



Telit CMUX Implementation User Guide

1VV0300994 Rev. 6 – 2017-02-07

TELIT
TECHNICAL
DOCUMENTATION

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

NOTICES LIST

While reasonable efforts have been made to assure the accuracy of this document, Telit assumes no liability resulting from any inaccuracies or omissions in this document, or from use of the information obtained herein. The information in this document has been carefully checked and is believed to be reliable. However, no responsibility is assumed for inaccuracies or omissions. Telit reserves the right to make changes to any products described herein and reserves the right to revise this document and to make changes from time to time in content hereof with no obligation to notify any person of revisions or changes. Telit does not assume any liability arising out of the application or use of any product, software, or circuit described herein; neither does it convey license under its patent rights or the rights of others.

It is possible that this publication may contain references to, or information about Telit products (machines and programs), programming, or services that are not announced in your country. Such references or information must not be construed to mean that Telit intends to announce such Telit products, programming, or services in your country.

COPYRIGHTS

This instruction manual and the Telit products described in this instruction manual may be, include or describe copyrighted Telit material, such as computer programs stored in semiconductor memories or other media. Laws in the Italy and other countries preserve for Telit and its licensors certain exclusive rights for copyrighted material, including the exclusive right to copy, reproduce in any form, distribute and make derivative works of the copyrighted material. Accordingly, any copyrighted material of Telit and its licensors contained herein or in the Telit products described in this instruction manual may not be copied, reproduced, distributed, merged or modified in any manner without the express written permission of Telit. Furthermore, the purchase of Telit products shall not be deemed to grant either directly or by implication, estoppel, or otherwise, any license under the copyrights, patents or patent applications of Telit, as arises by operation of law in the sale of a product.

COMPUTER SOFTWARE COPYRIGHTS

The Telit and 3rd Party supplied Software (SW) products described in this instruction manual may include copyrighted Telit and other 3rd Party supplied computer programs stored in semiconductor memories or other media. Laws in the Italy and other countries preserve for Telit and other 3rd Party supplied SW certain exclusive rights for copyrighted computer programs, including the exclusive right to copy or reproduce in any form the copyrighted computer program. Accordingly, any copyrighted Telit or other 3rd Party supplied SW computer programs contained in the Telit products described in this instruction manual may not be copied (reverse engineered) or reproduced in any manner without the express written permission of Telit or the 3rd Party SW supplier. Furthermore, the purchase of Telit products shall not be deemed to grant either directly or by implication, estoppel, or otherwise, any license under the copyrights, patents or patent applications of Telit or other 3rd Party supplied SW, except for the normal non-exclusive, royalty free license to use that arises by operation of law in the sale of a product.

USAGE AND DISCLOSURE RESTRICTIONS

I. License Agreements

The software described in this document is the property of Telit and its licensors. It is furnished by express license agreement only and may be used only in accordance with the terms of such an agreement.

II. Copyrighted Materials

Software and documentation are copyrighted materials. Making unauthorized copies is prohibited by law. No part of the software or documentation may be reproduced, transmitted, transcribed, stored in a retrieval system, or translated into any language or computer language, in any form or by any means, without prior written permission of Telit

III. High Risk Materials

Components, units, or third-party products used in the product described herein are NOT fault-tolerant and are NOT designed, manufactured, or intended for use as on-line control equipment in the following hazardous environments requiring fail-safe controls: the operation of Nuclear Facilities, Aircraft Navigation or Aircraft Communication Systems, Air Traffic Control, Life Support, or Weapons Systems (High Risk Activities"). Telit and its supplier(s) specifically disclaim any expressed or implied warranty of fitness for such High Risk Activities.

IV. Trademarks

TELIT and the Stylized T Logo are registered in Trademark Office. All other product or service names are the property of their respective owners.

V. Third Party Rights





















































The software may include Third Party Right software. In this case you agree to comply with all terms and conditions imposed on you in respect of such separate software. In addition to Third Party Terms, the disclaimer of warranty and limitation of liability provisions in this License shall apply to the Third Party Right software.

TELIT HEREBY DISCLAIMS ANY AND ALL WARRANTIES EXPRESS OR IMPLIED FROM ANY THIRD PARTIES REGARDING ANY SEPARATE FILES, ANY THIRD PARTY MATERIALS INCLUDED IN THE SOFTWARE, ANY THIRD PARTY MATERIALS FROM WHICH THE SOFTWARE IS DERIVED (COLLECTIVELY "OTHER CODE"), AND THE USE OF ANY OR ALL THE OTHER CODE IN CONNECTION WITH THE SOFTWARE, INCLUDING (WITHOUT LIMITATION) ANY WARRANTIES OF SATISFACTORY QUALITY OR FITNESS FOR A PARTICULAR PURPOSE.

NO THIRD PARTY LICENSORS OF OTHER CODE SHALL HAVE ANY LIABILITY FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING WITHOUT LIMITATION LOST PROFITS), HOWEVER CAUSED AND WHETHER MADE UNDER CONTRACT, TORT OR OTHER LEGAL THEORY, ARISING IN ANY WAY OUT OF THE USE OR DISTRIBUTION OF THE OTHER CODE OR THE EXERCISE OF ANY RIGHTS GRANTED UNDER EITHER OR BOTH THIS LICENSE AND THE LEGAL TERMS APPLICABLE TO ANY SEPARATE FILES, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES

APPLICABILITY TABLE

PRODUCTS

	Sw Version	Modules
GC FAMILY (COMPACT)		
  GE864-QUAD V2	10.00.xx7	
  GE864-QUAD V2	10.00.xx7	2G
  GE864-QUAD V2	10.00.xx7	
GE/GL FAMILY (EMBEDDED)		
  GE864-QUAD	10.00.xx7	
  GE864-QUAD V2	10.00.xx7	
  GE864-QUAD Automotive V2	10.00.xx7	
  GE864-QUAD ATEX	10.00.xx7	
  GE864-DUAL V2	10.00.xx7	
  GE864-GPS	10.00.xx7	
  GE865-QUAD	10.00.xx7	
  GL865-DUAL	10.00.xx7	
  GL865-QUAD	10.00.xx7	
  GL868-DUAL	10.00.xx7	2G
  GE910-QUAD	13.00.xx3	
  GE864-QUAD AUTO	13.00.xx5	
  GE910-GNSS	13.00.xx4	
  GL865-DUAL V3	16.00.xx2	
  GL865-QUAD V3	16.00.xx3	
  GL868-DUAL V3	16.00.xx2	
  GE910-QUAD V3	16.00.xx3	
  GE868-QUAD	16.00.xx3	
GT Family (Terminal)		
  GT863-PY	10.00.xx7	
  GT864-QUAD	10.00.xx7	2G
  GT864-PY	10.00.xx7	
HE910 Family (Embedded)		
  HE910 ¹	12.00.xx4	
  HE910-GA	12.00.xx4	

■ ■ HE910-D	12.00.xx4	3G
■ ■ HE910-EUR / HE910-EUD	12.00.xx4	
■ ■ HE910-EUG / HE910-NAG	12.00.xx4	
■ ■ UE910-NAR / HE910-NAD	12.00.xx4	
UE/UL Family (Embedded)		
■ ■ UE910-EUR / UE910-EUD	12.00.xx4	
■ ■ UE910-NAR / UE910-NAD	12.00.xx4	
■ ■ UL865-EUR / UL865-EUD	12.00.xx4	3G
■ ■ UL865-NAR / UL865-NAD	12.00.xx4	
■ ■ UL865-N3G	12.00.xx4	
HE863 Family (Embedded)		
■ ■ HE863-EUR / -EUD / -EUG	11.00.xx2	
■ ■ HE863-NAR / -NAD / -NAG	11.00.xx2	3G
■ ■ HE863-AUR / -AUD / -AUG	11.00.xx2	
UC864 Family (Compact)		
■ ■ UC864-E / -E-DUAL / UC864-G	08.01.xx8	
■ ■ UC864-E-AUTO / -AWS-AUTO	08.01.xx8	3G
■ ■ UC864-K / -AK	08.01.xx8	

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.

¹ HE910 is the “type name” of the products marketed as HE910-G & HE910-DG.

