and “access points” is depicted in Figure 14.

Table 7 summarizes the factory arrangement. USBX is the generic channel provided by the USB port.

	AT0	AT1	AT2	TT	GPS/NMEA
USB0					
USB1					
USB2					
USB3					
USB4					
USB5					
USIF0	X				
USIF1					
SPI			X		

Table 7 Factory ports arrangement

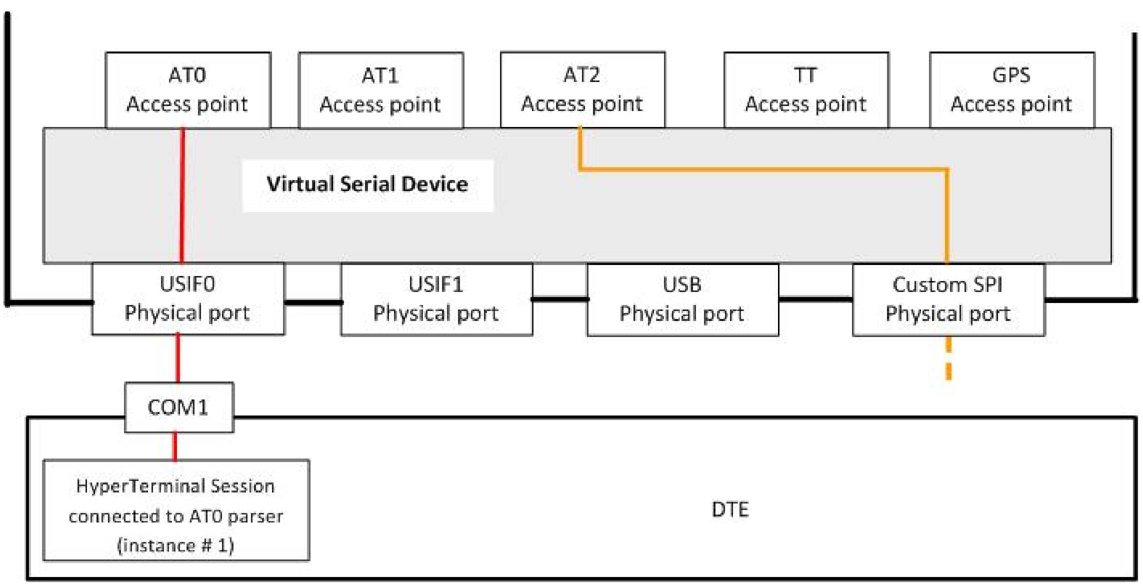


Figure 14 Factory ports arrangement

GPS/NMEA sentences on USIF0

Assume that the module is configured as shown in Figure 14 Factory ports arrangement.

Using the USIF0 port, you enter the AT$GPSP=1 and AT$GPSNMUN=1, … commands.

The just entered command is elaborated by AT0 parser and the module enters the configuration shown in Figure 15. Table 8 summarizes the new internal ports configuration.

	AT0	AT1	AT2	TT	GPS/NMEA
USB0					
USB1					
USB2					
USB3					
USB4					
USB5					
USIF0	X				X
USIF1					
SPI			X		

Table 8 USIF0 port supports NMEA sentences

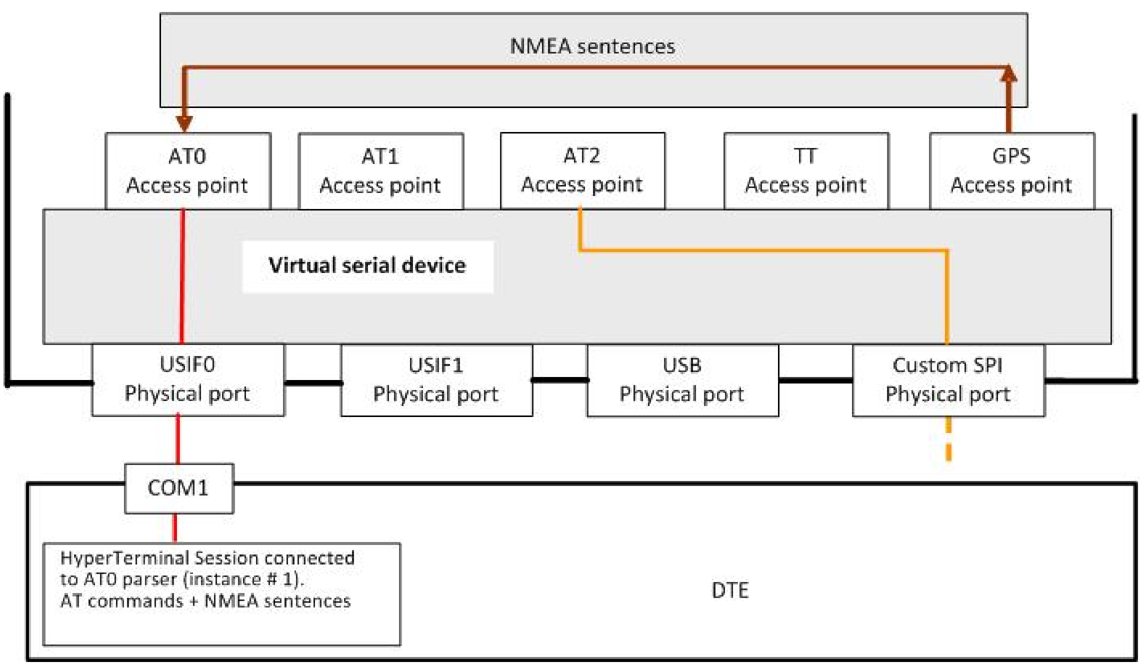


Figure 15 USIF0 port supports AT commands + NMEA sentences

GPS/NMEA sentences on SPI

Assume that the module is configured as shown in Figure 14. You enter the AT$GPSP=1 command through SPI port, it will be elaborated by AT2 parser and the module enters the configuration shown in Figure 16. Table 9 summarizes the new internal ports configuration.

	AT0	AT1	AT2	TT	GPS/NMEA
USB0					
USB1					
USB2					
USB3					
USB4					
USB5					
USIF0	X				
USIF1					
SPI			X		X

Table 9 SPI port supports NMEA sentences

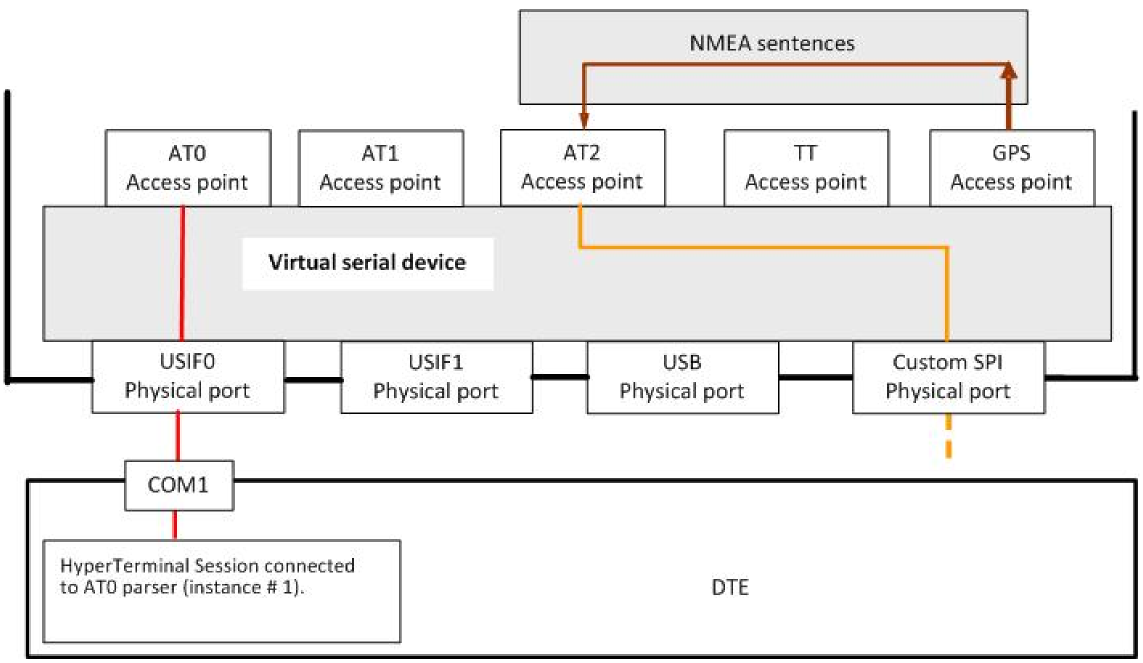


Figure 16 SPI port supports AT commands + NMEA sentences

Factory Ports Arrangement with USB cable

Assume that the module is powered on and configured as shown in Figure 14 (AT#PORTCFG=0).

Connect the USB cable to the module. The module recognizes the event and assumes the factory arrangement that is shown in Figure 17. Table 10 summarizes the new factory configuration.

	AT0	AT1	AT2	TT	GPS/NMEA
USB0		X			
USB1				MA	
USB2				3G	
USB3			X		
USB4					
USB5					
USIF0	X				
USIF1					
SPI					

Table 10 Factory ports arrangement when USB cable is connected

The entire port configurations list follows. Two trace routes are shown on the following figures:

- MA (Mobile Analyzer) Trace is addressed to Base Band, Real Time Operating System, Telit AT Parser;
- 3G-Trace is addressed to Layer 1 and Layer 3.

