

SR23-4130-2
Course 57287



**Field Engineering Education
Student Self-Study Course**

Synchronous Data Link Control

PREFACE

This publication is primarily intended for use by IBM personnel enrolled in course 57287.

Third Edition (June 1976)
This is a major revision of, and obsoletes SR23-4130-1.

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GENERAL INFORMATION

LEGEND

A	Address Field
bcc	Block Check Character
C	Control Field
CMDR	Command Reject (Response)
CRC	Cyclic Redundancy Check
DISC	Disconnect (Command)
DLC	Data Link Control
DTE	Data Terminal Equipment
F	Flag Field
FCS	Frame Check Sequence
GA	Go-Ahead
I	Information Type Frame or Information Field
IML	Initial Microcode Load
IPL	Initial Program Load
NDM	Normal Disconnected Mode
Nr	Receive Count Number
NRM	Normal Response Mode
NRZI	Non-Return to Zero Inverted
NS	Non-Sequenced (Frame Format)
Ns	Send Count Number
NSA	Non-Sequenced Acknowledgement (Response)
NSI	Non-Sequenced Information (Command/Response)
NSP	Non-Sequenced Poll (Command)
REJ	Reject (Command/Response)
RNR	Receive Not Ready (Command/Response)
ROL	Request On-Line (Response)
RQI	Request Initialization (Response)
RR	Receive Ready (Command/Response)
S	Supervisory (Frame Format)
SDLC	Synchronous Data Link Control
SIM	Set Initialization Mode
SNRM	Set Normal Response Mode
TEST	Test (Command/Response)
XID	Exchange Station Identification (Command/Response)

COURSE DESCRIPTION

This course provides a detailed description of the Synchronous Data Link Control (SDLC) procedures for controlling the communications link. All SDLC commands and responses are defined with typical examples of usage. Included in the course are descriptions and examples of error detection and recovery procedures.

Prerequisite

Course 50109 - General Teleprocessing Fundamentals
Course 50151 - Fundamentals of Synchronous Teleprocessing

MATERIAL REQUIRED

The FSS monitor or your branch office self-study administrator will supply you with all materials you will need to take this course.

INSTRUCTIONS TO THE STUDENT

This self-study course consists of four (4) study sessions and an evaluation session. The approximate time required to complete the course is 8.0 hours.

The local administrator will provide you with the quiz after you complete Session 4. Minimum passing score is 70%. Should you become confused as you proceed through the course:

1. Review the proceeding material.
2. Preview the next session.
3. If neither preceding suggestion helps, contact a CE knowledgeable of this subject or ask your monitor to contact STAG (Student Assistance Group).

Since this is a non-terminal self-study course, there will be no interaction with the FIS System on your part. The FSS monitor is responsible for entering your quiz answers, comments and course evaluation answers into the system via the terminal and returning your quiz results and remedial information directly to you.

A Data Collection Sheet is provided in the back of this book. The Data Collection Sheet will be used to record your quiz answers, course evaluation answers, total course hours, and comments to the author. You may want to use this sheet to record your comments while you are studying the text.

A Course Map is provided in this student guide. You should record your study time on this map after you complete each session. Your accumulated study time should then be recorded on the Data Collection Sheet at the completion of this course.

Course Length 6.0 10.0 8.0
 Low High Average

Session/Topic	Student On-Terminal Time (Estimate)	Student Off-Terminal Time (Estimate)	Student Actual Time (Filled in by student)	Monitor Terminal Time (Estimate)	Media Requirements (See legend below)	Training Machine Required*
Session 1-Introduction		0.5				
Session 2-SDLC Concepts		2.5				
Session 3-Application Situations		3.0				
Session 4-Operational and Error Sequences		1.5				
Quiz		0.5		0.2		
Time Totals		8.0		0.2		

- Legend
- | | | |
|---------------------|---------------|--------------|
| A. 16mm Motion Film | E. Microfiche | J. Simulator |
| B. 8mm Motion Film | F. Video Tape | K. |
| C. Filmstrip | G. Audio Tape | L. |
| D. Slides | H. Mock-Up | M. |

*Check if B/O Training Machine Required

SESSION 1 - INTRODUCTION

Refer to the Course Map for the approximate time to complete this session.

This session provides an overall definition of SDLC. SDLC is a procedure that specifies how the Data Link is set-up and controlled to provide data transfers between two or more Teleprocessing stations. SDLC also provides error checking and error recovery procedures for the Data Link. SDLC gets its name from that fact that each transmission is a continuous, synchronous stream of data signals for controlling the Data Link.

OBJECTIVE

Upon completion of this session, using the available documentation, you should be able to:

1. State the purpose of SDLC.
2. List the Data Link Control activities.
3. Identify the Data Link configurations.
4. State the reason for using NRZI transmission coding.

Highlights

- SDLC accomplishes information transfers via a "connected" communications channel on a link basis.
- SDLC defines the non-information transmissions for setting up, controlling, checking, and terminating the information exchanges.
- SDLC procedures define line control for point-to-point, multipoint, and loop configurations.
- SDLC does not define:
 - Initial origin (source) of a message.
 - Final disposition (sink) of a message.
 - End-to-End functions such as device control, device addressing, and record/message delimiting.
- Data Link configurations consist of a primary station and secondary stations.
- SDLC may utilize the NRZI (non-return to zero inverted) transmission coding to reduce the probability of losing bit synchronism.
- SDLC provides a Data Link Control for duplex links or half-duplex links .

Activity

Read Chapter 1 in the SDLC General Information Manual. NOTE: Disregard the comment to skip directly to Chapter 2 if you are familiar with DLC concepts. There is certain information in Chapter 1 that relates to SDLC that you probably have not seen before. Therefore, read Chapter 1 in its entirety.

Study Questions

1. Select the statement that best defines the term "Synchronous Data Link Control".
 - a. Selecting the input/output device on a link.
 - b. Controlling input/output devices.
 - c. Non-information exchanges between stations for setting up, controlling, checking, and terminating information exchanges.
 - d. Information exchanges between primary and secondary stations that perform the I/C device selection, controlling, and testing for I/O device ready conditions and I/C device error conditions.
2. (True/False) SDLC includes comprehensive detection and recovery procedures, at the data link level, for transmission errors that may be introduced by the communications channel.
3. What are the two basic Communications Channel configurations?
 - a. Half-duplex and duplex
 - b. Primary and Secondary
 - c. SDLC and Bi-Sync
 - d. Point-to-Point and Multipoint
4. List the four main two-way Data Link configurations.
 - a. _____
 - b. _____
 - c. _____
 - d. _____
5. (True/False) NRZI is accomplished by changing the level of the Send Data Lead for each zero bit and maintaining the existing state for each one bit.
6. Below is a stream of data bits. Show the up and down levels that would appear at the Send Data Lead assuming NRZI was used. Indicate an up level with a plus sign (+) and a down level with a minus sign (-). Assume that the Send Data Lead was in an up condition (+) when starting (as shown).

Data		1	1	0	0	0	0	1	1	0	0	0
Send Data	+	-	-	-	-	-	-	-	-	-	-	-

Answers

1. c
2. True
3. d
4. a. Duplex, multipoint (non-switched)
b. Duplex, point-to-point (non-switched)
c. Half-duplex, point-to-point (non-switched)
d. Half-Duplex, point-to-point (switched)
5. True
6. 1 1 0 0 0 0 1 1 0 0 0
 + + + - + - + + + - + -

SELF-EVALUATION QUESTIONS

1. Synchronous Data Link Control:
 - a. is a procedure that specifies how stations on a link will implement link control functions.
 - b. is a discipline for the management of the link to provide information transfer over a data communication channel.
 - c. is a discipline that specifies how data messages are handled by a station.
 - d. is a procedure that dictates the format of data for input/output device selection.
2. From the list below, select those items that are synchronous data link control activities.
 - a. Synchronizing the receiver to the transmitter
 - b. Selecting an I/O device
 - c. Detection and recovery from transmission errors
 - d. Controlling when sending and receiving will occur.
 - e. Specifying the original origin (source) of a message.
 - f. Reporting improper data link control procedures
 - g. I/O device control
3. (True/False) The four main data link configurations are: (1) Multipoint, duplex, (2) Point-to-Point, duplex, (3) Point-to-Point, half-duplex(non-switched), and (4) Point-to-Point, half-duplex(switched).
4. The primary reason for using NRZI coding is:
 - a. To provide ample transitions for the DTE and the modem when receiving long streams of zero bits.
 - b. To provide ample transitions for the DTE when receiving long streams of one bits.
 - c. To invert all zeros to reduce the power consumption on the communications channel.
 - d. To assure that the DTE stays in synchronization with the modem when transmitting a long stream of zero bits.

Refer to the Contents for the location of the self-evaluation question answers.

SESSION 2 - SDLC CONCEPTS

Refer to the Course Map for the approximate time to complete this session.

This session provides definitions of primary and secondary stations, transmission states, SDLC formats and sequences, and conditions that cause error recovery procedures to be invoked. Points that will be emphasized are: (1) primary/secondary station responsibilities; (2) three transmission states represent the condition of a station as defined by SDLC procedures; (3) every SDLC message is made up of groups of specific fields and is called a frame; (4) information frames can be checked for missing or duplicated frames; (5) there are three types of SDLC frames; (6) and SDLC procedures specify certain conditions that will cause "timeout" errors.

