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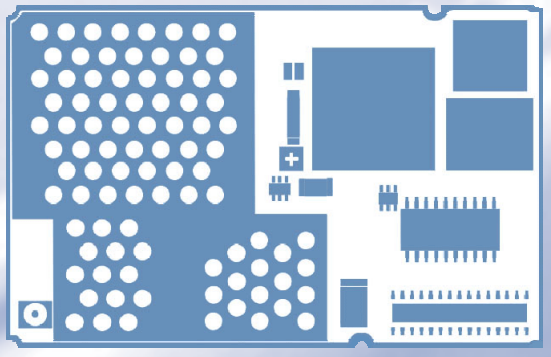

Multiplexer User's Guide

Siemens Cellular Engines

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User's Guide

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Contents

Figures

Tables

0 Document history

This chapter reports modifications and improvements over previous versions of this document.

Preceding document: “Multiplexer User's Guide” Version 06
New document: “Multiplexer User's Guide” Version **07**

Chapter	What is new
1.1	Added further supported products.
3.1.1	RTS/CTS not relevant on USB. Remark on periodic output of parameters.
3.1.4	Modified remark on AT&W.
3.1.6, 3.1.6.1	New sections “Relationship between multiplex channels and non-multiplexed physical interfaces and “First serial interface ASC0”
3.1.6.3	New section: “Operation of the USB interface (if applicable)”
3.3	More detailed info on supported CFUN levels.
3.2.1	RTS/CTS not relevant on USB.
5.1	Added note on Multiplexer protocol version for MC75, TC63, TC65.

Preceding document: “Multiplexer User's Guide” Version 05
New document: “Multiplexer User's Guide” Version 06

Chapter	What is new
1.1	Added further supported products.
3.1.1	Added note about closing Multiplexer.
3.1.2	Added note about maximum frame size N1.
4.2.4	Second byte for frame size greater than 127 bytes is not supported.
4.3.5	Corrected description of Close-down procedure.
5	Corrected description of multiplexer version control.
5.3.3	Corrected example.

Preceding document: “Multiplexer User's Guide” Version 04
New document: “Multiplexer User's Guide” Version 05

Chapter	What is new
1.1	Added further supported products.
3.1.4	Modified remark on AT&W.
3.1.6.2	Added chapter “Operation of a second physical serial interface ASC1 (if applicable)”

Preceding document: “Multiplexer User's Guide” Version 03
New document: “Multiplexer User's Guide” Version 04

Chapter	What is new
1.1	Added further supported products.
3 - 3.4	Restructured and revised all chapters.
3.1.2, 3.3, 4.3.10	To control SLEEP mode use PSC messages rather than entering AT+CFUN=<n>

1 Introduction

Siemens GSM engines support the basic option of the multiplexer according to the ETSI TS 101 369, GSM 07.10 Multiplexer Protocol. This allows a mobile to run a triple session over a serial link interface. Outside the GSM engine, on the application side of the serial interface, another multiplexer must be integrated in order to demultiplex the signal and distribute it on the three virtual channels. The external multiplexer needs to be provided by the customer.

This document describes how to use the multiplexer and then explains how to design an external multiplexer and integrate it into an application on top of a Siemens GSM engine.

Multiplexer protocol sources (WinMux2k), provided by Siemens AG, can be obtained on request from your local distributor. For more detailed information please refer to [5].

1.1 Supported products and related documents

Supported products

- AC43
- AC45
- MC35i
- MC35i Terminal
- MC39i
- MC45
- MC46
- MC388
- MC5x
- TC35i
- TC35i Terminal
- TC45
- XT55
- XT56
- MC75
- TC63
- TC65

Related documents

[1] Hardware Interface Description supplied with your GSM engine
[2] AT Command-Set supplied with your GSM engine
[3] Release Notes supplied with your GSM engine
[4] Remote-SAT User's Guide
[5] Multiplexer Driver Developer's Guide for Windows 2000 and Windows XP
[6] Multiplexer Driver Installation Guide for Windows 2000 and Windows XP

For further documents regarding your GSM engine please refer to the latest Release Notes supplied with the module.

To visit the Siemens Website you can use the following link:
http://www.siemens.com/wm

1.2 References

[1] Digital Cellular Telecommunications Systems (Phase 2+); Terminal Equipment to Mobile Station (TE-MS) "Multiplexer Protocol"; ETSI TS 101 369 V7.1.0 (1999-11), GSM 07.10 Version 7.1.0, Release 199

1.3 Term and abbreviations

Abbreviation	Description
CSD	Circuit Switched Data
CTS	Clear to Send
DCD	Data Carrier Detect
DLCI	Data Link Control Identifier
DSB	Developer Support Box
DSR	Data Set Ready
DTR	Data Terminal Ready
FC	Flow Control
FFC	Flat Flex Cable
GPRS	General Packet Radio Service
GSM	Global System of Mobile Communication
IEI	Information Element Identifier
IP	Internet Protocol
MO	Mobile originated
MP	Multiplexer Protocol
MS	Mobile Station
MSDN	Microsoft Developer Network
MT	Mobile terminated
MUX	Multiplexer
OS	Operating System
PC	Personal Computer
PSC	Power saving control
RTS	Request to Send
TE	Terminal Equipment
UART	Universal Asynchronous Receiver Transmitter

2 Multiplexer protocol – an overview

2.1 Product concept and architecture

The multiplexer mode enables one serial interface to transmit data to three different customer applications. This is achieved by providing three virtual channels using a multiplexer (Mux).

This is especially advantageous when a fax/data/GPRS call is ongoing. Using the multiplexer features, e.g. controlling the module or using the SMS service can be done via the additional channels without disturbing the data flow; access to the second UART is not necessary. Furthermore, several accesses to the module can be created with the multiplexer. This is of great advantage when several independent electronic devices or interfaces are used.

To access the three virtual interfaces, both the GSM engine and the customer application must contain Mux components which communicate over the multiplexer protocol.

In multiplexer mode, AT commands and data are encapsulated into packets. Each packet has a channel identification and may vary in length.

Note:
All statements regarding GPRS are valid only for Siemens wireless products capable of GPRS.

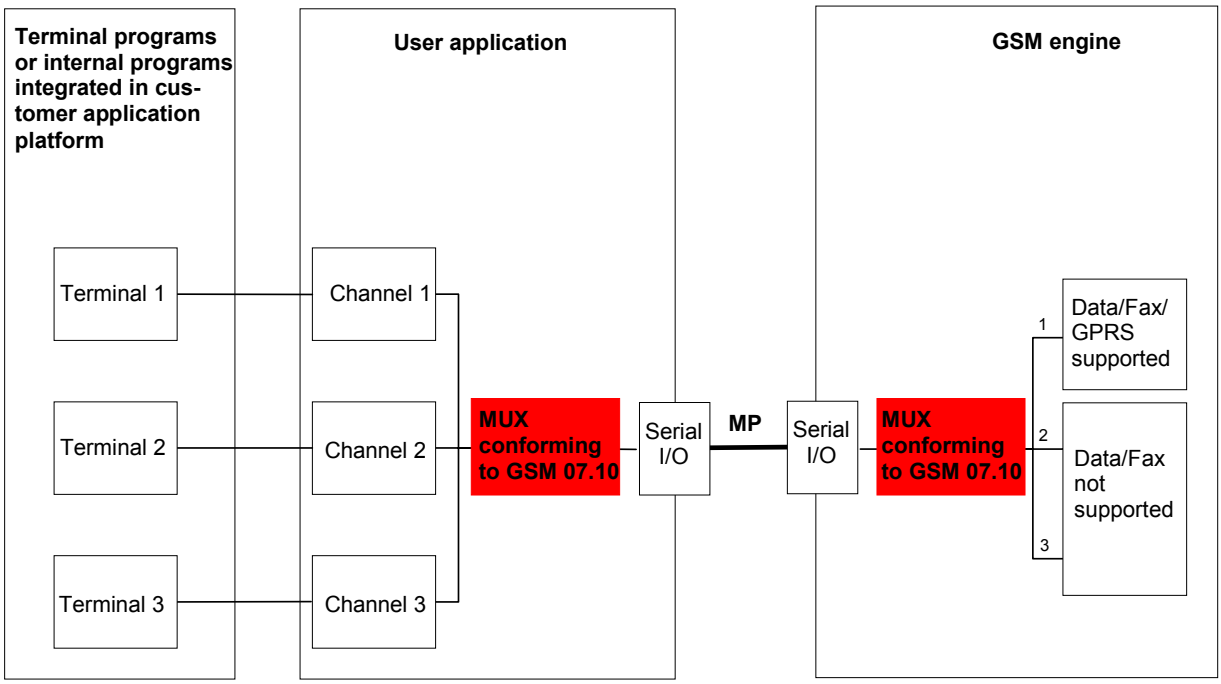

Figure 1: Multiplexer architecture

2.2 Virtual channels and AT commands

Please note that a cellular engine designed for multiplex operation does not include three different devices. Only one single air interface (RF part) is available.