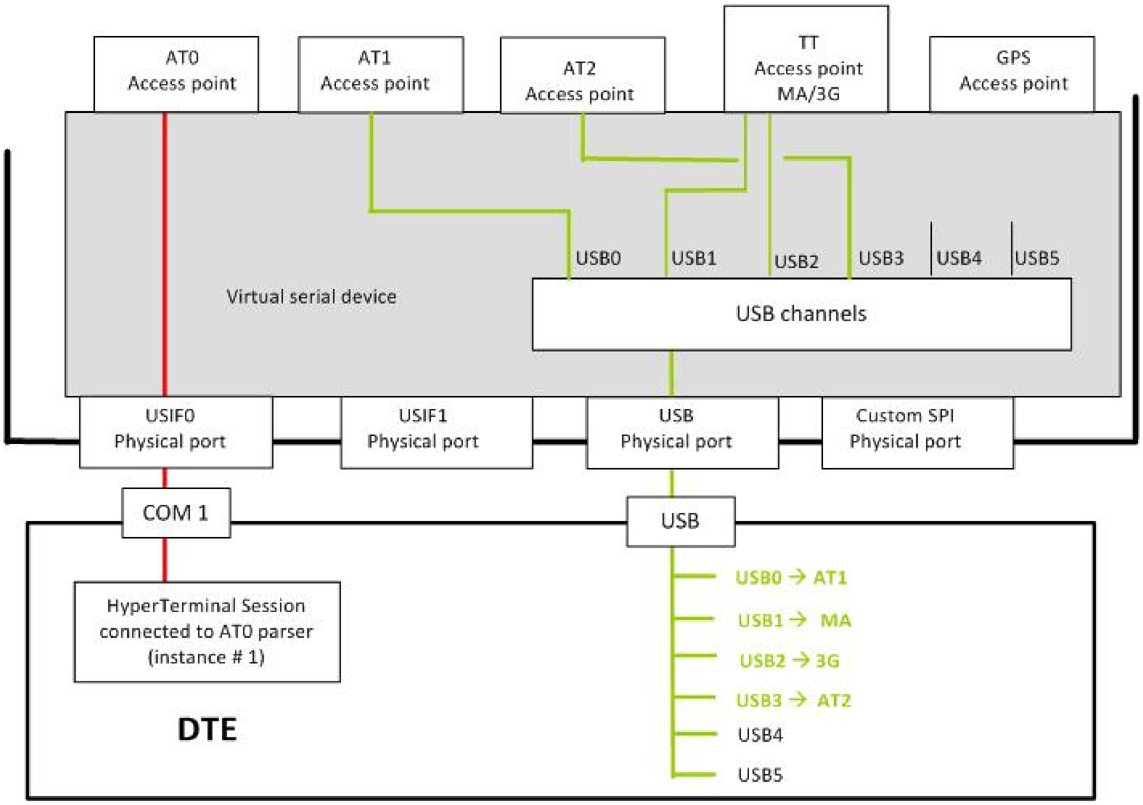


Figure 17 Factory ports arrangement when USB cable is connected

GPS/NMEA sentences on USB0

Assume that the module is configured as shown in Figure 17.

Enter the AT$GPSP=1 command through USB port, channel USB0. The AT1 parser elaborates and the module enters the configuration shown in Figure 18. Table 11 summarizes the new internal ports configuration.

	AT0	AT1	AT2	TT	GPS/NMEA
USB0		X			X
USB1				MA	
USB2				3G	
USB3			X		
USB4					
USB5					
USIF0	X				
USIF1					
SPI					

Table 11 USB-USB0 port supports NMEA sentences

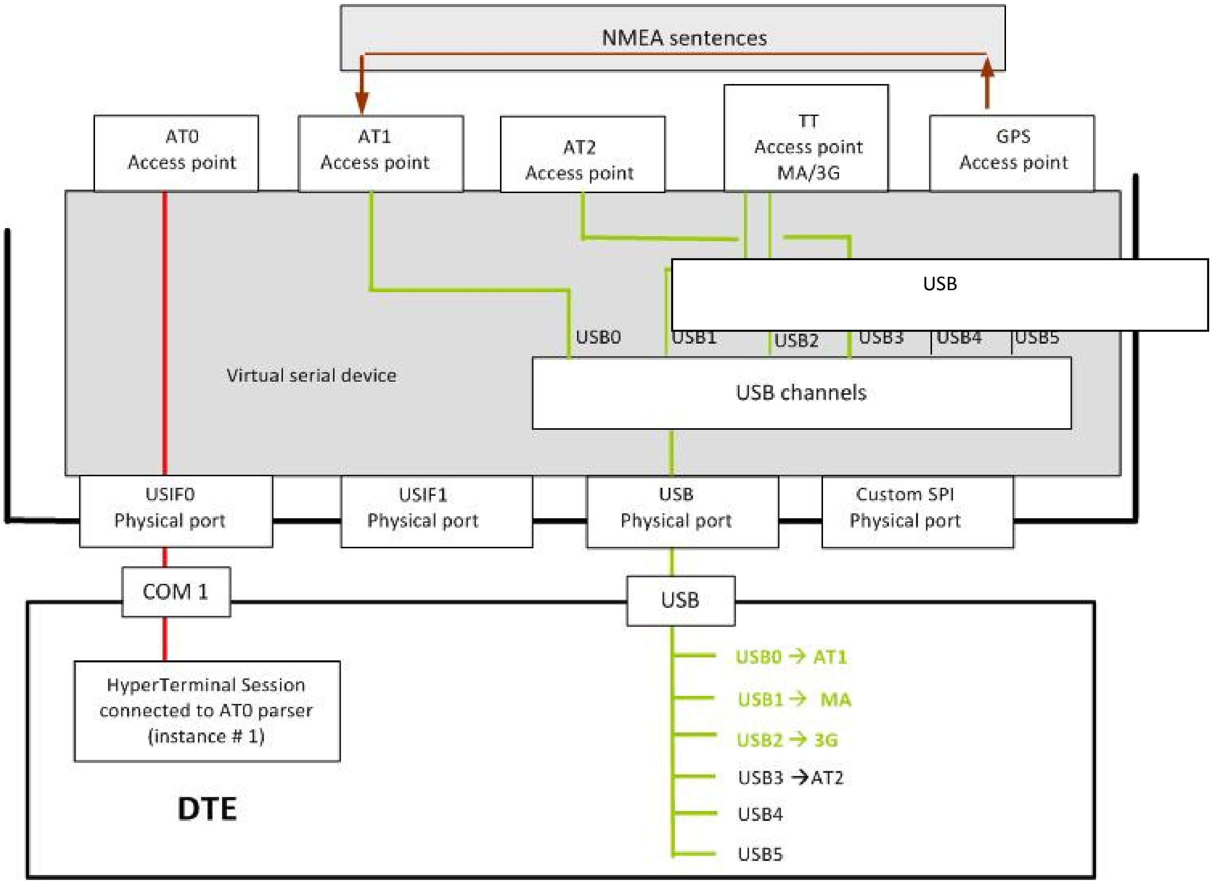


Figure 18 USB-USB0 port supports AT commands + NMEA sentences

The mechanism, shown in the examples of the previous sections, concerning the activation of the GPS/NMEA sentences on one physical port is applicable on the entire configuration covered by the present document. It can be reassumed as follows: NMEA sentences are sent on the physical port used by the operator to enter the AT$GPSP and AT$GPSNMUN commands.

AT#PORTCFG Command

The AT#PORTCFG command manages several internal ports arrangements by means of its parameter value. The tables and figures that follow show the various ports configurations you can achieve by changing the parameter value of the command and connecting the USB cable to the module. Use the following sequence to make the entered AT#PORTCFG command active:

- Assume that you are starting from the configuration shown in Figure 14, the factory setting of #PORTCFG is 0. Refer to Table 12.
- Enter, for example, the AT#PORTCFG=1 command through USIF0 port, AT0 parser elaborates the just entered command. No actions are taken.
- Power down the module.
- Power on the module. The command is executed and the ports arrangement described in Table 14 is implemented.

AT#PORTCFG=0					
	AT0	AT1	AT2	TT	GPS/NMEA
USB cable not connected					
USIF0	X				
USIF1					
SPI			X		

Table 12 #PORTCFG=0, no USB cable

AT#PORTCFG=0					
	AT0	AT1	AT2	TT	GPS/NMEA
USB0		X			
USB1				MA	
USB2				3G	
USB3			X		
USB4					
USB5					
USIF0	X				
USIF1					
SPI					