OBJECTIVE

Upon completion of this session, using the available documentation, you should be able to:

1. Identify the differences between a primary station and a secondary station.
2. List the three transmission states and relate these states to the station's Request-to-Send condition.
3. List the sequence of fields within an SDLC frame.
4. State how the send and receive counts in an information frame are used to detect missing or duplicated frames.
5. State the purpose of each field within an SDLC frame.
6. Identify the error checking capabilities included in SDLC.
7. State the purpose of zero bit insertion.
8. Identify a correct example of zero bit insertion.

PRIMARY AND SECONDARY STATIONS

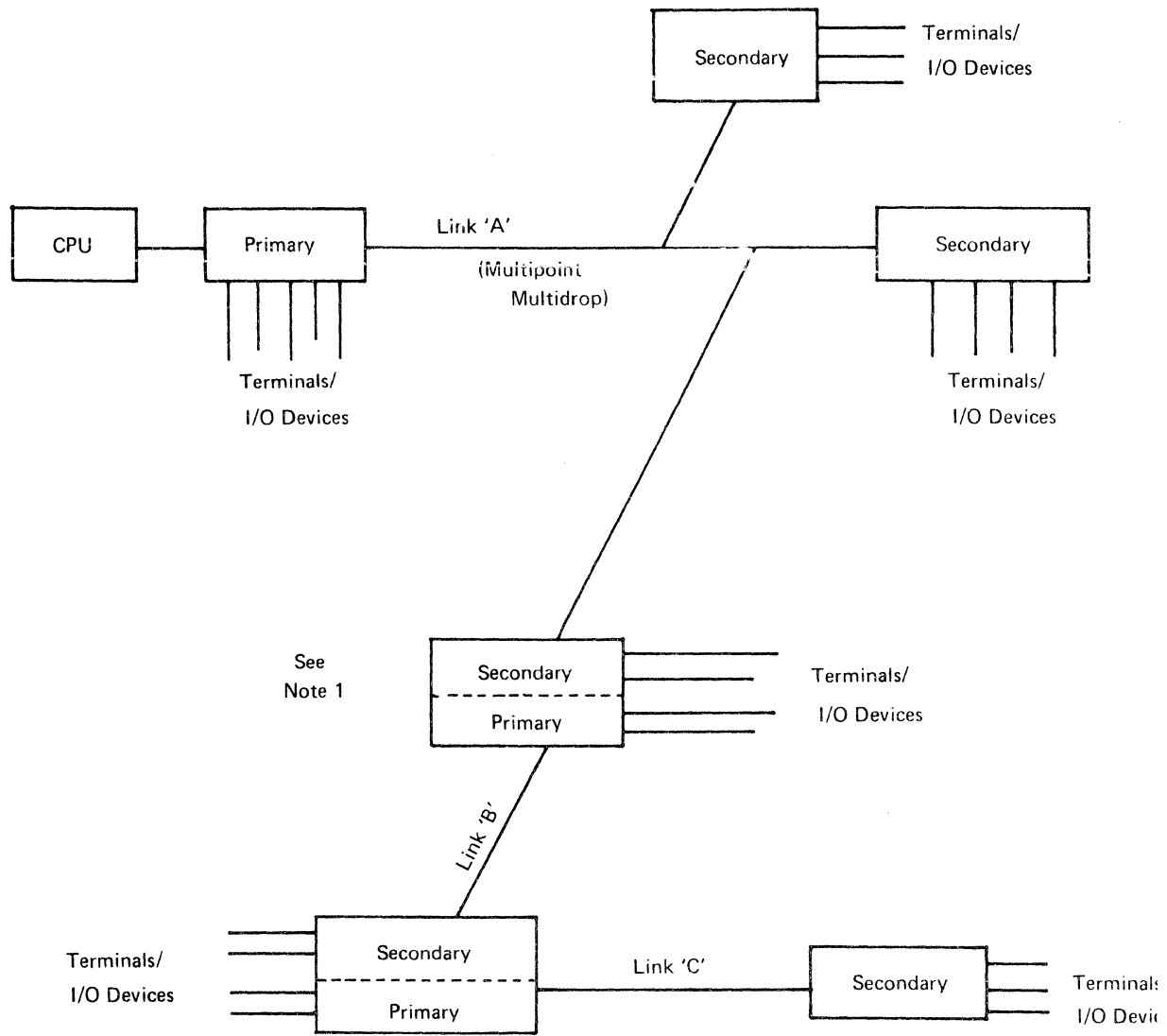
Highlights

- A data link involves at least two stations.
- The primary station is the control or commanding station.
- The secondary is the responding station.
- A station may be assigned as a secondary station for one data link and as a primary station for another data link in the same system.

Activity

Read the description of Primary and Secondary Stations in the SDLC General Information Manual, Chapter 2, Primary and Secondary Stations.

Study Figure A (in this manual). Figure A shows a somewhat complex arrangement of primary and secondary stations.



NOTE 1: This station acts as a secondary on LINK A and as a primary on LINK B.

FIGURE A. PRIMARY AND SECONDARY STATION CONFIGURATIONS

Study Questions

1. Which station has responsibility for a data link, primary or secondary?
2. (True/False) A station can act as both a primary and a secondary on two different data links.
3. (True/False) All information transfers must always be initiated by the primary station.
4. When a primary station issues a command, what is the responsibility of the secondary station.

Answers

1. Primary
2. True
3. True
4. To issue a response.

TRANSMISSION STATES

Highlights

- The condition when a station is setting up to transmit is called the Transient State.
- The condition when the communications channel, although operational, is inactive with no transmission in progress is called the Idle State.
- The condition when a station is transmitting or receiving data link control or data signals is called the Active State.

Activity

Read the description of Transmission States in the General Information Manual, Chapter 2.

Read the following:

Only one state may exist on the link at any given point in time except in the case of a duplex facility where both channels of the link are not necessarily in the same state at the same time.

Active State

In terms of modem interface, the active state corresponds to the period of time that the station has a logical Request-to-Send condition on and the modem has Clear-to-Send condition on.

NOTE: The active state is defined in terms of the transmitting station's logical Request-to-Send signal which indicates initiation or continuation of traffic. In those duplex configurations where Request-to-Send may be "strapped" or "set" to ON continuously, differentiation is made between station logical Request-to-Send and the actual modem/adaptor Request-to-Send condition.

Idle State

The idle state is defined as that period of time that the channel, although operational, is inactive with no transmission in progress. At any time the station does not have transmit priority, or has relinquished the same, it will normally revert to this state. This state corresponds to the station having logical Request-to-Send OFF.

Transient State

The transient state is defined as that period of time when carrier is being turned on initially, or reinitiated after having been previously turned off, in order to transmit.

This period normally consists of a delay between the station turning on Request-to-Send and the modem providing the Clear-to-Send signal (turn-around delay).

All stations, Primary and Secondary, maintain a steady MARK condition (no transitions, i.e., NRZI encoder disabled) on the Send Data circuit during this period.

Study Questions

1. Which transmission state is a station in when:
 - a. The station has raised request-to-send and is waiting for clear-to-send?
 - b. The station has request-to-send off?
 - c. The station has raised request-to-send and has received clear-to-send?

2. As defined in this assignment, what is the difference between logical and actual request-to-send?

Answers

1. a. transient state
b. idle state
c. active state
2. For half-duplex, there would be no difference. For duplex, logical request-to-send relates to the DTE initiating traffic whereas actual request-to-send relates to the actual signal lead condition at the modem.

FRAMES AND SEQUENCING

Highlights

- The frame is the vehicle for every command, every response, and all information that is transmitted using SDLC procedures.
- A group of contiguous frames is called a frame sequence.
- Each frame has CRC error checking within the frame.
- Each frame sequence has checking facilities to determine if any frame is missing or duplicated.

Activity

Read the section labeled Frames and Sequencing in Chapter 2 of the General Information Manual. NOTE: Do not be concerned, at this point, where the Ns and Nr counts are located within the frame. This will be covered in the next assignment along with more detail relating to the Ns and Nr counts.

Study Questions

1. What is the basic level of information grouping called?
2. What is the higher level of information grouping called?

Refer to Figure 12 in the SDLC manual to answer the following three questions.

3. (True/False) Each station (primary or secondary) has an Nr and an Ns count associated with it.
4. Assume Station B responds with an Nr count of 4. What should Station A do to recover?
5. Why should the transmitting station tell the receiving station to respond with its Nr count after transmitting 7 frames instead of waiting and asking for a response after 8 or more frames?

Answers

1. Frame
2. Frame sequence
3. True
4. Start retransmission with Frame 4
5. Since the counting capacity is 8 (0 through 7), the transmitter wouldn't know (after 8 frames) if the Nr count of 0 meant that 8 frames had been accepted or no frames had been accepted.

FRAME FORMATS

Highlights

- Each SDLC frame is enclosed in "flags".
- Every SDLC frame contains an 8 bit address field (address of the secondary station).
- Every SDLC frame contains an 8 bit control (command or response) field.
- Every SDLC frame contains a 16 bit CRC field called the FCS (Frame Check Sequence).
- SDLC information frames also contain an Information (I) field. The information field is not restricted in content.
- Zero bit insertion occurs on all data in the frame between flags.