As mentioned before the multiplexer enables one serial interface to run three sessions simultaneously. All incoming or outgoing calls are connected to the device.
Channel 1 supports the full range of functions, which is available without multiplexer tool.
Channel 2 and 3 are connected to a different AT interpreter and support a subset of the functional range of channel 1, for more details refer to Table 1.

Table 1: Comparison of multiplex channels

	Voice calls incoming outgoing	Data / fax calls incoming outgoing	SMS incoming outgoing	GPRS connection	Phonebook management	AT commands
Channel 1	●	●	●	●[2)]	●	●
Channel 2, 3	●	-	●	●[2)]	●	●[1)]

● indicates that the functionality is available on the channel
--- indicates that the functionality is not available on the channel
1) except for AT commands related to data and fax calls
2) only two channels can be used parallel to transmit GPRS data

Examples
- While a data call is in progress on channel 1, you can send a short message on channel 2 and edit the phonebook on channel 3.
- When receiving a fax on channel 1, you are able to check the battery capacity using the appropriate AT command on channel 2 or 3.

Note
Due to the technical requirements of multiplexer mode, data and fax calls can only be set up on logical channel 1 while GPRS connections can be established on every channel. Several AT commands have a different behavior on channels 2 and 3. Additional information regarding restrictions and interferences between the channels can be found in chapter 3.1 and in [2].

3 Integrating multiplexer into the customer application

When designing a multiplexer application, you can create your own sources or take advantage of the sources delivered upon request by Siemens. The Siemens sources are packed in a *.zip file which includes a driver for Windows 2000 and Windows XP. See [5] for a detailed description.

3.1 Characteristics

After establishing the multiplexer mode according to the multiplexer protocol, three logical channels are available. Please keep the following restrictions and requirements in mind:

3.1.1 Basic requirements

- The GSM engine supports the basic option and UIH Framing according to GSM 07.10.
- Character framing must be configured for 8 data bits, no parity and 1 stop bit.
  If you wish to use multiplexer mode with TC35i, TC63 or TC65, be sure not to change this setting.
- RTS/CTS hardware flow control (AT\Q3) is recommended for use with multiplexer mode. If used, it needs to be set before multiplexer mode is entered.
  On the USB interface, RTS/CTS hardware flow control is not relevant.
- Several customer software applications may be able to change the selected settings. These settings will be stored in the non-volatile memory and used whenever the module is powered up again. In this case the multiplexer fails to start. To avoid this, it is recommended to re-synchronize all settings before using the multiplexer mode again.
- Before closing the multiplexer make sure that there is no ongoing activity on one of the channels. For example, check that voice, CSD or GPRS connections have ended and wait until all pending AT command responses are received. The periodic output of parameters (such as cell information delivered by AT^MONI) must be terminated before closing the multiplexer.

3.1.2 Restrictions

If the GSM engine is operated in multiplexer mode, the following restrictions apply:
- MO and MT circuit-switched data and fax calls can only be set up on channel 1.
- It is not recommended to use AT+CFUN=<n> for selecting one of the SLEEP modes. For products supporting Multiplexer Protocol version 3, the best approach to properly control SLEEP mode in this case is to issue the PSC messages described in Chapter 4.3.10.
- During heavy GPRS traffic, the performance of the other multiplexer interfaces might be impaired. Some AT commands may behave differently than normal.

The multiplexer cannot be started if one of the following features is activated, nor can these features be used when multiplexer is active:
- Multiplex mode cannot be started while autobauding (AT+IPR=0) is enabled.
- The multiplexer is not available in charge-only mode and in alarm mode.
- XON/OFF flow control is not supported in multiplexer mode.

The maximum frame size N1 (defined in GSM 07.10) is fixed to 98 bytes and cannot be changed. The maximum frame size is the same for sending and receiving. See also Chapter 4 in this manual and GSM 07.10.

3.1.3 Dependencies between multiplex channels and restrictions of use

When using the following functions, be aware of possible dependencies between the different channels. One way of avoiding problems may be to dedicate certain commands/features to one of the channels or to assure that the application avoids conflicts.

- Call control: A voice call can be initiated, answered or ended on each channel. See AT commands like ATD, ATA or ATH.
  Please note that ATH terminates each voice, circuit switched data or fax call regardless on which logical channel ATH was executed, for details see [2].
- Phonebook access: If you wish to write the same phonebook entry on two different channels at the same time, please note that the last entry will be stored permanently. All other data will be deleted.
- SMS read, write and delete.
- Time settings: Though the AT commands AT+CALA and AT+CCLK can be used on either channel, the same time setting applies to all three channels. It is only the alarm message <text> which may be specific to each channel. The URC “+CALA” will be issued only on the channel where the last alarm setting was made. For details see [2].
- Device locks set with AT+CLCK.
- SIM card access.
- RF settings.

Example:

- An ongoing fax call has been established on channel 1. When answering an incoming voice call on channel 2 or 3 and terminating it, the held fax call will be ended as well.

3.1.4 Functions without channel dependencies

The following functions or events may be ongoing independently on different channels:

- Unsolicited Result Codes (URCs) will generally be transmitted to all logical channels. For example, an incoming voice call is indicated by the URC “RING” on all three channels. Incoming data calls are indicated on channel 1 only.
- Device information can be queried on a single channel.
- Signal quality and cell information can be retrieved on a single channel.
- Further commands that can be used separately on one channel without impact on the remaining channels: ATZ, AT&F, AT&V, AT+CEER, AT+CMEE.
- User profile: AT&W stores all global settings and the current settings of the interface on which the command was executed. See further details in sections 3.1.6.2 and 3.1.6.3.

Example:

- The battery capacity can be queried from channel 2 or 3 while a voice, fax or data call is made on channel 1.

3.1.5 Timing conditions

Switching on the multiplexer with AT+CMUX=0 causes a 5s timer to start. If the multiplexer control channel is not established within this time, the module returns to “normal AT command mode” without multiplexer. This prevents the module from being blocked if, for example, AT+CMUX=0 is sent from an application that does not support the multiplexer protocol.

Fax is based on a protocol, which needs to respect timings between the application and the module as well as between the module and the selected terminal equipment (TE). Hence, heavy parallel traffic load in the module can lead to mistiming. This may result in malfunction in both directions. Please consider the following recommendations:
Using the multiplexer it is not possible to define bandwidth and delay time per channel. Therefore, the customer application should take care that the channels 2 and 3 are not heavily loaded when faxing on channel 1.
Example 1: Checking the field strength every 2 seconds does not harm, sending an SMS every 10 seconds may lead to problems.
Example 2: Reading a complete phone book, may cause problems if a fax transmission is ongoing at the same time.

When switching on the module after a firmware update we recommend to wait 5 seconds before entering the first AT command.

3.1.6 Relationship between multiplex channels and non-multiplexed physical interfaces

Table 2 summarizes the allocation of non-volatile and user profile settings to the various multiplex channels and non-multiplexed physical interfaces. This allocation scheme shows where stored settings take effect when switching from multiplex to non-multiplex mode and vice versa. See sections below for further detail.

