



Operation Manual

X.25

Annex to TSW200E1's Operation Manual

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1 - Introduction

The test module X.25/xDLC allows testing and analyses of networks employing SDLC, HDLC, X.25, ASYNC, SYNC and DDCMP communication protocols.

Appendixes A and B give detailed information concerning these protocols.

The main characteristics of the X.25/xDLC operating module are:

- It performs tests for the SDLC, HDLC, X.25, ASYNC, SYNC and DDCMP protocols, checking link integrity;
- The ASYNC and SYNC tests monitor the data that passes through the link connecting a DTE to a DCE;
- Interfaces: V.24/RS232, V.35/V.11, V.36/V.11, X.21/V.11 and RS530;
- Operating speed: from 1200 bps to 256 Kbps, synchronous mode, or from 50 bps to 115200 bps, asynchronous mode;
- It uses ASCII, HEX and EBCDIC codes.

2 - X.25/xDLC Module Operation

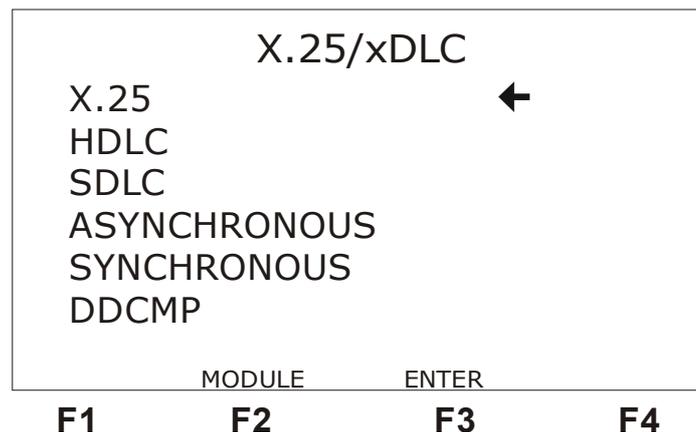
The TSW200E1 uses a transmitter and a receiver for the selected interface. The test is performed for the user/network interface (UNI). This test is conducted, in most cases, by the network interface and it allows checking the link integrity.

It is important to stress that the LAPB implementation of HDLC (adapted to X.25) is the type of X.25 that is tested by the TSW200E1.

This module can be divided in two test blocks. The first one includes tests for the bit-oriented protocols (SDLC, HDLC and X.25) and the second one includes tests for the byte-oriented protocols (ASYNC, SYNC and DDCMP).

2.1 - Choosing the test to perform

When choosing the X.25/xDLC Module at the Module screen, the following menu screen will be displayed.



At this screen the user chooses the tests to be carried out. Move the cursor with the ↑ and ↓ keys until it points to the desired test. Press the <F3> (ENTER) key. The first configurator screen for the chosen test will be exhibited.

Press the <F2> (MODULE) key to go back to the module menu.

2.2 - Testing in X.25

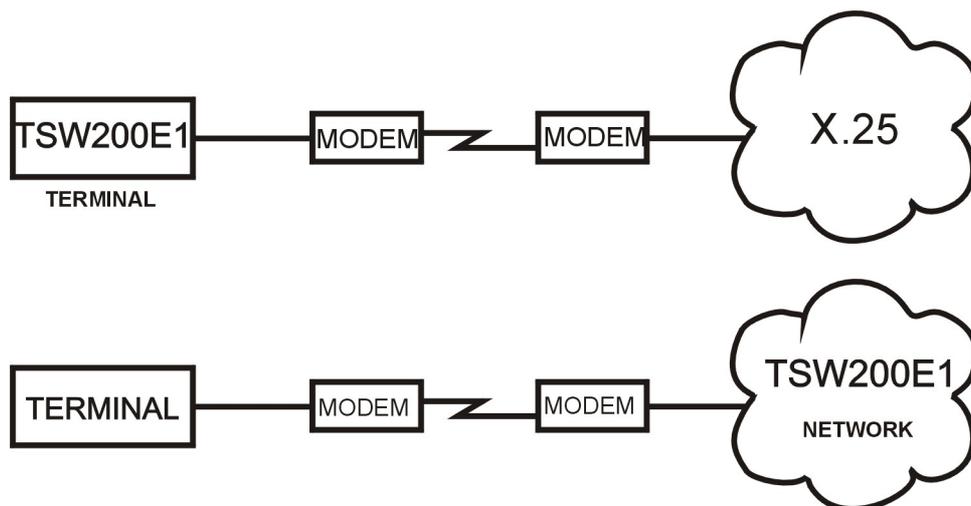
The TSW200E1 can be used to simulate either TERMINAL or NETWORK.

For level 1 (physical), level 2 (link - LAPB) and level 3 (network - X.25), this test checks operation of nodes connected to an X.25 network. For level 1, the TSW200E1 shows the presence or absence of interface and clock signals. For level 2, it shows the transmitted and received packages indicating that the link (LAPB) level is working (UP). For level 3, it allows making a call to any X.25 network node by activating a key and to end the call when needed, also after a single keystroke. If the remote node did not accept the call, a diagnostic code is displayed on screen and

the operator can know the reason why the connection was refused. The logic channel (LCN) through which the call is done can be altered to check which logic channels are enabled.

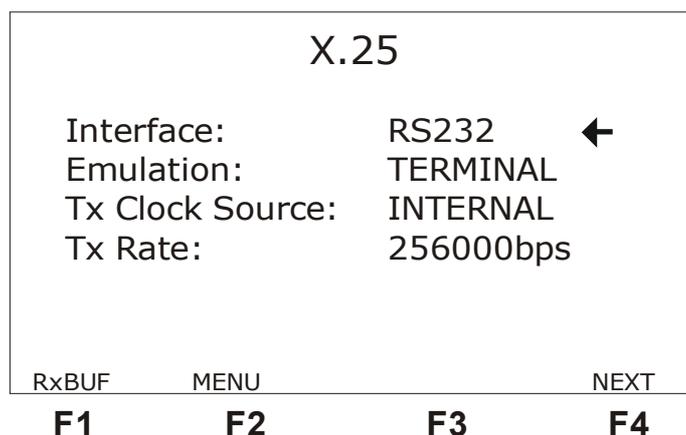
The TSW200E1 can be configured to simulate the X.25 network so as to check if the user equipment is adequately sending packages to the network. It checks if the destination and local DNAs, which are configured at the user equipment, are correct. To do this, when the TSW200E1 is being used as NETWORK, the source and destination DNIC/DNA must be equal to that of the terminal.

The two figures shown below represent the use of the TSW200E1 to simulate a terminal or network.



2.2.1 - X.25 Test Configuration

The X.25 test has the following configuration screens:



X.25			
LCN:	2048	←	
DNIC/DNA SOURCE:	121212121212		
DNIC/DNA DESTIN:	343434343434		
BACK	MENU		
F1	F2	F3	F4

To alternate between the screens use the <F1> (BACK) and <F2> (NEXT) keys. The description of the configuration parameters of these screens follows. To modify a parameter move the cursor up to the adequate position and use the ← and → keys. From the first configuration screen, press <F1> (RxBUFF) to see the sent and received frames in last test.

- Interface: Selects the operation interface as RS232, V35, V36, X.21 or RS530.
- Emulation: Selects the TSW200E1 emulation type as DTE or DCE.
- Tx Clock Source: Allows choosing the transmission clock source as EXTERNAL or INTERNAL.
- Tx Rate: Allows choosing the transmission rate. It can be any speed from 64Kbps to 256 Kbps. It is only available if the option above is selected as INTERNAL.
- LCN (logical channel number): The editing is done using the DATA key. It can vary from 0001 up to 4095.
- DNIC/DNA Source: International network code and source network address. Editing is done using the DATA key. During editing, use the keys ← and → to move the cursor. The CLEAR key erases all numbers. The <F2> (EMPTY) key erases the position pointed to by the cursor. To finish editing, press the <F4> (ENTER) key to confirm.
- DNIC/DNA Destin: International network code and destination network address. Editing is done analogously as for the preceding item.

