Quectel Cellular Engine

GSM Multiplexer Application Notes

GSM_MUX_AN_V1.00

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0. Revision history

Revision	Date	Author	Description of change
1.00	2009-06-27	Jay XIN	Initial

1. Introduction

The present document describes the Quectel multiplexer protocol and the technical details of how to make use of it.

1.1. Reference

Table 1: Reference

SN	Document name	Remark
[1]	M10_ATC_V1.00	
[2]	GSM 07.10 version 7.1.0 Release 1998	

1.2. Terms and abbreviations

Table 2: Terms and abbreviations

Abbreviation	Description
CLD	Multiplexer Close Down
DISC	Disconnect (DISC) command
DLC	Data Link Connection
DLCI	Data Link Connection Identifier
DM	Disconnected Mode
DV	Data Valid
FC	Flow Control
FCoff	Flow Control Off Command
FCon	Flow Control On Command
IC	Incoming Call Indicator
MS	Mobile Station
MSC	Modem Status Command
NSC	Non Support Command
PN	Parameter Negotiation
PSC	Power Saving Control
RLS	Remote Line Status Command
RPN	Remote Port Negotiation
RTC	Ready To Communicate
RTR	Ready To Receive
SABM	Set Asynchronous Balanced Mode
SNC	Service Negotiation Command
TE	Terminal Equipment
UA	Unnumbered Acknowledgement
UI	Unnumbered Information command and response
UIH	Unnumbered information with header check (UIH) command and response

2. Quectel Multiplexer Design Purpose

A device using GPRS or GSM data may wish to receive and transmit multiple streams of data simultaneously. These are Command data (AT commands), GPRS data and GSM circuit switched data (CSD). These streams are essentially independent to one another.

As to the non-multiplexer device, it is so inefficient to deal with only one kind or one channel of data steam during a period of time. Therefore, Quectel multiplexer is designed with GSM0710 standard to separate transmission device layer into several logic channels (DLC) in order to transmit data simultaneously. Each channel has its own buffer management and flow control mechanism.

2.1. Architecture Diagram

Quectel multiplexer architecture diagram is as following:

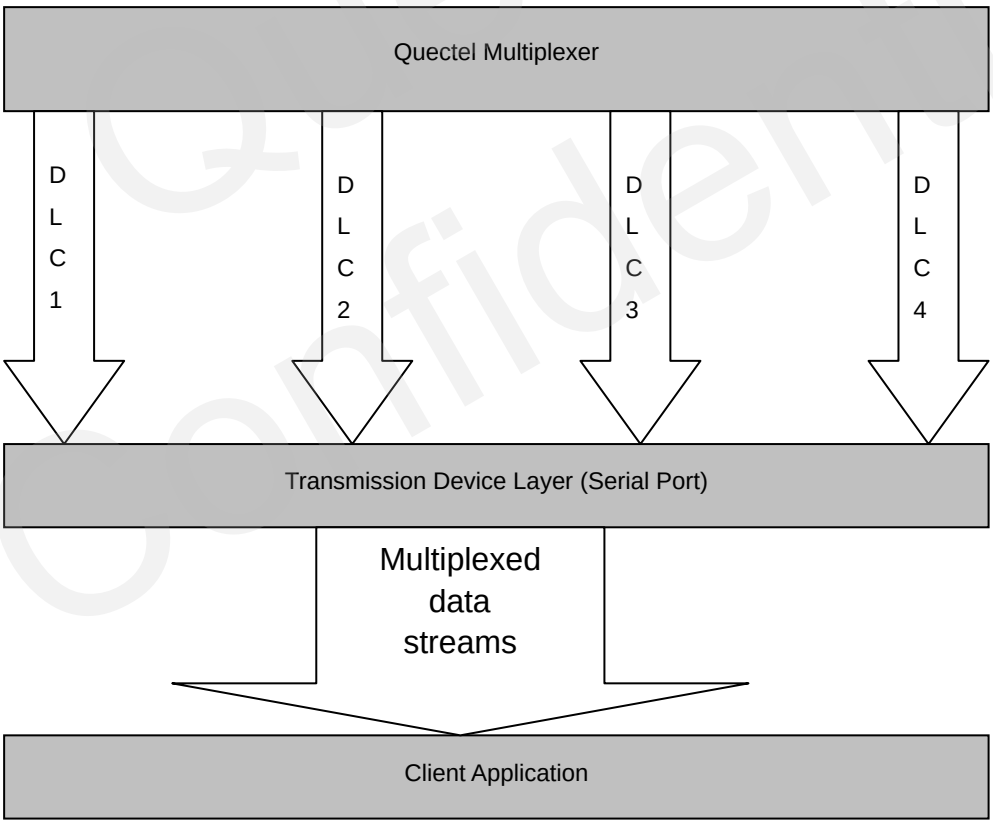

Figure 1: Quectel multiplexer architecture diagram

Quectel Multiplexer is established upon system transmission device layer (Commonly serial port).

Data streams are addressed with DLCI value and encapsulated in frames based on GSM 0710 protocol (Chapter 3, Quectel Multiplexer Protocol) and transmitted through interface provided by transmission device layer.

2.2. Restrictions

- DC1/XON and DC3/XOFF flow control is not supported.
- Error Recovery Mode is not supported.
- PN, NSC, RPN, RLS, SNC message frames are not supported.
- All the system parameters defined in GSM 0710 are set to default as following table.

Parameter	Value	Comment
T1 (Acknowledgement Timer)	100 milliseconds	Time that a station will wait for an acknowledgement before resorting to other action
N1 (Maximum Frame Size)	127	Maximum number of octets that that may be contained in an information field
N2 (Maximum number of retransmissions)	3	Not used
T2 (Response Timer for multiplexer control channel)	300 milliseconds	Not used
T3 (Response Timer for wake-up procedure)	10 seconds	Amount of time the transmitting station of a power wake-up command waits before raising an alarm when no response is received
K (Window Size)	N/A	Not used

- UI Frames are not supported.
- Only supports GSM 0710 Basic Option.

3. Quectel Multiplexer Protocol

Quectel Multiplexer protocol provides a data transmission mechanism by establishing DLC between TE and MS. Several DLC can be set up. Each one is independent to one another and has its own management of buffer and flow control. All information transmitted between the TE and MS is conveyed in frames.

3.1. Transmission Frame Structures

The frame structure is composed of an opening and a closing flag, an address field, a control field, a length field, an information field and FCS field. Please see following table.

Opening Flag	Address Field	Control Field	Length Field	Information Field	FCS Field	Closing Flag
1 byte	1 byte	1 byte	1 byte	Multi-byte	1 byte	1 byte

3.1.1. Opening and Closing Flag Field

Each frame begins and ends with a flag sequence octet which is defined as a constant bit pattern 0xF9.

3.1.2. Address Field

The address field consists of a single octet. It contains the Data Link Connection Identifier (DLCI), the C/R bit and the address field extension bit (EA) as following table.

Bit							
1	2	3	4	5	6	7	8
EA	**CR**	**DLCI**					

The range of the address field may be extended by use of the EA bit. When the EA bit is set to 1 in an octet, it signifies that this octet is the last octet of the address field. When the EA bit is set to 0, it signifies that another octet of the address field follows. Quectel multiplexer only supports one address octet so the EA bit is always set to 1.

The C/R (command/response) bit identifies the frame as either a command or a response.

The DLCI is used to identify an individual data stream as well as channels between TE and MS. Multiple DLCIs shall be supported but the number is implementation-specific. The DLCIs are

dynamically assigned.

3.1.3. Control Field

The content of the control field defines the type of frame. The control fields of the frames used in the present document are described in the following table.

Bit								HEX[1]	Frame Type	Comment
1	2	3	4	5	6	7	8			
1	1	1	1	P/F	1	0	0	0x2F	SABM	Set Asynchronous Balanced Mode
1	1	0	0	P/F	1	1	0	0x63	UA	Unnumbered Acknowledgement
1	1	1	1	P/F	0	0	0	0x0F	DM	Disconnected Mode
1	1	0	0	P/F	0	1	0	0x43	DISC	Disconnect
1	1	1	1	P/F	1	1	1	0xEF	UIH	Unnumbered Information with Header check
1	1	0	0	P/F	0	0	0	0x03	UI	Unnumbered Information(Not supported)

Note: Hex value does not count the bit 5 value.

3.1.4. Length Field

This field is present only in case when basic option is activated.