Table 2: Allocation of virtual channels to physical interfaces

Physical interface	ASC0	ASC1 (if available)	USB (if available)
Corresponding multiplex channel	Multiplex channel 1	Multiplex channel 2	Multiplex channel 3

3.1.6.1 First serial interface ASC0

ASC0 and the multiplex channel 1 are using the same parameters, and thus, the same user defined profile (if any). As a result, non-volatile settings and a user profile stored on multiplex channel 1 will take effect on ASC0 after closing the multiplexer and switching to the physical interface ASC0. Likewise, non-volatile settings and a user profile stored on ASC0 will be loaded on multiplex channel 1. See also note on AT&W in section 3.1.4.

3.1.6.2 Operation of a second physical serial interface ASC1 (if applicable)

This section applies only to Siemens GSM modules equipped with a second physical serial interface (referred to as ASC1).

ASC1 is disabled when the multiplexer is enabled on the first serial interface ASC0. Yet, both ASC1 and the multiplex channel 2 are using the same parameters, and thus, the same user defined profile (if any). As a result, non-volatile settings and a user profile stored on multiplex channel 2 will take effect on ASC1 after closing the multiplexer and starting up ASC1. Likewise, non-volatile settings and a user profile stored on ASC1 will be loaded on multiplex channel 2. See also note on AT&W in section 3.1.4.

This may be a problem when ASC1 is not connected, but flow control (for example AT\Q1 or AT\Q3) is stored to the user profile on the multiplex channel 2. In this case, flow control takes effect on ASC1, when the multiplexer is switched off. If then for example a large amount of URCs is generated, their transmission might be stopped due to the flow control. To avoid this problem we recommend that you do not activate flow control on multiplex channel 2 when setting up a user profile with AT&W.

3.1.6.3 Operation of the USB interface (if applicable)

This section applies only to Siemens GSM modules equipped with a USB interface, for details refer to [1].

ASC0 and ASC1 are disabled when the multiplexer is enabled on the USB interface.

The USB interface and the multiplex channel 3 are using the same parameters, and thus, the same user defined profile (if any). As a result, non-volatile settings and a user profile stored on multiplex channel 3 will take effect on the USB interface after closing the multiplexer and starting up USB. Likewise, non-volatile settings and a user profile stored on the USB interface will be loaded on multiplex channel 3. See also note on AT&W in section 3.1.4.

3.2 Multiplexer control and signaling lines

The following chapter covers all information you need to develop and set up a virtual driver. Differences and restrictions in comparison to the unframed module are pointed out.

3.2.1 Flow control

Logical flow control

The internal logical flow control (FC-BIT in MSC message, see Chapter 4.3.9) represents the existing flow control to the module. For example, if a data call is initiated and the customer application transmits data to the module on this channel, the module will stop the data transmission from time to time. This happens because the module operates with a bandwidth of 9k6 on air, but the customer application uses a larger width. In this case the module sends a MSC message with FC-BIT set. After all data stored in the internal buffer have been sent, the module will send a second MSC message with FC-BIT reset. As already pointed out, the logical flow control operates like RTS/CTS but with FC-BIT on every channel. The RTS/CTS are not used for flow control because the traffic on the logical channels may cause a temporary loss of bandwidth on another channel. This behavior has no impact on the handshake V.24 lines.

RTS/CTS on the physical channels

Hardware flow control (AT\Q3) is recommended for use with the multiplexer. For power saving it is indispensable. The setting AT\Q3 needs to be made before switching on the multiplexer. An exception is the USB interface where RTS/CTS flow control is of no use.

The customer application decodes and encodes the data. To prevent loss of data, the application must be able process the information about internal flow control (MSC) regulated by the module. Flow control information is transmitted within the data flow and contains messages whether or not the channel is allowed to send. See chapter 4.3.9 for MSC.

As of Multiplexer Protocol version 2, the customer application must set RTS (in the direction to the module) on channel 1. RTS shall not be switched off to prevent loss of data (control data cannot be sent in this case). If flow control is needed, it is recommended to use logical flow control on every channel.

RTS/CTS on the logical channels

The customer application needs to regulate the data flow according to the logical flow control. The implementation of the WinMux2k is a good example. It maps the 3 decoded channels to 3 serial interfaces as well as the logical flow control information (FC-BIT in MSC message) directly on the RTS/CTS-control lines.
In this case CTS superposes the STOP information (data sending disabled) sent by the module to control the data transmission from the customer application to the module. If RTS is reset, a STOP is transmitted to the module to control the data transmission from the module to the customer application. Figure 2 illustrates the data flow.

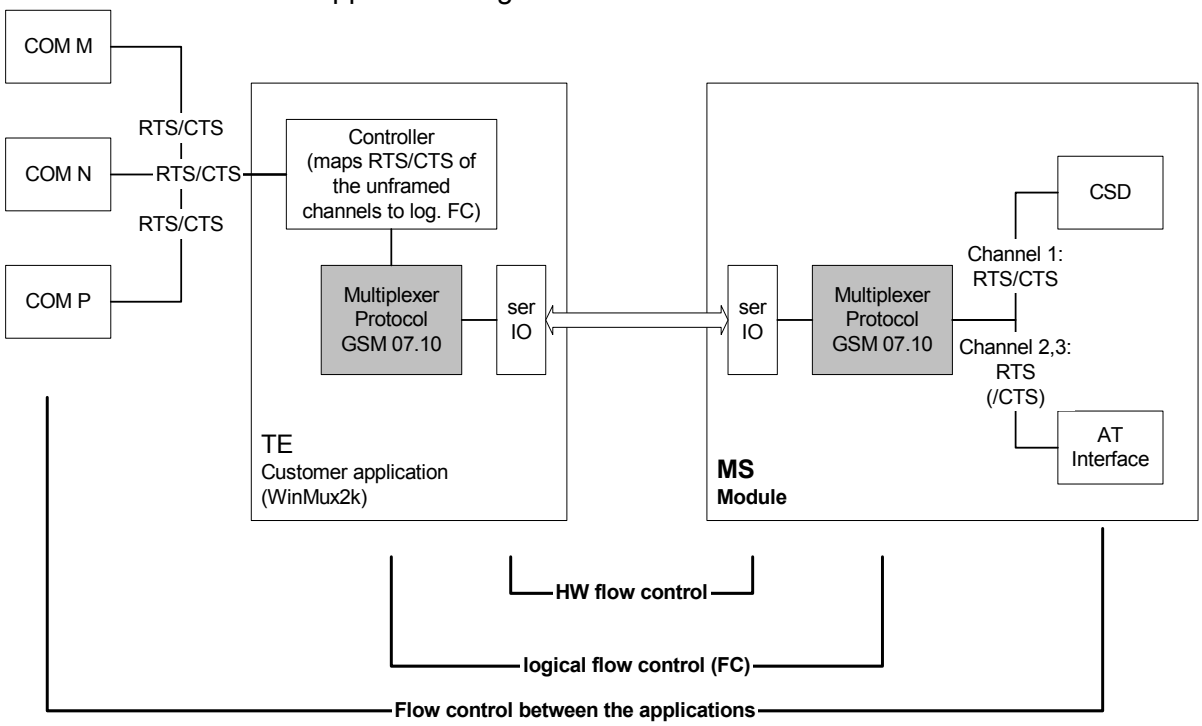

Figure 2: Logical flow control and RTS/CTS signaling behind the decoder

RING/DCD

Unlike all other lines DCD and RING are transmitted additionally on the UART directly by the module. These signals are logical ORs from the three logical channel status lines. However, the customer application must carefully decide how to handle these lines and ensure, that no conflicts occur between the different channels. E.g. in some situations it may be advisable to display RING on channel 1 only.
Please keep in mind that a call can be accepted on one channel only. Therefore some kind of mutual locking mechanism must be used.

3.2.2 Escape sequence

When the multiplexer protocol is active only coded data is transmitted over the UART. The coding includes a header and a checksum. Therefore, the direct parsing of this sequence is not possible. An escape might be undetected because the decoded time relations may be disturbed.

The following transmission path for the ESC signal has been implemented:

- DTR is transported within the logical channel. To terminate a call, the normal way of using DTR is available. Please keep in mind that the multiplexer cannot transport this signal in real time. Please use a certain gap time between signaling with DTR.
- It is possible to detect “+++” on the customer multiplex application and transport this information via the MSC signal to the module (see Chapter 4.3.9).
- As an alternative, ATH may be sent on one of the other channels, for more detailed information please refer to [2].