CONTENTS

NOTICES LIST	2
COPYRIGHTS	2
COMPUTER SOFTWARE COPYRIGHTS	2
USAGE AND DISCLOSURE RESTRICTIONS	3
I. License Agreements	3
II. Copyrighted Materials	3
III. High Risk Materials	3
IV. Trademarks	3
V. Third Party Rights	3
APPLICABILITY TABLE	4
CONTENTS	6
FIGURES LIST	8
TABLES LIST	8
AT COMMAND LIST	9
1. INTRODUCTION	10
1.1. Scope	10
1.2. Audience.....	10
1.3. Contact Info and Support	10
1.4. Text Conventions.....	11
1.5. Related Documents	12
1.6. Abbreviation and Acronyms	12
2. OVERVIEW	13
3. SERIAL MULTIPLEXER PROTOCOL	17
3.1. CMUX Frames Structures	17
3.1.1. UIH Control Channel Frame Coding	21
3.1.2. UIH Data Channel Frame Coding	26
4. HOW TO DEVELOP A MUX USER APPLICATION.....	27
5. SUMMARY AND RECOMMENDATIONS.....	33
6. TELIT SERIAL PORT MUX TOOL	36
6.1. Graphical Interface	36
7. APPENDIX	38

7.1.	How to select the Information Field length	38
7.2.	V.24 Link.....	39
7.3.	DTR Signal vs. CMUX Protocol	40
8.	DOCUMENT HISTORY	42

FIGURES LIST

Fig 1: GM, GC, GE/GL, GT Modules Families..	Error! Bookmark not defined.
Fig. 2: HE910 Module Family	15
Fig. 3: CMUX Frame Structure.....	17
Fig. 4: V.24 Octet DCE → DTE	23
Fig. 5: V.24 Octet DTE → DCE	23
Fig. 6: VSD Configuration at Power ON (GM, GC, GE/GL, GT Modules Families)	27
Fig. 7: VSD Configuration at Power ON (HE910 Family)	28
Fig. 8: CMUX Protocol	30
Fig. 9: Complete V.24 Link versus Telit Serial Port MUX Panel.....	39

TABLES LIST

Tab. 1: CMUX vs. Access Points	13
Tab. 2: Telit PSC.....	25
Tab. 3 CMUXMODE (con't).....	40
Tab. 4 CMUXMODE	41

AT COMMAND LIST

The following list, organized in alphabetical order, shows the AT commands covered by this User Guide. The number close to each command indicates the page of the first AT command occurrence.

AT#AUTOBND	23	AT#SII	20	AT+CMGW	82
AT#BND	23	AT#SIMDET	27	AT+CMSS	84
AT#CAP	49	AT#SLED	130	AT+CMUT	50
AT#CCLK	134	AT#SLEDSAV	130	AT+CNMI	80
AT#CEERNET	147	AT#SMSMODE	76	AT+COPS	31
AT#CMGLCONCINDEX	91	AT#WAKE	139	AT+CPBF	96
AT#CODEC	48	AT#WAKE	137	AT+CPBR	97
AT#CODECINFO	47	AT&P0	19	AT+CPBS	94
AT#CSURV	37	AT&W0	19	AT+CPBW	97
AT#DUALAPN	146	AT+CALA	134	AT+CPIN	24
AT#ENCALG	70	AT+CALD	135	AT+CPMS	79
AT#GPIO	127	AT+CAPD	138	AT+CPOL	33
AT#HFMICG	53	AT+CBST	56	AT+CRC	59
AT#HSMICG	50	AT+CCLK	132	AT+CREG	30
AT#JDRENH	130	AT+CFUN	100	AT+CRSM	29
AT#MONI	36	AT+CGACT	143	AT+CSCA	75
AT#NCM	145	AT+CGATT	143	AT+CSCB	90
AT#NITZ	133	AT+CGATT	86	AT+CSCS	73
AT#PDPAUTH	150	AT+CGCONTRDP	144	AT+CSIM	28
AT#QSS	26	AT+CGDCONT	143	AT+CSMP	71
AT#SERVINFO	36	AT+CGMM	22	AT+CSNS	58
AT#SGACT	145	AT+CGMR	22	AT+CSQ	34
AT#SHDN	58	AT+CGPADDR	147	AT+FCLASS	46
AT#SHFAGC	54	AT+CLCK	62	AT+IPR	18
AT#SHFEC	54	AT+CLIP	59	AT+SELINT	21
AT#SHFNR	55	AT+CLIR	60	AT+SNUM	29
AT#SHFSD	53	AT+CLVL	50	AT+WS46	23
AT#SHSAGC	52	AT+CMEE	22	ATD	47
AT#SHSEC	51	AT+CMGD	87	ATD*99#	141
AT#SHSNR	52	AT+CMGF	71	ATH	47
AT#SHSSD	51	AT+CMGL	88		

1. INTRODUCTION

1.1. Scope

This document covers the more significant standard and proprietary AT commands provided by Telit's modules. Several module features are described and for each one of them the related AT commands are explained through examples. This document is not an exhaustive description of the AT commands implemented on the Telit's modules series, its target is only to give you an entry point to the AT commands world.

1.2. Audience

The present User Guide is addressed to users that need to learn and use quickly standard and proprietary AT commands. The reader can learn the use of the AT commands through simple examples shown in the document, and then deepen the interested AT commands reading the documents [1]/[17] in accordance with the used module.

1.3. Contact Info and Support

For general contact, technical support services, technical questions and report documentation errors contact Telit Technical Support at:

- TS-EMEA@telit.com
- TS-AMERICAS@telit.com
- TS-APAC@telit.com
- TS-SRD@telit.com (for Short Range Devices)

Alternatively, use:

<http://www.telit.com/support>

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

<http://www.telit.com>

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. Text Conventions



Danger – This information **MUST** be followed or catastrophic equipment failure or bodily injury may occur.



Caution or Warning – Alerts the user to important points about integrating the module, if these points are not followed, the module and end user equipment may fail or malfunction.



Tip or Information – Provides advice and suggestions that may be useful when integrating the module.

All dates are in ISO 8601 format, i.e. YYYY-MM-DD.

1.5. Related Documents

- [1] 3GPP TS 07.10 Version 7.1.0, Release 4
- [2] Virtual Service Device, Application Note, code: 80000NT10045A
- [3] HE910 Family Ports Arrangements, User Guide, code: 1vv0300971
- [4] AT Commands Reference Guide, code: 80000ST10025A
- [5] HE910 AT Commands Reference Guide, code: 80378ST10091A
- [6] Telit Modules Software User Guide, code: 1vv0300784
- [7] IP Easy, User Guide, code: 80000ST10028A
- [8] SIM Access Profile, User Guide, code: 80000ST10029a
- [9] Easy Script in Python, code: 80000ST10020a

1.6. Abbreviation and Acronyms

DCE	Data Communication Equipment
DTE	Data Terminal Equipment
MUX	Multiplexer
NVM	Non Volatile Memory
OS	Operating System
TT	Trace Tool (Generic Trace Tool)
VSD	Virtual Service Device

2. OVERVIEW

Before dealing with the technical characteristics of the CMUX Standard Protocol [1] provided by the Telit Modules and the setting up and use of the Telit Serial Port MUX tool running on DTE (PC-Windows), it is useful to show how the two software components can be used together and which advantages they give. The Fig 1 shows four virtual connections (VC1, VC2, VC3 and VC4) which are running on a unique physical serial line (COM1/ASC0); the Module has entered the Multiplexed Mode. The four different Applications running on DTE are tied, via the virtual connections, to four Access Points in order to communicate with four different Services provided by the Telit Module.

Follow the example below to enter the Virtual Service Device Configuration² (Multiplexed Mode) showed on Fig 1:

- Telit Module and DTE are physical connected via ASC0/COM1 serial ports, and both are powered on;
- Run the Telit Serial Port MUX tool on DTE, refer to chapter 6;
- On DTE start, for example, three Hyper Terminals connected to three virtual ports provided by the Telit tool, e.g. COM3, COM4, COM5;
- Now the Hyper Terminals can send and receive data from the Module on three independent Virtual Channels by means of the Multiplexer Protocol implemented by the Telit Tool.

Tab 1 summarizes the VSD Configuration of Fig 1.

Legend:

“ASC0/VCx”: Virtual Connection (channels) that must be used to reach the Access Point indicated on the top of the column. The user can use one or more Access Points.

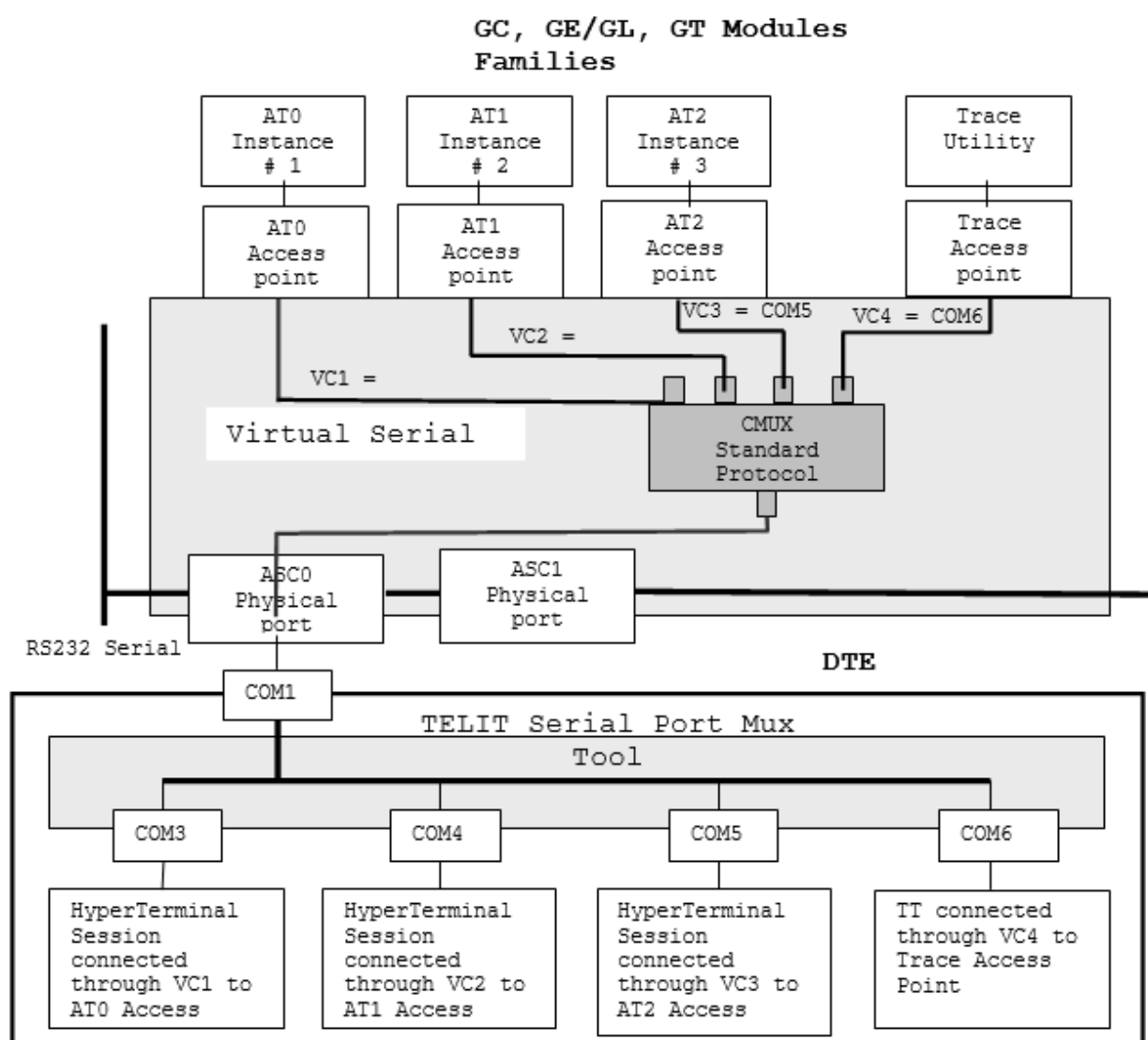
VSD Access Points			
AT0 Instance #1	AT1 Instance #2	AT2 Instance #3	Trace
ASC0/VC1	ASC0/VC2	ASC0/VC3	ASC0/VC4