Table 13 #PORTCFG=0, USB cable connected

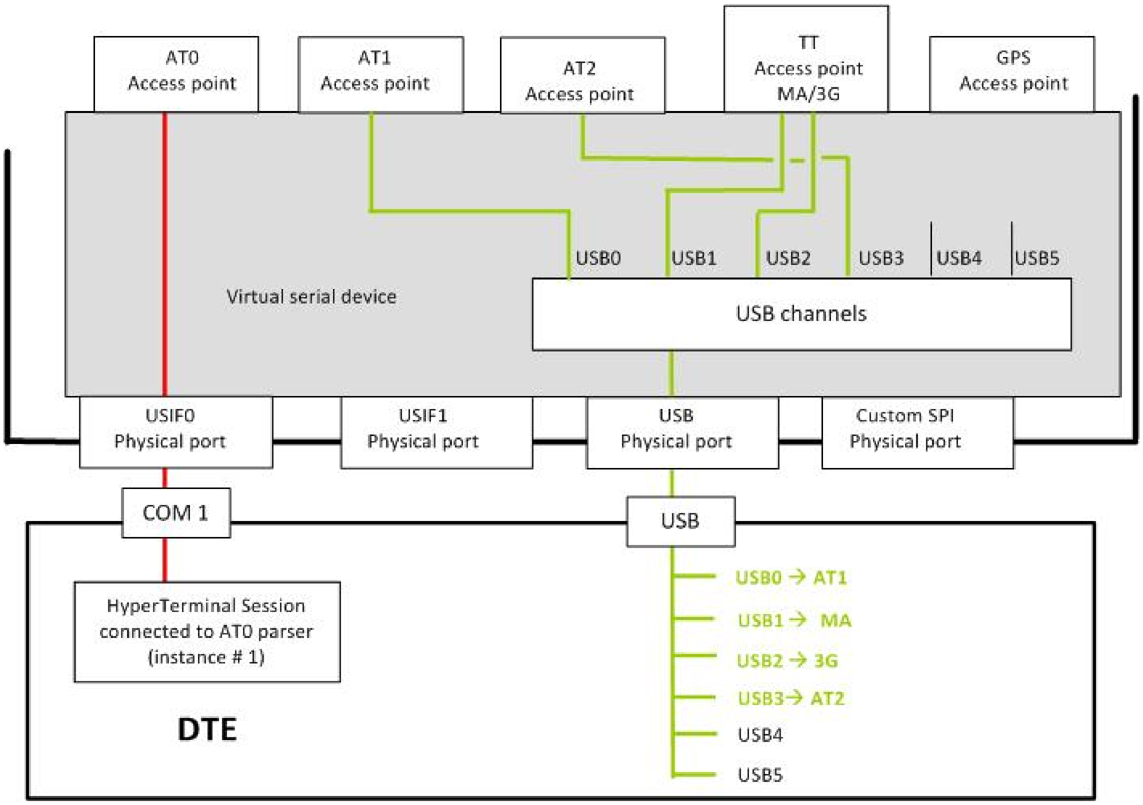


Figure 19 #PORTCFG=0 + USB cable connected

AT#PORTCFG=1					
	AT0	AT1	AT2	TT	GPS/NMEA
USB cable no connected					
USIF0	X				
USIF1				MA	
SPI					

Table 14 #PORTCFG=1, no USB cable

AT#PORTCFG=1					
	AT0	AT1	AT2	TT	GPS/NMEA
USB0		X			
USB1					
USB2				3G	
USB3			X		
USB4					
USB5					
USIF0	X				
USIF1				MA	
SPI					

Table 15 #PORTCFG=1, USB cable connected

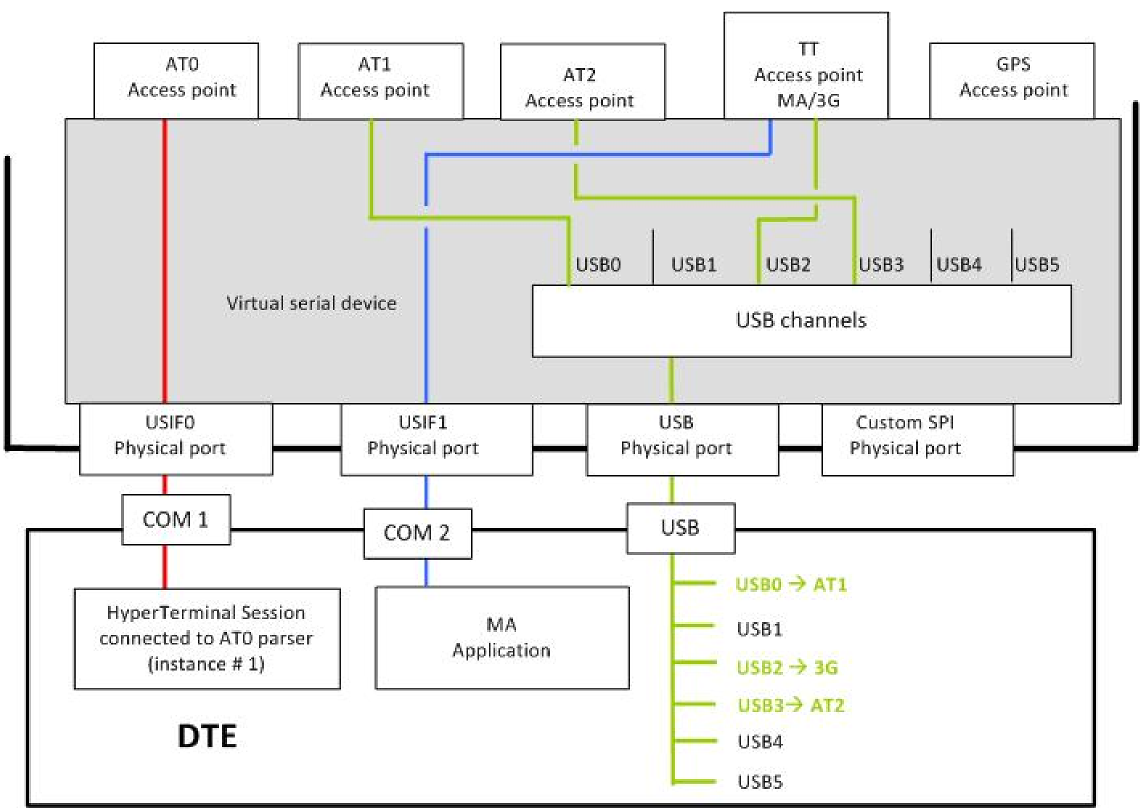


Figure 20 #PORTCFG=1 + USB cable connected

AT#PORTCFG=2					
	AT0	AT1	AT2	TT	GPS/NMEA
USB cable not connected					
USIF0	X				
USIF1					
SPI			X		

Table 16 #PORTCFG=2, no USB cable

AT#PORTCFG=2					
	AT0	AT1	AT2	TT	GPS/NMEA
USB0		X			
USB1				MA	
USB2				3G	
USB3					
USB4					
USB5					
USIF0	X				
USIF1					
SPI			X		

Table 17 #PORTCFG=2, USB cable connected

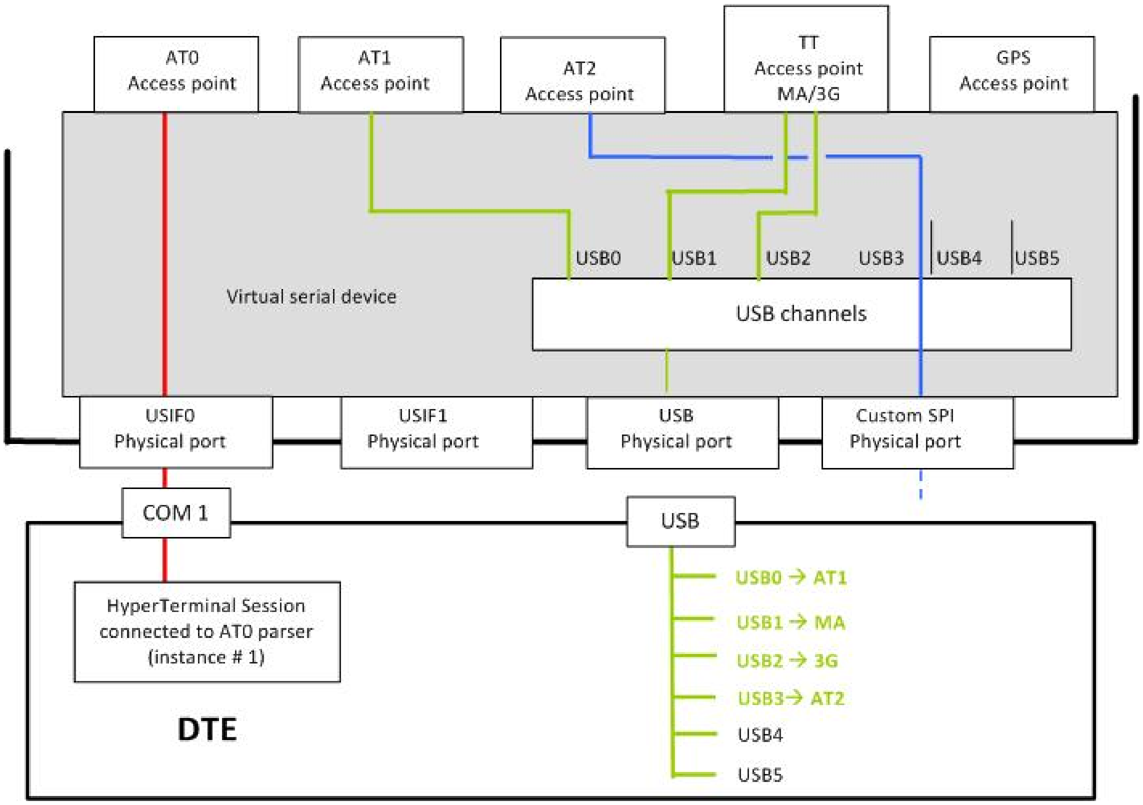


Figure 21 #PORTCFG=2 + USB cable connected

AT#PORTCFG=3					
	AT0	AT1	AT2	TT	GPS/NMEA
USB cable not connected					
USIF0	X				
USIF1			X		
SPI					

Table 18 #PORTCFG=3, no USB cable

AT#PORTCFG=3					
	AT0	AT1	AT2	TT	GPS/NMEA
USB0		X			
USB1				MA	
USB2				3G	
USB3					
USB4					
USB5					
USIF0	X				
USIF1			X		
SPI					