Activity

Read the section labeled Frame Format (F,A,C,I,FCS,F) in the SDLC General Information Manual, Chapter 2. NOTE: Do not start reading the section labeled Timeouts until directed to do so in the next assignment.

The following will provide review, re-inforcement, and a summary of the information you have just read in the General Information Manual.

Please read the following:

- SDLC will always have the following "Frame" format:

--- F,A,C,I,FCS,F ---

Frames may be contiguous as follows:

--- F,A,C,I,FCS,F,A,C,I,FCS,F,A,C --- etc.

"F" is the 8 bit "Flag" character that delineates the beginning or ending of a frame. The flag character has the bit configuration of 01111110; this bit sequence is never allowed on the line at any time except to indicate a flag. A procedure called "Zero Insertion", which is explained later, is used to prevent data, FCS, etc., from ever having a "01111110" bit sequence.

"A" is the 8 bit address of the secondary station and is present in transmissions to or from the secondary station. This address applies only to the station and does not select any I/O, Reader, Punch, Printer, etc.

"C" is the 8 bit Control/Response Field. It is a "Control" field if it is sent by the primary station to the secondary station. It contains frame numbering and acknowledgements as well as Control (Command) Information for the Secondary Station. It is a "Response" field if it is sent by the secondary station to the primary station. It contains frame numbering and acknowledgements as well as responses to primary station "Control" transmissions.

The "C" Field definition depends on whether a "Primary" or "Secondary" station transmitted it. For example: "SIM", Set Initialization Mode, Sent by the Primary Station has the identical bit configuration as "RQI", Request Initialization Mode, which is sent by the secondary station. (NOTE: Commands/Responses will be covered in the next session).

"I" - Following the "C" field there may be an information field that contains text or status. This field is required for some transmissions and is not allowed for others depending on the "C" field. IBM is using 8 bit increments in this field for both text and status.

"FCS" - The FCS (also sometimes referred to as the bcc) is a 16 bit Cyclic Redundancy Check (CRC).

Included in the transmitted FCS are the following:

- A - The Address Field
- C - The Control Field
- I - The Information Field (if present)

Any "inserted zeros" that may appear on the send data lead, are not included in the FCS computation.

The transmitting station complements (inverts) the FCS before it is transmitted.

The receiving station combines the received FCS with its own accumulated FCS in a manner that always results in Hex 'F0B8' left in the CRC register (assuming no error occurs).

"F" - The End Flag is exactly like the beginning flag and in fact, it may be the beginning flag of the next frame. The ending flag indicates that the previous 16 bits was the FCS and the CRC should now be Hex 'F0B8'.

- Zero Insertion - It was stated earlier that the flag had a bit sequence of 01111110 (Hex '7E') and that this sequence was never allowed on the Data Link except when a flag was intended. This is accomplished by inserting a zero after every fifth contiguous 1 bit (except flags) at the transmitting station and deleting it at the receiving station. For example: if the primary had the following bits to be sent (first line), the second line is what would actually be sent.

```

1st ....00 01100111 10001111 10111111 11111111 11--
2nd ....00 01100111 10001111 1001111101 111101111 101-
3rd ....00 01100111 10001111 10111111 11111111 11--

```

The underlined 0's of line two were inserted at the transmitting station and deleted at the receiving station. The third line is what actually goes to Buffer, (Output, etc.) at the receiving station and is exactly the same as the first line.

- An example of an implementation of SDLC using hardware controls is as follows:
 - a. Transmit the Flag
 - b. Turn on the Zero Insertion Circuitry
 - c. Transmit the Address
 - d. Transmit the Control
 - e. Transmit the Text
 - f. Transmit the FCS
 - g. Turn off the Zero Insertion Circuitry
 - h. Transmit the Flag

An example of an implementation using software controls would be similar to the above except for the following:

1. The software must count contiguous ones and insert the zero when transmitting.
2. The software must count contiguous ones and remove the inserted zero when receiving.

Note that counting of contiguous ones is not concerned with byte or character boundaries and that Zero Insertion is done for the Address, Control, Text (if any), and the FCS.

- Transparency - An inherent characteristic of Zero Insertion is that it provides full transparency all the time. Any bit pattern can be sent as data without any special action as zero insertion is active for everything except 'Flags' (and as will be shown later, for the Abort pattern).

- NRZI - Non Return to Zero Inverted

Data clocking that depended on transitions in the data would have trouble staying in sync with long strings of zeros or ones. This is true for business machine or modem clocking. SDLC uses Zero Insertion and NRZI to insure that there can never be more than six (6) bit times without a transition during Address, Control, Text, or FCS.

NRZI is accomplished by changing the level of the Send Data Lead for each zero and maintaining the existing state for each one.

For example:

```
Data          . . . 1 1 0 0 0 0 1 1 0 0 . . . Etc
Send Data     . . + + + - + - + + + - + . . . Etc
```

The Send Data was arbitrarily started at plus (+) for this example.

OR

```
Data          . . . 1 1 0 0 0 0 1 1 0 0 . . . Etc.
Send Data     . . - - - + - + - - - + - . . . Etc.
```

The Send Data was arbitrarily started at minus (-) for this example.

Zero Insertion ensures that the line can never be all ones and NRZI changes the state of the lines for each zero. Therefore the line will have transitions often enough for proper operation of the clock correction circuitry and the communication facilities.

For example:

```
Data          . . . 1 0 0 0 0 0 0 0 0 0 . . .
*Send Data    . . + + - + - + - + - + - Etc.
```

For all ones data the Send Data Line will be as follows:

```
Data          . . . 0 1 1 1 1 1 1 1 1 1 1 1 . . .
0's Inserted  . . . 0 1 1 1 1 1 0 1 1 1 1 1 0 1 1 . . Etc
*Send Data    . . - + + + + + + - - - - - + + + . . .
```

*Send data starting level arbitrarily chosen.

0 underlined zeros inserted by the transmitting station.

- There are three types of Frames:
 1. Information frame - used for data transfer
 2. Supervisory frame - used for flow control
 3. Non-sequenced frame - used for link control

NOTE: Both the supervisory and non-sequenced frames will be described in detail in the next session.

- The address field of the SDLC frame always specifies the address of a secondary station. For example, if a primary station is sending data to a secondary station, the address will be the assigned address of the secondary. Also, if a secondary is sending data to the primary, the address in the frame is still the assigned address of the secondary.
- The primary station can send data to the secondary at any time whereas the secondary station must be polled by the primary before the secondary can send data.
- Study Figure 16 in the SDLC General Information Manual. Notice that this represents the Control Field of the SDLC frame (8 bits). The (first sent)/(last sent) indicates the sequence of sending the bits on the communications channel.

Bit 7 specifies that the frame is either an information frame or a supervisory/non-sequenced frame.

If bit 7 is a one, then bit 6 indicates supervisory or non-sequenced. Bits 0, 1, 2 and 4, 5, 6 of the Information Transfer frame are used for the receive and send counts, respectively. With three bits, a count of 0 - 7 is possible, thereby, limiting the send or receive counts to 8. Recall that the counts are used to check for missing or duplicated frames by comparing the transmitter's send count with the receiver's receive count. For the Nr, bit 0 is the high order bit and bit 2 is the low order bit. For Ns, bit 4 is the high order bit and bit 6 is the low order bit.

Bit 3 is either a poll bit or a final bit depending on who is sending the frame. If the frame is going from the primary station to secondary station and bit 3 is on, it is a poll request to the secondary. If the frame is going from the secondary to the primary station and bit 3 is on, it is a final bit and indicates that this is the last frame of this sequence.

The remaining bits for the supervisory and non-sequenced formats are used for control purposes. In the next session of this course, we will examine each of these control functions.

- Study Figure 17 in the SDLC General Information Manual.

First consider the half-duplex operation, Figure 17A. Each division with the number above it represents an SDLC frame. The number represents the Ns count within the control field of that frame. The number in parenthesis represents the Nr count.

The primary station signals the secondary that a response or confirmation of frames received is required by turning on the poll bit in the control field. In Figure 17A this is shown by the letter "P". The secondary responds with an Nr count of one greater than the number of frames received since the previous poll bit. This is shown in Figure 17A as Nr=4. Recall that the primary and secondary

both have Nr and Ns counts. Therefore, when the secondary sends a response to the poll, it also sends an Ns count. Figure 17A arbitrarily started with counts of zero and shows the secondary responding with two frames (0 and 1). Frame 1 has the final bit on.

To aid in understanding the timing relationship between the Nr/Ns counts between primary and secondary, study Figure B (in this manual) while reading the following:

Assume the counts are all zero at the beginning. The primary sends a frame to the secondary. The primary Nr and Ns counts are both zero and the poll bit is off (indicated by the line over the P). After sending the first frame, the primary steps its Ns count to 1. When the secondary receives the frame, it does two things. It checks for CRC errors and compares the received Ns count against its Nr count. If a CRC error has occurred or the counts do not match, an error is recognized by the secondary and it does not advance its Nr count. However, if no errors are detected, the secondary increments its Nr count by one as soon as it has accepted the received frame.

This continues until the primary sends a frame with the poll bit on. This is shown in Figure B as the last frame sent by the primary. After accepting this frame, the secondary steps its Nr count by one and sends a response to the primary. Notice at the time of this frame the secondary Ns count is 0. The primary has the responsibility for comparing the secondary Nr count to the primary Ns count to determine if any sequence errors have occurred. The primary also is responsible for retransmitting any frames that might be required.