2.2.2 - Performing the X.25 Test

When the **START/STOP** key is pressed, the test starts at level 1. The transmitter sends *idle flags* continuously. The test set checks every interface signals and it flags the absence of the receive and transmit clocks, if it occurs, and it also checks the absence or presence of the *idle flag*.

If the physical layer is correct, the LAPB frames will start to be displayed on-screen and the TSW200E1 will answer to these frames signalling that level 2 is up.

Two cases can occur: the terminal generates SABM after having received two SARM or the terminal answers with UA after having received SABM. Right after this, the terminal sends the *Restart Request* (RestaReq) and the network answers with the *Restart Confirmation* (RestaCon). If there is a problem at level 2, the terminal and the network will remain exchanging RR (*Receiver Ready*).

The following screen is the X.25 test initial screen. The frames that are sent and received by the equipment are presented on that screen.

TX FRAME		RX FRAME	
	. . . .	SABM	
UA	. . . .	RR	
RR	. . . .	RR	
RR	. . . .	RR	
RR	. . . .	RR	
RR	. . . .	RR	
FREEZE	SEND	CALL	NEXT
F1	F2	F3	F4

If the screen remains with the column titles (TX FRAME and RX FRAME) at the first line only and the others are blank, there are no frames being sent by the network, indicating that there is a level 2 problem.

The <F1> (FREEZE) key allows freezing the screen for further examination. When that key is pressed, the frame sequences that have already been transmitted and received are displayed. The number of the last frame displayed is shown and the number of frames that have already been exchanged up to that moment are displayed too. The ↑ and ↓ keys allow visualising the exchanged frames stored in the frame buffer, one line at a time. The → key allows going to the last Frames screen and the ← key allows going back to the first screen. Pressing the <F1> (UPDATE) key, the screen goes back to displaying the on-line exchanging of frames. The CLEAR key clears the frame buffer.

The <F4> (NEXT) key allows the user to visualise the received frame counter. See the screen below.

SABM=0001	RR =0000		
DISC =0000	RNR =0000		
SARM=0000	REJ =0000		
UA =0001	INFO=0000		
FRMR=0000	OTH =0000		
SEND: SABM	TX: UA		
BACK	SEND	OK	NEXT
F1	F2	F3	F4

The counters are described below:

- SABM: indicates the total number of received SABM frames.
- DISC: indicates the total number of received DISC frames.

- SARM: indicates the total number of received SARM frames.
- UA: indicates the total number of received UA frames.
- FRMR: indicates the total number of received FRMR frames.
- RR: indicates the total number of received RR frames.
- RNR: indicates the total number of received RNR frames.
- REJ: indicates the total number of received REJ frames.
- INFO: indicates the total number of information frames (I FRAMES) received. This counter includes the level 3 X.25 packages.
- OTH: indicates the total number of any other frames that are not described above.

The SEND key allows the transmitter to send the frame with the command specified by the SEND option. The ← and → keys change the type of command that can be sent by the transmitter for the SEND option. The TX signal indicates the last frame transmitted (it can be the command that was sent by the SEND key or the response to the received command).

From the frame counters screen it is possible to visualise a screen that shows the general frame counters and the error counters, displayed below.

```

TX FRAME = 00002
RX FRAME = 00002
ERR FRAME = 00000
FCS ERROR = 00000
SQN ERROR = 00000
SEND: SNRM      TX:UA

BACK          SEND          OK
F1         F2         F3         F4
```

- TX FRAME: indicates the total number of frames transmitted during the test in progress.
- RX FRAME: indicates the total number of frames received during the test in progress.
- INV FRAME: indicates the total number of invalid frames (containing code which does not correspond to the LAPB frame).
- FCS ERROR: indicates the total number of FCS errors found (CRC-based error detection). That means that one or more bits arrived in error.
- SQN ERROR: indicates the total number of sequence errors in the response frames, that is, the number of frames that were lost by the network.

The table below describes the meaning of each frame (level 2).

Frame	Command	Name	1. Description
S	RR	Receiver Ready	It is an ACK that indicates that the receiver is ready to receive more frames (stop & wait)

X.25

S	RNR	Receiver Not Ready	It is an ACK that indicates that the receiver is NOT ready to receive more frames (stop & wait)
S	REJ	Reject	It is a NAK for the mode go-back-n
U	SARM	Set Asynchronous Response Mode	It is sent from one node to the other indicating that it must enter the normal call mode, with 8-bit control field, for the async mode
U	SABM	Set Asynchronous Balanced Mode	Identical to SARM for the async balanced mode
U	DISC	Disconnect	Informs the user that the emitter station will cease to be active.
U	UA	Unnumbered Acknowledgment	Indicates acceptance of the command sent
U	FRMR	Frame Reject	Indicates an error condition that cannot be recovered by sending an identical frame

The table below describes the meaning of each level 3 X.25 frame (packages).

Network to Terminal	Terminal to Network		Code
	Acronyms	Name	
Restart Indication	RSRQ/RestaReq	Restart Request	11111011
DCE Restart Indication	RSCO/RestaCon	DTE Restart Confirmation	11111111
Incoming Call	CARQ/Call Req	Call Request	00001011
Call Indication	CAAC/ Call Acc	Call Accept	00001111
Clear Indication	CLRQ/ClearReq	Clear Request	00010011
DCE Clear Confirmation	CLCO/ClearCon	DTE Clear Confirmation	00010111
DCE RR	RR Pack	DTE Receiver Ready of Packet	xxx00001
DCE RNR	RNR Pack	DTE Receiver not Ready of Packet	xxx00101
	REJ Pack	DTE Reject of Packet	xxx01001
Reset Indication	ResetReq	Reset Request	00011011
DCE Reset Confirmation	ResetCon	DTE Reset Confirmation	00011111
DCE Interrupt	Interrupt	DTE Interrupt	00100011
DCE Interrupt Confirmation	InterCon	DTE Interrupt Confirmation	00100111
DTE Data	DATA/Data Pack	DTE Data	xxxxxxx0

If there is no level 2 problem, the equipment will be able to make the call to the remote node. When the call is made by pressing the <F3> (CALL) key, the test enters in level 3. The TSW200E1 sends *Call Request* (Call Req), which is relayed through the network up to the node where the DTE destination is located. If it accepts the call, it sends a *Call Accepted* (Call Acc) package. Then, the CLRQ key will be shown instead of CALL. If CLRQ is pressed, the terminal sends to the remote DNA a package determining the ending of the *Clear Request* (ClearReq) virtual circuit. The network then responds with a *Clear Confirmation* (ClearCon) confirming the ending of

the call.

If there are no errors, then the OK Screen will be displayed, as in the figure below, indicating that the test was successfully completed at all levels. The CALL word will be again displayed to allow a new call.

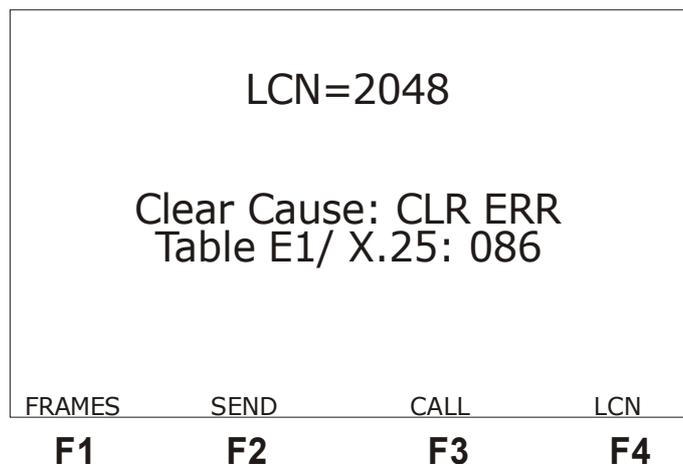


The key <F1> (FRAMES) allows going back to the frames screen.