Tab 1: CMUX vs. Access Points

² VSD is a function that manages the logical connections between the physical serial ports and the Access Points. To have more information concerning the several VSD configurations see [2], [3].

Refer to Fig 1: with the term “instance” is intended an AT Commands Parser. TELIT modules provide three logically independent AT Commands Parsers. Any instance is connected to an Access Point. In general, the Access Point is the connection between the communication path and the Service offered by the module.

Same considerations are valid for modules belonging to the HE910 Family, of course with the required adjustment, see Fig. 2



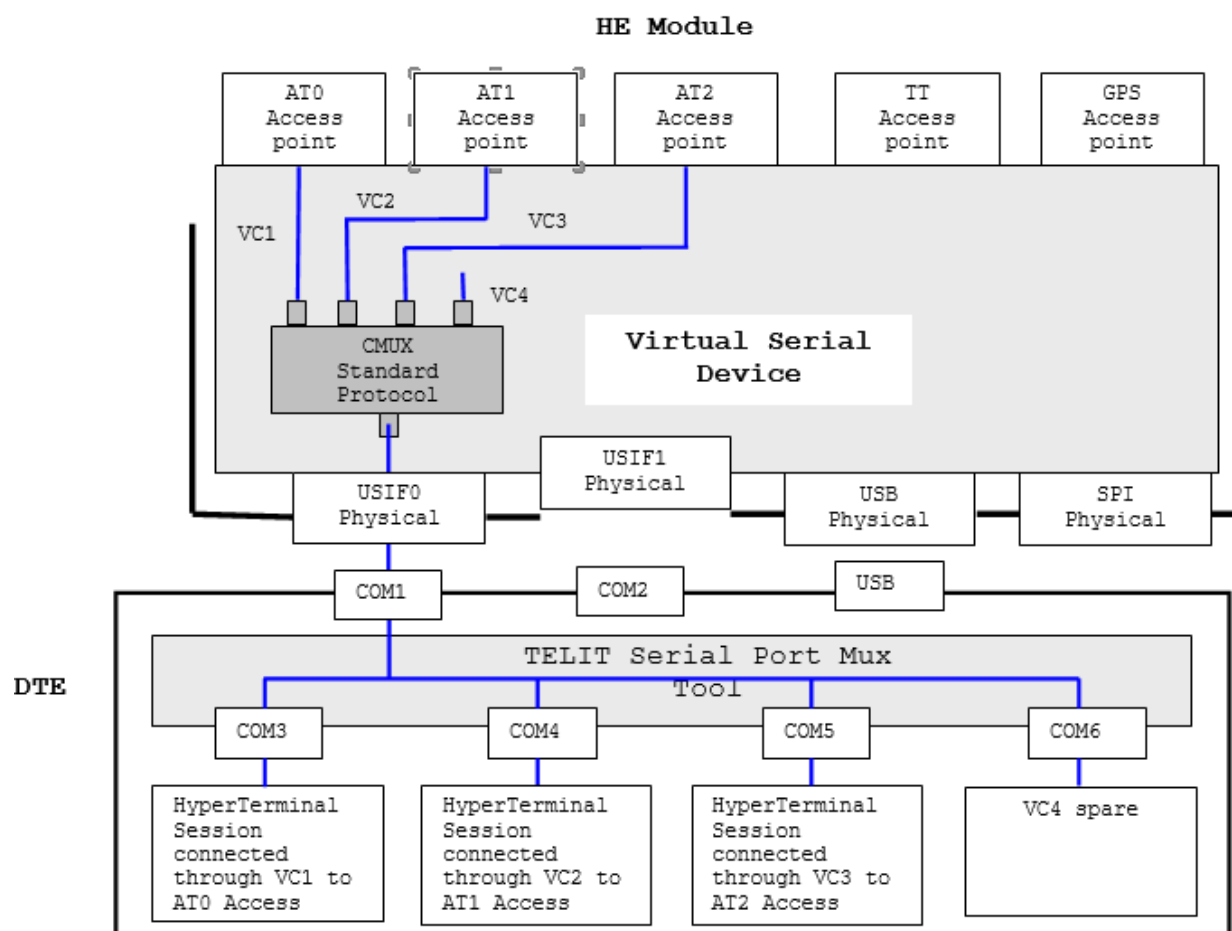


Fig. 1: HE910 Module Family

Thanks to the multiplexing feature, operations such as controlling the module or using the SMS service can be performed via vacant virtual channels without disturbing the existing data flow and no access to a second Serial Port is needed.



NOTICE

the use of the multiplexing feature is strictly connected with the configuration of the VDS, it is suggested to see the several different configuration provided by Telit Modules, refer to [2], [3].

Telit CMUX implementation supports the following features:

- Operating Option: Basic, refer to [1];
- Only UIH frames are supported, refer to [1];
- Four full DLCI (four Virtual Ports);
- Every CMUX Virtual Channel connected to an AT Instance has its own user profile storage in NVM;
- Independent setting of Unsolicited Message;
- Every CMUX Virtual Channel has its own independent flow control.

**NOTICE:**

CMUX can be activated only with the SELINT 2 interface, before activating CMUX check the current AT Interface Style, see [4], and [5] in accordance with the used module.

3. SERIAL MULTIPLEXER PROTOCOL

The next chapter introduces the CMUX Protocol and its Frames Structures with a particular attention to the Telit CMUX implementation. Refer to [1] to have the complete description.

3.1. CMUX Frames Structures

All information transmitted between the module and the application is based on frames that have the following structure (for Maximum Frame Structure Length see chapter 7.1):

Flag	Address	Control	Length Indicator	Information Field	FCS	Flag
1 octet	1 octet	1 octet	1 or 2 octets	Unspecified length but integral number of octets	1 octet	1 octet

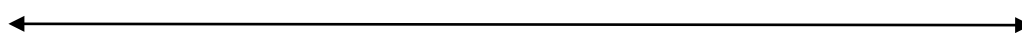


Fig. 2: CMUX Frame Structure

Flag Octet

Each frame begins and ends with a flag octet defined as 11111001 in Binary format (0xF9 in Hexadecimal format).

Address Octet

The form of address octet is the following:

0	1	2	3	4	5	6	7
EA	C/R	DLCI					

EA: Extension Bit

It is set to 1.

C/R: Command/Response

The Initiator is the entity that sends the first SABM command using DLCI 0. In the Telit CMUX implementation, the Initiator is always the Application, consequently it sends a command to the Module with C/R = 1; when the Module (Responder) answers C/R is still 1. If on the same Data Link session the Module sends a command towards the Application C/R is 0; when the Application answers C/R is still 0. The table below summarizes the concept.

Session Initiator	Direction	Responder	C/R Value	Command/Response
Application	→	Module	1	Command
Application	←	Module	1	Response
Application	←	Module	0	Command
Application	→	Module	0	Response

DLCI: Data Link Connection Identifier

DLCI value identifies the Virtual Port inside the Module with the following assignment:

DLCI	Virtual Port type
0	Reserved to Control Channel
1	Virtual Port #1
2	Virtual Port #2
3	Virtual Port #3
4	Virtual Port #4 Its use depends on the used module, refer to [2], [3]



NOTICE:

the Services connected to Virtual Port #4 depend on the used Telit Module and the VSD configuration. To have detailed information refer to [2] and [3].