Now consider the other condition as shown in Figure 17B, i.e., duplex operation. The operation is similar to half-duplex, except for the timing relationship of primary and secondary, i.e., both can be transmitting and receiving at the same time. Figure 17B shows the primary starting off with a poll frame. This will allow the secondary to transmit Information frames to the primary. Looking back at Figure 16, notice that the Nr and Ns counts are always part of the Control Field of Information Transfer Formats. Therefore, each Information transfer frame will also confirm the frames that have been received. The primary and secondary continually confirm received frames during duplex operation.

Detecting missing or duplicated frames (during duplex operations) is performed in exactly the same fashion as explained previously for half-duplex, i.e., by comparing Nr/Ns counts, except the timing relationship for duplex is more complex. This relationship can be best shown by examples and therefore will be left for later in this course when examples of all operations are given.

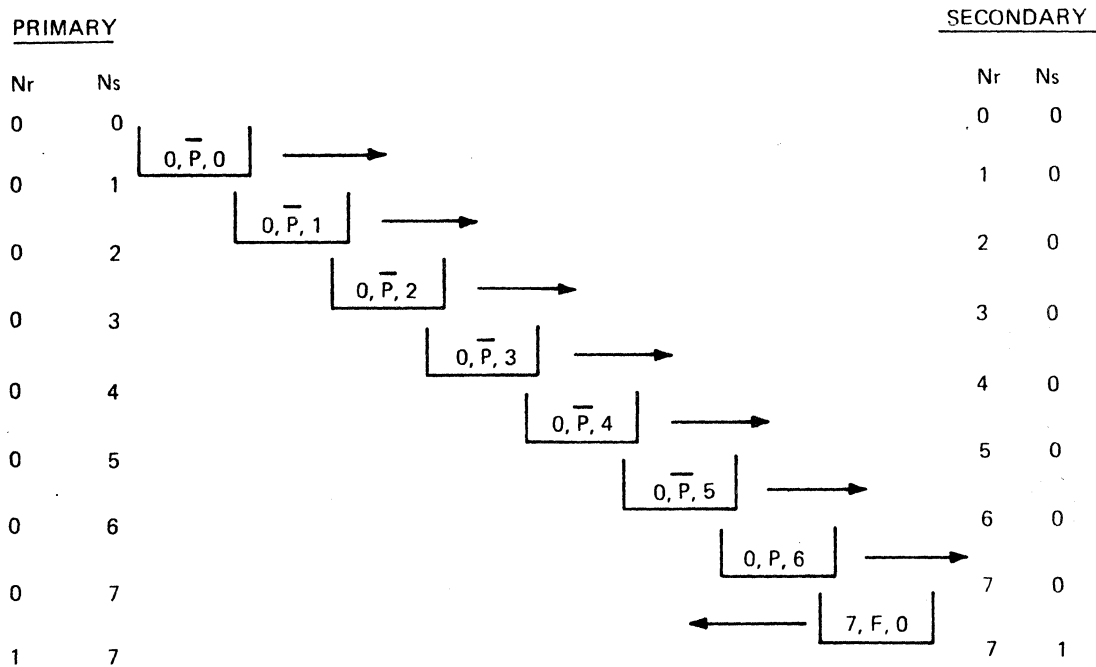


FIGURE B. FRAME SEQUENCE CHECKING

Study Questions

1. What is the binary bit configuration of the FLAG character?
2. (True/False) An SDLC frame always starts and ends with a Flag character.
3. (True/False) The sequence of frame fields is FLAG, CONTROL, ADDRESS, INFO, FCS, FLAG.
4. What is the purpose of the poll bit?
5. What does the final bit (being on) indicate to the primary station?
6. How many binary bits are used for the FCS field?
7. Assuming no CRC errors occur, what is the Hex value of the FCS (bcc) after the receiving station combines the received FCS with its own accumulated FCS?
8. Assume the transmitting station had the following data bits to send: 01111111001111111111100. Show the bit pattern that would appear on the Send Data Lead assuming zero insertion was operative (and NRZI was not active).
9. What is the basic purpose of an Information type frame?
10. Assume the address of the primary station is Hex 32 and the Address of a secondary station is Hex 6F. When the secondary is transmitting to the primary, what is the Hex address that appears in the Address Field of the SDLC frame?
11. Which bit in the control field of the frame specifies that the frame is either an Information Transfer frame or supervisory frame?
12. Assume the primary station has sent six frames to a secondary station. All frames are the Information Transfer format and the primary's Ns count was three (011, binary) prior to sending the six frames. If the poll bit was on in the sixth frame, what will be the Nr count sent back to the primary from the secondary? (Assume normal, no error, operation and half-duplex Communications Channel).

Answers

1. 01111110
2. True (with one exception, "abort", which will be covered in the next assignment).
3. False - The fields ADDRESS and CONTROL are reversed in the question.
4. Invites or requires the secondary station to transmit.
5. That the frame with the final bit on is the last frame of a sequence.
6. 16

7. FOE8
8. 01111101100111110111110100
9. Transfer data
10. Hex 6F
11. Bit 7
12. Nr=1 (001 binary)

TIMEOUT CONDITIONS AND RECOVERY PROCEDURES

Highlights

- The primary station has the responsibility to check for secondary responses within time limits.
- Idle Detect results when a secondary response does not occur within a specified time after the primary has polled the secondary.
- Non-productive Receive is the name for the situation where the response is received but is not intelligible.
- The counting of retry or retransmission attempts is not specified by SDLC procedures.
- The function of prematurely terminating a data link is called "abort".
- Recovery from data link impasse is normally accomplished by retransmission or manual intervention.

Activity

Read the sections Timeouts, Retry Counts, Abort Conditions, and Recovery from Data Link Impasse in the SDLC General Information Manual, Chapter 2.

Study Questions

1. What are the two basic timeouts operated by a primary station?
2. What is the timeout condition called that results when a secondary station fails to respond to a frame from the primary with the poll bit on?
3. What is the timeout condition called when the secondary responds to a poll but the response is unintelligible?
4. Does SDLC procedures specify how many retransmissions (retries) should occur before it is considered non-recoverable at the data link level?
5. Is zero bit insertion active when an abort character is transmitted on the communications channel?

Answers

1. Idle detect and non-productive receive.
2. Idle Detect
3. Non-productive receive
4. No
5. No

SELF-EVALUATION QUESTIONS

1. A primary station:
 - a. is the only station on a link that can transmit its Ns count.
 - b. must always respond when polled by a secondary station.
 - c. must always be located at the host CPU location.
 - d. issues control commands to other primary stations on the same data link.
 - e. has the responsibility for controlling the flow of data on the data link.
2. What are the three transmission states that a station may be in?
3. Listed below are three conditions of a station's request-to-send and clear-to-send leads. Match each of these conditions to the corresponding transmission state of a station.

a. Request-to-Send on,	1.	Active State
Clear-to-Send on	2.	Inactive State
b. Request-to-Send off,	3.	Transient
State		
Clear-to-Send off	4.	Error State
c. Request-to-Send on	5.	Insertion
State		
Clear-to-Send off	6.	Idle State
4. List the five fields, in proper sequence, that make up an SDLC frame.
5. How are the send (Ns) and receive (Nr) counts in the information transfer frame used to detect missing or duplicated frames?

6. Listed below are the five fields of a frame. Match the descriptions with the field it best describes.
- | | |
|----------------|--|
| a. Flag | 1. A 16 bit field used to check for CRC errors. |
| b. Address | 2. A character having a bit configuration of 01111110 used to indicate the beginning and end of a frame. |
| c. Control | 3. The data field |
| d. Information | 4. The field used to indicate which secondary station the frame is for. |
| e. FCS | 5. The field used to specify what the secondary is supposed to do. |
7. From the list below, select the items that are considered error checking features of the SDLC.
- CRC (FCS)
 - Parity Checking
 - Frame Sequence Counting
 - Timeouts between a poll and a response
 - Zero bit insertion
 - Error Correction Code (ECC)
8. What are two basic reasons for using zero bit insertion?
9. Assume zero bit insertion is active (and NRZI is inactive). The following bit stream is to be transmitted: 01111001111110. Select the answer that reflects the bit stream as it would appear on the Send Data lead after the zero bits have been properly inserted.
- 0111010011101110
 - 011110011111010
 - 001111000011111100
 - 01111001111110

Refer to the Contents for the location of the self-evaluation question answers.

SESSION 3 - APPLICATION SITUATIONS

Refer to the Course Map for the approximate time to complete this session.

This session provides a description of:

- Secondary station modes of operation
- SDLC commands and responses
- Loop Applications

OBJECTIVE

Upon completion of this session, using the available documentation, you should be able to:

1. List the secondary station modes of operation.
2. State the purpose of each command and response.
3. Determine if a specific bit pattern will be a command or will be a response.
4. List the conditions that will cause a command reject response.
5. State the command/response sequence in a loop configuration.
6. List the conditions needed to transmit data from a secondary to the primary station in a loop configuration.