3.3 Power saving

SLEEP mode reduces the functionality of the module to a minimum and, thus, minimizes the current consumption to the lowest level. SLEEP mode can be set with the AT+CFUN command which provides the choice of the functionality levels <fun>=0, 1, 5, 6, 7, 8 or 9. For further details on power saving and the functionality levels supported by your Siemens product see [1] and [2].

If the module is in multiplexer mode, it is not recommended to activate SLEEP mode with AT+CFUN=<n>. For products supporting Multiplexer Protocol version 3, the best approach to properly control SLEEP mode in this case is to issue the PSC messages described in Chapter 4.3.10.

3.4 Bandwidth of logical channels

Please take into account that a data transmission, e.g. on channel 1, causes a transmission delay on the remaining channels (see chapter 3.1). The multiplexer mode according to the GSM 07.10 multiplexer protocol encapsulates data and AT commands into packets which may vary in length. Therefore a header including protocol information located at the beginning of the protocol data unit has to be transmitted. To summarize, if the module is set to 115200 bps and an incoming GPRS call requires 5 kByte per second, the two other channels have to operate within the range of the remaining 5 kByte per second.

If three large data transmissions are running simultaneously, the available bandwidth will be shared equally among all channels. In such a case if channel 2 and 3 were used for data transmissions, e.g. editing the phonebook, both channels would need to share a bandwidth of approximately 3 kByte per second.

4 Structure of the multiplexer protocol

4.1 Introduction of the multiplexer protocol

The supported multiplexer protocol conforms to the GSM 07.10 Multiplexer Protocol. The non-error recovery mode was implemented with the basic option.
The frames have a start and a stop byte. A checksum is calculated to protect the transferred data. Frame repetition is not enabled.

Data and fax calls are transferred in the logical channel DLCI = 1 (DLCI: Data Link Connection Identifier). The remaining DLCIs are in AT command mode; two GPRS connections can be established simultaneously on every channel.
The multiplexer protocol must be started and the logical channels opened in compliance with specified procedures.

This chapter also discusses the following issues:
- Opening logical channels without parameter negotiation
- Opening logical channels with parameter negotiation
- Closing of logical channels

4.2 Data link layer

The following sections show the detailed structure of a data link frame.

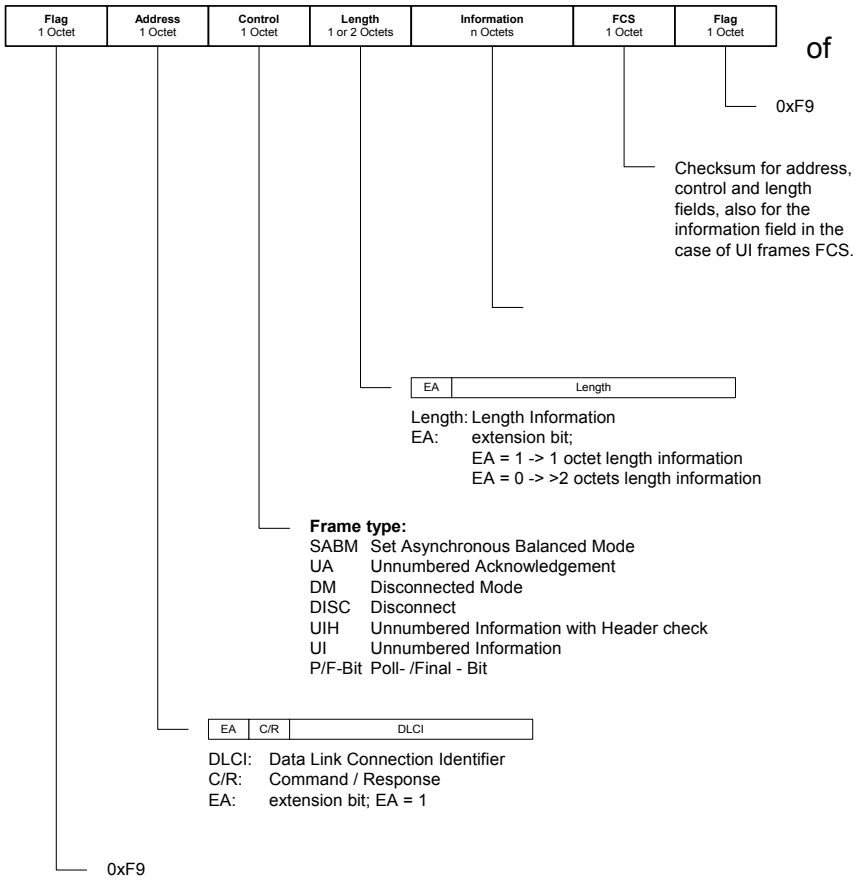

Figure 3: Data link layer

4.2.1 Flag sequence

A flag sequence is a specific bit pattern (usually 11111001; hexadecimal: 0xF9) used to mark the beginning and the end of a frame of data.
Each frame begins and ends with a flag sequence. Only one flag sequence occurs between any two frames. If two successive flag sequences do occur, the frame is regarded as being empty and is discarded.

The flag sequence is used for the synchronization of frames.

4.2.2 Address field

Data link connection identifier is a frame relay term defining a 10-bit field of the address field. The DLCI identifies the data link and its service parameters, including the frame size.
The values for the Data Link Connection Identifier (DLCI) are dynamically defined apart from DLCI = 0.

Table 3: Address field

EA	C/R	DLCI

DLCI: Data Link Connection Identifier
C/R: Command / Response
EA: extension bit; EA = 1

Table 4: Assignment of the DLCI

	DLCI number (decimal)	Priority
Multiplexer control channel (see chapter 4.3.6)	0	0 highest priority
AT commands, data, fax, GPRS	1	7
AT commands, GPRS	2,3	7

The command/response bit identifies the frame as a command or response. A command contains the address of the data link connection to which the command is sent. A response contains the address of the data link connection sending the frame.

Table 5: Use of the command/response bit

Command/Response	Direction	C/R
Command (SABM, DISC)	Customer µC → GSM engine	1
	GSM engine → Customer µC	0
Response (UA, DM)	Customer µC → GSM engine	0
	GSM engine → Customer µC	1

Every command expects a response. No provision is made to repeat the command if no response is received.

4.2.3 Control field

The control field contains control information to define the frame.

Table 6: Coding of the control field

Frame Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
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: Poll/Final bit
Commands: P = 1, Responses: F = 1
For each DLCI, only one frame with P = 1 may ever be expected.

4.2.4 Length indicator

The length indicator specifies the length of the following information field. As the maximum frame size N1 is 98 bytes and cannot be changed the E/A bit is always 1. The setting E/A = 0 defined in GSM 07.10 for a frame size greater than 127 bytes is not supported. See also Chapter 3.1.2 for details on the maximum frame size.

1st octet:

Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
E/A	L1	L2	L3	L4	L5	L6	L7

2nd octet (not supported by Siemens wireless modules):

Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
L8	L9	L10	L11	L12	L13	L14	L15

E/A = 1: only one octet for the Length Indicator
E/A = 0: two octets for the Length Indicator

4.2.5 Information field

The information field contains the data and has an octet structure. The field only exists for UIH frames (unnumbered information with header check).
To transfer information fields, the P/F bit is set to 0; a response is not necessarily expected.

4.2.6 Frame checking sequence field (FCS)

The Frame Checking Sequence (FCS) is computed with the address, control and length fields. It is a field added to the end of a frame that contains transmission error-checking information. This field contains a value which is calculated by the source computer. The receiving computer performs the same calculation. If the receiving computer's calculation does not match the result sent by the source computer, the packet is judged corrupt and discarded. An FCS calculation is made for each packet.

4.3 State diagrams

The multiplexer protocol is based on two state machines (see Figure 4). One state machine initiates the setup of the logical channels, the other one responds to the requests.

The GSM engine can only respond to requests. A higher level for controlling the state machines is not implemented.

The procedure for setting up the two state machines – the one for the customer µC and the one for the GSM engine – is shown in Figure 5 and Figure 6.