Control Octet

The content of the control octet defines the type of frame as in the following table:

Frame Type	Control Octet							
	0	1	2	3	4	5	6	7
SABM (Set Asynchronous Balanced Mode)	1	1	1	1	P/F	1	0	0
UA (Unnumbered Acknowledgement)	1	1	0	0	P/F	1	1	0
DM (Disconnected Mode)	1	1	1	1	P/F	0	0	0
DISC (Disconnect)	1	1	0	0	P/F	0	1	0
UIH (Unnumbered Information with Header check)	1	1	1	1	P/F	1	1	1

P/F stands for Poll/Final bit:

Refer to [1] to have a detailed description.

SABM (Set Asynchronous Balanced Mode)

The SABM command is used by the application to start the HDLC Connection and module will answer to this command with an UA Frame.

UA (Unnumbered Acknowledgement)

The UA response is sent by the module as an acknowledgement that a SABM or DISC command was accepted.

DM (Disconnected Mode)

In case module rejects SABM or DISC command it will send DM response, this happens if for example a SABM is sent for a DLCI not supported. Or if a DISC is sent to a DLCI Address already closed.

DISC (Disconnect)

The DISC is used to close a previously established connection. If the application sends a disc for the DLCI 0 (the control channel), all the established channels will be closed. The module will answer to this command with an UA Frame.

UIH (Unnumbered Information)

Please refer to the following chapters for the detailed information about UIH

Length Indicator

This Octet specifies the length of the Information Field

0	1	2	3	4	5	6	7
E/A	L1	L2	L3	L4	L5	L6	L7

E/A Bit should be 1 in case 7 bits are enough for the length (length ≤ 127) otherwise length should be coded with two octets as described below:

Octet 1:

0	1	2	3	4	5	6	7
0	L1	L2	L3	L4	L5	L6	L7

Octet 2:

0	1	2	3	4	5	6	7
L8	L9	L10	L11	L12	L13	L14	L15

To select the right length of the Information Field in accordance with the used Telit Module see chapter 7.1.

Information Field

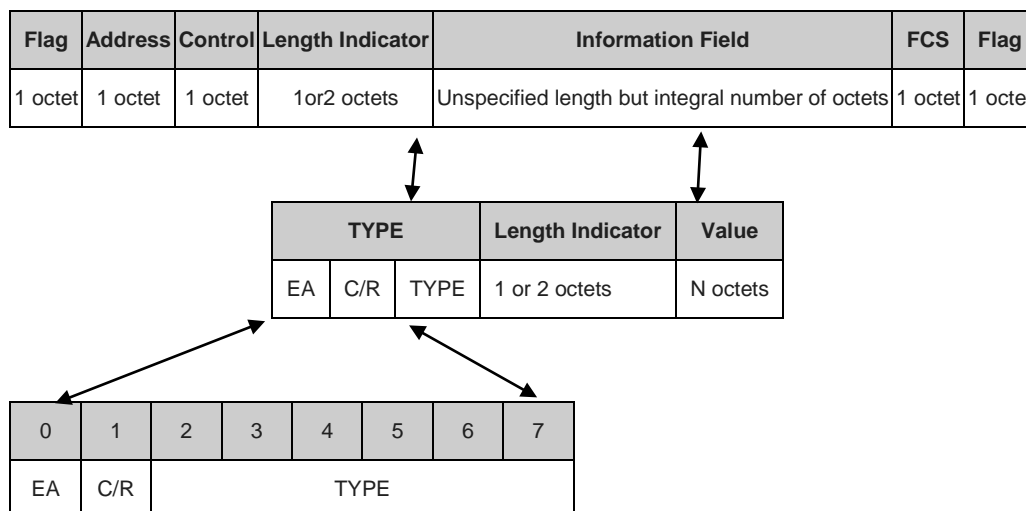
The information field is the payload of the frame and carries the user data. The field exists only for frame type that contains UIH Control Field. The P/F bit should be set to value 0 when this field is sent.

FCS (Frame Checking Sequence)

Refer to [1] to have a detailed description.

3.1.1. UIH Control Channel Frame Coding

Refer to Fig. 3 and the figure below: the Information field can carry UIH Commands or User Data. The Information field exists only for UIH frame type. The P/F bit should be set to value 0 when this field is sent. This chapter focuses on the UIH Commands; in this case DLCI shall always have the value 0. It means that the UIH Command is transferred on the logical Control Channel



Type Octet:

EA: Extension Bit

It is always set to 1.

C/R: Identifies if it is a Command or Response

TYPE: Hereafter are listed the UIH Commands TYPES followed by their Length Indicators (for its coding see chapter 3.1). If Length Indicators is not zero, it is followed the Values octets.

Multiplexer close down (CLD)

The CLD command is used to reset the link, exit Multiplexed Mode and enter AT Command Mode.

LSb								MSb								LSb								MSb							
Type																Length Indicator															
E/A		C/R		0	0	0	0	1	1	E/A		0	0	0	0	0	0	0	0												

Test Command (Test)

Test command is used to test the connection between module and the user application. The Length Indicator describes the number of values bytes, which are used as a verification pattern. The opposite entity shall respond with exactly the same value bytes. Least Significant bit is on left side of the octet:

LSb								MSb							
Type								Length Indicator	Value 1	Value 2	Value ...	Value length			
E/A	C/R	0	0	0	1	0	0	E/A	length	Any Char	Any Char	Any Char	Any Char		

Modem Status Command (MSC)

MSC command is used to send Virtual V.24 Signals status. Each Virtual Connection has its own independent Virtual V.24 Signals status. The two entities exchange MSC messages which formats depend on the CMUXMODE value, refer to chapter 7.3, Tab. 3:

CMUXMODE = 0 or 4

When an entity sends its Virtual V.24 Signals status, the other one answers with a message containing its own Virtual V.24 Signals status. There are two scenarios depend on who sends first the message:

DTE (*Application*) sends the first message:

DLCI=0, MSC (command from DTE with its V.24 Signals) DLCI=1

DCE (*Telit Module*) answers:

DLCI=0, MSC (response from DCE with its V.24 Signals) DLCI=1

DCE (*Telit Module*) sends the first message:

DLCI=0, MSC (command from DCE with its V.24 Signals) DLCI=1

DCE (*Application*) answers:

DLCI=0, MSC (response from DTE with its V.24 Signals) DLCI=1

CMUXMODE = 1 or 5

When an entity sends its Virtual V.24 Signals status, the other one acknowledges the received message using the same message with C/R bit negated (octet Type of the Information Field). There are two scenarios depend on who sends first the message:

DTE (*Application*) communicates its Virtual V.24 Signals status:

DLCI=0, MSC (command from DTE with its V.24 Signals) DLCI=1

DCE (*Telit Module*) acknowledges:

DLCI=0, MSC (response from DCE with DTE V.24 Signals) DLCI=1

DCE (*Telit Module*) communicates its Virtual V.24 Signals status:

DLCI=0, MSC (command from DCE with its V.24 Signals) DLCI=1

DTE (*Application*) acknowledges:

DLCI=0, MSC (response from DTE with DCE V.24 Signals) DLCI=1

Format without Break Indication:

LSb								MSb													
Type								Length Indicator								DLCI			V24 octet		
E/A	C/R	0	0	0	1	1	1	E/A	0	1	0	0	0	0	0	E/A	1	DLCI	E/A	Lines Status	

Format with Break Indication:

LSb								MSb													
Type								Length Indicator								DLCI			V24 octet		Break octet
E/A	C/R	0	0	0	1	1	1	E/A	1	1	0	0	0	0	0	E/A	1	DLCI	E/A	Lines Status	Break Status

V.24 Octet from Module to Application (see chapter 7.2)

0	1	2	3	4	5	6	7
1	FC	DSR	CTS	0	0	RING	DCD

Fig. 3: V.24 Octet DCE → DTE

V.24 Octet from Application to Module (see chapter 7.2)

0	1	2	3	4	5	6	7
1	FC	DTR	RTS	0	0	0	0

Fig. 4: V.24 Octet DTE → DCE

FC: this bit is set to 1 when module or application is not able to accept any frames.

CTS: this bit is set to 1 when module is able to receive data (ref. cmd &K,\Q and related)

RTS: this bit is set to 1 when application is able to receive data. (ref. cmd &K,\Q and related)

DSR: this bit is set to 1 when module is ready to communicate (ref. cmd &S, and related)

DTR: this bit is set to 1 when application is ready to receive data. (ref. cmd &D, and related)

RING: this bit is set to 1 when module receive an incoming call (ref. cmd \R, and related)

DCD: this bit is set to 1 when module has an active data connection. (ref. cmd &C, and related)



NOTICE:

when a new instance is established the default settings are FC = 1, RTS = 0, DTR = 0, this means that the module will not be able to send the data to application until user changes the default setting to FC = 0, RTS = 1, DTR = 1. The application will send an MSC command to change this value before starting sending data.

Break Octet valid in #CMUXMODE 0 and 4

0	1	2	3	4	5	6	7
1	0	0	0	0	0	0	0

This octet will be sent each time a Break Signal is simulated.

Break Octet valid in #CMUXMODE 1, 5 and in all modules that do not provide #CMUXMODE command.