SECONDARY STATION MODES

Highlights

- A Secondary Station's activity is conditioned by its mode status.
- A Secondary Station may be in one of three modes: normal response mode, normal disconnected mode, or initialization mode.
- Procedures for initialization mode are specified by the using system.
- Normal response mode and normal disconnected mode are governed by SDLC procedures.

Activity

Read Secondary Station Mode Definitions in the SDLC General Information Manual, Chapter 3.

Study Questions

1. (True/False) A Secondary in NRM may initiate unsolicited transmissions.

2. (True/False) A Secondary Station in NDM is off-line and cannot respond to any command from the primary.
3. A Disconnect command from the primary puts the secondary in what mode? _____
4. What mode does a secondary usually assume immediately after power has been applied to it?

Answers

1. False
2. False
3. Normal Disconnected Mode (NDM)
4. NDM

COMMANDS AND RESPONSES

Highlights

- There are three types of "C" field formats: Non-sequenced, Supervisory, and Information.
- Non-sequenced frames are not sequence-count checked. (Do not use Ns or Nr counts).
- Non-sequenced frames are used for commands, responses, and to move data from station to station.
- Supervisory frames are used for commands, responses, and confirmation of sequenced frames. (The Nr count is included in the "C" field).
- Information frames are the only frames that are sequence-count checked.
- Information frames are used to move data from station to station. No commands or responses are included within the information frame other than the poll or final bit.

Activity

This assignment will be accomplished in a somewhat different sequence from the previous assignments, i.e., you will be given a reading assignment in this self-study text first, and then be given a reading assignment in the SLLC General Information Manual.

- Please read the following:

Recall that every SDLC transmission is made up of frames. Each frame has fields, e.g., flag, address, etc. The "C" or Control Field of an SDLC frame specifies the type of frame it will be. Look back at Figure 16 in the SDLC General Information Manual. Notice that the "C" field specifies one of three possible types of frame formats. The "C" field consists of 8 binary bits. Bits 6 and/or 7 indicate the format type. Let's consider each of the three formats individually and see what the remaining bits are used for.

Information Transfer Format (Bit 7 = 0) - In a previous assignment we saw how the Nr and Ns bits were used for sequence checking of frames, therefore, we will not spend any more time on that now. Recall that the Poll/Final bit (bit 3) is used to signal the receiving station that a response is requested (Poll) or that this is the final frame of a transmission (final bit). This bit is used in the same way for all three format types.

Non-Sequenced Format (Bits 6 and 7 = 11) - Before any information can be sent between stations, certain modes of operation at the secondary station must be established, as seen in the previous assignment. Notice in Figure 16 there are five binary bits available for commands and responses (bits 0, 1, 2, 4 and 5) and are used, among other things, for mode setting.

The non-sequenced format is used to perform data link control functions and to provide a means for information transfer without regards to either an Ns or Nr sequence count. Ns and Nr sequence counts are not used for the transmission or receipt of a Non-sequenced format and as a result Non-sequenced commands/responses are not sequenced checked when received or acknowledged via a corresponding receive sequence count (Nr).

A Non-sequenced command is acknowledged by the secondary station only if it is received without error and has the poll bit ON (this is true for Information and Supervisory formats also).

Examine Figure 21 in the SDLC General Information Manual. Notice the binary structure and the list of commands/responses for the NS format. The following will describe each command and response.

Non-Sequenced Information (NSI)

Used to perform a non-sequenced information transfer or non-sequenced poll from primary to one or more secondary stations. The transmit (Ns) and receive (Nr) sequence counts are not affected by the transmission/receipt of this format. The Information field starts immediately after the last bit of the "C" field. The NSI may also be used to perform non-sequenced information transfers from a secondary to the primary.

Set Normal Response Mode (SNRM)

This command places the addressed secondary station in a Normal Response Mode (NRM) in which secondary station transmission (I/S/NS) is initiated only following the receipt of a frame with the Poll bit ON. Asynchronous (unsolicited) responses are not permitted. No information field is permitted with this command.

The SNRM command must have the Poll bit ON. Upon receipt of this command the secondary station will assume NRM (normal response mode) and confirm acceptance by the transmission of a Non-Sequenced Acknowledge (NSA) response with the Final bit ON. Following acceptance of this command the station sequence counts, Nr and Ns, are reset to zero values. If an SNRM command is received error free (good FCS) and the Poll bit is not ON the command will result in a command reject (CMDR) (except if in a Disconnected State) and the command is ignored (no mode change or reset). (NOTE: CMDR will be described later).

When in NRM the secondary station sets the final bit ON in the last frame transmitted as a result of a previous poll type frame. As the result of turning the final bit ON the secondary station relinquishes its right to transmit on the inbound channel until it receives a subsequent poll type frame.

Once entered, this mode continues in effect until changed by a DISC or SIM command from the primary station. A secondary station coming on-line (power-on/switched line/"off-hook") usually assumes NDM.

Non-Sequenced Acknowledge - (NSA)

This response is initiated by the secondary station to acknowledge the receipt and acceptance of a non-sequenced format command that has the Poll bit ON. It may also be used as the "no-traffic" pending response to an NSP command. (NSP command is covered in a later assignment). No information field is permitted with this response, and the final bit must be ON.

Request Initialization (RQI)

Used by the secondary station to request appropriate IPL (Initial Program Load) or IML (Initial Microcode Load) initialization data from the primary station required to become operational following power-on or loss of the secondary program. The transfer of basic "bootstrap" IPL/IML data must be accomplished in initialization mode. Therefore the only primary command accepted after issuing this request is a SIM.

Set Initialization Mode (SIM)

Used by the Primary station to initiate basic IPL/IML functions in the secondary station. This command/mode is provided for those cases where normal operation within normal response mode is not possible. In those secondary

stations that have a local IPL/IML capability, the SIM command will initiate a local IPL/IML. In those secondary stations which require IPL/IML data via the communications link, the SIM command will identify all data received in this mode as IPL/IML data. For this case the use of initialization mode is restricted to minimum "bootstrapping" data sufficient to restore/initialize the secondary station to a level of capability that permits operation in NRM.

Specifically this command is not to be used to initiate reconfiguration or new applications on an operable station. This type of function must be accomplished via normal information type messages.

Once initialization mode is entered, the actual initializing (IPL/IML) information is transferred via I or NSI format frames. Due to the exception nature of this mode, the normal requirements for response characteristics may vary, i.e., response time, established protocol, etc., during the time of information transfer.

An information field is prohibited with this command and the Poll bit must be CN. An NSA response will confirm acceptance.

The initialization mode will be terminated by the transmission and acceptance of a SNRM or DISC command as appropriate.

Disconnect (DISC)

This command places the addressed secondary station in a logically disconnected state. No information field is permitted in this command format. The acceptance of this command does not reset the station Ns and Nr sequence values.

The DISC command must have the poll bit ON. Upon receipt of this command the secondary station will confirm acceptance by the transmission of a Non-Sequenced Acknowledge (NSA) response with the final bit CN. If a DISC is received error free (good CRC) but the poll bit is OFF, the command will result in a CMDR being established (except if already in a disconnected state) and the command is ignored.

Following the acceptance of a DISC command the secondary station may optionally reinitialize, i.e., appear on line in either Normal Response Mode (NRM) or Normal Disconnected Mode (NDM) depending upon the initializing capabilities of the secondary station.

Request On Line (ROL)

Used by the secondary station to request an on line status when in a disconnected state, i.e., normal disconnected mode. The ROL indicates that the secondary station is in a disconnected state.

This response must have the final bit ON and no information field is permitted.

Non-Sequenced Poll (NSP)

This command is normally utilized in a Loop Application and will be described in the next assignment of this course.

Command Reject (CMDR)

Used by the secondary station to report that a system programming or hardware problem has been detected that resulted in:

1. The receipt of a command code in the 'C' field of an error free frame that is invalid or not applicable (not implemented) to that secondary station.
2. The information field of a received error free frame was too long to be accommodated by the buffer available/assigned (buffer overflow) in the secondary station. NOTE: Reporting this condition via the CMDR is optional with secondary station implementations. If CMDR is not used to report this condition the received frame is treated as valid from the SDLC point of view and suitable error reporting and recovery procedures are required by higher level function.
3. The receipt of an invalid Nr sequence count in an error free, in sequence (valid Ns count) frame as described in the following paragraph.

Should the Nr count received by a primary or secondary station point to an information frame that has previously been transmitted and confirmed or to an information frame that has not been transmitted and is not the next sequential frame scheduled for transmission (Nr confirms a frame that has not as yet been transmitted), a system error condition exists, e.g. programming logic error, hardware malfunction. In the case of a secondary station the exception condition is reported to the primary station via a command reject (CMDR) response. In any event, the primary station is responsible to resolve the situation by initiating appropriate error recovery action.

The final bit must be CN. The command reject exception condition is maintained and the CMDR response is transmitted at each respond opportunity until it is reset by the receipt of a SNRM, DISC, or SIM command.

A CMDR response must include a 24 bit information field to provide the necessary status to specify the reason the CMDR exception was established. The format of the status field is shown in Figure 22 in the SDLC General Information Manual. Note that the bits are shown, in Figure 22, from left to right in the order they would appear on the communications channel.

The following defines each byte of this information field:

1st Byte - exact duplication of control field that caused the CMDR exception to be established.

2nd Byte - the secondary station send (Ns) and receive (Nr) sequence counts that exist immediately prior to establishing the CMDR exception.