The logic channel (LCN) in which the call is made can be altered to verify which logic channels are enabled. Even when the call did not succeed, it is possible to increment the logic channel and to try to make the call again. To increment the logic channel, use the <F4> (LCN) key. The indication LCN = xxxx represents the logic channel of the last well-succeeded call.

Considering that the TSW200E1 is operating as a terminal, pressing the CLEAR key in the OK Screen or in the screen that displays the frames causes the terminal to disconnect and to send a DISC. Then, the network must send SABM to restart communication. When pressing the CLEAR key on any of the screens that display the counter, every screen counter is restarted without affecting the data transmission by the Test Set.

If the call is not accepted, the screen will display an error code indicating the problem to the operator. The called number can be busy, out of service, or the caller is not allowed to access it, etc. When any of these problems happen during communication, the network or the remote DTE remote can send a CLEAR.



Appendixes C and D display the meaning of what caused the Clear and the corresponding

diagnosis.

All these test procedures here explained for the X.25 are used for **SVC** circuits. If it is needed to perform the test for **PVC** circuits, use the SEND option sending data through the DATA option.

2.3 - Testing in SDLC and HDLC

This test, normally conducted by the network interface, allows checking if the link is active and if there is integrity in this link, checking if the frames are being transmitted and received correctly. For the SDLC and HDLC protocols, the tests are restricted to level 2. The TSW200E1 can simulate **TERMINAL** or **NETWORK**.

2.3.1 - SDLC and HDLC test configuration

The SDLC test has the following configuration screen.

SDLC			
Interface:	RS232 ←		
Emulation:	TERMINAL		
NRZI:	ON		
Addr:	FF		
Tx Clock Source:	INTERNAL		
Tx Rate:	256000bps		
MENU			
F1	F2	F3	F4

The HDLC test configuration screen is displayed in the figure below.

HDLC			
Interface:	RS232 ←		
Emulation:	TERMINAL		
Tx Clock Source:	INTERNAL		
Tx Rate:	256000bps		
MENU			
F1	F2	F3	F4

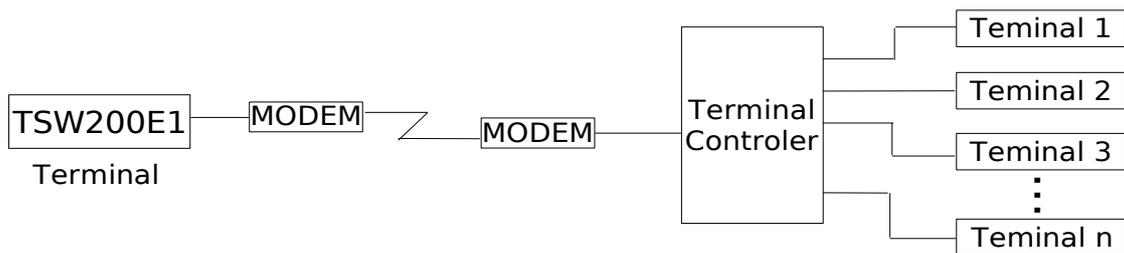
Now the parameters presented on the above screens are described.

- Interface: Selects the operating interface as RS232, V35, V36 , X.21 or RS530.
- Emulation: Selects the TSW200E1 emulation type as DTE or DCE.
- Tx Clock Source: Allows choosing the transmission clock source as EXTERNAL or INTERNAL.
- Tx Rate: Allows choosing the transmission rate from 64Kbps up to 256 Kbps. Available only if the previous option was chosen as INTERNAL.
- NRZI: (SDLC only): Allows the user to enable (ON) or disable (OFF) the NRZI line code (Non-Return to Zero Inverted).
- Addr: (SDLC only): Allows editing the secondary station link address that is sending or receiving the frame (from 00 to FF).

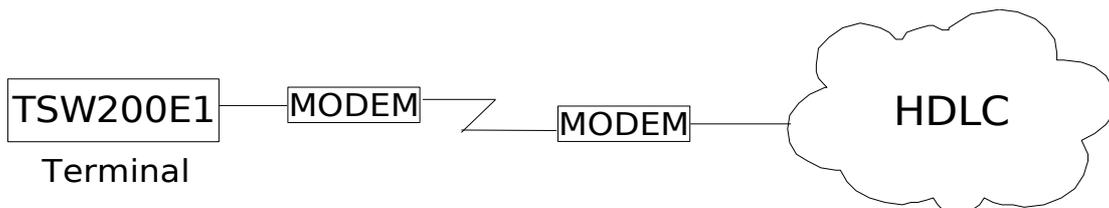
2.3.2 - Performing the SDLC and HDLC tests

After correctly configuring and connecting the test set, the test can be started by pressing the **START/STOP** key. The figures below exemplify the SDLC and HDLC tests.

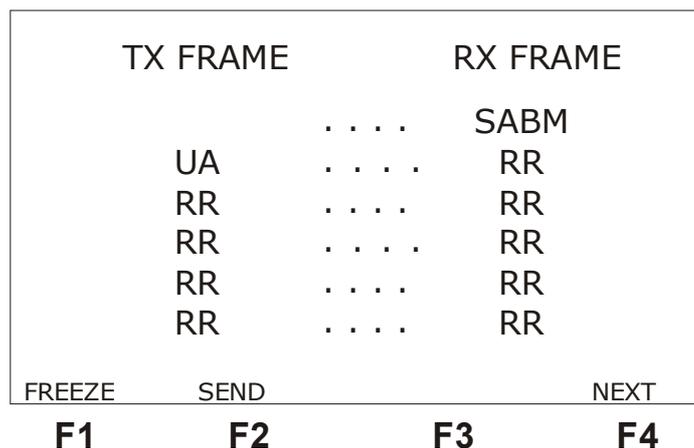
SDLC test example:



HDLC test example:



When the test is started, the equipment displays a screen like the one below.

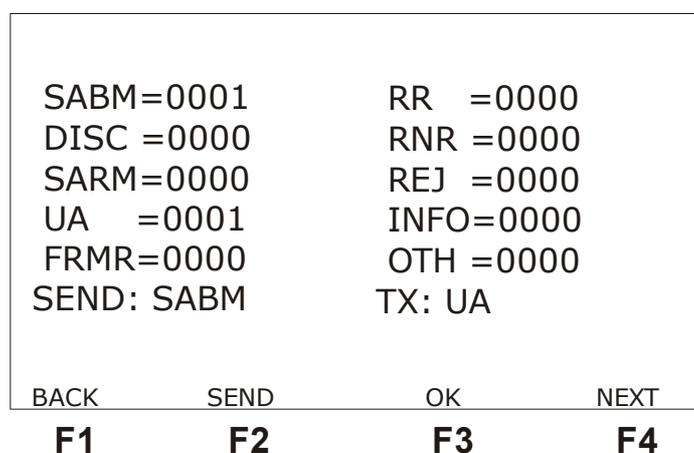


The test starts at the level 1. The test set checks all the interface signals and it flags the absence of the receive and transmit clocks, if it occurs. The absence or presence of the *idle flag* is also flagged. The transmitter keeps sending *idle flags*.

If the physical level is correct, the LAPB frames will start to be shown on the screen and the TSW200E1 will respond to these frames indicating that level 2 is up. The frame types exchanged between terminal and network vary from communication to communication. Two cases can occur: the terminal generates SABM after having received two SARM or the terminal responds with UA after having received SABM. Then, the terminal stops responding to the other frames generated by the network.