Table 19 #PORTCFG=3, USB cable connected

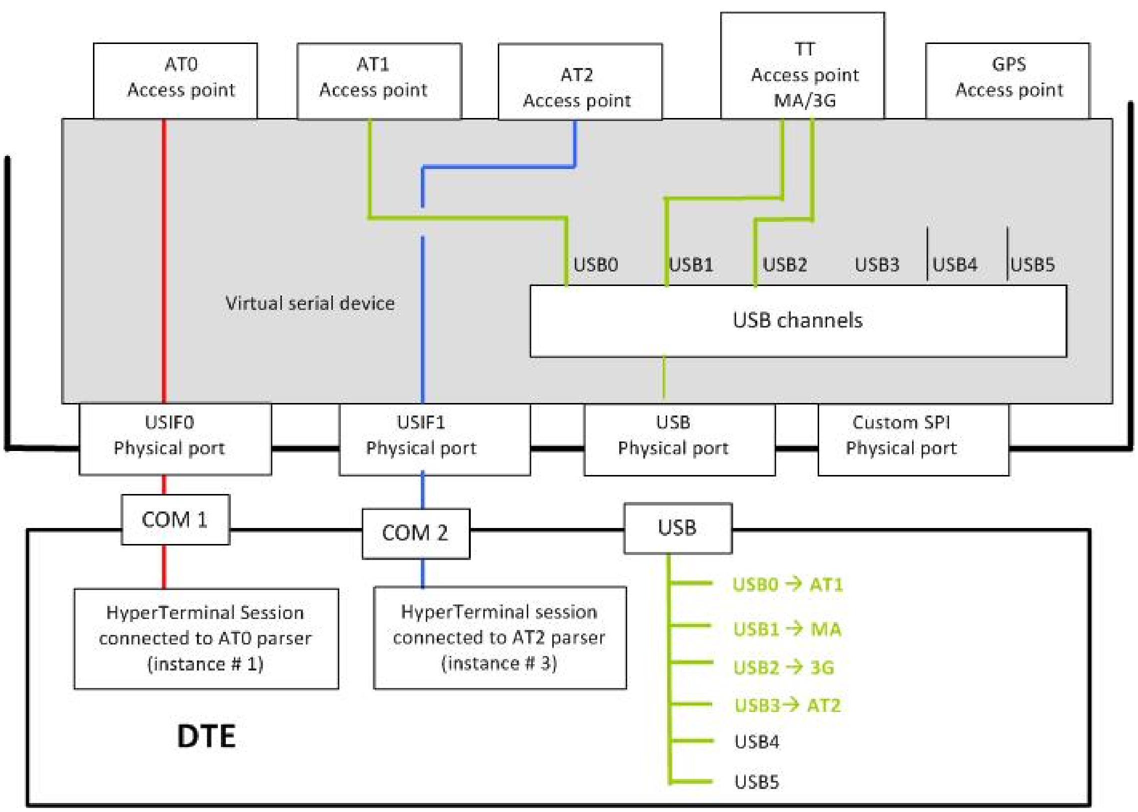


Figure 22 #PORTCFG=3 + USB cable connected

AT#PORTCFG=4					
	AT0	AT1	AT2	TT	GPS/NMEA
USB cable no connected					
USIF0		X			
USIF1					
SPI			X		

Table 20 #PORTCFG=4, no USB cable

AT#PORTCFG=4					
	AT0	AT1	AT2	TT	GPS/NMEA
USB0	X				
USB1				MA	
USB2				3G	
USB3			X		
USB4					
USB5					
USIF0		X			
USIF1					
SPI					

Table 21 #PORTCFG=4, +USB cable connected

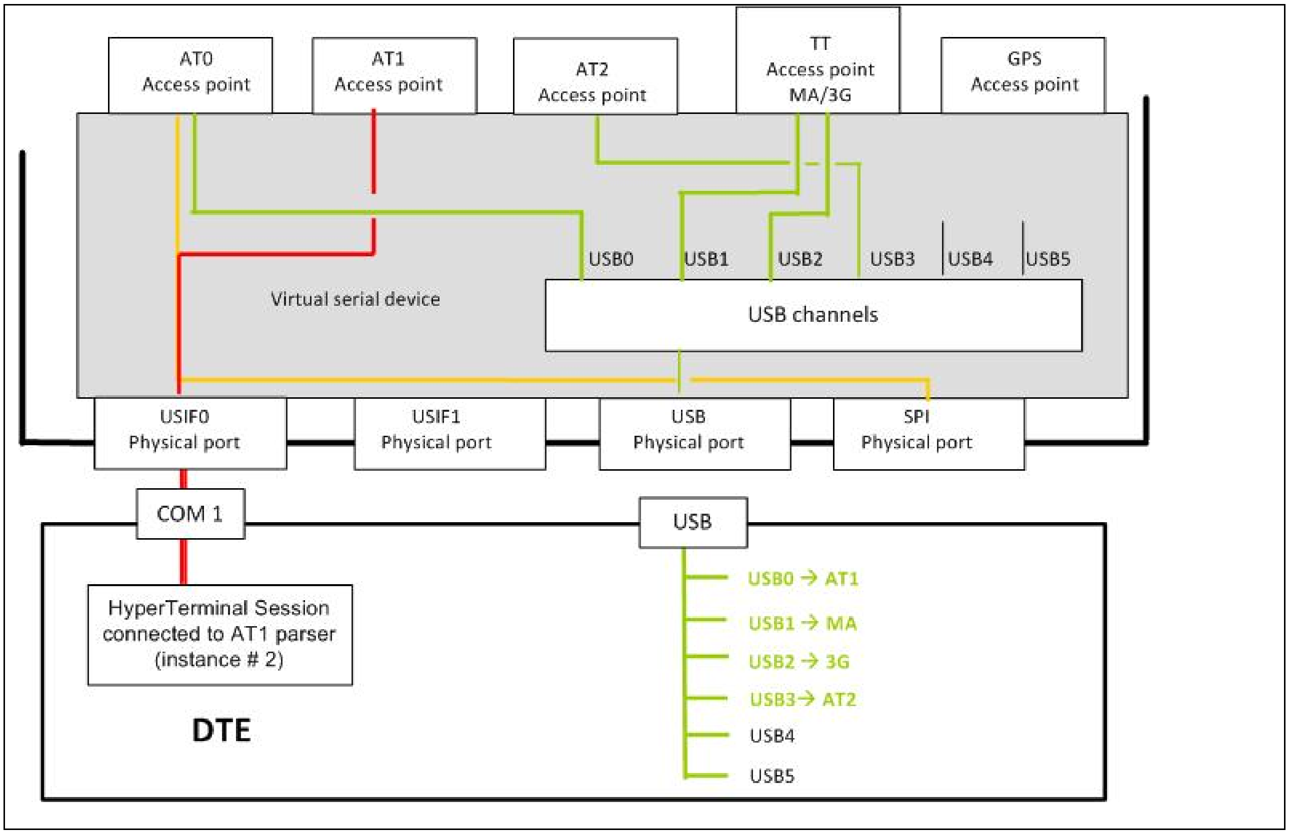


Figure 23 #PORTCFG=4 + USB cable connected

AT#PORTCFG=5					
	AT0	AT1	AT2	TT	GPS/NMEA
USB cable not connected					
USIF0					
USIF1					
SPI			X		

Table 22 #PORTCFG=5, no USB cable

AT#PORTCFG=5					
	AT0	AT1	AT2	TT	GPS/NMEA
USB0		X			
USB1				MA	
USB2				3G	
USB3	X				
USB4					
USB5					
USIF0					
USIF1					
SPI			X		

Table 23 #PORTCFG=5 +USB cable connected

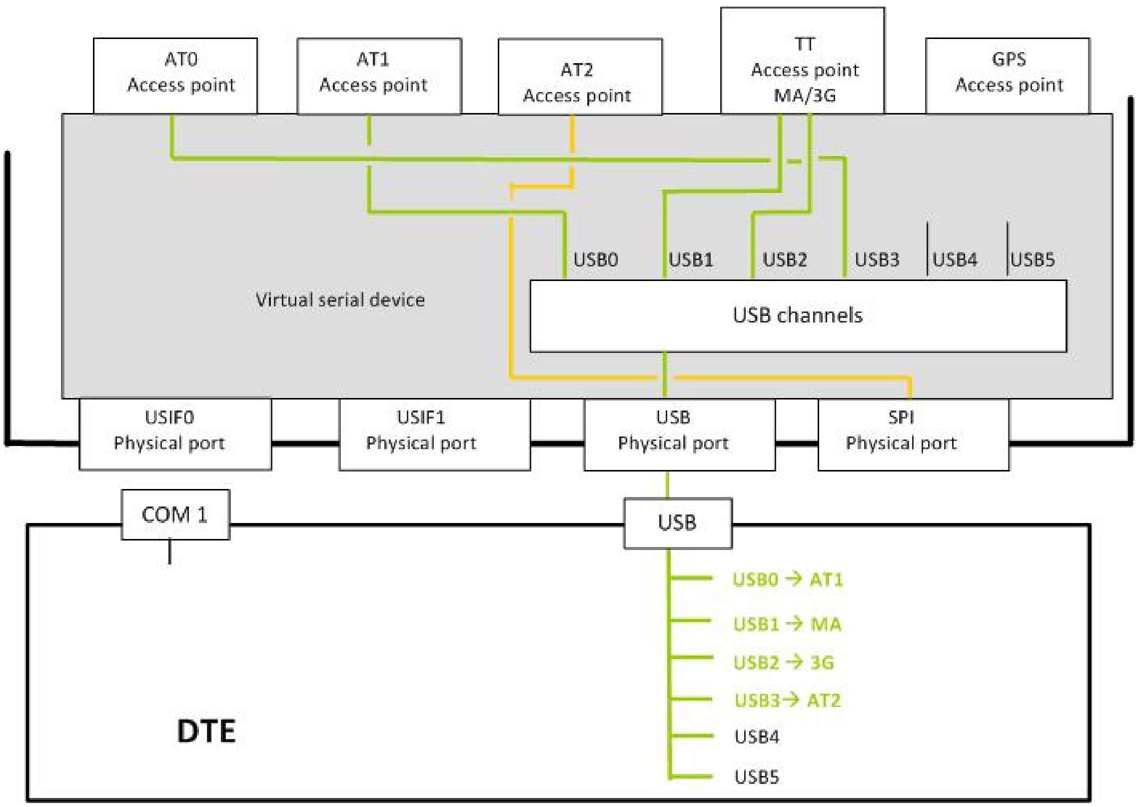


Figure 24 #PORTCFG=5 + USB cable connected

AT#PORTCFG=6					
	AT0	AT1	AT2	TT	GPS/NMEA
USB cable not connected					
USIF0			X		
USIF1					
SPI	X				