0	1	2	3	4	5	6	7
1	0/1	0	0	0	0	0	0

- bit1 = 0 → no Break
- bit1 = 1 → Break is required

Not Supported Command Response (NSC)

This response is sent in case a command type is not supported by the receiving entity.

LSb								MSb							
Type								Length Indicator							
E/A	C/R	0	0	1	0	0	0	E/A	1	0	0	0	0	0	0
								Command Type							
								E/A	C/R	command type					

Power Saving Control (PSC)

Standard PSC command is used to cause the Telit Module to enter the Power Saving Mode when it is in Multiplexed Mode. It simulates the **N=0** command.

LSb								MSb							
Type								Length Indicator							
E/A	C/R	0	0	0	0	1	0	E/A	0	0	0	0	0	0	0

Telit PSC command has one more octet containing the Power Saving Mode, see Tab 2.

MSb

Type								Length Indicator								Power Saving Mode
E/A	C/R	0	0	0	0	1	0	E/A	1	0	0	0	0	0	0	mode

The table below shows which CFUN modes can be simulated using standard (Std) and Telit PSC to cause the Telit Module to enter the Power Saving Mode in accordance with the used Module Family, refer to [6] to get more information.

AT+CFUN mode	GM, GC, GE/GL, GT Families		HE910 Family		HE863 Family		UC Family	
	Std PSC	Telit PSC	Std PSC	Telit PSC	Std PSC	Telit PSC	Std PSC	Telit PSC
0	no mode octet	mode = 0	not supported	mode = 0	not supported		no mode octet	not supported
1	not supported	mode = 1		mode = 1		not supported		
2		not supported		not supported				
4								
5								
7								
9							mode = 7	mode = 7
	mode = 9	mode = 9						

Tab 2: Telit PSC

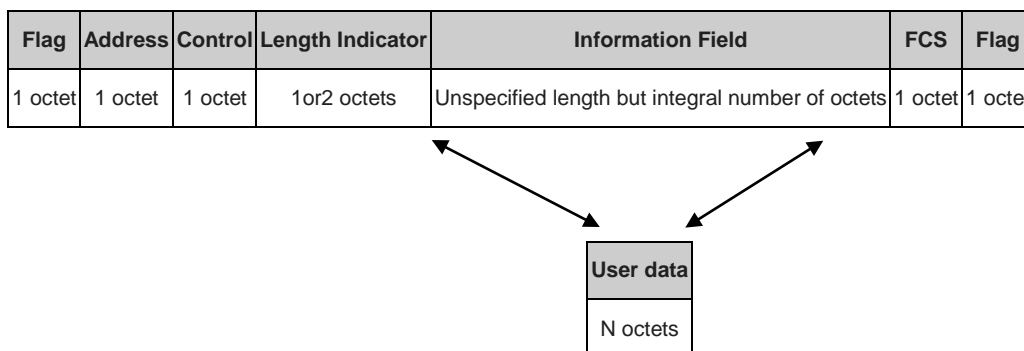


NOTICE:

AT+CFUN command can't be used in Multiplexed Mode.

3.1.2. UIH Data Channel Frame Coding

Refer to Fig. 3 and the figure above: the Information field is the payload of the frame and carries the user data. The Information field exists only for UIH frame type. The P/F bit should be set to value 0 when this field is sent.



Length indicator

It specifies the length of the Information field. See its coding in chapter 3.1

User Data

User payload, the number of octets is defined by the Length Indicator

4. HOW TO DEVELOP A MUX USER APPLICATION

Objective of this chapter is to provide the reader with the guidelines to develop a User Application able to cause the connected module enters Multiplexed Mode and support the Multiplexing Protocol without the assistance of the Telit Serial Port MUX tool.

Let's start with VSD Configuration at Module Power ON, see Fig. 6, Fig. 7 for all Telit Modules Families.

For example, take in consideration the Fig. 6: VSD Configuration connects the physical port ASC0 to the AT0 AT command parser; AT0 parser is matching the instance # 1. Telit Module provides two more AT parser instances: instance # 2 and # 3. The user, by means of DTE, can enter AT commands; they are parsed by the AT0 parser and executed by the module engine. VDS also connects physical port ASC1 to the Trace utility. The user, by means of Telit RTD application running on DTE, can see the trace log. In this configuration the CMUX Standard Protocol [1] is not still used.

Same considerations are valid for modules belonging to the HE910 Family, of course with the required adjustment, see Fig. 7.

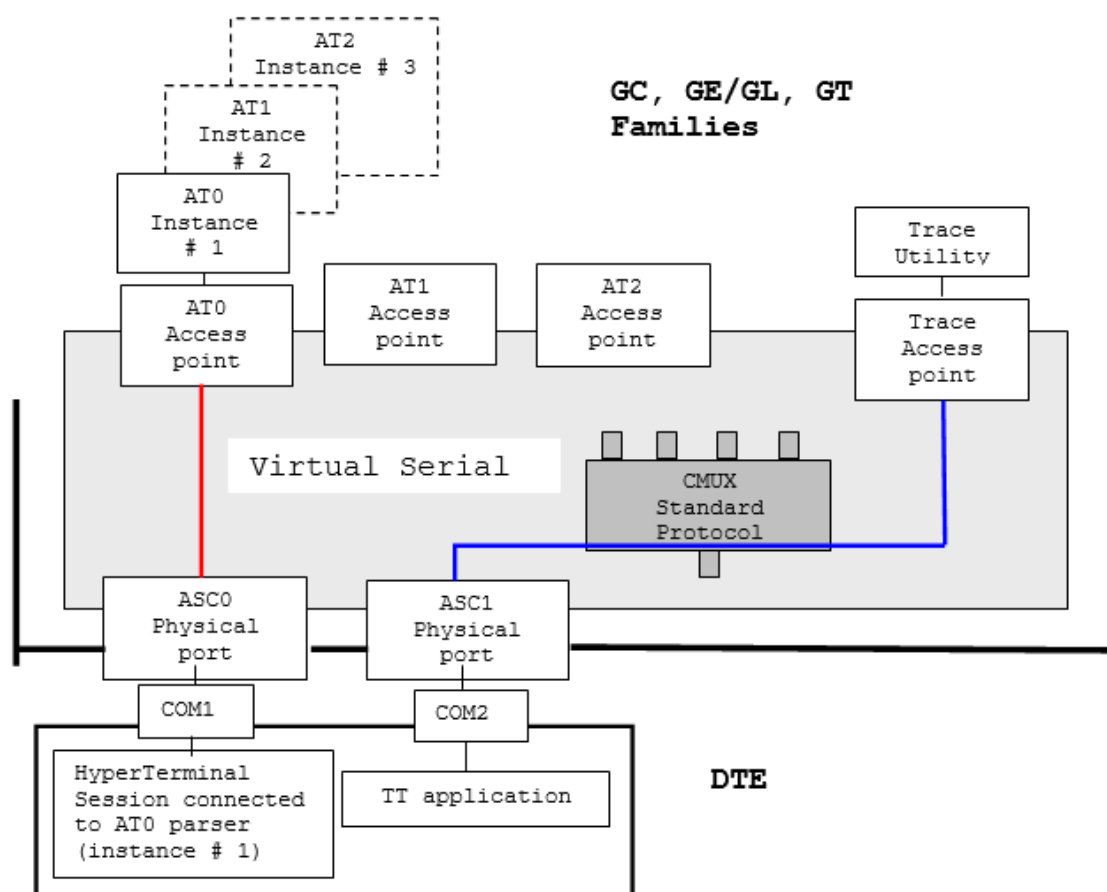


Fig. 5: VSD Configuration at Power ON (GM, GC, GE/GL, GT Modules Families)

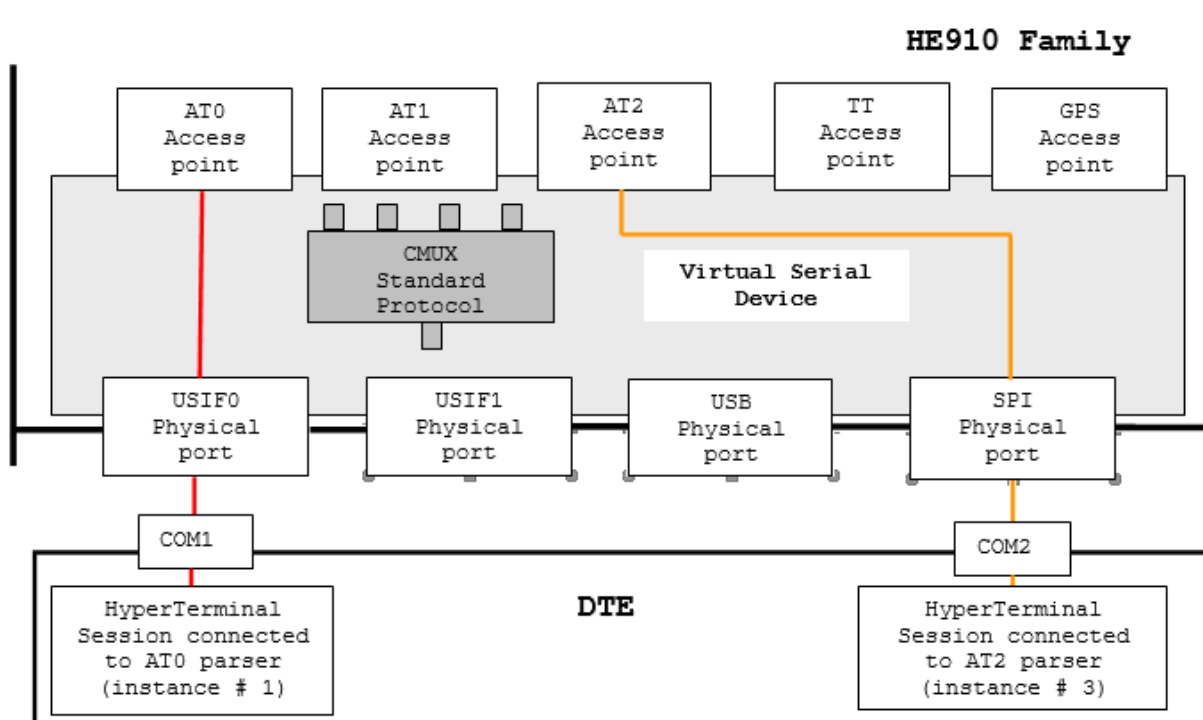


Fig. 6: VSD Configuration at Power ON (HE910 Family)

First of all, the User Application must force the connected module in Multiplexed Mode. To do that, it sends the AT commands listed below, see [4], [5], and [6] to get more information concerning the AT commands in accordance with the used module.