The <F1> (FREEZE) key allows freezing the screen for analysis. When the key is pressed, the frame sequences that have already been transmitted and received are displayed. The number of the last frame presented on screen and the number of frames that have already been exchanged at the moment are displayed. The ↑ and ↓ keys allow the user to run, in a line-by-line basis, through the buffer that stores the frames exchanged during the communication. The → key allows the user to go to the last Frames screen and the ← key allows going back to the first Frames screen. Pressing the <F1> (UPDATE) key, the screen again displays the frame exchange, on-line. The CLEAR key clears the frame buffer.

The key <F4> (NEXT) allows visualizing the received frame counters. See in the screen below.



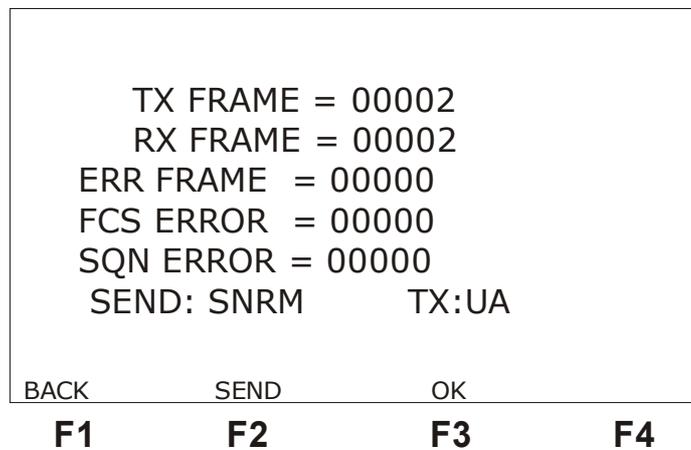
The counters are now described.

- SNRM: indicates the total number of SNRM frames received. It is shown when the protocol is SDLC.
- SABM: indicates the total number of SABM frames received. It is shown when the protocol is HDLC.
- DISC: indicates the total number of DISC frames received.
- SARM: indicates the total number of SARM frames received.
- UA: indicates the total number of UA frames received.
- FRMR: indicates the total number of FRMR frames received.
- RR: indicates the total number of RR frames received.
- RNR: indicates the total number of RNR frames received.
- REJ: indicates the total number of REJ frames received.
- INFO: indicates the total number of information frames (I FRAMES) received. This counter includes any level 2 information for the SDLC and HDLC modes.
- OTH: indicates the total number of any other frames received which are described not above.

The SEND key allows the transmitter to send the frame with the command specified in the SEND option. The ← and → keys change the type of command, in the SEND option, which can be sent by the transmitter. The TX signalling indicates the last transmitted frame (whether the command is sent by the SEND key or the response to the received command). The following table describes the meaning of each frame (level 2).

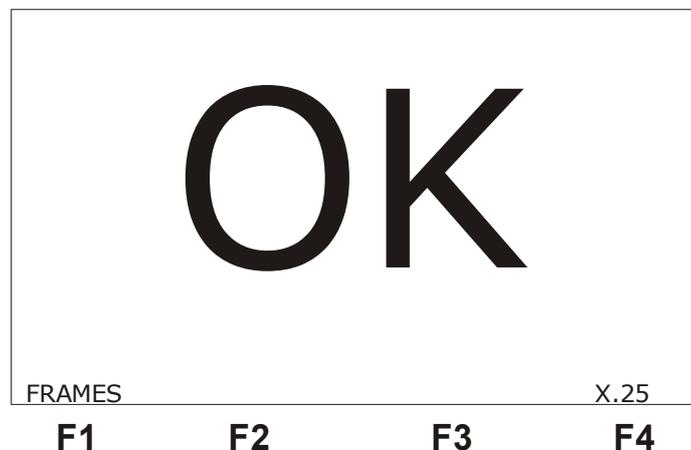
Frame	Command	Name	1. Description
S	RR	Receiver Ready	It is an ACK that indicates that the receiver is ready to receive more frames (stop & wait)
S	RNR	Receiver Not Ready	It is an ACK that indicates that the receiver is NOT ready to receive more frames (stop & wait)
S	REJ	Reject	It is a NAK for the mode go-back-n
U	SNRM	Set Normal Response Mode	It is sent from primary node to secondary node, indicating that it must enter the normal call mode, with 8-bit control field (only for SDLC)
U	SARM	Set Asynchronous Response Mode	It is sent from one node to the other indicating that it must enter the normal call mode, with 8-bit control field, for the async mode
U	SABM	Set Asynchronous Balanced Mode	Identical to SARM for the async balanced mode
U	DISC	Disconnect	Informs the user that the emitter station will cease to be active.
U	UA	Unnumbered Acknowledgment	Indicates acceptance of the command sent
U	FRMR	Frame Reject	Indicates an error condition that cannot be recovered by sending an identical frame

From the frame counters screen it is possible to visualise the general counters screen frame and the error counters displayed in the figure below.



- TX FRAME = XXXXX: indicates the total number of frames transmitted during the test in progress.
- RX FRAME: indicates the total number of frames received during the test in progress.
- INV FRAME: indicates the total number of invalid frames (with code that does not corresponds to an LAPB frame).
- FCS ERROR: indicates the total number of FCS errors (CRC-based error detection) found, that is, that one or more bits arrived in error.
- SQN ERROR: indicates the total number of sequence errors in the response frames, that is, the number of frames lost by the network.

Pressing the CLEAR key in the counters screen causes them to be reset to zero without affecting the data transmission by the test set. If everything is correct, the OK Screen will be displayed, indicating that the test was successfully concluded.



The <F1> (FRAMES) key allows the equipment to go back to the screen that displays the sent and received frames. Considering that the TSW200E1 is operating as TERMINAL, pressing

the CLEAR key in the OK Screen or in the Frames screen, the terminal disconnects sending a DISC. Then, the network restarts the communication sending SNRM (SDLC) or SABM (HDLC). When the TSW200E1 is operating as NETWORK, if the CLEAR key is pressed, the test set restarts the communication and sends SNRM (SDLC) or SABM (HDLC).

2.4 - Testing in Synchronous and Asynchronous

These tests allow monitoring the data that pass through the link connecting a DTE to a DCE. In this mode, it is possible to send and to receive data employing *buffers*.

2.4.1 - Asynchronous Test Configuration

The ASYNC test presents the following configuration screens.

ASYNCHRONOUS			
Interface:	RS232	←	
Init Trig:	FF		
End Trig:	FE		
Data Rate:	50 bps		
RxBUF	MENU		NEXT
F1	F2	F3	F4

ASYNCHRONOUS			
Bits Number:	8	←	
Parity:	NONE		
Stop Bits:	1		
Code:	HEX		
Tx Buffer:			
BACK	MENU		
F1	F2	F3	F4

A description of the configuration parameters shown on the above screen follows.

- Interface: Selects the operating interface as RS232, V.35, V.36, X.21 or RS530.
- Ini Trig: Trigger character that identifies the start of frame. It can range from 00 to FF, in hexadecimal values. To change the value use the ← and → keys.

- End Trig: Trigger character that identifies the end of frame. It can range from 00 to FF, in hexadecimal values. To change the value use the ← and → keys.
- Data Rate: Allows choosing the transmission speed. The user can choose from 50 up to 115200 bps. To change the value use the ← and → keys.
- Bits Number: Selects the size of the transmitted data word. This size can vary from 5 to 8 bits. To change the value use the ← and → keys.
- Parity: Selects the parity type for the asynchronous transmission. The options are NONE, EVEN, ODD, MARK and SPACE. To change the value, use the ← and → keys.
- Stop Bits: Selects the number of stop bits used in the transmission. The options are 1 or 2. To change the number of stop bits use the ← and → keys.
- Code: Allows the selection of the code to be used in the decoding of the received data and control characters. It is possible to choose among the HEX, ASCII and EBCDIC codes. To change the code, use the ← and → keys.
- Tx Buffer: Allows the editing of transmit buffer data. Pressing the DATA key displays the screen below. Use the alphanumeric keys to write the word values in hexadecimal. The ← and → keys change the cursor position in the word. The ↑ and ↓ keys change the word that will be edited. When the <F2> (FOX) key is pressed, the FOX pattern will be placed in the first buffer positions.