Table 24 #PORTCFG=6, no USB cable

AT#PORTCFG=6					
	AT0	AT1	AT2	TT	GPS/NMEA
USB0		X			
USB1				MA	
USB2				3G	
USB3			X		
USB4					
USB5					
USIF0					
USIF1					
SPI	X				

Table 25 #PORTCFG=6, +USB cable connected

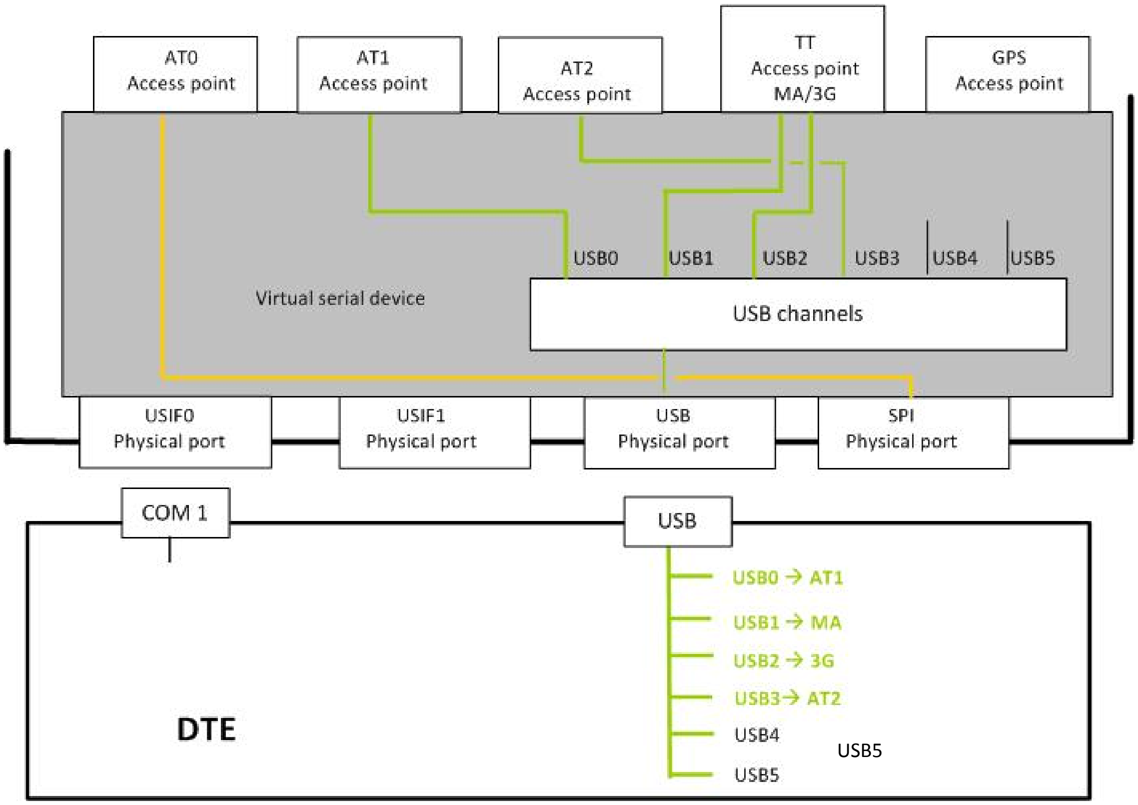


Figure 25 #PORTCFG=6 + USB cable connected

USIF0 and AT+CMUX Command

Assume that the module is configured as shown in Figure 14 (AT#PORTCFG=0).

Enter the AT+CMUX=0 command through USIF0 port. The parser AT0 recognizes the command, and according to it, changes the module configuration that is shown in Figure 14 into the configuration shown in Figure 26. Table 26 summarizes the new configuration.

	AT0	AT1	AT2	TT	GPS/NMEA
USB0- USB5					
USIF0-VC1	X				
USIF0-VC2		X			
USIF0-VC3			X		
USIF0-VC4					
USIF1					
SPI					

Table 26 Ports arrangement with CMUX

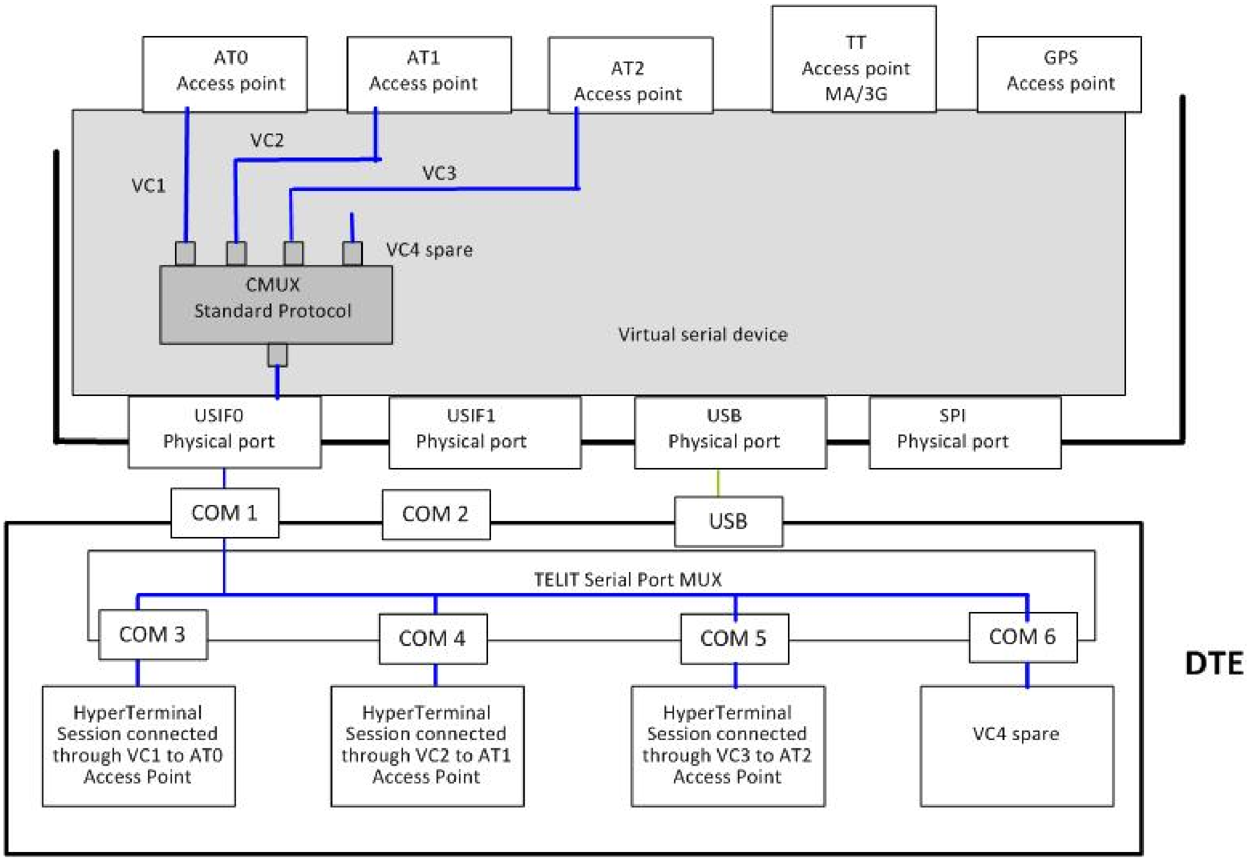


Figure 26 Ports arrangement with CMUX

If TT feature is needed, start from the following configuration: #PORTCFG=1 / no USB cable. Refer to Table 14.

Enter the AT+CMUX=0 command through USIF0 port. The parser AT0 recognizes the command and according to it changes the current module configuration into the configuration shown in Figure 27. Table 27 summarizes the new configuration.