Bit							
1	2	3	4	5	6	7	8
EA	**L1**	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**

The L1 to L7 bits indicates the length of the following data field.

The range of the length field may be extended by use of the EA bit. When the EA bit is set to 1 in an octet, it signifies that this octet is the last octet of the length field. When the EA bit is set to 0, it signifies that a second octet of the length field follows. Quectel multiplexer only supports one length octet so the EA bit is always set to 1.

Note: Length field should always be contained in each frame even though information field is empty.

3.1.5. Information Field

The information field is the payload of frame and carries the user data information (e.g. AT Command and PPP data packet). The field is octet structured. The information field is only present in UIH frames.

3.2. Frame Type

3.2.1. SABM

SABM is command frame and shall be used to establish DLC between TE and MS.

3.2.2. UA

UA frame is the response to SABM or DISC frame. Please see following diagram.

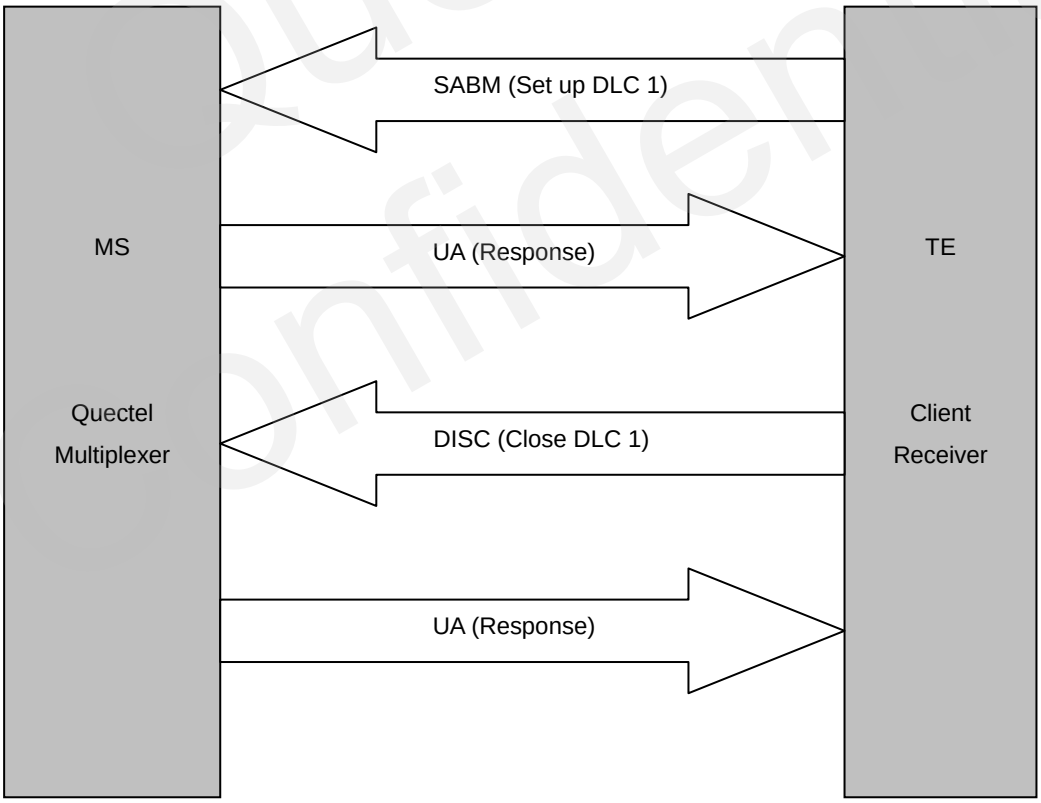

Figure 2: UA frame is the response

3.2.3. DISC

DISC is command frame and shall be used to close down DLC. Prior to acting the command, the receiving station shall confirm the acceptance of the DISC command by the transmission of a UA response. Please see the diagram above.

3.2.4. DM

The DM response frame shall be used to report a status whether the station is logically disconnected from the data link. When in disconnected mode no commands are accepted until the disconnected mode is terminated by the receipt of a SABM command. If a DISC command is received while in disconnected mode a DM response should be sent.

3.2.5. UIH

The UIH command/response shall be used to send user data at either station.

3.2.6. UI

Not Supported.