2.4.2 - Synchronous Test Configuration

The SYNC test presents the following configuration screens.

SYNCHRONOUS			
Interface:	RS232	←	
Emulation:	TERMINAL		
Tx Clock Source:	INTERNAL		
Tx Rate:	256000bps		
RxBUF	MENU		NEXT
F1	F2	F3	F4

SYNCHRONOUS			
Bcc:	CRC-CCITT	←	
Sync:	FF		
Idle:	FE		
Code:	ASCII		
Tx Buffer:			
BACK	MENU		
F1	F2	F3	F4

A description of the configuration parameters shown on the above screens is now presented. To change the value of these parameters, use the ← and → keys.

- Interface: Selects the operation interface as RS232, V.35, V.36, X.21 or RS530.
- Emulation: Selects the TSW200E1 emulation type as TERMINAL or NETWORK.
- Tx Clk Src: Allows choosing the signal clock source. It can be EXTERNAL or INTERNAL.
- Tx Rate: Allows choosing the transmission speed from 1200 up to 256000 bps. That option is only shown when the parameter Tx Clk Src is selected as INTERNAL.
- Bcc: The Block Checking Character defines the type of error checking to be employed. Allows the options NONE, CRC-CCITT, CRC-16 and LCR.
- Sync: Defines the sync character that identifies the start of frame. It is possible to choose from hexadecimal 00 to FF.
- Idle: Selects a code to be transmitted while no frame is being sent. It is possible to choose from hexadecimal 00 to FF.
- Code: Allows the selection of the code to be used in the decoding of the received data and control characters. It is possible to choose among the HEX, ASCII and EBCDIC codes.
- Tx Buffer: Allows editing of the transmission data buffer. See the previous section to check the editing procedure.

2.4.3 - Performing the tests

The tests are performed by sending the transmission data buffer and by monitoring the received data. The transmission data buffer can be user-edited or filled with the FOX pattern. The test set transmits the contents of the transmission data buffer (Tx Buffer) only when the SEND key is pressed. The data received are stored in the receive buffer. It is possible to visualise the contents of this buffer using three code types (selected in the configuration screens).

For the asynchronous case the line gets no data while the <F2> (SEND) key is not pressed.

For the synchronous case, an idle code is continuously transmitted until the <F2> (SEND) key is pressed.

After starting the test, the following counters screen is displayed.

```

TX BUFFER = 0000
RX BUFFER = 0000
CRC ERROR = 0000

SEND

F1      F2      F3      F4

```

- TX BUFFER: Indicates the total number of transmitted frames during the test in progress.
- RX BUFFER: Indicates the total number of received frames during the test in progress.
- CRC ERROR: Indicates the total number of CRC errors found in the received data. This counter is only shown when the test is SYNCHRONOUS.

To interrupt the test, press the START/STOP key. To check the received data press the <F1> (RXBUFF) key on the configurator screens. The data will be displayed according to the chosen code. If the user chooses the HEX code the following screen will be displayed.

```

Rx Buffer =

00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00

EXIT      PG UP      PG DN

F1      F2      F3      F4

```



```
TX FRAME = 00002
RX FRAME = 00002
ERR FRAME = 00000
FCS ERROR = 00000
SQN ERROR = 00000

BACK
```

F1 **F2** **F3** **F4**

A description of these counters follows.

- TX FRAME: indicates the total number of frames transmitted during the test in progress.
- RX FRAME: indicates the total number of frames received during the test in progress.
- INV FRAME: indicates the total number of invalid frames (containing code that does not correspond to an LAPB frame).
- FCS ERROR: indicates the total number of FCS errors found (CRC-based error detection). That is, one or more bits arrived in error.
- SQN ERROR: indicates the total number of sequence errors in the response frames. That means the number of frames lost by the network.

To go back to the frames screen press the <F1> (BACK) key. The test can be interrupted at any moment if the START/STOP key is pressed.

3 - Glossary

The meaning of many technical terms, as used throughout this manual, is now presented.

ARQ (*Automatic Request for Transmission*)

ARQ is a communication characteristic such that the receiver requests the transmitter to transmit or resend a frame block, generally due to errors detected by the receiver.

HDLC (*High-Level Data Link Control*)

HDLC is a level 2 MR-OSI specification with great acceptance, including many variants. It uses the synchronous transmission of frames and it is bit-oriented.

LAPB (*Link Access Procedure Balanced*)

HDLC-derived protocol used in the X.25 level 2 protocol.

LRC (*Longitudinal Redundancy Checking*)

Error-checking pattern.

NAK (*Negative Acknowledge Message*)

Message indicating no acknowledgement.

Protocol

Set of rules that define the message format and the timing in the communication between two systems.

SDLC (*Synchronous Data Link Control*)

See Appendix A.

Appendix A: SDLC, HDLC and X.25 frame structure

A.1 - SDLC Characteristics

SDLC is the bit-oriented communications protocol used by the IBM SNA (*Systems Network Architecture*), which was used as the base for the development of HDLC and of other link types, as the IEEE *Logic Link Control*.

The main characteristics of SDLC are:

- Bit-oriented, that is, SDLC does not perceive the data flow as a chain of characters, but as a continuous flow of bits;
- Synchronous transmission, where the synchronization (*clock*) of the data is done during the transmission itself, so as to avoid the use of synchronization-specific *bits* (the so-called “*start bit*” and “*stop bit*”). So, the transmission speed is improved and it is safer than asynchronous transmission;
- It is full duplex, also supporting the *half duplex* mode;
- The stations involved in a transmission are divided in primary and secondary.
- Frame delimiting, alignment and data transparency;
- The data transparency is guaranteed by the *bit stuffing* technique;
- Frame inspection to guarantee that each frame is formed by an integer number of octets before the zero insertion (*bit stuffing*) and after its retrieval, at the receiver;
- Inspection of the frame size to guarantee that its size is within the specified limits;
- Detection of transmission errors;
- The SDLC supports three operating modes:
 - ◆ Initialisation Mode: Before a secondary station enters in operation, the station stays in initialisation mode.
 - ◆ Unconnected Normal Mode: The unconnected mode is necessary to avoid that a secondary station unexpectedly appears in the link while a transmission process with other station is in progress.
 - ◆ Normal Response Mode (SNRM): This is the normal SDLC operating mode. In this mode, a station is identified as primary and another is defined as secondary.

A.2 - HDLC Characteristics

HDLC is short for *High Level Data Link Control*. It is the MR-OSI level 2 specification that finds various applications and that includes many variants.

The main characteristics of HDLC are:

- Bit-oriented;
- Operates in asynchronous response mode for both directions, with DTE and DCE both sporting primary and secondary functions;
- It is full duplex, supporting also the half duplex mode;
- Frame delimiting of frames, alignment and data transparency;
- Frame inspection to guarantee that it is formed by an integer number of octets before the insertion of zeros (*bit stuffing*) and after its retrieval, in the receiver;
- Inspection of frame size to guarantee that its size is within specified limits;

- Detection of transmission errors.
- It can operate in three response modes:
 - ◆ NRM - normal response mode: unbalanced connection where the secondary stations start to transmit only when the primary issues the authorization;
 - ◆ ARM - unbalanced asynchronous response mode: unbalanced connection where the secondary station can start to transmit without need of primary authorization;
 - ◆ ABM - asynchronous balanced response mode: balanced connection where the stations are considered logically equal: any of them can start or end the connection; both are responsible by the flow and error control and both can send commands and responses. Used only in node-to-node configurations;

A.3 - X.25 Characteristics

The X.25 is a set of protocols adhering to the first three layers of the OSI model, defining a communication discipline between terminals and public or private networks. Note that the X.25 is the standard interface in package (switched) networks. That discipline regularizes the completion of a call, data transmission, disconnection and data flow control.