	AT0	AT1	AT2	TT	GPS/NMEA
USB0- USB5					
USIF0-VC1	X				
USIF0-VC2		X			
USIF0-VC3			X		
USIF0-VC4					
USIF1				MA	
SPI					

Table 27 Ports arrangement with CMUX + TT

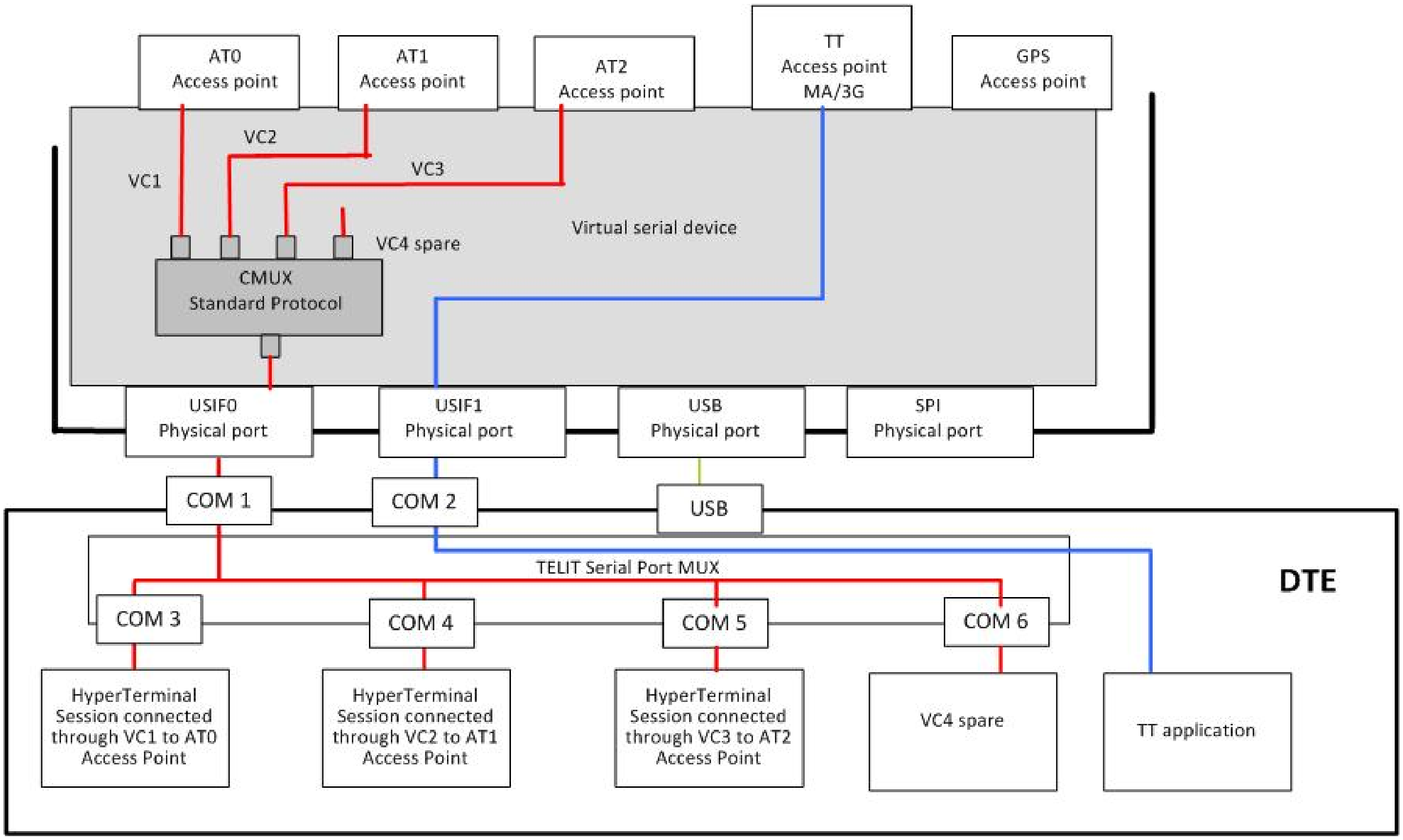


Figure 27 Ports arrangement with CMUX + TT

USB and AT+CMUX Command

Assume that the module is configured as shown in Figure 17.

Enter the AT+CMUX=0 command through USB0 or USB3. According to the parser used, (AT1 or AT2), the involved parser recognizes the command and changes the module configuration indicated by the Figure 17 into the configuration shown in Figure 28.

It is worth noting that the AT0 (instance # 1) is disconnected from USIF0 and connected to USB3-VC1, the TT stays on USB1. Table 28 summarizes the new configuration shown in Figure 28.

	AT0	AT1	AT2	TT	GPS/NMEA
USB0					
USB1				MA	
USB2				3G	
USB3-VC1	X				
USB3-VC2		X			
USB3-VC3			X		
USB3-VC4					
USB4					
USB5					
USIF0					
USIF1					
SPI					

Table 28 Ports arrangement when CMUX is connected to USB

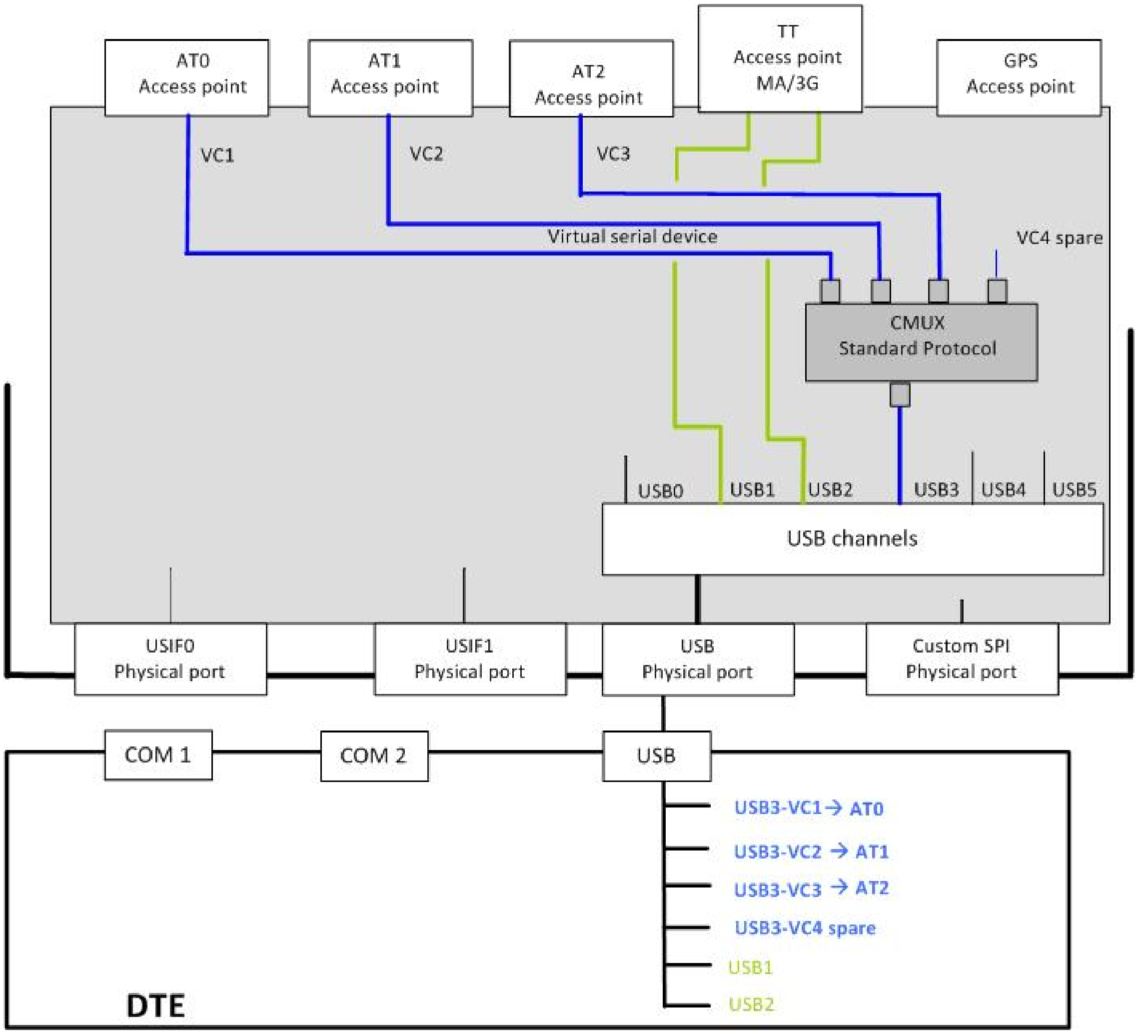


Figure 28 Ports arrangement when CMUX is connected to USB

GPS/NMEA sentences on USB3-VC3

This section describes another example of using AT$GPSP=1. Assume that the module is configured as shown in Figure 28.

Enter the AT$GPSP=1 command through USB3-VC3 port. It is elaborated by AT2 parser and the module enters the configuration shown in Figure 29. Table 29 summarizes the new internal ports configuration.