Executing the AT command AT+CMUX=0 starts the switchover from AT command mode to the multiplexer protocol and parameterizes the multiplexer control channel DLCI = 0. Both state machines are entering the DISCONNECTED state and immediately have the option of setting up the multiplexer control channel DLCI = 0 and other logical channels.

The logical channels are then set up (DLC establishment). If the DLC has been established successfully the state machine for that particular channel changes to CONNECTED. If the request is unsuccessful the logical channel cannot be established and the state machine remains in DISCONNECTED on this particular channel.

Information can be transferred over all channels in CONNECTED. Control commands can be transferred in the multiplexer control channel DLCI = 0; the other channels transfer data.

The parameters for all logical channels DLCI = 1...4 in DISCONNECTED can be set for the requested logical channels by parameter negotiation.

Disconnecting individual channels (DLC release) causes the state machine for those channels to revert to DISCONNECTED. Release of the multiplexer control channel DLCI = 0 corresponds to a CLOSE DOWN. The CLOSE DOWN command switches back.

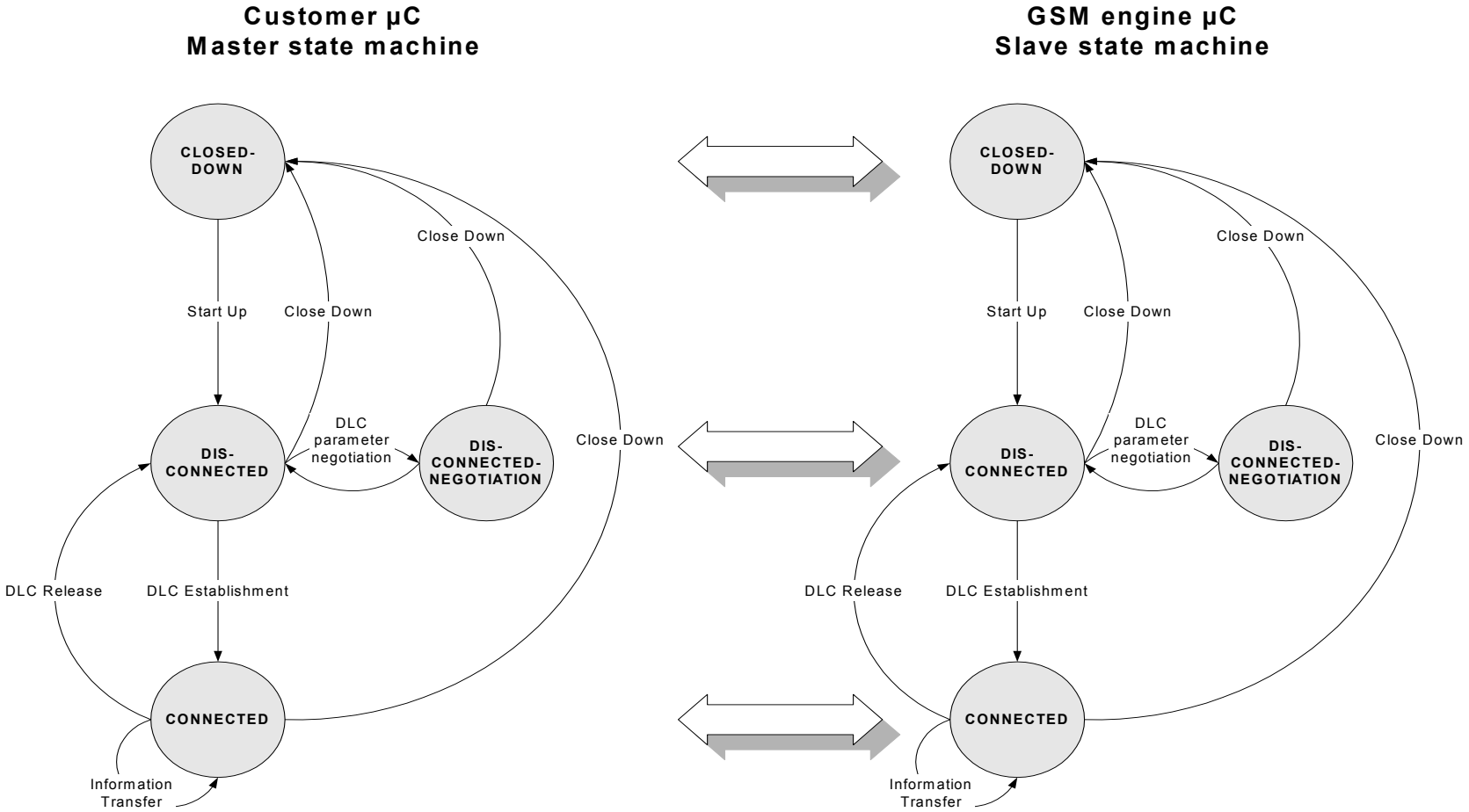

Figure 4: Relationship between the customer µC and the GSM engine µC

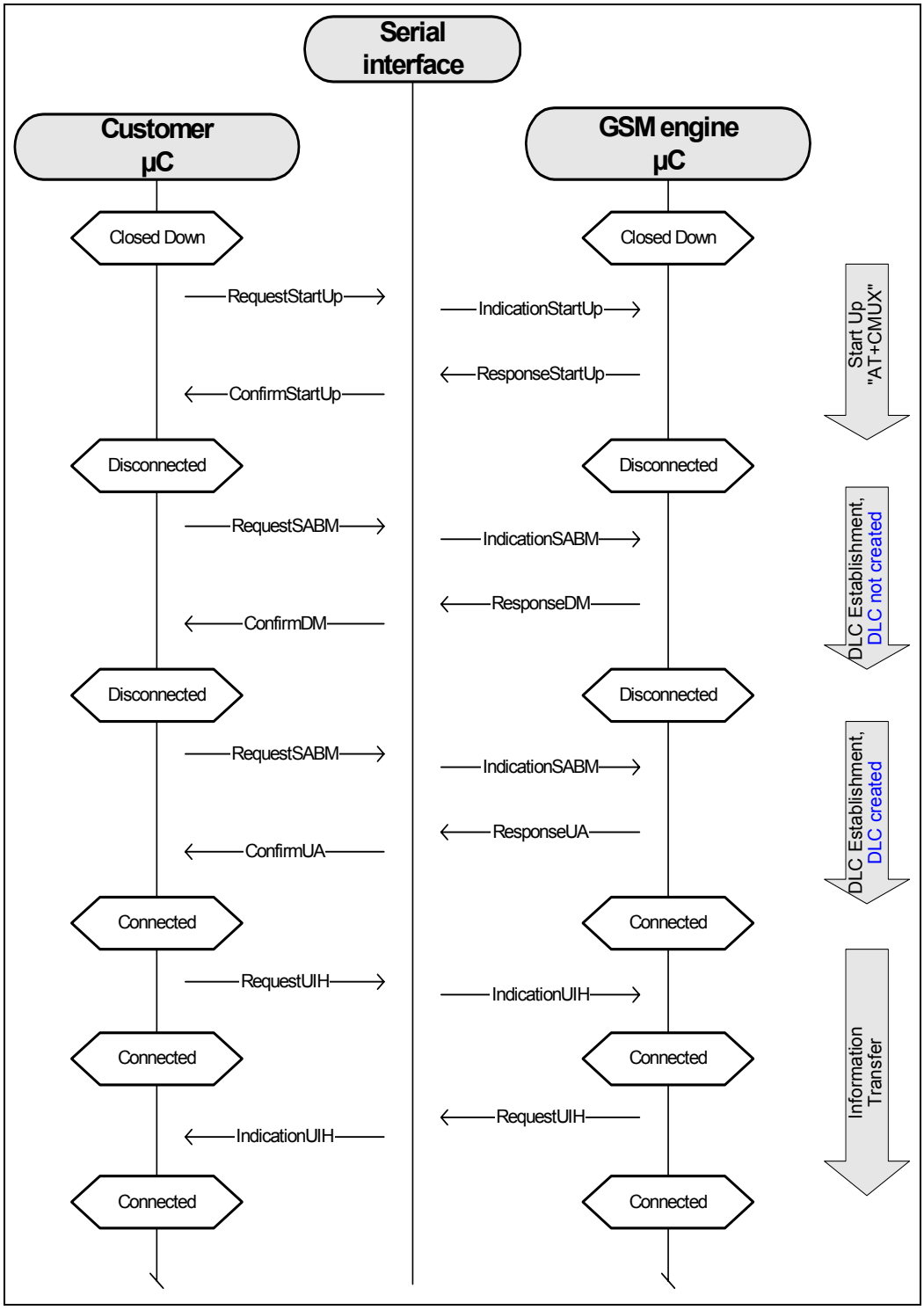