The X.25 Recommendation defines the interaction between a DTE and a DCE for the package commuting network. The interaction occurs in the DTE/DCE interface and is divided in three distinct procedure levels:

- X.25 - Level 3: this is the package level logical interface. In this level the package formats are defined. The procedures for exchanging packages containing data and control information between the DTE and the DCE are also defined. At this level, the transferred item is the package.
- X.25 - Level 2: this is the frames level logical interface. This level defines the connection procedure between DTE and DCE that allows data exchange. Here the transferred item is the frame.
- X.25 - Level 1: The mechanical, electrical, functional and procedural characteristics needed to activate and deactivate the physical means between the DTE and the DCE are defined at this level. The bit is the transferred item at this level.

The main characteristics of X.25 are:

- It is a bit-oriented protocol;
- The standard X.25 Level 2 is the LAP-B (Link Access Procedure Balanced). This is a variant of HDLC in balanced asynchronous mode.
- Level 2 is divided in 3 phases:
 - ◆ Connection Phase: The DTE/DCE link is established with an SABM frame. As this frame is transmitted as a command there must exist a response from the receiver, which must be an UA frame. The V(R) and V (S) frame sequencing mechanism are fixed in zero for both sides of the DTE/DCE link. The transference of the information frame can only occur after this phase is completed.
 - ◆ Information Transfer Phase: As soon as the DTE/DCE link is established, there are no impediments for transferring information. The I frame contains not only user information, but it also carries control bits, which are used to maintain the frame sequence and, consequently, the intelligibility of the information they carry.

- ◆ Disconnection Phase: The process starts by sending the DISC command frame. When the receiver gets the DISC command, it sends a response, an UA command, and starts the disconnection. The same occurs when receiving an UA to whom sent DISC.
- Level 3 defines a virtual circuit service. Two types of virtual circuit are used:
 - ◆ Temporary: “virtual call” or “switched virtual circuit” (SVC). They are established by the nodes and when they are not necessary anymore they are deactivated.
 - ◆ Permanent: “permanent virtual circuit” (PVC). They are previously established during the network initialisation between two DTEs. They are always available and do not require call setup (connect) or call clearing (disconnect) action by the DTE. They are fixed between two nodes, and cannot be altered.

A.4 - General Structure of SDLC, HDLC and X.25 (level 2) frames

The process of delivery of frames for the services consists, essentially, in the sending of frames with the format depicted below:

Frame Field	Characteristics
01111110	Flag
Address	8 or more bits
Control	8 or 16 bits
Data	variable length
FCS	16 bits
01111110	Flag

Note: The extension of the SDLC architecture allows data link addresses with many bytes, but that extension is seldom implemented.

The extension of the SDLC architecture that is implemented by some devices admits frames with two byte control fields.

A.4.1 - Idle Flag Sequence

These flag fields delimit the frame. All frames must start and end with a sequence of flags that consists of the first bit 0, followed by six bits 1 and a bit 0 (0111 1110 - 7E hexadecimal). The flag that comes before the address field is the start flag and the end of frame flag comes after the FCS.

The use of this technique of frame delimiting implies in the use of the *bit stuffing* strategy to guarantee the data transparency. That technique presupposes the insertion of a bit 0 each time that a sequence of five bits 1 is found in the transmitted information. In the receiver, for each sequence of 5 bits 1, the following bit must be suppressed, if it is equal to 0. If this bit is equal to 1, then the receiver knows it is the end of frame.

A.4.2 - Address Field

The address is used to identify the secondary node where the command is designated or the secondary node that issued the response. It is not necessary for a node-to-node configuration, but it always exists.

A.4.3 - Control Field

The control field starts with two bits that identify the type of information. There are three types of frame and the final part of this field is different for each of them. The three types of frame are:

- Information Frames - I Frames: used to transport data and can be used to carry an ARQ and flow control (“piggybacking”).
- Supervisory Frames - S Frames: when the “piggybacking” is not used, frames of this type are necessary for flow and error control.
- Unnumbered Frames - U Frames: such as their name indicates, and contrarily to the previous ones, these frames do not possess sequence numbers. The “U-frames” are used for many control functions, such as changing the mode of operation of nodes;

Bits	1	2	3	4	5	6	7	8
Frame - I	0	Ns- emission sequence number			P/F	Nr - a receive sequence number		
Frame - S	1	0	S Function		P/F	Nr - a receive sequence number		
Frame - U	1	1	U Function		P/F	U Function		

The bits marked P/F (“Poll/Final”) have many functions according to the type of frame, and according to the connection operating mode. For example, for an I frame in normal response mode (NRM), the primary node places this bit in 1 to allow the secondary node to respond and the secondary node places itself in one to indicate that it is the last response frame.

The I and S frames can have the control field expanded to 16 bits. This allows augmenting the sequence numbers from 3 to 7 bits. The commuting between 8 and 16 bits control is performed with U functions.

The data field exists only in the I frames and, in some cases, in the U frames. It contains the data to be transmitted to the destination node, although the standard defines no maximum length. Each particular implementation imposes its own limitations.

The data transferences are based on the I-frames. Each frame has an emission sequence number (Ns), and a receive sequence number (Nr). The receive sequence number works as a confirmation of the reception of previously sent frames in the inverse direction (“piggybacking”). It is the frame sequence number that is expected next. The maximum window size can vary between 7 and 127.

Although the I frames can control the errors and the flow by themselves, this way is not always adequate, for a situation can arise where there is no I frame ready to send or to transport the ACK. In this case the S frames are employed.

The S frames allow the implementation of ARQ in the “stop & wait”, “go-back-n” or “selective-repeat” modes. To do this, the following commands are defined:

Frame	Command	Description
S	RR	“Receiver Ready” is an ACK that indicates that the receiver is ready to receive more frames (stop & wait)
S	RNR	“Receiver Not Ready” is an ACK that indicates that the receiver is NOT ready to receive more frames (stop & wait)
S	REJ	“Reject” is a NAK for the mode go-back-n
S	SREJ	“Selective Reject” is a NACK for the mode “Selective-repeat” (only for HDLC)

The number of the frame to which the command is applied is indicated in the field “Number of Reception Sequence” of the S frame.

The functions allowed by the U frames are much more complete and diversified:

command (C) – response (R)	Description
SNRM (C)	“Set Normal Response Mode”. Sent from the primary node to the secondary node indicating that it must enter the normal call mode, with 8-bit control field.
SNRME (C)	“Set Normal Response Mode Extended”. Same as before, but with 16-bit control field.
SARM (C)	“Set Asynchronous Response Mode”. Same as SNRM for async mode (HDLC only)
SARME (C)	“Set Asynchronous Response Mode Extended”. Same as SNRME for async mode (HDLC only)
SABM (C)	“Set Asynchronous Balance Mode”. Same as SNRM for async balanced mode (X.25 and HDLC only)
SABME (C)	“Set Asynchronous Balance Mode Extended”. Same as SNRME for async balanced mode (X.25 and HDLC only)
SIM (C)	“Set Initialisation Mode”. It is sent from the primary node to the secondary, so the 2ary node starts an initialisation process. During this initialisation data are sent to the secondary node using U-frames with data field (UI). (SDLC and HDLC only)
DISC (C)	“Disconnect”. Informs the user that the emitting station will cease to be active.
UA (R)	“Unnumbered Acknowledgment”. Indicates the acceptance of the command that was sent.
DM (R)	“Disconnected Mode”. Response sent every time that a node sends a command indicating that the node is not under a call. This response is equally used to indicate that a command was not accepted.
RD (R)	“Request Disconnect”. This response is used to ask the interruption of an ongoing call (SDLC and HDLC only)
RIM (R)	“Request Initialisation Mode”. This response is used to ask disconnection of an ongoing call (SDLC and HDLC only)
UI (C/R)	“Unnumbered Information”. Used for information exchange between nodes (status, etc.) (SDLC and HDLC only)
UP (C)	“Unnumbered Poll”. Used to request information to nodes. The response will be an UI (HDLC only).