	AT0	AT1	AT2	TT	GPS/NMEA
USB0					
USB1				MA	
USB2				3G	
USB3-VC1	X				
USB3-VC2		X			
USB3-VC3			X		X
USB3-VC4					
USB4					
USB5					
USIF0					
USIF1					
SPI					

Table 29 USB3-VC3 port supports NMEA sentences

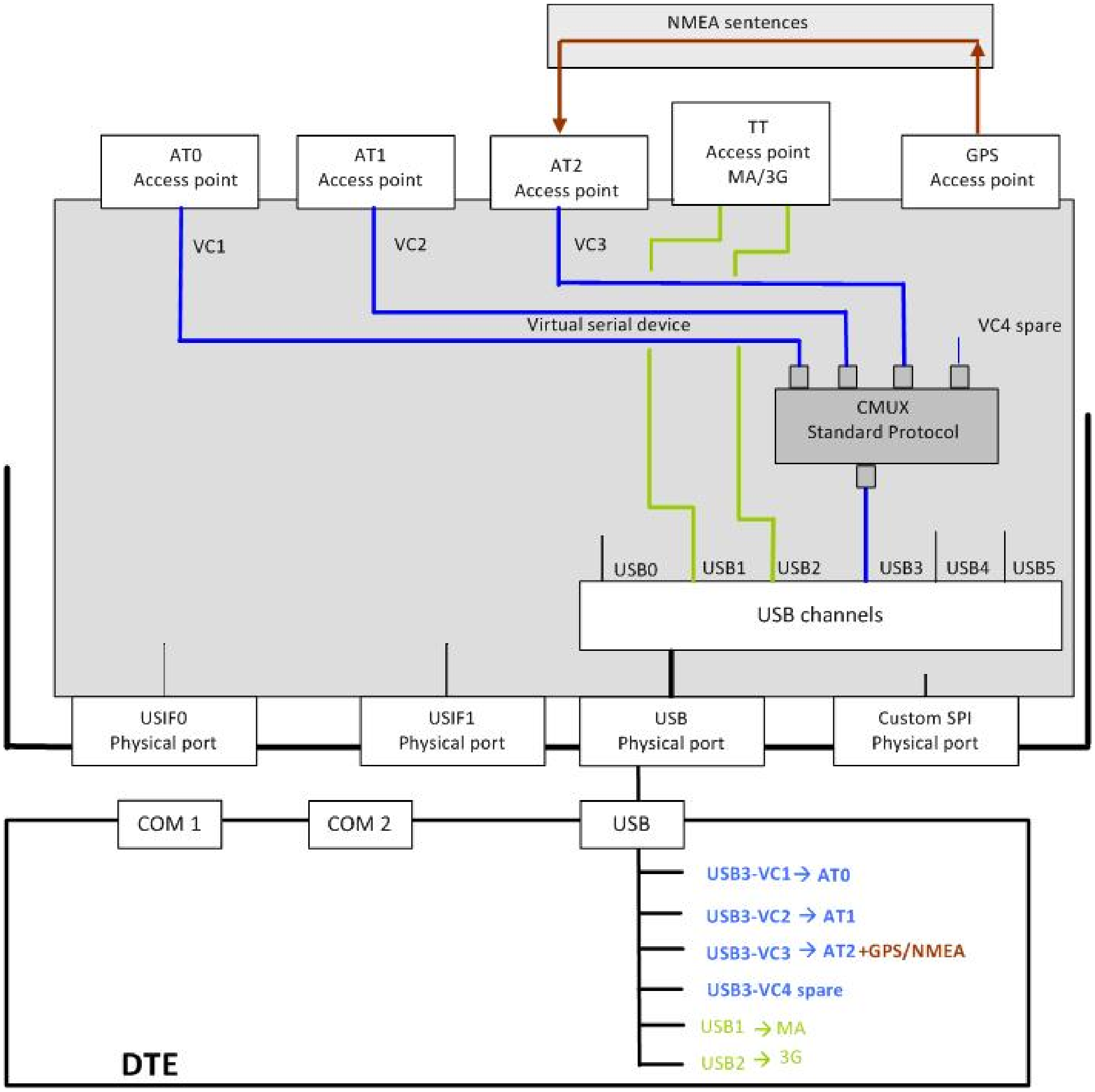


Figure 29 USB3-VC3 port supports NMEA sentences

The Successful Ports Configuration

This section describes how the device operates when you select different configurations in sequence.

There are two ways to change the ports arrangement without turning the module off and on:

- For most devices you can connect/disconnect the USB cable. However, for devices that receive power through the USB, you are effectively turning the module off and on when you unplug the USB cable.
- Enter the AT+CMUX=0 command.

Note: To put the entered AT#PORTCFG command into action, to change ports arrangement, you need to turn the module off and on.

The following priority policy is implemented on the module: Regardless of the actions or commands sequence that you implement to set the module into the desired ports configuration, the module must always enter the last requested configuration.

To help you better understand what is going on, some examples follow.

Example 1

Actor	Action
Module	Assume that its configuration is shown in Figure 14.
User	User enters AT+CMUX=0 command through USIF0.
Module	According to the command just entered, the AT0 Parser starts the CMUX protocol. The module enters the configuration shown in Figure 26.
User	User runs on the PC the CMUX counterpart application.
PC	Provides four virtual “com” (for example, COM3, COM4, COM5, COM6) required by the CMUX counterpart application running on PC.
User	User connects USB cable.
Module	Enters the configuration shown in Figure 17.
PC	Provides six new “COM” logically connected to the six USB channels. The CMUX application running on PC is no longer connected to the module and is closed. COM1 and COM2 are ready for new applications.
User	User disconnects USB cable.
Module:	Enters again the configuration shown in Figure 14.

Example 2

Actor	Action
Module	Assume the module is configured as shown in Figure 14.
User	User connects USB cable.
Module	Responding to user action, the module enters the configuration shown in Figure 17.
PC	Provides six virtual “COM” required by USB drivers to logically connect the six USBX channels.
User	User enters AT+CMUX=0 command through USB1 or USB2 channels.
Module	According to the command just entered, the AT1 or AT2 Parser (in accordance with the USBX channel used by the user) starts the CMUX protocol. The module enters the configuration shown in Figure 28.
User	User runs on the PC the CMUX counterpart application.
User	User disconnects USB cable.
Module	Enters the configuration shown in Figure 14.
PC	Discards the six “COM” logically connected to the six USBX channels. The CMUX counterpart application running on PC is no longer connected to the module, it is closed.

In the preceding examples, you can infer that the last required port configuration discards the previous one.

Services

Python

The modules provide the Python programming language. This gives you a tool to develop control scripts based on your communication and hardware resources. This section assumes that you are familiar with the Python language.

As shown in Figure 30 the VSD provides two access points called VHW DTE0 and VHW DTE1. MDM and MDM2 Python modules are logically connected respectively to VHW DTE0 and VHW DTE1 access points.

Assume that the module's factory setting (AT#PORTCFG=0) is not changed and the USB cable is not connected. Next power on the module.

The factory arrangement of the internal connections between physical ports and "access points" is shown in Figure 14. Table 7 summarizes the factory arrangement.

When the Python script runs the Python instruction import MDM, the VSD disconnects the USIF0/AT0 logical connection and establishes the logical connection VHW DTE0/AT0. Consequently the Python script can access the AT0 parser.

In the same way, import MDM2 instruction forces the VSD to establish the logical connection VHW DTE1/AT1. As shown in Figure 30 it is possible to infer that USIF0 is disconnected and un-used from external module side.

Python script can run another Python software module to use the USIF0 port using the instruction import SER. Figure 31 shows the new connection: through the physical port USIF0 it is possible to be connected with the Python script.

The three Python software modules (MDM, MDM2 and SER) make use of three independent resources: USIF0 physical port; AT0 and AT1 Access Point. No resources contention can arise among them. As a rule, the MDM, MDM2 and PRINT instructions take and use the resources regardless of the current owner.