3.3. DLC Establishment

The establishment of a DLC will be initiated by the TE.

TE wishing to establish a DLC transmits a SABM frame with the P-bit set to 1. The address field contains the DLCI value associated with the desired connection. If MS is ready to establish the connection it will reply with a UA frame with the F-bit set to 1. If MS is not ready or unwilling to establish the particular DLC it will reply with a DM frame with the F-bit set to 1.

3.4. Closing Down DLC

The release of a DLC will be initiated from by the transmission of a DISC frame with the P-bit set to 1. Confirmation of the DLC release is signaled by MS sending a UA frame with the F-bit set to 1. Once the DLC has been released the MS enter disconnected mode for that particular DLC. If MS receiving the DISC command is already in a disconnected mode it will send a DM response.

3.5. Control channel

Multiplexer control channel is the basic channel which is used to establish DLC, launch power saving, wake up from power saving and implement flow control mechanism.

Control channel is the first channel established at the initiation of the multiplexer between the TE and MS and it has the DLCI value 0.

UIH message frame is transmitted through control channel. All UIH message frame conform to the following format.

Type	Length	Value 1	Value 2	……	Value n

Each box in the table represents a field of minimum size one octet.

The first type field octet has the following format:

1	2	3	4	5	6	7	8
EA	C/R	T1	T2	T3	T4	T5	T6

The EA bit is an extension bit. It is set to 1 in the last octet of the sequence. In other octets EA is set to 0. Quectel multiplexer only supports one octet is transmitted. So EA is always set to 1.

The C/R bit indicates whether the message is a command or a response.

The T bits indicate the type coding. Each command has a unique pattern of bit sequence. This means that a single-octet type field can encode 63 different message types. Only single octet message types are defined in the present document.

The length field octet has the following structure:

1	2	3	4	5	6	7	8
EA	L1	L2	L3	L4	L5	L6	L7

The EA bit is an extension bit. It is set to 1 in the last octet of the sequence. In other octets EA is set to 0. Quectel multiplexer only supports one octet is transmitted. So EA is always set to 1.

The L bits define the number of value octets that follows. L1 is the LSB and L7 is the MSB; this permits messages with up to 127 value octets to be constructed.

The message frame is divided into following types:

3.5.1. PSC

Message type coding octet:

1	2	3	4	5	6	7	8
EA	C/R	0	0	0	0	1	0

Hex value is 0x43(Command), 0x41(Response)

The EA bit is always set to 1.

The length field in PSC message frame is 0. It has no value octet.

3.5.2. CLD

Message type coding octet:

1	2	3	4	5	6	7	8
EA	C/R	0	0	0	0	1	1

Hex value is 0xC3 (Command), 0xC1 (Response)

The EA bit is always set the 1.

The length field in CLD message frame is 0. It has no value octet.

3.5.3. Test

Message type coding octet:

1	2	3	4	5	6	7	8
EA	C/R	0	0	0	1	0	0

Hex value is 0x23 (Command), 0x21 (Response)

The EA bit is always set the 1.

The test command is used to test the connection between MS and the TE. The length byte describes the number of value bytes, which are used as a verification pattern. The opposite entity shall respond with exactly the same value bytes.

3.5.4. MSC

MSC message frame is designed to convey virtual V.24 control signals. It has one mandatory control signal byte and an optional break signal byte.

MSC shall be sent prior to any user data after a creation of a DLC.

Message format is:

Type	Length	DLCI	V.24 control signals	Break signals (Optional)

Message type coding octet:

1	2	3	4	5	6	7	8
EA	C/R	0	0	0	1	1	1

Hex value is 0xE3 (Command), 0xE1 (Response)

The EA bit is always set the 1.

The C/R bit is used to indicate if it is a Modem Status Command or Modem Status Response.

In a Modem Status Command it is the status of the sender's own V.24 signals that shall be sent, but in a Response it is copy of the V.24 signals that are received from the Command frame that shall be returned.

The DLCI field identifies the specific DLC to which the command applies. EA bit is always set to 1.

V.24 control signals format is:

1	2	3	4	5	6	7	8
EA	FC	RTC	RTR	reserved(0)	reserved (0)	IC	DV

Break signals is set to 0x01.