NOTICE:

the commands are sent by means of a regular serial line protocol, no Multiplexing Protocol is still activated during this phase..

Select #SELINT=2 AT Interface Style

AT#SELINT=2
OK

Disable Echo, Activate verbose format, Activate Hardware Flow Control, Program the DTR to close the current connection on its high to low transition

ATE0V1&K3&D2
OK

The following entered AT commands are not echoed; only OK is answered by the module.

Select the Serial Port Speed.

AT+IPR=115200

OK

Store the setting on profile 0 and at power on use profile 0

AT+W0&P0

OK

Select the CMUX mode, refer to chapter 7.3.

AT#CMUXMODE=1

OK

Start MUX protocol (Module enters Multiplexed Mode):

For Telit Modules provided with no
configurable CMUX, see chapter 7.1:

AT+CMUX=0

OK

For Telit Modules supporting configurable
CMUX, see chapter 7.1:

AT+CMUX=0,0,,122

OK

When the User Application receives the OK response of the +CMUX command, the module entered the Multiplexed Mode and the regular serial line protocol is no more available. The User Application can continue to be connected with the module only via the Multiplexing Protocol, see Fig. 8 and the example of CMUX messages sequence in hexadecimal format listed on the next page.

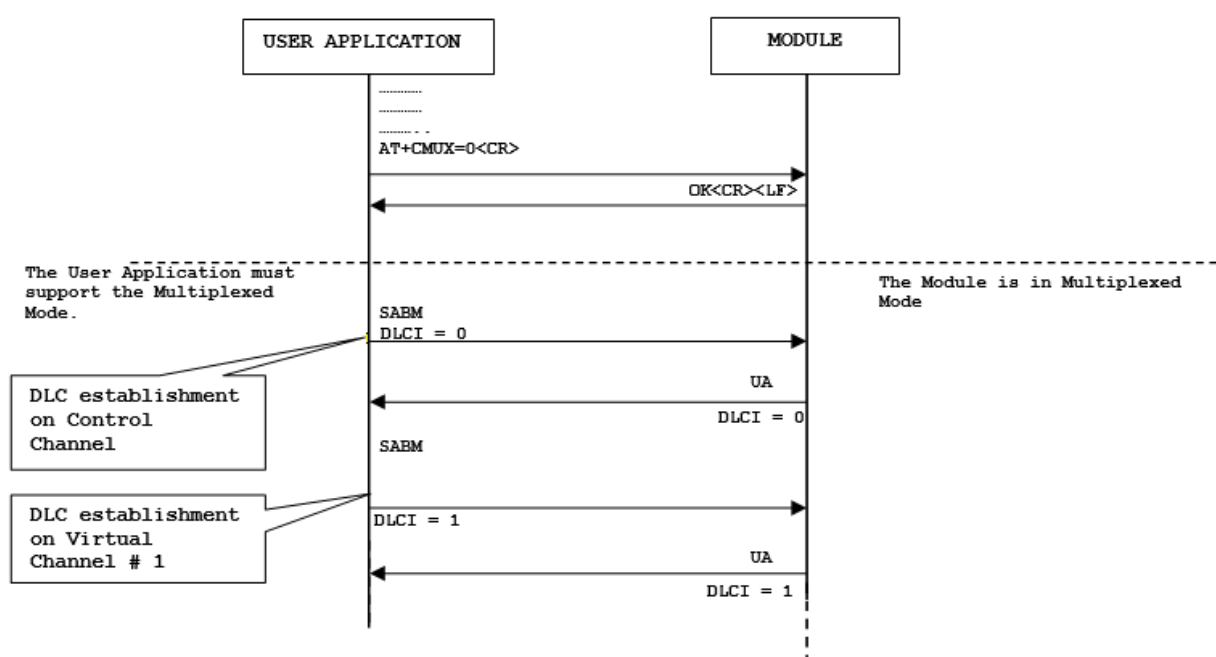


Fig. 7: CMUX Protocol

After entering +CMUX AT Command, the CMUX protocol substitutes the regular serial line protocol. Hereafter is listed an example of CMUX protocol. The messages are in hexadecimal format.

Legend:

Red - messages sent from User Application (DTE) to Module (DCE)

Green - messages sent from Module to User Application

Black - comments

DLC establishment on Control Channel:

F9 03 3F 01 1C F9 -DLCI = 0, SABM CMD, POLL BIT=1

F9 03 73 01 D7 F9 -DLCI = 0, UA RESPONSE, FINAL BIT=1

DLC establishment on Virtual Channel # 1 (Open Virtual Port #1):

F9 07 3F 01 DE F9 -DLCI = 1, SABM CMD, POLL BIT=1

F9 07 73 01 15 F9 -DLCI = 1, UA RESPONSE, FINAL BIT=1

.

.

.

DLC establishment on Virtual Channel # 2 (Open Virtual Port #2)

.

CMUXMODE = 1 or CMUXMODE = 5

User Application sends the module the Virtual V.24 Signal status concerning its Logical Port (COMx) connected to Virtual Channel #2: FC=0, RTS=0, DTR=1

F9 03 EF 09 E3 05 0B 05 FB F9 -DLCI = 0; UIH Frame, MSC CMD for Virtual Channel (DLCI) =2

Module answers with the just received Virtual V.24 Signal status. C/R bit belonging to the TYPE octet is negated

F9 01 EF 09 E1 05 0B 05 9A F9 -DLCI = 0; UIH Frame, MSC CMD for Virtual Channel (DLCI) =2

Module sends its Virtual V.24 Signal status concerning Virtual Port #2: FC=0, DSR=1, CTS=1, RING=1, DCD=0.

F9 01 EF 09 E3 05 0B 4D 9A F9

User Application answers with the just received Virtual V.24 Signal status. C/R bit belonging to the TYPE octet is negated.

F9 03 EF 09 E1 05 0B 4D FB F9

CMUXMODE = 0 or CMUXMODE = 4

User Application sends the module the Virtual V.24 Signal status concerning its Logical Port (COMx) connected to Virtual Channel #2: FC=0, RTS=0, DTR=1

F9 03 EF 09 E3 05 0B 05 FB F9 -DLCI = 0; UIH Frame, MSC CMD for Virtual Channel (DLCI) =2

Module sends its Virtual V.24 Signal status concerning Virtual Port #2: FC=0, DSR=1, CTS=1, RING=1, DCD=0

F9 03 EF 09 E1 05 0B 4C FB F9

.

User Application sends the AT Command: AT+CGMR

F9 07 EF 11 41 54 2B 43 47 4D 52 0D 2B F9

Module answers the AT command result: <CR><LF>07.02.504<CR><LF><CR><LF><OK>

F9 05 EF 27 0D 0A 30 37 2E 30 32 2E 35 30 34 0D 0A 0D 0A 4F 4B 0D 0A 80 F9

User Application causes the module to enter Power Saving Mode. UIH Frame, PSC CMD

F9 03 EF 05 41 01 F2 F9



NOTICE:

to get more information concerning Power Saving Mode refer to [6].



NOTICE:

in absence of communication between the Telit Module and the User Application it is suggested to send a periodic Test Command to the Telit Module in order to verify the CMUX protocol operating state.



NOTICE:

here is the Telit PSC command and the related response.

F9 03 EF 07 43 03 07 11 F9 PSC CMD: CFUN=7

F9 01 EF 07 41 03 01 70 F9 PSC RSP: ACK=01

5. SUMMARY AND RECOMMENDATIONS

*The customer/integrator to design its own Multiplexer Protocol Application shall remember:

- Telit Module supports the CMUX Basic Option and UIH Frames according to [1];
- Serial Port must be so configured: 8 data bits, no parity, 1 stop bit;
- It is mandatory to use the Hardware Flow control on the physical serial line that will support the Multiplexer Protocol. It should be set before entering Multiplexer Mode using AT command AT&K3 (both RTS/CTS active);
- DTR Lines should be set correctly (pulled-up), since a transition of the DTR signal causes the exit from Multiplexer Mode, this is valid only for modules equipped with a not updated software version, see chapter 7.3, Tab. 3.