3rd Byte - the reason for the CMDR exception where:

w = the 'C' field received and returned in the 1st byte represents an invalid or non-implemented command.

x = the 'C' field received and returned in the 1st byte was considered invalid because the frame contained an information field which is not allowed with that specific command. For example if the 'C' field was a supervisory or non-sequenced format for which no information field is permitted. Bit w above (invalid 'C' field) must be ON in conjunction with this bit.

y = the information field associated with a valid format was too long for the assigned/allotted buffer provided. The frame was not accepted. This bit is mutually exclusive with bit w above, i.e., never turned on for an invalid/non-implemented 'C' field. Use of CMDR for this reason is a system option. If other means are provided to indicate the occurrence of buffer overrun, the specific frame may or may not be acknowledged (via the Nr value) depending upon the system recovery provided.

z = the Receive (Nr) sequence count contained in the 'C' field which is returned in the 1st byte above is "out of range" as described previously. This bit is also mutually exclusive with bit w above.

Test (TEST)

A TEST Command may be issued by the Primary station to a Secondary station to perform a check of the SDLC link. The test frame may include an Information field. The Secondary station should respond with a TEST Response frame and (if the Secondary has the capability), wrap the Information field back to the Primary.

If a command reject condition exists at the Secondary when the TEST Command is received, the TEST Command is ignored and the CMDR Response is returned.

Exchange Station Identification (XID)

This Command/Response is normally used in a Switched Network Application (but is not restricted to only switched networks).

An XID Command is issued by the Primary station to solicit an XID Response which provides the Station Identification of the addressed Secondary station. An Information field is optional with this command. If an Information field is present, its contents are the Primary station's ID. Upon receiving an XID Command, the Secondary station will respond with an XID Response. An Information field in the response will contain the Secondary station's ID.

The station ID is a 48 bit field that identifies various characteristics of the station.

The following describes the third type of frame format.

Supervisory Format (Bits 6 and 7 =01)

Again refer to Figure 21 in the SLLC General Information Manual. Look at the commands and responses for the "S" format.

The supervisory format is used by the primary to acknowledge secondary I frames, to request retransmission of the secondary station I formats and to inhibit the secondary from sending I frames. The secondary uses this format to acknowledge primary I frames, to request retransmission of primary station I formats and to inform the primary it cannot accept additional I frames until the condition that prevents accepting any more I frames is cleared.

This format does not have an information field.

The Nr field contains the contents of the station's receive sequence count and informs the other station that frames with sequences thru Nr-1 are acknowledged. The transmission and/or receipt of frames with supervisory format do not increment the Ns or Nr sequence counts.

The supervisory commands/responses are defined as follows:

RR (Receive Ready)

The originating station acknowledges information format frames with sequence counts through Nr-1 and is ready to receive additional transmissions.

REJ (Reject)

The originating station did not receive/accept the frame with an Ns corresponding to the Nr count contained in this command/ response due to a sequence error in the received Ns count. A retransmission starting with the I frame corresponding to Nr is required. Frames Nr-1 are acknowledged.

REJ is normally employed by stations that have duplex information transfer capability and are operating with a station that has similar capability. It is transmitted by the station when it is actively transmitting when the sequence error condition is detected and is inserted in the transmit stream. Pending traffic may be transmitted immediately following the REJ response in which case the final bit in the REJ frame is OFF.

The REJ response is transmitted one time for a given exception condition. Only one exception condition is established at any given time. The exception condition is cleared (reset) upon the receipt of an I frame with an Ns count equal to the existing Nr (receive count) of the station.

RNR (Receive Not Ready)

The initiating station indicates it has a "busy" condition and cannot receive additional I or NSI frames that require receive buffers at this time. Frames Nr-1 are acknowledged. Frame Nr, if any, and subsequent frames were not accepted.

A secondary station receiving this command when in the process of transmitting (duplex secondary) is to stop transmitting at the earliest possible time by completing the frame in process. If a final type frame is required, a supervisory RR or RNR with the final bit on must also be transmitted. If a secondary transmission is not in progress and the RNR Poll bit is ON, the secondary station must respond with an appropriate S/NS format.

A primary station receiving this response when in the process of transmitting to that secondary station (duplex secondary) uses the same procedures as described above for terminating transmission except that no additional transmission is necessarily required. A primary station may use this command to solicit a response from the secondary station when input traffic is not desired by setting the Poll bit ON.

Following the receipt of an RNR, the station receiving it will not transmit additional traffic (I/NSI formats) until the condition is reported as cleared by the receipt of one of the following:

- An RR command/response with the Poll/Final bit either ON or OFF
- An I format that has the Poll/Final bit ON.

Study Figure C in this manual. This figure provides, in chart form, the proper responses that should be expected to each command. (After studying the chart, return to this point and read the next paragraph).

Now that you have gone through a detailed description of the 'C' field commands and responses, a brief review is in order. Read the section in Chapter 3 of the SDLC General Information Manual entitled "Command and Response Definitions". This will provide a good review of the subject.

<u>Primary Command (poll)</u>				<u>Expected Secondary Response</u>
NSI	-	-	-	I, NSI, NSA, RR, RNR, RQI, or ROL
SIM	-	-	-	NSA
SNRM	-	-	-	NSA
DISC	-	-	-	NSA
NSP	-	-	-	I, NSI, NSA, RR, RNR, RQI, or ROL
RR	-	-	-	I, NSI, RR, RNR, RQI, or ROL
RNR	-	-	-	RR, RNR, RQI, or ROL
REJ	-	-	-	I
I	-	-	-	I, RR, or RNR
TEST	-	-	-	TEST
XID	-	-	-	XID

<u>Secondary Response</u>					<u>Expected Primary Command</u>
NSI	-	-	-	-	I, NSI, NSA, RR, or RNR
RQI	-	-	-	-	SIM
ROL	-	-	-	-	SNRM
NSA	-	-	-	-	I, NSI, RR, or RNR
CMDR	-	-	-	-	SNRM, DISC, or SIM
RR	-	-	-	-	I, NSI, RR or RNR
RNR	-	-	-	-	RR or RNR
REJ	-	-	-	-	I
I	-	-	-	-	I, RR, or RNR

FIGURE C. - COMMANDS AND RESPONSES

Study Questions

1. What are the three (3) possible types of SDLC frames?
2. What is the bit configuration of bits 6 and 7 in the 'C' field of the NS format frame?
3. (True/False) The NS format provides a means for information transfer without regards to either an Ns or Nr sequence count.
4. What is the purpose of the SNRM command?
5. What is the normal response to a SNRM command with the poll bit ON?
6. What is the only acceptable command from the primary after a secondary has responded with RQI?
7. In those secondary stations that have a local IPL/IML capability, what does the SIM command do?
8. Which command places the addressed secondary station in a logically disconnected state?
9. What is the minimum number of I field bits necessary to provide the complete status for the CMDR response?
10. What commands will reset a CMDR condition in a secondary station?
11. Which of the three (3) SDLC formats, (information, supervisory, or non-sequenced) can never have an information field within the frame?
12. Which command/response is used to indicate that a station is ready to receive transmissions?
13. Which command/response is used during duplex operation to indicate a sequence error?
14. How many times would you expect to see the REJ response transmitted for a given exception condition?
15. What is the command/response used to indicate that a station is busy and cannot accept any more information type frames?
16. Assume the primary is transmitting information type frames to a secondary and a FCS (CRC) error occurs in a frame. How does the secondary inform the primary of this error condition?

Answers

1. Information (I), Supervisory (S), and Non-Sequenced (NS)
2. 11
3. True

4. Places the secondary station in a mode that allows the secondary to respond to the poll bit from the primary.
5. NSA (Non-Sequenced Acknowledge)
6. SIM (Set Initialization Mode)
- 7 Will initiate a local IPL/IML
8. DISC (Disconnect)
9. 24 bits
10. SNRM, DISC, or SIM
11. Supervisory
12. RR (Receive Ready)
13. REJ (Reject)
14. Only once
15. RNR (Receive Not Ready)
16. FCS errors are not specifically answered. Since FCS error frames are not accepted by the secondary, the Nr count would not be incremented. When the Nr count is returned to primary, an error is indicated. If the link was duplex, the sequence error produced could be reported immediately via a REJ command. (This is what happens if transmission error occurred when transmission was going from secondary to primary).

LOOP APPLICATIONS

Highlights

- Each secondary station on a loop is a repeater.
- All secondary stations monitor all traffic appearing at their loop connection.
- Any secondary station finding its address in the 'A' field captures that frame for action at the station.
- The loop is under direct control of the primary station (called the loop controller).
- A poll cycle is used to permit a secondary station to suspend the repeater function and initiate transmission.
- An NSP (Non-Sequenced Poll) Command followed by an all ones pattern starts a poll cycle.

Activity

- Read the following:

A loop configuration is essentially a simplex channel that has secondary stations attached to the channel (loop) in a serial fashion and then returns to the controlling (Primary) station as an input channel. All tributary (Secondary) stations monitor all traffic appearing at their loop connection and when addressed may intercept data from the link and/or insert their traffic for the primary station on to the link. Any primary station transmission not intercepted or modified by a secondary station returns to the primary station as transmitted but delayed in time. The amount of time delay is dependent upon the propagation delay around the loop plus any additional delays that are designed into the secondary stations, e.g. bit buffering/shift registers for logical purposes.