Figure 5: MPI – Startup, DLC establishment and information transfer

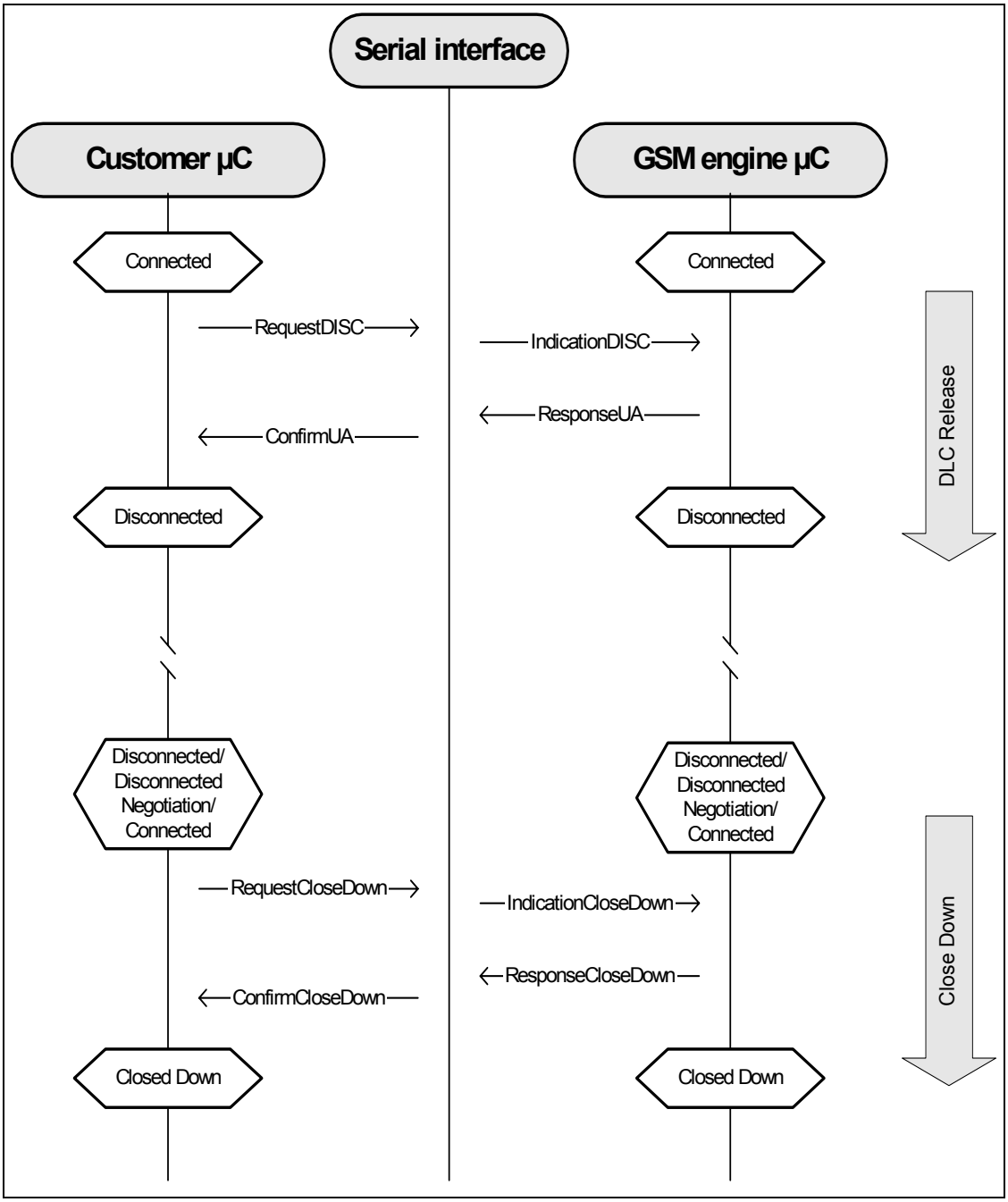

Figure 6: MP - DLC release and close down

4.3.1 Start-up procedure

The only approach to activate the multiplexer protocol is entering the appropriate AT command AT+CMUX=0. This enables the multiplexer control channel. The next step is to set up the multiplexer control channel as described in Chapter 4.3.2.

4.3.2 DLC establishment

The multiplexer control channel must be set up as the first channel followed by all other DLCIs. To do so, a SABM frame (see Chapter 4.2.3) must be sent to the GSM engine.

The module responds either with a UA frame if the DLCI was set up, or with a DM frame if the DLCI was not set up.

No provision is made for repeating the request if a response is not received.

The state machine requesting the multiplexer control channel DLCI = 0 is the "initiating station", while the other is called the "responding station".

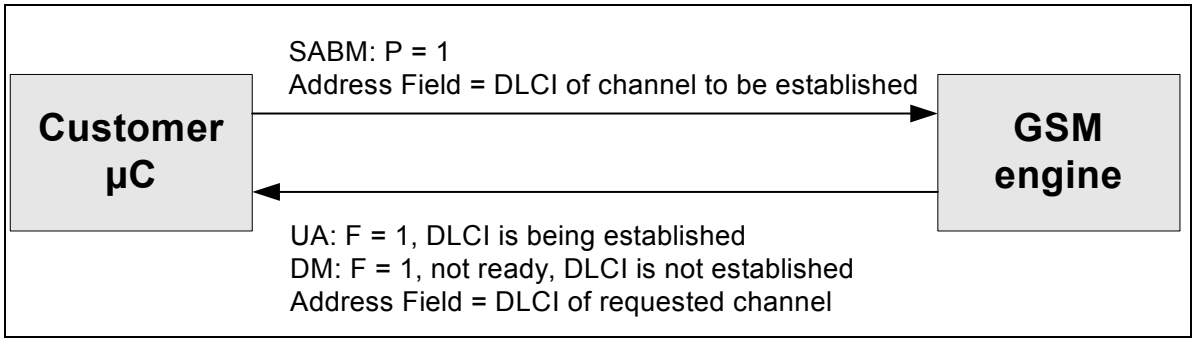

Figure 7: DLC establishment

4.3.3 Information transfer

A response is not essential for every command – for example, an unsolicited result code does not require a response.

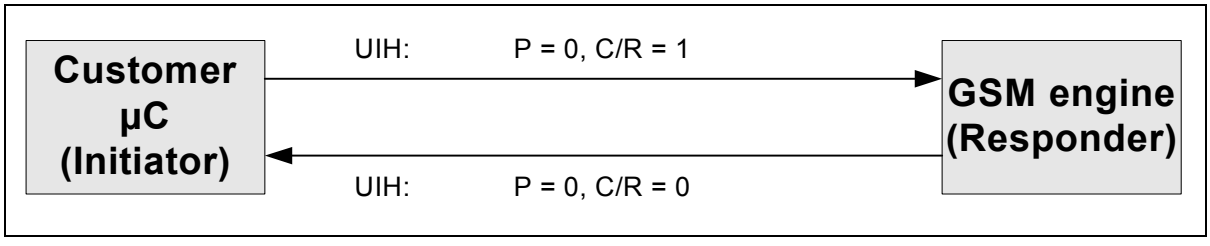

Figure 8: Information transfer

4.3.4 DLC release

No provision is made to repeat the request if no response is received.