* If the Telit Module is operating in Multiplexer Mode, the following restrictions will be applied:

- Software Flow control XON/XOFF is not supported;
- Call control: a voice call can be initiated, answered and closed on any channel;
- Call control: Data or Fax call can be initiated and answered on any channel but closed only on the channel where the call was started/answered;
- Phonebook access: if you wish to write the same phonebook entry using two or more different Virtual Channels at the same time, please note that only the last entry will be stored;
- When in Multiplexed Mode, the escape sequence '+++', sent on one Virtual Channel, will not be recognized and executed by the involved AT instance (except for HE910 Family). It is responsibility of the Application to use the Break Octet of the Modem Status Command (MSC). Break Octet simulates the escape sequence (not yet supported on HE910 Family).
- The commands listed below are ignored in case of Multiplexer Mode. To be more precise it is possible to read/write values but they will have no effect on the behavior of the module, refer to [4], [5].
 - AT+IPR
 - AT+IFC
 - AT+ICF
 - ATS2; ATS12; '+++'
 - ATS25
 - AT+CMUX
 - AT#SELINT
 - AT&F, ATZ, AT#Z
- Due to some restriction in the GSM/GPRS standard or limitation of the software the AT commands, listed below, will not be executed in parallel by the module. If one of the following commands are requested to be executed on one AT Instance (see chapter 2) while one of this command is running on another AT Instance, the latest execution is suspend until the first request is completed.
 - ATA <Until CONNECT is not displayed>
 - ATD <Until CONNECT is not displayed>
 - ATO
 - ATH
 - AT+CGATT <Set command>
 - AT+CGACT
 - AT+COPS <Set Command or Test Command>
 - AT+CREG <Set Command>
 - AT#SEMAIL <Blocked after Ctrl-z is sent>
 - AT#EMAILD <Blocked after Ctrl-z is sent>

- AT#SKTOP <Until CONNECT is not displayed>
- AT#SKTD <Until CONNECT is not displayed>
- AT#QDNS
- AT+CMM
- All FTP Command
- All CSURV Command
- All Supplementary Service Command
- All Phone Book related command



NOTICE:

this limitation appears only when two or more of the commands listed above are combined. E.g.: commands AT#MONI, +CGMR, AT+COPS? will always be executed without suspension since only one of the commands listed above is running.



NOTICE:

for further restriction on behavior of other commands please refer to the specific documentation: [4], [5], [7], and [8].

*In general an AT command executed by the selected AT Instance modified only the behavior of the used AT Instance. It has its own User Profile stored in NVM. Vice versa, the AT commands listed below modify the behavior of the all set of AT Instances, regardless the used AT Instance and its connected Virtual Circuit.

- AT#HFMICG
- AT#HSMICG
- AT+CMUT
- AT#STM
- AT#SHFEC
- AT#CAP
- AT+CLVL
- AT#SRS
- AT+CRSL
- AT#SRP
- AT#NITZ
- AT+CARM
- AT#SHFSD
- AT#DAC
- AT+COPS
- AT#CODEC
- AT#DVI
- AT#E2SMSRI
- AT#E2SLRI
- AT+CSCB

At Module power on, the physical port ASC0 is connected to the AT0 Instance as showed by Fig. 6, in accordance with that, ASC0 uses the profile of AT0 Instance. When the Module is in Multiplexer Mode, the Virtual Channel 1 is connected to AT0 Instance (see Fig 1) and consequently uses the AT0 Instance profile. Same considerations are valid for HE910 Family.

*When Telit Module is in Multiplexed Mode don't use AT+CFUN command, use the Power Saving Command (PSC), see Tab 2.

For example, don't use AT+CFUN=5 with Module equipped with a not updated software version because the transition High/Low of the DTR signal causes the disconnection of the CMUX protocol, see Tab. 3.

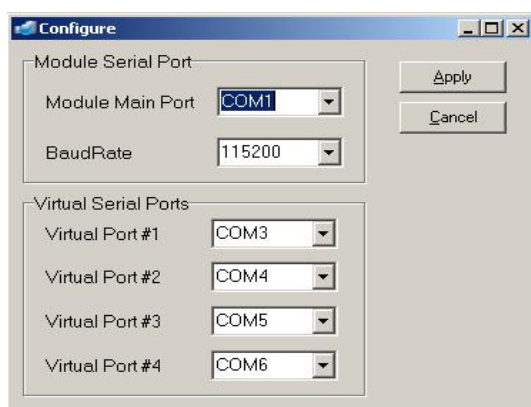
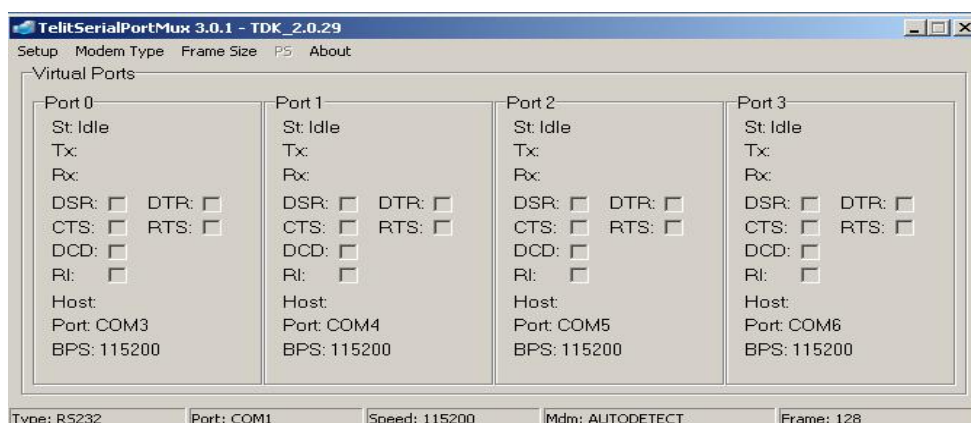
*CMUX Protocol and Python: see the AT command #CMUXSCR, refer to [9]

6. TELIT SERIAL PORT MUX TOOL

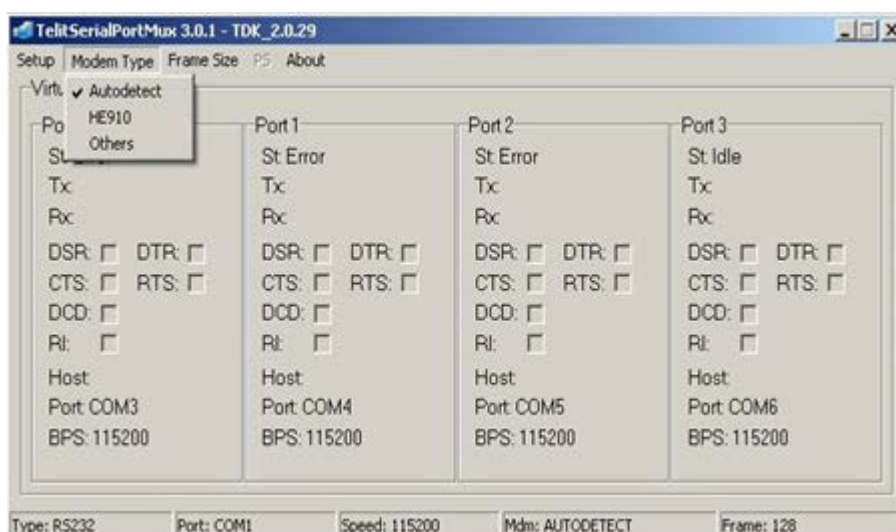
Telit has developed a tool called Telit Serial Port MUX showed in schematic manner on Fig 1 and Fig. 2; the tool is running on a PC-Windows. From the figures it is possible infer that four Virtual Channels can exist at the same time on one physical line (COM1). Four logical COMx, provided by the Windows OS, can be used by four different PC-Applications to gain one of the four Virtual Channels.

6.1. Graphical Interface

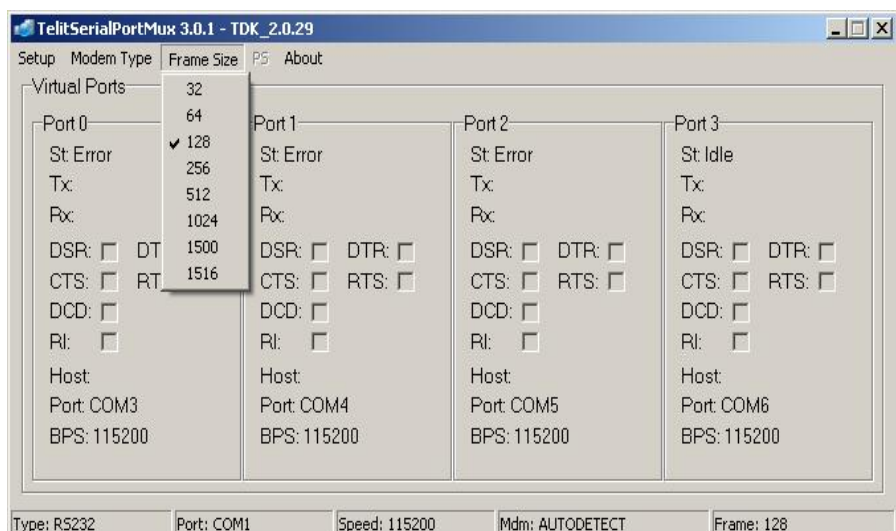
After installing Telit Serial Port Mux tool on PC-Windows, it looks as in the following figure:



Select Setup Menu to configure the Main Port and the Virtual Ports. The Configure Panel is self-explanatory.