- Read the section on Loop Applications in the SDLC General Information Manual, Chapter 3, which is a general overview of the SDLC for a loop operation. After reading in the General Information Manual, return here for a more detailed description of the loop operation.
- Read the following:

Loop Secondary Stations

A loop secondary station is limited to half-duplex information transfer capability.

Recognition of a Go-Ahead pattern is required prior to initiating any transmissions from a secondary station. A Go-Ahead pattern is defined as the sequence of a zero bit followed by seven one bits, i.e., 01111111. Go-Aheads are generated on the loop link by the primary station transmitting the ending FLAG and then continuous one bits until all secondary station transmissions, if any, are complete. (Although the primary continues to send one bits, they are inhibited from being propagated by the secondary station that is transmitting). This sequence must be used immediately following each poll type frame although one or more FLAGS may be inserted prior to initiating the Go-Ahead. A secondary station propagates a Go-Ahead following a response transmission by transmitting a final flag following the FCS field of the last response frame and then permitting the primary station's one bits to be propagated down-line. Upon recognition of a Go-Ahead, the secondary station will, if a transmission is pending/required, convert the Go-Ahead to a FLAG (01111110) by changing the seventh one bit to a zero bit. This FLAG serves as the beginning delimiting FLAG and the standard SDLC format is appended, i.e., A,C, (Information, if any), FCS. An ending FLAG delimiter is appended following the last frame to propagate the Go-Ahead to down channel secondary stations. If the transmission consists of multiple frames a FLAG is inserted between frames. The final bit is ON in the last frame.

Two types of polling are possible. The specific poll that you have seen earlier, e.g., the Information type frame with the poll bit on, the SNRM command with the poll bit on, the NSP Command with the Poll bit on, etc. This type of poll addresses a specific secondary station and requires a response from that secondary.

The other type of poll is an optional response poll where the secondary station's response is optional. The NSP command with the Poll bit off, is used to solicit traffic from the addressed secondary station(s) only if traffic or status is pending. This command may be used with a specific station address or in the case of LOCP configurations with a group/broadcast address. If neither traffic or status is pending no response is permitted.

The following describes the operation of the Loop Secondary stations in normal response mode (NRM).

Any poll type frame received from the primary station other than an NSP command with the Poll bit off, requires a secondary response (solicited). Such a solicited response must be transmitted following the receipt of the first Go-Ahead sequence (01111111). If a response is not transmitted following the first Go-Ahead received it is not transmitted and the primary station must initiate appropriate recovery procedures. Primary station poll type frames may be of any format, I/S/NS including a loop poll (NSP) with either a specific or all stations or group address.

The secondary station may initiate a transmission following the receipt of a loop poll (NSP, Poll bit off) command and the first subsequent Go-Ahead. The response may consist of one or more I frames and/or a report of current status (S or NS formats). If a transmission is not initiated coincident with the first Go-Ahead received following the loop poll command it may not be initiated until a subsequent loop poll cycle is initiated by the primary station. Any messages (I frames) and/or specified types of secondary station status that were transmitted by virtue of a loop poll may be retransmitted on a subsequent loop poll cycle if they have not been appropriately acknowledged by the primary station within a specified timeout period. The timeout period is system specified.

In all practical applications the loop poll (NSP, Poll bit off) command will contain an all-stations address. Therefore any response to a loop poll from any given secondary station may be essentially "unsolicited" as far as the primary station is concerned.

For example a given station which has just come on-line may initiate a transmission without prior primary station awareness.

Study Questions

1. As an 8 bit character, what is the bit configuration of the Go-Ahead pattern?
2. When will a secondary station normally respond to an NSP command (with the Poll bit off)?
3. (True/False) Any poll type frame (with the poll bit on) which is received by an addressed secondary, requires a secondary response.
4. To allow all secondary stations that have pending traffic to transmit, what type of address would be included in the NSP (Poll bit off) command frame?
5. If you were to examine the loop input to a secondary station that is transmitting, what binary pattern would you find?

6. Refer to Figure 23 in the SDLC General Information Manual. Assume the primary has issued an NSP(Poll bit off) command with an all stations address. Stations A and B both have information pending for transmission. Answer the following questions:
- a. Which station will respond first?
 - b. Will both stations receive the NSP command?
 - c. What is the first character station A puts on the loop?
 - d. When Station A has finished its transmission, how does it notify Station B that it may now transmit?
 - e. How does the primary (loop controller) recognize that all stations on the loop that had pending traffic have transmitted their traffic?
 - f. Does I frame sequence counting and FCS (CRC) error checking occur for data in a loop configuration in the same way it did for a point-to-point or multipoint network?

Answers

1. 01111111
2. When it has traffic or status pending for transmission to the primary.
3. True
4. An all stations address (that is system specified).
5. All ones
6.
 - a. Station A
 - b. Yes, all stations receive the primary transmissions until a secondary breaks the propagation by transmitting.
 - c. Flag (01111110)
 - d. By causing a Go-Ahead pattern on the loop immediately following Station A's last FCS field.
 - e. By receiving the Go-Ahead pattern at the primary.
 - f. Yes

SELF-EVALUATION QUESTIONS

1. List the three secondary station modes of operation that are determined by the primary station.
2. Listed below are some statements regarding the purpose of various commands or responses. Match the statements to the appropriate command or response.
 1. A command that puts a secondary in normal response mode. a. NSA
 2. Indicates that a station is not ready to receive (busy). b. NSP
 3. Indicates that the sequence count is in error and a transmit or retransmit is required. c. RNR
 4. A response used to acknowledge non-sequenced commands. d. NSI
 5. A response that indicates the secondary requires initialization. e. SNRM
 6. A command that will put a secondary in NDM. f. RQI
 7. This command, with the Poll bit off, invites a station to transmit. g. REJ
 8. This command or response is used to move data (information) but does not cause a change of or testing of the Nr or Ns counts. h. DISC
3. The following "C" field binary configuration was received at the primary station (assume left most bit was the last received): 00010011. What type of command/response was received.
 - a. NSI command with the poll bit on.
 - b. NSI response with the final bit off.
 - c. NSI response with the final bit on
 - d. NSI command with the poll bit off
4. Below are listed various error conditions that could be encountered. From the list, select the four (4) conditions that could cause a CMDR response.
 - a. Invalid commands
 - b. Nr count received from primary does not match the Ns count that was sent to it.
 - c. Ns count received from primary does not match the Nr count that was sent to it.
 - d. The received Ns count does not match the expected Ns count.
 - e. The received frame was a supervisory frame with an information field.
 - f. The received frames FCS field indicated a CRC error.
 - g. The information field received is too long to fit in the secondary stations buffers.

5. For an all-stations poll in a loop configuration, the poll command used is the:
 - a. NSI
 - b. I
 - c. SIM
 - d. NSP (Poll bit off)

6. From the list below, arrange the listed events in the correct order as they would occur assuming secondary station to primary station transmission of one frame (Loop Configuration).
 - a. Secondary changes the GA pattern into a flag
 - b. Primary issues an NSP command with the Poll bit off
 - c. Secondary transmits its own address
 - d. Secondary transmits an information field
 - e. Secondary transmits an FCS field
 - f. Secondary transmits a control field
 - g. Primary transmits a 0 bit followed by a continuous stream of 1 bits (go-ahead pattern).
 - h. Secondary transmits a single 0 bit and stops transmitting (go-ahead to next secondary).

Refer to the Contents for the location of the self-evaluation question answers.

SESSION 4 - OPERATIONAL AND ERROR SEQUENCES

Refer to the Course Map for the approximate time to complete this session.

This session provides a number of examples of SDLC sequences between primary and secondary stations showing the use of the majority of the SDLC commands and responses.

Included are examples of point-to-point half-duplex and duplex exchanges, multipoint duplex exchanges, and switched exchanges.

OBJECTIVE

Upon completion of this session, using the available documentation, you should be able to:

1. Recognize the correct sequence of commands and responses between primary and secondary stations for the following configurations:
 - a. Point-to-Point half-duplex
 - b. Point-to-Point duplex
 - c. Multipoint duplex
 - d. Switched
2. State the difference between frame sequence confirmation in half-duplex vs duplex operation.
3. List the proper responses when error conditions are detected.

POINT-TO-POINT HALF-DUPLEX EXCHANGES

Highlights

- Two stations, a primary and a secondary, are communicating with each other.
- The primary must poll the secondary each time a response is desired.
- The secondary returns the communications link to the primary by transmitting a frame with the final bit on.
- Primary and secondary confirm each others information frames with Nr counts.

Activity

- Read the Introduction to the examples at the top of the page labeled "Examples" in the SDLC General Information Manual, Chapter 3.

- Now study the first chart of the examples labeled "Negative Response to Poll" under the heading of "Point-to-Point Half-Duplex Exchanges" in the SDLC General Information Manual, Chapter 3.

Relate the symbolic format of the frame to the legend at the top of the page above the example. Notice that the address (A) field is always the address of the secondary station, in this case, labeled E. As you examine each of the commands and responses, if you are unsure as to their meaning and purpose, go back and review that command/response in Session 3 of this course. Looking at this first example, notice that two responses are required. The first response is to acknowledge receipt of the mode command, SNRM, and the second response indicates the secondary is ready but has nothing pending to transmit.