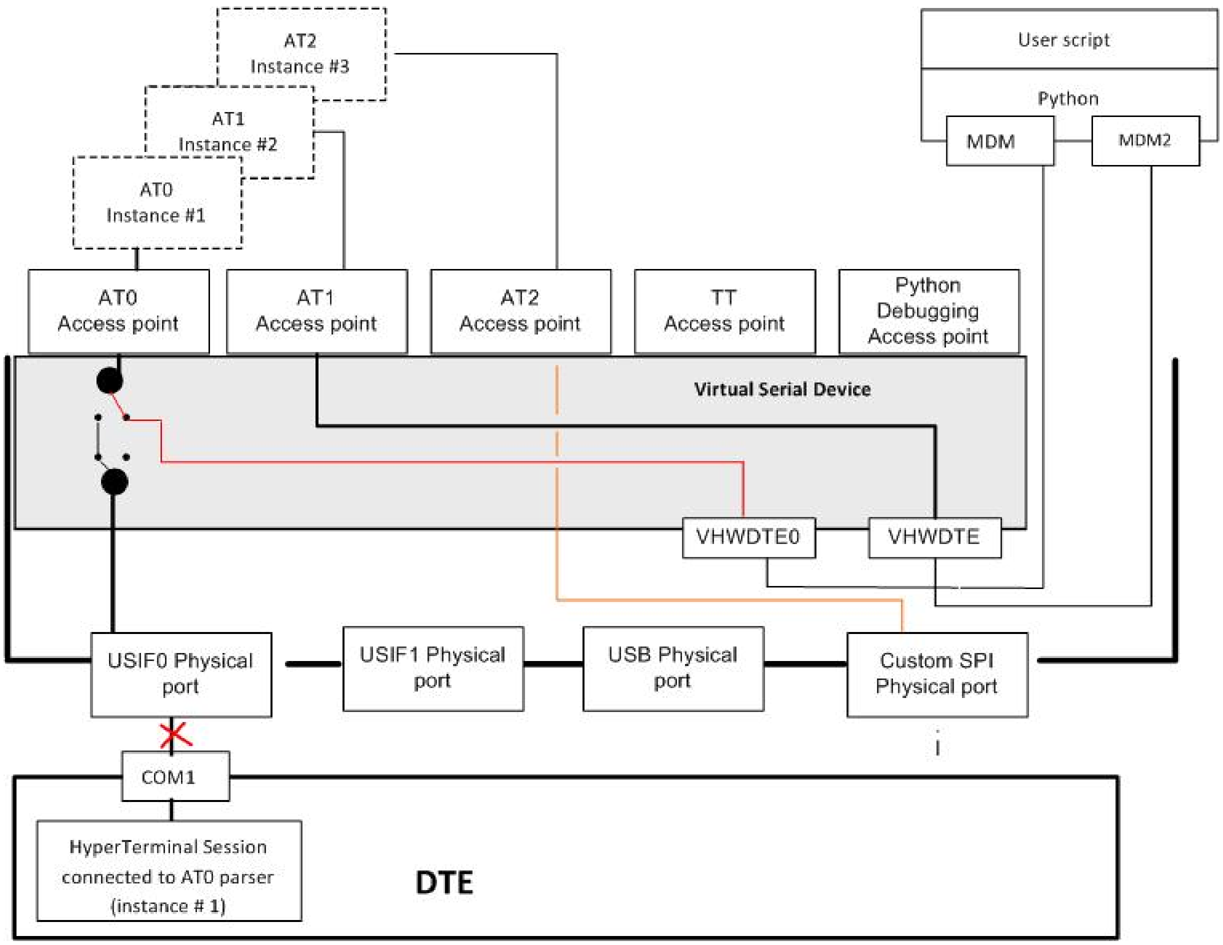


Figure 30 Python and MDM, MDM2 modules

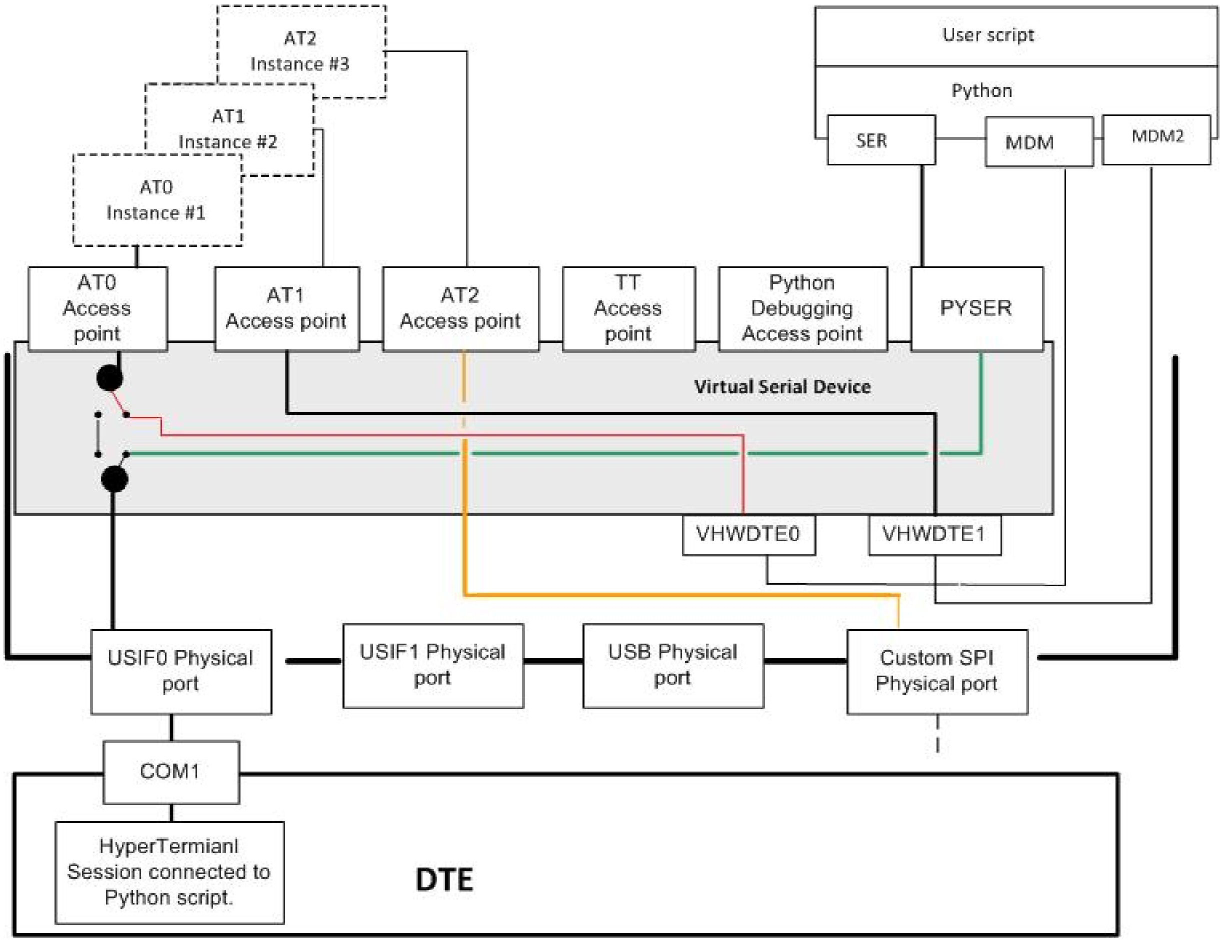


Figure 31 Python and MDM, MDM2, SER modules

Python Script Debugging

This section assumes you need to debug a new Python script. To perform the debug session, you force the module into #PORTCFG=3 configuration. Refer to Table 14.

The Python script runs: import MDM, import MDM2, import SER and print instructions. The figure that follows shows the actions of the first tree instructions, plus the action of the last one that makes available print messages on the generic terminal application connected to USIF1 port.

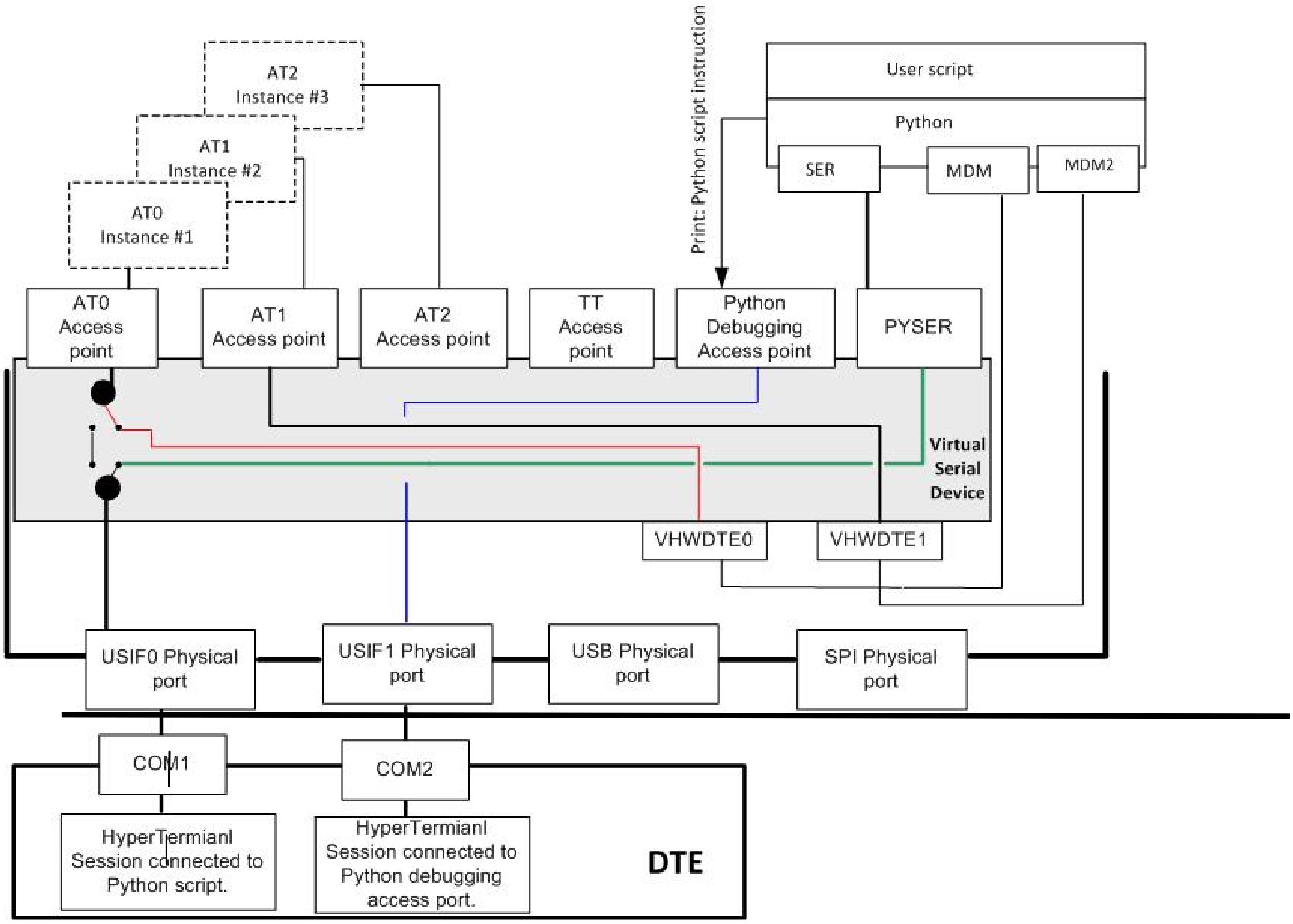


Figure 32 Python and MDM, MDM2, SER and print modules