Click Modem Type Menu to select the Telit Modem in accordance with the actual Telit Modem connected to the DTE.



Click Frame Size Menu to define the **Maximum Frame Structure Length**, see Fig. 3.

7. APPENDIX

7.1. How to select the Information Field length

To know if your actual used Telit Module supports a configurable CMUX protocol or if its configuration is fixed, use the following procedure. Assume a DTE is connected to your module and manually enter the listed below +CMUX commands.

Enter the command to see if the CMUX is configurable

AT+CMUX=?

+CMUX: (0),(0),(5),(1-1509),(1-255),(0-100),(2-255),(1-255),(1-7)

OK

The AT command response indicates that the CMUX can be configurable, several parameters can be changed.



NOTICE:

Some Telit Modules can answer only with the first four ranges.

Enter the command to get the actual values of the CMUX parameters

AT+CMUX?

+CMUX: 0,0,5,128,10,3,30,0,0

OK



NOTICE:

Some Telit Modules can answer only with the first four parameters.

The fourth parameter is the Information Field Length: 128 octets (referring to the AT command above). In this case two octets are needed to constitute the Length Indicator, see 3.1. The user can use the +CMUX command to change the CMUX configuration on the module, see [4], [5].



NOTICE:

for modules having software version equal to 10.00.xxx, see Applicability Table, it is mandatory to set the CPU clock with the AT#CPUMODE=3 command when the frame size is greater than 127 bytes.

For Telit Module equipped with a not updated software version the CMUX protocol could not be configurable.

Enter the command to see if the CMUX is configurable

AT+CMUX=?

+CMUX: (0),(0)

OK

The CMUX is not configurable. In this case the **Maximum Frame Structure Length**, see Fig. 3, is equal to 133 octets, in accordance with it the **Information Field length** is 127 (less than 128 octets). Only one octet is needed to constitute the Length Indicator.

7.2. V.24 Link

For reader convenience hereafter is showed the V.24 link supported by the Telit Modules. The reader can compare the physical V.24 interface with the two V.24 octets provided by the CMUX protocol for each Virtual Channel:

- V24 Octet from DCE (Module) to DTE (Application), refer to Fig. 4
- V24 Octet from DTE (Application) to DCE (Module), refer to Fig. 5

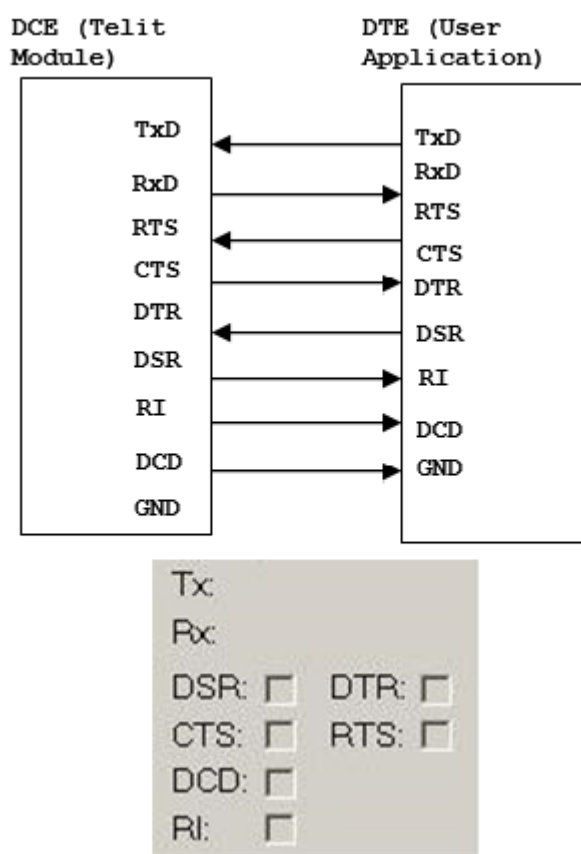


Fig. 8: Complete V.24 Link versus Telit Serial Port MUX Panel

- DSR: Data Set Ready
- CTS: Clear To Send
- DCD: Data Carrier Detect
- RI: Ring Indicator
- DTR: Data Terminal Ready
- RTS: Request to send

7.3. DTR Signal vs. CMUX Protocol

It is worth to remind that High → Low transition of the DTR signal causes the Module to exit the Multiplexed Mode. To avoid that and make available to the user the selection of one of the two CMUX implementations that can be provided by a Module, Telit has developed the following proprietary AT Command:

AT#CMUXMODE=<mode>

In accordance with the response of the **AT#CMUXMODE=?** Command, you can know the features supported by your Telit Module concerning the interaction between the CMUX protocol implementation and DTR transition:

AT#CMUXMODE=?

#CMUXMODE: (0,1)

OK

You have a Telit Module equipped with a not updated software version.

AT#CMUXMODE=?

#CMUXMODE: (0,1,4,5)

OK

You have a Telit Module supporting all modes.

The table below summarizes the command functionalities in accordance with the used Telit Module and the <mode> value selected by the user.

<mode>	MODULES equipped with a not updated software version		MODULES supporting all modes	
	DTR transition (H→L) causes:	Is activated a CMUX protocol that:	DTR transition (H→L) causes:	Is activated a CMUX protocol that:
0 ³	CMUX is closed	preserves backward compatibility	CMUX is closed	preserves backward compatibility
1	CMUX is closed	is more adherents to the Standard	CMUX is closed	is more adherent to the Standard
4	/	/	No actions on CMUX	preserves backward compatibility
5	/	/	No actions on CMUX	is more adherent to the Standard

Tab. 3 CMUXMODE (con't)

Modes 4 and 5 have been introduced to manage the cases where the Application Processor moves the DTR signal to enter itself the Power Saving state.

³ Factory setting

If the command result is ERROR, please refer to the Tab 4 to know the unique CMUX implementation provided by your Telit Module under test.

AT#CMUXMODE=?

ERROR

	Software Versions	
	10.xx.xxx <= 10.00.002	12.xx.xxx
CMUX implementation	preserves backward compatibility (see mode = 0)	is more adherent to the Standard (see mode = 5)

Tab 4 CMUXMODE



NOTICE:

A new Application should be developed compliant with #CMUXMODE=1, where it is possible. Warning: the mode is not stored in NVM..

8. DOCUMENT HISTORY

Revision	Date	Products/SW Versions	Changes
0	2012-02-15	/	The present Revision supersedes the CMUX User Guide, 30268ST10299A Rev. 5 – 2011-03-01 and all the previous revisions.
1	2012-06-18	/	Updated the Application Table. Added the AT#CPUMODE=3 command.
2	2012-07-05	/	Updated chapter 7.1. Updated Document History (Changes field of the Revision 0).
3	2013-02-15	/	Updated the Applicability Table. Detailed the use of the Break Octet in accordance with the #CMUXMODE and the used modules, chapter 3.1.1.
4	2014-03-06	/	Chapter 4: Modified the standard PSC command, and added a NOTICE related to Telit PSC command.

		Products added: GE910-QUAD AUTO / 13.00.xx5 GE910-GNSS / 13.00.xx4 GL865-QUAD V3 / 16.00.xx3 GE910-QUAD V3 / 16.00.xx3 GE866-QUAD / 16.00.xx3 UE910-EUR/EUD/12.00.xx4 UE910-NAR/NAD/12.00.xx4 UL865-EUR/EUD / 12.00.xx4 UL865-NAR/NAD / 12.00.xx4 UL865-N3G / 12.00.xx4	/
5	2014-03-11	/	Updated the Applicability Table.
6	2017-02-07		2017 Template applied



SUPPORT INQUIRIES

Link to www.telit.com and contact our technical support team for any questions related to technical issues.

www.telit.com



Telit Communications S.p.A.
Via Stazione di Prosecco, 5/B
I-34010 Sgonico (Trieste), Italy

Telit IoT Platforms LLC
5300 Broken Sound Blvd, Suite 150
Boca Raton, FL 33487, USA

Telit Wireless Solutions Inc.
3131 RDU Center Drive, Suite 135
Morrisville, NC 27560, USA

Telit Wireless Solutions Co., Ltd.
8th FL., Shinyoung Securities Bld.
6, Gukjegeumyung-ro8-gil, Yeongdeungpo-gu
Seoul, 150-884, Korea

Telit Wireless Solutions Ltd.
10 Habarzel St.
Tel Aviv 69710, Israel

Telit Wireless Solutions
Tecnologia e Servicos Ltda
Avenida Paulista, 1776, Room 10.C
01310-921 São Paulo, Brazil

Telit reserves all rights to this document and the information contained herein. Products, names, logos and designs described herein may in whole or in part be subject to intellectual property rights. The information contained herein is provided "as is". No warranty of any kind, either express or implied, is made in relation to the accuracy, reliability, fitness for a particular purpose or content of this document. This document may be revised by Telit at any time. For most recent documents, please visit www.telit.com

Copyright © 2016, Telit