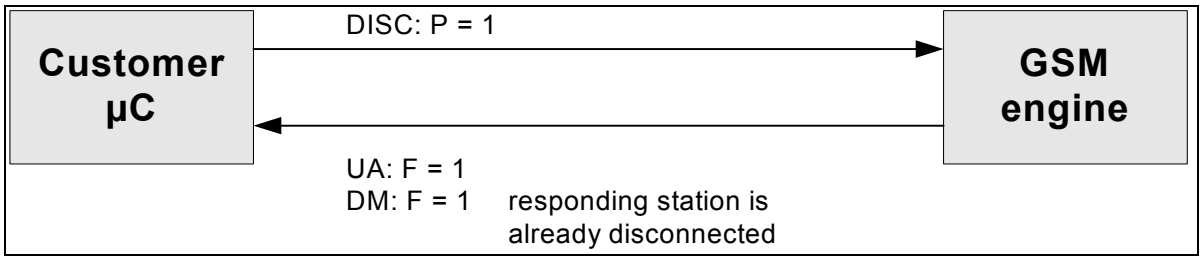

Figure 9: DLC release

4.3.5 Close-down procedure

To close down the multiplexer follow these two steps:

- First, disconnect all DLCIs by sending the DLCI Release command within the multiplexer control channel frame (as described in section 4.3.6).
- Finally, close down the multiplexer control channel (DLCI = 0) by sending the multiplexer close down command CLD (see section 4.3.7). After this, both the “initiating station” and the “responding station” revert to AT command mode.

Before closing the multiplexer make sure that there is no ongoing activity on one of the channels. For example, check that voice, CSD or GPRS connections have ended and wait until all pending AT command responses are received.

4.3.6 Multiplexer control channel

DLCI = 0

Figure 10: Multiplexer control channel

The commands are sent as information in the multiplexer control channel frame.

Type field:

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

EA bit: Extension bit.
In the last octet of the sequence the EA bit = 1, otherwise = 0.
If there is only on octet, EA bit = 1 is set.
C/R bit: Indicates whether the sequence is a command or a response.
T-bits: Coding of the command type.

Length field:

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

EA bit: Extension bit.
In the last octet of the sequence the EA bit = 1, otherwise = 0.
If there is only one octet, EA bit = 1 is set.

L-bits: Number of value octets; the following L1 is the LSB, L7 the MSB.

Multiple commands can be sent in a single frame only.

4.3.7 Multiplexer close down (CLD)

Type field:

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

Length byte = 0, no value octet

4.3.8 Test command (Test)

The test command is intended to test the connection between MS and TE.

Type field:

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

The length byte indicates the number of test bytes sent in the value bytes. The responding station should answer with exactly the same bit sequence. The test command is used for the version control. For more detailed information see Chapter 5.

4.3.9 Modem status command (MSC)

The Modem Status Command is used for software flow control.

Command	Length	DLCI	V.24 signals	Break Signals (optional)
1 octet	1 octet	1 octet	1 octet	1 octet

Command:

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

Figure 11: Modem status command (MSC)

C/R bit: Indicates whether the sequence is a command or a response.

Length: Length = 2 , EA-Bit = 1

DLCI:

Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
1	1	DLCI					

V.24 signals:

Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
1	FC	RTC	RTR	reserved 0	reserved 0	RING	DCD

FC bit: Flow control, included in all multiplexer versions
FC = 1: no frames are accepted

The following bits for V24 status lines as described in this chapter are included in multiplexer protocol version 3 only. However, if you wish to use the advantages of this version it is absolutely necessary to switch on the version 3, otherwise version 1 will be used, see Chapter 5.2.

Direction host application→ module (for request only) MUX V3:
RTC: mapped to DTR
RTR: mapped to RTS
Bit 5, 6, 7, 8 are not valid.

Direction module → host application (for request only) MUX V3:
RTC: mapped to DSR
RTR: mapped to CTS
RING: mapped to RING
DCD: mapped to DCD
Bit 5, 6 are not valid

Note:
The mappings are valid for version 3 and an MSC request only. Descriptions of all other versions are available in Chapter 5.
The response to any MSC must be always the same data already sent.
Please keep in mind that it is impossible to remap any response bits.
Remember that the bits described above are valid in Mux version 3 only, switched on by a version control handshake (see Chapter 5). More detailed information on older multiplexer versions are available in Chapter 5.2.

Break signal (optional):

Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
1	Not supported						

Usually the break signal octet carries information about a break condition detected from the host application in the data stream for the DLC.

Note:
This command supports no parameters. Instead we use this optional parameter to transport the escape sequence detection from the host to the module. If the customer application detects an escape sequence (usually +++), it sends this optional octet with bit 1 set to 1. The module calls its original escape sequence.

4.3.10 Power saving control (PSC)

The power saving control message uses the following type field octet:

Type:

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

Figure 12: Power Saving Control (PSC)

C/R bit: Indicates whether the sequence is a command or a response.

Length: The length byte contains the value 0 (no value octet) or 1 (one value octet).

Value octet (Length=1)

Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
P1	P2	P3	P4	0	0	0	0

The P-bits are defining the parameter value.

In commands:

Bit 1	Bit 2	Bit 3	Bit 4	Description
0	0	0	0	Switches to the same mode as without a value octet
1	0	0	0	Switches into full functionality mode, like AT+CFUN=1
0	1	0	0	Switches into NON-CYCLIC SLEEP mode, like AT+CFUN=0
1	1	0	0	Switches into CYCLIC SLEEP mode, like AT+CFUN=5
0	0	1	0	Switches into CYCLIC SLEEP mode, like AT+CFUN=6
1	0	1	0	Switches off, like AT^SMSO
0	1	1	0	Resets, like AT+CFUN=1,1
1	1	1	0	Switches into CYCLIC SLEEP mode, like AT+CFUN=7
0	0	0	1	Switches into CYCLIC SLEEP mode, like AT+CFUN=8

All wake up events and details of the CYCLIC and NON-CYCLIC SLEEP mode are specified in [2].

In responses:

Bit 1	Bit 2	Bit 3	Bit 4	Description
0	0	0	0	Failure
1	0	0	0	Success

No Value octet (Length=0)

Switches into SLEEP mode, like AT+CFUN=0

Note:
According to the GSM 07.10 standard PSC supports no value octets. The optional value octet was added to increase flexibility.

Developed as a substitute to the AT+CFUN command, PSC messages are recommended to control the various SLEEP modes and to reset the mobile. Be sure not to enter any PSC messages until after all responses to AT commands have been received and, in the case of a received URC, the logical ring line has been activated for 1 second and deactivated again. Please note that the behavior of the logical ring line is identical with the behavior of the physical RING0 line described in [1].

4.3.11 Non-supported command response (NSC)

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

Type field:

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

C/R bit: Indicates whether the sequence is a command or a response.

Value octet:

Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
EA	C/R	Command type of the non-supported command					

C/R bit: Returns the same value as in the received, non-supported command

Frames not recognized by the receiving entity are responded by a NSC-frame.

4.4 Example: Establishing logical channels without parameter negotiation

- Send AT+CMUX=0; wait for the response
- Send Request SABM for DLCI = 0; wait for the response
- Send Request SABM for all requested DLCIs; wait for the response

As a result the multiplexer is established and information / data can be transmitted (⇒ ready for Information Transfer).