RSET (C)	“Reset”. This command is used to recover from serious errors (FRMR). It indicates that the node restarted its sending sequence number. The destination node must also restart its response sequence number (HDLC only).
XID (C/R)	“Exchange Identification”. Used for information exchange about addresses and characteristics between two nodes (SDLC and HDLC only).
TEST (C/R)	“Test”. Allows testing the connection with another node, which must answer as soon as possible (SDLC and HDLC only).
FRMR (R)	“Frame Reject”. Indicates an error condition that cannot be recovered by a transmission of an identical frame.

The SNRM, SARM e SABM commands are used to establish the logical connection. The node that gets these commands responds with UA or DM if it accepts or if it doesn't accept the connection.

The DISC command is used to end the logical connection. The node that gets it responds with UA.

A.4.4 - FCS (Frame Check Sequence)

It is used to carry the 16-bit CRC-based error detection sequence (CCITT).

A.5 - General Structure of the Level 3 X.25 Package

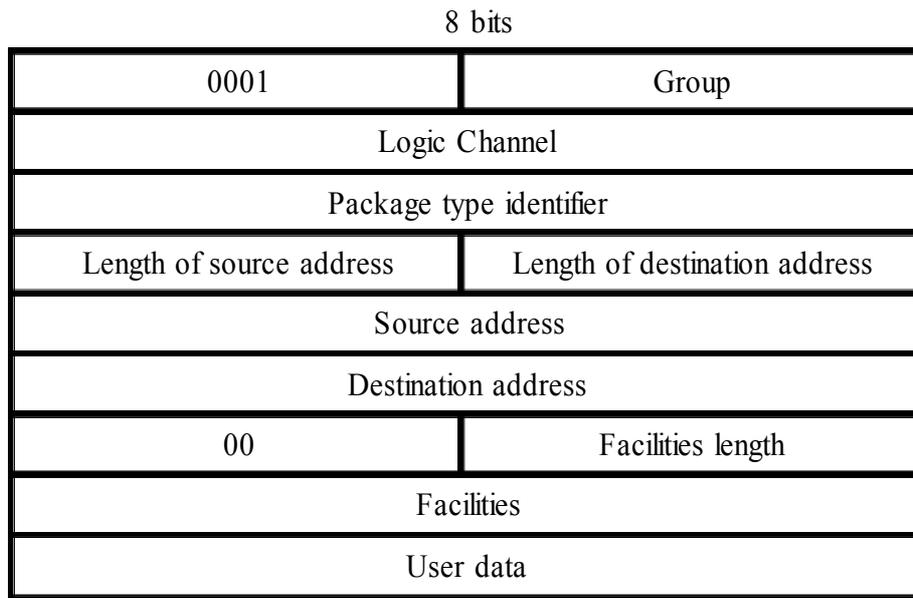
As there is package commuting, data must be delivered in certain predefined formats, according to certain rules. The first step is to establish a permanent virtual circuit (PVC) or a temporary one (SVC). Many virtual circuits can be established with one or more users. Level 3, the package level, manages of this operation.

In the X.25 recommendation there exists the datagram service option, where the information packages do not need to be preceded by the establishment of the virtual circuit. To allow the operation of multiple simultaneous virtual circuits, the logic channels are used. They are assigned to each of the virtual circuits, in the moment of its establishment.

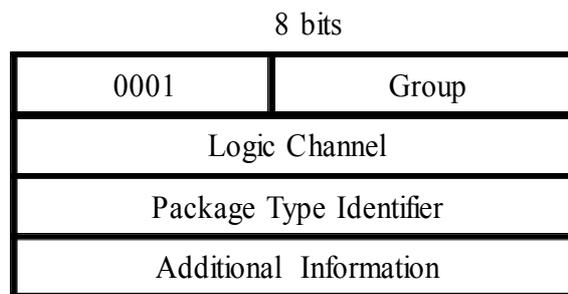
A.5.1 - Package structure

Each package must have at least three octets: a general format identifier, a logic channel identifier and a package type identifier. The package types are presented next:

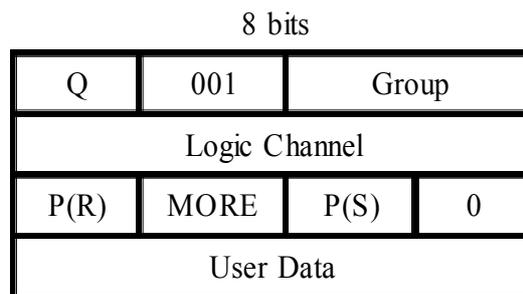
- 1) CALL REQUEST



2) CONTROL PACKAGE



3) DATA PACKAGE



The caller and destination DTE addresses have variable length. So the size of the address must be included in the CALL REQUEST package. The facilities field is used to request special characteristics for the virtual circuit, such as reverse billing. As the number of requested facilities is variable, this number must also be placed in the CALL REQUEST package.

The communication works in the following way: a CALL REQUEST package is sent. The DCE propagates this package through the network until the node where the DTE destination is located. This node gets an INCOMING CALL package. If it accepts the call, it sends a CALL ACCEPTED package, which gets to the originator as CALL CONNECTED. From then on they can exchange data packages.

At any moment it is possible to cancel the virtual circuit. To do so, any DTE must send a CLEAR REQUEST package. The corresponding local DCE responds with a CLEAR CONFIRMATION and informs to the remote DCE that the virtual circuit was cancelled. The remote DCE then sends to the DTE to which is connected a CLEAR INDICATION. This DTE then responds with a CLEAR CONFIRMATION. The CLEAR INDICATION package can contain the reason for the cancelling (busy number, defect...).

Concerning the data package, the Q field (1 bit) is used as a qualifier of two package levels, to identify to the higher protocol levels. The MORE field (1 bit) is used to indicate that the package pertains to the set of packages that represent a fragmented logic register. The P(R) field indicates the sequence number of the next package that can be transmitted and also works as an implicit ACK until the package P(R)-1. The field P (S) is a sequence number inserted by the emitter of a package to identify it.

Following are the codes for all types of packages:

From DCE to DTE	From DTE to DCE	Code
<i>Call set-up and clearing</i>		
INCOMING CALL	CALL REQUEST	00001011
CALL CONNECTED	CALL ACCEPTED	00001111
CLEAR INDICATION	CLEAR REQUEST	00010011
DCE CLEAR CONFIRMATION	DTE CLEAR CONFIRMATION	00010111
<i>Data and interrupt</i>		
DCE DATA	DTE DATA	XXXXXXXX0
DCE INTERRUPT	DTE INTERRUPT	00100011
DCE INTERRUPT CONFIRMATION	DTE INTERRUPT CONFIRMATION	00100111
<i>Flow control and reset</i>		
DCE RR	DTE RR	XXX00001
DCE RNR	DTE RNR	XXX00101
	DTE REJ	XXX01001
RESET INDICATION	RESET REQUEST	00011011
DCE RESET CONFIRMATION	DTE RESET CONFIRMATION	00011111
<i>Restart</i>		
RESTART INDICATION	RESTART REQUEST	11111011
DCE RESTART CONFIRMATION	DTE RESTART CONFIRMATION	11111111
<i>Registration</i>		
	REGISTRATION REQUEST	11110011
REGISTRATION CONFIRMATION		11110111

A.5.2 - Flow Control

To avoid jam in the network, the windows mechanism is used. The window size corresponds to the maximum number of unconfirmed packages that a DCE can have in a logic channel in a determined instant of time. Generally, the window size is 2.