3.5.5. FCoff

Message type coding octet is:

1	2	3	4	5	6	7	8
EA	C/R	0	0	0	1	1	0

Hex value is 0x63 (Command), 0x61 (Response)

The length byte contains the value 0 and there are no value octets.

3.5.6. FCon

Message type coding octet is:

1	2	3	4	5	6	7	8
EA	C/R	0	0	0	1	0	1

Hex value is 0xA3 (Command), 0xA1 (Response)

The length byte contains the value 0 and there are no value octets.

3.5.7. PN, NSC, RPN, RLS, SNC

Not Supported.

3.6. Data Channel

Quectel multiplexer data channels shall be used to transmit user data streams such as AT command data, GPRS data and GSM CSD data streams.

Data channels shall be established after and only after control channel (DLCI 0) connected.

3.7. About Flow Control

Quectel multiplexer supports software flow control mechanism. Software flow control is implemented by GSM 0710 MSC, FCoff and FCon message frame.

MS will send MSC message to TE with FC bit set to 1 in V.24 control signals when refuse to accept frames. Whereas, set to 0 to inform recovery of receiving frames.

TE will send MSC message to MS with FC bit set to 1 in V.24 control signals when refuses to accept frames. Whereas, set to 0 to inform recovery of receiving frames. When receiving MSC, MS will feed back MSC response to indicate recover data transmission.

TE also can send FCoff message to MS when refuses accept anything except control messages on DLC 0. After this, MS will stop sending any frames through all the data channels except control channels. Control channel is still alive and free to send any control message. Whereas, sends FCon to recover transmission. When receiving FCoff or FCon message, MS will feed back FCoff or FCon response.

The difference between MSC and FCon, FCoff is that the former only flow controls one of the data channels, and the latter controls all the data channels except controls channel.

3.8. Samples for Frame Structure

Sample 1:

F9	03	3F	01	1C	F9
Opening Flag	Address	Control Field	Length Field	FCS	Closing Flag

	Field				
Header	DLCI 0	SABM Frame	0, no information filed		Tail

This sample is a SABM frame to open DLCI 0.

Sample 2:

F9	05	EF	09	41 54 49 0D	58	F9
Opening Flag	Address Field	Control Field	Length Field	Information Field	FCS	Closing Flag
Header	DLC 1	UIH Frame	4	AT Command "ATI<CR>"		Tail

This sample is a UIH frame to transmit AT command "ATI<CR>".

Sample 3:

F9	01	EF	0B	E3 07 07 0D 01	79	F9
Opening Flag	Address Field	Control Field	Length Field	Information Field	FCS	Closing Flag
Header	DLC 0	UIH Frame	5	MSC Message, length 3		Tail

This sample is a MSC message carried in UIH frame to transmit V2.4 signal 0x0D.

3.9. Transmission bit sequence

Transmission is based on 1 start bit, 8 data bits, 1 stop bit, and no parity.

4. Examples

4.1. Establish Channels

Step 1: Launch Multiplexer

No	Step	Data Direction	Hex	Comment
		TE<——>MS		
1	TE launches MS multiplexer function by AT command	——>	61 74 2B 63 6D 75 78 3D 30 0D 0D 0A 4F 4B 0D 0A 0D 0A	AT+CMUX=0<CR><LF>
	MS feed back response	<——	61 74 2B 63 6D 75 78 3D 30 0D 0D 0A 4F 4B 0D 0A 0D 0A	AT+CMUX=0<CR><LF>OK<CR><LF><CR><LF>
	MS enters multiplexer mode and feeds back sync bytes	<——	F9 F9 F9 F9	Note

Note

The continuous bytes F9 F9 F9 F9 has the following effects:

1) Indicate MS multiplexer initialization is OK and waiting for further operations (Establish DLC).

2) The byte continuously transmitted by MS after receiving PSC message.

2) TE or MS uses to wake up the other one.

3) The synchronization bytes between TE and MS when synchronization lost.

Here, they take the 1) effect.