- Now study the second chart labeled "Affirmative Response to Poll; Secondary Station sends Sequenced Frames". The charts are arranged such that they continue from one to the next one down, i.e., secondary is still in NRM. As you study this chart, frames start getting a little complicated due to the Nr and Ns counts changing. If you have any difficulty with the Nr or Ns counts, be sure to go back to Session 2 in this course and review sequence counting procedures.
- Study the remaining three charts of this example and then use the charts to answer the following study questions.

Study Questions

1. What is the proper response to a mode setting command, e.g., SNRM or DISC?
2. In what mode is the secondary after accepting a DISC command?
3. What response does the secondary use to indicate that it is off-line when polled by an RR command?
4. After the secondary has transmitted four I frames and indicates the fourth is the final frame, what will be the Nr count in the next I or S frame from the primary? (Assume counts started at zero prior to secondary transmission and no errors occurred).
5. In the example in the SDLC General Information Manual, how did the primary indicate to the secondary that a CRC error occurred?

Answers

1. NSA (Non-Sequenced Acknowledge)
2. NDM (Normal Disconnected Mode)

3. ROL (Request On Line) or RQI (Request Initialization)
4. Nr = 4
5. Upon receipt of the frame with the final bit on, the primary transmits a command with the Nr count equal to the erroneous frame. When the secondary examines this count, it knows it must retransmit the frames not accepted by the primary (frames 2, 3, and 4).

POINT-TO-POINT DUPLEX EXCHANGES

Highlights

- Two stations, a primary and a secondary, are communicating with each other.
- The primary polls the secondary. The secondary responds while the primary continues to transmit.
- Once polled, the secondary can transmit at the same time that the primary is transmitting until the secondary sends a frame with the final bit on. The secondary must then be polled again before it can transmit.
- Information frame confirmation and error checking is performed the same as half-duplex operation.

Activity

- Read the following:

The example charts for duplex are drawn in the same way as those for half-duplex. However, some additional commands and responses have been included. They are RQI, SIM, RNR, CMDR, and REJ. With the exception of REJ response, these commands/responses could have been used in the previous example for half-duplex.

- Study the first chart labeled "Secondary Station Comes On Line; Primary and Secondary Stations Exchange Sequenced Frames".

Notice that when the information transfers between A and B begin they are occurring at the same time, but that station B has longer frames than station A. (The author of the book could just as easily have made it the other way around). The point is that frame sequence counting is not as simple for duplex as it is for half-duplex. Consider the second information transfer by station B. B's Nr count is 2, indicating it has successfully received frame 1, although B is in the process of receiving the primary's frame 2. In the chart, it is assumed that this transmission of frame 2 from the primary has begun but not completed, therefore station B's Nr count has not yet been stepped to 3. However in the case of the next information transfer by station B, it is assumed that frame has been completely received from station A.

- Study the remaining charts in this example (point-to-point duplex exchanges) and use the charts to answer the following study questions.

Study Questions

1. When a secondary accepts a SNRM command, what happens to its Ns and Nr counts?
2. Assume that the primary and secondary are both transmitting I frames. Assume the secondary's frames are much shorter than the primary's frames. In fact, assume that the secondary has transmitted seven frames while the primary is still transmitting one. What should the secondary do before transmitting the eighth frame?
3. Which command or response is used to indicate a station has become busy?
4. Which response is used to indicate that an invalid command was received.
5. In duplex mode, a frame sequence error can be indicated immediately upon detection. Which command or response is used to indicate the error?

Answers

1. They are both reset to zero
2. Suspend transmitting until the primary can confirm the seven (7) frames outstanding.
3. RNR (Receive Not Ready)
4. CMDR (Command Reject)
5. REJ (Reject)

MULTIPOINT DUPLEX EXCHANGES

Highlights

- More than two stations are on the same link.
- The primary may be transmitting to one secondary and receiving from another secondary at the same time.
- The primary maintains separate sequence counts (Ns and Nr) for each secondary station on the link.
- Secondaries may communicate with the primary only, not each other directly.

Activity

- Study the example charts for "Multipoint Duplex Exchanges" in the SDLC General Information Manual. NOTE: This example shows that Secondary B comes on in normal disconnect response mode. This was purely arbitrary and in practice would depend on the secondary type as to what mode they would assume.

Study Questions

1. Can the primary alternate frames being transmitted between the secondary stations?
2. How does a secondary tell the primary that it has sent all the frames it has queued?
3. Assume one secondary has a message to send to another secondary. How could this be accomplished?

Answers

1. Yes, primary does not need to complete all transmissions to one secondary before starting transmission to another.
2. By having the final bit on in the control field of the last frame.
3. The message is sent to the primary first. The coding within the information field would tell the primary to forward the message on to the other secondary. (A new SDLC frame would be developed).

POINT-TO-POINT SWITCHED EXCHANGES

Highlights

- The calling station may be either the Primary or Secondary station.
- The Primary station always initiates the data transfers.
- The XID Command/Response is used to identify the Secondary station to the Primary station.

Activity

- Read the following:

Look at the example chart labeled "Point-to-Point Switched Exchanges (Half-Duplex)" in the SDLC General Information Manual. Notice that after the Secondary completes the calling connection, three things occur. First, the Primary gets the ID of the Secondary. Second, the Primary puts the Secondary in Normal Response Mode. Third, the Primary initiates the data transfers from the Secondary.

Study this chart and note, with the exception of the XID Command, the Command/Response sequence is identical to the Point-to-Point Half-Duplex operation.

Study Questions

1. In what state (mode) is the Secondary Station after the telephone line connection is made?
2. What is the first command issued by the Primary Station after the connection is established?
3. True/False- The station that initiates the switched connection (calling station) will always assume the role of the Primary Station after the connection is established.

Answers

1. Normal Disconnected Mode (NDM)
2. XID
3. False- The Primary and Secondary stations are specified by the SDLC network design. If a Secondary initiates the call, it is still a Secondary station and is under the command of the Primary.

SELF-EVALUATION QUESTIONS

1. When the primary transmits a DISC command to an addressed secondary, what is the proper response?
2. Assume the commands/responses on a communication link appeared as follows:

<u>Command</u> -	<u>Response</u>
B,I(0)P(0)	
C,I(0)P(0)	B,I(0)F(1)
D,I(0)P(0)	C,I(0)F(1)
	D,I(0)F(1)

The type of communication facility being used is:

- a. Point-to-Point half-duplex
 - b. Point-to-Point duplex
 - c. Multipoint duplex
 - d. Point-to Point Switched
3. Assume the command/responses on a communications link appeared as follows:

<u>Command</u> -	<u>Response</u>
B,RR-P(0) -	
C,I(0)P(0)	B,I(0)F(0)
D,RR-P(0) -	C,RNR-F(1)
-	D,CMLR-F

Which of the following statements is true?

- a. All three secondary stations transmitted an information field with their responses.
 - b. Station C accepted the information frame from the primary but is now busy.
 - c. Station B is indicating a sequence error.
 - d. Station D received a frame with a FCS error.
4. Assume a secondary station established the communication link on a switched network. After the secondary informs the primary of its ID and the Primary sends a Receive Ready Command, what should be the next response transmitted by the Secondary Station?
 - a. XID
 - b. NSA
 - c. First I frame
 - d. ROL
 5. The only difference in frame sequence confirmation between half-duplex and duplex is:
 - a. In duplex, frames are confirmed only when a poll command or final response is transmitted.
 - b. In half-duplex, each frame is always confirmed as soon as it is accepted by the primary or secondary.
 - c. In duplex, frames are confirmed at the next transmission time after they are received.

6. What response should a secondary transmit if it receives a SIM command that had an information field?
 - a. REJ
 - b. NSA
 - c. RQI
 - d. CMDR

7. Assume a secondary station operating in duplex mode received a frame with a FCS error. What response could the secondary transmit to inform the primary that the frame should be retransmitted?
 - a. CMDR
 - b. REJ
 - c. NSA
 - d. NSI

Refer to the Contents for the location of the self-evaluation question answers.

SELF-EVALUATION QUESTION ANSWERS

SESSION 1 - INTRODUCTION

1. b.
2. a, c, d, f
3. True
4. a

SESSION 2 - SDLC CONCEPTS

1. e
2. Transient, Idle, or Active states
3. a. 1
b. 6
c. 3
4. Flag, Address, Control, Information, FCS
5. Upon receiving an information frame, the receiving station compares its Nr count with the received Ns count. They should be equal.
6. a. 2
b. 4
c. 5
d. 3
e. 1
7. a, c, d
8. 1. To allow any bit combination within the frame and not be concerned that the combination might appear as a flag (or abort).
2. Aids in providing more transitions for bit clocking.
9. b

SESSION 3 - APPLICATION SITUATIONS

1. Normal Response Mode (NRM), Normal Disconnected Mode (NDM), and Initialization Mode.
2. 1. e
2. c
3. g
4. a
5. f
6. h
7. b
8. d
3. c
4. a, b, e, g
5. d
6. b, g, a, c, f, d, e, h

SESSION 4 - OPERATIONAL AND ERROR SEQUENCES

1. NSA with the final bit CN.
2. c
3. b. (Nr count indicates acceptance of I frame from primary)
4. d
5. c
6. d
7. b

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