This means that to send a package containing a P(R) data, the DTE or the network are

informing that they are able to receive the packages: $P(R)$, $P(R)+1, \dots, P(R)+W-1$, where W is the window size.

An RNR package (Receiver Not Ready) informs that the receiver is temporarily disabled to receive packages. The RR and REJ packages are used similarly as for level 2, with the exception that only the DTE can send REJ packages to the DCE.

There are also control packages that do not have sequence numbers. These packages are confirmed by a special package. As there are not sequence numbers, only a control package can wait for confirmation.

The RESET package reinitialises a particular virtual circuit. All the packages are removed from the circuit and $P(R)$ and $P(S)$ are zeroed. The sequence of packages is: RESET REQUEST (DTE→ DCE), RESET CONFIRM (DCE→DTE) and RESET INDICATION (DCE→ DCE). The RESTART package is similar to the CLEAR package, but it cancels ALL the DTE virtual circuits and not only one as in the CLEAR package.

Appendix B: DDCMP frame structure

DDCMP (*Digital Data Communication Message Protocol*). It is the byte-oriented communication protocol developed by DEC (*Digital Equipment Corporation*).

The process of delivery of frames for the services consists, essentially, in the sending of three types of messages: data, control and maintenance.

B.1 - Data Message

Message that carries the data of the DDCMP link. The format of the numbered message is described below.



SOH= Identifier of numbered data message (81h=129=201o).

COUNT = byte counter field.

FLAGS = link flags (bit 0 - QSYNC flag, quick sync flag / bit 1 - SELECT flag).

RESP = The number of the response message.

NUM = The number of the transmitted message.

ADDR = station address field.

BLKCK1 = numbered message header checking block.

DATA = data field.

BLKCK2 = data field checking block.

B.2 - Control Message

Message that carries the information, transmit and status channel, and notification of initialisation between the protocol modules. The message general format is described below.



ENQ = Identifier of unnumbered control message.

TYPE = Type of control message.

SUBTYPE = subtype or modified type field.

FLAGS = link flag.

RCVR = receiver control message field.

SNDR = transmitter control message field.

ADDR = station address field.

BLKCK3 = block check control message.

- Acknowledge message (ACK)



ACKTYPE = Type of ACK message with 1.

ACKSUB = Subtype of ACK message with 0.

RESP = Number of response used to acknowledge the correctness of the received message.

FILL = Byte filled with value 0.

- Not Acknowledge Message (NAK)

ENQ	NAKTYPE	REASON	FLAGS	RESP	FILL	ADDR	BLKCK3
-----	---------	--------	-------	------	------	------	--------

NAKTYPE = Type of NAK message with 2.

REASON = Reason of the NAK error. Identifies the origin and the reason of NAK.

RESP = Number of response used to acknowledge the correctness of the received message.

- Response to Numbered Message (REP)

ENQ	REPTYPE	REPSUB	FLAGS	FILL	NUM	ADDR	BLKCK3
-----	---------	--------	-------	------	-----	------	--------

REPTYPE = REP message type with 3.

REPSUB = Subtype of message REP with 0.

NUM = The number of last sequential numbered data message.

- Response of Start (STRT)

ENQ	STRTTYPE	STRTSUB	FLAGS	FILL	FILL	ADDR	BLKCK3
-----	----------	---------	-------	------	------	------	--------

STRTTYPE = Type of message STRT with 6.

STRTSUB = Subtype of message REP with 0.

- Start Acknowledge response (STCK)

ENQ	STCKTYPE	STCKSUB	FLAGS	FILL	FILL	ADDR	BLKCK3
-----	----------	---------	-------	------	------	------	--------

STCKTYPE = Type of message STCK with 7.

STCKSUB = Subtype of message STCK with 0.

B.3 - Maintenance Message

The DDCMP protocol operates in two basic modes: *on-line* or normal mode and *off-line* or maintenance mode. The maintenance message format is described below.

DLE	COUNT	FLAGS	FILL	FILL	ADDR	BLKCK1	DATA	BLKCK2
-----	-------	-------	------	------	------	--------	------	--------

DLE = Maintenance message identifier (90h=144=220o).

COUNT = Byte counter field.

FLAGS = link flags. All flags are 1's for maintenance message.

FILL = 0-filled byte.

ADDR = Station address field.

BLKCK1 = Header checking block in the DLE field by means of address.

DATA = Data field.

BLKCK2 = Checking block only in the data field.

Appendix C: Network Clear Messages

Message CCITT	DPN
CLR OCC	- call cleared - destination busy
CLR NC	- call cleared - temporary network problem
CLR DER	- call cleared - destination not responding
CLR NA	- call cleared - access barred
CLR RNA	- call cleared - collect call refused
CLR NP	- call cleared - address not in service
CLR ERR	- call cleared - local procedure error
CLR RPE	- call cleared - remote procedure error
CLR INV	- call cleared - incompatible call options
CLR DTE	- call cleared - remote directive
CLR ID	- call cleared - incompatible destination

Appendix D: Annex E from ITU-T Recommendation X.25

DIAGNOSTIC	Bits								Decimal
	8	7	6	5	4	3	2	1	
<i>No additional information</i>	0	0	0	0	0	0	0	0	0
Invalid P(S)	0	0	0	0	0	0	0	1	1
Invalid P(R)	0	0	0	0	0	0	1	0	2
	0	0	0	0	1	1	1	1	15
<i>Packet type invalid</i>	0	0	0	1	0	0	0	0	16
For state r1	0	0	0	1	0	0	0	1	17
For state r2	0	0	0	1	0	0	1	0	18
For state r3	0	0	0	1	0	0	1	1	19
For state p1	0	0	0	1	0	1	0	0	20
For state p2	0	0	0	1	0	1	0	1	21
For state p3	0	0	0	1	0	1	1	0	22
For state p4	0	0	0	1	0	1	1	1	23
For state p5	0	0	0	1	1	0	0	0	24
For state p6	0	0	0	1	1	0	0	1	25
For state p7	0	0	0	1	1	0	1	0	26
For state d1	0	0	0	1	1	0	1	1	27
For state d2	0	0	0	1	1	1	0	0	28
For state d3	0	0	0	1	1	1	0	1	29
	0	0	0	1	1	1	1	1	31
<i>Packet not allowed</i>	0	0	1	0	0	0	0	0	32
Unidentifiable packet	0	0	1	0	0	0	0	1	33
Call one-way logical channel	0	0	1	0	0	0	1	0	34
Invalid valid type on a permanent virtual circuit	0	0	1	0	0	0	1	1	35
Packet on unassigned logical channel	0	0	1	0	0	1	0	0	36
Reject not subscribed to	0	0	1	0	0	1	0	1	37
Packet too short	0	0	1	0	0	1	1	0	38
Packet too long	0	0	1	0	0	1	1	1	39
Invalid general format identifier	0	0	1	0	1	0	0	0	40
Restart or registration packet with nonzero in bits 1 to 4 of octet 1, or bits 1 to 8 of octet 2	0	0	1	0	1	0	0	1	41
Packet type not compatible with facility	0	0	1	0	1	0	1	0	42
Unauthorized interrupt confirmation	0	0	1	0	1	0	1	1	43
Unauthorized interrupt	0	0	1	0	1	1	0	0	44
Unauthorized reject	0	0	1	0	1	1	0	1	45
	0	0	1	0	1	1	1	1	47
<i>Time expired</i>	0	0	1	1	0	0	0	0	48
For incoming call	0	0	1	1	0	0	0	1	49
For clear indication	0	0	1	1	0	0	1	0	50
For reset indication	0	0	1	1	0	0	1	1	51
For restart indication	0	0	1	1	0	1	0	0	52
For call deflection	0	0	1	1	0	1	0	1	53
	0	0	1	1	1	1	1	1	63