Step 2: Establish DLC 0

No	Step	Data Direction	Hex	Comment
		TE<——>MS		
1	TE requests to Establishes control channel DLCI 0, using SABM frame	——>	F9 **03 3F** 01 1C F9	SABM Frame
	MS feeds back UA for receiving SABM and accepts to create DLCI 0	<——	F9 **03 73** 01 D7 F9	UA Frame

Step3: Establish DLC 1, 2

No	Step	Data Direction	Hex	Comment
		TE<——>MS		
1	TE requests to establish DLCI9 using SABM frame	——>	F9 **27 3F** 01 0B F9	Note
	MS feeds back DM for receiving SABM but refuses to create DLCI 9	<——	F9 **27 1F** 01 21 F9	
2	TE requests to establish DLCI1 using SABM frame	——>	F9 **07 3F** 01 DE F9	
	MS feeds back UA for receiving SABM and accepts to create DLCI 1	<——	F9 **07** 73 01 15 F9	
	MS sends MSC message frame	<——	F9 **01** EF 0B E3 07 **07** 0D 01 79 F9	
	MS sends OK	<——	F9 **05** EF 0D 0D 0A **4F 4B** 0D 0A 5F F9	
	TE sends MSC message frames	——>	F9 **01** EF 0B **E3** 07 **07** 0D 01 79 F9	
	MS feeds back MSC response	<——	F9 **01** EF 0B **E1** 07 **07** 0D 01 79 F9	
3	TE requests to establish DLCI2 using SABM frame	——>	F9 **0B** 3F 01 59 F9	
	MS feeds back UA for receiving SABM and accepts to create DLCI 2	<——	F9 **0B** 73 01 92 F9	
	MS sends MSC message frame	<——	F9 **01** EF 0B E3 07 **0B** 0D 01 79 F9	
	TE sends MSC message frames	——>	F9 **01** EF 0B **E3** 07 **0B** 0D 01 79 F9	
	MS feeds back MSC response	<——	F9 **01** EF 0B **E1** 07 **0B** 0D 01 79 F9	
4	Establishment of DLC 3, 4 are the same as			

	above			
5	By now, 4 channels have come into existence. Multiplexer can work normally			

Note

This SABM is transmitted in order to determine whether MS is using Standard or Embedded Multiplexer.

1) MS is using Standard Multiplexer if responds with DM frame.

2) MS is using Embedded Multiplexer if responds with UA frame.

Here is Standard Multiplexer.

4.2. Frame Transmission

After establishment of control channel and data channels, TE and MS can transmit data through UIH frames between each other.

No	Step	Data Direction	Hex	Comment
		TE<——>MS		
1	TE sends AT command "ATI<CR>" through DLC 1	——>	F9 **05 EF** 09 **41 54 49 0D** 58 F9	UIH Frame
	MS feeds back through DLC 1	<——	F9 **05 EF** 09 **41 54 49 0D** 58 F9 F9 **05 EF** 9B 0D 0A 53 49 4D 43 4F 4D 5F 4C 74 64 0D 0A 53 49 4D 43 4F 4D 5F 53 49 4D 33 30 30 0D 0A 52 65 76 69 73 69 6F 6E 3A 53 49 4D 33 30 30 4D 33 32 28 53 50 41 4E 53 49 4F 4E 29 5F 56 31 30 2E 30 2E 38 5F 42 55 49 4C 44 30 33 0D 0A 0D 0A 47 F9 F9 **05 EF** 09 **4F 4B 0D 0A** 58 F9	UIH Frame
2	TE sends AT command "AT<CR>" through DLC 2”	——>	F9 **09 EF** 07 **41 54** 0D 35 F9	UIH Frame
	MS feeds back through DLC 2	<——	F9 **09 EF** 07 41 54 0D 35 F9 F9 **09 EF** 0D 0D 0A 4F 4B 0D 0A D8 F9	UIH Frame
3	DLC 3, 4 are same as above			

4.3. Power Saving Mode and Wake Up

Power saving

No	Step	Data Direction	Hex	Comment
		TE<——>MS		
1	TE sends PSC message through DLC 0	——>	F9 **03** EF 05 **43** 01 F2 F9	PSC Command Frame
	MS feeds back PSC message through DLC 0	<——	F9 **03** EF 05 **41** 01 F2 F9	PSC Response Frame
2	MS enters power saving mode, sending F9 continuously	——>	F9 F9 F9 F9……	

Wake up

No	Step	Data Direction	Hex	Comment
		TE<——>MS		
1	TE send wake up flags	——>	F9 F9 F9 F9	Note
	MS feeds back	<——	F9 F9 F9 F9	
2	MS is woken up, and data transmission is recovered			

Note

Both F9 F9 F9 F9 and normal data frames can be used to wake up MS. Here is using the former.