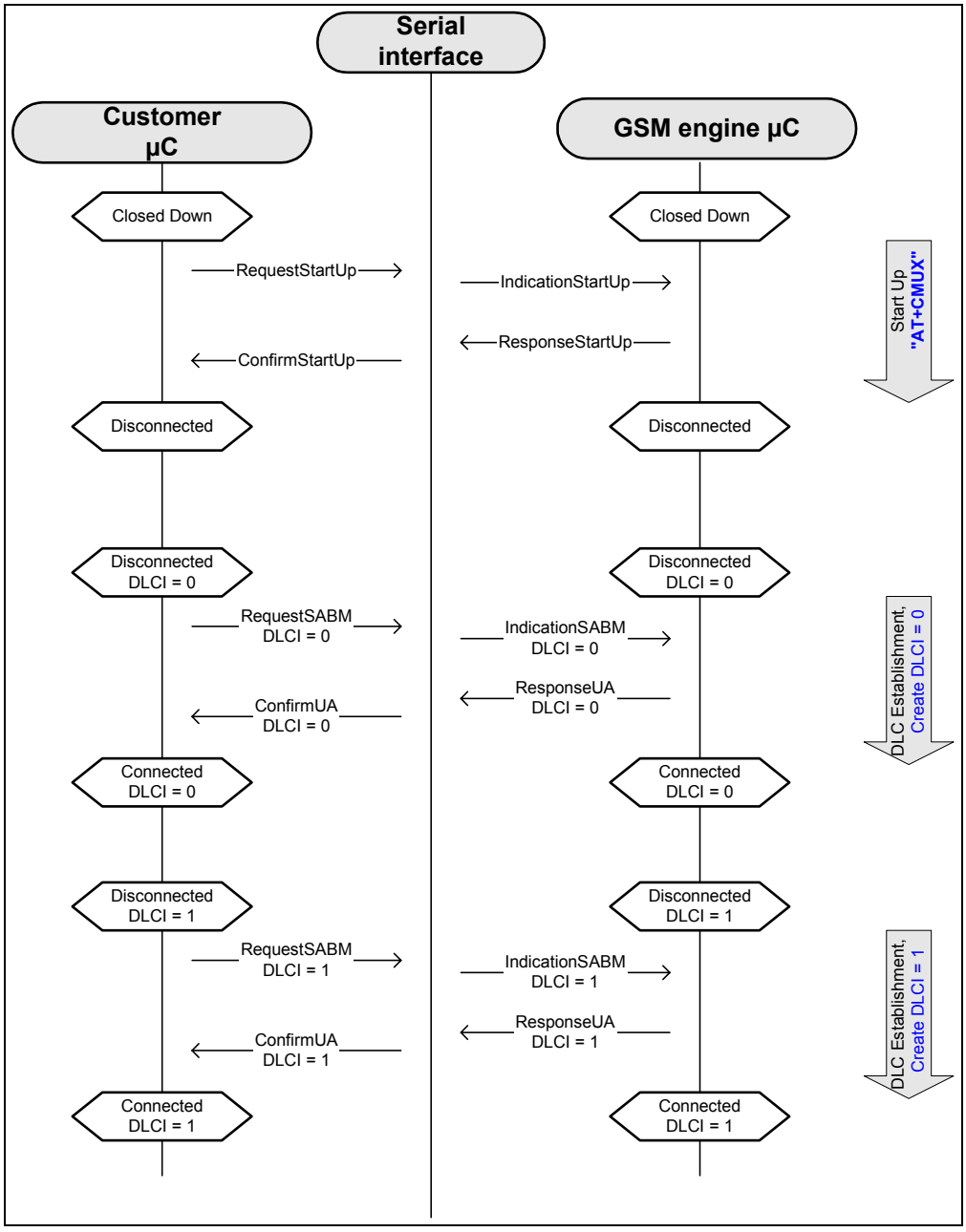

Figure 13: Establishing the multiplexer control channel and the logical channel

5 Multiplexer protocol version control

5.1 Introduction

The multiplexer protocol offers a version control to ensure that TE and MS support the same extent of functionality and to maintain upward and downward compatibility when later firmware versions of the GSM engines are released. The implementation of version control is a subset of the GSM 07.10 standards.

When the multiplexer is started, the MS and the application negotiate which MP version to use. If TE and MS do not support the same multiplexer protocol, the lower version will be agreed upon. If no version check is done the TE reverts, due to lack of version information, to multiplexer version 1. This means that both sides only agree on version 1, even though they may have the same and even higher version.

The TE and MS multiplexer version numbers can be traced on the serial interface.
They appear as follows:

- TE version (e.g. version 1): `TEMUXVERSION0001`
- MS version (e.g. version 2): `MSMUXVERSION0002`

In multiplexer protocol sources delivered by Siemens AG version control is integrated. When designing an application based on other sources take care to implement the version check as well, especially if you wish to upgrade to later firmware releases. **It is strongly recommended to implement the latest multiplexer version available.**

NOTE: The default configuration of MC75, TC63 and TC65 is multiplexer protocol version 3, which is the latest multiplexer version available.

5.2 Multiplexer protocol versions

This section summarizes the differences of the existing multiplexer protocol versions.

1. No version check
   - No break signal is sent

2. First version including the version check
   - Additional features: Transparent signals DTR and RTS, escape sequence +++ transportable via MSC

3. Advanced version integrated in all modules listed in Chapter 1.1
   - All features of version 2
   - Transparent signals DSR, CTS, RING and DCD
   - Send MSC request from module to host after version check on every channel to signal the initial state

Modem status command (MSC):

Command 1 octet	**Length** 1 octet	**DLCI** 1 octet	**V.24 signals** 1 octet	**Break Signals (optional)** 1 octet

Command:

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

Figure 14: MSC as used in version 3

Version specific differences in handling the modem status command MSC are explained in Table 7.

V.24 signals:

Bit 1	**Bit 2**	**Bit 3**	**Bit 4**	**Bit 5**	**Bit 6**	**Bit 7**	**Bit 8**
1	FC	RTC	RTR	reserved 0	reserved 0	RING	DCD

Table 7: Version differences for MSC

Version number	RTC RTR Host application ⇒ Module	RTC RTR RING DCD Module ⇒ Host application
1	1 1 If 0 is indicated, all calls are terminated	Not used
2	DTR RTS	Not used
3	DTR RTS	DSR CTS RING DCD

5.3 Implementing version control

The TE initiates the version check by sending the Test command via the multiplexer control channel DLCI 0 (with TEMUX_Version).

As specified in the GSM recommendation 07.10 (chapter 5.4.6.3.4) the opposite entity shall respond with exactly the same value bytes.

The MS shall return the Test command response with the same contents for the verification pattern. Hereafter the MS shall send a Test command message (with MSMUX_Version) to the TE, and the TE shall respond with the same contents. After sending the response a version compare is made on both sides. As a result, both sides shall agree upon the same multiplexer protocol version.

5.3.1 Troubleshooting

When the MS realizes the implemented software but the TE does not respond correctly, the following errors might occur:

- The “Request Test” message is not sent from the TE:
  No version check takes place. No retransmission for “Request Test“ message is triggered. The multiplexer starts with protocol version 1 because no version information was exchanged between TE and MS.

- The “Response Test” message is not sent from the TE:
  No timer has been implemented for the non responding cases. If the response message is not received as expected, the multiplexer stays in the state DLC_CONNECTEDWAIT4RESPONSE until another multiplexing related action takes place.

However, it is possible to send test commands with “any contents” (except for test messages with the specific IEI for the version check). If a test command with “any contents” is sent, it has to be sent back to the originator with the same contents.

5.3.2 Coding of “TestCommand” message

The coding of the multiplexer stack version is used specifically for SIEMENS equipment and is not defined in ETSI standards. The IEI values defined for the verification pattern of the “TestCommand” message are indicated in Table 8. See GSM recommendation 07.10, Section 5.4.6.3.4).

Table 8: IEI coding

IEI coding								Information element name
8	7	6	5	4	3	2	1	
0	0	0	0	0	1	0	0	TEMUX_VERSION
0	0	0	0	1	0	0	0	MSMUX_VERSION
Other values								reserved for future use

For easier analysis of multiplexer traces the message shall be sent in the following format:
(1.) Version IEI
(2.) TEMUXVERSION/MSMUXVERSION (send as ASCII)
(3.) Version Number (1...999 send as ASCII)

The message part after the Version IEI is coded with ASCII characters. This allows to read the version information from the trace file.
The version number must have a value between 1-999. If not all digits of the version number are used only the used digits are coded as ASCII sign(s). Digits that are not used are sent as zero string in the test message.

5.3.3 Example of “TestCommand” message

An example for coding a “TestCommand” message is illustrated in Table 9.

Table 9: Coding of “TestCommand” (Example)

Information element name	
0x	
F9	START Flag
03	Address Field DLCI=0,C/R=0,EA=0
EF	Control Field UIH Frame, P/F=0
25	Length LENGTH=18, EA=1
23	Type Field **TestCommand**, C/R=1, EA=1
21	Length Length=16, EA=1
04	TEMUX_VERSION
54	T
45	E
4D	M
55	U
58	X
56	V
45	E
52	R
53	S
49	I
4F	O
4E	N
39	Version number = 999
39	
39	
XX	FCS (is calculated)
F9	END Flag