4.4. Flow Control

No	Step	Data Direction	Hex	Comment
		TE<——>MS		
1	MS sends MSC message with FC bit set to 1 through control channel DLC 0 to indicate refusing to accept anything on DLC 1	<——	F9 **01** EF 0B **E3** 07 07 **8F** 01 79 F9	
2	MS sends MSC message with FC bit set to 0 through control channel DLC 0 to indicate recovery of DLC 1 data transmission	<——	F9 **01** EF 0B **E3** 07 07 **8D** 01 79 F9	
3	TE sends MSC message with FC bit set to 1 through control channel DLC 0 to indicate refusing to accept anything on DLC 1	——>	F9 **01** EF 0B **E3** 07 07 **8F** 01 79 F9	
4	TE sends MSC message with FC bit set to 0 through control channel DLC 0 to indicate recovery of DLC 1 data transmission	——>	F9 **01** EF 0B **E3** 07 07 **8D** 01 79 F9	
5	TE sends FCoff message through DLC 0 to indicate refusing to accept anything on all DLC except DLC 0	——>	F9 **01** EF 05 **63** 01 93 F9	
6	TE sends FCon message through DLC 0 to indicate recovery of data transmission	——>	F9 **01** EF 05 **A3** 01 93 F9	

4.5. Synchronization

After successful establishment of data channels, TE and MS are synchronized and data transmission is normal. Every transmission is implemented by frames which begins with a starting flag (0xF9) and ends with a closing flag (0xF9). So it is called that multiplexer is synchronized with flag 0xF9. Transmitting bytes other than 0xF9 between frames is considered as faulty or synchronization lost and needs re-sync.

No	Step	Data Direction	Hex	Comment
		TE<——>MS		
1	TE sends hex value 0xF1	——>	F1	Note 1
2	MS feeds back four hex value F9 to indicate illegal bytes received and needs re-sync	——>	F9 F9 F9 F9	Note 2
	TE sends sync flag to re-sync with MS	——>	F9 F9 F9 F9	
3	TE tests AT command transmission through DLC 1 after re-sync	——>	F9 05 EF 07 **41 54 0D** 06 F9	
	MS feeds back response and synchronization has been reset to normal	<——	F9 05 EF 07 **41 54 0D 67 F9 F9 25 EF 0D 0D 0A 4F 4B 0D 0A** 8A F9	

Note 1

Sending illegal hex byte (other than 0xF9) will lead to synchronization lost situation and can be used to simulate re-sync procedure.

Note 2

When receiving illegal hex byte between frames, MS will send four sync flag F9 F9 F9 F9 to indicate synchronization is lost and waits for four sync flag F9 F9 F9 F9 from TE to re-sync with it. Otherwise, any subsequent bytes received will be treated as abnormal and another four sync flag F9 F9 F9 F9 will again be feed back until F9 F9 F9 F9 received.

4.6. Closing Down Multiplexers

No	Step	Data Direction	Hex	Comment
		TE<——>MS		
1	TE sends DISC frame to request closing down DLC 1	——>	F9 **07 53** 01 3f F9	
	MS feeds back UA frame to accept	<——	F9 **07 73** 01 15 F9	
2	TE sends DISC frame to request closing down DLC 2	——>	F9 **0b 53** 01 B8 F9	
	MS feeds back UA frame to accept	<——	F9 **0b 73** 01 92 F9	
3	TE sends DISC frame to request closing down DLC 3	——>	F9 **0f 53** 01 3f F9	
	MS feeds back UA frame to accept	<——	F9 **0f 73** 01 15 F9	
4	TE sends DISC frame to request closing down DLC 4	——>	F9 **13 53** 01 3f F9	
	MS feeds back UA frame to accept	<——	F9 **13 73** 01 15 F9	
5	TE sends CLD message frame to request closing down multiplexer through DLC 0	——>	F9 **03** EF 05 **C3** 01 F2 F9	
	MS feeds back CLD response to accept	<——	F9 03 EF 05 **C1** 01 F2 F9	
6	By now, closing down procedure is over			

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